INVESTIGATIONS

Geohydrologic Evaluation of Aeneas Lake-Horse Springs Coulee, Okanogan County, Washington

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INTRODUCTION

The project area occupies a north-south trending valley, approximately 5 miles west of Tonasket, Washington, and lies between Aeneas Mountain on the west and Cayuse Mountain on the east. The valley is bounded on the north by Spectacle Lake and by Aeneas Creek on the south. The area is about 11 miles long and averages about 4 miles in width. The site is served by a surfaced county road from Tonasket and several gravel roads traverse the area.

Horse Springs Coulee and the associated mountains comprise an area of mature topography of moderate relief with rolling hills and wide valleys. The topography has been modified by the advance and recession of at least one, and perhaps two continental ice sheets which extended into this area from Canada. Horse Springs Coulee ranges in elevation from about 1350 feet at the south to 1600 feet at the north, with mountainous areas of Aeneas and Cayuse Mountains ranging between 2000 and 5000 feet. Land surface gradient averages approximately 25 feet/mile from north to south.

Purpose and Scope of Investigation

Since prior to 1964, water levels in Aeneas Lake and wells located in Horse Springs Coulee have declined steadily, indicating that increased pumping for irrigation purposes was exceeding the annual recharge and, if permitted to continue, would eventually deplete the water in storage in the underground reservoir.

In February, 1964, the Division of Water Resources of the Department of Conservation initiated a water level monitoring program designed to measure and record the rate of water level decline that was taking place in the Aeneas Lake-Horse Springs Coulee complex. On August 9, 1964, a meeting, sponsored by the Chamber of Commerce, was held in Tonasket to review the Aeneas Lake problem. In attendance were representatives of the Washington State Department of Water Resources, Bureau of Reclamation, Washington State Department of Game, local state legislators, as well as property owners in Horse Springs Coulee area and people interested in the recreational value of the lake. During the meeting, the senior author reviewed the water level decline that had taken place and projected probable future declines that would occur if withdrawals from the system continued at the present rate, without supplemental artificial recharge.

During the discussion that followed, the senior author mentioned several sources of water that were available to supplement natural recharge to the system and recommended that pumping from the Okanogan River directly into Aeneas Lake seemed to be the most practical method of recharge.

In July, 1968, Plateau Orchards Inc. of Oroville, Washington, submitted an application to the Department of Water Resources requesting a permit to appropriate 12 cfs to a total of 2700 acre-feet per year from the Okanogan River to maintain the level of Aeneas Lake and irrigate 900 acres of land in the vicinity of the lake. A permit was issued and construction of the pipeline was completed in the summer of 1970. The project is now being operated by the recently formed Aeneas Lake Irrigation District.

On March 23, 1970, a request was received from the Water Management Division of the Department of Water Resources to provide the geologic and hydrologic data needed to define and designate a ground water subarea in hydraulic continuity with Aeneas Lake. This report was prepared to satisfy that request.

Geologic interpretation by the senior author is based on personal reconnaissance mapping in 1948 and from personal observations made during the week of July 28, 1970. A portion of the area was mapped in 1962 as partial requirement for a Master of Science thesis by Robert W. Adams, University of Washington. Reconnaissance of the area was made by the authors, and Adams' mapping was verified. Therefore, his mapping was accepted for the applicable part of the project.

PROJECT AREA

Watershed

The study area is shown on Plate I. The Aeneas Lake-Horse Springs Coulee basin lies between the crests of Aeneas Mountain and Cayuse Mountain. The basin is bounded on the south by a northeast-southwest trending line connecting the southern extension of Lemansky Mountain near the center of the SE 1/4 of Sec. 35 and the crest of the upland in the center of the E 1/2 of Sec. 25, Twp. 37 N., Rge. 26 E. The area is bounded on the north by a westerly trending line connecting the northwest tip of Cayuse Mountain through several prominent bedrock outcrops in Horse Springs Coulee in Secs. 8 and 9, Twp. 38 N., Rge. 26 E., with the northeast tip of Aeneas Mountain near the west quarter corner of Sec. 8, Twp. 38N., Rge. 26E.

Except for water lost from evapotranspiration and through three possible subsurface outlets, all precipitation falling in the project area migrates toward and contributes to the project aquifer.

Aeneas Lake-Horse Springs Coulee Aquifer

The aquifer is defined as that part of the project area in direct hydraulic continuity with Aeneas Lake and is in a position geologically to benefit directly or indirectly from artificial recharge through water pumped from the Okanogan River and discharged into Aeneas Lake.

The aquifer is outlined on Plate I and the perimeter boundary described as follows:

> Beginning at the intersection of the county road and the south line of Sec. 25, Twp. 37 N., Rge. 26 E.W.M., thence west along said section line extended to its intersection with the 1600' contour as expressed on the U.S.G.S. quadrangle map, "Conconully, Washington," 1957, then following the 1600' contour in a northerly direction through Secs. 26, 33, 22, 15, 10, 9 and 4, Twp. 37 N., Rge. 26 E., and Secs. 34, 27, 22, 21, 16 and 9, Twp. 38 N., Rge. 26 E., to its intersection with the project north boundary line connecting the southeast corner with the center of Sec. 9, Twp. 38 N., Rge 26 E.W.M., then southeasterly along said line to its intersection with the 1600' contour near the west wall of Horse Springs Coulee, then following the 1600' contour in a southerly and easterly direction through Secs. 9, 16, 22, 27, 34 and

35, Twp. 38 N., Rge. 26 E.W.M., and Secs. 2, 11 and 14 to its intersection with the south line of Sec. 14, then east on the south line of said Sec. 14 approximately 1 1/2 miles to the southeast corner of Sec. 13, Twp. 37 N., Rge 26 E.W.M., then south on the east line of Secs. 24 and 25, a distance of approximately 1 1/4 miles to its intersection with the 1600' contour on the north slope of a prominent bedrock (andesite) hill, then along the 1600' contour in a westerly and southerly direction to a point 790 feet east of the county road in said Sec. 25, then south parallel to said county road, a distance of about 2640 feet to its intersection with the south line of Sec. 25, then west 790 feet to POB. The boundary encloses an area of approximately 8.94 square miles. (Note: All reference points are from the U.S.G.S. 15' quadrangle maps "Conconully" 1957 and "Tonasket" 1957.)

GEOLOGY, GENERAL

During late Triassic or post Triassic time, 7000 feet or more of continental clastic and chemical sediments were laid down in a large geosyclinal basin lying generally between the Okanogan River and the Sinlahekin Valley, north of the town of Riverside. The series consisted of fine-grained clastic sediments with interbeds of volcanic rock followed by a succession of carbonate rocks.

Deposition of the marine sediments was followed by orogenic deformation which resulted in a series of north-south trending anticlinal and synclinal folds. During deformation, the sediments were subjected to low grade metamorphism which altered the sediments and volcanic rocks. The sediments are now phyllites, schists and metaconglomerates and the volcanic rocks are meta-volcanics and greenstones. The limestones are impure dolomites and banded marble. Waters and Krauskoph, (1941) projected the Anarchist series southward from Canada into the study area. However, Adams (1962) indicated that no paleontological work or correlation of rock types has been performed in the study area. For these reasons it is not known if the meta-sediments within this area are of the Anarchist series. The name "Anarchist series" is used in this report to define the Mesozoic rock types. After a long period of quiescence, Tertiary rhyolites and andesites were extruded locally.

During Pleistocene time the irregular bedrock surface was further altered by the advance and recession of at least one major continental glacier that rode over the area from the north. Upland areas were scoured by the advancing ice.

Valleys and depressions were subsequently filled with sand, gravel, clay and silt (recessional outwash) as the last of the ice ablated away. These recessional outwash deposits serve as the main aquifer in Horse Springs Coulee.

Anarchist Series

For this report, the Tertiary andesites and rhyolites will be included with the meta-sediments and other rocks of the Anarchist series (R.A. Daley, 1912) (Waters and Krauskoph, 1941) because all these rock types are dense, fine-grained and impervious and do not serve as aquifers. Rather, they serve as the impervious base and walls for the Horse Springs Coulee aquifer system.

Glacial Drift

Pleistocene glacial deposits in the project area include drift of Fraser age and perhaps one earlier continental ice sheet. These deposits range between 20 and 150 feet or more in thickness and probably average about 100 to 125 feet thick under most of the area below 1600' MSL.

On the upland terraces between 1600 and 2000' elevation, the bedrock of the Anarchist series is overlain by a relatively thin deposit of glacial drift which thins rapidly toward the valley walls in the southern portion of the area. The drift appears to be "plastered" onto the walls in the northern part. In places, outliers of Anarchist rock appear as islands surrounded by the glacial drift.

The topography of the study area indicates kettle plain geomorphology. Kame terraces flank both sides of the coulee and Aeneas Lake is an excellent example of a kettle lake. The uplands to the southeast also show the classic mounds of sand and gravel. The valley floor consists of ground morainal and outwash material. This material is overlain by alluvial fans which were generated from the terrace material flanking the valley floor. (Figure 1)

HYDROLOGY

Watershed Area

The project watershed is outlined on Plate I and consists of an area of about 36 sq miles bounded on the east and west by the crests of the Cayuse and Aeneas mountain ranges, respectively on the south and by a somewhat arbitrary east-west line between Aeneas Lake and Aeneas Creek, and on the north by a line between Spectacle Lake and Horse Springs Coulee.

The mean annual precipitation at the nearest climatological data point (Oroville) was 11.42" over a 36-year period. (Figure 2)

Precipitation is light in summer, increasing in the fall, reaching a peak in winter, then decreasing in spring with an increase in May and June followed by a sharp drop near the first of July. Total rainfall for each of the months, July, August and September, is less than .1 of an inch in one summer out of ten; also, rainfall exceeds 1.6 inches in July, 2.1 inches in August and 1.3 inches in September in one out of ten summers. Annual precipitation ranged from 5.43 inches in 1929 to 18.92 inches in 1948. Summer precipitation frequently occurs as showers and several thunderstorms can be expected. Hail damage frequently occurs in some of the fruit areas. Winter precipitation occurs as snow or mixed as snow or rain. Snow can be expected after the first of December and remains for periods varying from four to ten weeks between mid-December and March. Snow accumulation generally reaches 10 to 15 inches and may increase to 20 inches or more in seasons of heavy snowfall. (Phillips, 1970)

Precipitation falling within the watershed and not lost to evapotranspiration will eventually provide recharge to the Aeneas Lake-Horse Springs Coulee aquifer.

Aeneas Lake-Horse Springs Coulee Aquifer

The aquifer is that part of the drainage area underlain by glacial drift materials lying below the elevation of 1600 feet MSL. The aquifer is outlined on Plate I.

Water levels in project U.S.B.R. wells 9J1 through 25P1 (see Plates I and II) show a ground water gradient from north to south at an average of 23 feet per mile. Gradient from well 9J1 to 27Q1 is 19 feet per mile; well 27Q1 to 10H1, 51 feet per mile; 10H1 to 23C1, 7.1 feet per mile; and 23C1 to Aeneas Lake and well 25P1, approximately 6 feet per mile. When plotted as a profile, it shows a relatively flat water surface between wells 9J1 and 27Q1, and 10H1 and 25P1, with a steep gradient between wells 27Q1 and 10H1. It is quite possible that the bedrock constriction at the site of well 27Q1 serves as a partial ground-water barrier, thereby may be causing a ground-water "cascade" immediately south of the constricted area. The hydraulic gradient probably flattens south of the ground-water cascade and coincides with the gradient between wells 10H1 and 25P1. This probability could not be confirmed since there are no known wells between wells 27Q1 and 10H1 (Plate II).

U.S.B.R. wells 9J1 and 27Q1 were drilled in April 1970 and are the only wells of record in the northern part of the project. Therefore, no historical data are available concerning water level changes in that part of the project. However, observations by the senior author indicate that Stevens Lake (Twp. 38 N., Rge. 26 E., Secs. 22 and 27) experienced a decline in water level over the past 6 years. The decline observed in Stevens Lake is similar (but of smaller magnitude) to the decline in the water level of Aeneas Lake.

The Aeneas Lake-Horse Springs Coulee aquifer is postulated as a single hydraulic unit and responds to precipitation falling within the total watershed.

A bedrock constriction divides the Aeneas Lake-Horse Springs Coulee aquifer from a second hydraulic unit. This unit may be a separate ground-water subarea. If Stevens Lake is indicative of the water table conditions in this subarea, the aquifer in the subarea is approximately 150' higher than the Aeneas Lake-Horse Springs Coulee aquifer at Aeneas Lake.

A third hydraulic unit may be a separate ground-water subarea. This unit is the terrace deposits which flank the Aeneas Lake-Horse Springs Coulee aquifer and contribute extensively to natural recharge of the aquifer.

Ground-Water Discharge

Water is lost from the ground water system by three primary ways:

1. Evapotranspiration directly from Aeneas Lake, cropland and the crops being grown;

2. Pumping through wells to irrigated land; and

3. Subsurface outflow.

Aeneas Lake, a glacial kettle, has existed in its present state as a fresh water lake since the close of the last continental glaciation approximately 12,000 years ago. The fresh water nature of the lake indicates that there are subsurface outlets for water in in addition to the pumping and evaporation losses.

This study indicates that there are two significant subsurface outlets through the glacial drift:

1. South from Aeneas Lake to Aeneas Creek (outflow from this outlet is being monitored to detect any change in flow due to artificial recharge to Aeneas Lake); and

2. Northeast from Aeneas Lake between the county road and the bedrock hill in the E 1/2 of Sec. 25. The miscellaneous measurement station is located in the SW 1/4 of Sec. 31, Twp. 37 N., Rge. 27 E.

A third possible subsurface outlet exists at the north end of Horse Springs Coulee in the SW 1/4 of Sec. 9 near project well 9J1. A review of geologic and hydrologic data indicates that subsurface discharge from this outlet is insignificant.

Aquifer Characteristics

The following parameters are defined to estimate availability of ground water within the basin:

Basin Area	36.34 sq. miles	23.258 acres
Qg/a & Qg Area	21.55 sq. miles	13,792 acres
Qg Area	12.61 sq. miles	8,070 acres
Qa Area	8.94 sq. miles	5,722 acres

Assuming an average thickness of 25 ft over the Qg/a area with 20% saturated (5') thickness, a porosity of 30% and a specific retention of 10%, one foot of water over 12.61 sq. miles or 8,070 A.F. of water is available from the ground-water unit called Qg/a.

Assuming an average thickness of 110 ft over the Qg area with 50% saturated (55 ft) thickness, a porosity of 30% and a specific retention of 10%, eleven (11) feet of water over 8.94 sq. miles or 62,942 A.F. of water is available from the ground-water unit called Qa.

The sum of Qg/a and Qa (8,070 A.F. + 62,942 A.F. = 71,012 A.F.) is the estimated quantity of water in storage in the area and available for appropriation from the Aeneas Lake-Horse Springs Coulee aquifer in the steady state (1964).

CONCLUSIONS

Declines of the water level in Aeneas Lake and in wells within the basin have averaged about 2.2 ft/year (a total of 8,450 A.F. of water assuming 30% porosity and 10% specific retention) during the 6-year period of observation from 1964 to 1970 (Figures 5-8). The area where water level decline occurs extends to the "cascade," the area of decline encompasses about 5 sq miles.

Artificial recharge of the aquifer is being made at the present time by diversion of water from the Okanogan River into Aeneas Lake. This recharge will cause an increase in level of the water table. The increase will be reflected by rising water levels in wells adjacent to Aeneas Lake. Only the wells in the valley floor will show this rise (14P1, 23C1, 25P1), with 10H1 responding at a much later date.

There are four alternatives in defining basin boundaries for area or subarea declaration for water resource management as required under RCW 90.44.130. These alternative boundaries are:

1. The Qg as outlined on plate 1 up to the east-west center line of Section 3, Twp. 37 N., Rge 26 E. which is the approximate location of the "cascade."

2. The total area mapped as Qg as outlined by the 1600' contour.

3. The sum of the areas mapped as Qg and Qg/a.

4. The entire drainage basin which has an area of 36.34 sq. miles.

All streams and springs contribute to the ground water in the basin and must be considered in any management discussion.

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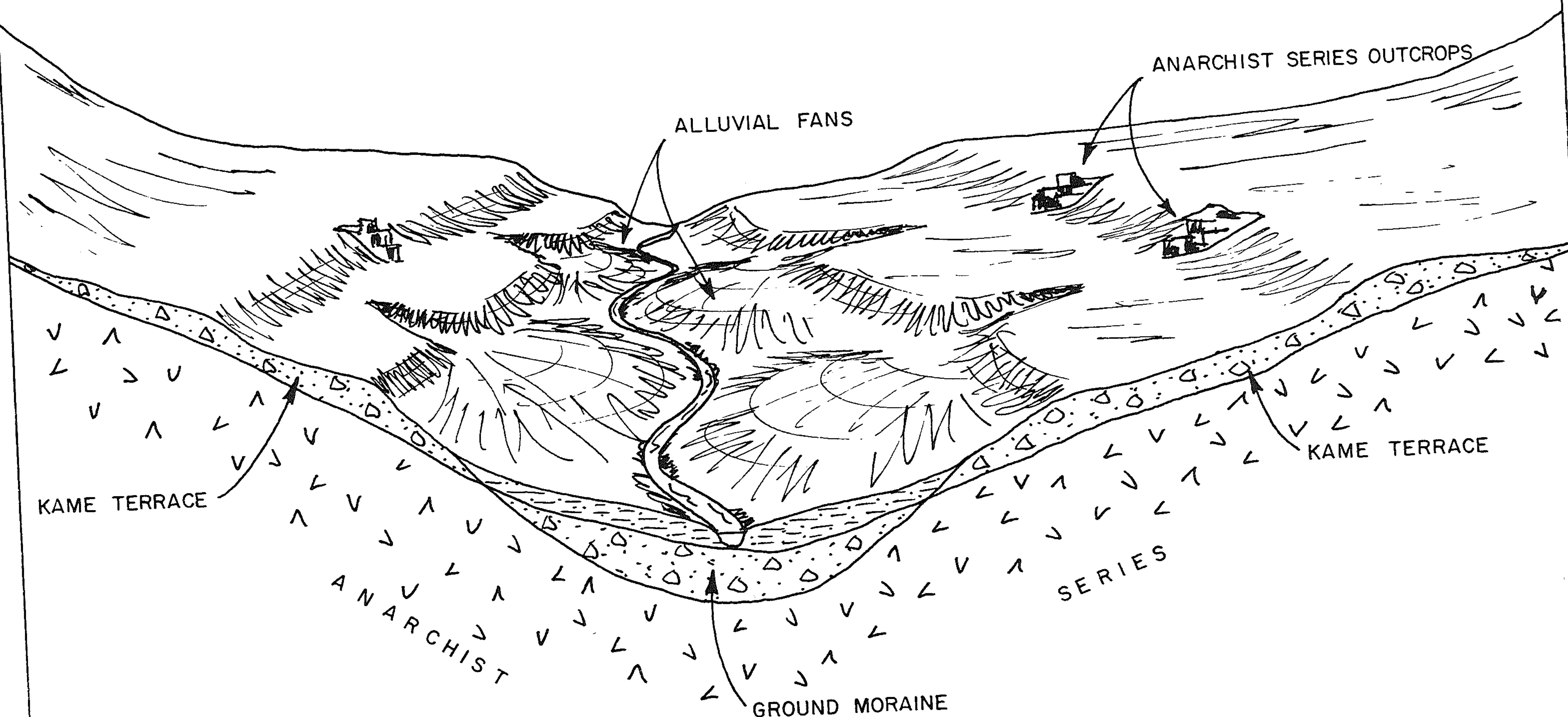
APPENDIX

FIGURES 1-8

PAGES 16-29



GEOMORPHIC ILLUSTRATION

FIGURE 1

Average Temperature (°F)

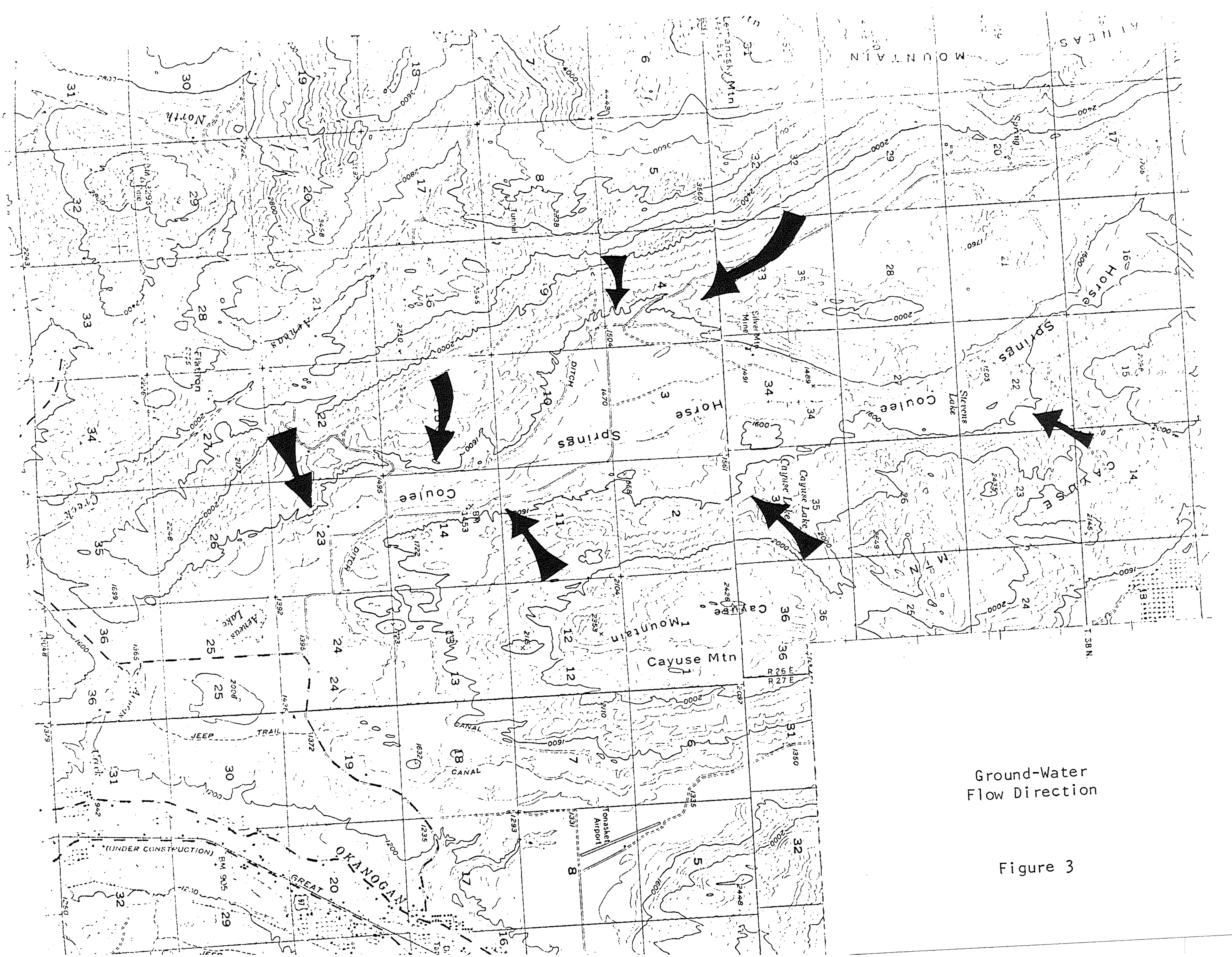
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
1931	33.0	33.9	43.4	52.6	61.6	65.0	72.4	69.4	58.2	48.8	34.7	26.4	50.0
1932	22.1	26.4	36.4	52.7	58.2	67.3	67.2	70.3	60.6	49.6	39.9	25.7	48.0
1933	27.8	20.8	40.5	50.8	54.4	63.9	69.4	70.4	56.4	48.3	40.0	31.6	47.9
1934	32.2	36.4	45.4	57.8	60.6	66.8	69.8	69.0	57.0	50.6	42.2	30.6	51.5
1935	25.2	35.0	38.8	47.9	57.6	63.6	69.1	66.0	62.0	45.9	33.3	31.9	48.0
1936	30.0	14.0	40.0	53.6	63.0	66.0	71.4	70.4	59.3	52.8	33.4	31.2	48.8
1937	11.6	22.2	41.7	49.6	58.4	65.6	73.2	65.4	62.0	51.4	38.3	32.0	47.6
1938	31.0	30.8	40.8	51.3	59.4	70.1	73.4	68.4	65.4	51.1	34.3	29.1	50.4
1939	33.1	27.4	40.4	53.0	60.3	63.4	72.2	71.9	62.2	49.6	39.4	37.0	50.8
1940	30.2	34.7	45.8	53.1	61.8	69.3	73.4	69.9	66.4	53.5	33.3	33.0	52.0
1941	33.0	36.6	47.0	54.3	58.4	65.6	74.5	69.5	57.4	49.0	40.3	33.6	51.6
1942	25.3	34.6	41.6	52.0	56.4	63.8	73.0	71.3	63.6	51.8	35.6	29.4	49.9
1943	18.2	32.1	38.6	53.0	56.0	64.1	73.0	69.3	63.7	51.2	38.4	30.4	49.0
1944	25.6	32.1	39.0	51.6	59.3	-	-	-	66.6	54.8	39.6	28.4	-
1945	31.9	35.9	41.4	48.8	60.3	65.2	74.8	75.0	61.4	52.7	36.0	31.0	51.2
1946	30.9	32.4	43.7	52.1	62.2	62.8	72.8	73.2	62.6	47.4	33.4	29.6	50.3
1947	24.4	34.1	45.4	53.0	63.1	64.4	73.0	70.6	63.6	51.8	38.8	33.7	51.3
1948	28.4	30.8	40.4	47.8	57.0	68.7	68.4	65.8	61.7	48.6	38.0	22.3	48.2
1949	13.5	24.1	41.0	53.7	62.9	65.5	72.2	71.6	64.3	48.6	42.8	28.7	49.1
1950	8.2	30.7	39.4	48.3	57.0	65.3	73.1	72.9	65.9	48.4	37.0	35.2	48.5
1951	27.6	31.5	35.4	50.8	59.4	64.9	74.4	71.7	63.6	49.0	36.6	23.1	49.0
1952	20.1	31.9	40.5	52.8	59.0	64.6	72.6	71.8	66.8	55.2	36.7	34.1	50.5
1953	36.7	38.3	43.8	49.6	57.2	61.7	71.8	71.1	62.5	51.9	41.8	34.5	51.8
1954	23.8	37.1	39.3	48.1	59.3	61.1	69.4	68.1	61.1	48.4	44.1	31.6	49.3
1955	28.6	30.0	34.0	46.7	55.6	66.0	70.1	72.7	63.8	50.0	29.2	25.1	47.6
1956	29.8	23.8	37.7	53.8	61.9	63.7	74.7	72.8	64.1	49.7	35.6	30.0	49.8
1957	15.7	26.2	41.7	52.6	62.9	67.0	71.2	68.6	67.3	48.8	37.9	35.4	49.6
1958	34.7	40.9	43.7	50.8	66.2	71.1	76.3	77.3	62.0	51.5	34.9	32.5	53.5
1959	28.8	30.0	42.1	52.8	56.5	64.9	74.1	68.6	60.4	48.9	33.3	32.3	49.4
1960	25.2	35.0	42.5	50.8	55.3	65.4	75.9	67.8	60.4	50.7	36.7	28.1	49.5
1961	31.7	38.3	43.1	49.5	58.4	69.5	73.9	74.2	57.7	46.8	32.0	28.4	50.3
1962	25.1	34.6	37.9	52.4	57.1	64.6	70.9	67.9	62.7	50.0	41.5	35.0	50.0
1963	24.8	36.6	43.3	49.4	59.3	65.7	69.0	70.8	65.1	51.6	38.8	29.0	50.3
1964	30.0	30.2	39.6	49.3	57.1	65.2	70.7	65.8	57.1	48.1	38.6	24.9	48.1

Total Precipitation (Inches)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l
1931	1.86	.32	.43	.02	.37	1.18	.07	.01	1.13	1.06	1.50	2.64	10.59
1932	.44	.03	1.89	1.59	.55	.06	.29	.32	.05	1.03	2.90	.99	10.14
1933	1.36	.58	1.54	.11	1.03	.50	.15	.18	1.19	1.45	.53	2.82	11.44
1934	.92	.28	.50	.20	.39	.14	.26	.58	.50	1.48	2.98	1.36	9.59
1935	.55	.53	.29	.18	.15	1.25	1.77	.40	.41	1.26	.53	.95	8.27
1936	1.60	.56	.04	1.03	.63	3.95	.59	.41	.71	.06	.09	.10	9.77
1937	.37	1.36	1.07	1.11	.30	3.22	.06	.28	1.26	.42	2.97	.96	13.38
1938	.97	2.36	1.40	.19	.08	.21	.64	.58	1.20	1.55	.52	.53	10.23
1939	1.14	.50	.36	.19	.14	1.03	.01	.02	.20	.51	.19	2.39	6.68
1940	.57	1.39	1.09	1.06	.77	.57	.66	.03	1.08	2.08	1.36	1.45	12.11
1941	.86	.56	.51	1.62	2.17	3.35	.86	2.35	3.00	.48	1.10	1.64	18.50
1942	1.32	.93	.08	1.22	3.18	.63	1.92	.14	.00	.46	1.00	1.66	12.54
1943	1.11	.47	.66	.67	.18	1.55	.08	1.02	.02	2.02	.41	.27	8.46
1944	.38	.81	.28	1.77	1.20	-	-	-	.81	.25	3.67	.51	-
1945	.67	1.88	.95	.10	1.58	.76	.43	.26	.73	1.27	2.00	2.56	13.19
1946	.89	1.27	.78	.25	.58	2.05	.23	.02	.33	.85	.97	.84	9.06
1947	.60	.56	1.03	.30	.18	3.32	1.40	.02	.76	2.31	.23	.63	11.34
1948	.69	.62	.45	3.46	2.71	3.36	1.59	2.06	.18	.31	1.97	1.52	18.92
1949	.25	.67	.60	.37	.43	.23	.26	.71	.47	.35	1.81	.68	6.83
1950	.70	1.72	2.13	1.76	.64	.94	.85	.34	.24	2.43	3.22	1.08	16.05
1951	1.84	.35	.87	1.01	.40	.73	.45	2.22	.16	1.81	2.58	1.27	13.69
1952	1.83	.43	.33	.68	.63	1.74	.22	.04	.19	T	.24	2.42	8.75
1953	1.85	.49	2.05	1.24	2.14	2.24	T	1.88	.05	.60	1.08	.55	14.17
1954	1.33	.91	.63	.10	2.15	1.16	1.02	1.53	.72	.15	1.35	.97	12.02
1955	.51	.73	.70	1.18	.62	1.41	.99	.05	.44	1.24	.99	2.32	11.18
1956	2.83	1.09	1.17	.26	.38	2.29	1.24	.66	.39	1.71	.44	.38	12.84
1957	.77	.86	1.07	.65	2.85	.75	.85	.71	.15	1.91	.72	1.50	12.79
1958	1.41	2.48	1.49	1.75	.32	3.14	.44	.61	.41	.62	1.71	.75	15.13
1959	4.65	1.42	.42	.25	1.72	.60	.21	.43	1.57	.71	.50	.71	13.19
1960	.75	1.01	.42	.87	-	.13	.14	1.65	.24	.40	2.23	1.26	-
1961	.24	2.84	1.78	.47	2.17	1.70	1.10	1.12	.15	.60	.44	1.82	14.43
1962	.95	.90	.69	.58	1.29	.31	.48	.88	.28	1.09	1.29	.60	9.34
1963	.39	.58	1.30	2.68	.59	1.40	.94	.28	.78	.34	2.68	1.31	13.27
1964	2.36	.20	.41	.34	.18	2.91	.39	1.41	.71	.15	1.94	1.12	12.12

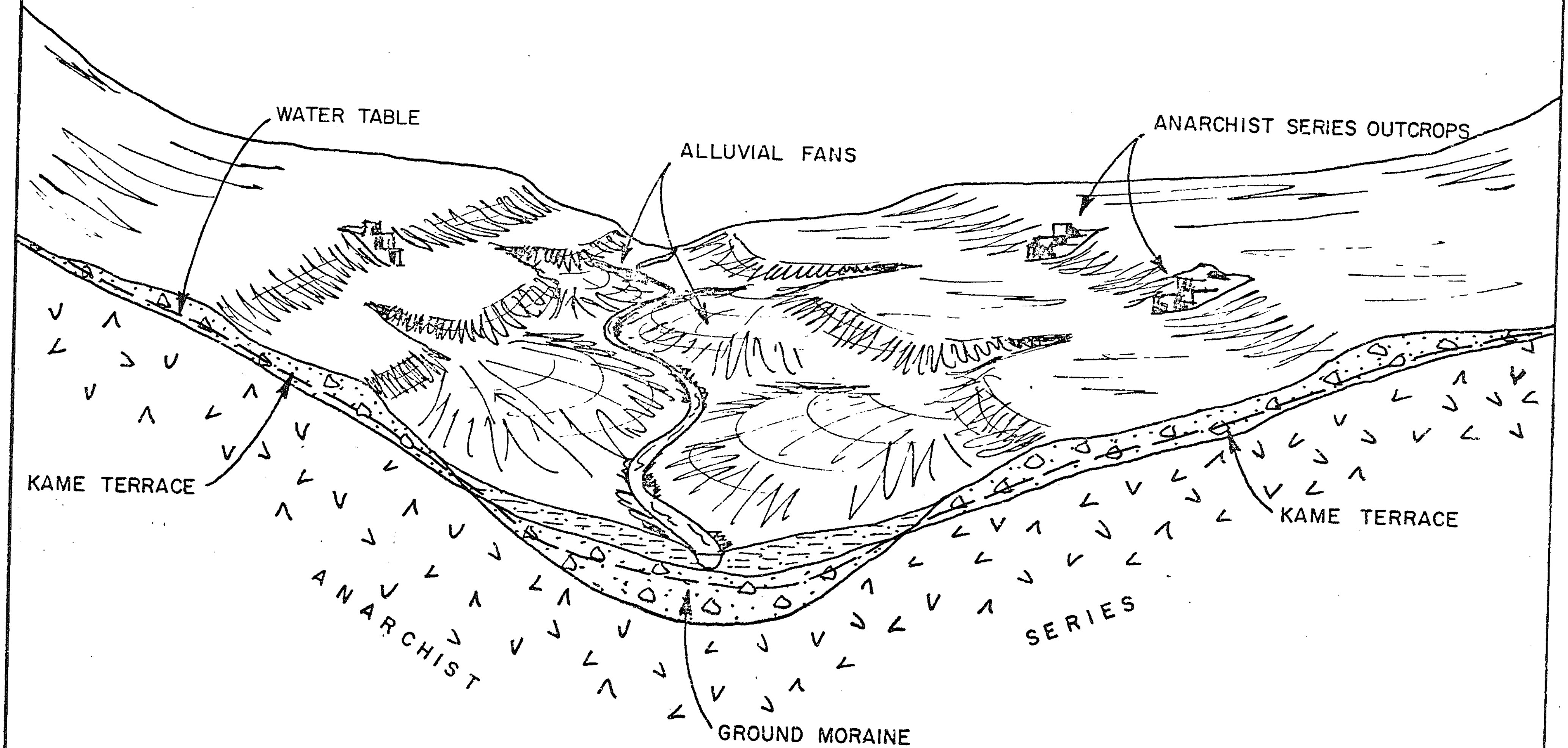
Mean monthly precipitation and temperature at Oroville, Washington.

Figure 2



Ground-Water
Flow Direction

Figure 3



GROUND-WATER GRADIENT ACROSS STUDY AREA

FIGURE 4

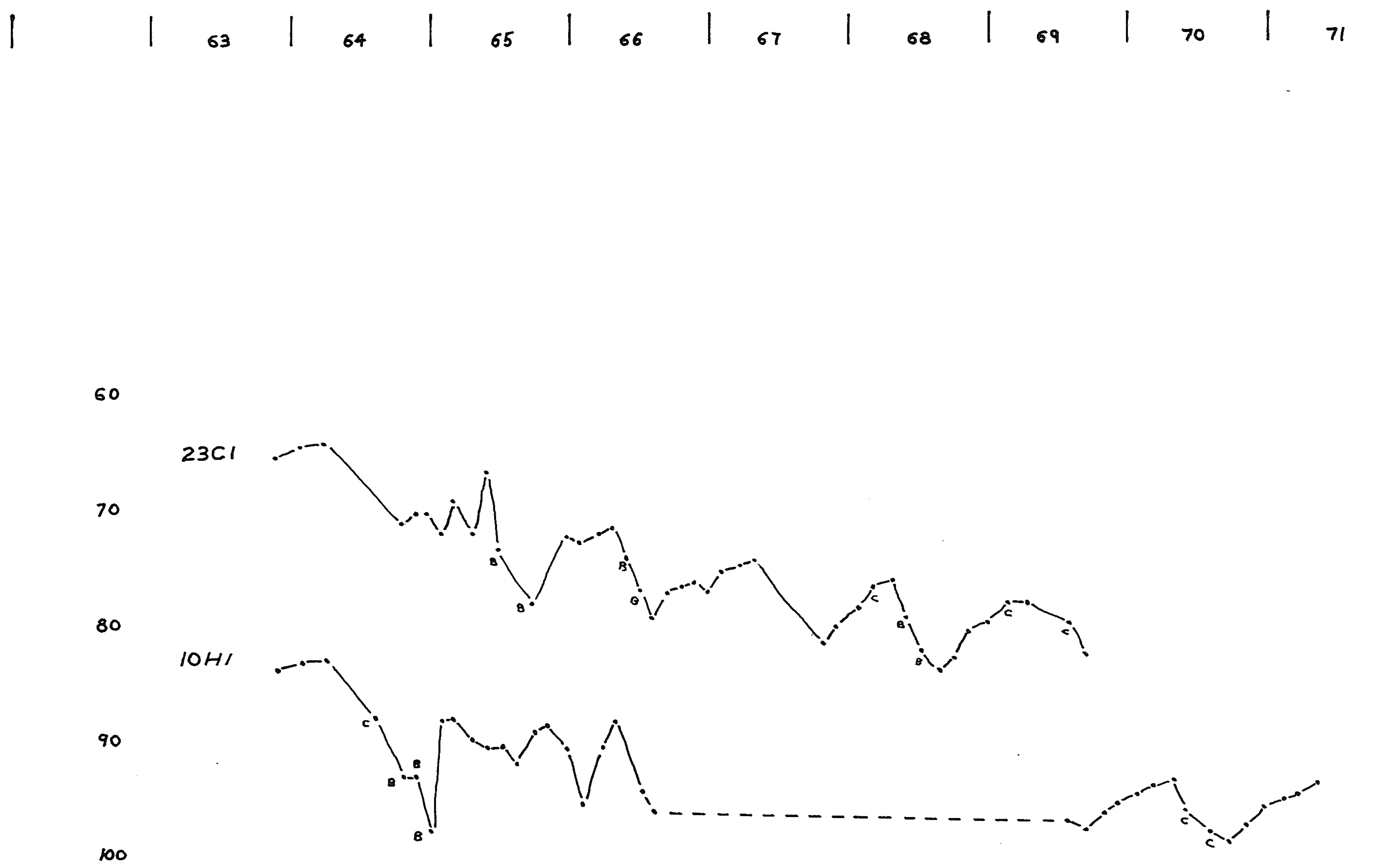


Figure 5

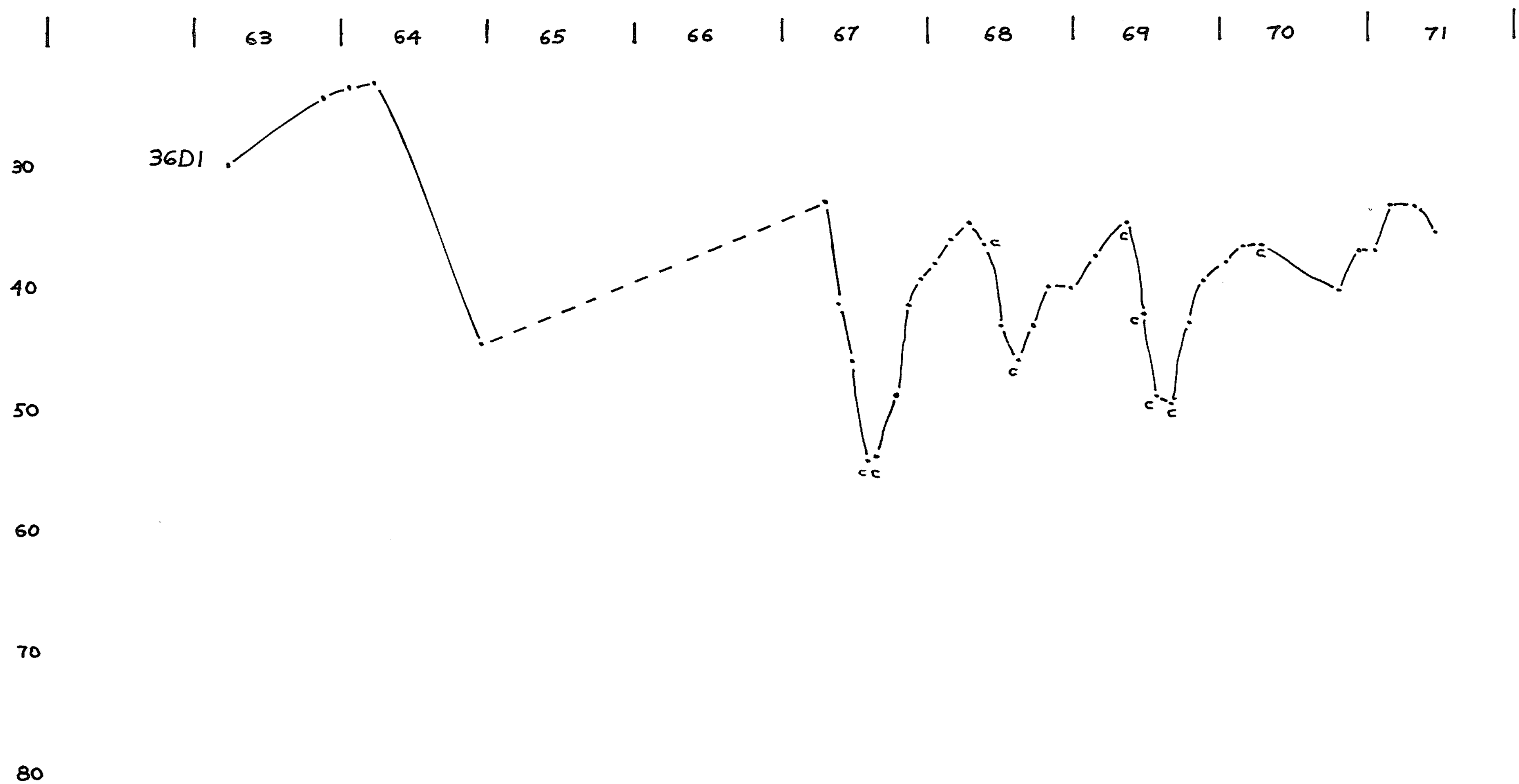


Figure 6

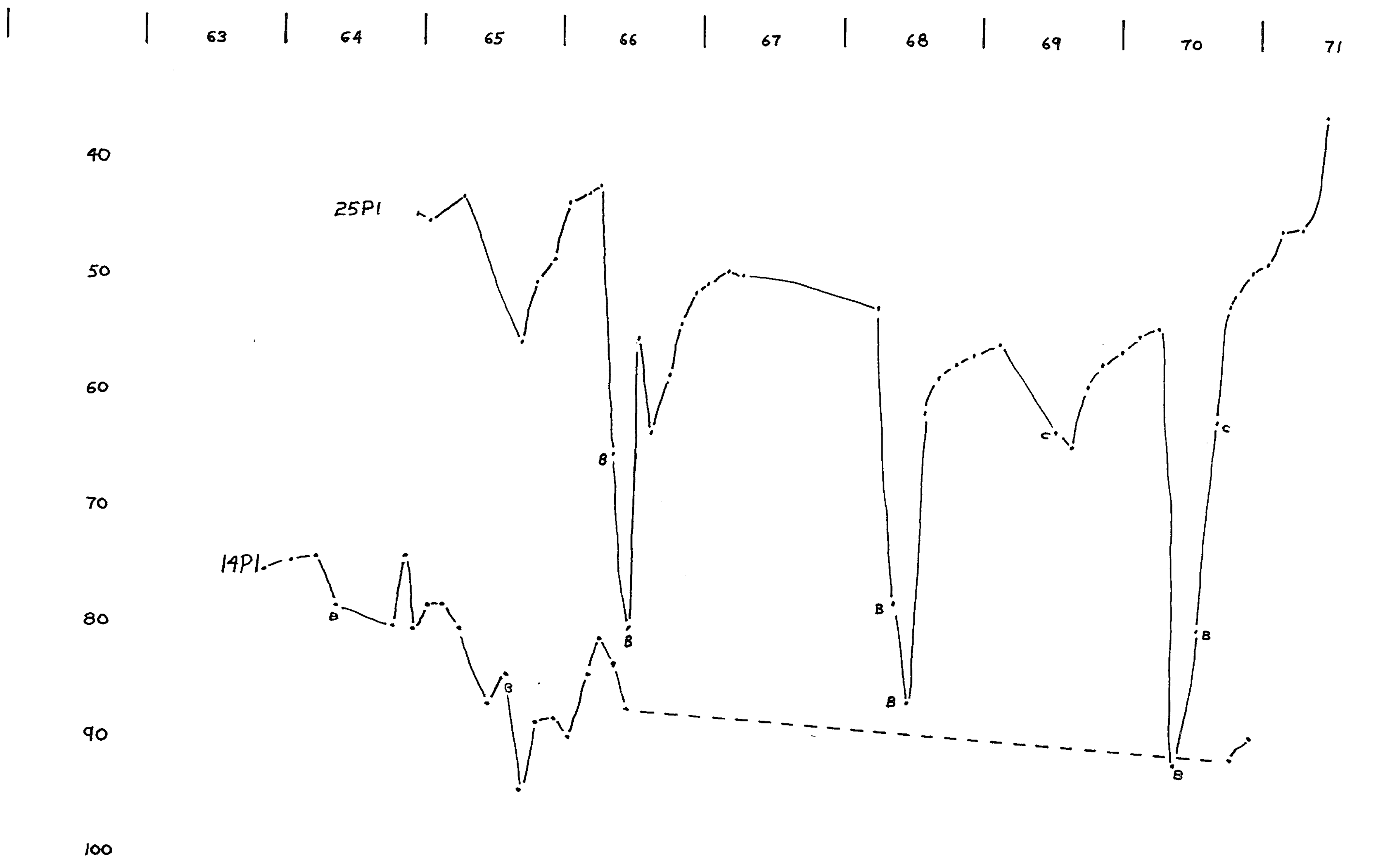


Figure 7

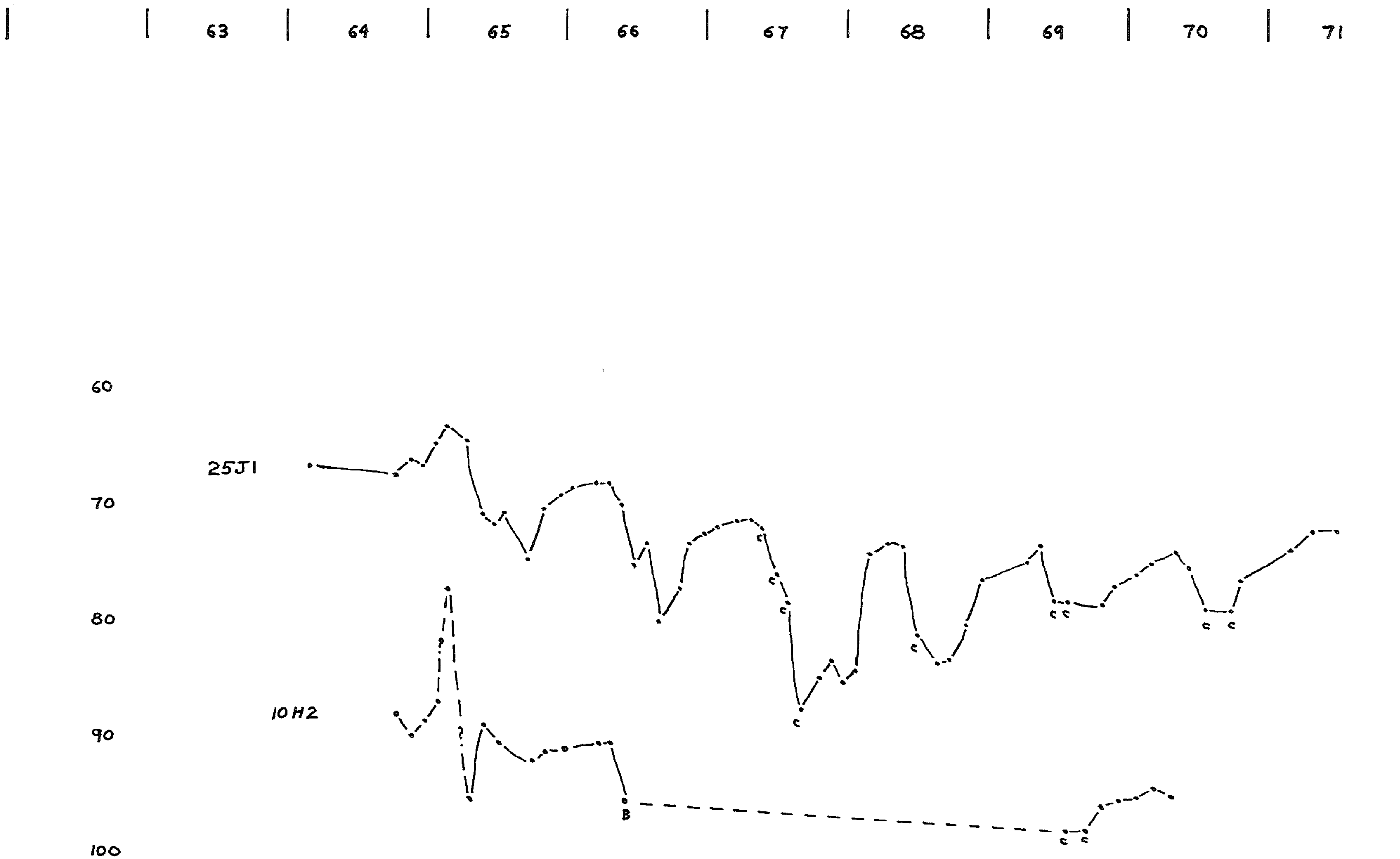


Figure 8

DATE	26J1	36D1	25P1	10J1
03-26-63		30.00A		
11-20-63		24.29A		
01-21-64		23.52A		
02-29-64	66.73A			
03-26-64		23.08A		
10-01-64	67.66A			
11-11-64	66.39A			
12-10-64	66.88A	44.89A	44.89A	
01-15-65	64.83A		45.16A	
02-25-65	63.30A			
04-09-65	64.54A		43.03A	
05-20-65	71.00A			
06-20-65	71.99A		D	
07-03-65	70.80A			
09-12-65	74.73A		55.63A	
10-25-65	70.45A			
10-26-65			50.30A	
12-08-65	69.35A		48.50A	
01-19-66	68.88A		43.40A	
03-02-66	68.40A		42.89A	
04-06-66	68.15A		42.16A	
05-13-66	70.03A		65.26B	
06-23-66	75.78A		80.53B	
07-21-66	73.33A		55.30A	
08-31-66	80.10A		63.50A	
10-06-66	77.40A		58.55A	
11-01-66	73.68A		53.90A	
12-15-66	72.77A		51.20A	
01-18-67	72.08A		50.40A	
03-01-67	71.65A		49.54A	
04-13-67	71.30A	33.11A	49.90A	
05-17-67	72.12C	41.70A		
06-24-67	76.03C	46.22A		
07-27-67	78.78C	54.58C		
08-29-67	87.90C	54.03C		
10-05-67	85.00A	49.15A		
11-08-67	78.70A	41.80A		
12-07-67	85.42A	39.49A		
01-10-68	84.46A			
01-11-68		38.26A		
02-28-68	74.37A	36.24A		
04-09-68	73.52A	35.04A	52.31A	
05-16-68	73.86C	36.71C	78.03B	
06-26-68	81.37C	43.40A	86.95B	
08-05-68	83.94A	46.43C	61.62A	
09-19-68	83.62A	43.44A	58.64A	
10-30-68	80.58A	40.36A	57.41A	
12-11-68	76.72A	40.47A	56.45A	
02-19-69		37.80A	55.63A	
04-01-69	75.17A			
05-07-69	73.84A	35.00C		
06-12-69	78.49C	42.70C		
07-15-69	78.48C	49.40C	63.03C	
08-25-69	E	50.02C	64.41A	
10-06-69	78.87A	43.17A	59.25A	
11-17-69	77.22A	39.71A	57.21A	

figure 9

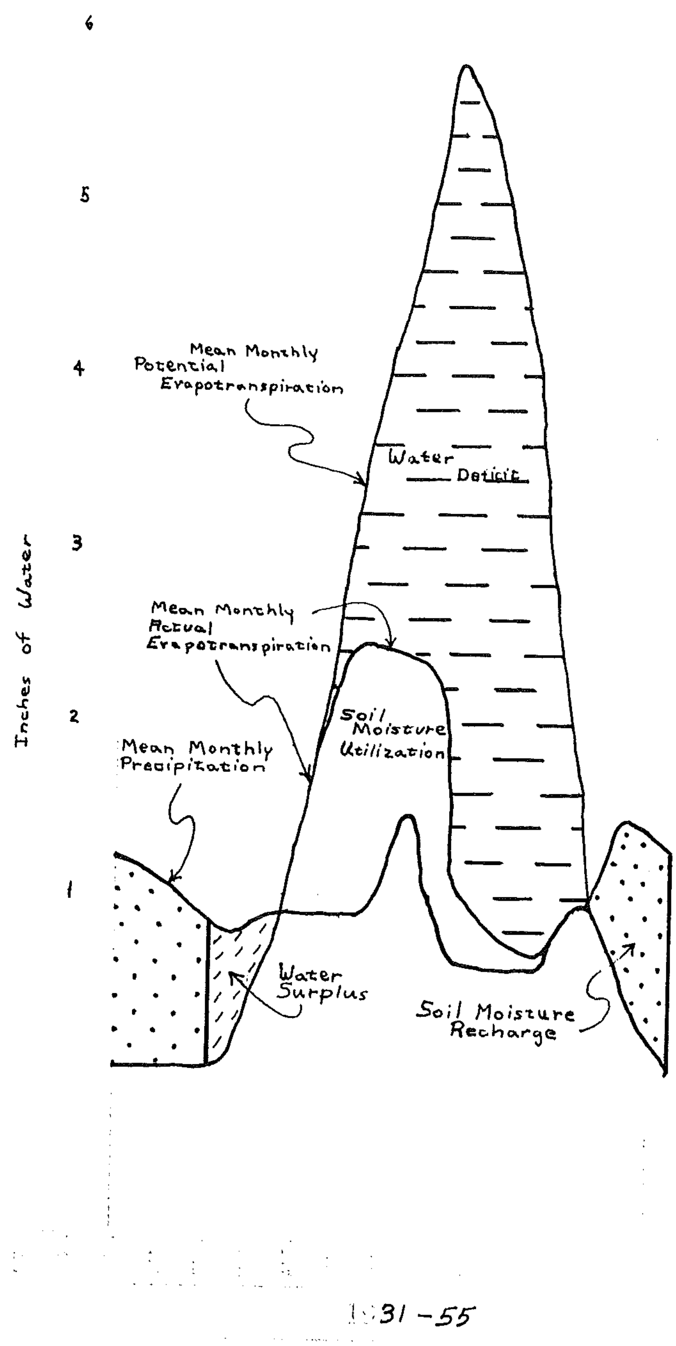
DATE	26J1	36D1	25P1	10J1
01-06-70	76.05A	38.16A	56.14A	
02-26-70	75.10A	37.02A	55.04A	
04-02-70	74.41A	36.97C	54.26A	
05-14-70	75.98C		91.90B	
07-22-70	79.07A		80.38B	
09-03-70	79.27C		62.19C	
10-14-70	76.88A	40.62A	52.13A	
10-29-70	83.65D		51.32A	97.73A
12-02-70		37.26A	49.27A	96.82A
01-13-71				95.24A
01-14-71	D	37.49A	48.53A	
02-23-71				95.50A
02-25-71	74.04A	33.73A	45.55A	
04-13-71	72.51A	33.73A	45.55A	94.84A
06-10-71	72.69A	35.94A	35.94A	98.09C

DATE	14P2	10J2	23K1
01-13-71		95.22A	63.92A
02-23-71	87.75A	95.92A	63.28A
04-13-71	86.95A	94.90A	62.28A
06-10-71	87.55A		

DATE	10H1	10H2	14P1	23C1
05----52			60.00A	
07-25-57				65.41A
09-23-60	69.00A			
11-19-63	83.81A		75.53A	65.41A
01-21-64	83.44A		74.63A	64.64A
03-26-64	83.37A		74.27A	64.31A
05-20-64			78.61B	
07-29-64	88.25C			
10-01-64	93.30B	88.30C	80.22A	71.21A
11-11-64	92.26B	90.04A	74.29A	70.50A
12-10-64	98.00B			70.57A
12-11-64		88.89A	80.60A	
12-17-64	98.00B			
01-15-65	88.30A	87.27A	78.46A	72.06A
02-25-65	88.30A	77.40A	78.40A	69.30A
04-09-65	90.20A	95.67A	80.34A	72.10A
05-20-65		89.50A		66.99A
05-21-65	90.85B			
06-20-65	90.90B	90.92A	86.90A	73.75B
08-03-65	92.01A		84.43B	D
09-12-65	89.52A	92.17A	94.60A	78.30B
10-20-65		91.45A		
10-25-65			88.60A	
10-26-65	88.88A			
12-08-65	91.00A		88.13A	72.60A
01-19-66	95.96A		89.90A	73.20A
03-02-66	90.75A		84.35A	72.30A
04-06-66	88.83A	90.80A	81.32A	71.90A
05-13-66		95.62B	83.69A	74.38B
06-23-66			87.28A	77.14B
06-25-66	94.78A			
07-21-66	96.45A		E	79.84A
08-31-66				77.60A
10-06-66				76.95A
11-01-66				76.68A
12-15-66				77.40A
01-18-67				75.60A
03-01-67				75.10A
04-13-67				74.80A
10-05-67				81.80A
11-08-67				80.39A
01-11-68				78.77A
02-28-68				77.03C
04-09-68				76.36A
05-16-68				79.63B
06-26-68				82.47B
08-05-68				84.16A
09-19-68				83.10A
10-30-68				80.96A
12-11-68				80.06A
02-05-69				78.54C
03-26-69				78.58A

DATE	10H1	10H2	14P1	23C1
04-09-69				E
07-01-69	97.46A	98.39C		
07-16-69				80.30C
08-25-69	98.29C	98.96C		82.90A
10-06-69	96.78A	96.64A		
11-17-69	95.96A			
01-06-70	95.21A	95.63A		
02-26-70	94.50A	94.94A		
04-09-70	93.90A	95.43A	113.2D	
05-14-70	96.66C			
07-22-70	98.47C			
09-03-70	99.33A			
10-14-70	97.97A		91.35A	
12-02-70	96.13A		89.60A	
01-14-71	95.63A			
02-23-71	95.38A			
04-13-71	94.38A			

A - Off
B - Pumping
C - Adj Well Pumping
D - Reading Poor
E - Dry



Mean Annual Water Budget - 6" Root Zone

Figure 10

NOTES

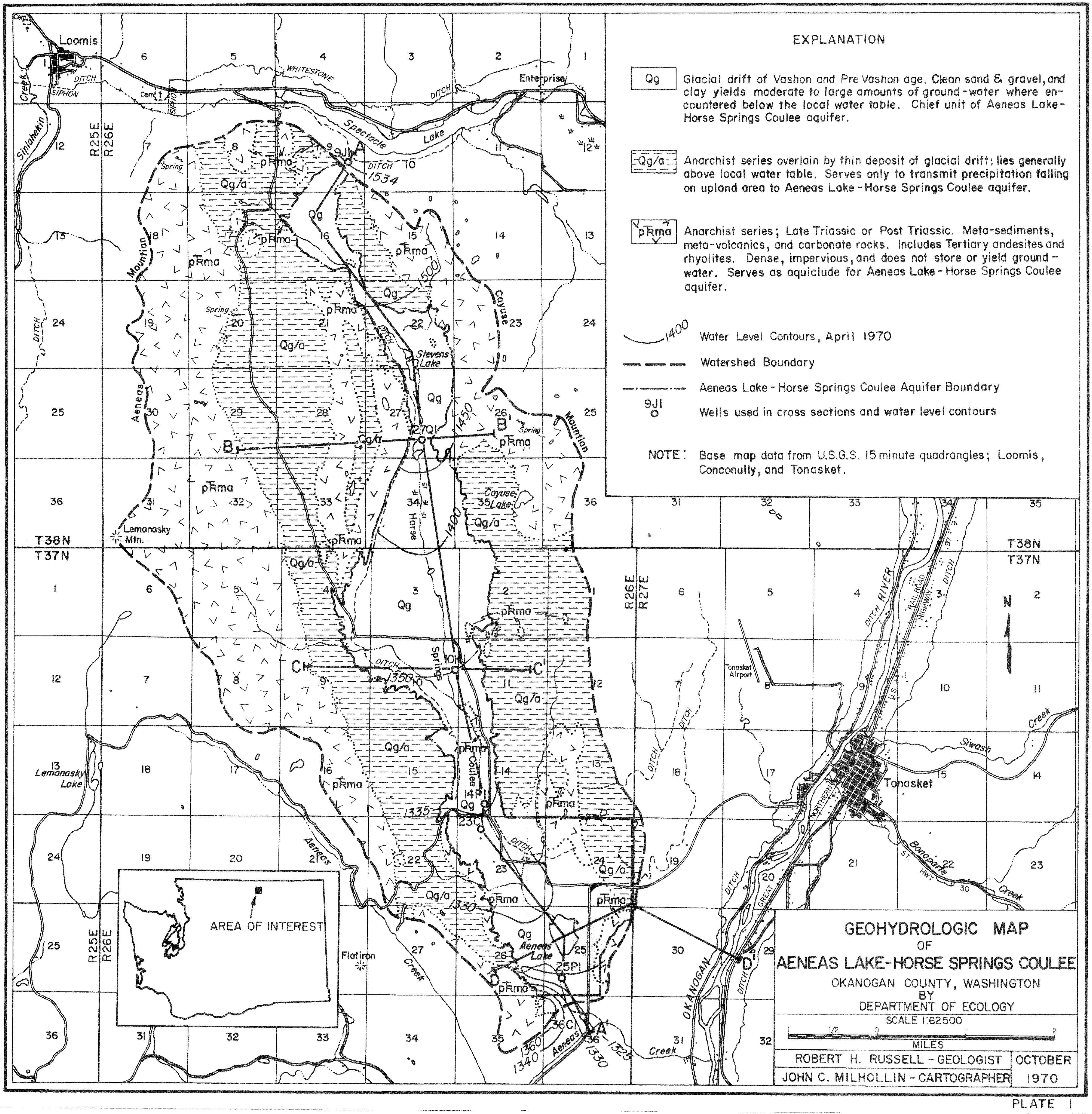
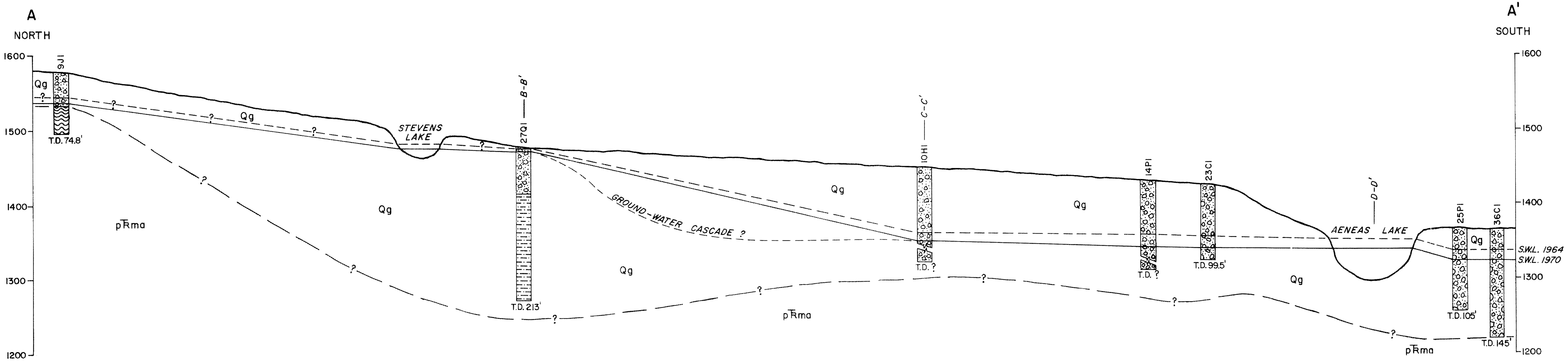

EXPLANATION
Qg Glacial drift of Vashon and Pre Vashon age. Clean sand & gravel, and clay yields moderate to large amounts of ground-water where encountered below the local water table. Chief unit of Aeneas Lake-Horse Springs Coulee aquifer.
Qg/a Anarchist series overlain by thin deposit of glacial drift; lies generally above local water table. Serves only to transmit precipitation falling on upland area to Aeneas Lake-Horse Springs Coulee aquifer.
pRma Anarchist series; Late Triassic or Post Triassic. Meta-sediments, meta-volcanics, and carbonate rocks. Includes Tertiary andesites and rhyolites. Dense, impervious, and does not store or yield ground-water. Serves as aquiclude for Aeneas Lake-Horse Springs Coulee aquifer.
1400 Water Level Contours, April 1970
Watershed Boundary
Aeneas Lake-Horse Springs Coulee Aquifer Boundary
9J1 Wells used in cross sections and water level contours
NOTE: Base map data from U.S.G.S. 15 minute quadrangles; Loomis, Conconully, and Tonasket.
Loomis
Enterprise
Spectacle Lake
WHITESTONE DITCH
SIPHON
Sinlahekin Creek
Mountain
Aeneas
Cayuse
Stevens Lake
Cayuse Lake
Horse Springs Coulee
Lemanasky Mtn.
Lemanasky Lake
Aeneas Lake
Aeneas Creek
Flatiron
Tonasket
Tonasket Airport
Siwash Creek
Bonaparte Creek
OKANOGAN RIVER
GREAT NORTHERN RAILROAD
U.S. HIGHWAY 97
T38N
T37N
R25E R26E
R26E R27E
9J1
27Q1
10N
14P1
23C
25P1
36C1
1534
1500
1450
1400
1350
1335
1330
1360
1340
1325
AREA OF INTEREST
GEOHYDROLOGIC MAP OF AENEAS LAKE-HORSE SPRINGS COULEE
OKANOGAN COUNTY, WASHINGTON
BY DEPARTMENT OF ECOLOGY
SCALE 1:62500
MILES
ROBERT H. RUSSELL - GEOLOGIST
JOHN C. MILHOLLIN - CARTOGRAPHER
OCTOBER 1970

PLATE I

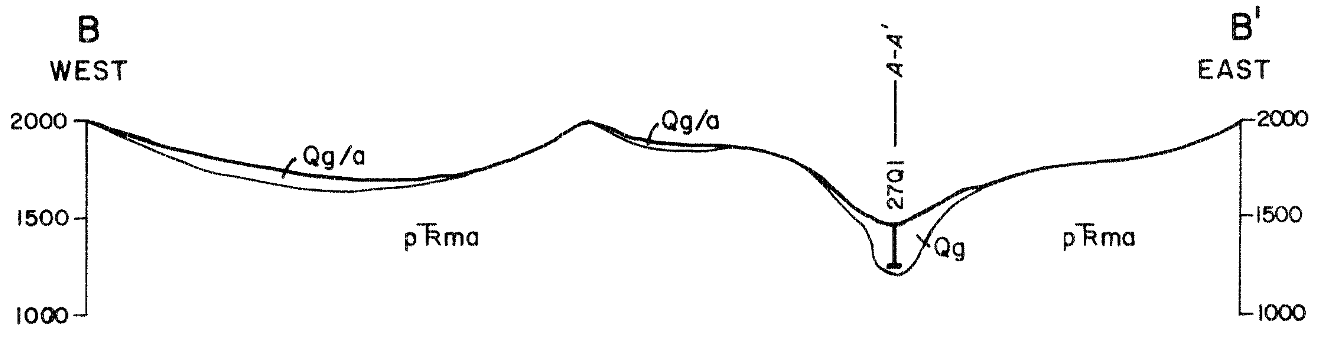


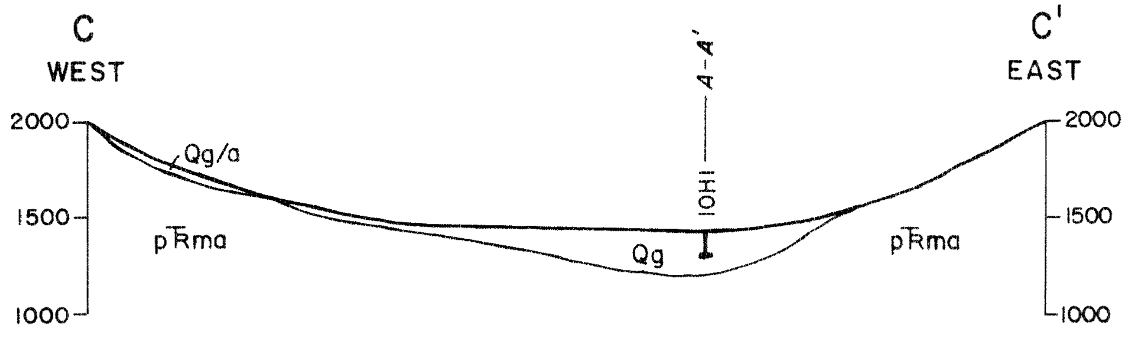
EXPLANATION

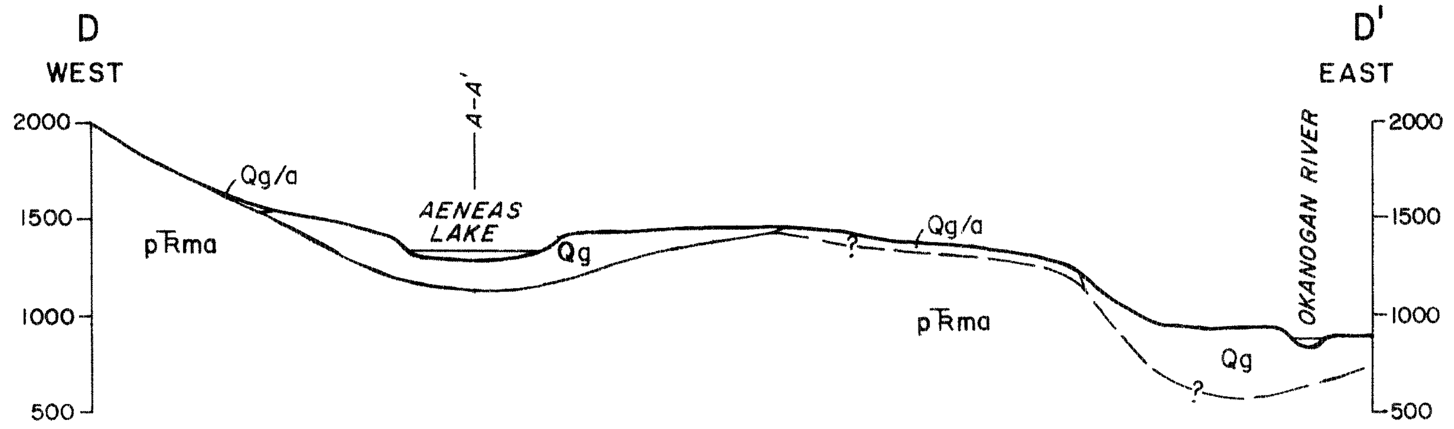
- Glacial drift, sand and gravel
- Glacial drift, compact clay
- Anarchist series, bedrock

NOTE: For an explanation of the geologic symbols see the Geohyrologic Map, plate 1.

SCALE { HORIZONTAL - 1:24000 (2" = 1 MILE)
VERTICAL - 1" = 100' (ELEVATION ABOVE MEAN SEA LEVEL)







SCALE { HORIZONTAL - 1:24000 (2" = 1 MILE)
VERTICAL - 1" = 1000' (ELEVATION ABOVE MEAN SEA LEVEL)

CROSS SECTIONS OF **AENEAS LAKE-HORSE SPRINGS COULEE** OKANOGAN COUNTY, WASHINGTON BY DEPARTMENT OF ECOLOGY	
SCALE AS DEFINED UNDER CROSS SECTIONS	
ROBERT H. RUSSELL - GEOLOGIST	OCTOBER
JOHN C. MILHOLLIN - CARTOGRAPHER	1970

PLATE 2