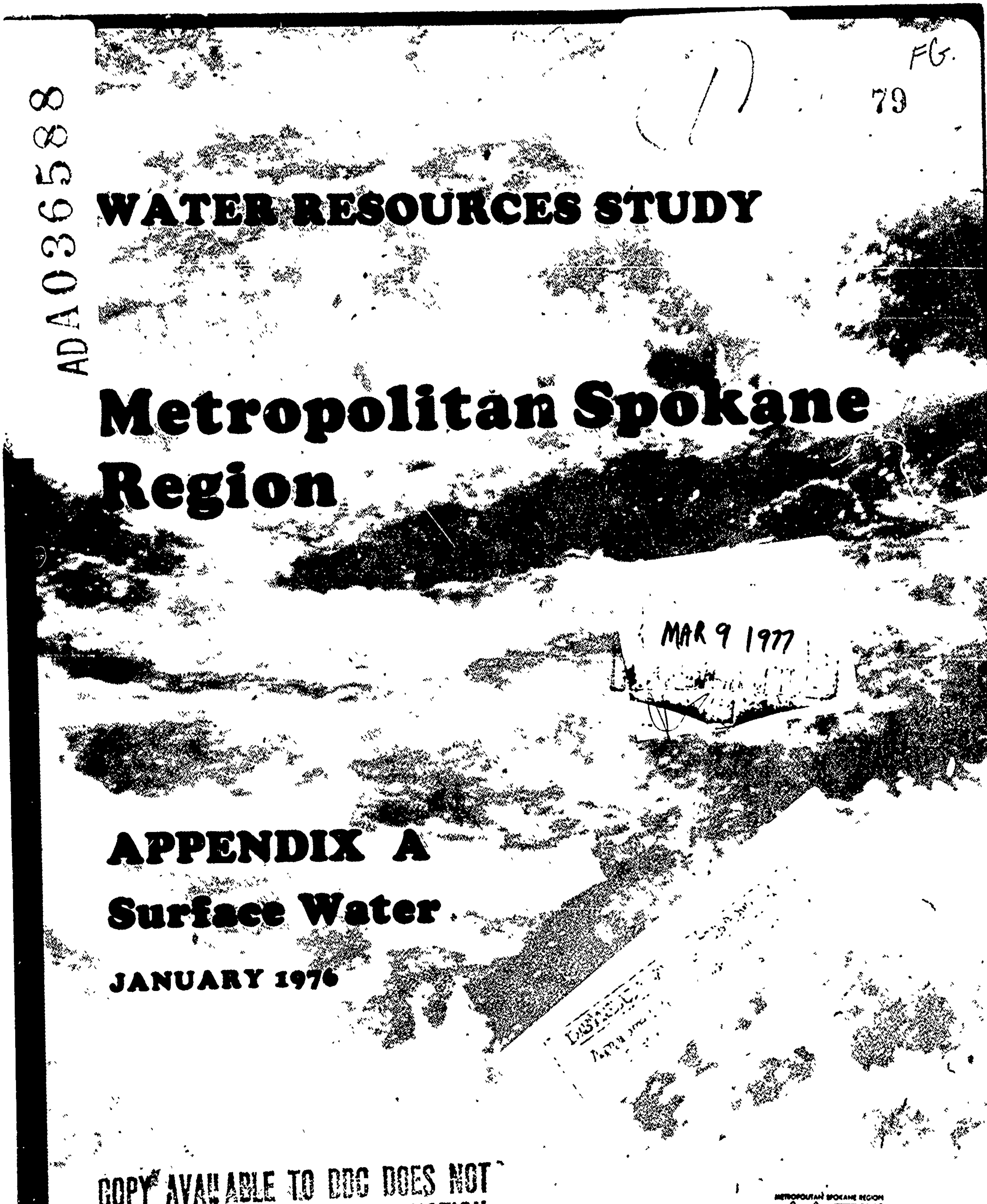

WATER RESOURCES STUDY

Metropolitan Spokane Region

APPENDIX A
Surface Water

JANUARY 1976

METROPOLITAN SPOKANE REGION
MSR WRS
WATER RESOURCES STUDY

LIST OF REPORTS AND APPENDICES

REPORTS

Summary Report

Technical Report

APPENDIX	TITLE
A	**SURFACE WATER**
B	Geology and Groundwater
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METROPOLITAN SPOKANE REGION WATER RESOURCES STUDY.

APPENDIX A

SURFACE WATER.

428 p.

JANUARY 1976

Department of the Army
Corps of Engineers, Seattle District

Kennedy-Tudor Consulting Engineers

410075

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The summary report was prepared by the Seattle District Corps of Engineers. The technical report and appendices were prepared for the Seattle District, Corps of Engineers by Kennedy-Tudor Consulting Engineers.

PREFACE

With the enactment of the Federal Water Pollution Control Act Amendment of 1972 (Public Law 92-500), new national goals have been established for the elimination of pollution discharges into our streams and lakes. This appendix is a part of the report prepared to assist local government in satisfying State and Federal Requirements relating to Public Law 92-500. The suggestions contained in this report are for implementation by local interests with available assistance from other local, State and Federal agencies. The study suggests a regional wastewater management plan for the metropolitan Spokane urban area and provides major input to Washington State Department of Ecology Section 303e plans for the Spokane River Basin in Washington State. Also included in the study are planning suggestions for urban runoff and flood control, and the protection of the area's water supply resources.

As listed on the inside front cover, documentation for this study consists of a Summary Report and a Technical Report with supporting Appendices A through J.

The Technical Report summarizes Appendices A through J, which contain 58 individual task section reports prepared during the study. These task sections are listed by title in Attachment I of the Technical Report. Generally, the numbering of appendix task sections reflects the following system:

Study Task Sections	Type of Study Activity
300's	Data Collection
400's	Data Evaluation and Projection
500's	Identification of Unmet Needs
600's	Development of Alternative Plans
700's	Evaluation Comparison and Selection of Plans
800's	Institutional Arrangements

Pages within each appendix are numbered by task section, as illustrated below:

701.2 - 45

Task section identifier — 701.2

Identifies page number, numbered consecutively from beginning of task section — 45

APPENDIX A - SURFACE WATER

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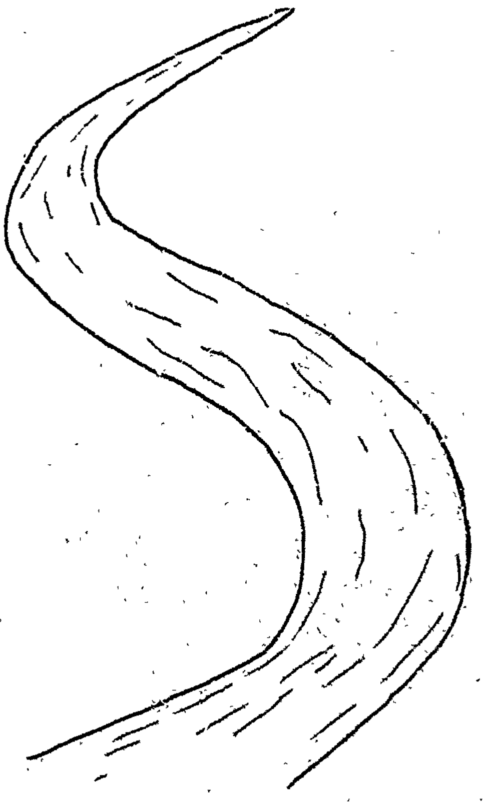
A detailed index for each task section precedes the respective section text.



SECTION 308

SURFACE WATER

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 308

SURFACE WATER

6 March 1974

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

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SURFACE WATER

Introduction

The Study Area represents the downstream portion of the hydrologic basin of the Spokane River and its tributaries. The hydrologic basin covers 6,640 square miles above the mouth of the Spokane River where it empties into the Franklin D. Roosevelt Lake impoundment of the Columbia River. The Study Area, which includes that part of the hydrologic basin that lies in the State of Washington, occupies approximately 2,295 square miles. The remainder of the hydrologic basin, approximately 4,345 square miles in area, is in the State of Idaho. Refer to Plate 308-1. Obviously, the surface water supply of the Study Area is dominated by considerations of the hydrologic basin in Idaho.

Hydrologic Basin in Idaho

The hydrologic basin in Idaho forms three tributary systems which enter the Study Area separately. The first and largest is the river system tributary to Coeur D'Alene Lake which is the source of the Spokane River. Secondly, there is another area topographically tributary to the Spokane River between the outlet of Coeur D'Alene Lake and the Washington border from which only part of the runoff reaches the river as surface supply. This second area lies mostly north of the Spokane River extending up the valley known as Rathdrum Prairie and includes the mountain slopes on the east and west sides of the valley. The floor of this valley consists of deep deposits of highly permeable glacial outwash gravel which becomes a groundwater repository for most of the runoff from this area. Thirdly, the tributary areas of Hangman Creek and its tributary Rock Creek extend into Idaho.

The tributary area of Coeur D'Alene Lake is approximately 3,700 square miles, thus occupying approximately 86 percent of the hydrologic basin in Idaho. This drainage area extends eastward to the crest of the Bitterroot Mountains that form the Montana-Idaho border. Two river systems drain the area. The northern portion is drained by the Coeur D'Alene River, with its tributaries, which enters the Lake near Harrison, Idaho. The southern portion is drained by the St. Joe and St. Maries Rivers which enter the southern end of the lake.

Both the Coeur D'Alene and St. Joe-St. Maries systems drain mountainous, forested country which rises from elevation 2120 feet at Coeur D'Alene Lake to elevation 6500 feet at the crest of the Bitterroot Mountains. The Coeur D'Alene River has a tributary area of 1488 square miles and the St. Joe River and its tributary, the St. Maries River, have a combined tributary area of 1886 square miles. A large proportion of the drainage basin of Coeur D'Alene Lake is in national forest land. To the north of the Coeur D'Alene River, the tributary area of the river is in Coeur D'Alene National Forest. East of Calder, the St. Joe River watershed is in St. Joe National Forest.

As noted in the section on climate, there is a west to east trend of increasing average annual precipitation caused by the rising terrain facing the predominant eastward moving marine air masses. This pattern gives further importance to the watershed of Coeur D'Alene Lake as the primary source of Spokane River waters. Except for the local condition at Mt. Spokane, the rainfall in the Washington portion of the hydrologic basin ranges from 15 inches in the west to about 25 inches at the Idaho border. From the Idaho border eastward, the annual rainfall increases from 25 inches to 50 inches in the headwaters of the Coeur D'Alene River and 70 inches at the headwaters of the St. Joe.

There are no existing impoundments of any significance on either the Coeur D'Alene system or the St. Joe system above Coeur D'Alene Lake. The rivers are unregulated and free discharging.

Coeur D'Alene Lake is a natural lake that has a natural outlet to the Spokane River. The Post Falls Dam on the Spokane River, nine miles below the outlet from Coeur D'Alene Lake, was constructed by Washington Water Power Company (WWP) to regulate the lake level to optimize water power production. A description of the operating philosophy of WWP for the Post Falls outlet works is given later in this section.

Coeur D'Alene Lake is approximately 24 miles long with widths in the range of 1 to 2 miles. The lake has a general north-south orientation with the major entering rivers at the south end and the Spokane River outlet at the north end. The fact that the lake is long and narrow and that the water has to flow through its length has important consequences for water quality which are discussed in other sections.

In addition to its physical properties, the flow regulation of Coeur D'Alene Lake is a consequence of the interaction between Idaho law and the requirement for power production in Washington Water Power Company's six installations on the Spokane River. The legally useable storage in Coeur D'Alene Lake is significantly less than what would be required to retain surplus natural flows of the peak runoff season for release during periods of natural low flow. For the same reason, the lake storage effect on flood flows is insufficient to prevent moderately large flows in the Spokane River. In the past, a number of studies have been made by the Corps of Engineers for impoundments on the Coeur D'Alene and St. Joe Rivers to optimize annual flow and reduce flood flows. None of these possibilities are currently being considered for implementation. The possibilities of implementation are presently so remote that the potential for any additional regulation above Coeur D'Alene Lake will not be considered in this study.

The Washington Water Power Company owns certain flowage rights associated with various levels of Coeur D'Alene Lake. Complete flowage rights are owned to elevation 2126.5, partial rights to 2128.0 and a few to 2130.0. Normal regulation of the level of Coeur D'Alene Lake for power production is restricted by Idaho law to the range between elevation 2120.5 and 2126.5. Other considerations governing the control of lake level and flow release to the Spokane

River are the lake level during the recreation season and the drainage of agricultural lands at the southern end of the lake. The present operating philosophy of Washington Water Power Company, taking the foregoing into consideraiton, is as follows*:

> The Coeur D'Alene Lake elevation is held nearly full, 2128.0 feet elevation, through the summer recreation season. Initial releases may commence in the latter part of August or first of September when Columbia River flows have receded following the summer runoff and Coeur D'Alene storage releases would be usable through the Columbia River plants downstream from the Spokane River. Draft from Coeur D'Alene normally occurs at the rate of about one to two feet per month during the months of September through January and at rates compatible with the hydraulic capability (turbine capacity) of the Spokane River plants. During this period, inflow to the lake can vary widely due to heavy rainfall and sudden "chinooks," so lowering of the lake level is seldom at a uniform rate.
>
> Minimum lake elevation usually occurs in late January or February. At this time, regulation of the outflow normally ceases and the lake is allowed to seek its minimum natural level in the interest of making the maximum amount of storage available for flood control. Minimum lake elevations are normally around the 2122.5 level, but in times of prolonged cold weather with no rainfall or snow melt, the lake level can go down as low as 2120.5.
>
> As the runoff season begins in late winter or spring, no control over the outflow from Coeur D'Alene Lake is exercised. During periods of rapid runoff and/or heavy rainfall, the lake can rise well above the summertime control level. Over a period of nearly 80 years, this springtime flood elevation is found to average about 2131.7. During the 1948 flood, however, the lake reached 2135.95 on May 30; but during the flood of December, 1933, the lake rose to elevation 2139.05, the highest yet recorded.
>
> Following the spring runoff, the lake level is allowed to drop to elevation 2126.5 feet. At this point, control of the lake is resumed. Most of the spill gates at Post Falls

*Paraphrased from a memorandum prepared by Washington Water Power sent to Kennedy-Tudor with their letter of 15 October 1973.

Dam are closed to hold the lake at this elevation for a short period of time - usually not more than a day or two. The purpose of this operation is to allow water to drain off certain low-lying farm lands bordering on the lake. The farm lands are protected by dikes for water levels to 2128.0. Following the draining operation, the balance of the spill gates are closed to refill the lake to elevation 2128.0 feet and hold the lake near this elevation through the summer recreation season. Closure of the Post Falls gates under this method of operation, depending upon the volume of spring runoff and the timing of this runoff, can vary from late May to early July.

The available volume of storage in Coeur D'Alene Lake above the minimum elevation 2120.5 is shown in Appendix I. Post Falls Dam control devices are capable of regulating flows of up to 15,000 CFS with lake level 2128.0. When the lake level increases beyond 2128.0, control passes from Post Falls Dam to the lake outlet. The free discharge capacity of the lake outlet is shown in Appendix II. The discharge capacity of Post Falls Dam with all sector gates wide open is shown in the table Appendix III.

From the outlet of Coeur D'Alene Lake at river mile 111.1, it is 14.6 miles to the Washington-Idaho state line. Throughout this reach, the Spokane River is perched on the permeable outwash gravels of the Rathdrum Prairie and Spokane Valley. Refer to the section on geology and groundwater. The river channel is sealed by a silt deposit and the river is substantially above the groundwater table. Various estimates have been made of the amount of water percolating from the river into groundwater in this reach. Pluhoski and Thomas (1968) give values of 250 CFS for the nine miles above Post Falls Dam and 120 CFS for the section below Post Falls extending to the vicinity of Otis Orchards, four to five miles into Washington. The outflow into the gravels is estimated to be especially high during flood flows.

As mentioned above, the watershed in Idaho north of the Spokane River and surrounding the Rathdrum Prairie makes no significant surface water contribution to the Study Area. The water from this tributary area enters the Study Area almost entirely as groundwater, joining the above described groundwater accretion from the Spokane River.

Hydrologic Basins of the Study Area

Introduction. The Study Area, with minor exceptions, is the hydrologic basin of the Spokane River within the State of Washington. The Study Area is subdivided into four Water Resource Inventory Areas as defined by the State Department of Ecology. The Water Resource Inventory Areas (WRIA) are each a natural hydrologic subbasin. The Study Area and its subdivisions are shown in Plate 308-2. The areas of its subdivision are shown in Table 1.

WRIA Number 54, Lower Spokane. This area includes the area tributary to the Spokane River from its mouth at Franklin D. Roosevelt Lake to its confluence with Hangman Creek, excluding the tributary area of the Little Spokane. The hydrologically tributary land area is 1650 square miles.

A small part of the City of Spokane is included on the east bank between the Hangman Creek and Little Spokane confluences. North of the Spokane River from the mouth of the Little Spokane to

Franklin D. Roosevelt Lake, the area included is almost entirely in Stevens County and is rolling upland with open ponderosa pine forests. The entire west half of the area north of the river is in the Spokane Indian Reservation. The largest tributary from the north is Chamokane Creek with an area of 176 square miles. Other significant streams are the little Chamokane and Sand Creek. The only population center north of the river is Wellpinit.

South of the Spokane River, the area is typically Columbia Plateau table lands cut by steep-sided ravines. The west half is in Lincoln County and the east half is in Spokane County. The area, except for the steep wooded ravines, is largely in wheat or cattle grazing. Tributary streams from the south include Coulee Creek, Deep Creek and Spring Creek. There are several population centers in addition to the suburbs of Spokane including Airway Heights, Spokane International Airport, Fairchild Air Force Base and Medical Lake.

Rainfall in WRIA 54 ranges from 15 to 20 inches per year.

WRIA Number 55, Little Spokane. This area includes the entire tributary area of the Little Spokane River, an area of 700 square miles. The Little Spokane drains a broad valley between the lower uplands to the west and the higher Selkirk Mountains to the east which culminate in Mount Spokane at an elevation of over 5000 feet. The northern part of the basin is mountainous also but has a saddle in the vicinity of Newport that opens into the valley of the Pend Oreille River.

The valley floor is largely open land devoted to agriculture, while the surrounding uplands are forested. Most of the basin is in Spokane County but a small portion to the west is in Stevens County and most of the northern highlands are in Pend Oreille County.

The valley of the lower reach of the Little Spokane, from Dartford to the mouth, forms the boundary of the present northern suburbs of Spokane. The city limits extend into the southern part of the basin and true urban type development extends north to the river.

The Little Spokane River has a number of significant tributaries. On the east side Peone, Deadman, Deep and Deer Creeks drain the Selkirk Mountains. On the west, Dragoon Creek drains the western part of the valley and extends to the westerly mountains. Above Milan, the Little Spokane divides into east and west branches. The west branch contains a series of lakes, including Eloika, Fan, Horseshoe, Trout and Sacheen. The east branch extends through a narrow valley that includes Chain Lake and continues almost to the town of Newport.

Centers of population beyond the City of Spokane and the North Spokane suburbs include Mead, Dartford, Colbert, Chatteroy and Deer Park.

Rainfall in WRIA 55 ranges from 18 inches per year near the mouth to over 45 inches per year on the summit of Mount Spokane. For this reason, the Little Spokane River has the highest yield in the Study Area. Ground water is also significant to surface yield in WRIA 55. Part is due to interaction with the groundwater of the Little Spokane Valley which originates within the watershed. In addition, there is a major inflow of groundwater from outside the basin into the reach below Dartford. These groundwaters are from the main Spokane Valley aquifer and originate largely from outside the Study Area. Refer to the section on geology and groundwater.

WRIA Number 56, Hangman Creek.* This area includes that part of the Hangman Creek watershed that lies in the State of Washington. The total hydrologic basin covers 689 square miles of which 486 square miles are in Washington and the remaining 203 square miles are in Idaho.

Except for the ridges that form the basin boundary in the southeast, almost all of the tributary area of Hangman Creek is rolling open country devoted to dry farming. The main stream and its tributaries are in steep-sided narrow canyons. The predominant soil is the Palouse which has high erosion potential. There is little prominent relief to the topography except for the steep canyon sides in the lower (northern) reaches of the river, in the boundary ridges along the northeast and southeast and a small isolated peak near Tekoa.

There are only two significant tributaries, Rock Creek on the east and Marshall Creek on the west. Rock Creek drains an area similar to the upper reaches of Hangman Creek.

*Formerly called Latah Creek.

Hangman Creek joins the Spokane River in the City of Spokane and there is some urban type development on terraces in the lower creek canyon. Most of the suburban development is adjoining the canyon, however. Beyond the city suburbs, the population centers in the basin include Cheney, Rockford, Fairfield and Tekoa. Tensed is the only significant community in the Idaho portion of the watershed.

Rainfall ranges from 17 inches per year in the northwest to 24 inches per year in the east and southeast.

WRIA 57, Upper Spokane. This area is not a complete hydrologic unit. It is composed of two parts of an area that is topographically tributary directly to the Spokane River within Washington and an area that is tributary to the Rathdrum Prairie in Idaho. The southern part of WRIA 57, south of Shadow Mountain, drains to the Spokane River within the Study Area but includes two areas tributary to lakes that have no surface outlets. The northern part, north of Shadow Mountain, drains to the Rathdrum Prairie east across the state boundary into Idaho.

The southern part includes the floor of the Spokane Valley and the bordering slopes. The valley floor is underlain with a deep deposit of glacial outwash gravels which are a continuation of the same aquifer that underlies the Rathdrum Prairie in Idaho and which continues into WRIA 55 via the Hillyard Trough and, perhaps, into WRIA 54. Again, refer to the section, "Geology and Groundwater." The Spokane River traverses the surface of this aquifer through

WRIA 57 and experiences interchanges with the groundwater. The river loses to the groundwater between the state boundary and Otis Orchards, but gains from the groundwater below Otis Orchards.

Both Newman Lake, on the north side of the valley, and Liberty Lake, on the south side of the valley, have no surface overflow. It is also believed that the fine materials which formed at the outlet plugs of side valleys after the outwash gravels were deposited are so impermeable that there is no underground outlet from these lakes either and that they are in equilibrium with their runoff supplies.

The west portion of the valley floor is largely covered with suburban and industrial development. The eastern portion is largely devoted to irrigated agriculture. The valley area receives from 18 to 22 inches of rainfall per year.

The northern part of WRIA 57 which drains into the Rathdrum Prairie in Idaho consists of the eastern slopes of the Selkirk Mountains. Annual precipitation throughout most of this area is in excess of 40 inches per year. The area includes the headwaters of Blanchard, Brickel and Fish Creeks. All three of these streams disappear into the Rathdrum Prairie aquifer and, presumably, eventually reach the Spokane Valley as groundwater.

Streamflow Data

The available streamflow records for surface waters in the Study Area are shown in Tables 3 and 4. Table 3 shows available records from which daily or monthly flow records are available.

Table 4 shows stations for which there are available records of annual peaks or low flow measurements but no continuous type record. The locations of stations listed in both tables are shown in Plate 308-2. Refer to Table 2 for an abridged river mile index.

Spokane River. Although there have been eleven stream flow gaging stations on the Spokane River between the mouth and Post Falls, Idaho, only four are currently operating and only five have records of over twenty years length. The remaining six stations have records of 2 to 6 years length, all but one being in the period 1948-1954. The five stations added in 1948 and operated for a short period were initiated for a special study on the exchange of groundwater with the river (Broom, 1951).

The longest record, 81 years, is available from USGS gage 12-4225-00 located upstream from the Hangman Creek confluence at river mile 72.9. The next longest record, 60 years, is available from USGS gage 12-4190-00 at Post Falls, Idaho. Although this gage is not in the Study Area, its record is included herein because its record is significantly longer than that at USGS gage 12-4195-00 near Harvard Road Bridge which has a record of 43 years. The Post Falls gage is at river mile 100.7 and the Harvard Road Bridge gage is at river mile 93.9. This places the Post Falls gage 4.2 miles upstream from the state line (river mile 96.5) and the Harvard Road gage 2.6 miles downstream from the state line. There are no surface water tributary streams in the 28.3 miles between the Hangman Creek confluence and Post Falls. However, this reach is subject to significant groundwater interchange and storm water overflow from adjoining urban development.

The only significant surface water diversion on the Spokane River at present is the cooling water diversion by the Trent works of Kaiser. There are the following impoundments on the Spokane River between Post Falls and the Hangman Creek confluence:

1. Spokane Dam, river mile 80.2,
2. Upper Falls Dam, river mile 76.2, and
3. Monroe Street Dam, river mile 74.24.

These impoundments are relatively small and the associated hydro-electric works are operated on a run-of-the-river basis. For a more complete description of these structures refer to the paragraphs below on hydroelectric facilities.

There are no Spokane River gages that show the combined flow below the Hangman Creek confluence or the combined flow below the Little Spokane confluence. The next Spokane River gage below number 12-4225-00 is at Long Lake Dam. The record for USGS gage number 12-4330-00 is derived from Washington Water Power Company powerhouse records of turbine operation, periodically checked by USGS stream flow measurements below the powerhouse.

The absence of a gage between the Hangman Creek and Little Spokane confluence does not pose a serious data gap since Hangman Creek is gaged near the confluence. Other inflows in this reach are (1) the discharge of the City of Spokane sewage treatment plant which are metered except during storm water overflow and bypass conditions, (2) a suspected but unevaluated groundwater inflow and (3) Deep Creek. Nine Mile Reservoir in the lower end of this reach with a surface area of 440 acres is subject to only minor regulation.

The absence of a gage below the Little Spokane confluence does pose a significant data gap for two reasons. The Little Spokane gage at Dartford, USGS number 12-4310-00, is 10.8 miles upstream from the confluence and there is a known significant groundwater inflow downstream from the gage. The flow record at Long Lake Dam 12-4330-00 can be used with the lake stage record 12-4325-00 and its area capacity characteristics, Appendix IV, to approximate the combined flow below the Little Spokane confluence. As presently operated, the level in Long Lake Reservoir is held as near as possible to elevation 1536 which puts the backwater upstream from the Little Spokane confluence. It was the adoption of this higher control level in 1952 that flooded out USGS gage number 12-4315-00 at river mile 3.9 on the Little Spokane.

The record at USGS gage 12-4335-00, river mile 27.5, below Little Falls would provide an approximate extension of the Long Lake record prior to 1940 and back to 1912 except that Spring Creek enters the Spokane River between these gages. The tributary area of Spring Creek is only 56 square miles out of 6340 tributary at Little Falls. This would give an aggregate record of 81 years, comparable to the gage at Spokane, number 12-4225-00. The Little Falls gage has been flooded out by high water levels in Franklin D. Roosevelt Lake since completion of the Grand Coulee Dam which is the reason for its discontinuation.

Considering the foregoing facts, the following station records are selected for the purposes indicated in subsequent stages of this study:

1. Spokane River at Spokane, USGS #12-4225-00, is selected for flood frequency analysis for determination of the 100 year return period flood because of length of record and because it best represents the flow in the reach from the Hangman Creek confluence to the state line for which the flood profile is to be determined.

2. Four gages, #12-4190-00 at Post Falls, #12-4195-00 at Harvard Road Bridge, #12-4225-00 at Spokane and #12-4330-00 at Long Lake are selected for frequency analysis for 7-day low flow with 10-year return frequency. The Post Falls gage is included, although outside the Study Area, for its longer record and what it may demonstrate about the importance of groundwater when compared with downstream gages.

   These same four gages are selected as most representative of the entire Spokane River in the Study Area for presentation herein in tabular and graphical form. Refer to Table 5 for a summary tabulation of mean annual and extreme flows and to Table 6 for maximum, minimum and mean monthly discharges. The maximum, minimum and mean monthly discharges for the gage at Spokane is shown in Figure A.

3. The record from the Harvard Road Bridge gage #12-4195-00 is selected as the source of the hydrologic input of the Spokane River as it enters the Study Area for use in the simulation model. Length of record beyond 20 years is not a consideration for this purpose. The more important consideration is that it includes groundwater effects up to the state line.

Hangman Creek. There is only one gage on Hangman Creek with over twenty years of record, the gage at the mouth, USGS number 12-4240-000. The five other gages on Hangman Creek and its tributaries all apply to very small segments of its watershed. Annual peak data are available from three of these for period of 10 to 18 years.

For the purpose of this study, there is a data gap in not having any record for Rock Creek where a flood problem exists.

Gage number 12-4240-00 is selected for frequency analysis for flood flows with 100-year return period and for 7-day low flow with 10-year return period. For this same gage, the mean annual and extreme flows are shown in Table 5, the maximum, minimum and mean monthly discharges are shown in Table 6 and Figure B.

Little Spokane River. Two gages on the Little Spokane River have records over twenty years in length, USGS number 12-4270-00 at Elk and USGS number 12-4310-00 at Dartford. The gage at Elk measures flows from 115 square miles on the headwaters of the east branch, approximately one-sixth of the total watershed. The gage at Dartford measures the flow from 665 square miles of the total 700 square miles in the watershed.

As mentioned above under the discussion of the Spokane River, the gage at Dartford is 10.8 miles upstream from the mouth and does not measure the known groundwater increment in the downstream reach. The backwater from Long Lake on the Spokane River caused the discontinuation of the downstream gage, USGS number 12-4315-00. The inability to measure the groundwater increment constitutes a data gap.

For the purpose of determination of flood flow in the reach from Chatteroy to the mouth, there is a data gap in the absence of record at Chatteroy or on the intervening tributary streams above

Dartford, namely Deadman and Peone Creeks.

There are a significant number of gages in the Little Spokane watershed devoted to annual peak and low flow measurements. There are seventeen devoted to low flow and five to peak annual flow. The gage on Deer Creek records both. Most of these records are from 1954 or 1955 to date. Dragoon Creek is the largest tributary with a watershed of 177 square miles, more than the gage on the main stream at Elk. Low flows are available for Dragoon but no peak flows. The geology and rainfall of the area east of the main stream are significantly different than the main valley and the west half. Lack of a more complete understanding of the hydrology of these streams is regarded as a data gap.

The gage at Dartford, number 12-4310-00 is selected for flood flow frequency analysis for 100-year return period. The two gages, at Dartford and at Elk are selected for frequency analysis for 7-day low flow with 10-year return. The annual mean and extreme for both the above gages is shown in Table 5 and the maximum, minimum and mean monthly discharges are shown in Table 6. The monthly data for the Dartford gage are shown graphically in Figure 6.

Other Streams. Only two streams in WRIA 54 other than the Spokane River itself have available flow records. There is a small fragment of record for USGS number 12-4255-00 on the headwaters of Deep Creek (54)*. For USGS gage number 12-4333-00 peak annual flow

*Note that there are two Deep Creeks in the Study Area. To avoid confusion the number of the WRIA in which the creek is located is included after the name.

records from 1954 to date are available for an unnamed tributary of Spring Creek near Reardon.

There were no data at all for the most significant tributary stream in WRIA 54, Chamokane Creek with a drainage area of 180 square miles, until gage number 12-4332-00 was established in February 1971. The only available record is from 1971 to date. There is no available record for Little Chamokane Creek which has a drainage area of 69 square miles.

Comparison of Elements. A graphical presentation comparing the three main hydrological elements of the Study Area is contained in Figure D. The annual flow patterns for the year 1972 are shown for the Spokane River at Spokane, Hangman Creek at Spokane and the Little Spokane River at Dartford.

Note the contrast in size of flows. The Spokane River flows are approximately ten times the flows in Hangman Creek and the Little Spokane River.

Note the contrast in character of flow pattern between Hangman Creek and the Little Spokane River. Hangman Creek exhibits a very flashy response to rainfall events which are plotted in parallel. On the other hand, the Little Spokane exhibits a very stable pattern.

The effect of low flow regulation for power production is evident in the Spokane River.

Historic Floods

Spokane River. Floods on the Spokane River are generated by hydrologic events on the Coeur D'Alene and St. Joe River systems, but are limited by routing through Coeur D'Alene Lake and by the restricted outlet of Coeur D'Alene Lake. The importance of the control imposed by Coeur D'Alene Lake can be demonstrated by consideration of the inflow versus outflow for the December 1933 flood. For this flood, the highest mean daily inflow to Coeur D'Alene Lake was 101,000 CFS and the estimated crest was 130,000 CFS. The peak experienced on the Spokane River in this same flood was 47,800 CFS.

Historic floods of record on the Spokane River are shown in Table 7. The two earliest floods were before the construction of Post Falls Dam. Refer to Appendix II which shows that for lake stages above 2128 and flows of 15,000 CFS, Post Falls Dam is not controlling. Therefore, flood flows are all on the same basis.

In Davenport (1922) there is a discussion of the relationship between the control of flow from Coeur D'Alene Lake and lake stage. This water-supply paper was written primarily in response to the problems of adjudicating the differences between WWP and land owners upstream from Coeur D'Alene Lake. Its primary interest today is the demonstration of how the configuration and slope of the Spokane River channel between Coeur D'Alene and Post Falls is the determining factor in volume of flood floor for any given stage of the lake.

Water-supply paper 532 (1924) is of interest for its remarks about the validity of flow records prior to October 1896 for the Spokane River at Spokane. This paper points out that the records prior to this date are of doubtful accuracy for several reasons. The extreme discharge of May 31, 1894 falls in this period and is given as 49,000 CFS as revised.

The following materials are abstracted from House Document No. 531 and describe the character and mechanism of floods on the Spokane River:

> Floods in Spokane River Basin usually occur in the spring as a result of the rapid melting of snow following unusual rises in temperature. Occasionally, as in April 1938, heavy rains occur simultaneously with the temperature rise, thereby increasing the flood flow to damaging proportions. Spring floods are normally of short duration. Within the 56-year period of record, the basin has experienced four damaging spring floods; i.e., in May 1893, May 1894, May 1917, and April 1938. (Subsequent to data available for Document No. 531, another spring flood of damaging size occurred in May 1948.) That of May 1894 was the greatest of the spring floods, having had an estimated maximum 24-hour discharge of 49,000 cubic feet per second at Spokane (see paragraph above quoting Water-Supply Paper #532 on accuracy of this figure) and a lake (Coeur d'Alene) elevation of 2,137.6 feet. Two severe winter floods have occurred in the period of record: in January 1918 and December 1933. The frequency of damaging floods is, therefore, about once in 9 years. The 1933 flood attained the highest recorded level, 2,139.05 feet in Coeur D'Alene Lake, but its peak discharge at Spokane was only 47,800 cubic feet per second. Winter floods are caused by unusually heavy rains in coincidence with chinook winds and consequent rapid melting of accumulated snow.
>
> The flood of December 1933 resulted from an unusually long period of excessive precipitation coupled with the rapid melting of accumulated snow by a chinook wind in the latter half of the month. Temperatures exceeded the normal for the month by an average of 7.7°F., the period of highest temperature coinciding with the periods of greatest precipitation. The melting of all snow below the 4,000 foot level and in exposed areas above that level, together with the

heavy rain, created floods in the tributary streams much larger than any previously recorded and raised Coeur D'Alene Lake to its highest known level. Weather conditions were similar throughout the upper drainage area, so that peak discharges in the tributaries occurred almost simultaneously. As a result, the crest inflow to the lake was more than double the crest outflow, the maximum 24-hour inflow being 106,000 cubic feet per second as compared with a maximum 24-hour discharge of 47,100 cubic feet per second at Spokane.

During the flood of May 1894, the rise in lake level was more gradual than that of the 1933 flood. The 1894 flood on the Spokane was part of the prolonged general flood of that year that extended over the entire Columbia River drainage area. This flood produced the highest discharge in the Columbia River that has been recorded in the 69 years of record on the gage at The Dalles, Oreg. The only records of the 1894 flood available for the Spokane River indicate that the peak discharge at Spokane was higher than that of December 1933, although the maximum level of Coeur D'Alene Lake was lower in 1894 than in December 1933.

The floods of greatest volume and highest levels in Coeur D'Alene Lake occur in the winter during short periods of high precipitation and temperature. It reasonably may be expected that, at some future date, there will occur a combination of meteorological, ground, and runoff conditions worse than those prevailing in December 1933, when the most severe flood in the past 55 years of record occurred in the basin. If the maximum probable storm predicted by the Hydrometeorological Section of the Weather Bureau were to occur at the time when the ground was covered with loosely packed snow, and if meteorological conditions were then such that rapid melting of the snow would occur simultaneously with the high rates of rainfall, there would be available for stream runoff not only the actual precipitation, but also the water released by the melting snow. It may be assumed that the increment from the melting snow would exceed water losses from absorption, percolation, evaporation, and transpiration. Then the river system would be called upon to carry all of the precipitation from the maximum 3-day storm, plus some snow melt. The runoff resulting from this maximum probable storm under these assumed conditions is shown in table 8, together with comparable data on the December 1933 flood. (The referenced table 8, not reproduced herein, shows that the maximum probable flood (MPF) would have produced flows into Coeur D'Alene Lake comparable to the December 1933 flood for the first four days, but that on the fifth and sixth day, the MPF inflows would be 320,000 and

172,000 CFS respectively compared with the December 1933 values of 101,400 and 92,300 CFS respectively.) Flood flows for the maximum probable flood have been calculated for a storm centered over the area tributary to Coeur D'Alene Lake.

Assuming an initial lake elevation of 2,126.5, which is the allowable upper limit for regulation of Coeur D'Alene Lake, and using the maximum inflows as shown in table 8, flood-routing computations indicate that the lake level would rise to elevation 2,146.9, and the mean daily discharge of the river at Spokane would be 83,600 cubic feet per second. (In other words, the MPF would produce flows in the Spokane River 70 percent greater than the greatest historical flood or the 100-year flood as shown below.)

Frequency studies were made of maximum annual stages of Coeur D'Alene Lake at Coeur D'Alene, Idaho, and observed peak discharges for the Spokane River at Spokane, Wash. The study for the lake was for the period of record 1905 through 1946, and for the river from 1892 through 1946. The results of these studies are as follows:

Average recurrence interval (year)	Maximum river discharge at Spokane	Maximum lake elevation
	Cubic feet per second	
2	24,500	2,130.9
10	37,800	2,135.0
20	41,500	2,136.5
50	46,000	2,138.2
100	49,000	2,139.5

The House Document No. 531 concluded that the resulting benefits, both upstream and downstream from Coeur D'Alene, would be insufficient to justify improvements to the lake outlet and Post Falls Dam that would increase capacity at lower lake levels to prevent the lake from reaching high levels and the peak discharges associated with the high levels.

House Document No. 531 concludes that discharges in the Spokane River in excess of 40,000 CFS result in damage. The only flood of this magnitude since 1894 was the flood of December 1933. The historical damage from the 1933 flood, below Post Falls, is given as follows:

Kind of Damage	Dollar Value
Agricultural	1,000
Residential	8,100
Industrial	150,800
Utility	77,000
TOTAL	237,500

The limits of the area flooded and the associated water profile for the December 1933 flood are available in several documents as follows:

1. Corps of Engineers Drawing File D-10-6-60.

2. U.S. Geological Survey Maps, Plan and Profile of Spokane River, Spokane, Washington to Post Falls, Idaho in 4 sheets.

Reference 1 above shows the outline of the flooded area in plane at a scale of 1" = 1000' from the vicinity of Division Street to City Water Works power house.

Reference 2 includes three sheets of topographic plans at 1" = 1000' from Cochrane St. to Post Falls but does not show flooded areas; only sheet four, a profile at 1" = 2000' shows 1933 water surface from the falls one-third of a mile above Mission Street Bridge.

In addition to the above, there are available seven graphs by Washington Water Power Company showing the day by day water surface elevation from December 8, 1933 to January 13, 1934 at Coeur D'Alene Lake, Post Falls, Upper Falls, Monroe Street, Nine Mile Dam, Long Lake, and Little Falls Dam.

The Corps of Engineers has made a flood level determination for the immediate vicinity of the Spokane Expo 74. The results of this study are shown on a drawing at scale 1" = 80' which delineates the 100-year flood plan from Howard Street to Division Street on both sides of Havermale Island.

A levee project on the right bank of the Spokane River in the vicinity of Trent Avenue was considered in 1938 but was never implemented. Subsequent investigations revealed that foundation conditions were unsatisfactory. Refer to House Document No. 53100.841.

The Spokane River below Spokane Falls (Monroe Street) has not been subject to flood problems. The depth of the canyon and absence of development in the canyon minimize flood potential. A flood level determination was made recently in connection with the proposed enlargement of City of Spokane sewage treatment plant.

Hangman Creek. Flood control problems have been studied by the Corps of Engineers at three locations in the Hangman Creek Watershed. These are: (1) The upper portion of Hangman Creek in the vicinity of Tekoa, Washington and Tensed, Idaho; (2) in the vicinity of the town of Rockford on the Rock Creek tributary; and (3) on the lower Hangman Creek between river mile 12.5 and 15.0.

Upper Hangman Creek. Reconnaissance reports were made, beginning in 1966 on a number of alternatives to the flooding problem in the vicinity of Tensed and Tekoa, all of which have been found to be economically unjustified. These alternatives included the following:

1. For the area from the Washington-Idaho border upstream to two miles above Tensed (approximately 9.3 miles) a channel improvement was proposed to protect against 40-year flood recurrence.

2. For the area in the vicinity of Tekoa, a combination of channel enlargement and levee construction and alternatively higher levees without channel improvement.

3. Upstream storage, alternatively 1 mile upstream from Tekoa and 4.5 miles upstream from Tensed.

The most recent evaluation of average annual damage in the 13.2 mile stretch from Tensed to Tekoa is $148,000 consisting of 68 percent agricultural, 22 percent roads, bridges, railroads, and streets, 7 percent residential property and 3 percent commercial property.

Vicinity of Rockford on Rock Creek. The most recent studies by the Corps of Engineers of the flood problem at Rockford indicates that floods with recurrence intervals of 20-, 50- and 100-years will flood areas of 10, 14, and 18 acres respectively. The area of the 100-year flood plain includes 5 public buildings, 15 commercial and 4 residences in addition to the associated streets and utilities and the fair grounds. The value of $114,000 at 1970 price levels is estimated for damages associated with a 100-year recurrence flood and an average annual damage rate of $4.300 from all floods.

Existing flood protection in Rockford consists of a levee on the right bank constructed by WPA after the 1933 flood. This levee protects to level of 20-year recurrence. Rockford was flooded again in 1963 and 1964. The levee was repaired by the

Corps of Engineers in 1965.

Subsequently, a preliminary plan of improvements was developed by the Corps of Engineers and found to have a benefit-cost ratio of 0.9. The plan has not been implemented. The proposed improvement consists of raising the levee 3 feet for a distance of 700 feet and rebuilding the remaining levee for a distance of approximately 1,000 feet, all to provide protection to the 100-year recurrence level.

Little Spokane River. The Little Spokane River from its mouth to the town of Chatteroy meanders through a flat valley floor with considerable potential for going overbank at high flow. The area is also now under development pressure from northward expansion of Spokane's suburbs.

There are no records of flood damages in this reach nor have there been any flood control studies made.

Hydroelectric Facilities.

Washington Water Power Company has six hydroelectric power plants on the Spokane River. All except the Post Falls facility are in the Study Area. The City of Spokane has a single hydroelectric plant on the Spokane River. Each of these seven hydroelectric facilities is associated with a dam. Table 9 lists the hydroelectric power facilities and Table 8 lists the associated dams and their characteristics.

The philosophy and schedule of operation of the Post Falls

Dam has been discussed above in connection with the regulation of the flow from and level in Coeur D'Alene Lake. See Appendix IV for rule curves. This operation essentially sets the pattern for all of the downstream power plants with minor exceptions. The impoundments associated with the city facility, Control Works (Upper Falls), Monroe Street and Nine Mile are so small that these plants are operated as run-of-the-river plants. Long Lake reservoir capacity is utilized to operate both Long Lake and Little Falls power houses to meet both daily and weekly peaking as well as end of season drawdown. These operating possibilities are evident in the flow rating of the installed equipment. The flow capacity of the installations at Monroe Street and above are essentially matched to Post Falls. Nine Mile has peak capability about 60 percent greater than Post Falls, and Long Lake and Little Falls, which also benefits from Long Lake Storage, have capabilities almost double Post Falls.

The present method of operating Long Lake is to maintain the lake at the highest possible level consistent with the limitation imposed by flooding easements which extend to elevation 1536 and the availability of water from Coeur D'Alene. Long Lake is not normally drawn down through the summer recreation season but is drawn down in January and February to utilize the stored waters when the supply is low.

Little Falls. Little Falls Dam is a gravity concrete dam that was built by WWP in 1911. The dam is "L" shaped in plan with an uncontrolled crest on the long leg of the "L" 412 feet long and another 185 feet of uncontrolled crest on the short leg along with two twenty-foot wide Taintor gates. The elevation of the uncontrolled crest is 1356 and the sill of the Taintor gates is 1341. The dam has a hydraulic height of 39 feet.

Capacity of the two Taintor gates wide open totals 10,000 CFS when the pool surface is 1356, the elevation of the overflow weir. Flash boards are added to the uncontrolled crest to bring the pool level to 1362. Wing wall crest is 1364. The capacity of the uncontrolled weir with flashboards removed is 60,000 CFS when the pool level reaches wing wall crest elevation 1364.

The surface area of the impoundment is 250 acres and extends 4.6 miles upstream to the toe of Long Lake Dam. Normal pool elevation is 1362 and the active storage volume above elevation 1351 is 2220 acre feet. There is no available record of dead storage below elevation 1351 which is estimated to be of the order 2000 acre feet.

The power house is located on the north bank and contains 4 units with a total nameplate rating of 32,000 kilowatts and a nameplate water rate of 6670 CFS. Peak capability is 36,000 kilowatts and 7500 CFS.

Since the available live storage is small compared with turbine capacity, operation is dependent upon releases from Long Lake power house immediately upstream.

Long Lake. Long Lake Dam is a gravity concrete dam built by WWP in 1915. The dam is "L" shaped with the penstocks descending from the south leg of the "L" to the power house on the south bank and the spillway gates installed in the north leg. There are eight roller gates, each 25 feet wide with sill elevation 1508. The dam has a hydraulic height of 213 feet.

Discharge capacity of each gate at maximum pool elevation 1536 is 14,500 CFS making total discharge capacity 116,000 CFS.

The surface area of the impoundment is 5060 acres at maximum pool elevation 1536. Active storage between maximum pool and sill elevation of gates is 105,080 acre feet. Dead storage below sill elevation is 149,490 acre feet. The lake extends approximately 24 miles upstream to beyond the Little Spokane confluence.

The power house contains four units with a total nameplate capacity of 70,000 kilowatts and water rate of 6180 CFS. Peak capability is 72,500 kilowatts and 6300 CFS.

Nine Mile. Nine Mile Dam and Power House were constructed in 1908. This is a gravity concrete structure with hydraulic height 58 feet. The power house is integral with the south abutment. The overflow crest is without permanent crest control and is 364 feet long at elevation 1596.57. The crest is equipped with two removable sets of flash boards. The first set has a crest elevation of 1601.57 and the second set raises the crest to 1606.57. Normal pool elevation is 1606 with the second set of flash boards in place. When river flow exceeds 5,000 CFS, the peak hydraulic capacity of the turbines, the second set of flash boards must be removed reducing the pool level.

A discharge of 17,000 CFS is the maximum which can be passed over the crest with the first row of flash boards in place resulting in a pool elevation of 1611. With all flash boards removed approximately 46,000 CFS can be passed at pool elevation 1611.

The impoundment storage between low pool 1590.57 and maximum pool at 1606.6 with both rows of flash board in is 4600 acre feet with a surface area of 440 acres at maximum pool. The storage volume below 1590.57 is estimated at 7,000 acre feet.

Nine Mile Power House contains four units with total nameplate capacity of 12,000 kilowatts at 3,330 CFS. Peak capability is 18,000 kilowatts at 5,000 CFS.

Monroe Street. Monroe Street Dam was the oldest dam on the river, the original structure having been built in 1890. The original structure was replaced by a new concrete structure in 1972. The new structure has the same crest elevation, 1806. There is no crest control, the structure being a simple overflow structure with a crest length of 217 feet and 25 feet hydraulic height. This structure serves both as a diversion structure for the Monroe Street Power House as well as tailwater level control for the Upper Falls Power House.

The impounded volume is negligible, estimated at less than 70 acre feet.

The Monroe Street Power House is located downstream from the dam to take advantage of the natural fall in the river below the dam. The five power units have a total nameplate capacity of 7200 kilowatts at 2,000 CFS. These old units are not given a peak rating over the nameplate rating.

Control Works (Upper Falls). The Control Works Dam is in the channel that passes north of Havermale Island and provides the overflow structure. A second dam closes the south channel and has no overflow provision but contains the inlets to the penstocks for the Upper Falls Power House which is located on the south bank at the foot of the falls. The complex of two dams and power house was built in 1922.

The Control Works Dam is a gravity concrete structure with control devices along the entire crest. Adjacent to the north bank are two 60-feet wide by 18-feet rolling sector gates with sill elevation 1854.9. The remainder of the crest to the south bank is filled with twenty lift gates each seven feet wide and all with sill elevation 1858.9. Normal operating pool level is 1870.5.

Discharge curves for the crest control devices are not available but there is a record of the upstream level at 1874.1 for the December 1933 flood, presumably with all gates open.

The sill of the sector gates at 1854.9 is essentially at river bottom so there is virtually no dead storage. The active storage between normal pool 1870.5 and low water at 1864.3 is 800 acre feet. The area of the normal pool is 136 acres.

The Power House is remote from the Control Works Dam being associated with the south channel closure to take advantage of the additional head provided by the natural falls. There is a single power unit with nameplate rating of 10,000 kilowatts at 2450 CFS.

Peak rating is 10,200 kilowatts at 2500 cfs.

Spokane Dam. Spokane Dam and Power House were built in 1937 by the City of Spokane to generate electrical power to drive well pumps of the city water system.

Spokane Dam is a concrete structure with eight Taintor gates filling the 26 foot wide spaces between three feet thick concrete buttresses. The gate sill elevation is 1893.45.* Normal pool elevation is 1910.45, below the top of closed gates. Normal operation calls for holding the pool at 1910.45 and not overtopping the gates; flow in excess of turbine capacity is released by partial opening of one or more gates.

The bottom of the gates when open is at 1917.45 thus leaving a space 24 feet high over the sill for flood flows. Design criteria call for the ability to pass 62,000 cfs at upstream water surface 1911.13, the maximum water surface that was recorded during the 1933 flood when the old dam existed. The old dam had a crest elevation of 1889.45, four feet lower than the crest of the new dam. Stage discharge data for the gates is not available from the City.

The crest of the dam is believed to be about twenty feet above the river bed. Combined with the seventeen feet to normal pool above the sill, this gives a maximum depth of 37 feet. The City has no data on the volume of dead or live storage but the total of these quantities is estimated to be of the order of 1500 acre feet. The area of the impoundment

*USGS datum to correspond with other structures described herein. USGS = City Elevation minus 16.55.

is estimated to be 150 acres.

Post Falls Dam. Post Falls Dam is outside the Study Area but a brief description is necessary to the understanding of its control of Coeur D'Alene Lake.

The river is divided into three channels at Post Falls. The dam on the middle channel contains the power house and has no overflow or level control function. The structure on the north channel has all of the crest control consisting of eight Taintor gates, seven each at 21 feet wide and one at 12 feet wide, and one sector gate 102 feet wide. The sill elevation of the Taintor gates is 2114.0 and of the sector gate is 2116.5. The tops of both gates are at 2128 in the closed position corresponding to the maximum elevation at which the lake is held. The south channel dam is 127 feet wide and contains six lift gates, six feet wide by 13 feet high at sill elevation 2108.62 and an overflow spillway 37 feet long with original crest elevation 2126.52 which has been raised to 2128.0 by crest logs.

As stated above in the description of WWP operating procedure, the Post Falls control structures can control flows up to 15,000 cfs with the Lake at 2128.0. Beyond 15,000 cfs or lake elevation 2125.0, the control shifts to the outlet channel of the lake.

The normal summer pool (lake) level is 2128.0 and the winter minimum is 2120.5. The active storage between these elevations is 217,000 acre feet or 108,500 second foot days. The lake has an area of approximately 42,800 acres at summer pool level and 27,000 acres at minimum pool.

Schematic Flow Diagram and Flow Balance

A schematic diagram of the Spokane River as it passes through the Study Area is shown in Figure E. The river is shown to scale by river mile and includes the successive dams and impoundments through which the river passes, the principal tributaries, the currently active stream gages and the estimates of Broom (1951) for groundwater interchange.

A complete flow balance cannot be achieved with the available surface flow data and the Broom estimates. It must be recognized, as Broom (1951) points out, that these groundwater interchanges are only estimates based on one year of data and that the results are far from conclusive. Also, these mean values represent highly variable conditions throughout the year, the rates and even direction of flow being a function of river stage. Years with different ratios of high flow to low flow could have significantly different mean annual interchange.

Considering the reach between Post Falls gage 4190 and Harvard Road gage 4195, the long term stream flow record indicates a surface flow increment of 63 cfs whereas the Broom estimate indicates that there should be a loss of water of about the same magnitude. Since this difference is of the order of 1 percent of the mean annual stream flow, this disagreement is not surprising.

From Harvard Road gage 4195 to the Cochran Street gage 4225, the measure of mean surface flow increment is 307 cfs. In this same reach, the Broom estimate indicates a total gain of approximately 930 cfs. The 600 cfs difference here is equal to 10 percent of the mean flow and is therefore more difficult to justify.

The next reach for which a balance can be tried is between the Cochran Street gage 4225 and Long Lake gage 4330. The trial balance is as follows:

Long Lake #4330	8381 cfs	Hangman Cr #4240	264 cfs
Cochran St #4225	6927 cfs	Little Spokane #4310	316 cfs
		Groundwater In	126 cfs
Difference	1454 cfs	" "	21 cfs
		" "	157 cfs
		" "	218 cfs
		TOTAL	1102 cfs

The difference between the surface flow gages of 1454 cfs and the estimated inflows of 1102 cfs leaves 352 cfs to be accounted for by local tributary area and Deep Creek. The unaccounted tributary area, including Deep Creek, is approximately 340 square miles. For this area, the mean annual discharge per square mile is probably similar to Hangman Creek at 0.4 cfs per square mile. This would account for an additional 136 cfs leaving the net unaccounted at 116 cfs or 1.4 percent of the mean annual discharge at Long Lake.

The net Broom groundwater increments total 1341 cfs gain. This is higher by approximately 300 cfs than the estimates of Piper and La Rocque (1944) and Plukowski and Thomas (1968). Refer to the section on geology and groundwater.

Lakes

All of the major lakes (surface area 100 acres or more) within the Study Area can be placed in four general classifications as follows:

1. Mountain lakes that have no significant outlet.

   Newman Lake
   Liberty Lake
   Diamond Lake

2. Natural lakes that are part of a stream system.

   Sacheen Lake
   Trout Lake
   Horseshoe Lake
   Eloika Lake
   Chain Lake

3. Lakes in Columbia Plateau terrain.

   Medical Lake
   West Medical Lake
   Silver Lake
   Clear Lake

4. Man-made lakes (river impoundments).

   Long Lake
   Nine Mile Reservoir
   Control Works (Upper Falls) Reservoir
   Spokane Dam

The river impoundments have been discussed above in connection with hydroelectric facilities and will not be repeated here.

Table 10 is an inventory of lakes in the Study Area compiled from the report "Lakes Constituting Shorelines of the State Shorelines Management Act of 1971" by the State Department of Ecology. Table 11 shows the important characteristics of the major lakes from this list including the availability of lake level records. Refer to Plate 308-2 for lake locations.

A brief discussion of the major lakes follows, taken in order of the classification given in the opening above. The primary use of all lakes in the Study Area, except the man-made lakes, is recreation.

The man-made lakes all have hydropower production as their primary use. Of the man-made lakes, only Long Lake has, at present, significant recreational use.

Newman Lake is the largest lake in the Study Area with a surface area of 1190 acres. It is located north of the Spokane Valley near the Washington-Idaho border and receives the runoff from 28 square miles in the south slopes of the Selkirk Mountains. The lake has a surface overflow that fails to reach the Spokane River and is believed to have no direct underground outlet either, the lake having been formed by a relatively impervious plug deposited in the mouth of the valley against the permeable valley fill. Refer to the Geology section. A level record is available which indicates a maximum variation of 4.24 feet. A bathymetric map of the lake is also available which shows that most of the lake is over 15 feet deep and has a maximum depth of 30 feet.

Liberty Lake is situated south of the Spokane River in a similar manner to Newman Lake and has similar outlet characteristics. Liberty Lake has an area of 711 acres and receives drainage from only 13 square miles. Level records indicate maximum variation of 4.94 feet. Bathymetric map shows most of the lake to be 25 feet deep and flat with a maximum depth of 26 feet.

Diamond Lake is located in the northern part of the Study Area in a blind watershed between the upper branches of the Little Spokane River. Diamond Lake is the second largest in the Study Area with a surface area 754.5 acres. Its surface elevation of 2360 feet makes it the highest lake in the northern area. The tributary area is very small, being only 6.1 square miles; that is, the lake covers approximately one sixth of the tributary area. A level record is available and shows a small variation of level at 1.99 feet. A bathymetric map is available which indicates that the lake is 50 feet deep throughout most of its area.

Eloika, Horseshoe, Trout and Sacheen Lakes are all part of the West Branch of the Little Spokane River. Sacheen Lake is the source and the river flows from Sacheen successively through Trout, Horseshoe and Eloika. Sacheen and Eloika are of considerable size, having areas of 282 and 659 acres respectively. Level records are available for both of these large lakes. Sacheen at the headwaters with a tributary area of 33.5 square miles, has a small range of level variation at 2.85 feet. Eloika Lake, at the lower end of the chain of lakes and with a tributary area of 101 square miles, has a level variation of 5.45 feet.

Sacheen Lake is relatively deep with a maximum of 40 feet. Eloika is very shallow for its size with a maximum depth of only 15 feet. Bathymetric maps are available for both lakes.

Trout and Horseshoe Lakes have areas of 94.8 acres and 128.0 acres respectively. Level records are not available for these lakes. Both lakes are unusually deep in spots. Trout Lake goes to 170 feet depth in its north end. The west bulb of Horseshoe Lake is 140 feet deep.

Medical Lake, West Medical Lake, Clear Lake and Silver Lake form a group in the Columbia plateau terrain southwest of the City of

Spokane. The area is one of generally low relief. The tributary areas to these lakes are poorly defined and are small compared with the area of the lakes. Under overflow conditions, these lakes would not drain into the Spokane River but rather into the Palouse watershed. All four of these lakes are long and narrow and trend north-south. All are moderately deep, ranging from 35 feet in West Medical Lake to 110 feet in Clear Lake.

TABLE 1

TRIBUTARY AREAS

Description	Area, Square Miles
Entire Hydrologic Basin of the Spokane River	6640
Hydrologic Basin in Idaho	4345
Hydrologic Basin in Washington	2295
Tributary to Coeur D'Alene Lake	3700
Hangman Creek (Total)	689
Hangman Creek in Washington (WRIA #56)	486
Little Spokane River (WRIA #55)	700
Chamokane Creek	176
WRIA #54 Lower Spokane	1650
WRIA #57 Upper Spokane	315

TABLE 2A

RIVER MILE INDEX (ABRIDGED)

SPOKANE RIVER

River Mile	Description	Drainage Area Square Miles Tributary Stream	Drainage Area Square Miles Main Stream	Water Elevation Feet[1]	River Mile	Description	Drainage Area Square Miles Tributary Stream	Drainage Area Square Miles Main Stream	Water Elevation Feet
0.0	Mouth of Spokane River at Columbia river mile 643.0		6580n[5]	1290[2]	33.9	LONG LAKE DAM		5920	1536[6]
8.1	Orazada Creek (R)[3]			1290	44.0	Hendricks Canyon (R)			
10.2	Hollies Creek (L)				45.5	Whitney Canyon (R)			
10.3	Sand Creek (R)			1290	50.7	Little Sandy Canyon (R)			
12.6	Blue Creek (R)			1290	56.3	Little Spokane River (R)	701n		1536
12.8	Green Canyon (L)			1290	57.6	Stream Gage, USGS #4260, below Nine Mile Dam (discontinued)		2505n	1535±[7]
20.4	Harker Canyon (L)			1290	58.1	NINE MILE DAM		5204n	1607
20.8	Mill Canyon (L)			1290	59.0	Deep Creek (L)	169n		
27.5	Stream Gage, USGS #4335, below Little Falls (discontinued)		6340n	1279[4]	64.2	Stream Gage, USGS #4245 (discontinued)		5020n	1630±
28.2	Spring Creek (L)				66.1	Riverside State Park Bridge			
29.3	LITTLE FALLS DAM		6283n	1362	67.2	City of Spokane Sewage Treatment Plant			
31.8	Little Chamokane Creek (R)	69n		1362	69.8	Fort Wright Bridge			
32.5	Chamokane Creek (R)	180			72.4	Hangman Creek (L)	689±		
33.88	Stream Gage, USGS #4330, at Long Lake		6016n	1364					

See Table 2C for Notes.

TABLE 2A (Continued)

River Mile	Description	Drainage Area Square Miles: Tributary Stream	Drainage Area Square Miles: Main Stream	Water Elevation Feet
72.9	Stream Gage, USGS #4225, Spokane River at Spokane		4290n	1717
74.1	SPOKANE FALLS			1806
74.24	MONROE STREET DAM			1806
76.2	CONTROL WORKS DAM (UPPER FALLS)			1870
77.9	Stream Gage, USGS #4220, below Greene Street (discontinued)		4220	1872±
78.0	Greene Street Bridge			
79.8	City Hydroelectric Plant			1871
80.2	SPOKANE DAM			1906
84.8	Stream Gage, USGS #4215 (discontinued)		4200n	1913±
85.3	Trent Road Bridge			
85.5	Stream Gage, USGS #4210, at Trent (discontinued)		4200	1914±
88.7	TOP OF FALLS			1950

River Mile	Description	Drainage Area Square Miles: Tributary Stream	Drainage Area Square Miles: Main Stream	Water Elevation Feet
89.0	Stream Gage, USGS #4205, at Greenacres (discontinued)		4150n	1954
93.9	Stream Gage, USGS #4195, above Liberty Bridge, near Otis Orchards		3800n	2010±
96.45	Canal (Not in use)			
96.5	Washington-Idaho State Line			2-25
100.7	Stream Gage, USGS #4190, near Post Falls		3840±	2061
101.7	Post Falls Power Plant			2067
102.1	POST FALLS DAM		3840	2128
102.11	Canal, Spokane Valley Farm Co.			
106.6	Rathdrum Prairie Canal			
111.1	Outlet of Coeur D'Alene Lake		3700±	2128

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	RIVER MILE INDEX (ABRIDGED) HANGMAN CREEK (LATAH CREEK)	TABLE 2A (Cont.)

TABLE 2B

RIVER MILE INDEX (ABRIDGED)

LITTLE SPOKANE RIVER

River Mile	Description	Drainage Area Square Miles: Tributary Stream	Drainage Area Square Miles: Main Stream	Water Elevation Feet[1]
0.0	Confluence with Spokane River			
0.6	Stream Gage, USGS #4320, near Spokane (discontinued)		705n[5]	
3.9	Stream Gage, USGS #43 , near Dartford (discontinued)		698	1554±
3.91	Rutter Parkway Bridge			
	Stream Gage, USGS #4312			
10.8	Stream Gage, USGS #4310 at Dartford		665	1593
10.81	Little Creek (R)[3]	12		
13.1	Deadman Creek (L)	133n		
14.22	Stream Gage, USGS #4303, above Deadman Creek (discontinued)		524n	
21.2	Stream Gage, USGS #4301.5 below Dragoon Creek		512n	
21.3	Dragoon Creek (R)	177n		
2[illegible].0	Deer Creek (L)	32n		
23.05	Stream Gage, USGS #4295 near Chattaroy (discontinued)		300n	
27.8	Bear Creek (R)	11n		
31.81	Stream Gage, USGS #4290 at Milan (discontinued)		274n	
32.9	West Branch Little Spokane River (R)	105±		
33.5	Otter Creek (R)			
34.6	Dry Creek (L)	21		
37.6	Stream Gage, USGS #4270 at Elk		115n	1875±
41.0	Chain Lake, Lower End			
42.2	Chain Lake, Upper End			
46.71	Stream Gage, USGS #4265, At Scotia (discontinued)		74n	2060±

See Table 2C for Notes.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	RIVER MILE INDEX (ABRIDGED) LITTLE SPOKANE RIVER	TABLE 2B

TABLE 2C

RIVER MILE INDEX (ABRIDGED)

HANGMAN CREEK (LATAH CREEK)

River Mile	Description	Drainage Area Square Miles		Water Elevation Feet[1]
		Tributary Stream	Main Stream	
0.0	Confluence with Spokane River			
0.8	Stream Gage, USGS #4240 at Spokane		689	1723±
4.2	Marshall Creek (L)[3]			
14.5	Stevens Creek (R)	87n[5]		
18.3	California Creek (R)	26n		
19.2	Spangle Creek (L)			
20.2	Rock Creek (R)	177n		

River Mile	Description	Drainage Area Square Miles		Water Elevation Feet
		Tributary Stream	Main Stream	
32.88	Rattler Run Creek (R)			
47.1	Cove Creek (R)			
54.3	Little Hangman Creek	65n		
54.61	Stream Gage, USGS #4230, at Tekoa (discontinued)		135n	2476±
57.4	Washington-Idaho State Line			
61.4	Lolo Creek (R)			

[1] Water surface elevations are at mean flow gaging stations, at normal pool for dams and reservoirs and above and below falls.

[2] Elevation 1290 is normal pool elevation for Franklin D. Roosevelt Lake created by Grand Coulee Dam.

[3] Entering side for tributaries is shown as (R) right or (L) left facing downstream.

[4] Elevation 1279 at USGS Gage 4335 is mean water surface when not influenced by backwater from FDR Lake.

[5] Drainage areas followed by a small "n" are revised calculated area by USGS Tacoma and may not agree with figure published prior to 1964.

[6] Elevation 1536 at Long Lake reservoir is maximum pool, limit of W.W.P. flood easement.

[7] Elevation 1535± at USGS Gage 4260 is mean water surface when not influenced by Long Lake backwater.

[8] Elevation 1554± at USGS Gage 4315 is mean water surface when not influenced by the backwater of Long Lake.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	RIVER MILE INDEX (ABRIDGED) SPOKANE RIVER	TABLE 2C

TABLE 3

STREAM GAGES WITH AVAILABLE
DAILY OR MONTHLY RECORD

River Mile	Location	USGS Gage Number	Period of Record	Presently Operating
Spokane River				
100.7	Port Falls	12-4190-00	1912--	Yes
93.9	Above Roberts Bridge near Otis Drive	12-4195-00	1929--	Yes
89.0	at Greenacres	12-4205-00	1948-1952	No
85.5	at Trent	12-4210-00	1911-1913	No
84.8	below Trent	12-4215-00	1948-1954	No
77.9	below Green Street	12-4220-00	1948-1952	No
72.9	at Spokane	12-4225-00	1891--	Yes
64.2	above 7 Mile Bridge	12-4245-00	1948-1952	No
57.6	below 9 Mile Dam	12-4260-00	1948-1950	No
33.88	at Long Lake	12-4330-00	1939--	Yes
27.5	below Little Falls	12-4335-00	1912-1940	No
Little Spokane River				
46.71	at Scotia	12-4265-00	1948.	No
37.6	at Elk	12-4270-00	1948-1971.	Yes
31.81	at Milan	12-4290-00	1948.	No
23.05	at Chattery	12-4295-00	1948.	No
10.8	at Dartford	12-4310-00	1929-32,1946--	Yes
3.9	near Dartford	12-4315-00	1903-1905, 1948-1952	No
0.6	near Spokane	12-4320-00	1913	No
Branches of the Little Spokane River				
	Wethey Creek near Deer Park	12-4300-00	1948	No
	Deep Creek at Colbert	12-4305-00	1948	No
Hangman Creek				
54.61	at Tekoa	12-4230-000	1904-05	No
0.8	at Spokane	12-4240-000	1948	Yes

TABLE 3 (Continued)

River Mile	Location	USGS Gage Number	Period of Record	Presently Operating
Branches of Hangman Creek				
	North Fork at Tekoa	12-4235-00	1904-1905	No
Deep Creek				
	near Spokane	12-4255-00	1949-1950	No
Chamokane Creek				
	below falls near Long Lake	12-4332-00	1971--	Yes

TABLE 4

STREAM GAGES WITH ANNUAL PEAK
AND/OR LOW FLOW RECORDS ONLY

River Mile	Location	USGS Gage Number	Period of Record: Annual Peak	Period of Record: Low Flow
Little Spokane River				
23.05	at Chatteroy	12-4295-00		1952: 1955--
21.2	below Dragoon Creek	12-4301-50		1952: 1955--
	at Buckeye	12-4302-00		1952: 1955--
	near Buckeye	12-4302-50		1952: 1955--
14.21	above Deadman Creek	12-4303-00		1952-1955
	below Deadman Creek	12-4306-00		1957--
	above Wandemere	12-4307-00		1953--
	Lake Creek below Country Club	12-4312-00		1953--
3.9	near Dartford	12-4315-00		1953: 1956-57; 1961--
0.6	near Spokane	12-4320-00		1920-24: 1930-32, 1947-48; 1953--
Branches of the Little Spokane				
	West Branch near Elk	12-4285-00		1962-63
	Bear Creek near Milan	12-4292-00	1962--	
	Deer Creek near Chatteroy	12-4296-00	1962--	1948; 1952; 1955--
	Mud Creek (branch of Dragoon) near Deer Park	12-4298-00	1954--	
	Dragoon Creek near Chatteroy	12-4301-00		1948; 1952; 1955--
	Deadman Creek near Mead	12-4303-50		1948; 1952; 1955-58; 1960-70
	Bigelow Gulch (branch of Deadman) near Spokane	12-4303-70	1950:1962--	
	Deadman Creek below 395	12-4304-00		1953--
	Deep Creek at Colbert	12-4305-00		1952--
	Wandemere Lake Creek near Dartford	12-4308-00		1953--
	Little Creek at Dartford	12-4311-00	1963--	

TABLE 4 (Continued)

River Mile	Location	USGS Gage Number	Period of Record: Annual Peak	Period of Record: Low Flow
Branches of Hangman Creek				
	Unnamed tributary near Lath	12-4235-50	1961--	
	Unnamed tributary of South Fork of Rock Creek near Fairfield	12-4237-00	1962--	
	Unnamed tributary of Stevens Creek near Moran	12-4239-00	1954--	
Branch of Spring Creek				
	Unnamed tributary near Reardon	12-4333-00	1954--	

TABLE 5

ANNUAL MEAN AND EXTREME FLOWS

Gaging Station (Number)	Drainage Area (Sq. Mi.)	Mean Annual Discharge (cfs)	Max Discharge (cfs)	Min Discharge (cfs)	Mean Discharge per Sq. Mi. (cfsm)
Spokane River near Post Falls, Idaho (12-4190)	3,840	6,557	49,800	88	1.708
Spokane River at Spokane, Wash. (12-4225)	4,290	6,927	49,000	574	1.615
Spokane River at Long Lake, Wash. (12-4330)	6,020	8,381	47,300	114	1,392
Little Spokane River at Dartford, Wash. (12-4310)	665	316	3,170	63	0.475
Little Spokane River at Elk, Wash. (12-4270)	115	56.4	148	26	0.490
Hangman Creek at Spokane Wash. (12-4240)	689	264	20,600	2.3	0.383
Spokane River above Liberty Bridge, Wash. (12-4195)	3880	6,620	33,200	70	1.706

TABLE 6

MAXIMUM, MINIMUM, AND MEAN MONTHLY FLOWS

Gaging Station (Period of Record)	ITEMS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Spokane River at Spokane Wash. (1892 1972)	Max	25,426	16,416	25,380	23,806	29,386	29,900	11,900	4,740	3,300	5,640	13,100	22,906
	Min	1,336	1,486	2,046	4,257	6,820	3,112	1,356	908	1,152	1,300	1,147	1,700
	Mean	5,497	6,082	8,072	14,747	19,069	11,743	3,653	1,916	1,767	2,150	3,374	5,110
Little Spokane River at Dartford, Wash. (1929 1972)	Max	616	1,108	1,211	1,301	1,176	710	331	193	175	234	311	353
	Min	99.6	160	167	170	132	98.2	80.3	67.8	80.3	87.9	113	122
	Mean	276	430	577	692	461	272	168	136	143	164	193	230
Little Spokane River at Elk, Wash. (1949 1971)	Max	69.7	107	110	137	98.7	78.6	64.7	54.0	52.2	56.9	61.2	61.3
	Min	38.6	44.6	47.1	47.2	43.4	38.8	35.4	35.5	35.5	37.0	39.2	4.09
	Mean	51.5	60.2	69.8	83.9	72.5	59.7	49.5	44.7	44.3	45.3	47.1	49.2
Hangman Creek at Spokane, Wash. (1948 1972)	Max	1,574	1,681	1,914	928	1,925	391	37.8	38.1	26.5	32.4	188	1,251
	Min	33.7	225	132	66.8	32.9	15	3.45	2.81	4.06	7.89	15.9	35.7
	Mean	494	803	821	401	250	95.3	22	13.4	13.9	18.4	44.7	197
Spokane River near Post Falls, Idaho (1913 1971)	Max	24,930	16,340	17,110	26,050	31,800	25,600	10,700	2,130	1,840	5,460	13,100	23,660
	Min	996	1,020	1,750	6,819	6,620	1,580	914	184	188	782	667	784
	Mean	5,132	5,963	7,430	14,977	22,039	9.829	1,985	931	1,055	1,682	2,927	4,731
Spokane River at Long Lake, Wash. (1940 1972)	Max	16,430	19,500	21,530	29,410	33,520	25,650	7,951	3,178	3,122	4,327	9,065	15,820
	Min	2,991	4,664	3,966	5,573	7,049	3,932	1,942	1,424	1,476	1,868	2,059	2,341
	Mean	7,011	8,934	10,380	16,498	20,887	12,499	4,571	2,661	2,788	3,704	4,264	6,377
Spokane River above Liberty Bridge, Wash. (1958 1972)	Max	12,590	16,050	24,440	22,540	25,870	21,870	3,351	1,408	1,731	3,281	5,892	14,420
	Min	2,702	2,251	2,890	7,999	8,197	3,253	913	159	356	748	1,729	1,790
	Mean	5,355	8,110	8,710	14,645	18,643	11,074	1,685	690	1,070	1,713	3,241	4,760

TABLE 7

HISTORICAL FLOODS ON THE SPOKANE RIVER

Date	Elevation of Coeur D'Alene Lake	Crest Discharge cfs	Crest Discharge cfs/sq. mile	Runoff for 5 days, inches per square mile on 4350 sq. mi.
# May 20-21, 1893	2,135.1	38,000	9.2	No Record
# May 31, 1894	2,137.6	49,000*	11.3	No Record
# May 17, 1917	2,135.9	41,900	9.6	1.69
# January 4, 1918	2,136.0	39,600	9.1	1.66
# December 22-26, 1933	2,139.0	47,800	11.0	1.90
# April 18-22, 1938	2,134.0	32,700	7.5	1.34

*Doubtful accuracy.

#Source, U.S. Army Corps of Engineers. 1950. Columbia River and Tributaries, Northwestern United States, Volume III. House Document No. 531.

TABLE 8

IMPOUNDMENTS

River Mile	Name	Reservoir Surface Area, Acres	Normal Pool Elev.	STORAGE VOLUMES, ACRE FEET: DEAD STORAGE: Volume	DEAD STORAGE: Below Elevation	LIVE STORAGE: Volume	LIVE STORAGE: Between Elevations: High	LIVE STORAGE: Between Elevations: Low	Total Volume
29.30	Little Falls	250	1362.00	2,000*	1351.00	2,220	1362.00	1351.00	4,220*
33.90	Long Lake	5060	1536.00	149,490	1508.00	105,080	1536.00	1508.00	254,570
58.10	Nine Mile	440	1606.60	7,000*	1590.57	4,600	1606.60	1590.57	11,600*
74.24	Monroe Street	5	1806.00	87*	1806.00	None	--	--	87*
76.20	Control Works (Upper Falls)	136	1870.50	None	1864.30	800	1870.5	1864.30	800
80.2	Spokane Dam	150*	1910.45	--	1889.45	--	1889.45	1910.45	1,500*

*Data unavailable--value shown is estimate.

TABLE 9

HYDROELECTRIC INSTALLATION

Facility	Owner-Operator	Dam River Mile Location	Total Nameplate Ratings		Peak Capability Ratings		Head	
			Kilowatts	cfs	Kilowatts	cfs	Range	Average
Post Falls	WWP	102.10	11,250	3,100	15,000	4,140	47-58	55
Spokane Dam	City	80.20	3,900		4,500			31
Upper Falls	WWP	76.20	10,000	2,450	10,200	2,500	54-64	61
Monroe Street	WWP	74.24	7,200	2,000	7,200	2,000	71-74	73
Nine Mile	WWP	58.10	12,000	3,330	18,000	5,000	56-65	61
Long Lake	WWP	33.90	70,000	6,180	72,500	6,300	154-172	169
Little Falls	WWP	29.30	32,000	6,670	36,000	7,500	66-74	72

TABLE 10

INVENTORY OF LAKES

County	Location Township-Range-Section	Name	Area Acres	Use*
Lincoln Stevens	T27N-R39E 20-B	Little Falls Res.	125.0 Lincoln Co.	
			125.0 Stevens Co.	
			250.0 Total	P,R
Pend Oreille	T30N-R43E 5-K/L	Lost Lk.	22.1	R
	T30N-R43E 8-N	Horseshoe Lk.	128.0	R
	T30N-R43E 9-A	Trout Lk.	94.8	R
	T30N-R43E 32-L	Fan Lk.	72.9	R
	T30N-R44E 3-SE 1/4	Diamond Lk.	754.5	R
	T30N-R44E 35-N 1/2	Chain Lk.	77.6	R
	T30N-R46E 30-M/N	Trask Pond	50.3	R
	T31N-R43E 35-B	Sacheen Lk.	282.2	R
	T31N-R45E 23-S 1/2	Unnamed Lk.	37.9	R
Spokane	T23N-R42E 5-A/H	Fish Lk.	47.1	R
	T23N-R42E 14-NW 1/4	Unnamed Lk.	20.3	R
	T23N-R42E 22-N	Intermittent Lk.	29.2	R
	T23N-R42E 27-C	Intermittent Lk.	24.0	R
	T24N-R40E 13-W 1/4	West Medical Lk.	234.8	R
	T24N-R40E 21-J/R	Unnamed Lk.	29.5	R
	T24N-R40E 27-NW 1/4	Lonelyville Lk.	22.8	R
	T24N-R41E 17-G/H	Silver Lk.	559.1	R
	T24N-R41E 18-W 1/2	Medical Lk.	148.9	R
	T24N-R41E 19-K/Q	Otter Lk.	26.1	R
	T24N-R41E 19-H	Ring Lake	22.9	R
	T24N-R41E 22-N/P	Granite Lk.	105.8	R
	T24N-R41E 22-P	Willow Lk.	79.7	R
	T24N-R41E 26-B	Meadow Lk.	31.9	R
	T24N-R41E 30-SW 1/4	Clear Lk.	374.8	R,I
	T24N-R42E 28-B	Queen Lucas Lk.	36.8	R
	T25N-R43E 18-J	Upper Falls Res.	146.0	P,R
	T25N-R44E 24-F/G	Shelley Lk.	35.6	R
	T25N-R45E 22-H	Liberty Lk.	711.4	R
	T26N-R40E 10-SW 1/4	Horseshoe Lk.	67.9	R
	T26N-R40E 10-G/K	Woods Lk.	32.0	R
	T26N-R42E 6-R	Nine Mile Res.	440.0	P,R
	T27N-R41E 7-K/L	Knight Lk.	34.0	R
	T28N-R43E 15-G/K	Bear Lk.	33.8	R
	T29N-R42E 34-K/Q	Dragoon Lk.	22.4	R,I
	T29N-R43E 15-L	Eloika Lk.	659.2	R
	T29N-R44E 19-J	Reflection Lk.	51.8	R
	T26N-R45E 11-G	Newman Lk.	1190.2	R
	T27N-R39E 13-M	Long Lk. (Res.)	2510.0 Spokane Co.	
			100.0 Lincoln Co.	
			2410.0 Stevens Co.	
			5020.0 Total	P,R

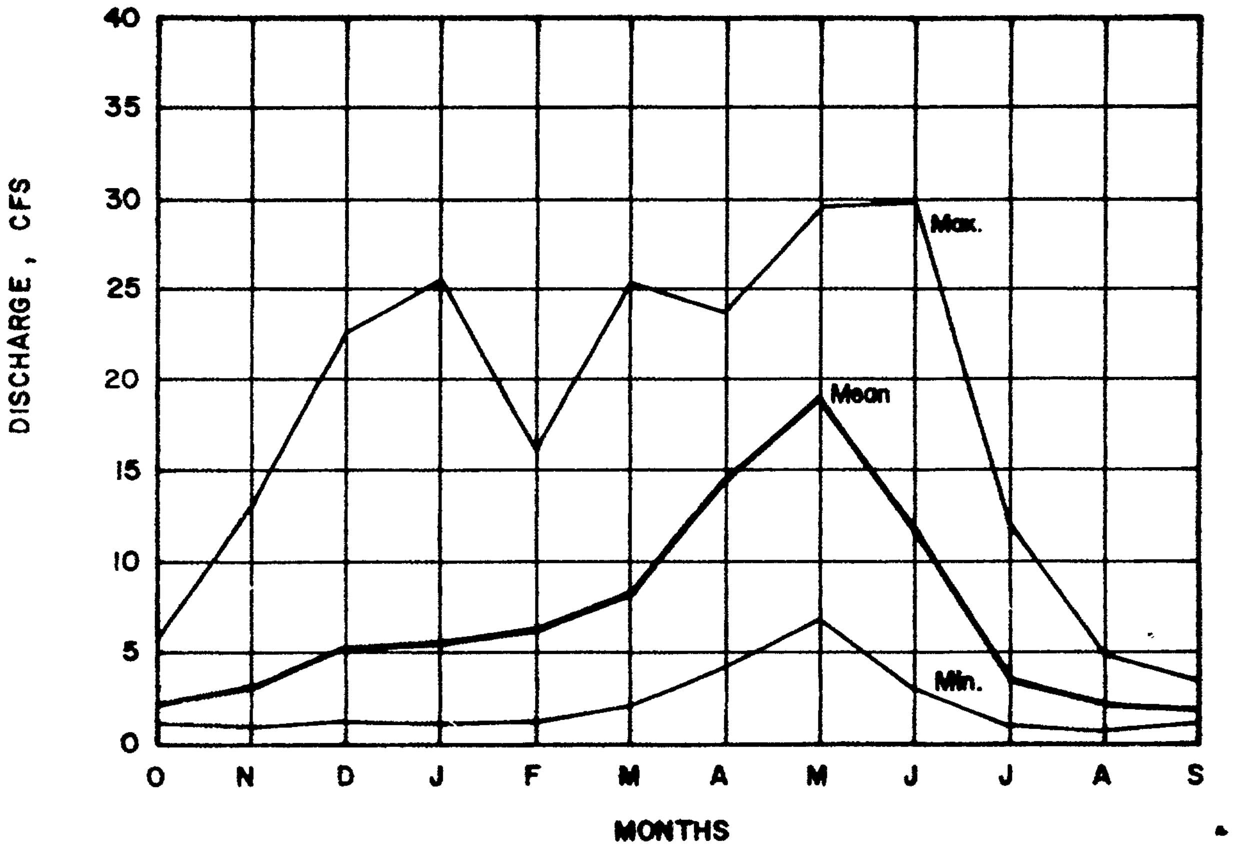
*P=Power, R=Recreation, I=Irrigation

TABLE 11

CHARACTERISTICS OF MAJOR LAKES*

Lake Name (Gage No.)	Lake Area (Acres)	Elevation (ft. msl)	Max. Depth (ft.)	Drainage Area (sq. mile)	Gage Height Range Max.(ft.)	Gage Height Range Min.(ft.)	Max. Gage Variation ft.	Level Record
Newman Lake (12-4198)	1,190.2	2124	30 #	28.6	11.4	7.20	4.24	1958--
Liberty Lake (12-4200)	711.4	2053	26 #	13.3	51.28	46.34	4.94	1950--
Diamond Lake (12-4275)	754.5	2360	58 #	6.1	4.95	2.96	1.99	1953--
Sacheen Lake (12-4280)	282.2	2250	40 #	33.5	6.46	3.61	2.85	1954--
Eloika Lake (12-4285)	659.2	1920	15 #	101.0	7.77	2.32	5.45	1953--
Horseshoe Lake	128.0	1975	140 #					
West Medical Lake	234.8	2423	35					
Silver Lake	559.1	2341	80					
Medical Lake (12-4250)	148.9	2394	60					1953-58.
Granite Lake	105.8	2381	--					
Clear Lake	374.8	2342	110					

*Exclusive of man-made lakes.
#Indicates that a bathymetric map is available in Woolcott (1964).

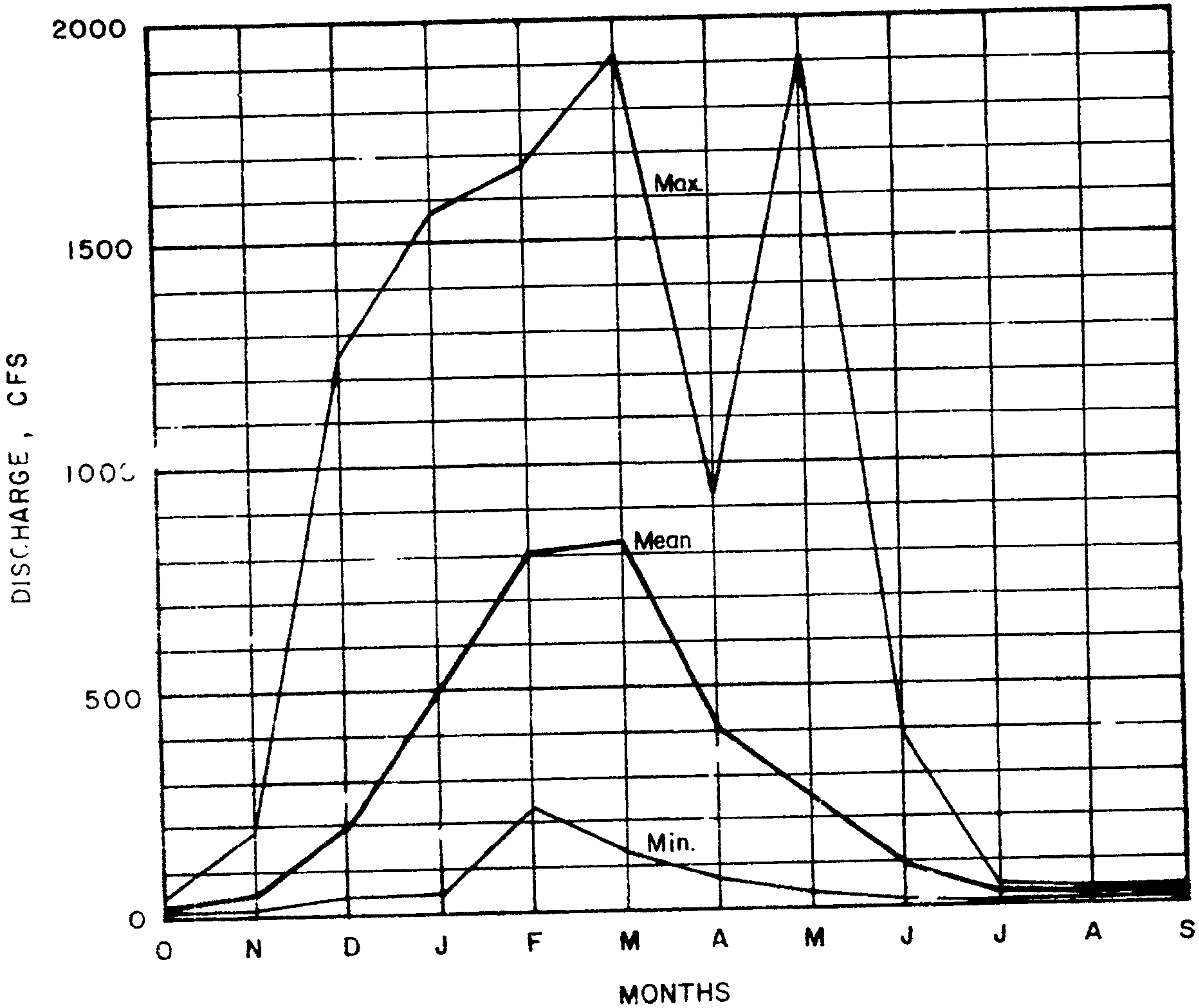


MAX.	MONTH	29,900 CFS
MAX.	YEAR	10,361 CFS
MEAN	ANNUAL	6,927 CFS
MIN.	MONTH	908 CFS
MIN.	YEAR	2,974 CFS

DRAINAGE AREA 4290 SQ.MI.

MEAN ANNUAL RUNOFF 21.92 INCHES

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy – Tudor Consulting Engineers	MAXIMUM, MINIMUM AND MEAN MONTHLY DISCHARGES SPOKANE RIVER AT SPOKANE	FIG. A

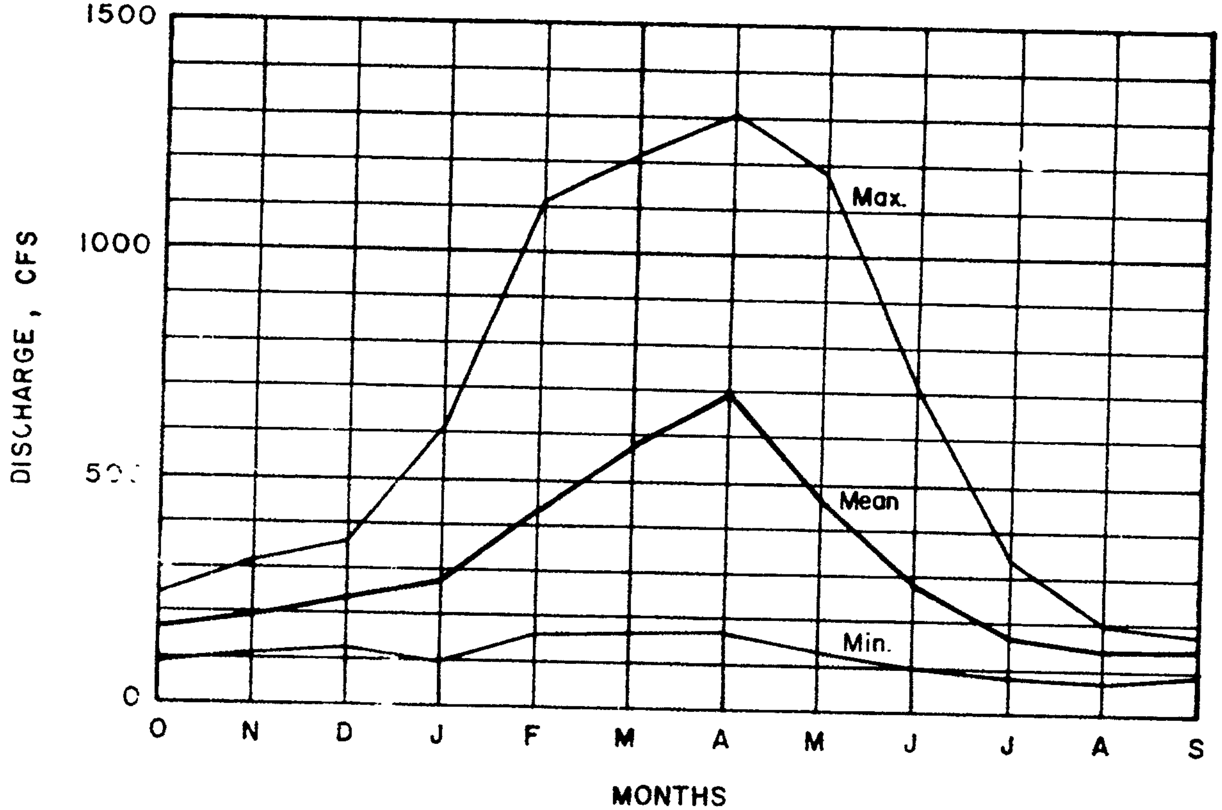


MAX. MONTH = 1,925 CFS
MAX. YEAR = 432 CFS
MEAN ANNUAL = 264 CFS
MIN. MONTH = 2.81 CFS
MIN. YEAR = 111 CFS

DRAINAGE AREA = 689 SQ.MI.

MEAN ANNUAL = 5.2 INCHES

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	MAXIMUM, MINIMUM AND MEAN MONTHLY DISCHARGES HANGMAN CREEK AT SPOKANE	FIG. B



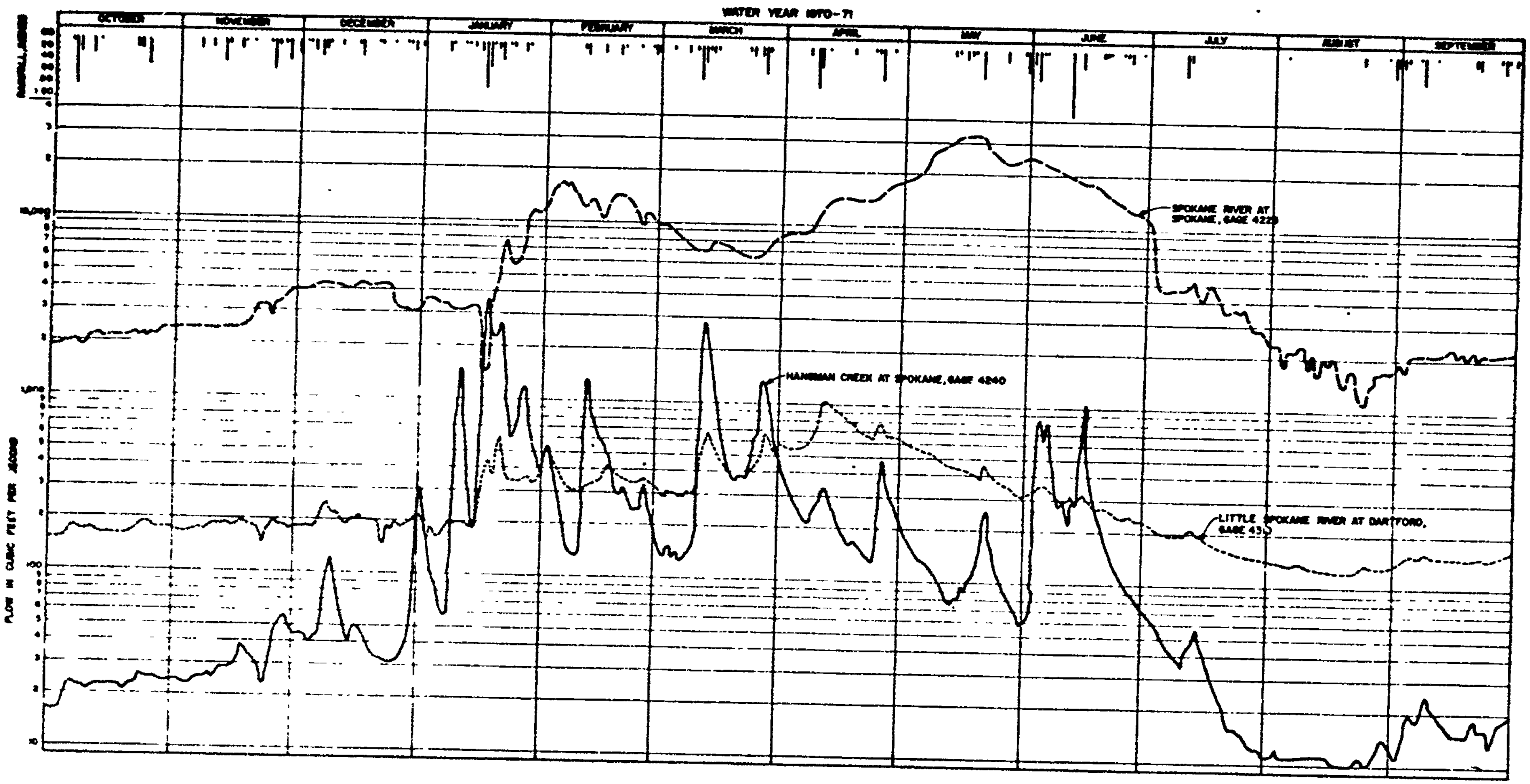
MAX. MONTH = 1,301 CFS
MAX. YEAR = 443 CFS
MEAN ANNUAL = 316 CFS
MIN. MONTH = 67.8 CFS
MIN. YEAR = 128 CFS

DRAINAGE AREA = 665 SQ.MI.

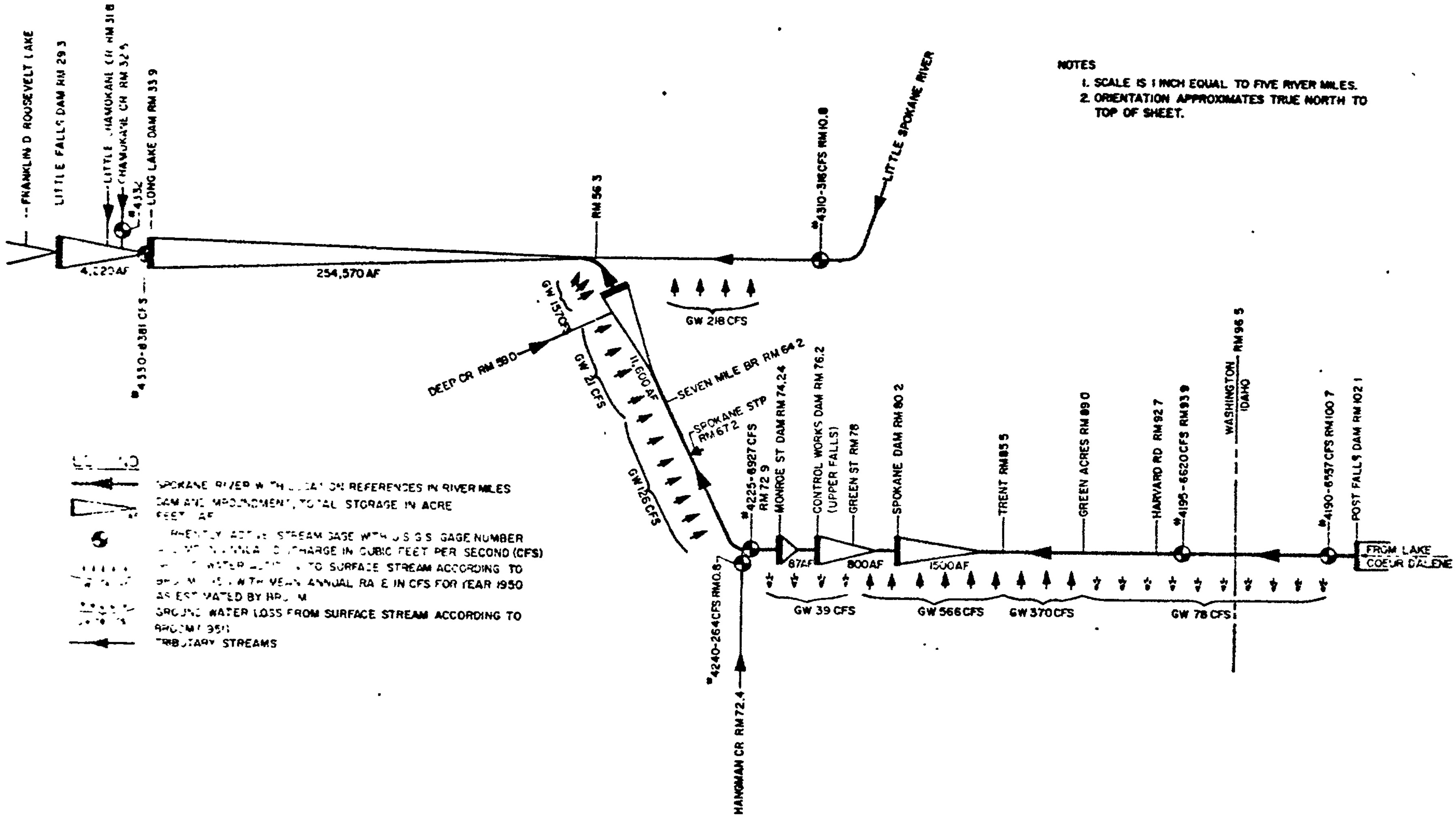
MEAN ANNUAL = 6.45 INCHES

308-59

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	MAXIMUM, MINIMUM AND MEAN MONTHLY DISCHARGES LITTLE SPOKANE RIVER AT DARTFORD	FIG. C



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION ... of the Army, Seattle District Corps of Engineers K... ...ly-Tudor Consulting Engineers	COMPARISON ANNUAL FLOW PATTERN 1972 SPOKANE RIVER AT SPOKANE HANGMAN CREEK AT SPOKANE LITTLE SPOKANE RIVER AT DARTFORD	FIG. D



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SCHEMATIC FLOW DIAGRAM OF THE STUDY AREA	FIG. E

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APPENDIX I

STORAGE VOLUME VERSUS STAGE
FOR COEUR D'ALENE LAKE

Stage Elevation Feet	Storage Volume Above Elevation 2120.80 Second Foot Days	Acre Feet
2138.00	377,300	747,100
2137.00	349,400	691,800
2136.00	321,600	636,800
2135.00	294,000	582,100
2134.00	266,500	527,700
2133.00	239,200	473,600
2132.00	212,100	420,000
2131.00	185,400	367,100
2130.00	159,000	314,800
2129.00	133,300	263,900
2128.00	108,500	214,800
2127.00	87,100	172,500
2126.50	78,400	155,200
2126.00	70,900	140,400
2125.00	57,000	112,900
2124.00	43,300	85,700
2123.00	29,700	58,800
2122.00	16,200	32,100
2121.00	2,700	5,300
2120.80	0	0

Data Source: Washington Water Power Company

APPENDIX II

STAGE-DISCHARGE RELATIONSHIP FOR POST FALLS DAM AND COEUR D'ALENE LAKE OUTLET

Stage Elevation	Discharge Capacity of Post Falls Dam with All Gates Open, cfs	Discharge Capacity of Coeur D'Alene Lake Outlet, cfs
2139.05		47,800*
2138.00		45,400
2136.00		36,500
2134.00		30,900
2132.00		25,500
2130.00		20,200
2129.50	47,800**	
2128.00	34,810***	15,000***
2126.00	27,240	9,500
2124.00	20,090	5,500
2122.00	13,360	2,600
2120.00	7,550	800
2118.00	2,860	0

Notes

1. The discharge capacity of Post Falls Dam gates is related to the stage elevation in the Post Falls forebay which can be substantially equal to lake stage only under controlled flow conditions, that is up to elevation 2128.

2. For lake stages up to 2128, discharge can be controlled by Post Falls. For lake stages above 2128, the lake outlet controls. Maximum controlled flow is 15,000 cfs.

3. Data are from Washington Water Power Company.

*Highest observed lake stage, December 1933.
**Observed stage in Post Falls Forebay, December 1933.
***Top of Post Falls gates in closed position.

APPENDIX III

STORAGE VOLUME VERSUS STAGE FOR
LONG LAKE RESERVOIR

Stage Elevation Feet	Storage Volume Above Elevation 1512 Second Foot Days	Acre Feet	Surface Area Acres
1,536	52,540	104,000	5,010
1,535	50,010	99,000	4,950
1,534	47,510	94,100	4,870
1,533	45,050	89,200	4,810
1,532	42,620	84,400	4,790
1,531	40,200	79,600	4,750
1,530	37,800	74,800	4,750
1,529	35,400	70,100	4,750
1,528	33,000	65,300	4,550
1,527	30,700	60,700	4,550
1,526	28,400	56,200	4,360
1,525	26,200	51,900	4,360
1,524	24,000	47,500	4,360
1,523	21,800	43,164	4,360
1,522	19,600	38,800	4,160
1,521	17,500	34,700	4,160
1,520	15,400	30,500	3,960
1,519	13,400	26,500	3,960
1,518	11,400	22,600	3,960
1,517	9,400	18,600	3,760
1,516	7,500	14,850	3,760
1,515	5,600	11,100	3,760
1,514	3,700	7,300	3,760
1,513	1,800	3,600	3,560
1,512	0	0	3,560

Data Source: Washington Water Power Company

APPENDIX IV

COEUR D'ALENE LAKE AND LONG LAKE
RULE CURVES

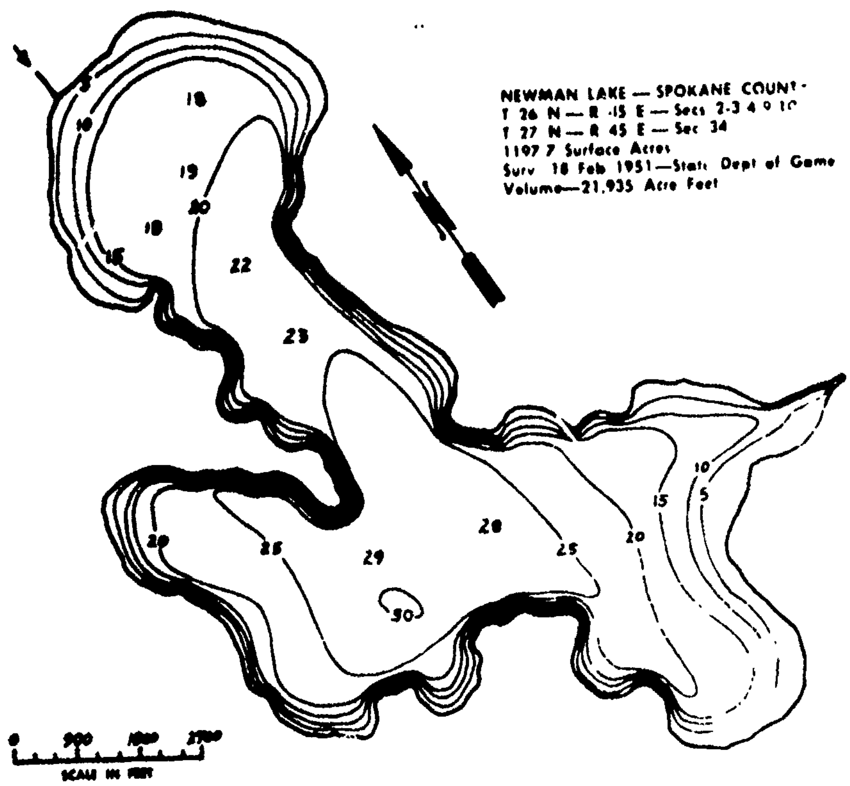
Elevation -- Feet

Coeur D'Alene Lake	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Adverse Water	2128.0	2127.5	2126.3	2124.6	2122.8	2122.2	2120.5	2120.5	2120.5	2124.0	2126.5	2128.0
Median Water	2128.0	2127.5	2126.3	2124.6	2122.8	2122.2	2122.6	2122.9	2125.5	2130.3	2128.5	2128.0

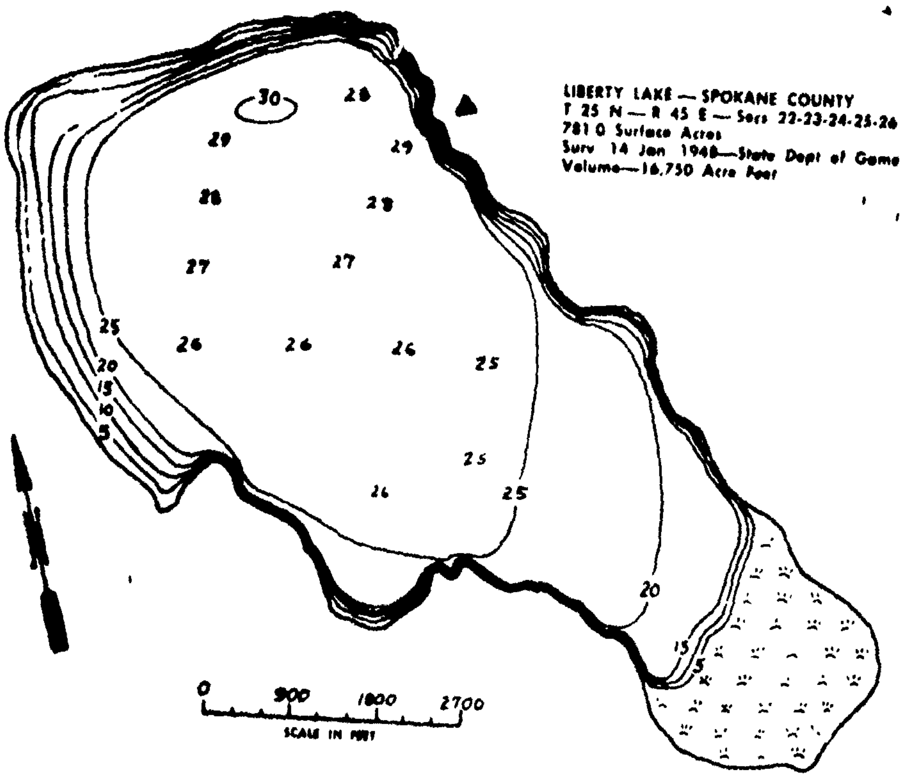
Note: Fill at Coeur D'Alene beginning in January under median water conditions is due to channel restriction.

Long Lake	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Adverse and Median Water	1536.0	1536.0	1535.5	1535.5	1535.5	1535.5	1524.7	1512.0	1512.0	1535.5	1536.0	1536.0

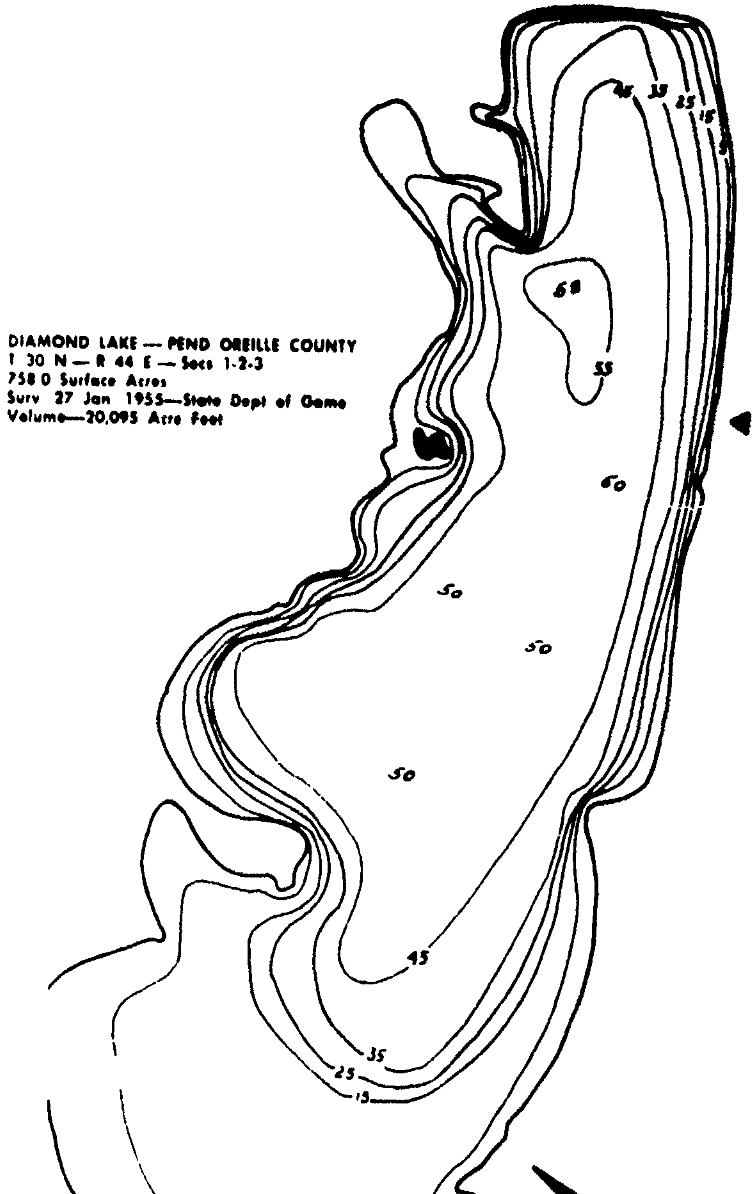
Data Source: Washington Water Power Company.



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BATHYMETRIC MAP NEWMAN LAKE	APPENDIX V - A



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BATHYMETRIC MAP LIBERTY LAKE	APPENDIX V-B



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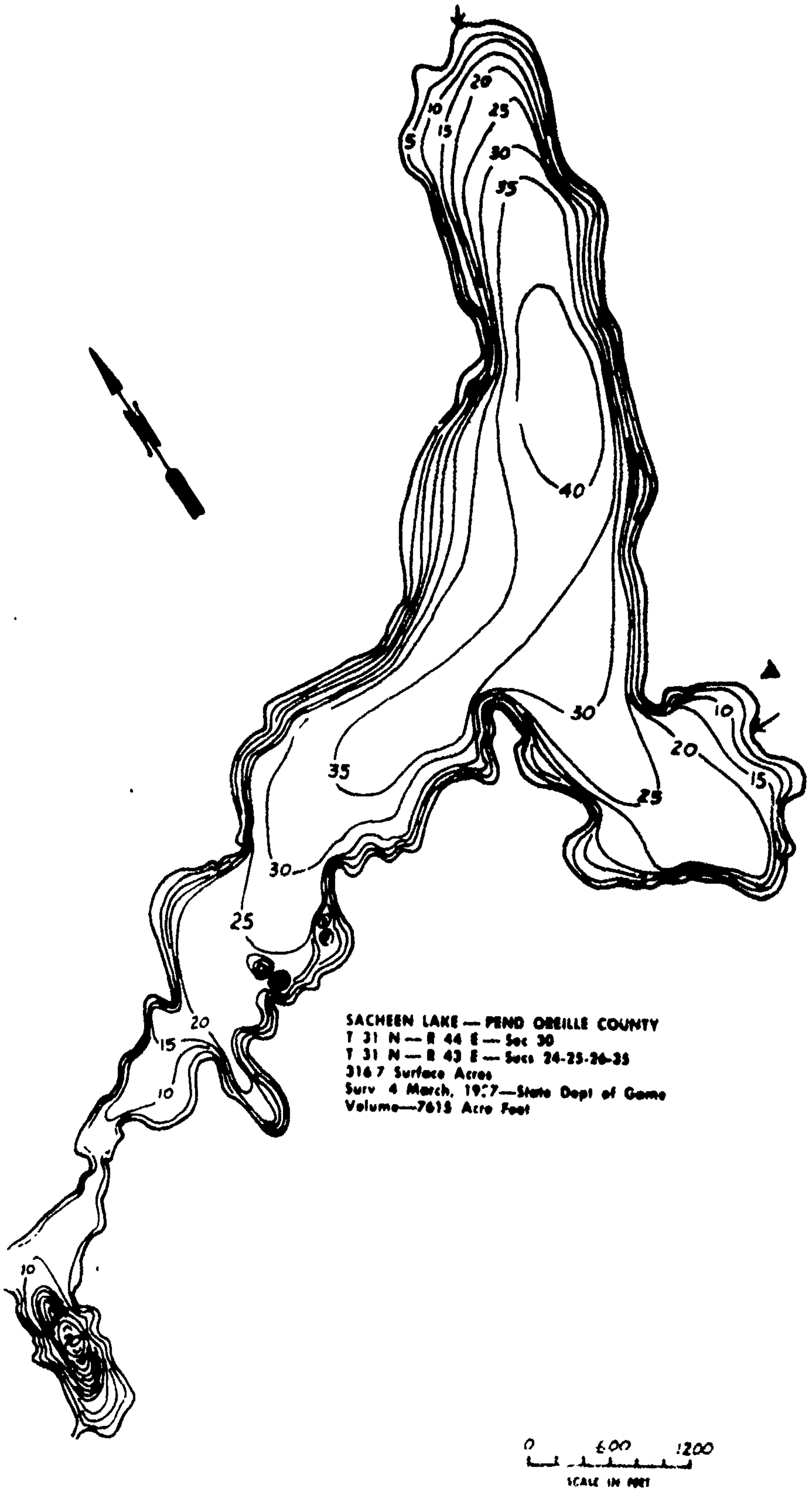
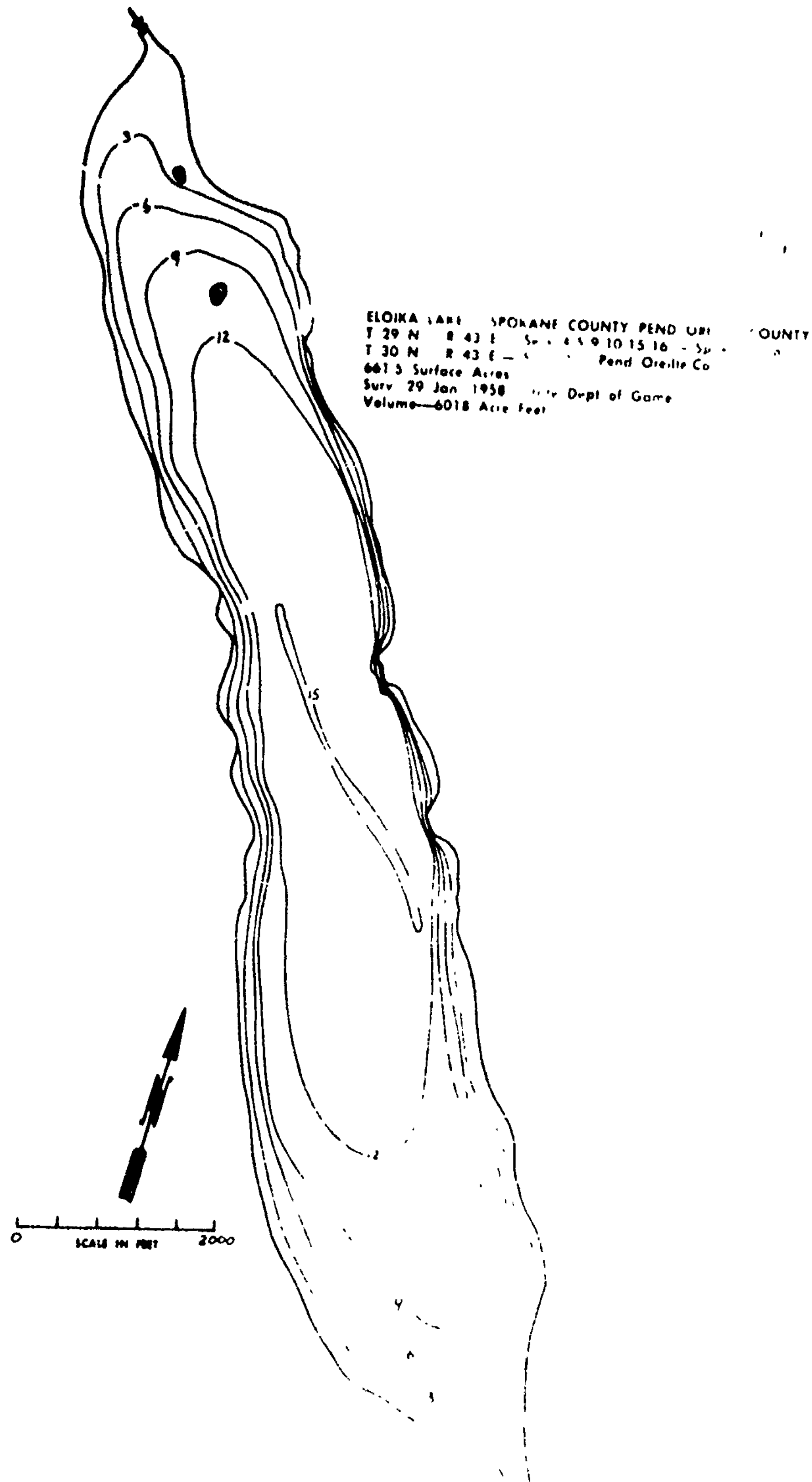


WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BATHYMETRIC MAP SACHEEN LAKE	APPENDIX V-D



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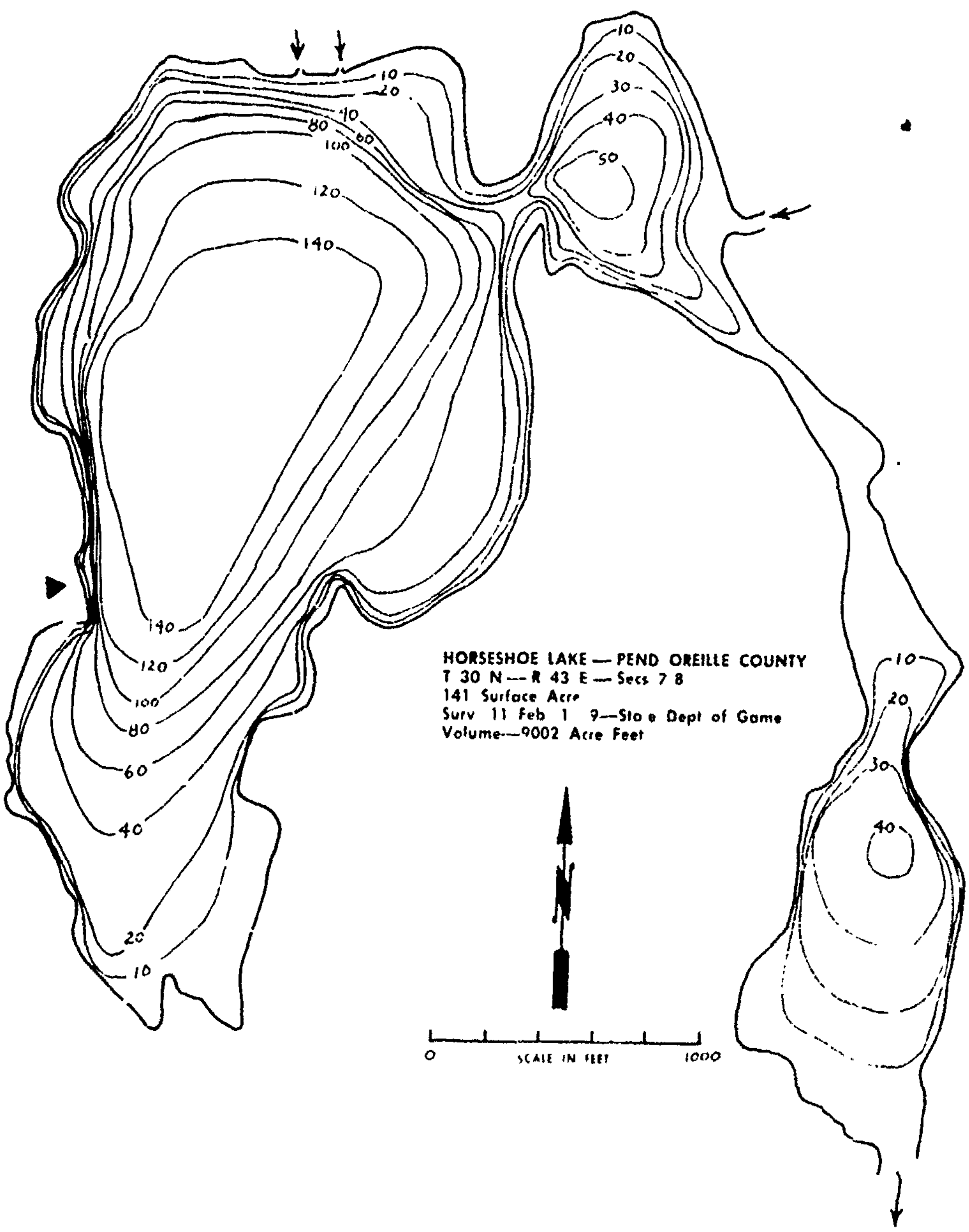
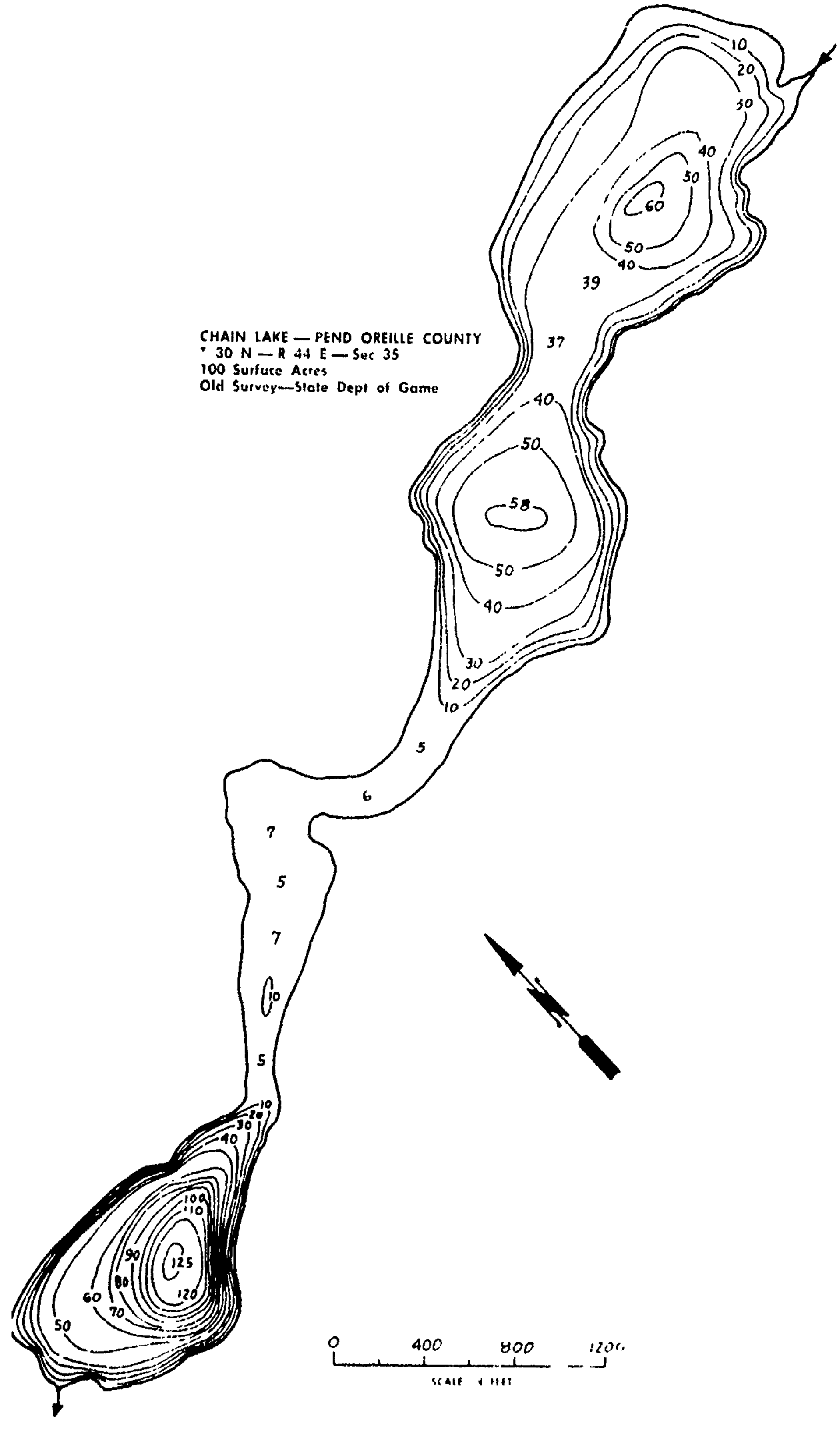


WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	**BATHYMETRIC MAP** **HORSESHOE LAKE**	**APPENDIX** **V-F**



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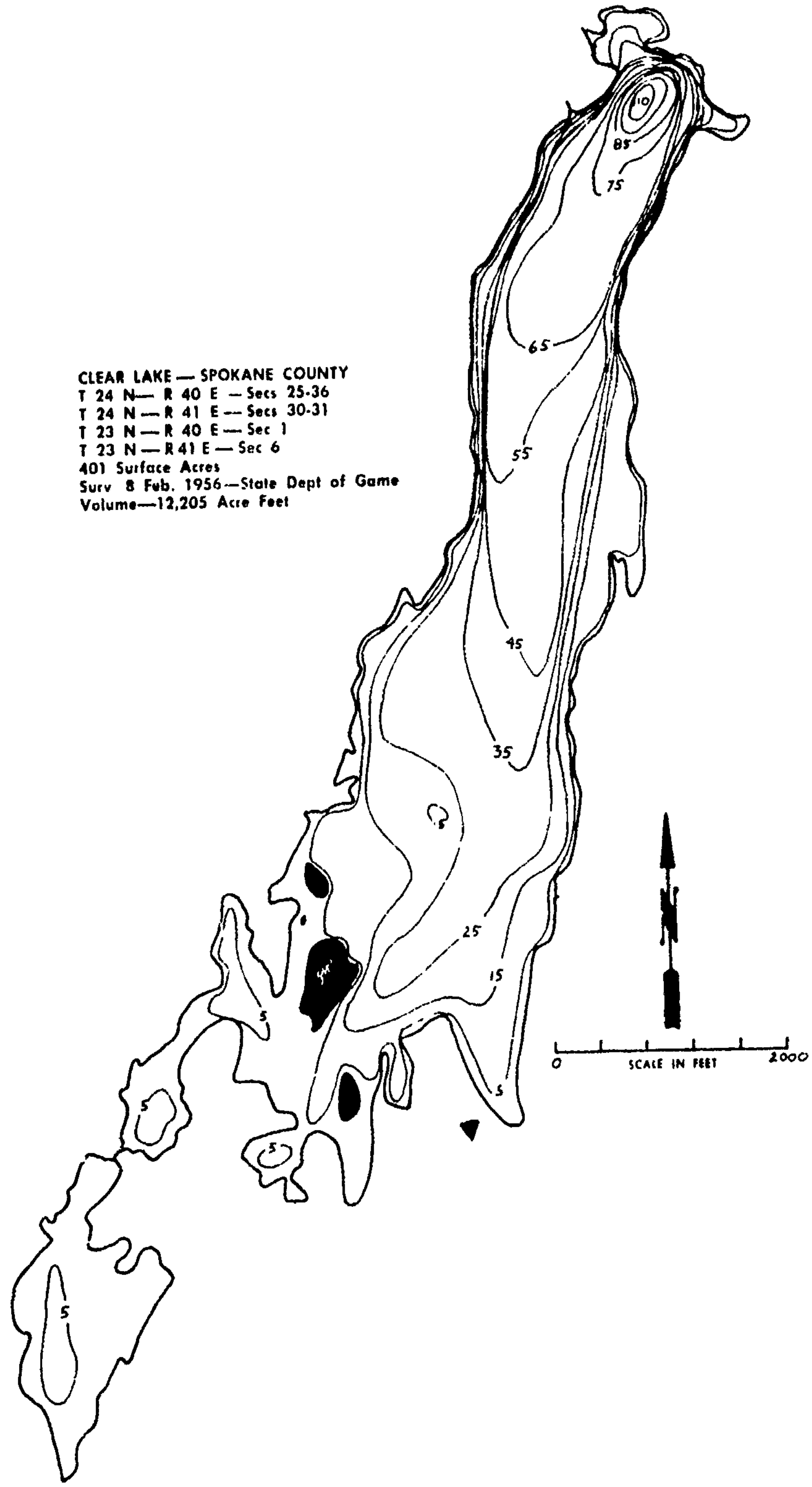
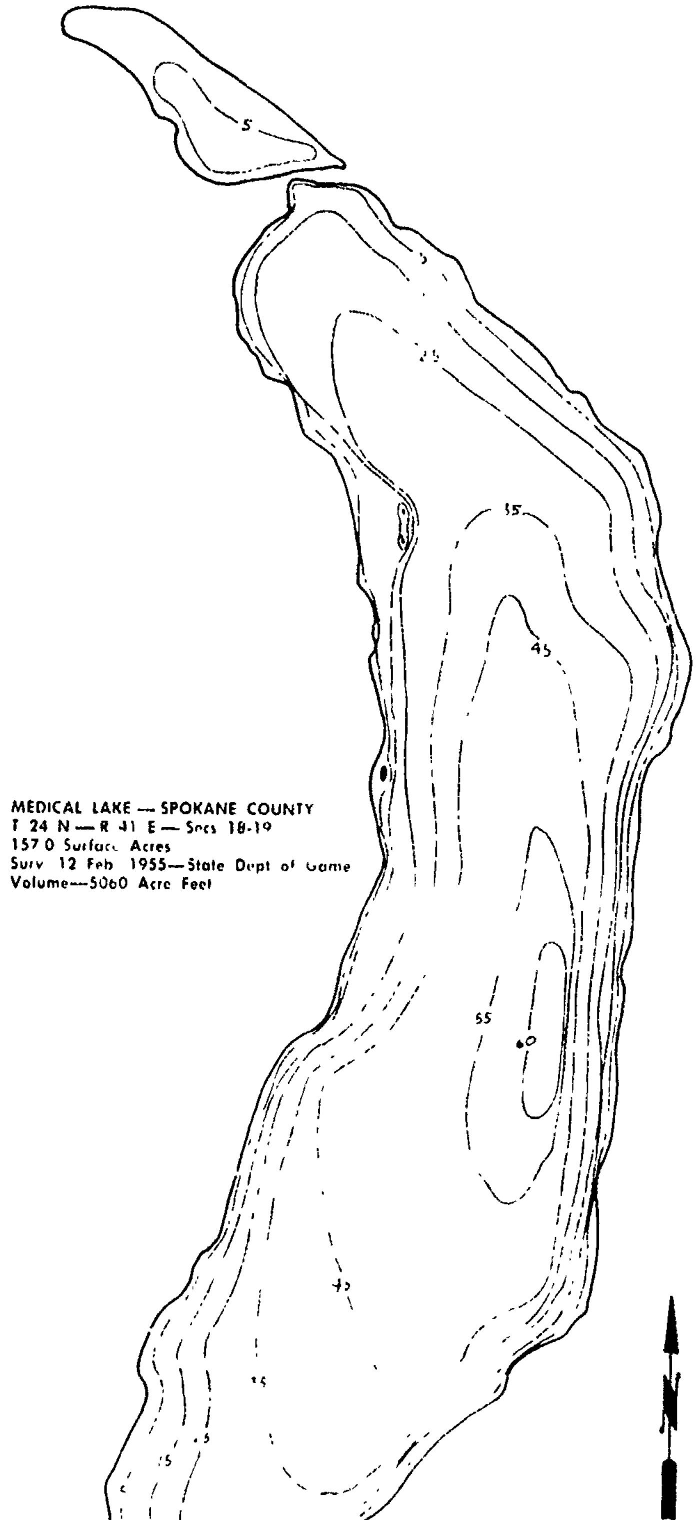
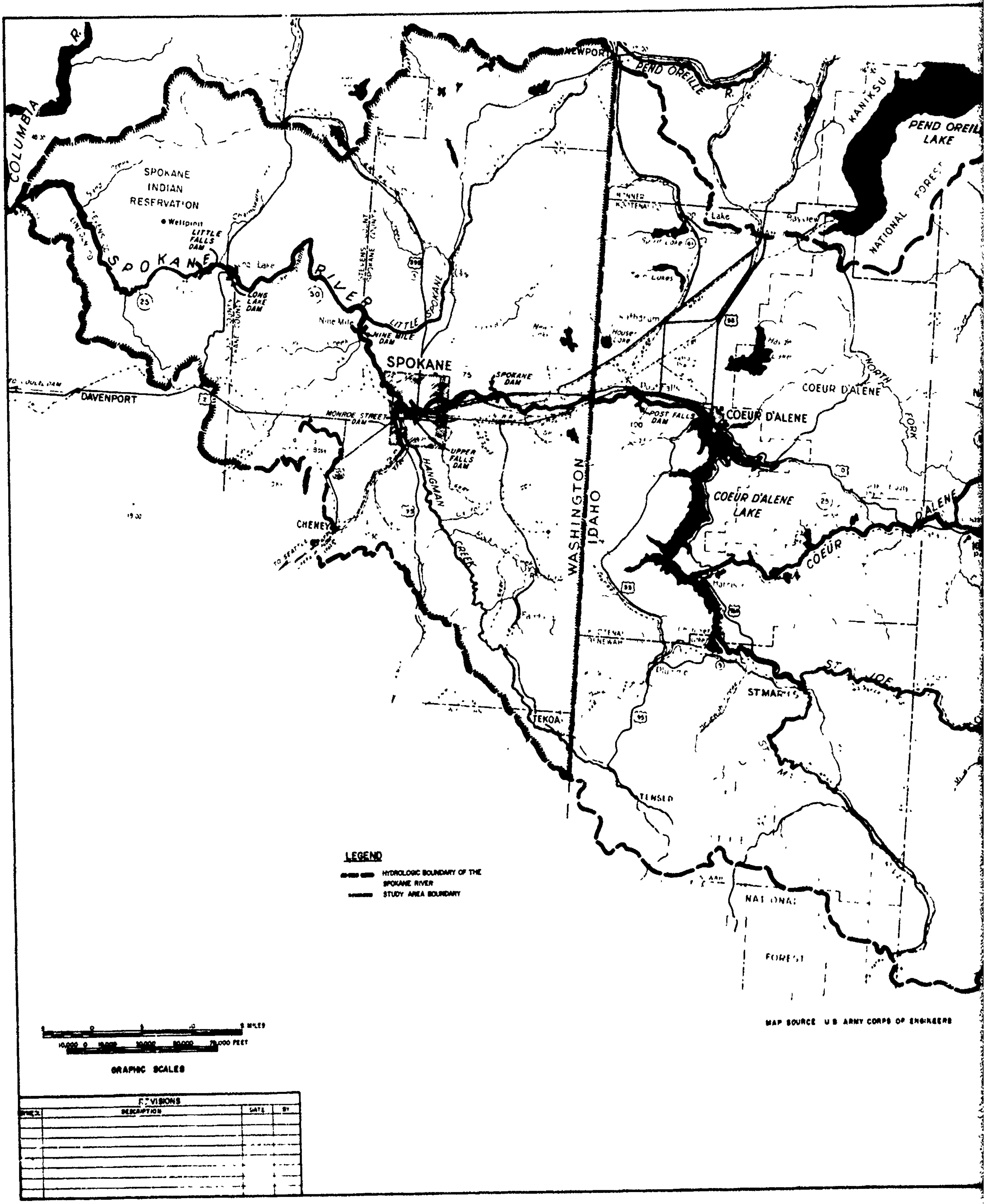


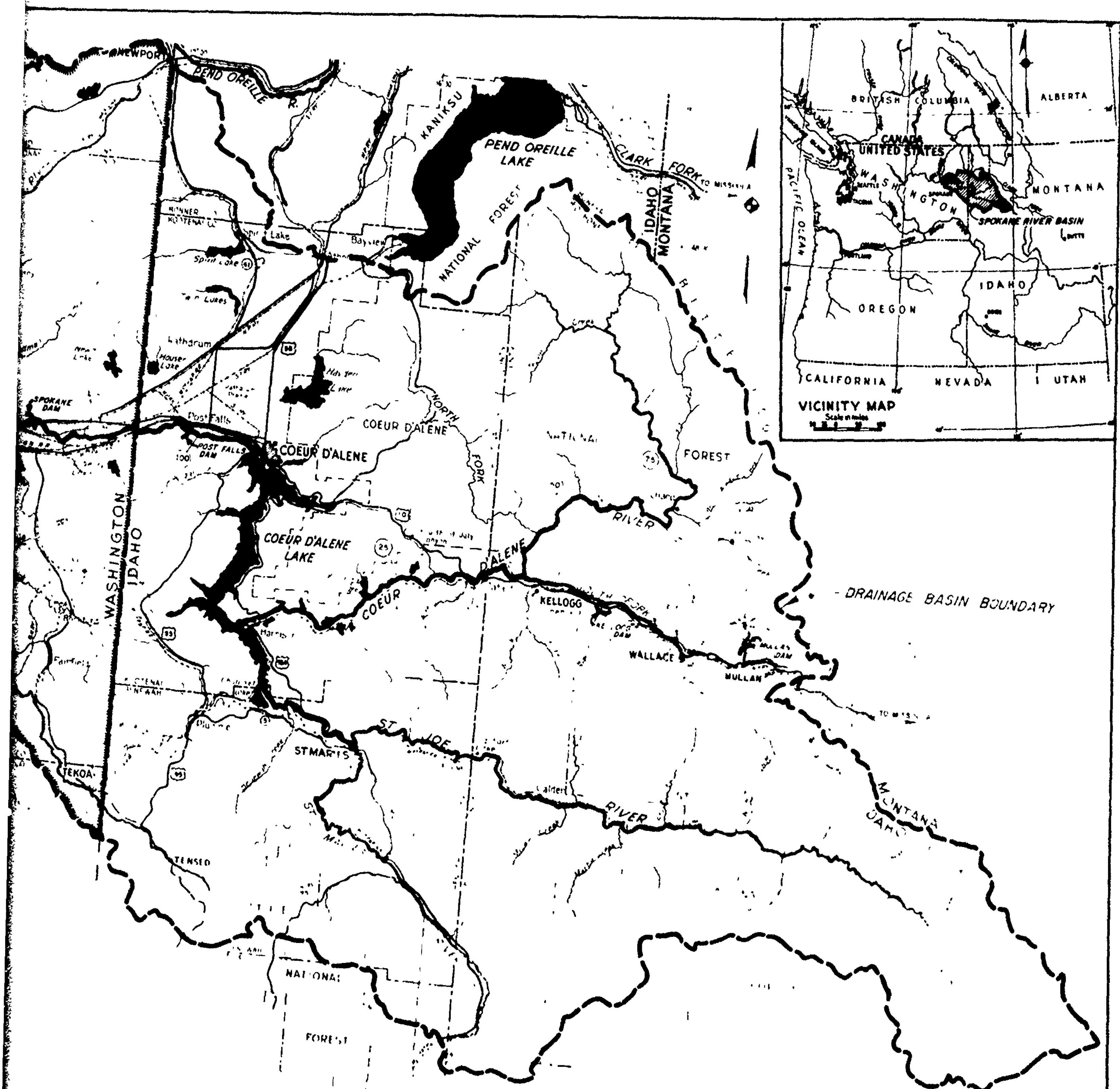
WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	**BATHYMETRIC MAP** **CLEAR LAKE**	**APPENDIX** **V-H**



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BATHYMETRIC MAP MEDICAL LAKE	APPENDIX V-I

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BATHYMETRIC MAP SILVER LAKE	APPENDIX V - J


COLUMBIA R.
NEWPORT
PEND OREILLE R.
KANIKSU
NATIONAL FOREST
PEND OREILLE LAKE
SPOKANE INDIAN RESERVATION
Wellpinit
LITTLE FALLS DAM
SPOKANE RIVER
LONG LAKE DAM
LITTLE SPOKANE
Nine Mile
NINE MILE DAM
SPOKANE
SPOKANE DAM
DAVENPORT
MONROE STREET DAM
UPPER FALLS DAM
HANGMAN CREEK
CHENEY
WASHINGTON
IDAHO
Post Falls
POST FALLS DAM
COEUR D'ALENE
NORTH FORK
COEUR D'ALENE LAKE
COEUR D'ALENE
ST. JOE
ST MARIES
TEKOA
TENSED
NATIONAL FOREST
LEGEND
HYDROLOGIC BOUNDARY OF THE SPOKANE RIVER
STUDY AREA BOUNDARY
GRAPHIC SCALES
MAP SOURCE U.S. ARMY CORPS OF ENGINEERS
REVISIONS
DESCRIPTION
DATE
BY



MAP SOURCE: U.S. ARMY CORPS OF ENGINEERS

KENNEDY TUDOR
CONSULTING ENGINEERS
SEATTLE WASHINGTON

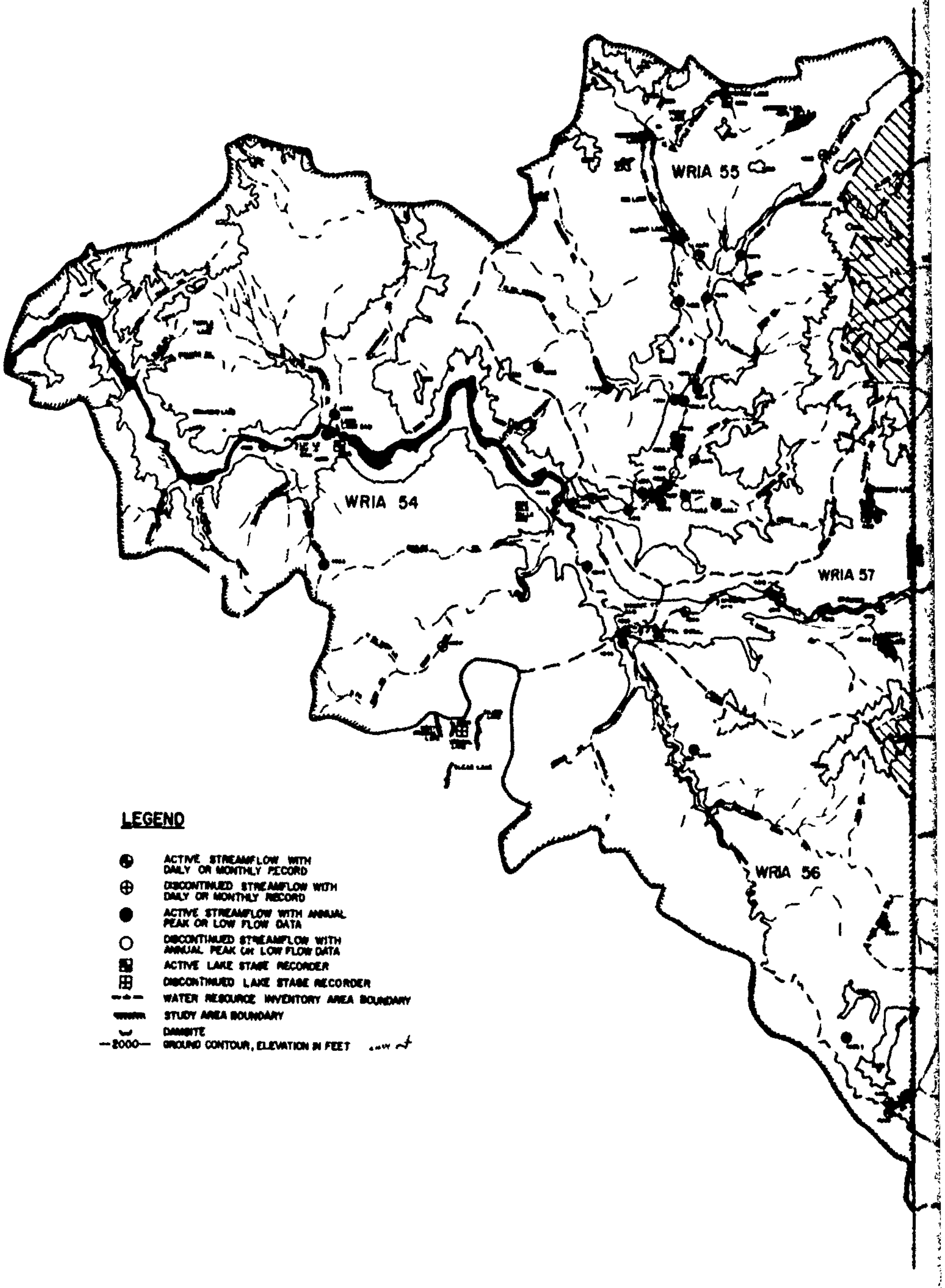
U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE WASHINGTON

WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION

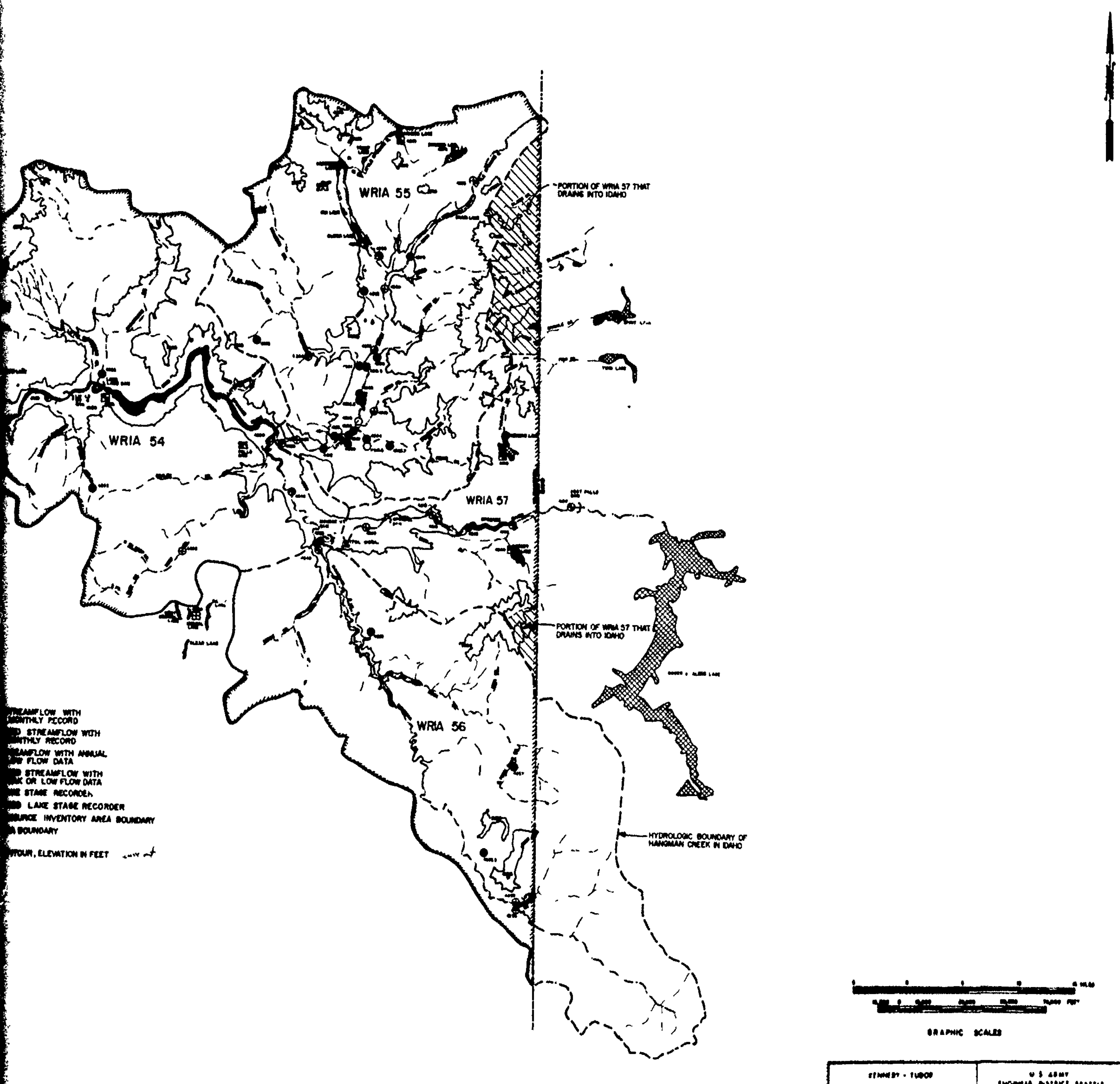
HYDROLOGIC BASIN
OF THE SPOKANE RIVER

DACW67 73-C-0006

PLATE 308-1


WRIA 55
WRIA 54
WRIA 57
WRIA 56
LEGEND
ACTIVE STREAMFLOW WITH DAILY OR MONTHLY RECORD
DISCONTINUED STREAMFLOW WITH DAILY OR MONTHLY RECORD
ACTIVE STREAMFLOW WITH ANNUAL PEAK OR LOW FLOW DATA
DISCONTINUED STREAMFLOW WITH ANNUAL PEAK OR LOW FLOW DATA
ACTIVE LAKE STAGE RECORDER
DISCONTINUED LAKE STAGE RECORDER
WATER RESOURCE INVENTORY AREA BOUNDARY
STUDY AREA BOUNDARY
DAMSITE
—2000— GROUND CONTOUR, ELEVATION IN FEET

REVISIONS			
	DESCRIPTION	DATE	BY



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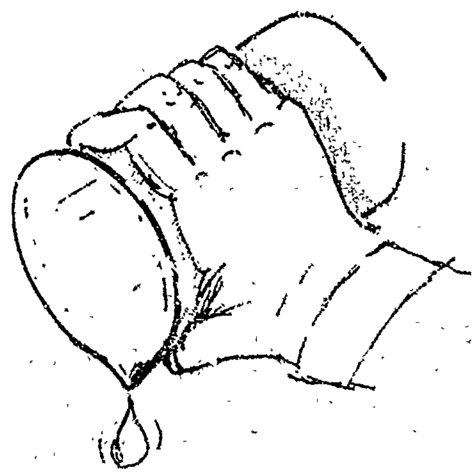
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON.

WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION

WATER RESOURCE
INVENTORY AREAS AND
GAGING STATION LOCATIONS

DACW67 73-C-0096

PLATE
308-2



SECTION 404

SURFACE WATER QUALITY SUMMARY AND EVALUATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 404

SURFACE WATER

QUALITY SUMMARY AND EVALUATION

19 May 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

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SECTION 404

SURFACE WATER QUALITY SUMMARY AND EVALUATION

Scope and Objectives

Sources of water quality data for the study area are summarized in Section 307-9. These data are scattered through numerous publications, including the Storet printout, and cover a wide variety of parameters at many locations over a period of years. It is the objective of this section to summarize recent data for a limited number of parameters of primary interest in a logical order to provide a concise overview of surface water quality.

The specific locations selected for surface water quality summary are as follows:

1. Spokane River below Little Falls Dam (RM 29)
2. Spokane River below Long Lake (RM 33.3)
3. Spokane River at Long Lake
4. Spokane River at Bowl & Pitcher (RM 66.2)
5. Spokane River at Ft. Wright Br. (RM 69.8)
6. Spokane River above Hangman Creek Confluence (RM 72.9)
7. Spokane River at Idaho state line (RM 96.5)
8. Hangman Creek at Mouth
9. Little Spokane River at Mouth (RM 1.1)
10. Little Spokane River at Dartford (RM 10.6)
11. Liberty Lake
12. Newman Lake

The water quality parameters selected for summary at each of these locations, where available, are as follows:

1. Temperature
2. Dissolved oxygen
3. BOD
4. Total phosphate
5. Ammonia
6. Total nitrogen
7. Total coliform
8. Zinc

Most parameters show significant variation in concentration with the seasons of the year. Therefore, summaries are prepared as mean values for three-month periods rather than on an annual basis for river stations and on a monthly basis for the natural lakes.

In general, only data taken 1970 and later are used in computing mean values to produce a picture of current conditions. In the case of the Little Spokane River and Newman Lake where recent data was not available, the data period is extended back to 1968.

It is not the purpose of this section to repeat the wide spectrum parameter data reported in sections 607.1 and 607.2 and covering only two specific dates. The purpose of this section is to show year around data for a limited number of parameters.

Sources of Data

The specific data sources from which the summaries in this section are taken are as follows (refer to List of References for complete identification of publications):

Publications

Bishop and Lee (1972)

Burkhalter et al (1970)

Condit (1972)

Funk (1973)

Lee (1969)

U.S. Geological Survey (1972)

U.S. Geological Survey (1973)

Other Sources

U.S. Environmental Protection Agency; STORET retrieval system.

Washington Water Power Co., unpublished temperature and dissolved oxygen observations on Long Lake, June-Oct. 1973.

Soltero, et al (1973) unpublished data supporting the published document.

Kennedy-Tudor sampling and analysis for this study as reported in Sections 607.1 and 607.2.

Appendices I through XII list the individual observations from the above listed sources which were used to compute the mean values shown in Tables 1 through 12. An exception is that unpublished data from Soltero at Spokane RM 69.8 and Little Spokane RM 1.1 are included in the calculated mean but not shown in the Appendix.

There are extensive data on Long Lake presented graphically in Soltero et al 1973 and Soltero et al 1974 which are not utilized in this summary for two reasons. First, it is judged preferable to refer to the original document for the complex relationships shown in these documents which could be lost or distorted in summary. Secondly, the graphical presentation and absence of original data in tabular form make translation to tabular form difficult and uncertain.

Data Summaries

Mean values for three-month periods for each parameter, where available, are shown for seven Spokane River locations in Tables 1 through 7, one Hangman Creek location in Table 8, and two Little Spokane River locations in Tables 9, 10. For the two natural lakes, Liberty and Newman, mean values by month at various depths are presented in Tables 11 and 12.

For the Spokane River, the tabular data are presented as quality profiles in Figures A through H. One parameter is presented on each figure, with a separate profile for each three-month time period.

Interpretation of Data

Spokane River. The quality of the Spokane River as it enters the study area from Idaho is a product of the quality of the Coeur D'Alene and St. Joe Rivers and their combined passages through Coeur D'Alene Lake. The two most significant quality changes to the incoming waters are pick-up of zinc from mine tailings on the Coeur D'Alene

River and the summer temperature increase due to passage through Coeur D'alene Lake. The entering stream does not meet coliform standards for most of the year, probably due to the treated municipal effluent from the City of Coeur D'Alene. Refer to Table 7. In general, the water is of high quality and meets drinking water standards for all parameters except coliform count.

There are four tributary sources to the Spokane River after it enters the study area which have a significant impact on quality, in addition to the inherent in-stream physical, chemical and biological processes. In the reach from the stateline at RM 96.5 to the Hangman Creek confluence at RM 72.9 there is a groundwater increment estimated at 500 to 600 cfs. This groundwater stream differs in quality from the surface flow in a number of significant ways.

1. The temperature is relatively constant at approximately 10° C.
2. Higher nitrates at 1.6 mg/l.
3. Lower zinc at 26 μg/l.

The effect of the groundwater inflow would be expected to be a maximum when surface flows were at a minimum. The temperature reduction in July-Sept is evident in Figure A and the zinc reduction throughout most of the year as shown in Figure H. There is, however, no evidence in Figure F of an increase in nitrate at the expected time.

In addition to the groundwater inflow between RM 96.5 and 72.9, there are cooling water and industrial waste discharges and intermittant overflows from the Spokane combined sewer system. The seasonal means tabulated herein show no significant evidence of these flows.

Hangman Creek joins the Spokane River at RM 72.9. The relative volume of this flow is very small at most times. Significant flows from Hangman Creek almost always occur when the Spokane River is also at high stage. The heavy silt load carried by Hangman Creek at flood stage is the most significant quality difference between Hangman Creek and the Spokane River. Other differences are higher ammonia throughout the year ranging from 0.104 to 0.642 mg/l, and higher total nitrogen at 1.38 to 2.61 mg/l. These ammonia and total nitrogen values are up to ten times higher than concentrations in the Spokane River. Phosphorus is also higher, at .085 to .395 mg/l; again the higher values being over ten times those in the Spokane River. As would be expected, the zinc levels are lower in Hangman Creek. The impact of these differences on the Spokane River is small in most cases due to the extreme differences in flow. Only the total nitrogen as shown in Figure F is seen to have an irregularly high impact and ammonia, as shown on Figure E actually decreases beyond the Hangman confluence. Phosphates show a small but consistent increase in Figure D.

The entrance of the existing primary treated sewage effluent from the City of Spokane treatment plant at RM 67.2 has the largest quality impact on the Spokane River. Except during the higher river flow season of April through June ammonia, total nitrogen, phosphorus and BOD show large increases below the City STP. Zinc shows a small increase.

The next stream to join the Spokane River below the City STP is the Little Spokane River. The Little Spokane River has a stable flow pattern and contributes a significant input at all times of year. Unfortunately, there has been little data collection either of the Little Spokane at its mouth or of the Spokane River in close proximity downstream from the confluence. The Spokane River is actually a lake at the confluence and most data taken downstream from the confluence follow many miles of lake condition and reflect in-stream changes due to lake activity as well as the result of mixing with the Little Spokane. The quality of the Little Spokane River at its mouth is very similar to that of the groundwater of the Spokane Valley aquifer, which is responsible for a large fraction of the Little Spokane flow at all seasons except flood flows. The Little Spokane has relatively low phosphorus, ammonia and zinc but high total nitrogen. Coliform counts are surprisingly high. Refer to Table 9. As indicated above, the impacts of these quality differences are not reported free of lake effects.

As indicated above, it is not intended to treat Long Lake quality in detail herein but rather to report and summarize seasonal means for principle parameters. For all seasons except the winter (Jan-Mar) the lake retention results in a significant increase in temperature as represented by the surface layer. This temperature increase is not reflected to the same degree in outlet temperatures below Long Lake Dam. See Figure A. The temperature stratification of Long Lake in the June-Sept period is evident in the 7° C spread from surface to bottom as shown in Table 3. The temperatures downstream of Long Lake dam reflect release from lower levels in the lake.

The high phosphorus levels entering Long Lake, which are a major factor for the eutrophication problem in summer and fall is shown in Figure D. The capture of the phosphorus by organisms in the summer and fall is shown by the lower leaving concentrations for July-Sept and Oct-Dec. During the winter and spring there appears to be a reversal with the leaving concentrations higher than the influent. The net effect throughout the year is of phosphorus levels downstream from Long Lake being significantly higher than the Spokane River as it enters the study area and above levels of concern for eutrophic activity.

Within Long Lake the most serious quality deficiency which develops as a consequence of thermal stratification and high nutrient levels is the reduction in dissolved oxygen below the surface layers caused by the demand of dying organisms settling to the bottom. Table 3 shows that both the middle and bottom layers have low dissolved oxygen concentrations during the summer and fall seasons.

Hangman Creek. Two factors must be kept in mind in interpreting quality data for Hangman Creek at its mouth. One is that the flow is extremely variable and the other is that summer flow may be largely Spokane Valley groundwater which enters in the last downstream mile. In the absence of concurrent precipitation or snowmelt, the upstream flow approaches zero. The relatively low summer temperature as compared with the higher spring temperature is probably a measure of the increasing proportion due to low temperature groundwater in the summer. See Table 8. Also note the similarity of summer quality to Spokane Valley aquifer quality.

Little Spokane River. Two locations on the Little Spokane River are selected to show the quality which predominates in the basin upstream from Dartford as compared with the quality at the mouth after the flow increment from the Spokane Valley aquifer below Dartford. Refer to Tables 9 and 10 respectively. The Little Spokane River has unusually sustained year around flow and low peak flows, both the result of a high degree of interchange between the river and the groundwater of the basin. Consequently, the quality above Dartford is affected by the groundwater quality within the basin. Below Dartford, the quality affect is from groundwater outside the basin.

The drop in spring and summer water temperature from Dartford to the mouth clearly shows the effect of the addition of 10° C Spokane Valley groundwater.

High coliform counts at Dartford, with significant attenuation at the mouth, is the primary quality deficiency. The only point source near enough to be considered as the source is the treated sanitary wastes from Kaiser Mead which are discharged into Peone Creek which joins the Little Spokane immediately upstream from Dartford.

Liberty and Newman Lakes. Practically all of the available water quality data on these lakes is from USGS for one period March to September 1971. See USGS (1971). The data are so limited as to preclude any generalized conclusion.

Lee (1969) examined Newman Lake and several other lakes in the study area but did not include Liberty Lake. Based on one observation October 22, 1968 which included a temperature and dissolved oxygen profile, Lee concluded as follows:

> Newman Lake was shallow, well-mixed (isothermal), with an orthograde dissolved oxygen profile ... A moderate algal bloom was present, reflected by a low Secchi disc transparency.

Projected Water Quality

The existing quality of the Spokane River as it enters the study area from Idaho is designated as a baseline condition for projection of future water quality in the study area. The primary quality deficiency at the stateline is bacteriological. Refer to Table 7. The other parameter of note is zinc. Although zinc concentration is well below drinking water standards, it is significantly higher than most natural waters. It is probable that the coliform count will be improved in the future by enforcement of effluent standards in Idaho, primarily for Coeur D'Alene. It is unlikely that a major change will be achieved in zinc concentrations which have their origin in leaching from mine tailings on the Coeur D'Alene River.

Baseline conditions on the Spokane River downstream from the stateline are being determined based on the water quality simulation model in a run with all existing point source pollutant loads removed. Projected conditions for surface water discharge of forecast year 2000 municipal flows treated to 1983 standards is the subject of another quality model simulation. Both of these results are reported in the task report on simulation model results.

TABLE 1

SURFACE WATER QUALITY SUMMARY
SPOKANE RIVER BELOW LITTLE FALLS DAM (RM 29.0)

Parameter	Units	Jan-Mar	MEAN VALUES Apr-June	July-Sept	Oct-Dec
Temperature	°C	-	12.4	18.7	9.6
Dissolved oxygen	mg/l	-	11.4	6.3	7.2
B.O.D.	mg/l	-	-	1.4*	-
Total phosphorus -P	mg/l	-	0.062	0.066	0.038
Ammonia -N	mg/l	-	0.050*	0.082	0.000*
Total N	mg/l	-	-	0.342*	-
Total coliforms	No./100 ml	-	267	317	604
Zinc	μg/l	-	-	17*	-

TABLE 2

SURFACE WATER QUALITY SUMMARY
SPOKANE RIVER BELOW LONG LAKE (RM 33.3)

Parameter	Units	Jan-Mar	MEAN VALUES Apr-June	July-Sept	Oct-Dec
Temperature	°C	3.7	11.1	18.2	8.3
Dissolved oxygen	mg/l	12.9	12.3	5.8	7.7
B.O.D.	mg/l	-	-	1.4*	-
Total phosphorus -P	mg/l	0.100	0.083	0.073	0.059
Ammonia -N	mg/l	0.183	0.082	0.124	0.249
Total N	mg/l	0.656	0.416	0.765	0.861
Total coliforms	No./100 ml	418	831	954	488
Zinc	μg/l	243	209	128	70

*Less than 5 data points.

TABLE 3

SURFACE WATER QUALITY SUMMARY
LONG LAKE (RM 37)

SURFACE LAYER (1.0 M DEPTH)

Parameter	Units	Jan-Mar	MEAN VALUES Apr-June	July-Sept	Oct-Dec
Temperature	°C	-	17.5	21.2	13.2
Dissolved oxygen	mg/1	-	11.2	10.7	9.4
B.O.D.	mg/1	-	-	1.2*	-
Total phosphorus -P	mg/1	-	-	0.046	-
Ammonia -N	mg/1	-	-	0.019*	-
Total N	mg/1	-	-	0.263*	-
Total coliforms	No./100 ml	-	-	385	-
Zinc	µg/1	-	-	20*	-

MIDDLE LAYER (15.0 M DEPTH)

Parameter	Units	Jan-Mar	MEAN VALUES Apr-June	July-Sept	Oct-Dec
Temperature	°C	-	14.6	16.8	6.5
Dissolved oxygen	mg/1	-	12.2	3.0	4.8
B.O.D.	mg/1	-	-	0.5*	-
Total phosphorus -P	mg/1	-	-	0.097	-
Ammonia -N	mg/1	-	-	0.116*	-
Total N	mg/1	-	-	0.28*	-
Total coliforms	No./100 ml	-	-	600*	-
Zinc	µg/1	-	-	-	-

BOTTOM LAYER (24.0 M DEPTH)

Parameter	Units	Jan-Mar	MEAN VALUES Apr-June	July-Sept	Oct-Dec
Temperature	°C	-	13.2	14.2	11.6
Dissolved oxygen	mg/1	-	4.1	[illegible].2	4.4
B.O.D.	mg/1	-	-	3.1*	-
Total phosphorus -P	mg/1	-	-	0.378*	-
Ammonia -N	mg/1	-	-	1.130*	-
Total N	mg/1	-	-	1.30*	-
Total coliforms	No./100 ml	-	-	-	-
Zinc	µg/1	-	-	-	-

*Less than 5 data points.

TABLE 4

SURFACE WATER QUALITY SUMMARY
SPOKANE RIVER AT BOWL & PITCHER (RM 66.2)

Parameter	Units	MEAN VALUES Jan-Mar	Apr-June	July-Sept	Oct-Dec
Temperature	°C	4.9	13.8	15.1*	6.9
Dissolved oxygen	mg/l	12.5	10.6	9.9*	11.5
B.O.D.	mg/l	2.3*	0.6*	3.8*	2.6
Total phosphorus -P	mg/l	0.080*	0.027*	0.198*	0.168
Ammonia -N	mg/l	0.230*	0.028*	0.180*	0.447
Total N	mg/l	1.336*	0.195*	-	0.964
Total coliforms	No./100 ml	-	2343*	20*	-
Zinc	μg/l	235*	240*	127*	172

TABLE 5

SURFACE WATER QUALITY SUMMARY
SPOKANE RIVER AT FT. WRIGHT BRIDGE (RM 69.8)

Parameter	Units	MEAN VALUES Jan-Mar	Apr-June	July-Sept	Oct-Dec
Temperature	°C	4.2	12.3	16.7	6.7
Dissolved oxygen	mg/l	12.5	11.4	9.6	11.7
B.O.D.	mg/l	1.3*	0.4*	1.6*	1.1
Total phosphorus -P	mg/l	0.079	0.043	0.028	0.036
Ammonia -N	mg/l	0.018	0.009	0.017	0.059
Total N	mg/l	1.314*	0.310	-	0.527
Total coliforms	No./100 ml	-	1644*	1050*	-
Zinc	μg/l	213*	190	85*	139

*Less than 5 data points.

TABLE 6

SURFACE WATER QUALITY SUMMARY
SPOKANE RIVER ABOVE HANGMAN CREEK (RM 72.9)

Parameter	Units	MEAN VALUES Jan-Mar	Apr-June	July-Sept	Oct-Dec
Temperature	°C	4.2	13.2*	14.2	6.8
Dissolved oxygen	mg/1	13.2	11.7*	9.7	11.4
B.O.D.	mg/1	0.6*	-	1.0	1.2
Total phosphorus -P	mg/1	0.020*	-	0.017	0.026
Ammonia -N	mg/1	0.050*	-	0.044*	0.073
Total N	mg/1	0.335*	-	0.150*	0.449
Total coliforms	No./100 ml	-	-	1068	-
Zinc	µg/1	285*	-	78*	174

TABLE 7

SURFACE WATER QUALITY SUMMARY
STATELINE RM 96.5

Parameter	Units	MEAN VALUES Jan-Mar	Apr-June	July-Sept	Oct-Dec
Temperature	°C	4.2	9.8	19.4	8.5
Dissolved oxygen	mg/1	12.6	11.1	9.0	10.2
B.O.D.	mg/1	1.4	3.3	1.3	1.0
Total phosphorus -P	mg/1	0.013	0.011	0.008	0.010
Ammonia -N	mg/1	0.066	0.108	0.088	0.029
Total N	mg/1	0.279	0.143	0.326	0.192
Total coliforms	No./100 ml	868	177	2002	986
Zinc	µg/1	241	248	168	261

*Less than 5 data points.

TABLE 8

SURFACE WATER QUALITY SUMMARY
HANGMAN CREEK AT MOUTH

Parameter	Units	Jan-Mar	Apr-June	July-Sept	Oct-Dec
		MEAN VALUES			
Temperature	°C	3.6	17.1	15.2	5.6
Dissolved oxygen	mg/l	12.8	9.7	8.6	12.6
B.O.D.	mg/l	-	-	11.8*	-
Total phosphorus -P	mg/l	0.395*	-	0.085*	0.258
Ammonia -N	mg/l	0.642	0.180*	0.104	0.205
Total N	mg/l	2.61	2.36*	1.96	1.38
Total coliforms	No./100 ml	-	-	323*	-
Zinc	µg/l	42*	27*	7	9*

*Less than 5 data points.

TABLE 9

SURFACE WATER QUALITY SUMMARY
LITTLE SPOKANE R. NEAR MOUTH (RM 1.1)

Parameter	Units	MEAN VALUES Jan-Mar	Apr-June	July-Sept	Oct-Dec
Temperature	°C	5.2	12.4	13.5	7.0
Dissolved oxygen	mg/l	10.5	8.9	8.8	10.5
B.O.D.	mg/l	1.1*	0.8*	0.5*	-
Total phosphorus -P	mg/l	0.086	0.084	0.039	0.030
Ammonia -N	mg/l	0.077	0.042	0.064	0.042
Total N	mg/l	1.300	1.105	1.530	1.206
Total coliforms	No./100 ml	1802	1012	1776	880*
Zinc	g/l	42	43*	4	15

TABLE 10

SURFACE WATER QUALITY SUMMARY
LITTLE SPOKANE R. AT DARTFORD (RM 10.6)

Parameter	Units	MEAN VALUES Jan-Mar	Apr-June	July-Sept	Oct-Dec
Temperature	°C	5.1	15.9	15.8	5.7
Dissolved oxygen	mg/l	11.6	9.0	10.0	-
B.O.D.	mg/l	1.4*	0.7*	0.6*	-
Total phosphorus -P	mg/l	0.038*	0.062	0.103	-
Ammonia -N	mg/l	0.000*	0.014	0.000*	-
Total N	mg/l	-	0.69*	-	-
Total coliforms	No./100 ml	5650*	2044	3867	-
Zinc	g/l	44*	-**	18*	28*

* Less than 5 data points.
**Only one observation available in the Apr-June season at 850 mg/l. There is no explanation for this high value.

TABLE 11

SURFACE WATER QUALITY SUMMARY

LIBERTY LAKE

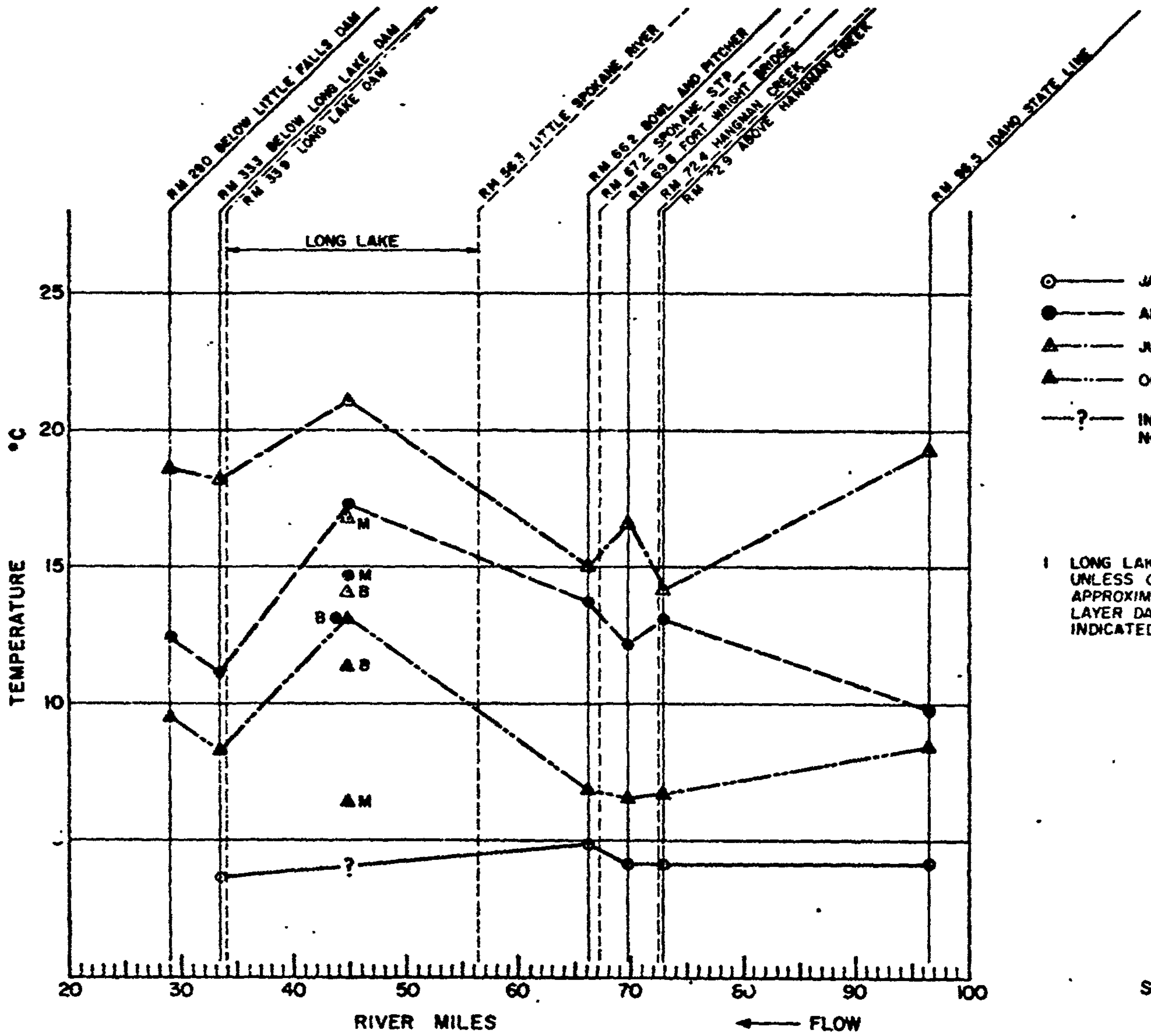
Parameter	Units	Depth-Ft.	March	May	July	Sept
Temperature	°C	3	-	19.0	24.5	14.5
"	°C	20	-	-	-	14.5
"	°C	21	-	14.0	19.0	-
Total phosphorus -P	mg/1	3	-	0.01	0.01	0.03
"	mg/1	13	0.05	-	-	-
"	mg/1	20	-	-	-	0.04
"	mg/1	21	-	0.02	0.03	-
Ammonia -N	mg/1	3	-	0.02	0.01	0.12
"	mg/1	13	0.12	-	-	-
"	mg/1	20	-	-	-	0.13
"	mg/1	21	-	0.07	0.21	-

TABLE 12

SURFACE WATER QUALITY SUMMARY

NEWMAN LAKE

Parameter	Units	Depth-Ft.	March	May	July	Sept	Oct
Temperature	°C	3	-	18.0	24.0	-	-
"	°C	0-15	-	-	-	-	9.1
"	°C	26	-	-	13.0	-	-
"	°C	27	-	11.0	-	-	-
"	°C	15-30	-	-	-	-	9.2
Dissolved oxygen	mg/1	0-15	-	-	-	-	9.6
"	mg/1	15-30	-	-	-	-	9.4
Total phosphorus -P	mg/1	3	-	0.01	0.01	0.02	-
"	mg/1	15	0.05	-	-	-	-
"	mg/1	26	-	-	0.01	0.01	-
"	mg/1	27	-	0.02	-	-	-
Ammonia -N	mg/1	3	-	0.07	0.23	0.12	-
"	mg/1	15	0.02	-	-	-	-
"	mg/1	26	-	-	0.02	0.16	-
"	mg/1	27	-	0.03	-	-	-



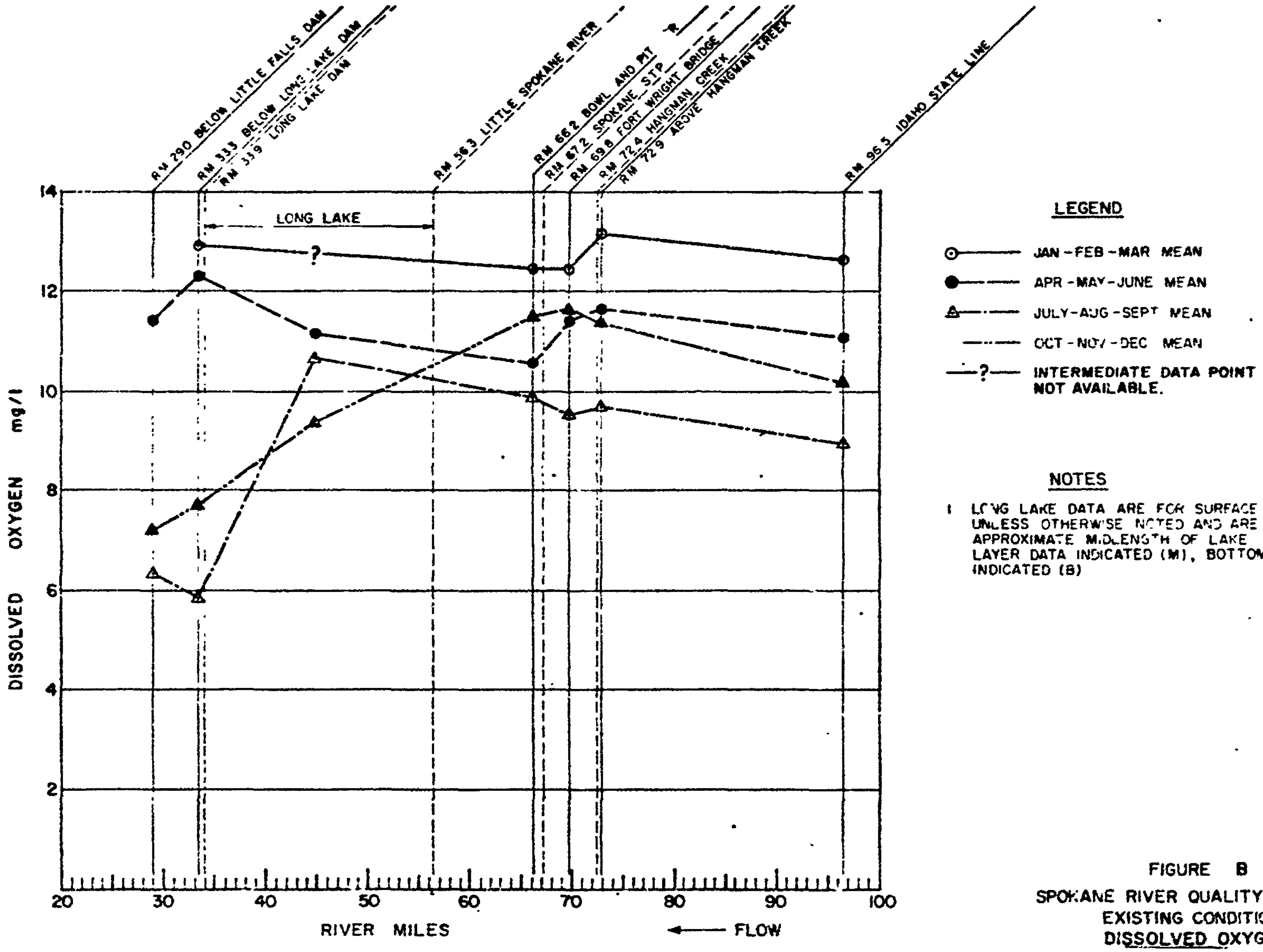
LEGEND

- ○—— JAN-FEB.-MAR MEAN
- ●— — APR-MAY-JUNE MEAN
- △—·— JULY-AUG-SEPT MEAN
- ▲—··— OCT-NOV-DEC MEAN
- —?— INTERMEDIATE DATA POINT NOT AVAILABLE.

NOTES

1 LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M), BOTTOM LAYER INDICATED (B)

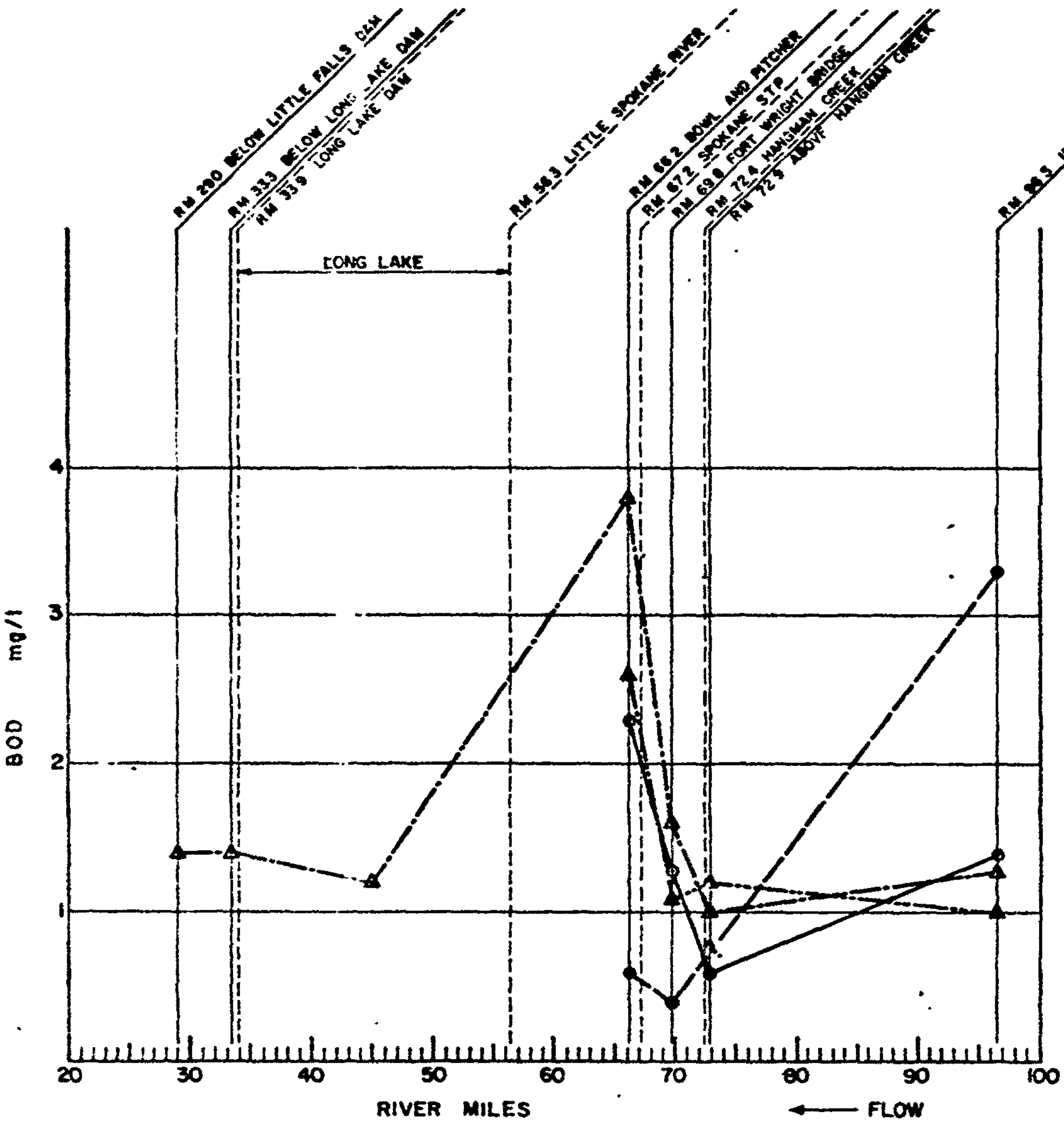
FIGURE A
SPOKANE RIVER QUALITY PROFILES
EXISTING CONDITIONS
TEMPERATURE



NOTES

1 LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M), BOTTOM LAYER INDICATED (B)

FIGURE B
SPOKANE RIVER QUALITY PROFILES
EXISTING CONDITIONS
DISSOLVED OXYGEN



LEGEND

- ⊙——— JAN-FEB-MAR. MEAN
- ●— — — APR-MAY-JUNE MEAN
- △—·—·— JULY-AUG.-SEPT MEAN
- ▲- ···- OCT-NOV-DEC MEAN
- —?— INTERMEDIATE DATA POINT NOT AVAILABLE.

NOTES

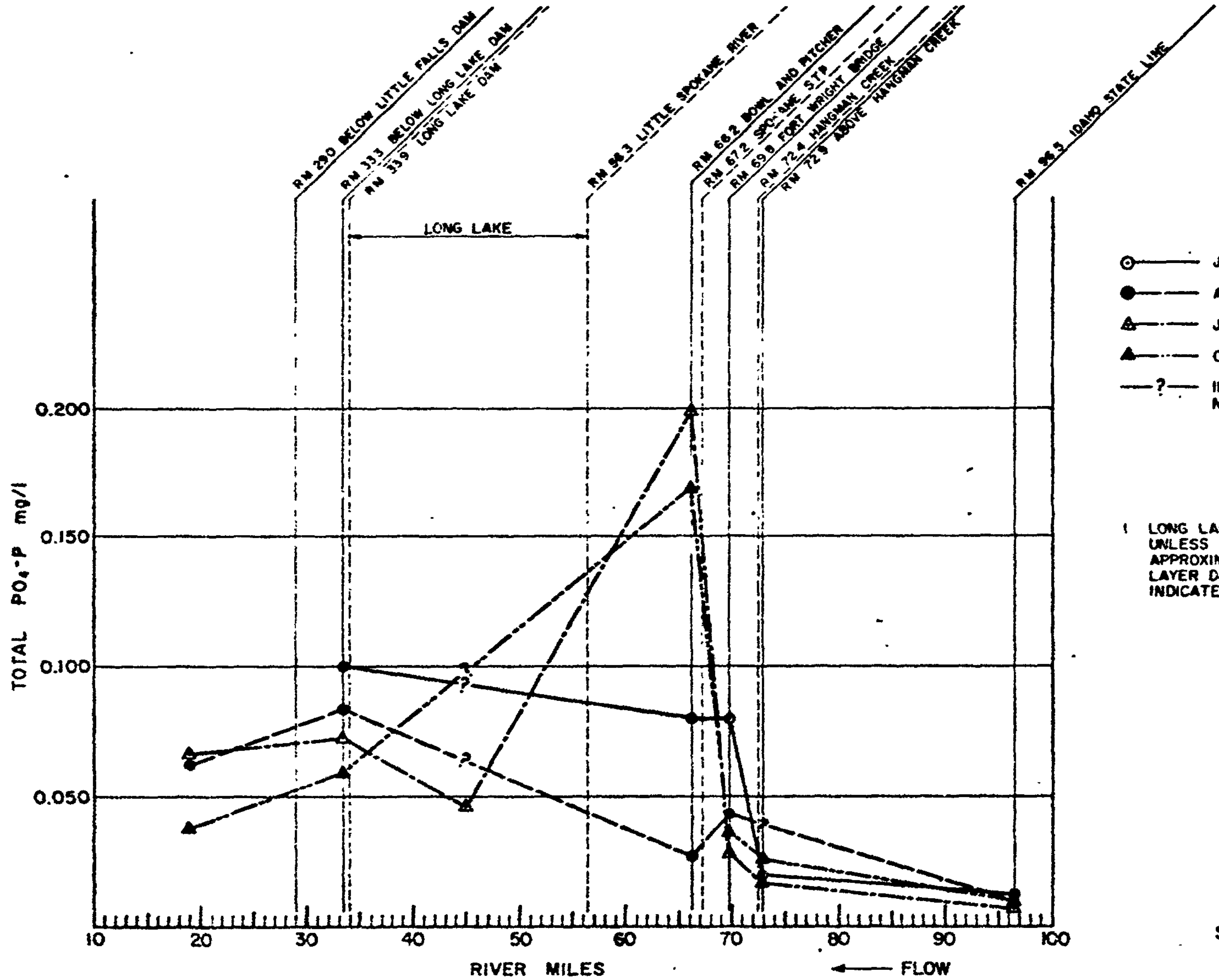
1 LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M), BOTTOM LAYER INDICATED (B)

FIGURE C

SPOKANE RIVER QUALITY PROFILES

EXISTING CONDITIONS

BOD



LEGEND

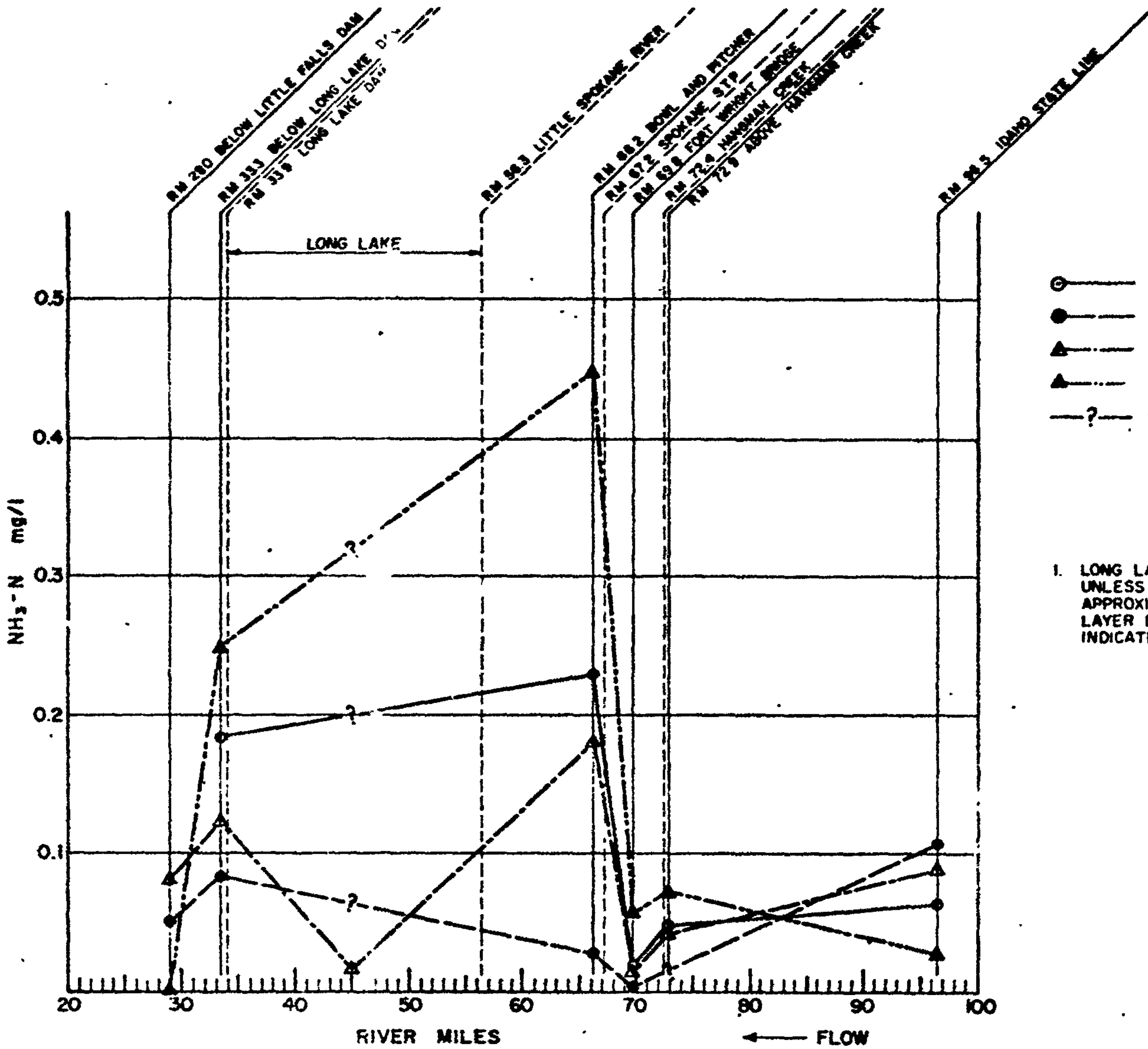
- JAN-FEB-MAR MEAN
- APR-MAY-JUNE MEAN
- JULY-AUG-SEPT MEAN
- OCT-NOV-DEC MEAN
- ? INTERMEDIATE DATA POINT NOT AVAILABLE.

NOTES

1 LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M), BOTTOM LAYER INDICATED (B)

FIGURE D

SPOKANE RIVER QUALITY PROFILES
EXISTING CONDITIONS
TOTAL PHOSPHATE



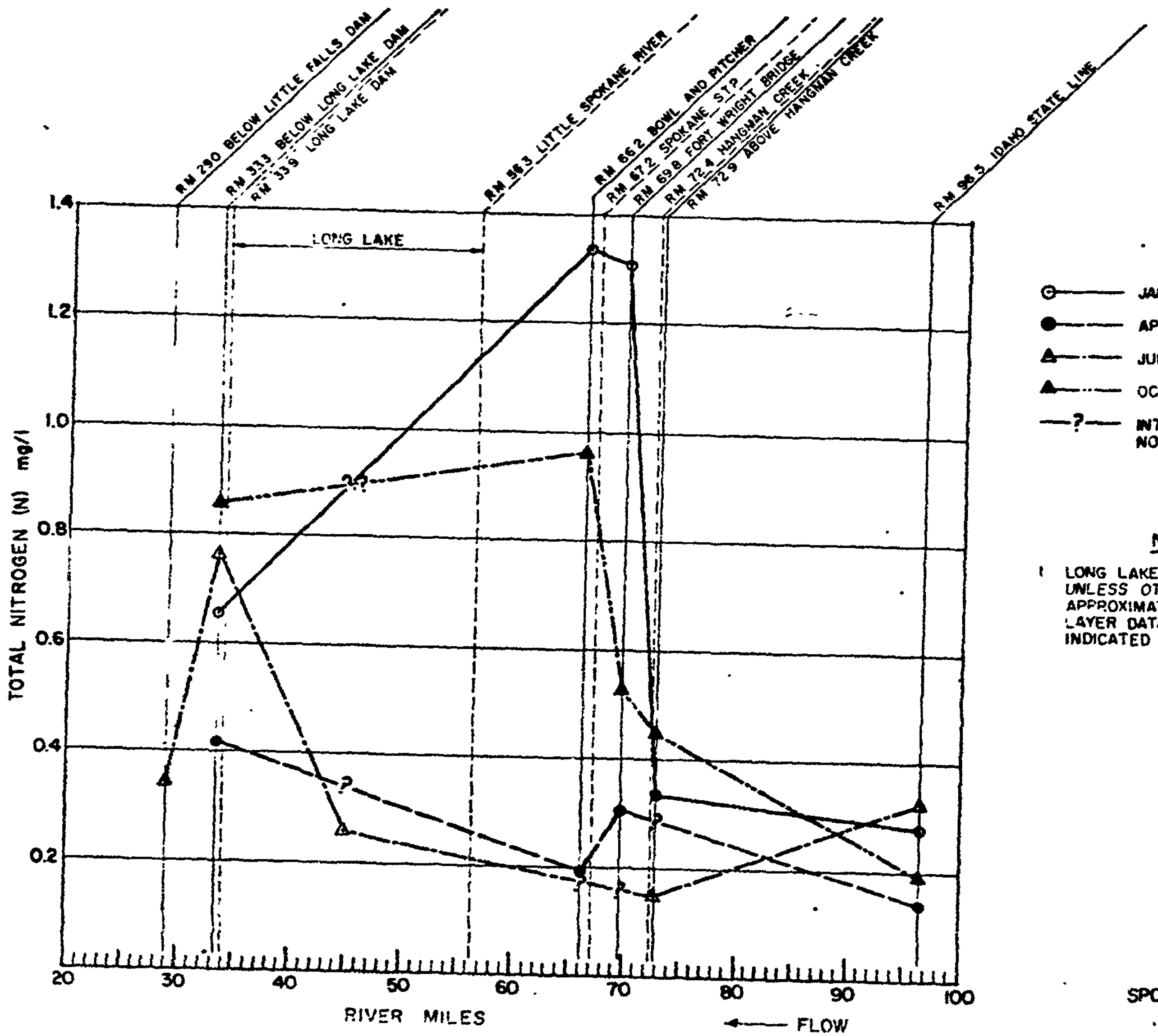
LEGEND

- JAN.-FEB.-MAR. MEAN
- APR.-MAY-JUNE MEAN
- JULY-AUG.-SEPT. MEAN
- OCT.-NOV.-DEC. MEAN
- —?— INTERMEDIATE DATA POINT NOT AVAILABLE.

NOTES

1. LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M), BOTTOM LAYER INDICATED (B).

FIGURE E
SPOKANE RIVER QUALITY PROFILES
EXISTING CONDITIONS
AMMONIA



LEGEND

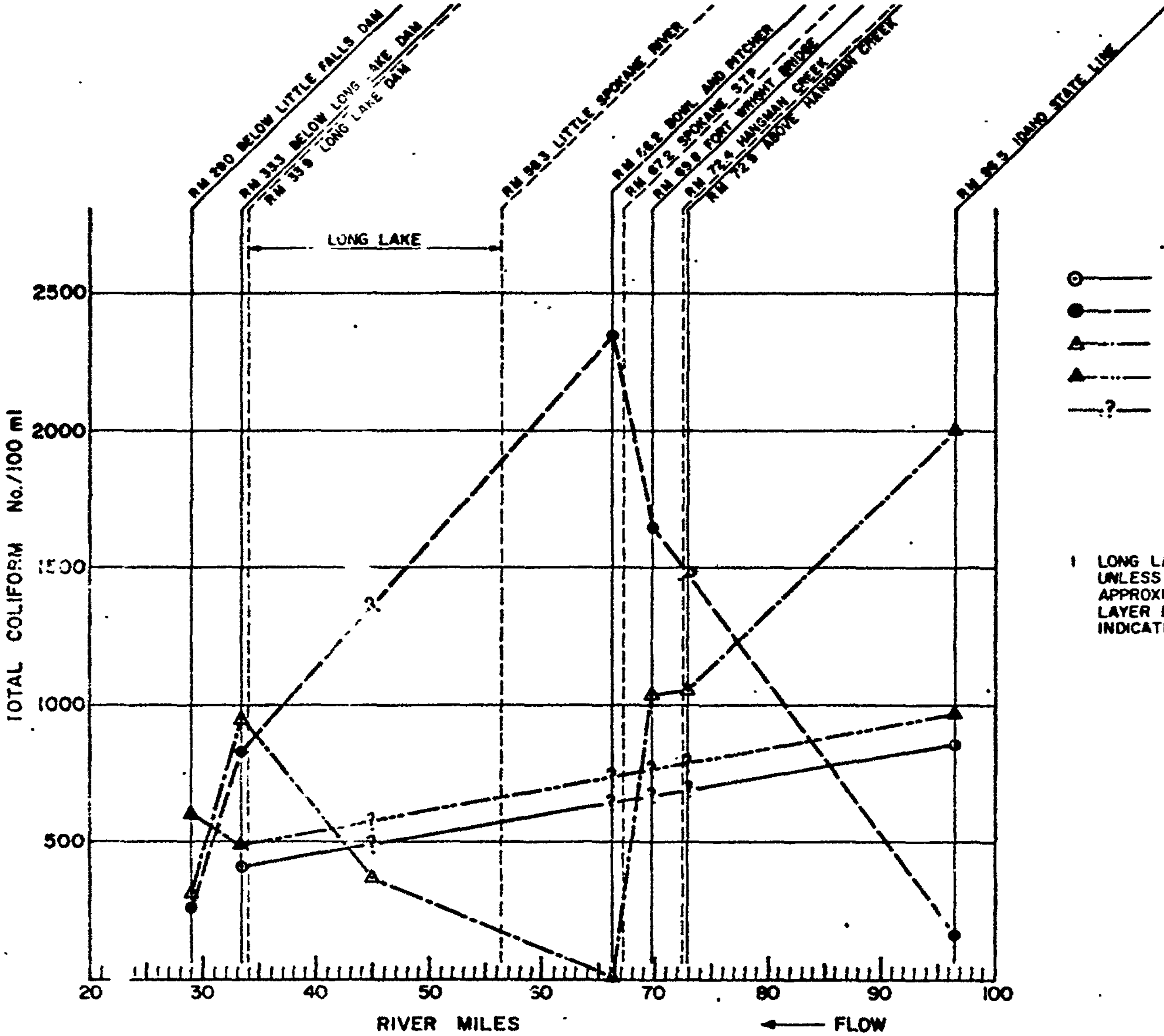
- JAN-FEB-MAR MEAN
- APR-MAY-JUNE MEAN
- JULY-AUG.-SEPT MEAN
- OCT-NOV-DEC MEAN
- ? INTERMEDIATE DATA POINT NOT AVAILABLE.

NOTES

LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M), BOTTOM LAYER INDICATED (B)

FIGURE F

SPOKANE RIVER QUALITY PROFILES
EXISTING CONDITIONS
TOTAL NITROGEN



LEGEND

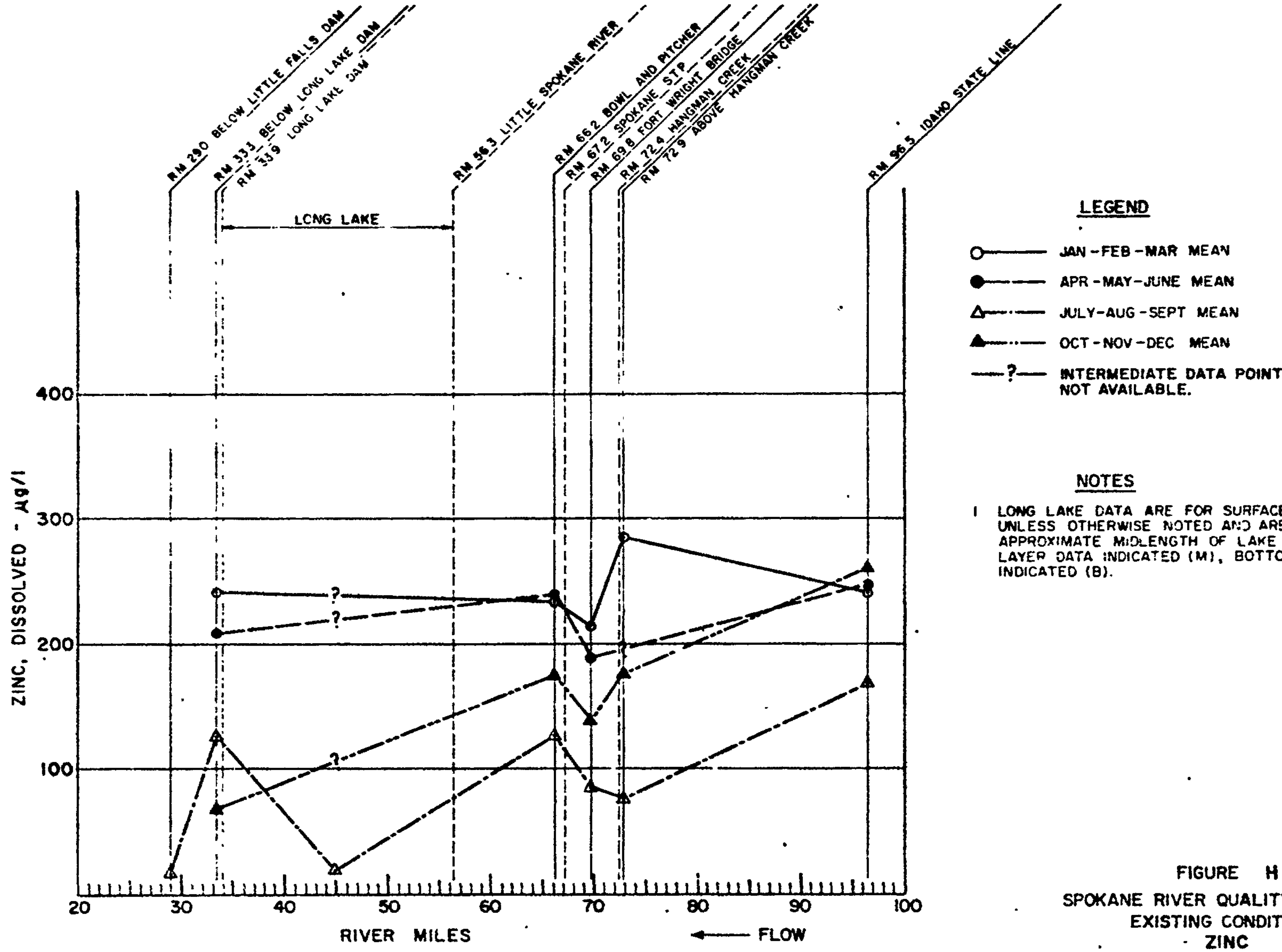
- JAN-FEB-MAR MEAN
- APR-MAY-JUNE MEAN
- JULY-AUG-SEPT MEAN
- OCT-NOV-DEC MEAN
- ? INTERMEDIATE DATA POINT NOT AVAILABLE.

NOTES

1 LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M); BOTTOM LAYER INDICATED (B).

FIGURE G

SPOKANE RIVER QUALITY PROFILES
EXISTING CONDITIONS
TOTAL COLIFORM



NOTES

1 LONG LAKE DATA ARE FOR SURFACE LAYER UNLESS OTHERWISE NOTED AND ARE PLOTTED AT APPROXIMATE MIDLENGTH OF LAKE. MIDDLE LAYER DATA INDICATED (M), BOTTOM LAYER INDICATED (B).

FIGURE H
SPOKANE RIVER QUALITY PROFILES
EXISTING CONDITIONS
ZINC

LIST OF REFERENCES

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TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX I SHEET NO. 1 OF 2
CHKD. BY ______ DATE ______ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER BELOW LITTLE FALLS DAM (RM 29.0)

DATA SOURCE	MONTH	PARAMETERS TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli no./100 ml	Zn, Diss. mg/l
K-T	SEPT	17.1	6.5	1.8	0.096	0.147	0.413	148	.19
Sept. 1973	"	16.6	6.4	1.3	0.037	0.123	0.315	230	.14
RM 29.2	"	16.5	6.0	1.2	0.077	0.131	0.297	—	.17
STORET	MAY	8.2	11.6	—	0.020	0.000	—	60	—
1970	JUNE	—	—	—	—	0.100	—	—	—
RM 29.0	JULY	—	—	—	—	0.000	—	—	—
	AUG	—	—	—	—	0.090	—	—	—
	SEPT	—	—	—	—	0.000	—	—	—
	OCT	—	—	—	—	0.000	—	—	—
BISHOP	APR	7.0	12.2	—	0.10			230	
1970-71	MAY	10.6	14.0	—	0.05			380	
RM 29.0	JUNE	15.0	11.7	—	0.10			360	
	"	16.7	10.0	—	0.04			320	
	"	16.7	9.2	—	—			2500	
	JULY	23.0	8.0	—	0.04			14	
	"	19.4	8.6	—	0.09			210	
	"	—	8.6	—	—			—	
	"	21.1	8.3	—	—			—	
	"	18.3	7.3	—	—			46	
	AUG	20.5	3.1	—	0.17			370	
	"	20.3	7.0	—	0.05			—	
	"	21.1	8.3	—	0.03			50	
	"	19.4	5.3	—	0.03			—	
	SEPT	19.4	3.5	—	0.09			500	
	"	—	5.4	—	0.04			—	
	"	17.2	5.2	—	0.09			55	
	"	16.1	3.4	—	0.02			180	
	"	14.6	5.8	—	—			200	
	"	—	—	—	—			1800	

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX I (Con't) SHEET NO. 2 OF 2
CHKD. BY ____ DATE ____ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER BELOW LITTLE FALLS DAM (RM 29.0)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli no./100ml	Zn, Diss. mg/l
BISHOP	OCT	13.4	5.5	—	0.02			2200	
1970-71	"	12.9	5.8	—	0.03			600	
RM 29.0	"	10.4	7.2	—	0.03			50	
CONT'D.	NOV	6.8	8.7	—	0.09			160	
	DEC	4.3	9.0	—	0.07			9	

TUDOR ENGINEERING COMPANY

BY BP DATE 12/5/74 SUBJECT APPENDIX II SHEET NO. 1 OF 4
CHKD. BY ____ DATE ____ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER BELOW LONG LAKE (RM 33.3)

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	TOT. PO_4-P mg/l	NH_3-N mg/l	TOT. N mg/l	TOT. COLI No./100ml	Zn, Diss. ug/l
K-T Sept. 1973 RM 33.3	SEPT.	17.2	4.5	1.3	0.088	0.135	0.420	194	26
		16.6	4.4	1.5	0.092	0.156	0.368	470	14
		16.6	5.0	1.5	0.065	0.066	0.253	—	19
USGS 1971-1972 RM 33.3	JAN.	2.4	9.9	—	0.080	0.25	—	20	140
	FEB	1.1	13.1	—	0.13	0.31	0.62	400	230
	"	3.0	14.2	—	0.19	0.54	1.85	200	250
	MAR	4.4	16.9	—	0.090	0.11	0.87	1400	380
	"	4.0	16.3	—	0.080	0.18	0.62	600	420
	APR	5.9	14.5	—	0.25	0.09	0.66	1100	330
	"	7.2	19.1	—	0.10	0.13	0.47	320	260
	MAY	10.5	13.1	—	0.050	0.07	0.46	400	190
	"	11.8	12.4	—	0.050	0.04	0.31	1600	170
	JUNE	14.4	12.4	—	0.050	0.10	0.62	1200	130
	"	16.0	9.8	—	0.040	0.06	0.46	—	140
	JULY	17.3	8.8	—	0.030	0.15	0.79	30	120
	"	16.5	7.4	—	0.050	0.17	1.01	35	60
	AUG	20.2	7.4	—	0.030	0.10	1.13	—	80
	"	18.4	9.0	—	0.060	0.27	1.15	350	30
	SEPT	17.5	—	—	—	0.16	0.99	—	40
	"	13.3	4.6	—	0.070	0.15	1.16	2200	20
	OCT	13.7	4.9	—	0.060	0.03	0.50	800	30
	"	12.2	6.7	—	0.060	0.39	—	50	20
	NOV	8.2	7.5	—	0.070	0.27	0.78	100	70
	"	6.7	8.0	—	0.090	0.33	1.30	20	—
	DEC	2.9	—	—	0.080	0.27	1.02	20	150

TUDOR ENGINEERING COMPANY

BY BP DATE 12/5/74 SUBJECT APPENDIX II (Con't) SHEET NO. 2 OF 4
CHKD. BY ____ DATE ____ JOB NO. 409
SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER BELOW LONG LAKE (RM 33.3)

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli no/100 ml	Zn Diss µg/l
USGS 1970-1971 RM 33.3	JAN	2.3	10.0	—	0.090	0.16	0.64	26	—
	"	3.1	10.0	—	0.050	0.01	0.77	—	200
	"	3.4	11.9	—	0.110	—	0.33	600	220
	FEB.	3.0	14.1	—	0.060	0.00	0.23	200	400
	"	3.3	12.9	—	0.030	0.04	0.33	320	400
	MAR	3.5	12.7	—	0.190	0.23	0.30	—	33
	APR	6.3	11.4	—	0.110	0.30	1.05	1400	270
	"	6.6	12.1	—	0.100	0.15	0.30	300	210
	MAY	8.0	12.9	—	0.160	0.00	0.21	600	280
	"	1.4	11.9	—	0.110	0.00	0.18	1500	200
	JUNE	12.9	13.3	—	0.030	0.02	0.07	500	190
	"	4.1	12.6	—	0.040	0.02	0.20	250	140
	JULY	16.4	7.9	—	0.030	0.16	0.34	600	130
	"	19.4	8.2	—	0.040	0.01	0.33	100	70
	AUG	20.2	6.1	—	0.040	0.06	0.75	800	100
	"	20.0	3.1	—	0.070	0.05	0.86	500	80
	SEPT	17.5	3.7	—	0.100	0.21	1.39	1200	40
	"	16.7	5.9	—	0.070	0.01	0.53	7500	—
	NOV.	6.7	11.1	—	0.030	0.21	0.53	20	100
	DEC.	3.7	9.2	—	—	—	—	22	200

TUDOR ENGINEERING COMPANY

BY BP DATE 12/5/74 SUBJECT APPENDIX II (Con't) SHEET NO. 3 OF 4

CHKD. BY ______ DATE ______ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER BELOW LONG LAKE (RM 33.3)

DATA SOURCE	MONTH	TEMP. °C	D.O. mg/l	BOD mg/l	TOT. PO_4-P mg/l	NH_3-N mg/l	TOT. N mg/l	TOT. COLI no/100ml	Zn, Diss. mg/l
EASHOP	APR	7.3	12.8	—	0.08	—	—	126	—
1970-71	MAY	10.6	14.2	—	0.07	—	—	680	—
RM 33.3	JUNE	15.0	11.6	—	0.05	—	—	64	—
	"	16.7	10.7	—	0.03	—	—	188	—
	"	17.2	9.2	—	—	—	—	3070	—
	JULY	22.9	8.0	—	0.04	—	—	2	—
	"	19.4	8.5	—	0.12	—	—	144	—
	"	18.9	7.4	—	—	—	—	—	—
	"	21.1	7.2	—	—	—	—	35	—
	"	18.3	6.2	—	—	—	—	—	—
	AUG	20.0	2.8	—	0.10	—	—	2900	—
	"	20.0	5.5	—	0.36	—	—	—	—
	"	19.4	5.5	—	0.04	—	—	—	—
	"	19.5	4.8	—	0.07	—	—	80	—
	SEPT	19.4	3.9	—	0.08	—	—	2300	—
	"	—	3.5	—	0.05	—	—	—	—
	"	17.8	4.5	—	0.02	—	—	0	—
	"	15.5	5.2	—	0.02	—	—	420	—
	"	14.9	2.9	—	—	—	—	1000	—
	"	—	5.4	—	—	—	—	2000	—
	OCT	13.0	6.3	—	0.01	—	—	3400	—
	"	10.4	5.7	—	0.03	—	—	1200	—
	"	13.7	7.3	—	0.02	—	—	220	—
	NOV	6.9	8.7	—	0.03	—	—	0	—
	DEC	5.3	9.3	—	0.05	—	—	10	—

TUDOR ENGINEERING COMPANY

BY BP DATE 12/5/74 SUBJECT APPENDIX II (Con 4) SHEET NO. 4 OF 4

CHKD. BY ____ DATE ____ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER BELOW LONG LAKE (RM 33.3)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli no./100 ml	Zn, Diss. mg/l
STORET 1971-1973	JAN.								185
	FEB	4.8							150
	"								190
	MAR	5.4							205
	"	7.5							
	APR	9.2							
	"	9.8							
	SEPT.	18.2			0.095			10	
	"							30	
	OCT	13.2							10
	"	10.5							20
	NOV	8.2				0.240	1.034		60
	"	7.6							43
	Dec.	3.4							50
	"	3.7							84

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX III SHEET NO. 1 OF 5

CHKD. BY ______ DATE ______ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LONG LAKE (DEPTH 0.0 - 1.0 m)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
K-T 1974	Sept	17.5	9.2	1.3	0.042	0.020	0.303	279	—
	"	17.3	8.1	0.8	0.041	0.017	0.245	190	—
	"	17.0	8.2	1.2	0.048	0.021	0.240	178	—
BISHOP	July	25.6	10.5		0.01				
	"	24.0	11.9		0.03				
	"	24.0	11.2		0.03				
	"	23.8	11.2		0.04				
	"	20.8	6.9		0.04				
	AUG.	24.0	14.6		0.02				
	"	22.5	11.8		0.08				
	"	26.0	12.2		0.03				
	"	24.2	9.8		0.04				
	"	26.0	10.8		0.06				
	"	24.0	10.4						
	"	27.0	11.2						
	"	21.8	9.0						
	"	26.0	10.3						
	"	23.0	9.4						
	"	21.0	9.6						
	Sept	20.5	10.2		0.02			800	
	"	18.0	5.6		0.08			480	
	"	18.0	9.8		0.04				
	"	19.5	5.7		0.03				
	"	18.5	7.9		0.05				
	"	17.9	7.2		0.02				
	"	19.5	6.8		0.05				
	"	18.0	9.1		0.02				
	"	17.9	8.1		0.13				
	"	19.0	7.0		0.09				
	"	18.0	10.0						
	"	16.5	10.8						
	"	16.0	8.0						

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX III (Con't) SHEET NO. 2 OF 5
CHKD. BY ______ DATE ______ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LONG LAKE (Depth 0.0 - 1.0 m)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
BISHOP	SEPT	15.5	7.8						
		13.5	7.0						
STORET 1972	SEPT	18.0	8.8	1.7	0.051			40	20
WWP 1971 & 72	JUNE	17.5 (26)*	11.2 (26)						
	JULY	21.6 (40)	11.4 (40)						
	AUG	22.5 (50)	11.1 (50)						
	SEPT	18.1 (18)	10.8 (18)						
	OCT	13.2 (8)	9.4 (8)						

* WT. FACTORS TO REFLECT NUMBER OF OBSERVATIONS

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX III (Con't) SHEET NO. 3 OF 5
CHKD. BY ____ DATE ____ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: LONG LAKE (Depth 15 m)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No/100ml	Zn, Diss. ug/l
K-T 1973	Sept	16.6	4.4	0.2	0.066	0.101	0.28	—	—
	"	16.4	2.9	0.4	0.071	0.094	0.28	—	—
	"	16.1	2.0	0.8	0.070	0.154	0.29	—	—
Bishop 1971 40-60'	July	18.0	7.5		0.08				
	"	16.7	5.5		0.09				
	"	16.0	1.8		0.12				
	Aug	19.5	4.4		0.17				
	"	20.0	0.3		0.15				
	"	19.0	1.6		0.13				
	"	19.0	2.0						
	"	18.5	3.0						
	"	18.7	2.2						
	"	20.0	3.7						
	"	20.0	5.2						
	"	18.6	6.1						
	Sept.	18.5	0.1		0.09			610	
	"	17.5	3.8		0.09			590	
	"	17.0	6.0		0.11				
	"	19.5	2.8		0.10				
	"	16.5	5.5		0.07				
	"	15.8	6.8						
	"	20.0	4.5						
	"	17.5	6.2						
	"	15.0	6.8						
	"	18.0	5.6						
	"	15.5	7.5						
	"	13.5	8.0						

TUDOR ENGINEERING COMPANY

BY BP DATE ______ SUBJECT APPENDIX III (Con't) SHEET NO. 4 OF 5

CHKD. BY ______ DATE ______ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LONG LAKE (Depth 15 m-Con't)

DATA SOURCE	MONTH	TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
STORET 1972 40-60'	SEPT	16.0 14.6 [19] 16.3 [27] 17.0 [37] 15.5 [14]	0.1 6.5 (19) 3.6 (22) 1.8 (37) 3.0 (14)						
	OCT.	12.2	4.8						

* Weighting factors to reflect number of observations

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX III (Con't) SHEET NO. 5 OF 5
CHKD. BY ______ DATE ______ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LONG LAKE (DEPTH 26 m)

DATA SOURCE	MONTH	PARAMETERS TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli NO/100 ml	Zn, Diss. ug/l
K-T 1973	SEPT.	13.2	0.0	1.9	0.535	1.227	1.46	—	—
	"	13.1	0.0	3.9	0.477	1.112	1.27	—	—
	"	13.1	0.0	3.5	0.450	1.050	1.18	—	—
BISHOP 75-95' 1971	JULY	16.0	5.4						
	AUG	16.0	*1.8						
	"	16.0	1.7						
	SEPT	16.0	0.5						
STORET 1972 75-95'	SEPT	15.2	0.0		0.05				
WWP 1972-73	JUNE	13.2	4.1						
	JULY	14.0 (15)*	2.4 (11)*						
	AUG	14.3 (17)	2.6 (17)						
	SEPT	13.9 (7)	1.8 (7)						
	OCT	11.6	4.4						

*WT. FACTORS TO REFLECT NUMBER OF OBSERVATIONS

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX IV SHEET NO. 1 OF 1

CHKD. BY ______ DATE ______ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER AT BOWL & PITCHER (RM 66.2)

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli no./100 ml	Zn, Dis. mg/l
K-T	June	14.5	9.4	0.6	0.013	0.025	0.19	—	—
June 1974	"	14.1	9.6	0.6	0.014	0.039	0.20	2343	240
RM. 66.2									
CONDIT	JUNE				0.032	0.02			
1972	AUG				0.16	0.18			118
RM 66.2									
FUNK	MAR.				0.05				
1972	MAY				0.05				
	JULY				0.32				
STORET	JAN	3.6	12.6	2.4	0.110	0.230	1.336		99
1972-73	FEB	2.8	12.8	2.2					330
RM 66.2	"	5.8	12.5						
	"	7.0							
	MAR	4.0	12.8						275
	"	5.6	12.0						
	"	5.4	12.4						
	APR.	10.0	11.9						
	"	9.2	12.9						
	June	17.4	10.0						
	"	17.8	9.7						
	July	18.0	10.0						136
	Sept	13.7	9.9	4.8	0.200			20	
	"	13.6	9.9	2.9	0.110				
	OCT	12.0	10.2	3.7	0.320	0.490	1.067		100
	"	8.0	11.6	3.5	0.220	0.660	1.279		110
	NOV.	8.0	10.3	2.7	0.130	0.430	1.010		150
	"	5.9	11.3	2.6	0.160	0.600	1.278		100
	Dec.	2.0	13.2	2.2	0.084	0.310	0.604		400
	"	5.6	12.2	0.6	0.093	0.190	0.543		

TUDOR ENGINEERING COMPANY

BY: BP DATE: 12/6/74 SUBJECT: APPENDIX V SHEET NO. 1 OF 2
CHKD. BY: DATE: JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER AT FT. WRIGHT BRIDGE (RM 69.8)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	TOT. PO_4-P mg/l	NH_3-N mg/l	TOT. N mg/l	TOT. COLI NO/100ml	Zn, DISS. ug/l
K-T 1974 RM (69.8)	JUNE	14.5	9.7	0.5	0.013	0.012	0.163	—	—
	"	14.3	10.1	0.4	0.009	0.019	0.138	1644	190
CONDIT 1972 RM (69.9)	JUNE				0.026	0.000			
	AUG				0.06	0.000			52
FUNK 1972	MAR				0.050				
	"				0.050				
	"				0.050				
	"				0.050				
	"				0.050				
	"				0.075				
	MAY				0.010				
	"				0.010				
	"				0.010				
SOLTERO (UNPUB) 1972 RM 69.8	JUNE	16.1	10.2			0.01	0.325		350
	"	15.0	9.0			0.05	0.525		90
	"	13.3	10.5			0.01	0.240		160
	"	16.6	10.8			0.01	0.466		160
STORET 1970-1973 RM 69.8	JAN	2.5	12.0	1.3	0.050	0.000	1.314		94
	"	3.0	12.1		0.100	0.040			
	"	4.3	12.5		0.050	0.040			
	"	3.6	12.9		0.079				
	FEB.	3.7	12.5		0.070	0.010			
	"	2.6	12.4		0.050	0.010			
	"	4.2	13.0						
	"	7.8	12.8						

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX V (Con't) SHEET NO. 2 OF 2
CHKD. BY ____ DATE ____ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER AT FT. WRIGHT BRIDGE (RM 69.8)

DATA SOURCE	MONTH	TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
STORET	MAR	3.0	12.2		0.300	0.000			260
1970-73	"	4.1	12.8						285
RM 69.8	"	5.8	12.5						
(CONT'D)	"	5.2	12.3						
	APR.	5.3	12.7		0.140	0.000			
	"	4.9	12.9		0.120	0.010			
	"	8.6	12.5						
	"	9.8	13.4						
	MAY	8.0	12.3		0.050	0.001			
	"	9.8	11.81		0.030	0.000			
	June	12.0	13.0		0.090				
	"	13.1	12.9		0.010	0.000			
	"	17.0	10.4			0.000			
	"	18.0	10.2						
	July	16.5	10.1		0.030	0.000			118
	"	22.0	7.6		0.020	0.000			
	"	18.4	9.7						
	AUG.	20.9	8.1		0.020	0.000			
	"	18.8	7.8		0.050	0.000			
	SEPT	15.6	9.9	2.0	0.010	0.040		1400	
	"	14.0	10.5	1.1	0.020	0.080		700	
	"	13.9	10.5		0.020				
	"	13.4	10.7		0.040				
	"	13.8	10.6		0.010				
	OCT.	9.5	9.8	1.5	0.038	0.030	0.584		100
	"	12.0	11.6	1.1		0.160	0.816		100
	"	7.5							
	NOV.	6.1	12.6	1.1	0.000	0.030	0.935		170
	"	7.8	11.5	0.9	0.039	0.030	0.644		125
	"	5.9	11.5		0.036	0.040			
	Dec.	4.4	11.0	0.8	0.018	0.000	0.424		200
	"	2.0	13.3	1.4	0.083	0.060	0.426		
	"	5.4	12.6			0.120			

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX VI SHEET NO. 1 OF 1

CHKD. BY ____ DATE ____ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE RIVER ABOVE HANGMAN CR. (RM 72.9)

DATA SOURCE	MONTH	PARAMETERS TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No/100ml	Zn, Diss. µg/l
K-T	Sept.	13.9	9.8	0.9	0.006	0.043	0.148	118	66
1973	"	13.1	9.5	0.5	0.014	0.036	0.128	230	60
RM 72.4	"	12.8	8.2	0.6	0.020	0.052	0.173		64
STORET	JAN	3.6	13.1	0.6	0.029	0.060	0.423		
1972-73	FEB	1.7	13.3		0.010	0.040	0.246		270
RM 73.4	"	4.2	13.4						
	"	6.6	13.4						
	MAR	4.0	13.2						300
	"	5.4	12.9						
	APR	8.6	11.9						
	"	8.8	14.0						
	June	17.0	10.8						
	"	18.4	10.2						
	July	18.2	9.8						120
	Sept	15.1	10.5	1.5	0.020			3300	
	"	12.0	10.2	1.3	0.020			1300	
	"	14.2	10.1		0.020			390	
	OCT	12.5	9.5	1.6	0.044	0.050	0.493		70
	"	8.0	10.9	1.5		0.220	0.675		120
	NOV	7.8	10.9	1.2	0.018	0.040	0.404		176
	"	5.6	11.1	0.9	0.030	0.050	0.564		225
	Dec	1.8	13.2	1.0	0.017	0.060	0.345		280
	"	5.4	12.9	0.7	0.020	0.020	0.215		

TUDOR ENGINEERING COMPANY

BY BP DATE 6-15-75 SUBJECT APPENDIX VII SHEET NO. 1 OF 2

CHKD. BY ____ DATE ____ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: SPOKANE R. AT STATELINE (RM 96.5)

DATA SOURCE	MONTH	TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
FUNK	OCT.			0.6		0.002		1160	200
↓	"			1.2		0.002		1430	200
	"			1.0		0.000		680	210
	"							316	
	NOV.			1.4		0.003			290
	"			1.7		0.000			280
	"			0.5		0.000			280
	DEC.			0.2		0.001			270
STORET	JAN.			0.7	0.006	0.080	0.260	170	
↓	"				0.016			340	
	"				.005				
	FEB.	5.0		0.8	0.000	0.090	0.527	3500	25
	"			1.4	0.006	0.040	0.194	200	290
	"			1.5	0.013	0.040	0.237	250	300
	"				0.002			1400	
	"				0.012				
	"				0.001				
	"				0.005				
	MAR.	4.0	12.6	1.4	0.010	0.060	0.292	1600	350
	"	4.8		1.1	0.006	0.050	0.165	400	
	"	3.0			0.078	0.100		0	
	"				0.029			820	
	"				0.011				
	"				0.008				
	APR.	8.6	12.0	2.1	0.006	0.060	0.192	120	325
	"	7.5			0.010	0.070	0.205	1100	
	"				0.033	0.100		5	
	MAY	6.0	12.0		0.013	~~0.800~~*		40	
	"	9.9	10.2		0.023	0.200		106	
					0.013	0.200		460	
↓					0.006				

* Discounted in mean

TUDOR ENGINEERING COMPANY

BY BP DATE 5-5-75 SUBJECT APPENDIX VII (cont.) SHEET NO. 2 OF 2
CHKD. BY ______ DATE ______ JOB NO. 404

SURFACE WATER QUALITY DATA
LOCATION: SPOKANE R. AT STATELINE (RM 96.5)

DATA SOURCE	MONTH	TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
STORET	JUNE	17.0	10.2	3.2	0.003	0.08	0.103	410	170
↓	"			4.5	0.003	0.05	0.071		
	"				0.003	0.100			
	"				0.003				
	JULY	17.8	9.8	1.0	0.003	0.040	0.192	1300	190
	"	20.0	9.3	1.4	0.010	0.070	0.286	620	182
	"				0.023	0.100	0.272	2800	
	"				0.003	0.100			
	"				0.003	0.050			
	"				0.009	0.050			
	"				0.010	0.020			
	"				0.020				
	AUG.	21.0	9.0		0.006	0.100		1000	180
	"	22.1	8.9		0.003	0.200		3000	140
	"							5900	
	SEPT.	17.3	8.3	2.0	0.003	0.150	0.553	1000	146
	"	18.0	8.9	0.9	0.004			400	
	"			1.1					
	OCT.	13.5	10.1	0.9	0.023	0.050	0.222	550	190
	"	13.2		1.6	0.010	0.030	0.194	800	220
	"	13.2			0.005			360	
	NOV.	7.4		1.3	0.026	0.040	0.192	500	340
	"	5.4		0.5	0.003	0.050	0.187	2000	275
	"				0.003	0.100		40	
	DEC.	5.0	10.2	1.3	0.010	0.060	0.242	650	300
	"	2.0		0.8	0.003	0.060	0.116	4000	340
	"				0.93	0.030		330	
	"				0.011				
					0.003				

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX VIII SHEET NO. 1 OF 2
CHKD. BY ____ DATE ____ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: HANGMAN CR. AT MOUTH

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli no./100 ml	Zn, Diss. ug/l
K-T 1973	Sept	16.2	10.0	1.2	0.013	0.030	0.25	78	9
	"	15.2	7.6	17.9	0.065	0.062	0.74	92	24
	"	13.8	6.4	16.2	0.211	0.042	0.73	—	26
SOLTERO 1972-3 (UNPUB)	MAY	14.3	9.0			0.22	—		30
	JUNE	20.3	7.5			.10	1.458		30
	"	15.1	7.3			.22	3.260		20
	JULY	16.3	7.8			.15	1.730		0
	"	17.1	7.5			.12	2.930		0
	"	15.7	7.5			.22	4.710		0
	"	15.5	7.7			.14	1.840		0
	"	16.9	8.0			.10	1.830		0
	AUG	16.9	7.6			.10	2.290		0
	"	16.0	8.6			.08	2.560		20
	"	18.6	7.9			.09	1.790		0
	"	17.5	8.1			.16	2.150		0
	Sept	14.6	7.8			.09	1.900		0
	"	10.4	9.6			.07	1.85		20
	"	11.7	8.8			.11	2.04		0
	"	6.6	10.5			.10	2.00		0
	OCT	7.6	10.4			.08	1.46		20
	NOV.	4.6	11.8			.11	1.35		10
	Dec	5.0	12.9			.05	2.83		0
	JAN	0.5	14.4			1.26	3.59		10
	FeB	2.4	12.8			.40	2.68		20
	MAR	3.6	12.8			.34	2.68		90

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX VIII (Con't) SHEET NO. 2 OF 2
CHKD. BY ______ DATE ______ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: HANGMAN CR. AT MOUTH

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100ml	Zn, Diss. ug/l
STORET 1972-73	JAN	2.0	13.2		0.230	0.360	1.520		
	FEB	0.6	13.3		0.560	0.850	2.56		50
	"	2.8	13.0						
	"	7.0	13.2						
	MAR	3.8	11.8						
	"	9.4	10.4						
	APR	12.4	11.1						
	"	16.1	11.2						
	JUNE	20.0	12.2						
	"	21.2	12.2						
	JULY	19.0	11.7						24
	SEPT		12.3		0.050			800	
	OCT	11.3	11.5		0.048	0.240	1.089		
	"	4.0	14.6		0.046	0.020	0.951		
	NOV	6.1	13.8		0.057	0.110	0.990		5
	"	2.3	14.1		0.096	0.060	0.998		
	DEC	4.0	11.7		1.100	0.920			

TUDOR ENGINEERING COMPANY

BY BP DATE 12/9/74 SUBJECT APPENDIX IX SHEET NO. 1 OF 3

CHKD. BY ____ DATE ____ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LITTLE SPOKANE AT MOUTH (RM 1.1)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. µg/l
K-T 1973 RM 1.1	Sept.	12.3	8.4	0.2	0.015	0.006	0.093	332	3
	"	12.3	8.3	0.2	0.013	0.007	0.072	425	11
	"	13.7	7.1	1.2	0.021	0.011	0.077	–	14
USGS 1970-1971 RM 1.1	JAN	3.6	10.2		0.070	0.02	1.250	400	
	"	5.2	9.5		0.060	0.01	0.85	700	
	"	6.8	9.4		0.160	–	–	500	
	FEB	6.1	9.9		0.090	0.12	0.91	400	
	"	5.0	10.2		0.040	0.05	2.17	200	
	MAR	5.0	9.1		0.220	0.13	1.23	3500	
	APR	7.8	9.6		0.120	0.07	0.73	1000	
	"	8.3	9.6		0.120	0.06	0.54	600	
	MAY	13.8	8.6		0.160	0.03	0.54	600	
	"	10.9	8.7		0.110	0.00	0.74	700	
	JUNE	12.0	9.8		0.020	0.01	0.74	800	
	"	13.9	9.5		0.010	0.00	0.88	700	
	JULY	13.8	9.4		0.030	0.02	1.28	1000	
	"	15.9	8.6		0.040	0.02	1.37	2500	
	AUG	15.8	8.2		0.090	0.02	1.30	2200	
	"	13.7	9.0		0.020	0.03	1.39	1600	
	SEPT	12.8	10.0		0.020	0.02	2.25	800	
	"	9.6	10.5		0.020	0.01	2.15	600	
	NOV	7.2	12.2		0.010	0.00	0.926	960	
	DEC	5.0	9.5		0.030	0.00	0.958	800	
BURKHALTER 1968	FEB	5.5	10.5	1.5	0.03	0.00		7500	
	MAR	7.4	10.5	0.7	0.05	0.00		1220	
	MAY	12.5	8.1	0.8	0.03	0.00		2700	
	JUNE	12.4	8.1		0.10	0.00		1000	
	AUG	12.3	9.8	0.4	0.20	0.00		6200	
	SEPT	12.0	8.6		0.04	0.00		2100	

TUDOR ENGINEERING COMPANY

BY BP DATE 12/9/74 SUBJECT APPENDIX IX (Con't) SHEET NO. 2 OF 3

CHKD. BY ______ DATE ______ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: LITTLE SPOKANE AT MOUTH (RM1.1)

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No/100ml	Zn, Diss. ug/l
STORET 1970-73 RM1.1	JAN	1.6	11.3		~~2.700~~*	0.140	~~7.075~~*		
	FEB	4.2	10.0		0.055	0.100	1.294		20
	"	6.0	10.4						
	"	7.0	11.9						
	MAR	6.2	12.2						49
	"	4.4	12.0						
	"	6.4							
	APR	11.5	10.6						
	"	11.8	9.4						
	JUNE	14.4	8.8						
	"	15.2	8.6						
	JULY	16.0	9.6						18
	SEPT	13.0	9.5		0.020				
	"	13.4	9.7		0.028				
	OCT.	7.5	8.7			0.030	1.153		
	"	10.0	11.7		0.031	0.030	1.166		
	NOV.	8.3	12.2		0.023	0.030	1.440		15
	"	6.0	10.5		0.028	0.080	1.185		40
	Dec.	0.8	9.9		0.018	0.040	1.106		
	"	6.6			0.070	0.080	1.221		

* Discounted in mean

TUDOR ENGINEERING COMPANY

BY BP DATE 12/9/74 SUBJECT APPENDIX IX (con't) SHEET NO. 3 OF 3

CHKD. BY ______ DATE ______ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LITTLE SPOKANE AT MOUTH (RM 1.1)

DATA SOURCE	MONTH	TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100ml	Zn, Diss. ug/l
SOLIPRO 1972 (UNPUB.)	JAN	2.9	11.9			0.23	1.380		30
	FEB	6.0	10.0			0.08	1.250		70
	MAR	5.0	10.6			0.04	1.370		40
	MAY	12.5	8.0			0.21	—		80
	JUNE	16.3	7.8			0.04	2.640		40
	"	13.4	7.1			0.06	2.032		10
	JULY	13.9	7.7			0.12	1.970		0
	"	15.3	7.7			0.03	1.750		0
	"	14.3	8.0			0.08	1.640		0
	"	18.5	7.9			0.07	1.720		0
	"	14.3	8.4			0.13	2.080		0
	AUG	14.0	7.8			0.09	—		0
	"	13.6	8.1			0.03	1.850		0
	"	14.9	8.6			0.06	1.970		0
	"	14.5	9.2			0.11	2.180		0
	SEPT	12.8	7.6			0.25	1.890		20
	"	10.5	9.5			0.27	1.980		0
	"	11.5	9.0			0.05	1.890		0
	"	8.9	8.7			0.04	1.730		0
	OCT	8.7	9.6			0.03	1.650		20
	NOV	10.1	10.1			0.05	1190		0
	DEC	6.4	10.6			0.09	1.290		0

TUDOR ENGINEERING COMPANY

BY BP DATE 12/6/74 SUBJECT APPENDIX X SHEET NO. 1 OF 2

CHKD. BY ____ DATE ____ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LITTLE SPOKANE AT DARTFORD (RM 10.6)

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No/100ml	Zn, Diss. mg/l
K-T 1974 RM 10-6	June	22.3	8.2	0.2	0.044	0.040	0.69	3030	—
	"	19.8	7.0	0.4	0.047	0.041	0.69	3860	850
BURKHALTER 1968 RM 10.6 STA-445	FEB	4.0	12.2	1.9	0.02	0.000		13,000	
	"	4.0	12.1	1.6	0.03	0.000		8600	
	MAR	6.2	10.7	1.1	0.06	0.000		1000	
	"	6.2	10.4	0.9	0.04	0.000		1000	
	MAY	14.0	9.9	1.3	0.04	0.000		1300	
	"	14.0	9.9	0.9	0.04	0.000		—	
	June	16.2	9.6		0.10	0.000		1300	
	"	16.6	9.6		0.10	0.000		730	
	AUG	15.0	9.9	0.6	0.22	0.000		5300	
	"	14.9	9.4	0.6	0.22	0.000		5400	
	SEPT	15.0	9.8		0.06	0.000		5400	
	"	15.0	9.6		0.05	0.003		7000	

TUDOR ENGINEERING COMPANY

BY BP DATE 12/9/74 SUBJECT APPENDIX X (Con't) SHEET NO. 2 OF 2

CHKD. BY ______ DATE ______ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: LITTLE SPOKANE AT DARTFORD (RM 10.6)

DATA SOURCE	MONTH	PARAMETERS: TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
STORET	FEB	5.1	12.6						20
1970-1973	"	5.0							20
RM 10.6	"								
	MAR	4.4							92
	"	6.0							
	APR	11.0							
	"	11.2							
	MAY	18.0	8.6						
	JULY								18
	SEPT	14.8	10.7		0.030			70	
	"	14.0	10.2		0.090			30	
	"		10.4						
	"		10.6						
	OCT	10.0							
	"	5.0							
	NOV	6.6							10
	"	2.3							53
	DEC.	4.4							20
	AUG.	22.0	9.5						

TUDOR ENGINEERING COMPANY

BY BP DATE 12/9/74 SUBJECT APPENDIX XI SHEET NO. 1 OF 1

CHKD. BY ______ DATE ______ JOB NO. 404

SURFACE WATER QUALITY DATA

LOCATION: LIBERTY LAKE

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
USGS 1970-71	MAR (13')				0.05	0.12			
	MAY (3')	19.0			0.01	0.02			
	" (21')	14.0			0.02	0.07			
	JULY (3')	24.5			0.01	0.01			
	" (21')	19.0			0.03	0.21			
	SEPT (3')	14.5			0.03	0.12			
	" (20')	14.5			0.04	0.13			

TUDOR ENGINEERING COMPANY

BY BP DATE 12/9/74 SUBJECT APPENDIX XII SHEET NO. 1 OF 1
CHKD. BY ____ DATE ____ JOB NO. 409

SURFACE WATER QUALITY DATA

LOCATION: NEWMAN LAKE

DATA SOURCE	MONTH	PARAMETERS							
		TEMP. °C	D.O. mg/l	BOD mg/l	Tot. PO_4-P mg/l	NH_3-N mg/l	Tot. N mg/l	Tot. Coli No./100 ml	Zn, Diss. ug/l
Lee 1968	OCT								
	0-15'	9.1	9.6						
	15-30'	9.2	9.4						
USGS 1970-71									
	MAR (15')				0.05	0.20			
	MAY (3')	18.0			0.01	0.07			
	" (27')	11.0			0.02	0.03			
	JULY (3)	24.0			0.01	0.23			
	" (26')	13.0			0.01	0.02			
	SEPT (3')				0.02	0.12			
	" (26')				0.01	0.16			

SECTION 410.1

STATISTICAL ANALYSIS OF STREAMFLOW RECORDS

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 410.1

STATISTICAL ANALYSIS OF STREAMFLOW RECORDS

18 Oct 1974

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

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SECTION 410.1

STATISTICAL ANALYSIS OF STREAMFLOW RECORDS

Purpose and Scope

The purpose of this section is to apply standard statistical methods to the available stream flow records of the study area toward determination of the magnitude and recurrence frequency of flood flows and low flows. The flood flows are used in a subsequent section to delineate the flood plain at the following locations:

1. Spokane River from the Hangman Creek confluence to the Idaho boundary.
2. Little Spokane River from confluence with the Spokane River to the vicinity of Chattaroy.
3. Rock Creek in the vicinity of Rockford.
4. Hangman Creek in the vicinity of potential urban developement.

The criterion for flood plain delineation is the peak flow with 100 year recurrence interval. Peak flows of lesser return frequency are also determined in the process of analysis, but the peak flows of 100 year return frequency are the critical objectives.

The low flow data are developed for the purpose of providing a basis for evaluation of critical supply for maintenance of natural stream life and for evaluation of critical assimilative and dilution potential for wastewater disposal alternatives. The criterion for low flow evaluations is the 7-day interval of lowest mean flow with recurrence interval of

10 years. As with flood flow analysis, low flows of other return frequencies are developed but primary interest is for short return intervals.

Low Flow Analysis

General. The available stream gages in the study area with periods of record adequate for statistical analysis are listed in Table 1. For reasons discussed below the entire available period for each gage is not used for all gages.

Elimination of Low Flows Due to Freezing. The primary use of the resultant low flow data is to be evaluation of water quality management problems which are most critical during summer when low flows are combined with higher water temperatures. For the Little Spokane River and Hangman Creek there are winter low flow events caused by freezing. To avoid distortion of the summer lows, which are of primary interest, these winter lows are excluded from the statistical analysis by deletion of all events occurring before March 1 or after October 31. Other than the exclusion of freezing season events, the entire period of available record is utilized for the two gages on the Little Spokane River and the one on Hangman Creek. These records are twenty years in length and should give adequate results for determination of return frequencies of 10 years and less.

Regulation and Diversions. Low flow events in the Spokane River as it enters the study area are significantly affected by the controlled releases at Post Falls Dam due to Washington Water Power Companies' (WWP) hydroelectric operations. There are relatively small interchanges between the Spokane River and groundwater between Post Falls and the study area boundary and practically none between the dam and gage number 4190. There is, however, a major groundwater interchange with the Spokane River between the study area boundary and gage number 4225 located a short distance upstream from the Hangman Creek confluence. Hence, the records for gage number 4190 reflect an almost complete dependence upon Post Falls regulation but those at gage number 4225 are only partially dependent upon regulation.

The regulation exercised by WWP is in accordance with an operating policy that has been in effect and substantially unchanged since 1946. Prior to 1946 operating policy relative to flow regulation was different due to different system capability and power requirements. Therefore, the records prior to 1946 represent a significantly different flow regime. The flow regime from 1946 to present, although fully regulated, approximates natural conditions. The current WWP operating policy is to bring Coeur D'Alene Lake to its summer level as soon as possible after the spring high flows and then to maintain that level constant throughout the summer by regulation of release rates at Post Falls.

There have been two significant irrigation diversions on the Spokane River above the streamgage near Post Falls #4190. These two irrigation diversions and the gages used to record them are:

		USGS Gage#
1.	Spokane Valley Farm's Company Canal at Post Falls	4185
2.	Rathdrun Prairie Canal at Huetter	4180

The Spokane Valley Farms canal began operation in 1913 and continued to supply irrigation water through the 1966 irrigation season. In 1967 the operation of the canal was suspended. Irrigation water is now being supplied from groundwater sources. The Rathdrun Prairie canal began operation in 1947 and is still an active supplier of irrigation water.

The WWP operating policy since 1946 has, in effect, been to release at Post Falls an amount of water which, combined with the irrigation diversions, is equal to the total inflow to Coeur D'Alene Lake less evaporation losses. The primary sources of inflow to Coeur D'Alene Lake are the Coeur D'Alene River and the St. Joe River. It is recognized that, at times, WWP may, for technical operating reasons, release more or less than what the natural outflow from Coeur D'Alene Lake would be, but it is believed that these occurrences are of such rare occurence and short duration as to not affect the statistical analysis.

In order that the low flow analysis best represent natural flows that could be expected to be available for water resources management, the diversions above the Post Falls Dam have been added to the flow released at the dam by Washington Water Power Company before statistical analysis. Both irrigation diversions are added back into the flow, that of the discontinued diversion and that of the continuing diversion.

There are no regulating structures on either the Little Spokane River or Hangman Creek. There are no significant diversions from Hangman Creek. A number of water rights are held for diversions from the Little Spokane River. These rights from DOE records total 111 cfs. There are, however, no records of the amounts actually diverted on seasonal basis, let alone on a time basis, that could be correlated with stream flow records. Hence, the statistical analysis of the Little Spokane River is done on the basis of measured flow uncorrected for diversions and is, therefore, not necessarily representative of natural streamflow conditions.

In summary, the data subject to statistical analysis for low flow is as follows:

1. Spokane River near Post Falls, gage 4190. Total record available 1913 to 1972. Record used 1947 to 1972. Irrigation diversions from gages 4180 and 4185 added in before analysis.

2. Spokane River at Spokane, gage 4225. Total record available 1891 to 1972. Record used 1947 to 1972. Irrigation diversions from gages 4180 and 4185 added in before analysis.

3. Little Spokane River at Elk, gage 4270. Record available and used 1948 to 1972, except that low flows Nov. 1 to Feb. 28 (or 29) not considered.

4. Little Spokane River at Dartford, gage 4310. Record available and used 1929 to 1932 and 1947 to 1973, except that low flows Nov. 1 to Feb. 28 (or 29) are not considered.

5. Hangman Creek at Spokane, gage 4240. Record available and used 1949 to 1972, except that low flows Nov. 1 to Feb. 28 (or 29) are not considered.

Computation Procedure. The computation procedure for low flow analysis using the data described above in annual series is carried out in the following steps.

1. Identify the 7-day low flow event for each year included in the analysis.
2. Rank the data in terms of increasing discharge.
3. Assign plotting positions to each piece of data - from Beard, Statistical Method in Hydrology.
4. Plot the data on probability paper.
5. Draw a curve through the data points.
6. The magnitude of the 10-year event is the value where the curve intersects the probability of recurrence of 10 percent.

Frequency curves are developed graphically by plotting on log-probability paper. Refer to Figures A through E. A break in slope is an expected feature of these low flow curves, connecting two straight line plots. The location of the break in slope is clearly indicated in the plots for the Little Spokane at Dartford and for the Spokane River at Spokane in the vicinity of 25 percent. This insight is used to select the indistinct break exhibited by the data for Hangman Creek at Spokane River near Post Falls. The final fittings are made using the method of least squares. The Little Spokane River at Elk data does not exhibit any break in slope but is rather a single straight line throughout. The plotting positions for the split record on the Little Spokane River are determined by the method of Beard's Exhibit 11 in recognition of the probability that 1930 and 1931 are the lowest years in the last 45 years (and possibly the lowest since 1891).

Results. The determined value of 7-day low flow with recurrence frequency of 10 years for the five gages is summarized in Table 1.

While the Spokane Valley Farms diversion, USGS gage #4185, and Rathdrun Prairie Canal, USGS gage #4180, were both in service from 1947 through 1966, the total of both diversions is in the range 230 to 290 cfs for most years during the critical low flow period. Beginning in 1967, with only the Rathdrun Prairie Canal in operation, the total diversion during critical low flows is approximately 50 cfs. Assuming the Rathdrun Prairie Canal continues in operation, the calculated statistical low flows which do not include these diversions are approximately 50 cfs greater than would be observed.

Discussion of Low Flow Results

Spokane River. The observed flow at Post Falls, as indicated above, is essentially equal to the inflow of the Coeur D'Alene and St. Joe river systems into Coeur D'Alene Lake less evaporation from Coeur D'Alene Lake. Since there are no significant storage structures in these rivers, the observed flow represents natural conditions. If the natural low flow condition occurs concurrently with the irrigation season for the Rathdrun Prairie Canal, the actual flow experienced below Post Falls would be about 50 cfs less than shown in Figure A due to the diversion, making net the 10 year flow approximately 145 cfs.

The tributary area at Post Falls, gage 4190, is 3840 square miles and at Spokane, gage 4225, is 4290 square miles, or 12 percent more. The

7-day low flow at Spokane is 860 compared with 195 at Post Falls or 4.4 times greater. This much larger flow is due to the groundwater increment between Post Falls and Spokane which not only affects the quantity but the quality and temperature. It should be noted that the ultimate source of most of the groundwater increment is outside of the tributary area of the river above Post Falls. The 7-day low flow is 0.05 cfs per square mile at Post Falls and 0.20 cfs per square mile at Spokane.

Hangman Creek. The 7-day low flow at the Hangman Creek gage 4240 is only 3.4 cfs or 0.005 cfs per square mile of tributary area. The entire watershed is essentially in the Columbia Plateau region which consists of Palouse topsoil on a base of basalt interbeded with Latah formation. There is essentially no groundwater body in the area except that which occupies the fractures in the basalt element. The topsoil has good moisture holding qualities for agriculture but stores no free water for subsequent release to groundwater. Therefore, it is to be expected that the streamflow outside the rainfall season would be very small.

The 7-day low flow with 10 year recurrence actually gives an optimistic picture of what can happen, as it actually did in the fall of 1974 when it essentially went dry. This is indicated by the steep slope of the curve to the right of the break.

Little Spokane River. The shape of the curves obtained at the Elk gage, number 4270, and the Dartford gage, number 4310, as well as the yield per square mile of tributary area indicate different hydrologic regimes. The curve at Elk exhibits no break and shows a yield of 0.31 cfs per square mile at 7-day low flow with 10 year recurrence. The curve for Dartford shows a break and has a corresponding yield of 0.13 cfs per square mile.

As indicated above, there is an unknown effect on the Dartford yield due to the exercise of water rights for diversions of up to 111 cfs. This would tend to decrease the apparent yield at Dartford. The geology, on the other hand, indicates a more favorable groundwater condition for the Dartford gage since it includes the Deer Park basin gravels, whereas the areas above Elk are believed to have small gravel deposits on relatively impermeable base rock.

Flood Frequency Analysis

General. The stream gages subject to analysis and their periods of available record are shown in Table 2. The Spokane River gage with its 83 years of available record is the only gage with a record of adequate length for relatively high confidence determination of the 100 year recurrence event which is of primary interest. The Little Spokane and Hangman Creek records are both less than 30 years length and, for this reason, should be extended by interbasin correlation to increase reliability.

Regulation. There are no regulating structures on either the Little Spokane River or Hangman Creek. The record of flood flows on these streams is a record of natural unregulated flow. The diversions noted above in the Little Spokane basin, allowed by water rights, are negligibly small when compared with flood stage flows.

The Spokane River is subject to a degree of flood flow regulation by the control of the level of Coeur D'Alene Lake by WWP. The rivers tributary to Coeur D'Alene Lake are unregulated. The area tributary to Coeur D'Alene Lake is 3700 square miles. The area tributary to the Spokane River below Coeur D'Alene Lake and upstream from gage 4225 is 4290 square miles but the flow reaching the river from this incremental area is negligible due to the permeable valley floor between the uplands and the river channel which prevent the formation of any significant surface drainage ways.

Post Falls Dam which forms the outlet regulating structure of Coeur D'Alene Lake is capable of regulating flows of up to 15,000 cfs at lake levels up to 2128 feet. Once the lake level reaches elevation 2128 feet and the quantity available for spill exceeds 15,000 cfs, the Post Falls structure no longer exercises control and control passes to the natural outlet of the lake. Refer to Section 308 for stage discharge relations of the lake outlet and the stage capacity of Coeur D'Alene Lake. Post Falls Dam was constructed in 1906.

It is theoretically possible to partially attenuate peak flood flows in the Spokane River by lowering the lake level in anticipation of a large runoff. The storage capacity of Coeur D'Alene Lake between elevation 2120.5, the lowest level, and elevation 2128, the level at which control normally passes to the natural outlet is 108,500 second foot days or 217,000 acre feet. This volume of storage is equal to 1.1 inches of runoff from the tributary area or one week's mean daily flow for the April, May, June period. The net effect of the potential Post Falls regulation on flood flow peaks is unknown without analyzing each event by a reversed routing through Coeur D'Alene Lake. Due to the large volume associated with snowmelt events compared with the potential storage, it appears unlikely that snowmelt events could be much attenuated by a planned lowering. On the other hand, rainfall events usually cannot be anticipated sufficiently in advance to make a planned lowering. Planned operations are therefore believed to have small effects on experienced peak flows. The data used herein is as recorded and reflects the net effect of all conditions including whatever effect planned interventions may be capable of achieving.

Rainfall and Snowmelt. Examination of flood records and the causative meteorological events indicates that for the Spokane River and Little Spokane River, flood flows can result from both rainfall and snowmelt events. For Hangman Creek, significant flood flows are predominantly caused by rainfall events. Since rainfall and snowmelt form separate statistical populations, it is necessary to develop separate analysis of flood flows from these two causes for both the Spokane River and Little Spokane River where both events cause significant floods.

Computation Procedure. The computation procedure for flood flow analysis is as follows:

1. Identify the annual flood peak or peaks for the years of available record. For the Spokane River at Spokane, gage 4225, and the Little Spokane River at Dartford, gage 4310, flood peaks are identified with relation to their cause, rainfall or snowmelt, by the examination of concurrent climatological data for weather stations in the watershed. For Hangman Creek at Spokane, gage 4240, one peak per year is identified based on a similar climatological screening which indicates that all significant floods are a consequence of rainfall events.

2. Since the available records of peak instantaneous discharge, in general, report only one peak per year, there is a blank in one

or the other rainfall or snowmelt series, after the reported peak is categorized. It is necessary to fill these blanks by correlations between the instantaneous peaks and the corresponding daily flow. Since the entire year record is available as daily flows, the correlation provides a means of converting other identifiable daily discharges to the corresponding instantaneous peak. The method used for correlation is the single linear correlation described by Beard (1962) at paragraph 9-02. As a result of this correlation technique, complete annual series for the period of record of each station are obtained.

3. The short record stations, Hangman Creek #4240 and Little Spokane #4310, are extended by interbasin correlation with Spokane River #4225. The method used is simple linear correlation per Beard (1962). This interbasin correlation results in extended annual series for the short record stations.

4. The annual series for each station as filled in and extended by correlation are subjected to statistical analysis by the logarithmic Pearson Type III method as described in Beard (1962). The results are calculated frequency curves and the statistical coefficients which provide an indication of the degree of reliability of the analysis. Skew coefficients are calculated and compared with the regional minimum value of -0.36. Calculated skews larger than -0.36 are utilized in determination of k factors but the regional minimum is used in lieu of smaller calculated values.

5. In addition to the calculated frequency curves, the peak flow data are also plotted on log-probability paper to show the relative response of the calculated frequency curves to length of record and statistical parameters.

6. For stations with annual series for both rainfall and snowmelt events, a combined probability curve is developed using the relationship as follows:

$$P_{average} = P_{rain} + P_{snow} - \frac{P_{rain} \times P_{snow}}{100}$$

Final results for the three stations are shown graphically in Figures F, G and H which show the full range of exceedence events. The critical values shown to have a probability of exceedence of once in a hundred years are marked on these curves and recorded as figures in Table 2.

Supporting data are shown in the Appendix as follows:

For the Spokane River at Spokane, Gage 4225. Raw data for rainfall and snowmelt peaks flows 1892 to 1974 are shown in Appendix(A) VI and VII. The annual series of peak rainfall and snowmelt events filled in by correlation with one day discharges is shown in A VIII and A IX together with the statistical properties of the results. The ordered peak flows, their logarithims and plotting position are shown in A X and XI and the plotted points in A XIII and XIV. The peak flow flow frequency curve calculation for both rainfall and snowmelt events is shown in A XII together with statistical properties, calculated skew and skew factors used in calculation. The calculated curves are plo d on A X and A XI for comparison with unadjusted points. The calculated curves are repeated in Figure F where the combined curve is developed.

For the Little Spokane River at Dartford, Gage 4310. Raw data for rainfall and snowmelt events 1930 - 1932 and 1947 - 1974 are shown in A XV and A XVI. Correlation with gage 4225 is shown in A XVII and A XVIII together with filled in peaks with the period of record from correlation within the basin. The extended record developed from inter-basin correlation with gage 4225 is shown in A XIX and A XX. Ordered peak flows, their logarithims and plotting position are recorded in A XXI and A XXII and points are plotted on A XXIV and A XXV. The peak flow frequency curve calculation for both rainfall and snowmelt events is shown in A XXIII together with statistical properties, calculated skew and skew factors used in calculation. The calculated curves are plotted on A XXIV and A XXV for comparison with unadjusted points. The calculated curves are repeated in Figure G where the combined curve is developed.

For Hangman Creek at Spokane, Gage 4240. Recorded data for events which have all been identified as rainfall events for the period of record, 1949 to 1974, are shown in A XXVI. It is not necessary for this gage to fill any gaps by correlation within its own record. Extension by correlation with the rainfall events of gage 4225 is shown in A XXVII. The ordered peak flows, their logarithims and plotting position are shown in A XXVIII and points are plotted in Figure H. The peak flow frequency curve and its statistical properties, calculated skew and adopted skew are shown in A XXIX. The calculated curve is plotted in Figure H.

Discussion of Flood Flow Results

Spokane River. The record for this gage is 82 years, which, if complete, would provide a substantial data base for determination of events with one per hundred year exceedence. Since only one peak instantaneous flow was recorded per year without regard to whether it was a rainfall or snowmelt event, the record is not complete for either. Since 87 percent of the recorded peaks are determined to have been snowmelt events, the rainfall data is weakest. This weakness is reflected in the computed value of N at 48.8 years for the series when filled out by correlation, indicating that the reliability of the rainfall event record is equal to 48.8 years rather than 82. For all except very rare events, snowmelt peaks are more critical than rainfall.

The determined "100 year" flood of 52,000 cfs is equal to 12.1 cfs per square mile based on the gross tributary area or 13.5 cfs per square mile if only the area above Coeur D'Alene Lake is considered. The yield is dominated by the high mountain terrain in Idaho on the headwaters of the Coeur D'Alene and St. Joe Rivers.

Little Spokane River. The short record for this station and the fact that it involves both rainfall and snowmelt events requires two stages of correlation for completion of the data series, extended. The correlations between peak events and 1-day events within the basin are very good. Therefore, the effect on reliability of the second correlation is substantially that due to the second correlation alone. The N values computed are based on that assumption and indicate an extended record equal in quality to 31.1 and 39.0 years respectively for rainfall and snowmelt.

The Little Spokane River exhibits the opposite characteristic of the Spokane River with respect to the significance of snowmelt and rainfall events. For the Little Spokane River rainfall events of the same frequency are larger than snowmelt events over the entire range. For the "100 year" flood, the peak flow of 4700 cfs is almost entirely determined by the rainfall event curve. The flood flow is equal to a runoff of 7.05 cfs per square mile. The forest cover and permeable valley fills tend to attenuate peak flows on this basin as compared with Hangman Creek. The lower overall yield due to the lower precipitation range in the Little Spokane Valley as compared with the watershed of the Spokane River accounts for the difference between these two rivers, which more than makes up for the routing effect of Coeur D'Alene Lake.

Hangman Creek. Flood flows are entirely dominated by rainfall events. The extension by correlation is not as beneficial as for the Little Spokane due to poorer interbasin correlation. The extended data has an N of only 28.8 years.

The "100 year" flood flow at 28,000 cfs is equal to a runoff of

40.6 cfs per square mile. This reflects the absence of significant forest cover and permeable soils in the tributary area. The positive skew of the calculated curve is indicative of the potential for even greater extremes of flood flow for rare events.

TABLE 1

LOW FLOW ANALYSIS

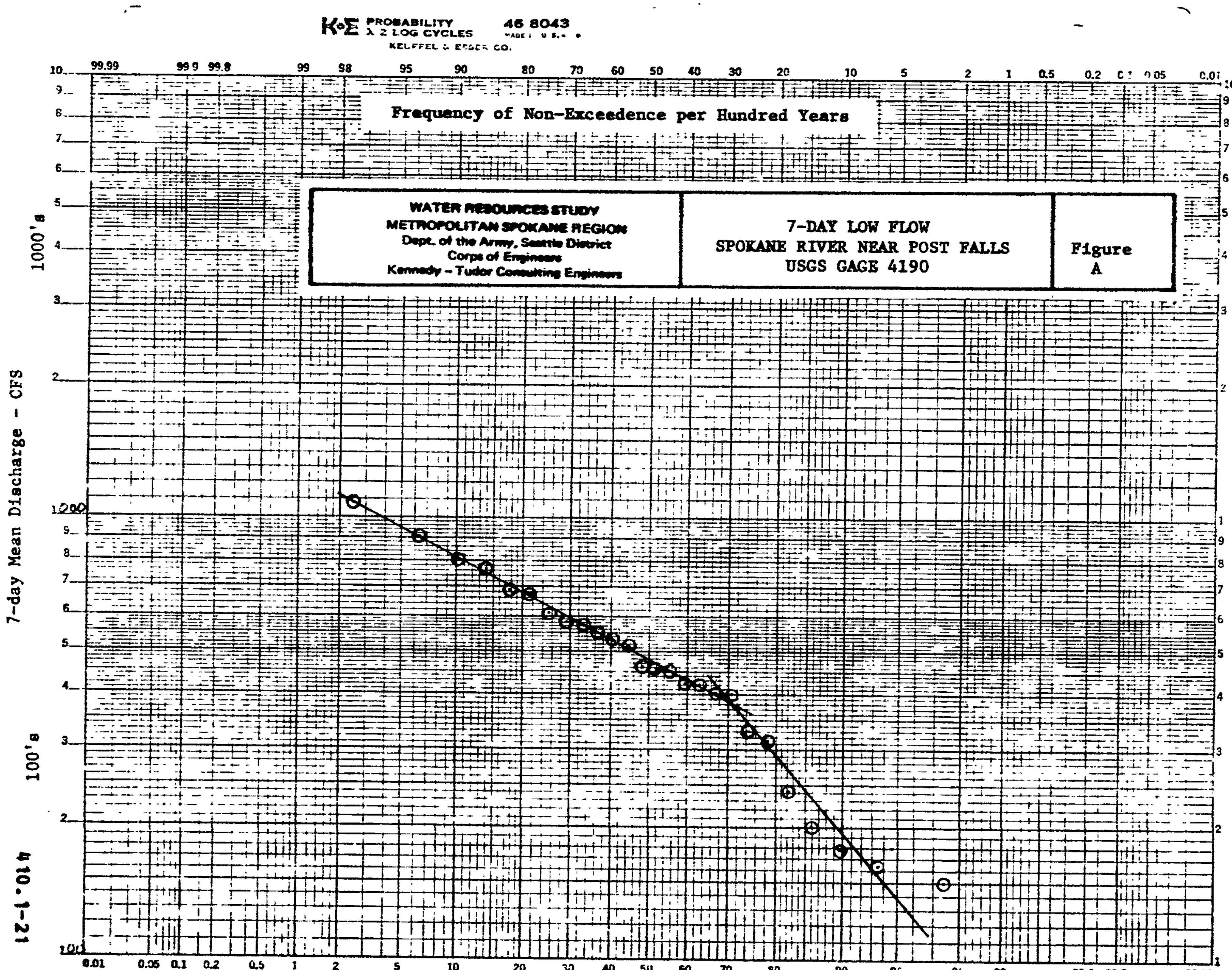
USGS Gage Number	Name	Available Record		Record Utilized*		7-day Low Flow with 10 year Recurrence cfs
		From	To	From	To	
4190	Spokane R. near Post Falls	1913	1972	1947	1972	195
4225	Spokane R. at Spokane	1891	1972	1947	1972	860
4240	Hangman Cr. at Spokane	1949	1972	1949	1972	3.4
4270	Little Spokane R. at Elk	1948	1972	1948	1972	35.5
4310	Little Spokane R. at Dartford	1929 1947	1932 1973	1929 1947	1932 1973	92

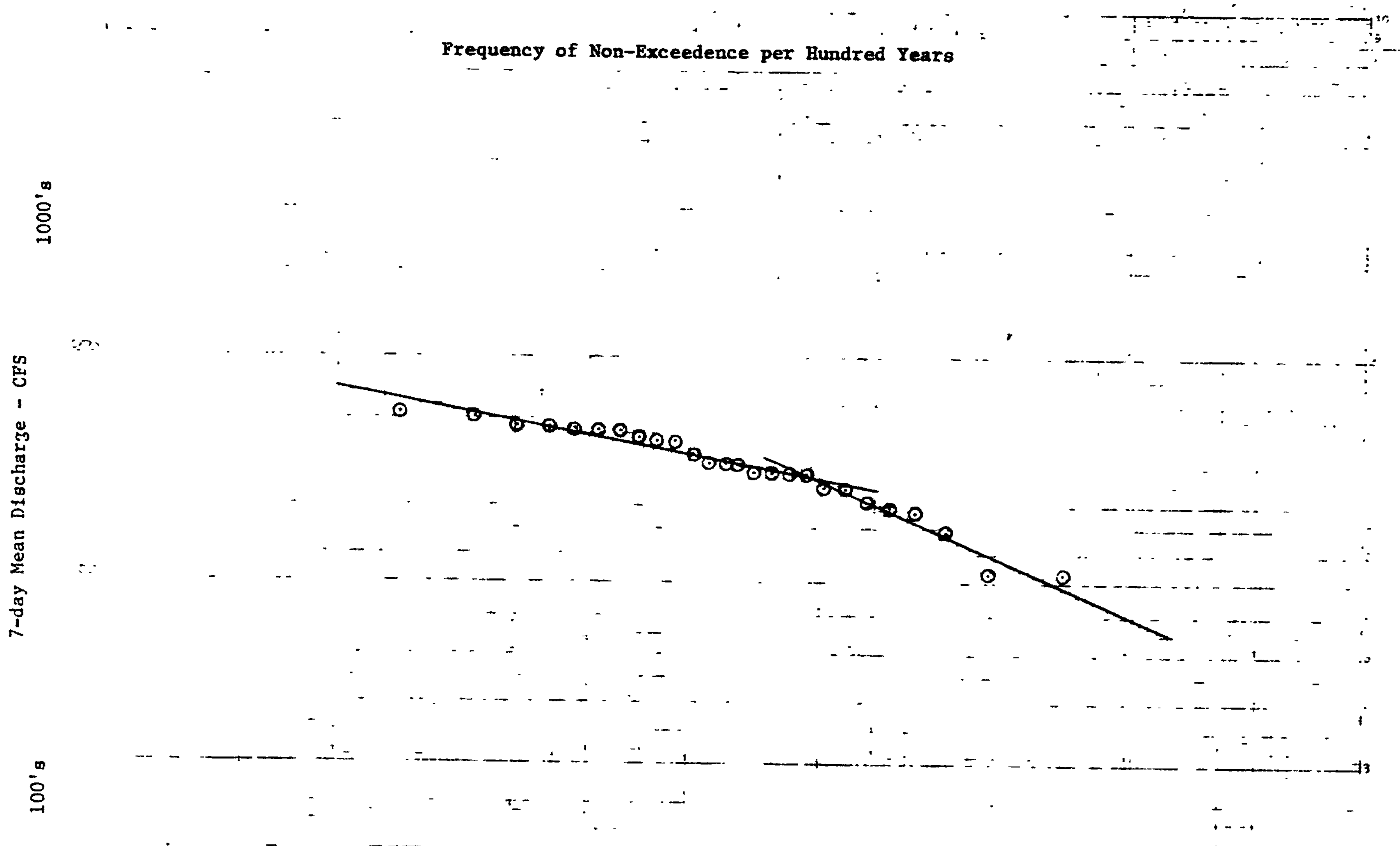
* Except that low flows in the freezing season, Nov. 1 to Feb. 28 (29), are excluded from analysis.

TABLE 2

FLOOD FLOW ANALYSIS

USGS Gage Number	Name	Tributary Area Square Miles	Available Record From	Available Record To	100 year Flood Flow cfs
4225	Spokane R. at Spokane	4290	1891	1974	52,000
4240	Hangman Cr. at Spokane	689	1949	1974	28,000
4310	Little Spokane R. at Dartford	665	1930	1932	4,700
			1947	1974	

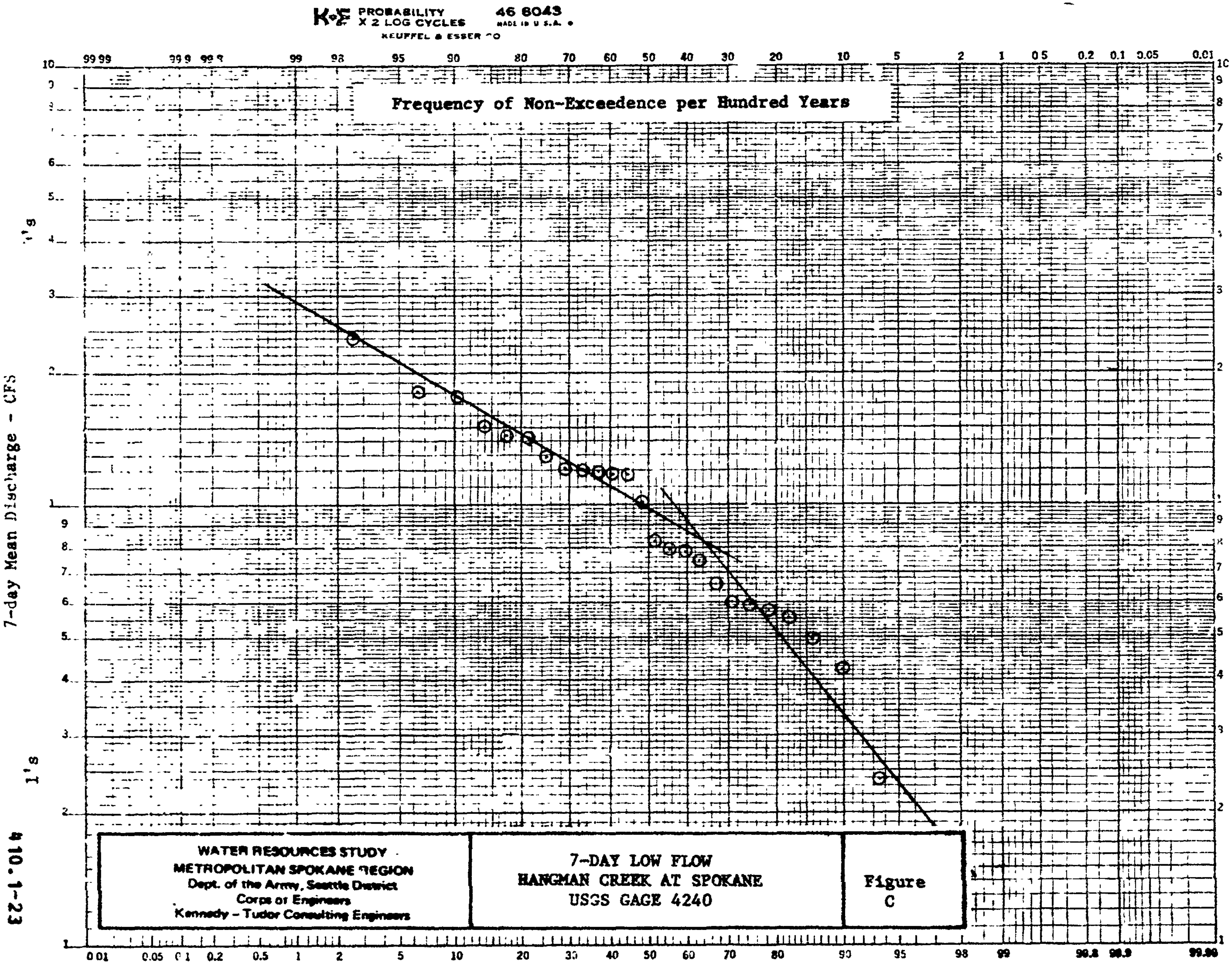

K&E PROBABILITY X 2 LOG CYCLES 46 8043
KEUFFEL & ESSER CO.
Frequency of Non-Exceedence per Hundred Years
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers
7-DAY LOW FLOW
SPOKANE RIVER NEAR POST FALLS
USGS GAGE 4190
Figure A
7-day Mean Discharge - CFS
1000's
100's



WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers

7-DAY LOW FLOW
SPOKANE RIVER AT SPOKANE
USGS GAGE 4225

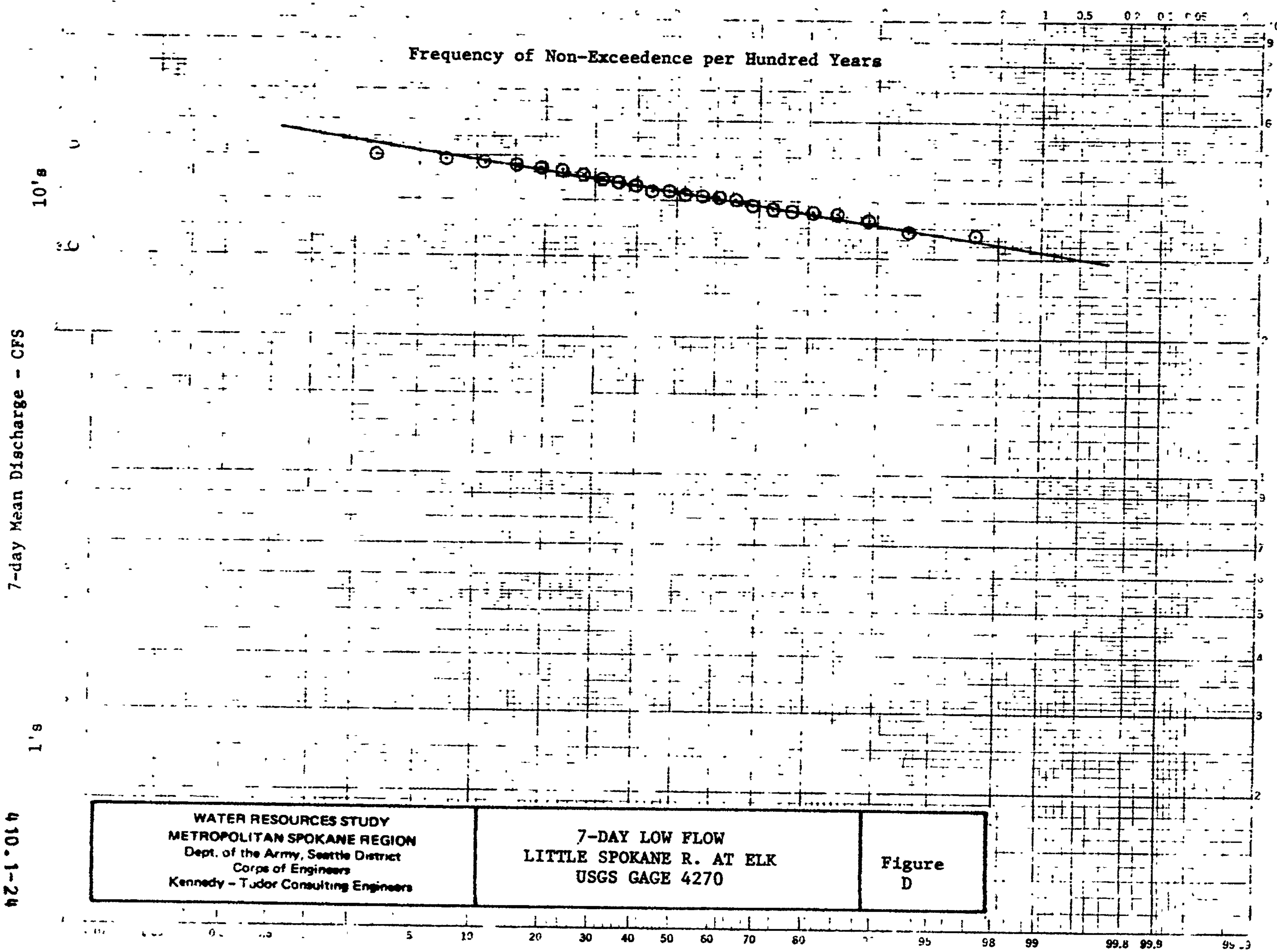
Figure B



WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers

7-DAY LOW FLOW
HANGMAN CREEK AT SPOKANE
USGS GAGE 4240

Figure C



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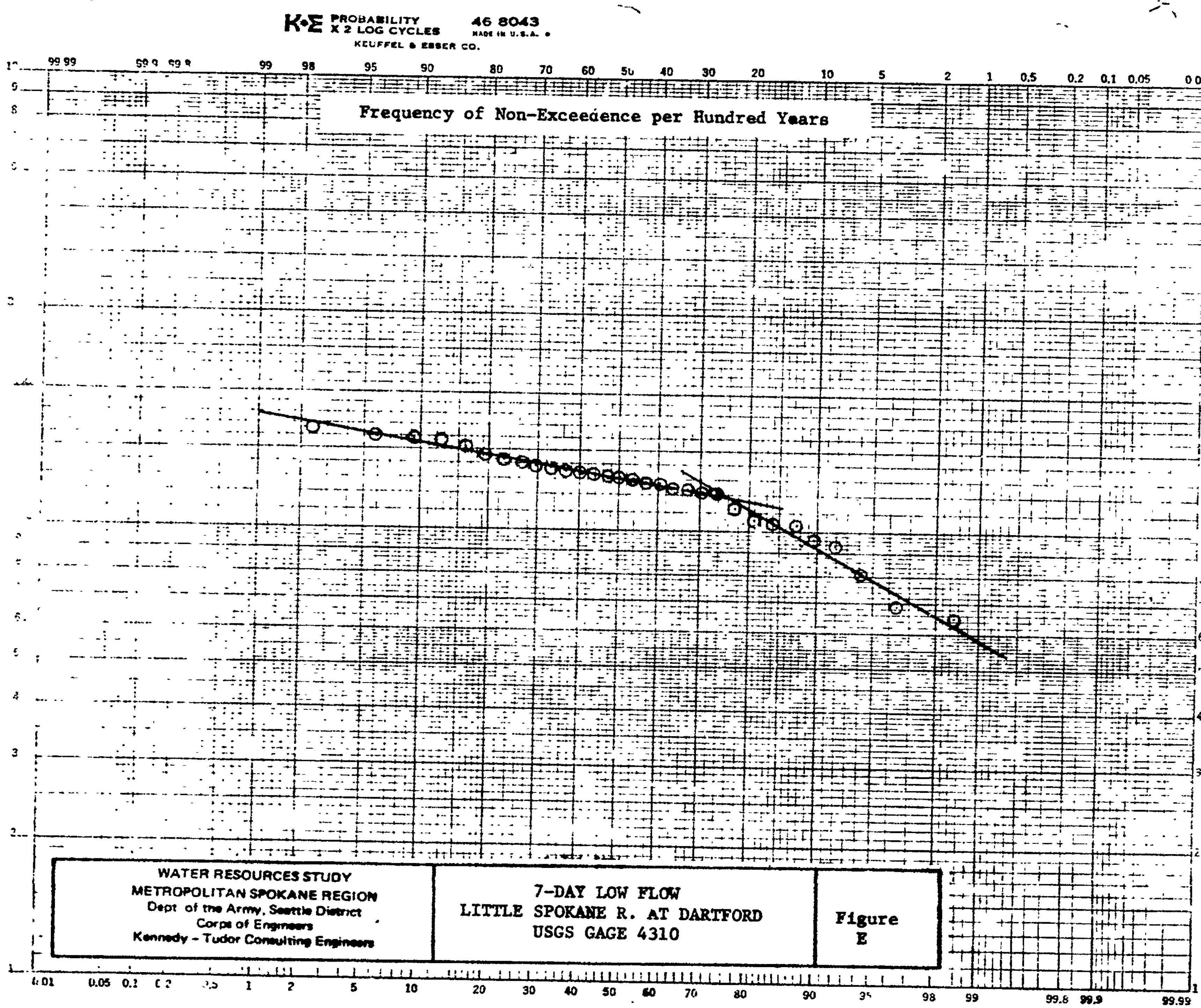
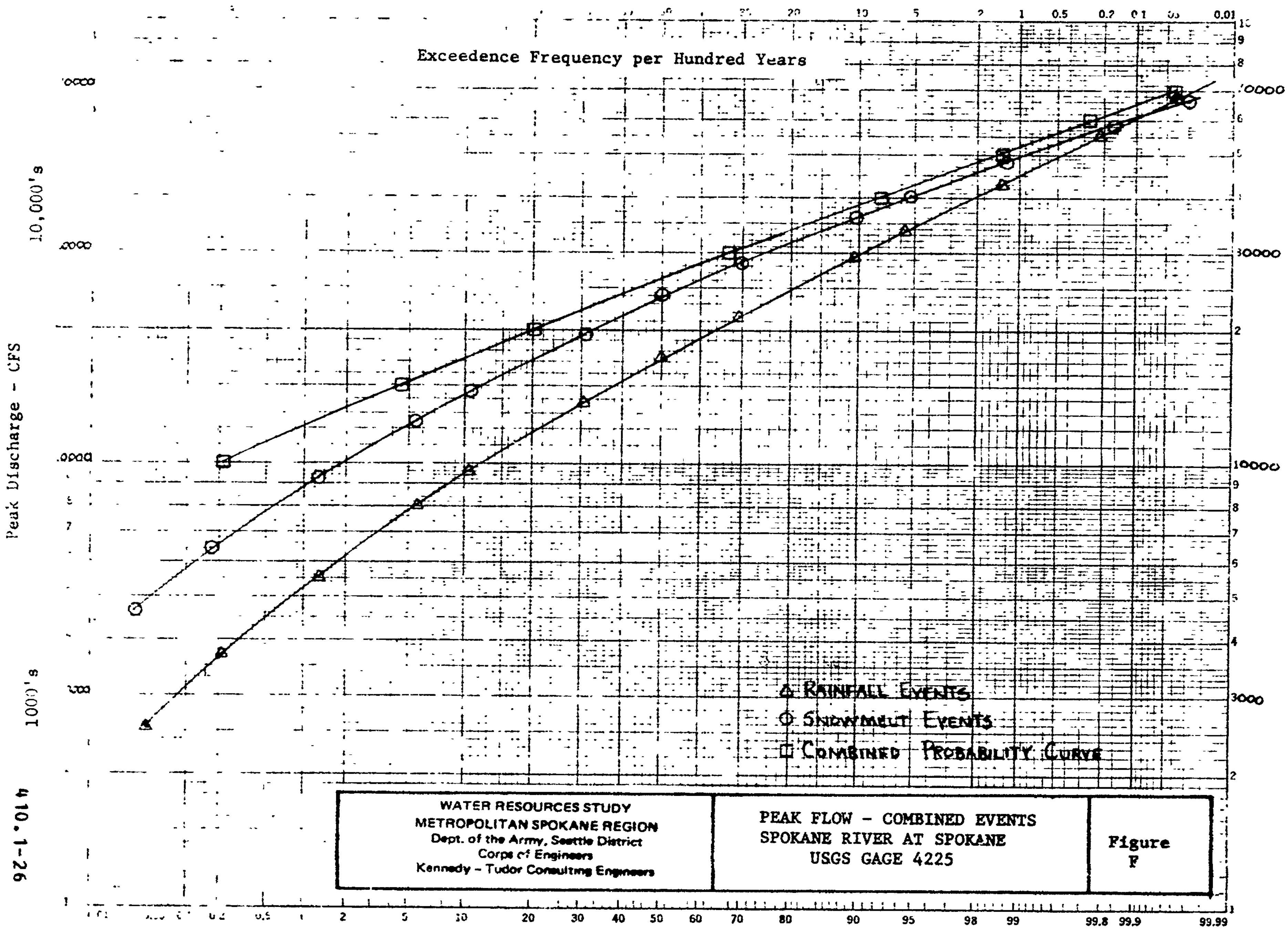
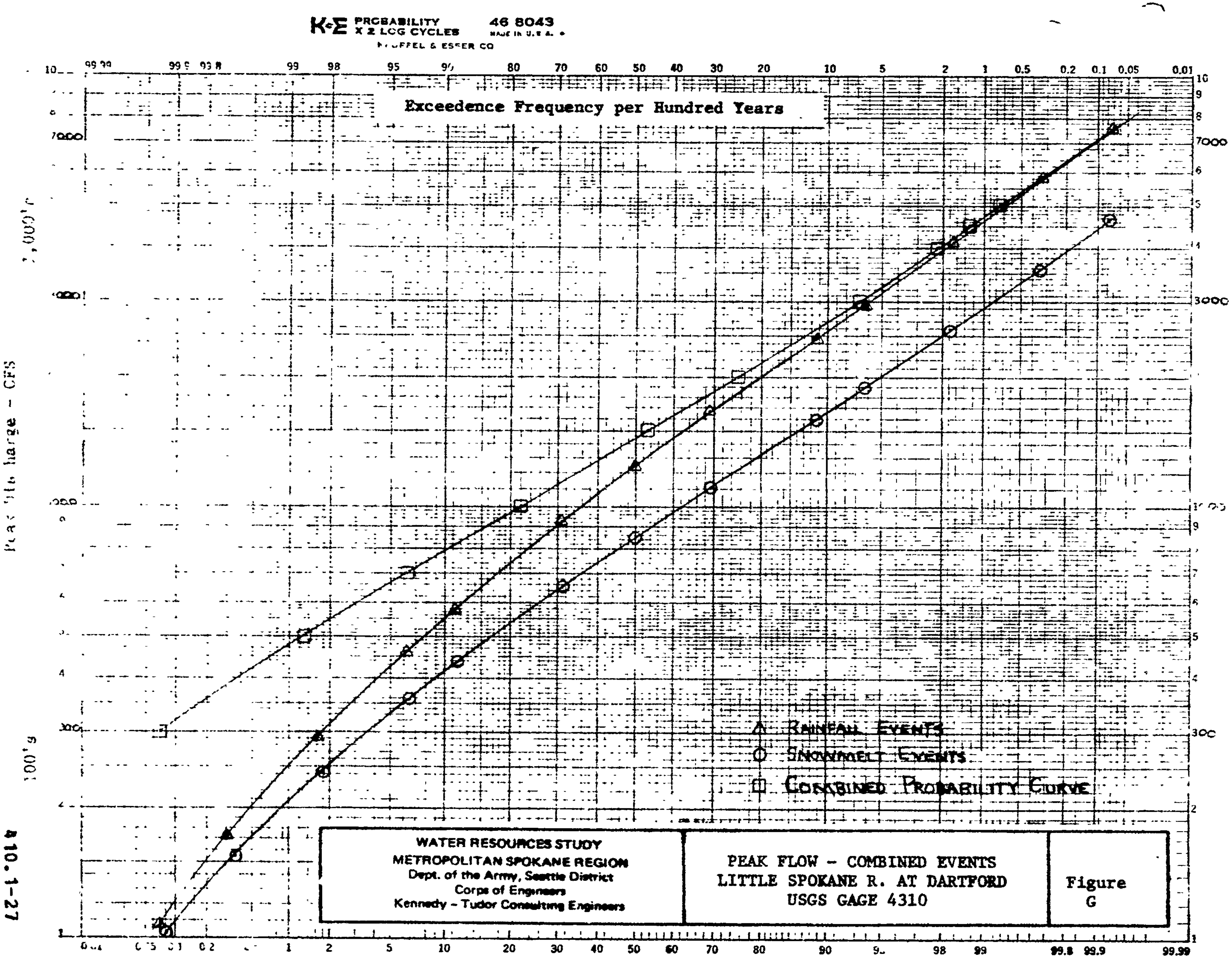
7-DAY LOW FLOW
LITTLE SPOKANE R. AT ELK
USGS GAGE 4270

Figure D


K•E PROBABILITY X 2 LOG CYCLES 46 8043
MADE IN U.S.A.
KEUFFEL & ESSER CO.
Frequency of Non-Exceedence per Hundred Years
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers
7-DAY LOW FLOW
LITTLE SPOKANE R. AT DARTFORD
USGS GAGE 4310
Figure
E
Rev. 28 Jan. 75


Exceedence Frequency per Hundred Years
Peak Discharge - CFS
10,000's
1000's
△ Rainfall Events
○ Snowmelt Events
□ Combined Probability Curve
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers
PEAK FLOW - COMBINED EVENTS
SPOKANE RIVER AT SPOKANE
USGS GAGE 4225
Figure
F



K+E PROBABILITY X 2 LOG CYCLES 46 8043
KEUFFEL & ESSER CO
Exceedence Frequency per Hundred Years
Peak Discharge - CFS
Rainfall Events
Snowmelt Events
Combined Probability Curve
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
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Corps of Engineers
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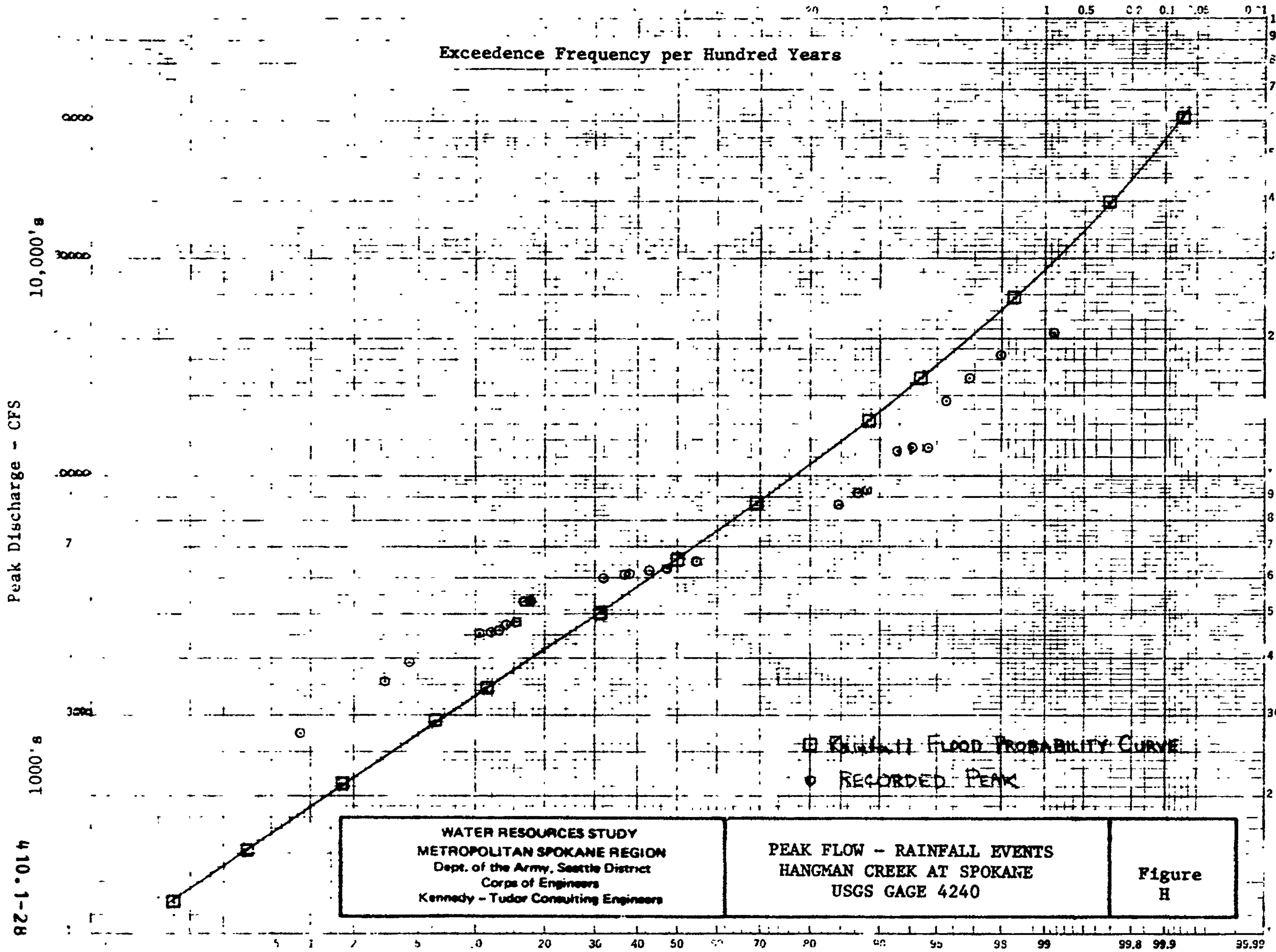
PEAK FLOW - COMBINED EVENTS
LITTLE SPOKANE R. AT DARTFORD
USGS GAGE 4310
Figure G


Exceedence Frequency per Hundred Years
Peak Discharge - CFS
10,000's
1000's
Flood Probability Curve
Recorded Peak
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers
PEAK FLOW - RAINFALL EVENTS
HANGMAN CREEK AT SPOKANE
USGS GAGE 4240
Figure
H

LIST OF REFERENCES

Beard, Leo R., 1962. Statistical Methods in Hydrology. U. S. Army Corps of Engineers, Civil Works Investigations Project CS - 151

APPENDIX I
7-day Low Flow Events
Spokane R. near Post Falls

KENNEDY-TUDOR
CONSULTING ENGINEERS
WATER RESOURCES STUDY — METROPOLITAN SPOKANE REGION

BY PHS DATE 15 May '74 SUBJECT 7-Day Low Flow SHEET NO. ____ OF ____
TASK NO. 410.1 REV. DATE Spokane R. near Post Falls FILE NO. ____

USGS GAGE 4190

Water Year Ending	7-day Event Ending	7-day Mean Discharges, cfs: Recorded at 4190	Total Diversions	Recorded Plus Diversions	Ordered Number	Plotting Position
1947	Sept. 1	164	287	451	12	44.3
1948	Sept. 19	560	118	678	21	78.4
1949	Sept. 25	149	1	150	1	2.64
1950	Sept. 24	155	46	201	4	14.0
1951	Sept. 23	299	14	313	6	21.6
1952	Sept 3	147	276	423	11	40.5
1953	Sept. 11	283	250	533	16	59.5
1954	Oct. 1	555	19	574	18	67.1
1955	Sept 3	163	291	454	13	48.1
1956	Sept 9	210	252	462	14	51.9
1957	Aug. 25	139	265	404	9	32.9
1958	Oct. 6			400	8	29.6
1959	Aug. 31	312	273	585	19	70.8
1960	Aug. 25	268	282	550	17	63.3
1961	Oct. 24	330	1	331	7	25.4
1962	Sept 9	139	282	421	10	36.7
1963	Oct. 16	243	0	243	5	17.8
1964	Sept 16	648	156	804	24	89.8
1965	Sept 11	409	204	613	20	74.6
1966	Sept 25	148	30	178	3	10.2
1967	Sept 1	110	53	163	2	6.4
1968	Aug 12	462	53	515	15	55.7
1969	Aug 21	718	54	772	23	86.0
1970	Sept. 26	1079	0	1079	26	97.4
1971	Aug 24	853	52	905	25	93.6
1972	Sept 15	638	50	688	22	82.2

APPENDIX II
7-day Low Flow Events
Spokane R. at Spokane

KENNEDY TUDOR
CONSULTING ENGINEERS
WATER RESOURCES STUDY — METROPOLITAN SPOKANE REGION

BY PHS DATE 15 May '74 SUBJECT 7-Day Low Flow SHEET NO. ____ OF ____
TASK NO. 410.1 REV. DATE Spokane R. at Spokane FILE NO. ____

USGS GAGE 4225

Water Year Ending	7-day Event Ending	7-day Mean Discharge, cfs Recorded at 4225	Total Diversions	Recorded Plus Diversions	Ordered Number	Plotting Position
1947	Sept. 2	879	283	1162	9	32.9
1948	Sept 19	1323	100	1423	20	74.6
1949	Sept 26	969	1	970	4	14.0
1950	Sept 24	1045	46	1091	7	25.4
1951	Sept. 24	1109	11	1020	6	21.6
1952	Sept 4	951	275	1226	15	55.7
1953	Sept. 12	916	250	1166	11	40.5
1954	Oct. 2	1354	0	1354	18	67.1
1955	Sept. 15	950	276	1226	14	51.9
1956	Sept 9	1179	252	1431	21	78.4
1957	Aug. 26	1013	268	1281	16	59.5
1958	Aug. 28	877	290	1167	12	44.3
1959	Aug. 19	1149	294	1443	24	89.8
1960	Aug. 25	1159	282	1441	22	82.2
1961	Oct. 24	1094	1	1095	8	29.2
1962	Sept. 10	884	280	1164	10	36.7
1963	Oct 16	881	0	881	3	10.2
1964	Sept 16	1384	156	1540	26	97.4
1965	Oct. 4	1321	49	1370	19	70.8
1966	Sept. 26	701	26	727	1	2.64
1967	Sept 1	677	53	730	2	6.4
1968	Aug 12	940	53	993	5	17.8
1969	Aug. 20	1153	54	1207	13	48.1
1970	Sept. 1	1454	51	1505	25	93.6
1971	Aug 24	1390	52	1442	23	86.0
1972	Sept 15	1299	50	1349	17	63.3

KENNEDY-TUDOR
CONSULTING ENGINEERS
WATER RESOURCES STUDY — METROPOLITAN SPOK

7-day Low Flow Events
Hangman Creek at Spokane

BY PHS DATE 19 May '74 SUBJECT 7-day Low Flows SHEET NO. ____ OF ____
TASK NO. ____ REV. DATE Hangman Creek at Spokane FILE NO. ____
USGS GAGE 4240

Water Year Ending	7-day Event Ending	7-day low mean disch. cfs	Ordered Number	Plotting Position
1948	Sept. 16	24.0	26	97.4
1949	Sept. 9	12.14	19	70.8
1950	Sept. 24	17.71	24	89.8
1951	Aug. 23	12.0	18	67.1
1952	Oct. 2	15.07	23	86.0
1953	Aug. 23	11.71	15	55.7
1954	Aug. 15	8.27	13	48.1
1955	Sept. 9	4.21	3	10.2
1956	Aug. 25	18.07	25	93.6
1957	Sept. 16	11.86	17	63.3
1958	Aug 23	11.71	16	59.5
1959	Aug. 19	14.36	21	78.4
1960	July 31	5.76	6	21.6
1961	Aug 8	7.86	11	40.5
1962	Aug. 1	5.91	7	25.4
1963	Sept. 7	6.0	8	29.2
1964	Aug. 17	7.9	12	44.3
1965	July 21	14.43	22	82.2
1966	Aug. 2	5.53	5	17.8
1967	Sept 7	4.97	4	14.0
1968	Aug. 7	2.39	2	6.4
1969	Sept 18	12.86	20	74.6
1970	Aug. 25	7.5	10	36.7
1971	Aug 21	10.14	14	51.9
1972	Aug. 14	6.6	9	32.9
1973	Sept 17	1.54	1	2.64

APPENDIX IV
7-day Low Flow Events
Little Spokane R. at Elk

KENNE[illegible] [illegible]UDOR
CONSULTING ENGINEERS
WATER RESOURCES STUDY — METROPOLITAN SPOKANE REGION

BY PHS DATE 19 May '74 SUBJECT 7-day Low Flow SHEET NO. ____ OF ____
TASK NO. 410.1 REV. DATE Little Spokane R. at Elk FILE NO. ____
USGS GAGE 4270

Water Year Ending	7-day Event Ending	7day low mean disch. cfs	Ordered Number	Plotting Position
1948	Oct. 13	44.71	17	68.4
1949	Sept. 6	45.71	18	72.6
1950	Sept. 16	48.14	22	89.0
1951	Sept. 19	47.0	20	80.8
1952	Oct. 7	50.0	24	97.2
1953	Sept. 16	42.0	13	52.0
1954		42.3	14	56.2
1955	Sept 15	37.71	4	15.2
1956	Oct. 15	46.71	19	76.6
1957		39.43	8	31.6
1958	Oct. 31	43.43	15	60.2
1959	Aug 6	41.0	10	39.8
1960	Sept. 21	49.0	23	93.0
1961	Oct. 9	47.71	21	84.8
1962	Sept. 8	42.0	12	48.0
1963	Sept. 12	39.0	7	27.4
1964	Oct. 31	37.86	5	19.2
1965	Oct. 7	43.86	16	64.4
1966	Sept 12	34.14	2	7.0
1967	Sept. 30	36.43	3	11.0
1968	Aug. 1	33.86	1	2.85
1969		41.43	11	43.8
1970	Aug. 31	38.0	6	23.4
1971	Aug. 21	40.14	9	35.6

Rev. 28 Jan 15

KENNEDY-TUDOR
CONSULTING ENGINEERS
WATER RESOURCES STUDY — METROPOLITAN SPC........

7-day Low Flow Events
Little Spokane R. at Dartford

BY PHS DATE 19 May 74 SUBJECT 7-day Low Flow SHEET NO. ____ OF ____
TASK NO. 410.1 REV. DATE Little Spokane R. at Dartford FILE NO. ____
USGS GAG 4310

Water Year Ending	7-day Event Ending	7-day low mean disch. cfs	Ordered Number	Plotting Position
1929	Sept. 6	96.71	5	10.3
1930	July 29	68.14	2	3.7
1931	Aug 20	65.27	1	1.53
1932	Sept. 18	104.29	6	12.6
1947	July 26	105.71	7	16.0
1948	Sept. 19	158	28	87.4
1949	Aug 21	130.29	17	50.0
1950	Sept 5	151.71	27	84.0
1951	Aug. 24	141.71	25	77.2
1952	Oct 2	166.43	31	97.64
1953	Aug. 23	138.57	23	70.4
1954	Aug 15	133.14	19	56.8
1955	Sept 7	126.57	14	39.8
1956	Sept 27	158.71	29	90.8
1957	Aug. 29	122.0	10	26.2
1958	Aug 26	135.71	21	63.6
1959	Aug 19	136.86	22	67.0
1960	Oct 6	159.86	30	94.2
1961	Aug 15	145.57	26	80.6
1962	Aug 21	134.43	20	60.2
1963	Sept 8	127.8	15	43.2
1964	Aug 17	140.71	24	73.8
1965	Aug 17	[illegible]	12	33.0
1966	Aug 25	[illegible]	8	19.4
1967	Aug 22	112.71	9	22.8
1968	Aug. 5	93.57	4	8.1
19[illegible]	Aug 28	[illegible]	18	53.4
[illegible]	Aug. 22	123.0	11	29.6
[illegible]71	Aug. [illegible]	124.57	13	36.4
197[illegible]	Aug 13	[illegible]	16	46.6
19[illegible]	Aug 7	[illegible]	[illegible]	5.9

410.1-34

APPENDIX V

KENNEDY ENGINEERS 11306 Bridgeport Way, S.W., Tacoma

BY EJM DATE 28 Jan '75 SUBJECT WRS - Spokane JOB NO ___/___ SHEET ___ OF ___

7-Day Low Flow - Little Spokane R. at Dartford
Gage 4310

Order No	Year	7 day mean cfs	Plotting Positions N=29	N=45	Selected
1	1931	65.29		1.53	1.53
2	1930	68.14		3.7	3.7
3	1973	81.43	2.36	5.9	5.9
4	1968	93.57	5.8	8.1	8.1
5	1929	96.71	9.2	10.3	10.3
6	1932	104.29	12.6	12.5	12.6
7	1947	105.71	16.0	14.7	16.0
8	1966	107.14	19.4	17.0	19.4
9	1967	112.71	22.8	19.2	22.8
10	1957	122.0	26.2	21.4	26.2
11	1970	123.0	29.6	23.6	29.6
12	1965	123.86	33.0	25.8	33.0
13	1971	124.57	36.4		36.4
14	1955	126.57	39.8		39.8
15	1963	127.86	43.2		43.2
16	1972	130.14	46.6		46.6
17	1949	130.29	50.0		50.0
18	1969	130.86			53.4
19	1954	133.14			56.8
20	1962	134.43			60.2
21	1958	135.71			63.6
22	1959	136.86			67.0
23	1953	138.57			70.4
24	1964	140.71			73.8
25	1951	141.71			77.2
26	1961	145.57			80.6
27	1950	151.71			84.0
28	1948	158			87.4
29	1956	158.71			90.8
30	1960	159.86			94.2
31	1952	166.43			97.64

APPENDIX VI
Peak Flows, Raw Data, Rainfall Events
Spokane R. at Spokane

YEAR	MAX.PEAK	1 DAY PEAK	YEAR	MAX.PEAK	1 DAY PEAK
1891	0	0	1933	0	9700
1892	0	11200	1934	47800	47100
1893	0	3600	1935	0	10900
1894	0	10600	1936	0	7570
1895	0	9240	1937	0	2190
1896	0	12600	1938	0	13600
1897	0	17000	1939	0	4230
1898	0	19000	1940	0	[illegible]
1899	0	11000	1941	0	8600
1900	0	15800	1942	0	13500
1901	0	19000	1943	0	11300
1902	0	8850	1944	0	3450
1903	0	13000	1945	0	4500
1904	0	11500	1946	0	12900
1905	0	7510	1947	25000	24400
1906	0	8250	1948	0	16700
1907	0	12800	1949	0	14000
1908	0	14000	1950	0	20800
1909	0	9900	1951	[illegible]	27700
1910	28100	28100	1952	0	13000
1911	0	7540	1953	0	16900
1912	0	9880	1954	0	11700
1913	0	29600	1955	0	4880
1914	0	13000	1956	0	22700
1915	0	9180	1957	0	11400
1916	0	25100	1958	0	16700
1917	0	3350	1959	0	20200
1918	39600	39600	1960	0	17100
1919	0	13400	1961	[illegible]	27400
1920	0	10500	1962	0	6060
1921	0	19300	1963	19900	19600
1922	0	8920	1964	0	[illegible]
1923	0	9600	1965	0	[illegible]
1924	0	12600	1966	0	1790
1925	0	22500	1967	0	11800
1926	0	8850	1968	[illegible]	22300
1927	0	15800	1969	0	15400
1928	0	24500	1970	1	13000
1929	0	8120	1971	0	17000
1930	0	10100	1972	[illegible]	14100
1931	0	12000	1973	0	6560
1932	0	11700	1974	[illegible]	[illegible]

APPENDIX VII
Peak Flows, Raw Data, Snowmelt Events
Spokane R. at Spokane

YEAR	MAX.PEAK	1 DAY PEAK
1891	12000	12300
1892	21800	21800
1893	37500	37500
1894	49000	49000
1895	17100	17100
1896	21400	21400
1897	33900	33900
1898	27200	27200
1899	28900	28900
1900	17000	17000
1901	22200	22200
1902	24800	24800
1903	23900	23900
1904	27900	27900
1905	9510	9510
1906	18400	18300
1907	21400	21400
1908	21700	21700
1909	17700	17700
1910	0	26000
1911	17200	17200
1912	21200	21200
1913	33600	33200
1914	19600	19600
1915	11500	11500
1916	28400	28200
1917	41900	41500
1918	0	18800
1919	24600	24600
1920	18200	18200
1921	26200	26200
1922	26300	25700
1923	22000	21500
1924	17800	17800
1925	31700	31100
1926	15800	14700
1927	28200	28200
1928	26600	26000
1929	14700	14300
1930	12900	12300
1931	15800	15800
1932	33500	32900

YEAR	MAX.PEAK	1 DAY PEAK
1933	28500	28000
1934	0	25700
1935	25400	24900
1936	33700	33700
1937	22100	22100
1938	32700	32200
1939	23300	22800
1940	16500	16100
1941	16100	14200
1942	18400	15300
1943	32400	31900
1944	11400	9370
1945	22800	22300
1946	28400	27[illegible]0
1947	0	21600
1948	39600	39500
1949	34200	34200
1950	32700	32100
1951	0	19600
1952	32100	31900
1953	22400	22200
1954	31000	30800
1955	27000	26600
1956	37800	36800
1957	35600	34600
1958	24400	23200
1959	26500	25200
1960	27400	27000
1961	0	24000
1962	27600	25200
1963	0	14400
1964	31800	31000
1965	33200	32600
1966	20700	19700
1967	25600	25400
1968	0	10100
1969	30400	29700
1970	23600	23100
1971	34000	33800
1972	0	33800
1973	7310	7310
1974	0	0

APPENDIX VIII
Peak Flows, Correlated, Rainfall Events
Spokane R. at Spokane

	1 DAY	PEAK
1891	0	0
1892	11200	-15597
1893	3600	-6798
1894	10600	-14981
1895	9240	-13549
1896	12600	-17001
1897	17000	-21166
1898	19000	-22961
1899	11000	-15393
1900	15800	-20062
1901	19000	-22961
1902	8850	-13128
1903	13000	-17394
1904	11500	-15902
1905	7510	-11642
1906	8250	-12471
1907	12800	-17198
1908	14000	-18363
1909	9900	-14251
1910	28100	28100
1911	7540	-11676
1912	9880	-14230
1913	29600	-31759
1914	13000	-17394
1915	9180	-13485
1916	25100	-28149
1917	3350	-6449
1918	39600	39600
1919	13400	-17784
1920	10500	-14878
1921	19300	-23226
1922	8920	-13204
1923	9600	-13933
1924	12600	-17001
1925	22500	-25985
1926	8850	-13128
1927	15800	-20062
1928	24500	-27655
1929	8120	-12327
1930	10100	-14461
1931	12000	-16405
1932	11700	-16104
1933	9700	-14039
1934	47100	47800
1935	10900	-15290
1936	7570	-11710
1937	2190	-4725
1938	13600	-17976
1939	4230	-7649
1940	15300	-19596
1941	8600	-12856
1942	13500	-17881
1943	11300	-15699
1944	3950	-7276
1945	9500	-13827
1946	12900	-17296
1947	24400	25000
1948	16700	-20892
1949	14000	-18363
1950	20000	-23839
1951	27700	28200
1952	13800	-18171
1953	16900	-21075
1954	11700	-16104
1955	4880	-8493
1956	22700	-26153
1957	11400	-15800
1958	16700	-20892
1959	20200	-24013
1960	17100	-21257
1961	27400	28200
1962	6860	-10896
1963	13600	18900
1964	4630	-8172
1965	29900	-31994
1966	4790	-8378
1967	14800	-19125
1968	22300	30400
1969	15400	-19690
1970	13000	-17394
1971	17000	-21166
1972	34100	34400
1973	6560	-10545
1974	46100	46100

COEFFICIENT OF CORRELATION = 0.950782304
STANDARD ERROR= 1.193351444
- SIGN INDICATES ESTIMATED FLOWS

EXTENDED STATISTICS
M= 4.231513616 S= 0.188608147 N= 48.79783938

APPENDIX IX
Peak Flows, Correlated, Snowmelt Events
Spokane R. at Spokane

	1 DAY	PEAK		1 DAY	PEAK
1891	12300	12800	1933	28000	28500
1892	21800	21800	1934	25700	-26145
1893	37500	37500	1935	24900	25400
1894	49000	49000	1936	33700	33700
1895	17100	17100	1937	22100	22100
1896	21400	21400	1938	32200	32700
1897	33900	33900	1939	22800	23300
1898	27200	27200	1940	16100	16500
1899	28900	28900	1941	14200	16100
1900	17000	17000	1942	15300	18400
1901	22200	22200	1943	31900	32400
1902	24800	24800	1944	9370	11400
1903	23900	23900	1945	22300	22800
1904	27900	27900	1946	27100	28400
1905	9510	9510	1947	21600	-22098
1906	18300	18400	1948	39500	39600
1907	21400	21400	1949	34200	34200
1908	21700	21700	1950	32100	32700
1909	17700	17700	1951	19600	-20114
1910	26000	-26441	1952	31900	32100
1911	17200	17200	1953	22200	22400
1912	21200	21200	1954	30800	31000
1913	33200	33600	1955	26000	27000
1914	19600	19600	1956	36800	37800
1915	11500	11500	1957	34600	35600
1916	28200	28400	1958	23200	24400
1917	41500	41900	1959	25200	26500
1918	18800	-19319	1960	27000	27400
1919	24600	24600	1961	24000	-24470
1920	18200	18200	1962	25200	27600
1921	26200	26200	1963	14400	-14925
1922	25700	26300	1964	31000	31800
1923	21500	22000	1965	32600	33200
1924	17800	17800	1966	19700	20700
1925	31100	31700	1967	25400	25600
1926	14700	15800	1968	10100	-10589
1927	28200	28200	1969	29700	30400
1928	26000	26600	1970	23100	23600
1929	14300	14700	1971	33800	34000
1930	12300	12900	1972	33800	-34083
1931	15800	15800	1973	7310	7310
1932	32900	33500	1974	0	0

COEFFICIENT OF CORRELATION = 0.995289849
STANDARD ERROR= 1.071620255
\- SIGN INDICATES ESTIMATED FLOWS

EXTENDED STATISTICS
M= 4.3692166[illegible] S= 0.154514887 N= 82.90523814

APPENDIX X
Ordered Flows and Plotting Positions,
Rainfall Events, Spokane R. at Spokane

N	Q	LOG Q	POS	N	Q	LOG Q	POS
1	47800	4.6794	0.84	43	17198	4.2355	51.20
2	46100	4.6637	2.04	44	17001	4.2305	52.40
3	39600	4.5977	3.24	45	17001	4.2305	53.60
4	34400	4.5366	4.44	46	16405	4.2150	54.80
5	31994	4.5051	5.64	47	16104	4.2069	56.00
6	31759	4.5019	6.83	48	16104	4.2069	57.19
7	30400	4.4829	8.03	49	15902	4.2014	58.39
8	28200	4.4502	9.23	50	15800	4.1987	59.59
9	28200	4.4502	10.43	51	15699	4.1959	60.79
10	28149	4.4495	11.63	52	15597	4.1930	61.99
11	28100	4.4487	12.83	53	15393	4.1873	63.19
12	27655	4.4418	14.03	54	15290	4.1844	64.39
13	26153	4.4175	15.23	55	14981	4.1755	65.59
14	25985	4.4147	16.43	56	14878	4.1725	66.79
15	25000	4.3979	17.63	57	14461	4.1602	67.99
16	24013	4.3805	18.82	58	14251	4.1538	69.18
17	23839	4.3773	20.02	59	14230	4.1532	70.38
18	23226	4.3660	21.22	60	14039	4.1473	71.58
19	22961	4.3610	22.42	61	13933	4.1441	72.78
20	22961	4.3610	23.62	62	13827	4.1407	73.98
21	21257	4.3275	24.82	63	13549	4.1319	75.18
22	21166	4.3256	26.02	64	13485	4.1298	76.38
23	21166	4.3256	27.22	65	13204	4.1207	77.58
24	21075	4.3238	28.42	66	13128	4.1182	78.78
25	20892	4.3200	29.62	67	13128	4.1182	79.98
26	20892	4.3200	30.82	68	12856	4.1091	81.18
27	20062	4.3024	32.01	69	12471	4.0959	82.37
28	20062	4.3024	33.21	70	12327	4.0909	83.57
29	19690	4.2942	34.41	71	11710	4.0686	84.77
30	19596	4.2922	35.61	72	11676	4.0673	85.97
31	19125	4.2816	36.81	73	11642	4.0660	87.17
32	18900	4.2765	38.01	74	10896	4.0373	88.37
33	18363	4.2639	39.21	75	10545	4.0231	89.57
34	18363	4.2639	40.41	76	8493	3.9291	90.77
35	18171	4.2594	41.61	77	8378	3.9231	91.97
36	17978	4.2547	42.81	78	8172	3.9123	93.17
37	17881	4.2524	44.00	79	7649	3.8836	94.36
38	17784	4.2500	45.20	80	7276	3.8619	95.56
39	17394	4.2404	46.40	81	6798	3.8324	96.76
40	17394	4.2404	47.60	82	6449	3.8095	97.96
41	17394	4.2404	48.80	83	4725	3.6744	99.16
42	17296	4.2379	50.00				

APPENDIX XI
Ordered Flows and Plotting Positions
Snowmelt Events, Spokane R. at Spokane

N	Q	LOG Q	POS	N	Q	LOG Q	POS
1	49000	4.6902	0.84	43	24470	4.3886	51.20
2	41900	4.6222	2.04	44	24400	4.3874	52.40
3	39600	4.5977	3.24	45	23900	4.3784	53.60
4	37800	4.5775	4.44	46	23600	4.3729	54.80
5	37500	4.5740	5.64	47	23300	4.3674	56.00
6	35600	4.5514	6.83	48	22800	4.3579	57.19
7	34200	4.5340	8.03	49	22400	4.3502	58.39
8	34083	4.5325	9.23	50	22200	4.3464	59.59
9	34000	4.5315	10.43	51	22100	4.3444	60.79
10	33900	4.5302	11.63	52	22098	4.3443	61.99
11	33700	4.5276	12.83	53	22000	4.3424	63.19
12	33600	4.5263	14.03	54	21800	4.3385	64.39
13	33500	4.5250	15.23	55	21700	4.3365	65.59
14	33200	4.5211	16.43	56	21400	4.3304	66.79
15	32700	4.5145	17.63	57	21400	4.3304	67.99
16	32700	4.5145	18.82	58	21200	4.3263	69.18
17	32400	4.5105	20.02	59	20700	4.3160	70.38
18	32100	4.5065	21.22	60	20114	4.3035	71.58
19	31800	4.5024	22.42	61	19600	4.2923	72.78
20	31700	4.5011	23.62	62	19319	4.2860	73.98
21	31000	4.4914	24.82	63	18400	4.2648	75.18
22	30400	4.4829	26.02	64	18400	4.2648	76.38
23	28900	4.4609	27.22	65	18200	4.2601	77.58
24	28500	4.4548	28.42	66	17800	4.2504	78.78
25	28400	4.4533	29.62	67	17700	4.2480	79.98
26	28400	4.4533	30.82	68	17200	4.2355	81.18
27	28200	4.4502	32.01	69	17100	4.2330	82.37
28	27900	4.4456	33.21	70	17000	4.2304	83.57
29	27600	4.4409	34.41	71	16500	4.2175	84.77
30	27400	4.4378	35.61	72	16100	4.2068	85.97
31	27200	4.4346	36.81	73	15800	4.1987	87.17
32	27000	4.4314	38.01	74	15800	4.1987	88.37
33	26600	4.4249	39.21	75	14925	4.1739	89.57
34	26500	4.4232	40.41	76	14700	4.1673	90.77
35	26441	4.4223	41.61	77	12900	4.1106	91.97
36	26300	4.4200	42.81	78	12800	4.1072	93.17
37	26200	4.4183	44.00	79	11500	4.0607	94.36
38	26145	4.4174	45.20	80	11400	4.0569	95.56
39	25600	4.4082	46.40	81	10589	4.0248	96.76
40	25400	4.4048	47.60	82	9510	3.9782	97.96
41	24800	4.3945	48.80	83	7310	3.8639	99.16
42	24600	4.3909	50.00				

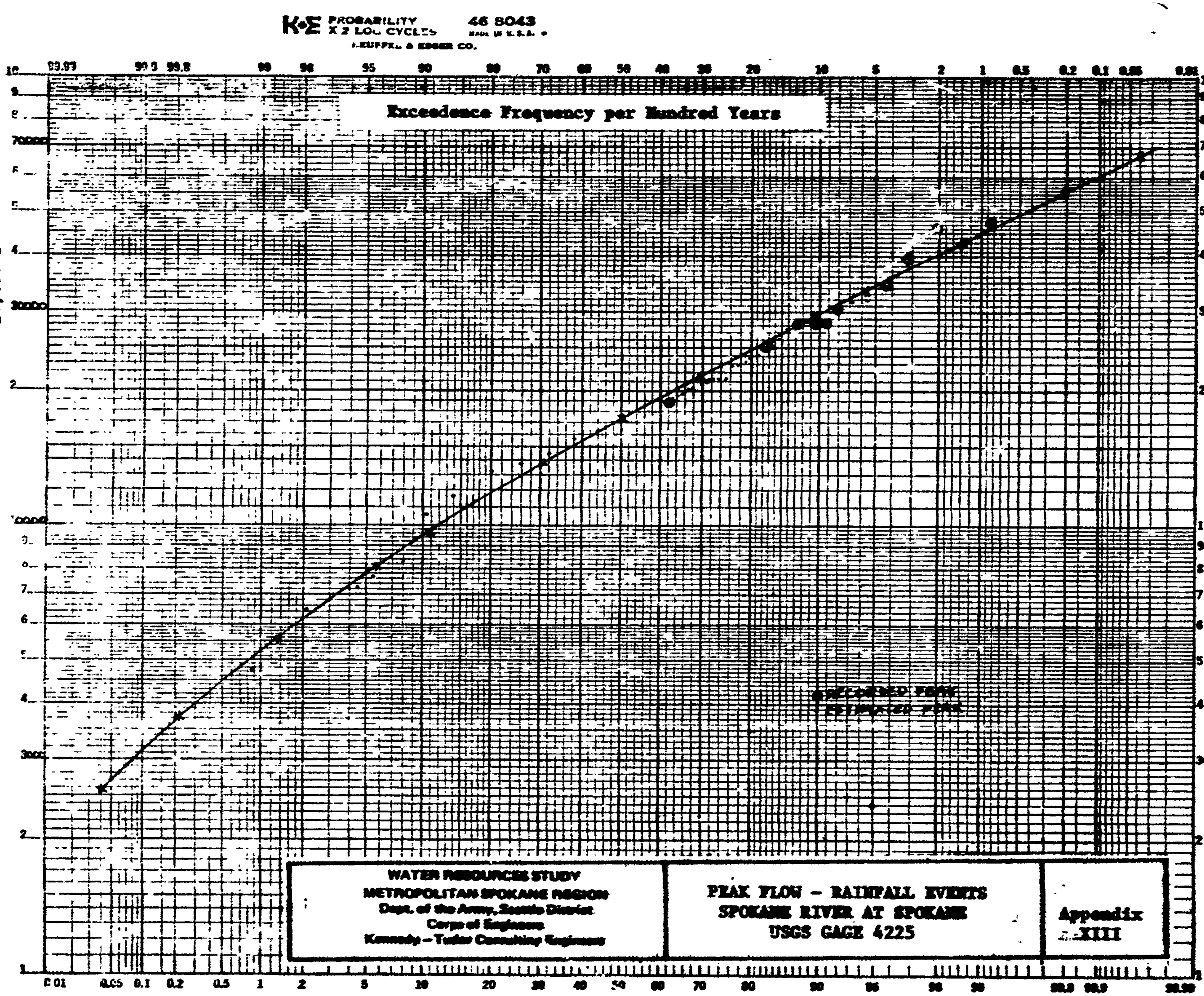
APPENDIX XII
Computed Peak Flow Curves, Rainfall and Snowmelt Events, Spokane R. at Spokane

RAINFALL EVENTS				SNOWMELT EVENTS			
P INF	K	FLOWS	P(N)	P INF	K	FLOWS	P(N)
0.01	3.15	67047	0.04	0.01	2.99	67881	0.03
0.10	2.70	55110	0.22	0.10	2.59	58849	0.17
1.00	2.12	42871	1.38	1.00	2.06	48762	1.26
5.00	1.56	33524	5.69	5.00	1.53	40365	5.48
10.00	1.25	29282	10.69	10.00	1.24	36313	10.48
30.00	0.55	21655	30.44	30.00	0.56	28559	30.34
50.00	0.05	17387	50.00	50.00	0.06	23903	50.00
70.00	-0.48	13810	69.56	70.00	-0.47	19777	69.66
90.00	-1.31	9667	89.31	90.00	-1.31	14675	89.52
95.00	-1.71	8094	94.31	95.00	-1.73	12624	94.52
99.00	-2.53	5670	98.62	99.00	-2.59	9301	98.74
99.90	-3.49	3738	99.78	99.90	-3.61	6468	99.83
99.99	-4.35	2579	99.96	99.99	-4.54	4657	99.97

ADJUSTED VALUES:
RAINFALL EVENTS: M= 4.231513616 S= 0.188608147 N= 48.79783938
SNOWMELT EVENTS: M= 4.369218623 S= 0.154514883 N= 82.90523814

RAINFALL CALCULATED SKEW FACTOR= -0.278057536
SNOWMELT CALCULATED SKEW FACTOR= -0.785962836

SKEW FACTOR USED IN COMPUTATION:
RAINFALL CALCULATED G= -0.278057536
SNOWMELT REGIONAL G= -0.36


K+E PROBABILITY X 2 LOG CYCLES 46 8043
KEUFFEL & ESSER CO.
Exceedance Frequency per Hundred Years
Peak Discharge - CFS
10,000's
1000's
RECORDED PEAK
ESTIMATED PEAK
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers
PEAK FLOW - RAINFALL EVENTS
SPOKANE RIVER AT SPOKANE
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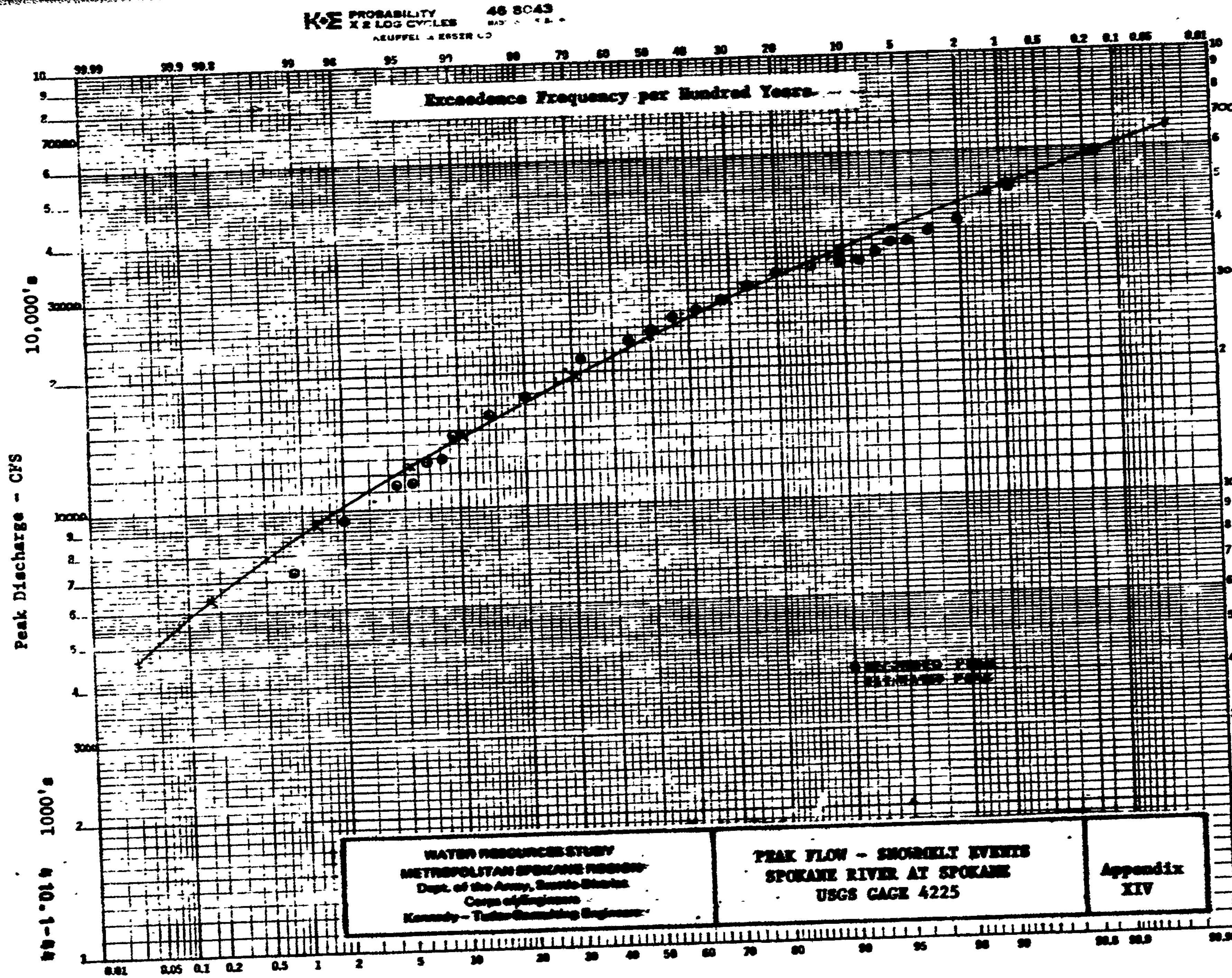
K+E PROBABILITY X 2 LOG CYCLES 46 8043
KEUFFEL & ESSER CO.
Exceedance Frequency per Hundred Years
Peak Discharge - CFS
10,000's
1000's
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy - Tudor Consulting Engineers
PEAK FLOW - SNOWMELT EVENTS
SPOKANE RIVER AT SPOKANE
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APPENDIX XV
Peak Flows, Raw Data, Rainfall Events
Little Spokane R. at Dartford

YEAR	MAX.PEAK	1 DAY PEAK	YEAR	MAX.PEAK	1 DAY PEAK
1929	0	0	1952	0	818
1930	730	675	1953	0	762
1931	0	238	1954	1110	977
1932	1900	1670	1955	1320	1220
1933	0	0	1956	0	740
1934	0	0	1957	2060	1680
1935	0	0	1958	2040	1870
1936	0	0	1959	2060	1610
1937	0	0	1960	2460	1900
1938	0	0	1961	1870	1700
1939	0	0	1962	1260	1180
1940	0	0	1963	1950	1720
1941	0	0	1964	0	525
1942	0	0	1965	0	980
1943	0	0	1966	1110	984
1944	0	0	1967	1470	1350
1945	0	0	1968	1160	910
1946	0	0	1969	0	356
1947	640	596	1970	3170	2800
1948	0	1380	1971	1110	1050
1949	1620	1520	1972	970	945
1950	2240	2090	1973	1680	1480
1951	1560	1400	1974	2860	2750

APPENDIX XVI
Peak Flows, Raw Data, Snowmelt Events
Little Spokane R. at Dartford

YEAR	MAX.PEAK	1 DAY PEAK
1929	0	0
1930	0	227
1931	260	260
1932	0	1010
1933	0	0
1934	0	0
1935	0	0
1936	0	0
1937	0	0
1938	0	0
1939	0	0
1940	0	0
1941	0	0
1942	0	0
1943	0	0
1944	0	0
1945	0	0
1946	0	0
1947	0	390
1948	1660	1620
1949	0	1120
1950	0	1030
1951	0	1260

YEAR	MAX.PEAK	1 DAY PEAK
1952	1580	1520
1953	1950	900
1954	0	642
1955	0	564
1956	1720	1680
1957	0	645
1958	0	730
1959	0	894
1960	0	694
1961	0	1390
1962	0	803
1963	0	692
1964	940	900
1965	1230	1180
1966	0	583
1967	0	732
1968	0	441
1969	1970	1820
1970	0	795
1971	0	797
1972	0	517
1973	0	350
1974	0	0

APPENDIX XVII
Peak Flows, Correlated, Rainfall Events
Little Spokane R. at Dartford

	1 DAY	PEAK		1 DAY	PEAK
1891	0	0	1933	0	0
1892	0	0	1934	0	0
1893	0	0	1935	0	0
1894	0	0	1936	0	0
1895	0	0	1937	0	0
1896	0	0	1938	0	0
1897	0	0	1939	0	0
1898	0	0	1940	0	0
1899	0	0	1941	0	0
1900	0	0	1942	0	0
1901	0	0	1943	0	0
1902	0	0	1944	0	0
1903	0	0	1945	0	0
1904	0	0	1946	0	0
1905	0	0	1947	596	640
1906	0	0	1948	1380	-1547
1907	0	0	1949	1520	1620
1908	0	0	1950	2090	2240
1909	0	0	1951	1400	1560
1910	0	0	1952	818	-907
1911	0	0	1953	762	-844
1912	0	0	1954	977	1110
1913	0	0	1955	1220	1320
1914	0	0	1956	740	-819
1915	0	0	1957	1680	2060
1916	0	0	1958	1870	2040
1917	0	0	1959	1610	2060
1918	0	0	1960	1900	2460
1919	0	0	1961	1[illegible]00	1870
1920	0	0	1962	1180	1260
1921	0	0	1963	1720	1950
1922	0	0	1964	525	-577
1923	0	0	1965	980	-1091
1924	0	0	1966	984	1110
1925	0	0	1967	1350	1470
1926	0	0	1968	910	1160
1927	0	0	1969	356	-388
1928	0	0	1970	2800	3170
1929	0	0	1971	1050	1110
1930	675	730	1972	945	970
1931	238	-257	1973	1400	1680
1932	1670	1900	1974	2750	2860

COEFFICIENT OF CORRELATION = 0.986753551
STANDARD ERROR= 1.141700[illegible]6
- SIGN INDICATES ESTIMATED FLOWS

EXTENDED STATISTICS
M= 3.10105518[illegible] S= 0.246823088 H= 30.71880549

APPENDIX XVIII
Peak Flows, Correlated, Snowmelt Events
Little Spokane R. at Dartford

	1 DAY	PEAK		1 DAY	PEAK
1891	0	0	1933	0	0
1892	0	0	1934	0	0
1893	0	0	1935	0	0
1894	0	0	1936	0	0
1895	0	0	1937	0	0
1896	0	0	1938	0	0
1897	0	0	1939	0	0
1898	0	0	1940	0	0
1899	0	0	1941	0	0
1900	0	0	1942	0	0
1901	0	0	1943	0	0
1902	0	0	1944	0	0
1903	0	0	1945	0	0
1904	0	0	1946	0	0
1905	0	0	1947	390	-455
1906	0	0	1948	1620	1660
1907	0	0	1949	1120	-1272
1908	0	0	1950	1030	-1172
1909	0	0	1951	1260	-1427
1910	0	0	1952	1520	1580
1911	0	0	1953	900	1950
1912	0	0	1954	642	-739
1913	0	0	1955	564	-652
1914	0	0	1956	1680	1720
1915	0	0	1957	645	-743
1916	0	0	1958	730	-838
1917	0	0	1959	894	-1021
1918	0	0	1960	694	-798
1919	0	0	1961	1390	-1570
1920	0	0	1962	803	-920
1921	0	0	1963	692	-795
1922	0	0	1964	900	940
1923	0	0	1965	1180	1230
1924	0	0	1966	583	-673
1925	0	0	1967	732	-840
1926	0	0	1968	441	-513
1927	0	0	1969	1820	1970
1928	0	0	1970	795	-911
1929	0	0	1971	797	-913
1930	227	-268	1972	517	-599
1931	260	260	1973	350	-409
1932	1010	-1150	1974	0	0

COEFFICIENT OF CORRELATION = 0.908402381
STANDARD ERROR= 1.75803327
- SIGN INDICATES ESTIMATED FLOWS

EXTENDED STATISTICS
M= 2.947010030 S= 0.248958796 N= 20.26049508

APPENDIX XIX
Peak Flows, Extended, Rainfall Events
Little Spokane R. at Dartford

	#4225	#4310
1891	0	0
1892	-15597	-1195
1893	-6798	-956
1894	-14981	-1182
1895	-13549	-1151
1896	-17001	-1223
1897	-21166	-1297
1898	-22961	-1326
1899	-15393	-1191
1900	-20062	-1279
1901	-22961	-1326
1902	-13128	-1141
1903	-17394	-1231
1904	-15902	-1201
1905	-11642	-1105
1906	-12471	-1126
1907	-17198	-1227
1908	-18363	-1249
1909	-14251	-1167
1910	28100	-1400
1911	-11676	-1106
1912	-14230	-1166
1913	-31759	-1447
1914	-17394	-1231
1915	-13485	-1149
1916	-28149	-1401
1917	-6449	-943
1918	39600	-1535
1919	-17784	-1238
1920	-14878	-1180
1921	-23226	-1330
1922	-13204	-1143
1923	-13933	-1160
1924	-17001	-1223
1925	-25985	-1371
1926	-13128	-1141
1927	-20062	-1279
1928	-27655	-1394
1929	-12327	-1122
1930	-14461	730
1931	-16405	-257
1932	-16104	1900
1933	-14039	-1162
1934	47800	-1615
1935	-15290	-1189
1936	-11710	-1107
1937	-4725	-867
1938	-17978	-1242
1939	-7649	-987
1940	-19596	-1271
1941	-12856	-1135
1942	-17881	-1240
1943	-15699	-1197
1944	-7276	-974
1945	-13827	-1157
1946	-17296	-1229
1947	25000	640
1948	-20892	-1547
1949	-18363	1620
1950	-23839	2240
1951	28200	1560
1952	-18171	-907
1953	-21075	-844
1954	-16104	1110
1955	-8493	1320
1956	-26153	-819
1957	-15800	2060
1958	-20892	2040
1959	-24013	2060
1960	-21257	2460
1961	28200	1870
1962	-10896	1260
1963	18900	1950
1964	-8172	-577
1965	-31994	-1091
1966	-8378	1110
1967	-19125	1470
1968	30400	1160
1969	-19690	-388
1970	-17394	3170
1971	-21166	1110
1972	34400	970
1973	-10545	1680
1974	46100	2860

COEFFICIENT OF CORRELATION = 0.079226849
STANDARD ERROR= 3.104359842
- SIGN INDICATES ESTIMATED FLOWS

EXTENDED STATISTICS
M= 3.087789414 S= 0.246985311 N= 31.10449345

APPENDIX XX
Peak Flows, Extended, Snowmelt Events
Little Spokane R. at Dartford

	#4225	#4310		#4225	#4310
1891	12800	-512	1933	28500	-932
1892	21800	-795	1934	-26145	-924
1893	37500	-1245	1935	25400	-902
1894	49000	-1554	1936	33700	-1140
1895	17100	-650	1937	22100	-804
1896	21400	-783	1938	32700	-1112
1897	33900	-1145	1939	23300	-840
1898	27200	-955	1940	16500	-631
1899	28900	-1004	1941	16100	-619
1900	17000	-647	1942	18400	-691
1901	22200	-807	1943	32400	-1103
1902	24800	-884	1944	11400	-465
1903	23900	-858	1945	22800	-825
1904	27900	-975	1946	28400	-989
1905	9510	-400	1947	-22098	-455
1906	18400	-691	1948	39600	1660
1907	21400	-783	1949	34200	-1272
1908	21700	-792	1950	32700	-1172
1909	17700	-669	1951	-20114	-1427
1910	-26441	-933	1952	32100	1580
1911	17200	-653	1953	22400	1950
1912	21200	-777	1954	31000	-739
1913	33600	-1137	1955	27000	-652
1914	19600	-728	1956	37800	1720
1915	11500	-468	1957	35600	-743
1916	28400	-989	1958	24400	-838
1917	41900	-1365	1959	26500	-1021
1918	-19319	-719	1960	27400	-798
1919	21600	-879	1961	-24470	-1570
1920	18200	-685	1962	27600	-920
1921	26200	-926	1963	-14925	-795
1922	26300	-929	1964	31800	940
1923	22000	-801	1965	33200	1230
1924	17800	-672	1966	20700	-673
1925	31700	-1084	1967	25600	-840
1926	15800	-609	1968	-10589	-513
1927	28200	-984	1969	30400	1970
1928	26600	-937	1970	23600	-911
1929	14700	-574	1971	34000	913
1930	12900	-268	1972	-34083	-599
1931	15800	260	1973	7910	-409
1932	33500	-1150	1974	0	0

COEFFICIENT OF CORRELATION = 0.602309190
STANDARD ERROR = 0.322690631
- SIGN INDICATES ESTIMATED FLOWS

[illegible]
M= [illegible] S= 0.2202015[illegible] N= [illegible]

APPENDIX XXI
Ordered Flows and Plotting Positions
Rainfall Events, Little Spokane R. at Dartford

N	Q	LOG Q	POS	N	Q	LOG Q	POS
1	3170	3.5011	0.84	43	1197	3.0782	51.20
2	2860	3.4564	2.04	44	1195	3.0775	52.40
3	2460	3.3909	3.24	45	1191	3.0759	53.60
4	2240	3.3502	4.44	46	1189	3.0751	54.80
5	2060	3.3139	5.64	47	1182	3.0727	56.00
6	2060	3.3139	6.83	48	1180	3.0719	57.19
7	2040	3.3096	8.03	49	1167	3.0669	58.39
8	1950	3.2900	9.23	50	1166	3.0667	59.59
9	1900	3.2788	10.43	51	1162	3.0652	60.79
10	1870	3.2718	11.63	52	1160	3.0645	61.99
11	1680	3.2253	12.83	53	1160	3.0643	63.19
12	1620	3.2095	14.03	54	1157	3.0634	64.39
13	1615	3.2081	15.23	55	1151	3.0610	65.59
14	1560	3.1931	16.43	56	1149	3.0605	66.79
15	1547	3.1895	17.63	57	1143	3.0580	67.99
16	1535	3.1862	18.82	58	1141	3.0573	69.18
17	1470	3.1673	20.02	59	1141	3.0573	70.38
18	1447	3.1604	21.22	60	1135	3.0549	71.58
19	1401	3.1464	22.42	61	1126	3.0513	72.78
20	1400	3.1461	23.62	62	1122	3.0500	73.98
21	1394	3.1443	24.82	63	1110	3.0453	75.18
22	1371	3.1370	26.02	64	1110	3.0453	76.38
23	1330	3.1239	27.22	65	1110	3.0453	77.58
24	1326	3.1226	28.42	66	1107	3.0440	78.78
25	1326	3.1226	29.62	67	1106	3.0437	79.98
26	1320	3.1206	30.82	68	1105	3.0433	81.18
27	1297	3.1131	32.01	69	1091	3.0377	82.37
28	1279	3.1068	33.21	70	987	2.9943	83.57
29	1279	3.1068	34.41	71	974	2.9885	84.77
30	1271	3.1041	35.61	72	970	2.9868	85.97
31	1260	3.1004	36.81	73	956	2.9805	87.17
32	1249	3.0965	38.01	74	943	2.9744	88.37
33	1242	3.0940	39.21	75	907	2.9575	89.57
34	1240	3.0934	40.41	76	867	2.9381	90.77
35	1238	3.0928	41.61	77	844	2.9261	91.97
36	1231	3.0902	42.81	78	819	2.9131	93.17
37	1231	3.0902	44.00	79	730	2.8633	94.36
38	1229	3.0895	45.20	80	640	2.8062	95.56
39	1227	3.0889	46.40	81	577	2.7608	96.76
40	1223	3.0875	47.60	82	388	2.5685	97.96
41	1223	3.0875	48.80	83	257	2.4093	99.16
42	1201	3.0797	50.00				

APPENDIX XXII
Ordered Flows and Plotting Positions
Snowmelt Events, Little Spokane R. at Dartford

N	Q	LOG Q	POS	N	Q	LOG Q	POS
1	1970	3.2945	0.84	43	840	2.9243	51.20
2	1950	3.2900	2.04	44	838	2.9232	52.40
3	1720	3.2355	3.24	45	825	2.9165	53.60
4	1660	3.2201	4.44	46	807	2.9069	54.80
5	1580	3.1987	5.64	47	804	2.9053	56.00
6	1570	3.1959	6.83	48	801	2.9037	57.19
7	1554	3.1913	8.03	49	798	2.9018	58.39
8	1427	3.1543	9.23	50	795	2.9006	59.59
9	1365	3.1351	10.43	51	795	2.9004	60.79
10	1272	3.1044	11.63	52	792	2.8987	61.99
11	1245	3.0952	12.83	53	783	2.8937	63.19
12	1230	3.0899	14.03	54	783	2.8937	64.39
13	1172	3.0690	15.23	55	777	2.8904	65.59
14	1150	3.0607	16.43	56	743	2.8708	66.79
15	1145	3.0590	17.63	57	739	2.8688	67.99
16	1140	3.0568	18.82	58	728	2.8622	69.18
17	1137	3.0558	20.02	59	719	2.8570	70.38
18	1112	3.0460	21.22	60	691	2.8395	71.58
19	1103	3.0427	22.42	61	691	2.8395	72.78
20	1084	3.0349	23.62	62	685	2.8355	73.98
21	1021	3.0090	24.82	63	673	2.8280	75.18
22	1004	3.0017	26.02	64	672	2.8276	76.38
23	992	2.9966	27.22	65	669	2.8255	77.58
24	989	2.9954	28.42	66	653	2.8152	78.78
25	989	2.9954	29.62	67	652	2.8140	79.98
26	984	2.9928	30.82	68	650	2.8131	81.18
27	975	2.9890	32.01	69	647	2.8110	82.37
28	955	2.9799	33.21	70	631	2.8003	83.57
29	940	2.9731	34.41	71	619	2.7915	84.77
30	937	2.9719	35.61	72	609	2.7847	85.97
31	933	2.9697	36.81	73	599	2.7771	87.17
32	929	2.9678	38.01	74	574	2.7588	88.37
33	926	2.9664	39.21	75	513	2.7098	89.57
34	924	2.9657	40.41	76	512	2.7091	90.77
35	920	2.9636	41.61	77	468	2.6706	91.97
36	913	2.9604	42.81	78	465	2.6675	93.17
37	911	2.9593	44.00	79	455	2.6578	94.36
38	902	2.9553	45.20	80	409	2.6120	95.56
39	884	2.9467	46.40	81	400	2.6024	96.76
40	879	2.9438	47.60	82	268	2.4287	97.96
41	858	2.9334	48.80	83	260	2.4150	99.16
42	840	2.9244	50.00				

APPENDIX XXIII
Computed Peak Flow Curves, Rainfall and Snowmelt Events, Little Spokane R. at Dartford

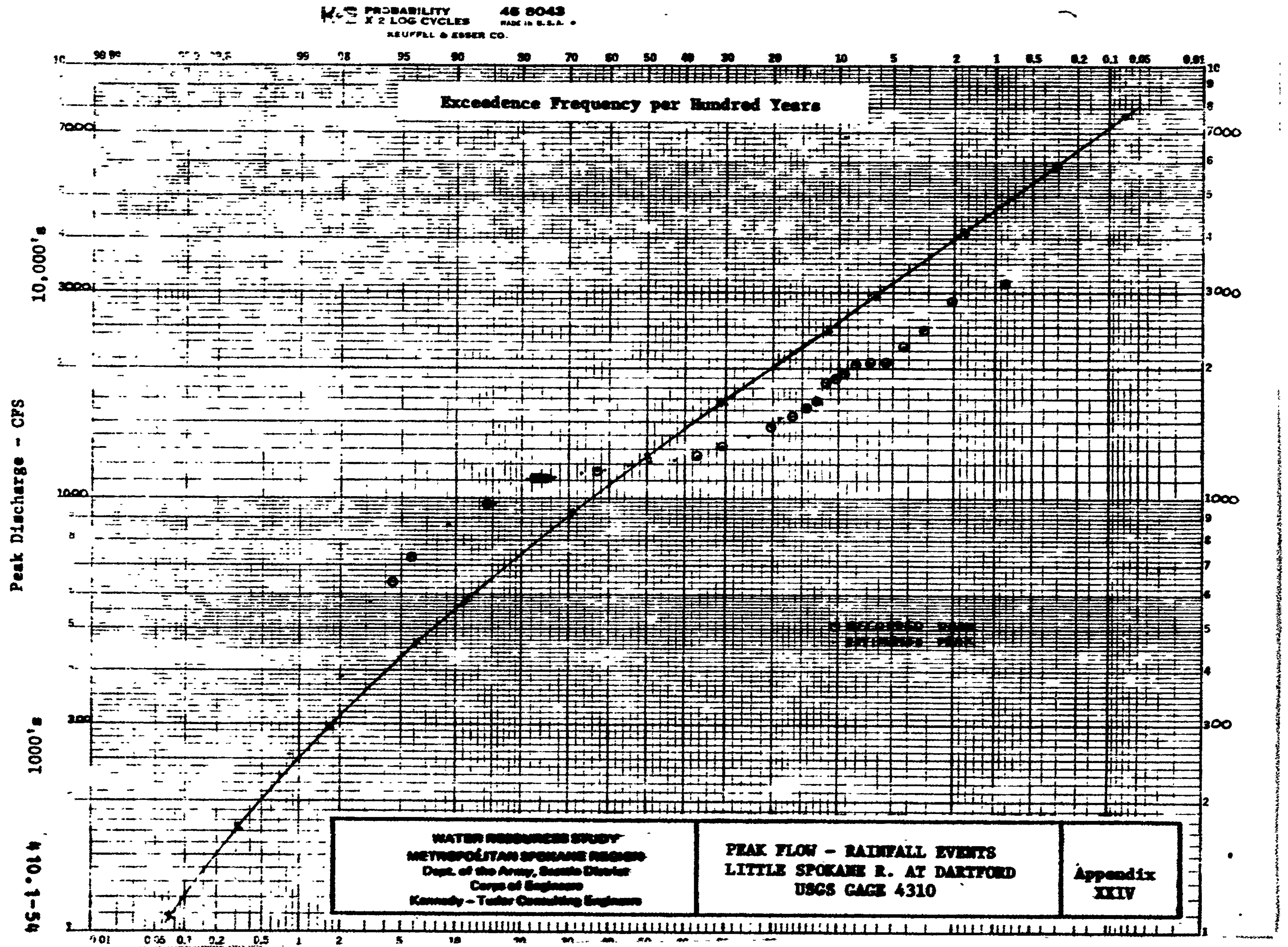
RAINFALL EVENTS				SNOWMELT EVENTS			
P INF	K	FLOWS	P(N)	P INF	K	FLOWS	P(N)
0.01	3.22	7649	0.07	0.01	3.36	4623	0.08
0.10	2.75	5845	0.32	0.10	2.94	3559	0.36
1.00	2.15	4156	1.70	1.00	2.20	2571	1.80
5.00	1.57	2986	6.22	5.00	1.59	1887	6.38
10.00	1.25	2493	11.22	10.00	1.26	1597	11.38
30.00	0.55	1672	31.02	30.00	0.54	1109	31.18
50.00	0.04	1252	50.00	50.00	0.03	856	50.00
70.00	-0.49	927	68.98	70.00	-0.50	655	68.82
90.00	-1.30	583	88.78	90.00	-1.30	437	93.62
95.00	-1.71	464	93.78	95.00	-1.69	358	93.62
99.00	-2.51	294	98.30	99.00	-2.46	242	98.20
99.90	-3.44	173	99.68	99.90	-3.35	154	99.64
99.99	-4.27	108	99.93	99.99	-4.12	104	99.92

ADJUSTED VALUES:
RAINFALL EVENTS: M= 3.087789414 S= 0.246985311 N= 31.10449345
SNOWMELT EVENTS: M= 2.925821566 S= 0.220291512 N= 39.04482686

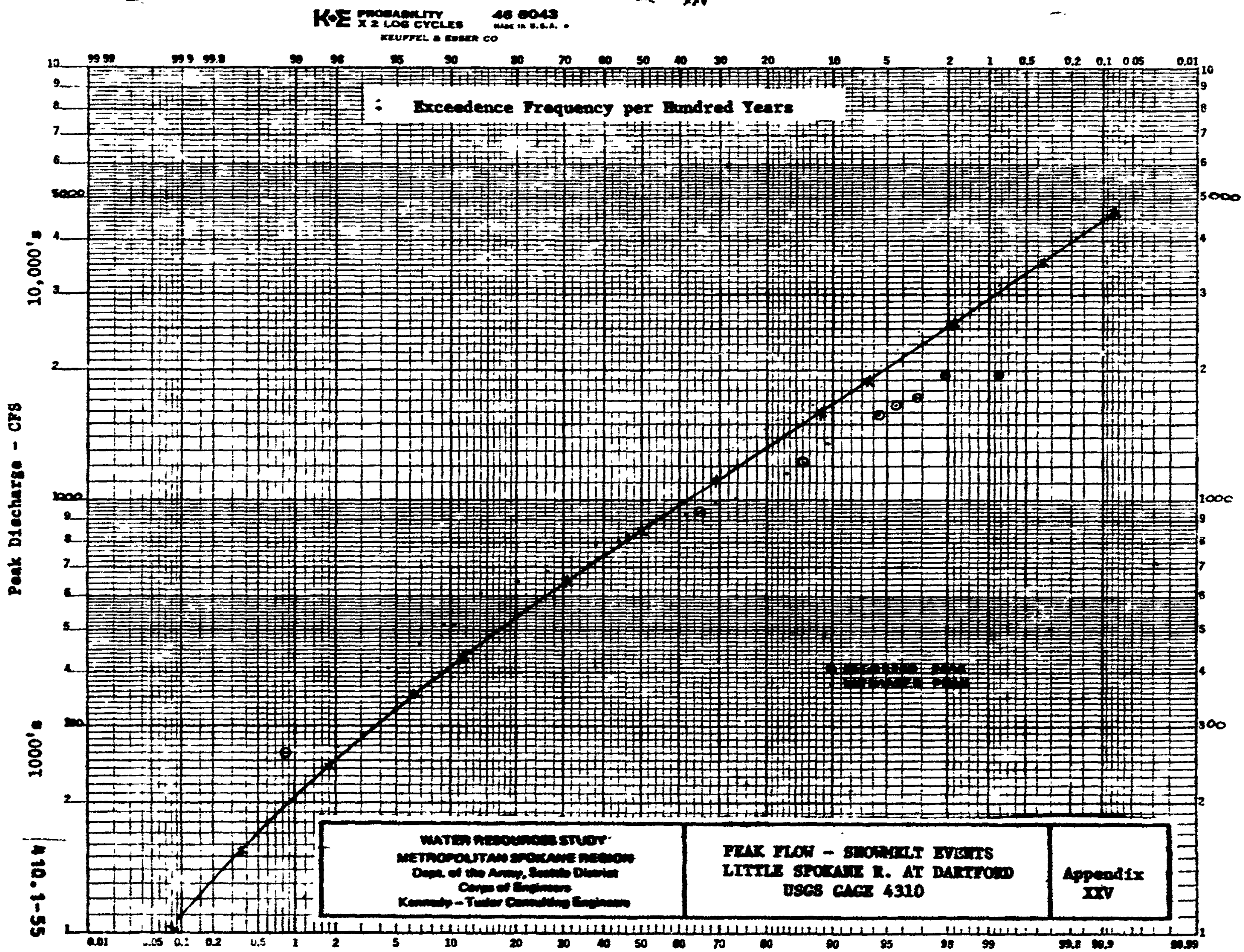
RAINFALL CALCULATED SKEW FACTOR= -0.243985903
SNOWMELT CALCULATED SKEW FACTOR= -0.178348374

SKEW FACTOR USED IN COMPUTATION:
RAINFALL CALCULATED G= -0.243985903
SNOWMELT CALCULATED G= -0.178348374

XXIV


K&E PROBABILITY X 2 LOG CYCLES
46 8043
MADE IN U.S.A.
KEUFFEL & ESSER CO.
Exceedence Frequency per Hundred Years
Peak Discharge - CFS
10,000's
1000's
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION
Dept. of the Army, Seattle District
Corps of Engineers
Kennedy – Tudor Consulting Engineers
PEAK FLOW - RAINFALL EVENTS
LITTLE SPOKANE R. AT DARTFORD
USGS GAGE 4310
Appendix
XXIV
#10.1-54

XXV


K+E PROBABILITY X 2 LOG CYCLES 46 8043
KEUFFEL & ESSER CO
Exceedence Frequency per Hundred Years
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METROPOLITAN SPOKANE REGION
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Kennedy - Tudor Consulting Engineers
PEAK FLOW - SNOWMELT EVENTS
LITTLE SPOKANE R. AT DARTFORD
USGS GAGE 4310
Appendix XXV
410.1-55

APPENDIX XXVI
Peak Flows, Raw Data, Rainfall Events, Hangman Cr. at Spokane

YEAR	MAX.PEAK	1 DAY PEAK	YEAR	MAX.PEAK	1 DAY PEAK
1949	6210	4830	1962	4610	4060
1950	9150	6820	1963	20600	10100
1951	6080	4270	1964	3900	3190
1952	4800	3840	1965	14500	9650
1953	3560	3100	1966	4560	3300
1954	6500	3660	1967	5310	4160
1955	4730	3880	1968	4590	3720
1956	11300	9280	1969	6000	5030
1957	9320	6440	1970	8650	7370
1958	6090	4710	1971	5340	3780
1959	16200	9560	1972	11600	11000
1960	2710	2170	1973	11500	4500
1961	6320	5550	1974	18300	14500

APPENDIX XXVII

Peak Flows, Extended, Rainfall Events, Hangman Cr. at Spokane

	#4225	#4240
1891	0	0
1892	-15597	-6378
1893	-6798	-4213
1894	-14981	-6251
1895	-13549	-5945
1896	-17001	-6659
1897	-21166	-7429
1898	-22961	-7737
1899	-15393	-6337
1900	-20062	-7233
1901	-22961	-7737
1902	-13128	-5853
1903	-17394	-6735
1904	-15902	-6419
1905	-11642	-5512
1906	-12471	-5704
1907	-17198	-6697
1908	-18363	-6920
1909	-14251	-6097
1910	28100	-8559
1911	-11676	-5520
1912	-14230	-6093
1913	-31759	-9098
1914	-17394	-6735
1915	-13485	-5931
1916	-28149	-8566
1917	-6449	-4104
1918	39600	-10158
1919	-17784	-6810
1920	-14878	-6230
1921	-23226	-7782
1922	-13204	-5869
1923	-13933	-6029
1924	-17001	-6659
1925	-25985	-8231
1926	-13128	-5853
1927	-20062	-7233
1928	-27655	-8491
1929	[illegible]	-5671
1930	-14461	-6142
1931	-16405	-6541
1932	-16104	-6481

	#4225	#4240
1933	-14039	-6052
1934	47800	-11159
1935	-15290	-6315
1936	-11710	-5528
1937	-4725	-3513
1938	-17978	-6847
1939	-7649	-4469
1940	-19596	-7149
1941	-12856	-5792
1942	-17881	-6829
1943	-15699	-6399
1944	-7276	-4358
1945	-13827	-6006
1946	-17296	-6716
1947	25000	-8073
1948	-20892	-7381
1949	-18363	6210
1950	-23839	9150
1951	28200	6080
1952	-18171	4800
1953	-21075	3560
1954	-16104	6500
1955	-8493	4730
1956	-26153	11300
1957	-15800	9320
1958	-20892	6090
1959	-24013	16200
1960	-21257	2710
1961	28200	6320
1962	-10896	4610
1963	18900	20600
1964	-8172	3900
1965	-31994	14500
1966	-8378	4560
1967	-19125	5310
1968	30400	4590
1969	-19690	6000
1970	-17394	8650
1971	-21166	5340
1972	34400	11600
1973	-10545	11500
1974	46100	18300

COEFFICIENT OF CORRELATION = 0.376100774
STANDARD ERROR = 2.670390486
- SIGN INDICATES ESTIMATED FLOWS

EXTENDED STATISTICS
M= [illegible].8239294[illegible] S= 0.22[illegible]704680 H- [illegible]

APPENDIX XXVIII
Ordered Flows and Plotting Positions
Rainfall Events, Hangman Cr. at Spokane

N	Q	LOG Q	POS	N	Q	LOG Q	POS
1	20600	4.3139	0.84	43	6337	3.8019	51.20
2	18300	4.2625	2.04	44	6320	3.8007	52.40
3	16200	4.2095	3.24	45	6315	3.8004	53.60
4	14500	4.1614	4.44	46	6251	3.7960	54.80
5	11600	4.0645	5.64	47	6230	3.7945	56.00
6	11500	4.0607	6.83	48	6210	3.7931	57.19
7	11300	4.0531	8.03	49	6142	3.7883	58.39
8	11159	4.0476	9.23	50	6097	3.7851	59.59
9	10158	4.0068	10.43	51	6093	3.7848	60.79
10	9320	3.9694	11.63	52	6090	3.7846	61.99
11	9150	3.9614	12.83	53	6080	3.7839	63.19
12	9099	3.9590	14.03	54	6052	3.7819	64.39
13	8650	3.9370	15.23	55	6029	3.7803	65.59
14	8566	3.9328	16.43	56	6006	3.7786	66.79
15	8559	3.9324	17.63	57	6000	3.7782	67.99
16	8491	3.9289	18.82	58	5945	3.7742	69.18
17	8231	3.9154	20.02	59	5931	3.7732	70.38
18	8073	3.9070	21.22	60	5869	3.7686	71.58
19	7782	3.8911	22.42	61	5853	3.7673	72.78
20	7737	3.8886	23.62	62	5853	3.7673	73.98
21	7737	3.8886	24.82	63	5792	3.7628	75.18
22	7429	3.8709	26.02	64	5704	3.7562	76.38
23	7381	3.8681	27.22	65	5671	3.7537	77.58
24	7233	3.8593	28.42	66	5528	3.7425	78.78
25	7233	3.8593	29.62	67	5520	3.7419	79.98
26	7149	3.8542	30.82	68	5512	3.7413	81.18
27	6920	3.8401	32.01	69	5340	3.7275	82.37
28	6847	3.8355	33.21	70	5310	3.7251	83.57
29	6829	3.8344	34.41	71	4800	3.6812	84.77
30	6810	3.8332	35.61	72	4730	3.6749	85.97
31	6735	3.8284	36.81	73	4610	3.6637	87.17
32	6735	3.8284	38.01	74	4590	3.6618	88.37
33	6716	3.8271	39.21	75	4560	3.6590	89.57
34	6697	3.8259	40.41	76	4469	3.6502	90.77
35	6659	3.8234	41.61	77	4358	3.6393	91.97
36	6659	3.8234	42.81	78	4213	3.6246	93.17
37	6541	3.8157	44.00	79	4104	3.6132	94.36
38	6500	3.8129	45.20	80	3900	3.5911	95.56
39	6481	3.8116	46.40	81	3560	3.5514	96.76
40	6440	3.8089	47.60	82	3513	3.5457	97.96
41	6399	3.8061	48.80	83	2710	3.4330	99.16
42	6376	3.8047	50.00				

XXIX

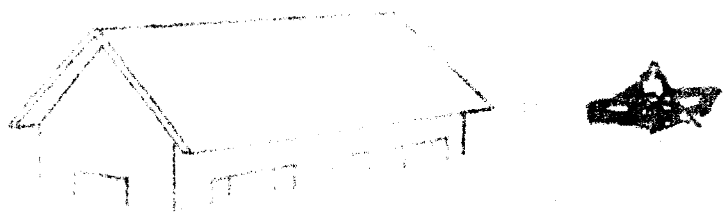
APPENDIX XXIX
Computed Peak Flow Curve
Hangman Creek at Spokane

RAINFALL EVENTS				SNOWMELT EVENTS			
P INF	K	FLOWS	P(N)	P INF	K	FLOWS	P(N)
0.01	4.20	60777	0.07	0.00	0.00	0	0.00
0.10	3.39	39859	0.32	0.00	0.00	0	0.00
1.00	2.48	24684	1.68	0.00	0.00	0	0.00
5.00	1.70	16300	6.18	0.00	0.00	0	0.00
10.00	1.30	13224	11.18	0.00	0.00	0	0.00
30.00	0.49	8645	30.98	0.00	0.00	0	0.00
50.00	-0.04	6545	50.00	0.00	0.00	0	0.00
70.00	-0.54	5005	69.02	0.00	0.00	0	0.00
90.00	-1.26	3441	88.82	0.00	0.00	0	0.00
95.00	-1.58	2903	93.82	0.00	0.00	0	0.00
99.00	-2.17	2121	98.32	0.00	0.00	0	0.00
99.90	-2.79	1530	99.68	0.00	0.00	0	0.00
99.99	-3.29	1179	99.93	0.00	0.00	0	0.00

ADJUSTED VALUES:
RAINFALL EVENTS: M= 3.823929406 S= 0.22878466 N= 28.797428
SNOWMELT EVENTS: M= 0 S= 0 N= 0

RAINFALL CALCULATED SKEW FACTOR= 0.210806590

SKEW FACTOR USED IN COMPUTATION:
RAINFALL CALCULATED G= 0.210806590
SNOWMELT PERIOD NOT ANALYSED



SECTION 410.2

FLOOD PLAIN DELINEATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 410.2

FLOOD PLAIN DELINEATION

25 April 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

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* Not bound in this report.

SECTION 410.2

FLOOD PLAIN DELINEATION

INTRODUCTION

The flood plain analysis area is composed of four reaches: the Spokane River from the confluence with Hangman Creek, RM 72.4, to the Idaho state line, RM 96.5; the Little Spokane River from the confluence with the Spokane River, RM 0.0, to the vicinity of Chattaroy, RM 23.2; Hangman Creek from its confluence with the Spokane River, RM 0.0 to the end of the adjacent residential development, approximate RM 4.0; and Rock Creek in the reach through Rockford. The results of the analysis are presented as follows for each of the respective reaches: for the Spokane River, a profile delineating the 100 yr flood water surface and a plan delineation of the 100 yr flood plain on 1" = 400' orthophoto backgrounds for the entire reach; for the Little Spokane River, a profile delineating the 100 yr flood water surface for the entire reach and a plan delineation of the 100 yr flood plain on 1" = 400' orthophoto and topographic backgrounds for the reaches between RM 0.0 and approximate RM 16 south of the town of Buckeye and on 1" = 2000' USGS maps RM 16 to Chattaroy; for Hangman Creek, a plan delineation of the 100 yr flood plain on 1" = 400' orthophoto backgrounds for RM 0.0 through RM 5.0; for Rock Creek, a profile delineating the 100 yr floodwater surface for the reaches through Rockford and plan at 1" = 400'. Large scale mapping is on plates which are bound at the end of this section.

The flood flows of 100 year return frequency are developed from statistical analysis of available stream gage records in another section of this study. The results are summarized below:

Gage Number	Description	Flood Flow of 100 year recurrence cfs
4224	Spokane River at Spokane	52,000
4310	Little Spokane River at Dartford	4,700
4240	Hangman Creek at Spokane	28,000

The Spokane River and Hangman Creek gages are located at the downstream end of the study reaches and the Little Spokane River gage at approximate mid-reach.

There is no stream gage on Rock Creek, a tributary of Hangman Creek, from which the 100 year flood flow can be developed directly by statistical analysis. The 100 year flood flow for Rock Creek at Rockford is developed by area correlation as discussed below.

Limitations

The flood plain delineations made in this study are for the purpose of general planning in water management. The results are not intended for use in establishing legal flood plain boundaries or for other uses with legal implications such as flood insurance. Neither the data base on which the studies are made nor the methodology employed in the analysis meet the requirements of such specialized legal application.

It will be noted on maps delineating the flood plain that the edge of the flood plain is shown in some cases to cross and recross contour lines. This is because greater weight is given to actual observed flooding than contour shape. The contour mapping is accurate to plus or minus 1/2 an interval or 2.5 feet. This, and other considerations, is an example of the limitations cited.

The Spokane River

Development of the profile delineating the 100 yr high water surface, as shown in Figs G & H, is subdivided into three parts.

1. Hangman Creek to City Waterworks bridge, RM 72.4 to RM 79.6. The City of Spokane invert profile at City datum is adjusted and matched to the Corps of Engineers study of the December 1933 flood profile at USC & GS datum using the datum shift of 16.58'. Since the 1933 flood was caused by discharge of 47,800 cfs whereas the 100 yr discharge is 52,000 cfs an upward adjustment of the 1933 profile is required to describe the 100 yr flood. Modifications are made to the 1933 profile in two sections: (a) RM 72.4 to 74.0 is raised 0.6' which reflects the incremental elevation difference between the two floods as indicated by extrapolation of the rating curve of USGS gage #4225 at RM 72.9, see Figure A; (b) The water surface in the vicinity of USGS streamgage #4220 RM 77.9, is raised 1.4 ft. to reflect the elevation difference between 47,800 cfs and 52,000 cfs as determined from the extrapolated rating curve associated with this gage. See Figure B.

2. Between Green Street Bridge, RM 78.0, and Argonne Road, RM 82.6 the invert and the 100 yr high water surface are assumed to be represented by linear joining of known conditions at the two endpoints, there being no historical data for either in this subreach.

3. Argonne Road bridge, RM 82.6, to Idaho state line, RM 96.5. This is approximately a 13 mile subreach with profile elevations and corresponding cross-section data available at about 2 mile intervals. At each of these intervals a high water measurement has been recorded for the Jan. 1974 flood of 46,100 cfs. The profile for the 1974 flood in this subreach is adjusted upward to represent the 100 yr flood by + 0.75' at RM 84.8 and + 1.5' at RM 93.9 and linearally prorated to adjacent subreaches. These increases are due to the elevation difference between the 100 yr discharge

of 52,000 cfs and the Jan. 1974 discharge of 46,100 cfs as indicated by extrapolation of USGS gages #4195 and #4215 respectively. See Figures C and D. A linear slope for both the invert and high water surface profile is assumed for all subreaches between the observed data at the cross-sections.

The flood plain delineation is produced on Plates 410-1 through 410-13 by plotting the high water line on 1" = 400' orthophoto maps with the basic reference for the extent of flooding being the vertical photos taken by the Corps of Engineers during the 1974 flood. Supplemental data are drawn from field observations, field photos and the water surface profile.

In general the Spokane River is well contained by its banks and control structures. Bridges provide ample clearance to pass large floods and urban development outside the city proper is not threatened by floods. In the city, three areas are subject to partial inundation by large floods. Areas of Pleasant Valley adjacent to the River downstream of Monroe St. bridge were flooded in the Jan. 1974 occurrence and this situation would be repeated for other large magnitude floods. Other urban areas which can be expected to experience moderate inundation by a 100 yr flood are reaches along Upriver Drive and the buildings located in the flats north of the river in the vicinity of East and West Trent bridges.

Little Spokane River

The 100 yr water surface profile as shown in Figure I is developed from a series of field measurements made by K-T. This Data includes high water observations for the Feb. 1970 flood of 3170 cfs, several cross-sections and both aerial and ground photographs. These measurements were applied to the Corps of Engineers HEC-2 mathematical model and one run was made which yielded an approximate water surface profile. This profile is adjusted to more accurately fit the associated high water marks. The incremental depth from the observed 100 yr flood at the USGS gage #4310 at Dartford RM 10.8 is determined from the extrapolated rating curve shown in Figure E. The difference between the 1970 flood and the 100 yr flood of 4700 cfs is 1.1 ft. This increment is prorated by depth over the entire reach and added to the 1970 profile to yield the 100 yr high water surface profile. The backwater from Long Lake which is assumed to be elevation 1539 at RM 0.0 concurrent with the 100 yr flood on the Little Spokane. The estimated water surface profile of the Little Spokane at 100 year flood is also approximately 1539 at RM 0.0 matching the assumed lake backwater indicating negligible backwater effect extending into the river.

The limits of the 100 yr flood plain are presented on 1" = 400' topographic maps from the confluence of the Little Spokane and the Spokane rivers to Buckeye. Refer to Plates 410-17 through 410-24. The extent of the 100 yr flood plain is estimated by combining the elevations predicted on the 100 yr profile with oblique photos of the Dec. 1973 and Jan. 1974 flooding of the Little Spokane River.

A large magnitude flood on the Little Spokane river can be expected to inundate adjacent residential dwellings in the vicinity of Dartford and Buckey. In the lower reaches, RM 0.0 to RM 10.3, due to the flat nature of the overbank, extensive flooding occurs when the flood stage becomes higher than the low channel banks. Even moderate occurrences tend to have this effect. These reaches contain several dwellings and a school which have a history of flood threats and damage. The upper reaches, RM 16.3 to 21.0, also have low channel banks with a wide flat overbank which are inundated with moderate to large floods. However, very few residences are presently located on this flood plain.

Hangman Creek

A flood plain delineation on Hangman Creek is presented on 1" = 400' orthophoto maps from its confluence with the Spokane River to RM 3.0. Refer to Plates 410-1 & Plates 410-14 to 410-16. The basic reference utilized to determine extent of flooding is the photo record of the January 1974 flood made by Kennedy-Tudor. The limits of flooding are adjusted to reflect the 2.6 ft difference in the water surface between the Jan. 1974 flood of 18,300 cfs and the 100 yr flood of 28,000 cfs. This incremental adjustment is obtained by comparison of the flood discharges to the extrapolated rating curve of USGS stream gage #4240, RM 0.8 as shown in Fig. F. The gage is within the reach being analysed.

Both the mapped flood area as shown on referenced plates and the oblique aerial photos of the December 1973 and January 1974 floods indicate flooding potential to several isolated residences in the reach below the railroad bridge at RM 3.1. There is also a strip about 1/2 mile long in the vicinity of RM 2.6 not presently occupied that has flooding potential. During the December '73 and January '74 floods there was some minor flood damage reported in the newspapers in the lower Hangman Creek area.

The news photos show that the primary source of damage was by undercutting of structures built on alluvium deposited by previous floods.

Analysis of oblique aerial photos of the entire length of Hangman Creek made during the Dec. 1973 and Jan. 1974 floods indicates the following locations of other potential flooding problems:

1. There is overbank flow in the vicinity of RM 11.0, however, there are no structures involved.

2. There is overbank flow in the golf course at RM 14 which encroaches on fairways and comes near the clubhouse. The reach through the present golf course site was the subject of a previous flood profile analysis by the Corps of Engineers, results of which are not reported herein.

3. Overbank flow exists between RM 23.9 and 25.0 but there are no buildings involved.

4. There is overbank flow north of Waverly between RM 36 and RM 37 which covered the county road and threatened a bridge during the Jan. 1974 flood. There are no buildings affected.

5. Minor road flooding and a threat to isolated farm buildings occurs in the vicinity of RM 41.0.

6. At Latah and north of Latah, RM 46.0 to RM 48.0, there is overbank inundation with road flooding. Some farm buildings are also involved at RM 48.0.

7. There is extensive overbank flooding in and around Tekoa. Farm land, farm buildings, roads and some residential areas are involved. Reconnaissance reports on the flooding problem in the Tekoa area were prepared in 1966 and 1970 by the Corps of Engineers, results of which are not

reported herein.

In general, this survey of aerial photos of recent flood flows indicates that there is essentially no urban development subject to or threatened by flooding of Hangman Creek between RM 4 and Tekoa.

Rock Creek at Rockford

A 100 yr high water surface profile is presented for the reaches of Rock Creek through Rockford in Figure J. Data for this analysis, including five cross-sections, was obtained by a joint field survey by the Corps of Engineers and K-T. The high water surface for the Jan. 1974 flood is plotted relative to the stream bed profile defined by the survey cross sections. The discharge associated with this observed flood of January 1974 is estimated to be 3100 cfs based on the area discharge relationship for the Hangman Creek watershed developed from USGS gage #4240. This flow of 3100 cfs when applied to normal depth analysis of the two upstream cross sections gave close agreement with the observed 1974 high water marks and verified the basis for flow correlation. The 100 year discharge on Rock Creek at Rockford is estimated on this same basis to be 4750 cfs. The normal depth analysis for a flow of 4750 cfs yields an incremental surface elevation of 1.0 ft. at the previously analysed cross-sections. This increment is added to the observed 1974 flood profile to yield the 100 yr flood profile as shown in Figure J. The profile shown in Figure J does not include any consideration of backwater potential created by the highway bridge which abuts the downstream end of the levee. The bridge deck is at the same elevation as the top of the levee. The bridge was close to inundation during the Jan. 1974 flood causing a substantial backwater upstream along the levee. There is a possibility that a larger flood would destroy the bridge.

The January 1974 flood did not cause any significant flood damage. The flood profile developed in this study for the 100 year recurrence without consideration of backwater from the highway bridge indicates that water surface would be within one foot of the present levee top.

Modifications to the channel downstream from the highway bridge and the end of the levee have been made since the Jan. 1974 flood which will reduce the 100 yr profile somewhat in this part of the reach. Also, a culvert without backflow prevention under the levee allows sections of the town to be flooded at high river stage.

The existing levee was constructed by WPA after the 1933 flood. The alleged protection level of the levee is for 20 year flood recurrence. Rockford was flooded again in 1963 and 1964 and the levee was repaired by the Corps of Engineers in 1965.

Subsequently, a preliminary plan of improvements was developed by the Corps of Engineers and found to have a benefit-cost ratio of 0.9. The plan has not been implemented. The proposed improvement consists of raising the levee 3 feet for a distance of 700 feet and rebuilding the levee for a distance of approximately 1,000 feet, all to provide protection for the 100 year recurrence level.

The approximate limits of the 100 year flood are shown in Figure K. These limits are from the Corps of Engineers study referred to above and are not derived from the profile in Figure J. The Rockford vicinity and relation to the flood plain are shown in Plate 410-27.

Photographic Record of Flooding

Two opportunities for photographic documentation of flooding problems occurred during the study period, one in December 1973 and another in January 1974. Kennedy-Tudor made photographic records of these two flood events, as follows:

December 1973 Event

1. Oblique aerial photos, color, of the Little Spokane River from mouth to vicinity of Chattaroy, 61 photos, 12-18-73.
2. Ground level photos, color, of the Little Spokane River from mouth to vicinity of Chattaroy, 77 photos, 12-17-73 to 12-21-73.
3. Oblique aerial photos, color, of Hangman Creek, from mouth to Tekoa, 36 photos, 12-18-73.
4. Ground level photos, black and white, Spokane River, Hangman Creek confluence to State Line, 40 photos, 1-17-74 to 1-20-74.

January 1974 Event

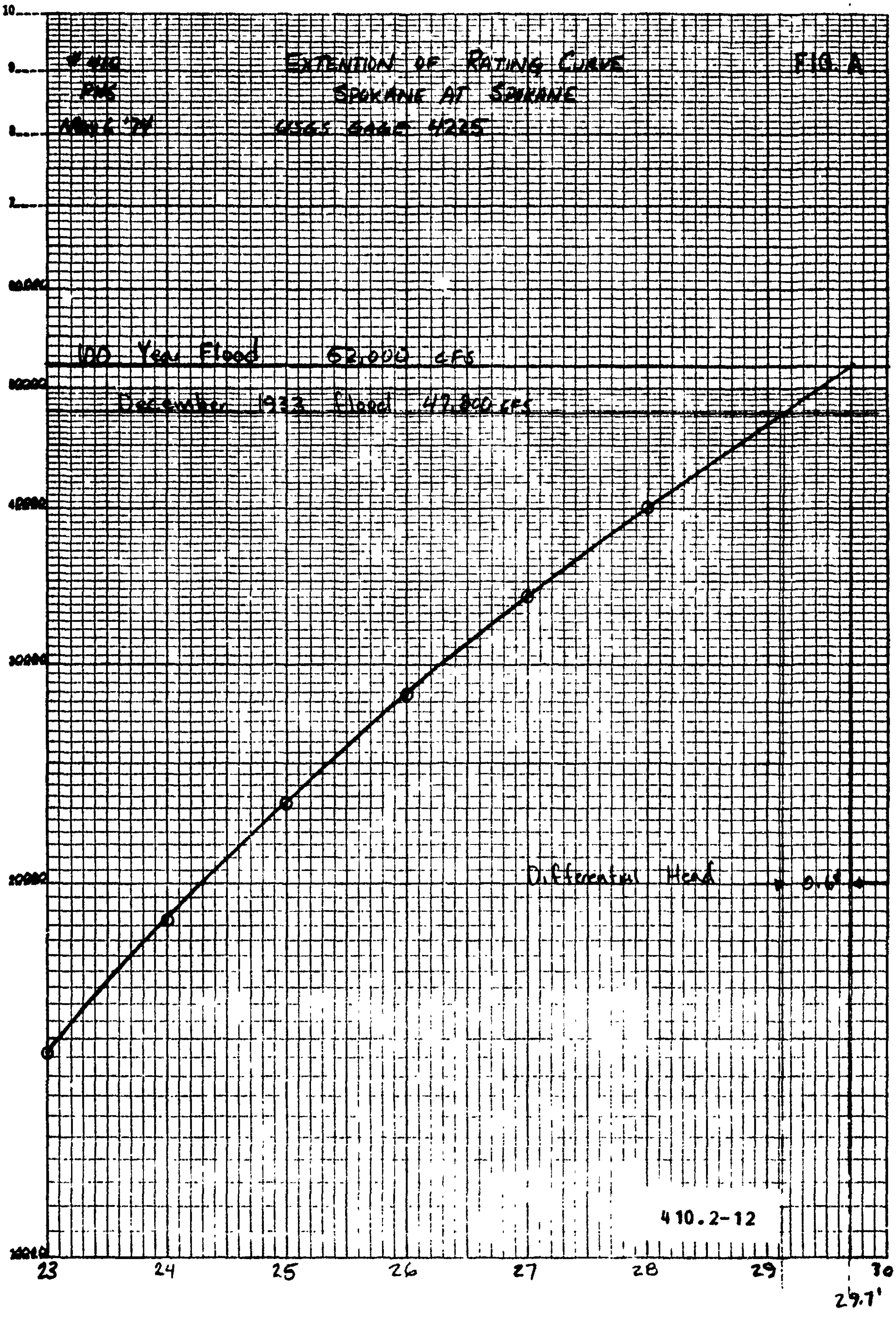
1. Oblique aerial photos, black and white, of the Little Spokane River from mouth to above Chattaroy, 18 photos, 1-16-74.
2. Oblique aerial photos, black and white, of Hangman Creek from mouth to Tekoa, 86 photos, 1-16-74.
3. Oblique aerial photos, black and white, Rock Creek from mouth to Idaho boundary, 31 photos, 1-16-74.
4. Ground level photos, black and white, Rockford vicinity, 7 photos, 1-15-74.

In addition to the photo record made by Kennedy-Tudor as described above, vertical aerial photography was made for the Corps of Engineers as follows: Spokane River from Hangman Creek confluence to Coeur D'Alene Lake on January 19, 1974, and Hangman Creek from mouth to Tekoa on January 17, 1974.

The oblique aerial photos of the December 1973 events on the Little Spokane River and Hangman Creek are included herein as Appendices I and II respectively. Contact prints of the oblique aerial photos of the January 1974 event are included herein as Appendix III. Appendix IV provides a map index to the photos shown in Appendices I through III. Appendices I and II are arranged in order from the mouth upstream in each case. Appendix III photos are in the order indicated on the map, Appendix IV.

Ground level photos and enlargements of the oblique aerial photos shown at contact size in Appendix III are available in project files. Corps of Engineers vertical photos of the Spokane River are returned to Corps files.

The 1974 event on the Spokane River which reached a peak of 46,100 cfs on January 20, 1974 was sustained at substantially peak volume over January 19, 20 and 21 so that the verticals made for the Corps on January 19 are a record of the peak flow flooding. The 1974 event on Hangman Creek peaked at 2200 hours on January 15, 1974 at 18,300 cfs but had dropped to 12,300 cfs by January 16, 1974 between 1100 and 1300 hours when the K-T oblique color photos were made. The verticals flown for the Corps on January 17, 1974 were after the high flow period.



K·E SEMI-LOGARITHMIC 46 4650
1 CYCLE X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

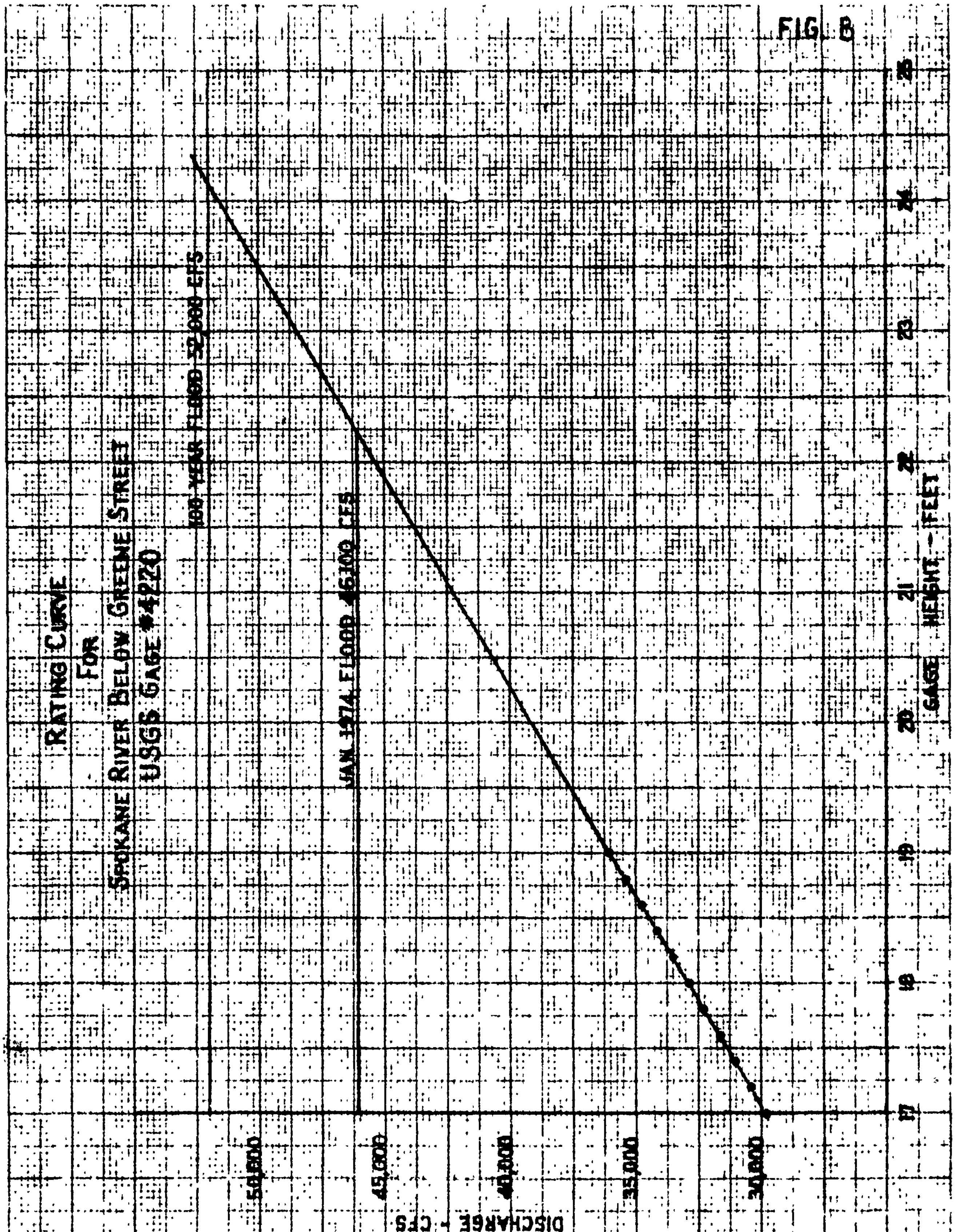
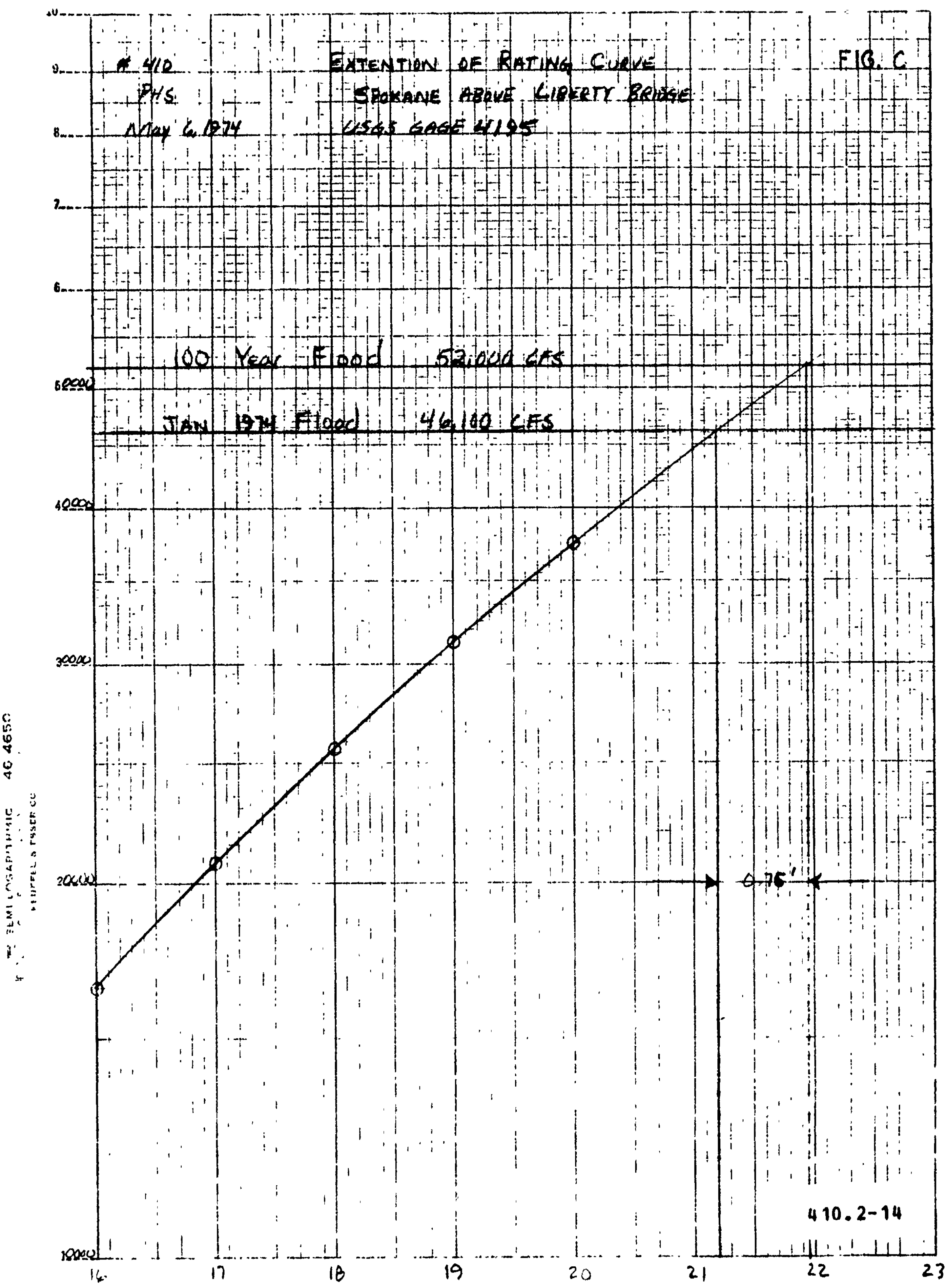


FIG. B
RATING CURVE
FOR
SPOKANE RIVER BELOW GREENE STREET
USGS GAGE #4220
100 YEAR FLOOD 52,000 CFS
JAN 1974 FLOOD 46100 CFS
DISCHARGE - CFS
30,000
35,000
40,000
45,000
50,000
GAGE HEIGHT - FEET
17
18
19
20
21
22
23
24
25



410
PHS
May 6, 1974
EXTENTION OF RATING CURVE
SPOKANE ABOVE LIBERTY BRIDGE
USGS GAGE 4195
FIG. C
100 Year Flood 52,000 CFS
JAN 1974 Flood 46,100 CFS
0.75'
50000
40000
30000
20000
10000
16
17
18
19
20
21
22
23
46 4650
SEMI-LOGARITHMIC
KEUFFEL & ESSER CO.

410.2-14

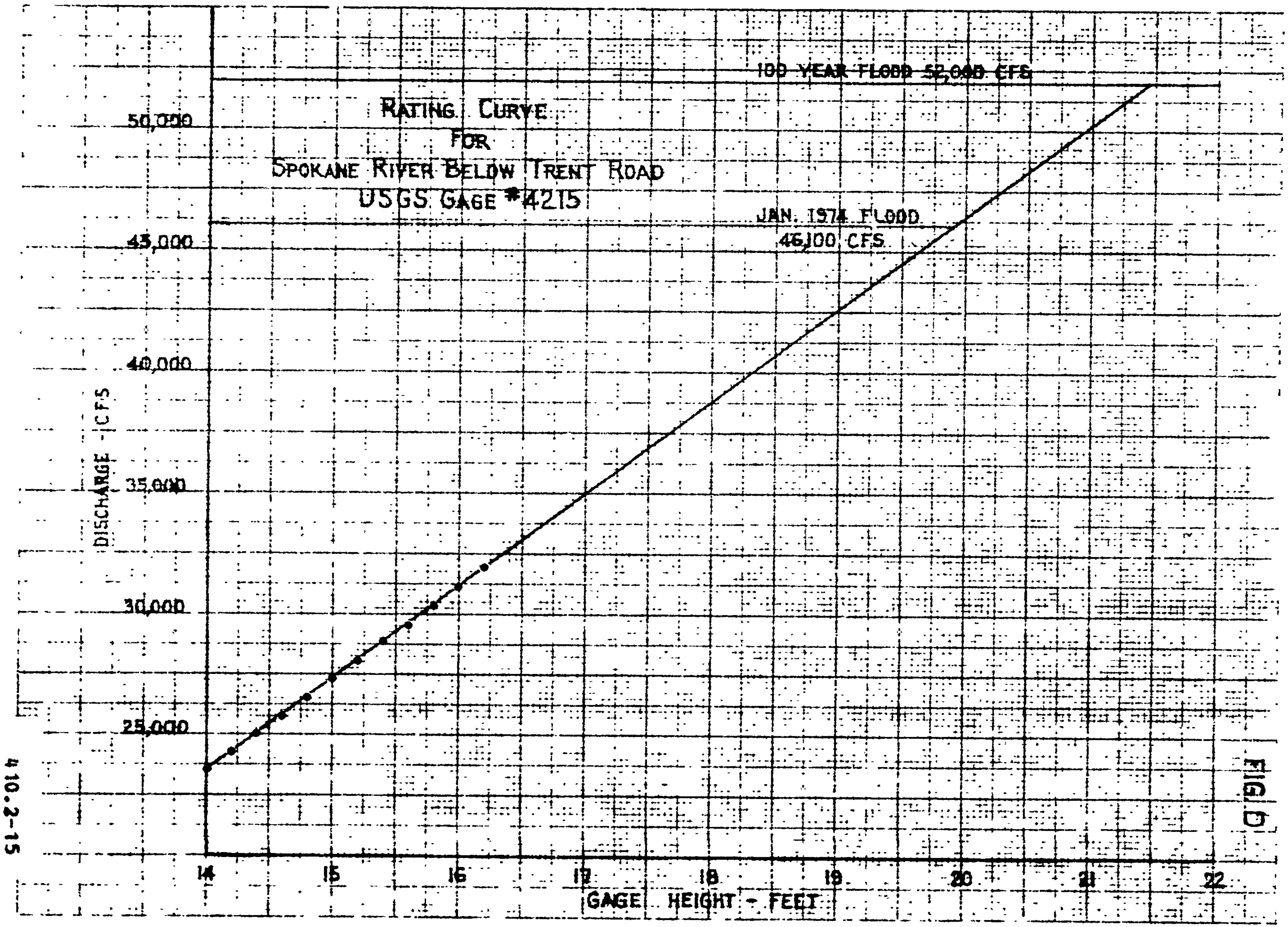

RATING CURVE
FOR
SPOKANE RIVER BELOW TRENT ROAD
USGS GAGE #4215
100 YEAR FLOOD 52,000 CFS
JAN. 1974 FLOOD
46,100 CFS
50,000
45,000
40,000
35,000
30,000
25,000
DISCHARGE - CFS
14
15
16
17
18
19
20
21
22
GAGE HEIGHT - FEET

FIG. D

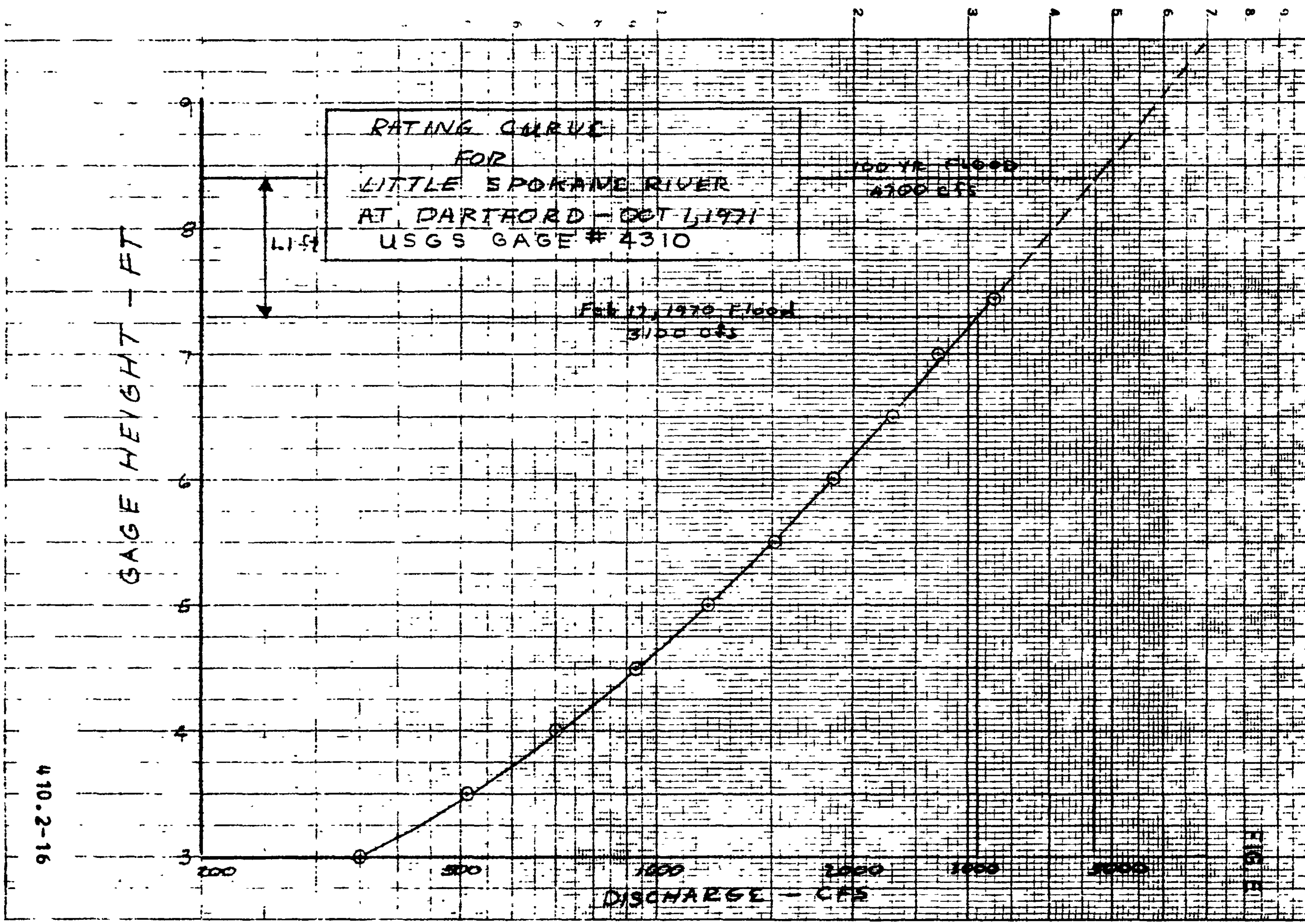

RATING CURVE
FOR
LITTLE SPOKANE RIVER
AT DARTFORD - OCT 1, 1971
USGS GAGE # 4310
100 YR. FLOOD
4700 cfs
Feb 17, 1970 Flood
3100 cfs
1.1 ft
GAGE HEIGHT - FT
DISCHARGE - CFS
3
4
5
6
7
8
9
200
500
1000
2000
3000
5000

FIG. 8

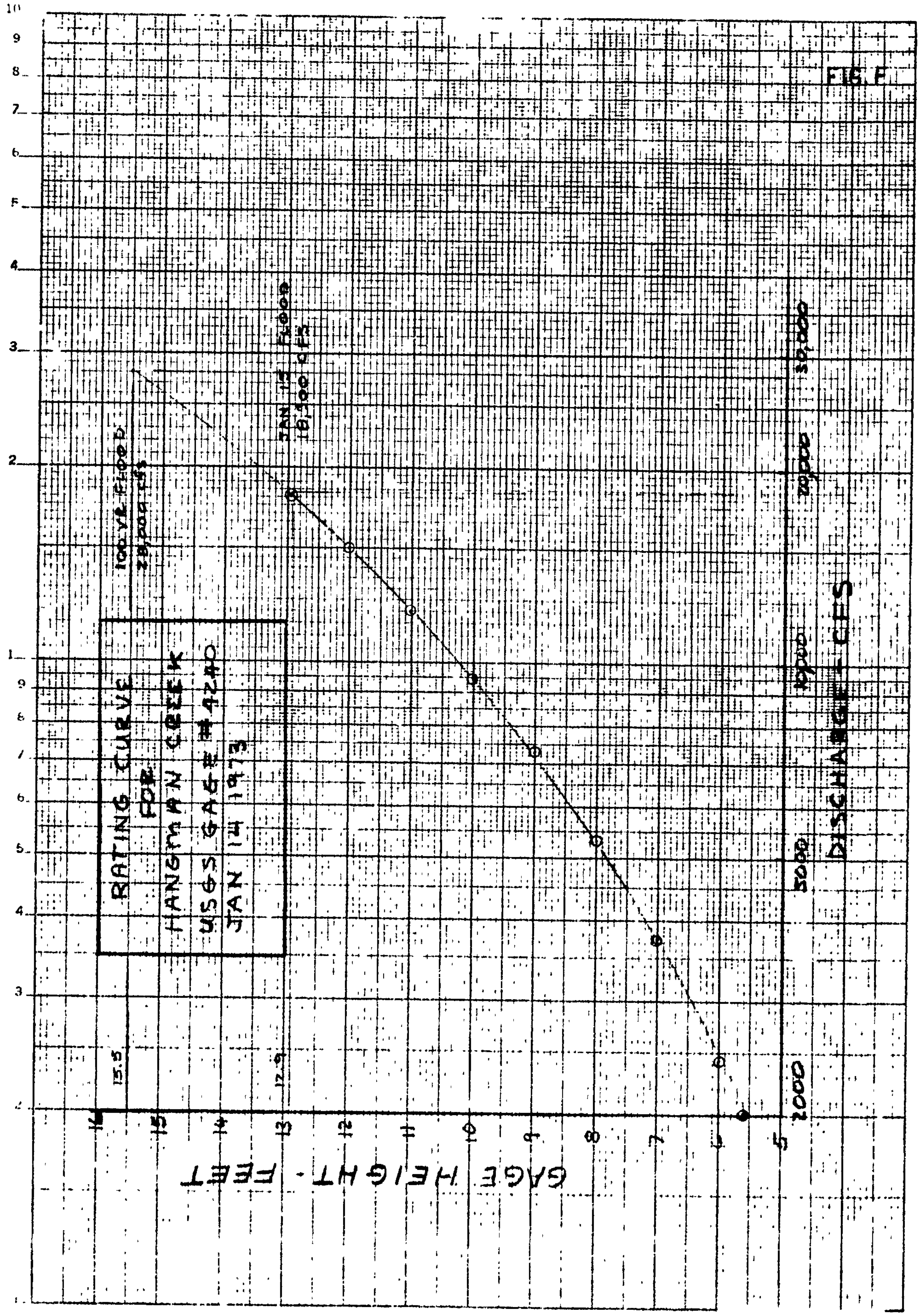
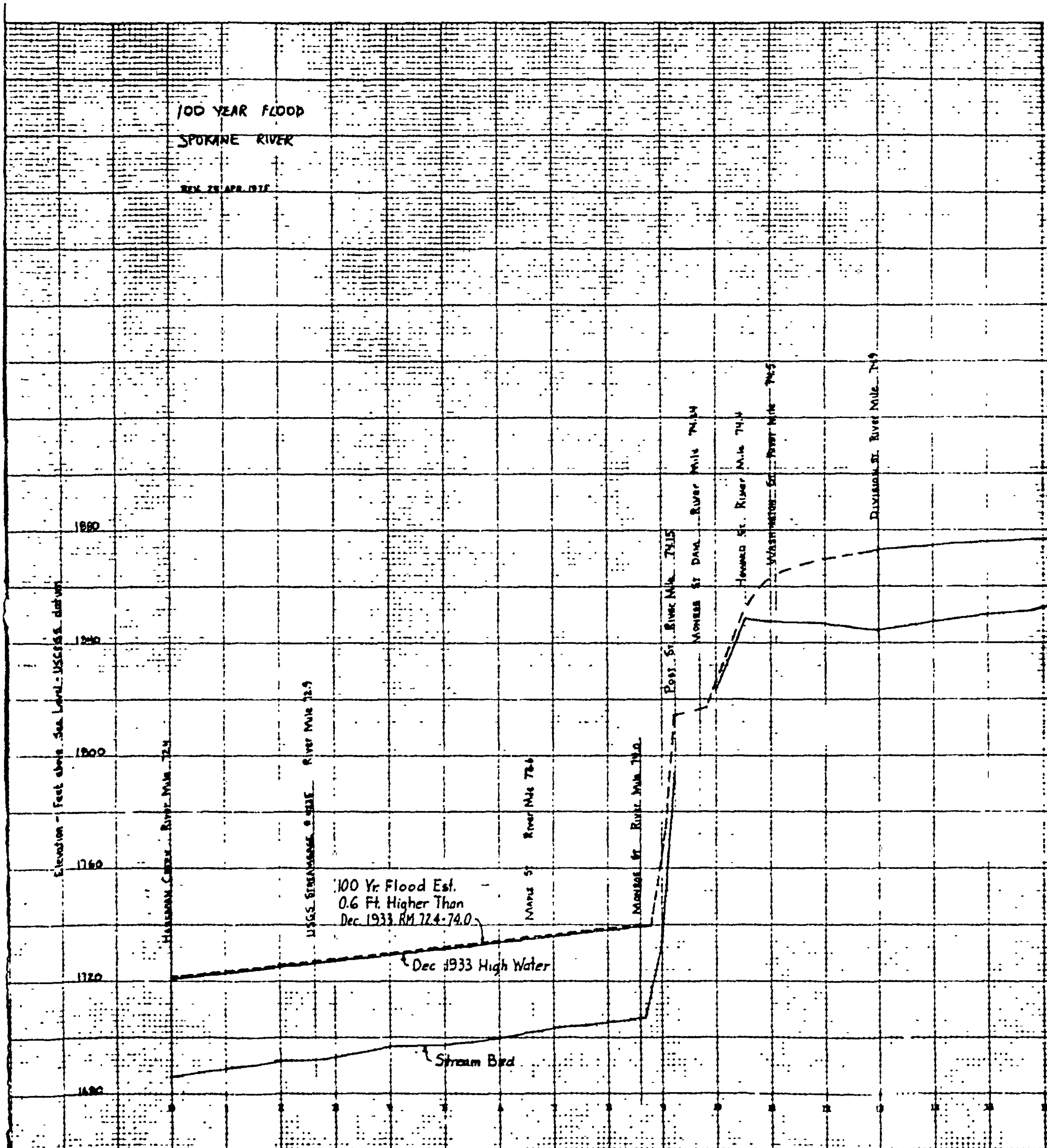
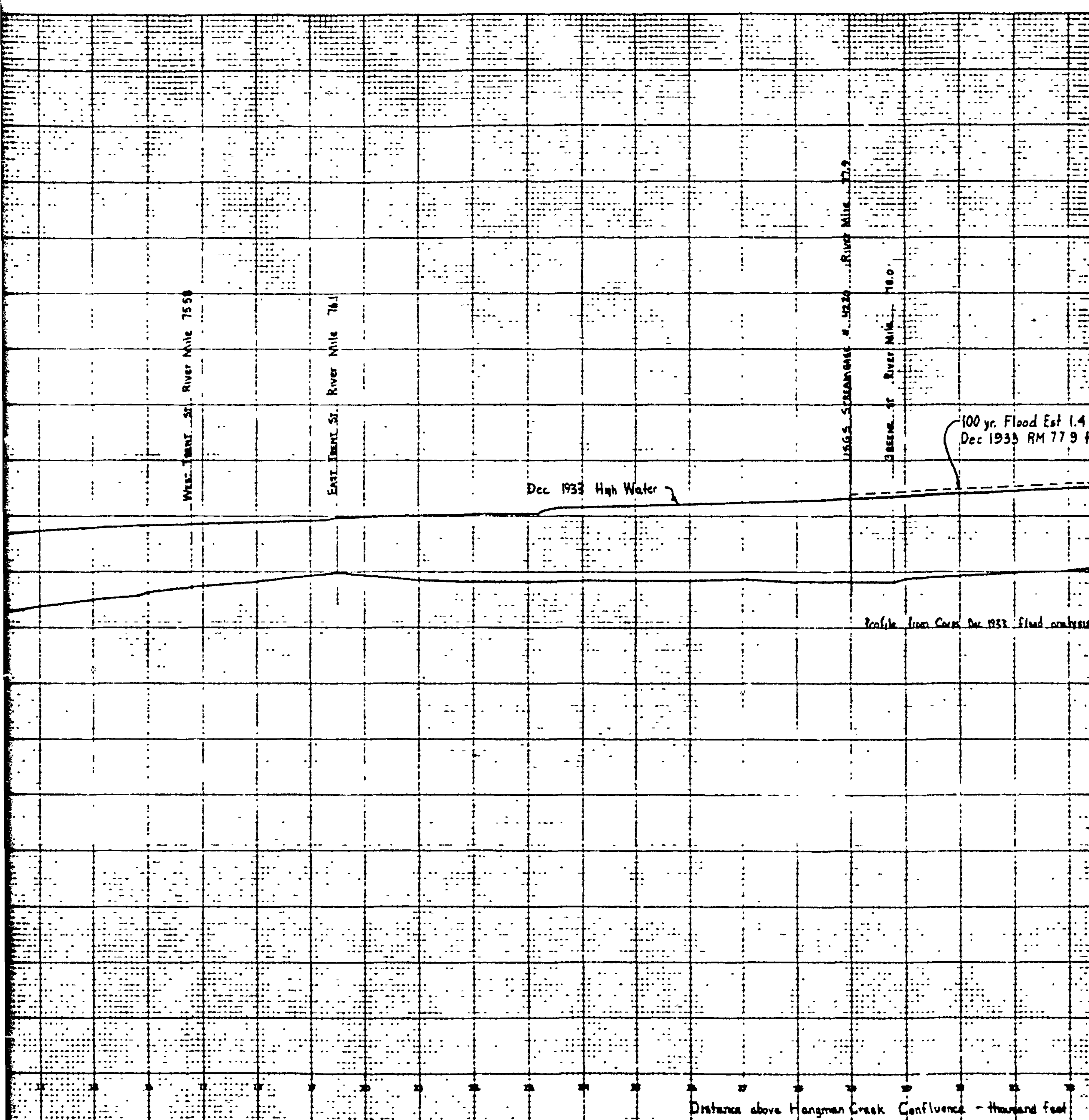
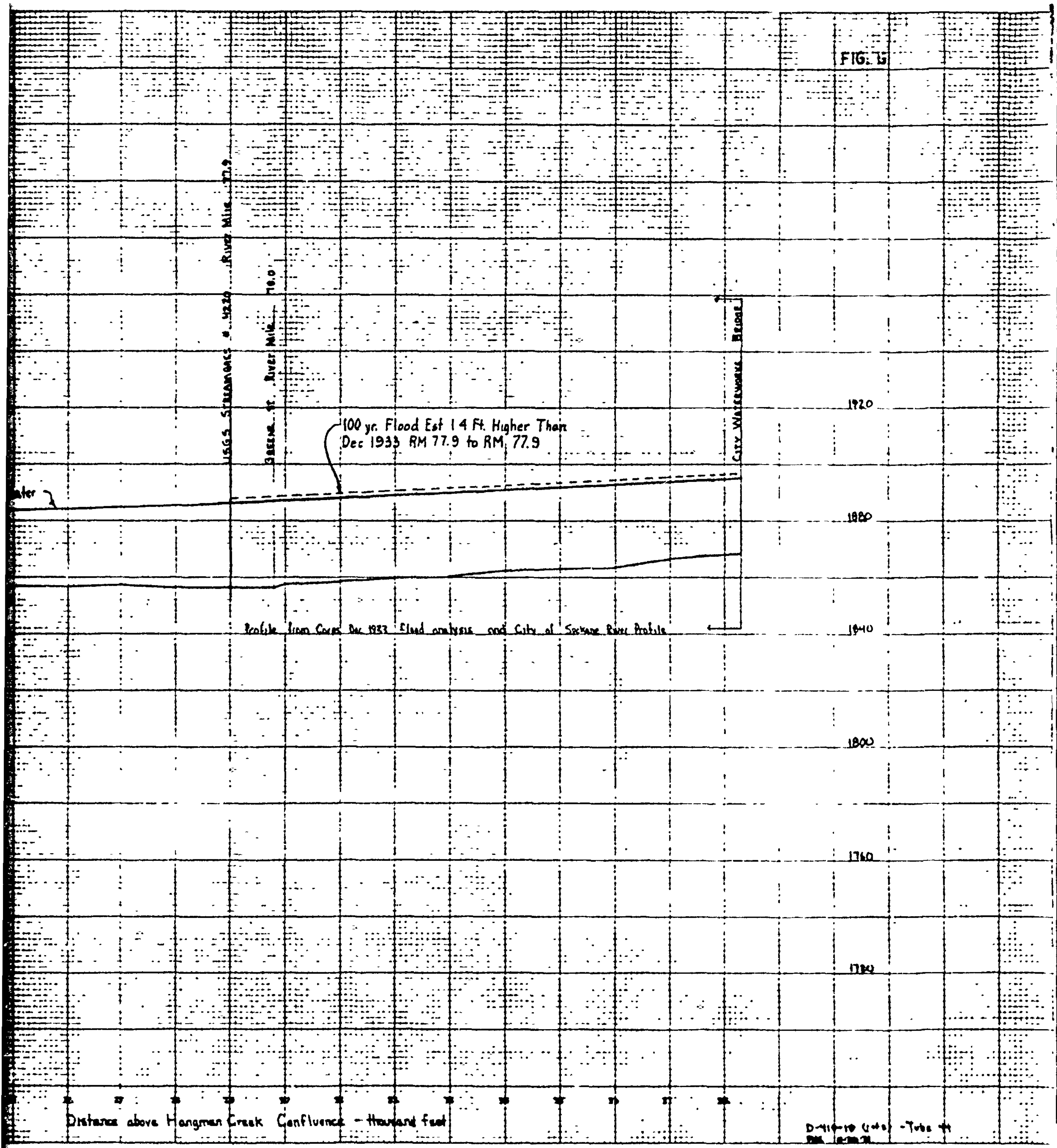


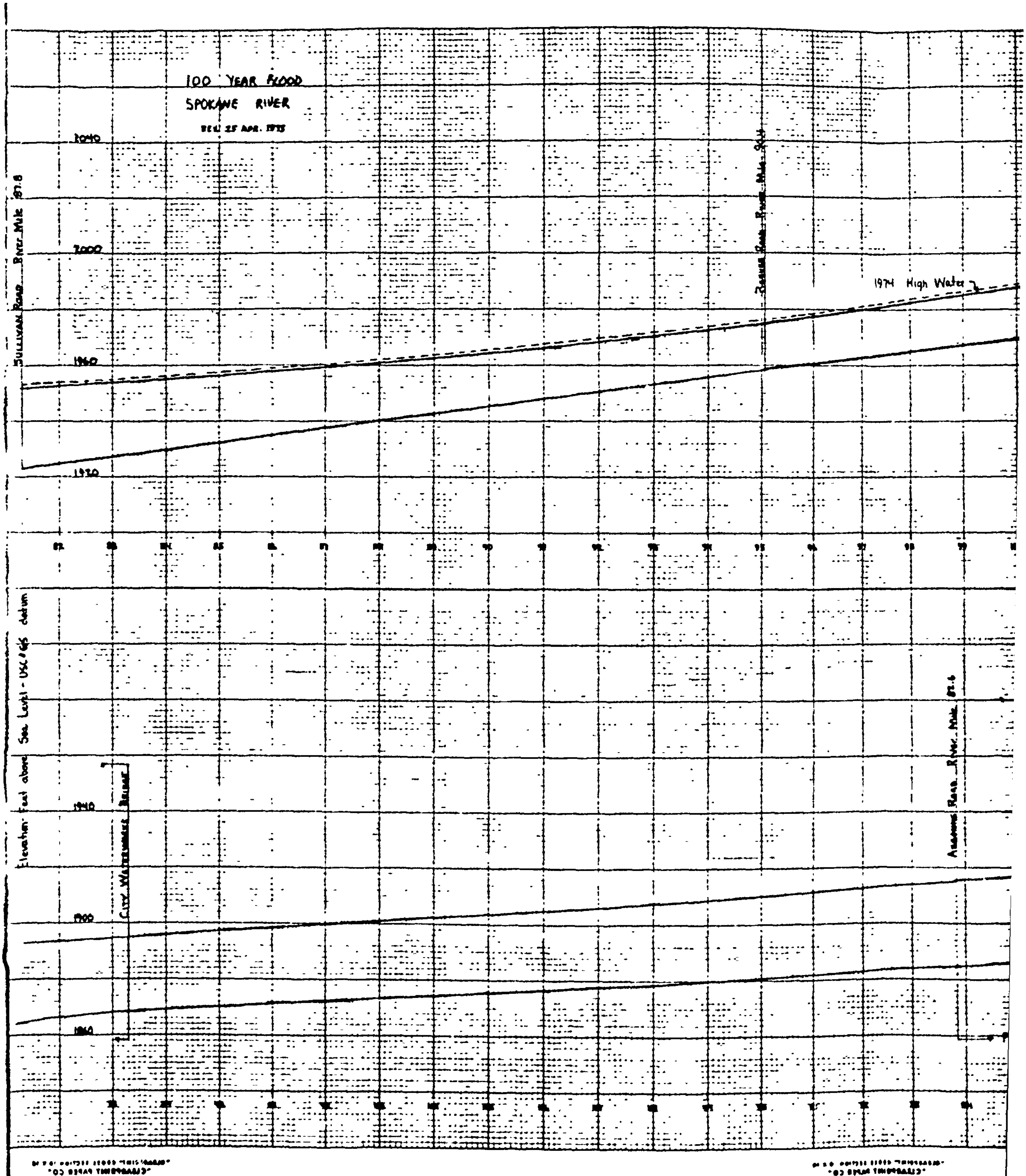
FIG. F
RATING CURVE
FOR
HANGMAN CREEK
USGS GAGE #4240
JAN 14 1973
100 YR FLOOD
28,000 CFS
JAN 14 FLOOD
10,400 CFS
DISCHARGE - CFS
GAGE HEIGHT - FEET
2000
5000
10000
20000
30000

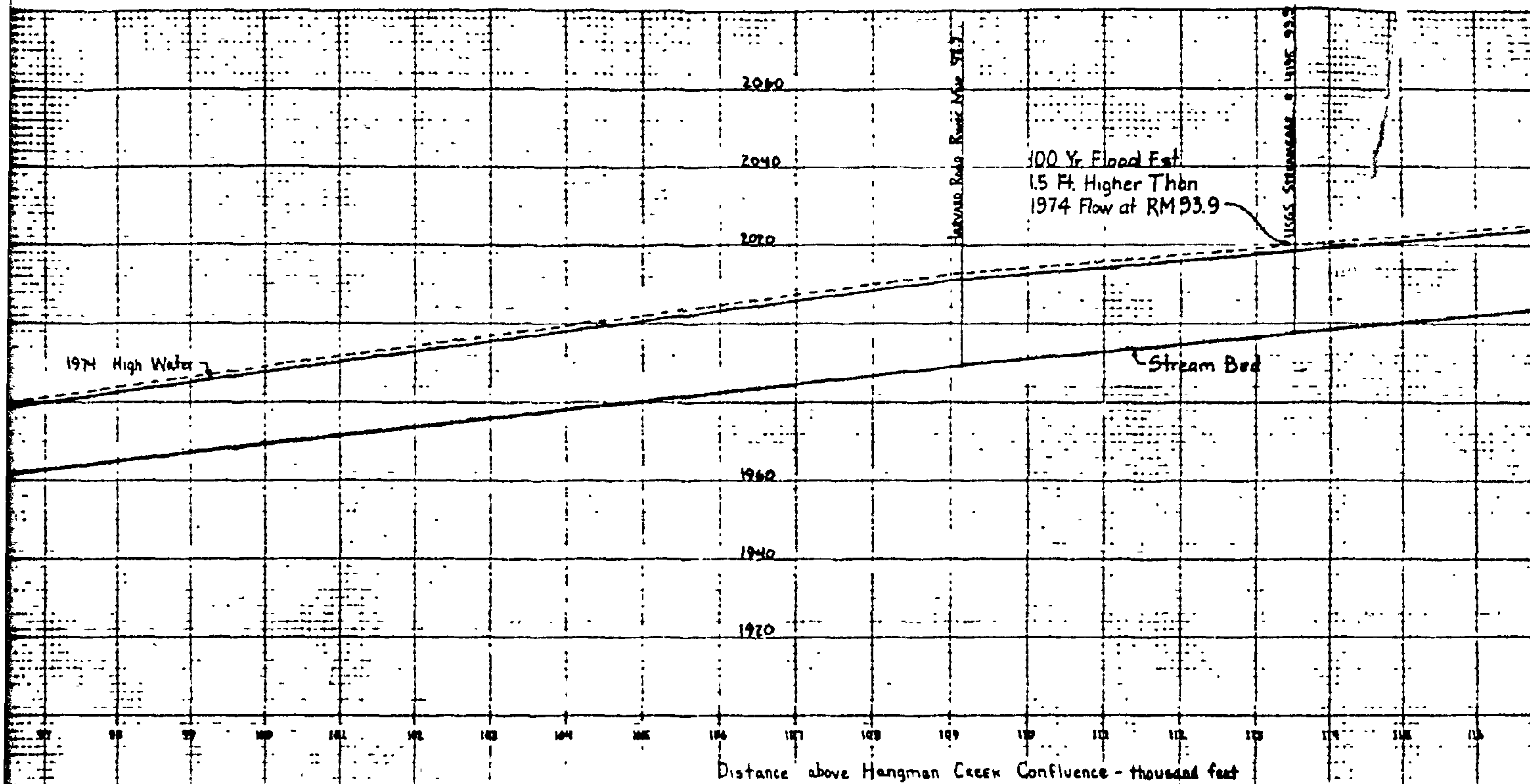


100 YEAR FLOOD
SPOKANE RIVER
REV. 28 APR.
Elevation - Feet above Sea Level - USC&GS datum
1880
1840
1800
1760
1720
1680
Hangman Creek River Mile 72.4
USGS Streamgage River Mile 72.9
Maple St River Mile 73.6
Monroe St River Mile 74.0
Post St. River Mile 74.15
Monroe St Dam River Mile 74.34
Howard St. River Mile 74.4
Washington St. River Mile 74.5
Division St. River Mile 74.9
100 Yr. Flood Est.
0.6 Ft. Higher Than
Dec. 1933 RM 72.4-74.0
Dec 1933 High Water
Stream Bed

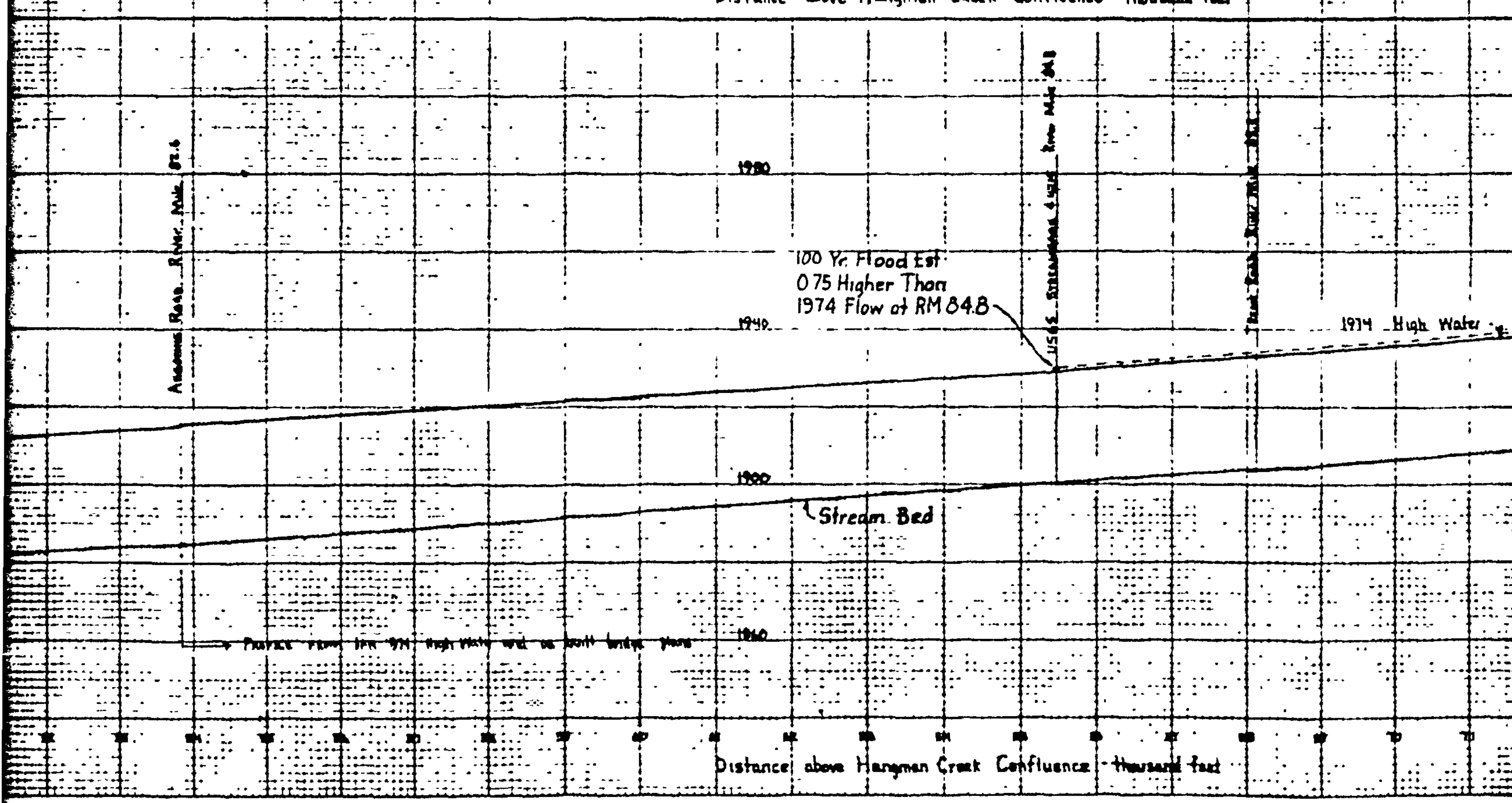

West Trent St. River Mile 75.5
East Trent St. River Mile 76.1
USGS Streamgage # 4220 River Mile 77.9
Greene St. River Mile 78.0
100 yr. Flood Est 1.4
Dec 1933 RM 77.9
Dec 1933 High Water
Profile from Corps Dec 1933 flood analysis
Distance above Hangman Creek Confluence - Thousand feet


USGS Streamgage # 4220 River Mile 77.9
Greene St. River Mile 78.0
City Waterworks Bridge
100 yr. Flood Est 1.4 Ft. Higher Than Dec 1933 RM 77.9 to RM 77.9
Profile from Corps Dec 1933 Flood analysis and City of Spokane River Profile
1920
1880
1840
1800
1760
Distance above Hangman Creek Confluence - Thousand feet

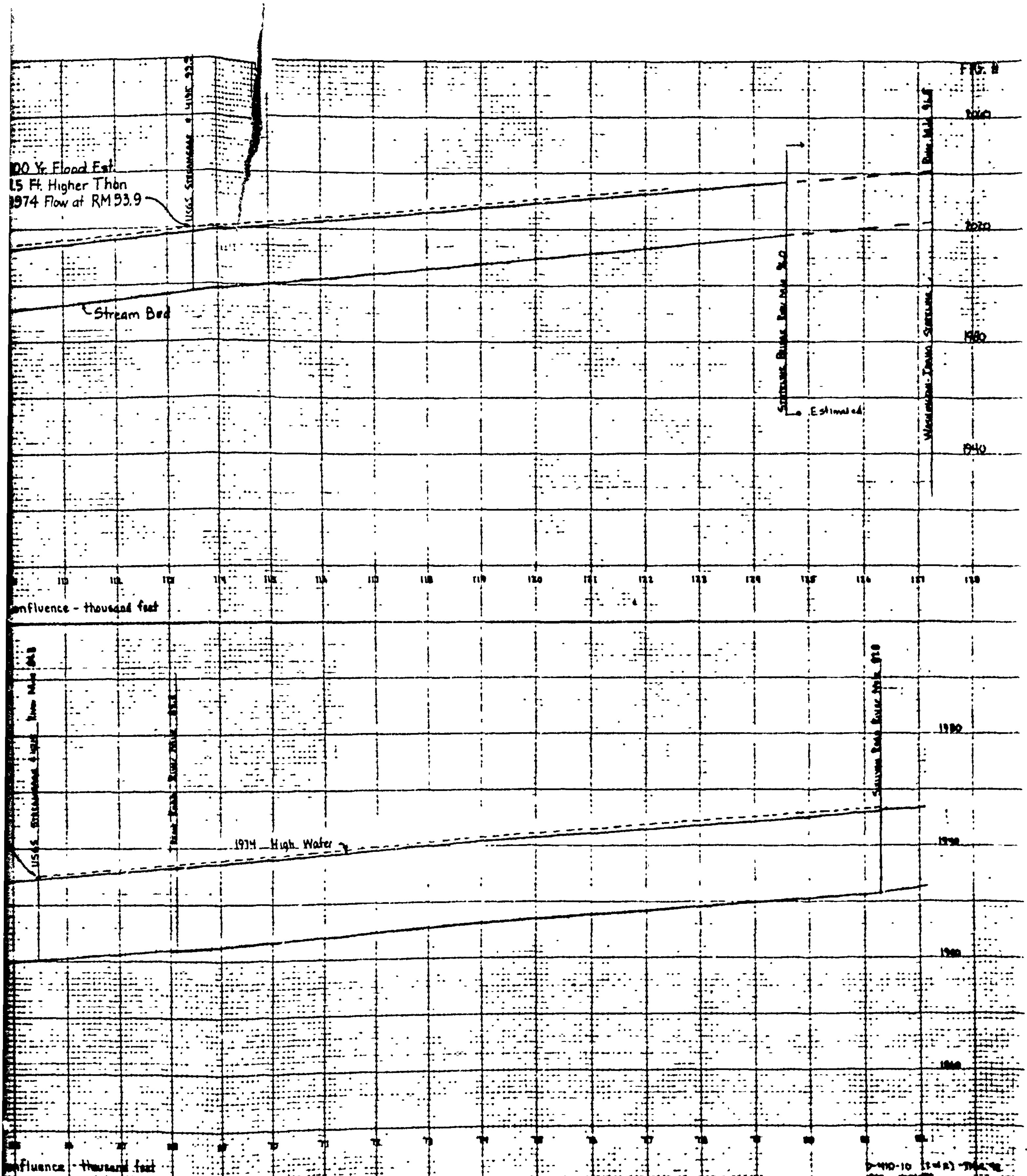

100 YEAR FLOOD
SPOKANE RIVER
1974 High Water
Elevation: Feet above Sea Level - USC&GS datum
City Waterworks Bridge
2040
2000
1960
1920
1940
1900
1860



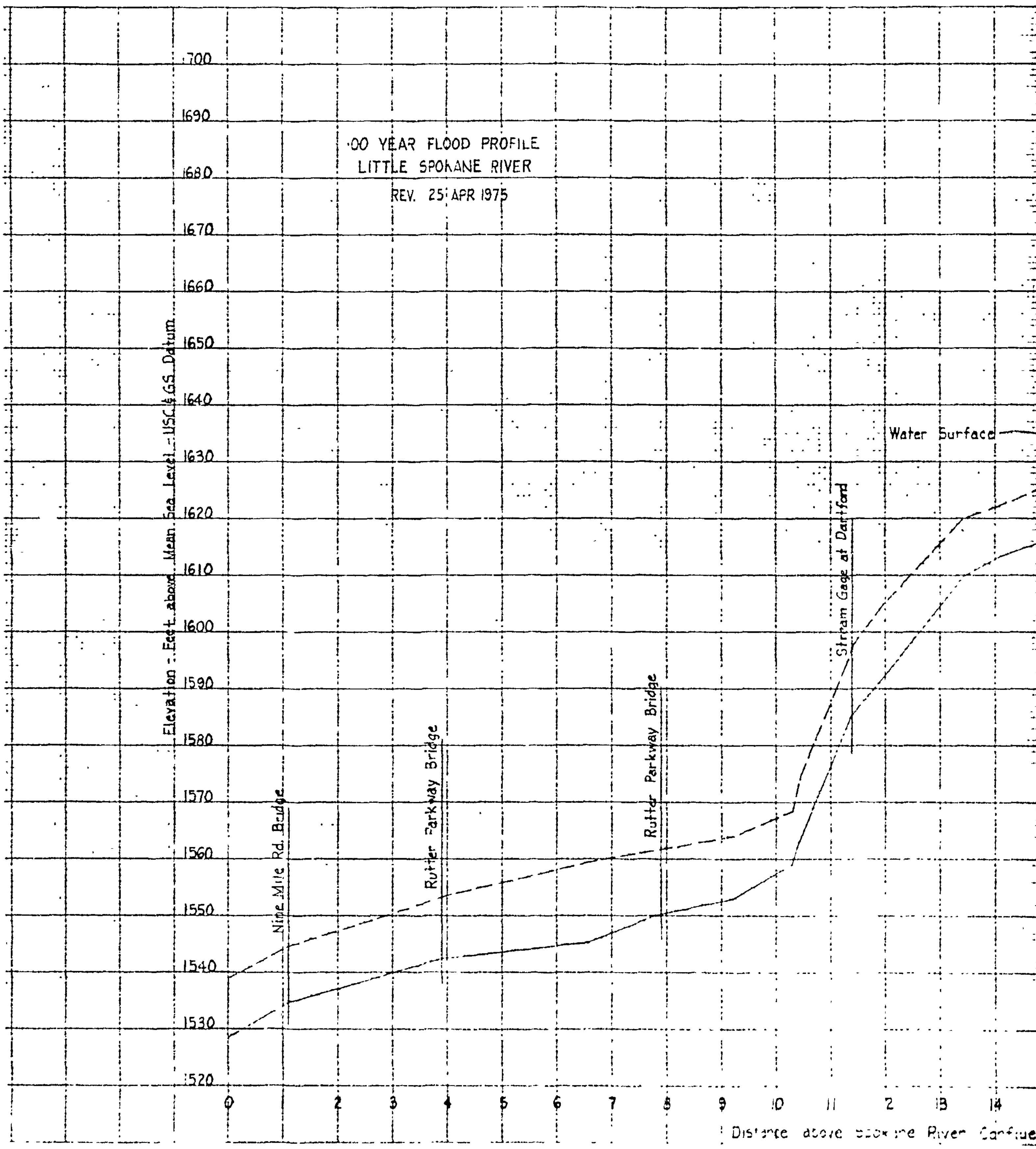
2060
2040
2020
1960
1940
1920
100 Yr. Flood Est
1.5 Ft. Higher Than
1974 Flow at RM 93.9
1974 High Water
Stream Bed
Distance above Hangman Creek Confluence - thousand feet



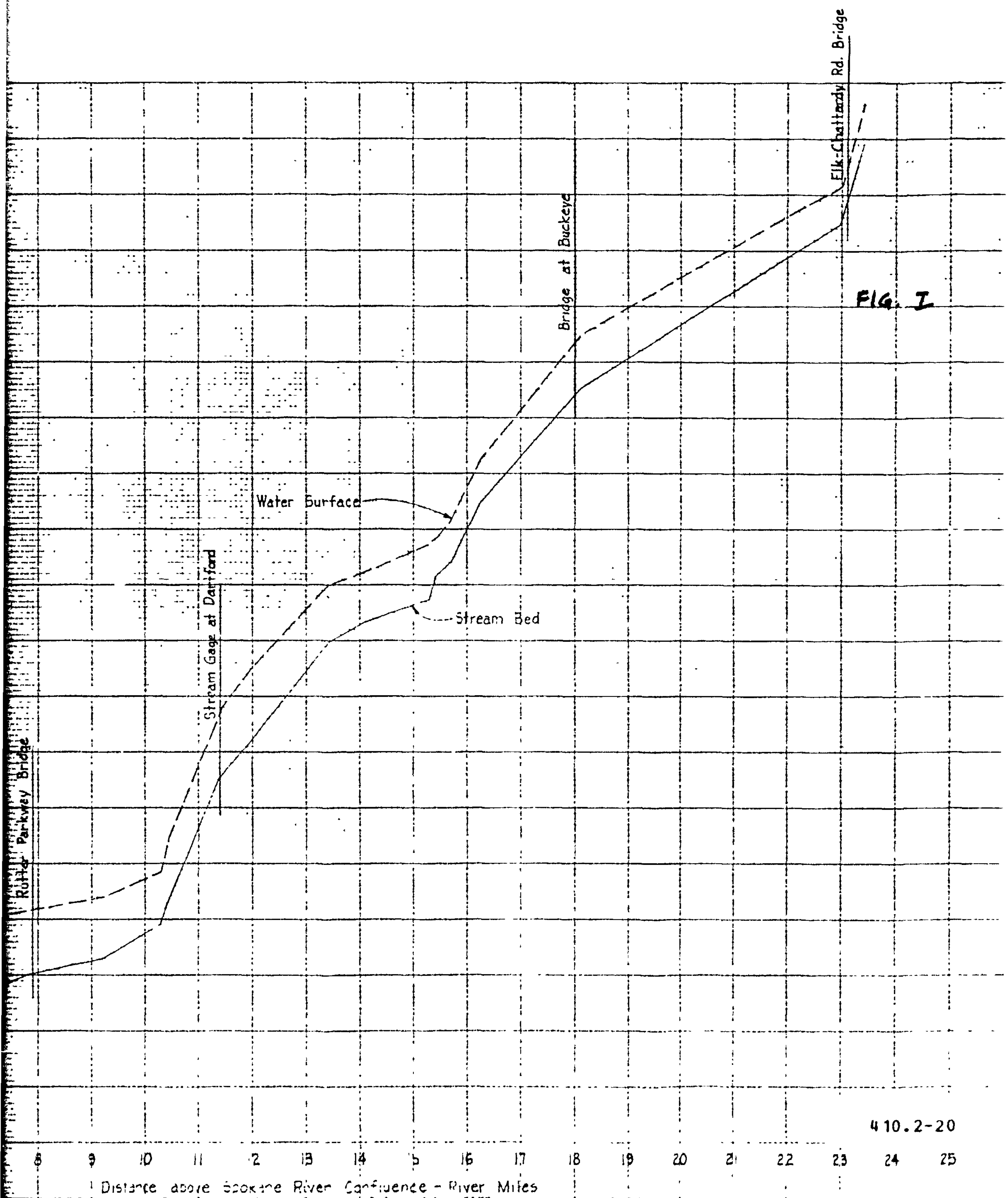
1980
1940
1900
1860
100 Yr. Flood Est
0.75 Higher Than
1974 Flow at RM 84.8
1974 High Water
Stream Bed
Distance above Hangman Creek Confluence - thousand feet



00 Yr. Flood Est.
5 Ft. Higher Than
974 Flow at RM 53.9
Stream Bed
Estimated
2060
2020
1980
1940
onfluence - thousand feet
1974 High Water
nfluence - thousand feet



·00 YEAR FLOOD PROFILE
LITTLE SPOKANE RIVER
REV. 25 APR 1975
Elevation - Feet above Mean Sea Level - USC&GS Datum
1700
1690
1680
1670
1660
1650
1640
1630
1620
1610
1600
1590
1580
1570
1560
1550
1540
1530
1520
Water Surface
Nine Mile Rd. Bridge
Rutter Parkway Bridge
Rutter Parkway Bridge
Stream Gage at Dartford
0
2
3
4
5
6
7
8
9
10
11
2
13
14
Distance above Spokane River Confluen



Elk-Chattaroy Rd. Bridge
Bridge at Buckeye
FIG. I
Water Surface
Stream Bed
Stream Gage at Dartford
Rutter Parkway Bridge
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
Distance above Spokane River Confluence - River Miles

410.2-20

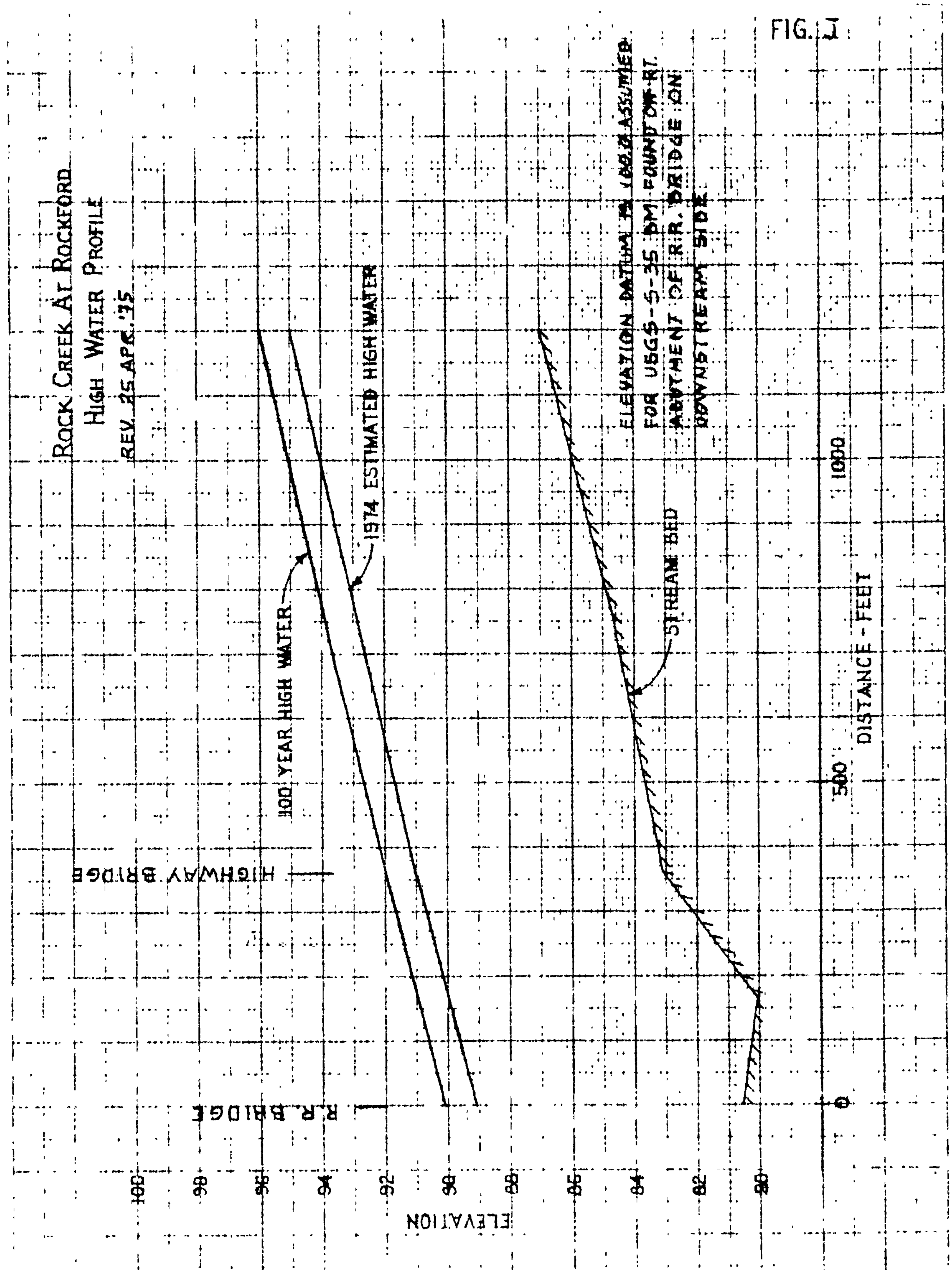
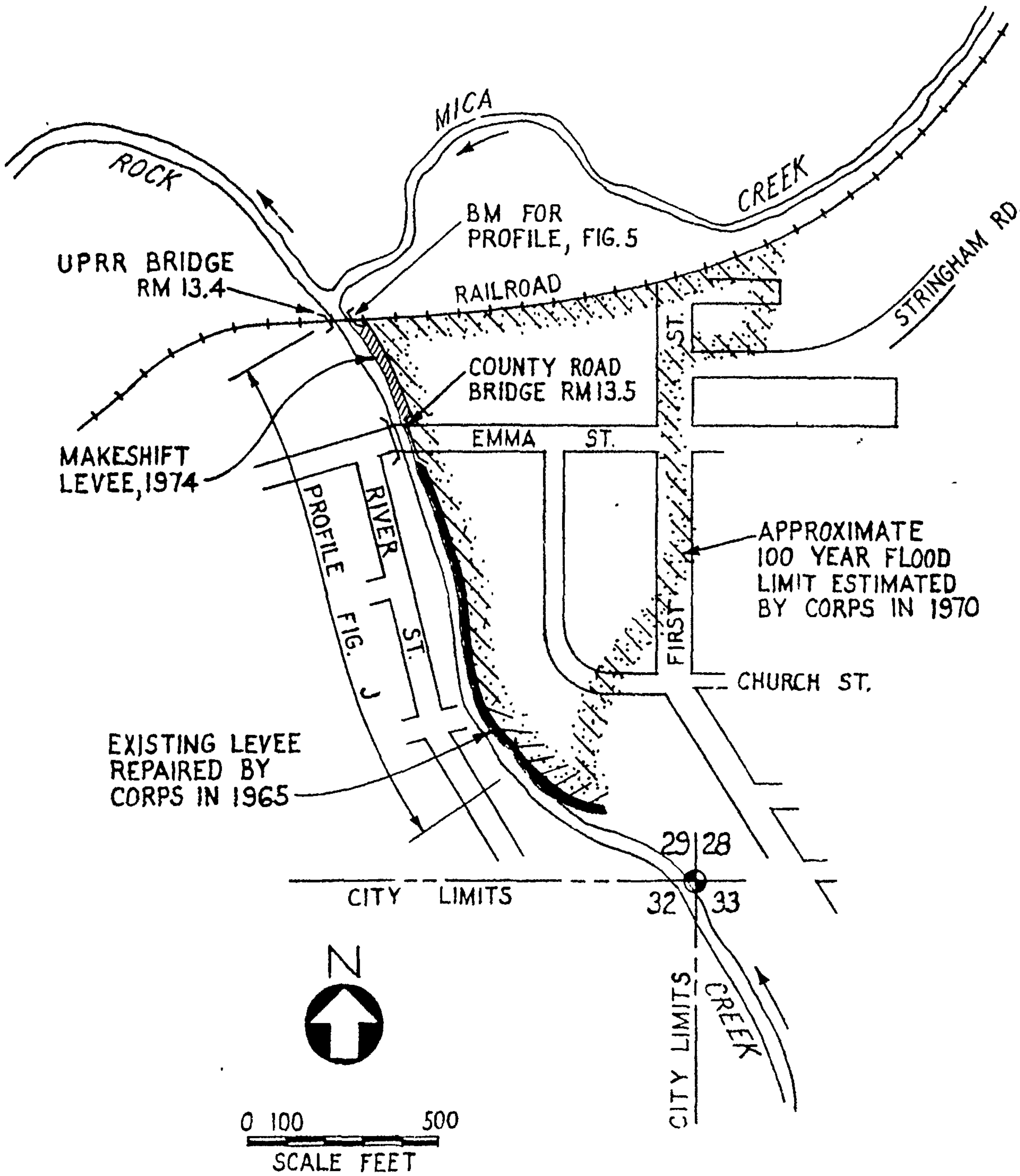

ROCK CREEK AT ROCKFORD
HIGH WATER PROFILE
REV. 25 APR. '75
1974 ESTIMATED HIGH WATER
100 YEAR HIGH WATER
HIGHWAY BRIDGE
R.R. BRIDGE
STREAM BED
ELEVATION DATUM IS 100.0 ASSUMED FOR USGS-5-35 BM FOUND ON RT. ABUTMENT OF R.R. BRIDGE ON DOWNSTREAM SIDE
DISTANCE - FEET
ELEVATION
0
500
1000
100
98
96
94
92
90
88
86
84
82
80

FIG. I



100 YEAR FLOOD PLAIN
ROCK CREEK AT
ROCKFORD, WASHINGTON
RM 13.4 TO 13.7

FIGURE K

#3-32 R.M. 0.5 L.S.R.
12-18-73

#3-31 R.M. 0.5 L.S.R.
12-18-73

#2-2 R.M. 0.0 L.S.R.
12-18-73

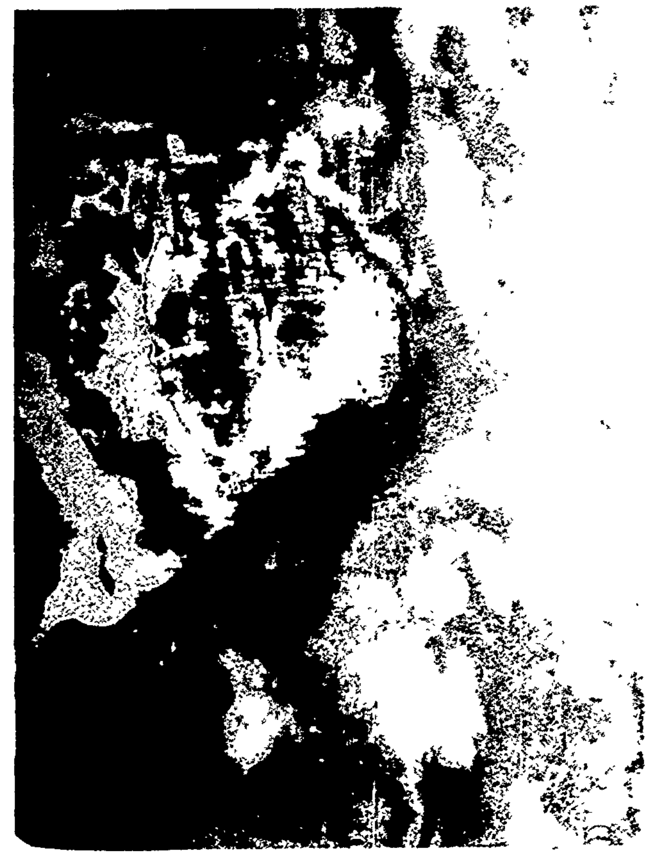
#2-4 R.M. 2.6 L.S.R.
12-18-73

#2-3 R.M. 1.0 L.S.R.
12-18-73

#3-30 R.M. 0.5 L.S.R.
12-18-73

#3-28 R.M. 4.5 L.S.R.
12-18-73

#2-5 R.M. 4.0 L.S.R.
12-18-73

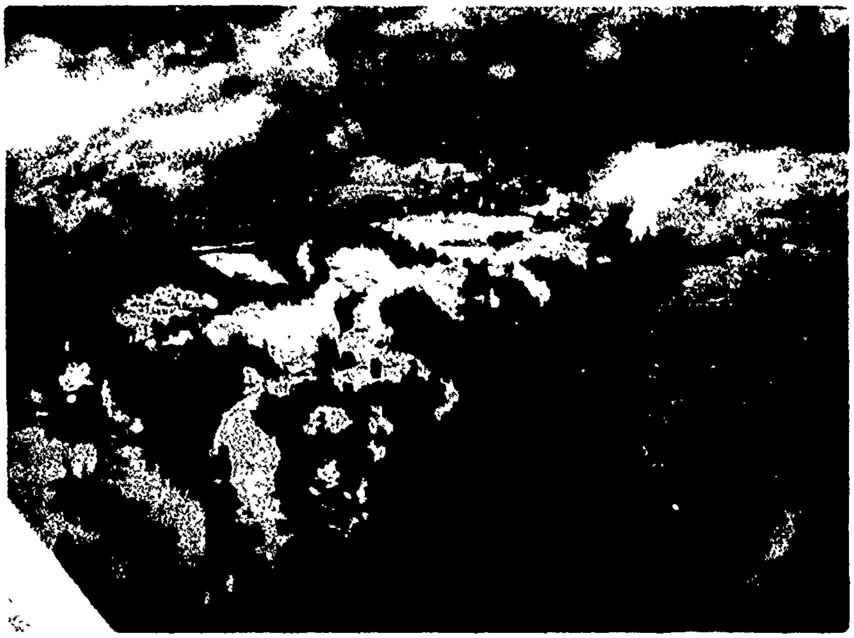


#3-29 R.M. 3.0 L.S.R.
12-18-73

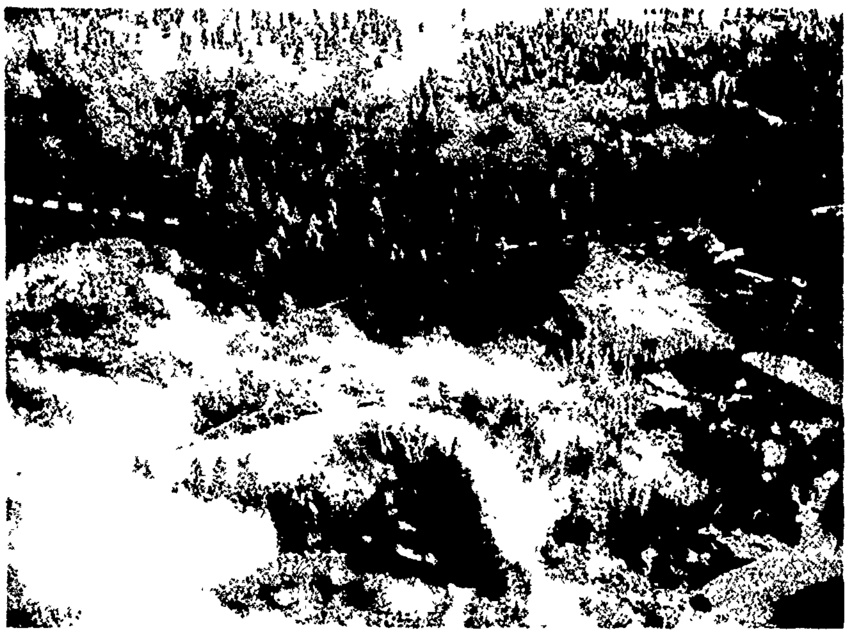
#2-8 R.M. 6.7 L.S.R.
12-18-73

#2-6 R.M. 5.8 L.S.R.
12-18-73

#3-27 R.M. 5 + L.S.R.
12-18-73



#3-26 R.M. 7.1 L.S.R.
12-18-73



#2-7 R.M. 7.3 L.S.R.
12-18-73

#2-9 R.M. 8.0 L.S.R.
12-18-73

#3-23 R.M. 10.1 L.S.R.
12-18-73

#3-24 R.M. 9.8 L.S.R.
12-18-73

#3-25 R.M. 9.3 L.S.R.
12-18-73

#2-10 R.M. 10.9 L.S.R.
12-18-73

#3-21 R.M. 10.4 L.S.R.
12-18-73

#3-22 R.M. 10.2 L.S.R.
12-18-73

#3-20 R.M. 11.8 L.S.R.
12-18-73

#2-12 R.M. 11.7 L.S.R.
12-18-73

#2-11 R.M. 11.5 L.S.R.
12-18-73

#3-18 R.M. 14.2 L.S.R.
12-18-73

#3-19 R.M. 13.2 L.S.R.
12-18-73

#2-13 R.M. 12.6 L.S.R.
12-18-73

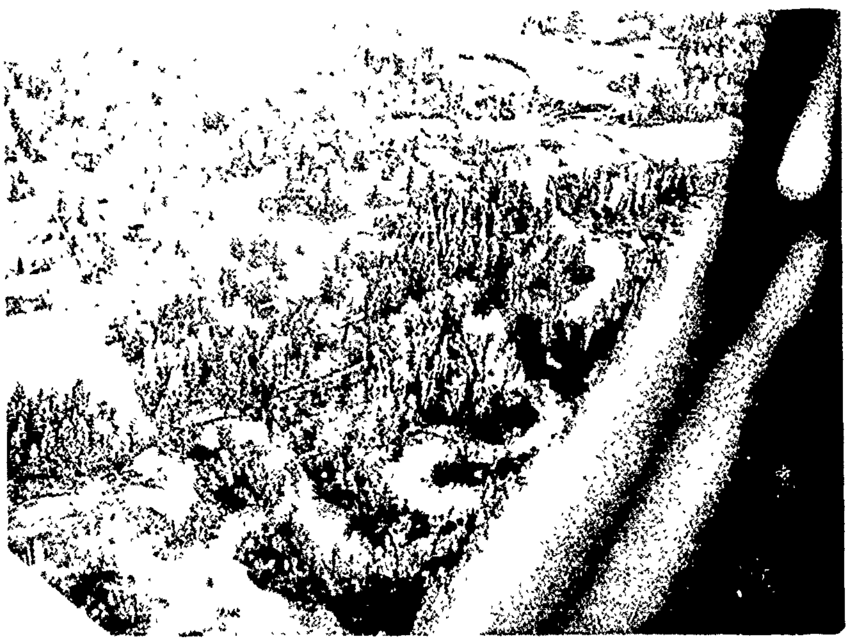
APPENDIX I

#2-15 R.M. 15.5 L.S.R.
12-18-73

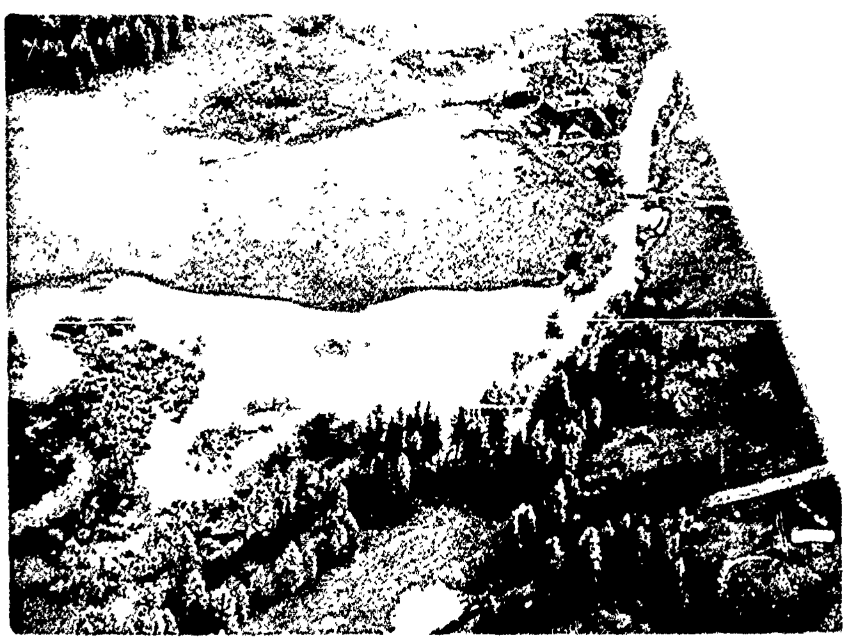
#3-16 R.M. 15.2 L.S.R.
12-18-73

#2-14 R.M. 14.3 L.S.R.
12-18-73

#3-17 R.M. 15.7 L.S.R.
12-18-73



#2-16 R.M. 15.9 L.S.R.
12-18-73



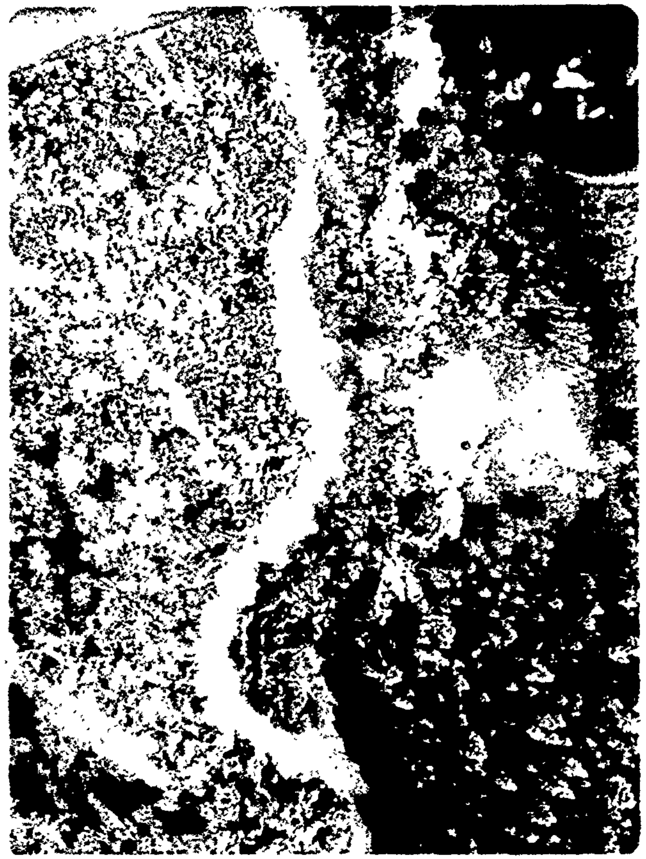
#3-15 R.M. 16.0 L.S.R.
12-18-73

#2-18a R.M. 17.0 L.S.R.
12-18-73

#3-14 R.M. 16.9 L.S.P.
12-18-73

2-17 R.M. 16.6 L.S.R.
12-18-73

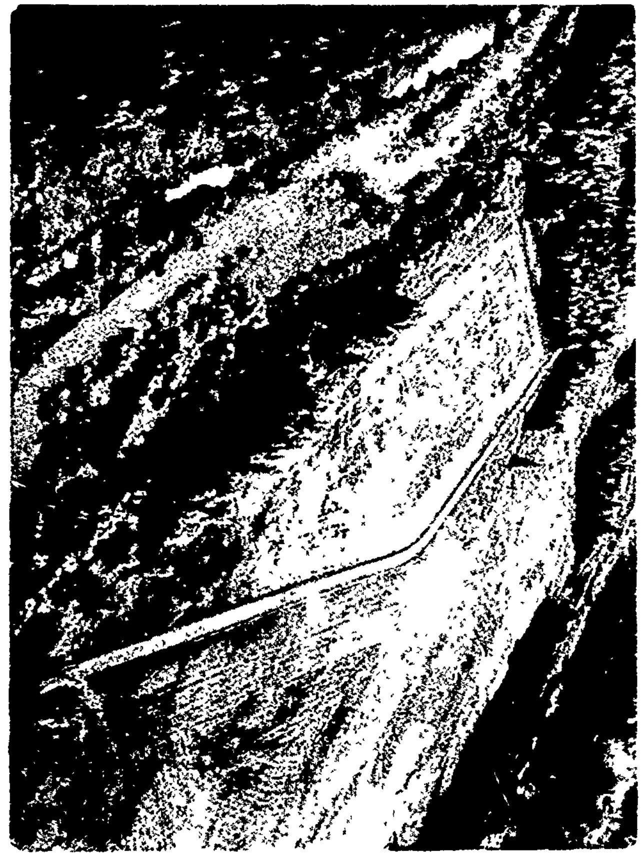
#2-19 R.M. 17.9 L.S.R.
12-18-73



#3-13 R.M. 17.5 L.S.R.
12-18-73

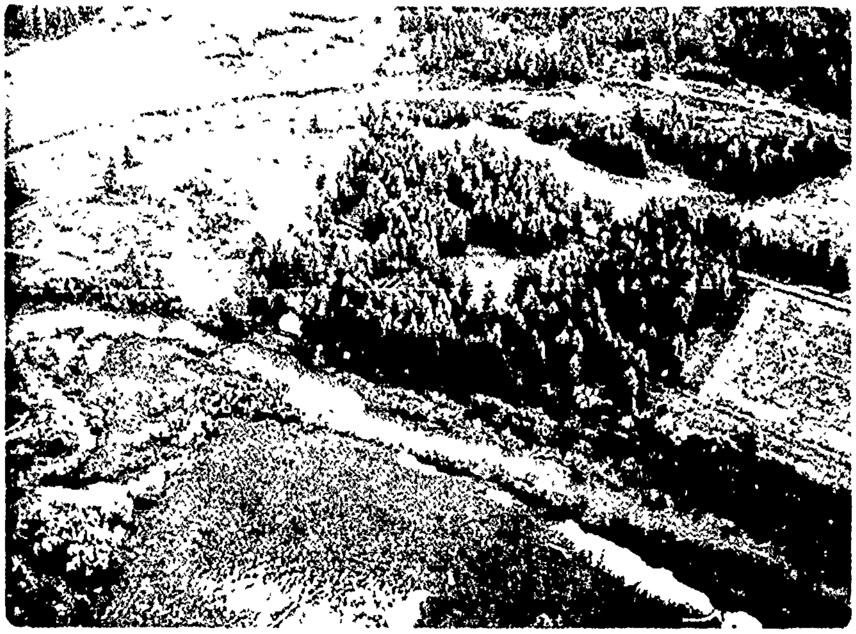
#2-18 R.M. 17.2 L.S.R.
12-18-73

#2-21 R.M. 18.5 L.S.R.
12-18-73

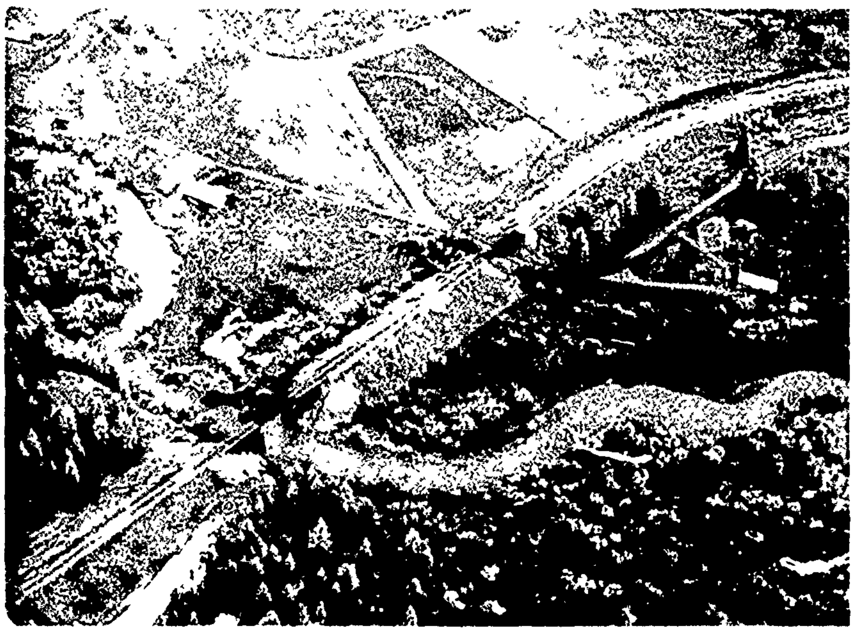


#3-11 R.M. 18.4 L.S.R.
12-18-73

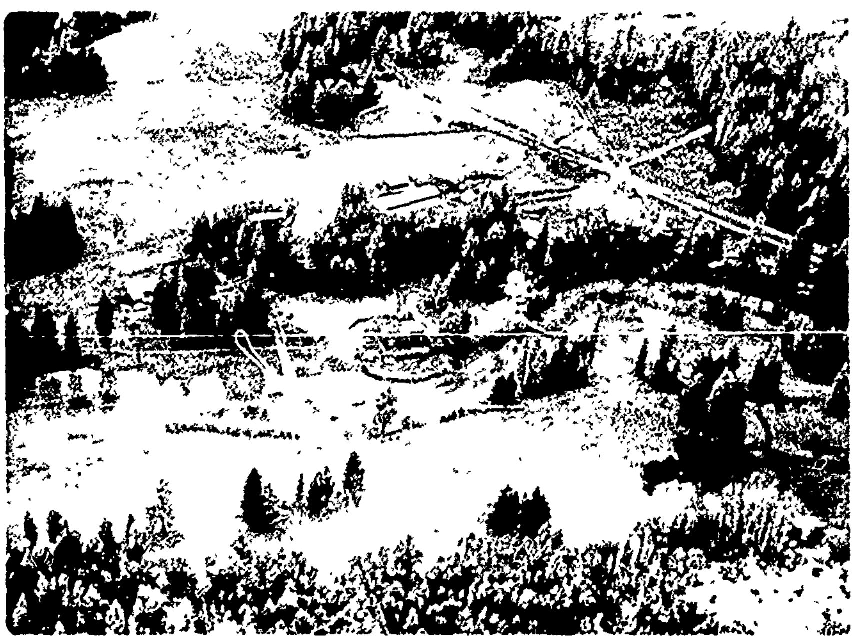
#3-12 R.M. 18.1 L.S.R.
12-18-73



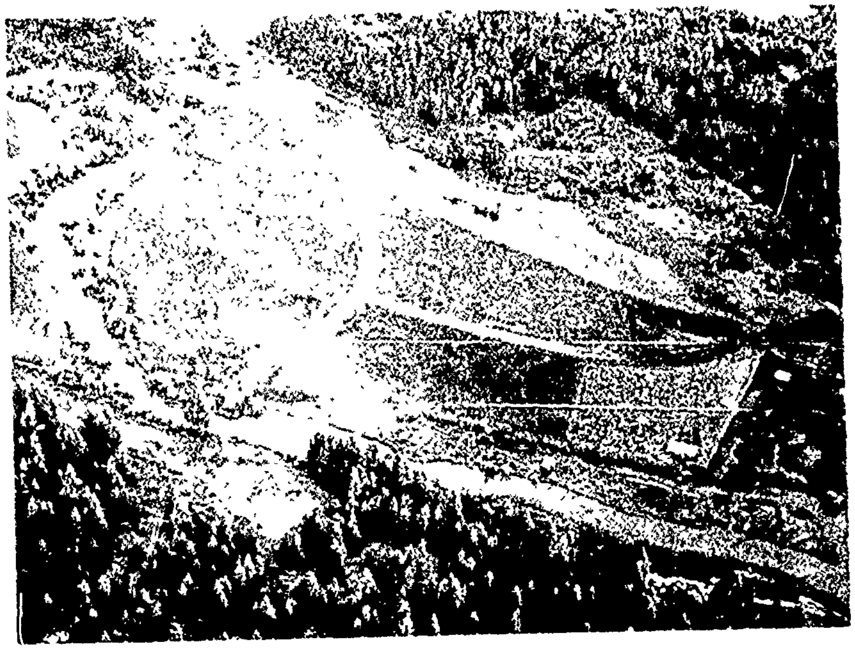
#3-10 R.M. 18.6 L.S.R.
12-18-73



#3-9 R.M. 19.0 L.S.R.
12-18-73



#2-20 R.M. 19.1 L.S.R.
12-18-73



#3-8 R.M. 19.2 L.S.R.
12-18-73

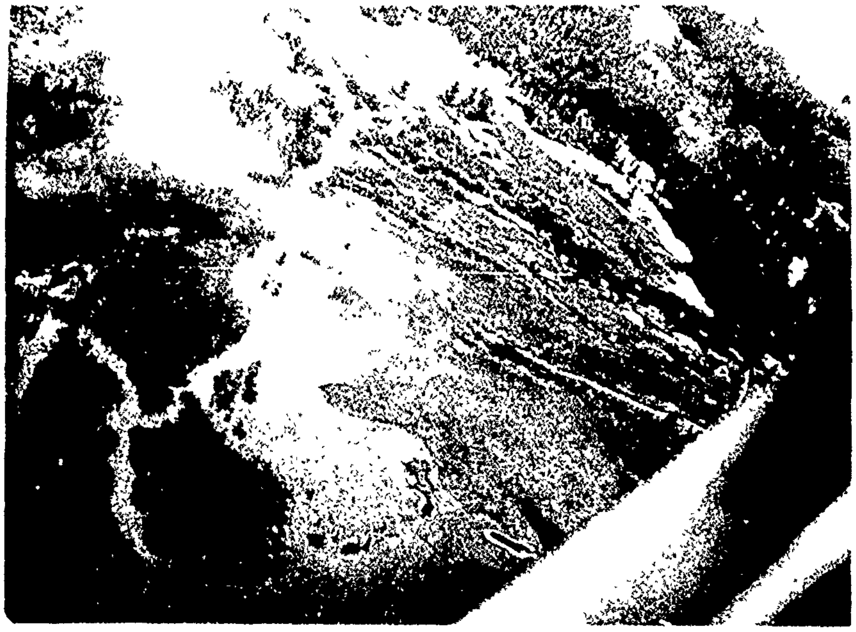
#2-23 R.M. 19.4 L.S.R.
12-18-73

#3-6 R.M. 20.4 L.S.R.
12-18-73

#3-5 R.M. 21.2 L.S.R.
12-18-73

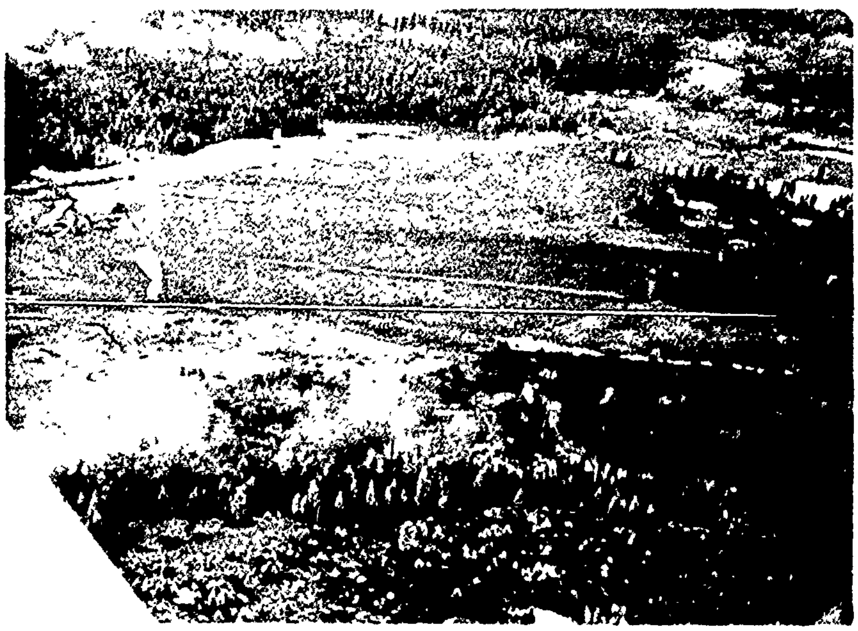
#2-25 R.M. 21.0 L.S.R.
12-18-73

#3-7 R.M. 20.8 L.S.R.
12-18-73



#3-4 R.M. 21.5 L.S.R.
12-18-73

#2-26 R.M. 22.0 L.S.R.
12-18-73

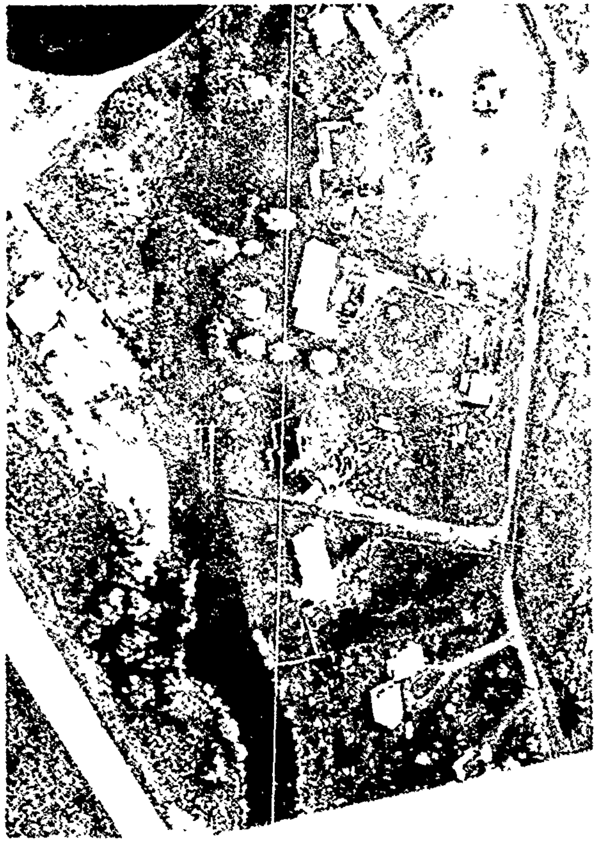


#2-27 R.M. 22.3 L.S.R.
12-18-73

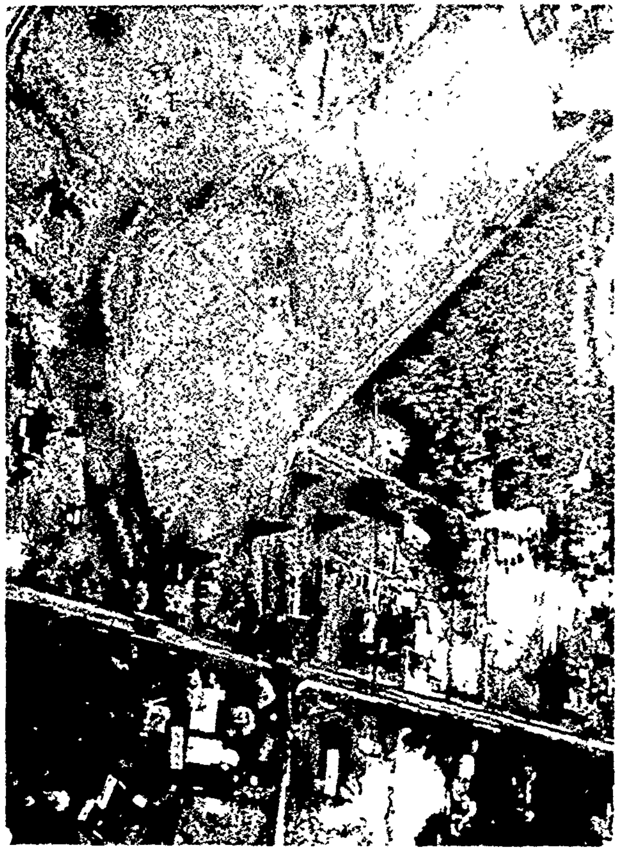
#2-29 R.M. 22.9 L.S.R.
12-18-73

#3-3 R.M. 22.5 L.S.R.
12-18-73

#2-28 R.M. 22.5 L.S.R.
12-18-73



#2-30 R.M. 23.2 L.S.R.
12-18-73



#2-31 R.M. 23.1 L.S.R.
12-18-73

#3-2 R.M. 23.2 L.S.R.
12-18-73

#3-1 R.M. 24.2 L.S.R.
12-18-73

#4-1 Spokane River below confluence with Hangman Creek.

#4-2 R.M.0.0 Confluence of Spokane River and Hangman Creek.

#4-3 R.M.1.3 Union Pacific and I-90 bridges over Hangman Creek.

#4-6 R.M.3.2 Hangman Creek looking north towards Spokane.

#4-5 R.M.3.1 Hangman Creek.

#4-4 R.M.2.4 Hangman Creek.

#4-9 R.M.11.5 Hangman Creek.

#4-8 R.M.7.8 Hangman Creek High Drive Parkway Bridge.

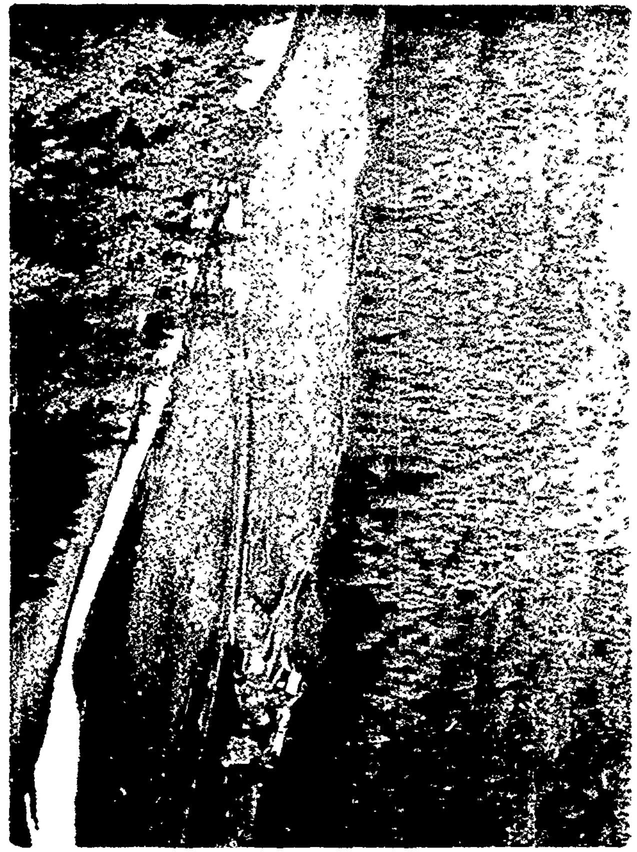
#4-7 R.M.6.2 Hangman Creek

#4-10 R.M.14.4 Hangman Creek.

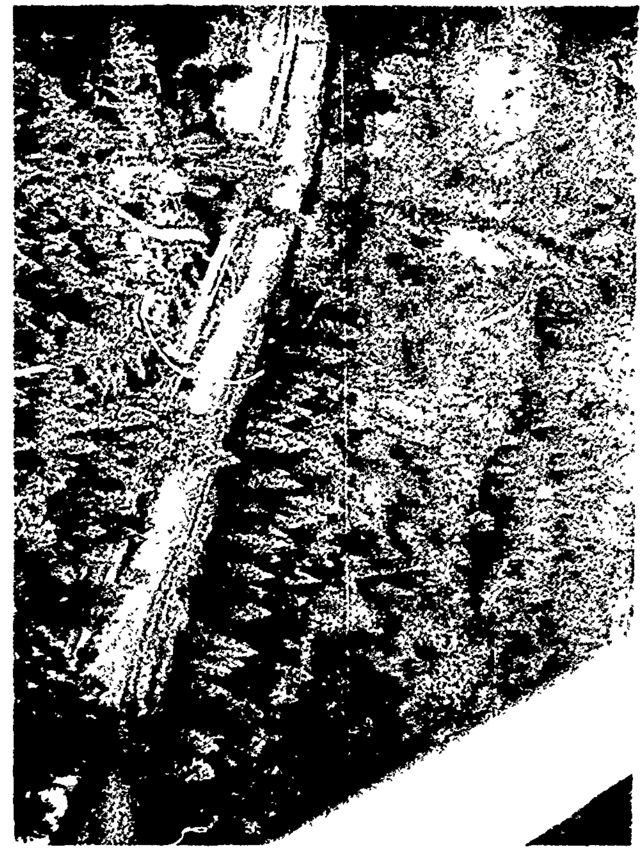
#4-11 R.M.16.6 Hangman Creek.

#4-12 R.M.13.4 Hangman Creek above confluence with California Creek.

#4-15 R.M.20.2 Confluence of Rock Creek with Hangman Creek.



#4-14 R.M. 19.9 Hangman Creek Duncan-Mt. Hope road bridge.



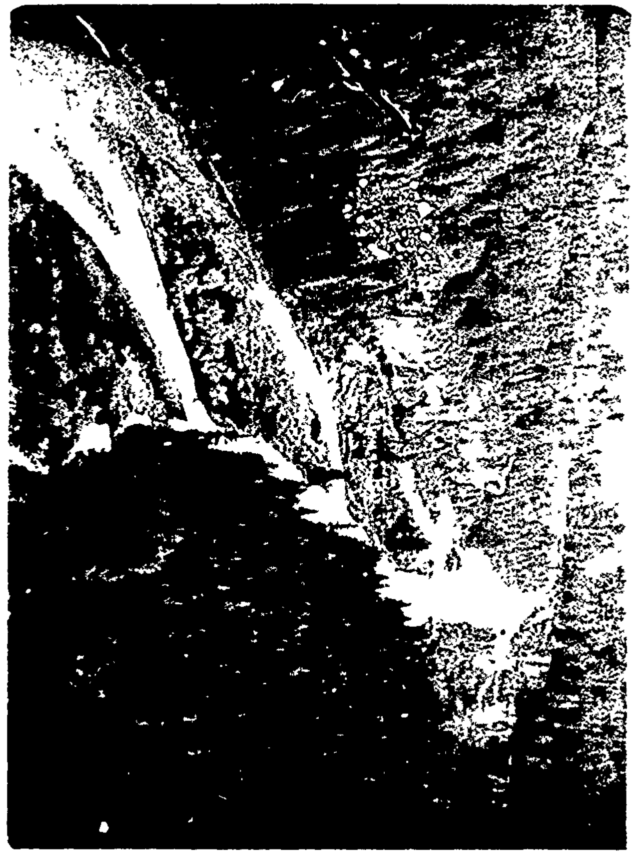
#4-13 R.M.19.2 Confluence of Spangle Creek with Hangman Creek.

#4-18 R.M.21.7 Hangman Creek.

#4-17 R.M.21.3 Hangman Creek looking upstream.

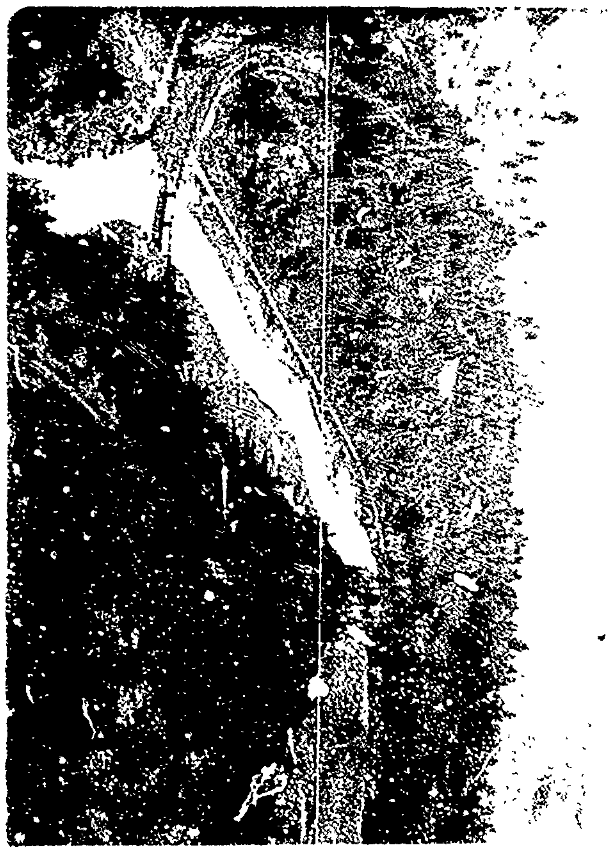
#4-16 R.M.20.7 Hangman Creek.

#4-21 R.M. 27.9 Hangman Creek looking upstream.



#4-20 R.M.25.0 Hangman Creek looking upstream.

#4-19 R.M.23.9 Hangman Creek.



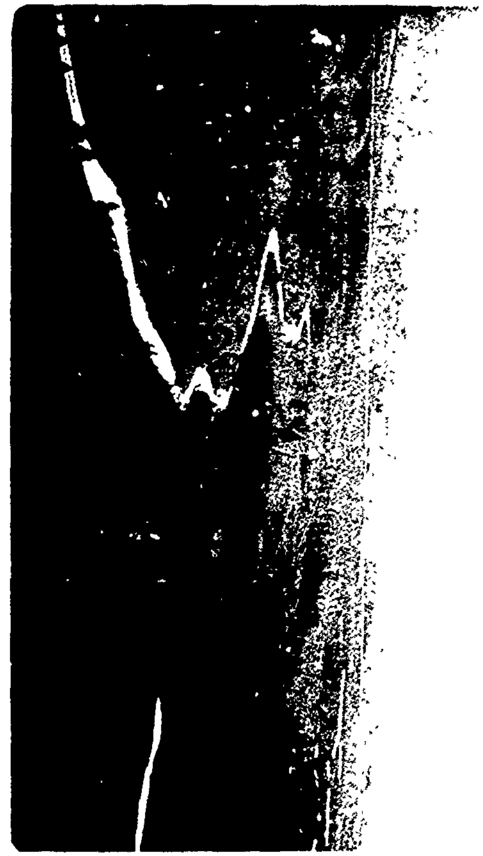
#4-24 R.M.32.9 Hangman Creek. West Bradshaw road bridge.

#4-23 R.M.31.1 Hangman Creek. West Bradshaw road bridge.

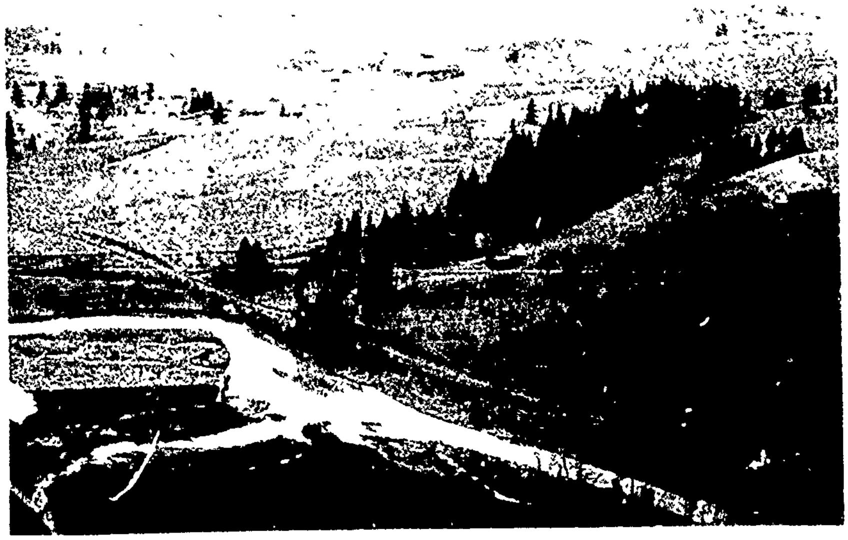
#4-22 R.M.31.1 Hangman Creek. West Bradshaw road bridge.

#4-27 R.M.39.0 Hangman Creek. Palouse Highway Bridge.

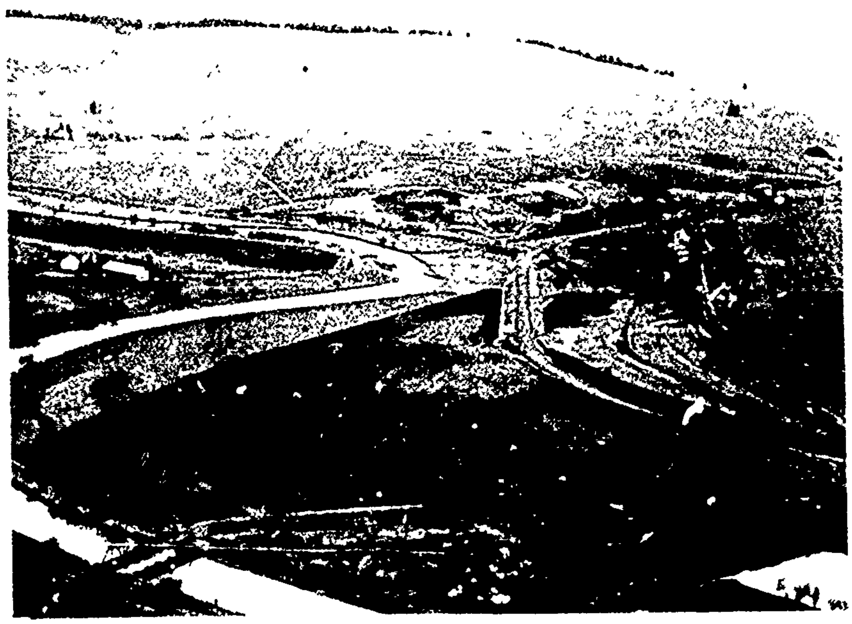
#4-26 R.M.37.4 Hangman Creek Bridge near Wavely.



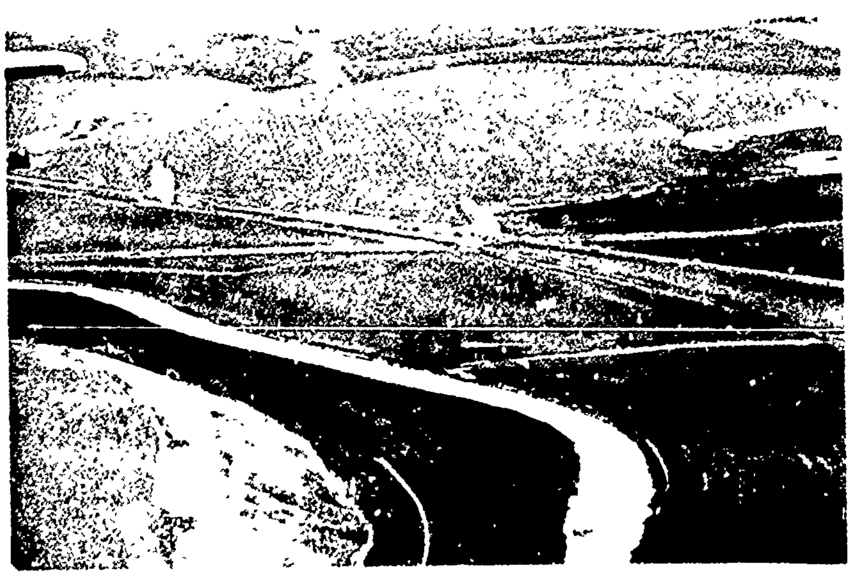
#4-25 R.M.36.4 Hangman Creek below Wavely.



#4-28 R.M.40.5 Hangman Creek. Looking north towards Wavely.



#4-29 R.M.41.1 Hangman Creek.



#4-30 R.M.43.3 Hangman Creek.

#4-33 R.M.46.6 Hangman Creek. Bridge at Latah

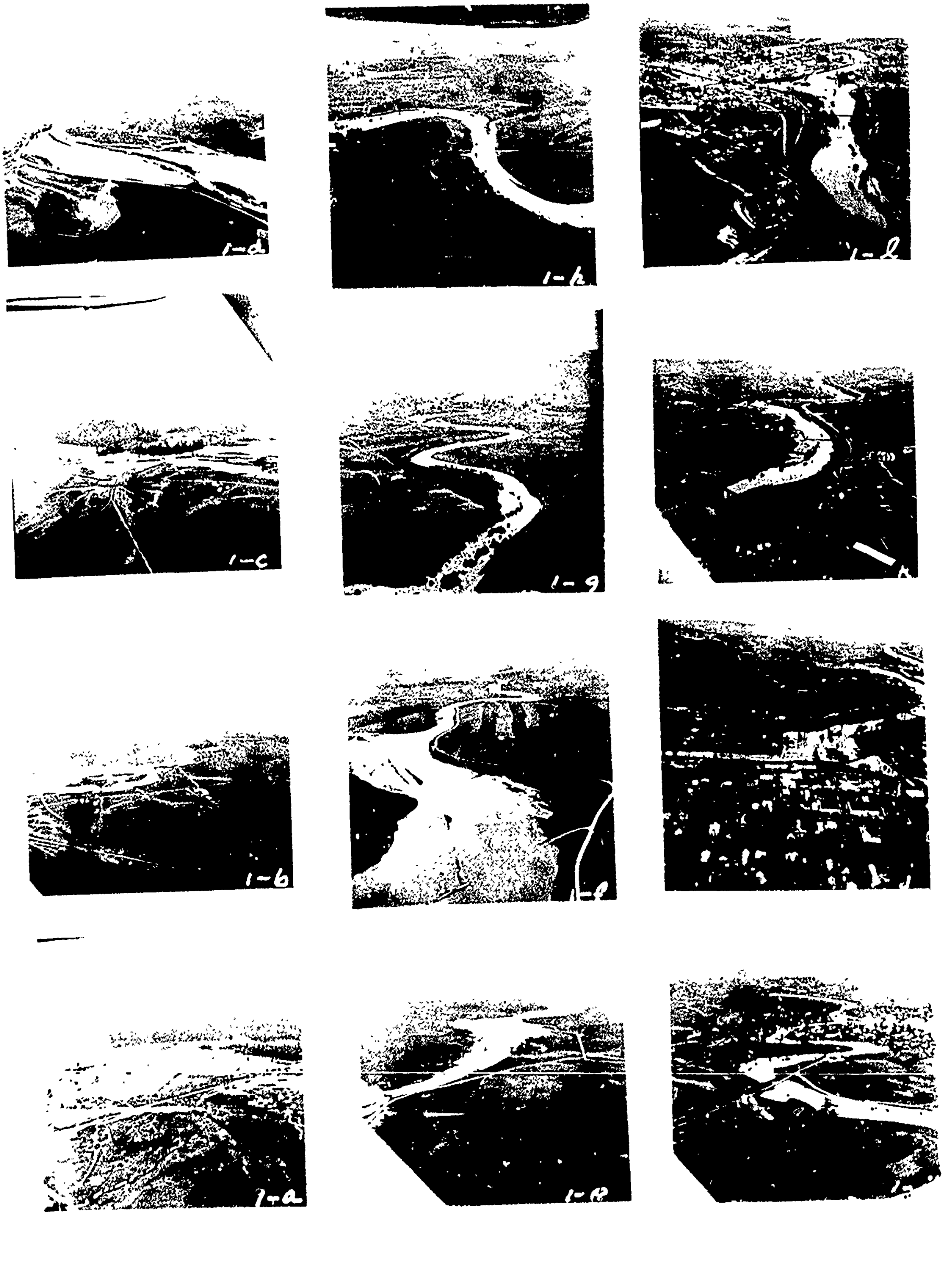
#4-32 R.M.45.6 Hangman Creek.

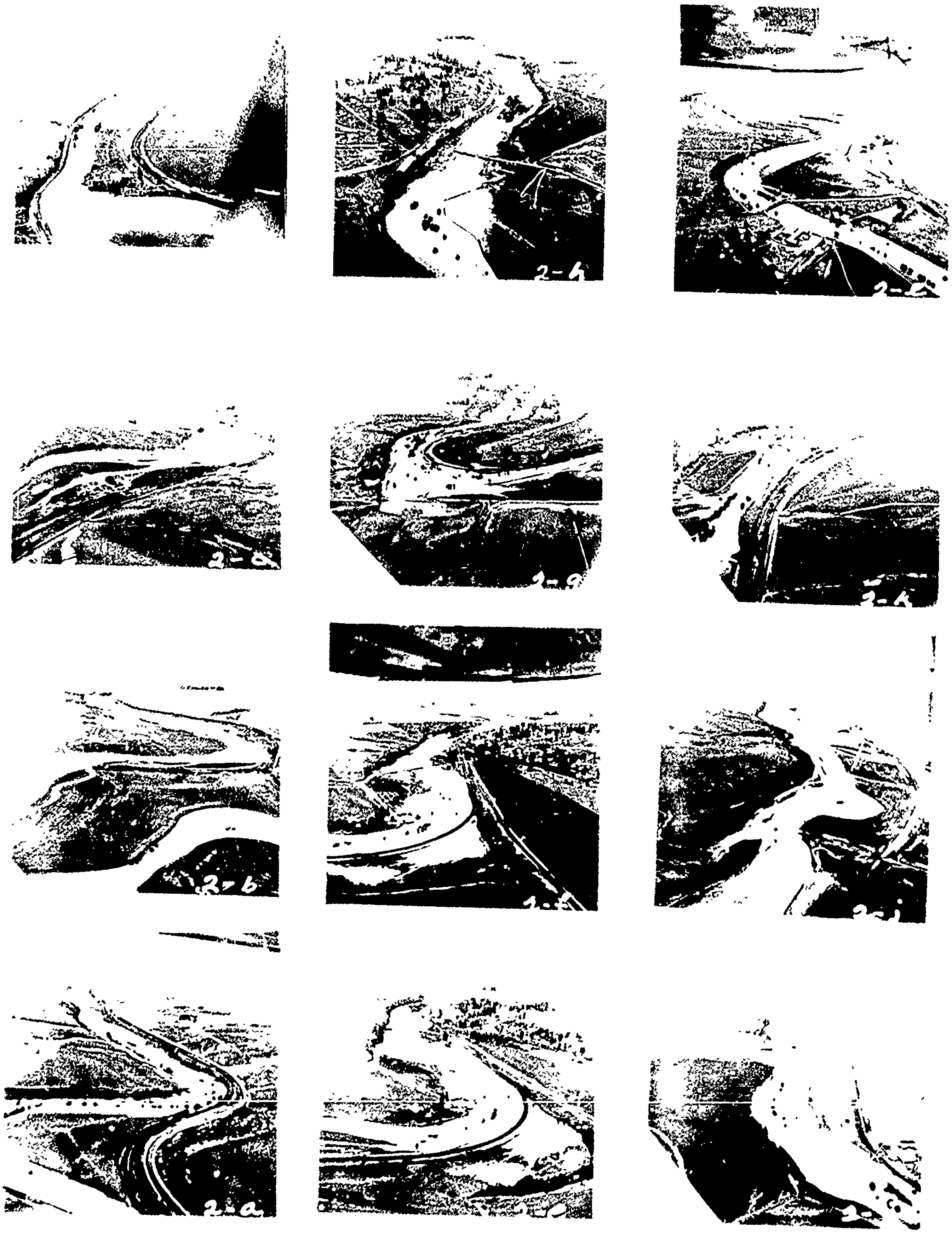
#4-31 R.M.45.0 Hangman Creek below Latah.

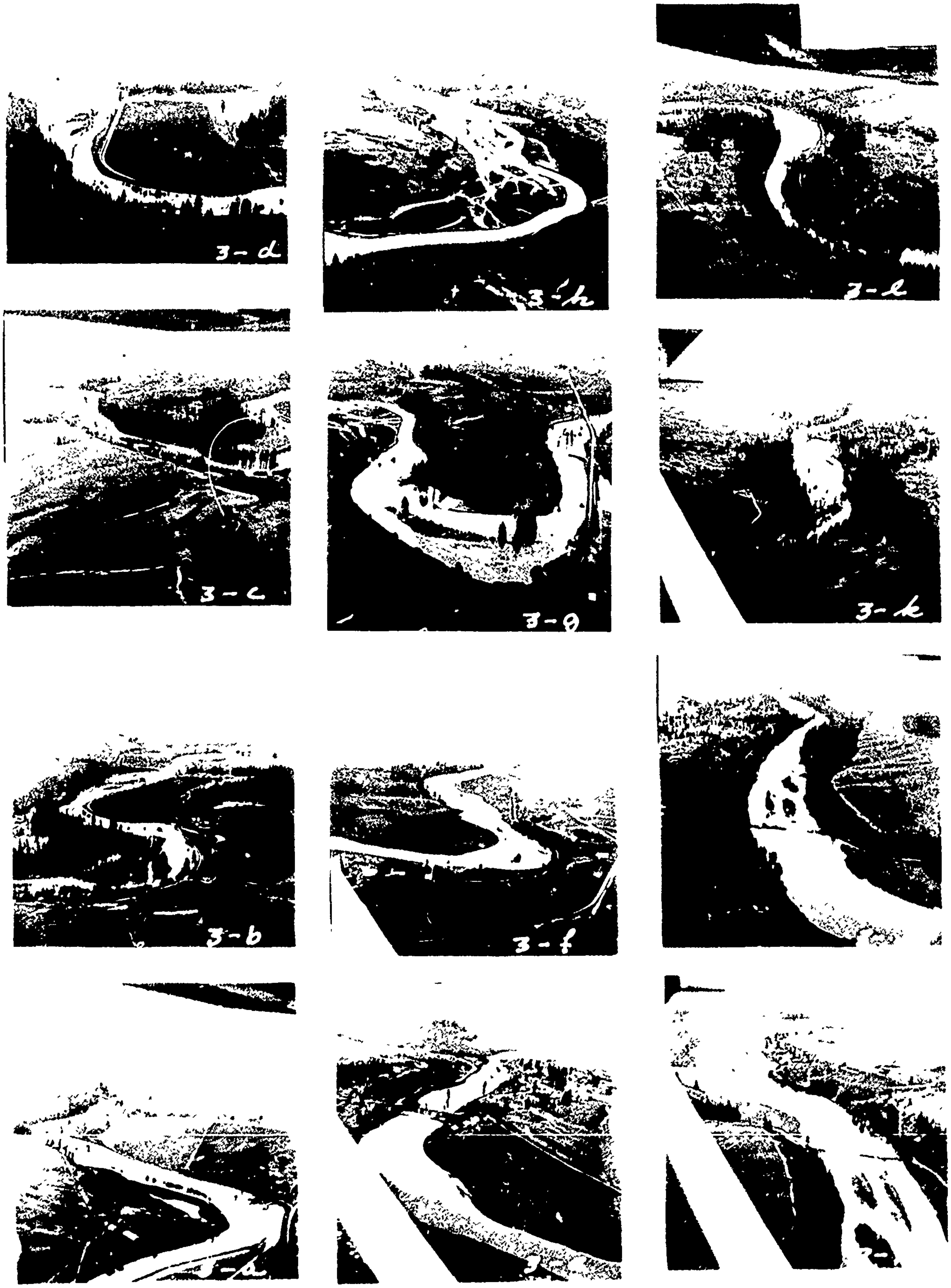
#4-36 R.M.48.2 Hangman Creek above Latah.

#4-35 R.M.47.6 Hangman Creek looking downstream towards Latah.

#4-34 R.M. 47.2 Hangman Creek looking upstream.



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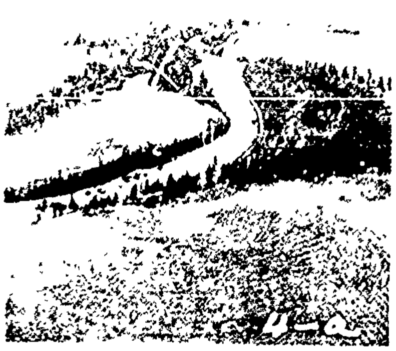
3-c
3-g
3-k
3-b
3-f
3-a

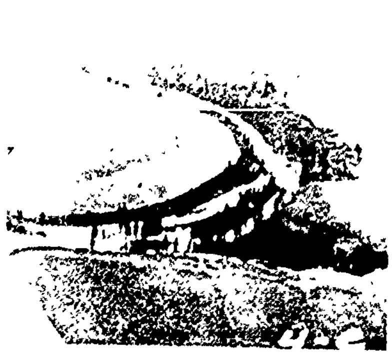

4-d

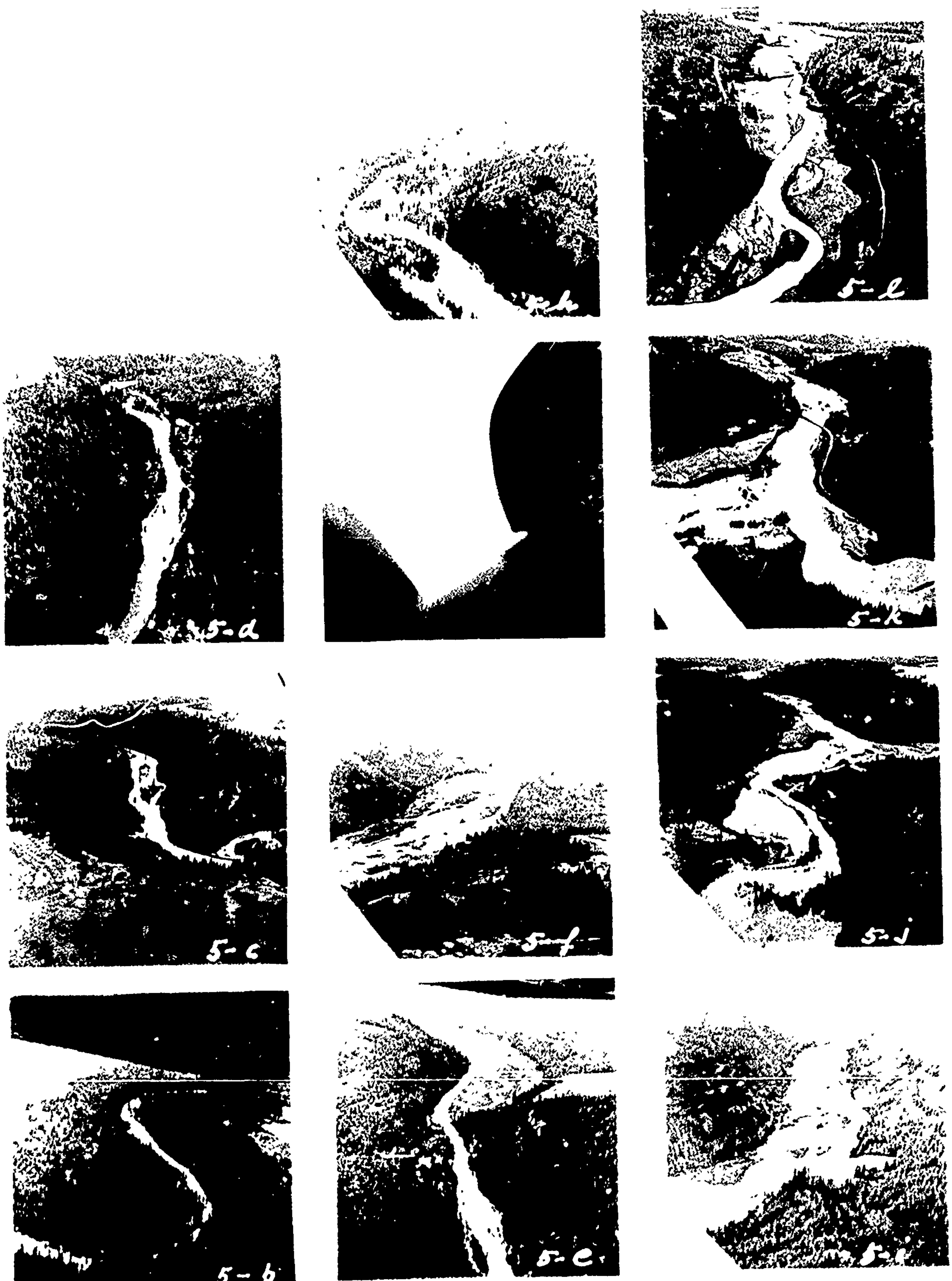

4-g


4-k


4-f



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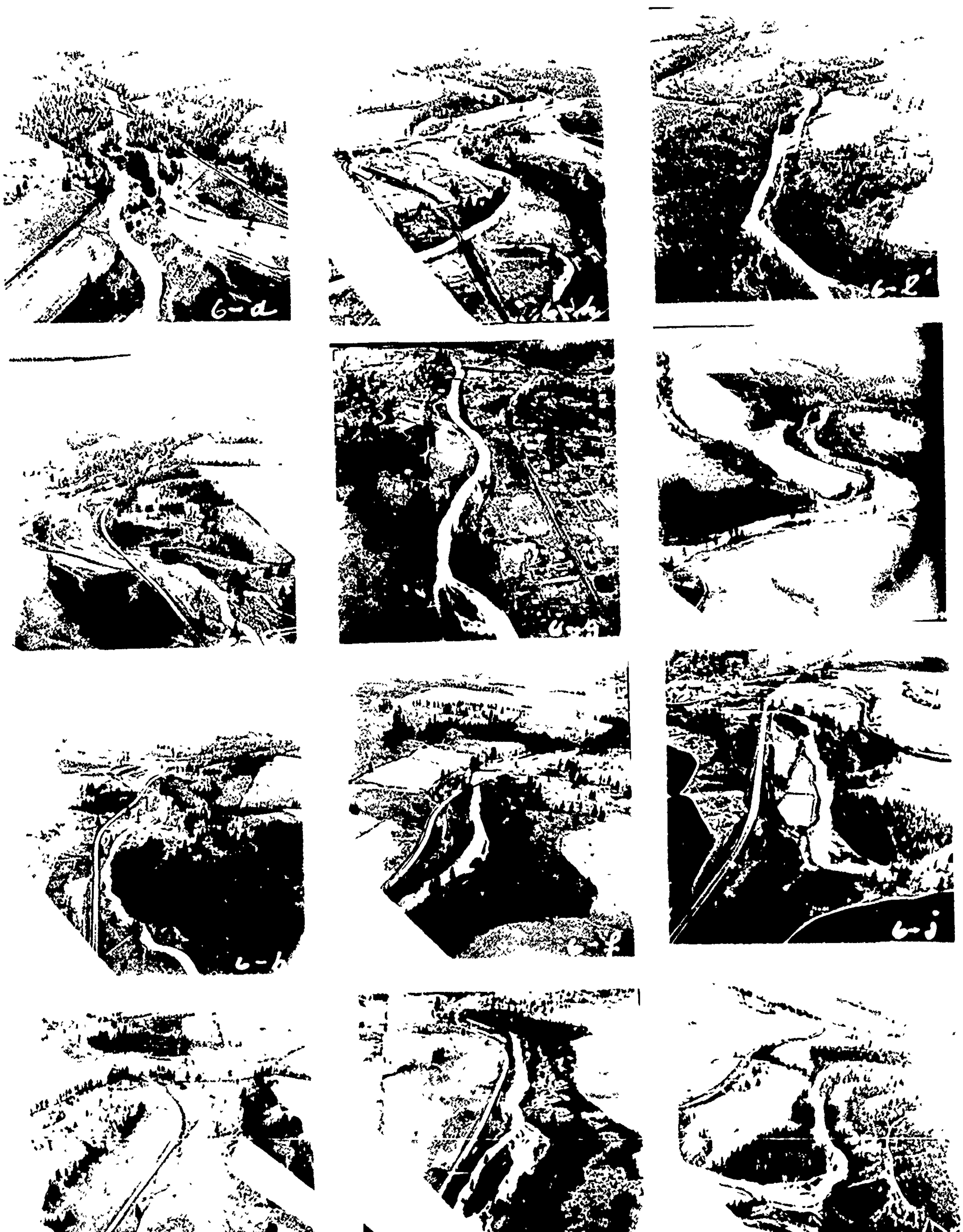
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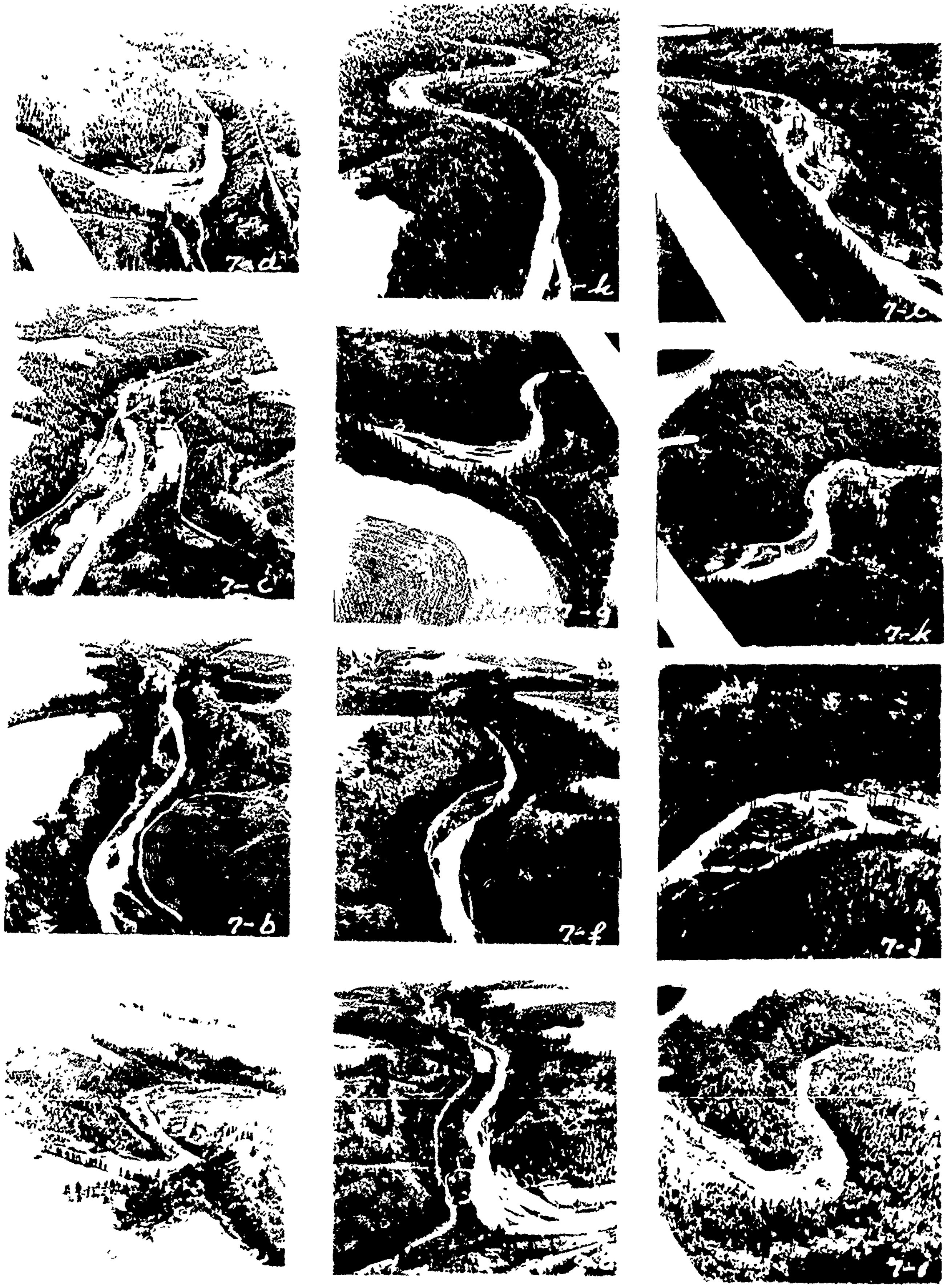
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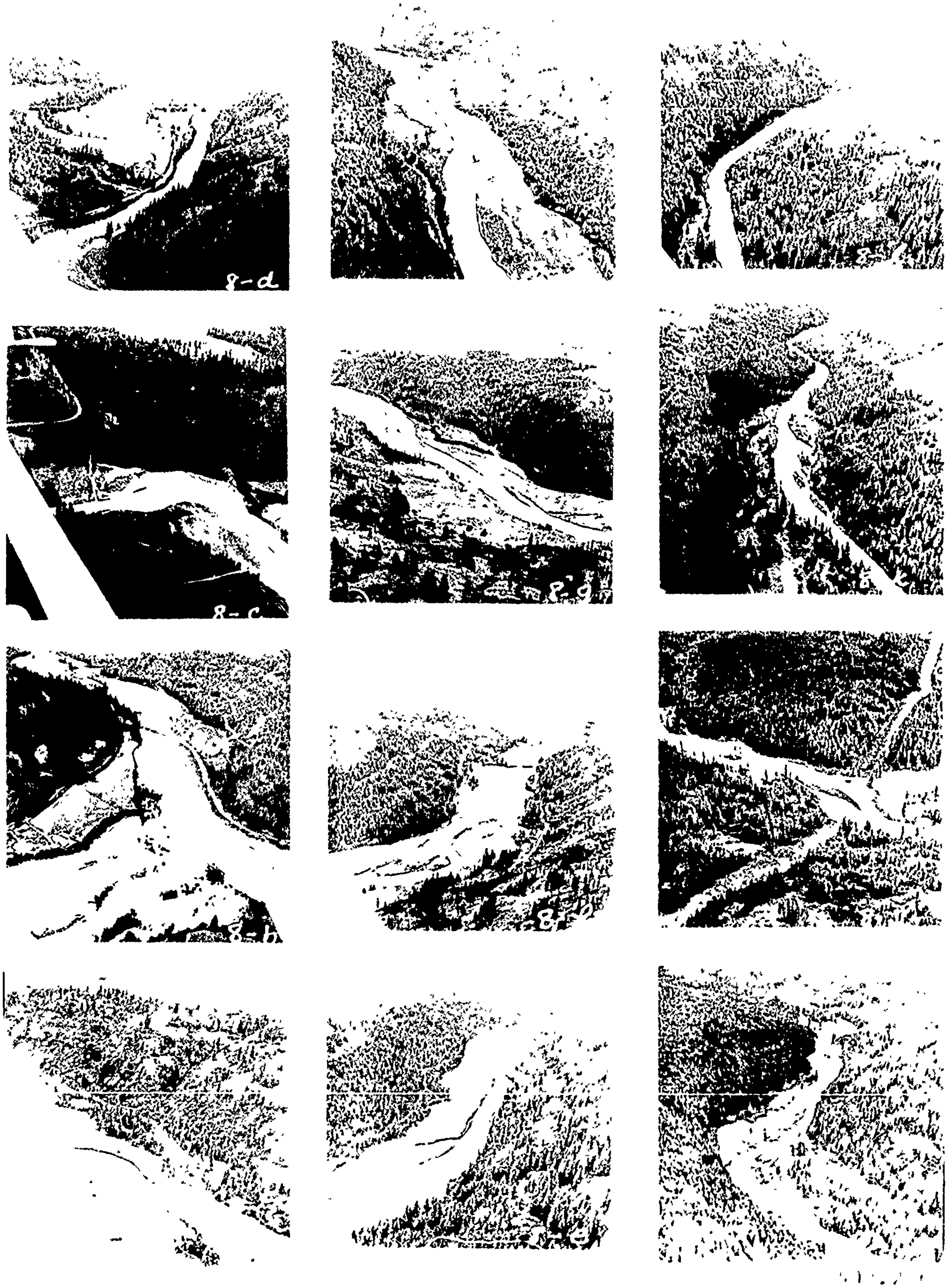
7-f
7-g
7-k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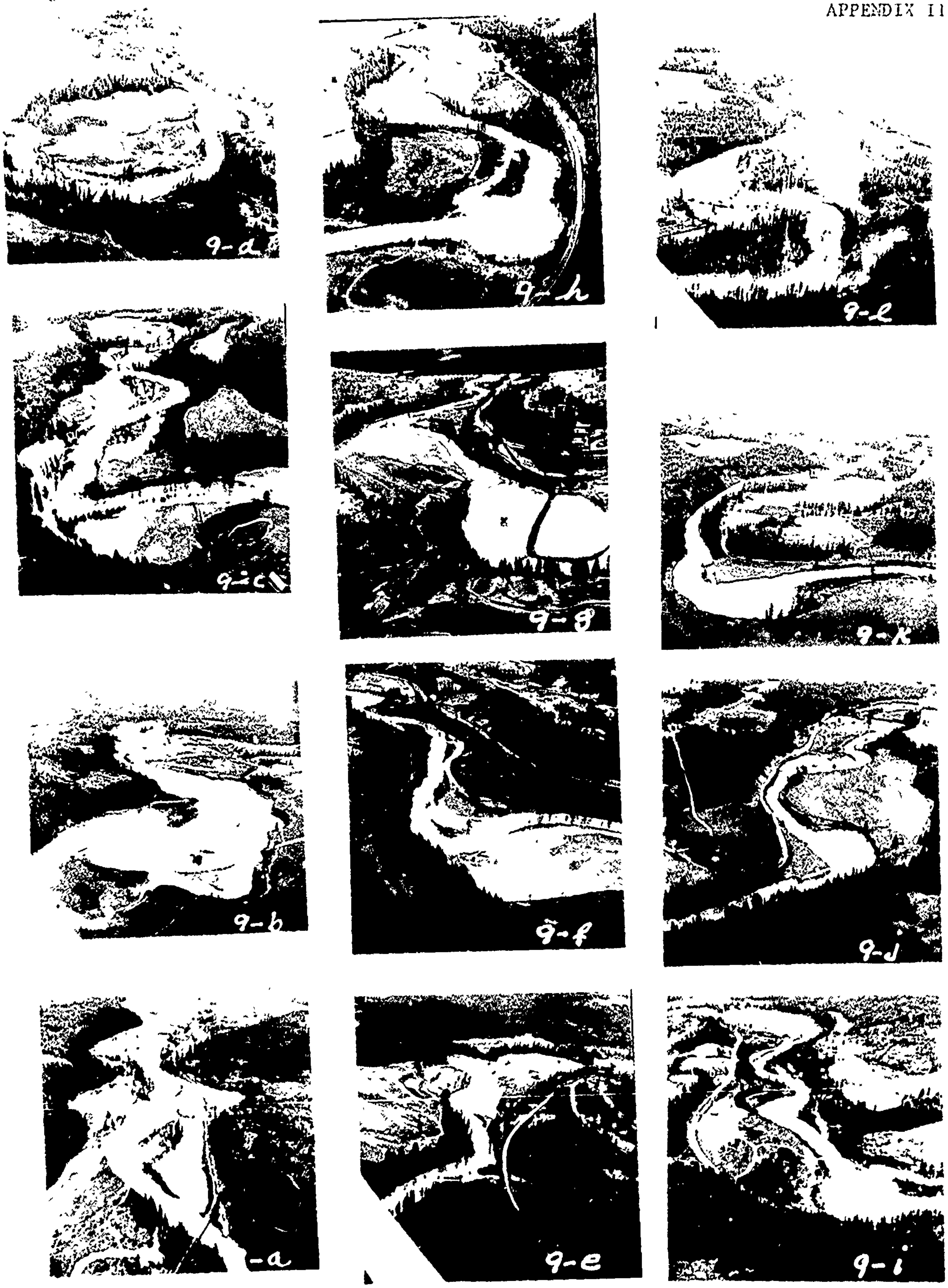
8-c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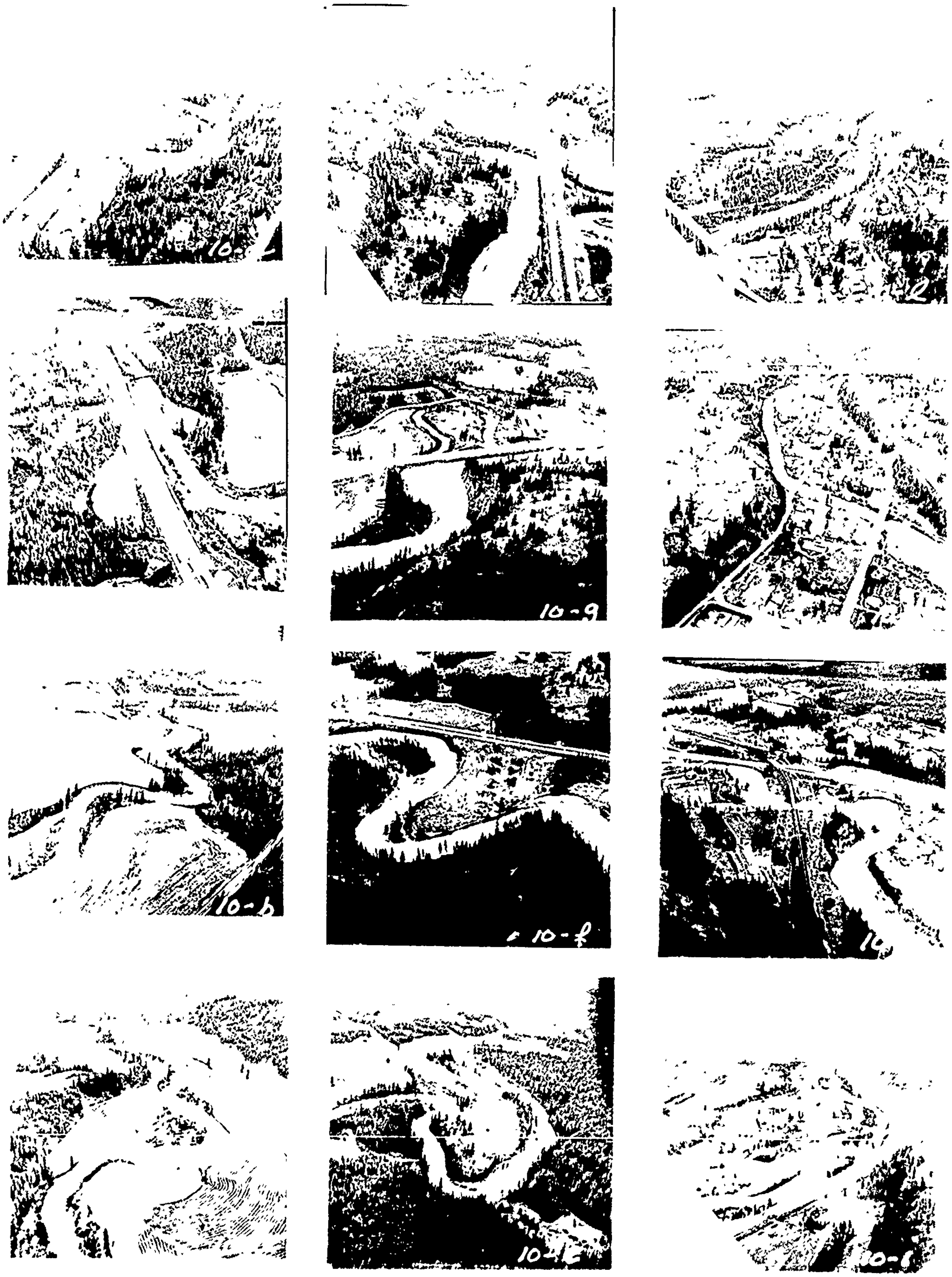
-a
9-e
9-i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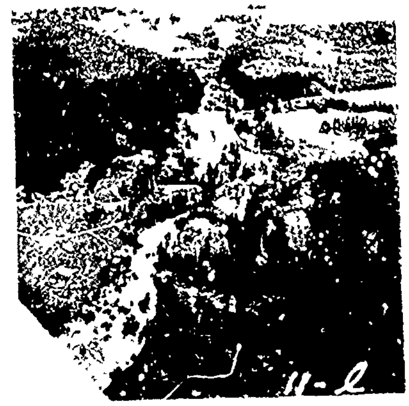
11-h

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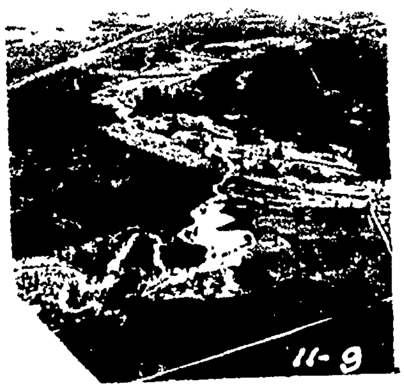
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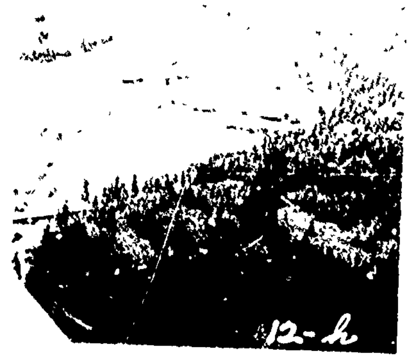
11-k

11-b


11-j

11-a


11-i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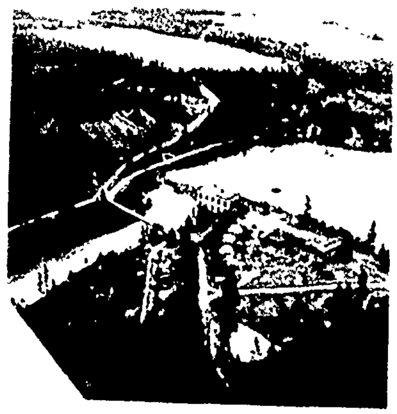
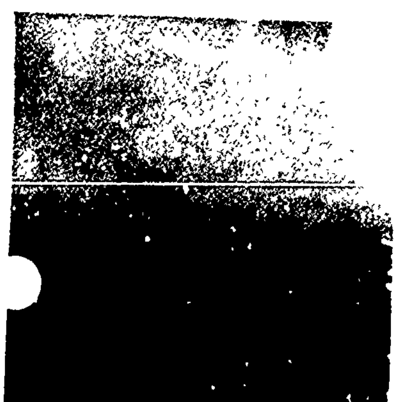
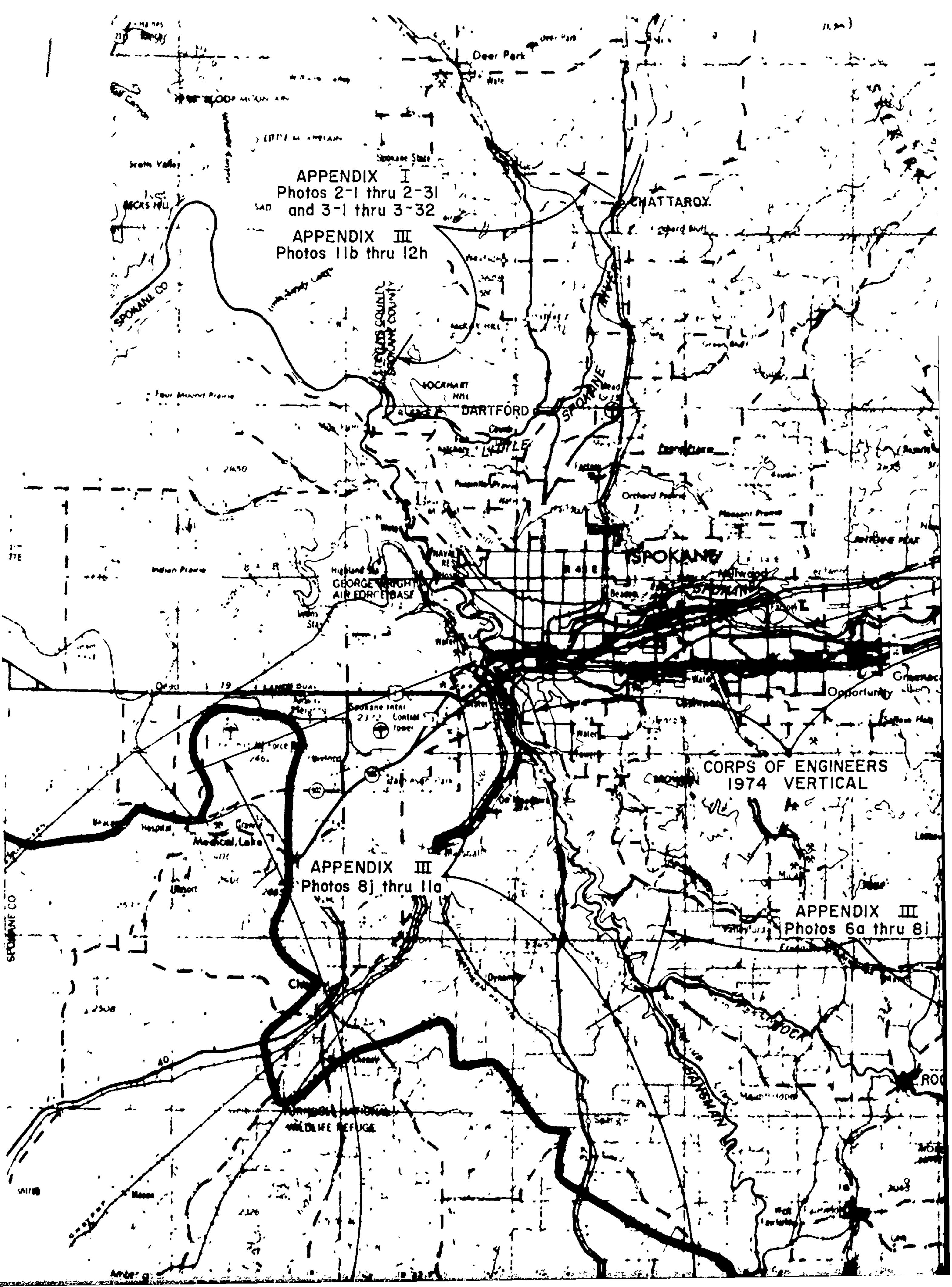
12-g






2-e



APPENDIX I
Photos 2-1 thru 2-31
and 3-1 thru 3-32
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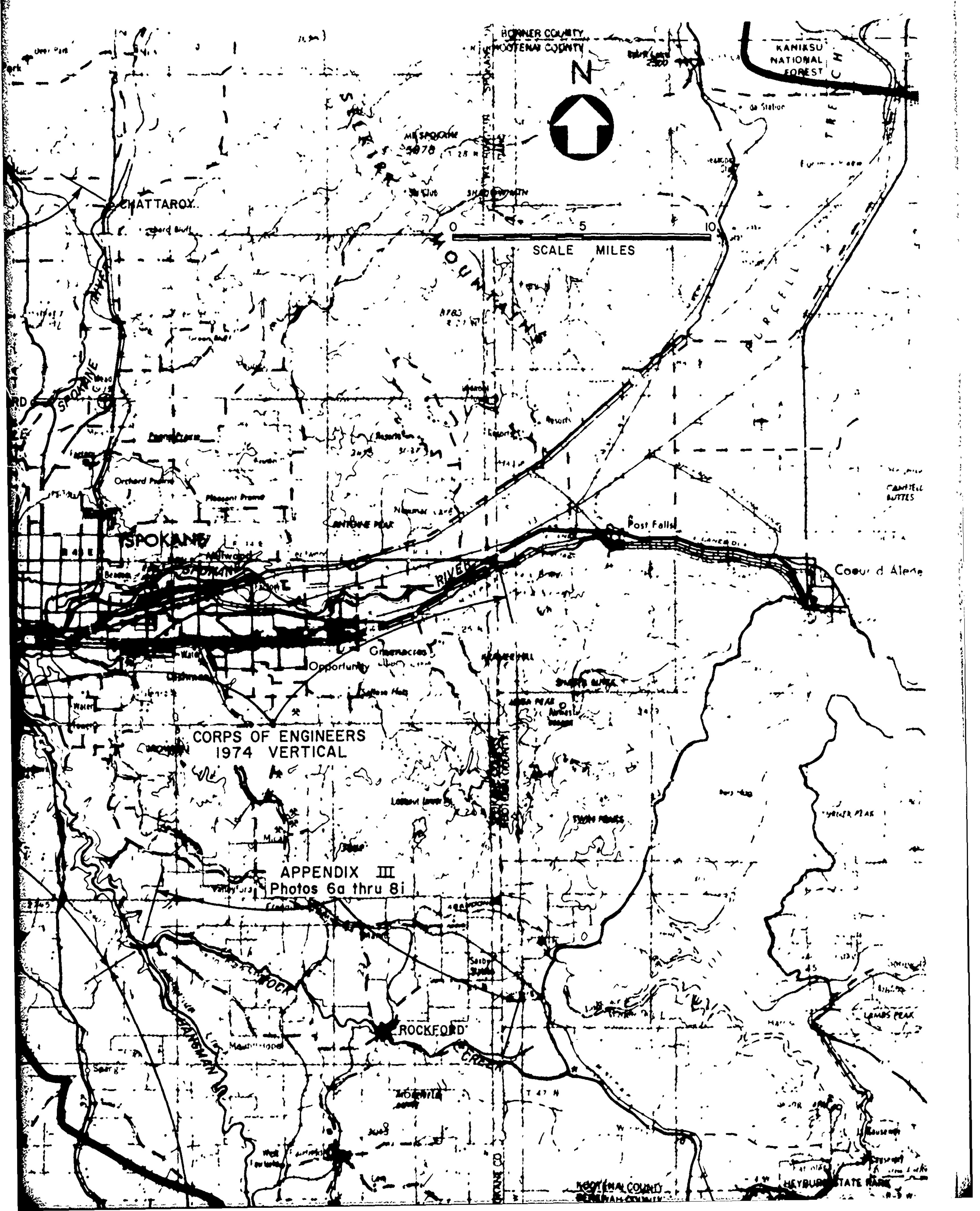
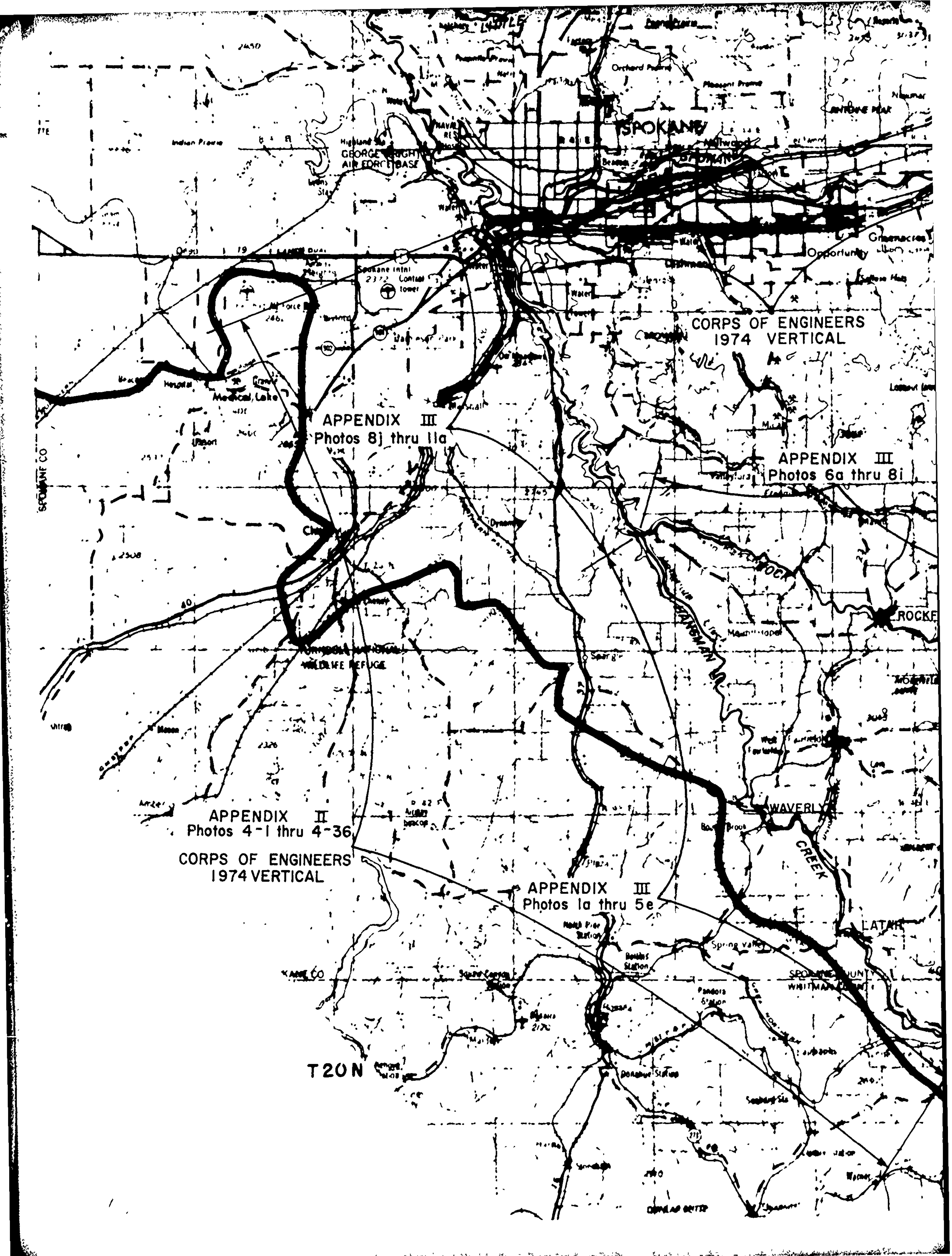
Photos 11b thru 12h
Deer Park
CHATTAROY
DARTFORD
SPOKANE
GEORGE WRIGHT
AIR FORCE BASE
Medical Lake
Opportunity
CORPS OF ENGINEERS
1974 VERTICAL
APPENDIX III
Photos 8j thru 11a
APPENDIX III
Photos 6a thru 8i
STEVENS COUNTY
SPOKANE COUNTY
SPOKANE CO
WILDLIFE REFUGE


BONNER COUNTY
KOOTENAI COUNTY
KANIKSU
NATIONAL
FOREST
N
0
5
10
SCALE MILES
CHATTAROY
SPOKANE
Post Falls
Coeur d Alene
Greenacres
Opportunity
CORPS OF ENGINEERS
1974 VERTICAL
APPENDIX III
Photos 6a thru 8i
ROCKFORD
KOOTENAI COUNTY
HEYBURN STATE PARK


SPOKANE
GEORGE WRIGHT AIR FORCE BASE
Medical Lake
CORPS OF ENGINEERS
1974 VERTICAL
APPENDIX III
Photos 8j thru 11a
APPENDIX III
Photos 6a thru 8i
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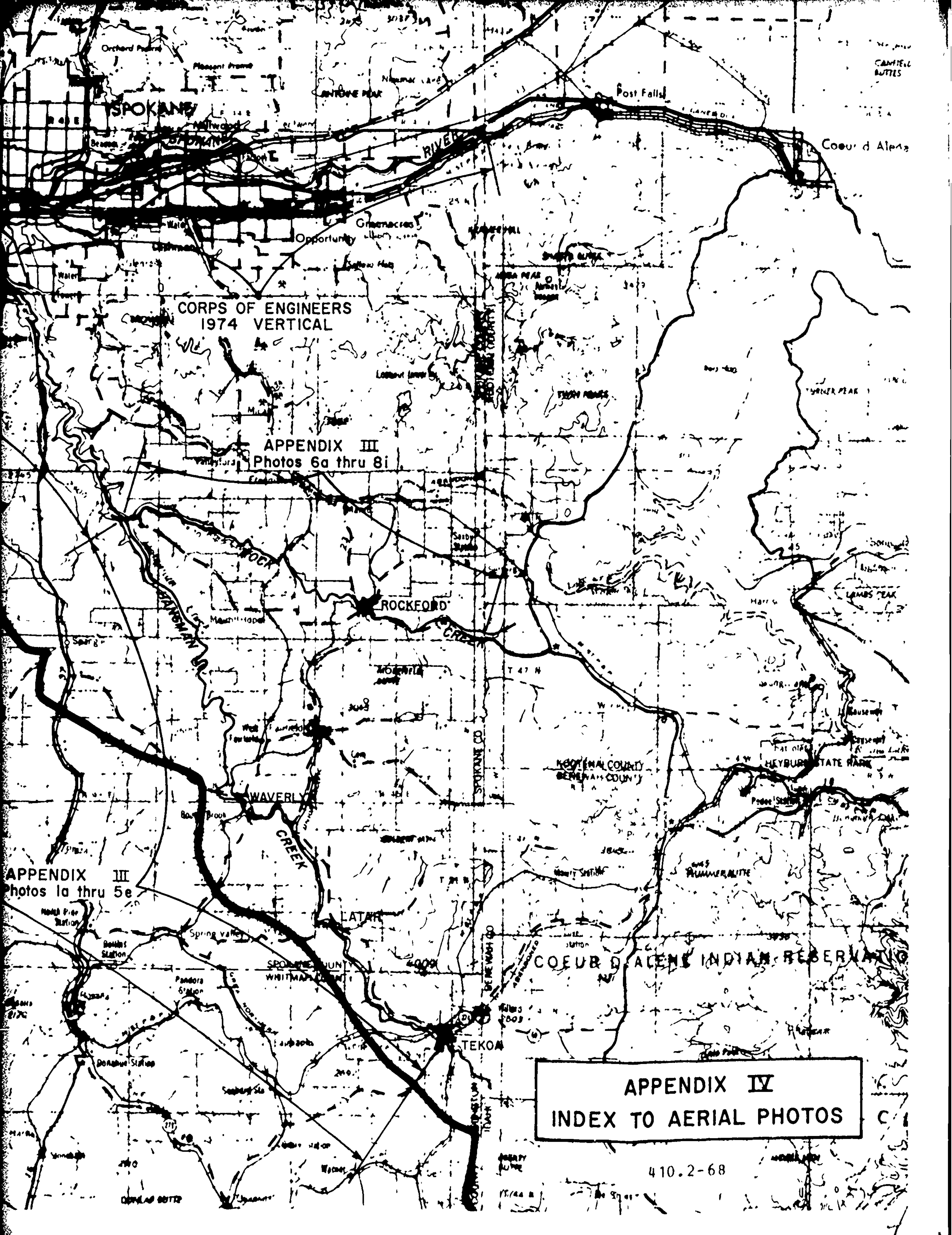
CORPS OF ENGINEERS
1974 VERTICAL
APPENDIX III
Photos 1a thru 5e
WAVERLY
CREEK
LATAH
T20N
Opportunity
Spring Valley



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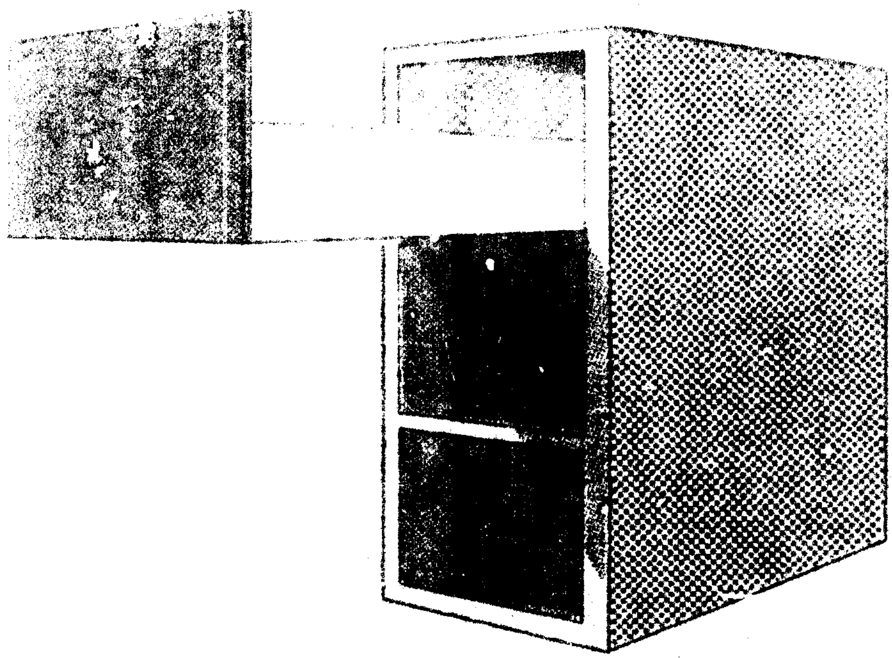

SECTION 307

INVENTORY OF WATER QUALITY DATA AND IDENTIFICATION OF DATA GAPS

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 307

INVENTORY OF WATER QUALITY DATA
AND IDENTIFICATION OF DATA GAPS

18 March 1974

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

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INVENTORY OF WATER QUALITY DATA AND IDENTIFICATION OF DATA GAPS

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Scope and Objectives

The objectives of Tasks 3070 and 3090 are to inventory all available surface water and groundwater quality data within the Study Area and to analyze the inventory for data gaps. Data analysis and interpretation are not within the scope of this section.

Surface water data are to be inventoried for streams, man made on-stream impoundments and natural lakes. Groundwater data are to be inventoried for all groundwater bodies within the study area including the primary aquifer of the Spokane Valley, other alluvial aquifers and the basalt aquifers.

All kinds of water quality data are to be indentified. In addition to water temperature and the traditional chemical constituents, particular attention is directed toward inventory of data which includes parameters significant to oxygen balance, nutrients, aquatic growths, heavy metals toxicity, organic toxicity, bacterial contamination, oil contamination and evidence of detergents.

The sources of data to be explored are correspondingly broad. In addition to the basic Water Quality Papers of the U.S. Geological Survey, the canvas of data includes published reports, the Storet system, and unpublished sources.

Overview

Surface Water Data. There have been a succession of varied interests in surface water quality in the Study Area. The earliest cause for concern and consequent monitoring of quality was the increase in heavy metal ions, particularly zinc, which entered the basin from Idaho due to the leaching of mine waste on the Coeur D'Alene River. Next came the concern from gross untreated sewage pollution caused by the City of Spokane sewer system. After the completion of the City primary treatment plant, the focus of interest has been on eutrophication of Long Lake. This latter interest, which remains the primary focus to this day, was first documented in a data collection effort directed at coordination of quality parameters significant to eutrophication by Cunningham and Pine in 1966 and reported in Cunningham and Pine (1969). Since 1966, there has been an increasing concentration of investigations leading to Bishop and Lee (1972) and, finally, Soltero (1973). The Soltero investigation is ongoing and is scheduled to report again in 1974. In addition to individual investigations, the Department of Ecology is maintaining five monitoring stations on the Spokane River and one on the Little Spokane River which are normally sampled twice a month.

The concern for water quality in natural lakes is increasing as the few lakes within commuting distance of Spokane are subjected to residential development. There was little data prior to the Department of Ecology efforts which began in 1968. There are unpublished data on identification of lake biota from the 1930's that may prove useful for estimating water quality prior to lakeside development.

The fundamental basic source of water quality data since

1941 has been the annual publication of the U.S. Geological Survey. For the Study Area, the available USGS records for three stations go back to 1959.

Groundwater Data. There has not been the impetus for intensive new quality studies of groundwater in the Study Area similar to those for surface water. Recognition of the fact that there could be a potential for pollution from surface waste disposal in the highly permeable primary aquifer lead to the report by Crosby (1971). However, this report does not contain additional groundwater quality data since the investigation employed another approach to the problem. There is currently under way a study of the potential for contamination of groundwater in the basalt aquifer by Ernest Gilmore of Eastern Washington State.

Consequently, the available groundwater data are largely of the routine type which report the chemical constituents normally associated with a public health evaluation of drinking water. There has not been specific wide ranging programs for parameters which might be indicative of pollution from senitary, industrial or agricultural waste sources. Bacteriological data have been gathered routinely under the requirements of state law for sampling public water systems. Unfortunately, these data are not summarized or published.

The STORET System

General. In an effort to make all water quality data readily available, the Environmental Protection Agency has established the STORET data storage and retrieval system. When fully implemented this system is proposed to be the repository of all significant water quality data, continuously kept up-to-date. At present, the system is too new to be fully implemented and its utility must be supplemented by additional data searches. The system is, however, a major repository of data organized for retrieval and is selected as the basic source for this search.

Two printouts from STORET have been obtained. The first printout is the inventory of stations and parameters. The second printout is of selected raw data based on the indicated availability in the inventory.

Other sources of data canvassed to supplement and check the STORET data are:

1. Published Reports.
2. Request to Department of Social and Health Services for unpublished data.
3. Request to Washington Water Power for unpublished data.
4. Request to USGS for data not yet put in STORET.
5. Request to DOE for data from their ongoing monitoring program.
6. Request to Inland Empire Paper for records of their effluent quality and quantity.
7. Request to City of Spokane for records of sewage treatment plant effluent quality and quantity.

The STORET Data Source. The Station Inventory Printout lists the points at which water quality data are available, the parameters measured and the period of record. In addition to listing the parameters measured, the inventory also gives the number of observations, their mean, variance, standard deviation, coefficient of variability, standard error, and the maximum and minimum value. See sample page, Appendix I.

The location is identified in several ways:

1. There are station numbers assigned by the agencies which entered the data. There appear to be only three agencies which have inserted data, namely USGS, DOE and EPA. Each has its own numbering system.

2. The latitude and longitude are given.

3. There is a word description.

4. And for stations on rivers and streams, the river mile is generally given.

More than one agency can and does put in the same data as another agency. The printout is categorized by originating agency and there is one page or group of pages per station per agency which has put in data. There has been no attempt to eliminate duplicate data. And, in spite of all the alternative station identifiers used, it is frequently very difficult to identify duplications by inspection of the inventory. Except where the identifying numbers of both agencies are given and are identical, it may not be possible to identify a duplication because the word descriptions, latitude and longitude and river mile identifications used by the various agencies may not be identical. Only a line by line comparison of the analytical data will confirm the identity in some cases.

There is no sorting program available that will give the consolidation of data from all agencies for any particular point and eliminate duplications. The data is available only as input by each agency.

The primary source of duplications appears to be between

USGS and DOE. USGS policy is to put in only data that they have analyzed including joint operations with other agencies like DOE. DOE also puts in data from their joint operations with USGS, usually at a much earlier date than USGS. The Corps of Engineers apparently has made no input to STORET in Washington or Idaho. There are a very few special inputs.

After examination of the Storet inventory printout, it is possible to make a selective order of raw data.

One of the physical limitations of the raw data printout is that it is arranged to print on each page not more than 10 columns across, one per parameter, with the date of observation and parameter values vertically. See sample page, Appendix II. This limitation of 10 parameters per sheet requires either a bulky printout or a limited selection of parameters. There are large numbers of parameters because of the variations in methods of reporting some parameters in addition to the fact that a very broad spectrum of constituents have been sampled.

Surface Water Data from STORET. A raw data printout in river mile order was obtained for the parameters listed in Table 1. Table 2 lists the other available parameters that were not ordered. Table 3 lists the surface water stations for which water quality is available in STORET and the period of record. Table 3 includes identification of common stations from various input agencies.

Groundwater Data from STORET. For groundwater quality, a raw data printout was ordered organized by the geographical areas shown in Figure A. The purpose of this arrangement is to collect those wells in the Study Area which are in the primary Spokane Valley aquifer within the designated areas 2, 3 and 4 and to collect all other wells in the Study Area in designated area 1. Similarly, designated area 5 is to collect all the wells in the extension of the primary aquifer into Idaho's Rathdrum Prairie and other Idaho wells in area 6. The data received indicates that no groundwater quality data for areas 1, 5, and 6 has been placed into the STORET data files. The parameters requested for groundwater are shown in Table 4.

STORET Printouts. The above described water quality data from STORET is available as computer printout and is made a part of this report by reference. The documents are as follows:

Kennedy-Tudor File Number	Description
D-307-15	STORET DATA, Inventory
D-307-16	STORET DATA, Ground Water Quality Data, Springs and Wells
D-307-17	STORET DATA, Spokane River from Mouth to Post Falls, Idaho
D-307-18	STORET DATA, Surface Waters above Post Falls Dam
D-307-19	STORET DATA, Surface Waters within Washington other than Spokane River.

Data from Published Reports

Tables 5 and 6 list published reports studied to see if the water quality data contained therein was already in STORET or whether it was supplemental to STORET. Table 5 concerns surface water data and Table 6 covers groundwater data. Where supplemental data are indicated in Tables 5 and 6, this data is incorporated into the summary Tables 8 and 9 and the stations are mapped on Plate 307-1 except where otherwise noted.

Since certain of these published reports contain, in addition to the referenced water quality data, interpretive data of significance, abstracts for selected reports have been prepared for reference.

All published USGS data is in STORET.

Data from State Department of Social and Health Services (DHSH)

The request to DSHS revealed that they have two primary sources of unpublished data. One is a file of chemical quality data and the other is a file of bacteriological test data. Neither of these files has been summarized for the Spokane study area. The data are in a completely raw state.

The chemical quality data for Spokane County consists of approximately 500 laboratory report sheets, each for a single sample. The sheets are unorganized as to location or date. The locations or systems to which the sample applies are difficult to identify in many cases. The paramete s tested for typically are as follows:

a. Silica
b. Iron
c. Manganese
d. Calcium
e. Magnesium
f. Sodium
g. Potassium
h. pH
i. Conductance
j. Color
k. Odor
l. Taste
m. Free CO_2
n. Bicarbonate

o. Carbonate
p. Sulfate
q. Chloride
r. Fluoride
s. Nitrate
t. Nitrite
u. Phosphate
v. Total Solids
w. Total Hardness
x. Alkalinity

Copies of the DSHS chemical analysis reports for the years 1970, 1971 and 1972 for Spokane County have been obtained by making copies of the unsorted file in the Seattle Office of DSHS. These data are available in Kennedy-Tudor files. None of these data are in STORET. No attempt has been made at this time to classify or analyze this mass of data. The locations of the wells for which the data exists are not included in the plot on Plate 307-1.

A sample of the chemical analysis report sheet is included as Appendix III.

Similar chemical water quality data are available, sorted by counties, for Whitman, Lincoln, Stevens and Pend Oreille Counties. There are a total of about 400 sheets for these four counties together, only part of which would be in the Study Area.

Since the sources of these samples taken by DSHS are the public water systems, and since practically all public water supply systems in the area are from wells, these data are all essentially of groundwater quality.

The DSHS file of bacteriological tests are likewise from public water systems and, as stated above, are essentially groundwater samples. The samples may be taken from any location in the public water system and may or may not be indicative of the bacteriological quality of the groundwater source. Only samples taken at or in the immediate vicinity of the well head prior to chlorination, if any, could be considered as exclusively representative of groundwater quality.

The bacteriological tests are made in numbers and frequencies called for in WAC 248-54-430 which range from 2 per month for systems serving less than 2400 persons to 150 per month for systems serving 200,000 persons. Since there are 84 water systems in Spokane County listed in the DSHS Water Facilities Inventory, these bacteriological tests are extremely numerous.

The results are reported as "satisfactory" or "unsatisfactory." Unsatisfactory is broken down into the levels represented by the five test dilutions and are given as 2.2, 4.4, 8.8 or 16. A positive indicator for dilutions beyond 2.2 is classified as unsatisfactory. Refer to sample analysis report sheet included as Appendix IV.

Neither a record nor a summary of results of bacteriological tests is maintained at State level. The tests are all run at the State laboratory in Seattle. It is our understanding that there is no record of these results except in the form of the individual slips of paper reporting each test result. There is no register or file of letters notifying the operating agency of an unsatisfactory test. There are three copies of the test result, one is returned to the area DSHS office, one is returned to the system operator and one is sent to the County or District Health Department. The DSHS laboratory keeps a record only of the test number and result without regard to system identification or location. The file is by test number only.

The only level at which a summary or analysis can be made is at the local level DSHS office or the County Health District, each of which receives a copy. A copy of such a tabulation has been obtained from Spokane County Health District for the year 1972. A copy of this table is included as Appendix V. Those systems that provide chlorination have been marked. Where the systems are not chlorinated, a lack of "unsatisfactory" results may be interpreted as satisfactory with regard to source. Where there are "unsatisfactory" results, there is no way of knowing whether this was due to source contamination, system contamination or sample contamination.

None of this bacteriological data is in STORET and none is plotted in Plate 307-1.

Note that the definition of a "public water system" apparently does not include schools with an individual well supply system since no bacteriological tests are routinely taken of these systems of which there are a significant number. Refer to the section reporting existing water systems.

Data from Washington Water Power (WWP)

At an interview with WWP employees on September 10, 1972, a request was made for water quality data held by WWP and not available elsewhere. The request was answered as follows.

1. WWP has some data for 1972 on Long Lake that is available. WWP is continuing the monitoring in 1973.

2. WWP has some bottom sediment samples from spring of

1973 for Nine Mile Reservoir.

3. The power house log at Long Lake Dam records water temperature each day. These temperature data are not summarized anywhere. To get them would mean recording each day from a separate log sheet.

The 1972 data on Long Lake have been received and consist of dissolved oxygen and temperature data at six locations and at 5 foot depth increments at 16 different dates between June 13 and October 16. (File D-307-2)

It is not proposed to abstract the daily temperature records from the Long Lake power plant records except to the extent that it is necessary for calibration of the simulation model.

Data from USGS

A request was made to USGS for groundwater quality data that was neither on STORET nor published in a water supply paper. Three groups of data were received. The first group consists of groundwater quality analysis for 18 stations that are being monitored in an ongoing study. This data will eventually be entered into STORET. The second group of data is 1970 chemical analysis of 2 wells, numbers 24/41-23K1 and 27/41-26Q2. The two wells lie, respectively, south and north of the main aquifer.

In addition, USGS has supplied a partially completed inventory of wells located within the main aquifer. USGS is updating their inventory at wells as a part of their ongoing project with DOE to hydraulically model the Spokane Valley Aquifer.

Data from Inland Empire Paper Company

Inland Empire Paper Company monitors their effluent waste flow daily. In addition to the average daily flow, the following water quality parameters are reported:

Parameter	Units
Biochemical Oxygen Demand	Pounds Per Day
Suspended Combustible Solids	Pounds Per Day
pH	Maximum, Minimum and Average
Temperature	Degrees F, Maximum, Minimum and Average

Files of these data have been obtained for the period January 1972 to June 1973. Subsequent to April 1972, periodic tests were made for zinc content of the plant raw water supply, plant effluent and the Spokane River.

Data from City of Spokane on Sewage Treatment Plant

As part of the normal operation of the City of Spokane Sewage Treatment Plant, certain water quality parameters of the plant effluent are monitored. The parameters monitored are as follows:

Parameter	Frequency of Observation
Dissolved Oxygen	5-10 Day Intervals
Biochemical Oxygen Demand	2-5 Day Intervals
pH	Daily
Suspended Solids	Work Days
Chlorine Residual	Daily
Total Coliform	4 Per Month, Average
Fecal Coliform	4 Per Month, Average

Also available is the total daily discharge in millions of gallons per day.

These flow and quality data for the period April 1972 to April 1973 are shown in the section of this report on waste source. The data for other time periods are available in the treatment plant records.

The City does not make any observation of receiving water quality either upstream or downstream from the sewage treatment plant outfall.

None of the City data are in STORET.

Summarization of Available Surface Water Quality Data

All locations for which surface water quality data are available are listed in Table 8 and shown in Plate 307-1. This listing includes all sources found and assigns to each location a number, described in Table 8 as the K-T number, which is used as the identifier in Plate 307-1.

The kind of data and the span of time represented by these data are shown for each location in Table 8. Rather than identify each individual quality parameter, these numerous parameters and their variation have been grouped into seven categories as shown in Table 7. If a minimum number of parameters from a category as shown in Table 7 are available for a location, that category is listed as covered for that location in Table 8. Coverage is indicated by listing two dates covering the span of time from the earliest to latest reporting of the covered parameters. Note that the two dates do not imply a continuous record between the dates indicated, or that all parameters are available over the indicated span.

The order of location listing in Table 8 is by river mile, first for the Spokane River, followed by the Little Spokane River, Hangman Creek and Chamokane Creek. Lakes and waste sources are shown last.

The sources of water quality data are shown in Table 8 in several ways. In the first column after the description, there is a numerical reference to the list of sources included at the end of Table 8. The column to the right of the quality categories headed "Total Indicated Record in STORET" provides a quick indication of whether all the data indicated for a particular location is in the STORET source or whether supplemental sources must be consulted. Where there is a "NO" in this column, the space to the right headed "Source of Elements Not in STORET" indicates the source that should be consulted for the elements not in STORET. For example, at K-T 24, the time span dates are 12-16-65 to 9-13-72 for three categories and 3-26-66 to 9-13-72 for another; followed by the indication that all data are not in STORET and the note "Soltero 5-6-72/3-15-73." This means that the older data are on STORET but that the data between 5-6-72 and 3-15-73 must be sought from the Soltero reference.

The most important published sources not represented in STORET are Bishop and Lee (1972), Condit (1972), Cunningham and Pine (1969), Funk (1973) and Soltero (1973). Cunningham and Rothwell (1971) and Todhunter and Cunningham (1972) are all in STORET.

Under remarks, the most common information shown is a cross reference of the location and description shown in Table 8 to the identification used in the applicable reference. Using the same example above of K-T 24, the note "Soltero # Seven Mile" means that the station identified as K-T 24 on Seven Mile Bridge is the same location as Soltero's "Seven Mile" or S.M. as he abbreviates in his tables.

Also under "Remarks," locations corresponding to the sampling and analysis program for simulation model calibration are shown by the station number with the identifier K-T S&M. The data being produced by this program are not indicated in Table 8. Refer to the section of this report devoted to reporting the results of this sampling and analysis program.

The data availability indicated by reference to Soltero (1973) require special explanation. The published report, Soltero (1973), contains a Table V on pages 17 and 18 that lists the range and mean values for 24 parameters at six river locations for the period May 6, 1972 to March 15, 1973. The referenced report does not contain the individual observations on which Table V is based, these data being unpublished to date. Table 8 herein indicates Soltero (1973) as the source of this data whereas the raw data is actually unpublished. It is our understanding that specific requests for the raw data may be addressed to Dr. Soltero at Eastern Washington State University.

From a geographic standpoint, there is intensive coverage of the Spokane River from Long Lake Dam to Post Falls, Idaho. Gaps between sampling points are three miles or less. From Long Lake Dam to the Columbia River confluence, the spacing is 4 to 10 miles.

The Little Spokane River is well covered from the confluence with the Spokane upstream to Mead. Above Mead there are only four sampling points. Hangman Creek is devoid of water quality sampling except for two stations near the mouth. There are no sampling points on any other branch of the three main streams except for one on Chamokane Creek near Ford, Washington.

Only three natural lakes are significantly sampled, Newman Lake, Liberty Lake and Diamond Lake. Minor data for one date are available on Medical and Silver Lakes. There are no data for other lakes, the most significant of which are the chain of lakes on the west branch of the Little Spokane River.

Considering the water quality categories in combination with geographical location, the availability of data are summarized as follows:

On the Spokane River:

Standard Tests: None available below Long Lake Dam. Well covered from Long Lake to Post Falls.

Nutrients: Well covered with 1971 and 1972 data for full length.

Oxygen Balance: Well covered for full length.

Heavy Metals: None available below Long Lake Dam. Light recent coverage from Long Lake Dam to Spokane Dam. Good recent coverage from Spokane Dam to Post Falls.

Bacteriological: Thin coverage for entire length. None below City STP until Nine Mile Dam.

Biological: Only one location covered below Long Lake Dam. Long Lake well covered primarily by Soltero. Sparse in both location and intensity from Long Lake to Post Falls.

Pollutants: Only one location below Long Lake and none in Long Lake. Sparse coverage from Nine Mile Dam to Post Falls. About half the available data is from 1966.

On the Little Spokane River:

Practically all available data on the Little Spokane River is from Burkhalter, Cunningham and Tracy (1970) which reports analyses made in 1968. This report provides Standard Tests, Nutrients, Oxygen Balance and Bacteriological data for each of the Little Spokane locations and provides Biological data for all but three locations. Heavy metal data are available from other sources for three locations at and below Dartford. There are no Pollutants data.

On Hangman Creek:

There are only two locations on Hangman Creek for which water quality data are available, one at the mouth and one five miles upstream. The station at the mouth has 1972-73 data for all categories except Biological. The upstream station has Standard Test data only for a period in 1968.

On Chamokane Creek:

There is only one location with Standard Test data only for a period in 1968.

Liberty and Newman Lakes:

Only Standard Tests and Nutrient data are available for a period in 1971. There are no Oxygen Balance, Heavy Metals, Bacteriological, Biological or Pollutant data.

Diamond Lake:

There are Standard Tests, Nutrients, Oxygen Balance, and Biological data primarily from Bishop (1973). There are no Heavy Metals, Bacteriological or Pollutants data.

West Medical and Silver Lakes:

Bishop (1969) provides only temperature, pH, conductivity and Dissolved Oxygen for a single date in 1968.

Surface Water Quality Data Needs

In order to evaluate data gaps, it is necessary to establish the quality data needs with respect to:

1. Parameters.
2. Geological Locations.
3. Distribution in Time.

First, considering parameters, the needs for this specific water management study give highest priority to the following:

1. Temperature.
2. Elements of the oxygen balance, DO, BOD, COD.
3. Total dissolved solids.
4. Nutrients, primarily NO_3, NH_3, and Ortho-P.
5. Total and Fecal coliforms.
6. Heavy metals, primarily zinc.
7. pH.
8. Chlorides.
9. Surfactants.
10. Oil and grease.

In addition to the above, chlorophyll A and Zooplankton data are needed for major man-made impoundments and natural lakes. Next, considering geographic location, the minimum needs are to define present quality at the following locations:

On the Spokane River:

Upon entering the Study Area and representative of the river downstream to where the first major point source enters, in this case, upstream from Inland Paper.

Upstream from where city storm drains and sewer outflows begin; that is, approximately at the east city limits.

Immediately upstream from the confluence of Hangman Creek.

Below Hangman Creek confluence but upstream from the City of Spokane sewage treatment plant outfall.

Below the STP outfall but above the Little Spokane confluence.
- In Nine Mile Reservoir.
- Below Nine Mile Reservoir.

In Long Lake.
- Immediately below the Little Spokane Confluence.
- Selected locations throughout the length of the lake and at various depths.

Below Long Lake Dam.

In Little Falls Reservoir.

Below Little Falls Reservoir at entrance to the backwater formed by FDR Lake.

Cn Hangman Creek.

Immediately above the mouth.

At least one upstream location beyond the urban development area.

On the Little Spokane River.

Immediately above the mouth.

Upstream from the groundwater inflow from the primary aquifer, around Dartford.

One tributary from the Selkirk mountains.

One tributary from the West, Dragoon Creek.

On the major natural lakes.

Newman
Liberty
Diamond
Eloika
Sacheen
Medical
West Medical
Silver

Finally, considering distribution in time, the primary need is for representation over a full year cycle under the most current conditions. It is also desirable to have concurrent observations of conditions throughout the basin to obtain data on the interrelationships from point to point. For lakes which have considerable pollutional inertia, it would be desirable to have long term, year long, records of such key parameters as nutrients and dissolved oxygen.

Surface Water Quality Data Gaps

Comparing the foregoing needs with the availability, the most important data gaps are as follows:

Spokane River

The presence of heavy metals, particularly zinc, is well established as the Spokane River enters the Study Area. More recent data at representative locations from Spokane Dam downriver to Long Lake Dam is needed to determine if the metal levels persist through this reach year round.

Bacteriological data at regular time intervals is needed throughout the reach from the State line to Long Lake Dam to permit a statistical evaluation of the time-duration of excessive levels. This is particularly applicable to the reach from Trent to Nine Mile Dam. Note the absence of data below the City STP to Nine Mile Dam.

Year round recent data for pollutants such as surfactant, oil and grease, pesticides is needed from Trent to Nine Mile Dam.

Little Spokane River

The primary need is for more recent data for all parameters that have been measured plus pollutants that have not been measured. An updating program could use a year round program of the parameters listed under needs above at the following locations:

1. Near mouth.
2. At Dartford.
3. On the Deadman Creek tributary.
4. On the Dragoon Creek tributary.
5. One each on the east and west branches near where they join.

Hangman Creek

The primary need is for data upstream from the urban development area to evaluate the impact of that development. A location at or above the California or Rock Creek confluence would be appropriate.

Chamokane Creek

Although this stream drains an area with a low level of development, there is a need for at least one series of tests for a broader spectrum of pollution parameters than presently available to evaluate the stream.

Deep Creek

There are no data at all for this tributary which enters the Spokane River above Nine Mile Dam. It drains an area for which there are no representative data. A minimum program analysis for one location near the mouth would fill this gap.

Liberty and Newman Lakes

These two lakes are the two most subject to developmental pressures. The presently available data stops far short of that needed to evaluate the present condition of these lakes. The data needs to be expanded to include oxygen balance and biological parameters at various depths and locations and to include bacteriological and pollutant categories.

Medical, West Medical and Silver Lakes

West Medical and Silver Lakes are described by Lee (1969) as being alkaline and eutrophic. Presumably Medical Lake is similar. These conditions require documentation beyond the minimal data shown in Lee (1969) and USGS (1971).

Diamond, Eloika and Sasheen Lakes

These lakes are less subject to developmental pressure. Only Diamond Lake has been studied significantly, Bishop (1973). Corresponding studies of Eloika and Sasheen are needed as a minimum.

Waste Sources

Spokane STP. The STORET data covers the period from 9-12-72 to 9/20/72 only. The specific parameters covered are:

Parameter	Number of Observations
Temperature	17
BOD	4
Conductivity	2
DO	17
pH	14
Total Hardness	2
Nitrate	1
Kjeldahl N	1
Total P	1
Ortho P	1
Residue, Diss 105	4
Fecal Coliforms	17
Lead	1
Mercury	1
Cadmium	1
COD	5
Residue Total NFLT	5
Residue Settleable	4
Total Coliforms	17

These data from STORET are so meagre and for such a limited time period that they provide little to supplement the City records which are far more extensive and complete for the fundamental parameters of BOD, DO, Temperature, Suspended Solids and Coliforms. The STORET data does not fill the gaps in city data which are the nutrients, heavy metals, oils, surfactants, and pesticides.

The Soltero (1973) data which covers a period from 5-6-72 to 3-15-73 has excellent coverage of all the parameters of interest except oils, surfactants and pesticides. Soltero (1973) does not duplicate the parameters that are routinely well covered by the City's monitoring. Therefore, between Soltero (1973) and the City there is adequate coverage for the 1972-73 period excepting oils, surfactants and pesticides.

Inland Empire Paper Company. The STORET data is limited to the period from 9-11-72 to 9-14-72 and covers the following parameters:

Parameter	Number of Observations
Temperature	3
BOD	3
Conductivity	3
DO	3
Total Hardness	2
Ammonia	1
Nitrate	3
Kjeldahl N	3
Phosphate	3
Fecal Coliform	3
Lead	3
Mercury	3
Cadmium	3

The only other data except the Company's own monitoring is from Cunningham (1968) which does not reflect current operations. The Company's daily monitoring gives complete coverage for BOD and suspended combustible solids. The primary data gaps for this waste source are COD and nutrients over an extended period. In addition, a full broad spectrum analysis should be made to be sure there are no pollutants being overlooked. This broad spectrum should include sulfite, all of the metals, surfactants, oils and pesticides.

Kaiser #1, Kaiser #2, Spokane Industrial Park and Hillyard Processing. These four major dischargers to the Spokane River are represented only by the data for 9-11-72 to 9-20-72 contained in STORET. The parameters covered are as follows:

	Number of Observations			
Parameter	Kaiser #1	Kaiser #2	Spokane Ind. Park	Hillyard Processing
Temperature	3	3	4	3
BOD	2	2	4	3
Conductivity	2	2	3	3
DO	3	3	16	3
pH	-	-	13	-
Total Hardness	4	2	2	2
Chloride	1	-	-	1
Total Nitrate	3	2	2	3
Ammonia	-	-	1	1
Kjeldahl Nitrate	2	1	2	3
Total Phosphorus	3	2	2	3
Fecal Coliform	3	3	16	3
Ortho Phosphate	1	-	-	-
Lead	5	2	2	3
Mercury	4	2	2	3
Aluminum	4	2	-	2
Cadmium	5	2	2	3
COD	3	2	5	3
Residue Total NFLT	3	2	6	3
Total Coliform	3	3	16	3
Residue Diss 105	-	-	4	-
Residue Settleable	-	-	4	-

There are no other data available for these waste sources.

In addition to the gap inherent in the short period of time represented by the above listed test, there is a gap in parameters for oils, surfactants and pesticides.

Summarization of Groundwater Quality Data

Divisions of the Study Area. The study area has two aquifers of major interest to present water supply, namely the primary Spokane Valley aquifer (hereafter referred to as the "primary aquifer") and the "basalt aquifer." There are a number of other aquifers of lesser importance which, for the purpose of water quality summarization are herein referred to as "other aquifers." Refer to the section Geology and Groundwater for detailed descriptions of these aquifers. A grossly simplified summary description follows.

The outline of the primary aquifer is shown on Plate 309-3. It consists of the gravel filled valley through which the Spokane River flows from the Washington-Idaho boundary to the confluence of the Little Spokane River. The flow of the groundwater through this aquifer is from east to west and the primary source of water is in Idaho. There is interchange of surface and groundwater as the Spokane River flows through the aquifer. In general, at average flow and less, the river looses to the aquifer between the Idaho border and Greenacres and gains from the aquifer throughout the remainder. At higher river stages, the section which looses to the aquifer increases in length and quantity.

The basalt aquifer covers the study area south and southwest of the Spokane River below the Hangman Creek confluence and includes much of the Hangman Creek tributary area. This area is delineated on Plates 309-1, 2 and 3. The basalt aquifer consists of horizontally bedded layers of basalt (ancient lava flows) interlayer with relatively impervious siltstone known as the Latah formation.

The major elements of the other aquifer category are the gravel deposits in the valley of the Little Spokane River and its tributaries and the Chamokane Creek. There are also isolated wells in rock formation which predominate in the highlands of the northeast parts of the study area.

The availability of groundwater quality data is discussed in terms of its availability within each of these three main aquifer classifications.

Before making the breakdown summaries by aquifer, the groundwater quality data sources for the entire study area are discussed and a total inventory of quality data for the study area is developed and presented in Table 9.

Columns indicating the location of each well relative to these three aquifer classifications are shown on the total quality inventory of Table 9. Tables separating the wells by aquifer are discussed after the description of study area sources.

STORET contains groundwater quality data for 4 springs in the area. One of these is the Fish Hatchery Springs which is included in the USGS-EPA ongoing study. STORET is the only source of data for the other three springs. These springs were all sampled once by EPA for a wide spectrum of parameters and should be classified as Group II data sources.

Availability from STORET. STORET contains groundwater quality data on 41 wells in the study area. Of these 41 wells, the data for 21 are significant with respect to the breadth of coverage of parameters reported and that data are available for more than one time. The remaining 20 wells have data for only one time, with minor exception, and for a list of parameters usually limited to the "standards" list as shown in Table 7.

All of the groundwater quality data in STORET is for the primary Spokane Valley aquifer, with the exception of one well in the Little Spokane Valley aquifer near Mead. There are no data in STORET for the basalt aquifer. See discussion below on the aquifers in the study area.

Sources of Data in STORET. All data in STORET appear to be from published USGS sources, except that there are a few recent entries for which a published source has not been identified. The three published sources which provide practically all of the data in STORET are Weigle and Mundorf (1952), Van Denburgh and Santos (1965), and Cline (1969). Discussions below will show that not all the data available in these publications has been transferred to STORET. There are some entries that do not have the USGS well identifier number.

Availability of Data from Published Sources. The publications listed in Table 6 were canvased for groundwater quality data. Only the three publications referred to above as sources for STORET were found to contain data. These three published sources contain water quality data for 226 wells in the study area, including wells that are inside the primary aquifer and wells in basalt and other aquifers. These 226 wells and the available data and source are listed in Table 9 in order of the USGS identification number which, inherently, also gives location.

The availability of water quality data is shown in terms of the parameter categories defined in Table 7 except that the inapplicable categories are omitted and a new category is added to describe a special limited group of parameters as discussed below.

Earlier investigations such as Weigle and Mundorf (1952) and Van Denburgh and Santos (1965) usually included nitrates in their analyses but rarely included phosphates. The category "nutrients" being used herein for these two parameters is a misnomer as far as these early investigations are concerned since they were not looking for "nutrients" but were interested in nitrate (and/or nitrite) as related to the public health concern for methemogobinemia (blue baby).

Weigle and Mundorf (1952) is the source of data on 140 wells listed in Table 9. Of these, all but 22 have water quality data limited to the following four parameters: chlorides, total hardness, conductivity and alkalinity. Furthermore, these parameters were sampled and tested only once and all were in the period May - June 1951. This limited group of parameters is placed in a special category on Table 9. For 22 wells a wider spectrum of parameters is reported, being essentially the full set of the "standard" parameters listed in Table 7 plus nitrate for most. Also the dates of analysis for these 22 are not restricted to May - June 1951. In general the wells with limited parameters are not in STORET whereas the wells with a wider spectrum of data are included.

Van Denburgh and Santos (1965) is statewide in scope. Within the study area, data are included for wells in both the primary Spokane Valley aquifer and in the basalt and other areas. Thirty-seven wells from this source are in Table 9. Twelve of these wells are the same wells covered by Weigle and Mundorf. The spectrum of parameters reported in Van Denburgh is a complete set of "standard" tests per Table 7 plus nitrates and orthophosphates. Only part of the Van Denburgh and Santos (1965) data appears to be in STORET.

Cline (1969) covers north central Spokane County and southeastern Stevens County, the coverage being entirely with the study area. Cline (1969) reports on 41 wells both inside the primary Spokane Valley aquifer and those outside in basalt or other aquifers. Twenty-three analyses are for a single date of sample collection and the parameters reported are the "standard" list per Table 7 plus nitrates and phosphates in many cases. The analyses of the remaining 18 wells are of the very limited type reporting only hardness and specific conductance. STORET appears to contain most of the Cline (1969) data for wells within the primary aquifer but none of those outside.

Unpublished Sources of Data. There are two sources of unpublished groundwater quality data. The first is USGS who were able to provide chemical data on a total of 16 wells and 4 springs. The data for all except two miscellaneous wells are the result of the ongoing USGS-EPA program.

The USGS-EPA ongoing groundwater monitoring program is being carried out by USGS in conformance with criteria established by EPA. The program will run from June 1973 to June 1974 and will consist of 4 samples taken at 18 locations. The samples are being analyzed for the parameters listed in Table 10. Three sampling cycles have been completed. The wells and springs to be sampled are also listed in Table 10 and are plotted on Plate 309-3.

The locations were selected to meet the goals as indicated by the categories below:

Group	Purpose	Sample Points
A	To sample aquifer quality as it discharges from springs along the Little Spokane River	26/42 11J1 (s) 26/42 12A1 (s) 26/43 7B1 (s) 26/43 5L1 (s)
B	To sample the aquifer discharge to the Spokane River in the gap between the falls and Shadle Park	25/42 13B1
C	To sample a cross section of the aquifer in the vicinity of Park Rd. in East Spokane	25/44 19D1 25/44 18D2 25/43 13A1 25/44 7C1
D	To sample a cross section of the aquifer as it enters Washington	26/45 35F1 26/45 36N1 26/45 36Q1
E	To sample the possible effect of the Indian Trails (City) sanitary land fill	26/42 27N1
F	To sample the demolition waste disposal sites in East Spokane	25/43 14K1
G	To sample wells in a heavy industrial area, Trentwood	25/44 1J[illegible] 25/44 2Q[illegible]
H & I	To sample the possible effect of the County land disposal site at Greenacres (recently made inactive)	25/45 16K1 25/45 15D1

Both the USGS-EPA ongoing locations and the two miscellaneous locations are included in the total groundwater quality inventory of Table 9.

The second unpublished data source is the DSHS chemical and bacteriological files described previously. Neither of these files is in STORET and the data availability is not inventoried herein in Table 9.

Study Area Summary. As described above, the available groundwater quality data are summarized for the entire study area in Table 9, arranged in order of USGS number. In addition to showing the data availability by category per Table 7, Table 9 indicates the following:

1. Whether the data is available on STORET
2. If data is not on STORET, the other data source
3. The location of the well by aquifer
4. The geographical location of the well, inherent in the USGS number
5. An indication of the importance of the well as a water producer by symbol identifying those producing more than 5 million gallons per year.

The locations of the wells listed in Table 9 are shown on Plates 309-1, 309-2 and 309-3.

Available Data in the Primary Aquifer. The wells within this aquifer for which significant water quality data are available are listed in Table 11 and 12 and are located on Plate 309-3. Tables 11 and 12 do not list all wells for which water quality data are available, only those regarded as significant. For example none of the wells with "limited" data are listed.

Tables 11 and 12 categorize the significant source further into Group I data and Group II data respectively. Group I data is defined as at least standard tests plus nutrients and more than one test. All of the USGS-EPA ongoing series fall in this category since they include standard, nutrient, metal and pollutant parameters. Group II is defined as having at least one parameter category other than "limited" for a single date.

Of the 37 wells and springs listed in Table 11 having Group I data, only 12 have data prior to 1970. Wide spectrum analysis in general is represented predominantly by the more recent studies. By comparison, of the 29 wells listed in Table 12 having Group II data, 26 are prior to 1970.

The USGS-EPA ongoing program consisting of 14 wells and 4 springs provides 15 listings in Table 11 that are entirely dependent upon that source and only 3 that are represented by another data source. Therefore, approximately 40 percent of the presently available wide spectrum analysis data are dependent upon this ongoing program.

Data Gaps for the Primary Aquifer. The following factors are considered in evaluation of data gaps for the primary aquifer:

1. Parameters reported
2. Time period of record
3. Geographical location
   a. Relative to total area of the aquifer
   b. Relation to flow direction of the groundwater body
   c. Relation to the interchange with surface waters
   d. Relation to location of surface disposal of pollutants
4. Coverage of major water producing wells
5. Possible affect of rate of withdrawal on quality samples

Parameters Reported

The USGS-EPA ongoing program provides the widest available spectrum of parameters. The coverage in the standard, nutrient and metals categories is adequate. Only phenols and detergents are reported in the pollutants category and no bacteriological tests are made. Since none of the other sources report pesticides from the pollutant category, this absence constitutes a data gap. Due to the unsummarized condition of bacterial testing by DSHS, bacterial testing is also a data gap.

Time Period Reported

The primary interest is in existing conditions as far as absolute values are concerned but there is also an interest in trends which the present absolute values may not indicate. Twenty-eight of the 37 Group I sources are recent data representative of current conditions. Only 11 of the Group I sources go back 10 years or more but 25 of the Group II sources are 10 years old or more. Therefore, there is good recent coverage of a broad spectrum of parameters but there is good historical coverage only of the standard tests which dominate Group I.

The high rate of flushing of this aquifer indicated in the section on Geology and Groundwater probably reduces the potential for accumulation of pollutants. Hence, the difference, if any, between historical and current observations would be a measure of transient change rather then permanent long term accumulations.

From a time standpoint the data gap is for historical data on phosphates, metals and MBAS substances.

Geographical Location

Refer to Plate 309-3 on which groundwater quality locations are plotted for the primary aquifer. Four symbols are used to indicate class of data available at the locations:

1. Group I data from studies other than USGS-EPA ongoing program

2. USGS-EPA ongoing station (some of this also has data from previous studies, see Table 11)

3. Group II data

4. Limited chemical data

Considering the aquifer as a whole, the coverage of Group I data (which includes USGS-EPA ongoing) is absent or thin in the following locations:

1. North of the river from the Industrial Park to Otis Orchards

2. South of the river in the Dishman Opportunity area

3. Throughout the service area of the City of Spokane water system and north of the City to the Little Spokane

The direction of aquifer flow, the location of surface water interchange and relation to potential percolation of pollutants are considered together. Refer to the following plates in other sections of the report for delineation of these factors.

1. Plates 303-28 to 35 from the section on Geology and Groundwater for groundwater surface contours indicating direction of flow.

2. Figure E of the section on Surface Waters showing the location of groundwater and surface water interchanges and direction of flow under mean annual conditions.

3. Plates 311-1 from the section on Waste Water Sources and Systems for the location of areas presently served by septic tank and drain field disposal systems.

There are four Group I sources which span the aquifer in the vicinity of the Washington-Idaho line to measure the quality as the primary groundwater flow enters the study area. Three of these, however, are close to the river in a section where there is surface water discharge from the river into the aquifer. Comparison of the analytical data for 26/45-36N1 (Siverson) and 26/45-36Q1 (Borden) indicate that the Siverson well may be heavily influenced by the river as indicated by 560 mg/l concentration of zinc. It would appear that one or two more wells farther from the river are needed to reinforce the data on the groundwater before it is subject to the surface water inflow.

The surface water exchange to groundwater extends approximately to Greenacres. There are no sample stations near the river in this stretch to detect the extent of this influence.

The heavy concentration of septic tanks and drainfields begins near Trentwood, speaking in terms of the direction of groundwater flow. There are no Group I wells to adequately span the cross section of the aquifer prior to entering the area of drainfields.

There is a good concentration of Group I sources spanning the aquifer in two bands just east of the City limit which should adequately represent the groundwater flow through this narrows of the aquifer. These wells are under and downstream in terms of aquifer flow from the drainfield area.

There are no Group I observations in the City area as the primary aquifer flow turns north away from the river toward the Hillyard Trough and continues through the trough to the springs along the Little Spokane, except for one Kaiser well. There is another drainfeild area beginning north of the City and extending to the Little Spokane River. All of the Group I samples as the aquifer reaches the Little Spokane River are springs. These springs probably do not fully represent the deep flow entering the Little Spokane. Lack of sampling points within the City, at the Hillyard Trough and well samples at the Little Spokane constitute data gaps.

Coverage of Major Water Producing Wells

Table 15 lists the major water producing wells in the primary aquifer abstracted from the section Water Systems and Useage. This list is marked to indicate which are represented by Group I and Group II data.

Of the 37 Group I sources, 24 correspond to major water users and 13 are not listed in Table 15. The significance of a well not being in Table 15 is that it is not part of a municipal or industrial system. Of the 13 not listed, four are private domestic wells, three are commercial/industrial wells serving small businesses, one serves the Holiday Hills recreation area, one is owned by the Federal government and four are springs. Significantly, eleven of the unlisted wells are part of the USGS-EPA ongoing program.

Of the 24 Group I sources that are also major municipal or industrial wells, 18 have data from previous studies and 6 have the USGS-EPA ongoing program as their source.

Comparing the 29 Group II sources with Table 15 indicates that 18 coincide with listed major water users and that 11 are not in Table 15. The unlisted wells consist of 8 private, 2 Washington Water Power, and one Union Sand and Gravel. The 2 Washington Water Power wells are not in the inventory of active wells furnished to the consultant for this study. The Union Sand and Gravel well is reported as having been destroyed.

Considering the data gap in representation of major producers together with the geographical gaps discussed above, Table 18 is presented listing major users that are not represented by quality data in three geographical areas where there is weak representation.

Possible Affect of Rate of Withdrawal

The primary aquifer is unique in the volume of water flowing through its cross section. Refer to the section Geology and Groundwater. If pollution is reaching the surface of this large flow volume it probably would remain on the surface without significant vertical mixing in the aquifer. Large volume wells undoubtedly draw from lower layers as well as the surface of the aquifer as evidenced by the extremely small drawdowns observed. Therefore it is possible that large volume wells represent a smaple of the aquifer that contains proportionately less of the surface layer than might a very small volume well essentially skimming from the surface.

The fact that there are few broad spectrum samples from very small wells may constitute a data gap.

Possible Affect of Season

The availability of moisture in sufficient volume to possibly carry ground surface pollution down through the unsaturated zone of the aquifer is dependent upon the time of year. The maximum volume per unit of time would be available either at the thaw or at a heavy precipitation period following a thaw. Concentrations of surface water occuring at dry well disposal sites for streets and highways might be particularly critical.

Most of the wide spectrum data presently available is the USGS-EPA ongoing program which is for June, September and December.

The lack of data at and following the spring thaw may constitute a data gap.

Consistency in Available Data

Reference to Table 10 containing the USGS-EPA ongoing analytical results locations shown for these analyses on Plate 309-3 indicates the following with reference to consistency of key parameters throughout the aquifer.

1. The Ruth Jeffers well shows such radically different quality combined with its location at the approximate contact line of the aquifer indicate that it probably is not a primary aquifer well. The following statements are with reference to the remainder of the Table 10 list without the Ruth Jeffers well.

2. Conductivity, total hardness and pH show great consistency from where the aquifer enters the study area from Idaho to where it discharges into the Spokane and Little Spokane River. pH is almost constant, varying from 7.4 to 7.8. Conductivity and hardness show a slight trend of increase as the water travels through the aquifer but there are individual exceptional cases. Conductivity and hardness ranges from approximately 275 and 140 respectively to 300 plus and 150.

3. Except for the Borden, Siverson and Kaiser wells the zinc content is in the range 10 to 50 mg/1. These three exceptional cases show values of 120, 560 and 360 respectively. Since the river water zinc concentration ranges between 10 and 730 mg/1 with an average of 290 mg/1 and these three wells are near the river and in a reach where surface water transfer to the aquifer is suspected, these analytical results appear to confirm the interchanges.

4. There is a slight trend toward increased chloride content as the water progresses through the aquifer. The CID #10 well which appears to be uninfluenced by the river, shows 0.8 mg/1 chloride. All other wells are higher, ranging up to 8.6 mg/1, but two major springs at the aquifer discharge are 2.3 mg/1.

5. MBAS was detected at 0.03 mg/1 in only one well, Kaiser. MBAS was undetected at all others.

The foregoing indicates that there is a high degree of consistency throughout the aquifer and that for the standard chemical tests, little additional information will be obtained from additional locations. A search could be made through the uncatalogued files of DSHS chemical tests for the standard tests made on the particular wells listed in Table 18 to confirm the consistency of these parameters.

Summary of Primary Aquifer Gaps

Summarizing from the foregoing paragraphs, the data gaps for groundwater quality in the primary aquifer are as follows:

1. Pesticide analyses for the entire area
2. Bacterial testing or a major categuing and summarization effort for existing DSHS data
3. Geographical areas and major users as listed in Table 18
4. Sampling at time of year where there is maximum percolation from the aquifer surface combined with low rate withdrawal from the surface of the aquifer.

Available Data in the Basalt Aquifer. The wells within the basalt aquifer for which significant quality data are available are listed in Table 13 and locations are shown on Plates 309-1 and 2. All except one well listed in Table 13 has Van Denburgh and Santos (1965) as its source. Therefore these data consist of standard tests plus nitrate and are for the years 1960 and earlier.

Table 16 lists the major water users of the basalt aquifer. Only four wells in Table 16 coincide with those for which data are available. The municipal wells for Tekoa, Latah, Fairfield, Cheney, Rockford, Spangle and Airway Heights are not represented by water quality data.

Since the available data spectrum is no better than the DSHS routine chemical tests, all the wells listed on Table 16 could presumably be brought up to the same data availability level as those on Table 13 by a search of the uncatalogued files of DSHS.

There are no data for this aquifer in the metals, bacteriological and pollutant categories of Table 7.

Data Gaps for the Basalt Aquifer. This aquifer is entirely different in character than the primary aquifer which is essentially one larger continuous underground body of water. This aquifer is believed to be essentially discontinuous vertically; that is, between horizontal layers of water bearing basalt and the extent of lateral movement in each layer is unknown. Therefore, coverage must be considered on an individual well basis rather than by area. The scatter of wells for which data are available would not necessarily be a measure of the quality of relatively nearby major producers not sampled.

For the wells which produce most of the water in the area, this aquifer can be said to be without water quality data for the entire broad spectrum of parameters.

Available Data in Other Aquifers. The wells in other aquifers for which significant quality data are available are listed in Table 14 and locations are shown on Plate 309-1. There are only 14 wells for which standard tests or better are available. Of these only Liberty Lake Utilities and Spokane County Golf Course wells have Group I data.

Table 17 lists the major water users in the other aquifers. The Little Spokane Valley is the largest single unit in the "other aquifers" category with 15 municipal service wells. The next largest group are those bordering the Spokane River in the vicinity of Long Lake with 7 wells. The remainder are the two Bureau of Indian Affairs wells at Wellpinit and the two wells in the Liberty Lake area. Refer to Plate 314-10 for the location of these wells. Of the wells listed in Table 17, only the following four have water quality data as listed in Table 14:

Washington Water Power Riverview Hills in Little Spokane area

Lakeridge Water Co. in the Long Lake area

Liberty Lake Utilities and Spokane County Golf Course, both in Liberty Lake area

Data Gaps for the Other Aquifer

There are no wells in the Little Spokane Valley area, the Wellpinit area and the Long Lake area for which there are broad spectrum analyses. A data gap exists for these three areas essentially for all parameters.

There are two wells in the Liberty Lake area with Group I data. The data gap for this area consists of bacteriological data.

TABLE 1

SURFACE WATER PARAMETERS ORDERED FROM STORET

Storet Code #	Parameter	Units
00010	Water Temperature	°C
00060	Stream Flow	CFS
00070	Turbidity	JTU
00310	BOD_5	mg/1
00095	Conductivity @ 25°C	micromhos
00300	DO	mg/1
00400	pH	SU
00500	Residue, Total	mg/1
00900	Total Hardness-$CaCO_3$	mg/1
00940	Chloride	mg/1
00610	NH_3-N, Total	mg/1
00615	NO_2-N, Total	mg/1
00620	NO_3-N, Total	mg/1
00625	Total Kjeldahl-N	mg/1
00665	Phosphorus, Total	mg/1
00671	Dissolved Orthophosphate-P	mg/1
00515	Residue, Dissolved, 105°C	mg/1
70300	Residue, Dissolved, 180°C	mg/1
31504	Total Coliform, MFIMLES	No/100ml
31616	Fecal Coliform	No/100ml
00915	Calcium, Dissolved	mg/1
00925	Magnesium, Dissolved	mg/1
00930	Sodium, Dissolved	mg/1
00935	Potassium, Dissolved	mg/1
00945	Sulfate-SO_4	mg/1
00950	Fluoride, Dissolved	mg/1
01040	Copper, Dissolved	ug/1
01045	Iron, Total	ug/1
01055	Manganese	ug/1
00760	Sulfite Waste Liquor-PBI	mg/1
01090	Zinc, Dissolved	ug/1
01051	Lead, Total	ug/1
71900	Mercury, Total	ug/1
01020	Boron, Dissolved	ug/1
01025	Cadmium, Dissolved	ug/1

TABLE 1 (Continued)

Storet Code #	Parameter	Units
01030	Chromium, Dissolved	ug/l
01075	Silver, Dissolved	ug/l
01105	Aluminum, Total	ug/l
01000	Arsenic, Dissolved	ug/l
01027	Cadmium, Total	ug/l
00340	COD, High Level	mg/l
00530	Residue, Total Nonfilterable	mg/l
00545	Residue, Settleable	mg/l
71850	Nitrate, Total NO_3	mg/l
71855	Nitrite, Total NO_2	mg/l
71845	Ammonia, Total NH_4	mg/l
00631	NO_2 and NO_3-N, Dissolved	mg/l
00636	NH_3 and Organic-N, Dissolved	mg/l
00650	Total Phosphate-PO_4	mg/l
31501	Total Coliform-MFIMENDO	No/100ml
60050	Algae, Total	No/ml
60820	Protozoa, Total	No/ml
60990	Zooplankton	No/liter

For complete description of parameters, see referenced code number in Storet Training Course (1972), Vol. I.

TABLE 2

PARTIAL LIST OF OTHER SURFACE WATER PARAMETERS
AVAILABLE FROM STORET

Storet Code #	Parameter	Units
00077	Transparency	Secchi inches
00080	Color	PT-CO
00301	DO Saturation	%
00311	Dissolved BOD_5	mg/1
00322	BOD_{10}	mg/1
00323	BOD_{15}	mg/1
00324	BOD_{20}	mg/1
00335	COD, Low Level	mg/1
00341	Dissolved COD	mg/1
00410	Total Alkalinity-$CaCO_3$	mg/1
00425	HCO_3 Alkalinity-$CaCO_3$	mg/1
00440	HCO_3 Ion	mg/1
00445	CO_3 Ion	mg/1
00505	Residue, Total Volatile	mg/1
00520	Residue, Volatile Filterable	mg/1
00535	Residue, Volatile Nonfilterable	mg/1
00600	Total Nitrogen	mg/1
00605	Organic-N	mg/1
00608	NH_3-N, Dissolved	mg/1
00613	NO_2-N, Dissolved	mg/1
00618	NO_3-N, Dissolved	mg/1
00630	NO_2 and NO_3, Total	mg/1
00635	NH_3 and Organic-N, Total	mg/1
00653	Soluble PO_4, Total	mg/1
00660	Ortho PO_4	mg/1
00666	Phosphorus, Dissolved	mg/1
00680	Total Organic Carbon	mg/1
00691	Dissolved Organic Carbon	mg/1
00685	Total Inorganic Carbon	mg/1
00690	Total Carbon	mg/1
00720	Cyanide	mg/1
00902	Hardness-Noncarbonate	mg/1
00910	Calcium, $CaCO_3$	mg/1
00916	Calcium, Total	mg/1
00927	Magnesium, Total	mg/1

TABLE 2 (Continued)

Storet Code #	Parameter	Units
00929	Sodium, Total	mg/l
00931	Sodium Absorption	ratio
00932	Sodium	percent
00937	Potassium, Total	mg/l
00951	Fluoride, Total	mg/l
00955	Silica, Dissolved	mg/l
00956	Silica-SiO_2	mg/l
01001	Arsenic, Suspended	ug/l
01002	Arsenic, Total	ug/l
01005	Barium, Dissolved	ug/l
01010	Beryllium, Dissolved	ug/l
01016	Bismuth, Suspended	ug/l
01022	Boron, Total	ug/l
01032	Chromium, Hex-valent	ug/l
01034	Chromium, Total	ug/l
01035	Cobalt, Dissolved	ug/l
01037	Cobalt, Total	ug/l
01042	Copper, Total	ug/l
01046	Iron, Dissolved	ug/l
01049	Lead, Dissolved	ug/l
01056	Manganese, Dissolved	ug/l
01057	Thallium, Dissolved	ug/l
01059	Thallium, Total	ug/l
01060	Molybdenum, Dissolved	ug/l
01062	Molybdenum, Total	ug/l
01065	Nickel, Dissolved	ug/l
01067	Nickel, Total	ug/l
01077	Silver, Total	ug/l
01080	Strontium, Dissolved	ug/l
01082	Strontium, Total	ug/l
01092	Zinc, Total	ug/l
01095	Antimony, Dissolved	ug/l
01097	Antimony, Total	ug/l
01106	Aluminum, Dissolved	ug/l
01130	Lithium, Dissolved	ug/l

TABLE 2 (Continued)

Storet Code #	Parameter	Units
01132	Lithium, Total	ug/l
01145	Selenium, Dissolved	ug/l
01147	Selenium, Total	ug/l
01501	Alpha, Total	pc/l
01503	Alpha, Dissolved	pc/l
01505	Alpha, Suspended	pc/l
03501	Beta, Total	pc/l
03503	Beta, Dissolved	pc/l
03505	Beta, Suspended	pc/l
31503	Total Coliform, MFDLENDO	No/100ml
31506	Total Coliform, MPN Conf	No/100ml
31507	Total Coliform, MPN Comp	No/100ml
31615	Fecal Coliform, MPNECMED	No/100ml
32730	Phenols	ug/l
38260	MBAS	mg/l
70507	Phos-T, Ortho	mg/l
70301	Dissolved Solids	mg/l
70303	Dissolved Solids	tons/acre-feet
39330	Aldrin	ug/l
39340	BHC	ug/l
39350	Chlordane	ug/l
39360	DDD	ug/l
39365	DDE	ug/l
39370	DDT	ug/l
39380	Dieldrin	ug/l
39390	Endrin	ug/l
39400	Toxphene	ug/l
39410	Heptachlor	ug/l
39420	Heptachlor Epoxide	ug/l
39782	Lindane	ug/l
60100	Algae, COC BG	No/ml
60200	Algae, COC Grn	No/ml
60150	Algae, Fil BG	No/ml
60250	Algae, Fil Grn	No/ml
60300	Algae, Flag-Grn	No/ml
60350	Algae, Flag-other	No/ml
60390	Diatoms, dom spec.	% of total

TABLE 3A

SURFACE WATER QUALITY STATION AVAILABLE FROM STORET
SPOKANE RIVER

K-T Number	River Mile	Description	Period of Record From	Period of Record To	Remarks
1	2.0	Below Little Falls Dam	5-6-70	11-24-70	Sta. 1-9 correspond to Sta. 3-11 in Bishop & Lee report
2	5.7	"	"	"	
3	10.3	"	"	"	
4	12.8	"	"	"	STORET contains the 1970 data from Bishop & Lee study but does not contain 1971 data contained in the Spokane River Cooperative Water Quality Study
5	17.1	"	"	"	
6	20.8	"	"	"	
7	29.0	"	"	"	
8	33.3	Below Long Lake Dam	11-10-71	6-12-73	EPA Data
8	33.3	At Long Lake Dam	10-24-62	6-26-73	DOE Data Same Station
8	33.3	At LONG Lake Dam	10-1-59	3-28-73	USGS Data
9	34.0	Lower Long Lake	9-15-72		EPA - vertical H_2O Quality Profile
		.5 Miles above Long Lake Dam	Entered as stations in STORET but without data. Appears to be an abortive attempt to enter Cunningham & Pine data.		DOE # 54A071
		Above Long Lake Dam			DOE # 54A075
		1 Mile below Tumtum			DOE # 54A079
15	42.5	Long Lake near Tumtum	9-15-72		EPA Data
		4 Miles above Tumtum	Entered as stations in STORET but without data. Appears to be an abortive attempt to enter Cunningham & Pine data.		DOE # 54A083
		8 Miles above Tumtum			DOE # 54A087

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WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SURFACE WATER QUALITY STATION AVAILABLE FROM STORET SPOKANE RIVER	TABLE 3A

TABLE 3A (cont.)

K-T Number	River Mile	Description	Period of Record From	To	Remarks
20	51.0	At Upper Long Lake	9-14-72		EPA - vertical H_2O Quality Profile
22	56.7	Below 9 Mile Dam	3-14-68	6-12-73	EPA } Same Station
22	56.7	Below 9 Mile Dam	11-30-70	4-24-73	USGS } Same Station
22		At 9 Mile Bridge	11-30-70	7-11-73	DOE } Same Station
23	58.1	Above 9 Mile Dam	9-12-72	9-13-72	EPA - 7 samples
24	61.9	At 7 Mile Bridge	9-12-72	9-13-72	EPA - 2 samples } Same Station
24	61.9	At 7 Mile Bridge	10-10-72	4-24-72	USGS } Same Station
25	66.0	At Bowl & Pitcher/Riverside Park	9-12-72	6-12-73	EPA } Same Station
25	66.0	At Riverside State Park	10-10-72	6-26-73	DOE } Same Station
29	69.8	At Fort Wright Bridge	9-12-72	6-12-73	EPA } Same Station
29	69.8	At Fort Wright Bridge	11-30-70	7-11-73	DOE } Same Station
29	69.8	At Fort Wright Bridge	10-10-72	4-24-73	USGS } Same Station
31	73.4	At Cochran St. Gage	9-12-72	6-12-73	EPA } Same Station
31	73.4	At Spokane	10-10-72	7-11-73	DOE } Same Station
31	73.4	At Cochran St. Gage	10-10-72	4-24-73	USGS } Same Station
32	74.0	At Monroe St. Bridge	9-12-72	9-14-72	EPA - 3 samples
35	74.5	At Washington St. Bridge	9-12-72	9-14-72	EPA - 3 samples
38	76.8	At Mission St. Bridge	9-12-72	6-12-73	EPA } Same Station
38	76.8	At Mission St. Bridge	11-30-70	7-11-73	DOE } Same Station
38	76.8	At Mission St. Bridge	10-10-72	4-24-73	USGS } Same Station
41	79.5	Below Spokane City Dam	9-12-72	9-13-72	EPA - 2 samples
42	80.5	Above Spokane City Dam	9-12-72	9-15-72	EPA - 7 samples
44	81.7	Near Sekani	9-12-72	9-13-72	EPA - 6 samples
45	82.6	At Argonne Road Bridge	9-12-72	9-15-72	EPA - 3 samples

TABLE 3A (cont.)

K-T Number	River Mile	Description	Period of Record From	Period of Record To	Remarks
46	85.3	At Trent Road Bridge	9-12-72	6-12-73	EPA } Same Station
46	85.3	At Trent Road Bridge	10-10-72	7-11-73	DOE } Same Station
46	85.3	At Trent Road Bridge	10-10-72	4-24-73	USGS } Same Station
47	87.8	At Sullivan Road Bridge	9-12-72	9-15-72	EPA - 3 samples
48	90.4	At Barker Road Bridge	9-12-72	9-13-72	EPA - 2 samples
49	92.7	At Harvard Road Bridge	9-12-72	9-15-72	EPA - 3 samples
50	93.9	Above Liberty Bridge	11-4-59	9-24-71	USGS
50	93.9	Near Otis Orchards	7-29-59 & 11-30-70	10-29-63 7-11-73	DOE
51	96.3	At Stateline Bridge			USGS } Same Station
51	96.5	At Stateline Bridge	9-12-72	3-27-73	EPA } Same Station
51	96.3	At Stateline Bridge	10-10-72	7-11-73	EPA } Same Station
51	96.3	At Stateline	4-8-69	8-17-72	Idaho St. } Same Station
53	98.7	Below Post Falls Dam	8-20-69	8-25-71	EPA
54	101.8	WPSS Post Falls Dam	5-14-62	3-9-71	FWPCA - 4 samples/month

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SURFACE WATER QUALITY STATION AVAILABLE FROM STORET SPOKANE RIVER	TABLE 3A

TABLE 3B

SURFACE WATER QUALITY STATION AVAILABLE FROM STORET
LITTLE SPOKANE RIVER

K-T Number	River Mile	Description	Period of Record From	Period of Record To	Remarks	
55	1.1	Near Fort Spokane near mouth	9-13-72	6-12-73	EPA	Same Station
55	1.1	Near mouth	11-30-70	7-11-73	DOE	Same Station
55	1.1	Near Fort Spokane near mouth	11-30-70	4-24-73	USGS	Same Station
58	10.2	At Dartford	9-13-72	9-14-72	EPA	
58		At Dartford	7-28-60	9-20-70	USGS	
59	10.8	Near Dartford	9-13-72	6-12-73	EPA	Same Station
59		Above Wandermere	7-28-60	4-24-66	DOE	Same Station
59	10.75	Near Dartford at Gage			USGS	Same Station

TABLE 3C

SURFACE WATER QUALITY STATION AVAILABLE FROM STORET
HANGMAN AND CHAMOKANE CREEKS

K-T Number	River Mile	Description	Period of Record From	To	Remarks
		HANGMAN CREEK			
66	0.6	At mouth at Spokane	9-12-72	6-12-73	EPA } Same Station
66	0.6	At mouth at Spokane	10-10-72	7-11-73	DOE } Same Station
66	0.6	At mouth at Spokane	10-10-72	4-24-73	USGS } Same Station
67		Near Spokane	2-2-68	6-28-68	USGS
		CHAMOKANE CREEK			
68		At Ford Washington	2-21-68	6-29-68	USGS

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SURFACE WATER QUALITY STATION AVAILABLE FROM STORET HANGMAN AND CHAMOKANE CREEKS	TABLE 3C

TABLE 3D

SURFACE WATER QUALITY STATION AVAILABLE FROM STORET
WASTE SOURCES AND LAKES

K-T Number	River Mile	Description	Period of Record From	To	Remarks
		WASTE SOURCES			
1-W	67.2	Spokane STP effluent	9-12-72	9-20-72	EPA - 31 samples
2-W	56.3/21.3/ 15.3	Deer Park STP effluent	9-19-72	9-20-72	EPA - 20 samples (discharge to Oregon Cr.
3-W	82.6	Inland Empire Paper effluent	9-11-72	9-14-72	EPA - 9 samples
4-W	86.0	Kaiser #2 effluent	9-12-72	9-14-72	EPA - 7 samples
5-W	86.8	Kaiser #1 effluent	9-12-72	9-14-72	EPA - 9 samples
6-W	87.0	Spokane Industrial Park STP - Effluent	9-12-72	9-20-72	EPA - 24 samples
7-W	87.5	Hillyard Processing Effluent	9-11-72	9-14-72	EPA - 9 samples
		LAKES			
1-L	N.A.	Liberty Lake at Liberty Lake	3-30-71	9-27-71	USGS
2-L	N.A.	Newman Lake near Newman Lake	3-29-71	9-29-71	USGS

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SURFACE WATER QUALITY STATION AVAILABLE FROM STORET WASTE SOURCES AND LAKES	TABLE 3D

TABLE 4

GROUNDWATER QUALITY PARAMETERS ORDERED FROM STORET

Parameter	Units	Parameter	Units
Water Temperautre	°C	Residue - d 180°C	mg/l
Conductivity	Micromhos	Sodium - d	mg/l
Dissolved Oxygen	mg/l	Potassium - d	mg/l
BOD_5	mg/l	Sulfate - d	mg/l
COD	mg/l	Fluoride - d	mg/l
pH		Iron - total	ug/l
Residue - total	mg/l	Manganese	ug/l
Total Hardness - $CaCO_3$	mg/l	Calcium - d	mg/l
Chloride	mg/l	Nitrate - total NO_3	mg/l
Silica - d	mg/l		
Aluminum - total	ug/l		
Mercury - total	ug/l		
Copper - d	ug/l		
Zinc - d	ug/l		
Boron - d	ug/l		
Arsenic - d	ug/l		
Cadmium - d	ug/l		
Chromium - d	ug/l		
Silver - d	ug/l		

TABLE 5

PUBLISHED REPORTS SEARCHED FOR
SURFACE WATER QUALITY DATA

Publication	All Available Data Already In STORET	Data Supplemental To STORET	Remarks
Bishop, Robert A. Loon, Deer and Diamond Lakes Water Quality Study, State of Washington Department of Ecology, 1973.	NO	Baseline physical, chemical and biological data for these lakes.	
Bishop, Robert A. and Ronald A. Lee. Spokane River cooperative water quality study. Washington (State) Department of Ecology, 1972.	NO	For year 1971	1970 Data in STORET but 1971 not
Burkhalter, Richard A., Richard K. Cunningham and Harry B. Tracy. A report on the water quality of the Little Spokane River. Washington (State) Water Pollution Control Commission, 1970.	NO	10 stations on the Little Spokane 1968	None of the available data is in STORET
Condit, Richard J. "Phosphorus and Algal Growth in the Spokane River" in Northwest Science Vol. 46 No. 3, 1972.	N	-	Contains water quality data but no dates. Not added to summary
Cunningham, Richard K. Effluent study; Inland Empire Paper Company-Millwood, Washington. Washington (State) Pollution Control Commission, 1968.	NO	Data from Sept. 23 & 24 1968	None of the data in this report is available from STORET
Cunningham, Richard K. and Roland E. Pine. Preliminary investigations of the low dissolved oxygen concentrations that exist in Long Lake located near Spokane, Washington. Washington (State) Water Pollution Control Commission, 1969.	NO	-	Stations 1, 5, 7, 11, 12 and 14 corresponds to Stations 11, 13, 15, 17, 18, and 19 respectively in the Bishop and Lee report
Cunningham, Richard K. and Gary Rothwell. Water quality report of the Spokane and Little Spokane Rivers, December, 1970 - March, 1971. Washington (State) Department of Ecology. Also same title for periods 4/71 to 6/71 and 7/71 to 9/71.	YES	-	Data for all 3 time periods is on STORET
Haggarty, Thomas G. Water pollution in the Spokane River. Status report. Washington (State) Department of Ecology, 1970.	-	-	No original data as such. This report cites DO and Bacteriological data but without reference to source and gives a general outline of the major W.Q. problem areas.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	PUBLISHED REPORTS SEARCHED FOR SURFACE WATER QUALITY DATA	TABLE 5

TABLE 5 (cont.)

Publication	All Available Data Already In STORET	Data Supplemental To STORET	Remarks
Lee, Ronald A. Limnological studies of selected Washington State Lakes. Washington (State) Water Pollution Control Commission, 1969.	NO	Data on Newman, Diamond, West Medical, and Silver Lake	DO & Temperature profiles for 10-22-68
Soltero, Raymond A. An investigation of the cause and effect of eutrophication in Long Lake, Washington. Data of publication - August, 1973.	NO	Monthly data for 6 river Stations and 5 Stations in Long Lake 1972-73	Continuing program into 1973-74
Todhunter, R. A. and R. K. Cunningham. Water quality report on the Spokane and Little Spokane Rivers, April, 1971 - June, 1971. Washington (State) Department of Ecology, 1972.	YES		
Washington (State) Pollution Control Commission. Preliminary report - Spokane River water quality below Long Lake Reservoir. Published jointly with Lincoln County Health Department and U.S. National Park Service, 1971.			
U.S. Public Health Service, Pacific Northwest Drainage Basin Office. Report on water pollution control, Spokane River Basin, 1972	NO	Heavy metal data from 1930's and some DO & BOD data from 1950's	

TABLE 6

PUBLISHED REPORTS SEARCHED FOR GROUNDWATER QUALITY DATA

Publication	All Available* Data Already In STORET	Data Supplemental To STORET	Remarks
Cline, D.R., Groundwater resources and related geology, north-central Spokane and southeastern Stevens counties, of Washington. Washington (State) Department of Water Resources, Water Supply Bulletin No. 27, 1969.	NO	29 well samples 5-7-42/ 1-29-65	12 wells are listed that are on STORET. For all wells standard parameters were analyzed.
Crosby, J.W. and Others, Final report: investigation of techniques to provide advance warning of groundwater pollution hazards with special references to aquifers in glacial outwash. August, 1971.	—	No chemical data	No analyses of groundwater were made as part of this study. The approach used concentrated on measurements in the unsaturated zone.
Esvelt and Saxton Consulting Engineer, public health relationship of the Minnihana Sewer District to the greater Spokane community. 1965.	—	No chemical data	Two case histories of groundwater contamination in Spokane.
Fosdick, E.R. A study of groundwater in the Spokane and Rathdrum Valleys. Washington Water Power Company. 1931.	—	No chemical date	General discussion of the Spokane Valley Aquifer.
Johnson, Walter E., Spokane groundwater, mimeographed report, Washington State University. 1971.	—	No chemical data	Discussion of the quantity of groundwater flowing into Washington.
Mace, R.L., and Fader, S.W., Record of wells on Rathdrum Prairie. Bonner and Kootenai Counties, Northern Idaho, Geological Survey, Boise. 1950	—	No chemical data	Report states that chemical data will be released in subsequent report. Not found.
Phillips, R.A. and Others, Spokane Valley groundwater pollution study. Washington State University. 1962	NO	Bacteriological and ABS	Bacteriological data for 17 wells and ABS data for 2 wells. Also reports bacteriological & ABS test results for soil sample from special borings.
Van Denbrugh, A.S., and J.F. Santos, Groundwater in Washington - its chemical and physical quality. Water Supply Bulletin #24, Washington (State) Department of Natural Resources. 1965	NO	An additional 80 samples representing approximately 20 wells	Wells grouped by counties in report Many wells are located on Fort Wright or Fairchild AFB
Weigle, J.M. and M.J. Mundorff, Record of wells, water levels and quality of groundwater in Spokane Valley, Spokane County, Washington. U.S. Geological Survey, Groundwater Report No. 2, Tacoma. 1952	NO	Alkalinity, total hardness, chloride and conductivity readings for many additional wells	Well locations & drill logs. Single sample analysis of 22 wells. Alkalinity, hardness, Cl, & conductivity analysis for all wells mentioned.
Woodward, Walter, Consulting Engineers, A report of an inventory and study; water resources and utilities; Spokane tribe of Indians, Spokane reservation. 1971	NO	Qualitative chemical data for 2 wells on reservation.	Very little chemical data (2 wells) Good inventory of wells on Spokane Indian Reservation as well as their approximate yield. Data not quantitative.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	PUBLISHED REPORTS SEARCHED FOR GROUNDWATER QUALITY DATA	TABLE 6

TABLE 7

GROUPING OF WATER QUALITY PARAMETERS INTO CATEGORIES

Category	Parameter in Category	Minimum Number of Parameters to Qualify for Category Coverage
Standard Test	S_1O_2, Fe, Mn, Ca, Mg, Na, K, HCO_3, SO_4, Cl, F, Settleable Solids, Dissolved Solids, Total Dissolved Solids, Hardness, Conductivity, Alkalinity, Color, pH, Turbidity, Temperature	5
Nutrients	NH_3, NO_3, NO_2, Total N, Total Kjel N, Total P, Ortho P	2
Oxygen Balance	BOD, COD, DO	1
Metals	Zinc, Lead, Mercury, Cadmium, Chromium, Silver, Copper, Arsenic, Boron	1
Bacteriological	Total Coli, Fecal Coli	1
Biological	Algae, Protozoa, Zooplankton	1
Pollutants	Oil & Grease, Pesticides, Surfactants, Sulfite Waste Liquor, Phenols	1

TABLE 8

INVENTORY OF SURFACE WATER QUALITY DATA

K-T Number	(1) Location	River Mile	Description	COVERAGE BY PA Standard Test From	Standard Test To	Nutrients From	Nutrients To
1	S	2	Below Little Falls Dam			5-6-70	9-14-71
2	S	5.7	Below Little Falls Dam			5-6-70	9-14-71
3	S	10.3	Below Little Falls Dam			5-6-70	9-14-71
4	S	12.8	Below Little Falls Dam			6-22-70	9-14-71
5	S	17.1	Below Little Falls Dam			6-22-70	9-14-71
6	S	20.8	Below Little Falls Dam			6-22-70	9-14-71
7	S	29.0	Below Little Falls Dam			6-22-70	12-8-71
8	S	33.3	Below Long Lake Dam	9-12-66	3-15-73	9-12-66	3-15-73
9	S	34.0	Lower Long Lake Near Dam	7-27-71	9-15-72	7-27-71	9-15-72
10	S	35.0	Long Lake	9-14-66	9-15-66	9-16-66	9-16-66
11	S	36.5	Long Lake	9-14-66	9-14-66		
12	S	39.0	Long Lake			7-21-71	9-15-71
13	S	40.5	Long Lake			9-16-66	9-16-66
14	S	41.5	Long Lake	5-6-72	3-15-73	7-21-71	3-15-73
15	S	42.5	Long Lake Near Tumtum			9-12-66	9-15-72
16	S	44.0	Long Lake			9-14-66	9-16-66
17	S	45.0	Long Lake	5-6-72	3-15-73	5-6-72	3-15-73
18	S	47.0	Long Lake	7-26-71	9-22-71	7-21-71	9-15-71
19	S	49.0	Long Lake	5-6-72	3-15-73	5-6-72	3-15-73
20	S	51.0	Upper Long Lake	9-14-66	9-16-66	9-14-66	9-14-72

See Sheet 63 for Notes

COVERAGE BY PARAMETER CATEGORIES

Nutrients		Oxygen Balance		Metals		Bacteriological		Biological		F
rom	To	From	To	From	To	From	To	From	To	
-6-70	9-14-71	5-6-70	9-14-71			5-6-70	9-14-71			
-6-70	9-14-71	5-6-70	9-14-71			5-6-70	9-14-71			
-6-70	9-14-71	5-6-70	9-14-71			5-6-70	9-14-71			
-22-70	9-14-71	6-23-70	9-14-71			6-23-70	9-14-71	6-15-71	8-17-71	
-22-70	9-14-71	6-23-70	9-14-71			6-23-70	9-14-71			
-22-70	9-14-71	6-23-70	9-14-71			6-23-70	12-8-71			
-22-70	12-8-71	6-23-70	12-8-71			6-23-70	12-8-71			
-12-66	3-15-73	9-12-66	3-15-73	9-14-72	6-26-73	9-13-66	9-15-72			9-1
-27-71	9-15-72	7-27-71	9-15-72	9-15-72	9-15-72	7-27-71	9-21-71	7-27-71	9-21-71	
-16-66	9-16-66	9-14-66	9-15-66							
								5-6-72	3-15-73	
-21-71	9-15-71	7-27-71	9-21-71			9-1-71	9-1-71			
-16-66	9-16-66									
-21-71	3-15-73	7-27-71	9-21-71			9-1-71	9-1-71	6-21-71	3-15-73	
-12-66	9-15-72	9-12-66	9-15-72	9-12-66	9-15-72					
-14-66	9-16-66									
-6-72	3-15-73	5-6-72	3-15-73					5-6-72	3-15-73	
-21-71	9-15-71	7-26-71	9-22-71			9-1-71	9-1-71	7-21-71	7-21-71	
-6-72	3-15-73	5-6-72	3-15-73			5-6-72	3-15-73	5-6-72	3-15-73	
-14-66	9-14-72	9-14-66	9-14-72	9-14-72	9-14-73	9-1-71	9-1-71			

Biological From	Biological To	Pollutants From	Pollutants To	(2) References	(3)	Remarks
				1,3	NO	(5)
				1,3	NO	(5)
				1,3	NO	(5)
6-15-71	8-17-71			1,3	NO	(5)
				1,3	NO	(5)
				1,3	NO	(5)
				1,3	NO	(5)
		9-16-66	9-16-66	1,2,3,4,5	NO	KT-8 equal No. 8 in Ref. 2, Dam in Ref. 4 & DOE 54A070 and No. 10 of KT S&A. See Ref.2 for 1966, Ref. 3 for 1970-71, Ref.4 for 1972-73 and STORET for metals. (5)
7-27-71	9-21-71			1,2,3,4,7	NO	KT-9 equal No. 0 in Ref. 4. See Ref. 7 for 1971 bio and Ref. 4 for 1972-73 bio. (5)
				2	NO	KT-10 equal No. 2 in Ref. 2
5-6-72	3-15-73			2,4	NO	KT-11 equal No. 3 in Ref. 2 and No. 1 in Ref.4 and No. 9 of KT S&A. See Ref.4 for 1966 and Ref. 4 for 1972-73
				3	NO	Equal No. 12 in Ref. 3
				2	NO	Equal No. 4 in Ref. 2
6-21-71	3-15-73			2,3,4	NO	Equal No. 5 in Ref. 2 and No. 2 in Ref. 4 Biological in Ref. 4
				1,2	NO	Equal No. 5.5 in Ref. 2
				2	NO	Equal No. 6 in Ref. 2
5-6-72	3-15-73			4	NO	Equal No. 3 in Ref. 4
7-21-71	7-21-71			3	NO	Equal No. 14 in Ref. 3
5-6-72	3-15-73			4	NO	Equal No. 4 in Ref. 4
				1,2,3	NO	Equal No. 15 in Ref. 3 and No. 7 in Ref. 2 1966 in Ref. 2, 1971 in Ref. 3, 1972 in Ref. 1

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF SURFACE WATER QUALITY DATA	TABLE 8

TABLE 8 (cont.)

INVENTORY OF SURFACE WATER QUALITY DATA

K-T Number	(1) Location	River Mile	Description	COVERAGE BY PARA Standard Test From	To	Nutrients From	To
21	S	56.5	Long Lake Above Little Spokane			8-23-71	9-15-71
22	S	56.7	Below 9 Mile Dam at Bridge	3-14-68	7-11-73	3-14-68	2-6-73
23	S	58.1	Above 9 Mile Dam	9-12-72	9-13-72	9-12-72	9-13-72
24	S	61.9	At 7 Mile Bridge	12-16-65	9-13-72	12-16-65	9-13-72
25	S	66.0	Bowl/Pritcher State Park	9-14-66	7-11-73	9-14-66	1-18-73
26	S		Below STP	3-31-72	3-31-72		
27	S		Above STP	3-12-72	3-31-72		
28	S		Adjacent to Rivercrest	3-31-72	3-31-72		
29	S	69.8	Fort Wright Bridge	9-12-66	3-20-73	9-12-66	1-18-73
30	S		Above Fort Wright			3-12-72	3-31-72
31	S	73.4	At Cochran St. Gage	10-10-72	6-12-73	10-10-72	4-24-73
32	S	74.0	At Monroe St. Bridge	9-12-66	9-14-72	9-12-66	9-14-72
33	S		Black Angus			3-12-72	3-31-72
34	S		Spokane Linen			3-12-72	3-31-72
35	S	74.5	At Washington St. Bridge			9-12-72	9-13-72
36	S		Below Gonzaga Univ.			3-12-72	3-31-72
37	S		Gonzaga Univ.			6-15-72	7-25-72
38	S	96.8	At Mission St. Bridge	11-30-70	6-26-73	11-30-70	4-24-73
39	S	78.0	At Greene St. Bridge	9-12-66	9-16-66	9-12-66	9-16-66
40	S		Above Greene St.			3-12-72	3-31-72
41	S	79.5	Below Spokane Dam			3-12-72	9-13-72
42	S	80.5	Above Spokane Dam			9-12-72	9-15-72
43	S		Upriver Drive (Felts)	1-10-72	9-14-72	1-10-72	9-14-72
44	S	81.7	Near Sekani			9-12-72	9-15-72
45	S	82.6	At Argonne Rd. Bridge	9-12-66	9-15-72	9-12-66	9-15-72

See Sheet 63 for Notes

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METER CATEGORIES

Oxygen Balance From	Oxygen Balance To	Metals From	Metals To	Bacteriological From	Bacteriological To	Biological From	Biological To	Pollutants From	Pollutants To	Refer
7-26-71	9-22-71							11-30-70	9-19-71	1,
3-14-68	7-11-73	4-17-68	11-22-72	11-30-70	7-11-73					
9-12-72	9-13-72	9-12-72	9-13-72	9-12-72	9-13-72					1
12-16-65	9-13-72	3-26-66	9-13-72							
9-14-66	7-11-73					6-15-71	6-15-71	9-14-66	9-16-66	1,2,
9-12-66	6-26-73	11-19-71	7-11-73	11-30-70	6-26-73	6-15-71	8-17-71	9-14-66	9-19-72	1,2,
10-10-72	4-10-73	11-19-71	7-11-73	10-10-72	7-11-73			9-12-66	9-14-72	
9-12-66	9-14-72			9-12-72	9-14-72					
9-12-72	9-14-72	9-12-72	9-13-72	9-12-72	9-13-72					
6-15-72	6-15-72							11-30-70	9-19-71	
10-10-72	4-24-73	10-10-72	3-27-73	10-10-72	3-13-73	6-15-71	8-17-71	9-16-66	9-16-66	1,
9-12-66	9-16-66									
9-12-72	9-13-72	9-12-72	9-13-72	9-12-72	9-13-72			9-15-72	9-15-72	
9-12-72	9-15-72	9-12-72	9-15-72	9-12-72	9-13-72					
1-10-72	9-14-72	1-10-72	4-1-72	3-1-71	11-19-72	10-1-72	9-14-72	9-13-72	9-13-72	
9-12-72	9-15-72	9-12-72	9-15-72	9-12-72	9-15-72			9-12-66	9-13-72	
9-12-66	9-15-72	9-12-72	9-15-72	9-12-72	9-15-72					

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	Biological		Pollutants		(2)		
	From	To	From	To	References	(3)	Remarks
					3	NO	Equal No. 16 of Ref. 3
-73			11-30-70	9-19-71	1,2,5	NO	Equal No. 10 of Ref. 2
-72					1	YES	Equal No. 7 of KT S&A
					1,4	NO	Equal "Seven Mile" of Ref. 4. See Ref. 4 for 1972-73.
	6-15-71	6-15-71	9-14-66	9-16-66	1,2,3,6,7	NO	Equal No. 11 of Ref. 2 and No. 17 of Ref. 3. See Ref. 6 for 1972 nutrient and oxygen balance.
					6	NO	
					6	NO	
					6	NO	
-73	6-15-71	8-17-71	9-14-66	9-19-72	1,2,3,4,5,7	NO	Equal "Fort Wright" in Ref. 4,6 & 7, No.12 in Ref. 2 and No. 18 in Ref. 3
					6	NO	
-73					1	YES	
-72			9-12-66	9-14-72	1,2	NO	Equal No. 13 in Ref. 2. See Ref. 1 for 1972 and Ref. 2 for 1966.
					6	NO	
					6	NO	
-72					1	YES	
					6	NO	
					6	NO	
-73			11-30-70	9-19-71	1,5	NO	
	6-15-71	8-17-71	9-16-66	9-16-66	1,2,3,7	NO	Equal No. 14 of Ref. 2, No. 9 of Ref. 3 and No. 4 of KT S&A. Ref. 3 contains data from Ref. 7.
					6	NO	
-72					1,6	NO	
-72			9-15-72	9-15-72	1	YES	
9-72	10-1-72	9-14-72			6	NO	
-72			9-13-72	9-13-72	1	YES	
-72			9-12-66	9-13-72	1,2	NO	Equal No. 15 of Ref. 2. See Ref. 2 for 1966 and Ref. 1 for 1972

TABLE 8 (cont.)

INVENTORY OF SURFACE WATER QUALITY DATA

COVERAGE BY PARA

K-T Number	(1) Location	River Mile	Description	Standard Test From	Standard Test To	Nutrients From	Nutrients To
46	S	85.3	At Trent Rd. Bridge	9-12-66	7-11-73	9-12-66	1-18-73
47	S	87.8	At Sullivan Rd. Bridge			9-12-72	9-15-72
48	S	90.4	At Barker Rd. Bridge	9-12-72	9-13-72		
49	S	92.7	At Harvard Rd. Bridge	10-10-71	9-15-72	10-10-71	9-14-72
50	S	93.9	Above Liberty Bridge	11-4-59	7-11-73	11-4-59	9-23-71
51	S	96.3	At Stateline Bridge	4-8-69	10-18-72	9-12-66	9-13-72
52	S	97.0	Corbin Park	10-10-71	12-2-71	10-10-71	12-2-71
53	S	98.7	Below Post Falls Dam	8-20-69	8-25-71	8-20-69	8-25-71
54	S	101.8	WPSS Post Falls Dam	5-14-62	3-9-71	12-7-64	3-9-71
55	LS	1.1	Near Mouth	2-13-68	6-26-73	2-13-68	6-2-73
56	LS	3.9	At Rutter Parkway	2-13-68	9-10-68	2-13-68	9-10-68
57	LS	7.9	At Waikiki Rd.	2-13-68	9-10-68	2-13-68	9-10-68
58	LS	10.2	River at Dartford	2-13-68	9-10-68	2-13-68	9-10-68
59	LS	10.8	River near Dartford	7-28-60	7-11-73	7-28-60	7-11-73
60	LS	13.1/1.0	Little Deep Creek @ Confluence	2-13-68	9-10-68	2-13-68	9-10-68
61	LS	13.8	At Little Spokane Rd.	2-13-68	9-10-68	2-13-68	9-10-68
62	LS	21.3	Dragoon Creek @ Confluence	2-13-68	9-10-68	2-13-68	9-10-68
63	LS	31.8	At Milan	2-13-68	9-10-68	2-13-68	9-10-68
64	LS	33.0	E. Little Spokane above W. Little Spokane	2-13-68	9-10-68	2-13-68	9-10-68
65	LS	32.9/1.0	W. Little Spokane near E. Little Spokane	2-13-68	9-10-68	2-13-68	9-10-68

See Sheet 63 for Notes

COVERAGE BY PARAMETER CATEGORIES

Nutrients		Oxygen Balance		Metals		Bacteriological		Biological		P
From	To	From	To	From	To	From	To	From	To	From
6	1-18-73	9-12-66	7-11-73	9-12-72	7-11-73	10-10-72	7-11-7			9-12-
2	9-15-72	9-12-72	9-15-72	9-12-72	9-15-72	9-12-72	9-12-72	6-15-71	8-17-71	
		9-12-72	9-13-72			9-12-72	9-13-72			
71	9-14-72	10-10-71	9-14-72	10-10-71	5-12-72	10-10-71	11-9-72	10-1-71	9-14-72	
9	9-23-71	11-4-59	7-11-73	12-3-59	9-23-71	11-30-70	7-11-73			11-30
6	9-13-72	9-12-66	9-13-72	7-13-71	7-11-73					
71	12-2-71	10-10-71	12-2-71	10-10-71	12-2-71	10-21-71	11-18-71			
9	8-25-71	8-20-69	8-25-71	12-15-70	8-25-71	10-21-69	8-25-71			
4	3-9-71	12-5-68	1-9-71	10-1-62	1-1-68	12-5-68	3-9-71	5-14-62	4-15-63	9-23-
8	6-2-73	2-13-68	6-26-73	11-19-71	7-11-73	2-13-68	6-26-73	2-13-68	9-10-68	
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68	2-13-68	9-10-68	
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68	2-13-68	9-10-68	
8	9-10-68	2-13-68	9-10-68	9-14-72	9-14-72	2-13-68	9-10-68	2-13-68	9-10-68	
0	7-11-73	7-28-60	7-11-73	4-25-60	7-11-73	2-13-68	7-11-73			
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68			
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68	2-13-68	9-10-68	
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68			
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68	2-13-68	9-10-68	
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68	2-13-68	9-10-68	
8	9-10-68	2-13-68	9-10-68			2-13-68	9-10-68	2-13-68	9-10-68	

Biological From	Biological To	Pollutants From	Pollutants To	(2) References	(3)	Remarks
		9-12-66	7-11-73	1,2	NO	Equal No. 2 of KT S&A and No. 16 of Ref. 2. See Ref. 2 for 1966
6-15-71	8-17-71			1,3,7	NO	Equal No. 20 of Ref. 3. Biological data is from Ref. 3 reprinted from Ref.7
				1	YES	
10-1-71	9-14-72			1,6	NO	Equal No. 1 of KT S&A
		11-30-70	7-11-73	1,5	YES	Also called near Otis Orchards
				1,2,6	NO	Equal No. 17 of Ref. 2 and "Stateline" of Ref. 6
				6	NO	
				1	YES	
5-14-62	4-15-63	9-23-64	9-29-67	1	YES	
2-13-68	9-10-68			1,4,5,9	NO	No. Ref. 4 or 9 data is in STORET (Ref.1) (6)
2-13-68	9-10-68			9	NO	(6)
2-13-68	9-10-68			9	NO	(6)
2-13-68	9-10-68			1,9	NO	(6)
				1,9	NO	(6)
				9	NO	(6)
2-13-68	9-10-68			9	NO	(6)
				9	NO	(6)
2-13-68	9-10-68			9	NO	(6)
2-13-68	9-10-68			9	NO	(6)
2-13-68	9-10-68			9	NO	(6)

TABLE 6 (cont.)

INVENTORY OF SURFACE WATER QUALITY DATA

K-T Number	(1) Location	River Mile	Description	COVERAGE BY PA... Standard Test From	Standard Test To	Nutrients From	Nutrients To
66	HC	72.4/0.6	At Mouth at Spokane	10-10-72	3-13-73	10-10-72	4-24-73
67	HC	72.4/5.0	Near Spokane	2-20-68	6-28-68		
68	CC	32.5/6.9	Near Ford	2-21-68	6-29-68		
1	W	67.2	Spokane STP eff.	5-6-72	3-15-73	5-6-72	3-15-73
2	W	21.3/15.3	Deer Park STP eff.				
3	W	82.6	Inland Empire Paper eff.	9-23-66	9-14-72	9-12-72	9-14-72
4	W	86.0	Kaiser #2	9-13-72	9-14-72	9-13-72	9-14-72
5	W	86.8	Kaiser #1	9-13-72	9-14-72	9-13-72	9-14-72
6	W	87.0	Spokane Industrial Park	9-12-72	9-14-72	9-12-72	9-14-72
7	W	87.5	Hillyard Processing	9-12-72	9-14-72	9-12-72	9-14-72
1	LK	N.A.	Liberty Lake @ Liberty Lake	3-30-71	9-27-71	3-30-71	9-27-71
2	LK	N.A.	Newman Lake nr. Newman Lake	3-29-71	9-29-71	3-29-71	9-29-71
3	LK	N.A.	Diamond Lake	10-22-68	9-16-71	4-14-71	10-16-71
4	LK	N.A.	West Medical Lake	Temp., P.O.,	pH,	& Conductivity,	10/21/68
5	LK	N.A.	Silver Lake	" "	"	"	"

COVERAGE BY PARAMETER CATEGORIES

...trients		Oxygen Balance		Metals		Bacteriological		Biological		P...
	To	From	To	From	To	From	To	From	To	From
-72	4-24-73	10-10-72	4-10-73	11-19-71	6-12-73	10-10-72	6-26-73			10-10
2	3-15-73	5-6-72	3-15-73	5-6-72	3-15-73	9-12-72	9-20-72			
		9-19-72	9-20-72			9-19-72	9-20-72			
72	9-14-72	9-23-66	9-14-72	9-12-72	9-14-72	9-12-72	9-14-72			
72	9-14-72	9-13-72	9-14-72	9-13-72	9-14-72	9-13-72	9-14-72			
72	9-14-72	9-13-72	9-14-72	9-13-72	9-14-72	9-13-72	9-14-72			
72	9-14-72	9-12-72	9-14-72	9-12-72	9-14-72	9-12-72	9-14-72			
72	9-14-72	9-12-72	9-14-72	9-12-72	9-14-72	9-12-72	9-14-72			
71	9-27-71									
71	9-29-71									
71	10-16-71	4-14-71	8-31-72					4-14-71	8-31-72	
y,	10/21/68									
	"									

l	Biological From	Biological To	Pollutants From	Pollutants To	(2) References	(3)	Remarks
26-73			10-10-72	10-31-72	1,4	NO	Equal "HC" Station of Ref. 4
					1	YES	
						YES	
20-72					1,4	NO	
20-72					1	YES	
14-72					1,8	NO	
14-72					1	YES	
14-72					1	YES	
14-72					1	YES	
14-72					1	YES	
					1,12	NO	
					1,11,12	NO	
	4-14-71	8-31-72			10,11,13	NO	
					11	NO	
					11	NO	

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF SURFACE WATER QUALITY DATA	TABLE 8 (cont.)

Notes for Table 8:

(1) S = Spokane River, LS = Little Spokane River, HC = Hangman Creek, CC = Chamokane Creek, W = Waste Source, LK = Lake

(2) References for Table 8

Reference Number	Source of Data
1	STORET
2	Cunningham and Pine (1969)
3	Bishop and Lee (1972)
4	Soltero (1973)
	Cunningham and Rothwell (1971)
5	Todhunter and Cunningham (Nov. 1972)
	Todhunter and Cunningham (Aug. 1972)
6	Funk (1973)
7	Condit (1972)
8	Cunningham (1968)
9	Burkhalter, Cunningham and Tracy (1970)
10	Bishop (1973)
11	Lee (1969)
12	US Geological Survey (1971)
13	US Geological Survey (1971)

(3) Total indicated record on STORET, yes or no

(4) KT S&A indicates sampling and analysis station for simulation model calibration.

(5) Refer to Ref. 3 for 1971 data
Refer to Ref. 3 for biological data reprinted from Ref. 7
KT identification number 1-9 correspond to Sta. 3-11 in Ref. 3
KT-7 approx. same location as No. 11 of KT S&A (4)

(6) KT Station 55-65 correspond to Stations 1-11 in Ref. 9.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF SURFACE WATER QUALITY DATA	TABLE 8

TABLE 9

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer Primary	Aquifer Basalt	Aquifer Other	USGS Well Number	(1)	Coverage by Parameter Categories: Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	(2) Data Sources	Remarks
	X		T22N. R43E-32L			X	X				1	
	X		T24N. R40E-3N1	5		X	X				1	
	X		-22L1			X	X				1	Five samples
	X		T24N. R41E-3N			X	X				1	Nineteen samples
	X		-11N1			X	X				1	
	X		23K-1			X	X	X		X	4	
		X	T24N. P45E-4(a)			X	X				1	
	X		T25N. R40E-14R1			X	X				1	
	X		34NE 1/4			X	X				1	
	X		T25N. R41E-1R1			X	X				1	
	X		-10G1			X	X				1	
	X		-28			X	X				1	
	X		-34C			X	X				1	
X			T25N. R42E-3H1	5		X	X	X			2, 3, 4, $	Group I Part is composite with 3H-2
X			-11	5		X	X				1,$	Group I
X			11M1			X	X				1,$	Group I
X			11M2			X	X				1	Group I Seven samples
X			11R1		X						3	
X			12E1		X						3	
X			12M1		X						3	
X			13B1			X	X	X		X	1,3,4	Group I
X			23B1		X						3	
X			24A1		X						3	
	X		25SW 1/4			X	X				1	
	X		29R1	5		X	X				1	Eleven samples
	X		31J1			X	X				3	
		X	T25N. R43E-2D1		X						3	
X			2Q1		X						3	
X			4B1	5		X	X				3	
X			4B2	5		X	X				1,2,3,$	

(1) (2) See Sheet 7) For Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9

TABLE 9 (cont.)

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer Primary	Aquifer Basalt	Aquifer Other	USGS Well Number	(1)	Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	(2) Data Sources	Remarks
					COVERAGE BY PARAMETER CATEGORIES							
X			T25N. R43E-4J1		X						3	
X			6Q1		X						3	
X			T25N. R43E-8A1	5	X						3	
X			8D1			X	X				1,3,$	
X			8F1		X						3	
X			8H1		X						3	
X			9G1			X	X				1,3,$	
X			9G2		X						3	
X			9H1		X						3	
X			9H2		X						3	
X			9H3		X						3	
X			10H1		X						3	
X			10J1		X						3	
X			10M1		X						3	
X			10R1		X						3	
X			11A1(s)			X	X	X	X		S	Spring
X			11B1		X						3	
X			11C1		X						3	
X			11C2		X						3	
X			11D2		X						3	
X			11E1		X						3	
X			11G1	5		X	X	X	X		1,3,$	Group I Part is composite with 11G3
X			11G2	5	X							
X			11G3		X						3	
X			11G4			X	X	X			1,3,$	Group I
X			11G5		X						3	
X			11J1	5		X	X				1	Group I
X			11J2	5				X			S	
X			11J4	5				X			S	
X			11N2		X						3	
X			11N3		X						3	

(1) (2) See Sheet 71 For Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9 (cont.)

TABLE 9 (cont.)

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer: Primary	Basalt	Other	USGS Well Number	(1)	COVERAGE BY PARAMETER CATEGORIES: Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	(2) Data Sources	Remarks
X			T25N. R43E-11R1		X						3	
X			12H1	5		X	X	X			3,5	Group I
X			13A1	5		X	X	X		X	4	
X			13K1		X						3	
X			13L2		X						3	
X			13Q1		X						3	
X			14C1		X						3	
X			14F1		X						3	
X			14P2		X						3	
X			14G1		X						3	
X			14G2		X						3	
X			14J1		X						3	
X			14K1			X	X	X		X	4	Group I
X			15C1		X						3	
X			15G1		X						3	
X			15G2		X						3	
X			16J1	5	X						3	
X			17D1		X						3	
X			17D2		X						3	
		X	18G1		X						3	
		X	18L1		X						3	
X			19D1		X						3	
X			21B1		X						3	
X			22F1	5		X	X				3	Composite with 22 F2
X			23A1	5		X	X	X			5	Group I
X			23A2			X	X	X			5	Group I
X			24G1	5		X	X	X			5	Group I
X			T25N. R44E-1J1	5		X	X	X		X	3,4	Group I
X			1M1			X					3	
X			2B1	5		X					2,3,5	

(1) (2) See Sheet [illegible] For Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9 (cont.)

TABLE 9 (cont.)

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer			USGS		COVERAGE BY PARAMETER CATEGORIES						(2)	
Primary	Basalt	Other	Well Number	(1)	Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	Data Sources	Remarks
X			T25N. R44E-2Q1			X	X	X		X	4	Group I
X			4J1		X						3	
X			4K1		X						3	
X			4K2		X							
X			4R3	5		X	X	X			4,S	
X			6A1	5		X	X				2,S	
X			7C1	5		X	X	X		X	4	Group I
X			7J1		X						3	
X			8N1						X		5	
X			9J1		X						3	
X			9J2			X	X	X	X		3	
X			11R1(s)		X						S	
X			13M1						X		5	
X			13M2	5	X						3	
X			15E1	5		X	X		X		1,3,5,S	
X			15E2	5		X	X	X	X		5,S	Group I
X			15J1	5	X				X		3,5	
X			16E1						X		5	
X			17A1						X		5	
X			17M1						X		5	
X			18D2	5		X	X	X		X	4	Group I
X			18M1			X	X				1,3,S	
X			19D1			X	X	X		X	4	Group I
X			20J1	5	X						3	
X			20J2		X						3	
X			20K1		X						3	
X			21J1						X		5	
X			22N1						X		5	
X			2[illegible]R1	5	X				X		3,5	
X			26D1	5		X	X	X	X		3,5,S	Group I

(1) (2) See Sheet 71 For Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9 (cont.)

TABLE 9 (cont.)

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer			USGS		COVERAGE BY PARAMETER CATEGORIES						(2)	
Primary	Basalt	Other	Well Number	(1)	Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	Data Sources	Remarks
X			T25N. R44E-26L1	5	X				X		3,5	
X			27E1	5		X	X	X			5	Group I
X			28E1		X						3	
X			28M1		X						3	
X			29A1	5		X	X	X			5	Group I
X			29B1		X						3	
X			29Q1		X						3	
X			29Q2		X						3	
X			T25N. R45E-4A1			X	X				1,3,5	
		X	14N1			X	X				1,5	
		X	14M2	5		X	X	X			5	
X			15D1			X	X	X		X	4	
		X	16K1			X	X	X		X	4	Group I
X			17Q1		X						3	
X			18A1	5		X	X				1,3,5	
X			18R1	5		X	X	X			5	Group I
		X	20P2		X						3	
		X	20R1		X						3	
X			T26N. R42E-3E1		X						3	
X			4L1		X						3	
X			5C1		X						3	
X			5F1		X						3	
X			5L1		X						3	
X			6K1		X						3	
X			7A1		X						3	
X			7A2		X						3	
X			7A3		X						3	
X			7G1			X	X				1,3	Shown 32 mg/l NO_3
X			7G2		X						3	
X			8M1		X						3	
X			8N1		X						3	

(1) (2) See Sheet 7 For Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9 (cont.)

TABLE 9 (cont.)

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer Primary	Aquifer Basalt	Aquifer Other	USGS Well Number	(1)	Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	(2) Data Sources	Remarks
					COVERAGE BY PARAMETER CATEGORIES							
X			T26N. R42E-8P1		X						3	
X			8R1		X						3	
X			10F1		X						3	
		X	10L1		X						3	
X			11J1(s)			X	X	X	X	X	S,2,4	Group I Spring
X			12A1(s)			X	X	X		X	4	Group I
X			12L1			X	X				2,S	
		X	15B1		X						3	
X			15E1		X						3	
X			16K1		X						3	
X			17A1		X						3	
X			17A2		X						3	
X			20A1		X						3	
X			20A2		X						3	
X			20 SW 1/4			X	X				1	Group I Eight samples
X			21D1		X						3	
X			21D2		X						3	
X			21D3		X						3	
X			21E1		X						3	
X			21G1		X						3	
X			27N1			X	X	X		X	2,S	Group I
X			27N2			X	X				2,S	
X			28(s)			X	X	X	X		S	Spring
X			34N1		X						3	
X			T26N. R43E-5L1(s)			X	X	X		X	4	Group I Spring
X			6G1			X	X				2,S	
X			7B1(s)			X	X	X		X	4	Group I Spring
X			8B4			X	X				2,S	
X			10K1	5		X	X				2,S	
		X	11F2			X	X				2	

(1) (2) See Sheet 71 For Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9 (cont.)

TABLE 9 (cont.)

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer Primary	Aquifer Basalt	Aquifer Other	USGS Well Number	(1)	Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	(2) Data Sources	Remarks
					COVERAGE BY PARAMETER CATEGORIES							
		X	T26N. R43E-12G1		X						2	
X			16C1			X					3	
X			16D2			X					3	
X			16D3		X						3	
X			16F1			X					3	
X			16F2			X	X				1,2,5	Group I
X			17G1		X						3	
X			19A1	5		X	X				1,2,3	
X			19G1		X						3	
X			19H2		X						3	
X			19L1		X						3	
X			19L2		X						3	
X			19R1		X						3	
X			20J2		X						2	
X			22N1		X						3	
		X	24L2		X						2	
		X	24N1		X						2	
		X	27A1		X						3	
X			27E1	5		X	X				1,2,3,5	
X			27L1		X						3	
X			27R1		X						3	
		X	30D1		X						3	
X			30R2	5		X	X				2,5	
X			34E1		X						3	
X			34P1		X						3	
		X	T26N. R44E-30D2		X						2	
X			32R1			X	X				2	
X			T26N. R45E-35F1	5		X	X	X		X	4	Group I
X			36E1			X	X				1,3	
X			36N1			X	X	X		X	4	Group I

(1) (2) See Sheet 7) For Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9 (cont.)

TABLE 9 (cont.)

INVENTORY OF GROUNDWATER QUALITY DATA

Aquifer Primary	Aquifer Basalt	Aquifer Other	USGS Well Number	(1)	Limited	Standard Test	Nutrients	Metals	Bacteriological	Pollutants	(2) Data Sources	Remarks
					COVERAGE BY PARAMETER CATEGORIES							
X			T26N. R45E-36Q1			X	X	X		X	4	Group I
X			T26N. R46E-31M1	5		X	X	X			S	Group I
		X	T27N. R41E-26Q2			X					4	
		X	T27N. R43E-17H1		X						2	
		X	18J1		X						2	
		X	22M1	5		X	X				2	
		X	26M1			X	X				S	
		X	T28N. R39E-25H			X	X				1	
		X	T28N. R41E-11P1		X						2	
		X	T28N. R42E-3A1		X						2	
		X	34P1		X						2	
		X	T28N. R43E-6N1		X						2	
		X	6N2		X						2	
		X	22D1			X	X				2	
		X	T28N. R44E-19P1		X						2	
		X	T29N. R42E-14M1		X						2	
		X	18P1		X						2	
		X	20J1		X						2	
		X	23K1			X	X				2	
		X	35P2	5	X						2	
		X	T29N. R43E-14D1		X						2	
		X	29N1			X	X				2	
		X	29N2			X	X				2	
		X	T29N. R44E-6H2			X	X				1,2	

Notes for Table 9

(1) A 5 in this column indicates that the well produces 5 million gallons per year or more.
(2) Data sources are identified as follows:

1 - Van Denburgh and Santos (1965)
2 - Cline (1969)
3 - Weigle and Mundorf (1952)
4 - USGS - EPA ongoing study, unpublished

S - Entire indicated record in STORET
$ - Portion of record in STORET
5 - Phillips (1962)

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF GROUNDWATER QUALITY DATA	TABLE 9 (cont.)

PARAMETER	UNITS	25/42 13B1 Spokane Cold Storage 6-28-73	9-26-73	12-17-73	3-20-74	25/43 13A1 W.W.P. #1-3 6-29-73	9-25-73	12-17-73
Ammonia	mg/l	0.010	0.010	0.010	0.02	0.020	0.020	0.010
Alkalinity Total (as $CaCO_3$)	mg/l	138.000	135.000	135.000	140	126.000	119.000	119.000
Arsenic	ug/l	0.000	6.000	2.000	1	29.000	5.000	2.000
Bicarbonate	mg/l	168.000	165.000	165.000	171	153.000	145.000	145.000
Cadmium	ug/l	1.000	0.000	0.000	0	1.000	0.000	0.000
Calcium	mg/l	39.000	40.000	43.000	47	32.000	32.000	30.000
Carbon Dioxide	mg/l			3.300	8.7			1.500
Carbonate	mg/l	0.000	0.000	0.000	0	0.000	0.000	0.000
Chloride	mg/l	8.600	12.000	24.000	24	1.700	2.100	1.400
Chromium	ug/l	0.000	0.000	0.000	0	0.000	0.000	0.000
Conductivity	umhos/cm	336.000	335.000	388.000	410	270.000	265.000	261.000
Copper	ug/l	2.000	4.000	3.000	8	20.000	30.000	50.000
Detergents MBAS	mg/l	0.000	0.030	0.020	0.03	0.000	0.100	0.000
Fluoride	mg/l	0.100	0.000	0.200	0.1	0.100	0.000	0.200
Hardness, Noncarbonate	mg/l	17.000	18.000	34.000	43	12.000	15.000	10.000
Hardness, Total	mg/l	160.000	150.000	170.000	180	140.000	130.000	130.000
Iron	ug/l	30.000	110.000	30.000	10	130.000	10.000	150.000
Lead	ug/l	0.000	4.000	0.000	1	3.000	3.000	4.000
Magnesium	mg/l	14.000	13.000	15.000	16	14.000	13.000	13.000
Manganese	ug/l	0.000	0.000	0.000	140	0.000	10.000	30.000
Mercury, Total	ug/l	0.000	0.000	0.000	0	0.100	0.000	0.000
Nitrate	mg/l	1.700	1.400	1.300	1.6	.840	1.000	1.000
Nitrite	mg/l	0.002	0.001	0.002	0.003	0.000	0.003	0.003
Nitrogen, Kjeldahl	mg/l	0.120	0.160	0.070	0.25	0.050	0.040	0.030
pH		7.4	7.7	7.9	7.5	7.7	8.2	8.2
Phenols	ug/l	0.000	1.000	0.000	0	0.000	0.000	0.000
Phosphate, Ortho, as P	mg/l	0.005	0.006	0.009	0.006	0.007	0.005	0.025
Phosphate, Total, as P	mg/l	0.006	0.006	0.010	0.007	0.011	0.006	0.031
Potassium	mg/l	2.300	2.500	2.800	2.8	1.800	1.900	2.000
Residue	ton/AFT	0.240	0.260	0.290	0.31	0.210	0.230	0.190
Residue 180C	mg/l	179.000	188.000	210.000	231	154.000	170.000	140.000
SAR		0.200	0.200	0.400	0.3	0.100	0.100	0.100
Sodium	mg/l	6.600	7.000	11.000	9.5	3.000	2.700	3.200
Sodium	percent	8.000	9.000	12.000	10	4.000	4.000	5.000
Sulfate	mg/l	16.000	16.000	17.000	21	13.000	12.000	12.000
Water Temperature	°C	12.400	12.000	12.000	12.0	10.000	17.000	18.500
Zinc	ug/l	10.000	20.000	30.000	30	50.000	20.000	90.000

TABLE 10

GROUNDWATER QUALITY DATA FROM
THE ONGOING USGS-EPA PROGRAM

25/43 13A1			25/43 14K1				25/44 1J-1					
W.P. #1-3			Acme Concrete Co.				Spokane Industrial Park No. 2				Kaiser Alum	
-73	12-17-73	3-22-74	6-27-73	9-25-73	12-17-73	3-20-74	6-27-73	9-25-73	12-17-73	3-20-74	6-27-73	9-25
20	0.010	0.03	0.010	0.010	0.010	0.02	0.010	0.010	0.010	0.03	0.010	0.
00	119.000	121	107.000	107.000	107.000	100	136.000	143.000	148.000	135	146.000	145.
00	2.000	2	0.000	0.000	0.000	1	3.000	4.000	4.000	3	4.000	6.
00	145.000	147	131.000	131.000	130.000	122	166.000	174.000	181.000	164	178.000	177.
00	0.000	0	1.000	0.000	0.000	0	0.000	0.000	0.000	0	1.000	0.
00	30.000	32	29.000	30.000	30.000	30	35.000	37.000	41.000	35	39.000	40.
	1.500	3			1.700	3.1			3.600	6.6		
00	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.000	0	0.000	0.
00	1.400	2.2	1.500	2.100	1.800	2.3	1.500	1.100	1.400	0.9	4.400	3.
00	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.000	0	0.000	0.
00	261.000	268	235.000	236.000	238.000	235	284.000	297.000	325.000	293	336.000	320.
00	50.000	50	6.000	4.000	3.000	4	10.000	16.000	2.000	5	9.000	3.
00	0.000	0	0.000	0.000	0.030		0.000	0.060	0.010	0.1	0.030	0.
00	0.200	0	0.000	0.000	0.200	0.1	0.100	0.000	0.200	0.2	0.100	0.
00	10.000	17	6.000	8.000	9.000	16	5.000	3.000	16.000	6	5.000	4.
00	130.000	140	110.000	120.000	120.000	120	140.000	150.000	160.000	140	150.000	150.
00	150.000	60	50.000	30.000	0.000	20	60.000	20.000	0.000	10	40.000	20.
00	4.000	17	4.000	3.000	1.000	1	2.000	3.000	0.000	1	3.000	5.
00	13.000	14	10.000	9.900	10.000	9.9	13.000	13.000	15.000	13	13.000	12.
00	30.000	20	0.000	0.000	0.000	14	0.000	0.000	0.000	50	0.000	0.
00	0.000	0	0.100	0.000	0.000	0.0	0.200	0.000	0.000	0	0.000	0.
00*	1.000	0.9	1.100	1.100	0.900	1.1	0.810	0.710	2.100	0.82	2.000	1.
03	0.003	0.001	0.001	0.002	0.002	0.002	0.001	0.003	0.002	0.001	0.000	0.
40	0.030	0.84	0.050	0.040	0.020	0.12	0.050	0.030	0.080	0.4	0.080	0.
	8.2	7.9	7.6	8.0	8.100	7.8	7.700	7.900	7.900	7.6	7.600	7.
00	0.000	0	2.000	0.000	0.000	0	0.000	0.000	0.000	0	7.000	0.
05	0.025	0.005	0.003	0.005	0.004	0.003	0.002	0.007	0.008	0.003	0.003	0.
06	0.031	0.007	0.012	0.008	0.010	0.005	0.010	0.008	0.008	0.005	0.008	0.
00	2.000	2.2	2.000	1.600	1.700	1.6	1.700	1.900	2.000	1.9	7.500	6.
0	0.190	0.20	0.170	0.210	0.190	0.18	0.220	0.220	0.240	0.22	0.240	0.
00	140.000	149	126.000	152.000	136.000	130	160.000	160.000	177.000	160	175.000	174
00	0.100	0.1	0.100	0.100	0.100	0.1	0.100	0.100	0.100	0.1	0.200	0
00	3.200	2.9	3.100	2.400	3.100	3.1	3.600	3.000	3.900	3.3	5.800	4
00	5.000	4	6.000	4.000	5.000	5	5.000	4.000	5.000	5	7.000	6
00	12.000	13	12.000	11.000	12.000	12	11.000	9.900	11.000	11	12.000	11
00	18.500	10.2	11.600	11.500	11.000	10.2	10.600	10.500	10.000	9.6	10.200	9
00	90.000	70	10.000	40.000	0.000	20	30.000	20.000	0.000	20	360.000	60

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25/44 1J-1 ...e Industrial Park No. 2			25/44 2Q-1 Kaiser Aluminum (Eastgate Well)				25/44 7C1 Orchard Ave. Irrigation Dist. (Well #2)			
9-25-73	12-17-73	3-20-74	6-27-73	9-25-73	12-18-73	3-20-74	6-27-73	9-25-73	12-18-73	3-19-74
0.010	0.010	0.03	0.010	0.010	0.020	0.69	0.020	0.020	0.010	0.01
143.000	148.000	135	146.000	145.000	147.000	160	144.000	139.000	146.000	144
4.000	4.000	3	4.000	6.000	3.000	2	6.000	1.000	6.000	3
174.000	181.000	164	178.000	177.000	179.000	195	176.000	170.000	178.000	176
0.000	0.000	0	1.000	0.000	0.000	0	1.000	0.000	1.000	0
37.000	41.000	35	39.000	40.000	43.000	49	38.000	35.000	36.000	36
	3.600	6.6			3.600	9.9			2.800	5.6
0.000	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.000	0
1.100	1.400	0.9	4.400	3.000	7.300	60	1.700	2.100	1.900	2.2
0.000	0.000	0	0.000	0.000	0.000	30	0.000	0.000	0.000	0
297.000	325.000	293	336.000	320.000	357.000	590	309.000	306.000	315.000	321
16.000	2.000	5	9.000	3.000	4.000	4	5.000	2.000	3.000	3
0.060	0.010	0.1	0.030	0.050	0.020	0.1	0.000	0.000	0.030	0 0
0.000	0.200	0.2	0.100	0.000	0.100	0.1	0.100	0.000	0.200	0 2
3.000	16.000	6	5.000	4.000	18.000	28	21.000	14.000	10.000	16
150.000	160.000	140	150.000	150.000	170.000	190	160.000	150.000	160.000	160
20.000	0.000	10	40.000	20.000	60.000	10	30.000	10.000	30.000	20
3.000	0.000	1	3.000	5.000	0.000	1	0.000	1.000	0.000	1.0
13.000	15.000	13	13.000	12.000	14.000	16	17.000	16.000	16.000	17
0.000	0.000	50	0.000	0.000	0.000	0	0.000	10.000	0.000	14
0.000	0.000	0	0.000	0.100	0.000	0	0.100	0.000	0.000	0 0
0.710	2.100	0.82	2.000	1.400	3.100	5.4	0.840	0.760	1.000	1.2
0.003	0.002	0.001	0.000	0.002	0.003	0.013	0.000	0.002	0.003	0.001
0.030	0.080	0.4	0.080	0.050	0.060	0.91	0.040	0.020	0.100	0.04
7.900	7.900	7.6	7.600	7.900	7.900	7.5	7.600	8.100	8.000	7.7
0.000	0.000	0	7.000	0.000	0.000	0	0.000	2.000	0.000	0
0.007	0.008	0.003	0.003	0.004	0.018	0.003	0.007	0.011	0.012	0.008
0.008	0.008	0.005	0.008	0.004	0.020	0.004	0.009	0.011	0.016	0.014
1.900	2.000	1.9	7.500	6.900	7.100	12	1.900	2.000	2.100	2.1
0.220	0.240	0.22	0.240	0.240	0.270	0.45	0.230	0.280	0.240	0.23
160.000	177.000	160	175.000	174.000	197.000	329	169.000	206.000	175.000	172
0.100	0.100	0.1	0.200	0.200	0.200	1.1	0.100	0.100	0.100	0.1
3.000	3.900	3.3	5.800	4.500	5.400	34	3.300	2.800	4.100	3.7
4.000	5.000	5	7.000	6.000	6.000	27	4.000	4.000	5.000	5
9.900	11.000	11	12.000	11.000	11.000	16	16.000	15.000	15.000	16
10.500	10.000	9.6	10.200	9.500	9.500	9.5	9.600	9.000	8.000	9.6
20.000	0.000	20	360.000	60.000	80.000	90	10.000	20.000	0.000	30

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	GROUNDWATER QUALITY DATA FROM THE ONGOING USGS-EPA PROGRAM	TABLE 10

USGS Well Number		25/44 18D2			25/44 19D1		
Owner		W.W.P. #1-4			Edgecliff Sanatorium		
Test Date		6-27-73	9-25-73	12-18-73	6-27-73	9-26-73	12-18-73
PARAMETER	UNITS						
Ammonia -N	mg/1	0.010	0.010	0.010	0.040	0.010	0.010
Alkalinity Total (as $CaCO_3$)	mg/1	129.000	124.000	123.000	161.000	169.000	163.000
Arsenic	ug/1	2.000	2.000	4.000	4.000	6.000	6.000
Bicarbonate	mg/1	157.000	151.000	150.000	196.000	206.000	199.000
Cadmium	ug/1	1.000	1.000	0.000	1.000	0.000	0.000
Calcium	mg/1	32.000	33.000	32.000	48.000	49.000	48.000
Carbon Dioxide	mg/1			2.400			5.000
Carbonate	mg/1	0.000	0.000	0.000	0.000	0.000	0.000
Chloride -DISS	mg/1	2.000	2.500	1.800	6.000	11.000	6.000
Chromium	ug/1	0.000	0.000	0.000	0.000	0.000	0.000
Conductivity	umhos/cm	282.000	278.000	270.000	369.000	390.000	373.000
Copper	ug/1	6.000	4.000	3.000	8.000	2.000	5.000
Detergents MBAS	mg/1	0.000	0.080	0.060	0.000	0.040	0.040
Fluoride	mg/1	0.000	0.000	0.200	0.100	0.000	0.200
Hardness, Noncarbonate	mg/1	9.000	12.000	10.000	25.000	15.000	18.000
Hardness, Total	mg/1	140.000	140.000	130.000	190.000	180.000	190.000
Iron	ug/1	40.000	20.000	10.000	10.000	30.000	10.000
Lead	ug/1	0.000	1.000	0.000	0.000	4.000	0.000
Magnesium	mg/1	14.000	13.000	13.000	16.000	15.000	15.000
Manganese	ug/1	10.000	0.000	0.000	0.000	0.000	10.000
Mercury, Total	ug/1	0.000	0.000	0.000	0.100	0.000	0.000
Nitrate -N	mg/1	1.200	1.100	1.100	2.800	3.000	2.600
Nitrite -N	mg/1	0.000	0.002	0.003	0.000	0.001	0.002
Nitrogen, Kjeldahl -N	mg/1	0.030	0.070	0.060	0.070	0.230	0.070
pH		7.6	8.1	8.0	7.5	7.7	7.8
Phenols	ug/1	2.000	0.000	0.000	0.000	2.000	0.000
Phosphate, Ortho As P	mg/1	0.005	0.006	0.007	0.021	0.009	0.023
Phosphate, Total, As P	mg/1	0.010	0.011	0.010	0.023	0.025	0.026
Potassium	mg/1	1.800	1.900	1.900	2.400	2.700	2.700
Residue	ton/AFT	0.200	0.260	0.200	0.290	0.280	0.280
Residue 180C	mg/1	150.000	193.000	147.000	211.000	206.000	207.000
SAR		0.100	0.100	0.100	0.200	0.200	0.200
Sodium	mg/1	3.400	3.200	3.900	5.700	7.000	6.200
Sodium	percent	5.000	5.000	6.000	6.000	8.000	7.000
Sulfate	mg/1	14.000	13.000	12.000	14.000	13.000	12.000
Water Temperature	°C	10.600	10.500	11.000	11.900	11.500	11.500
Zinc - DISS	ug/1	10.000	40.000	0.000	20.000	10.000	10.000

TABLE 10 (Continued)

-73	25/44 19D1 ...cliff Sanatorium 12-18-73	3-20-74	25/45 15D1 Holiday Hills 6-28-73	9-25-73	12-18-73	3-20-74	25/45 16K1 Ruth Jeffers 6-28-73	9-25-73	12-18-73	3-20-74	6-27-73
.010	0.010	0.01	0.030	0.010	0.010	0.03	0.020	0.020	0.010	0.01	0.020
.000	163.000	170	116.000	111.000	107.000	102	386.000	410.000	422.000	429	157.000
.000	6.000	4	5.000	6.000	5.000	2	0.000	0.000	0.000	0	1.000
.000	199.000	207	141.000	135.000	131.000	124	471.000	500.000	514.000	523	192.000
.000	0.000	0	1.000	0.000	0.000	0	1.000	0.000	0.000	0	1.000
.000	48.000	49.	32.000	35.000	35.000	33	110.000	120.000	120.000	120	39.000
	5.000	6.6			1.700	3.1			52.000	105	
.000	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.000	0	0.000
.000	6.000	7.1	2.300	2.300	2.500	2.6	17.000	16.000	17.000	16	5.800
.000	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.000	0	0.000
.000	373.000	394	266.000	259.000	263.000	242	780.000	811.000	837.000	832	367.000
.000	5.000	8	3.000	6.000	3.000	5	13.000	9.000	7.000	10	0.000
.040	0.040	0.08	0.000	0.040	0.020		0.000	0.050	0.040	0.1	0.000
.000	0.200	0.1	0.100	0.100	0.200	0.1	0.500	0.400	0.600	0.5	0.000
.000	18.000	18	1.000	12.000	16.000	14	24.000	34.000	22.000	15	22.000
.000	180.000	190	120.000	120.000	120.000	120	410.000	440.000	440.000	440	180.000
.000	10.000	10	10.000	10.000	0.000	20	10.000	10.000	0.000	30	10.000
.000	0.000	1	1.000	2.000	0.000	1	1.000	6.000	1.000	0	0.000
.000	15.000	16	8.900	8.700	8.800	8.2	33.000	35.000	35.000	35	20.000
.000	10.000	36	10.000	0.000	0.000	7	0.000	10.000	0.000	0	0.000
.000	0.000	0	0.100	0.000	0.000	0.1	0.200	0.200	0.100	0.2	0.100
.000	2.600	2.2	2.800	1.500	2.000	1.3	1.200	1.600	0.930	1.0	2.500
.001	0.002	0.001	0.000	0.002	0.002	0.002	0.002	0.002	0.005	0.003	0.002
.230	0.070	0.13	0.060	0.050	0.040	0.56	0.120	0.130	0.110	0.18	0.050
.7	7.8	7.7	7.6	8.1	8.100	7.8	6.900	7.100	7.200	6.9	7.600
.000	0.000	0	0.000	4.000	0.000	0	1.000	3.000	1.000	0	3.000
.009	0.023	0.018	0.021	0.022	0.073	0.021	0.097	0.010	0.096	0.095	0.005
.025	0.026	0.026	0.021	0.023	0.073	0.023	0.098	0.095	0.990	0.098	0.009
.700	2.700	2.8	1.800	1.900	2.000	1.8	3.100	3.400	3.500	3.4	2.400
.280	0.280	0.31	0.210	0.210	0.210	0.19	0.610	0.650	0.610	0.66	0.270
.000	207.000	226	158.000	157.000	154.000	143	445.000	480.000	452.000	486	200.000
.200	0.200	0.2	0.200	0.200	0.200	0.2	0.200	0.200	0.200	0.2	0.200
.000	6.200	6.3	4.400	3.900	4.400	4.5	9.700	10.000	10.000	9.3	6.700
.000	7.000	7	7.000	6.000	7.000	8	5.000	5.000	5.000	4	5.000
.000	12.000	14	12.000	11.000	11.000	8	12.000	11.000	11.000	12	20.000
.500	11.500	11.2	12.000	12.000	12.000	11.8	14.100	12.000	13.000	12.9	10.800
.000	10.000	20	10.000	50.000	0.000	20	90.000	200.000	170.000	140	10.000

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25/45 16K1 Ruth Jeffers			26/42 11J1(s) Hatchery Springs				26/42 12A1(s) Spokane Country Club			
25-73	12-18-73	3-20-74	6-27-73	9-26-73	12-17-73	3-19-74	6-29-73	9-26-73	12-17-73	3-19-74
0.020	0.010	0.01	0.020	0.020	0.010	0.010	0.020	0.010	0.010	0.01
410.000	422.000	429	157.000	157.000	151.000	149	137.000	135.000	128.000	127
0.000	0.000	0	1.000	9.000	4.000	3	1.000	0.000	5.000	2
500.000	514.000	523	192.000	191.000	184.000	182	167.000	164.000	156.000	155
0.000	0.000	0	1.000	0.000	0.000	0.000	1.000	0.000	0.000	0
120.000	120.000	120	39.000	39.000	39.000	37.0	31.000	31.000	29.000	28
	52.000	105			2.900	5.8			1.600	2.5
0.000	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.000	0
16.000	17.000	16	5.800	5.900	5.600	5.8	2.300	3.400	2.500	2.2
0.000	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.000	0
811.000	837.000	832	367.000	360.000	354.000	358	301.000	297.000	291.000	287
9.000	7.000	10	0.000	0.000	1.000	3	1.000	0.000	0.000	7
0.050	0.040	0.1	0.000	0.000	0.020	0.08	0.000	0.000	0.030	0.05
0.400	0.600	0.5	0.000	0.000	0.200	0.10	0.100	0.000	0.200	0.1
34.000	22.000	15	22.000	19.000	25.000	25	10.000	13.000	10.000	9
440.000	440.000	440	180.000	180.000	180.000	170	150.000	150.000	140.000	140
10.000	0.000	30	10.000	50.000	0.000	20	30.000	10.000	10.000	10
6.000	1.000	0	0.000	3.000	0.000	2	1.000	2.000	0.000	2
35.000	35.000	35	20.000	19.000	19.000	20	17.000	17.000	16.000	16
10.000	0.000	0	0.000	0.000	40.000	36	0.000	0.000	0.000	14
0.200	0.100	0.2	0.100	0.000	0.000	0.0	0.000	0.000	0.000	0
1.600	0.930	1.0	2.500	2.500	2.300	2.0	1.300	1.100	0.920	1.1
0.002	0.005	0.003	0.002	0.002	0.004	0.001	0.000	0.001	0.004	0.002
0.130	0.110	0.18	0.050	0.210	0.040	0.26	0.050	0.150	0.150	0.12
7.100	7.200	6.9	7.600	8.000	8.000	7.7	7.700	8.100	8.200	8.0
3.000	1.000	0	3.000	1.000	0.000	0	3.000	4.000	0.000	0
0.010	0.096	0.095	0.005	0.043	0.010	0.007	0.002	0.002	0.007	0.003
0.095	0.990	0.098	0.009	0.048	0.012	0.013	0.003	0.004	0.008	0.013
3.400	3.500	3.4	2.400	2.400	2.600	2.5	2.100	2.300	2.400	2.1
0.650	0.610	0.66	0.270	0.250	0.270	0.27	0.230	0.220	0.210	0.21
480.000	452.000	486	200.000	186.000	198.000	195	166.000	165.000	157.000	156
0.200	0.200	0.2	0.200	0.200	0.200	0.2	0.100	0.100	0.100	0.1
10.000	10.000	9.3	4.700	5.100	5.300	4.8	3.300	3.500	3.400	3.2
5.000	5.000	4	5.000	6.000	6.000	6	5.000	5.000	5.000	5
11.000	11.000	12	20.000	19.000	18.000	20	16.000	14.000	15.000	15
12.000	13.000	12.9	10.800	11.000	11.000	10.3	11.800	10.500	10.000	9.5
200.000	170.000	140	10.000	10.000	0.000	20	30.000	10.000	20.000	10

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	GROUNDWATER QUALITY DATA FROM THE ONGOING USGS-EPA PROGRAM	TABLE 10 (cont.)

PARAMETER	UNITS	6-29-73	9-26-73	12-17-73	3-19-74	6-29-73	9-26-73
USGS Well Number			26/42 27N1				26/43
Owner			B.W. Livengood				Wanderm
Ammonia	mg/1	0.030	0.010	0.010	0.01	0.000	0.010
Alkalinity Total (as $CaCO_3$)	mg/1	130.000	129.000	126.000	125	140.000	135.000
Arsenic	ug/1	5.000	7.000	4.000	2	10.000	3.000
Bicarbonate	mg/1	159.000	157.000	154.000	152	171.000	165.000
Cadmium	ug/1	1.000	0.000	0.000	0	1.000	0.000
Calcium	mg/1	36.000	34.000	36.000	35	44.000	38.000
Carbon Dioxide	mg/1			1.200	3.1		
Carbonate	mg/1	0.000	0.000	0.000	0	0.000	0.000
Chloride	mg/1	4.000	3.500	3.700	4	15.000	14.000
Chromium	ug/1	0.000	0.000	0.000	0	0.000	0.000
Conductivity	umhos/cm	293.000	290.000	292.000	291	393.000	387.000
Copper	ug/1	2.000	0.000	2.000	4	0.000	0.000
Detergents MBAS	mg/1	0.000	0.040	0.020	0	0.000	0.000
Fluoride	mg/1	0.100	0.000	0.200	0.1	0.200	0.000
Hardness, Noncarbonate	mg/1	13.000	10.000	17.000	16	48.000	38.000
Hardness, Total	mg/1	140.000	140.000	140.000	140	190.000	170.000
Iron	ug/1	10.000	20.000	20.000	30	40.000	30.000
Lead	ug/1	0.000	3.000	0.000	1	0.000	3.000
Magnesium	mg/1	13.000	13.000	13.000	13	19.000	19.000
Manganese	ug/1	0.000	0.000	0.000	43	0.000	0.000
Mercury, Total	ug/1	0.100	0.000	0.000	0	0.100	0.000
Nitrate	mg/1	1.200	1.100	0.970	1.3	1.300	1.100
Nitrite	mg/1	0.000	0.006	0.003	0.001	0.000	0.002
Nitrogen, Kjeldahl	mg/1	0.030	0.120	0.030	0.22	0.050	0.110
pH		7.6	8.1	8.3	7.9	7.6	8.0
Phenols	ug/1	12.000	1.000	0.000	0	2.000	0.000
Phosphate, Ortho, AS P	mg/1	0.007	0.001	0.013	0.006	0.002	0.004
Phosphate, Total, AS P	mg/1	0.008	0.022	0.014	0.022	0.006	0.005
Potassium	mg/1	1.900	2.200	2.200	2.1	3.000	3.400
Residue	ton/AFT	0.210	0.220	0.220	0.22	0.300	0.290
Residue 180C	mg/1	157.000	164.000	159.000	162	221.000	214.000
SAR		0.100	0.200	0.200	0.2	0.300	0.400
Sodium	mg/1	4.000	4.300	4.600	4.2	10.000	11.000
Sodium	percent	6.000	6.000	6.000	6	10.000	12.000
Sulfate	mg/1	16.000	14.000	14.000	15	38.000	40.000
Water Temperature	°C	11.800	12.000	11.000	10.8	11.600	12.000
Zinc	ug/1	40.000	90.000	130.000	160	10.000	20.000

TABLE 10 (Continued)

26/43 5L1(s) Wandermere Inc. 9-26-73	12-17-73	3-19-74	26/43 7B1(s) Dept. of Game 6-29-73	9-26-73	12-17-73	3-19-74	26/45 35F1 Consolidated I.D. Well #10 6-28-73	9-25-73	6-28-
0.010	0.020	0.01	0.020	0.020	0.020	0.01	0.010	0.010	0.0
135.000	134.000	131	137.000	140.000	130.000	135	132.000	127.000	141.0
3.000	1.000	2	4.000	64.000	3.000	2	1.000	2.000	0.0
165.000	163.000	160	167.000	171.000	159.000	165	161.000	155.000	172.0
0.000	0.000	0	1.000	0.000	0.000	0	1.000	0.000	3.0
38.000	39.000	38	31.000	32.000	32.000	32	31.000	33.000	33.0
	2.100	5.1			1.600	2.6			
0.000	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.0
14.000	14.000	14	2.300	2.300	2.300	2.4	0.800	1.000	1.1
0.000	0.000	0	0.000	0.000	0.000	0	0.000	0.000	0.0
387.000	394.000	391	305.000	304.000	294.000	311	276.000	277.000	296.0
0.000	0.000	2	0.000	0.000	1.000	6	3.000	5.000	70.0
0.000	0.050	0.08	0.000		0.020	0	0.000	0.040	0.0
0.000	0.200	0.1	0.100	0.000	0.200	0.1	0.100	0.100	0.1
38.000	42.000	42	15.000	14.000	19.000	19	3.000	13.000	7.0
170.000	180.000	170	150.000	150.000	150.000	150	140.000	140.000	150.0
30.000	10.000	90	10.000	10.000	10.000	10	110.000	30.000	2400.0
3.000	0.000	2	0.000	1.000	0.000	1	0.000	11.000	45.0
19.000	19.000	19	18.000	18.000	17.000	18	14.000	14.000	16.0
0.000	0.000	29	0.000	0.000	0.000	36	0.000	10.000	30.0
0.000	0.000	0	0.000	0.100	0.000	0.1	0.100	0.000	0.1
1.100	0.950	1.1	1.300	1.100	0.850	1.1	0.470	0.430	0.
0.002	0.007	0.001	0.001	0.002	0.005	0.002	0.000	0.001	0.0
0.110	0.090	0.05	0.050	0.150	0.060	0.04	0.050	0.040	0.0
8.0	8.1	7.7	7.6	8.0	8.200	8.0	7.600	8.000	7.4
0.000	0.000	0	4.000	1.000	0.000	0	4.000	0.000	1.0
0.004	0.005	0.003	0.001	0.003	0.005	0.003	0.002	0.006	0.0
0.005	0.006	0.010	0.004	0.003	0.008	0.007	0.003	0.006	0.0
3.400	3.300	3.3	2.000	2.300	2.200	2.2	1.700	1.800	1.1
0.290	0.300	0.3	0.230	0.230	0.210	0.22	0.200	0.210	0.1
214.000	222.000	217	168.000	166.000	155.000	162	149.000	151.000	139.
0.400	0.400	0.3	0.100	0.100	0.100	0.1	0.100	0.100	0.
11.000	11.000	10	3.200	3.400	3.300	3.1	2.900	2.400	2.
12.000	12.000	11	4.000	5.000	5.000	4	4.000	4.000	4.
40.000	42.000	39	16.000	15.000	15.000	16	14.000	13.000	13.
12.000	11.500	10.8	11.200	11.000	10.000	9.6	8.600	8.500	9.
20.000	0.000	20	10.000	10.000	0.000	20	30.000	30.000	560.

26/45 35F1 Consolidated I.D. Well #10		26/45 36N1 G.N. Siverson			26/45 36Q1 Borden Well		
-73	9-25-73	6-28-73	9-26-73	12-18-73	6-27-73	9-26-73	12-18-73
010	0.010	0.090	0.030	0.060	0.040	0.020	0.010
000	127.000	141.000	144.000	142.000	129.000	130.000	129.000
000	2.000	0.003	5.000	7.000	4.000	31.000	6.000
000	155.000	172.000	176.000	173.000	157.000	159.000	157.000
000	0.000	3.000	0.000		0.000	0.000	0.000
000	33.000	33.000	34.000	36.000	32.000	32.000	33.000
				1.700			2.500
000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
000	1.000	1.300	1.000	1.200	1.500	1.800	1.600
000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
000	277.000	296.000	301.000	305.000	274.000	274.000	279.000
000	5.000	70.000	29.000		9.000	1.000	4.000
000	0.040	0.000	0.000	0.000	0.000	0.030	0.000
100	0.100	0.100	0.000	0.200	0.100	0.000	0.200
000	13.000	7.000	6.000	14.000	9.000	7.000	11.000
000	140.000	150.000	150.000	160.000	140.000	140.000	140.000
000	30.000	2400.000	550.000	1500.000	50.000	60.000	60.000
000	11.000	45.000	11.000		2.000	4.000	0.000
000	14.000	16.000	16.000	16.000	14.000	14.000	14.000
000	10.000	30.000	0.000	30.000	0.000	0.000	0.000
100	0.000	0.100	0.000	0.000	0.000	0.000	0.000
470	0.430	0.620	0.870	0.770	1.000	1.000	0.940
000	0.001	0.001	0.001	0.006	0.000	0.004	0.002
050	0.040	0.090	0.090	0.040	0.050	0.060	0.030
600	8.000	7.400	7.900	8.200	7.800	7.900	8.000
000	0.000	1.000	1.000	1.000	0.000	2.000	0.000
.002	0.006	0.001	0.004	0.006	0.002	0.005	0.009
.003	0.006	0.014	0.005	0.023	0.004	0.008	0.009
.700	1.800	1.900	2.000	2.100	1.900	2.000	2.200
.200	0.210	0.190	0.210	0.230	0.200	0.210	0.240
.000	151.000	139.000	158.000	168.000	148.000	155.000	176.000
.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
.900	2.400	2.800	2.900	2.800	2.700	3.000	3.000
.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
.000	13.000	13.000	14.000	13.000	13.000	12.000	11.000
.600	8.500	9.600	9.000	9.000	11.000	11.000	11.000
.000	30.000	560.000	250.000	460.000	120.000	120.000	160.000

TABLE 11
GROUP I WATER QUALITY
LOCATIONS IN THE PRIMARY SPOKANE VALLEY AQUIFER

USGS Well Number		Agency (or Owner)	Data (1) Source	Record Span From	Record Span To	Remarks	(2)
25/42	3H-1	City of Spokane, Baxter	2,S	'44&11/70	10/72	44 data from source 2	T15
	11	U.S. Fort Wright #5	1,S	2/47	7/58	Serves Fairchild AFB	T15
	11M-1	U.S. Fort Wright #6	1,S	1/48	11/60	Serves Fairchild AFB	T15
	11M-2	U.S. Fort Wright #7	1	10/54	11/60	Serves Fairchild AFB	T15
	13B-1	Spokane Cold Storage	1,3,4,$	'42&6/73	6/74	5/42 data in Sources 1 & 3	T15
25/43	11G-1	City of Spokane #1	1,3,$	12/38	9/72	'71 data only in STORET	T15
	11G-4	City of Spokane #4	1,$	7/61	1/73	'73 data only in STORET	T15
	11J-1	City of Spokane Parkwater #5	1	10/59	7/61		T15
	12H-1	Orchard Ave. Irr. Dist. #1	3,$	'51&9/71	1/73	'51 data only in Source 3	T15
	13A-1	Wash. Water Power #1-3	4	6/73	6/74		T15
	14K-1	Acme Concrete Co.	4	6/73	6/74		T15
	23A-1	Wash. Water Power #1-5A	S	5/70	10/72		T15
	23A-2	Wash. Water Power #1-5B	S	7/71	10/72		T15
	24G-1	East Spokane Irr. Dist. #1	S	12/70	10/72		T15
25/44	1J-1	Spokane Industrial Park #2	4	6/73	6/74		T15
	2Q-1	Kaiser Trentwood - East Gate	4	6/73	6/74		T15
	7C-1	Orchard Ave. Irr. Dist. #2	4	6/73	6/74		T15
	15E-2	Modern Electric #1	S	5/70	10/72		T15
	18D-2	Wash. Water Power #1-4	4	6/73	6/74		T15
	19D-1	Edgecliff Sanitorium	4	6/73	6/74		
	26D-1	Vera Irr. Dist.	3,$	'51&11/60	10/72	'51 data only in Source 3	T15
	27E-1	Modern Electric #9	S	5/70	10/72		T15
	29A-1	Wash. Water Power #2-4	S	9/70	10/72		T15
25/45	15D-1	Holiday Hills	4,$	7&71	6/74	'71/72 data in Storet	
	16K-1	Ruth Jeffers	4	6/73	6/74		
	18R-1	Consolidated Irr. Dist. #2A	S	5/70	10/72		T15
26/42	11J-1(s)	Hatchery Springs	4,$	9/72	6/74	Spring 9/72 & 1/73 data in STORET	
	12A-1(s)	Spokane Country Club	4	6/73	6/74	Spring	
	20 SW1/4	U.S. Gov't.	1	12/53	11/60		
	27N-1	B.W. Livengood	2,S,4	'62&6/73	6/74	'62 data in Cline & STORET (McCrea Well)	
26/43	5L-1(s)	Wandermere Inc.	4	6/73	6/74	Spring	
	7B-1(s)	Wash. State Dept. of Game	4	6/73	6/74	Spring	

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	LOCATIONS IN THE PRIMARY SPOKANE VALLEY AQUIFER	TABLE 11

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TABLE 11 (cont.)

GROUP I WATER QUALITY

LOCATIONS IN THE PRIMARY SPOKANE VALLEY AQUIFER

USGS Well Number		Agency (or Owner)	Data (1) Source	Record Span From	Record Span To	Remarks	(2)
26/43	16F-2	Kaiser Mead #5	1,S	10/59	5/60		T15
26/45	35F-1	Consolidated Irr. Dist. #10A	4	6/73	6/74		T15
	36N-1	G.N. Siverson	4	6/73	6/74		
	36Q-1	Carl Borden	4	6/73	6/74		
26/46	31M-1	Consolidated Irr. Dist. #11A	S	5/70	10/72		T15

Notes For Table 11

(1) 1 Van Denburgh and Santos (1965)
2 Cline (1969)
3 Weigle and Mundorf (1952)
4 USGS - DOE ongoing, unpublished
S Entire indicated record in STORET
$ Part of record in STORET

(2) T15 indicates well is listed as major producer in Table 15

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TABLE 12

GROUP II WATER QUALITY LOCATIONS
IN THE PRIMARY SPOKANE VALLEY AQUIFER

USGS Well Number		Agency (or Owner)	Data (1) Source	Record Date	Remarks	(2)
25/43	4B-1	City of Spokane, Hoffman #1	3	9/44	Composite with 4B-2	T15
	4B-2	City of Spokane, Hoffman #2	1,2,3,S	4/18/52	Source 3 has '51 data	T15
	8D-1	Union San and Gravel	1,3	5/7/42	Source 3 has '51 data Destroyed	
	9G-1	Charles Perry	1,3	6/6/51	Source 3 has '51 data	
25/43	11A1(s)	Spring near Spokane City Dam	S	9/12/72	On North just downstream from dam	
	11J-2	City of Spokane, Parkwater #2.	S	1/15/73	Includes heavy metal data	T15
	11J-4	City of Spokane, Parkwater #4	S	1/15/73	Includes heavy metal data	T15
	22F-1	City of Spokane, Ray St. #1	3	10/45		T15
25/44	1M-1	Spokane Industrial Park #1	3	No Date		T15
	2B-1	Trentwood Irr. Dist. #1	2,S	1/3/55		T15
	4R-3	Irvin Water Dist. #3	S	11/10/70		T15
	6A-1	Pasadena.Park Irr. Dist. #1	2,S	1/3/55		T15
25/44	11R1(s)	Sullivan Springs	S	9/12/72	On North side of river below Sullivan Bridge	
	15E-1	Modern Elect. #5	1,3,S	5/7/42		T15
	18M	F.C. Lawhead	1,3,S	6/6/51		
25/45	4A-1	Hagan	1,S	6/6/51		
	18A-1	Nilson	1,S	5/7/42		
26/42	7G-1	E.M. Covington	1,3	6/6/51		
	12L-1	Wash. Water Power, Kingswood	2,S	5/12/64	Not active	
	27N-2	R. Costello	S	2/9/62		
26/42	28 (s)	Spring below Spokane STP	S	9/13/72	Located approximately 1mi. above 7 Mile Bridge	
26/43	6G-1	Kivilla Water Co. #1	2,S	5/12/64		T15
	8B-4	Wash. Water Power, Mead #2	2,S	5/12/64	Not active	
	10K-1	Wash. Water Power, Mead #3-4	2,S	5/12/64		T15
	16C-1	Kaiser	3	8/15/42		T15
	16D-2	Kaiser	3	6/8/42		T15
	16F-1	Kaiser	3	8/3/42		T15
	19A-1	Whitworth W.D. #2	1,2,3	5/7/42	Was Country Home Estates	T15
	27E-1	N. Spokane Irr. Dist. #3	1,2,3,S	6/6/51		T15
	30R-2	Wash. Water Power #3-1	2,S	5/12/64		T15

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	GROUP II WATER QUALITY LOCATIONS IN THE PRIMARY SPOKANE VALLEY AQUIFER	TABLE 12

TABLE 12

GROUP II WATER QUALITY LOCATIONS IN THE PRIMARY SPOKANE VALLEY AQUIFER

USGS Well Number		Agency (or Owner)	Data (1) Source	Record Data	Remarks (2)
26/44	32R-1	Hutton Settlement	2	1/3/55	
26/45	36E-1	J.T. Simpson	1,3	5/7/42	

Notes For Table 12

(1) 1 Van Denburgh and Santos (1965)
2 Cline (1969)
3 Weigle and Mundorf (1952)
4 USGS - DOE ongoing, unpublished
S Entire indicated record in STORET
$ Part of record in STORET

(2) T15 indicates well is listed as major producer in Table 15

TABLE 13

WATER QUALITY WELLS IN THE BASALT AQUIFER

USGS Well Number		Agency (or Owner)	Span of Record From	To	Number of Samples	Data (1) Source	Remarks	(2)
22/43	32L	W. Hendrixson	5/2/61		1	1		T16
24/40	3N-1	Eastern State Hospital	12/1/59	5/16/60	2	1		
	22L-1	U.S. Gov't. #45-C	11/6/57	11/8/60	5	1		
24/41	3N	U.S. Gov't. Fairchild AFB #2	2/26/47	10/10/61	19	1		
	11N-1	U.S. Gov't. #37C & L	11/5/57	11/8/60	4	1		
	23K-1	Four Lakes Water Dist. #1	11/10/70		1	-	Source USGS Unpublished	T16
25/40	14R-1	U.S. Gov't. #87L	11/6/57	11/8/60	4	1		
	34NE 1/4	U.S. Gov't. #87C #2	11/5/57	11/8/60	4	1		
25/41	1R-1	U.S. Gov't. #07C #2	7/23/58	11/8/60	3	1		
	10G-1	U.S. Gov't. #07L	11/6/57	11/8/60	4	1		
	28	U.S. Gov't. Fairchild AFB #3	12/16/53		1	1		
	34	U.S. Gov't.	10/30/56	11/8/60	4	1		
25/42	29R-1	Spokane Int'l. Airport	2/14/52	10/3/61	11	1	Was Geiger Field	T16
	31J-1	Geiger Field	5/6/42		1	3		
25/42	25SW 1/4	U.S. Gov't.	9/59	11/60	2	1		

Notes For Table 13

(1) Data Source Identification
- 1 Van Denburgh and Santos (1965)
- 3 Weigle and Mundorf (1952)

(2) T16 in this column indicates listing in Table 16 as major water source

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	WATER QUALITY WELLS IN THE BASALT AQUIFER	TABLE 13

TABLE 14

WATER QUALITY DATA IN OTHER AQUIFERS

(3) General Location	USGS Well Number		Agency (or Owner)	Data (1) Source	Record Span From	Record Span To	Remarks (4)	(2)
LSV	26/43	11P-2	Kathleen & Ethlyn DeCamp	2	5/59			
LSV	27/43	22M-1	Wash. Water Power Riverview Hills	2				T17
LSV		26M-1	Mead School Dist. 354	S	10/6/71			
LSV	28/43	22D-1	Chatteroy Hills Subdivision	2	8/14/64	9/1/64		
[illegible]	[illegible]	23K	Paul Bates	2	5/59			
	[illegible]	[illegible]	U.S. Air Force	2	10/9/61	4/29/64		
			U.S. Air Force	2	10/9/61	4/29/64		
			L. Ambacher	1,2	5/2/61			
			Liberty Lakes Utilities	S	4/1/71	9/1/72	Group I data	T17
			Spokane County Golf Course	1,S	10/22/59	5/17/60	Group II	T17
			U.S. Air Force	1	11/5/57	10/10/59	Spring	
			Porter Carter	1	12/1/59	5/17/60	In Spokane Indian Reservation	
			[illegible] Water Company	-	11/10/70		Source USGS unpublished Long Lake vicinity	T17

[illegible] remarks

[illegible] test unless otherwise noted.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	WATER QUALITY DATA IN OTHER AQUIFERS	TABLE 14

TABLE 15

INVENTORY OF MAJOR PRODUCING WELLS

IN THE PRIMARY SPOKANE VALLEY AQUIFER

USGS Well Number	Agency	Agency Well No.	(1) Production	(2) Availability of Quality Data Group I	Group II
25/42 - 03H1	Spokane	Baxter #1	5	X	
25/42 - 03H	Spokane	Baxter #2	5		
25/42 - 11-M01	Fairchild AFB	5	5	X	
25/42 - 11-M02	Fairchild AFB	6	5	X	
25/42 - 11	Fairchild AFB	7	5	X	
25/42 - 13-B1	Spokane Cold Storage				
25/42 - 14-C01	Central Pre-Mix Concrete	Ft. Wright	5		
25/42 - 23-M	Spokane	Indian Canyon	5		
25/43 - 03-C01	Hillyard Processing Co.	Wellesley	5		
25/43 - 04-B01	Spokane	Hoffman #1	5		X
25/43 - 04-B02	Spokane	Hoffman #2	5		X
25/43 - 08-A01	Spokane	Grace	5		
25/43 - 08-A02	Spokane	Nevada	5		
25/43 - 11-G	Crystal Linen	1	5		
25/43 - 11-G	Spokane	Well Elec. #1	5	X	
25/43 - 11-G	Spokane	Well Elec. #2	5	X	
25/43 - 11-J01	Spokane	Parkwater #1	5	X	
25/43 - 11-J02	Spokane	Parkwater #2	5		X
25/43 - 11-J03	Spokane	Parkwater #3	5		
25/43 - 11-J04	Spokane	Parkwater #4	5		X
25/43 - 11	Spokane Rendering	1	5		
25/43 - 11	Burlington Northern	Parkwater #1	5		
25/43 - 11	Burlington Northern	Parkwater #2	5		
25/43 - 12-H	Orchard Ave. I.D. #6	1	5	X	
25/43 - 12-M	American Sign & Indicator	1			
25/43 - 13-A01	W.W.P.	1-3	5	X	
25/43 - 14	Central Pre-Mix Concrete	Yardley	5		

See Sheet 85 for Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF MAJOR PRODUCING WELLS IN THE PRIMARY SPOKANE VALLEY AQUIFER	TABLE 15

TABLE 15 (cont.)

USGS Well Number	Agency	Agency Well No.	(1) Production	(2) Availability of Quality Data Group I	Group II
25/43 - 16-J	Hygrade Foods	1	5		
25/43 - 16-K	Centennial Mills	Trent St.			
25/43 - 17-J	ALSCO Linen	1	5		
25/43 - 17-R	Centennial Mills	Sprague St.	5		
25/43 - 21-B	Troy Laundry	1	5		
25/43 - 22-F01	Spokane	Ray St. #1	5		X
25/43 - 22-F	Spokane	Ray St. #2	5		
25/43 - 23-A01	W.W.P.	1-5 (5A)	5	X	
25/43 - 23-A02	W.W.P.	1-5A (5B)	5	X	
25/43 - 23-C	Carnhope I.D. #7	1	5		
25/43 - 24-G	E. Spokane W.D. #1	1	5	X	
25/43 - 24-J	E. Spokane W.D. #1	3	5		
25/43 - 24-L	E. Spokane W.D. #1	2	5		
25/44 - 01-D	Trentwood I.D. #3	5	5		
25/44-- 01-J01	Spokane Industrial Park	2	5	X	
25/44 - 01-M01	Spokane Industrial Park	1	5		X
25/44 - 02-B01	Trentwood I.D. #3	1	5		X
25/44 - 02-Q01	Kaiser (Trentwood)	1		X	
25/44 - 03-A01	Trentwood I.D. #3	2	5		
25/44 - 03-B01	Trentwood I.D. #3	4	5		
25/44 - 04-R03	Irvin W.D. #6	3	5		X
25/44 - 05-K01	Pasadena Pk. I.D. #17	2	5		
25/44 - 05-R	Millwood	3	5		
25/44 - 05	Inland Empire Paper Co.	1	5		
25/44-- 05	Inland Empire Paper Co.	2	5		
25/44 - 05	Inland Empire Paper Co.	3	5		
25/44-- 05	Inland Empire Paper Co.	4	5		
25/44 - 06-A01	Pasadena Pk. I.D. #17	1	5		X
25/44 - 06-E	Pasadena Pk. I.D. #17	3	5		
25/44 - 07-B01	Millwood	1	5		
25/44 - 07-C01	Orchard Ave. I.D. #6	2	5	X	
25/44 - 07-J02	W.W.P.	1-2	5		
25/44 - 08-D	Millwood	2	5		
25/44 - 08-N01	Modern Elec. Water Co.	6	5		
25/44 - 09-C01	Irvin W.D. #6	1	5		
25/44 - 09-F02	Irvin W.D. #6	2	5		
25/44 - 11-J02	Hillyard Processing Co.	Sullivan St.	5		

See Sheet 85 for Notes

TABLE 15 (cont.)

USGS Well Number	Agency	Agency Well No.	(1) Production	(2) Availability of Quality Data Group I	Group II
25/44 - 12	Spokane Industrial Park	3	5		
25/44 - 13-M	Vera I.D. #15	2	5		
25/44 - 14-D01	Consolidated I.D. #19	1A	5		
25/44 - 14-D02	Consolidated I.D. #19	1B	5		
25/44 - 14-D03	Consolidated I.D. #19	1C	5		
25/44 - 15-E01	Modern Elec. Water Co.	5	5		X
25/44 - 15-E02	Modern Elec. Water Co.	1	5	X	
25/44 - 15-J01	Vera I.D. #15	1	5		
25/44 - 16-E01	Modern Elec. Water Co.	2	5		
25/44 - 17-A01	Modern Elec. Water Co.	8	5		
25/44 - 17-M01	Modern Elec. Water Co.	4	5		
25/44 - 18-D02	W.W.P.	1-4	5	X	
25/44 - 18-F01	W.W.P.	1-1	5		
25/44 - 18-J	Hutchinson I.D. #16	1	5		
25/44 - 18-J	Hutchinson I.D. #16	2	5		
25/44 - 19-B	Dishman Water Co.	1	5		
25/44 - 20-J01	W.W.P.	2-7	5		
25/44 - 21-J01	Modern Elec. Water Co.	3	5		
25/44 - 21-L01	Model I.D. #18	4	5		
25/44 - 21-N01	Model I.D. #18	1	5		
25/44 - 22-H02	Vera .D. #15	6	5		
25/44 - 22-N01	Modern Elec. Water Co.	7	5		
25/44 - 22-R01	Vera I.D. #15	3	5		
25/44 - 23-C01	Vera I.D. #15	7	5		
25/44 - 26-D01	Vera I.D. #15	5	5	X	
25/44 - 26-L01	Vera .D. #15	4	5		
25/44 - 27-E01	Modern Elec. Water Co.	9	5	X	
25/44 - 27-L01	W.W.P.	2-5	5		
25/44 - 28-L01	Model I.D. #18	2	5		
25/44 - 28-P01	Model I.D. #18	3	5		
25/44 - 28-R01	W.W.P.	2-2	5		
25/44 - 29-A01	W.W.P.	2-4	5	X	
25/44 - 29-H01	W.W.P.	2-1	5		
25/45 - 02-G02	Consolidated I.D. #19	9A	5		
25/45 - 02-G03	Consolidated I.D. #19	9B	5		
25/45 - 02-G04	Consolidated I.D. #19	9C	5		
25/45 - 03-F01	Consolidated I.D. #19	8A	5		
25/45 - 03-F02	Consolidated I.D. #19	8B	5		
25/45 - 03-F03	Consolidated I.D. #19	8C	5		

See Sheet 85 for Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF MAJOR PRODUCING WELLS IN THE PRIMARY SPOKANE VALLEY AQUIFER	TABLE 15

TABLE 15 (cont.)

USGS Well Number	Agency	Agency Well No.	(1) Production	(2) Availability of Quality Data Group I	Group II
25/45 - 04-C03	Consolidated I.D. #19	6A	5		
25/45 - 04-C04	Consolidated I.D. #19	6B	5		
25/45 - 04-C05	Consolidated I.D. #19	6C	5		
25/45 - 07-A01	Consolidated I.D. #19	5A	5		
25/45 - 07-A02	Consolidated I.D. #19	5B	5		
25/45-- 07-A03	Consolidated I.D. #19	5C	5		
25/45 - 17-D01	Consolidated I.D. #19	4A	5		
25/45 - 17-D02	Consolidated I.D. #19	4B	5		
25/45 - 17-D03	Consolidated I.D. #19	4C	5		
25/45 - 17-D04	Consolidated I.D. #19	4D	5		
25/45 - 17-P01	Consolidated I.D. #19	3A	5		
25/45 - 17-P02	Consolidated I.D. #19	3B	5		
25/45 - 17-P03	Consolidated I.D. #19	3C	5		
25/45 - 18-A01	Greenacres Water Works	1 (Nilson Well)	5		X
25/45 - 18-R01	Consolidated I.D. #19	2A	5	X	
25/45 - 18-R02	Consolidated I.D. #19	2B	5		
25/45 - 18-R03	Consolidated I.D. #19	2C	5		
26/42 - 06	W.W.P. (Nine Mile)	1			
26/42 - 12-K	Whitworth W.D. #2	4	5		
26/43 - 03-P	W.W.P.	3-7	5		
26/43 - 03-Q	W.W.P.	3-6	5		
26/43 - 05-Q	W.W.P.	3-5	5		
26/43 - 06-G01	Rivilla Water Corp.	1	5		X
26/43 - 07-K	Whitworth W.D. #2	3A	5		
26/43 - 07-P	Whitworth W.D. #2	3	5		
26/43 - 10-K01	W.W.P.	3-4 & 3-4A	5		X
26/43 - 16-C1	Kaiser				
26/43 - 16-D2	Kaiser				
26/43 - 16-F1	Kaiser				
26/43 - 16-F02	Kaiser (Mead)	1	5	X	
26/43 - 19-A	Whitworth W.D. #2	2	5		
26/43 - 19-P	Whitworth W.D. #2	1A	5		
26/43 - 20-D	Whitworth W.D. #2	2A	5		
26/43 - 20-N	W.W.P.	3-2	5		
26/43 - 21	Kaiser (So. Mead)	1	5		
26/43 - 27-E01	N. Spokane I.D. #8	3	5		X

See Sheet 85 for Notes

TABLE 15 (cont.)

USGS Well Number	Agency	Agency Well No.	(1) Production	(2) Availability of Quality Data Group I	Group II
26/43 - 27-E02	N. Spokane I.D. #8	4	5		
26/43 - 28-H	N. Spokane I.D. #8	1	5		
26/43 - 28-H	N. Spokane I.D. #8	2	5		
26/43 - 30-F	Whitworth W.D. #2	1	5		
26/43 - 30-R02	W.W.P.	3-1	5		X
26/43 - 31-A	Spokane	Central #1	5		
26/43 - 31-A	Spokane	Central #2	5		
26/43 - 34	Burlington Northern	Hillyard	5		
26/44 - 32-P	Pleasant Prairie Water Co.	1	5		
26/44 - 35-R01	Trentwood I.D. #3	3	5		
26/45 - 24-P	Moab I.D. #20	1	5		
26/45 - 34-L01	Consolidated I.D. #19	7A	5		
26/45 - 34-L02	Consolidated I.D. #19	7B	5		
26/45 - 34-L03	Consolidated I.D. #19	7C	5		
26/45 - 35-F01	Consolidated I.D. #19	10A	5	X	
26/45 - 35-F02	Consolidated I.D. #19	10B	5		
26/45 - 35-F03	Consolidated I.D. #19	10C	5		
26/46 - 31-M01	Consolidated I.D. #19	11A	5	X	
26/46 - 31-M02	Consolidated I.D. #19	11B	5		
26/46 - 31-M03	Consolidated I.D. #19	11C	5		

(1) A 5 in this column indicates annual production of 5 million gallons or more

(2) An X in these columns indicates the class of data available. Blank indicate unavailable.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF MAJOR PRODUCING WELLS IN THE PRIMARY SPOKANE VALLEY AQUIFER	TABLE 15

TABLE 16

INVENTORY OF MAJOR PRODUCING WELLS IN THE BASALT AQUIFER

USGS Well Number	Agency	Agency Well No.	(1) Production	(2) Availability of Quality Data Group I	Group II
20/45 - 13-M	Tekoa	3	5		
20/45 - 13-Q	Tekoa	1	5		
20/45 - 13-Q	Tekoa	2	5		
21/44 - 03-C	Waverly Hts. Water Assoc.	1			
21/45 - 30-B	Latah	1	5		
22/43 - 04-B	Spangle	1	5		
22/43 - 04-F	Spangle	2	5		
22/45 - 19-C	Fairfield	2	5		
22/45 - 19-D	Fairfield	1	5		
22/45 - 19-E	Fairfield	3			
23/41 - 12-N	Cheney	3	5		
23/41 - 13-C	Eastern Wash.State College	1	5		
23/41 - 13-C	Eastern Wash. State College	2	5		
23/41 - 13-D	Cheney	1	5		
23/41 - 13-D	Cheney	2	5		
23/41 - 13-E	Cheney	4	5		
23/45 - 28-N	Rockford	1	5		
24/40 - 03-N01	Eastern State Hospital	1	5		X
24/40 - 03-N02	Eastern State Hospital	2	5		
24/41 - 03-N	Fairchild AFB	2	5	X	
24/41 - 23-K01	Four Lakes W.D. #10	1			X
24/41 - 23	Four Lakes W.D. #10	2			
24/42 - 12	Cedar Knolls Water Assoc.	1			
24/42 - 21-A	Marshall Comm. Water Assoc.	1			
24/43 - 02	Glenrose Water Assoc.	1			
25/41 - 25-E	Airway Heights	2			
25/41 - 26-H	Airway Heights	3	5		
25/41 - 26-J	Airway Heights	1	5		
25/41 - 26-J	Airway Heights	4	5		

See Sheet 87 for Notes

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF MAJOR PRODUCING WELLS IN THE BASALT AQUIFER	TABLE 16

TABLE 16 (cont.)

USGS Well Number	Agency	Agency Well No.	(1) Production	(2) Availability of Quality Data Group I	Group II
25/42 - 18-E	Balmer's Garden	2			
25/42 - 18-F	Balmer's Garden	1			
25/42 - 29-R01	Spokane Int. Airport	1	5		X
25/42 - 32-J	Spokane Int. Airport	2	5		
27/41 - 27-G	West Shore Water Co.	1			

(1) A 5 in this column indicates annual production of 5 million gallons or more.

(2) An X in these columns indicates the class of data available. Blank indicates unavailable.

TABLE 17

INVENTORY OF MAJOR PRODUCING WELLS IN OTHER AQUIFERS

USGS Well Number	Agency	Agency Well No.	Production (1)	Availability of Quality Data (2) Group I	Group II
LIBERTY LAKE					
25/45 - 23-D01	Liberty Lake Impvt	1	5		
25/45 - 23-D02	Liberty Lake Impvt	2	5		
25/45 - 14-[illegible]	Liberty Lake Utilities	2	5	X	
25/45 - 15-R01	Liberty Lake Utilities	1	5		
WELLPINIT					
27/38 - 10-A	B.I.A. Wellpinit	1			
27/38 - 15	B.I.A. Wellpinit	2			
LONG LAKE					
27/39 - 14(spring)	W.W.P. (Long Lake)	1			
27/39 - 20	W.W.P. (Little Falls)	1			
27/41 - 05-D	W.W.P.	6-1			
27/41 - 26-Q01	Lakeridge Water Co.	1			
27/41 - 26-Q02	Lakeridge Water Co.	2			X
LITTLE SPOKANE VALLEY					
27/43 - 19-J	N. Mt. View Water Co.	1			
27/43 - 22-M01	W.W.P.	3-9	5		X
27/43 - 22-M	W.W.P.	3-9A	5		
27/43 - 32-K	Whitworth W.D. #2	9			
27/43 - 33-B	Whitworth W.D. #2	8			
27/43 - 33-N	W.W.P.	3-8	5		
27/43 - 33-N	W.W.P.	3-8A	5		
27/43 - 34-H	Colbert W.D. #9	1	5		
28/42 - 02-M	Deer Park	3	5		
28/42 - 03-H	Deer Park	1	5		
28/42 - 03-H	Deer Park	2	5		
28/43 - 23-M	W.W.P.	3-10	5		
29/42 - 35-P	Deer Park	4	5		
29/43 - 35	Milan Water Co.	1			
29/43 - 35	Milan Water Co.	2			
29/44 - 17-D	Elk Water Assoc.	1			

(1) A 5 in this column indicates annual production of 5 million gallons or more.
(2) An X in these columns indicates the class of data available. Blank indicates unavailable.

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	INVENTORY OF MAJOR PRODUCING WELLS IN OTHER AQUIFERS	TABLE 17

TABLE 18

MAJOR WATER PRODUCING WELLS IN THE PRIMARY AQUIFER

NOT REPRESENTED BY QUALITY DATA

General (1) Location	Map (2) Locator	USGS Well Number	Owner Identification	Annual Production Millions of Gallons
A	33	25/45 04 C-03	Consolidated I.D #6A	553
		C-04	" 6B	
		C-05	" 6C	
A	34	26/45 34 L-[illegible]	Consolidated I.D #7A	514
		02	" 7B	
		03	" 7C	
A	35	25/45 03 F-01	Consolidated I.D #8A	651
		02	" 8B	
		03	" 8C	
A	36	25/45 02 G-02	Consolidated I.D #9A	611
		03	" 9B	
		04	" 9C	
A	40	26/45 24 P	Moab #1	474
B	28	25/44 14 D-01	Consolidated I.D #1A	232
		02	" 1B	
		03	" 1C	
B	46	25/44 05 K-01	Pasadena #2	180
B	50	25/44 15 J-01	Vera #1	856
		22 H-02	" #6	
		23 C-01	" #7	
B	51	25/44 13 M	" #2	479
B	84	25/44 16 E-01	Modern #2	134
		17 A-01	" #8	
B	85	25/44 21 J-01	Modern #3	92
B	86	25/44 17 M-01	Modern #4	125
B	87	25/44 08 N-01	Modern #6	109
B	125	25/44 05	Inland Empire Paper #1,2, 3, & 4	1,244

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	MAJOR WATER PRODUCING WELLS IN THE PRIMARY AQUIFER NOT REPRESENTED BY QUALITY DATA	TABLE 18

TABLE 18 (cont.)

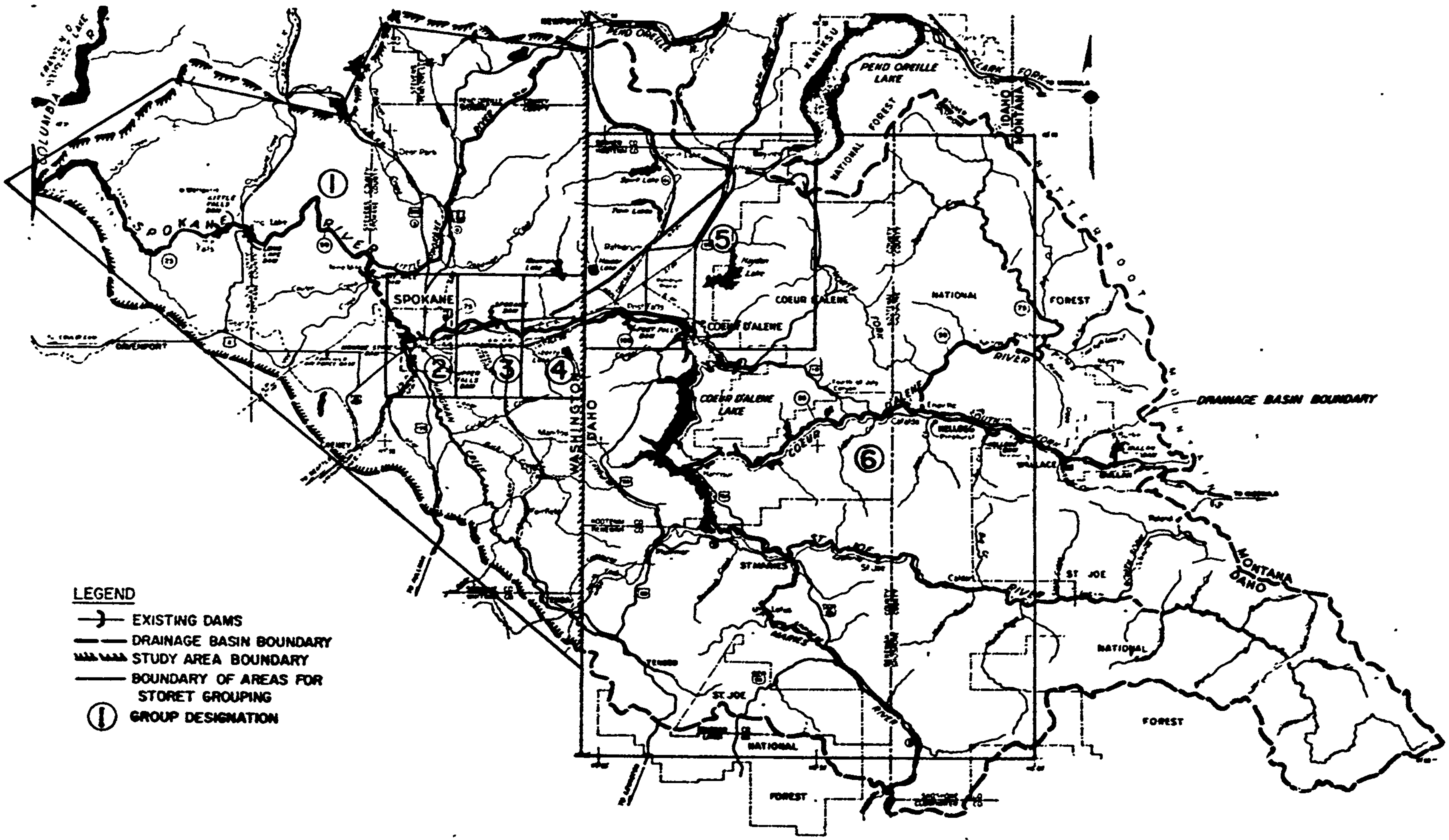
General (1) Location	Map (2) Locator	USGS Well Number	Owner Identification	Annual Production Millions of Gallons
C	12	26/43 31 A-01	Spokane,Central #1	1,771
		A-02	" " 2	
C	13	25/43 08 A-01	Spokane, Grace	4,920
		A-02	" Nevada	
C	22	26/43 30 F	Whitworth W.D. #1	14
		19 P	" " #1A	84
C	23	20 D	" " #2A	18
C	24	26/43 07 P	" " #3	182
		07 K	" " #3A	37
C	25	26/42 12 K	" " #4	23
C	100	26/43 20 N	W.W.P. Well #3-2	139
C	102	26/43 05 Q	W.W.P. Well #3-5	13
C	127	26/43 21	Kaiser South Mead	2,299

Notes:

(1) A = East end of the valley, north of the Spokane River
B = Dishman - Opportunity area
C = In the City of Spokane and north through the Hillyard Trough

(2) Refers to Location Numbers used on Plate 314-10

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	MAJOR WATER PRODUCING WELLS IN THE PRIMARY AQUIFER NOT REPRESENTED BY QUALITY DATA	TABLE 18



WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy – Tudor Consulting Engineers	GROUNDWATER QUALITY STATIONS BY GEOGRAPHICAL GROUPING FROM STORET	FIG. A

List of References

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STORET DATE 73/07/24

543108 12424200 57A105
47 41 48.0 117 29 48.0 2
SPOKANE R @ BOWLEPITCHER/RIV PK
53 WASHINGTON
PACIFIC NORTHWEST
SPOKANE RIVER BASIN
1119C050 02111204
0000

INDEX 1310001 006500
MILES 0643.00 0066.00

PARAMETER				NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00008	LAB	IDENT.	NUMBER	16	7795.81	.339E+08	5829.45	.747767	1457.36	24306.0	1805.00	72/09/12	73/06/12
00010	WATER	TEMP	CENT	12	7.76666	16.4661	4.05784	.522469	1.17140	13.7000	.000000	72/09/12	73/06/12
00042	ALTITUDE	FEET	AB MSL	1	1640.00					1640.00	1640.00	01/01/01	01/01/01
00060	STREAM	FLOW	CFS	11	4450.18	3496312	1869.84	.420172	563.779	7740.00	1582.00	72/09/12	73/04/24
00061	STREAM	FLOW,	INST-CFS	3	3026.67	5685640	2384.46	.787817	1376.67	5780.00	1650.00	72/09/12	73/03/13
00095	CNDUCTVY	AT 25C	MICROMHO	2	203.500	12.5000	3.53553	.017374	2.50000	206.000	201.000	72/09/12	72/09/13
00300	DO		MG/L	2	9.89999	.000214	.014616	.001476	.010335	9.90000	9.90000	72/09/12	72/09/13
00310	BOD	5 DAY	MG/L	2	3.85000	1.80466	1.34349	.348960	.949994	4.80000	2.90000	72/09/12	72/09/13
00400	PH		SU	2	7.45000	.004990	.070637	.009482	.049948	7.50000	7.40000	72/09/12	72/09/13
00410	T ALK	CACO3	MG/L	2	83.0000	8.00000	2.82843	.034077	2.00000	85.0000	81.0000	72/09/12	72/09/13
00620	NO3-N	TOTAL	MG/L	2	.450000	.003200	.056568	.125708	.040000	.490000	.410000	72/09/12	72/09/13
00625	TOT KJEL	N	MG/L	2	.715000	.162451	.403052	.563709	.285001	1.00000	.430000	72/09/12	72/09/13
00665	PHOS-T	P-WET	MG/L	2	.155000	.004050	.063640	.410578	.045000	.200000	.110000	72/09/12	72/09/13
00671	PHOS-D	ORTHO	MG/L P	1	.020000					.020000	.020000	71/06/08	71/06/08
00680	T ORG C	C	MG/L	2	3.50000	.500000	.707107	.202030	.500000	4.00000	3.00000	72/09/12	72/09/13
01000	ARSENIC	AS,DISS	UG/L	7	1.85714	.142860	.377969	.203522	.142859	2.00000	1.00000	72/10/10	73/03/27
01002	ARSENIC	AS,TOT	UG/L	12	2.83333	4.15152	2.03753	.719128	.588184	8.00000	1.00000	72/09/12	73/03/27
01025	CADMIUM	CD,DISS	UG/L	11	1.81818	.963641	.981652	.539909	.295979	4.00000	1.00000	72/10/10	73/06/12
01027	CADMIUM	CD,TOT	UG/L	14	2.07143	1.60989	1.26882	.612532	.339105	5.00000	1.00000	72/09/12	73/06/12
01030	CHROMIUM	CR,DISS	UG/L	11	3.63636	6.25455	2.50091	.687750	.754053	10.0000	2.00000	72/10/10	73/06/12
01034	CHROMIUM	CR,TOT	UG/L	14	6.21428	21.1044	4.59395	.739257	1.22778	15.0000	2.00000	72/09/12	73/06/12
01040	COPPER	CU-DISS	UG/L	11	5.45454	10.4728	3.23616	.593297	.975740	14.0000	3.00000	72/10/10	73/06/12
01042	COPPER	CU,TOT	UG/L	14	6.85714	11.6704	3.41619	.498194	.913015	14.0000	3.00000	72/09/12	73/06/12
01045	IRON	TOTAL	UG/L	11	2745.55	.331E+08	5756.89	2.09681	1735.77	19500.0	65.0000	72/10/10	73/06/12
01046	IRON	FE,DISS	UG/L	10	114.900	25633.4	160.104	1.39342	50.6295	540.000	20.0000	72/10/10	73/06/12
01049	LEAD	PB,DISS	UG/L	11	7.36364	11.4546	3.38446	.459618	1.02045	15.0000	5.00000	72/10/10	73/06/12
01051	LEAD	PB,TOT	UG/L	15	9.73333	20.3524	4.51136	.463496	1.16483	20.0000	5.00000	72/09/12	73/06/12
01055	MANGNESE	MN	UG/L	12	51.7500	4912.02	70.0858	1.35431	20.2320	256.000	4.00000	72/10/10	73/06/12
01056	MANGNESE	MN,DISS	UG/L	11	10.8182	200.564	14.1620	1.30910	4.27002	52.0000	2.00000	72/10/10	73/06/12
01080	STRONTUM	SR,DISS	UG/L	11	42.8182	64.5652	8.03525	.187660	2.42272	52.0000	29.0000	72/10/31	73/04/10
01082	STRONTUM	SR,TOT	UG/L	13	45.2308	101.861	10.0926	.223136	2.79918	67.0000	29.0000	72/10/10	73/04/10
01090	ZINC	ZN,DISS	UG/L	8	195.500	14737.7	121.399	.620967	42.9210	400.000	99.0000	72/10/10	73/03/27
01092	ZINC	ZN,TOT	UG/L	13	231.077	12169.2	110.314	.477392	30.5957	400.000	60.0000	72/09/12	73/06/12
01097	ANTIMONY	SB,TOT	UG/L	2	9.00000	8.00000	2.82843	.314270	2.00000	11.0000	7.00000	72/09/12	72/09/13
01145	SELENIUM	SE,DISS	UG/L	8	2.25000	.500000	.707107	.314270	.250000	4.00000	2.00000	72/10/10	73/02/27
01147	SELENIUM	SE,TOT	UG/L	10	2.20000	.400006	.632460	.287482	.200001	4.00000	2.00000	72/10/10	73/03/27
31501	TOT COLI	MFIMENDO	/100ML	1	20.0000					20.0000	20.0000	72/09/13	72/09/13
31616	FEC COLI	MFM-FCBR	/100ML	1	10.0000					10.0000	10.0000	72/09/13	72/09/13

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SAMPLE PAGE OF STORET INVENTORY DATA	APPENDIX I

STORET RETRIEVAL DATE 73/08/14
SPOKANE RIVER BASIN BY RIVER MILE
RUN 2
SET 2

57A105 543108 6357AL05 12424200
47 41 48.0 117 29 48.0
SPOKANE R. AT RIVERSIDE STATE PK
53 WASHINGTON
PACIFIC NORTHWEST
SPOKANE SUBREGION I
21540000 2111204
2 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00610 NH3-N TOTAL MG/L	00615 NO2-N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00665 PHOS-T P-WET MG/L	00671 PHOS-D ORTHO MG/L P	00515 RESIDUE DISS-105 C MG/L	70300 RESIDUE DISS-180 C MG/L	31504 TOT COLI MFIM LES /100ML	31616 FEC COLI MFM-FCBR /100ML
72/10/10	18 15		0.490	0.007	0.360	0.700	0.320	0.144			40K	40K
72/10/31	13 50		0.660	0.009	0.390	0.880	0.220	0.100			20K	20K
72/11/19	14 15		0.430	0.010	0.340	0.660	0.130	0.083			44	20K
72/11/29	12 55		0.600	0.008	0.420	0.850	0.160	0.061			120	20K
72/12/12	13 50		0.310	0.004	0.170	0.430	0.084	0.045			40K	20K
72/12/27	12 05		0.190	0.013	0.200	0.330	0.093	0.026			800	40K
73/01/18	13 10		0.230	0.006	0.490	0.840	0.110	0.035			1000	100K
73/02/06	14 15										200	40K
73/02/22	13 10										200K	40K
73/02/27	13 45										400	100K
73/03/13	11 05										280	40K
73/03/19	12 15										100K	40K
73/03/27	15 20										40	40K
73/04/10	12 00										40K	40K
73/04/24	15 10										40K	20K
73/06/12	14 30										200	20K
73/06/26	10 00										250	20K
73/07/11	11 45										140	20K

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SAMPLE PAGE OF STORET RAW DATA	APPENDIX II

WATER SAMPLE INFORMATION FOR CHEMICAL ANALYSES

(Fill out completely -Use P % Il nly please--ink will run)

SYSTEM I.D. NUMBER

SYSTEM NAME	COUNTY	COUNTY NO.	COLLECTED BY

D-- COLLECTED	TIME COLLECTED	DATE LAST SAMPLE	TAKEN FROM
			☐ PUMP ☐ STORAGE TANK ☐ FAUCET ☐ HYDRANT ☐ OTHER (Specify)

SOURCE (Name) ☐ LAKE ________ ☐ WELL ________ ☐ OTHER (Specify) ☐ STREAM ________ ☐ SPRING ________

SAMPLE COLLECTED FROM PUBLIC WATER SYSTEM AT

FIELD TESTS pH ____ TEMPERATURE ____ ALKALINITY ____

THIS WATER IS ☐ FILTERED ☐ UNTREATED ☐ OTHER TREATMENT ________

REMARKS

SEND REPORT TO:

____

____

Washington

(City) (Zip)

State of Washington
Department of Social and Health Services
HEALTH SERVICES DIVISION
Smith Tower Seattle, Washington 98104

DO NOT WRITE BELOW THIS LINE - LABORATORY USE ONLY

		+mg/1	++me/1			+mg/1	++me/1
Silica	(SiO_2)			*Bicarbonate	(HCO_3)		
Aluminum	(Al)			Carbonate	(CO_3)		
Iron	(Fe)						
Manganese	(Mn)			Sulfate	(SO_4)		
				Sulfite	(SO_3)		
				Chloride	(Cl)		
:ium	(Ca)			Fluoride	(F)		
Magnesium	(Mg)			Nitrate (NO_3) as Nitrogen	(N)		
Sodium	(Na)			Nitrite (NO_2) as Nitrogen	(N)		
Potassium	(K)			Phosphate	(PO_4)		
TOTAL				TOTAL			

				mg/1
pH, Lab		Suspended Solids		
Specific conductance (Micromhos/cm, 25° C)		Dissolved Solids		
		Total Solids		
Turbidity (JTU)		**Total Solids		
Color (units)		Total Hardness	($CaCO_3$)	
Odor (threshold dilution factor)		Alkalinity	($CaCO_3$)	
Taste (threshold dilution factor)		**Noncarbonate hardness	($CaCO_3$)	
**Free CO_2 (mg/1)		**Calcium hardness	($CaCO_3$)	
		**Magnesium hardness	($CaCO_3$)	
		**Calculated hardness	($CaCO_3$)	

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SAMPLE OF DSHS FORM FOR CHEMICAL ANALYSIS 307-97	APPENDIX III

WATER BACTERIOLOGICAL ANAYLSIS

Health Services Division
Smith Tower, Seattle, Washington 98104

NOTE

1. See back of this form for sampling instructions.
2. Print on a HARD SURFACE, clearly and heavily. Treated paper will make copies without carbon.
3. Return ALL copies of this form with your sample.
4. This water sample will not be examined if over 30 hours old upon receipt in the laboratory.
5. All information must be complete or sample will not be analyzed.

FOR LAB USE ONLY LAB. NO. (1-7) | CO.-CITY (8-10) | (11-14)

DATE COLLECTED (15-20) Month / Day / Year | DATE ANALYZED (21-26) | 27 | (28-30)

TIME OF DAY COLLECTED ☐A.M. ☐P.M. | I.D. NUMBER (Public Systems) 31 32 33 34 35 | COUNTY NAME

NAME OF WATER SYSTEM

SYSTEM ADDRESS

LOCATION WHERE SAMPLE WAS COLLECTED (fire station, school, 5th st., etc.)

COLLECTED BY: (Name)

TYPE OF SYSTEM (36) 1◯ Municipal Community or 2◯ Industrial Commercial or 3◯ Private Residence

SEND REPORT TO: (Print Full Name, Address and Zip Code)

__________, WASHINGTON ______

SOURCE TYPE (37)
1◯ Surface; 2◯ Well; 3◯ Spring; 4◯ Purchased; 9◯ Combination or Other

TYPE OF SAMPLE (38)
1◯ Drinking Water 2◯ Raw Water 3◯ New Main 4◯ Swimming Pool
5◯ Swimming Beach 6◯ Sanitary Survey 7◯ Seawater 9◯ Other (Specify) ______

IS THIS SAMPLE A FOLLOW-UP TO A PREVIOUS, NON CONFORMING SAMPLE ? (39) 1◯ Yes 0◯ No

IF YES, GIVE PREVIOUS LAB. NO. ______

SYSTEM TREATMENT (Check only for Drinking Water Samples)
◯ None; ◯ Chlorination; ◯ Filtration; ◯ Fluoridation;
◯ Other (Specify) ______

REMARKS: (Special Tests Desired, etc.)

LABORATORY RESULTS
SEE REVERSE SIDE FOR INTERPRETATIONS

DRINKING WATER, NEW MAINS, MPN(40)
POS PORTIONS/TOTAL PORTIONS

0/5 SATISFACTORY	< 2.2	◯ 1
1/5 UNSATISFACTORY	2.2	◯ 2
2/5 UNSATISFACTORY	5.1	◯ 3
3/5 UNSATISFACTORY	9.2	◯ 4
4/5 UNSATISFACTORY	16.0	◯ 5
5/5 UNSATISFACTORY	> 16.0	◯ 6

COLONIES/100ml ______
Satisfactory ☐
(41-44) ____ E ____ Unsatisfactory ☐

RAW WATER, SANITARY SURVEY, SWIMMING WATER
MPN ____ MF ____
(45-48) ____ E ____ (49-52) ____ E ____
TOTAL PLATE COUNT ____/ml
(53-56) ____ E ____
FECAL COLIFORM
MPN ____ MF ____
(57-60) ____ E ____ (61-64) ____ E ____
NITRATES (65-67) ____ mg/L as N

DATE RECEIVED | DATE COMPLETED Month (75-76)

HEA 176(12-71)

FOR DRINKING WATER

MPN:

If the multiple tube technique (MPN) is used, the following statements apply: A standard sample analysis involves five 10 ml. tubes If no tube (0/5) shows presence of coliform organisms (MPN), the results are SATISFACTORY.

If one or more tubes shows presence of coliform organisms, the result is UNSATISFACTORY. Investigate trouble IMMEDIATELY. SUBMIT ADDITIONAL SAMPLES.

To meet State Board of Health bacteriological standards, a public water supply must conform to the following:

Of all the standard 10 ml portions examined per month, not more than 10 percent shall show the presence of coliform organisms. In addition, the presence of the coliform group in three or more 10 ml portions of a standard sample shall not be allowable if this occurs

(1) In two consecutive samples;
(2) In more than one sample per month when less than twenty are examined per month; or
(3) In more than five percent of the samples when twenty or more are examined per month.

MF:

IF the membrane filter technique (MF) is used, the arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 4/100 ml in:

(1) In two consecutive samples;
(2) In more than one sample per month when less than twenty are examined per month; or
(3) In more than five percent of the samples when twenty or more are examined per month.

The examination of this water sample was made in accordance with the latest edition of Standard Methods of Water Analysis.

For additional information, contact the Department of Social and Health Services, Health Services Division, Water Supply and Waste Unit.

1309 SMITH TOWER
SEATTLE 98104
(206) 464-7670

P. O. BOX 1788
OLYMPIA 98504
(206) 753-3466

WEST 924 SINTO
SPOKANE 99201
(509) 456-3115

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	SAMPLE OF DSHS FORM FOR BACTERIOLOGICAL ANALYSIS 307-98	APPENDIX IV

APPENDIX V

SPOKANE COUNTY HEALTH DISTRICT - BACTERIOLOGICAL RECORD OF WATER SAMPLES - 1972

K-T Number	DSHS Number	Agency	Total Number of Samples Taken and Number of Positive Tubes ( ) Found											
			Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
A1.01	00650	Town of Airway Heights	2	2	2	2	2	2	2(5)	2	2	2	2	2
.02	12400	City of Cheney	8	8	8	8	8	12	8	8	8(1)	8	8	8
.03	18500	City of Deer Park	2	2	2	2	2	2	2	2	2(1)	2	2(2)	2(4)
.04	24450	Town of Fairfield	2	2	2	2	2	2	2	2	2	2	8(2)	2
.05	46150	Town of Latah	2	2	2	2	2	2	2(5)	2	2	2	2(1)	2
.06	53400	Town of Medical Lake	4(1)	4(1)	4	4	4(1)	4(1)	4(1)	4	4	4	4	5
.07	54850	Town of Millwood	2	2	2	2	2	2	2	2	2	2	2	2
.08	73550	Town of Rockford	2	2	2	2	2(4)	2(3)	7(5)	2	5(6)	9(14)	1(5)	8(4)
.09	82870	Town of Spangle	2	2	2	2	2	2	2	2	2	2	2	2
.10	83100	City of Spokane	174	174	185	172(5)	195(3)	165	138	166	136(3)	133	141(5)	149
A2.01		Colbert Water District No. 9	0	0	0	0	0	0	0	0	0	0	0	0
.02A	21650	East Spokane Water District No. 1 (Basic)	3	3	3	4	3	3	3	5	4	4	4	4
.02B	06265	Ditto (Beverly Hills Zone)	2	2	2	2	2	2	2	2	2	2	2	2
.03	26200	Four Lakes Water District No. 10	2	0	2	2	2(5)	2(2)	2	2(5)	3	2	3	2(1)
.04	36050	Irvin Water District No. 6	2	3	3	2	2	2	2(2)	2	2	2	2	2(2)
.05A	96600	Whitworth Water District No. 2 (Zone 1)	2	2	2(1)	2	1	2	2	2	2	2	2	2(5)
.05B	96601	Ditto (Zone 2)	4	3	4	4(4)	4	4(3)	4	4	4	4	4	4
.05C&D	96602	Ditto (Zone 3)	2(2)	2(1)	2	2	2(2)	2	2	2	2(1)	2	2	3
.05E	96603	Ditto (Zone 4)	2(1)	2	2(4)	2	2	2	2	2	2	2	2	1
.05F	96607	Ditto (Zone 8)	2	2	2	2	2	2	2	2	2	2(2)	2	2
.05F	28000	Ditto (Gleneden, Part of Zone 8)	2	2	2	2	3	2	2	2	2	2	2	2
A3.01	11250	Carnhope Irr. District No. 7	2	2	3	2(1)	2	2	2	2	2	2(2)	2(3)	2
.02A	10220	Consolidated Irr. District No. 19 (Carder)	2	2	2	2	3	2	2	2	2	2	2	2(1)
.02B	10223	Ditto (Corbin)	2	2	2	2	2	2	2	3	3	3	3	3
.02C	10228	Ditto (East Farms)	2	2	3	4	3	2	2	3	2	2	2	2
.02D	10232	Ditto (Greenacres)	0	0	2	2	3	2	0	0	2	2	2	2
.02E	10236	Ditto (Otis Orchards)	2	2	2	2	3	2	2	2	3	2	2	2
.02F	10240	Ditto (West Farms)	0	0	1	1	0	3	2	2	2	1	0	0
.03	35100	Hutchinson Irr. District No. 16	3	3	3	4	3	4	5(4)	2	2	2	2	2
.04	55440	MOAB Irr. District No. 20	2	2	2(1)	2	3	2	2(5)	2	2(5)	2	2	2(1)
.05	55550	Model Irr. District No. 18	3(1)	3	3	4	7(5)	4	3	2(2)	2	2	2	2

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BACTERIOLOGICAL RECORD OF WATER SAMPLES, 1972	APPENDIX V

APPENDIX V (continued)

K-T Number	DSHS Number	Agency		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
				Total Number of Samples Taken and Number of Positive Tubes ( ) Found											
A3.06	61300	North Spokane Irr. District No. 8		0	2	2(2)	2	2	2	2	2	2	2	2	2
.07	64000	Orchard Ave. Irr. District No. 6		6	8(8)	5(3)	6	6	5(1)	5	6	6	6	6	6
.08	66300	Pasadena Park Irr. District No. 17		2	2	2	2(3)	2	2	3	2	2	2	2	2
.09	89250	Trentwood Irr. District NO. 3		3	3	3	3	3	3	3	2	2	2	2	2
.10	91450	Vera Irr. District No. 15		11(2)	11	12	15	12	16	14(1)	14(1)	13	12(1)	12	12
A4.01	19450	Dishman Water Company		2	3	2	2	2	2	2	2	2	2	2	2(1)
.02	29650	Greenacres Waterworks		2	2(1),2	2	2	2	2	2	2	2	2	2	2
.03	47150	Liberty Lake Utilities Company		2	2	2	3	2	2	2	2	2	2	2	2
.05	55600	Modern Electric Water Company		13(1)	18(1)	21(1)	23	25	21(2)	19(5)	23	19(5)	20	19	17
.06	60780	North Mountain Veiw Water Company, Inc.		2	2	2	2	2	2	2	2(5)	2	2	2	2
.07	67880	Pleasant Prairie Water Company		2	2	2	2	2	2	2(2)	2(2)	2	2	2	2
.08	73050	Rivilla Water Corp.		2	2	2	2	2	2	2	2	2	2(5)	2	2
.09	93350	Washington Water Power Company	(Zone 1)	4	4	4	6	4	5	4	5	5	5	6	5
.10	93351	Ditto	(Zone 2)	2	6	4	5	4	4	4	6	6	6	5	7(3)
.11	93353	Ditto	(Zone 3A)	4	4	4	4	4	4(6)	4	4	4	4	5	5(1)
.12	93354	Ditto	(Zone 3B)	2	2(1)	2	2	2	2	2	2	2	2	2(1)	2
.13	93355	Ditto	(Zone 3BP)	2	2	2	2	2	2	2	2	2	2	2	2
.14	93356	Ditto	(Zone 3C)	2	2	2	6(8)	2	2(3)	2(1)	2	2(3)	2	2	2
.15	93357	Ditto	(Zone 3D)	2(1)	2	2	2	2	2	2(1)	2	2	2	2	2
.16	93358	Ditto	(Zone 4)	2(1)	2	2	2	2	2	2(4)	1	6	5	5	4
.17	93360	Ditto	(Zone 6)	0	0	0	0	0	1	2	2	2	0	0	0
.18	59550	Ditto	(Nine Mile Power Station)	2	2(1)	2	2	2(1)	2	2(1)	2(2)	2	2(4)	2	2
.19	95450	West Shore Water Company, Inc.		2	2	2	2	2	2	2	2	2	2	2	2(2)
.04		Milan Water Company		0	0	0	0	0	0	0	0	0	0	0	0
A5.01	04179	Balmers Gardens Comm. Water Assn.		2	2	2	2	2	2	2	3	2	2	5(3)	2
.02	11935	Cedar Knolls Water Assn.		0	0	0	0	2	1	1	1	1	1	1	1
.03	22915	Elk Community Water Assn.		2	2	2(1)	2	2	2	2	2	2	2	2	2
.04	28125	Glenrose Water Assn.		1(2)	4	2(1)	2	2(5)	1	2(2)	2(1)	2	2(1)	2(6)	2(2)
.05	47145	Liberty Lake Improvement Club		2	2(1)	4	3	2	2	2	2	2	3	2	2
.06	51845	Marshall Community Water Assn.		2	2	2	2	2	2	2	2	2	2	2(1)	2
.07	93820	Waverly Heights Water Assn.		2	2	2	2	2	2	2	2	2	2	2	2
A6.01	30420	Halfmoon Ranchos		1	2	2	2(4)	2(6)	3(1)	2	2	2	2	2	2
.02	60520	North Glen Estates		2	1	2	2	2	2	2	2	2	2	2	2
.03	65910	Panorama Acres		2(2)	2	2	2	2	2	2	2	2	2	2	2

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy – Tudor Consulting Engineers	BACTERIOLOGICAL RECORD OF WATER SAMPLES, 1972	APPENDIX V (cont.)

APPENDIX V (continued)

Total Number of Samples Taken and Number of Positive Tubes (·) Found

K-T Number	DSHS Number	Agency	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
A6.04	69165	Prairie Pines	2	1	0	0	0	0	0	0	2	1	0	0
.05	72962	Rivervale	0	0	0	0	2	0	1	0	1	1	1(1)	1
.06	83034	Spokane Lake Park	0	0	0	0	0	0	0	0	0	0	0	0
.07	91445	Velview Estates	2(1)	2(3)	2(3)	2	2	2	2(1)	2	2	2	2(1)	2
B1.01	24350	Fairchild Air Force Base	2	2	0	0	2	2	2	2	2	2	1	2
B2.01	21850	Eastern State Hospital	2(1)	2	2	2	2	2	2	2	2	2	2	2
.02	21900	Eastern Washington State College	2	2(2)	2	2	2	2	2	2	2	2	2	2
.03*	56620	Mt. Spokane State Park	0	0	0	0	0	0	0	0	0	0	0	0
.04*	72840	Riverside State Park	0	0	0	0	0	0	0	0	0	0	0	0
B3.01		Spokane International Airport	0	0	0	0	0	0	0	0	0	2	2	0
C4.10	56610	Mt. Spokane Motel (Colbert Area)	0	2	2	2	2	2	2(1)	2	2	7(3)	2	2
C2.13	37420	Kaiser - Mead Works	0	0	0	0	0	0	0	0	0	0	0	0
.14		Kaiser - South Mead Works	0	0	0	0	0	0	0	0	0	0	0	0
.15	37450	Kaiser - Trentwood Works	0	0	0	0	0	0	0	0	0	3(3)	3	3(4)
.19	83027	Spokane Industrial Park	0	0	0	0	3	3	2	3	3			

* Not on Health District Record

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BACTERIOLOGICAL RECORD OF WATER SAMPLES, 1972	APPENDIX V (cont.)

APPENDIX VI

SPOKANE COUNTY HEALTH DISTRICT - BACTERIOLOGICAL RECORD OF WATER SAMPLES - 1973

K-T Number	DSHS Number	Agency	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
			Total Number of Samples Taken and Number of Positive Tubes ( ) Found											
A1.01	00650	Town of Airway Heights	2	2	2	2	4	2	2	2	2			
.02	12400	City of Cheney	8	8	8	8	8	8	7	8	8			
.03	18500	City of Deer Park	2(1)	2	2	2	2	2	2	2	2			
.04	24450	Town of Fairfield	2	2	2	2	2	2	2	2	2			
.05	46150	Town of Latah	2	2	2	2	1	0	1	0	0			
.06	53400	Town of Medical Lake	5	5	5	2	2(3)	2	16	2	2(1)			
.07	54850	Town of Millwood	2	2	2	2	2	2	2	2	2			
.08	73550	Town of Rockford	2	2	2	2	2(1)	2	2(4)	2	2(1)			
.09	82870	Town of Spangle	2	2	2	2	1	1	1	0	0			
.10	83100	City of Spokane	160	166	135	158(1)	151	151(2)	142	163(1)	159(73)			
A2.01		Colbert Water District No. 9	0	0	0	0	0	0	1	0	0			
.02A	21650	East Spokane Water District No. 1 (Basin)	4	4	4	3	3	3	3	3	2			
.02B	06265	Ditto (Berverly Hills Zone)	2	2	2	1	0	0	0	0	0			
.03	26200	Four Lakes Water District No. 10	2	2	2	1	1(2)	2(4)	2(3)	3(1)	1			
.04	36050	Irvin Water District No. 6	2(3)	2	2	2	2	2	2	2	3			
.05A	96600	Whitworth Water District No. 2 (Zone 1)	3	2	2	2	2	2	2(1)	2	2			
.05B	96601	Ditto (Zone 2)	4	4	4	5(4)	4	4	3	5	5			
.05C	96602	Ditto (Zone 3)	2	2	2	2	2	2	2(2)	3	1			
.05D	96603	Ditto (Zone 4)	2	2	2	2	1	0	2	0	0			
.05E	96607	Ditto (Zone 8)	2	2(2)	2	1	0	0	1	0	0			
.05F	28000	Ditto (Gleneden, Part of Zone 8)	2	2	2	2	0	0	1	1	0			
A3.01	11250	Carnhope Irr. District No. 7	2(1)	2	2	2	2	2	2	2	2			
.02A	10220	Consolidated Irr. District No. 19 (Carder)	2	2	2	2	0	0	1	0	0			
.02B	10223	Ditto (Corbin)	3	3	3	3	3	3	3	3	3			
.02C	10228	Ditto (East Farms)	2(2)	2(1)	3	3	2	2	2	2	2			
.02D	10232	Ditto (Greenacres)	2	2	2	2	2	2	2	2	2			
.02E	10236	Ditto (Otis Orchards)	2(2)	2	2	2	2	2(5)	3	2	1			
.02F	10240	Ditto (West Farms)	0	0	0	0	2	2	2(1)	2	1			
.03	35100	Hutchinson Irr. District No. 16	2	2	2	2	2	2	2	2	2			
.04	55440	MOAB Irr. District No. 20	2	2	2(1)	1	1	0	0	1	0			
.05	55550	Model Irr. District No. 18	2	2	2	3	4	4	4	4	6			

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BACTERIOLOGICAL RECORD OF WATER SAMPLES, 1973	APPENDIX VI

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APPENDIX VI (continued)

K-T Number	DSHS Number	Agency		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
				Total Number of Samples Taken and Number of Positive Tubes ( ) Found											
A3.06	61300	North Spokane Irr. District No. 8		2	2	2	2	2	2	1	2	2			
.07	64000	Orchard Ave. Irr. District No. 6		6(4)	6	5	4	4	4	4	4	4			
.08	66300	Pasadena Park Irr. District No. 17		2	2	2	3(1)	2	2	2	2	2			
.09	39250	Trentwood Irr. Dist. No. 3		2	2	2	3	6	4	4	4	4(2)			
.10	91450	Vera Irr. District No. 15		13	12	11	14	13	13	13	13	11			
A4.01	19450	Dishman Water Company		4	2	2	2	2	2	2	2	2			
.02	29650	Greenacres Waterworks		2	2	2	2	2	2	2	2	2			
.03	47150	Liberty Lake Utilities Company		2	2	2	2	2	2	2	2	2			
.04		Milan Water Company		0	0	0	0	0	0	0	0	1			
.05	55600	Modern Electric Water Company		17(1)	17(2)	17(1)	18	18	18	18	18	18			
.06	60780	North Mountain View Water Co., Inc.		2	2	2	2	0	0	1	0	0			
.07	67980	Pleasant Prairie Water Company		2	2	2	1	0	0	0	0	0			
.08	73050	Rivilla Water Corp.		2	2	2	2	0	0	1	0	0			
.09	93350	Washington Water Power Company	(Zone 1)	5	5	5	5	5	4	6	5	4			
.10	93351	Ditto	(Zone 2)	6(3)	6	6	6	6	6	5	6	6			
.11	93353	Ditto	(Zone 3A)	5	5	5	5	5	5	5	5	5			
.12	93354	Ditto	(Zone 3B)	2	2	2	3(2)	2	2	1	2	2			
.13	93355	Ditto	(Zone 3BP)	2	2	2	2	2	2	1	2(5)	2			
.14	93356	Ditto	(Zone 3C)	2	2	2	1	1	1	1	1	1(1)			
.15	93357	Ditto	(Zone 3D)	2	2	2	2	1	1	2(1)	1	1			
.16	93358	Ditto	(Zone 4)	2	2	2	2	2	2	2	2	2			
.17	93360	Ditto	(Zone 6)	0	0	0	0	1	0	0	0	0			
.18	54550	Ditto (Nine Mile Power Station)		2(1)	2(1)	2	1	1	1	1	1	1			
.19	95450	West Shore Water Company		2	2	2	1	1	0	0	1	0			
A5.01	04179	Balmers Gardens Comm. Water Assn.		2	2	2	1	1	0	0	1	0			
.02	11935	Cedar Knolls Water Assn.		1	1	1	1	0	0	1	0	0			
.03	22915	Elk Community Water Assn.		2	2	2	1	1	0	1	1	0			
.04	28125	Glenrose Water Assn.		2(2)	2	2	11(5)	1	1	1(3)	5(2)	1			
.05	47145	Liberty Lake Improvement Club		2	2	2	2	2	2	2	3(1)	2			
.06	51845	Marshall Community Water Assn.		2	2	2	1	0	0	1	0	0			
.07	93820	Waverly Heights Water Assn.		2	2	2	2	1	0	1	0	3(5)			

WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy – Tudor Consulting Engineers	BACTERIOLOGICAL RECORD OF WATER SAMPLES, 1973	APPENDIX VI (cont.)

APPENDIX VI (continued)

K-T Number	DSHS Number	Agency	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
			Total Number of Samples Taken and Number of Positive Tubes ( ) Found											
A6.01	30420	Halfmoon Ranchos	2	2	2	2	0	0	1	0	0			
.02	60520	North Glen Estates	2	2	2	2	0	0	1	0	0			
.03	65910	Panorama Acres	2	5	2	1	0	0	1	0	1			
.04	69165	Prairie Pines	0	0	2	1	1	0	0	0	1			
.05	72962	Rivervale	1	1	2	2(1)	1	1	1(2)	1	1(5)			
.06	83034	Spokane Lake Park	0	0	1	0	1	0	0	1	0			
.07	91445	Velview Estates	2	2	2	1	0	0	1	1	0			
B1.01	24350	Fairchild Air Force Base	2	2	2	2	2	2	2	2	2			
B2.01	21850	Eastern State Hospital	2	2	2	4	4	4	12(29)	4	4			
.02	21900	Eastern Washington State College	2	2	2	2	2	2	2	2	2			
.03*	56620	Mt. Spokane State Park												
.04*	72840	Riverside State Park												
B3.01		Spokane International Airport	2	2	1	2	2	2	2	2	2			
C4.10	56610	Mt. Spokane Motel (Colbert Area)	2	2	2	2	0	0	1	0	0			
C2.13	37420	Kaiser - Mead Works	0	0	0	2	2	2	2	2(1)	2			
.14		Kaiser - South Mead Works	0	0	0	2	2	2	2	2(1)	2			
.15	37450	Kaiser - Trentwood Works	0	0	0		2	2	2	2	2			
.19	83027	Spokane Industrial Park	3	3	4	3	3	3	3	3	3			

* Not on Health District Record

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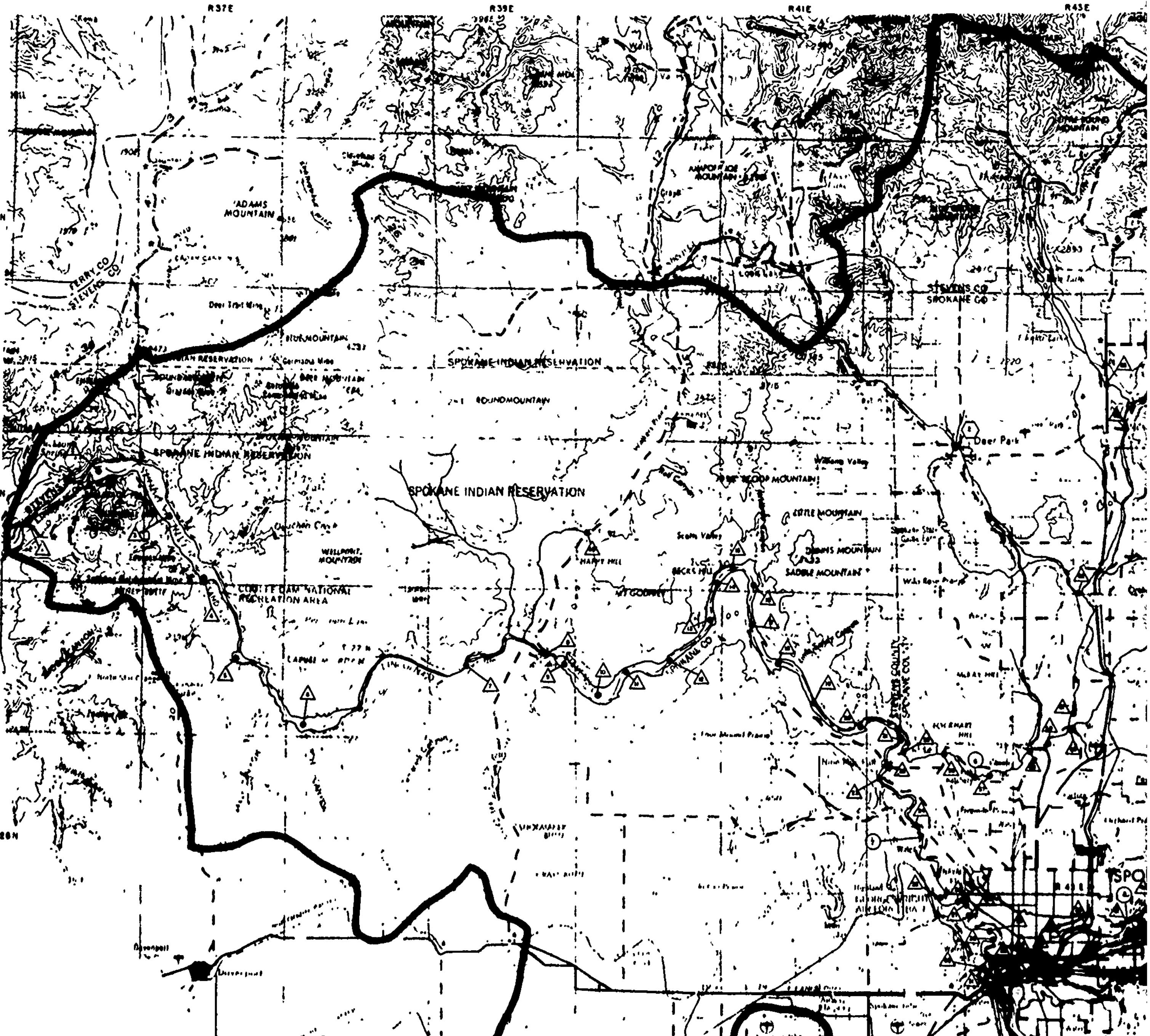
- WATER RESOURCES STUDY METROPOLITAN SPOKANE REGION Dept. of the Army, Seattle District Corps of Engineers Kennedy - Tudor Consulting Engineers	BACTERIOLOGICAL RECORD OF WATER SAMPLES, 1973	APPENDIX VI (cont.)



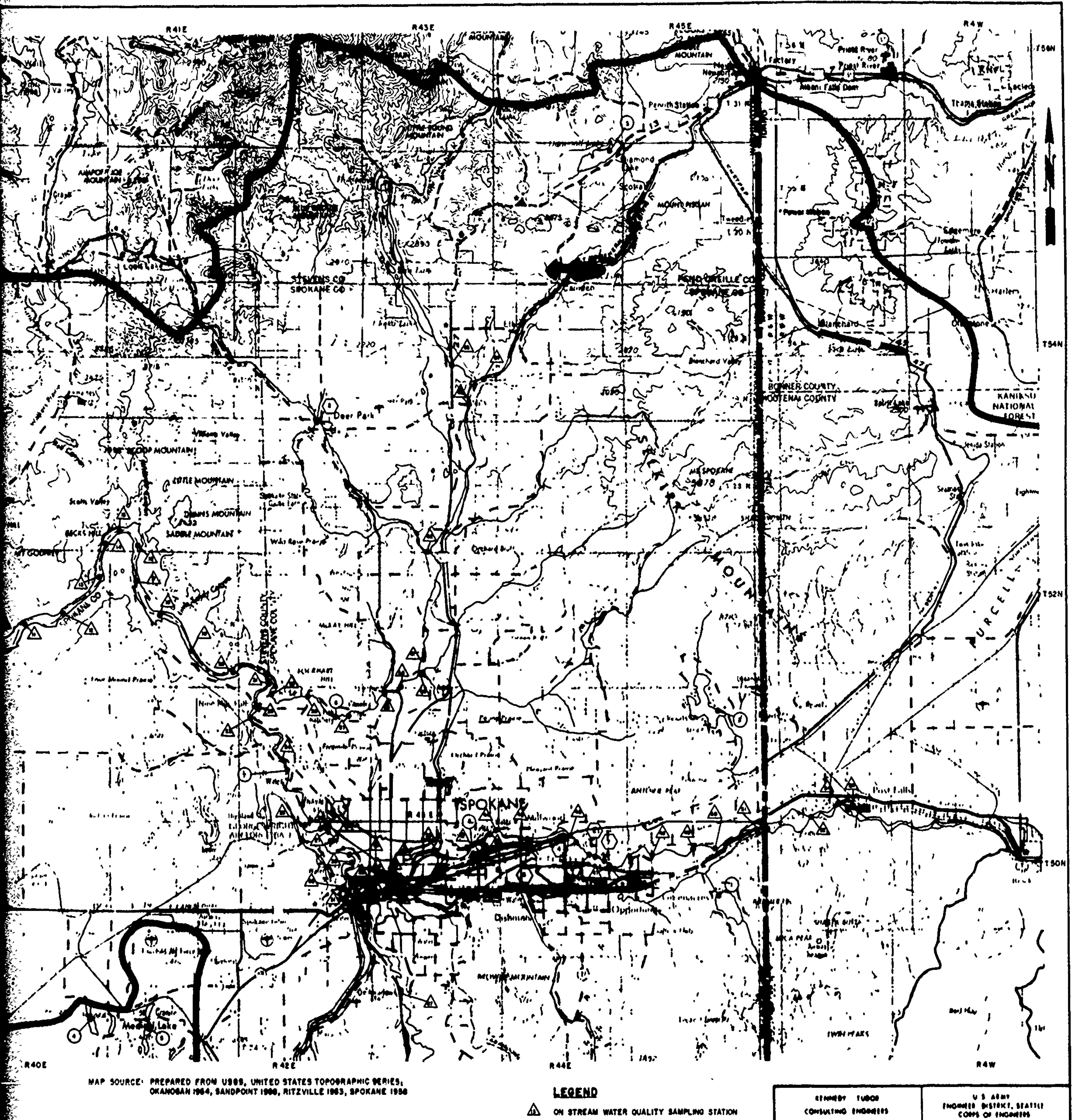
MAP SOURCE: PREPARED FROM USGS, UNITED STATES TOPOGRAPHIC SERIES, OKANOGAN 1964, SANDPOINT 1968, RITZVILLE 1963, SPOKANE 1958

5 4 3 2 1 0 5 MILES

5,000 0 5,000 10,000 15,000 20,000 25,000 FEET

GRAPHIC SCALES

REVISIONS			
SYMBOL	DESCRIPTION	DATE	BY



MAP SOURCE: PREPARED FROM USGS, UNITED STATES TOPOGRAPHIC SERIES, OKANOGAN 1964, SANDPOINT 1966, RITZVILLE 1963, SPOKANE 1958

LEGEND

- △ ON STREAM WATER QUALITY SAMPLING STATION
- ⬡ MUNICIPAL OR INDUSTRIAL WASTE DISCHARGE
- ○ OFF STREAM WATER QUALITY SAMPLING STATION

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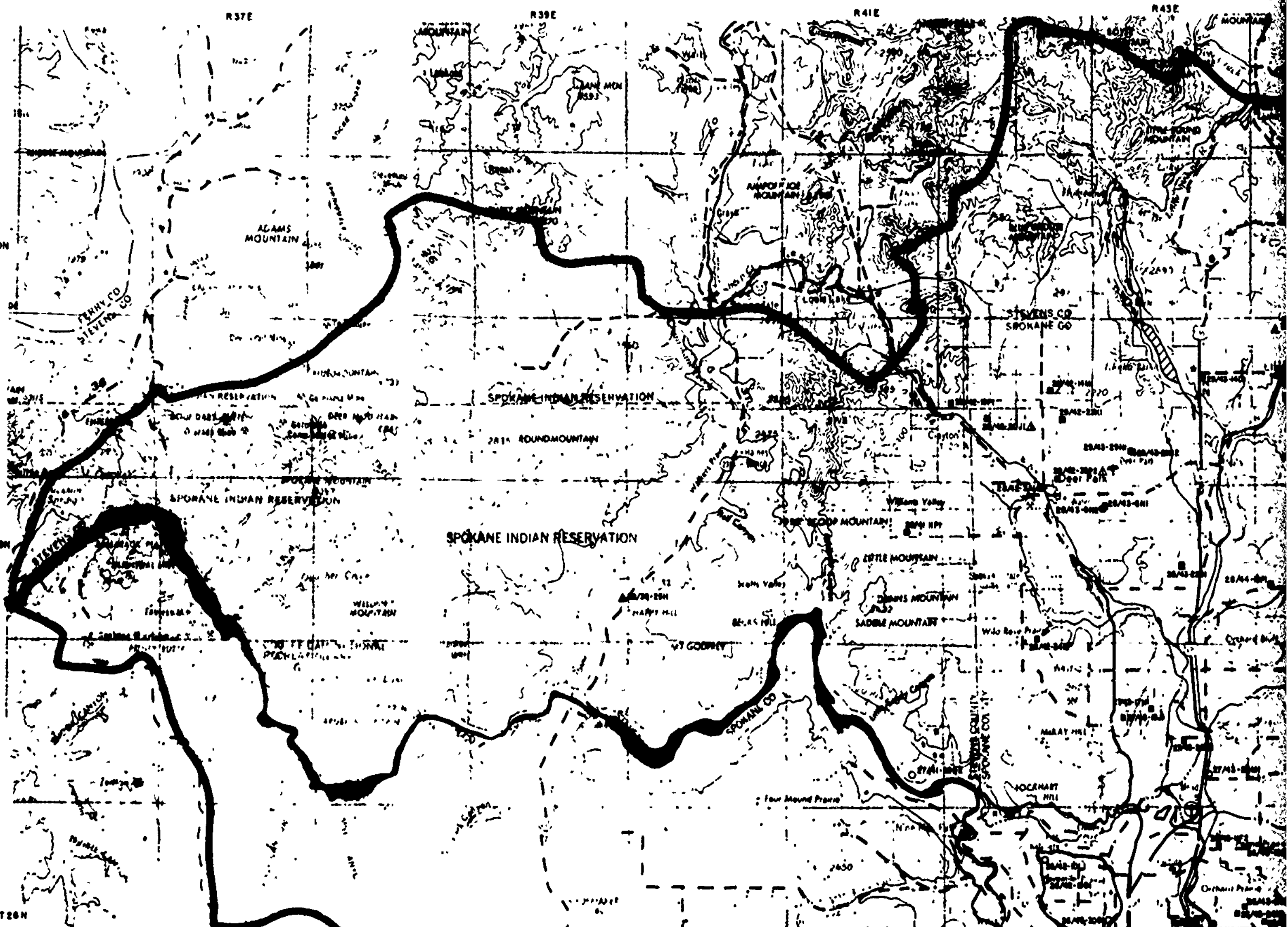
WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION

SURFACE WATER QUALITY STATIONS

PLATE 307-1

DACW67-73-C-0096



MAP SOURCE: PREPARED FROM USGS, UNITED STATES TOPOGRAPHIC SERIES, OKANOGAN 1954, SANDPOINT 1958, RITZVILLE 1953, SPOKANE 1958

5 4 3 2 1 0 5 MILES

5,000 0 5,000 15,000 25,000 35,000 FEET

GRAPHIC SCALES

REVISIONS			
SYMBOL	DESCRIPTION	DATE	BY
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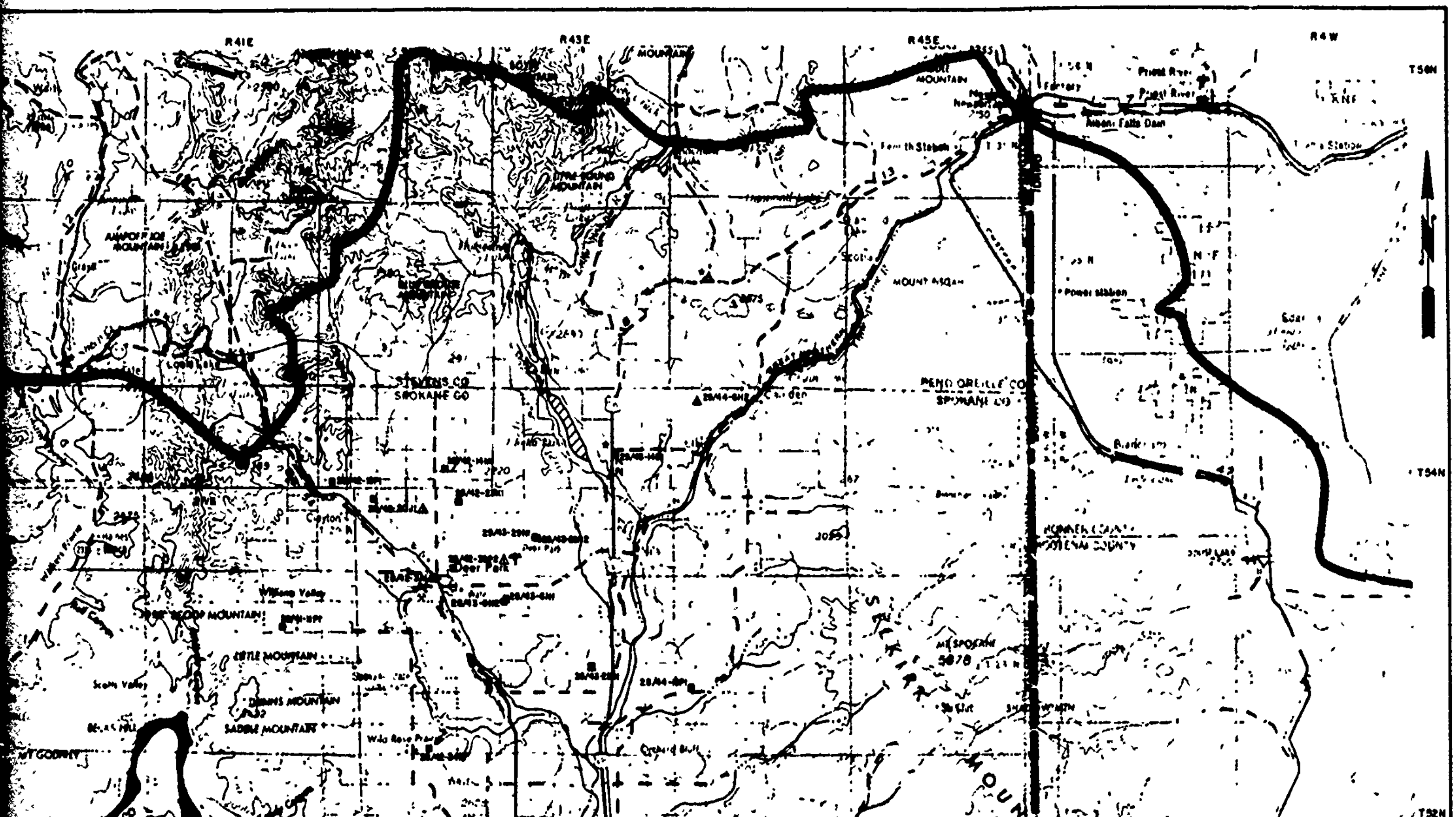


MAP SOURCE: PREPARED FROM USGS, UNITED STATES TOPOGRAPHIC SERIES, OKANOGAN 1964, SANDPOINT 1958, RITZVILLE 1963, SPOKANE 1958

LEGEND

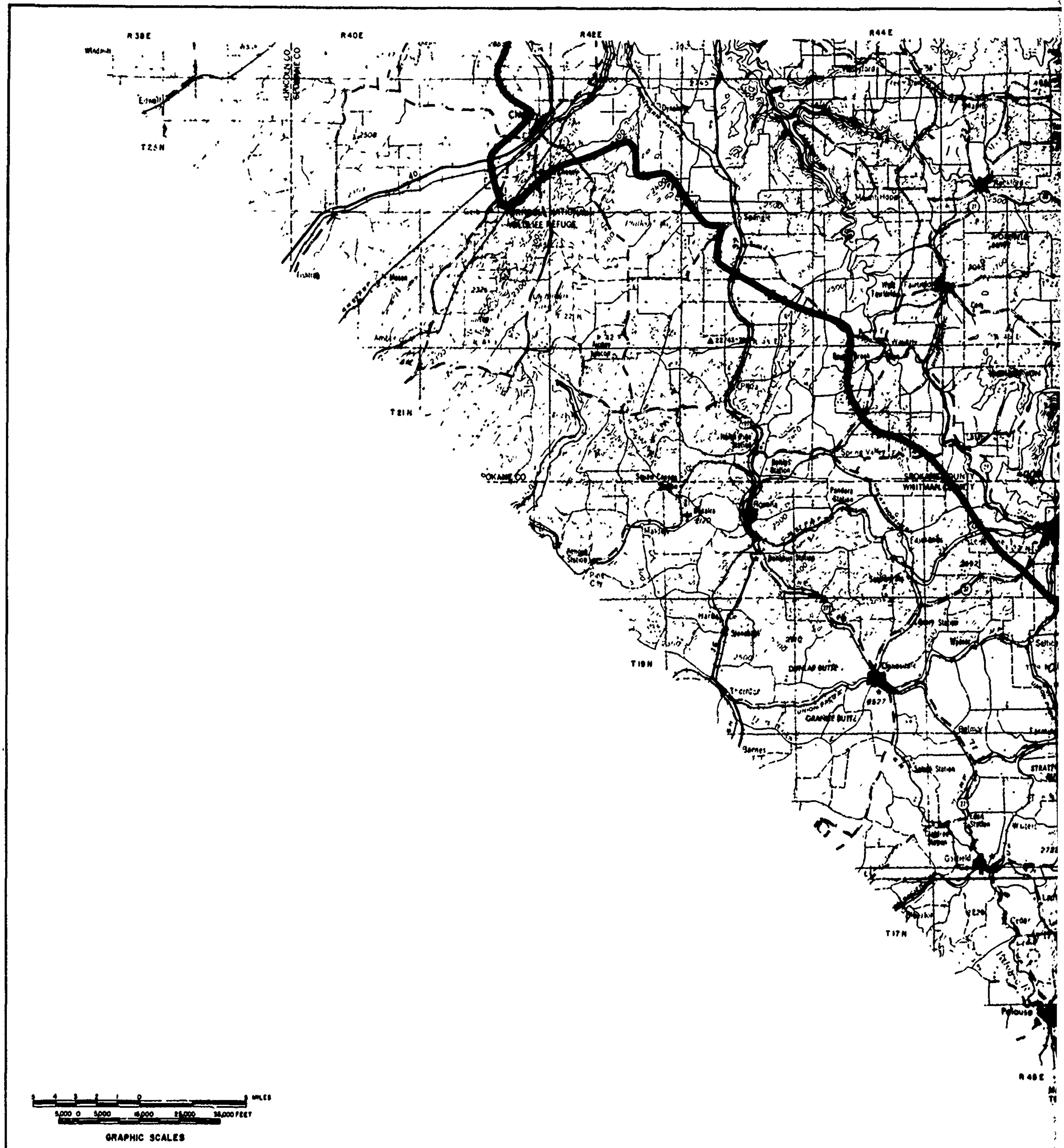
- —— APPROXIMATE SPOKANE VALLEY AQUIFER BOUNDARY
- ▲ VAN DENBURGH
- ■ CLINE
- ● WEIGLE & MUNDORFF
- ○ U.S.G.S. UNPUBLISHED

KENNEDY TUDOR CONSULTING ENGINEERS SEATTLE, WASHINGTON	U.S. ARMY ENGINEER DISTRICT, SEATTLE CORPS OF ENGINEERS SEATTLE, WASHINGTON

WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION

GROUNDWATER QUALITY STATIONS
NORTH PORTION OF STUDY AREA

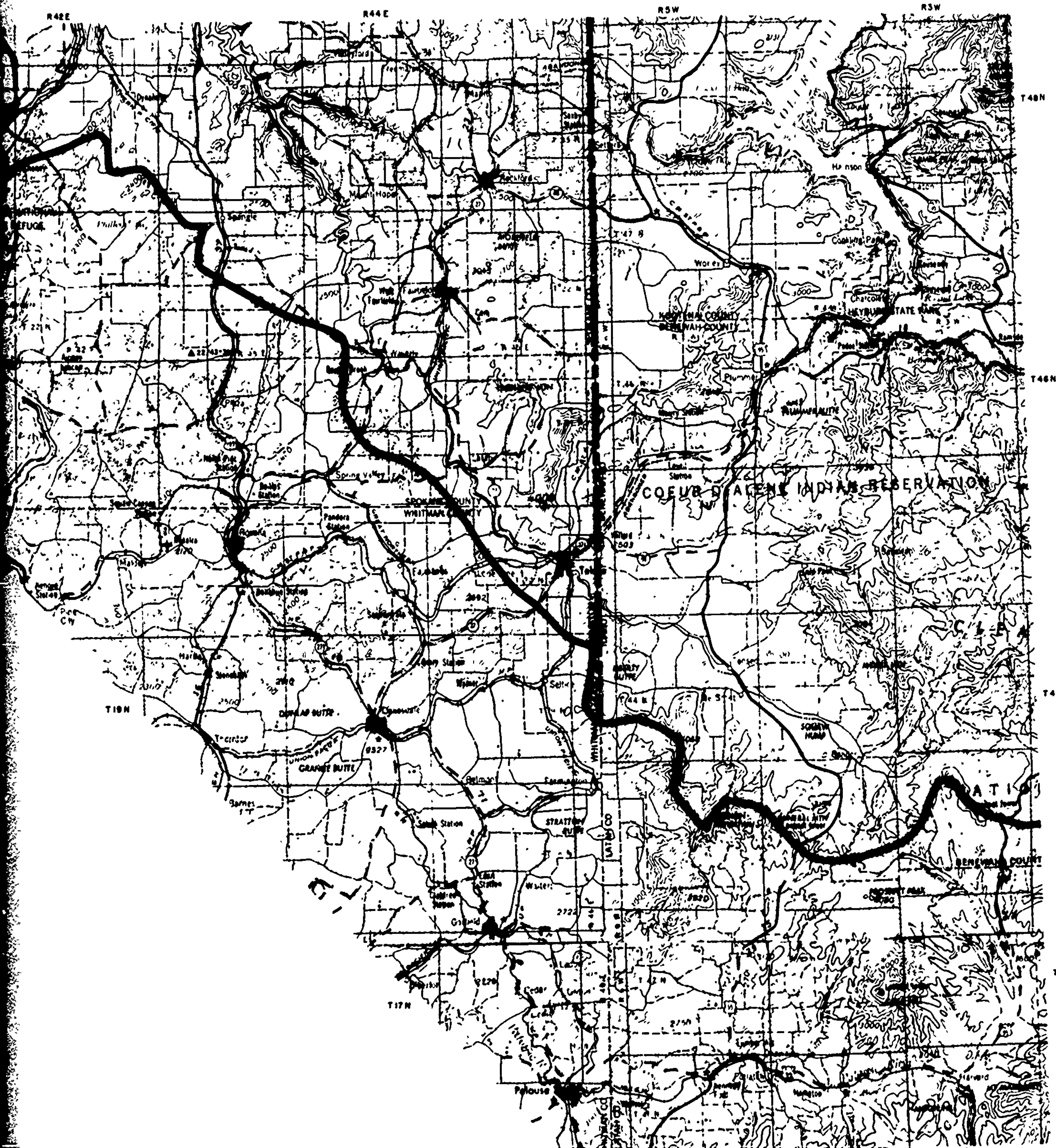
PLATE 309-1



REVISIONS			
SYMBOL	DESCRIPTION	DATE	BY

LEGEND

▲ VAN DENBURGH



MAP SOURCE: PREPARED FROM USGS, UNITED STATES TOPOGRAPHIC SERIES; SPOKANE 1950, PULLMAN 1955

LEGEND

▲ VAN DENBURGH

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SEATTLE, WASHINGTON

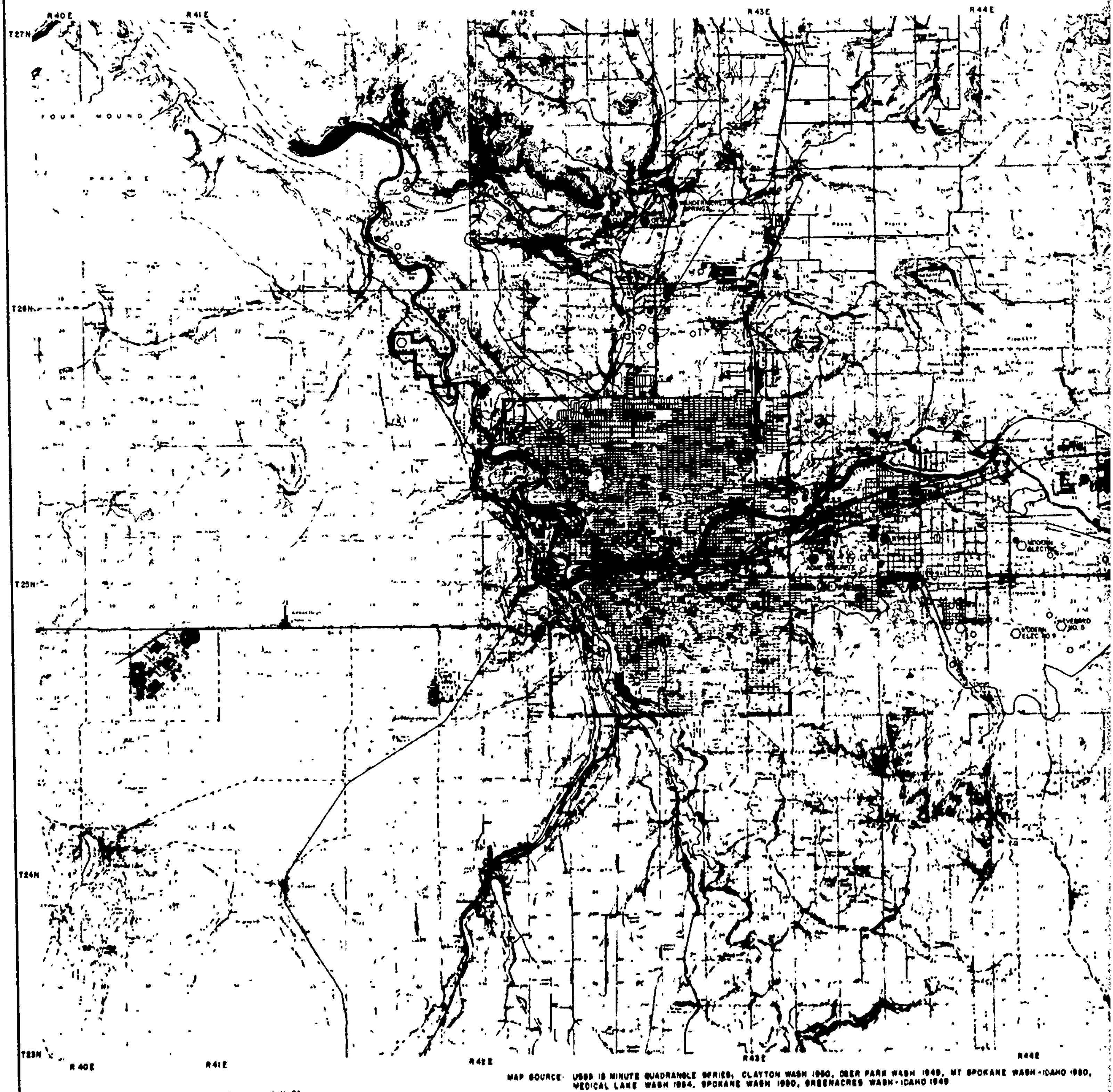
U S ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE WASHINGTON

WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION

GROUNDWATER QUALITY STATIONS
SOUTH PORTION OF STUDY AREA

DACW67 73-C-0096

PLATE 309-2



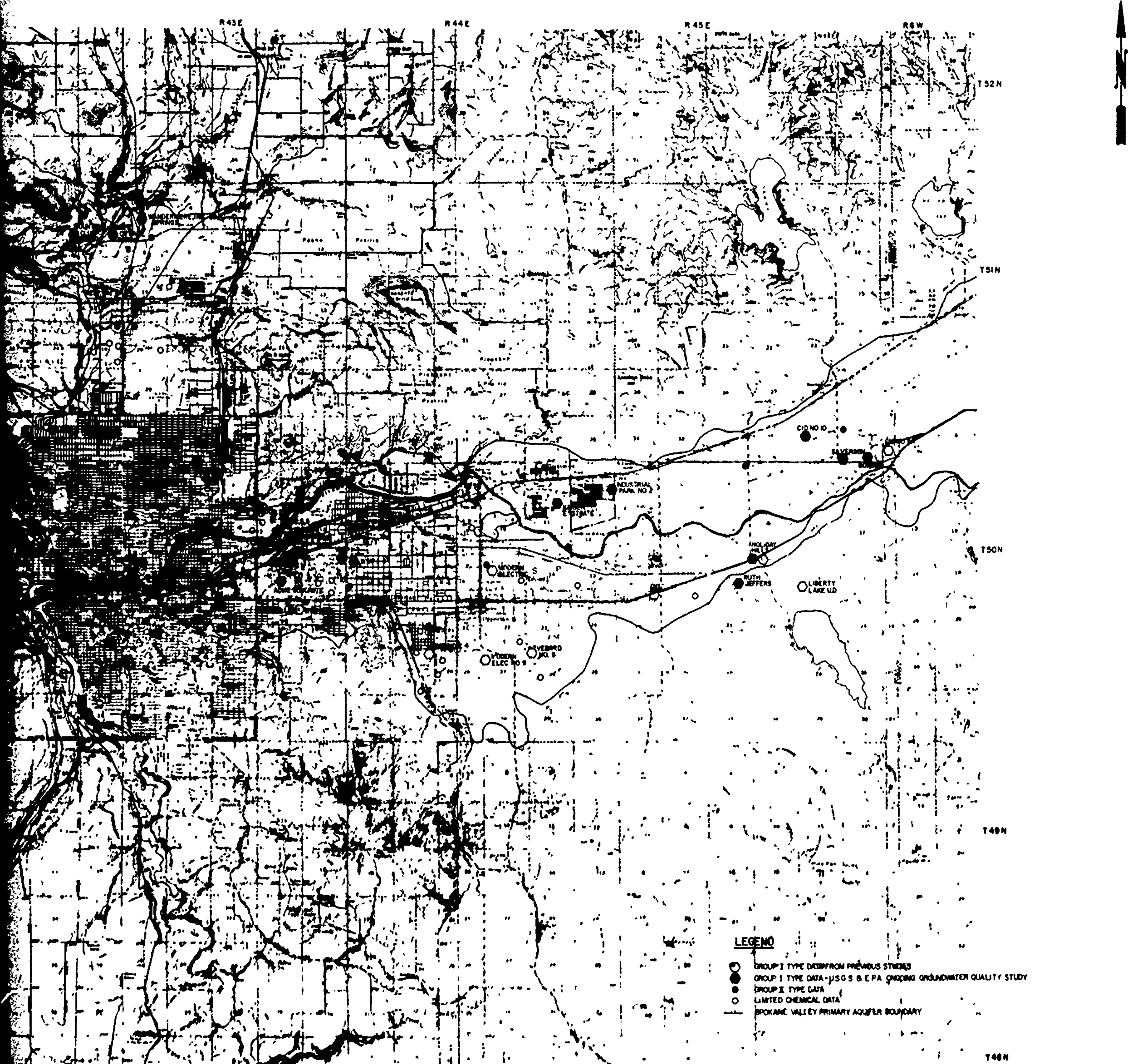
MAP SOURCE: USGS 15 MINUTE QUADRANGLE SERIES, CLAYTON WASH 1950, DEER PARK WASH 1949, MT SPOKANE WASH-IDAHO 1950, MEDICAL LAKE WASH 1954, SPOKANE WASH 1950, GREENACRES WASH-IDAHO 1949

1/2 0 1 2 3 4 MILES

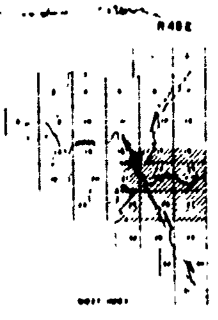
5000 0 5000 10000 15000 20000 FEET

GRAPHIC SCALES

REVISIONS			
SYMBOL	DESCRIPTION	DATE	BY



USGS 15 MINUTE QUADRANGLE SERIES, CLAYTON WASH 1950, DEER PARK WASH 1949, MT SPOKANE WASH-IDAHO 1950, MEDICAL LAKE WASH 1954, SPOKANE WASH 1950, GREENACRES WASH-IDAHO 1949.



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CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WATER RESOURCES STUDY
METROPOLITAN SPOKANE REGION

GROUNDWATER QUALITY STATIONS
PRIMARY SPOKANE VALLEY AQUIFER

PLATE 309-3