WINTER QUARTERS CANYON DATA ADEQUACY

TEXT
APPENDICES A, B, AND C

INTRODUCTION
GEOLOGIC AND COAL DATA
WATER RESOURCES

VOLUME 1

TABLE OF CONTENTS

	Volume No.
Text	1
APPENDIX A - INTRODUCTION	1
Manti-La Sal Forest, Data Adequacy Letter	
Skyline Mine Identification of Interest	
APPENDIX B - GEOLOGIC AND COAL DATA	1
Geologic Data, UCO, Inc., September 1982	
APPENDIX C - WATER RESOURCES	1
Hydrologic Inventory & Baseline Study, UCO, Inc., Vaughn Hansen Associated, Inc., 1982	
Surface Water Rights, Skyline Mine Reclamation Plan, Environmental Data, Volume 4, 1992	
Watershed Inventory and Analysis, Price River Watershed, James L. Iaquinta, 1985	
Groundwater Hydrology, Skylines Mines, Mining & Reclamation Plan, Volume 1, 1992	
Water Resources Questar Pipeline Company's, Final Environmental Impact Statement, 1990	
Hydrologic Monitoring of Selected Streams in Fields of Central and Southern Utah, 1987	
Gen. Hydrologic Considerations Related to Coal Development and Subsequent Impacts, 1981	
Municipal Watersheds, Price City Water Letter, 1981	
Hydrology of Area 56, Northern Great Plains and Rocky Mountains Coal Provinces, Utah	
Water Quality in Pleasant Valley, Utah, 1981	
Surface Water Hydrology, Skyline Mines, Mining and Reclamation Plan, Volume 1, 1992	

RECEIVED
SEP 04 2002
DIVISION OF
OIL, GAS AND MINING

TABLE OF CONTENTS

Volume No.

Selected Well Water Levels, Skyline Mines, Mining and Reclamation Plan, Volume 4, 1992

Hydrologic Inventory of Skyline Property and Adjacent Areas, 1979 1

APPENDIX C (Continued) - WATER RESOURCES 2

U.S. Forest Service, Manti-La Sal Forest, Dennis Kelly Data Files, Huntington Creek

U.S. Forest Service, Manti-La Sal Forest, Dennis Kelly Data Files, Kitchen Creek

U.S. Forest Service, Manti-La Sal Forest, Dennis Kelly Data Files, Gooseberry Creek

U.S. Forest Service, Manti-La Sal Forest, Dennis Kelly Data Files, Eccles Canyon Creek

Hydrologic Analysis for Eccles Canyon, Christopher Knopp, 1980

100 Year Flood Plan Determination of Eccles Creek, Skyline Mines, Appendix Volume A-1

U.S. Forest Service, Manti-La Sal Forest, Dennis Kelly Data Files, Mud Creek

U.S. Forest Service, Manti-La Sal Forest, Dennis Kelly Data Files, Fish Creek

U.S. Forest Ser., Manti-La Sal Forest, Dennis Kelly Data Files, Winter Quarters Cany. Creek

Winter Quarter Canyon Seep & Spring Surveys

United States of America, Forest Service Water Rights, WUC-No's

Surface Water Rights, 1992

Letters Regarding Schofield Reservoir, Department of Health & Pleasant Valley Committee

Schofield Reservoir Phase I, 314 Clean Lakes Study 1980 - 1982, Utah Dept. of Health

Chemical and Physical Characteristics of Water & Sediment in Schofield Reservoir, USGS

Hydrology of the Price River Basin, Utah with Emphasis on Selected Coalfield Areas

TABLE OF CONTENTS

	Volume No.
Selected Hydrologic Data Price River Basin Utah, USGS, 1982	2
APPENDIX D - SOILS AND ASSOCIATED RECLAMATION	3
Soil Survey of Carbon Area, Utah	
Soils, Skyline Mines, Mining and Reclamation Plan, Volume 1, 1992	
Soils, Questar Pipeline Company's, Final Environmental Impact Statement	
U.S. Dept. of Agriculture, Alluvial Valley Floors and Natural Resources Waters Letter	
Soil and Land Use Inventories Schofield Project, UCO, Inc.	
Skyline Mine Area Aerial Photographs	
APPENDIX E - WILDLIFE AND THREATENED AND ENDANGERED SPECIES	3
Fauna of Southeastern Utah and Life Requisites Regarding Their Ecosystems	
Assessment of Baseline Wildlife Data, Bio\West, Inc.	
Preliminary Ground Surveys for Nesting Raptors, Bio\West, Inc.	
APPENDIX F - CULTURAL RESOURCES	4
Archaeological Evaluations in Winter Quarters Locality, AERC Project 1282	
Cultural Resources Inventory Report for Questar Pipeline Company, 1990	
Cultural Resources, Questar Pipeline Company's, Final Environmental Impact Statement, 1990	
Historical and Cultural Resources, UCO, Inc., 1982	

TABLE OF CONTENTS

	Volume No.
APPENDIX G - AIR QUALITY	**4**
Climatology and Air Quality, UCO, Inc., 1982	
Air Quality, Questar Pipeline Company's, Final Environmental Impact Statement, 1990	
Clear Creek, Utah Monitoring Program, Radian Corporation, 1979	
APPENDIX H - VEGETATION AND LAND USE	**4**
Data Adequacy Information for the Skyline Mine: Vegetation of the Winterquarters Tract	
Biologic Resources, Questar Pipeline Company's, Final Environmental Impact Statement, 1990	
Riparian Survey, Questar Pipeline Company's, 1990	
Vegetation Resources Ground Coal Mining Permit Application, UCO, Inc., 1982	
Land Status and Mineral Ownership, BLM	
Manti-La Sal Forest -- Price Ranger District Sheep Grazing Allotment Data	
Land Use, Skyline Mines Mining and Reclamation Plan, Volume 1, 1992	
U.S. Dept. of Agriculture Forest Service, Special Use Permit, Questar Pipeline Company	
Soil and Land Use Inventories Schofield Project, UCO, Inc., 1982	
Questar Pipeline Company's, Abstract, Summary, and Record of Decision, 1990	
Carbon County Plats and Consolidated Coal Company Land Ownership Plate	

TABLE OF CONTENTS

Volume No.

APPENDIX I - SOCIOECONOMICS 4

Census of Population & Housing, Carbon County Office of Planning & Budget

Socioeconomic Assessment, UCO, Inc. 1982

Socioeconomics, Questar Pipeline Company's Final Environmental Impact Statement, 1990

Community Infrastructure & Socio-Economics, Skyline Mines Mining and Reclam. Plan, Volume 1, 1992

TEXT

WINTER QUARTERS CANYON DATA ADEQUACY

GEOLOGIC AND COAL DATA

The geologic and coal data presented in this document was collected simultaneously but is not complete. Additional information relating to this subject will be collected and presented by the Bureau of Land Management.

WATER RESOURCES

Essential Streamflow Data

Watercourses are discussed and shown in various reports but specially on Plate 13 "Streams in the Vicinity of Skyline Property" located at the end of Appendix C. Runoff characteristics, streamflow of perennial streams, and surface-water/groundwater interactions are presented in Appendix C. A survey of the Winter Quarters Canyon area seeps and springs have been completed for the fall flow of 1991 and the spring flow of 1992.

Water Resource Inventory

Schofield reservoir if fed by the seeps and springs located in the Winter Quarters Canyon Area as well as others in the area. Water uses/water rights are identified on a table in Appendix C (Continued).

Water quality - on streams in the area, water uses/water rights, and geologic or groundwater sources and their stratigraphic relationships to the coal seam are included in Appendix C (Continued).

Water wells in the area are identified in the groundwater data related to the Skyline Mine.

Flood Plains

In a personal communication with Dennis Kelly in March of 1992, flood plain calculations were unnecessary if not the applicant was not planning on building roads on the potential lease area. Therefore no 100 year floodplains are identified in immediate area, however one for Eccles Canyon has been included in Appendix C (Continued).

No "Natural Resource Waters" occur in the area of the possible lease, according the a personal conversation with Dennis Kelly, March 1992. A letter included in Appendix D also discusses resource waters.

Watersheds are found on the Watershed and Water Rights Map in Appendix C (Continued) "Surface Water Rights, 1992.

Groundwater Aquifers

Depth below surface, generalized geologic structure, possible subsidence areas, potentiometric surface, groundwater recharge/discharge, rates of groundwater flow, and interrelationships with special hydrologic features are presented in Appendix C.

SOILS AND ASSOCIATED RECLAMATION

An Order 2 soil survey needed to provide the necessary information can be found in the Soil Survey of Carbon Area, Utah: Soil Conservation Service, and Soil and Land Use Inventories Schofield Project: UCO,Inc., located in Appendix D.

An approximate coal tract boundary has been included on some plates within this submission, however, the coal tract boundary has not yet been delineated.

Skyline Mine Area Aerial Photographs have been provided for the determination of the extent of the following areas:

Soil Mapping Units
Forest Areas (see Appendix H, Mt. Nebo Scientific report)
Hay/tame Pastures
Intended Dryland Agriculture
Irrigated Areas
Alluvial Valleys
Areas of Unique or Special Concern Riparian, Wetlands

Reports and maps are included in Appendix D describing the soils present in the area, and their classifications.

The United States Department of Agriculture report "Soil Survey of Carbon Area, Utah in Appendix D addresses the area soils physical and chemical properties and water features. The soil volumes were not calculated since the coal tract boundary lease has not yet been delineated.

The applicant concurs that topsoil will be stockpiled and if needed revegetated. However no surface disturbances are anticipated at this time.

WILDLIFE AND THREATENED AND ENDANGERED SPECIES

Primary species occurrence for piscinian, amphibian, reptilian, avian, and mammalian species are identified in Appendix E. All information pertaining to wildlife can be found in Appendix E, Volume 4.

A rating per animal species for the biological value of ecosystems inhabitated and their distribution by standard habitat site are located in Appendix E.

The relative abundance of each animal has been denoted as common, uncommon, limited, rare, threatened, endangered, occasional, or accidental in "Fauna of Southeastern Utah and Life Requisites Regarding their Ecosystems".

Rank of biological value (critical, high-priority, substantial, or limited) as well as depictions on a map for seasonal use areas (e.g. big game winter or summer ranges and parturition areas; fish or wildlife migration routes, avian or bat like animals roost concentration areas, grouse/leks and associated nest/brooding areas; drumming logs; raptor aerie or nest sites; snake or animal dens; fish nest or spawning zones as well as rearing habitat; waterfowl staging areas) of threatened/endangered and sensitive species or those of high Federal/State interest are located in the wildlife appendices.

Plant species occurrence, description and abundance are identified in Appendix H, Volume 5. No threatened of endangered plant species are known to inhabit the area.

CULTURAL RESOURCES

A Class I literature search for the areas to be considered for leasing and a Class II cultural resource evaluation in the vicinity of Winter Quarters Canyon was conducted in October of 1991 by AERC (Archeological-Environmental Research Corporation) and included in Appendix F. Any sites evaluated in the proposed leasing area qualify for the National Register of Historic Places are described in the AERC report.

AIR QUALITY

Existing Ambient Air Quality Data

No surface facilities are planned at this time, however air quality data for the vicinity is included as Appendix G. UCO, Inc. prepared a coal mining permit application in 1982 which

contained a section on air quality for Winter Quarter Canyon which has been included in the appendix. The Clear Creek Monitoring Program including sites on Boardinghouse Peak, Eccles Canyon and Clear Creek, prepared by Radian Corporation is also included.

Coal lease boundaries have not yet been delineated, thus level of development, life of the facility, and coal production as a function of time cannot be determined.

VEGETATION AND LAND USE

Surface and mineral ownership are identified in Appendix H.

Vegetation communities are delineated and described in a report entitled "Data Adequacy Information for the Skyline Mine: Vegetation of the Winterquarters Tract" (Appendix H). The area is forest and contains no farmlands. The rangelands within the area (grazed by livestock, big game and small wildlife), and timberlands are identified in Appendix H.

The land use in Winter Quarters Canyon and adjacent areas consists of grazing, recreation, forestry and natural gas transmission, there are no special use areas or cemeteries within the area. Existing livestock use and carrying capacity are described data provided by Manti-La Salt Forest Range Specialist and in the Skyline Mine and Reclamation Plan, Volume 1 (Appendix H).

Areas with potential reclamation problems are identified in Appendix H in the Questar Pipeline Company report.

The only existing right-of-way, easements, withdrawals, or special classified area is the Questar Pipeline Special Use Permit identified in Appendix H. There are no existing railroad, transportation routes, or transmission systems within the potential coal lease area.

SOCIOECONOMICS

Appendix I consists of data available to meet the data adequacy standards.

APPENDIX A

INTRODUCTION

APPENDIX A
INTRODUCTION

Table of Contents

Manti-La Sal Forest, Data Adequacy Letter A-1

Skyline Mine Identification of Interest A-2

MANTI-LA SAL FOREST
DATA ADEQUACY LETTER

United States Department of Agriculture | Forest Service | Manti-La Sal National Forest | 599 W. Price River Dr. Price, Utah 84501

Reply to: 2820

Date: August 1, 1991

James M. Parker
Bureau of Land Management
Utah State Office
324 South State, Suite 301
Salt Lake City, Utah 84111-2303

Dear Mr. Parker,

The Manti-La Sal National Forest has completed preliminary Forest Plan consistency and data adequacy reviews of the three general areas presently under application for leasing under the Lease-on-Application procedures. Since tract delineation teams have not yet evaluated the proposed tracts and specific tract boundaries have not been delineated, the review results cannot be considered final. More specific information can be provided once the tracts are delineated for evaluation.

The Forest Plan consistency review showed that all three areas are available for further consideration for coal leasing subject to application of the coal lease unsuitability criteria (site-specific review), management decisions and completion of site-specific evaluations. Concerns and threshold limitations have been established for each of the areas. Until specific tract boundaries are delineated, it is not possible to make a definitive determination on Forest Plan consistency. Specific Forest Plan direction for each of the areas is as follows:

Crandall Canyon/Huntington Canyon Area

The proposed tracts lie within Coal Multiple Use Evaluation Area 2 (Huntington Canyon-Gentry Mountain). Further lease actions using Huntington Canyon for transportation and mine development, other than supplying existing operations, will be delayed until it is determined that unacceptable impacts to existing resources would not occur. Specific resource concerns include potential conflicts with water quality and flow, recreation, traffic on State Highway 31 (Fairview-Huntington Highway), and visual quality.

Cottonwood Canyon/North Trail Mountain Area

This proposed tract lies within Coal Multiple Use Evaluation Area 8 (Ferron Canyon, Cottonwood - Trail Mountain). Coal lands other than in the Joes Valley Graben will be available for further lease action consideration. Leasing activity will be limited to insure that any activity will not adversely affect minimum viable populations for management indicator species. Impacts to water quality and flow are also major concerns.

Winterquarters Canyon Area

This proposed tract lies within Coal Multiple Use Evaluation Area 1 (Pleasant Valley - Fish Creek). Further lease action considerations other than for supplying existing operations will be delayed until current impacts to water quality have been mitigated and proposed development activities related to leasing will not cause the threshold to be exceeded. Pollution of Scofield Reservoir is the identified concern. Utah water quality standards are established as a threshold for water quality. Protection of perennial flows is also a major concern in this area.

Enclosed are preliminary data adequacy review reports for the three areas. The reports specifically address each task identified in the data adequacy requirements. In summary, there are data deficiencies in the areas of hydrology, cultural resources, and wildlife. The amount of time needed to obtain this information would depend on the size and configuration of the tracts delineated by the tract delineation teams. Data adequacy standards for coal reserves were not addressed in the reports since this is a responsibility of the Bureau of Land Management.

If you have any questions, contact the Forest Supervisor's Office in Price, Utah.

Sincerely,

/s/ Aaron L. Howe
for
GEORGE A. MORRIS
Forest Supervisor

Enclosures

cc:
D-2
D-3
C.Reed
RO

Preliminary
Data Adequacy Standards Review
July, 1991
Coastal States Energy Co. LBA No. 6 (UTU-67939)
Winterquarters Canyon Area

Geologic and Coal Data

Will be addressed by BLM

Water Resources (1,2) Essential Streamflow Data	Flow 3 Yrs. Data or Channel Geom	Quality 3 Yrs. Data on Per. Streams	Surface/ Groundwater Interaction
Winterquarters Canyon	N	Y	N
Woods Canyon	N	N	N
Eccles/Green Canyons	Y	Y	Y
Kitchen (North)	N	Y	N
Upper Huntington Creek	Y	Y	N
Fish Creek	Y	Y	N
Gooseberry/Mill Creeks	N	Y	N

Water Resource Inventory

(3) Identify Water Reservoirs

a. Runoff fed	Y
b. Spring fed	Y
1. geologic or goundwater sources	N
2. water quality	Y
c. Water uses/water rights	Y

(4) Identify springs, seeps and perennial streams

a. water quantity	Y
b. water quality (perennial streams)	Y
c. water uses/water rights	Y
d. geologic/groundwater sources	N

(5) Identify wells and determine

a. water uses/water rights	Y
b. water levels	N
c. geologic sources/aquifer conditions	N
c. water quality	Y (from springs and in-mine drill holes)

(6) Identify and Map

a. Active flood plains	
1. areas with evidence of historic surface irrigation	Y
2. nonirrigated land phys. similar to irrigated land	Y
b. 100 yr. floodplains	Y
c. Municipal Watersheds	Y
d. Natural Resources Waters	Y

(7) Identify aquifers

a. Depth-range below surface	Y
b. Generalized geologic structure	Y
c. Possible subsidence areas	Y
d. Generalized potentiometric surface	N
e. Generalized groundwater recharge/discharge	Y
f. Estimated rates of groundwater flow	N
g. Interrelationships (discharge & recharge) w/ special hydrologic features	N

Additional Hydrologic investigations are needed to identify perennial drainages, map the piezometric surface of ground water in the Starpoint/Blackhawk aquifer and to determine the interrelationship between geology and ground and surface water. This information is needed to determine what impacts mining could have on ground and surface flow and quality.

Soils and Associated Reclamation

(1) Determine if soil survey exists	N
Need order 2 survey	(3rd order complete) (adequate for analysis)
(2) Delineate coal tract boundaries on soil maps	Y
(3) Determine aerial extent of:	
a. soil mapping units	Y
b. forest areas	Y
c. hay/tame pastures	Y
d. intensive dryland agriculture	Y
e. irrigated areas	Y
f. alluvial valleys	Y
g. areas of unique or special concern riparian, wetlands	N (Riparian mapping not completed)
(4) Interpret soil mapping units to determine	
a. soils present in tract	Y
b. soils series composition (Table 3)	Y
c. prime farmland soils	Y
d. soils of statewide importance	Y
e. saline soils	Y
f. sodic soils	Y
g. land capability class	Y
h. potential nature vegetation community	Y
(5) Rate soils for:	
a. soil reconstruction material	Y
b. determine volume	Y
c. seeding mixtures	Y

Existing data should be sufficient to complete soil calculations and meet the data adequacy standards.

Wildlife and Threatened and Endangered Species	Others	Raptors	Sensitive Species
(1) Identify primary species occurrence	Y	Y/N (Eccles Canyon Only)	*N
(2) Provide rating per animal species	Y	Y	Y
(3) Provide depiction of animal distribution	Y	N	N
(4) Denote relative abundance	Y	N	N
(5) Provide rank of biological Value	Y	Y	Y

*The Townsend's Big-eared Bat, Flammulated Owl, and Three-toed Woodpecker are sensitive species which could inhabit the area. No survey has been done for these species.

Additional field investigations will be needed to determine if raptor nests exist within the tract area and their status. Two years of data is required which must be completed in the spring. Field investigations will be necessary to determine if the sensitive species listed above inhabit the area (one year of data required).

Threatened, Endangered and Sensitive Plants	
(1) Identify plant species occurrence	Y (none known)
(2) Depict plant species occurrence	Y
(3) Relative abundance	Y

Cultural Resources	
(1) Complete Class I literature search (National Register Sites)	Y
(2) Where no data, complete Class II inventory	N
(3) Consult with SHPO	N
(4) National Register sites unsuitable - consult SHPO and ACHP on exemptions	(To be completed during lease analysis)

Only a small portion of the area has been surveyed, consisting of cultural resource clearance surveys for exploration drill holes and other proposed projects. Based on previous surveys in adjacent areas, prehistoric cultural properties can be expected to occur along escarpments and ridge areas. A Class II field reconaissance will be needed in these areas.

Air Quality	Y

Vegetation and Land Use	
(1) Identify surface and mineral ownership	Y
(2) Delineate and describe vegetation communities and and relative abundance(acres) of each community	N
(3) Identify existing farmlands, prime or unique rangelands, and timberlands.	Y
(4) Describe existing livestock use and carrying capacity	Y
(5) Identify areas of potential reclamation problems	Y
(6) Identify existing rights-of-way, easements, withdravals, and special classified areas.	Y
(7) Delineate existing railroad, transportation, or transmission systems	Y

(8) Identify other land use: VQO, recreation, commercial timber, paleontological sites, cemeteries, defense installations, special-use areas, etc. Y

Some field work (2 days) is needed to refine information obtained from aerial photographs and range inventory maps.

Socioeconomic Y

There is data available to meet the data adequacy standards.

References Available

BLM, 1988, Data Adequacy Standards for Federal Coal Leasing, Uinta-Southwestern Utah Coal Region, Bureau of Land Management

Danielson, et. al., 1981, Hydrology of Coal-Resource Areas in the Upper Drainage of Huntington and Cottonwood Creeks, Central Utah: U.S. Geological Survey Water Investigations Open-File Report 81-539

Price, D., and Plantz, G.G., 1987, Hydrologic Monitoring of Selected Streams in Coal Fields of Central and Southern Utah - Summary of Data Collected, August 1978 - September 1984: U. S. Geological Survey Water - Resources Investigations Report 86-4017.

Simons, Li & Associates, Inc., 1984, Final Report, Cumulative Hydrologic Impact Assessment, Huntington Creek Basin, Emery County, Utah, on file at the Office of Surface Mining, Western Technical Center, Denver, CO.

Lindskov, K. L., 1986, Potential Effects of Anticipated Coal Mining on Salinity of the Price, San Rafael, and Green Rivers, Utah: U. S. Geological Survey Water-Resources Investigations Report 86-4019.

Kelly, G. Dennis, 1984, Watershed Inventory and Analysis for the Huntington Creek Watersheds. USDA - Soil Conservation Service, SCS-TP-149.

Manti-La Sal National Forest, 1984, Updated 1988, Inventory of Landslides Including 1983 and 1984 data. Manti Division. USDA-Forest Service, Price, Utah. Atlas.

Kelly, G. Dennis, 3/26/80, Municipal Supply Watersheds for Cleveland, Elmo, Lawrence and Adjacent Farm Areas. Manti-La Sal National Forest, Price, Utah. File 2540.

Kelly, G. Dennis, 3/26/80, Huntington Watersource. Manti-La Sal National Forest, Price, Utah. File 2540.

Kelly, G. Dennis, 12/17/81, Flushing Flow in Huntington Creek. Manti-La Sal National Forest, Price, Utah. File 2530.

Utah Fuel Co., 1991, Mining and Reclamation Plan, Skyline Mines, on file at the Office of Surface Mining, Western Field Office, Denver, CO

State of Utah, Department of Health, 1986, State of Water Quality Report, Department of Health, Division of Environmental Health, Bureau of Water Pollution Control, Salt Lake City, Utah

State of Utah, Department of Health, 1982, State of Utah Lakes Inventory and Classification, Department of Health, Division of Environmental Health, Bureau of Water Pollution Control, State of Utah, Salt Lake City, Utah

Waddell, K.M., D.W. Darby, and S.M. Theobald, N.D. Chemical and Physical Characteristics of Water and Sediment inScofield Reservoir, Carbon County, Utah: U.S. Geological Survey Open File Report 83-252

Waddell, K.M., D.W. Darby, and S.M. Theobald, 1985, Chemical and Physical Characteristics of Water and Sediment in Scofield Reservoir, Carbon County, Utah: U.S. Geological Survey Water Supply Paper 2247

Clyde, Calvin G., et. al., 1981, Water Quality in Pleasant Valley, Utah, Hydrology and Hydraulics Series UWRL/H-81/02, Utah Water Research Laboratory, Utah State University, Logan, Utah

Denton, R.L., Myron I. Cox, and Laverne B. Merritt, 1983, Scofield Reservoir Phase I, Clean Lakes Study 1980-1982, Utah State Department of Health, Salt Lake City, Utah

Iaquinta, James L., 1985, Watershed Inventory and Analysis for the Price River Watershed, Price Ranger District, Manti-La Sal National Forest, Manti-La Sal National Forest, Price, Utah

Larsen, Dan, et. al., N.D., Soil Resource Inventory, Manti Division, in preparation at the Manti-La Sal National Forest, Price, Utah

Cultural Resources Survey Results ML-89-514 and ML-80-242

Hauck, F.R., 1991, Cultural Resource Evaluation of Three Proposed Coal Exploration Well Locations and Associated Access Routes in the Winter Quarters Canyon and Granger Ridge Locality of Carbon County, Utah, Archeological-Environmental Research Corporation, Bountiful, Utah.

Winter Quarters Canyon
Data Adequacy

October 1992

SKYLINE MINE
IDENTIFICATION OF INTEREST

SKYLINE MINE IDENTIFICATION OF INTEREST

Utah Fuel Company, a wholly owned subsidiary of Coastal States Energy Company, operates the Skyline Mines. The Skyline Mines are owned by Coastal States Energy Company and Skyline Coal Company, the Permittees. Coastal States Energy Company is a wholly owned subsidiary of The Coastal Corporation; Skyline Coal Company is a wholly owned subsidiary of Coastal States Energy Company.

Utah Fuel Company has not carried on any coal mining activities in any name other than in the name of the company as aforestated. Coastal States Energy Company and thereby The Coastal Corporation (Coastal States Energy Company's parent corporation) owns an underground coal mine (Mine Permit ACT/041/002) located near Salina, Utah, operated as Southern Utah Fuel Company. Coastal States Energy Company has not carried on any coal mining activity during the past five years other than those operations at the SUFCO Mine and the Skyline Mine.

Coastal States Energy Company currently holds an approved mining permit Number ACT/007/005 for the Skyline Mines dated December 1, 1989.

The Skyline Mines operates on the leasehold interests owned by the Permittee, Coastal States Energy Company and Skyline Mining Company. The lands on which mining occurs are a part of the Manti-LaSal National Forest. The leasehold interests involve all or part of the following coal leases, which have been subleased and/or assigned to Coastal States Energy Company and Skyline Mining Company;

Federal Lease	Issued to	Date of Issuance
Utah - 020305	Emmett K. Olsen	03/01/62
Utah - 044076	Armeda N. McKinnon	09/01/65
Utah - 0142235	Malcolm N. McKinnon	10/01/64
Utah - 0147570	Malcolm N. McKinnon	05/01/65
Utah - 073120	Independent Coal & Coke Company	

County Lease	Issued to	Date of Issuance
Carbon County Coal Lease	Kanawha & Hocking Coal and Coke Company	05/01/74

The legal description of the above listed coal leases are:

Federal Coal Lease Serial #Utah - 020305

T. 13 S., R. 6 E., SL Meridian, Utah

Sec. 13: SW-1/4 SW-1/4 (Lot 7);
Sec. 14: SE-1/4 SE-1/4;
Sec. 23: E-1/2 E-1/2;
Sec. 24: W-1/2 NW-1/4, SE-1/4 NW-1/4, S-1/2;
Sec: 25: All (Lots 1 thru 4, S-1/2 N-1/2, S-1/2);
Sec. 26: E-1/2 E-1/2;
containing 1,439.40 acres;

Federal Coal Lease Serial #Utah - 044076

T. 13 S., R. 6 E., SL Meridian, Utah

Sec. 26: W-1/2 E-1/2, W-1/2;
Sec. 27: Lots 1, 2, 3, 4, E-1/2, E-1/2, W-1/2, excluding Lawrence Reservior;
Sec. 34: Lots 1, 2, 3, 4, 5, 6, 7, 8, and S-1/2 excluding Lawrence Reservoir;
Sec. 35: Lots 1, 2, 3, 4, 5, 6, 7, NE-1/4, E-1/2, NW-1/4, NW-1/4 SW-1/4. N-1/2 SW-1/4;
containing 2,357.82 acres;

Federal Coal Lease Serial #Utah - 0142235

T. 13 S., R. 6 E., SL Meridian, Utah

Sec. 11: S-1/2 S-1/2;
Sec. 14: W-1/2, SW-1/4 SE-1/4;
containing 520.00 acres;

Federal Coal Lease Serial #Utah - 0147570

T. 13 S., R. 6 E., SL Meridian, Utah

Sec. 10: Lots e and 4, E-1/2 SW-1/4 and SE-1/4;
Secs.15 and 22, All;
Sec. 23: W-1/2 E-1/2 and W-1/2;
containing 2,092.70 acres;

Federal Coal Lease Serial #Utah - 073120

T. 13 S., R. 6 E., SL Meridian, Utah

Sec. 13: Lots 1, 2, 3, 4, 5, 6, 8;
Sec. 14: NE-1/4, N-1/2 SE-1/4;
Sec. 24: NE-1/4 NW-1/4;
containing 557.22 acres

Carbon County Coal Lease

Township 13 South, Range 6 East SLM

Sec. 24: Portion of W-1/2 NE-1/4
containing 65.0 acres

The leases above listed are subject to that certain Exchange Agreement dated September 9, 1975 between Valley Camp of Utah, Inc. and Energy Fuels Corporation, a Colorado corporation. The effect of the Exchange Agreement was to transfer the ownership of coal rights such that Energy Fuels Corporation, (now owned by Coastal States Energy Company and Skyline Coal Company), owns or controls the coal which is located north and west of the Connelville Fault. The Connelville Fault is the south-easterly boundary of the Skyline permit area. Actual location of the fault may vary when encountered through actual mining operations. The result of this agreement is that only a portion of the originally leased property is controlled by the Permittee and included in the permit area.

The right to enter the leaseholds conveyed by the Federal Coal leases is conferred to the lessees by the Mineral Leasing Act of 1920 and the leases themselves. Approximately 6,290 acres are contained in the leaseholds of the leases. Due to limiting factors of "no or thin coal areas and vertical seam proximity areas", restrictions of the Exchange Agreement or other restraints, underground coal mining will occur only on a portion of the Federal leaseholds.

Coastal States Energy Company and Skyline Coal Company, (formerly Getty Mining Company) by the Joint Venture Agreement effective September 8, 1978, have agreed that Utah Fuel Company, a wholly owned subsidiary of Coastal States Energy Company, is to operate the Skyline Mines, and that Utah Fuel Company shall have the right to enter the subject leaseholds.

The proposed North Lease area is adjacent to coal leases already held by the Coastal Corporation and is therefore a logical extention of already existing leases. The Coastal Corporation is therefore interested in obtaining coal leases on this area to extend the life of the Skyline Mines which will result in the orderly extraction of this coal resource.

APPENDIX B

GEOLOGIC AND COAL DATA

GEOLOGIC DATA
UCO, INC
SEPTEMBER 1982

APPENDIX B
GEOLOGIC AND COAL DATA

Table of Contents

Geologic Data, UCO, Inc., September 1982 B-1

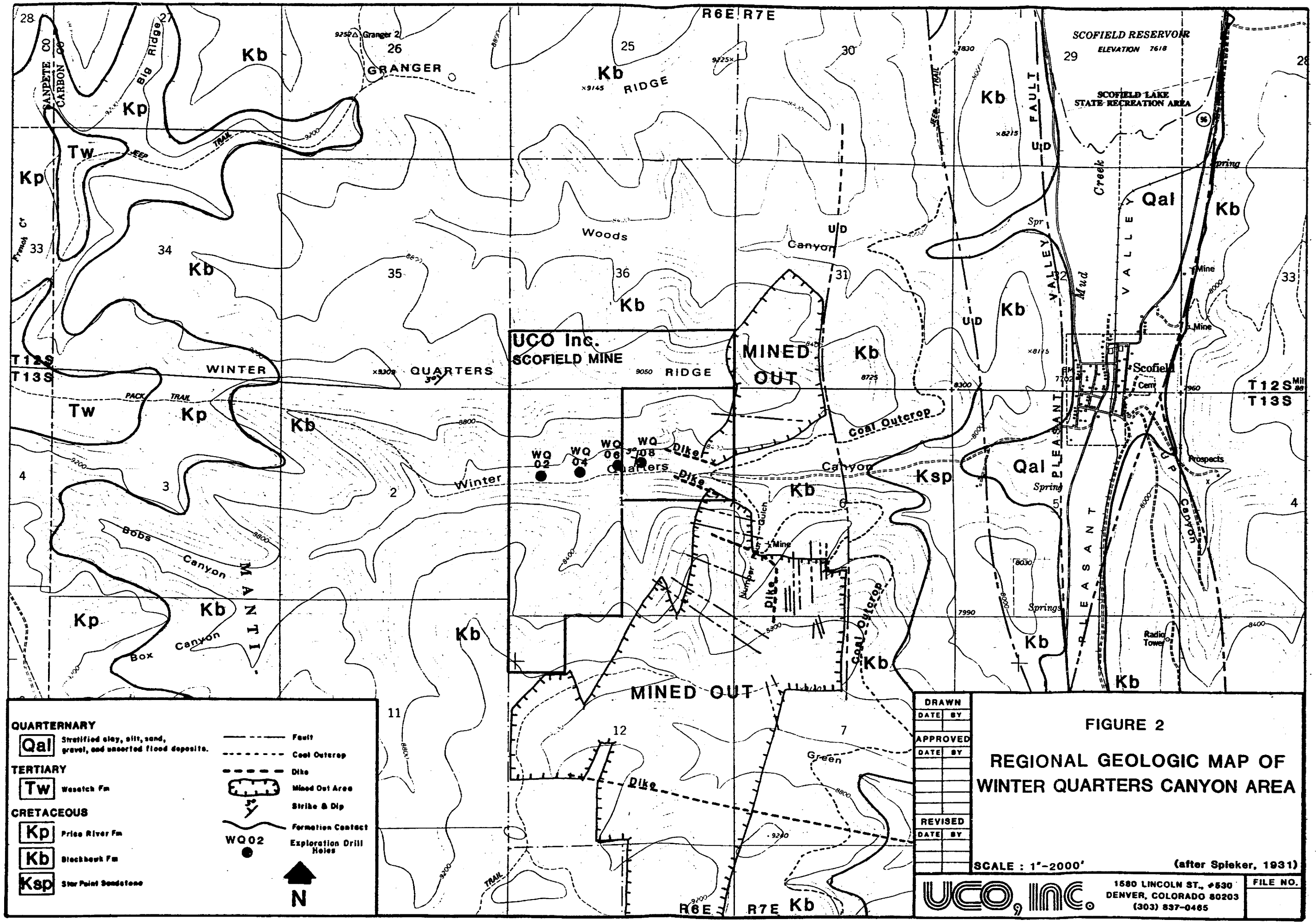
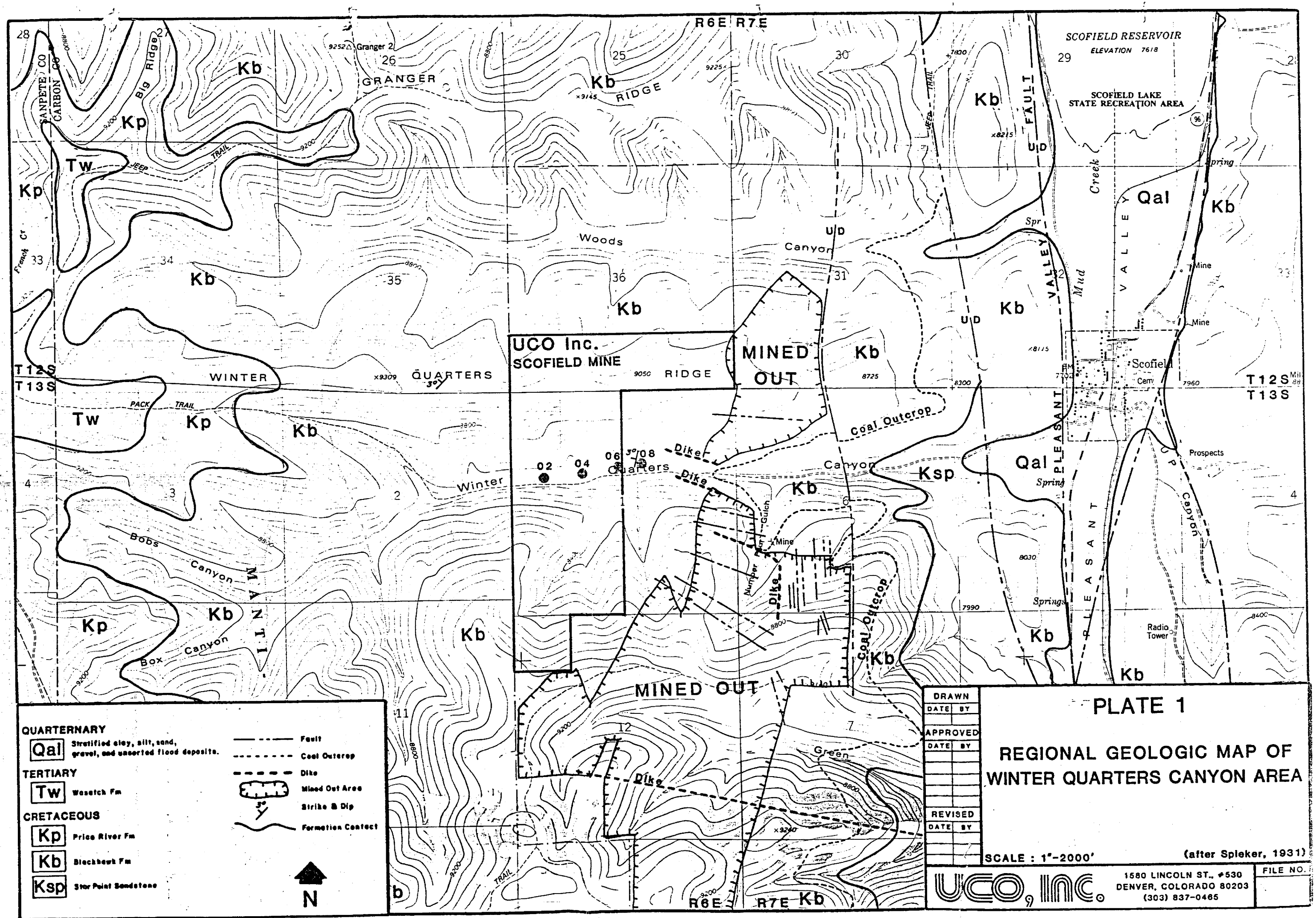


FIGURE 2

REGIONAL GEOLOGIC MAP OF WINTER QUARTERS CANYON AREA


R6E R7E
SCOFIELD RESERVOIR
ELEVATION 7618
SCOFIELD LAKE
STATE RECREATION AREA
SANPETE CO
CARBON CO
Big Ridge
GRANGER
RIDGE
Granger 2
Woods
Canyon
FAULT
U D
VALLEY
Mud
Creek
Spring
Mine
Scofield
Cem
Prospects
Radio Tower
UP Canyon
PLEASANT
Spring
Springs
Kb
Kp
Tw
Qal
Ksp
JEEP TRAIL
PACK TRAIL
Fresh Cr
T12S
T13S
WINTER
QUARTERS
RIDGE
UCO Inc.
SCOFIELD MINE
MINED OUT
Coal Outcrop
Dike
Winter
Quarters
Canyon
Number
Gulch
Bobs
Canyon
MANTI
Box
Canyon
Green
02
04
06
08
QUARTERNARY
Qal Stratified clay, silt, sand, gravel, and unsorted flood deposits.
TERTIARY
Tw Wasatch Fm
CRETACEOUS
Kp Price River Fm
Kb Blackhawk Fm
Ksp Star Point Sandstone
Fault
Coal Outcrop
Dike
Mined Out Area
Strike & Dip
Formation Contact
N
DRAWN
DATE BY
APPROVED
DATE BY
REVISED
DATE BY
PLATE 1
REGIONAL GEOLOGIC MAP OF
WINTER QUARTERS CANYON AREA
SCALE : 1"-2000'
(after Spieker, 1931)
UCO, INC.
1580 LINCOLN ST., #530
DENVER, COLORADO 80203
(303) 837-0465
FILE NO.

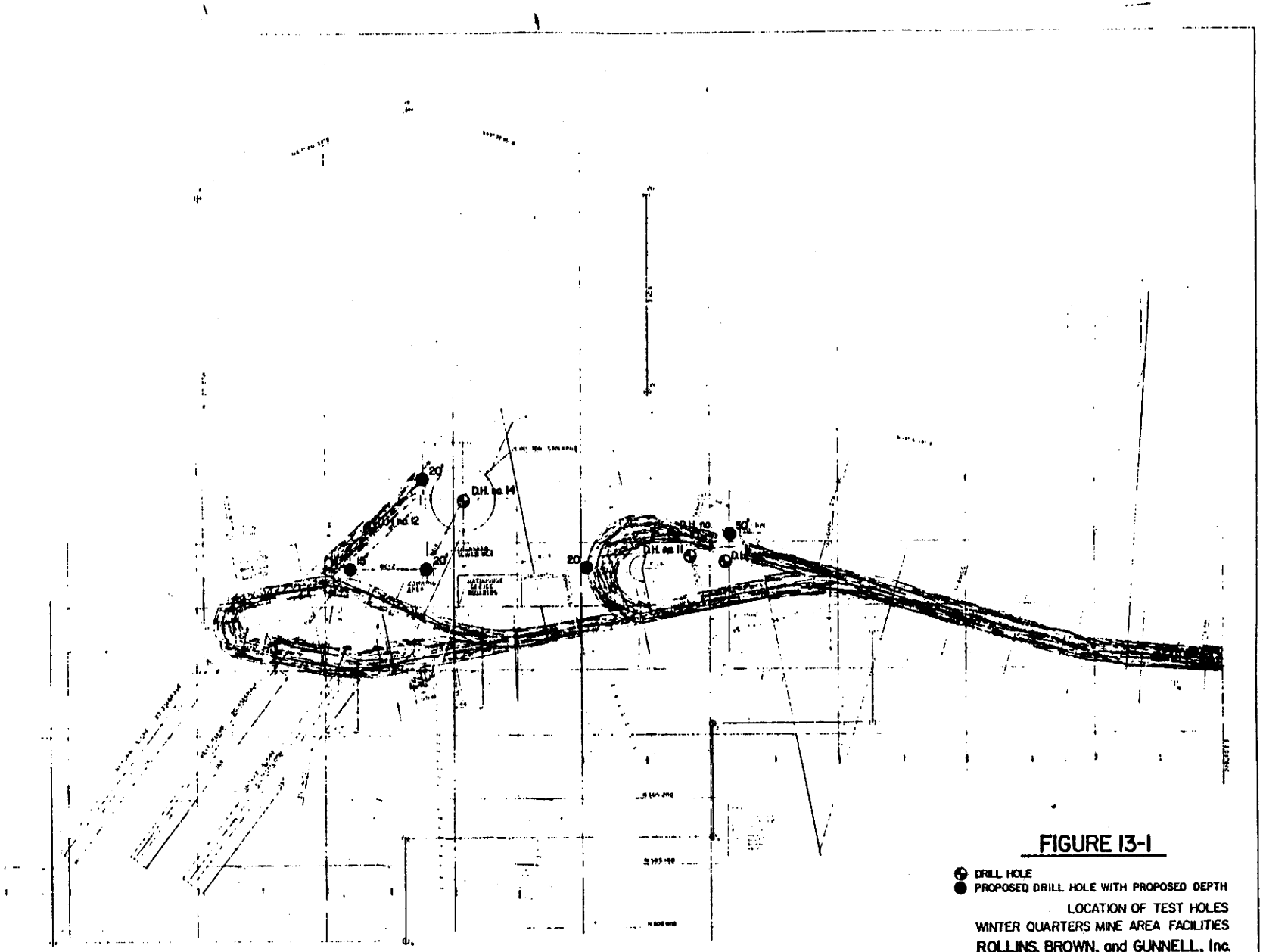


FIGURE 13-1

● DRILL HOLE
● PROPOSED DRILL HOLE WITH PROPOSED DEPTH

LOCATION OF TEST HOLES
WINTER QUARTERS MINE AREA FACILITIES
ROLLINS, BROWN, and GUNNELL, Inc.

ATTACHMENT A

Lithologic Descriptions of Drill-holes
WQ-02, WQ-04, WQ-06, WQ-08

(by James P. Walsh & Associates)

Hole WQ-02

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	0.0- 10.0	Dusky yellow (5Y6/4) fine- to medium-grained calcareous SANDSTONE, abundant limonitic staining, minor olive gray shale fragments.
	10.0- 20.0	Light olive (5Y6/2) fine-grained calcareous SANDSTONE and light olive gray (5Y5/1) SHALE.
	20.0- 40.0	Greenish gray (5GY4/1-6/1) calcareous SHALE and SANDY SHALE.
	40.0- 70.0	Dark yellowish orange (10YR6/6) and dusky yellow (5Y6/4) medium-grained, subround, poorly sorted, silty, very calcareous SANDSTONE, abundant limonitic staining, friable; clayey from 65-70.
	70.0- 80.0	Greenish gray (5G4/1) CLAY and SANDY SHALE, soft to low hardness.
	80.0- 90.0	Light olive gray (5Y4/1) soft CLAY and light gray (N7) slightly calcareous, fine-grained SANDSTONE.
	90.0-100.0	Greenish gray (5G4/1) soft CLAY and light gray (N7) slightly calcareous, fine-grained

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		SANDSTONE.
	100.0-120.0	Light yellowish gray fine-grained calcareous SANDSTONE, moderate hardness, and minor gray silty shale, local hematite cement.
	120.0-130.0	Dark olive gray (5Y3/1) SILTY SHALE, moderate hardness, slightly calcareous.
	130.0-170.0	Light olive gray (5Y6/1) to yellowish gray (5Y7/2) fine-grained, subangular, moderately sorted calcareous SANDSTONE, local hematite cement, minor thin, dark olive gray (5Y3/1) silty shale beds.
	170.0-180.0	Light olive gray (5Y7/1) to olive gray (5Y4/1) fine-grained, silty, slightly calcareous SANDSTONE, local iron oxide cement.
	180.0-190.0	Greenish gray (5GY4/1) SILTY SHALE, slightly calcareous, and N6 fine-grained, calcareous SANDSTONE.
	190.0-220.0	Light olive gray (5Y6/1) fine-grained, calcareous SANDSTONE and (5Y4/1) slightly calcareous silty SANDSTONE.
	220.0-240.0	Light olive gray (5Y6/1) fine-grained calcareous SANDSTONE and (5Y4/1) slightly calcareous sandy SHALE, moderately hard, minor carbonaceous fragments, minor iron oxide cement.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	240.0-260.0	Light olive gray (5Y6/1) and yellowish gray (5Y7/2) fine-grained silty calcareous SANDSTONE, moderate local limonitic cement, and dark olive gray (5Y3/1) silty, clayey, slightly calcareous, fine-grained SANDSTONE.
	260.0-300.0	Yellowish gray (5Y7/2) fine- to medium-grained, subangular, calcareous SANDSTONE, minor local iron oxide cement, moderate hardness, and dark olive gray (5Y3/1) clayey, slightly calcareous very fine grained SANDSTONE, coal fragments in 290-300' interval.
	300.0-350.0	Dark olive gray (5Y3/1) calcareous SILTSTONE, minor carbonaceous fragments, and fine- to medium-grained, yellowish gray (5Y7/2), subround, moderately sorted, very calcareous SANDSTONE, local iron oxide cement in the SANDSTONE from 330-340', relative amount of SANDSTONE greater than SILTSTONE.
	350.0-360.0	Black COAL, blocky fracture, and greenish gray (5GY5/1) silty SHALE, and light olive gray (5Y4/1-6/1) fine-grained, subround, slightly calcareous SANDSTONE, minor limonitic staining.
	360.0-370.0	Dark olive gray (5Y3/1) calcareous SILTSTONE, minor carbonaceous fragments, and fine- to medium-grained, yellowish gray (5Y7/2) subround, moderately sorted, very calcareous SANDSTONE.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	370.0-380.0	Dark olive gray (5Y3/1) calcareous SILTSTONE, minor carbonaceous fragments, and fine- to medium-grained, yellowish gray (5Y7/2) subround, moderately sorted, very calcareous SANDSTONE, local iron cement.
	380.0-420.0	Dark gray (N2) silty COAL and dark olive gray (5Y3/1) calcareous SILTSTONE, minor carbonaceous fragments, and fine- to medium-grained, yellowish gray (5Y7/2) subround, moderately sorted, very calcareous SANDSTONE. Abundant iron oxide in upper half of interval. Siltstone (more clayey, darker) predominant in lower half.
	420.0-460.0	Light gray (N6) to light olive gray very fine grained, sandy, calcareous SILTSTONE, moderately hard; well cemented, abundant very fine grained coal fragments between 430.0 and 440.0; sandier (friable) toward base.
	460.0-470.0	Yellowish gray (5Y7/2) fine-grained, very calcareous SANDSTONE and dark olive gray (5Y3/1) silty SHALE.
	470.0-471.5	Medium light gray, fine-grained, subangular, well-sorted, slightly calcareous SANDSTONE, minor carbonaceous debris and coal fragments, moderate hardness.
	471.5-472.3	(N2) carbonaceous SHALE and SILTY SHALE, accessory pyrite, moderate hardness.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Desciption
	472.3-474.0	Dark olive gray (5Y3/1) carbonaceous SILTSTONE, minor coal rooting, moderate hardness, clayey at 473.5
	474.0-476.8	Light olive gray (5Y6/1) massive fine-grained, moderately sorted, subround, calcareous SANDSTONE, hard, minor coal fragments.
	476.8-478.4	Greenish gray (5GY4/1) slightly calcareous silty MUDSTONE.
	478.4-480.2	Light olive gray (5Y6/1) very fine grained, moderately sorted silty SANDSTONE, limonitic staining at 478.8-480.0.
	480.2-484.3	Olive gray (5Y4/1-6/1 and N4) very fine grained silty SANDSTONE, abundant fossil leaf casts, slightly calcareous, distorted low angle crossbedding, hard, coarsens to medium-grained at 484.0, minor rusted pyrite.
1 (484.3-497.4)	484.3-487.9	Dark greenish gray (5G2/1) silty, carbonaceous SHALE, moderate hardness, and greenish gray (5GY5/1) SILTSTONE, moderate hardness.
	487.9-492.0	Light gray (N6) and dark gray (N4) massive, very fine grained, calcareous SANDSTONES, minor thin greenish gray 5G5/2 shale breaks, darker sands, more silty than lighter sands, with abundant carbonaceous fragments.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	492.0-495.1	Light gray (N6-N7) fine- to very fine grained calcareous SANDSTONE, distorted bedding, moderate coal fragments, hard.
	495.1-496.9	Dark olive gray (5Y3/1) carbonaceous SILTSTONE, minor leaf casts, hard.
	496.9-497.4	Dark olive gray (5Y2/1) sandy SILTSTONE, abundant thin coal lamina, moderate pyrite.
2 (507.7-517.0)	507.7-508.2	Grayish brown (5YR3/1) medium- to fine-grained massive carboneacous SANDSTONE, abundant and fragments.
	508.2-512.8	Dark yellowish brown fine- to medium-grained, moderately sorted, subangular, carbonaceous SANDSTONE, major organic staining, moderate hardness.
	512.8-520.0	(N6) and (N4) crossbedded medium- to fine-grained, subround, moderately sorted SANDSTONE, abundant coal fragments; 10% white feldspar, moderate hardness.
	520.0-530.0	Light olive gray (5Y6/1) very fine to fine-grained, subrounded, moderately sorted, slightly calcareous SANDSTONE with dark gray shale fragments.
	530.0-540.0	Dark gray (N2) silty SHALE, light olive gray (5Y5/2) SHALE, and minor light olive gray (5Y6/1), fine-grained, subangular, poorly sorted, slightly calcareous SANDSTONE.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	540.0-550.0	Dark gray (N3) SHALE, in hard chips, with minor pyrite and minor limonite staining, a few small coal fragments and light gray (N7) fine sands coating and mixed with shale fragments.
	540.0-550.0	Dark gray (N3) SHALE, in hard chips, with minor pyrite and minor limonite staining, a few small coal fragments and light gray (N7) fine sands coating and mixed with the shale fragments.
	550.0-560.0	Dark gray (N3) SHALE, in hard chips, with minor limonite staining, and few small coal fragments, and light olive gray (5Y6/1) calcareous silty very fine sands coating and mixed with shale fragments.
	560.0-570.0	Dark gray (N3) slightly calcareous SHALE in hard chips and light gray (N7) very fine sandy SILTSTONE in hard chips and abundant small coal fragments.
	570.0-580.0	Dark gray (N3) SHALE with slickensided surfaces, and light gray (N7) very fine sandy SILTSTONE with minor limonite staining and thin dark gray partings and some black carbonaceous Shale fragments, slightly calcareous silt and fine sands coating shale fragments.
	580.0-590.0	Medium dark gray (N4) SHALE and dark gray (N3) carbonaceous SHALE, and few very small

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		coal fragments, slightly calcareous sands coating shale fragments.
	590.0-600.0	Medium gray (N5) to dark gray (N3) and black (N1) carbonaceous SHALE, with a very few minor coal fragments, and few light gray (N7) very fine sandy SILTSTONES, and slightly calcareous very fine sands coating shale fragments.
	600.0-610.0	Greenish gray (5GY4/1) slightly calcareous CLAYSTONE fragments and dark gray (N3) to grayish black (N2) carbonaceous SHALE and black coal fragments, a few dusky yellow (5Y6/4) hard SILTSTONE fragments.
	610.0-620.0	Medium gray (N5) SHALE in hard chip, and one yellowish gray (5Y7/2) veryfine silty, slightly calcareous SANDSTONE fragment; and a few very small coal fragments.

Hole WQ-04

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	0.0- 10.0	Greenish gray (5GY5/1) and brownish gray (5YR4/1) CLAY and SANDY CLAY, minor limonitic staining.
	10.0- 30.0	Dusky yellow to dark yellowish orange (10YR6/6) fine-grained, subround, poorly sorted, slightly calcareous, clayey SANDSTONE, abundant limonitic staining.
	30.0- 40.0	Olive gray (5Y5/1-5GY5/1) slightly calcareous CLAY and SILTY CLAY.
	40.0- 60.0	Yellowish gray (5Y7/2) fine-grained, well-sorted, subround, slightly clayey, non-calcareous SANDSTONE, moderate limonite; and greenish gray (5G5/1) calcareous sandy CLAY from 50.0-60.0.
	60.0- 90.0	Greenish gray (5G4/1) and light olive gray (5Y4/1) CLAY and SILTSTONE, calcareous, moderate hardness, highly carbonaceous (sooty) SILT, coal fragments between 80.0-90.0.
	90.0-110.0	Yellowish gray (5Y7/2) to dark yellowish orange (10YR6/6) fine- to medium-grained,

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		poorly sorted, subround SANDSTONE, moderate to abundant limonite.
	110.0-120.0	Olive gray (5Y4/1), SANDY CLAY and dark olive gray (5Y3/1) slightly calcareous SHALE.
	120.0-130.0	Greenish gray (5G4/1) sandy, slightly calcareous SILTSTONE, minor coal fragments.
	130.0-200.0	Gray (N6) to light olive gray fine-grained, moderately sorted, subround, calcareous SANDSTONE and (5Y4/1) SILTSTONE, minor carbonaceous fragments. More clayey, more siltstone, more carbonaceous from 150.0-160.0. Slightly calcareous from 160.0-170.0. Clay breaks from 170.0-180.0, 190.0-200.0.
	200.0-240.0	Light gray (N6) to yellowish gray (5Y7/2) fine-grained, clayey, calcareous SANDSTONES, and greenish gray (5G4/1-5Y3/1) clayey SILTSTONES. More SANDSTONE and carbonaceous fragments, less clay from 230.0-240.0.
	240.0-250.0	Yellowish gray (5Y7/2 & N5) distorted bedding, fine-grained clayey calcareous SANDSTONE, alternating lamina of organic debris-rich sand and clean sand.
	250.0-270.0	Light olive gray (5Y7/1) to gray (N6) fine- to medium-grained, poorly sorted, calcareous SANDSTONE, minor coal fragments, and dark olive gray (5Y3/1) carbonaceous SILTSTONE.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	270.0-280.0	Black COAL and light olive gray (5Y5/1) to gray (N6) fine- to medium-grained, poorly sorted, calcareous SANDSTONE, minor coal fragments, and dark olive gray (5Y3/1) carbonaceous SILTSTONE.
	280.0-290.0	Light gray (N6) to light greenish gray (5GY6/1) fine-grained, clayey, very slightly calcareous SANDSTONE, minor local iron oxide cement, and (5Y4/1) SILTSTONE.
	290.0-300.0	Yellowish gray fine- to medium-grained, subround, slightly calcareous SANDSTONE, minor carbonaceous matrix.
	300.0-330.0	Light gray to light olive gray (N6-5Y6/1-5GY6/1) fine-grained, slightly calcareous clayey SANDSTONE, and dark olive gray (5Y3/1) carbonaceous SILTSTONE; less clay 320.0-330.0.
	330.0-340.0	Shaly COAL fragments in light gray to light olive gray (N6-5Y6/1-5GY6/1) fine-grained, slightly calcareous SANDSTONE.
	340.0-360.0	Light gray (N6) fine- to medium-grained, poorly sorted, subround, calcareous SANDSTONE, and dark olive gray (5Y2/1) carbonaceous, silty SHALE.
	360.0-380.0	Medium gray (N6) fine-grained, silty, slightly calcareous SANDSTONE; coarsens downward to fine- to medium-grained, yellow

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		gray (5Y7/2), and dark olive gray (5Y3/1) SILTSTONE.
	380.0-390.0	Light gray to light olive gray (N6-5Y6/1-5GY6/1) fine-grained, slightly calcareous clayey SANDSTONE, and dark olive gray (5Y3/1)carbonaceous SILTSTONE.
	390.0-400.0	Light gray (N6) to light olive gray (5Y6/1) fine- to medium-grained calcareous SANDSTONE.
	400.0-410.0	Medium gray (N6) fine-grained, silty, slightly calcareous SANDSTONE; coarsens downward to fine- to medium-grained yellow gray (5Y7/2), and dark olive gray (5Y3/1) SILTSTONE.
	410.0-430.0	Light gray (N6) to light olive gray (5Y6/1) fine- to medium-grained calcareous SANDSTONE.
3 (434.9-443.3)	430.0-435.8	N5 to 5Y5/1 very fine grained subangular laminated slightly calcareous SANDSTONE, hard, probably silica cement, moderate carbonaceous fragments, leaf stem casts on bedding surfaces, at 433.0-433.2 a greenish gray 5G4/1 silty CLAY break.
	435.8-439.7	Dark greenish gray (5G3/1-4/1) carbonaceous SILTSTONE and SILTY SHALE, abundant large coal fragments, hard.
	439.7-440.4	Dark olive gray (5Y3/1) carbonaceous CLAY,

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		thin coal lamina.
	440.4-442.7	Greenish gray (5GY5/1) and dark greenish gray (5GY3/1) SILTY SHALE and MUDSTONE, abundant carbonaceous debris in darker layers, moderate hardness.
	442.7-443.3	Dark olive gray (5Y3/1 to 2/1) coaly SILTSTONE, hard.
4 (454.0-460.0)	454.0-454.5	N3 fine-grained, subround, carbonaceous SANDSTONE, abundant coal clasts.
	454.5-456.3	Olive gray (5Y5/1) fine- to medium-grained, subround, carbonaceous SANDSTONE, abundant carbonaceous matrix.
	456.3-460.0	N6 and N4 fine- to medium-grained laminated and crossbedded moderately sorted SANDSTONE, 10% white feldspar, 5-10% coal clasts, noncalcareous, hard.
	460.0-480.0	Light olive gray (5Y6/1) fine, subrounded, moderately sorted, slightly calcareous silty SANDSTONE and dark gray (N3) hard SHALE fragments, and a few very minor coal fragments.
	480.0-490.0	Dark gray (N3) calcareous SHALE, nondescript, with a few minor pyrite masses (approx. 1 mm diameter); with very fine sands coating shale fragments.
	500.0-520.0	Medium dark gray (N4) SHALE, and a few

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		grayish black (N2) carbonaceous SHALE fragments, with yellowish gray (5Y7/2) fine, subrounded, well sorted, calcareous sands coating shale fragments.
	520.0-540.0	Yellowish gray (5Y7.2) slightly calcareous, very fine grained, silty SANDSTONE in hard chips; with dark gray (N3) and grayish black (N2) carbonaceous SHALE and dark gray SHALE (N3).
	540.0-560.0	Slight olive gray (5Y6/1) clean, fine- and medium-grained, subrounded, moderately sorted, calcareous SANDS; with medium dark gray (N4) SHALE fragments.

Hole WQ-06

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
5(0.0-30.0)	0.0- 10.0	Light olive gray (5Y5/2) to light olive brown (5Y5/6) calcareous, sandy CLAY; fine-grained poorly sorted clayey SANDSTONE, low hardness, moderate limonite.
	10.0- 20.0	Olive brown (5Y5/4) calcareous sandy (fine-grained) CLAYSTONE, moderate limonite.
	20.0- 30.0	Dusky yellow (5Y6/4) calcareous sandy (fine-grained to silt) SHALE; probably thinly interbedded well-sorted sands and shales, moderate limonite.
6(30.0-93.0)	30.0- 40.0	Light olive brown (5Y5/6-5/4) fine- to very fine grained subround silty, clayey, calcareous, SANDSTONE, low hardness, minor coal clasts.
	40.0- 50.0	Light olive brown (5Y5/6) and light olive gray (5Y5/2) slightly calcareous SHALES, and fine-grained SANDSTONES, minor carbonaceous fragments, minor to abundant limonite.
	50.0- 60.0	Light olive gray and yellowish brown slightly calcareous sandy (fine-grained) clayey SHALE.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	60.0- 70.0	Bluish gray (5B6/1) soft sticky CLAY, locally calcareous, accessory carbonaceous fragments.
	70.0- 80.0	Dusky yellow (5Y6/4) and yellowish brown (10YR5/2) fine- to very fine grained subangular moderately sorted very calcareous SANDSTONE and minor SHALES, moderate limonite.
7(93.0-140.0)	80.0- 90.0	Olive gray (5Y4/1) fine-grained subangular poorly sorted, very calcareous SANDSTONE, scarce limonite.
	90.0-100.0	Olive gray (5Y3/1) silty, calcareous SHALE, hard chips.
	100.0-110.0	Medium greenish gray (5GY5/1) sandy clay and SHALE, calcareous, soft, minor carbonaceous fragments, and dark brownish gray (5YR3/1) carbonaceous SHALE.
	110.0-120.0	Greenish gray (5GY6/1) silty calcareous SHALE and fine-grained, well-sorted SANDSTONE.
	120.0-130.0	Light gray (N7) to light greenish gray (5GY7/1) fine-grained, subangular, moderately sorted, very calcareous SANDSTONE, minor shale.
	130.0-140.0	Dark yellowish brown (10YR2/2) silty carbonaceous SHALE and medium olive gray

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		(5Y4/1) very fine grained, moderately sorted, very calcareous SANDSTONE.
8(140.0-145.0) 9(145.0-185.0)	140.0-150.0	Dusky brown (5YR2/2) sooty lignitic shaly COAL, and olive gray (5Y4/1) fine-grained subangular SANDSTONE.
	150.0-160.0	Brownish gray (5YR4/1) to medium dark gray (N4) fine-grained, subangular, poorly sorted, silty, slightly calcareous SANDSTONE.
	160.0-170.0	Medium olive gray (5Y5/1) fine-grained, subangular, modetely sorted, calcareous SANDSTONE, minor coal fragments, some spots of limonitic staining, minor dark gray silty SHALES.
	170.0-180.0	Medium olive gray (5Y5/1) and medium dark gray (N5) fine-grained, subangular, moderately sorted, calcareous SANDSTONE, minor coal fragments, some spots of limonitic staining, minor dark gray silty SHALES.
10(185.0-195.0)	180.0-190.0	Medium olive gray (5Y5/1) fine-grained subangular, moderately sorted, calcareous SANDSTONE, minor coal fragments, some sopts of limonitic staining, minor dark gray silty SHALES, accessory pyrite, and medium dark gray (N4) calcareous silty SHALES.
	190.0-200.0	Light olive gray (5Y6/1) fine-grained, well-sorted, subround, calcareous SANDSTONE,

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
11(195.0-240.0)		moderate carbonaceous fragments.
	200.0-210.0	Light olive gray (5Y4/1) fine-grained, poorly sorted, subround, slightly calcareous SANDSTONE, accessory limonitic staining.
	210.0-220.0	Dark brownish gray (5YR3/1) carbonaceous SHALE, and light gray (N7) fine-grained calcareous SANDSTONE.
	220.0-230.0	Olive gray (5Y5/1) fine-grained, subangular,moderately sorted, calcareous SANDSTONE, minor iron oxide cement (rusted pyrite?), and dark gray (N3) SHALE.
	230.0-240.0	Olive gray (5Y5/1) fine-grained, poorly sorted, slightly calcareous SANDSTONE, and greenish gray (5GY5/1) SHALE.
12(240.0-295.0)	240.0-250.0	Light olive gray (5Y6/1) fine- to medium-grained, subround, moderately sorted, slightly calcareous SANDSTONE, accessory pyrite.
	250.0-260.0	Light olive gray (5Y6/1) fine- to medium-grained, subround, moderately sorted, calcareous SANDSTONE, accessory pyrite, and dark brownish gray silty SHALE.
	260.0-270.0	Medium olive gray (5Y5/1) fine- to medium grained, poorly sorted, subround, slightly calcareous SANDSTONE.
	270.0-280.0	Light olive gray fine-grained, subangular,

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		well sorted, very calcareous SANDSTONE, minor iron oxide cement.
	280.0-290.0	Light olive gray, fine-grained, subround, poorly sorted, silty, slightly calcareous SANDSTONE, and dark brownish gray SHALE.
13(295.0-311.2)	290.0-300.0	Dusky yellow (5Y6/4) fine-grained, poorly sorted SANDSTONE, minor limonite, and medium greenish gray (5G5/1) CLAY, and brownish gray (5YR4/1) SHALE.
	300.0-310.0	Greenish gray (5GY6/1) silty SHALE, slightly calcareous.
	310.4-310.6	Medium dark gray (N4) silty SHALE, moderate hardness, slightly calcareous.
	310.6-311.2	Olive gray (5Y5/1) to dark greenish gray (5GY4/1) SILTSTONE, hard, calcareous, minor coal fragments.
14(311.2-321.7)	311.2-312.2	Dark gray to medium dark gray (N4) slightly calcareous, silty SHALE, moderate hardness, poorly fissile.
	312.2-313.3	Medium gray (N5) slightly calcareous SILTSTONE, hard, abundant pyrite coatings along large woody fragments.
	313.3-320.7	Light gray (N7) and medium dark gray (N4) fine-grained, subangular, moderately sorted, slightly calcareous SANDSTONE, distorted bedding with horizontal burrow structures

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		and some sand bed slumping. Darker beds contain matrix of organic debris, hard.
	320.7-321.7	Medium dark gray (N4) to olive gray (5Y4/1) SILTSTONE, abundant clay, moderate coal fragments, slightly calcareous.
15(331.3-340.0)	331.35-332.9	Dark brownish gray (5YR3/1) to moderate yellowish gray (10YR5/2) massive, fine-grained, subangular, well-sorted SANDSTONE, abundant carbonaceous debris as matrix, fine- to medium-grained coal fragments greater than 10 percent, friable, moderate hardness.
	332.9-334.0	Light olive gray (5Y6/1) very fine to fine-grained subround moderately sorted massive SANDSTONE, friable, moderate hardness.
	334.0-340.0	Light gray (N7) and medium dark gray (N4) low angle crossbedded, fine-grained, subround, well- sorted SANDSTONE, friable, hard, variable amounts of coal clasts.
	340.0-360.0	Light gray, fine- to medium-grained, moderately sorted, subround, slightly calcareous, clean SANDSTONE, minor coal fragments.
	360.0-370.0	Light gray, fine- to medium-grained, moderately sorted, subround, calcareous, clean SANDSTONE, hard, minor coal fragments.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	370.0-380.0	Light gray (N7) fine-grained, well-sorted, subangular, very calcareous, clean SANDSTONE, hard, accessory pyrite.
	380.0-390.0	Light gray (N7) fine-grained, well-sorted, subangular, very calcareous, clean SANDSTONE, hard, accessory pyrite, with interbedded medum gray SILTSTONE
	390.0-400.0	Light gray (N7) fine-grained, moderately sorted, subangular, calcareous, clean SANDSTONE, hard, accessory pyrite, minor coal fragments.
	400.0-410.0	Light gray (N7) SANDSTONE, and medium dark gray (N5) calcareous SHALE, and abundant coal fragments.
	410.0-420.0	Dark olive gray (5Y3/1) calcareous SHALE and carbonaceous SHALE, accessory iron oxide cement.
	420.0-440.0	Light olive gray (5Y6/1) fine-grained, moderately sorted, subround, slightly calcareous SANDSTONE, coarse grain size coal fragments.

Hole WQ-08

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
16(0.0- 23.0)	0.0- 10.0	Dusky yellow (5Y6/4-5Y6/6) medium-grained, subround, poorly sorted, calcareous SAND (talus and topsoil), moderate limonite, friable, minor olive gray (5Y3/2) non-calcareous clay matrix.
17(23.0-37.0)	10.0- 20.0	Dusty yellow (5Y6/4-5Y5/4) medium-grained, subround, moderately sorted (fine to coarse), moderately calcareous SANDSTONE, friable, minor limonite staining, feldspars weathering to clays, accessory iron oxide cement.
18(37.0-63.0)	20.0- 30.0	Light olive brown (5Y5/6) medium- to fine-grained, subround, well-sorted, moderately calcareous SANDSTONE, moderate limonite, minor clay matrix; accessory sooty carbonaceous matrix.
	30.0- 40.0	Light dusky yellow (5Y6/2-6/4) fine-grained, subround, moderately sorted, slightly calcareous, silty SANDSTONE, minor limonitic staining, accessory iron oxide cement, minor clay matrix.
	40.0- 50.0	Dusky yellow (5Y6/4) fine- to

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		medium-grained, subround, poorly sorted, moderately calcareous, silty, clayey SANDSTONE, minor olive gray (5Y4/1) silty shale fragments, moderately hard.
19(63.0-70.0)	50.0- 60.0	Dusky yellow medium- to very fine grained, subround to subangular, poorly sorted, slightly calcareous SANDSTONE; minor medium dark gray (N4) to olive gray (5Y4/1) clay matrix, minor black carbonaceous shale fragments (1-5 mm).
	60.0- 70.0	Greenish gray (5GY6/1-5G6/1) clayey SHALE, poorly fissile, soft, and dark gray (N3) sooty, silty COAL, and black COAL, hard, accessory carbonate cement.
20(70.0-110.0)	70.0- 80.0	Greenish gray (5GY6/1) clayey, silty SHALE, soft; minor slightly calcareous SANDSTONE, and dark brownish gray (5YR3/1) carbonaceous SHALE, fissile, moderately hard.
	80.0- 90.0	Medium light gray (N6) to light olive gray (5Y6/1) fine-grained, subround to subangular, poorly sorted, moderately calcareous SANDSTONE, minor clay, moderately hard, and minor dark brownish gray (5YR3/1) fissile SHALE, moderately hard.
	90.0-100.0	Greenish gray (5GY6/1) slightly calcareous clayey SHALE and SANDY SHALE, soft, minor, fine-grained, calcareous SANDSTONE, moderately hard.

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	100.0-110.0	Medium gray (N5) silty SHALE, moderately hard, and greenish gray (5GY6/1) clayey SHALE, and fine-grained, subangular, poorly sorted, moderately calcareous SANDSTONE, friable.
21(110.0-120.0)	110.0-120.0	Greenish gray (5GY6/1) silty clayey SHALE, soft, and black shaley COAL, moderately hard to hard, and light olive gray (5Y6/1), very fine grained, silty SANDSTONE, minor light gray (N6) calcareous SILTSTONE, friable.
22(120.0-135.0)	120.0-130.0	Medium light gray (N6) to light olive gray (5Y6/1) fine- to very fine grained, subangular, moderately sorted, calcareous, silty SANDSTONE, minor slightly calcareous SILTSTONE, moderately hard, and greenish gray (5GY6/1) silty clayey shale, soft.
23(135.0-170.0)	130.0-140.0	Greenish gray (5GY6/1) silty clayey SHALE, soft, crumbly, and very light olive gray (5Y7/1) moderately calcareous SILTSTONE, minor fine-grained SANDSTONE, moderately hard, and black COAL, hard, brittle.
	140.0-150.0	Very light olive gray (5Y7/1) to light gray (N7) slightly calcareous SILTSTONE, minor clay matrix, accessory fine-grained, subangular sand, accessory carbonaceous matrix, moderately hard, and light greenish gray (5GY7/1) silty clayey SHALE, soft.
	150.0-160.0	Light gray (N7) slightly calcareous SILTSTONE, accessory fine-grained,

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		subangular SAND, and medium greenish gray (5GY5/1) SHALE, low hardness, minor silt.
	160.0-170.0	Light olive gray (5Y6/1) to medium light gray (N6) fine- to very fine grained, subangular, slightly calcareous silty SANDSTONE, moderately hard, minor greenish gray (5GY6/1) SILTSTONE, accessory rusted pyrite grains, accessory limonite.
24(170.0-221.0)	170.0-180.0	Light olive gray (5Y6/1 to 5GY6/1) silty SHALE, minor carbonaceous and coal fragments, and medium light gray (N6) slightly calcareous SILTSTONE, minor fine-grained sand.
	180.0-190.0	Light olive gray (5Y6/1) slightly calcareous SILTSTONE, and very fine grained SANDSTONE, moderately hard, minor clay matrix, and greenish gray (5GY6/1) clayey SHALE, minor coal fragments.
	190.0-200.0	Light olive gray (5Y6/1) slightly calcareous SILTSTONE and very fine grained SANDSTONE, moderately hard, minor clay matrix, and greenish gray (5GY6/1) clayey SHALE, minor coal fragments.
	200.0-210.0	Light gray (N7) to very light olive gray (5Y7/1) fine-grained subangular moderately sorted, moderately calcareous SANDSTONE, hard, minor SILTSTONE, minor carbonaceous fragments, accessory iron oxide cement (rusted pyrite grains?)

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
	210.0-230.0	Medium greenish gray (5G5/1) to medium gray (N5) clayey SHALE and SILTY SHALE, minor carbonaceous fragments, low hardness.
25(221.0-234.5)		
	230.0-231.8	Light gray (N7) to light greenish gray (5GY7/1) very fine grained, subround, well-sorted, silty, slightly calcareous SANDSTONE, very hard, cement may be dolomite as well as calcite, accessory fine-grained carbonaceous fragments; 1" interbeds of calcareous siltstone.
	231.8-232.6	Olive gray (5Y5/1) silty calcareous SHALE, hard, carbonate cement may be partly dolomite;fractured as compression cylinder.
	232.6-233.0	Dark olive gray (5Y3/1) SHALE, irregularly bedded, some coal rooting; vertical slickensides, fractured, moderate hardness, accessory pyrite.
	233.0-233.9	LOST
	233.9-234.3	Olive gray (5Y4/1) CLAY and brownish gray (5YR4/1) clayey SHALE, low hardness, abundant coarse-grained size coal fragments, accessory pyrite.
	234.3-234.5	Greenish black (5G2/1) SHALE, moderate hardness, poorly fissile, moderate pyrite on coal contact surface.
26(245.5-255.0)	245.5-247.8	Very dark yellowish brown (10YR3/2)

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		fine-grained, well sorted, subround, carbonaceous SANDSTONE, fine- to medium-grained coal fragments; moderate coal rooting, hard yet slightly friable.
	247.8-252.0	Olive gray (5Y5/1) grading to medium light gray (N6) at 248.7, massive (and laminated) fine-grained, well-sorted, subround, friable SANDSTONE, minor fine-grained coal fragments.
	252.0-260.0	Medium light gray (N6) and medium dark gray (N4) high to low angle crossbedded (laminar at 253.5-254.1) fine- to very fine grained, subround, moderately sorted SANDSTONE, moderate hardness, friable, bands made by varying amounts of coal fragment clasts.
	260.0-270.0	Light gray (N7) to very light olive gray (5Y7/1) medium- to fine-grained, subround, well-sorted, very slightly calcareous SANDSTONE, accessory local iron oxide cement, accessory coal fragments.
	270.0-280.0	Light gray (N7) to very light gray clean medium- to fine-grained, well-sorted, moderately calcareous SANDSTONE.
	280.0-290.0	Light gray (N7) to very light gray (5Y7/1) fine-grained, subangular, well-sorted, moderately calcareous SANDSTONE, minor dark gray SILTSTONE, hard.
	290.0-300.0	Medium light gray (N6) fine- to very fine

Geochemical Sample # And Interval	Lithologic Interval Column	Lithologic Description
		grained, moderately sorted, subangular, moderately calcareous SANDSTONE, accessory limonite staining, minor silt, moderately hard, accessory coal fragments.
	300.0-310.0	Light gray (N7) fine-grained, subangular, well-sorted, moderately calcareous SANDSTONE, abundant pyrite (fresh, striated faces), minor other heavy minerals.
	310.0-320.0	Medium gray (N6) to light olive gray (5Y6/1) fine- to very fine grained moderately sorted, moderately calcareous silty SANDSTONE, minor coal fragments, moderate pyrite.
	320.0-340.0	Medium gray (N7) very fine grained, subangular, moderately sorted, silty SANDSTONE, moderately hard, calcareous, minor SHALE, minor coal fragments, accessory limonite.

ATTACHMENT B

Geochemical Analyses: Laboratory Methods

AGRICULTURAL CONSULTANTS INC
240 SOUTH FIRST AVE
PO DRAWER 507
BRIGHTON, COLORADO 80601
(303)-659-2313

DATE: MARCH 6, 1981

REPORT TO: DON WASSEM

COMPANY: JAMES P. WALSH & ASSOCIATES, INC.

PROJECT ID: 27 OVERBURDEN SAMPLES HOLE WQ-2 TO WQ-8

DESCRIPTION OF ABBREVIATIONS USED FOR SOIL TEST REPORT COLUMN HEADINGS

PH- PASTE PH

EC- ELECTRIC CONDUCTIVITY, MMHOS/CC, , USDA HANDBOOK 60 CHAPT 6 (4) CONDUCTIVITY ELECTRODE/WHEATSTONE BRIDGE

SAT%- WATER HOLDING CAPACITY AT SATURATION , USDA HANDBOOK 60 CHAPT 6 (3D)

CA- CALCIUM, MEQ/L, , USDA HANDBOOK 60 CHAPT 6 (8)/QUANTITATION BY AAS

MG- MAGNESIUM, MEQ/L, , USDA HANDBOOK 60 CHAPT 6 (9)/QUANTITATION BY AAS

NA- SODIUM, MEQ/L, , USDA HANDBOOK 60 CHAPT 6 (10A)/QUANTITATION BY AAS

LM- LIME, % , USDA HANDBOOK 60 CHAPT 6 (23) CACO3 EQV

B- BORON (SOLUBLE), PPM, , USDA HANDBOOK 60 CHAPT 8 (73B)/CURCUMIN

SE- SELENIUM (SOLUBLE), PPM, DAN/FLUORIMETRIC

PB- LEAD, PPM, DTPA EXT/AAS QUANTITATION

MO- MOLYBDENUM, PPM,(NH4)2CO3 EXTRACTABLE

ZN- ZINC, PPM, DTPA EXT/AAS QUANTITATION

FE- IRON, PPM, DTPA EXT/AAS QUANTITATION

CU- CO[illegible], PPM, DTPA EXT/AAS QUANTITATION

MN- MANGANESE, PPM, DTPA EXT/AAS QUANTITATION

CD- CADMIUM, PPM, DTPA EXT/AAS QUANTITATION

NI- NICKEL, PPM, DTPA EXT/AAS QUANTITATION

HG- MERCURY, PPM, ACID EXT/COLD VAPOR AAS

AS- ARSENIC, PPM, ACID EXT/FLAMELESS AAS

F- FLUORIDE, PPM,SPECIFIC ION ELECTRODE

ABP- ACID/BASE POTENTIAL (SMITH HYDROGEN PEROXIDE) -=ACID +=BASE T/1000T

C.

ATTACHMENT C

Geochemical Analyses: Results

AGRICULTURAL CONSULTANTS, INC./JAMES P. WALSH AND ASSOCIATES, INC.

SAMPLING DATE: FEBRUARY 9, 1981 DATE OF ANALYSIS: MARCH 5, 1981

HOLE NO.	SAMPLE INTERVAL FEET	TO	FEET	PH (PASTE)	EC (MMHOS/CM)	SATURATION %	CA MEQ/L	NA MEQ/L	MG MEQ/L	ZN PPM	NI PPM	MN PPM
WQ-2	484.7	TO	497.4	7.8	3.6	28.5	16.62	6.11	9.37	0.7	-.1	4.6
WQ-2	507.7	TO	517.0	7.8	1.7	31.7	10.08	3.29	2.10	0.6	-.1	1.5
WQ-4	434.9	TO	443.3	7.8	4.2	31.4	18.92	7.76	12.75	3.8	-.1	3.2
WQ-4	454.0	TO	460.0	7.4	2.5	27.2	10.28	2.55	2.45	0.7	-.1	1.7
WQ-6	0.0	TO	30.0	7.9	1.4	54.1	7.40	3.22	1.23	0.7	-.1	54.0
WQ-6	30.0	TO	93.0	8.0	1.5	49.5	7.28	3.51	1.35	3.9	-.1	36.0
WQ-6	93.0	TO	140.0	7.8	2.1	33.5	10.74	5.19	1.99	5.3	-.1	7.7
WQ-6	140.0	TO	145.0	7.9	1.6	48.4	7.44	4.31	1.38	2.4	-.1	7.9
WQ-6	145.0	TO	185.0	7.7	3.2	32.3	4.96	3.23	6.20	1.4	-.1	6.9
WQ-6	185.0	TO	195.0	7.7	3.0	28.4	4.23	3.68	4.70	16.0	-.1	12.0
WQ-6	195.0	TO	240.0	7.6	3.8	27.2	18.58	7.66	4.90	1.9	-.1	7.7
WQ-6	240.0	TO	295.0	7.8	3.5	30.0	5.34	3.48	8.90	1.3	-.1	5.4
WQ-6	295.0	TO	311.8	7.9	2.9	43.9	11.88	4.75	6.07	3.4	-.1	7.2
WQ-6	311.8	TO	321.0	8.2	3.8	27.3	5.87	3.83	7.34	0.9	-.1	4.1
WQ-6	331.3	TO	340.0	7.8	2.3	27.8	12.96	3.76	4.80	0.4	-.1	1.6
WQ-8	0.0	TO	23.0	7.8	2.4	30.3	13.20	4.59	4.40	0.4	-.1	35.0
WQ-8	23.0	TO	37.0	8.0	1.5	55.6	7.88	2.50	1.20	0.7	-.1	51.0
WQ-8	37.0	TO	63.0	7.8	1.6	52.7	6.08	1.32	3.80	3.2	-.1	39.0
WQ-8	63.0	TO	70.0	7.8	1.3	65.9	7.18	3.17	2.02	1.3	-.1	6.2

WQ-8	70.0	TO	110.0	7.7	2.8	33.0	13.81	6.32	4.04	2.0	-.1	14.0
WQ-8	110.0	TO	120.0	7.7	2.6	32.7	13.39	6.38	4.07	1.0	-.1	6.7
WQ-8	120.0	TO	135.0	7.6	3.3	31.8	14.34	7.65	6.29	1.4	-.1	7.3
WQ-8	135.0	TO	170.0	7.7	2.2	36.5	11.50	4.77	3.66	1.4	-.1	5.3
WQ-8	170.0	TO	221.0	7.7	2.5	34.5	12.70	6.05	5.80	2.1	-.1	7.2
WQ-8	221.0	TO	234.5	8.0	4.2	27.3	8.78	5.09	9.76	2.1	-.1	3.1
WQ-8	245.5	TO	255.0	7.9	1.3	31.1	7.72	2.24	2.15	0.5	-.1	2.4
COAL	0.0	TO	0.0	7.5	2.1	30.8	10.38	4.51	4.33	0.3	-.1	1.1

C.

HOLE NO.	SAR	SE PPM	B PPM	LN %	MO PPM	CU PPM	ACID-BASE POT. +TONS CACO3 EQUIV./ 1000 TONS	PB PPM	AS PPM	CD PPM	FE PPM	HG PPM	F PPM
WQ-2	1.7	0.01	1.0	4.9	0.0	0.6	+50	1.2	-0.1	0.1	74	-.01	6.3
WQ-2	1.3	-.01	0.7	0.3	0.0	0.4	+4	0.7	-0.1	0.0	27	-.01	0.8
WQ-4	2.0	-.01	1.6	1.3	0.0	1.3	+15	2.6	-0.1	0.1	31	-.01	5.0
WQ-4	1.0	0.01	0.7	0.4	0.0	0.4	+5	0.9	-0.1	0.0	62	-.01	0.7
WQ-6	1.5	0.02	0.8	5.7	1.4	0.7	+60	1.6	-0.1	0.1	110	-.01	3.2
WQ-6	1.7	0.02	0.9	4.0	1.8	0.6	+42	7.0	-0.1	0.1	130	-.01	1.8
WQ-6	2.1	0.01	1.6	4.6	0.7	0.7	+48	5.9	-0.1	0.1	170	-.01	1.8
WQ-6	2.1	0.02	1.6	3.5	1.7	1.2	+36	2.6	-0.1	0.1	140	-.01	2.1
WQ-6	1.4	0.03	1.1	4.7	0.0	0.7	+49	2.1	-0.1	0.1	260	-.01	1.6
WQ-6	1.7	0.02	0.9	3.5	0.0	0.7	+36	19.0	-0.1	0.1	190	-.01	1.5
WQ-6	2.2	0.02	1.6	4.0	0.0	0.8	+42	2.9	-0.1	0.0	64	-.01	4.3
WQ-6	1.3	0.03	0.9	4.6	0.0	0.6	+48	2.1	-0.1	0.0	71	-.01	2.3
WQ-6	1.6	0.02	2.2	3.1	1.8	1.1	+33	4.2	-0.1	0.1	46	-.01	5.0
WQ-6	1.5	-.01	0.8	5.5	0.0	0.6	+57	1.4	-0.1	0.0	84	-.01	2.3
WQ-6	1.3	-.01	0.6	0.4	0.0	0.5	+6	0.6	-0.1	0.0	24	-.01	0.8
WQ-8	1.5	0.01	0.7	6.8	0.0	0.4	+70	0.7	-0.1	0.1	32	-.01	2.3
WQ-8	1.2	0.03	0.8	3.7	2.8	0.7	+39	1.5	-0.1	0.1	43	-.01	2.2
WQ-8	0.6	0.03	0.8	5.9	1.8	0.6	+61	4.9	-0.1	0.1	64	-.01	1.5
WQ-8	1.5	0.01	1.4	2.2	2.3	0.8	+24	3.7	-0.1	0.1	51	-.01	2.2
WQ-8	2.1	0.01	0.9	4.6	0.5	0.9	+48	2.8	-0.1	0.1	79	-.01	1.8
WQ-8	2.2	0.03	1.3	4.8	0.0	0.8	+50	2.1	-0.1	0.1	110	-.01	2.1
WQ-8	2.4	0.05	1.3	6.2	0.5	0.7	+64	2.3	-0.1	0.1	130	-.01	2.1

WO-8	2.0	0.04	1.4	5.8	0.5	0.7	+60	2.6	-0.1	0.1	220	-.01	2.3
WO-8	1.7	-.01	1.6	2.8	0.0	0.8	+30	3.4	-0.1	0.1	38	-.01	4.4
WO-8	1.0	-.01	0.7	0.1	0.0	0.4	+3	1.4	-0.1	0.1	43	-.01	0.7
COAL	1.7	-.01	0.3	0.2	0.0	0.2	-15	0.9	-0.1	0.0	2	-.01	0.6

C.

GEOLOGIC DATA
UCO, INC
SEPTEMBER 1982

APPENDIX C

WATER RESOURCES

WATER RESOURCES
APPENDICES

APPENDIX C
WATER RESOURCES

Table of Contents

Hydrologic Inventory & Baseline Study, UCO, Inc., Vaughn Hansen Associated, Inc., 1982 C-1

Surface Water Rights, Skyline Mine Reclamation Plan, Environmental Data, Volume 4, 1992 C-2

Watershed Inventory and Analysis, Price River Watershed, James L. Iaquinta, 1985 C-3

Groundwater Hydrology, Skylines Mines, Mining & Reclamation Plan, Volume 1, 1992 C-4

Water Resources Questar Pipeline Company's, Final Environmental Impact Statement, 1990 C-5

Hydrologic Monitoring of Selected Streams in Fields of Central and Southern Utah, 1987 C-6

Gen. Hydrologic Considerations Related to Coal Development and Subsequent Impacts, 1981 C-7

Municipal Watersheds, Price City Water Letter, 1981 C-8

Hydrology of Area 56, Northern Great Plains and Rocky Mountains Coal Provinces, Utah C-9

Water Quality in Pleasant Valley, Utah, 1981 C-10

Surface Water Hydrology, Skyline Mines, Mining and Reclamation Plan, Volume 1, 1992 C-11

Selected Well Water Levels, Skyline Mines, Mining and Reclamation Plan, Volume 4, 1992 C-12

Hydrologic Inventory of Skyline Property and Adjacent Areas, 1979 C-13

Winter Quarters Canyon
Data Adequacy

October 1992

HYDROLOGIC INVENTORY & BASELINE STUDY
UCO, INC.
VAUGHN HANSEN ASSOCIATES, INC., 1982

HYDROLOGIC INVENTORY AND BASELINE STUDY OF THE SCOFIELD MINE AND ADJACENT AREAS, CARBON COUNTY, UTAH

Prepared for

UCO, INCORPORATED

Denver, Colorado

By

VAUGHN HANSEN ASSOCIATES, INC.

Salt Lake City, Utah

Updated

July, 1982

1.0 TABLE OF CONTENTS

2.0 GROUNDWATER HYDROLOGY..... 1

2.1 Scope..... 1

2.2 Existing Groundwater Resources..... 3

2.2.1 Regional Groundwater Hydrologic System... 3

2.2.2 Mine Project Area Aquifers, Seeps, and Springs..... 8

2.3 Groundwater Development and Mine Dewatering..... 21

2.3.1 Water Supply..... 25

2.3.2 Mine Dewatering..... 26

2.4 Effects of Mining Operation on the Groundwater Hydrologic Balance..... 26

2.4.1 Hydrologic Balance..... 27

2.4.2 Quality..... 29

2.5 Mitigation and Control Plans..... 30

2.6 Groundwater Monitoring Plans..... 31

3.0 SURFACE WATER HYDROLOGY..... 35

3.1 Scope..... 35

3.2 Existing Surface Water Resources..... 36

3.2.1 Regional Surface Water Hydrology..... 36

3.2.2 Mine Project Area Watersheds and Streams. 39

3.3 Surface Water Development, Control, and Diversions..... 57

3.3.1 Water Supply..... 57

3.3.2 Sedimentation Control Structures and Diversions..... 62

TABLE OF CONTENTS (continued)

3.4 Effects of Mining on the Surface Water Hydrologic Balance..... 78

3.4.1 Quantity..... 78

3.4.2 Quality..... 79

3.5 Mitigation and Control Plans..... 79

3.6 Surface Water Monitoring Plan..... 80

4.0 ALLUVIAL VALLEY FLOOR DETERMINATION..... 82

4.1 Scope..... 83

4.2 Site Description..... 83

4.3 Alluvial Valley Floor Characteristics..... 84

4.3.1 Geomorphic Criteria..... 84

4.3.2 Water Quality and Availability..... 84

4.4 Alluvial Valley Floor Identification..... 85

4.5 Potential Impacts to the Alluvial Valley Floors.. 86

5.0 BIBLIOGRAPHY..... 87

ATTACHMENT A..... 91

ATTACHMENT B..... 139

LIST OF FIGURES

Figures		Page
1	Scofield Mine project area.	2
2	Generalized stratigraphic section (modified from U.S. Geological Survey, 1979).	5
3	Graphical results of the slug test for Well WQ-8 when the hole terminated below the coal zone.	10
4	Graphical results of the recovery test conducted in Well WQ-1A.	14
5	Graphical results of the recovery test conducted in Well WQ-6.	15
6	Price River Basin.	37
7	Unit hydrograph terminology.	44
8	Variation of hydrograph shape with C_3T_p.	47
9	Twenty-four-hour rainfall distributions (from Kent, 1973).	48
10	Nomograph for determining the inlet capacity of CMP culverts.	64
11	Nomagraph for determining the capacity of CMP culverts when outlet control governs.	66
12	Stage-capacity curve for sedimentation pond.	72
13	Stage-capacity for a 27-inch spillway riser.	74

ATTACHMENT A

A-1	Graphical results of the slug test for Well WQ-1 conducted when the hole terminated in the zone above the coal.	96
A-2	Graphical results of the slug test for Well WQ-1A conducted when the hole terminated in the coal zone.	101

A-3	Graphical results of the slug test for Well WQ-1A conducted when the hole terminated below the coal zone.	103
A-4	Graphical results of the drawdown test for Well WQ-1A.	105
A-5	Graphical results of the recovery test conducted in Well WQ-1A.	106
A-6	Graphical results of the slug test for Well WQ-6 conducted when the hole terminated above the coal zone.	111
A-7	Graphical results of the slug test for Well WQ-6 conducted when the hole terminated in coal zone.	113
A-8	Graphical results of the slug test for Well WQ-6 conducted when the hole terminated below the coal zone.	115
A-9	Graphical results of the recovery test conducted in Well WQ-6.	117
A-10	Graphical results of the slug test conducted in Well WQ-8 when the hole terminated above the coal zone.	122
A-11	Graphical results of the slug test for Well WQ-8 when the hole terminated in the coal zone.	124
A-12	Graphical results of the slug test for Well WQ-8 when the hole terminated below the coal zone.	126
A-13	Graphical results of the drawdown test for Well WQ-12.	137
A-14	Graphical results of the recovery test conducted in Well WQ-12.	138

LIST OF TABLES

Table		Page
1	Aquifer test results.	11
2	Groundwater rights located on and adjacent to the Scofield Mine project area.	22
3	Water right exchanges near the Scofield Mine project area.	24
4	List of water quality parameters.	32
5	100-year, 24-hour precipitation caused floods in streams near the Scofield Mine project area using the SCS synthetic hydrograph procedure.	50
6	Utah Division of Health numerical standards for water in the state.	54
7	Numerical standards for Class 3C water use in Utah.	55
8	Surface water rights located on and adjacent to the Scofield Mine project area.	58
9	Peak flow determinations and related information.	67
10	Diversion and interceptor ditch design criteria.	70
11	Design values of the sedimentation pond.	76

ATTACHMENT A

A-1	Miscellaneous information pertaining to Well WQ-1.	92
A-2	Lithologic description of Well WQ-1.	93
A-3	Water level measurements in Well WQ-1.	94
A-4	Tabulated slug test data for Well WQ-1 conducted when hole terminated in the zone above the coal.	95

LIST OF TABLES (continued)

A-5	Miscellaneous information pertaining to Well WQ-1A.	97
A-6	Lithologic description of Well WQ-1A.	98
A-7	Water level measurements in Well WQ-1A.	99
A-8	Tabulated slug test for Well WQ-1A conducted in open hole when hole terminated in coal zone.	100
A-9	Tabulated slug test data for Well WQ-1A conducted in open hole terminated in zone below coal.	102
A-10	Tabulated drawdown and recovery data for Well WQ-1A.	104
A-11	Miscellaneous information pertaining to Well WQ-6.	107
A-12	Lithologic description of Well WQ-6.	108
A-13	Water level measurements in Well WQ-6.	109
A-14	Tabulated slug test data for Well WQ-6 conducted in open hole when hole terminated in zone above coal.	110
A-15	Tabulated slug test data for Well WQ-6 conducted in open hole when hole terminated in the coal zone.	112
A-16	Tabulated slug test data for Well WQ-6 conducted when hole terminated in the zone below the coal.	114
A-17	Tabulated recovery data for Well WQ-6.	116
A-18	Miscellaneous information pertaining to Well WQ-8.	118
A-19	Lithologic description of Well WQ-8.	119
A-20	Water level measurements in Well WQ-8.	120
A-21	Tabulated slug test data for Well WQ-8 conducted in open hole when hole terminated in the zone above the coal.	121

LIST OF TABLES (continued)

A-22	Tabulated slug test data for Well WQ-8 conducted in open hole when hole terminated in the coal zone.	123
A-23	Tabulated slug test data for Well WQ-8 conducted in open hole when hole terminated in the zone below the coal.	125
A-24	Miscellaneous information pertaining to Well WQ-10.	127
A-25	Water level measurements in Well WQ-10.	128
A-26	Miscellaneous information pertaining to Well WQ-11.	129
A-27	Water level measurements in Well WQ-11.	130
A-28	Miscellaneous information pertaining to Well WQ-12.	131
A-29	Water level measurements in Well WQ-12.	132
A-30	Tabulated drawdown and recovery data for Well WQ-12.	133

ATTACHMENT B

B-1	Results of chemical analyses of surface water quality samples collected at Station U-1.	140
B-2	Results of chemical analyses of surface water quality samples collected at Station U-2.	142
B-3	Results of chemical analyses of surface water quality samples collected at Station U-3.	144
B-4	Results of chemical analyses of surface water quality samples collected at Station U-4.	146
B-5	Results of chemical analyses of surface water quality samples collected at Station U-5.	148
B-6	Results of chemical analyses of surface water quality samples collected at Station U-6.	150

LIST OF TABLES (continued)

B-7	Results of chemical analyses of surface water quality samples collected at Station U-7.	152
B-8	Results of chemical analyses of surface water quality samples collected at Station U-8.	154
B-9	Results of chemical analyses of ground water quality samples collected at Station U1-1.	156
B-10	Results of chemical analyses of ground water quality samples collected at Station U1-2.	158
B-11	Results of chemical analyses of ground water quality samples collectd at Station U1-3.	159
B-12	Results of chemical analyses of ground water quality samples collected at Station U1-4.	160
B-13	Results of chemical analyses of ground water quality samples collected at Station U1-5.	162
B-14	Results of chemical analyses of ground water quality samples collected at Station U1-6.	164
B-15	Results of chemical analyses of ground water quality samples collected at Station U1-13.	166
B-16	Results of chemical analyses of ground water quality samples collected at Station U2-1.	167
B-17	Results of chemical analyses of ground water quality samples collected at Station U2-2.	169
B-18	Results of chemical analyses of ground water quality samples collected at Well WQ-1.	171
B-19	Results of chemical analyses of ground water quality samples collected at Well WQ1-A.	173
B-20	Results of chemical analyses of ground water quality samples collected at Well WQ-6.	175
B-21	Results of chemical analyses of ground water quality samples collected at Well WQ-8.	177
B-22	Results of chemical analyses of ground water quality samples collected at Well WQ-12.	178

LIST OF PLATES

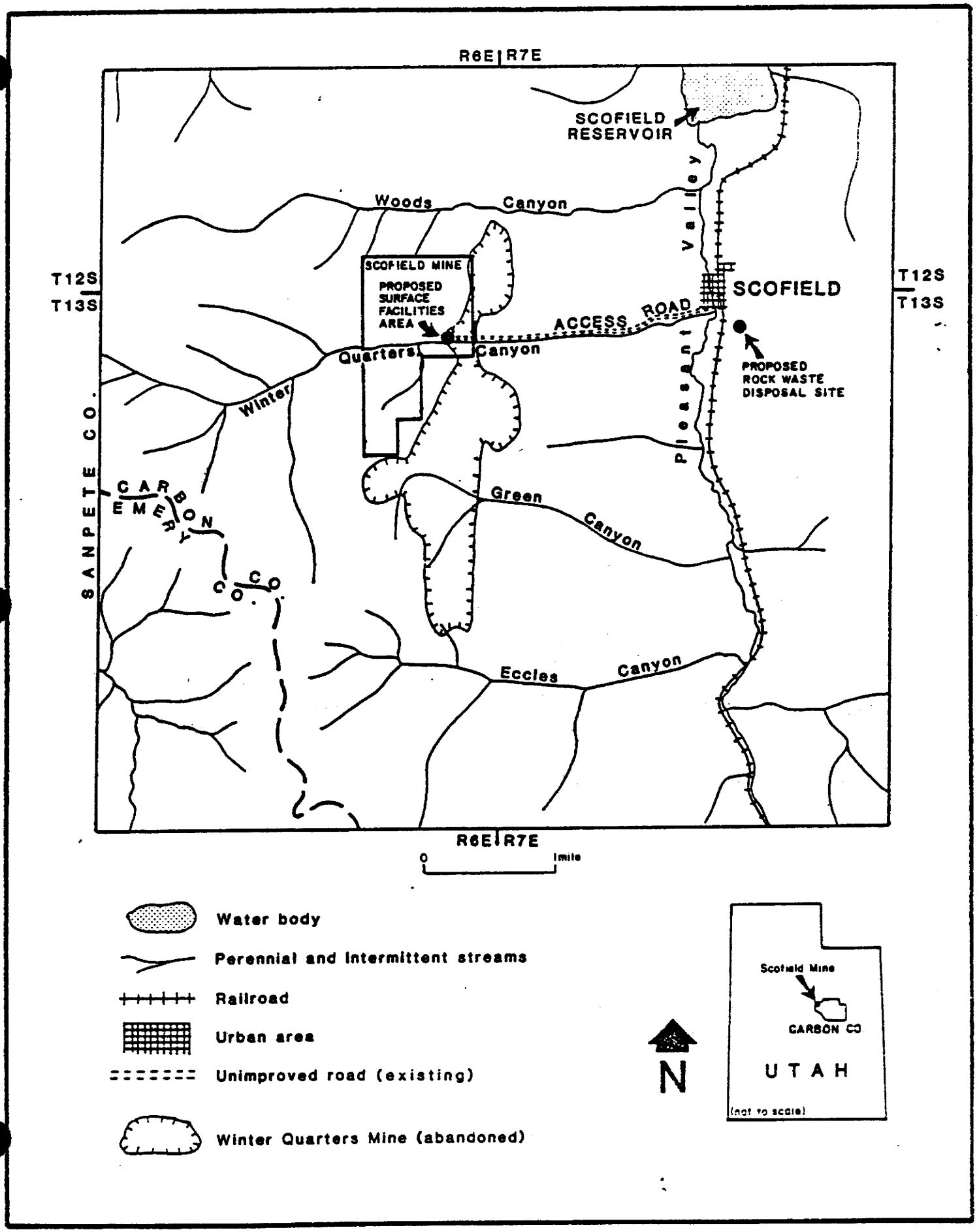
Plates	
1	Groundwater quality data on and adjacent to the Scofield Mine project area.
2	Groundwater contours on the Scofield Mine project area.
3	Identified seeps and springs.
4	Groundwater rights on and adjacent to the Scofield Mine project area.
5	Existing ground and surface water monitoring sites.
6	Ground and surface water monitoring sites for on-going monitoring.
7	Surface water quality in and adjacent to Scofield Mine project area.
8	Surface water rights on and adjacent to the Scofield Mine project area.
9	Runoff control plan for the Scofield Mine site.
10	Sediment pond design details and layout.
11	Extent of alluvium

2.0 GROUNDWATER HYDROLOGY

Regulations set forth by the Utah Division of Oil, Gas and Mining (DOGM) (Utah Code Annotated 40-10 et. seq.) require that water monitoring programs be established in areas of underground coal mining to monitor the effects of mining activities and protect the hydrologic balance of such areas. Therefore, a hydrologic investigation has been conducted on the proposed Scofield Mine project area. This report updates and supercedes an earlier report prepared during the hydrologic study (Vaughn Hansen Associates, 1981). The Scofield Mine project area, containing approximately 700 acres of land, lies within Winter Quarters Canyon approximately two miles west of Scofield, Utah (see Figure 1). The abandoned Winter Quarters Mines (operated from 1876 to 1928) lie directly east of the project area.

2.1 SCOPE

The scope of the groundwater section of this report is to describe the existing groundwater hydrologic conditions of the Scofield Mine project and adjacent areas and to describe the methods that have been and will be used to predict and monitor the impacts from mining. Sections within the groundwater section of this report will cover the following major topics: existing groundwater resources, groundwater development and mine dewatering, effects of mining operation on the groundwater



SCOFIELD MINE PROJECT AREA

FIGURE 1

hydrologic balance, mitigation and control plans, and groundwater monitoring plans.

Information used in preparing the groundwater hydrologic section of this report has been gleaned from field investigations and from pertinent literature. Water quality samples have been and will continue to be analyzed by a certified laboratory. Water rights were determined by examining current records of the Utah Division of Water Rights.

2.2 Existing Groundwater Resources

This section of the report deals with the groundwater resources of not only the Scofield Mine project area, but also of the adjacent area. An understanding of geology as it relates to groundwater hydrology is very important, and consequently will be discussed briefly.

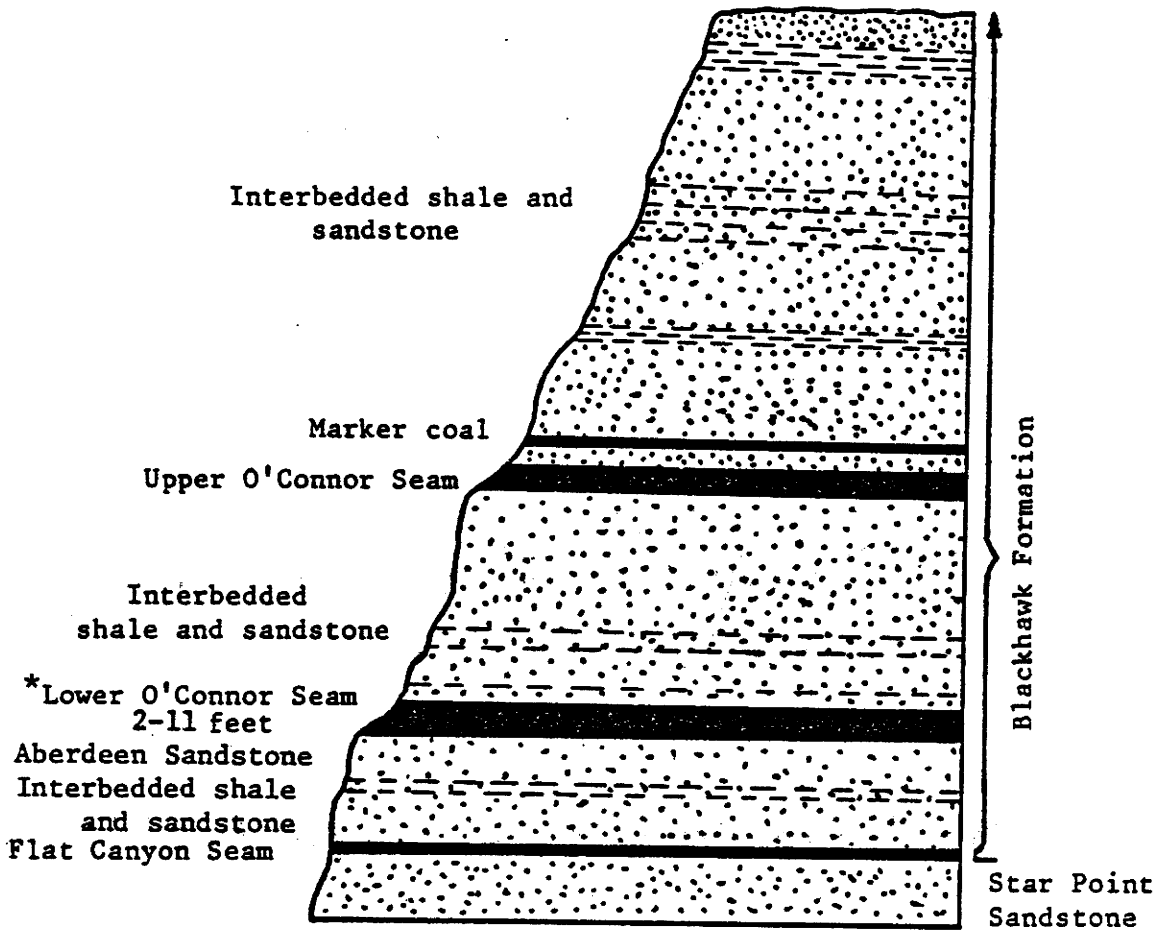
2.2.1 Regional Groundwater Hydrologic System

The principal factor controlling the occurrence and availability of groundwater in any area is geology. As noted by Price and Waddell (1973), nearly all of the region surrounding the Scofield Mine project area is underlain by rocks of continental and marine origin, consisting predominately of interbedded sandstones and shales. Although some of the sandstones in the region serve as the principal water-bearing strata, their ability to yield water for extended periods of time is largely controlled

by the existence of the relatively impermeable interbedded shale layers, which prevent the downward movement of a significant amount of water. Also, the sandstones are well cemented and have a low permeability.

Geology. The Scofield Mine project area lies in the northern end of the Wasatch Plateau, on the northwest flank of the Clear Creek Anticline (Doelling, 1972). The dip of the strata is generally west-northwest, ranging from about two to six percent (one to four degrees).

With the exception of local alluvial deposits, the only exposed unit on and immediately adjacent to the Scofield Mine project area is the Cretaceous Blackhawk Formation of the Mesaverde Group (see Figure 2). The Blackhawk Formation, an interbedded formation of sandstones and shales, is Utah's chief coal producer (Stokes, 1964). The sands in this 1000-foot thick member are fine- to medium-grained and cemented by either calcite or silica with some iron discoloration. The sandstones tend to be local in extent and have locally high clay contents (Spieker, 1931; Doelling, 1972). An exception to this is the Aberdeen sandstone, a coarse-grained, light-colored sand with a thickness of 20 to 80 feet, which can be traced throughout the region (Spieker, 1931). The generally discontinuous nature of the Blackhawk sands and their apparent low specific yield (Cordova, 1964) indicate that the water yielding capabilities of the Blackhawk are only locally important.



*The Lower O'Connor Seam is the seam proposed to be mined.

Figure 2. Generalized stratigraphic section (modified from U.S. Geological Survey, 1979).

Spieker (1931) has identified three types of shale in the Blackhawk Formation, all continental in origin---a common clay shale which is soft and granular, a carbonaceous shale, and a smoke-gray shale usually associated with the coal. As was the case with the sandstones, the shales are irregularly bedded (Spieker, 1931). The abundance of shale in the Blackhawk acts as a barrier to the downward movement of water within the formation, greatly reducing its overall vertical permeability and the amount of water which percolates through the formation to lower units. Water which reaches the Blackhawk, therefore, generally percolates downward until it meets a shale layer, which causes horizontal movement to the surface or another "drain" (i.e. sandstone finger) within the formation.

No major faults are known to exist within the Scofield Mine project area. Some faulting was encountered to the east in the abandoned Winter Quarters Mines. The nearest known major faulting system is the Pleasant Valley Fault about two miles east of the mine project area. Other identified faulting in the area has resulted in only small displacements. It is suspected that these faults have only local hydrologic importance within the Blackhawk Formation because of its high clay content, giving it an ability to seal rapidly. Tension fracturing of the members likely increases the water yielding capacity due to the creation of secondary porosity.

According to the U.S. Geological Survey (1979), groundwater in the region exists under water table, artesian, and perched conditions. Water table conditions exist primarily in shallow alluvial deposits along larger perennial streams and in relatively flat-lying sedimentary rocks. Artesian conditions exist at greater depths where a confining layer overlies a more permeable member. However, pressures are generally not sufficient to produce flowing wells. Perched or impeded conditions exist where the confining layer lies beneath the water-bearing strata.

Only a small portion of the annual precipitation, probably much less than five percent, recharges the groundwater supply (Price and Arnow, 1974; U.S. Geological Survey, 1979). The amount of water infiltrating through the surface to saturated beds is small due to the presence of the relatively impermeable shale layers near the surface over much of the area.

Price and Arnow (1974) indicate that properly constructed wells in the Price River Basin would have only limited yields (normally less than 50 gallons per minute). Wells in or immediately adjacent to the mine project area could normally be expected to yield less than 10 gallons per minute (gpm). Increased yields could be expected from wells penetrating sandstones which were fractured as a result of tension.

Rocks in the mountainous areas near the mine project area generally have low specific yields (0.2 to 0.7 percent) and low

hydraulic conductivities (Price and Waddell, 1973). The volume of recoverable water in the area is small, averaging less than 600 acre-feet per square mile in the upper 100 feet of saturated rock (Price and Arnow, 1974).

The quality of groundwater in the Price River Basin deteriorates with distance downstream much the same as surface water. Total dissolved solids (TDS) contents in groundwater range from less than 200 milligrams per liter (mg/l) in and near the mine project area to over 3000 mg/l near the confluence of the Price River with the Green River (Price and Waddell, 1973). This increase in the TDS concentration is the result of increased contact of water and rock as travel distance increases, with saline shales contributing the major portion of the dissolved constituents.

2.2.2 Mine Project Area Aquifers, Seeps, and Springs

Wells have been drilled, tested, and monitored in an effort to determine aquifer characteristics in the Scofield Mine project area. Seeps and springs in the area have also been identified and monitored.

Results of Aquifer Testing. In an effort to determine the aquifer characteristics within the Scofield Mine project area, aquifer tests were conducted at five different wells (WQ-1, WQ-1A, WQ-6, WQ-8, and WQ-12 all shown on Plate 1). Initially, "slug" tests as outlined by Lohman (1972) were performed in wells WQ-1,

WQ-1A, WQ-6, and WQ-8. Later, drawdown and recovery tests were conducted at Wells WQ-1A and WQ-6 for comparison with the slug test results. Drawdown and recovery tests were also conducted at Well WQ-12. The slug tests were conducted by rapidly injecting a quantity or "slug" of water down the well and then measuring the recovery of the water level to its original level. The data is analyzed by plotting the value of H/H_o versus time (t) on a semilog plot where H is the head inside the well at time t (in seconds) after injection of the slug above the initial head and H_o is the head inside the well above the initial head at the instant the slug is injected (see Figure 3). This plot is then superimposed over type curves presented by Lohman (1972) in which H/H_o is plotted against Tt/r^2 (T is the transmissivity in feet squared per second, r is the radius of the well or casing in feet, and H, Ho, and t are as previously defined). From the superimposed curves, a match line is selected for the value of t at

$$\frac{Tt}{r^2} = 1.0 \qquad (1)$$

The transmissivity is determined by solving Equation 1 for T after substituting in the match line value of t and the radius of the well (r). The resulting value of T can be converted to units of gallons per day per foot (gpd/ft) by multiplying it by a factor of 646,560. The results of the slug tests performed in the Scofield Mine wells are contained in Attachment A and summarized in Table 1. Transmissivity is a measure of the productiveness of

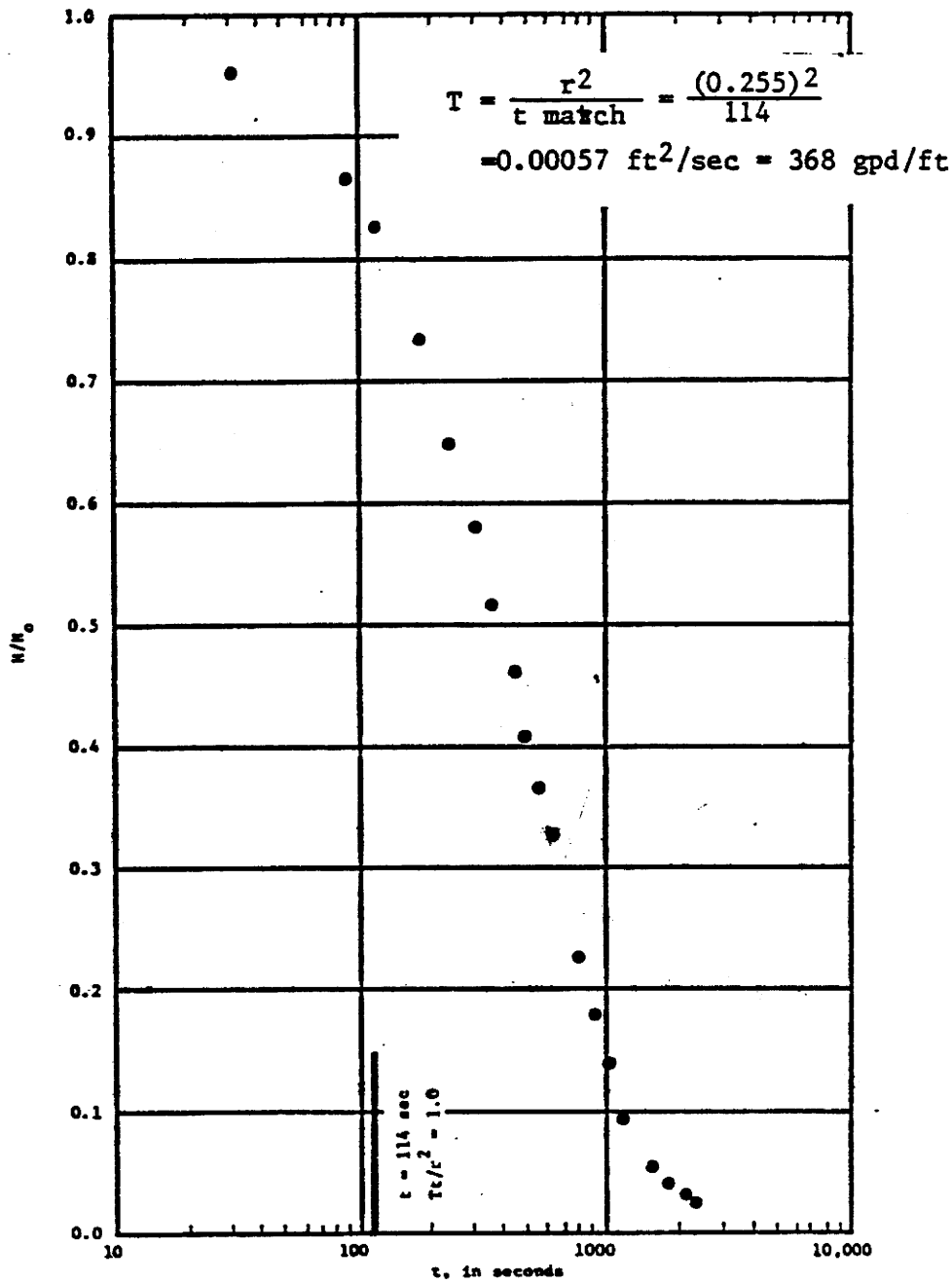


Figure 3. Graphical results of the slug test for Well WQ-8 when the hole terminated below the coal zone.

the well. As can be seen from Table 1, the productiveness of the wells increased only slightly if at all below the coal zone to be mined. This is consistent with the experience in other drilling programs in the area which have shown that the Aberdeen Sandstone and Starpoint Formation which are underneath the Lower O'Connor coal seam are very impervious and produce significant amounts of water only in fracture zones.

In May of 1981, drawdown and/or recovery tests were conducted in wells WQ-1A and WQ-6 for comparison with the slug test results. In November of 1981, drawdown and recovery tests were conducted in Well WQ-12. Water was discharged from the wells using a submersible pump. The data were analyzed over the straight-line portion of the semilog time-drawdown (or time-residual drawdown) curve using the Jacob equation (U.S. Bureau of Reclamation, 1977), which states that

$$T = \frac{2.303\ Q}{4\pi \partial s/\partial(\log\ t)} \qquad (2)$$

where T is the transmissivity, Q is the flow rate from the well during the drawdown test, s is the drawdown, and t is the time since pumping began. In the case of a recovery test, s becomes s' (the residual drawdown or difference between the measured head and the head prior to the start of pumping) and the time term becomes t/t', where t' is time since pumping ceased (U.S. Bureau of Reclamation, 1977). For a particular distance, Equation 2 is the equation of a straight-line plot of s versus log t (or s' versus log t/t'). For one log cycle, ∂ log t (or ∂ log t/t') is equal to

Table 1. Aquifer test results

Well	Slug Test above Coal **	Slug Test at Coal Level **	Slug Test below Coal **	Drawdown Test	Recovery Test
*WQ-1	T = 570 gpd/ft	----	----	----	----
*WQ-1A	----	T = 420 gpd/ft	T = 310 gpd/ft	T = 135 gpd/ft	T = 280 gpd/ft
*** WQ-6	T = 1200 gpd/ft	T = 1830 gpd/ft	T = 1830 gpd/ft	----	T = 20 gpd/ft
WQ-8	T = 85 gpd/ft	T = 310 gpd/ft	T = 370 gpd/ft	----	
WQ-12	----	----	----	T = 480 gpd/ft	T = 143 gpd/ft

*Well WQ-1 was abandoned at the 371 feet level because of drilling problems. Well WQ-1A was drilled about 30 feet from Well WQ-1.

**The coal seam to be mined (Lower O'Connor Seam)

*** The slug tests were conducted several months before the recovery test. It is expected that the walls of the well sloughed in during this period, thus sealing portions of the well and significantly reducing the transmissivity of the well.

one. With this in mind, and converting to the gallon-day-foot system of units, Equation 2 can be written as

$$T = \frac{264\ Q}{\Delta s} \qquad (3)$$

where T is the transmissivity, in gallons per day per foot (gpd/ft); Q is the constant discharge rate, in gallons per minute (gpm); and Δs is the drawdown difference per log cycle of time, in feet. The recovery test equation substitutes s' for s.

Drawdown and recovery tests were run in Well WQ-1A. The data are plotted in Figures 4 and 5. The data are contained in Attachment A. As Table 1 shows, the estimated transmissivities from the drawdown and recovery tests are quite similar to the estimate from the slug test. The recovery test run in Well WQ-6 however, indicated that the transmissivity of the well was much less than the estimated transmissivity from the slug tests in the same well. This is expected to be a result of sloughing of the well walls around the casing through the winter period that separated the slug and recovery tests, thus sealing much or even most of the well. Consequently, the recovery test in Well WQ-6 probably was a test of a small and quite impermeable zone in the upper portion of the well which was in the lower portion of the Blackhawk Formation. This is quite consistent with other well tests in the Blackhawk and Starpoint formations at nearby mines which show low permeabilities and transmissivities. The sloughing

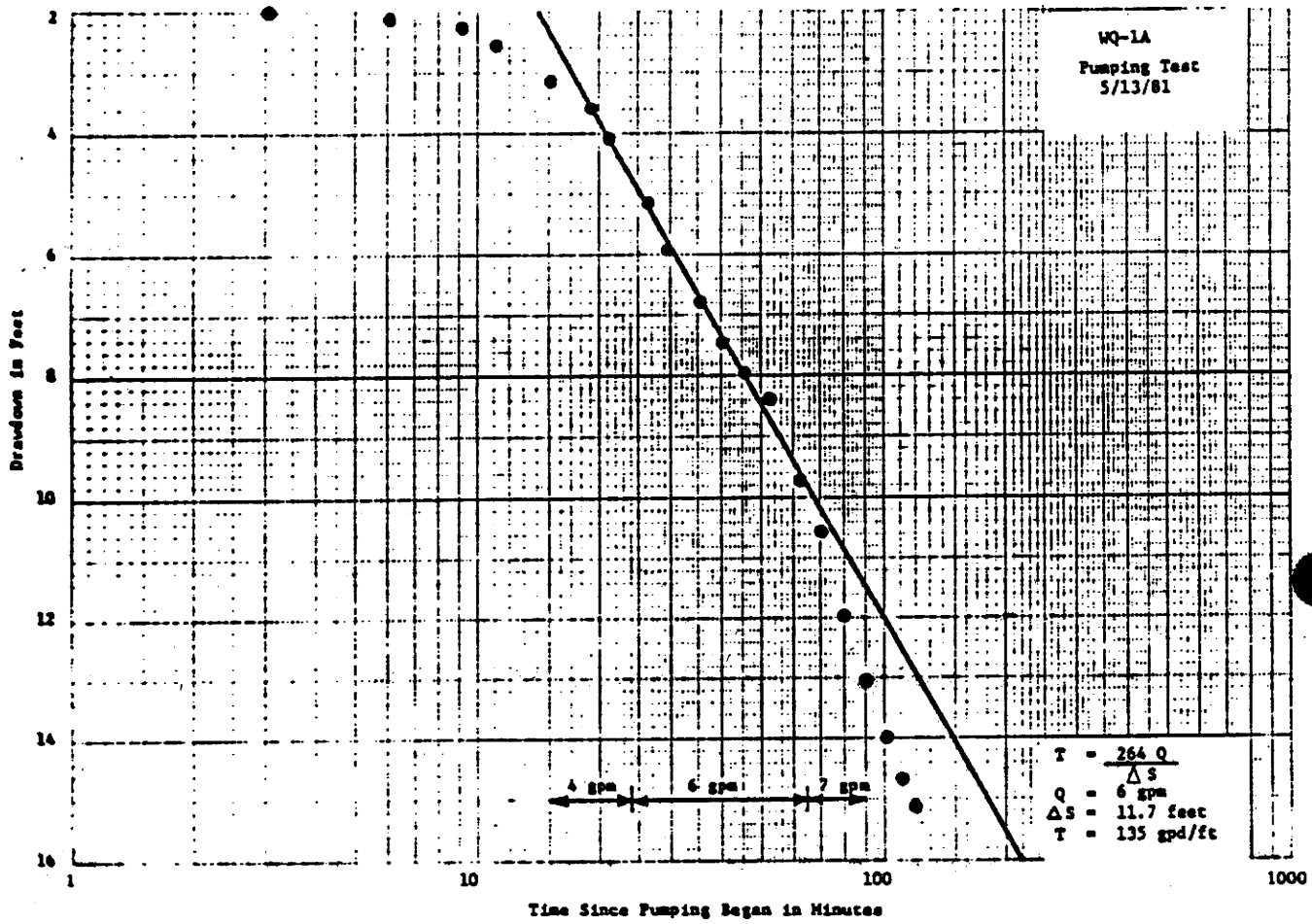


Figure 4. Graphical results of the recovery test conducted in Well WQ-1A.

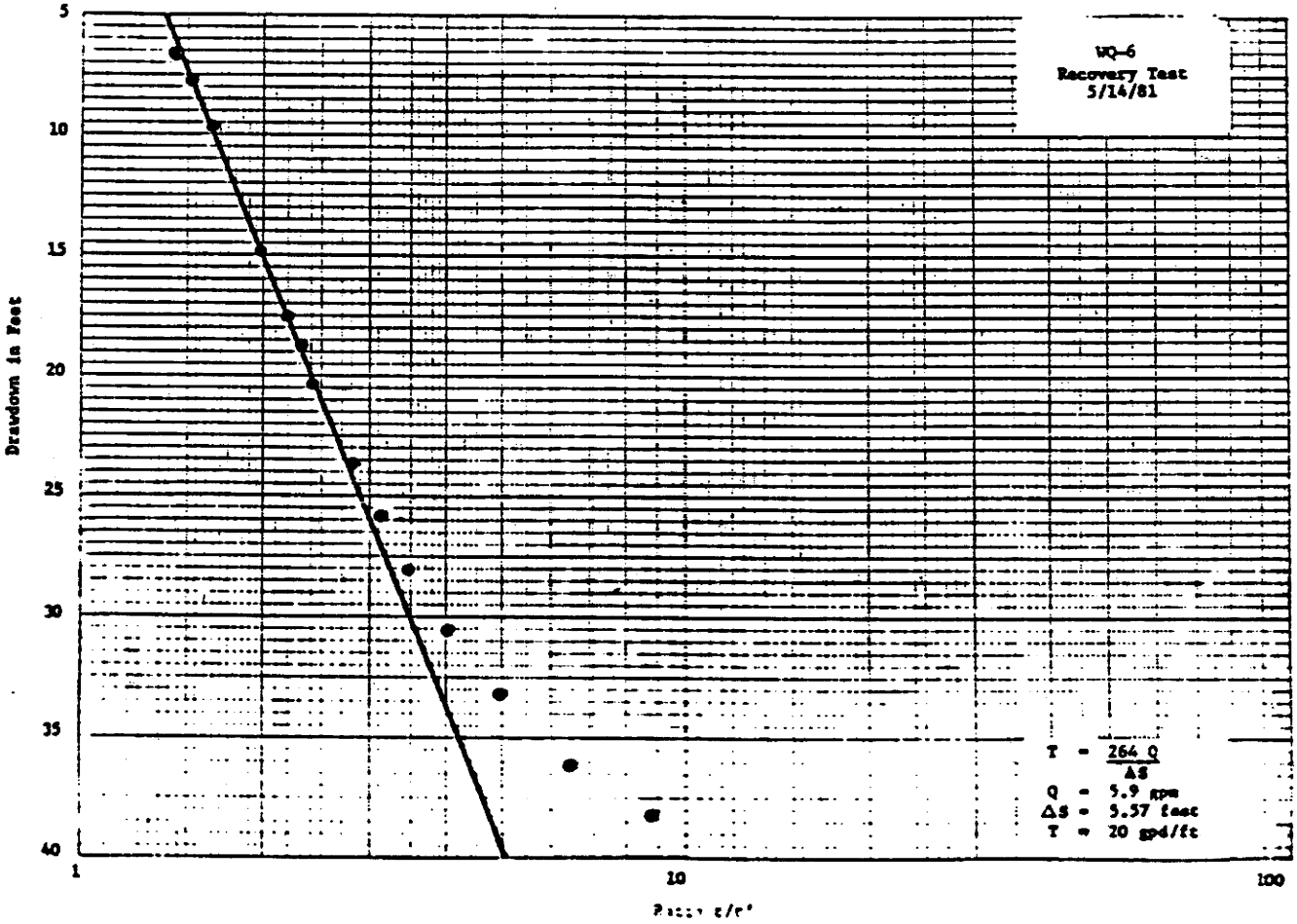


Figure 5. Graphical results of the recovery test conducted in Well WQ-6.

and sealing which apparently occurred in the Blackhawk Formation is also very consistent with other information indicating the Blackhawk has the ability to seal itself with time to significant water movement.

Well WQ-12 was drilled in November of 1981 as part of an exploratory program. The well intercepted a fracture zone which produced a source of water that appeared to have potential as a culinary water source for the mine. Consequently drawdown and recovery tests were conducted. The results of these tests indicated similar transmissivities to those measured in the drawdown and recovery tests for Well 1A (see Table 1 and Attachment A).

The quite low transmissivities and flow rates of the aquifer tests indicate that the Blackhawk Formation is at best a poor aquifer. The Aberdeen Sandstone below the Lower O'Connor coal seam is a very poor aquifer. The lenticular nature of the Blackhawk Formation does cause wells to have some degree of variability.

A potentiometric contour map (See Plate 2) of the mine project area has been prepared using water level measurements taken in October of 1981 from the water level monitoring wells. As shown in this map, potentiometric contours have a similar shape as the ground surface, although the magnitude of the gradient of the potentiometric contours is much less than the land slope

generally. The potentiometric surface is above the elevation of the Lower O'Connor coal seam throughout the project area.

Water levels in the four wells for which data are available during most of the 1981 water year have not varied significantly. The magnitude of maximum variation has ranged from 2.2 feet in WQ-1 to 25.55 feet in Well WQ-6 (see Attachment A).

Characteristics of Springs and Seeps. As an index of groundwater hydrologic conditions in the mine project area, a fall inventory (i.e. during the low flow season) was made of existing seeps and springs on and adjacent to the mine project area. During this time, the mine project area was covered on foot and all seeps and springs found were noted on a map (see Plate 3).

Flows from individual springs were variable during the fall inventory. Three springs were flowing at rates greater than or equal to 10 gpm (U1-5 at 12 gpm, U1-6 at 10 gpm, and U6-1 at 30 gpm). Spring U1-13 may be discharging from old workings of the abandoned Winter Quarters Mines. Most of the springs were flowing less than three gallons per minute. Sampling of springs in the surrounding region has shown that flows from a given spring may vary by as much as an order of magnitude during the year, with the higher flows coming during the snowmelt season. All of the springs in the Scofield Mine project area are located in or near canyon bottoms. Most of the springs are located on the west-facing slopes of north-south canyons. These springs are on the down-dip side of the ridges. No springs were found in the portion

of the mine project area that is within the Woods Canyon drainage basin.

Groundwater Quality. Water quality samples were collected and analyzed for nine springs and five wells within and adjacent to the Scofield Mine project area as an index of groundwater hydrologic conditions. The results of the chemical analyses for samples taken from wells and springs are presented in Attachment B.

Groundwater from springs and wells varied from a sodium to calcium-bicarbonate type. Quarterly average cation-anion diagrams of the water samples collected from the groundwater samples collected from the monitoring stations are shown on Plate 1. Total dissolved solids (TDS) levels ranged from 210 to 1980 mg/l for springs, while well samples ranged between 135 and 710 mg/l. The average TDS concentration from the groundwater samples collected was about 430 mg/l.

The hydrogen ion activity (pH) of the groundwater has varied from 6.7 in Well WQ-12 to 9.4 in Well WQ-1A. The pH measured in the springs varied less than did the well samples (pH values ranged from 6.9 to 8.1 in the springs). The usually slight basic condition of the groundwater is due primarily to the high concentrations of bicarbonates (American Public Health Association et al., 1976).

As mentioned in more detail later in Section 3.2.2 of this report, the Utah Division of Health has established some water quality criteria for surface waters in the Scofield Mine project area. As groundwater contributes (in the form of seeps and springs) to surface waters, the quality of groundwaters in the project area are briefly compared in this report to the state standards for surface waters in the area.

Dissolved and total iron concentrations in the samples from the springs are within the water quality standards established by the state. The wells have each been cased with steel casings, and consequently many of the well samples have had relatively high iron concentrations.

Both ammonia and phosphate levels in the groundwater samples have often exceeded state water quality standards. Ammonia concentrations have ranged up to 1.49 mg/l in Spring U2-2. Of the groundwater samples analyzed for ammonia, about two-thirds have exceeded the standard of 0.02 mg/l set by the state. Almost 60 percent of the samples tested for phosphate exceeded the state standard of 0.05 mg/l with the highest measured concentration of phosphate being 1.00 mg/l from Well WQ-1A. These ammonia and phosphate levels are fairly typical of other values measured in the Scofield area.

Dissolved copper concentrations in excess of state water quality standards (0.01 mg/l) have been measured at wells WQ-1,

WQ-1A, WQ-6. WQ-8, and Spring U2-2. The highest copper concentration measured has been 0.09 mg/l in Well WQ-6.

Spring U1-5 had a mercury concentration of 0.0115 mg/l which is above the state standard of 0.00005 mg/l. All other samples have had mercury concentrations below detectable levels of routine laboratory procedures.

Well WQ-8 had a dissolved lead concentration of 0.252 mg/l which exceeds the state standard for the area of 0.05 mg/l. All other dissolved lead concentrations have been well within state standards.

Wells WQ-1, WQ-1A, WQ-6, WQ-8, and Spring U2-2 have each had dissolved zinc concentrations in excess of the state standard of 0.05 mg/l. The highest dissolved zinc concentration has been measured in Well WQ-8 as 0.26 mg/l.

The concentrations of other constituents have consistently been present in very low concentrations. For example, nitrate, nitrite, and dissolved aluminum, arsenic, barium, chromium, manganese, molybdenum, selenium, and vanadium have always beem measured in levels well within state water quality standards. Many parameters have generally been undetected with normal laboratory procedures (particularly molybdenum, arsenic, chromium, vanadium, and selenium).

Water Rights. Groundwater rights in and adjacent to the Scofield Mine project area on file as of December, 1981 with the Utah Division of Water Rights are listed in Table 2 and shown on Plate 4. No groundwater rights currently exist within the Scofield Mine project area, although in June of 1981 UCO filed a water right exchange application with the Utah Division of Water Rights to effect a transfer of 20 shares in the Price River Water Users Association from agricultural use to industrial/domestic use at the Scofield Mine site as explained in Section 2.3.1. Further downstream near the mouth of Winter Quarters Canyon and in Pleasant Valley Canyon, some groundwater rights have been granted. Specified uses of most of these rights are for stockwatering although some rights have been granted for irrigation and domestic uses. Table 3 lists exchanges of water rights in the area. These exchanges are also shown on Plate 4. Because of the distance between the mine project area and existing groundwater rights and also because of the very limited use of the groundwater supplies, the impact of the Scofield Mine on existing groundwater rights is expected to be unnoticeable or non-existent.

2.3 Groundwater Development and Mine Dewatering

This section of the report discusses groundwater usage in the mine plan and adjacent areas as well as the development of a water supply for the mine. The potential for mine dewatering will also be discussed.

Table 2. Ground water rights located on and adjacent to the Scofield Mine project area.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
9-200	Utah Natural Gas Company (½ interest)	Underground Water, Well	0.134	Domestic Irrigation	January 1 to December 31
91-201	Earl Thomas	Spring with storage	0.068	Stockwatering	April 15 to November 1
91-424	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-425	Nick Marakis (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-432	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-433	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-434	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-435	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-455	Robert Radakovich	Spring	0.011	Stockwatering	May 1 to December 15
91-463	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-464	John Marakis Estate (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-472	John Marakis Estate (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-473	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-474	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-475	John Marakis Estate (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-481	Robert Radakovich	Spring	0.011	Stockwatering	May 1 to December 15
91-1035	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1036	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1039	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1045	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1046	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1644	Lee Thomas (1/3 interest)	Spring	-----	Stockwatering	May 1 to October 31
91-1986	Angelo Georgedes	Spring with storage	0.05	Fish Culture	January 1 to December 31
91-2049	John Jouflas Estate (2/3 interest)	Spring	0.011	Stockwatering	May 1 to October 31

Table 2. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-2144	Elrie and Bertha Simonsen (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2145	Robert Radakovich (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2288	Elrie & Bertha Simonsen	Spring	0.011	Stockwatering	June 1 to November 30
91-2494	Elrie & Bertha Simonsen	Mooney Mine Spring	----	Irrigation Stockwatering	March 1 to November 30
91-2669	Della Simonsen	Spring	0.011	Stockwatering	April 1 to November 30
91-2970	Angelo Georgedes	Spring	0.015	Stockwatering	May 1 to October 31
91-2975	Justus O. Seely	Spring	0.011	Irrigation Stockwatering	January 1 to December 31
91-2976	Justus O. Seely	Spring	0.011	Irrigation Stockwatering	January 1 to December 31
91-3012	Angelo Georgedes	Spring	0.015	Irrigation Stockwatering	January 1 to December 31
91-3094	Scofield Town	3 Springs	0.033	Municipal	January 1 to December 31
91-3401	Waino E. Burton	Underground Water, Well	0.011	Stock & Domestic	January 1 to December 31
91-3402	Waino E. Burton	Underground Water, Well	0.011	Stock & Domestic	January 1 to December 31
91-3460	Mountain Fuel Supply Co. (½ interest)	Underground Water, Well	0.134	Domestic, Irrigation Misc.	January 1 to December 31
91-3601	Della L. Madsen	Spring	0.011	Stockwatering	June 1 to November 30
91-3634	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3638	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3668	Angelo Georgedes	Spring	0.015	Stockwatering	May 1 to October 31

Table 3. Water right exchanges near the Scofield Mine project area.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-164	Louise Gorichek	Well	1.0 A.F.	Domestic	January 1 to December 31
91-452	Robert Radakovich	Well	1.0 A.F.	Stockwatering	March 1 to November 30
91-772	Valley Camp Coal Company	Well	0.446 cfs	Industrial Domestic	January 1 to December 31
91-1658	Price River Water Users Assoc.	Spring	2.0 A.F.	Domestic	January 1 to December 31

2.3.1 Water Supply

Development of groundwater in the area has not been a common practice. Most groundwater use in the area has been confined to undeveloped springs for stockwatering purposes. Several water wells have been completed in the town of Scofield. Mining operations in surrounding canyons have drilled several water wells to provide water needed for their operation.

As indicated previously, wells in the Price River Basin generally have limited yields except where sandstones have been fractured as a result of tension. In these cases, the fractures act as conduits to convey water. Where wells have encountered these fractures, yields are larger. Well WQ-12 is in such a fracture.

Well WQ-12 was drilled as part of an exploration program during the fall of 1981. A water-yielding fracture was encountered in the well. Consequently, the well was completed in such a manner that it could be developed as a culinary water source if tests were favorable. Subsequent aquifer and water quality tests have been favorable, and summaries of these tests are contained in Attachments A and B respectively. If Well WQ-12 is not adequate for the needs of the Scofield Mine, an additional well(s) will be drilled to supply the needed water. UCO currently owns 100 shares in the Price River Water Users Association which stores water in Scofield Reservoir. An application to exchange the water represented by 20 shares of UCO's stock to industrial/municipal use at the Scofield Mine (diverted from the

groundwater system) is currently pending with the Utah Division of Water Rights. Approval of this exchange application is expected to be granted in March of 1982.

2.3.2 Mine Dewatering

Water encountered in the mine is expected to be generally in the form of small roof leakers of usually less than five gallons per minute that dry up within a few days or weeks. It is expected that tension cracks associated with deformations will occasionally yield larger flows of up to about 150 gpm. These increased flows have been encountered in other mines in the Wasatch Plateau. The water made within the mine will be used for dust suppression and fire protection within the mine. Water not used for these purposes normally will be stored in reservoirs within the mine. In the event that excess water is encountered underground, mine water will be discharged to Winter Quarters Creek in accordance with an EPA approved NPDES permit that was issued by the EPA on May 24, 1982.

2.4 Effects of Mining Operation on the Groundwater Hydrologic Balance

The Scofield area in the Wasatch Plateau coal field can expect mining activities to continue into the twenty-first century. As has been noted, the occurrence and quality of water in any region is highly controlled by geology. Because the region surrounding the Scofield Mine project area consists of the same

geologic formations, impacts from the Scofield Mine are expected to be the same as those minor impacts that have occurred from mining during the past 100 or more years. For example, the abandoned Winter Quarters Mines, mined from approximately 1876 through 1928, have had no noticeable impact on the hydrology of the area. Thus, it is presumed that mining activities in the Scofield area will have little adverse impact on the area hydrologic system.

2.4.1 Hydrologic Balance

Springs. The Scofield Mine project area is covered entirely by the Blackhawk Formation. This formation consists of interbedded layers of sandstone and shale separated by various mineable and nonmineable coal seams. The sandstone beds are generally massive while the shale layers are bentonitic, tending to swell when wet and decompose into an impervious clay. Because of this fact, the downward percolation of water through the Blackhawk Formation is quite limited. This is why mines in the Blackhawk generally encounter only small amounts of groundwater inflow (Vaughn Hansen Associates, May 1981).

A check of the abandoned Winter Quarters Mines, which are adjacent to the Scofield Mine project area, showed that flows within the Winter Quarters Mines were generally quite low and fairly comparable to flows with other nearby mines. Exploration holes drilled for UCO show quite similar patterns of alternating layers of shales and sandstones. Consequently, it appears that the effect of mining in the Scofield Mine on the groundwater will

be minimal as in other nearby mines and in the adjacent, abandoned Winter Quarters Mines which are also in the same Blackhawk Formation.

Formations underlying the Scofield Mine project area may have slightly less shale which may allow slightly more water to enter the mine than at other mines. However, this difference, if real, is expected to be minor. Removal of water from within the mine beneath the local water table is not expected to affect the quantity or quality of flow from springs which exist within or adjacent to the mine project area. The water which is removed from the mine mouth, which would normally have traveled to an outlet some distance from the mine project area, will represent only a small fraction of the water flowing from the watershed.

Subsidence. Should subsidence occur, it is felt that the quantity of water will be affected only minimally. Because of the ability of the shale material to swell and decompose into an impervious clay, fractures in the shale members do not act as conduits, but rather as barriers to potentially vertically flowing water. Thus, the quantity of water present in seeps and springs in the area should remain nearly unaffected by mining in the project area. This pattern has been observed throughout the coal-mining areas in the Blackhawk Formation.

A photogrammetric investigation for subsidence and subsidence related vegetative changes over the adjacent and abandoned Winter Quarters Mines was undertaken by Applied Earth Sciences of

Colorado, LTD (1981). Their investigation revealed "...no unnatural breaks in the terrain". They also did not "...detect any anomalous changes in the vegetal pattern that would coincide with the occurrence of subsidence and the possible disturbance of the surface water and soil environment". In general, overburden will be greater over the Scofield Mine than over the abandoned Winter Quarters Mines. Consequently, any effects of subsidence are expected to probably be less in the Scofield Mine project area than they were above the Winter Quarters Mines.

2.4.2 Quality

The mines in the coal fields of the Wasatch Plateau tend to act as interceptor drains. The groundwater that is brought to the surface has a lower dissolved solids content than would have existed if the water was to continue its downward movement through shale layers, dissolving increased amounts of salt with distance (Southeastern Utah Association of Governments, 1977; Vaughn Hansen Associates, 1979). This pattern is shown in the generally strong calcium-bicarbonate type water and the low TDS concentrations of mine water from nearby mines relative to poorer quality waters yielded from lower in the stratigraphic section. For example, as explained previously, the Scofield Mine project area springs issue near canyon bottoms and have had slightly higher TDS levels than have the wells in the area. These springs are thought to be further along in the hydrologic system than is the water monitored by the wells.

For the reason explained above, the proposed Scofield Mine may have a slightly beneficial impact on the chemical quality of water in the region, because if any water is brought to the surface and discharged into the stream channel, the TDS levels will be lower than if the water had continued to move through the shale formations (Bentley, et al., 1978). Although suspended sediment and oil and grease may increase in the mine, these constituents will be removed in keeping with regulatory requirements prior to any potential discharge into adjacent streams.

Because of the high alkalinity and low acidity concentrations in the area (differing by about two orders of magnitude), acid drainage problems should not occur as a result of mining. This is fortified by the fact that coal in the area has a low sulphur content (U.S. Geological Survey, 1979 and James P. Walsh and Associates, Inc., 1981).

2.5 Mitigation and Control Plans

As was previously discussed, no significant impacts to the groundwater system are expected from the mining operation. The groundwater monitoring plan, discussed in the following section, will provide a means to follow the possible effect of the mining activities on the groundwater system.

2.6 Groundwater Monitoring Plans

An extensive groundwater monitoring program, which began in October of 1980, has been underway at each of the groundwater stations shown on Plate 5. Monitoring was conducted on a monthly basis through April, 1981 (when accessible). At that time the monitoring was reduced to a bimonthly basis in accordance with new guidelines issued by the Utah Division of Oil, Gas, and Mining, and the parameter list for laboratory analysis was modified to the schedule outlined in Table 4. Attachment B contains tabulations of the results of the water quality analyses. A one-year baseline data gathering period has been completed at most of the stations shown on Plate 5, and consequently the monitoring schedule has been recently modified to reflect information obtained during the baseline period.

The currently existing monitoring program outlined below will continue during the operational phase of the mine unless permission to change the program is obtained from the appropriate regulatory agencies. Water levels in the wells on Plate 6 will be measured quarterly (when accessible). Springs U1-1, U1-4, U1-5, and U1-6 have been deleted because the stations located at the mouths of the respective drainages (U-2 and U-3) will provide sufficient monitoring of the effect of mining on the groundwater which issues as springs in the drainages. Well WQ-8 has been deleted because of its close proximity and similarity to Well WQ-6 which will continue to be monitored. Well WQ-1 is being

Table 4. List of water quality parameters.

Field Parameters	Lab Parameters	
Water Levels or Flow	Aluminum, Dissolved	Manganese, Dissolved
pH	Ammonia (NH_3 as N)	Mercury, Dissolved
Specific Conductance	Arsenic, Dissolved	Molybdenum, Dissolved
Temperature	Barium, Dissolved	Nickel, Dissolved
	Boron, Dissolved	Nitrate
	Carbonate	Nitrite
	Bicarbonate	Potassium
	Cadmium, Dissolved	Phosphate, Dissolved***
	Calcium	Phosphate, Total**
	Chloride	Selenium, Dissolved
	Chromium, Dissolved	Sodium
	Copper, Dissolved	Sulfate
	Fluoride	*Sulfide
	Iron, Total	Total Combustible Solids**
	Iron, Dissolved	Total Dissolved Solids
	Lead, Dissolved	Total Hardness (as $CaCO_3$)
	Magnesium	Total Suspended Solids **
	Manganese, Total	Zinc, Dissolved

*Only if visible coal fines, oil, or grease are observed.

**Surface water samples only

***Groundwater samples only

monitored for water levels only, as Well WQ-1A is only about 30 feet away and will provide sufficient quality data at the site. Discharge, pH, temperature, and specific conductance of the monitoring springs shown on Plate 6 are also being measured quarterly (when accessible). Water quality samples are being collected biannually from the springs shown on Plate 6 during high and low-flow periods as determined by baseline studies. Water quality samples will also be collected biannually from Wells WQ-1 and WQ-6 and within the mine near the working face. Water quality samples will be analyzed according to the schedule in Table 4 unless otherwise approved by the Utah Division of Oil, Gas, and Mining.

Baseline data indicate that many of the parameters listed in Table 4 are of little or no concern in the Scofield Mine project area. Consequently, a proposal to reduce the parameters of Table 4 for the operational monitoring phase will be submitted at a later date for consideration by the Division of Oil, Gas, and Mining. Mine water and sediment pond discharge will be monitored in accordance with the NPDES permit requirements. Results of all water quality data will be submitted quarterly to the Utah Division of Oil, Gas, and Mining.

Post-mining monitoring of groundwater will continue at representative stations determined with the aid and approval of the Utah Division of Oil, Gas and Mining. Representative groundwater stations will be monitored biannually during high and

low flow conditions. Duration of monitoring and parameter selection will be determined after appropriate consultation with state and federal agencies.

3.0 SURFACE WATER HYDROLOGY

Regulations of the Utah Division of Oil, Gas, and Mining require that water monitoring programs be established in areas of underground coal mining to monitor the effects of mining activities and protect the hydrologic balance of such areas. This section outlines the surface water hydrologic investigation and the surface water monitoring plan for the Scofield Mine project area.

3.1 Scope

The scope of this surface water section of this report is to describe the existing hydrologic conditions of the Scofield Mine project and adjacent areas and to describe the methods that have been and will be used to predict, monitor, and mitigate the impacts of mining. Sections within this surface water section of this report will cover the following major topics: existing surface water resources, surface water development, control and diversions, effects of mining on the surface water hydrologic balance, mitigation and control plans, and surface water monitoring plans.

Information used in preparing the surface water hydrologic section of this report has been gathered by field investigations. Pertinent literature has also been examined. Water quality

samples have been and will continue to be analyzed by a certified laboratory. Water rights were determined by examining current records of the Utah Division of Water Rights.

3.2 Existing Surface Water Resources

This section of the report deals with the region in general and the Scofield Mine project area more specifically. Watershed and stream characteristics are both described.

3.2.1 Regional Surface Water Hydrology

The Scofield Mine project area is situated in the headwaters of the Price River Basin (see Figures 1 and 6). The total surface acreage of the mine project area drains to the east through Winter Quarters and Woods Canyon creeks which are both tributaries of Mud Creek (sometimes called Pleasant Valley Creek). It should be noted however, as can be seen on Figure 1, that the affected surface disturbance area (portals, surface facilities, access/haul road, etc.) drains only through Winter Quarters Canyon. Consequently the majority of the surface water monitoring locations are located within Winter Quarters Canyon.

Snowmelt is the primary source of water for the perennial streams in the basin with summer precipitation usually producing little runoff (U.S. Geological Survey, 1979). Ephemeral streams are also abundant in the Price River Basin, existing primarily at

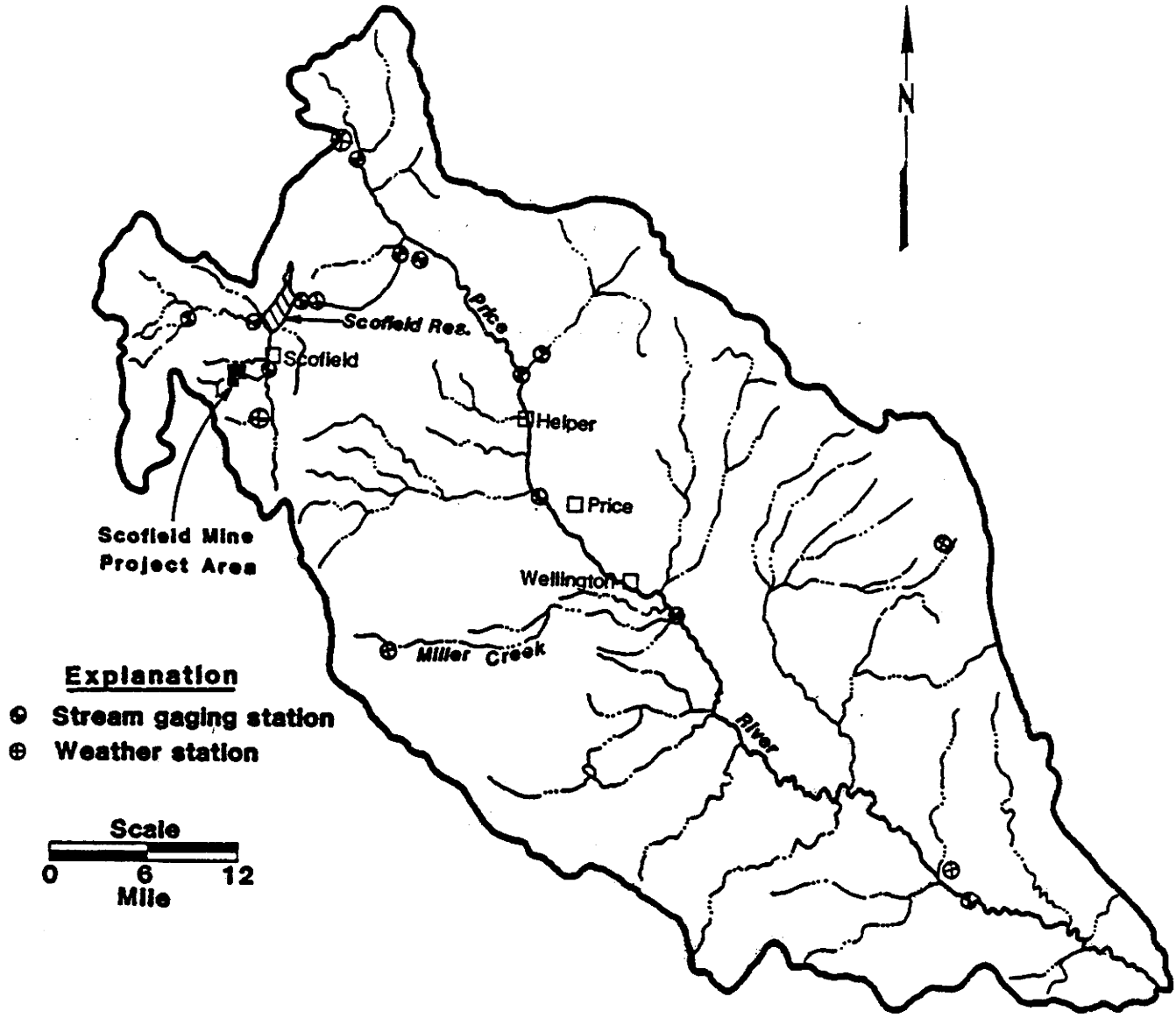


Figure 6. Price River Basin.

lower elevations where evapotranspiration significantly exceeds precipitation.

Water use upstream from Castle Valley (the valley containing most of the agricultural land) is primarily for stockwatering and industrial purposes (coal mining and electrical power generation). Within Castle Valley, agriculture and power production utilize nearly all of the inflowing water (Mundorff, 1972) with minimum flows in the gaged steams and rivers in the basin occasionally reaching zero. Storage reservoirs are common at higher elevations. Transbasin diversions occur throughout the area.

In general, the chemical quality of water in the headwaters of the Price River Basin is excellent with the watershed providing most of the domestic water needs of the people below. However, this quality rapidly deteriorates as the streams cross shale formations (particularly the Mancos Shale in and adjacent to Castle Valley) and receive irrigation return flows from lands situated on Mancos-derived soils (Price and Waddell, 1973). Within the basin for example, Mundorff (1972) reports that the Price River and its tributaries generally have TDS concentrations of less than 400 mg/l above the stream gaging station just above the town of Helper shown in Figure 6. The water in this area is of the calcium-bicarbonate type. Between this point and the confluence with Miller Creek, most of the flows originate on or tranverse Mancos shales. Much of the flow is derived from irrigation return flows. At Wellington, near the center of the basin, the Price River has an average TDS concentration of about 1700 mg/l and is of a mixed chemical type

(calcium-magnesium-sodium-sulfate). At Woodside, about 22 miles upstream from the confluence of the Price River with the Green River, the weighted average of the dissolved solids content has generally been between 2000 and 4000 mg/l with the water type being strongly sodium-sulfate.

Sediment yield from the upper portions of the basin is probably negligible (Mundorff, 1972). According to the U.S. Soil Conservation Service (1975), erosion rates in the Price River Basin vary from 0.1 to 3.0 acre-feet per square mile per year. The bulk of the sediment yielded each year at the mouth of the river comes from limited areas covered with highly erodable shales (Mundorff, 1972) and not in the upper elevations characteristic of the Scofield Mine project area.

3.2.2 Mine Project Area Watersheds and Streams

The Scofield Mine surface acreage lies within the drainages of two perennial streams--Winter Quarters and Woods Canyon creeks. However, surface facilities lie only within the drainage of Winter Quarters Creek. These streams and their tributaries form generally dendritic patterns over the area. The landscape of the area varies greatly, with most of the property being covered with conifer, aspen, or mountain shrubland vegetative communities on fairly steep slopes.

Watershed Characteristics. Slopes within the mine project area vary from greater than 60 percent (31 degrees) on the south-

facing slopes of Winter Quarters Canyon to less than 4 percent (2.3 degrees) along the bottom of Winter Quarters Canyon. The average slope over the area is approximately 37 percent (20 degrees) as determined from a 1:24,000 scale map of the area. Aspects also vary greatly because of the near ridge-top location of the property and the variety of channelized flow directions. However, the property does have a dominant aspect to the east. The topography is rugged, with elevations ranging from about 8000 to 9500 feet above mean sea level (a range of about 1500 feet).

Water sources in the mine project area include undeveloped springs and seeps, as well as Winter Quarters and Woods Canyon creeks, the characteristics of which will be covered in subsequent sections.

Water Quantity. The mean annual water yield from the Scofield Mine project area was calculated by two separate methods and compared with an estimate of the mean annual water yield given in Jeppson et al. (1968) to increase the level of confidence. The first method of calculation, referred to as "Grunsky's Rule", was originally developed by Grunsky (1908) and later adapted by Sellars (1965). In accordance with this method, the average annual water yield can be determined from

$$Q = \alpha P^2 \quad [\text{for } P \leq 1/2\alpha)] \qquad (4)$$

or

$$Q = P - 1/(4\alpha) \quad [\text{for } P \geq 1/(2\alpha)] \qquad (5)$$

where Q is the mean annual water yield, in inches; P is the normal annual precipitation, in inches; and α is the runoff coefficient, in inches^{-1}. An alpha (α) of 0.015 was determined from guidelines set forth by Hawkins (1976). Normal annual precipitation for the area is 28 inches (Jeppson et al., 1968). Substitution of variables resulted in an estimated yield of 11.2 inches.

The second method of calculation is known as Ol'deKop's formula (Sellars, 1965). According to this method, the mean annual water yield is determined from

$$Q = P - E_o \tanh \frac{P}{E_o} \qquad (6)$$

where Q and P are as previously defined and E_o is the annual potential evapotranspiration, in inches. For the area evapotranspiration is estimated at 17 inches (Jeppson et al., 1968). Substituting P and E_o into Equation 6, the mean annual water yield is estimated to be 12.2 inches.

Both estimates from these calculations compare favorably with the mean annual yield estimate of 10.0 inches made by Jeppson et al. (1968).

The runoff volume resulting from a particular rainfall depth was determined using the runoff curve number technique, as defined by the U.S. Soil Conservation Service (1972). According to the curve number methodology, the algebraic and hydrologic relations

between storm rainfall, soil moisture storage, and runoff can be expressed by the equations

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \tag{7}$$

and

$$CN = \frac{1000}{10 + S} \tag{8}$$

where Q is the direct runoff volume, in inches, P is the storm rainfall depth, in inches; S is a watershed storage factor, in inches, defined as the maximum possible difference between P and Q; and CN is a dimensionless expression of S referred to as the curve number. Curve number values were chosen using information supplied by the U.S. Soil Conservation Service (1972), Hawkins (1973), Hawkins (1979), and personal hydrologic judgment following field observations. Weighted curve numbers were used for heterogeneous areas. Values of P were obtained for selected durations and return periods from Miller et al. (1973). A 24-hour storm was used for design purposes.

Equation 7 is based upon the assumption that $I_a = 0.2S$, where I_a is the initial abstraction from storm rainfall, defined as the rainfall which must fall before runoff begins (i.e. to satisfy interception, evaporation, and soil-water storage). Therefore, determination of runoff from Equation 7 is valid only when $P \geq I_a$ or $P \geq 0.2S$. Below this point, no runoff can occur.

between storm rainfall, soil moisture storage, and runoff can be expressed by the equations

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (7)$$

and

$$CN = \frac{1000}{10 + S} \qquad (8)$$

where Q is the direct runoff volume, in inches, P is the storm rainfall depth, in inches; S is a watershed storage factor, in inches, defined as the maximum possible difference between P and Q; and CN is a dimensionless expression of S referred to as the curve number. Curve number values were chosen using information supplied by the U.S. Soil Conservation Service (1972), Hawkins (1973), Hawkins (1979), and personal hydrologic judgment following field observations. Weighted curve numbers were used for heterogeneous areas. Values of P were obtained for selected durations and return periods from Miller et al. (1973). A 24-hour storm was used for design purposes.

Equation 7 is based upon the assumption that $I_a = 0.2S$, where I_a is the initial abstraction from storm rainfall, defined as the rainfall which must fall before runoff begins (i.e. to satisfy interception, evaporation, and soil-water storage). Therefore, determination of runoff from Equation 7 is valid only when $P \geq I_a$ or $P \geq 0.2S$. Below this point, no runoff can occur.

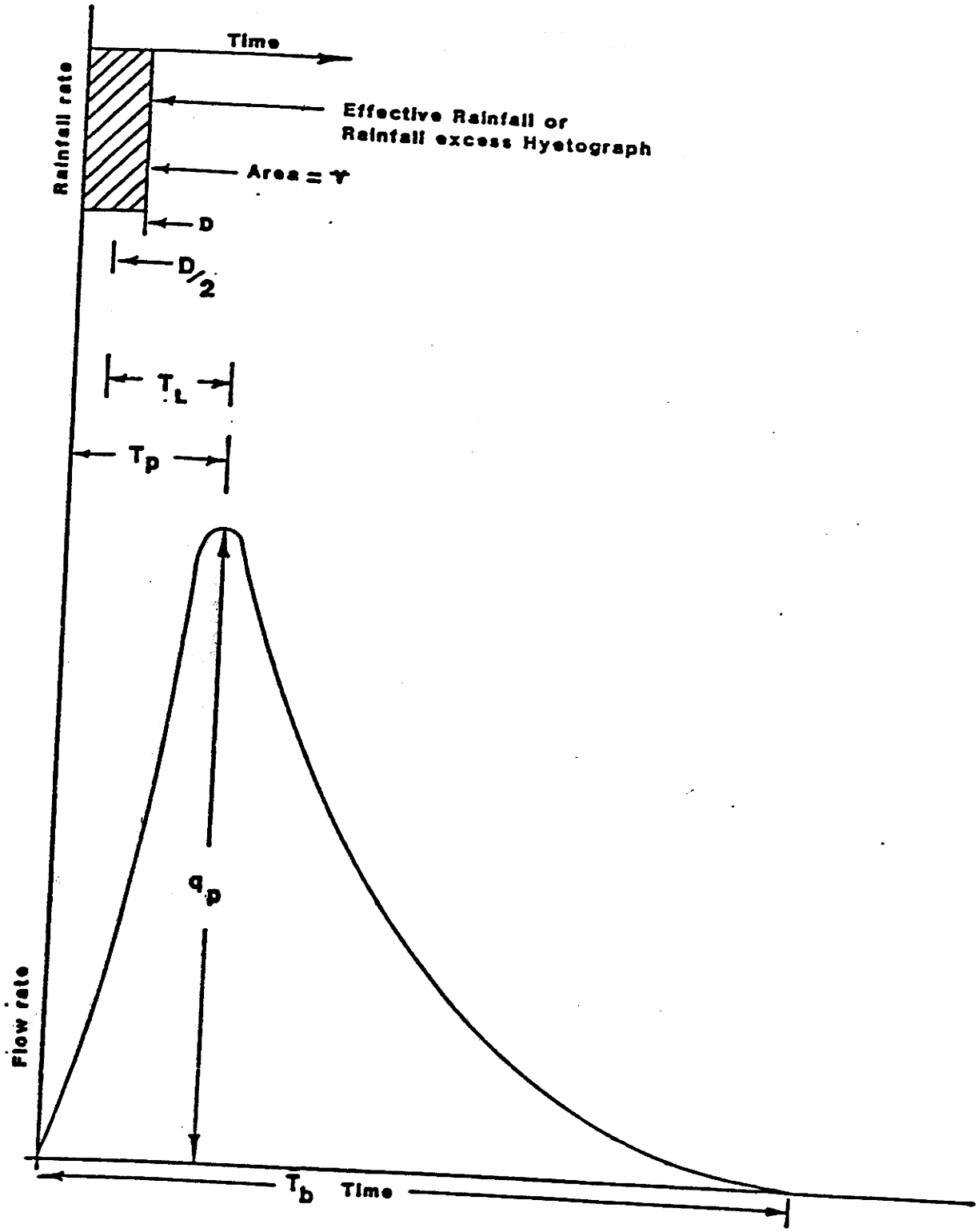


Figure 7. Unit hydrograph terminology.

Estimates of the peak discharge to be expected from various rainfall events were made using the dimensionless unit hydrograph procedure developed by the U.S. Soil Conservation Service (1972). Figure 7 shows a runoff hydrograph and the associated terminology. In the upper portion of this figure a hyetograph of a single block of rainfall excess with duration D is shown. The lower portion of the figure contains the resultant runoff hydrograph. For runoff from excess rainfall, the area under the hydrograph curve and the area enclosed by the rainfall hyetograph represent the same volume of water (Q). The peak flow rate for the hydrograph is represented by q_p, while T_p represents the time to peak, which is defined as the flow from the start of the hydrograph to q_p. The base time (T_b) is the duration of the hydrograph. The time from the center of mass of rainfall excess to the peak of the runoff hydrograph is the lag time (T_L).

The time of concentration (T_c), (not shown on Figure 7) is defined as the time for flow from the hydraulically most remotepoint in a basin to reach the basin inlet.

Time to peak, T_p, is assumed to be a function of watershed lag (T_L) which is determined according to the equation

$$T_L = \frac{\ell^{0.8} (S+1)^{0.7}}{1900\ Y^{0.5}} \qquad (9)$$

where T_L is the watershed lag, in hours; ℓ is the hydraulic length, or the length of the mainstream to the farthest divide, in feet; S

is as previously defined; and Y is the average watershed slope, in percent. Values of Y were obtained by using methods outlined by Craig and Rankl (1977). The hydraulic length was taken from an appropriate topographic map while S was determined from Equation 8 once the runoff curve number was estimated.

According to the U.S. Soil Conservation Service (1972), the watershed lag is equal to 0.6 T_c and the time of concentration (T_c) is equal to 1.5 T_p. Combining these two expressions it can be seen that

$$T_p = 1.11L \tag{10}$$

where both variables are as previously defined.

The peak discharge constant used in the dimensionless unit hydrograph method is determined according to the equation

$$q_p = \frac{484\ AQ}{T_p} \tag{11}$$

where q_p is the peak discharge constant, in cfs; A is the drainage area, in square miles; Q is the runoff volume, in inches (as determined by Equation 7); 484 is a conversion factor, and T_p is the time elapsed from the beginning of runoff to the hydrograph peak, in hours.

Dimensionless unit hydrographs are developed by simulating many natural unit hydrographs using the time to peak and the peak

discharge constant. Haan (1970) proposed a dimensionless unit hydrograph based on the gamma function

$$\frac{q(t)}{q_p} = \left[\frac{t}{T_p} e^{(-t/Tp)}\right]^{(C_3T_p)} \qquad (12)$$

where q(t) is the hydrograph ordinate at time t in cfs, the parameters q_p and T_p are as previously defined, and C_3 is a parameter defined by the equation

$$Q = q_p \; T_p\left[\frac{e}{C3Tp}\right]^{C_3T_p} \; \Gamma(C_3T_p) \qquad (13)$$

where Q is the runoff volume in inches (one inch for a unit hydrograph) and Γ is the gamma function.

Figure 8 shows how shape of the hydrograph defined by Equation 12 changes as C_3T_p changes. The higher the value of C_3T_p, the sharper the peak of the hydrograph.

The dimensionless unit hydrograph method involves the development of a runoff hydrograph from a complex rainstorm. The storm is divided into blocks of duration D. Values of D must be less than or equal to T_p. Practically, the selection of D as a multiple of T_p will ensure that the peak will be encountered. The rainfall distribution for the 24-hour storm is generated from the theoretical NOAA Type II storm distribution shown in Figure 9.

Rainfall excess is generated from the rainfall depths of duration D, and the rainfall-runoff relationship expressed in

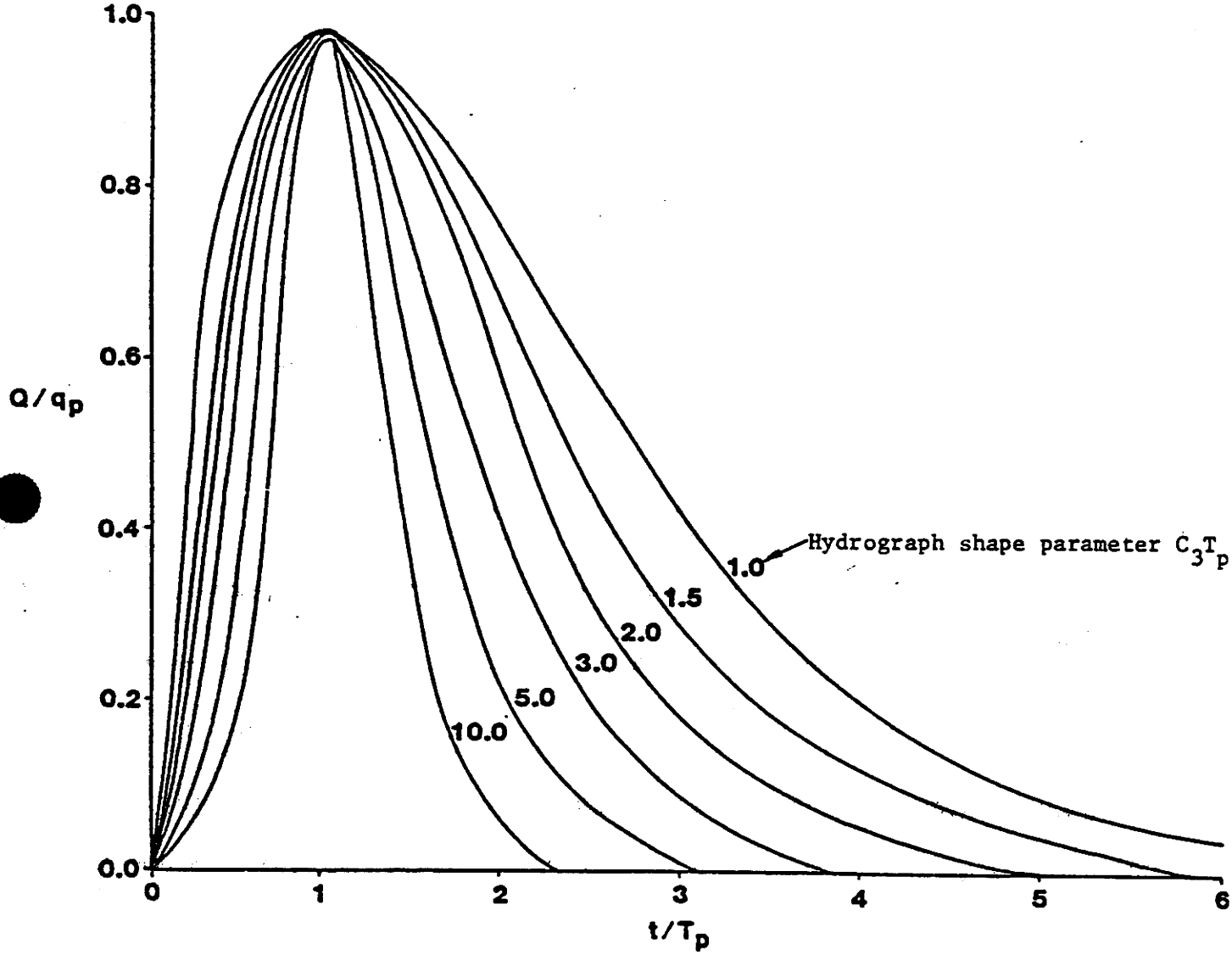


Figure 8. Variation of hydrograph shape with C_3T_p.

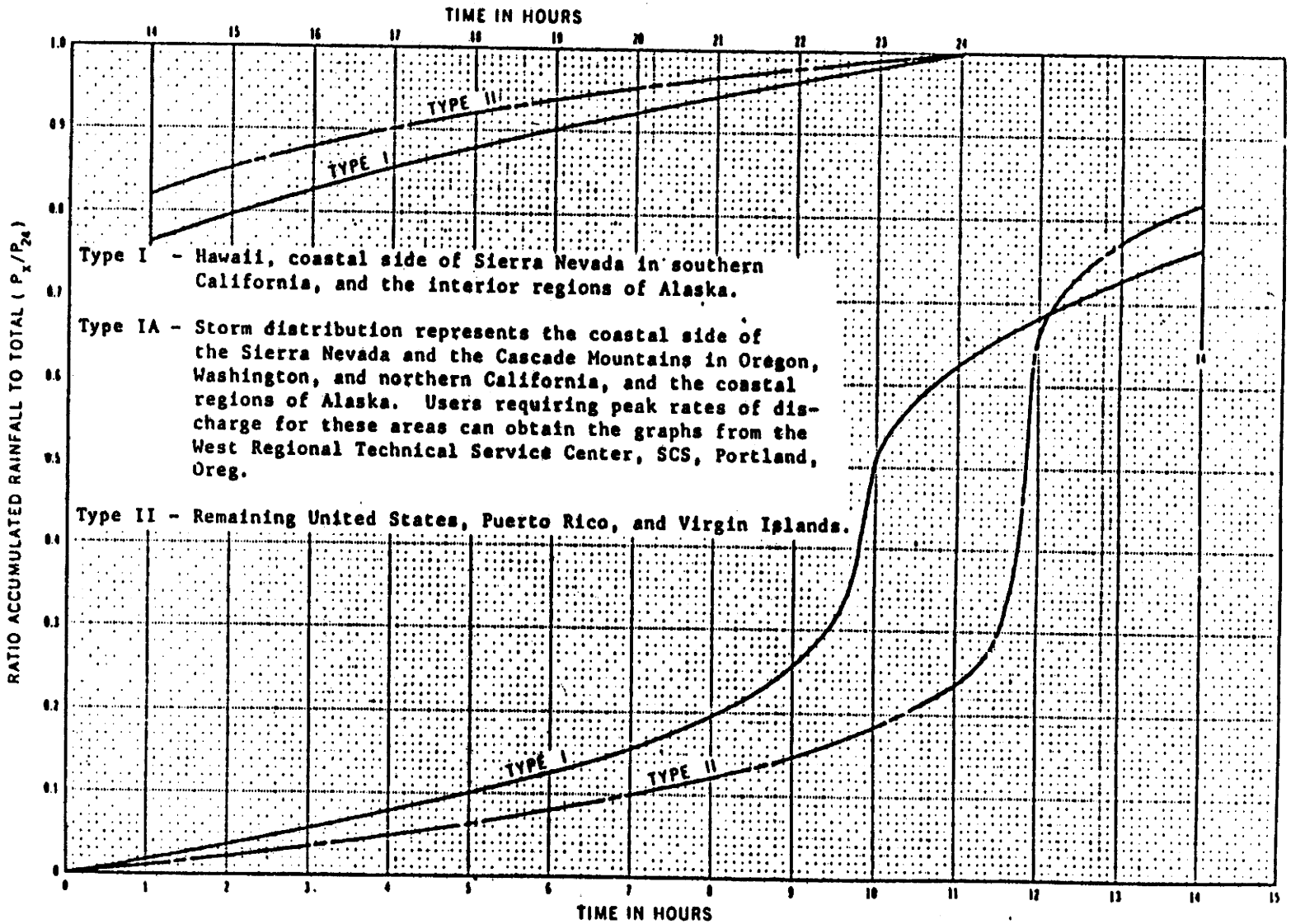


Figure 9. Twenty-four-hour rainfall distributions (from Kent, 1973).

Equation 7. The rainfall excess from each time increment of duration D is then multiplied by the unit hydrograph ordinates to produce a component hydrograph. Each of the component hydrographs are then lagged by a time increment D and are concurrently summed to produce the synthetic runoff hydrograph.

Estimates of peak rainfall related flood peaks for the major streams draining the Scofield Mine project area using this method are shown in Table 5.

A snowmelt peak discharge estimate for Winter Quarters Creek was determined by comparing Winter Quartes Creek with a nearby gaged stream (Eccles Creek) for which flood estimates have been previously estimated. A comparison of area, elevation, slope, aspect, soils, and cover characteristics shows that the Eccles Creek watershed (about two miles south of Winter Quarters Canyon) is very similar to Winter Quarters Canyon above the mine facilities location. The aspect and area of both canyons are similar. Both watersheds are east-facing of approximately 3500 acres. The average watershed slopes for the Eccles and Winter Quarters watersheds are very similar at 31 and 27 percent respectively. The soils in each watershed are generally B/C hydrologic type soils and vegetative type and cover is essentially the same for both watersheds.

With the similarity between the two watersheds, it is felt that the peak discharges for Winter Quarters Creek do not differ

Table 5. 100-year, 24-hour precipitation caused floods in streams near the Scofield Mine project area using the SCS synthetic hydrograph procedure.

Site Description	Area (ac)	Average Watershed Slope (%)	Curve Number	Precip. Depth (inches)	Storm Duration (hours)	Hydraulic Length (feet)	Unit Hyd. Peak Flow (cfs)	Peak Flow (cfs)
Wood Canyon Creek	3280	37.8	43	3.5	24	27,500	1140	16.7
Winter Quarters Creek above Mud Creek	4220	38.1	43	3.5	24	26,000	1539	21.6
Winter Quarters Creek at Mine Facilities	3480	37.2	43	3.5	24	18,500	1649	18.3

greatly from the peaks on Eccles Creek. The 100-year peak flow on Eccles Creek has been estimated to be 65 cfs (Vaughn Hansen Associates, 1980). As cam be seen by comparing this value with the storm runoff peak flow shown in Table 5, the 100-year snowmelt flood on Winter Quarters Creek is larger than the 100-year storm runoff peak flow.

Water Quality. Since monitoring began in October of 1980, eight surface water sites on or near the Scofield Mine project area (shown on Plate 7) have been sampled. Appendix B contains the results of the chemical analyses of surface water samples collected during this period. All stations were established for the collection of grab samples.

As depicted in Plate 7, surface waters in and near the Scofield Mine project area are generally of the calcium-bicarbonate type. Total dissolved solids (TDS) concentrations ranged from 140 mg/l in Winter Quarters Creek (Station U-8), to 450 mg/l in a tributary to Winter Quarters Creek (Station U-2). Between April and June, when stream discharges are highest due to direct snowmelt, a diluting effect occurs in surface waters, resulting in lower TDS concentrations. Later in the year as flow decreases and is largely derived from groundwater, this dilution effect becomes less pronounced and TDS concentrations increase.

Suspended solids concentrations during the inventory period were found to vary from 1.0 mg/l at the mouth of Woods Canyon Creek

(Station U-5) and two stations in the Winter Quarters drainage (Stations U-1 and U-2) to 636 mg/l in Mud Creek (Station U-7). It is known that suspended solids concentrations tend to vary somewhat proportionately with flow rate (Vaughn Hansen Associates, 1979). The experience on the Scofield Mine property substantiates this in that the highest suspended solids concentrations occurred during April and May when flows are generally high due to snowmelt runoff.

The hydrogen ion activity (pH) of the surface waters was found to be relatively constant throughout the Scofield Mine project area, varying from 6.6 to 8.5. The usually slight basic condition of the surface water is due primarily to the high concentrations of bicarbonates (American Public Health Association et al., 1976). River waters with pH values in the range of those measured throughout the mine plan area are generally not influenced by pollution (Hem, 1970).

The cementing agents of the Blackhawk Formation are expected to be the major source of iron in the surface waters of the mine project area. In the vicinity of Scofield Reservoir, it has been determined that total iron concentrations are directly related to flow rate, resulting from the probable association of iron with sediments (Vaughn Hansen Associates, 1979). Experience gained to date substantiates this as the highest iron concentrations in the surface waters were measured in samples with the highest suspended solids levels. Therefore, as a result of the occurrence of the Blackhawk Formation throughout the area, it is felt that total iron

concentrations will increase during the high flow periods and decrease during low flow periods. Total and dissolved iron concentrations varied throughout the mine plan area from 0.040 to 10.0 mg/l and from 0.010 to 2.72 mg/l, respectively (the large majority of the samples had iron concentrations less than 1.0 mg/l).

Total manganese concentrations are low within and adjacent to the mine project area, varying during the inventory period from 0.002 mg/l measured in a tributary to Winter Quarters Creek at Station U-3 to 0.51 mg/l in Mud Creek at Station U-7.

The Utah Division of Health has classified the waters within and adjacent to the Scofield Mine project area as 1C (protected for domestic purposes with prior treatment by standard complete treatment processes), 3A (protected for cold water species of game fish and other cold water aquatic life), and 4 (protected for agricultural uses including irrigation of crops and stockwatering). Classifications 1C, 3A, and 4 apply to Winter Quarters and Woods Canyon creeks, which drain into Mud Creek. Tables 6 and 7 contain the numerical water quality standards applicable to these various classifications. Few exceedances of these chemical standards were noted during the baseline study. With the exception of ammonia, phosphate, and one slight exceedance of dissolved silver (0.033 mg/l at Station U-1), all of the constituents were well within the limits established for the dissolved constituents in the chemical standards of Table 6.

Table 6. Utah Division of Health numerical standards for water in the state.

Constituent	CLASSES: Domestic Source 1A	1B	1C	Recreation & Aesthetics 2A	2B	Aquatic Wildlife 3A	3B	3C	3D	Agriculture 4	Industry 5	Special 6
Bacteriological (No./100 ml)												
(30-day Geometric Mean)												
Maximum Total Coliforms	1	50	5,000	1,000	5,000	*	*		*	*		
Maximum Fecal Coliforms	*	*	2,000	200	2,000	*	*		*	*		
Physical												
Total Dissolved Gasses	*	*	*	*	*	(b)	(b)		*	*		
Minimum DO (mg/l) (a)	*	*	5.5	5.5	5.5	6.0	5.5		5.5	*		
Maximum Temperature	*	*	*	*	*	20°C	27°C		*	*		
Maximum Temp. Change	*	*	*	*	*	2°C	4°C		*	*		
pH	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0		6.5-9.0	6.5-9.0		
Turbidity increase (c)	*	*	*	10 NTU	10 NTU	10 NTU	10 NTU		15 NTU	*		
Chemical (Maximum mg/l)												
Arsenic, dissolved	.05	.05	.05	*	*	*	*		*	.1		
Barium, dissolved	1	1	1	*	*	*	*		*	*		
Cadmium, dissolved	.010	.010	.010	*	*	.0004(d)	.004(d)		*	.01		
Chromium, dissolved	.05	.05	.05	*	*	.10	.10		.10	.10		
Copper, dissolved	*	*	*	*	*	.01	.01		*	.2		
Cyanide	*	*	*	*	*	.005	.005		*	*		
Iron, dissolved	*	*	*	*	*	1.0	1.0		1.0	*		
Lead, dissolved	.05	.05	.05	*	*	.05	.05		*	.1		
Mercury, total	.002	.002	.002	*	*	.00005	.00005		.00005	*		
Phenol	*	*	*	*	*	.01	.01		*	*		
Selenium, dissolved	.01	.01	.01	*	*	.05	.05		*	.05		
Silver, dissolved	.05	.05	.05	*	*	.01	.01		*	*		
Zinc, dissolved	*	*	*	*	*	.05	.05		*	*		
NH_3 as N (un-ionized)	*	*	*	*	*	.02	.02		*	*		
Chlorine	*	*	*	*	*	.002	.01		*	*		
Fluoride, dissolved (e)	1.4-2.4	1.4-2.4	1.4-2.4	*	*	*	*		*	*		
NO_3 as N	10	10	10									
Boron, dissolved	*	*	*	*	*	*	*		*	.75		
H_2S	*	*	*	*	*	.002	.002		*	*		
TDS (f)	*	*	*	*	*	*	*		*	1200		
Radiological (Maximum pCi/l)												
Gross Alpha	15	15	15	*	*	15(g)	15(g)		15(g)	15(g)		
Radium 226, 228 combined	5	5	5	*	*	*	*		*	*		
Strontium 90	8	8	8	*	*	*	*		*	*		
Tritium	20,000	20,000	20,000	*	*	*	*		*	*		
Pesticides (Maximum ug/l)												
Endrin	.2	.2	.2	*	*	.004	.004		.004	*		
Lindane	4	4	4	*	*	.01	.01		.01	*		
Methoxychlor	100	100	100	*	*	.03	.03		.03	*		
Toxaphene	5	5	5	*	*	.005	.005		.005	*		
2, 4-D	100	100	100	*	*	*	*		*	*		
2, 4, 5-TP	10	10	10	*	*	*	*		*	*		
Pollution Indicators (g)												
Gross Beta (pCi/l)	50	50	50	*	*	50	50		50	50		
BOD (mg/l)	*	*	5	5	5	5	5		5	5		
NO_3 as N (mg/l)				4	4	4	4		*	*		
PO_4 as P (mg/l)(h)	*	*	*	.05	.05	.05	.05		*	*		

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS (See Table 7)

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS

* Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.

(a) These limits are not applicable to lower water levels in deep impoundments.

(b) Not to exceed 110% of saturation.

(c) For Classes 2A, 2B, 3A, and 3B at background levels of 100 NTUs or greater, a 10% increase limit will be used instead of the numeric values listed. For Class 3D at background levels of 150 NTUs or greater, a 20% increase limit will be used instead of the numeric value listed. Short term variances may be considered on a case-by-case basis.

(d) Limit shall be increased threefold if $CaCO_3$ hardness in water exceeds 150 mg/l.

(e) Maximum concentration varies according to the daily maximum mean air temperature.

Temp. °C	mg/l
12.0 and below	2.4
12.1 to 14.6	2.2
14.7 to 17.6	2.0
17.7 to 21.4	1.8
21.5 to 26.2	1.6
26.3 to 32.5	1.4

(f) Total dissolved solids (TDS) limit may be adjusted on a case-by-case basis.

(g) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

(h) PO_4 as P(mg/l) limit for lakes and reservoirs shall be .025.

Table 7. Numerical standards for Class 3C water use in Utah.

Physical	
Minimum D.O. (mg/l)	5
Maximum Temperature	27°C
Maximum Temperature Change	4°C
pH	6.5-9-0
Turbidity Increase (NTU)	15****
Chemical	
Cadmium, dissolved	0.004
Chromium, dissolved	0.1
Copper, dissolved	0.01
Cyanide	0.005
Iron, dissolved	1.0
Lead, dissolved	0.05
Mercury, total	0.0005
Phenol	0.01
Selenium, dissolved	0.05
Silver, dissolved	0.01
Zinc, dissolved	0.05
Chloride	0.2
H_2S	0.02
Radiological (Maximum pCi/l)	
Gross Alpha	15
Gross Beta	30
Pesticides (Maximum mg/l)	
Endrin	0.004
Lindane	0.01
Methoxychlor	0.03
Toxaphene	0.005
Pollution Indicators***	
BOD (mg/l)	5.0
NO_3 as N (mg/l)	4.0

***Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

****At background levels of 150 NTU's or greater, a 10% increase limit will be used instead of the numeric values. Short term variances may be considered on a case-by-case basis.

Phosphates were analyzed in either the ortho form (a portion of total phosphate) and/or the total form. Of the samples analyzed for total phosphate, almost 85 percent exceeded the limit of 0.05 mg/l. Total phosphate concentrations as P ranged from 0.02 to 5.2 mg/l. There is no state standard for orthophosphate concentrations. The appearance of phosphorus in the surface waters of the mine plan area can be attributed to two sources: the degredation of animal wastes from grazing stock in the area, and deriving phosphates from the phosphorous content of the soils and sediments (McElroy et al., 1976).

Another exception to the statement of few exceedances to the standard is ammonia. Each of the eight surface water stations had at least one ammonia sample that exceeded the state standard of 0.02 mg/l. These exceedances ranged from 0.10 mg/l at several stations to 1.48 mg/l on Mud Creek at Station U-6. One reason for the appearance of ammonia in the Scofield Mine project area is attributed to biological degradation of nitrogenous organic matter. As mentioned previously, ammonia has also been measured in groundwater in the area.

Only one exceedance of mercury was measured. A dissolved mercury concentration of 0.0004 mg/l was measured on Winter Quarters Creek at Station U-4. All other sampled mercury concentrations were below the detection of routine laboratory techniques.

Water temperatures in Mud Creek and Woods Canyon Creek were measured exceeding state standards of 20°C. When the July 1981 sample was collected, the water temperature was 22°C in both Mud Creek stations (U-6 and U-7) and 23°C in Woods Canyon Creek (Station U-5).

The concentrations of other constituents sampled at stations throughout the area were generally well below the state standard. In many instances, trace metal concentrations have been consistently below the level of detection by routine laboratory techniques (particularly arsenic and cadmium).

Water Rights. Surface water rights in and adjacent to the Scofield Mine project area on file as of December 1981 with the Utah Division of Water Rights are listed on Table 8 and shown on Plate 8. All surface water rights in the area are for stock-watering except for some irrigation rights near the mouth of Winter Quarters Creek and on Mud Creek. The very limited use in the area is not expected to be adversely affected by the Scofield Mine.

3.3 Surface Water Development, Control, and Diversions

This section of the report deals with the surface water supply in the area as well as the runoff and sedimentation control measures planned for the Scofield Mine.

3.3.1 Water Supply

The surface water supply in the mine project and adjacent

Table 8. Surface water rights located on and adjacent to the Scofield Mine project area.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-345	Tom Nicolaides Leon Nicolaides Mary Stahis Bessie Daraban	Green Canyon Spring Stream	0.75	Irrigation	March 1 to November 30
91-423	Nick Marakis (½ interest)	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-431	Nick Marakis (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-436	Nick Marakis (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-437	Nick Marakis (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-462	John Marakis Estate (½ interest)	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-471	John Marakis Estate (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-476	John Marakis Estate (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-477	John Marakis Estate (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-482	Robert Radakovich	Stream	----	Stockwatering	May 1 to December 15
91-483	Robert Radakovich	Winter Quarters Creek	0.443	Irrigation Stockwatering	March 1 to December 15
91-1029	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1030	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1031	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1032	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1033	U.S. Forest Service	Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1034	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1037	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1038	U.S. Forest Service	Woods Canyon Creek	----	Stockwatering	July 1 to September 30

Table 8. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1148	Leon & Tom Nicolaides	Green Canyon Stream	----	Stockwatering	January 1 to December 31
91-2018	Angelo Georgedes	Green Canyon Stream with storage	----	Stockwatering	May 1 to October 31
91-2019	Angelo Georgedes	Stream with storage	----	Stockwatering	May 1 to October 31
91-2020	Angelo Georgedes	Green Canyon Stream	----	Stockwatering	May 1 to October 31
91-2048	John Jouflas Estate	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2146	Elrie and Bertha Simonsen	Winter Quarters Creek	----	Stockwatering	June 1 to November 30
91-2495	Elrie and Bertha Simonsen	Woods Canyon Creek	----	Stockwatering	June 1 to November 30
91-2496	Elrie and Bertha Simonsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-2548	John Jouflas Estate (2/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2549	Lee S. Thomas (1/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2971	Lee S. Thomas (1/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2972	John Jouflas Estate (2/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2973	John Jouflas Estate	Clear Creek	0.381	Irrigation	March 1 to November 30
91-2974	Justus O. Seely	Clear Creek	0.170	Irrigation Stockwatering	March 1 to November 30
91-2977	S. J. Harkness	Clear Creek	0.075	Irrigation	March 1 to November 30
91-2978	Justus O. Seely	Clear Creek	0.683	Irrigation Stockwatering	March 1 to November 30
91-2979	S. J. Harkness	Clear Creek	0.453	Irrigation	March 1 to November 30
91-2980	Helen Miller	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2981	Orson Marsing	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2982	Lillie Pearson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2983	Thomas Biggs, Jr.	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2984	Waino E. Burton	Clear Creek	0.10	Irrigation	March 1 to November 30

Table 8. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
1-2985	Phyllis M. Conover	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2986	Willima & Armeda Sherman	Clear Creek	0.015	Irrigation	March 1 to November 30
91-2987	Leah B. Johnson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2988	E. D. & Elizabeth Jacobson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2989	Scofield Town	Clear Creek	0.10	Irrigation	March 1 to November 30
91 2990	Della L. Madsen	Clear Creek	1.166	Irrigation	March 1 to November 30
91-2991	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2992	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2993	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2994	John B. Jones	Woods Canyon Creek	----	Irrigation	March 1 to November 30
91-2995	John B. Jones	Woods Canyon Creek	----	Irrigation	March 1 to November 30
91-2996	Gladys P. Butler (4.85/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2997	Alice M. Pannier (4.85/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2998	Boyd W. & Johannah M. Hafen (12.0/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2999	Reed & Leoan M. Gunderson	Woods Canyon Creek	0.136	Irrigation	March 1 to November 30
91-3002	Della L. Madsen	Woods Canyon Creek	0.035	Irrigation	March 1 to November 30
91-3003	Charles J. Jacobsen Evelyn M. Jacobsen Stephen C. Jacobsen Charlyn J. DAlebout (18.1/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30
91-1004	Louise M. Watts Helen L. Watts John Andy Watts (7.9/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30

Table 8. (Continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3007	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.63	Irrigation	March 1 to November 30
91-3008	S. J. Harkness	Winter Quarters Creek	0.693	Irrigation	March 1 to November 30
91-3009	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.68	Irrigation	March 1 to November 30
91-3010	S. J. Harkness	Winter Quarters Creek	0.213	Irrigation	March 1 to November 30
91-3011	S. J. Harkness	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-3056	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Daraban	Stream	----	Stockwatering	January 1 to December 31
91-3405	Elrie & Bertha Simonsen	Woods Canyon Creek	----	Irrigation Stockwatering	March 1 to November 30
91-3622	Mae Nicolademas	Clear Creek	0.016	Irrigation	March 1 to November 30
91-3631	D. Euray Allred	Woods Canyon Creek	----	Stockwatering	May 1 to November 30
91-3633	D. Euray Allred	Winter Quarters Creek	----	Stockwatering	May 1 to November 30
91-3635	D. Euray Allred	Stream	----	Stockwatering	May 1 to November 30
91-3641	Pete Frandsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-3644	Justus O. Seely	Clear Creek	----	Stockwatering	June 1 to November 30
91-3645	S. J. Harkness	Clear Creek	----	Stockwatering	June 1 to November 30
91-3648	John B. Jones	Clear Creek	----	Stockwatering	January 1 to December 31
*91-3655	John B. Jones	Woods Canyon Creek	----	Stockwatering	January 1 to December 31
91-3658	John B. Jones	Stream with storage	----	Stockwatering	January 1 to December 31
91-3665	John Marakis Estate	Clear Creek	----	Stockwatering	January 1 to December 31
91-3666	Nick Marakis (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-3667	Angelo Georgedes	Clear Creek	----	Stockwatering Domestic	January 1 to December 31
91-3910	Reed & Lanan M. Cunderson	Clear Creek (Scofield Res.)	----	Stockwatering	May 1 to November 30
91-3911	Delia L. and Hilda M. Madsen	Clear Creek (Scofield Res.)	----	Stockwatering	May 1 to November 30

areas is extensively used for stockwatering and to a lesser extent for irrigation (see Plate 8). Little development of the surface waters has occurred for stockwatering purposes. Irrigation diversions have been constructed near the mouth of Winter Quarters Creek.

No development of surface water by the mine is proposed. Construction of water diverion structures for protection of the water resources will occur as discussed in section 3.3.2 of this report.

3.3.2 Sedimentation Control Structures and Diversions

One sedimentation pond with corresponding runoff control facilities will be required to provide sediment control for the Scofield Mine. The layout of the sedimentation control plan, including pond location, pond drainage area boundary, ditches, and berms are illustrated in Plate 9. Design details for the sedimentation pond and interceptor ditches passing runoff from the undisturbed areas past disturbed areas are described in this section.

Conveyance Facilities Design. Three diversion ditches required to divert runoff from disturbed areas into the sedimentation pond have been designed to pass runoff from the 10-year, 24-hour storm (2.45 inches). With the exception of Culvert No. 7 and Interceptor Ditch No. 2, all interceptor ditches and culverts diverting runoff from undisturbed areas past the sedimentation pond

have also been designed to pass runoff from the 10-year, 24-hour storm. Interceptor Ditch No. 2 was designed to pass runoff from the 100-year, 24-hour storm (3.55 inches). Culvert No. 7 is a bypass culvert for Winter Quarters Creek. This culvert was sized to pass the 100-year flood which, in the case of Winter Quarters Creek, is a snowmelt event as explained in Section 3.2.2. The 100-year, 24-hour storm produces a flood which is smaller than the 100-year snowmelt flood, so the 100-year snowmelt flood governed the culvert size. UMC regulations do not require designing Culvert No. 7 nor Interceptor Ditch No. 2 for the 100-year floods. However, because of their importance with regard to the overall design of surface facilities, UCO has chosen to use the 100-year flood event for design purposes of these two conveyances. As mentioned in Section 3.2.2, the 100-year flood on Winter Quarters Creek at the mine site is expected to be very similar to the 100-year flood in the mouth of Eccles Creek which has been estimated to be about 65 cfs. This is because of the very significant similarities between the two streams and their drainage basins. Consequently Culvert No. 7 on Winter Quarters Creek will be sized so that it can readily handle a 65 cfs flood. In fact, in an effort to be conservative, the culvert will be sized to handle a flood of over 80 cfs. Culverts along the access/haul road will be spaced in accordance with requirements of UMC 817.153 and will have a minimum diameter of 18 inches.

Culvert capacities were determined from nomagraphs presented by the U.S. Soil Conservation Service (1972). Figure 10 contains a

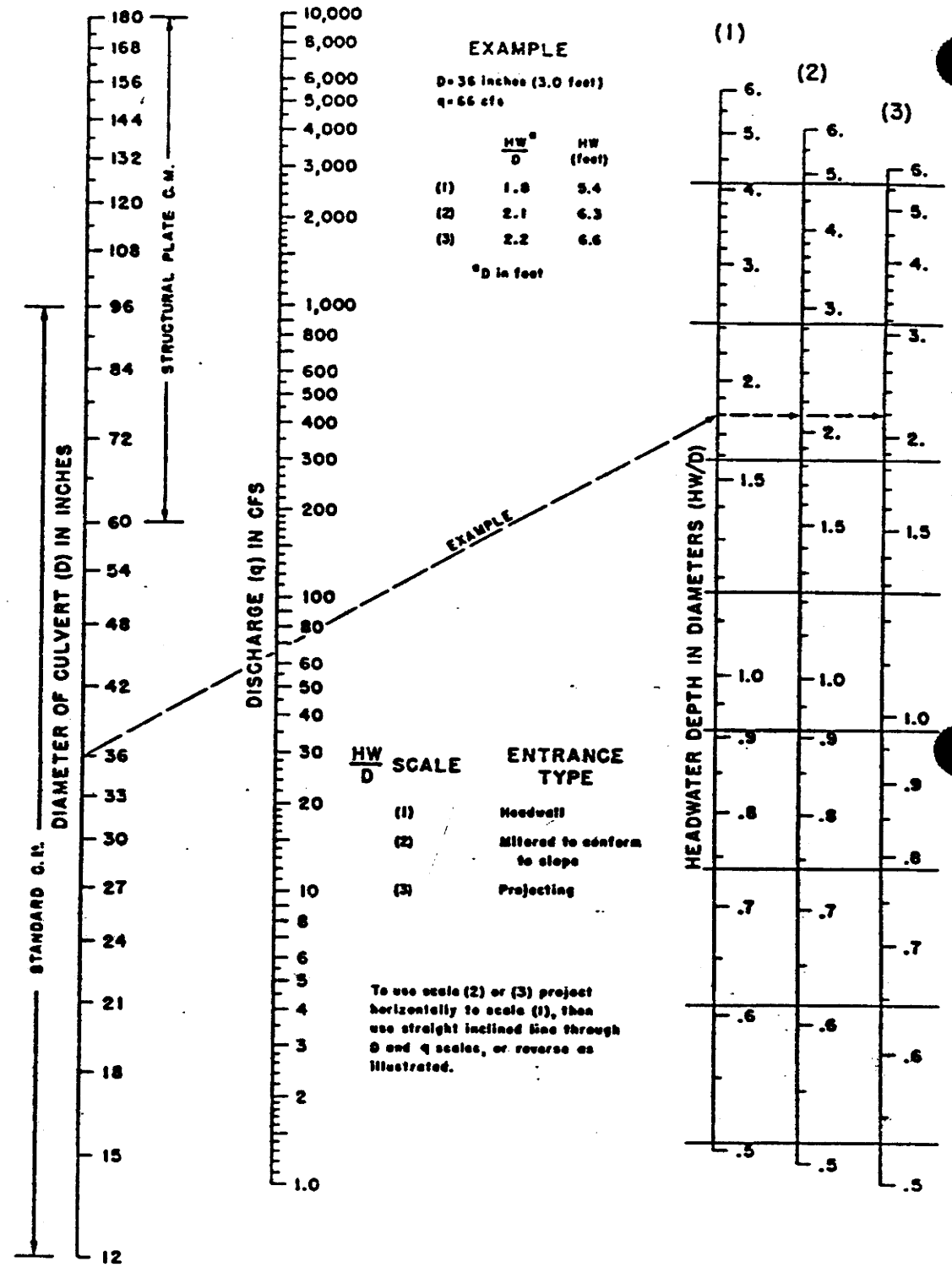


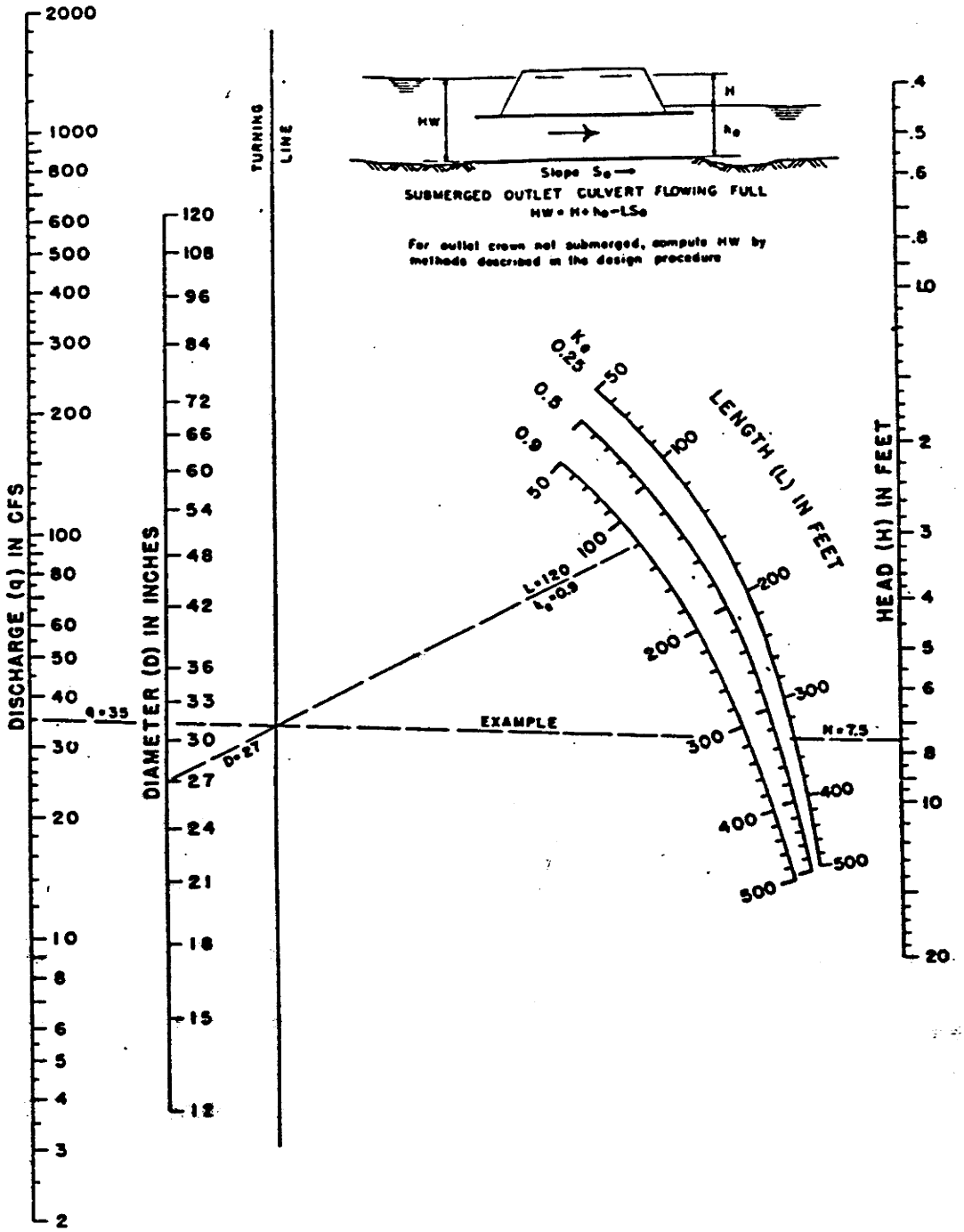
Figure 10. Depth for corrugated metal pipe culverts with inlet control (U.S. Soil Conservation Service, 1972).

nomagraph used for determining the inlet capacity of the culverts. Outlet capacities were determined from the nomograph shown in Figure 11 or from the Darcy-Weisbach headless formula in the case of Culvert No. 7. Inlet capacities governed in every case. No surcharge is needed above the culverts to pass the design flow except for Culvert No. 7. Culvert No. 7 needs a surcharge head of 7 inches to pass a flow of 65 cfs, or a surcharge head of 28 inches to pass a flow of 90 cfs. More than ample headwall height will be provided to accomodate such extreme events.

The diversion and interceptor ditches have been designed assuming a trapezodial cross-section. Open channel flow capacities were determined using the Manning equation. According to this method:

$$Q = \frac{1.486}{n} AR^{0.67} S^{0.50} \qquad (14)$$

where Q is the flow, in cubic feet per second; A is the cross-sectional area of flow, in square feet; n is the Manning roughness coefficient; R is the hydraulic radius, in feet, defined as the area divided by the wetted perimeter; and S is the hydraulic slope, in feet per feet. A maximum permissible velocity of five feet per second was assumed in all cases for diversion and interceptor ditches without a riprap lining. A Manning's roughness coefficient (n) of 0.03 was used for designing the ditches (except when riprap channel sections were used, and a roughness coefficient of 0.038 was used). Peak flows and peak flow design related information for the ditches are contained in Table 9. Culverts have been sized to



BUREAU OF PUBLIC ROADS JAN. 1963

Figure 11. Head for standard corrugated metal pipe culverts flowing full n = 0.024 (U.S. Soil Conservation Service, 1972).

Table 9. Peak flow determinations and related information for diversion and interceptor ditches and culverts.

Diversion Name	Area (acres)	Average Watershed Slope (%)	Curve Number	Precipitation* Depth (inches)	Storm Duration (hours)	Hydraulic Length (ft)	T_p (hrs)	Q_p (cfs)
Diversion Ditch No. 1	1.7	20.0	90	2.45	24	400	0.027	2.74
Diversion Ditch No. 2A	0.43	1.5	90	2.45	24	140	0.042	0.67
Diversion Ditch No. 2B	0.43	1.5	90	2.45	24	140	0.042	0.67
Diversion Ditch No. 3	0.72	2.8	90	2.45	24	360	0.065	1.15
Interceptor No. 1	10.8	56.0	55	2.45	24	1850	0.151	0.11
Interceptor No. 2	82.3	47.4	55	3.55	24	2800	0.229	15.05
Interceptor No. 3	16.3	29.0	55	2.45	24	2625	0.279	0.16
Interceptor No. 4	8.6	43.0	55	2.45	24	2250	0.202	0.09
Interceptor No. 5	7.7	48.5	55	2.45	24	2500	0.207	0.08

*All design storms are 10-year, 24-hour events except the storm for Interceptor Ditch No. 2 which uses a 100-year, 24-hour design storm. Culvert No. 7 is governed by a snowmelt flood and not storm runoff and consequently is not shown in this table.

Table 9. (continued)

Diversion Name	Area (acres)	Average Watershed Slope (%)	Curve Number	Precipitation* Depth (inches)	Storm Duration (hours)	Hydraulic Length (ft)	T_p (hrs)	Q_p (cfs)
Culvert No. 1	1.2	20.0	90	2.45	24	400	0.027	1.88
Culvert No. 2	1.31	7.6	90	2.45	24	510	0.052	2.12
Culvert No. 3	0.72	2.8	90	2.45	24	360	0.065	1.15
Culvert No. 4	9.8	43.4	55	2.45	24	1850	0.172	0.10
Culvert No. 5	24.9	39.0	55	2.45	24	2625	0.24	0.24
Culvert No. 6	0.61	11.5	90	2.45	24	385	0.034	0.95

pass the peak flow requirements for their associated diversion ditches. The overall sedimentation control plan, including pond location and required diversion and runoff facilities are illustrated in Plate 9. Plate 9 also includes ditch, berm, and culvert dimensions and slopes.

Runoff curve numbers used in computing storm-caused runoff peaks have been estimated based on vegetative types, hydrologic soil groupings, and ground cover densities as outlined by the U.S. Soil Conservation Service (1972). Ground cover densities are taken from Western Resource Development Corporation (1981). Based on hydrologic soil group C, and sage-grass vegetation with 68 percent cover, the resulting curve number is 55 for the south-facing sage-covered slopes north of the mine site. On the north-facing slopes, the vegetative cover is significantly higher than on the sage-covered slopes, and consequently the curve number should be significantly lower than 55. However for all undisturbed slopes contributing to the interceptor ditches, a curve number of 55 was used in the peak flow calculations. This curve number is expected to be very conservative on the north-facing slopes. A runoff curve number of 90 was used for disturbed areas that will be drained into the sediment pond. The runoff curve numbers were used in the procedure outlined previously in Section 3.2.2 to compute peak flows.

Design criteria and calculation results for sizing the various diversion ditches are presented in Table 10 and Plate 9. Also

Table 10. Diversion and interceptor ditch design criteria.

Diversion Name	Manning's n	Maximum Channel Slope (Smax, ft/ft)	Channel Side Slope (m)	Bottom Width (B) (ft)	Flow Depth at Smax (ft)	Velocity at Smax (fps)	Design Discharge (cfs)	Minimum Channel Slope (Smin, ft/ft)	Flow Depth at Smin (ft)	Freeboard (ft)	Total Channel Depth (D) (ft)	Mean Riprap Diameter (D_{50}) (ft)
Diversion Ditch No. 1	0.03	0.02	1.5	0.5	0.60	3.25	2.74	0.0075	0.75	0.5	1.3	----
Diversion Ditch NO. 2A	0.03	0.21	1.5	1.5	0.09	4.35	0.67	0.05	0.14	0.8	1.0	----
Diversion Ditch No. 2B	0.03	0.018	1.5	0.5	0.56	3.03	2.28	0.005	0.76	0.5	1.3	----
Diversion Ditch No. 3	0.03	0.04	1.5	0.5	0.33	3.50	1.15	0.01	0.47	0.5	1.0	----
Interceptor No. 1	0.03	0.17	1.5	0.0	0.15	3.23	0.11	0.01	0.26	0.7	1.0	----
Interceptor No. 2A	0.03	0.025	2.0	3.5	0.65	4.84	15.05	0.0035	1.10	0.5	1.6	----
Interceptor No. 2B	0.038	0.18	2.0	3.5	0.43	8.13	15.05	0.025	0.74	0.5	1.3	1.00
Interceptor No. 3A	0.03	0.05	1.5	0.5	0.11	2.11	0.16	0.005	0.21	0.7	1.0	----
Interceptor No. 3B	0.038	0.35	2.0	1.0	0.04	3.86	0.16	----	----	0.9	1.0	0.75
Interceptor No. 4	0.03	0.02	1.5	0.5	0.11	1.29	0.09	0.005	0.16	0.8	1.0	----
Interceptor No. 5A	0.03	0.025	1.5	0.5	0.09	1.35	0.08	0.005	0.15	0.8	1.0	----
Interceptor No. 5B	0.038	0.37	2.0	1.0	0.03	2.3	0.08	0.02	0.08	0.9	1.0	0.75

contained in Table 10 are the required mean rock diameters (D_{50}) for those channels requiring riprap.

Sedimentation Pond Design. A sedimentation pond will be required to provide sediment control for the surface facilities of the Scofield Mine. The pond is designed to contain runoff from the entire disturbed area at the mine site. The sedimentation pond is designed to contain an accumulated sediment storage volume of 0.035 acre-feet per acre of disturbed area draining into the pond. When 60 percent of the design sediment storage volume has been filled, the sediment will be cleaned out of the pond and disposed of in an appropriate manner that will protect the hydrologic balance.

Spillway capacity requirements for the sedimentation pond are based on runoff from the 25-year, 24-hour storm (2.9 inches). Table 11 contains the volume and spillway capacity requirements for the pond as well as additional design related information. Runoff storage volume requirements are based on the 10-year, 24-hour design storm.

The pond design details for the sedimentation pond are illustrated on Plate 10 with the stage-capacity curve for the pond given in Figure 12. The sedimentation pond will consist of a sediment storage pool, a dead pool, and a runoff control pool equal to the inflow volume from a 10-year, 24-hour storm (2.45 inches). The Utah Division of Oil, Gas, and Mining requests that a dewatering device be placed in the pond to draw the pond level down

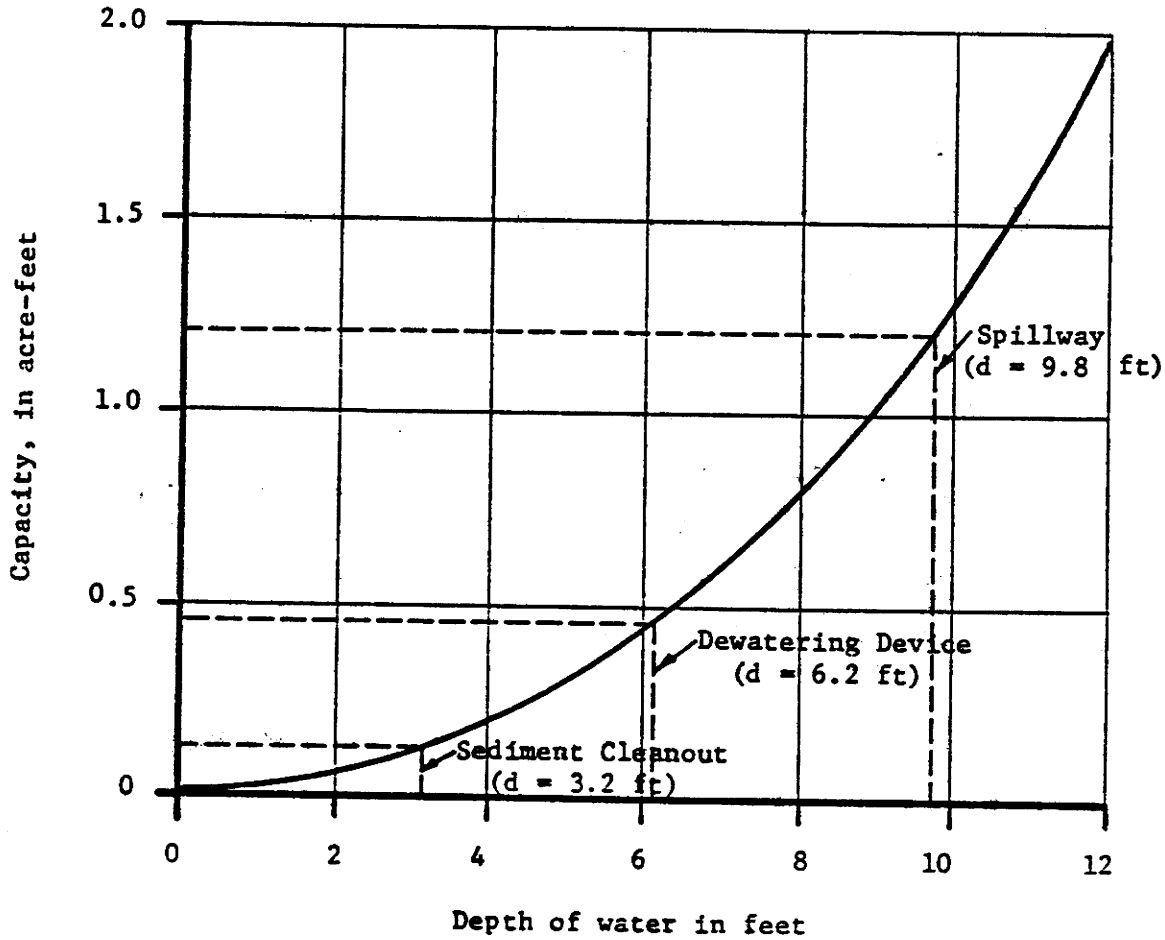


Figure 12. Stage-capacity curve for sedimentation pond.

to the bottom of the runoff control pool in anticipation of a future runoff event. This dewatering device must be placed above the top of the sediment storage pool. However, the Utah Division of Health requires that no dewatering device be placed within three feet of the top of the sediment cleanout level (60 percent). Thus, a dead storage pool has been created in order to meet the requirements of both agencies.

The proposed principal and emergency spillway system consists of a corrugated metal riser and conduit with an anti-vortex device, a trash rack, and anti-seep collars. Anti-seep collars have been proposed based on methods outlined by the U.S. Environmental Protection Agency (1976). The discharge capacity of the riser-conduit combination with a riser diameter of 27 inches is adequate to pass the peak inflow resulting from the 25-year, 24-hour storm (see Figure 13). The stage-discharge relationship of the corrugated metal riser and conduit used in the pond spillway (shown in Figure 13) was determined from methods outlined by Mynear and Haan (1977), who state that the discharge of the spillway is calculated as the smallest of the possible flows due to weir flow, orifice flow, or pipe flow at any stage. The coefficients suggested by Mynear and Haan (1977) were used in the appropriate equations.

The total embankment height was obtained by adding the stage at full storage capacity, the head of water over the spillway under design flow conditions, the required freeboard height (1.0 foot), and a five percent settlement allowance. The embankment top width

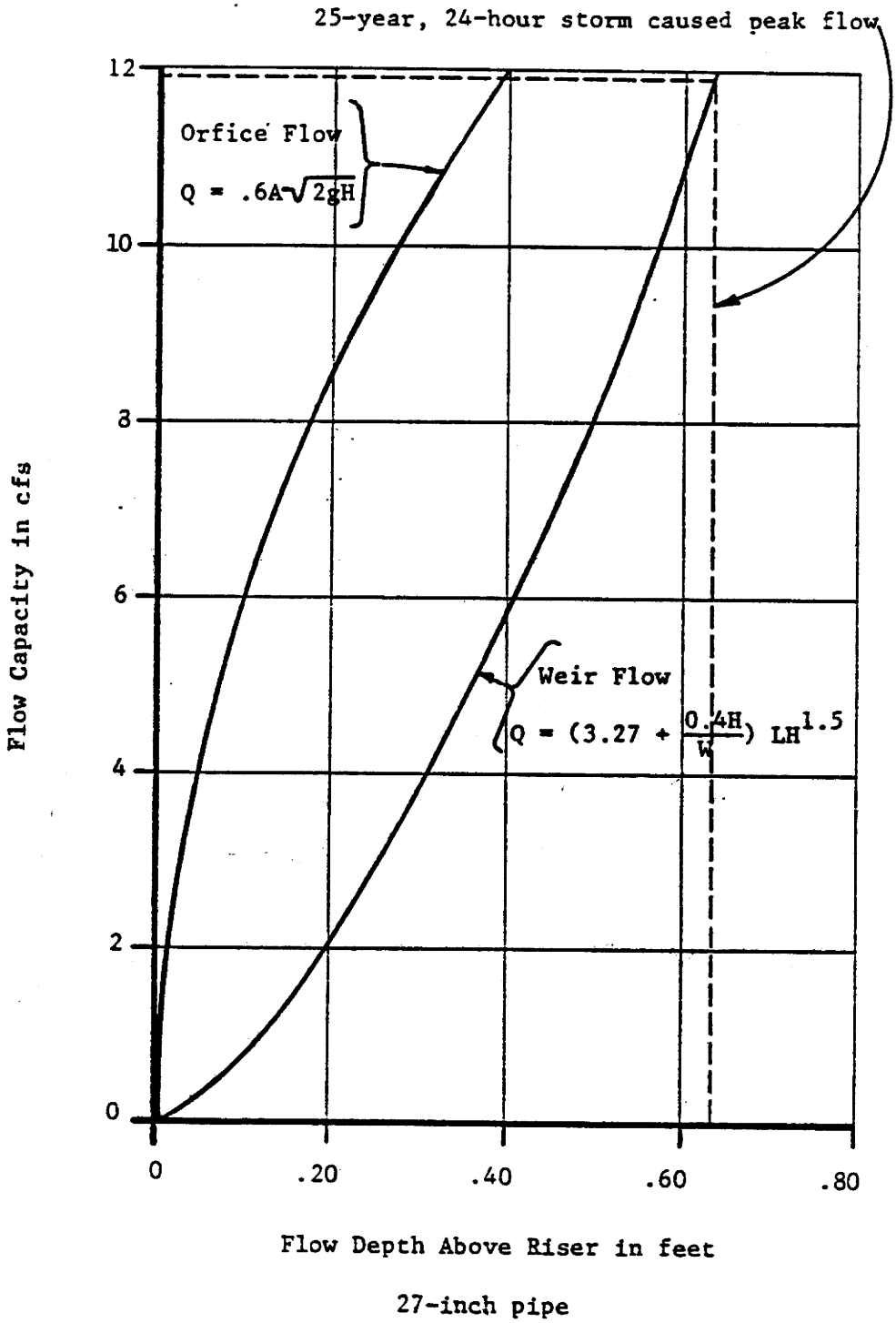


Figure 13. Stage-discharge curves for a 27-inch spillway riser.

should not be less than (H + 35)/5 where H is the height of the embankment, in feet. Table 11 summarizes the design specifications for the sedimentation pond.

The pond embankment will be lined to prevent seepage and piping with 18 inches of 10:1 mixture of the embankment material and bentonite, respectively.

Both the spillway and dewatering device should be constructed of similar materials, with the dewatering device consisting of a 12-inch corrugated metal riser, a 6-inch conduit drainline, an anti-vortex device, and anti-seep collars. The anti-vortex device will also act as a skimming device by not allowing water to be pulled directly from the surface of the pond. A water control gate valve will be in the 6-inch diameter conduit within the pond embankment.

Sufficient space must be available in the pond to completely detain the runoff resulting from the 10-year, 24-hour storm. At the same time, sufficient settling time must be allowed in order to meet applicable effluent standards in the discharged water. It is therefore suggested that water in the pond be released through the dewatering device after several days, unless there is a good probability of occurrence of a runoff-producing storm prior to that time, under which condition the water should be released before the storm occurrence. This will allow sufficient time for all but the

Table 11. Design values of the sedimentation pond.

Parameter	Value
Sediment Storage Volume	0.21 acre-feet
Runoff Storage Volume (from a 10-year, 24-hour storm)	0.75 acre-feet
Embankment Height at Design Volume*	9.8 feet
Spillway Capacity (for a 25-year, 24-hour storm)	11.9 cfs
Spillway Diameter	27 inches
Head above Spillway Crest at Design Discharge	0.64 feet
Required Freeboard	1.0 feet
Required Total Embankment Height*	11.4 feet
Required Total Embankment Height* Including 5% Settlement Allowance	12.0 feet
Crest Width of Embankment	10 feet
Disturbed Area	6.0 acres
Curve Number	90
Hydraulic Length	1125 feet
Average Watershed Slope	21 percent
T_p	0.06 hours

*As measured from the upstream toe of the embankment.

fine clay and colloidal particles to settle (U.S. Environmental Protection Agency, 1976).

Riprap shall be placed in the inlet channels and below the outlet conduit of the pond to dissipate energy and reduce erosion potential. Riprap shall also be placed on the inside slope of the pond embankment to a width of five feet on both sides of the spillway and dewatering device up the full height of the embankment to protect the embankment from erosion.

Sediment Disposal Plans. Federal and State regulations require that sediment, which has accumulated in the pond, be removed when 60 percent of the design sediment storage volume has been filled. The point at which cleanout becomes necessary will be marked with paint on the spillway riser following construction of the pond. Sediment removed from the pond will be disposed of in a place and manner that will protect the hydrologic balance.

Pond Reclamation. Federal and State regulations require that areas disturbed by pond construction be stablized with an effective vegetative cover as soon as possible after disturbance. This cover should be composed of native and other plants which are adaptable to the site and provide soil stability. Disturbed areas associated with the pond will be seeded with the exception of the interior of the pond below the dewatering device level. Shallow rooting species will be used to preserve the integrity of the structure.

3.4 Effects of Mining on the Surface Water Hydrologic Balance

Mining activities in the Scofield area can be expected to continue into the twenty-first century. The occurrence and quality of water in any region is highly controlled by geology. The majority of the Scofield Mine project area is strong structurally and consists of the Blackhawk geologic formation. Considering the lack of impact from 100 years of mining in the Scofield area, it is presumed that mining activities will have little adverse impact on the area hydrologic system.

3.4.1 Quantity

As mentioned earlier in the report, the major perennial drainages conveying runoff away from the mine project area are streams in Winter Quarters Canyon and Woods Canyon. Mining beneath Winter Quarters Creek will be limited so that the stream will not be subsided. Consequently, subsidence will not cause any significant impact on the surface water system. Surface facilities will be located in Winter Quarters Canyon. Unless unusual flows are encountered in the mine, it is not expected that any mine water will be discharged into surface streams. If discharges become necessary, they will be made in compliance with the NPDES permit program. Even if discharges do become necessary, the volume of water will be small compared to the natural springflow. As a result, taking into account the sedimentation control structures and diversions, it is felt that the mining operation will have no significant impact on the surface water system.

3.4.2 Quality

The quality of the flow from the headwaters of the Price River Basin is excellent. However, this quality rapidly deteriorates downstream as the streams cross shale formations and receive irrigation return flows from Mancos-derived soils. The impact of the mining on this system will be very minor.

The construction of surface facilities utilized in conjunction with the Scofield Mine (yard areas, roads, etc.) will result in temporary increases in the suspended sediment concentration of the adjacent stream. However, because of compliance with the regulatory requirement that sediment control be provided for all areas of surface disturbance, concentrations should be quickly normalized.

3.5 Mitigation and Control Plans

Runoff from all distrubed areas will be passed through sediment control facilities or protected from abnormal erosion. Any discharge from facilities will be monitored in accordance with NPDES permit standards, and state and federal regulations.

The effects of the mining operation on the surface water system will be analyzed through the surface water monitoring plan described in the Section 3.6 of this report. In the unlikely event that monitoring shows that the surface water system is being adversely affected by the mining activities, additional steps will

be taken to rectify the situation in cooperation with local, state, and federal regulatory agencies.

3.6 Surface Water Monitoring Plan

An extensive hydrologic monitoring program, which began in October, 1980, has been underway at each of the surface water stations shown on Plate 5. Stations were established to monitor water quality and quantity above and below the mine project area. Monitoring was conducted on a monthly basis through April, 1981 (when accessible). At that time the monitoring was reduced to a bimonthly basis in accordance with new guidelines issued by the Utah State Division of Oil, Gas, and Mining, and the parameter list for laboratory analyses was modified to the schedule outlined in Table 4. Attachment B contains tabulations of the results of the water quality analyses.

A one-year baseline data gathering period has been completed at each of the surface water stations shown on Plate 5, and the monitoring schedule is now modified to reflect information obtained during the baseline monitoring period. This currently existing monitoring program will continue during the operational phase of the mine. Stations U-1, U-5, U-6, and U-7 have been deleted from the monitoring program. Stations U-5, U-6, and U-7 have been deleted because of their remoteness from the project area. The surface water monitoring stations shown on Plate 6 are being monitored quarterly (when accessible) for flow and quality to

delineate seasonal variation and correlate discharge with changes in water quality. The water quality samples are being analyzed for the parameters listed in Table 4. Future data may show that modifications of this monitoring schedule are justified. Any changes to the monitoring schedule (frequency or parameters) will be made only with the approval of the Utah Division of Oil, Gas, and Mining. Results of all water quality data will be submitted to that agency quarterly.

Post-mining monitoring of surface water will continue at representative stations determined with the aid and approval of the Utah Division of Oil, Gas and Mining. Representative surface water stations will be monitored biannually during high and low flow conditions. Duration of monitoring and parameter selection will be determined after appropriate consultation with local, state, and federal agencies.

4.0 ALLUVIAL VALLEY FLOOR DETERMINATION

Utah regulations (UMC Section 785.19c) require that the presence of alluvial valley floors in or adjacent to the mine project area be identified. The regulations (UMC Section 700.5) define an alluvial valley floor as "unconsolidated stream-laid deposits holding streams with water availability sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by unconcentrated runoff or slope wash together with talus, or other mass-movement accumulations, and windblown deposits". The existence of an alluvial valley floor is therefore determined to exist if:

1) Unconsolidated stream-laid deposits holding streams are present, and
2) There is sufficient water to support agricultural activities as evidenced by:
    a) The existence of flood irrigation in the area in question or its historical use;
    b) The capability of an area to be flood irrigated, based on stream-flow water yield, soils, water quality, topography, and regional practices; or
    c) Subirrigation of the lands in question, derived from the groundwater system of the valley floor.

4.1 Scope

The purpose of this section of the report is to examine the potential existence of alluvial valley floors in and adjacent to the areas to be affected by surface operations associated with the proposed Scofield Mine.

This section of this report is divided into three parts. First, a general description of the surface operations and site disturbances associated with the Scofield Mine is presented. Next, discussions of the characteristics of geomorphology and irrigation, and the water quality and availability of Mud Creek and Winter Quarters Canyon drainages as possible alluvial valley floors are presented. Finally, the conclusions of the alluvial valley floor determination are summarized.

4.2 Site Description

Surface facilities associated with the Scofield Mine project area will consist of the portal area and associated facilties located in Winter Quarters Canyon and an access/haul road up Winter Quarters Canyon.

The climate of the general area is semi-arid to arid and continental. Mean monthly temperatures range from about 5° F to the mid-70's. Temperatures in the region tend to be inversely related to elevation. Average annual precipitation is

approximately 28 inches. Seventy percent of the annual precipitation falls during the winter as snow with most of the remainder coming as summer thunderstorms (Jeppson et al., 1968).

4.3 Alluvial Valley Floor Characteristics

In this section of the report the various criteria for determining the existence of an alluvial valley floor are examined in relation to the Scofield Mine project and adjacent areas.

4.3.1 Geomorphic Criteria

Alluvial deposits in and adjacent to the mine project area are shown on Plate 11. Plate 11 shows the extent of the alluvium as presented by Doelling (1972). This plate shows that the alluvium is found primarily along Mud Creek in Pleasant Valley and at the mouth of Winter Quarters and Woods canyons. Only very narrow bands of alluvium are found along the latter creeks above the canyon mouths.

4.3.2 Water Quality and Availability

An evaluation of the potential for flood and sub-irrigation in conjunction with the alluvial valley floor determination is presented in this section.

Flood Irrigation. Flood irrigation near the project area is currently (and has historically been) confined to the alluvial areas of Mud Creek (in Pleasant Valley) and the mouth of Winter

Quarters Canyon. Water is diverted at several points along both creeks to irrigate fields on the alluvium.

Flood irrigation has historically not been practiced on the narrow alluvium land upstream in canyons opening to Pleasant Valley. A reconnaissance survey of the surrounding region indicates that flood irrigation is also absent in other areas of similar hydrologic, geologic, and biotic characteristics. The historic lack of flood irrigation in these steep, narrow canyons suggests that such activities are not feasible in the region.

Water quality of both Mud Creek and Winter Quarters Creek is very good. A detailed review of the surface water quality has been presented previously in this report.

Subirrigation. Some subirrigation of vegetation does occur on the alluvial valley floors shown in Plate 11. The subirrigated species (mainly willows) are found along the channels of Mud Creek and Winter Quarters Creek. This suggests that subirrigation is confined to the channel areas where the water table is near the surface (Western Resources Development Corporation, 1981).

4.4 Alluvial Valley Floor Identification

Based on the foregoing reconnaissance analysis, the canyon floors opening to Pleasant Valley cannot be considered alluvial valley floors due to the very limited area for supporting an

agriculturally useful crop. The valley floor of Mud Creek and the mouth of Winter Quarters Canyon, however, can be classified as alluvial valley floors due to the presence of both flood irrigation and limited subirrigation on the alluvium. However, it should be noted that the potential for an agriculturally useful crop is very limited. The flood or subirrigated alluvial areas currently used are located over a mile below the mine facilities and are used for pasture.

4.5 Potential Impacts to the Alluvial Valley Floors

Plate 11 shows that the Scofield Mine project area is one mile above the alluvial valley floor at the mouth of Winter Quarters Canyon. Little potential exists for the mine operation to impact the alluvial valley floor. The access/haul road to the mine will disturb a minimal amount of alluvial area. All surface disturbances in the portal area will be protected by sediment control facilities and have been designed and will be constructed according to UMC standards and in an environmentally sound manner.

The hydrologic monitoring program will help determine the actual impact of surface activities and aid in selecting mitigating measures, if necessary. However, it is felt that the Scofield Mine and associated activites will have no significant hydrological impacts to the alluvial valleys. Details concerning this monitoring program are outlined in a previous section of this report.

5.0 BIBLIOGRAPHY

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1976. Standard Methods for the Examination of Water and Wastewater. Fourteenth Edition, Washington, D.C.

Applied Earth Sciences of Colorado, LTD, 1981. Letter to UCO, Inc. dated March 20, 1981.

Bentley, R. G., Jr., K. O. Eggleston, D. Price, E. R. Frandsen, and A. R. Dickerman, 1978. The Effects of Surface Disturbance on the Salinity of Public Lands in the Upper Colorado River Basin - 1977 Status Report. U.S. Bureau of Land Management. Denver, Colorado.

Cordova, R. M., 1964. Hydrogeologic Reconnaissance of Part of the Headwaters Area of the Price River, Utah. Utah Geological and Mineralogical Survey Water Resources Bulletin No. 4. Salt Lake City, Utah.

Craig, G. D. and J. G. Rankl, 1977. Analysis of Runoff from Small Drainage Basins in Wyoming. USGS Open File Report 77-727. Cheyenne, Wyoming.

Doelling, H. H., 1972. Wasatch Plateau Coal Fields. In Doelling, H. H. (ed.). Central Utah Coal Fields; Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery. Utah Geological and Mineralogical Survey Monograph Series No. 3. Salt Lake City, Utah.

Fields, F. K., 1975. Estimating Streamflow Characteristics for Streams in Utah Using Selected Channel-Geometry Parameters. U.S. Geological Survey Water Resouces Investigations 34-74. Salt Lake City, Utah.

Grunsky, C. E., 1908. Rain and Runoff Near San Francisco, California. Transactions of the American Society of Civil Engineers. p. 496-543.

Haan, C.T., 1970. A dimensionless hydrograph equation. File Report, Agricultural Engineering Department, University of Kentucky. Lexington, Kentucky.

Hawkins, R. H., 1973. Improved Prediction of Storm Runoff in Mountain Watersheds. ASCE Journal of the Irrigation and Drainage Division. 99 (IR4):519-523.

Hawkins, R. H., 1976. Estimating Annual Water Yield-Grunsky's Rule. Class handout prepared for WS540 (Watershed Operations). Watershed Science Unit. Utah State University. Logan, Utah.

Hem, J. D., 1970. Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geological Survey Water-Supply Paper 1473. Second Edition. Washington, D.C.

James P. Walsh and Associates, 1981. Geologic Description Scofield Mine Permit Application. Report prepared for UCO, Inc. Denver, Colorado.

Jeppson, R. W., G. L. Ashcroft, A. L. Huber, G. V. Skogerboe, and J. M. Bagley, 1968. Hydrologic Atlas of Utah. Utah Water Research Laboratory and State of Utah Department of Natural Resources. PRWG35-1. Utah State University. Logan, Utah.

Kent, K. M., 1973. A Method for Estimating Volume and Rate of Runoff in Small Watersheds. USDA Soil Conservation Service. SCS-TP-149.

Lohman, S. W., 1972. Groundwater Hydraulics, Geological Survey Professional Paper 708, United States Government Printing Office, Washington, D.C. 20402.

McElroy, A. D., S. Y. Chiu, J. W. Nebgen, A. Aleti, and F. W., 1976. Loading Functions for Assessment of Water Pollution From Nonpoint Sources. U.S. Environmental Protection Agency, Office of Research and Development. EPA-600/2-76-151. Washington, D.C.

Miller, J. F., R. H. Frederick, and R. J. Tracey, 1973. Precipitation Frequency Atlas of the West, NOAA Atlas 2. Volume VI-Utah, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Silver Springs, Md.

Mundorff, J. C., 1972. Reconnaissance of Chemical Quality of Surface Water and Fluvial Sediment in the Price River Basin, Utah. Utah Department of Natural Resources, Division of Water Rights. Technical Publication No. 39. Salt Lake City, Utah.

Mynear, D.K. and C.T. Haan, 1977. Optimal Systems of Storm Water Detention Basins in Urban Areas. Research Report No. 104. University of Kentucky. Water Resources Research Institute. Lexington, Kentucky.

Price, D., and T. Arnow, 1974. Summary Appraisals of the Nation's Ground Water Resources - Upper Colorado Region. U.S. Geological Survey Professional Paper 813-C. Washington, D.C.

Price, D. and K. M. Waddel, 1973. Selected Hydrologic Data in the Upper Colorado River Basin. U.S. Geological Survey Hydrologic Investigations Atlas HA-477. Washington, D.C.

Sellars, W. D., 1965. Physical Climatology. University of Chicago Press. Chicago, Illinois.

Southeastern Utah Association of Governments, 1977. Waste Water Quality Management Planning Program (208) for Emery, Carbon, and Grand Counties, Utah. Price, Utah.

Spieker, E. M., 1931. The Wasatch Plateau Coal Field, Utah. U.S. Geological Survey Bulletin No. 819. Washington, D.C.

Stokes, W. L. (ed), 1964. Geological Map of Utah. University of Utah. Salt Lake City, Utah.

U.S. Bureau of Reclamation, 1977. Ground Water Manual - A Water Resources Technical Publication. U.S. Department of the Interior. Washington, D.C.

U.S. Department of Transportation, December 1965. Hydraulic Charts for the Selection of Highway Culverts. Hydraulic Engineering Circular No. 5. Washington. D.C.

U.S. Environmental Protection Agency, 1976. Erosion and Sediment Control: Design. EPA Technology Transfer Seminar Publication.

U.S. Geological Survey, 1979. Development of Coal Resources in Central Utah - Final Environmental Statement. Salt Lake City, Utah.

U.S. Soil Conservation Service, 1972. SCS National Engineering Handbook - Section 4: Hydrology. Washington, D.C.

Vaughn Hansen Associates, 1979. Hydrologic Inventory of the Skyline Property and Adjacent Areas, Carbon and Emery Counties, Utah. Report prepared for Coastal States Energy Company. Salt Lake City, Utah.

Vaughn Hansen Associates, 1980. Determination of the 100-year Flood Plan of Eccles Creek and Mud Creek. Report prepared for Coastal States Energy Company. Salt Lake City, Utah.

Vaughn Hansen Associates, 1981. Hydrologic Inventory and Baseline Study of the UCO Mine Permit and Adjacent Areas, Carbon County, Utah - The Scofield Mine. Report prepared for UCO, Incorporated. Denver, Colorado.

Vaughn Hansen Associates, May, 1981. General Hydrologic Considerations Related to Coal Development and Subsequent Impacts. Report prepared for Coastal States Energy Company. Salt Lake City, Utah.

Western Resource Development Corporation, December, 1981. Reclamation Plan Scofield Mine Carbon County, Utah. Report prepared for UCO, Inc. Denver, Colorado.

Western Resource Development Corporation, December, 1981. Vegetation Resources Scofield Mine Carbon County, Utah. Report prepared for UCO, Inc. Denver, Colorado.

ATTACHMENT A

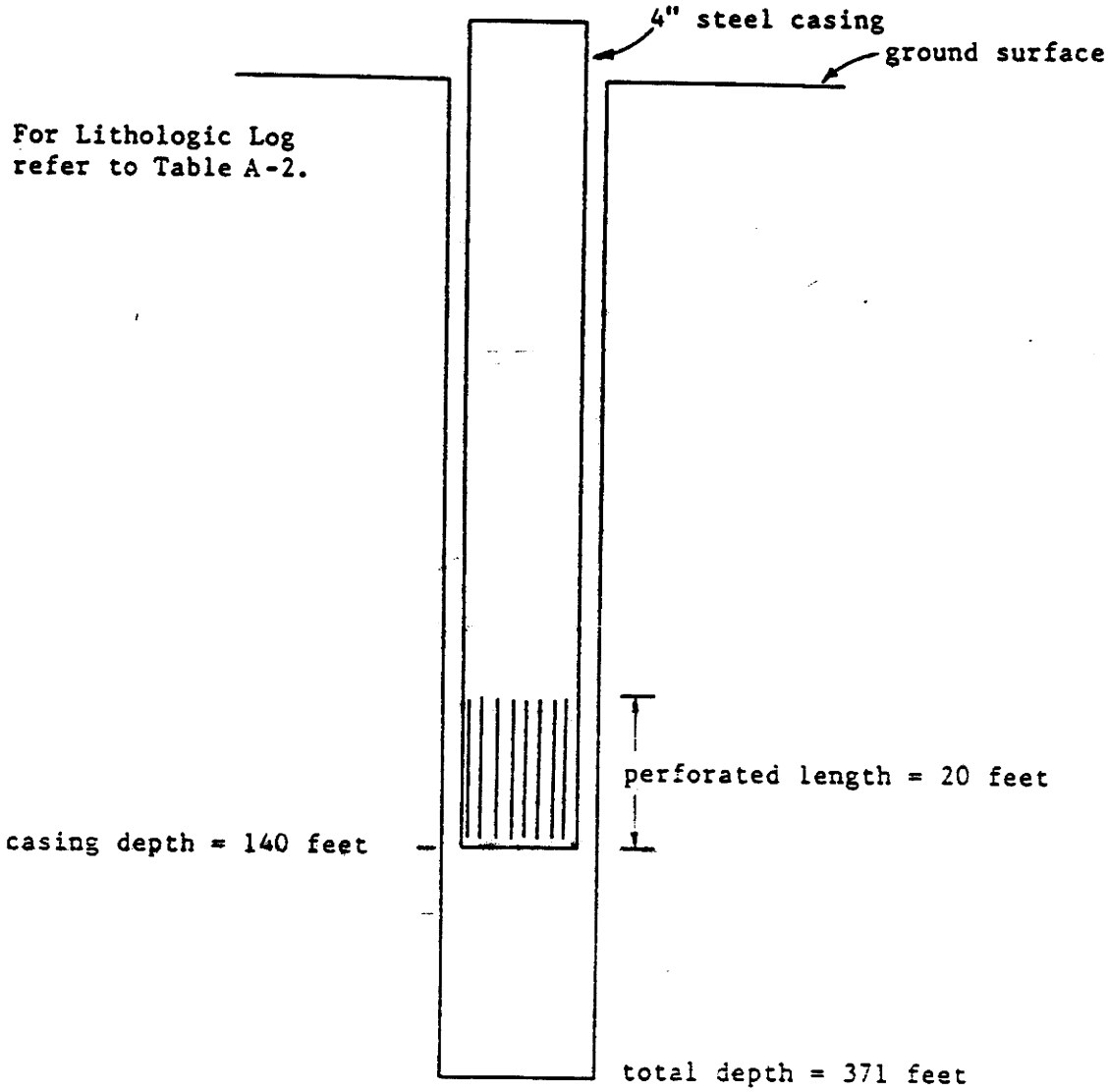
WATER WELL INFORMATION

INCLUDING

WATER LEVELS, AND AQUIFER TEST RESULTS

Table A-1. Miscellaneous information pertaining to Well WQ-1.

Location Number:	WQ-1	Hydrologic Zone Monitored:	Combined below, in, and above coal.
Date Drilled:	10/18/80	Surface Elevation:	8232 ft. MSL
Total Depth:	371 feet	Casing Depth:	140 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8138 ft. MSL	Perforated Interval:	120 to 140 feet



(Not to Scale)

Table A-2. Lithologic description of Well WQ-1.

Hole Number WQ- 1

BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S)	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
7	0	7	0		090	Sand-Sh - talus, weathered, lt brown	
10	0	3	0		500	SS - red (oxidized), fgr, silty	
10	5		5		216	Sh-coal - br to bk, v. sooty (soft), mod argillaceous	
21	0	9	5		512	SS-br, frg, v. silty, mod consol, intbd clay sh	Sand poorly sorted, subangular, silty, weathered
25	0	4	0		225	Sh- gy to dk gy, soft, abundant carb stringers	
						(rooting) argillaceous	
39	0	14	0		522	SS- lt br, v. silty, mod consol, fgr (poorly sorted)	sltst intbd lt gy w/minor carb debris
44	0	5	0		522	SS- gy to lt red, v. calcareous (v. react Hcl) intbd zones	minor calcite crystalization
52		8	0		225	Sh - dk gy, (green-gy) mod consol to soft	
54		2	0		260	Sh - dk gy, mhd, v. calcareous (react Hcl), hd drilling	
64		10	0		225	Sh - dk gy, soft, mod argillaceous	
70		6	0		521	Sh - lt to dk gy, argillaceous, v. silty, minor vhd	Water (minor) @ 69' - switched to H_2O injection
						calcareous stringers	
105	0	35	0		532	SS - dk gy, vhd (v. calcareous) zones 0-1.0', generally	
						mod consol, vfgr to fgr down section - flowing 8-10 gpm	- mod argillaceous 100.0 - 105.0
114		9	0		511	Sh- gy, v. soft, v. argillaceous, minor carb debris	mod to unconsol
160		46	0		510	SS- gy, mod consol, v silty, fgr, lt gy, vfgr down unit	
						120-130', pyrite noted 150-155', mgr, poorly consol 130-160	
172		12	0		522	SS- gy, vhd, v calcareous (v react Hcl) hd drilling	large 1-2" ss fragments caving in from above
191		19	0		622	SS- gy, hd, (not as hard as above) v fgr (almost silt)	
						calcareous	still caving, trouble changing pipe
229		38	0		510	Above lithology continues except there are occasional	
						sandy shale zones ~ 3' max	Water flow measured at 5½ gpm
252		23	0		625	SS- gy, vhd, vfgr to fgr, calcareous (few coal chips)	impossible to tell where small amount of
262		10	0			SS - gy, hd, fgr, w/interbeds of siltstone	coal comes from
272		10	0		510	SS -gy, fgr, softer	
280		8	0		320	Shale, dk gy, sandy	
340		60	0		510	SS -gy, fgr, hd w/shale interbed	shale lenses read from geolograph
364		24	0		320	SH-SS gy to dk gy, mod consol	water output dropped considerably @322
371		7	0		630	Sandstone, gy, lt gy, mhd	Drilling 3-5' per/hr pulled pipe @ 371'
							bit completely worn w/one core missing
						LOST CONE IN HOLE HAD TO ABANDON. HOLE SLOUGHED IN ON 2125	*Surface weathered SS closing hole @ 15'
370 -	390					No sample - error on drill depth	

Table A-3. Water level measurements in Well WQ-1. Ground surface is approximately 8232 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
12-31-80	13:30	96.4	8138.2	Collar is 2.59 feet above ground surface.
1-28-81	12:25	95.8	8138.8	"
2-11-81	Inaccessible			
3-11-81	Inaccessible			
4-22-81	12:30	95.88	8138.7	"
5-14-81	12:00	95.?	8139	"
7-23-81	---	94.22	8140.4	"
9-22-81	12:35	96.14	8138.5	"
11-13-81	11:18	95.94	8138.7	"

Table A-4. Tabulated slug test data for Well WQ-1 conducted when hole terminated in the zone above the coal.

Ground Surface Elevation = 8232 ft. MSL.
Static Depth to Water = 79.8 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 371 feet
H_o = 6.75 feet

Date	Time	t (sec)	Depth to water (feet)	H (feet)	H/H_o
10/18/80	10:51	0	73.05	6.75	1.00
	10:54:45	225	76.29	3.51	0.52
	10:56:45	345	77.41	2.39	0.35
	10:58:15	375	78.12	1.68	0.25
	10:59:52	532	78.51	1.29	0.19
	11:00:30	570	78.80	1.00	0.15
	11:02:30	690	79.02	0.78	0.12
	11:03.30	750	79.15	0.65	0.10
	11:04:00	780	79.22	0.58	0.09
	11:05:00	840	79.37	0.43	0.06
	11:06:30	930	79.52	0.28	0.04
	11:07:30	990	79.60	0.20	0.030
	11:09:00	1080	79.66	0.14	0.021
	11:10:30	1170	79.71	0.09	0.013
	11:12:30	1290	79.81	0.00	0.000

At Match Line t = 83 seconds

$$T = \frac{r^2}{t\ \text{match}} = \frac{(0.255)^2}{83} = 0.00078\ \text{ft}^2/\text{sec} = 566\ \text{gpd/ft}$$

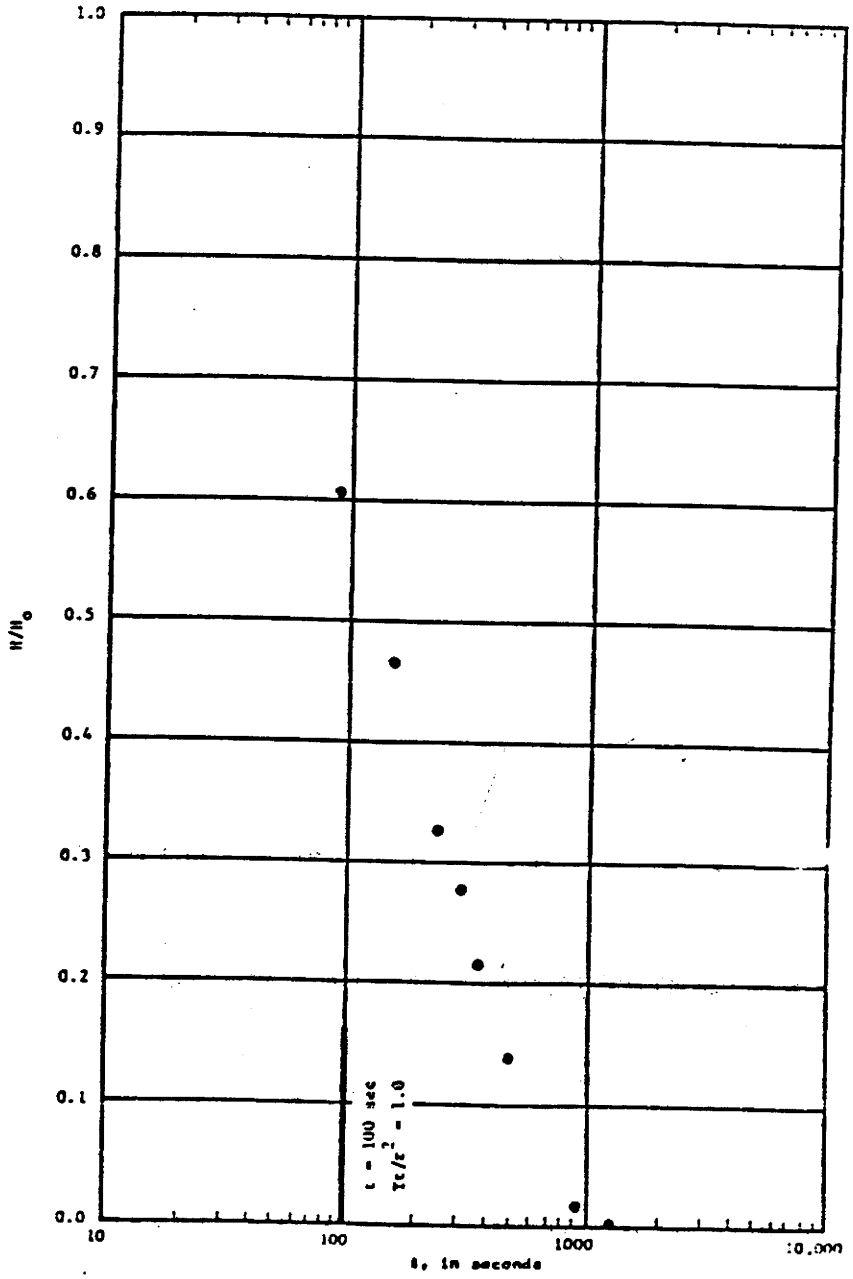
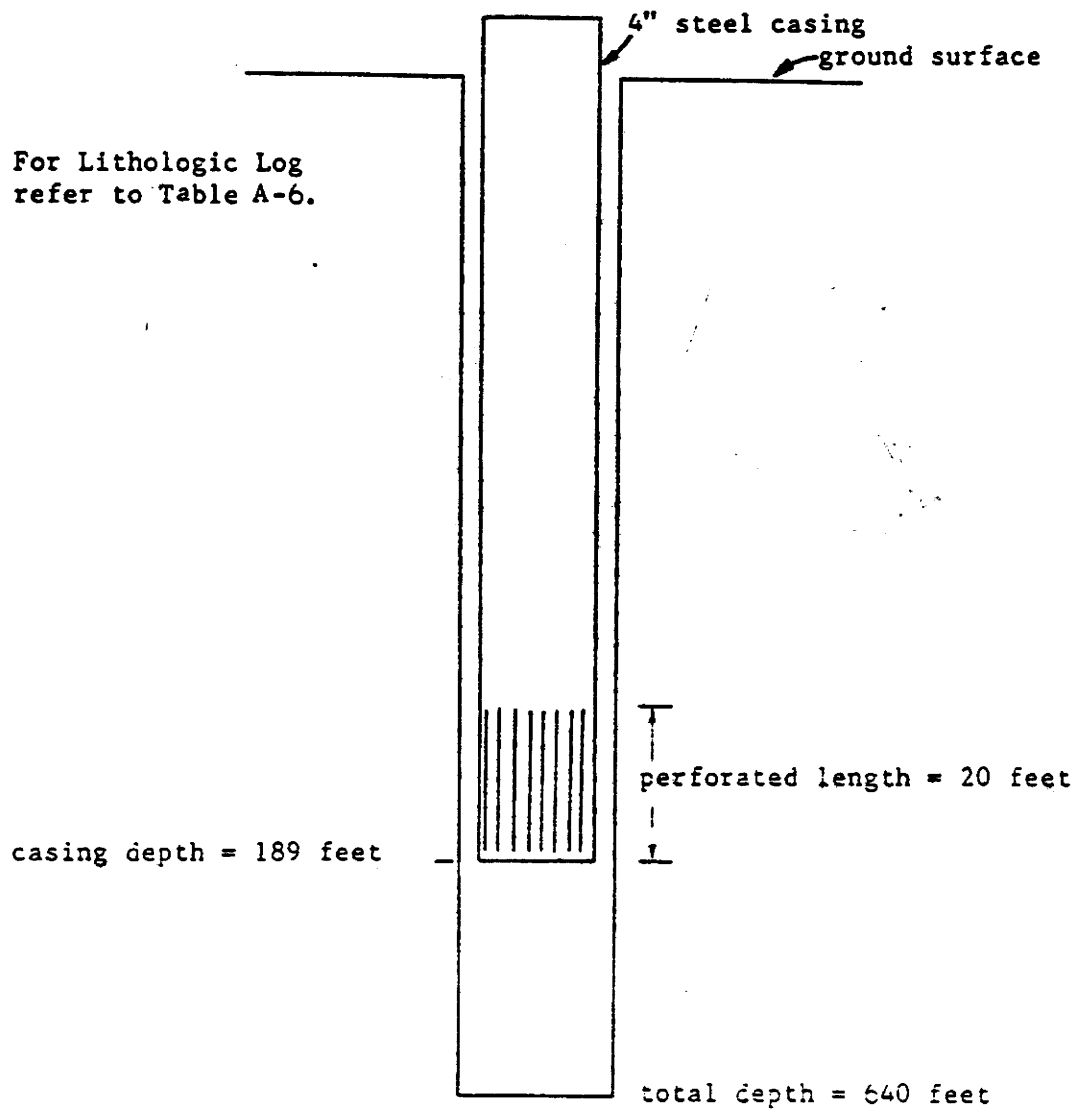


Figure A4. Graphical results of the slug test for Well WQ-1 conducted when hole terminated in the zone above the coal.

Table A-5. Miscellaneous information pertaining to Well WQ-1A.

Location Number:	WQ-1A	Hydrologic Zone Monitored:	Combined below, in and above coal.
Date Drilled:	10/23/80	Surface Elevation:	8231.9 feet MSL
Total Depth:	640 feet	Casing Depth:	189 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8127 feet MSL	Perforated Interval:	169 - 189 feet



(Not to Scale)

Table A-6. Lithologic description of Well WQ-1A.

Hole Number WQ-1A

CORE INTERVAL TOP/BASE	CUT/REC.	BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S)	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
		400	0	10	0		662	Sandstone - gy to dk gy, med grain	log continued from WQ-01
		410		10	0		225	Shale - bk w/coal frags. w/intbd ss	
		420		10	0		530	SS - gy, fg to mgr, mod consol	water @ 413'
		460		40	0		530	SS - gy w/abund sh intbd, minor coal trace (bk sh)	
		470		10	0		310	Sh - dk gy, v sandy, (vfgr)	
		490		20	0		660	SS - gy, mgr, mod sh	
		499		9	0		530	SS - gy, abundant bk sh, vfgr, coal & bk sh frags.	
		500		1	0			Coal(?) - drilled very fast, very sparse cuttings	
500/51-	14/14						*	Core 14.0 Rec. 14.0 100%	
		500	5		5			Sh - dk gy, hd, sl calcerous	Zone appears crystaline (like quartzite)
		501	8	1	3			SS - gy, vhd, v calcerous, vfgr, massive	" "
		502	0		2			Sh - bk to dk gy, minor coal frags	" "
		507	3	5	3			SS - gy, vhd, v calcerous, massive	
		510	0	2	7			Silst - gy, vhd, v calcerous, abundant coal frags, mass	
		510	4		4			Sh - bk, platev, mod consol, pyrite bands, intbd	Sent to lab [509.9-510.4 roof
		514	0	3	6			COAL - bk, hd, sl blky, ., broken core	[510.4-519.65 coal
								but intact, mod pyrite along cleat, minor amber noted	[519.65-520.15 floor
51-519.1	15.1/15							v. bright (abundant vitrain)	513.8-514.0 (sent to methane lab
		519	65	5	65			COAL - intact, some gypsum crystals occasional pyrite	515.0-515.2 (Utah State Geologist)
								and amber, good cleat, v bright, no partings	518.0-518.2
		519	85		2			SS - med gr, gy - coalified roots	
		522	9	3	15			SS - med gr, subangular, massive, dk br to br	not calcareous, coalified roots in top
		525	5	2	6			SS - gy to wh, mgr, v well sorted, subangular	not calcareous
		529	1	4	6			SS - gy, mgr, subangular grains, heavy min, or	
								coffee grounds, massive	End of core
		560		30	9			SS - gy, mgr	
		570		10	0			Sh - gy, bk, sandy	poor cuttings yield
		573		3	0			Sh - gy br, argillaceous	
		574		1	0			Coal	
		577		3	0			Sh - gy br	
		591	0	24	0			SS - lt gy, mgr, v hd, sl calcareous	
		595	0	4	0			Sh - br gy, sandy	
		619		24	0			SS - gy, v hd, w/shale	
		620		1	0			Sh - intbd, not hard	
		629		9	0			COAL - carb shale	
		640		11	0			Sh - gy br, soft	
								TD 640	

Table A-7. Water level measurements in Well WQ-1A. Ground surface is 8231.9 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
12-31-80	13:45	107.4	8127.90	Collar is 3.4 ft. above ground surface.
1-28-80	12:36	111.07	8124.23	"
2-11-81	Inaccessible			
3-11-81	Inaccessible			
4-22-81	11:43	100.72	8134.58	"
5-13-81	---	104.14	8131.16	"
7-23-81	10:40	102.32	8132.98	"
9-22-81	12:55	104.83	8130.47	"
11-13-81	10:56	100.47	8134.83	"

Table A-8. Tabulated slug test data for Well WQ-1A conducted in open hole when hole terminated in coal zone.

Ground Surface Elevation = 8231.9 ft. MSL
Static Depth to Water = 154.85 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 520 feet
H_o = 4.85 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/23/80	0		4.85	1.00
	90	151.91	2.94	0.61
	150	152.57	2.28	0.47
	240	153.23	1.62	0.33
	300	153.51	1.34	0.28
	360	153.79	1.06	0.22
	480	154.16	0.69	0.14
	600	154.38	0.47	0.10
	900	154.75	0.10	0.02
	1260	154.83	0.02	0.004

At Match Line t = 100 seconds

$$T = \frac{r^2}{t\ match} = \frac{(0.255)^2}{100} = 0.00065\ ft^2/sec = 420\ gpd/ft$$

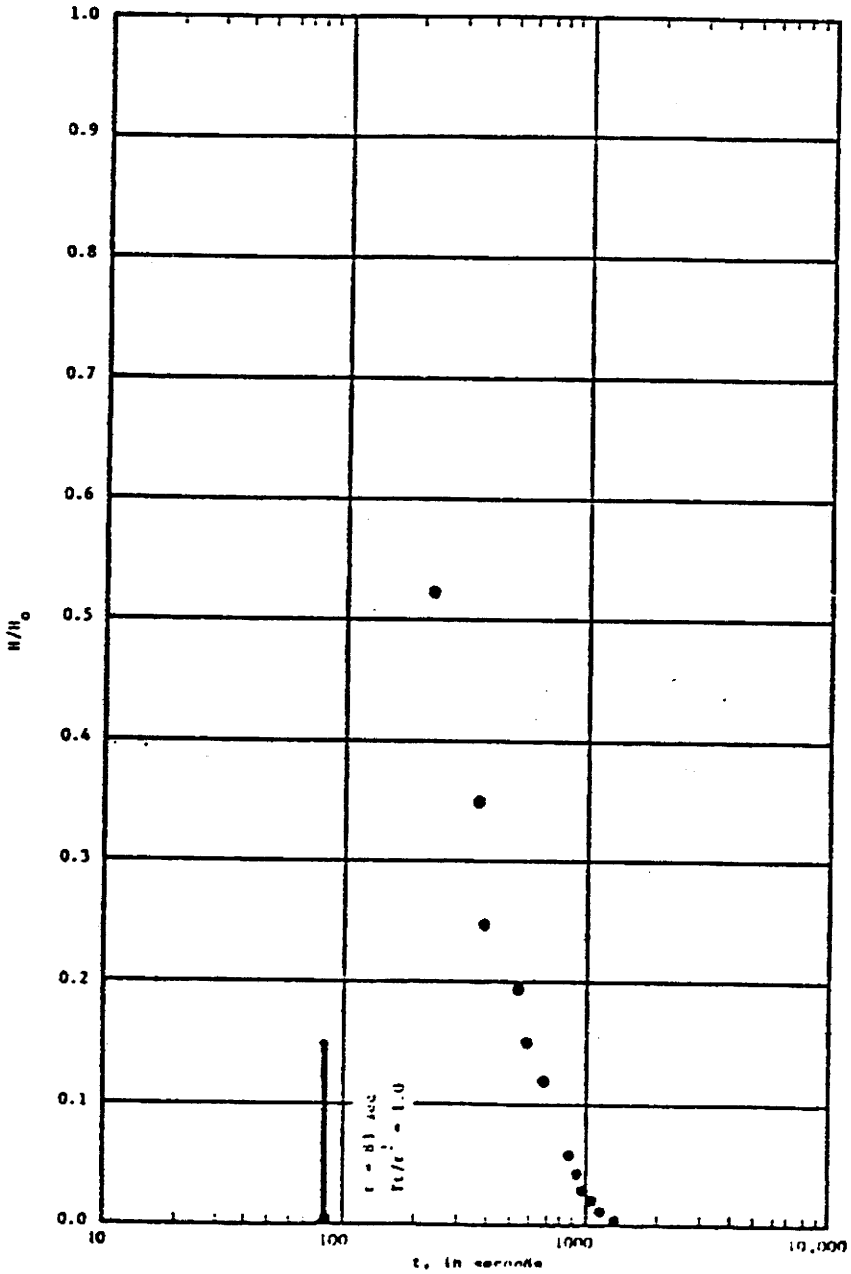


Figure A-2. Graphical results of the slug test for Well WQ-1A conducted when the hole terminated in the coal zone.

Table A-9. Tabulated slug test data for Well WQ-1A conducted in open hole terminated in zone below coal.

Ground Surface Elevation = 8231.9 ft. MSL
Static Depth to Water = 116.58 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 640 feet
H_o = 9.4 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/7/80	0		9.4	1.0
	30	108.46	8.12	0.87
	90	110.47	6.11	0.65
	120	111.02	5.56	0.59
	150	111.45	5.13	0.548
	210	112.15	4.43	0.473
	270	112.72	3.86	0.413
	330	113.13	3.45	0.369
	390	113.56	3.02	0.323
	450	113.83	2.75	0.295
	510	114.05	2.53	0.271
	570	114.23	2.35	0.252
	630	114.38	2.20	0.236
	750	114.65	1.93	0.207
	930	114.89	1.69	0.182
	1110	115.04	1.54	0.166
	1410	115.11	1.47	0.150
	1710	115.28	1.30	0.140
	1950	115.32	1.26	0.136

At Match Line t = 35 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{135} = 0.00048 \text{ ft}^2/\text{sec} = 311 \text{ gpd/ft}$$

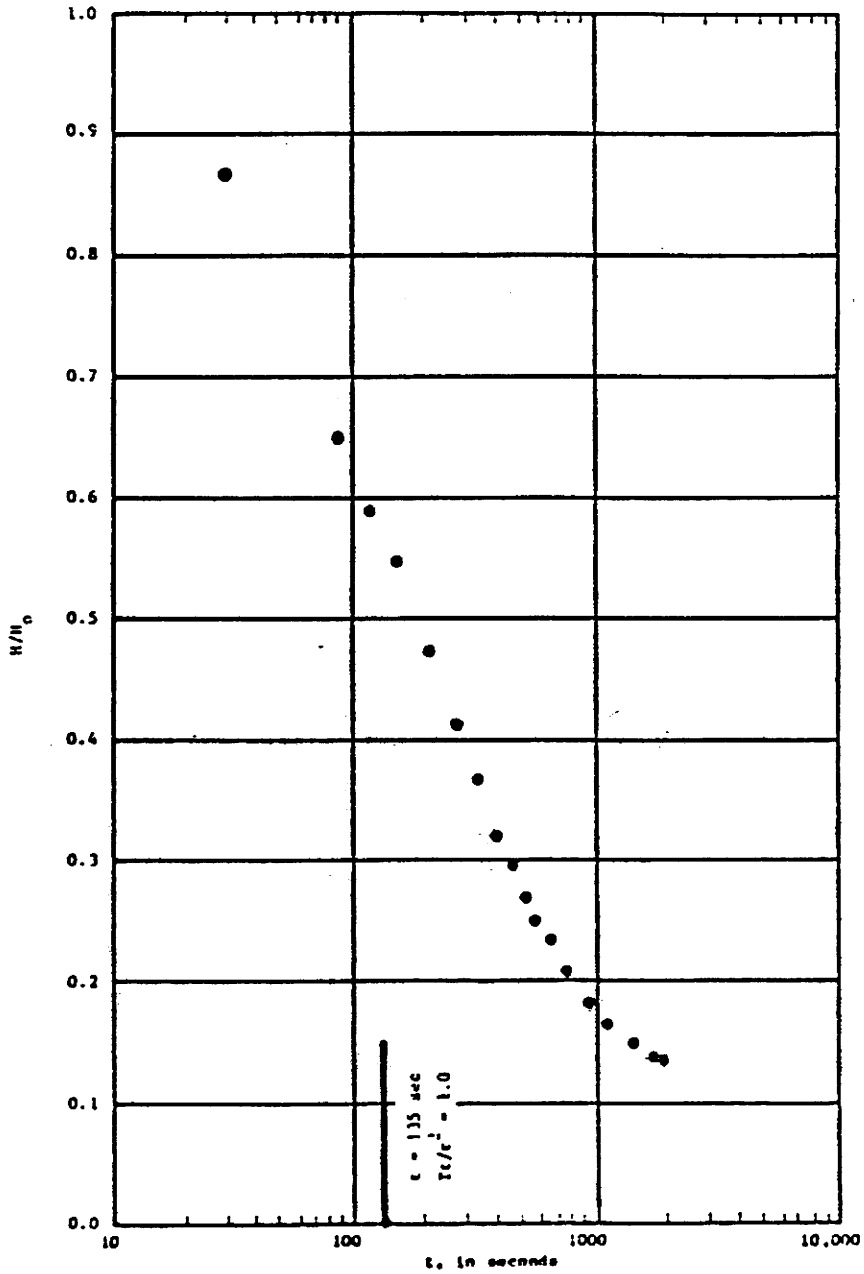


Figure A-3. Graphical results of the slug test for Well WQ-1A conducted when the hole terminated below the coal zone.

Table A-10. Tabulated drawdown and recovery data for Well WQ-1A.

Date	Time	t (min)	t' (min)	t/t'	Depth water (ft)	Drawdown (ft)	Remarks
5-15-81	3:40	0			103.88	0	
		1			105.29	1.41	
		3			105.89	2.01	
		6			105.99	2.11	
		9			106.18	2.30	
		11			106.45	2.57	
		15			107.05	3.17	
		19			107.48	3.60	Flow - 5.9 gpm
		21			107.97	4.09	Hole is cased to
		26			109.03	5.15	depth of 126 feet.
		29			109.85	5.97	Casing is perforated in
		35			110.70	6.82	lower 20 feet
		40			111.35	7.47	
		45			111.88	8.00	
		52			112.32	8.44	
		62			113.63	9.75	
		70			114.46	10.58	
		80			115.83	11.95	
		90			116.93	13.05	
		100			117.90	14.02	
		110			118.55	14.67	
		120	0		119.06	15.18	
		120.5	0.5	241	118.67	14.79	
		121.0	1.0	121	116.44	12.56	
		121.5	1.5	81	115.95	12.07	
		122.0	2.0	61	115.77	11.89	
		122.5	2.5	49	115.58	11.70	
		123	3	41	115.34	11.46	
		124	4	31	114.97	11.09	
		125	5	25	114.67	10.79	
		126	6	21	114.58	10.70	
		126.5	6.5	19.5	113.98	10.10	
		128	8	16.0	113.93	10.05	
		130	10	13.0	113.60	9.72	
		132	12	11.0	113.41	9.53	
		134	14	9.6	113.23	9.35	
		136	16	8.5	113.05	9.17	
		138	18	7.7	112.93	9.05	
		140	20	7.0	112.77	8.89	
		145	25	5.8	112.47	8.59	
		150	30	5.0	112.23	8.35	
		160	40	4.0	111.78	7.90	
		170	50	3.4	111.38	7.50	
		180	60	3.0	111.08	7.20	

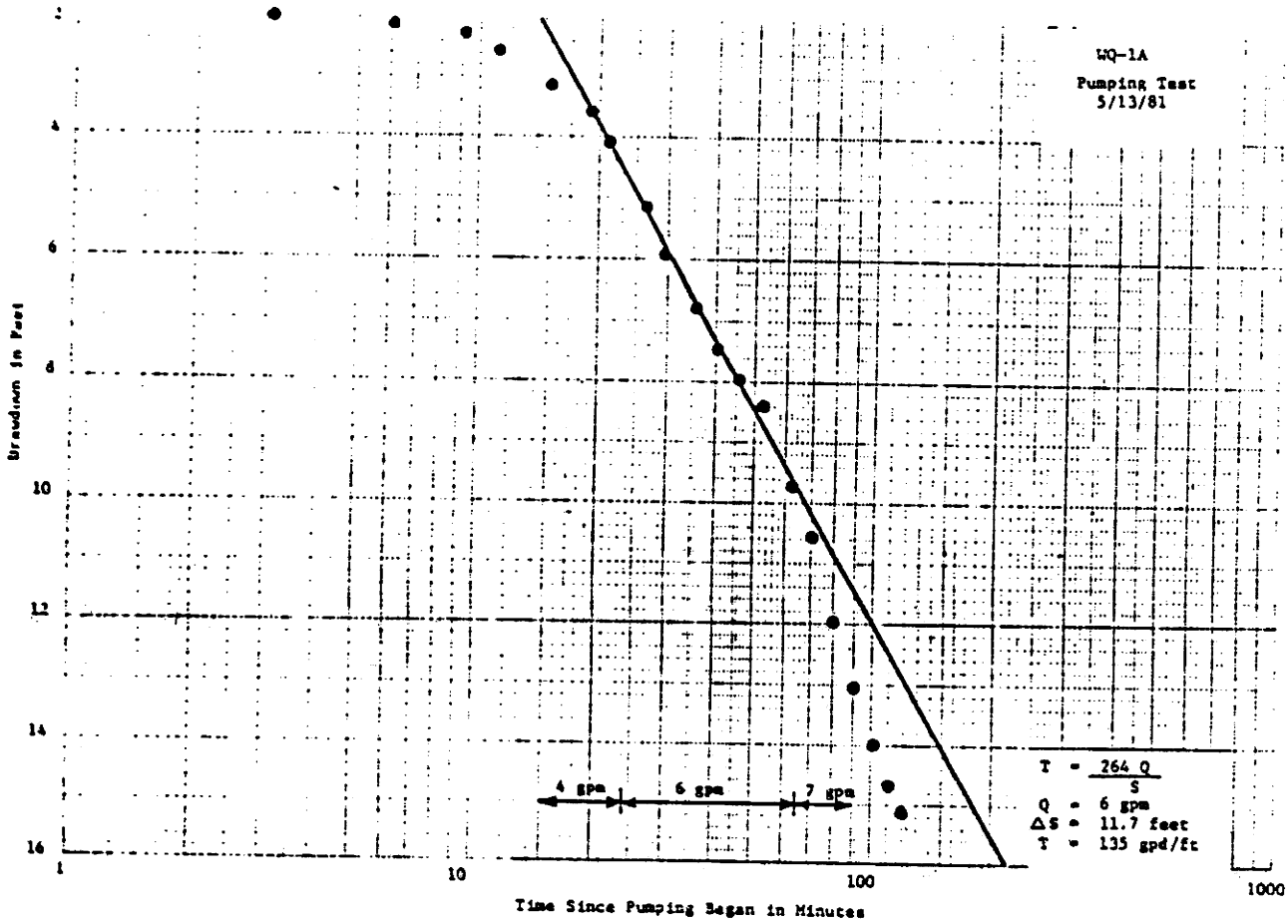


Figure A-4. Graphical results of the drawdown test for Well WQ-1A.

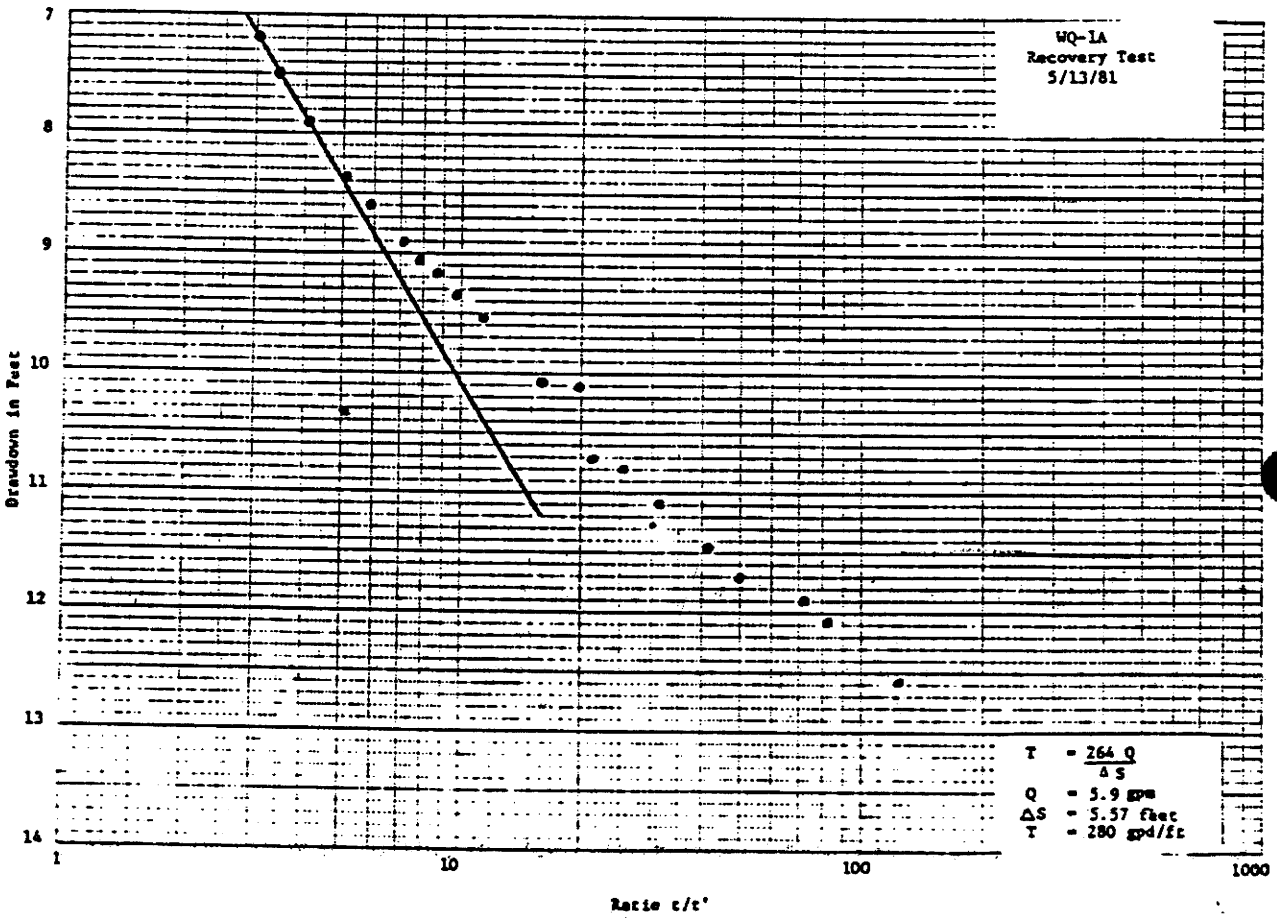


Figure A-5. Graphical results of the recovery test conducted in Well WQ-1A.

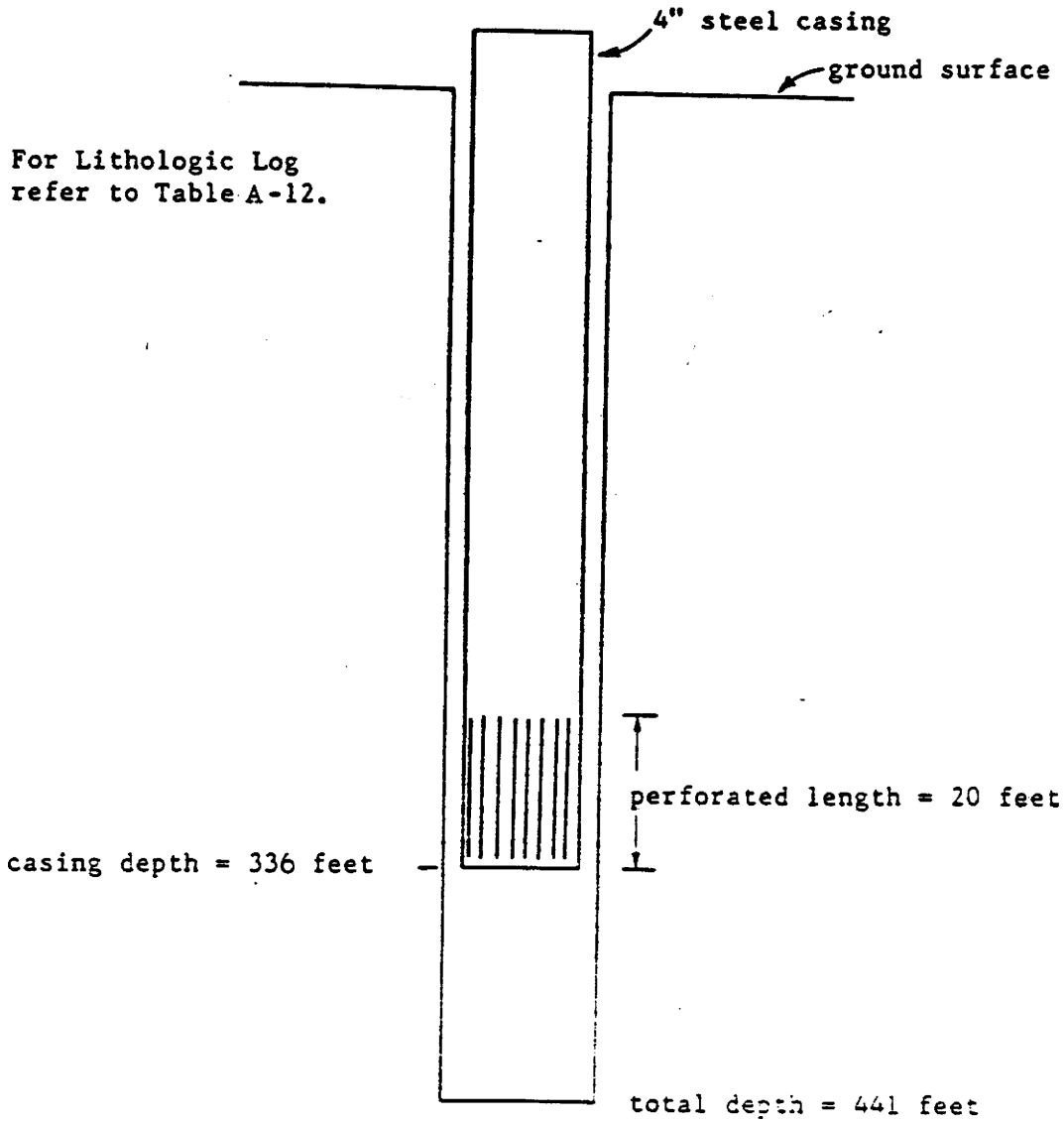
Table A-12. Lithologic description of Well WQ-6.

Hole Number WQ-06

CORE INTERVAL TOP / BASE	CUT / REC.	BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S.	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
		17	0	17	0			Clay, soft, br, sandy w/depth	
		33	0	16	0			Sh - br, lot of clay, sandy	
		36	0	3	0			Sh - gy to dk gy, sandy, mod consol	Set 34'of casing
		38	0	2	0			SS - gy br, fgr, mgr, hd v calcareous	Looks like limestone!!
		44	0	6	0			Sh - dk gy to bk, soft silty	
		54	0	10	0			SS - lt gy, fgr, hd	
		71	0	17	0			Sh - bk, mod consol, silty to sandy	
		74	0	3	0			SS - lt gy, calcareous	
		79	0	5	0			Sh - gy to dk gy, silty	
		120	0	41	0			SS - lt gy, fgr, v hd	
		138	0	18	0			SS:Sh gy to dk gy, minor bk sh zones	
		144	0	6	0			Sh - gy to dk gy, min to mod ss (mgr)	
		148	0	4	0			COAL w/bk sh	
		207	0	59	0			SS - gy, mgr to crsgr, v silty, unconsol	
								w/mod dk gy shale zones, hd zones (calcareous?)	
		212		5	0			Sh - dk gy, mod ss and silst	
		216		4	0			SS - lt gy, mgr, mod to well consol	
		235	0	19	0			Sh - dk gy, as previous and mod carb frags	
		238	0	3	0			SS - gy, mgr to crsgr,	
		250	0	12	0			Sh - dk gy, mod consol, min bk carb	
		296	0	46	0			SS - lt gy w/sh intbds, (ss v hd)	
		310						Sh - dk gy to bk, silty, soft, some ss streaks 300 to 310	
310, 325	15/14.6	310	4		4			Lost top 0.4'	
		311	8	1	4			Silst - gy, massive, calcareous	Hard
		312	2		4			Sh - gy, only sl calcareous	
		320	7	8	5			SS - lt gy, vfgr, massive w/clay and carb debris in	Has crystalline texture (sugary)
								distorted beds (burrowed) [fgr @316']	
		321			3			Sh - gy w/carb frags	
325/340	15/15	331	35	10	35			COAL - v bright, (vitrain) good cleat, blky, resin	Very clean
								crystals (amber) pyrite along fracture, some gypsum	Sent to Lab:
		331	55		2			SS - mgr, dk br, coal lenses	Roof 320.5-321
		332	55	1	0			SS - mgr, br	COAL 321-331.35
		340	0	7	45			SS - lt gy, mgr to fgr, mod calcareous, massive	Floor 331.35-331.85
								well sorted	
								END CORE 340	Methane Test - Utah G. S.
									321-321.2 (0.2')
									327-327.2 (0.2')
									328.8-329.0(0.2')

Table A-11. Miscellaneous information pertaining to Well WQ-6.

Location Number:	WQ-6	Hydrologic Zone Monitored:	Combined below, in, and above coal
Date Drilled:	10/29/80	Surface Elevation:	8167.06 feet MSL
Total Depth:	441 feet	Casing Depth:	336 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8053 feet MSL	Perforated Interval:	316 - 336 feet



(Not to Scale)

Table A-13. Water level measurements in Well WO-6. Ground surface is 8167.06 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
12-31-80	14:15	116.05	8053.51	Collar is 2.5 feet above ground surface.
2-11-81	Inaccessible			
3-11-81	Inaccessible			
4-22-81	11:00	90.5	8079.06	"
5-14-81	---	111.31	8058.25	"
7-23-81	9:50	110.6	8058.96	"
9-22-81	11:45	111.2	8058.36	"
11-13-81	9:50	111.41	8058.15	"

Table A-14. Tabulated slug test data for Well WQ-6 conducted in open hole when hole terminated in zone above coal.

Ground Surface Elevation = 8167.06 ft. MSL
Static Depth to Water = 88.65 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 200 feet
H_o = 12.15 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/29/80	0		12.15	1.0
	60	80.33	8.32	0.68
	120	83.00	5.65	0.47
	180	85.26	3.39	0.28
	240	86.62	2.03	0.17
	300	87.33	1.32	0.11
	360	87.87	0.78	0.064
	420	88.21	0.44	0.036
	480	88.38	0.27	0.022
	540	88.50	0.15	0.012
	600	88.56	0.09	0.007
	720	88.60	0.05	0.004
	840	88.63	0.02	0.002
	1560	88.63	0.02	0.002

At Match Line t = 35 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{35} = 0.00186 \text{ ft}^2/\text{sec} = 1201 \text{ gpd/ft}$$

Table A-15. Tabulated slug test data for Well WQ-6 conducted in open hole when hole terminated in the coal zone.

Ground Surface Elevation = 8167.06 ft. MSL
Static Depth to Water = 95.2 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 345 feet
H_o = 15.20 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/29/80	0		15.20	1.0
	60	84.95	10.25	0.67
	120	88.24	6.96	0.46
	180	90.67	4.53	0.30
	240	92.34	2.86	0.19
	300	93.40	1.80	0.12
	360	94.16	1.04	0.068
	420	94.56	0.64	0.042
	480	94.80	0.40	0.026
	540	94.92	0.28	0.018
	600	94.98	0.22	0.014
	720	95.05	0.15	0.010
	840	95.06	0.14	0.009
	960	95.07	0.13	0.009
	1080	95.07	0.13	0.009
	1200	95.08	0.12	0.008

At Match Line t = 23 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{23} = 0{,}000283 \text{ ft}^2/\text{sec} = 1528 \text{ gpd/ft}$$

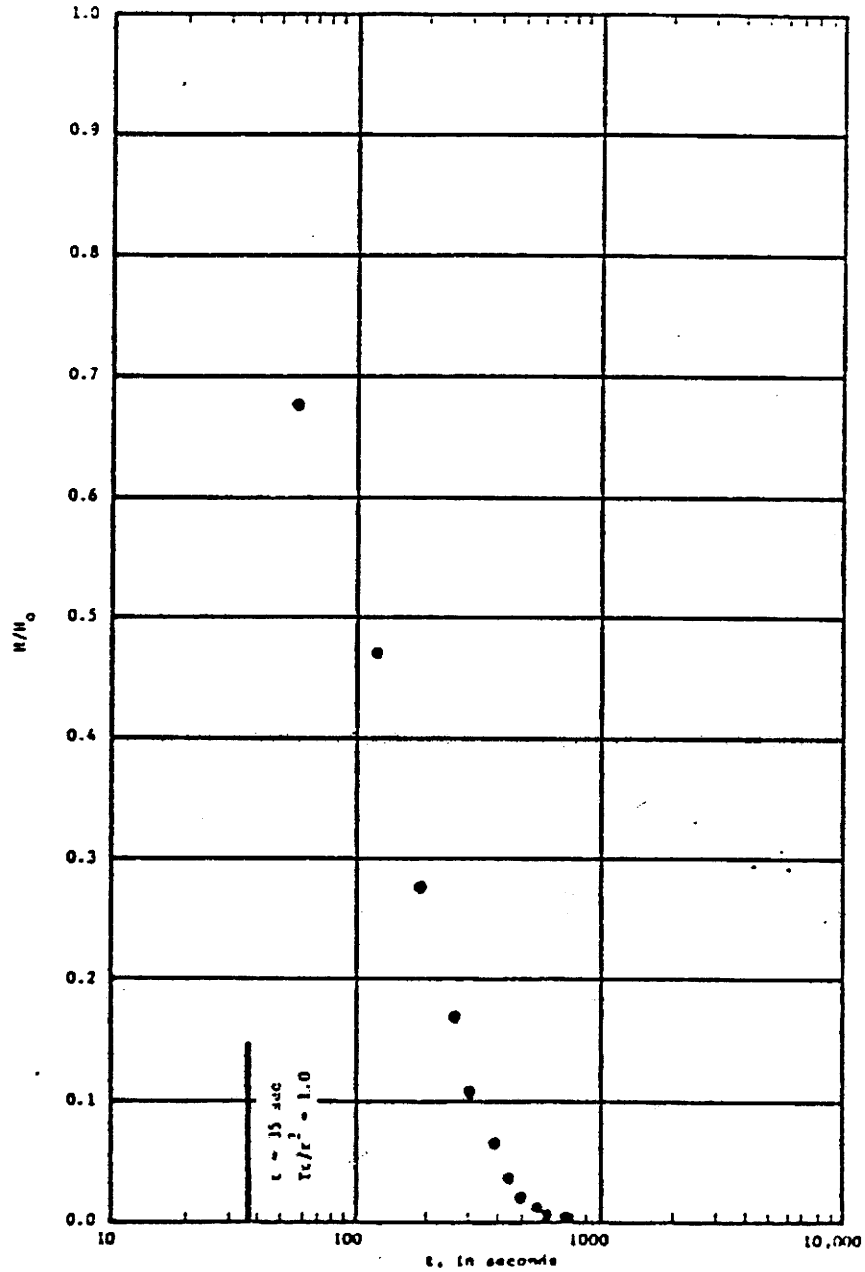


Figure A-6. Graphical results of the slug test for Well WQ-6 conducted when the hole terminated above the coal zone.

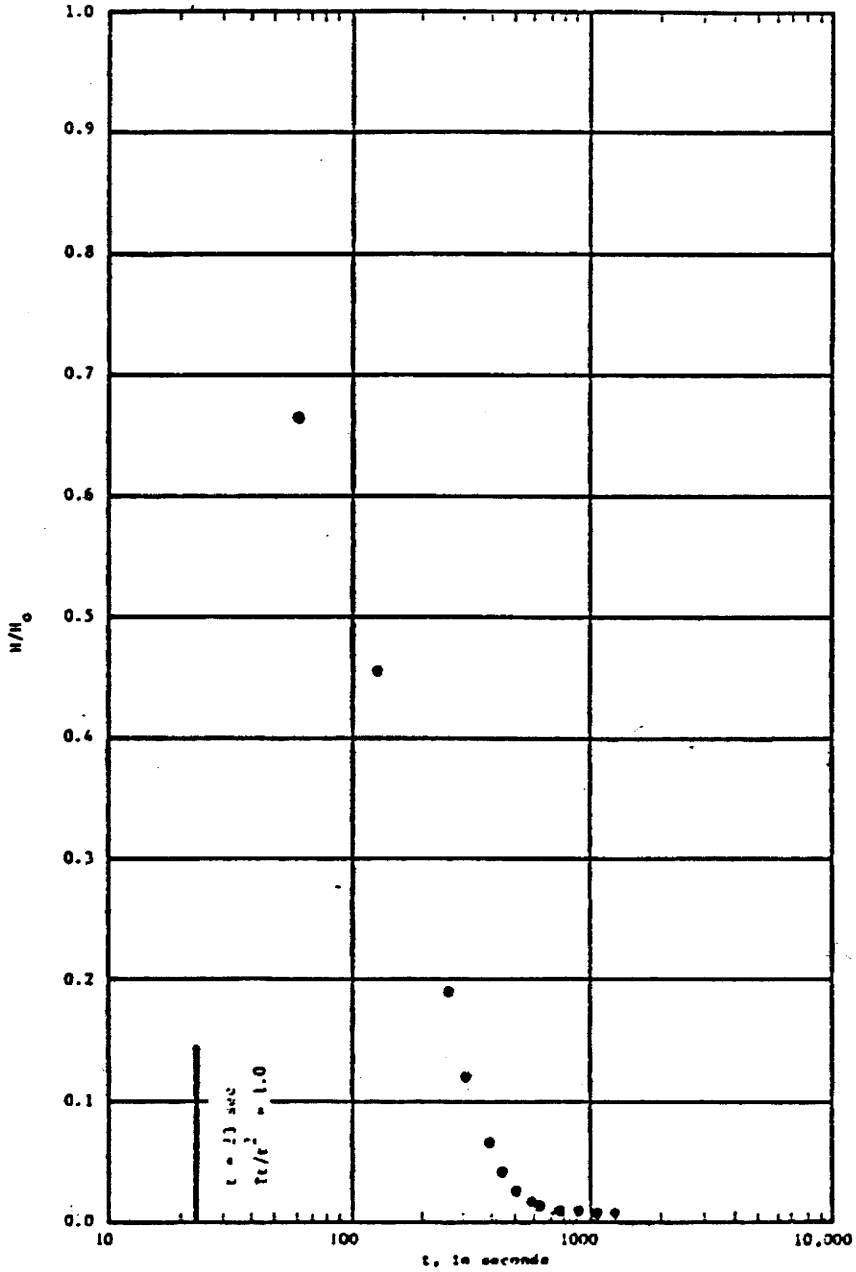


Figure A-7. Graphical results of the slug test for Well WQ-6 conducted when the hole terminated in the coal zone.

Table A-16. Tabulated slug test data for Well WQ-6 conducted in open hole when hole terminated in the zone below the coal.

Ground Surface Elevation = 8167.06 ft. MSL
Static Depth to Water = 99.12 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 441 feet
H_o = 10.82 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
10/30/80	0		10.82	1.0
	30	89.66	9.46	0.87
	60	91.46	7.66	0.71
	120	94.30	4.82	0.45
	180	95.27	3.85	0.36
	210	96.17	2.95	0.27
	240	97.23	1.89	0.17
	300	98.08	1.04	0.10
	390	98.38	0.74	0.07
	420	98.48	0.64	0.06
	480	98.57	0.55	0.05
	540	98.68	0.44	0.041
	600	98.70	0.42	0.039
	660	98.72	0.40	0.037

At Match Line t = 23 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{23} = 0.00283 \text{ ft}^2/\text{sec} = 1828 \text{ gpd/ft}$$

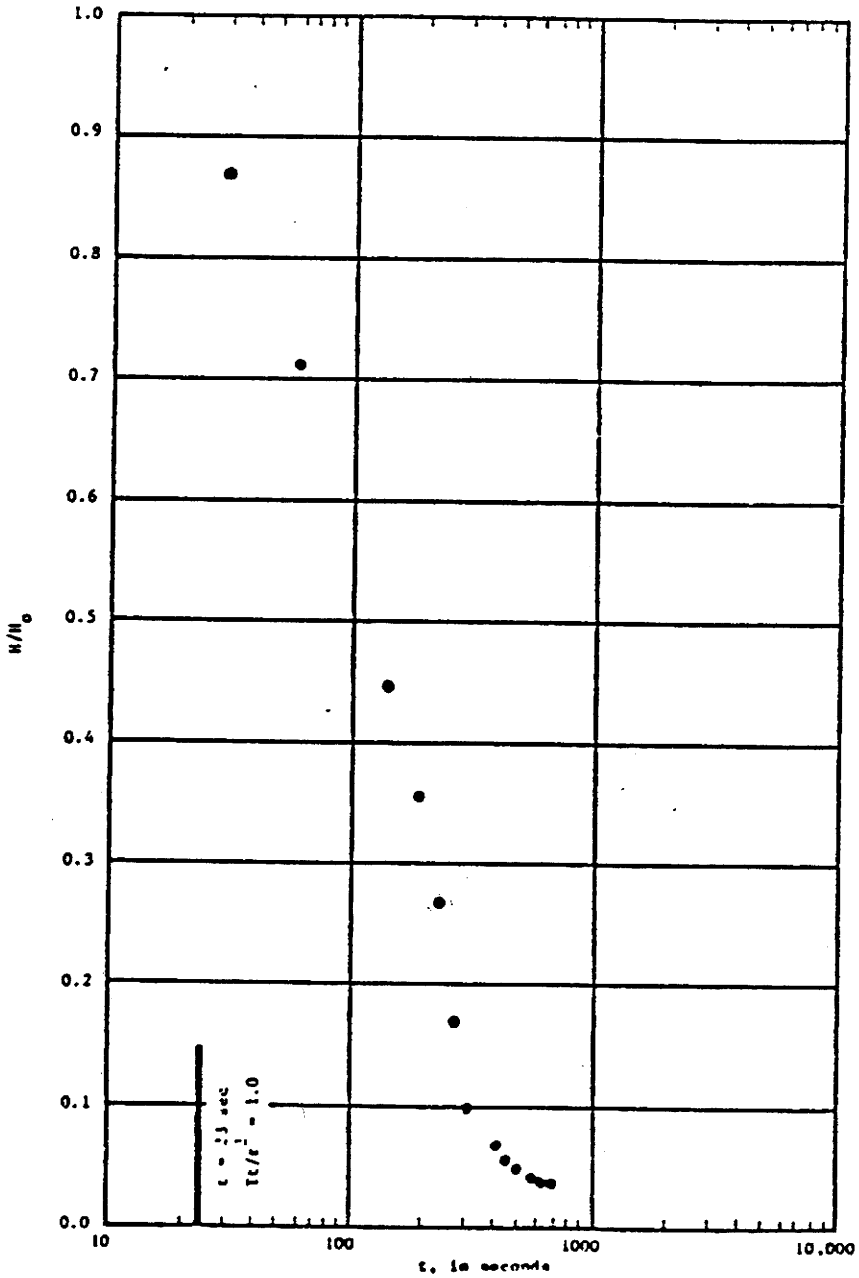


Figure A-8. Graphical results of the slug test for Well WQ-6 conducted when the hole terminated below the coal zone.

Table A-17. Tabulated recovery data for Well WQ-6.

Date	Time	t (min)	t' (min)	t/t'	Depth Water (feet)	Drawdown (feet)	Remarks
5-15-81	1:40	0	-	-	107.32		
		3	-	-			
		6	-	-			
		14	-	-			
		19	-	-			
		25	-	-			Flow = 4.6 gpm
		27	0	-			
		30.5	3.5	8.7	145.55	38.23	Hole is cased to a depth of 336 feet.
		32	5	6.4	143.51	36.19	
		34	7	4.9	140.50	33.18	
		36	9	4.0	137.86	30.54	Casing is perforated in lower 20 feet.
		38	11	3.5	135.43	28.11	
		40	13	3.1	133.19	25.87	
		42	15	2.8	131.07	23.75	
		46	19	2.4	127.67	20.35	
		48	21	2.3	126.11	18.79	
		50	23	2.2	124.83	17.51	
		55	28	2.0	122.24	14.92	
		70	43	1.6	117.02	9.70	
		80	53	1.5	115.15	7.83	
		90	63	1.4	113.91	6.59	

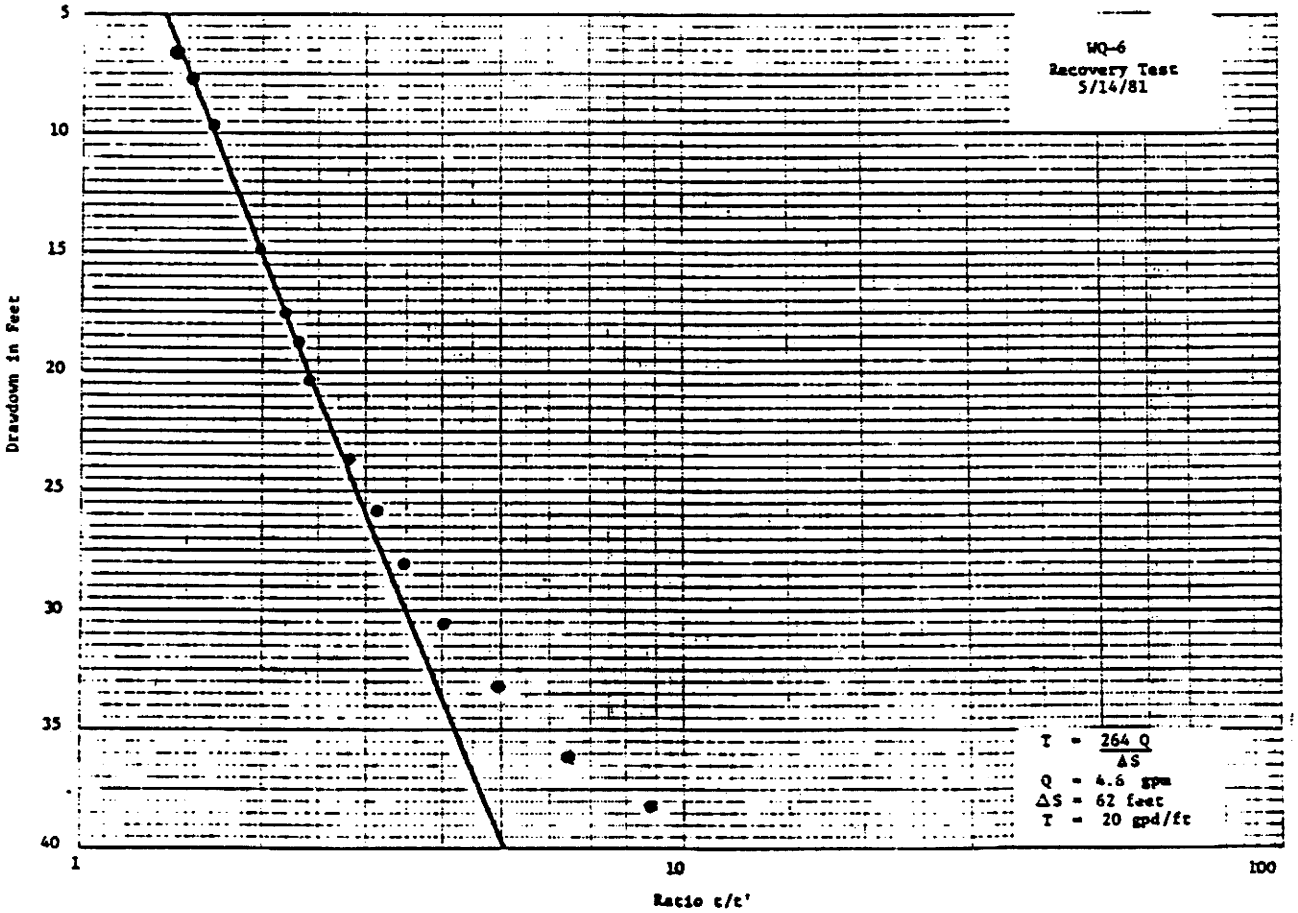
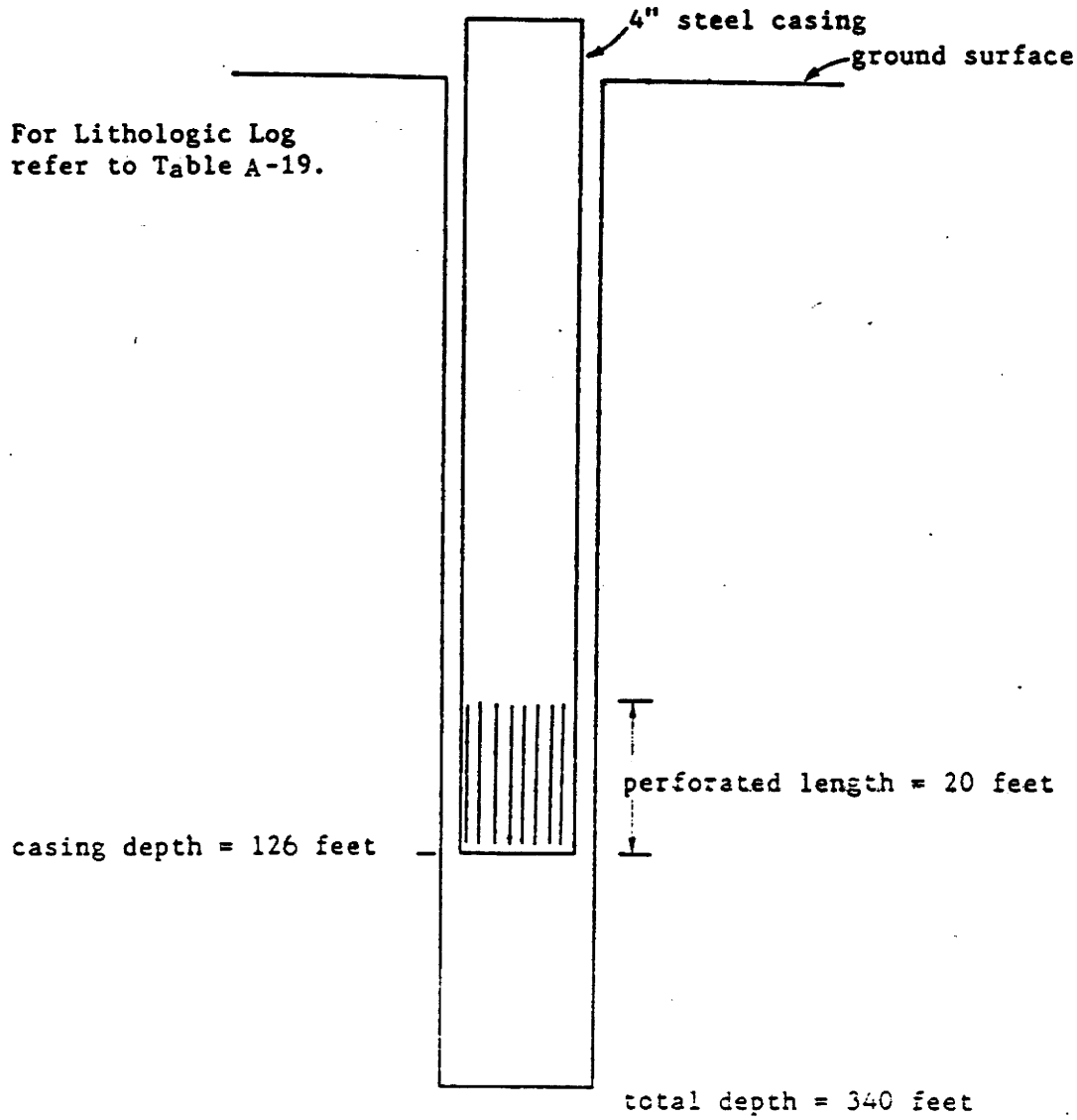


Figure A-9. Graphical results of the recovery test conducted in Well WQ-6.

Table A-18. Miscellaneous information pertaining to Well WQ-8.

Location Number:	WQ-8	Hydrologic Zone Monitored:	Combined below, in, and above coal.
Date Drilled:	11/7/80	Surface Elevation:	8120.75 feet MSL
Total Depth:	340 feet	Casing Depth:	126 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8058 feet MSL	Perforated Interval:	106 - 126 feet



(Not to Scale)

Table A-19. Lithologic description of Well WQ-8.

Hole Number [illegible]

CORE INTERVAL TOP / BASE	CUT / REC.	BASE OF UNIT		UNIT THICKNESS		MEMBER CODE (S)	LITHOLOGIC DESCRIPTIONS: ROCK CLASSIFICATION SYSTEM: ROCK CODE	DESCRIPTION	REMARKS
		40	0	40	0			Sand - topsoil & talus, br to lt br, fgr, v silty	
		60	0	20	0			SS - br, mgr, mod gy sh frags	
		66	0	6	0			Sh - gy, argillaceous	
		68	0	2	0			Coal - bk, hd, abundant carb sh frags	
		90		22	0			Sh - gy to dk gy, mhd mod consol, min sand, mod bk sh	
		108	0	18	0			Sh - w/ss (mod) as above	
		109	0	1	0			Coal - abund bk sh	Sh drills fairly hd w/ mod t minor intbd
		115	0	6	0			Sh - w/ss as previous	ss. minor water, less than 1 gpm, apparent
		117	0	2	0			Coal & sh (bk) - hd.	from coal @ 66'
		160	0	43	0			Sh w/ss (mod) dk gy sh, vfgr sand	
		170	0	10	0			SS - gy w/mod sh intbd, mhd fgr to mgr	
		197	0	27	0			Sh - gy to dk gy, mod consol, min carb frags, mod to abundant ss	
		221		24	0			SS - lt gy to gy, vhd, fgr to vfgr	
		230		9	0			Sh - gy, soft, mod consol, argillaceous	
								BEGIN CORE 230.0	
[illegible]-5	15/11.9	231	8	1	8			SS - lt gy, vhd, v silty, vfgr, appears calcareous, intact core	
		232	0		8			Sh - gy, pbdd, mhd, intact core slickenslides	
		233	0		4			Sh - as above, v broken, appears to be where loss	
		233	9		9		LOST??	occur (primary loss) rounded frags	LOST
		234	2		3			Clay - gy, v soft, mod swelling, pve, pbdd	
		234	4		2			Sh - gy, , soft to mhd, mod coal and carb stringers	
		234	5		1			Sh - bk, v carb, abundant coal bands	
		242	8	8	3			COAL - bk, mhd, blky, btm 3.5'	
		245	0	2	2	LOST		minor pyrite and amber along cleats noted	LOST
245/260	15/15	245	5	0	5			COAL - bk, broken, blky, as above	sent to lab
		246	2	0	7			SS - br, carb and coal rooting throughout, massive fgr	Roof 233.9-234.5
									Coal 234.5-245.5 (11.0-lost 2.2)
									Floor 245.5-246.0
		248	3	2	1				
		260	4	12	4			SS - lt gy, massive, fgr, coffee grounds or heavy min	
								in btm 6'	
									Log 236.0-247.5 (11.0')
									Core 8.8
									Lost 2.2' coal @ btm

Table A-20. Water level measurements in Well WQ-3. Ground surface is 8120.75 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
2-11-81	Inaccessible			Collar is 0.4 feet above ground surface.
3-11-81	Inaccessible			
4-22-81	14:05	64.86	8056.29	"
5-27-81	---	64.9	8056.25	"
7-23-81	---	60.22	8060.93	"
9-22-81	11:30	60.34	8060.81	"

Table A-21. Tabulated slug test data for Well WQ-8 conducted in open hole when hole terminated in the zone above the coal.

Ground Surface Elevation = 8120.75 ft. MSL
Static Depth to Water = 63.0 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 161 feet
H_o = 41.5 feet

At Match Line t = 500 seconds

$$T = \frac{r^2}{t\,match} = \frac{(0.255)^2}{500} = 0.00013\ ft^2/sec = 84\ gpd/ft$$

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/7/80	0		41.5	1.0
	65	25.0	38.00	0.92
	125	26.45	36.55	0.88
	185	27.80	35.20	0.85
	240	29.00	34.00	0.82
	300	29.98	33.02	0.80
	360	30.83	32.17	0.775
	420	31.71	31.29	0.754
	480	32.70	30.30	0.730
	540	33.57	29.43	0.709
	600	34.41	28.59	0.689
	660	35.25	27.75	0.669
	720	36.13	26.87	0.647
	840	37.73	25.27	0.609
	960	39.25	23.75	0.572
	1020	39.97	23.03	0.555
	1320	43.37	19.63	0.473
	1620	45.93	17.07	0.411
	1920	50.49	12.51	0.301
	2220	52.20	10.80	0.260
	2520	53.78	9.22	0.222
	2820	55.15	7.85	0.189
	3120	56.33	6.67	0.161
	3420	57.31	5.69	0.137
	3720	58.28	4.72	0.114

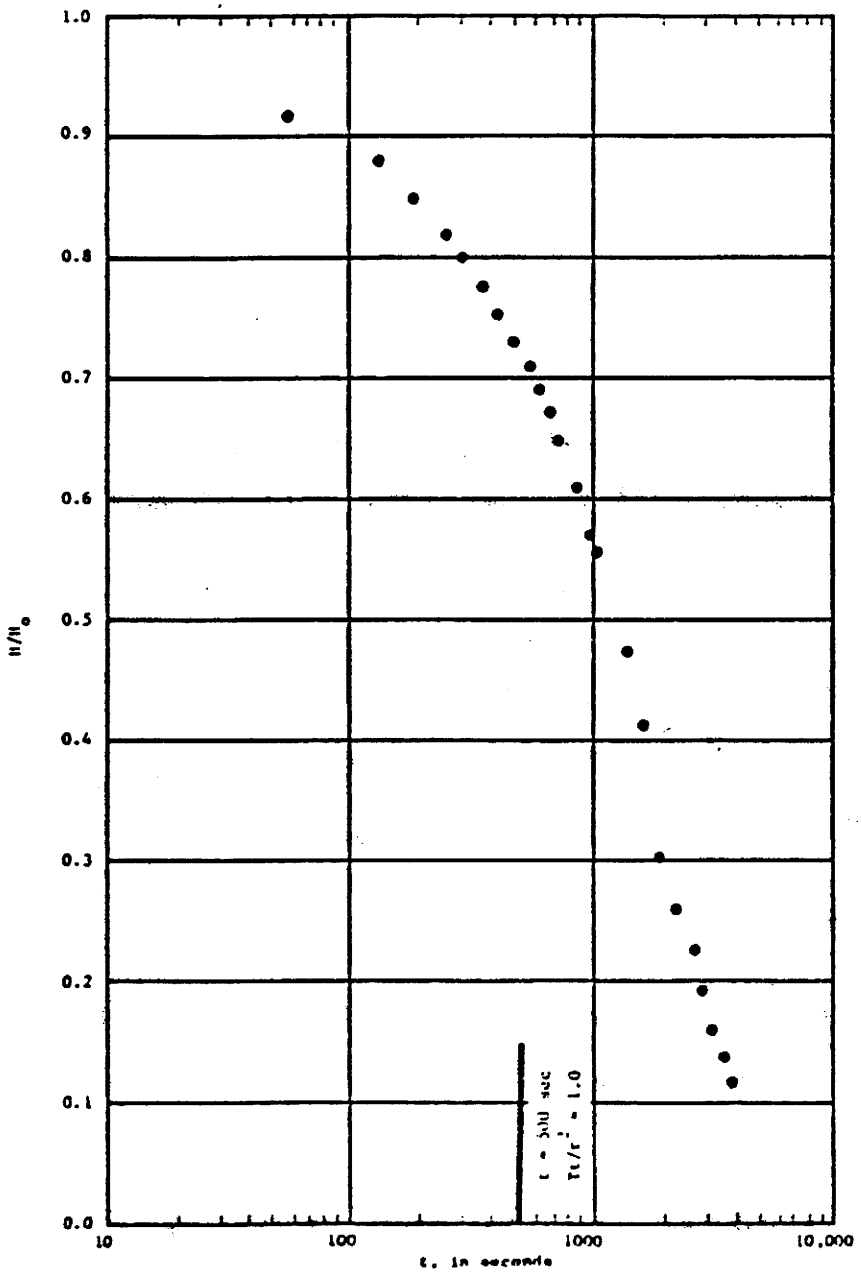


Figure A-10. Graphical results of the slug test conducted in Well WQ-8 when the hole terminated above the coal zone.

Table A-22. Tabulated slug test data for Well WQ-8 conducted in open hole when hole terminated in the coal zone.

Ground Surface Elevation = 8120.75 ft. MSL
Static Depth to Water = 64.0 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 260 feet
H_o = 20.0 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/8-80	0		20.00	1.00
	45	47.02	16.98	0.85
	120	50.93	13.07	0.65
	180	52.37	11.63	0.58
	240	53.44	10.56	0.53
	300	54.36	9.64	0.48
	360	55.03	8.97	0.45
	420	55.72	8.28	0.414
	540	56.93	7.07	0.354
	600	57.53	6.47	0.324
	720	58.53	5.47	0.274
	840	59.45	4.55	0.228
	960	60.24	3.76	0.188
	1080	60.92	3.08	0.154
	1200	61.48	2.52	0.126
	1320	61.99	2.01	0.101
	1440	62.40	1.60	0.080
	1560	62.70	1.30	0.065
	1680	62.91	1.09	0.055

At Match Line t = 135 seconds

$$T = \frac{r^2}{t\ \text{match}} = \frac{(0.255)^2}{135} = 0.00048\ \text{ft}^2/\text{sec} = 312\ \text{gpd/ft}$$

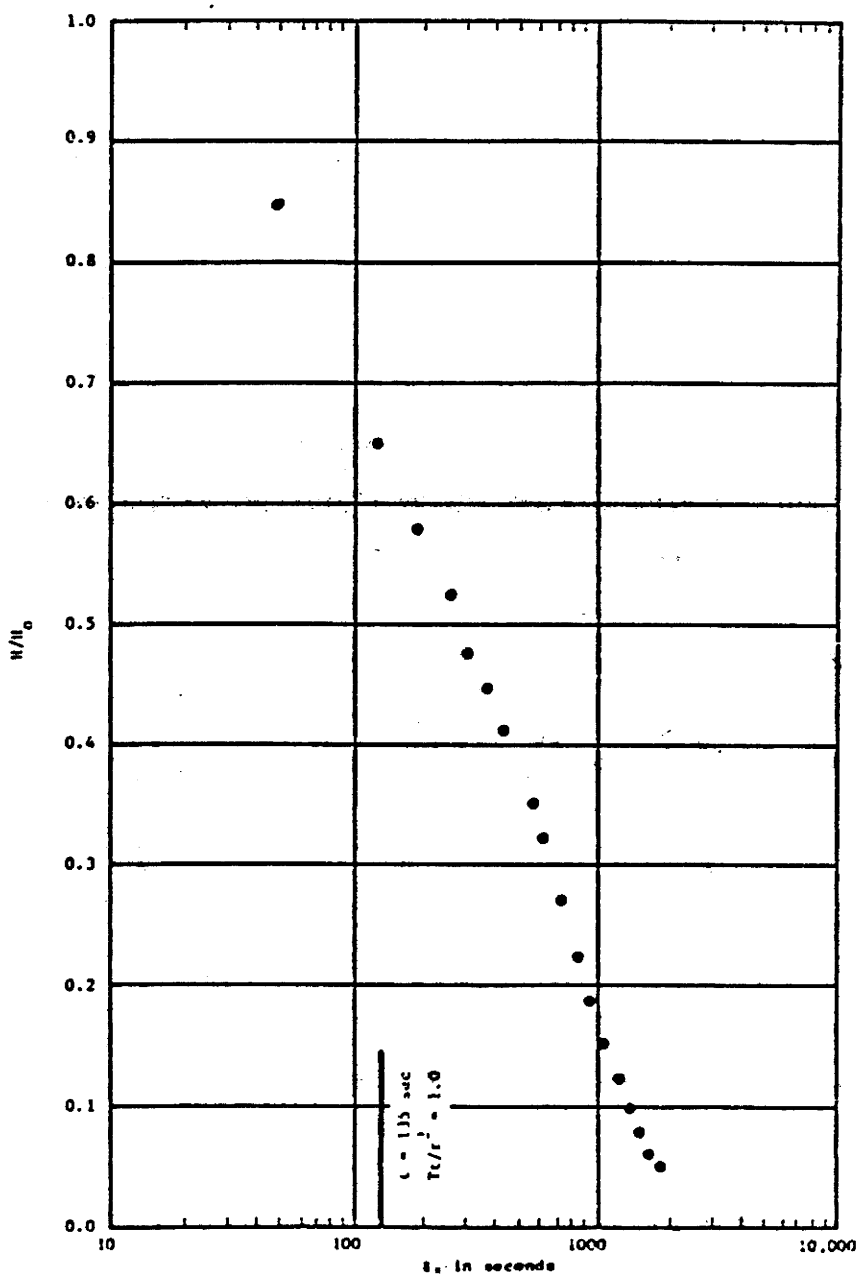


Figure A-11. Graphical results of the slug test for Well WQ-8 when the hole terminated in the coal zone.

Table A-23. Tabulated slug test data for Well WQ-8 conducted in open hole when hole terminated in the zone below the coal.

Ground Surface Elevation = 8120.75 ft. MSL
Static Depth to Water = 60.22 feet
Radius of Hole (r) = 3 1/16 inches (0.255 feet)
Depth of Hole = 340 feet
H_o = 27.8 feet

Date	Time t (sec)	Depth to Water (feet)	H (feet)	H/H_o
11/12/80	0		27.8	1.000
	30	33.67	26.55	0.955
	90	36.11	24.11	0.867
	120	37.19	23.03	0.828
	180	39.80	20.42	0.735
	240	42.09	18.13	0.652
	300	44.00	16.22	0.583
	360	45.83	14.39	0.518
	420	47.33	12.89	0.464
	480	48.78	11.44	0.412
	540	49.98	10.24	0.368
	600	51.08	9.14	0.329
	780	53.78	6.44	0.232
	900	55.16	5.06	0.182
	1020	56.31	3.91	0.141
	1200	57.57	2.65	0.095
	1500	58.67	1.55	0.056
	1800	59.09	1.13	0.041
	2100	59.28	0.94	0.034
	2400	59.38	0.84	0.030

At Match Line t = 114 seconds

$$T = \frac{r^2}{t \text{ match}} = \frac{(0.255)^2}{114} = 0.00057 \text{ ft}^2/\text{sec} = 368 \text{ gpd/ft}$$

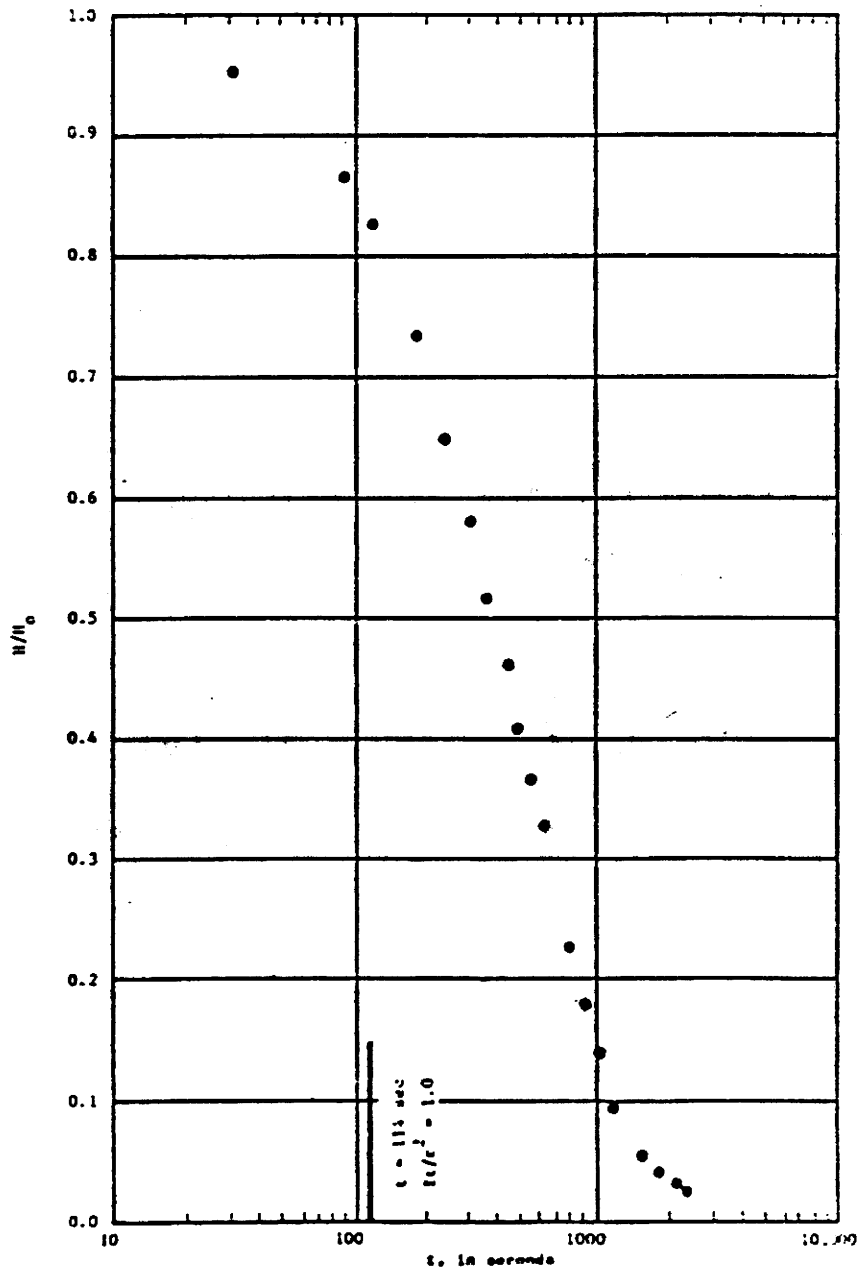
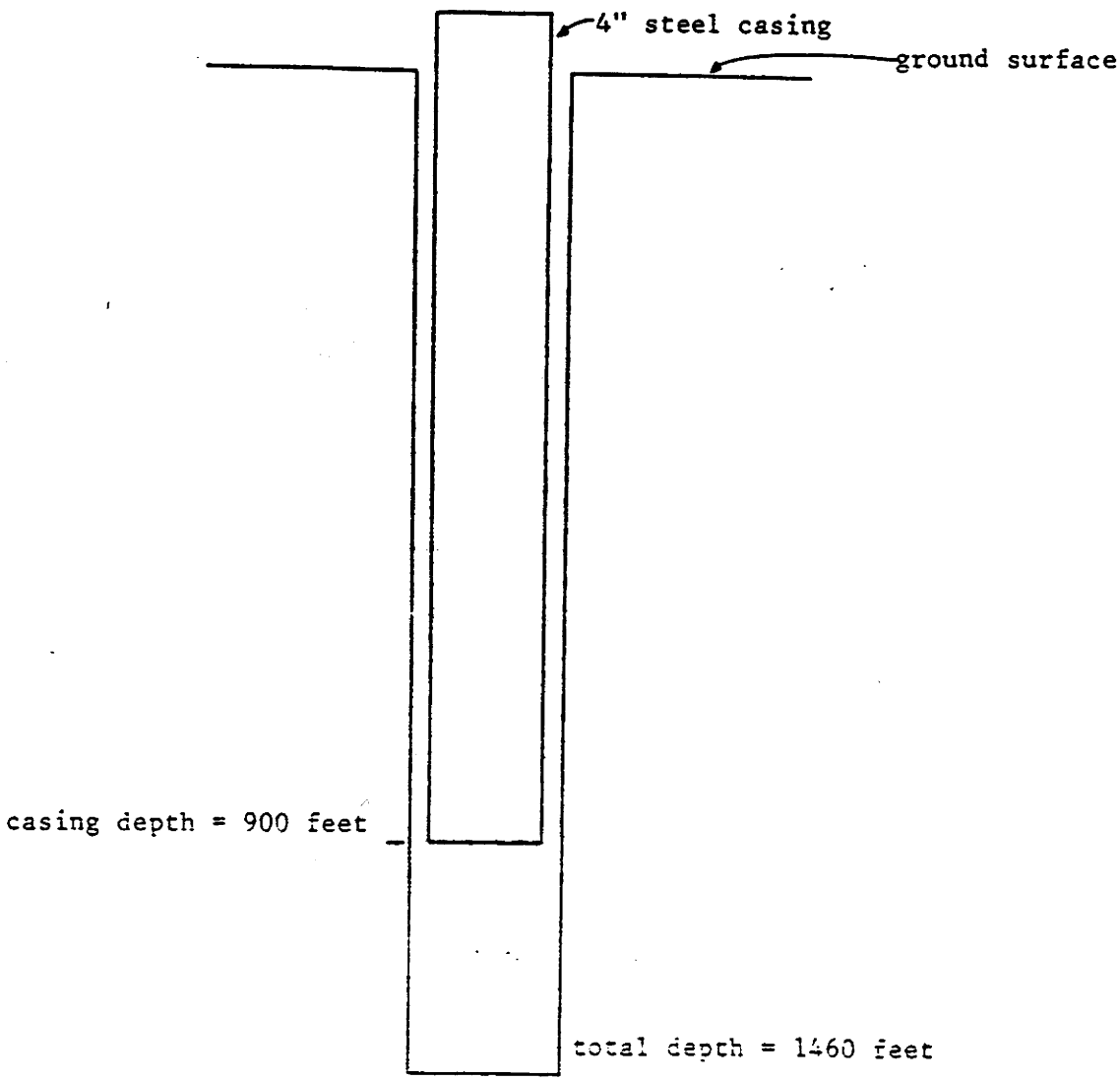


Figure A-12. Graphical results of the slug test for Well WQ-8 when the hole terminated below the coal zone.

Table A-24. Miscellaneous information pertaining to Well WQ-10.

Location Number:	WQ-10	Hydrologic Zone Monitored:	Combined below, in, and above coal.
Date Drilled:	November, 1981	Surface Elevation:	9077.15 ft. MSL
Total Depth:	1460 feet	Casing Depth:	900 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8470 ft. MSL	Perforated Interval:	None - open end



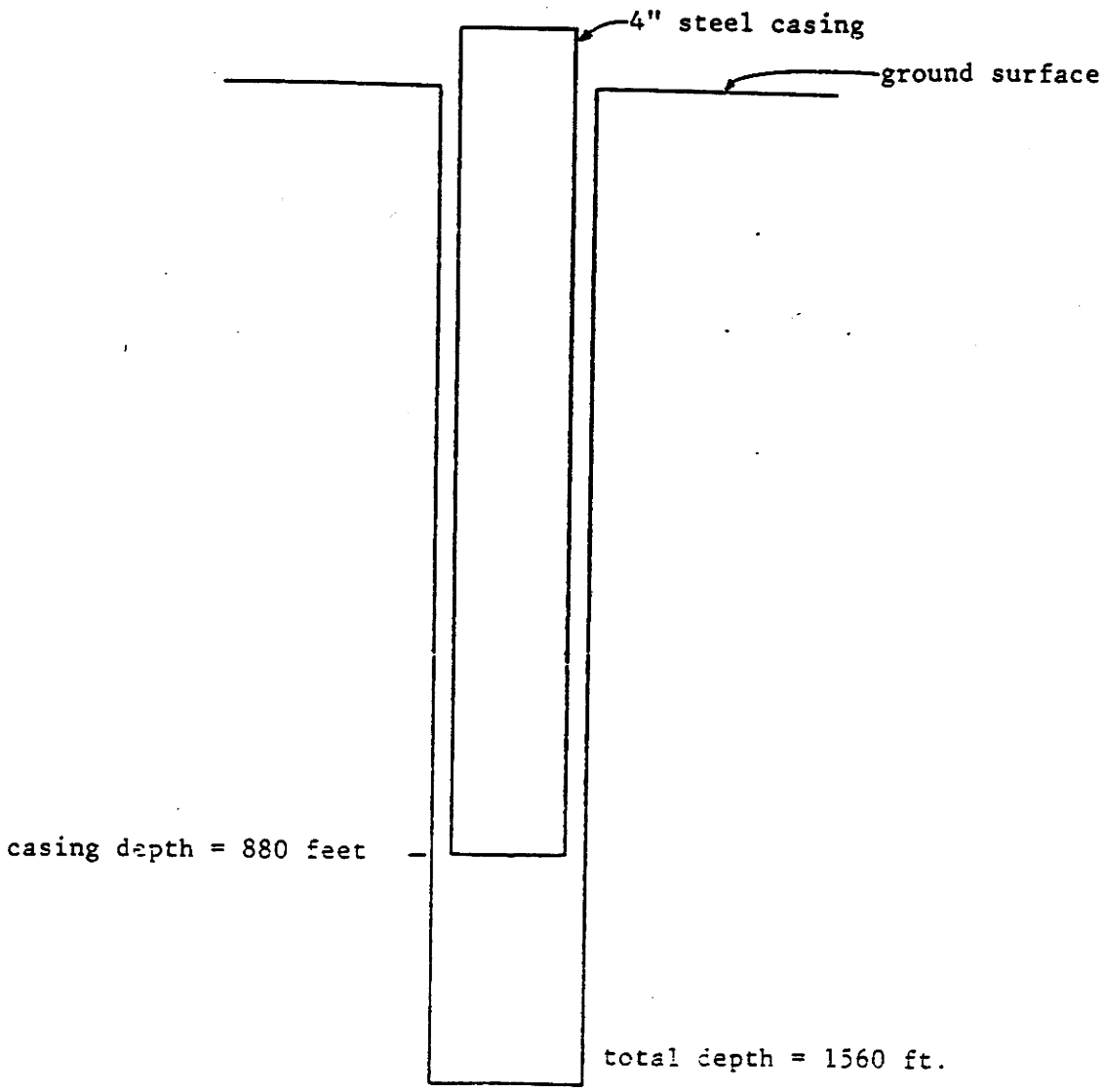
(Not to Scale)

Table A-25. Water level measurements in Well WQ-10. Ground surface is 9077.15 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
11-11-81	---	611	8466	Collar is assumed to be 2 feet above ground surface.
11-13-81	---	607	8470	"

Table A-26. Miscellaneous information pertaining to Well WQ-11.

Location Number:	WQ-11	Hydrologic Zone Monitored:	Combined below, in, and above coal.
Date Drilled:	October, 1981	Surface Elevation:	abt. 9300 feet MSL
Total Depth:	1560 feet	Casing Depth:	880 feet
Drill Bit Diameter:	6 1/8 inches	Casing Diameter:	4 inches
Static Water Level:	8432 ft. MSL	Perforated Interval:	None - open end



(Not to Scale)

Table A-27. Water level measurements in Well WQ-11. Ground surface is about 9300 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
11-5-81	---	889.6	8412.1	Collar is 1.7 feet above ground surface.
11-13-81	---	870.0	8431.7	"

Table A-29. Miscellaneous information pertaining to Well WO-12.

Location Number: WO-12

Date Drilled: November 1981

Total Depth: 280 ft. concrete plug from 130 to 280 ft.

Static Water Level: 8049 ft. MSL

Drill Bit Diameter: 8 3/4" to 20 ft; 7 7/8" to 60 ft; 6 1/8" to 280 ft.

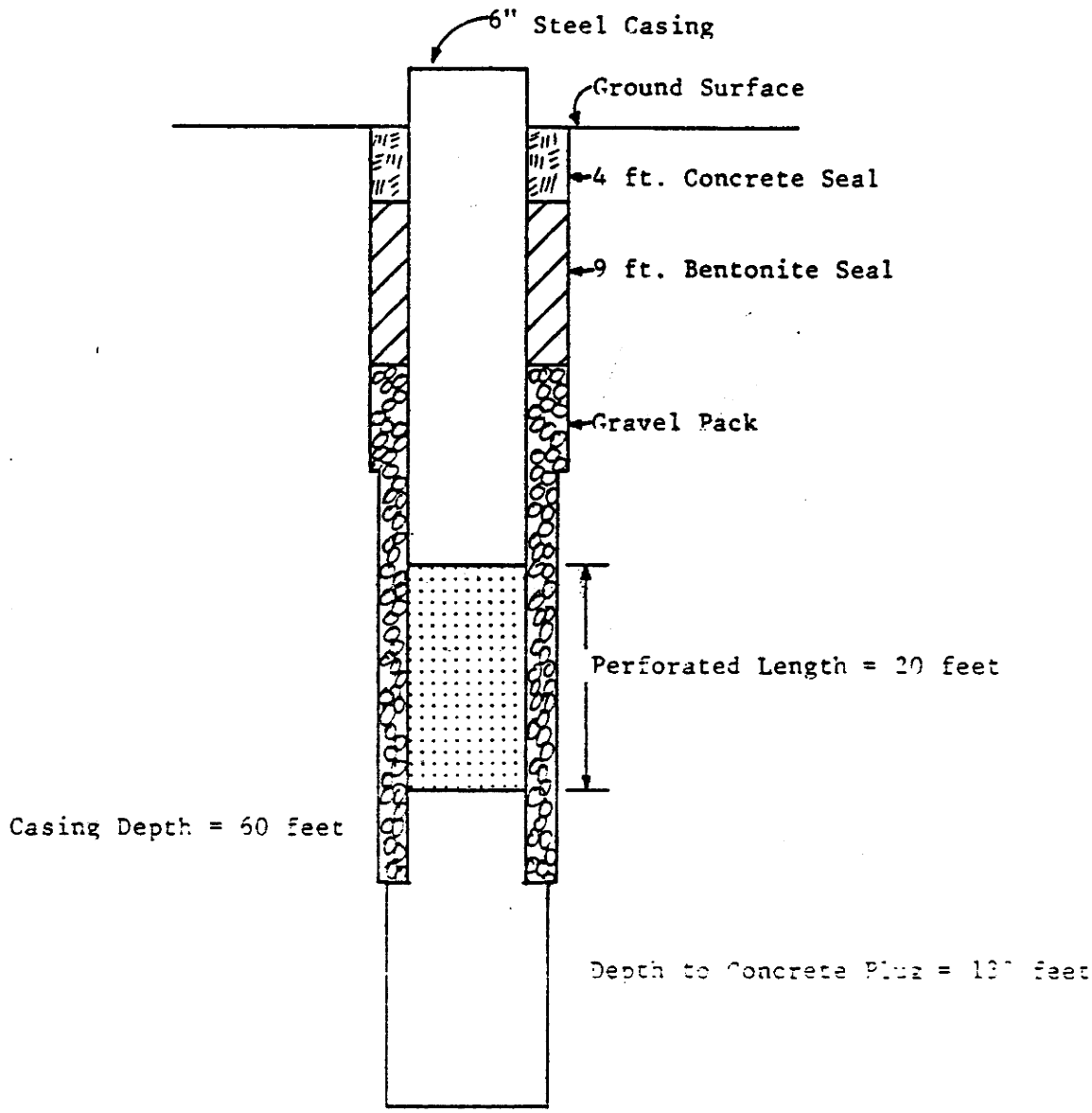
Hydrologic Zone Monitored: Above Coal

Surface Elevation: 8065.26 ft MSL

Casing Depth: 60 feet

Casing Diameter: 6 inches

Perforated Interval: 30 to 50 feet



(Not to scale)

Table A-29. Water level measurements in Well WQ-12. Ground surface is 8065.26 feet above MSL.

Date	Time	Depth from Collar	Elevation above MSL	Remarks
11-10-81	18:05	18.73	8049.04	Collar is 2.51 feet above ground surface.

Table A-30. Tabulated drawdown and recovery data for Well WO-12.

Date	Time	t (min)	t' (min)	t/t'	Depth Water (ft)	Drawdown (ft)	Remarks
11-10-81	18:05	0			18.65	0	
		1			21.37	2.64	
		2			21.96	3.23	
		3			22.92	4.19	
		4			23.73	5.00	
		5			24.53	5.80	
		6			25.29	6.56	
		7			25.71	6.98	
		8			26.33	7.60	
		9			26.98	8.25	
		10			27.43	8.70	
		11.5			28.11	9.38	
		12			28.35	9.62	
		13			28.81	10.08	
		14			29.23	10.50	
		15.2			29.69	10.96	
		16			30.04	11.31	
		17.2			30.43	11.70	
		18			30.71	11.98	
		19			31.13	12.40	
		20			31.54	12.81	
		22			32.27	13.54	
		24.2			32.83	14.10	
		26			33.35	14.62	Flow 36 gpm
		28			34.05	15.32	
		30			34.49	15.76	
		35.3			35.75	17.02	
		40			36.89	18.16	
		45			37.87	19.14	

Table A-30 continued.

Date	Time	t (min)	t' (min)	t/t'	Depth Water (ft)	Drawdown (ft)	Remarks
		51			38.96	20.23	
		56			39.88	21.15	
		60			40.33	21.60	
		65			40.48	21.75	
		70			40.60	21.87	
		75			40.64	21.91	
		80			40.64	21.91	
		105			40.74	22.01	Flow 36 gpm
		115			40.77	22.04	
		145			41.19	22.46	
		175			41.09	22.36	Pump Off - 4 min.
		205			42.06	23.33	
		235			42.63	23.90	
		295			43.60	23.87	
11-11-81		355			46.01	27.28	
		415			55.12	26.39	Flow 27 gpm
		425			45.83	27.10	Cut Back Water Level Down To Pump
		475			45.70	26.97	
		565			45.83	27.10	
		655			46.00	27.27	Flow 27 gpm
		745			46.36	27.63	Pump Off 0.5 min.
		775			46.00	27.27	
		835	0		47.25	28.52	Flow 27 gpm
		835.5	0.5	1671	45.03	26.30	
		836.0	1.0	836	44.80	26.07	Water is Spilling Inside Casing Very Loud
		836.5	1.5	557.67	44.74	26.01	
		837.0	2.0	418.50	44.61	25.88	
		837.5	2.5	335	44.52	25.79	
		838.0	3.0	279.33	44.46	25.73	
		838.5	3.5	239.56	44.34	25.61	

Table A-30 continued.

Date	Time	t (min)	t' (min)	t/t'	Depth Water (ft)	Drawdown (ft)	Remarks
		839.0	4.0	209.75	44.32	25.59	
		839.5	4.5	186.56	44.27	25.54	
		840.0	5.0	168	44.24	25.51	
		841	6	140.17	44.17	25.44	
		842	7	120.29	44.12	25.39	
		843	8	105.38	44.07	25.34	
		844	9	93.78	44.03	25.30	
		845	10	84.50	43.99	25.26	
		847	12	70.58	43.95	25.22	
		849	14	60.64	43.86	25.13	
		851	16	53.19	43.80	25.07	
		853	18	47.39	43.71	24.98	
		855	20	42.75	43.68	24.95	
		857	22	38.95	43.66	24.93	
		859	24	35.79	43.64	24.91	Water Continues Spilling Inside Casing
		861	26	33.12	43.60	24.87	
		863	28	30.82	43.50	24.77	
		865	30	28.83	43.43	24.70	
		870	35	24.86	43.28	24.55	
		876	41	21.37	43.01	24.28	
		880	45	19.56	42.95	24.22	
		885	50	17.70	42.78	24.05	
		890	55	16.18	42.62	23.89	
		895	60	14.92	42.38	23.65	
		905	70	12.93	42.09	23.36	
		915	80	11.44	41.81	23.08	
		926	91	10.18	41.35	22.62	
		935	100	9.35	40.93	22.20	
		945	110	8.59	40.48	21.75	
		955	120	7.96	39.87	21.14	
		965	130	7.42	39.06	20.33	Water Spilling Inside Casing Almost Gone
		975	140	6.96	37.96	19.23	

Table A-30 continued.

Date	Time	t (min)	t' (min)	t/t'	Depth Water (ft)	Drawdown (ft)	Remarks
		986	151	6.53	36.58	17.85	
		995	160	6.22	35.35	16.62	
		1005	170	5.91	34.06	15.33	
		1015	180	5.64	32.79	14.06	
		1025	190	5.39	31.64	12.91	
		1035	200	5.18	30.56	11.83	
		1045	210	4.98	29.58	10.85	
		1060	225	4.71	28.15	9.42	
		1075	250	4.48	27.15	8.42	Water Has Stopped Spilling Inside Casing
		1090	255	4.27	26.30	7.57	
		1106	271	4.08	25.56	6.83	
		1125	290	3.88	25.04	6.31	
		1200	365	3.29	22.72	3.99	

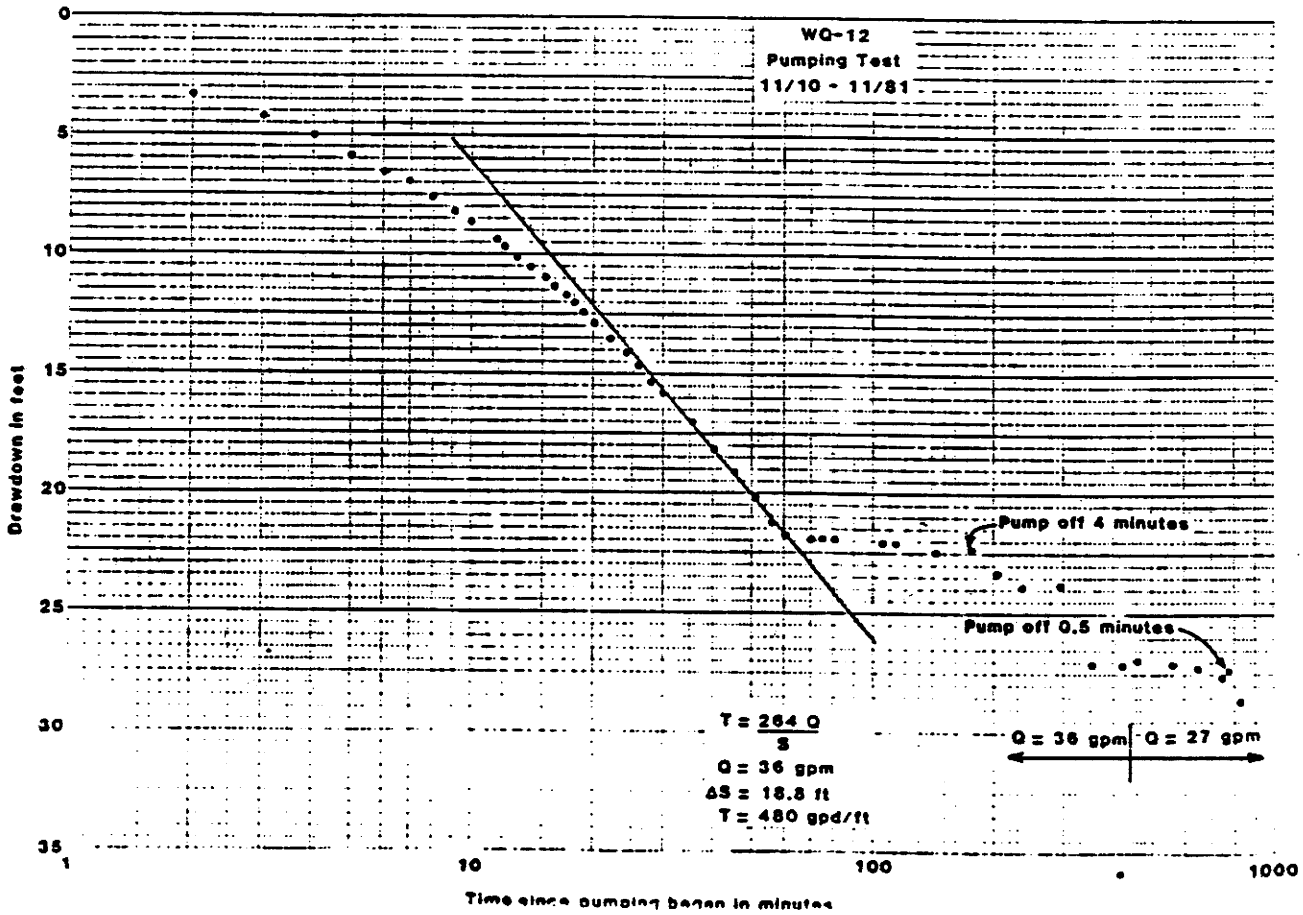


Figure A-13. Graphical results of the drawdown test for Well WQ-12.

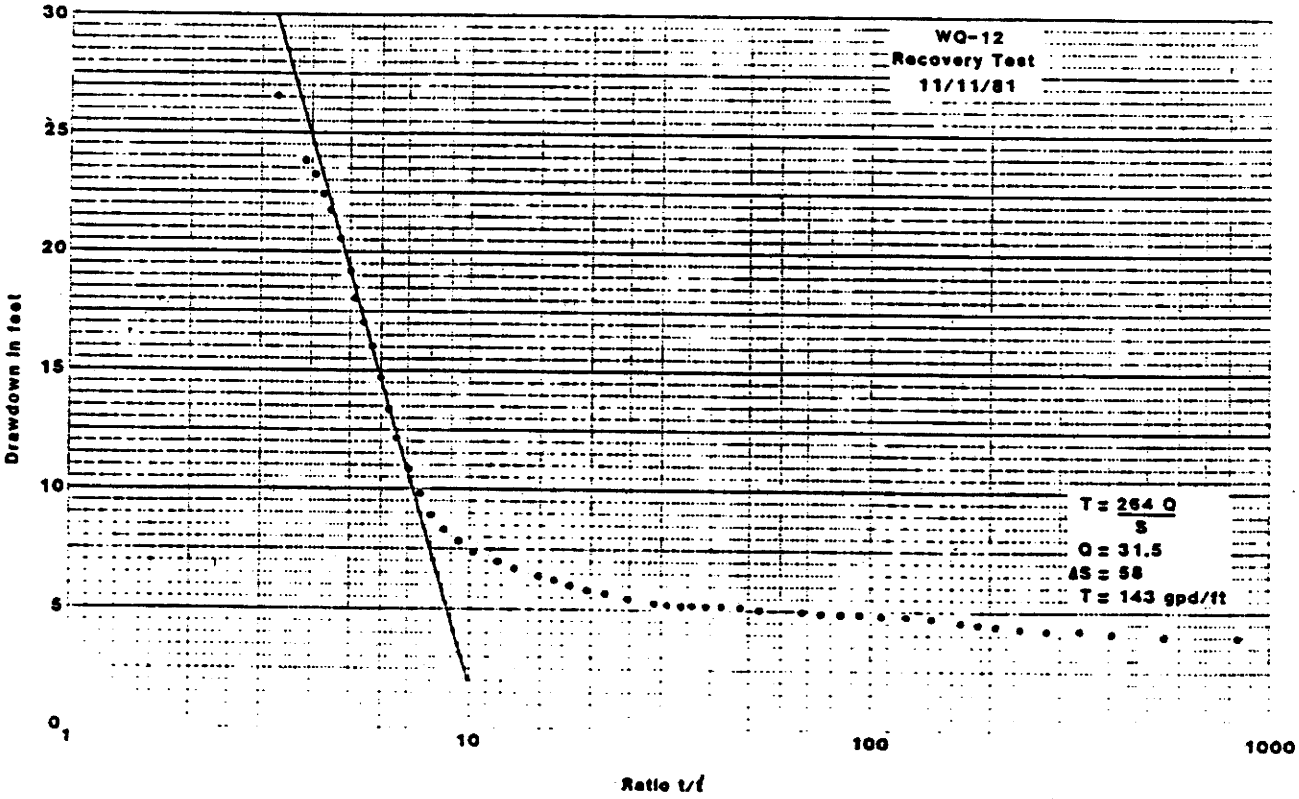


Figure A-14. Graphical results of the recovery test conducted in Well WQ-12.

ATTACHMENT B

WATER QUALITY ANALYSES

Table B-1. Results of chemical analyses of surface water quality samples collected at Station U-1.

Date	10-22-80	11-7 80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	1.2	1.6	1.7		Inaccessible	Inaccessible
Specific Conductance, umhos/cm	400	420	225	215		
Temperature, Air °C	10	6	1	5		
Temperature, Water °C	4	1	0	0		
pH	7.8	7.8	7.1	7.7		
Oil & Grease	5.80	<0.01	3.80	0.40		
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01	<0.01		
Nitrate as NO3-N mg/l	0.07	0.15	0.28	0.23		
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.03	0.20	0.10	0.10		
Phosphate as PO4-P Total mg/l	0.040	0.160	0.120	0.060		
Phosphate as PO4-P Ortho mg/l	<0.001	<0.001	0.040	0.040		
Sulfate as SO4 mg/l	16.5	18.0	15.0	12.0		
Sulfide mg/l						
Total Suspended Solids mg/l	6.0	4.0	1.0	26.0		
Total Dissolved Solids mg/l	260	252	235	252		
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01	<0.01		
Bicarbonate as HCO3 mg/l	280.60	275.72	273.28	283.04		
Alkalinity as CaCO3 (Total) mg/l	230	226	224	232		
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	4.0	26.0	8.0	16.0		
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001	<0.001		
Barium as Ba (Total) mg/l	0.050	0.024	0.035	0.055		
Boron as B (Total) mg/l	0.036	0.066	0.080	0.020		
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001	0.001		
Calcium as Ca mg/l	71.20	76.80	71.20	68.00		
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001	<0.001		
Copper as Cu (Total) mg/l	<0.001	<0.001	0.010	0.002		
Iron as Fe (Total) mg/l	0.144	0.850	0.230	0.230		
Lead as Pb (Total) mg/l	<0.001	0.010	0.003	0.002		
Magnesium as Mg mg/l	13.92	9.12	12.48	12.00		
Manganese as Mn (Total) mg/l	0.015	0.030	0.035	0.030		
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002	<0.0002		
Molybdenum as Mo (Total) mg/l	< 0.001	< 0.001	< 0.001	< 0.001		
Potassium as K mg/l	1.38	1.44	1.50	1.53		
Selenium as Se (Total) mg/l	<0.001	<0.001	0.003	<0.001		
Silver as As (Total) mg/l	0.002	<0.001	<0.001	<0.001		
Sodium as Na mg/l	6.40	6.80	4.20	12.00		
Zinc as Zn (Total) mg/l	0.005	0.022	0.005	0.015		
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.035	0.020	0.025	0.020		
Boron as B (Dissolved) mg/l	0.005	0.030	0.070	0.015		
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Chloride as Cl (Dissolved) mg/l	4.7	3.6	0.44	5.35		
Chromium as Cr (Dissolved) mg/l	0.001	0.001	0.001	0.001		
Copper as Cu (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Fluoride as F (Dissolved) mg/l	0.11	0.11	0.09	0.19		
Iron as Fe (Dissolved) mg/l	0.065	0.830	0.040	0.010		
Lead as Pb (Dissolved) mg/l	<0.001	0.007	<0.001	0.002		
Manganese as Mn (Dissolved) mg/l			0.035			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001		
Zinc as Zn (Dissolved) mg/l	0.002	0.020	0.005	0.005		

Table B-1. Continued.

Date	4-22-81	5-27-81	7-23-81	9-22-81	11-13-81
Flow, cfs		9	1.6	0.5	
Specific Conductance, umhos/cm	330	140	340	338	
Temperature, Air °C			20	15	
Temperature, Water °C	8	8	17	18	
pH	8.3	8.2	8.1	8.4	7.5
Oil & Grease		0.2			
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01	0.61	0.39
Nitrate as NO3-N mg/l	0.36	0.12	0.02	<0.01	0.03
Nitrite as No2-N mg/l		<0.01	<0.01	<0.01	< 0.01
Nitrogen as KJELDAHL (Total) mg/l					
Phosphate as PO4-P Total mg/l	0.110	0.050	0.280	0.265	0.330
Phosphate as PO4-P Ortho mg/l	0.030	0.040			
Sulfate as SO4 mg/l	15.0	27.0	19.0	33.0	98.0
Sulfide mg/l		0.01	0.65	3.60	2.75
Total Suspended Solids mg/l	21.0	5.0	54.0	1.0	3.0
Total Dissolved Solids mg/l	175	162	220	330	345
Total Combustible Solids					
Carbonate as CO3 mg/l	9.60	0.01	2.40	2.40	7.20
Bicarbonate as HCO3 mg/l	151.28	141.52	226.92	331.84	228.40
Alkalinity as CaCO3 (Total) mg/l	140	116	190	276	199.20
Total Hardness as CaCO3 mg/l		118	210	226	210
Acidity as CaCO3 mg/l	<0.01	<0.01	<0.1	<0.01	< 0.01
Arsenic as As (Total) mg/l	<0.001				
Barium as Ba (Total) mg/l	0.015				
Boron as B (Total) mg/l	0.015				
Cadmium as Cd (Total) mg/l	<0.001				
Calcium as Ca mg/l	57.60	40.00	68.00	69.60	66.00
Chromium as Cr (Total) mg/l	<0.001				
Copper as Cu (Total) mg/l	0.010				
Iron as Fe (Total) mg/l	0.080	0.070	0.520	0.320	0.335
Lead as Pb (Total) mg/l	0.002				
Magnesium as Mg mg/l	5.28	4.32	9.60	12.48	13.00
Manganese as Mn (Total) mg/l	0.030	0.030			
Mercury as Hg (Total) mg/l	< 0.0002				
Molybdenum as Mo (Total) mg/l	< 0.001				
Potassium as K mg/l	1.30	0.83	1.50	1.30	1.30
Selenium as Se (Total) mg/l	< 0.001				
Silver as As (Total) mg/l	0.076				
Sodium as Na mg/l	3.50	13.00	3.60	43.00	40.90
Zinc as Zn (Total) mg/l	0.010				
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Aluminum as Al (Dissolved) mg/l		0.030	< 0.001	< 0.001	0.010
Barium as Ba (Dissolved) mg/l	0.010	0.015	0.018	0.025	0.020
Boron as B (Dissolved) mg/l	0.010	0.010	0.012	0.020	0.015
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	12.00	4.00	5.27	10.00	3.50
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper as Cu (Dissolved) mg/l	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001
Fluoride as F (Dissolved) mg/l					
Iron as Fe (Dissolved) mg/l	0.080	0.020	0.210	0.130	0.120
Lead as Pb (Dissolved) mg/l	< 0.001	< 0.001	0.002	0.002	0.003
Manganese as Mn (Dissolved) mg/l	0.010	0.020	0.030	0.020	0.021
Mercury as Hg (Dissolved) mg/l		< 0.0002	< 0.0002	< 0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/l		< 0.001	< 0.001	< 0.001	< 0.001
Nickel as Ni (Dissolved) mg/l		< 0.001	< 0.001	< 0.001	< 0.01
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Silver as As (Dissolved) mg/l	0.033				
Zinc as Zn (Dissolved) mg/l	0.002	0.005	0.012	0.008	0.010
Vanadium		< 0.001	< 0.001	< 0.001	< 0.001

Table B-2. Results of chemical analyses of surface water quality samples collected at Station U-2.

Date	4-22-81	5-27-81	7-23-81	9-22-81	11-13-81
Flow, cfs	0.02	0.01		0.004	
Specific Conductance, umhos/cm	480	400	640	505	
Temperature, Air °C				18	
Temperature, Water °C	3	10		10	
pH	8.3	7.8	7.7	8.5	8.0
Oil & Grease		0.01			
Ammonia as NH3-N mg/l	< 0.01	< 0.01	0.10	0.52	0.48
Nitrate as NO3-N mg/l	0.14	0.07	0.10	< 0.01	0.07
Nitrite as No2-N mg/l		< 0.01	< 0.01	< 0.01	< 0.01
Nitrogen as KJELDAHL (Total) mg/l					
Phosphate as PO4-P Total mg/l	0.160	0.270	0.230	0.250	0.520
Phosphate as PO4-P Ortho mg/l	0.004	0.080			0.020
Sulfate as SO4 mg/l	24.0	39.0	55.0	243	33.0
Sulfide mg/l		0.01	0.44	1.65	2.00
Total Suspended Solids mg/l	36.0	1.0	12.0	1.0	
Total Dissolved Solids mg/l	260	350	415	450	425
Total Combustible Solids					
Carbonate as CO3 mg/l	12.00	< 0.01	< 0.01	2.40	< 0.01
Bicarbonate as HCO3 mg/l	253.76	353.80	429.44	119.56	474.50
Alkalinity as CaCO3 (Total) mg/l	228	290	352	102	389
Total Hardness as CaCO3 mg/l		320	408	366	360
Acidity as CaCO3 mg/l	<0.01	3.80	5.70	2.00	8.00
Arsenic as As (Total) mg/l	<0.001				
Barium as Ba (Total) mg/l	0.030				
Boron as B (Total) mg/l	0.036				
Cadmium as Cd (Total) mg/l	<0.001				
Calcium as Ca mg/l	67.20	72.00	100	76.00	99.00
Chromium as Cr (Total) mg/l	<0.001				
Copper as Cu (Total) mg/l	0.010				
Iron as Fe (Total) mg/l	0.510	0.060	0.530	0.040	0.050
Lead as Pb (Total) mg/l	0.004				
Magnesium as Mg mg/l	21.12	33.60	37.92	42.24	38.50
Manganese as Mn (Total) mg/l	0.020	0.010			
Mercury as Hg (Total) mg/l	<0.0002				
Molybdenum as Mo (Total) mg/l	<0.001				
Potassium as K mg/l	2.30	3.00	3.12	2.95	1.80
Selenium as Se (Total) mg/l	0.002				
Silver as As (Total) mg/l	0.003				
Sodium as Na mg/l	3.50	9.00	5.80	6.10	8.30
Zinc as Zn (Total) mg/l	0.020				
Arsenic as As (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001	< 0.001
Aluminum as Al (Dissolved) mg/l		< 0.001	< 0.001	< 0.001	< 0.001
Barium as Ba (Dissolved) mg/l	0.022	0.030	0.035	0.040	0.045
Boron as B (Dissolved) mg/l	0.036	0.050	0.027	0.060	0.045
Cadmium as Cd (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	6.00	10.00	6.75	16.00	4.40
Chromium as Cr (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper as Cu (Dissolved) mg/l	0.010	< 0.001	0.010	< 0.001	< 0.001
Fluoride as F (Dissolved) mg/l	0.20				
Iron as Fe (Dissolved) mg/l	0.160	0.010	0.112	0.020	0.025
Lead as Pb (Dissolved) mg/l	0.004	< 0.001	0.003	< 0.001	< 0.001
Manganese as Mn (Dissolved) mg/l	0.020	0.010	0.020	0.010	0.020
Mercury as Hg (Dissolved) mg/l		< 0.0002	< 0.0002	< 0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/l		< 0.001	< 0.001	< 0.001	< 0.001
Nickel as Ni (Dissolved) mg/l		< 0.001	< 0.001	< 0.001	< 0.01
Selenium as Se (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001	< 0.001
Silver as As (Dissolved) mg/l	0.002				
Zinc as Zn (Dissolved) mg/l	0.010	0.002	0.022	0.010	0.280
Vanadium		< 0.001	< 0.001	< 0.001	< 0.001

Table B-2. Continued.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.03		0.003	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	560	680	352			
Temperature, Air °C	10		1			
Temperature, Water °C	5		2			
pH	7.5	7.3	7.0			
Oil & Grease	1.80	<0.01	2.00			
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01			
Nitrate as NO3-N mg/l	0.05	0.05	0.12			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.10	0.05	0.12			
Phosphate as PO4-P Total mg/l	0.035	0.100	0.170			
Phosphate as PO4-P Ortho mg/l	0.030	<0.001	0.040			
Sulfate as [illegible] mg/l	18.0	42.0	34.5			
Sulfide mg/l						
Total Suspe[illegible] Solids mg/l	16.0	12.0	8.0			
Total Dissolved Solids mg/l	362	360	396			
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01			
Bicarbonate as HCO3 mg/l	400.16	397.72	448.96			
Alkalinity as CaCO3 (Total) mg/l	328	326	368			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	12.0	44.0	20.0			
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001			
Barium as Ba (Total) mg/l	0.133	0.086	0.050			
Boron as B (Total) mg/l	0.025	0.070	0.085			
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001			
Calcium as Ca mg/l	80.80	83.20	94.40			
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001			
Copper as Cu (Total) mg/l	0.003	0.015	0.006			
Iron as Fe (Total) mg/l	0.166	0.660	0.310			
Lead as Pb (Total) mg/l	<0.001	0.009	0.004			
Magnesium as Mg mg/l	30.24	30.24	39.36			
Manganese as Mn (Total) mg/l	0.014	0.010	0.010			
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002			
Molybdenum as Mo (Total) mg/l	< 0.001	<0.001	<0.001			
Potassium as K mg/l	2.91	2.69	2.70			
Selenium as Se (Total) mg/l	<0.001	<0.001	0.003			
Silver as As (Total) mg/l	<0.001	<0.001	<0.001			
Sodium as Na mg/l	10.00	19.00	4.80			
Zinc as Zn (Total) mg/l	0.011	0.035	0.005			
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.024	0.040	0.040			
Boron as B (Dissolved) mg/l	0.010	0.060	0.075			
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001			
Chloride as Cl (Dissolved) mg/l	5.4	3.7	0.51			
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001			
Copper as Cu (Dissolved) mg/l	<0.001	0.010	<0.001			
Fluoride as F (Dissolved) mg/l	0.21	0.16	0.13			
Iron as Fe (Dissolved) mg/l	0.095	0.630	0.120			
Lead as Pb (Dissolved) mg/l	<0.001	0.006	<0.001			
Manganese as Mn (Dissolved) mg/l			0.010			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001			
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001			
Zinc as Zn (Dissolved) mg/l	0.008	0.030	0.005			

Table B-3. Results of chemical analyses of surface water quality samples collected at Station U-3.

Date	10-22-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.04			Inaccessible	Inaccessible	0.02
Specific Conductance, umhos/cm	450	600	205			280
Temperature, Air °C	11		6			
Temperature, Water °C	3		0			2
pH	7.6	7.6	7.8			8.1
Oil & Grease	0.80	< 0.01	1.20			
Ammonia as NH3-N mg/l	< 0.01	< 0.01	0.16			< 0.01
Nitrate as NO3-N mg/l	0.15	0.20	0.25			0.18
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.05	0.12	0.15			
Phosphate as PO4-P Total mg/l	0.040	0.160	0.180			0.770
Phosphate as PO4-P Ortho mg/l	0.020	< 0.001	0.160			0.090
Sulfate as SO4 mg/l	39.0	15.0	12.00			9.0
Sulfide mg/l						
Total Suspended Solids mg/l	24.0	33.0	2.0			507
Total Dissolved Solids mg/l	288	260	220			159
Total Combustible Solids						
Carbonate as CO3 mg/l	< 0.01	< 0.01	< 0.01			4.80
Bicarbonate as HCO3 mg/l	283.04	292.80	265.96			161.04
Alkalinity as CaCO3 (Total) mg/l	232	240	218			140
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	12.0	24.0	10.0			< 0.01
Arsenic as As (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Barium as Ba (Total) mg/l	0.036	0.050	0.050			0.060
Boron as B (Total) mg/l	0.015	0.068	0.025			0.030
Cadmium as Cd (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Calcium as Ca mg/l	62.40	72.00	68.80			44.80
Chromium as Cr (Total) mg/l	< 0.001	< 0.001	< 0.001			0.002
Copper as Cu (Total) mg/l	0.002	< 0.001	0.015			0.030
Iron as Fe (Total) mg/l	0.117	0.280	0.170			6.550
Lead as Pb (Total) mg/l	< 0.001	< 0.001	0.009			0.013
Magnesium as Mg mg/l	20.64	12.00	12.00			9.12
Manganese as Mn (Total) mg/l	0.002	0.030	0.020			0.440
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002			< 0.0002
Molybdenum as Mo (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Potassium as K mg/l	1.62	1.61	1.48			2.02
Selenium as Se (Total) mg/l	< 0.001	< 0.001	< 0.001			0.002
Silver as As (Total) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Sodium as Na mg/l	14.20	11.00	6.00			2.50
Zinc as Zn (Total) mg/l	0.009	0.011	0.020			0.060
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.025	0.030	0.020			0.035
Boron as B (Dissolved) mg/l	0.006	0.060	0.015			0.020
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Chloride as Cl (Dissolved) mg/l	3.9	3.5	5.62			
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001			< 0.001
Copper as Cu (Dissolved) mg/l	< 0.001	< 0.001	0.010			0.010
Fluoride as F (Dissolved) mg/l	0.17	0.03	0.17			
Iron as Fe (Dissolved) mg/l	0.088	0.020	0.020			2.180
Lead as Pb (Dissolved) mg/l	< 0.001	< 0.001	0.001			0.005
Manganese as Mn (Dissolved) mg/l						0.420
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001			< 0.001
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001			< 0.001
Zinc as Zn (Dissolved) mg/l	0.004	0.010	0.002			0.023

Table B-3. Continued.

Date	5-14-81	7-23-81	9-22-81	11-13-81
Flow, cfs	0.04	---	0.004	
Specific Conductance, umhos/cm	310		402	266
Temperature, Air °C			16	
Temperature, Water °C			18	
pH	8.4		8.2	7.4
Oil & Grease				
Ammonia as NH3-N mg/l	< 0.01		1.45	0.56
Nitrate as NO3-N mg/l	< 0.01		< 0.01	0.01
Nitrite as No2-N mg/l	< 0.01		< 0.01	<0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l			0.155	0.420
Phosphate as PO4-P Ortho mg/l	< 0.001			0.020
Sulfate as SO4 mg/l	38.0		9.0	60.0
Sulfide mg/l	0.84		4.80	2.00
Total Suspended Solids mg/l			115	
Total Dissolved Solids mg/l	259		275	335
Total Combustible Solids				
Carbonate as CO3 mg/l	0.01		4.80	<0.01
Bicarbonate as HCO3 mg/l	248		295.24	301.30
Alkalinity as CaCO3 (Total) mg/l	248		250	248
Total Hardness as CaCO3 mg/l			240	168
Acidity as CaCO3 mg/l			<0.01	8.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	59.00		68.80	77.00
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	0.170		1.600	0.825
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	24.00		16.32	19.00
Manganese as Mn (Total) mg/l	0.020			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	1.62		1.78	1.80
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	4.00		14.00	20.80
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	< 0.001		< 0.001	<0.001
Aluminum as Al (Dissolved) mg/l	< 0.001		< 0.001	<0.015
Barium as Ba (Dissolved) mg/l	0.025		0.030	0.025
Boron as B (Dissolved) mg/l	0.020		0.030	0.020
Cadmium as Cd (Dissolved) mg/l	< 0.001		< 0.001	<0.001
Chloride as Cl (Dissolved) mg/l	8.00		12.00	3.50
Chromium as Cr (Dissolved) mg/l	< 0.001		< 0.001	<0.001
Copper as Cu (Dissolved) mg/l	< 0.001		< 0.001	<0.001
Fluoride as F (Dissolved) mg/l				0.17
Iron as Fe (Dissolved) mg/l	0.020		0.010	0.015
Lead as Pb (Dissolved) mg/l	0.003		0.002	<0.001
Manganese as Mn (Dissolved) mg/l	0.010		0.010	0.065
Mercury as Hg (Dissolved) mg/l	< 0.0002		< 0.0002	<0.0002
Molybdenium as Mo (Dissolved) mg/l	< 0.001		< 0.001	<0.001
Nickel as Ni (Dissolved) mg/l	< 0.001		< 0.001	<0.01
Selenium as Se (Dissolved) mg/l	< 0.001		< 0.001	<0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l			0.005	0.014
Vanadium			< 0.001	<0.001

Table B-4. Results of chemical analyses of surface water quality samples collected at Station U-4.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	1.4	1.9	1.5	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	420	430	232			
Temperature, Air °C	1	7	1			
Temperature, Water °C	0	2	0			
pH						
Oil & Grease	0.60	<0.01	1.80			
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01			
Nitrate as NO3-N mg/l	0.09	0.19	0.29			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.10	0.10	0.10			
Phosphate as PO4-P Total mg/l	0.065	0.140	0.130			
Phosphate as PO4-P Ortho mg/l	0.050	<0.001	0.120			
Sulfate as SO4 mg/l	45.0	18.0	30.0			
Sulfide mg/l						
Total Suspended Solids mg/l	9.0	5.0	3.0			
Total Dissolved Solids mg/l	266	240	240			
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01			
Bicarbonate as HCO3 mg/l	284.88	263.52	248.88			
Alkalinity as CaCO3 (Total) mg/l	204	216	204			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	8.0	26.0	12.0			
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001			
Barium as Ba (Total) mg/l	0.450	0.044	0.046			
Boron as B (Total) mg/l	0.010	0.050	0.065			
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001			
Calcium as Ca mg/l	67.20	71.20	69.60			
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001			
Copper as Cu (Total) mg/l	0.001	0.016	0.008			
Iron as Fe (Total) mg/l	0.159	0.960	0.160			
Lead as Pb (Total) mg/l	<0.001	0.010	<0.001			
Magnesium as Mg mg/l	19.68	10.08	13.44			
Manganese as Mn (Total) mg/l	0.007	0.030	0.025			
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002			
Molybdenum as Mo (Total) mg/l	<0.001	<0.001	<0.001			
Potassium as K mg/l	1.43	1.54	1.40			
Selenium as Se (Total) mg/l	<0.001	<0.001	0.002			
Silver as As (Total) mg/l	<0.001	<0.001	<0.001			
Sodium as Na mg/l	4.00	7.00	3.60			
Zinc as Zn (Total) mg/l	0.012	0.038	0.007			
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.400	0.030	0.025			
Boron as B (Dissolved) mg/l	0.008	0.060	0.050			
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001			
Chloride as Cl (Dissolved) mg/l	4.1	3.5	0.34			
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001			
Copper as Cu (Dissolved) mg/l	<0.001	0.010	<0.001			
Fluoride as F (Dissolved) mg/l	0.13	0.12	0.09			
Iron as Fe (Dissolved) mg/l	0.045	0.880	0.040			
Lead as Pb (Dissolved) mg/l	<0.001	0.008	<0.001			
Manganese as Mn (Dissolved) mg/l			0.020			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001			
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001			
Zinc as Zn (Dissolved) mg/l	0.006	0.030	0.007			

UPPER MIDDLE FORK OF ECCLES CREEK

Table B-4. Continued.

Date	4-22-81	7-23-81	9-22-81	11-13-81
Flow, cfs		1.4	1.5	0.8
Specific Conductance, umhos/cm	320	320	350	200
Temperature, Air °C				
Temperature, Water °C	7		18	
pH	8.40	8.1	8.4	8.2
Oil & Grease				
Ammonia as NH3-N mg/l	<0.01	< 0.01	1.44	0.43
Nitrate as NO3-N mg/l	0.43	1.01	< 0.01	0.07
Nitrite as No2-N mg/l		< 0.01	< 0.01	< 0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l	0.085	0.260	0.198	0.330
Phosphate as PO4-P Ortho mg/l	0.070			
Sulfate as SO4 mg/l	14.0	20.0	12.00	145
Sulfide mg/l		0.71	2.82	2.32
Total Suspended Solids mg/l	55.0	7.0	14.0	1.0
Total Dissolved Solids mg/l	168	210	350	370
Total Combustible Solids				
Carbonate as CO3 mg/l	7.20	14.40	< 0.01	7.20
Bicarbonate as HCO3 mg/l	153.72	187.88	385.52	217.60
Alkalinity as CaCO3 (Total) mg/l	138	168	316	190.40
Total Hardness as CaCO3 mg/l		200	220	200
Acidity as CaCO3 mg/l	<0.01	< 0.01	< 0.01	< 0.01
Arsenic as As (Total) mg/l	<0.001			
Barium as Ba (Total) mg/l	0.015			
Boron as B (Total) mg/l	0.014			
Cadmium as Cd (Total) mg/l	<0.001			
Calcium as Ca mg/l	55.20	60.00	64.00	67.00
Chromium as Cr (Total) mg/l	<0.001			
Copper as Cu (Total) mg/l	0.010			
Iron as Fe (Total) mg/l	0.400	0.152	0.010	0.155
Lead as Pb (Total) mg/l	0.002			
Magnesium as Mg mg/l	5.28	12.00	14.40	13.00
Manganese as Mn (Total) mg/l	0.020			
Mercury as Hg (Total) mg/l	<0.0002			
Molybdenum as Mo (Total) mg/l	<0.001			
Potassium as K mg/l	1.18	1.41	1.44	1.50
Selenium as Se (Total) mg/l	0.002			
Silver as Ag (Total) mg/l	<0.001			
Sodium as Na mg/l	3.00	4.40	56.00	58.20
Zinc as Zn (Total) mg/l	0.010			
Arsenic as As (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Aluminum as Al (Dissolved) mg/l		< 0.001	< 0.001	0.060
Barium as Ba (Dissolved) mg/l	0.011	0.015	0.020	0.025
Boron as B (Dissolved) mg/l	0.010	0.016	0.022	0.015
Cadmium as Cd (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	8.00	4.99	14.10	2.70
Chromium as Cr (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Copper as Cu (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Fluoride as F (Dissolved) mg/l				0.14
Iron as Fe (Dissolved) mg/l	0.020	0.152	0.017	0.098
Lead as Pb (Dissolved) mg/l	<0.001	0.003	< 0.001	< 0.001
Manganese as Mn (Dissolved) mg/l	<0.001	0.020	< 0.001	0.006
Mercury as Hg (Dissolved) mg/l		0.0004	< 0.0002	< 0.0002
Molybdenum as Mo (Dissolved) mg/l		< 0.001	< 0.001	< 0.001
Nickel as Ni (Dissolved) mg/l		< 0.001	< 0.001	< 0.01
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Silver as As (Dissolved) mg/l	< 0.001			
Zinc as Zn (Dissolved) mg/l	0.002	0.015	0.002	0.012
Vanadium		< 0.001	< 0.001	< 0.001

Table B-5. Results of chemical analyses of surface water quality samples collected at Station U-5.

Date	10-22-80	11-12-80	12-12-80	1-28-81	2-11-81	3-11-81	4-8-81
Flow, cfs	0.8	0.9	1.0	1.0	1.1	1	1
Specific Conductance, umhos/cm	470	440	450	255	490	289	298
Temperature, Air °C	8	6	7	-2	4	6	4
Temperature, Water °C	4	6	2	3	4	5	6
pH	7.6	7.1	7.5	7.4	7.8	8.0	7.6
Oil & Grease	0.20	0.80	2.00	0.40	<0.01	1.50	0.60
Ammonia as NH3-N mg/l	<0.01	<0.01	0.10	<0.01	<0.01	<0.01	0.10
Nitrate as NO3-N mg/l	<0.01	0.003	0.04	<0.01	<0.01	0.02	1.29
Nitrite as No2-N mg/l							
Nitrogen as KJELDAHL (Total) mg/l	0.08	0.10	0.20	0.10	0.04	<0.01	0.12
Phosphate as PO4-P Total mg/l	0.070	0.160	0.040	0.060	0.020	0.050	0.340
Phosphate as PO4-P Ortho mg/l	0.020	0.020	0.032	0.015	<0.001	0.040	<0.001
Sulfate as SO4 mg/l	15.0	9.0	21.0	17.0	23.0	17.0	34.0
Sulfide mg/l							
Total Suspended Solids mg/l	9.0	29.0	27.0	1.0	1.0	8.0	248
Total Dissolved Solids mg/l	295	290	290	300	320	280	290
Total Combustible Solids							
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01	<0.01	4.80	<0.01	<0.01
Bicarbonate as HCO3 mg/l	317.20	334.28	336.72	331.84	331.84	350.00	287.92
Alkalinity as CaCO3 (Total) mg/l	260	274	276	272	280	250	236
Total Hardness as CaCO3 mg/l							
Acidity as CaCO3 mg/l	8.0	18.0	14.0	20.0	4.0	4.0	18.0
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Barium as Ba (Total) mg/l	0.114	0.070	0.110	0.120	0.110	0.150	0.130
Boron as B (Total) mg/l	0.014	0.100	0.095	0.050	0.035	0.035	0.046
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Calcium as Ca mg/l	76.0	70.40	66.40	78.40	80.00	76.80	77.60
Chromium as Cr (Total) mg/l	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001
Copper as Cu (Total) mg/l	<0.001	0.010	0.012	0.010	0.010	0.010	0.030
Iron as Fe (Total) mg/l	0.210	0.150	0.390	0.220	0.190	0.190	0.230
Lead as Pb (Total) mg/l	<0.001	0.010	0.007	0.013	0.003	0.005	0.011
Magnesium as Mg mg/l	10.08	16.80	26.40	21.12	24.00	18.24	18.24
Manganese as Mn (Total) mg/l	0.010	0.045	0.012	0.030	0.030	0.020	0.036
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001	0.014	<0.001	<0.001	<0.001	<0.001	<0.001
Potassium as K mg/l	2.24	2.33	2.30	2.32	2.48	2.30	2.35
Selenium as Se (Total) mg/l	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Silver as As (Total) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sodium as Na mg/l	22.50	19.00	10.20	8.60	11.50	8.40	7.90
Zinc as Zn (Total) mg/l	0.010	0.020	0.014	0.015	0.006	0.010	0.016
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aluminum as Al (Dissolved) mg/l							
Barium as Ba (Dissolved) mg/l	0.100	0.036	0.095	0.100	0.095	0.100	0.050
Boron as B (Dissolved) mg/l	0.005	0.025	0.080	0.030	0.030	0.030	0.046
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride as Cl (Dissolved) mg/l	7.9	8.34	2.56	8.81	13.80	12.76	10.00
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper as Cu (Dissolved) mg/l	<0.001	0.003	0.010	<0.001	<0.001	<0.001	<0.001
Fluoride as F (Dissolved) mg/l	0.21	0.19	0.24	0.24	0.32	0.23	0.20
Iron as Fe (Dissolved) mg/l	0.063	0.830	0.060	0.160	0.040	0.040	0.150
Lead as Pb (Dissolved) mg/l	<0.001	0.007	0.003	0.002	0.003	<0.001	0.002
Manganese as Mn (Dissolved) mg/l						0.020	0.024
Mercury as Hg (Dissolved) mg/l						<0.0002	
Molybdenium as Mo (Dissolved) mg/l						< 0.001	
Nickel as Ni (Dissolved) mg/l						< 0.001	
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc as Zn (Dissolved) mg/l	0.003	0.013	0.013	0.003	0.006	0.005	0.005

Table B-5. Continued.

Date	5-27-81	7-22-81	9-23-81	11-11-81
Flow, cfs	0.03	0.3	1.2	0.9
Specific Conductance, umhos/cm	250	420	386	321
Temperature, Air °C	10	28	17	9
Temperature, Water °C	11	23	13	7
pH	8.3	8.0	8.0	7.7
Oil & Grease	0.20			
Ammonia as NH3-N mg/l	<0.01	0.10	0.53	0.30
Nitrate as NO3-N mg/l	<0.01	0.04	<0.01	0.05
Nitrite as No2-N mg/l	<0.01	<0.01	<0.01	<0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l	0.120	0.220	0.210	0.510
Phosphate as PO4-P Ortho mg/l	0.030			
Sulfate as SO4 mg/l	15.0	27.0	9.0	34.0
Sulfide mg/l	<0.01	2.97	2.74	0.25
Total Suspended Solids mg/l	4.0	22.0	1.0	53.0
Total Dissolved Solids mg/l	312	275	339	297
Total Combustible Solids				
Carbonate as CO3 mg/l	0.01	4.80	0.01	<0.01
Bicarbonate as HCO3 mg/l	346.48	268.40	378.20	295.20
Alkalinity as CaCO3 (Total) mg/l	284	228	310	242.90
Total Hardness as CaCO3 mg/l	254	234	286	290
Acidity as CaCO3 mg/l	7.6	<0.01	<0.01	16.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	59.20	56.00	65.50	60.00
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	0.350	0.280	0.360	0.354
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	25.44	22.56	29.28	20.50
Manganese as Mn (Total) mg/l	0.020			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	3.70	3.83	3.82	3.50
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	24.00	13.00	25.00	22.60
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Aluminum as Al (Dissolved) mg/l	0.110	0.030	<0.001	<0.001
Barium as Ba (Dissolved) mg/l	0.335	0.195	0.270	0.140
Boron as B (Dissolved) mg/l	0.050	0.050	0.050	0.040
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Chloride as Cl (Dissolved) mg/l	10.00	9.40	18.00	6.20
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Copper as Cu (Dissolved) mg/l	<0.001	<0.001	<0.001	0.003
Fluoride as F (Dissolved) mg/l				0.025
Iron as Fe (Dissolved) mg/l	0.190	0.070	0.320	0.250
Lead as Pb (Dissolved) mg/l	0.002	0.004	0.003	0.005
Manganese as Mn (Dissolved) mg/l	0.020	0.060	0.050	0.050
Mercury as Hg (Dissolved) mg/l	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenium as Mo (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Nickel as Ni (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.01
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l	0.005	0.010	0.008	0.010
Vanadium	<0.001	<0.001	<0.001	<0.001

Table B-6. Results of chemical analyses of surface water quality samples collected at Station U-6.

Date	11-12-80	12-12-80	1-28-81	2-11-81	3-11-81	4-8-81
Flow, cfs	8	6	13.4	Frozen	4.2	6.6
Specific Conductance, umhos/cm	500	500	215		271	316
Temperature, Air °C			3		2	5
Temperature, Water °C			1		2	7
pH	7.3	7.6	7.7		8.3	7.4
Oil & Grease	<0.01	1.80	1.60		4.30	0.40
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Nitrate as NO3-N mg/l	0.06	0.11	0.08		0.07	<0.01
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.11	0.16	0.05		<0.01	0.15
Phosphate as PO4-P Total mg/l	0.150	0.050	0.190		0.180	0.220
Phosphate as PO4-P Ortho mg/l	0.020	0.020	0.160		0.160	<0.001
Sulfate as SO4 mg/l	63.0	40.0	41.0		59.0	60.0
Sulfide mg/l						
Total Suspended Solids mg/l	16.0	10.0	3.0		10.0	137.00
Total Dissolved Solids mg/l	330	325	316		350	320
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Bicarbonate as HCO3 mg/l	295.24	346.48	312.32		319.64	283.04
Alkalinity as CaCO3 (Total) mg/l	242	284	256		262	232
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	18.0	10.0	16.0		<0.1	24.00
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Barium as Ba (Total) mg/l	0.045	0.076	0.110		0.050	0.110
Boron as B (Total) mg/l	0.080	0.115	0.048		0.060	0.110
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Calcium as Ca mg/l	76.00	68.80	80.00		81.60	76.80
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Total) mg/l	0.005	0.011	0.003		<0.001	0.031
Iron as Fe (Total) mg/l	0.210	0.290	0.210		0.350	0.310
Lead as Pb (Total) mg/l	0.006	0.019	0.005		0.004	0.011
Magnesium as Mg mg/l	18.24	34.56	24.00		28.64	25.44
Manganese as Mn (Total) mg/l	0.050	0.008	0.040		0.050	0.011
Mercury as Hg (Total) mg/l	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002
Molybdenum as Mo (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Potassium as K mg/l	4.03	2.35	2.47		2.50	2.50
Selenium as Se (Total) mg/l	<0.001	<0.001	<0.001		<0.001	0.002
Silver as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Sodium as Na mg/l	22.50	6.50	5.70		9.20	10.40
Zinc as Zn (Total) mg/l	0.015	0.010	0.015		0.010	0.005
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.040	0.045	0.045		0.045	0.060
Boron as B (Dissolved) mg/l	0.035	0.010	0.035		0.040	0.060
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Chloride as Cl (Dissolved) mg/l	5.53	2.04	7.95		12.75	16.00
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Dissolved) mg/l	0.002	0.010	<0.001		<0.001	<0.001
Fluoride as F (Dissolved) mg/l	0.14	0.16	0.18		0.18	0.14
Iron as Fe (Dissolved) mg/l	0.050	0.020	0.200		0.150	0.250
Lead as Pb (Dissolved) mg/l	<0.001	<0.001	0.005		<0.001	<0.001
Manganese as Mn (Dissolved) mg/l					0.040	0.004
Mercury as Hg (Dissolved) mg/l					<0.0002	
Molybdenium as Mo (Dissolved) mg/l					<0.001	
Nickel as Ni (Dissolved) mg/l					0.001	
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Zinc as Zn (Dissolved) mg/l	0.007	0.005	0.008		0.003	0.002

Table B-6. Continued.

Date	5-27-81	7-22-81	9-23-81	11-11-81
Flow, cfs	5.1	3.4	6.8	6.1
Specific Conductance, umhos/cm	230	490	364	340
Temperature, Air °C	12	28	19	9
Temperature, Water °C	11	22	11	4
pH	6.6	8.5	8.3	7.7
Oil & Grease	0.80			
Ammonia as NH3-N mg/l	0.10	<0.01	1.48	
Nitrate as NO3-N mg/l	0.08	0.03	<0.01	0.04
Nitrite as No2-N mg/l	0.02	<0.01	<0.01	<0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l	5.200	0.160	0.114	0.460
Phosphate as PO4-P Ortho mg/l	0.130			
Sulfate as SO4 mg/l	28.5	48.0	27.0	30.0
Sulfide mg/l	0.01	0.60	3.00	2.67
Total Suspended Solids mg/l	534	7.0	5.0	32.0
Total Dissolved Solids mg/l	316	366	350	312
Total Combustible Solids				
Carbonate as CO3 mg/l	0.01	4.80	2.40	<0.01
Bicarbonate as HCO3 mg/l	214.72	209.84	346.48	322.00
Alkalinity as CaCO3 (Total) mg/l	176	180	288	264.30
Total Hardness as CaCO3 mg/l	198	234	288	278
Acidity as CaCO3 mg/l	3.80	<0.01	<0.01	12.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	52.80	50.40	65.60	57.60
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	4.380	0.180	0.260	0.340
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	15.84	25.92	29.76	25.00
Manganese as Mn (Total) mg/l	0.180			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	1.80	2.62	2.65	2.30
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	4.00	6.20	26.00	25.30
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Aluminum as Al (Dissolved) mg/l	1.440	0.020	0.001	<0.001
Barium as Ba (Dissolved) mg/l	0.070	0.045	0.045	0.040
Boron as B (Dissolved) mg/l	0.030	0.040	0.040	0.040
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001	0.002
Chloride as Cl (Dissolved) mg/l	8.00	10.50	26.00	7.70
Chromium as Cr (Dissolved) mg/l	0.002	<0.001	<0.001	<0.001
Copper as Cu (Dissolved) mg/l	<0.001	0.010	<0.001	<0.001
Fluoride as F (Dissolved) mg/l				0.18
Iron as Fe (Dissolved) mg/l	1.480	0.040		0.160
Lead as Pb (Dissolved) mg/l	0.008	0.003	0.003	0.004
Manganese as Mn (Dissolved) mg/l	0.150	0.020	0.030	0.028
Mercury as Hg (Dissolved) mg/l	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenium as Mo (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Nickel as Ni (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.01
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	<0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l	0.020	0.012	0.005	0.009
Vanadium	<0.001	<0.001	<0.001	<0.001

Table B-7. Results of chemical analyses of surface water quality samples collected at Station U-7.

Date	11-12-80	12-12-80	1-28-81	2-11-81	3-11-81	4-8-81
Flow, cfs	10.7	6.8		Frozen		
Specific Conductance, umhos/cm	440	450	280		285	352
Temperature, Air °C	6	7	0		4	6
Temperature, Water °C	5	0			2	6
pH	7.4	7.4	7.8		8.0	7.9
Oil & Grease	0.40	4.40	0.40		10.40	0.40
Ammonia as NH3-N mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Nitrate as NO3-N mg/l	0.10	0.10	0.08		0.05	0.04
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.05	0.20	0.10		<0.01	0.11
Phosphate as PO4-P Total mg/l	0.120	0.040	0.040		0.150	0.220
Phosphate as PO4-P Ortho mg/l	0.020	0.015	0.020		0.080	0.001
Sulfate as SO4 mg/l	42.0	18.0	33.0		33.0	40.0
Sulfide mg/l						
Total Suspended Solids mg/l	9.0	7.0	14.0		7.0	28.0
Total Dissolved Solids mg/l	282	293	335		295	312
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Bicarbonate as HCO3 mg/l	283.04	346.48	353.80		295.24	292.80
Alkalinity as CaCO3 (Total) mg/l	232	284	290		242	240
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	16.0	14.0	10.0		6.0	8.0
Arsenic as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Barium as Ba (Total) mg/l	0.040	0.080	0.050		0.050	0.065
Boron as B (Total) mg/l	0.120	0.078	0.044		0.050	0.050
Cadmium as Cd (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Calcium as Ca mg/l	61.60	64.80	78.40		73.60	76.80
Chromium as Cr (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Total) mg/l	0.005	0.015	0.003		<0.001	0.010
Iron as Fe (Total) mg/l	0.390	0.360	0.350		0.110	0.370
Lead as Pb (Total) mg/l	<0.001	0.017	0.004		0.003	0.003
Magnesium as Mg mg/l	25.44	30.24	24.00		23.52	23.52
Manganese as Mn (Total) mg/l	0.045	0.005	0.040		0.050	0.050
Mercury as Hg (Total) mg/l	0.0002	0.0002	0.0002		0.0002	0.0002
Molybdenum as Mo (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Potassium as K mg/l	2.39	2.40	2.38		2.35	2.20
Selenium as Se (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Silver as As (Total) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Sodium as Na mg/l	8.00	6.80	15.00		7.50	9.40
Zinc as Zn (Total) mg/l	0.005	0.010	0.015		0.017	0.012
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l	0.035	0.050	0.050		0.050	0.050
Boron as B (Dissolved) mg/l	0.050	0.075	0.035		0.035	0.030
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Chloride as Cl (Dissolved) mg/l	5.56	1.66	7.33		14.89	18.00
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Copper as Cu (Dissolved) mg/l	<0.001	0.010	<0.001		<0.001	0.010
Fluoride as F (Dissolved) mg/l	0.11	0.18	0.20		0.18	0.16
Iron as Fe (Dissolved) mg/l	0.010	0.030	0.050		0.020	0.100
Lead as Pb (Dissolved) mg/l	<0.001	<0.001	<0.001		0.001	<0.001
Manganese as Mn (Dissolved) mg/l					0.040	0.040
Mercury as Hg (Dissolved) mg/l					<0.0002	
Molybdenum as Mo (Dissolved) mg/l					< 0.001	
Nickel as Ni (Dissolved) mg/l					< 0.001	
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Silver as As (Dissolved) mg/l	<0.001	<0.001	<0.001		<0.001	<0.001
Zinc as Zn (Dissolved) mg/l	0.001	0.005	0.007		0.007	0.010

Table B-7. Continued.

Date	5-27-81	7-22-81	9-23-81	11-11-81
Flow, cfs			4	
Specific Conductance, umhos/cm	225	400	402	333
Temperature, Air °C	8	25	19	9
Temperature, Water °C	5	22	14	5
pH	8.2	8.5	8.2	7.9
Oil & Grease	< 0.01			
Ammonia as NH3-N mg/l	0.10	< 0.01	1.45	< 0.01
Nitrate as NO3-N mg/l	0.08	0.02	< 0.01	0.05
Nitrite as No2-N mg/l	< 0.01	< 0.01	< 0.01	< 0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l	0.390	0.600	0.155	0.500
Phosphate as PO4-P Ortho mg/l	0.140			
Sulfate as SO4 mg/l	28.5	42.0	80.0	24.0
Sulfide mg/l	0.01	1.20	1.60	2.59
Total Suspended Solids mg/l	636	29.0	145	41.0
Total Dissolved Solids mg/l	210	265	349	325
Total Combustible Solids				
Carbonate as CO3 mg/l	<0.01	9.60	4.80	< 0.01
Bicarbonate as HCO3 mg/l	204.96	234.24	246.44	328.20
Alkalinity as CaCO3 (Total) mg/l	168	208	210	269.50
Total Hardness as CaCO3 mg/l	174	242	316	248
Acidity as CaCO3 mg/l	1.90	< 0.01	< 0.01	10.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	32.00	58.40	64.80	44.80
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	10.000	0.480	4.600	3.541
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	22.56	23.04	36.96	27.00
Manganese as Mn (Total) mg/l	0.510			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	2.30	2.51	2.85	2.90
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	14.00	8.00	8.20	34.00
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Aluminum as Al (Dissolved) mg/l		0.020	<0.001	< 0.001
Barium as Ba (Dissolved) mg/l	0.145	0.050	0.095	0.080
Boron as B (Dissolved) mg/l	0.040	0.050	0.050	0.045
Cadmium as Cd (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	12.00	10.70	28.00	7.30
Chromium as Cr (Dissolved) mg/l	0.004	<0.001	<0.001	< 0.001
Copper as Cu (Dissolved) mg/l	0.010	<0.001	0.010	0.009
Fluoride as F (Dissolved) mg/l				0.19
Iron as Fe (Dissolved) mg/l	2.720	0.040		0.224
Lead as Pb (Dissolved) mg/l	0.014	0.002	0.002	0.003
Manganese as Mn (Dissolved) mg/l	0.500	0.060	0.130	0.150
Mercury as Hg (Dissolved) mg/l	<0.0002	<0.0002	<0.0002	< 0.0002
Molybdenum as Mo (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Nickel as Ni (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.01
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l	0.045	0.010	0.005	0.004
Vanadium	<0.001	<0.001	<0.001	< 0.015

Table B-8. Results of chemical analyses of surface water quality samples collected at Station U-8.

Date	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	2		Inaccessible	Inaccessible	Inaccessible	
Specific Conductance, umhos/cm	440	252				340
Temperature, Air °C		0				
Temperature, Water °C		0				6
pH	7.6	7.4				8.3
Oil & Grease	< 0.01	< 0.10				
Ammonia as NH3-N mg/l	< 0.01	< 0.01				< 0.01
Nitrate as NO3-N mg/l	0.15	0.26				0.41
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l	0.15	0.14				
Phosphate as PO4-P Total mg/l	0.160	0.140				0.070
Phosphate as PO4-P Ortho mg/l	<0.001	0.040				0.040
Sulfate as SO4 mg/l	49.0	44.0				9.0
Sulfide mg/l						
Total Suspended Solids mg/l	15.0	2.0				24.0
Total Dissolved Solids mg/l	270	292				185
Total Combustible Solids						
Carbonate as CO3 mg/l	<0.01	< 0.01				2.40
Bicarbonate as HCO3 mg/l	253.76	295.24				195.20
Alkalinity as CaCO3 (Total) mg/l	208	242				164
Total Hardness as CaCO3 mg/l						< 0.01
Acidity as CaCO3 mg/l	22.0	8.0				< 0.001
Arsenic as As (Total) mg/l	< 0.001	< 0.001				0.020
Barium as Ba (Total) mg/l	0.030	0.035				0.025
Boron as B (Total) mg/l	0.044	0.085				
Cadmium as Cd (Total) mg/l	< 0.001	< 0.001				< 0.001
Calcium as Ca mg/l	74.40	82.40				56.00
Chromium as Cr (Total) mg/l	< 0.001	< 0.001				< 0.001
Copper as Cu (Total) mg/l	0.010	0.010				0.010
Iron as Fe (Total) mg/l	1.120	0.280				0.360
Lead as Pb (Total) mg/l	< 0.001	< 0.001				< 0.001
Magnesium as Mg mg/l	17.28	17.28				8.64
Manganese as Mn (Total) mg/l	0.090	0.040				0.020
Mercury as Hg (Total) mg/l	< 0.0002	< 0.0002				< 0.0002
Molybdenum as Mo (Total) mg/l	< 0.001	< 0.001				< 0.001
Potassium as K mg/l	1.57	1.95				1.30
Selenium as Se (Total) mg/l	< 0.001	0.003				0.002
Silver as As (Total) mg/l	< 0.001	< 0.001				< 0.001
Sodium as Na mg/l	4.00	5.80				3.50
Zinc as Zn (Total) mg/l	0.020	0.010				0.010
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Aluminum as Al (Dissolved) mg/l						0.018
Barium as Ba (Dissolved) mg/l	0.020	0.025				0.020
Boron as B (Dissolved) mg/l	0.030	0.065				< 0.001
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001				
Chloride as Cl (Dissolved) mg/l	4.2	0.50				< 0.001
Chromium as Cr (Dissolved) mg/l	0.001	0.001				< 0.001
Copper as Cu (Dissolved) mg/l	< 0.001	0.010				
Fluoride as F (Dissolved) mg/l	12.0	0.10				0.160
Iron as Fe (Dissolved) mg/l	0.050	0.040				
Lead as Pb (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Manganese as Mn (Dissolved) mg/l		0.040				0.020
Mercury as Hg (Dissolved) mg/l						
Molybdenum as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Silver as As (Dissolved) mg/l	< 0.001	< 0.001				< 0.001
Zinc as Zn (Dissolved) mg/l	0.010	0.010				0.005

Table B-8. Continued.

Date	5-27-81	7-23-81	9-22-81	11-13-81
Flow, cfs	0.9	1.2	1	.8
Specific Conductance, umhos/cm	130	330	330	212
Temperature, Air °C	11	25	18	8
Temperature, Water °C	9	18	15	1
pH	8.1	8.2	8.0	7.2
Oil & Grease	0.01			
Ammonia as NH3-N mg/l	0.10	< 0.01	1.46	0.87
Nitrate as NO3-N mg/l	0.17	0.06	< 0.01	0.06
Nitrite as No2-N mg/l	<0.01	< 0.01	< 0.01	< 0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l	0.170	0.360	0.210	0.400
Phosphate as PO4-P Ortho mg/l	0.020			
Sulfate as SO4 mg/l	18.0	16.5	133	95.0
Sulfide mg/l		0.51	2.20	2.60
Total Suspended Solids mg/l	16.0	6.0	73.0	2.0
Total Dissolved Solids mg/l	140	212	295	346
Total Combustible Solids				
Carbonate as CO3 mg/l	<0.01	2.40	12.00	7.20
Bicarbonate as HCO3 mg/l	134.20	231.80	80.52	234.90
Alkalinity as CaCO3 (Total) mg/l	110	194	86.00	204.60
Total Hardness as CaCO3 mg/l	122	204	244	196
Acidity as CaCO3 mg/l	0.95	0.01	0.01	< 0.01
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	38.40	54.40	69.60	69.00
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	0.370	0.320	0.400	0.452
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	6.24	16.32	16.80	14.00
Manganese as Mn (Total) mg/l	0.030			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	0.86	1.62	1.78	3.50
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	4.00	5.30	4.50	35.50
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Aluminum as Al (Dissolved) mg/l	0.230	< 0.001	< 0.001	0.015
Barium as Ba (Dissolved) mg/l	0.015	0.020	0.025	0.020
Boron as B (Dissolved) mg/l	0.030	0.024	0.030	0.015
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	4.00	5.89	20.00	3.40
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Copper as Cu (Dissolved) mg/l	< 0.001	0.010	< 0.001	< 0.001
Fluoride as F (Dissolved) mg/l				0.15
Iron as Fe (Dissolved) mg/l	0.250	0.095	0.010	0.098
Lead as Pb (Dissolved) mg/l	< 0.001	< 0.001	0.002	0.005
Manganese as Mn (Dissolved) mg/l	0.020	0.020	0.030	0.015
Mercury as Hg (Dissolved) mg/l	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Nickel as Ni (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.01
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l	0.005	0.012	0.002	0.009
Vanadium	< 0.001	< 0.001	< 0.001	< 0.001

Table B-9. Results of chemical analyses of ground water quality samples collected at Station U1-1.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.02	0.01	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	990	520				
Temperature, Air °C	6	8				
Temperature, Water °C	5					
pH	7.2	6.9				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	12.0	13.5				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	651	312				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	756.40	346.48				
Alkalinity as CaCO3 (Total) mg/l	620					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	88.0	80.0				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	19.20	24.00				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potassium as K mg/l	1.36	1.30				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	150	3.00				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	3.0	3.3				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l	0.21					
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-9. Continued.

Date	5-27-81	7-23-81	9-22-81	11-13-81
Flow, cfs	0.02	0.007	0.004	
Specific Conductance, umhos/cm	345	500	435	315
Temperature, Air °C		21	18	
Temperature, Water °C		6	6	
pH	7.5	7.7	7.8	7.5
Oil & Grease				
Ammonia as NH3-N mg/l	< 0.01	< 0.01	1.46	0.39
Nitrate as NO3-N mg/l	0.27	0.24	0.01	0.22
Nitrite as No2-N mg/l	< 0.01	< 0.01	0.02	<0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l		0.390	0.315	0.380
Phosphate as PO4-P Ortho mg/l	0.001	0.140	0.070	<0.001
Sulfate as SO4 mg/l	25.0	22.5	80.0	177
Sulfide mg/l	< 0.01	< 0.01	1.68	1.26
Total Suspended Solids mg/l				
Total Dissolved Solids mg/l	210	330	350	560
Total Combustible Solids				
Carbonate as CO3 mg/l	< 0.01	< 0.01	4.80	<0.01
Bicarbonate as HCO3 mg/l	317	346.48	239.12	360.30
Alkalinity as CaCO3 (Total) mg/l		284	204	295
Total Hardness as CaCO3 mg/l				166
Acidity as CaCO3 mg/l		3.0	0.01	8.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	88.00	62.40	96.00	98.50
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	0.230	0.250	0.970	0.350
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	18.00	6.72	15.84	18.00
Manganese as Mn (Total) mg/l	0.010			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	1.30	1.38	1.33	1.40
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	3.50	56.00	4.00	77.40
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	<0.001
Aluminum as Al (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	<0.001
Barium as Ba (Dissolved) mg/l	0.020	0.025	0.025	0.025
Boron as B (Dissolved) mg/l	0.020	0.020	0.020	0.025
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	<0.001
Chloride as Cl (Dissolved) mg/l	10.00	5.03	16.00	3.00
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	<0.001
Copper as Cu (Dissolved) mg/l	0.010	0.010	< 0.001	0.002
Fluoride as F (Dissolved) mg/l	0.20	0.20	0.22	0.18
Iron as Fe (Dissolved) mg/l	0.010	0.042	0.010	0.012
Lead as Pb (Dissolved) mg/l	< 0.001	0.003	0.004	<0.001
Manganese as Mn (Dissolved) mg/l	0.001	0.010	0.010	0.014
Mercury as Hg (Dissolved) mg/l	< 0.0002	< 0.0002	< 0.0002	<0.0002
Molybdenium as Mo (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	<0.001
Nickel as Ni (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	<0.01
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	<0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l		0.005	0.015	0.016
Vanadium		< 0.001	< 0.001	<0.001

Table B-10. Results of chemical analyses of ground water quality samples collected at Station U1-2.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.002	0.002	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1800	680				
Temperature, Air °C	6	8				
Temperature, Water °C	4	3				
pH	7.2	7.1				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	15.0	15.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	1180	328				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	136.64	380.64				
Alkalinity as CaCO3 (Total) mg/l	1120					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	84.0	84.0				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	21.60	26.40				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potassium as K mg/l	1.45	1.25				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	380	4.20				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	5.1	4.7				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l		0.21				
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-11. Results of chemical analyses of ground water quality samples collected at Station U1-3.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.004	0.002	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1320	600				
Temperature, Air °C	6	8				
Temperature, Water °C	6	5				
pH	7.3	7.2				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	15.0	15.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	860	290				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	988.20	326.96				
Alkalinity as CaCO3 (Total) mg/l	810					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	84.0	76.00				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	21.60	21.60				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potassium as K mg/l	1.19	1.11				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	240	4.40				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	5.1	4.7				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l		0.21				
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-12. Results of chemical analyses of ground water quality samples collected at Station U1-4.

Date	10-21-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.007	0.004	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1450	540				
Temperature, Air °C		8				
Temperature, Water °C		5				
pH						
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	12.0	12.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	944	310				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	1098	361.12				
Alkalinity as CaCO3 (Total) mg/l	900					
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	84.00	76.00				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	26.40	21.60				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potassium as K mg/l	1.82	1.73				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	270	4.40				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	3.8	2.7				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l		0.15				
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-12. Continued.

Date	5-14-81	7-23-81	9-22-81	11-13-81
Flow, cfs	0.004	0.002	< 0.001	
Specific Conductance, umhos/cm	280	430	420	229
Temperature, Air °C		14	14	
Temperature, Water °C	3	5	6	
pH	7.7	7.7	8.0	7.5
Oil & Grease				
Ammonia as NH3-N mg/l	< 0.01	0.15	1.48	0.04
Nitrate as NO3-N mg/l	0.18	0.07	< 0.01	0.03
Nitrite as No2-N mg/l	0.01	< 0.01		< 0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l		0.390	0.250	0.530
Phosphate as PO4-P Ortho mg/l	< 0.001	< 0.010	0.095	0.050
Sulfate as SO4 mg/l	25.0	21.0	63.0	34.0
Sulfide mg/l	1.50	< 0.01	2.10	4.00
Total Suspended Solids mg/l				
Total Dissolved Solids mg/l	285	285	322	320
Total Combustible Solids				
Carbonate as CO3 mg/l	< 0.01	< 0.01	3.60	< 0.01
Bicarbonate as HCO3 mg/l	295	305	253.76	337.80
Alkalinity as CaCO3 (Total) mg/l		250	214	277
Total Hardness as CaCO3 mg/l	272	222	296	144
Acidity as CaCO3 mg/l		4.50	< 0.01	8.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	78.00	65.65	80.00	87.00
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	0.480	0.450	0.340	0.350
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	18.20	13.90	23.04	20.50
Manganese as Mn (Total) mg/l	0.010			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	1.48	1.57	1.63	2.60
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	4.70	24.00	5.70	6.50
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Aluminum as Al (Dissolved) mg/l	< 0.001	0.010	< 0.001	0.015
Barium as Ba (Dissolved) mg/l	0.030	0.030	0.030	0.035
Boron as B (Dissolved) mg/l	0.020	0.030	0.020	0.030
Cadmium as Cd (Dissolved) mg/l	< 0.001	0.001	< 0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	8.00	5.44	18.00	3.20
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Copper as Cu (Dissolved) mg/l	0.010	< 0.001	0.010	< 0.001
Fluoride as F (Dissolved) mg/l	0.21	0.23	0.21	0.19
Iron as Fe (Dissolved) mg/l	0.060	0.050	0.010	0.011
Lead as Pb (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	0.002
Manganese as Mn (Dissolved) mg/l	< 0.001	0.010	0.010	0.018
Mercury as Hg (Dissolved) mg/l	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Nickel as Ni (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.01
Selenium as Se (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l		0.006	0.020	0.013
Vanadium (Dissolved) mg/l				< 0.001

Table B-13. Results of chemical analyses of ground water quality samples collected at Station U1-5.

Date	10-22-80	11-7-80	1-28-81	2-11-81	3-11-81	4-22-81
Flow, cfs	0.03	0.02	Inaccessible	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	550	510				
Temperature, Air °C	4	12				
Temperature, Water °C	4	5				
pH	7.3	7.2				
Oil & Grease						
Ammonia as NH3-N mg/l						
Nitrate as NO3-N mg/l						
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l						
Phosphate as PO4-P Ortho mg/l						
Sulfate as SO4 mg/l	51.0	36.0				
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	368	340				
Total Combustible Solids						
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	353.80	375.76				
Alkalinity as CaCO3 (Total) mg/l	290	308				
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l						
Arsenic as As (Total) mg/l						
Barium as Ba (Total) mg/l						
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l						
Calcium as Ca mg/l	96.0	72.0				
Chromium as Cr (Total) mg/l						
Copper as Cu (Total) mg/l						
Iron as Fe (Total) mg/l						
Lead as Pb (Total) mg/l						
Magnesium as Mg mg/l	14.40	31.20				
Manganese as Mn (Total) mg/l						
Mercury as Hg (Total) mg/l						
Molybdenum as Mo (Total) mg/l						
Potassium as K mg/l	2.80	2.92				
Selenium as Se (Total) mg/l						
Silver as As (Total) mg/l						
Sodium as Na mg/l	19.00	15.00				
Zinc as Zn (Total) mg/l						
Arsenic as As (Dissolved) mg/l						
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l						
Boron as B (Dissolved) mg/l						
Cadmium as Cd (Dissolved) mg/l						
Chloride as Cl (Dissolved) mg/l	3.9	4.17				
Chromium as Cr (Dissolved) mg/l						
Copper as Cu (Dissolved) mg/l						
Fluoride as F (Dissolved) mg/l						
Iron as Fe (Dissolved) mg/l						
Lead as Pb (Dissolved) mg/l						
Manganese as Mn (Dissolved) mg/l						
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l						
Silver as As (Dissolved) mg/l						
Zinc as Zn (Dissolved) mg/l						

Table B-13. Continued.

Date	5-27-81	7-23-81	9-22-81	11-13-81
Flow, cfs	1	1	1	
Specific Conductance, umhos/cm	320	610	500	374
Temperature, Air °C		22		
Temperature, Water °C	5	10	12	
pH	7.6	7.7	8.1	7.3
Oil & Grease	0.40			
Ammonia as NH3-N mg/l	<0.01	0.15	0.50	0.42
Nitrate as NO3-N mg/l	0.25	< 0.01	< 0.01	0.01
Nitrite as No2-N mg/l	<0.01	< 0.01	< 0.01	<0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l	0.430	0.370	0.145	0.600
Phosphate as PO4-P Ortho mg/l	0.070	0.060	0.036	0.040
Sulfate as SO4 mg/l	45.0	39.0	165	53.0
Sulfide mg/l	0.01	0.19	2.10	2.89
Total Suspended Solids mg/l	71.0			
Total Dissolved Solids mg/l	382	400	415	430
Total Combustible Solids				
Carbonate as CO3 mg/l	<0.01	< 0.01	4.80	<0.01
Bicarbonate as HCO3 mg/l	387.96	422.12	209.84	439.20
Alkalinity as CaCO3 (Total) mg/l	318	346	180	360
Total Hardness as CaCO3 mg/l	378	390	360	234
Acidity as CaCO3 mg/l	22.80	6.0	< 0.01	6.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	46.40	98.40	86.40	105.00
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	0.030	0.200	0.500	0.320
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	38.88	34.56	34.56	33.50
Manganese as Mn (Total) mg/l				
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	2.50	3.14	2.79	5.50
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	46.00	5.10	5.40	8.50
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.001
Aluminum as Al (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.001
Barium as Ba (Dissolved) mg/l	0.030	0.050	0.040	0.050
Boron as B (Dissolved) mg/l	0.050	0.060	0.040	0.045
Cadmium as Cd (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.001
Chloride as Cl (Dissolved) mg/l	12.00	7.05	10.00	4.60
Chromium as Cr (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.001
Copper as Cu (Dissolved) mg/l	<0.001	0.010	< 0.001	0.005
Fluoride as F (Dissolved) mg/l	0.24	0.27	0.25	0.19
Iron as Fe (Dissolved) mg/l	0.010	0.080	0.010	0.015
Lead as Pb (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.001
Manganese as Mn (Dissolved) mg/l	<0.001	0.020	0.010	0.012
Mercury as Hg (Dissolved) mg/l	0.0115	< 0.0002	< 0.0002	<0.0002
Molybdenium as Mo (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.001
Nickel as Ni (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.01
Selenium as Se (Dissolved) mg/l	<0.001	< 0.001	< 0.001	<0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l	0.005	0.020	0.007	0.015
Vanadium	<0.001	< 0.001	< 0.001	<0.001

Table B-14. Results of chemical analyses of ground water quality samples collected at Station U1-6.

Date	10-23-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.03	0.02	0.01	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	600	600	382			
Temperature, Air °C	4	10	1			
Temperature, Water °C	5	5	4			
pH	7.2	7.2	7.0			
Oil & Grease			< 0.10			
Ammonia as NH3-N mg/l			< 0.01			
Nitrate as NO3-N mg/l			0.20			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l			0.13			
Phosphate as PO4-P Total mg/l			0.100			
Phosphate as PO4-P Ortho mg/l			0.020			
Sulfate as SO4 mg/l	51.0	37.5	179			
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	390	390	470			
Total Combustible Solids						
Carbonate as CO3 mg/l			< 0.01			
Bicarbonate as HCO3 mg/l	414.80	427.00	287.92			
Alkalinity as CaCO3 (Total) mg/l	340	350	236			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l			28.0			
Arsenic as As (Total) mg/l			< 0.001			
Barium as Ba (Total) mg/l			0.048			
Boron as B (Total) mg/l			0.100			
Cadmium as Cd (Total) mg/l			< 0.001			
Calcium as Ca mg/l	88.0	95.20	112			
Chromium as Cr (Total) mg/l			< 0.001			
Copper as Cu (Total) mg/l			0.011			
Iron as Fe (Total) mg/l			0.330			
Lead as Pb (Total) mg/l			0.002			
Magnesium as Mg mg/l	38.40	29.28	32.64			
Manganese as Mn (Total) mg/l			0.010			
Mercury as Hg (Total) mg/l			< 0.0002			
Molybdenum as Mo (Total) mg/l			< 0.001			
Potassium as K mg/l	2.81	2.60	2.74			
Selenium as Se (Total) mg/l			0.003			
Silver as As (Total) mg/l			< 0.001			
Sodium as Na mg/l	7.00	14.30	4.90			
Zinc as Zn (Total) mg/l			0.007			
Arsenic as As (Dissolved) mg/l			< 0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l			0.033			
Boron as B (Dissolved) mg/l			0.065			
Cadmium as Cd (Dissolved) mg/l			< 0.001			
Chloride as Cl (Dissolved) mg/l						
Chromium as Cr (Dissolved) mg/l			< 0.001			
Copper as Cu (Dissolved) mg/l			0.010			
Fluoride as F (Dissolved) mg/l						
Iron as Fe (Dissolved) mg/l			0.260			
Lead as Pb (Dissolved) mg/l			< 0.001			
Manganese as Mn (Dissolved) mg/l			0.005			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			< 0.001			
Silver as As (Dissolved) mg/l			< 0.001			
Zinc as Zn (Dissolved) mg/l			0.005			

Table B-14. Continued.

Date	4-22-81	5-27-81	7-23-81	9-22-81	11-13-81
Flow, cfs	Inaccessible	0			
Specific Conductance, umhos/cm			660	501	410
Temperature, Air °C					
Temperature, Water °C				8	
pH			7.4	7.8	7.6
Oil & Grease					
Ammonia as NH3-N mg/l			< 0.01	0.51	0.32
Nitrate as NO3-N mg/l			0.20	< 0.01	0.21
Nitrite as No2-N mg/l			< 0.01	< 0.01	<0.01
Nitrogen as KJELDAHL (Total) mg/l					
Phosphate as PO4-P Total mg/l			0.220	0.150	0.440
Phosphate as PO4-P Ortho mg/l			0.100	0.059	0.020
Sulfate as SO4 mg/l			37.5	125	64.0
Sulfide mg/l			0.24	3.89	2.44
Total Suspended Solids mg/l					
Total Dissolved Solids mg/l			435	510	499
Total Combustible Solids					
Carbonate as CO3 mg/l			0.01	2.40	<0.01
Bicarbonate as HCO3 mg/l			448.96	300.12	502.60
Alkalinity as CaCO3 (Total) mg/l			368	250	412
Total Hardness as CaCO3 mg/l			278	394	340
Acidity as CaCO3 mg/l			4.50	< 0.01	18.00
Arsenic as As (Total) mg/l					
Barium as Ba (Total) mg/l					
Boron as B (Total) mg/l					
Cadmium as Cd (Total) mg/l					
Calcium as Ca mg/l			86.40	88.00	119.00
Chromium as Cr (Total) mg/l					
Copper as Cu (Total) mg/l					
Iron as Fe (Total) mg/l			0.268	0.370	0.320
Lead as Pb (Total) mg/l					
Magnesium as Mg mg/l			14.88	41.76	37.00
Manganese as Mn (Total) mg/l					
Mercury as Hg (Total) mg/l					
Molybdenum as Mo (Total) mg/l					
Potassium as K mg/l			2.61	2.75	4.90
Selenium as Se (Total) mg/l					
Silver as As (Total) mg/l					
Sodium as Na mg/l			60.00	5.60	15.20
Zinc as Zn (Total) mg/l					
Arsenic as As (Dissolved) mg/l			< 0.001	< 0.001	<0.001
Aluminum as Al (Dissolved) mg/l			0.100	< 0.001	0.020
Barium as Ba (Dissolved) mg/l			0.045	0.040	0.050
Boron as B (Dissolved) mg/l			0.050	0.040	0.050
Cadmium as Cd (Dissolved) mg/l			< 0.001	< 0.001	<0.001
Chloride as Cl (Dissolved) mg/l			6.98	14.00	4.40
Chromium as Cr (Dissolved) mg/l			< 0.001	< 0.001	<0.001
Copper as Cu (Dissolved) mg/l			0.010	< 0.001	<0.001
Fluoride as F (Dissolved) mg/l			0.27	0.26	0.24
Iron as Fe (Dissolved) mg/l			0.140	0.010	0.014
Lead as Pb (Dissolved) mg/l			< 0.001	< 0.001	<0.001
Manganese as Mn (Dissolved) mg/l			< 0.001	< 0.001	0.005
Mercury as Hg (Dissolved) mg/l			< 0.0002	< 0.0002	<0.0002
Molybdenium as Mo (Dissolved) mg/l			< 0.001	< 0.001	<0.001
Nickel as Ni (Dissolved) mg/l			< 0.001	< 0.001	<0.01
Selenium as Se (Dissolved) mg/l			< 0.001	< 0.001	<0.001
Silver as As (Dissolved) mg/l					
Zinc as Zn (Dissolved) mg/l			0.010	0.003	0.005
Vanadium			< 0.001	< 0.001	<0.001

Table B-15. Results of chemical analyses of ground water quality samples collected at Station U1-13.

Date	11-25-81
Flow, cfs	0.07
Specific Conductance, umhos/cm	1000
Temperature, Air °C	-3
Temperature, Water °C	10
pH	8.0
Oil & Grease	
Ammonia as NH3-N mg/l	0.17
Nitrate as NO3-N mg/l	0.05
Nitrite as No2-N mg/l	0.01
Nitrogen as KJELDAHL (Total) mg/l	0.35
Phosphate as PO4-P Total mg/l	0.450
Phosphate as PO4-P Ortho mg/l	
Sulfate as SO4 mg/l	480
Sulfide mg/l	
Total Suspended Solids mg/l	
Total Dissolved Solids mg/l	1920
Total Combustible Solids	
Carbonate as CO3 mg/l	<0.01
Bicarbonate as HCO3 mg/l	463.60
Alkalinity as CaCO3 (Total) mg/l	380.00
Total Hardness as CaCO3 mg/l	942
Acidity as CaCO3 mg/l	12.00
Arsenic as As (Total) mg/l	
Barium as Ba (Total) mg/l	
Boron as B (Total) mg/l	
Cadmium as Cd (Total) mg/l	
Calcium as Ca mg/l	164.00
Chromium as Cr (Total) mg/l	
Copper as Cu (Total) mg/l	
Iron as Fe (Total) mg/l	0.450
Lead as Pb (Total) mg/l	
Magnesium as Mg mg/l	101.00
Manganese as Mn (Total) mg/l	
Mercury as Hg (Total) mg/l	
Molybdenum as Mo (Total) mg/l	
Potassium as K mg/l	12.20
Selenium as Se (Total) mg/l	
Silver as As (Total) mg/l	
Sodium as Na mg/l	20.00
Zinc as Zn (Total) mg/l	
Arsenic as As (Dissolved) mg/l	<0.001
Aluminum as Al (Dissolved) mg/l	<0.001
Barium as Ba (Dissolved) mg/l	0.015
Boron as B (Dissolved) mg/l	0.230
Cadmium as Cd (Dissolved) mg/l	<0.001
Chloride as Cl (Dissolved) mg/l	3.60
Chromium as Cr (Dissolved) mg/l	<0.001
Copper as Cu (Dissolved) mg/l	0.002
Fluoride as F (Dissolved) mg/l	0.48
Iron as Fe (Dissolved) mg/l	0.160
Lead as Pb (Dissolved) mg/l	<0.001
Manganese as Mn (Dissolved) mg/l	0.040
Mercury as Hg (Dissolved) mg/l	<0.0002
Molybdenium as Mo (Dissolved) mg/l	<0.001
Nickel as Ni (Dissolved) mg/l	0.005
Selenium as Se (Dissolved) mg/l	<0.001
Silver as As (Dissolved) mg/l	<0.001
Zinc as Zn (Dissolved) mg/l	0.020

Table B-16. Results of chemical analyses of ground water quality samples collected at Station U2-1.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.002	0.01	0.004	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	1100	830	452			
Temperature, Air °C	5	7	5			
Temperature, Water °C	7	7	6			
pH	7.5	7.4	7.4			
Oil & Grease			2.60			
Ammonia as NH3-N mg/l			< 0.01			
Nitrate as NO3-N mg/l			0.02			
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l			0.15			
Phosphate as PO4-P Total mg/l			0.210			
Phosphate as PO4-P Ortho mg/l			0.170			
Sulfate as SO4 mg/l	48.0	51.0	50.0			
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	718	460	420			
Total Combustible Solids						
Carbonate as CO3 mg/l			< 0.01			
Bicarbonate as HCO3 mg/l	719.20	414.80	378.00			
Alkalinity as CaCO3 (Total) mg/l	590	340	310			
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l			16.0			
Arsenic as As (Total) mg/l			<0.001			
Barium as Ba (Total) mg/l			0.050			
Boron as B (Total) mg/l			0.090			
Cadmium as Cd (Total) mg/l			<0.001			
Calcium as Ca mg/l	116	116	108			
Chromium as Cr (Total) mg/l			<0.001			
Copper as Cu (Total) mg/l			<0.001			
Iron as Fe (Total) mg/l			1.130			
Lead as Pb (Total) mg/l			<0.001			
Magnesium as Mg mg/l	28.40	28.80	23.28			
Manganese as Mn (Total) mg/l			0.125			
Mercury as Hg (Total) mg/l			<0.0002			
Molybdenum as Mo (Total) mg/l			< 0.001			
Potassium as K mg/l	2.89	2.73	2.36			
Selenium as Se (Total) mg/l			0.005			
Silver as As (Total) mg/l			<0.001			
Sodium as Na mg/l	130	18.0	16.30			
Zinc as Zn (Total) mg/l			0.008			
Arsenic as As (Dissolved) mg/l			<0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l			0.030			
Boron as B (Dissolved) mg/l			0.080			
Cadmium as Cd (Dissolved) mg/l			<0.001			
Chloride as Cl (Dissolved) mg/l	34.1	39.7	26.0			
Chromium as Cr (Dissolved) mg/l			<0.001			
Copper as Cu (Dissolved) mg/l			<0.001			
Fluoride as F (Dissolved) mg/l			0.21			
Iron as Fe (Dissolved) mg/l			0.334			
Lead as Pb (Dissolved) mg/l			<0.001			
Manganese as Mn (Dissolved) mg/l			0.005			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			0.003			
Silver as As (Dissolved) mg/l			< 0.001			
Zinc as Zn (Dissolved) mg/l			0.002			

Table B-16. Continued.

Date	4-22-81
Flow, cfs	0
Specific Conductance, umhos/cm	
Temperature, Air °C	
Temperature, Water °C	
pH	
Oil & Grease	
Ammonia as NH3-N mg/l	
Nitrate as NO3-N mg/l	
Nitrite as No2-N mg/l	
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	
Phosphate as PO4-P Ortho mg/l	
Sulfate as SO4 mg/l	
Sulfide mg/l	
Total Suspended Solids mg/l	
Total Dissolved Solids mg/l	
Total Combustible Solids	
Carbonate as CO3 mg/l	
Bicarbonate as HCO3 mg/l	
Alkalinity as CaCO3 (Total) mg/l	
Total Hardness as CaCO3 mg/l	
Acidity as CaCO3 mg/l	
Arsenic as As (Total) mg/l	
Barium as Ba (Total) mg/l	
Boron as B (Total) mg/l	
Cadmium as Cd (Total) mg/l	
Calcium as Ca mg/l	
Chromium as Cr (Total) mg/l	
Copper as Cu (Total) mg/l	
Iron as Fe (Total) mg/l	
Lead as Pb (Total) mg/l	
Magnesium as Mg mg/l	
Manganese as Mn (Total) mg/l	
Mercury as Hg (Total) mg/l	
Molybdenum as Mo (Total) mg/l	
Potassium as K mg/l	
Selenium as Se (Total) mg/l	
Silver as As (Total) mg/l	
Sodium as Na mg/l	
Zinc as Zn (Total) mg/l	
Arsenic as As (Dissolved) mg/l	
Aluminum as Al (Dissolved) mg/l	
Barium as Ba (Dissolved) mg/l	
Boron as B (Dissolved) mg/l	
Cadmium as Cd (Dissolved) mg/l	
Chloride as Cl (Dissolved) mg/l	
Chromium as Cr (Dissolved) mg/l	
Copper as Cu (Dissolved) mg/l	
Fluoride as F (Dissolved) mg/l	
Iron as Fe (Dissolved) mg/l	
Lead as Pb (Dissolved) mg/l	
Manganese as Mn (Dissolved) mg/l	
Mercury as Hg (Dissolved) mg/l	
Molybdenium as Mo (Dissolved) mg/l	
Nickel as Ni (Dissolved) mg/l	
Selenium as Se (Dissolved) mg/l	
Silver as As (Dissolved) mg/l	
Zinc as Zn (Dissolved) mg/l	

Table B-17. Results of chemical analyses of ground water quality samples collected at Station U2-2.

Date	10-22-80	11-7-80	12-31-80	1-28-81	2-11-81	3-11-81
Flow, cfs	0.002	0.01	0.004	Inaccessible	Inaccessible	Inaccessible
Specific Conductance, umhos/cm	720	830	442			
Temperature, Air °C		7	11			
Temperature, Water °C		5	8			
pH	7.5	7.4	7.4			
Oil & Grease			1.80			
Ammonia as NH3-N mg/l			<0.01			
Nitrate as NO3-N mg/l			0.02			
Nitrite as No2-N mg/l			0.10			
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l			0.200			
Phosphate as PO4-P Ortho mg/l			0.110			
Sulfate as SO4 mg/l	130	45.0	76.0			
Sulfide mg/l						
Total Suspended Solids mg/l						
Total Dissolved Solids mg/l	469	449	430			
Total Combustible Solids			<0.01			
Carbonate as CO3 mg/l						
Bicarbonate as HCO3 mg/l	292.80	358.52	366.00			
Alkalinity as CaCO3 (Total) mg/l	240	316	300			
Total Hardness as CaCO3 mg/l			18.0			
Acidity as CaCO3 mg/l			<0.001			
Arsenic as As (Total) mg/l			0.068			
Barium as Ba (Total) mg/l			0.095			
Boron as B (Total) mg/l						
Cadmium as Cd (Total) mg/l			<0.001			
Calcium as Ca mg/l	96.00	100.00	97.60			
Chromium as Cr (Total) mg/l			<0.001			
Copper as Cu (Total) mg/l			<0.001			
Iron as Fe (Total) mg/l	0.460					
Lead as Pb (Total) mg/l			<0.001			
Magnesium as Mg mg/l	38.40	31.20	29.28			
Manganese as Mn (Total) mg/l			0.025			
Mercury as Hg (Total) mg/l			<0.0002			
Molybdenum as Mo (Total) mg/l			<0.001			
Potassium as K mg/l	2.86	2.23	2.75			
Selenium as Se (Total) mg/l			0.004			
Silver as As (Total) mg/l			<0.001			
Sodium as Na mg/l	17.10	19.00	16.40			
Zinc as Zn (Total) mg/l			0.010			
Arsenic as As (Dissolved) mg/l			<0.001			
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l			0.030			
Boron as B (Dissolved) mg/l			0.085			
Cadmium as Cd (Dissolved) mg/l			<0.001			
Chloride as Cl (Dissolved) mg/l						
Chromium as Cr (Dissolved) mg/l			<0.001			
Copper as Cu (Dissolved) mg/l			<0.001			
Fluoride as F (Dissolved) mg/l						
Iron as Fe (Dissolved) mg/l			0.210			
Lead as Pb (Dissolved) mg/l			<0.001			
Manganese as Mn (Dissolved) mg/l			0.005			
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			0.002			
Silver as As (Dissolved) mg/l			<0.001			
Zinc as Zn (Dissolved) mg/l			0.005			

Table B-17. Continued.

Date	4-22-81	5-14-81	7-23-81	9-22-81	11-13-81
Flow, cfs	0.004	0.004			
Specific Conductance, umhos/cm	740	600	780	750	469
Temperature, Air °C		15			
Temperature, Water °C	13	8		21	
pH	8.1	7.7	7.8	7.9	7.3
Oil & Grease					
Ammonia as NH3-N mg/l	0.65	< 0.01	0.20	1.49	0.97
Nitrate as NO3-N mg/l	0.03	0.02	0.04	< 0.01	<0.01
Nitrite as No2-N mg/l		< 0.01	< 0.01	< 0.01	<0.01
Nitrogen as KJELDAHL (Total) mg/l					
Phosphate as PO4-P Total mg/l	0.070		0.340	0.260	2.200
Phosphate as PO4-P Ortho mg/l	0.070	< 0.001	0.050	0.075	0.030
Sulfate as SO4 mg/l	66.0	79.0	84.0	121	78.0
Sulfide mg/l		< 0.01	< 0.01	8.00	1.75
Total Suspended Solids mg/l	44.0				
Total Dissolved Solids mg/l	420	495	488	493	470
Total Combustible Solids					
Carbonate as CO3 mg/l	4.80	< 0.01	< 0.01	3.60	<0.01
Bicarbonate as HCO3 mg/l	322.08	368	358.86	270.84	366.60
Alkalinity as CaCO3 (Total) mg/l	272		294	228	301
Total Hardness as CaCO3 mg/l		430	430	418	192
Acidity as CaCO3 mg/l	< 0.01		3.00	0.01	10.00
Arsenic as As (Total) mg/l	< 0.001				
Barium as Ba (Total) mg/l	0.060				
Boron as B (Total) mg/l	0.058				
Cadmium as Cd (Total) mg/l	< 0.001				
Calcium as Ca mg/l	94.40	107.00	107.20	97.60	120.00
Chromium as Cr (Total) mg/l	< 0.001				
Copper as Cu (Total) mg/l	0.030				
Iron as Fe (Total) mg/l	3.170	0.970	0.850	12.500	0.110
Lead as Pb (Total) mg/l	0.010				
Magnesium as Mg mg/l	29.76	38.90	38.88	41.76	31.50
Manganese as Mn (Total) mg/l	0.190	0.030			
Mercury as Hg (Total) mg/l	< 0.0002				
Molybdenum as Mo (Total) mg/l	< 0.001				
Potassium as K mg/l	2.78	2.60	2.86	3.35	2.90
Selenium as Se (Total) mg/l	0.004				
Silver as As (Total) mg/l	0.002				
Sodium as Na mg/l	21.00	17.50	18.10	18.50	4.50
Zinc as Zn (Total) mg/l	0.050				
Arsenic as As (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Aluminum as Al (Dissolved) mg/l		< 0.001	< 0.001	0.020	<0.001
Barium as Ba (Dissolved) mg/l	0.044	0.030	0.035	0.035	<0.035
Boron as B (Dissolved) mg/l	0.050	0.040	0.050	0.060	0.035
Cadmium as Cd (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Chloride as Cl (Dissolved) mg/l	50.00	58.00	60.90	70.00	43.50
Chromium as Cr (Dissolved) mg/l	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Copper as Cu (Dissolved) mg/l	0.010	< 0.001	0.010	< 0.001	<0.015
Fluoride as F (Dissolved) mg/l		0.39	0.35	0.38	0.23
Iron as Fe (Dissolved) mg/l	0.980	0.070	0.440	0.050	0.030
Lead as Pb (Dissolved) mg/l	0.002	< 0.001	< 0.001	0.004	<0.001
Manganese as Mn (Dissolved) mg/l	0.180	< 0.001	0.010	0.010	0.015
Mercury as Hg (Dissolved) mg/l		< 0.0002	< 0.0002	< 0.0002	<0.0002
Molybdenium as Mo (Dissolved) mg/l		< 0.001	< 0.001	< 0.001	<0.001
Nickel as Ni (Dissolved) mg/l		< 0.001	< 0.001	< 0.001	<0.01
Selenium as Se (Dissolved) mg/l	0.002	0.002	0.002	< 0.001	<0.001
Silver as As (Dissolved) mg/l	< 0.001				
Zinc as Zn (Dissolved) mg/l	0.020		0.100	0.015	0.255
Vanadium			< 0.001	< 0.001	<0.001

Table B-18. Results of chemical analyses of ground water quality samples collected at Well WQ-1.

Date	10-19-80	12-31-80	1-28-81	2-11-81	3-11-81	4-22-81
Depth to Water, feet		96.4	95.8	Inaccessible	Inaccessible	95.88
Specific Conductance, umhos/cm	340	295				
Temperature, Air °C			1			
Temperature, Water °C			7			
pH	8.6		8.0			8.7
Oil & Grease			1.00			
Ammonia as NH3-N mg/l			0.50			<0.01
Nitrate as NO3-N mg/l			<0.01			<0.01
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l			0.020			0.070
Phosphate as PO4-P Ortho mg/l			0.010			0.030
Sulfate as SO4 mg/l	193		58.0			90.0
Sulfide mg/l						
Total Suspended Solids mg/l						201
Total Dissolved Solids mg/l	580		300			310
Total Combustible Solids						
Carbonate as CO3 mg/l			<0.01			7.20
Bicarbonate as HCO3 mg/l	270.84		256.20			185.44
Alkalinity as CaCO3 (Total) mg/l	222		210			164
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	8.0		2.0			<0.01
Arsenic as As (Total) mg/l			<0.010			<0.001
Barium as Ba (Total) mg/l			0.050			0.005
Boron as B (Total) mg/l			0.160			0.210
Cadmium as Cd (Total) mg/l			0.001			<0.001
Calcium as Ca mg/l	13.6		33.60			17.60
Chromium as Cr (Total) mg/l			0.006			<0.001
Copper as Cu (Total) mg/l			0.015			0.050
Iron as Fe (Total) mg/l			34.00			29.000
Lead as Pb (Total) mg/l			0.134			0.025
Magnesium as Mg mg/l	1.92		19.20			16.80
Manganese as Mn (Total) mg/l	0.860		0.230			0.150
Mercury as Hg (Total) mg/l			< 0.0002			<0.0002
Molybdenum as Mo (Total) mg/l			<0.001			< 0.001
Potassium as K mg/l	47.00		14.00			13.50
Selenium as Se (Total) mg/l			< 0.001			< 0.001
Silver as As (Total) mg/l			< 0.001			< 0.001
Sodium as Na mg/l	163	46.90				43.00
Zinc as Zn (Total) mg/l			0.450			0.075
Arsenic as As (Dissolved) mg/l			< 0.001			< 0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l			0.020			0.004
Boron as B (Dissolved) mg/l			0.155			0.190
Cadmium as Cd (Dissolved) mg/l			< 0.001			< 0.001
Chloride as Cl (Dissolved) mg/l	22.22		5.80			
Chromium as Cr (Dissolved) mg/l			< 0.001			< 0.001
Copper as Cu (Dissolved) mg/l			0.010			0.040
Fluoride as F (Dissolved) mg/l			0.63			
Iron as Fe (Dissolved) mg/l	0.350		0.030			25.000
Lead as Pb (Dissolved) mg/l			0.002			0.025
Manganese as Mn (Dissolved) mg/l						0.140
Mercury as Hg (Dissolved) mg/l						
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l			< 0.001			< 0.001
Silver as As (Dissolved) mg/l			< 0.001			< 0.001
Zinc as Zn (Dissolved) mg/l			0.012			0.070

Table B-18. Continued.

Date	5-14-81	7-23-81	9-22-81	11-13-81
Depth to Water, feet	95.7	94.22	96.14	95.94
Specific Conductance, umhos/cm		600	379	
Temperature, Air °C	15	23	22	
Temperature, Water °C	8	10	11	
pH	8.7	8.5	8.1	8.3
Oil & Grease				
Ammonia as NH3-N mg/l	0.60	0.75	0.31	0.95
Nitrate as NO3-N mg/l	< 0.01	< 0.01	< 0.01	0.12
Nitrite as No2-N mg/l	< 0.01	< 0.01	0.09	< 0.01
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l		0.300	0.250	0.720
Phosphate as PO4-P Ortho mg/l	< 0.001	0.030	0.050	< 0.001
Sulfate as SO4 mg/l	67.0	64.0	36.0	36.0
Sulfide mg/l	< 0.01	< 0.01	3.89	2.67
Total Suspended Solids mg/l				
Total Dissolved Solids mg/l	285	390	335	298
Total Combustible Solids				
Carbonate as CO3 mg/l	0.01	9.60	12.00	< 0.01
Bicarbonate as HCO3 mg/l	212.00	348.92	280.60	266.80
Alkalinity as CaCO3 (Total) mg/l		202	250	219
Total Hardness as CaCO3 mg/l	138	160	164	150
Acidity as CaCO3 mg/l		<0.01	<0.01	8.00
Arsenic as As (Total) mg/l				
Barium as Ba (Total) mg/l				
Boron as B (Total) mg/l				
Cadmium as Cd (Total) mg/l				
Calcium as Ca mg/l	18.40	25.60	25.60	18.00
Chromium as Cr (Total) mg/l				
Copper as Cu (Total) mg/l				
Iron as Fe (Total) mg/l	29.000	17.200	15.500	12.900
Lead as Pb (Total) mg/l				
Magnesium as Mg mg/l	22.10	23.04	24.00	23.50
Manganese as Mn (Total) mg/l	0.130			
Mercury as Hg (Total) mg/l				
Molybdenum as Mo (Total) mg/l				
Potassium as K mg/l	14.50	13.90	14.10	3.80
Selenium as Se (Total) mg/l				
Silver as As (Total) mg/l				
Sodium as Na mg/l	48.50	86.00	57.00	61.00
Zinc as Zn (Total) mg/l				
Arsenic as As (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Aluminum as Al (Dissolved) mg/l	<0.001	<0.001	<0.001	0.015
Barium as Ba (Dissolved) mg/l	0.015	0.020	0.015	0.010
Boron as B (Dissolved) mg/l	0.150	0.160	0.150	0.155
Cadmium as Cd (Dissolved) mg/l	0.006	<0.001	<0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	10.00	8.30	16.00	16.30
Chromium as Cr (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Copper as Cu (Dissolved) mg/l	<0.001	0.010	<0.001	0.011
Fluoride as F (Dissolved) mg/l			0.54	0.46
Iron as Fe (Dissolved) mg/l	0.010	0.410	0.430	1.250
Lead as Pb (Dissolved) mg/l	0.003	<0.001	0.002	< 0.001
Manganese as Mn (Dissolved) mg/l	0.030	0.070	0.060	0.068
Mercury as Hg (Dissolved) mg/l	<0.0002	<0.0002	<0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Nickel as Ni (Dissolved) mg/l	0.053	0.027	<0.001	0.03
Selenium as Se (Dissolved) mg/l	<0.001	<0.001	<0.001	< 0.001
Silver as As (Dissolved) mg/l				
Zinc as Zn (Dissolved) mg/l		0.065	0.007	0.095
Vanadium		<0.001	<0.001	< 0.001

Table B-19. Results of chemical analyses of ground water quality samples collected at Well WQ1-A.

Date	11-7-80	12-31-80	1-28-80	2-11-81	3-11-81	4-22-81
Depth to Water, feet		107.4	111.07	Inaccessible	Inaccessible	100.72
Specific Conductance, umhos/cm	550	250				
Temperature, Air °C			No Sample			
Temperature, Water °C		10				
pH	7.8	7.8				8.1
Oil & Grease		2.20				
Ammonia as NH3-N mg/l		< 0.01				<0.01
Nitrate as NO3-N mg/l		< 0.01				<0.01
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l						
Phosphate as PO4-P Total mg/l		0.300				0.180
Phosphate as PO4-P Ortho mg/l		<0.001				0.040
Sulfate as SO4 mg/l	39.0	57.0				53.0
Sulfide mg/l						
Total Suspended Solids mg/l						276
Total Dissolved Solids mg/l	340	165				185
Total Combustible Solids						
Carbonate as CO3 mg/l		<0.01				<0.01
Bicarbonate as HCO3 mg/l	322.08	85.40				107.36
Alkalinity as CaCO3 (Total) mg/l	264	70.0				88.00
Total Hardness as CaCO3 mg/l						
Acidity as CaCO3 mg/l	18.0	4.0				5.00
Arsenic as As (Total) mg/l		<0.001				<0.001
Barium as Ba (Total) mg/l		0.035				0.010
Boron as B (Total) mg/l		0.050				0.065
Cadmium as Cd (Total) mg/l		<0.001				<0.001
Calcium as Ca mg/l	29.60	28.00				26.40
Chromium as Cr (Total) mg/l		<0.001				<0.001
Copper as Cu (Total) mg/l		0.170				0.030
Iron as Fe (Total) mg/l	15.800	28.700				13.900
Lead as Pb (Total) mg/l		0.072				0.019
Magnesium as Mg mg/l	13.92	10.08				12.48
Manganese as Mn (Total) mg/l	0.250	0.305				0.140
Mercury as Hg (Total) mg/l		<0.0002				<0.0002
Molybdenum as Mo (Total) mg/l		<0.001				< 0.001
Potassium as K mg/l	12.30	1.75				3.60
Selenium as Se (Total) mg/l		0.002				0.001
Silver as As (Total) mg/l		<0.001				<0.001
Sodium as Na mg/l	67.40	9.30				13.00
Zinc as Zn (Total) mg/l		0.045				0.085
Arsenic as As (Dissolved) mg/l		<0.001				<0.001
Aluminum as Al (Dissolved) mg/l						
Barium as Ba (Dissolved) mg/l		0.015				0.003
Boron as B (Dissolved) mg/l		0.050				0.050
Cadmium as Cd (Dissolved) mg/l		<0.001				<0.001
Chloride as Cl (Dissolved) mg/l	4.9	1.44				
Chromium as Cr (Dissolved) mg/l		<0.001				<0.001
Copper as Cu (Dissolved) mg/l		<0.001				0.030
Fluoride as F (Dissolved) mg/l		0.09				
Iron as Fe (Dissolved) mg/l	12.400	0.285				10.700
Lead as Pb (Dissolved) mg/l		<0.001				
Manganese as Mn (Dissolved) mg/l		0.075				0.016
Mercury as Hg (Dissolved) mg/l						0.140
Molybdenium as Mo (Dissolved) mg/l						
Nickel as Ni (Dissolved) mg/l						
Selenium as Se (Dissolved) mg/l		<0.001				
Silver as As (Dissolved) mg/l		<0.001				<0.001
Zinc as Zn (Dissolved) mg/l		0.002				<0.001
						0.070

Table B-19. Continued.

Date	5-13-81	7-23-81	9-22-81	11-13-81
Depth to Water, feet	104.14	102.32	104.83	100.47
Specific Conductance, umhos/cm		240	198	178
Temperature, Air °C	12	23	22	16
Temperature, Water °C	8	9	17	9
pH	7.6	8.9	9.4	8.5
Oil & Grease				
Ammonia as NH3-N mg/1	0.55	0.30	0.72	0.89
Nitrate as NO3-N mg/1	0.06	<0.01	<0.01	0.08
Nitrite as No2-N mg/1	0.18	<0.01	<0.01	<0.01
Nitrogen as KJELDAHL (Total) mg/1				
Phosphate as PO4-P Total mg/1		0.530	0.550	1.000
Phosphate as PO4-P Ortho mg/1	0.020	0.530	0.466	0.020
Sulfate as SO4 mg/1	309	52.0	12.0	15.0
Sulfide mg/1	0.17	0.01	8.0	1.75
Total Suspended Solids mg/1				
Total Dissolved Solids mg/1	710	155	345	135
Total Combustible Solids				
Carbonate as CO3 mg/1	<0.01	7.20	7.20	7.20
Bicarbonate as HCO3 mg/1	339.16	90.28	239.12	91.99
Alkalinity as CaCO3 (Total) mg/1		86.00	208.00	87.40
Total Hardness as CaCO3 mg/1	432	94.0	82.0	104.0
Acidity as CaCO3 mg/1		<0.01	<0.01	<0.01
Arsenic as As (Total) mg/1				
Barium as Ba (Total) mg/1				
Boron as B (Total) mg/1				
Cadmium as Cd (Total) mg/1				
Calcium as Ca mg/1	67.20	9.60	8.80	5.00
Chromium as Cr (Total) mg/1				
Copper as Cu (Total) mg/1				
Iron as Fe (Total) mg/1	0.610	14.520	8.200	15.830
Lead as Pb (Total) mg/1				
Magnesium as Mg mg/1	63.36	16.80	14.40	18.00
Manganese as Mn (Total) mg/1				
Mercury as Hg (Total) mg/1				
Molybdenum as Mo (Total) mg/1				
Potassium as K mg/1	11.00	4.60	5.50	2.60
Selenium as Se (Total) mg/1				
Silver as As (Total) mg/1				
Sodium as Na mg/1	83.00	22.90	72.50	8.99
Zinc as Zn (Total) mg/1				
Arsenic as As (Dissolved) mg/1	<0.001	<0.001	<0.001	< 0.001
Aluminum as Al (Dissolved) mg/1	0.002	0.010	0.010	0.030
Barium as Ba (Dissolved) mg/1	0.045	0.005	0.005	0.005
Boron as B (Dissolved) mg/1	0.210	0.060	0.060	0.060
Cadmium as Cd (Dissolved) mg/1	<0.001	<0.001	<0.001	< 0.001
Chloride as Cl (Dissolved) mg/1	12.00	15.20	20.00	13.70
Chromium as Cr (Dissolved) mg/1	<0.001	<0.001	<0.001	< 0.001
Copper as Cu (Dissolved) mg/1	<0.001	<0.001	<0.001	0.002
Fluoride as F (Dissolved) mg/1	1.14	0.24	0.12	0.23
Iron as Fe (Dissolved) mg/1	0.090	8.950	0.030	6.450
Lead as Pb (Dissolved) mg/1	<0.001	<0.001	<0.001	< 0.001
Manganese as Mn (Dissolved) mg/1	0.020	0.030	0.020	
Mercury as Hg (Dissolved) mg/1	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/1	<0.001	<0.001	<0.001	< 0.001
Nickel as Ni (Dissolved) mg/1	<0.001	<0.001	<0.001	0.04
Selenium as Se (Dissolved) mg/1	<0.001	<0.001	<0.001	< 0.001
Silver as As (Dissolved) mg/1				
Zinc as Zn (Dissolved) mg/1		0.090	0.010	0.055
Vanadium		<0.001	<0.001	0.01[illegible]

Table B-20. Results of chemical analyses of ground water quality samples collected at Well WQ-6.

Date	11-7-80	12-31-80	4-22-81	5-14-81	7-23-81	9-22-81
Depth to Water, feet		116.05	90.5	111.31	110.6	111.2
Specific Conductance, umhos/cm	940	490		590	680	470
Temperature, Air °C				15	20	22
Temperature, Water °C		10		9	11	14
pH	7.2	7.4	8.1	7.6	7.4	7.6
Oil & Grease		2.60				
Ammonia as NH3-N mg/l		<0.01	<0.01	0.10	0.15	0.62
Nitrate as NO3-N mg/l		<0.01	<0.01	0.03	0.02	<0.01
Nitrite as No2-N mg/l						
Nitrogen as KJELDAHL (Total) mg/l		0.10				
Phosphate as PO4-P Total mg/l		0.160	0.300		0.120	0.155
Phosphate as PO4-P Ortho mg/l		0.020	0.025	0.001	0.010	0.045
Sulfate as SO4 mg/l	170	120	119	112	95.0	104
Sulfide mg/l				<0.01	<0.01	0.25
Total Suspended Solids mg/l			319			
Total Dissolved Solids mg/l	610	320	300	510	440	426
Total Combustible Solids						
Carbonate as CO3 mg/l		<0.01	<0.01	<0.01	<0.01	6.00
Bicarbonate as HCO3 mg/l	409.92	161.04	82.96	373	322.08	285.48
Alkalinity as CaCO3 (Total) mg/l	336	132	68.00		264	244
Total Hardness as CaCO3 mg/l				442	376	374
Acidity as CaCO3 mg/l	6.0	12.0	3.00		13.50	0.01
Arsenic as As (Total) mg/l		<0.001	<0.001			
Barium as Ba (Total) mg/l		0.039	0.025			
Boron as B (Total) mg/l		0.100	0.080			
Cadmium as Cd (Total) mg/l		<0.001	0.003			
Calcium as Ca mg/l	100	28.00	25.60	88.00	61.60	41.60
Chromium as Cr (Total) mg/l		0.022	0.002			
Copper as Cu (Total) mg/l		0.250	0.100			
Iron as Fe (Total) mg/l	39.300	123	35.700	16.800	17.540	26.500
Lead as Pb (Total) mg/l		0.075	0.011			
Magnesium as Mg mg/l	52.80	43.68	26.88	53.00	56.28	64.80
Manganese as Mn (Total) mg/l	0.500	0.800	0.400	0.090		
Mercury as Hg (Total) mg/l		<0.0002	<0.0002			
Molybdenum as Mo (Total) mg/l		<0.001	<0.001			
Potassium as K mg/l	5.10	5.90	6.50	6.40	6.00	7.10
Selenium as Se (Total) mg/l		0.001	0.001			
Silver as As (Total) mg/l		<0.001	<0.001			
Sodium as Na mg/l	15.20	17.10	18.50	16.50	8.00	18.50
Zinc as Zn (Total) mg/l		0.112	0.120			
Arsenic as As (Dissolved) mg/l		<0.001	<0.001	< 0.001	< 0.001	< 0.001
Aluminum as Al (Dissolved) mg/l				< 0.001	0.010	< 0.001
Barium as Ba (Dissolved) mg/l		0.020	0.016	0.075	0.005	0.010
Boron as B (Dissolved) mg/l		0.010	0.070	0.080	0.070	0.050
Cadmium as Cd (Dissolved) mg/l		<0.001	0.003	< 0.001	< 0.001	< 0.001
Chloride as Cl (Dissolved) mg/l	36.2	23.80		50.00	44.40	50.00
Chromium as Cr (Dissolved) mg/l		<0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper as Cu (Dissolved) mg/l		<0.001	0.090	0.010	0.030	< 0.001
Fluoride as F (Dissolved) mg/l		<0.01		0.19	0.13	0.26
Iron as Fe (Dissolved) mg/l	33.400	0.510	19.000	8.050	7.250	1.990
Lead as Pb (Dissolved) mg/l		<0.001	0.011	0.003	< 0.001	< 0.001
Manganese as Mn (Dissolved) mg/l		0.215	0.330	0.090	0.170	0.130
Mercury as Hg (Dissolved) mg/l				< 0.0002	< 0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/l				< 0.001	< 0.001	< 0.001
Nickel as Ni (Dissolved) mg/l				< 0.001	0.068	0.035
Selenium as Se (Dissolved) mg/l		<0.001	<0.001	< 0.001	< 0.001	< 0.001
Silver as As (Dissolved) mg/l		<0.001	<0.001			
Zinc as Zn (Dissolved) mg/l		0.015	0.100		0.110	0.013
Vanadium					< 0.001	< 0.001

Table B-20. Continued.

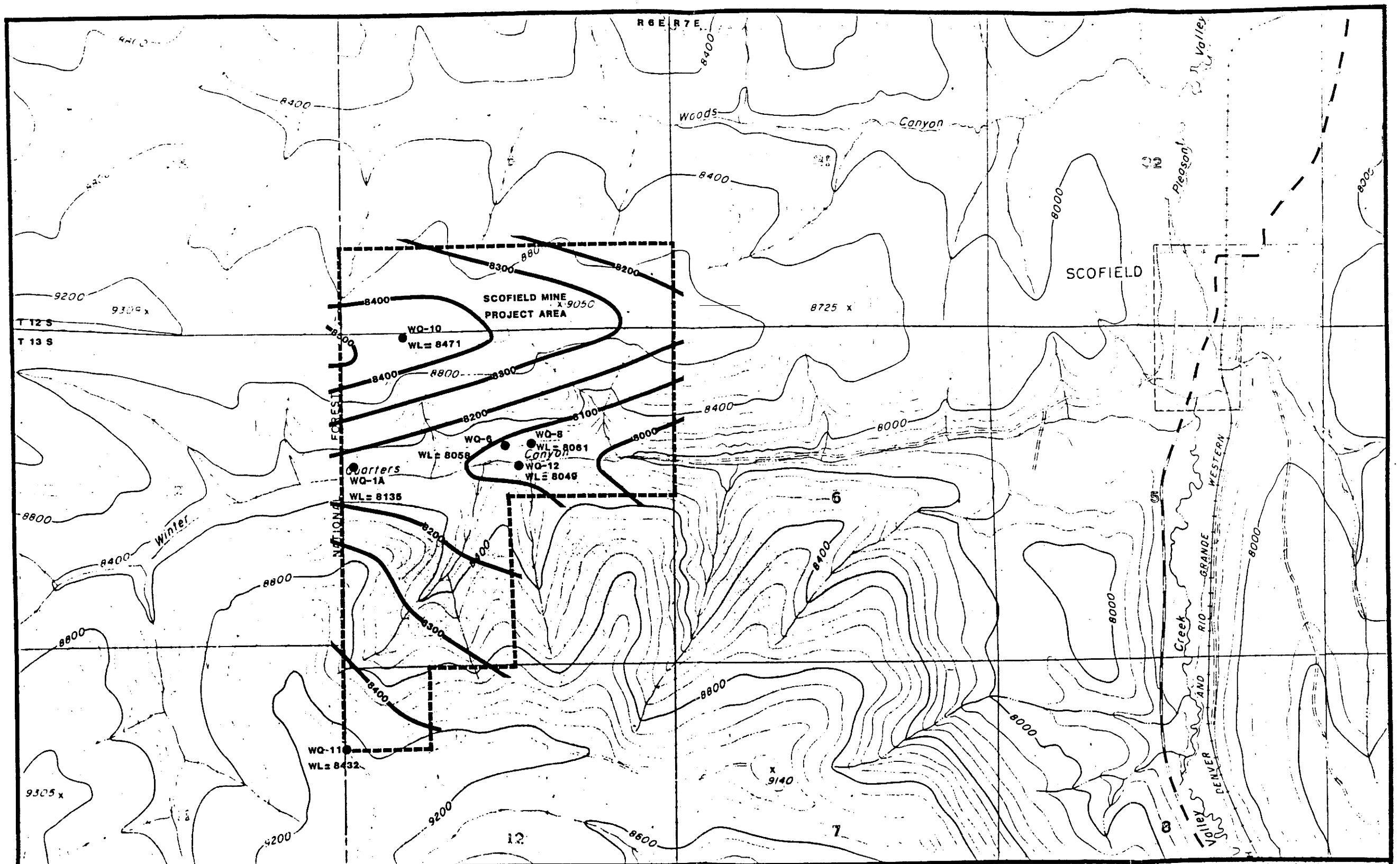
Date	11-13-81
Depth to Water, feet	111.41
Specific Conductance, umhos/cm	285
Temperature, Air °C	14
Temperature, Water °C	10
pH	7.2
Oil & Grease	
Ammonia as NH3-N mg/l	0.47
Nitrate as NO3-N mg/l	0.14
Nitrite as No2-N mg/l	< 0.01
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	0.820
Phosphate as PO4-P Ortho mg/l	0.080
Sulfate as SO4 mg/l	58.0
Sulfide mg/l	4.92
Total Suspended Solids mg/l	
Total Dissolved Solids mg/l	230
Total Combustible Solids	
Carbonate as CO3 mg/l	7.20
Bicarbonate as HCO3 mg/l	133.30
Alkalinity as CaCO3 (Total) mg/l	121.40
Total Hardness as CaCO3 mg/l	206
Acidity as CaCO3 mg/l	< 0.01
Arsenic as As (Total) mg/l	< 0.001
Barium as Ba (Total) mg/l	
Boron as B (Total) mg/l	
Cadmium as Cd (Total) mg/l	
Calcium as Ca mg/l	10.00
Chromium as Cr (Total) mg/l	
Copper as Cu (Total) mg/l	
Iron as Fe (Total) mg/l	
Lead as Pb (Total) mg/l	
Magnesium as Mg mg/l	45.00
Manganese as Mn (Total) mg/l	
Mercury as Hg (Total) mg/l	
Molybdenum as Mo (Total) mg/l	
Potassium as K mg/l	6.50
Selenium as Se (Total) mg/l	
Silver as As (Total) mg/l	
Sodium as Na mg/l	5.90
Zinc as Zn (Total) mg/l	
Arsenic as As (Dissolved) mg/l	< 0.001
Aluminum as Al (Dissolved) mg/l	0.040
Barium as Ba (Dissolved) mg/l	0.10
Boron as B (Dissolved) mg/l	0.055
Cadmium as Cd (Dissolved) mg/l	< 0.001
Chloride as Cl (Dissolved) mg/l	42.40
Chromium as Cr (Dissolved) mg/l	< 0.001
Copper as Cu (Dissolved) mg/l	< 0.025
Fluoride as F (Dissolved) mg/l	0.08
Iron as Fe (Dissolved) mg/l	6.650
Lead as Pb (Dissolved) mg/l	< 0.001
Manganese as Mn (Dissolved) mg/l	0.150
Mercury as Hg (Dissolved) mg/l	< 0.0002
Molybdenium as Mo (Dissolved) mg/l	< 0.001
Nickel as Ni (Dissolved) mg/l	0.08
Selenium as Se (Dissolved) mg/l	< 0.001
Silver as As (Dissolved) mg/l	
Zinc as Zn (Dissolved) mg/l	0.114
Vanadium	< 0.001

Table B-21. Results of chemical analyses of ground water quality samples collected at Well WQ-8.

Date	4-22-81	5-27-81	7-23-81	9-22-81
Depth to Water, feet	64.86	64.9	60.22	60.34
Specific Conductance, umhos/cm			750	338
Temperature, Air °C				22
Temperature, Water °C			15	12
pH	7.6	8.0	6.9	7.3
Oil & Grease				
Ammonia as NH3-N mg/l	<0.01	0.01	0.02	0.50
Nitrate as NO3-N mg/l	<0.01	0.01	0.01	0.01
Nitrite as No2-N mg/l		0.01	0.01	0.04
Nitrogen as KJELDAHL (Total) mg/l				
Phosphate as PO4-P Total mg/l	0.150	0.160	0.200	0.163
Phosphate as PO4-P Ortho mg/l	0.060	<0.001	0.060	0.065
Sulfate as SO4 mg/l	28.5	49.5	45.0	27.0
Sulfide mg/l		0.01	0.57	1.78
Total Suspended Solids mg/l	131			
Total Dissolved Solids mg/l	210	199	185	310
Total Combustible Solids				
Carbonate as CO3 mg/l	<0.01	<0.01	<0.01	6.00
Bicarbonate as HCO3 mg/l	226.92	143.96	139.08	283.04
Alkalinity as CaCO3 (Total) mg/l	186	118	114	242
Total Hardness as CaCO3 mg/l		164	160	182
Acidity as CaCO3 mg/l	3.0	2.85	4.50	< 0.01
Arsenic as As (Total) mg/l	<0.001			
Barium as Ba (Total) mg/l	0.040			
Boron as B (Total) mg/l	0.082			
Cadmium as Cd (Total) mg/l	<0.001			
Calcium as Ca mg/l	38.40	36.80	41.60	34.60
Chromium as Cr (Total) mg/l	<0.001			
Copper as Cu (Total) mg/l	0.050			
Iron as Fe (Total) mg/l	38.000	2.420	36.950	11.100
Lead as Pb (Total) mg/l	0.279			
Magnesium as Mg mg/l	13.92	17.28	13.44	23.04
Manganese as Mn (Total) mg/l	0.300			
Mercury as Hg (Total) mg/l	<0.0002			
Molybdenum as Mo (Total) mg/l	<0.001			
Potassium as K mg/l	1.37	1.31	1.40	1.42
Selenium as Se (Total) mg/l	0.001			
Silver as As (Total) mg/l	<0.001			
Sodium as Na mg/l	12.00	7.90	8.90	53.00
Zinc as Zn (Total) mg/l	0.300			
Arsenic as As (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Aluminum as Al (Dissolved) mg/l		< 0.001	< 0.001	< 0.001
Barium as Ba (Dissolved) mg/l	0.020	0.110	0.035	0.035
Boron as B (Dissolved) mg/l	0.070	0.020	0.020	0.020
Cadmium as Cd (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Chloride as Cl (Dissolved) mg/l		14.00	12.00	26.00
Chromium as Cr (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Copper as Cu (Dissolved) mg/l	0.040	< 0.001	0.010	< 0.001
Fluoride as F (Dissolved) mg/l		0.29	0.28	0.33
Iron as Fe (Dissolved) mg/l	27.400	2.250	0.442	2.880
Lead as Pb (Dissolved) mg/l	0.252	< 0.001	< 0.001	0.002
Manganese as Mn (Dissolved) mg/l	0.290	0.190	0.210	0.210
Mercury as Hg (Dissolved) mg/l		< 0.0002	< 0.0002	< 0.0002
Molybdenium as Mo (Dissolved) mg/l		< 0.001	< 0.001	< 0.001
Nickel as Ni (Dissolved) mg/l		0.062	0.094	0.023
Selenium as Se (Dissolved) mg/l	<0.001	< 0.001	< 0.001	< 0.001
Silver as As (Dissolved) mg/l	<0.001			
Zinc as Zn (Dissolved) mg/l	0.260	0.010	0.250	0.025
Vanadium		<0.001	<0.001	<0.001

Table B-22. Results of chemical analyses of ground water quality samples collected at Well WQ-12.

Date	11-11-81
Depth to water, feet	
Specific Conductance, umhos/cm	299
Temperature, Air °C	3
Temperature, Water °C	2
pH	6.7
Oil & Grease	<0.01
Ammonia as NH3-N mg/l	0.30
Nitrate as NO3-N mg/l	0.07
Nitrite as No2-N mg/l	<0.01
Nitrogen as KJELDAHL (Total) mg/l	
Phosphate as PO4-P Total mg/l	0.065
Phosphate as PO4-P Ortho mg/l	0.040
Sulfate as SO4 mg/l	15.0
Sulfide mg/l	0.57
Total Suspended Solids mg/l	6.0
Total Dissolved Solids mg/l	292
Total Combustible Solids	
Carbonate as CO3 mg/l	<0.01
Bicarbonate as HCO3 mg/l	335.20
Alkalinity as CaCO3 (Total) mg/l	275
Total Hardness as CaCO3 mg/l	292
Acidity as CaCO3 mg/l	4.00
Arsenic as As (Total) mg/l	
Barium as Ba (Total) mg/l	
Boron as B (Total) mg/l	
Cadmium as Cd (Total) mg/l	
Calcium as Ca mg/l	68.00
Chromium as Cr (Total) mg/l	
Copper as Cu (Total) mg/l	
Iron as Fe (Total) mg/l	0.360
Lead as Pb (Total) mg/l	
Magnesium as Mg mg/l	26.00
Manganese as Mn (Total) mg/l	
Mercury as Hg (Total) mg/l	
Molybdenum as Mo (Total) mg/l	
Potassium as K mg/l	2.50
Selenium as Se (Total) mg/l	
Silver as As (Total) mg/l	
Sodium as Na mg/l	6.90
Zinc as Zn (Total) mg/l	
Arsenic as As (Dissolved) mg/l	<0.001
Aluminum as Al (Dissolved) mg/l	0.004
Barium as Ba (Dissolved) mg/l	0.045
Boron as B (Dissolved) mg/l	0.055
Cadmium as Cd (Dissolved) mg/l	<0.001
Chloride as Cl (Dissolved) mg/l	3.80
Chromium as Cr (Dissolved) mg/l	<0.001
Copper as Cu (Dissolved) mg/l	<0.001
Fluoride as F (Dissolved) mg/l	0.24
Iron as Fe (Dissolved) mg/l	0.150
Lead as Pb (Dissolved) mg/l	<0.001
Manganese as Mn (Dissolved) mg/l	0.004
Mercury as Hg (Dissolved) mg/l	<0.0002
Molybdenium as Mo (Dissolved) mg/l	<0.001
Nickel as Ni (Dissolved) mg/l	<0.01
Selenium as Se (Dissolved) mg/l	<0.001
Silver as As (Dissolved) mg/l	
Zinc as Zn (Dissolved) mg/l	0.006
Vanadium (Dissolved) mg/l	0.010
Phenol mg/l	<0.001
Turbidity NTU	0.30
Alpha Radio-Activity pci/L	<0.2
Beta Radio-Activity pci/L	<0.5



Prepared by

Vaughn Hansen Associates

Salt Lake City, Utah

December, 1981

N

Scale: 1 inch = 1000 feet

LEGEND

● WQ-8	Monitoring well location and number
WL= 8061	Water level elevation (msl)
—8400—	Ground water contour and elevation (msl)

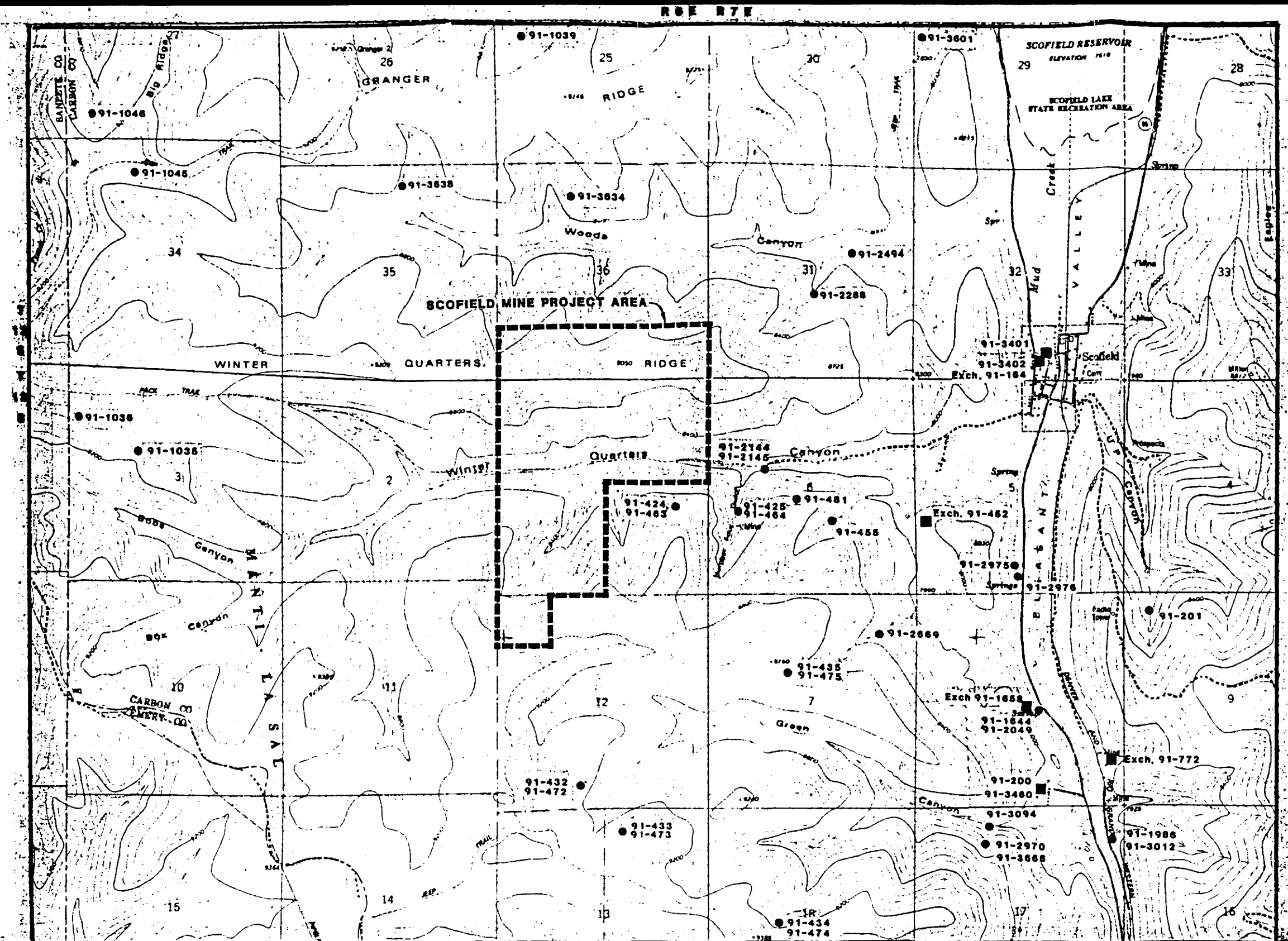
DRAWN	
8/6/8	BY
7/31/81	JH
APPROVED	
DATE	BY
REVISED	
DATE	BY

PLATE 2.

GROUNDWATER CONTOURS ON THE SCOFIELD MINE PROJECT AREA

UCO, INC.
1580 LINCOLN ST., #520
DENVER, COLORADO 80203
(303) 837-0405

FILE NO



Prepared by

Vaughn Hansen Associates

Salt Lake City, Utah

December, 1981

N

Scale: 1 inch = 2000 feet

LEGEND

91-432 Water use claim number

■ Well or mine water

● Spring

DRAWN	
DATE	BY
5-81	JM
APPROVED	
DATE	BY
REVISED	
DATE	BY
DCH	2-81

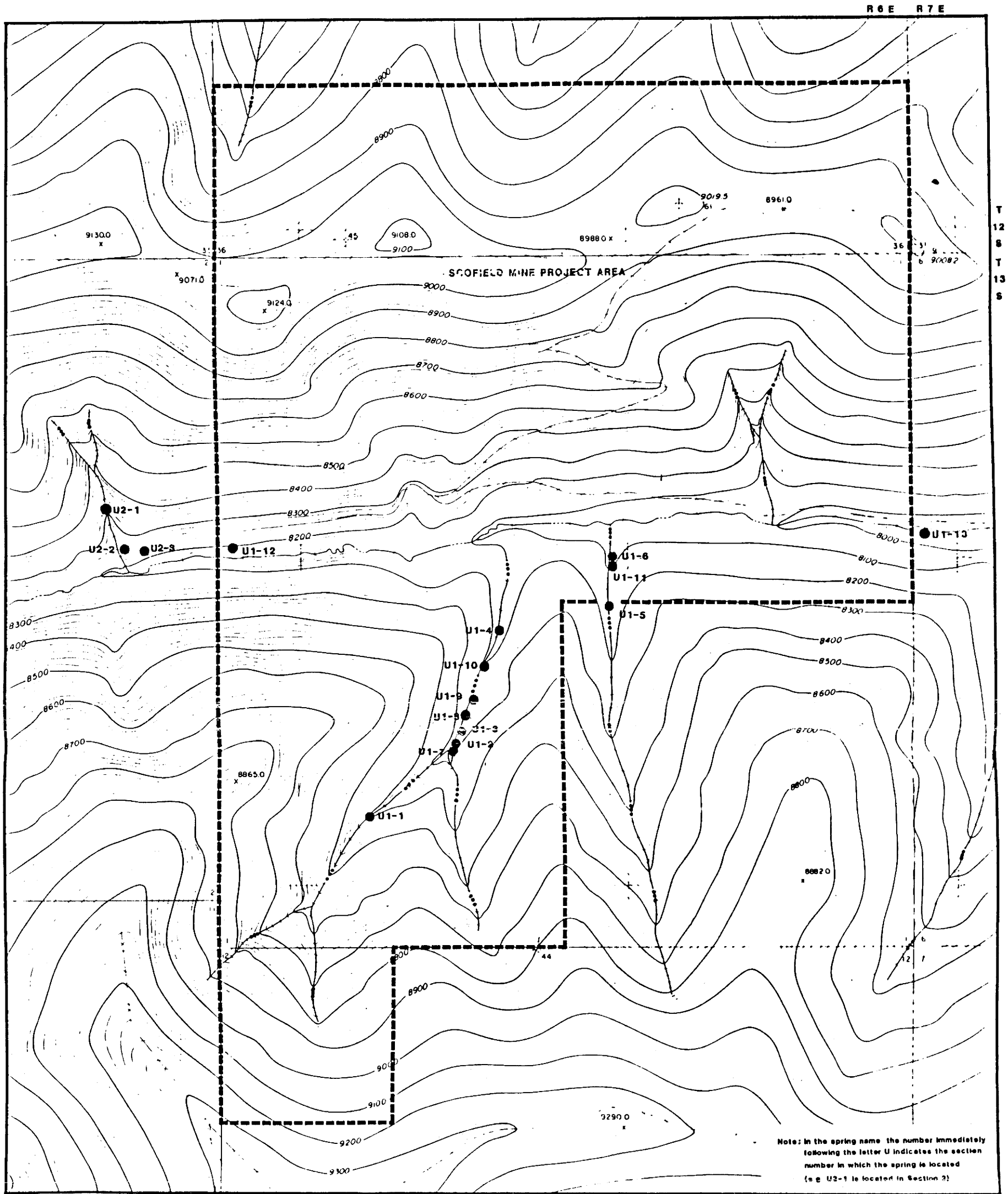
PLATE 4.

GROUNDWATER RIGHTS ON AND ADJACENT TO THE SCOFIELD MINE PROJECT AREA

UCO, INC.

1660 LINCOLN ST., #630
DENVER, COLORADO 80203
(303) 837-0485

FILE NO.



intermittent stream

perennial stream

N

Scale : 1 inch = 500 feet

Prepared by
Vaughn Hansen Associates
Salt Lake City, Utah
December, 1981

Spring No.	Date	Flow (gpm)	Conductance (umhos)
U1-1	10-21-80	7	470
U1-2	10-21-80	1	610
U1-3	10-21-80	2	620
U1-4	10-21-80	3	560
U1-5	10-23-80	12	750
U1-6	10-23-80	15	760
U1-7	10-21-80	.5	—
U1-8	10-21-80	2	—
U1-9	10-21-80	2	—
U1-10	10-21-80	2	—
U1-11	10-23-80	.5	680
U1-12	5-14-81	Seep	—
U2-1	10-22-80	1	830
U2-2	10-22-80	1	840
U2-3	10-22-80	Seep	—
U1-13	11-25-81	30	1000

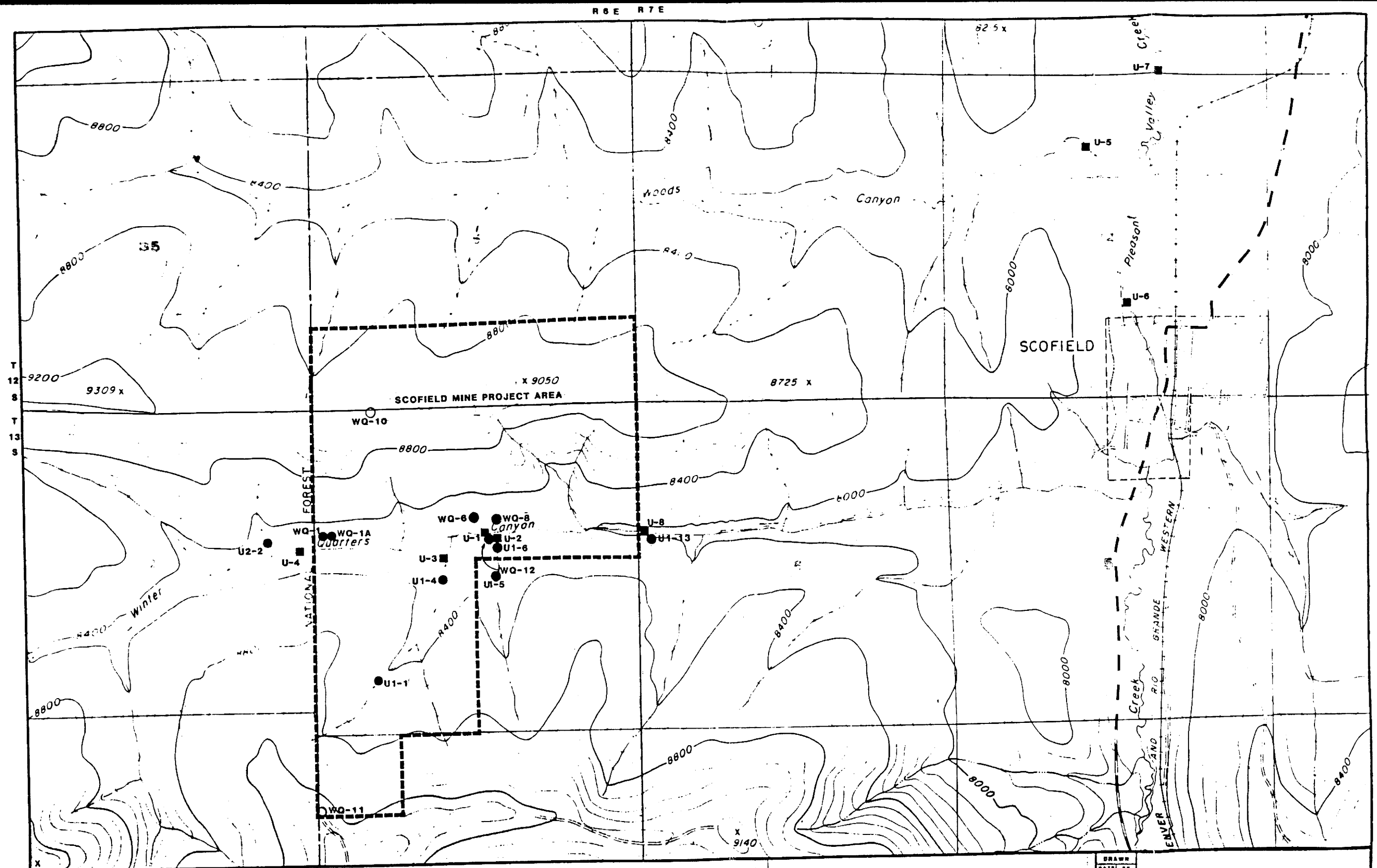
DRAWN	
DATE	BY
6-81	JVH
APPROVED	
DATE	BY
REVISED	
DATE	BY
[illegible]	[illegible]

PLATE 3.

IDENTIFIED SEEPS AND SPRINGS

UCO, INC.
1580 LINCOLN ST., #530
DENVER, COLORADO 80203
(303) 837-0465

FILE NO



Prepared by

Vaughn Hansen Associates

Salt Lake City, Utah

December 1981

Scale : 1 inch = 1000 feet

N

LEGEND

- Existing groundwater monitoring site (well or spring).
- Existing surface water monitoring site.
- Existing well monitoring station for water levels only.

DRAWN	
DATE	BY
6-8-81	JVH
APPROVED	
DATE	BY
REVISED	
DATE	BY
2-81	
8-81	

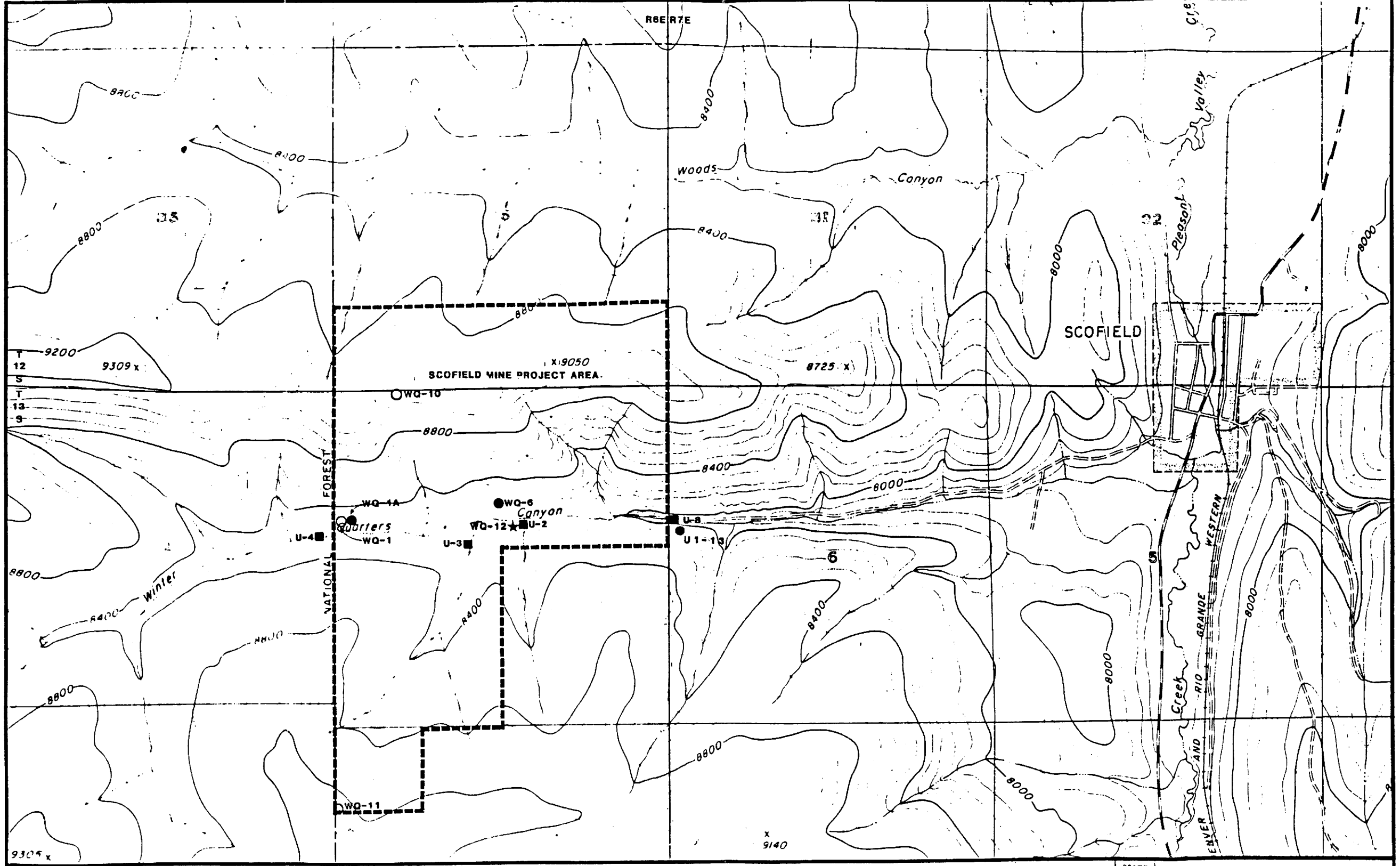
PLATE 5

EXISTING GROUND AND SURFACE WATER MONITORING SITES

UCO, INC.

1500 LINCOLN ST., #630
DENVER, COLORADO 80203
(303) 837-0400

FILE NO.



Prepared by

Vaughn Hansen Associates

Salt Lake City, Utah

December 1981

Scale: 1 in = 1000 ft

LEGEND

- ● U1-13 — Groundwater monitoring site for flow and quality for springs; water level and quality for wells
- ■ U-4 — Surface water monitoring site for flow and quality
- ○ WQ-11 — Monitoring site for water levels only
- ★ WQ-12 — Well quality samples only

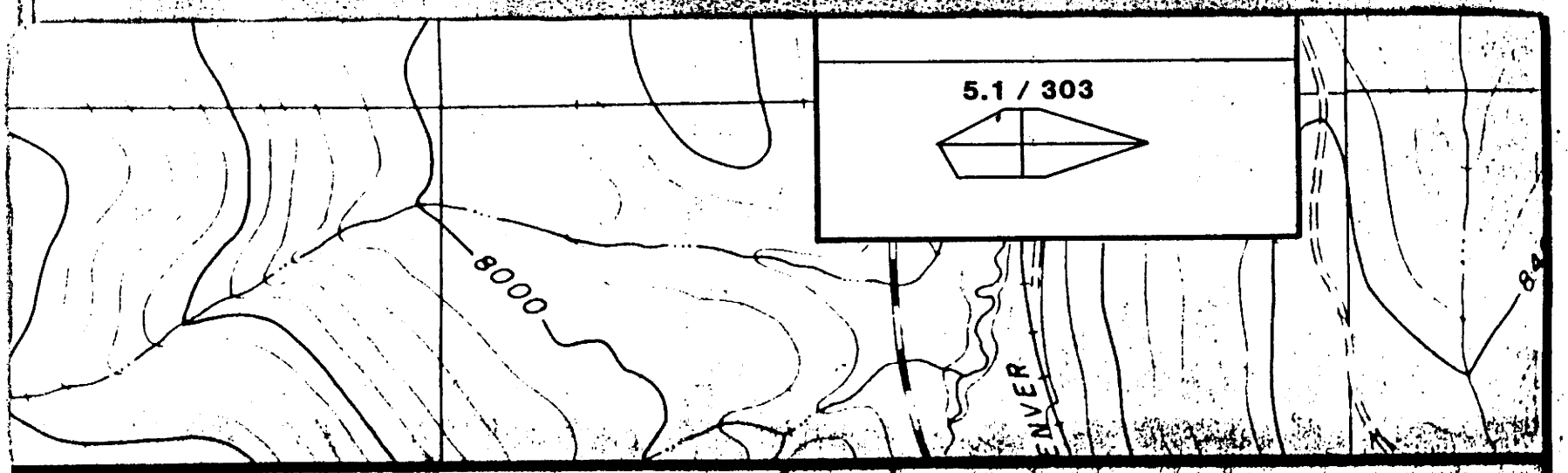
DRAWN DATE: BY:
APPROVED DATE: BY:
REVISED DATE: BY:

PLATE 6.

GROUND AND SURFACE WATER MONITORING SITES FOR ONGOING MONITORING

UCO, INC. 1560 LINCOLN ST. #530 DENVER, COLORADO 80203 (303) 837-0465

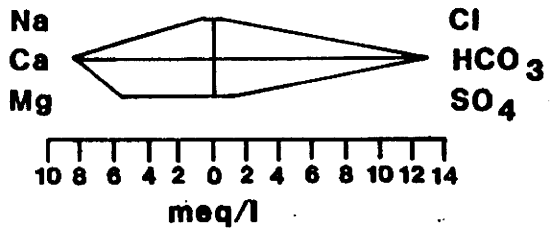
FILE NO.



Quarterly Average

Cations|Anions

verage flow (cfs) / Average TDS (mg/l)



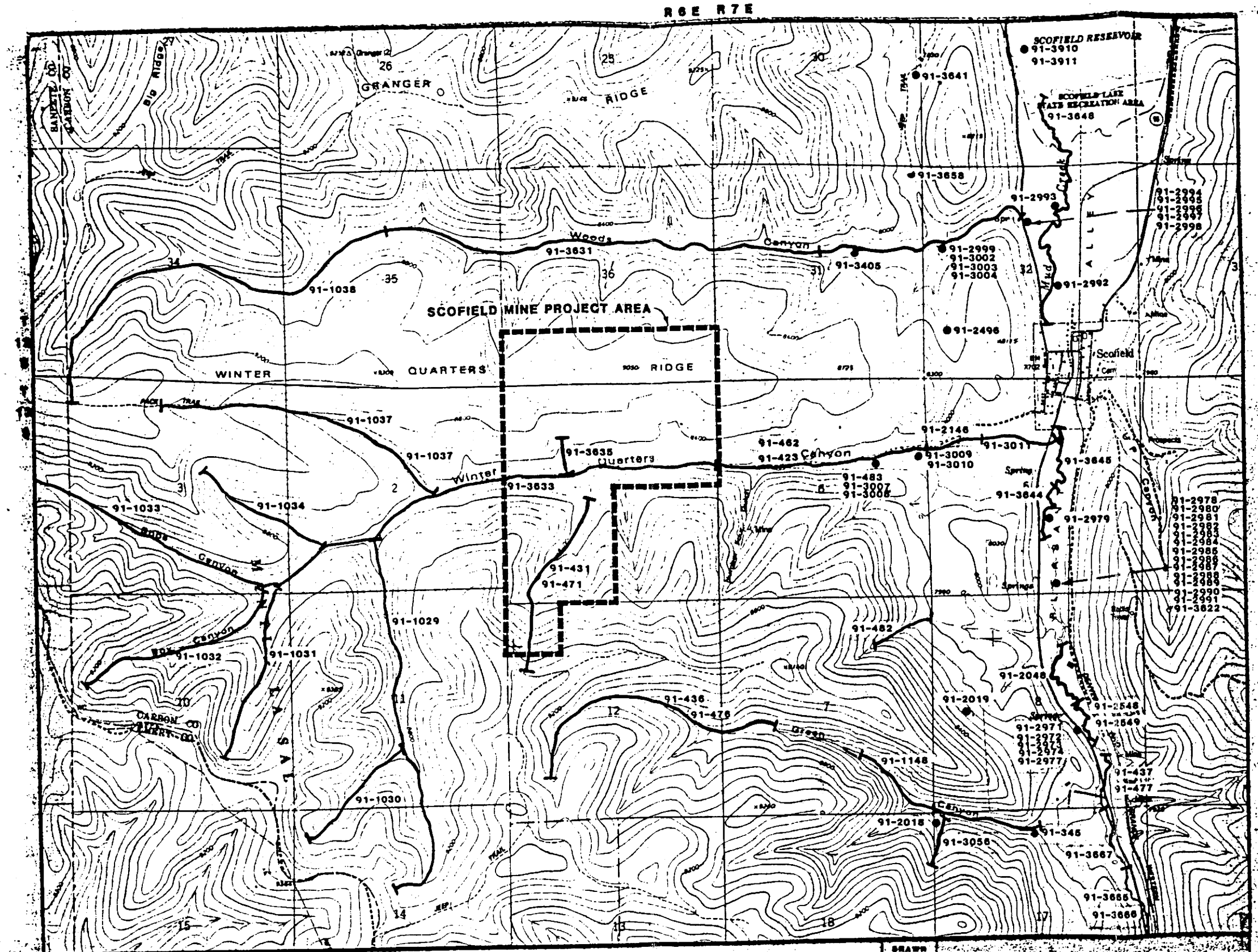
DRAWN	
DATE	BY
12-81	DRB
APPROVED	
DATE	BY
REVISED	
DATE	BY

PLATE 7.

SURFACE WATER QUALITY DATA IN AND ADJACENT TO THE SCOFIELD MINE PROJECT AREA

UCO, INC.
1560 LINCOLN ST., #530
DENVER, COLORADO 80203
(303) 837-0465

FILE NO.



Prepared by

Vaughn Hansen Associates

Salt Lake City, Utah

December, 1981

N

Scale: 1 inch = 2000 feet

LEGEND

91-1031 Water use claim number

Stream segment

Diversion point, stock pond or reservoir use

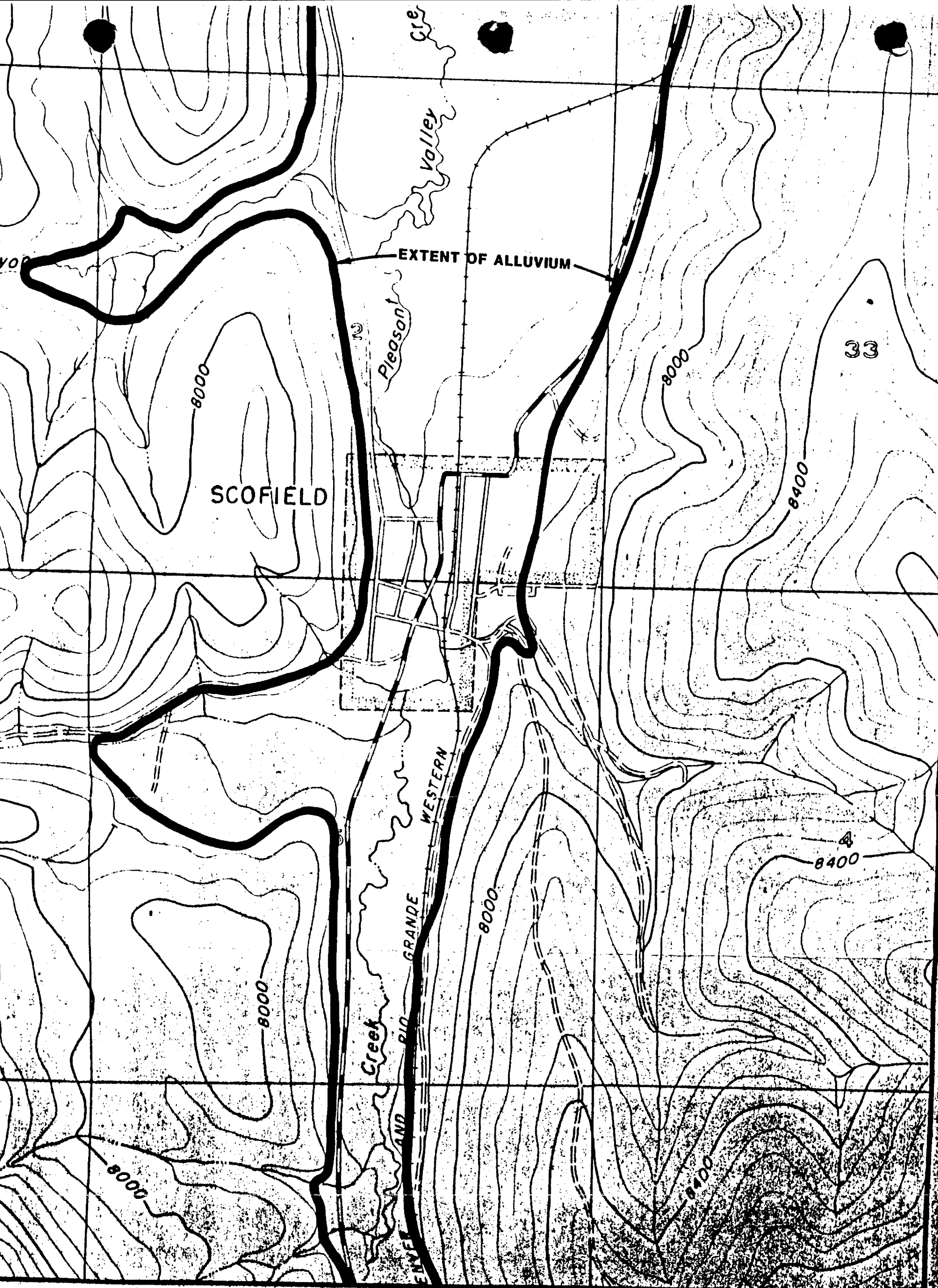
DRAWN		
DATE	BY	
5-81	JWH	
APPROVED		
DATE	BY	
REVISED		
DATE	BY	
12-81	DCH	

PLATE 8.

SURFACE WATER RIGHTS ON AND ADJACENT TO THE SCOFIELD MINE PROJECT AREA

UCO, INC.
1660 LINCOLN ST., #630
DENVER, COLORADO 80203
(303) 837-0458

FILE NO.



DRAWN	
DATE	BY
6-81	JVH
APPROVED	
DATE	BY
REVISED	
DATE	BY
12-81	DOH

PLATE 11

EXTENT OF ALLUVIUM

UCO, INC.

FILE NO.

er Quarters Town Site (42 Cb 268)

ıts House)

9. #3 MINE PORTAL
10. TIPPLE
11. CABLE HOUSE
12. #1 MINE PORTAL
13. #2 MINE PORTAL
14. FINN TOWN
15. ROCK SHELTER (42 Cb 269)
16. RESERVOIR

SCALE : Approx. 1"-500'

DRAWN	
DATE	BY
APPROVED	
DATE	BY
REVISED	
DATE	BY

FIGURE 4

AERIAL PHOTO
WINTER QUARTERS CANYON

UCO, INC.

1660 LINCOLN ST., #530
DENVER, COLORADO 80203
(303) 837-0465

FILE NO.

SURFACE WATER RIGHTS
SKYLINE MINE RECLAMATION PLAN
ENVIRONMENTAL DATA
VOLUME 4, 1992

SKYLINE MINES RECLAMATION PLAN 1992

ENVIRONMENTAL DATA VOL 4

SURFACE WATER RIGHTS IN THE PRICE RIVER BASIN LOCATED ON AND ADJACENT TO THE SKYLINE PROPERTY

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-252	Utah Div. of Wildlife Resources	Gooseberry Creek with Storage	5.0	Fish Culture	January 1 to December 31
91-345	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Doraban	Green Canyon Spring Stream	0.75	Irrigation	March 1 to November 30
91-423	Nick Marakis (½ interest)	Winter Quarters Creek	---	Stockwatering	January 1 to December 31
91-431	Nick Marakis (½ interest)	Stream	---	Stockwatering	January 1 to December 31
91-436	Nick Marakis (½ interest)	Stream	---	Stockwatering	January 1 to December 31
91-437	Nick Marakis (½ interest)	Clear Creek	---	Stockwatering	January 1 to December 31
91-438	Nick Marakis (½ interest)	Clear Creek	---	Stockwatering	January 1 to December 31
91-440	Nick Marakis (½ interest)	Wash with storage	---	Stockwatering	January 1 to December 31
91-441	Nick Marakis (½ interest)	Stream with storage	---	Stockwatering	Janaury 1 to December 31
91-462	John Marakis Estate (½ interest)	Winter Quarters Creek	---	Stockwatering	January 1 to December 31
91-471	John Marakis Estate (½ interest)	Stream	---	Stockwatering	January 1 to December 31
91-476	John Marakis Estate (½ interest)	Stream	---	Stockwatering	January 1 to December 31
91-477	John Marakis Estate (½ interest)	Clear Creek	---	Stockwatering	January 1 to December 31
91-478	John Marakis Estate (½ interest)	Clear Creek	---	Stockwatering	January 1 to December 31

SURFACE WATER RIGHTS IN THE PRICE RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1022	U.S. Forest Service	S. Fork Eccles Canyon Cr.	----	Stockwatering	July 1 to September 30
91-1023	U.S. Forest Service	Tributary to South Fork Eccles Canyon Creek	----	Stockwatering	July 1 to September 30
91-1024	U.S. Forest Service	Tributary to South Fork Eccles Canyon Creek	----	Stockwatering	July 1 to September 30
91-1025	U.S. Forest Service	Tributary to Eccles Canyon Cr.	----	Stockwatering	July 1 to September 30
91-1026	U.S. Forest Service	Tributary to Eccles Canyon Cr.	----	Stockwatering	July 1 to September 30
91-1027	U.S. Forest Service	Eccles Canyon Creek	----	Stockwatering	July 1 to September 30
91-1028	U.S. Forest Service	Eccles Canyon Creek	----	Stockwatering	July 1 to September 30
91-1029	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1030	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1031	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1032	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1033	U.S. Forest Service	Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1034	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1037	U.S. Forest Service	Tributary to Winter Quarters Canyon Creek	----	Stockwatering	July 1 to September 30
91-1038	U.S. Forest Service	Woods Canyon Creek	----	Stockwatering	July 1 to September 30
91-1040	U.S. Forest Service	East Fork Dairy Creek	----	Stockwatering	July 1 to September 30
91-1041	U.S. Forest Service	Andrew Dairy Creek	----	Stockwatering	July 1 to September 30

SURFACE WATER RIGHTS IN THE PRICE RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1148	Leon & Tom Nicolaides Mary Stathis Bessie Daraban	Green Canyon Stream	----	Stockwatering	January 1 to December 31
91-1149	U.S. Forest Service	Gooseberry Creek with Storage	----	Stockwatering	July 1 to October 5
91-1678	Calvin K. Jacob	Stream	----	Stockwatering	May 1 to November 30
91-1713	N.M. Jensen Investment Co.	Spring Stream	----	Stockwatering Domestic	January 1 to December 31
91-2018	Angelo Georgedes	Green Canyon Stream with Storage	----	Stockwatering	May 1 to October 31
91-2019	Angelo Georgedes	Stream with storage	----	Stockwatering	May 1 to October 31
91-2020	Angelo Georgedes	Green Canyon Stream	----	Stockwatering	May 1 to October 31
91-2048	John Jouflas Estate	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2146	Elrie and Bertha Simonsen	Winter Quarters Creek	----	Stockwatering	June 1 to November 30
91-2495	Elrie & Bertha Simonsen	Woods Canyon Creek	----	Stockwatering	June 1 to November 30
91-2496	Elrie & Bertha Simonsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-2548	John Jouflas Estate (2/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2549	Lee S. Thomas (1/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2971	Lee S. Thomas (1/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2972	John Jouflas Estate (2/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2973	John Jouflas Estate	Clear Creek	0.381	Irrigation	March 1 to November 30

SURFACE WATER RIGHTS IN THE PRICE RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-2997	Alice M. Pannier (4.85/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2998	Boyd W. & Johannah M. Hafen (12.0/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2999	Reed & Leoan M. Gunderson	Woods Canyon Creek	0.136	Irrigation	March 1 to November 30
91-3002	Della L. Madsen	Woods Canyon Creek	0.035	Irrigation	March 1 to November 30
91-3003	Charles J. Jacobsen Evelyn M. Jacobsen Stephen C. Macobsen Charlyn J. Dalebout (7.9/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30
91-3004	Louise M. Watts Helen L. Watts John Andy Watts (18.1/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30
91-3007	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.63	Irrigation	March 1 to November 30
91-3008	S. J. Harkness	Winter Quarters Creek	0.693	Irrigation	March 1 to November 30
91-3009	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.68	Irrigation	March 1 to November 30
91-3010	S. J. Harkness	Winter Quarters Creek	0.213	Irrigation	March 1 to November 30
91-3011	S. J. Harkness	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-3014	Anton Michelog	Sniddr Creek	----	Stockwatering	January 1 to December 31
91-3015	Anton Michelog	Mud Creek	----	Stockwatering	January 1 to December 31
91-3040	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Darsban	Clear Creek	----	Stockwatering	January 1 to December 31
91-3045	Milton A. Oman	Clear Creek	----	Stockwatering	January 1 to December 31

SURFACE WATER RIGHTS IN THE PRICE RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3083	Lavern Jensen	Finn Canyon Creek	----	Stockwatering	January 1 to December 31
91-3084	Milton A. Oman	Finn Canyon Creek	----	Stockwatering	January 1 to December 31
91-3086	Anton Michelog	Long Canyon Creek	----	Stockwatering	January 1 to December 31
91-3086	Anton Michelog	Long Canyon Creek	----	Stockwatering	January 1 to December 31
91-3090	Anton Michelog	Stream with storage	----	Stockwatering	January 1 to December 31
91-3405	Elvie & Bertha Simonsen	Woods Canyon Creek	----	Irrigation Stockwatering	March 1 to November 30
91-3440	Calvin K. Jacob	Clear Creek	----	Stockwatering	May 1 to November 30
91-3587	North American Coal Corp.	Boardinghouse Canyon Creek	----	Stockwatering	June 1 to November 30
91-3588	North American Coal Corp.	Finn Canyon Creek	----	Stockwatering	June 1 to November 30
91-3589	North American Coal Corp.	Mud Creek	----	Stockwatering	June 1 to November 30
91-3622	Mae Nicolodemas	Clear Creek	0.016	Irrigation	March 1 to November 30
91-3630	Utah Board of State Lands	Gooseberry Creek	----	Stockwatering	June 1 to November 30
91-3631	D. Euray Allred	Woods Canyon Creek	----	Stockwatering	May 1 to November 30
91-3633	D. Euray Allred	Winter Quarters Creek	----	Stockwatering	May 1 to November 30
91-3635	D. Euray Allred	Stream	----	Stockwatering	May 1 to November 30
91-3641	Pete Frandsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-3644	Justus O. Seely	Clear Creek	----	Stockwatering	June 1 to November 30
91-3645	S. J. Harkness	Clear Creek	----	Stockwatering	June 1 to November 30
91-3648	John B. Jones	Clear Creek	----	Stockwatering	January 1 to December 31
91-3655	John B. Jones	Woods Canyon Creek	----	Stockwatering	January 1 to December 31

GROUND WATER RIGHTS IN THE PRICE RIVER BASIN LOCATED ON AND ADJACENT TO THE SKYLINE PROPERTY

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-119	U.S. Forest Service	Spring	0.03	Domestic, Irrigation	March 1 to November 30
91-136	U.S. Forest Service	Beaver Dam Ridge Spring	0.006	Stockwatering	May 1 to October 31
91-200	Utah Natural Gas Company (½ interest)	Underground Water, well	0.134	Domestic Irrigation	January 1 to December 31
91-201	Earl Thomas	Spring with storage	0.068	Stockwatering	April 15 to November 1
91-288	U.S. Forest Service	Gooseberry Campground Spring	0.098	Domestic	May 1 to October 31
91-408	Calvin K. Jacob	Spring	0.011	Stockwatering	May 1 to November 30
91-424	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-425	Nick Marakis (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-432	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-433	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-434	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-435	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-455	Robert Radakovich	Spring	0.011	Stockwatering	May 1 to December 15
91-463	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-464	John Marakis Estate (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-472	John Marakis Estate (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31

GROUND WATER RIGHTS IN THE PRICE RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1158	N.M. Jensen Investment Co.	Aagard Spring	0.638	Irr.,Stock., Domestic	June 1 to October 31
91-1643	Jack Thomas	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-1644	Lee Thomas (1/3 interest)	Spring	-----	Stockwatering	May 1 to October 31
91-1679	Calvin K. Jacob	Spring	0.011	Stock. and Domestic	May 1 to November 30
91-1680	Calvin K. Jacob	Spring	0.011	Stockwatering	May 1 to November 30
91-1681	Calvin K. Jacob	Spring	0.011	Stockwatering	May 1 to November 30
91-1699	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1700	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1701	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1702	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1710	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1711	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1714	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1986	Angelo Georgedes	Spring with storage	0.05	Fish Culture	January 1 to December 31
91-2049	John Jouflas Estate (2/3 interest)	Spring	0.011	Stockwatering	May 1 to October 31
91-2144	Elrie and Bertha Simonsen (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2145	Robert Radakovich (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2288	Elrie & Bertha Simonsen	Spring	0.011	Stockwatering	June 1 to November 30
91-2494	Elrie & Bertha Simonsen	Mooney Mine Spring	----	Irrigation Stockwatering	March 1 to November 30

GROUND WATER RIGHTS IN THE PRICE RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3601	Della L. Madsen	Spring	0.011	Stockwatering	June 1 to November 30
91-3634	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3638	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3642	John B. Jones	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-3668	Angelo Georgedes	Spring	0.015	Stockwatering	May 1 to October 31
91-3971	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3973	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3974	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3975	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3976	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3977	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3978	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3979	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3980	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3981	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3982	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3983	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
91-3985	Lionel L. Peterson	Spring	0.022	Stock. & Domestic	May 1 to November 30
P*91-4217	Carol C. Dixon	Collard Spring	9.64	Stock. & Domestic	January 1 to December 31
P*91-4319	Robert Anderson	Robert Anderson Spring	0.035AF	Stock. & Domestic	January 1 to December 31

P* - Pending

SURFACE WATER RIGHTS IN THE SAN RAFAEL RIVER BASIN LOCATED ON AND ADJACENT TO THE SKYLINE PROPERTY

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-1	U.S. Forest Service	Kitchen Fork of Huntington Cr.	-----	Stockwatering	July 1 to October 10
93-2	U.S. Forest Service	Kitchen Fork of Huntington Cr.	-----	Stockwatering	July 1 to September 30
93-3	U.S. Forest Service	Kitchen Fork of Huntington Cr.	-----	Stockwatering	July 1 to September 30
93-4	Crowther Investment Co.	Kitchen Fork of Huntington Cr.	-----	Stockwatering	July 1 to September 30
93-6	U.S. Forest Service	N. Fork of Huntington Creek	-----	Stockwatering	July 1 to September 30
93-8	U.S. Forest Service	Unnamed for of Huntington Cr.	-----	Stockwatering	July 1 to September 30
93-9	U.S. Forest Service	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-10	L.D.S. Church	Swens Canyon Creek	-----	Stockwatering	----------
93-11	U.S. Forest Service	Swen's Canyon Creek	-----	Stockwatering	July 1 to September 30
93-12	U.S. Forest Service	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-13	U.S. Forest Service	Burnout Canyon Creek	-----	Stockwatering	July 1 to September 30
93-14	U.S. Forest Service	James Canyon Creek	-----	Stockwatering	July 1 to September 30
93-16	U.S. Forest Service	James Canyon Creek	-----	Stockwatering	July 1 to September 30
93-18	U.S. Forest Service	Flat Canyon Creek	-----	Stockwatering	July 1 to September 30
93-19	U.S. Forest Service	Flat Canyon Creek	-----	Stockwatering	July 1 to September 30
93-20	U.S. Forest Service	Boulger Creek	-----	Stockwatering	July 1 to September 30
93-21	U.S. Forest Service	Boulger Creek	-----	Stockwatering	July 1 to September 30
93-32	Lela C. Mower	Jackson Spring #1 Stream	-----	Irrigation Stockwatering	----------
93-33	Clyde K. Cox	Jackson Spring #1 Stream	-----	Irrigation Stockwatering	----------

SURFACE WATER RIGHTS IN THE SAN RAFAEL RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-77	Utah Power & Light Co.	Bear Canyon Creek	-----	Stockwatering	July 1 to September 30
93-78	U.S. Forest Service	Coal Creek	-----	Stockwatering	July 1 to September 30
93-79	U.S. Forest Service	Coal Creek	-----	Stockwatering	July 1 to September 30
93-80	Reed Neilson	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-81	Bernard Nielsen	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-82	Utah Power and Light Co.	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-83	U.S. Forest Service	Cox Canyon Creek	-----	Stockwatering	July 1 to September 30
93-84	U.S. Forest Service	Valentine Gulch	-----	Stockwatering	July 1 to September 30
93-85	U.S. Forest Service	Valentine Gulch	-----	Stockwatering	July 1 to September 30
93-89	Valenine Gulch Inc.	Valentine Gulch	-----	Stockwatering	July 1 to September 30
93-96	Utah Power and Light Co.	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-265	Utah Power and Light Co.	Coal Creek	-----	Stockwatering	July 1 to September 30
93-290	Utah Power and Light Co.	Coal Creek	-----	Stockwatering	July 1 to September 30
93-338	U.S. Forest Service	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-346	L.D.S. Church	Little Swens Canyon Cr.	-----	Stockwatering Domestic	June 1 to November 30
93-348	U.S. Forest Service	Spring Creek	-----	Stockwatering	June 16 to October 5
93-399	Utah Power and Light Co.	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-434	William R. Whitehead et al	Kitchen Fork of Huntington Cr.	-----	Stockwatering	June 1 to November 30
93-543	Morris S. & Betty A. Cook	Coal Creek	-----	Stockwatering	July 1 to September 30
93-551	Utah Power and Light Co.	Cox Canyon Creek	-----	Stockwatering	July 1 to September 30
93-553	Utah Power and Light Co.	James Canyon Creek	-----	Stockwatering	July 1 to September 30

GROUND WATER RIGHTS IN THE SAN RAFAEL RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-59	Clyde K. Cox	Saw Mill Spring	-----	Stockwatering, Irrig.	----------
93-60	Roscoe C. Cox	Stan Spring #1	-----	Stockwatering	----------
93-61	Roscoe C. Cox	Stan Spring #2	-----	Stockwatering	----------
93-62	Stanley Cox	Saw Mill Springs	-----	Stockwatering, Irrig.	----------
93-63	Stanley Cox	Stan Spring #1	-----	Stockwatering, Irrig.	----------
93-64	Roscoe C. Cox	Stan Spring #1	-----	Stockwatering, Irrig.	----------
93-65	Doris R. Cox	Stan Spring #2	-----	Stockwatering, Irrig.	----------
93-66	Donald B. Cox	Stan Spring #2	-----	Stockwatering, Irrig.	----------
93-67	Newel B. Cox	Mineral Spring #2	-----	Stockwatering, Irrig.	----------
93-68	Evan Cox	Stan Spring #2	-----	Stockwatering, Irrig.	
93-69	A. Ira Cox	Stan Spring #2	-----	Stockwatering, Irrig.	----------
93-70	Olea D. Cox	Mineral Spring #2	-----	Stockwatering, Irrig.	----------
93-71	Roscoe C. Cox	Worth Spring Stream	-----	Stockwatering, Irrig.	----------
93-72	Evan Cox	Ross Spring #2	-----	Stockwatering	----------
93-75	Evan Cox	Ross Spring #3	-----	Stockwatering	----------
93-90	L.D.S. Church	Unnamed Spring	0.022	Stockwatering Domestic	June 1 to November 30
93-114	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-127	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-145	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-153	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-154	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30

GROUND WATER RIGHTS IN THE SAN RAFAEL RIVER BASIN (continued)

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-404	Russel O. Brown	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-411	M. Dover Hunt	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-429	Don Evans	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-430	Eli Clayson	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-431	Clark T. Thorstensen	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-432	Crowther Investment Company	Brooks Canyon Divide	0.011	Stockwatering	June 1 to October 15
93-433	William R. Whitehead et al	Unnamed Spring	0.011	Stockwatering	June 1 to October 15
93-435	Crowther Investment Company	Unnamed Spring	0.011	Stockwatering	June 1 to October 15
93-449	Crowther Investment Company	Unnamed Spring	0.011	Stockwatering Domestic	June 1 to October 15
93-763	Robert N. Anderson	Unnamed Spring #8	0.018	Stockwatering	June 15 to October 15
93-770	W. Chad Cox	Spring House Spring	-----	Irrigation Stockwatering	----------
93-771	Donald B. Cox	Spring House Spring	-----	Irrigation Stockwatering	----------
93-773	Roscoe C. Cox	Ross Spring #1	-----	Stockwatering	----------
93-774	A. Ira Cox	Ike Spring #1	-----	Stockwatering	----------
93-775	A. Ira Cox	Ike Spring #2	-----	Stockwatering	----------
93-838	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-839	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-840	N. M. Jensen Investment Company	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-841	N. M. Jensen Investment Company	Unnamed Spring	0.022	Stockwatering Domestic	June 1 to November 30

WATER RIGHT EXCHANGES IN THE SKYLINE PROPERTY AREA

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-164	Louise Gorishek	Well	1.0 A.F.	Domestic	January 1 to December 31
91-452	Robert Radakovich	Well	1.0 A.F.	Stockwatering	March 1 to November 30
91-772	Valley Camp Coal Company	Well	0.446 cfs	Industrial Domestic	January 1 to December 31
91-940	Gooseberry Enterprise Inc	Springs	66.0 A.F.	Domestic	January 1 to December 31
91-1058	Price River Water Users Association	Well	7.7 A.F.	Industrial Domestic	January 1 to December 31
91-1114	Coastal States Energy Co.	Wells	30.0 A.F.	Industrial Domestic	January 1 to December 31
91-1560	Coastal States Energy Co.	Wells	118.0 A.F.	Industrial Domestic	January 1 to December 31
91-1658	Robert Radakovich	Spring	1.0 A.F.	Domestic	January 1 to December 31
91-1669	T.O.E. Investments	Well	3.0 A.F.	Industrial	January 1 to December 31
91-1691	Valley Camp of Utah Inc	Well	7.7 A.F.	Industrial Domestic	January 1 to December 31
91-1906	Coastal States Energy Co.	Wells	118.0 A.F.	Industrial Domestic	January 1 to December 31
91-1912	Jim Nicolodemos	Well	1.0 A.F.	Domestic	January 1 to December 31
91-2188	LDS Church	Well	1.0 A.F.	Domestic	May 1 to October 30
91-2385	Max A. Blackam	Spring	0.5 A.F.	Domestic	January 1 to December 31
91-2475	LDS Church	Well	1.0 A.F.	Domestic	January 1 to December 31

Winter Quarters Canyon
Data Adequacy

October 1992

WATERSHED INVENTORY & ANALYSIS
PRICE RIVER WATERSHED
JAMES L. IAQUINTA, 1985

VARIOUS

WATERSHED INVENTORY AND ANALYSIS
FOR
PRICE RIVER WATERSHED

(Main Report)

By: James L. Iaquinta

Volume I of III

D. Kelly

United States
Department of
Agriculture

Forest
Service

Manti-LaSal N.F.

Reply to: 2530 Water Resource Management

Date: October 3, 1985

Subject: Water Resource Inventory and Analysis of the Price River Watershed

To: Regional Forester

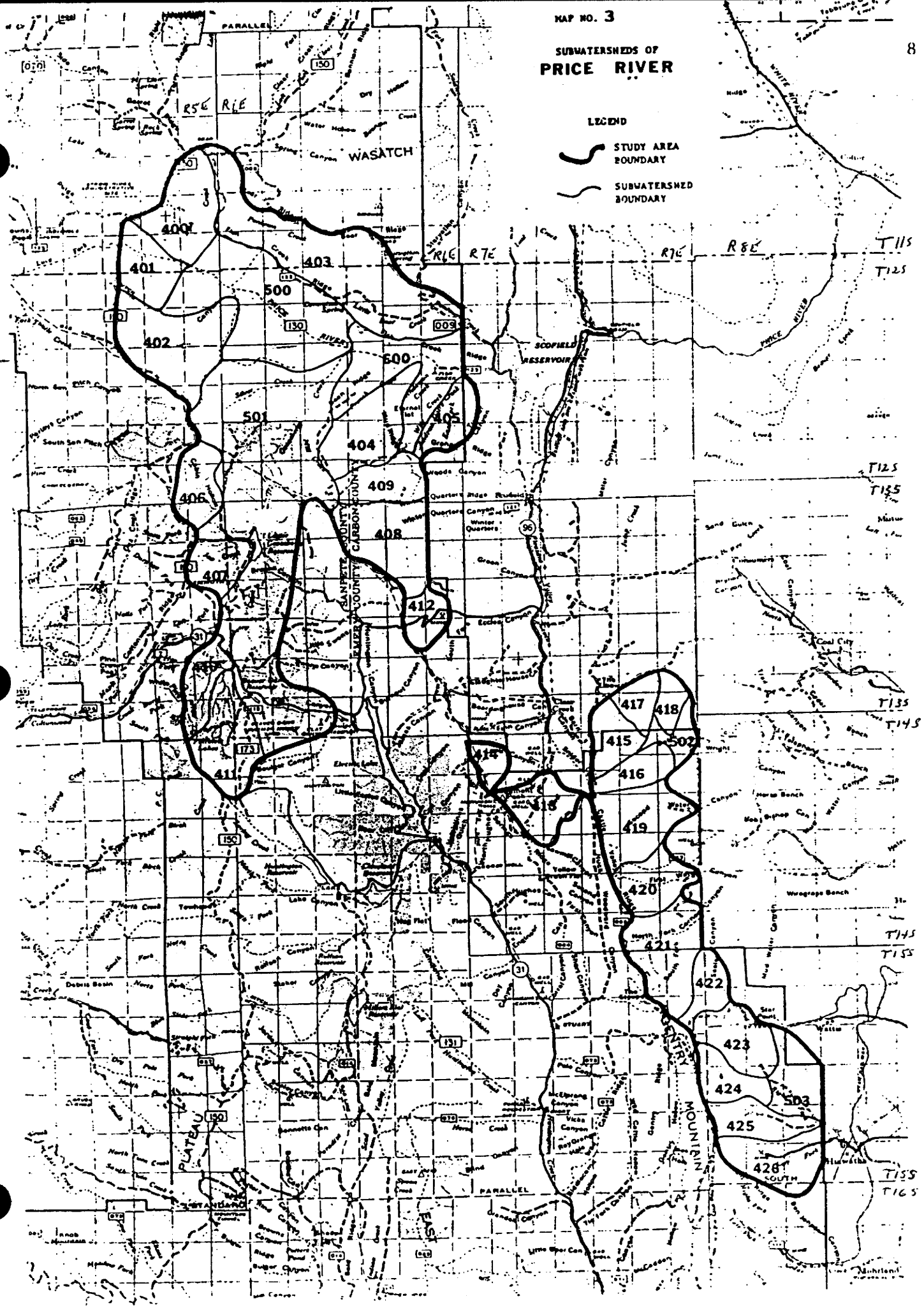
Enclosed for your information is a copy of the subject report.

/s/ Reed C. Christensen

REED C. CHRISTENSEN
Forest Supervisor

Enclosure

cc: D-3
J.Iaquinta
D.Kelly
J.Frandsen


MAP NO. 3
SUBWATERSHEDS OF
PRICE RIVER
LEGEND
STUDY AREA BOUNDARY
SUBWATERSHED BOUNDARY
WASATCH
SCOFIELD RESERVOIR
PRICE RIVER
CARBON COUNTY
EMERY COUNTY
PLATEAU
MOUNTAIN
EAST
PARALLEL
400
401
402
403
500
600
501
404
405
406
409
408
407
412
411
414
413
415
502
416
417
418
419
420
421
422
423
424
503
425
426
R5E
R6E
R7E
R8E
T11S
T12S
T13S
T14S
T15S
T16S

SUBWATERSHED NOMENCLATURE

TABLE 1

Line Number	Subwatershed Number	Subwatershed Name	Area in Acres
1	400	Upper Fish Creek	2196
2	401	Straight Fork of Fish Creek	1666
3	402	C Canyon	3263
4	403	Pontown Creek	6245
5	404	French Creek	2731
6	405	Andrew Dairy Creek	1237
7	406	Cabin Hollow	1570
8	407	Japanese Creek	1198
9	408	Winter Quarters Canyon	2826
10	409	Woods Canyon	1446
11	410	Narrows Tunnel	1130
12	411	Fairview Lakes	2154
13	412	Eccles Canyon	695
14	413	Mud Creek	1533
15	414	Long Canyon	524
16	415	Western Tributary to Bob Wright Canyon	1247
17	416	Southern Tributary to Bob Wright Canyon	823
18	417	Northwest Tributary to Bob Wright Canyon	821
19	418	Northern Tributary to Bob Wright Canyon	613
20	419	Second Water Canyon	2735
21	420	First Water Canyon	1757
22	421	North and South Fork of Corner Canyon	2640
23	422	Seely Canyon	756
24	423	Star Point	1855
25	424	Right Fork of Miller Creek	1227
26	425	Middle Fork of Miller Creek	1347
27	426	Left Fork of Middle Creek	2197
28	500	Fish Creek	12,583
29	501	Gooseberry Creek	19,680
30	502	Bob Wright Canyon	4083
31	503	Miller Creek	5859
32	600	Price River	37,510

TABLE 5

INDEX OF FLOODING POTENTIAL

Instantaneous Peak Flows for the 50 Year 6 Hour Storm Event.
Arranged from Highest to Lowest CFS/mi^2 and Ranked.

Rank	Watershed Number	Watershed Name	CFS/mi^2*	Classification
1	407	Japanese Creek	100	
2	411	Fairview Lake	82	
3	410	Narrows Tunnel	79	Extreme
4	417	Northwest Tributary to Bob Wright Canyon	62	
5	418	Northern Tributary to Bob Wright Canyon	55	
6	416	Southern Tributary to Bob Wright Cn.	47	
7	422	Seeley Canyon	43	
8	406	Cabin Hollow	42	
9	415	Western Tributary to Bob Wright Cn.	40	
10	423	Star Point	37	High
11	424	Right Fork of Miller Creek	36	
12	425	Middle Fork of Miller Creek	36	
13	420	First Water Canyon	36	
14	419	Second Water Canyon	34	
15	502	Bob Wright Canyon	33	
16	426	Left Fork of Miller Creek	31	
17	503	Miller Creek	25	
18	421	North and South Fork of Corner Canyon	23	
19	404	French Creek	22	
20	501	Gooseberry Creek	22	
21	412	Eccles Canyon	21	
22	409	Woods Canyon	21	
23	408	Winter Quarters Canyon	18	Normal
24	414	Long Canyon	18	
25	400	Upper Fish Creek	17	
26	401	Straight Fork of Fish Creek	17	
27	405	Andrew Dairy Creek	16	
28	500	Fish Creek	14	
29	402	C Canyon	13	
30	413	Mud Creek	12	
31	600	Price River	12	
32	403	Pontown Creek	7	Low

*Flows shown are from printouts in Appendix 5.

TABLE 6

INDEX OF RUNOFF CHARACTERISTICS

Runoff Curve Number (RCN) - For 50 Year 6 Hour Storm Event

Rank	Subwatershed Number	Subwatershed Name	RCN	Classification
1	407	Japanese Creek	76	Extreme
1	411	Fairview Lakes	76	
2	410	Narrows Tunnel	75	
3	501	Gooseberry Creek	74	
4	417	Northwest Tributary to Bob Wright Cn.	71	
4	418	Northern Tributary to Bob Wright Cn.	71	
4	600	Price River	71	
5	406	Cabin Hollow	70	
5	416	Southern Tributary to Bob Wright Cn.	70	
5	425	Middle Fork of Miller Creek	70	
5	502	Bob Wright Canyon	70	
6	419	Second Water Canyon	69	High
6	426	Left Fork of Miller Creek	69	
6	503	Miller Creek	69	
7	415	Western Tributary to Bob Wright Cn.	68	
7	420	First Water Canyon	68	
7	422	Seeley Canyon	68	
7	423	Star Point	68	
7	424	Right Fork of Miller Creek	68	
7	500	Fish Creek	68	
8	421	North and South Fork of Corner Cn.	67	
9	409	Wood Canyon	66	
10	405	Andrew Dairy Creek	65	
10	408	Winter Quarters Canyon	65	
11	400	Upper Fish Creek	64	
11	403	Pontown Creek	64	
11	412	Eccles Canyon	64	
12	401	Straight Fork of Fish Creek	63	
12	402	C Canyon	63	
12	404	French Creek	63	
13	413	Mud Creek	62	
13	414	Long Canyon	62	

TABLE 7

SEDROUTE DATA - INDEX OF WATER QUALITY BASED ON SUSPENDED SEDIMENT

Rank	Subwatershed Number	Subwatershed Name	Mg/L	Classification
1	426	Left Fork of Miller Creek	2226	Extreme
2	425	Middle Fork of Miller Creek	1933	
3	503	Miller Creek	1076	
4	421	North and South Fork of Corner Cn.	1045	
5	424	Right Fork of Miller Creek	919	
6	417	Northwest Tributary to Bob Wright Canyon	727	
7	418	Northern Tributary to Bob Wright Cny.	721	High
8	502	Bob Wright Canyon	564	
9	419	Second Water Canyon	497	
10	415	Western Tributary to Bob Wright Cny.	454	
11	420	First Water Canyon	452	
12	416	Southern Tributary to Bob Wright Cny.	390	
13	423	Star Point	311	
14	413	Mud Creek	276	
15	422	Seeley Canyon	241	
16	404	French Creek	189	
17	600	Price River	144	
18	414	Long Canyon	122	
19	403	Pontown Creek	103	
20	405	Andrew Dairy Creek	98	Moderate
21	501	Gooseberry Creek	93	
22	407	Japanese Creek	90	
23	410	Narrows Tunnel	86	
24	500	Fish Creek	81	
25	401	Straight Fork of Fish Creek	74	
26	412	Eccles Canyon	74	
27	400	Upper Fish Creek	71	
28	409	Woods Canyon	70	
29	408	Winter Quarters Canyon	63	
30	406	Cabin Hollow	60	
31	402	C Canyon	56	
32	411	Fairview Lakes	52	

TABLE 8 SEDROUTE DATA - INDEX OF SEDIMENT PRODUCTION

Rank	Subwatershed Number	Subwatershed Name	$T/Mi^2/Yr$	Classification*
1	421	North and South Fork of Corner Canyon	525	Extreme
2	425	Middle Fork of Miller Creek	450	
3	426	Left Fork of Miller Creek	415	
4	418	Northern Tributary to Bob Wright Canyon	369	High
5	417	Northwest Tributary to Bob Wright Canyon	364	
6	503	Miller Creek	349	
7	424	Right Fork of Miller Creek	305	
8	502	Bob Wright Canyon	285	
9	419	Second Water Canyon	250	
10	415	Western Tributary to Bob Wright Canyon	237	
11	420	First Water Canyon	233	
12	413	Mud Creek	233	
13	416	Southern Tributary to Bob Wright Canyon	196	Moderate
14	404	French Creek	159	
15	423	Star Point	149	
16	600	Price River	125	
17	414	Long Canyon	105	
18	422	Seeley Canyon	96	Low
19	403	Pontown Creek	88	
20	405	Andrew Dairy Creek	85	
21	501	Gooseberry Creek	80	
22	407	Japanese Creek	77	
23	410	Narrows Tunnel	73	
24	500	Fish Creek	70	
25	401	Straight Fork of Fish Creek	64	
26	412	Eccles Canyon	63	
27	400	Upper Fish Creek	60	
28	409	Woods Canyon	58	
29	408	Winter Quarter Canyon	55	
30	406	Cabin Hollow	51	
31	402	C Canyon	49	Insignificant
32	411	Fairview Lakes	46	

*Sediment Production Classification was developed for the Manti-LaSal National Forest Plan Analysis of the Management Situation (AMS).

1985

PEAK FLOW

STORMS

WINTER QUARTERS CANYON

WOODS CANYON

WATERSHED INVENTORY AND ANALYSIS FOR THE PRICE RIVER WATERSHED

July 1985

Volume II of III

Appendixes 3, 4, and Part of 5

Sedroute Printout Results

The Sedroute Program provides a title page that explains some pertinent information about the Sedroute Report. Page 1 shows sediment delivery, bedload, and ground water coefficients and sediment weight parameters used in the program calculations. Printout page 2 is the sediment routing table for the Price River subwatersheds. This table shows each subwatershed flowing into each higher order subwatershed to the National Forest boundary. Printout page 3 is the input information and some calculations for watershed 400 - Upper Fish Creek. Landtype, acres, runoff curve number, erosion rate, and water yield rate data were assembled for this analysis for each landtype. The program calculated annual erosion, delivery coefficient, sediment yield rate, annual sediment yield, annual water yield, and the totals for each landtype and result column were determined by the program. Printout page 4 is a summary of the existing conditions (totals line from page 3), and milligrams per liter of suspended sediment load for the annual water yield and the annual water yield adjusted for bedload, ground water losses, and both bedload and ground water losses.

The information on printout pages 3 and 4 is prepared for each subwatershed and is arranged in order of increasing subwatershed number.

For further information about the Sedroute Program, contact:

G. Dennis Kelly, Hydrologist, Manti-LaSal National Forest
599 West Price River Drive
Price, Utah 84501

Kelly, G. Dennis and Nebeker, Jerel, 1976. User's Guide for the Computer Program SEDROUTE, Caribou National Forest, Pocatello, Idaho, USDA - Forest Service.

Kelly, G. Dennis, 1978, SEDROUTE Procedure for Estimating Erosion and Sediment Impacts. Presented at the 1978 summer meeting. American Society of Agricultural Engineers, Utah State University, Logan, Utah. ASAE Technical Paper No. 78-2081.

Kelly, G. Dennis, 1977. A Brief Summary of Suspended Sediment Production Data Collected from a Few Streams of the Diamond Creek Planning Unit. Caribou National Forest, USDA - Forest Service, Pocatello, Idaho.

PROGRAM SEDROUTE

DATE 30 APR 85 PAGE 19

WATERSHED 408: WINTER QUARTERS CANYON

EXISTING CONDITION

LAND TYPE	ACRES	RUNOFF CURVE NUMBER	EROSION RATE (IN)	ANNUAL EROSION (AC FT)	DELIVERY COEFF. (%)	SEDIMENT YIELD RATE (IN/YR)	ANNUAL SEDIMENT YIELD (AC FT)	WATER YIELD RATE (IN)	ANNUAL WATER YIELD (AC FT)
401.000	81.	52.0	.024	.162	7.	.00159	.011	11.0	74
411.000	250.	83.0	.015	.312	8.	.00124	.026	12.0	250
561.000	834.	47.0	.006	.417	3.	.00017	.012	12.0	834.
713.000	1205.	65.0	.005	.502	14.	.00071	.072	12.0	1205.
820.000	456.	64.0	.003	.114	11.	.00033	.013	11.5	437.
TOTALS	2826.	60.7	.006	1.508	9.	.00056	.133	11.9	2800.

PROGRAM SEDROUTE

SUMMARY OF EXISTING CONDITIONS

WATERSHED 408 WINTER QUARTERS CANYON

LAND TYPE	ACRES	RUNOFF CURVE NUMBER	EROSION RATE (IN)	ANNUAL EROSION (AC FT)	DELIVERY COEFF. (%)	SEDIMENT YIELD RATE (IN/YR)	ANNUAL SEDIMENT YIELD (AC FT)	EXISTING CONDITION WATER YIELD RATE (IN)	EXISTING CONDITION ANNUAL WATER YIELD (AC FT)
TOTALS	2826.	60.7	.006	1.508	9.	.00056	.133	11.9	2800.

.133 ACRE FEET OF SEDIMENT
---------- = 63.35 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
2800. ACRE FEET OF WATER

ADJUSTED FOR BEDLOAD BEDLOAD COEFFICIENT = 10.0 %

.119 ACRE FEET OF SEDIMENT
---------- = 57.02 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
2800. ACRE FEET OF WATER

ADJUSTED FOR GROUNDWATER LOSSES GROUND WATER COEFFICIENT = 10.0 %

.133 ACRE FEET OF SEDIMENT
---------- = 70.39 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
2520. ACRE FEET OF WATER

ADJUSTED FOR BOTH BEDLOAD AND GROUNDWATER

.119 ACRE FEET OF SEDIMENT
---------- = 63.35 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
2520. ACRE FEET OF WATER

PROGRAM SEDROUTE

DATE 30 APR 85 PAGE 21

WATERSHED 409 WOODS CANYON

EXISTING CONDITION

LAND TYPE	ACRES	RUNOFF CURVE NUMBER	EROSION RATE (IN)	ANNUAL EROSION (AC FT)	DELIVERY COEFF. (%)	SEDIMENT YIELD RATE (IN/YR)	ANNUAL SEDIMENT YIELD (AC FT)	WATER YIELD RATE (IN)	ANNUAL WATER YIELD (AC FT)
110.000	71.	49.0	.024	.142	8.	.00189	.011	10.0	59.
411.000	49.	83.0	.015	.061	8.	.00124	.005	12.0	49.
713.000	647.	65.0	.005	.270	14.	.00071	.038	12.0	647.
820.000	679.	64.0	.003	.170	11.	.00033	.019	11.5	651.
TOTALS	1446.	64.4	.005	.643	11.	.00061	.073	11.7	1406.

SUMMARY OF EXISTING CONDITIONS

WATERSHED 409 WOODS CANYON

LAND TYPE	ACRES	RUNOFF CURVE NUMBER	EROSION RATE (IN)	ANNUAL EROSION (AC FT)	DELIVERY COEFF. (%)	SEDIMENT YIELD RATE (IN/YR)	ANNUAL SEDIMENT YIELD (AC FT)	EXISTING CONDITION WATER YIELD RATE (IN)	EXISTING CONDITION ANNUAL WATER YIELD (AC FT)
TOTALS	1446.	64.4	.005	.643	11.	.00061	.073	11.7	1406.

.073 ACRE FEET OF SEDIMENT
1406. ACRE FEET OF WATER = 69.79 MG/L AVERAGE SUSPENDED SEDIMENT LOAD

ADJUSTED FOR BEDLOAD BEDLOAD COEFFICIENT = 10.0 %

.066 ACRE FEET OF SEDIMENT
1406. ACRE FEET OF WATER = 62.81 MG/L AVERAGE SUSPENDED SEDIMENT LOAD

ADJUSTED FOR GROUNDWATER LOSSES GROUND WATER COEFFICIENT = 10.0 %

.073 ACRE FEET OF SEDIMENT
1265. ACRE FEET OF WATER = 77.54 MG/L AVERAGE SUSPENDED SEDIMENT LOAD

ADJUSTED FOR BOTH BEDLOAD AND GROUNDWATER

.066 ACRE FEET OF SEDIMENT
1265. ACRE FEET OF WATER = 69.79 MG/L AVERAGE SUSPENDED SEDIMENT LOAD

WATERSHED 501 GOOSEBERRY CREEK EXISTING CONDITION

LAND TYPE	ACRES	RUNOFF CURVE NUMBER	EROSION RATE (IN)	ANNUAL EROSION (AC FT)	DELIVERY COEFF. (%)	SEDIMENT YIELD RATE (IN/YR)	ANNUAL SEDIMENT YIELD (AC FT)	WATER YIELD RATE (IN)	ANNUAL WATER YIELD (AC FT)
32.000	55.	80.0	.034	.156	17.	.00593	.027	12.0	55.
41.000	484.	82.0	.020	.807	5.	.00102	.041	12.0	484.
42.000	406.	68.0	.006	.203	4.	.00022	.007	12.0	406.
109.000	742.	63.0	.022	1.360	15.	.00336	.207	12.0	742.
402.000	62.	78.0	.014	.072	13.	.00188	.010	7.0	36.
411.000	5951.	83.0	.015	7.439	8.	.00124	.617	12.0	5951.
412.000	985.	80.0	.014	1.149	8.	.00113	.092	12.0	985.
413.000	375.	79.0	.010	.313	6.	.00060	.019	14.0	438.
561.000	6002.	47.0	.006	3.001	3.	.00017	.085	12.0	6002.
711.000	194.	60.0	.003	.049	17.	.00051	.008	7.0	113.
713.000	4027.	65.0	.005	1.678	14.	.00071	.239	12.0	4027.
820.000	116.	64.0	.003	.029	11.	.00033	.003	11.5	111.
998.000 RESERVOIRS	281.	99.0	.000	.000	75.	.00000	.000	12.0	281.
TOTALS	19680.	66.9	.010	16.255	8.	.00083	1.357	12.0	19631.

SUMMARY OF EXISTING CONDITIONS

WATERSHED 501 GOOSEBERRY CREEK EXISTING CONDITION

LAND TYPE	ACRES	RUNOFF CURVE NUMBER	EROSION RATE (IN)	ANNUAL EROSION (AC FT)	DELIVERY COEFF. (%)	SEDIMENT YIELD RATE (IN/YR)	ANNUAL SEDIMENT YIELD (AC FT)	WATER YIELD RATE (IN)	ANNUAL WATER YIELD (AC FT)
TOTALS	19680.	66.9	.010	16.255	8.	.00083	1.357	12.0	19631.

1.357 ACRE FEET OF SEDIMENT
---------- = 92.53 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
19631. ACRE FEET OF WATER

ADJUSTED FOR BEDLOAD BEDLOAD COEFFICIENT = 10.0 %

1.221 ACRE FEET OF SEDIMENT
---------- = 83.28 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
19631. ACRE FEET OF WATER

ADJUSTED FOR GROUNDWATER LOSSES GROUND WATER COEFFICIENT = 10.0 %

1.357 ACRE FEET OF SEDIMENT
---------- = 102.81 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
17668 ACRE FEET OF WATER

ADJUSTED FOR BOTH BEDLOAD AND GROUNDWATER

1.221 ACRE FEET OF SEDIMENT
---------- = 92.53 MG/L AVERAGE SUSPENDED SEDIMENT LOAD
17668. ACRE FEET OF WATER

The following printouts show peak flow for 14 individual storm events on each of the 32 subwatersheds.

The BASIC language computer program for the Data General System is also presented. This appendix is continued in Volume III.

KENT PEAK FLOW MODEL, SCS TP-149. 1968.
MODIFIED SO THAT THE RUNOFF CURVE NUMBER IS WEIGHTED BY VOLUME.

PRICE RIVER BASIN
SUBWATERSHED 408 WINTER QUARTERS CANYON 85/04/30 08:41:00

STORM NUMBER (#)	PRECIPITATION AMOUNT (INCHES)	RECURRENCE INTERVAL (YEARS)	STORM DURATION (HOURS)
1	1.6	1.5	24
2	1.7	2.0	24
3	2.5	10.0	24
4	2.9	25.0	24
5	3.2	50.0	24
6	3.6	100.0	24
7	4.4	500.0	24
8	1.0	1.5	6
9	1.1	2.0	6
10	1.6	10.0	6
11	1.9	25.0	6
12	2.1	50.0	6
13	2.3	100.0	6
14	2.8	500.0	6

PRICE RIVER BASIN
SUBWATERSHED 408 WINTER QUARTERS CANYON 85/04/30 08:41:58

STORM NUMBER = 6 PRECIP = 3.6 IN 24 HOURS RECURRENCE = 100.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
401.000	81	52	3.6	.28003	1.89
411.000	250	83	3.6	1.94298	40.43
561.000	834	47	3.6	.14326	9.96
713.000	1205	65	3.6	.80503	80.84
820.000	456	64	3.6	.75625	28.74

TOTAL AREA = 2826 ACRES TOTAL VOLUME = 161.90 AC FT

WATERSHED AREA = 4.42 SQUARE MILES

FOR WATERSHED 408 THE AVERAGE RCN IS 63 FOR RT= 100

STORM DURATION= 24 HOURS
MINIMUM ELEVATION = 8240 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 15206 FEET
LAG = 2.04 HOURS

PEAK FLOW (RT= 100.0)= 178.15 CFS = 40.35 CFS/SQ MI

PRICE RIVER BASIN
SUBWATERSHED 408 WINTER QUARTERS C 5/04/30 08:42:09

STORM NUMBER = 7 PRECIP = 4.4 IN 24 HOURS RECURRENCE = 500.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
401.000	81	52	4.4	.55344	3.74
411.000	250	83	4.4	2.63689	54.94
561.000	834	47	4.4	.34271	23.82
713.000	1205	65	4.4	1.26817	127.35
820.000	456	64	4.4	1.20513	45.79

TOTAL AREA = 2826 ACRES TOTAL VOLUME = 255.63 AC FT

WATERSHED AREA = 4.42 SQUARE MILES

FOR WATERSHED 408 THE AVERAGE RCN IS 63 FOR RT= 500

STORM DURATION= 24 HOURS
MINIMUM ELEVATION = 8240 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 15206 FEET
LAG = 2.04 HOURS

PEAK FLOW (RT= 500.0)= 300.28 CFS = 68.00 CFS/SQ MI

PRICE RIVER BASIN
SUBWATERSHED 408 WINTER QUARTERS CANYON 85/04/30 08:43:10

STORM NUMBER = 13 PRECIP = 2.3 IN 6 HOURS RECURRENCE = 100.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
401.000	81	52	2.3	.02127	.14
411.000	250	83	2.3	.90730	18.90
501.000	834	47	2.3	.00018	.01
713.000	1205	65	2.3	.22639	22.73
820.000	456	64	2.3	.20303	7.72

TOTAL AREA = 2826 ACRES TOTAL VOLUME = 49.51 AC-FT

WATERSHED AREA = 4.42 SQUARE MILES

FOR WATERSHED 408 THE AVERAGE RCN IS 65 FOR RT= 100

STORM DURATION= 6 HOURS
MINIMUM ELEVATION = 8240 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 15206 FEET
LAG = 1.81 HOURS

PEAK FLOW (RT= 100.0)= 111.89 CFS = 25.34 CFS/SQ MI

PRICE RIVER BASIN
SUBWATERSHED 408 WINTER QUARTERS CANYON 85/04/30 08:43:20

STORM NUMBER = 14 PRECIP = 2.8 IN 6 HOURS RECURRENCE = 500.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
401.000	81	52	2.8	.08933	.60
411.000	250	83	2.8	1.28732	26.82
561.000	834	47	2.8	.02510	1.74
713.000	1205	65	2.8	.41772	41.95
820.000	456	64	2.8	.38433	14.60

TOTAL AREA = 2826 ACRES TOTAL VOLUME = 85.72 AC FT

WATERSHED AREA = 4.42 SQUARE MILES

FOR WATERSHED 408 THE AVERAGE RCN IS 64 FOR RT= 500

STORM DURATION= 6 HOURS
MINIMUM ELEVATION = 8240 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 15206 FEET
LAG = 1.92 HOURS

PEAK FLOW (RT= 500.0)= 190.96 CFS = 43.25 CFS/SQ MI

KENT PEAK FLOW MODEL, SCS TP-149. 1965.
MODIFIED SO THAT THE RUNOFF CURVE NUMBER IS WEIGHTED BY VOLUME. 5-146

PRICE RIVER BASIN
SUBWATERSHED 409 WOODS CANYON 85/04/30 08:43:44

STORM NUMBER (#)	PRECIPITATION AMOUNT (INCHES)	RECURRENCE INTERVAL (YEARS)	STORM DURATION (HOURS)
1	1.6	1.5	24
2	1.7	2.0	24
3	2.5	10.0	24
4	2.9	25.0	24
5	3.2	50.0	24
6	3.6	100.0	24
7	4.4	500.0	24
8	1.0	1.5	6
9	1.1	2.0	6
10	1.6	10.0	6
11	1.9	25.0	6
12	2.1	50.0	6
13	2.3	100.0	6
14	2.8	500.0	6

PRICE RIVER BASIN
SUBWATERSHED 409 WOODS CANYON 85/04/30 08:44:42

STORM NUMBER = 6 PRECIP = 3.6 IN 24 HOURS RECURRENCE = 100.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
110.000	71	49	3.6	.19330	1.14
411.000	49	83	3.6	1.94298	7.93
713.000	647	65	3.6	.80503	43.40
820.000	679	64	3.6	.75625	42.79

TOTAL AREA = 1446 ACRES TOTAL VOLUME = 95.27 AC FT

WATERSHED AREA = 2.26 SQUARE MILES

FOR WATERSHED 409 THE AVERAGE RCN IS 65 FOR RT= 100

STORM DURATION= 24 HOURS
MINIMUM ELEVATION = 8320 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 14784 FEET
LAG = 1.79 HOURS

PEAK FLOW (RT= 100.0)= 109.11 CFS = 48.29 CFS/SQ MI

PRICE RIVER BASIN
SUBWATERSHED 409 WOODS CANYON 85/04/30 08:46:01

STORM NUMBER = 13 PRECIP = 2.3 IN 6 HOURS RECURRENCE = 100.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
110.000	71	49	2.3	.00449	.03
411.000	49	83	2.3	.90730	3.70
713.000	647	65	2.3	.22639	12.21
820.000	679	64	2.3	.20303	11.49

TOTAL AREA = 1446 ACRES TOTAL VOLUME = 27.43 AC FT

WATERSHED AREA = 2.26 SQUARE MILES

FOR WATERSHED 409 THE AVERAGE RCN IS 66 FOR RT= 100

STORM DURATION= 6 HOURS
MINIMUM ELEVATION = 8320 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 14784 FEET
LAG = 1.69 HOURS

PEAK FLOW (RT= 100.0)= 66.82 CFS = 29.58 CFS/SQ MI

PRICE RIVER BASIN
SUBWATERSHED 409 WOODS CANYON 85/04/30 03:44:55

STORM NUMBER = 7 PRECIP = 4.4 IN 24 HOURS RECURRENCE = 500.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
110.000	71	49	4.4	.42233	2.50
411.000	49	83	4.4	2.63689	10.77
713.000	647	65	4.4	1.26817	68.33
820.000	679	64	4.4	1.20513	68.19

TOTAL AREA = 1446 ACRES TOTAL VOLUME = 149.83 AC FT

WATERSHED AREA = 2.26 SQUARE MILES

FOR WATERSHED 409 THE AVERAGE RCN IS 65 FOR RT= 500

STORM DURATION= 24 HOURS
MINIMUM ELEVATION = 8320 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 14784 FEET
LAG = 1.79 HOURS

PEAK FLOW (RT= 500.0)= 179.65 CFS = 79.51 CFS/SQ MI

PRICE RIVER BASIN
SUBWATERSHED 409 WOODS CANYON 85/04/30 08:46:11

STORM NUMBER = 14 PRECIP = 2.8 IN 6 HOURS RECURRENCE = 500.0 YEARS

LANDTYPE	AREA (ACRES)	RCN	PRECIP (INCHES)	Q-INCHES	Q-ACFT
110.000	71	49	2.8	.04638	.27
411.000	49	83	2.8	1.28732	5.26
713.000	647	65	2.8	.41772	22.52
820.000	679	64	2.8	.38433	21.75

TOTAL AREA = 1446 ACRES TOTAL VOLUME = 49.80 AC FT

WATERSHED AREA = 2.26 SQUARE MILES

FOR WATERSHED 409 THE AVERAGE RCN IS 65 FOR RT= 500

STORM DURATION= 6 HOURS
MINIMUM ELEVATION = 8320 FEET
MAXIMUM ELEVATION = 9622 FEET
STREAM CHANNEL LENGTH = 14784 FEET
LAG = 1.79 HOURS

PEAK FLOW (RT= 500.0)= 111.41 CFS = 49.31 CFS/SQ MI

Winter Quarters Canyon
Data Adequacy

October 1992

GROUNDWATER HYDROLOGY
SKYLINE MINES
MINING & RECLAMATION PLAN
VOLUME 1, 1992

SKYLINE MINES

MINING AND RECLAMATION PLAN

COASTAL STATES ENERGY COMPAN

1992

VOLUME 1

2.3 GROUND WATER HYDROLOGY

The principle factor controlling the occurrence and availability of ground water in any area is geology. Nearly all of the region surrounding the project area is underlain by rocks of continental and marine origin, consisting predominately of interbedded sandstones and shales (See Section 2.2). The existence of these relatively impermeable shales tends to limit the ability of the rock units to yield a significant amount of water for extended periods of time due to the recharge impediment.

The project area is located in the headwaters of the Price and San Rafael River Basins (See Figure 2.12-A). Wells in these basins normally yield less than 50 gallons per minute. In the immediate vicinity of the project area essentially dry wells have been experienced. Exceptions to these yield estimates occur where wells penetrate highly fractured sandstones.

Rock strata in the mountainous areas near the project area have low specific yields (0.2 to 0.7 percent) and low hydraulic conductivities. The volume of recoverable water is small, averaging less than 600 acre-feet per square mile in the upper 100 feet of saturated rock.

Ground water quality in the Price and San Rafael River Basins deteriorates in a downstream direction. Dissolved solids content in the ground water ranges from less than 125 milligrams per liter in the headwaters near the Skyline permit area to approximately 4,000 milligrams per liter near the confluence of the two rivers with the Green River. This large increase results from the contact of the water with fine-grained units, particularly the saline Mancos Shale.

Information presented in this section summarizes and updates the original consultants reports found in Appendix Volume A-1. A more complete discussion and baseline information for summaries presented herein may be found in Volumes 4 and A-1.

2.3.1 Geologic Setting of the Ground Water System

The Skyline permit area lies in the northern end of the Wasatch Plateau, on the west edge of the Clear Creek anticline. As such, the dip of the strata is generally towards the west, varying between six percent (three degrees) and ten percent (six degrees).

With the exception of local alluvial deposits, all of the units exposed on and immediately adjacent to the project area are formations of the Cretaceous Mesaverde Group. The Star Point Sandstone is a massive, medium-grained sandstone which is approximately 1,000 feet thick and nearly devoid of shale in the project area. A generalized columnar section of the Skyline property is shown in Figure 2.2-A.

The Blackhawk Formation, which immediately overlies the Star Point, is an interbedded formation of sandstones, shales, siltstones, and coal. The sands of the Blackhawk Formation are fine-to-medium- grained, tending to have locally high clay contents. The shales of the Blackhawk Formation in the permit area are irregularly bedded and due to their tendency to swell when wet, they should, in most cases, form an effective barrier to vertical movement of ground water.

The youngest geologic unit in the permit area is the Castlegate Sandstone, found only in a small area in the northwestern portion of the permit area. This unit consists of massive medium to coarse grained sandstones with interbedded conglomerates near the base.

Faults within the permit area commonly occur as zones of parallel to in-echelon fault segments with individual slips containing gouge zones ranging from 6 inches to 4 feet wide. Displacements are normally small (less than 20 feet) with the exception of the Connelville fault zone which forms the eastern boundary of the permit area, and the Upper Joes Valley fault zone in the southwestern portion of the area. It is suspected that faults

have only local hydrologic importance within the Blackhawk formation because of its clay content in the permit area. Of 44 individual fault planes encountered to date in Skyline Mines 1 and 3, only 5 contained dripping water. Four of these 5 appeared to intersect water saturated sandstone paleo channels in the immediate mine roof. Water also emerged from the Star Point Sandstone along 2 faults encountered in Skyline Mine 3, resulting in some water drainage from the floor. In both of these cases, no water dripped from the roof.

In most cases it appears the faults within the Blackhawk formation in the permit area are not allowing vertical movement of ground water into the mines. The most logical cause of this apparently low permeability along most of the faults is clay content.

A detailed discussion of the geological characteristics of the project area is presented in the preceding section (Section 2.2).

2.3.2 Characteristics of Seeps and Springs

As a result of field investigations during 1978, 174 seeps and springs were located on and immediately adjacent to the Skyline project area (Volume A-1, Hydrology) This equates to an average of one water source for approximately every 40 acres existing in the area. The quality of the subsurface water was evaluated at select springs and is shown in Appendix Volume A-1. Additional ground water quality data may be found in the tabulations submitted regularly to the Division of Oil, Gas and Mining and in Volume 4. The travel distance between water supplies is short for the wildlife and sheep which utilize the area. Therefore, should a frequently-used spring dry up, animals using the water supply would not be greatly affected.

As requested by the Division, the operator conducted a survey of springs in the South Fork of Eccles Creek area where mining will take place during this permit term. This survey, conducted

during August of 1988, varies slightly in locations from that found in the consultant's report. The differences are most likely the result of mapping errors. The results of this survey may be found on Figure 2.3.2-1.

Geologic conditions play an important role in the occurrence of springs in the project area. A majority of the springs issue from west-facing slopes, often at a sandstone-shale interface considerably above the adjacent stream bed. Apparently, water which infiltrates into the soil and is not consumptively used percolates down until an impeding shale lens is met. It then follows the shale member downdip until an outlet is reached (either the surface or a discontinuous sandstone member). Thus, deep ground water recharge is apparently slow in the project area due to the presence of large amount of shale.

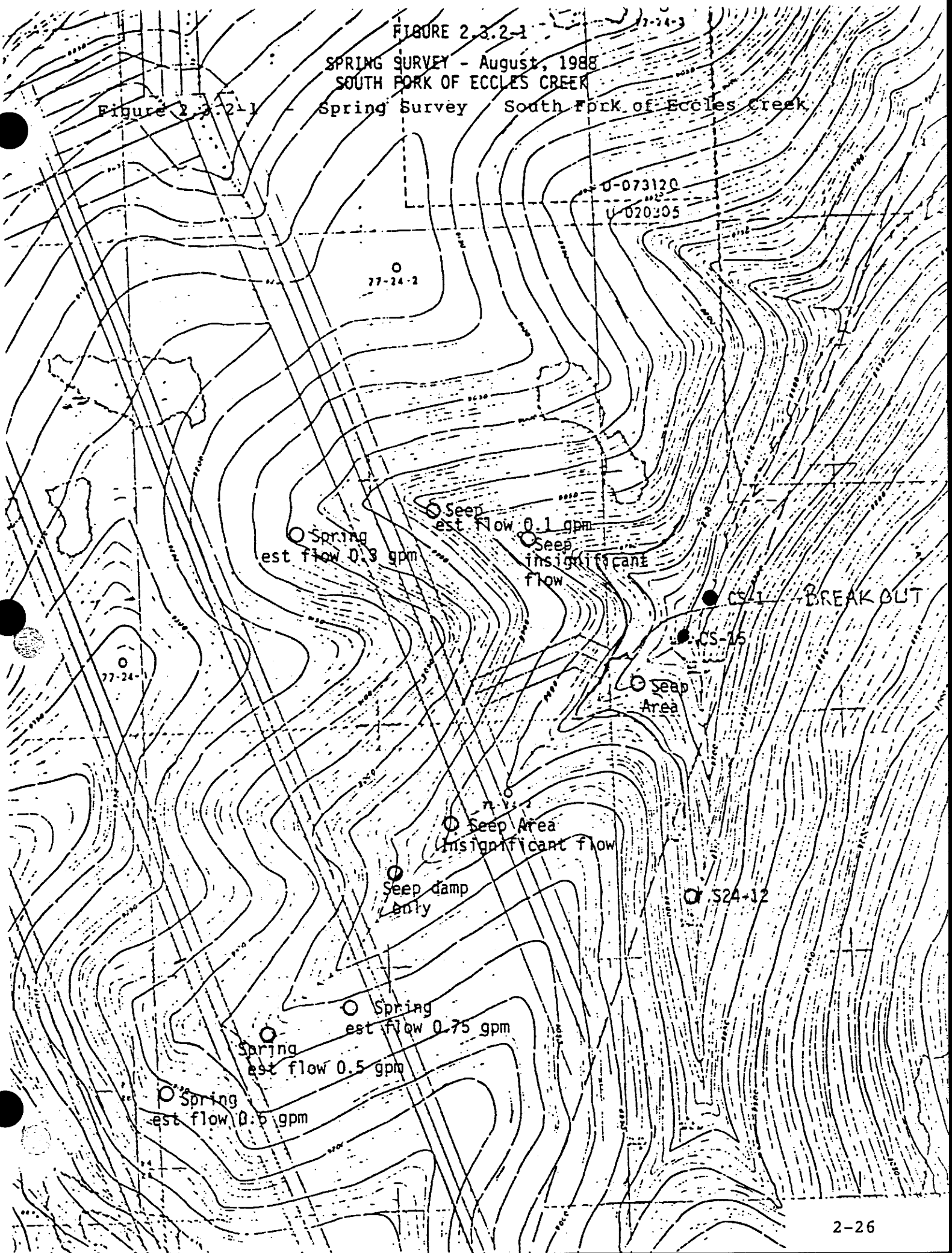
Very few seeps and springs in the project area appear to be fault-related, due to the sealing ability of the Blackhawk Formation. Instead, spring water appears to originate in the small surface depressions or basins in the immediate vicinity.

Sustained flows from individual springs tend to be low. Only four of the springs were measured having flows greater than or equal to 10 gallons per minute during the fall, low-flow inventory. Most measurements were two gallons per minute or less. Approximately 30 percent of the sources were seeps. Some of these had dried entirely during previous summers. Flows at a given spring may vary by as much as one order of magnitude during the year, with the higher flows occurring during the snowmelt season. This observation further substantiates the theory that water supplying the springs is generally very local in origin. Water originating from a deeper, more regionalized source would normally provide a more constant flow. It also implies that flows from springs are quite sensitive to the amount of precipitation received during the previous winter.

FIGURE 2.3.2-1

SPRING SURVEY - August, 1988
SOUTH FORK OF ECCLES CREEK

Figure 2.3.2-1 - Spring Survey South Fork of Eccles Creek



2.3.3 Stream Seepage

A very small percentage of the average annual flow of Huntington Creek above Electric Lake is contributed by ground water. In contrast, ground water yield accounts for nearly 64 percent (8.59 inches) of the average annual yield of Eccles Creek above Pleasant Valley Creek. The principle cause of the high ground water yield in Eccles Canyon relative to Huntington Creek is the Star Point Sandstone, which is present over approximately 25 percent of the surface of Eccles Canyon but does not appear on the surface in the Huntington Creek Basin.

To better define recharge-discharge conditions for major streams in the area, seepage studies were conducted on the Main Fork of Eccles Creek, the South Fork of Eccles Creek, and Huntington Creek. The studies were conducted by measuring the flow rate and collecting a water quality sample at selected points along the stream segment and at points of major tributary inflow. Data from that study are presented in Volume A-1, Hydrology.

Significant changes occur in the Main Fork of Eccles Creek when it crosses the Star Point Sandstone. These changes are especially noticeable at the O'Connor Fault, which crosses the stream at a point about one mile downstream from the confluence of the Main and South Forks. This fault apparently acts as a conveyance structure in the fractured Star Point, discharging water into Eccles Creek.

Another significant change in the characteristics of Eccles Creek occurs near the mouth of the canyon at the Pleasant Valley Fault. This probable flow barrier appears to be bringing water to the surface which had previously been flowing in the rock beneath the stream channel.

Changes in conditions along the South Fork of Eccles Creek can be largely accounted for by surface phenomena (hillside springs, tributary inflow, etc.). The Connelville Fault zone has little

apparent effect on the recharge-discharge characteristics of the stream. This confirms the previous conclusion that faults in the Blackhawk do not act as conduits to the surface, but rather, seal to prevent vertical water movement.

Downstream changes in the characteristics of Huntington Creek can also be largely accounted for by tributary inflows, hillside springs, etc. The flow losses which do occur in the lower portions of the stream (immediately upstream from Electric Lake) can presumably be attributed to recharge of the alluvium. This recharge water is suspected to travel below the surface of the shale-alluvium interface towards Electric Lake.

2.3.4 Aquifer Characteristics

Measurements at a network of observation wells installed in the project study area indicate that ground water flows in a west to southwest direction, generally following the dip of the strata. Flow gradients average approximately 250 feet per mile over most of the project area although a gradient averaging 700 feet per mile was encountered in the southern portion of the lease area. This anomaly is probably associated with the Valentine Fault zone, which passes through one of the observation well sites. The fracture has apparently connected the sandstone lenses of the Blackhawk Formation with the underlying Star Point Sandstone, thereby significantly increasing the water yield characteristics of the rock at this point and influencing the piezometric head in the area.

The differences between the elevation of water in the observation wells and that of surrounding springs indicates that two ground water systems occur in the Skyline project area. A shallow system, very local in extent and discontinuous, provides water to numerous seeps and springs through thin sandstone layers in the Blackhawk Formation. A deep ground water system is present in the saturated rocks surrounding and below the coal. This deep system has little apparent effect on the surface hydrologic

regime of the permit area since the water is located well below the perennial streams of the permit area. The system continues to dip to the west and southwest beyond the permit area and remains below the Sanpete Valley floor. It is not known to outcrop down dip. A fence diagram depicting the relationship of the wells with their location and with the geology may be found in Drawing 2.3.4-1.

Springs in the Blackhawk Formation are fed from perched water in shallow sandstone lenses underlain with shale well above the regional ground water level.

Useable quantities of water from wells in either the Storrs Sandstone or the lower tongues of the Star Point Sandstone are unlikely unless a fracture zone is encountered. Drawdown and recovery tests, which were conducted at two different depths in an open test well located in the proposed portal area, indicated that the transmissivity of the Blackhawk Formation is approximately 18 gallons per day per foot (Volume A-1, Hydrology). No significant difference in transmissivity exists between the coal zone and the Aberdeen Sandstone. The low transmissivities and discharge rates (approximately 5 gallons per minute) indicate that the Blackhawk Formation is, at best, a poor aquifer.

Potentiometric surfaces are below the ground surface, even in the canyon bottoms, with the deeper holes under the Blackhawk showing a generally higher potentiometric surface than the shallower holes. East of the permit area, where the Star Point Sandstone is exposed, the potentiometric surface intersects the ground surface in the canyons, thereby producing springs along the bottoms of the canyons. Water table conditions exist primarily in shallow alluvial deposits along larger perennial streams. Potentiometric surfaces, as currently understood, are shown on Plates 11 and 12 of the Hydrology report - Appendix Volume A-1.

2.3.4.1 Waste Rock Disposal Site

There is little information available concerning the ground water system at the waste rock disposal site. No test wells are available in the area and there are no seeps or springs to provide water quality data. The site is an isolated system, located above the water table and has little inflow and no outflow. There is no known hydrological connection between the site and Pleasant Valley Creek.

The waste material placed in the site has tested negatively for toxicity. A discussion of these tests may be found in Section 4.4.5.

The groundwater situation is complicated by the present of underground workings of the old Union Pacific Mine. The present condition of these workings is unknown and unobtainable due to an underground smoldering fire.

2.3.5 Uses of Water in the Aquifers

2.3.5.1 Surface Water Rights

The water rights on and adjacent to the Skyline property which were on record with the Utah Division of Water Rights as of December, 1986 are listed in Volume 4. The locations of these water rights can be found on Plate 2.3.5.1-1.

In addition to those existing water rights identified in Volume 4, the Forest Service has water rights claims pending action in District Court for the Seventh Judicial District in and for Emery and Carbon Counties. The claim for upper Huntington Creek was filed on August 19, 1983. The claim for Eccles Creek and the South Fork of Eccles Creek was filed May 18, 1987.

Surface water rights in the area are primarily for stockwatering and irrigation. Stockwatering rights are almost entirely

directly on the stream. Irrigation rights are centered around the town of Scofield and in Flat Canyon, southwest of the center of the property. Irrigated lands consist almost entirely of pasture. Only stockwatering rights are present on the lease area.

2.3.5.2 Ground Water Rights

Ground water rights on and adjacent to the Skyline Property, on record with the Utah Division of Water Rights as of December, 1986, are listed in Volume 4 and presented on Plate 2.3.5.2-1. Again, rights are primarily for stockwatering and irrigation (mainly lawns and gardens). Only one spring on the lease area has a filed water right. Only a limited number of wells are located in the area.

Also shown on Plate 2.3.5.2-1 are exchanges of Scofield Reservoir water for ground water in Pleasant Valley Creek Basin. These are also listed in Volume 4. All exchanges are wells, with the exception of 91-940. Most of the exchanges serve the industrial and domestic needs for mining companies in the area.

2.3.6 Ground Water Quality

The high cost associated with properly constructing and developing the observation wells drilled in the formations found in the area precluded the collection of reliable water quality data from the wells.

Several core holes, however, have been used to obtain limited ground water information. As these wells are being drilled, static water levels were measured above the coal zone, in the coal zone, and below the coal zone in the Star Point Sandstone. The wells were finally cased down to the Star Point and the bottom 20 feet of the casings were perforated. Measuring the static water levels at different stages of drilling showed that deeper ground water had a higher piezometric head than the shallow ground water. Because of this, four shallow wells were

drilled adjacent to four of these deep wells, and casings with perforations in the bottom 20 feet were installed. Piezometric heads were measured in shallow and deep holes showing the vertical piezometric gradient associated with the ground water. Data obtained from these wells are shown in graphic form in Volume 4.

The instability of the Blackhawk Formation made it difficult to keep uncased holes open for several hours. Reliable water quality samples could therefore not be obtained from the core holes. Several holes were more than 1,000 feet deep and one was more than 2,000 feet deep.

Two wells have been drilled in Eccles Canyon to determine aquifer characteristics of the Star Point Sandstone. The locations of these wells, W13-1 and W17-1, are shown on Plate 2.3.6-1. Well W13-1 extends through the Blackhawk Formation into the Star Point Sandstone and is now cased. During the draw down and recovery tests, the casing had not yet been installed.

The water quality analyses were measured from samples collected after periods of pumping from the well. Well W17-1 is located adjacent to Eccles Creek in the canyon bottom and extends through alluvial materials before penetrating the Star Point Sandstone. The well had been pumped for a few hours when the water quality sample was collected. Well 13-1 was drilled near the portal area topsoil stockpile as a water supply source, but was abandoned because of insufficient flow. The data, however, are useful in showing groundwater quality. Results of the laboratory analysis of these samples are contained in the Hydrology section of Appendix Volume A-1.

A comparison of water quality data collected from the permit area springs, local mines, and a well indicated that the springs were of a quality similar to that of the deep ground water system of the area. Thus, inferences on ground water quality have been drawn principally from data collected almost entirely from springs.

Almost without exception, the ground water in the area is of a strong calcium bicarbonate type. However, the sulfate and magnesium influence during the period of record shows an increase downstream in Eccles Creek and in Pleasant Valley Creek near Scofield. Although the quality of the deeper ground water is expected to be more uniform, the data show that three distinctive qualities of spring water can be found in the project area. Springs issuing near the outcrop of the Castlegate Sandstone in the northwest corner of the project area have a very low dissolved solids content (normally less than 100 milligrams per liter). This results from the lack of shaley layers in the Castlegate. Local conditions have probably resulted in the slightly higher concentrations in the springs issuing in the headwaters of Eccles Canyon (dissolved solids concentrations between 300 and 350 milligrams per liter). Springs issuing over the remainder of the project area have dissolved solids content which generally varies from 180 to 260 milligrams per liter, averaging 220 milligrams per liter. (See Water Quality Data - Volume 4 and Hydrology Section - Appendix Vol. A-1.)

Seasonal changes in ground water quality constituents show no consistent trends. Concentrations are generally lower in spring water than noted in surface water samples, although the differences do not appear to be very significant. In many cases, trace metal concentrations were consistently below the detection limit of routine laboratory techniques.

The sample analysis reports located in the Hydrology Section of Appendix Volume 1-A, as submitted by Commercial Testing and Engineering Company, Denver, Colorado, are tendered to document that no potential acid-forming or toxic-forming material is to be found either above or below the coal seams. The equipotential figures do show some alkalinity producing tendencies occur.

The analysis reports are arranged by seam, i.e., McKinnon, Upper O'Connor, and Lower O'Connor A; and then by sample location, e.g., roof, floor.

The locations of the exploration holes at which these samples were taken are shown on Plate 2.3.6-1.

Obtaining ground water data from abandoned mines in the area has been investigated but found not practical. The only abandoned portal in the permit area is the old Eccles Canyon Mine. This portal was sealed and covered during construction of the Skyline portal area surface facilities and is no longer accessible.

There are several abandoned mines in the adjacent area, located in Winter Quarters, Pleasant Valley and Boarding House Canyons. A search of UDOH and EPA (Storet) records did not reveal any discharge data from these old portals.

2.3.7 Groundwater Monitoring Program

The ground water monitoring program outlined in this section is a continuation of a program approved with the original Mining and Reclamation Permit Application. It incorporates practices designed to provide the baseline data necessary to validate the determination of the probable hydrologic consequences of proposed and existing mining and reclamation operations. The program also is designed to meet site specific requirements and incorporates the flexibility for change if necessary.

A monitoring program is being conducted at each of the ground water stations identified on Table 2.3.7-3 and depicted on Plate 3.2.6-1.

Water quality samples are collected from the 15 selected springs in the project area. The samples are comprehensively analyzed each summer for the parameters listed in Table 2.3.7-1. All water samples collected for use in this permit have been collected and analyzed according to methods in either the "Standard Methods for the Examination of Water and Wastewater" or the 40 CFR parts 136 and 434.

Seasonally, Spring high flow and Fall low flow, these springs will be monitored for those constituents listed on Table 2.3.7-2. A listing identifying the station types is shown on Table 2.3.7-3.

In addition to the collection of the outlined water quality data, water level data will be collected from each of the nine wells (if functional) as scheduled on Tables 2.3.7-1, 2.3.7-2 and 2.3.7-3, and noted on Plate 2.3.6-1. Summary information on these observation wells is found on Table 2.3.7-4.

The amount of water discharged from each mine on each monitoring occasion will also be monitored at the mine mouth through the use of a totalizing flow meter or similar device. Significant changes in the source of water in the mine will be noted during the period of operation. Underground water pumped from each mine will be monitored for water quality. Mine #1 discharge is sampled at Station CS-14. Mine #3 discharge is sampled at Station CS-12. Should the concentrations result in a sedimentation pond discharge which exceeds the NPDES discharge permit limitations or indicates potential disturbance to the hydrologic balance, an attempt will be made to isolate the contributing source and an evaluation made of possible appropriate remedial action. The best alternative remedial action will be implemented as soon as practicable to ensure protection of Eccles Creek water quality.

As required, ground water quality data collected from the property area will be submitted to the Utah Division of Oil, Gas, and Mining. Such reports will be submitted within 90 days after completion of the quarterly monitoring program. An annual report which will include a summary of water quality data and water well level data for the previous year will be submitted within 90 days of the end of each year.

Table 2.3.7-1

COMPREHENSIVE WATER QUALITY ANALYTICAL SCHEDULE
(SURFACE AND GROUNDWATER STATIONS)
-LOW SUMMER FLOW-
(AUGUST - SEPTEMBER)

ANNUAL - WATER QUALITY STATIONS CS-1, CS-2, CS-3, CS-4, CS-6, CS-7, CS-8, CS-9, CS-10, CS-11, CS-12, CS-13, CS-14, UPL-10, VC-6, VC-9, VC-10, S10-1, S12-1, S13-2, S13-7, S14-4, S15-3, S17-2, S22-5, S22-11, S23-4, S24-12, S26-13, S34-12, S35-8, S36-12, WRDS #1, WRDS #2, WRDS #3 and WRDS #4.

FIELD MEASUREMENTS	LABORATORY MEASUREMENTS	
Flow	Acidity	Lead, Total & Dis
Dissolved Oxygen	Alkalinity	Magnesium
pH	Ammonia	Manganese, Total & Dis
Specific Conductance	Barium, Total & Dis	Nitrate
Temperature, Air	Bicarbonate	Phosphate
Temperature, Water	Boron, Total & Dis	Potassium
Turbidity	Calcium	Sodium
	Chloride	Sulfate
Note: Station VC-9 will use calculated flow from Station CS-6 and CS-13.	Copper, Total & Dis	Suspended Solids
	Fluoride	Total Dissolved Solids
	Iron, Total & Dis	

ADDITIONS TO THE COMPREHENSIVE SCHEDULE FOR
ECCLES CANYON STREAM STATIONS
AND WASTE ROCK DISPOSAL SITE

Includes stations CS-1, CS-2, CS-3, CS-4, CS-6, CS-9, CS-11, CS-12, CS-13, CS-14, VC-6, VC-9, VC-10, WRDS #1, WRDS #2, WRDS #3 and WRDS #4.

Cyanide	Phenols
Oil & Grease	Total Organic Carbon

WELLS - WATER LEVEL ONLY

Well locations: W79-10-1A, W79-10-1B, W79-14-2A, W79-14-2B, W79-22-2-1, W79-22-2-2, W79-26-1, W79-35-1A, W79-35-1B.

TABLE 2.3.7-2

ABBREVIATED WATER QUALITY ANALYTICAL SCHEDULE
(SURFACE AND GROUNDWATER STATIONS)
-HIGH SPRING (APRIL - JUNE) AND
LATE FALL (OCTOBER - NOVEMBER) FLOWS-

SEASONAL - WATER QUALITY STATIONS CS-1, CS-2, CS-3, CS-4, CS-6, CS-7, CS-8, CS-9, CS-10, CS-11, CS-12, CS-13, CS-14, UPL-10, VC-6, VC-9, VC-10, S10-1, S12-1, S13-2, S13-7, S14-4, S15-3, S17-2, S22-5, S22-11, S23-4, S24-12, S26-13, S34-12, S35-8, S36-12, WRDS #1, WRDS #2, WRDS #3 and WRDS #4.

FIELD MEASUREMENT	LABORATORY MEASUREMENTS	
Flow	Ammonia	Nitrate
pH	Bicarbonate	Phosphate
Specific Conductance	Calcium	Potassium
Temperature, Air	Chloride	Sodium
Temperature, Water	Iron, Total	Sulfate
Turbidity	Magnesium	Suspended Solids
	Manganese, Total	Total Dissolved Solids

NOTE: Station VC-9 will use calculated flow data from Stations CS-6 and CS-13.

- Dissolved oxygen will be measured at Stations CS-2, CS-6, VC-6 and VC-9.

SEASONAL ADDITIONS TO THE ABBREVIATED SCHEDULE
FOR ECCLES CANYON STREAM STATIONS
AND WASTE ROCK DISPOSAL SITE STATIONS

Includes stations CS-1, CS-2, CS-3, CS-4, CS-6, CS-9, CS-11, CS-12, CS-13, CS-14, VC-6, VC-9, VC-10, WRDS #1, WRDS #2, WRDS #3 and WRDS #4.

Phenols
Oil & Grease

WELLS - WATER LEVEL ONLY

Well locations: W79-10-1A, W79-10-1B, W79-14-2A, W79-14-2B, W79-22-2-1, W79-22-2-2, W79-26-1, W79-35-1A, W79-35-1B.

In addition to the high spring and late fall monitorings taken at all stations, winter season monitoring (Dec. - Feb.) for the above abbreviated schedule, including seasonal additions, will be taken at the following stations as accessibility permits: CS-2, CS-3, CS-6, CS-9, CS-11, CS-12, CS-13, CS-14, VC-6, VC-9 and VC-10. Station CS-15 will be monitored for flow only each Spring, Summer and Fall beginning Fall 1988.

TABLE 2.3.7-3

MONITORING STATION IDENTIFICATION

ECCLES CANYON

STREAM STATIONS - 11 Stations

CS-1	CS-2	CS-3	CS-4	CS-6	CS-9
CS-11	CS-15	VC-6	VC-9	VC-10	

MINE DISCHARGE STATIONS - 2 Stations

CS-12 (Mine #3) CS-14 (Mine #1)

FRENCH DRAIN STATIONS - 1 Station

CS-13

HUNTINGTON CANYON

STREAM STATIONS - 5 Stations

CS-7	CS-8	CS-10	UPL-3*	UPL-10

WASTEROCK DISPOSAL SITE

STREAM STATIONS - 4 Stations

WRDS #1	WRDS #2	WRDS #3	WRDS #4

GROUNDWATER STATIONS

SPRINGS - 15 Stations

S10-1	S12-1	S13-2	S13-7	S14-4
S15-3	S17-2	S22-5	S22-11	S23-4
S24-12	S26-13	S34-12	S35-8	S36-12

WELLS (MONITORING) - 9 Well Stations

W79-10-1A	W79-10-1B	W79-14-2A	W79-14-2B	W79-22-2-1
W79-22-2-2	W79-26-1	W79-35-1A	W79-35-1B.	

WELLS, CULINARY -Referenced but not monitored

W13-1	W13-2	W17-1	W17-3	W24-1

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES)

001 Portal Area 002 Loadout Area

*Discontinued spring 1989

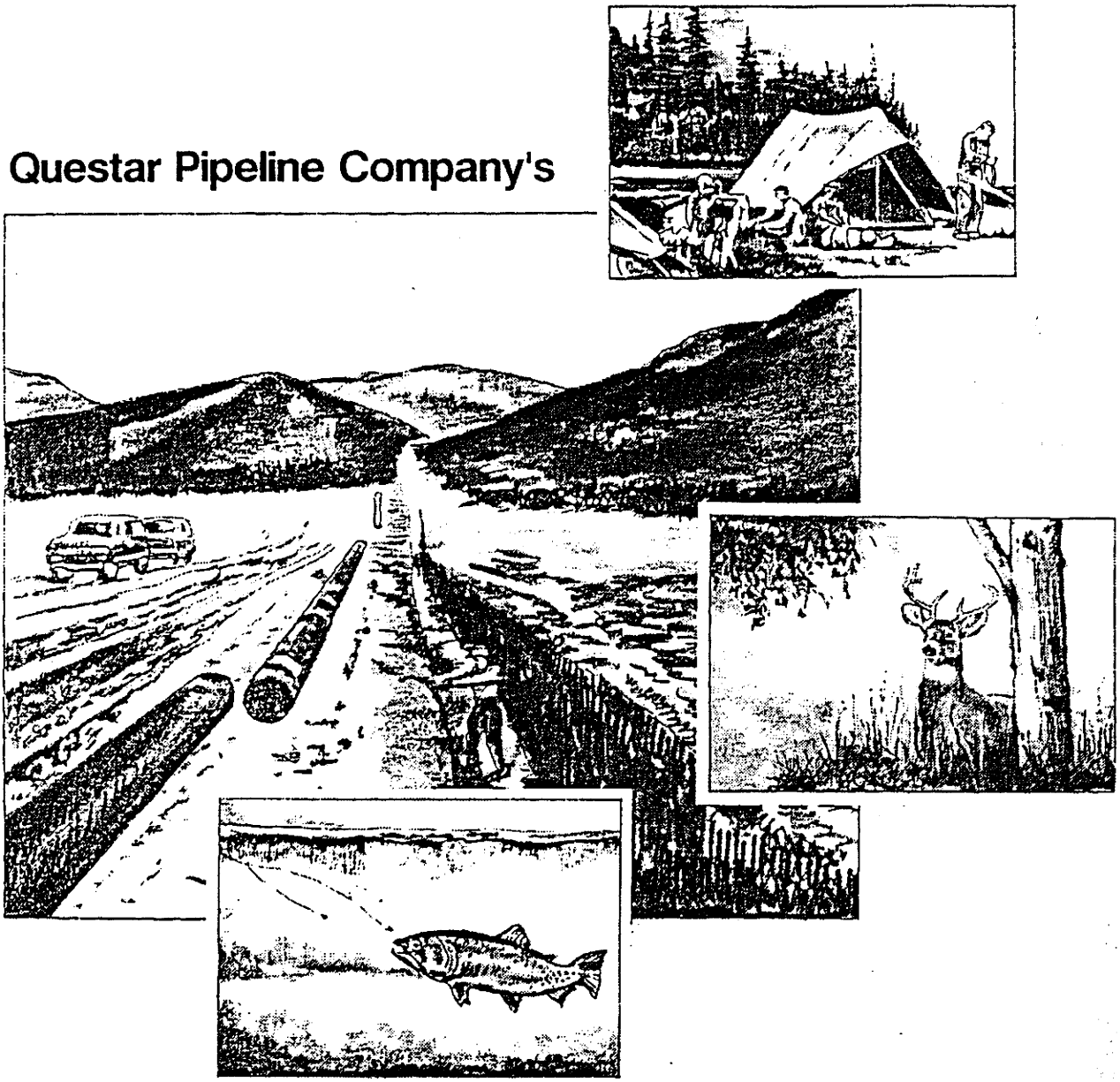
TABLE 2.3.7-4

SUMMARY INFORMATION ON GROUNDWATER OBSERVATION WELLS

OBSERVATION WELL NO.	COLLAR ELEVATION GROUND	TOTAL DEPTH DRILLED (FT)	TOTAL DEPTH CASED (FT)	TOP OF CASING-FT ABOVE COLLAR	PERFORATIONS	TOP OF COAL SEAM	COORDINATES	FORMATION MONITORED	COMMENTS
79-10-1A	9379.4	2190	2190	2.8	Bottom 20'	7402.8	N 498,739.290 E 2,073,496.481	Starpoint	
79-10-1B	9382.8	1110	1110	2.8	Bottom 20'	7402.8	N 498,783.026 E 2,073,448.969	Blackhawk	
79-14-2A	9051.7	122	122	3.0	Bottom 20'	8356.2	N 492,097.621 E 2,080,520.351	Blackhawk	
79-14-2B	9047.0	965	965	3.0	Bottom 20'	8356.2	N 492,100.107 E 2,080,487.589	Starpoint	Casing failed approx. 6/89
79-22-2-1	9040.0	585	585	2.5	Bottom 20'	9044.3	N 292,837.390 E 2,074,072.647	Blackhawk	
79-22-2-2	9041.8	1395	1395	2.5	Bottom 20'	9044.3	N 491,792.440 E 2,074,097.687	Starpoint	Casing failed approx. 9/85
79-26-1	9012.0	200	200	2.8	Bottom 20'	8414.0	N 483,357.8 E 2,079,916.0	Blackhawk	
79-35-1A	8726.4	1000	1000	2.5	Bottom 20'	8162.2	N 480,546.932 E 2,076,684.501	Starpoint	
79-35-1B	8724.4	150	150	2.5	Bottom 20'	8162.2	N 480,524.290 E 2,076,686.489	Starpoint	

WATER RESOURCES
QUESTAR PIPELINE COMPANY'S
MAIN LINE No. 41
FINAL ENVIRONMENTAL IMPACT STATEMENT
DAMES & MOORE, 1990

Questar Pipeline Company's



Main Line No. 41 Reroute at Skyline Mine

Final Environmental Impact Statement

US Department of Agriculture
Forest Service, Manti-La Sal National Forest

JULY 1990
Dames & Moore

TABLE OF CONTENTS

	PAGE
Summary	S- 1
Chapter 1 - Purpose of and Need for Action	1- 1
Introduction	1- 1
Purpose of and Need for Action	1- 1
Decision Needed	1- 3
Identifying the Issues	1- 3
Issues Identified	1- 4
Authorizing Actions and Permits	1- 4
Land Use Plans	1- 4
Permits and Other Regulations	1- 5
Scope of the Environmental Impact Statement	1- 5
Chapter 2 - Proposed Action and Alternatives	2- 1
Formulation of the Alternatives	2- 1
Alternatives Evaluated But Not Further Considered	2- 2
Alternatives Evaluated in Detail	2- 2
Mitigation Measures	2- 8
Summary Comparison of Alternatives	2- 8
Forest Service's Preferred Alternative	2- 8
Chapter 3 - Affected Environment	3- 1
Earth Resources	3- 1
Geology	3- 2
Coal	3- 6
Paleontology	3-13
Soils	3-14
Water Resources	3-16
Biological Resources	3-19
Riparian/Wetlands	3-19
Rangeland	3-21
Timber	3-22
Aquatic Resources	3-25
Terrestrial Wildlife	3-27
Special Status Species	3-28
Air Quality	3-28
Recreation	3-29
Visual Characteristics	3-31
Noise	3-34
Socioeconomics	3-34
Cultural Resources	3-36
Chapter 4 - Environmental Consequences	4- 1
Earth Resources	4- 2
Geology	4- 2
Coal	4- 5
Paleontology	4- 9
Soils	4- 9

Table of Contents (continued)

PAGE

Water Resources 4-12
Biological Resources 4-17
Riaprian/Wetlands 4-17
Rangeland 4-18
Timber 4-19
Aquatic Resources 4-20
Terrestrial Resources 4-22
Special Status Species 4-23
Air Quality 4-23
Recreation 4-24
Visual Characteristics 4-25
Noise 4-28
Socioeconomics 4-28
Cultural Resources 4-33
Combined Resource Effects 4-34
Short-term Uses Versus Long-term Productivity 4-34
Irreversible and Irretrievable Commitment of Resources 4-36
Cumulative Effects 4-37

Chapter 5 - List of Preparers 5- 1
EIS Preparation 5- 1
Contributors and Document Reviewers 5- 3

Chapter 6 - Consultation with Others - Public Involvement Process 6- 1
Project Scoping and Updates 6- 1
Public Comments and Agency Responses 6- 1

Chapter 7 - References 7- 1

Chapter 8 - Glossary 8- 1

Chapter 9 - Index 9- 1

Appendices
A - Construction, Operation, and Maintenance Plan (including Stipulations)
B - Descriptions of Proposed Route Locations
C - Study Area Map
D - Public Involvement Materials

Water Resources

The issues concerning water resources are sedimentation, changes in water quality of streams, and possible changes in stream flow due to surface alteration resulting from vegetation removal and soil compaction. Intermittent and perennial streams, reservoirs, springs, and riparian areas were delineated from topographic maps and field surveys.

Background

The study area lies within two major drainage basins on the western edge of the Upper Colorado hydrologic region. Huntington Creek and its tributaries are within the Huntington Creek watershed. Mud Creek, Gooseberry Creek, and their tributaries are within the Price River watershed and are tributary to Scofield Reservoir.

The area has warm, dry summers and cold, relatively moist winters. Annual precipitation ranges from 16 to 30 inches and occurs primarily as snow and occasional summer thunderstorm events. The freeze-free period is between 20 and 100 days and snowfall occurs approximately 8 months of the year. Floods in the area are produced primarily by snow melt in the spring. Occasional high-intensity, summer thunderstorms cause localized flooding.

At the Straight Canyon Barometer Watershed, located approximately 30 miles south of the study area near Joes Valley Reservoir, the monthly average precipitation depth in the conifer-aspen areas from July to August ranges from about 1.2 to 1.3 inches, then decreases in September to about 0.8 inch. The number of storms greater than 0.1 inch and lasting longer than 1 hour follow the same trend. From July to August, the number of storms increases from 5 to 8 and decrease to about 3 in September.

The surface hydrology of the project area is characterized by numerous intermittent channels draining into small perennial streams forming a dendritic pattern. Numerous springs and seeps are present throughout the project area. The larger springs are located on the hillslopes east of Huntington Creek and along the west edge of Pleasant Valley. Wet areas are found along the east-facing slopes east of Skyline Drive. A large marsh is present southeast of Lower Gooseberry Reservoir. Reservoirs within the study area include Scofield Reservoir, Electric Lake, Beaver Dam Reservoir, Boulger Reservoir, and Lower Gooseberry Reservoir.

Most of the stream crossings (riparian areas) have sections along the stream banks that are slumping into the stream to some degree and are partially vegetated. The stream bottoms are generally composed of fine materials with gravels and cobbles. The stream bottoms along Mud Creek near Scofield and Gooseberry Creek have large areas of silts with no gravels or cobbles.

Studies in the Wasatch Plateau indicate that most recharge to the ground-water system is due to infiltration of rainfall and snow melt at higher elevations. Much of the water is discharged by springs that flow from the Flagstaff Limestone and the North Horn Formation only a short distance from recharge areas (Lines 1984). This also appears to be the case in the Blackhawk Formation along the hillslopes east of Huntington Creek. Many of these springs flow throughout the summer and fall months. In the eastern highland area of the Gooseberry graben, a few summer home owners have piped spring water into their homes. The water is used without treatment.

The dissolved solids in the ground water are estimated to be generally less than 250 milligrams per liter (mg/l). Chemical testing of the ground water shows small concentrations of trace elements that do not exceed maximum mandatory limits for public supply (Lines 1984).

Unpublished studies by the Manti-La Sal National Forest hydrologist indicate that phosphate concentrations appear to be higher in streams located near the Blackhawk Formation than in the North Horn and Flagstaff Formations. This indicates that eutrophication of Scofield Reservoir, attributed to increased phosphate concentrations, occurs naturally from phosphate in the Blackhawk Formation. None of the phosphate concentrations measured exceeded the State of Utah minimum water-quality standards.

Specific Descriptions

Descriptions of the water resources along each of the segments were obtained using topographic maps and limited field reconnaissance. Locations of the stream crossings were obtained from a field survey of riparian areas and are presented in Table 3-3.

Alternative A and B - The existing pipeline crosses beneath 2 perennial streams at Gooseberry Creek and Mud Creek. Intermittent streams are crossed just east of Gooseberry Creek and at the head of a drainage in Section 14 on the Skyline lease area. Approximately 0.4 mile of the pipeline route is within 500 feet of a perennial stream.

Alternative C - Burnout Canyon Route (1) - Along the entire Burnout Canyon route there would be 12 perennial stream crossings, 10 of which would be located along segments that could be affected by construction. Two perennial stream crossings occur along the existing right-of-way on Gooseberry Creek and on Mud Creek. The perennial stream

crossings that could be impacted by construction are located on Upper Huntington Creek (9 crossings) and on Burnout Creek (1 crossing). Three intermittent stream crossings would occur along the entire route: one east of Gooseberry Creek on the existing pipeline, one in the canyon north of The Kitchen, and one in the canyon northeast of The Kitchen. A small seep area with standing water would be crossed in Segment 2 at the toe of the road fill along the paved road just south of Swens Canyon. The pipeline route would cross through a small area of springs located on the hillslope south of Burnout Creek. No reservoirs or marshes would be crossed by any of the segments. Approximately 3.3 miles of the route would lie within 500 feet of a perennial stream.

Alternative C - Burnout Canyon Route (2) - The inventory along this route is the same as Burnout Canyon Route (1), except only 2 intermittent stream crossings would occur: 1 along the existing route and 1 in the canyon northeast of The Kitchen.

Alternative C - Burnout Canyon Route (3) - Along the entire route there would be 5 perennial stream crossings, 3 of which would be affected by construction. The 2 existing stream crossings would be the same as Burnout Canyon (1); the 3 perennial stream crossings affected by construction would occur on Upper Huntington Creek (2 crossings), and the stream in Burnout Canyon (1 crossing). This route would cross the same intermittent streams as Burnout Canyon Route (1). Approximately 3.5 miles of the route would lie within 500 feet of a perennial stream.

Alternative C - Burnout Canyon Route (4) - The inventory along this route would be the same as Burnout Canyon Route (3), except only 2 intermittent stream crossings would occur: 1 along existing Segment 12* and 1 along Segment 15 in the canyon northeast of The Kitchen.

Alternative D - Gooseberry Route - The entire Gooseberry Route would cross perennial streams at 7 locations, 6 of which are along the segments that would be crossed by new pipeline. One perennial stream crossing occurs along the existing pipeline on Mud Creek. Of the 6 new stream crossings, 1 would occur on Gooseberry Creek, 1 on Swens Canyon Creek, 3 on Upper Huntington Creek, and 1 on the stream in Burnout Creek. There were no intermittent streams identified that cross this route. A small area of springs would be crossed on the hillslope south of the stream in Burnout Canyon. Approximately 1.8 miles of the route would lie within 500 feet of a perennial stream.

Valley Camp Triangle Connectors (1) through (3) - Segment 5/6 (Connector 2) would cross 1 small spring and Segment 8 (Connector 2) would cross below a spring located on the hillslope that flows along the inside ditch of the dirt road. The connectors would not be within 500 feet of a perennial stream.

Alternative E - Winter Quarters Route (1) - Along the entire Winter Quarters Route, there would be 3 perennial stream crossings, 2 of which would be located along segments of new pipeline. One perennial stream crossing occurs along the existing line on Gooseberry Creek, the 2 other perennial stream crossings would be located on Winter Quarters Creek and Mud Creek near Scofield. Approximately 0.4 mile of the route would be within 500 feet of a perennial stream. Associated Segments 19* and 23* cross 1 perennial stream (Mud Creek along Segment 19*). No springs were identified along these segments.

Alternative E - Winter Quarters Route (2) - There would be 6 perennial stream crossings along the entire route, of which 5 would occur on segments of new pipeline. The 5

stream crossings would be located along Winter Quarters Creek (1 stream crossing), Mud Creek near Scofield between Broads Canyon and Magazine Canyon (3 stream crossings), and on Broads Canyon Creek (1 stream crossing). Approximately 2.2 miles of the route would be within 500 feet of a perennial stream. Segment 19*, associated with this alternative, crosses 1 perennial stream (Mud Creek). No springs were identified along the segment.

Water Resources

The primary issues associated with this project are the effects to floodplains and wetland riparian areas caused by increased flow, effects to the quality of stream and reservoir water caused by sedimentation and phosphate increases, and consequences of slope failure on water quality. Eutrophication of Scofield Reservoir is an issue since phosphates are carried with sediments.

Increases in runoff were estimated using a computer program provided by the Forest Service that calculates the total volume of runoff and the peak flow rate. A storm of 6 hours and a recurrence interval of 10 years (1.6 inches) was used as a basis for the analysis. The Japanese Creek subwatershed was chosen as the worst case situation

because this subwatershed had the largest ratio of impacted area to subwatershed area. For this analysis, a corridor width of 50 feet was used (early in the project) and assumed as a worst case to expose bare soil for the entire width. Actually, vegetation would be completely removed only where necessary (i.e., area of the trench). Given a runoff curve number of 95, the results showed that runoff would increase by less than 4 percent over existing conditions. Since this is the worst case situation, then increases from runoff from the project would be considered insignificant.

The soil erosion and the annual sediment yield to streams were estimated using procedures developed by the Forest Service (Kelly 1976; Tew 1973). Two subwatersheds were used in this analysis. The first estimated sediment yield for the worst case situation on the Japanese Creek subwatershed (along Segment 1). The second estimated sediment yield in the Electric Lake subwatershed for the proposed Burnout Canyon Route (includes Segments 2, 3a, 3b, 4, 9, and most of 16). Both watersheds used a 50-foot corridor width and an impact area of bare soil mulched to 50 percent ground cover. The results showed that the estimated increases in sediment yield to the Japanese Creek and the Electric Lake subwatersheds were about 0.4 percent and 0.1 percent, respectively. In reality, the sedimentation along Upper Huntington Creek would be much less considering that the model uses the land surface condition of the impacted area as the condition of the land surface between the impacted area and the stream. In these canyons, the land surface between the impacted area and the stream has very dense vegetation that would prevent most sediment from entering the stream. Almost all sedimentation of the stream from the proposed project would probably occur near stream crossings from water flowing along the proposed corridor to the stream.

With these values representing the worst case situation and the most sensitive area, the increases in sediment yield to streams and reservoirs near the proposed routes would be low. However, these estimates are for the watersheds as a whole and do not indicate site-specific increases such as at stream crossings.

The sedimentation at each of the stream crossings was estimated using the same model that was used for the watersheds as a whole. The area that would contribute sediment directly to the stream was considered to be from 150 to 300 feet from the stream crossing. The estimates assume a 50-foot corridor width and an impact area of bare soil mulched to 50 percent cover. The annual sediment yield for all of the stream crossings in Upper Huntington Canyon for the Burnout Canyon Routes and the Gooseberry Routes is estimated to be approximately 0.27 ton and 0.12 ton, respectively. These values are approximately 0.02 percent and 0.01 percent of the annual sediment yield for the Electric Lake watershed, for which Upper Huntington Canyon is a part. The results indicate that short-term impacts from sedimentation at stream crossings would be very small compared to the watershed as a whole. However, since the sediment source would be from a very localized area, and Upper Huntington and Burnout Creeks are high-value spawning areas and important to statewide fishery restocking programs, even a small increase of sediment could have the potential to cause a substantial impact on the fisheries.

The amount of sedimentation at stream crossings would be substantially reduced by the use of effective sediment control devices other than mulching.

No impacts to water quality in Electric Lake and Scofield Reservoir are expected. The increased sediment yield from this project is small when compared to natural sediment yields. The sediment deposition in Scofield Reservoir was approximately 3000 acre-feet

from 1943 to 1979, which is about 83 acre-feet per year (Waddell et al. 1985). Extending the worst case situation on the Japanese Creek subwatershed to the longest proposed route, the increase in the amount of sedimentation is about 0.04 acre-feet. This amounts to about a 0.05 percent increase in the sediment deposition to Scofield Reservoir.

The amount of phosphate loading from this project would be directly related to the amount of sedimentation of the streams. The estimated increase in the amount of phosphorus loading in Scofield Reservoir would be about the same as the sediment yield, approximately 0.05 percent.

Downstream impacts to the water and fisheries would be low during construction since it would occur during nonspawning periods and during periods of low stream flow. Impacts to fisheries in future years would be moderate due to silting in of the spawning gravels.

Areas along Upper Huntington Creek within the 500-year floodplain were identified so that no petroleum products, chemicals, or hazardous materials would be stored there during construction in accordance with Executive Order 11988. Discharge volumes for the 500-year flood event, obtained from the Forest Service, are 159 cubic feet per second (cfs) at The Kitchen, 233 cfs at the mouth of Swens Canyon, and 283 cfs at the mouth of Burnout Canyon. The flow velocity along Upper Huntington Canyon is estimated at 5 feet per second using Manning's equation. By dividing the discharge by the flow velocity, the cross-sectional area that would be inundated by the water is 33 square feet at The Kitchen, about 50 square feet at the mouth of Swens Canyon, and about 60 square feet at the mouth of Burnout Canyon. Considering the valley bottom geometry of Upper Huntington Canyon, the 500-year floodplain lies in the low areas about 50 feet from the stream channel.

The proposed Gooseberry Narrows Project is located just south of the Gooseberry Creek crossing on Segment 1. No conflicts between the proposed Main Line No. 41 Reroute Project and the proposed Gooseberry Narrows Project have been identified.

If appropriate mitigation is not implemented, the consequences of slope failure on the water resources would be great and may include the damming of existing streams, high sedimentation of streams and reservoirs, erosion from the area of land failure, loss of critical fish habitat, and a decrease in water quality affecting municipal drinking water. The likelihood of slope failure occurrence is low for most of the project area. Appropriate mitigation (Appendix A) and caution during construction is essential along the slope west of Gooseberry Creek on Segment 1 and along the north slope of Burnout Canyon on Segment 3b, if the toe of the slope is excavated. Criteria used to assess potential impacts are summarized below.

High Impacts

- high increases in the amounts of sedimentation (approximately greater than 5 percent over existing conditions)

Moderate Impacts

- nonvegetated construction areas occurring within 500 feet of a perennial stream
- sedimentation increases between 1 and 5 percent

Low Impacts

- small increase of sediment (up to 1 percent)

No Identifiable Impact

- nonvegetated construction areas with no perennial stream within 500 feet of the proposed route
- no sedimentation or water quality changes

Specific Descriptions

Table 4-5 shows the number of perennial stream crossings, tons of annual erosion, and tons of annual sediment yield. It is important to note that the descriptions below describe the worst-case results (before mitigation) generated from the model described above.

Alternative A - No-Action - No short-term or long-term impacts from this project were identified.

Alternative B - Leave in Place, Full Extraction Mining - No short-term or long-term impacts from this project were identified.

Alternative C - Burnout Canyon Route (1) - The long-term impacts along the entire route would be low because with proper mitigation the impacted soils would revegetate and sedimentation of the stream would be reduced to existing conditions. Moderate-to-high short-term impacts (2.7 miles within 500 feet of the stream) from pipeline construction would occur from the uppermost creek crossing to Electric Lake along Upper Huntington Creek and moderate short-term impacts (0.6 mile) between the stream crossing on Burnout Creek and Electric Lake. The spring area on the slope south of the creek in Burnout Canyon would be avoided. From construction, the worst-case annual sediment yield is estimated to be 0.27 tons for each of the 9 perennial stream crossings in Upper Huntington Canyon and 0.19 tons for the 1 perennial stream crossing in Burnout Canyon, until the impacted area is revegetated. Low short-term impacts could occur at 2 intermittent stream crossings north and east of The Kitchen (Segments 14 and 16) if water is present or in the event of a rainstorm. The sediment from the stream crossings would eventually be deposited in Electric Lake.

Alternative C - Burnout Canyon Route (2) - The impacts would be the same as Burnout Canyon Route (1) except low short-term impacts could occur at one intermittent stream crossing east of The Kitchen (Segments 15 and 16) if water is present or in the event of a rainstorm.

Creek, and 1 stream crossing on the creek in Broads Canyon. From construction, the worst-case annual sediment yield is estimated to be 0.03 ton at the perennial stream crossing on the creek in Winter Quarters Canyon, 0.09 ton at the 3 perennial stream crossings on Mud Creek, and 0.03 ton at the stream crossing on the creek in Broads Canyon. The sediment from these stream crossings would eventually be deposited in Scofield Reservoir. No new impacts would occur along associated Segment 19*.

TABLE 4-5
SUMMARY OF POTENTIAL IMPACTS: WATER

Route	Riparian Area	Number of Perennial Crossings (1)	Total Annual Erosion (tons)	Total Annual Sediment Yield (tons)
Alternative A				
No-Action	No riparian area impacted	0	0.00	0.00
Alternative B				
Leave in Place, Full Extraction Mining	No riparian area impacted	0	0.00	0.00
Alternative C				
Burnout Canyon (1)	Upper Huntington Canyon	9	0.63	0.27
	Burnout Canyon	1	0.18	0.19
Burnout Canyon (2)	Upper Huntington Canyon	9	0.63	0.27
	Burnout Canyon	1	0.18	0.19
Burnout Canyon (3)	Upper Huntington Canyon	2	0.14	0.06
	Burnout Canyon	1	0.18	0.19
Burnout Canyon (4)	Upper Huntington Canyon	2	0.14	0.06
	Burnout Canyon	1	0.18	0.19
Alternative D				
Gooseberry Route	Upper Huntington Canyon	4	0.28	0.12
	Burnout Canyon	1	0.18	0.19
	Gooseberry Creek	1	1.38	1.15
Valley Camp Triangle Connectors				
(1)	No riparian area impacted	0	0.00	0.00
(2)	No riparian area impacted	0	0.00	0.00
(3)	No riparian area impacted	0	0.00	0.00
Alternative E				
Winter Quarters (1)	Winter Quarters Canyon	1	0.07	0.03
	Mud Creek near Scofield	1	0.07	0.03
Winter Quarters (2)	Winter Quarters Canyon	1	0.07	0.03
	Mud Creek near Scofield	1	0.07	0.03
	Mud Creek between Broads Canyon and Magazine Canyon	3	0.21	0.09

(1) - Only perennial stream crossings impacted by pipeline construction are presented.

Note: Upper Huntington Canyon includes the stream crossing on the creek at the mouth of Swens Canyon. For stream crossings in Upper Huntington Canyon, at the mouth of Winter Quarters Canyon, Mud Creek near Scofield, and Mud Creek between Broads Canyon and Magazine Canyon the length of the area affected on each side of the stream channel was estimated to be approximately 150 feet. For the stream crossing in Burnout Canyon the length of the affected area was estimated to be 150 feet on the north side (gentle slopes) and 300 feet on the south side (steep slopes). The length of the affected area on each side of the stream crossing at Gooseberry Creek was estimated to be approximately 300 feet (steep slopes).

Moderate Impacts

- nonvegetated construction areas occurring within 500 feet of a perennial stream
- sedimentation increases between 1 and 5 percent

Low Impacts

- small increase of sediment (up to 1 percent)

No Identifiable Impact

- nonvegetated construction areas with no perennial stream within 500 feet of the proposed route
- no sedimentation or water quality changes

Specific Descriptions

Table 4-5 shows the number of perennial stream crossings, tons of annual erosion, and tons of annual sediment yield. It is important to note that the descriptions below describe the worst-case results (before mitigation) generated from the model described above.

Alternative A - No-Action - No short-term or long-term impacts from this project were identified.

Alternative B - Leave in Place, Full Extraction Mining - No short-term or long-term impacts from this project were identified.

Alternative C - Burnout Canyon Route (1) - The long-term impacts along the entire route would be low because with proper mitigation the impacted soils would revegetate and sedimentation of the stream would be reduced to existing conditions. Moderate-to-high short-term impacts (2.7 miles within 500 feet of the stream) from pipeline construction would occur from the uppermost creek crossing to Electric Lake along Upper Huntington Creek and moderate short-term impacts (0.6 mile) between the stream

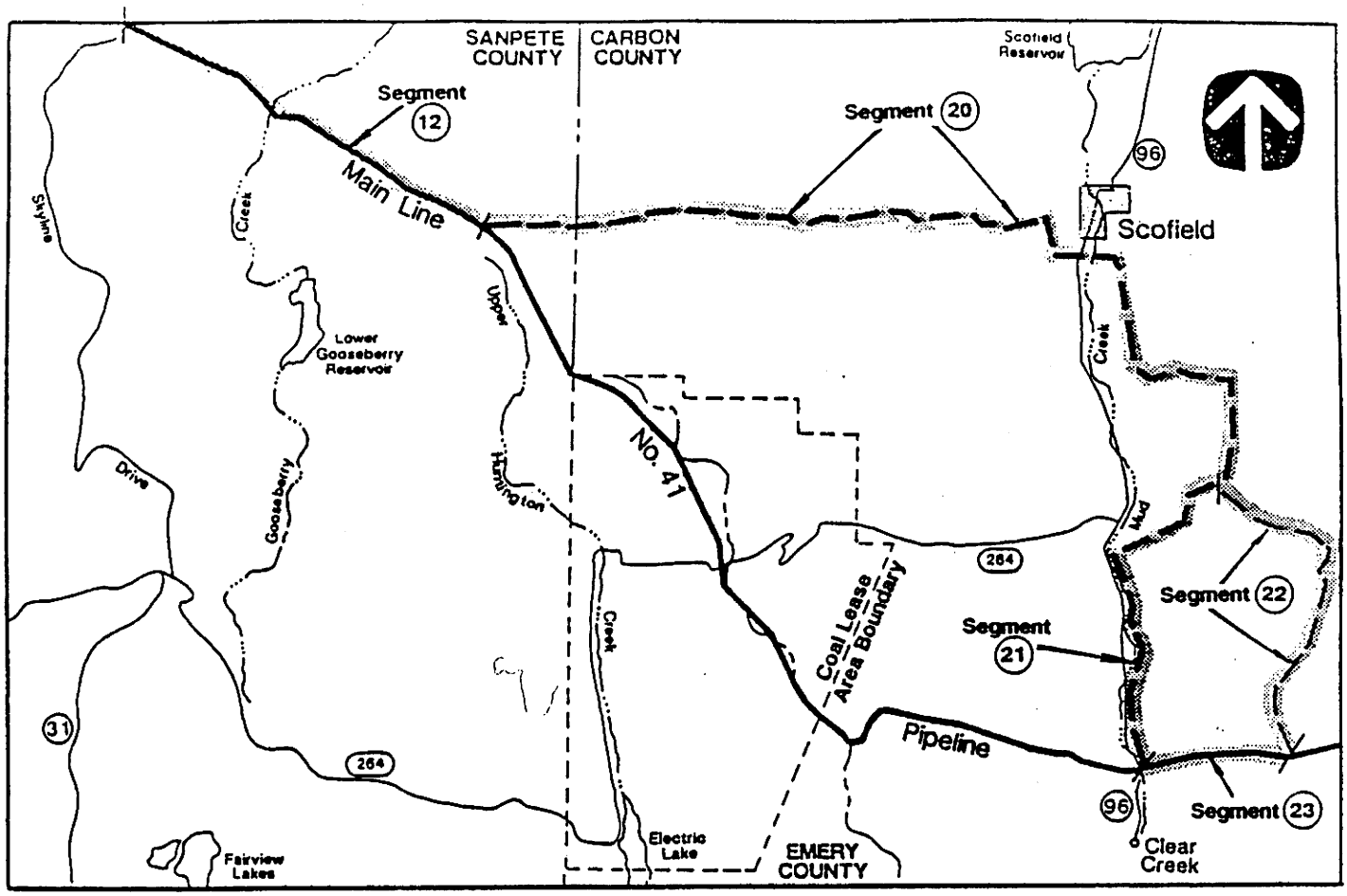


FIGURE B-4. THE WINTER QUARTERS ROUTE

Segments 12*, 20, 21, 23*; variation Segment 22; associated Segment 19*

Segment 12* (3.7 miles in length) is part of the existing pipeline and for purpose of this study begins in the northwest quarter of Section 25, T.12 S., R.5 E. (SLM) at the headward side of the Cabin Hollow Creek Drainage. The pipeline trends southeasterly from near the junction of Skyline Drive and an unimproved two-track road, the latter of which runs adjacent to the pipeline for one-half mile before turning south. One-third mile thereafter, the pipeline begins descending some 1,000 feet in elevation over the next mile to the crossing at Gooseberry Creek, then ascends nearly 1,400 feet over the remaining 2.2 miles.

An unimproved two-track road roughly parallels the pipeline for some 2.6 miles beginning about 0.4 mile west of the Gooseberry Creek crossing to the eastern end of Segment 12*. The roadway crosses the pipeline at numerous locations along the segment.

Segment 20 (9.1 miles in length) trends east/west for approximately two-thirds of its proposed length along the upland reaches of Winter Quarters Ridge before descending just west of Scofield to crossings situated at an unimproved two-track road, Winter Quarters Creek and Mud Creek. After skirting the southern corporate limits of Scofield, the segment turns southward just east of Mud Creek atop the ridgeline separating Pleasant Valley on the west and UP Canyon to the east for the distance of 1.1 miles. At

that point, the proposed segment turns east for .75 mile and then south for the remaining distance.

An unimproved two-track road would run adjacent to the proposed pipeline segment from the vicinity of Scofield to the junction with either Segment 21 or 22.

Segment 21 (3.1 miles in length) descends the ridgeline north of Broads Canyon crossing along its course 2 unimproved roads and the stream at the mouth of Broads Canyon before reaching and crossing Mud Creek. The proposed pipeline segment then runs upstream adjacent to and west of Mud Creek until the mouth of Slaughter House Canyon where the pipeline crosses to the east side of the creek near an existing highway culvert. The segment then continues upstream to connect with the existing pipeline just east of Utah State Highway 96.

Segment 23* (1.3 miles in length), part of the existing pipeline, differs in elevation by over 1,200 feet between the western end (lowest) and eastern end (highest) of the segment. The pipeline follows the ridgeline between Boneyard Canyon on the north and Magazine Canyon to the south and continues eastward to a topographic feature referred to as "The Elbow". This location marks the eastern extent of the proposed pipeline reroute project and is situated in the southwestern quarter of Section 27, T.13 S., R.7 E. (SLM).

Segment 22 (3.3 miles in length) is an eastern alternative for the Winter Quarters Route. The proposed segment instead of descending along the ridgeline of Broads Canyon like Segment 21, sidles eastward and southward along the upper reaches of Broads Canyon before rejoining the existing pipeline at "The Elbow". Unimproved two-track roads exist adjacent to the proposed pipeline alignment.

Segment 19* (2.8 miles of existing pipeline) is not a part of either Winter Quarters Routes (1) or (2). However, if either of these routes is selected, the existing pipeline of Segment 19* cannot be abandoned as it is needed to supply gas to a tap line that joins Main Line No. 41 at the western terminus of Segment 19*. Because this segment cannot be abandoned, the environmental resources are addressed along Segment 19* not as part of the routes, but as a segment associated with the route.

The first one-half mile on the western end of Segment 19* trends northeasterly before turning in a southeasterly direction. The southeastern component follows the ridgeline between Slaughter House Canyon on the north and Boardinghouse Canyon to the south and crosses and runs parallel to a unimproved road for nearly 0.5 mile at the western end of the component. At the eastern end of the segment, the topography descends nearly 1,100 feet over the last 0.5 mile, crossing State Highway 96 and Mud Creek near the junction with Segment 23*.

CHAPTER 7 - REFERENCES

EARTH RESOURCES

Geology

Baum, Rex L. and Robert W. Fleming. 1989. Landslides and Debris Flows in Ephraim Canyon, Central Utah. U. S. Geological Survey Bulletin 1842-C.

Coastal States Energy Company. 1986. Skyline Mines Mining and Reclamation Plan, Vol.1.

Coastal States Energy Company. 1981. Skyline Coal Mining Project, Geology Report, Carbon and Emery Counties, Utah. Coastal States Energy Company. Midvale, Utah.

Design Engineering. 1989. Study of Subsidence Induced Stresses in Main Line No. 41. Prepared for Questar Pipeline Company.

Fischer, D.J., E.E. Erdmann and J.B. Reeside, Jr. 1960. Cretaceous and Tertiary Formations of the Book Cliffs, Carbon, Emery, and Grand counties; Utah Garfield and Mesa counties, Colorado: U.S. Geological Survey Professional Paper 332, 80p.

Hintze, Lehi F. 1988. Geologic History of Utah. Brigham Young University Geology Studies, Special Publication 7.

Kenneth C. Ko and Associates. 1989. Subsidence Study Along Gas Pipeline Section. Project No. 2096. Prepared for Utah Fuel Company.

Knowles, Steven P. 1985. Geology of the Scofield 7.5 Minute Quadrangle in Carbon, Emery and Sanpete Counties, Utah. Brigham Young University Geology Studies, V.32, part 1, p. 85-100.

Oberhansley, Gary G. 1980. Fairview Lakes Quadrangle, Utah. Utah Geological and Mineral Survey. Map No. 56.

Spieker E.M. and J.B. Reeside. 1925. Cretaceous and Tertiary Formations of the Wasatch Plateau, Utah. Geological Society of America Bulletin, V.36, P 435-54.

Stokes, William L. 1986. Geology of Utah. Published by Utah Museum of Natural History and the Utah Geological and Mineral Survey.

Tingey, David G. 1986. Miocene Mica Peridotite Dike Swarm, Wasatch Plateau, Utah Geological Society of America, Abstracts With Programs.

US Department of Agriculture. 1989. Environmental Assessment. Proposed Realignment of Main Line No. 41, South Fork Thistle Creek and Gooseberry Creek Areas. Manti-La Sal National Forest.

Utah State Division of Water Rights. 1990. Written communication.

Coal Resources

Belina Mines. 1984. Valley Camp Mine Plan, Belina No. 1 and 2.

Bureau of Land Management. 1990. Coal Reserves Report for Questar's Proposed Reroute of Main Line Pipeline No. 41.

Coastal States Energy Company. 1986. Skyline Mines Mining and Reclamation Plan. Vol.1.

___. 1981. Skyline Coal Mining Project, Geology Report, Carbon and Emery Counties, Utah. Midvale, Utah.

Design Engineering. 1989. Study of Subsidence Induced Stresses in Main Line No. 41. Prepared for Questar Pipeline Company.

Kenneth C. Ko and Associates. 1989. Subsidence Study Along Gas Pipeline Section. Technical Report for Utah Fuel Company, Project No. 2096.

UCO, Inc. 1982. Scofield Mine, Application for Mining Permit to State of Utah. Prepared for Division of Oil, Gas, and Mining.

Utah Geological and Mineral Survey. 1987. Maps of Mined-out Area in the Scofield Quadrangle, unpublished.

Paleontological Resources

Knowles, Steven P. 1985. Geology of the Scofield 7.5 Minute Quadrangle in Carbon, Emery and Sanpete Counties, Utah. Brigham Young University Geology Studies, V.32, part 1, p. 85-100.

Madsen, David. 1990. Utah State Archaeologist. Personal communication.

Oberhansley, Gary G. 1980. Fairview Lakes Quadrangle, Utah. Utah Geological and Mineral Survey. Map No. 56.

Rose, Judy A. 1980. A Cultural Resources Survey of the Fairview Revegetation Project. U.S. Forest Service, Manti-La Sal National Forest.

US Department of Agriculture. 1989. Personal communication with Steve Robison, paleontologist, Forest Service, Inter-Mountain Regional Office.

Soil Resources

Swenson, John L., Wesley Keetch and Laurel Stott. 1983. Soil Survey of the Parts of the River and Huntington River Watersheds. US Forest Service, Manti-La Sal National Forest. Mesa Corporation, Salt Lake City, UT.

US Department of Agriculture. 1988. Soil Survey of Carbon Area, Utah. Soil Conservation Service.

Water Resources

Dames & Moore. 1990. Draft Report for Questar Pipeline Company's Main Line No. 41 Reroute at Skyline Mine, Riparian Survey. Prepared for Forest Service, Manti-La Sal National Forest.

Denton, Richard. 1983. State of Utah, Scofield Reservoir Phase I, Clean Lakes Study. Department of Health, Division of Environmental Health, Bureau of Pollution Control. State of Utah.

Division of Water Rights. Administrative Rules for Stream Channel Alternations. State of Utah.

Fletcher, Joel E. et al. 1981. Precipitation Characteristics of Summer Storms at Straight Canyon Barometer Watershed, Utah. US Department of Agriculture, Forest Service, Intermountain Forest and Range Experimental Station. Research Paper INT-274.

Iaquinta, James L. 1985. Watershed Inventory and Analysis for Price River Watershed. U.S. Forest Service. Manti-La Sal National Forest

Kelly, Dennis. 1976. User's Guide for the Computer Program SEDROUTE. US Department of Agriculture, Manti-La Sal National Forest.

Kelly, Dennis. n.d. Unpublished Computer Program to Estimate Flood Peak Flows Using Weighted Discharge instead of Weighted Area. US Department of Agriculture, Manti-La Sal National Forest.

Kelly, Dennis K. n.d. Unpublished Research on Phosphate Contributions to Streams in the Manti-La Sal National Forest. US Department of Agriculture, Forest Service.

Lines, Gregory, et al. 1984. Hydrology of Area 56, Northern Great Plains and Rocky Mountain Coal Provinces, Utah. US Geological Survey. Water Resources Investigations Open-file Report 83-38.

Tew, Ronald K. 1973. Estimating Soil Erosion Losses from Utah Watersheds. US Department of Agriculture, Forest Service.

US Department of Agriculture. 1987. Water Information Management System Handbook. FSH 2509.17 Forest Service.

___. 1984. Watershed Inventory and Analysis for the Huntington Creek Watershed. US Forest Service. Manti-La Sal National Forest.

Waddell, et al. 1985. Chemical and Physical Characteristics of Water and Sediment in Scofield Reservoir, Carbon County, Utah. US Geological Survey Water-Supply Paper 2247.

Biological Resources

Coastal States Energy Company. 1981. Skyline Mines Project. Midvale, Utah.

Dalton, Larry B. 1989. Letter from Larry B. Dalton, Utah Division of Wildlife Resources, to Ira Hatch, Forest Supervisor, Manti-La Sal National Forest. November 15, 1989.

Dalton, Larry B., et al. 1978. Species list of vertebrate wildlife that inhabit southeastern Utah. Utah Division of Wildlife Resources Publication, Salt Lake City, Utah, 78-16. From: Western Resource Development Corporation 1981. Fish and wildlife resources, Scofield Mine, Carbon County, Utah.

Dames & Moore. 1990. Draft Report for Questar Pipeline Company's Main Line No. 41 Reroute at Skyline Mine, Riparian Survey. Prepared for Forest Service, Manti-La Sal National Forest, Price, Utah.

Mangum, Fred A. 1984. Aquatic Ecosystem Inventory Macroinvertebrate Analyses For Selected Streams on the Manti-La Sal National Forest. US Department of Agriculture, Forest Service.

___. 1983. Aquatic Ecosystem Inventory Macroinvertebrate Analysis, Manti-La Sal National Forest. US Department of Agriculture, Forest Service.

US Department of Agriculture, Forest Service, 1989. Personal communication with Rod Player.

___. 1990. Personal communication with Glen Jackson, recreation and timber specialist, Manti-La Sal National Forest, Price, Utah.

___. 1989. Personal communication with Robert Thompson, vegetation and reclamation specialist, Manti-La Sal National Forest, Price, Utah.

___. 1986. Land and Resource Management Plan, Manti-La Sal National Forest, Price, Utah.

___. Final environmental impact statement, Manti-La Sal National Forest. US Department of Agriculture.

US Department of the Interior, Fish and Wildlife Service. 1989. Arizona candidate plant species. Compiled by Sue Rutman, Phoenix, Arizona.

Utah Department of Natural Resources. 1989. Personal communication between Mr. Larry Dalton, Regional Wildlife Program Manager, Division of Wildlife Resources and Dr. Loren Hettinger, Biologist, Dames & Moore, October 18, 1989.

___. 1989. Completion Report. Huntington Creek (Section 6) Catalog No. II AI 130. Prepared by Walt Donaldson, Fishery Manager, February 27, 1987.

Utah Department of Natural Resources. 1987. Completion Report. Huntington Creek (Section 6) Catalog No.II AI 130. Prepared by Walt Donaldson, Fishery Manager, February 27, 1987.

Utah Department of Natural Resources. 1981. Fish and Wildlife resource information. UCO, Inc. Scofield Mining Project. Price, Utah. From: Western Resource Develop. Corp. 1981. Fish and wildlife resources, Scofield Mine, Carbon County, Utah.

Western Resource Development Corporation 1982. Vegetation resources, Scofield Mine, Carbon County, Utah.

Land Use/Visual Characteristics

Carbon County. 1989. Personal communication with Dennis Dernly, County Clerk.

___. 1989. Personal communication with Larris Hunting, County Job Service.

___. 1989. Personal communication with Harold Marston, County Planner.

___. n.d. Master title plats.

Emery County. 1989. Personal communication with Ina Lee Magneson, County Recorder.

___. 1983. Master title plats.

Sanpete County. 1989. Personal communication with Janet Lund, County Recorder.

___. 1981. Master title plats.

US Department of Agriculture, Forest Service. 1989. Manti-La Sal National Forest Map.

___. 1989. Personal communication with James Jensen, visual quality specialist, Manti-La Sal National Forest, Price, Utah.

___. 1989. Personal communication with Glen Jackson, recreation and timber specialist, Manti-La Sal National Forest, Price, Utah.

___. 1987. Project Planning ROS User's Guide Chapter 60.

___. 1986. Manti-La Sal National Forest Final Environmental Impact Statement.

___. 1986. Manti-La Sal National Forest Plan and maps, Intermountain Region.

___. 1986. Manti-La Sal National Forest ROS map.

___. 1984-86. Manti-La Sal visual resources inventory maps.

___. 1974. National Forest Landscape Management, Chapter Two - The Visual Management System.

Utah State Lands. 1989. Personal communication with Lands Clerk.

Socioeconomics

Questar Pipeline Company. 1989. Personal communication with Tim Blackham.

___. 1989. Personal communication with Kim Blair.

___. 1989. Personal communication with Rex Headd.

Six County Planning and Economic Development. 1989. Personal communication with Emery Poleloneus.

Southeastern Utah Association of Local Governments. 1989. Personal communication with Bill Howell.

US Department of Agriculture, Forest Service. 1989. Personal communication with Carter Reed, Manti-La Sal National Forest, Supervisor's Office, Price, Utah.

US Department of Commerce, Bureau of the Census. 1987. State Government Finances for Utah.

___. 1980. General Social and Economic Characteristics, Utah.

___. 1980. General Population Characteristics, Utah.

US Department of the Interior, Bureau of Land Management. 1989. Personal communication with Max Nielson, Utah State Office.

University of New Mexico, Bureau of Business and Economic Research. 1989. Personal communication with Kevin Kargacin.

Utah Department of Employment Security. 1989. Personal communication with Ken Jensen, Labor Market Information Service.

Utah Division of Business and Economic Development. 1989. Personal communication with Jonnie Wilkinson.

Utah Fuel Company. 1989. Personal communication with John Garr.

___. 1989 Personal communication with Craig Hilton.

Cultural Resources

Black, Kevin D. and Michael D. Metcalf. 1986. THe Castle Valley Archaeological Project: An Inventory and Predictive Model of Selected Tracts. Cultural Resource Series No. 19. Utah State Office, Bureau of Land Management, Salt Lake City.

Bruder, J. Simon, E.J. Bassett and A.E. Rogge. 1989. Cultural Resources Inventory Report for the Questar Pipeline Company Mainline No. 41 Reroute Project: National Forest Lands. Prepared for Manti-La Sal National Forest. Dames & Moore, Phoenix.

Euler, Robert C. 1966. Southern Paiute Ethnohistory. University of Utah Anthropological Papers No. 78. Salt Lake City.

Gillette, David D. 1989. The Huntington Mountain Mammoth: The Last Holdout? Canyon Legacy, Spring, pp. 3-8.

Gruhn, Ruth. 1961. The Archeology of Wilson Butte Cave, South-Central Idaho. Occasional Papers of the Idaho State College Museum No. 6.

Hauch, F.R. 1979. Cultural Resource Evaluation in South Central Utah 1977-1978. Cultural Resource Series No. 4. Utah State Office, Bureau of Land Management, Salt Lake City.

Holmer, Richard N. and Dennis G. Weder. 1980. Common Post-Archaic Projectile Points of the Fremont Area. In, Fremont Perspectives. Ed. D.B. Madsen. Antiquities Section Selected Papers VII (16):55-68. Salt Lake City.

Intermountain Reporter. 1988. Mysterious Manti Mammoth, pp. 2-4.

Jennings, Jesse D. 1978. Prehistory of Utah and the Eastern Great Basin. University of Utah Anthropological Papers 98. Salt Lake City.

Jennings, Jesse D. and Dorothy Sammons-Lohse. 1981. Bull Creek. University of Utah Anthropological Papers 105. Salt Lake City.

Madsen, David. 1990. Utah State Archaeologist. Personal communication.

Nickens, Paul R. 1982. A Summary of the Prehistory of Southeastern Utah. In, Contributions to the Prehistory of Southeastern Utah, assembled by S.G. Baker. Cultural Resource Series No. 13, Utah State Office, Bureau of Land Management, Salt Lake City.

Schroedl, Alan R. 1976. The Archaic of the Northern Colorado Plateau. PhD dissertation, University of Utah, Salt Lake City.

Smith, Anne M. 1974. Ethnography of the Northern Ute. Papers in Anthropology No. 17. Museum of New Mexico Press, Santa Fe.

Steward, Julian H. 1938. Basin-Plateau Aboriginal Socio-Political Groups. Smithsonian Institution Bureau of American Ethnology Bulletin 120.

Stewart, Omer C. 1966. Ute Indians: Before and After White Contact. Utah Historical Quarterly 34:38-61.

Watts, A.C. 1948. Opening of First Commercial Coal Mine Described. Centennial Echoes form Carbon County, T.V. Reynolds et al., compilers. Daughters of Utah Pioneers of Carbon County, Price.

Wheat, Margaret M. 1967. Survival Arts of the Primitive Paiutes. University of Nevada Press, Reno.

Wikle, Les. 1982. Cultural Resources Survey Note concerning the Utah Department of Transportation 1981 Eccles Canyon Road Project. On file, Manti-La Sal National Forest, Price, Utah.

Winter Quarters Canyon
Data Adequacy

October 1992

HYDROLOGIC MONITORING OF SELECTED STREAMS IN FIELDS OF CENTRAL AND SOUTHERN UTAH AUGUST 1978 - SEPTEMBER 1984 U.S. GEOLOGICAL SURVEY WATER RESOURCES INVESTIGATIONS REPORT 86-4017

HYDROLOGIC MONITORING OF SELECTED STREAMS IN COAL FIELDS OF CENTRAL AND SOUTHERN UTAH—SUMMARY OF DATA COLLECTED, AUGUST 1978-SEPTEMBER 1984

By Don Price and Gerald G. Plantz

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 86-4017

Salt Lake City, Utah
1987

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey, WRD
Room 1016 Administration Building
1745 West 1700 South
Salt Lake City, Utah 84104

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports
Federal Center, Bldg. 41
Box 25425
Denver, Colorado 80225
[Telephone (303) 236-7476]

CONTENTS

	Page
Abstract	1
Introduction	1
Purpose and scope	1
Previous investigations	2
Gaging station numbering system	5
Physiographic, geologic, and hydrologic setting	5
Central Utah coal-fields area	5
Alton coal-field area	7
Price River basin	10
Mud Creek and Eccles Canyon creek	10
Beaver Creek	20
Willow Creek	23
Price River	27
Spring Canyon creek	31
North Fork of Gordon Creek	36
Coal Creek	39
Soldier Creek	45
Dugout Creek	46
Grassy Trail Creek	51
Horse Canyon creek	60
San Rafael River basin	65
Huntington Creek, Crandall Canyon creek, and Tie Fork	65
Cottonwood Creek	78
Dirty Devil River basin	81
Quitchupah Creek, Convulsion Canyon creek, and Christensen Wash	81
Kanab Creek basin	93
Sink Valley Wash	93
Thompson Creek	97
Conclusions	97
References cited	101

ILLUSTRATIONS
[Plate in pocket]

Plate 1. Maps showing areas of the central Utah and Alton coal fields, Federal coal leases, selected active underground coal mines, and streamflow-gaging stations used for hydrologic monitoring, August 1978-September 1984

Figure 1. Diagrammatic section of geologic formations in the coal fields of central Utah	6
2. Diagrammatic section of geologic formations in the Alton coal-field area	8

Page

Figure 3-32 Graphs showing:
3. Maximum, average, and minimum daily mean flow of Eccles Canyon creek at station 09310600, water years 1980-84 14
4. Maximum, average, and minimum daily mean flow of Mud Creek at station 09310700, water years 1979-84 18
5. Base flow of Mud Creek 19
6. Base flow of Beaver Creek as related to geology ... 24
7. Maximum, average, and minimum daily mean flow of Willow Creek at station 09312900, water years 1980-81 25
8. Base flow of Willow Creek as related to geology ... 26
9. Maximum, average, and minimum daily mean flow of the Price River at station 09313000, water years 1935-70, 1980-81 30
10. Maximum, average, and minimum daily mean flow of Spring Canyon creek at station 09313040, water years 1979-81 34
11. Base flow of Spring Canyon creek as related to geology 35
12. Base flow of the North Fork of Gordon Creek as related to geology 40
13. Maximum, average, and minimum daily mean flow of Coal Creek at station 09313965, seasonal record for water years 1979-81 41
14. Base flow of Coal Creek as related to geology 42
15. Maximum, average, and minimum daily mean flow of Soldier Creek at station 09313975, seasonal record for water years 1979-84 47
16. Base flow of Soldier Creek as related to geology .. 48
17. Maximum, average, and minimum daily mean flow of Dugout Creek at station 09313985, seasonal record for water years 1980-81 52
18. Maximum, average, and minimum daily mean flow of Grassy Trail Creek at station 09314340, water years 1979-84 56
19. Base flow of Grassy Trail Creek as related to geology 57
20. Maximum, average, and minimum daily mean flow of Horse Canyon creek at station 09314374, water years 1979-81 61
21. Base flow of Horse Canyon creek as related to geology 62
22. Maximum, average, and minimum daily mean flow of Crandall Canyon creek at station 09317919, complete record for water year 1979 and seasonal record for water years 1980-84 67

ILLUSTRATIONS—Contents

Page

Figure 23. Maximum, average, and minimum daily mean flow of Tie Fork at station 09317920, complete record for water year 1979 and seasonal record for water years 1980-81 70
24. Maximum, average, and minimum daily mean flow of Huntington Creek at station 09317997, water years 1980-81 74
25. Base flow of Huntington Creek as related to geology 75
26. Maximum, average, and minimum daily mean flow of Cottonwood Creek at station 09324200, complete record for water year 1979 and seasonal record for water years 1980-81 79
27. Base flow of Cottonwood Creek as related to geology 80
28. Maximum, average, and minimum daily mean flow of Convulsion Canyon creek at station 09331850, seasonal record for water years 1981-84 85
29. Maximum, average, and minimum daily mean flow of Quitchupah Creek at station 09331900, water years 1979-81 89
30. Base flow of Quitchupah Creek as related to geology 90
31. Maximum, average, and minimum daily mean flow of Christiansen Wash at station 09331950, water years 1979-84 94
32. Daily mean flow of Thompson Creek at station 09403670, water year 1981 98

TABLES

Table 1. Gaging stations in the coal-field areas of central and southern Utah 3
2. Annual coal production by coal field, 1978-83 4
3. Summary of gaging-station records for the coal-field areas of central and southern Utah 12

Tables 4-21: Summary of chemical analyses of streamflow in:
4. Eccles Canyon creek at station 09310600, water years 1980-84 15
5. Mud Creek at station 09310700, water years 1979-84 21
6. Willow Creek at station 09312900, water years 1979-81 28
7. Price River at station 09313000, water years 1980-81 32
8. Spring Canyon creek at station 09313040, water years 1979-81 37

TABLES—Continued

	Page
Table 9. Coal Creek at station 09313965, water years 1979-81	43
10. Soldier Creek at station 09313975, water years 1979-84	49
11. Dugout Creek at station 09313985, water years 1980-81	53
12. Grassy Trail Creek at station 09314340, water years 1979-84	58
13. Horse Canyon creek at station 09314374, water years 1979-81	63
14. Crandall Canyon creek at station 09317919, water years 1979-84	68
15. Tie Fork at station 09317920, water years 1979-81	72
16. Huntington Creek at station 09317997, water years 1980-81	76
17. Cottonwood Creek at station 09324200, water years 1979-81	82
18. Convulsion Canyon creek at station 09331850, water years 1981-84	86
19. Quitchupah Creek at station 09331900, water years 1979-81	91
20. Christiansen Wash at station 09331950, water years 1979-84	95
21. Thompson Creek at station 09403670, water year 1981	99

CONVERSION FACTORS

Most values are given in this report in inch-pound units. For those readers who may prefer to use metric units, the conversion factors for the terms used in this report are listed below. Multiply the inch-pound unit by the factor to obtain the metric equivalent.

Inch-pound Unit	Abbreviation	Conversion factor	Metric unit
Acre		0.4047	Square hectometer
Acre-foot	acre-ft	0.001233	Cubic hectometer
Cubic foot per second	ft^3/s	0.02832	Cubic meter per second
Cubic foot per second per mile	$(ft^3/s)/mi$	0.017609	Cubic meter per second per kilometer
Cubic foot per second per square mile	$(ft^3/s)/mi^2$	0.01093	Cubic meter per second per square kilometer
Foot	ft	0.3048	Meter
Gallon per minute	gal/min	0.06309	Liter per second
Inch	in.	25.40	Millimeter
		2.540	Centimeter
Mile	mi	1.609	Kilometer
Square mile	mi^2	2.590	Square kilometer
Ton (short, 2,000 pounds)		0.9072	Megagram (metric ton)

Chemical concentration and water temperatures are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (ug/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is about the same as for concentrations in parts per million.

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$^{o}F = 1.8(^{o}C) + 32.$$

Hydrologic Monitoring of Selected Streams in Coal Fields of Central and Southern Utah--Summary of Data Collected, August 1978-September 1984

by Don Price and Gerald G. Plantz

ABSTRACT

The U.S. Geological Survey conducted a coal-hydrology monitoring program in coal-field areas of central and southern Utah during August 1978-September 1984. The monitoring was implemented to determine possible hydrologic impacts of future mining and to provide a better understanding of the hydrologic systems of the coal-resource areas monitored. Data were collected at 19 gaging stations--18 stations in the Price, San Rafael, and Dirty Devil River basins, and 1 in the Kanab Creek basin. Streamflow data were collected continuously at 11 stations and seasonally at 5 stations. At the other three stations streamflow data were collected continuously during the 1979 water year and then seasonally for the rest of their periods of record.

Types of data collected at each station included quantity and quality of streamflow; suspended-sediment concentrations; and descriptions of stream-bottom sediments, benthic-invertebrate, and phytoplankton samples. Also, base-flow measurements were made annually upstream from 12 of the gaging stations.

Stream-bottom sediment sampled at nearly all the monitoring sites contained small to moderate quantities of coal, which may be attributed chiefly to pre-monitoring mining. Streamflow sampled at several sites contained large concentrations of sulfate and dissolved solids. Also, concentrations of various trace elements at 10 stations, and phenols at 18 stations, exceeded the criteria of the U.S. Environmental Protection Agency for drinking water. This may be attributed to contemporary (water years 1979-84) mine-drainage activities.

The data collected during the complete water years (1979-84) of monitoring do provide a better understanding of the hydrologic systems of the coal-field areas monitored. The data also provide a definite base by which to evaluate hydrologic impacts of continued or increased coal mining in those areas.

INTRODUCTION

Purpose and Scope

The purpose of this report is to summarize selected hydrologic data collected from August 1978 to September 1984 in coal-field areas of central and southern Utah. Virtually all data have been published in the U.S. Geological Survey annual report series "Water resources data for Utah." (See, for example, ReMillard and others, 1985.) They are also available in the files of the U.S. Geological Survey.

Collection of the data was started in August 1978, when the U.S. Geological Survey installed 12 gaging stations downstream from active underground coal mines and areas leased for underground coal mining in the Wasatch Plateau, Book Cliffs, and Emery coal fields of central Utah (pl. 1). The 12 stations were part of a network designed to help define the hydrology of the coal-resource areas and to provide baseline data that could be used to determine the hydrologic impacts of future coal mining. Each station was established to monitor quantity and quality of the streamflow, fluvial sediment, and benthic invertebrates. During August 1978-September 1979, the monitoring also included base-flow measurements at 52 sites, generally upstream from the 12 gaging stations. Water samples for chemical analyses also were collected at 13 of the sites used for base-flow measurements. The data collected from the network during August 1978-September 1979 were published by the U.S. Geological Survey (1980) and are summarized in a report by Lines and Plantz (1981).

During October 1979-September 1984 the monitoring network was modified in several ways. Some gaging stations were discontinued, and others were added to the network. One of the stations added (09403670) was in the Kanab Creek basin, in the Alton coal-field area in southern Utah (pl. 1).

Data collection during October 1979-September 1984 varied somewhat from data collection during the early period of monitoring. For example, in water year 1981 (the year ending September 30, 1981) samples were collected for determinations of phytoplankton instead of benthic invertebrates, and water analyses included determinations of radiochemicals in addition to standard dissolved chemical ions (table 1). The radiochemical data are not summarized in this report, but they are included in U.S. Geological Survey (1982). Base-flow measurements (generally two sets a year) were continued upstream from most gaging stations (mostly through August 1981).

The monitoring program was discontinued September 30, 1984, although several gaging stations remained in operation for special projects. When the monitoring was started in August 1978, 23 coal mines were active in the Wasatch Plateau, Book Cliffs, and Emery coal fields, and they produced about 9.2 million tons of coal that year. There was no mining in the Alton coal field (table 2). During the monitoring period, the annual coal production in the Wasatch Plateau, Book Cliffs, and Emery coal fields increased to as much as 17.6 million tons (in 1982), but there was only some exploratory drilling in the Alton coal field.

Previous Investigations

The U.S. Geological Survey conducted many hydrologic studies in the areas of central and southern Utah coal-fields prior to, and during the monitoring program summarized in this report. Those studies resulted in many reports that deal with various aspects of hydrology. Lines and others (1983) gives a complete listing of those hydrologic reports for the central Utah coal-fields area, and Price and others (1987) gives a complete listing of those hydrologic reports for the southern Utah coal-fields area.

Table 1.—Gaging stations in the coal-field areas of central and southern Utah
(see plate 1 for locations of stations)

Station number: See text for explanation of numbering system.
Water years and data collected: Solid bar represents complete daily record, open bar indicates seasonal record only. Letters under bars indicate types of data collected in addition to rates of streamflow: B, benthic invertebrates; C, general chemical quality; P, phytoplankton; R, radiochemical determinations; and S, fluvial sediment. (See ReMillard and others, 1985, and other reports in the same series.)

Station Number	Station Name	Water years and data collected 1979	1980	1981	1982	1983	1984
	COLORADO RIVER BASIN						
	GREEN RIVER BASIN						
	PRICE RIVER:						
	Mud Creek:						
09310600	Eccles Canyon near Scofield		BCS	CPRS	S	CS	CS
09310700	Mud Creek below Winter Quarters Canyon, at Scofield	BCS	BCS	CPRS		CS	CS
09312900	Willow Creek at Castle Gate		BCS	CPRS			
09313000(1)	Price River near Heiner		BCS	CPRS			
09313040	Spring Canyon below Sowbelly Gulch, at Helper	BCS	BCS	CPRS			
09313965	Coal Creek near Helper	BCS	BCS	CPRS			
09313975	Soldier Creek below mine, near Wellington	BCS	BCS	CPRS	BC	C	C
09313985	Dugout Creek near Sunnyside		BCS	CPRS			
09314340	Grassy Trail Creek at Sunnyside	BCS	BCS	CPRS	BC	C	C
09314374	Horse Canyon near Sunnyside	BCS	BCS	CPRS			
	SAN RAFAEL RIVER:						
	Huntington Creek:						
09317919	Crandall Canyon at mouth, near Huntington	BCS	BCS	CPRS	BC	C	C
09317920	Tie Fork near Huntington	BCS	BCS	CPRS			
09317997	Huntington Creek near Huntington		BCS	CPRS			
09318000(1)	Huntington Creek near Huntington	BCS					
09324200	Cottonwood Creek above Straight Canyon, near Orangeville	BCS	BCS	CPRS			
	DIRTY DEVIL RIVER BASIN						
	MUDDY CREEK:						
	Quitchupah Creek:						
09331850	Convulsion Canyon near Emery			CPRS	BC	C	C
09331900	Quitchupah Creek near Emery	BCS	BCS	CPRS			
09331950	Christiansen Wash near Emery	BCS	BCS	CPRS	BC	C	C
	KANAB CREEK BASIN						
	JOHNSON WASH:						
	Skutumpah Creek:						
094036 70	Thompson Creek near Glendale			CPRS			

(1) Previously operated as part of the statewide network (see text).

Table 2.—Annual coal production by coal field, 1978-83
[Production in thousands of short tons, from unpublished data of Utah Geological and Mineral Survey.]

Coal field	Number of producing mines	1978 Production	Number of producing mines	1979 Production	Number of producing mines	1980 Production	Number of producing mines	1981 Production	Number of producing mines	1982 Production	Number of producing mines	1983 Production
Wasatch Plateau	17	6,499	17	8,640	17	9,875	-	10,190	-	12,873	26	10,248
Book Cliffs	4	2,207	4	2,725	4	2,993	4	3,365	4	3,900	4	1,646
Emery	2	497	2	732	2	761	2	650	2	852	1	88
Alton	0	0	0	0	0	0	0	0	0	0	0	0
Totals (rounded)	23	9,200	23	12,100	-	13,600	-	14,200	-	17,600	31	12,000

Gaging-Station Numbering System

Gaging stations operated by the U.S. Geological Survey are assigned an eight-digit number as shown on plate 1 and table 1. The first two digits, 09, indicate that the stations are on streams in the Colorado River Basin. The next six digits indicate the relative downstream order of the stations in the Basin. Thus, station 09310600 (table 1) is the farthest upstream station in the Colorado River Basin in the area of this report (pl. 1), and station 09403670 (table 1) is the farthest downstream station in the Basin in the area of this report.

PHYSIOGRAPHIC, GEOLOGIC, AND HYDROLOGIC SETTING

Central Utah Coal-Fields Area

Much of the information given below is taken from reports by Lines and Plantz (1981, p. 2-6) and Lines and others (1983). The reader is referred to those reports for additional information about the physiographic, geologic, and hydrologic setting of the central Utah coal-fields area.

The area consists largely of high plateaus dissected by deep, winding canyons. Land-surface altitudes range from about 6,000 to 11,000 feet in the Wasatch Plateau coal-field area, from about 6,000 to 10,000 feet in the Book Cliffs coal-field area, and from about 6,000 to 8,000 feet in the Emery coal-field area. Local relief commonly exceeds 1,000 feet in the Wasatch Plateau and Book Cliffs coal-field areas and is generally less than 800 feet in the Emery coal field.

Rocks that crop out in the central Utah coal-fields area consist chiefly of sandstone, mudstone, and shale as shown diagrammatically in figure 1. The Blackhawk Formation of Cretaceous age is the principal coal-bearing formation in the Wasatch Plateau and Book Cliffs coal fields, and the Ferron Sandstone Member of the Mancos Shale of Cretaceous age is the principal coal-bearing formation in the Emery coal field. Coal in the Blackhawk is mineable only by underground mining; whereas coal in the Ferron Sandstone Member is mineable by both surface and underground mining, but mostly by underground mining.

Average annual precipitation varies from about 10 to 40 inches on the Wasatch Plateau coal-field area, from about 10 to 20 inches on the Book Cliffs coal-field area, and from about 8 to 30 inches on the Emery coal-field area. Most of the annual precipitation falls during October-April, chiefly as snow. Some of the snow accummulates on the high Wasatch and West Tavaputs Plateaus, and the meltwater is a principal source of streamflow during early summer. May-September precipitation generally falls during thunderstorms or cloudbursts which commonly result in considerable local flooding.

Total mean annual runoff from the central Utah coal-fields area ranges from less than 1 inch (less than 55 acre-feet per square mile) in the lower altitudes to about 15 inches (about 800 acre-feet per square mile) in the higher altitudes of the Wasatch Plateau. Most of the runoff is to the Price, San Rafael, and Dirty Devil Rivers. The Price and San Rafael flow into the Green River, a major tributary of the Colorado River; the Dirty Devil flows directly into the Colorado at Lake Powell. (See index map of Utah on Plate 1.)

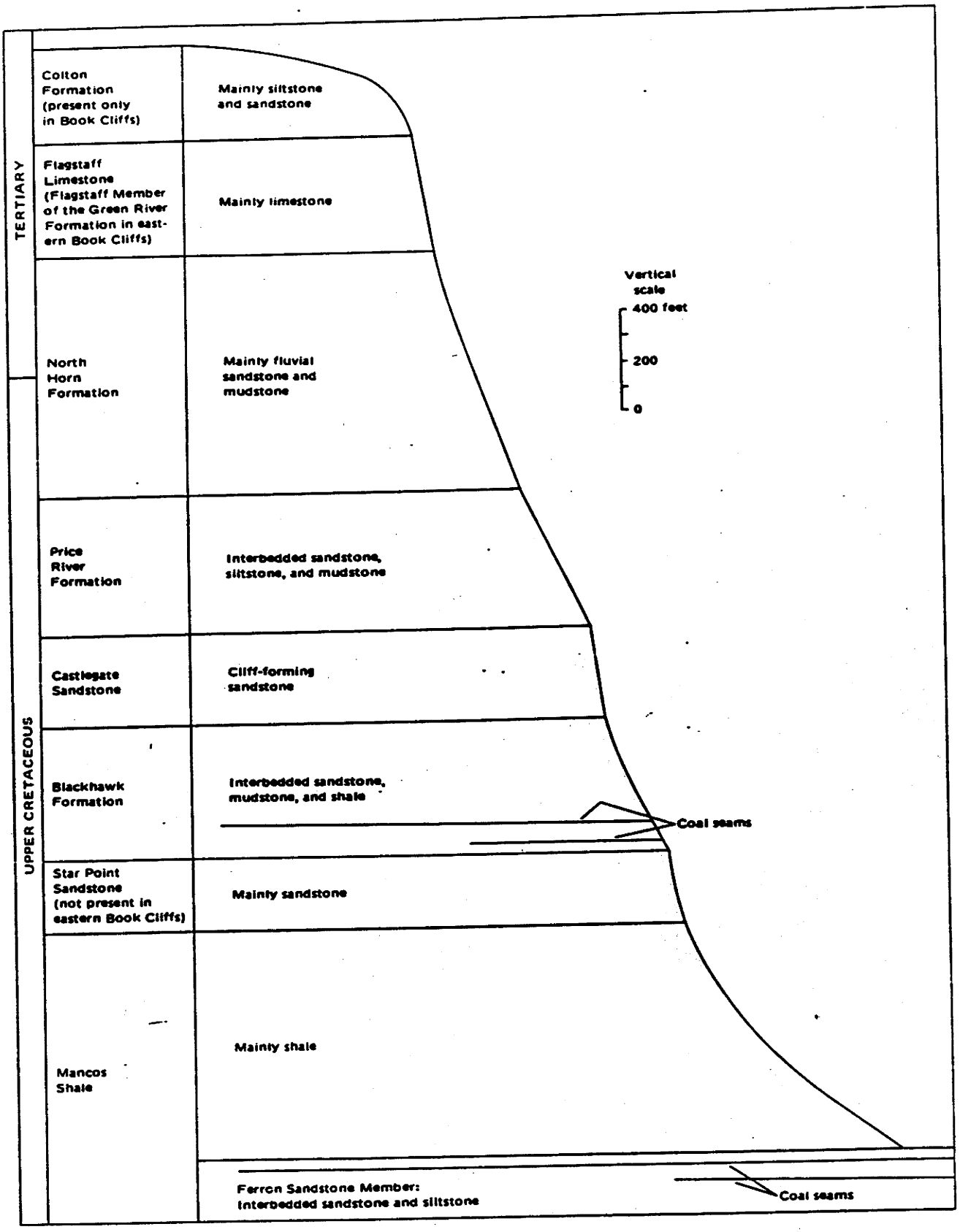


Figure 1.—Diagrammatic section of geologic formations in the coal fields of central Utah (from Lines and Plantz, 1981, fig. 1).

Dissolved-solids concentrations in streamflow in the central Utah coal-fields area generally are less than 300 milligrams per liter in headwaters of the smaller higher-altitude tributary streams during both high- and low-flow periods. The concentrations, however, commonly exceed 3,000 milligrams per liter in the downstream reaches of some streams, especially during periods of low flow. The principal source of the larger dissolved-solids concentrations is the Mancos Shale and surficial deposits derived from the Mancos, which contain considerable gypsum and other comparatively easily dissolved minerals. Those minerals are dissolved and carried to the streams by overland runoff, ground water, and ground water derived from irrigation-return flows.

Water occurs in virtually all the rocks that underly the central Utah coal fields. The Flagstaff Limestone of Tertiary age and North Horn Formation of Cretaceous and Tertiary age discharge water to numerous springs in the higher parts of the Wasatch and West Tavaputs Plateaus. The Blackhawk Formation, Star Point Sandstone of Cretaceous age, and the Ferron Sandstone Member of the Mancos Shale discharge water to mine workings and to several springs. The Ferron Sandstone Member also is tapped by several wells near the town of Emery. Seepage from some of the formations helps to sustain the base flow of the streams.

Dissolved-solids concentrations in the ground water vary considerably depending on altitude and geologic formation. Springs that discharge from the Flagstaff Limestone and North Horn Formation high on the Wasatch Plateau generally contain less than 500 milligrams per liter of dissolved solids. Water that discharges from the Mancos Shale in the lower altitudes generally contains more than 3,000 milligrams per liter of dissolved solids. Mine water from the Blackhawk Formation and Star Point Sandstone generally contains 400 to 1,000 milligrams per liter of dissolved solids, but mine water from the Ferron Sandstone Member contains as much as 5,000 milligrams per liter of dissolved solids.

Alton Coal-Field Area

The following discussion is taken partly from a report by Price and others (1987). Readers are referred to that report for additional information about the physiographic, geologic, and hydrologic setting of the Alton coal-field area and adjacent coal fields of southern Utah.

The Alton coal-field area is made up largely of benches, terraces, and high plateaus which are dissected by deep, narrow canyons. Land-surface altitudes range from about 5,000 feet on the lower benches to more than 9,000 feet on the Paunsaugunt plateau, and local relief commonly exceeds 1,000 feet.

Rocks that range in age from Jurassic to Quaternary are exposed in the area. They are mostly of continental sedimentary origin, consisting chiefly of shale, siltstone, and sandstone, as shown diagrammatically in figure 2. Those formations are mantled in many places by stream-valley alluvium and other unconsolidated deposits of Quaternary age. The principal coal-bearing formation is the Dakota Sandstone of Cretaceous age, but the Tropic Shale of Cretaceous age also contains some coal seams. Both formations contain considerable gypsun and other comparatively easily dissolved minerals.

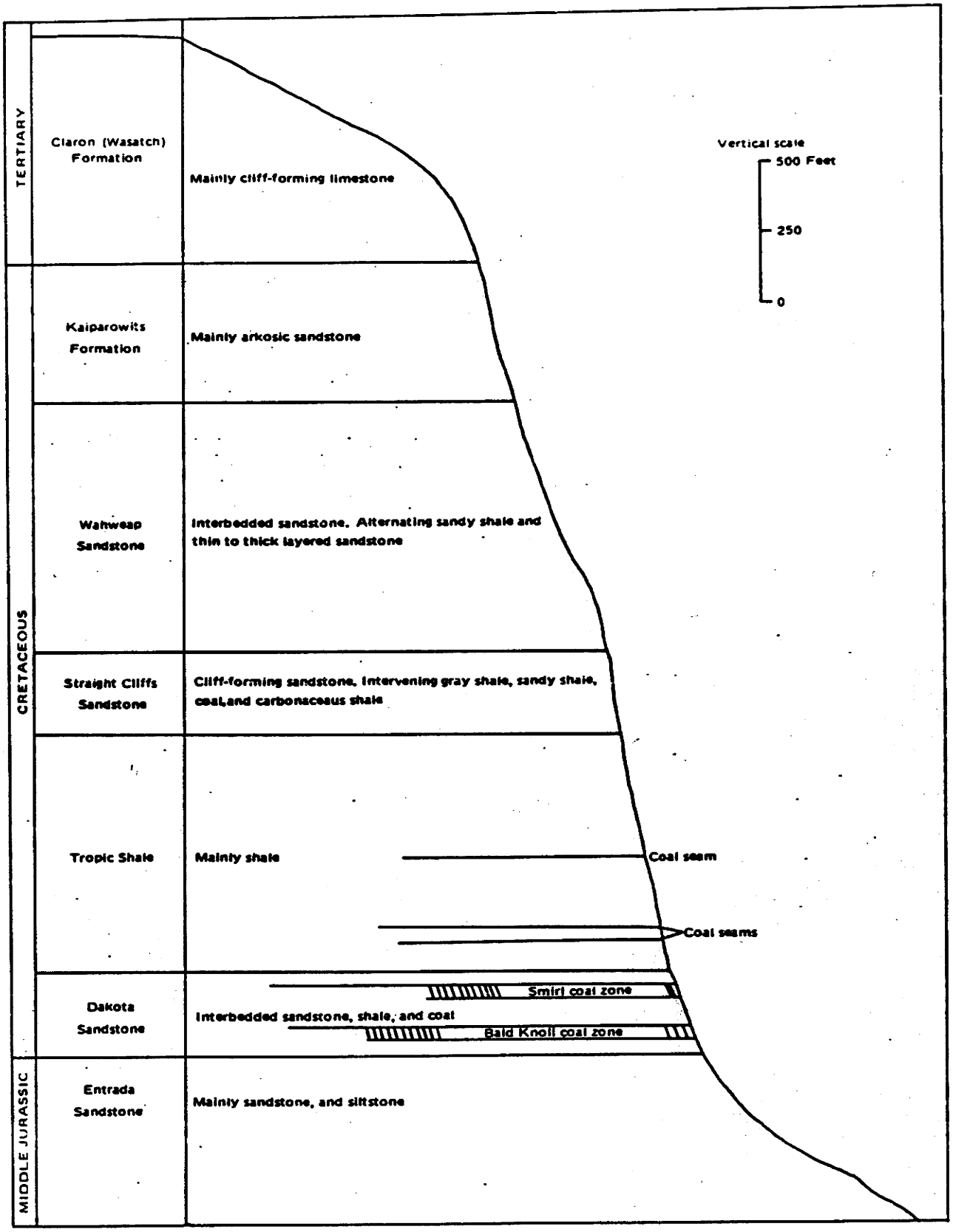


Figure 2.—Diagrammatic section of geologic formations in the Alton coal-field area (adapted from Doelling and Graham, 1972, fig. 6).

Average annual precipitation in the Alton coal-field area ranges from less than 12 inches in the lower altitudes to about 25 inches in the higher altitudes. Most of the precipitation falls during October-April, generally occurs as snow which accummulates in the higher altitudes. Those high-altitude snowpacks are the principal source of streamflow in the area. May-September precipitation commonly falls during thunderstorms or cloudbursts which can result in local flash floods.

Average annual runoff from the area ranges from less than 0.5 inch (less than 30 acre-feet per square mile) in the lower altitudes to about 5 inches (about 267 acre-feet per square mile) in the higher altitudes. The high-altitude runoff is produced chiefly by snowmelt, whereas the low-altitude runoff is produced chiefly by local thunderstorms. Most of the runoff from the area is to Kanab Creek, which discharges directly into the Colorado River about 50 miles south of the Arizona-Utah State line. Some runoff from the area is to the Virgin and Paria Rivers (in the Colorado River Basin) and to the Sevier River (in the Great Basin).

Dissolved-solids concentrations in the streamflow in headwater areas are generally less than 500 milligrams per liter during periods of both high and low flow. The concentrations generally exceed 1,000 milligrams per liter in some lower stream reaches, chiefly during periods of low flow. The principal source of the larger dissolved-solids concentrations is the Tropic Shale. Minerals are dissolved from the Tropic Shale and carried to the streams by overland runoff and by ground water that seeps through the shale.

Water occurs in virtually all formations that underly the Alton coal-field area. Most of the exposed formations discharge water to springs in the area, but they probably would not yield more than about 50 gallons per minute to individual wells. The Navajo Sandstone of Triassic(?) and Jurassic age, which is not exposed in the area, is a highly-productive regional aquifer in southern Utah. It discharges water to many springs along Kanab Creek south of the Alton coal field, and it is tapped by a number of irrigation wells that yield as much as 1,000 gallons per minute several miles south of the Alton coal field. Within the coal field, however, the Navajo lies beneath several hundred to more than 1,000 feet of younger formations.

Dissolved-solids concentrations in ground water in the Alton coal-field area vary considerably depending mainly on altitude and the geologic formation. Springs that discharge from the Wasatch Formation in the high plateaus generally contain less than 500 milligrams per liter of dissolved solids. Water in the Tropic Shale commonly contains more than 3,000 milligrams per liter of dissolved solids. Water in the other exposed formations generally contains 500 to 2,000 milligrams per liter of dissolved solids, the smaller concentrations occurring in the higher altitudes.

PRICE RIVER BASIN

Mud Creek and Eccles Canyon Creek

Mud (Pleasant Valley) Creek originates on the Wasatch Plateau at an altitude of about 9,600 feet in an area directly underlain by the Flagstaff Limestone. The stream descends about 1,600 feet to where it enters Pleasant Valley near the community of Clear Creek. From that point it meanders northward through Pleasant Valley and enters Scofield Reservoir (source of the Price River) at about 7,600 feet. Station 09310700 (pl. 1 and table 1) is about 1 mile upstream from Scofield Reservoir at 7,720 feet. Eccles Canyon creek is one of several streams that enter Mud Creek from the west between the community of Clear Creek and Scofield Reservoir. Station 09310600 (pl. 1 and table 1) was established near the mouth of Eccles Canyon at 7,980 feet.

Coal mining was started in the Mud Creek basin during the late 1800's and has continued intermittently to the present (1985). During the monitoring period at station 09310600 and 09310700, several mines were active in the Mud Creek basin. As noted by Lines and Plantz (1981, p. 6), all the mines produce water, but most of the water produced is used and consumed in the mining operations. It is not known how much water is discharged from mines to Mud Creek or its tributaries; however, such discharge generally seems to be of good chemical quality. For example, the dissolved-solids concentration of water discharged from the Utah No. 2 Mine (pl. 1) in September 1975 was 482 milligrams per liter. (See Lines and Plantz, 1981, p. 6.)

Eccles Canyon creek enters Mud Creek about 3 miles upstream from station 09310700 (pl. 1). The annual mean flow in Eccles Canyon creek, where it is gaged at station 09310600, ranged from 1.64 cubic feet per second in water year 1981 to 6.78 cubic feet per second in water year 1984 (table 3). Most of the annual flow in Eccles Canyon creek is from late April to early July, as shown in figure 3. The maximum recorded peak flow at station 09310600 was 71.0 cubic feet per second on May 23, 1984 (table 3).

The chemical quality of streamflow in Eccles Canyon is generally good, that is, the water is chemically suitable for most common uses. Dissolved-solids concentrations in 46 samples collected at station 09310600 during the 1980-84 water years ranged from 160 to 490 milligrams per liter with a mean of 293 milligrams per liter (table 4). Calcium, magnesium, and bicarbonate were the dominant ions found in the samples. With the exception of manganese, concentrations of trace elements that were analyzed were smaller than the criteria of the U.S. Environmental Protection Agency (1976) for drinking water supplies[1]. The mean concentration of manganese for 28 samples was 67 micrograms per liter, compared to a criterion of 50 micrograms per liter. The phenol concentrations in some samples exceeded the criterion of 1 microgram per liter (U.S. Environmental Protection Agency, 1976, p. 183).

---

[1]The criteria of the U.S. Environmental Protection Agency (1976) are in total ions, whereas the values listed in tables 4-21 in this report are in dissolved ions.

page 12 follows

Table 3.--Summary of gaging-station records for the coal-field areas of central and southern Utah. (See ReMillard

Number	Station	Period of record used (water years)	Drainage Basin: Area (square miles)	Drainage Basin: Altitude at gage (feet)	Annual mean flow (cubic feet per second) Water years 1979	1980	1981	1982	1983	1984
09310500	Eccles Canyon near Scofield	1980-84	5.5	7,980	--	4.02	1.64	4.61	6.47	6.78
09310700	Mud Creek below Winter Quarters Canyon, at Scofield	1979-84	29.1	7,720	8.51	18.6	5.52	19.0	26.8	30.7
09312900	Willow Creek at Castle Gate	1980-81	77.4	6,100	--	17.3	4.58	--	--	--
09313000(1)	Price River near Heiner	1935-69, 1980-81	415	6,000	--	195	73.8	--	--	--
09313040	Spring Canyon below Scubelly Gulch, at Helper	1979-81	23.0	6,110	.12	.35	.41	--	--	--
09313965	Coal Creek near Helper	(2)1979-81	25.3	6,370	--	--	--	--	--	--
09313975	Soldier Creek below mine, near Wellington	(2)1979-84	17.7	6,650	--	--	--	--	--	--
09313985	Dugout Creek near Sunnyside	(2)1980-81	5.8	6,950	--	--	--	--	--	--
09314340	Grassy Trail Creek at Sunnyside	1979-84	40.1	6,540	7.02	11.3	2.43	7.25	24.2	7.16
09314374	Horse Canyon near Sunnyside	1979-81	12.5	6,180	.40	.43	.29	--	--	--
09317919	Crandall Canyon at mouth, near Huntington	(4)1979-84	5.7	7,350	2.19	--	--	--	--	--
09317920	Tie Fork near Huntington	(4)1979-81	11.7	7,400	2.04	--	--	--	--	--
09317997	Huntington Creek near Huntington	1980-81	181	6,850	--	112	63.0	--	--	--
09318000(1)	Huntington Creek near Huntington	1910-17, 1922-29, 1931-73, 1978-79	190	6,210	77.4	--	--	--	--	--
09324200	Cottonwood Creek above Straight Canyon, near Orangeville	(4)1979-81	21.9	6,940	.87	--	--	--	--	--
09331850	Convulsion Canyon near Emery	(2)1981-84	21.5	7,120	--	--	--	--	--	--
09331900	Quitchupah Creek near Emery	1979-81	104	5,900	6.73	10.8	7.76	--	--	--
09331950	Christiansen Wash near Emery	1979-84	13.6	5,920	2.66	3.32	2.09	3.54	5.80	6.42
09403670	Thompson Creek near Glendale	(2)1981	19.2	6,050	--	--	--	--	--	--

(1)Previously operated as part of the statewide network (see text).

(2)Seasonal record. (See table 1.)

(3)No flow for parts of few to many days most years.

(4)Continuous record for 1979 water year, seasonal record for remainder of period. (See table 1.)

and others, 1985, and earlier reports in the same series for complete records.)

Average Annual Flow (Cubic feet per second)	Average Annual Flow (Cubic feet per second per square mile)	Years of complete record	Extreme flow recorded for period of record used (cubic feet per second) Maximum	Date	Minimum	Date
4.70	0.85	5	71.0	5-23-84	0.62	1-10-80
18.2	.62	6	389	5-21-84	1.4	9- 8-79
—	—	2	210	5-23-80	.60	1-13,26-80
112	.30	37	9,340 1,100	9-13-40 5-31-80	.40 3.6	8-21-61 11-11,14-80
.29	.01	3	271	7-12-81	.02	7- 2-79
—	—	—	458	8-13-79	0	(3)
—	—	—	472	9-23-81	.08	8- 5-81
—	—	—	127	9- 5-81	0	(3)
9.89	.25	6	631	5-31-83	0	(3)
—	—	3	93.0	9- 5-81	0	(3)
—	—	1	97.0	5-24-84	.24	3-10-79
—	—	1	29.0	4-30-80	.17	3-10-79
—	—	2	1,020	6-11-80	3.0	2-2,5-81
95.3	.51	61	2,500 684	8- 2-30 8-13-79	.87 .87	11-26-76 11-28-78
—	—	1	22.0	6- 5-80	0	(3)
—	—	—	34.0	7-30-84	.01	9-22,25-82
—	—	3	2,590	9- 8-81	.66	8-10-81
3.97	.30	6	1,540	9- 8-81	.29	7-21,23-81
—	—	—	1,030	8-14-81	.23	7-31,8-9-81

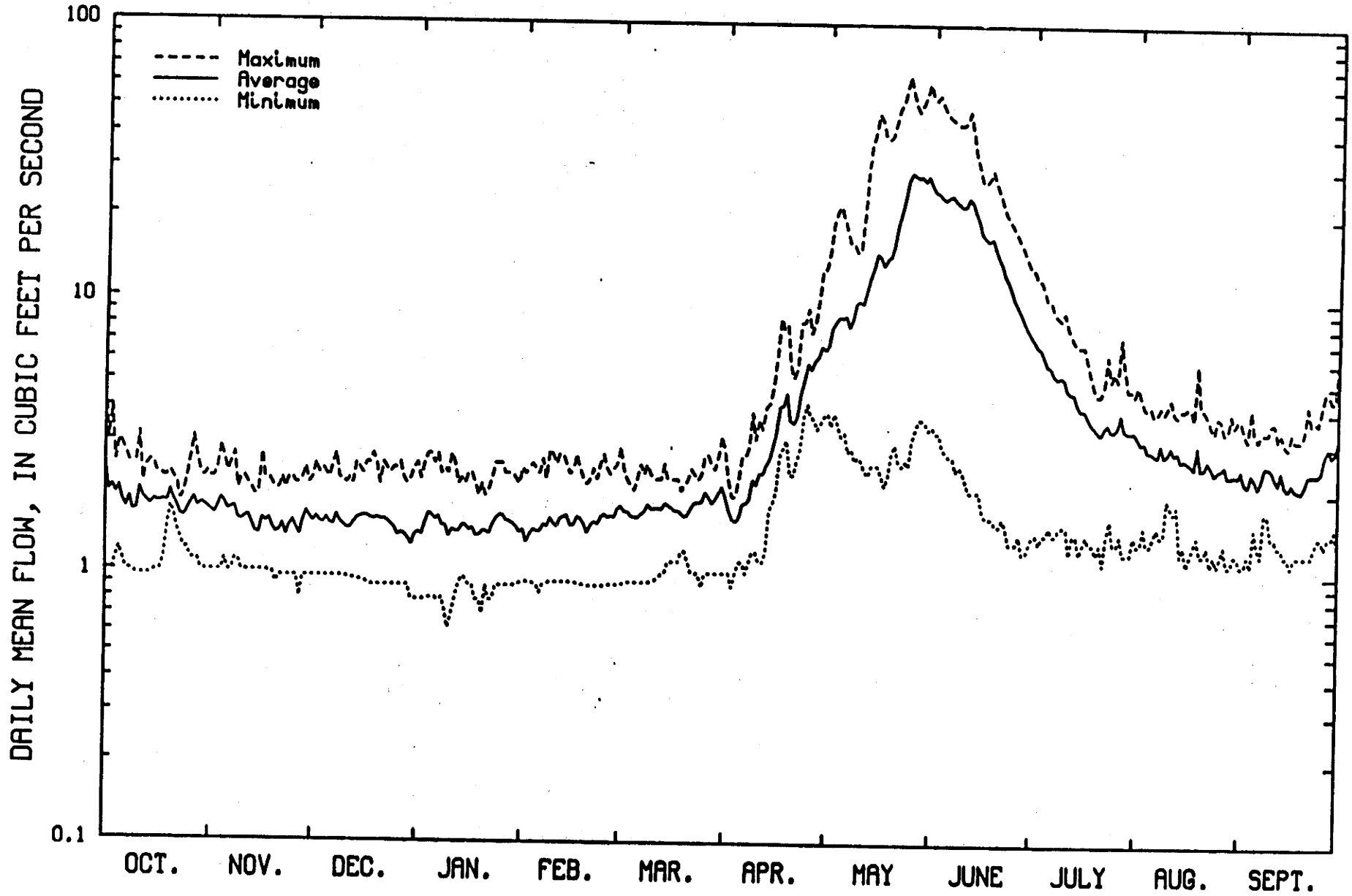


Figure 3.--Maximum, average, and minimum daily mean flow of Eccles Canyon creek at station 09310600, water years 1980-84.

Table 4.—Summary of chemical analyses of streamflow in Eccles Canyon creek at station 09310600, water years 1980-84

[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	47	6.0	0.82-53
Water temperature (degrees Celsius)	46	7.0	.0-14.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	47	511	285-880
pH (units)	42	--	7.6-8.6
Sodium-adsorption ratio	33	.13	.1-.3
Milligrams per liter			
Dissolved solids, sum of constituents	46	293	160-490
Oxygen, dissolved (O_2)	37	9.0	7.6-10.3
Carbon dioxide, dissolved (CO_2)	25	2.7	.9-5.3
Alkalinity ($CaCO_3$)	31	237	130-300
Bicarbonate (HCO_3)[1]	25	296	200-360
Carbonate (CO_3)[1]	25	1.6	.0-8.0
Nitrogen, dissolved (N)	19	.90	.16-3.4
Nitrogen, organic dissolved (N)	8	.74	.00-2.2
Nitrogen, ammonia dissolved (N)	23	—	<.01-.100
Nitrogen, nitrite dissolved (N)	8	—	<.014
Nitrogen, nitrate dissolved (N)	8	—	<.05-1.2
Nitrogen, nitrite + nitrate dissolved (N)	30	—	<.01-1.2
Phosphorus, dissolved (P)	26	—	<.01
Phosphorus, ortho phosphates dissolved (P)	17	—	<.001-.100
Carbon, organic dissolved (C)	14	5.9	1.2-39
Hardness, (as $CaCO_3$)	33	272	150-440
Hardness, (as noncarbonate, $CaCO_3$)	31	39.9	.0-170
Calcium, dissolved (Ca)	43	69.3	43-85
Magnesium, dissolved (Mg)	43	23.4	9.4-58
Sodium, dissolved (Na)	43	5.1	2.5-12
Potassium, dissolved (K)	38	2.1	1.1-3.1
Chloride, dissolved (Cl)	43	10.0	2.0-110
Sulfate, dissolved (SO_4)	46	42.0	13.0-9.4
Fluoride, dissolved (F)	29	.19	.10-.60
Silica, dissolved (SiO_2)	38	6.7	5.1-10

Table 4.—Summary of chemical analyses of streamflow in Eccles Canyon creek at station 09310600, water years 1980-84—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	18	—	<1-1
Barium, dissolved (Ba)	5	—	<100-100
Boron, dissolved (B)	29	—	<10-3,600
Cadmium, dissolved (Cd)	16	—	<1-2
Chromium, dissolved (Cr)	20	—	<20
Copper, dissolved (Cu)	15	—	<10
Iron, dissolved (Fe)	39	—	<10-200
Lead, dissolved (Pb)	19	—	<1-2
Lithium, dissolved (Li)	9	—	<10-30
Manganese, dissolved (Mn)	28	67	16-110
Mercury, dissolved (Hg)	13	—	<.1
Nickel, dissolved (Ni)	7	—	<1-3
Selenium, dissolved (Se)	17	—	<1-2
Strontium, dissolved (Sr)	9	—	<10-230
Zinc, dissolved (Zn)	20	—	<3-180
Phenols	11	—	<1-8

[1]Fixed-end-point determined by titration in the field.

Suspended-sediment concentrations in 90 streamflow samples collected at station 09310600 ranged from 10 milligrams per liter January 13, 1981 to 45,100 milligrams per liter on May 30, 1983. Instantaneous suspended-sediment loads determined from the suspended-sediment samples concentrations and flow data are as follows:

Water year	Suspended-sediment load (tons/day)	
	Minimum	Maximum
1980	0.16	228
1981	.03	6.9
1982	.12	206
1983	(1) .21	(1) 419
1984	(1) .11	(1) 551

(1) Determined from additional samples collected for another project.

Benthic invertebrates and phytoplankton may be indicators of the general quality of streamflow and stream-bottom habitats. Good diversity (uniform distribution of organisms) in benthic-invertebrate samples generally reflects unpolluted stream-bottom conditions. Also, good diversity of phytoplankton and a predominance of green algae may reflect generally good chemical quality of the water. A predominance of blue-green algae may be indicative of relatively large dissolved-solids concentrations (including nutrients) in the water. Two benthic invertebrate samples collected at station 09310600 in the 1980 water year had fairly good diversity--that is, a fairly uniform distrubution of individual organisms. (See U.S. Geological Survey, 1981, p. 231.) Four phytoplankton samples collected at the same site during water year 1981 had a good representation of green algae with good diversity (U.S. Geological Survey, 1982, p. 228). Blue-green algae, however, were well represented in the samples collected during August when the streamflow was relatively warm and its dissolved-solids concentration was relatively large.

Station 09310700 on Mud Creek was operated continuously during the 1979-84 water years (table 1). Annual mean flow during that period ranged from 5.52 cubic feet per second in water year 1981 to 30.7 cubic feet per second in water year 1984 and averaged 18.2 cubic feet per second (table 3). Most of the annual flow occurs from early May to mid July, as shown in figure 4, and this flow is chiefly due to snowmelt. The maximum peak discharge recorded at station 09310700 was 389 cubic feet per second on May 21, 1984 (table 3).

Results of base-flow measurements made along Mud Creek during August 1978-September 1984 are illustrated in figure 5. The measurements show substantial inflows from creeks in Boardinghouse, Eccles, and Winter Quarters Canyons.

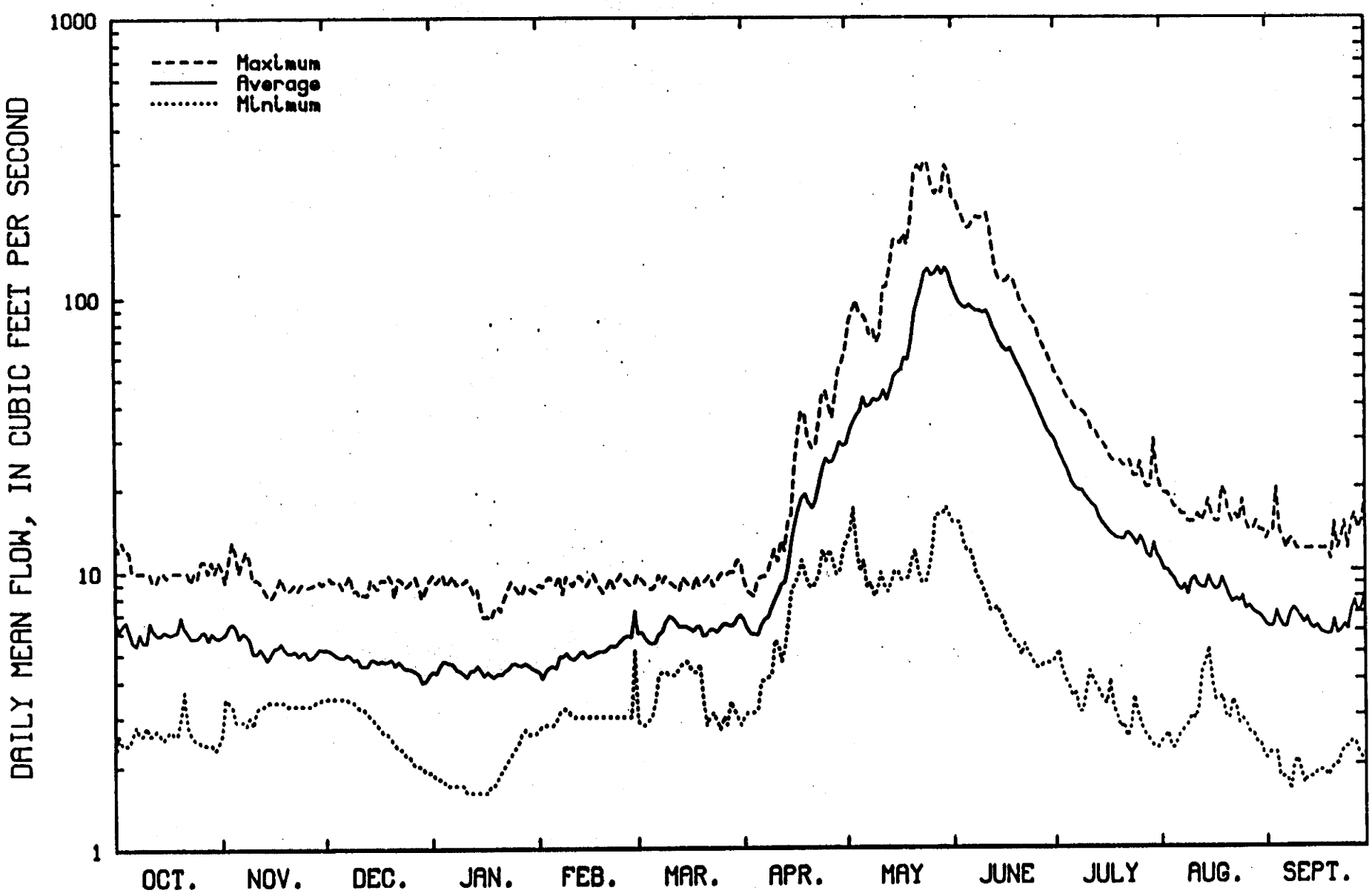


Figure 4.—Maximum, average, and minimum daily mean flow of Mud Creek at station 09310700, water years 1979-84.

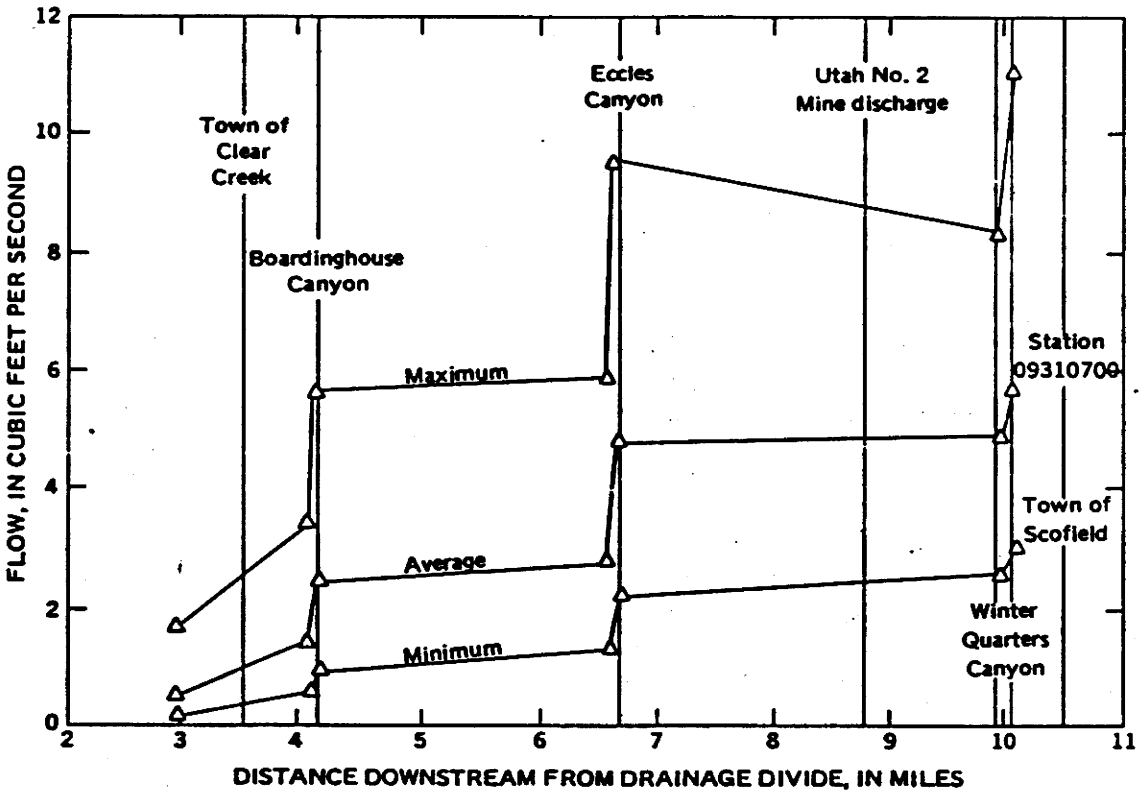


Figure 5.—Base flow of Mud Creek (based on 10 measurements made at each site from August 1978 to September 1984).

Dissolved-solids concentrations in 51 streamflow samples collected at station 09310700 during August 1978-September 1984 ranged from 170 to 390 milligrams per liter; and the mean was 315 milligrams per liter (table 5). Dominant ions found in the samples were calcium, magnesium, and bicarbonate. Of the trace elements that were analyzed, cadmium and manganese were found in concentrations that exceed the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum concentration of cadmium and manganese were 53 and 70 micrograms per liter, and these exceeded the criteria of 10 and 50 micrograms per liter for those elements. The phenol concentration in some samples exceeded the criterion of 1 microgram per liter (U.S. Environmental Protection Agency, 1976, p. 182).

Suspended-sediment concentrations in 137 streamflow samples collected at station 09310700 ranged from 14 milligrams per liter on January 13, 1981, to 1,690 milligrams per liter on May 1, 1980. The largest suspended-sediment loads are during May and June when suspended-sediment concentrations are large, and the snowmelt runoff produces the greatest sustained streamflow. Larger concentrations and loads, however, could occur in runoff from rare, intense thunderstorms. Instantaneous suspended-sediment loads determined from the suspended-sediment samples collected at station 09310700 are as follows:

Water year	Suspended-sediment load (tons/day)	
	Minimum	Maximum
1979	0.37	147
1980	.85	554
1981	.13	11
1983	(1) 1.4	(1) 12,700
1984	(1) .70	(1) 1,420

(1) Determined from additional samples collected for another project.

Benthic invertebrates were sampled at station 09310700 four times during the 1979-80 water years, and phytoplankton were sampled at the same site during the 1981 water year. The benthic invertebrates had good diversity as noted by Lines and Plantz (1981, p. 11) indicating an apparently unpolluted stream-bottom environment. The phytoplankton (five samples) had fairly uniform distribution of green algae (U.S. Geological Survey, 1982, p. 235). Some blue-green algae was found in all five phytoplankton samples.

Beaver Creek

Beaver Creek originates on the Wasatch Plateau at an altitude of about 9,200 feet, and it descends about 2,100 feet to its confluence with the Price River at about 7,100 feet. The creek originates on the coal-bearing Blackhawk Formation and flows over progressively younger geologic formations to its mouth, where it is on the Flagstaff Limestone. The Gordon Creek No. 2 Mine (pl. 1) extends into the upper Beaver Creek basin. That mine was in operation during the complete monitoring period.

Table 5.—Summary of chemical analyses of streamflow in Mud Creek at station 09310700, water years 1979-84

[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	59	19.6	1.6-245
Water temperature (degrees Celsius)	58	8.1	.0-23.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	59	515	255-650
pH (units)	52	—	7.6-8.6
Sodium-adsorption ratio	54	.17	.0-.4
Milligrams per liter			
Dissolved solids, sum of constituents	51	315	170-390
Oxygen, dissolved (O_2)	49	9.2	7.0-11.1
Carbon dioxide, dissolved (CO_2)	39	2.6	1.1-6.7
Alkalinity ($CaCO_3$)	47	198	139-350
Bicarbonate (HCO_3)[1]	37	279	170-360
Carbonate (CO_3)[1]	38	1.6	.0-16
Nitrogen, dissolved (N)	20	.82	.29-2.2
Nitrogen, organic dissolved (N)	15	.75	.05-1.2
Nitrogen, ammonia dissolved (N)	22	—	<.01-.140
Nitrogen, nitrite dissolved (N)	15	—	<.014
Nitrogen, nitrate dissolved (N)	15	—	<.05-.66
Nitrogen, nitrite + nitrate dissolved (N)	33	—	<.01-1.5
Phosphorus, dissolved (P)	25	—	<.01
Phosphorus, ortho phosphates dissolved (P)	23	—	<.001
Carbon, organic dissolved (C)	16	6.8	1.9-38
Hardness, (as $CaCO_3$)	53	275	130-360
Hardness, (as noncarbonate, $CaCO_3$)	42	44.0	.0-77
Calcium, dissolved (Ca)	54	69.0	41-89
Magnesium, dissolved (Mg)	54	22.8	7.0-30
Sodium, dissolved (Na)	54	6.4	2.6-15
Potassium, dissolved (K)	49	2.5	1.2-7.5
Chloride, dissolved (Cl)	54	9.4	2.4-24
Sulfate, dissolved (SO_4)	57	45.7	18.0-82
Fluoride, dissolved (F)	31	.20	.10-.60
Silica, dissolved (SiO_2)	49	5.0	4.9-8.0

Table 5.—Summary of chemical analyses of streamflow in Mud Creek at station 09310700, water years 1979-84—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	22	—	<1-2
Barium, dissolved (Ba)	5	—	<100-100
Boron, dissolved (B)	32	—	<10-180
Cadmium, dissolved (Cd)	13	—	<1-53
Chromium, dissolved (Cr)	18	—	<20
Copper, dissolved (Cu)	13	—	<10
Iron, dissolved (Fe)	39	—	<10-210
Lead, dissolved (Pb)	18	—	<1-30
Lithium, dissolved (Li)	13	—	<10-20
Manganese, dissolved (Mn)	21	59	10-70
Mercury, dissolved (Hg)	10	—	<.1
Nickel, dissolved (Ni)	6	—	<1-2
Selenium, dissolved (Se)	21	—	<1-1
Strontium, dissolved (Sr)	13	201	110-260
Zinc, dissolved (Zn)	22	—	<3-35
Phenols	16	—	<1-7

[1]Fixed-end-point determined by titration in the field.

The monitoring program summarized in this report for Beaver Creek was limited to only a series of base-flow measurements. The U.S. Geological Survey, however, has operated station 09312700 on the creek (pl. 1) since water year 1961 as part of a Statewide network. (See ReMillard and others, 1985, and previous reports in that series.) Average flow for water years 1961-84 was 4.58 cubic feet per second, and the mean monthly flow ranged from about 0.68 cubic feet per second in January to about 24.5 cubic feet per second in May. The maximum peak flow was 204 cubic feet per second May 27, 1973, and there was no flow on a number of days.

Maximum, minimum, and average base flows in Beaver Creek as measured during August 1978-August 1981 (generally two sets of measurements per year) are related to geology in figure 6. The average base flow increased about 0.3 cubic feet per second per mile where the stream crosses the Blackhawk Formation and Castlegate Sandstone, and decreased about 0.1 cubic feet per second per mile where the stream crosses the Price River Formation and younger rocks.

During 1969-70, some water-quality data were collected at station 09312700. Those data are summarized by Mundorff (1972, table 4). The data show that dissolved-solids concentrations in the streamflow ranged from 203 to 271 milligrams per liter, and that calcium and bicarbonate were the dominant dissolved ions.

Willow Creek

Willow Creek originates on the Green River Formation of Tertiary age at an altitude of about 9,200 feet on the West Tavaputs Plateau. The stream descends more than 3,000 feet through progressively older geologic formations to its confluence with the Price River at about 6,000 feet. At the confluence, both streams are on the coal-bearing Blackhawk Formation. Coal in the Blackhawk was being mined at the Braztah Mines (pl. 1) in the lower Willow Creek drainage during the monitoring period on Willow Creek.

Station 09312900 (pl. 1, table 1) was operated on lower Willow Creek during water years 1980-81. Data collected at that station supplement the long-term record at upstream station 09312800 (pl. 1) which is part of the U.S. Geological Survey's statewide network (ReMillard and others, 1985).

The annual mean flow of Willow Creek at station 09312900 was 17.3 cubic feet per second in water year 1980 and 4.58 cubic feet per second in water year 1981 (table 3). The maximum, minimum, and average daily mean flow recorded at the station during the 2 water years are shown in figure 7, which shows most of the annual flow in Willow Creek is from April to July. The source of the flow is chiefly snowmelt from the West Tavaputs Plateau. The short-term increases in flow during August and September reflect runoff from thunderstorms. The maximum peak flow recorded at the station was 210 cubic feet per second on May 23, 1980 (table 3).

During August 1978-August 1981, seven sets of base-flow measurements were made along Willow Creek downstream from station 09312800. Those measurements are related to geology in figure 8. They show a slight gain in flow where the stream crosses the North Horn Formation but virtually no change in flow where it crosses older rocks, including the coal-bearing Blackhawk Formation.

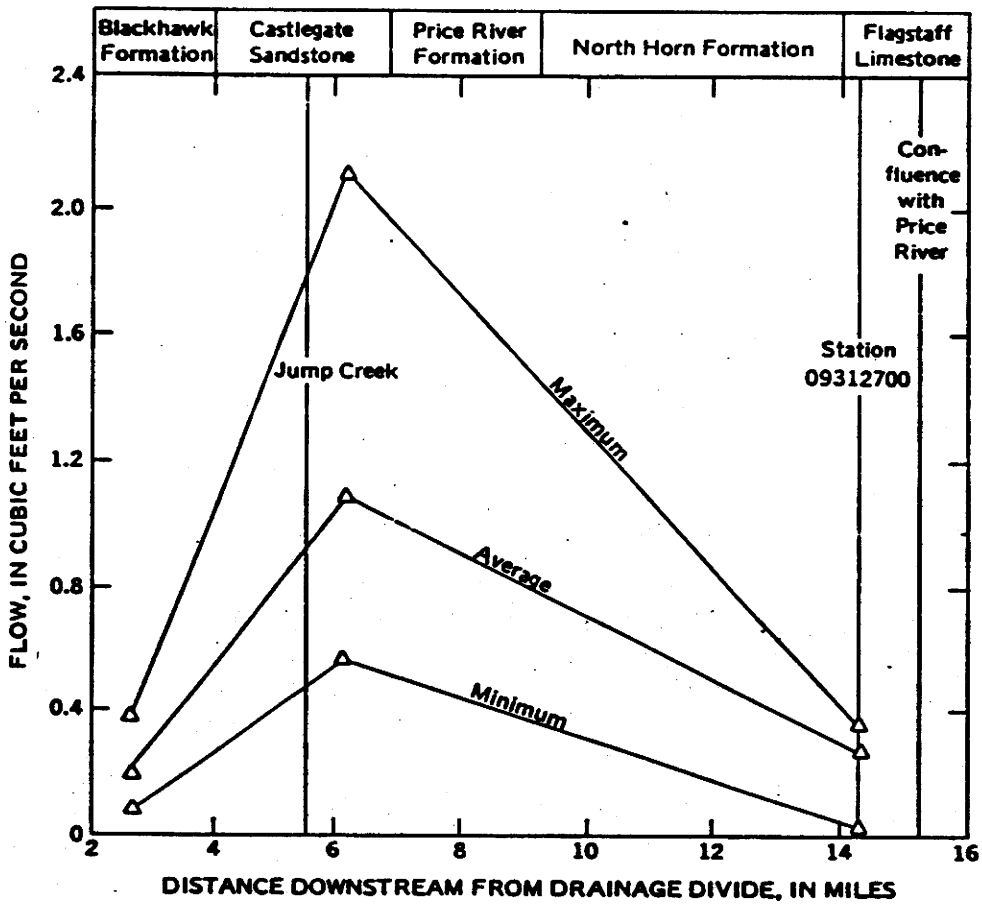


Figure 6.—Base flow of Beaver Creek as related to geology (based on 7 measurements made at each site from August 1978 to August 1981).

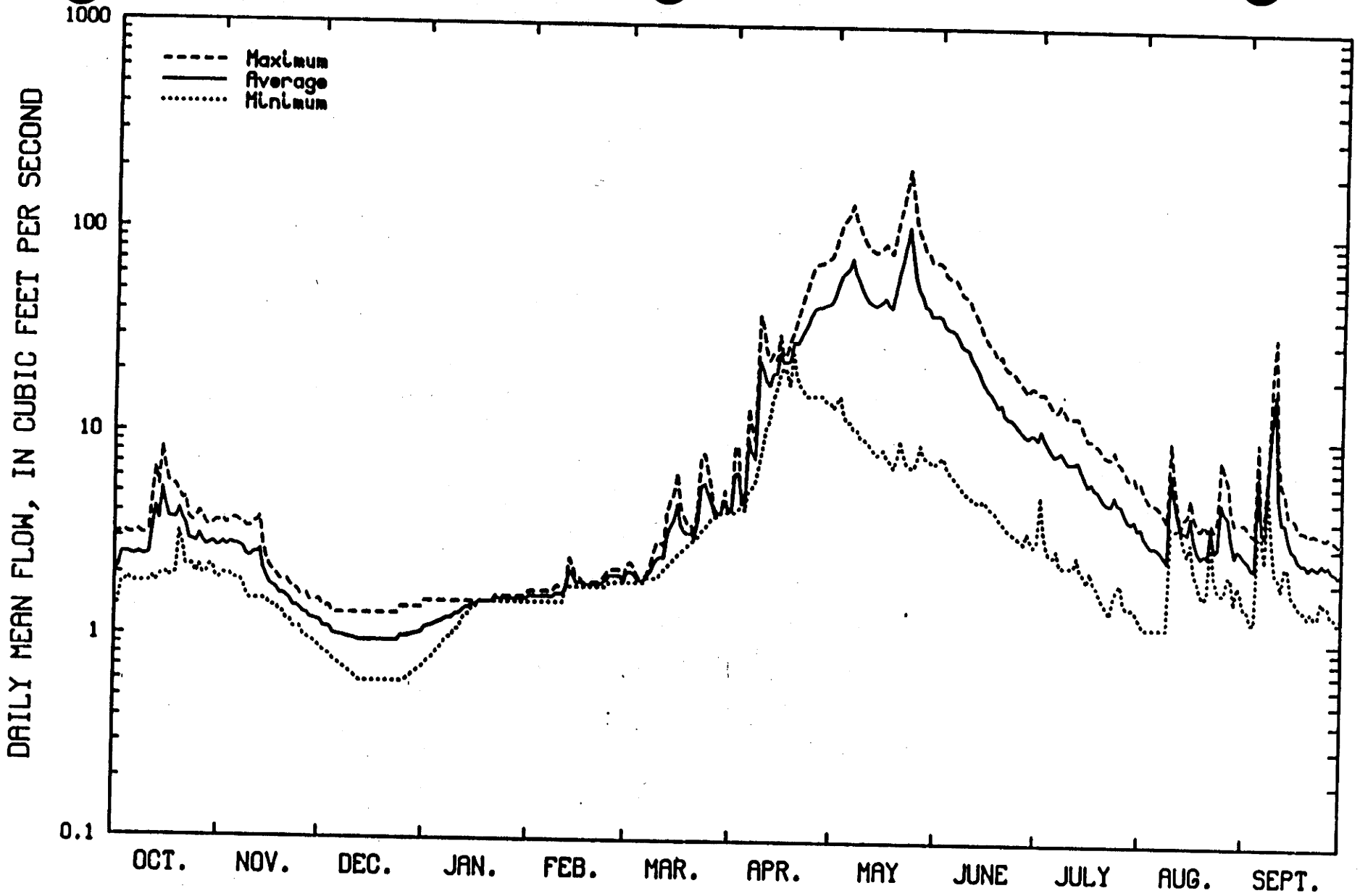


Figure 7.—Maximum, average, and minimum daily mean flow of Willow Creek at station 09312900, water years 1980-81.

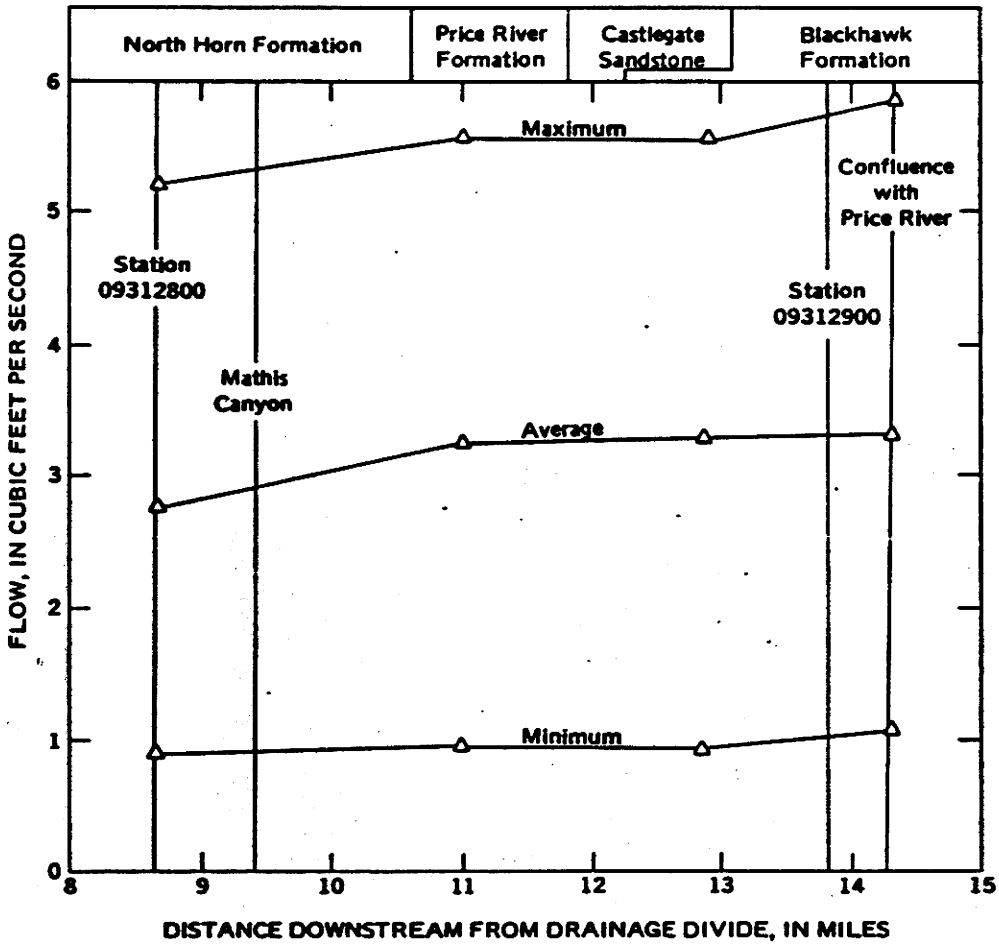


Figure 8.—Base flow of Willow Creek as related to geology (based on 7 measurements made at each site from August 1978 to August 1981).

Chemical analyses of 24 streamflow samples collected at station 09312900 during the 1980 and 1981 water years are summarized in table 6. Dissolved-solids concentrations in the samples ranged from 350 to 810 milligrams per liter, with a mean of 591 milligrams per liter. Magnesium and bicarbonate were respectively the dominant cation and anion in most of the samples regardless of the total dissolved-solids concentrations. Although strontium was found in concentrations as large as 1,100 micrograms per liter, no other trace element that was analyzed was found in concentrations that exceed the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. Analysis of eight samples for phenol concentration showed that all equaled or exceeded the U.S. Environmental Protection Agency (1976, p. 183) criterioin of 1 microgram per liter.

Sediment data also were collected at station 09312900 during the 1980 and 1981 water years. Suspended-sediment concentrations in 20 samples ranged from 2 milligrams per liter on December 6, 1980, to 4,820 milligrams per liter on April 15, 1981. The calculated instantaneous suspended-sediment loads ranged from 0.02 to 902 tons per day in water year 1980 and from 0.01 to 547 tons per day in water year 1981. Analyses of stream-bottom sediments at station 09312900 indicate that those sediments consist of as much as 2.3 percent coal. The most likely source of the coal is upstream coal storage or mine spoils on the land surface.

Two benthic invertebrate samples were collected during water year 1980 and five phytoplankton samples were collected during water year 1981 at station 09312900. The benthic invertebrates had fairly good diversity (U.S. Geological Survey, 1981, p. 248), indicating an apparently unpolluted stream-bottom environment. The phytoplankton showed considerable variation in the samples (U.S. Geological Survey, 1982, p. 246).

Price River

Flow of the Price River upstream from station 09313000 (pl. 1, table 1) is regulated at Scofield Reservoir. Between station 09313000 and Scofield Reservoir, the Price River receives significant inflows from the White River and Beaver and Willow Creeks. The Braztah Mining Co. was mining coal in the general area of station 09313000 during water years 1980-81 when the station was being monitored.

Prior to the monitoring program, station 09313000 was operated for many years as part of the U.S. Geological Survey's statewide network. The annual average flow at the station during 37 years of record, including the monitoring period, was 112 cubic feet per second (table 3). The maximum, minimum, and average daily mean flow at the station during those 37 years, which is shown in figure 9, indicates a relatively uniform year-round flow that reflects regulation at Scofield Reservoir. The short-term peaks of the maximum daily mean in August and September probably are due to thunderstorms over the drainage basins of one or more of the three main tributaries to the Price River. The maximum peak flow was 9,340 cubic feet per second on September 13, 1940 (table 3). This flow, which resulted from thunderstorm activity over the drainage basins of the three above-mentioned tributaries, caused considerable flood damage in the cities of Price and Helper (Butler and Marsell, 1972, p. 53).

Table 6.—Summary of chemical analyses of streamflow in Willow Creek at station 09312900, water years 1980-81
[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	25	12.1	0.35-173
Water temperature (degrees Celsius)	25	10.0	.0-27.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	25	920	450-1,280
pH (units)	25	—	8.1-8.8
Sodium-adsorption ratio	25	1.8	.9-2.0
Milligrams per liter			
Dissolved solids, sum of constituents	24	591	350-810
Oxygen, dissolved (O_2)	25	9.3	6.4-12.0
Carbon dioxide, dissolved (CO_2)	24	1.9	.7-4.7
Alkalinity ($CaCO_3$)[1]	24	284	210-350
Bicarbonate (HCO_3)[1]	24	331	230-420
Carbonate (CO_3)[1]	24	7.3	.0-16
Nitrogen, dissolved (N)	8	.45	.15-.74
Nitrogen, organic dissolved (N)	4	.37	.11-.63
Nitrogen, ammonia dissolved (N)	4	—	<.01-.030
Nitrogen, nitrite dissolved (N)	4	—	.01
Nitrogen, nitrate dissolved (N)	4	—	<.05-.06
Nitrogen, nitrite + nitrate dissolved (N)	8	—	<.01-.27
Phosphorus, dissolved (P)	4	—	<.01-.240
Phosphorus, ortho phosphates dissolved (P)	4	—	.001-.010
Carbon, organic dissolved (C)	8	6.2	1.5-14
Hardness, (as $CaCO_3$)	25	342	180-500
Hardness, (as noncarbonate, $CaCO_3$)	24	65	.0-150
Calcium, dissolved (Ca)	25	56	32.0-82
Magnesium, dissolved (Mg)	25	49	20-72
Sodium, dissolved (Na)	25	77	30-100
Potassium, dissolved (K)	25	2.7	1.7-3.6
Chloride, dissolved (Cl)	25	26.1	9.8-45
Sulfate, dissolved (SO_4)	25	194	70-300
Fluoride, dissolved (F)	17	.26	.20-0.50
Silica, dissolved (SiO_2)	25	12.2	6.8-15

Table 6.—Summary of chemical analyses of streamflow in Willow Creek at station 09312900, water years 1980-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	6	2.2	2.0-3.0
Barium, dissolved (Ba)	12	150	100-200
Boron, dissolved (B)	17	97	60-180
Cadmium, dissolved (Cd)	2	—	<1-1
Chromium, dissolved (Cr)	5	—	<10-10
Copper, dissolved (Cu)	2	2.5	2-3
Iron, dissolved (Fe)	17	—	<10-80
Lead, dissolved (Pb)	6	—	<1-2
Lithium, dissolved (Li)	6	28	20-40
Manganese, dissolved (Mn)	17	12.2	2-30
Mercury, dissolved (Hg)	2	—	<.1
Nickel, dissolved (Ni)	2	—	<1
Selenium, dissolved (Se)	6	1.7	1.0-3.0
Strontium, dissolved (Sr)	6	717	350-1,100
Zinc, dissolved (Zn)	6	4.2	3.0-7.0
Phenols	8	7.2	1.0-33

[1]Fixed-end-point determined by titration in the field.

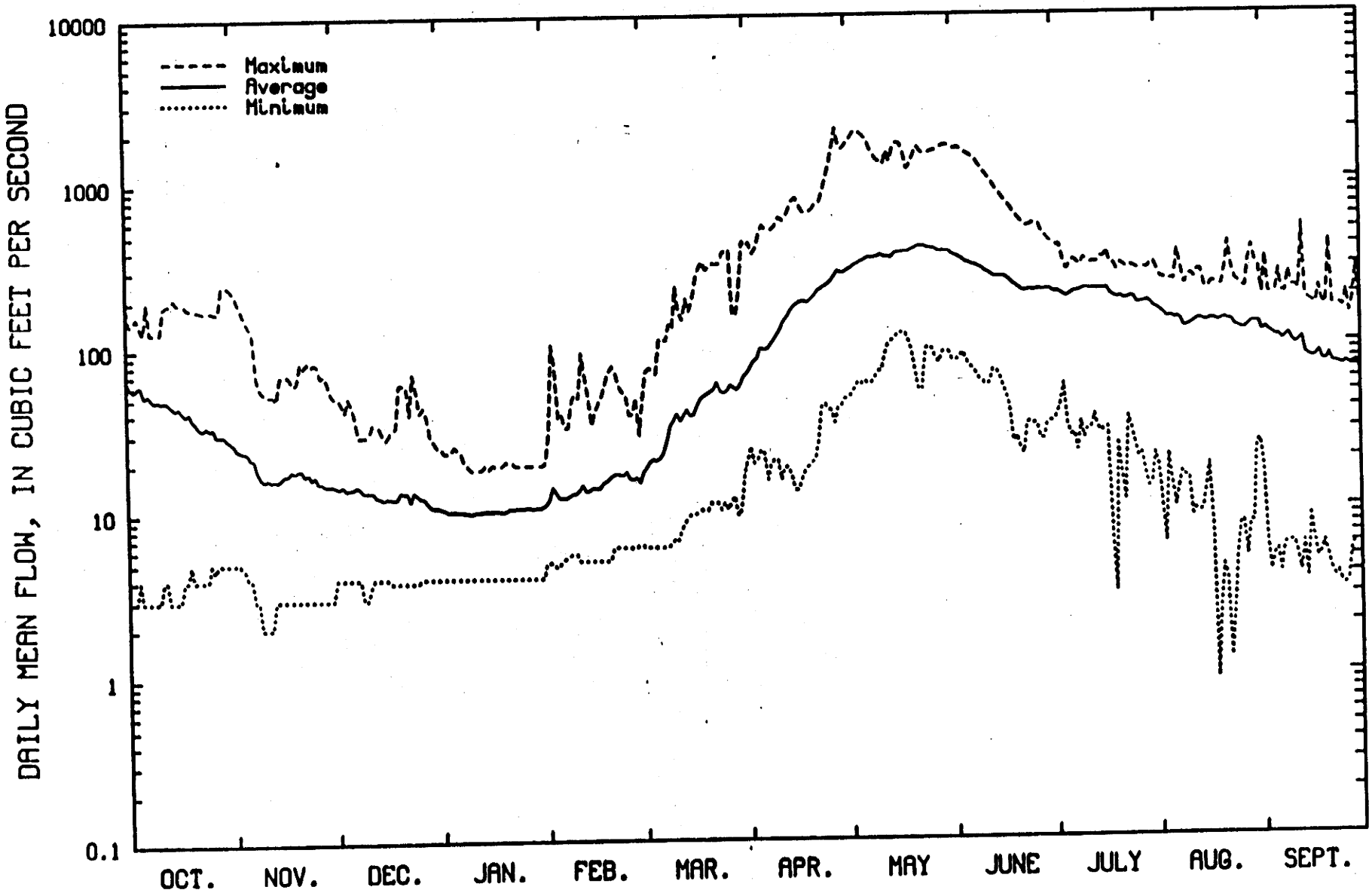


Figure 9.--Maximum, average, and minimum daily mean flow of the Price River at station 09313000, water years 1935-70, 1980-81.

Dissolved-solids concentrations in 24 streamflow samples collected from the Price River at station 09313000 during October 1979-September 1981 ranged from 200 to 580 milligrams per liter with a mean of 367 milligrams per liter (table 7). Calcium and magnesium were the dominant dissolved cations, and bicarbonate was the dominant dissolved anion. Concentrations of all trace elements that were analyzed were smaller than the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The phenol concentration in some samples, however, exceeded the criterion of 1 microgram per liter.

Concentrations of suspended sediment in 21 streamflow samples collected at station 09313000 ranged from 58 to 1,520 milligrams per liter during water year 1980 and from 21 to 4,270 milligrams per liter during water year 1981. Instantaneous suspended-sediment loads ranged from 2.7 to 3,770 tons per day during water year 1980 and from 0.59 to 1,090 tons per day during water year 1981. Coal was as much as 8 percent of the stream-bottom sediments sampled at the station.

Two samples of benthic invertebrates collected at station 09313000 during the 1980 water year had good diversity (U.S. Geological Survey, 1981, p. 253), indicating an apparently unpolluted stream bottom at the station. Five samples of phytoplankton collected during water year 1981 showed a uniform distribution of green algae with good diversity (U.S. Geological Survey, 1982, p. 253).

Spring Canyon Creek

Spring Canyon creek orginates on the Wasatch Plateau at an altitude of about 9,800 feet. It descends about 4,000 feet to its confluence with the Price River at about 5,800 feet. All the Cretaceous formations shown on figure 1 are exposed in the canyon, and station 09313040 is located where the creek flows on the Mancos Shale at an altitude of 6,110 feet.

Coal mining started in Spring Canyon during the late 1800's and continued intermittently to the present (1985). During the monitoring period of water years 1979-81 at station 09313040, coal was actively mined at the Braztah Mines (pl. 1) with portals in Spring Canyon. Most of the water produced by the mines is consumed in the mining operations; however, a small, but unknown quantity was intermittently discharged to Spring Canyon creek.

Most of the flow in Spring Canyon creek originates in seeps or springs. The annual mean flow at station 09313040 during the 3 years of record ranged from 0.12 cubic feet per second during water year 1979 to 0.41 cubic feet per second during water year 1981 (table 3). The flow varies considerably, and the short-term increases in flow during June-November shown in figure 10 probably resulted from thunderstorms. The maximum peak flow recorded, which was 271 cubic feet per second on July 12, 1981 (table 3), resulted from a thunderstorm.

The results of base-flow measurements made in Spring Canyon creek upstream from station 09313040 are related to geology in figure 11. The marked increase in base flow beginning about 2.5 miles upstream from the station probably reflects increased spring inflow to the canyon from near the contact between the Mancos Shale and the Star Point Sandstone.

Table 7.—Summary of chemical analyses of streamflow in the Price River at station 09313000, water years, 1980-81

[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	25	124	6.8-918
Water temperature (degrees Celsius)	25	9.4	.0-20.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	25	579	330-930
pH (units)	25	—	8.1-9.0
Sodium-absorption ratio	25	.7	.3-1.0
Milligrams per liter			
Dissolved solids, sum of constituents	24	367	200-580
Oxygen, dissolved (O_2)	25	9.8	7.5-13.1
Carbon dioxide, dissolved (CO_2)	24	1.4	.5-3.9
Alkalinity ($CaCO_3$)[1]	24	217	140-290
Bicarbonate (HCO_3)[1]	24	250	170-400
Carbonate (CO_3)[1]	24	5.8	.0-22
Nitrogen, dissolved (N)	8	.70	.20-.94
Nitrogen, organic dissolved (N)	4	.35	.11-.52
Nitrogen, ammonia dissolved (N)	4	—	<.01-.050
Nitrogen, nitrite dissolved (N)	4	—	<.010
Nitrogen, nitrate dissolved (N)	4	—	<.05-.50
Nitrogen, nitrite + nitrate dissolved (N)	8	.27	.03-.50
Phosphorus, dissolved (P)	4	.075	.010-.270
Phosphorus, ortho phosphates dissolved (P)	4	—	<.001-.010
Carbon, organic dissolved (C)	8	7.0	2.2-15
Hardness, (as $CaCO_3$)	25	255	160-390
Hardness, (as noncarbonate, $CaCO_3$)	24	44.8	0-130
Calcium, dissolved (Ca)	25	57	36-85
Magnesium, dissolved (Mg)	25	27	16-47
Sodium, dissolved (Na)	25	27.7	7.9-56.0
Potassium, dissolved (K)	25	1.9	.9-3.2
Chloride, dissolved (Cl)	25	17.2	5.8-41.0
Sulfate, dissolved (SO_4)	25	88	28-200
Fluoride, dissolved (F)	17	.2	.1-.3
Silica, dissolved (SiO_2)	25	8.1	3.3-14.0

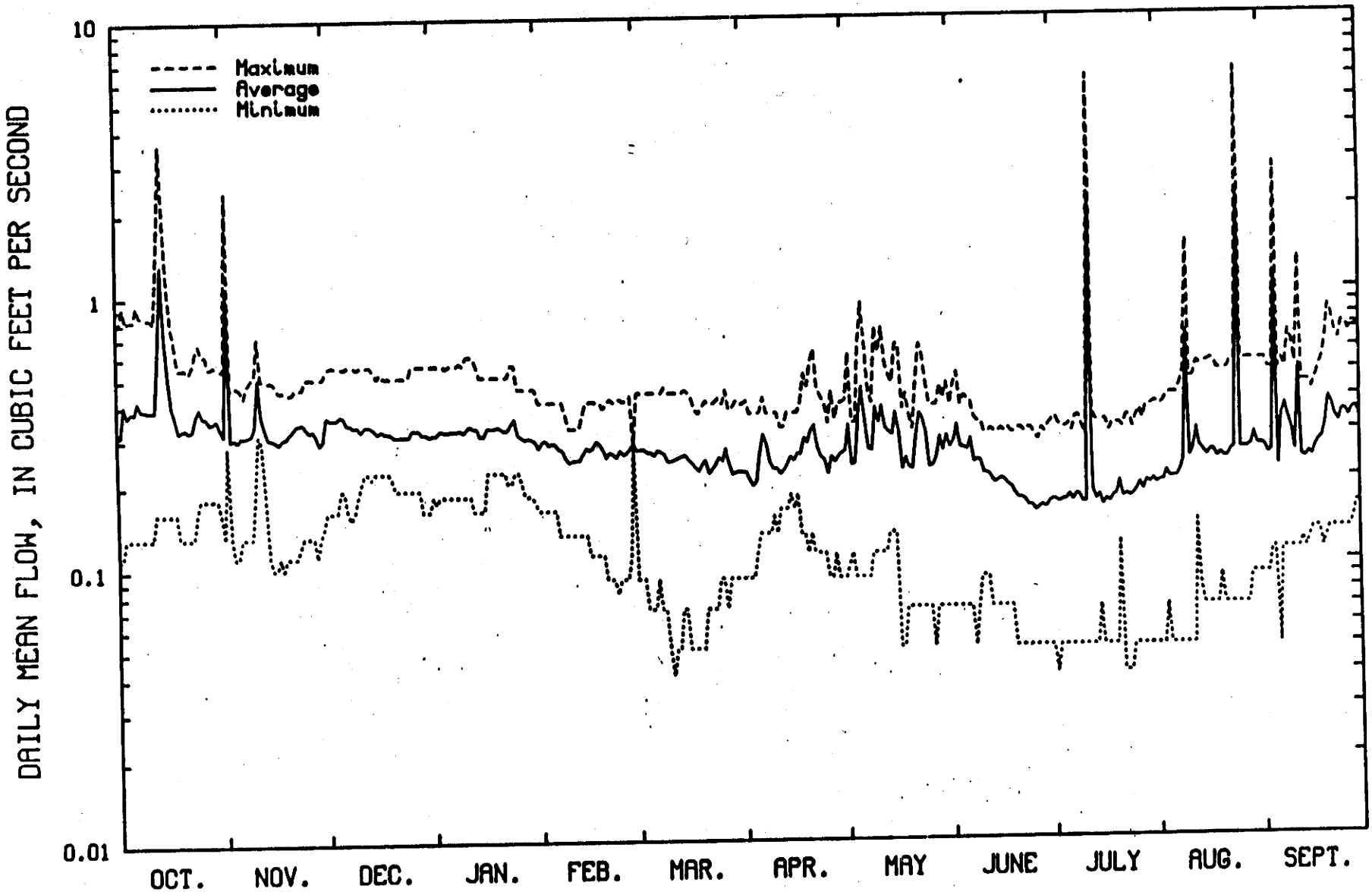


Figure 10.—Maximum, average, and minimum daily mean flow of Spring Canyon creek at station 09313040, water years 1979-81.

Table 7.—Summary of chemical analyses of streamflow in the Price River at station 09313000, water years, 1980-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	6	1.7	1.0-3.0
Barium, dissolved (Ba)	2	—	<100-200
Boron, dissolved (B)	17	136	20-610
Cadmium, dissolved (Cd)	2	—	<1-2
Chromium, dissolved (Cr)	6	—	<10-20
Copper, dissolved (Cu)	2	3.0	2.0-4.0
Iron, dissolved (Fe)	17	—	<10-30
Lead, dissolved (Pb)	6	—	<1-5.0
Lithium, dissolved (Li)	6	—	<10-30
Manganese, dissolved (Mn)	17	11.2	3.0-30
Mercury, dissolved (Hg)	2	—	<.1
Nickel, dissolved (Ni)	2	8	2-14
Selenium, dissolved (Se)	6	—	<1-3.0
Strontium, dissolved (Sr)	6	455	300-630
Zinc, dissolved (Zn)	6	—	<3-20
Phenols	7	—	<1-10

[1]Fixed-end-point determined by titration in the field.

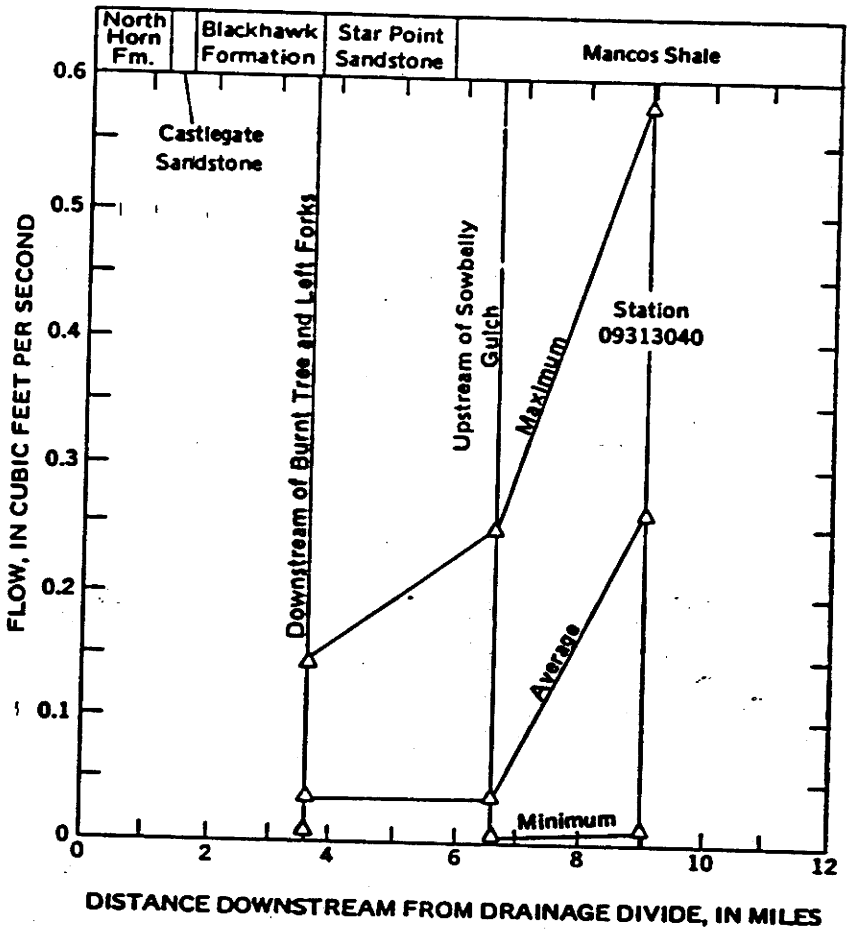


Figure 11.—Base flow of Spring Canyon creek as related to geology (based on 7 measurements made at each site from August 1978 to August 1981).

Dissolved-solids concentrations in 37 streamflow samples taken from Spring Canyon creek at station 09313040 ranged from 481 to 2,600 milligrams per liter; with a mean of 2,260 milligrams per liter (table 8). Magnesium and sulfate were the dominant cation and anion. Strontium was the dominant trace element, with concentrations as large as 1,400 micrograms per liter. Of the trace elements that were analyzed, only lead and selenium were found in concentrations that exceeded the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. Both the maximum and mean concentrations of selenium exceeded the criterion of 10 micrograms per liter, and the maximum concentration of lead exceeded the criterion of 50 micrograms per liter.

Suspended-sediment concentrations in 25 streamflow samples collected from Spring Canyon creek at station 09313040 during the 3 years of monitoring ranged from 3 milligrams per liter on December 6, 1981 to 99,800 milligrams per liter on July 12, 1981. Instantaneous suspended-sediment loads ranged from 0.05 to 0.07 tons per day during water year 1979, 0.01 to 0.43 tons per day in water year 1980, and from less than 0.01 to 10,200 tons per day in water year 1981. No determinations were made of the composition of suspended sediment in samples collected during the monitoring period. On August 29, 1969, however, Spring Canyon creek, while flowing at a rate of 0.6 cubic feet per second, had a suspended-sediment concentration of 2,260 milligrams per liter and about 90 percent of the suspended sediment was coal (Mundorff, 1972, p. 37). Most likely sources of the coal particles are coal spills, mine spoils, and coal-loading facilities associated with the earlier mines in the canyon.

Four samples of benthic invertebrates were collected at station 09313040 during the 1980 water year showed only fair diversity (U.S. Geological Survey, 1981, p. 258). Lines and Plantz (1981, p. 17) had a similar report for water year 1979. Five samples of phytoplankton during the 1981 water year showed a fairly uniform dispersion of green algae. Blue-green algae, however, were also well represented in the samples (U.S. Geological Survey, 1982, p. 260).

North Fork of Gordon Creek

The North Fork of Gordon Creek originates on the coal-bearing Blackhawk Formation at an altitude of about 9,600 feet. The stream has cut a canyon through the Blackhawk and the older geologic formations shown in figure 1. It apparently receives most of its base flow from Coal Canyon (Lines and Plantz, 1981, p. 17).

Most of the Gordon Creek No. 2 Mine is in the North Fork of Gordon Creek drainage. The mine was in operation during the complete monitoring period. According to Lines and Plantz (1981, p. 17) an unknown quantity of water which is intermittently discharged from the mine, has a dissolved-solids concentration of about 800 milligrams per liter. This is about 35 percent of the largest dissolved-solids concentration found in Gordon Creek near where it discharges to the Price River (Mundorff, 1972, table 4).

Table 8.—Summary of chemical analyses of streamflow in Spring Canyon creek at station 09313040, water years 1979-81
[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	37	1.4	0.05-38.0
Water temperature (degrees Celsius)	37	11.4	4.0-26.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	37	2,890	770-3,200
pH (units)	37	—	7.8-8.4
Sodium-adsorption ratio	37	1.6	.3-5.5
Milligrams per liter			
Dissolved solids, sum of constituents	37	2,260	481-2,600
Oxygen, dissolved (O_2)	37	9.0	7.0-11.2
Carbon dioxide, dissolved (CO_2)	36	4.9	1.9-7.7
Alkalinity ($CaCO_3$)	36	382	100-430
Bicarbonate (HCO_3)[1]	36	468	120-520
Carbonate (CO_3)[1]	36	—	.0-2
Nitrogen, dissolved (N)	7	7.1	3.1-8.5
Nitrogen, organic dissolved (N)	8	.71	.40-1.4
Nitrogen, ammonia dissolved (N)	8	—	<.01-.190
Nitrogen, nitrite dissolved (N)	3	—	<.01-.020
Nitrogen, nitrate dissolved (N)	7	5.9	5.0-6.8
Nitrogen, nitrite + nitrate dissolved (N)	12	6.0	1.5-7.8
Phosphorus, dissolved (P)	4	—	<.01-.220
Phosphorus, ortho phosphates dissolved (P)	8	—	<.001-.030
Carbon, organic dissolved (C)	8	8.7	2.6-28
Hardness, (as $CaCO_3$)	37	1,440	370-2,100
Hardness, (as noncarbonate, $CaCO_3$)	36	1,190	270-1,700
Calcium, dissolved (Ca)	37	202	79-230
Magnesium, dissolved (Mg)	37	258	42-380
Sodium, dissolved (Na)	37	143	15-360
Potassium, dissolved (K)	37	17.5	1.7-21
Chloride, dissolved (Cl)	37	84.9	36-120
Sulfate, dissolved (SO_4)	37	1,300	200-1,500
Fluoride, dissolved (F)	21	.4	.3-.5
Silica, dissolved (SiO_2)	37	11.4	5.0-16

Table 8.—Summary of chemical analyses of streamflow in Spring Canyon creek at station 09313040, water years 1979-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	11	—	<1-3
Barium, dissolved (Ba)	2	150	100-200
Boron, dissolved (B)	21	—	<10-700
Cadmium, dissolved (Cd)	3	—	<1-1
Chromium, dissolved (Cr)	7	—	<10-30
Copper, dissolved (Cu)	3	5	2-10
Iron, dissolved (Fe)	21	34	10-60
Lead, dissolved (Pb)	11	—	<1-81
Lithium, dissolved (Li)	10	173	150-190
Manganese, dissolved (Mn)	21	23	10-50
Mercury, dissolved (Hg)	3	—	<1-1
Nickel, dissolved (Ni)	3	2.7	1-6
Selenium, dissolved (Se)	11	15	3-21
Strontium, dissolved (Sr)	10	1,200	1,000-1,400
Zinc, dissolved (Zn)	11	20	10-40
Phenols	8	—	<1-14

[1]Fixed-end-point determined by titration in the field.

Hydrologic monitoring on the North Fork of Gordon Creek was limited to seven sets of base-flow measurements during August 1978-August 1981. The results of those measurements are related to geology in figure 12, and they indicate that the base flow increases significantly directly downstream from the confluence of Coal Canyon and the North Fork of Gordon Creek.

Coal Creek

Coal Creek originates near the crest of the Book Cliffs at an altitude of about 9,000 feet. The headwater area is underlain by the Green River and Wasatch Formations of Tertiary age. The stream has cut a deep, narrow canyon into the Cretaceous formations shown in figure 1. The channel is steep to the base of the Book Cliffs, thereupon the stream meanders over a gently sloping plain on the Mancos Shale to its confluence with the Price River. Station 09313965 (pl. 1, table 1) is on the Star Point Sandstone at 6,370 feet.

There was no active coal mining in the Coal Creek basin during the monitoring period. There are, however, several hundred acres of leased Federal coal (pl. 1) and two abandoned mines in the basin.

Seasonal records were collected at station 09313965 during water years 1979-81 (table 1). The maximum, minimum, and average daily mean flow recorded at the station is shown in figure 13. Most of the recorded flow is from late May to early June, and it originates primarily from snowmelt in the higher altitudes of the basin. The maximum peak flow recorded at the station during the 3 water years of seasonal record, which was 458 cubic feet per second on August 13, 1979, resulted from an intense thunderstorm.

Base-flow measurements in Coal Creek upstream from station 09313965 are related to geology in figure 14. The average and maximum base-flow values indicate that the stream gains flow from both the Blackhawk Formation and the Star Point Sandstone. The minimum values, however, indicate that the stream loses flow near the Blackhawk-Star Point contact.

The dissolved-solids concentrations in 22 streamflow samples collected from Coal Creek at station 09313965 during the 1979-81 water years ranged from 480 to 810 milligrams per liter, with a mean of 605 milligrams per liter (table 9). Magnesium and sodium were generally the dominant cations, while bicarbonate and sulfate were generally the dominant anions. Of the trace elements that were analyzed, manganese and mercury were found in concentrations that exceed the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum concentrations of manganese and mercury were 80 and 5 micrograms per liter, compared to criteria of 50 and 2 micrograms per liter. The maximum phenol concentration was 35 micrograms per liter, compared to a criterion of 1 microgram per liter.

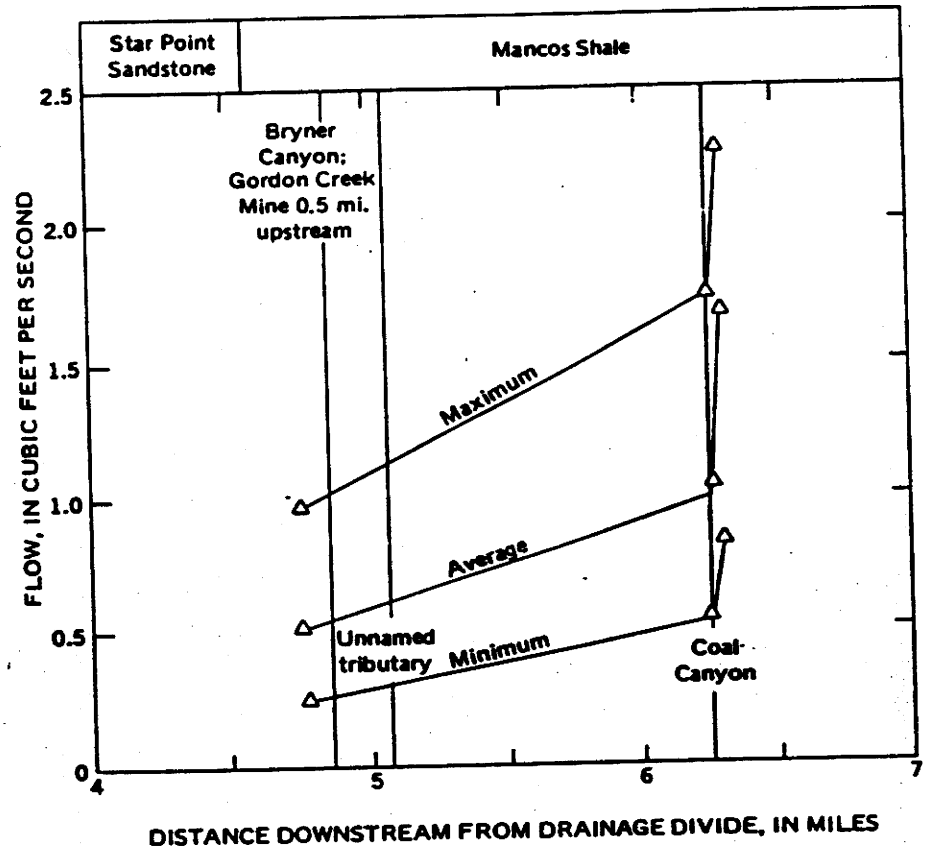


Figure 12.—Base flow of the North Fork of Gordon Creek as related to geology (based on 7 measurements made at each site from August 1978 to August 1981).

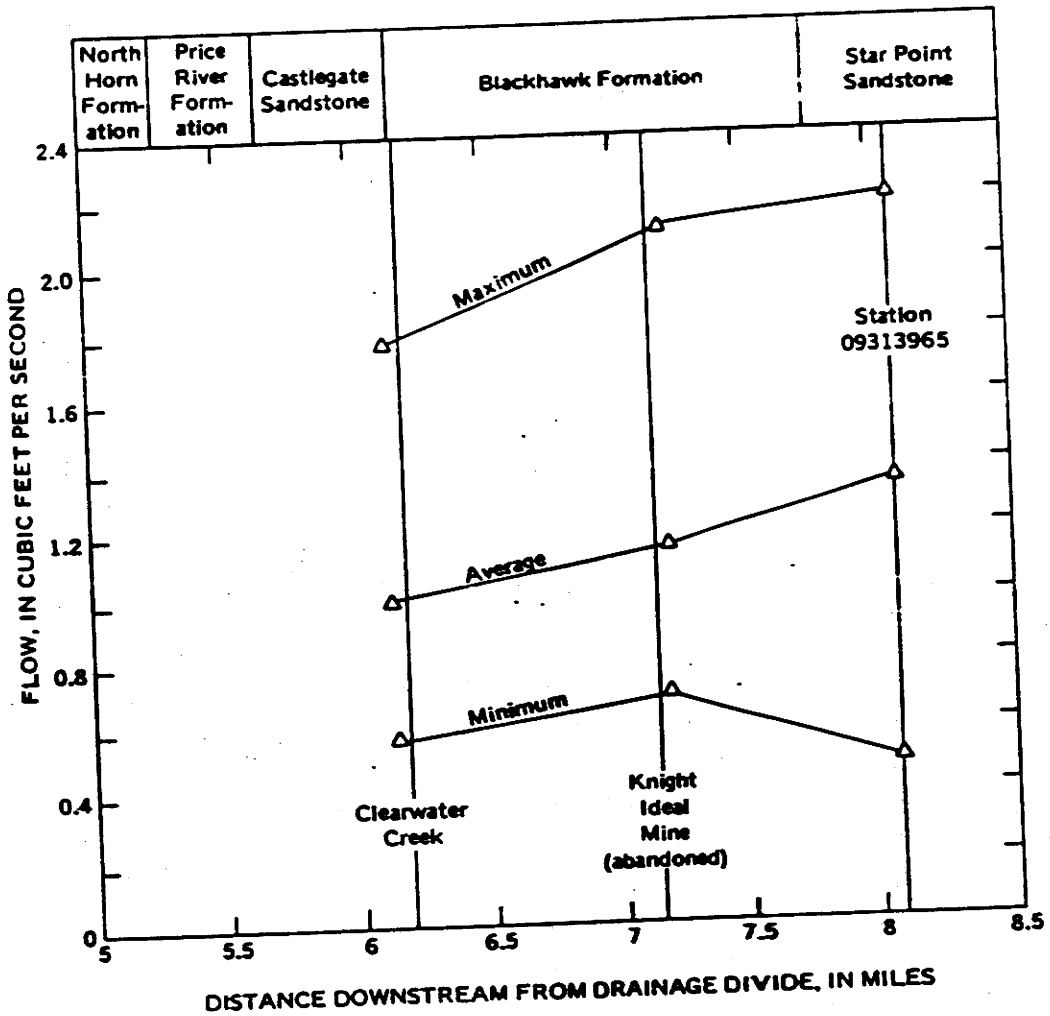


Figure 14.—Base flow of Coal Creek as related to geology (based on 7 measurements made at each site from August 1978 to August 1981).

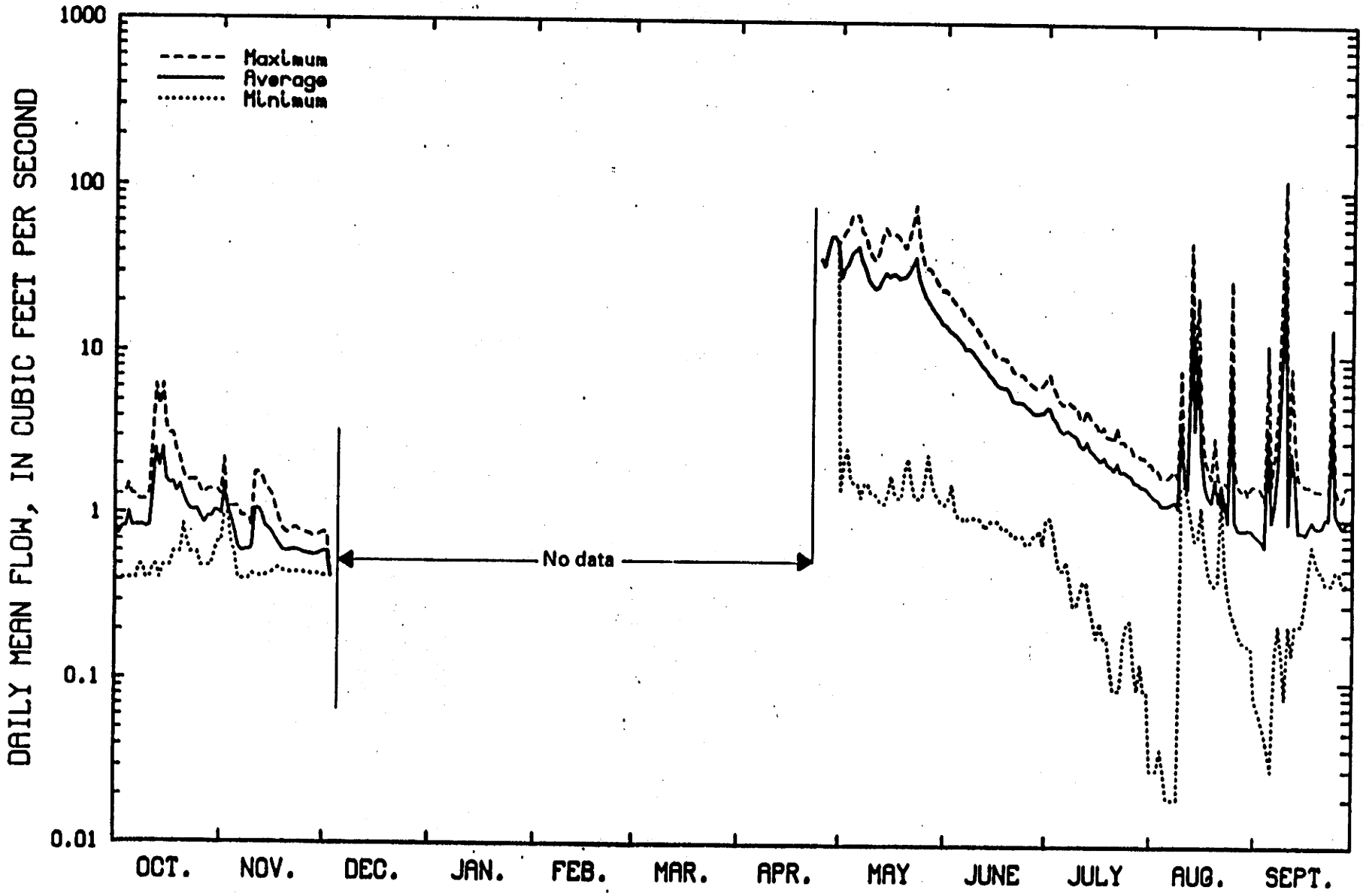


Figure 13.—Maximum, average, and minimum daily mean flow of Coal Creek at station 09313965, seasonal record for water years 1979-81.

Table 9.—Summary of chemical analyses of streamflow in Coal Creek at station 09313965, water years 1979–81

[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum–maximum
Streamflow (cubic feet per second)	23	3.1	0.39–0.33
Water temperature (degrees Celsius)	22	12.0	.0–22.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	23	927	760–1,220
pH (units)	23	—	8.3–9.0
Sodium-adsorption ratio	23	1.8	.5–3.0
Milligrams per liter			
Dissolved solids, sum of constituents	22	605	480–810
Oxygen, dissolved (O_2)	23	8.8	6.8–11.6
Carbon dioxide, dissolved (CO_2)	22	1.5	.5–3.1
Alkalinity ($CaCO_3$)	22	317	260–400
Bicarbonate (HCO_3)[1]	21	360	310–470
Carbonate (CO_3)[1]	21	17.1	0–41
Nitrogen, dissolved (N)	7	.76	.32–1.90
Nitrogen, organic dissolved (N)	6	4.26	.19–24.0
Nitrogen, ammonia dissolved (N)	6	—	.070
Nitrogen, nitrite dissolved (N)	6	—	<.010
Nitrogen, nitrate dissolved (N)	6	.16	.07–25
Nitrogen, nitrite + nitrate dissolved (N)	9	.17	.04–.29
Phosphorus, dissolved (P)	3	.020	.010–.050
Phosphorus, ortho phosphates dissolved (P)	6	—	<.001–.040
Carbon, organic dissolved (C)	9	12.8	3.4–50
Hardness, (as $CaCO_3$)	23	353	210–500
Hardness, (as noncarbonate, $CaCO_3$)	22	45.5	.0–110
Calcium, dissolved (Ca)	23	52	29–78
Magnesium, dissolved (Mg)	23	54	28–78
Sodium, dissolved (Na)	23	77	22–110
Potassium, dissolved (K)	23	43	2.4–12.0
Chloride, dissolved (Cl)	23	21	11–52
Sulfate, dissolved (SO_4)	23	178	110–270
Fluoride, dissolved (F)	14	.4	.03–.5
Silica, dissolved (SiO_2)	23	8.0	5.7–9.6

Table 9.—Summary of chemical analyses of streamflow in Coal Creek at station 09313965, water years 1979-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	9	1.8	1.0-4.0
Barium, dissolved (Ba)	2	—	100-100
Boron, dissolved (B)	14	141	70-230
Cadmium, dissolved (Cd)	3	—	<1
Chromium, dissolved (Cr)	7	—	<10-<20
Copper, dissolved (Cu)	3	—	<2-30
Iron, dissolved (Fe)	14	—	<10-86
Lead, dissolved (Pb)	9	—	<1-19
Lithium, dissolved (Li)	8	39	20-50
Manganese, dissolved (Mn)	14	23	2.0-80
Mercury, dissolved (Hg)	3	—	<.1-5
Nickel, dissolved (Ni)	3	—	<1-2
Selenium, dissolved (Se)	9	—	<1-4.0
Strontium, dissolved (Sr)	8	572	470-720
Zinc, dissolved (Zn)	9	—	<3-70
Phenols	9	—	<1-35

[1]Fixed-end-point determined by titration in the field.

The suspended-sediment concentrations in 13 streamflow samples collected during the 3 water years of monitoring at station 09313965 ranged from 3 milligrams per liter on July 12, 1981 to 2,710 milligrams per liter August 12, 1981. Instantaneous suspended-sediment loads calculated for station 09313965 during the 1979-81 water years are summarized as follows:

Water year	Suspended-sediment loads (tons/day) Minimum	Maximum
1979	0.21	0.48
1980	.04	302
1981	Less than .01	6.4

Coal was only 0.4 percent of the stream-bottom sediments sampled.

Two samples of benthic invertebrates at station 09313965 during water year 1980 showed about the same diversity as the one benthic invertebrate sampled during water year 1979. (See Lines and Plantz, 1981, table 2.) According to Lines and Plantz (1981, p. 23), the diversity indicates a fairly healthy stream-bottom environment. Four samples of phytoplankton during water year 1981 all had a fairly uniform distribution of green algae (U.S. Geological Survey, 1982, p. 265). This probably reflects the fairly good chemical quality of the streamflow, as indicated by its dissolved-solids concentration (table 9).

Soldier Creek

The Soldier Creek drainage basin is adjacent to and east of the Coal Creek basin. Like Coal Creek, Soldier Creek originates near the crest of the Book Cliffs, but at a somewhat lower altitude (about 8,800 feet). Soldier Creek also has cut a canyon through Cretaceous formations, and it also meanders over the Mancos Shale to the Price River. Station 09313975 (pl. 1, table 1) is on the Blackhawk Formation at an altitude of 6,650 feet.

The Soldier Canyon Mine was in operation during water years 1979-84. Most of the water produced in the mine is consumed in the mining operations; however, a small, but unknown quantity is discharged intermittently to Soldier Creek.

Station 09313975 was operated seasonally during the 1979-84 water years. Maximum, minimum, and average daily mean flow in Soldier Creek is shown in figure 15. Most of the flow is during April-June, and it results chiefly from snowmelt in the higher altitudes of the drainage basin. The short-term increases in flow during June-November resulted from thunderstorms in the basin. The maximum peak flow recorded at station 09313975 during the seasonal record for water years 1979-84 was 472 cubic feet per second on September 23, 1981, and it resulted from a thunderstorm.

Base-flow measurements in Soldier Creek upstream from station 09313975 are related to geology in figure 16. The maximum values indicate that Soldier Creek loses flow slightly where it crosses the Castlegate Sandstone or the upper part of the Blackhawk Formation, but it gains flow substantially from

the lower part of the Blackhawk. The minimum and average values indicate a consistent gain from the Castlegate and Blackhawk. If there was any discharge from the Soldier Canyon Mine during the base-flow measurements, it was negligible.

The chemical quality of the water in Soldier Creek is similar to that of the water in Coal Creek; however, according to Lines and Plantz (1981, p. 24), there are some notable differences during low-flow conditions. They suggest that this probably indicates a difference in some sources of ground-water discharge in the two basins. The dissolved-solids concentrations in 31 streamflow samples collected from Soldier Creek at station 09313975 ranged from 280 to 710 milligrams per liter, with a mean of 533 milligrams per liter (table 10). Sodium, magnesium, and calcium were the dominant cations, and bicarbonate and sulfate were the dominant anions. Of the trace elements that were analyzed, only manganese was found in concentrations that exceeded the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum concentration of manganese was 60 micrograms per liter, compared to a criterion of 50 micrograms per liter. The maximum phenol concentration was 38 micrograms per liter, compared to a criterion of 1 microgram per liter.

The suspended-sediment concentrations in 13 streamflow samples collected at station 09313975 ranged from 6 milligrams per liter on July 9, 1981, to 406 milligrams per liter on August 12th of the same year. Coal was 0.3 percent of the stream-bottom sediments sampled.

Six samples of benthic invertebrates were collected at station 09313975 during the 1979-80 and 1982 water years. The samples for water year 1980 showed about the same diversity as those for water year 1979 (Lines and Plantz, 1981, p. 27); and the samples in both water years had fairly good diversities of benthic invertebrates. This might have been indicative of an unpolluted stream-bottom environment. The benthic invertebrates sampled during water year 1982 were not fully evaluated. Five samples of phytoplankton were collected during water year 1981. Blue-green algae were well dispersed in those samples (U.S. Geological Survey, 1982, p. 271) which indicates fairly good chemical quality.

Dugout Creek

Dugout Creek is a tributary of Grassy Trail Creek, which is discussed in the following section. Dugout Creek originates near the crest of the Book Cliffs at an altitude of about 8,800 feet. The stream has cut a steep canyon through most of the formations shown on figure 1, as it descends about 1,800 feet to the base of the Book Cliffs, whereupon it meanders over a relatively low gradient on the Mancos Shale before joining Grassy Trail Creek at about 5,500 feet. Station 09313985 (pl. 1, table 1) is at 6,960 feet on the coal-bearing Blackhawk Formation.

No mines were active in the Dugout Creek basin during the monitoring period at station 09313985. There are several thousand acres of leased Federal coal in the basin (pl. 1), however, some exploratory mining was started upstream from the station in recent years. The proposed (1985) Sage Point-Dugout Canyon Mine will have portals in Dugout Canyon.

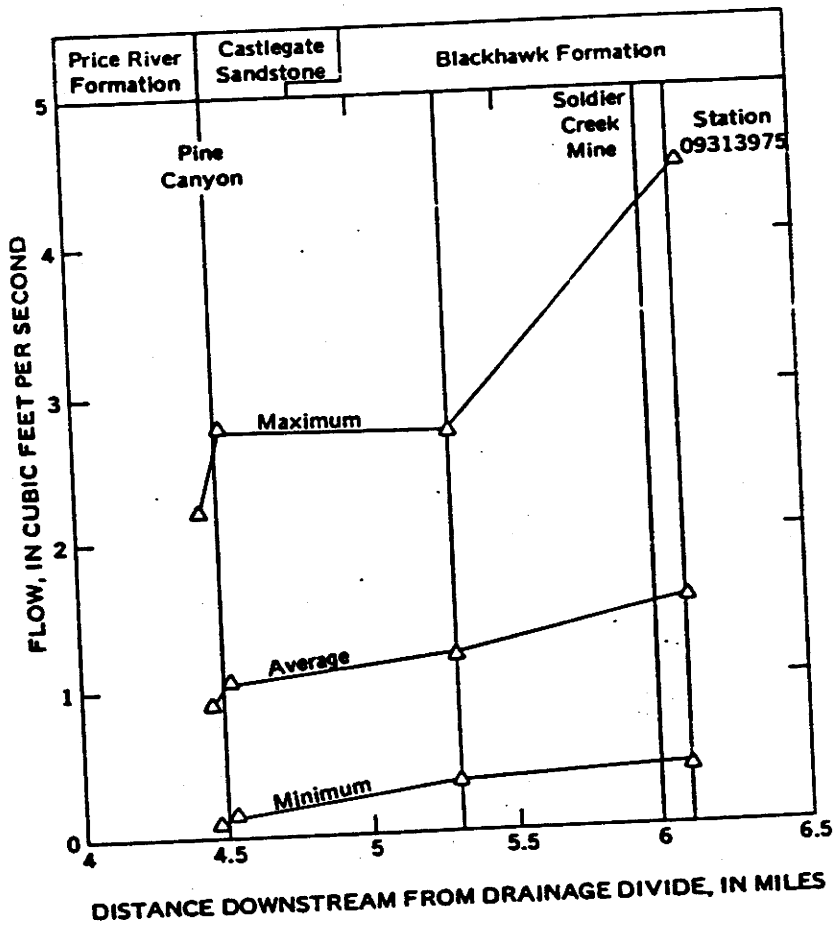


Figure 16.—Base flow of Soldier Creek as related to geology (based on 10 measurements made at each site from August 1978 to September 1984).

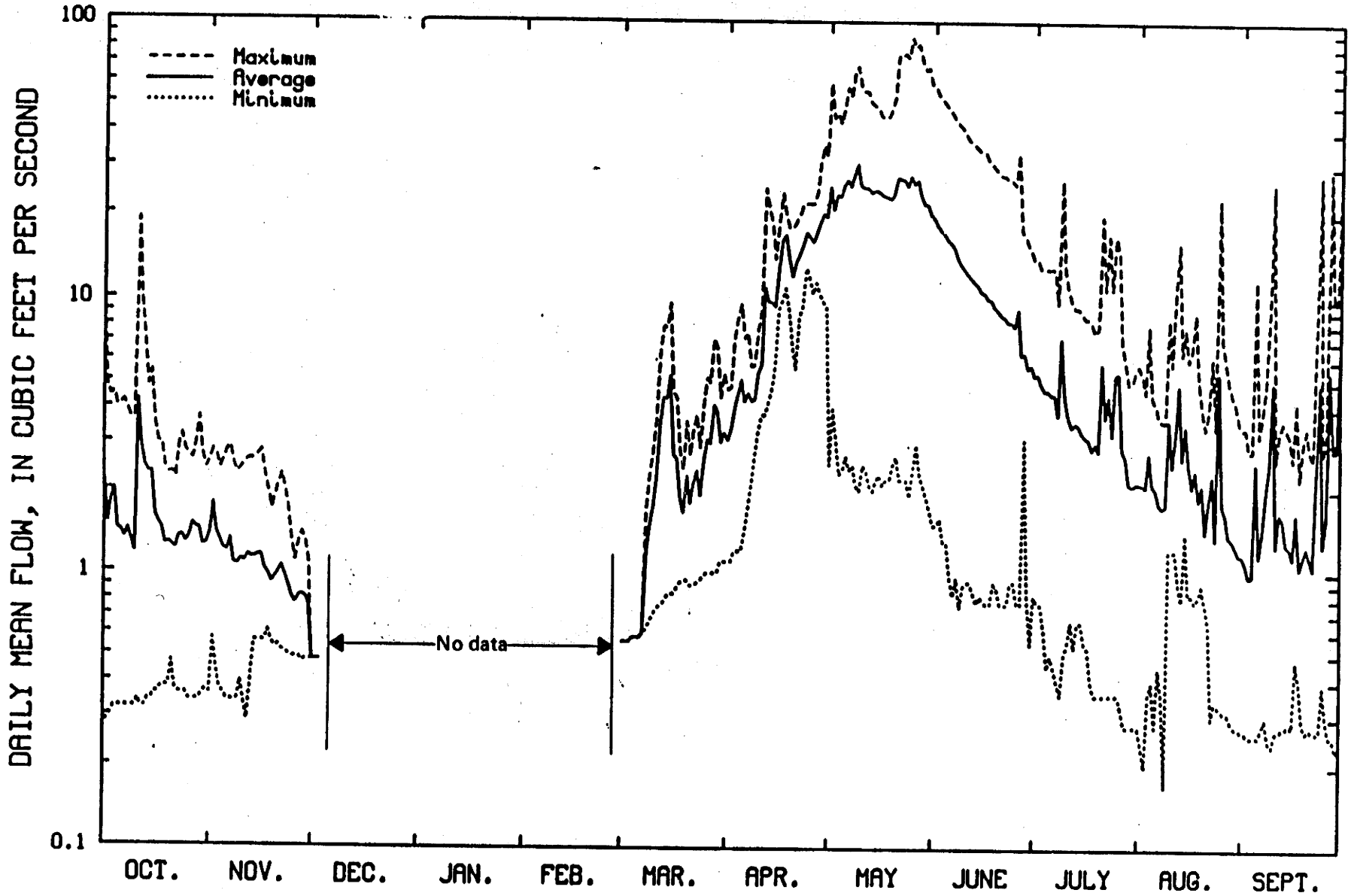


Figure 15.—Maximum, average, and minimum daily mean flow of Soldier Creek at station 09313975, seasonal record for water years 1979-84.

Table 10.—Summary of chemical analyses of streamflow in Soldier Creek at station 09313975, water years 1979-84
[<indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	33	6.3	0.35-54
Water temperature (degrees Celsius)	31	15.5	.0-25.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	33	840	500-1,190
pH (units)	31	—	8.1-8.8
Sodium-adsorption ratio	33	.2	.6-4.0
Milligrams per liter			
Dissolved solids, sum of constituents	31	533	280-710
Oxygen, dissolved (O_2)	31	8.0	6.7-11.5
Carbon dioxide, dissolved (CO_2)	21	1.7	.8-3.8
Alkalinity ($CaCO_3$)	23	310	210-440
Bicarbonate (HCO_3)[1]	21	209	240-500
Carbonate (CO_3)[1]	21	13.4	0-26
Nitrogen, dissolved (N)	9	.53	.20-1.2
Nitrogen, organic dissolved (N)	7	.38	.18-.85
Nitrogen, ammonia dissolved (N)	7	—	<.01-.130
Nitrogen, nitrite dissolved (N)	7	—	<.01-.010
Nitrogen, nitrate dissolved (N)	7	—	<.05-.14
Nitrogen, nitrite + nitrate dissolved (N)	20	—	<.01-.24
Phosphorus, dissolved (P)	13	—	<.010-.080
Phosphorus, ortho phosphates dissolved (P)	7	—	<.001-.040
Carbon, organic dissolved (C)	18	8.2	2.2-32
Hardness, (as $CaCO_3$)	33	302	150-390
Hardness, (as noncarbonate, $CaCO_3$)	22	1.0	.0-47
Calcium, dissolved (Ca)	33	47.7	31-65
Magnesium, dissolved (Mg)	33	44.4	18-58
Sodium, dissolved (Na)	33	79.6	21-150
Potassium, dissolved (K)	33	4.0	1.5-8.6
Chloride, dissolved (Cl)	33	16.1	5.2-30
Sulfate, dissolved (SO_4)	33	122	44-230
Fluoride, dissolved (F)	25	.47	.20-.70
Silica, dissolved (SiO_2)	33	8.1	6.6-9.6

Table 10.—Summary of chemical analyses of streamflow in Soldier Creek at station 09313975, water years 1979-84—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	16	—	<1-2.0
Barium, dissolved (Ba)	5	—	<100-290
Boron, dissolved (B)	24	—	<40-310
Cadmium, dissolved (Cd)	10	—	<1
Chromium, dissolved (Cr)	13	—	<10
Copper, dissolved (Cu)	10	—	<2-3
Iron, dissolved (Fe)	25	—	<10-140
Lead, dissolved (Pb)	14	—	<1-18
Lithium, dissolved (Li)	11	36.6	20-65
Manganese, dissolved (Mn)	23	338	7-60
Mercury, dissolved (Hg)	10	—	<.1-1.3
Nickel, dissolved (Ni)	9	—	<1-13
Selenium, dissolved (Se)	16	—	<1-3
Strontium, dissolved (Sr)	11	483	340-630
Zinc, dissolved (Zn)	16	—	<3-60
Phenols	15	—	<1-38

[1]Fixed-end-point determined by titration in the field.

Seasonal records were collected at station 09313985, during water years 1980-81. The maximum, minimum, and average daily mean flow shown in figure 17 indicate that most of the recorded flow in Dugout Creek is during May and June, resulting from snowmelt in the higher altitudes. The short-term increases in discharge during August and September, however, indicate that considerable flow in the creek results from thunderstorms. The maximum peak flow recorded at the station was 127 cubic feet per second on September 5, 1981 (table 3), and that flow resulted from a thunderstorm.

The chemical quality of the streamflow in Dugout Creek is apparently slightly better than that of Coal and Soldier Creeks. Dissolved-solids concentrations in 15 streamflow samples collected at station 09313985 during water years 1980-81 ranged from 350 to 480 milligrams per liter, with a mean of 396 milligrams per liter (table 11). Calcium and magnesium were the dominant dissolved cations and bicarbonate was the dominant dissolved anion. None of the trace elements that were analyzed were found in concentrations that exceed the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum phenol concentration was 10 micrograms per liter, compared to a criterion of 1 microgram per liter.

Suspended-sediment concentrations in 11 streamflow samples collected at station 09313985 during water years 1980-81 ranged from 5 milligrams per liter on July 9, 1981 to 1,000 milligrams per liter on April 30, 1980. Instantaneous suspended-sediment loads calculated for the station ranged from 0.01 to 38 tons per day during water year 1980 and from less than 0.01 to 0.08 tons per day during water year 1981.

Two samples of benthic invertebrates collected at station 09313985 during water year 1980 showed good diversity (U.S. Geological Survey, 1981, p. 272). Five samples of phytoplankton collected at the same site during water year 1981 showed a fairly uniform distribution of green algae (U.S. Geological Survey, 1982, p. 276).

Grassy Trail Creek

Grassy Trail Creek originates near the crest of the Book Cliffs at an altitude of about 10,000 feet. The channel has cut through most of the formations shown in figure 1 as it descends steeply more than 3,000 feet to the base of the Book Cliffs near the town of Sunnyside. From there the channel is on the Mancos Shale, until its confluence with the Price River. Station 09314340 (pl. 1, table 1) is at Sunnyside at an altitude of 6,540 feet. The Sunnyside Mines (pl. 1) were in operation in the Grassy Trail Creek basin during the monitoring period at the station.

According to Lines and Plantz (1981, p. 28), about 1 cubic foot per second of unconsumed mine water is discharged to Grassy Trail Creek upstream from station 09314340. The mine waters reportedly have dissolved-solids concentrations as large as 1,600 milligrams per liter (Waddell and others, 1981, table 8).

The annual mean flow in Grassy Trail Creek recorded at station 09314340 ranged from 2.43 cubic feet per second during water year 1981 to 24.2 cubic feet per second during water year 1983, with an average of 9.89 cubic feet

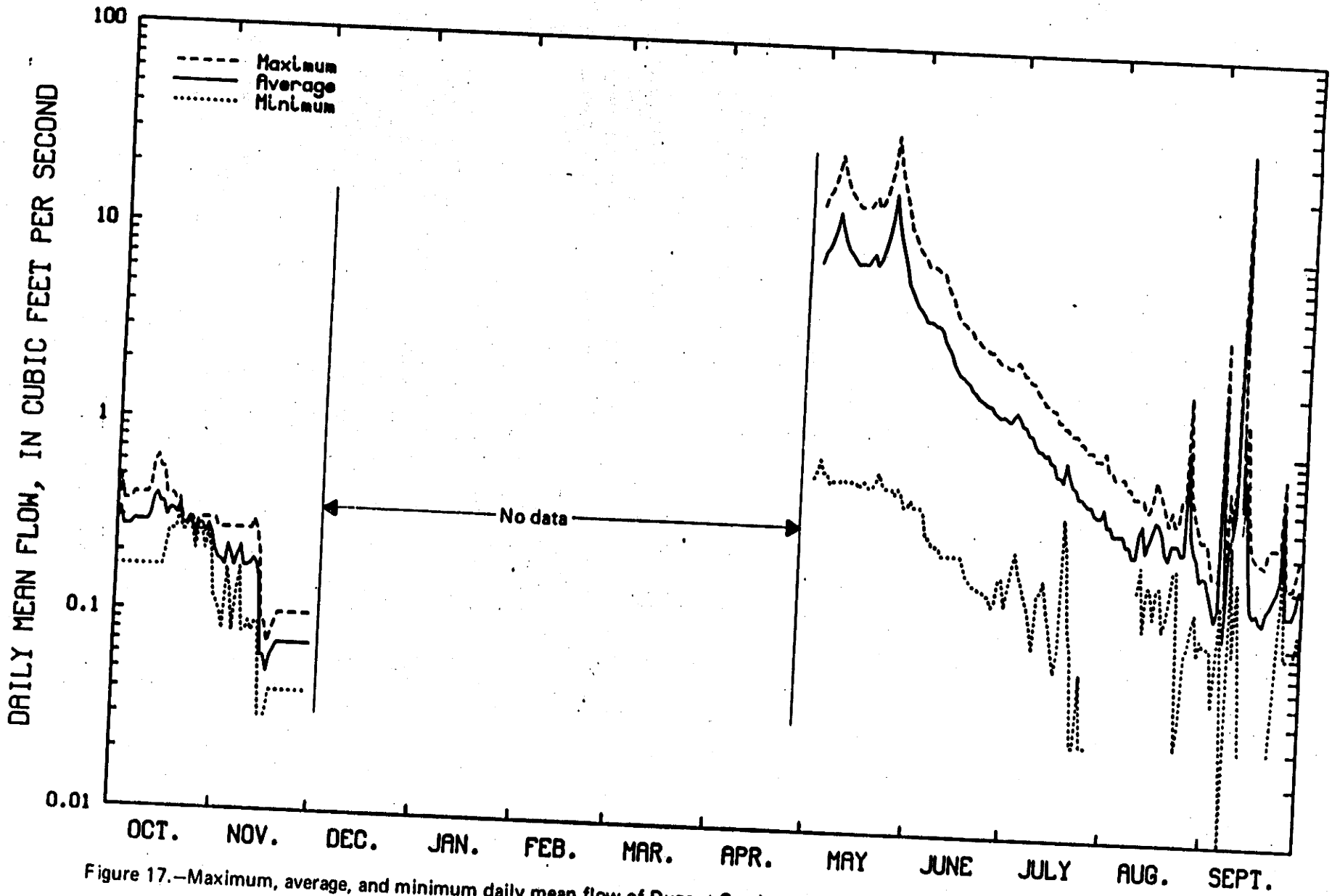


Figure 17.—Maximum, average, and minimum daily mean flow of Dugout Creek at station 09313985, seasonal record for water years 1980-81.

Table 11.—Summary of chemical analyses of streamflow in Dugout Creek at station 09313985, water years 1980-81
[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	16	1.8	0.05-19.0
Water temperature (degrees Celsius)	16	10.3	1.0-20.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	16	667	590-820
pH (units)	16	—	8.1-8.6
Sodium-adsorption ratio	16	.6	.4-0.6
Milligrams per liter			
Dissolved solids, sum of constituents	15	396	350-480
Oxygen, dissolved (O_2)	16	8.7	7.0-10.8
Carbon dioxide, dissolved (CO_2)	15	2.6	1.3-5.3
Alkalinity ($CaCO_3$)	15	287	240-350
Bicarbonate (HCO_3)[1]	14	347	320-420
Carbonate (CO_3)[1]	14	2.6	.0-8.0
Nitrogen, dissolved (N)	6	.38	.24-.65
Nitrogen, organic dissolved (N)	3	.37	.32-.43
Nitrogen, ammonia dissolved (N)	3	—	<.01-.040
Nitrogen, nitrite dissolved (N)	3	—	<.01
Nitrogen, nitrate dissolved (N)	3	—	<.05-.21
Nitrogen, nitrite + nitrate dissolved (N)	6	—	<.01-.21
Phosphorus, dissolved (P)	3	.02	.010-.020
Phosphorus, ortho phosphates dissolved (P)	3	—	<.001-.060
Carbon, organic dissolved (C)	6	9.1	2.9-17
Hardness, (as $CaCO_3$)	16	325	300-380
Hardness, (as noncarbonate, $CaCO_3$)	15	38	16-65
Calcium, dissolved (Ca)	16	58	50-68
Magnesium, dissolved (Mg)	16	44	36-52
Sodium, dissolved (Na)	16	23	15-27
Potassium, dissolved (K)	16	2.9	1.7-4.1
Chloride, dissolved (Cl)	16	5.9	4.9-6.8
Sulfate, dissolved (SO_4)	16	81	51-110
Fluoride, dissolved (F)	11	.3	.2-.5
Silica, dissolved (SiO_2)	16	8.7	7.5-9.8

Table 11.—Summary of chemical analyses of streamflow in Dugout Creek at station 09313985, water years 1980-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	6	1.2	1.0-2.0
Barium, dissolved (Ba)	2	—	<100-100
Boron, dissolved (B)	11	—	<10-150
Cadmium, dissolved (Cd)	3	—	<1
Chromium, dissolved (Cr)	6	—	<10
Copper, dissolved (Cu)	3	—	<2
Iron, dissolved (Fe)	11	—	<10-20
Lead, dissolved (Pb)	6	—	<1-4
Lithium, dissolved (Li)	5	20	10-30
Manganese, dissolved (Mn)	11	—	<1-25
Mercury, dissolved (Hg)	3	—	<.1-.2
Nickel, dissolved (Ni)	3	—	<1-2.0
Selenium, dissolved (Se)	6	—	<1-1.0
Strontium, dissolved (Sr)	5	354	320-400
Zinc, dissolved (Zn)	6	—	<3-4
Phenols	6	—	<1-10

[1]Fixed-end-point determined by titration in the field.

per second (table 3). The maximum peak flow recorded was 631 cubic feet per second on May 31, 1983. The maximum, minimum, and average daily mean flow is shown in figure 18. The runoff in Grassy Trail Creek peaks in late May, somewhat later than the corresponding peaks for Dugout, Soldier, and Coal Creeks, which also head near the crest of the Book Cliffs. More snow accummulates in the Grassy Trail Creek basin because the creek originates at a higher altitude than do the other streams, and the snow begins to melt later in the spring.

The base flow in Grassy Trail Creek increases substantially between Grassy Trail Reservoir and station 09314340 (fig. 19). The increase is attributed to ground-water inflow from rocks younger than the Castlegate Sandstone and to intermittent discharges of mine water (Lines and Plantz, 1981, p. 28). The intermittent discharge of mine water results in considerable variations in base flow downstream from the Sunnyside Mines.

The dissolved-solids concentrations in 47 streamflow samples collected at station 09314340 during water years 1979-84 ranged from 330 to 1,900 milligrams per liter; with a mean concentration of 988 milligrams per liter (table 12). A seasonal variation in the ratios of dissolved ions in the streamflow (Lines and Plantz, 1981, fig. 17) is related to the quantity of dissolved-solids, which in turn is related to seasonal variation of streamflow and inflow of mine water. In general, however, calcium and magnesium were the dominant cations, and bicarbonate and sulfate were the dominant anions. The mine water may possibly be a source of the sulfate. Of the trace elements that were analyzed, only lead was found in concentrations that exceeded the criteria of the U.S. Environmental Protection Agency (1976, p. 5) for drinking-water supplies. The maximum concentration of lead was 55 micrograms per liter, compared to a criterion of 50 micrograms per liter. The mine water also may be a source of lead. The maximum concentration of phenol was about 40 micrograms per liter, compared to a criterion of 1 microgram per liter.

Suspended-sediment concentrations in 25 streamflow samples collected from Grassy Trail Creek at station 09314340 ranged from 4 milligrams per liter on March 13, 1979, and December 9, 1980, to 1,640 milligrams per liter on May 22, 1980. The largest calculated instantaneous suspended-sediment load was 518 tons per day on May 22, 1980. Coal was about 17 percent of the stream-bottom sediments that were sampled. The principal source of the coal probably is the mine water because the stream contains considerable quantities of suspended coal particles during periods of mine dewatering.

Nine samples of benthic invertebrates collected at station 09314340 during water years 1979, 1980, and 1982 had good diversity. (See for example Lines and Plantz, 1981, table 2 and p. 32.) Five samples of phytoplankton collected during water year 1981 probably reflected the variable chemical quality of the streamflow. Green algae had a uniform distribution in the five samples; however, blue-green algae appeared in relatively larger numbers in three of the samples (U. S. Geological Survey, 1982, p. 285).

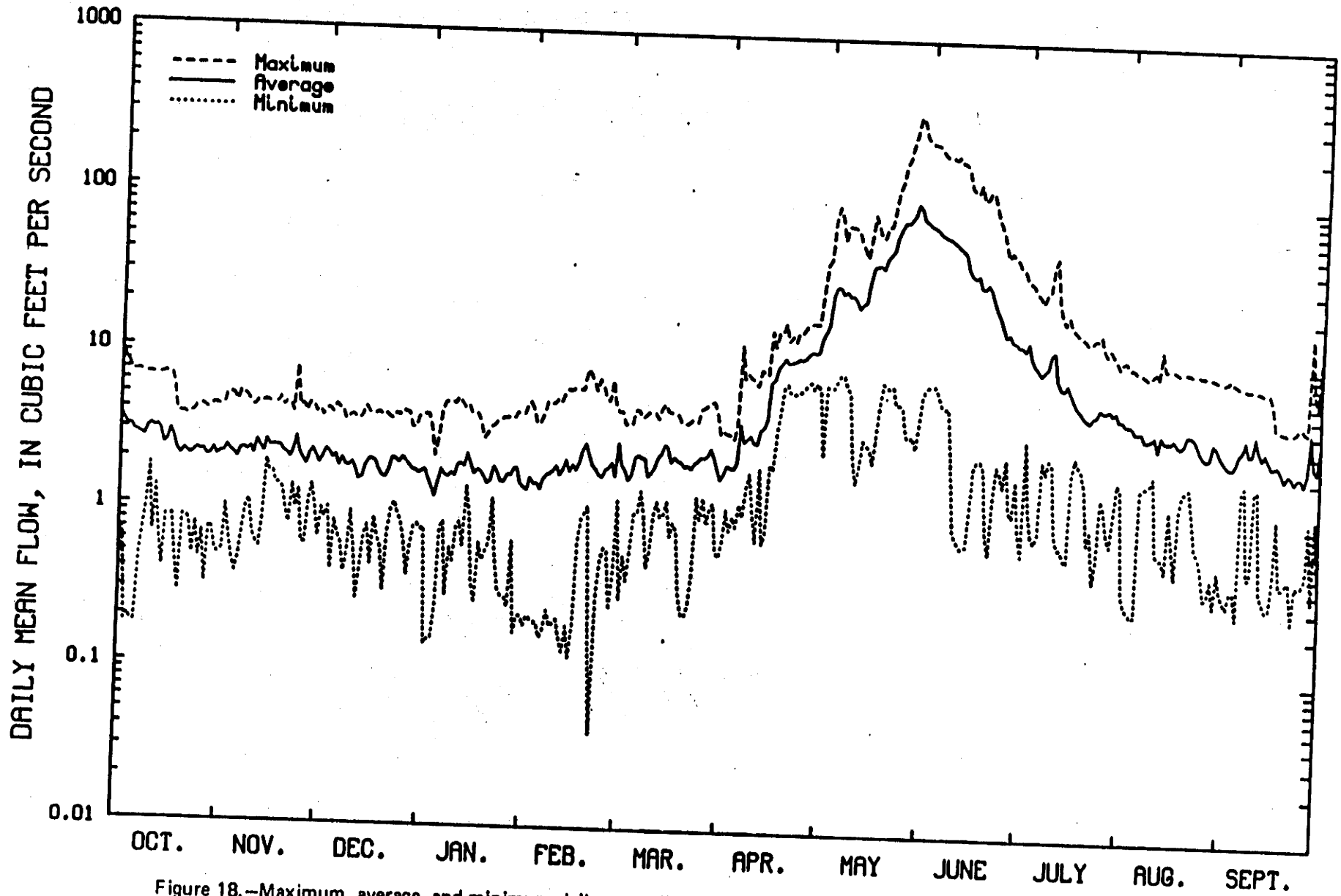


Figure 18.—Maximum, average, and minimum daily mean flow of Grassy Trail Creek at station 09314340, water years 1979-84.

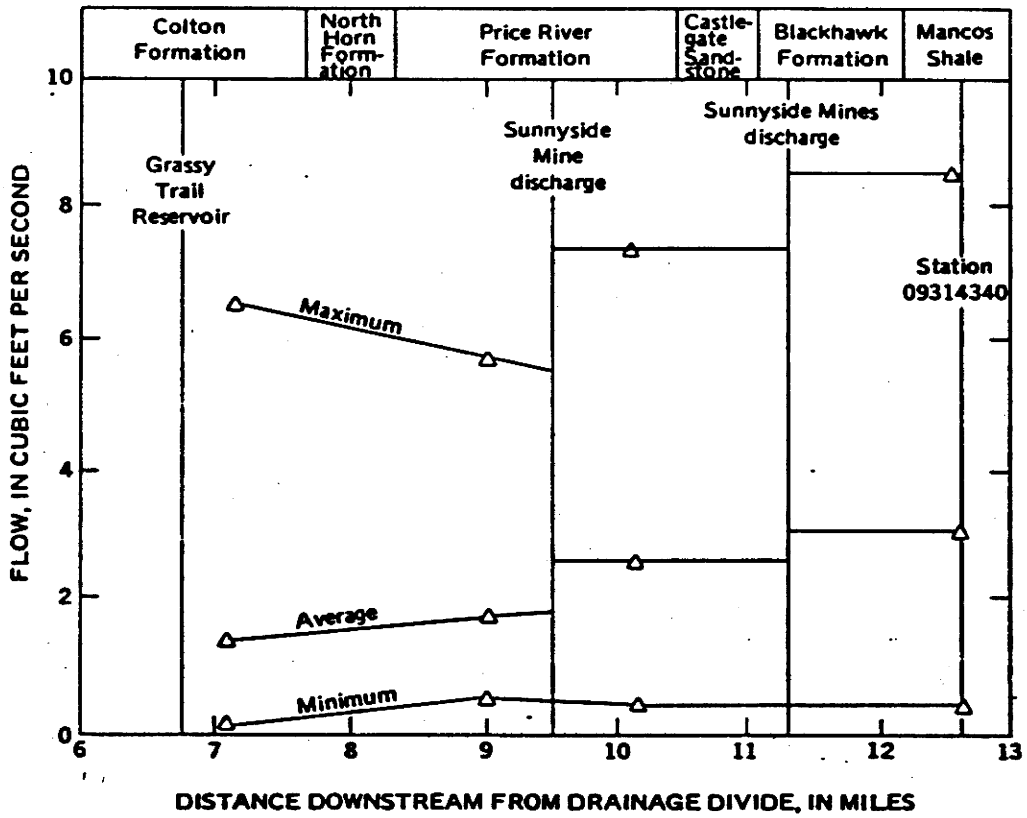


Figure 19.—Base flow of Grassy Trail Creek as related to geology (based on 10 measurements made at each site from August 1978 to September 1984).

Table 12.—Summary of chemical analyses of streamflow in Grassy Trail Creek at station 09314340, water years 1979-84

[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	49	10.8	0.15-204
Water temperature (degrees Celsius)	49	10.9	.0-23.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	49	1,420	510-2,600
pH (units)	49	—	8.1-9.1
Sodium-adsorption ratio	49	6.0	.6-14
Milligrams per liter			
Dissolved solids, sum of constituents	47	988	330-1,900
Oxygen, dissolved (O_2)	49	8.9	6.6-11.7
Carbon dioxide, dissolved (CO_2)	39	1.7	.6-3.9
Alkalinity ($CaCO_3$)	39	420	240-670
Bicarbonate (HCO_3)[1]	39	471	250-770
Carbonate (CO_3)[1]	39	22.3	.0-75
Nitrogen, dissolved (N)	14	0.62	.26-1.1
Nitrogen, organic dissolved (N)	10	.32	.16-0.63
Nitrogen, ammonia dissolved (N)	10	—	<.01-.210
Nitrogen, nitrite dissolved (N)	10	—	<.01-.040
Nitrogen, nitrate dissolved (N)	10	—	<.05-.35
Nitrogen, nitrite + nitrate dissolved (N)	23	—	<.01-.36
Phosphorus, dissolved (P)	13	—	<.01-.060
Phosphorus, ortho phosphates dissolved (P)	10	—	<.001-.040
Carbon, organic dissolved (C)	23	5.3	1.6-22
Hardness, (as $CaCO_3$)	49	302	220-420
Hardness, (as noncarbonate, $CaCO_3$)	39	10.4	.0-83
Calcium, dissolved (Ca)	49	44.9	24-76
Magnesium, dissolved (Mg)	49	45.9	33-64
Sodium, dissolved (Na)	49	216	23-530
Potassium, dissolved (K)	49	4.4	1.3-15
Chloride, dissolved (Cl)	49	23.8	2.6-77
Sulfate, dissolved (SO_4)	49	355	59-730
Fluoride, dissolved (F)	32	.52	.10-1.0
Silica, dissolved (SiO_2)	49	10.7	4.2-16

Table 12.—Summary of chemical analyses of streamflow in Grassy Trail Creek at station 09314340, water years 1979-84—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	18	—	<1-3
Barium, dissolved (Ba)	3	—	<100-100
Boron, dissolved (B)	32	—	<20-370
Cadmium, dissolved (Cd)	8	—	<1
Chromium, dissolved (Cr)	12	—	<10-40
Copper, dissolved (Cu)	8	—	<2-2.0
Iron, dissolved (Fe)	32	—	<10-40
Lead, dissolved (Pb)	12	—	<1-55
Lithium, dissolved (Li)	15	—	<10-80
Manganese, dissolved (Mn)	32	—	<1-30
Mercury, dissolved (Hg)	8	—	<.1-1.4
Nickel, dissolved (Ni)	8	—	<1-4.0
Selenium, dissolved (Se)	18	—	<1-2.0
Strontium, dissolved (Sr)	15	390	260-610
Zinc, dissolved (Zn)	17	—	<3-40
Phenols	20	—	<40

[1]Fixed-end-point determined by titration in the field.

Horse Canyon Creek

Horse Canyon creek originates near the crest of the Book Cliffs at an altitude of about 9,600 feet. The channel has cut a steep canyon through most of the formations shown in figure 1 as it descends steeply more than 3,000 feet to the base of the Book Cliffs near the Geneva Mine (pl. 1). Station 09314374 (pl. 1, table 1) is near the lower end of Horse Canyon at an altitude of about 6,200 feet.

The portal of the Geneva Mine (pl. 1) is in Horse Canyon, but the mine workings extend into adjacent drainage basins. The mine was in operation during monitoring at station 09314374. According to Lines and Plantz (1981, p. 32) an average of about 0.2 cubic feet per second may be discharged intermittently from the Geneva Mine to Horse Canyon creek just upstream from the station.

The annual mean flow in Horse Canyon creek at station 09314374 during the monitoring period ranged from 0.29 cubic feet per second during water year 1981 to 0.43 cubic feet per second during water year 1980 (table 3). Flow at the station is intermittent and quite variable as indicated in figure 20. The variation is due chiefly to intermittent discharge of water from the Geneva Mine to Horse Canyon creek. The maximum peak flow recorded was 93.0 cubic feet per second on September 5, 1981, which resulted from a thunderstorm.

Base-flow measurements along Horse Canyon creek (fig. 21) show that the creek was dry at least once at each site. The average values indicate some ground-water inflow to the creek from the Price River, Castlegate, or Blackhawk Formations. Both the average and maximum values, however, reflect the discharge of water to the creek from the Geneva Mine.

Most of the streamflow samples collected at station 09314374 for chemical analyses apparently were mostly or virtually all mine water. The dissolved-solids concentrations in 33 samples ranged from 970 to 4,200 milligrams per liter, with a mean of 1,890 milligrams per liter (table 13). Sodium and sulfate were the dominant ions in virtually all the samples. Strontium was found in concentrations as large as 2,000 micrograms per liter. Of the trace elements that were analyzed only manganese exceeded the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum concentration of manganese was 540 micrograms per liter, compared to a criterion of 50 micrograms per liter. The maximum phenol concentration was 5 micrograms per liter, compared to a criterion of 1 microgram per liter.

Suspended-sediment concentrations in 21 streamflow samples collected from Horse Canyon creek at station 09314374 during water years 1979-81 ranged from 2 milligrams per liter on January 16, 1981 to 2,270 milligrams per liter on May 4, 1981. The smaller concentrations reflect low-flow periods, whereas the larger concentrations generally reflect greater turbidity during periods of high flow resulting from snowmelt or thunderstorms. Calculated suspended-sediment loads ranged from less than 0.01 to 1.3 tons per day in water year 1979, from less than 0.01 to 0.29 tons per day during water year 1980, and from less than 0.01 to 2.0 tons per day during water year 1981. Coal was only 0.5 percent of the stream-bottom sediments sampled.

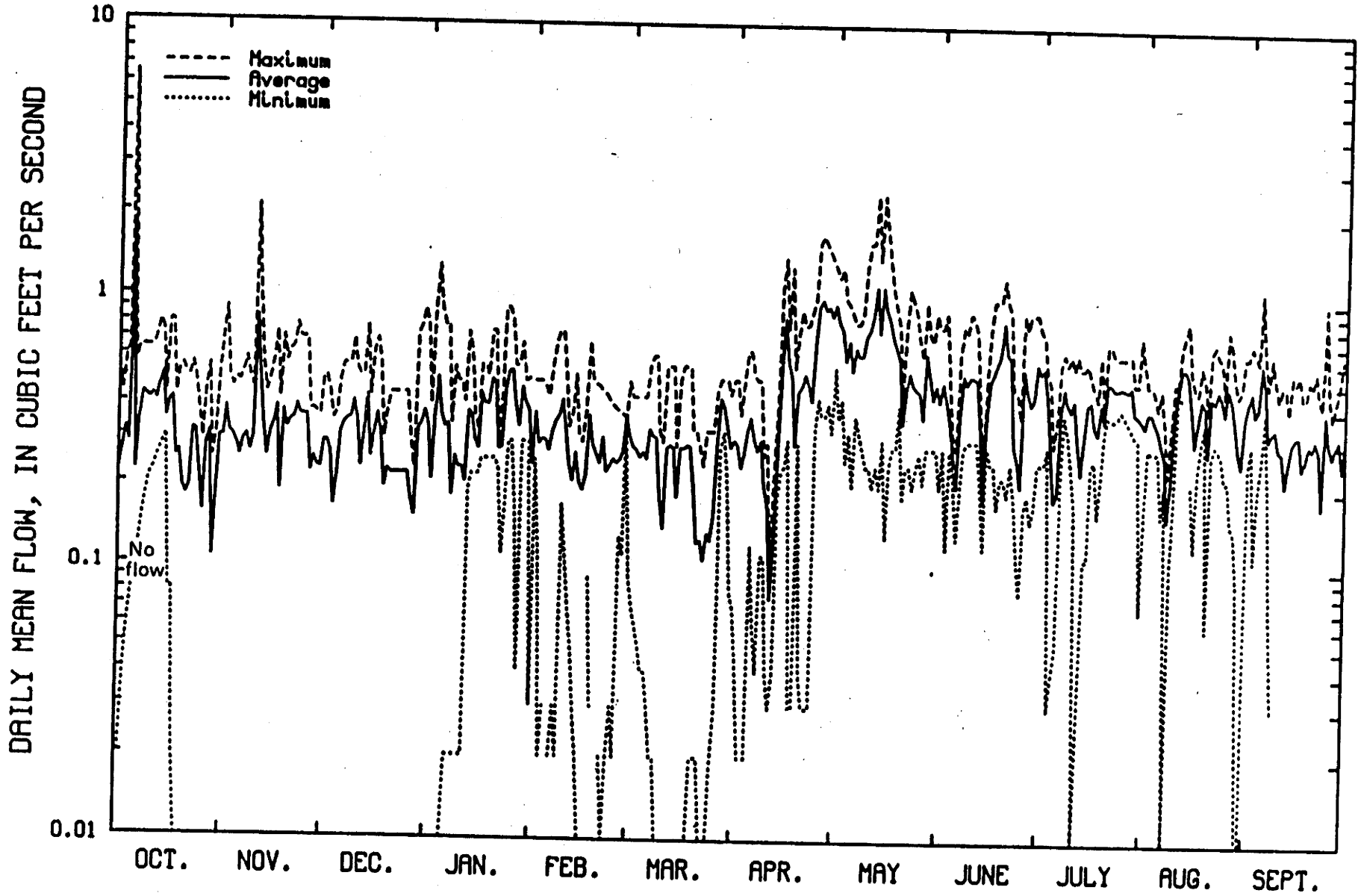


Figure 20.—Maximum, average, and minimum daily mean flow of Horse Canyon creek at station 09314374, water years 1979 81

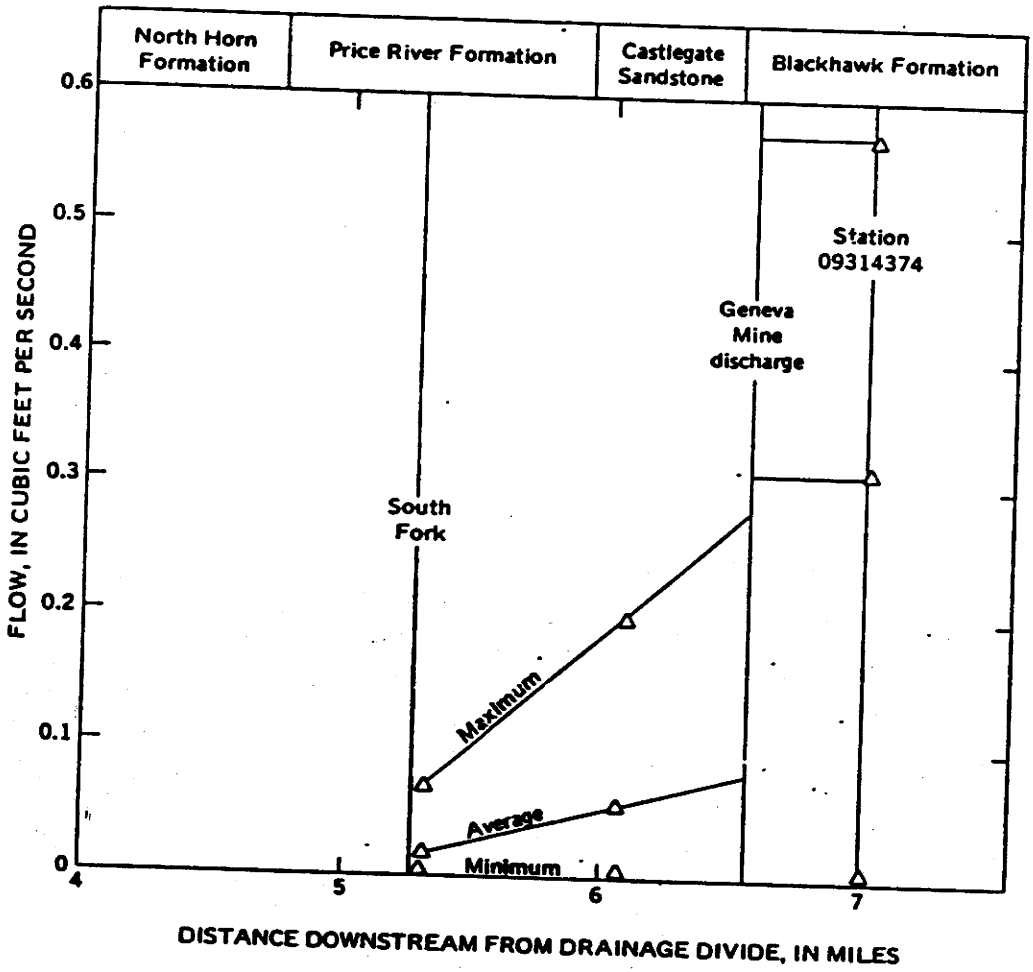


Figure 21.—Base flow of Horse Canyon creek as related to geology (based on 7 measurements made at each site from August 1978 to August 1981).

Table 13.—Summary of chemical analyses of streamflow in Horse Canyon creek at station 09314374, water year 1979-81
[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	33	0.34	0.01-0.61
Water temperature (degrees Celsius)	33	17.3	6.0-27.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	33	2,600	1,390-7,000
pH (units)	33	—	8.2-8.7
Sodium-adsorption ratio	33	6.1	1.0-12.0
Dissolved solids, sum of constituents	33	1,890	970-4,200
Oxygen, dissolved (O_2)	33	7.8	6.0-10.6
Carbon dioxide, dissolved (CO_2)	33	2.1	1.1-4.2
Alkalinity ($CaCO_3$)[1]	33	370	279-480
Bicarbonate (HCO_3)[1]	32	426	340-570
Carbonate (CO_3)[1]	32	13.9	.0-26.0
Nitrogen, dissolved (N)	9	1.25	.44-22.0
Nitrogen, organic dissolved (N)	7	.30	.05-.49
Nitrogen, ammonia dissolved (N)	7	—	<.01-.610
Nitrogen, nitrite dissolved (N)	7	—	<.01-.060
Nitrogen, nitrate dissolved (N)	7	—	<.13-1.20
Nitrogen, nitrite + nitrate dissolved (N)	11	.61	.13-1.20
Phosphorus, dissolved (P)	4	—	<.01-.050
Phosphorus, ortho phosphates dissolved (P)	7	—	<.001-.020
Carbon, organic dissolved (C)	11	6.4	1.4-18.0
Hardness, (as $CaCO_3$)	33	709	420-1,600
Hardness, (as noncarbonate, $CaCO_3$)	33	340	100-1,300
Calcium, dissolved (Ca)	33	93	51-210
Magnesium, dissolved (Mg)	33	116	65-260
Sodium, dissolved (Na)	33	359	130-1,000
Potassium, dissolved (K)	33	8.6	4.6-26
Chloride, dissolved (Cl)	33	80	18-1,500
Sulfate, dissolved (SO_4)	33	974	440-1,300
Fluoride, dissolved (F)	16	.30	.20-.50
Silica, dissolved (SiO_2)	33	11.3	7.1-16.0

Milligrams per

Table 13.—Summary of chemical analyses of streamflow in Horse Canyon creek at station 09314374, water year 1979-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	8	—	<1-2.0
Barium, dissolved (Ba)	2	—	100-100
Boron, dissolved (B)	16	—	<20-490
Cadmium, dissolved (Cd)	1	—	1
Chromium, dissolved (Cr)	6	—	<20
Copper, dissolved (Cu)	1	—	2
Iron, dissolved (Fe)	16	—	<10-<110
Lead, dissolved (Pb)	7	—	<1-47
Lithium, dissolved (Li)	9	—	<10-630
Manganese, dissolved (Mn)	16	—	<1-540
Mercury, dissolved (Hg)	1	—	<.1
Nickel, dissolved (Ni)	1	—	1
Selenium, dissolved (Se)	8	—	<1-5
Strontium, dissolved (Sr)	9	1,280	720-2,000
Zinc, dissolved (Zn)	9	—	<3-43
Phenols	10	—	<1-5

[1]Fixed-end-point determined by titration in the field.

Three samples of benthic invertebrates collected at station 09314374 during water year 1980 had about the same fair-to-poor diversity as those reported by Lines and Plantz, (1981, p. 35) for water year 1979. Three phytoplankton samples collected during water year 1981 (U.S. Geological Survey, 1982, p. 291) had a poor distribution of green algae, and a fairly uniform distribution of blue-green algae.

SAN RAFAEL RIVER BASIN

Huntington Creek, Crandall Canyon Creek, and Tie Fork

Huntington Creek originates on the Flagstaff Limestone at an altitude above 10,000 feet on the Wasatch Plateau. The creek has cut a deep, narrow canyon into the Flagstaff and the underlying Cretaceous formations shown on figure 1. It flows from its canyon into Castle Valley at about 5,000 feet, where it has incised the Mancos Shale. Stations 09317997 and 09318000 are on the Mancos Shale between 6,200 and 6,500 feet. Flow of the stream is regulated at several upstream reservoirs.

During the 1979 water year, monitoring was at station 09318000 (pl. 1, table 1), which was operated by Utah Power & Light Co. During the 1980 and 1981 water years, monitoring was at station 09317997 (pl. 1, table 1). Station 09317997 is 1.3 miles upstream from station 09318000, and the records of the two stations are virtually equivalent. The data collected at station 09318000 during the 1979 water year are summarized by Lines and Plantz (1981, p. 35-39). The data collected at station 09317997 during the 1980-81 water years are summarized in this report. All the data collected at both stations are published by ReMillard and others (1985, and previous editions of that report).

Crandall Canyon creek and Tie Fork, tributaries to Huntington Creek, also could be affected by coal mining. Those streams were monitored at gaging stations 09317919 and 09317920 (pl. 1, table 1). Station 09317919, which is near the mouth of Crandall Canyon, is on the Star Point Sandstone at an altitude of 7,350 feet. Station 09317920, which is near the mouth of Tie Fork, also is on the Star Point Sandstone; but it is at an altitude of about 7,400 feet. Both stations were operated continuously during the 1979 water year (see Lines and Plantz, 1981, p. 35) but only seasonally during the remainder of the monitoring period (table 1).

The Huntington Creek drainage basin is one of the more actively-mined parts of the central Utah coal-fields area. More than 20,000 acres in the basin were leased for coal mining in 1980, including the Deer Creek Mine. Most of the mine workings require dewatering, but available data indicate that a total of less than 1 cubic foot per second of mine water is discharged to Huntington Creek. The mine waters reportedly contain about 500-800 milligrams per liter of dissolved solids.

A potential exists for mine-related interbasin transfer of ground water between Huntington Creek basin and adjacent basins. For example, the Deer Creek Mine workings have been extended into the Cottonwood Creek basin, and workings of the Hiawatha Mine (pl. 1) have been extended from the Miller Creek

basin into the Huntington Creek basin. Also, workings of the Belina Nos. 1 and 2 Mines probably will extend from the Mud Creek basin into the Huntington Creek basin.

Lines and Plantz (1981, fig. 20) showed that most of the annual flow in Crandall Canyon creek during the 1979 water years was from mid May to early July, probably due to melting of high-altitude snow. Figure 22 of this report, which includes records for the 1979 water year and seasonal record for water years 1980-84, indicates that the peak seasonal flow begins in late April. During the 1979 water year, the mean flow in Crandall Canyon creek at station 09317919 was 2.19 cubic feet per second (table 3). The maximum peak flow recorded in Crandall Canyon creek at station 09317919 was 97.0 cubic feet per second on May 24, 1984, which resulted from snowmelt.

The dissolved-solids concentrations in 30 streamflow samples collected from Crandall Canyon creek at station 09317919 during August 1978-September 1984 ranged from 229 to 320 milligrams per liter, with a mean of 263 milligrams per liter (table 14). Calcium, magnesium, and bicarbonate were the dominant ions in all the samples. Concentrations of none of the trace elements that were analyzed exceeded the criteria established by the Environmental Protection Agency (1976) for drinking-water supplies. The maximum phenol concentration was 25 micrograms per liter, compared to a criteria of 1 microgram per liter.

The suspended-sediment concentrations of 12 samples obtained during the monitoring period ranged from 4 to 121 milligrams per liter. The calculated instantaneous suspended-sediment loads at station 09317919 ranged from 0.08 to 0.15 tons per day during water year 1979, 0.08 to 0.92 tons per day during water year 1980, and less than 0.01 to 0.25 tons per day during water year 1981. Stream-bottom sediment sampled during water years 1981 and 1982 consisted of less than 0.6 percent coal.

Samples of benthic invertebrates and phytoplankton collected at station 09317919 probably reflect the chemical quality of the streamflow (as described earlier) in Crandall Canyon creek. Two samples of the benthic invertebrates collected during water year 1980 (U.S. Geological Survey, 1981, p. 305) had good diversity, and five samples of phytoplankton collected during water year 1981 (U.S. Geological Survey, 1982, p. 313) displayed uniform distribution of green algae.

Streamflow in Tie Fork, as in Crandall Canyon creek, occurs chiefly from snowmelt. The flow per square mile in Tie Fork however, is much less than it is in Crandall Canyon creek (table 3) because the Crandall Canyon creek basin generally is higher and receives more precipitation than the Tie Fork basin.

Station 09317920 (pl. 1, table 1), which is near the mouth of Tie Fork was operated continuously during the 1979 water year. The mean flow for that period was 2.04 cubic feet per second. The maximum, minimum, and average daily mean flow (fig. 23) reflects maximum snowmelt runoff during late April-June. The maximum peak flow was 29.0 cubic feet per second on April 30, 1980, which resulted from snowmelt.

The dissolved-solids concentrations in 22 streamflow samples collected from Tie Fork at station 09317920 during water years 1979-81 ranged from 240

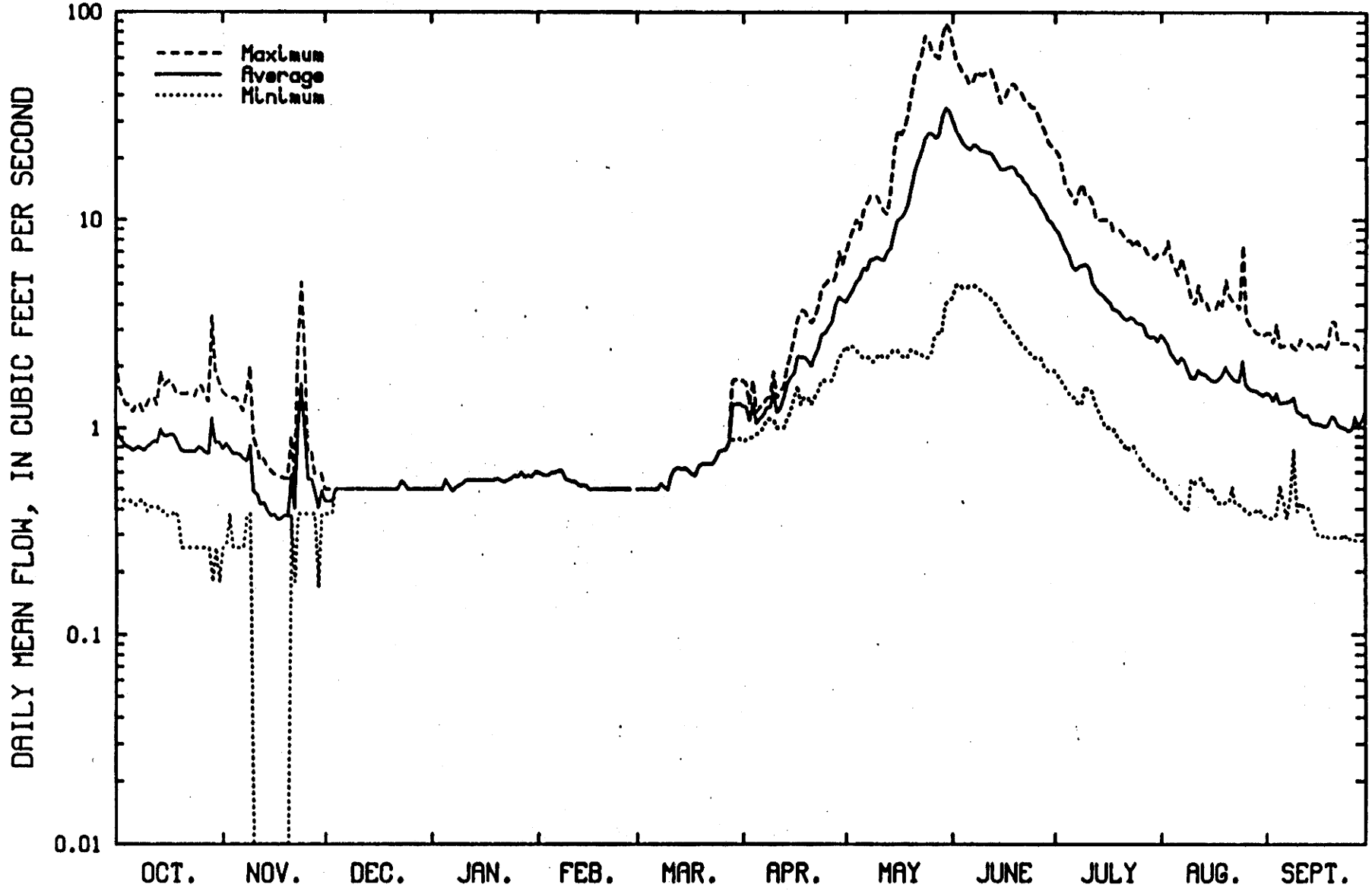


Figure 22.—Maximum, average, and minimum daily mean flow of Crandall Canyon creek at station 09317919, complete record for water year 1979 and seasonal record for water years 1980-84.

Table 14.—Summary of chemical analyses of streamflow in Crandall Canyon creek at station 09317919, water years 1979-84

[<indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	30	4.7	0.38-49
Water temperature (degrees Celsius)	30	11.5	.0-25.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	30	464	350-580
pH (units)	30	—	8.1-8.7
Sodium-adsorption ratio	30	.12	.1-.3
Milligrams per liter			
Dissolved solids, sum of constituents	30	263	229-320
Oxygen, dissolved (O_2)	30	8.8	7.1-111
Carbon dioxide, dissolved (CO_2)	20	1.3	.7-2.5
Alkalinity ($CaCO_3$)	20	226	195-280
Bicarbonate (HCO_3)[1]	20	262	230-330
Carbonate (CO_3)[1]	20	7.8	.0-20
Nitrogen, dissolved (N)	10	.50	.19-1.1
Nitrogen, organic dissolved (N)	6	.38	.14-1.1
Nitrogen, ammonia dissolved (N)	6	—	<.01-0.070
Nitrogen, nitrite dissolved (N)	6	—	<.010
Nitrogen, nitrate dissolved (N)	6	—	<.05-.05
Nitrogen, nitrite + nitrate dissolved (N)	18	—	<.01-.20
Phosphorus, dissolved (P)	12	—	<.01-.060
Phosphorus, ortho phosphates dissolved (P)	6	—	<.001-.010
Carbon, organic dissolved (C)	18	3.8	1.4-8.2
Hardness, (as $CaCO_3$)	31	248	230-300
Hardness, (as noncarbonate, $CaCO_3$)	20	31.7	12-57
Calcium, dissolved (Ca)	30	55.4	48-63
Magnesium, dissolved (Mg)	30	28.4	21-35
Sodium, dissolved (Na)	30	5.2	4.2-6.7
Potassium, dissolved (K)	30	1.4	.50-4.1
Chloride, dissolved (Cl)	30	4.6	3.4-6.3
Sulfate, dissolved (SO_4)	30	32.3	20-43
Fluoride, dissolved (F)	23	.13	.10-.20
Silica, dissolved (SiO_2)	30	6.0	4.8-7.0

Table 14.—Summary of chemical analyses of streamflow in Crandall Canyon creek at station 09317919, water years 1979-84

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	15	—	<1-2.0
Barium, dissolved (Ba)	5	—	<100
Boron, dissolved (B)	23	—	<10-60
Cadmium, dissolved (Cd)	9	—	<1
Chromium, dissolved (Cr)	12	—	<10-10
Copper, dissolved (Cu)	9	—	<2
Iron, dissolved (Fe)	23	—	<3-10
Lead, dissolved (Pb)	14	—	<1-15
Lithium, dissolved (Li)	11	—	<10-30
Manganese, dissolved (Mn)	23	—	<1-17
Mercury, dissolved (Hg)	9	—	<1-.9
Nickel, dissolved (Ni)	9	—	<1-10
Selenium, dissolved (Se)	15	—	<1-1
Strontium, dissolved (Sr)	11	195	180-220
Zinc, dissolved (Zn)	15	—	<3-82
Phenols	15	—	<1-25

[1]Fixed-end-point determined by titration in the field.

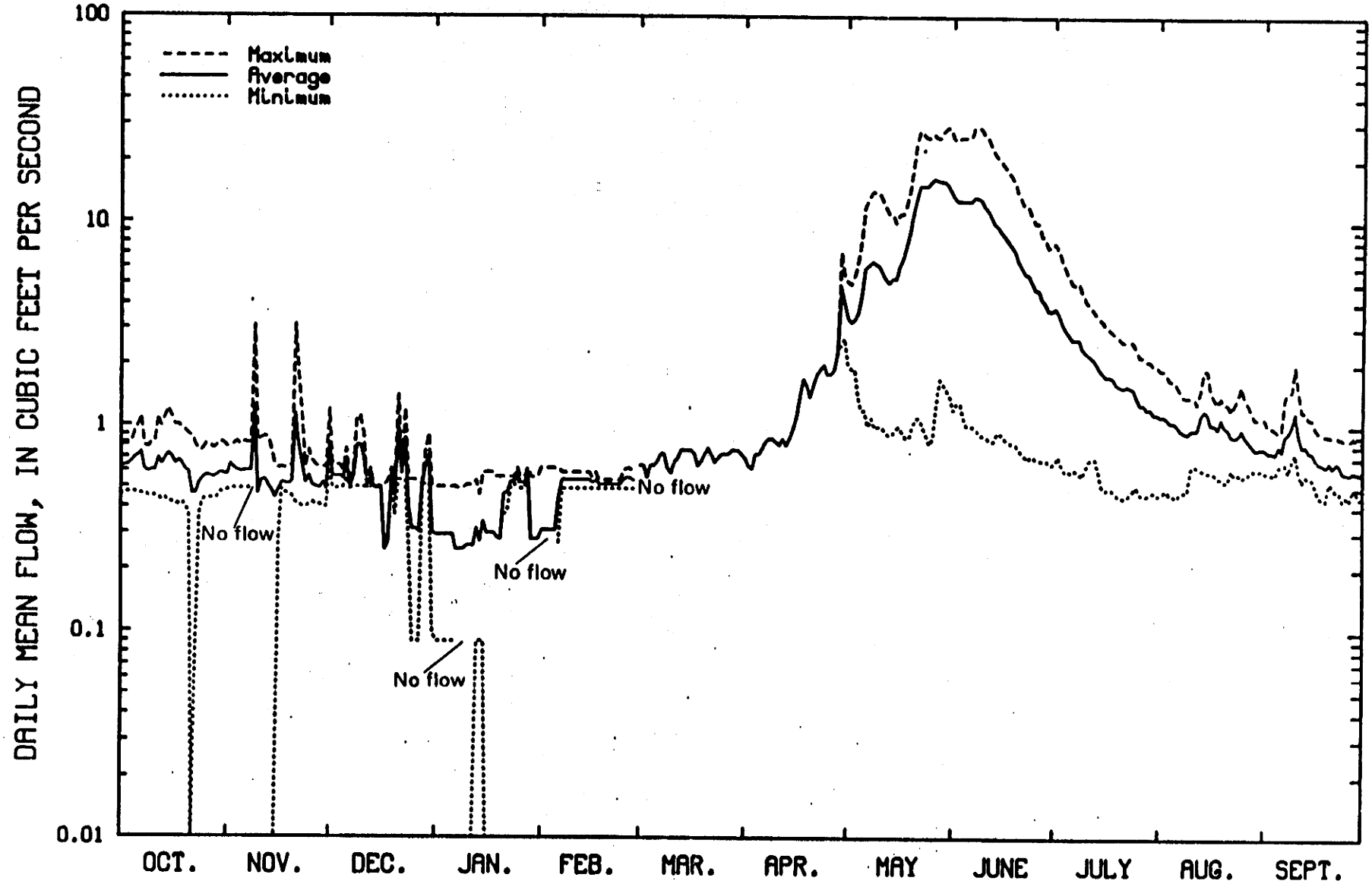


Figure 23.—Maximum, average, and minimum daily mean flow of Tie Fork at station 09317920, complete record for water year 1979 and seasonal record for water years 1980-81.

to 330 milligrams per liter, with a mean of 287 milligrams per liter (table 15). Calcium and magnesium were the dominant dissolved cations, and bicarbonate was the dominant dissolved anion. None of the trace elements were found in concentrations that exceeded the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum phenol concentration was 39 micrograms per liter, compared to a criterion of 1 microgram per liter.

The suspended-sediment concentrations in 13 streamflow samples collected at station 09317920 during the 1979-81 water years ranged from 2 milligrams per liter on January 26, 1981, to 648 milligrams per liter on May 25, 1980. The calculated instantaneous suspended-sediment loads at the station ranged from 0.12 to 0.17 tons per day during water year 1979, 0.03 to 45 tons per day during water year 1980, and less than 0.01 to 0.12 tons per day during water year 1981. Coal was 0.5 percent of the stream-bottom sediments sampled at the station.

Two samples of benthic invertebrates collected at station 09317920 during the 1980 water year had fairly good diversity (U.S. Geological Survey, 1981, p. 310), reflecting an apparently unpolluted stream-bottom environment at the site during sampling. Five phytoplankton samples collected during water year 1981 had a fairly uniform distribution of green algae (U.S. Geological Survey, 1982, p. 318).

Station 09317997 was operated continuously during water years 1980 and 1981 (table 1). The annual mean flow ranged from 63 cubic feet per second during water year 1981 to 112 cubic feet per second in water year 1980 (table 3). Maximum, minimum, and average daily mean flow recorded at the station is shown in figure 24.

Base-flow measurements in Huntington Creek were made upstream from station 09318000 during August 1978-August 1981. The results of those measurements, which are related to geology in figure 25, indicate negligible gain or loss of flow as the stream crosses the Mancos Shale or the Star Point Sandstone. Discharge from the Deer Creek Mine did not reach the stream during 1979 (Lines and Plantz 1981, p. 35); therefore, it was assumed not to have done so during the entire period of base-flow measurements.

The chemical analyses of 25 streamflow samples collected from Huntington Creek at station 09317997 during October 1979-September 1981 are summarized in table 16. Dissolved-solids concentrations ranged from 160 to 270 milligrams per liter, with a mean of 218 milligrams per liter. The dominant cation was calcium and the dominant anion was bicarbonate. None of the trace elements that were analyzed were found in concentrations that exceeded the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum phenol concentration was 14 micrograms per liter, compared to a criterion of 1 microgram per liter.

Suspended-sediment data were collected at station 09317997 during the 1980 and 1981 water years. Suspended-sediment concentrations in 23 streamflow samples collected ranged from 5 to 1,830 milligrams per liter. The calculated instantaneous suspended-sediment loads at the station ranged from 2.2 to 1,830 tons per day during the 1980 water year, and from 0.39 to 529 tons per day

Table 15.—Summary of chemical analyses of streamflow in Tie Fork at station 09317920, water years 1979-81
[<indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	22	2.4	0.38-26
Water temperature (degrees Celsius)	22	7.9	.0-14.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	22	488	425-580
pH (units)	22	—	8.2-8.7
Sodium-adsorption ratio	22	0.08	.0-.1
Milligrams per liter			
Dissolved solids, sum of constituents	22	287	240-330
Oxygen, dissolved (O_2)	22	9.3	7.9-11.4
Carbon dioxide, dissolved (CO_2)	21	1.5	.8-3.3
Alkalinity ($CaCO_3$)	21	234	205-280
Bicarbonate (HCO_3)[1]	21	262	230-340
Carbonate (CO_3)[1]	21	7.0	.0-16
Nitrogen, dissolved (N)	7	.74	.32-2.0
Nitrogen, organic dissolved (N)	6	.32	.12-.52
Nitrogen, ammonia dissolved (N)	6	—	<.01-.06
Nitrogen, nitrite dissolved (N)	6	—	<.01-.01
Nitrogen, nitrate dissolved (N)	6	.37	.09-1.4
Nitrogen, nitrite + nitrate dissolved (N)	9	.30	.09-1.4
Phosphorus, dissolved (P)	3	.02	.01-.02
Phosphorus, ortho phosphates dissolved (P)	6	—	<.001-.040
Carbon, organic dissolved (C)	9	7.2	1.2-21
Hardness, (as $CaCO_3$)	22	266	220-310
Hardness, (as noncarbonate, $CaCO_3$)	21	31.9	8.0-56
Calcium, dissolved (Ca)	22	57	49-70
Magnesium, dissolved (Mg)	22	30	18-36
Sodium, dissolved (Na)	22	4.2	3.0-5.3
Potassium, dissolved (K)	22	1.7	1.0-4.6
Chloride, dissolved (Cl)	22	4.9	3.6-9.8
Sulfate, dissolved (SO_4)	22	34	18-41
Fluoride, dissolved (F)	14	.1	.1-.2
Silica, dissolved (SiO_2)	22	6.2	4.8-7.0

Table 15.—Summary of chemical analyses of streamflow in Tie Fork at station 09317920, water years 1979-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	9	—	<1-2.0
Barium, dissolved (Ba)	2	—	<100
Boron, dissolved (B)	14	—	<10-60
Cadmium, dissolved (Cd)	3	—	<1
Chromium, dissolved (Cr)	7	—	<20
Copper, dissolved (Cu)	3	—	<2-2
Iron, dissolved (Fe)	14	—	<10-40
Lead, dissolved (Pb)	8	—	<1-19
Lithium, dissolved (Li)	8	—	<10-30
Manganese, dissolved (Mn)	14	—	<10
Mercury, dissolved (Hg)	3	—	.10
Nickel, dissolved (Ni)	3	—	.0-<1
Selenium, dissolved (Se)	8	—	<1-1
Strontium, dissolved (Sr)	8	232	200-260
Zinc, dissolved (Zn)	9	—	<3-50
Phenols	9	11	1-39

[1]Fixed-end-point determined by titration in the field.

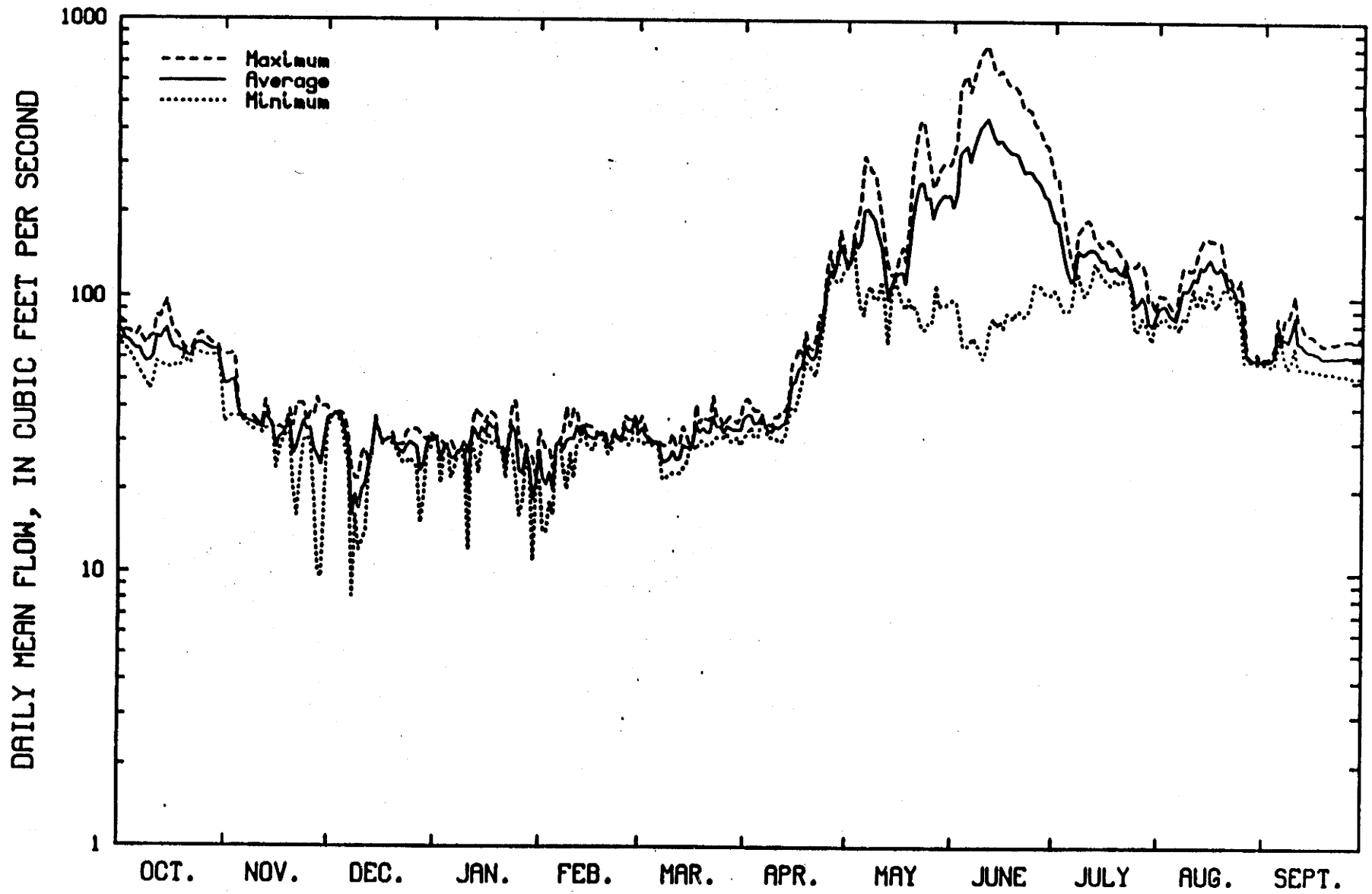


Figure 24.—Maximum, average, and minimum daily mean flow of Huntington Creek at station 09317997, water years 1980 81.

Table 16.—Summary of chemical analyses of streamflow in Buntington Creek at station 09317997, water years 1980-81
[<indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	25	87	16-374
Water temperature (degrees Celsius)	25	7.1	0.0-16.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	25	379	290-470
pH (units)	25	—	8.1-8.7
Sodium-adsorption ratio	25	0.1	.0-0.2
Milligrams per liter			
Dissolved solids, sum of constituents	25	218	160-270
Oxygen, dissolved (O_2)	25	9.8	7.7-11.6
Carbon dioxide, dissolved (CO_2)	24	1.4	.5-3.2
Alkalinity ($CaCO_3$)	24	188	150-230
Bicarbonate (HCO_3)[1]	24	221	170-270
Carbonate (CO_3)[1]	24	—	.0-8.0
Nitrogen, dissolved (N)	11	.62	.30-1.0
Nitrogen, organic dissolved (N)	7	.42	.27-.76
Nitrogen, ammonia dissolved (N)	7	—	<.01-.030
Nitrogen, nitrite dissolved (N)	7	—	<.01-.010
Nitrogen, nitrate dissolved (N)	7	—	<.05-.30
Nitrogen, nitrite + nitrate dissolved (N)	11	—	<.01-.30
Phosphorus, dissolved (P)	4	—	<.01-.30
Phosphorus, ortho phosphates dissolved (P)	7	—	<.001-.010
Carbon, organic dissolved (C)	11	9.3	2.2-36.0
Hardness, (as $CaCO_3$)	25	193	110-250
Hardness, (as noncarbonate, $CaCO_3$)	24	14.0	.0-34.0
Calcium, dissolved (Ca)	25	50	38-59
Magnesium, dissolved (Mg)	25	17	11-24
Sodium, dissolved (Na)	25	4.4	2.5-7.3
Potassium, dissolved (K)	25	1.2	.6-1.5
Chloride, dissolved (Cl)	25	4.3	1.7-8.2
Sulfate, dissolved (SO_4)	25	—	<1.0-39.0
Fluoride, dissolved (F)	20	.1	.1-.2
Silica, dissolved (SiO_2)	25	3.8	2.5-6.0

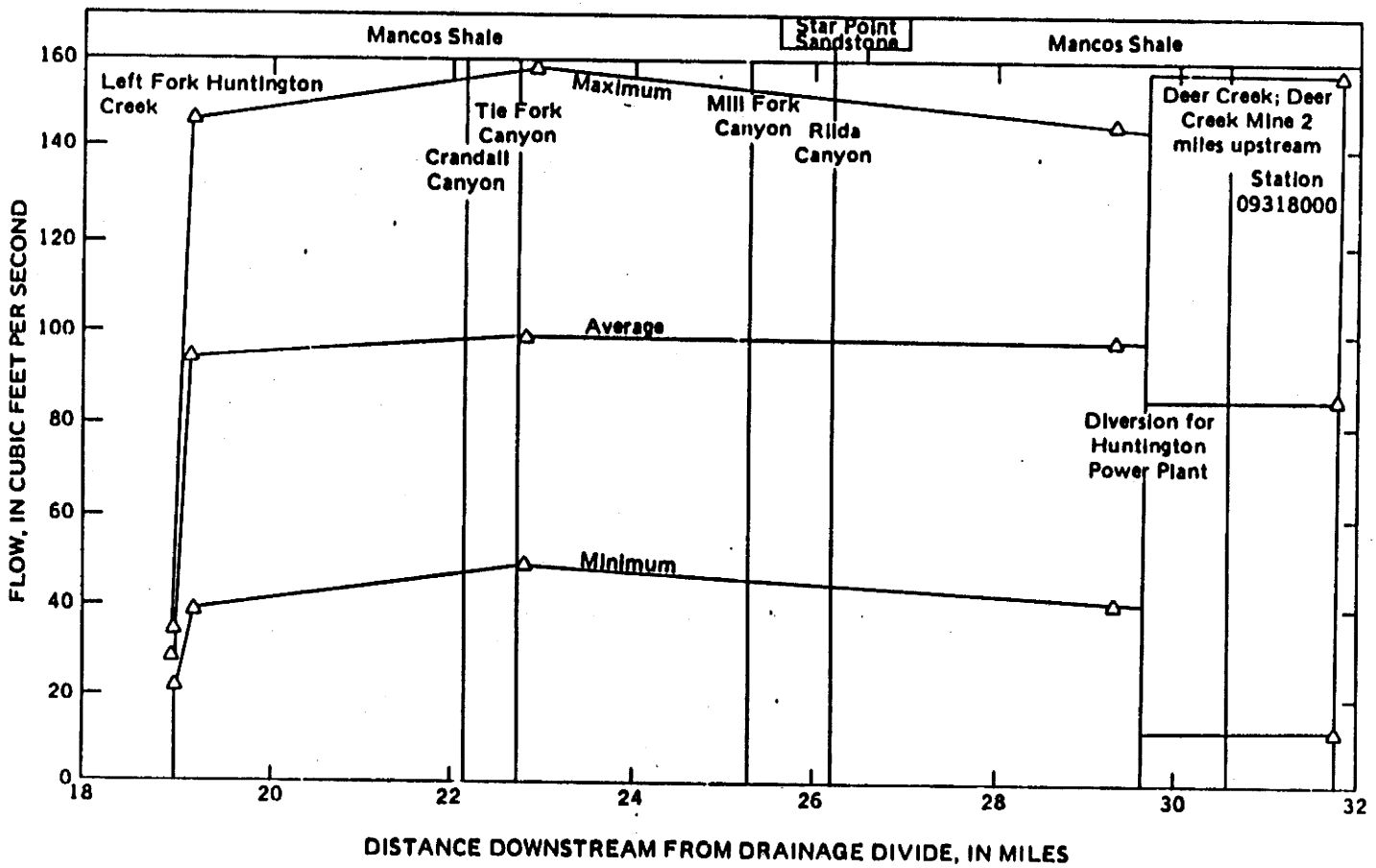


Figure 25.—Base flow of Huntington Creek as related to geology (based on 8 measurements made at each site from August 1978 to August 1981; the maximum value at station 09318000 reflects overflow from a small storage pond).

Table 16.—Summary of chemical analyses of streamflow in Huntington Creek at station 09317997, water years 1980-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	9	—	<1.0-2.0
Barium, dissolved (Ba)	2	—	<100-200
Boron, dissolved (B)	20	—	<10-160
Cadmium, dissolved (Cd)	2	—	<1
Chromium, dissolved (Cr)	9	—	<10-20
Copper, dissolved (Cu)	2	—	1-1
Iron, dissolved (Fe)	20	—	<10-110
Lead, dissolved (Pb)	9	—	<1.0-1
Lithium, dissolved (Li)	9	—	<10-30
Manganese, dissolved (Mn)	20	7.1	4.0-32.0
Mercury, dissolved (Hg)	2	—	<.1
Nickel, dissolved (Ni)	2	1.5	1.0-2.0
Selenium, dissolved (Se)	9	—	<1-1.0
Strontium, dissolved (Sr)	9	133	110-170
Zinc, dissolved (Zn)	9	—	<3-7.0
Phenols	11	—	<1-14

[1]Fixed-end-point determined by titration in the field.

during the 1981 water year. Coal was 1.2 percent of the stream-bottom samples.

Six samples of benthic invertebrates collected at station 09317997 during the 1980 and 1981 water years (U.S. Geological Survey, 1981, p. 315; 1982, p. 326), and the benthic invertebrates collected at station 09318000 during the 1979 water year (Lines and Plantz, 1981, p. 39), all apparently reflect the excellent chemical quality of water in Huntington Creek (table 16). Three samples of phytoplankton were collected at station 09317997 during water years 1980 and 1981. Green algae were well distributed in most early summer samples, but blue-green algae was more dominant in the August (low-flow) samples.

Cottonwood Creek

Cottonwood Creek originates on the Flagstaff Limestone at an altitude of about 10,500 feet on the Wasatch Plateau. It has cut a deep, narrow canyon through the Cretaceous formations shown in figure 1, and where it emerges from the canyon into Castle Valley it is flowing over the Mancos Shale at an altitude of about 6,000 feet. The lower reach of the creek receives most of its flow by releases from Joes Valley Reservoir through Straight Canyon. Station 09324200 (pl. 1, table 1) is upstream from the confluence with Straight Canyon, but it is several hundred feet downstream from the Trail Mountain Mine (pl. 1). At the station, Cottonwood Creek is flowing on the Star Point Sandstone at an altitude of 6,940 feet.

The Trail Mountain Mine was placed in operation several years before station 09324200 was installed, and the land leveling required for mine-portal facilities left considerable loose silt and soil adjacent to Cottonwood Creek. The mine was in operation during the monitoring period, but apparently it did not discharge water into Cottonwood Creek. Some workings of the Deer Creek Mine (pl. 1) advanced from the Huntington Creek basin into the Cottonwood Creek basin during the monitoring period.

Data collected at station 09324200 during the 1979-81 water years (table 1) supplement streamflow and water-quality data collected at the long-term gaging station 09324500, which is about 3 miles downstream from the confluence with Straight Canyon (pl. 1). (See ReMillard and others, 1985, p. 185.) The mean flow recorded at station 09324200 during the 1979 water year was 0.87 cubic feet per second (table 1). This is less than 1 percent of the corresponding flow recorded at station 09324500. The maximum, minimum, and average daily mean flow of Cottonwood Creek at station 09324200 is shown in figure 26. Much of the flow is from late May to early July, chiefly in response to snowmelt on the Wasatch Plateau. The maximum peak flow recorded was only 22.0 cubic feet per second on June 5, 1980, and the minimum was zero (table 3).

A series of base-flow measurements (generally two sets per year) were made along Cottonwood Creek upstream from station 09324200 during August 1978-August 1981. The results of those measurements are related to geology in figure 27. The stream seems to gain some flow where it crosses the Blackhawk Formation. The minimum flow line, however, indicates some loss from the stream.

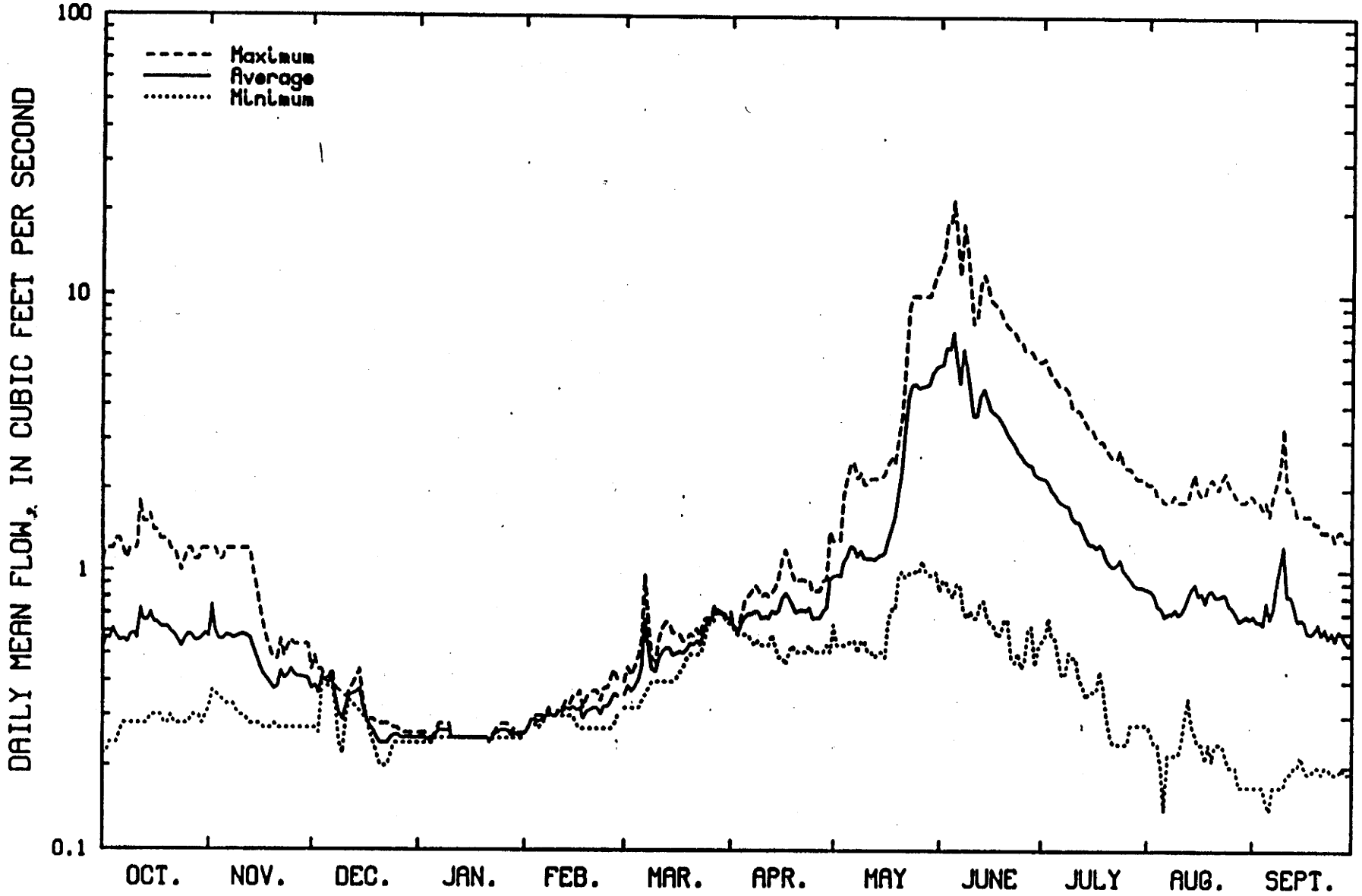


Figure 26.—Maximum, average, and minimum daily mean flow of Cottonwood Creek at station 09324200, complete record for water year 1979 and seasonal record for water years 1980-81.

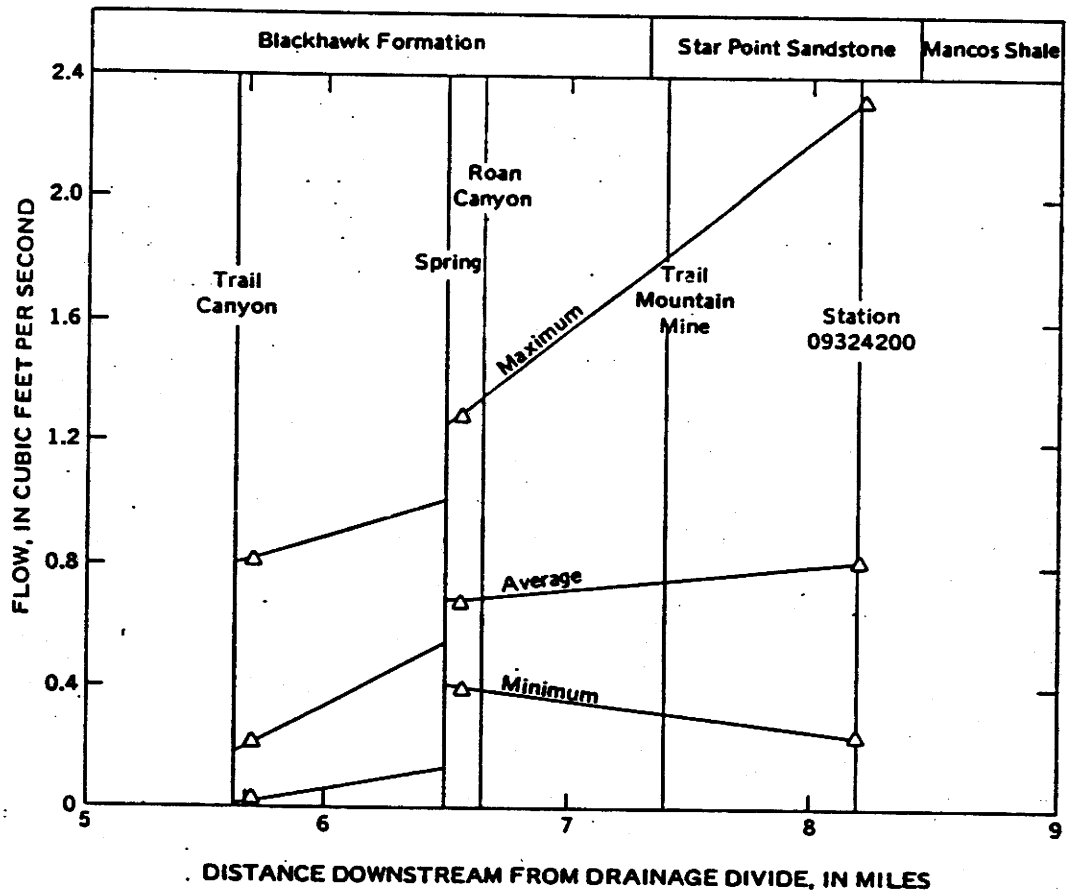


Figure 27.—Base flow of Cottonwood Creek as related to geology (based on 7 measurements made at each site from August 1978 to August 1981).

Chemical analyses of 22 streamflow samples collected at station 09324200 during the 1979-81 water years are summarized in table 17. The dissolved-solids concentrations ranged from 290 to 460 milligrams per liter, with a mean of 350 milligrams per liter. Magnesium and calcium were the dominant cations while bicarbonate was the dominant anion. Of the trace elements that were analyzed, lead and manganese were found in concentrations that exceed the criteria established by the U.S. Environmental Protection Agency (1976), for drinking-water supplies. The maximum concentration of lead and manganese was 130 and 110 micrograms per liter, compared to the criteria of 50 micrograms per liter for both ions. The maximum concentration of phenol was 13 micrograms per liter, compared to a criterion of 1 microgram per liter.

Suspended-sediment data were collected at station 09324200 during the 1979 water year, and according to Lines and Plantz (1981, p. 44) the instantaneous suspended-sediment loads ranged from 0.01 to 0.20 tons per day. The suspended-sediment concentrations in 13 streamflow samples collected during the 1980 and 1981 water years ranged from 4 milligrams per liter in June and August 1981 to 1,270 milligrams per liter on November 10, 1980. Calculated instantaneous suspended-sediment loads ranged from 0.21 to 32 tons per day during the 1980 water year, and from less than 0.01 to 0.51 tons per day during the 1981 water year. Stream-bottom sediments consisted of as much as 4.4 percent coal.

Two samples of benthic invertebrates were collected at station 09324200 during the 1980 water year (U.S. Geological Survey, 1981, p. 323) and five samples of phytoplankton were collected during the 1981 water year (U.S. Geological Survey, 1982, p. 335). The benthic invertebrates collected during water year 1980 had good diversity, as did the two samples collected during water year 1979 (Lines and Plantz, 1981, p. 44). The phytoplankton samples contained a uniform distribution of green algae, but some blue-green algae was observed in August and September (low flow) samples.

DIRTY DEVIL RIVER BASIN

Quitchupah Creek, Convulsion Canyon Creek, and Christiansen Wash

Quitchupah Creek originates on the southern part of the Wasatch Plateau at an altitude of about 10,800 feet. It heads on the Flagstaff Limestone and has cut a canyon through the Cretaceous formations shown in figure 1. Station 09331900 (pl. 1, table 1) is on the coal-bearing Ferron Sandstone Member of the Mancos Shale at an altitude of 5,900 feet.

Convulsion Canyon creek and Christiansen Wash are tributaries of Quitchupah Creek. Convulsion Canyon creek originates on the Flagstaff Limestone at an altitude of about 9,000 feet. It cuts through the coal-bearing Blackhawk Formation and joins Quitchupah Creek at an altitude of about 6,600 feet. Station 09331850 on Convulsion Canyon creek (pl. 1, table 1) is at an altitude of 7,120 feet. Christiansen Wash originates on the Castlegate Sandstone at an altitude of about 8,800 feet. It cuts through the older Cretaceous formations shown in figure 1 and joins Quitchupah Creek at an altitude of about 5,900 feet. Station 09331950 on Christiansen Wash (pl. 1, table 1) is upstream from the confluence with Quitchupah Creek at an altitude

Table 17.—Summary of chemical analyses of streamflow in Cottonwood Creek at station 09324200, water years 1979-81
[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	22	1.6	0.20-11.0
Water temperature (degrees Celsius)	22	11.7	.0-21.5
Specific conductance (microsiemens per centimeter at 25° Celsius)	22	573	500-660
pH (units)	22	—	8.3-8.9
Sodium-adsorption ratio	22	0.5	.3-0.5
Milligrams per liter			
Dissolved solids, sum of constituents	22	350	290-460
Oxygen, dissolved (O_2)	22	8.8	6.8-11.6
Carbon dioxide, dissolved (CO_2)	21	1.3	.6-3.3
Alkalinity ($CaCO_3$)	21	262	197-440
Bicarbonate (HCO_3)[1]	21	299	240-520
Carbonate (CO_3)[1]	21	11.6	.0-24
Nitrogen, dissolved (N)	7	.72	.22-1.10
Nitrogen, organic dissolved (N)	6	.34	.13-.68
Nitrogen, ammonia dissolved (N)	6	—	<.01-.070
Nitrogen, nitrite dissolved (N)	6	—	<.01-.01
Nitrogen, nitrate dissolved (N)	6	.24	.08-.34
Nitrogen, nitrite + nitrate dissolved (N)	9	.28	.08-.52
Phosphorus, dissolved (P)	3	.01	.01-.02
Phosphorus, ortho phosphates dissolved (P)	6	—	<.001-.040
Carbon, organic dissolved (C)	9	6.2	1.5-19
Hardness, (as $CaCO_3$)	22	287	250-340
Hardness, (as noncarbonate, $CaCO_3$)	21	32.5	.0-61
Calcium, dissolved (Ca)	22	48	34-67
Magnesium, dissolved (Mg)	22	40	31-47
Sodium, dissolved (Na)	22	17	13-22
Potassium, dissolved (K)	22	2.3	.8-6.1
Chloride, dissolved (Cl)	22	11.6	8.5-19
Sulfate, dissolved (SO_4)	22	57	40-80
Fluoride, dissolved (F)	14	.1	.1-.2
Silica, dissolved (SiO_2)	22	6.8	5.8-7.2

Table 17.—Summary of chemical analyses of streamflow in Cottonwood Creek at station 09324200, water years 1979-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	9	—	<1-2.0
Barium, dissolved (Ba)	2	—	<100
Boron, dissolved (B)	14	48	20-200
Cadmium, dissolved (Cd)	3	—	<1
Chromium, dissolved (Cr)	6	—	<10-10
Copper, dissolved (Cu)	3	—	<2-2.0
Iron, dissolved (Fe)	14	—	<10-30
Lead, dissolved (Pb)	8	—	<1-130
Lithium, dissolved (Li)	8	—	<10-40
Manganese, dissolved (Mn)	14	—	<2-20
Mercury, dissolved (Hg)	3	—	<.1
Nickel, dissolved (Ni)	3	—	<1
Selenium, dissolved (Se)	9	—	1
Strontium, dissolved (Sr)	8	342	300-390
Zinc, dissolved (Zn)	9	—	<3-10
Phenols	9	—	<1-13

[1]Fixed-end-point determined by titration in the field.

of 5,920 feet. The confluence of Convulsion Canyon creek and Christiansen Wash with Quitchupah Creek are on the coal-bearing Ferron Sandstone Member of the Mancos Shale.

More than 6,000 acres of Federal coal have been leased in the Quitchupah Creek basin upstream from stations 09331850, 09331900, and 09331950 (pl. 1). The Convulsion Canyon Mine, upstream from station 09331850, was producing coal from the Blackhawk Formation during the complete monitoring period at that station. The Emery Mine was producing coal from the Ferron Sandstone Member during the monitoring periods at stations 09331900 and 09331950.

According to Waddell and others (1981, table 8), as much as 0.2 cubic feet per second of unconsummed mine water containing about 275 milligrams per liter of dissolved-solids has been discharged intermittently from the Convulsion Canyon Mine to Convulsion Canyon creek. The dominant ions in water from the Convulsion Canyon Mine were magnesium, calcium, and bicarbonate.

According to Lines and Plantz (1981, p. 47), an average of 0.7 cubic feet per second of unconsummed mine water was discharged in 1979 from the Emery Mine to Quitchupah Creek. The water discharged from the Emery Mine is of poor chemical quality. Three samples collected during 1976 and 1979 showed a range of dissolved solids from 3,040-5,100 milligrams per liter (Lines and Plantz, 1981, p. 47). The predominant dissolved ions were sodium and sulfate.

Seasonal records were collected at station 09331850 on Convulsion Canyon creek, during water years 1981-84, and the maximum, minimum, and average daily mean flows are shown in figure 28. Most of the flow occurs during the April-June period of snowmelt. The maximum peak flow recorded at the station was 34.0 cubic feet per second on July 30, 1984, which resulted from a thunderstorm.

The dissolved-solids concentrations in 14 streamflow samples collected at station 09331850 ranged from 320 to 860 milligrams per liter, with a mean of 509 milligrams per liter (table 18). Calcium, magnesium, and bicarbonate were the dominant ions in most samples. Of the trace elements that were analyzed, only manganese was found in concentrations that exceed the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum concentration of manganese was 61 micrograms per liter, compared to a criterion of 50 micrograms per liter. The maximum concentration of boron was 790 micrograms per liter, which exceeded the criterion of 750 micrograms per liter for long-term irrigation on sensitive crops (U.S. Environmental Protection Agency, 1976, p. 25). The maximum concentration of phenol was 9 micrograms per liter, compared to a criterion of 1 microgram per liter.

A small quantity of sediment data were collected at station 09331850. A streamflow sample collected on October 22, 1980 had a suspended-sediment concentration of 17 milligrams per liter, and another sample collected on September 7, 1981, had a suspended-sediment concentration of 180 milligrams per liter. Calculated instantaneous suspended-sediment loads at station 09331850 during water year 1981 ranged from less than 0.01 to 0.73 tons per day. No bottom-sediment samples were collected.

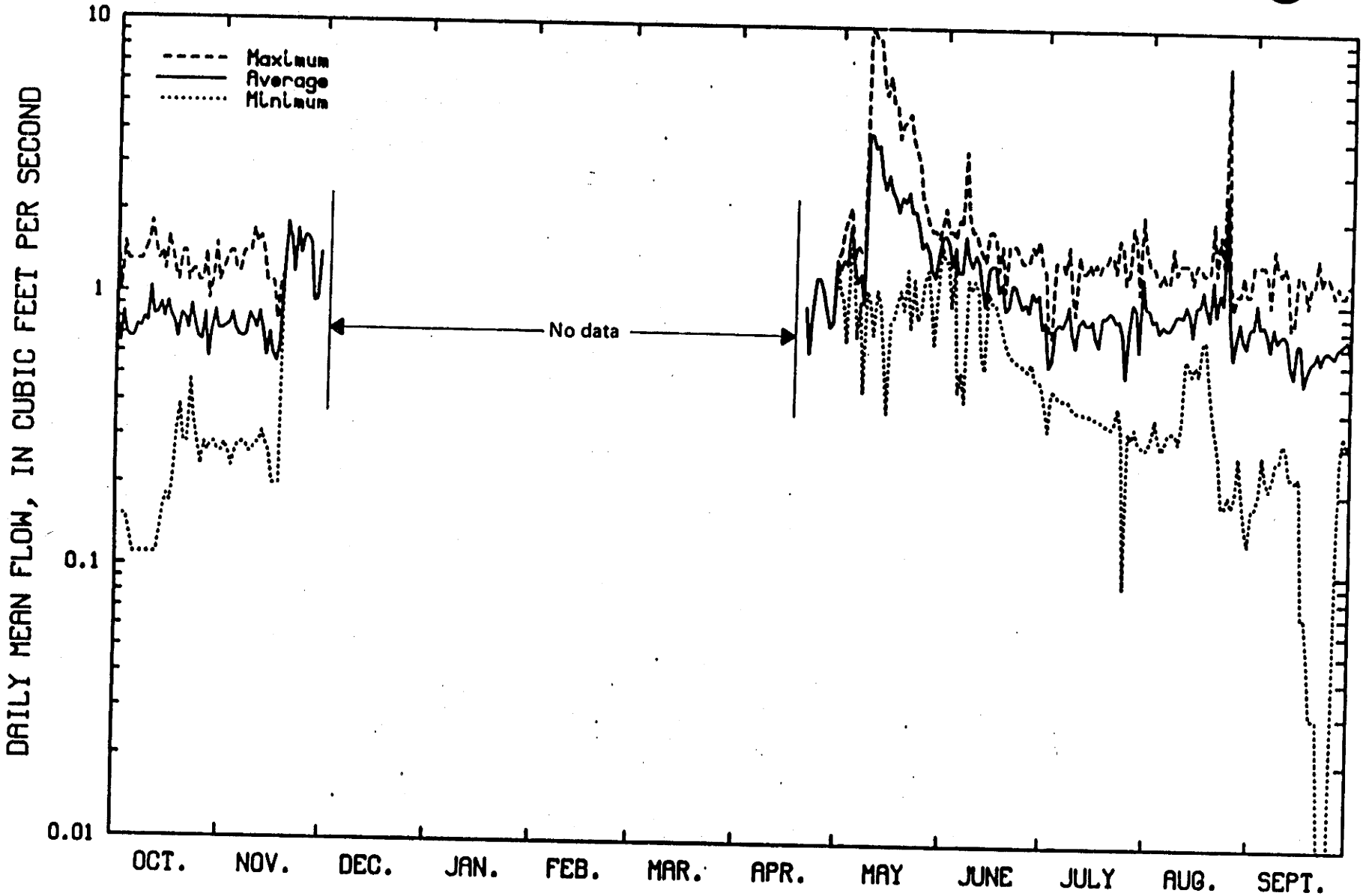


Figure 28.—Maximum, average, and minimum daily mean flow of Convulsion Canyon creek at station 09331850, seasonal record for water years 1981-84.

Table 18.—Summary of chemical analyses of streamflow in Convulsion Canyon creek at station 09331850, water years 1981-84
[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	14	0.86	0.15-1.7
Water temperature (degrees Celsius)	14	12.5	4.5-16.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	14	395	680-1,330
pH (units)	14	—	8.1-8.6
Sodium-adsorption ratio	14	.71	.50-1.0
Milligrams per liter			
Dissolved solids, sum of constituents	14	509	320-860
Oxygen, dissolved (O_2)	14	8.0	7.2-9.4
Carbon dioxide, dissolved (CO_2)	7	2.3	1.4-4.0
Alkalinity ($CaCO_3$)[1]	7	257	220-330
Bicarbonate (HCO_3)[1]	7	307	260-400
Carbonate (CO_3)[1]	7	3.3	.0-9.0
Nitrogen, dissolved (N)	6	.56	.37-0.76
Nitrogen, organic dissolved (N)	-	—	—
Nitrogen, ammonia dissolved (N)	-	—	—
Nitrogen, nitrite dissolved (N)	-	—	—
Nitrogen, nitrate dissolved (N)	-	—	—
Nitrogen, nitrite + nitrate dissolved (N)	9	—	.03-1.1
Phosphorus, dissolved (P)	9	—	<.01-.080
Phosphorus, ortho phosphates dissolved (P)	-	—	—
Carbon, organic dissolved (C)	9	4.5	1.3-8.4
Hardness, (as $CaCO_3$)	14	428	300-640
Hardness, (as noncarbonate, $CaCO_3$)	7	103	88-150
Calcium, dissolved (Ca)	14	81.7	58-110
Magnesium, dissolved (Mg)	14	54.1	38-90
Sodium, dissolved (Na)	14	33.6	23-51
Potassium, dissolved (K)	14	3.6	2.0-6.6
Chloride, dissolved (Cl)	14	35.5	12-97
Sulfate, dissolved (SO_4)	14	166	100-280
Fluoride, dissolved (F)	14	.26	.20-.50
Silica, dissolved (SiO_2)	14	11.5	10-13

Table 18.—Summary of chemical analyses of streamflow in Convulsion Canyon creek at station 09331850, water years 1981-84—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	7	—	<1-3.0
Barium, dissolved (Ba)	3	—	<100
Boron, dissolved (B)	14	249	100-790
Cadmium, dissolved (Cd)	7	—	<3
Chromium, dissolved (Cr)	7	—	<10-10
Copper, dissolved (Cu)	7	—	<2-2
Iron, dissolved (Fe)	14	—	<10-27
Lead, dissolved (Pb)	7	—	<1-3
Lithium, dissolved (Li)	3	31.3	20-44
Manganese, dissolved (Mn)	14	21.8	9.0-61
Mercury, dissolved (Hg)	7	—	<.1-.4
Nickel, dissolved (Ni)	7	1.7	1.0-2.0
Selenium, dissolved (Se)	7	—	<1-4.0
Strontium, dissolved (Sr)	3	527	500-550
Zinc, dissolved (Zn)	7	—	<3-30
Phenols	6	3.2	1.0-9.0

[1]Fixed-end-point determined by titration in the field.

Two of five samples of phytoplankton collected at station 09331850 during water year 1981 had large counts of blue-green algae (U.S. Geological Survey, 1982, p. 361). The samples were collected during August and September, and they apparently represent low-flow conditions.

Station 09331900 on Quitchupah Creek was operated continuously during water years 1979-81. The annual mean flow ranged from 6.73 cubic feet per second during water year 1979 to 10.8 cubic feet per second during water year 1980 (table 3). The maximum, minimum, and average daily mean flow shown in figure 29 indicate that the flow is relatively uniform throughout the year. This reflects a significant ground-water component of the total flow in Quitchupah Creek. Peaks during April-June represent snowmelt runoff, and peaks during July-November represent storm runoff from thunderstorms. The maximum peak flow recorded at station 09331900 during water years 1979-81 was 2,590 cubic feet per second on September 8, 1981 (table 3). That flow resulted from a thunderstorm.

Base-flow measurements in Quitchupah Creek during water years 1979-81 are related to geology in figure 30. The average, maximum, and minimum values show an increase in the base flow of Quitchupah Creek downstream from U.S. Highway 10. According to Lines and Plantz (1981, p. 47), the increase in flow is chiefly due to the return of water diverted for irrigation. The return flow results in an addition to the dissolved-solids concentrations, consisting mainly of sodium and sulfate.

The dissolved-solids concentrations in 39 streamflow samples collected from Quitchupah Creek at station 09331900 during water years 1979-81 ranged from 580 to 4,300 milligrams per liter, with a mean of 1,760 milligrams per liter (table 19). The smaller concentrations probably represent runoff from storms and snowmelt, whereas the larger concentrations represent mine discharge and irrigation return flow. Sodium and sulfate were the dominant ions in virtually all the samples regardless of the dissolved-solids concentrations. Strontium was found in concentrations as large as 4,800 micrograms per liter; however, none of the trace elements that were analyzed exceeded the criteria established by the U.S. Environmental Protection Agency (1976) for drinking-water supplies. The maximum phenol concentration was 120 micrograms per liter, compared to a criterion of 1 microgram per liter.

Quitchupah Creek transports considerable quantities of sediment during storms and periods of snowmelt. The suspended-sediment concentrations in 35 streamflow samples collected at station 09331900 during water years 1979-81 ranged from 150 milligrams per liter on December 13, 1978 to 30,200 milligrams per liter on March 6, 1979. Instantaneous suspended-sediment loads calculated for the station ranged from 1.9 to 4,120 tons per day during water year 1979, 5.4 to 322 tons per day during water year 1980, and 2.3 to 778 tons per day during water year 1981. Coal was 0.3 percent of the stream-bottom sediments.

The two samples of benthic invertebrates collected at station 09331900 during the 1980 water year had poor diversity (U.S. Geological Survey, 1981, p. 354). The four samples of phytoplankton that were collected during water year 1981 (U.S. Geological Survey, 1982, p. 367) had good representations of both green and blue-green algae.

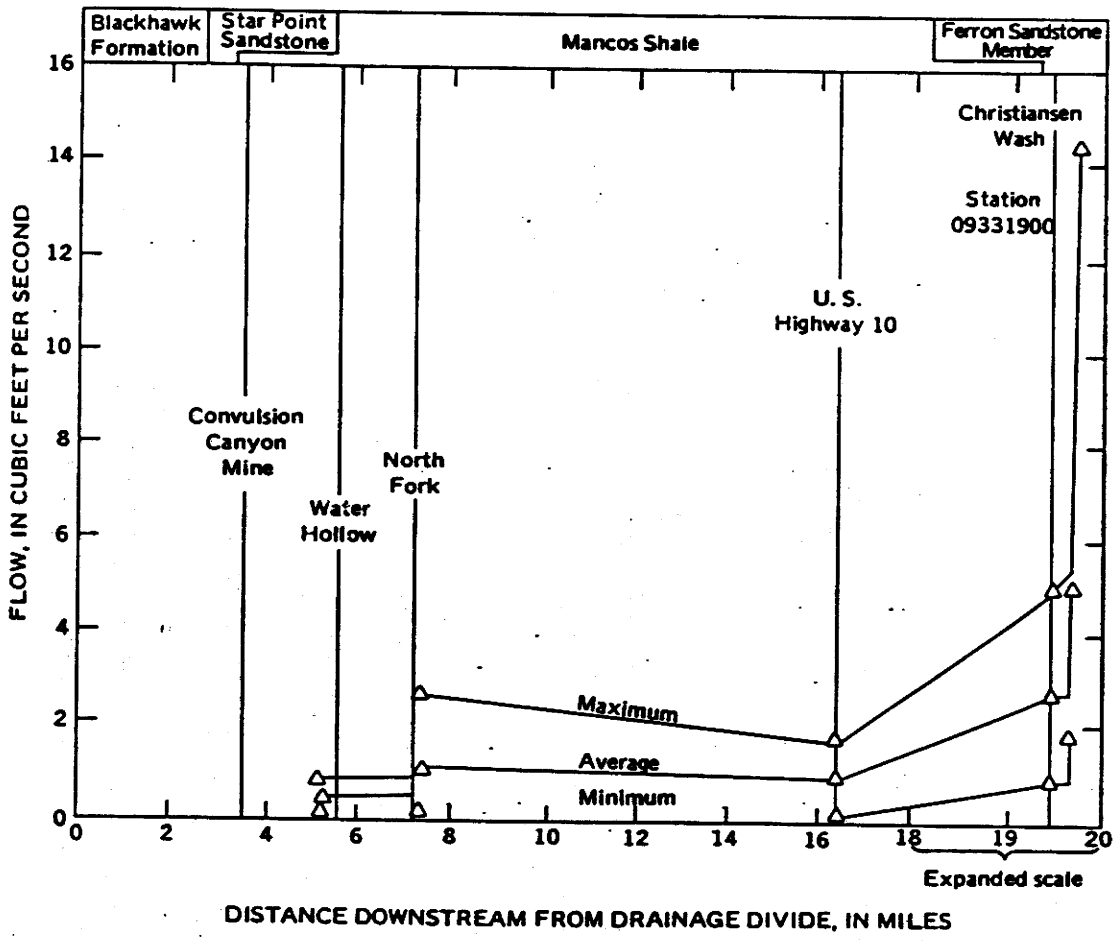


Figure 30.—Base flow of Quitchupah Creek as related to geology (based on 7 measurements made from August 1978 to October 1981).

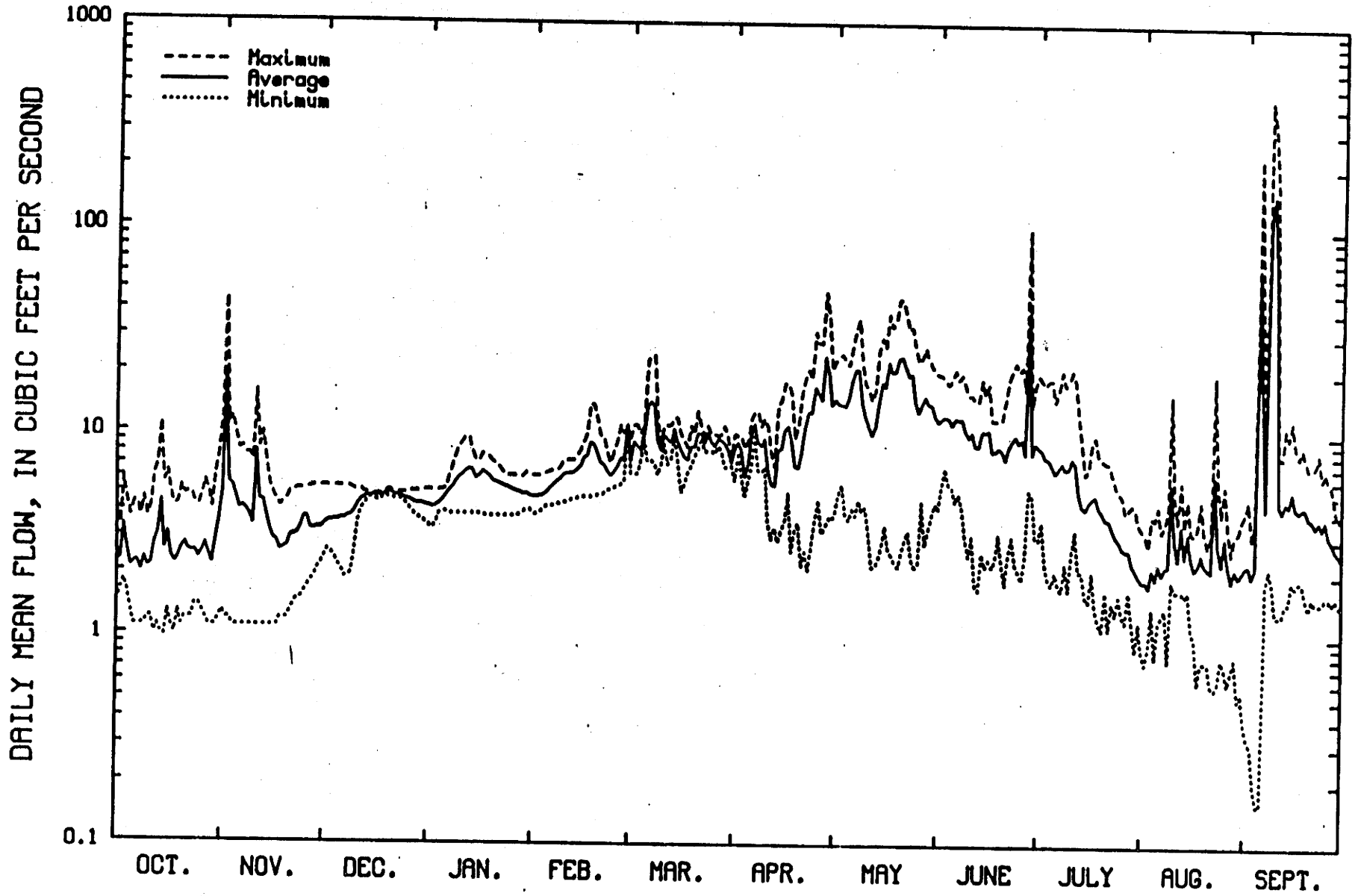


Figure 29.—Maximum, average, and minimum daily mean flow of Quitchupah Creek at station 09331900, water years 1979-81.

Table 19.—Summary of chemical analyses of streamflow in Quitchupah Creek at station 09331900, water years 1979-81

[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	39	6.7	0.97-25
Water temperature (degrees Celsius)	39	11.0	.0-26.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	39	2,280	890-5,500
pH (units)	39	—	8.1-8.8
Sodium-adsorption ratio	39	5.4	2.0-13.0
Milligrams per liter			
Dissolved solids, sum of constituents	39	1,760	580-4,300
Oxygen, dissolved (O_2)	39	9.3	6.3-11.8
Carbon dioxide, dissolved (CO_2)	38	3.0	.7-15
Alkalinity ($CaCO_3$)	38	341	212-960
Bicarbonate (HCO_3)[1]	38	407	250-1,180
Carbonate (CO_3)[1]	38	3.9	.0-14
Nitrogen, dissolved (N)	11	2.1	1.0-4.7
Nitrogen, organic dissolved (N)	9	0.44	.14-0.78
Nitrogen, ammonia dissolved (N)	9	—	<.01-.060
Nitrogen, nitrite dissolved (N)	9	.18	.010-.050
Nitrogen, nitrate dissolved (N)	9	1.0	.41-2.1
Nitrogen, nitrite + nitrate dissolved (N)	13	1.3	.42-2.8
Phosphorus, dissolved (P)	4	—	<.01-.180
Phosphorus, ortho phosphates dissolved (P)	9	—	<.001-.100
Carbon, organic dissolved (C)	13	7.3	2.7-13.0
Hardness, (as $CaCO_3$)	39	660	330-1,700
Hardness, (as noncarbonate, $CaCO_3$)	38	319	.0-1,300
Calcium, dissolved (Ca)	39	119	69-230
Magnesium, dissolved (Mg)	39	88	37-280
Sodium, dissolved (Na)	39	326	71-960
Potassium, dissolved (K)	39	5.5	.9-17
Chloride, dissolved (Cl)	39	58	15-140
Sulfate, dissolved (SO_4)	39	939	220-2,600
Fluoride, dissolved (F)	22	.5	.3-1.0
Silica, dissolved (SiO_2)	39	8.9	5.8-14

Table 19.—Summary of chemical analyses of streamflow in Quitchupah Creek at station 09331900, water years 1979-81—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	11	—	<1-2.0
Barium, dissolved (Ba)	2	150	100-200
Boron, dissolved (B)	22	—	<20-700
Cadmium, dissolved (Cd)	2	—	<1-2.0
Chromium, dissolved (Cr)	9	—	<10-20
Copper, dissolved (Cu)	2	—	<2-2.0
Iron, dissolved (Fe)	22	—	<10-40
Lead, dissolved (Pb)	8	—	<1-38
Lithium, dissolved (Li)	11	119	40-180
Manganese, dissolved (Mn)	22	—	4-30
Mercury, dissolved (Hg)	2	—	<.1
Nickel, dissolved (Ni)	2	—	2.0
Selenium, dissolved (Se)	11	3.8	2.0-7.0
Strontium, dissolved (Sr)	11	1,910	780-4,800
Zinc, dissolved (Zn)	10	—	<3-20
Phenols	12	—	<1-120

[1]Fixed-end-point determined by titration in the field.

Although Christiansen Wash is intermittent in its upper reaches, it is perennial at station 09331950. The annual mean flow at the station ranged from 2.09 cubic feet per second during water year 1981 to 6.42 cubic feet per second during water year 1984, with an average of 3.97 cubic feet per second (table 3). Most of the flow is during April-August (fig. 31), but the maximum peak flow was 1,540 cubic feet per second on September 8, 1981, which resulted from a thunderstorm.

The chemical quality of the flow in Christiansen Wash at station 09331950 is similar to that of the flow in Quitchupah Creek at station 09331900. Dissolved-solids concentrations in 46 streamflow samples collected from Christiansen Wash ranged from 450 to 4,500 milligrams per liter, with a mean of 2,440 milligrams per liter (table 20), and sodium and sulfate were generally the dominant ions. The maximum determined concentrations for lead, manganese, and selenium of 59, 300, and 60 micrograms per liter (table 20) exceeded the criteria of 50, 50, and 10 micrograms per liter established by the U.S. Environmental Protection Agency (1976, p. 5) for drinking-water supplies. The maximum phenol concentration was 22 micrograms per liter, compared to a criterion of 1 microgram per liter.

Suspended-sediment concentrations in 31 streamflow samples collected from Christiansen Wash at station 09331950 ranged from 79 milligrams per liter on September 21, 1980 to 15,200 milligrams per liter on September 8, 1981. Instantaneous suspended-sediment loads ranged from 1.6 to 326 tons per day during water year 1979, 0.83 to 70 tons per day during water year 1980, and 0.95 to 57 tons per day during water year 1981. Coal was 0.2 percent of the stream-bottom sediments.

Five samples of benthic invertebrates at station 09331950 during water years 1980 and 1982 had about the same diversity as those sampled by Lines and Plantz (1981, p. 53) during water year 1979. They all apparently reflected the generally poor chemical quality of the flow in Christiansen Wash as indicated in table 20 and discussed earlier. Four samples of phytoplankton at station 09331950 during water year 1981 showed fairly good diversity but also a fairly uniform distribution of blue-green algae (U.S. Geological Survey, 1982, p. 374). This probably also reflected the generally poor chemical quality of streamflow.

KANAB CREEK BASIN

Sink Valley Wash

Station 09403550 was operated in Sink Valley Wash during 1981 (pl. 1). Although the stream was dry during all visits to the station, gage-height record indicates that there were short periods of minimal flow on May 28, July 16, August 13, and 15, and September 6 and 14. The morphology of Sink Valley Wash indicates that the channel has carried large flows that resulted from intense thunderstorms.

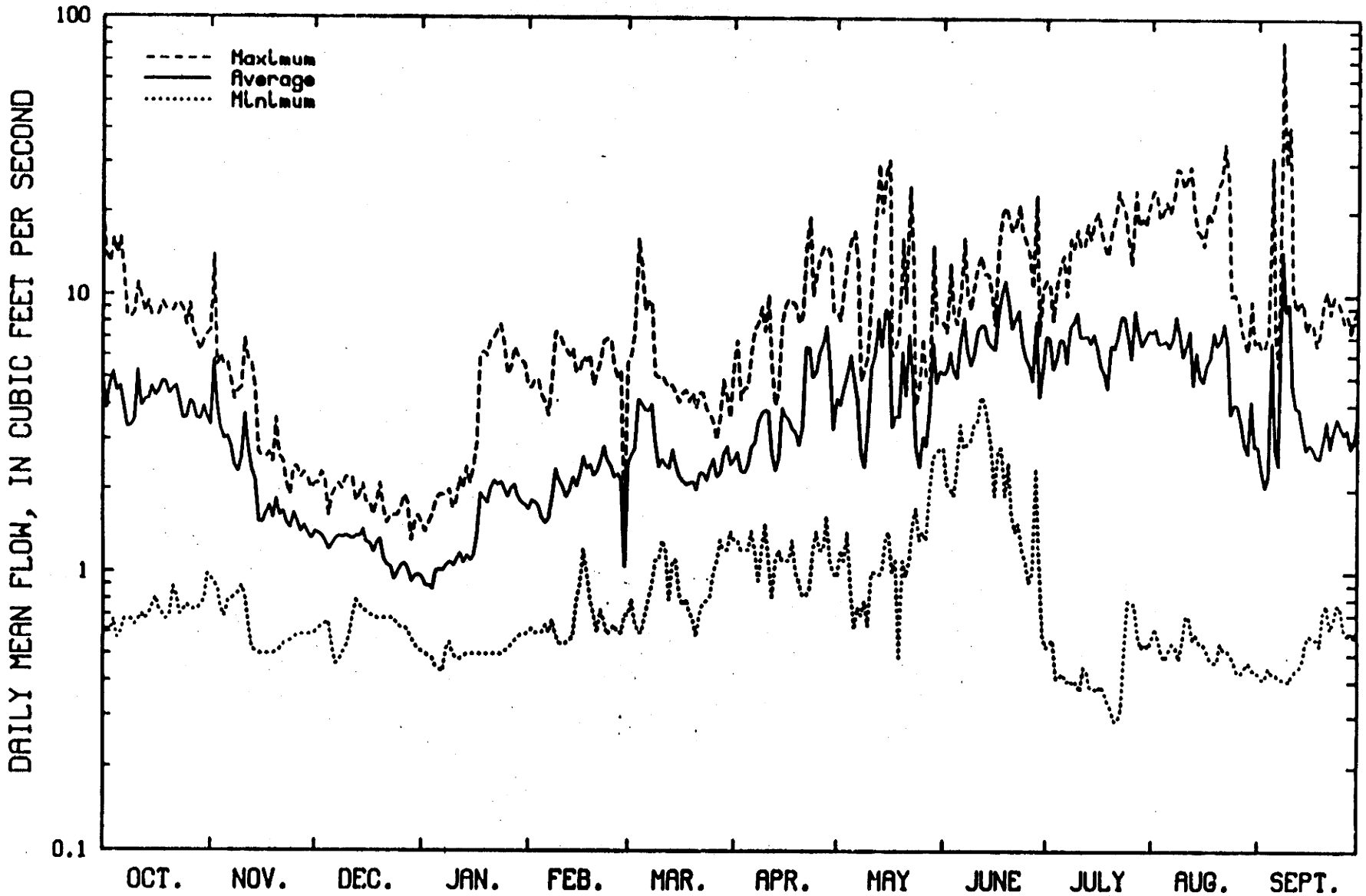


Figure 31.--Maximum, average, and minimum daily mean flow of Christiansen Wash at station 09331950, water years 1979-84.

Table 20.—Summary of chemical analyses of streamflow in Christiansen Wash at station 09331950, water years 1979-84
[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	47	4.1	0.40-24.0
Water temperature (degrees Celsius)	47	10.5	.0-24.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	47	3,100	690-5,040
pH (units)	47	—	8.1-8.7
Sodium-adsorption ratio	47	4.6	1.0-8.0
Milligrams per liter			
Dissolved solids, sum of constituents	46	2,440	450-4,500
Oxygen, dissolved (O_2)	47	9.2	6.7-12.2
Carbon dioxide, dissolved (CO_2)	39	3.2	1.2-8.6
Alkalinity ($CaCO_3$)[1]	39	420	180-2,600
Bicarbonate (HCO_3)[1]	39	432	210-860
Carbonate (CO_3)[1]	39	5.1	.0-18
Nitrogen, dissolved (N)	16	7.5	1.3-23
Nitrogen, organic dissolved (N)	9	1.4	.45-2.5
Nitrogen, ammonia dissolved (N)	9	—	<.01-0.140
Nitrogen, nitrite dissolved (N)	9	0.053	.030-.080
Nitrogen, nitrate dissolved (N)	9	9.1	1.6-23
Nitrogen, nitrite + nitrate dissolved (N)	21	6.8	.76-23
Phosphorus, dissolved (P)	12	—	<.01-.17
Phosphorus, ortho phosphates dissolved (P)	9	—	<.001-.030
Carbon, organic dissolved (C)	21	13.0	3.2-24
Hardness, (as $CaCO_3$)	47	1,090	280-2,100
Hardness, (as noncarbonate, $CaCO_3$)	39	788	.0-1,700
Calcium, dissolved (Ca)	47	165	53-340
Magnesium, dissolved (Mg)	47	166	35-310
Sodium, dissolved (Na)	47	356	40-710
Potassium, dissolved (K)	47	7.0	1.2-17
Chloride, dissolved (Cl)	47	52.6	7.3-150
Sulfate, dissolved (SO_4)	47	1,410	150-2,900
Fluoride, dissolved (F)	30	.49	.30-.70
Silica, dissolved (SiO_2)	47	10.6	5.5-16

Table 20.—Summary of chemical analyses of streamflow in Christiansen Wash at station 09331950, water years 1979-84—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	17	—	<1-2.0
Barium, dissolved (Ba)	5	—	<100-200
Boron, dissolved (B)	30	306	50-590
Cadmium, dissolved (Cd)	8	—	<1-6
Chromium, dissolved (Cr)	17	—	<10-20
Copper, dissolved (Cu)	8	1.9	1.0-3.0
Iron, dissolved (Fe)	30	—	<10-60
Lead, dissolved (Pb)	15	—	<1-59
Lithium, dissolved (Li)	14	197	51-370
Manganese, dissolved (Mn)	30	—	8-300
Mercury, dissolved (Hg)	8	—	<.1-.8
Nickel, dissolved (Ni)	8	—	<1-13
Selenium, dissolved (Se)	17	13.5	2.0-60
Strontium, dissolved (Sr)	14	1,700	530-3,400
Zinc, dissolved (Zn)	17	—	<3-94
Phenols	18	—	<1-22

[1]Fixed-end-point determined by titration in the field.

Thompson Creek

Thompson Creek originates on the Wasatch Formation of Tertiary age at an altitude of about 9,100 feet near the crest of the Pink Cliffs, southwest of Bryce Canyon National Park. It is a headwater tributary of Johnson Creek, the largest tributary of Kanab Creek that drains the Alton coal field. Thompson Creek drains strata of Tertiary and Cretaceous age, including the coal-bearing Tropic Shale of Cretaceous age.

Station 09403670 was operated on Thompson Creek during the 1981 water year (pl. 1, table 1). The daily mean flow in Thompson Creek at the station is illustrated in figure 32. The May-June flow was chiefly from snowmelt near the crest of the Pink Cliffs. The short-term increases in flow during June-September reflect thunderstorm runoff. Based on an indirect measurement made near station 09403670 on August 14, 1981, a thunderstorm produced a maximum peak flow of 1,030 cubic feet per second.

Chemical analyses of eight streamflow-samples collected from Thompson Creek at station 09403670 during the 1981 water year are summarized in table 21. The dissolved-solids concentrations ranged from 1,100 to 1,800 milligrams per liter, with a mean of 1,400 milligrams per liter. Magnesium was generally the dominant cation, and sulfate was generally the dominant anion. None of the trace elements that were analyzed were found in concentrations that exceed the criteria established by the Environmental Protection Agency (1976) for drinking-water supplies. The maximum phenol concentration was 8 micrograms per liter, compared to a criterion of 1 microgram per liter.

Some of the geologic strata drained by Thompson Creek are easily eroded, therefore, potential annual sediment yields to Thompson Creek are large (U.S. Department of Agriculture, 1973). Sandberg (1979, p. 29) reported a maximum suspended-sediment concentration of 372,000 milligrams per liter in July 1977.

Suspended-sediment concentrations in seven streamflow samples obtained at station 09403670 during the 1981 water year ranged from 468 milligrams per liter on July 13, 1981, to 18,600 milligrams per liter on December 3, 1980. Instantaneous suspended-sediment loads ranged from 0.29 to 131 tons per day. The stream-bottom sediments consisted of about 0.4 percent coal.

Two of three phytoplankton samples collected at station 09403670 during the 1981 water year had a predominance of blue-green algae (U.S. Geological Survey, 1982, p. 407).

CONCLUSIONS

An objective of the monitoring program summarized in this report was to determine hydrologic impacts of future coal mining in coal fields of central and southern Utah. During the monitoring period of August 1978-September 1984, coal production nearly doubled at existing mines in the coal fields of central Utah, and there was no mining in the only coal field (Alton) of southern Utah included in the monitoring program. Data collected during the 6 water years of monitoring reflect the effects of both pre-monitoring mining and contemporary (water years 1979-84) mining. Stream-bottom sediments sampled at nearly all the monitoring sites contained small to moderate quantities of coal. This may be attributed chiefly to the pre-monitoring

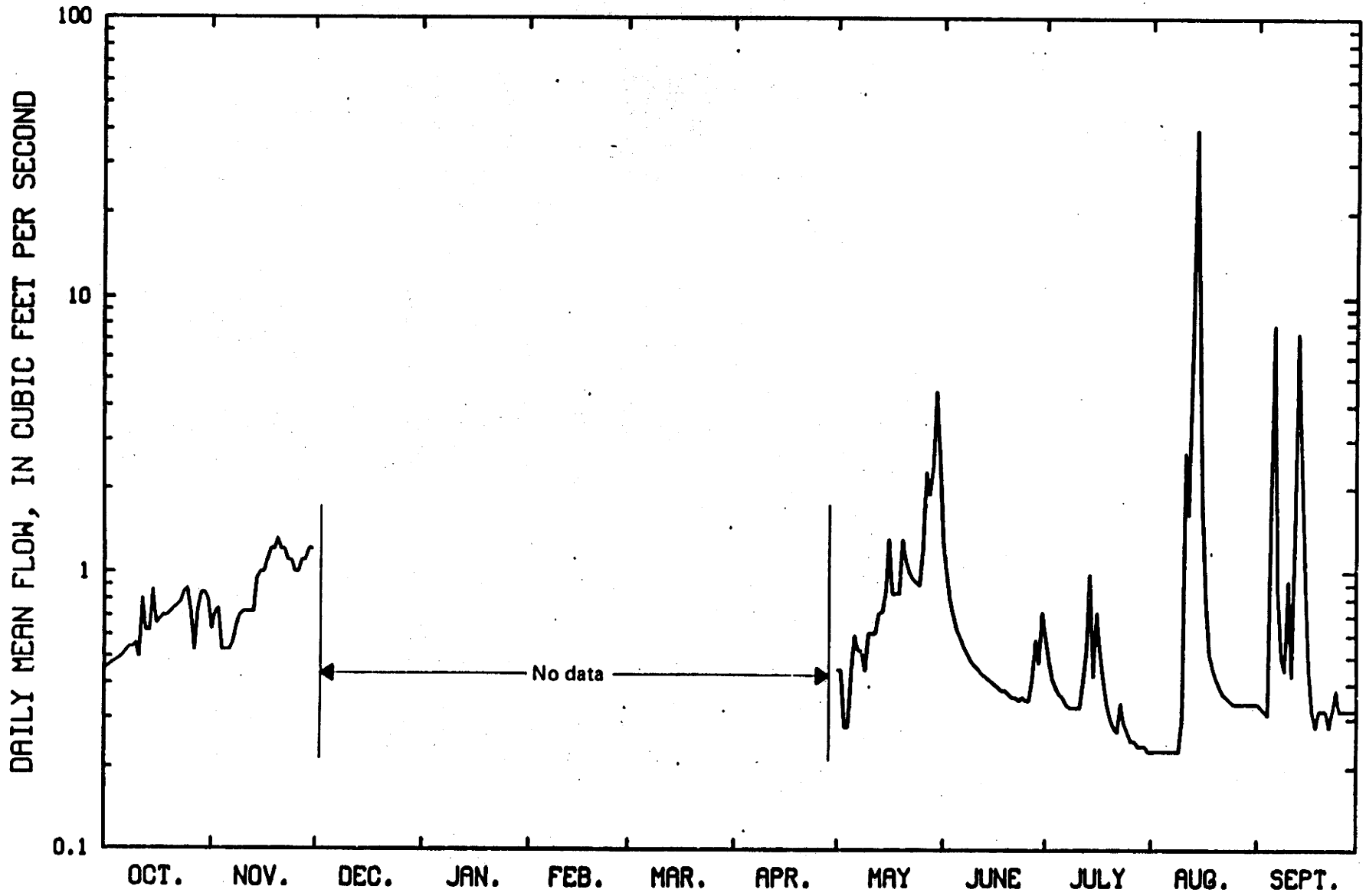


Figure 32.—Daily mean flow of Thompson Creek at station 09403670, water year 1981.

Table 21.—Summary of chemical analyses of streamflow in Thompson Creek at station 09403670, water year 1981

[< indicates actual value is smaller than the detectable value shown]

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Streamflow (cubic feet per second)	8	0.65	0.15-2.6
Water temperature (degrees Celsius)	8	20.5	2.0-29.0
Specific conductance (microsiemens per centimeter at 25° Celsius)	8	1,830	1,440-2,250
pH (units)	8	—	8.1-8.4
Sodium-adsorption ratio	8	1.1	1.0-2.0
Dissolved solids, sum of constituents	8	1,400	1,100-1,800
Oxygen, dissolved (O_2)	8	7.3	6.2-10.9
Carbon dioxide, dissolved (CO_2)	7	2.4	1.4-3.1
Alkalinity ($CaCO_3$)[1]	7	260	170-410
Bicarbonate (HCO_3)[1]	5	320	210-490
Carbonate (CO_3)[1]	7	1.4	.0-6.0
Nitrogen, dissolved (N)	3	.90	.86-0.97
Nitrogen, organic dissolved (N)	-	—	—
Nitrogen, ammonia dissolved (N)	-	—	—
Nitrogen, nitrite dissolved (N)	-	—	—
Nitrogen, nitrate dissolved (N)	-	—	—
Nitrogen, nitrite + nitrate dissolved (N)	3	.40	.17-.60
Phosphorus, dissolved (P)	3	.030	.010-.070
Phosphorus, ortho phosphates dissolved (P)	-	—	—
Carbon, organic dissolved (C)	3	5.1	3.7-7.0
Hardness, (as $CaCO_3$)	8	892	700-1,200
Hardness, (as noncarbonate, $CaCO_3$)	7	621	290-1,000
Calcium, dissolved (Ca)	8	137	96-220
Magnesium, dissolved (Mg)	8	134	94-160
Sodium, dissolved (Na)	8	88	61-120
Potassium, dissolved (K)	8	11.1	8.1-15.0
Chloride, dissolved (Cl)	8	22	17-30
Sulfate, dissolved (SO_4)	8	818	590-1,200
Fluoride, dissolved (F)	8	.4	.3-.5
Silica, dissolved (SiO_2)	8	9.2	8.1-10.1

Milligrams per liter

Table 21.—Summary of chemical analyses of streamflow in Thompson Creek at station 09403670, water year 1981—Continued

Properties and constituents	No. of analyses	Mean	Minimum-maximum
Milligrams per liter			
Arsenic, dissolved (As)	3	1.3	1.0-2.0
Barium, dissolved (Ba)	2	—	<100-100
Boron, dissolved (B)	8	149	90-250
Cadmium, dissolved (Cd)	3	—	<1-2.0
Chromium, dissolved (Cr)	3	—	<10-10
Copper, dissolved (Cu)	3	—	<2-4
Iron, dissolved (Fe)	8	—	<10-30
Lead, dissolved (Pb)	3	3.7	2-5
Lithium, dissolved (Li)	2	105	100-110
Manganese, dissolved (Mn)	8	19	8-40
Mercury, dissolved (Hg)	3	—	<.1
Nickel, dissolved (Ni)	3	—	<.1-4.0
Selenium, dissolved (Se)	3	—	1
Strontium, dissolved (Sr)	2	1,200	1,000-1,400
Zinc, dissolved (Zn)	3	12.7	8-20
Phenols	3	—	<1-8

[1]Fixed-end-point determined by titration in the field.

mining activities. Streamflow sampled at several sites contained large concentrations of sulfate and dissolved solids. Also, concentrations of various trace elements in streamflow at 10 sites, and of phenols in streamflow at 18 sites exceed the criteria of the U.S. Environmental Protection Agency for drinking water. This may be attributed to mine-drainage activities associated with the contemporary mining.

Another objective of the monitoring program summarized in this report was to obtain hydrologic data needed for a better definition or understanding of the hydrologic systems in the resource areas monitored. The large volume of data collected during the 6 water years of monitoring will help both the coal operators and regulatory agencies to better understand the hydrologic systems in their coal-resource areas of interest. The data also provide a more definite data-base with which to evaluate any adverse hydrologic impacts that might result from increased post-monitoring mining in those coal-field areas monitored.

REFERENCES CITED

Butler, Elmer, and Marsell, R. E., 1972, Cloudburst floods in Utah, 1939-69: Utah Division of Water-Resources Cooperative-Investigations Report 11, 103 p.

Doelling, H. H., and Graham, R. L., 1972, Southwestern Utah coal fields: Alton, Kaiparowits Plateau, and Kolob-Harmony: Utah Geological and Mineralogical Survey Monograph 1, 333 p.

Lines, G. C., and Plantz, G. G., 1981, Hydrologic monitoring in the coal fields of central Utah, August 1978-September 1979: U.S. Geological Survey Water-Resources Investigations Report 81-138, 56 p.

Lines, G. C., and others, 1983, Hydrology of area 56, northern Great Plains and Rocky Mountain coal provinces, Utah: U.S. Geological Survey Water-Resources Investigations Report 83-38, 69 p.

Mundorff, J. C., 1972, Reconnaissance of the chemical quality of surface water and fluvial sediment in the Price River basin, Utah: Utah Department of Natural Resources Technical Publication 39, 55 p.

Price, Don and others, 1987, Hydrology of area 57, northern Great Plains and Rocky Mountain coal provinces, Utah and Arizona: U.S. Geological Survey Water-Resources Investigations Report 84-068, 40 p.

ReMillard, M. D., Andersen, G. C., Birdwell, G. A., and Hookano, Ezra, Jr., 1985, Water-resources data, Utah, water year 1984: U.S. Geological Survey Water-Data Report Ut-84-1 463 p.

Sandberg, G. W., 1979, Hydrologic evaluation of the Alton reclamation site, Alton coal field, Utah: U.S. Geological Survey Open-File Report 79-346, 53 p.

U.S. Department of Agriculture, 1973, Estimating sediment-yield rates for the State of Utah: Western United States water-plan map, scale 1:500,000.

U.S. Environmental Protection Agency, 1976, Quality criteria for water: Washington D.C., U.S. Government Printing Office, 256 p.

U.S. Geological Survey, 1980, Water-resources data for Utah, water year 1979: U.S. Geological Survey Water-Data Report Ut 79-1, 604 p.

_____, 1981, Water-resources data for Utah, water year 1980: U.S. Geological Survey Water-Data Report UT 80-1, 684 p.

_____, 1982, Water-resources data for Utah, water year 1981: U.S. Geological Survey Water-Data Report UT 81-1, 708 p.

Waddell, K. M., Contratto, P. Kay, Sumsion, C. T., and Butler, J. R., 1981, Hydrologic reconnaissance of the Wasatch Plateau-Book Cliffs coal-fields area, Utah: U.S. Geological Survey Water-Supply Paper 2068, 45 p.

ORDERING INFORMATION

Do not mix orders for books and open-file reports with orders for other USGS products.

Please use publication number and complete title. If publication number is not available, please list author, title, and year of release.

No additional charge is required for mailing/handling unless first class transportation is desired. For first class transportation within the United States, add 10 percent of total bill to cover costs.

For transmittal of reports outside of the United States (except Canada and Mexico), a surcharge of 25 percent of the net bill must be added to cover postage charge. Remittance should be in the form of an International Money Order or a check drawn on a U.S. bank ~~with the~~ amount in U.S. funds.

* * * * * * * * * * * * *

New publications are announced, with prices, in the monthly list, "New Publications of the Geological Survey." A free subscription to the list may be obtained on application to the Mailing List Unit, U.S. Geological Survey, 582 National Center, Reston, VA 22092.

A list of open-file reports released for the years 1938 through April, 1974, is available from the Open-File Services Section in microfiche format. Open-file reports released from May, 1974 to current are listed in the publications of the U.S. Geological Survey shown below.

A price list for paper and microfiche copies of open-file reports (without title and author information), is available from the Open-File Service Section in microfiche format. This list is updated monthly. The current price for this list can be obtained from the Open-File Services Section.

Publications Lists Available:

Publications of the U.S. Geological Survey 1979-1961	$6.00 paper copy $4.00 microfiche
Publications of the U.S. Geological Survey 1962-1970	$6.00 paper copy $4.00 microfiche
Publications of the U.S. Geological Survey 1971-1981	$15.00 paper copy $ 8.00 microfiche
Publications of the U.S. Geological Survey 1982	$3.00 paper copy
Publications of the U.S. Geological Survey 1983	$3.00 paper copy
Publications of the U.S. Geological Survey 1984	$3.25 paper copy
Publications of the U.S. Geological Survey 1985	$3.75 paper copy
Publications of the U.S. Geological Survey 1986	$4.25 paper copy
Price and Availability List of U.S. Geological Survey Publications	Free

Form 9-1986
March 1987

Mail this ORDER FORM to:

BOOKS AND OPEN-FILE REPORTS SECTION
BRANCH OF DISTRIBUTION
U.S. GEOLOGICAL SURVEY
BOX 25425, FEDERAL CENTER
DENVER, COLORADO 80225

(303) 236-7476

U.S. Department of the Interior
Geological Survey

BOOK AND OPEN-FILE REPORT ORDER FORM

FROM:

Name _____

Street Address _____

City State ZIP Code

Do not write in this space

Customer Order No.

Date

Total Reports Ordered

Amount Enclosed:

$ _____

___Check ___Money Order

Report No.	Title	Quantity		Unit Price		Total Cost
		Paper	Micro-fiche	Paper	Micro-fiche	
					TOTAL	
					GRAND TOTAL	

PREPAYMENT REQUIRED

Remittance payable to:
Department of the Interior-USGS

for PROMPT, ACCURATE SHIPMENT PLEASE FILL IN THE FOLLOWING LABEL
Please PRINT or TYPEWRITE

BOOKS AND OPEN-FILE SERVICES SECTION
BRANCH OF DISTRIBUTION
U.S. GEOLOGICAL SURVEY
BOX 25425, FEDERAL CENTER
DENVER, COLORADO 80225

Name

Street Address

City State ZIP Code

SEE REVERSE SIDE FOR ADDITIONAL ORDERING INFORMATION

GENERAL HYDROLOGIC CONSIDERATIONS RELATED TO COAL DEVELOPMENT AND SUBSEQUENT IMPACTS VAUGHN HANSEN ASSOCIATES, 1981

GENERAL HYDROLOGIC CONSIDERATIONS RELATED TO COAL DEVELOPMENT AND SUBSEQUENT IMPACTS

Prepared for

SKYLINE MINES PROJECT

of the

UTAH FUELS COMPANY

a Subsidiary of

COASTAL STATES ENERGY COMPANY

Salt Lake City, Utah

By

VAUGHN HANSEN ASSOCIATES

Salt Lake City, Utah

February 1981

GENERAL HYDROLOGIC CONSIDERATIONS RELATED TO COAL DEVELOPMENT AND SUBSEQUENT IMPACTS

The following report is being prepared for Utah Fuels Company at the suggestion of the Office of Surface Mining. Stipulations pertaining to hydrology were made by OSM when the mining permit was granted. Following a technical discussion in Denver with the OSM staff on November 17, 1980, Mr. Nadolski suggested that preparation of a report containing the information discussed at the meeting would meet the hydrologic stipulations pertaining to fault and ground water identification.

Experience at other mines in the vicinity will be used to project probable impacts resulting from the new Skyline Mines project. Since hydrologically similar conditions exist in the area, experience from operating mines provides a rather consistent pattern. When exceptions do occur, they have been caused by anomolies that are reasonably identifiable. These exceptions will be discussed.

Description of Hydrologically Related Aspects

Topography, land use, geology, climate, and water quality and quantity all influence hydrology and the impacts resulting from mining. A brief discussion of these factors will provide a background for the more detail consideration of impacts to be expected from coal mining at the Skyline Mine.

Topography of the Wasatch Plateau coal field can be subdivided into three distinctly characteristic zones. The generally east-facing slopes, where the coal is exposed, are steep and rocky, often with narrow promontory ridges. Rainfall is less than potential evapotranspiration. Most runoff occurs from melting snows and summer thunderstorms. Springs and seeps are scarce on the steep rocky slopes.

Further to the west the watershed is less steep, the elevation is higher, rainfall is sufficient to produce a good vegetative cover, and numerous springs exist. Snowpack is heavier than on the steeper surfaces to the east, and thus base flows from springs are greater. Springs seldom flow more than five gallons per minute. Most springs in the fall flow only one or two gallons per minute.

Farther to the west, the watershed is a high, rather flat plateau with considerable snowfall accumulation in the winter with heavy vegetation and with numerous springs.

Geologic Formations

The coal bearing formation is Blackhawk composed of alternating layers of sandstone and shale with several mineable coal seams. The Blackhawk formation is underlain with up to 1,000 feet of rather uniform Starpoint sandstone. This underlying sandstone layer is very dense, well cemented, and has a low transmissivity. Water moves through the Starpoint sandstone mainly in fractures.

Above the Blackhawk formation is Castlegate sandstone. Some Castlegate sandstone exists on the northern portion of the Skyline Mine property where it is extensively fractured and rather permeable.

Sandstones in the Blackhawk as well as the underlying Starpoint sandstone are dense, well-cemented, and have low transmissivity. They are not significant water yielding acquifers. Most water travels through the sandstone in fractures, both in the Blackhawk and in the Starpoint sandstone.

Shales in the Blackhawk are very resistive to downward movement of water. Consequently, most springs occur below a small basin where more than normal snow accumulates. Groundwater from melting snow, after percolating below the soil mantle moves downdip on the top of a shale layer mainly in fractures in the sandstone to the ground surface. Most springs occur on the downdip side of the formation.

The land is used primarily by livestock and by wild game. A few springs have been developed with watering troughs.

Faults and Leakers

The basis for the following discussion is a detailed study of faulting on and adjacent to the Skyline project augmented by careful observations within existing mines.

Principal faults bear north, northeast. A complementary pattern, approximately orthogonal to the principal faulting pattern, bears east. Within the mines, water generally does not travel in the faults nor does it generally back up behind the faults. Leakers near the faults are not noticeably different from leakers farther from the faults.

Normally the flow from leakers will not exceed 10 gallons a minute, and the flow will decrease noticeably within a few days. Most leakers have dried up 500 feet behind an active working face. Two noticeable exceptions have occurred in mines relatively near the Skyline Mine property. Recently in the Plateau Mine, a fold was encountered with a tension crack in the roof through which occurred an initial flow of 150 gallons a minute. Within a few days, the flow dropped considerably. At U.S. Fuels, a flow of 200 gpm from a fault has continued without noticeable reduction in quantity. Overhead on the surface, a small perennial flow occurs along the edge of a graben. The surface stream serves as an overlying source of water that percolates down into the mine.

When mining above the regional water table, flow into the mine from leakers is from downward percolating water backed up above a shale layer that generally lies above the coal seam being mined. When this perched water is removed, the leaker stops flowing. The exception is near the east portal where overburden is less, and where more snow accumulates on the east facing hill near the mine entrance. In the late spring, melting snow percolates into the mine through the more fractured overburden near the face.

When mining below the water table, the flow from leakers will decrease with time, but more water can be expected than when mining above the water table. Tension or faults, which serve as collector plumbing, will be encountered occasionally and flow will occur until the water table is lowered below the mine.

Hydrologic Impacts From Mining

Potential hydrologic impacts from mining on the Skyline Mine property will occur from altering both the water table and also the perched water conditions above the water table. Changes will occur as a result of water drainage into the mine and also from subsidence.

Subsidence Impacts

As pillars are pulled or as long wall mining occurs, subsidence will extend to the surface when the overburden is shallow and weak or fractured. In the Plateau Mine where piles have been pulled over rather extensive areas, surface disturbance has occurred primarily in the rocky promontories where overburden is shallow and fractured. In these areas where subsidence has occurred, essentially no springs or surface waters exist.

On the Skyline property, the overburden even near the portal is much more comparable to the adjacent Valley Camp Mine where no adverse surface subsidence has yet been observed from extracting pillars.

Subsidence cracks resulting from the Skyline Mine are expected to heal rather quickly because of an abundance of organic matter and because of the weathering of shaley layers. The weathered shale will tend to block lateral and vertical water movement in a subsidence crack. The general absence of springs along the numerous normal and tranverse faults indicates that subsidence cracks will not seriously alter the surface water supply.

More than 150 water sources were found on and adjacent to the Skyline lease during the initial phases of the baseline study, averaging one for each 40 acres. Hence, if a given spring is altered, the impact will not be as severe as if only one water source existed in each section (640 acres).

The overlying formations are known to be strong (except on the rocky promotories east of the Skyline Mine). The angle of draw has been estimated to be less than 15 degrees, which also is indicative of strong overburden material. Serious subsidence cracks will likely not occur except near the portals where the overburden is shallow and fractured.

The general conclusion is that subsidence will have a minor impact on surface and subsurface hydrology. The surface water supply for wildlife and cattle should not be significantly reduced.

Groundwater Impacts

When mining above the water table, perched water above the mine will be drained. When mining below the water table, more water will be intercepted, drawdown of the water table will occur, and some change in yield will result. To understand the relative magnitude of these impacts, the hydrologic properties of the formation need to be understood. A statement of general conditions is based upon experience gleaned from core drilling, from test wells, from water wells, and from flow into other mines.

Holes drilled into the Blackhawk are very unstable. An open hole will sluff badly within a few days. The shale weathers readily. Unless a fracture in the sandstone is encountered, the yield of water from core holes, test wells, and water-producing wells drilled into the Blackhawk has been less than 10 gpm, frequently less than 5 gpm. The sand layers, as previously stated, have low transmissivities. The underlying Starpoint sandstone is also very tight. Two water wells drilled by Valley Camp into the Blackhawk near the Skyline lease were unproductive, yielding less than 5 gpm. Valley Camp drilled another well below their portal area into a fracture in the Starpoint and obtained a flow in excess of 50 gpm.

Coastal States drilled a water well near their portal area that went through the Blackhawk and into the Starpoint sandstone. The sustained yield was less than 5 gpm. Coastal States attempted to drill into a fracture zone for this well but was unsuccessful in locating any fractures. They drilled two more water wells in a fractured area east in the portal of Eccles Canyon near South Fork. Both wells encountered fractures in the Starpoint sandstone, and the sustained yields may exceed 100 gpm. Thus, a water-producing aquifer does not exist above or below the coal veins. The only possibility for obtaining a water well in these formations is to drill into the sandstone where a fault has fractured the formation.

The sustained flow from the fault in the U.S. Fuels' mine, the producing well below the Valley Camp portal, and the two producing wells drilled by Coastal

States in Eccles Canyon near South Fork all have a significant similarity. In each case, a stream exists on the ground surface, a large fault is present, and the sandstone is fractured. The Valley Camp and Coastal States wells are getting their water from fractures in the Starpoint sandstone. The overlying streams are likely recharging the fractured Starpoint.

An interesting similarity exists between the productive Valley Camp-Coastal States wells and Little Bear Spring in Huntington Canyon near the Swisher Mine. Little Bear Spring is issuing from a fracture in the Starpoint sandstone. Extensive tests have confirmed that the water is not coming from the Blackhawk formation in the watershed to the west. Rather the water issuing from Little Bear Spring is moving from Huntington Creek further upstream through a fracture in the Starpoint. Likewise the productive Valley Camp-Coastal States wells are receiving their water through fractures in the Starpoint sandstone, and the water is likely coming primarily from overlying streams, not from the Blackhawk formation in the watershed to the west.

Movement of water downward through the sandstones to the regional water table is slow and is impeded by shale layers. Most of the water that percolates into the rather permeable surface soils reappears in nearby seeps and springs. Recharge of the regional water table is greatest under the relatively flat high plateau above the 9500 feet elevation, where greater opportunity exists for percolation and where the precipitation is signicantly greater than the transpiration.

Lateral movement beneath the regional water table is very slow. Gradients are steep and the regional water table is generally a considerable distance below the bottom of the canyons. Detailed observations from a helicopter on the Plateau lease area indicate that movement of groundwater is so slow that when the water table approaches the ground surface in the bottom of the canyons, deep-rooted vegetation extracts the water before it reaches the shallow-rooted grasses, which are the principal source of forage for game and livestock. Distribution and variety of the shallow-rooted grasses show that they obtain their water from local precipitation, not the deeper water table.

Figure 1 shows the piezometric contours in the Blackhawk formation while Figure 2 shows them for the Starpoint sandstone. The groundwater divide occurs slightly east of the topographic divide where the precipitation is greatest. The piezometric divide in the Starpoint is approximately one-half mile west of the divide in the overlying Blackhawk. This shift is caused by the migration downdip as the groundwater encounters the shale layers in the Blackhawk. Discharge of groundwater to the east of the lease occurs in the lower part of Eccles Canyon where Starpoint sandstone is not overlain with Blackhawk. Here where shale layers are absent, seeps and springs are in the bottom of the canyon and are indicative of the position of the water table.

Groundwater flow to the west is overlain with Blackhawk, and the water table generally lies well below the bottom of the canyons. Volume of recharge is

not sufficient to bring the water table to the surface. To the west in the Blackhawk, the water table is under the perched springs which appear generally on the hillside underlain by shale.

Thus in summary, the amount of water seeping downward to the regional water table is small, movement is very slow, and a contribution from the regional water table to adjacent streams and springs is small. Regional groundwater is used primarily by deep-rooted trees rather than grass. Most of the water yield leaving the watershed comes from melting snows and summer thunderstorms. A change in the level of the regional water table caused by mining will not materially affect surface flows or surface vegetation.

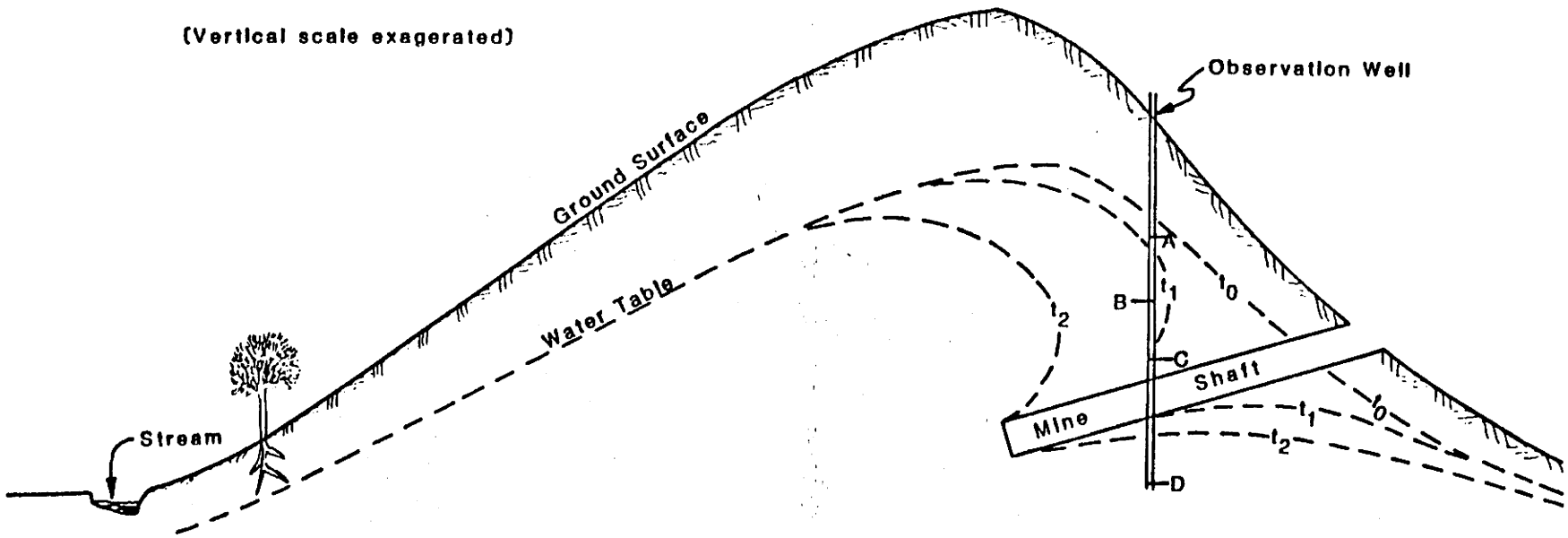


Figure 3. Impact of mine on water table.

the downdip region where the water is being used would likely be several years because of the low transmissivities. The tree shown in Figure 3 has its roots extending to the water table. A small change in depth to water caused by mining would not significantly alter the growth of the tree. The deep-rooted vegetation in most areas where the Blackhawk formation exists keeps the water table below the root zone of shallower forage plants.

Since in the Blackhawk, the springs are associated with perched water, they would not be affected by a change in water table depth. Likewise the forage in the canyon bottoms would not be significantly affected, because the water table is generally below the rooting depth. In lower Eccles Canyon where the springs do emerge from the Starpoint formation in the bottom of the canyon, some slight change in flow might be expected because of the water intercepted at the mine.

Water Levels at the Valentine Fault

Earlier specific reference was made to the possibility of placing observation wells adjacent to the Valentine Fault to determine the likelihood that excessive water would be encountered when the mine reached the fault. Because of overburden, it is difficult to precisely locate the fault and to delineate its dip angle. To intercept the fault at a specific depth would be difficult. Also, to know when the fault was intercepted would also be difficult unless a fracture was encountered. Since most faults encountered in the mines have not exhibited fractured areas, and since most faults encountered in the mines are not tension faults, the ability to place observation wells meaningfully adjacent to the Valentine fault is questionable.

Tension cracks, which yield considerable water, generally occur in the tension portion of a fold, rather than in faults. The mine operators cannot predict with much certainty where these folds will occur. The only practical solution is to have enough pump capacity available to handle a flow of at least 200 gpm when and if such a flow occurs.

Summary

Coal mines within the Wasatch Plateau exhibit remarkably similar conditions. Hence, experience gleaned from operating mines can be used to predict probable operating conditions in the soon to be developed Skyline Mine.

The impact from mining on the surface and ground water hydrology will be minimal. Subsidence should not alter significantly the availability of surface water. Runoff from the watershed comes mainly from melting snow and summer thunderstorms. Changes in water table depth resulting from mining will not significantly effect the yield of ground water to downstream users. Most of the percolating water reappears in nearby seeps and springs.

SKYLINE MINES

MINING AND RECLAMATION PLAN

CENTRAL STATES ENERGY COMPANY

1986

APPENDIX

VOLUME A-1

MUNICIPAL WATERSHEDS
PRICE CITY WATER LETTER
U.S. DEPT. OF AGRICULTURE
MANTI-LA SAL FOREST SERVICE
2540 WATER USES AND DEVELOPMENT, 1981

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Manti-LaSal NF

W/S 02 1981
Price City Water Supply
Price River

REPLY TO: 2540 Water Uses and Development

February 27, 1981

SUBJECT: Municipal Watersheds - Price City Water Collection System

TO: A. Joel Frandsen, Branch Chief - Watershed

This memo documents information about the Price City Water Collection System gained from Mr. Mark Hansen during a phone conversation on February 26, 1981.

The primary water supply for Price City is seven springs near the confluence of Price River (Fish Creek) and White River at Colton. It is believed that these springs flow from a bedrock aquifer. However, it also appears that the rate of flow from these springs varies with the water level in Scofield Reservoir. The State of Utah has classified this as an approved system.

In addition, Price City owns shares of Scofield water which supplements the spring sources during late summer and dry years when water use is high and spring flows are down. The Scofield water must be filtered and treated, since it is a polluted source. The filtration and treatment plant is near Castlegate. In addition, Price City purchases water (5-10 gallons per minute) from Utah Power and Light Company's well source near Colton. This well supplement is especially helpful during winter low flow periods.

Price City is also a member of the Price River Water Improvement District, which supplies all of the water to the surrounding areas outside of Price City and Helper. The water supply for the Price River Water Improvement District is also the Scofield Reservoir. The supply is used mainly during dry years.

G. Dennis Kelly

G. DENNIS KELLY
Hydrologist

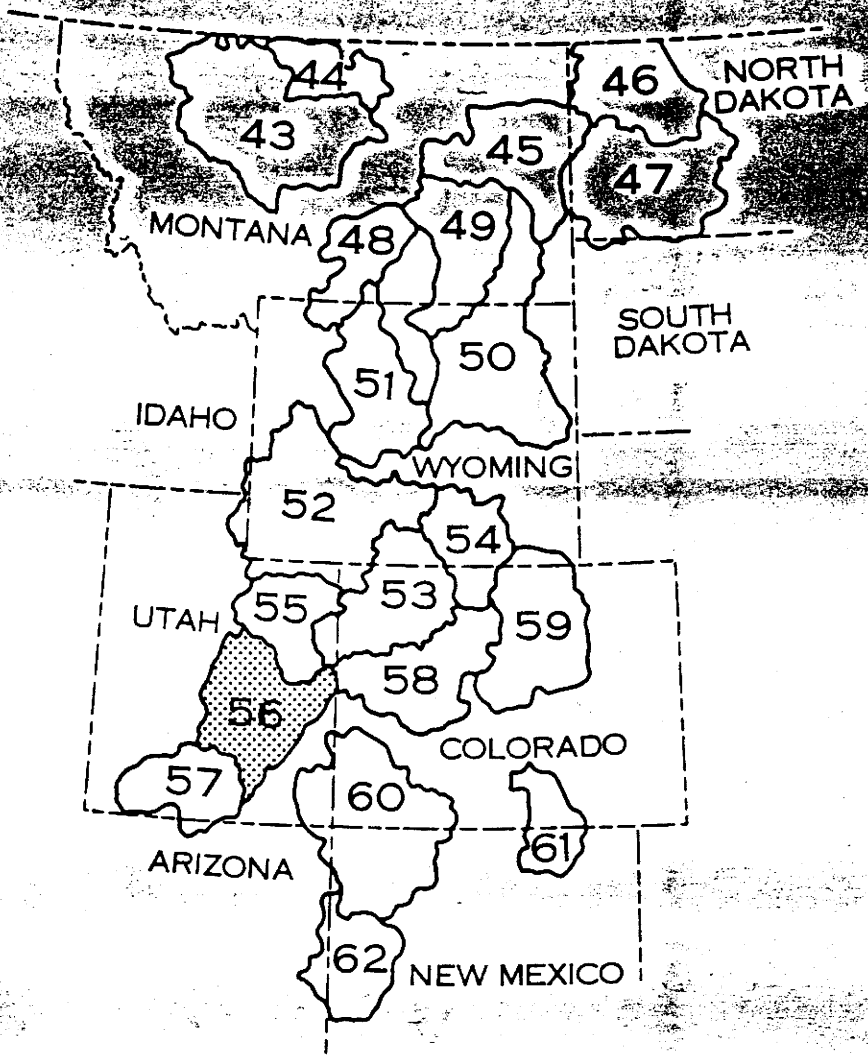
cc: D-3
MCall
JLucero

Winter Quarters Canyon
Data Adequacy

October 1992

HYDROLOGY OF AREA 56
NORTHERN GREAT PLAINS AND ROCKY MOUNTAIN COAL PROVINCES, UTAH

HYDROLOGY OF AREA 56, NORTHERN GREAT PLAINS AND ROCKY MOUNTAIN COAL PROVINCES, UTAH



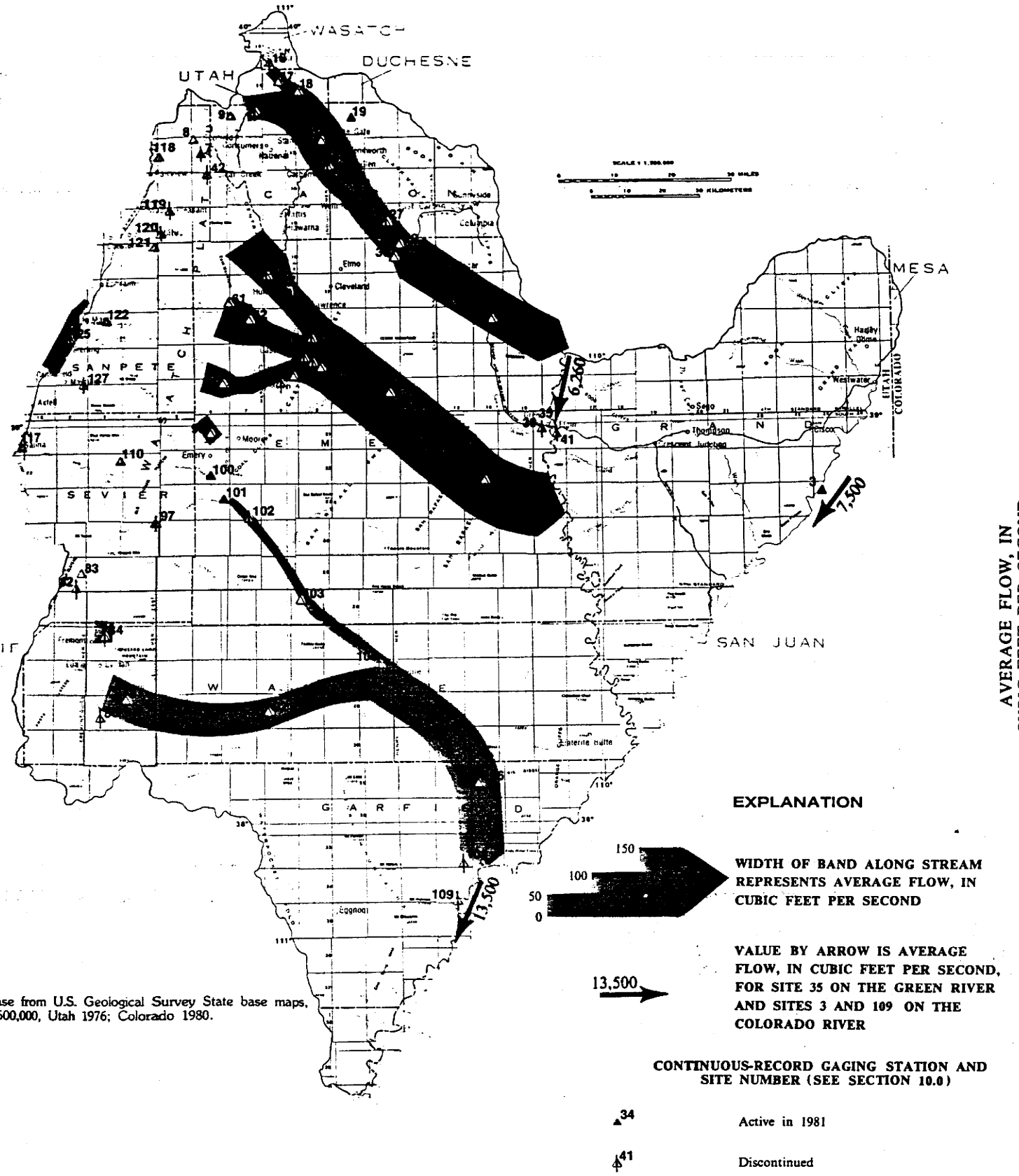
- GREEN RIVER
- PRICE RIVER
- COLORADO RIVER
- SAN RAFAEL RIVER
- DIRTY DEVIL RIVER
- SAN PITCH RIVER

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 83-38

Base from U.S. Geological Survey State base maps, 1:500,000, Utah 1976; Colorado 1980.

Figure 6.1-1 Surface-water network.



Base from U.S. Geological Survey State base maps, 1:500,000, Utah 1976; Colorado 1980.

Figure 6.2-3 Average flow of large streams and location of selected continuous-record gaging stations.

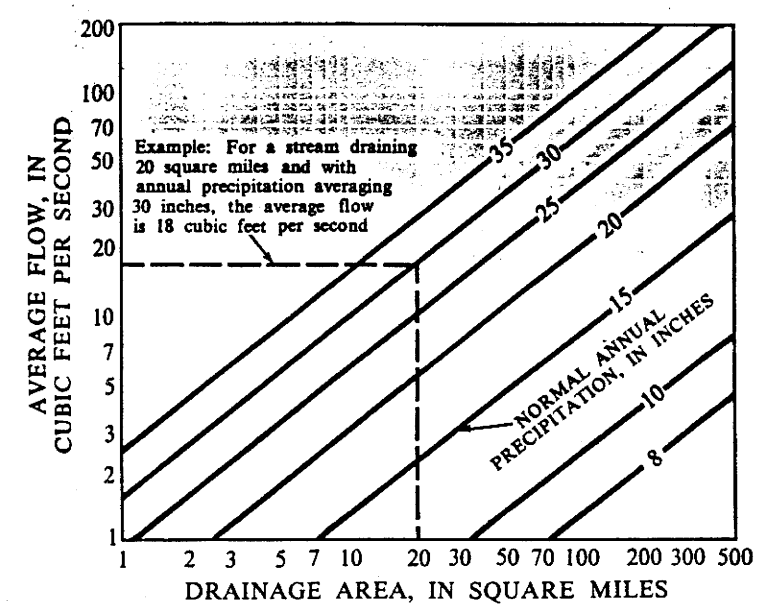
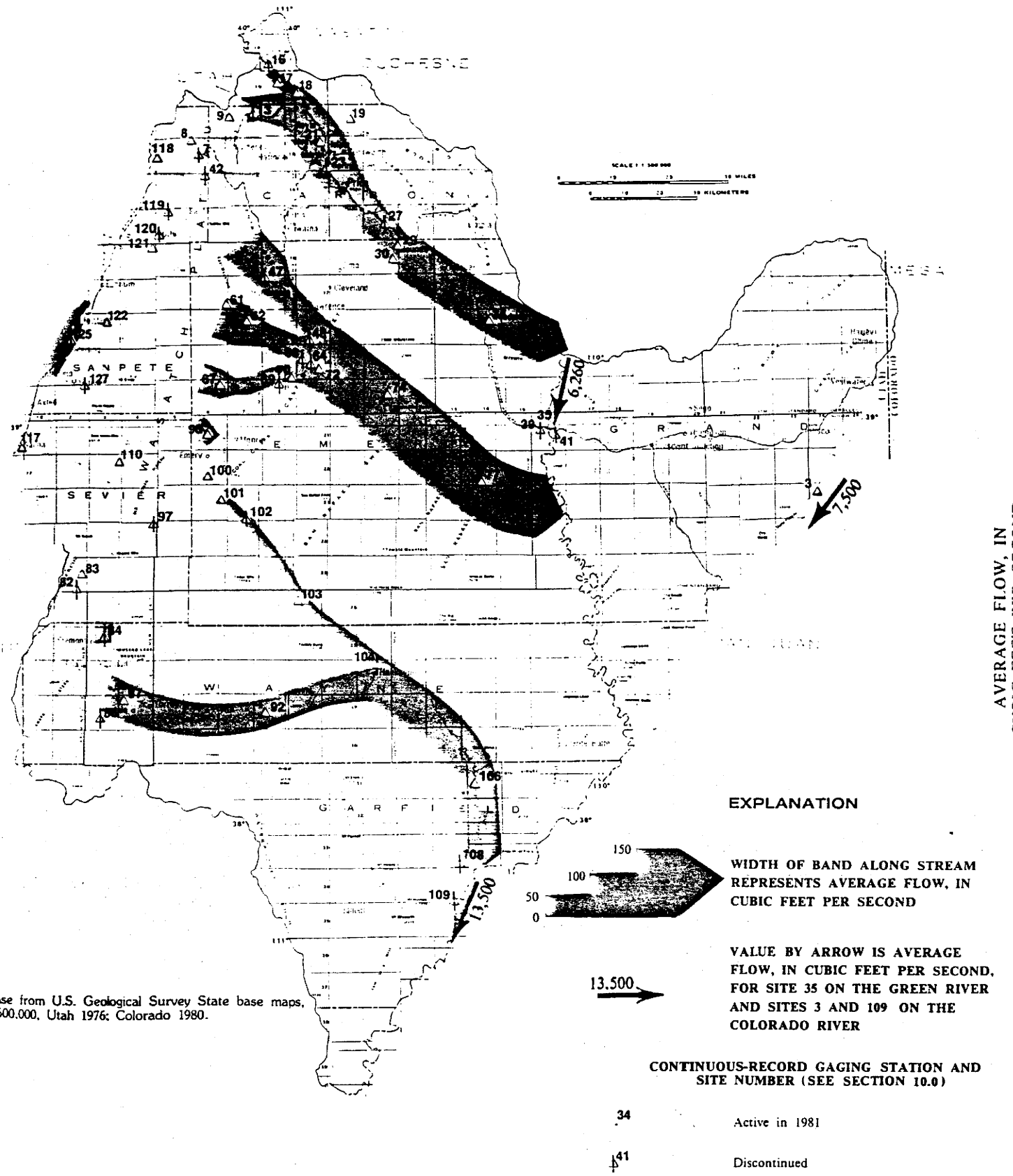


Figure 6.2-4 Relation of average flow to drainage area and normal annual precipitation.

Table 6.2-1 Average flow for continuous-record gaging stations with 5 or more complete years of record.

Site No. (see Section 10.0)	Average flow (cubic feet per second)	Drainage area (square miles)	Normal annual precipitation for drainage area (inches)
3	7,500	24,100	–
7	9.38	7.9	35
8	18.2	16.8	32
9	46.8	60.1	29
13	59.7	155	27
16	19.4	53	26
17	27.3	75.6	25
18	3.88	26.1	21
19	8.15	62.8	17
21	112	415	20
23	143	530	–
27	75.4	850	–
29	84.0	956	–
30	22.6	191	–
34	103	1,540	–
35	6,260	44,850	–
39	2.99	180	8
41	.95	75	8
42	3.86	1.9	35
47	96.3	190	23
48	70.2	325	17
62	95.0	208	25
63	54.8	261	20
64	94.3	680	–
67	66.0	138	26
69	35.6	210	21
70	39.5	221	20
72	104	930	–
74	76.8	1,284	–
77	145	1,628	–
82	7.02	27	18
83	14.1	24	27
84	41.2	205	21
86	3.98	104	18
87	86.8	751	–
92	67.2	1,208	–
95	37.3	105	25
97	3.91	50	20
101	16.4	418	14
102	15.4	440	14
103	21.9	841	–
104	29.0	1,552	–
106	96.3	4,159	–
108	1.20	136	7
109	13,500	76,600	–
110	17.3	51.8	25
117	21.3	292	20
118	10.7	11.8	24
119	17.7	16.4	28
120	8.37	5.9	30
121	10.3	8.35	29
122	29.3	26.4	26
125	44.9	672	–
127	30.9	59.4	26



Base from U.S. Geological Survey State base maps, 1:500,000, Utah 1976; Colorado 1980.

Figure 6.2-3 Average flow of large streams and location of selected continuous-record gaging stations.

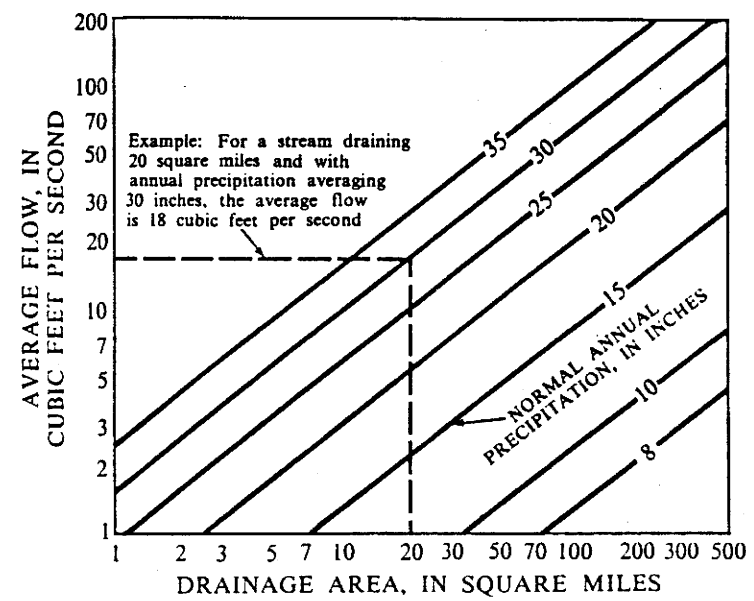


Figure 6.2-4 Relation of average flow to drainage area and normal annual precipitation.

Table 6.2-1 Average flow for continuous-record gaging stations with 5 or more complete years of record.

Site No. (see Section 10.0)	Average flow (cubic feet per second)	Drainage area (square miles)	Normal annual precipitation for drainage area (inches)
3	7,500	24,100	–
7	9.38	7.9	35
8	18.2	16.8	32
9	46.8	60.1	29
13	59.7	155	27
16	19.4	53	26
17	27.3	75.6	25
18	3.88	26.1	21
19	8.15	62.8	17
21	112	415	20
23	143	530	–
27	75.4	850	–
29	84.0	956	–
30	22.6	191	–
34	103	1,540	–
35	6,260	44,850	–
39	2.99	180	8
41	.95	75	8
42	3.86	1.9	35
47	96.3	190	23
48	70.2	325	17
62	95.0	208	25
63	54.8	261	20
64	94.3	680	–
67	66.0	138	26
69	35.6	210	21
70	39.5	221	20
72	104	930	–
74	76.8	1,284	–
77	145	1,628	–
82	7.02	27	18
83	14.1	24	27
84	41.2	205	21
86	3.98	104	18
87	86.8	751	–
92	67.2	1,208	–
95	37.3	105	25
97	3.91	50	20
101	16.4	418	14
102	15.4	440	14
103	21.9	841	–
104	29.0	1,552	–
106	96.3	4,159	–
108	1.20	136	7
109	13,500	76,600	–
110	17.3	51.8	25
117	21.3	292	20
118	10.7	11.8	24
119	17.7	16.4	28
120	8.37	5.9	30
121	10.3	8.35	29
122	29.3	26.4	26
125	44.9	672	–
127	30.9	59.4	26

Graham, M. J., Tooley, J. E., and Price, Don, 1981, Preliminary hydrologic evaluation of the North Horn Mountain coal-resource area, Utah: U.S. Geological Survey Open-File Report 81-141, 33 p.

Hackman, R. J., and Williams P. L., 1972, Map showing drainage basins and historic cloudburst floods in the Salina Quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-591-N, scale 1:250,000.

Hintze, L. F., 1980, Geologic map of Utah: Utah Geological and Mineral Survey, 2 sheets, scale 1:500,000.

Hood, J. W., and Danielson, T. W., 1979, Aquifer tests of the Navajo Sandstone near Caineville, Wayne County, Utah: Utah Department of Natural Resources Technical Publication 66, 69 p.

_____1981, Bedrock aquifers in the lower Dirty Devil River basin area, Utah, with special emphasis on the Navajo Sandstone: Utah Department of Natural Resources Technical Publication 68, 143 p.

Iorns, W. V., Hembree, C. H., Phoenix, D. A., and Oakland, G. L., 1964, Water resources of the Upper Colorado River Basin--basic data: U.S. Geological Survey Professional Paper 442, 1036 p.

Iorns, W. V., Hembree, C. H., and Oakland, G. L., 1965, Water resources of the Upper Colorado River Basin--technical report: U.S. Geological Survey Professional Paper 441, 370 p.

King, N. J., and Mace, M. N., 1953, Sedimentation in small reservoirs on the San Rafael Swell, Utah: U.S. Geological Survey Circular 256, 21 p.

Lines, G. C., 1981, Hydrologic studies of the U.S. Geological Survey in major coal-resource areas of Utah through 1980: U.S. Geological Survey Open-File Report 81-216, 20 p.

Lines, G. C., and Morrissey, D. J., 1981, Hydrology of the Ferron sandstone aquifer and effects of proposed surface-coal mining in Castle Valley, Utah, *with a section on* Stratigraphy by T. A. Ryer and *a section on* Leaching of overburden by R. H. Fuller: U.S. Geological Survey Open-File Report 81-535, 108 p. (to be printed as U.S. Geological Survey Water-Supply Paper 2195).

Lines, G. C., and Plantz, G. G., 1981, Hydrologic monitoring in coal fields of central Utah, August 1978-September 1979: U.S. Geological Survey Water-Resources Investigations 81-138, 56 p.

Marine, I. W., 1962, Water-supply possibilities at Capitol Reef National Monument, Utah: U.S. Geological Survey Water-Supply Paper 1475-G, p. 201-208.

Morrissey, D. J., Lines, G. C., and Bartholoma, S. D., 1980, Three-dimensional digital-computer model of the Ferron sandstone aquifer near Emery, Utah: U.S. Geological Survey Water-Resources Investigations 80-62, 101 p.

Mundorff, J. C., 1968, Fluvial sediment in Utah, 1905-65, a data compilation: Utah Department of Natural Resources Information Bulletin 20, 400 p.

_____1971, Nonthermal springs of Utah: Utah Geological and Mineralogical Survey Water-Resources Bulletin 16, 70 p.

_____1972, Reconnaissance of chemical quality of surface water and fluvial sediment in the Price River basin, Utah: Utah Department of Natural Resources Technical Publication 39, 55 p.

_____1979, Reconnaissance of chemical quality of surface water and fluvial sediment in the Dirty Devil River basin, Utah: Utah Department of Natural Resources Technical Publication 65, 132 p.

Mundorff, J. C., and Thompson, K. R., 1980, Reconnaissance of the quality of surface water in the San Rafael River basin, Utah: U.S. Geological Survey Open-File Report 80-574, 54 p. (to be printed as Utah Department of Natural Resources Technical Pubication 72).

Price, Don, 1972a, Map showing general availability of ground water in the Salina Quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-591-M, scale 1:250,000.

Price, Don, 1972b, Map showing general chemical quality of ground water in the Salina Quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Map I-591-K, scale 1:250,000.

Price, Don, and Arnow, Ted, 1974, Summary appraisals of the Nation's ground-water resources--upper Colorado Region: U.S. Geological Survey Professional Paper 813-C, 40 p.

Price, Don, and Waddell, K. M., 1973, Selected hydrologic data in the Upper Colorado River Basin: U.S. Geological Survey Hydrologic Investigations Atlas HA-477, 2 sheets, scale 1:250,000.

Riggs, H. C., 1973, Regional analysis of streamflow characteristics: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 4, Chapter B3, 15 p.

Robinson, G. B., Jr., 1968, Selected hydrologic data, San Pitch River drainage basin, Utah: U.S. Geological Survey open-file report (duplicated as Utah Basic-Data Release 14), 44 p.

_____1971, Ground-water hydrology of the San Pitch drainage basin, San Pete County, Utah: U.S. Geological Survey Water-Supply Paper 1896, 80 p.

Sumsion, C. T., 1979, Selected coal-related ground-water data, Wasatch Plateau-Book Cliffs area, Utah: U.S. Geological Survey Open-File Report 79-915 (duplicated as Utah Hydrologic-Data Report 32), 25 p.

U.S. Bureau of Land Management, 1973, Utah public lands guide: U.S. Bureau of Land Management map of Utah, scale about 1:2,000,000.

U.S. Department of Agriculture, 1973, Estimating sediment yield rates for the State of Utah: Western United States Water-Plan Map, scale 1:500,000.

U.S. Environmental Protection Agency, 1976, National interim primary drinking water regulations: Washington, D. C., U.S. Government Printing Office, 159 p.

U.S. Geological Survey, issued annually since 1975, Water resources data for Utah: Water Resources Division, Salt Lake City.

_____1980, Index to topographic maps of Utah: map of Utah, scale 1:1,000,000.

U.S. Weather Bureau, [1963], Normal annual and May-September precipitation (1931-60) for the State of Utah: Map of Utah, scale 1:500,000.

Utah Department of Agriculture, 1981, Utah agricultural statistics, 1981: Utah Department of Agriculture duplicated report, 95 p.

Utah Geological and Mineral Survey, 1975, Energy resources map of Utah: Map 36, scale 1:500,000.

Waddell, K. M., Contratto, P. K., Sumsion, C. T., and Butler, J. R., 1981, Hydrologic reconnaissance of the Wasatch Plateau-Book Cliffs coal-fields area, Utah: U.S. Geological Survey Water-Supply Paper 2068, 45 p.

Waddell, K. M., Vickers, H. L., Upton, R. T., and Contratto, P. K., 1978, Selected hydrologic data, 1931-77, Wasatch Plateau-Book Cliffs coal-fields area, Utah: U.S. Geological Survey Open-File Report 78-121 (duplicated as Utah Basic-Data Release 31), 33 p.

Waring, G. A., 1935, Ground water in part of southeastern Utah and southwestern Colorado *with a chapter on* Moab and Spring Valleys by M. M. Knechtel: U.S. Geological Survey open-file report, 119 p.

Young, R. A., and Carpenter, C. H., 1965, Ground-water conditions in the central Sevier Valley, Utah: U.S. Geological Survey Water-Supply Paper 1787, 95 p.

10.0 LIST OF SURFACE-WATER STATIONS

Site No. (see figure 6-1.1)	Station No.	Station Name	Location Latitude ° ' "	Location Longitude ° ' "	Drainage area (square miles)	Period and type of record: Discharge	Period and type of record: Water quality
1	09163550	Harley Dome Wash near Harley Dome, Utah	39 09 25	109 08 40	3.1	[1]1959-68	–
2	09163700	Cisco Wash near Cisco, Utah	38 57 50	109 20 10	29	[1]1959-74	–
3	09180500	Colorado River near Cisco, Utah	38 48 38	109 17 34	24,100	1895-1981	1928-81
4	09182600	Salt Wash near Thompson, Utah	38 57 10	109 39 30	3.9	[1]1959-74	–
5	09309500	Fairview ditch near Fairview, Utah (Transmountain diversion)	39 39 36	111 19 38	–	1949-67	–
6	09309600	Fairview tunnel near Fairview, Utah (Transmountain diversion)	39 40 03	111 18 41	–	1967-81	–
7	09309800	Gooseberry Creek near Fairview, Utah	39 40 27	111 18 15	7.9	1959-69	–
8	09310000	Gooseberry Creek near Scofield, Utah	39 42 57	111 17 58	16.8	1930-31, 1940-81	–
9	09310500	Fish Creek above reservoir, near Scofield, Utah	39 46 28	111 11 25	60.1	1931-32, 1938-81	–
10	09310600	Eccles Canyon near Scofield, Utah	39 41 07	111 09 22	5.5	1979-81	1979-81
11	09310700	Mud Creek below Winter Quarters Canyon, at Scofield, Utah	39 43 18	111 09 38	29.1	1978-81	1978-81
12	09311000	Scofield Reservoir near Scofield, Utah	39 47 15	111 07 30	154	1941-81	–
13	09311500	Price River (Fish Creek) near Scofield, Utah	39 47 13	111 07 10	155	1917-21, 1925-31, 1938-69	–
14	09311700	Price River near Soldier Summit, Utah	39 49 40	111 00 30	180	1961-63	–
15	09312000	North Fork White River near Soldier Summit, Utah	39 56	111 04	23.3	1942-47	–
16	09312500	White River near Soldier Summit, Utah	39 55 20	111 03 25	53	1938-67	–
17	09312600	White River below Tabbyune Creek, near Soldier Summit, Utah	39 52 33	111 02 12	75.6	1967-81	–
18	09312700	Beaver Creek near Soldier Summit, Utah	39 49 50	110 58 07	26.1	1960-81	–
19	09312800	Willow Creek near Castle Gate, Utah	39 46 37	110 47 30	62.8	1962-81	–
20	09312900	Willow Creek at Castle Gate, Utah	39 43 37	110 51 41	77.4	1979-81	1979-81

Site No. (see figure 6-1.1)	Station No.	Station Name	Location Latitude ° ′ ″	Location Longitude ° ′ ″	Drainage area (square miles)	Period and type of record: Discharge	Period and type of record: Water quality
21	09313000	Price River near Heiner, Utah	39 43 08	110 51 55	415	1934-69, 1979-81	1979-81
22	09313040	Spring Canyon below Sowbelly Gulch, at Helper, Utah	39 41 19	110 53 09	23.0	1978-81	1978-81
23	09313500	Price River near Helper, Utah	39 39 05	110 51 25	530	1904-34	–
24	09313965	Coal Creek near Helper, Utah	39 42 09	110 40 38	25.3	1978-81	1978-81
25	09313975	Soldier Creek below mine, near Wellington, Utah	39 41 43	110 36 52	17.7	1978-81	1978-81
26	09313985	Dugout Creek near Sunnyside, Utah	39 40 47	110 32 52	5.8	1979-81	1979-81
27	09314000	Price River near Wellington, Utah	39 30 40	110 40 50	850	1949-58	–
28	09314200	Miller Creek near Price, Utah	39 32	110 49	62	[1]1960-74	–
29	09314250	Price River below Miller Creek, near Wellington, Utah	39 26 59	110 37 38	956	1972-81	–
30	09314280	Desert Seep Wash near Wellington, Utah	39 25 16	110 38 44	191	1972-81	–
31	09314340	Grassy Trail Creek at Sunnyside, Utah	39 33 20	110 22 46	40.1	1978-81	1978-81
32	09314374	Horse Canyon near Sunnyside, Utah	39 27 26	110 21 33	12.5	1978-81	1978-81
33	09314400	Coleman Wash tributary near Woodside, Utah	39 23	110 24	3.6	[1]1959-68	–
34	09314500	Price River at Woodside, Utah	39 15 50	110 20 45	1,540	1909-11, 1945-81	1946-49, 1951-81
35	09315000	Green River at Green River, Utah	38 59 10	110 09 02	44,850	1894-1899, 1904-81	1928-81
36	09315150	Saleratus Wash tributary near Woodside, Utah	39 08	110 20	10	[1]1959-74	–
37	09315200	Saleratus Wash tributary No. 2 near Woodside, Utah	39 06	110 19	4.4	[1]1959-74	–
38	09315400	Saleratus Wash above Cottonwood Wash, near Green River, Utah	39 01	110 18	120	[1]1959-68	–
39	09315500	Saleratus Wash at Green River, Utah	38 58 53	110 14 46	180	1948-70	–
40	09315900	Browns Wash tributary near Green River, Utah	38 59	110 06	3.89	[1]1959-74	–

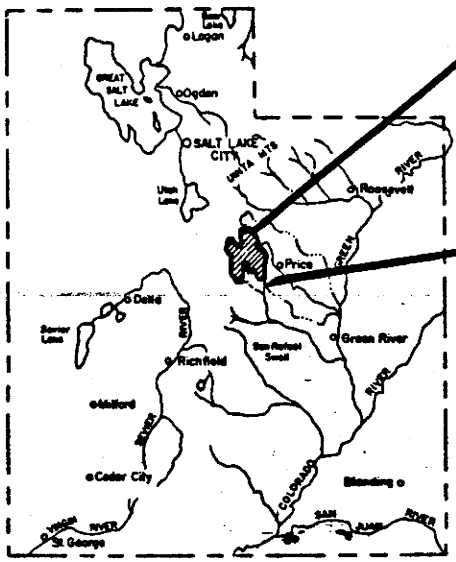
WATER QUALITY IN PLEASANT VALLEY, UT
UTAH WATER RESEARCH LABORATORY
UTAH STATE UNIVERSITY
UWRL/H-81/02, 1981

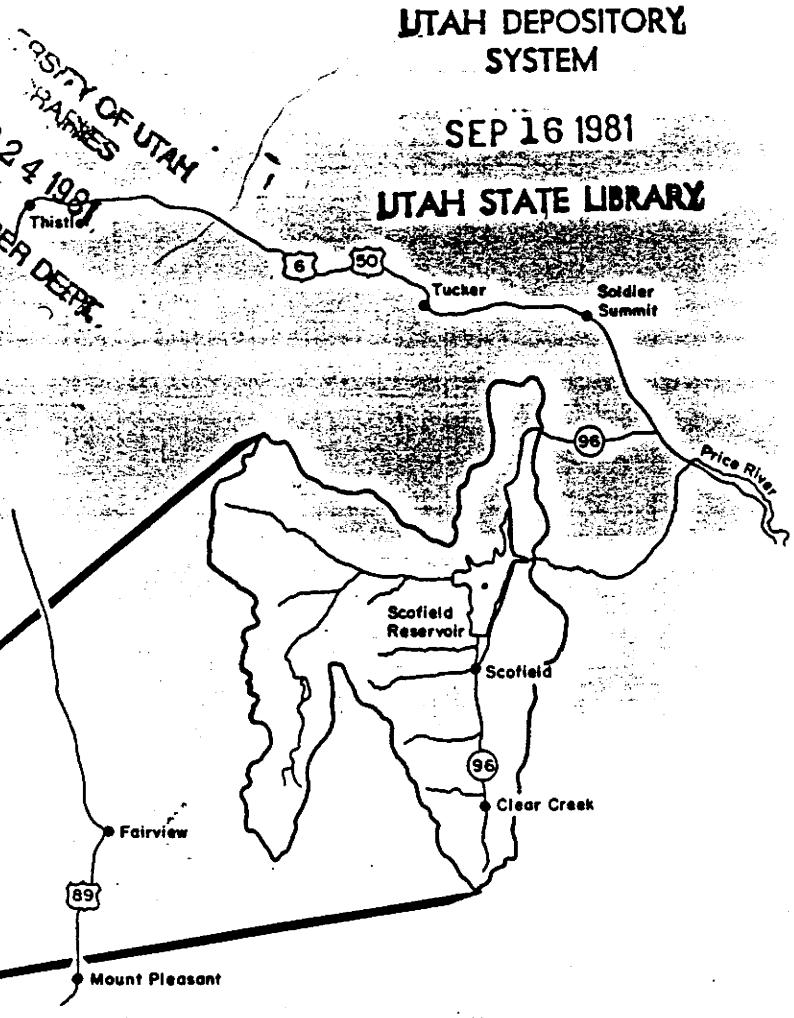
CSCL 4/15/92

Water Quality In Pleasant Valley, Utah

Calvin G. Clyde
Dennis B. George
Kun Mo Lee
Phil Pucel
William Hay

UTAH DEPOSITORY SYSTEM
SEP 16 1981
UTAH STATE LIBRARY
UNIVERSITY OF UTAH LIBRARIES
SEP 24 1981
GEHALS ORDER DEPT.





Utah Water Research Laboratory
Utah State University
Logan, Utah 84322

March 1981

Hydrology and Hydraulics Series
UWRL/H-81/02

WATER QUALITY IN PLEASANT VALLEY, UTAH

by

Calvin G. Clyde
Dennis B. George
Kun Mo Lee
Phil Pucel
William Hay

Final Report

WG-281

HYDROLOGY AND HYDRAULICS SERIES

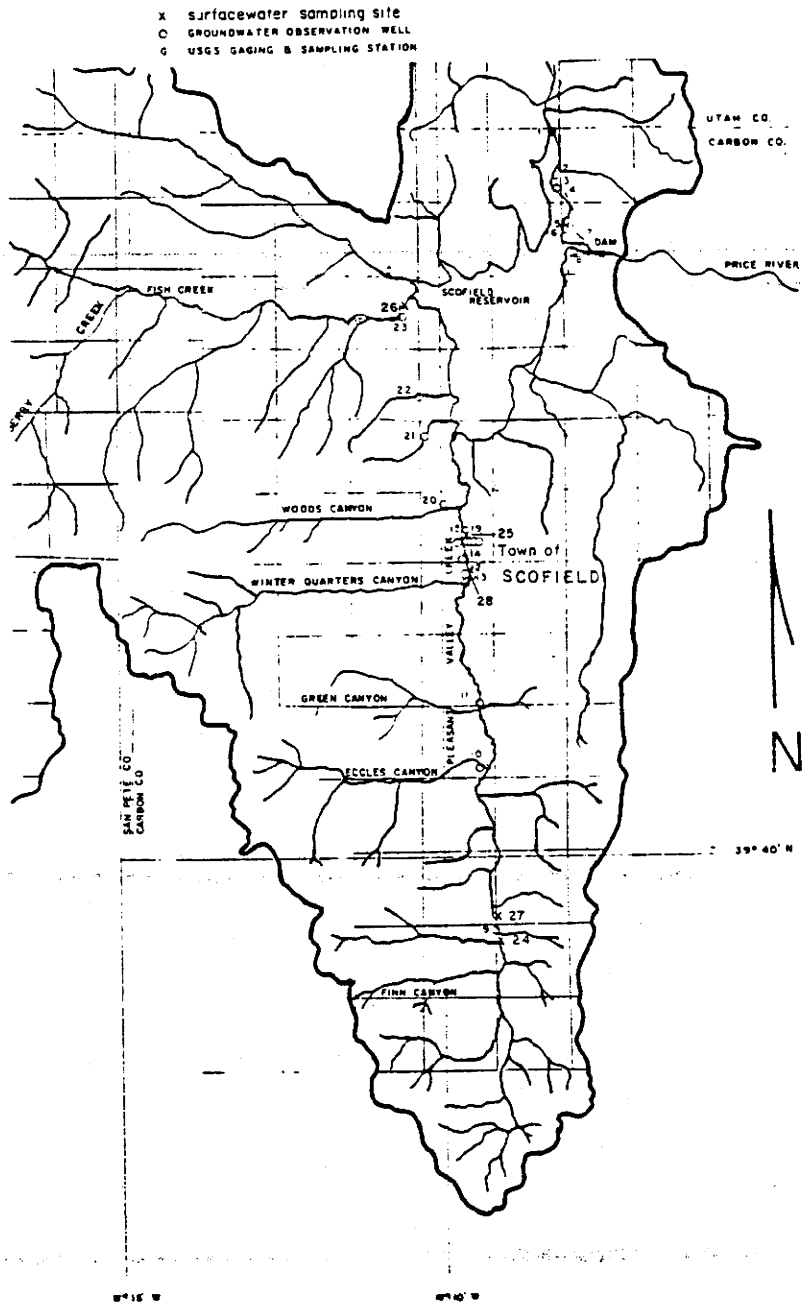
UWRL/H-81/02

Utah Water Research Laboratory
Utah State University
Logan, Utah 84322

March 1981

Table 1. USGS gaging stations in Pleasant Valley.

Number	Station	Near	County	Drainage Area
09310500	Fish Creek	Scofield	Carbon	168 km^2 (65 mi^2)
09311000	Scofield Reservoir	Scofield	Carbon	401 km^2 (155 mi^2)
09311500	Price River	244 m (800 ft)	downstream of the dam	



Note: Pleasant Valley Creek is also known as Mud Creek.

Figure 5. Location of water sampling sites.

Table 2. Sheep allotments on the Manti-LaSal National Forest in the Pleasant Valley, Utah.

Allotment Name	Allotment	Dates
Bob Wright	1,013	July 1 to Sept. 30
Yellow Brush Flat and Trough Spring Ridge	1,849	July 1 to Sept. 30
Mon Peak	601	July 1 to Sept. 30
Coal Ridge	377	July 6 to Sept. 25
Burnout	678	July 1 to Sept. 25
Eccles	1,000	July 1 to Sept. 30
Bean Ridge	1,000	July 1 to Sept. 30
French Creek	1,156	July 1 to Sept. 30
Granger Ridge	1,156	July 1 to Sept. 30
Winter Quarters	848	July 1 to Sept. 30
Bennion	656	July 1 to Sept. 30
W. Bear	663	July 1 to Sept. 30
W. Fish Creek	897	July 1 to Sept. 30
E. Fish Creek	991	July 1 to Sept. 30
C Canyon	900	July 1 to Sept. 30
Silver Creek	936	July 1 to Sept. 30
Cabin Hollow	1,050	July 1 to Sept. 30
E. Gooseberry	269	July 1 to Oct 30
Mansion	727	July 1 to Oct. 30
Johnson Ridge	684	July 1 to Sept. 30
Pondtown	1,417	July 1 to Sept. 30
E. Bear Ridge	1,200	June 11 to Sept. 30

(Personal communication: USFS: Manti-LaSal National Forest 1980)

Recreation is characterized by boating and fishing in the summer, hunting in the fall, snowmobiling and cross-country skiing during the winter.

Population

The population of the town of Scofield and of the summer home develoments varies widely between the summer and winter seasons. Scofield boasts a year-round residency of 35, which increases to 150 during the summer months. The average family size is 3.18 people per household. The summer home developments are vacated during the winter and early spring, with the peak population occurring between Memorial Day and Labor Day (Southeastern Utah Association of Governments 1980). Bolotas subdivision and the County Street subdivision at the north end of the lake and Perry's boat camp just south of the outlet provide space for housing, camping, and other facilities mostly for summertime recreational use. A few residents stay all year. Some additional year-round homes are located in the settlement at Clear Creek and other scattered locations.

A State Park, which hosted 125,000 visitors during the summer of 1979, is located south of the county subdivision on the shoreline of the reservoir. Facilities include two trailers used as living quarters for the state rangers, parking area, a water supply obtained from a nearby 42 m (140 ft) well, a boat ramp, restrooms and a fish-cleaning station.

WOOD CANYON 20
WINTER QUARTER 12, 13, 28
GREEN CANYON 11
ECCLES CANYON 10
Fish Creek 26, 23

METHODS AND PROCEDURES

Selection of Sampling Sites

Several factors were considered during the selection of sampling sites: 1) likely locations for detection of contaminants; 2) wide areal coverage of the lower inhabited parts of the basin; 3) accessibility; 4) owners' permission; and 5) economics. Points where contaminants were likely to be detected were 1) down-gradient from tile or leach fields (particularly in areas where houses are clustered); 2) in valley alluvium downstream of possible pollution sources; and 3) in valley alluvium at the mouth of canyons where grazing occurred. Wide areal coverage provided a general sampling of groundwater contamination in the basin. Accessibility was a practical consideration in the drilling of wells and the collection of samples. Owners' permission dictated the location of several wells. Economics (well drilling costs and analytical costs) was a factor in determining the number of wells to be drilled.

Description of Individual Sampling Sites

Figures 5, 6, and 7 and Tables 3 and D-2 (Appendix D) show the well locations. Well #1, which is a flowing well, was the sole sampling station on the north end of the Scofield Reservoir, Utah. Wells #2, 3, and 4 are located in the Bolotas subdivision on the east shore of the Scofield Reservoir. Wells #5 and 6 are in the Scofield Reservoir Campsite subdivision. This subdivision and the Bolotas subdivision were characterized by clusters of the few score cottages. Contamination of the shallow groundwater and the reservoir by domestic waste from septic tank leach fields and pit privies might occur due to a high groundwater table (1.22 m from the ground surface) and the short distance between the shoreline and the cottages (less than 200 m). Well #7 is located down-gradient of the state park septic tank leach field which treats wastes produced from tourists and sportsmen during the spring, summer, and fall.

Well #8 is in Perry's Boat Camp. The owner designated a well location approximately one hundred meters southwest of the pit privies, which was not a good location to detect the pollutants from pit privies.

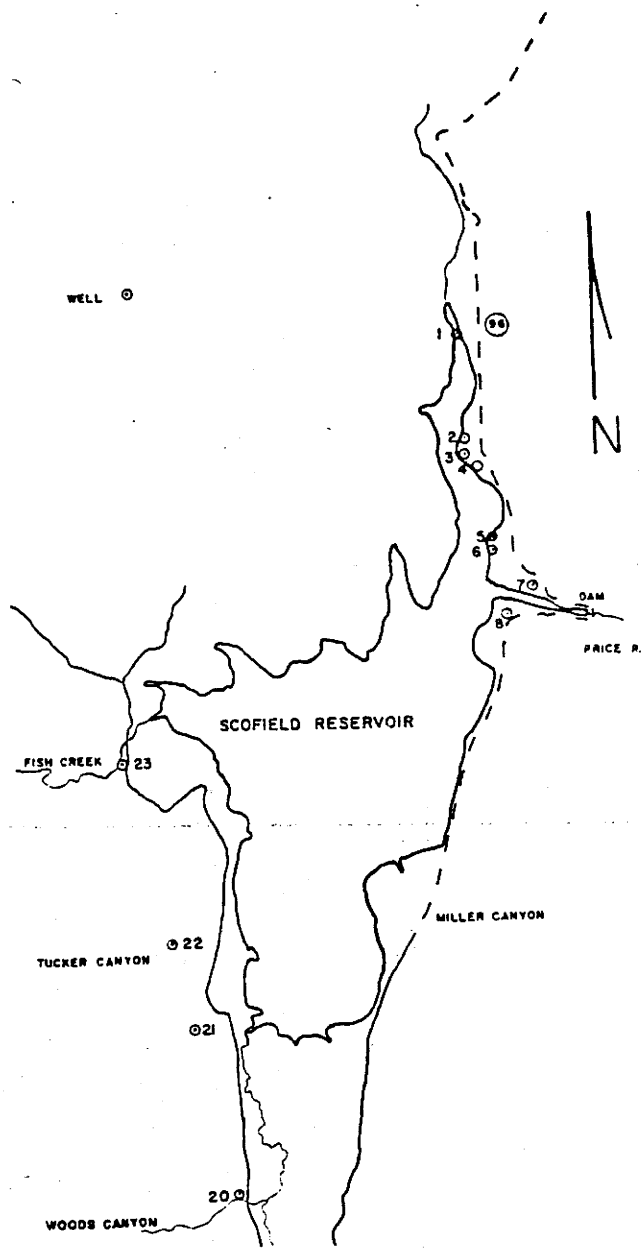


Figure 6. Location of groundwater observation wells adjacent to the Scofield Reservoir.

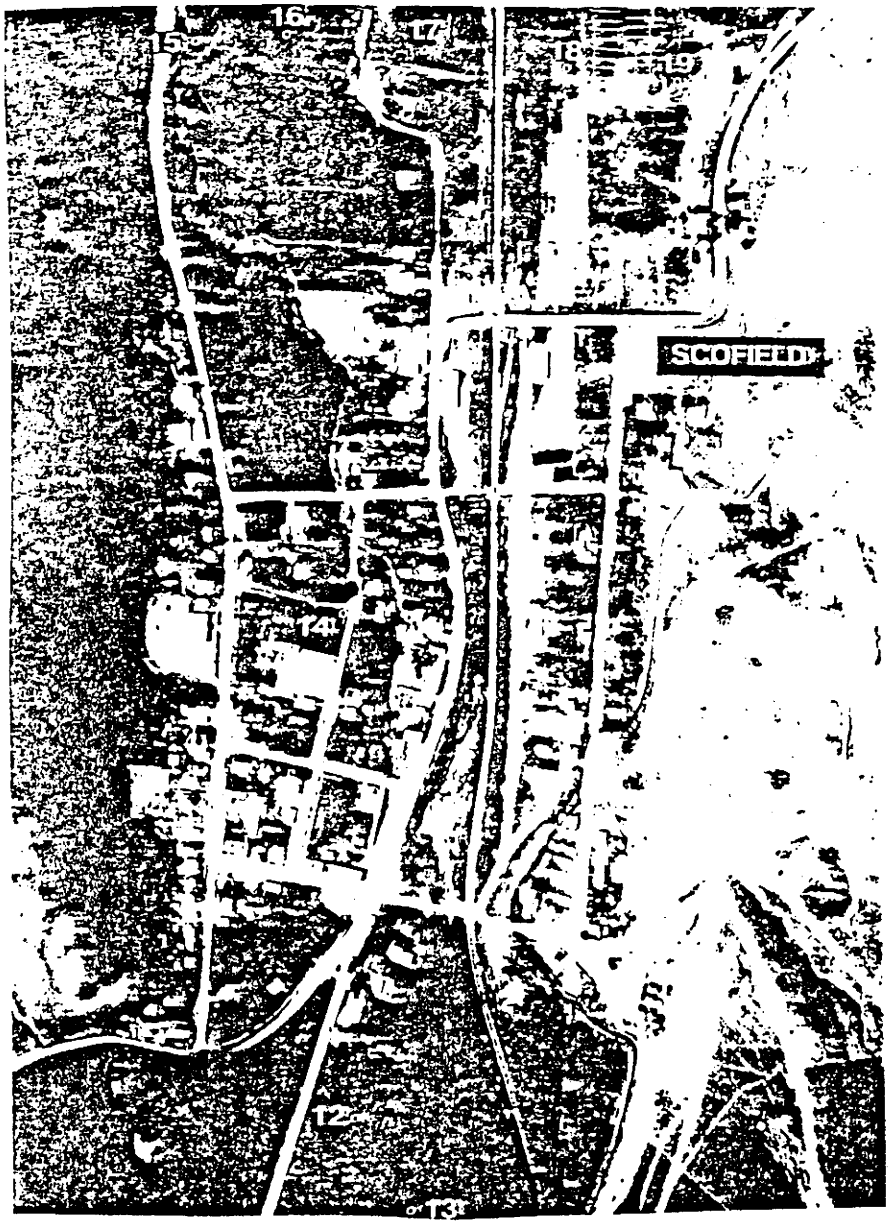


Figure 7. Town of Scofield and location of groundwater observation wells.

Well #9 is located in the Mud Creek alluvium, downstream of the town of Clear Creek and approximately 10 meters (33 feet) from the streambed. Although the exact location of the town communal tile leach field was unknown, the well was estimated to be downstream of the field. There are two surface water sampling sites near well #9 (Figure 5), wells #24 and 27 located south and north, respectively, of Clear Creek town.

Well #10 was drilled by a private firm under contract with Coastal States Energy Company. It is at the base of Eccles Canyon which was used mostly by hunters and picnickers prior to the beginning of coal company operations.

Well #11 was drilled in the Mud Creek alluvium at a distance of approximately 150 meters (490 feet) from the Valley Camp Coal Company leach field.

One cluster of four wells is located south of Scofield. Well #12 is located south of the town and west of Mud Creek in a pasture. Well #13 is nearby but east of Mud Creek. In addition, two uncased, un-numbered piezometers or observation wells were drilled only for the measurement of water table. Their location and the observations made in them are given in Table D-1 (Appendix D). Wells #12 and 13 were selected to define the groundwater quality upstream from the town of Scofield. The north group of wells (#15 to 19) was established to assess the

Table 3. Location of sampling sites.

Site	Location	Drilled Depth (m)	Drilled Depth (ft)	Latitude		Longitude	
Well #1 (Flowing)	North Lake Location	6.10	20'	39°	48.75'	111°	8.25'
Well #2	Bolotas Subdivision, Orr	5.67	18'6"	39°	48.17'	111°	8.21'
Well #3	Bolotas Subdivision, Pappas	6.40	21'	39°	48.09'	111°	8.22'
Well #4	Bolotas Subdivision, Joufflas	6.10	20'	39°	48.03'	111°	8.12'
Well #5	County St. Subdiv., First Ave.	5.18	17'	39°	47.65'	111°	8.00'
Well #6	County St. Subdiv., 4th Ave.	5.49	18'	39°	47.58'	111°	8.03'
Well #7	State Park	5.33	17'6"	39°	47.43'	111°	7.82'
Well #8	Perry's Boat Camp	4.20	13'9½"	39°	47.25'	111°	7.96'
Well #9	Clear Creek	3.05	10'	39°	39.12'	111°	9.18'
Well #10	Eccles Canyon	8.33	27'4"	39°	41.08'	111°	9.45'
Well #11	Valley Camp Coal Co.	5.18	17'	39°	41.82'	111°	9.50'
Well #12	South Profile #1, Hallsten	2.59	8'6"	39°	43.30'	111°	9.70'
Well #13	South Profile #2, Tucker	2.89	9'6"	39°	43.28'	111°	9.60'
Well #14	Scofield Town	4.27	14'	39°	43.54'	111°	9.66'
Well #15	North Profile #1	3.35	11'	39°	43.84'	111°	9.71'
Well #16	North Profile #2	3.50	11'6	39°	43.83'	111°	9.65'
Well #17	North Profile #3	3.05	10'	39°	43.82'	111°	9.59'
Well #18	North Profile #4	2.74	9'	39°	43.81'	111°	9.53'
Well #19	North Profile #5	3.35	11'	39°	43.80'	111°	9.47'
Well #20	Woods Canyon	3.00	9'10"	39°	44.23	111°	9.90'
Well #21	Section 29 Canyon	5.03	16'6"	39°	45.11	111°	10.17'
Well #22	Mountain Home Subdivision	6.27	20'7"	39°	45.57'	111°	10.29'
Well #23	Fish Creek	4.42	14'6"	39°	46.53'	111°	10.56'
Surface Sample #24	South Edge of Clear Creek Town			39°	38.46'	111°	9.20'
Surface Sample #25	North Edge of Scofield			39°	43.66'	111°	9.64'
Surface Sample #26	Fish Creek			39°	46.65'	111°	10.54'
Surface Sample #27	North Edge of Clear Creek Town			39°	39.21'	111°	9.23'
Surface Sample #28	South Edge of Scofield			39°	43.36'	111°	9.40'

groundwater underflow and groundwater quality downstream of the town. The comparison of data from the wells north and south of the town was expected to provide information on the impact of the town of Scofield on groundwater quality. Surface sampling site #28 is in the Mud Creek near well #12.

Well #14 is located in the town of Scofield approximately 50 meters (160 feet) from Mud Creek. This well site was selected in an attempt to assess groundwater quality in a residential area. Surface water sampling site #25 was in the Mud Creek near well #15.

Well #20 is located at the mouth of Woods Canyon, 20 meters (66 feet) west of the road. The depth of this well was limited to 3 meters (10 feet) by an impassable boulder. Sulfur springs and seeps were found 75 meters (250 feet) up-gradient of well #20. Cattle and sheep graze in this canyon from June to September.

The location of well #21 was established at the mouth of a small canyon between Tucker Canyon and Woods Canyon. This well site was chosen to evaluate the groundwater quality of an undeveloped basin which was subject to occasional livestock grazing. Seeps are situated 60 meters (200 feet) northwest of the well.

Well #22 is located near the entrance to Mountain Home Subdivision in the valley alluvium of Tucker Canyon.

Well #23 is at the mouth of Fish Creek Canyon, 3 meters (10 feet) west of the road. The only human activity in the area was fishing. One surface sampling site, #26, was in Fish Creek near well #23. Wells #20 to 23 are located at the mouths of canyons in valley alluvium to monitor diffuse sources of pollution to the reservoir.

As indicated above, many wells were located to monitor point-source pollution, i.e., pollution originating from a well-defined source such as an individual septic tank system or a group of systems. Other sampling sites, such as surface water, were intended to monitor diffuse sources of pollution contributed from nature, town, livestock, and mines.

Drilling, Casing, and Developing the Observation Wells

A hydraulic auger was used to drill the first 3 meters (10 ft) of the 50 mm (2 in) diameter well. Soil samples were collected, labeled, and logged. A 50 mm (2 in) diameter steel pipe was used as a temporary well casing. Well logs are in Appendix D.

August 1980 sampling periods, two 3.8 liter containers were used for several wells to provide enough water for seeded BOD analyses on a number of the samples.

Inasmuch as the elapsed time between sampling and analyzing was nearly 32 hours for some samples, a delayed-incubation MF method (EPA 1978) was used in May. 10 ml and 100 ml samples for the total coliform microorganisms were filtered through a 0.45 μ pore size membrane filter, using a filtering flask (of ground glass) connected to a pump which provides a vacuum and draws water through the filter. The filter was placed in a petri dish with the holding medium. The holding medium served to keep coliform alive in the filter paper, but did not allow the bacteria to grow. The holding medium was prepared one day in advance of the sampling date and inspected for contamination before leaving the lab. The usual glass-bottle samples were taken for the purpose of comparison between the Membrane Filter Method and the Delayed-Incubation Membrane Filter Method. Comparable results were obtained (see Appendix E). Tweezers were sanitized by rinsing in 70 percent ethyl alcohol and flaming. The funnel and filter were sanitized by immersion in 70 percent ethyl alcohol for a least 20 minutes, followed by rinsing with well water and sterile peptone water. Autoclaved 0.1 percent peptone water with pH of 7.0 ± 0.1 was used.

Labels on all containers indicated the site number and appropriate analyses to be conducted. Field book entries were then checked for completeness with regard to place, time, date, and pertinent observations. Sample bottles were placed in a large container (cooler) for the purpose of maintaining the sample at a temperature just above the freezing point. During the winter, a number of the samples (particularly the coliform samples) froze during transport from the field well sites to the pickup truck. Freezing of a water sample will drastically increase the rate of coliform kill. Fecal coliform is very sensitive to freezing conditions. Therefore, frozen samples were not analyzed for bacteria contamination. In more moderate temperatures, the samples were packed with snow or ice in a cooler to maintain samples at a temperature just above the freezing point.

Nitrate- and nitrite-nitrogen was preserved in the field by adding concentrated sulfuric acid to the sample (APHA et al. 1976). In addition heavy metals were preserved by acidifying the sample. Five (5) ml concentrated nitric acid per liter of sample was added at the time of sampling (APHA et al. 1976).

Upon completion of sampling, the equipment and hose were removed from the well site. The well cap was greased, if necessary, and replaced. Based on the samples taken the first two months and in order to improve the reliability of the data, modifications were planned for the continuing analyses on the project. Particulates in turbid samples can mask coliform colonies on the filter after incubation or heavy metals may kill bacteria by toxicity. The toxicity problem was handled by the addition of a chelating agent which suspends heavy metals (EPA 1978).

As shown in Appendix A, concentrations of zinc exceed the threshold requiring the chelating agent for many wells.

Water Quality Analysis and Methods Employed

Water samples were analyzed for various combinations of physical, chemical, and biological water quality parameters (Table 4). Water quality analysis data in Appendix A give the results of each test.

Among the various water quality parameters, only certain analyses were common to all wells and all samples throughout the entire study period. These parameters included temperature, pH, coliform bacteria, ammonia-N, nitrite-N, nitrate-N, orthophosphate, total phosphorus, BOD_5, and specific conductivity. This partial water quality analysis was performed on water samples obtained from wells #1, 8, 10, 18, 20, and 22 throughout the entire study period. Water collected from the remaining sampling sites was tested for all the parameters of Table 4. Complete analyses were conducted on certain well water only once (wells #11, 12, 14, 15, 17, 19, and 21)

The availability of trailers equipped with laboratory facilities enabled more field measurements to be made during the July and August 1980 sampling period. In addition to pH, temperature, and DO, parameters measured in the field mobile laboratory were BOD_5, orthophosphate, ammonia-nitrogen, coliform bacteria, and fecal streptococci.

Temperature was measured with mercury thermometers which had been calibrated with a standard certified thermometer. pH was measured with a portable battery operated pH meter. The pH meter was calibrated immediately prior to use in the field, using pH buffers 4.0, 7.0, and 9.0. Dissolved oxygen was measured by DO meters in the beginning of the study. Due to freezing of electrodes and apparent malfunction, the DO meter was replaced by Hach Kits during November 1979, February and April 1980 sampling. During the May through August 1980 sampling periods, the Winkler method azide modification (APHA et al. 1976) was used.

Bacteriological tests of water samples included total coliform and fecal coliform until the June 1980 sampling period. Fecal streptococci (APHA et al. 1976) were measured in July and August 1980. Here, a 0.45 μ filter was used to filter a 10 ml and 100 ml water sample. After incubation, the number of colonies that developed was counted.

Table 4. Water quality parameters and procedures for analyses performed.

Biochemical Oxygen Demand (BOD_5)	Standard Methods	APHA et al. 1976
Total Coliform	Standard Methods (Membrane)	APHA et al. 1976
Fecal Coliform	Standard Methods (Membrane)	APHA et al. 1976
Fecal STreptococci	Standard Methods (Membrane)	APHA et al. 1976
MBAS	Standard Methods (Surfactants)	APHA et al. 1976
Fluoride	Standard Methods	APHA et al. 1976
Total Dissolved Solids	Standard Methods	APHA et al. 1976
Total Phosphorus	EPA Methods	EPA 1976
Orthophosphorus	Strickland & Parsons (Murphy-Riley Technique)	Strickland & Parsons 1968
Ammonia	Solorzano (Indophenol)	Solorzano 1969
Nitrite	Strickland & Parsons (Diasotization Method)	Strickland & Parsons 1968
Nitrate	Strickland & Parsons (Cadmium-Reduction Method)	Strickland & Parsons 1968
Heavy Metals (i.e. Cd, Mo, Mn, Cu, Co)	Standard Methods (Atomic Absorption Spectrophotometry)	
Calcium	Standard Methods	APHA et al. 1976
Magnesium	Standard Methods	APHA et al. 1976
Potassium	Standard Methods (Atomic Absorption Spectrophotometry)	APHA et al. 1976
Sodium	Standard Methods (Atomic Absorption Spectrophotometry)	APHA et al. 1976
Boron	Standard Methods (Atomic Absorption Spectrometry)	APHA et al. 1976
Chloride	Standard Methods	APHA et al. 1976
Alkalinity	Standard Methods	APHA et al. 1976
Temperature	Standard Methods	APHA et al. 1976
Conductivity	Standard Methods	APHA et al. 1976
Sulfate	Standard Methods	APHA et al. 1976
Dissolved Oxygen	Standard Methods	APHA et al. 1976
pH	Standard Methods	APHA et al. 1976

APPENDIX A

WATER SAMPLE DATA AND ANALYSES

Table A-10. Well #10.

	October	November	February	April	May	June	July	August
Date	10-25-79	11-25-79	2-24-80	4-20-80	5-21-80	6-22-80	7-22-80	Well Buried in parking lot
Time	10:00	11:00	10:00	8:20	16:35	—	12:20	
Temp								
Air (°C)	—	—	2	11	24	22	21	
Water (°C)	8	6	5	4.5	6	5.5	7	
Depth to Water Table (ft)	-7.02	-6.64	-6.13	-3.72	-4.25	-5.43	-6.08	
(m)	-2.13	-2.20	-1.86	-1.13	-1.29	-1.65	-1.85	
Snow Depth (inches)	—	—	58	35	—			
DO (mg/l)	2.2	—	1.5	2	0.8	—	2.8	
pH (Field)	—	6.7	7.2	6.3	7.1	7.2	7.6	
Coliform								
Total/100 ml	<1	<1	<1	<1	<1	<1	<1	
Fecal/100 ml	<1	<1	<1	<1	<1	<1	<1	
Fecal Streptococci/100 ml							1	
Nitrogen								
NH_3-N (µg/l)	18	36	23	41	19	23	72	
NO_3-N (mg/l)	0.13	0.06	0.99	0.07	0.18	0.27	0.05	
NO_2-N (µg/l)	3	1	20	2	5	3	4	
Phosphate								
Ortho (µg/l)	<10	<10	<10	<10	10	<10	24	
Total (µg/l)	48	37	103	48	15	81	33	
BOD (mg/l)				<1	<1	<2	1.0	
TDS (mg/l)								
Specific Conductivity (µmhos/cm at 25°C)	608	578	523	539	532	492	555	
Cations								
Na (mg/l)								
Mg as $CaCO_3$ (mg/l)								
K (mg/l)								
Ca as $CaCO_3$ (mg/l)								
Anions								
Cl (mg/l)							5	
SO4 (mg/l)								
B (mg/l)								
Total Hardness as $CaCO_3$ (mg/l)								
Total Alkalinity as $CaCO_3$ (mg/l)								
pH (Lab)				7.77		7.30	7.40	
Surfactant as MBAS (µg/l)								
Trace Inorganics								
As (µg/l)								
Ba (µg/l)								
Cd (µg/l)								
Cr (µg/l)								
Cu (µg/l)								
Fe (µg/l)								
Hg (µg/l)								
Mn (µg/l)								
Pb (µg/l)								
Se (µg/l)								
Ag (µg/l)								
Zn (µg/l)								
F (mg/l)								

Table A-10. Well #10.

	October	November	February	April	May	June	July	August
Date	10-25-79	11-25-79	2-24-80	4-20-80	5-21-80	6-22-80	7-22-80	Well Buried in parking lot
Time	10:00	11:00	10:00	8:20	16:35	—	12:20	
Temp								
Air (°C)	—	—	2	11	24	22	21	
Water (°C)	8	6	5	4.5	6	5.5	7	
Depth to Water Table (ft)	-7.02	-6.64	-6.13	-3.72	-4.25	-5.43	-6.08	
(m)	-2.13	-2.20	-1.86	-1.13	-1.29	-1.65	-1.85	
Snow Depth (inches)	—	—	58	35	—			
DO (mg/l)	2.2	—	1.5	2	0.8	—	2.8	
pH (Field)	—	6.7	7.2	6.3	7.1	7.2	7.6	
Coliform								
Total/100 ml	<1	<1	<1	<1	<1	<1	<1	
Fecal/100 ml	<1	<1	<1	<1	<1	<1	<1	
Fecal Streptococci/100 ml							1	
Nitrogen								
NH_3-N (μg/l)	18	36	23	41	19	23	72	
NO_3-N (mg/l)	0.13	0.06	0.99	0.07	0.18	0.27	0.05	
NO_2-N (μg/l)	3	1	20	2	5	3	4	
Phosphate								
Ortho (μg/l)	<10	<10	<10	<10	10	<10	24	
Total (μg/l)	48	37	103	48	15	81	33	
BOD (mg/l)				<1	<1	<2	1.0	
TDS (mg/l)								
Specific Conductivity (μmhos/cm at 25°C)	608	578	523	539	532	492	555	
Cations								
Na (mg/l)								
Mg as $CaCO_3$ (mg/l)								
K (mg/l)								
Ca as $CaCO_3$ (mg/l)								
Anions								
Cl (mg/l)							5	
SO_4 (mg/l)								
B (mg/l)								
Total Hardness as $CaCO_3$ (mg/l)								
Total Alkalinity as $CaCO_3$ (mg/l)								
pH (Lab)				7.77		7.30	7.40	
Surfactant as MBAS (μg/l)								
Trace Inorganics								
As (μg/l)								
Ba (μg/l)								
Cd (μg/l)								
Cr (μg/l)								
Cu (μg/l)								
Fe (μg/l)								
Hg (μg/l)								
Mn (μg/l)								
Pb (μg/l)								
Se (μg/l)								
Ag (μg/l)								
Zn (μg/l)								
F (mg/l)								

Table A-11. Well #11.

	October	November	April	May	June	July	August
Date	10-25-79	11-25-79	4-20-80	5-20-80	6-22-80	7-24-80	8-23-80
Time	11:00	8:00	10:15	16:40	-	14:10	-
Temp							
Air (°C)	--	--	17	--	26	25	18
Water (°C)	10.5	5.5	6	7	6.5	9	9
Depth to Water Table (ft)	-7.25	-7.18	-3.73	-3.97	-4.68	-6.75	-7.60
(m)	-2.21	-2.19	-1.14	-1.21	-1.43	-2.06	-2.32
Snow Depth (inches)	--	--	0	--	--	--	--
DO (mg/l)	2.7	1.0	2.5	3.3	--	7.3	3.2
pH (Field)	--	6.7	6.6	6.9	7.0	7.3	6.7
Coliform							
Total/100 ml	<1	<1	<1	<1	<1	1	<1
Fecal/100 ml	<1	<1	<1	<1	<1	<1	<1
Fecal streptococci/100 ml						4	1
Nitrogen							
NH_3-N (µg/l)	15	15	<10	15	<10	16	20
NO_3-N (mg/l)	0.05	0.04	3.34	5.82	4.49	0.53	0.45
NO_2-N (µg/l)	6	1	2	25	8	2	5
Phosphate							
Ortho (µg/l)	117	152	101	132	114	67	50
Total (µg/l)	148	152	101	135	115	112	67
BOD (mg/l)	0.60	1	1	1	<2	<1	--
TDS (mg/l)	480	461	434	550	558	574	566
Specific Conductivity (µmhos/cm at 25°C)	602	648	869	929	850	682	908
Cations							
Na (mg/l)	7	7	11	10	9		
Mg as $CaCO_3$ (mg/l)			108	138	144	125	149
K (mg/l)	<3		6	3	3		
Ca as $CaCO_3$ (mg/l)			46	306	389	347	343
Anions							
Cl (mg/l)	4	<1	2	2	19	23	<1
SO_4 (mg/l)	85	74	65	72	71	78	80
B (mg/l)	0.535			<0.1	0.39	0.2	0.31
Total Hardness as $CaCO_3$ (mg/l)			154	444	533	472	492
Total Alkalinity as $CaCO_3$ (mg/l)			361	345	198	420	394
pH (Lab)			8.30	8.44	7.38	8.07	7.35
Surfactant as MBAS (µg/l)	<30		<100	<25	<25		<25
Trace Inorganics							
As (µg/l)	<1		<1	<1	<1		
Ba (µg/l)	39		<50	20	<3		
Cd (µg/l)	<3		<3	<2	<2		
Cr (µg/l)	<8		<10	<11	<11		
Cu (µg/l)	<7		<7	<7	<7	<5	
Fe (µg/l)	<1	<19	<12	<11	<11	<11	15
Hg (µg/l)	<0.5		5	3	2.6		
Mn (µg/l)	<6	20	<5	<5	<4	<6	<7
Pb (µg/l)	1		<1	<1	13	<1	
Se (µg/l)	<1		<1	<1	<1	<1	
Ag (µg/l)	2		3	<6	3		
Zn (µg/l)	15	20	16	48	46		
F (mg/l)	0.16		0.38	0.32	0.38	0.41	0.44

Table A-12. Well #12.

	October	November	February	April	May	June	July	August
Date	10-25-79	11-25-79	2-24-80	4-20-80	5-20-80	6-22-80	7-22-80	8-23-80
Time	12:00	12:30	--	11:40	14:10	--	13:35	
Temp								
Air (°C)	--	--	4	17	--	26.5	25	20.5
Water (°C)	10	4	3	4.5	7	6	10	10
Depth to Water Table (ft)	-2.67	-3.12	-2.73	-1.45	-1.95	-2.21	-2.00	-2.48
(m)	-0.82	-0.96	-0.84	-0.45	-0.60	-0.68	-0.61	-0.76
Snow Depth (inches)	--	--	35	0	--	--	--	--
DO (mg/l)	2.2	--	1	1.5	3.2	--	3.7	1.7
pH (Field)	--	6.7	7.3	6.3	6.9	7.2	7.5	6.6
Coliform								
Total/100 ml	<1	<1	<1	40	<1	<1	1	<1
Fecal/100 ml	<1	<1	<1	<1	<1	<1	--	<1
Fecal Strepotococci/100 ml							1	3
Nitrogen								
NH_3-N (µg/l)	35	34	36	42	43	200	68	30
NO_3-N (mg/l)	0.13	<0.04	1.05	0.13	0.06	0.08	0.06	0.04
NO_2-N (µg/l)	12	1	3	10	4	<2	4	6
Phosphate								
Ortho (µg/l)	3	<1	<10	<5	<10	<10	39	35
Total (µg/l)	220	39	136	11	<10	56	39	37
BOD (mg/l)				1	1	<2	1.5	--
TDS (mg/l)						495	485	477
Specific Conductivity (µmhos/cm at 25°C)	873	645	577	794	894	677	--	777
Cations								
Na (mg/l)						13		
Mg as $CaCO_3$ (mg/l)						90		87
K (mg/l)						10		
Ca as $CaCO_3$ (mg/l)						300		298
Anions								
Cl (mg/l)						29.9	30	5
SO_4 (mg/l)						53.3	--	75
B (mg/l)						0.39	--	0.82
Total Hardness as $CaCO_3$ (mg/l)						390		385
Total Alkalinity as $CaCO_3$ (mg/l)						413	355	300
pH (Lab)				7.67	7.17	7.03	8.31	7.35
Surfactant as MBAS (µg/l)						<25	--	<25
Trace Inorganics								
As (µg/l)						<1		
Ba (µg/l)						4		
Cd (µg/l)						<2	<2	
Cr (µg/l)						<11	<11	
Cu (µg/l)						<7	<5	
Fe (µg/l)						1120	323	<12
Hg (µg/l)						1.4		
Mn (µg/l)						206	211	187
Pb (µg/l)						<1	<1	
Se (µg/l)						2	<1	
Ag (µg/l)						<3	<3	
Zn (µg/l)						50		
F (mg/l)						0.18	0.12	0.23

Table A-13. Well #13.

	October	November	February	April	May	June	July	August
Date	10-25-79	11-25-79	2-24-80	4-20-80	5-20-80	6-22-80	7-24-80	8-23-80
Time	14:00	13:00	13:25	12:00	15:05	--	12:30	
Temp								
Air (°C)	—	—	-4	—	17	26	24	20.5
Water (°C)	10	4	3.5	5.5	8	8	10	11
Depth to Water Table (ft)	-3.48	-3.79	-3.48	—	-1.50	-4.61	-5.87	-6.30
(m)	-1.06	-1.15	-1.06	—	-0.46	-1.41	-1.79	-1.92
Snow Depth (inches)	—	—	29		—	—	—	
DO (mg/l)	1.8	—	1.3	1.0	0.9	—	1.1	1.3
pH (Field)	—	6.8	7.2	6.6	7.0	7.2	7.3	7.2
Coliform								
Total/100 ml	<1	<1	~10	<1	<1	7	<1	<1
Fecal/100 ml	<1	<1	<1	<1	<1	<1	<1	<1
Fecal Streptococci/100 ml							3	3
Nitrogen								
NH_3-N (μg/l)	169	53	32	113	10	47	136	113
NO_3-N (mg/l)	0.07	<0.04	0.56	0.04	0.05	0.10	<0.04	0.04
NO_2-N (μg/l)	8	1	5	1	4	2	3	6
Phosphate								
Ortho (μg/l)	24	36	<10	<5	24	<10	33	40
Total (μg/l)	210	128	243	494	25	115	130	73
BOD (mg/l)	0.70	1	<1	2	<1	<2	1	--
TDS (mg/l)	526	325	400	459	572	510	523	494
Specific Conductivity (μmhos/cm at 25°C)	806	439	594	904	1055	716	851	891
Cations								
Na (mg/l)	8	8	8	9	9	6		
Mg as $CaCO_3$ (mg/l)	386	157	91	120	195	155	149	149
K (mg/l)	<3			5	3	2		
Ca as $CaCO_3$ (mg/l)	98	212	222	31	164	356	318	328
Anions								
Cl (mg/l)	<1	1	10	<1	<1	7.4	7	<1
SO_4 (mg/l)	72	58	57	48	48	44	43	51
B (mg/l)	<0.05		0.20		<0.1	0.45	0.91	0.34
Total Hardness as $CaCO_3$ (mg/l)	484	369	312	151	359	511	467	477
Total Alkalinity as $CaCO_3$ (mg/l)	443	445	294	504	371	402	415	429
pH (Lab)	8.28	8.3	8.09	7.55	8.19	7.47	7.63	7.24
Surfactant as MBAS (μg/l)	<30	—		<100		27		<25
Trace Inorganics								
As (μg/l)	<1			2	<1	<1		
Ba (μg/l)	113			160	39	24		
Cd (μg/l)	<3			<3	<2	<2		
Cr (μg/l)	<8			<10	<11	<11		
Cu (μg/l)	<7			<7	<7	<7	<5	
Fe (μg/l)	5579	200	1215	10,200	<11	88	<11	<12
Hg (μg/l)	<0.5		1.6	2	3	2		
Mn (μg/l)	278	86	201	543	83	113	232	253
Pb (μg/l)	<1			<1	<1	1	<1	
Se (μg/l)	<1			6	44	<1	<1	
Ag (μg/l)	7			<3	<6	<3		
Zn (μg/l)	33	5	13	360	178	123		
F (mg/l)	0.11			0.26	0.32	0.25	0.27	0.27

Table A-20. Well #20.

	September	October	December	April	May	June	July	August
Date	9-21-79	10-16-79	12-11-79	4-19-80	5-21-80	6-22-80	7-23-80	8-22-80
Time	—	—	12:10	15:15	11:50	18:40	20:50	
Temp								
Air(°C)	—	—	—	—	—	24	16	20.5
Water (°C)	—	—	—	—	6	9	10	10
Depth to Water Table (ft)	-8.50	Dry	Dry	Dry	-3.83	-0.17	-0.88	-4.38
(m)	-2.59				-1.17	-0.06	-0.27	-1.33
Snow Depth (inches)	—	—	—	—	—	—	—	
DO (mg/l)	—	—	—	—	9.2	—	7.3	3.9
pH (Field)	—	—	—	—	7.3	7.0	7.5	7.2
Coliform								
Total/100 ml	—	—	—	—	<1	1	<1	<1
Fecal/100 ml	—				<1	—	<1	<1
Fecal Streptococci/100 ml							<1	2
Nitrogen								
NH_3-N (μg/l)	—				15	84	—	25
NO_3-N (mg/l)					0.39	0.59	0.11	0.04
NO_2-N (μg/l)					7	<2	2	·5
Phosphate								
Ortho (μg/l)					115	125	100	90
Total (μg/l)					292	152	131	106
BOD (mg/l)					<1	<2	1.5	—
TDS (mg/l)								
Specific Conductivity (μmhos/cm at 25°C)					585	464	472	499
Cations								
Na (mg/l)								
Mg as $CaCO_3$ (mg/l)								
K (mg/l)								
Ca as $CaCO_3$ (mg/l)								
Anions								
Cl (mg/l)							9	7
SO_4 (mg/l)								
B (mg/l)								
Total Hardness as $CaCO_3$ (mg/l)								
Total Alkalinity as $CaCO_3$ (mg/l)								
pH (Lab)						7.41	7.58	7.67
Surfactant as MBAS (μg/l)								
Trace Inorganics								
As (μg/l)								
Ba (μg/l)								
Cd (μg/l)								
Cr (μg/l)								
Cu (μg/l)								
Fe (μg/l)								
Hg (μg/l)								
Mn (μg/l)								
Pb (μg/l)								
Se (μg/l)								
Ag (μg/l)								
Zn (μg/l)								
F (mg/l)								

Table A-23. Well #23.

	October	November	April	April	May	June	July	August
Date	10-23-79	11-25-79	4-19-80	4-20-80	5-21-80	6-22-80	7-23-80	8-22-80
Time	18:00	14:00	18:15	16:00	18:15	—	20:12	
Temp								
Air (°C)	—	—	—	—	22	—	21	24
Water (°C)	8.5	6.0	—	—	5	—	7	8
Depth to Water Table (ft)			-5.96	-5.60		—	-2.00	-5.00
(m)			-1.82	-1.71		—	-0.61	-1.52
Snow Depth (inches)						—	—	
DO (mg/l)	1.6				0.7	—	<0.1	1.7
pH (Field)		6.1			6.5		7.55	7.6
Coliform								
Total/100 ml	<1	<1			<1	—	<1	<1
Fecal/100 ml	<1	<1			<1	—	<1	<1
Fecal Streptococci/100 ml							2	<1
Nitrogen								
NH_3-N (μg/l)	98	68			72		140	91
NO_3-N (mg/l)	0.17	<0.04			0.14		<0.04	<0.04
NO_2-N (μg/l)	2	1			13		4	7
Phosphate								
Ortho (μg/l)	6	<1			<10		<10	30
Total (μg/l)	30	26			12		43	30
BOD (mg/l)	0.80	<1			<1		3.5	—
TDS (mg/l)	327	285						
Specific Conductivity (μmhos/cm at 25°C)	504	395			472		446	494
Cations								
Na (mg/l)	5	4						
Mg as $CaCO_3$ (mg/l)	80	288						
K (mg/l)	<3							
Ca as $CaCO_3$ (mg/l)	200	184						
Anions								
Cl (mg/l)	<1	3					4	2
SO_4 (mg/l)	17	13						
B (mg/l)	0.535							
Total Hardness as $CaCO_3$ (mg/l)		472						
Total Alkalinity as $CaCO_3$ (mg/l)	244	227						
pH (Lab)	8.36	8.3			7.36		7.98	7.78
Surfactant as MBAS (μg/l)	<30							
Trace Inorganics								
As (μg/l)	<1							
Ba (μg/l)	83							
Cd (μg/l)	<3							
Cr (μg/l)	<8							
Cu (μg/l)	<7							
Fe (μg/l)	22	1140						
Hg (μg/l)	<0.5							
Mn (μg/l)	249	182						
Pb (μg/l)	1							
Se (μg/l)	<1							
Ag (μg/l)	6							
Zn (μg/l)	18	27						
F (mg/l)	0.12							

Table A-26. Surface sample #26.

	October	April	May	June	July	August
Date	10-23-79	4-20-80	5-20-80	2-22-80	7-23-80	8-22-80
Time	17:30	16:00	18:30	—	20:10	
Temp						
Air (°C)		—	22	23	21	24
Water (°C)	5	0	5	17	20	16.5
Depth to Water Table (ft)						
(m)						
Snow Depth (inches)						
DO (mg/l)	9.6	10	8.0	—	8.0	7.8
pH (Field)	9.2	—	6.8	8.4	8.4	8.1
Coliform						
Total/100 ml	115	90	30	10	30	10
Fecal/100 ml	106	<1	43	4	25	30
Fecal streptococci/100 ml					TNTC	40
Nitrogen						
NH_3-N (µg/l)	49	<10	69	60	—	28
NO_3-N (mg/l)	0.13	0.34	0.46	0.20	<0.04	<0.04
NO_2-N (µg/l)	3	4	6	3	3	5
Phosphate						
Ortho (µg/l)	15	29	185	<10	33	10
Total (µg/l)	15	136	185	36	62	12
BOD (mg/l)	0.90	2	1	<2	2.2	—
TDS (mg/l)	241					
Specific Conductivity (µmhos/cm at 25°C)	—	285	334	323	343	323
Cations						
Na (mg/l)	5					
Mg as $CaCO_3$ (mg/l)	54					
K (mg/l)	<3					
Ca as $CaCO_3$ (mg/l)	122					
Anions						
Cl (mg/l)	1				3	3
SO_4 (mg/l)	15					
B (mg/l)	<0.05					
Total Hardness as $CaCO_3$ (mg/l)						
Total Alkalinity as $CaCO_3$ (mg/l)						
pH (Lab)		8.16	8.54	8.49	8.61	8.31
Surfactant as MBAS (µg/l)	<30					
Trace Inorganics						
As (µg/l)	<1					
Ba (µg/l)	60					
Cd (µg/l)	<3					
Cr (µg/l)	<8					
Cu (µg/l)	<7					
Fe (µg/l)	8					
Hg (µg/l)	<0.5					
Mn (µg/l)	21					
Pb (µg/l)	<1					
Se (µg/l)	<1					
Ag (µg/l)	8					
Zn (µg/l)	<1					
F (mg/l)	0.08					

Table A-28. Surface sample #28.

	April	May	June	July	August
Date	4-20-80	5-20-80	6-22-80	7-22-80	8-23-80
Time	12:00	19:30		14:05	
Temp					
Air (°C)	16	--	26	25	20.5
Water (°C)	8	9	10	11	13
Depth to Water Table (ft)					
(m)					
Snow Depth (inches)					
DO (mg/l)	9	--	--	8.8	8.3
pH (Field)	7.6	--	8.1	8.4	8.1
Coliform					
Total/100 ml	210	--	~106	TNTC	830
Fecal/100 ml	<1	~110	~200	TNTC	55
Fecal streptococci/100 ml				TNTC	180
Nitrogen					
NH_3-N (µg/l)	62	61	23	44	30
NO_3-N (mg/l)	0.57	0.94	0.28	0.05	<0.04
NO_2-N (µg/l)	7	8	3	2	6
Phosphate					
Ortho (µg/l)	100	33	18	20	32
Total (µg/l)	177	3370	220	22	42
BOD (mg/l)	<1	4	<2	<1	--
TDS (mg/l)	222	141	200	191	265
Specific Conductivity (µmhos/cm at 25°C)	478	318	293	303	504
Cations					
Na (mg/l)	-9	1	2		
Mg as $CaCO_3$ (mg/l)	60	41	59	48	93
K (mg/l)	5	2	2		
Ca as $CaCO_3$ (mg/l)	50	172	133	121	182
Anions					
Cl (mg/l)	15	5	1.5	3	5
SO_4 (mg/l)	36	23	19.9	12	40
B (mg/l)		<0.1	0.1	<0.1	0.1
Total Hardness as $CaCO_3$ (mg/l)	110	213	192	169	275
Total Alkalinity as $CaCO_3$ (mg/l)	218	146	135	186	234
pH (Lab)	8.30	8.39	8.28	8.36	8.26
Surfactant as MBAS (µg/l)	<100	48	<25	--	<25
Trace Inorganics					
As (µg/l)	<1	<1	<1		
Ba (µg/l)	<50	36	<3		
Cd (µg/l)	<3	<2	<2		
Cr (µg/l)	<10	<11	<11		
Cu (µg/l)	<7	<7	<7	<5	
Fe (µg/l)	106		39	17	13
Hg (µg/l)	3		1.6		
Mn (µg/l)	131	<4	19	<6	<7
Pb (µg/l)	<1	<1	2	<1	
Se (µg/l)	15	<1	2	<1	
Ag (µg/l)	<3	<3	<3		
Zn (µg/l)	24	87	20		
F (mg/l)	0.26	0.24	0.20	0.42	0.28

APPENDIX D

OBSERVATION WELL LOCATIONS AND LOGS

Table D-1. Piezometer information.

Site: East Piezometer Near Well #13					
Location: South Profile					
Date	10-25-79	11-25-79	2-24-80	4-20-80	5-20-80
Time	14:00	13:00	13:25	12:00	15:05
SWL	-2'10½"	-3'6 3/4"	-2'11 3/4"	Submerged	-1'5½"
Snow Depth	--	--	3'4"	1'7"	
Site: South Piezometer Near Well #13					
Location: South Profile					
Date	10-25-79	11-25-79	2-24-80	4-20-80	5-20-80
Time	14:00	13:00	13:25	12:00	15:05
SWL	-3'1 3/4"	-3'4"	-2'7 3/8"	-1 1/8"	-7 3/4"
Site: North Piezometer Near Well #17					
Location: North Profile					
Date	--	11-26-79	2-24-80	4-20-80	5-20-80
Time	--	11:00	18:00	16:35	15:50
SWL	--	-7'6"	Dry	-7'2 7/8"	-4' 10 5/8"
Snow Depth	--	--	3'2"	2'	--
Site: West Piezometer Near Well #17					
Location: North Profile					
Date	9-25-79	11-26-79	2-24-80	4-20-80	5-20-80
Time	--	11:00	18:00	16:35	15:50
SWL	-2'10"	-7'11 1/8"	-8'5 1/8"	-7'7 3/4"	-4'11"
Snow Depth	--	--	33"	24"	--

SWL = Static Water Level

Table D-2. Other well locations--Pleasant Valley study area.

CLAIM NUMBER	NAME	LOCATION	DEPTH/STATIC
x-678	Albert S. Veltri	NW¼NW¼ Sec. 3, T12S, R7E	
x-1581	Ernest Salerno	W½NW¼ Sec. 3, T12S, R7E	
x-430	Theresa A. Phelps	SW¼SW¼ Sec. 3, T12S, R7E	
x-1245	Glyn Matthews	SW¼SW¼ Sec. 3, T12S, R7E	120'/45
827	Boyd Bunnell	SW¼SW¼ Sec. 3, T12S, R7E	
x-660	James D. Bertelsen	SW¼SW¼ Sec. 3, T12S, R7E	
x-709	Clede Andreini	NE¼SE¼ Sec. 4, T12S, R7E	
x-1166, 1350	Carl R. Hatch	NE¼SE¼ Sec. 4, T12S, R7E	100'/60
290, x-175	Francis & Rudy Scartezina	NE¼SE¼ Sec. 4, T12S, R7E	85'
x-397	Robert S. Mallard	SW¼SW¼ Sec. 4, T12S, R7E	
x-336	Frank Marrelli	SE¼SE¼ Sec. 4, T12S, R7E	
284	Chris Jouflas	SE¼SE¼ Sec. 4, T12S, R7E	
112	Carbon County	SW¼NE¼ Sec. 9, T12S, R7E	
193	Carbon County	SW¼NE¼ Sec. 10, T12S, R7E	
285	James J. Diamanti	SW¼NW¼ Sec. 10, T12S, R7E	
206	Paul Mancina	SW¼SW¼ Sec. 10, T12S, R7E	
223	Paul Sutton	NW¼NW¼ Sec. 15, T12S, R7E	
x-1483	G. Pete Frandsen	N½NE¼ Sec. 30, T12S, R7E	
3401	Waino Burton	SW¼SE¼ Sec. 32, T12S, R7E	
3402	Waino Burton	SW¼SE¼ Sec. 32, T12S, R7E	
x-164	Louis Gorishek	SW¼SE¼ Sec. 32, T12S, R7E	
x-452	Robert Radakovich	NW¼SW¼ Sec. 5, T13S, R7E	
x-772	Valley Camp Coal Company	SE¼SE¼ Sec. 8, T13S, R7E	210'/75
200, 3460	Mountain Fuel Supply Co. and Utah Natural Gas Company	SW¼SE¼ Sec. 8, T13S, R7E	
x-1560	Coastal States Energy Company	SE¼SW¼ Sec. 13, T13S, R6E	
		SE¼SE¼ Sec. 13, T13S, R6E	
		SW¼SW¼ Sec. 17, T13S, R7E	
x-1114	Coastal States Energy Company	S½SW¼ Sec. 13, T13S, R6E	
		NE¼NE¼ Sec. 23, T13S, R6E	
		SE¼NW¼ Sec. 24, T13S, R6E	
x-1058	Price River Water Users Assn.	NW¼NW¼ Sec. 30, T13S, R7E	

Well #1 North Lake Location

Sample Number	Depth	Description
1	0' - 8½'	Dark, fine quartz sandy, silt and clay rich in organics. Drilled with soils auger.
2	8½' - 11½'	Dark, fine quartz sandy, silt and clay rich in organics. Drilled with jet rig from 8½' to base of bore hole.
3	11½' - 14'	Grayish brown coarse iron stained quartz sand to fine silt and clay.
4	14' - 17½'	Grayish medium quartz sand with some silt and clay.
5	17½' - 19'	Medium gravely, grayish quartz sand - gravel is rounded sandstone fragments.
6	19' - 20'	Coarse rounded sandstone gravel with gray quartz sandstone.

Well is located in an area of silting of the lake.

Cased to 20' with 1" PVC, perforated from 12' - 20' with 1½" galvanized surface casing cemented in place.

Well #2 ORR PROPERTY

Sample Number	Depth	Description
1	0 - 3'	Brown, sandy soil with some rounded pebbles up to ½" in diameter.
2	3' - 5'	Brown, sandy soil with some rounded pebbles up to ½" in diameter.
3	5' - 8½'	Brownish gray fine quartz sand with some fine gravel.
4	8½' - 9'	Brownish gray fine quartz sand with coarse pebbles 1" in diameter.
5	9' - 10½'	Tannish brown medium quartz sand and silt - drilled to 10½' with soils auger.
6	10½' - 14'	Tan medium quartz sand and silt - drilled to 18½' with jet rig.
7	14' - 18½'	Tan coarse quartz sand to fine silt.

Cased to 18½' with 1" PVC, perforated from 8' to 18½', with 1½" galvanized surface casing cemented in place.

Well #3 PAPPAS WELL

Sample Number	Depth	Description
1	0 - 4'	Light tan fine silty sand with pebbles up to 1½" in diameter.
2	4' - 10½'	Light tan fine silty sand with pebbles up to 1½" in diameter - drilled with soils auger.
3	10½' - 14'	Coarse to fine light tan sand with some sandstone rock fragments - drilled with jet rig.
4	14' - 14½'	Sandy clay layer - clay is light in color and firm.
5	14½' - 16½'	Coarse to fine light tan sand.
6	16½' - 21'	Medium gravel with tan sand rock fragments from several different sandstones.

Cased to 20' with 1" PVC, perforated from 13' to 20' with 1½" galvanized surface casing cement in place.

Well #4 JOUFFLAS WELL

Sample Number	Depth	Description
1	0 - 2'	Tannish brown silty soil.
2	2' - 3'	Badly weathered sandstone boulder.
3	3' - 4'	Tannish brown medium quartz silty sand.
4	4' - 10'	Tannish brown medium quartz silty sand with clay - drilled with soils auger.
5	10' - 15'	Tannish brown fine quartz silty sand with streaks of clay - drilled to depth with jet rig.
6	15' - 20'	Tannish brown fine quartz silty sand with some layers of medium to coarse sand.

Cased to 20' with 1' PVC, perforated from 7' to 20', with 1½" galvanized surface casing cemented in place.

Well #5 First Avenue Well

Sample Number	Depth	Description
1	0 - 11'	Tannish fine silty sand.
2	11' - 13'	Tannish medium to fine silty sand - contains some clay.
3	13' - 15'	Tannish medium to fine sand with medium to fine gravel - gravel is sandstone fragments - very angular.
4	15' - 17'	Medium to coarse sand with medium gravel - gravel is sandstone fragments.

Cased with 1" PVC to a depth of 16' with perforations from 9' to 16'. Surface cased with 1½" galvanized pipe 1½' long cemented in place.

Well #6 4th Avenue Well

Sample Number	Depth	Description
1	0 - 10'	Light tan fine sand to coarse silt - drilled with soils auger.
2	10' - 11'	Light tannish white silty clay.
3	10' - 18'	Light tan medium to fine gravel with sand and firm clay.
	18'	Coarse gravel - lost circulation.

Lost circulation at 18' in coarse gravel, unable to continue drilling.

Cased with 1' PVC to 17' with 65 perforations from 10' - 17', surface cased with 1½" galvanized pipe 1½' long.

Well #7 STATE PARK WELL

Sample Number	Depth	Description
1	0 - 9'	Yellowish tan silty quartz sand with some highly weathered pebbles turning to clay - drilled with soils auger.
2	9' - 14'	Same as above - drilled with jet rig.
3	14' - 15'	Tannish coarse to fine sand with large angular sandstone fragments with clumps of gray clay.
4	15' - 17½'	Tan gravely coarse to fine sand with clumps of gray clay.

Cased with 1" PVC to 17½', performated from 10½' to 17½', surface cased with 1½" galvanized pipe 2½' long.

Well #8 PERRY'S BOAT CAMP

Sample Number	Depth	Description
1	0 - 8'	Rust brown, very fine silt and clay.
2	8' - 11'	Yellowish brown fine sand with some silt.
	11' - 11½'	Thin hard layer - no cuttings to suggest coarse material.
	11½' - 12½'	Firm grayish white clay.

Lost circulation several times.

Cased to 12½' with 1" PVC, perforated from 4' to 12½', with 1½" galvanized surface casing 2½' long cemented in place.

Well #9 CLEAR CREEK

Sample Number	Depth	Description
	0 - 3'	Railroad bed material with coal intermixed along with scrap iron fragments.
1	3' - 8½'	Dark brown coarse silt with medium sand sized coal fragments with intermitent light tan sand and silt.
	8½' - 10'	Light tan sand and silt similar to layer encountered above.

Cased to 10' with 1" PVC, perforated from 2½' to 10' with 1½" galvanized surface casing cemented in place.

Well #10 ECCLES CANYON

Sample Number	Depth	Discription
	0 - 15'	Fine to coarse sandy silt, with trace of clay.
	15' - 21'	Silty fine coarse sand with some clay and silt.
	21' - 29'	Fine to coarse sandy fine gravel with clay and silt.
	29' - 31'	Grades to sandy fine to coarse gravel to coarse sand with some gravel.

Well was drilled by Raymond International Inc. for Daine and Moore Consultant Engineers.

Cased to 29' with 1" PVC, perforated from 9' - 29' with 1½" galvanized surface casing cemented in placed.

Well #11 VALLEY CAMP WELL

Sample Number	Depth	Description
1	0 - 1'	Light brown fine to coarse sand with fine to coarse gravel-fill material.
2	1' - 4'	Dark brown fine to medium sandy soil with some pebbles.
3	4' - 6'	Dark brown fine to coarse sand with some pebbles.
4	6' - 10½'	Light brown fine to coarse silt with fine sand.
5	10½' - 12'	Light tan fine to coarse sand with fine gravel.
6	12' - 17'	Light tan fine to coarse sand with gravel increasing until circulation was lost

Cased to 17' with 1" PVC, perforated from 11' to 17' with 1½" galvanized surface casing cemented in place.

Well #12 SOUTH PROFILE #1

Sample Number	Depth	Description
1	0 - 2'	Dark brown-black soil with some sand and sand-sized coal fragments.
2	2' - 4'	Tannish brown soil with light colored quartz sand intermixed.
3	4' - 5½'	Tannish brown soil and sand with layers of yellowish tan iron stained sand and gravel.
	5½' - 6'	Gravel layer with rounded pebbles up to 1" in diameter.
	6' - 7'	Dark gray mud with some silt and fine sand.
4	7' - 8½'	Dark gray mud with some silt and fine sand with a few pebbles.
	8½'	Large rock at bottom of hole stopped progress.

Cased to 8½' with 1" PVC, perforated from 4' to 8½' with 1½" galvanized surface casing cemented in place.

Well #13 SOUTH PROFILE #2

Sample Number	Depth	Description
1	0' - 3'	Dark brown-black soil with some sand and silt.
2	3' - 5½'	Tannish brown soil with light colored quartz sand, some iron or limonite staining.
3	5½' - 6½'	Brown silty fine to medium sand, some iron or limonite staining.
	6½' - 7½'	Dark brown "soil" silty sandy with a few pebbles about 1" in length.
4	7½' - 9'	Tannish brown silty sand with gravel increasing in percent and size.
5	9' - 9½'	Tan and gray medium gravel, angular sandstone fragments with some silt and sand.
	9½'	Cobbles - Discontinued drilling.

Cased to 9½' with a 6' section of 1" teflon pipe attached to a 3' galvanized extension, galvanized surface casing cemented in place.

Well #14 SCOFIELD TOWN

Sample Number	Depth	Description
1	0 - 3'	Dark Brown soil with some silt and sand.
2	3' - 6'	Medium brown silty sandy soil with some small pebbles.
3	6' - 10½'	Gray medium to fine sandy silt.
4	10½' - 13'	Tan fine to coarse sand with fine to medium subround sandstone gravel
5	13' - 14'	Tan fine to coarse sand with fine gravel - lost circulation.

Cased to 14' with 1" PVC, 95 perforations from 4' - 14' with 1½' galvanized surface casing cemented in place.

Well #15 NORTH PROFILE #1

Sample Number	Depth	Description
1	0 - 2'	Dark fine silty soil.
2	2' - 5'	Dark fine silty soil with increase in clay.
3	5' - 9'	Tan to brown silty fine to medium sand with some clay - iron staining present.
	9'	Thin gravel layer.
	9' - 9½'	Gray silty clay layer with a few ¼' pebbles.
	9½' - 10½'	Fine to medium sand with small amounts of fine gravel.
	10½' - 11'	Bedrock or boulder near bedrock - drilled into it a few inches - weathered sandstone.

Cased to 11' with 1" PVC, perforated from 6' to 11' with 2½" galvanized surface casing cemented in place.

Well #16 NORTH PROFILE #2

Sample Number	Depth	Description
1	0' - 5½'	Dark fine sandy silty soil.
2	5' - 7½'	Dark fine sandy silty soil with fine gravel.
	7½' - 9'	Sandy gravel - very permeable - auger bit came out clean - no sample.
3	9' - 10'	Subround medium to coarse gravel - gravel was sandstone fragments.
	10' - 11'	Subround to round fine gravel.
	11' - 11½'	Subround medium to coarse gravel.

Cased to 11'4" with 1" PVC, perforated from 5'4" to 11'4" with 1½" galvanized surface casing cemented in place.

Well #18 NORTH PROFILE #4

Sample Number	Depth	Description
	0 - 3'	Dark fine silty soil.
	3' - 6'	Tan to brown silty clay with minor amounts of fine gravel.
	6'	Fine to medium gravel layer only a few inches thick.
1	6' -7'	Tan fine to coarse silty clay - some iron oxide staining present.
2 & 3	7' - 9'	Tan fine to coarse silty clay with layers of fine to medium gravel.

Cased to 8' with 1' PVC, perforated from 3' to 8' with 1½" galvanized surface casing cemented in place.

Well #17 NORTH PROFILE #3

Sample Number	Depth	Description
1	0 - 4½"	Dark fine silty soil.
2	4½' - 7'	Tan to brown silty clay with thin gravel layer at 6'.
3	7' - 9'	Light tan fine sand to silty clay.
	9' - 10'	Light tan fine to coarse sand with fine to medium gravel rounded pebbles and sandstone fragements.

Cased with 1" teflon tube, perforated from 2'3" to 9'3" and surface cased with 1½" galvanized pipe cemented in place.

Well #19 NORTH PROFILE #5

Sample Number	Depth	Description
1	0 - 3½'	Dark fine silty soil.
	3½' - 4½'	Dark fine silty soil grades into tan silting sand.
2	4½' - 5½'	Tan coarse silty sand with minor amounts of fine gravel.
3	5½' - 7½'	Tan coarse silty sand with fine to medium gravel - gravel comprised of sandstone fragments.
4	7½' - 9½'	Fine to coarse gravel with tan silty sand matrix.
	9½' - 11'	Fine to coarse gravel with tan silty sand matrix.

Cased to 11' with 1" PVC, perforated from 6' to 11' with 1½" galvanized surface casing cemented in place.

Well #20 WOODS CANYON

Sample Number	Depth	Description
1	0 - 3'	Dark silty sandy soil with turf roots and other organic material.
2	3' - 6'	Tannish brown silty fine sand.
3	6' - 9'	Light gray fine to medium quartz sand and silt.
4	9' - 9½'	Tan fine to medium quartz sand and silt.
	9'10"	Bottom - firm boulder or bedrock.

Cased to 9'10" with 1" PVC, perforated from 4½' to 9'10" with 1½" galvanized surface casing cemented in place.

Well #21 SECTION 29 CANYON

Sample Number	Depth	Description
1	0 - 4'	Dark brown to black fine silty soil with some organics.
2 & 3	4' - 9'	Gray-black silty soil.
4	10' - 13½'	Gray fine to coarse silt with firm clay and layers of fine to medium clay.
5	13½' - 14½'	Gray fine to medium sand with silt and clay.
6	14½' - 16½'	Fine gravel sized sandstone fragments and firm gray clay - bedrock at 16½'.

Cased to 16½' with 1" PVC, perforated from 6' to 16' with 1½" galvanized surface casing cemented in place.

Well #22 MOUNTAIN HOME

Sample Number	Depth	Description
1 & 2	0 - 9'	Light brown silty soil.
3	9' - 12'	Tannish brown fine to medium sand and silt with fine gravel.
4 & 5	12' - 13½'	Yellowish tan fine to medium sand and silt with fine to medium gravel.
6 & 7	13½' - 18'	Yellowish tan fine to coarse sand with fine to medium gravel.
8	18' - 19½'	Yellowish tan silt and clay with weathered sandstone pebbles.
9	19½' - 20½'	Weathered bedrock - angular broken sandstone fragments.
	21'	Bedrock - sandstone.

Cased to 20' 7" with 1" PVC, perforated from 7' to 20'7" with 2½" galvanized surface casing cemented in place.

Well #23 FISH CREEK

Sample Number	Depth	Description
1	0 - 5'	Light tan silty very fine sand.
2	5' - 7'	Light tan silty fine sand with layers of coarse sand.
3	7' - 8'	Dark brown fine to coarse sand with pebbles up to 1".
4	8' - 8½'	Gray silty fine to coarse sand.
	8½' - 14½'	Intermitant layers of coarse sand and fine gravel with pebbles up to 1" in diameter dispersed throughout.

Cased to 14½' with 1" PVC, perforated from 11' to 14½' with 1½" galvanized surface casing cemented in place.

APPENDIX G

SLUG TESTS IN SELECTED OBSERVATION WELLS

Well #12

Slug Test Data

SWL = 70.49 cm

Well Depth = 272.73 cm

Perforated = 121.92 cm to bottom

Depth to Bedrock = 762.00 cm

Estimated y_o = 30.5 cm

Time t sec.	Drawdown y_t cm.
0	30.5
10	7.8

r_c = 1.27 cm L_w = 202.24 cm H = 691.51 cm A = 3.5

r_w = 1.91 cm L_e = 121.92 cm L_e/r_w = 63.8 B = .60

$$\ln \frac{R_e}{r_w} = \frac{1}{\dfrac{1.1}{\ln (202.24 \text{ cm}/1.91 \text{ cm})} + \dfrac{3.5 + .6 \ln (691.51 \text{ cm} - 202.24 \text{ cm})/1.91 \text{ cm}}{63.8}}$$

$$= 2.916$$

$$K = \frac{(1.27 \text{ cm})^2 (2.916)}{2 (121.92 \text{ cm})} \frac{1}{10 \text{ sec}} \ln \frac{30.5 \text{ cm}}{7.8 \text{ cm}}$$

$$= .0026 \text{ cm/sec}$$

Well #14

Slug Test Data

SWL = 113.35 cm

Well Depth = 444.50 cm

Perforated = 121.92 cm

Depth to Bedrock = 762.00 cm

Estimated y_o = 30.5 cm

Time t sec.	Drawdown y_t cm.
0	30.5
10	3.6

r_c = 1.27 cm L_w = 331.15 cm H = 648.65 A = 5.5

r_w = 1.91 cm L_e = 322.58 cm L_e/r_w = 168.9 B = 1.0

$$\ln \frac{R_e}{r_w} = \frac{1}{\dfrac{1}{\ln (331.15 \text{ cm}/1.91 \text{ cm})} + \dfrac{5.5 + 1 \ln (648.65 \text{ cm} - 331.15 \text{ cm})/1.91 \text{ cm}}{168.9}}$$

$$= 3.62$$

$$K = \frac{(1.27 \text{ cm})^2 (3.62)}{2 (322.58 \text{ cm})} \frac{1}{10} \ln \frac{30.5 \text{ cm}}{3.6 \text{ cm}}$$

$$= .0019 \text{ cm/sec}$$

Well #20

Slug Test Data

SWL = 177.8 cm

Well Depth = 307.6 cm

Perforated = 137.2 cm to bottom

Depth to Bedrock = 307.6 cm

Estimated y_o = 30.5 cm

Time t sec.	Drawdown y_t cm.
0	30.5
35	7.9

r_c = 1.27 cm L_w = 129.8 cm H = 129.8 cm C = 3.8

r_w = 1.91 cm L_e = 170.4 cm L_e/r_w = 89.2 cm

$$\ln \frac{R_e}{r_w} = \frac{1}{\frac{1.1}{\ln (129.8 \text{ cm}/1.91 \text{ cm})} + \frac{3.8}{(170.4 \text{ cm}/1.91 \text{ cm})}}$$

$$= 3.30$$

$$K = \frac{(1.27 \text{ cm})^2 (3.30)}{2 (170.4 \text{ cm})} \quad \frac{1}{35 \text{ sec}} \quad \ln \frac{30.5 \text{ cm}}{7.9 \text{ cm}}$$

$$= .0006 \text{ cm/sec}$$

Well #21

Slug Test Data

SWL = 102.55

Well Depth = 503.55

Perforated = 182.88

Depth to Bedrock = 762.00

Estimated y_o = 30.5 cm

Time t sec.	Drawdown y_t cm.
0	30.5
10	4.0

r_c = 1.27 cm L_w = 401.00 H = 659.45 A = 5.5

r_w = 1.91 cm L_e = 320.67 L_e/r_w = 167.89 B = 1.0

$$\ln \frac{R_e}{r_w} = \frac{1}{\frac{1.1}{\ln (401.00 \text{ cm}/1.91 \text{ cm})} + \frac{5.5 + 1.0 \ln \ (659.45 = 401.00)/1.91 \text{ cm}}{167.89}}$$

$$= 3.74$$

$$K = \frac{(1.27 \text{ cm})^2 (3.74)}{2 (320.67 \text{ cm})} \quad \frac{1}{10} \quad \ln \frac{30.5 \text{ cm}}{4.0}$$

$$= .0019 \text{ cm/sec}$$

APPENDIX I

WATER TABLE ELEVATIONS IN OBSERVATION WELLS

Table I-a. Water levels in observation wells.

Well Number	Ground Surface (ft)	Water Table (feet above sea level) October	November	February	April	May	June	July	August	Remarks
1	7619.15	7620.65	7620.69 (Dec)	-	7620.75	7622.07				Flowing well
2	7620.31	7609.61	7609.13	7610.04	7610.50	7615.90	7618.73	7616.81	7613.98	
3	7620.86	7610.07	7609.47	7610.15	7611.23	7616.03	7618.73	7617.19	7614.34	
4	7623.80	7610.55	7610.17	-	7611.65	7616.00	7618.51	7617.30	7614.96	
5	7621.16	7608.16	7608.20	7609.68	7608.49	7612.10	7618.72	7616.91	7613.35	
6	7620.89	7608.22	7608.37	7609.72	7608.51	7612.05	7618.72	7616.89	7613.32	
7	7623.99	7611.90	7611.19	7613.49	7616.53	7617.07	7618.90	7616.99	7614.47	
8	7622.37	Dry	Dry	-	-	7615.79	7618.70	7616.37	7612.86	
9	8263.31	8259.85	8259.06	8261.28	8262.06	8261.64	8261.55	8261.34	8261.04	Well was buried in a parking lot in July 1980
10	Unknown	* 6.99	7.22	6.10	3.71	4.23	5.41	6.07	-	
11	7838.28	7831.03	7831.10	-	7834.54	7834.30	7833.60	7831.53	7830.68	
12	7703.82	7701.16	7700.70	7701.08	7702.37	7701.87	7701.61	7701.82	7701.35	
13	7705.81	7702.31	7702.02	7702.31	-	7704.31	7701.18	7699.93	7699.51	
13-East piez.	7705.58	7702.70	7702.01	7702.60	-	7704.12	7700.84	7699.49	-	
13-South piez.	7706.37	7703.22	7703.04	7703.75	7705.25	7705.72	7701.94	7700.73	-	
14	7685.55	7682.30	7681.75	7681.97	7685.35	7683.60	7682.55	7681.97	7681.83	
15	7666.82	7662.82	7662.80	7662.84	-	7664.26	7663.70	7661.32	7661.52	
16	7665.90	7664.05	7661.88	7660.69	7664.07	7663.73	7661.57	7659.90	7659.12	
17	7665.56	-	7657.65	7656.15	7657.94	7660.69	7658.31	7656.23	Dry	
17-North piez.	7664.09	-	7656.59	Dry	7656.84	7659.21	7657.13	7655.59	Dry	
17-West piez.	7665.71	-	7657.78	7657.28	7658.06	7660.79	7658.40	7657.38	Dry	
18	7664.85	7659.88	7657.48	-	7659.02	7659.35	7658.31	7656.44	Dry	
19	7667.53	7659.53	7657.51	-	7657.85	7660.37	7658.53	7656.95	Dry	(7661.20 in Sept)
20	7672.98	7664.48 (Sept)	Dry	-	Dry	7669.15	7672.81	7672.10	7668.61	
21	7654.31	7650.94	7650.66	-	7649.29	7648.85	7653.20	7651.54	7651.14	
22	7781.61	7764.33 (Sept)	7799.79 (Dec)	-	7763.57	Flowing	Flowing	7781.02	7768.98	
23	7618.38	-	-	-	7612.40	-	Flooded	7616.38	7613.38	

*For well #10, the depth to the water table is given

Table I-b. Water levels in observation wells.

Well Number	Ground Surface (ft)	Water Table (meters above sea level) October	November	February	April	May	June	July	August	Remarks
1	2322.32	2322.78	2322.79 (Dec)	-	2322.81	2323.21				Flowing well
2	2322.67	2319.41	2319.26	2319.54	2319.68	2321.33	2322.19	2321.61	2320.74	
3	2322.84	2319.55	2319.37	2319.57	2319.90	2321.37	2322.19	2321.72	2320.85	
4	2323.73	2319.69	2319.58	-	2320.03	2321.36	2322.12	2321.75	2321.04	
5	2322.93	2318.97	2318.98	2319.43	2319.07	2320.17	2322.19	2321.63	2320.55	
6	2322.85	2318.99	2319.03	2319.44	2319.07	2320.15	2322.19	2321.63	2320.54	
7	2323.79	2320.11	2319.89	2320.59	2321.52	2321.68	2322.24	2321.66	2320.89	
8	2323.30	Dry	Dry	-	-	2321.29	2322.18	2321.47	2320.40	
9	2518.66	2317.60	2517.36	2518.04	2518.28	2518.15	2518.12	2518.06	2517.97	Well was buried in a parking lot in July 1980
10	Unknown	* 2.13	2.20	1.86	1.13	1.29	1.65	1.85	-	
11	2389.11	2386.90	2386.92	-	2387.97	2387.90	2387.68	2387.05	2386.79	
12	2348.13	2347.31	2347.17	2347.29	2347.68	2347.53	2347.45	2347.52	2347.37	
13	2348.73	2347.67	2347.58	2347.67	-	2348.27	2347.32	2346.94	2346.81	
13-East piez.	2348.66	2347.78	2347.57	2347.75	-	2348.22	2347.22	2346.81	-	
13-South piez.	2348.90	2347.94	2347.89	2348.10	2348.56	2348.71	2347.55	2347.18	-	
14	2342.56	2341.57	2341.40	2341.47	2342.50	2341.96	2341.64	2341.47	2341.42	
15	2336.85	2335.63	2335.62	2335.64	-	2336.07	2335.90	2335.17	2335.23	
16	2336.57	2336.00	2335.34	2334.98	2336.01	2335.91	2335.25	2334.74	2334.50	
17	2336.46	-	2334.05	2333.59	2334.14	2334.98	2334.25	2333.62	Dry	
17-North piez.	2336.01	-	2333.73	Dry	2333.80	2334.53	2333.89	2333.42	Dry	
17-West piez.	2336.51	-	2334.09	2333.94	2334.18	2335.01	2334.28	2333.97	Dry	
18	2336.25	2334.73	2334.00	-	2334.47	2334.57	2334.25	2333.68	Dry	
19	2337.06	2334.63	2334.01	-	2334.11	2334.88	2334.32	2333.84	Dry	(2335.13 in Sept)
20	2338.73	2336.14 (Sept)	Dry	-	Dry	2337.56	2338.67	2338.46	2337.40	
21	2333.03	2332.01	2331.92	-	2331.50	2331.37	2332.69	2332.19	2332.07	
22	2371.84	2366.57 (Sept)	2377.38 (Dec)	-	2366.34	Flowing	Flowing	2371.66	2367.99	
23	2322.08	-	-	-	2320.26	-	Flooded	2321.47	2320.56	

*For well #10, the depth to the water table is given

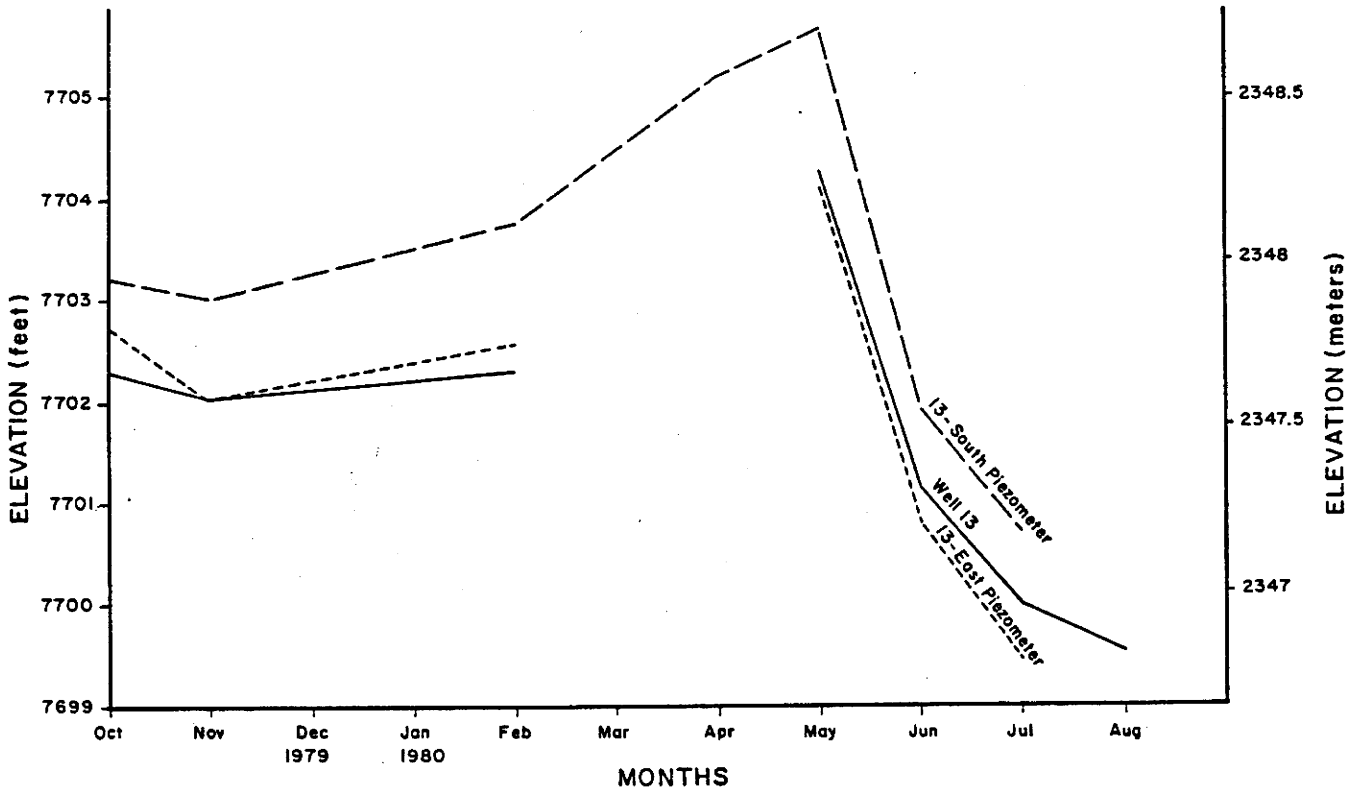


Figure I-4. Water level in well 13 and nearby piezometers.

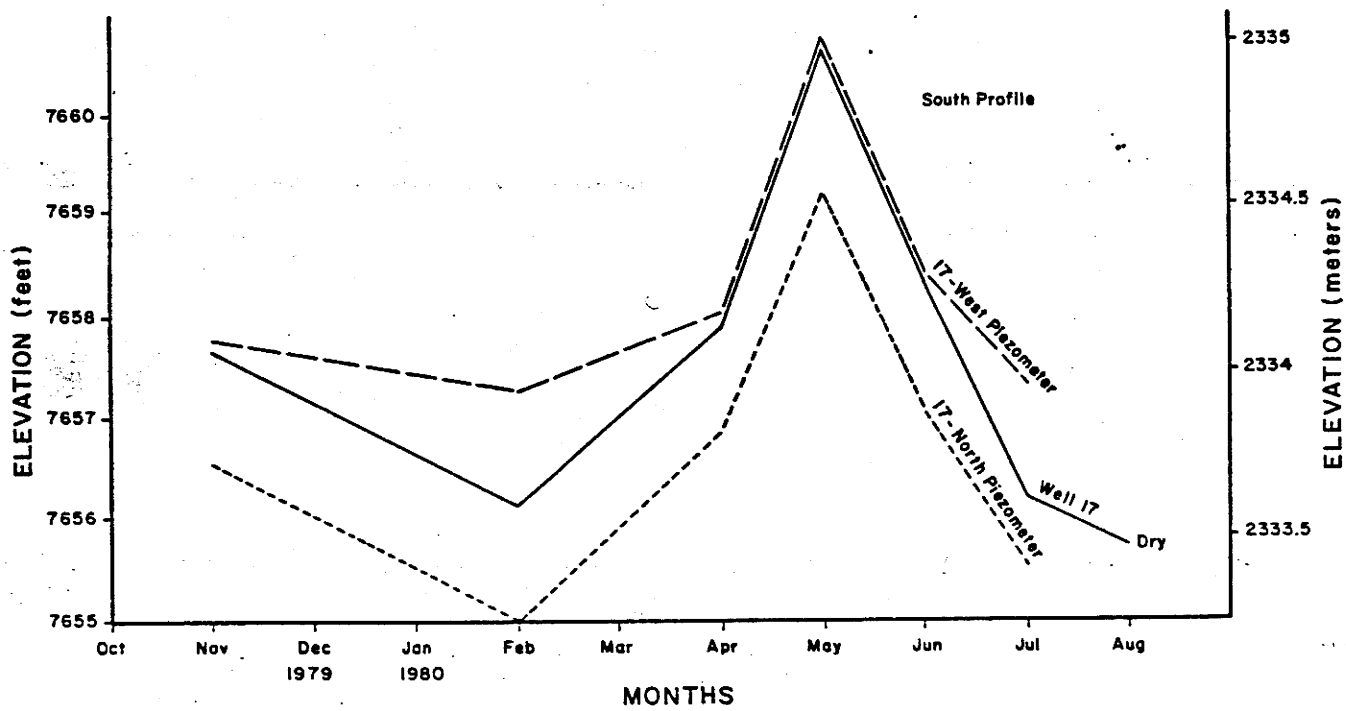


Figure I-5. Water level in well 17 and nearby piezometers.

APPENDIX N

GEOLOGY AND STRATIGRAPHY OF THE WASATCH PLATEAU COAL FIELD

Geology

The Wasatch Plateau comprises Tertiary and Cretaceous strata, predominantly limestone, sandstone, and shale that differ in resistance to erosion; the limestones and sandstones form cliffs, and the shales form slopes. The consolidated rocks of the [Wasatch Plateau] coal field [see Figures N-1 to N-4] ... range in age from Late Cretaceous to Paleocene. [See Table N-1.] (Davis and Doelling 1977, p. 3.)

Stratigraphy

Masuk Shale

The Masuk Shale is the uppermost member of the Mancos Shale. It consists of light gray to blue gray sandy marine shale of Santonian age. The Masuk ranges in thickness from 91 m to 396 m (300 to 1,300 feet) and forms the slope at the base of the Wasatch Plateau beneath the Star Point Sandstone. (Davis and Doelling 1977, p. 3.)

Star Point Sandstone

The oldest formation, Campanian in age (Upper Cretaceous), exposed in and around Pleasant Valley is the Star Point Sandstone. The Star Point is considerably thicker here than in other parts of the [Wasatch Plateau coal] field; on the west side of Pleasant Valley between Clear Creek and Scofield at least 304 m (1,000 ft) of sandstone have been measured beneath the horizon of the Hiawatha coal bed.... The thickness tapers to 61 m (200 ft) in the eastern part of the coal field. (Doelling 1972, p. 217.)

As the lowermost of three formations composing the Mesaverde Group of the Wasatch Plateau, the Star Point consists of several tan, massive, cliff-forming sandstones separated by one or several shale tongues of the underlying Masuk Shale. (Davis and Doelling 1977, p. 3.)

The Mancos Shale is not exposed at the surface beneath the sandstone. The yellow-gray sandstone beds are mostly massive but occasionally broken by shale partings or partings of shaley sandstone. The amount of shale in the unit is also considerably less than to the east. (Doelling 1972, p. 217.)

Blackhawk Formation

The Blackhawk Formation, the middle member of the Mesaverde Group, contains the minable coal beds of the Wasatch Plateau. All the thick and important coal beds are in the lower half of the formation. The Blackhawk is Campanian in age, and the type section is near the Blacknawk mine at Hiawatha (sec. 3, T. 16 S., R. 8 E.).

The unit consists of light to medium gray sandstone, light gray to black shale, light to medium gray siltstone, and coal. The sandstones are mostly fine grained and weather to shades of tan, yellow brown, yellow gray, and occasionally white. They form ledges and cliffs. The shales and siltstones underlie covered slopes. Many of the siltstones and darker shales are carbonaceous, containing leaf imprints of sequoias, ferns, and willows.

Price River Formation

Castlegate Sandstone Member. The Price River Formation is the uppermost member of the Mesaverde Group, and the Castlegate Sandstone is the lowermost unit of the Price River. The Castlegate is Campanian in age, and the type section is in Price River Canyon about 3.2 km (2 mi) above the old town of Castlegate.

Along the eastern front of the plateau and within the canyons, the unit forms the uppermost cliff of the escarpment. Ranging in thickness from 45 to 152 m (150 to 500 ft), it consists of fluvial sandstones, conglomerates, and a few thin beds of gray sandy shale. The sandstones, chiefly medium to coarse grained and massive, weather to shades of light gray, tan, white, and yellow brown. The cliff, however, generally has a light gray hue. The conglomerates, light gray in most places, contain pebbles of white quartzite and gray limestone in a coarse sandy matrix.

Upper Price River Member. The upper Price River Member forms a steep receding slope above the Castlegate Sandstone cliff. The strata are predominantly fluvial sandstones, but there are a few thin interbedded pebble conglomerates and gray shales. The sandstones are gray, grayish tan, tan, and brown; most are medium to coarse grained, but some are fine grained.

North Horn Formation

The North Horn generally forms slopes and, in places, produces a hummocky terrain. Mostly it consists of shales, but it has

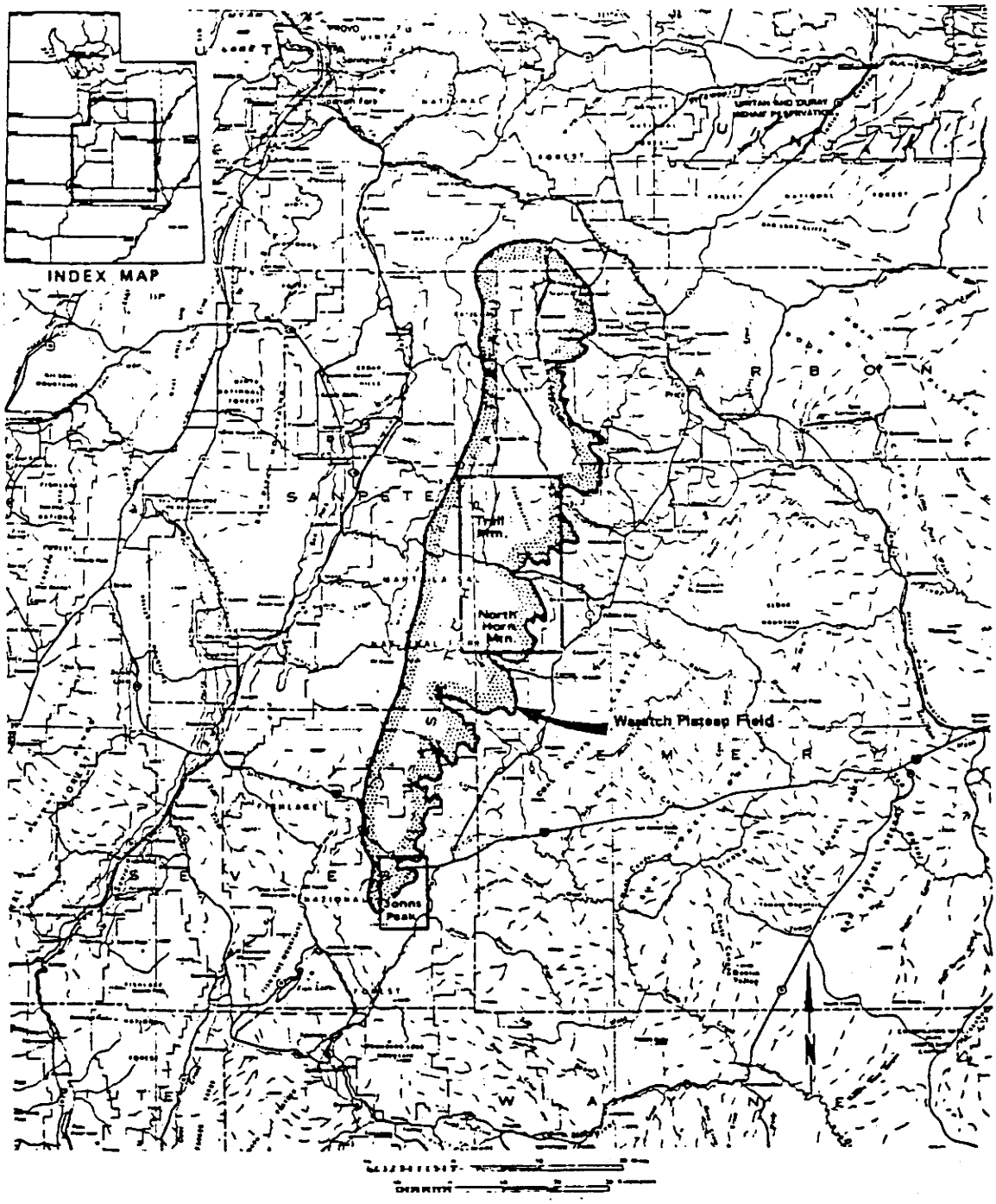


Figure N-1. Location map of Wasatch Plateau and adjacent areas in central Utah (Davis and Doelling 1977, p. 2).

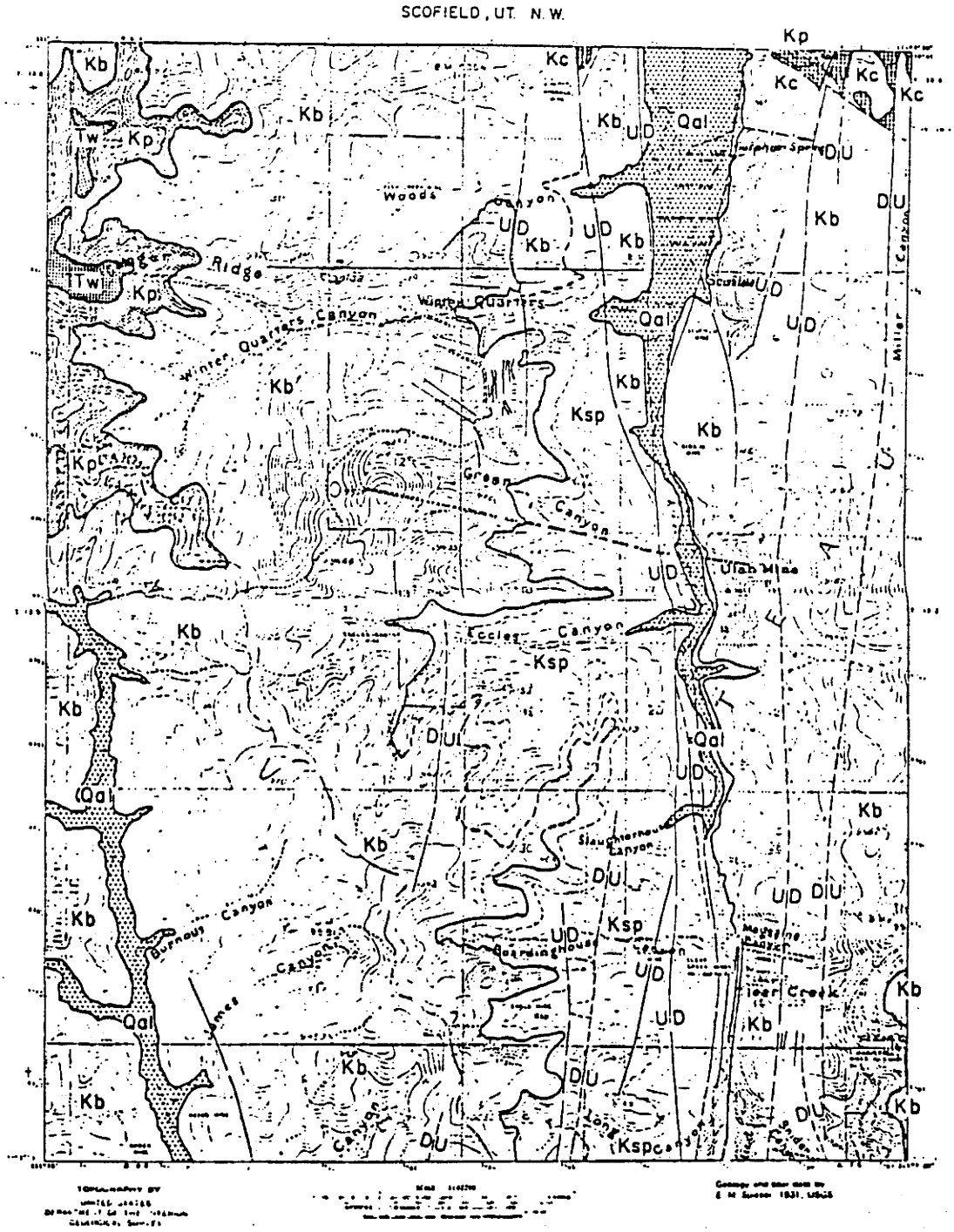


Figure N-2. Coal fields and geology, Scofield NW quadrangle. (Explanation on Figures N-3 and N-4)

QUATERNARY

Qal — **Alluvium**
Stratified clay, silt, sand, gravel and some unsorted flood deposits.

Ql — **Landslide Deposits**
Mixed rubble and blocks of material slumped from formations at higher elevations.

Qg — **Gravel Deposits**
Partly consolidated poorly sorted and stratified deposits of rock fragments of local origin, pediments or terrace, up to 75 feet thick.

TERTIARY

Tv — **Volcanic Flows**
Bullion Canyon Series, volcanic flows.

Tg — **Green River Formation**
Chiefly greenish lacustrine shale and siltstone.

Tc — **Colton Formation**
Varicolored shale with sandstone and limestone lenses, thickest to the north. 300-1,500 feet.

Tf — **Flagstaff Formation**
Dark yellow-gray to cream limestone, evenly bedded with minor amounts of sandstone, shale and volcanic ash, ledge former. 200-1,500 feet.

TERTIARY
CRETACEOUS

Tw — **North Horn Formation**
Variegated shales with subordinate sandstone, conglomerate and freshwater limestone, thickens to north, slope former. 500-2,500 feet.

Kp — **Price River Formation**
Gray to white gritty sandstone interbedded with subordinate shale and conglomerate, ledge and slope former. 200-1,000 feet.

Kc — **Castlegate Sandstone**
White to gray, coarse-grained often conglomeratic sandstone, cliff former, weathers to shades of brown. 150-500 feet.

-Unconformity-

Kb — **Blackhawk Formation**
Yellow to gray, fine- to medium-grained sandstone, interbedded with subordinate gray and carbonaceous shale, several thick coal seams. 600-1,500 feet.

Ksp — **Star Point Sandstone**
Yellow-gray massive cliff-forming sandstone, often in several tongues separated by Masuk Shale, thickens westward. 90-1,000 feet.

Km — **Masuk Shale**
Yellow to blue-gray sandy shale, slope former, thick in north and central plateau area thins southward. 300-1,300 feet.

Ke — **Emery Sandstone**
Yellow-gray friable sandstone tongue or tongues, cliff former, may contain coal (?) in south part of plateau if mapping is correct, thickens to west and south. Coal may be present in subsurface to west. 50-800 feet.

Kbg — **Blue Gate Shale**
Pale blue-gray, nodular and irregularly bedded marine mudstone and siltstone with several arenaceous beds, weathers into low rolling hills and badlands, thickens northerly. 1,500-2,800 feet.

Kf — **Ferron Sandstone**
Alternating yellow-gray sandstone, sandy shale and gray shale with important coal beds of Emery coal field, resistant cliff former, thickens to the south. 50-950 feet.

Kt — **Tununk Shale**
Blue-gray to black sandy marine slope forming mudstone. 400-650 feet.

Figure N-3. Key to Figure N-2 (Doelling 1972, p. 137).

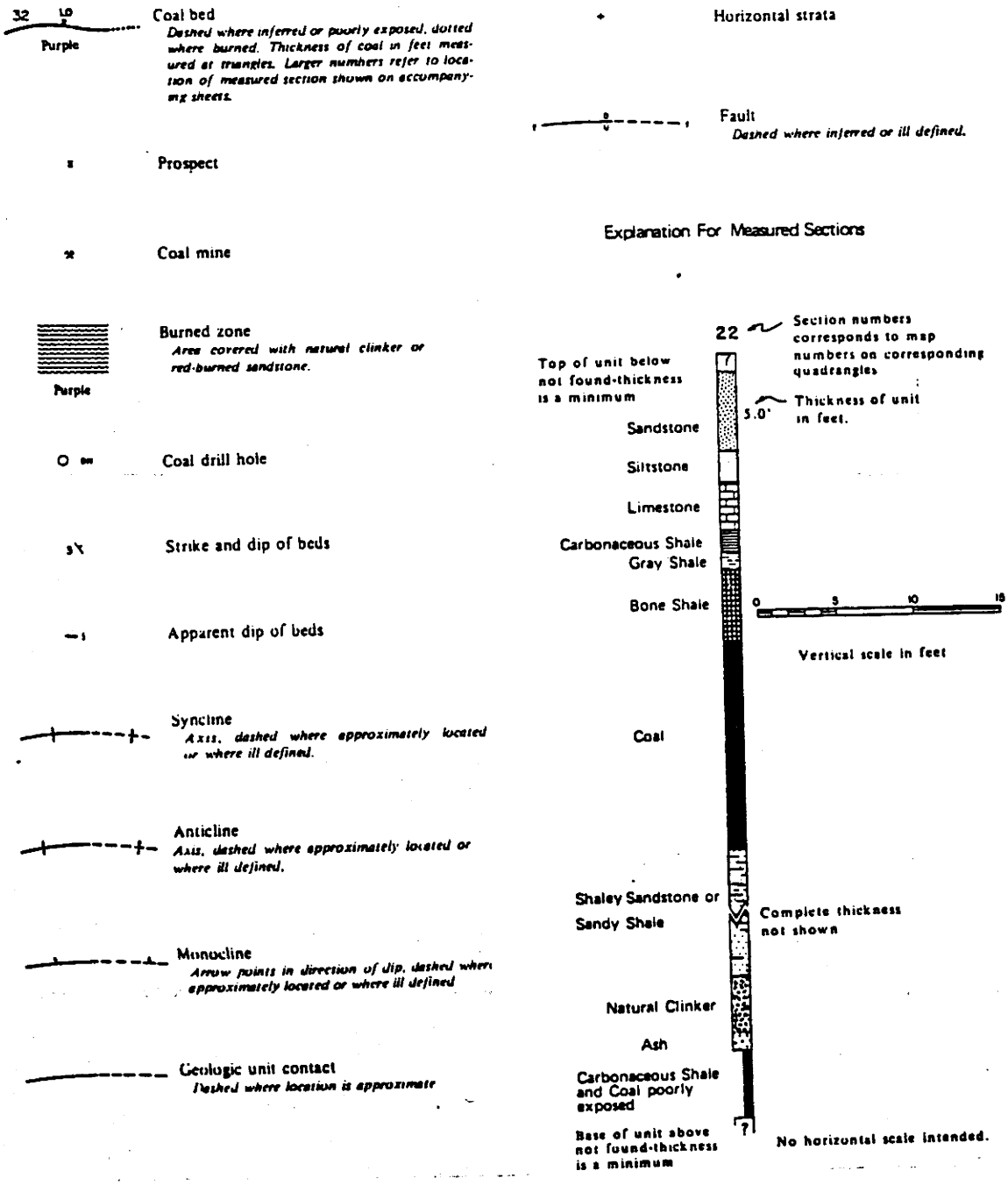


Figure N-4. Key to Figure N-2 (Doelling 1972, p. 137).

Table N-1. Generalized section of rocks in the Wasatch Plateau coal field.

System	Group	Formation		Description
Tertiary	Wasatch	Flagstaff Limestone		Light gray to cream limestone; thin and even bedded; dense; fossiliferous; ledge- and cliff-forming.
		North Horn Formation		Mostly red-, brown-, and salmon-colored shales; varying thicknesses of sandstone, fresh-water limestone and conglomerate; slope-forming.
Cretaceous	Mesaverde	Price River Fm.	Upper Price River Member	Mostly tan and gray, medium- to coarse-grained sandstone; some gray shale and conglomeratic sandstone; ledge- and slope-forming.
			Castlegate Sandstone Member	Light gray, yellowish brown, and white, medium- to coarse-grained sandstone and conglomeratic sandstone; cliff-forming.
		Disconformity		
		Blackhawk Formation		Light to medium gray sandstones; gray to black shales; gray siltstones; important coal beds in lower half; sandstones weather tan, brown, yellowish brown; ledge- and slope-forming.
		Star Point Sandstone		Tan, light gray, and white massive sandstones separated by one or more shale tongues; cliff-forming.
	Mancos Shale	Masuk Shale		Light gray to blue gray sandy marine shale; thins to west and south; slope forming.

subordinate amounts of sandstone and thin beds of white and light gray freshwater limestone. Distant views of the formation show it distinctly pink or salmon colored. Late Cretaceous fossils have been found in the lower part of the unit, and Tertiary fossils have been identified from the upper part.

Flagstaff Limestone

The Flagstaff was the original middle member of the Wasatch Formation, but it now has formational status. The unit forms a white cliff around the highest summits and ridges of the plateau and consists of white and light gray, thin-bedded lacustrine limestone with some thin beds of gray shale and dense white volcanic ash. The Flagstaff is Paleocene in age.

Quarternary Deposits

Unconsolidated consist of alluvium (stream channel and valley fill deposits), regolith, glacial drift, moraines, and colluvium (including talus) on slopes and at the base of slopes and cliffs. These deposits consist of mixed proportions of clay, silt, sand, and gravel with boulders.

Structure

Tectonically, the Wasatch Plateau is in a transition zone between the relatively stable Colorado Plateau on the east side and the relatively complex and unstable Basin and Range province on the west side. On the west side the strata of the plateau dip into a complexly faulted monocline, whereas on the east side, gentle dips prevail and faults are less numerous [Figure N-5].

The Pleasant Valley fault zone is a north-trending graben with an average width of about 6.4 km (4 mi). The bounding faults have the greatests displacements, up to 457 m (1,500 ft), but many splinter faults within the zone have much less. This fault zone extends from the north end of Pleasant Valley southward across Huntington Creek and dies out in the cliffs just north of Cottonwood Creek between Grimes Wash and Danish Bench. (Davis and Doelling 1977, p. 4-9.)

The importance of faults has been well illustrated by Taff (1906, p. 343):

The principal fault of the Pleasant Valley group is the westernmost one. It follows the west side of the valley in an almost due south course, crossing the foothills and spurs near the stream and passing through the west sides of Scofield and Clear Creek. North of Scofield it lies in a swampy valley and is not traceable. Whether there is a series of fractures or a single fault is not determinable .... Near the head of the valley opposite Clear Creek the throw is nearly 304 m (1,000 ft)...

Two elongate faults parallel the ridge on the east side of Pleasant Valley. Their displacement is unknown; several paralleling subsidiary faults possibly occur between them.

The strata enclose a north-south trending anticline with an ill-defined axis and an east side faulted by the Pleasant Valley zone. East of Pleasant Valley the beds are nearly horizontal dipping less than 2 degrees. To the west the beds dip 3 to 4 degrees northwesterly down the gentle limb of the anticline.

Unconformities

The upper Cretaceous formations in the Wasatch Plateau reveal a remarkable succession of mixed and intertonguing marine and continental sediments. Up to the end of the deposition of the Blackhawk strata, these sediments are mainly fine grained, thus indicating relatively long intervals of quiet and uniform conditions. The erosion and flood of the coarse clastics of the Castlegate Sandjstone produced an erosional disconformity at the top of the Blackhawk Formation. These coarse continental sediments indicate crustal disturbance to the west and probably the first phase of the Laramide orogeny. The model of deposition of the Price River Formation produced many intraformational disconformities and local unconformities. (Davis and Doelling 1977, p. 9-10.)

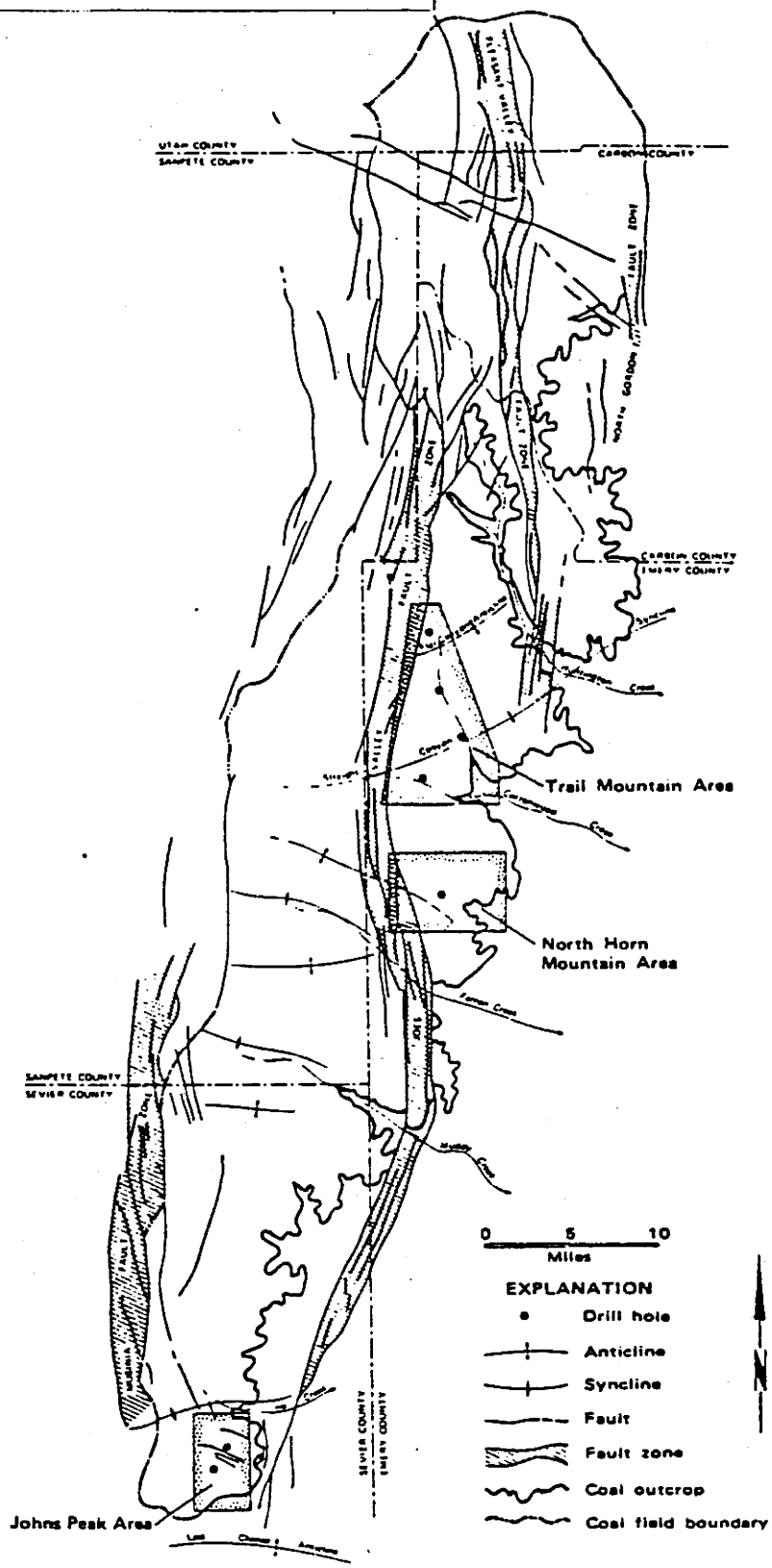


Figure N-5. Principal structural features of the Wasatch Plateau coal field (Davis and Doelling 1977, p. 8).

Winter Quarters Canyon
Data Adequacy

October 1992

SURFACE WATER HYDROLOGY
SKYLINE MINES
MINING AND RECLAMATION PLAN
VOLUME 1, 1992

2.4 SURFACE WATER HYDROLOGY

As previously discussed, the Skyline permit area is located in the headwaters of the Price and San Rafael River Basins. Snowmelt is the primary source of water for the perennial streams in the two basins, with only a small amount of the total flow in the region being derived from rainfall. As a result, flow volumes per unit area are high in the headwaters and low near the mouths of the two basins.

The quality of surface water in the headwaters region is excellent, with total dissolved solids (TDS) concentration normally varying between 100 and 400 milligrams per liter. However, this quality deteriorates rapidly as the streams cross the saline Mancos Shale downstream and receive irrigation return flows from Mancos-derived soils. TDS concentrations in the Price and San Rafael Rivers, near their confluence with the Green River, generally vary between 1,500 and 4,000 milligrams per liter. Sediment yields in the two basins experience similar geographic variations, with the bulk of the sediment yielded at the mouths of the two major rivers coming from those areas which are underlain by the highly erodable Mancos Shale. Data summaries presented in this section are taken from the Skyline water quality monitoring program, Mundorff (1972) and Southeastern Association of Governments (1979). Information presented in this section summarizes and updates the original consultant's reports found in Appendix Volume A-1.

2.4.1 Drainage Basin Characteristics

Portions of four perennial watersheds drain the Skyline project area and include the Eccles Canyon, Green Canyon, Winter Quarters Canyon (all tributaries of Pleasant Valley Creek in the Price River Basin) and upper Huntington Creek (a tributary of the San Rafael River). Channels draining the permit area form dendritic patterns, with stream channels of the area flowing in all four

major directions. All surface streams have been classified by the Utah Division of Health as follows:

- 1C - protected for domestic use with prior treatment process,
- 3A - protected for cold water aquatic life, and
- 4 - protected for agricultural uses including stockwatering.

Electric Lake has been classified as 3A and 4 while Scofield Reservoir has been classified as 1C, 3A, 4, and well as 2B, protected for recreational uses, excluding swimming.

Slopes on the permit area are steep, averaging approximately 31 percent. Dominant drainage aspects are to the west in the Huntington Creek Basin and to the east in the Price River Basin. The landscape varies greatly, with most of the permit area being covered with conifer and aspen vegetative communities.

Because of the climatological conditions of the area (high precipitation and low evapotranspiration resulting in excess water), there are numerous water sources in the Skyline project area. Most of these are undeveloped springs, seeps and streams. The one notably developed water body located partially in the project area is Electric Lake, a 31,200 acre-foot reservoir whose upstream tip covers a small portion of the southwest corner of the project area in the Huntington Creek Basin. This reservoir is owned and operated by Utah Power and Light Company as a storage facility for water used at coal-fired power plants.

The thick vegetative cover on the project area has resulted in a well-maintained soil of high organic matter content, thus developing a more open soil structure with high infiltration rates. As a result, the potential for runoff from a rainfall event on the project area is low. Thus, snowmelt produces most of the runoff from the area during periods when soils are frozen and/or saturated.

2.4.2 Flow Characteristics

The seasonal distribution of flows in the perennial streams draining the project area is typical of western high elevation, snowmelt streams, where the majority of the flow occurs within a relatively short period of time in late spring and early summer (April, May and June). Flows in Huntington Creek above Electric Lake can be expected to vary from 1 to 100 cubic feet per second while those of Eccles Creek above Pleasant Valley Creek normally vary between 1 and 50 cubic feet per second.

The watersheds draining the project area yield an average of approximately 13.5 inches of water annually to the Price River Basin. However, because the relatively impermeable Blackhawk Formation underlies all of the Huntington Creek Basin above the southern boundary of the project area (either on the surface or directly beneath the surface member), the yield to the San Rafael River Basin is slightly higher (averaging approximately 16 inches per year).

A significant surface water quality sampling program has been conducted in Eccles Creek and Huntington Creek as well as in a representative sampling of seeps and springs in the Skyline permit area. The following briefly describes the major water quality characteristics of the permit area.

Surface water in the Skyline project area is of a calcium bicarbonate type. Total dissolved solids concentrations in the area are generally lowest during the months of April through June when flows are highest and affected by the diluting effect of direct snowmelt. As flows decrease and the majority of the flow is derived from seepage of local groundwater systems, the dilution effect becomes less pronounced and dissolved solids concentrations tend to increase. As a result, the dissolved solids content of surface water in the area varies from less than 100 milligrams per liter (headwaters of Huntington Creek during the high flow season) to slightly greater than 500 milligrams per liter (Eccles Creek during low flow conditions).

Suspended solids concentrations in the area tend to vary proportionately with flow rate. During the snowmelt runoff season, concentrations are also naturally higher in Eccles Canyon than in the Huntington Creek drainage basin. Channel erosion, although relatively low throughout the area, appears to be more extensive in the steeper Eccles Canyon than in the Huntington Creek Basin and is probably the source of most of the increased sediment concentrations. Mud slides, when present, add considerably to the suspended solids concentration.

Hydrogen ion activity (pH) tends to be rather constant in the surface waters on and adjacent to the Skyline project area, varying normally between 6.5 and 8.6. The basic condition of the water with low acidity and high alkalinity indicates that acid drainage problems do not develop as a result of mining in the permit area.

Total and dissolved iron measurement values vary widely throughout the area, with the potential source being the iron contained in Blackhawk Formation cementing agents. Total iron, which varied in measurements from less than 0.01 to over 45 milligrams per liter during the observation period, tends to be somewhat directly related to the flow rate, and is associated with sediment loading. In contrast, dissolved iron tends to be much more constant.

Total manganese concentrations in the area were low, varying normally between 0.01 and 2.0 milligrams per liter with occasional higher concentrations associated with sediment loading. No distinct seasonal variations were noted.

Baseline concentrations of various constituents were normally well within the State of Utah standards for waters of the Skyline project area.

A summary documenting the water quality data in the mine area may be found in Volume 4.

2.4.3 Sediment Yield

The Skyline project area has a sediment yield which averages approximately 0.44 acre-feet per square mile per year, based on methods developed by the Pacific Southwest Inter-Agency Committee (1968) (Volume A-1, Hydrology, page 49). This converts to a total annual yield of 1.25 acre-feet of sediment to the Price River Basin and 3.07 acre-feet of sediment to the San Rafael River Basin. The majority of this sediment is yielded as suspended sediment, with only a small fraction occurring as bedload.

2.4.4 Monitoring Program

The surface water monitoring program outlined in this section is a continuation of a program approved with the original Mining and Reclamation Plan application. It incorporates practices designed to provide the baseline data necessary to validate the determination of the probable hydrologic consequences of proposed and existing mining and reclamation operations. The program also is designed to meet site specific requirements and have the flexibility for change if necessary. Surface water monitoring programs are conducted at each of the appropriate stations identified in Table 2.3.7-3 and shown on Plate 2.3.6-1. Surface water stations in Eccles Canyon were sampled more frequently than those on Huntington Creek during the initial phases of mining.

Eccles Canyon stream stations as shown on Table 2.3.7-3 and are analyzed for those constituents identified in Table 2.3.7-2 with an annual monitoring as per Table 2.3.7-1. South Fork tributary station CS-15 will be monitored for flow only beginning fall 1988. The purpose of this station is to check for subsidence effects from longwall mining.

Samples are collected annually from all surface water stations and analyzed as outlined in Table 2.3.7-1. These samples are collected during summer low flow in the month of August or September each year.

As mining has progressed towards Huntington Creek, seasonal samples from the five Huntington Creek stations are being collected when access permits and analyzed as outlined in Tables 2.3.7-1 and 2.3.7-2.

Sampling will continue at all surface water stations throughout the post-mining period and until the reclamation effort is determined successful by the regulatory authority. Samples will also continue to be analyzed for the parameters outlined in Tables 2.3.7-1 and 2.3.7-2 throughout the post-mining period, unless deletions in the list of parameters is determined to be appropriate.

In addition to the above outlined monitoring program, UPDES discharge permits have been acquired as necessary. Monitoring and operation of all surface water discharges are conducted in accordance with conditions of this permit. Discharges of water from disturbed areas will be in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining contained in 40 CFR part 434. A copy of this permit (UPDES No UT-0023540) is appended to Volume A-1, Hydrology Section. The monitoring locations are shown on Map 2.3.6-1.

As required, water quality data collected from the surface water monitoring stations will be submitted to the Utah Division of Oil, Gas, and Mining. Such reports will normally be submitted within 90 days of the completion of each quarterly monitoring program. An annual report, which will include a summary of the water quality data for the previous year, will be submitted within 90 days of the end of each year.

The Permittee conducted a search for seeps or springs in the downslope area west of the rock disposal site in the spring of 1984 and found no seeps or springs. Should surface flow occur, surface water monitoring will be carried out, though the exceedingly ephemeral nature of the water flows in the area will

necessarily affect the frequency of sampling. The Permittee commits to the following surface water monitoring program when surface flow is present.

1. Four monitoring stations will be established: two stations on the drainage from the east and two sites on the drainage from the south. Stations will be located both above and below the rock waste disposal site in each of the drainages. (See Drawing 2.3.6-1.)

2. When flow is present, these stations will be monitored, when accessible, at the same frequency and for the same constituents as the stations in Eccles Creek. The data will be tabulated and reported in the same manner as the Skyline water quality data.

3. The data from these stations will be evaluated for non-point source contribution from ground water aquifers. This procedure offers the best potential for detection of ground water contamination.

The Upper O'Connor seam required a breakout to improve ventilation. The breakout is on a south facing slope in a side canyon of the South Fork of Eccles Creek (see map no. 3.2.11-1). A new road was built across this canyon to gain access to the breakout area. The canyon flows water in all but the driest of years. During construction, the creek was sampled above and below the site on a daily basis. The samples were tested for total suspended solids and settleable solids as an aid in regulating construction activities and in implementing control measures. Construction related solids fluctuations were encountered throughout this phase of the project.

LITERATURE CITED

Mundorff, J.C. 1972. Reconnaissance of Chemical Quality of Surface Water and Fluvial Sediment in the Price River Basin, Utah Department of Natural Resources, Division of Water Rights. Technical Publication No. 39. Salt Lake City, Utah.

Pacific Southwest Inter-Agency Committee. 1968. Factors Affecting Sediment Yield in the Pacific Southwest Area. Water Management Subcommittee. Sedimentation Task Force.

Southeastern Utah Association of Governments. 1979. Waste Water Quality Management Planning Program (208) for Emery, Carbon, and Grand Counties, Utah. Price, Utah.

SKYLINE MINES

MINING AND RECLAMATION PLAN

COASTAL STATES ENERGY COMPAN

1992

VOLUME 1

SELECTED WELL WATER LEVELS
SKYLINE MINES
MINING & RECLAMATION PLAN
ENVIRONMENTAL DATA
VOLUME 4, 1992

SKYLINE MINES

MINING AND RECLAMATION PLAN

COASTAL STATES ENERGY COMPA

1992

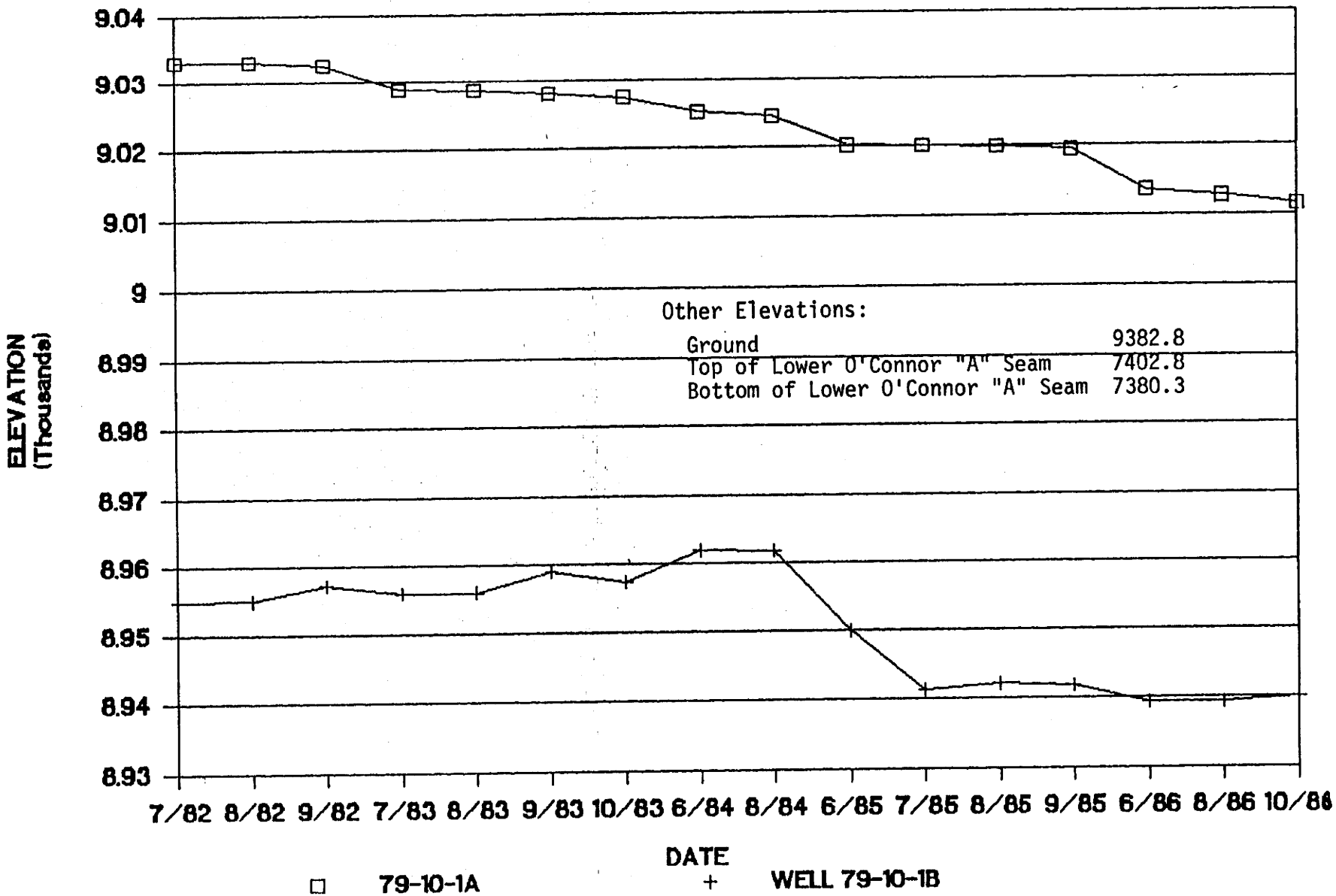
ENVIRONMENTAL

DATA

VOLUME 2

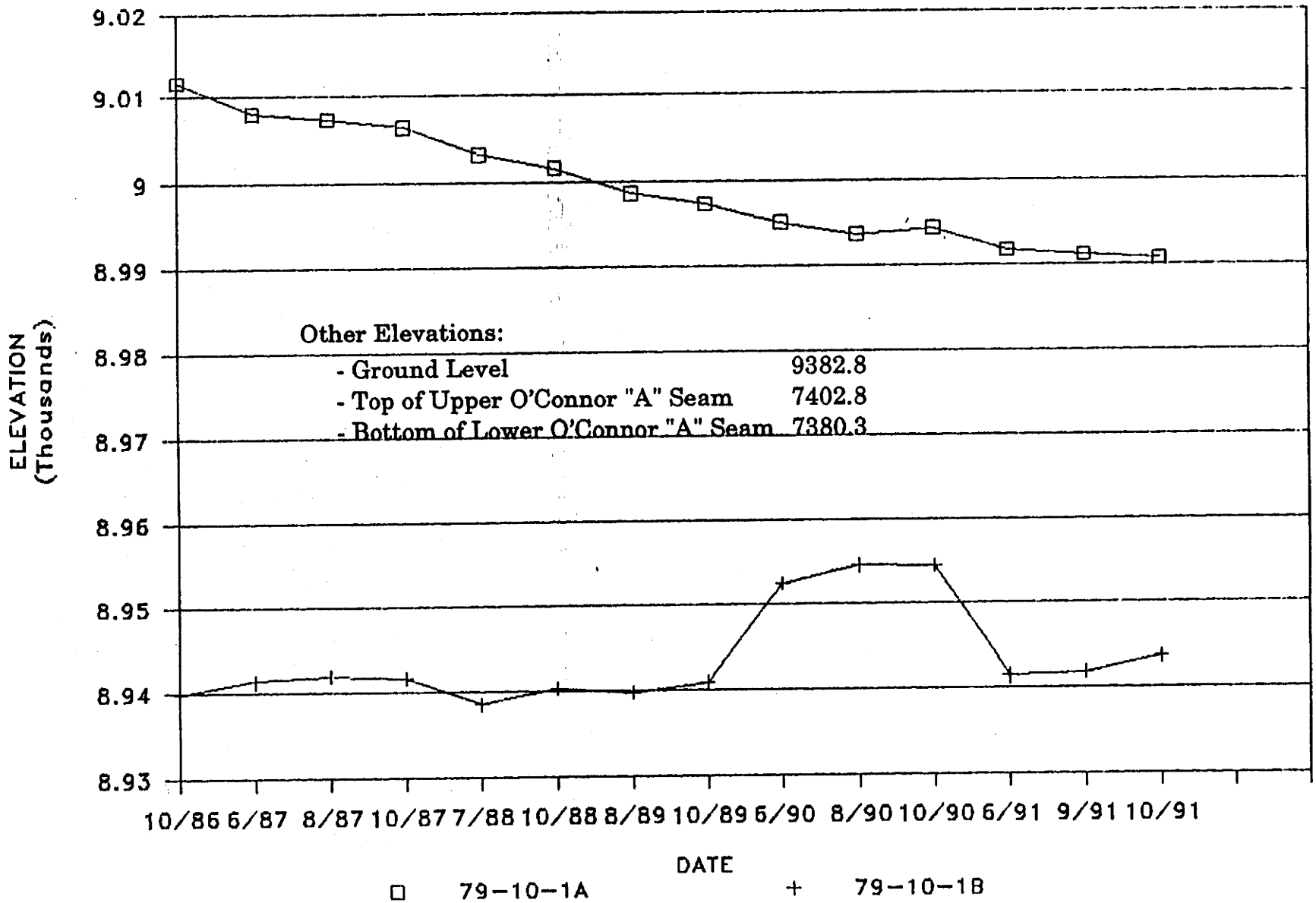
WELL WATER LEVEL, 1982 – 1986

Wells 79-10-1A and 79-10-1B



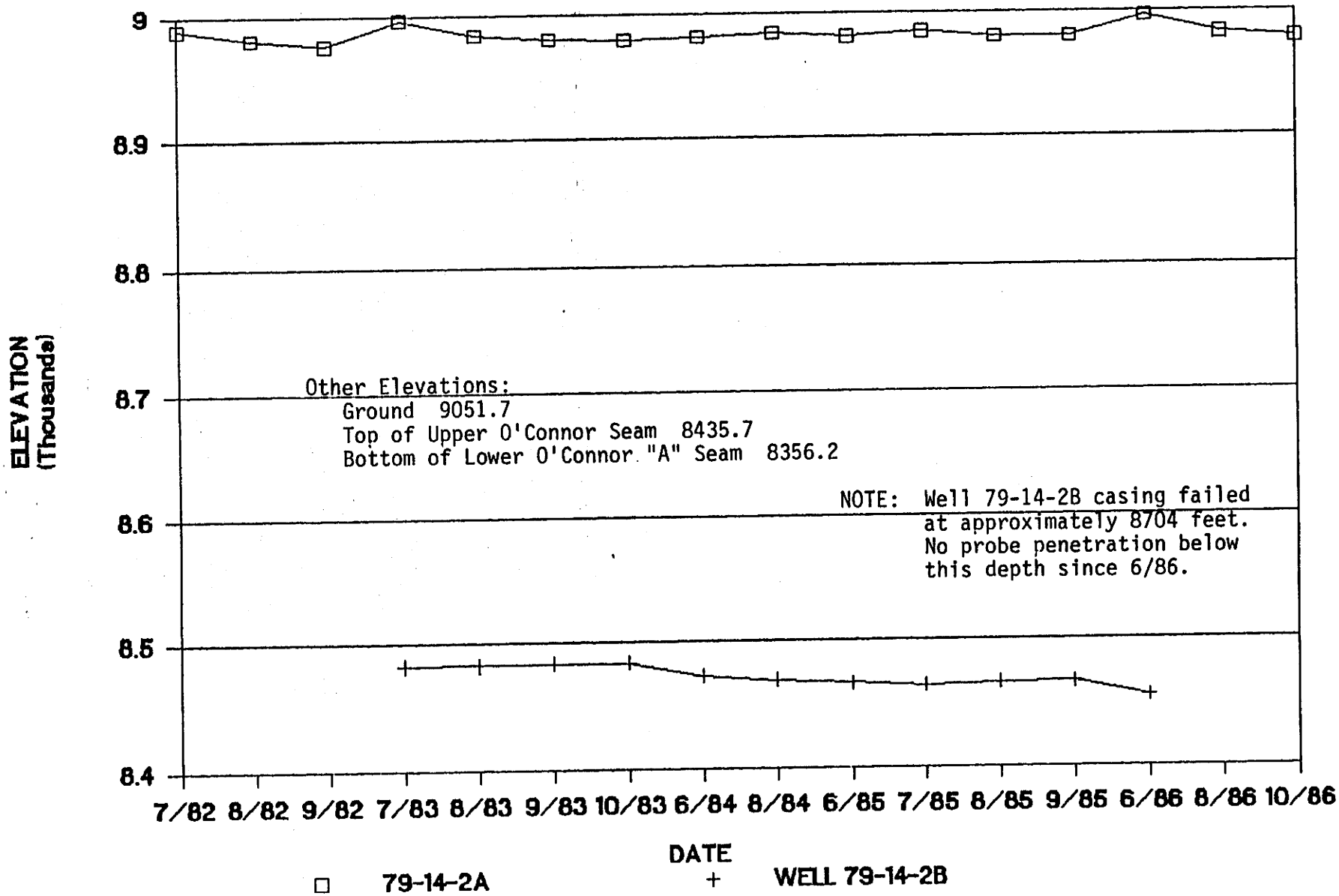
WELL WATER LEVEL 1987 -

Wells 79-10-1A AND 79-10-1B



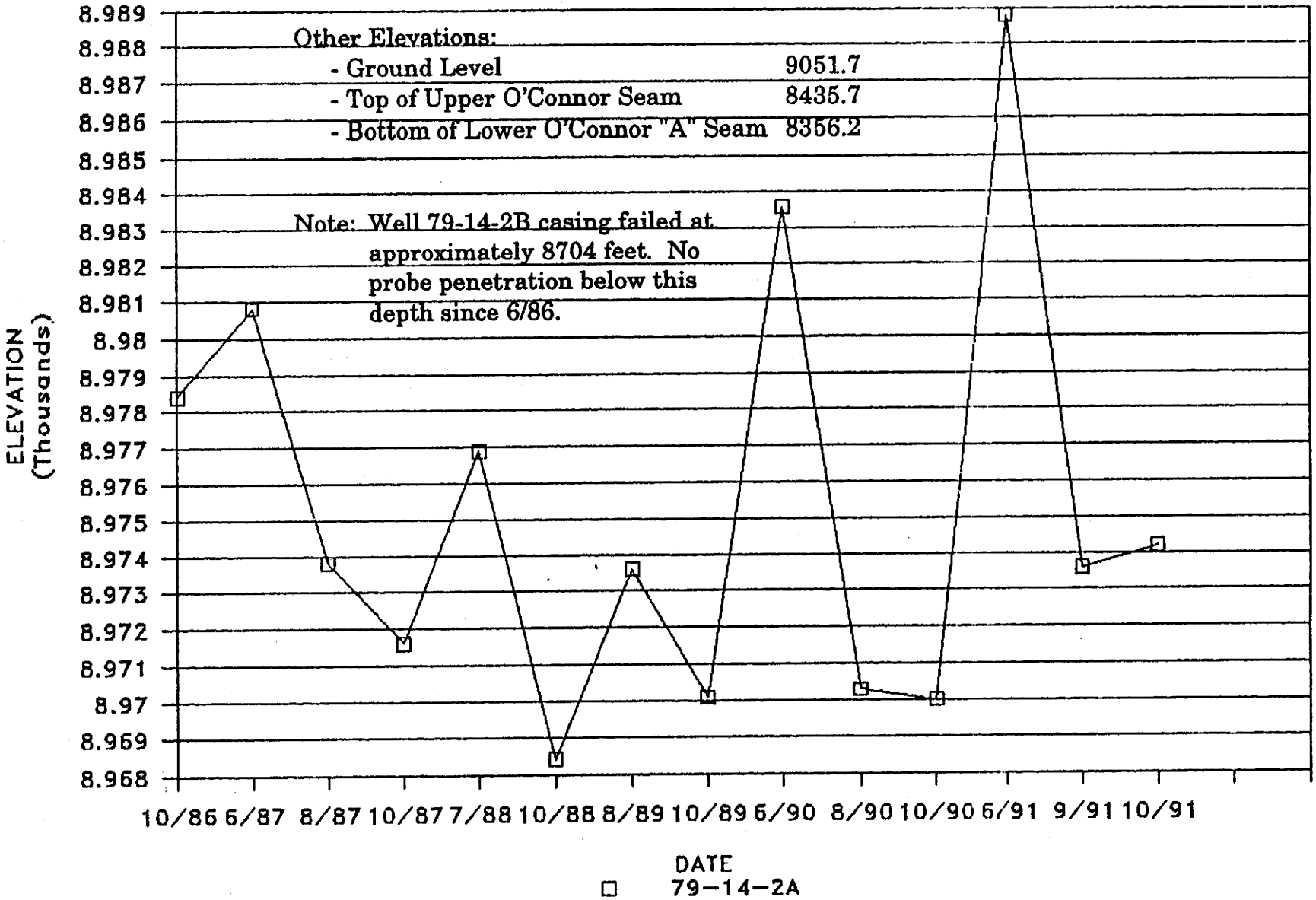
WELL WATER LEVEL, 1982 – 1986

Wells 79-14-2A and 79-14-2B



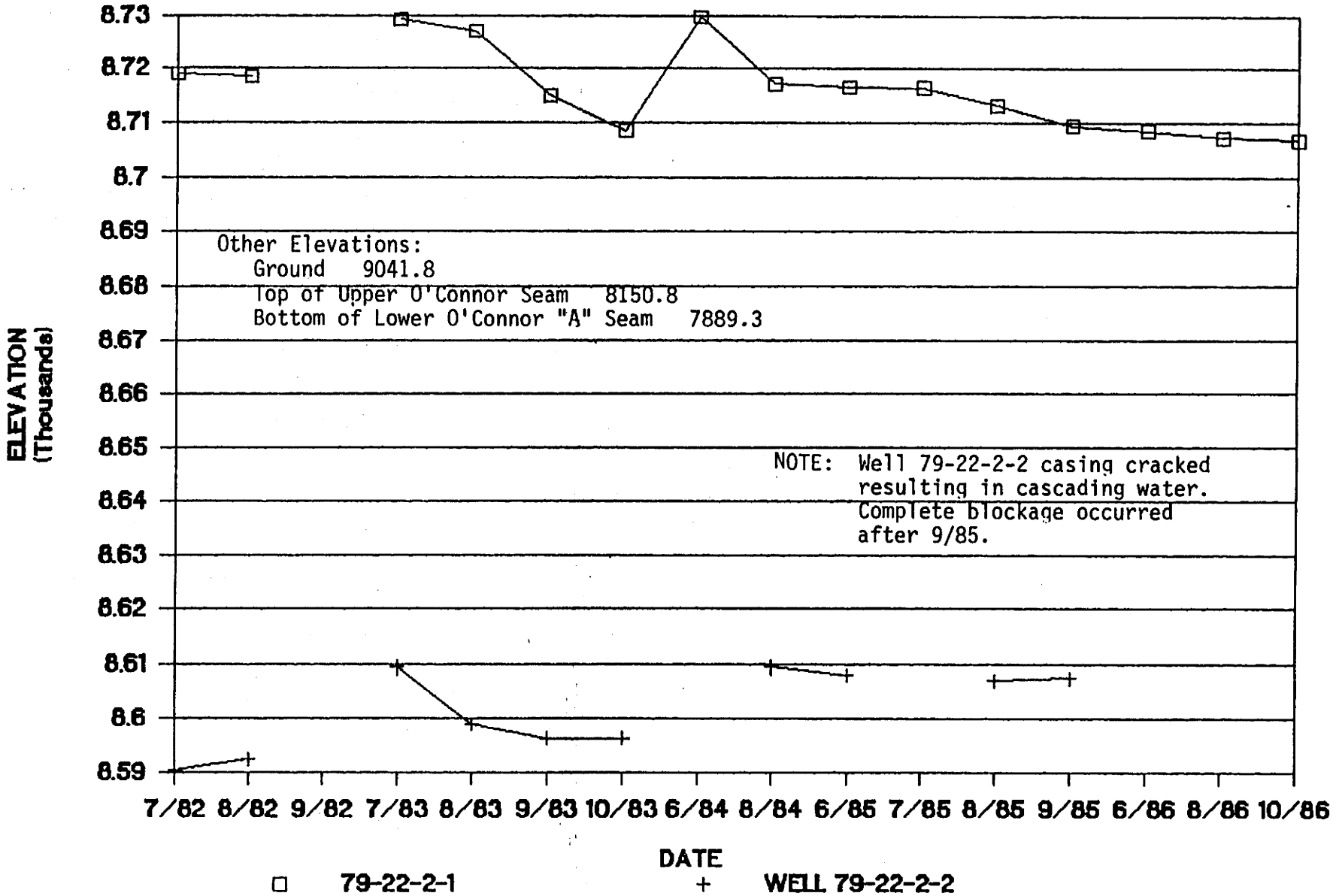
WELL WATER LEVEL 1987 -

Well 79 - 14 - 2A



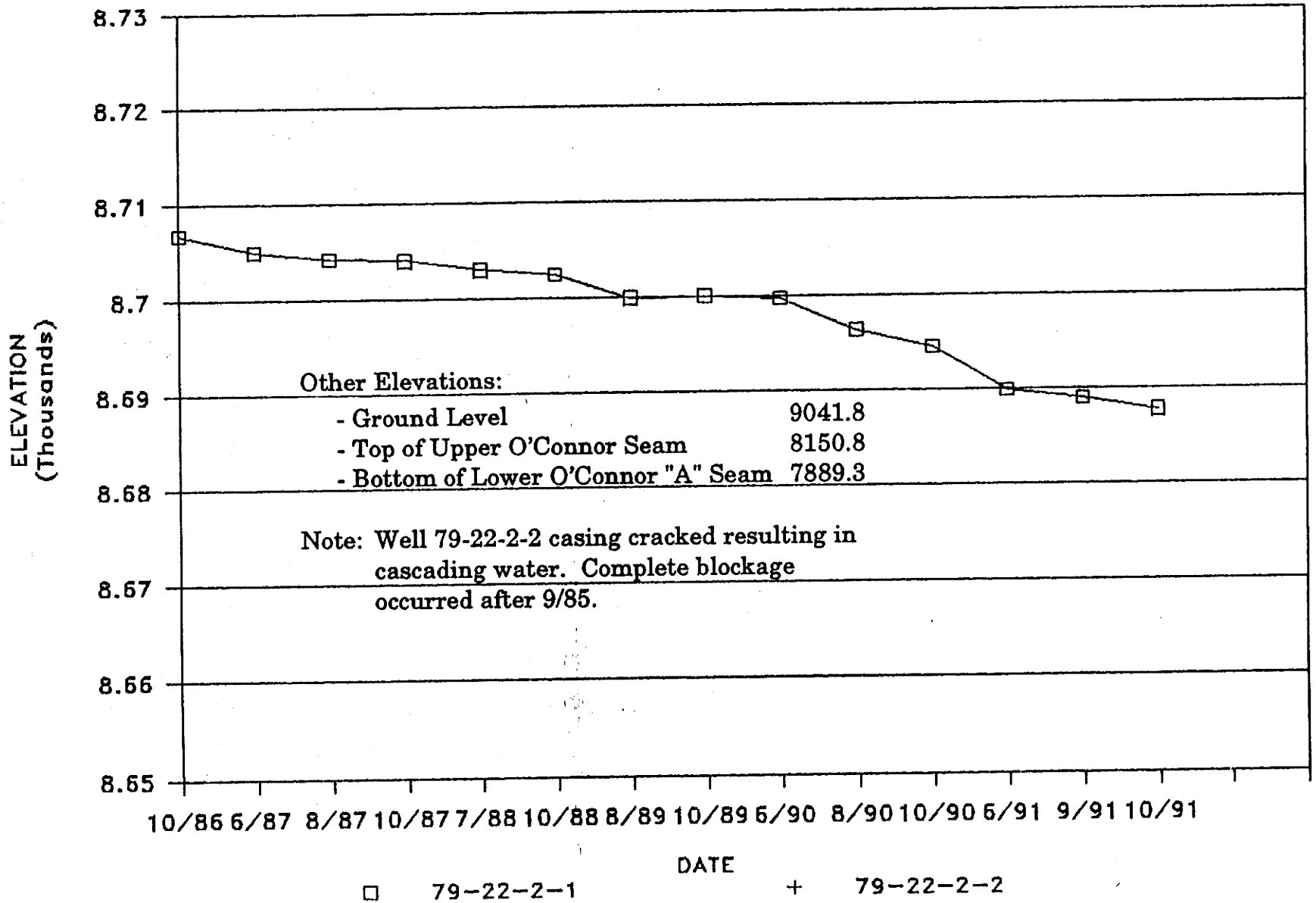
WELL WATER LEVEL, 1982 – 1986

Wells 79-22-2-1 and 79-22-2-2



WELL WATER LEVEL 1987 -

Wells 79-22-2-1 AND 79-22-2-2

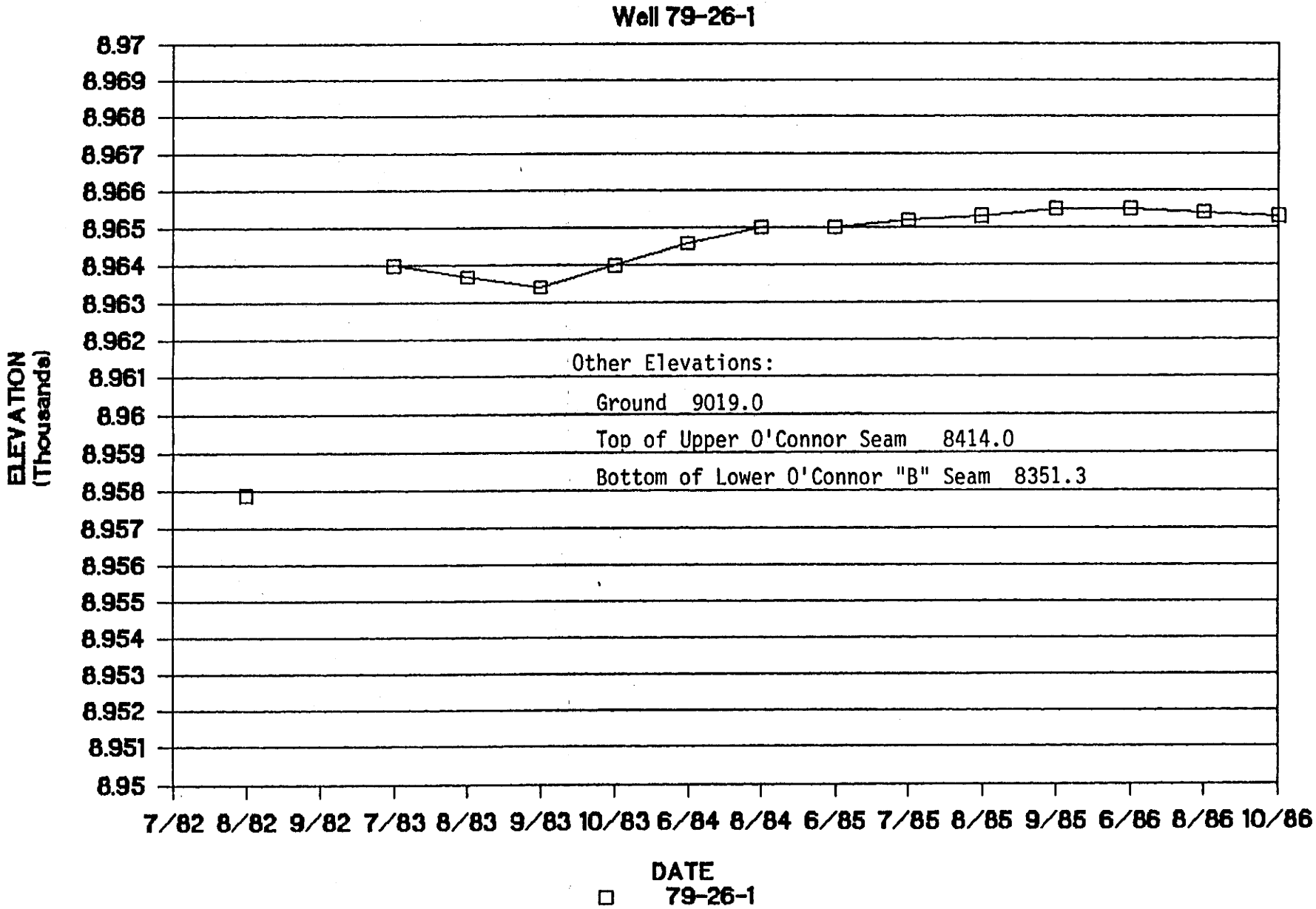


Other Elevations:

- Ground Level	9041.8
- Top of Upper O'Connor Seam	8150.8
- Bottom of Lower O'Connor "A" Seam	7889.3

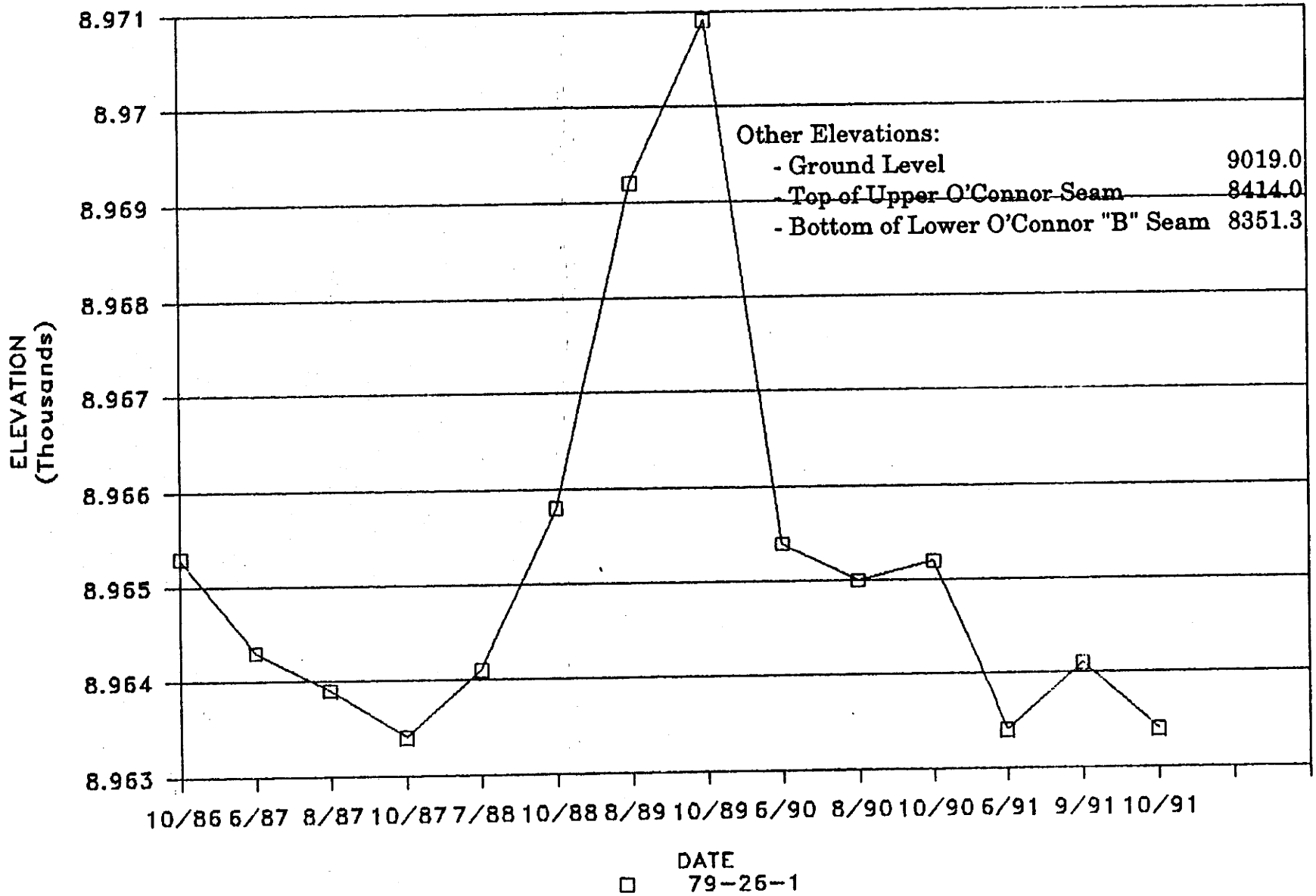
Note: Well 79-22-2-2 casing cracked resulting in cascading water. Complete blockage occurred after 9/85.

WELL WATER LEVEL, 1982 – 1986



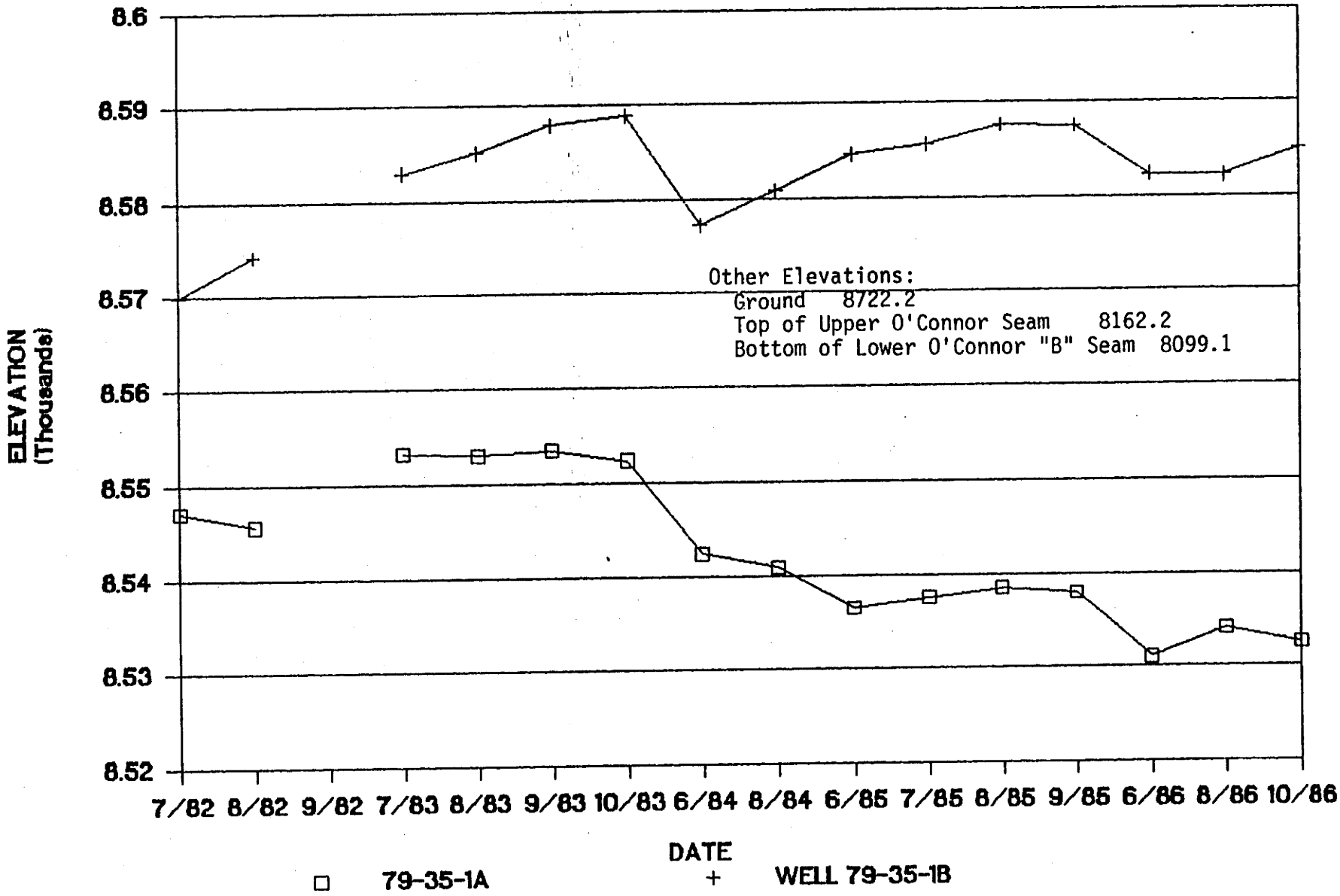
WELL WATER LEVEL 1987 -

Well 79 - 26 - 1



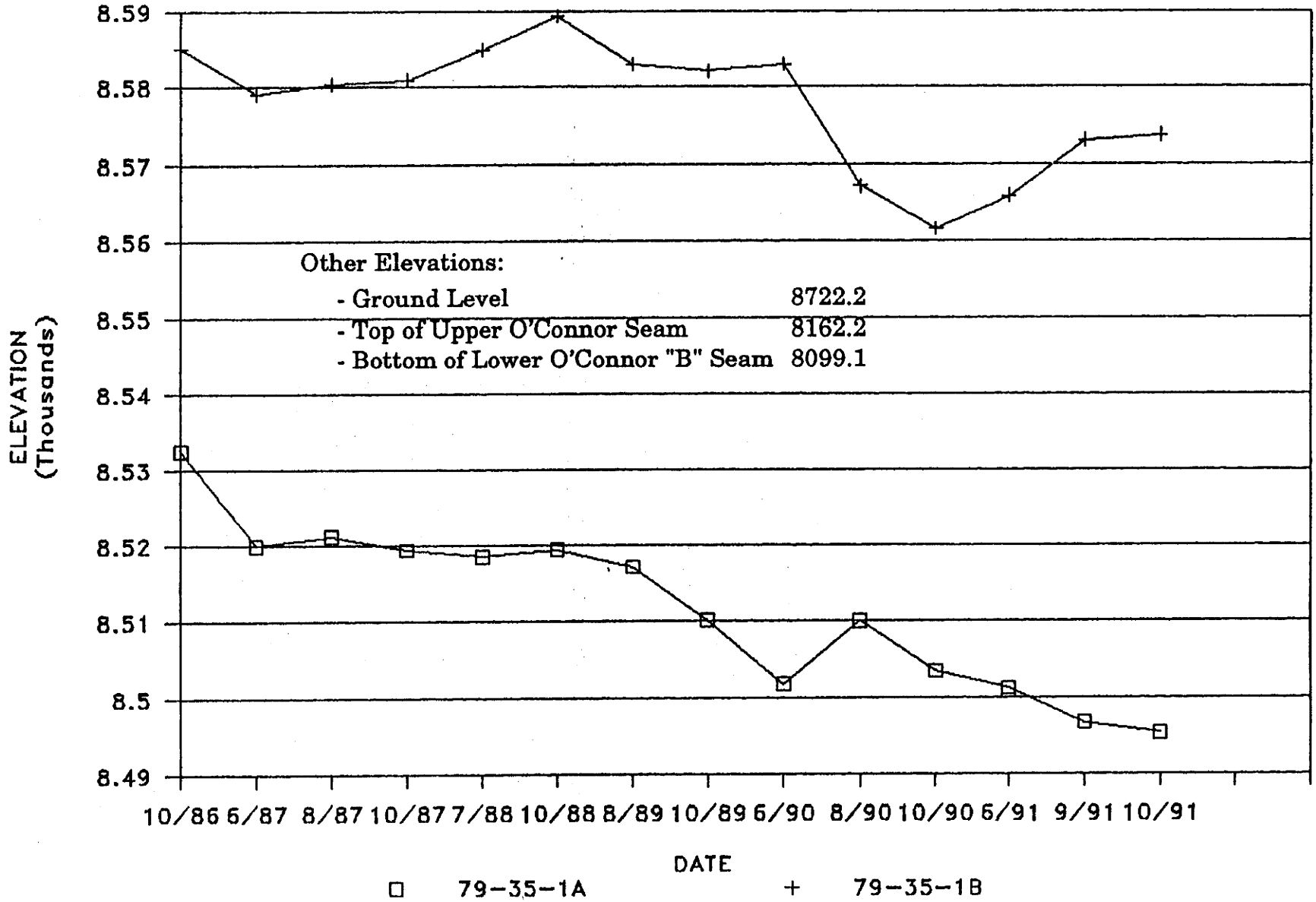
WELL WATER LEVEL, 1982 – 1986

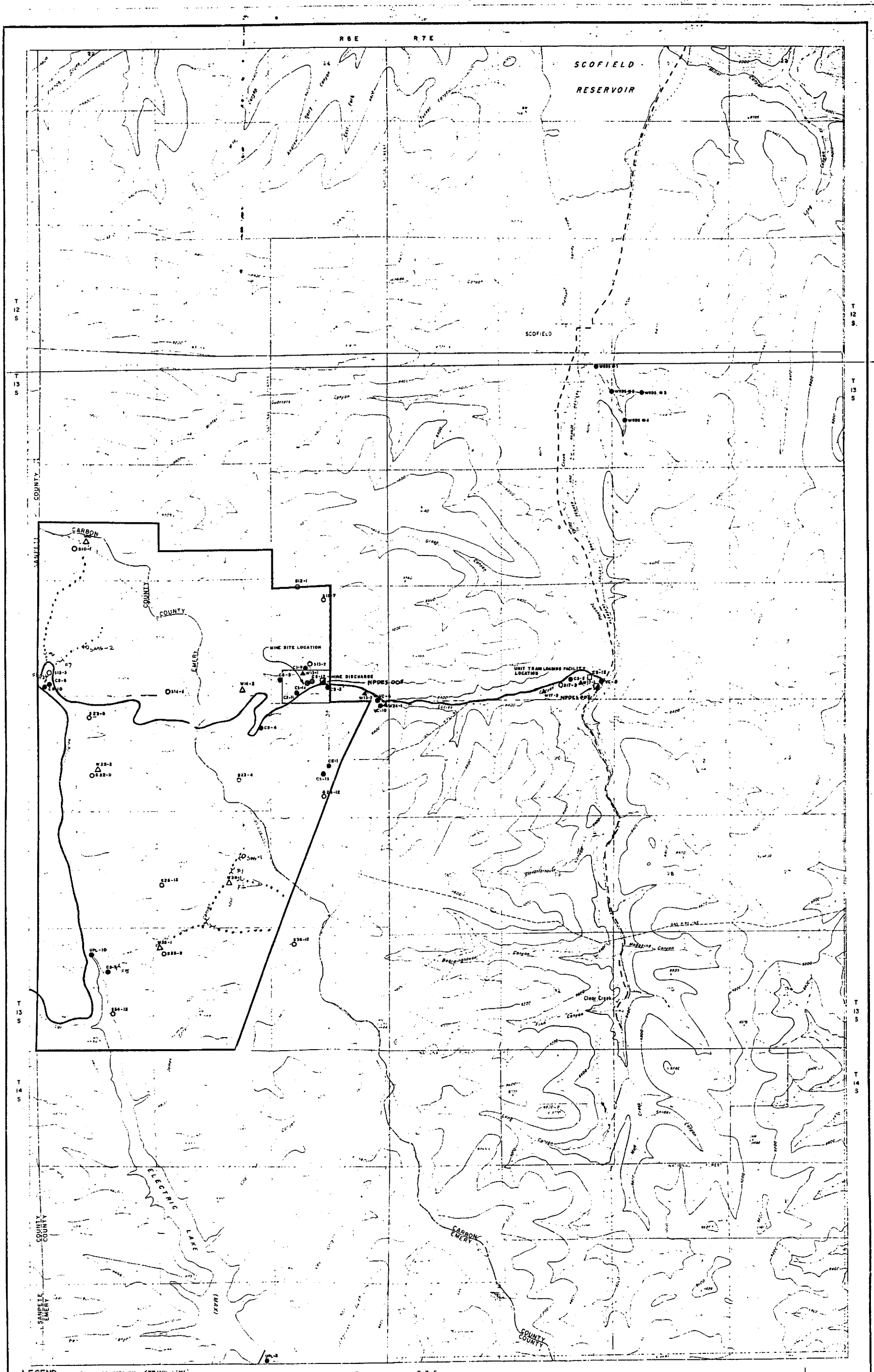
Wells 79-35-1A and 79-35-1B



WELL WATER LEVEL 1987 -

Wells 79-35-1A AND 79-35-1B





LEGEND
- ● STREAM
- ○ SPRING
- △ WELL - MONITORING
- ▲ WELL - CULINARY OR ABANDONED
- ◉ MINE DISCHARGE
- ☐ FRENCH DRAIN
- ✕ FLUME LOCATION
- ◪ NPDES DISCHARGE POINTS

TOPOGRAPHY BY USGS

NO.		REVISION		
5	10-3-91	ADDED RESIDENCE INFO.		
4	7-1-86	ADDED NPDES DISCHARGE POINTS		
3	2-89	ADDED 2ND WELL, AND FRENCH DRAIN		
2	10-88	ADDED STREAM INFORMATION LOCATED ON SCHEMATIC		
1	5-2-88	ADDED MINE DISCHARGE TO LEGEND AND MAP.		

		DATE
DESIGNED BY:	K WELCH	
DRAWN BY:	B. Cameron	6/86
CHECKED BY:	CH 7/89	
APPROVED BY:	K Welch	7-89
APPROVED BY:		
REFERENCE DWGS.		

PROFESSIONAL SEAL

UTAH FUEL COMPANY
SKYLINE MINES
P.O. BOX 719
HELPER, UTAH 84526

TITLE: LOCATION OF HYDROLOGIC MONITORING STATIONS

REV. NO. 1 | LOCATION | SHEET 1 OF 1 | SCALE 1" = 2000' | PLATE 2.3.6-1

RECEIVED
SEP 04 2002
DIVISION OF
OIL, GAS AND MINING

HYDROLOGIC INVENTORY OF SKYLINE PROPERTY & ADJACENT AREAS VAUGHN HANSEN ASSOCIATES, 1979

HYDROLOGIC INVENTORY OF
THE SKYLINE PROPERTY AND ADJACENT AREAS,
CARBON AND EMERY COUNTIES, UTAH

Prepared for

COASTAL STATES ENERGY COMPANY

Houston, Texas

By

VAUGHN HANSEN ASSOCIATES

Salt Lake City, Utah

October 1979

SURFACE WATER HYDROLOGY

Regional Surface Hydrologic System

The Skyline Property is situated in the headwaters of the Price and San Rafael River Basins, with the Carbon-Emery county line marking the watershed divide (see Figure 1). Approximately 1820 acres drain on the surface to the east primarily through Eccles Creek, a tributary of Pleasant Valley Creek which reaches the Price River via Scofield Reservoir (see Figure 4). The drainage from the remaining 4470 acres west of the divide flows towards the San Rafael River via Huntington Creek.

Snowmelt is the primary source of water for the perennial streams in the two major basins with summer precipitation usually producing little runoff (U.S. Geological Survey, 1979). Ephemeral streams are also abundant in the Price and San Rafael River Basins, existing primarily at lower elevations where evapotranspiration significantly exceeds precipitation.

Water use upstream from Castle Valley (the monoclinal valley containing most of the agricultural land noted in Figure 4) is primarily for stockwatering and industrial purposes (coal mining and electrical power generation). Within Castle Valley, agriculture and power production utilize nearly all of the inflowing water (Mundorff, 1972) with minimum flows in the gaged streams and rivers in the two basins occasionally reaching zero. Storage reservoirs are common at higher elevations. Transbasin diversions occur throughout the area.

In general, the chemical quality of water in the headwaters of the Price and San Rafael River Basins is excellent, with these watersheds providing most of the

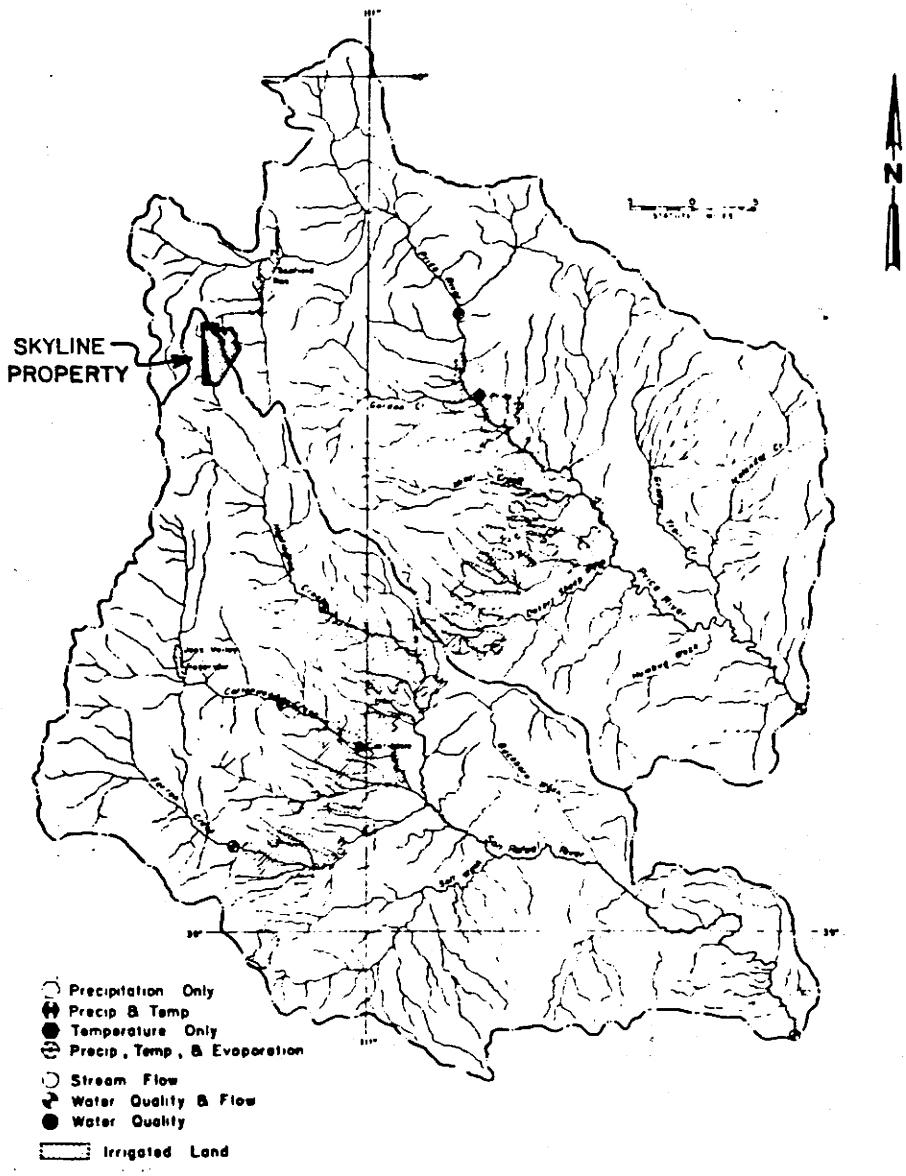


Figure 4. Price and San Rafael River Basins (modified from Hyatt et al., 1970).

domestic water needs of the people below. However, this quality rapidly deteriorates downstream as the streams cross shaley formations (particularly the Mancos Shale in and adjacent to Castle Valley) and receive irrigation return flows from lands situated on Mancos-derived soils (Price and Waddell, 1973). Within the Price River Basin, for example, Mundorff (1972) reports that the Price River and its tributaries generally has a dissolved solids content of less than 400 milligrams per liter above the upper stream gaging station shown in Figure 4. The water in this area is of the calcium bicarbonate type. Between this point and the confluence with Miller Creek, most of the flows originate on or traverse Mancos shales. Much of the flow is derived from irrigation return flows. The Price River at Wellington, which is near the center of the basin, has an average dissolved solids content of about 1700 milligrams per liter and is of a mixed chemical type (calcium-magnesium-sodium sulfate). At Woodside, which is about 22 miles upstream from the confluence of the Price River with the Green River, the weighted average dissolved solids content has generally been between 2000 and 4000 milligrams per liter, with the water type being strongly sodium sulfate. Similar deterioration patterns exist in the San Rafael River Basin.

Sediment yield from the upper portions of the two major basins is probably negligible (Mundorff, 1972). According to the U.S. Soil Conservation Service (1975), erosion rates in the Price and San Rafael River Basins vary from 0.1 to 3.0 acre-feet per square mile per year. The bulk of the sediment yielded each year at the mouths of the major rivers comes from limited areas covered with highly erodable shales (Mundorff, 1972).

Drainage Basin Characteristics

Portions of four perennial watersheds drain the Skyline Property including Eccles Canyon, Green Canyon, Winter Quarters Canyon (all tributaries of Pleasant Valley Creek in the Price River Basin), and Huntington Creek (a tributary of the San Rafael River). Channels draining the lease area form dendritic patterns, with stream channels on the property flowing in all four major directions. The landscape of the area varies greatly, with most of the property being covered with conifer and aspen vegetative communities on relatively steep slopes.

Slopes on the lease area vary from greater than 120 percent (50 degrees) near the Carbon-Emery County line to less than one percent (0.6 degree) along Huntington Creek. The average slope over the area is approximately 31 percent (17 degrees) as determined from a 1:24,000 scale map of the area. Dominant aspects are of the west on the Emery County side of the property and to the east on the Carbon County side. The topography is somewhat rugged, with elevations ranging from 8510 to 9655 feet above mean sea level (a range of 1145 feet).

Because of the climatological conditions of the area (high precipitation and low evapotranspiration resulting in excess water), there are numerous water sources on the Skyline Property. Most of these are undeveloped springs, seeps, and streams, the characteristics of which will be covered in subsequent sections. The one notable developed water body located partially on the property is Electric Lake, a 31,200 acre-foot reservoir whose upstream tip covers a small portion (103 acres) of the southwest corner of the property in Huntington Creek. This reservoir is owned and operated by Utah Power and Light Company as a storage facility for water used at coal fired power plants in Castle Valley.

Rainfall-runoff relations of the Skyline Property were determined in order to give an index of general surface hydrologic conditions and as a guide in designing future runoff control facilities. The runoff curve number, as defined by the U.S. Soil Conservation Service (1972), was used as a basis for this determination. According to the curve number methodology, the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \tag{1}$$

and

$$CN = \frac{1000}{10+S} \tag{2}$$

where Q is the direct runoff volume, in inches; P is the storm rainfall depth, in inches; S is a watershed storage factor, in inches, defined originally as the maximum possible difference between P and Q; and CN is a dimensionless expression of S referred to as the curve number.

It is known that runoff curve numbers tend to vary inversely with precipitation depth in forested mountain watersheds (Hawkins, 1973). In later studies of this phenomenon, Hawkins (1979) concluded that a relatively constant runoff source (i.e. "impervious") area produces this inverse relationship. Because wildland watersheds seldom experience overland flow, this constant source area coincides generally with the area occupied by live (perennial) streams and nearby impervious areas (roads, etc.). Hawkins (1979) found that the curve number could be

expressed as

$$CN = \frac{100}{1 + P \cdot f(c)/2} \qquad (3)$$

where $$f(c) = 1 + 2C - (4C^2 + 5C)^{\frac{1}{2}} \qquad (4)$$

and C is the fraction of the total area contained in the source area. Data were presented by Hawkins (1979) for various watersheds throughout the Rocky Mountain-Intermountain region as well as values of C determined by an iterative least squares technique. Conditions at two of the watersheds studied by Hawkins (Morris Creek and West Branch of Chicken Creek, located on the Davis County Experimental Watershed near Farmington, Utah) compare favorably with the surface characteristics of the Skyline Property. The relationship between CN and P at these two watersheds is presented in Figure 5. Also shown on this figure for reference purposes is the curve depicting CN_o, which Hawkins (1973) defines as the curve number for a given P below which there is no runoff.

The curve in Figure 5 which describes the West Branch of Chicken Creek is presumably representative of those watersheds on the Skyline Property where road development is extensive and adjacent to the stream channel (i.e. Main Fork Eccles Canyon, Huntington Creek, etc.). The curve representing Morris Creek presumably describes conditions of watersheds where road development is minimal or nonexistent or where old roads located away from the channel have been reclaimed, making the live stream the major source area in the basin through channel interception (i.e. Burnout Canyon, etc.). Note that runoff characteristics in a watershed can be described by both curves, depending upon the specific location of concern within the watershed (i.e. Huntington Creek, as a whole, is described by the upper curve but subbasins, such as Burnout Canyon, can be represented by the Morris Creek curve).

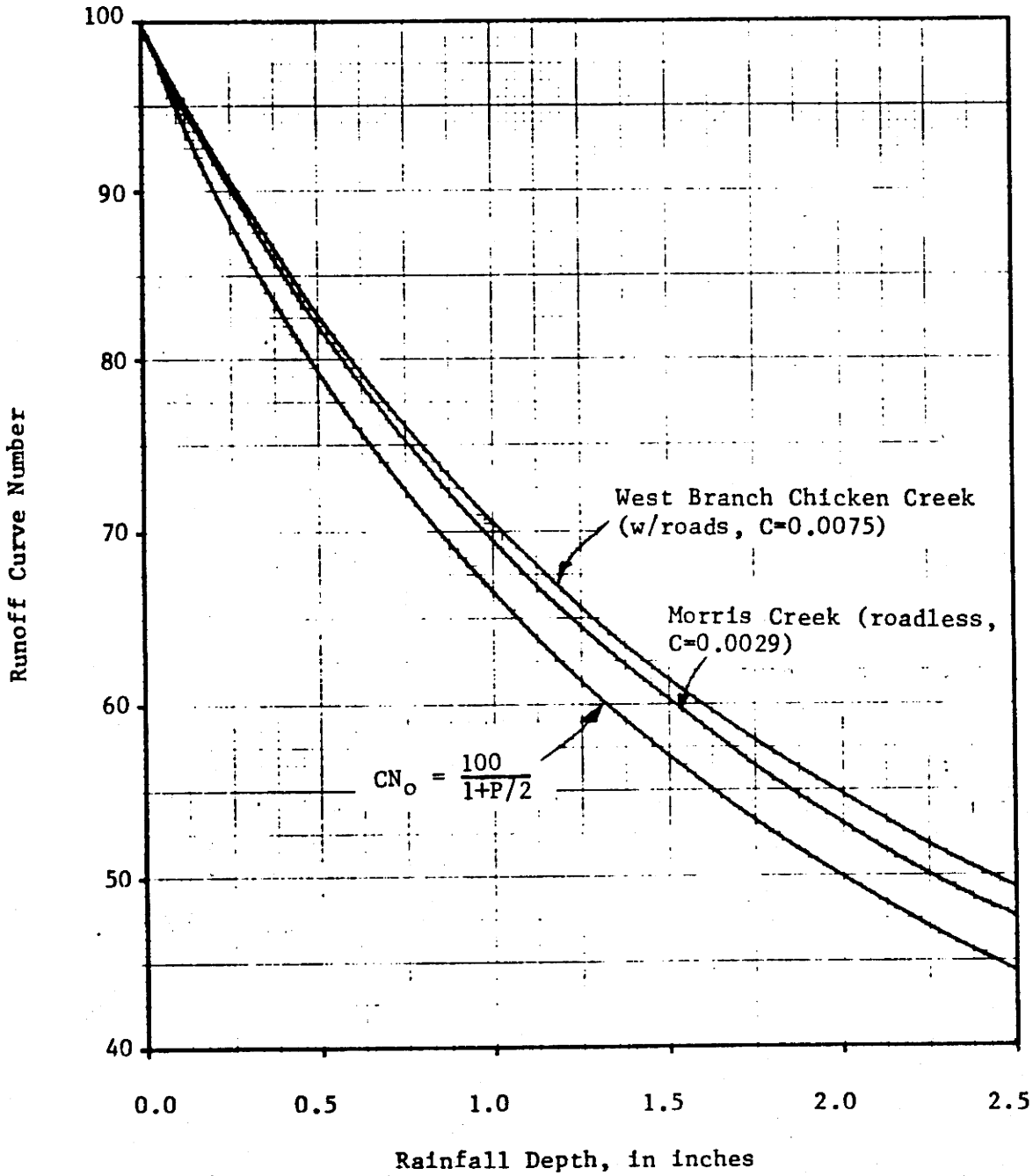


Figure 5. Variation of runoff curve number with rainfall depth at the Davis County Experimental Watershed, Utah.

Two comments should be made about the information presented in Figure 5. First, the potential for runoff from a rainfall event on the Skyline Property is low. As Hawkins (1979) has indicated and as can be seen in Figure 6, the term C in equation 4 can be thought of as equivalent to the runoff coefficient in the equation Q = CP and tends to be constant for a wildland watershed with a perennial stream (unlike CN). Thus, only a very small portion of the rainfall becomes runoff (between 0.29 and 0.75 percent, depending upon watershed conditions). This indicates that runoff from the Skyline Property occurs almost entirely from snowmelt, not rainfall.

A second comment is that the curves shown in Figure 5 assume that overland flow is non-existent from the majority of the watershed. This is a reasonable assumption for the Skyline Property under most circumstances because of the high infiltration rate relative to storm intensity and the apparent uniform antecedent moisture conditions of the soil surface created by relatively low summer rainfall volumes (see the previous discussion on local climate). Extremes in rainfall intensity and/or soil wetness may cause areas other than the normal source areas to contribute runoff, and thus create departures from the curves shown in Figures 5 and 6. Such conditions are assumed to be rare on the Skyline Property.

Flow Characteristics

Three hydrologic methods were used to determine the average annual water yield from the area, thereby increasing the level of confidence. Grunsky's Formula, which was originally developed by Grunsky (1908) and later reworked by Sellars (1965), states that

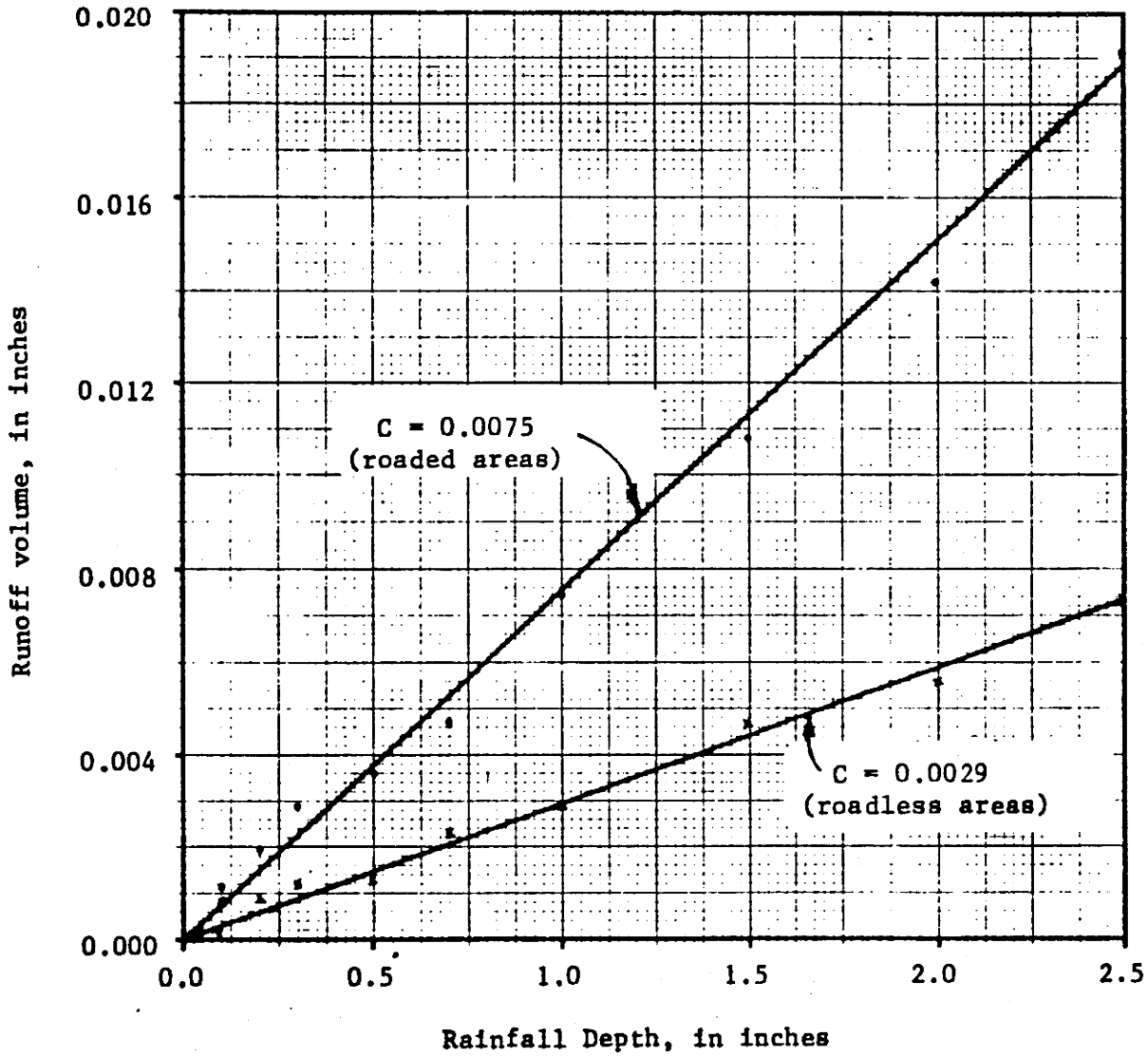


Figure 6. Runoff volumes resulting from a given rainfall depth on the Skyline Property.

$$Q = \alpha P^2 \quad (\text{for } P \leq 1/(2\alpha)) \tag{5}$$

and

$$Q = P - 1/(4\alpha) \quad (\text{for } P \geq 1/(2\alpha)) \tag{6}$$

where Q is the long-term average annual runoff, in inches; P is the long-term average annual precipitation, in inches; and α is a runoff coefficient, in inches^{-1}. A value of 0.015 was assumed for α based on guidelines set forth by Hawkins (1976). Thus, $1/(2\alpha)$ equals 33.3 which is greater than P (30 inches) and equation 5 is used for determining the average annual runoff from the Skyline Property, with a resulting value of 13.5 inches.

A second method used to estimate average annual water yield from the area is often referred to as Ol'deKop's Formula (Sellers, 1965 and Linsley, 1976). According to this method,

$$Q = P - E_o \tanh \frac{P}{E_o} \tag{7}$$

where Q and P are as previously defined; E_o is the potential evapotranspiration; and tanh represents the hyperbolic tangent. As noted in the previous discussion on climate, P and E_o on the Skyline Property are equal to 30 and 17 inches, respectively. Substituting these values into equation 7 results in an average annual water yield of 14.0 inches.

The final method used to determine average annual flows in the Skyline Property area was through the derivation of flow duration curves for Huntington Creek above Burnout Canyon and Eccles Creek above Pleasant Valley Creek. The flow duration curve, as described by Searcy (1959), combines into one curve the flow characteristics of a stream throughout the range of observed discharges and can be defined as a cumulative frequency curve that shows the percent of time during which specified discharges were equalled or exceeded in a given period. Although it

does not show the chronological sequence of these flows, it can be used to determine several hydrologic characteristics of a watershed, including the mean annual flow.

Long-term flow duration curves at the two locations of concern were derived from short-term existing records using the index station method described by Searcy(1959). According to the index station method, flow duration curves are prepared for the period of record at the short-term station and the corresponding period of record at the long-term (index) station. The discharges at selected percent-duration points on the curve of the short-term station are then plotted on logarithmic paper against the discharges for the same percent-duration points from the curve of the long-term station. The relation between discharges at the two stations for the short concurrent period is assumed to represent the relation for a long period. Following the construction of the long-term flow duration curve for the index station, the flow available a given percent of time at the long-term station can be used to enter the curve of relation (based on the short period of record), in order to obtain the adjusted (to long term) flow available the same percent of time at the short-term station.

Short-term records on Huntington Creek above Burnout Canyon were gathered from Utah Power and Light Company who maintained a continuously recording temporary gaging station at the site from October, 1971 through September, 1973 (a period of two water years) prior to the construction of Electric Lake. Instantaneous discharge measurements made during the periodic collection of water quality samples were used for the short-term record on Eccles Creek above Pleasant Valley Creek. These discharges were ranked from high to low to obtain a duration curve. It is assumed that the instantaneous discharge was equal to the mean daily discharge for the day of measurement (see Riggs, 1969). The period of record for these

15 measurements spanned water years 1976 through 1978. Long-term records (monthly flows and flow duration tables) for possible index stations were obtained from the U.S. Geological Survey.

The selection of an index (long-term) station was based on comparisons of monthly flow volumes for concurrent periods of record of Huntington Creek above Burnout Canyon and five gaged streams in the general area. The assumption was made that the behavior of Eccles Creek would be similar to that of Huntington Creek and that an index station chosen for Huntington Creek would, therefore, also be valid for Eccles Canyon. Comparisons were made using linear, exponential, logarithmic, and geometric regressions with the standard error of the estimate selected as the objective function to be minimized. Results of the linear regressions (which proved to be superior) are summarized in Table 1. In this table, S_e is the standard error of the estimate, in acre-feet per month; r^2 is the coefficient of determination; and r is the coefficient of correlation. Based on these results, the White River below Tabbyune Creek near Soldier Summit, Utah (USGS Station No. 09312600 with an 11 year period of record from October 1967 through September 1978) was selected as the index station for both Huntington Creek and Eccles Creek.

Figures 7 and 8 give the flow duration curves for water years 1972 and 1973 of Huntington Creek above Burnout Canyon and the index station (White River below Tabbyune Creek near Soldier Summit, Utah). Note the change of scale on the ordinates of the two figures. The curve of relation is plotted in Figure 9 using discharge values corresponding to the equal percent duration points of 0.1, 1.0, 5.0, 10.0, 25.0, 50.0, 75.0, 90.0, 95.0, and 99.0. Based on this curve

Table 1. Results of linear regression analyses of monthly flows of Huntington Creek above Burnout Canyon and local long-term stream gaging stations for water years 1972 and 1973.

Comparison Station	S_e	r^2	r
White River below Tabbyune Creek near Soldier Summit, Utah	330	0.928	0.963
Beaver Creek near Soldier Summit, Utah	401	0.893	0.945
Huntington Creek near Huntington, Utah	429	0.878	0.937
Minnie Maud Creek near Myton, Utah	447	0.868	0.931
Willow Creek near Castle Gate, Utah	595	0.765	0.875

of relation and the long-term flow duration curve of the index station, the long-term flow duration curve of Huntington Creek above Burnout Canyon was developed (Figure 10). The dotted section in the low flow region of the adjusted Huntington Creek flow duration curve is based on instantaneous discharge estimates made by Dr. Robert N. Winget of Brigham Young University in conjunction with biological sample collections at the site during the summer of 1977, a period of severe drought in the western United States (Hughes et al., 1978). The high flow section of the curve was estimated based on an observation by Searcy (1959) that streams whose high flows come largely from snowmelt tend to have flow duration curves with flat slopes in their upper sections.

Searcy (1959) indicates that the average annual flow of a stream can be found by determining the area under the flow duration curve. This determination is presented in Table 2 for Huntington Creek above Burnout Canyon. The indicated average

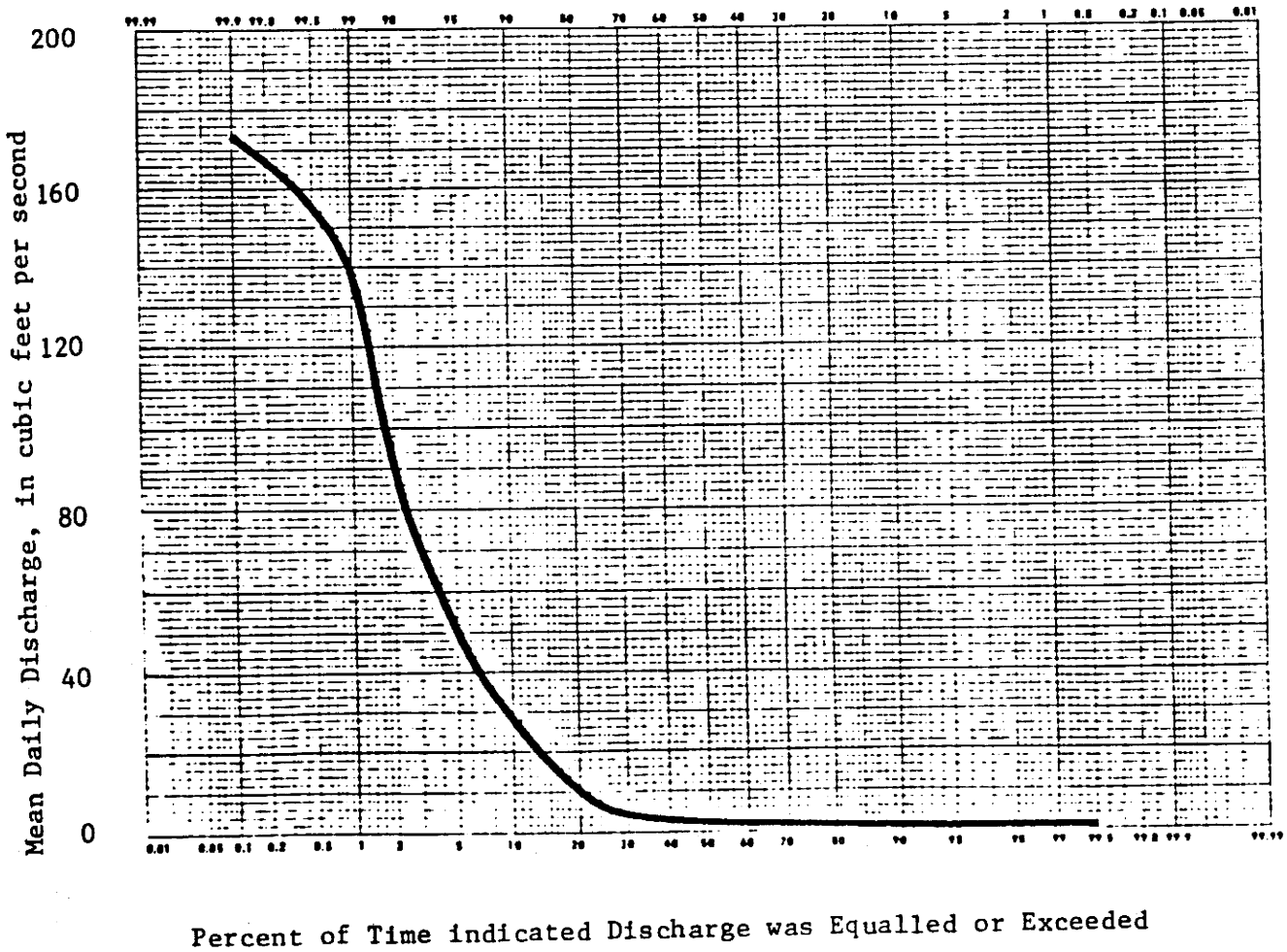


Figure 7. Duration curve of mean daily flows of Huntington Creek above Burnout Canyon for water years 1972 and 1973.

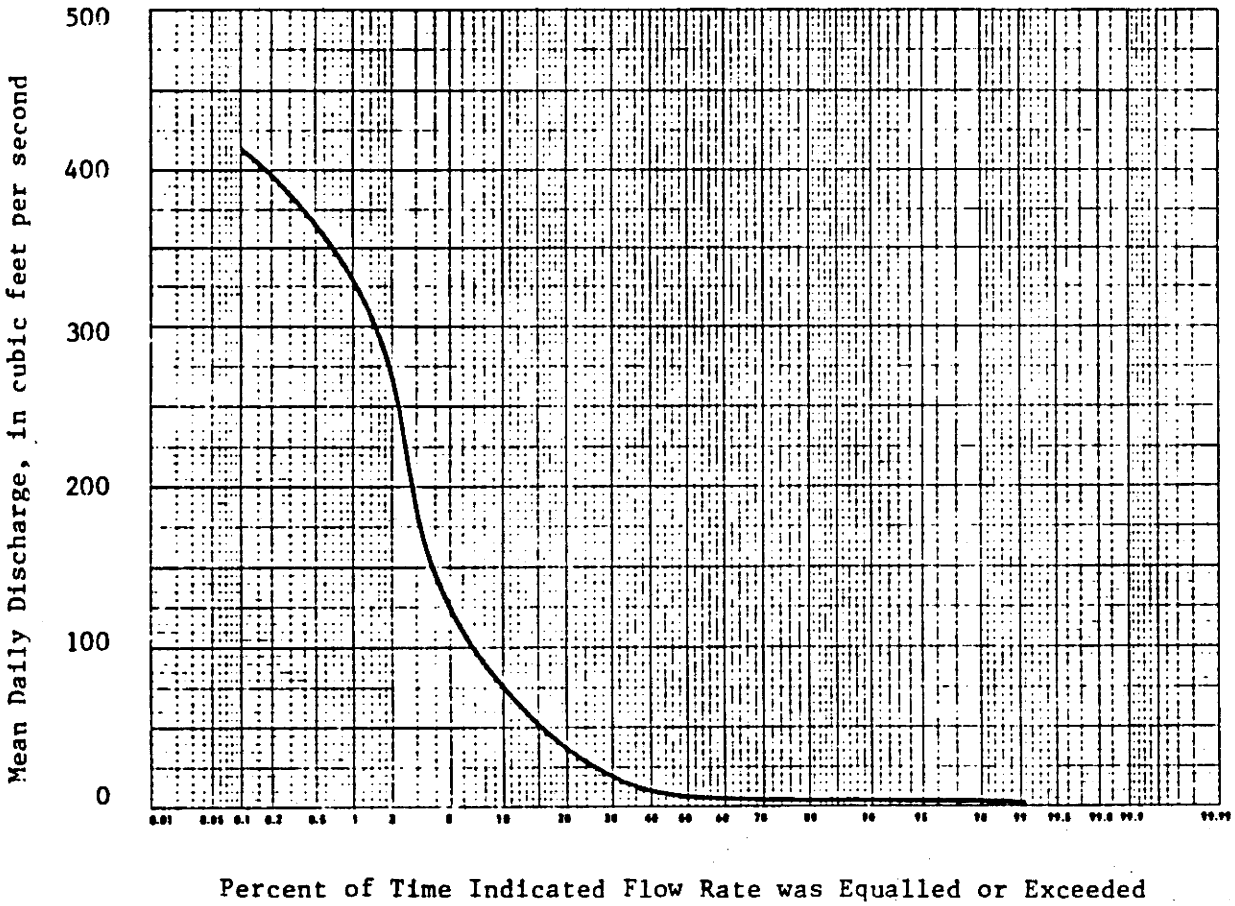


Figure 8. Duration curve of mean daily flows of the White River below Tabbyune Creek near Soldier Summit, Utah for water years 1972 and 1973.

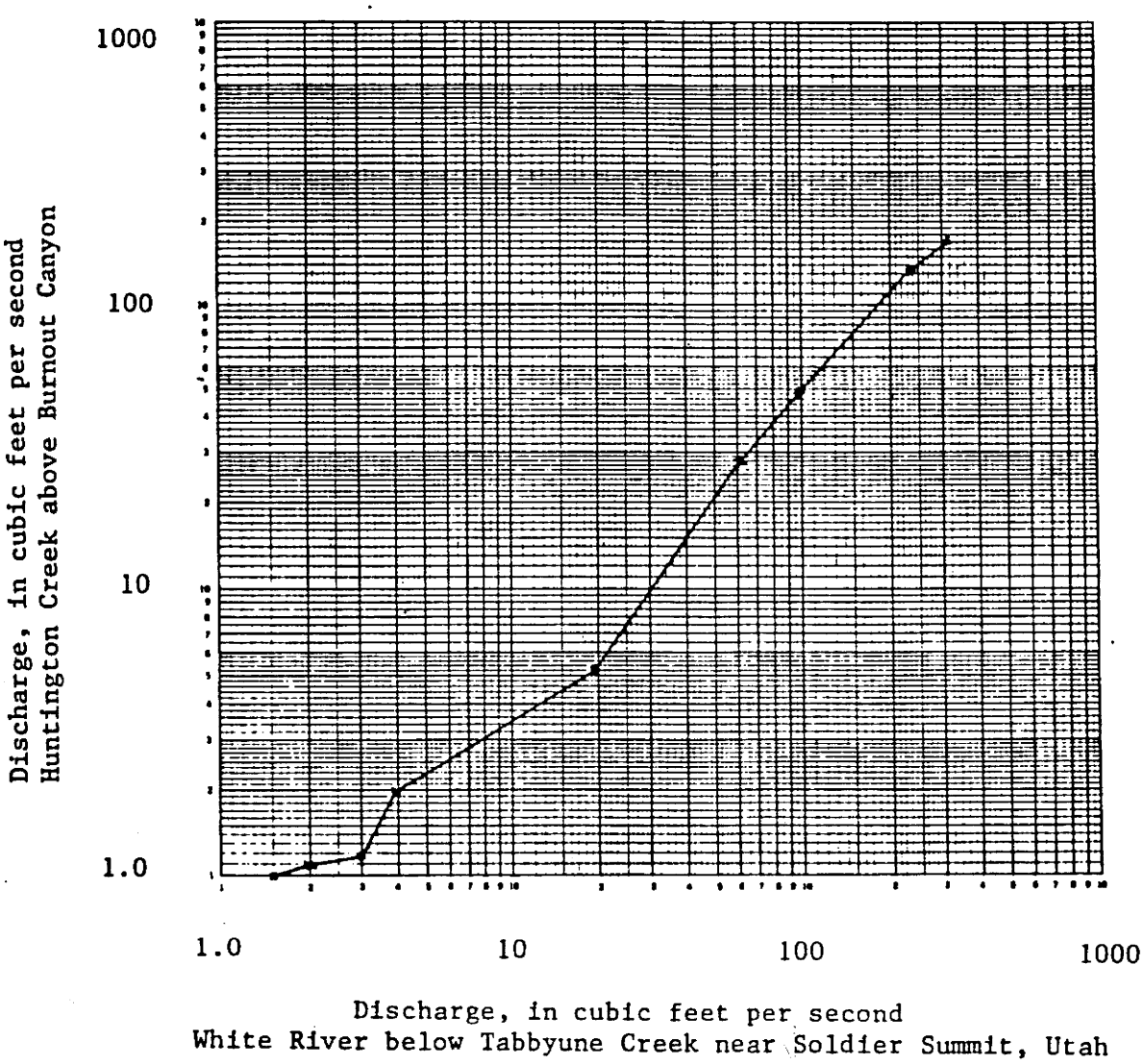


Figure 9. Correlation between Huntington Creek above Burnout Canyon and White River below Tabbyune Creek near Soldier Summit, Utah for water years 1972 and 1973, based on discharges of equal percent duration.

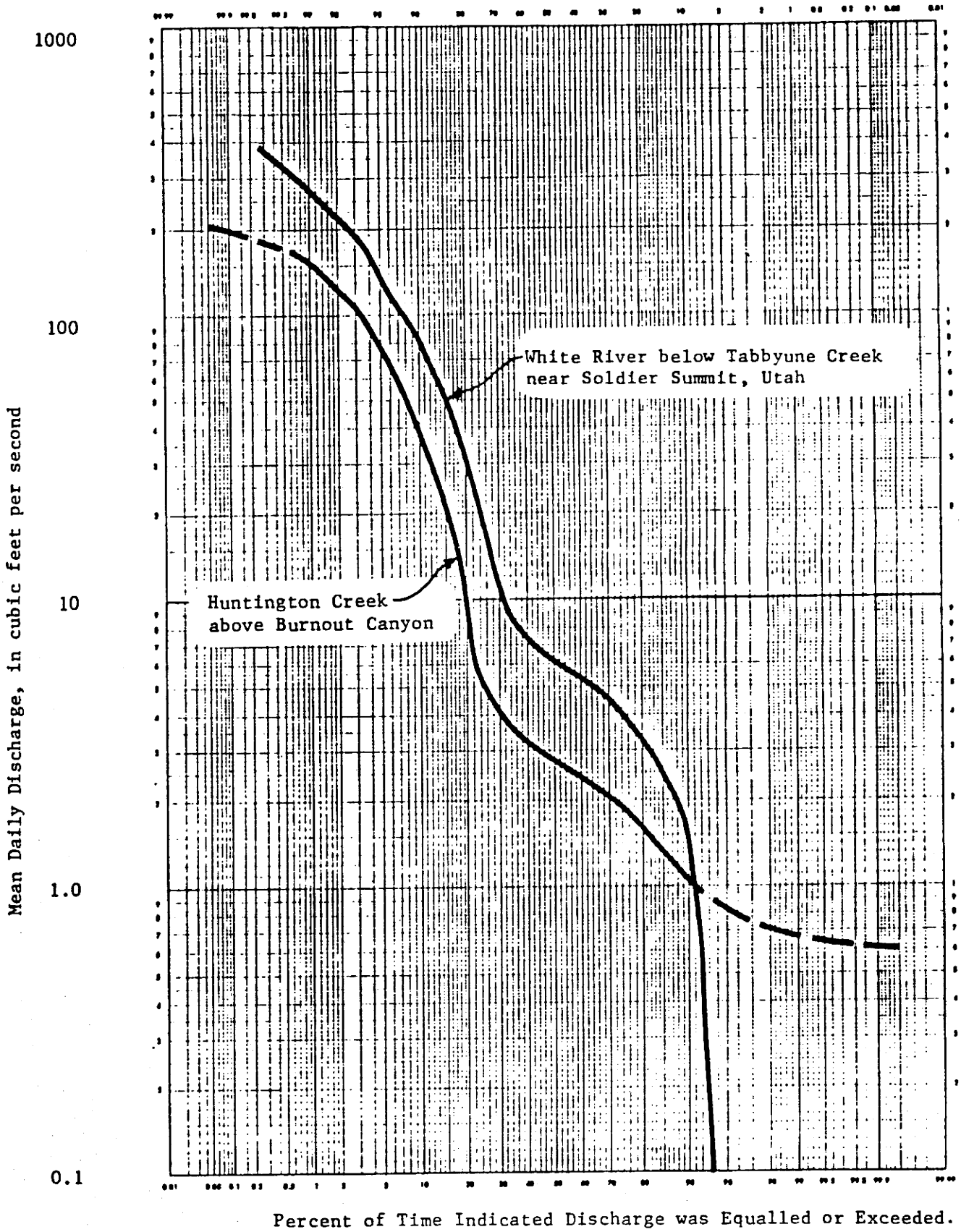


Figure 10. Long-term duration curves of mean daily flows of the White River below Tabbyune Creek near Soldier Summit, Utah and Huntington Creek above Burnout Canyon.

Table 2. Computation of long-term mean discharge of Huntington Creek above Burnout Canyon, based on the adjusted flow duration curve.

Duration Curve Percentages			Discharge (cfs)	
Limits	Interval	Mean of Limits	Q for Mean of Limits	Increment in Interval
0.00 - 0.10	0.10	0.05	209	0.21
0.10 - 0.20	0.10	0.15	195	0.20
0.20 - 1.00	0.80	0.60	168	1.34
1.0 - 3.0	2.0	2.0	128	2.56
3.0 - 5.0	2.0	4.0	92	1.84
5.0 - 9.0	4.0	7.0	59	2.36
9 - 15	6	12	30	1.80
15 - 25	10	20	9.2	0.92
25 - 35	10	30	4.1	0.41
35 - 45	10	40	3.2	0.32
45 - 55	10	50	2.7	0.27
55 - 65	10	60	2.4	0.24
65 - 75	10	70	2.1	0.21
75 - 85	10	80	1.6	0.16
85 - 95	10	90	1.05	0.11
95 - 99	4	97	0.76	0.03
99 - 99.6	0.6	99.3	0.65	<0.01
99.6 - 99.8	0.2	99.7	0.61	<0.01
99.8 - 100.0	0.2	99.9	0.61	<0.01
Total	100.0	-	-	12.84

annual flow of 12.84 cubic feet per second converts to an average annual yield of 16.0 inches over the 6944 acre watershed.

The relatively high estimated average annual flow rate of 16 inches could be caused by one or more of a few reasons. First, the possibility exists that the methodology and the assumptions which were used do not apply to the conditions studied. Specifically, the curve of relation developed from data during water years 1972 and 1973 may, in actuality, not be representative of long-term conditions. The shape differences between the White River curves shown in Figures 8 and 10 indicate that this is likely a major cause of the high estimate.

A second reason for the high water yield is that most of the Huntington Creek watershed above Burnout Canyon is underlain by the relatively impermeable Blackhawk Formation. As a result, a relatively small amount of snowmelt infiltrates into the soil mantle. Thus, a greater portion of the precipitation which reaches the watershed is yielded to direct runoff during the snowmelt runoff season.

A final explanation for the high water yield relative to other estimates also deals with the geology of the area. As noted in a previous section, the strata in the area dip to the west (see Plate 1). As a result, some water may travel beneath the ground in sandstone layers from the adjacent portion of the Price River Basin to the Huntington Creek watershed. Although no precise estimate can be given of the amount of water falling into this category, it is suspected to be small relative to the total yield of the watershed. This assumption is based on the fact that the continuous sands in the area (i.e. the Aberdeen and Star Point Sandstones) dip considerably below Huntington Creek (Doelling ,1972)

and are capped by shale layers, providing little opportunity for the sands to yield water directly to the creek.

Figures 11 and 12 give the flow duration curves for water years 1976 through 1978 of Eccles Creek above Pleasant Valley Creek and the index station (White River below Tabbyune Creek near Soldier Summit, Utah). The curve of relation is given in Figure 13, based on the discharge at equal percent duration points of 5.0, 10.0, 20.0, 30.0, 50.0, 70.0, 80.0, 90.0, and 95.0. The long-term flow duration curve is presented in Figure 14.

As was the case with Figure 10, the shape of the Eccles Creek curve in Figure 14 was estimated in the upper and lower portions. Once again, the low flow estimate was based on instantaneous discharge measurements taken during 1977 by Vaughn Hansen Associates in conjunction with the collections of water quality samples. The high flow region was estimated based on hydrologic judgement and the fact that snowmelt streams tend to have flat flow duration curves in their high flow portion (Searcy, 1959)

The area under the Eccles Creek long-term duration curve was computed according to Table 3. The indicated average annual flow of 5.43 cubic feet per second converts to an average annual yield of 13.4 inches over the 3510 acre watershed. This compares favorably with the estimates computed previously by Grunsky's and Ol'deKop's Formulas.

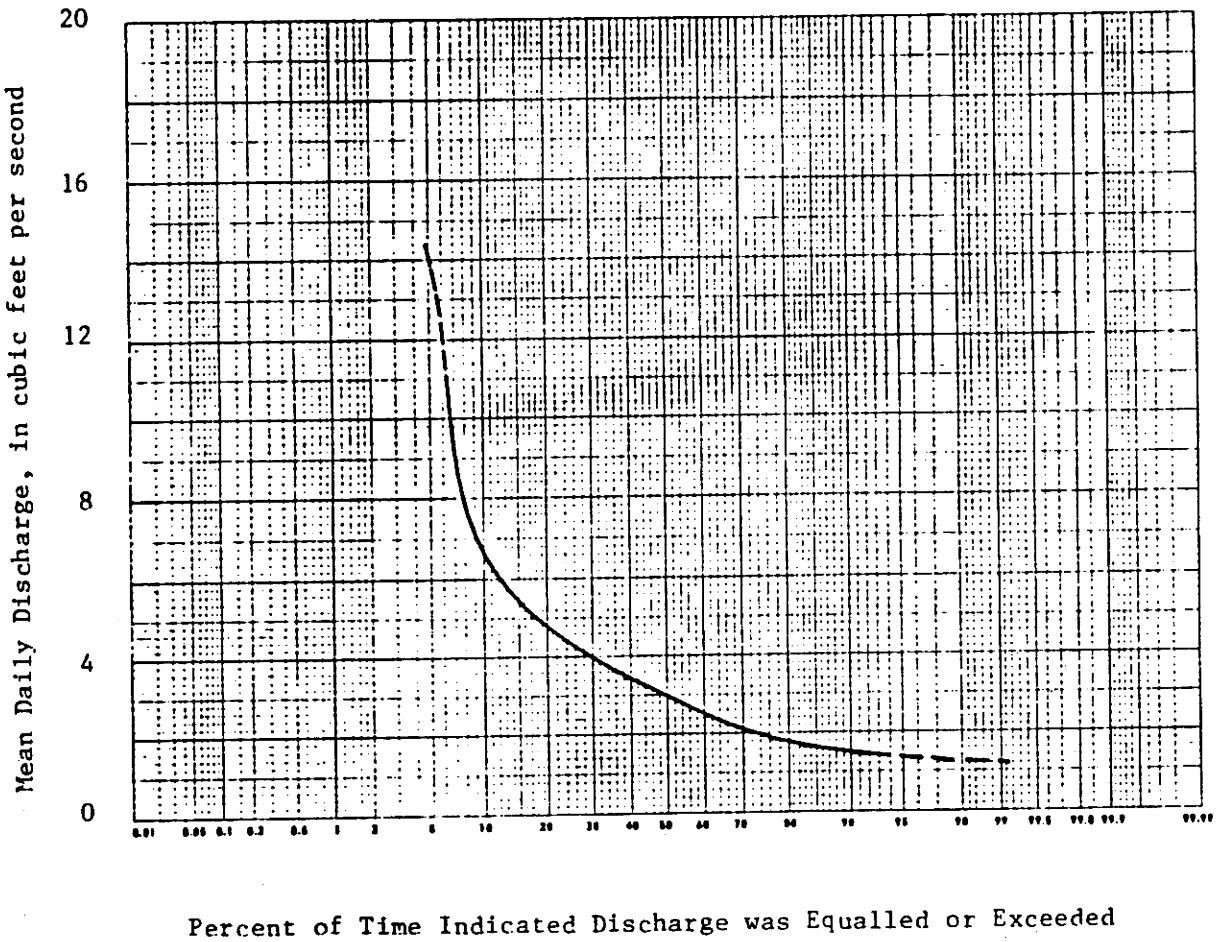


Figure 11. Duration curve of mean daily flows of Eccles Creek above Pleasant Valley Creek for water years 1976 through 1978.

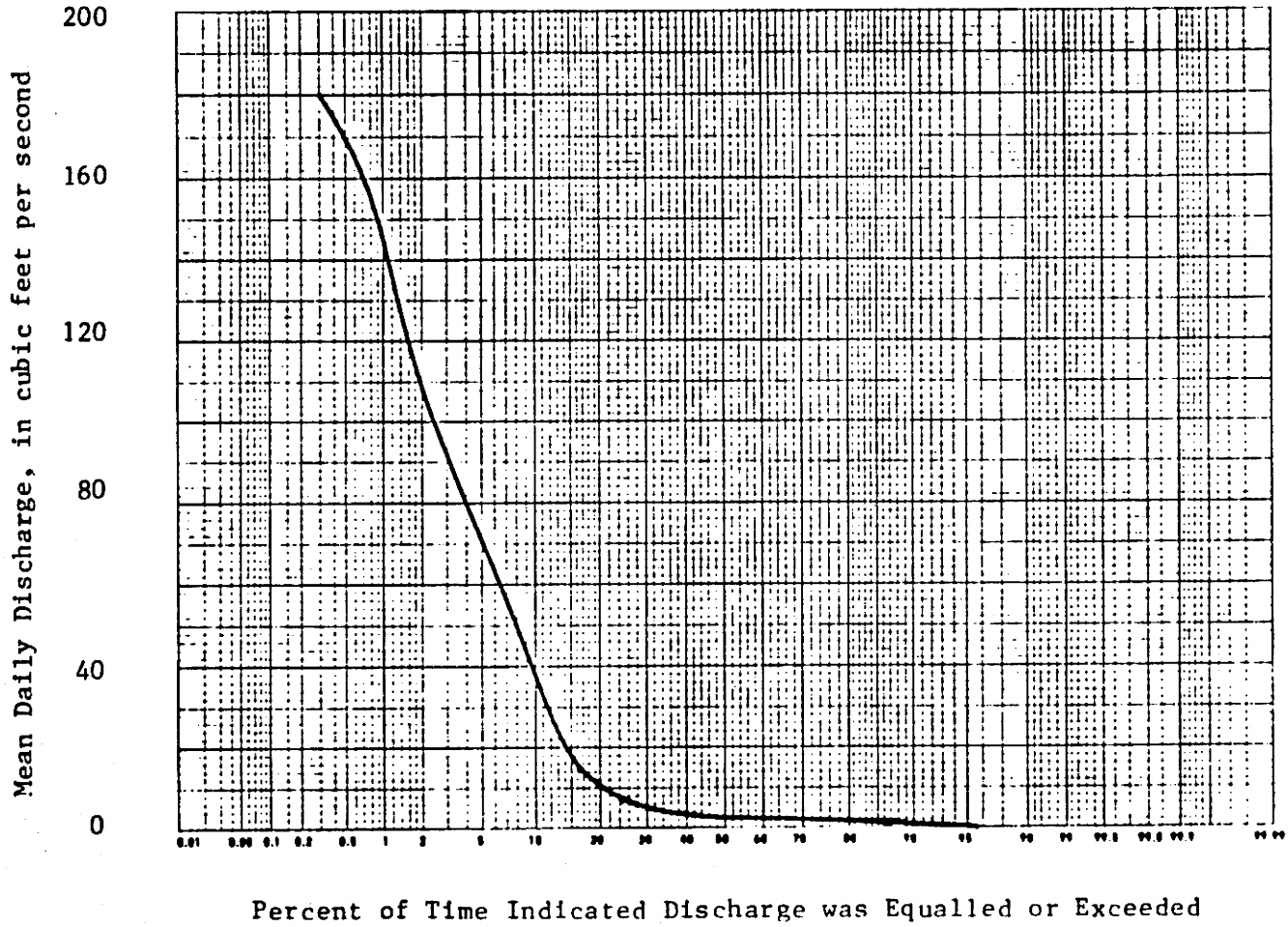


Figure 12. Duration curve of mean daily flows of the White River below Tabbyune Creek near Soldier Summit, Utah for water years 1976 through 1978.

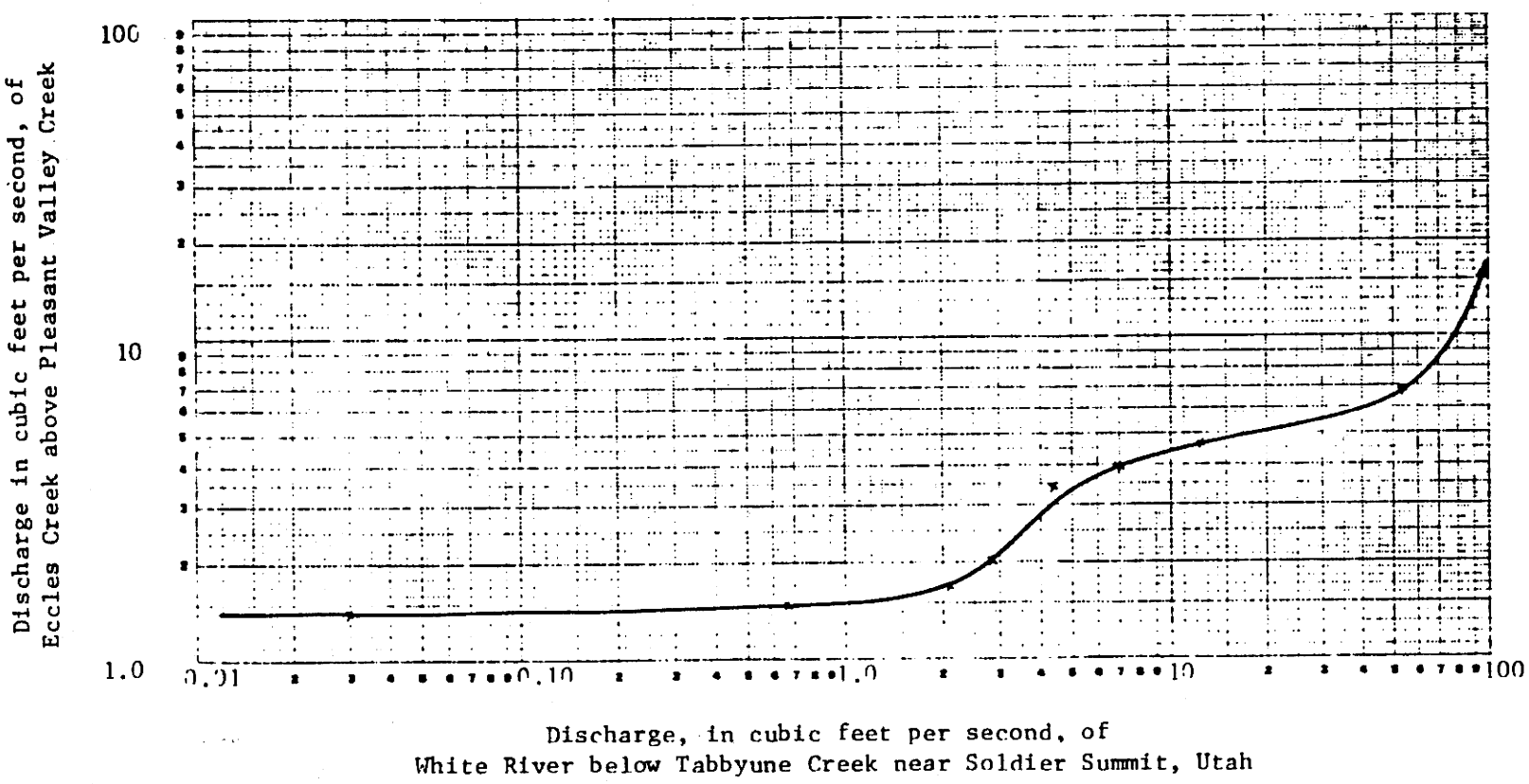


Figure 13. Correlation between Eccles Creek above Pleasant Valley Creek and White River below Tabbyune Creek near Soldier Summit, Utah for water years 1976 through 1978, based on discharges of equal percent duration.

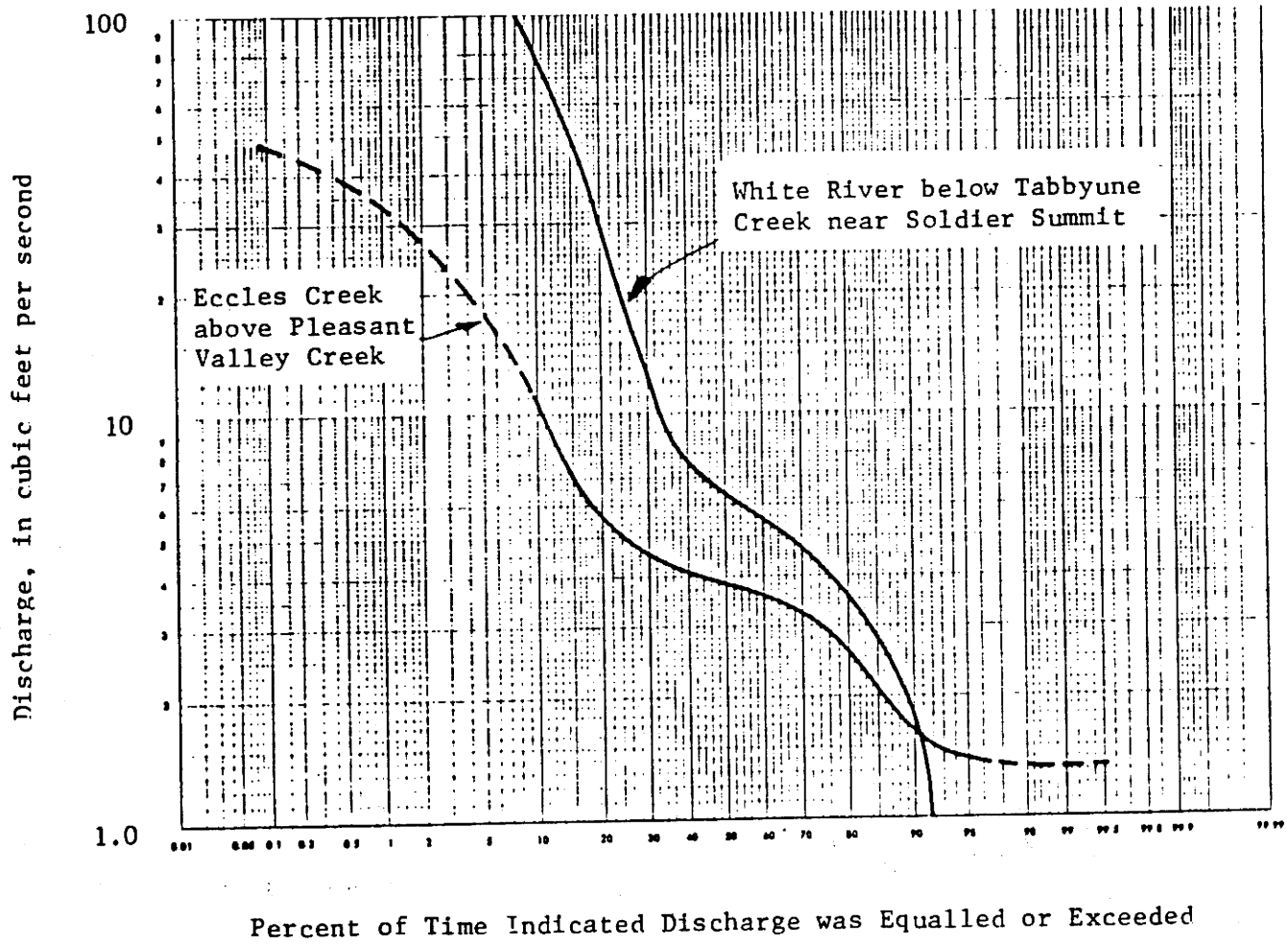


Figure 14. Long-term duration curves of mean daily flows of the White River below Tabbyune Creek near Soldier Summit, Utah and Eccles Creek above Pleasant Valley Creek.

Table 3. Computation of long-term mean discharge of Eccles Creek above Pleasant Valley Creek, based on the adjusted flow duration curve.

Duration Curve Percentage			Discharge (cfs)	
Limits	Interval	Mean of Limits	Q for Mean of Limits	Increment in Interval
0.1 - 0.5	0.4	0.3	40	0.16
0.5 - 1.0	0.5	0.75	36	0.18
1.0 - 3.0	2.0	2.0	28	0.56
3.0 - 5.0	2.0	4.0	21	0.42
5.0 - 9.0	4.0	7.0	15	0.60
9 - 15	6.0	12	9.0	0.54
15 - 25	10	20	5.6	0.56
25 - 35	10	30	4.6	0.46
35 - 45	10	40	4.1	0.41
45 - 55	10	50	3.8	0.38
55 - 65	10	60	3.6	0.36
65 - 75	10	70	3.3	0.33
75 - 85	10	80	2.5	0.25
85 - 95	10	90	1.6	0.16
95 - 99	4.0	97	1.3	0.05
99 - 99.6	0.6	99.3	1.3	0.01
Total	100.0	-	-	5.43

In order to determine the seasonal distribution of flows in the Skyline Property area, average monthly flows of Huntington Creek above Burnout Canyon for water years 1972 and 1973 were computed as a percent of the average annual flow for the same period. These results are plotted in Figure 15. Although the exact percentages will change from year to year, the distribution pattern is expected to remain fairly constant, as evidenced by the flows of gaged streams in the area (see Figure 16). The seasonal distribution shown in the two figures, which is presumably representative of conditions in perennial streams throughout the Skyline Property area, is typical of western high elevation, snowmelt streams, where the majority of the flow occurs within a relatively short amount of time in late spring and early summer.

Based on the flow duration curve presented in Figure 10, mean daily flows in Huntington Creek above Burnout Canyon can be expected to range from an occasional low of about 0.6 cubic foot per second to an occasional high of approximately 200 cubic feet per second. Similarly, according to Figure 14, the mean daily flows in Eccles Creek above Pleasant Valley Creek likely vary between 1 and 50 cubic feet per second.

Estimates of peak flow recurrence intervals in the property area were made based on techniques presented by Fields (1975). According to Fields (1975), the 25- and 50-year recurrence interval flood discharges of Utah streams are related to channel geometry characteristics. Specifically, for the area of the Skyline Property, the following relationships were found to apply:

$$q_{25} = 3.7W^{1.57} \qquad (8)$$

and

$$q_{50} = 3.9W^{1.58} \qquad (9)$$

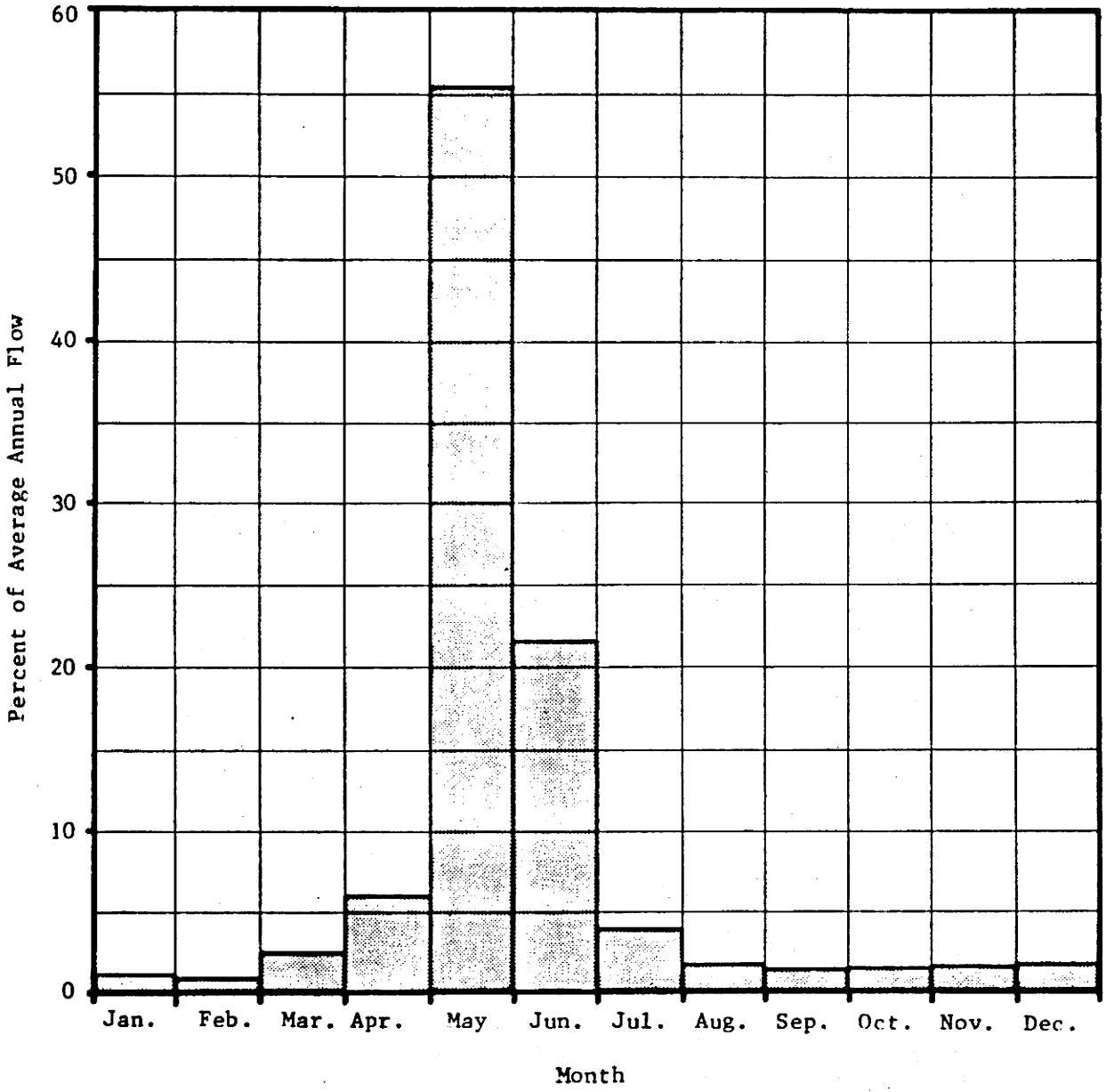
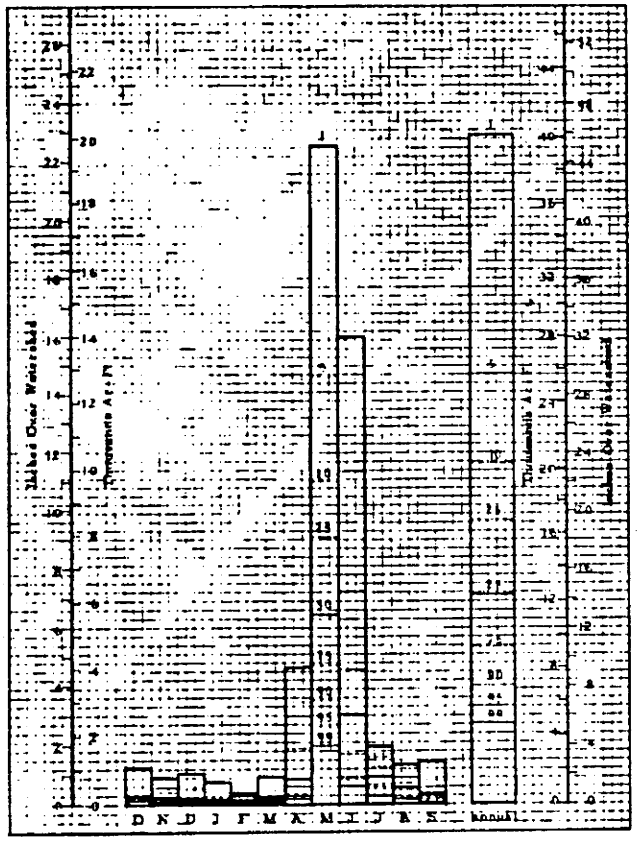
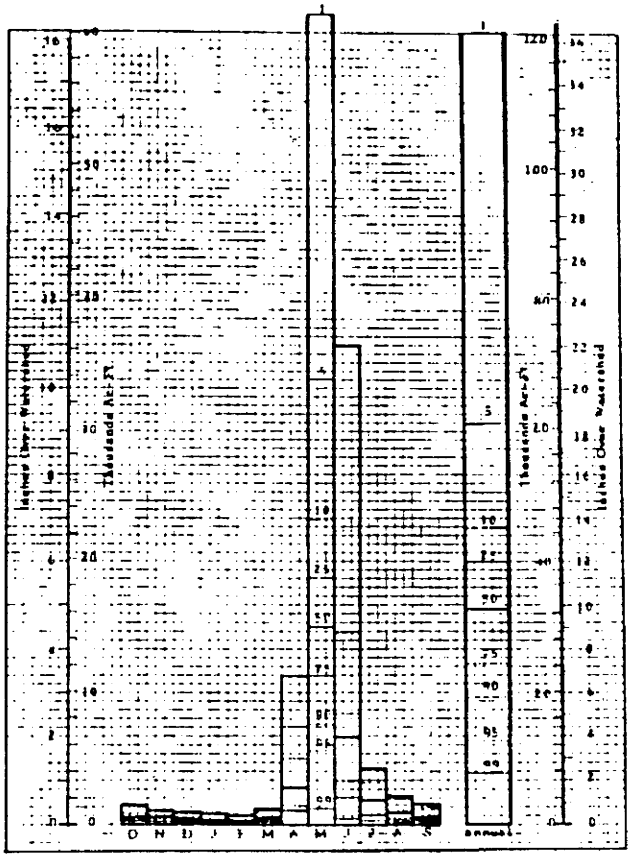


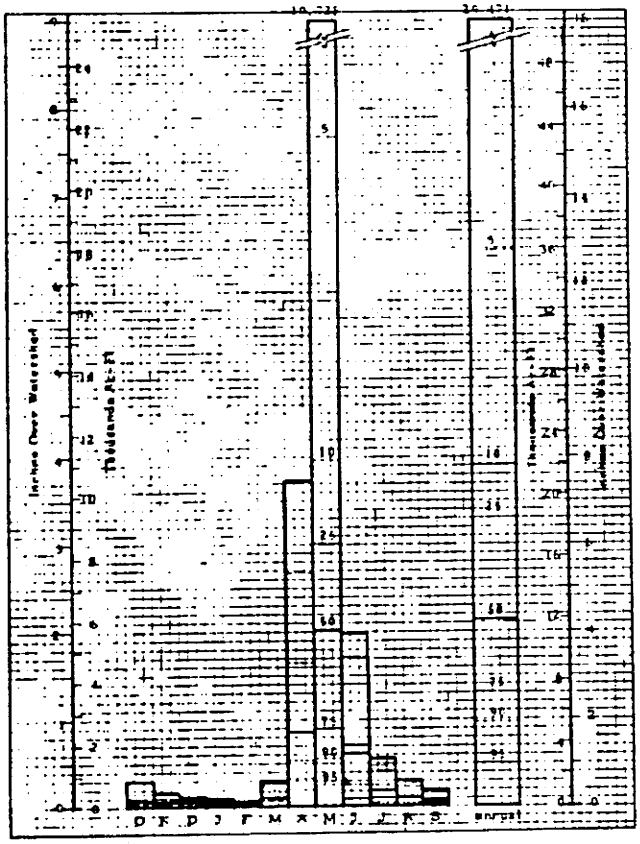
Figure 15. Monthly distribution of flows of Huntington Creek above Burnout Canyon for water years 1972 and 1973.



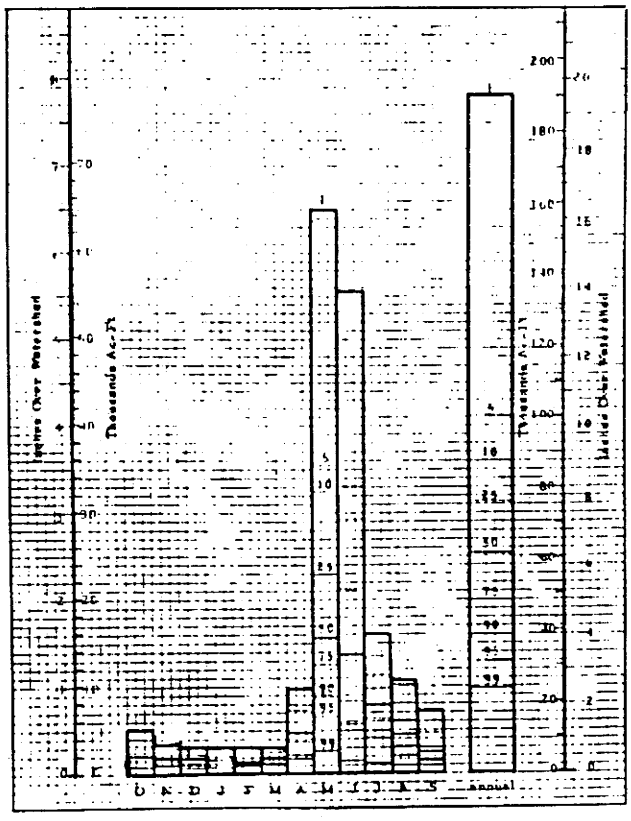
9-3100 Gooseberry Creek near Scofield, Utah



9-3105 Price River above Scofield Reservoir near Scofield, Utah



9-3125 White River near Soldier Summit, Utah



9-3180 Huntington Creek near Huntington, Utah

Figure 16. Frequency of occurrence of monthly and annual flows of streams in the Skyline Property area (from Jeppson et al., 1968).

where W is the width of the channel bar cross section, in feet, and q_{25} and q_{50} are the 25- and 50-year recurrence interval flood discharges, respectively. The respective standard errors associated with equations 5 and 6 are 28 and 33 percent.

Table 4 presents the resulting flood frequency information. Although the standard errors are relatively high for the prediction equations, the discharge estimate appear to be reasonable.

Surface Water Quality

Fourteen sites on and adjacent to the Skyline Property were chosen for the collection of baseline surface water quality data. (see Plate 3). Stations were located to obtain data from streams above and below potential surface disturbances and points of inflow to and outflow from the lease area. Published information was also searched for local data and water quality information was found for two stations on Pleasant Valley Creek near Scofield (SCR-2 and SCR-3) as tabulated by Mundorff (1972) and the Southeastern Utah Association of Governments (1977). All stations were established for the collection of grab samples.

Water quality samples collected by VHA were analyzed according to the list found in Table 5. Analytical methods utilized in the field and in the laboratory are summarized in Attachment A. Field analyses were completed immediately upon sample collection. Samples were preserved for later laboratory analysis according to methods outlined by the American Public Health Association et al. (1976). Attachment B contains the results of chemical analyses of surface water samples collected in the property area during the baseline period.

Table 4. Flood frequency discharge estimates of selected streams on and adjacent to the Skyline Property.

Stream	Channel Bar Width, in feet	25-Year Peak, in cfs	50-Year Peak, in cfs
Main Fork Eccles Creek above South Fork	2.0	11.0	11.7
South Fork Eccles Creek above Main Fork	2.5	15.6	16.6
Eccles Creek above Pleasant Valley Creek	3.5	26.4	28.2
Huntington Creek above Burnout Canyon	7.0	78.5	84.4

Seasonal variations in water quality, as indexed by major cations and anions, are depicted on Plate 3. As is to be expected, total dissolved solids concentrations in the area are lowest during the months of April through June when flows are highest and affected by the diluting effect of direct snowmelt. As flows decrease later in the year and the majority of the flow is derived from seepage out of local ground water systems, this dilution effect becomes less pronounced and concentrations tend to increase (see Figure 17).

According to Plate 3, surface water in the Skyline Property area is of a strong calcium-bicarbonate type, which agrees with the findings of Mundorff (1972). Magnesium concentrations tend to proportionately increase with lower flows, especially at the lower elevations (see the results of stations VC-6, VC-9, VC-10, SCR-2, and SCR-3). Total dissolved solids concentrations are relatively low throughout the general area, ranging from less than 100 milligrams per liter in the headwaters of Huntington Creek Basin during the high flow season (stations CS-8 and CS-10) to slightly greater than 500 milligrams per liter in Pleasant Valley Creek during low flow conditions (stations SCR-2 and SCR-3).

Table 5. Comprehensive water quality analytical schedule

Field Measurements	Laboratory Measurements	
Discharge	Acidity (as $CaCO_3$)	Lead, Total
Dissolved Oxygen	Alkalinity (as $CaCO_3$)	Lead, Dissolved
pH	Ammonia (NH_3 as N)	MPN Fecal Coliform
Specific Conductance	Arsenic, Total	MPN Total Coliform
Temperature, Air	Arsenic, Dissolved	Magnesium
Temperature, Water	BOD (5 Day)*	Manganese, Total
	Barium, Total	Mercury, Total
	Barium, Dissolved	Nitrate (NO_3 as N)
	Bicarbonate	Oil and Grease
	Boron, Total	Phenol
	Boron, Dissolved	Phosphate (PO_4 as P)
	Cadmium, Total	Potassium
	Cadmium, Dissolved	Selenium, Total
	Calcium	Selenium, Dissolved
	Chloride	Silver, Total
	Chromium, Total	Silver, Dissolved
	Chromium, Dissolved	Sodium
	Copper, Total	Sulfate
	Copper, Dissolved	Suspended Solids
	Cyanide	Total Dissolved Solids
	Fluoride	Total Organic Carbon
	Gross Alpha Radioactivity	Turbidity (NTU)
	Gross Beta Radioactivity	Zinc, Total
	Iron, Total	Zinc, Dissolved
	Iron, Dissolved	

*Above and below proposed surface disturbances

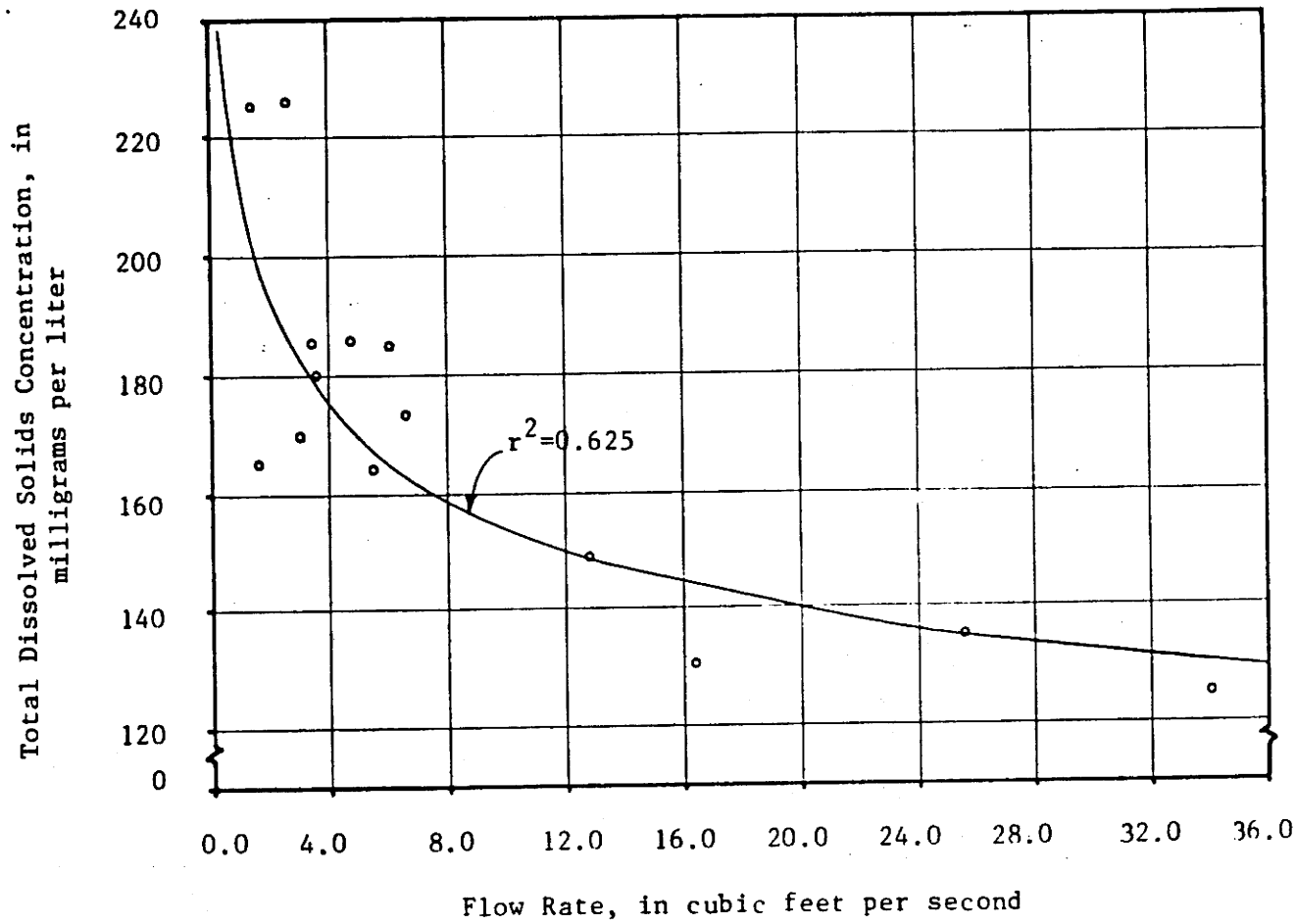


Figure 17. Variation in dissolved solids concentration with flow rate at station UPL-10.

Suspended solids concentrations in the area tend to vary proportionately with flow rate, although the relation is not as distinct as is the case with dissolved solids. As a result, concentrations are generally higher during the snowmelt runoff period than during that portion of the year when baseflow conditions exist. The data assembled to date also indicate that suspended solids concentrations during the snowmelt runoff period are naturally higher in Eccles Canyon than in the Huntingto Creek drainage basin. During this period it is not uncommon for suspended solids concentrations in Eccles Canyon to significantly and naturally exceed Federal coal mining effluent standards (45 milligrams per liter; see OSM regulation section 817.42). However, this difference tends to disappear as the low flow season

approaches. As an example, the average suspended solids concentration for the period of record during the months of April through June equalled 178 milligrams per liter at VC-9 (6 samples) and 7.7 milligrams per liter at UPL-10 (3 samples). During the months of October through December, concentrations dropped to 11.0 and 6.7 milligrams per liter at VC-9 (2 samples) and UPL-10 (3 samples), respectively. Channel erosion, although relatively low throughout the area, appears to be more extensive in Eccles Canyon than in the Huntington Creek Basin and is probably the source of most of this difference during the high flow season (see Renfro, 1975).

Hydrogen ion activity (pH) over the Skyline Property area tends to be rather constant, varying normally between 7.5 and 8.5. The slightly basic waters in the area result from the high bicarbonate concentrations (American Public Health Association et al., 1975). Although pH values tend to be slightly higher during the spring and summer months, probably due to the increased dissolved carbon dioxide uptake by aquatic organisms during daylight hours, the relatively constant and basic pH indicates that waters in the area are not significantly influenced by pollution (Hem, 1970). The basic condition of the water, together with the low acidity (maximum measured was 28 milligrams per liter as calcium carbonate) and the relatively high alkalinity, indicates that acid drainage problems should not develop as a result of mining in the property area.

Both total and dissolved iron concentrations vary widely over the area, with the source likely being the cementing agents in the Blackhawk Formation which were previously mentioned. Total iron, which has varied over the area from less than 0.01 to 5.84 milligrams per liter during the baseline period, tends to be somewhat directly related to flow rate (i.e. higher concentrations during the snowmelt runoff period). This is as expected, due to the probable association of iron with sediment,

which tends to increase with flow. Total iron concentrations also tend to be higher in Eccles Canyon than in Huntington Creek (See Figure 18), probably due somewhat to the increased sediment concentrations in Eccles Canyon relative to Huntington Creek as previously discussed.

Seasonal concentrations of dissolved iron at a given station appear to be much more variable than total iron. As a result, no specific patterns can be detected However, dissolved iron concentrations are normally one-fifth to one-tenth of the concurrent total iron concentration. The difference is greatest during the spring when total iron concentrations are greatest.

Total manganese concentrations in the area are low, varying normally between 0.02 and 0.06 milligrams per liter. The low manganese concentrations are likely associated with the low acidity (Hem, 1970). No distinct seasonal variations can be noticed.

The Utah Division of Health has classified all water in the Skyline Property area as 1C (protected for domestic use with prior treatment by standard complete treatment processes), 2B (protected for recreational uses, excluding swimming), 3A (protected for cold water aquatic life), and 4 (protected for agricultural uses). The numerical standards which apply to these classifications are given in Table 6. Because the chemical standards are generally for dissolved constituents, few exceedances have been noted during the baseline study. One sample collected at VC-9 May 11, 1979) showed exceedances of dissolved copper (0.017 milligrams per liter, exceeding the limit by 0.007 milligrams per liter) and dissolved zinc (0.061 milligrams per liter, exceeding the limit by 0.011 milligrams per liter). Single exceedances of the state standards were also detected for cyanide (station CS-1 on May 11, 1979) and nitrate (station CS-9 on August 23, 1979).

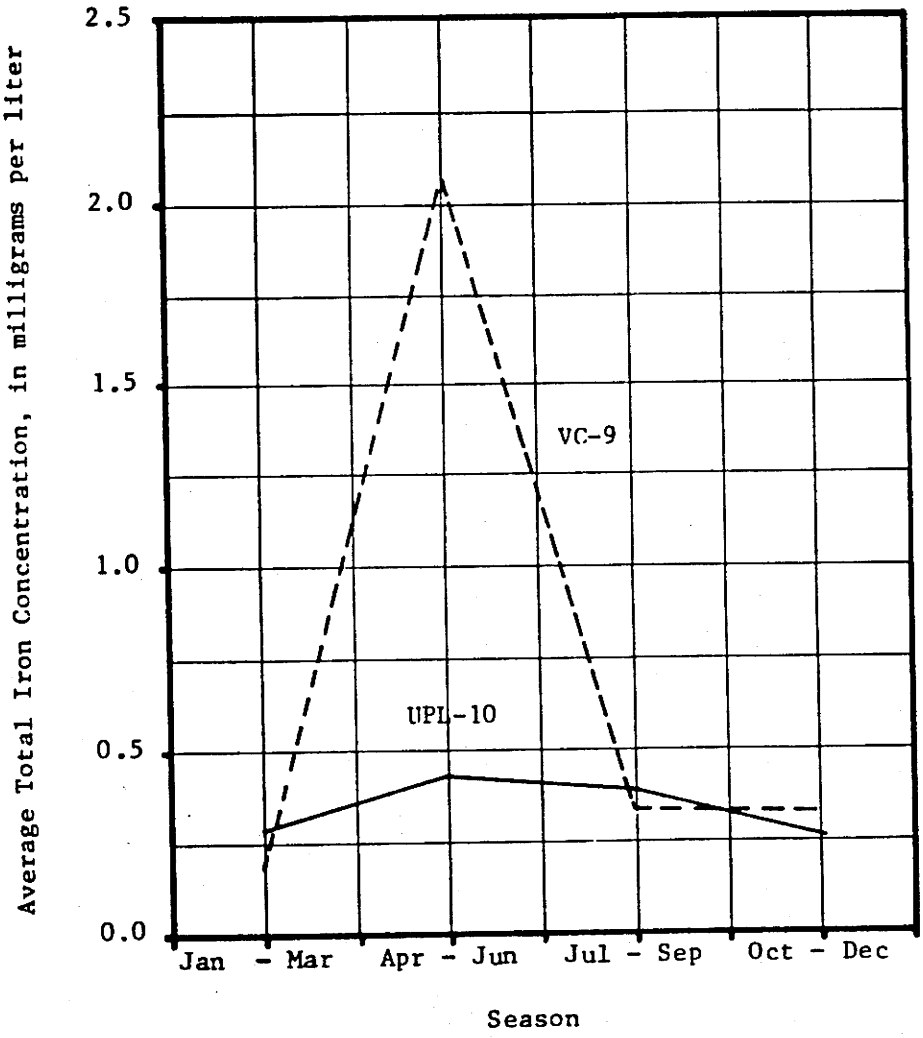


Figure 18. Seasonal variation of average total iron concentrations in Eccles Canyon and Huntington Creek during the period of record.

Table 6. Utah Division of Health numerical standards for water in the state.

Constituent	CLASSES										
	Domestic Source			Recreation & Aesthetics		Aquatic Wildlife				Agri-culture	Indus-try	Special
	1A	1B	1C	2A	2B	3A	3B	3C	3D	4	5	6
Bacteriological (No./100 ml)												
(30-day Geometric Mean)												
Maximum Total Coliforms	1	50	5,000	1,000	5,000	*	*		*	*		
Maximum Fecal Coliforms	*	*	2,000	200	2,000	*	*		*	*		
Physical												
Total Dissolved Gasses	*	*	*	*	*	(b)	(b)		*	*		
Minimum DO (mg/l) (a)	*	*	5.5	5.5	5.5	6.0	5.5		5.5	*		
Maximum Temperature	*	*	*	*	*	20°C	27°C		*	*		
Maximum Temp. Change	*	*	*	*	*	2°C	4°C		*	*		
pH	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0		6.5-9.0	5.5-9.0		
Turbidity increase (c)	*	*	*	10 NTU	10 NTU	10 NTU	10 NTU		15 NTU	*		
Chemical (Maximum mg/l)												
Arsenic, dissolved	.05	.05	.05	*	*	*	*		*	.1		
Barium, dissolved	1	1	1	*	*	*	*		*	*		
Cadmium, dissolved	.010	.010	.010	*	*	.0004(d)	.004(d)		*	.01		
Chromium, dissolved	.05	.05	.05	*	*	.10	.10		.10	.10		
Copper, dissolved	*	*	*	*	*	.01	.01		*	.2		
Cyanide	*	*	*	*	*	.005	.005		*	*		
Iron, dissolved	*	*	*	*	*	1.0	1.0		1.0	*		
Lead, dissolved	.05	.05	.05	*	*	.05	.05		*	.1		
Mercury, total	.002	.002	.002	*	*	.00005	.00005		.00005	*		
Phenol	*	*	*	*	*	.01	.01		*	*		
Selenium, dissolved	.01	.01	.01	*	*	.05	.05		*	.05		
Silver, dissolved	.05	.05	.05	*	*	.01	.01		*	*		
Zinc, dissolved	*	*	*	*	*	.05	.05		*	*		
NH_3 as N (un-ionized)	*	*	*	*	*	.02	.02		*	*		
Chlorine	*	*	*	*	*	.002	.01		*	*		
Fluoride, dissolved (e)	1.4-2.4	1.4-2.4	1.4-2.4	*	*	*	*		*	*		
NO_3 as N	10	10	10									
Boron, dissolved	*	*	*	*	*	*	*		*	.75		
H_2S	*	*	*	*	*	.002	.002		*	*		
TDS (f)	*	*	*	*	*	*	*		*	1200		
Radiological (Maximum pCi/l)												
Gross Alpha	15	15	15	*	*	15(g)	15(g)		15(g)	15(g)		
Radium 226, 228 combined	5	5	5	*	*	*	*		*	*		
Strontium 90	8	8	8	*	*	*	*		*	*		
Tritium	20,000	20,000	20,000	*	*	*	*		*	*		
Pesticides (Maximum ug/l)												
Endrin	.2	.2	.2	*	*	.004	.004		.004	*		
Lindane	4	4	4	*	*	.01	.01		.01	*		
Methoxychlor	100	100	100	*	*	.03	.03		.03	*		
Toxaphene	5	5	5	*	*	.005	.005		.005	*		
2, 4-D	100	100	100	*	*	*	*		*	*		
2, 4, 5-TP	10	10	10	*	*	*	*		*	*		
Pollution Indicators (g)												
Gross Beta (pCi/l)	50	50	50	*	*	50	50		50	50		
BOD (mg/l)	*	*	5	5	5	5	5		5	5		
NO_3 as N (mg/l)				4	4	4	4		*	*		
PO_4 as P (mg/l)(h)	*	*	*	.05	.05	.05	.05		*	*		

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS (SEE APPENDIX A)

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS

STANDARDS WILL BE DETERMINED ON A CASE-BY-CASE BASIS

* Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.

(a) These limits are not applicable to lower water levels in deep impoundments.

(b) Not to exceed 110% of saturation.

(c) For Classes 2A, 2B, 3A, and 3B at background levels of 100 NTUs or greater, a 10% increase limit will be used instead of the numeric values listed. For Class 3D at background levels of 150 NTUs or greater, a 10% increase limit will be used instead of the numeric value listed. Short term variances may be considered on a case-by-case basis.

(d) Limits should be decreased threefold at CaCO hardness

(e) Maximum concentration varies according to the daily maximum mean air temperature.

Temp. °C	mg/l
12.0 and below	2.4
12.1 to 14.6	2.2
14.7 to 17.6	2.0
17.7 to 21.4	1.8
21.5 to 26.2	1.6
26.3 to 32.5	1.4

(f) Total dissolved solids (TDS) limit may be adjusted on a case-by-case basis.

(g) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

Exceptions to the statement regarding few standard exceedances deal with phenol, unionized ammonia, and total phosphate. Approximately 19 percent of the phenol analyses listed in Attachment B exceeded the state standard of 0.01 milligrams per liter. Most stations had at least one sample with an exceedance. A maximum concentration in the area of 0.194 milligrams per liter was noted at UPL-3 on July 19, 1979. The reason for the relative abundance of phenolic compounds in the Skyline Property area is not precisely known since it is normally considered an indicator of waste products. However, the U.S. Environmental Protection Agnecy (1975) indicates that phenolic compounds also arise from naturally occurring, organic sources. The breakdown of organic residue in the area (both plant and animal) may be the source of which of the background phenol occurrences.

Most of the samples whose background ammonia concentrations exceeded the state standard for class 3A waters (0.02 milligrams per liter) were collected at stations VC-6 and VC-9. Although ammonia concentrations at most stations during the period of record were less than 0.001 milligrams per liter, it has not been uncommon to find concentrations of 0.1 to 0.2 milligrams per liter in Eccles Canyon. The presence of ammonia in the local streams is probably the result of biological degredation of nitrogenous organic matter.

Nearly 50 percent of the total phosphate baseline samples exceeded the state standard of 0.05 milligrams per liter. Although the standard was exceeded at least once at nearly all stations, most of the high phosphate concentrations were recorded at stations UPL-3, VC-6, and VC-9. Phosphate concentrations in the area have ranged from less than 0.002 to 2.00 milligrams per liter, averaging normally about 0.07 milligrams. Variations are again large, with no detectable pattern. A portion of the phosphates may result from the degredation of animal wastes resulting from grazing in the area (Hem, 1970). Most of the phosphates entering the streams,

however, are probably carried in on sediment and have as their source the phosphous content of the soils (McElroy et al., 1976). This phosphate-sediment interaction explains the generally higher phosphate concentrations in Eccles Creek relative to Huntington Creek above Electric Lake (see the previous discussion on sediment concentrations).

The concentrations of other constituents sampled at stations throughtout the area are generally well below the state standard. In many instances, trace metal concentrations are consistently below the level of detection of routine laboratory techniques (particularly arsenic, cadmium, mercury, selenium, and silver).

Sediment Yield

Estimates of the average annual sediment yield to be expected from the Skyline Property area were made using the PSIAC method (Pacific Southwest Inter-Agency Committee, 1968) and the Universal Soil Loss Equation (U.S. Soil Conservation Service, 1977; Clyde et al., 1978. Tables 7 and 8 contain the parameter estimates and sediment yield computation results of the respective methods. Using a sediment delivery ratio of 25 percent (based on Renfro, 1975), the average annual sediment yield predicted by the Universal Soil Loss Equation is 1.41 tons per acre. This converts to 0.52 acre-feet per square mile if a sediment unit weight of 80 pounds per cubic foot is assumed (see Flaxman, 1975). This compares favorably with the estimate made by the PSIAC method, considering the accuracy of the methods, although it is felt to be somewhat high. The sediment delivery ratio estimate probably accounts for a majority of the difference.

Because of the cost involved, a measured estimate of sediment yield was not made. However, based on guidelines given by Strand (1975) for gravel-bottom streams, it is estimated that approximately 10 percent of the sediment yielded from the

Table 7. Average annual sediment yield estimate of the Skyline Property using the PSIAC method.

Factor	Description	Rating
Surface Geology	Interbedded shales and sandstones, moderately fractured	8
Soils	Medium textured with high percentage of coarse fragments	0
Climate	Precipitation primarily as snow, humid	0
Runoff	Large volume, high peak per unit area	10
Topography	Steep, high relief, little flood plain development	20
Ground Cover	Area completely protected	-10
Land Use	Ordinary road construction, intensive grazing over some areas, recent logging	0
Upland Erosion	About 25 percent of area characterized by landslide erosion	10
Channel Erosion	Occassionally eroding banks, moderate flow depth	10
	Total	48

Sediment yield (from Figure 19) = 0.44 $AF/mi^2/yr$

Table 8. Average annual sediment yield estimate of the Skyline Property using the Universal Soil Loss Equation.

Equation: A = RKLSCP

Variable	Meaning	Assigned Value
R	Rainfall factor	26
K	Soil erodability factor	0.24
L S	Slope length factor (800 ft) Slope gradient factor (31%)	30
C	Cropping management factor	0.03
P	Erosion control practice factor	1.0
A	Estimated soil loss (tons/acre/year)	5.62

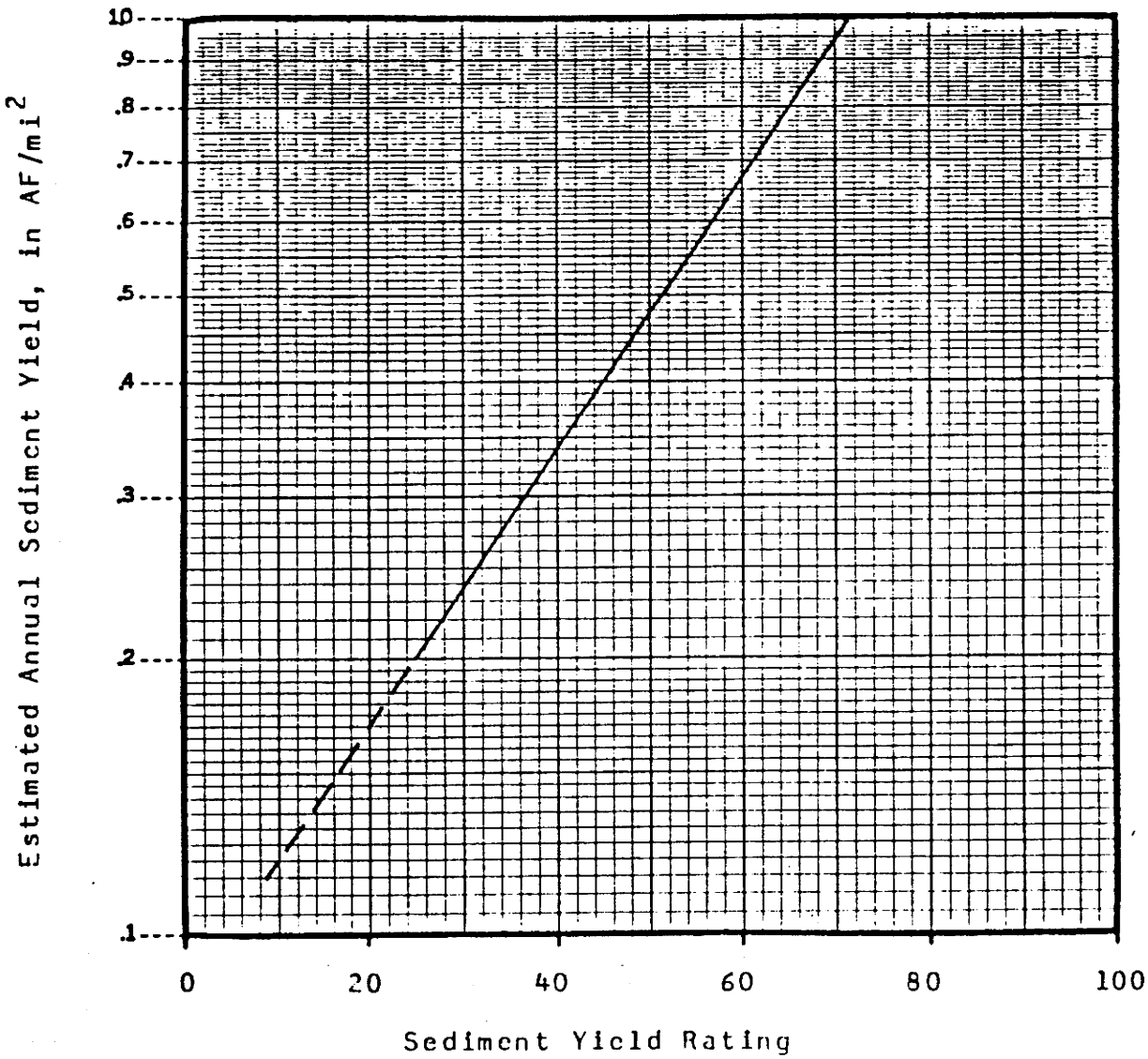


Figure 19. Sediment yield as determined by the PSIAC method (adapted from Shown, 1970).

property area occurs as bedload. The remaining 90 percent occurs presumeably as suspended sediment load.

Assuming that the PSIAC estimate is correct, the Skyline Property yields an average of 1.25 acre-feet of sediment to the Price River Basin and 3.07 acre-feet of sediment to the San Rafael River Basin. Although no published sediment yield data are available for the upland areas of the two basins, this is undoubtedly only a small portion of the total amount of sediment yielded from the mountainous areas of the Price and San Rafael River Basins.

Monitoring Program

An ongoing hydrologic monitoring program will be conducted at each of the stations shown on Plate 4. In order to concentrate on areas of immediate impact, however, it is proposed that the surface water stations in Eccles Canyon be sampled more frequently than those on Huntington Creek during the initial phases of construction and mining. Data will be collected at all of the previously established stations in the two basins with the exception of CS-1. This station was originally established because of a potential mine yard which was considered upstream from the site and later abandoned. Station VC-10 will allow adequate monitoring of activities in the South Fork of Eccles Canyon without CS-1. In addition, station CS-6 will be established immediately upstream from the proposed loadout facility as an aid in monitoring its impact. This station will be located at or near the site of a proposed U.S. Geological Survey stream gaging station on Eccles Creek, thereby increasing the amount of data available at the site.

Samples will be collected from all stations shown on Plate 4 annually and analyzed as outlined in the comprehensive schedule given in Table 5. These samples will be collected during the month of August each year to allow sufficient time prior to

snowfall to collect additional data if the laboratory results show unique, unexpected conditions. Samples will be analyzed according to Attachment A and preserved as previously outlined. Those stations where samples will be collected for BOD analyses will include CS-2, CS-3, CS-6, CS-9, CS-11, and VC-9.

In addition to the annual comprehensive samples, stations in Eccles Canyon will be sampled monthly (when accessible) during construction and the first two years of operation. These samples will be analyzed for the parameters listed in the abbreviated schedule given in Table 9. If future data indicate a need, parameters may be added to or deleted from this table with time. Following the first two years of mine operation, the frequency of sampling will be decreased to a seasonal basis (spring runoff, early fall, mid-winter) unless data prior to this time indicate that an unstable condition exists.

The derivation of Table 9 was based on the need to clarify background conditions and future impacts. Because of the inherently high chemical quality of waters in the Skyline Property area, as determined by the baseline study, suspended solids has been included in the abbreviated schedule as the single most important impact indicator. Ammonia, phenol, and phosphate are included because of the high background concentrations found previously. Total dissolved solids, specific conductance, temperature, and the major cations and anions are included as indexes of major change. Total iron, total manganese, and pH determinations are required by OSM regulations.

As mining progresses towards Huntington Creek, seasonal samples will be collected also from the five Huntington Creek stations when access permits and analyzed as outlined in Table 9, beginning one year prior to any potential underground impact. As will be the case in Eccles Canyon, comprehensive analyses (Table 5) will be run once a year (in August) even after seasonal sampling begins.

Table 9. Abbreviated water quality analytical schedule.

Field Measurements	Laboratory Measurements	
Discharge	Ammonia (NH_3 as N)	Phenol
pH	Bicarbonate	Phosphate (PO_4 as P)
Specific conductance	Calcium	Potassium
Temperature, air	Chloride	Sodium
Temperature, water	Iron, Total	Sulfate
	Magnesium	Suspended Solids
	Manganese, Total	Total Dissolved Solids

Surface water monitoring will continue on a seasonal basis (spring runoff, fall, and mid-winter) as outlined in the abbreviated water quality schedule (Table 9) during the post-mining operations. Post-mining data collection will continue at each of the stations until the reclamation effort is deemed successful by the regulatory authority. The August sample will continue to be analyzed according to Table 5 (or an approved abbreviated schedule) through the post-mining period.

In addition to the above outlined monitoring program, an NPDES discharge permit will be acquired as necessary. Monitoring of all discharges will be conducted in accordance with this permit.

As required, water quality data collected from surface water monitoring stations will be submitted to the regulatory authority (Utah Division of Oil, Gas, and Mining). Such reports will normally be submitted within 60 to 90 days of the end of each quarter, depending upon the speed of the laboratory analyses.

GROUND WATER HYDROLOGY

Regional Ground Water Hydrologic System

The principle factor controlling the occurrence and availability of ground water in any area is geology. As noted by Price and Waddell (1973), nearly all of the region surrounding the Skyline Property is underlain by rocks of continental and marine origin, consisting predominately of interbedded sandstones and shales. Although some of the sandstones in the region serve as the principle water bearing strata, their ability to yield water for extended periods of time is largely controlled by the existence of the relatively impermeable interbeded shale layers, which prevent the downward movement of a significant amount of water.

According to the U.S. Geological Survey (1979), ground water in the region exists under water table, artesian, and perched conditions. Water table conditions exist primarily in shallow alluvial deposits along larger perennial streams and in relatively flat lying sedimentary rocks. Artesian conditions exist at greater depths where a confining layer overlies a more permeable member. However, pressures are generally not sufficient to produce flowing wells. Perched or impeded conditions exist where the confining layer lies beneath the water bearing strata.

Because of the high annual precipitation, the Book Cliffs and the adjacent Wasatch Plateau, where the Skyline Property is located, act as recharge areas for regional ground water systems (Price and Arnow, 1974). However,

only a small portion of the annual precipitation, probably much less than five percent, recharges the ground water supply (Price and Arnow, 1974; U.S. Geological Survey, 1979). Although the depth of water infiltrating through the surface to saturated beds is small (due to the presence of the relatively impermeable shale layers near the surface over much of the area), the total recharge volume is rather significant because of the areal extent of the zone of recharge.

Price and Arnow (1974) indicate that properly constructed wells in the Price and San Rafael River Basins would have only limited yields (normally less than 50 gallons per minute). Wells immediately adjacent to the Skyline Property could normally be expected to yield less than 10 gallons per minute. Increased yields could be expected from wells penetrating highly fractured sandstones.

Rocks in the mountainous areas near the Skyline Property generally have low specific yields (0.2 to 0.7 percent) and low hydraulic conductivities (Price and Waddell, 1973). The volume of recoverable water in the area is small, averaging less than 600 acre-feet per square mile in the upper 100 feet of saturated rock (Price and Arnow, 1974).

The quality of ground water in the Price and San Rafael River Basins deteriorates with distance downstream much the same as surface water. Dissolved solids contents in ground water range from less than 250 milligrams per liter near the Skyline Property to 3000 milligrams per liter near the confluence of the rivers with the Green River (Price and Waddell, 1973). This increase in dissolved solids concentration is the result of increased contact of water and rock as travel distance increases, with saline shales contributing the major portion of the dissolved constituents.

Characteristics of Seeps and Springs

As an index of ground water hydrologic conditions in the Skyline Property area, an inventory was made of existing seeps and springs on and adjacent to the lease area during the months of September and October, 1978 and again during September, 1979 (i.e. the low flow season). During this time, the lease area was covered on foot and all seeps and springs found were noted on a map. In addition, an estimate was made of the discharge, a water quality sample was collected, and determinations were made of water temperature and specific conductance. Based on these data, selected samples were chosen which were representative of flow, quality, and geographic variations over the property and sent to the laboratory to be anlayzed for calcium, magnesium, potassium, sodium, bicarbonate, chloride, sulfate, and total dissolved solids. The results of the analyses can be found in Attachment C.

The results of the field investigation and the chemical analyses are summarized on Plate 5. Also shown on this plate are geologic formations, faults, etc. which may have an influence on the behavior of seeps and springs. Note that a value for total dissolved solids concentration is reported for each spring rather than specific conductance. This tranformation was made after establishing a local relation between the two paratmeters for the samples where chemical analyses were completed (see Figure 20). A conversion factor of 0.54 was used. This low factor is probably the result of low sulfate concentrations in the area (Hem, 1970).

Because of the large number of springs in the area, some were possibly missed during the inventory. However, it is felt that the majority of the springs were sampled and representative conditions were covered.

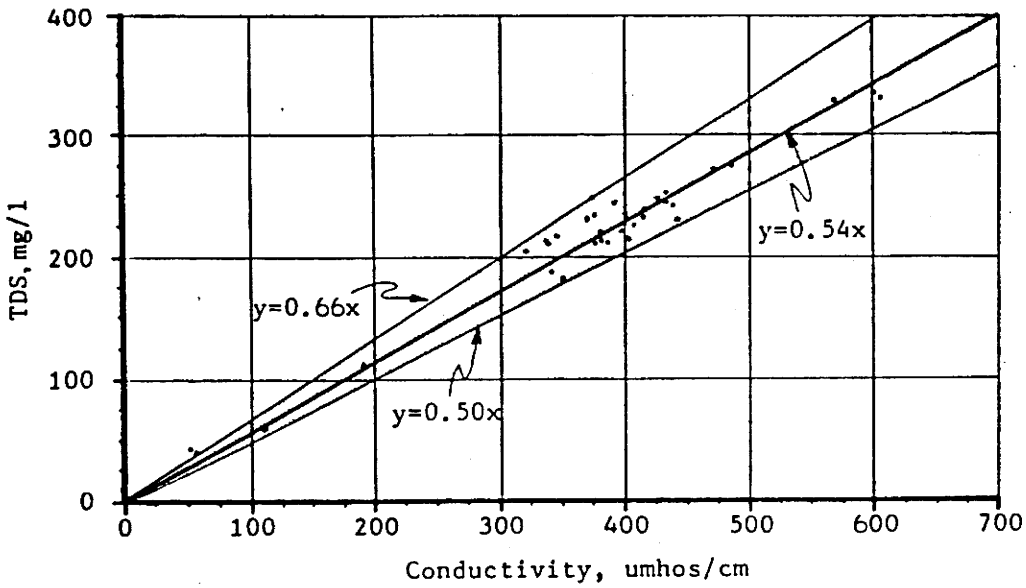


Figure 20. Relation between specific conductance and total dissolved solids concentration for springs in the Skyline Property area.

As shown on Plate 5, 174 seeps and springs were noted on and immediately adjacent to the Skyline Property. Thus, an average of one water source exists for approximately every 40 acres in the area, not including the perennial streams. As a result, the travel distance between water supplies is short for the wildlife and sheep which utilize the area. Therefore, should a frequently used spring dry up as a result of mining impacts, etc., those using the water supply would not be greatly affected.

Several observations should be made regarding the occurrence of seeps and springs in the Skyline Property area. First, a majority of the seeps and springs issue from west facing slopes. This probably results from the westerly dip of the strata previously discussed.

A second observation of significance made in the field is that many springs issue near the base of a sandstone lense (where contact is made with a shale member) often a considerable distance (from a few feet to tens of feet) above the adjacent streambed (normally considered the drain in a perennial watershed). This indicates that the shale layers in the Blackhawk Fromation act as impeding members, carrying at least a portion of the water which percolates through the soil mantle back to the surface where it is eventually discharged into an adjacent stream. Thus, because of the presence of a large amount of shale in the property area, deep ground water recharge is likely slow.

A third observation deals with the origin of the water issuing from the seeps and springs. Plate 5 indicates that a number of springs are located at relatively high elevations. This, together with the fact that the sandstone lenses in the Blackhawk Formation are very discontinuous (see the previous discussion on geology), implies that much, if not all, of the water found in a given spring originates in the small surface depression or basin immediately adjacent to the spring. Thus, springs are supplied by a bedrock member which is extremely local in extent, as opposed to a larger, more regional system. The same condition presumably applies to springs at lower elevations.

A fourth observation to be made concerning location is that very few seeps and springs appear to be fault-related. This phenomenon has also been noted elsewhere along the Wasatch Plateau. As noted by the U.S. Geological Survey (1979), the shale layers of the Blackhawk Formation are bentonitic, tending to swell when wet and decompose into an imprevious clay. Apparently, fractures in the Blackhawk Formation seal readily because of the ability of the shaley layers to swell and decompose, providing a seal to water movement.

As a final observation, travertine deposits are often associated with springs in the area. Although this may suggest a deeper seated water source than a localized sandstone, Hem (1970) indicates that this may also result from the high calcium bicarbonate content of the water. This explanation is felt to be reasonable, thereby not rejecting the hypothesis that faults in the Blackhawk Formation are not ready conveyors of water.

Flows from individual springs were quite small during the inventory. Only four springs were flowing at rates greater than or equal to 10 gallons per minute (15-2 at 10 gallons per minute, 22-11 at 30 gallons per minute, 34-12 at 12 gallons per minute, and 2-2 at 12 gallons per minute). Most of the springs were flowing two gallons per minute or less. Approximately 30 percent of the sources indicated in Plate 5 were seeps (wet on the surface with no measurable flow), some of which had dried up during the summer. Subsequent samplings during the summer of 1979 have indicated that flows at a given spring may vary by as much as an order of magnitude during the year, with the higher flows coming near the snowmelt season. This further substantiates the theory that water supplying the springs is generally very local in origin. Water originating from a deeper, more regionalized source would likely have a more constant flow. It also indiates that flows are quite sensitive to the amount of precipitation received during the previous winter. (For example, following the dry winter of 1977, local residents indicated that most of the springs in the area had gone dry by mid-summer).

Almost without exception, the chemical analyses shown on Plate 5 indicate that ground water in the lease area, as indexed by springs, is of a strong calcium

bicarbonate type. The data show that three distinctive qualities of spring water can be found in the property area. Springs issuing near the outcrop of the Castlegate Sandstone (northwest corner of the property) have very low dissolved solids contents, ranging from 17 to 64 milligrams per liter during the inventory. These low dissolved solids concentrations apparently result from the lack of shaley layers in the Castlegate Sandstone. Because shales and siltstones tend to contain soluble minerals in abundance and afford more surface contact to water flowing through them than would be expected in coarse-textured rocks (Bently et al., 1978), the lack of shales in the Castlegate should result in a higher quality water than elsewhere on the property where shales are encountered by percolating groundwater.

The few springs issuing in the headwaters of the Main Fork of Eccles Creek had the highest dissolved solids concentrations found in the lease area during the inventory (normally greater than 300 milligrams per liter). These higher concentrations likely result from local conditions which cause prolonged contact of the water with shaley layers prior to discharge.

Springs over the remainder of the property area had dissolved solids contents which varied quite consistently between about 180 to 260 milligrams per liter, averaging approximately 220 milligrams per liter. These springs are apparently all affected by about the same geologic conditions, resulting in the same approximate contact time and salt pickup.

Nine of the springs shown in Plate 5 were chosen for continued monitoring of water quality and quantity. The selection of representative springs was

based on variations in flow, quality, and geographic location as noted in Table 10 and discussed previously. Priority was given to developed and/or high flowing springs, since potential impacts would likely be greatest on these sources. A discussion of the data collected during subsequent samplings will be presented in the section covering ground water quality.

Stream Seepage

Iorns et al. (1965) developed a method of estimating the amount of ground water contributed to streams using flow duration curves. They indicate that the method applies primarily to headwater streams whose flows come largely from snowmelt and are affected little by the activities of man. Thus, the methodology applies to Skyline Property streams.

Table 10. Springs selected for continued monitoring

Station Number	Reason for Continued Sampling
S10-1	Low TDS content
S13-2	High flow, high TDS content
S14-4	Developed
S15-3	High flow, developed, headwaters of Huntington Creek
S22-11	High flow, middle of property along Huntington Creek
S23-4	Headwaters of Eccles Canyon
S26-13	High elevation, developed
S34-12	High flow, lower Huntington Creek
S36-2	High flow, headwaters area

Note: The letter S in the station number indicates that the source is a spring.

According to this methodology, the average time that flow in a snowmelt-type stream is affected by ground water discharge can be approximated by drawing a line tangent to the steep part of the flow duration curve of the stream and noting the departure point from the lower portion of the curve. The flow represented by the part of the curve below this departure point consists primarily of water discharged from ground water storage. Arithmetic integration between the departure point and the 100 percent duration point is used to determine the ground water discharge rate during baseflow conditions.

The average rate of ground water discharge during the time that streams are controlled by direct runoff (i.e. during the snowmelt season) can be approximated by the flow duration curve discharge that is equalled or exceeded 70 percent of the time. By adding this value to that obtained by integrating the flow duration curve below the departure point, the average annual rate of ground water discharge contributed to the stream is obtained.

Estimates of long-term average annual ground water discharge of Huntington Creek above Burnout Canyon and Eccles Creek above Pleasant Valley Creek were made using the above outlined methodology and the flow duration curves developed previously (see Figures 10 and 14). The ground water discharge of Huntington Creek above Burnout Canyon is described by Figure 21 and Table 11. Eccles Creek is described by Figure 22 and Table 12.

The average annual ground water yield to Huntington Creek above Burnout Canyon (2.43 cubic feet per second) represents approximately 19 percent of the total annual flow (12.84 cubic feet per second, see Table 2), or 3.03 inches over the 6944 acre watershed. By contrast, nearly 64 percent of the average annual

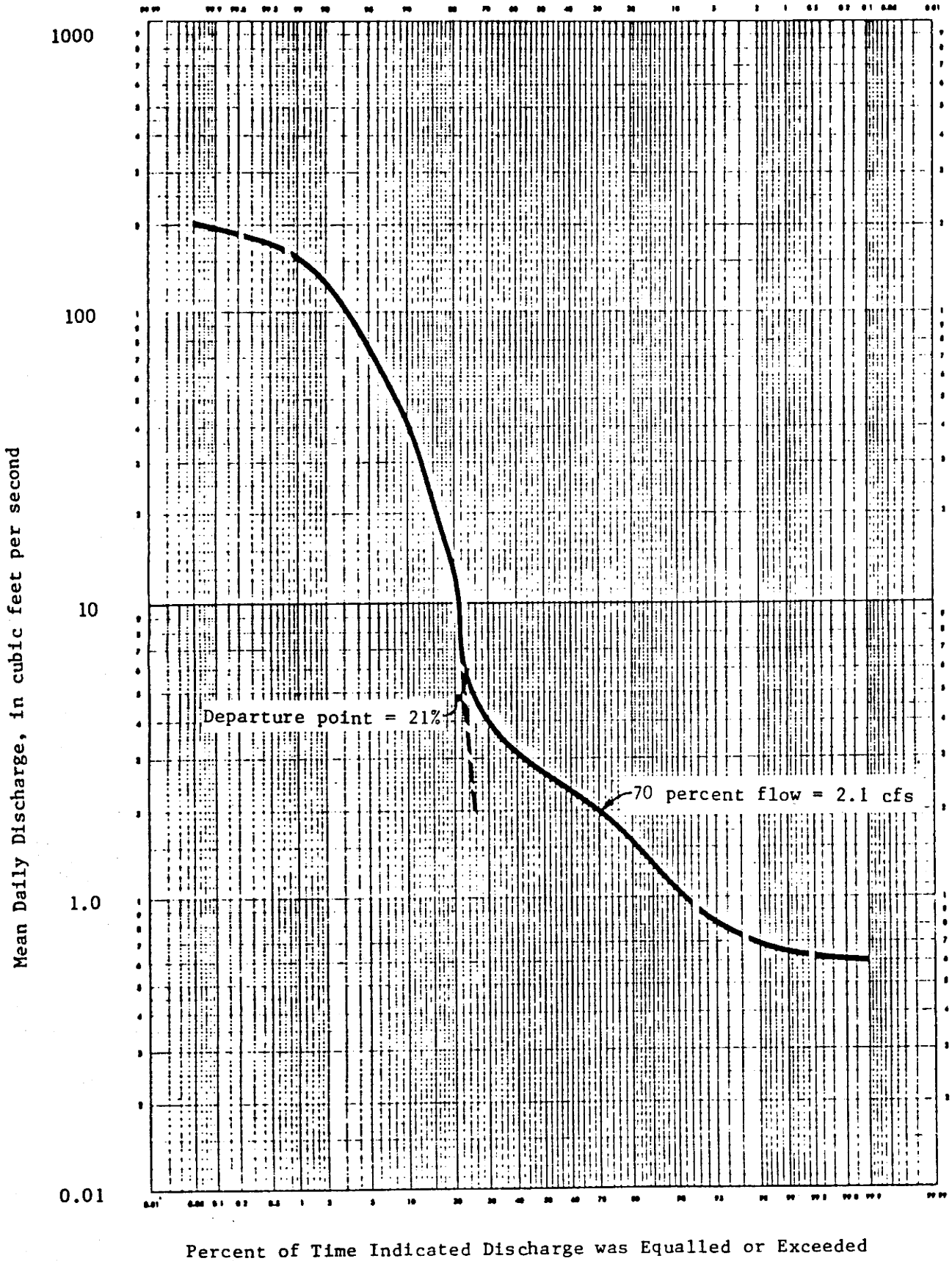


Figure 21. Long-term duration curve of mean daily flows of Huntington Creek above Burnout Canyon showing departure point and 70 percent discharge.

Table 11. Computation of long-term average annual ground water discharge of Huntington Creek above Burnout Canyon.

Duration Curve Percentage			Discharge (cfs)	
Limits	Interval	Mean of Limits	Q for Mean of Limits	Increment in Interval
0-21.0	21.0	-	2.1	0.44
21.0-25.0	4.0	23.0	6.0	0.24
25-35	10	30	4.1	0.41
35-45	10	40	3.2	0.32
45-55	10	50	2.7	0.27
55-65	10	60	2.4	0.24
65-75	10	70	2.1	0.21
75-85	10	80	1.6	0.16
85-95	10	90	1.05	0.11
95-99	4	97	0.76	0.03
99.0-99.6	0.6	99.3	0.65	< 0.01
99.6-99.8	0.2	99.7	0.62	< 0.01
99.8-100.0	0.2	99.9	0.61	< 0.01
Total	100.0	-	-	2.43

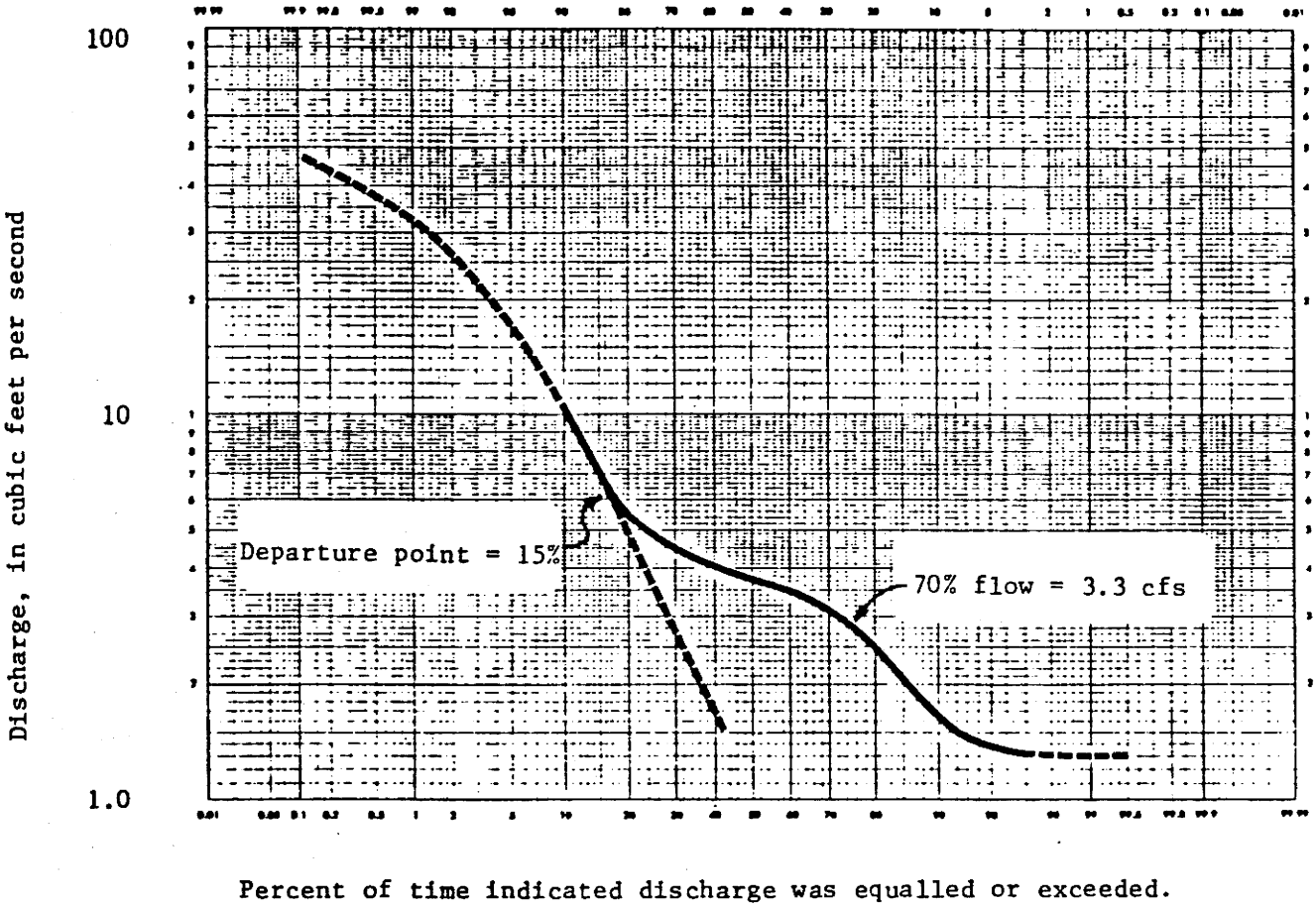


Figure 22. Long-term duration curve of mean daily flows of Eccles Creek above Pleasant Valley Creek showing departure point and 70 percent discharge.

Table 12. Computation of long-term average annual ground water discharge of Eccles Creek above Pleasant Valley Creek.

Duration Curve Percentage			Discharge (cfs)	
Limits	Interval	Mean of Interval	Q for Mean of Limits	Increment in Interval
0-15	15	-	3.3	0.50
15-25	10	20	5.6	0.56
25-35	10	30	4.6	0.46
35-45	10	40	4.1	0.41
45-55	10	50	3.8	0.38
55-65	10	60	3.6	0.36
65-75	10	70	3.3	0.33
75-85	10	80	2.5	0.25
85-95	10	90	1.6	0.16
95-99	4.0	97	1.3	0.05
99-99.6	0.6	99.3	1.3	0.01
99.6-100.0	0.4	99.8	1.3	0.01
Total	100	-	-	3.47

flow of Eccles Creek above Pleasant Valley Creek (3.47 cubic feet per second or 8.59 inches) is contributed by ground water discharge. Although the methodologies utilized in arriving at these values may have resulted in some error, it appears that the yield of ground water per unit area to streams in the Eccles Creek drainage basin is greater than in the Huntington Creek drainage basin. As noted previously, the reverse is true for total water yielded within the two basins. The principle cause of the high ground water yield in Eccles Canyon relative to Huntington Creek is likely the Star Point Sandstone, which is present on the surface over approximately 25 percent of Eccles Canyon but does not appear on the surface in the Huntington Creek Basin. Field observations indicate that this sandstone is nearly full to the upper reaches of the outcrop in Eccles Canyon and yielding water to the creek throughout the canyon (i.e. many seeps and springs can be found along the stream to this point). The Blackhawk Formation which appears on the surface over most of the Huntington Creek Basin, on the other hand, yields water essentially only from thin, discontinuous sandstone lenses which are often sandwiched in between shale layers. Thus, ground water discharges into Huntington Creek are more localized and, therefore, lower.

In order to better define ground water recharge-discharge conditions on major streams in the area, seepage studies were conducted on the Main Fork of Eccles Creek, the South Fork of Eccles Creek, and Huntington Creek. The Main Fork of Eccles Creek was chosen to assess changes as the water flows across the Star Point Sandstone and major faults. Studies on the South Fork of Eccles Creek were undertaken to assess changes along the Connelville Fault zone, which

the stream generally follows, thereby allowing an estimate to be made of the water conditions which might be encountered in the mine near the fault. Although Huntington Creek itself may not be undermined, Huntington Creek studies were made as a measure of recharge-discharge conditions which might be encountered in the proposed mines near this valley fill area.

In conducting the seepage studies, at selected points along the stream segments and at points of major tributary inflow, flow rates were determined using either a small, portable Parshall flume (2-inch or 6-inch throat width) or a Marsh-McBirney current meter. Head measurements in the flumes were converted to discharges using tables provided by the U.S. Bureau of Reclamation (1974). Small inflow rates were measured volumetrically or using floats (Buchanan and Somers, 1969) or visually estimated.

In addition to the flow measurements, water quality samples were collected at each seepage study station. These samples were analyzed for the parameters listed in Table 13. All constituents were analyzed in terms of total concentrations. Attachment D contains the results of the analyses.

Plate 6 summarizes the concentrations of major chemical constituents found at each of the seepage study stations utilizing cation-anion diagrams. Although there is a gradual deterioration in water qualtiy in each of the three streams with distance downstream, no major changes were noticeable from the figure. The increased travel time alone may be sufficient to cause the gradual increases in dissolved solids which have been noted.

Table 13. Water quality analytical schedule used for seepage studies

Acidity	Iron
Alkalinity	Lead
Arsenic	Magnesium
Barium	Manganese
Bicarbonate	Mercury
Boron	Potassium
Cadmium	Selenium
Calcium	Silver
Chloride	Sodium
Chromium	Sulfate
Conductivity	Suspended Solids
Copper	Total Dissolved Solids
Fluoride	Zinc

The concentrations of significant parameters were converted to loads to better assess changes in the streams. By subtracting out the loads contributed by measured tributaries, only unmeasured gains or losses in the subject stream are left, thus giving an index of the effect of geologic conditions on a given stream segment.

Figure 23 summarizes the changes in flow and constituent loads measured in the Main Fork of Eccles Creek. The data presented in the figure have been corrected for major tributary inflow (i.e. sources where water quality samples were collected). That is, the figure shows the conditions which would have existed if all inflow at the measured tributaries had been stopped during the seepage study.

Changes above station SS24-1, as the stream flows across the Blackhawk Formation, appear to be rather insignificant. The small losses noted may well be the result of water from the stream entering local sandstone lenses in the Blackhawk and following the dip to the west.

The fact that little change occurs between stations SS13-1 and SS24-1 indicates that the Connelville fault zone, which crosses the stream just above the lower station, does not convey a significant amount of water to the surface. This fault has presumably been sealed to flow by the expanding shales.

Significant changes occur in the stream's characteristics near and below station SS24-1. As noted in Plate 6, these hydrologic changes are also accompanied by a change in the surface geologic formation (to the Star Point

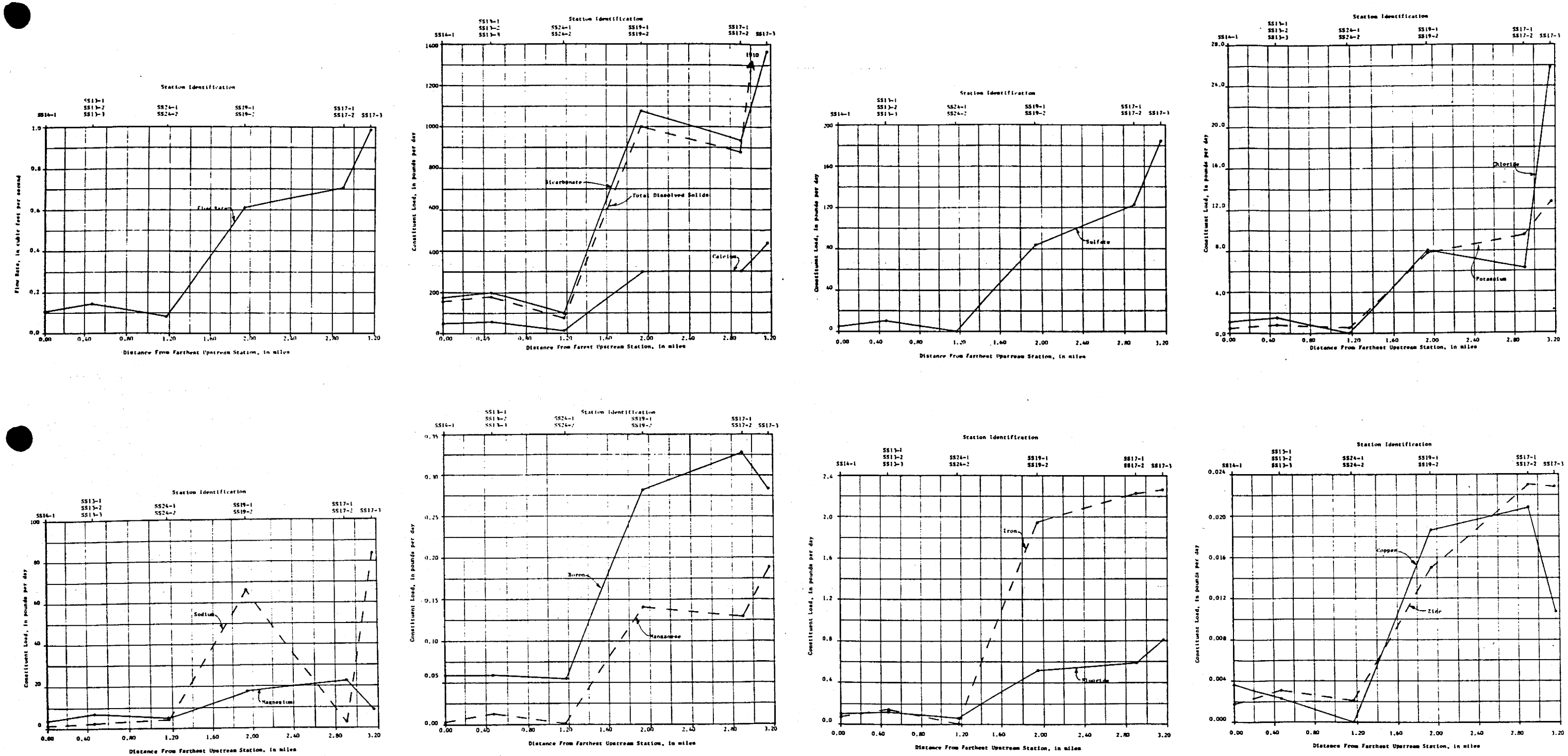


Figure 23. Results of seepage study flows and stream loading calculations for the Main Fork of Eccles Creek. All values have been corrected for tributary inflow.

Sandstone) and the existence of two major fault zones which traverse the stream segment (the O'Connor Fault near SS19-1 and the Pleasant Valley Fault near SS17-1).

Based on the number of springs along the stream, it appears that the O'Connor Fault is discharging into Eccles Creek, thus causing the graphical peaks in flow and loads noted in Figure 23 at station SS19-1. As a check, the assumption was made that all of the change found at SS19-1 was coming from the O'Connor Fault and adjacent fractures. Table 14 gives the results of calculations to determine the individual concentrations of various parameters which must be present to produce the changes noted in Figure 23, based on the measured flow increase of 0.53 cubic foot per second. Also noted are the results of two water quality analyses: one of seepage from the floor of the O'Connor Mine at the O'Connor Fault (flow equaled one gallon per minute) collected on March 27, 1979 and a second of a spring located on the south side of Eccles Creek near the O'Connor Fault collected on September 10, 1979 and labeled S-1 (flow equaled 15 gallons per minute). The results compare well with the calculations in most cases. Ion exchange and/or dissociation may well explain most of the discrepancies. Thus, it appears reasonable to assume that the O'Connor Fault is acting as a conveyance structure in the fractured sandstone, thereby discharging into Eccles Creek and causing a major portion of the changes noted by the seepage study.

The Pleasant Valley Fault is present at a Blackhawk-Star Point interface and, as a result, probably serves more as a barrier than a conduit. The likelihood of this happening is borne out by the rapid change in most constituents

Table 14. Computed concentrations of major constituents flowing into Eccles Creek during seepage studies, as compared with water collected along the O'Connor Fault in the O'Connor Mine and a nearby spring.

Parameter	Corrected Constituent Load, in pounds per day			Calculated Inflow Conc., in mg/l	Measured Conc., in mg/l	
	At SS24-1	At SS19-1	Increase		O'Connor Mine	S-1
Bicarbonate	95	1075	980	342.4	241.6	356.2
Calcium	20	300	280	97.8	82.4	110.4
Chloride	0	8.0	8.0	2.8	2.0	4.0
Fluoride	0.06	0.52	0.46	0.16	0.17	-
Iron	0	1.94	1.94	0.68	-	0.97
Magnesium	5	18	13	4.5	25.9	2.9
Manganese	0	0.14	0.14	0.05	-	0.05
Potassium	0.05	7.8	7.3	2.55	2.21	2.58
Sodium	4	66	62	21.7	1.84	15.2
Sulfate	0	84	84	29.4	118	30.0
Total Diss. Solids	75	1000	925	323	335	345

between SS17-1 and SS17-3 and the fact that the computed inflow concentrations required to produce the measured load increase far exceed measured concentrations from the Alpine School District well, located at the mouth of Green Canyon adjacent to the Pleasant Valley Fault. It appears that subsurface water may be flowing beneath the creek and being forced to the surface at the Pleasant Valley Fault due to the presence of a barrier created by the impermeable Blackhawk Formation. Much of this is likely deeper water which has not previously mixed with water in the stream above this point (note the dilution-caused decrease above SS17-1 followed by a large increase in total dissolved solids load shown in Figure 23).

Figure 24 presents a similar stream loading analysis of the South Fork seepage study results. The data gathered from this stream are much more variable than encountered in the main fork. However, a few general patterns can be seen.

Nearly all parameters experienced an increase between the first two stations (SS25-1 and SS24-3). Many seeps and springs appeared on the hillside in this section, accounting presumably for most, if not all, of the increase.

Only a small amount of inflow from seeps (approximately 5 gallons per minute) was noted on the surface between SS24-3 and SS24-4. The remaining 20 gallons per minute of the noted increase likely resulted from diffuse inflow which follows the dip, flowing from east to west towards the stream. Chemically, the segment experienced some exchanging of sodium for calcium and magnesium.

No significant flow changes were noted between SS24-3 and SS24-7. Because of this, it is assumed that the chemical changes noted in Figure 24 resulted almost entirely from ion exchange, dissociation, or precipitation. Small, local

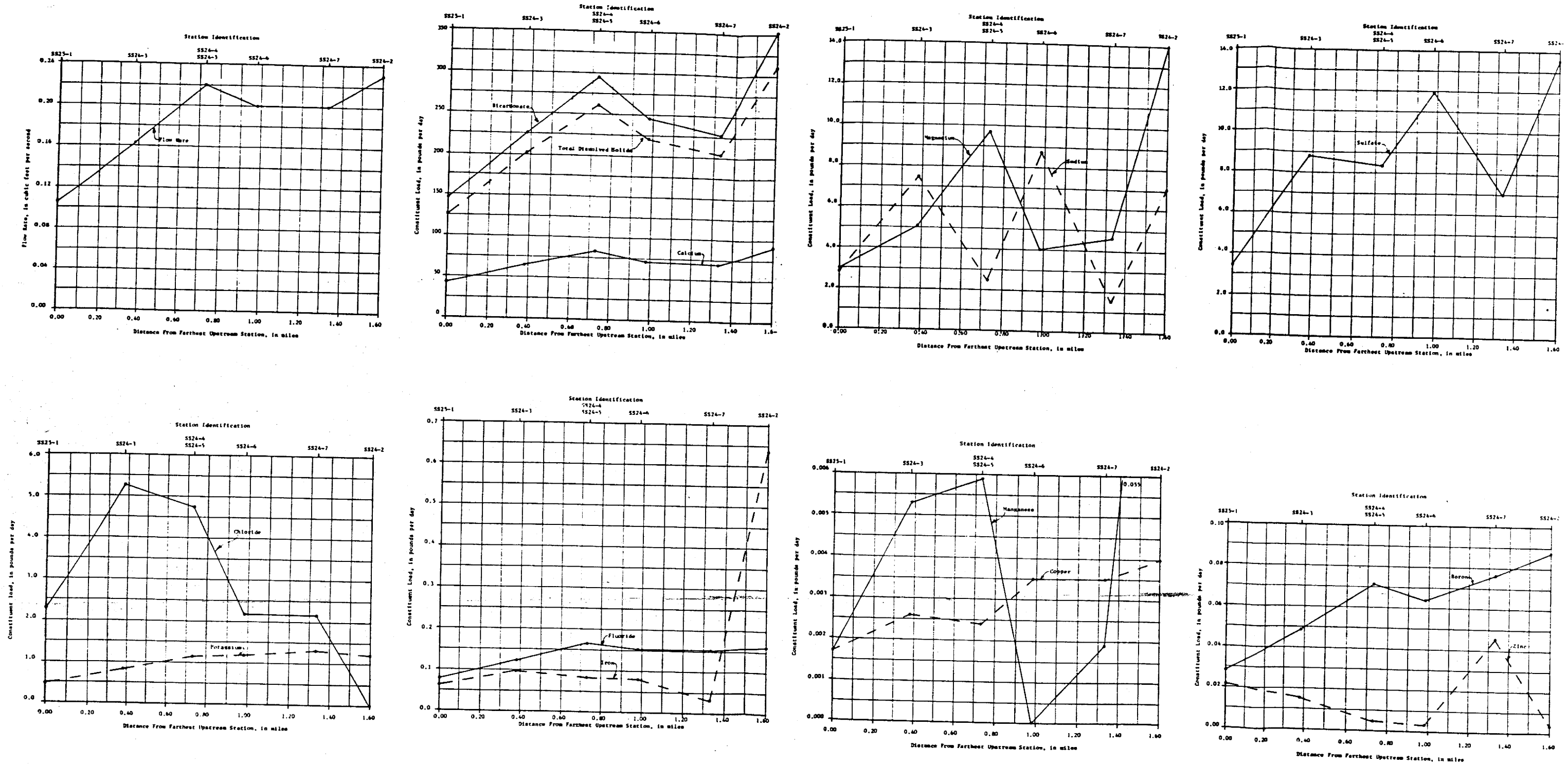


Figure 24. Results of seepage study flows and stream loading calculations for the South Fork of Eccles Creek. All values have been corrected for tributary inflow.

the flow decreased to about 25 gallons per minute.[2] On the other hand, if a shale layer had been encountered by the mine at the fault, only a slight increase in the inflow rate to the mine would have been expected (as experienced by the insignificant changes noted in the seepage study). In either case, the increased inflow to the mine probably has as its source water which was stored behind the barrier created by the fault (similar to the condition implied at the Pleasant Valley Fault). Because of the discontinuous nature of the Blackhawk Formation and its apparent slow recharge rate, only an underground area of local extent would be expected to yield water at the fault, thus explaining the relatively rapid decrease in flow at the fault noted in the Belina No. 1 mine.

The results of the Huntington Creek seepage study are presented in Figure 25. Because of spurious flow data, information collected at the four stations above SS22-2 was not included in the stream loading calculations. In addition, tributary inflow at SS34-2 was below the lower station and is, therefore, also not included here. The data are included, however, in Attachment D.

Measurements of discharge rates from springs issuing on the hillside east of the creek (from the west facing slope) accounted for nearly 90 percent of the measured flow increase seen in Huntington Creek between SS22-2 and SS27-2.

---

[2] Malcohm Dye, Valley Camp of Utah, Inc. Personal communication dated October 12, 1979.

changes in flow conditions may have occurred in the stretch also, causing some of the chemical change, but overall alterations in flow were insignificant.

A large beaver pond has been built between SS24-7 and SS24-2. It is reasonable to expect that most changes noted below SS24-7 have resulted either directly from the pond or from springs located in the pond. Some change may have also resulted where the Connelville Fault zone crosses the Star Point Sandstone. The magnitude of this, however, is expected to be small since the Connelville Fault was not shown to be a significant contributor of water to the main fork.

Thus, it appears that changes in conditions along the South Fork of Eccles Creek can be larely accounted for by springs which issue in the headwaters area and a large beaver pond at the mouth. The Conneville Fault zone itself apparently has little effect on the stream. This confirms the previous conclusion that the fault is not acting as a conduit but, rather, has likely sealed itself.

Although surface flow conditions throughout the length of the Connelville Fault appear to be uniform, the amount of water encountered in the mines near the fault zone may vary, depending upon whether shale or sandstone is encounted at the fault by the advancing mine face. For example, in approaching the fault from the east, Valley Camp of Utah, Inc. encountered a sandstone lense at the fault in the Belina No. 1 Mine in section 24, T. 13 S., R. 6 E. which yielded approximately 1000 gallons per minute. In the 10 weeks since the fault was first encountered,

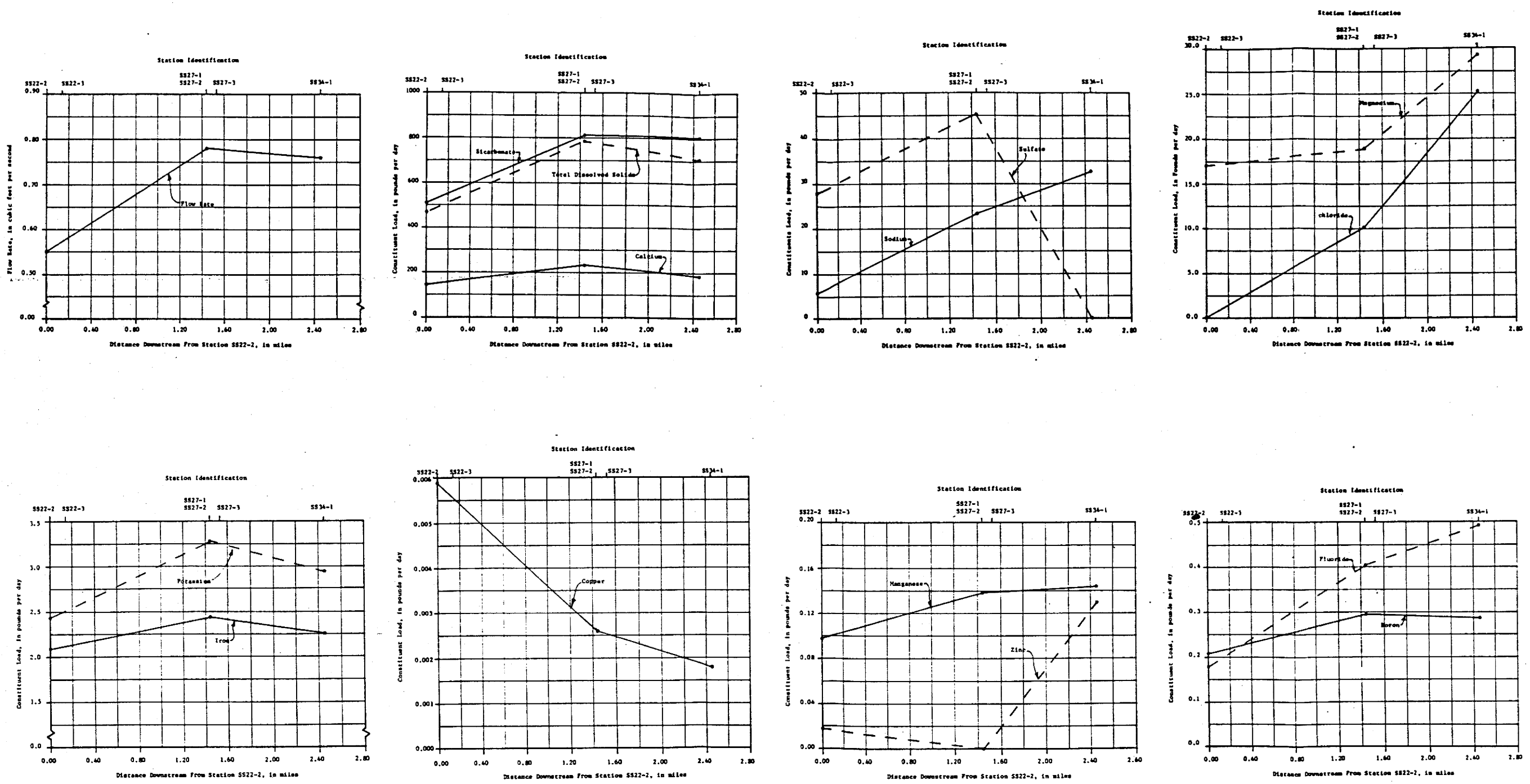


Figure 25. Results of seepage study flows and stream loading calculations for Huntington Creek. All values have been corrected for tributary inflow.

Because of inaccuracies in estimating spring discharge rates, it is likely that surface sources accounted for all of the increase in flow noted in Figure 25. Chemical changes presumably also resulted from inflowing spring water.

Corrected flows between SS27-2 and SS34-1 decreased by 0.02 cubic foot per second (9 gallons per minute). A general decrease in constituent loads also occurred in this stretch. In addition, approximately 30 gallons per minute of spring discharge was measured in the segment. Thus, a total of 39 gallons per minute was lost in the segment.

Streamside vegetation may account for a portion of this loss through evapotranspiration. This, however, is expected to be insignificant. It is, therefore, assumed that the majority of the loss can be attributed to recharge of the alluvium. Because of the tight nature of the Blackhawk Formation which underlies the alluvium, this recharged water presumably travels below the surface at the shale-alluvium interface towards Electric Lake (i.e. water likely percolates into the bedrock below at much lower rates than shown by the measured loss).

Observation Wells

The U.S. Geological Survey and the U.S. Forest Service (Manti-LaSal National Forest) gave permission to drill a limited number of coal exploration holes to augment the drilling that had been done in prior years. Locations were selected to obtain the most useful geologic information and minimize potential environmental impacts resulting from the operation. Five of the locations were selected for conversion to ground water observation wells. At each of the five sites, 2-inch casing was installed into the Star Point Sandstone with the lower 20 feet being

perforated, thus providing a measure of the piezometric head in the Star Point. Another shallower hole was drilled nearby, normally above the coal zone, and 2-inch casing, perforated over the lower 20 feet, was installed. Geophysical logs of each of the holes will be placed on file with the U. S. Geological Survey, Area Mining Supervisor, in Salt Lake City, Utah by Coastal States Energy Company as soon as the data are compiled and interpreted. Geologists who had drilled exploratory holes on the Skyline Property in prior years were consulted regarding the stability of an open hole in the Blackhawk Formation. They were unanimous in their statements that a hole generally would not remain open longer than a day or two. For this reason, it was decided that the placement of baskets and cement to seal off formations at the depths required (ranging from 108 to 2013 feet and averaging over 700 feet) would be a difficult and uncertain process. Hence, the decision was made to drill two holes at each site to obtain a measure of vertical water movement (one shallow and one deep) rather then placing two piezometers in a single hole (above and below a cemented seal).

Because the lower 20 feet of casing was perforated in each hole, the water level in the hole is a measure of the piezometric head near the bottom of the casing. Should vertical flow occur in the hole outside the casing, the vertical gradient will be less in magnitude but unaltered in direction. With time, sloughing will occur in the hole and the difference in the head, if any, between the shallow and deep holes will be more pronounced.

Deep observation wells with 2-inch casing were installed at each of the five locations. Shallow observation wells with 2-inch casing were installed at four locations. Even though three drilling rigs were operating on the property,

sufficient time was not available to drill a deep hole at W26-1 due to the U.S. Forest Service requirement that all drilling operations be suspended by the commencement of the elk hunt (October 3) with the exception of a test well in the portal area.

Ground Water Movement

Peizometric heads were measured during the fall of 1979 in the shallow and deep observation wells and in two open holes, one on and one east of the property. Data from the shallow wells (see Plate 7) show the ground water flowing in a west to southwest direction. The direction of ground water flow in the underlying Star Point Sandstone (as measured in the deep holes) is essentially the same as that measured in the shallow holes.

As seen on Plate 7, an anomalous condition exists between W26-1 and W35-1. While ground water gradients over much of the rest of the property average about 250 feet per mile, the gradient steepens to nearly 700 feet per mile between the two holes. This anomaly is likely associated with the Valentine Fault zone, which passes through W35-1. During drilling operations, flows in excess of 110 gallons per minute were discharged from W35-1, a higher flow rate than experienced any where else on the property. The core confirmed that this hole crossed a high angle fault. Apparently, the fracture has connected the sandstone lenses of the Blackhawk Formation with the Star Point Sandstone, thereby significantly increasing the water yield characteristics of the rock at this point and influencing the piezometric head in the area.

At W10-1, near the northwest corner of the lease area, the piezometric head under the coal zone was 35 feet greater than above the coal. At W22-2 to the

south, the underlying piezometric head was 40 feet greater. At W14-2, about 3000 feet west of the portal area in Eccles Canyon, the piexometric head was 5 feet less under the coal than above it. Likewise, at W35-1 near Electric Lake, the piezometric head was 15 feet less under the coal. Thus, the northwest quadrant is experiencing upward flow from the underlying sandstone.

The water level at W35-1 is 165 feet below the ground surface. However, two springs occur 50 feet up on the hillside adjacent to the observation well. This further substantiates the theory that water issuing from springs on the lease area has a very localized source and indicates that two ground water systems occur in the area of the Skyline Property. A shallow system is very local in extent and discontinuous, providing water to numerous seeps and springs through thin sandstone layers in the Blackhawk Formation (ranging in thickness from about 1 foot to 60 feet). A deep ground water system is present in the saturated rocks surrounding the coal. This system has little effect on the surface hydrologic regime of the Skyline Property, passing far below the perennial streams of the lease area.

Deep holes, depth of water, and variability of sandstone layers made it impossible to estimate water yield from the holes during drilling. As already noted, air rigs were discharging over 110 gallons per minute at deeper depths in W35-1. In other locations, flows were usually under 5 gallons per minute and often zero.

The presence of Huntington Creek and Electric Lake appears to have little effect on the ground water contours shown on Plate 7. At W35-1, less than 3000 feet northeast of the upper end of Electric Lake, the water table, at an elevation of 8535 feet above mean sea level, is 40 feet below the normal water level in the lake at 8575 feet. Assuming that the ground water gradient remains as plotted,

the water table is about 150 feet below the lake under its upper end. Flow measurements in Huntington Creek above Electric Lake do not show acretions in excess of surface inflows from small hillside springs. Thus, ground water flowing westward under the property appears to pass under Huntington Creek and Electric Lake, indicating that these two water bodies are perched atop impeding shale layers and not contributing significantly to the deeper ground water system. However, one or more observation wells are needed in the southwest portion of the property to better define these conditions. Because mining will not occur in this area for quite some time, the data can be collected during normal, exploratory dilling operations.

Aquifer Test Results

Drawdown and recovery tests were conducted at two different depths in a test well located in the proposed portal area (see Plate 7). Each test consisted of approximately 65 minutes of drawdown testing and an equal period of recovery testing. Water was discharged from the well using a bailer. The data were analyzed over the straight-line portion of the semilog time-drawdown (or time-residual drawdown) curve using the Jacob equation (U.S. Bureau of Reclamation, 1977), which states that

$$T = \frac{2.303\ Q}{4\pi\ \partial s / \partial (\log\ t)} \qquad (10)$$

where T is the transmissivity, Q is the flow rate from the well during the drawdown test, s is the drawdown, and t is the time since pumping began. In the case of a recovery test, s becomes s' (the residual drawdown or difference between the measured head and the head prior to the start of pumping) and the time term becomes t/t', where t' is time since pumping ceased (U.S. Bureau of Reclamation, 1977). For a particular distance, equation 10 is the equation

of a straight-line plot of s versus log t (or s' versus log t/t'). For one log cycle, ∂ log t (or ∂ log t/t') is equal to one. With this in mind, and converting to the gallon-day-foot system of units, equation 10 can be written as

$$T = \frac{264\ Q}{\Delta s} \qquad (11)$$

where T is the transmissivity, in gallons per day per foot; Q is the constant discharge rate, in gallons per minute; and Δs is the drawdown difference per log cycle of time, in feet. The recovery test equation substitutes s' for s.

Tests were run in the open hole at depths of 200 feet (within the coal zone of the Blackhawk Formation, above the Aberdeen Sandstone) and 300 feet (at the bottom of the Blackhawk Formation, below the Aberdeen Sandstone). The data are plotted in Figures 26 and 27. At the 200 foot depth, transmissivities of 21.0 and 16.6 gallons per day per foot were calculated for the drawdown and recovery tests, respectively. Transmissivities of 16.3 and 17.9 gallons per day per foot were calculated for the respective drawdown and recovery tests at the 300 foot depth.

Two observations can be made regarding the test results. First, the low transmissivities and discharge rates indicate that the Blackhawk Formation is, at best, a poor aquifer. Water is yielded from discontinuous, localized sandstone lenses which prohibit large scale development.

The second observation is that no significant differences exist between the aquifer properties of the coal zone and those of the Aberdeen Sandstone. Thus, the Aberdeen cannot be considered a major water-bearing zone.

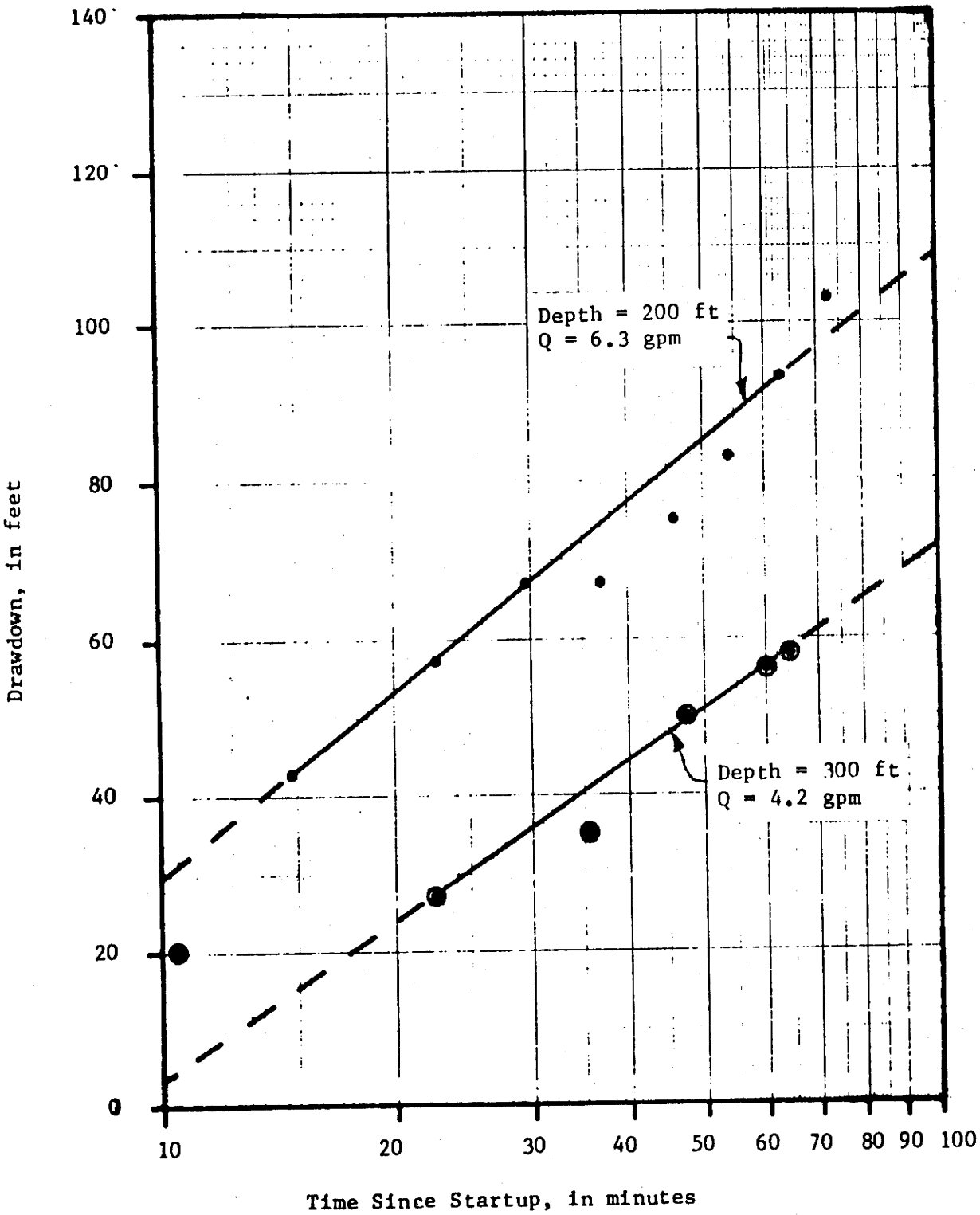


Figure 26. Results of drawdown tests at portal area test well at hole depths of 200 and 300 feet.

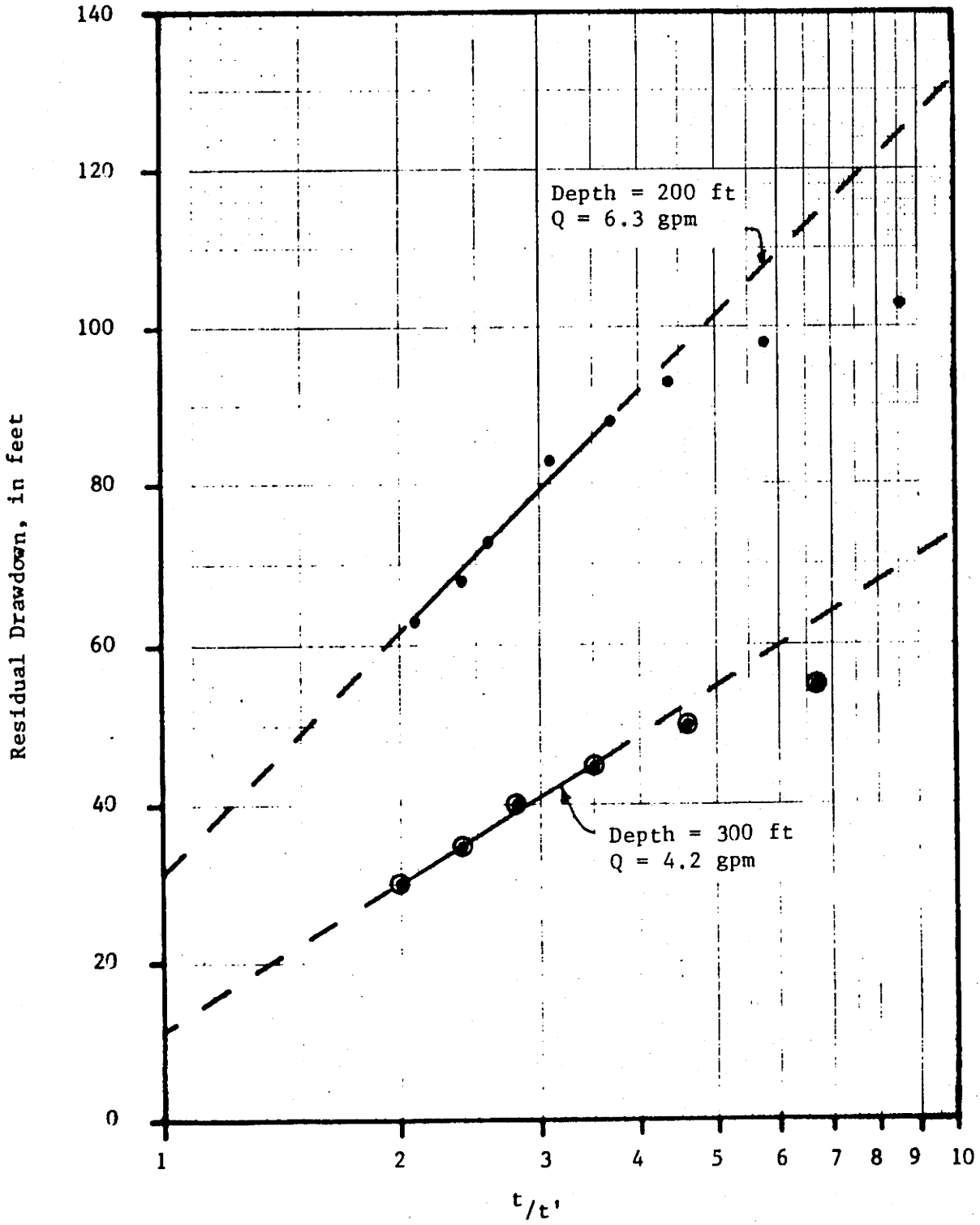


Figure 27. Results of recovery tests at portal area test well at hole depths of 200 and 300 feet.

Continued drilling at the test well has shown that the Star Point Sandstone is yielding over 70 gallons per minute at the site even though it is not yet fully pentrated. It appears that this unit is a reliable aquifer and has the potential for development as a water supply for use at the mine. Future testing of the Star Point will be completed at the site to determine its long-term yield properties.

Ground Water Quality

As has been previously mentioned, comprehensive water quality samples were collected during the summer of 1979 from the nine springs listed in Table 10 and shown on Plate 5. Access problems prevented the collection of samples during the winter and spring following the initial inventory. In addition, samples were collected for limited analyses from seepage in the O'Connor and the Belina No. 1 Mines, located immediately to the east of the lease area and operated by Valley Camp of Utah, Inc., and from a well located in section 8, T. 13 S., R. 7 E. This well is operated by the Alpine School District and is completed in the Blackhawk Formation.

High cost precluded the collection of reliable water quality data from the observation wells which were drilled in the area. Because of downhole instability and the depth to which the holes were drilled (varying between 108 and 2013 feet), standard well construction practices were not feasible. The cost of properly constructing and developing the wells to obtain reliable water quality data would have far exceeded the benefits of obtaining a subsurface water quality sample, considering the discontinuous nature of the Blackhawk Formation and the lack of ground water use in the area through wells (i.e. nearly all ground water usage in the area is through springs - see the following section on

water rights). Considerable pumped ground water usage in the area may have justified the cost. However, as wil be shown, the springs which were sampled were reliable indexes of deeper ground water quality and, thus, adequately describe local conditions.

All samples were collected and preserved as previously outlined. The analyses which were completed are noted in Table 5. Attachment E contains the results of water quality analyses of samples collected from the springs.

As a measure of the ability of spring water to index the quality of deeper water in the area, the average concentrations of various constituents, as measured at the nine monitored springs, were compared with the concentrations of those same constituents sampled in the O'Connor and Belina No. 1 Mines and the Alpine School District well. These data, which are presented in Table 15 and in Figure 28, indicate that the springs do adequately index deeper water (i.e. the samples collected in the mines and the well fall within the range of samples collected at the springs). Thus, ground water quality in the property area has presumeably been adequately sampled.

The patterns noted during the initial spring inventory (see Plate 5) did not vary significantly during subsequent measurements. The geographic variations discussed previously remained unchanged as did the strong calcium bicarbonate content of the water.

Unlike surface water quality measurements, changes in ground water constituent concentrations with time showed no consistent trends. Concentrations of a

Table 15. Results of chemical analyses of water samples collected in March, 1979 from the O'Connor Mine, the Belina No. 1 Mine, and the Alpine School District well.

Parameter	Concentration, in mg/l		
	O'Connor Mine	Belina No. 1 Mine	Alpine Well
Arsenic			0.004
Barium			0.06
Bicarbonate	241.56	312.32	197.64
Cadmium			0.001
Calcium	82.40	69.60	32.00
Chloride	2.0	< 1.0	2.0
Chromium			< 0.001
Conductivity	510	370	285
Fluoride	0.17	0.11	0.84
Iron			0.530
Lead			< 0.001
Magnesium	25.92	21.12	9.60
Mercury			< 0.0002
Nitrate			< 0.02
Orthophosphate			< 0.01
Potassium	2.213	0.836	1.289
Selenium			< 0.001
Silver			< 0.001
Sodium	1.84	1.75	21.32
Sulfate	118	6.0	6.0
TDS	335	250	182
pH	7.47	7.49	7.39

Notes: Conductivity in micromhos per centimeter at 25°C; pH in standard units.

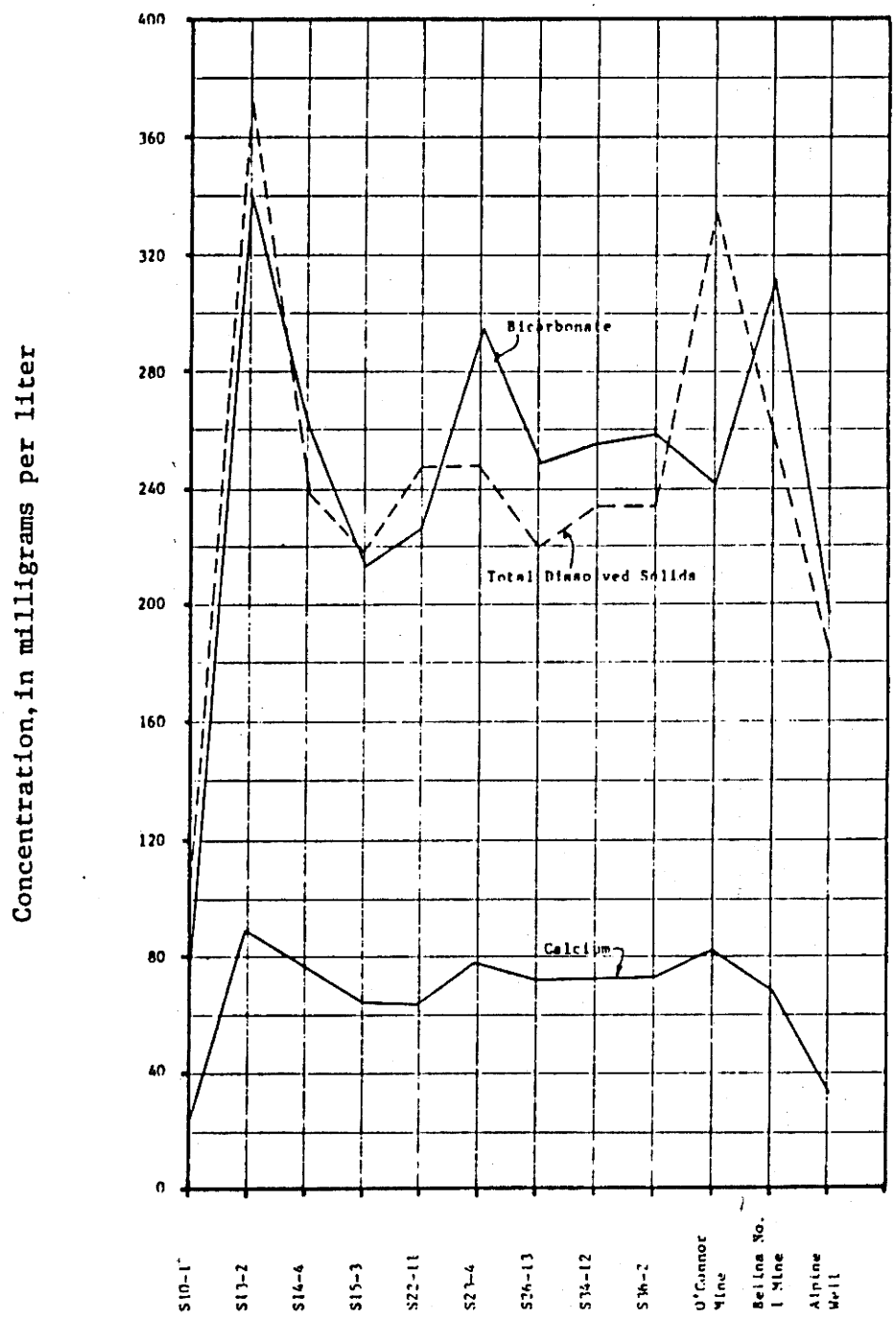


Figure 28. Comparison of water quality data collected from springs, a well, and mines in the Skyline Property area.

given constituent varied both directly and inversely with flow from spring to spring.

Maximum, minimum, and mean concentrations of various parameters measured on the property are noted in Table 16. Concentrations are generally lower than noted for the same constituents in surface water samples, although the differences do not appear to be very significant. As was noted previously, the high alkalinity, low acidity, and general basic nature of the water indicates that acid drainage problems should not develop as a result of mining on the lease area.

Table 16. Maximum, minimum, and mean concentrations of various ground water constituents.

Parameter	Concentration, in mg/l		
	Maximum	Minimum	Mean
Acidity, as $CaCO_3$	14.0	4.0	9.3
Alkalinity, as $CaCO_3$	290	50	192
Ammonia, unionized	0.10	< 0.01	0.01
Iron, Total	0.96	0.06	0.28
Iron, Dissolved	0.050	0.010	0.018
Manganese, Total	0.018	< 0.001	0.005
pH	8.3	5.9	7.3
Phenol	0.020	< 0.001	0.001
Phosphate, Total	0.08	0.02	0.04
Total Diss. Solids	449	64	234

Un-ionized ammonia, phenol, and total phosphate concentrations measured during the baseline period again exceeded the state water quality standards for the uses specified for water the the area, although not with the regularity noted in surface water measurements. An un-ionized ammonia concentration of 0.10 milligrams per liter (exceeding the state standard by 0.08 milligrams per liter) was measured once at S34-12 on August 23, 1979. One phenol measurement exceeded the standard of 0.01 milligrams per liter by 0.01 milligrams per liter (station S23-4 on August 23, 1979).

Four total phosphate measurements exceeded the state standard of 0.05 milligrams per liter during the baseline period (once at S23-4, twice at S26-13, and once at S34-12). However, the maximum measured concentration was only 0.08 milligrams per liter. It thus appears that surface phenomena are primarily responsible for the exceedances noted in the surface water samples as opposed to being indigenous to the geologic characteristics, as would be expected.

Although iron concentrations in the area ground waters are not excessively high, total iron often reaches concentrations varying between 0.5 and 1.0 milligrams per liter. The natural occurrence of these relatively high concentrations probably results from the iron content of the cementing agents in the Blackhawk Formation, as previously discussed.

As was the case with surface waters in the area, the concentrations of other constituents sampled at stations throughout the area are generally quite low. In many instances, trace metal concentrations were consistently below the detection limit of routine laboratory techniques (especially arsenic, cadmium, chromium, lead, mercury, selenium and silver).

Monitoring Program

An ongoing ground water monitoring program will be conducted at each of the ground water stations shown on Plate 4. In addition, data will be collected from the mines and the proposed water supply well being drilled in the portal area.

As has been shown, the quality of water issuing from springs on the Skyline Property is representative of deep water conditions. In addition, as will be discussed in the water rights section, ground water usage in the area consists almost entirely of springs. Thus, because of the desire to monitor impacts at the site of use, the monitoring of springs in the area takes on added importance.

Although streams in the area may be accessible most of the year, such is not the case with most wells and springs. Thus, water quality data will be collected once each year (during the month of August) from the springs noted on Plate 4, the water supply well in the portal area, and seepage in the mines. The collection of an earlier sample may result in the inclusion of a significant amount of snowmelt runoff whereas a later sample would not normally allow the collection of additional data before snowfall if unique, unexpected conditions are found. Each of the water quality samples will be analyzed as outlined by the comprehensive list contained in Table 5 or an approved abbreviated schedule. The data collected at the springs will give a measure of the impact of mining on the ground water system at its primary point of use. The measurements taken from the mines and the well will give an indication of impacts on the deep ground water system.

Water level data will also be collected during August of each year from each of the wells noted on Plate 4. The amount of water discharged from the mines

will also be monitored at the mine mouth through the use of a totalizing flow meter or similar device. Significant changes in the source of water in the mines will be noted during the period of operation.

In addition to the above outlined monitoring program, an NPDES discharge permit will be acquired for mine water discharges as necessary. Monitoring of all discharges will be conducted in accordance with this permit.

As required, ground water quality data collected from the property area will be submitted to the Utah Division of Oil, Gas, and Mining. Such reports will normally be submitted within 60 to 90 days of the end of each quarter, depending upon the speed of laboratory analyses.

WATER RIGHTS

Surface Water Rights

Tables 17 and 18 list the surface water rights on and adjacent to the Skyline Property which were on record with the Utah Division of Water Rights as of September, 1979. The locations of these water rights can be found on Plate 8.

Surface water rights in the area are primarily for stockwatering and irrigation. Stockwatering rights are almost entirely directly on the stream. Irrigation rights are centered around the town of Scofield and in Flat Canyon, southwest of the center of the property. Irrigated lands consist almost entirely of pasture. Only stockwatering rights are present on the lease area.

Ground Water Rights

Ground water rights on and adjacent to the Skyline Property, on record with the Utah Division of Water Rights as of September, 1979, are listed in Table 19 and 20 and presented on Plate 9. Again, rights are primarily for stockwatering and irrigation (mainly lawns and gardens). Only one spring on the lease area has a filed water right. Only a limited number of wells are located in the area.

Also shown on Plate 9 are exchanges of Scofield Reservoir water for ground water in Pleasant Valley Creek Basin. These are listed in Table 21. All exchanges are wells, with the exception of 91-940. Most of the exchanges serve the industrial and domestic needs of mining companies in the area.

Table 17. Surface water rights in the Price River Basin located on and adjacent to the Skyline Property.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-252	Utah Div. of Wildlife Resources	Gooseberry Creek with Storage	5.0	Fish Culture	January 1 to December 31
91-345	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Daraban	Green Canyon Spring Stream	0.75	Irrigation	March 1 to November 30
91-423	Nick Marakis (½ interest)	Winter Quarters Creek	——	Stockwatering	January 1 to December 31
91-431	Nick Marakis (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-436	Nick Marakis (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-437	Nick Marakis (½ interest)	Clear Creek	——	Stockwatering	January 1 to December 31
91-438	Nick Marakis (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-440	Nick Marakis (½ interest)	Wash with storage	——	Stockwatering	January 1 to December 31
91-441	Nick Marakis (½ interest)	Stream with storage	——	Stockwatering	Janaury 1 to December 31
91-462	John Marakis Estate (½ interest)	Winter Quarters Creek	——	Stockwatering	January 1 to December 31
91-471	John Marakis Estate (½ interest)	Stream	----	Stockwatering	January 1 to December 31
91-476	John Marakis Estate (½ interest)	Stream	——	Stockwatering	January 1 to December 31
91-477	John Marakis Estate (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-478	John Marakis Estate (½ interest)	Clear Creek	——	Stockwatering	January 1 to December 31

Table 17. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-479	John Marakis Estate (½ interest)	Wash with storage	----	Stockwatering	January 1 to December 31
91-480	John Marakis Estate (½ interest)	Stream with storage	----	Stockwatering	January 1 to December 31
91-482	Robert Radakovich	Stream	----	Stockwatering	May 1 to December 15
91-483	Robert Radakovich	Winter Quarters Creek	0.443	Irrigation Stockwatering	March 1 to December 15
91-592	John Marakis Estate (½ interest)	Mud Creek	----	Stockwatering	January 1 to December 31
91-593	Nick Marakis (½ interest)	Mud Creek	----	Stockwatering	January 1 to December 31
91-1009	U.S. Forest Service	Tributary to Snider Canyon Cr.	----	Stockwatering	July 1 to September 30
91-1010	U.S. Forest Service	Tributary to Mud Creek	----	Stockwatering	July 1 to September 30
91-1011	U.S. Forest Service	Mud Creek	----	Stockwatering	July 1 to September 30
91-1012	U.S. Forest Service	Mud Creek	----	Stockwatering	July 1 to September 30
91-1014	U.S. Forest Service	Tributary to Mud Creek	----	Stockwatering	July 1 to September 30
91-1015	U.S. Forest Service	Tributary to Mud Creek	----	Stockwatering	July 1 to September 30
91-1016	U.S. Forest Service	Long Canyon Creek	----	Stockwatering	July 1 to September 30
91-1017	U.S. Forest Service	Tributary to Long Canyon Cr.	----	Stockwatering	July 1 to September 30
91-1018	U.S. Forest Service	Tributary to Mud Creek	----	Stockwatering	July 1 to September 30
91-1019	U.S. Forest Service	Tributary to Boardinghouse Canyon Creek	----	Stockwatering	July 1 to September 30
91-1020	U.S. Forest Service	Boardinghouse Canyon Creek	----	Stockwatering	July 1 to September 30
91-1021	U.S. Forest Service	Boardinghouse Canyon Creek	----	Stockwatering	July 1 to September 30

Table 17. Continued

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1043	U.S. Forest Service	Wife Creek	----	Stockwatering	July 1 to September 30
91-1044	U.S. Forest Service	Wife Creek	----	Stockwatering	July 1 to September 30
91-1047	U.S. Forest Service	Tributary to French Creek	----	Stockwatering	July 1 to September 30
91-1048	U.S. Forest Service	Tributary to French Creek	----	Stockwatering	July 1 to September 30
91-1049	U.S. Forest Service	French Creek	----	Stockwatering	July 1 to September 30
91-1050	U.S. Forest Service	French Creek	----	Stockwatering	July 1 to September 30
91-1112	U.S. Forest Service	Mill Creek	----	Stockwatering	July 1 to October 10
91-1113	U.S. Forest Service	Mill Creek	----	Stockwatering	July 1 to September 30
91-1114	U.S. Forest Service	Tributary to Mill Creek	----	Stockwatering	July 1 to September 10
91-1115	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	July 1 to October 10
91-1116	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	July 1 to October 10
91-1117	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	July 1 to October 10
91-1118	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	July 1 to October 10
91-1119	U.S. Forest Service	Tributary to Gooseberry Cr.	----	Stockwatering	July 1 to October 10
91-1120	U.S. Forest Service	Tributary to Gooseberry Cr.	----	Stockwatering	July 1 to October 10
91-1121	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	June 6 to October 10
91-1128	U.S. Forest Service	Jap Creek	----	Stockwatering	June 6 to October 10
91-1129	U.S. Forest Service	Jap Creek	----	Stockwatering	July 1 to September 30
91-1142	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	June 6 to October 10
91-1143	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	July 1 to October 5
91-1146	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	July 1 to October 5
91-1147	U.S. Forest Service	Gooseberry Creek	----	Stockwatering	July 1 to September 30

Table 17. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1148	Leon & Tom Nicolaides Mary Stathis Bessie Daraban	Green Canyon Stream	----	Stockwatering	January 1 to December 31
91-1149	U.S. Forest Service	Gooseberry Creek with Storage	----	Stockwatering	July 1 to October 5
91-1678	Calvin K. Jacob	Stream	----	Stockwatering	May 1 to November 30
91-1713	N.M. Jensen Investment Co.	Spring Stream	----	Stockwatering Domestic	January 1 to December 31
91-2018	Angelo Georgedes	Green Canyon Stream with Storage	----	Stockwatering	May 1 to October 31
91-2019	Angelo Georgedes	Stream with storage	----	Stockwatering	May 1 to October 31
91-2020	Angelo Georgedes	Green Canyon Stream	----	Stockwatering	May 1 to October 31
91-2048	John Jouflas Estate	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2146	Elrie and Bertha Simonsen	Winter Quarters Creek	----	Stockwatering	June 1 to November 30
91-2495	Elrie & Bertha Simonsen	Woods Canyon Creek	----	Stockwatering	June 1 to November 30
91-2496	Elrie & Bertha Simonsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-2548	John Jouflas Estate (2/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2549	Lee S. Thomas (1/3 interest)	Pleasant Creek	----	Stockwatering	May 1 to October 31
91-2971	Lee S. Thomas (1/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2972	John Jouflas Estate (2/3 interest)	Clear Creek	0.106	Irrigation	March 1 to November 30
91-2973	John Jouflas Estate	Clear Creek	0.381	Irrigation	March 1 to November 30

Table 17. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-2974	Justus O. Seely	Clear Creek	0.170	Irrigation Stockwatering	March 1 to November 30
91-2977	S. J. Harkness	Clear Creek	0.075	Irrigation	March 1 to November 30
91-2978	Justus O. Seely	Clear Creek	0.683	Irrigation Stockwatering	March 1 to November 30
91-2979	S. J. Harkness	Clear Creek	0.453	Irrigation	March 1 to November 30
91-2980	Helen Miller	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2981	Orson Marsing	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2982	Lillie Pearson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2983	Thomas Biggs, Jr.	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2984	Waino E. Burton	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2985	Phyllis M. Conover	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2986	William & Armeda Sherman	Clear Creek	0.015	Irrigation	March 1 to November 30
91-2987	Leah B. Johnson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2988	E. D. & Elizabeth Jacobson	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2989	Scofield Town	Clear Creek	0.10	Irrigation	March 1 to November 30
91-2990	Della L. Madsen	Clear Creek	1.166	Irrigation	March 1 to November 30
91-2991	John B. Jones	Clear Creek	4.58	Irrigaion	March 1 to November 30
91-2992	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2993	John B. Jones	Clear Creek	4.58	Irrigation	March 1 to November 30
91-2994	John B. Jones	Woods Canyon Creek	---	Irrigation	March 1 to November 30
91-2995	John B. Jones	Woods Canyon Creek	---	Irrigation	March 1 to November 30
91-2996	Gladys P. Butler (4.85/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30

Table 17. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-2997	Alice M. Pannier (4.85/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2998	Boyd W. & Johannah M. Hafen (12.0/21.70 interest)	Woods Canyon Creek	0.50	Irrigation	March 1 to November 30
91-2999	Reed & Leoan M. Gunderson	Woods Canyon Creek	0.136	Irrigation	March 1 to November 30
91-3002	Della L. Madsen	Woods Canyon Creek	0.035	Irrigation	March 1 to November 30
91-3003	Charles J. Jacobsen Evelyn M. Jacobsen Stephen C. Hacobsen Charlyn J. Dalebout (7.9/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30
91-3004	Louise M. Watts Helen L. Watts John Andy Watts (18.1/26.0 interest)	Woods Canyon Creek	0.433	Irrigation	March 1 to November 30
91-3007	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.63	Irrigation	March 1 to November 30
91-3008	S. J. Harkness	Winter Quarters Creek	0.693	Irrigation	March 1 to November 30
91-3009	Elrie M. & Bertha Simonsen	Winter Quarters Creek	0.68	Irrigation	March 1 to November 30
91-3010	S. J. Harkness	Winter Quarters Creek	0.213	Irrigation	March 1 to November 30
91-3011	S. J. Harkness	Winter Quarters Creek	----	Stockwatering	January 1 to December 31
91-3014	Anton Michelog	Snidder Creek	----	Stockwatering	January 1 to December 31
91-3015	Anton Michelog	Mud Creek	----	Stockwatering	January 1 to December 31
91-3040	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Darsban	Clear Creek	----	Stockwatering	January 1 to December 31
91-3045	Milton A. Oman	Clear Creek	----	Stockwatering	January 1 to December 31

Table 17. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3051	John Marakis Estate (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-3052	Nick Marakis (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-3053	Milton A. Oman	Clear Creek	----	Stockwatering	January 1 to December 31
91-3056	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Daraban	Stream	----	Stockwatering	January 1 to December 31
91-3057	Milton A. Oman	South Fork Eccles Canyon Cr.	----	Stockwatering	January 1 to December 31
91-3059	John Marakis Estate (½ interest)	South Fork Eccles Canyon Cr.	----	Stockwatering	January 1 to December 31
91-3060	Nick Marakis (½ interest)	South Fork Eccles Canyon Cr.	----	Stockwatering	January 1 to December 31
91-3070	John Marakis Estate (½ interest)	Eccles Canyon Creek	----	Stockwatering	January 1 to December 31
91-3071	Nick Marakis (½ interest)	Eccles Canyon Creek	----	Stockwatering	January 1 to December 31
91-3072	Milton A. Oman	Eccles Canyon Creek	----	Stockwatering	January 1 to December 31
91-3074	Milton A. Oman	Eccles Canyon Creek	----	Stockwatering	January 1 to December 31
91-3075	Tom Nicolaides Leon Nicolaides Mary Stathis Bessie Daraban	Eccles Canyon Creek	----	Stockwatering	Janaury 1 to December 31
91-3080	Milton A. Oman	Boardinghouse Canyon Creek	----	Stockwatering	January 1 to December 31
91-3081	Jack Thomas	Boardinghouse Canyon Creek	----	Stockwatering	January 1 to December 31
91-3082	Milton A. Oman	Boardinghouse Canyon Creek	----	Stockwatering	January 1 to December 31

Table 17. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3083	Lavern Jensen	Finn Canyon Creek	----	Stockwatering	January 1 to December 31
91-3084	Milton A. Oman	Finn Canyon Creek	----	Stockwatering	January 1 to December 31
91-3086	Anton Michelog	Long Canyon Creek	----	Stockwatering	January 1 to December 31
91-3086	Anton Michelog	Long Canyon Creek	----	Stockwatering	January 1 to December 31
91-3090	Anton Michelog	Stream with storage	----	Stockwatering	January 1 to December 31
91-3405	Elrie & Bertha Simonsen	Woods Canyon Creek	----	Irrigation Stockwatering	March 1 to November 30
91-3440	Calvin K. Jacob	Clear Creek	----	Stockwatering	May 1 to November 30
91-3587	North American Coal Corp.	Boardinghouse Canyon Creek	----	Stockwatering	June 1 to November 30
91-3588	North American Coal Corp.	Finn Canyon Creek	----	Stockwatering	June 1 to November 30
91-3589	North American Coal Corp.	Mud Creek	----	Stockwatering	June 1 to November 30
91-3622	Mae Nicolodemas	Clear Creek	0.016	Irrigation	March 1 to November 30
91-3630	Utah Board of State Lands	Gooseberry Creek	----	Stockwatering	June 1 to November 30
91-3631	D. Euray Allred	Woods Canyon Creek	----	Stockwatering	May 1 to November 30
91-3633	D. Euray Allred	Winter Quarters Creek	----	Stockwatering	May 1 to November 30
91-3635	D. Euray Allred	Stream	----	Stockwatering	May 1 to November 30
91-3641	Pete Frandsen	Stream with storage	----	Stockwatering	June 1 to November 30
91-3644	Justus O. Seely	Clear Creek	----	Stockwatering	June 1 to November 30
91-3645	S. J. Harkness	Clear Creek	----	Stockwatering	June 1 to November 30
91-3648	John B. Jones	Clear Creek	----	Stockwatering	January 1 to December 31
91-3655	John B. Jones	Woods Canyon Creek	----	Stockwatering	January 1 to December 31

Table 17. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3658	John B. Jones	Stream with storage	----	Stockwatering	January 1 to December 31
91-3664	Lionel L. Peterson	Gooseberry Creek	----	Stockwatering	May 1 to November 30
91-3665	John Marakis Estate	Clear Creek	----	Stockwatering	January 1 to December 31
91-3666	Nick Marakis (½ interest)	Clear Creek	----	Stockwatering	January 1 to December 31
91-3667	Angelo Georgedes	Clear Creek	----	Stockwatering Domestic	January 1 to December 31
91-3910	Reed & Leoan M. Gunderson	Clear Creek (Scofield Res.)	----	Stockwatering	May 1 to November 30
91-3911	Della L. and Hilda M. Madsen	Clear Creek (Scofield Res.)	----	Stockwatering	May 1 to November 30

Table 18. Surface water rights in the San Rafael River Basin located on and adjacent to the Skyline Property.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-1	U.S. Forest Service	Kitchen Fork of Huntington Cr.	-----	Stockwatering	July 1 to October 10
93-2	U.S. Forest Service	Kitchen Fork of Huntingcon Cr.	-----	Stockwatering	July 1 to September 30
93-3	U.S. Forest Service	Kitchen Fork of Huntington Cr.	-----	Stockwatering	July 1 to September 30
93-4	Crowther Investment Co.	Kitchen Fork of Huntington Cr.	-----	Stockwatering	July 1 to September 30
93-6	U.S. Forest Service	N. Fork of Huntington Creek	-----	Stockwatering	July 1 to September 30
93-8	U.S. Forest Service	Unnamed for of Huntington Cr.	-----	Stockwatering	July 1 to September 30
93-9	U.S. Forest Service	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-10	L.D.S. Church	Swens Canyon Creek	-----	Stockwatering	----------
93-11	U.S. Forest Service	Swen's Canyon Creek	-----	Stockwatering	July 1 to September 30
93-12	U.S. Forest Service	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-13	U.S. Forest Service	Burnout Canyon Creek	-----	Stockwatering	July 1 to September 30
93-14	U.S. Forest Service	James Canyon Creek	-----	Stockwatering	July 1 to September 30
93-16	U.S. Forest Service	James Canyon Creek	-----	Stockwatering	July 1 to September 30
93-18	U.S. Forest Service	Flat Canyon Creek	-----	Stockwatering	July 1 to September 30
93-19	U.S. Forest Service	Flat Canyon Creek	-----	Stockwatering	July 1 to September 30
93-20	U.S. Forest Service	Boulger Creek	-----	Stockwatering	July 1 to September 30
93-21	U.S. Forest Service	Boulger Creek	-----	Stockwatering	July 1 to September 30
93-32	Lela C. Mower	Jackson Spring #1 Stream	-----	Irrigation Stockwatering	----------
93-33	Clyde K. Cox	Jackson Spring #1 Stream	-----	Irrigation Stockwatering	----------

Table 18. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-35	Newel B. Cox	Cabin Hollow Stream	----	Irrigation Stockwatering	----------
93-36	Newel B. Cox	Cove Spring Stream	----	Irrigation Stockwatering	----------
93-37	Newel B. Cox	Jackson Spring #1 Stream	----	Irrigation Stockwatering	----------
93-38	Clyde K. Cox	Cabin Hollow Stream	----	Irrigation Stockwatering	----------
93-41	Newel B. Cox	Burns Cox Spring Stream	----	Irrigation Stockwatering	----------
93-48	Stanley Cox	Jackson Hollow Stream	----	Irrigation Stockwatering	----------
93-49	Clyde K. Cox	Jackson Hollow Stream	----	Irrigation Stockwatering	----------
93-51	Stanley Cox	West Fork Jackson Hollow Stream	----	Irrigation Stockwatering	----------
93-55	Stanley Cox	Clyde Spring Stream	----	Irrigation Stockwatering	----------
93-56	Clyde K. Cox	Clyde Spring Stream	----	Irrigation Stockwatering	----------
93-57	Clyde K. Cox	Worth Spring Stream	----	Irrigation Stockwatering	----------
93-58	Stanley Cox	Worth Spring Stream	----	Irrigation Stockwatering	----------
93-73	A. Ira Cox	Ross Spring Stream	----	Irrigation Stockwatering	----------
93-74	Evan Cox	Ross Spring Stream	----	Irrigation Stockwatering	----------

Table 18. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-77	Utah Power & Light Co.	Bear Canyon Creek	-----	Stockwatering	July 1 to September 30
93-78	U.S. Forest Service	Coal Creek	-----	Stockwatering	July 1 to September 30
93-79	U.S. Forest Service	Coal Creek	-----	Stockwatering	July 1 to September 30
93-80	Reed Neilson	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-81	Bernard Nielsen	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-82	Utah Power and Light Co.	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-83	U.S. Forest Service	Cox Canyon Creek	-----	Stockwatering	July 1 to September 30
93-84	U.S. Forest Service	Valentine Gulch	-----	Stockwatering	July 1 to September 30
93-85	U.S. Forest Service	Valentine Gulch	-----	Stockwatering	July 1 to September 30
93-89	Valenine Gulch Inc.	Valentine Gulch	-----	Stockwatering	July 1 to September 30
93-96	Utah Power and Light Co.	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-265	Utah Power and Light Co.	Coal Creek	-----	Stockwatering	July 1 to September 30
93-290	Utah Power and Light Co.	Coal Creek	-----	Stockwatering	July 1 to September 30
93-338	U.S. Forest Service	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-346	L.D.S. Church	Little Swens Canyon Cr.	-----	Stockwatering Domestic	June 1 to November 30
93-348	U.S. Forest Service	Spring Creek	-----	Stockwatering	June 16 to October 5
93-399	Utah Power and Light Co.	Huntington Creek	-----	Stockwatering	July 1 to September 30
93-434	William R. Whitehead et al	Kitchen Fork of Huntington Cr.	-----	Stockwatering	June 1 to November 30
93-543	Morris S. & Betty A. Cook	Coal Creek	-----	Stockwatering	July 1 to September 30
93-551	Utah Power and Light Co.	Cox Canyon Creek	-----	Stockwatering	July 1 to September 30
93-553	Utah Power and Light Co.	James Canyon Creek	-----	Stockwatering	July 1 to September 30

Table 18. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-559	Utah Power and Light Co.	Bear Canyon Creek	-----	Stockwatering	July 1 to September 30
93-768	W. Chad Cox	Burns Cox Spring Stream	-----	Stockwatering, Irrig.	----------
93-769	Donald B. Cox	Burns Cox Spring Stream	-----	Stockwatering, Irrig.	----------
93-772	Donald B. Cox	West Fork Jackson Hollow Stream	-----	Stockwatering, Irrig.	----------
93-776	Newel B. Cox	Flat Canyon Creek	-----	Stockwatering	----------
93-777	Donald B. Cox	Flat Canyon Creek	-----	Stockwatering	----------
93-778	A. Ira Cox	Flat Canyon Creek	-----	Stockwatering	----------
93-831	Clark-Montana Realty Co.	Bear Canyon Creek	-----	Stockwatering	----------
93-938	Cottonwood Gooseberry Irr. Co.	Boulger Creek	11.9	Irrigation Domestic	May 15 to September 5

Table 19. Ground water rights in the Price River Basin located on and adjacent to the Skyline Property.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-119	U.S. Forest Service	Spring	0.03	Domestic, Irrigation	March 1 to November 30
91-136	U.S. Forest Service	Beaver Dam Ridge Spring	0.006	Stockwatering	May 1 to October 31
91-200	Utah Natural Gas Company (½ interest)	Underground Water, well	0.134	Domestic Irrigation	January 1 to December 31
91-201	Earl Thomas	Spring with storage	0.068	Stockwatering	April 15 to November 1
91-288	U.S. Forest Service	Gooseberry Campground Spring	0.098	Domestic	May 1 to October 31
91-408	Calvin K. Jacob	Spring	0.011	Stockwatering	May 1 to November 30
91-424	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-425	Nick Marakis (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-432	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-433	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-434	Nick Marakis (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-435	Nick Marakis (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-455	Robert Radakovich	Spring	0.011	Stockwatering	May 1 to December 15
91-463	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-464	John Marakis Estate (½ interest)	Spring	0.022	Stockwatering	January 1 to December 31
91-472	John Marakis Estate (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31

Table 19. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-473	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-474	John Marakis Estate (½ interest)	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-475	John Marakis Estate (½ interest)	Spring	0.011	Stockwatering	January 1 to December 31
91-481	Robert Radakovich	Spring	0.011	Stockwatering	May 1 to December 15
91-1035	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1036	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1039	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1045	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1046	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to September 30
91-1122	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 10
91-1123	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 5
91-1124	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 5
91-1125	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 5
91-1126	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 5
91-1127	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 5
91-1144	U.S. Forest Service	Gooseberry Campground Spring	0.015	Stockwatering	June 6 to October 10
91-1150	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 5
91-1151	U.S. Forest Service	Spring	0.015	Stockwatering	July 1 to October 5
91-1153	U.S. Forest Service	Summer Home Area Spring	0.015	Stockwatering	June 1 to November 1

Table 19. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-1158	N.M. Jensen Investment Co.	Aagard Spring	0.638	Irr.,Stock., Domestic	June 1 to October 31
91-1643	Jack Thomas	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-1644	Lee Thomas (1/3 interest)	Spring	----	Stockwatering	May 1 to October 31
91-1679	Calvin K. Jacob	Spring	0.011	Stock. and Domestic	May 1 to November 30
91-1680	Calvin K. Jacob	Spring	0.011	Stockwatering	May 1 to November 30
91-1681	Calvin K. Jacob	Spring	0.011	Stockwatering	May 1 to November 30
91-1699	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1700	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1701	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1702	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1710	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1711	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1714	N.M. Jensen Investment Co.	Spring	0.022	Stockwatering	June 1 to October 31
91-1986	Angelo Georgedes	Spring with storage	0.05	Fish Culture	January 1 to December 31
91-2049	John Jouflas Estate (2/3 interest)	Spring	0.011	Stockwatering	May 1 to October 31
91-2144	Elrie and Bertha Simonsen (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2145	Robert Radakovich (½ interest)	Simonsen Spring	0.022	Domestic	January 1 to December 31
91-2288	Elrie & Bertha Simonsen	Spring	0.011	Stockwatering	June 1 to November 30
91-2494	Elrie & Bertha Simonsen	Mooney Mine Spring	----	Irrigation Stockwatering	March 1 to November 30

Table 19. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-2669	Della Simonsen	Spring	0.011	Stockwatering	April 1 to November 30
91-2970	Angelo Georgedes	Spring	0.015	Stockwatering	May 1 to October 31
91-2975	Justus O. Seely	Spring	0.011	Irrigation, Stock.	January 1 to December 31
91-2976	Justus O. Seely	Spring	0.011	Irrigation, Stock.	January 1 to December 31
91-3012	Angelo Georgedes	Spring	0.015	Irrigation, Stock.	January 1 to December 31
91-3076	Milton A. Oman	Spring	0.011	Stockwatering	January 1 to December 31
91-3078	Milton A. Oman	Spring	0.011	Stockwatering	January 1 to December 31
91-3087	Anton Michelog	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-3094	Scofield Town	3 Springs	0.033	Municipal	January 1 to December 31
91-3163	Pete Frandsen	Spring	0.011	Stockwatering	June 1 to November 30
91-3401	Waino E. Burton	Underground water, well	0.011	Stock. and Domestic	January 1 to December 31
91-3402	Waino E. Burton	Underground water, well	0.011	Stock. and Domestic	January 1 to December 31
91-3406	Della L. Madsen	Spring	0.011	Stockwatering	April 1 to November 30
91-3460	Mountain Fuel Supply Co. (½ interest)	Underground Water, well	0.134	Domestic, Irr., Misc.	January 1 to December 31
91-3499	Lavern Jensen	Finn Spring	0.011	Stock. and Domestic	January 1 to December 31
91-3500	Lavern Jensen	Spring	0.011	Stock. and Domestic	January 1 to December 31
91-3586	North American Coal Corp.	Clear Creek Spring Area	0.50	Domestic, Stock., Irr., Industrial	January 1 to December 31
91-3590	North American Coal Corp. (Underground Water)	Clear Creek Mine Tunnel No. 3	0.446	Industrial	January 1 to December 31
91-3596	North American Coal Corp. (Underground Water)	O'Connor Mine Tunnel No. 2	0.047	Industrial	January 1 to December 31

Table 19. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
91-3601	Della L. Madsen	Spring	0.011	Stockwatering	June 1 to November 30
91-3634	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3638	D. Euray Allred	Spring	0.011	Stockwatering	May 1 to November 30
91-3642	John B. Jones	Spring with storage	0.011	Stockwatering	January 1 to December 31
91-3668	Angelo Georgedes	Spring	0.015	Stockwatering	May 1 to October 31
91-3971	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3973	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3974	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3975	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3976	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3977	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3978	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3979	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3980	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3981	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3982	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3983	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30
91-3985	Lionel L. Peterson	Spring	0.022	Stock. and Domestic	May 1 to November 30

Table 20. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-59	Clyde K. Cox	Saw Mill Spring	-----	Stockwatering, Irrig.	----------
93-60	Roscoe C. Cox	Stan Spring #1	-----	Stockwatering	----------
93-61	Roscoe C. Cox	Stan Spring #2	-----	Stockwatering	----------
93-62	Stanley Cox	Saw Mill Springs	-----	Stockwatering, Irrig.	----------
93-63	Stanley Cox	Stan Spring #1	-----	Stockwatering, Irrig.	----------
93-64	Roscoe C. Cox	Stan Spring #1	-----	Stockwatering, Irrig.	----------
93-65	Doris R. Cox	Stan Spring #2	-----	Stockwatering, Irrig.	----------
93-66	Donald B. Cox	Stan Spring #2	-----	Stockwatering, Irrig.	----------
93-67	Newel B. Cox	Mineral Spring #2	-----	Stockwatering, Irrig.	----------
93-68	Evan Cox	Stan Spring #2	-----	Stockwatering, Irrig.	
93-69	A. Ira Cox	Stan Spring #2	-----	Stockwatering, Irrig.	----------
93-70	Olea D. Cox	Mineral Spring #2	-----	Stockwatering, Irrig.	----------
93-71	Roscoe C. Cox	Worth Spring Stream	-----	Stockwatering, Irrig.	----------
93-72	Evan Cox	Ross Spring #2	-----	Stockwatering	----------
93-75	Evan Cox	Ross Spring #3	-----	Stockwatering	----------
93-90	L.D.S. Church	Unnamed Spring	0.022	Stockwatering Domestic	June 1 to November 30
93-114	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-127	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-145	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-153	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-154	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30

Table 20. Continued.

Water Use Claim No.	Owner	Source	Flow (cfs)	Purpose of Use	Period of Use
93-404	Russel O. Brown	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-411	M. Dover Hunt	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-429	Don Evans	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-430	Eli Clayson	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-431	Clark T. Thorstensen	Unnamed Spring	0.0222	Stockwatering	June 1 to October 15
93-432	Crowther Investment Company	Brooks Canyon Divide	0.011	Stockwatering	June 1 to October 15
93-433	William R. Whitehead et al	Unnamed Spring	0.011	Stockwatering	June 1 to October 15
93-435	Crowther Investment Company	Unnamed Spring	0.011	Stockwatering	June 1 to October 15
93-449	Crowther Investment Company	Unnamed Spring	0.011	Stockwatering Domestic	June 1 to October 15
93-763	Robert N. Anderson	Unnamed Spring #8	0.018	Stockwatering	June 15 to October 15
93-770	W. Chad Cox	Spring House Spring	-----	Irrigation Stockwatering	----------
93-771	Donald B. Cox	Spring House Spring	-----	Irrigation Stockwatering	----------
93-773	Roscoe C. Cox	Ross Spring #1	-----	Stockwatering	----------
93-774	A. Ira Cox	Ike Spring #1	-----	Stockwatering	----------
93-775	A. Ira Cox	Ike Spring #2	-----	Stockwatering	----------
93-838	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-839	L.D.S. Church	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-840	N. M. Jensen Investment Company	Unnamed Spring	0.022	Stockwatering	June 1 to November 30
93-841	N. M. Jensen Investment Company	Unnamed Spring	0.022	Stockwatering Domestic	June 1 to November 30

Table 21. Water right exchanges in the Skyline Property area.

Water Use Claim No.	Owner	Source	Flow	Purpose of Use	Period of Use
91-164	Louise Gorishek	Well	1.0 A.F.	Domestic	January 1 to December 31
91-452	Robert Radakovich	Well	1.0 A.F.	Stockwatering	March 1 to November 30
91-772	Valley Camp Coal Company	Well	0.446 cfs	Industrial Domestic	January 1 to December 31
91-940	Gooseberry Enterprise Inc.	Springs	66.0 A.F.	Domestic	January 1 to December 31
91-1058	Price River Water Users Assoc.	Well	7.7 A.F.	Industrial Domestic	January 1 to December 31
91-1114	Coastal States Energy Co.	Wells	30.0 A.F.	Industrial Domestic	January 1 to December 31
91-1560	Coastal States Energy Co.	Wells	118.0 A.F.	Industrial Domestic	January 1 to December 31

Although the Blackhawk Formation is saturated above the mine workings, a relatively insignificant quantity of water will likely be encountered in the mines due to the impermeable nature of the formation and its inability to yield water readily. Hansen(1979) reports that mines in the Wasatch Plateau coal field generally yield less than 10 gallons per minute per active face, with drifts dry approximately 500 feet up-dip from the face. Once a section dries up, leaks reappear only very occassionally in the future. This condition has been observed locally in the O'Connor and Belina No. 1 Mines. Apparently, only a zone of saturated rock immediately adjacent to the mine is dewatered by the drift.

Should the mines encounter sandstone lenses at the face of a fault, the inflow rate to the mine could change rapidly for a short period of time, as noted in the nearby Belina No. 1 Mine. Such a condition is expected at the Connelville Fault (as occurred in the Belina No. 1 Mine) and at the Valentine Fault (as noted in increased flows while drilling W35-1). Under these conditions, inflow rates could exceed 1000 gallons per minute for a short period, decreasing rapidly to a more normal rate (10 to 25 gallons per minute).

In any case, water encountered in the mines will be utilized underground for dust suppression, etc. As a result, only those inflows which temporarily exceed storage and mine use requirements should be discharged to the surface. Because of the westerly dip of the strata in the area, this water normally would have been destined for a basin west of the Carbon-Emery County line. Thus, discharging this water to the surface in Eccles Canyon should result in a small depletion in the amount of water which would have reached another basin. However, because most of the water will be reused in the mine, the volume of this discharged water will be insignificant. As a result, most of the water which

some distance away from the lease area. As a result of these natural conditions, this water is likely much more saline when it finally discharges than when it leaves the property area.

Because mines in the coal fields of the Wasatch Plateau act as interceptor drains, the ground water that is brought to the surface has a lower dissolved solids content than would have existed if the water was to continue its downward movement through shaley layers, dissolving increased amounts of salt with distance (Southeastern Utah Association of Governments, 1977; Hansen, 1979). As a result, the Skyline Mines will have a slightly beneficial impact on the chemical quality of water in the region, because the small amount of water which is brought to the surface will dissolve fewer constituents in the stream channel than it would have in the shaley formations (particularly the Mancos Shale below the Star Point Sandstone) which it would have encountered (Bentley et al.,1978). Although suspended sediment and oil and grease may increase at the mine mouth, these constituents will be removed in keeping with regulatory requirements prior to any potential discharge into adjacent streams.

Because of the high alkalinity and low acidity concentrations in the area (differing normally by two orders of magnitude), acid drainage problems should not occur as a result of mining. This is fortified by the fact that coal in the area has a low sulphur content (U.S. Geological Survey, 1979).

Cumulative Impact

The Scofield-Clear Creek area is one of the oldest and most consistent mining areas in the Wasatch Plateau coal field (Doelling, 1972). Mining activities should continue in the area into the 21st century.

Renfro, G. W. 1975. Use of Erosion Equations and Sediment Delivery Ratios for Predicting Sediment Yield. In Present and Prospective Technology for Predicting Sediment Yields and Sources. USDA Agricultural Research Service. ARS-S-40. Oxford, Mississippi.

Riggs, H. C. 1969. Mean Streamflow From Discharge Measurement. Bulletin of the International Association of Scientific Hydrology. 14(4): 95-110.

Sanders Associates, Inc. No Date. An Evaluation of the Coal Reserves, McKinnon Coal Properties, Western Portion of the Clear Creek Mining District, Carbon and Emery Counties, Utah. Report prepared for Murphy Oil Corporation. Kaysville, Utah.

Searcy, J. K. 1959. Flow Duration Curves. U.S. Geological Survey Water Supply Paper 1542-A. Washington, D.C.

Sellars, W. D. 1965. Physical Climatology. University of Chicago Press. Chicago, Illinois.

Shown, L.M. 1970. Evaluation of a Method for Estimating Sediment Yield. USGS Professional Paper 700-B. p. B245-B249.

Southeastern Utah Association of Governments. 1979. Waste Water Quality Management Planning Program (208) for Emery, Carbon, and Grand Counties, Utah. Price, Utah.

Spieker, E. M. 1931. The Wasatch Plateau Coal Field, Utah. U.S. Geological Survey Bulletin No. 819. Washington, D.C.

Stokes, W. L. (ed). 1964. Geological Map of Utah. University of Utah. Salt Lake City, Utah.

Storey, H. C., R. L. Hobba, and J.M. Rosa, 1964. Hydrology of Forest Lands and Rangelands. In V.T. Chow (ed). Handbook of Applied Hydrolgoy. McGraw-Hill Book Company. New York, New York.

Strand, R. I. 1975. Bureau of Reclamation Procedures for Predicting Sediment Yields. In Present and Prospective Technology for Predicting Sediment Yields and Sources. USDA Agricultural Research Service. ARS-S-40. Oxford, Mississippi.

U.S. Bureau of Reclamation. 1974. Water Measurement Manual. Second Edition-Revised Reprint. Denver, Colorado.

U.S. Bureau of Reclamation, 1977. Ground Water Manual- A Water Resources Technical Publication. U.S. Department of the Interior. Washington, D.C.

U.S. Environmental Protection Agency. 1975. Quality Criteria for Water - Preliminary Draft. Washington, D.C.

U.S. Geological Survey. 1979. Development of Coal Resources in Central Utah - Final Environmental Statement. Salt Lake City, Utah.

U.S. Soil Conservation Service. 1972. SCS National Engineering Handbook - Section 4: Hydrology. Washington, D.C.

LITERATURE CITED

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1976. Standard Methods for the Examination of Water and Wastewater. Fourteenth Edition, Washington. D. C.

Bentley, R. G., Jr., K. O. Eggleston, D. Price, E. R. Frandsen, and A. R. Dickerman. 1978. The Effects of Surface Disturbance on the Salinity of Public Lands in the Upper Colorado River Basin - 1977 Status Report. U. S. Bureau of Land Management. Denver, Colorado.

Buchanan, T. J. and W. P. Somers, 1969. Discharge Measurements at Gaging Stations. Techniques of Water-Resources Investigations of the United States Geological Survey. Book 3, Chapter A8.

Clyde, C. G., E. E. Israelsen, P. E. Packer, E. E. Farmer, J. E. Fletcher, E. K. Israelsen, F. W. Haws, N. V. Rao, and J. Hansen. 1978. Manual of Erosion Control Principles and Practices. Hydraulics and Hydrology Series Report H-78-002. Utah Water Research Laboratory. Utah State University. Logan, Utah.

Cordova, R. M. 1964. Hydrogeologic Reconnaissance of Part of the Headwaters Area of the Price River, Utah. Utah Geological and Mineralogical Survey Water Resources Bulletin No. 4. Salt Lake City, Utah.

Doelling, H. H. 1972. Wasatch Plateau Coal Fields. In Doelling, H. H. (ed.). Central Utah Coal Fields; Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery. Utah Geological and Mineralogical Survey Monograph Servies No. 3. Salt Lake City, Utah.

Fields, F. K. 1975. Estimating Streamflow Characteristics for Streams in Utah Using Selected Channel-Geometry Parameters. U.S. Geological Survey Water-Resources Investigations 34-74. Salt Lake City, Utah.

Flaxman, E. M. 1975. The Use of Suspended-Sediment Load Measurements and Equations for Evaluation of Sediment Yield in the West. In Present and Prospective Technology for Predicting Sediment Yields and Sources. USDA Agricultural Research Service. ARS-S-40. Oxford, Mississippi.

Grunsky, C. E. 1908. Rain and Runoff Near San Francisco, California. Transactions of the American Society of Civil Engineers. p. 496-543.

Hansen, V. E. 1979. Mines Prevent Deterioration in Water Quality. Paper presented at the American Water Resources Association Symposium:Water Resource Management in a Changing Society. Las Vegas, Nevada.

Hawkins, R. H. 1973. Improved Prediction of Storm Runoff in Mountain Watersheds. ASCE Journal of the Irrigation and Drainage Division. 99 (IR4):519-523.

Hawkins, R. H. 1976. Estimating Annual Water Yield-Grunsky's Rule. Class handout prepared for WS540 (Watershed Operations). Watershed Science Unit. Utah State University. Logan, Utah.

SKYLINE MINES

MINING AND RECLAMATION PLAN

COASTAL STATES ENERGY COMPANY

1986

APPENDIX

VOLUME A-1

Winter Quarters Canyon
Data Adequacy

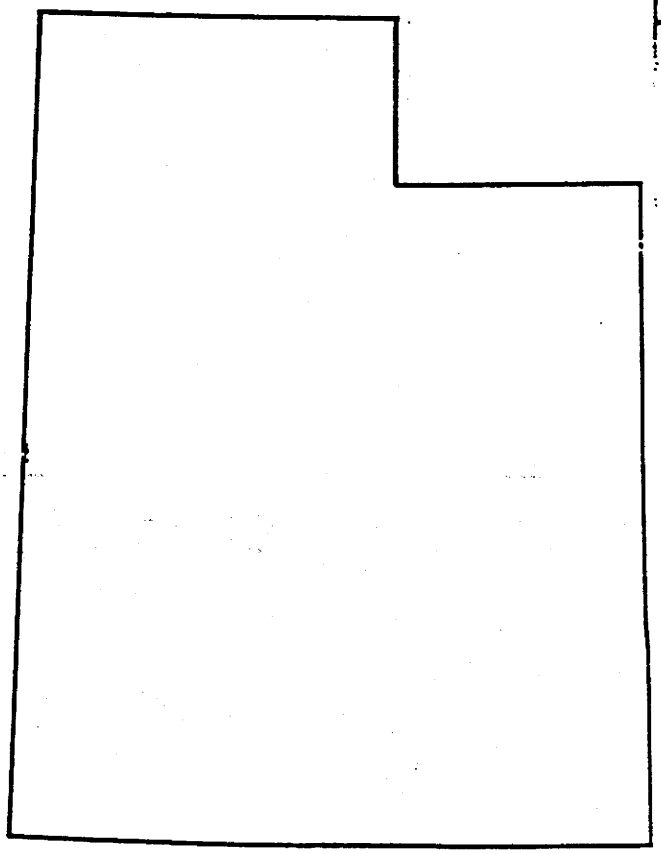
October 1992

U.S. FOREST SERVICE
MANTI LA SAL FOREST
DENNIS KELLY DATA FILES

HUNTINGTON CREEK

Water Resources Data
Utah
Water Year 1990

MANTI-LASAL N.F.
JUN 1 9 1991
FS | ROUTE
RG
TM
EN
RE
AC
RANGER COPY



U.S. GEOLOGICAL SURVEY WATER-DATA REPORT UT-90-1
Prepared in cooperation with the State of Utah
and with other agencies

09317997 HUNTINGTON CREEK NEAR HUNTINGTON, UT

LOCATION.--Lat 39°23'07", long 111°05'15", in SE¼NE¼SW¼, sec. 36, T. 16 S., R. 7 E., Emery County, Hydrologic Unit 14060009, on right bank about 500 ft upstream from bridge to Deer Creek Mine, 8 mi northwest of Huntington.

DRAINAGE AREA.--178 mi^2, approximately.

PERIOD OF RECORD.--October 1979 to current year. Water years 1981-85 not published, records available in office of Utah Power & Light Co., located in Salt Lake City, Ut.

GAGE.--Water-stage recorder. Elevation of gage is 6,450 ft above NGVD of 1929, from topographic map.

REMARKS.--Records good. Small transmountain diversions to tributaries of San Pitch River (Sevier Lake Basin). Flow regulated by reservoirs above station.

COOPERATION.--Records collected by Utah Power & Light Co.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharage, 1,680 ft^3/s May 24, 1984, gage height, 4.96 ft; minimum, 3.0 ft^3/s Feb. 2-5, 1981.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 283 ft^3/s Aug. 15, gage height, 3.62 ft; minimum discharge, 3.60 ft^3/s Dec. 2.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	23	16	15	18	19	19	29	51	78	100	52	48
2	24	17	12	21	19	19	30	52	76	99	52	53
3	22	18	15	13	15	19	31	60	76	97	51	51
4	21	17	11	12	19	19	32	63	81	80	51	54
5	23	17	14	19	20	19	32	70	84	78	47	87
6	25	18	27	18	16	19	35	71	80	79	47	66
7	23	17	20	20	22	19	39	69	79	79	50	60
8	22	16	17	21	17	18	38	70	81	81	56	59
9	19	16	20	21	17	19	34	66	81	80	56	58
10	18	16	16	20	22	19	32	94	84	76	59	57
11	18	16	8.4	20	20	19	35	86	119	59	61	56
12	18	16	10	18	20	17	40	90	124	60	59	55
13	18	16	13	19	20	17	46	86	95	59	60	52
14	18	18	19	19	18	18	49	88	84	59	71	45
15	20	19	22	19	11	19	55	89	78	61	83	44
16	19	21	19	18	19	18	59	87	79	60	79	47
17	17	22	18	17	25	22	59	91	80	58	79	45
18	17	22	18	14	23	24	57	94	82	66	74	60
19	19	22	13	19	22	25	58	95	80	64	73	66
20	19	22	14	14	20	26	63	95	67	69	74	63
21	20	22	17	11	20	27	67	93	63	64	71	61
22	21	21	18	15	21	28	65	99	62	60	57	65
23	19	21	16	20	22	29	65	89	65	59	59	65
24	18	22	17	16	22	28	63	79	66	62	59	80
25	17	23	13	15	22	29	52	77	72	56	56	69
26	16	23	15	20	21	30	54	83	78	53	53	58
27	15	17	20	14	20	30	49	83	107	52	51	42
28	17	17	23	20	19	30	58	84	103	51	53	48
29	16	16	16	21	---	29	54	85	101	52	45	48
30	16	17	20	20	---	28	51	79	101	53	49	46
31	17	---	17	21	---	28	---	79	---	54	47	---
TOTAL	595	561	513.4	553	551	710	1431	2497	2506	2080	1834	1708
MEAN	19.2	18.7	16.6	17.8	19.7	22.9	47.7	80.5	83.5	67.1	59.2	56.9
MAX	25	23	27	21	25	30	67	99	124	100	83	87
MIN	15	16	8.4	11	11	17	29	51	62	51	45	42
AC-FT	1180	1110	1020	1100	1090	1410	2840	4950	4970	4130	3640	3390

CAL YR 1989 TOTAL 20082.4 MEAN 55.0 MAX 139 MIN 8.4 AC-FT 39830
WTR YR 1990 TOTAL 15539.4 MEAN 42.6 MAX 124 MIN 8.4 AC-FT 30820

SUMMARY OF WATER QUALITY
ANALYSIS - SITE CS-7

STATION LOCATION - BURNOUT CREEK AT CONFLUENCE WITH HUNTINGTON CREEK

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/17/88	06/03/88	07/28/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					9	19	17
FLOW (CFS)					5.07	1.97	0.38
WATER TEMPERATURE (C)					4	9	11.5
SPEC. COND. (UMHOS/CM) FIELD					287	359	387
PH (SU) FIELD					7.2	7.6	7.6
TURBIDITY (NTU) FIELD					17.5	1.45	1.6
TOTAL SUSP. SOLIDS							
TOTAL DISS. SOLIDS MEAS.							
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)							
MAGNESIUM (MG)							
SODIUM (NA)							
POTASSIUM (K)							
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)							
SULFATE (SO4)							
CHLORIDE (CL)							
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)							
TOTAL PHOSPHATE (PO4)							
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL							
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL							
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS							
OIL AND GREASE							
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA

STATION LOCATION - BURNOUT CREEK AT CONFLUENCE WITH HUNTINGTON CREEK

SAMPLE DATE	08/18/88	10/11/88	06/22/89	09/07/89	10/17/89	06/05/90	09/11/90
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	19	13	15	17	8	22	23
FLOW (CFS)	0.09	0.21	0.58	0.14	0.13	1.31	0.16
WATER TEMPERATURE (C)	9.5	8	7	5.5	3	9	15
SPEC. COND. (UMHOS/CM) FIELD	407	413	410	447	320	293	374
PH (SU) FIELD	7.3	7.2	7.3	7.1	8.15	7.5	8.1
TURBIDITY (NTU) FIELD	1.8	0.8	1.0	0.88	0.83	4.7	2.0
TOTAL SUSP. SOLIDS	7		3	<1.00	<1.00	12	2
TOTAL DISS. SOLIDS MEAS.	230		212	209	225	166	178
OXYGEN (O) DISS	8.4			9.2			7.7
COMMON IONS							
CALCIUM (CA)	69.6		61.71	60.83	60.75	53.85	51.87
MAGNESIUM (MG)	8.16		9.22	12.91	11.65	7.92	12.33
SODIUM (NA)	4.18		9.20	1.48	1.83	3.59	1.77
POTASSIUM (K)	<0.50		<0.50	0.92	0.67	<0.50	0.82
ACIDITY AS CACO3	7			<0.10			3.60
ALKALINITY AS CACO3 (LAB)	194			189			178
BICARBONATE (HCO3) (LAB)	237		251	230	227	196	217
SULFATE (SO4)	19		7	14	11	10	7.9
CHLORIDE (CL)	1.9		1.9	2.1	2.0	1.3	2.2
FLUORIDE (F)	0.13			0.10			0.10
NUTRIENTS							
NITRATE (NO3-N)	0.62		0.57	0.72	1.22	0.52	0.52
AMMONIA (NH3 AS N)	0.08		<0.03	0.15	0.11	<0.03	0.05
TOTAL PHOSPHATE (PO4)	<0.04		<0.04	<0.04	<0.04	<0.04	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.03			0.02			0.03
BARIUM (BA) DISS				0.02			0.02
BORON (B) TOTAL	<0.001			<0.001			<0.005
BORON (B) DISS				<0.001			<0.005
COPPER (CU) TOTAL	0.02			<0.01			<0.01
COPPER (CU) DISS				<0.01			<0.01
IRON (FE) TOTAL	0.12		0.13	0.09	<0.07	0.09	0.09
IRON (FE) DISS				<0.01			<0.03
LEAD (PB) TOTAL	<0.001			<0.001			<0.002
LEAD (PB) DISS				<0.001			<0.002
MANGANESE (MN) TOTAL	0.03		0.02	<0.02	<0.01	<0.01	0.02
MANGANESE (MN) DISS				<0.01			<0.01
ZINC (ZN) TOTAL	<0.005						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	2.77						
PHENOLS	<0.001						
OIL AND GREASE	0.4						
CYANIDE (CN) TOTAL	<0.001						

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION CS-7
NT SAMPLE

STATION LOCATION - BURNOUT CREEK AT CONFLUENCE WITH HUNTINGTON CREEK

SAMPLE DATE	10/24/90	06/19/91	09/05/91	10/15/91
PHYSICAL PARAMETERS				
AIR TEMPERATURE (C)	10.5	16	20.5	22.5
FLOW (CFS)	0.17	3.56	0.28	0.37
WATER TEMPERATURE (C)	7	13.5	10.5	9
EC. COND. (UMHOS/CM) FIELD	406	322	356	387
PH (SU) FIELD	7.7	8.25	8.15	7.88
TURBIDITY (NTU) FIELD	0.5	5	2	1.9
TOTAL SUSP. SOLIDS	<1.0	15	2	<1
TOTAL DISS. SOLIDS MEAS.	210	174	188	206
OXYGEN (D) DISS			5.8	
COMMON IONS				
CALCIUM (CA)	61.77	57.72	51.21	60.44
MAGNESIUM (MG)	11.47	9.24	12.97	12.35
SODIUM (NA)	2.42	3.07	0.63	2.10
POTASSIUM (K)	1.01	1.13	0.72	<0.70
ACIDITY AS CACO3			3.80	
ALKALINITY AS CACO3 (LAB)			178	
BICARBONATE (HCO3) (LAB)	232	283	218	221
SULFATE (SO4)	8.0	16.5	10.4	9.1
CHLORIDE (CL)	2.2	5.0	1.9	2.8
FLUORIDE (F)			<0.20	
NUTRIENTS				
NITRATE (NO3-N)	0.54	0.38	0.51	0.84
AMMONIA (NH3 AS N)	<0.03	0.06	0.02	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	<0.05	0.05	0.03
TRACE ELEMENTS				
BARIUM (BA) TOTAL			0.040	
BARIUM (BA) DISS			0.020	
BORON (B) TOTAL			<0.050	
BORON (B) DISS			<0.050	
COPPER (CU) TOTAL			<0.006	
COPPER (CU) DISS			<0.006	
IRON (FE) TOTAL	0.08	0.320	0.030	0.15
IRON (FE) DISS			0.010	
LEAD (PB) TOTAL			<0.003	
LEAD (PB) DISS			<0.003	
MANGANESE (MN) TOTAL	<0.01	<0.033	<0.048	<0.02
MANGANESE (MN) DISS			<0.018	
ZINC (ZN) TOTAL				
ORGANIC PARAMETERS				
ORGANIC CARBON (TOTAL)				
PHENOLS				
OIL AND GREASE				
CYANIDE (CN) TOTAL				

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSIS - SITE CS-8

STATION LOCATION - RIGHT FORK OF UPPER HUNTINGTON CREEK

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/16/88	06/03/88	07/28/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					23	21	17
FLOW (CFS)					9.74	1.59	0.14
WATER TEMPERATURE (C)					6.5	6.5	8
SPEC. COND. (UMHOS/CM) FIELD					123	193	362
PH (SU) FIELD					6.7	7.6	7.3
TURBIDITY (NTU) FIELD					26	1.45	1.6
TOTAL SUSP. SOLIDS							
TOTAL DISS. SOLIDS MEAS.							
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)							
MAGNESIUM (MG)							
SODIUM (NA)							
POTASSIUM (K)							
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)							
SULFATE (SO4)							
CHLORIDE (CL)							
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)							
TOTAL PHOSPHATE (PO4)							
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL							
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL							
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS							
OIL AND GREASE							
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION DS - 8

STATION LOCATION - RIGHT FORK OF UPPER HUNTINGTON CREEK

SAMPLE DATE	08/18/88	10/11/88	06/21/89	09/06/89	10/17/89	06/05/90	09/11/90
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	13	12	14	24	7	19	25.5
FLOW (CFS)	0.1	0.10	0.32	0.05	0.04	1.23	0.074
WATER TEMPERATURE (C)	7	7	12	12	2	12	13.5
SPEC. COND. (UMHOS/CM) FIELD	393	418	293	448	350	140	401
PH (SU) FIELD	7.2	7.0	7.4	7.0	7.9	7.0	8.1
TURBIDITY (NTU) FIELD	1.6	2.35	1.5	1.5	1	9.3	4.3
TOTAL SUSP. SOLIDS	2		2	3	<1	10	<1.00
TOTAL DISS. SOLIDS MEAS.	245		158	204	225	84	218
OXYGEN (O) DISS	8.8			8.1			7.4
COMMON IONS							
CALCIUM (CA)	75.2		39.46	63.09	62.19	24.13	65.44
MAGNESIUM (MG)	9.12		5.44	12.06	11.16	3.19	11.44
SODIUM (NA)	4.28		5.08	2.08	2.72	4.82	3.08
POTASSIUM (K)	<0.50		<0.50	0.92	1.04	<0.50	0.052
ACIDITY AS CACO3	<0.05			<0.10			14.60
ALKALINITY AS CACO3 (LAB)	193			173			193
BICARBONATE (HCO3) (LAB)	235		146	211	211	85.0	235
SULFATE (SO4)	34		9	30	25	16	16.0
CHLORIDE (CL)	2.1		2.3	2.9	3.9	3.1	4.7
FLUORIDE (F)	0.12			0.16			0.06
NUTRIENTS							
NITRATE (NO3-N)	0.56		0.27	0.47	0.47	0.12	0.46
AMMONIA (NH3 AS N)	0.08		<0.03	0.04	0.13	0.05	0.04
TOTAL PHOSPHATE (PO4)	<0.04		<0.04	<0.04	<0.04	<0.04	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.02			0.02			0.02
BARIUM (BA) DISS				0.02			0.02
BORON (B) TOTAL	<0.001			0.040			<0.020
BORON (B) DISS				0.035			<0.020
COPPER (CU) TOTAL	0.02			<0.01			<0.01
COPPER (CU) DISS				<0.01			<0.01
IRON (FE) TOTAL	0.16		0.22	0.09	0.10	0.44	0.13
IRON (FE) DISS				<0.03			<0.03
LEAD (PB) TOTAL	<0.001			<0.001			<0.001
LEAD (PB) DISS				<0.001			<0.001
MANGANESE (MN) TOTAL	0.03		0.04	<0.01	<0.01	<0.01	<0.01
MANGANESE (MN) DISS				<0.01			<0.01
ZINC (ZN) TOTAL	<0.005						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	2.49						
PHENOLS	<0.001						
OIL AND GREASE	0.7						
CYANIDE (CN) TOTAL	<0.001						

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION CS - 2

STATION LOCATION - RIGHT FORK OF UPPER HUNTINGTON CREEK

MOST RECENT SAMPLE

SAMPLE DATE	10/25/90	06/12/91	09/03/91	10/16/91
PHYSICAL PARAMETERS				
AIR TEMPERATURE (C)	4	15	21	19
FLOW (CFS)	0.08	4.58	0.061	0.06
WATER TEMPERATURE (C)	3	8.5	10.5	8
SPEC. COND. (UMHOS/CM) FIELD	404	125	390	392
PH (SU) FIELD	6.5	7.50	7.93	7.88
TURBIDITY (NTU) FIELD	2	3	4.5	3.4
TOTAL SUSP. SOLIDS	1	10	<2.0	2
TOTAL DISS. SOLIDS MEAS.	220	106	182	224
OXYGEN (O) DISS			3.9	
COMMON IONS				
CALCIUM (CA)	58.90	20.74	78.43	63.65
MAGNESIUM (MG)	10.13	2.90	8.79	11.00
SODIUM (NA)	4.19	2.46	<0.51	3.87
POTASSIUM (K)	1.10	<0.32	<0.51	0.75
ACIDITY AS CACO3			7.70	
ALKALINITY AS CACO3 (LAB)			205	
BICARBONATE (HCO3) (LAB)	205	78.0	251	218
SULFATE (SO4)	16.5	6.1	4.6	17.5
CHLORIDE (CL)	5.6	2.8	1.3	6.3
FLUORIDE (F)			<0.20	
NUTRIENTS				
NITRATE (NO3-N)	0.38	0.21	0.46	
AMMONIA (NH3 AS N)	<0.03	0.05	0.03	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	0.03	0.06	0.03
TRACE ELEMENTS				
BARIUM (BA) TOTAL			0.020	
BARIUM (BA) DISS			0.020	
BORON (B) TOTAL			0.400	
BORON (B) DISS			<0.050	
COPPER (CU) TOTAL			0.030	
COPPER (CU) DISS			<0.002	
IRON (FE) TOTAL	0.09	0.590	0.070	0.19
IRON (FE) DISS			<0.009	
LEAD (PB) TOTAL			0.003	
LEAD (PB) DISS			<0.002	
MANGANESE (MN) TOTAL	0.03	<0.033	0.013	<0.02
MANGANESE (MN) DISS			<0.018	
ZINC (ZN) TOTAL				
ORGANIC PARAMETERS				
ORGANIC CARBON (TOTAL)				
PHENOLS				
OIL AND GREASE				
CYANIDE (CN) TOTAL				

SUMMARY OF WATER QUALITY
ANALYSIS - SITE CS-10

STATION LOCATION - UPPER LEFT FORK OF HUNTINGTON CREEK

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/16/88	06/03/88	07/28/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					23	18.5	17
FLOW (CFS)					28.04	5.2	0.42
WATER TEMPERATURE (C)					9	6.5	11
SPEC. COND. (UMHOS/CM) FIELD					133	191	272
PH (SU) FIELD					6.5	7.0	7.3
TURBIDITY (NTU) FIELD					51	7.6	4.9
TOTAL SUSP. SOLIDS							
TOTAL DISS. SOLIDS MEAS.							
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)							
MAGNESIUM (MG)							
SODIUM (NA)							
POTASSIUM (K)							
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)							
SULFATE (SO4)							
CHLORIDE (CL)							
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)							
TOTAL PHOSPHATE (PO4)							
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL							
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL							
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS							
OIL AND GREASE							
CYANIDE (CN)							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE CS-10

STATION LOCATION - UPPER LEFT FORK OF HUNTINGTON CREEK

SAMPLE DATE	08/18/88	10/11/88	06/21/89	09/06/89	10/17/89	06/05/90	09/11/90
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	15	10	14	20	-5	18	24.5
FLOW (CFS)	0.29	0.30	1.66	0.28	0.25	4.22	0.34
WATER TEMPERATURE (C)	9.5	5.50	13	12	1	10	14.7
SPEC. COND. (UMHOS/CM) FIELD	292	309	262	330	235	132	291
PH (SU) FIELD	7.0	7.1	7.4	6.8	7.7	7.2	7.5
TURBIDITY (NTU) FIELD	4.7	4.9	2.6	5.5	6.3	12.2	6.6
TOTAL SUSP. SOLIDS	1		1	<1.0	2	8	2
TOTAL DISS. SOLIDS MEAS.	180		114	135	158	80	152
OXYGEN (D) DISS	7.6			8.9			9.5
COMMON IONS							
CALCIUM (CA)	56.00		36.61	44.13	45.54	24.18	42.18
MAGNESIUM (MG)	3.84		3.81	6.38	5.66	2.24	6.11
SODIUM (NA)	3.24		2.00	1.10	1.63	3.60	1.70
POTASSIUM (K)	1.06		<0.50	1.08	1.09	<0.50	1.07
ACIDITY AS CACO3	3.00			<0.1			7.20
ALKALINITY AS CACO3 (LAB)	118			104			118
BICARBONATE (HCO3) (LAB)	144		124	127	133	84.0	144
SULFATE (SO4)	39		10	29	26	7	20.2
CHLORIDE (CL)	3.0		1.6	1.8	2.5	1.3	2.0
FLUORIDE (F)	0.10			0.09			0.08
NUTRIENTS							
NITRATE (NO3-N)	0.17		0.16	0.15	0.18	0.08	0.24
AMMONIA (NH3 AS N)	0.04		<0.03	<0.03	0.06	0.04	0.09
TOTAL PHOSPHATE (PO4)	0.06			<0.04	0.07	0.05	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.04			0.03			0.03
BARIUM (BA) DISS				0.03			0.03
BORON (B) TOTAL	<0.001			<0.001			<0.005
BORON (B) DISS				<0.001			<0.005
COPPER (CU) TOTAL	0.02			<0.01			<0.01
COPPER (CU) DISS				<0.01			<0.01
IRON (FE) TOTAL	0.61		0.45	0.69	0.72	0.65	0.73
IRON (FE) DISS				0.16			0.20
LEAD (PB) TOTAL	<0.001			<0.001			<0.001
LEAD (PB) DISS				<0.001			<0.001
MANGANESE (MN) TOTAL	0.05		0.05	0.08	0.06	<0.01	0.04
MANGANESE (MN) DISS				0.06			0.02
ZINC (ZN) TOTAL	<0.005						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	2.82						
PHENOLS	<0.001						
OIL AND GREASE	0.3						
CYANIDE (CN)	<0.001						

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-10

STATION LOCATION - UPPER LEFT FORK OF HUNTINGTON CREEK

SAMPLE DATE	10/24/90	06/12/91	09/05/91	10/16/91
PHYSICAL PARAMETERS				
AIR TEMPERATURE (C)	14	15	17	19
FLOW (CFS)	0.54	12.74	0.24	0.28
WATER TEMPERATURE (C)	7	9	9.8	6
SPEC. CONC. (UMHOS/CM) FIELD	281	123	281	284
PH (SU) FIELD	7.4	7.48	7.22	7.84
TURBIDITY (NTU) FIELD	6	12	3.5	3.5
TOTAL SUSP. SOLIDS	4	9	11	11
TOTAL DISS. SOLIDS MEAS.	162	102	142	156
OXYGEN (O) DISS			6.8	
COMMON IONS				
CALCIUM (CA)	43.28	21.77	51.51	46.31
MAGNESIUM (MG)	5.19	2.26	5.83	5.69
SODIUM (NA)	1.79	3.84	<0.51	1.69
POTASSIUM (K)	1.46	1.01	0.88	<0.70
ACIDITY AS CACO3			1.90	
ALKALINITY AS CACO3 (LAB)			117	
BICARBONATE (HCO3) (LAB)	143	63.0	142	138
SULFATE (SO4)	23.8	6.3	19.3	23.6
CHLORIDE (CL)	2.8	1.6	1.8	3.0
FLUORIDE (F)			<0.20	
NUTRIENTS				
NITRATE (NO3-N)	0.11	0.17	0.19	
AMMONIA (NH3 AS N)	<0.03	0.06	0.05	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	0.02	0.05	0.02
TRACE ELEMENTS				
BARIUM (BA) TOTAL			0.040	
BARIUM (BA) DISS			0.030	
BORON (B) TOTAL			<0.050	
BORON (B) DISS			<0.050	
COPPER (CU) TOTAL			0.010	
COPPER (CU) DISS			<0.006	
IRON (FE) TOTAL	0.63	0.570	0.310	0.55
IRON (FE) DISS			0.110	
LEAD (PB) TOTAL			<0.003	
LEAD (PB) DISS			<0.003	
MANGANESE (MN) TOTAL	0.06	<0.033	0.020	0.03
MANGANESE (MN) DISS			<0.018	
ZINC (ZN) TOTAL				
ORGANIC PARAMETERS				
ORGANIC CARBON (TOTAL)				
PHENOLS				
OIL AND GREASE				
CYANIDE (CN)				

SUMMARY OF WATER QUALITY
ANALYSES SITE UPL-3

STATION LOCATION - HUNTINGTON CREEK BELOW ELECTRIC LAKE

SAMPLE DATE	11/11/86	12/10/86	01/22/87	02/23/87	03/19/87	04/22/87	05/20/87
		STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE		
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	4.0					18.0	8.0
FLOW (CFS)							
WATER TEMPERATURE (C)	4.0					4.0	5.0
SPEC. COND. (UMHOS/CM) FIELD	226					242	275
PH (SU) FIELD	7.10					7.40	7.70
TURBIDITY (NTU) FIELD	1.50					1.30	1.95
TOTAL SUSP. SOLIDS							
TOTAL DISS. SOLIDS MEAS.							
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)							
MAGNESIUM (MG)							
SODIUM (NA)							
POTASSIUM (K)							
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)							
SULFATE (SO4)							
CHLORIDE (CL)							
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)							
TOTAL PHOSPHATE (PO4)							
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL							
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL							
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS							
OIL AND GREASE							
CYANIDE (CN)							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES SITE UPL-3

STATION LOCATION - HUNTINGTON CREEK BELOW ELECTRIC LAKE

SAMPLE DATE	06/23/87	07/28/87	08/19/87	09/22/87	10/21/87	11/19/87	12/15/87
							STATION NOT ACCESSIBLE
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	21.0	19.0	20.0	24.0	12.0	7.0	
FLOW (CFS)							
WATER TEMPERATURE (C)	9.0	9.0	12.0	9.0	7.0	5.0	
SPEC. COND. (UMHOS/CM) FIELD	235	230	223	228	258	252	
PH (SU) FIELD	7.90	7.20	7.60	8.10	6.70	7.00	
TURBIDITY (NTU) FIELD	0.53	1.00	0.91	0.78	0.55	0.83	
TOTAL SUSP. SOLIDS			<1				
TOTAL DISS. SOLIDS MEAS.			130.00				
OXYGEN (O) DISS			8.40				
COMMON IONS							
CALCIUM (CA)			35.54				
MAGNESIUM (MG)			6.40				
SODIUM (NA)			17.20				
POTASSIUM (K)			0.88				
ACIDITY AS CACO3			2.00				
ALKALINITY AS CACO3 (LAB)			147.00				
BICARBONATE (HCO3) (LAB)			179				
SULFATE (SO4)			8				
CHLORIDE (CL)			1.6				
FLUORIDE (F)			0.11				
NUTRIENTS							
NITRATE (NO3-N)			1.81				
AMMONIA (NH3 AS N)			0.05				
TOTAL PHOSPHATE (PO4)			<0.04				
TRACE ELEMENTS							
BARIUM (BA) TOTAL			0.02				
BARIUM (BA) DISS							
BORON (B) TOTAL			<0.001				
BORON (B) DISS							
COPPER (CU) TOTAL			<0.01				
COPPER (CU) DISS							
IRON (FE) TOTAL			0.03				
IRON (FE) DISS							
LEAD (PB) TOTAL			<0.001				
LEAD (PB) DISS							
MANGANESE (MN) TOTAL			<0.01				
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL			<0.005				
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)			31.31				
PHENOLS			<0.001				
OIL AND GREASE			<0.1				
CYANIDE (CN)			0.05				

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES SITE UPL-3

STATION LOCATION - HUNTINGTON CREEK BELOW ELECTRIC LAKE

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/17/88	06/03/88	07/27/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					8.0	18.0	25
FLOW (CFS)							
WATER TEMPERATURE (C)					3.0	6.0	11
SPEC. COND. (UMHOS/CM) FIELD					313	317	281
PH (SU) FIELD					6.70	7.0	7.2
TURBIDITY (NTU) FIELD					3.85	1.95	0.61
TOTAL SUSP. SOLIDS							
TOTAL DISS. SOLIDS MEAS.							
OXYGEN (D) DISS							
COMMON IONS							
CALCIUM (CA)							
MAGNESIUM (MG)							
SODIUM (NA)							
POTASSIUM (K)							
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)							
SULFATE (SO4)							
CHLORIDE (CL)							
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)							
TOTAL PHOSPHATE (PO4)							
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL							
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL							
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS							
OIL AND GREASE							
CYANIDE (CN)							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES SITE UPL-3

STATION LOCATION - HUNTINGTON CREEK BELOW ELECTRIC LAKE

SAMPLE DATE	08/18/88	11/02/88	06/21/89	09/07/89
				STATION DISCONTINUED
PHYSICAL PARAMETERS				
AIR TEMPERATURE (C)	18	6.50	18.00	
FLOW (CFS)				
WATER TEMPERATURE (C)	9	7.0	11.00	
SPEC. COND. (UMHOS/CM) FIELD	278	300	285	
PH (SU) FIELD	6.9	7.20	6.7	
TURBIDITY (NTU) FIELD	0.63	0.71	0.8	
TOTAL SUSP. SOLIDS	1		<1.00	
TOTAL DISS. SOLIDS MEAS.	155		130.00	
OXYGEN (O) DISS	6.6			
COMMON IONS				
CALCIUM (CA)	49.60		36.82	
MAGNESIUM (MG)	<0.10		6.70	
SODIUM (NA)	4.53		4.90	
POTASSIUM (K)	<0.50		<0.50	
ACIDITY AS CACO3	3.00			
ALKALINITY AS CACO3 (LAB)	129			
BICARBONATE (HCO3) (LAB)	157		148	
SULFATE (SO4)	6		7	
CHLORIDE (CL)	2.3		3.5	
FLUORIDE (F)	0.11			
NUTRIENTS				
NITRATE (NO3-N)	0.28		0.19	
AMMONIA (NH3 AS N)	0.05		0.11	
TOTAL PHOSPHATE (PO4)	<0.04		<0.04	
TRACE ELEMENTS				
BARIUM (BA) TOTAL	0.03			
BARIUM (BA) DISS				
BORON (B) TOTAL	0.030			
BORON (B) DISS				
COPPER (CU) TOTAL	<0.01			
COPPER (CU) DISS				
IRON (FE) TOTAL	0.09		<0.03	
IRON (FE) DISS				
LEAD (PB) TOTAL	<0.001			
LEAD (PB) DISS				
MANGANESE (MN) TOTAL	0.03		<0.01	
MANGANESE (MN) DISS				
ZINC (ZN) TOTAL	<0.005			
OTHER PARAMETERS				
ORGANIC CARBON (TOTAL)	3.91			
PHENOLS	<0.001			
OIL AND GREASE	0.4			
CYANIDE (CN)	<0.001			

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES SITE UPL-10

STATION LOCATION - HUNTINGTON CREEK ABOVE ELECTRIC LAKE

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/17/88	06/03/88	07/28/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					10	17	15
FLOW (CFS)						20.39	2.10
WATER TEMPERATURE (C)					4	8	12
SPEC. COND. (UMHOS/CM) FIELD					174	251	329
PH (SU) FIELD					7.1	7.4	7.5
TURBIDITY (NTU) FIELD					32	6.3	3.5
TOTAL SUSP. SOLIDS							
TOTAL DISS. SOLIDS MEAS.							
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)							
MAGNESIUM (MG)							
SODIUM (NA)							
POTASSIUM (K)							
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)							
SULFATE (SO4)							
CHLORIDE (CL)							
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)							
TOTAL PHOSPHATE (PO4)							
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL							
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL							
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS							
OIL AND GREASE							
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA

STATION LOCATION - HUNTINGTON CREEK ABOVE ELECTRIC LAKE

STATION UPL - 10

SAMPLE DATE	08/18/88	10/11/88	06/21/89	09/07/89	10/17/89	06/05/90	09/11/90
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	19	13	15	17	8	17	23
FLOW (CFS)	1.67	1.40	4.10	0.95	1.35	13.3	1.10
WATER TEMPERATURE (C)	10	9	16	7.5	6	8	17.8
SPEC. COND. (UMHOS/CM) FIELD	341	353	287	383	280	183	329
PH (SU) FIELD	7.2	7.2	7.6	6.8	8.15	7.3	8.4
TURBIDITY (NTU) FIELD	3.0	2.95	2.0	3.15	3.6	8.5	3.55
TOTAL SUSP. SOLIDS	3		2	<1	<1	10	<1.00
TOTAL DISS. SOLIDS MEAS.	185		198	188	179	104	172
OXYGEN (O) DISS	7.4			8.7			8.7
COMMON IONS							
CALCIUM (CA)	60.80		43.19	53.37	52.87	33.78	46.92
MAGNESIUM (MG)	0.96		0.03	9.83	8.50	3.61	9.03
SODIUM (NA)	8.50		16.00	1.50	1.97	4.57	2.65
POTASSIUM (K)	<0.50		<0.50	0.70	0.87	<0.50	0.90
ACIDITY AS CACO3	<0.05			<0.10			3.60
ALKALINITY AS CACO3 (LAB)	162			146			159
BICARBONATE (HCO3) (LAB)	198		177	178	176	124	194
SULFATE (SO4)	10		7	24	20	6	10.5
CHLORIDE (CL)	1.9		11.4	2.6	3.3	2.9	3.9
FLUORIDE (F)	0.11			0.09			0.08
NUTRIENTS							
NITRATE (NO3-N)	0.18		0.17	0.11	0.24	0.13	0.07
AMMONIA (NH3 AS N)	0.05		0.05	<0.03	<0.03	<0.03	0.10
TOTAL PHOSPHATE (PO4)	<0.04		<0.04	<0.04	0.47	<0.04	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.04			0.04			0.03
BARIUM (BA) DISS				0.03			0.03
BORON (B) TOTAL	0.020			<0.001			<0.005
BORON (B) DISS				<0.001			<0.005
COPPER (CU) TOTAL	<0.01			<0.01			<0.01
COPPER (CU) DISS				<0.01			<0.01
IRON (FE) TOTAL	0.33		0.30	0.36	0.32	0.56	0.31
IRON (FE) DISS				0.05			0.06
LEAD (PB) TOTAL	<0.001			<0.001			<0.002
LEAD (PB) DISS				<0.001			<0.001
MANGANESE (MN) TOTAL	0.04		0.03	<0.01	0.02	0.05	0.02
MANGANESE (MN) DISS				<0.01			<0.01
ZINC (ZN) TOTAL	<0.005						
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)	2.51						
PHENOLS	<0.001						
OIL AND GREASE	0.2						
CYANIDE (CN) TOTAL	<0.001						

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION UPL - 10

STATION LOCATION - HUNTINGTON CREEK ABOVE ELECTRIC LAKE

RECENT SAMPLE

SAMPLE DATE	10/24/90	06/19/91	09/05/91	10/15/91
PHYSICAL PARAMETERS				
AIR TEMPERATURE (C)	10.5	16	23	22.5
FLOW (CFS)	1.27	7.53	1.51	1.04
WATER TEMPERATURE (C)	9	13.5	14	11.8
SPEC. COND. (UMHOS/CM) FIELD	342	210	325	322
PH (SU) FIELD	7.3	8.33	8.26	8.03
TURBIDITY (NTU) FIELD	2.7	15	5.5	2.6
TOTAL SUSP. SOLIDS	<1	8	<1	<1
TOTAL DISS. SOLIDS MEAS.	186	116	142	204
OXYGEN (O) DISS			6.9	
COMMON IONS				
CALCIUM (CA)	51.29	37.40	58.26	53.01
MAGNESIUM (MG)	7.79	4.26	8.82	8.69
SODIUM (NA)	2.18	2.32	1.04	2.48
POTASSIUM (K)	0.68	1.45	0.79	<0.70
ACIDITY AS CACO3			<0.10	
ALKALINITY AS CACO3 (LAB)			148	
BICARBONATE (HCO3) (LAB)	184	108	180	177
SULFATE (SO4)	13.7	8.2	10.4	12.8
CHLORIDE (CL)	4.8	4.6	4.8	5.4
FLUORIDE (F)			<0.20	
NUTRIENTS				
NITRATE (NO3-N)	0.15	0.11	0.12	
AMMONIA (NH3 AS N)	<0.03	0.09	0.04	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	<0.05	0.04	0.02
TRACE ELEMENTS				
BARIUM (BA) TOTAL			0.030	
BARIUM (BA) DISS			0.030	
BORON (B) TOTAL			<0.050	
BORON (B) DISS			<0.050	
COPPER (CU) TOTAL			<0.006	
COPPER (CU) DISS			<0.006	
IRON (FE) TOTAL	0.31	0.320	0.130	0.29
IRON (FE) DISS			0.030	
LEAD (PB) TOTAL			<0.003	
LEAD (PB) DISS			<0.003	
MANGANESE (MN) TOTAL	0.03	<0.033	0.020	<0.02
MANGANESE (MN) DISS			<0.018	
ZINC (ZN) TOTAL				
OTHER PARAMETERS				
ORGANIC CARBON (TOTAL)				
PHENOLS				
OIL AND GREASE				
CYANIDE (CN) TOTAL				

Winter Quarters Canyon
Data Adequacy

October 1992

U.S. FOREST SERVICE
MANTI-LA SAL FOREST
DENNIS KELLY DATA FILES

KITCHEN CREEK

Kitchen Creek

1981

STORET RETRIEVAL DATE 81/09/02 - INVENT - VERSION OF MAR. 1981

100300430151 SL13S06E2312
39 40 25.0 111 14 30.0 2
KITCHEN CREEK NO. 1 - Tenth Chance
49015 UTAH
COLORADO RIVER BASIN 110691
GREEN RIVER BASIN
113FORS4
0000 CLASS 00 CSN-RSP 0246116-0341078

/TYPA/AMBNT/STREAM

PARAMETER				NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00011	WATER	TEMP	FAHN	22	47.2273	78.7565	8.87449	.187910	1.89205	64.0000	34.0000	75/07/14	80/08/30
00021	AIR	TEMP	FAHN	18	66.2222	154.658	12.4362	.187794	2.93123	84.0000	45.0000	75/07/14	80/08/30
00060	STREAM	FLOW	CFS	15	4.98667	76.8527	8.76657	1.75800	2.26352	36.0000	1.30000	75/07/14	79/07/24
00061	STREAM	FLOW,	INST-CFS	4	3.00000	11.3333	3.36650	1.12217	1.68325	8.00000	1.00000	80/06/23	80/09/24
00070	TURB	JKSN	JTU	3	175.667	17446.4	132.085	.751905	76.2591	300.000	37.0000	77/10/26	78/06/22
00095	CNDUCTVY	AT 25C	MICROMHO	3	237.000	5349.00	73.1369	.308594	42.2256	320.000	182.000	77/10/26	78/06/22
00300	DO		MG/L	23	10.2739	2.55112	1.59722	.155464	.333044	13.1000	5.00000	75/07/14	80/09/24
00400	PH		SU	19	8.45263	1.22154	1.10523	.130756	.253558	9.50000	5.20000	75/07/14	79/07/24
00410	T ALK	CACO3	MG/L	22	155.682	552.518	23.5057	.150985	5.01143	206.000	103.000	75/07/14	80/09/24
00530	RESIDUE	TOT NFLT	MG/L	13	6.38461	30.0897	5.48541	.859161	1.52138	17.0000	1.00000	77/06/21	80/09/24
00620	NO3-N	TOTAL	MG/L	13	.146923	.010506	.102501	.697653	.028429	.310000	.020000	77/06/21	80/09/24
00650	T PO4	PO4	MG/L	9	.101111	.001111	.033333	.329671	.011111	.150000	.050000	75/07/14	76/11/23
00665	PHOS-TOT		MG/L P	9	.039556	.001549	.039351	.994838	.013117	.140000	.010000	77/06/21	79/07/24
00900	TOT HARD	CACO3	MG/L	22	184.455	2266.17	47.6043	.258081	10.1493	274.000	103.000	75/07/14	80/09/24
00940	CHLORIDE	TOTAL	MG/L	11	4.45454	12.0227	3.46738	.778392	1.04545	10.0000	.500000	75/07/14	78/06/22
00945	SULFATE	SO4-TOT	MG/L	11	17.0091	15.7154	3.96426	.233067	1.19527	23.0000	8.00000	75/07/14	78/06/22
31501	TOT COLI	MFIMENDO	/100ML	15	147.400	83731.1	289.364	1.96312	74.7133	930.000	.000000	75/08/28	80/09/24
31616	FEC COLI	MFM-FCBR	/100ML	15	10.1333	182.981	13.5270	1.33491	3.49267	30.0000	.000000	75/08/28	80/09/24
70299	RES-SUSP	AT 180 C	MG/L	9	5.44111	19.5087	4.41687	.811759	1.47229	12.0000	1.00000	75/07/14	76/11/23
70300	RESIDUE	DISS-180	C MG/L	11	175.818	1436.37	37.8995	.215561	11.4271	220.000	90.0000	77/08/03	80/09/24
70507	PHOS-T	ORTHO	MG/L P	4	.032500	.000225	.015000	.461540	.007500	.050000	.020000	80/06/23	80/09/24
71850	NITRATE	TOT-NO3	MG/L	9	.322222	.021120	.145326	.451012	.048442	.690000	.210000	75/07/14	76/11/23

Kitchen Creek
1981

STORET RETRIEVAL DATE 81/09/02 - INVENT - VERSION OF MAR. 1981

100300430251 SL13S06E2206
39 40 45.0 111 15 15.0 2
KITCHEN CREEK NO. 2 - Trib below
49015 UTAH
COLORADO RIVER BASIN 110692
GREEN RIVER BASIN
113FORS4
0000 CLASS 00 CSN-RSP 0246117-0341080

/TYPA/AMBNT/STREAM

PARAMETER				NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00011	WATER	TEMP	FAHN	21	47.6190	81.3496	9.01940	.189407	1.96819	64.0000	34.0000	75/07/14	80/08/30
00021	AIR	TEMP	FAHN	18	66.7778	150.070	12.2503	.183449	2.88742	84.0000	45.0000	75/07/14	80/08/30
00060	STREAM	FLOW	CFS	15	5.00000	77.4286	8.79935	1.75987	2.27198	36.0000	1.00000	75/07/14	79/07/24
00061	STREAM	FLOW,	INST-CFS	4	3.00000	11.3333	3.36650	1.12217	1.68325	8.00000	1.00000	80/06/23	80/09/24
00070	TURB	JKSN	JTU	3	204.667	18009.4	134.199	.655695	77.4798	304.000	52.0000	77/10/26	78/06/22
00095	CNDUCTVY	AT 25C	MICROMHO	3	268.333	5108.41	71.4731	.266359	41.2650	330.000	190.000	77/10/26	78/06/22
00300	DO		MG/L	22	10.3818	2.02633	1.42349	.137114	.303490	12.4000	8.00000	75/07/14	80/09/24
00400	PH		SU	19	8.49473	1.30055	1.14042	.134250	.261630	10.0000	5.90000	75/07/14	79/07/24
00410	T ALK	CACO3	MG/L	22	156.455	540.262	23.2435	.148564	4.95554	189.000	103.000	75/07/14	80/09/24
00530	RESIDUE	TOT NFLT	MG/L	12	6.16667	17.9697	4.23907	.687417	1.22371	15.0000	1.00000	77/06/21	80/09/24
00620	NO3-N	TOTAL	MG/L	12	.203333	.074770	.273440	1.34479	.078935	1.02000	.010000	77/06/21	80/09/24
00650	T PO4	PO4	MG/L	9	.158889	.002236	.047288	.297617	.015763	.230000	.080000	75/07/14	76/11/23
00665	PHOS-TOT		MG/L P	9	.040222	.002414	.049134	1.22157	.016378	.170000	.018000	77/06/21	79/07/24
00900	TOT HARD	CACO3	MG/L	22	189.136	1997.97	44.6987	.236330	9.52979	275.000	86.0000	75/07/14	80/09/24
00940	CHLORIDE	TOTAL	MG/L	11	4.57273	6.98819	2.64352	.578106	.797051	10.0000	2.00000	75/07/14	78/06/22
00945	SULFATE	SO4-TOT	MG/L	11	17.3454	20.7491	4.55512	.262612	1.37342	23.5000	8.00000	75/07/14	78/06/22
31501	TOT COLI	MFIMENDO	/100ML	15	346.267	480142	692.923	2.00112	178.912	2300.00	.000000	75/08/28	80/09/24
31616	FEC COLI	MFM-FCBR	/100ML	15	11.4667	189.267	13.7574	1.19977	3.55215	36.0000	.000000	75/08/28	80/09/24
70299	RES-SUSP	AT 180 C	MG/L	9	6.11111	92.8611	9.63645	1.57687	3.21215	31.0000	.000000	75/07/14	76/11/23
70300	RESIDUE	DISS-180	C MG/L	10	169.800	1641.08	40.5102	.238576	12.8104	219.000	90.0000	77/08/03	80/09/24
70507	PHOS-T	ORTHO	MG/L P	3	.180000	.019600	.140000	.777778	.080829	.320000	.040000	80/06/23	80/09/24
71850	NITRATE	TOT-NO3	MG/L	9	.333333	.034575	.185943	.557830	.061981	.730000	.020000	75/07/14	76/11/23

Winter Quarters Canyon
Data Adequacy

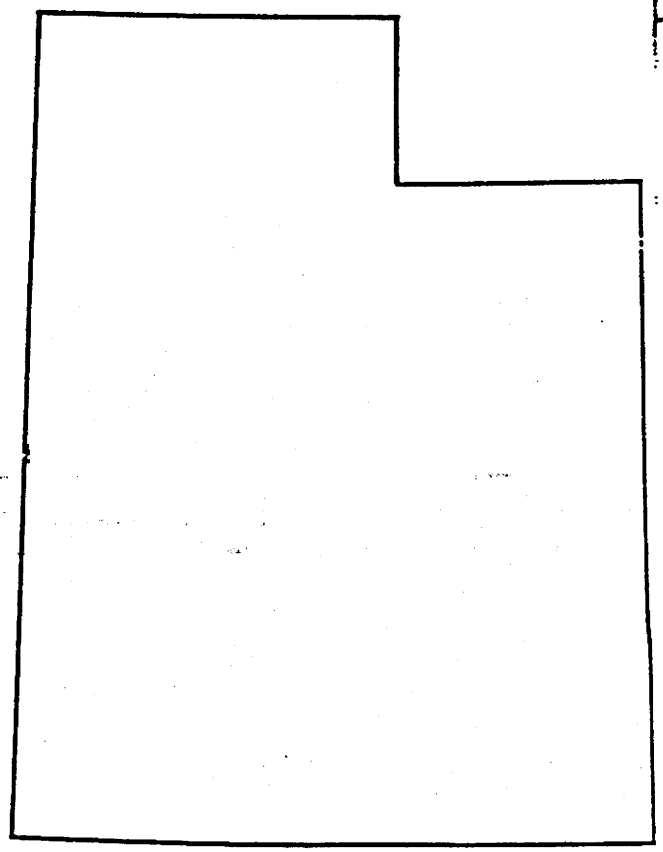
October 1992

U.S. FOREST SERVICE
MANTI LA SAL FOREST
DENNIS KELLY DATA FILES

GOOSEBERRY CREEK

Water Resources Data
Utah
Water Year 1990

MANTI-LASAL N.F.
JUN 1 9 19
ROUTE
MASTER COPY



U.S. GEOLOGICAL SURVEY WATER-DATA REPORT UT-90-1

Prepared in cooperation with the State of Utah
and with other agencies

09310000 GOOSEBERRY CREEK NEAR SCOFIELD, UT

LOCATION.--Lat 39°42'57", long 111°17'58", in NW¼SE¼SW¼ sec. 6, T. 13 S., R. 6 E., Sanpete County, Hydrologic Unit 14060007, on left bank 300 ft downstream from old Mammoth Dam, 5.5 mi upstream from mouth, and 7 mi west of Scofield.

DRAINAGE AREA.--16.8 mi^2.

PERIOD OF RECORD.--October 1930 to September 1931, May 1940 to current year.

REVISED RECORDS.--WDR UT-77-1: Drainage area.

GAGE.--Water-stage recorder. Elevation of gage is 8,400 ft above NGVD of 1929, from topographic map. October 1930 to September 1931, at different datum, May 1940 to September 1954, at datum 0.50 ft higher.

REMARKS.--Records fair except for estimated daily discharges, which are poor. Transmountain diversion above station for irrigation in Sevier River basin, part of which is water diverted into Gooseberry Creek from Boulger Creek. A small reservoir on Gooseberry Creek 5 mi above station, capacity about 1,900 acre-ft is used to regulate these diversions. Flow also affected by small reservoir 1 mi above station.

AVERAGE DISCHARGE.--51 years, 19.1 ft^3/s, 13,840 acre-ft/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum daily discharge, 419 ft^3/s May 22, 1984; maximum gage height, 3.37 ft May 27, 1986; no flow Nov. 11, 1964, Sept. 23-26, 1966.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 100 ft^3/s May 8, gage height, 1.85 ft; minimum discharge, 1.5 ft^3/s Sept. 29.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.3	2.7	e2.7	e2.9	e2.7	2.8	5.2	31	28	10	3.6	2.2
2	3.1	2.6	e2.7	e2.9	e2.7	2.8	5.5	37	28	11	3.5	2.4
3	2.7	2.7	e2.7	e2.8	2.7	2.8	5.8	44	25	11	3.7	2.5
4	2.5	2.8	e2.7	e2.6	e2.7	2.7	6.5	51	23	11	3.6	2.5
5	2.5	2.9	2.8	e2.6	e2.7	2.9	7.5	61	21	10	3.5	3.0
6	2.6	3.0	2.8	2.6	e2.7	2.9	11	78	20	8.2	3.5	4.2
7	2.6	2.9	2.8	2.6	e2.9	2.7	9.9	89	19	7.3	3.3	5.5
8	2.6	2.7	e2.7	2.7	e2.9	2.8	11	83	19	8.2	3.3	4.4
9	2.6	2.7	2.7	2.6	e2.9	2.7	9.5	60	18	9.4	3.7	3.5
10	2.8	2.8	2.7	2.5	e2.9	2.7	10	59	18	9.6	3.9	3.1
11	2.6	2.9	e2.6	2.8	e3.1	2.8	9.5	58	32	9.3	3.6	2.8
12	2.6	3.1	e2.6	2.7	3.1	e2.8	9.8	58	40	9.0	3.5	2.6
13	2.6	32	e2.6	2.6	e3.1	2.8	12	57	33	8.4	3.3	2.5
14	2.6	61	e2.7	2.8	e2.9	2.8	17	58	26	8.5	3.1	2.3
15	3.3	32	2.7	e2.7	e2.9	e2.8	23	58	24	8.6	3.0	2.2
16	3.2	12	2.7	e2.7	e2.9	2.8	31	55	23	8.2	3.5	2.3
17	2.9	5.4	2.8	e2.7	e2.9	2.8	33	51	22	7.6	4.4	2.3
18	2.8	3.5	2.7	2.7	e2.9	2.6	33	51	21	7.1	4.2	2.1
19	2.7	3.2	e2.6	2.7	e3.0	e2.7	40	50	19	7.1	3.7	2.5
20	2.7	3.1	e2.7	e2.6	e3.1	2.9	50	48	19	7.4	3.5	2.6
21	3.0	2.9	e2.8	e2.6	e3.0	e3.0	65	47	18	7.3	3.2	2.5
22	4.0	2.7	e2.8	e2.6	e3.0	e3.1	66	47	16	6.7	2.9	2.5
23	3.6	2.7	e2.8	e2.6	e3.1	3.4	73	46	11	6.6	2.8	2.4
24	3.1	2.7	e3.0	e2.6	e3.1	e3.6	66	45	11	6.9	2.8	2.6
25	3.0	2.9	e2.9	e2.5	e3.1	e4.0	51	43	6.6	7.0	2.8	2.5
26	3.4	e2.9	e2.9	e2.6	e3.1	e4.2	46	40	4.8	6.1	2.4	2.3
27	3.1	e2.8	e2.9	e2.7	3.0	4.4	35	38	6.0	5.2	2.2	2.4
28	3.1	e2.7	e2.9	e2.6	3.1	4.4	38	35	8.0	5.0	2.2	2.4
29	3.1	e2.7	e2.9	e2.7	---	4.4	40	34	9.2	4.0	2.2	2.0
30	2.8	e2.7	2.9	e2.7	---	4.5	33	34	10	3.3	2.3	1.7
31	2.8	---	e2.9	e2.7	---	5.0	---	29	---	3.7	2.2	---
TOTAL	90.3	213.7	85.7	82.7	82.2	99.6	853.2	1575	578.6	238.7	99.4	80.8
MEAN	2.91	7.12	2.76	2.67	2.94	3.21	28.4	50.8	19.3	7.70	3.21	2.69
MAX	4.0	61	3.0	2.9	3.1	5.0	73	89	40	11	4.4	5.5
MIN	2.5	2.6	2.6	2.5	2.7	2.6	5.2	29	4.8	3.3	2.2	1.7
AC-FT	179	424	170	164	163	198	1690	3120	1150	473	197	160

CAL YR 1989 TOTAL 4328.1 MEAN 11.9 MAX 99 MIN 2.2 AC-FT 8580
WTR YR 1990 TOTAL 4079.9 MEAN 11.2 MAX 89 MIN 1.7 AC-FT 8090

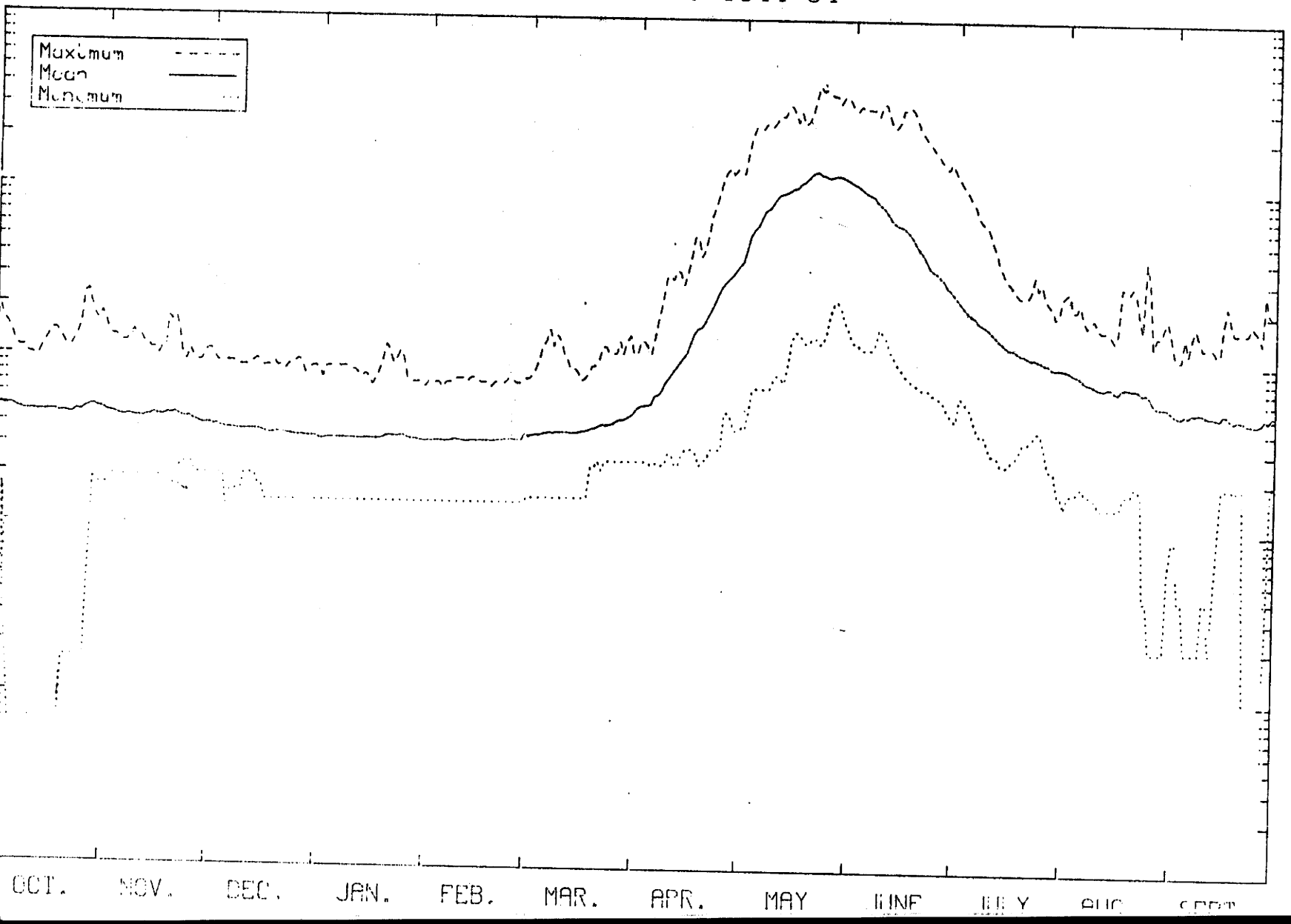
e Estimated

sec Reek
1944-1984

STATION NUMBER 09310000

GOOSEBERRY CREEK NEAR SCOFIELD, UTAH

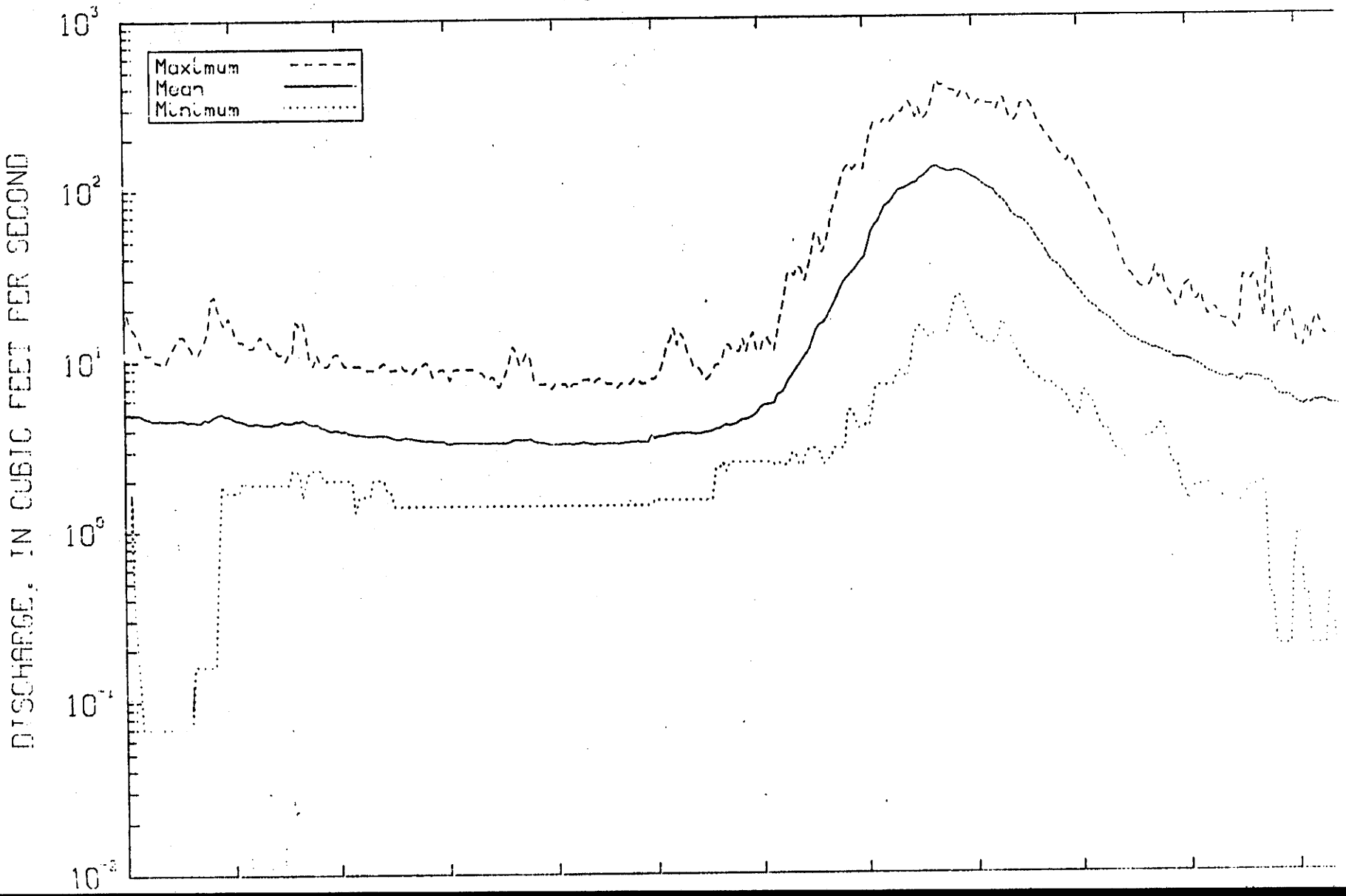
FOR WATER YEARS 1944-84



STATION NUMBER 09310000

GOOSEBERRY CREEK NEAR SCOFIELD, UTAH

FOR WATER YEARS 1944-84



Gooseberry
June 1986

200 yds below white house
Road Cr... NW¼ SW¼ Sec 30 T13S R6E

UNITED STATES
DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Meas. No. .....
Comp. by .....
Checked by .....

DISCHARGE MEASUREMENT NOTES

Sta. No. .....
Station Name Gooseberry Creek Sec 30
Date 6/17, 1986 Party Al Mills, Dean Kelly
Width ..... Area ..... Vel. ..... G. H. ..... Disch. .....
Method ..... No. secs. ..... G. H. change ..... in ..... hrs. Susp. .....
Method coef. ..... Hor. angle coef. ..... Susp. coef. ..... Meter No. .....

GAGE READINGS				
Time		Recorder	Inside	Outside
Weighted M. G. H.				
G. H. correction				
Correct M. G. H.				

Date rated ..... Used rating
for rod ..... susp. Meter ..... ft.
above bottom of wt. Tags checked .....
Spin before meas. ..... after .....
Meas. plots ..... % diff. from ..... rating
Wading, cable, ice, boat, upstr., downstr., side
bridge ..... feet, mile, above, below
gage, and .....
Check-bar, chain found .....
changed to ..... at .....
Correct .....
Levels obtained .....

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following
conditions: Cross section .....
Flow ..... Weather High Cirus Clouds
Other ..... Air ..... °F@ .....
Gage ..... Water ..... °F@ .....
..... Record removed ..... Intake flushed U L .....
Observer Al Mills
Control Marsh MacBarney Model 201
electronic Current Meter
Remarks .....
G. H. of zero flow ..... ft.

2500-4(12/77)

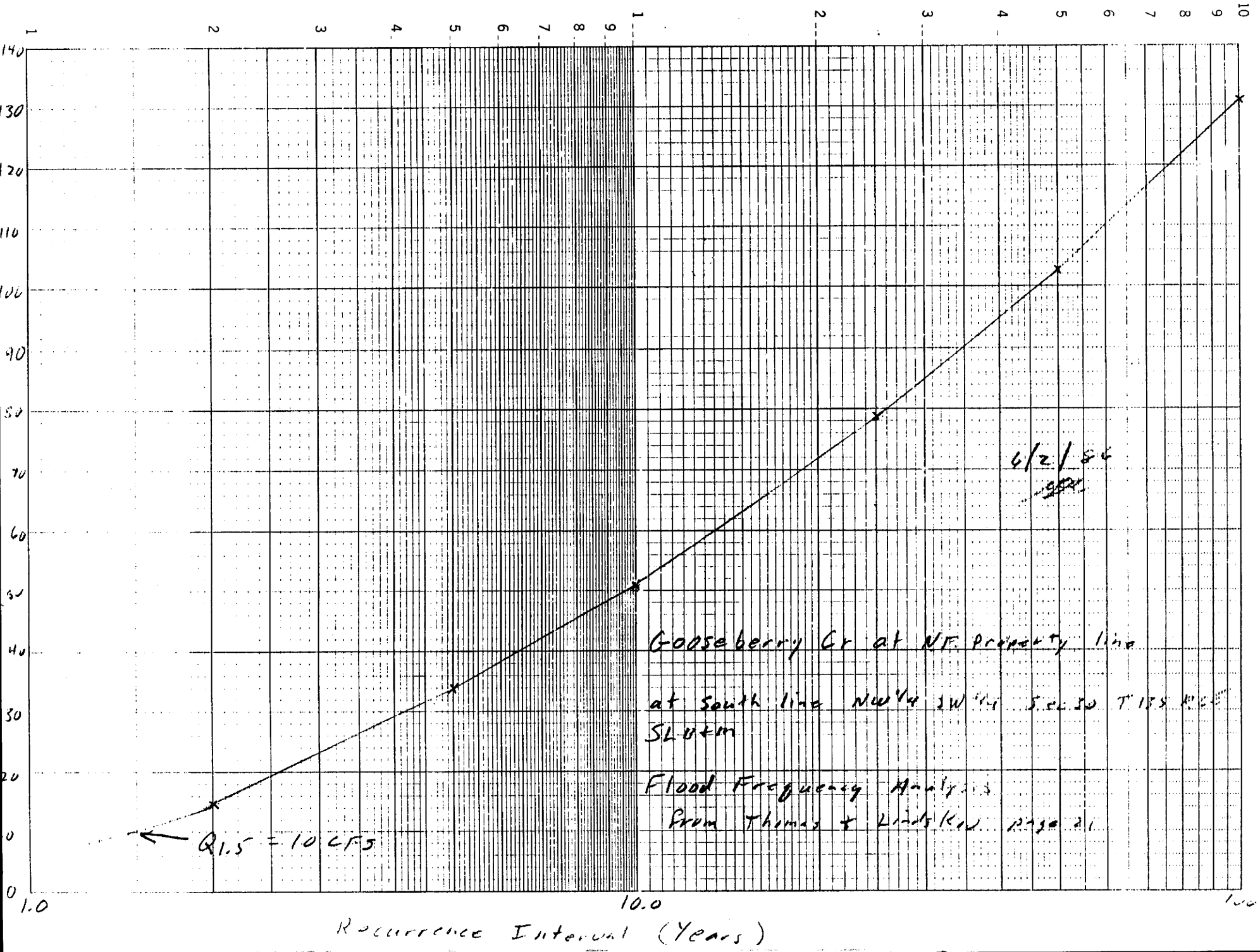
GPO : 1978 O - 268-758

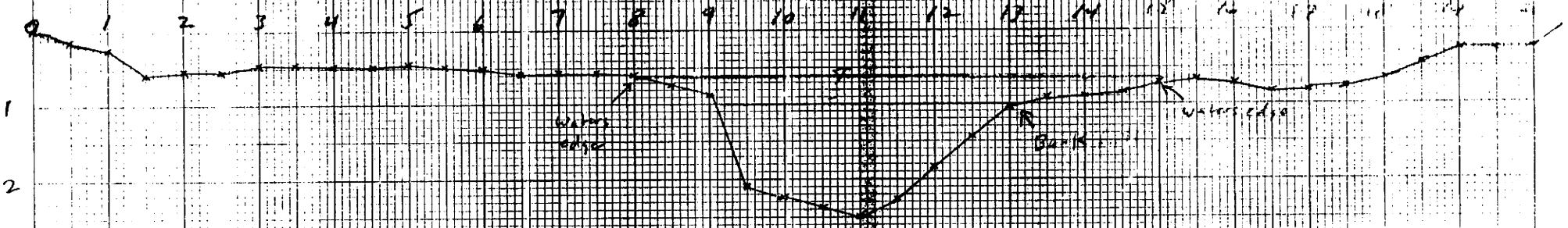
River at—

Angle coefficient	Dist. from initial point	10.5 hrs Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY At point	VELOCITY Mean in vertical	Adjusted for hor. angle or	Area	Discharge
	8.0	water's edge									
	8.5	0.75	.15	0.08			0.7	0.7		0.1125	
	9.0	0.5	0.3	0.18			1.8	1.8			
	9.5	0.5	1.5	0.30			3.0	2.75			
				1.20			2.5				
	10.0	0.5	1.6	0.32			3.4	3.25		0.8	2.600
				1.28			3.1				
	10.5	0.5	1.60	0.32			3.2	3.55		0.8	2.84
				1.24			3.9				
	11.0	0.5	1.8	0.36			2.6	2.90		0.9	2.61
				1.44			3.2				
	11.5	0.5	1.8	0.36			1.6	2.65		0.9	2.385
				1.44			3.7				
	12.0	0.5	1.3	0.52			0.90	0.90		0.65	0.585
⊙											
	12.5	0.5	0.8	0.32			1.60	1.60		0.4	0.640
	13.0	0.5	0.3	0.15			0.50	0.50		0.15	0.075
	13.5	0.5	0.2	0.10			0.10	0.10		0.10	0.010
	14.0	1.25	0.25	0.13			0.50	0.50		0.3125	0.156
	15.0		water's edge.								
									Σ	5.275	12.250

greater than Bank full.

K+E SEMI-LOGARITHMIC ♦2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 4970





STREAM CHANNEL
CROSS SECTION
FROM MEASUREMENTS
6/17/86 ~~10~~.

W/S 002 PRICE RIVER

Gooseberry Creek
Below the Road Crossing
NW 1/4 SW 1/4 Sec 30 T13S R6E Sum...

$Q = AV$

$A = 5.275$ sq ft at waters edge.

$V = 2.322$ ft/sec.

$V = \frac{1.486}{n}(R^{2/3})(S^{1/2})$

$S = 0.01518$

$R = \frac{A}{WP} = \frac{5.275}{8.8} = 0.599$

$WP = 8.8$ ft

$n = \frac{1.486}{2.322}(0.599)^{2/3}(0.01518)^{1/2}$

$n = 0.056$

K+E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1323

Gooseberry
June 1986

SW 4 SW 19 T13S R6 SLB&M
300 feet [illegible] W. Section [illegible] Sec 19.

UNITED STATES
DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Meas. No. _____
Comp. by _____
Checked by _____

DISCHARGE MEASUREMENT NOTES

Sta. No. _____

Station Name Gooseberry 24

Date June 17, 1986 Party Al Mills, [illegible]

Width _____ Area _____ Vel. _____ G. H. _____ Disch. _____

Method _____ No. secs. _____ G. H. change _____ in _____ hrs. Susp. _____

Method coef. _____ Hor. angle coef. _____ Susp. coef. _____ Meter No. _____

GAGE READINGS

Time		Recorder	Inside	Outside
Weighted M. G. H.				
G. H. correction				
Correct M. G. H.				

Date rated _____ Used rating for rod _____ susp. Meter _____ ft. above bottom of wt. Tags checked _____

Spin before meas. _____ after _____

Meas. plots _____% diff. from _____ rating

Wading, cable, ice, boat, upstr., downstr., side bridge _____ feet, mile, above, below gage, and _____

Check-bar, chain found _____ changed to _____ at _____

Correct _____

Levels obtained _____

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions: Cross section _____

Flow _____ Weather _____

Other _____ Air _____°F@ _____

Gage _____ Water _____°F@ _____

_____ Record removed _____ Intake flushed U L _____

Observer _____

Control _____

Remarks _____

G. H. of zero flow _____ ft.

GPO : 1978 O - 268-758

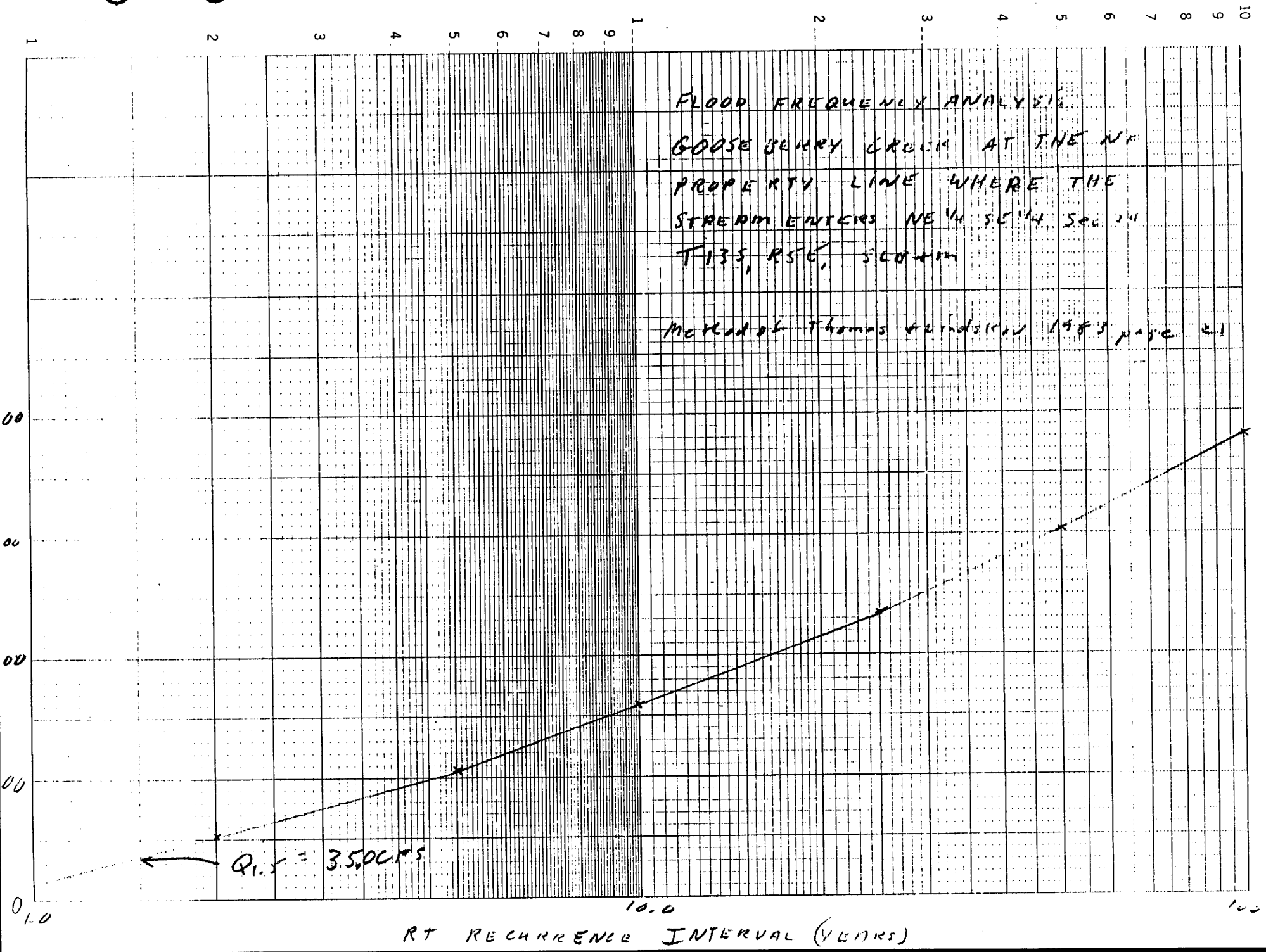
2500-4(12/77)

River at—

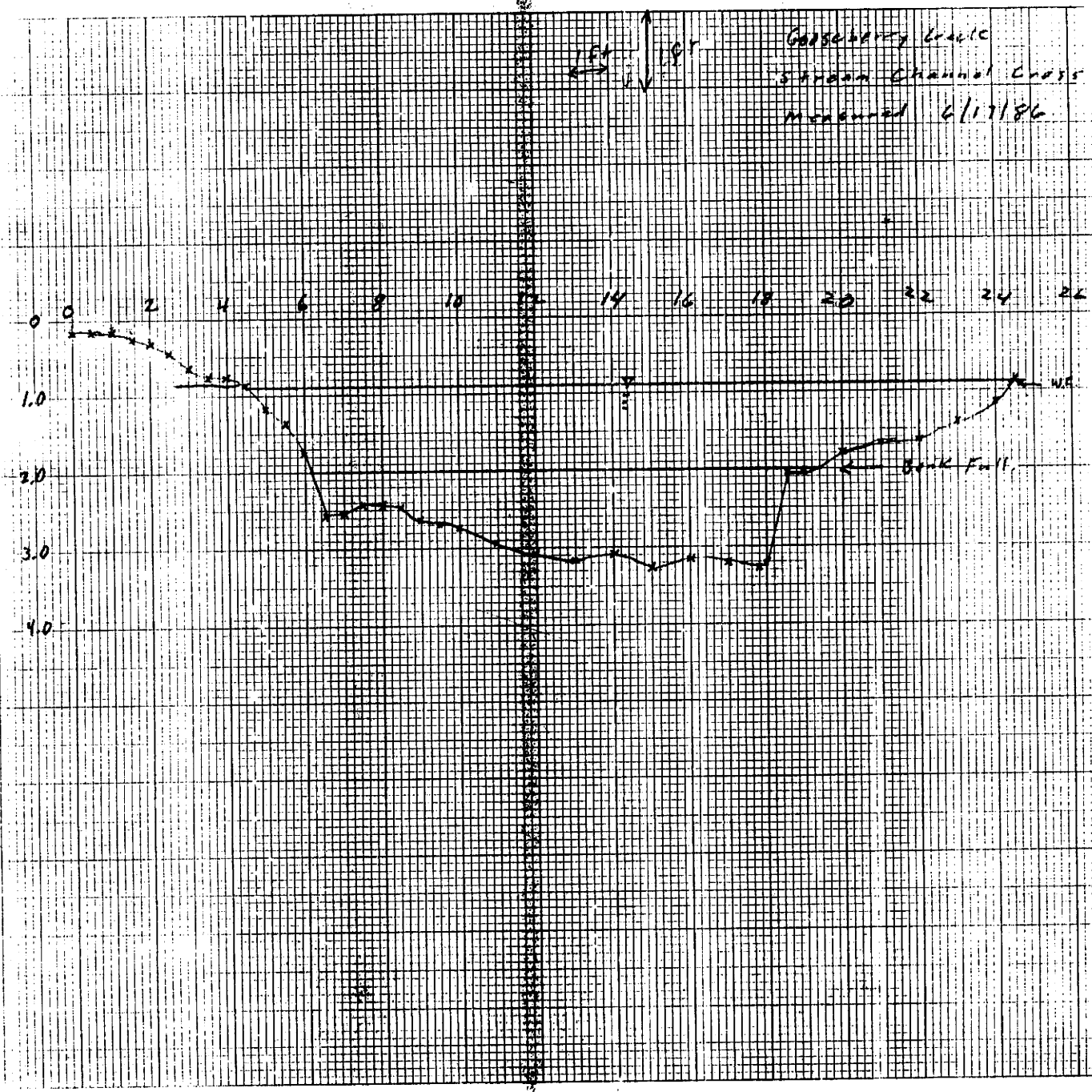
Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY At point	VELOCITY Mean in vertical	Adjusted for hor. angle or ———	Area	Discharge
			0	water edge							
	5.5	1.5	[illegible]	[illegible]			[illegible]	0.7		[illegible]	[illegible]
	6.[illegible]	1.0	.70	[illegible]			[illegible]	0.3		1.700	[illegible]
				1.43			[illegible]				
	7.5	1.0	1.60	[illegible]			[illegible]	0.7		1.600	1.12
				1.28			0.8				
	8.5	1.0	1.7	0.34			0	1.0		1.700	1.70
				1.43			1.0				
	9.5	1.0	1.8	0.36			1.0	1.1		1.800	1.98
				[illegible]							
				1.44			1.2				
	10.5	1.0	2.0	0.4			1.4	1.35		2.000	2.70
				1.6			1.3				
	11.5	1.0	2.1	0.42			1.6	1.6		2.100	3.36
⊙				1.68			1.6				
	12.5	1.0	2.2	0.44			1.7	1.8		2.200	3.96
				1.76			1.9				
	13.5	1.0	2.4	0.48			2.1	2.0		2.400	4.80
				1.92			1.9				
	14.5	1.0	2.4	0.48			2.1	2.2		2.400	5.28
				1.92			2.3				
	15.5	1.0	2.3	0.46			1.7	2.05		2.300	4.715
				1.84			2.4				
	16.5	1.0	2.3	0.46			2.4	2.45		2.300	5.635
				1.84			2.5				
	17.5	1.0	2.3	0.46			2.2	2.35		2.300	5.405
				1.84			2.5				
	18.5	1.0	1.2	0.24			1.2	1.90		1.200	2.28
				0.96			2.6				
	19.5	1.0	1.0	0.6			1.20	1.20		1.000	1.200
	20.5	1.0	0.9	0.54			1.00	1.00		0.900	0.900
	21.5	1.0	0.7	0.42				1.1		0.700	0.770
	22.5	1.0	0.7	0.42				0.8		0.700	0.560
	23.5	1.4	0.3	0.15				0.4		0.42	0.168
	24.4		0		water edge						
										30.32	47.283

Greater than Bank full

K+E SEMI-LOGARITHMIC • 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 4970



K+E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



SAGGED TAPE CROSS SECTION AND DISCHARGE NOTES

Gooseberry 6/17/86 Mills & Kelly

Tape-Length Wt. #/Ft
Stakes @ = Elev.? /Yes/or/No/

Tape Dist. From Left* Stake	VERTICAL DEPTH To Grd.	VERTICAL DEPTH Of Water	CURRENT VELOCITY Revs.	CURRENT VELOCITY Time	CURRENT VELOCITY Ft/Sec
0	0.15				
0.5	0.14				
1.0	0.1				
1.5	0.2[illegible]				
2.0	0.50				
2.5	0.44				
3.0	0.6[illegible]				
3.5	0.77				
4.0	0.75				
4.5	0.8[illegible]	waters edge			
5.0	1.17	0.36			
5.5	1.34	0.53			
6.0	1.74	0.93		Break in pipe	
6.5	2.54	1.78			
7.0	2.[illegible]5	1.68			
7.5	2.45	1.64			
8.0	2.4[illegible]	1.[illegible]			
8.5	2.47	1.67			
9.0	2.62	1.80			
9.5	2.62	1.28			
10.0	2.73	1.94			
11.0	2.91	2.16			
12.0	3.08	2.26			
13.0	3.13	2.34			
14.0	3.09	2.29			
15.0	3.[illegible]5	2.44			
16.0	3.13	2.31			

Notes Continued

Tape Dist. From Left* Stake	VERTICAL DEPTH To Grd.	VERTICAL DEPTH Of Water	CURRENT VELOCITY Revs.	CURRENT VELOCITY Time	CURRENT VELOCITY Ft/Sec
17.0	3.20	2.38			
17.8	3.23	2.39	Break		
18.0	3.20	2.36			
18.5	2.04	1.23			
19.0	2.02	1.19			
20.0	1.78	0.97			
21.0	1.68	0.84			
22.0	1.63	0.77			
23.0	1.40	0.54			
24.0	1.14	0.24			
24.4	0.92	0	waters edge		
24.5	0.85	—			

Ave. Depth.... Velocity..
Width_____Ft., Discharge_____c.f.s.

Observations and Remarks:

SW 1/4, SW 1/4, Sec 19, T135 R6E, SLB+M 300 feet upstream [illegible] West section line section 19.

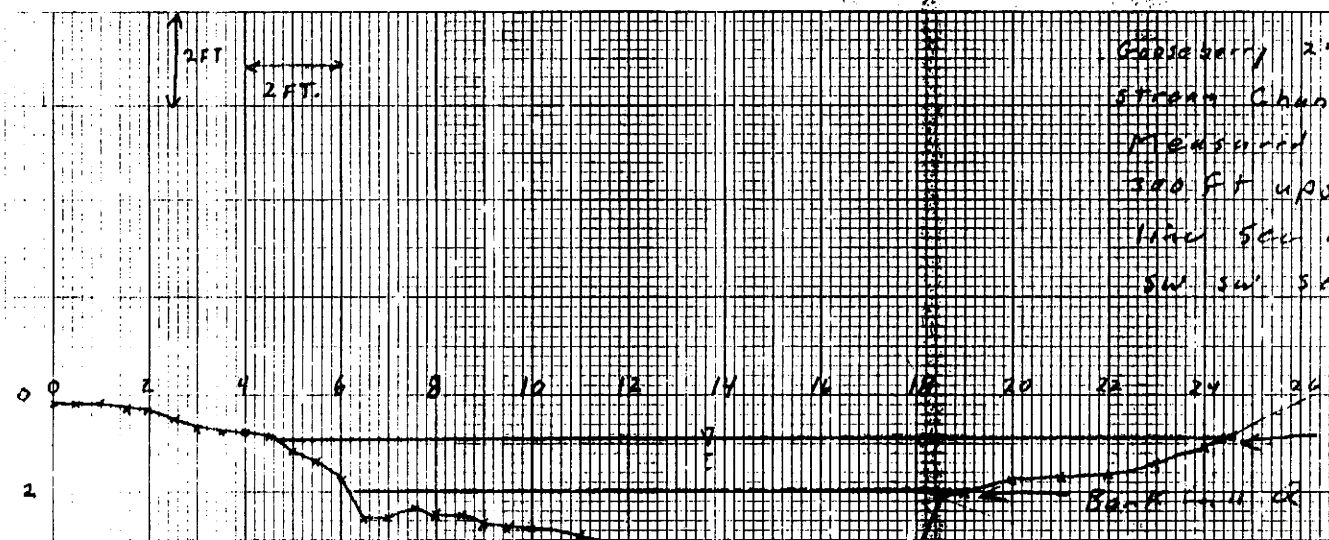
Signature: _____ Page ___ of ___.

Note: Use one star(*) in the left margin to indicate PRESENT WATER LINE,

K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

6/18/86 [illegible]

Gooseberry 24
Stream Channel Cross Section
Measured 6/17/86
300 ft upstream from the road
Line Sec 19.
SW SW Sec 19 T13S R6E S.L.B.&M.



Stream flow 6/17/86 = 47.282 CFS

X section Area = 30.32 ft²

$V = \frac{47.282}{30.32} = 1.559$ FT/sec $= \frac{1.486}{n}(R^{2/3} S^{1/2})$

wetted perimeter = 23.143 ft.

Slope = 0.575% = 0.00575

$R = \frac{A}{WP}$

$\frac{1.559}{1.486} n = \left(\frac{30.32}{23.143}\right)^{2/3} (0.00575)^{1/2}$

$1.049\, n = (1.197)(0.0758)$

$n = 0.0865$

GOOSEBERRY
Aug 1986

SW 1/4 NW 1/4 SEC 15 T 12S R6E SLB&M W/S 002
Sub W/S 501

UNITED STATES
DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Meas. No. .....
Comp. by .....

DISCHARGE MEASUREMENT NOTES

Checked by .....

Sta. No. .....
Station Name Gooseberry Creek above Fish Crk. Cnfl.
Date 8-6, 1986 Party Kelly / Mills
Width ..... Area ..... Vel. ..... G. H. ..... Disch. .....
Method ..... No. secs. ..... G. H. change ..... in ..... hrs. Susp. .....
Method coef. ..... Hor. angle coef. ..... Susp. coef. ..... Meter No. .....

GAGE READINGS				
Time		Recorder	Inside	Outside
Weighted M. G. H.				
G. H. correction				
Correct M. G. H.				

Date rated ..... Used rating for rod ..... susp. Meter ..... ft. above bottom of wt. Tags checked .....
Spin before meas. ..... after .....
Meas. plots ..... % diff. from ..... rating
Wading, cable, ice, boat, upstr., downstr., side bridge ..... feet, mile, above, below gage, and .....
Check-bar, chain found ..... changed to ..... at .....
Correct .....
Levels obtained .....

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions: Cross section .....
Flow ..... Weather .....
Other ..... Air ..... °F@ .....
Gage ..... Water ..... °F@ .....
..... Record removed ..... Intake flushed U L .....
Observer .....
Control .....
Remarks 200 yards above confluence with Fish Creek. Velocity measured with Gurley Pygmy meter.
G. H. of zero flow ..... ft.

2500-4(12/77)

GPO : 1978 O - 268-758

River at—

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY At point	VELOCITY Mean in vertical	Adjusted for hor. angle or ----------	Area FT²	Discharge CFS
X	7.5	H2O Edge					FT/sec				
	9.0	2.0	.25	.12	1	59	0.017			0.31	0.005
	10.0	1.0	.28	.14	15	64	0.234			0.28	0.066
	11.0	1.0	.30	.15	47	60	0.783			0.30	0.235
	12.0	1.0	.74	.30	82	60	1.367			0.74	1.012
	13.0	1.0	.55	.22	17	61	0.279			0.55	0.153
	14.0	1.0	.50	.25	35	60	0.583			0.50	0.292
	15.0	1.0	.44	.22	95	60	1.583			0.44	0.697
	16.0	1.0	.96	.38	136	60	2.267			0.96	2.176
	17.0	1.0	.72	.28	73	60	1.217			0.72	0.876
	18.0	1.0	.72	.28	71	60	1.183			0.72	0.852
	19.0	1.0	.80	.32	49	60	0.817			0.80	0.654
	20.0	1.0	.92	.37	23	61	0.377			0.92	0.347
	21.0	1.0	.92	.37	70	60	1.167			0.92	1.074
⊙	22.0	1.0	.98	.39	17	61	0.279			0.98	0.273
	23.0	1.0	.38	.19	55	60	0.917			0.38	0.348
	24.0	1.0	.80	.32	86	60	1.433			0.80	1.146
	25.0	1.0	.80	.32	117	60	1.950			0.80	1.560
	26.0	1.0	.92	.37	63	60	1.050			0.92	0.966
	27.0	1.0	.86	.34	16	63	0.254			0.86	0.218
	28.0	1.0	.92	.37	32	61	0.525			0.92	0.483
	29.0	1.0	.75	.30	53	60	0.883			0.75	0.662
	30.0	1.0	0	—			0			0	0
	31.0	1.0	.40	.20	35	62	0.565			0.40	0.226
	32.0	0.6	.50	.25	24	60	0.400			0.28	0.112
X	32.1	H2O Edge	—								
										15.25	14.433

distance below tape ELEVATION	AREA (ft.)	(ft.) MEAN DEPTH	(ft.) TOP WIDTH	(ft.) MAXIMUM DEPTH
0	1[illegible]	3.46507	44.1016	5.09
.1	141.[illegible]	3.44439	43.1017	4.99
.2	144.19	3.42394	42.3017	4.89
.3	139.[illegible]	3.33693	41.7016	4.79
.4	135.645	3.24709	41.2016	4.69
.5	131.751	3.23695	40.7016	4.59
.6	127.712	3.20367	39.9015	4.49
.7	123.733	3.13196	39.9015	4.39
.8	119.902	3.10616	39.6014	4.29
.9	116.05	3.02203	38.4014	4.19
1	112.226	2.94546	38.1014	4.09
1.1	108.426	2.86837	37.8014	3.99
1.2	104.659	2.78336	37.6014	3.89
1.3	100.912	2.69806	37.4014	3.79
1.4	97.1876	2.61952	37.1013	3.69
1.5	93.4266	2.53342	36.9013	3.59
1.6	89.306	2.447	36.7013	3.49
1.7	86.1491	2.36016	36.5013	3.39
1.8	82.505	2.26654	36.4013	3.29
1.9	78.8771	2.17885	36.2013	3.19
2	75.2728	2.10841	35.7013	3.09
2.1	71.7367	2.04371	35.1012	2.99
2.2	68.2473	1.96671	34.7012	2.89
2.3	64.8174	1.92902	33.6011	2.79
2.40001	61.5176	1.88696	32.6011	2.68999
2.50001	58.2892	1.82148	32.001	2.58999
2.60001	55.1088	1.74943	31.501	2.48999
2.70001	51.977	1.67123	31.101	2.38999
2.80001	48.8956	1.59785	30.601	2.28999
2.90001	45.9057	1.57747	29.1009	2.18999
3.00001	43.0248	1.50432	28.6008	2.08999
3.10001	40.1946	1.43037	28.1008	1.98999
3.20001	37.4135	1.35552	27.6008	1.88999
3.30001	34.6756	1.27951	27.1007	1.78999
3.40001	31.9796	1.20221	26.6007	1.68999
3.50001	29.3578	1.12479	26.1007	1.58999
3.60001	26.7551	1.02902	26.0007	1.48999
3.70001	24.1642	.936571	25.8007	1.38999
3.80001	21.5858	.839892	25.7007	1.28999
3.90001	19.0381	.767646	24.8006	1.18999
4.00001	16.5385	.685461	24.2006	1.08999
4.10001	14.2143	.607437	23.4005	.989988
4.20001	11.5995	.519617	22.9005	.889988
4.30001	9.64465	.436401	22.1004	.789988
4.40001	7.63485	.396081	19.2003	.689987
4.50001	5.71766	.312437	18.3002	.589987
4.60001	3.99108	.24485	16.3001	.489986
4.70001	2.43661	.179309	13.6	.389986
4.80001	1.20474	.109522	11	.289986
4.90001	.35432	6.74244E-02	5.70002	.189985
5.00002	5.27837E-02	4.59364E-02	1.2	8.99849E-02

Watershed 02 Price River
Subwatershed #501 Gooseberry Creek
Site: 200 yards upstream from the confluence with Fish Creek.
SW 1/4, NW 1/4, Sec. ~~34~~ 15, T12S, R6E,SLBM.
Data collected: 8/6/86
R4CROSS2.2
Run date: 8/11/86 checked:mjw 8/11/86
Item#4

CROSS SECTION DATA FOR GOOSEBERRY CREEK

DISTANCE	WATER DEPTH	INCREMENTAL AREA
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	1.000028E-03
9	.29	.1218
10	.3	.424301
11	.25	.739801
12	.36	1.1318
13	.600001	1.8068
14	.62	2.4398
15	.4	2.9388
16	.91	3.6193
17	.689999	4.40829
18	.640001	5.07079
19	.76	5.77679
20	.810001	6.5643
21	.92	7.4348
22	.94	8.3658
23	1.05	9.3663
24	.79	10.2733
25	.76	11.0468
26	.95	11.9113
27	.76	12.7568
28	.930001	13.6103
29	.840001	14.4908
30	0	14.8358
31	.54	15.1328
32	.46	15.6288
33	0	15.6288
34	0	15.6288
35	0	15.6288
36	0	15.6288
37	0	15.6288
38	0	15.6288
39	0	15.6288
40	0	15.6288
41	0	15.6288
42	0	15.6288
43	0	15.6288
44	0	15.6288

MEAN DEPTH = .65591

MANNINGS N = .173605
WETTED PERIMETER = 25.4300

Data collected: 8/6/86
R4CROSS2.2
Run date: 8/11/86 checked:mjw 8/11/86
Item#1

Watershed 02 Price River
Subwatershed #501 Gooseberry Creek

Site: 200 yards upstream from the confluence with Fish Creek
SW 1/4,NW 1/4, Sec. ~~22~~ 15,T12S,R6E,SLBM.

CROSS SECTION AND DISCHARGE NOTES

Tape-Length ____ Wt. ____ #/Ft
Stakes @ = Elev.? /Yes/or/No/

Tape Dist. From Left* Stake	VERTICAL DEPTH To Grd.	VERTICAL DEPTH Of Water	CURRENT VELOCITY Revs.	CURRENT VELOCITY Time	CURRENT VELOCITY Ft/Sec
0	0				
0.5	0.58				
1.0	0.64				
1.3	1.08				
* 1.4	1.95	QB			
2.0	2.05				
2.5	2.22				
3.0	2.30				
3.5	2.44				
4.0	2.64				
4.5	2.81				
5.0	2.94				
5.5	3.37				
6.0	3.44				
6.5	3.87				
7.0	3.89				
* 7.5	4.05	H2O Edge			
8.0	3.83				
8.5	4.14				
9.0	4.33				
9.5	4.35				
10.0	4.34				
10.5	4.40				
11.0	4.29				
11.5	4.33	Thalweg			
12.0	4.90				
12.5	4.69				

Notes Continued

Tape Dist. From Left* Stake	VERTICAL DEPTH To Grd.	VERTICAL DEPTH Of Water	CURRENT VELOCITY Revs.	CURRENT VELOCITY Time	CURRENT VELOCITY Ft/Sec
13.0	4.64				
13.5	4.69				
14.0	4.66				
15.0	4.44				
16.0	4.95				
17.0	4.73				
18.0	4.68				
19.0	4.80				
20.0	4.85				
21.0	4.96				
22.0	4.98				
23.0	5.09				
24.0	4.83				
25.0	4.80				
26.0	4.99				
27.0	4.80				
28.0	4.97				
29.0	4.88				
* 29.6	4.31	Thalweg			
30.0	4.04				
31.0	4.58				
32.0	4.50				
* 32.1	4.04	H2O Edge			

Ave. Depth.... ____ Velocity.. ____
Width ____ Ft., Discharge ____ c.f.s.

200 yds above Fish Creek confluence

Observations and Remarks: Gooseberry Creek above Fish Creek Confluence (200 yards) 8-6-86 Kelly/Mills
W/S 02 Prior River Sub w/s 501 Gooseberry Cr. SW 1/4 NW 1/4 Sec 15 T 10 R 6 E SLBM

Signature: Kelly/Mills Page 1 of 2.

Note: Use one star(*) in the left margin to indicate PRESENT WATER LINE, **for NORMAL HIGH WATER or "Grass" LINE & *** for EXTREME HWL.

SAGGED TAPE CROSS SECTION AND DISCHARGE NOTES

Tape-Length ____ Wt. ____ #/Ft
Stakes @ = Elev.? (Yes) or (No)

Tape Dist. From Left* Stake	VERTICAL DEPTH To Grd.	VERTICAL DEPTH Of Water	CURRENT VELOCITY Revs.	CURRENT VELOCITY Time	CURRENT VELOCITY Ft/Sec
32.2	3.43				
33.0	3.16				
34.0	2.90				
35.0	2.81				
36.0	2.36				
37.0	2.27	QB			
38.0	1.61				
39.0	1.17				
40.0	0.69				
41.0	0.53				
42.0	0.29				
43.0	0.11				
44.0	0.02				

Notes Continued

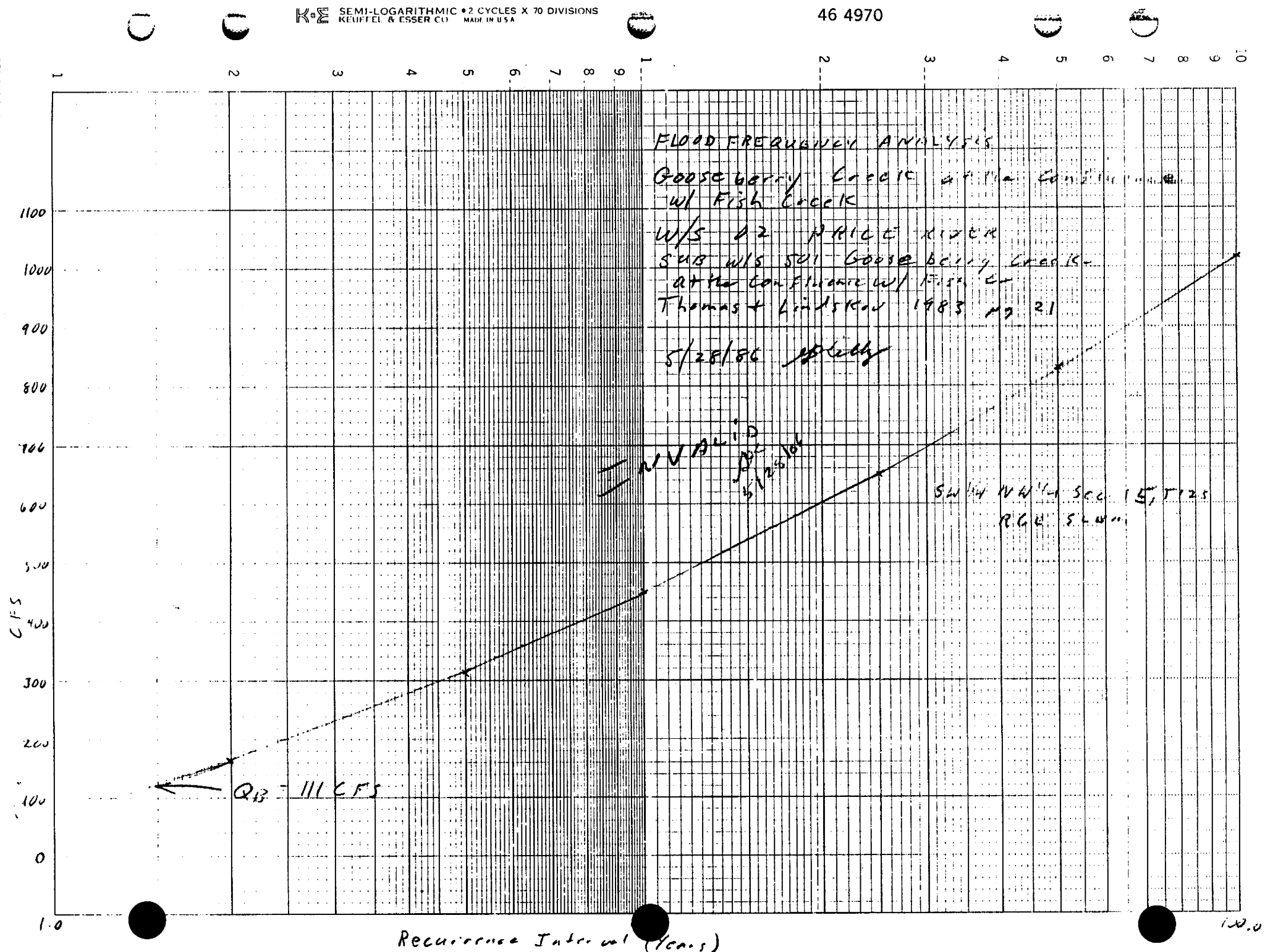
Tape Dist. From Left* Stake	VERTICAL DEPTH To Grd.	VERTICAL DEPTH Of Water	CURRENT VELOCITY Revs.	CURRENT VELOCITY Time	CURRENT VELOCITY Ft/Sec

Ave. Depth.... ____ Velocity.. ____
Width ____ Ft., Discharge ____ c.f.s.

Observations and Remarks: Gooseberry Creek above Fish Creek Confluence (200 yards) 8-6-86
u/s 02 Subwb 501

Use one star(*) in the left margin to indicate PRESENT WATER LINE, ** NORMAL HIGH WATER or "Grass" LINE & *** for EXTREME HWL.

Signature: Kelly Mills


K+E SEMI-LOGARITHMIC • 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 4970
FLOOD FREQUENCY ANALYSIS
Goose berry Creek at the confluence
w/ Fish Creek
W/S 02 PRICE RIVER
SUB W/S 501 Goose berry Creek
at the confluence w/ Fish Cr
Thomas + Lindskov 1983 pg 21
5/28/86
SW/4 NW/4 Sec 15, T12S
R6E Salt Lake
Q13 = 111 CFS
CFS
1100
1000
900
800
700
600
500
400
300
200
100
0
1.0
10.0
Recurrence Interval (Years)

W/S 02
Sub W/S 501 Gooseberry Creek - At the mouth
Above the confluence of Fish Creek

5/28/86

Sub NW 1/4 Sec 15 T 12S
R 6E SLBM

Based on Notes by Reeder & Stanford 6/23/77

[illegible]

Above the confluence with Fish Creek. Since the mouth of Gooseberry Creek is downstream I propose to use the following formula to determine bank full Q.

$$Q_B = \left(\frac{A_u}{A_G}\right)^{.7} Q_G.$$

Q_G = 445 CFS Flood Frequency Analysis of USGS Gage Fish Creek near Seofield

A_u = 30.819 mi^2 from Area Elevation Analysis by Kelly 5/28/86

A_G = 60.1 mi^2 from Water resources data for Utah 1984

Q_B = 279 CFS for the mouth of Gooseberry Creek.

This appears to be a reasonable estimate for a point between two gage sites: Gooseberry Creek near Seofield and Fish Creek near Seofield.

STREAMFLOWS WITH GAINS

10/25/91

W/S 02-501
Gooseberry Creek.

TABLE 1
GOOSEBERRY CREEK STREAMFLOWS WITH GAINS (CFS)
AVERAGE YEAR (1968)

	MONTH	A=7.6 SQ.MI. GOOSEBERRY NR. FAIRVIEW REACH 1	GAIN	A=8.7 SQ.MI. REACH 2	GAIN	A=9.6 SQ.MI. REACH 3	REACH 1-4 GAIN	A=16.5 SQ.MI. GOOSEBERRY NR. SCOFIELD REACH 4
PREPROJECT	OCT	2.2	0.2	2.4	0.4	2.6	1.9	4.1
	NOV	1.7	0.3	2.0	0.5	2.2	2.1	3.8
	DEC	1.5	0.3	1.8	0.5	2.0	2.3	3.8
	JAN	1.4	0.3	1.7	0.6	2.0	2.6	4.0
	FEB	1.4	0.3	1.7	0.6	2.0	2.7	4.1
	MAR	1.5	0.3	1.8	0.6	2.1	2.7	4.2
	APR	3.9	0.4	4.3	0.8	4.7	3.6	7.5
	MAY	50.0	4.0	54.0	7.2	57.2	32.1	82.1
	JUNE	67.7	3.0	70.7	5.5	73.2	24.4	92.1
	JULY	8.0	0.6	8.6	1.1	9.1	4.8	12.8
	AUG	5.4	0.6	6.0	1.0	6.4	4.6	10.0
	SEPT	3.5	0.4	3.9	0.7	4.2	2.9	6.4
PROJECT	OCT	1.0	0.2	1.2	0.4	1.4	1.9	2.9
	NOV	1.0	0.3	1.3	0.5	1.5	2.1	3.1
	DEC	1.0	0.3	1.3	0.5	1.5	2.2	3.2
	JAN	1.0	0.3	1.3	0.6	1.6	2.6	3.6
	FEB	1.0	0.3	1.3	0.6	1.6	2.7	3.7
	MAR	1.0	0.3	1.3	0.6	1.6	2.7	3.7
	APR	1.0	0.4	1.4	0.8	1.8	3.6	4.6
	MAY	1.0	4.0	5.0	7.2	8.2	32.1	33.1
	JUNE	27.4	3.0	30.4	5.5	32.9	24.5	51.9
	JULY	1.0	0.6	1.6	1.1	2.1	4.9	5.9
	AUG	1.0	0.6	1.6	1.0	2.0	4.6	5.6
	SEPT	1.0	0.4	1.4	0.7	1.7	2.9	3.9

[illegible] channels to maintain water levels

Pl[illegible] [illegible] fisheries assume fish biologist

1977

TABLE 2

GOOSEBERRY CREEK STREAMFLOWS WITH GAINS (CFS)

DRY YEAR (1977)

	MONTH	A=7.6 SQ.MI. GOOSEBERRY NR. FAIRVIEW REACH 1	GAIN	A=8.7 SQ.MI. REACH 2	GAIN	A=9.6 SQ.MI. REACH 3	REACH 1-4 GAIN	A=16.5 SQ.MI. GOOSEBERRY NR. SCOFIELD REACH 4
PREPROJECT	OCT	1.7	0.2	1.9	0.3	2.0	1.3	3.0
	NOV	1.5	0.1	1.6	0.3	1.8	1.2	2.7
	DEC	0.8	0.1	0.9	0.2	1.0	1.1	1.9
	JAN	1.1	0.1	1.2	0.2	1.3	1.0	2.1
	FEB	1.3	0.1	1.4	0.2	1.5	1.1	2.4
	MAR	1.3	0.2	1.5	0.3	1.6	1.3	2.6
	APR	6.0	0.6	6.6	1.1	7.1	4.9	10.9
	MAY	16.7	-0.5	16.2	-0.9	15.8	-3.8	12.9
	JUNE	7.1	0.3	7.4	0.6	7.7	2.7	9.8
	JULY	3.3	0.1	3.4	0.1	3.4	0.5	3.8
	AUG	1.6	0.0	1.6	0.1	1.7	0.4	2.0
	SEPT	1.0	0.1	1.1	0.2	1.2	0.9	1.9
PROJECT	OCT	1.0	0.2	1.2	0.3	1.3	1.3	2.3
	NOV	1.0	0.1	1.1	0.2	1.2	1.1	2.1
	DEC	1.0	0.1	1.1	0.2	1.2	1.1	2.1
	JAN	1.0	0.1	1.1	0.2	1.2	1.0	2.0
	FEB	1.0	0.1	1.1	0.2	1.2	1.1	2.1
	MAR	1.0	0.1	1.1	0.3	1.3	1.2	2.2
	APR	1.0	0.6	1.6	1.1	2.1	4.9	5.9
	MAY	1.0	-0.1	0.9	-0.2	0.8	-1.0	0.0
	JUNE	1.0	0.3	1.3	0.6	1.6	2.7	3.7
	JULY	1.0	0.0	1.0	0.1	1.1	0.4	1.4
	AUG	1.0	0.0	1.0	0.1	1.1	0.3	1.3
	SEPT	1.0	0.1	1.1	0.2	1.2	0.9	1.9

1984

TABLE 3

GOOSEBERRY CREEK STREAMFLOWS WITH GAINS (CFS)

WET YEAR (1984)

	MONTH	A=7.6 SQ.MI. GOOSEBERRY NR. FAIRVIEW REACH 1	GAIN	A=8.7 SQ.MI. REACH 2	GAIN	A=9.6 SQ.MI. REACH 3	REACH 1-4 GAIN	A=16.5 SQ.MI. GOOSEBERRY NR. SCOFIELD REACH 4
PREPROJECT	OCT	5.2	0.6	5.8	1.1	6.3	5.0	10.2
	NOV	3.7	0.6	4.3	1.1	4.8	5.1	8.8
	DEC	4.6	0.5	5.1	1.0	5.6	4.4	9.0
	JAN	2.6	0.6	3.2	1.2	3.8	5.2	7.8
	FEB	2.7	0.6	3.3	1.1	3.8	4.9	7.6
	MAR	2.7	0.5	3.2	1.0	3.7	4.3	7.0
	APR	5.8	0.7	6.5	1.2	7.0	5.4	11.2
	MAY	111.8	10.8	122.6	19.7	131.5	87.5	199.3
	JUNE	102.3	7.4	109.7	13.4	115.7	59.7	162.0
	JULY	14.2	1.2	15.4	2.2	16.4	9.9	24.1
	AUG	6.6	0.5	7.1	0.9	7.5	4.1	10.7
	SEPT	4.7	0.3	5.0	0.6	5.3	2.7	7.4
PROJECT	OCT	3.5	0.6	4.1	1.1	4.6	5.0	8.5
	NOV	3.2	0.6	3.8	1.1	4.3	5.0	8.2
	DEC	4.6	0.5	5.1	1.0	5.6	4.4	9.0
	JAN	2.6	0.6	3.2	1.2	3.8	5.2	7.8
	FEB	2.6	0.6	3.2	1.1	3.7	5.0	7.6
	MAR	2.7	0.5	3.2	1.0	3.7	4.3	7.0
	APR	5.8	0.7	6.5	1.2	7.0	5.4	11.2
	MAY	108.0	10.8	118.8	19.6	127.6	87.4	195.4
	JUNE	97.5	7.4	104.9	13.4	110.9	59.7	157.2
	JULY	1.8	1.2	3.0	2.2	4.0	9.9	11.7
	AUG	1.0	0.5	1.5	0.9	1.9	4.1	5.1
	SEPT	1.0	0.3	1.3	0.6	1.6	2.7	3.7

TABLE 4

GOOSEBERRY CREEK NEAR FAIRVIEW (BELOW NARROWS DAMSITE)

COMPARISON OF DEPTH OF FLOW (FEET)

REACH 1

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
PREPROJECT CONDITION	AVE YEAR	0.3	0.3	0.3	0.3	0.3	0.3	0.4	1.2	1.4	0.5	0.4	0.4
	DRY YEAR	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.7	0.5	0.3	0.3	0.2
	WET YEAR	0.4	0.4	0.4	0.3	0.3	0.3	0.4	1.8	1.7	0.7	0.5	0.4
PROJECT CONDITION	AVE YEAR	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.9	0.2	0.2	0.2	
	DRY YEAR	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	WET YEAR	0.4	0.3	0.4	0.3	0.3	0.3	0.4	1.7	1.6	0.3	0.2	0.2
DIFFERENCE	AVE YEAR	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	1.2	0.3	0.2	0.4
	DRY YEAR	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.5	0.3	0.1	0.1	0.0
	WET YEAR	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.3	0.2
	MAXIMUM	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	0.3	0.4	0.3	0.4

TABLE 6
GOOSEBERRY CREEK (ABOUT 0.9 MILE BELOW NARROWS DAMSITE)
COMPARISON OF DEPTH OF FLOW (FEET)
REACH 2

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
PREPROJECT CONDITION	AVE YEAR	0.3	0.3	0.3	0.3	0.3	0.3	0.4	1.2	1.3	0.6	0.5	0.4
	DRY YEAR	0.3	0.3	0.2	0.3	0.3	0.3	0.5	0.7	0.5	0.4	0.3	0.2
	WET YEAR	0.5	0.4	0.5	0.4	0.4	0.4	0.5	1.7	1.6	0.7	0.5	0.5
PROJECT CONDITION	AVE YEAR	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.9	0.3	0.3	0.3
	DRY YEAR	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.3
	WET YEAR	0.4	0.4	0.5	0.4	0.4	0.4	0.5	1.6	1.5	0.4	0.3	0.3
DIFFERENCE	AVE YEAR	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.4	0.3	0.2	0.1
	DRY YEAR	0.0	0.0	-0.1	0.0	0.0	0.0	0.2	0.5	0.2	0.2	0.1	-0.1
	WET YEAR	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.2	0.2
	MAXIMUM	0.1	0	0	0	0	0	0.2	0.7	0.4	0.3	0.2	0.2

TABLE 6

GOOSEBERRY CREEK (ABOUT 1.9 MILES BELOW NARROWS DAMSITE)

COMPARISON OF DEPTH OF FLOW (FEET)

REACH 3

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
PREPROJECT CONDITION	AVE YEAR	0.4	0.4	0.4	0.4	0.4	0.4	0.5	1.5	1.7	0.7	0.6	0.5
	DRY YEAR	0.4	0.4	0.3	0.3	0.4	0.4	0.6	0.9	0.7	0.5	0.4	0.3
	WET YEAR	0.6	0.5	0.5	0.5	0.5	0.5	0.6	2.2	2.1	0.9	0.7	0.6
PROJECT CONDITION	AVE YEAR	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	1.2	0.4	0.4	0.4
	DRY YEAR	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.3	0.3	0.3
	WET YEAR	0.5	0.5	0.5	0.5	0.5	0.5	0.7	2.2	2.1	0.5	0.4	0.4
DIFFERENCE	AVE YEAR	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.5	0.3	0.2	0.1
	DRY YEAR	0.1	0.1	0.0	0.0	0.1	0.1	0.2	0.6	0.3	0.2	0.1	0.0
	WET YEAR	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.4	0.3	0.2
	MAXIMUM	0.1	0.1	0	0	0.1	0.1	0.2	0.9	0.5	0.4	0.3	0.2

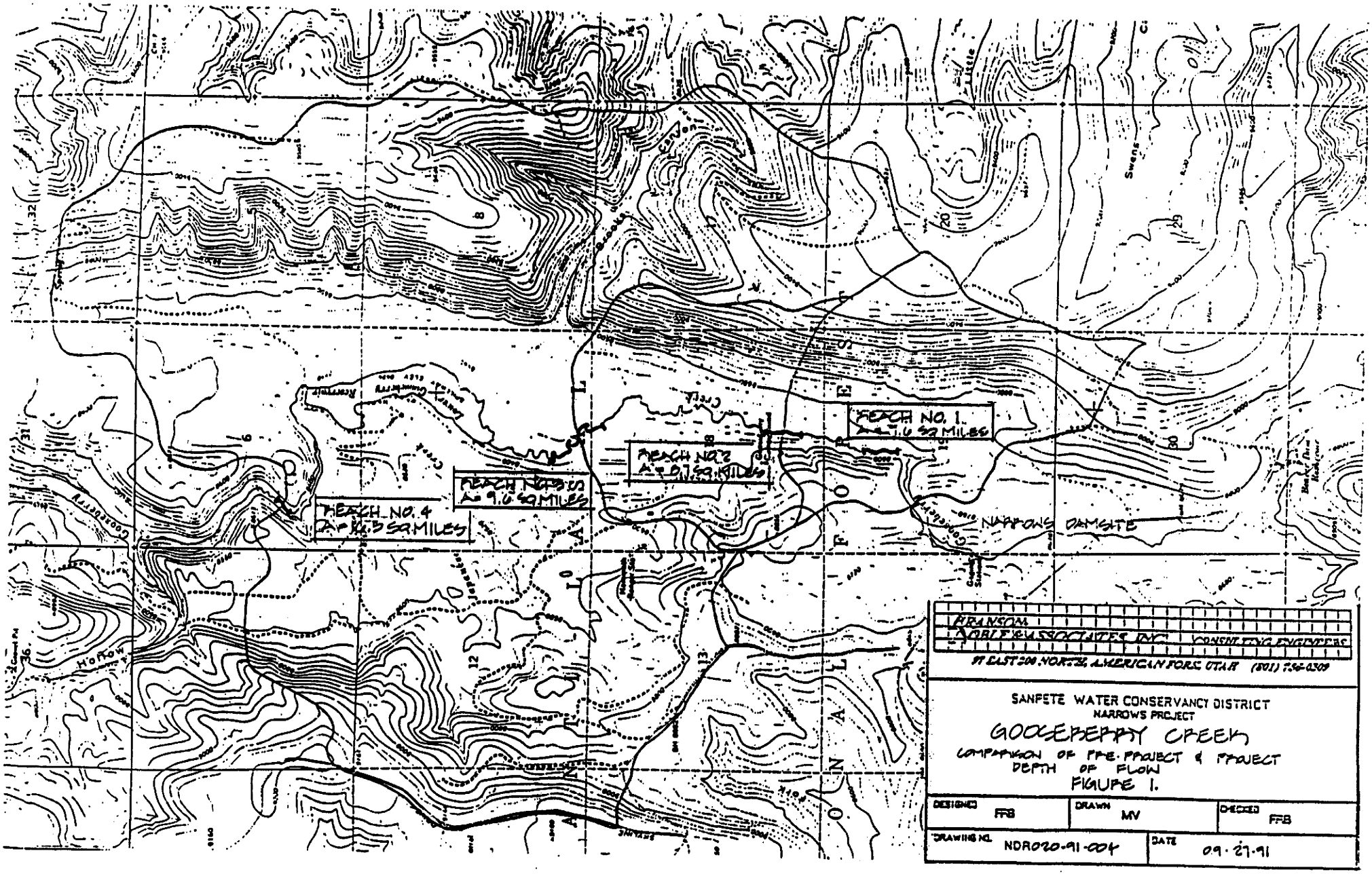
TABLE 7

GOOSEBERRY CREEK (ABOUT 3.8 MILES BELOW NARROWS DAMSITE)

COMPARISON OF DEPTH OF FLOW (FEET)

REACH 4

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT
PREPROJECT CONDITION	AVE YEAR	0.5	0.5	0.5	0.5	0.5	0.5	0.6	1.5	1.7	0.7	0.7	0.6
	DRY YEAR	0.5	0.5	0.4	0.5	0.5	0.5	0.7	0.7	0.7	0.5	0.5	0.5
	WET YEAR	0.7	0.7	0.7	0.6	0.6	0.6	0.7	2.4	2.2	0.9	0.7	0.6
PROJECT CONDITION	AVE YEAR	0.5	0.5	0.5	0.5	0.5	0.5	0.6	1.1	1.3	0.6	0.6	0.5
	DRY YEAR	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.0	0.5	0.4	0.4	0.5
	WET YEAR	0.7	0.7	0.7	0.6	0.6	0.6	0.7	2.4	2.1	0.7	0.6	0.5
DIFFERENCE	AVE YEAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.1	0.1	0.1
	DRY YEAR	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.7	0.2	0.1	0.1	0.0
	WET YEAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1
	MAXIMUM	0	0	0	0	0	0	0.1	0.7	0.4	0.2	0.1	0.1


REACH NO. 1
A = 1.6 SQ MILES
REACH NO. 2
A = 0.1 SQ. MILES
REACH NO. 3
A = 9.6 SQ MILES
REACH NO. 4
A = 14.5 SQ MILES
NARROWS DAMSITE
Gooseberry
Hollow
Swens
Little
Canyon
RANSOM
NOBLE & ASSOCIATES INC
CONSULTING ENGINEERS
97 EAST 200 NORTH, AMERICAN FORK UTAH (801) 756-0309
SANPETE WATER CONSERVANCY DISTRICT
NARROWS PROJECT
GOOSEBERRY CREEK
COMPARISON OF PRE-PROJECT & PROJECT
DEPTH OF FLOW
FIGURE 1.
DESIGNED FRB
DRAWN MV
CHECKED FRB
DRAWING NO. NDR020-91-004
DATE 09-27-91

Woodward-Clyde Consultants

Memorandum

1968
Gooseberry
Fish Creek

To: Fishery Team

From: Quentin Bliss

Office: Omaha

Date: November 22, 1991

Subject: Aquatic Ecology Report for Narrows Project

Enclosed is a draft of the revised Aquatic Ecology Report for the Narrows Project using the new PHABSIM data obtained by Dr. Tom Hardy. Please review so it can be discussed at the team meeting scheduled for the afternoon of December 2 at the Bureau's office in Provo.

Thanks.

Quentin

Supporting data for EIS

MANTI-LASAL N.F.
NOV 25 1991

Narrows.mem/cee

w/s 02
S.. 5 501

TABLE 1

EXISTING FLOWS [1] IN GOOSEBERRY AND FISH CREEKS (cfs)

Month	Gooseberry Creek		Fish Creek Downstream from Confluence with Gooseberry Creek
	Narrows Gorge	Downstream from Gooseberry Reservoir	
January	1.3	3.9	9.5
February	1.3	4.0	10.7
March	1.4	4.0	14.6
April	3.5	7.9	20.7
May	45.3	81.3	255.6
June	61.8	97.6	230.8
July	7.2	14.2	36.5
August	4.9	10.3	22.0
September	3.2	6.1	14.7
October	2.0	4.1	10.6
November	1.5	3.5	10.2
December	1.4	3.7	9.1
Average	11.2	20.0	53.8

[1] Average year flows based on 1968 flows.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SELECTED HYDROLOGIC DATA, PRICE RIVER BASIN, UTAH, WATER YEARS 1979 AND 1980

by K. M. Waddell, J. E. Dodge, D. W. Darby, and S. M. Theobald

---

U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 82-916

Prepared in cooperation with the

U.S. BUREAU OF LAND MANAGEMENT

Salt Lake City, Utah
1982

Table 15.—Mineralogic analyses of streambed samples

Site No: See plate 1.
Visual estimates: tr, trace.

Stream	Site No.	Date	Particle-size diameter (mm)	Mineral composition (Percent by weight)														Visual estimates (Percent by volume)		
				Quartz	Potassium feldspar	Plagioclase feldspar	Calcite	Dolomite	Ankerite	Rhodochrosite	Goethite	Chlorite	Kaolinite	Illite	Montmorillonite	Mixed clay layer	Total	Organic	Pyrite	Coal
Gooseberry Creek	1	7-19-79	<0.476	37	2	3	24	5	3	4	0.1	0.4	2	7	0.4	0.1	88	0	0	tr
			<.062	37	4	4	12	4	0	3	2			16			82	--	--	--
			<.002	--	--	--	--	--	--	--	--	4	19	72	4	1	--	--	--	--
Fish Creek	2	7-18-79	<.476	69	2	0	11	0	0	1	0	0	3	0	0	3	89	0	0	0
			<.062	37	2	0	27	<.5	0	6	0			2			76	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	52	0	0	48	--	--	--	--
Pondtown Creek	3	7-18-79	<.476	74	4	.2	2	0	0	0	2	0	4	4	0	.9	91	0	0	0
			<.062	72	8	2	4	<.5	0	0	2			9			97	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	44	46	0	10	--	--	--	--
	4	7-18-79	<.476	71	2	.1	4	0	1	.1	3	0	4	4	0	2	91	tr	0	tr
			<.062	61	7	1	9	<.5	<.5	1	2			8			89	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	43	40	0	17	--	--	--	--
Mud Creek	5	7-17-79	<.476	75	4	.1	4	1	.3	0	2	0	3	3	0	2	94	0	0	.5
			<.062	77	8	1	1	1	1	<.5	0			10			99	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	37	33	0	30	--	--	--	--
	18	7-17-79	<.476	72	6	2	2	1	.1	1	3	0	3	4	0	2	96	0	0	3
			<.062	69	11	2	3	1	1	0	<.5			8			95	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	35	42	0	23	--	--	--	--
Eccles Canyon	20	7-17-79	<.476	60	3	.1	10	.9	.9	.9	3	0	5	2	0	.9	87	tr	0	tr
			<.062	69	7	1	6	<.5	<.5	<.5	0			8			91	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	58	30	0	12	--	--	--	--
	29	7-17-79	<.476	67	3	1	4	1	.9	0	3	0	4	2	0	2	88	0	0	3
			<.062	79	7	1	5	4	<.5	0	0			8			104	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	49	31	0	20	--	--	--	--
Mud Creek	34	7-17-79	<.476	67	2	2	4	1	.1	2	5	0	4	3	0	1	91	0	0	2
			<.062	62	5	1	7	1	1	1	0			9			87	--	--	--
			<.002	--	--	--	--	--	--	--	--	0	46	37	0	17	--	--	--	--
Soldier Creek	42	7-19-79	<.476	30	3	6	24	3	2	4	2	.8	.6	3	.8	3	82	0	0	0
			<.062	40	6	11	8	6	0	1	1			14			87	--	--	--
			<.002	--	--	--	--	--	--	--	--	9	7	39	10	35	--	--	--	--
Pine Canyon	51	7-19-79	<.476	38	2	1	25	4	3	3	2	.5	2	6	.7	2	89	tr	0	0
			<.062	46	4	3	11	6	1	2	1			12			88	--	--	--
			<.002	--	--	--	--	--	--	--	--	5	17	50	6	22	--	--	--	--
Soldier Creek	57	7-19-79	<.476	44	3	5	18	4	2	3	0	.6	1	4	.7	3	88	0	tr	0
			<.062	42	4	6	12	6	<.5	3	0			12			85	--	--	--
			<.002	--	--	--	--	--	--	--	--	7	14	37	8	35	--	--	--	--
	59	7-19-79	<.476	38	6	10	12	6	2	4	.3	.4	1	7	1	4	92	tr	0	0
			<.062	30	5	11	6	5	1	3	1			26			85	--	--	--
			<.002	--	--	--	--	--	--	--	--	3	10	52	7	28	--	--	--	--

SELECTED HYDROLOGIC DATA, PRICE RIVER BASIN, UTAH, WATER YEARS 1979 AND 1980
U.S. GEOLOGICAL SURVEY
OPEN FILE REPORT 82-916

Gooseberry Creek
1931 - 1984

STATION 09310000 GOOSEBERRY CREEK NEAR SCOFIELD, UTAH

DISCHARGE (CUBIC FEET/SECOND)
NORMAL MONTHLY MEANS (ALL DAYS)

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	ANNUAL
1931	4.55	6.73	4.00	*	*	*	17.8	40.8	12.6	4.32	2.74	2.00	11.4
1940	*	*	*	*	*	*	*	111.	24.5	11.8	5.74	4.73	14.0
1941	4.52	4.00	3.65	3.00	3.00	4.52	8.23	170.	82.1	22.4	13.2	9.53	27.6
1942	12.0	10.0	9.00	7.00	6.00	8.35	55.4	134.	67.8	21.7	12.6	5.07	29.2
1943	4.26	3.03	3.03	2.00	3.00	3.42	42.8	54.8	49.0	15.2	10.6	4.23	16.3
1944	4.40	4.00	4.00	3.00	3.00	3.50	5.00	129.	93.3	16.9	7.40	4.95	23.2
1945	4.56	4.52	3.00	3.00	3.50	3.50	6.77	126.	70.1	18.0	10.7	6.17	21.8
1946	4.68	4.33	3.16	3.00	3.14	3.77	44.8	65.0	23.8	9.10	5.66	3.16	14.5
1947	5.09	4.01	3.35	2.50	2.50	3.58	22.9	122.	31.7	12.4	8.45	5.11	18.8
1948	4.78	4.25	3.35	2.50	2.30	2.37	10.5	78.2	23.9	10.1	6.46	3.08	12.7
1949	3.30	3.24	3.10	2.90	2.89	3.76	38.0	137.	48.7	13.2	6.45	3.76	22.3
1950	3.91	2.91	2.21	2.00	2.00	3.02	19.1	92.1	40.7	12.4	6.25	5.76	16.1
1951	3.62	6.25	3.30	2.45	2.45	3.28	24.8	98.3	42.0	13.5	9.12	4.63	17.9
1952	5.45	4.42	3.58	3.00	3.00	3.66	20.6	239.	156.	26.1	14.1	8.04	40.7
1953	5.34	5.04	3.35	2.60	2.54	3.42	10.3	69.4	68.7	15.3	9.65	5.76	16.8
1954	4.50	4.97	4.26	4.00	4.50	4.76	28.7	52.5	15.5	8.16	4.00	4.31	11.7
1955	3.83	3.71	2.72	2.50	2.50	3.34	8.95	76.2	30.4	9.92	7.38	3.81	13.0
1956	2.46	2.16	2.10	2.00	1.90	3.27	27.5	94.5	25.6	10.0	5.48	2.67	15.0
1957	3.61	2.98	2.20	2.20	2.66	3.76	9.01	77.6	164.	23.8	10.2	5.73	25.6
1958	6.11	5.66	3.50	3.00	3.18	4.27	16.2	153.	58.5	13.3	8.26	3.88	23.4
1959	3.26	3.44	2.89	2.74	2.50	2.91	8.55	55.3	23.1	9.41	3.92	2.87	10.1
1960	3.23	2.90	1.81	1.40	1.40	3.40	11.0	78.8	26.1	9.99	3.54	2.75	12.3
1961	3.16	3.37	3.05	2.20	2.20	2.56	10.4	36.5	13.2	5.64	2.32	3.93	7.42
1962	3.44	3.82	2.98	3.00	4.64	4.50	29.2	145.	66.4	19.5	10.3	6.56	25.1
1963	4.30	3.75	2.34	1.41	1.97	2.13	3.92	92.5	35.2	11.6	8.84	6.33	14.6
1964	3.00	2.92	2.50	3.00	3.00	3.00	5.66	92.6	60.1	16.5	9.13	6.79	17.4
1965	3.65	2.92	4.08	4.23	3.95	3.50	9.96	92.1	94.9	21.6	16.7	14.1	22.7
1966	9.42	6.86	4.83	4.31	4.60	6.54	35.5	69.0	15.9	6.04	7.49	4.12	14.6
1967	5.86	3.51	3.26	2.50	2.50	2.99	5.70	93.4	80.3	16.5	8.32	5.38	19.3
1968	4.07	3.76	3.79	3.97	4.00	4.23	7.51	82.0	91.9	12.8	9.97	6.39	19.5
1969	5.73	4.57	3.42	2.90	2.98	3.83	22.4	196.	43.6	15.3	7.46	6.18	26.5
1970	6.81	5.77	4.89	4.80	4.15	4.93	7.35	110.	52.5	13.6	5.84	4.94	18.9
1971	5.28	5.16	6.53	7.39	3.63	4.15	12.5	85.1	38.2	10.7	5.58	4.70	15.8
1972	4.98	4.60	5.00	5.35	4.97	10.6	24.1	60.4	18.4	5.72	3.26	3.91	12.6
1973	4.71	4.63	3.79	3.50	3.50	4.28	8.36	119.	57.6	13.1	5.73	5.20	19.5
1974	4.40	4.22	4.20	4.80	4.12	4.01	8.48	111.	24.1	7.35	3.65	2.66	15.4
1975	3.38	3.36	2.67	3.00	3.00	3.00	3.37	52.8	149.	25.0	8.76	5.18	21.8
1976	5.91	5.27	5.06	5.00	4.72	3.95	8.69	85.0	19.9	7.27	3.14	2.39	13.1
1977	3.05	2.68	1.90	2.12	2.38	2.58	10.9	12.9	9.80	3.75	1.96	1.89	4.65
1978	2.45	2.73	2.67	2.50	2.64	3.11	17.3	105.	122.	14.9	8.89	4.30	24.1
1979	0.65	4.39	2.82	2.80	2.80	2.80	8.00	102.	51.2	9.91	5.33	3.37	16.5
1980	3.73	3.38	3.49	3.50	3.50	3.50	15.9	108.	131.	17.2	7.02	5.81	25.5
1981	5.02	4.74	3.86	3.68	3.70	5.15	25.4	59.3	26.7	7.10	3.86	3.59	12.7
1982	5.48	4.28	3.02	2.28	2.21	3.02	19.4	142.	75.6	18.1	8.26	8.36	24.5
1983	13.5	11.6	8.13	6.94	6.73	7.99	10.7	73.7	239.	47.9	14.0	10.1	37.4
1984	10.1	8.75	8.98	7.83	7.37	6.95	11.1	199.	162.	24.0	10.7	7.36	38.7
PER	4.88	4.52	3.75	3.40	3.35	4.07	16.9	99.3	62.1	14.3	7.58	5.12	19.3

* INDICATES A NO-VALUE MONTH

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY

STATION NUMBER 09310000 GOOSEBERRY CREEK NEAR SCOFIELD, UTAH
LATITUDE 394257 LONGITUDE 1111758 STATE 49 COUNTY 039

MAXIMUM DISCHARGE, IN CUBIC FEET PER SECOND
FOR WATER YEARS 1931, 1940-84

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	16.0	16.0	11.0	8.50	7.30	8.00	14.0	125.0	311.0	124.0	26.0	12.0
2	19.0	14.0	10.0	7.70	7.30	8.10	18.0	165.0	302.0	114.0	27.0	11.0
3	16.0	13.0	9.40	8.90	7.30	8.80	23.0	204.0	319.0	106.0	21.0	11.0
4	15.0	13.0	9.40	8.90	7.30	10.0	27.0	235.0	302.0	98.0	21.0	15.0
5	14.0	12.0	9.40	8.90	6.80	12.0	27.0	235.0	308.0	90.0	23.0	12.0
6	12.0	12.0	9.40	8.90	7.30	13.0	25.0	230.0	305.0	83.0	19.0	15.0
7	12.0	12.0	9.40	8.90	7.30	15.0	25.0	247.0	305.0	72.0	18.0	18.0
8	12.0	13.0	9.20	8.90	7.30	12.0	25.0	236.0	280.0	67.0	18.0	18.0
9	12.0	14.0	9.00	8.90	7.70	14.0	30.0	242.0	322.0	66.0	19.0	13.0
10	12.0	13.0	9.00	8.50	7.70	13.0	34.0	260.0	333.0	60.0	20.0	13.0
11	12.0	13.0	9.00	8.50	7.70	11.0	39.0	275.0	283.0	52.0	21.0	13.0
12	12.0	12.0	9.00	8.10	7.30	10.0	47.0	274.0	245.0	46.0	23.0	13.0
13	12.0	12.0	9.40	7.70	7.70	8.80	56.0	300.0	240.0	38.0	20.0	12.0
14	12.0	11.0	9.70	8.10	7.80	8.90	68.0	319.0	257.0	35.0	18.0	15.0
15	12.0	11.0	9.40	7.70	7.40	8.50	80.0	294.0	304.0	31.0	18.0	18.0
16	13.0	10.0	9.00	7.00	7.30	8.00	80.0	255.0	305.0	30.0	18.0	23.0
17	14.0	11.0	9.00	7.60	7.30	8.00	80.0	290.0	316.0	28.0	29.0	19.0
18	14.0	11.0	9.00	8.40	7.30	8.30	70.0	268.0	301.0	26.0	28.0	16.0
19	13.0	17.0	9.40	9.90	6.90	9.20	65.0	258.0	262.0	25.0	27.0	16.0
20	12.0	16.0	9.00	12.0	7.30	9.30	68.0	282.0	236.0	25.0	29.0	16.0
21	12.0	17.0	9.00	11.0	7.30	10.0	74.0	341.0	217.0	25.0	27.0	16.0
22	12.0	14.0	9.00	9.30	7.30	12.0	90.0	419.0	202.0	27.0	20.0	16.0
23	12.0	10.0	9.00	10.0	7.30	12.0	110.0	394.0	190.0	33.0	16.0	18.0
24	13.0	10.0	9.40	11.0	7.70	11.0	110.0	397.0	178.0	28.0	41.0	17.0
25	15.0	11.0	9.40	10.0	7.70	11.0	116.0	378.0	167.0	30.0	31.0	16.0
26	23.0	10.0	9.80	7.70	7.30	11.0	128.0	368.0	154.0	25.0	13.0	14.0
27	24.0	10.0	9.40	7.30	7.30	13.0	135.0	366.0	148.0	26.0	15.0	27.0
28	20.0	10.0	9.00	7.30	7.30	11.0	125.0	330.0	136.0	22.0	15.0	21.0
29	17.0	10.0	9.00	7.30	7.70	13.0	132.0	356.0	149.0	19.0	17.0	20.0
30	16.0	11.0	9.00	7.30	---	14.0	130.0	364.0	136.0	19.7	19.0	20.0
31	18.0	---	9.00	7.00	---	12.0	---	339.0	---	25.0	16.0	---

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY

STATION NUMBER 09310000 GOOSEBERRY CREEK NEAR SCOFIELD, UTAH
LATITUDE 394257 LONGITUDE 1111758 STATE 49 COUNTY 039

MEAN DISCHARGE, IN CUBIC FEET PER SECOND
FOR WATER YEARS 1931, 1940-84

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.02	4.89	4.09	3.35	3.32	3.62	5.46	40.5	110.0	23.9	9.77	5.27
2	5.20	4.78	4.02	3.35	3.30	3.68	5.75	47.0	107.4	22.5	9.60	5.15
3	5.07	4.75	4.06	3.39	3.33	3.71	5.93	55.1	103.1	21.3	9.35	5.12
4	5.10	4.70	3.93	3.40	3.33	3.69	6.07	59.8	98.5	20.1	9.17	5.31
5	5.12	4.62	3.91	3.40	3.32	3.75	6.16	62.4	95.1	19.4	9.01	5.19
6	5.02	4.53	3.85	3.41	3.29	3.77	6.70	68.8	93.0	18.8	8.76	5.37
7	4.91	4.56	3.87	3.39	3.34	3.83	6.83	75.2	91.8	17.7	8.46	5.52
8	4.85	4.60	3.85	3.39	3.35	3.80	7.14	78.0	86.5	17.1	8.35	5.62
9	4.78	4.53	3.81	3.39	3.39	3.84	7.90	82.6	82.2	16.7	8.18	5.38
10	4.77	4.49	3.82	3.38	3.36	3.83	8.39	89.8	78.9	16.1	8.06	5.28
11	4.84	4.50	3.82	3.38	3.32	3.83	9.08	95.5	73.4	15.4	8.01	5.25
12	4.83	4.44	3.83	3.37	3.30	3.83	9.74	97.9	67.4	14.6	7.97	5.28
13	4.78	4.52	3.84	3.37	3.32	3.80	10.6	99.8	64.4	14.0	7.97	5.18
14	4.77	4.54	3.84	3.40	3.34	3.81	11.4	101.9	62.1	13.5	7.87	5.18
15	4.74	4.65	3.81	3.39	3.32	3.82	12.4	103.8	61.1	13.0	7.49	5.39
16	4.76	4.56	3.74	3.37	3.34	3.91	14.3	104.5	58.7	12.8	7.29	5.32
17	4.77	4.54	3.68	3.37	3.33	3.92	16.2	110.2	55.9	12.7	7.52	5.07
18	4.75	4.55	3.64	3.38	3.34	3.96	17.1	113.4	52.5	12.3	7.56	4.87
19	4.65	4.66	3.68	3.43	3.32	4.05	17.6	116.9	48.4	12.0	7.51	5.00
20	4.67	4.59	3.73	3.50	3.33	4.07	18.6	121.4	45.1	11.9	7.41	4.98
21	4.68	4.69	3.67	3.52	3.37	4.18	20.7	126.9	42.7	11.6	7.37	4.89
22	4.59	4.58	3.65	3.50	3.37	4.27	23.0	129.2	39.2	11.3	7.21	4.74
23	4.65	4.48	3.62	3.50	3.40	4.22	25.8	125.8	35.7	11.3	6.90	4.77
24	4.82	4.45	3.59	3.52	3.40	4.27	28.2	125.6	34.1	11.1	6.90	4.69
25	4.73	4.49	3.56	3.53	3.42	4.32	30.2	122.6	33.2	10.9	6.63	4.69
26	4.87	4.32	3.54	3.43	3.38	4.48	31.4	123.8	31.6	10.7	6.07	4.78
27	4.99	4.26	3.57	3.39	3.37	4.57	32.9	124.9	30.2	10.7	5.83	5.02
28	5.16	4.18	3.54	3.38	3.37	4.61	34.7	123.2	27.9	10.2	5.74	4.87
29	5.22	4.11	3.52	3.35	3.64	4.76	36.8	120.6	26.7	9.98	5.72	5.19
30	5.07	4.19	3.52	3.32	---	4.91	38.9	116.5	25.2	10.0	5.69	5.18
31	5.05	---	3.53	3.29	---	5.10	---	112.7	---	9.92	5.51	---

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY

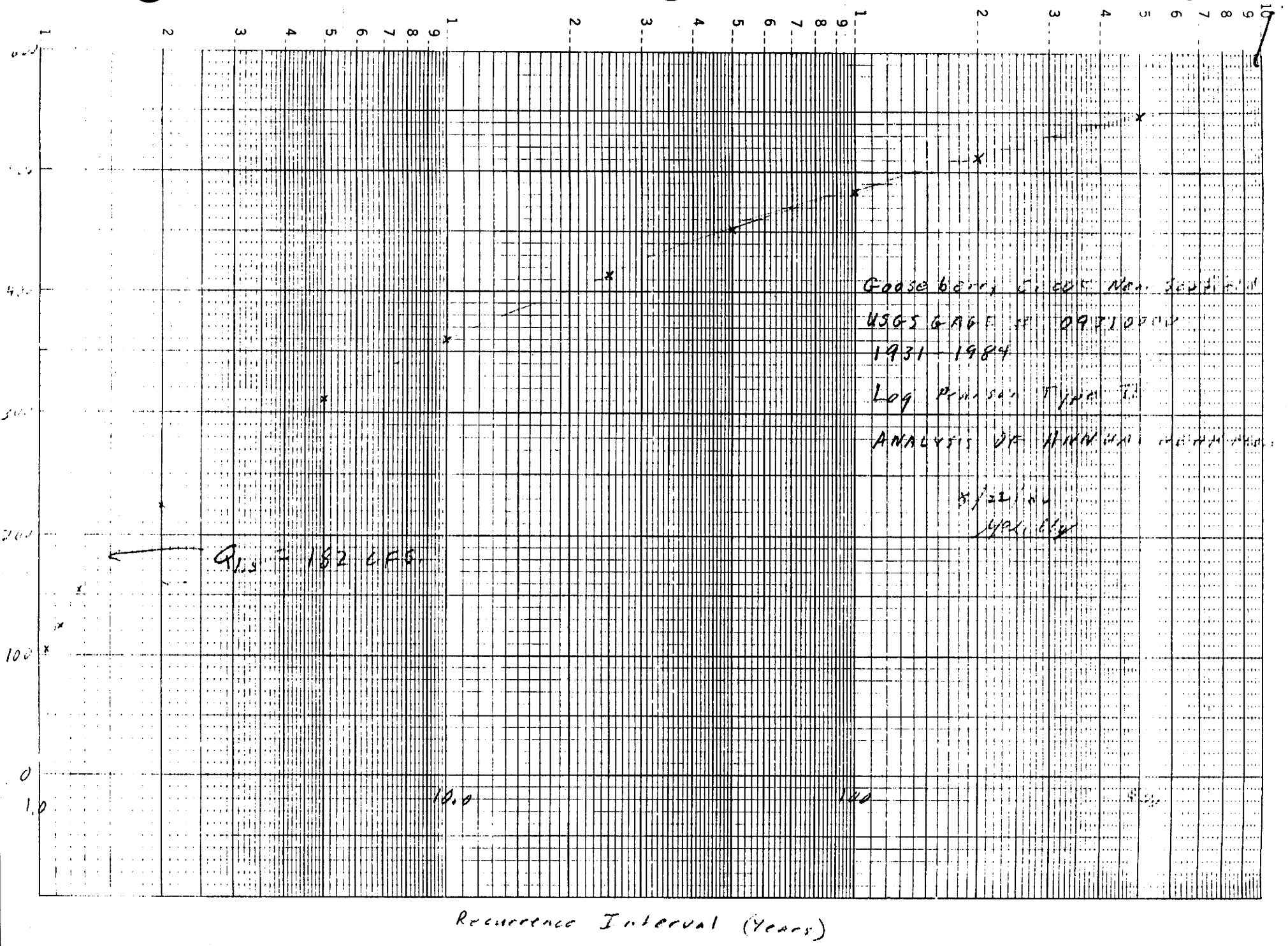
STATION NUMBER 09310000 GOOSEBERRY CREEK NEAR SCOFIELD, UTAH
LATITUDE 394257 LONGITUDE 1111758 STATE 49 COUNTY 039

MINIMUM DISCHARGE, IN CUBIC FEET PER SECOND
FOR WATER YEARS 1931, 1940-84

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.00	1.70	2.00	1.40	1.40	1.50	2.50	4.10	14.0	4.60	1.40	0.900
2	2.10	1.70	2.00	1.40	1.40	1.50	2.50	4.00	13.0	6.00	1.70	0.900
3	1.70	1.70	2.00	1.40	1.40	1.50	2.50	5.00	13.0	6.00	1.70	0.400
4	0.340	2.00	2.00	1.40	1.40	1.50	2.50	6.90	12.0	5.70	1.70	0.400
5	0.160	1.90	2.00	1.40	1.40	1.50	2.40	7.00	12.0	5.40	1.80	0.200
6	0.070	1.90	1.30	1.40	1.40	1.50	2.50	7.00	12.0	4.60	1.90	0.200
7	0.070	1.90	1.60	1.40	1.40	1.50	2.40	7.00	12.0	4.00	1.70	0.200
8	0.070	1.90	1.60	1.40	1.40	1.50	2.40	7.00	13.0	3.70	1.70	0.200
9	0.070	1.90	1.60	1.40	1.40	1.50	2.40	7.00	16.0	3.80	1.60	0.200
10	0.070	1.90	1.60	1.40	1.40	1.50	2.80	7.90	15.0	3.30	1.60	0.400
11	0.070	1.90	2.00	1.40	1.40	1.50	2.80	8.40	14.0	2.90	1.40	0.400
12	0.070	1.90	2.00	1.40	1.40	1.50	2.40	8.10	12.0	2.90	1.40	0.200
13	0.070	1.90	2.00	1.40	1.40	1.50	2.40	7.60	11.0	2.80	1.40	0.400
14	0.070	1.90	2.00	1.40	1.40	1.50	2.80	9.50	10.0	2.50	1.40	0.900
15	0.070	1.90	1.70	1.40	1.40	1.50	3.00	13.0	9.60	2.50	1.40	1.90
16	0.070	1.90	1.70	1.40	1.40	1.50	3.00	15.0	8.70	2.50	1.40	1.90
17	0.070	1.90	1.40	1.40	1.40	1.50	3.00	15.0	8.30	2.70	1.40	1.90
18	0.070	2.30	1.40	1.40	1.40	1.50	2.80	14.0	7.90	2.80	1.70	1.90
19	0.070	2.30	1.40	1.40	1.40	2.30	2.40	13.0	7.70	3.00	1.70	1.80
20	0.070	2.00	1.40	1.40	1.40	2.30	2.60	13.0	7.40	3.40	1.70	2.00
21	0.160	1.60	1.40	1.40	1.40	2.50	2.60	14.0	7.10	3.40	1.90	2.00
22	0.160	2.00	1.40	1.40	1.40	2.20	3.00	14.0	7.10	3.50	1.90	0.100
23	0.160	2.30	1.40	1.40	1.40	2.50	3.00	13.0	7.10	3.00	1.70	0.000
24	0.160	2.30	1.40	1.40	1.40	2.50	3.00	13.0	6.60	3.00	0.400	0.000
25	0.160	2.30	1.40	1.40	1.40	2.50	3.00	15.0	6.60	3.00	0.400	0.000
26	0.160	2.00	1.40	1.40	1.40	2.50	5.00	19.0	6.30	3.00	0.200	0.000
27	0.160	2.00	1.40	1.40	1.40	2.50	5.00	22.0	6.20	2.60	0.200	0.100
28	0.670	2.00	1.40	1.40	1.40	2.50	4.50	23.0	5.50	2.30	0.200	0.200
29	1.90	2.00	1.40	1.40	1.40	2.50	3.90	21.0	5.10	2.30	0.200	1.90
30	1.70	2.00	1.40	1.40	---	2.50	4.00	18.0	4.70	1.70	0.200	2.00
31	1.70	---	1.40	1.40	---	2.50	---	16.0	---	1.70	0.600	---

K+E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 5490



Gooseberry Creek
1931 - 1984

STREAM FLOW (CFS)
MEAN

GOOSEBERRY CREEK NEAR SCOFIELD, UTAH — STATION # 09310000

WATER YEAR - 1978

DAY	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT
1	2.10	2.50	3.50	2.50	2.50	3.20	7.90	28.00	184.00	28.00	8.20	3.90
2	2.10	2.30	3.20	2.50	2.50	3.50	7.60	31.00	189.00	26.00	7.80	3.80
3	2.10	2.10	2.80	2.50	2.50	3.80	7.10	34.00	189.00	24.00	7.40	3.80
4	1.90	2.10	3.20	2.50	2.50	2.80	6.40	41.00	187.00	22.00	7.40	3.50
5	1.90	1.90	3.20	2.50	2.50	3.20	6.70	35.00	181.00	22.00	7.20	3.80
6	3.20	1.90	3.20	2.50	2.50	2.80	6.50	30.00	170.00	20.00	6.80	4.00
7	6.10	1.90	3.20	2.50	2.50	2.50	6.60	26.00	170.00	19.00	6.60	4.30
8	5.40	1.90	2.80	2.50	2.50	2.50	7.30	24.00	170.00	19.00	6.40	4.60
9	3.50	1.90	2.80	2.50	2.50	2.50	8.30	23.00	168.00	18.00	6.40	4.60
10	2.50	1.90	2.50	2.50	2.50	2.50	10.00	31.00	165.00	18.00	6.20	3.80
11	2.30	1.90	2.50	2.50	2.50	2.50	13.00	47.00	160.00	17.00	6.00	4.00
12	2.10	1.90	2.50	2.50	2.50	3.20	17.00	57.00	148.00	16.00	7.00	4.60
13	2.10	1.90	2.50	2.50	2.50	3.20	21.00	83.00	147.00	16.00	9.00	4.70
14	2.10	1.90	2.50	2.50	2.50	3.20	20.00	117.00	149.00	15.00	10.00	4.40
15	1.90	1.90	2.50	2.50	2.50	2.80	21.00	152.00	153.00	14.00	8.40	4.10
16	1.90	1.90	2.50	2.50	2.50	2.50	24.00	156.00	148.00	13.00	7.20	4.10
17	1.90	1.90	2.50	2.50	2.50	2.80	21.00	113.00	134.00	13.00	5.80	3.90
18	1.90	2.30	2.50	2.50	2.50	2.80	17.00	85.00	123.00	12.00	5.60	5.70
19	1.70	2.60	2.50	2.50	2.50	2.50	16.00	84.00	111.00	12.00	5.40	5.90
20	1.90	3.10	2.50	2.50	2.50	2.80	15.00	112.00	97.00	11.00	5.20	5.40
21	2.30	3.50	2.50	2.50	3.00	2.80	18.00	149.00	87.00	11.00	5.00	5.40
22	2.50	3.90	2.50	2.50	3.00	3.50	17.00	180.00	72.00	11.00	4.80	5.30
23	2.50	4.10	2.50	2.50	3.00	3.80	16.00	188.00	59.00	10.00	16.00	4.80
24	2.50	3.80	2.50	2.50	3.00	3.50	16.00	181.00	52.00	10.00	41.00	4.30
25	2.30	3.80	2.50	2.50	3.00	3.80	21.00	175.00	48.00	9.80	31.00	3.90
26	2.30	4.40	2.50	2.50	3.00	3.20	32.00	178.00	47.00	9.60	13.00	3.90
27	1.90	4.40	2.50	2.50	3.00	2.80	42.00	173.00	41.00	9.40	6.90	3.60
28	1.70	4.40	2.50	2.50	3.00	2.80	35.00	169.00	38.00	9.00	5.10	3.50
29	1.90	4.10	2.50	2.50		3.20	33.00	187.00	33.00	8.80	4.40	3.60
30	2.50	3.80	2.50	2.50		4.10	30.00	191.00	30.00	8.60	4.10	3.80
31	2.80		2.50	2.50		5.40		188.00		8.40	4.20	
AVG	2.44	2.72	2.67	2.50	2.64	3.11	17.31	105.41	121.66	14.85	8.88	4.29
MAX	6.10	4.40	3.50	2.50	3.00	5.40	42.00	191.00	189.00	28.00	41.00	5.90
MIN	1.70	1.90	2.50	2.50	2.50	2.50	6.40	23.00	30.00	8.40	4.10	3.50

WATER YEAR 1978 TOTAL = 8791.08 MAX = 191.00 MIN = 1.70 AVG = 24.08

STREAM FLOW (CFS)
MEAN

GOOSEBERRY CREEK NEAR SCOFIELD, UTAH — STATION # 09310000

WATER YEAR - 1979

DAY	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT
1	3.50	3.20	4.10	2.80	2.80	2.80	2.80	26.00	123.00	16.00	5.40	3.10
2	3.60	5.30	4.10	2.80	2.80	2.80	2.80	28.00	109.00	15.00	5.20	3.40
3	1.70	8.00	3.80	2.80	2.80	2.80	2.80	27.00	101.00	14.00	5.30	3.50
4	.34	6.70	3.50	2.80	2.80	2.80	2.80	35.00	96.00	14.00	5.00	3.60
5	.16	5.70	2.30	2.80	2.80	2.80	2.80	48.00	92.00	14.00	4.80	3.50
6	.07	4.90	1.30	2.80	2.80	2.80	2.80	57.00	88.00	13.00	4.90	3.20
7	.07	4.40	1.60	2.80	2.80	2.80	3.00	48.00	84.00	12.00	5.00	3.30
8	.07	4.40	2.30	2.80	2.80	2.80	4.10	42.00	76.00	12.00	5.70	3.30
9	.07	4.20	2.80	2.80	2.80	2.80	4.50	37.00	70.00	11.00	5.60	3.20
10	.07	3.90	2.80	2.80	2.80	2.80	5.10	33.00	64.00	10.00	5.40	3.60
11	.07	4.60	2.80	2.80	2.80	2.80	4.90	31.00	58.00	9.80	5.20	3.50
12	.07	5.80	2.80	2.80	2.80	2.80	4.30	31.00	53.00	9.80	5.80	3.20
13	.07	7.00	2.80	2.80	2.80	2.80	5.00	38.00	48.00	9.40	6.60	3.20
14	.07	5.40	2.80	2.80	2.80	2.80	4.00	48.00	44.00	9.00	6.80	3.20
15	.07	5.20	2.80	2.80	2.80	2.80	4.10	57.00	41.00	8.70	6.90	3.20
16	.07	4.80	2.80	2.80	2.80	2.80	5.20	84.00	38.00	8.30	6.80	3.20
17	.07	4.60	2.80	2.80	2.80	2.80	7.60	114.00	36.00	8.30	6.60	3.20
18	.07	4.30	2.80	2.80	2.80	2.80	9.40	134.00	34.00	8.30	6.70	3.20
19	.07	4.00	2.80	2.80	2.80	2.80	10.00	156.00	32.00	7.90	6.40	3.10
20	.07	3.80	2.80	2.80	2.80	2.80	9.40	163.00	31.00	8.00	6.30	3.50
21	.16	3.70	2.80	2.80	2.80	2.80	8.70	171.00	28.00	8.70	6.00	3.50
22	.16	3.80	2.80	2.80	2.80	2.80	9.00	179.00	26.00	11.00	5.70	3.60
23	.16	3.50	2.80	2.80	2.80	2.80	9.90	179.00	25.00	10.00	5.10	3.60
24	.16	2.50	2.80	2.80	2.80	2.80	11.00	182.00	24.00	10.00	4.80	3.50
25	.16	3.10	2.80	2.80	2.80	2.80	12.00	173.00	23.00	8.70	4.30	3.60
26	.16	3.50	2.80	2.80	2.80	2.80	12.00	174.00	20.00	7.90	4.10	3.40
27	.16	2.50	2.80	2.80	2.80	2.80	15.00	187.00	19.00	7.40	4.10	3.50
28	.67	2.50	2.80	2.80	2.80	2.80	18.00	202.00	18.00	6.80	3.90	3.50
29	2.10	2.70	2.80	2.80		2.80	23.00	186.00	18.00	6.40	3.90	3.20
30	2.50	3.60	2.80	2.80		2.80	24.00	160.00	17.00	6.10	3.50	3.20
31	3.30		2.80	2.80		2.80		138.00		5.70	3.30	
AVG	.64	4.38	2.81	2.79	2.79	2.79	7.99	102.19	51.19	9.90	5.32	3.36
MAX	3.60	8.00	4.10	2.80	2.80	2.80	24.00	202.00	123.00	16.00	6.90	3.80
MIN	.07	2.50	1.30	2.80	2.80	2.80	2.80	26.00	17.00	5.70	3.30	3.10

WATER YEAR 1979 TOTAL = 6008.32 MAX = 202.00 MIN = .07 AVG = 16.46

STATION 09310000 GOOSEBERRY CREEK NEAR SCOFIELD, UTAH

DISCHARGE, IN CUBIC FEET PER SECOND
MONTHLY AND ANNUAL MEANS

YEAR	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	ANNUAL
1931	4.55	6.73	4.	*	*	*	17.83	40.81	12.63	4.32	2.74	2.	11.45
1940	*	*	*	*	*	*	*	111.	24.53	11.84	5.74	4.73	14.05
1941	4.52	4.	3.65	3.	3.	4.52	8.23	169.9	82.07	22.42	13.19	9.53	27.55
1942	12.	10.	9.	7.	6.	8.35	55.4	133.68	67.8	21.71	12.65	5.07	29.18
1943	4.26	3.03	3.03	2.	3.	3.42	42.8	54.81	49.03	15.19	10.61	4.23	16.3
1944	4.4	4.	4.	3.	3.	3.5	5.	128.61	93.33	16.9	7.4	4.95	23.25
1945	4.56	4.52	3.	3.	3.5	3.5	6.77	125.55	70.13	18.	10.69	6.17	21.76
1946	4.68	4.33	3.16	3.	3.14	3.77	44.81	65.	23.83	9.1	5.66	3.16	14.51
1947	5.09	4.01	3.35	2.5	2.5	3.58	22.95	121.87	31.73	12.43	8.45	5.11	18.79
1948	4.78	4.25	3.35	2.5	2.3	2.37	10.46	78.19	23.87	10.06	6.46	3.08	12.72
1949	3.3	3.24	3.1	2.9	2.89	3.76	38.05	136.58	48.67	13.18	6.45	3.76	22.3
1950	3.91	2.91	2.21	2.	2.	3.02	19.06	92.13	40.67	12.42	6.25	5.76	16.13
1951	3.62	6.25	3.3	2.45	2.45	3.28	24.81	98.26	42.03	13.48	9.12	4.63	17.92
1952	5.62	4.43	3.58	3.	3.	3.66	20.58	238.71	155.77	26.06	14.13	8.04	41.57
1953	5.34	5.04	3.35	2.6	2.54	3.42	10.34	69.39	68.67	15.29	9.65	5.76	16.84
1954	4.5	4.97	4.26	4.	4.5	4.76	28.72	52.55	15.54	8.16	4.	4.31	11.73
1955	3.83	3.71	2.72	2.5	2.5	3.34	8.95	76.16	30.4	9.92	7.38	3.81	13.03
1956	2.46	2.16	2.1	2.	1.9	3.27	27.51	94.45	25.63	10.01	5.48	2.67	15.05
1957	3.61	2.98	2.2	2.2	2.66	3.76	9.01	77.65	163.6	23.81	10.22	5.73	25.59
1958	6.11	5.66	3.5	3.	3.18	4.27	16.17	152.94	58.5	13.29	8.26	3.88	23.42
1959	3.26	3.44	2.89	2.74	2.5	2.91	8.55	55.29	23.1	9.41	3.92	2.87	10.14
1960	3.23	2.9	1.81	1.4	1.4	3.4	11.	78.77	26.1	9.99	3.54	2.75	12.27
1961	3.16	3.37	3.05	2.2	2.2	2.56	10.4	36.52	13.25	5.64	2.32	3.93	7.42
1962	3.44	3.82	2.98	3.	4.64	4.5	29.17	145.42	66.37	19.55	10.25	6.56	25.12
1963	4.3	3.75	2.34	1.41	1.97	2.13	3.92	92.45	35.2	11.55	8.84	6.33	14.64
1964	3.	2.92	2.5	3.	3.	3.	5.66	92.58	60.1	16.52	9.13	6.79	17.41
1965	3.65	2.92	4.08	4.23	3.95	3.5	9.96	92.13	94.9	21.65	16.71	14.07	22.71
1966	9.42	6.86	4.83	4.31	4.6	6.54	35.53	68.97	15.85	6.04	7.49	4.12	14.62
1967	5.86	3.51	3.26	2.5	2.5	2.99	5.71	93.39	80.29	16.5	8.32	5.38	19.27
1968	4.07	3.76	3.79	3.97	4.	4.23	7.51	82.	91.87	12.76	9.97	6.39	19.52
1969	5.73	4.57	3.42	2.9	2.98	3.83	22.4	195.94	43.6	15.25	7.46	6.18	26.46
1970	6.81	5.77	4.89	4.8	4.15	4.93	7.35	109.66	52.5	13.56	5.84	4.94	18.9
1971	5.28	5.16	6.53	7.39	3.63	4.15	12.51	85.06	38.2	10.72	5.58	4.7	15.85
1972	4.98	4.6	5.	5.35	4.97	10.57	24.07	60.42	18.41	5.72	3.26	3.91	12.65
1973	4.71	4.63	3.79	3.5	3.5	4.28	8.36	118.65	57.57	13.05	5.73	5.2	19.55
1974	4.4	4.22	4.2	4.8	4.12	4.01	8.48	111.13	24.07	7.35	3.65	2.66	15.41
1975	3.38	3.36	2.67	3.	3.	3.	3.37	52.82	148.57	25.	8.76	5.18	21.8
1976	5.91	5.27	5.06	5.	4.72	3.95	8.69	85.	19.9	7.27	3.14	2.39	13.11
1977	3.05	2.68	1.9	2.12	2.38	2.58	10.89	12.86	9.8	3.75	1.96	1.89	4.65
1978	2.45	2.73	2.67	2.5	2.64	3.11	17.31	105.42	121.67	14.86	8.89	4.3	24.08
1979	0.65	4.39	2.82	2.8	2.8	2.8	8.	102.19	51.2	9.91	5.33	3.37	16.46
1980	3.73	3.38	3.49	3.5	3.5	3.5	15.89	107.84	131.07	17.15	7.02	5.81	25.46
1981	5.02	4.74	3.86	3.68	3.7	5.15	25.38	59.32	26.67	7.1	3.86	3.59	12.72
1982	5.78	4.33	3.32	*	*	*	29.82	121.77	160.	*	*	*	59.7
PER	4.55	4.26	3.53	3.24	3.19	3.93	17.2	96.98	57.15	13.21	7.34	4.88	18.65

* INDICATES A NO-VALUE MONTH

$\frac{Q}{Q_{avg}}$ = .033 .031 .026 .023 .023 .029 .126 .708 .417 .096 .054 .036 .136

Qavg = 137.0 CFS

STATION 09310000 GOOSEBERRY CREEK NEAR SCOFIELD, UTAH

AGENCY: USGS
STATE: 49
COUNTY: 039
DISTRICT: 49

STATION LOCATOR
LAT. LONG.
394257 1111758

DRAINAGE AREA: 16.80 SQ MI
CONTRIBUTING DRAINAGE AREA: SQ MI
GAGE DATUM: 8400.00 (NGVD)
BASE DISCHARGE:

WATER YEAR	DATE	PEAK DISCHARGE (CFS)		DISCHARGE CODES	GAGE HEIGHT (FT)	GAGE HT CODES	HIGHEST SINCE	MAX GAGE HEIGHT (FT)	DATE	GAGE HT CODES	NUMBER OF PARTIAL PEAKS
1931	05/03/31	98.00		5	1.09	3	6				0
1932	/ /32	325.00		5	2.04	3					0
1941	05/18/41	366.00		5	2.25	3					0
1942	05/25/42	304.00		5	2.05	3					0
1943	06/01/43	178.00		5	1.57	3					0
1944	05/15/44	265.00		5	1.95	3					0
1945	05/12/45	240.00	1	5							0
1946	04/29/46	170.00		5	1.55	3					0
1947	05/04/47	292.00		5	2.06	3					0
1948	05/16/48	167.00		5	1.54	3					0
1949	05/17/49	360.00		5	2.31	3					0
1950	05/22/50	235.00		5	1.82	3					0
1951	05/20/51	189.00		5	1.68	3					0
1952	05/30/52	414.00		5	2.36	3					0
1953	05/27/53	218.00		5	1.59	3					0
1954	05/07/54	89.00		5	0.87	3					0
1955	05/12/55	161.00		5	1.99		6				0
1956	05/09/56	165.00		5	2.02						0
1957	06/06/57	369.00		5	2.98						0
1958	05/23/58	345.00		5	2.85						0
1959	05/14/59	122.00		5	1.79						0
1960	05/13/60	203.00		5	2.20						0
1961	05/12/61	74.00		5	1.42						0
1962	05/09/62	279.00		5	2.57						0
1963	05/19/63	173.00		5	2.05						0
1964	05/23/64	272.00		5	2.54						0
1965	05/20/65	230.00		5	2.42						0
1966	05/10/66	133.00		5	1.84						0
1967	05/28/67	252.00		5	2.48						0
1968	05/22/68	239.00		5	2.41						0
1969	05/14/69	338.00		5	2.95						0
1970	05/19/70	281.00		5	2.71						0
1971	05/15/71	224.00		5	2.27						0
1972	05/07/72	101.00		5	1.76						0
1973	05/21/73	312.00		5	2.84						0
1974	05/09/74	251.00		5	2.61						0
1975	06/06/75	256.00	1	5	2.58						0
1976	05/14/76	184.00		5	2.31						0
1977	04/17/77	32.00		5	1.01						0
1978	05/30/78	205.00		5	2.62						0
1979	05/28/79	208.00		5	2.64						0
1980	05/23/80	230.00		5	2.77						0
1981	05/03/81	147.00		5	2.16						0
1982	05/27/82	254.00		5	2.92						0
1983	06/10/83	333.00	1	5							0
1984	05/22/84	419.00	1	5							0

Gooseberry Creek
1940 - 1988

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY

STATION USGS 09310000 - GOOSEBERRY CREEK NEAR SCOFIELD, UTAH
LATITUDE 39425 LONGITUDE 111175 STATE 49 COUNTY 039

MINIMUM DISCHARGE, IN CUBIC FEET PER SECOND
FOR WATER YEARS 1931, 1940-88

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.00	1.70	2.00	1.40	1.40	1.50	2.50	4.10	14.0	4.60	1.40	0.900
2	2.10	1.70	2.00	1.40	1.40	1.50	2.50	4.00	13.0	6.00	1.70	0.900
3	1.70	1.70	2.00	1.40	1.40	1.50	2.50	5.00	13.0	6.00	1.70	0.400
4	0.340	2.00	2.00	1.40	1.40	1.50	2.50	6.90	12.0	5.70	1.70	0.400
5	0.160	1.90	2.00	1.40	1.40	1.50	2.40	7.00	12.0	5.40	1.80	0.200
6	0.070	1.90	1.30	1.40	1.40	1.50	2.50	7.00	12.0	4.60	1.90	0.200
7	0.070	1.90	1.60	1.40	1.40	1.50	2.40	7.00	12.0	4.00	1.70	0.200
8	0.070	1.90	1.60	1.40	1.40	1.50	2.40	7.00	13.0	3.70	1.70	0.200
9	0.070	1.90	1.60	1.40	1.40	1.50	2.40	7.00	16.0	3.80	1.60	0.200
10	0.070	1.90	1.60	1.40	1.40	1.50	2.80	7.90	15.0	3.30	1.60	0.400
11	0.070	1.90	2.00	1.40	1.40	1.50	2.80	8.40	14.0	2.90	1.40	0.400
12	0.070	1.90	2.00	1.40	1.40	1.50	2.40	8.10	12.0	2.90	1.40	0.200
13	0.070	1.90	2.00	1.40	1.40	1.50	2.40	7.60	11.0	2.80	1.40	0.400
14	0.070	1.90	2.00	1.40	1.40	1.50	2.80	9.50	10.0	2.50	1.40	0.900
15	0.070	1.90	1.70	1.40	1.40	1.50	3.00	13.0	9.60	2.50	1.40	1.90
16	0.070	1.90	1.70	1.40	1.40	1.50	3.00	15.0	8.70	2.50	1.40	1.90
17	0.070	1.90	1.40	1.40	1.40	1.50	3.00	15.0	8.30	2.70	1.40	1.90
18	0.070	2.30	1.40	1.40	1.40	1.50	2.80	14.0	7.90	2.80	1.70	1.90
19	0.070	2.30	1.40	1.40	1.40	2.30	2.40	13.0	7.70	3.00	1.70	1.80
20	0.070	2.00	1.40	1.40	1.40	2.30	2.60	13.0	7.40	3.40	1.70	2.00
21	0.160	1.60	1.40	1.40	1.40	2.50	2.60	14.0	7.10	3.40	1.90	2.00
22	0.160	2.00	1.40	1.40	1.40	2.20	3.00	14.0	7.10	3.50	1.90	0.100
23	0.160	2.30	1.40	1.40	1.40	2.50	3.00	13.0	7.10	3.00	1.70	0.000
24	0.160	2.30	1.40	1.40	1.40	2.50	3.00	13.0	6.60	3.00	0.400	0.000
25	0.160	2.30	1.40	1.40	1.40	2.50	3.00	15.0	6.60	3.00	0.400	0.000
26	0.160	2.00	1.40	1.40	1.40	2.50	5.00	19.0	6.30	3.00	0.200	0.000
27	0.160	2.00	1.40	1.40	1.40	2.50	5.00	22.0	6.20	2.60	0.200	0.100
28	0.670	2.00	1.40	1.40	1.40	2.50	4.50	23.0	5.50	2.30	0.200	0.200
29	1.90	2.00	1.40	1.40	1.40	2.50	3.90	21.0	5.10	2.30	0.200	1.90
30	1.70	2.00	1.40	1.40	---	2.50	4.00	18.0	4.70	1.70	0.200	2.00
31	1.70	---	1.40	1.40	---	2.50	---	16.0	---	1.70	0.600	---

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY

STATION USGS 09310000 - GOOSEBERRY CREEK NEAR SCOFIELD, UTAH
LATITUDE 39425 LONGITUDE 111175 STATE 49 COUNTY 039

MAXIMUM DISCHARGE, IN CUBIC FEET PER SECOND
FOR WATER YEARS 1931, 1940-28

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	16.0	16.0	11.0	8.50	7.30	8.00	28.0	125.0	311.0	124.0	26.0	12.0
2	19.0	14.0	10.0	7.70	7.30	8.10	31.0	165.0	302.0	114.0	27.0	11.0
3	16.3	13.0	9.40	8.90	7.30	8.80	29.0	204.0	319.0	106.0	21.0	11.0
4	15.0	13.0	9.40	8.90	7.30	10.0	27.0	248.0	302.0	98.0	21.0	15.0
5	14.0	12.0	9.40	8.90	6.80	12.0	27.0	254.0	308.0	90.0	23.0	12.0
6	12.0	12.0	9.40	8.90	7.30	13.0	25.0	241.0	305.0	83.0	19.0	15.0
7	12.0	12.0	9.40	8.90	7.30	15.0	28.0	250.0	305.0	72.0	18.0	18.0
8	12.0	13.0	9.20	8.90	7.30	12.0	27.0	239.0	280.0	67.0	18.0	18.0
9	12.0	14.0	9.00	8.90	7.70	14.0	30.0	242.0	322.0	66.0	19.0	13.0
10	12.0	13.0	9.00	8.50	7.70	13.0	34.0	260.0	333.0	60.0	20.0	13.0
11	12.0	13.0	9.00	8.50	7.70	11.0	41.0	275.0	283.0	52.0	21.0	13.0
12	12.0	12.0	9.00	8.10	7.30	10.0	50.0	274.0	245.0	46.0	23.0	13.0
13	12.0	12.0	9.40	7.70	7.70	8.80	58.0	300.0	240.0	38.0	20.0	12.0
14	12.0	11.0	9.70	8.10	7.80	8.90	68.0	319.0	257.0	35.0	18.0	15.0
15	12.0	11.0	9.40	8.20	7.40	8.50	80.0	294.0	304.0	31.0	18.0	18.0
16	13.0	10.0	9.00	7.80	7.30	8.00	99.0	255.0	305.0	30.0	18.0	23.0
17	14.0	11.0	9.00	7.60	7.30	8.00	119.0	290.0	316.0	28.0	29.0	19.0
18	14.0	11.0	9.00	8.40	8.00	8.30	138.0	268.0	301.0	26.0	28.0	16.0
19	13.0	17.0	9.40	9.90	10.0	9.20	110.0	258.0	262.0	25.0	27.0	16.0
20	12.0	16.0	9.00	12.0	9.00	9.30	84.0	282.0	236.0	25.0	29.0	16.0
21	12.0	17.0	9.00	11.0	7.60	10.0	74.0	341.0	217.0	27.9	27.0	16.0
22	12.0	14.0	9.00	9.30	7.30	12.0	90.0	419.0	202.0	27.0	20.0	16.0
23	12.0	10.0	9.00	10.0	7.30	12.0	110.0	394.0	190.0	33.0	16.0	18.0
24	13.0	10.0	9.40	11.0	7.70	11.0	110.0	397.0	178.0	28.0	41.0	17.0
25	15.0	11.0	9.40	10.0	7.80	11.0	116.0	378.0	167.0	30.0	31.0	16.0
26	23.0	10.0	9.80	7.70	7.60	11.0	128.0	368.0	154.0	25.0	13.0	14.0
27	24.0	10.0	9.40	7.30	7.40	13.0	135.0	366.0	148.0	26.0	15.0	27.0
28	20.0	10.0	9.00	7.30	7.40	11.0	125.0	330.0	136.0	22.0	15.0	21.0
29	17.0	10.0	9.00	7.30	7.70	13.0	132.0	356.0	149.0	19.0	17.0	20.0
30	16.0	11.0	9.00	7.30	---	15.0	130.0	364.0	136.0	19.7	19.0	20.0
31	18.0	---	9.00	7.22	---	22.0	---	339.0	---	25.0	16.0	---

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY

STATION USGS 09310000 - GOOSEBERRY CREEK NEAR SCOFIELD, UTAH
LATITUDE 39425 LONGITUDE 111175 STATE 49 COUNTY 039

MEAN DISCHARGE, IN CUBIC FEET PER SECOND
FOR WATER YEARS 1931, 1940-83

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.08	4.99	4.26	3.45	3.40	3.71	5.90	43.9	111.7	23.5	9.65	5.28
2	5.40	4.89	4.20	3.45	3.40	3.79	6.26	51.7	109.1	22.1	9.47	5.18
3	5.33	4.87	4.25	3.50	3.44	3.80	6.41	60.9	104.8	20.9	9.23	5.13
4	5.29	4.81	4.13	3.53	3.42	3.81	6.50	66.7	100.3	19.8	9.06	5.32
5	5.22	4.73	4.11	3.53	3.41	3.87	6.56	68.0	96.7	19.1	8.92	5.17
6	5.15	4.65	4.07	3.52	3.37	3.88	7.11	73.3	94.4	18.5	8.67	5.33
7	5.18	4.68	4.05	3.49	3.41	3.94	7.35	79.2	92.5	17.5	8.39	5.47
8	5.12	4.76	4.03	3.50	3.42	3.93	7.73	81.3	87.1	16.8	8.27	5.56
9	4.98	4.70	3.98	3.50	3.44	3.98	8.57	85.2	82.6	16.4	8.09	5.33
10	4.95	4.65	3.97	3.48	3.42	3.97	9.20	91.8	78.8	15.8	7.98	5.24
11	5.00	4.67	3.96	3.49	3.39	3.97	10.0	96.2	73.0	15.2	7.91	5.22
12	5.08	4.58	3.96	3.48	3.38	3.96	10.8	98.1	67.1	14.5	7.87	5.28
13	5.00	4.66	3.97	3.49	3.41	3.91	11.8	99.7	63.9	13.9	7.88	5.17
14	4.96	4.69	3.96	3.52	3.43	3.92	12.7	101.8	61.5	13.3	7.77	5.15
15	4.90	4.79	3.92	3.54	3.41	3.92	14.0	103.8	60.5	12.8	7.40	5.33
16	4.90	4.70	3.86	3.51	3.45	4.00	16.4	104.2	58.0	12.7	7.21	5.27
17	4.93	4.68	3.81	3.49	3.46	4.01	18.7	109.2	55.0	12.6	7.41	5.03
18	4.93	4.70	3.79	3.49	3.48	4.07	20.0	113.1	51.6	12.2	7.43	4.84
19	4.81	4.86	3.79	3.54	3.50	4.20	18.8	117.5	47.4	11.9	7.38	5.02
20	4.83	4.78	3.86	3.59	3.49	4.13	20.0	122.8	44.1	11.8	7.29	4.99
21	4.83	4.83	3.80	3.63	3.49	4.26	24.9	129.0	41.6	11.9	7.28	4.89
22	4.77	4.71	3.74	3.61	3.47	4.33	24.2	131.1	38.2	11.6	7.12	4.74
23	4.78	4.61	3.72	3.60	3.50	4.29	27.2	126.9	34.8	11.6	6.82	4.76
24	4.94	4.61	3.69	3.61	3.50	4.39	29.9	126.7	33.3	11.2	6.84	4.73
25	4.85	4.69	3.66	3.62	3.54	4.43	31.7	124.1	32.7	11.0	6.60	4.75
26	4.98	4.49	3.64	3.52	3.49	4.59	32.7	125.6	31.0	10.6	6.05	4.82
27	5.11	4.42	3.67	3.49	3.48	4.69	33.9	127.2	29.6	10.6	5.81	5.01
28	5.26	4.36	3.64	3.47	3.48	4.74	36.0	125.8	27.3	10.1	5.71	4.87
29	5.31	4.31	3.62 QLI	3.45	3.64	4.91	38.7	123.2	26.2	9.92	5.68	5.17
30	5.17	4.37	3.61	3.41	---	5.10	41.6	118.9	24.8	9.93	5.65	5.16
31	5.17	---	3.62	3.40	---	5.44	---	114.9	---	9.82	5.49	---

U.S. FOREST SERVICE
MANTI LA SAL FOREST
DENNIS KELLY DATA FILES

ECCLES CANYON CREEK

United States
Department of
Agriculture

Forest
Service

Manti-LaSal N.F.

W/S 02
Sub w/s 304

Reply to:

Date:

Subject: Functional Status Report -- Skyline Mine Breakout

To: District Ranger, Price

The Skyline Mine proposes to breakout in the South Fork of Eccles Canyon in order to get additional ventilation in the Skyline Mine.

The location of the proposed breakout is in the NE 1/4 SW 1/4, Sec 24, T. 13 S., R. 6 E., SLB&M.
The project construction is estimated to take two weeks. It may take longer.

AFFECTED ENVIRONMENT:

Drainage Network:
The breakout would be in a tributary of the South Fork of Eccles Canyon. The South Fork of Eccles Canyon is tributary to Eccles Canyon which is tributary to Pleasant Valley Creek which is tributary to Scofield Reservoir. The outlet from Scofield Reservoir is Price River which is tributary to the Green River which is tributary to the Colorado River which is tributary to the sea at the Gulf of California.

Watershed Conditions.

The South Fork of Eccles Canyon is a third order stream at the Forest boundary. The proposed breakout is on one of 4 small tributaries of the South Fork. The drainage area above the breakout is 135 acres. The stream is perennial. The watershed is well vegetated.

The only existing development is a network of roads that have revegetated. Erosion and sediment yield rates are low.

Water Production:
The mean annual precipitation is 30 inches. (Jeppsen, et.al., 1968)
The seasonal precipitation is 8.5 inches. (ibid)
The mean annual water yield is 12 inches. (ibid)

Streams and springs.
The project would affect about 1/4 mile of stream channel on the National Forest.

Water quality:
The Skyline and Balina Mines have together been monitoring 8 stations in the South Fork of Eccles Canyon since 1979.

The Forest Service monitored the South Fork of Eccles Canyon at the Forest boundary from 1977 to 1980. High values of total Cadmium, total copper, and total iron were reported by Kelly (1983). Turbidity ranged from 470 to 3 n.t.u. A minimum value of dissolved Oxygen at 1.6 mg/l was also reported.

Storms and floods.

Jim Iaquinta (1985) reported on the recurrence of storms and calculated the flood frequency of the Woods Canyon Drainage.

Table 1. Winter Quarters Canyon Sub watershed
Storms and floods:

Recurrence Interval (years)	Storm Duration (hours)	Precip Amount (inches)	Flood Flow (cubic feet per second per sq.mi.)
25	24	2.9	26.18
.50	24	3.2	34.90
100	24	3.6	48.29
500	24	4.4	79.51
25	6	1.9	13.72
50	6	2.1	20.94
100	6	2.3	29.58
500	6	2.8	49.31

This indicates that the 100 Year flood flow would be less than 15 cfs.

Water rights:

The Forest Service filed for instream flows at the stream crossing of South Fork of Eccles Creek and the National Forest Boundary during the adjudication of the Price River basin.

Beneficial Uses:

The numerical standards include "Price River and tributaries, from Castle Gate below Price City Water Treatment Plant intake to headwaters" with the beneficial use classes of 1C, 2B, 3A, and 4.

Class 1C -- protected for domestic purposes with prior treatment as required by the Utah Department of Health.

Class 2b -- Protected for recreational boating, water skiing, and similar uses, excluding recreational bathing (swimming).

Class 3A -- Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.

Class 4 -- Protected for agricultural uses including irrigation of crops and stockwatering.

The stream is an antidegradation segment for water quality.

EFFECTS OF IMPLEMENTATION:

B. Effects of Implementation Common to alternatives 2,3 and 4

The upgrading of the road for 1/4 mile on the National Forest will increase the potential for erosion and sedimentation. The upgraded road will have less (no) vegetation and be much more subject to the erosion forces. The mitigation measures will reduce these impacts but are not likely to prevent them altogether.

The hauling of the coal necessary for the development of the breakout will cause a detaching of soil and rock particles from the road surface which may reach the creek during erosion events (rainstorms, snowmelt, and traffic). The proposed mitigations will reduce the amount of sediment that reaches the creek but will not totally prevent some sediment from reaching the stream.

The slope that will be disturbed by the construction is considered to be unstable. Savanyo rated the slope as moderately unstable. If a slope failure (landslide) occurs then some erosion debris may reach the stream channel. This would likely cause an increase in sediment production from the subwatershed.

Pollution of the streams:

Increased Sediment: The current sediment yields are considered to be low. Sediment increases from landslides, portal construction, road construction and traffic is likely. The addition of sediment may cause accelerated erosion of the stream channel.

Sediment from Soil Stockpiles: Part of the proposal is to stockpile the topsoil and the fill material for the stream crossing. These stockpiles of soil material are subject to erosion and should be protected from erosion forces by vegetation and sediment control structures. These are included in the mitigation measures. It is likely that some sediment will reach the stream in spite of the mitigation efforts.

Sediment from the Construction Site: The mitigation measures are to use mulch, tackifiers and silt fences to prevent material eroded from the construction disturbed areas from reaching the stream. It is likely that some sediment will reach the stream anyway and that there will be a degradation of the ability of the stream to produce aquatic organisms that are important to the food chain of the game fish in the drainage network.

Sediment from Road Use: The traffic on the road will cause a detachment of soil and rock particles that are easily eroded by wind, water and the traffic. Some of these particles are likely to reach the stream. The mitigation measures will contain most of the sediment but some impact to the stream is likely.

Sediment from Slope Failures: If landslide(s) occur and sediment from the landslides reaches the creek then the sediment load of the stream will be increased. It is anticipated that landslides if any will be small sized and will not reach the stream.

Increase in Phosphate and Nitrate: The Clean Lakes Study of the State of Utah rated Scofield Reservoir as a high priority for being cleaned up. The eutrofication is caused by high phosphate and nitrate loads. Studies to identify the source of Phosphate and nitrate associate these chemicals with the erosion products carried by the streams. When sediment is reduced the phosphate loading is also reduced. When sediment is increased the phosphate loading is also increased.

C. Effects of Culvert Left in the Creek for the Life of the Mine

The fill material placed over the culvert has the potential for eroding and producing sediment into the creek. The proposed mitigation measures will control most of the erosion and prevent most of the sediment from reaching the creek. However, some sediment is likely to reach the stream -- especially during the first three years following construction. Mitigation by using mulches and tackifiers will greatly reduce the hazard.

D. Effect of 36 Inch Culvert Removed After Construction and Replaced for Final Rehabilitation.

The effect of installation will be the same as for the installation discussed in C above. There will be some additional sediment during the process of removing the culvert and again at the end of the project when the culvert is reinstalled and then removed for a second time.

By removing the culvert following the initial construction the fill material is removed from the immediate proximity of the creek and stockpiled along the road. The slope of the stockpiled material may be gentler than when it is in place as a stream crossing. The stockpile will be revegetated. Between the stockpile and the creek will be a buffer of well vegetated slope that has the potential of catching and holding any sediment that is produced from the stockpile. No such buffer would exist if the fill were left at the creek crossing.

The stream will have an opportunity to recover from the impacts of the construction if the fill is removed. Many years later the reestablishment of the crossing will create a new impact. If the fill is left in place the sediment that is produced will reach the stream and the impacts although probable small will be long term.

E. Effects of a Bottomless Arch:
The construction impact will be greater. There will be more disturbance at the stream crossing because the construction will require excavation for footings for the pipe arch. After construction the stream bed has the potential for continuing as aquatic habitat until the final reclamation when the arch would be removed. The difference in impact will be the effect on the stream bed for the length of the pipe or pipe arch.

MITIGATIONS:

Page 3-64a The estimates of disturbed area should include the acreage of the road that will be opened.

Page 3-64b reference the revegetation plans described on page 4-26a.

Page 4-26a Soil stockpiles should be revegetated and/or mulched to prevent erosion until final reclamation.

Page 4-90 Rip rap sizes should have few fines that could erode and add sediment to the creek. A gradation of sizes larger than fines is needed to prevent gaps in the riprap that could erode.

Page 4-93 and 4-93a. Add "revegetation to acceptible standards."

The data collected for the project monitoring should be compared with the historical data for the station to display what changes if any occur as a result of the project.

The data should be compared with the data for the main stem of Eccles Creek to determine if a correlation exists between the two streams.

The effects of the Skyline mine on the water quality in Eccles Canyon should be evaluated to identify which effects may occur in the South Fork of Eccles Canyon.

Samples should be collected daily during the construction period (estimated for the I.D. Team to be about 2 weeks). Sampling should be done above and below the construction activity.

The amount of traffic on the old Forest Service road should be described. The I.D. Team estimated 300 truck loads of coal would be hauled out of the project site. In a two week period that amounts to at least 21 round trips per day. What effect will that have on the road surface? How much erosion of the road surface will reach the creek? What mitigation measures are planned to prevent the sediment from reaching the creek from the road? I suggest straw bales and silt fences will be needed along the road from the project to the Forest Boundary. Accumulated sediment in these barriers should be seeded and mulched along with the reclamation of the road. The straw bales should remain until the vegetation is effective and then the straw should be removed. Other mitigation may be effective.

Hauling should not be allowed in wet weather to avoid unacceptable rutting.

LISTED REFERENCES:

Iaquinta, James. and G. Dennis Kelly. 1985. Watershed Inventory and Analysis for Price River Watershed. Manti-LaSal National Forest, Price, Utah.

Jeppson, et.al. 1968. Hydrologic Atlas of Utah. Report wg-35-1. Utah Water Resources Laboratory. Utah State University, Logan, Utah.

Kelly. G. Dennis. 1983. Selected Stream Water Quality Data. Manti-LaSal National Forest. 1967-1980. Manti-LaSal National Forest, Price, Utah. File 2540.

G. Dennis Kelly
Hydrologist

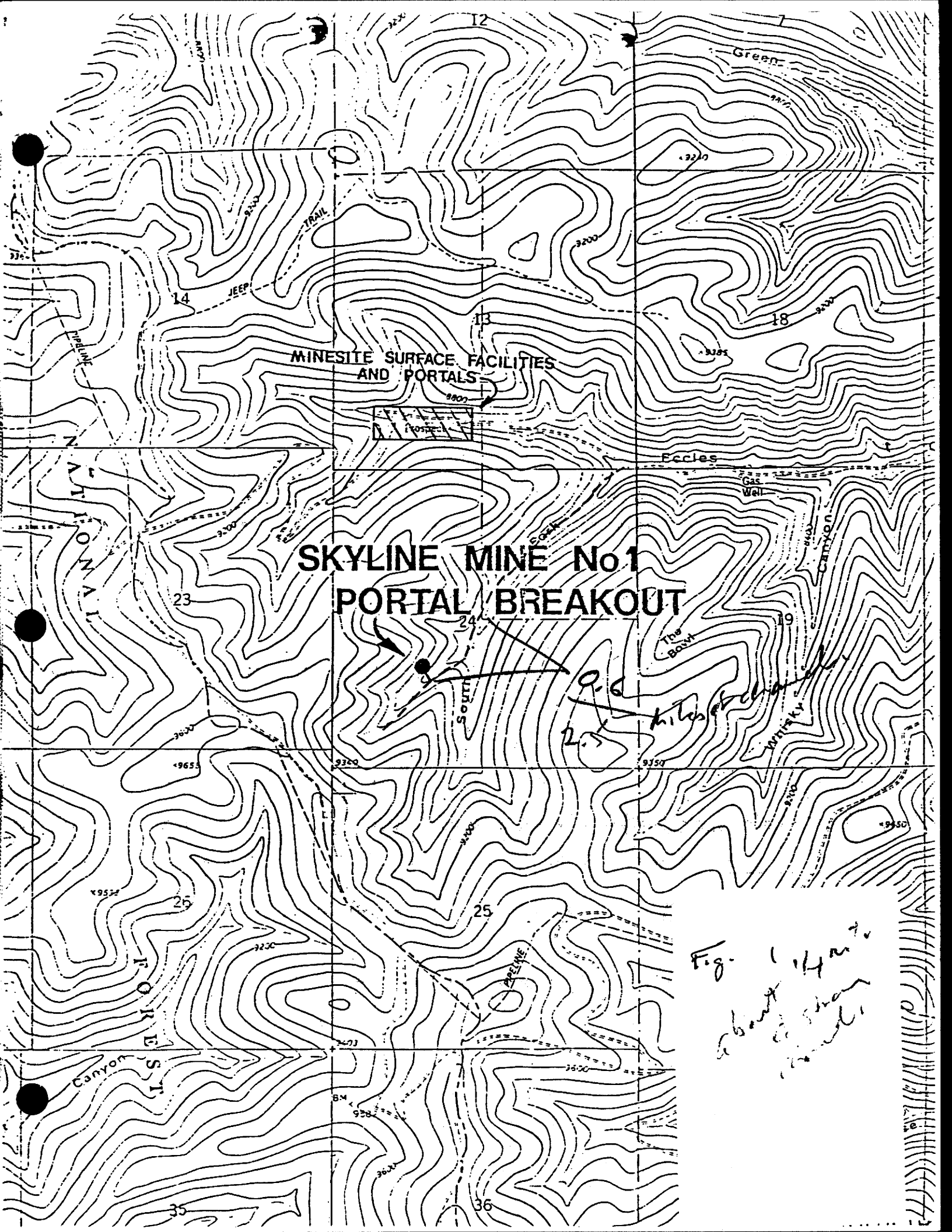


Fig. 1 14mi to about 2 miles

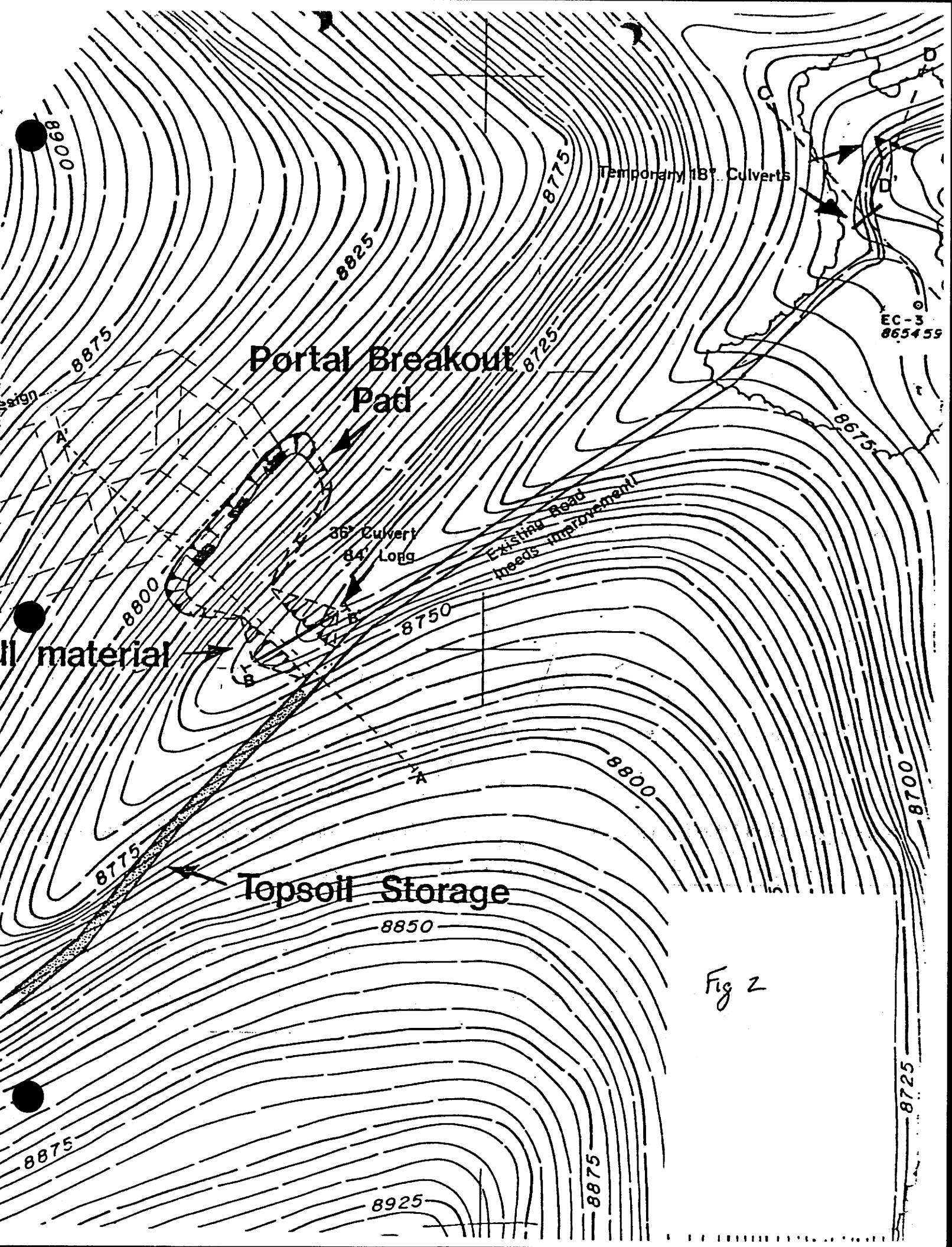

Temporary 18" Culverts
Portal Breakout Pad
36" Culvert 84' Long
Existing Road needs improvement
Topsoil Storage
EC-3
865459
8900
8875
8825
8775
8725
8675
8800
8750
8700
8850
8925
A
A'
B
B'
D
D'

Fig 2

FOREST BOUNDARY
SOUTH FORK
FOREST & CANYON WATERSHED

1979

Eccles CANYON

2530 FLOOD DATA

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Manti-LaSal National Forest
350 East Main Street
Price, Utah 84501

March 28, 1979

Mr. Richard DePaula
Coastal States Energy
9 Greenway Plaza
Houston, Texas 77046

Dear Mr. DePaula:

Enclosed are the peak flow data you requested for the Eccles Canyon drainage. These were generated using the S.C.S. runoff curve number method which is documented in their National Engineering Handbook, Section 4: Hydrology. Several tributaries have potential for influencing development in this drainage, flood peaks were generated for each of these tributaries and for combinations of them that may jointly affect development.

The attached map and table present the flood data with much of the information that was used to obtain the flood peaks. Identification of the points on the map was accomplished using aerial photographs to help locate recent developments such as roads on the relatively old map. The flood peaks for individual subwatersheds such as the one above Point 1 were based on the characteristics of the entire drainage above that point. Point 1345 represents the minimum drainage that contains subwatersheds 1, 3, 4, and 5. Flow at Point 13456A6B6C78 drains the entire watershed that contains the South Fork and main stem of Eccles Creek above the juncture of the two streams.

If you have further questions concerning this information, please feel free to contact our staff.

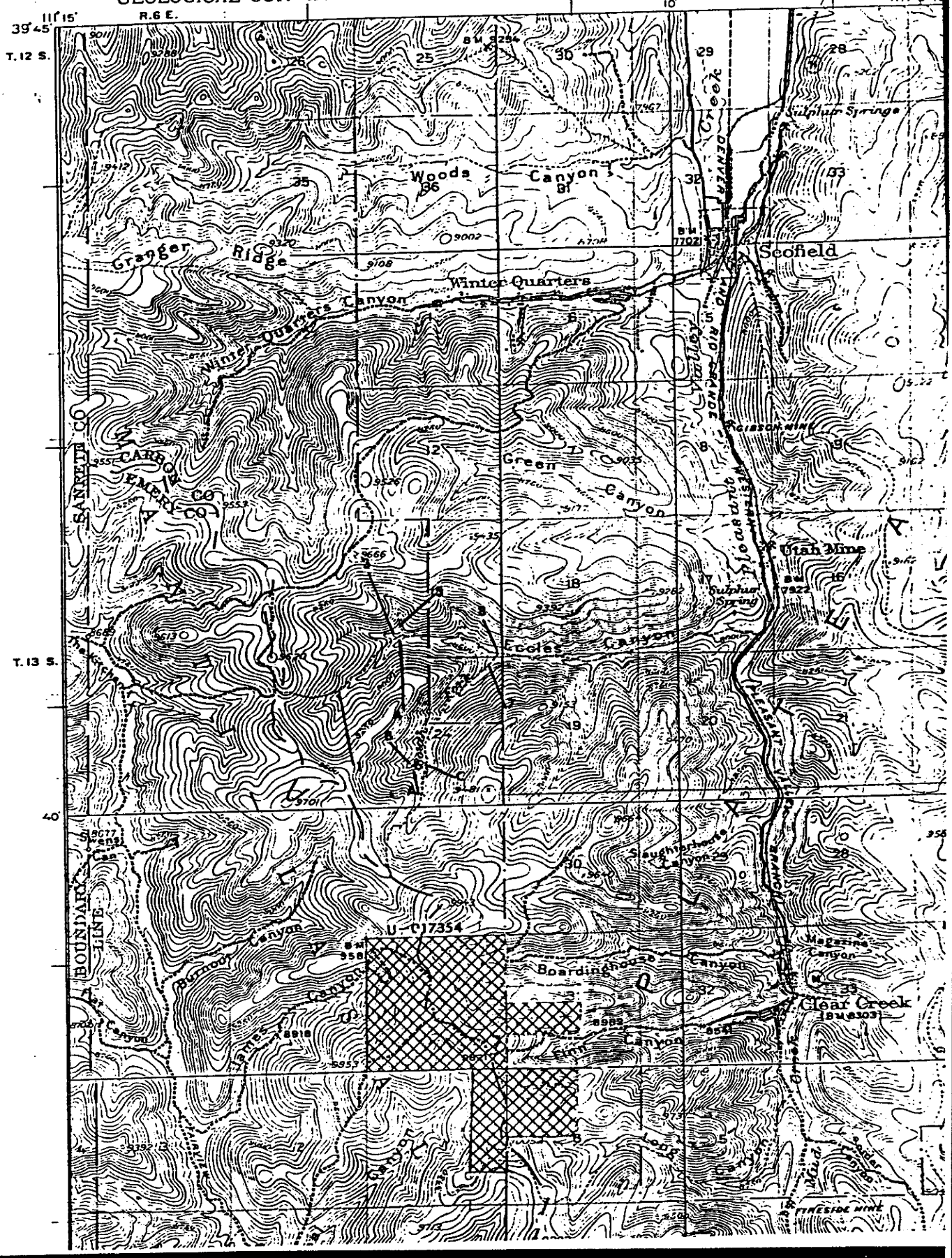
Sincerely,

for
REED C. CHRISTENSEN
Forest Supervisor

Enclosures

	Q_{20}	Q_{50}	Q_{100}	$Q_{Max.\ Prob.}$	Acres	CN_{20}	CN_{50}	CN_{100}	CN_{MP}	Area Mi.	Length	Height
1	.4294	1.9118	4.8217	168.4252	148.8	54.17	53.24	52.70	49.85	.231	.45	600
3	10.9308	17.2190	25.3307	275.9907	142.00	63.57	62.73	62.20	60.26	.222	.97	880
4	.3914	1.3720	2.8922	117.6921	158.6	54.01	52.43	50.97	44.07	.248	.67	760
5	6.9197	9.5084	12.3542	71.6713	40.4	69.17	68.17	67.24	58.0	.063	.75	920
1345	18.6713	30.0112	45.3988	633.7793	489.8	60.10	58.63	57.55	52.06	.765	1.12	760
13458	19.7636	32.8502	53.4172	847.5466	738.5	58.77	57.15	56.16	50.07	1.154	1.86	1000
6C	15.1100	22.2238	30.3534	291.2232	451.9	59.53	57.52	55.71	52.35	.715	1.27	1310
6B	- - -	- - -	- - -	113.5934	192.7	- - -	- - -	- - -	41.57	.301	.75	950
6A	.0150	.2461	.7533	46.4499	56.7	52.66	51.34	50.25	45.28	.089	.45	650
6A6B6C7	15.1250	22.4699	31.1067	461.0793	707.3	58.04	55.83	53.8541	42.61	1.105	2.01	1550
13456A6B6C78	34.8886	55.3201	84.5239	1308.6259	1445.8	58.42	56.53	55.10	46.58	2.259	1.86	1000
7	- - -	- - -	- - -	9.8129	146.6	- - -	- - -	- - -	29.80			
8	1.0923	2.8390	8.0184	213.7672	248.7	54.69	52.97	52.69	45.89			

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



Glen A. Zumwalt
Vice President and
General Manager

1984
MUDSLIDE

Utah Fuel Company
P.O. Box 719
Helper, Utah 84526
(801) 637-7925 or
Salt Lake (801) 566-7111

RECEIVED
MANTI-LASAL N.F.
MAY 18 1984
AO
AA
PERSONNEL
RESOURCE
Kelly
ERA
FEN RANGER
DIST RANGER

Subsidiary of
Coastal States
Energy Company

Vay 18 1984

Reed Christensen, Forest Supervisor
599 West Price Drive
Price, Utah 84501

Re: Eccles Canyon Mudslide - 1984

Dear Reed:

During the past week a number of mudslides have occurred in the Eccles Creek drainages on Forest Service ground above the Skyline minesite. One slide event occurring in the North Fork of the Eccles Creek drainage completely filled a significant retention area behind our topsoil stockpile with mud, rock and tree debris covering our newly-designed and implaced inlet structures which should have handled events of the size occurring last year. The slide occurred on Tuesday morning in an area at the head of the drainage with a like amount of material still moving above that area. Additional activity is occurring on other hillsides in this canyon. One such slump or slide potential area is at least 150 yards wide by approximately 300 yards long.

Both the Middle Fork and the South Fork of the upper Eccles Creek drainages remain snowpacked and will undoubtedly exhibit similar tendencies. With the retention area above our stockpile filled, Utah Fuel is concerned about the safety of the minesite facilities and the personnel working there. We have taken initial precautionary steps to help secure the property and prevent further damage; however, our assessment of the potential slide hazard can only be of a cursory nature because of our lack of expertise in the actual mechanics and history of such slide activity.

Since the U.S. Forest Service has the surface control and responsibilities for the lands immediately adjacent to and up drainage from our minesite, we are requesting your assistance in assessing potential slide activity in those drainages. Immediate evaluation by Forest Service experts such as Earl Olsen of your regional office will be beneficial.

Your help will be greatly appreciated.

Sincerely,

Glen A. Zumwalt

Glen A. Zumwalt
Vice President & General Manager

GAZ:jsg

W/S 02 Price River
Sub W/S 412 Eccles Canyon
1978

Water Quality Data
Seeps and Springs
Skyline Project

STATION	DATE	FLOW	WATER TEMP.	pH	SULFATE AS SO_4	T.D.S.	SPECIFIC COND.	BICARBONATE ALK. AS HCO_3	CALCIUM TOTAL	CHLORIDE DISS.	MAGNESIUM TOTAL	POTASSIUM TOTAL	SODIUM TOTAL
		gpm	°C		mg/l	mg/l	umhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
2-2	9-06-78	12	10	7.35	4.0	213	395	258.6	71.2	8.0	8.1	3.56	2.1
10-1	9-08-78	0.3			5.0	64	118	70.7	17.6	<1.0	3.30	1.96	1.54
13-2	9-08-78	7	6.5		31.0	328	608	351.3	97.6	8.0	17.3	1.18	5.01
13-3	9-14-78	0.5	7	7.4	38.0	308	570	324.5	89.6	12.0	22.5	1.293	5.33
14-1	9-08-78	0.3	7		5.0	189	350	212.2	62.4	<1.0	4.8	0.83	1.58
14-4	9-14-78	0.8	6	7.5	20.0	235	435	248.9	75.2	6.0	10.0	1.061	2.5
15-3	9-08-78	8	5		18.0	184	340	229.3	64.0	4.0	10.0	0.77	2.16
15-4	9-14-78	2	6	7.05	34.0	254	470	280.6	73.6	2.0	17.7	0.932	3.00
15-6	9-14-78	Seep	8	7.7	8.0	29	54	26.8	11.2	2.0	1.0	0.506	2.08
15-7	9-14-78	0.5	9	7.6	28.0	104	193	80.5	29.6	2.0	4.8	0.81	2.06
15-9	9-14-78	0.5	3	7.48	26.0	210	388	217.1	67.2	2.0	9.1	0.874	2.30
15-15	10-26-78	0.3	4	7.6	22.0	30	55	17.1	7.2	0.1	3.84	0.727	2.16
22-5	9-07-78	2	4		16.0	219	405	231.8	65.6	<1.0	10.0	0.68	2.37
22-10	9-14-78	7	3	7.55	4.0	188	348	263.5	72.0	2.0	9.1	1.158	2.12
22-11	9-14-78	30	7	7.5	18.0	205	380	229.3	60.0	2.0	11.5	0.770	3.20
23-1	9-07-78		5		10.0	186	345	214.7	64.0	<1.0	5.7	0.56	1.85
23-3	9-07-78	2	5	7.6	12.0	203	375	261.1	72.0	2.0	11.0	0.65	2.47
23-4	9-08-78	1	6		9.0	262	485	326.9	75.2	<1.0	17.7	1.17	1.97
23-6	9-08-78	3	7		9.0	205	380	256.2	68.0	<1.0	11.0	1.22	1.81
24-1	9-08-78	0.8	4.5		45.0	327	605	341.6	96.0	<1.0	20.6	1.48	2.92
24-6	10-26-78	1	5	7.5	9.0	190	352	290.4	79.2	.01	9.60	1.257	2.95
25-1	9-06-78	2	5		4.0	219	405	278.1	70.4	6.0	11.0	2.95	4.10
25-2	10-26-78	4	4		14.0	174	322	231.8	62.4	.01	9.60	0.664	2.10
25-4	10-26-78	3	2.5	7.5	10.0	232	430	283.0	71.2	.01	13.44	0.808	1.95
26-1	9-07-78	2	5		9.0	200	370	258	70.4	2.0	7.7	1.11	6.70
26-10	10-26-78	5	9		8.0	227	420	280.6	74.4	<1.0	11.5	0.75	2.47
27-3	9-07-78	7	6		12.0	232	430	263.5	73.6	2.0	11.0	0.87	2.34
27-6	9-07-78	7	4		10.0	208	385	251.3	69.6	<1.0	9.6	0.78	2.10
34-2	10-18-78	224	10		10.0	203	375	270.8	60.0	.01	7.20	0.889	25.7
34-12	10-26-78	2	7	7.3	14.0	238	440	253.8	68.0	< .01	12.0	0.816	2.34

Prepared By Vaughn Hansen Associates

Water Quality Data
Seeps and Springs
Skyline Project

STATION	DATE	FLOW	WATER TEMP.	pH	SULFATE AS SO_4	T.D.S.	SPECIFIC COND.	BICARBONATE ALK. AS HCO_3	CALCIUM TOTAL	CHLORIDE DISS.	MAGNESIUM TOTAL	POTASSIUM TOTAL	SODIUM TOTAL
		gpm	°C		mg/l	mg/l	umhos/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
35-1	9-06-78	2	12	7.65	9.0	224	415	275.7	72.0	<1.0	11.5	0.88	2.21
35-8	9-07-78	7	4		20.0	212	392	263.5	68.8	2.0	6.7	0.89	16.10
36-1	9-10-78	0.8	4.5	7.5	11.0	205	380	236.6	66.4	<1.0	8.6	0.42	1.64
36-2	9-06-78	4	4	7.7	10.0	221	410	261.1	72.8	<1.0	9.1	0.90	1.80

1-8-79

Prepared By Vaughn Hansen Associates

ECCLES CANYON
1981

STORET RETRIEVAL DATE 81/09/02 - INVENT - VERSION OF MAR. 1981

100300230751 SL13SR6E1314
39 41 05.0 111 11 59.0 2
NORTH FORK ECCLES CANYON
49007 UTAH
COLORADO RIVER 1405
GREEN RIVER
113FORS4 780825
0000 CLASS 00 CSN-RSP 0476355-0341059

/TYPA/AMBNT/STREAM

PARAMETER				NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00011	WATER	TEMP	FAHN	34	42.2647	76.1411	8.72589	.206458	1.49648	63.0000	32.0000	77/09/29	80/12/08
00021	AIR	TEMP	FAHN	23	52.7826	382.088	19.5471	.370331	4.07584	83.0000	19.0000	78/08/29	80/12/08
00060	STREAM	FLOW	CFS	22	1.19182	1.27436	1.12888	.947189	.240677	5.00000	.010000	77/09/29	79/08/17
00061	STREAM	FLOW,	INST-CFS	14	1.69643	1.89634	1.37708	.811751	.368039	5.00000	.200000	80/04/29	80/12/08
00070	TURB	JKSN	JTU	10	241.420	39845.5	199.613	.826830	63.1233	510.000	3.20000	77/09/29	78/06/22
00095	CNDUCTVY	AT 25C	MICROMHO	10	319.600	4848.37	69.6303	.217867	22.0190	420.000	170.000	77/09/29	78/06/22
00300	DO		MG/L	36	8.42221	7.38080	2.71676	.322571	.452794	12.0000	1.10000	77/09/29	80/12/08
00400	PH		SU	19	8.03684	.291368	.539785	.067164	.123835	8.70000	6.70000	77/09/29	80/05/16
00410	T ALK	CACO3	MG/L	35	243.514	2231.82	47.2422	.194002	7.98538	325.000	137.000	77/09/29	80/12/08
00530	RESIDUE	TOT NFLT	MG/L	36	47.5417	8454.49	91.9483	1.93406	15.3247	501.000	3.00000	77/08/26	80/12/08
00550	OIL-GRSE	TOT-SXLT	MG/L	30	4.81666	135.988	11.6614	2.42105	2.12907	63.2000	.400000	77/08/26	80/12/08
00620	NO3-N	TOTAL	MG/L	36	.680275	.235786	.485578	.713797	.080930	2.20000	.020000	77/08/26	80/12/08
00665	PHOS-TOT		MG/L P	22	.094136	.019793	.140686	1.49449	.029994	.620000	.010000	77/08/26	79/08/17
00900	TOT HARD	CACO3	MG/L	35	273.143	2726.00	52.2111	.191149	8.82529	376.000	154.000	77/09/29	80/12/08
00945	SULFATE	SO4-TOT	MG/L	25	15.3760	66.4012	8.14869	.529962	1.62974	35.4000	1.00000	77/08/26	80/12/08
00951	FLUORIDE	F,TOTAL	MG/L	28	.155000	.001670	.040872	.263688	.007724	.290000	.050000	77/08/26	80/12/08
01002	ARSENIC	AS,TOT	UG/L	25	1.04000	.040001	.200002	.192310	.040000	2.00000	1.00000	77/08/26	80/12/08
01007	BARIUM	BA,TOT	UG/L	4	38.7500	372.916	19.3110	.498350	9.65552	65.0000	20.0000	80/07/23	80/10/23
01027	CADMIUM	CD,TOT	UG/L	25	1.76000	14.4400	3.80000	2.15909	.760000	20.0000	1.00000	77/08/26	80/12/08
01034	CHROMIUM	CR,TOT	UG/L	25	1.40000	3.25000	1.80278	1.28770	.360555	10.0000	1.00000	77/08/26	80/12/08
01042	COPPER	CU,TOT	UG/L	4	3.25000	20.2500	4.50000	1.38461	2.25000	10.0000	1.00000	80/07/23	80/10/23
01045	IRON	FE,TOT	UG/L	28	393.571	1201377	1096.07	2.78494	207.138	5920.00	21.0000	77/08/26	80/12/08
01051	LEAD	PB,TOT	UG/L	25	4.84000	280.307	16.7424	3.45916	3.34847	85.0000	1.00000	77/08/26	80/12/08
01055	MANGNESE	MN	UG/L	28	39.0000	1355.26	36.8138	.943945	6.95716	190.000	3.00000	77/08/26	80/12/08
01147	SELENIUM	SE,TOT	UG/L	28	1.00000	.000000	.000000		.000000	1.00000	1.00000	77/08/26	80/12/08
31501	TOT COLI	MFIMENDO	/100ML	32	30.2500	2443.68	49.4336	1.63417	8.73870	190.000	.000000	77/09/29	80/12/08
31616	FEC COLI	MFM-FCBR	/100ML	32	12.8750	1537.02	39.2048	3.04503	6.93049	200.000	.000000	77/09/29	80/12/08
70300	RESIDUE	DISS-180	C MG/L	35	261.857	2654.44	51.5213	.196753	8.70868	360.000	159.000	77/08/26	80/11/19
70507	PHOS-T	ORTHO	MG/L P	14	.089571	.006448	.080299	.896484	.021461	.250000	.001000	80/04/29	80/12/08

STORET RETRIEVAL DATE 81/09/02 - INVENT - VERSION OF MAR. 1981

100300230851 SL13SR6E2407
39 40 26.0 111 11 56.0 2
SOUTH FORK ECCLES CANYON
49007 UTAH
COLORADO RIVER 1405
GREEN RIVER
113FORS4 780825
0000 CLASS 00 CSN-RSP 0476356-0341062

/TYPA/AMBNT/STREAM

PARAMETER				NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00011	WATER	TEMP	FAHN	32	42.0937	76.0232	8.71913	.207136	1.54134	63.0000	32.0000	77/09/29	80/12/08
00021	AIR	TEMP	FAHN	21	55.8571	259.230	16.1006	.288246	3.51344	83.0000	24.0000	78/08/29	80/12/08
00060	STREAM	FLOW	CFS	18	1.78944	2.07659	1.44104	.805300	.339656	5.00000	.010000	77/09/29	79/08/17
00061	STREAM	FLOW,	INST-CFS	14	1.83571	1.85478	1.36190	.741894	.363984	5.00000	.200000	80/04/29	80/12/08
00070	TURB	JKSN	JTU	5	266.220	54391.1	233.219	.876038	104.299	470.000	3.10000	77/09/29	78/02/27
00095	CNDUCTVY	AT 25C	MICROMHO	9	364.555	21662.7	147.183	.403732	49.0609	580.000	180.000	77/09/29	78/06/22
00300	DO		MG/L	27	9.04815	9.80183	3.13079	.346014	.602520	14.3000	1.60000	77/09/29	80/12/08
00400	PH		SU	14	8.23571	.239427	.489313	.059414	.130774	8.60000	6.60000	77/09/29	80/05/16
00410	T ALK	CACO3	MG/L	33	236.424	3133.75	55.9799	.236777	9.74485	463.000	154.000	77/09/29	80/12/08
00500	RESIDUE	TOTAL	MG/L	1	9.00000					9.00000	9.00000	80/07/09	80/07/09
00530	RESIDUE	TOT NFLT	MG/L	34	39.0647	8552.41	92.4792	2.36734	15.8601	459.000	1.00000	77/08/26	80/12/08
00550	OIL-GRSE	TOT-SXLT	MG/L	28	12.4821	2787.20	52.7939	4.22957	9.97711	281.700	.800000	77/08/26	80/12/08
00620	NO3-N	TOTAL	MG/L	34	.391176	.269035	.518685	1.32596	.088954	1.96000	.010000	77/08/26	80/12/08
00665	PHOS-TOT		MG/L P	19	.036105	.002822	.053121	1.47129	.012187	.250000	.010000	77/08/26	79/08/17
00900	TOT HARD	CACO3	MG/L	33	248.485	1399.56	37.4107	.150555	6.51237	309.000	172.000	77/09/29	80/12/08
00945	SULFATE	SO4-TOT	MG/L	22	12.9227	35.6878	5.97393	.462281	1.27365	22.0000	3.00000	77/08/26	80/12/08
00951	FLUORIDE	F,TOTAL	MG/L	26	.146153	.000841	.028995	.198387	.005686	.240000	.100000	77/08/26	80/12/08
01002	ARSENIC	AS,TOT	UG/L	22	1.00000	.000000	.000000		.000000	1.00000	1.00000	77/08/26	80/12/08
01007	BARIUM	BA,TOT	UG/L	4	40.2500	760.250	27.5726	.685034	13.7863	81.0000	20.0000	80/07/23	80/10/24
01027	CADMIUM	CD,TOT	UG/L	22	2.95454	84.0455	9.16763	3.10289	1.95454	44.0000	1.00000	77/08/26	80/12/08
01034	CHROMIUM	CR,TOT	UG/L	21	1.26190	.690478	.830950	.658489	.181328	4.00000	1.00000	77/08/26	80/06/23
01042	COPPER	CU,TOT	UG/L	4	14.2500	238.250	15.4353	1.08318	7.71767	30.0000	1.00000	80/07/23	80/10/24
01045	IRON	FE,TOT	UG/L	26	203.154	28714.7	169.454	.834117	33.2327	620.000	10.0000	77/08/26	80/12/08
01051	LEAD	PB,TOT	UG/L	22	2.09091	8.27706	2.87699	1.37595	.613376	14.0000	1.00000	77/08/26	80/12/08
01054	MANGNESE	MN,SUSP	UG/L	1	1.00000					1.00000	1.00000	80/12/08	80/12/08
01055	MANGNESE	MN	UG/L	26	28.4615	417.779	20.4396	.718150	4.00854	60.0000	1.00000	77/08/26	80/12/08
01147	SELENIUM	SE,TOT	UG/L	26	1.00000	.000000	.000000		.000000	1.00000	1.00000	77/08/26	80/12/08
20300	INVALID	PAR	NUMBER	1	170.000					170.000	170.000	80/06/09	80/06/09
31501	TOT COLI	MFIMENDO	/100ML	30	21.8666	1526.26	39.0673	1.78662	7.13269	150.000	.000000	77/09/29	80/12/08
31616	FEC COLI	MFM-FCBR	/100ML	30	6.83333	287.109	16.9443	2.47965	3.09359	80.0000	.000000	77/09/29	80/12/08
70300	RESIDUE	DISS-180	C MG/L	32	238.156	1325.90	36.4129	.152895	6.43696	320.000	166.000	77/08/26	80/11/19
70507	PHOS-T	ORTHO	MG/L P	15	.053933	.008557	.092504	1.71515	.023884	.370000	.001000	80/04/29	80/12/08

D. Kelly

ECCLES CANYON

United States Department of Agriculture | Forest Service | Manti-LaSal N.F.

Reply to: 2530

Date: October 12, 1988

Subject: Water Quality Incident in Eccles Canyon

To: District Ranger, Price R.D.

On October 11, 1988, I received a phone call from Rick Summers of the Utah Division of Oil, Gas and Mining concerning a water quality incident in Eccles Canyon below the Skyline Mine culvert outlet.

Eccles Canyon is tributary to Pleasant Valley Creek which is tributary to Scofield Reservoir. Scofield Reservoir supplies a portion of the municipal water for Price and other nearby communities. Scofield reservoir is highly valued as a recreation and fishing area. In recent years the eutrophication rate of Scofield has been high and much work has been done to reduce the algae growth in the reservoir.

Rick reported that on September 28, 1988, he detected a discharge of black slime from the Skyline Mine culvert. Further investigation showed that the macroinvertebrate population had been greatly diminished, the fish population had been reduced from previous readings of 300 per mile of stream to 6 per mile of stream. Chemical analysis of water samples showed high readings for nitrate (13 mg/l) and nitrite (0.6 mg/l). The creek was foaming from bank to bank. MBAS (a test for detergent) was high.

Investigations continue to find and correct the cause of the problem. A meeting has been called for October 18, 1988, at 2:00 p.m. at the Utah Division of Wildlife Resources office in Price, Utah. Fisheries Biologists from the DWR, UDOGM, the Utah Bureau of Water Pollution Control, the Skyline Mine, and the Manti-LaSal National Forest have been invited to attend.

/s/ G. Dennis Kelly

G. DENNIS KELLY
Hydrologist

CC:
J. Frandsen
A. Howe
C. Reed
D. Kelly ✓

D. Kelly

Eccles
w/s 02 Canyon

Sub w/s 4/2

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Manti-LaSal N.F.

REPLY TO: 2530 Hydrologic Surveys, Prescriptions, and Plans

December 15, 1980

SUBJECT: Relocation of Eccles Creek

TO: Sam A. Hotchkiss, Geologist

The plan, dated October 16, 1980, by Coastal States Energy Company for the stream improvement from Eccles Creek to the portal at South Fork is only an amendment to an approved mining and reclamation plan already submitted by Coastal States Energy.

The proposal involved relocation of Eccles Creek because additional space for separation of the road and conveyor facilities down Eccles Canyon was required. Coastal States Energy stated they had made extensive on-the-ground surveys this past summer and have determined that certain sections of Eccles Creek are located differently than shown on the U.S. Geologic Survey maps their original design was based upon. Coastal States Energy felt that rather than proceeding ahead with the original reclamation plan, construction should be delayed until the amended proposal be reviewed.

The amended reclamation plan for the relocation of Eccles Creek reads basically the same from a hydrologic standpoint as the original plan submitted on the creek relocation (V-3 Section 4.19 - 4.19-4). The only difference is that specific stations where channel reclamation is required are specified.

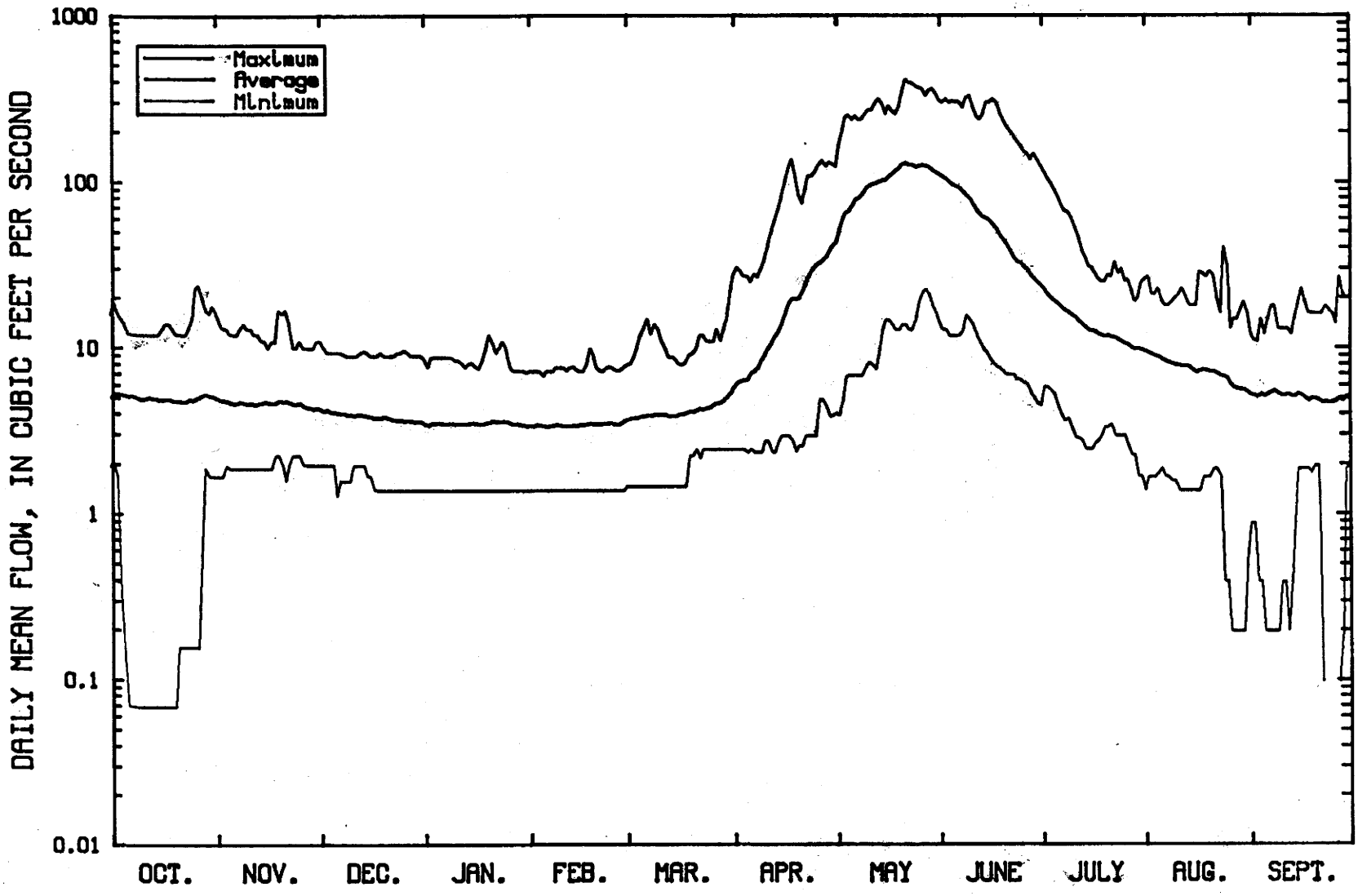
Several stations (17+80, 21+55, 26+00 and 30+70) in the comments state using large rock (1 to 2.5 feet diameter) for various channel work is sufficient.

In order to effectively increase channel roughness and maintain channel banks, the reclamation plan should specify rock spacing, configuration and slope (angular, subangular, rounded) because stream flow velocities vary significantly with differences in rock placement and conformation.

/s/ Jeffrey M. Lucero

JEFFREY M. LUCERO
Hydrologist

cc: D. Kelly
M. Call
J. Lucero



09310000

FOR WATER YEARS 1931, 1940-88

Table 14.—Benthic-invertebrate analyses of selected stream sites—Continued

Organism	Site 29 – Eccles Canyon—Continued				Site 34 – Mud Creek—Continued				Site 42 – Soldier Creek—Continued		
	7-17-79	9-29-79	7-29-80	10-16-80	7-17-79	9-20-79	7-30-80	10-16-80	7-19-79	9-18-79	7-31-80
Arthropoda—Continued											
. Insecta—Continued											
.. Tricoptera											
... Rhyacophilidae											
.... *Rhyacophila acropedes*	4	–	5	6	–	–	–	–	–	–	–
.... *Rhyacophila angelita*	6	–	3	–	–	–	–	–	–	–	–
.... *Rhyacophila* sp. B	–	–	–	–	–	–	–	–	–	–	–
.... *Rhyacophila* sp. C	1	–	–	–	–	–	–	–	–	–	–
.... *Rhyacophila* sp. D	1	10	5	1	–	–	2	–	–	–	–
... Hydropsychidae											
.... *Arctopsyche grandis*	–	–	–	1	–	–	–	–	–	–	–
.... *Arctopsyche* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Symphitopsyche* sp. A	1	11	–	5	13	124	37	24	8	221	308
... Hydroptilidae											
.... *Neotrichia* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Ochrotrichia* sp.	2	2	6	–	56	8	6	–	–	1	–
... Brachycentridae											
.... *Brachycentrus americanus*	1	37	2	2	10	36	24	12	–	–	–
.... *Micrasema* sp.	–	–	–	3	–	–	–	–	–	–	–
... Lepidostomatidae											
.... *Lepidostoma* sp.	–	–	–	–	–	–	–	–	–	–	–
... Leptoceridae											
.... *Oecetis* sp.	–	–	–	–	–	–	–	–	–	–	–
... Limnephilidae											
.... *Amphicosmoecus canax*	1	–	–	–	2	–	–	–	–	–	–
.... *Dicosmoecus atripes*	1	–	1	–	1	–	–	–	–	–	–
.... *Ecclisomyia* sp.	1	–	–	–	–	–	–	–	–	–	–
.... *Hesperophylax* sp.	–	15	–	1	–	–	–	3	–	3	–
.... *Limnephilus* sp. A	–	–	–	–	–	–	–	–	–	–	–
.... *Neothremma* sp.	–	1	–	–	–	4	–	–	–	–	–
.... *Oligophlebodes* sp.	–	1	–	–	–	–	–	–	–	–	–
.... *Onocosmoecus* sp.	–	–	–	–	–	–	–	–	–	–	–
.. Diptera											
... Tipulidae											
.... *Antocha* sp.	–	–	–	1	–	–	–	–	–	–	–
.... *Dicranota* sp.	–	1	–	1	–	–	–	1	–	–	–
.... *Erioptera* sp.	–	–	–	–	–	–	–	–	–	2	–
.... *Gonomyia* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Hesperoconopa* sp.	1	–	–	–	–	–	–	–	–	–	–
.... *Hexatoma* sp.	1	–	–	–	16	36	4	3	–	–	–
.... *Limnophila* sp.	1	2	–	–	–	20	–	5	–	–	–
.... *Limonia* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Ormosia* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Pedicia* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Tipula* sp. A	–	–	–	1	3	–	2	–	–	–	–
.... *Tipula* sp. B	–	–	–	–	–	–	1	–	–	–	–
... Psychodidae											
.... *Pericoma* sp.	–	–	–	–	–	–	–	–	–	–	–
... Dixidae											
.... *Dixa* sp.	–	–	–	–	–	–	–	–	–	–	–
... Simuliidae											
.... *Prosimulium onychodactylum*	–	–	–	–	–	–	–	–	–	–	–
.... *Prosimulium* sp. A	–	–	–	–	–	–	–	–	–	–	–
.... *Prosimulium* sp. B	1	–	–	–	–	–	–	–	–	–	–
.... *Simulium argus*	–	–	–	–	–	–	–	–	–	–	540
.... *Simulium aureum*	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium pugetense*	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium vittatum*	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium* sp. A	–	–	–	–	154	–	–	–	4	–	–
.... *Simulium* sp. B	20	–	–	–	2	–	306	–	4	–	1
.... *Simulium* sp. C	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium* sp. D	–	–	–	–	472	8	–	–	–	–	–
.... *Simulium* sp. E	–	–	–	–	–	52	–	–	–	9	–
.... *Simulium* sp. F	–	–	–	–	–	–	–	–	–	–	–
... Ptychopteridae											
.... *Ptycoptera* sp.	–	–	–	–	–	–	–	–	–	–	–
... Chironomidae											
.... *Ablabesmyia* sp. A	–	–	–	–	–	–	–	–	–	–	–
.... *Ablabesmyia* sp. B	–	–	–	–	–	–	–	–	–	–	–
.... *Brillia* sp.	1	–	1	1	–	–	–	–	–	–	–
.... *Cladotanytarsus* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Constempellina* sp. A	–	2	–	–	–	–	–	–	–	–	–
.... *Constempellina* sp. B	3	–	–	–	–	–	–	–	–	–	–
.... *Corynoneura* sp.	3	–	–	–	11	4	–	–	–	9	–
.... *Cricotopus* sp. A	–	–	–	–	41	12	–	–	–	–	–
.... *Cricotopus* sp. B	6	–	–	–	–	–	–	–	–	–	–
.... *Cricotopus* sp. C	26	–	–	3	31	–	3	3	–	–	–
.... *Demicryptochironomus* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Diamesa* sp.	1	423	8	–	–	–	–	–	–	–	–
.... *Dicrotendipes* sp.	–	–	–	–	–	–	–	–	–	–	–
.... *Eukiefferiella* sp. A	5	–	–	–	19	8	–	–	–	–	–
.... *Eukiefferiella* sp. B	11	–	78	1	562	8	65	1	–	2	–
.... *Eukiefferiella* sp. C	–	–	–	–	40	12	1	–	–	–	–
... *Eukiefferiella* sp. D	16	–	–	–	–	20	–	–	–	–	–
.... *Eukiefferiella* sp. E	–	–	–	–	–	–	–	–	–	–	–
.... *Eukiefferiella* sp. F	–	–	–	–	–	–	–	–	–	–	–

U.S. GEOLOGICAL SURVEY, OPEN FILE REPORT 82-916

Table 14.—Benthic-invertebrate analyses of selected stream sites—Continued

Organism	Site 5 — Mud Creek—Continued				Site 18 — Mud Creek—Continued				Site 20 — Eccles Canyon—Continued			
	7-17-79	9-20-79	7-30-80	10-16-80	7-17-79	9-20-79	7-30-80	10-16-80	7-17-79	9-20-79	7-29-80	10-16-80
Arthropoda—Continued												
. Insecta—Continued												
.. Tricoptera												
... Rhyacophilidae												
.... *Rhyacophila acropedes*	–	–	–	–	–	–	–	–	5	–	6	1
.... *Rhyacophila angelita*	32	–	1	–	–	–	–	–	1	–	1	–
.... *Rhyacophila* sp. B	–	–	–	–	–	1	–	–	–	–	–	–
.... *Rhyacophila* sp. C	–	–	–	–	–	–	–	–	–	–	–	–
.... *Rhyacophila* sp. D	1	–	1	–	–	–	–	–	110	112	73	16
... Hydropsychidae												
.... *Arctopsyche grandis*	–	–	–	–	–	–	–	1	–	–	–	1
.... *Arctopsyche* sp.	–	–	–	–	–	2	–	–	37	60	9	–
.... *Symphitopsyche* sp. A	2	4	–	–	7	129	2	3	–	–	–	1
... Hydroptilidae												
.... *Neotrichia* sp.	–	–	–	–	–	–	1	–	–	–	–	–
.... *Ochrotrichia* sp.	–	–	–	–	56	6	1	–	1	–	–	–
... Brachycentridae												
.... *Brachycentrus americanus*	–	2	–	–	4	20	1	1	–	–	–	–
.... *Micrasema* sp.	–	–	–	–	–	–	–	–	–	–	–	–
... Lepidostomatidae												
.... *Lepidostoma* sp.	–	–	–	–	–	–	–	–	–	–	–	–
... Leptoceridae												
.... *Oecetis* sp.	–	–	–	–	–	–	–	–	–	–	–	–
... Limnephilidae												
.... *Amphicosmoecus canax*	3	–	–	–	2	–	–	–	–	–	–	–
.... *Dicosmoecus atripes*	4	–	–	1	1	–	–	–	1	–	–	–
.... *Ecclisomyia* sp.	–	–	–	–	–	–	–	–	–	–	–	–
.... *Hesperophylax* sp.	1	12	–	1	30	3	–	1	–	24	–	–
.... *Limnephilus* sp. A	–	–	–	–	–	–	–	–	–	–	–	–
.... *Neothremma* sp.	–	–	–	1	–	–	–	–	214	264	230	4
.... *Oligophlebodes* sp.	–	5	–	18	–	–	–	–	–	124	–	1
.... *Onocosmoecus* sp.	–	–	–	–	–	–	–	–	–	–	–	–
.. Diptera												
... Tipulidae												
.... *Antocha* sp.	–	1	–	–	8	53	–	2	–	–	–	–
.... *Dicronota* sp.	5	5	1	4	–	5	–	1	3	88	–	5
.... *Erioptera* sp.	1	–	–	–	–	–	–	–	–	–	–	–
.... *Gonomyia* sp.	–	–	–	–	–	–	–	–	–	–	1	–
.... *Hesperoconopa* sp.	–	–	–	–	–	–	–	–	–	–	–	–
.... *Hexatoma* sp.	–	–	–	–	9	6	4	1	8	–	–	–
.... *Limnophila* sp.	–	–	–	–	–	–	–	1	5	12	1	–
.... *Limonia* sp.	–	1	–	–	–	–	–	–	–	–	–	–
.... *Ormosia* sp.	–	–	–	–	–	–	–	–	7	–	–	–
.... Pedicia sp.	–	–	–	–	–	–	–	–	–	–	1	–
.... *Tipula* sp. A	1	–	–	–	2	–	–	–	1	12	–	–
.... *Tipula* sp. B	2	–	–	–	–	–	–	–	1	–	1	–
... Psychodidae												
.... *Pericoma* sp.	–	182	–	4	–	1	–	–	–	–	–	–
... Dixidae												
.... *Dixa* sp.	–	–	–	–	–	–	–	–	2	4	–	–
... Simuliidae												
.... *Prosimulium onychodactylum*	–	–	–	–	–	–	–	–	–	–	1	–
.... *Prosimulium* sp. A	–	–	–	–	–	–	–	–	–	–	–	–
.... *Prosimulium* sp. B	–	–	–	–	–	–	–	–	6	–	–	–
.... *Simulium argus*	–	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium aureum*	–	–	–	–	–	–	–	–	–	–	–	2
.... *Simulium pugetense*	–	–	–	–	–	–	–	–	–	–	1	–
.... *Simulium vittatum*	–	–	–	–	–	–	1	–	–	–	–	–
.... *Simulium* sp. A	–	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium* sp. B	–	–	–	–	25	–	6	–	–	–	–	–
.... *Simulium* sp. C	–	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium* sp. D	7	–	–	–	–	–	–	–	–	–	–	–
.... *Simulium* sp. E	–	–	–	–	–	2	–	–	–	–	–	–
.... *Simulium* sp. F	–	–	–	–	–	–	–	–	–	–	–	–
... Ptychopteridae												
.... *Ptycoptera* sp.	–	–	–	–	–	–	1	–	–	–	–	–
... Chironomidae												
.... *Ablabesmyia* sp. A	–	–	–	–	–	–	–	–	–	–	–	–
.... *Ablabesmyia* sp. B	–	–	–	–	–	–	–	–	–	–	–	–
.... *Brillia* sp.	3	1	–	–	–	–	–	–	–	16	–	1
.... *Cladotanytarsus* sp.	–	–	–	–	5	–	–	–	–	–	–	–
.... *Constempellina* sp. A	–	–	–	–	–	–	–	–	–	24	–	5
.... *Constempellina* sp. B	–	–	1	–	–	–	–	–	232	–	37	–
.... *Corynoneura* sp.	4	–	–	–	2	1	1	–	34	12	28	1
.... *Cricotopus* sp. A	–	5	–	–	–	–	–	–	–	–	15	1
.... *Cricotopus* sp. B	–	–	–	–	3	–	–	–	2	–	–	–
.... *Cricotopus* sp. C	5	–	–	–	14	4	–	–	–	–	–	–
.... *Demicryptochironomus* sp.	–	–	–	–	–	–	–	–	–	–	–	–
.... *Diamesa* sp.	16	1	–	–	5	4	–	2	–	–	143	–
.... *Dicrotendipes* sp.	–	–	–	–	–	–	–	–	–	–	–	–
.... *Eukiefferiella* sp. A	–	–	–	–	16	1	1	–	–	–	–	–
.... *Eukiefferiella* sp. B	30	–	–	–	35	3	26	–	72	9	20	1
.... *Eukiefferiella* sp. C	5	1	–	–	–	–	1	–	16	–	10	–
.... *Eukiefferiella* sp. D	–	–	1	–	35	–	16	–	1	–	–	–
.... *Eukiefferiella* sp. E	–	–	–	–	1	–	–	–	–	–	–	–
.... *Eukiefferiella* sp. F	–	1	–	–	–	5	–	1	–	–	–	–

U.S. GEOLOGICAL SURVEY, OPEN FILE REPORT 82-916

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-6

STATION LOCATION - ECCLES CREEK AT USGS GAGING STATION

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/27/88	05/18/88	06/06/88	07/21/88
	STATION NOT ACCESSIBLE						
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)		-2	9	10	8	14	21
FLOW (CFS)			3.83	3.46	9.81	5.86	2.04
WATER TEMPERATURE (C)		0.5	3.5	4.5	6.5	9.5	11
SPEC. COND. (UMHOS/CM) FIELD		944	1052	974	607	649	692
PH (SU) FIELD		7.5	7.2	7.5	7.5	8.1	7.9
TURBIDITY (NTU) FIELD		9.5	12	6.7	25.5	4.8	6.8
TOTAL SUSP. SOLIDS		22	15	8	71	27	11
TOTAL DISS. SOLIDS MEAS.		480	606	510	350	359	360
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)		84.82	137.6	72	96	96	99.2
MAGNESIUM (MG)		29.33	7.2	43.2	0.48	7.2	20.64
SODIUM (NA)		44.68	58.85	46.25	25	21.42	20.66
POTASSIUM (K)		3.9	4.45	4.19	2.56	2.29	3.3
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)		284	252	285	218	209	295
SULFATE (SO4)		129	180	146	86	114	104
CHLORIDE (CL)		51	76	59	25.1	16.1	20.4
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						0.07	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL		0.56	0.65	0.4	0.98	0.38	0.4
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL		0.11	0.13	0.1	0.1	0.05	0.06
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						0.015	
OIL AND GREASE						0.8	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE CS-6

STATION LOCATION - ECCLES CREEK AT USGS GAGING STATION

SAMPLE DATE	08/16/88	11/02/88	02/01/89	06/22/89	09/13/89	10/31/89	1/17/90
			STATION NOT ACCESSIBLE				
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	26	10		11	13	-1	-6
FLOW (CFS)	1.5	2.16		2.29	1.99	3.30	
WATER TEMPERATURE (C)	15	7		8	8	2	2
SPEC. COND. (UMHOS/CM) FIELD	717	736		814	879	862	750
PH (SU) FIELD	7.4	7.5		7.4	7.2	7.85	8.05
TURBIDITY (NTU) FIELD	7.3	4.4		4.0	3.6	4.4	10.7
TOTAL SUSP. SOLIDS	22	10		15	4	10	16
TOTAL DISS. SOLIDS MEAS.	476	492		580	510	556	506
OXYGEN (O) DISS	7.8			8.4	7.7		10.7
COMMON IONS							
CALCIUM (CA)	83.2	158.00		120.00	85.90	83.77	82.47
MAGNESIUM (MG)	36	<0.10		30.03	41.21	42.31	35.85
SODIUM (NA)	26.66	12.77		35.19	27.45	38.43	26.03
POTASSIUM (K)	4.12	3.11		4.80	5.85	6.57	4.05
ACIDITY AS CACO3	5				<0.01		
ALKALINITY AS CACO3 (LAB)	218				234		
BICARBONATE (HCO3) (LAB)	266	283		283	285	272	285
SULFATE (SO4)	169	161		228	177	220	150
CHLORIDE (CL)	15.7	15.9		19.4	26.6	19.4	22.3
FLUORIDE (F)	0.27				0.29		
NUTRIENTS							
NITRATE (NO3-N)	0.15	0.20		0.50	0.55	0.93	0.51
AMMONIA (NH3 AS N)	0.06	<0.03		<0.03	0.05	<0.03	<0.03
TOTAL PHOSPHATE (PO4)	0.07	<0.04		<0.04	0.05	0.06	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.07				0.06		
BARIUM (BA) DISS					0.06		
BORON (B) TOTAL	0.08				0.080		
BORON (B) DISS					0.075		
COPPER (CU) TOTAL	0.02				<0.01		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.55	0.51		0.39	0.38	0.40	0.63
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.06	0.06		0.05	0.04	0.07	0.08
MANGANESE (MN) DISS					<0.04		
ZINC (ZN) TOTAL	<0.005						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	4.06				8.78		
PHENOLS	<0.001	<0.001		<0.001	<0.001	<0.001	0.830
OIL AND GREASE	0.9	0.4		0.4	0.3	0.6	0.3
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION CS - 6

STATION LOCATION - ECCLES CREEK AT USGS GAGING STATION

SAMPLE DATE	06/06/90	09/12/90	11/14/90	02/14/91	06/11/91	09/17/91	11/05/91
PHYSICAL PARAMETERS				*			
AIR TEMPERATURE (C)	18	27.5	7.5	2	23	18	7
FLOW (CFS)	4.60	2.34	3.03		9.73	2.77	3.59
WATER TEMPERATURE (C)	15	13.8	5.3	4.1	12.6	10.8	5.5
SPEC. COND. (UMHOS/CM) FIELD	595	928	895	949	531	1218	1222
PH (SU) FIELD	7.7	7.8	8.3	7.96	8.17	8.08	7.59
TURBIDITY (NTU) FIELD	10.1	11	31	6.0	80	15	21
TOTAL SUSP. SOLIDS	15	18	24	10	238	23	44
TOTAL DISS. SOLIDS MEAS.	438	504	740	710	330	860	814
OXYGEN (D) DISS	8.3	7.0	8.2	11.2	9.8	11.7	8.8
COMMON IONS							
CALCIUM (CA)	65.54	98.41	101.34	103.92	71.16	93.54	92.10
MAGNESIUM (MG)	24.55	48.41	44.27	55.59	26.32	73.16	65.70
SODIUM (NA)	22.40	21.49	27.40	61.26	17.48	71.21	86.40
POTASSIUM (K)	3.80	5.19	6.15	7.69	1.48	9.52	11.80
ACIDITY AS CACO3		8.40				<0.10	
ALKALINITY AS CACO3 (LAB)		225				259	
BICARBONATE (HCO3) (LAB)	220	274	285	284	181	316	329
SULFATE (SO4)	136	224	209	253	85.0	405	378
CHLORIDE (CL)	20.6	19.7	18.7	60.0	22.5	24.6	31.5
FLUORIDE (F)		0.28				0.31	
NUTRIENTS							
NITRATE (NO3-N)	0.14	0.90	0.83	0.70	0.83	1.80	
AMMONIA (NH3 AS N)	0.04	<0.03	0.17	0.60	0.13	0.28	0.36
TOTAL PHOSPHATE (PO4)	<0.04	<0.04	0.74	0.11	0.11	<0.10	0.10
TRACE ELEMENTS							
BARIUM (BA) TOTAL		0.08				0.060	
BARIUM (BA) DISS		0.08				0.060	
BORON (B) TOTAL		0.069				0.250	
BORON (B) DISS		0.069				0.250	
COPPER (CU) TOTAL		<0.01				<0.006	
COPPER (CU) DISS		<0.01				<0.006	
IRON (FE) TOTAL	0.39	0.45	0.90	0.51	1.340	0.420	0.630
IRON (FE) DISS		<0.03				0.020	
LEAD (PB) TOTAL		<0.002				<0.003	
LEAD (PB) DISS		<0.002				<0.003	
MANGANESE (MN) TOTAL	<0.01	0.04	0.09	0.9	0.070	0.090	0.120
MANGANESE (MN) DISS		0.03				0.080	
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)		2.54				2.31	
PHENOLS	0.086	<0.010	0.020	0.055	0.180	<0.20	<0.08
OIL AND GREASE	<0.10	0.6	0.9	0.9	0.4	0.3	<0.2
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

* ABSENCE OF FLOW DATA INDICATES THAT STREAM WAS ICED OVER.

SUMMARY OF WATER QUALITY ANALYSES -SITE CS-4

STATION LOCATION - UPPER LEFT FORK OF ECCLES CREEK

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/17/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					8.00	16.00	18.00
FLOW (CFS)					0.36	0.22	0.05
WATER TEMPERATURE (C)					3.00	6.00	8.00
SPEC. COND. (UMHOS/CM) FIELD					275.00	313.00	392.00
PH (SU) FIELD					7.30	7.80	8.0
TURBIDITY (NTU) FIELD					13.00	1.95	4.60
TOTAL SUSP. SOLIDS					28.00	4.00	4.00
TOTAL DISS. SOLIDS MEAS.					140.00	175.00	258.00
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)					47.20	58.40	76.80
MAGNESIUM (MG)					<0.10	3.80	11.52
SODIUM (NA)					3.78	3.72	3.87
POTASSIUM (K)					<0.10	<0.01	<0.50
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)					133.00	159.00	256.00
SULFATE (SO4)					11.00	33.00	30.00
CHLORIDE (CL)					2.40	1.50	1.80
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						<0.03	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL					0.46	0.12	0.08
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL					0.02	<0.01	<0.01
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						0.01	
OIL AND GREASE						0.50	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES -SITE CS-4

STATION LOCATION - UPPER LEFT FORK OF ECCLES CREEK

SAMPLE DATE	08/15/88	11/02/88	06/22/89	09/12/89	10/30/89	06/06/90	09/11/90
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	20.0	8.0	22.0	9.5	-2.0	18.0	19.0
FLOW (CFS)	0.030	0.016	0.100	0.022	0.019	0.210	0.020
WATER TEMPERATURE (C)	12.5	3.0	7.0	6.0	0.5	4.0	12.0
SPEC. COND. (UMHOS/CM) FIELD	418	465	382	474	385	255	466
PH (SU) FIELD	7.30	7.50	7.0	7.30	7.20	7.50	7.70
TURBIDITY (NTU) FIELD	1.9	3.4	1.0	4.1	4.9	8.1	11.5
TOTAL SUSP. SOLIDS	4.0	8.0	2.0	3.0	12.0	14.0	17.0
TOTAL DISS. SOLIDS MEAS.	266	349	190	240	232	206	240
OXYGEN (O) DISS	9.20			9.40			7.2
COMMON IONS							
CALCIUM (CA)	84.00	96.00	52.66	73.27	66.52	44.40	72.56
MAGNESIUM (MG)	8.40	26.40	7.12	12.69	11.63	5.93	12.89
SODIUM (NA)	4.00	4.57	4.52	1.69	7.46	4.96	1.79
POTASSIUM (K)	<0.50	<0.01	<0.50	0.92	1.10	<0.50	<0.50
ACIDITY AS CACO3	<0.05			<0.01			17.10
ALKALINITY AS CACO3 (LAB)	212			219			228
BICARBONATE (HCO3) (LAB)	259	256	200	267	256	170	278
SULFATE (SO4)	34	9	5	11	6	5	8.1
CHLORIDE (CL)	1.90	91.0	3.30	4.0	12.4	5.70	4.8
FLUORIDE (F)	0.15			0.12			0.13
NUTRIENTS							
NITRATE (NO3-N)	0.23	1.41	0.27	0.25	0.32	0.25	0.29
AMMONIA (NH3 AS N)	0.07	<0.03	0.04	<0.03	0.05	<0.03	<0.03
TOTAL PHOSPHATE (PO4)	0.10	0.23	<0.04	<0.11	0.10	<0.04	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.03			0.02			0.02
BARIUM (BA) DISS				0.02			0.02
BORON (B) TOTAL	<0.001			<0.010			0.030
BORON (B) DISS				<0.010			0.030
COPPER (CU) TOTAL	0.03			<0.01			0.02
COPPER (CU) DISS				<0.01			0.02
IRON (FE) TOTAL	0.13	0.08	0.06	0.04	0.20	0.27	0.09
IRON (FE) DISS				<0.02			<0.03
LEAD (PB) TOTAL	<0.001			<0.001			<0.001
LEAD (PB) DISS				<0.001			<0.001
MANGANESE (MN) TOTAL	0.02	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
MANGANESE (MN) DISS				<0.01			<0.01
ZINC (ZN) TOTAL	0.01						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	3.08						4.01
PHENOLS	<0.001	<0.001	<0.001	<0.001	<0.001	<0.02	<0.010
OIL AND GREASE	0.7	0.5	0.4	0.4	1.1	0.4	0.3
CYANIDE (CN) TOTAL	<0.001			0.001			<0.010

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES -SITE CS-4

STATION LOCATION - UPPER LEFT FORK OF ECCLES CREEK

SAMPLE DATE	10/25/90	06/12/91	09/16/91	10/17/91
PHYSICAL PARAMETERS				
AIR TEMPERATURE (C)	6.5	16.0	14.5	5.5
FLOW (CFS)	0.020	0.570	0.061	0.059
WATER TEMPERATURE (C)	2.3	5.5	7.9	4.3
SPEC. COND. (UMHOS/CM) FIELD	423	258	456	480
PH (SU) FIELD	7.70	7.71	3.26	7.90
TURBIDITY (NTU) FIELD	3.5	4.0	1.2	6.3
TOTAL SUSP. SOLIDS	38	30.0	16.0	17.0
TOTAL DISS. SOLIDS MEAS.	362	164	274	270
OXYGEN (O) DISS			12.1	
COMMON IONS				
CALCIUM (CA)	70.88	45.48	62.97	62.03
MAGNESIUM (MG)	12.00	6.17	13.95	14.70
SODIUM (NA)	2.43	3.98	3.76	2.59
POTASSIUM (K)	1.27	<0.32	1.47	0.79
ACIDITY AS CACO3			1.90	
ALKALINITY AS CACO3 (LAB)			239	
BICARBONATE (HCO3) (LAB)	265	116	292	269
SULFATE (SO4)	8.0	26.0	11	10.5
CHLORIDE (CL)	4.80	14.0	7.50	5.7
FLUORIDE (F)			<0.20	
NUTRIENTS				
NITRATE (NO3-N)	0.23	0.30	0.24	
AMMONIA (NH3 AS N)	<0.03	0.04	<0.03	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	0.05	<0.10	0.09
TRACE ELEMENTS				
BARIUM (BA) TOTAL			0.020	
BARIUM (BA) DISS			0.010	
BORON (B) TOTAL			<0.050	
BORON (B) DISS			<0.050	
COPPER (CU) TOTAL			0.010	
COPPER (CU) DISS			<0.006	
IRON (FE) TOTAL	0.13	0.480	0.130	0.05
IRON (FE) DISS			0.020	
LEAD (PB) TOTAL			<0.003	
LEAD (PB) DISS			<0.003	
MANGANESE (MN) TOTAL	0.05	<0.033	0.020	<0.02
MANGANESE (MN) DISS			<0.020	
ZINC (ZN) TOTAL				
ORGANIC PARAMETERS				
ORGANIC CARBON (TOTAL)			3.38	
PHENOLS	<0.010	0.120	<0.20	<0.08
OIL AND GREASE	<0.10	0.3	1.3	<0.2
CYANIDE (CN) TOTAL			<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES -SITE CS-3

STATION LOCATION - UPPER MIDDLE FORK OF ECCLES CREEK

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/17/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					4	18	22
FLOW (CFS)					1.41	0.41	0.12
WATER TEMPERATURE (C)					3	8	12.5
SPEC. COND. (UMHOS/CM) FIELD					243	384	423
PH (SU) FIELD					7.5	7.9	7.9
TURBIDITY (NTU) FIELD					17.5	3.2	4.4
TOTAL SUSP. SOLIDS					41	2	3
TOTAL DISS. SOLIDS MEAS.					142	210	315
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)					41.6	196	57.6
MAGNESIUM (MG)					3.36	4.3	34.56
SODIUM (NA)					4.2	4	4.6
POTASSIUM (K)					<0.10	<0.01	1.04
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)					130	196	235
SULFATE (SO4)					14	34	92
CHLORIDE (CL)					2.3	2.4	2.8
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						<0.03	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL					0.69	0.1	0.1
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL					0.05	<0.01	0.03
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS							
OIL AND GREASE						0.9	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES -SITE CS-3

STATION LOCATION - UPPER MIDDLE FORK OF ECCLES CREEK

SAMPLE DATE	08/15/88	11/02/88	02/01/89	06/22/89	09/12/89	10/30/89	1/19/90
			STATION NOT ACCESSIBLE				STATION NOT ACCESSIBLE
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	20	8		18	13	-6	
FLOW (CFS)	0.04	0.05		0.013	0.028		
WATER TEMPERATURE (C)	15	1		11	7.5	0.5	
SPEC. COND. (UMHOS/CM) FIELD	460	505		436	483	455	
PH (SU) FIELD	7.1	7.4		7.4	7.3	7.05	
TURBIDITY (NTU) FIELD	1.25	1.9		1.0	0.6	2.8	
TOTAL SUSP. SOLIDS	2	6		<1.00	4	9	
TOTAL DISS. SOLIDS MEAS.	268	350		218	245	245	
OXYGEN (O) DISS	7.8				8.8		
COMMON IONS							
CALCIUM (CA)	92	100.00		62.44	70.93	71.00	
MAGNESIUM (MG)	3.12	22.80		10.85	14.97	13.30	
SODIUM (NA)	4.68	5.23		5.71	2.25	5.02	
POTASSIUM (K)	0.98	0.64		0.74	1.17	1.04	
ACIDITY AS CACO3	6				<0.01		
ALKALINITY AS CACO3 (LAB)	224				218		
BICARBONATE (HCO3) (LAB)	273	263		235	266	287	
SULFATE (SO4)	11	14		10	17	5	
CHLORIDE (CL)	12	80.0		5.2	5.1	3.8	
FLUORIDE (F)	0.18				0.15		
NUTRIENTS							
NITRATE (NO3-N)	0.46	3.30		0.43	0.54	0.73	
AMMONIA (NH3 AS N)	0.1	<0.03		<0.03	0.05	<0.03	
TOTAL PHOSPHATE (PO4)	0.08	<0.04		<0.04	0.07	0.10	
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.03				0.01		
BARIUM (BA) DISS					0.01		
BORON (B) TOTAL	<0.001				<0.010		
BORON (B) DISS					<0.010		
COPPER (CU) TOTAL	0.02				<0.01		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.09	0.09		0.06	<0.03	0.11	
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.05	0.03		<0.01	<0.01	<0.01	
MANGANESE (MN) DISS					<0.01		
ZINC (ZN) TOTAL	<0.005						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	3.71						
PHENOLS	<0.001	<0.001		<0.001	<0.001	<0.001	
OIL AND GREASE	0.4	1.3		0.2	0.5	0.7	
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES -SITE CS-3 STATION LOCATION - UPPER MIDDLE FORK OF ECCLES CREEK

SAMPLE DATE	06/06/90	09/12/90	10/25/90	02/14/91	06/11/91	09/16/91	10/17/91
				STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	17	20	16		15.5	15	17
FLOW (CFS)	0.47	0.05	0.0075		0.56	0.05	0.02
WATER TEMPERATURE (C)	7	10	10.5		9.0	7.1	3.5
SPEC. COND. (UMHOS/CM) FIELD	302	484	543		275	470	501
PH (SU) FIELD	7.5	7.8	7.9		8.16	7.93	7.91
TURBIDITY (NTU) FIELD	5.4	1.1	5		4.5	2.5	3.5
TOTAL SUSP. SOLIDS	9	4	14		31	4	<1
TOTAL DISS. SOLIDS MEAS.	222	244	316		168	278	282
OXYGEN (O) DISS		7.2				12.4	
COMMON IONS							
CALCIUM (CA)	48.18	65.13	72.61		46.83	59.86	82.75
MAGNESIUM (MG)	7.20	16.16	19.32		6.66	15.34	16.59
SODIUM (NA)	4.80	3.40	4.95		5.05	3.69	3.16
POTASSIUM (K)	0.63	1.19	1.38		<0.32	1.83	1.23
ACIDITY AS CACO3		4.80				1.90	
ALKALINITY AS CACO3 (LAB)		227				233	
BICARBONATE (HCO3) (LAB)	196	277	262		129	284	296
SULFATE (SO4)	8	12.2	36.8		28.0	19.5	13.8
CHLORIDE (CL)	5.6	6.7	7.5		13.0	6.8	8.8
FLUORIDE (F)		0.15				<0.20	
NUTRIENTS							
NITRATE (NO3-N)	0.47	1.25	1.35		0.57	0.63	0.80
AMMONIA (NH3 AS N)	<0.03	<0.03	<0.03		0.07	0.04	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	<0.04	<0.04		0.07	<0.10	0.11
TRACE ELEMENTS							
BARIUM (BA) TOTAL		0.02				0.020	
BARIUM (BA) DISS		<0.01				0.010	
BORON (B) TOTAL		<0.005				<0.050	
BORON (B) DISS		<0.005				<0.050	
COPPER (CU) TOTAL		<0.01				<0.006	
COPPER (CU) DISS		<0.01				<0.006	
IRON (FE) TOTAL	0.19	<0.03	0.12		0.440	0.030	0.03
IRON (FE) DISS		<0.03				0.010	
LEAD (PB) TOTAL		<0.001				<0.003	
LEAD (PB) DISS		<0.002				<0.003	
MANGANESE (MN) TOTAL	<0.01	0.03	0.08		<0.033	<0.020	<0.02
MANGANESE (MN) DISS		0.02				<0.020	
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)		3.11				3.16	
PHENOLS	<0.013	<0.013	<0.010		0.070	<0.20	<0.08
OIL AND GREASE	1.5	24.0	<0.10		0.8	<0.20	<0.1
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-2

STATION LOCATION - ECCLES CREEK AT USFS BOUNDARY

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/18/88	06/06/88	07/21/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE				
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)				4	4	17	15.5
FLOW (CFS)				1.65	2.34	1.77	0.25
WATER TEMPERATURE (C)				6	6.5	12.5	10
SPEC. COND. (UMHOS/CM) FIELD				992	685	780	655
PH (SU) FIELD				7.4	7.2	7.1	7.6
TURBIDITY (NTU) FIELD				92.5	38	7.4	6.9
TOTAL SUSP. SOLIDS				387	57	12	7
TOTAL DISS. SOLIDS MEAS.				835	560	445	399
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)				104	92	101.6	65.2
MAGNESIUM (MG)				78.72	44.3	12	38.16
SODIUM (NA)				55.46	30.41	32.79	22.49
POTASSIUM (K)				6.76	3.87	3.91	2.93
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)				237	204	227	293
SULFATE (SO4)				438	277	172	106
CHLORIDE (CL)				37.1	15.4	6.9	13.8
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						0.07	
TOTAL PHOSPHATE (PO4)						0.08	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL				7.88	0.9	0.29	0.57
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL				0.28	0.09	0.08	0.28
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						<0.001	
OIL AND GREASE						0.6	
CYANIDE (CN)							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-2

STATION LOCATION - ECCLES CREEK AT USFS BOUNDARY

SAMPLE DATE	08/16/88	11/02/88	02/01/89	06/23/89	09/12/89	10/31/89	1/19/90
			STATION NOT ACCESSIBLE				STATION NOT ACCESSIBLE
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	19	8		7	4	-6	
FLOW (CFS)	0.59	0.13		2.02	1.96	1.65	
WATER TEMPERATURE (C)	14	7		10	10	7	
SPEC. COND. (UMHOS/CM) FIELD	850	759		986	1138	1056	
PH (SU) FIELD	7.2	7.3		7.5	7.0	8.0	
TURBIDITY (NTU) FIELD	7.8	3.4		10.0	172	165	
TOTAL SUSP. SOLIDS	10	4		7	17	22	
TOTAL DISS. SOLIDS MEAS.	560	510		559	695	635	
OXYGEN (O) DISS	6.8			8.8	6.6		
COMMON IONS							
CALCIUM (CA)	80.8	126.00		81.82	87.19	84.61	
MAGNESIUM (MG)	39.12	27.60		35.72	55.83	46.78	
SODIUM (NA)	45.1	21.64		54.93	55.18	55.57	
POTASSIUM (K)	6.13	2.93		7.69	10.66	9.19	
ACIDITY AS CACO3	10				<0.01		
ALKALINITY AS CACO3 (LAB)	214				203		
BICARBONATE (HCO3) (LAB)	261	279		257	248	240	
SULFATE (SO4)	227	112		238	336	300	
CHLORIDE (CL)	12	85.0		13.3	22.8	14.9	
FLUORIDE (F)	0.42				0.48		
NUTRIENTS							
NITRATE (NO3-N)	0.51	2.80		1.23	1.60	1.51	
AMMONIA (NH3 AS N)	0.2	0.18		0.10	0.06	0.05	
TOTAL PHOSPHATE (PO4)	0.11	<0.04		<0.04	0.08	0.08	
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.08				0.05		
BARIUM (BA) DISS					<0.02		
BORON (B) TOTAL	0.13				0.200		
BORON (B) DISS					0.015		
COPPER (CU) TOTAL	0.02				<0.01		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.77	0.76		0.33	0.33	0.44	
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.19	0.36		0.09	0.06	0.06	
MANGANESE (MN) DISS					0.03		
ZINC (ZN) TOTAL	0.017						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	8.49				4.10		
PHENOLS	<0.001	<0.001		<0.001	<0.001	<0.001	
OIL AND GREASE	1.2	0.2		0.4	0.7	0.9	
CYANIDE (CN)	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-2

STATION LOCATION - ECCLES CREEK AT USFS BOUNDARY

SAMPLE DATE	06/06/90	09/12/90	10/25/90	02/14/91	06/11/91	09/17/91
			STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE		
PHYSICAL PARAMETERS						
AIR TEMPERATURE (C)	20	16			14	13
FLOW (CFS)	2.03	1.17			3.71	2.13
WATER TEMPERATURE (C)	14	12.5			8.7	13.7
SPEC. COND. (UMHOS/CM) FIELD	673	1248			636	1620
PH (SU) FIELD	7.1	7.8			7.9	7.78
TURBIDITY (NTU) FIELD	16.4	24.5			25	45
TOTAL SUSP. SOLIDS	17	11			48	20
TOTAL DISS. SOLIDS MEAS.	558	746			436	1246
OXYGEN (O) DISS	8.6	6.6			11.03	8.8
COMMON IONS						
CALCIUM (CA)	79.42	126.70			80.43	113.90
MAGNESIUM (MG)	27.56	70.20			37.64	102.46
SODIUM (NA)	25.36	26.39			19.80	99.09
POTASSIUM (K)	4.82	10.31			3.12	14.34
ACIDITY AS CACO3		8.40				5.70
ALKALINITY AS CACO3 (LAB)		210				285
BICARBONATE (HCO3) (LAB)	226	256			181	348
SULFATE (SO4)	189	432			156	633
CHLORIDE (CL)	15.5	14.8			18.5	14.0
FLUORIDE (F)		0.43				0.55
NUTRIENTS						
NITRATE (NO3-N)	0.60	1.89			1.56	2.40
AMMONIA (NH3 AS N)	0.05	0.55			0.25	0.71
TOTAL PHOSPHATE (PO4)	<0.04	9.30			0.07	<0.10
TRACE ELEMENTS						
BARIUM (BA) TOTAL		0.09				0.040
BARIUM (BA) DISS		0.09				0.040
BORON (B) TOTAL		0.189				0.420
BORON (B) DISS		0.179				0.410
COPPER (CU) TOTAL		<0.01				<0.010
COPPER (CU) DISS		<0.01				<0.006
IRON (FE) TOTAL	0.37	0.04			0.360	0.490
IRON (FE) DISS		<0.03				0.010
LEAD (PB) TOTAL		<0.002				<0.003
LEAD (PB) DISS		<0.002				<0.003
MANGANESE (MN) TOTAL	0.07	0.09			<0.033	0.190
MANGANESE (MN) DISS		0.10				0.160
ZINC (ZN) TOTAL						
ORGANIC PARAMETERS						
ORGANIC CARBON (TOTAL)		2.79				4.73
PHENOLS	<0.011	<0.010			0.160	<0.20
OIL AND GREASE	1.3	0.2			1.0	1.3
CYANIDE (CN)		<0.010				<0.100

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-2

STATION LOCATION - ECCLES CREEK AT USFS BOUNDARY

SAMPLE DATE	11/05/91
PHYSICAL PARAMETERS	
AIR TEMPERATURE (C)	3
FLOW (CFS)	2.89
WATER TEMPERATURE (C)	3.6
SPEC. COND. (UMHOS/CM) FIELD	1650
PH (SU) FIELD	7.50
TURBIDITY (NTU) FIELD	42
TOTAL SUSP. SOLIDS	29
TOTAL DISS. SOLIDS MEAS.	1184
OXYGEN (O) DISS	8.4
COMMON IONS	
CALCIUM (CA)	113.30
MAGNESIUM (MG)	86.20
SODIUM (NA)	138.20
POTASSIUM (K)	15.00
ACIDITY AS CACO3	
ALKALINITY AS CACO3 (LAB)	
BICARBONATE (HCO3) (LAB)	373
SULFATE (SO4)	647
CHLORIDE (CL)	26.0
FLUORIDE (F)	
NUTRIENTS	
NITRATE (NO3-N)	
AMMONIA (NH3 AS N)	1.01
TOTAL PHOSPHATE (PO4)	0.14
TRACE ELEMENTS	
BARIUM (BA) TOTAL	
BARIUM (BA) DISS	
BORON (B) TOTAL	
BORON (B) DISS	
COPPER (CU) TOTAL	
COPPER (CU) DISS	
IRON (FE) TOTAL	0.280
IRON (FE) DISS	
LEAD (PB) TOTAL	
LEAD (PB) DISS	
MANGANESE (MN) TOTAL	0.170
MANGANESE (MN) DISS	
ZINC (ZN) TOTAL	
ORGANIC PARAMETERS	
ORGANIC CARBON (TOTAL)	
PHENOLS	0.10
OIL AND GREASE	<0.2
CYANIDE (CN)	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES SITE CS-1

STATION LOCATION - UPPER SOUTH FORK OF ECCLES CREEK

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/18/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE		
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)						17	18
FLOW (CFS)						1.18	0.25
WATER TEMPERATURE (C)						11	13
SPEC. COND. (UMHOS/CM) FIELD						360	422
PH (SU) FIELD						7.9	8
TURBIDITY (NTU) FIELD						3.55	3.6
TOTAL SUSP. SOLIDS						3	3
TOTAL DISS. SOLIDS MEAS.						192	174
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)						64.8	84.8
MAGNESIUM (MG)						3.3	3.84
SODIUM (NA)						3.83	4.17
POTASSIUM (K)						<0.01	0.94
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)						188	262
SULFATE (SO4)						24	17
CHLORIDE (CL)						1	1.5
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						<0.03	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL						0.14	0.08
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL						<0.01	<0.01
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						<0.001	
OIL AND GREASE						0.5	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION CS - 1

STATION LOCATION - UPPER SOUTH FORK OF ECCLES CREEK

SAMPLE DATE	08/16/88	10/20/88	06/22/89	09/12/89	10/19/89	06/06/90	09/12/90
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	23	9	17	8	1.5	19	23.5
FLOW (CFS)	0.12	0.13	0.25	0.04	0.06	0.70	0.05
WATER TEMPERATURE (C)	16	3	7	6.5	1	9	11.6
SPEC. COND. (UMHOS/CM)	417	535	412	464	430	272	463
PH (SU) FIELD	7.5	7.8		7.3	7.95	7.7	8.0
TURBIDITY (NTU) FIELD	0.42	0.42	0.8	0.3	0.34	4.3	2.05
TOTAL SUSP. SOLIDS	<1.0	<1.0	<1.0	<1.0	4	3	2
TOTAL DISS. SOLIDS MEAS.	250	305	199	245	265	224	160
OXYGEN (O) DISS	8.2			8.9			7.8
COMMON IONS							
CALCIUM (CA)	66.4	112.00	57.85	61.45	67.77	43.82	53.17
MAGNESIUM (MG)	12.74	<0.10	13.24	19.36	20.35	8.29	18.47
SODIUM (NA)	4.33	0.81	1.40	1.43	2.00	4.36	1.60
POTASSIUM (K)	0.67	1.03	<0.50	0.91	0.95	<0.50	1.06
ACIDITY AS CACO3	8			<0.01			3.60
ALKALINITY AS CACO3 (LAB)	201			208			221
BICARBONATE (HCO3) (LAB)	245	266	233	254	278	184	270
SULFATE (SO4)	19	54	15	25	24	8	16.1
CHLORIDE (CL)	5.2	2.3	1.3	3.1	2.1	1.4	1.9
FLUORIDE (F)	0.17			0.13			0.11
NUTRIENTS							
NITRATE (NO3-N)	0.11		0.13	0.12	0.32	0.12	0.19
AMMONIA (NH3 AS N)	0.07	0.04	<0.03	0.04	0.10	0.04	<0.03
TOTAL PHOSPHATE (PO4)	0.06	<0.04	<0.04	0.06	<0.04	<0.04	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.04			0.01			0.04
BARIUM (BA) DISS				0.01			0.02
BORON (B) TOTAL	<0.001			<0.010			<0.005
BORON (B) DISS				<0.010			<0.005
COPPER (CU) TOTAL	0.02			<0.01			<0.01
COPPER (CU) DISS				<0.01			<0.01
IRON (FE) TOTAL	0.04	<0.01	<0.03	<0.03	<0.03	0.17	<0.03
IRON (FE) DISS				<0.03			<0.03
LEAD (PB) TOTAL	<0.001			<0.001			<0.002
LEAD (PB) DISS				<0.001			<0.002
MANGANESE (MN) TOTAL	0.02	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
MANGANESE (MN) DISS				<0.01			<0.01
ZINC (ZN) TOTAL	<0.005						
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)	2.89			5.83			2.87
PHENOLS	<0.001	<0.001	<0.001	<0.001	<0.001	<0.024	<0.010
OIL AND GREASE	0.6	0.6	0.5	0.7	1.50	<0.10	0.5
CYANIDE (CN) TOTAL	<0.001			<0.001			<0.010

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DAT
STATION CS - 1

STATION LOCATION - UPPER SOUTH FORK OF ECCLES CREEK

SAMPLE DATE	10/25/90	06/10/91	09/18/91	10/17/91
PHYSICAL PARAMETERS	*			
AIR TEMPERATURE (C)	2	15	12.5	11
FLOW (CFS)		2.73	0.15	0.08
WATER TEMPERATURE (C)	1.3	5.8	4.6	5.2
SPEC. COND. (UMHOS/CM)	482	271	594	785
PH (SU) FIELD	7.6	7.85	8.06	7.89
TURBIDITY (NTU) FIELD	0.6	5	2.0	0.85
TOTAL SUSP. SOLIDS	<1.0	42	2	<1.0
TOTAL DISS. SOLIDS MEAS.	264	180	480	502
OXYGEN (O) DISS	8.0	11.3	13.1	
COMMON IONS				
CALCIUM (CA)	54.96	50.03	96.51	99.60
MAGNESIUM (MG)	18.58	9.30	39.91	42.13
SODIUM (NA)	1.69	3.59	3.18	2.79
POTASSIUM (K)	1.25	<0.32	2.76	2.52
ACIDITY AS CACO3			<0.10	
ALKALINITY AS CACO3 (LAB)			239	
BICARBONATE (HCO3) (LAB)	271	160	292	295
SULFATE (SO4)	17.3	30.0	136	75.5
CHLORIDE (CL)	2.3	7.0	3.4	40.5
FLUORIDE (F)			0.21	
NUTRIENTS				
NITRATE (NO3-N)	0.17	0.39	0.19	0.65
AMMONIA (NH3 AS N)	<0.03	0.05	<0.06	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	0.07	<0.10	0.13
TRACE ELEMENTS				
BARIUM (BA) TOTAL			0.040	
BARIUM (BA) DISS			0.040	
BORON (B) TOTAL			0.190	
BORON (B) DISS			<0.060	
COPPER (CU) TOTAL			0.010	
COPPER (CU) DISS			0.010	
IRON (FE) TOTAL	<0.03	0.640	0.030	<0.01
IRON (FE) DISS			0.010	
LEAD (PB) TOTAL			<0.003	
LEAD (PB) DISS			<0.003	
MANGANESE (MN) TOTAL	<0.01	<0.033	<0.020	<0.02
MANGANESE (MN) DISS			<0.020	
ZINC (ZN) TOTAL				
OTHER PARAMETERS				
ORGANIC CARBON (TOTAL)			1.54	
PHENOLS	<0.010	0.010	<0.20	0.21
OIL AND GREASE	<0.10	1.6	3.0	<0.20
CYANIDE (CN) TOTAL			0.010	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

** ABSENCE OF FLOW DATA INDICATES STREAM WAS ICED OVER.*

SUMMARY OF WATER QUALITY
ANALYSES SITE CS-1

STATION LOCATION - UPPER SOUTH FORK OF ECCLES CREEK

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/18/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE		
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)						17	18
FLOW (CFS)						1.18	0.25
WATER TEMPERATURE (C)						11	13
SPEC. COND. (UMHOS/CM) FIELD						360	422
PH (SU) FIELD						7.9	8
TURBIDITY (NTU) FIELD						3.55	3.6
TOTAL SUSP. SOLIDS						3	3
TOTAL DISS. SOLIDS MEAS.						192	174
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)						64.8	84.8
MAGNESIUM (MG)						3.3	3.84
SODIUM (NA)						3.83	4.17
POTASSIUM (K)						<0.01	0.94
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)						188	262
SULFATE (SO4)						24	17
CHLORIDE (CL)						1	1.5
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						<0.03	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL						0.14	0.08
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL						<0.01	<0.01
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						<0.001	
OIL AND GREASE						0.5	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION 09 - 1

STATION LOCATION - UPPER SOUTH FORK OF EDDLES CREEK

SAMPLE DATE	08/16/88	10/20/88	06/22/89	09/12/89	10/19/89	06/06/90	09/12/90
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	22	9	17	8	1.5	19	23.5
FLOW (CFS)	0.12	0.13	0.25	0.04	0.06	0.70	0.05
WATER TEMPERATURE (C)	16	3	7	6.5	1	9	11.8
SPEC. COND. (UMHOS/CM)	417	535	412	464	430	272	463
PH (SU) FIELD	7.5	7.8		7.3	7.95	7.7	8.0
TURBIDITY (NTU) FIELD	0.42	0.42	0.8	0.3	0.34	4.3	2.05
TOTAL SUSP. SOLIDS	<1.0	<1.0	<1.0	<1.0	4	3	2
TOTAL DISS. SOLIDS MEAS.	250	305	199	245	265	224	168
OXYGEN (O) DISS	8.2			8.9			7.8
COMMON IONS							
CALCIUM (CA)	66.4	112.00	57.85	61.45	67.77	47.92	53.17
MAGNESIUM (MG)	12.74	<0.10	13.24	19.36	20.35	8.29	18.47
SODIUM (NA)	4.33	0.81	1.40	1.43	2.00	4.36	1.60
POTASSIUM (K)	0.67	1.03	<0.50	0.91	0.95	<0.50	1.06
ACIDITY AS CACO3	8			<0.01			3.60
ALKALINITY AS CACO3 (LAB)	201			208			221
BICARBONATE (HCO3) (LAB)	245	266	233	254	278	184	270
SULFATE (SO4)	19	54	15	25	24	8	16.1
CHLORIDE (CL)	5.2	2.3	1.3	3.1	2.1	1.4	1.9
FLUORIDE (F)	0.17			0.13			0.11
NUTRIENTS							
NITRATE (NO3-N)	0.11		0.13	0.12	0.32	0.12	0.19
AMMONIA (NH3 AS N)	0.07	0.04	<0.03	0.04	0.10	0.04	<0.03
TOTAL PHOSPHATE (PO4)	0.06	<0.04	<0.04	0.06	<0.04	<0.04	<0.04
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.04			0.01			0.04
BARIUM (BA) DISS				0.01			0.02
BORON (B) TOTAL	<0.001			<0.010			<0.005
BORON (B) DISS				<0.010			<0.005
COPPER (CU) TOTAL	0.02			<0.01			<0.01
COPPER (CU) DISS				<0.01			<0.01
IRON (FE) TOTAL	0.04	<0.01	<0.03	<0.03	<0.03	0.17	<0.03
IRON (FE) DISS				<0.03			<0.03
LEAD (PB) TOTAL	<0.001			<0.001			<0.002
LEAD (PB) DISS				<0.001			<0.002
MANGANESE (MN) TOTAL	0.02	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
MANGANESE (MN) DISS				<0.01			<0.01
ZINC (ZN) TOTAL	<0.005						
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)	2.69			5.83			2.87
PHENOLS	<0.001	<0.001	<0.001	<0.001	<0.001	<0.024	<0.010
OIL AND GREASE	0.6	0.6	0.5	0.7	1.50	<0.10	0.5
CYANIDE (CN) TOTAL	<0.001			<0.001			<0.010

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DAT
STATION CS - 1

STATION LOCATION - UPPER SOUTH FORK OF ECCLES CREEK

SAMPLE DATE	10/25/90	06/10/91	09/18/91	10/17/91
PHYSICAL PARAMETERS	*			
AIR TEMPERATURE (C)	2	15	12.5	11
FLOW (CFS)		2.73	0.15	0.08
WATER TEMPERATURE (C)	1.3	5.5	4.6	5.2
SPEC. COND. (UMHOS/CM)	482	271	594	796
PH (SU) FIELD	7.6	7.85	8.06	7.89
TURBIDITY (NTU) FIELD	0.5	5	2.0	0.35
TOTAL SUSP. SOLIDS	<1.0	42	2	<1.0
TOTAL DISS. SOLIDS MEAS.	264	180	480	602
OXYGEN (O) DISS	8.0	11.3	13.1	
COMMON IONS				
CALCIUM (CA)	54.96	50.03	96.61	99.60
MAGNESIUM (MG)	18.58	9.30	39.91	42.13
SODIUM (NA)	1.69	3.69	3.18	2.79
POTASSIUM (K)	1.25	<0.32	2.76	2.62
ACIDITY AS CACO3			<0.10	
ALKALINITY AS CACO3 (LAB)			239	
BICARBONATE (HCO3) (LAB)	271	150	292	295
SULFATE (SO4)	17.3	30.0	136	75.5
CHLORIDE (CL)	2.3	7.0	3.4	40.5
FLUORIDE (F)			0.21	
NUTRIENTS				
NITRATE (NO3-N)	0.17	0.39	0.19	0.65
AMMONIA (NH3 AS N)	<0.03	0.05	<0.08	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	0.07	<0.10	0.13
TRACE ELEMENTS				
BARIUM (BA) TOTAL			0.040	
BARIUM (BA) DISS			0.040	
BORON (B) TOTAL			0.190	
BORON (B) DISS			<0.050	
COPPER (CU) TOTAL			0.010	
COPPER (CU) DISS			0.010	
IRON (FE) TOTAL	<0.03	0.640	0.030	<0.01
IRON (FE) DISS			0.010	
LEAD (PB) TOTAL			<0.003	
LEAD (PB) DISS			<0.003	
MANGANESE (MN) TOTAL	<0.01	<0.033	<0.020	<0.02
MANGANESE (MN) DISS			<0.020	
ZINC (ZN) TOTAL				
OTHER PARAMETERS				
ORGANIC CARBON (TOTAL)			1.54	
PHENOLS	<0.010	0.010	<0.20	0.21
OIL AND GREASE	<0.10	1.6	3.0	<0.20
CYANIDE (CN) TOTAL			0.010	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

** ABSENCE OF FLOW DATA INDICATES STREAM WAS ICED OVER.*

SUMMARY OF WATER QUALITY
ANALYSIS - SITE CS-9

STATION LOCATION - RIGHT FORK OF ECCLES CREEK ABOVE MINE

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/18/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					6	18	21.5
FLOW (CFS)					0.12	0.001	0.03
WATER TEMPERATURE (C)					5	14.5	15.5
SPEC. COND. (UMHOS/CM) FIELD					397	508	485
PH (SU) FIELD					7.5	7.9	8.3
TURBIDITY (NTU) FIELD					49	19.5	9.2
TOTAL SUSP. SOLIDS					278	94	29
TOTAL DISS. SOLIDS MEAS.					120	240	329
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)					72.8	88.8	70
MAGNESIUM (MG)					<0.10	<0.10	26.88
SODIUM (NA)					5.47	6.01	7.15
POTASSIUM (K)					2.1	<0.01	1.11
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)					205	246	239
SULFATE (SO4)					17	22	97
CHLORIDE (CL)					3.9	5.8	7.1
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						<0.03	
TOTAL PHOSPHATE (PO4)						0.08	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL					1.96	0.62	0.18
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL					0.15	0.09	0.05
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						<0.001	
OIL AND GREASE						0.5	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSIS - SITE CS-9

STATION LOCATION - RIGHT FORK OF ECCLES CREEK ABOVE MINE

SAMPLE DATE	08/15/88	11/02/88	02/01/89	06/22/89	09/13/89	10/31/89	1/19/90
			STATION NOT ACCESSIBLE				STATION NOT ACCESSIBLE
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	23	8		18	11	5	
FLOW (CFS)	0.01	0.011		0.019	0.012	0.009	
WATER TEMPERATURE (C)	14	7		12	11.5	1.5	
SPEC. COND. (UMHOS/CM) FIELD	513	587		546	618	485	
PH (SU) FIELD	7.3	7.4		7.1	7.2	7.85	
TURBIDITY (NTU) FIELD	5.4	19		6.0	19	21.5	
TOTAL SUSP. SOLIDS	21	58		96	105	91	
TOTAL DISS. SOLIDS MEAS.	310	405		278	330	310	
OXYGEN (D) DISS	7.4				7.8		
COMMON IONS							
CALCIUM (CA)	79.2	128.00		73.22	86.92	83.07	
MAGNESIUM (MG)	18.24	13.20		16.22	22.65	19.19	
SODIUM (NA)	6.64	7.24		7.77	5.07	7.13	
POTASSIUM (K)	<0.50	1.14		1.18	1.46	1.71	
ACIDITY AS CACO3	6				<0.01		
ALKALINITY AS CACO3 (LAB)	224				251		
BICARBONATE (HCO3) (LAB)	273	271		267	306	302	
SULFATE (SO4)	49	39		31	50	39	
CHLORIDE (CL)	6.9	81.0		6.8	9.8	8.0	
FLUORIDE (F)	0.17				0.18		
NUTRIENTS							
NITRATE (NO3-N)	1.96	3.70		2.05	1.74	1.56	
AMMONIA (NH3 AS N)	0.08	<0.03		0.04	<0.03	<0.03	
TOTAL PHOSPHATE (PO4)	0.08	0.08		<0.04	0.10	0.20	
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.03				<0.01		
BARIUM (BA) DISS					<0.01		
BORON (B) TOTAL	<0.001				0.030		
BORON (B) DISS					<0.010		
COPPER (CU) TOTAL	0.02				0.02		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.31	0.66		0.46	1.10	1.24	
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.07	0.16		0.09	0.21	0.23	
MANGANESE (MN) DISS					0.10		
ZINC (ZN) TOTAL	<0.005						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	3.67				7.09		
PHENOLS	0.023	<0.001		<0.001	<0.001	<0.001	
OIL AND GREASE	0.7	0.5		0.4	0.7	2.8	
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSIS - SITE CS-9

RECENT SAMPLE

SAMPLE DATE	06/06/90	09/13/90	10/25/90	02/14/91	06/11/91	09/16/91	10/17/91
				STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	17	12	12.5		21.5	19.5	13
FLOW (CFS)	0.028	0.017	0.051		0.16	0.013	0.009
WATER TEMPERATURE (C)	9	9.5	2.7		13.5	12.5	6
SPEC. COND. (UMHOS/CM) FIELD	437	591	371		414	512	579
PH (SU) FIELD	7.3	8.0	7.8		8.16	7.81	7.79
TURBIDITY (NTU) FIELD	16	10.5	2		8	3.5	3.4
TOTAL SUSP. SOLIDS	65	188	41		90	24	3
TOTAL DISS. SOLIDS MEAS.	248	296	276		254	294	334
OXYGEN (O) DISS		5.6				9.0	
COMMON IONS							
CALCIUM (CA)	67.31	64.22	80.28		72.64	51.45	82.21
MAGNESIUM (MG)	13.26	17.54	15.38		13.54	21.40	21.62
SODIUM (NA)	7.46	6.15	3.86		5.17	5.73	5.05
POTASSIUM (K)	0.91	0.91	1.31		<0.32	2.15	1.39
ACIDITY AS CACO3		6.00				3.80	
ALKALINITY AS CACO3 (LAB)		239				226	
BICARBONATE (HCO3) (LAB)	260	292	279		215	276	302
SULFATE (SO4)	25	35.9	13.0		36.0	38.3	35.9
CHLORIDE (CL)	6.1	7.7	4.9		10.0	7.4	7.4
FLUORIDE (F)		0.13				<0.20	
NUTRIENTS							
NITRATE (NO3-N)	1.32	1.74	0.64		1.76	1.60	1.54
AMMONIA (NH3 AS N)	<0.03	<0.03	<0.03		0.05	<0.03	<0.06
TOTAL PHOSPHATE (PO4)	0.05	<0.04	<0.04		0.03	<0.10	0.06
TRACE ELEMENTS							
BARIUM (BA) TOTAL		0.02				0.020	
BARIUM (BA) DISS		<0.01				0.020	
BORON (B) TOTAL		<0.005				<0.050	
BORON (B) DISS		<0.005				<0.050	
COPPER (CU) TOTAL		<0.01				0.010	
COPPER (CU) DISS		<0.01				<0.006	
IRON (FE) TOTAL	0.35	0.64	0.17		0.500	0.300	0.06
IRON (FE) DISS		<0.03				0.020	
LEAD (PB) TOTAL		<0.002				<0.003	
LEAD (PB) DISS		<0.002				<0.003	
MANGANESE (MN) TOTAL	0.03	0.18	0.03		<0.033	0.080	0.07
MANGANESE (MN) DISS		0.12				0.020	
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)		3.06				3.31	
PHENOLS	<0.019	<0.010	<0.010		0.110	<0.20	<0.08
OIL AND GREASE	<0.10	1.4	3.9		0.5	0.9	<0.10
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSIS - SITE CS-9

MOST RECENT SAMPLE

SAMPLE DATE	06/06/90	09/13/90	10/25/90	02/14/91	06/11/91	09/16/91
				STATION NOT ACCESSIBLE		
PHYSICAL PARAMETERS						
AIR TEMPERATURE (C)	17	12	12.5		21.5	19.5
FLOW (CFS)	0.028	0.017	0.051		0.16	0.013
WATER TEMPERATURE (C)	9	9.5	2.7		13.5	12.5
SPEC. COND. (UMHOS/CM) FIELD	437	591	371		414	512
PH (SU) FIELD	7.3	8.0	7.8		8.16	7.81
TURBIDITY (NTU) FIELD	16	10.5	2		8	3.5
TOTAL SUSP. SOLIDS	65	188	41		90	24
TOTAL DISS. SOLIDS MEAS.	248	296	276		254	294
OXYGEN (D) DISS		6.6				9.0
COMMON IONS						
CALCIUM (CA)	67.31	64.22	80.28		72.64	51.45
MAGNESIUM (MG)	13.26	17.54	15.38		13.54	21.40
SODIUM (NA)	7.46	6.15	3.86		5.17	5.73
POTASSIUM (K)	0.91	0.91	1.31		<0.32	2.15
ACIDITY AS CACO3		6.00				3.80
ALKALINITY AS CACO3 (LAB)		239				226
BICARBONATE (HCO3) (LAB)	260	292	279		215	276
SULFATE (SO4)	25	35.9	13.0		36.0	38.3
CHLORIDE (CL)	6.1	7.7	4.9		10.0	7.4
FLUORIDE (F)		0.13				<0.20
NUTRIENTS						
NITRATE (NO3-N)	1.32	1.74	0.64		1.76	1.60
AMMONIA (NH3 AS N)	<0.03	<0.03	<0.03		0.05	<0.03
TOTAL PHOSPHATE (PO4)	0.05	<0.04	<0.04		0.03	<0.10
TRACE ELEMENTS						
BARIUM (BA) TOTAL		0.02				0.020
BARIUM (BA) DISS		<0.01				0.020
BORON (B) TOTAL		<0.005				<0.050
BORON (B) DISS		<0.005				<0.050
COPPER (CU) TOTAL		<0.01				0.010
COPPER (CU) DISS		<0.01				<0.006
IRON (FE) TOTAL	0.35	0.64	0.17		0.500	0.300
IRON (FE) DISS		<0.03				0.020
LEAD (PB) TOTAL		<0.002				<0.003
LEAD (PB) DISS		<0.002				<0.003
MANGANESE (MN) TOTAL	0.03	0.18	0.03		<0.033	0.080
MANGANESE (MN) DISS		0.12				0.020
ZINC (ZN) TOTAL						
ORGANIC PARAMETERS						
ORGANIC CARBON (TOTAL)		3.06				3.31
PHENOLS	<0.019	<0.010	<0.010		0.110	<0.20
OIL AND GREASE	<0.10	1.4	3.9		0.5	0.9
CYANIDE (CN) TOTAL		<0.010				<0.100

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-11

STATION LOCATION - LEFT FORK OF ECCLES CREEK IMMEDIATELY ABOVE MINE

SAMPLE DATE	01/22/88	02/17/88	03/23/88	04/26/88	05/17/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)					4	17	21
FLOW (CFS)					1.37	0.51	0.002
WATER TEMPERATURE (C)					3	8	9
SPEC. COND. (UMHOS/CM) FIELD					291	358	426
PH (SU) FIELD					7.4	8.0	8.1
TURBIDITY (NTU) FIELD					180	4.2	11
TOTAL SUSP. SOLIDS					626	11	14
TOTAL DISS. SOLIDS MEAS.					160	156	186
OXYGEN (D) DISS							
COMMON IONS							
CALCIUM (CA)					43.2	60	48.20
MAGNESIUM (MG)					5.28	1.9	7.20
SODIUM (NA)					9.73	4.4	4.81
POTASSIUM (K)					2.06	<0.01	0.85
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)					142	194	176
SULFATE (SO4)					18	7	11
CHLORIDE (CL)					11.3	2.8	3.7
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						<0.03	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL					8.78	0.14	0.12
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL					0.24	<0.01	0.02
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						<0.001	
OIL AND GREASE						0.5	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE CS-11

STATION LOCATION - LEFT FORK OF ECCLES CREEK IMMEDIATELY ABOVE MINE

SAMPLE DATE	08/15/88	11/02/88	02/01/89	06/22/89	09/12/89	10/30/89	1/19/90
			STATION NOT ACCESSIBLE				STATION NOT ACCESSIBLE
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	20	5		18	10	-2	
FLOW (CFS)	0.07	0.026		0.22	0.03		
WATER TEMPERATURE (C)	9	3		9	6	0.5	
SPEC. COND. (UMHOS/CM) FIELD	419	506		437	534	490	
PH (SU) FIELD	7.5	7.6		7.5	7.3	7.7	
TURBIDITY (NTU) FIELD	4.45	2.4		2.0	2.7	4.6	
TOTAL SUSP. SOLIDS	7	12		8	6	15	
TOTAL DISS. SOLIDS MEAS.	240	294		234	328	320	
OXYGEN (O) DISS	9.4				9.2		
COMMON IONS							
CALCIUM (CA)	64.00	68.00		59.80	73.74	78.20	
MAGNESIUM (MG)	11.52	28.80		10.12	17.73	16.14	
SODIUM (NA)	4.06	5.25		7.38	28.00	17.36	
POTASSIUM (K)	0.60	0.56		0.60	0.99	1.13	
ACIDITY AS CACO3	6.00				<0.01		
ALKALINITY AS CACO3 (LAB)	202				228		
BICARBONATE (HCO3) (LAB)	246	274		222	339	279	
SULFATE (SO4)	10	16		9	21	18	
CHLORIDE (CL)	3.7	36.0		11.9	20.0	40.7	
FLUORIDE (F)	0.14				0.15		
NUTRIENTS							
NITRATE (NO3-N)	0.14	2.65		0.24	0.17	0.32	
AMMONIA (NH3 AS N)	0.05	<0.03		<0.03	0.04	<0.03	
TOTAL PHOSPHATE (PO4)	0.06	0.06		<0.04	0.06	0.10	
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.04				0.02		
BARIUM (BA) DISS					0.02		
BORON (B) TOTAL	<0.001				<0.010		
BORON (B) DISS					<0.010		
COPPER (CU) TOTAL	0.02				<0.01		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.19	0.10		0.09	0.05	0.28	
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	<0.02	0.02		<0.01	<0.01	0.04	
MANGANESE (MN) DISS					<0.01		
ZINC (ZN) TOTAL	<0.005						
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)	3.69				4.24		
PHENOLS	<0.001	<0.001		<0.001	<0.001	<0.001	
OIL AND GREASE	0.5	0.7		<0.10	0.3	1.9	
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY
ANALYSES - SITE CS-11

STATION LOCATION - LEFT FORK OF ECCLES CREEK IMMEDIATELY ABOVE MINE

MOST RECENT SAMPLE

SAMPLE DATE	06/06/90	09/12/90	10/25/90	02/14/91	06/12/91	09/16/91	10/17/91
			STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	15	13			17	14	7.5
FLOW (CFS)	0.58	0.048			2.04	0.059	0.068
WATER TEMPERATURE (C)	5	8			6.5	7.1	3.3
SPEC. COND. (UMHOS/CM) FIELD	312	579			320	530	541
PH (SU) FIELD	7.5	7.9			7.88	8.24	7.92
TURBIDITY (NTU) FIELD	11.9	6.4			6.5	3	4.6
TOTAL SUSP. SOLIDS	19	9			51	23	4
TOTAL DISS. SOLIDS MEAS.	294	288			51	324	322
OXYGEN (O) DISS		7.1				11.7	
COMMON IONS							
CALCIUM (CA)	51.71	73.88			55.32	79.88	79.62
MAGNESIUM (MG)	8.17	19.26			9.12	17.94	17.53
SODIUM (NA)	7.42	8.00			5.76	9.52	6.64
POTASSIUM (K)	<0.50	1.15			<0.32	1.70	0.88
ACIDITY AS CACO3		3.60				1.90	
ALKALINITY AS CACO3 (LAB)		228				235	
BICARBONATE (HCO3) (LAB)	194	278			142	287	287
SULFATE (SO4)	10	23.0			29.5	20.0	18.7
CHLORIDE (CL)	12.6	21.3			16.5	26.6	18.6
FLUORIDE (F)		0.15				<0.20	
NUTRIENTS							
NITRATE (NO3-N)	0.22	0.29			0.40	0.20	
AMMONIA (NH3 AS N)	0.06	<0.03			0.06	<0.03	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	<0.04			0.07	<0.10	0.05
TRACE ELEMENTS							
BARIUM (BA) TOTAL		0.03				0.030	
BARIUM (BA) DISS		<0.01				0.020	
BORON (B) TOTAL		<0.005				<0.050	
BORON (B) DISS		<0.005				<0.050	
COPPER (CU) TOTAL		<0.01				0.010	
COPPER (CU) DISS		<0.01				0.010	
IRON (FE) TOTAL	0.26	0.09			0.620	0.210	0.05
IRON (FE) DISS		<0.03				0.020	
LEAD (PB) TOTAL		<0.002				<0.003	
LEAD (PB) DISS		<0.001				<0.003	
MANGANESE (MN) TOTAL	<0.01	<0.01			<0.033	0.030	<0.02
MANGANESE (MN) DISS		<0.01				0.020	
ZINC (ZN) TOTAL							
ORGANIC PARAMETERS							
ORGANIC CARBON (TOTAL)		3.77				2.68	
PHENOLS	<0.022	<0.010			0.050	<0.20	<0.08
OIL AND GREASE	<0.10	2.5			0.5	1.3	<0.20
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION C3 - 15

STATION LOCATION - RIGHT FORK OF UPPER SOUTH FORK OF ECCLES CREEK

VARIATION FROM MEAN	SAMPLE DATE	10/20/88	05/03/89	06/22/89	09/12/89	10/19/89	06/06/90	09/12/9
	PHYSICAL PARAMETERS							
	AIR TEMPERATURE (C)							
-0.044	FLOW (CFS)	0.0068	0.15	0.071	0	0	0.082	
	WATER TEMPERATURE (C)							
	SPEC. COND. (UMHOS/CM)							
	PH (SU) FIELD							
	TURBIDITY (NTU) FIELD							
	TOTAL SUSP. SOLIDS							
	TOTAL DISS. SOLIDS MEAS.							
	OXYGEN (O) DISS							
	COMMON IONS							
	CALCIUM (CA)							
	MAGNESIUM (MG)							
	SODIUM (NA)							
	POTASSIUM (K)							
	ACIDITY AS CACO3							
	ALKALINITY AS CACO3 (LAB)							
	BICARBONATE (HCO3) (LAB)							
	SULFATE (SO4)							
	CHLORIDE (CL)							
	FLUORIDE (F)							
	NUTRIENTS							
	NITRATE (NO3-N)							
	AMMONIA (NH3 AS N)							
	TOTAL PHOSPHATE (PO4)							
	TRACE ELEMENTS							
	BARIUM (BA) TOTAL							
	BARIUM (BA) DISS							
	BORON (B) TOTAL							
	BORON (B) DISS							
	COPPER (CU) TOTAL							
	COPPER (CU) DISS							
	IRON (FE) TOTAL							
	IRON (FE) DISS							
	LEAD (PB) TOTAL							
	LEAD (PB) DISS							
	MANGANESE (MN) TOTAL							
	MANGANESE (MN) DISS							
	ZINC (ZN) TOTAL							
	OTHER PARAMETERS							
	ORGANIC CARBON (TOTAL)							
	PHENOLS							
	OIL AND GREASE							
	CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION CS - 15
MOST RECENT SAMPLE

STATION LOCATION - RIGHT FORK OF UPPER SOUTH FORK OF ECCLES CREEK

SAMPLE DATE	10/25/90	06/10/91	09/18/91	10/17/91
PHYSICAL PARAMETERS				
AIR TEMPERATURE (C)				
FLOW (CFS)	0	0.31	0	0
WATER TEMPERATURE (C)				
SPEC. COND. (UMHOS/CM)				
PH (SU) FIELD				
TURBIDITY (NTU) FIELD				
TOTAL SUSP. SOLIDS				
TOTAL DISS. SOLIDS MEAS.				
OXYGEN (O) DISS				
COMMON IONS				
CALCIUM (CA)				
MAGNESIUM (MG)				
SODIUM (NA)				
POTASSIUM (K)				
ACIDITY AS CACO3				
ALKALINITY AS CACO3 (LAB)				
BICARBONATE (HCO3) (LAB)				
SULFATE (SO4)				
CHLORIDE (CL)				
FLUORIDE (F)				
NUTRIENTS				
NITRATE (NO3-N)				
AMMONIA (NH3 AS N)				
TOTAL PHOSPHATE (PO4)				
TRACE ELEMENTS				
BARIUM (BA) TOTAL				
BARIUM (BA) DISS				
BORON (B) TOTAL				
BORON (B) DISS				
COPPER (CU) TOTAL				
COPPER (CU) DISS				
IRON (FE) TOTAL				
IRON (FE) DISS				
LEAD (PB) TOTAL				
LEAD (PB) DISS				
MANGANESE (MN) TOTAL				
MANGANESE (MN) DISS				
ZINC (ZN) TOTAL				
OTHER PARAMETERS				
ORGANIC CARBON (TOTAL)				
PHENOLS				
OIL AND GREASE				
CYANIDE (CN) TOTAL				

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-6

STATION LOCATION - ECCLES CREEK ABOVE CONFLUENCE WITH SOUTH FORK

SAMPLE DATE	01/28/88	02/17/88	03/23/88	04/26/88	05/18/88	06/06/88	07/21/88
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	-2	-5	7	3	8	18.5	23
FLOW (CFS)			1.8	2.27	4.34	1.95	0.31
WATER TEMPERATURE (C)	3	2.5	7	3	6	13	16.5
SPEC. COND. (UMHOS/CM) FIELD	1110	1209	1264	989	673	772	710
PH (SU) FIELD	7.5	7.5	7.3	7.7	7.5	8.0	8.3
TURBIDITY (NTU) FIELD	14	24	32	88	34	4.85	5.1
TOTAL SUSP. SOLIDS	19	72	34	367	75	16	5
TOTAL DISS. SOLIDS MEAS.	680	648	768	821	410	465	420
OXYGEN (D) DISS							
COMMON IONS							
CALCIUM (CA)	121.74	95.26	132	96	104	124.8	91.20
MAGNESIUM (MG)	31.66	31.26	15.8	79.68	1.92	<0.10	32.64
SODIUM (NA)	57.41	81.72	90.45	55.44	34.04	33.83	20.71
POTASSIUM (K)	7.66	5	6.84	6.71	3.44	3.68	3.51
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)	249	244	206	220	193	229	283
SULFATE (SO4)	306	233	274	429	145	176	114
CHLORIDE (CL)	38.2	81	94.5	45.2	23.2	10.2	20.9
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)						0.05	
AMMONIA (NH3 AS N)						0.08	
TOTAL PHOSPHATE (PO4)							
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL	0.35	0.61	0.76	7.4	1.3	0.25	0.34
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL	0.14	0.17	0.14	0.28	0.12	0.08	0.03
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						0.016	
OIL AND GREASE						0.4	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-6

STATION LOCATION - ECCLES CREEK ABOVE CONFLUENCE WITH SOUTH FORK

SAMPLE DATE	08/16/88	11/02/88	02/01/89	06/23/89	09/13/89	10/31/89	1/17/90
			STATION NOT ACCESSIBLE				
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	7	10.5		10	15	-3	-6
FLOW (CFS)	1.57	0.10		2.20	1.14	1.88	
WATER TEMPERATURE (C)	12	7		10	11	6	3
SPEC. COND. (UMHOS/CM) FIELD	891	972		978	1105	990	1074
PH (SU) FIELD	7.6	7.7		7.7	7.3	7.9	7.8
TURBIDITY (NTU) FIELD	6.4	1.65		6.5	16	13	12.0
TOTAL SUSP. SOLIDS	17	2		8	30	25	37
TOTAL DISS. SOLIDS MEAS.	625	550		575	695	645	792
OXYGEN (O) DISS	8.4			8.2	7.6	7.8	10.9
COMMON IONS							
CALCIUM (CA)	119.20	146.00		82.27	98.39	82.93	98.65
MAGNESIUM (MG)	21.60	15.60		35.62	53.44	45.49	3.50
SODIUM (NA)	56.16	29.33		57.60	50.23	56.23	154.00
POTASSIUM (K)	7.74	3.66		4.85	9.83	9.11	9.83
ACIDITY AS CACO3	7.00				<0.01		
ALKALINITY AS CACO3 (LAB)	214				201		
BICARBONATE (HCO3) (LAB)	261	272		243	245	238	269
SULFATE (SO4)	285	144		264	335	305	366
CHLORIDE (CL)	9.3	80.0		11.2	24.9	14.8	13.2
FLUORIDE (F)	0.46				0.46		
NUTRIENTS							
NITRATE (NO3-N)	0.75	1.30		1.21	1.40	1.54	1.37
AMMONIA (NH3 AS N)	0.11	0.10		0.07	0.05	<0.03	0.19
TOTAL PHOSPHATE (PO4)	0.06	<0.04		<0.04	0.33	0.13	<0.02
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.08				0.05		
BARIUM (BA) DISS					0.04		
BORON (B) TOTAL	0.210				0.200		
BORON (B) DISS					0.180		
COPPER (CU) TOTAL	<0.01				0.02		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.30	0.25		0.27	0.47	0.45	0.68
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.11	0.16		0.07	0.09	0.06	0.07
MANGANESE (MN) DISS					0.08		
ZINC (ZN) TOTAL	0.008						
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)	10.86				5.50		
PHENOLS	<0.001	<0.001		<0.001	<0.001	<0.001	0.463
OIL AND GREASE	<0.1	0.3		0.7	0.4	0.8	1.2
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA

STATION LOCATION - ECCLES CREEK ABOVE CONFLUENCE WITH SOUTH FORK

STATION VC - 6
MOST RECENT SAMPLE

SAMPLE DATE	06/06/90	09/12/90	11/14/90	02/14/91	06/10/91	09/17/91	11/05/91
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	21	21	3	2	19	17	4
FLOW (CFS)	1.40	0.92	1.57		4.15	1.57	1.01
WATER TEMPERATURE (C)	13	14.1	4.6	6.5	9.7	11.6	7.22
SPEC. COND. (UMHOS/CM)	639	1215	1184	1314	464	1590	1530
PH (SU) FIELD	7.6	8.0	8.3	8.00	8.07	8.13	7.60
TURBIDITY (NTU) FIELD	11.5	18	33	14	40	48	33
TOTAL SUSP. SOLIDS	12	24	19	24	56	44	30
TOTAL DISS. SOLIDS MEAS.	538	820	808	1006	318	1214	1102
OXYGEN (O) DISS	7.7	7.5	8.3	10.94	10.1	11.5	
COMMON IONS							
CALCIUM (CA)	80.04	129.10	100.82	134.55	64.91	112.40	99.10
MAGNESIUM (MG)	24.78	52.40	51.44	77.90	20.94	101.04	80.50
SODIUM (NA)	26.39	30.56	36.10	70.85	15.46	100.56	129.20
POTASSIUM (K)	4.39	9.19	10.20	13.10	2.04	14.00	14.30
ACIDITY AS CACO3		6.00				5.70	
ALKALINITY AS CACO3 (LAB)		194				274	
BICARBONATE (HCO3) (LAB)	222	237	265	274	160	334	345
SULFATE (SO4)	178	421	359	398	75.0	632	551
CHLORIDE (CL)	18.0	16.2	10.6	22.0	21.0	13.0	44.0
FLUORIDE (F)		0.44				0.40	
NUTRIENTS							
NITRATE (NO3-N)	0.56	1.67	1.50	0.95	1.00	2.30	
AMMONIA (NH3 AS N)	0.42	0.28	0.34	1.15	0.13	0.73	0.88
TOTAL PHOSPHATE (PO4)	<0.04	<0.04	0.07	0.11	0.04	<0.10	0.13
TRACE ELEMENTS							
BARIUM (BA) TOTAL		0.07				0.060	
BARIUM (BA) DISS		<0.01				0.050	
BORON (B) TOTAL		0.150				0.230	
BORON (B) DISS		0.090				0.230	
COPPER (CU) TOTAL		<0.01				0.010	
COPPER (CU) DISS		<0.01				<0.006	
IRON (FE) TOTAL	0.27	0.14	0.37	0.570	0.820	0.350	0.260
IRON (FE) DISS		<0.03				0.010	
LEAD (PB) TOTAL		<0.001				<0.003	
LEAD (PB) DISS		<0.001				<0.003	
MANGANESE (MN) TOTAL	0.04	0.08	0.08	0.130	0.050	0.170	0.160
MANGANESE (MN) DISS		0.08				0.160	
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)		2.81				1.90	
PHENOLS	<0.017	<0.010	<0.010	<0.050	0.060	<0.20	0.12
OIL AND GREASE	<0.1	0.9	<0.1	5.0	1.6	0.5	<0.20
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-10

STATION LOCATION - SOUTH FORK ABOVE CONFLUENCE WITH ECCLES CREEK

SAMPLE DATE	01/28/88	02/17/88	03/23/88	04/26/88	05/18/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE				
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)				5	8	18.5	23
FLOW (CFS)				0.36	2.7	1.38	0.20
WATER TEMPERATURE (C)				1	3	11.5	17
SPEC. COND. (UMHOS/CM) FIELD				508	340	367	407
PH (SU) FIELD				7.6	7.5	8.0	8.1
TURBIDITY (NTU) FIELD				2.5	12.5	3.15	3.7
TOTAL SUSP. SOLIDS				6	26	6	3
TOTAL DISS. SOLIDS MEAS.				265	185	188	230
OXYGEN (D) DISS							
COMMON IONS							
CALCIUM (CA)				68	60	64.8	55.20
MAGNESIUM (MG)				19.68	<0.10	<0.10	22.08
SODIUM (NA)				4.14	5.8	2.89	3.96
POTASSIUM (K)				0.87	0.3	<0.01	0.98
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)				270	188	183	249
SULFATE (SO4)				32	9	13	18
CHLORIDE (CL)				2.6	1.3	1.4	8.0
FLUORIDE(F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						0.05	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL				0.18	0.61	0.1	0.11
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL				0.02	0.03	<0.01	<0.01
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						<0.001	
OIL AND GREASE						0.2	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-10

STATION LOCATION - SOUTH FORK ABOVE CONFLUENCE WITH ECCLES CREEK

SAMPLE DATE	08/16/88	11/02/88	02/01/89	06/23/89	09/13/89	10/31/89	1/19/90
			STATION NOT ACCESSIBLE				STATION NOT ACCESSIBLE
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	7	8		10	15	-3	
FLOW (CFS)	0.11	0.14		0.35	0.06		
WATER TEMPERATURE (C)	7	3		6	4.5	0	
SPEC. COND. (UMHOS/CM) FIELD	436	482		434	493	420	
PH (SU) FIELD	7.5	7.6		7.7	7.0	7.55	
TURBIDITY (NTU) FIELD	0.69	1.45		1.5	0.88	0.63	
TOTAL SUSP. SOLIDS	2	1		<1.00	<1.00	<1.00	
TOTAL DISS. SOLIDS MEAS.	255	635		230	248	286	
OXYGEN (D) DISS	9.0				9.3		
COMMON IONS							
CALCIUM (CA)	78.40	118.00		59.91	65.08	68.01	
MAGNESIUM (MG)	10.08	6.00		13.79	20.02	20.95	
SODIUM (NA)	3.85	4.22		1.65	2.45	1.66	
POTASSIUM (K)	0.96	0.70		0.55	0.74	1.24	
ACIDITY AS CACO3	<0.05				<0.01		
ALKALINITY AS CACO3 (LAB)	220				211		
BICARBONATE (HCO3) (LAB)	268	260		238	257	282	
SULFATE (SO4)	20	102		11	31	24	
CHLORIDE (CL)	2.0	2.6		1.7	3.3	2.6	
FLUORIDE(F)	0.16				0.14		
NUTRIENTS							
NITRATE (NO3-N)	0.07	2.09		0.12	0.04	0.35	
AMMONIA (NH3 AS N)	0.06	<0.03		<0.03	<0.03	<0.03	
TOTAL PHOSPHATE (PO4)	<0.04	<0.04		<0.04	0.05	0.05	
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.03				0.02		
BARIUM (BA) DISS					0.01		
BORON (B) TOTAL	0.040				<0.010		
BORON (B) DISS					<0.010		
COPPER (CU) TOTAL	0.01				<0.01		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.07	0.12		0.05	0.09	0.12	
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.02	<0.01		0.02	<0.01	0.04	
MANGANESE (MN) DISS					<0.01		
ZINC (ZN) TOTAL	<0.005						
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)	5.96				4.32		
PHENOLS	0.025	<0.001		<0.001	<0.001	<0.001	
OIL AND GREASE	0.6	0.4		0.2	0.7	1.6	
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION VC - 10

STATION LOCATION - SOUTH FORK ABOVE CONFLUENCE WITH ECCLES CREEK

RECENT SAMPLE

SAMPLE DATE	06/06/90	09/12/90	11/14/90	02/14/91	06/10/91	09/17/91	10/17/91
				STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	21	22	3		19	17	11.5
FLOW (CFS)	0.55	0.08			2.51	0.16	0.07
WATER TEMPERATURE (C)	11	10	0.1		8.1	7.0	4.09
SPEC. COND. (UMHOS/CM) FIELD	280	453	462		283	622	706
PH (SU) FIELD	7.5	8.4	8.2		8.28	8.18	7.89
TURBIDITY (NTU) FIELD	3.4	1.6	5		3	2.5	6.4
TOTAL SUSP. SOLIDS	3	2	1		72	5	6
TOTAL DISS. SOLIDS MEAS.	238	232	244		186	396	442
OXYGEN (O) DISS		7.2	9.5		10.9	12.8	
COMMON IONS							
CALCIUM (CA)	46.10	52.25	67.35		51.58	69.60	95.15
MAGNESIUM (MG)	9.76	18.25	18.53		9.94	35.14	36.76
SODIUM (NA)	1.62	2.47	2.02		1.94	3.13	2.67
POTASSIUM (K)	<0.50	1.03	1.32		<0.32	2.50	2.12
ACIDITY AS CACO3		<0.60				<0.10	
ALKALINITY AS CACO3 (LAB)		216				230	
BICARBONATE (HCO3) (LAB)	188	264	248		157	281	268
SULFATE (SO4)	9	16.5	19.2		18.0	118	155
CHLORIDE (CL)	1.3	2.1	1.9		4.5	3.7	7.0
FLUORIDE(F)		0.12				<0.20	
NUTRIENTS							
NITRATE (NO3-N)	0.05	0.09	0.20		0.36	0.10	
AMMONIA (NH3 AS N)	0.05	<0.03	<0.03		0.08	<0.03	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	<0.04	0.05		0.06	<0.10	0.06
TRACE ELEMENTS							
BARIUM (BA) TOTAL						0.060	
BARIUM (BA) DISS		<0.01				0.030	
BORON (B) TOTAL						<0.050	
BORON (B) DISS		<0.005				<0.050	
COPPER (CU) TOTAL						0.030	
COPPER (CU) DISS		<0.01				<0.006	
IRON (FE) TOTAL	0.06		0.19		0.700	0.090	0.11
IRON (FE) DISS		0.04				0.020	
LEAD (PB) TOTAL						<0.003	
LEAD (PB) DISS		<0.002				<0.003	
MANGANESE (MN) TOTAL	0.02		0.03		<0.033	0.020	<0.02
MANGANESE (MN) DISS		<0.01				<0.020	
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)		3.24				1.73	
PHENOLS	<0.010	<0.010	<0.010		0.070	<0.20	<0.08
OIL AND GREASE	<0.1	0.2	2.0		0.2	0.2	<0.2
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-10

STATION LOCATION - SOUTH FORK ABOVE CONFLUENCE WITH ECCLES CREEK

SAMPLE DATE	01/28/88	02/17/88	03/23/88	04/26/88	05/18/88	06/06/88	07/20/88
	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE	STATION NOT ACCESSIBLE				
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)				5	8	18.5	23
FLOW (CFS)				0.36	2.7	1.38	0.20
WATER TEMPERATURE (C)				1	3	11.5	17
SPEC. COND. (UMHOS/CM) FIELD				508	340	367	407
PH (SU) FIELD				7.6	7.5	8.0	8.1
TURBIDITY (NTU) FIELD				2.5	12.5	3.15	3.7
TOTAL SUSP. SOLIDS				6	26	6	3
TOTAL DISS. SOLIDS MEAS.				265	185	188	230
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)				68	60	64.8	55.20
MAGNESIUM (MG)				19.68	<0.10	<0.10	22.08
SODIUM (NA)				4.14	5.8	2.89	3.96
POTASSIUM (K)				0.87	0.3	<0.01	0.98
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)				270	188	183	249
SULFATE (SO4)				32	9	13	18
CHLORIDE (CL)				2.6	1.3	1.4	8.0
FLUORIDE(F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						0.05	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL				0.18	0.61	0.1	0.11
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL				0.02	0.03	<0.01	<0.01
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)							
PHENOLS						<0.001	
OIL AND GREASE						0.2	
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-10

STATION LOCATION - SOUTH FORK ABOVE CONFLUENCE WITH ECCLES CREEK

SAMPLE DATE	08/16/88	11/02/88	02/01/89	06/23/89	09/13/89	10/31/89	1/19/90
			STATION NOT ACCESSIBLE				STATION NOT ACCESSIBLE
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	7	9		10	15	-3	
FLOW (CFS)	0.11	0.14		0.35	0.06		
WATER TEMPERATURE (C)	7	3		6	4.5	0	
SPEC. COND. (UMHOS/CM) FIELD	436	482		434	493	420	
PH (SU) FIELD	7.5	7.6		7.7	7.0	7.55	
TURBIDITY (NTU) FIELD	0.69	1.45		1.5	0.88	0.63	
TOTAL SUSP. SOLIDS	2	1		<1.00	<1.00	<1.00	
TOTAL DISS. SOLIDS MEAS.	255	635		230	248	286	
OXYGEN (D) DISS	9.0				9.3		
COMMON IONS							
CALCIUM (CA)	78.40	118.00		59.91	65.08	68.01	
MAGNESIUM (MG)	10.08	6.00		13.79	20.02	20.95	
SODIUM (NA)	3.85	4.22		1.65	2.45	1.66	
POTASSIUM (K)	0.96	0.70		0.55	0.74	1.24	
ACIDITY AS CACO3	<0.05				<0.01		
ALKALINITY AS CACO3 (LAB)	220				211		
BICARBONATE (HCO3) (LAB)	268	260		238	257	282	
SULFATE (SO4)	20	102		11	31	24	
CHLORIDE (CL)	2.0	2.6		1.7	3.3	2.6	
FLUORIDE(F)	0.16				0.14		
NUTRIENTS							
NITRATE (NO3-N)	0.07	2.09		0.12	0.04	0.35	
AMMONIA (NH3 AS N)	0.06	<0.03		<0.03	<0.03	<0.03	
TOTAL PHOSPHATE (PO4)	<0.04	<0.04		<0.04	0.05	0.05	
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.03				0.02		
BARIUM (BA) DISS					0.01		
BORON (B) TOTAL	0.040				<0.010		
BORON (B) DISS					<0.010		
COPPER (CU) TOTAL	0.01				<0.01		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.07	0.12		0.05	0.09	0.12	
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.02	<0.01		0.02	<0.01	0.04	
MANGANESE (MN) DISS					<0.01		
ZINC (ZN) TOTAL	<0.005						
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)	5.96				4.32		
PHENOLS	0.025	<0.001		<0.001	<0.001	<0.001	
OIL AND GREASE	0.6	0.4		0.2	0.7	1.6	
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION VC - 10

STATION LOCATION - SOUTH FORK ABOVE CONFLUENCE WITH ECCLES CREEK

RECENT SAMPLE

SAMPLE DATE	06/06/90	09/12/90	11/14/90	02/14/91	06/10/91	09/17/91	10/17/91
				STATION NOT ACCESSIBLE			
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	21	22	3		19	17	11.5
FLOW (CFS)	0.55	0.08			2.51	0.16	0.07
WATER TEMPERATURE (C)	11	10	0.1		8.1	7.0	4.09
SPEC. COND. (UMHOS/CM) FIELD	280	453	462		283	622	706
PH (SU) FIELD	7.5	8.4	8.2		8.28	8.18	7.89
TURBIDITY (NTU) FIELD	3.4	1.6	5		3	2.5	6.4
TOTAL SUSP. SOLIDS	3	2	1		72	5	6
TOTAL DISS. SOLIDS MEAS.	238	232	244		186	396	442
OXYGEN (D) DISS		7.2	9.5		10.9	12.8	
COMMON IONS							
CALCIUM (CA)	46.10	52.25	67.35		51.58	69.60	95.15
MAGNESIUM (MG)	9.76	18.25	18.53		9.94	35.14	36.76
SODIUM (NA)	1.62	2.47	2.02		1.94	3.13	2.67
POTASSIUM (K)	<0.50	1.03	1.32		<0.32	2.50	2.12
ACIDITY AS CACO3		<0.60				<0.10	
ALKALINITY AS CACO3 (LAB)		216				230	
BICARBONATE (HCO3) (LAB)	188	264	248		157	281	268
SULFATE (SO4)	9	16.5	19.2		18.0	118	155
CHLORIDE (CL)	1.3	2.1	1.9		4.5	3.7	7.0
FLUORIDE(F)		0.12				<0.20	
NUTRIENTS							
NITRATE (NO3-N)	0.05	0.09	0.20		0.36	0.10	
AMMONIA (NH3 AS N)	0.05	<0.03	<0.03		0.08	<0.03	<0.06
TOTAL PHOSPHATE (PO4)	<0.04	<0.04	0.05		0.06	<0.10	0.06
TRACE ELEMENTS							
BARIUM (BA) TOTAL						0.060	
BARIUM (BA) DISS		<0.01				0.030	
BORON (B) TOTAL						<0.050	
BORON (B) DISS		<0.005				<0.050	
COPPER (CU) TOTAL						0.030	
COPPER (CU) DISS		<0.01				<0.006	
IRON (FE) TOTAL	0.06		0.19		0.700	0.090	0.11
IRON (FE) DISS		0.04				0.020	
LEAD (PB) TOTAL						<0.003	
LEAD (PB) DISS		<0.002				<0.003	
MANGANESE (MN) TOTAL	0.02		0.03		<0.033	0.020	<0.02
MANGANESE (MN) DISS		<0.01				<0.020	
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)		3.24				1.73	
PHENOLS	<0.010	<0.010	<0.010		0.070	<0.20	<0.08
OIL AND GREASE	<0.1	0.2	2.0		0.2	0.2	<0.2
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-9

STATION LOCATION - ECCLES CREEK ABOVE CONFLUENCE WITH MUD CREEK

SAMPLE DATE	01/28/88	02/17/88	03/23/88	04/22/88	05/18/88	06/06/88	07/21/88
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	1	-4	9	6	11	16	20
FLOW (CFS)							
WATER TEMPERATURE (C)	2	0	4	4.5	7	15	11.5
SPEC. COND. (UMHOS/CM) FIELD	937	934	1045	960	618	656	702
PH (SU) FIELD	7.4	7.6	7.4	7.8	7.6	8.2	8.0
TURBIDITY (NTU) FIELD	2.9	12	6.1	5.9	26	5.2	8.0
TOTAL SUSP. SOLIDS	5	90	12	10	67	29	18
TOTAL DISS. SOLIDS MEAS.	436	488	594	495	342	340	410
OXYGEN (O) DISS							
COMMON IONS							
CALCIUM (CA)	94.8	87.76	118.4	89.6	84	81.6	79.20
MAGNESIUM (MG)	29.48	30.52	17.7	27.84	10.56	15.8	32.64
SODIUM (NA)	31.77	41.92	58.08	46.29	22.59	20.94	20.71
POTASSIUM (K)	4.32	3.5	4.16	3.87	1.98	2.01	3.51
ACIDITY AS CACO3							
ALKALINITY AS CACO3 (LAB)							
BICARBONATE (HCO3) (LAB)	268	282	242	277	216	217	283
SULFATE (SO4)	160	141	179	133	87	104	114
CHLORIDE (CL)	36.1	41.7	77.5	58	24.5	17.9	20.9
FLUORIDE (F)							
NUTRIENTS							
NITRATE (NO3-N)							
AMMONIA (NH3 AS N)						<0.03	
TOTAL PHOSPHATE (PO4)						<0.04	
TRACE ELEMENTS							
BARIUM (BA) TOTAL							
BARIUM (BA) DISS							
BORON (B) TOTAL							
BORON (B) DISS							
COPPER (CU) TOTAL							
COPPER (CU) DISS							
IRON (FE) TOTAL	0.024	1.19	0.4	0.34	1.15	0.42	0.34
IRON (FE) DISS							
LEAD (PB) TOTAL							
LEAD (PB) DISS							
MANGANESE (MN) TOTAL	0.08	0.14	0.12	0.09	0.1	0.07	0.03
MANGANESE (MN) DISS							
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)						0.034	
PHENOLS						0.5	
OIL AND GREASE							
CYANIDE (CN) TOTAL							

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

SUMMARY OF WATER QUALITY ANALYSES - SITE VC-9

STATION LOCATION - ECCLES CREEK ABOVE CONFLUENCE WITH MUD CREEK

SAMPLE DATE	08/16/88	11/03/88	02/01/89	06/23/89	09/13/89	10/31/89	1/17/90
			STATION NOT ACCESSIBLE				
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	18	6		14	16	-3	-1
FLOW (CFS)				2.30	2.00	3.31	
WATER TEMPERATURE (C)	10	9		8	9.5	2	0.5
SPEC. COND. (UMHOS/CM) FIELD	769	820		822	904	800	736
PH (SU) FIELD	7.2	7.6		7.3	7.0	7.3	7.8
TURBIDITY (NTU) FIELD	0.65	8.8		4.0	3.1	3.2	10.4
TOTAL SUSP. SOLIDS	20	26		20	6	11	18
TOTAL DISS. SOLIDS MEAS.	484	599		455	526	554	494
OXYGEN (O) DISS	8.2			9.0	9.0	9.8	10.9
COMMON IONS							
CALCIUM (CA)	92.00	184.00		78.33	85.76	80.95	79.02
MAGNESIUM (MG)	30.24	2.40		30.02	42.01	37.88	6.50
SODIUM (NA)	30.27	24.39		33.83	28.85	37.85	100.00
POTASSIUM (K)	4.44	3.37		4.75	5.92	5.94	4.21
ACIDITY AS CACO3	9.00				10.00		
ALKALINITY AS CACO3 (LAB)	221				227		
BICARBONATE (HCO3) (LAB)	270	265		281	277	264	276
SULFATE (SO4)	175	272		142	195	198	170
CHLORIDE (CL)	15.5	13.8		17.0	25.9	19.9	21.9
FLUORIDE (F)	0.32				0.30		
NUTRIENTS							
NITRATE (NO3-N)	0.24	0.46		0.50	0.58	0.91	0.49
AMMONIA (NH3 AS N)	0.06	<0.03		<0.03	<0.03	<0.03	<0.03
TOTAL PHOSPHATE (PO4)	0.05	<0.04		<0.04	0.06	0.06	<0.02
TRACE ELEMENTS							
BARIUM (BA) TOTAL	0.07				0.06		
BARIUM (BA) DISS					0.06		
BORON (B) TOTAL	0.100				0.080		
BORON (B) DISS					0.080		
COPPER (CU) TOTAL	<0.01				<0.01		
COPPER (CU) DISS					<0.01		
IRON (FE) TOTAL	0.44	0.51		0.36	0.20	0.40	0.53
IRON (FE) DISS					<0.03		
LEAD (PB) TOTAL	<0.001				<0.001		
LEAD (PB) DISS					<0.001		
MANGANESE (MN) TOTAL	0.06	0.05		0.06	0.03	0.06	0.06
MANGANESE (MN) DISS					<0.01		
ZINC (ZN) TOTAL	<0.005						
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)	4.49				5.25		
PHENOLS	<0.001	<0.001		<0.001	<0.001	<0.001	1.210
OIL AND GREASE	<0.1	0.7		0.4	0.3	0.7	4.8
CYANIDE (CN) TOTAL	<0.001				<0.001		

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

TABULATION
OF
WATER QUALITY DATA
STATION VC - 9

STATION LOCATION - ECCLES CREEK ABOVE CONFLUENCE WITH MUD CREEK

MOST RECENT SAMPLE

SAMPLE DATE	06/06/90	09/13/90	11/14/90	02/14/91	06/11/91	09/17/91	11/05/91
PHYSICAL PARAMETERS							
AIR TEMPERATURE (C)	20	23.5	9.5	4	26	18	7
FLOW (CFS)	4.62	2.35	3.04		9.74	2.79	3.59
WATER TEMPERATURE (C)	16.5	11.8	3.8	3.75	12.8	12	5.6
SPEC. COND. (UMHOS/CM) FIELD	581	931	913	920	584	1213	1188
PH (SU) FIELD	7.6	8.0	8.2	8.00	8.32	8.11	7.62
TURBIDITY (NTU) FIELD	12.5	9.1	27.5	5	75	14	17
TOTAL SUSP. SOLIDS	27	22	22	104	266	30	67
TOTAL DISS. SOLIDS MEAS.	416	552	590	696	382	850	810
OXYGEN (O) DISS	8.2	7.3	9.7	12.44	9.7	12.1	
COMMON IONS							
CALCIUM (CA)	65.85	97.88	99.46	99.23	74.18	81.04	90.40
MAGNESIUM (MG)	25.01	47.66	41.70	51.21	28.17	73.81	62.40
SODIUM (NA)	22.00	20.80	27.27	54.03	18.47	63.01	78.70
POTASSIUM (K)	3.70	0.23	5.96	7.62	2.84	9.64	9.30
ACIDITY AS CACO3		3.60				3.80	
ALKALINITY AS CACO3 (LAB)		211				251	
BICARBONATE (HCO3) (LAB)	201	257	277	274	188	306	312
SULFATE (SO4)	140	220	191	252	103	385	366
CHLORIDE (CL)	20.7	21.6	20.7	57.0	21.5	3.7	31.0
FLUORIDE (F)		0.31				<0.20	
NUTRIENTS							
NITRATE (NO3-N)	0.05	0.15	0.97	0.71	1.01	1.35	
AMMONIA (NH3 AS N)	<0.03	<0.03	0.10	0.52	0.12	0.24	0.29
TOTAL PHOSPHATE (PO4)	<0.04	<0.04	0.07	0.14	0.16	<0.10	0.11
TRACE ELEMENTS							
BARIUM (BA) TOTAL		0.03				0.060	
BARIUM (BA) DISS		<0.01				0.060	
BORON (B) TOTAL		<0.005				0.230	
BORON (B) DISS		<0.005				0.230	
COPPER (CU) TOTAL		<0.01				0.030	
COPPER (CU) DISS		<0.01				<0.006	
IRON (FE) TOTAL	0.48	<0.03	0.57	1.690	2.150	0.350	0.700
IRON (FE) DISS		<0.03				0.010	
LEAD (PB) TOTAL		<0.002				<0.003	
LEAD (PB) DISS		<0.002				<0.003	
MANGANESE (MN) TOTAL	<0.01	<0.01	0.07	0.160	0.120	0.080	0.120
MANGANESE (MN) DISS		<0.01				0.060	
ZINC (ZN) TOTAL							
OTHER PARAMETERS							
ORGANIC CARBON (TOTAL)		104				2.13	
PHENOLS	<0.011	<0.010	0.015	<0.050	0.090	0.24	<0.08
OIL AND GREASE	<0.1	0.7	0.6	11.1	1.5	0.6	<0.2
CYANIDE (CN) TOTAL		<0.010				<0.100	

ALL QUANTITIES IN MILLIGRAMS PER LITER UNLESS OTHERWISE NOTED.

HYDROLOGIC ANALYSIS FOR ECCLES CANYON
CHRISTOPHER KNOPP, 1980

file copy 1980
Eccles Canyon

HYDROLOGIC ANALYSIS

FOR

ECCLES CANYON

Coal Lease Development by Coastal States Energy and Getty Mineral Resource Company.

CHRISTOPHER KNOPP
January 1980

TABLE OF CONTENTS

Introduction 1
Issues and Concerns 1
Discussion and Possible Mitigations 1
Summary 3

APPENDIX

Map of Facility Location Within Eccles Canyon W.S. A-1
Meteorological Data A-2
Watershed Evaluation Data A-3
Water and Sediment Yield Summary A-4
Water Yield for Mine Facility A-5
Water Yield Hydrograph - Eccles W.S. A-6
Runoff Calc. Using Skyline Data A-7

INTRODUCTION

The following hydrologic analysis has been prepared in response to a request from the Price District concerning the proposed Skyline Coal Mining Project. Comments in this report are directed to the 1979 version of the mining plan submitted by Coastal States Energy Co. and Getty Mineral Resources Co. It is understood that this report provides information to be included in the larger, more comprehensive Environmental Assessment Report.

ISSUES AND CONCERNS

1. That acceptible flood prediction techniques were utilized in establishing the size of the design flow.

2. That the sediment containment basin will hold the expected flow from the portal facilities area.

3. That facilities design is adequate should the mine intercept substantial groundwater.

4. That subsidence does not adversly affect the hydrologic resource.

5. That the project is not located in a 100 year flood plane.

DISCUSSION AND POSSIBLE MITIGATIONS

1. Surface runoff appears to have been calculated by several contributing disciplines using various methods. The calculation of most concern relates to the capacity of the culverts underneath the proposed mine facilities. The flow has been calculated from a 24 hour, 100 year storm, equal to 2.25 inches. The company has estimated runoff volume at 0.12 inches with a peak flow of 130 cfs (V-3, p. 4, 19). Our own calculations, using the identical precipitation and runoff volume, indicated the peak flow would be only 41 cfs (Appendix, p. 7, SCS Runoff curve number w/dimensionless hydrograph). Our independent calculations using a 6 hour, 100 year storm of 2.29 inches yielded 36 cfs, which is felt to be directly comparable (Appendix, p. 4, SCS, Runoff curve numbers). Since the error is one of overestimating the runoff peak, no adverse environmental impacts will result. The proposed facilities, as presently designed, will also pass our estimate of the 247 year flood (63 cfs) which is our preferred design storm since it gives an estimated 15 percent chance of failure over the 40 year life of the facility (Chow, p. 9-59).

2. Because of the very short time of concentration on the portal facilities area (5.2 minutes)*, the peak flow is only 4.8 cfs for a maximum 5 minute precipitation event of 0.3 inches ** (equivalent to the 247 year event). ***

   The maximum runoff volume was calculated in response to a 6 hour - 247 year event equivalent to 2.65 inches of rain.** That volume was calculated as 3.5 acre-feet (SCS - RCN). (A RCN of 81 was utilized in the maximum volume calculations as an equivalent to the Rational Coefficient of 0.4 that was used to calculate the flow peaks.) These extreme storm events should be contained in the sediment basin as presently described (Cap. 12 ac-ft). Ideally, a free board sufficient to contain 3.5 acre-feet of water should always be maintained in the sediment pond. This would contain a 247 year event and also provide storage for an unexpected occurance of groundwater within the mine.

   * Calculated using Hathaway's time of concentration formula (Kirby, 1959, Civ. Eng. V-29, p. 174).

   ** From 'Estimated return periods for short duration precipitation in Utah', E.A. Richardson, 1971.

   *** The 'Rational Method' was used to calculate the runoff peak in the mine fac. area. See Appendix p. 5.

3. Emphasis within the report is placed upon the hypothesis that the Blackhawk formation is virtually impermeable and that the local faults do not transmit large quantities of water. As a minor point of disagreement, we feel that while encounters with groundwater will be infrequent, they will occur in substantial volume, several times during the life of the mine. During the mine's first years, before adequate underground storage is available, active discharge from the portals may be required. Mine facilities must be capable of withstanding a prolonged discharge.

   The evidence for making the assumption that some substantial quantities of groundwater will be encountered is as follows:

   A. The Belina No. 4 mine encountered one localized water source that initially flowed an estimated 1000 gal per min. A rough estimate of the quantity of water discharged showed 2.6 acre-feet over a ten week period (Volume A-1, p. 77-78).

   B. On the South Fork of Eccles, along the Connelville Fault, water quality changes are attributed to the existence of a beaver dam. However, both bicarbonate ion and magnesium show definite increases in transported load (Vol. A-1, figure 24). This would not occur soley as the result of beaver activity and seems to indicate a new water source. Springs as indicated in the report, are the most likely.

C. On page 73 Vol. A-1, the O'Conner Fault is seen acting as a conveyance structure through fractured sandstone.

D. (On page 82, 83, Vol. A-1). An observation well (W35-1) discharged 110 gal/min. On page 82, this discharge was associated with a high angle fault. "The fracture has connected the sandstone lenses of the Blackhawk formation with the Star Point Sandstone, thereby significantly increasing the water yield characteristics of the rock..."

Interception of large volumes of groundwater, while not common, will probably occur. The water storage facilities should be designed to handle several acre-feet, and to accomodate a continuous discharge for several months. The sediment pond's spillway should be armored to the extent that a continuous flow will not undercut the structure.

4. Subsidence is expected to be widespread and of little specific local impact. No adverse affects are anticipated.

5. The mining facilities are not located in a flood plain as described in the Forest Service Manual (2527.05a), since only headwater streams are involved. The facility is designed to pass the 100 year flood.

SUMMARY

Given the short time available to develop a comprehensive hydrologic survey the submitted plan is adequate (with the noted exceptions).

APPENDIX

Note: The meteorology and hydrologic data is included as a comparison of our own estimates of these parameters. They are the values used for our calculations, except were specifically noted. Differences in the meteorology information is not deemed to be significant. Summaries are included should a review of procedures be required. All calculations were done using a Tl-59 and custom programs. Clarification of procedures is available upon request.

METEOROLOGY DATA

Normal Annual Precip	22 - 26 in./yr.
May - Sept.	5"
Oct. - April	19"
Max. Jan. Temp.	30°F
Mean Min. Jan. Tmp.	6°F
Mean Max. July Tmp.	78°F
Mean Min. July Tmp.	39°F

Length of Freeze Free Season 50 days
(From: June 29 - Aug. 18)

Mean Annual Water Yield 14 in.

Data Source: Utah Hydrologic Atlas,
& Straight Canyon Barometer Watershed Data

Intensity Data for flood frequency from 'Estimated return period for short-duration precipitation in Utah'. Richardson, 1971.

WATERSHED EVALUATION DATA
(SCS-Runoff curve numbers)

Watershed	A	B	C
Area Ac.	377.6	288.0	140.8
RCN w/20 Tr	54.0	63.6	69.2
RCN w/50 Tr	52.4	62.7	68.2
RCN w/100 Tr	51.0	62.2	67.2
RCN w/247 Tr	49.9	62.0	67.0
Max. Elevation Ft	9655	9560	9620
Min. Elevation Ft	8600	8600	8600
Channel Length Ft	7550	5940	3960
W.S. Slope (AVG) Ft/Ft	.159	.171	.257

(Inches) P_{20}	1.76	---------->
P_{50}	2.07	---------->
P_{100}	2.29	---------->
P_{247}	2.65	---------->

Universal Soil Loss Equation Variables			
K	.14	.34	.10
C	.008	.012	.026
P	1.0	1.0	1.0

'R' Factors Calculated from area Q & peak flow as described in Fogel, Heckman, & Duckstein, 1976. 'A Stochastic Sediment Yield Model, Using the Modified USLE'.

RESULTS SUMMARY*

Water and Sediment Yield Off Eccles W.S.

Note: These results are our best estimate of potential flows down Eccles Creek. The method used to estimate flows for culvert sizes within the report is not clear.

WATERSHED	A	B	C	Total
	5% chance of occurance - 20 year storm			
Peak Flow q(20) CFS	0.2	7.8	8.8	16.8
Sediment S(20) tons	.002	.867	1.355	2.2
Concentrat. Est. mg/1	30	130	180	
	2% chance of occurance - 50 year storm			
Peak Flow q(50) CFS	2.0	13.6	11.4	27.0
Sediment S(50) tons	.027	1.768	2.354	4.1
Concentrat. Est. mg/1	30	150	200	
	1% chance of occurance - 100 year storm			
Peak Flow q(100) CFS	3.1	19.0	14.1	36.2
Sediment S(100) tons	.055	2.601	3.039	6.0
Concentrat. Est. mg/1	30	150	210	
	0.4% chance of occurance - 247 year storm			
Peak Flow q(247) CFS	7.1	30.8	24.9	62.8
Sediment S(247) tons	.151	4.290	4.799	9.2
Concentrat. Est. mg/1	30	140	220	

* (Included soley for procedural verification)
SCS runoff curve numbers used with dimensionless Hydrograph to generate peak flow estimates.

FLOOD SUMMARY FOR MINE FACILITIES AREA

(Included for procedural verification only)

A. Rational method (R.M.) used to calculate the Peak Flow Rate (q) for the following reasons:

1. R.M. was developed to calculate runoff from small (< 5 mi.^{2}) disturbed watersheds.

2. Selected because of its sensitivity to high intensity short duration precipitation events.

3. Time of concentration = 5 minutes; greatest peak flow will occur from 5 min. intensity storm (since it will yield the largest 5 min. volume).

Peak Flow Rate (Mine facilities area)

20 year - 5 min. precip = 0.22 in., q = 3.5 cfs

50 year - 5 min. precip = 0.25 in., q = 4.0 cfs

100year - 5 min. precip = 0.27 in., q = 4.3 cfs

247year - 5 min. precip = 0.30 in., q = 4.8 cfs

B. SCS Runoff Curve No. Method to Calc. Q. (Volume)

1. RCN of 81 was calculated as coinciding with Rational coef. of 0.4. It is in the medium-low range for a surface of a heavily utilized site. Appendix p. 7, describes this procedure.

2. RCN was based upon 'C' of .4. Rational calculations completed first.

Maximum Volume (Mine Facilities Area)

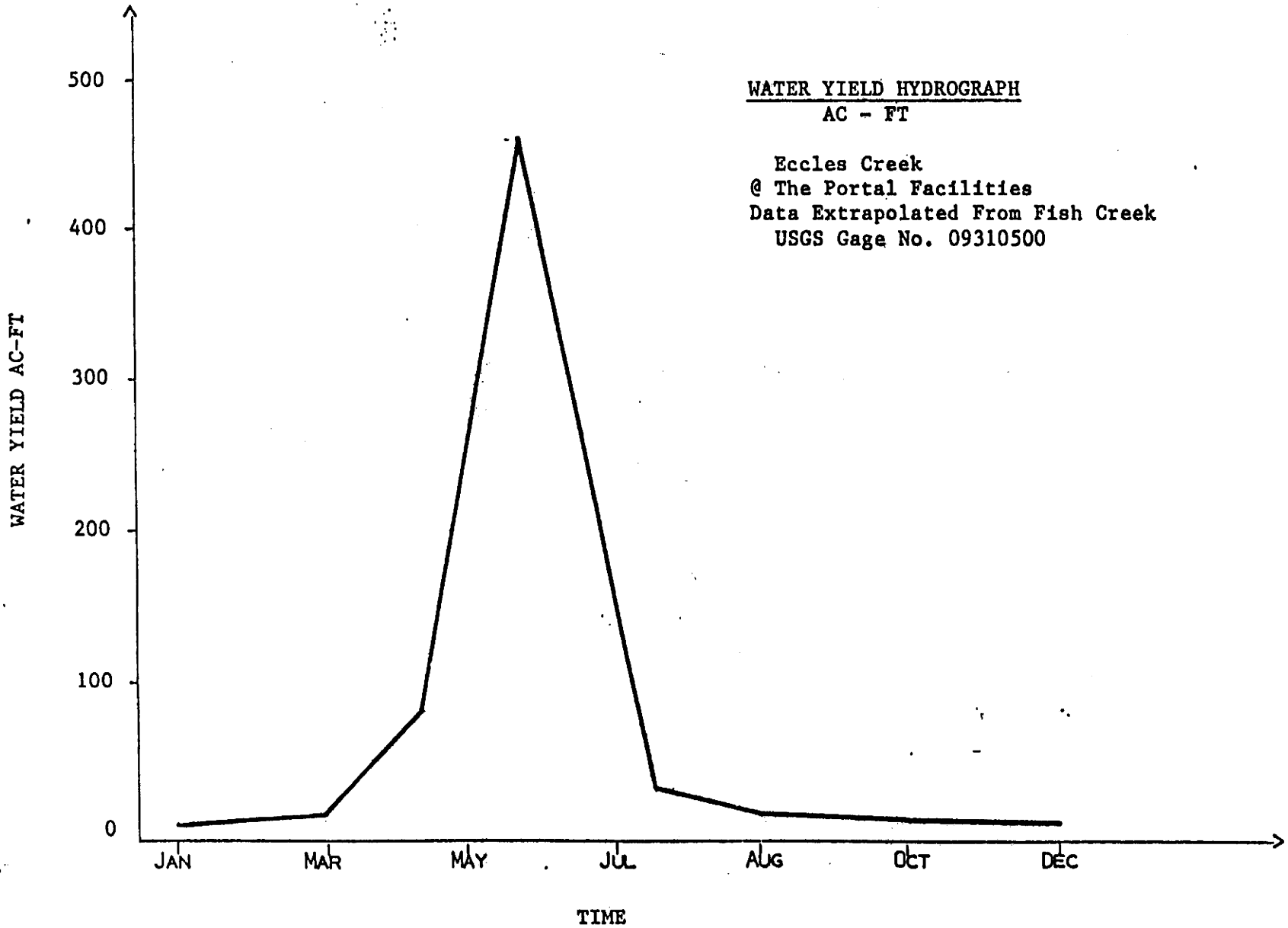
20 year 6 hour precip = 1.76 in., Q = 1.5 Ac Ft.

50 year 6 hour precip = 2.07 in., Q = 2.2 Ac Ft.

100 year 6 hour precip = 2.29 in., Q = 2.7 Ac Ft.

247 year 6 hour precip = 2.65 in., Q = 3.5 Ac Ft.

3. 6 hour storm used to maximize runoff volume; SCS - RCN method is designed to utilize 6 hour events.


WATER YIELD HYDROGRAPH
AC - FT
Eccles Creek
@ The Portal Facilities
Data Extrapolated From Fish Creek
USGS Gage No. 09310500
WATER YIELD AC-FT
500
400
300
200
100
0
JAN
MAR
MAY
JUL
AUG
OCT
DEC
TIME

Reply to Section 4.19, Volume 3

Assumption: 100 Year, 24 hour event = 2.25 in.
(As given in report)

Assumption: Area inches runoff = 0.12 inc.
(As listed in report, V-3 p. 4.19)

Calculations:

1. Derivation of RCN Used (Hawkins, Utah State Univ.)

$S = 5\ (P + 2Q - (4Q^2 + 5PQ)^{\frac{1}{2}}$

RCN = 1000/(10 + 5)

S = 1.3036 X 5 = 6.518

RCN = 1000/(10 + 6.518) = 60.54

2. Calculation of 24 hour Storm Peak
(SCS - Runoff Curve Numbers)

Assumptions: Duration = 6 hours

RCN = 60.54, P_{100} = 2.25 in., Area = 820 Ac. (1.28 $mi.^2$)

L = 7550' (Max. Channel length in S.W. Watershed which is the longest of the three)

S = .196 (Avg. Slope of three watersheds)

N (Roughness coef.) = 0.5, T_o = 3.5, (For time of concentration. Hathaway's Formula From Kirby, W.S. 1959 in Civ. Eng., V 29, p. 174.)

T_o/T_p Used = 6, Hydrologic Family = 5.

Result:

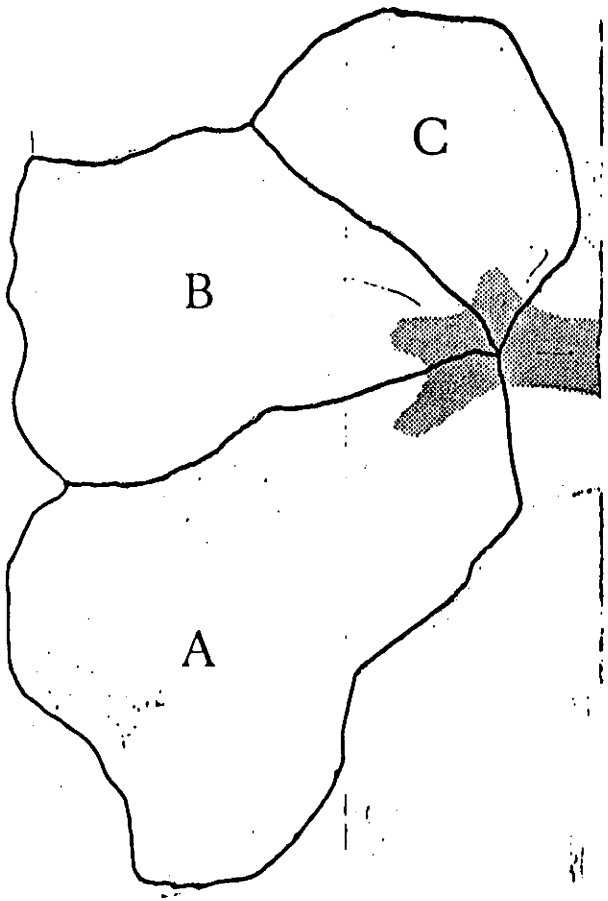
Peak Flow Occurs @ 3.6 hours
q = 41 cfs (Using Avg. CN Procedure)

Note: Changing to a 6 hour duration from a 24 hour duration will result in higher specific rainfall intensities with a correspondingly higher peak flow.

CCLES CANYON COAL DEVELOPMENT

COASTAL STATES ENERGY

HYDROLOGIC ANALYSIS



proposed development

Canyon

Winter Quarters Canyon
Data Adequacy

October 1992

100 YEAR FLOOD PLAN DETERMINATION OF ECCLES CREEK
SKYLINE MINES
MINING & RECLAMATION PLAN
APPENDIX VOLUME A-1, 1986

SKYLINE MINES

MINING AND RECLAMATION PLAN

COASTAL STATES ENERGY COMPANY

1986

APPENDIX

VOLUME A-1

100-YEAR FLOOD PLAIN DETERMINATION OF ECCLES CREEK

100-Year Rainfall-Caused Flood of Eccles Creek

In determining 100-year peak flows near mining facilities in Eccles Canyon, both precipitation caused floods and snowmelt floods were examined. The SCS curve number method was used for estimating the precipitation caused flood events. Precipitation amounts for various duration storms were obtained from the NOAA Atlas 2 for Utah. The 100-year 24-hour and 6-hour precipitation values were 3.7 and 2.3 inches respectively. Curve numbers were determined from information obtained in the Hydrologic Inventory of the Skyline Property and Adjacent Areas, Carbon and Emery Counties, Utah prepared previously by Vaughn Hansen Associates. Curve numbers were determined to be 40 and 52 for the 100-year 24-hour and 100-year 6-hour storms respectively. The 6-hour storms produced the heaviest runoff---7.9 cfs leaving the portal area and 22.2 cfs at the mouth of the canyon near the loadout facility. (Appendix A).

100-Year Snowmelt Flood of Eccles Creek

A correlation of high flows on nearby Gooseberry Creek with flows measured on the same day in the mouth of Eccles Creek was run. Yearly flood peaks on Eccles Creek were estimated by using the resulting regression equation and applying it to the yearly flood peaks on Gooseberry Creek for the 38 years of record. The resulting predicted peaks

were ranked and then plotted on log-normal plotting paper, and a curve was drawn through the points. This curve was then extrapolated to give an estimate of the 100-year peak flow on Eccles Creek of about 25.7 cfs. An examination of the peak flows on Gooseberry Creek shows that they occur during periods of high snowmelt runoff. Consequently, the peak flow of 25.7 cfs is assumed to be an estimate of the snowmelt runoff flood (Appendix B).

100-Year Flood Chosen For Flood Plain Determination

The largest of the floods produced by these previously outlined methods was used as the appropriate 100-year flood peak flow. Consequently, in the mouth of Eccles Canyon the snowmelt peak of 25.7 cfs was used. In the portal area, the snowmelt peak flow was obtained by dividing the 25.7 cfs proportionally according to the drainage area above the mouth of Eccles Canyon. The resulting flow was less than the flows produced using the SCS curve number method for the 100-year 6-hour storm. Consequently, the flows produced using the latter method were used in the portal area.

Flood Plain Computations

In the mouth of Eccles Canyon, flood plain widths near proposed facilities were calculated using Mannings equation (Appendix C). These cross sections are shown on the enclosed map of the loadout facility. The flood plain was then interpolated between these cross sections and shaded (Plate 2). The enclosed map shows that even in a 100-year flood, the natural stream course capacity is not exceeded.

In the portal area, as stated previously, the 100-year 6-hour precipitation caused flood was used. As shown in Appendix A and on the map of the portal area (Plate 1), the 100-year peak flows for the three small channels coming into the portal area are estimated to be 3.6, 2.6, and 1.7 cfs. They combine to produce a flow of about 7.9 leaving the portal area. These flows are quite small and, in the relatively steep channels in which they flow, are quite easily handled. Consequently, the flood plain is about the same as the stream width and has therefore not been drawn in on the attached map of the portal area.

According to Coastal States, all culverts in both the portal and loadout areas have been designed to carry much more than the 100-year peak flows to facilitate maintenance.

100-YEAR FLOOD PLAIN DETERMINATION OF MUD CREEK

100-Year Rainfall-Caused Flood of Mud Creek

The 100-year peak flow for rainfall-caused flooding in Mud Creek was computed similarly to the method described for Eccles Creek. The SCS curve number method was used with curve numbers of 40 and 52 being used for the 24- and 6-hour storms respectively. The computation sheet is contained in Appendix D. The 100-year 6-hour flood was the largest and indicated a 100-year flood peak of approximately 52.1 cfs could be expected in Mud Creek immediately above the confluence with Eccles Creek.

100-Year Snowmelt Flood of Mud Creek

Inadequate flow measurements during spring runoff on Mud Creek were available for correlating with other gaged streams. Because of this similarity between the Mud Creek and Eccles Creek drainage basins, an estimate of Mud Creek runoff was made based on results from the Eccles Creek flood estimates explained previously. This estimate was based on the assumption that snowmelt peak runoff rates between the two streams are proportional to the size of the drainage. Based on this assumption, the 100-year peak snowmelt runoff in Mud Creek above Eccles Creek is estimated to be 75 cfs. Because this is larger than the flow of 52.1 cfs predicted for rainfall produced flooding, the 75 cfs value was used in determining the flood plain size.

Flood Plain Computations

Flood plain widths were calculated using Mannings equation at various sections of Mud Creek (Appendix E). These cross-sections and the flood plain widths are shown on Plates 3 and 4.

APPENDIX A

Basin	Area (mi²)	CN[1]	l (ft)	Y[2] (%)	Computed Tp (hrs)	Hyd. Factor	Precip[4] (inches)	Runoff[5] (inches)	To (hrs)	To/Tp Computed	To/Tp Used	Tp (hrs)	HSAD Tp (hrs)	Flow (cfs)
A (SW branch draining partial area)	0.386	40	7200	35.8	0.38	5	3.7	0.031	10.3	11.73	10	1.03	8.54	1.8
B (North branch draining partial area)	0.422	40	5400	37.4	0.68	5	3.7	0.031	10.3	15.15	16	.64	9.89	1.4
C (North branch draining partial area)	0.245	40	3600	40.4	0.47	5	3.7	0.031	10.3	21.91	25	.41	8.97	0.8
													Total (Downstream partial area)	4.0

(1) From Hydrologic Inventory Equations

(2) $\frac{(\text{Difference Bet. 2 } 200' \text{ contour lines})(200 \text{ ft})}{\text{Area (ft}^2)}$

(3) $T_p = 1.17(L) = 1.17\left[\frac{l^{.8}(S+1)^{.7}}{1900\, Y^{.5}}\right]$ where $S = \frac{1000}{CN} - 10$

(4) From HOAD Atlas

(5) $Q = \frac{(P-.2S)^2}{P+.8S}$

100 yr flood boundary from partial area = 4.0 cfs

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

COMPUTED ____ CLIENT ____
CHECKED ____ PROJECT ____
DATE ____ FEATURE ____

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

COMPUTED _____ CLIENT _____
CHECKED _____ PROJECT _____
DATE _____ FEATURE _____

Basin	Area (mi²)	CN	l (ft)	Y (%)	Computed Tc (hrs)	Hyd. Form. Flo	Precip (inches)	Runoff (inches)	To (hrs)	To/Tp Computed	To/Tp Used	Tpeak (hrs)	484AQ/Tpeak	Flow (cfs)
A	0.586	52	7200	35.8	0.64	5	2.3	.0174	2.32	3.63	4	0.58	8.51	3.6
B	0.422	52	5400	37.4	0.49	5	2.3	.0174	2.32	4.73	4	0.58	6.13	2.6
C	0.245	52	3600	40.4	0.35	5	2.3	.0174	2.32	6.63	6	0.39	5.29	1.7

Total = 7.9

100 yr flood leaving the
total area = 7.9 cfs

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

COMPUTED ____ CLIENT ____
CHECKED ____ PROJECT ____
DATE ____ FEATURE ____

Basin	Area (acres)	CN	L (ft)	Y (%)	Compute Tc (hrs)	Hyd Fore. No	Precip (inches)	Runoff (inches)	To (hrs)	To/Tc Computed	To/Tc Used	Tc (hrs)	Tc (min)	Flow (cfs)
1	1.73	HO	10,400	35.4	1.00	5	3.7	0.031	10.3	10.3	10	1.03	25.2	5.3
2	3.47	HO	14,800	38.8	1.27	5	3.7	0.031	10.3	8.11	10	1.03	50.55	10.7
3	4.77	HO	15,800	39.2	1.34	5	3.7	0.031	10.3	7.7	6	1.72	41.5	13.5
4	5.55	HO	21,300	40.2	1.67	5	3.7	0.031	10.3	6.1	6	1.72	48.4	15.7

100-yr Storm [illegible]
Existing Condition = 15.7 cfs

VAUGHN HANSEN ASSOCIATES
CONSULTANTS: ENGINEERS

COMPUTED _____ CLIENT _____
CHECKED _____ PROJECT _____
DATE _____ FEATURE _____

Basin	Area (mi²)	C.N	l (ft.)	Y (%)	Computed T_p (hrs)	Hyd. Fam No.	Precip (inches)	Runoff (inches)	T_o (hrs)	T_o/T_p Computed	T_o/T_p Used	$(T_p)_{new}$	$\frac{11.4AQ}{(T_p)_{new}}$	Flow (cfs)
1	1.73	52	10,400	35.4	.86	5	2.3	.0174	2.32	2.70	3	.77	18.9	9.6
2	3.47	52	14,800	38.8	1.10	5	2.3	.0174	2.32	2.11	2	1.16	25.2	16.2
3	4.77	52	15,300	39.2	1.15	5	2.3	.0174	2.32	2.03	2	1.16	34.6	22.2
4 (mouth of Eccles Canyon)	5.55	52	21,500	40.2	1.45	5	2.3	.0174	2.32	1.60	1.5	1.55	30.15	22.2

100-yr Flood at mouth of Eccles Canyon
[illegible] to be 22.2 cfs.

APPENDIX B

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

COMPUTED _____ CLIENT _____
CHECKED _____ PROJECT _____
DATE _____ FEATURE _____

Date	Flow in Feet (@ VC-9)	Flow Summary (Hydrograph)
4-28-76	4.3	11
6-14-76	5.7	21
5-10-78	5.0	31
6-14-78	11.3	149
7-12-78	3.4	16
5-11-79	5.2	51
6-20-79	7.1	30

All consistent base points were at the Goodwin Creek Pass were >10 cfs.

Linear regression is probably the best in this case

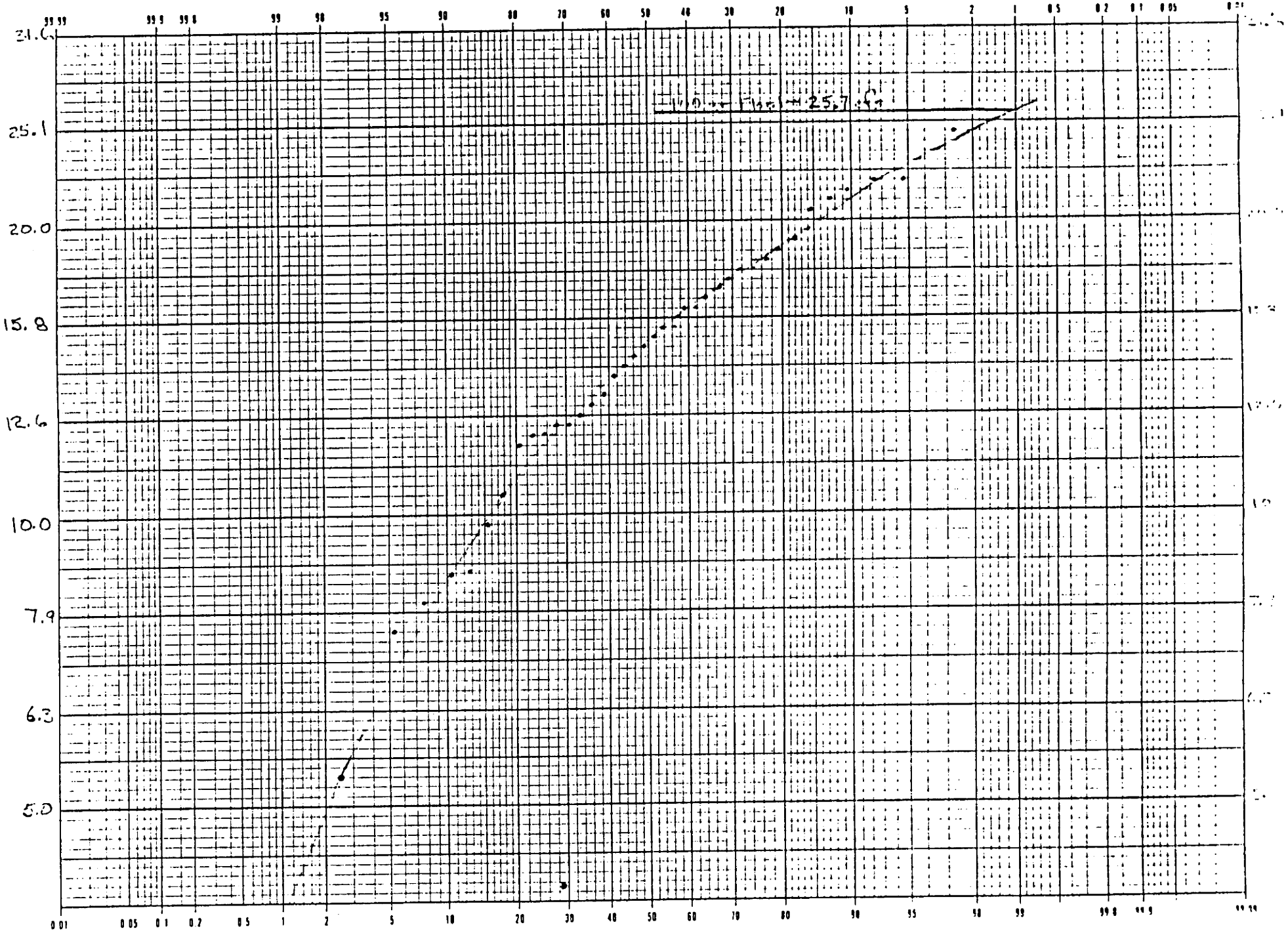
$$EC = 3.8 + 0.049(BC) \qquad r^2 = .83$$

Yearly Goodwin Peak Flows Year	Flows	Predicted Eccles Creek Peak Flows	Rank
1931	98	8.7	4
1941	366	21.9	36
1942	304	18.8	31
1943	178	12.6	13
1944	265	16.9	26
1946	170	12.2	11
1947	292	18.3	30
1948	167	12.1	10
1949	360	21.6	35
1950	225	15.4	21
1951	189	13.2	15
1952	414	24.3	38
1953	218	14.6	18
1954	89	3.2	3
1955	161	11.3	8
1956	165	12.0	9
1957	369	22.1	37
1958	345	20.9	34
1959	122	9.8	6
1960	203	13.9	16
1961	74	7.5	2
1962	279	17.6	28
1963	173	12.4	12
1964	272	17.3	27
1965	230	15.2	20
1966	133	9.4	7
1967	222	16.3	24
1968	229	15.6	22
1969	332	20.5	33

Yearly Goodwin Peak Flows Year	Flows	Predicted Eccles Creek Peak Flows	Rank
1971	224	14.9	19
1972	101	8.8	5
1973	312	19.2	32
1974	251	16.2	23
1975	256	16.5	25
1976	184	12.9	14
1977	32	5.4	1
1978	205	14.0	17

TELEDYNE POST

20MH-000 PROBABILITY X 90
LITHO IN U.S.A.



APPENDIX C

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

COMPUTED _____ CLIENT _____
CHECKED _____ PROJECT _____
DATE _____ FEATURE _____

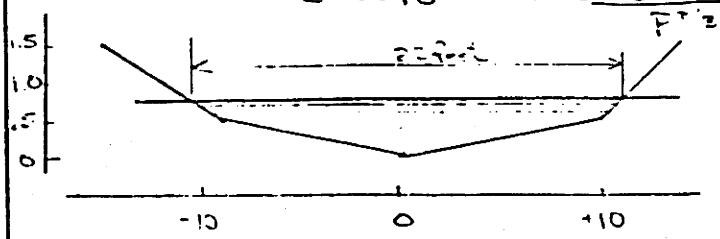
[illegible]

[illegible] Manning's n is assumed, conservatively, to be 0.040

$$Q = \frac{1.5\, A^{5/3}\, S^{1/2}}{n\, P^{2/3}}$$

Section ①

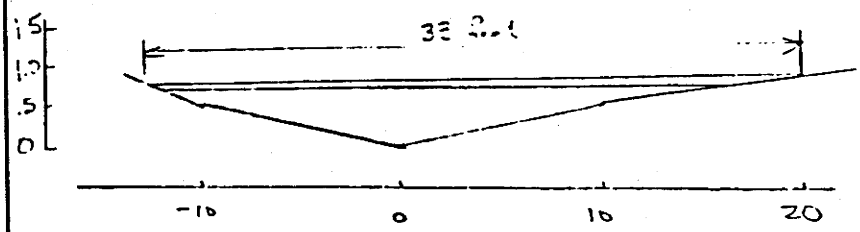
$S = .018$ $\quad Q = \frac{5.03\, A^{5/3}}{P^{2/3}}$



Depth	A	P	Q
.6	5.7	19	12.9
.7	7.7	20	20.5
.74			

Section ②

$S = .0076$ $\quad Q = \frac{3.27\, A^{5/3}}{P^{2/3}}$

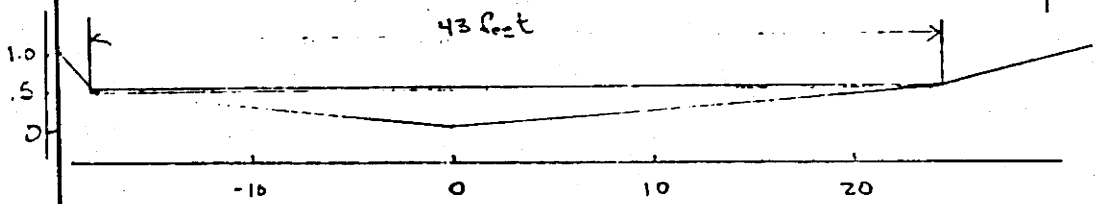


Depth	A	P	Q
.7	9.8	28	15.9
.8	12.8	32.5	22.5
.84			

Section ③

$S = .015$ $\quad Q = \frac{4.59\, A^{5/3}}{P^{2/3}}$

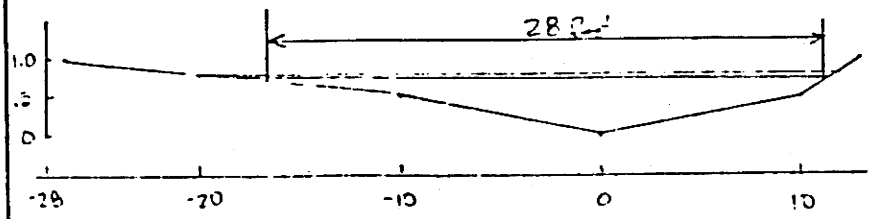
Depth	A	P	Q
.5	10.5	42	19.1
.55	12.6	42.5	25.7



Section ④

$S = .015$ $\quad Q = \frac{4.59\, A^{5/3}}{P^{2/3}}$

Depth	A	P	Q
.8	12.8	32	31.9
.75	11.3	29.5	27.4
.73			

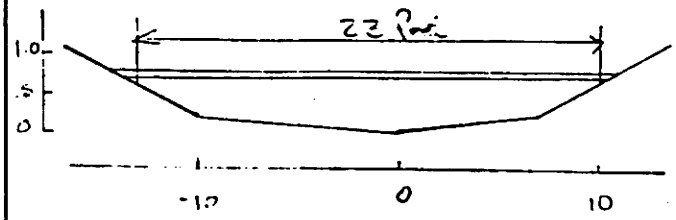


VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

COMPUTED ___ CLIENT ___
CHECKED ___ PROJECT ___
DATE ___ FEATURE ___

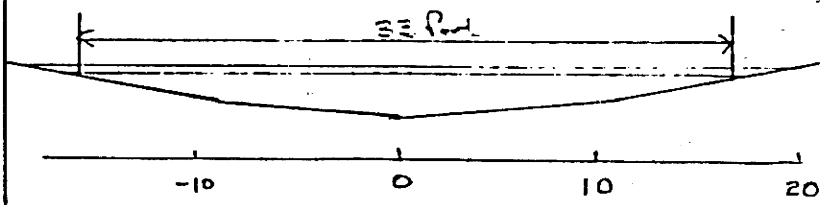
Section (5) S = .014 $Q = \frac{4.44\ A^{5/3}}{P^{2/3}}$

Depth	A	P	Q
.8	14.2	25	43.3
.7	11.7	24	32.2
.65			



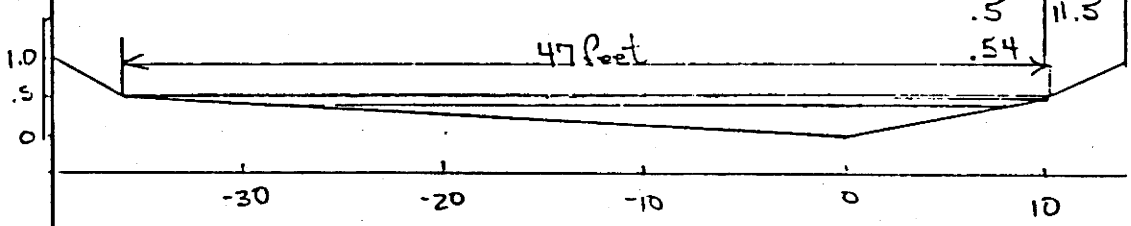
Section (6) S = .013 $Q = \frac{4.28\ A^{5/3}}{P^{2/3}}$

Depth	A	P	Q
.7	16.1	38	38.9
.6	12.5	34	27.5
.59			



Section (7) S = .014 $Q = \frac{4.44\ A^{5/3}}{P^{2/3}}$

Depth	A	P	Q
.4	7.4	37	11.3
.5	11.5	46	20.3
.54			



APPENDIX D

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

SUBJECT _____ CLIENT _____
CHECKED _____ PROJECT _____
DATE _____ FEATURE _____

100 yr. Flow (6 and 24 hr) for Mud Creek
Results Includes Cr. Jos
[illegible]

Duration of Storm	Area (mi²)	CN	l (ft)	Y (%)	Computed Tp (hrs)	Hyd. Family No.	Precip. (in/mo)	Runoff (in/mos)	To (hours)	To/Tp Computed	To/Tp Used	Tp (used) (hrs)	484 AQ / Tp (used)	Flow (cfs)
6 hr.	16.19	52	35,400	37.8	2.22	5	2.3	0.0174	2.3.	1.04	1	2.22	61.42	52.1
24 hr	16.19	40	35,100	37.8	3.04	5	3.6	0.031	9.6	3.16	3	3.20	75.91	38.6

of these, the 100 yr, 6-hr flood is largest with a flow = 52.1 cfs

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

COMPUTED [illegible] CLIENT [illegible]
CHECKED [illegible] PROJECT [illegible]
DATE [illegible] FEATURE [illegible]

Area of Drainage Basin of [illegible] Creek
[illegible]

Subbasin average

Area = 7870 acres

Length of 400' contours = 321,500

Turn-Bruce subbasin

Area = 150 acres

Length of 400' contours = 7450 l.f.

Cardiera Hamann subbasin

Area = 2340 acres

Length of 400' contours = 100,600 l.f.

Total Area = 7870 + 150 + 2340 = 10,360 acres = 16.19 mi²

Average Slope = (Linear Feet of 400' contours)(400')
Area (ft²)

= (422,000)(400) / (16.19)(5280)(5280) = 37.8 %

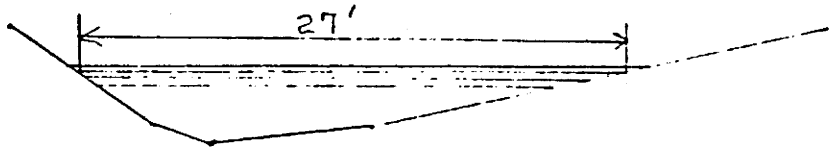
APPENDIX E

Hydraulic Calculations of Flows Through Section on the Cross-Drainage Culvert Channel

Q from estimate for a 100 year flood is 75 cfs. Manning n is assumed to be 0.040

$$Q = \frac{1.5}{n} \frac{A^{5/3} S^{1/2}}{P^{2/3}}$$

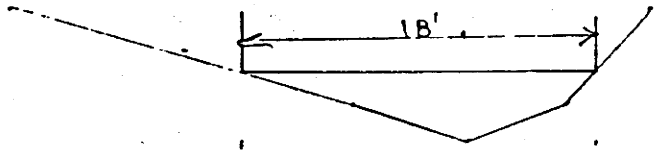
Section (1)



Depth	A	P	Q
1.5	14.7	22	35.1
1.7	19.5	25.5	51.0
2.0	28.5	30	86.2
1.9			←

S = .0069 $Q = \frac{3.13 A^{5/3}}{P^{2/3}}$

Section (2) S = 0.016 $Q = \frac{4.69 A^{5/3}}{P^{2/3}}$

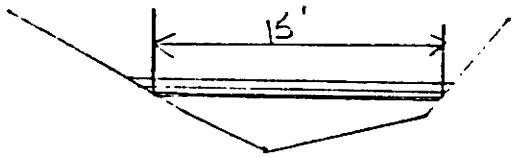


Depth	A	P	Q
1.8	17.1	18	77.5
1.79			←

VAUGHN HANSEN ASSOCIATES
CONSULTANTS/ENGINEERS

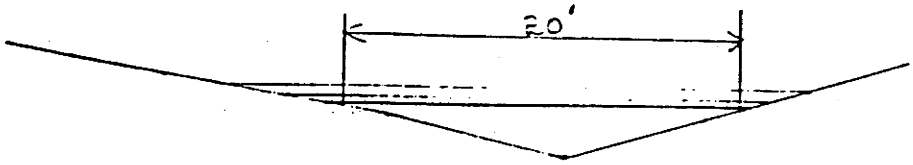
CLIENT
CHECKED
PROJECT
DATE
FEATURE

Section 3 $S = .024$ $Q = \frac{7.31\ A^{5/3}}{P^{2/3}}$



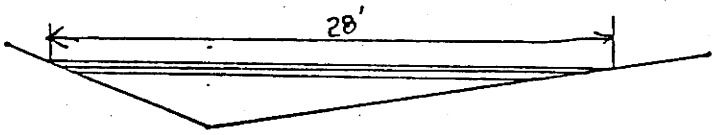
Depth	A	P	Q
1.8	17.4	17	129
1.6	14.2	16	95.9
1.4	11.2	15	67.4
1.48			←

Section 4 $S = .010$ $Q = \frac{3.75\ A^{5/3}}{P^{2/3}}$



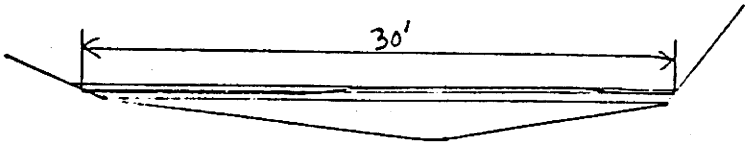
Depth	A	P	Q
1.8	34	30	139
1.5	25.9	25	99
1.3	21.5	22	79.4
1.23			←

Section 5 $S = .011$ $Q = \frac{3.93\ A^{5/3}}{P^{2/3}}$



Depth	A	P	Q
1.2	13.3	24	34.7
1.4	18.1	27.5	53.8
1.55	22.2	29.5	72
1.6			←

Section 6 $S = .015$ $Q = \frac{4.62\ A^{5/3}}{P^{2/3}}$



Depth	A	P	Q
1.0	14	29	39.8
1.4	25.6	32	101.9
1.3	22.6	31	84.6
1.25			←

U.S. FOREST SERVICE
MANTI LA SAL FOREST
DENNIS KELLY DATA FILES

MUD CREEK

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SELECTED HYDROLOGIC DATA, PRICE RIVER BASIN, UTAH, WATER YEARS 1979 AND 1980

by K. M. Waddell, J. E. Dodge, D. W. Darby, and S. M. Theobald

---

U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 82-916

Prepared in cooperation with the

U.S. BUREAU OF LAND MANAGEMENT

Salt Lake City, Utah
1982

Table 10.--Discharge and specific conductance of water at seepage study sites--Continued

Stream	Site No. (see pl. 1)	Date	Discharge (ft^3/s)	Specific conductance (µmho/cm at 25°C)
		Mud Creek basin--Continued		
Whiskey Canyon	27	10-11-79	0.53	--
		9- 5-80	.25	--
Eccles Canyon	28	10-11-79	.93	320
		9- 5-80	1.7	495
	30	10-11-79	1.0	475
		9- 5-80	2.1	490
Mud Creek	31	10-12-79	2.5	495
		9- 5-80	4.1	510
Green Canyon	32	10-12-79	.02	490
		9- 5-80	0	--
Mud Creek	33	10-12-79	2.4	--
		9- 5-80	4.7	500
	34	10-12-79	2.7	500
		9- 5-80	4.6	475
Winter Quarters Canyon	35	10-12-79	.30	580
		9- 5-80	.51	600
		Soldier Creek drainage basin		
Soldier Creek	38	10-10-79	.20	880
		9- 4-80	.57	910
	39	10-10-79	.20	800
		9- 4-80	.61	870
Unnamed	40	10-10-79	.18	830
		9- 4-80	.27	720
	41	10-10-79	.01	700
		9- 5-80	.04	610
Soldier Creek	42	10-10-79	.43	830
		9- 5-80	.92	800
Pine Canyon	43	10-10-79	.02	590
		9- 4-80	.03	580
	44	10-10-79	.01	540
		9- 4-80	.04	480
Unnamed	45	10-10-79	.02	530
		9- 4-80	.03	510
Pine Canyon	46	10-10-79	.02	530
		9- 4-80	.05	435
		10-11-80	.07	500

OPEN FILE REPORT 82-916

Table 12.--Nutrient analyses of

Site No: See plate 1.
Specific conductance: Field measurements.
pH: Field measurements.

Stream	Site No.	Date of sample	Specific conductance (µmhos/cm at 25°C)	pH (units)	Dissolved solids, sum of constituents	Nitrogen, $NO_2 + NO_3$ (as N) Dissolved	Nitrogen, $NO_2 + NO_3$ (as N) Total	Nitrogen, nitrate (as N) Dissolved	Nitrogen, nitrate (as N) Total
Gooseberry Creek	1	7-20-79	265	7.8	148	0.19	-	-	-
		7-30-80	210	-	95	.00	0.00	0.00	0.00
Fish Creek	2	7-18-79	335	8.3	191	.11	-	-	-
		11-15-79	360	-	202	.03	.03	.03	.03
		12-13-79	405	-	-	.17	.19	.16	.17
		2-21-80	425	-	-	.22	.28	.21	.27
		4-24-80	330	-	-	.32	.32	.29	.31
		5-28-80	330	-	189	.46	.46	.46	.46
		7-15-80	330	-	189	.05	.05	.04	.04
		8-20-80	330	-	192	.00	.00	.00	.00
		10- 8-80	300	-	-	-	-	-	-
Pondtown Creek	3	7-18-79	420	8.2	246	.10	-	-	-
		7-29-80	420	-	-	.00	.00	.00	.00
	4	7-18-79	415	8.3	244	.09	-	-	-
		11-15-79	550	-	347	.05	.05	.04	.00
		12-13-79	530	-	-	-	.06	-	.04
		2- 6-80	440	-	-	.11	.12	.11	.11
		4-24-80	320	-	190	.46	.46	.43	.46
		5- 7-80	305	-	177	.73	.73	.72	.73
		5-27-80	345	-	200	.52	.52	.51	.51
		7-15-80	425	-	251	.01	.05	.01	.04
		8-20-80	430	-	246	.00	.00	.00	.00
Mud Creek	5	7-17-79	295	8.2	159	.01	-	-	-
		7-30-80	330	-	190	.00	.00	.00	.00
		9- 5-80	405	-	233	.00	-	-	-
	8	9- 5-80	415	-	231	.00	-	-	-
	11	9- 5-80	580	-	346	.03	-	-	-
	13	9- 5-80	500	-	286	.00	-	-	-
	16	9- 5-80	530	-	301	.00	-	-	-
	18	7-17-79	465	8.1	262	.02	-	-	-
		7-30-80	460	-	236	.00	.00	.00	.00
	19	9- 5-80	530	-	306	.00	-	-	-
Eccles Canyon	20	7-17-79	455	8.2	258	.98	-	-	-
		7-29-80	430	-	236	1.1	1.0	1.1	1.1
	24	9- 5-80	550	-	271	.49	-	-	-
	26	9- 5-80	520	-	268	.00	-	-	-
	29	7-17-79	460	8.3	275	.02	-	-	-
		12-12-79	560	8.1	312	.14	-	.14	-
		3- 4-80	570	8.0	325	.16	-	.16	-
		4-23-80	460	-	280	.78	.78	.76	.76
		5- 8-80	315	-	180	1.2	1.2	1.2	1.2
		5-22-80	285	-	161	1.2	1.2	1.2	1.2
		6-26-80	365	8.6	209	.21	-	.20	-
		7-16-80	465	-	271	.20	.20	.19	.19
		8-18-80	490	-	283	.00	.01	.00	.01
Mud Creek	30	9- 5-80	495	-	280	.23	-	-	-
	31	9- 5-80	520	-	298	.13	-	-	-
	33	9- 5-80	510	-	286	.00	-	-	-
	34	3-17-79	570	8.1	354	.16	-	.15	-
	35	12- 9-78	620	8.3	357	.13	-	.12	-
		6-14-79	320	8.1	171	.27	-	.26	-
		9-13-79	530	8.5	314	.01	-	.00	-
	36	11-16-79	610	-	391	.05	.05	.04	.04
		12-12-79	650	8.1	388	.12	-	.12	-
		12-14-79	620	-	-	.14	.22	.13	.21
		2- 6-80	580	-	-	.15	.16	.14	.15
		3- 4-80	590	8.2	342	.13	-	.13	-
		4-23-80	455	-	-	.63	.63	.60	.62
		5-28-80	335	-	192	.66	.67	.66	.66
		6-26-80	340	8.4	190	.09	-	.08	-
		7-16-80	445	-	254	.06	.08	.05	.07
		8-18-80	500	-	279	.00	.00	.00	.00
		10-16-80	560	8.3	338	.00	-	-	-
Price River	37	11-15-79	300	-	160	.10	.11	.09	.10
		12-14-79	310	-	-	.17	.17	.16	.16
		2- 6-80	335	-	-	.15	.15	.14	.14
		4-23-80	315	-	184	.36	.36	.32	.32
		5-28-80	300	-	168	.15	.15	.14	.14
		7-15-80	315	-	180	.08	.09	.07	.08
		8-20-80	290	-	168	.00	.00	.00	.00

SITE 19-3b
OPEN FILE REPORT 82-916
U.S. GEOLOGICAL SURVEY

Milligrams per liter											
Nitrogen, nitrite (as N)		Nitrogen, ammonia plus organic (as N)		Nitrogen, ammonia (as N)		Nitrogen, organic (as N)		Phosphorus, (as P)		Phosphorus, orthophosphate (as P)	
Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
-	-	-	-	-	-	-	-	0.030	0.030	-	-
0.00	0.00	0.34	0.35	0.04	0.04	0.30	0.31	.010	.010	0.00	0.00
-	-	-	-	-	-	-	-	.010	-	-	-
.00	.00	.31	.32	.02	.02	.29	.30	.000	.000	.00	.00
.01	.02	1.1	1.2	.00	.06	1.1	1.1	.010	.010	.00	.01
.01	.01	.15	.29	.06	.06	.09	.23	.000	.010	.00	.00
.03	.03	.72	.80	.00	.08	.72	.72	.010	.050	.00	.00
.00	.00	.25	.62	.01	.01	.24	.61	.010	.050	.04	.04
.01	.01	.69	.70	.05	.06	.64	.64	.030	.120	.00	.02
.00	.00	.45	.46	.02	.03	.43	.43	.000	.010	.00	.01
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	.030	-	-	-
.00	.00	.30	.38	.03	.02	.27	.36	.010	.050	.00	.01
-	-	-	-	-	-	-	-	.020	-	-	-
.01	.01	.51	.51	.03	.03	.48	.48	.000	.020	.01	.01
-	.01	-	.97	-	.02	-	.95	-	.010	-	.01
.00	.01	.02	.13	.03	.03	.00	.10	.000	.000	.00	.00
.03	.03	.78	1.2	.06	.08	.72	1.1	.010	.210	.01	.01
.01	.01	.57	1.0	.01	.07	.56	.93	.030	.150	.03	.03
.01	.01	.63	.95	.04	.04	.59	.91	.020	.200	.05	.06
.00	.01	.52	.57	.05	.05	.47	.52	.040	.050	.02	.02
.00	.00	.44	.46	.06	.06	.38	.40	.010	.040	.00	.02
-	-	-	-	-	-	-	-	.030	-	-	-
.00	.00	.34	.59	.04	.03	.30	.56	.020	.030	.00	.01
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	.010	-	-	-
.00	.00	.21	.26	.03	.05	.18	.21	.010	.040	.00	.01
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	2.700	-	-	-
.00	.00	.91	1.8	.04	.04	.87	1.8	.010	.010	.01	.01
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	.010	-	-	-
.00	-	.27	.36	.04	-	.23	-	-	.010	.01	-
.00	-	.00	.35	.00	-	.00	-	-	.070	.01	-
.02	.02	1.0	3.2	.07	.07	.93	3.1	.050	1.600	.10	.33
.01	.01	1.2	1.3	.01	.03	1.2	1.3	.030	.400	.02	.05
.01	.02	2.2	20	.01	.07	2.2	20	.040	4.300	.04	.15
.01	-	.46	.64	.03	-	.43	-	-	.390	.01	-
.01	.01	.71	.96	.03	.03	.68	.93	.020	.040	.03	.03
.00	.00	.24	.33	.02	.03	.22	.30	.010	.020	.00	.01
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
.01	-	.15	.33	.00	-	.15	-	.020	.010	.00	-
.01	-	.18	.50	.00	-	.37	-	-	.110	.00	-
.01	-	.37	.62	.00	-	.60	-	-	.020	.01	-
.01	-	.60	.20	.01	-	.17	-	.020	.030	.00	-
.01	.01	1.2	1.2	.11	.11	1.1	1.1	.010	.010	.01	.01
.00	-	.43	.52	.06	-	.37	-	-	.010	.01	-
.01	.01	.90	1.0	.03	.03	.87	.97	.010	.040	.01	.03
.01	.01	.18	.26	.01	.03	.17	.23	.000	.030	.00	.00
.00	-	.62	.65	.00	-	.62	-	-	.050	.03	-
.03	.03	1.2	1.2	.08	.17	1.1	1.1	.020	.230	.03	.03
.00	.01	.27	.54	.03	.03	.24	.51	.030	.090	.03	.05
.01	-	.44	.91	.03	-	.41	-	-	.080	.03	-
.01	.01	.60	1.3	.01	.03	.59	1.3	.040	.050	.00	.01
.00	.00	.29	.29	.03	.03	.26	.26	.010	.020	.00	.01
-	-	.39	.65	-	.00	-	.65	.050	.270	-	-
.01	.01	.73	.80	.15	.22	.58	.58	.010	.010	.00	.01
.01	.01	1.3	1.3	.19	.19	1.1	1.1	.010	.030	.01	.01
.01	.02	2.0	2.1	.28	.39	1.7	1.7	.000	.010	.00	.01
.04	.04	.81	.84	.20	.22	.61	.62	.010	.030	.00	.01
.01	.01	.78	1.1	.09	.10	.69	1.0	.010	.030	.03	.04
.01	.01	.21	.90	.11	.11	.10	.79	.050	.050	.02	.02
.00	.00	.34	.58	.03	.15	.31	.43	.000	.030	.00	.01

Table 13.--Discharge, specific conductance, and temperature of water from selected stream sites

Site No.: See plate 1.
Time: Military.
Discharge: Instantaneous except for Price River (site 37), which is daily mean from October 25, 1979, to September 12, 1980.
Specific conductance: Field measurements.

Stream	Site No.	Date	Time	Discharge (ft^3/s)	Specific conductance (µmho/cm at 25°C)	Temperature (°C)
Fish Creek	2	10-25-79	1345	10	325	5.5
		6- 4-80	1200	549	315	7.5
		6- 6-80	1010	659	305	6.0
		6-17-80	1700	265	325	15.5
		6-25-80	1415	111	360	14.5
Pondtown Creek	4	5-18-79	--	33	400	6.0
		7-19-79	--	1.3	380	20.0
		9-19-79	--	.3	--	12.0
		10-24-79	--	1.3	450	8.0
		10-25-79	--	1.3	455	9.0
		5-13-80	2235	32	--	--
		5-14-80	1320	26	--	--
		5-20-80	1440	44	--	--
		5-20-80	2220	62	--	--
		5-22-80	2235	99	--	--
		5-28-80	1300	44	340	8.0
		6- 4-80	1415	50	335	10.5
		6- 6-80	1025	55	325	5.5
		6-11-80	1930	29	350	15.0
		6-17-80	--	15	380	15.5
		6-25-80	1235	9.3	405	12.5
		7-20-80	--	2.8	425	15.5
		7-29-80	1000	1.5	430	15.5
Eccles Canyon	29	5- 1-80	1445	46	445	4.5
		5-12-80	1740	7.2	--	--
		5-14-80	1515	7.2	--	--
		5-15-80	--	4.8	--	--
		5-27-80	1850	17	325	4.5
		5-28-80	1330	13	325	7.5
		6- 4-80	1010	23	290	4.5
		6- 4-80	1730	22	240	6.5
		6- 6-80	0935	26	265	4.0
		6-13-80	1215	32	275	6.5
		6-17-80	1545	24	295	11.0
		6-25-80	1720	11	295	14.0
		9-12-80	1215	1.8	505	8.5

OPEN FILE REPORT 82-916
U.S. GEOLOGICAL SURVEY

Table 13.--Discharge, specific conductance, and temperature of water from selected stream sites--Continued

Stream	Site No.	Date	Time	Discharge (ft^3/s)	Specific conductance (µmho/cm at 25°C)	Temperature (°C)
Mud Creek	36	7-18-79	--	22	325	19.5
		10-25-79	1710	3.8	520	9.5
		12-14-79	0930	2.8	620	0.0
		5- 1-80	1330	30	410	6.0
		6- 4-80	0915	115	270	4.0
		6- 6-80	0950	135	260	4.5
		6-17-80	1610	79	290	12.5
		6-25-80	1700	46	325	16.0
Price River	37	5-18-79	--	2.1	400	8.0
		6-22-79	1000	1.3	320	14.5
		10-25-79	--	7.2	270	10.0
		12-14-79	--	6.0	310	4.0
		3-25-80	--	11	325	4.0
		6- 4-80	0950	645	295	9.5
		6- 5-80	0840	651	320	12.0
		6- 6-80	0840	682	320	11.0
		6- 6-80	0900	682	315	10.5
		6- 7-80	0820	694	320	10.0
		6- 8-80	0820	694	320	12.0
		6- 9-80	0915	682	325	10.0
		6-10-80	0825	682	325	12.0
		6-11-80	0820	669	325	12.0
		6-12-80	1225	651	325	14.0
		6-13-80	0815	639	325	14.0
		6-13-80	1425	639	310	12.0
		6-14-80	0740	603	325	11.0
		6-15-80	1030	574	325	15.0
		6-16-80	0945	538	330	12.0
		6-17-80	0845	491	325	14.0
		6-17-80	1250	491	310	13.0
		6-18-80	0835	395	330	14.0
		6-19-80	0815	374	330	16.0
		6-20-80	0800	279	330	14.0
		6-21-80	0815	271	330	14.0
		6-22-80	0810	257	330	14.0
		6-23-80	0735	225	325	15.0
		6-24-80	0840	215	330	15.0
		6-25-80	0820	201	330	16.0
		6-25-80	0845	201	320	12.5
		6-26-80	0815	192	330	15.0
		6-27-80	0820	186	330	15.0
		6-28-80	0815	185	335	14.0
		6-29-80	0810	203	335	17.0
		6-30-80	0825	195	330	17.0

Site No.: See plate 1.
Specific conductance: Field measurements.
pH: Field measurements.

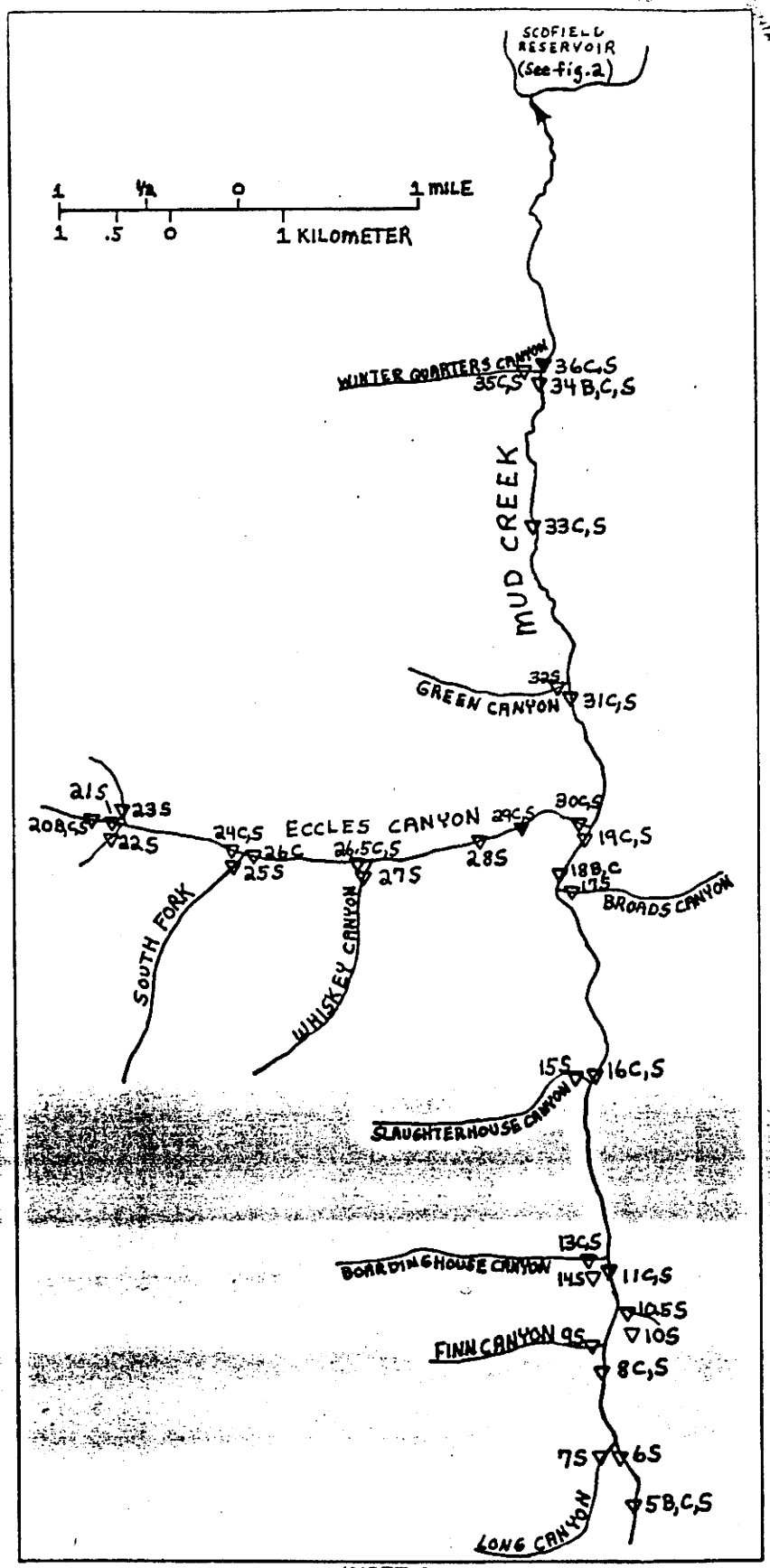
Table 11.—Inorganic chemical analyses of major ions

Stream	Site No.	Date of sample	Temperature (°C)	Discharge (ft^3/s)	Specific conductance (µmhos/cm at 25°C)	pH (units)	Dissolved solids, sum of constituents (Milligrams)	Dissolved silica (as SiO_2) (Milligrams)	Dissolved calcium (as Ca) (Milligrams)	Dissolved magnesium (as Mg) (Milligrams)	Dissolved sodium (as Na) (Milligrams)
Gooseberry Creek	1	7-20-79	20.0	9.3	265	7.8	148	2.2	39	11	1.9
		7-30-80	21.5	9.2	210	-	95	1.2	21	9.1	.8
Fish Creek	2	11-16-78	.0	10	540	-	-	-	-	-	-
		4- 3-79	.0	7.8	420	-	-	-	-	-	-
		5-18-79	3.5	393	300	-	-	-	-	-	-
		6-12-79	18.0	131	360	-	-	-	-	-	-
		7-18-79	19.5	22	335	8.3	191	4.7	55	12	2.9
		8-16-79	10.5	15	330	-	-	-	-	-	-
		9-19-79	13.0	8.0	320	-	-	-	-	-	-
		10-18-79	8.0	8.0	300	-	-	-	-	-	-
		11-15-79	1.0	10	360	-	202	4.6	57	14	2.4
		12-13-79	.0	12	415	-	-	-	-	-	-
		2- 6-80	.0	10	390	-	-	-	-	-	-
		2-21-80	3.5	9.6	425	-	-	-	-	-	-
		4-24-80	7.0	84	330	-	-	-	-	-	-
		5-28-80	6.0	413	330	-	189	4.6	60	9.2	1.9
		5-29-80	11.0	468	300	-	-	-	-	-	-
		6-19-80	12.5	227	330	-	-	-	-	-	-
		7-15-80	18.5	39	330	-	189	4.1	52	12	2.5
		8-14-80	18.0	18	310	-	-	-	-	-	-
		8-20-80	8.5	14	330	-	192	4.6	49	12	2.6
		10- 8-80	14.0	12	300	-	-	-	-	-	-
Pondtown Creek	3	7-18-79	14.5	1.4	420	8.2	246	5.8	66	13	3.9
	4	7-18-79	20.0	1.3	415	8.3	244	6.1	68	13	4.3
		11-15-79	2.5	.64	550	-	347	6.7	94	18	6.1
		12-13-79	.0	.72	530	-	-	-	-	-	-
		2- 6-80	.0	.91	440	-	-	-	-	-	-
		4-24-80	.5	13	320	-	190	5.0	56	9.1	3.2
		5- 7-80	-	43	305	-	177	5.1	53	7.6	2.6
		5-27-80	8.0	52	345	-	200	5.5	63	8.7	2.6
		7-15-80	19.5	3.2	425	-	251	5.6	70	13	4.0
		8-20-80	14.0	.14	430	-	246	5.5	67	13	4.4
Mud Creek	5	7-17-79	13.0	2.1	295	8.2	159	3.7	43	10	1.9
		7-30-80	12.0	.83	330	-	190	4.2	52	12	2.2
		9- 5-80	6.0	.45	405	-	233	5.1	61	16	3.1
	8	9- 5-80	6.5	.39	415	-	231	4.9	60	16	2.8
	11	9- 5-80	7.0	.98	580	-	346	6.6	81	27	4.9
	13	9- 5-80	7.5	1.2	500	-	286	5.9	70	24	3.3
	16	9- 5-80	5.5	2.0	530	-	301	6.3	74	25	4.4
	18	7-17-79	15.0	2.8	465	8.1	262	5.2	63	19	4.2
		7-30-80	17.5	3.4	460	-	236	5.6	67	21	4.0
	19	9- 5-80	6.0	2.4	530	-	306	6.4	71	26	5.0
Eccles Canyon	20	7-17-79	13.0	-	455	8.3	258	5.8	75	13	3.5
		7-29-80	10.0	.26	430	-	236	4.7	73	13	2.8
		9- 5-80	10.0	.12	480	-	257	6.4	72	14	3.2
	24	9- 5-80	10.0	.31	550	-	271	6.9	72	19	4.3
	26.5	9- 5-80	11.0	1.1	520	-	268	6.4	67	20	3.3
	29	7-17-79	14.0	2.7	460	8.3	275	6.2	67	21	3.5
		10-12-79	7.0	.96	510	8.5	364	6.2	81	29	3.7
		11- 9-79	3.0	.95	550	8.0	330	6.3	79	27	4.1
		12-12-79	1.0	1.0	560	8.1	312	7.0	79	27	4.8
		1-15-80	3.0	1.0	520	8.0	302	6.5	74	24	3.5
		2- 5-80	2.0	1.0	550	8.2	322	6.8	77	28	3.5
		3- 4-80	3.0	.82	570	8.0	325	6.8	73	25	9.0
		4- 8-80	3.0	1.0	560	8.1	343	7.4	77	26	5.7
		4-23-80	4.5	4.0	460	-	280	7.0	71	19	6.9
		5- 8-80	4.5	16	315	-	180	5.3	50	11	2.8
		5-21-80	5.0	21	330	8.3	189	5.5	50	11	2.6
		5-22-80	-	29	285	-	161	5.1	43	9.4	2.7
		6-26-80	12.0	8.3	365	8.6	209	5.7	57	13	2.5
		7-10-80	11.5	4.0	430	8.6	253	5.5	62	17	3.0
		7-16-80	14.5	2.9	465	-	271	5.8	68	19	9.5
		8-15-80	12.0	1.7	500	8.5	269	6.7	67	22	3.8
		8-18-80	12.0	1.3	490	-	283	10	69	24	4.0
		9-19-80	10.0	2.2	510	7.9	288	7.0	69	26	4.0
Mud Creek	30	9- 5-80	10.5	2.2	495	-	280	6.6	64	25	4.4
	31	9- 5-80	6.0	4.2	520	-	298	6.5	68	26	4.9
	33	9- 5-80	7.0	4.7	510	-	286	6.4	66	26	4.8
	34	7-17-79	18.5	3.6	473	8.2	273	6.6	67	21	4.7
		9- 5-80	8.0	4.6	485	-	281	6.0	61	25	5.0
	35	10-17-78	9.5	2.7	520	8.5	310	6.4	72	26	5.8
		11-14-78	-	4.9	590	8.4	329	6.6	76	26	6.5
		12- 9-78	.0	3.4	620	8.3	357	7.1	86	28	6.2
	36	1-17-79	.0	3.1	580	8.3	330	7.3	77	25	5.7
		2-20-79	.0	3.0	600	8.1	342	7.7	84	26	5.3

SITES 19-32 - SURFACE WATER SITE PLATE
OPEN FILE REPORT 82-916
U.S. GEOLOGICAL SURVEY

and trace metals in water from selected stream sites

per liter					Micrograms per liter							
Dissolved potassium (as K)	Alkalinity (as $CaCO_3$)	Dissolved sulfate (as SO4)	Dissolved chloride (as Cl)	Dissolved fluoride (as F)	Dissolved arsenic (as As)	Dissolved boron (as B)	Dissolved copper (as Cu)	Dissolved iron (as Fe)	Dissolved lead (as Pb)	Dissolved mercury (as Hg)	Dissolved selenium (as Se)	Dissolved zinc (as Zn)
0.1	133	11	1.6	0.1	1	10	-	0	0	0.0	0	<3
.2	92	5.5	1.3	.1	-	0	-	40	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
.6	160	15	2.9	.2	-	10	-	160	-	.0	0	10
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
.8	170	17	3.4	.1	1	10	1	20	3	-	0	<3
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	0	20	<10	-	13	-	0	4
-	-	-	-	-	0	-	2	-	2	.0	0	10
.6	170	5.8	2.2	.1	1	30	3	10	0	.0	0	<3
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
.7	170	11	2.5	1.3	1	30	1	20	0	.0	0	<3
-	-	-	-	-	-	-	-	-	-	-	-	-
.8	160	23	3.9	.1	1	0	0	30	0	.0	0	<3
-	-	-	-	-	-	-	-	-	-	-	-	-
2.2	217	18	5.2	.3	1	20	-	420	45	.0	0	10
1.2	208	19	6.1	.2	1	30	-	450	-	.0	0	10
1.4	260	55	8.7	.1	0	20	0	10	12	-	0	4
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	0	20	<10	-	21	-	0	<3
1.0	150	18	5.5	.3	0	30	1	10	3	.0	0	<3
1.0	150	11	3.5	.1	1	6	2	20	1	.0	0	<3
.7	170	9.6	4.8	.1	1	20	4	20	0	.0	0	4
1.2	220	18	6.1	.3	1	40	1	40	0	.0	0	440
1.1	210	21	7.9	.2	1	8	0	10	0	.0	0	<3
.6	139	14	2.0	.1	0	20	-	0	79	.0	0	9
.6	170	14	2.5	.1	-	20	-	20	-	-	-	-
.7	200	23	3.4	.1	-	-	-	-	-	-	-	-
.9	200	22	3.8	.2	-	-	-	-	-	-	-	-
2.2	270	56	5.5	.2	-	-	-	-	-	-	-	-
1.6	240	33	3.9	.2	-	-	-	-	-	-	-	-
1.8	230	45	5.9	.2	-	-	-	-	-	-	-	-
1.7	212	35	5.9	.2	1	40	-	20	-	.0	0	30
1.6	160	34	6.0	.1	-	30	-	10	-	-	-	-
2.1	240	44	7.0	.2	-	-	-	-	-	-	-	-
1.1	-	18	3.2	.2	1	20	-	10	45	.0	0	10
1.0	200	13	3.1	.2	-	30	-	40	-	-	-	-
1.3	230	14	3.1	.2	-	-	-	-	-	-	-	-
1.8	230	22	4.5	.2	-	-	-	-	-	-	-	-
2.0	230	27	4.2	.2	-	-	-	-	-	-	-	-
1.7	230	32	4.5	.1	0	30	-	10	-	.0	0	10
2.6	240	94	4.6	-	-	-	-	-	-	-	-	-
2.2	270	44	4.5	-	-	-	-	-	-	-	-	-
2.4	240	43	4.5	.2	1	30	-	10	0	-	0	5
2.3	250	39	4.7	-	-	-	-	-	-	-	-	-
2.3	260	42	4.8	-	-	-	-	-	-	-	-	-
2.1	250	40	15	.2	1	30	-	<10	0	-	0	<3
2.3	280	45	12	-	-	-	-	-	-	-	-	-
2.1	200	35	15	.2	0	40	9	50	5	.0	0	10
1.3	140	16	3.9	.1	0	8	4	40	1	.0	0	<3
1.3	170	16	3.8	-	-	-	-	-	-	-	-	-
1.3	130	13	3.2	.2	1	30	6	30	0	.0	0	4
1.1	179	19	2.0	.1	1	0	-	20	2	-	0	<3
1.6	210	33	4.6	-	-	-	-	-	-	-	-	-
1.8	220	25	7.9	.3	1	40	2	30	0	.0	0	20
2.1	240	37	10	-	-	-	-	-	-	-	-	-
1.9	220	36	5.5	.2	0	20	0	<10	0	.0	0	180
2.7	300	41	6.5	-	-	-	-	-	-	-	-	-
2.1	220	39	5.8	.2	-	-	-	-	-	-	-	-
2.1	230	44	7.1	.2	-	-	-	-	-	-	-	-
2.1	220	42	6.6	.2	-	-	-	-	-	-	-	-
2.1	-	32	6.2	.2	1	40	-	40	-	.0	0	10
2.4	220	-	7.6	.2	-	-	-	-	-	-	-	-
2.7	232	50	7.6	-	-	-	-	-	-	-	-	-
2.8	245	56	8.7	-	-	-	-	-	-	-	-	-
2.8	271	55	8.2	.2	0	60	-	10	30	-	1	10
2.4	254	52	7.5	-	-	-	-	-	-	-	-	-
2.2	250	55	9.0	-	-	-	-	-	-	-	-	-

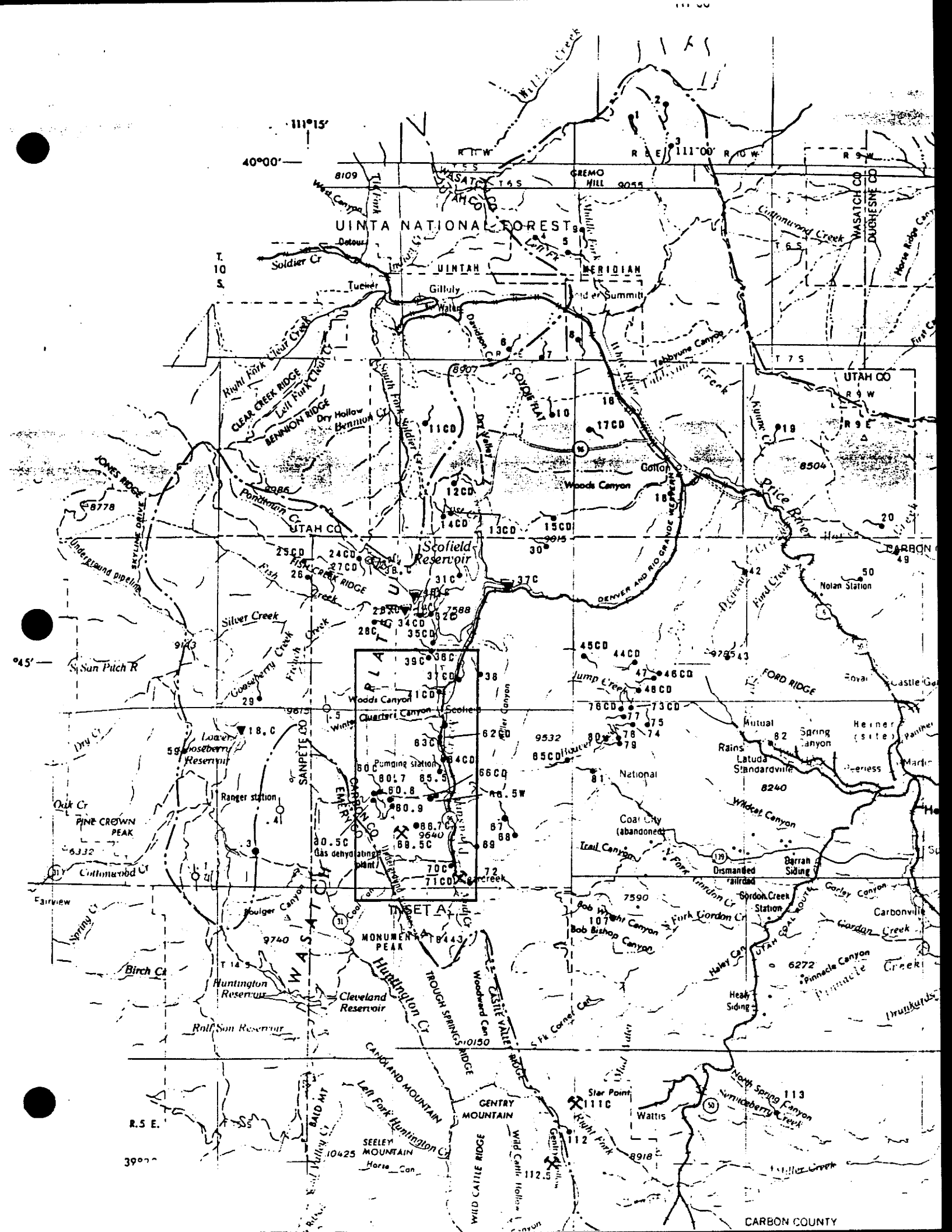


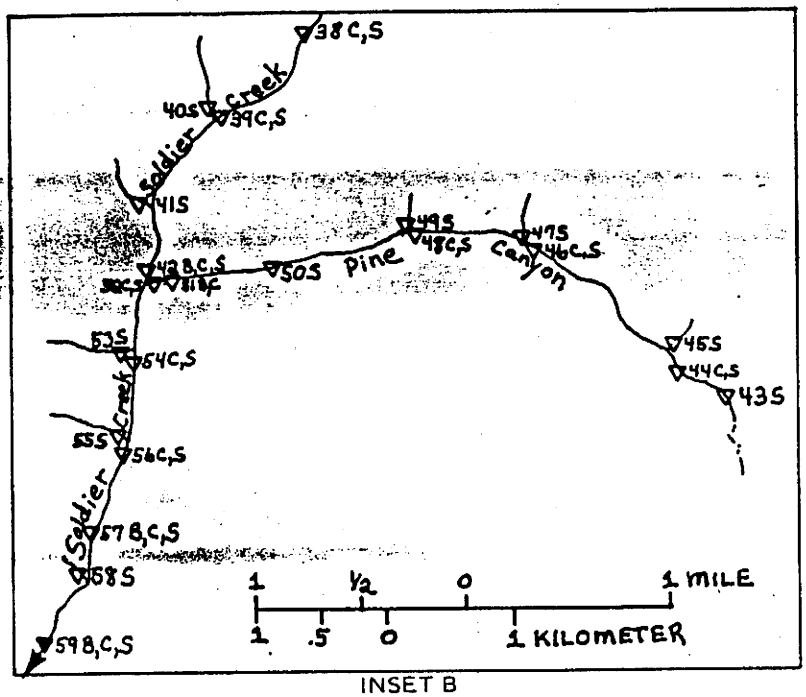
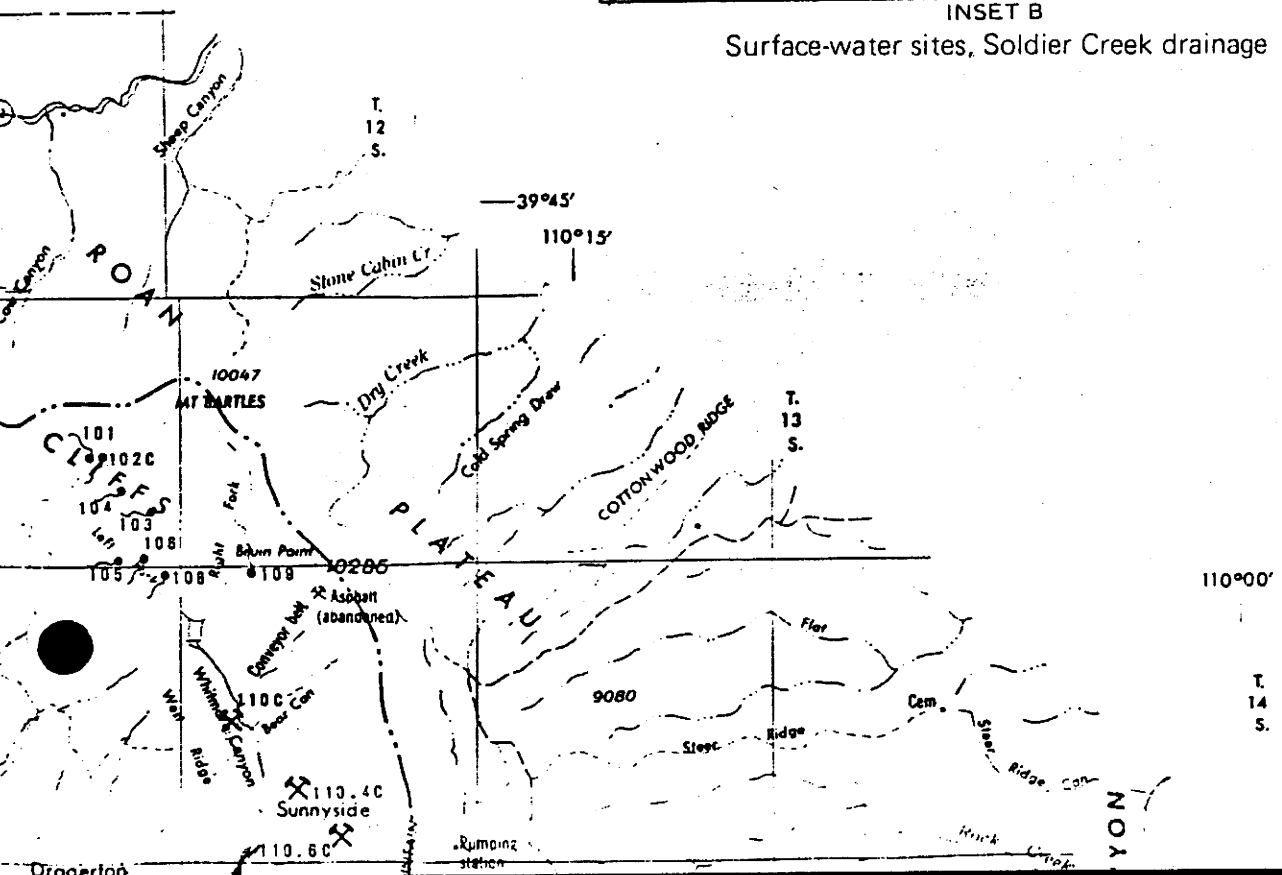
INSET A

Surface-water sites Scofield Reservoir area

Base from U. S. Geological Survey 1:250,000 series Price, Utah (1956) and Salt Lake City, Utah (1954)

MAP SHOWING


111°15'
40°00'
111°00'
UINTA NATIONAL FOREST
WASATCH CO
DUCHESNE CO
UINTAH
MERIDIAN
UTAH CO
CARBON CO
EMERY CO
SANPETE CO
Soldier Cr
Tucker
Gilluly
Summit
Scofield Reservoir
Price River
Nolan Station
Woods Canyon
Quarter Canyon
Scofield
Pumping station
Gas dehydrating plant
Ranger station
Lower Gooseberry Reservoir
PINE CROWN PEAK
Huntington Reservoir
Cleveland Reservoir
Rolf Son Reservoir
MONUMENT PEAK
Huntington Cr
TROUGH SPRING RIDGE
CASTLE VALLEY RIDGE
CANDLAND MOUNTAIN
GENTRY MOUNTAIN
SEELEY MOUNTAIN
WILD CATTLE RIDGE
BALD MT
Star Point
Wattis
Mutual
Spring Canyon
Latuda
Standardville
National
Coal City (abandoned)
Dismantled railroad
Barrah Siding
Gordon Creek Station
Carbonville
Helper (site)
Heady Siding
Pinnacle Canyon
Wildcat Canyon
Trail Canyon
Bob Wright Canyon
Bob Bishop Canyon
Bowlger Canyon
Fairview
Birch Cr
Oak Cr
Cottonwood Cr
Spring Cr
Dry Cr
Silver Creek
Gooseberry Creek
Fish Creek
Ford Creek
Jump Creek
Gordon Creek
Garley Canyon
Pinnacle Creek
North Spring Canyon
Huntington Creek
Cottonwood Creek
Tabbyune Canyon
Price River
Denver and Rio Grande Western
Underground pipeline
SKYLINE DRIVE
JONES RIDGE
CLEAR CREEK RIDGE
BENNION RIDGE
FISH CREEK RIDGE
FORD RIDGE
COYOTE FLAT
Dry Hollow
Bennion Cr
Pondtown Cr
Right Fork Clear Creek
Left Fork Clear Cr
South Fork Soldier Cr
Dry Valley
Kunn Cr
Horse Ridge Canyon
Gordon Cr
Fork Gordon Cr
Haley Canyon
Left Fork Huntington Cr
Wild Cattle Hollow
Horse Can
Rock Valley Cr
Right Fork
Fairview
INSET A
R.5 E.
T 14 S
T 10 S
T 7 S
T 6 S
T 5 S
R 11 W
R 10 W
R 9 W
R 9 E
CARBON COUNTY



INSET B
Surface-water sites, Soldier Creek drainage