AVAILABILITY OF SUPPLEMENTAL WATER SUPPLIES AT SALMONID FISH-PROPAGATION STATIONS IN WISCONSIN

Open-File Report 79-1170

Prepared in cooperation with the

Wisconsin Department of Natural Resources

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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By C. A. Harr and R. P. Novitzki

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CONVERSION FACTORS

Factors for converting the inch/pound units used in this report to International System (SI) units are shown below.

Multiply	By	To obtain
ft (foot)	3.048×10^{-1}	m (meter)
lb (pound)	4.536×10^{-1}	kg (kilogram)
gal/min (gallon per minute)	6.309×10^{-2}	L/s (liter per second)
gal/d (gallon per day)	3.785	L/d (liter per day)
ft/d (foot per day)	3.048×10^{-1}	m/d (meter per day)
$(gal/d)/ft^2$ (gallon per day per foot squared)	4.074×10^{-2}	m/d (meter per day)
°F (degree Fahrenheit)	0.556(°F-32)	°C (degree Celsius)

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ABSTRACT

Supplemental water supplies are available at all the 12 fish-propagation stations. At seven of the stations water may be obtained by diverting or impounding streams. Ground water is available from glacial sand-and-gravel aquifers at all the stations and from sandstone aquifers at 7 of the 12 stations. Probable well yields range from 100 to 1,000 gallons per minute from the sand and gravel and from 50 to 1,000 gallons per minute from the sandstone.

The response of pumping 1,600 gallons per minute from a ground-water source at Crystal Springs, Langlade, Nevin, and Osceola was estimated by a digital model. Estimated drawdown after 10 years of pumping ranged from 10 to 28 feet (6 to 35 percent of the saturated thickness of the aquifers).

INTRODUCTION

This report provides hydrologic information to the Bureau of Fish Management for evaluating its salmonid fish-propagation program. Streamflow characteristics, provided by previous studies, were used to estimate surface-water availability. Data from previous hydrologic and geologic studies, supplemented by test drilling, were used to estimate ground-water availability. The response of the ground-water system to water-supply development was estimated for the Crystal Springs, Osceolo, Langlade, and Nevin stations.

The current source and inflow rate of water supplies at the 12 stations (fig. 1) is given in table 1.

AVAILABILITY OF SUPPLEMENTAL WATER SUPPLIES

Surface Water

Information on streamflow characteristics was available for streams near 7 of the 12 stations. This information was used to estimate the

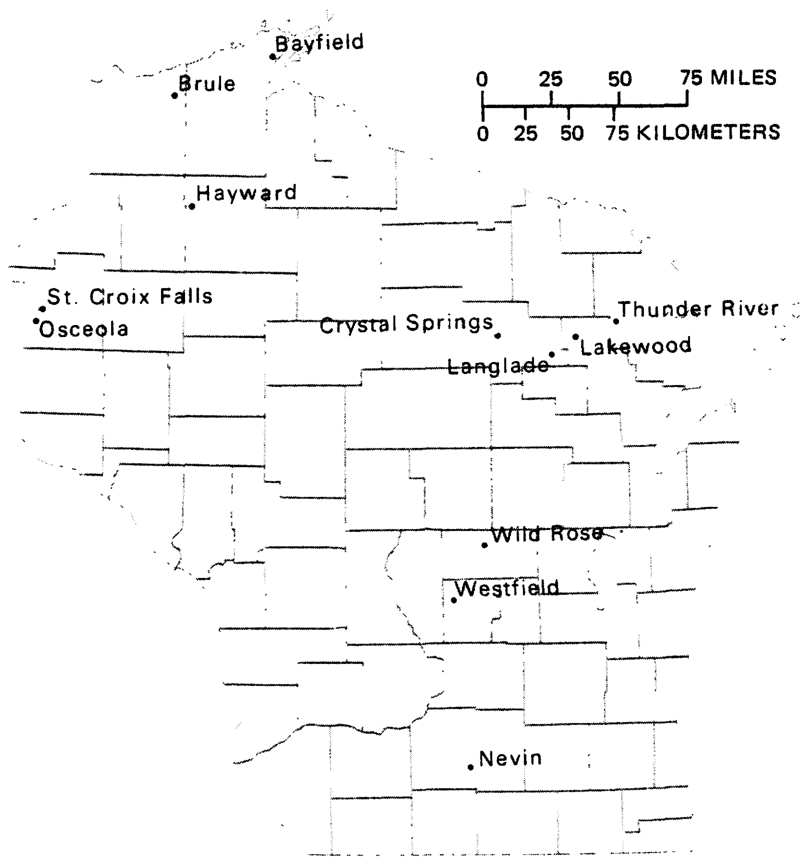


Figure 1. Location of salmonid fish-propagation stations in Wisconsin.

lowest flow that would be available for diversion in a specified period. Estimates of the lowest mean discharge that occurs for 7 consecutive days on the average of once in 2 years (7-day Q_2) or once in 10 years (7-day Q_{10}) were based on a drainage area-discharge relationship (table 2). These data indicate the relative amounts of water available for water supplies by diversion. Greater amounts of water could be used at these sites if surplus flows were impounded. (Impoundment design requires mean discharge data that were not available during this study.)

Table 1.--Source of supply and inflow rate at fish-propagation stations

Station	Source of supply	Inflow (gal/min)
Bayfield	Pikes Creek, artesian well, springs	2,400
Brule	Little Bois Brule River	2,400
Crystal Springs	Artesian wells, springs	950
Hayward	Springs	500
Lakewood	Artesian wells, springs	1,100
Langlade	Dalton Creek	1,600
Nevin	Artesian wells	965
Osceola	Artesian wells, springs	2,200
St. Croix Falls	Infiltration galleries	2,000
Thunder River	South Fork Thunder River	2,100
Westfield	Artesian wells	380
Wild Rose	Artesian wells, springs	2,500

Table 2.--Low-flow characteristics of streams near fish-propagation stations. Streams ranked in order of decreasing low flow.[1]

Station	Stream	7-day Q_2 (gal/min)	7-day Q_{10} (gal/min)
St. Croix Falls	St. Croix River	670,000	480,000
Osceola	St. Croix River	670,000	480,000
Bayfield	Pikes Creek	3,600	2,800
Thunder River	South Fork Thunder River	3,400	2,600
Brule[1]	Little Bois Brule River	1,300	1,100
Langlade	Dalton Creek	1,200	600
Crystal Springs	East Branch Eau Claire River	30	5

[1]Data from Holmstrom, 1979.

Ground Water

Water is available from the sand-and-gravel aquifer at all stations and from the sandstone aquifer at 7 of the 12 stations. Wells in the sand-and-gravel aquifer may yield from 100 to 1,000 gal/min. Wells in the sandstone aquifer may yield from 50 to 1,000 gal/min. Development of a supplemental water supply from the sand-and-gravel aquifer at the Bayfield, Brule, Hayward, Nevin, Osceola, St. Croix Falls, and Thunder River stations is not feasible because of the low probable yield. At the Crystal Springs, Hayward, Lakewood, Langlade, and Thunder River stations, a supplemental water supply from the bedrock aquifer is not available. A description of the aquifers at each site and probable well yields is given in table 3.

Because of planned early development, additional information was obtained at the Crystal Springs, Langlade, Nevin, and Osceola stations. Test drilling provided data on glacial aquifer characteristics and saturated thickness. Digital-model analysis indicated the relative effect of developing the aquifers at these sites. To provide a basis of comparison among the four sites, the model assumed that at each site four wells would be located symmetrically about the hatchery and each pumped at a constant rate of 400 gal/min.

Crystal Springs

The sand-and-gravel aquifer at the Crystal Springs station is composed of pitted outwash sand and gravel. Sand and gravel occurs at the surface except near the raceway, where one test hole penetrated 25 ft of gray clay at the surface. The extent of the clay is unknown, but it probably underlies the entire raceway area. Test holes were drilled to 129 ft, but bedrock was not reached.

Aquifer characteristics were estimated from pumping test data in the Antigo Flats area reported by Harder and Drescher (1954, p. 22). Hydraulic conductivity was estimated as 2,000 ft/d, and storage coefficient was estimated as 0.15. The aquifer was modeled as a wedge ranging in thickness from 70 ft northeast of the station to 190 ft southwest of the station and having an average saturated thickness of 125 ft.

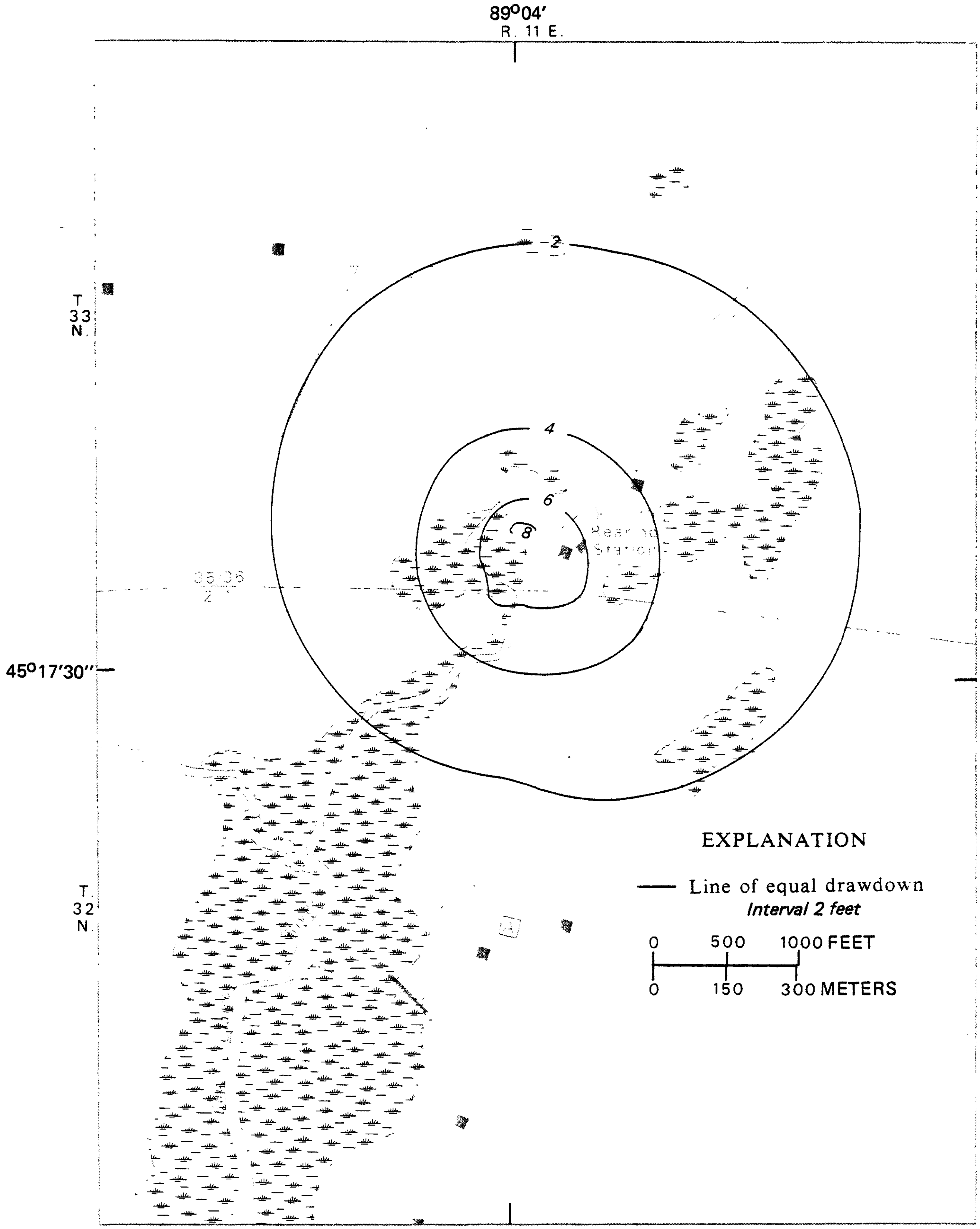
Digital-model analysis (McLeod, 1975) indicated a probable maximum drawdown of 10 ft after 10 years of continuously pumping 1,600 gal/min from four wells in the sand-and-gravel aquifer. This drawdown is 8 percent of the average saturated thickness. Drawdown distribution is shown in figure 2. The circular distribution reflects the assumed uniform aquifer characteristics.

Langlade

The sand-and-gravel aquifer at the Langlade station is composed of outwash and ice-contact sand-and-gravel deposits. Test holes were drilled to 38 ft, but bedrock was not reached.

Table 3.--Ground-water availability at fish-propagation stations

Station	Sand-and-gravel aquifer			Bedrock aquifer	
	Description	Thickness (ft)	Probable well yield (gal/min)	Description	Probable well yield (gal/min)
Bayfield	Isolated deposits of sand and gravel buried beneath glacial-lake clay. Generally thin and discontinuous.	<50	<100	Precambrian sandstone. Contains some shale and conglomerate. Generally less permeable than sandstones of Cambrian age.	50-150
Brule	Isolated deposits of sand and gravel buried beneath glacial-lake clay.	200-300	<100	Precambrian sandstone. Contains some shale and conglomerate. Generally less permeable than sandstones of Cambrian age.	50-150
Crystal Springs	Pitted outwash composed of well-sorted sand and gravel.	100-200	500-1,000	Precambrian crystalline rocks. Not considered an aquifer except locally where fractured or decomposed.	0-10
Hayward	Buried sand-and-gravel deposits beneath or within ground and end moraines.	50-100	<100	Undifferentiated Cambrian sand-stones. Yields are low where the aquifer is thin.	0-10
Lakewood	Stratified outwash and ice-contact deposits of sand, and sand and gravel.	100-200	100-500	Precambrian crystalline rocks. Not considered an aquifer except locally where fractured or decomposed.	0-10
Langlade	Well-sorted stratified outwash and ice-contact deposits of sand, and sand and gravel.	100-200	500-1,000	Precambrian crystalline rocks. Not considered an aquifer except locally where fractured or decomposed.	0-10
Nevin	Ground moraine composed of unsorted clay, silt, sand, gravel, and boulders.	50-100	<100	Undifferentiated Cambrian sandstones. May be as much as 3,000 ft thick.	>1,000
Osceola	Ground moraine composed of unsorted clay, silt, sand, gravel, and boulders.	<50	<100	Undifferentiated Cambrian sand-stones.	100-500
St. Croix Falls	Ground moraine composed of unsorted clay, silt, sand, gravel, and boulders.	50-100	<100	Precambrian lava flows. Not considered an aquifer except where fractured or decomposed.	<100
Thunder River	Stratified outwash and ice-contact deposits of sand, and sand and gravel.	100-200	<100	Precambrian crystalline rocks. Not considered an aquifer except locally where fractured or decomposed.	0-10
Westfield	Stratified outwash deposits of permeable sand and gravel.	100-200	500-1,000	Undifferentiated Cambrian sand-stones.	100-500
Wild Rose	Stratified outwash deposits of permeable sand and gravel.	200-300	500-1,000	Undifferentiated Cambrian sand-stones.	100-500



Base from U.S. Geological Survey
1:48,000 quadrangles

Figure 2. Estimated drawdown caused by withdrawing 1,600 gal/min for 10 years from the sand-and-gravel aquifer at the Crystal Springs station.

Aquifer characteristics were estimated from pumping test data in the Antigo Flats area reported by Harder and Drescher (1954, p. 22). Hydraulic conductivity was estimated as 2,000 ft/d, and storage coefficient was estimated as 0.15. Saturated thickness of the aquifer was modeled as a uniform 80 ft. Induced leakage from Dalton Creek was included in the model.

Digital-model analysis (McLeod, 1975) indicated a probable maximum drawdown of 28 ft after 10 years of continuously pumping 1,600 gal/min from four wells in the sand-and-gravel aquifer. This is 35 percent of the saturated thickness. Drawdown distribution is shown in figure 3. Drawdown along the stream, where leakage occurs, does not reach as far out from the pumping center as it does away from the stream.

Nevin

The sand-and-gravel aquifer at the Nevin station is sandy ground moraine, lying in a preglacial valley in the underlying sandstone. The sandstone is several hundred feet thick. The sand and gravel and the upper zone of the sandstone function as a hydrologic unit.

Aquifer characteristics were reported by McLeod (1975). Hydraulic conductivity was estimated at 170 ft/d for the sandy ground moraine and at 85 ft/d for the sandstone. The storage coefficient was estimated at 0.10 for both aquifers. Saturated thickness of the combined sand-and-gravel and sandstone aquifer was estimated at 200 ft.

Digital-model analysis (McLeod, 1975) indicated a probable maximum drawdown of 22 ft after 10 years of continuously pumping 1,600 gal/min from four wells in both the sand-and-gravel and sandstone aquifers. Because there is a positive artesian head of approximately 10 ft, the net drawdown below land surface is only 12 ft, or 6 percent of the saturated thickness. Drawdown distribution is shown in figure 4. The drawdown extends farther into the sand-and-gravel aquifer than into the sandstone, and the shape of the drawdown cone is elongate along the trend of the preglacial bedrock valley.

Osceola

The sand-and-gravel aquifer at the Osceola station is a morainal deposit composed of poorly sorted silt, sand, and gravel. It is only about 20 ft thick. The bedrock aquifer is composed of sandstone and is of small extent, contained within a southwest-to-northeast trending fault zone.

Hydraulic conductivity was estimated as 85 ft/d in the glacial sand and as 125 ft/d in the sandstone. The storage coefficient was estimated as 1.1×10^{-3} for both aquifers. Saturated thickness was assumed to be 300 ft.

Digital-model analysis (McLeod, 1975) indicated a probable maximum drawdown of 16 ft after 10 years of continuously pumping 1,600 gal/min from four wells in the sand-and-gravel and sandstone aquifers. This is 6 percent

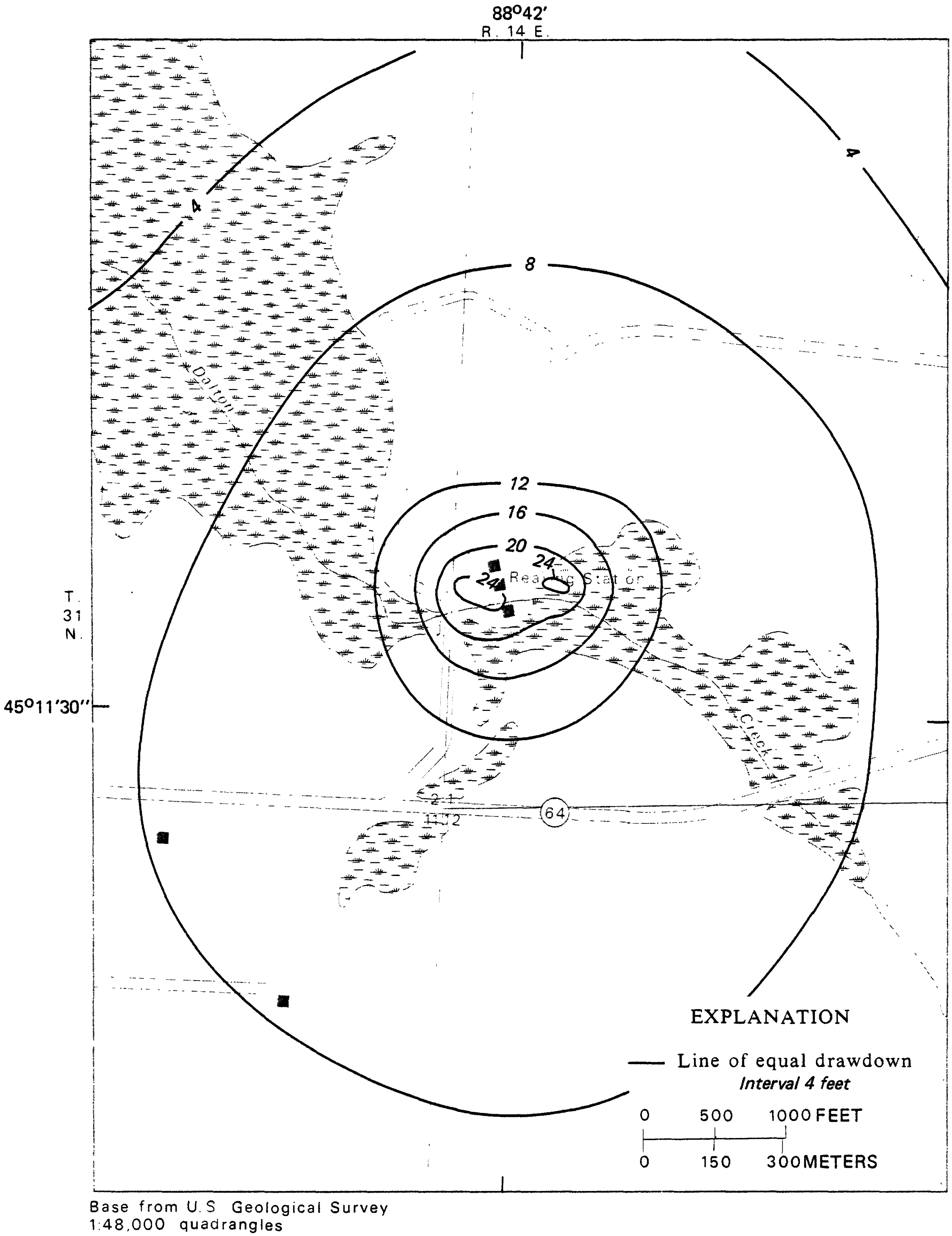


Figure 3. Estimated drawdown caused by withdrawing 1,600 gal/min for 10 years from the sand-and-gravel aquifer at the Langlade station.

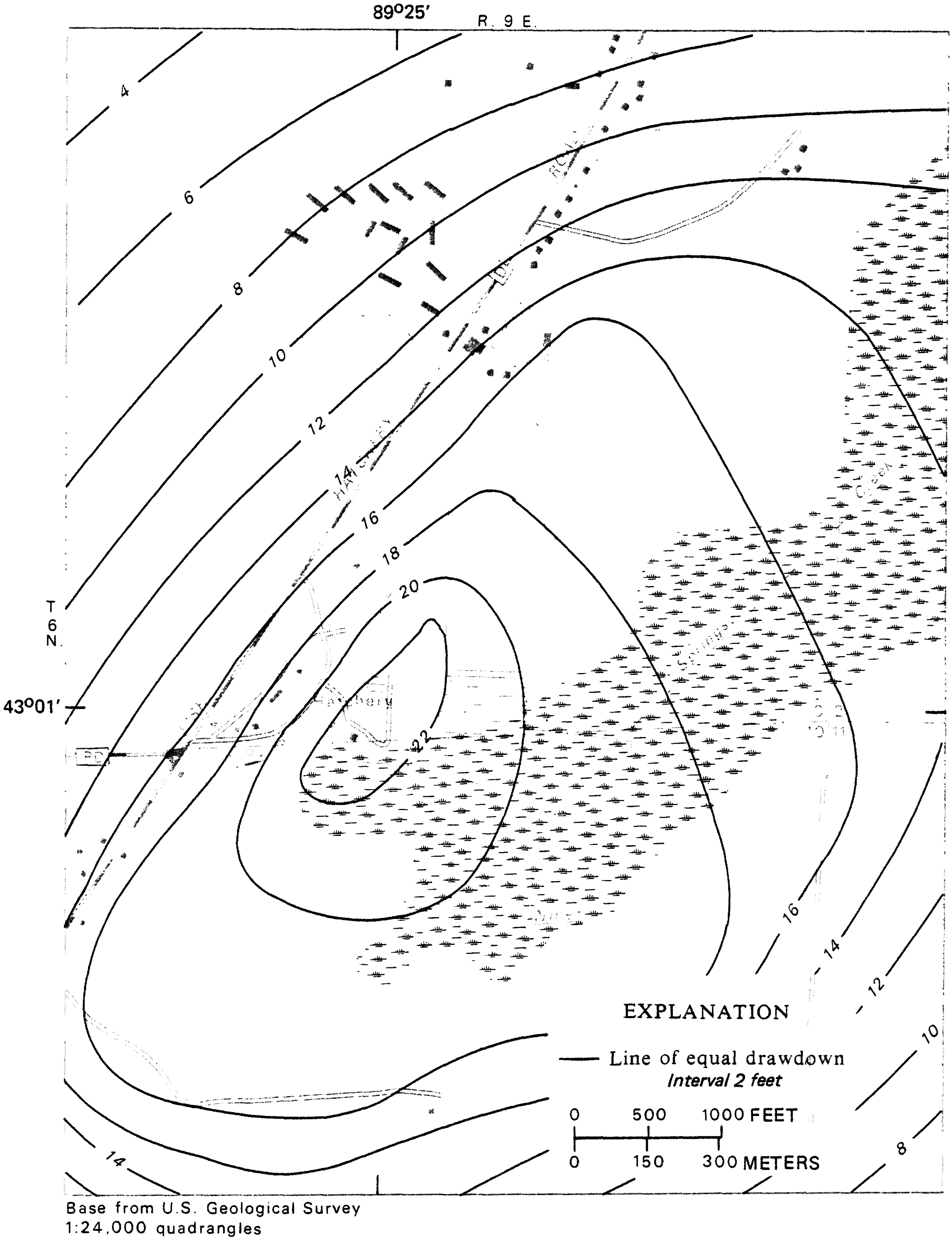
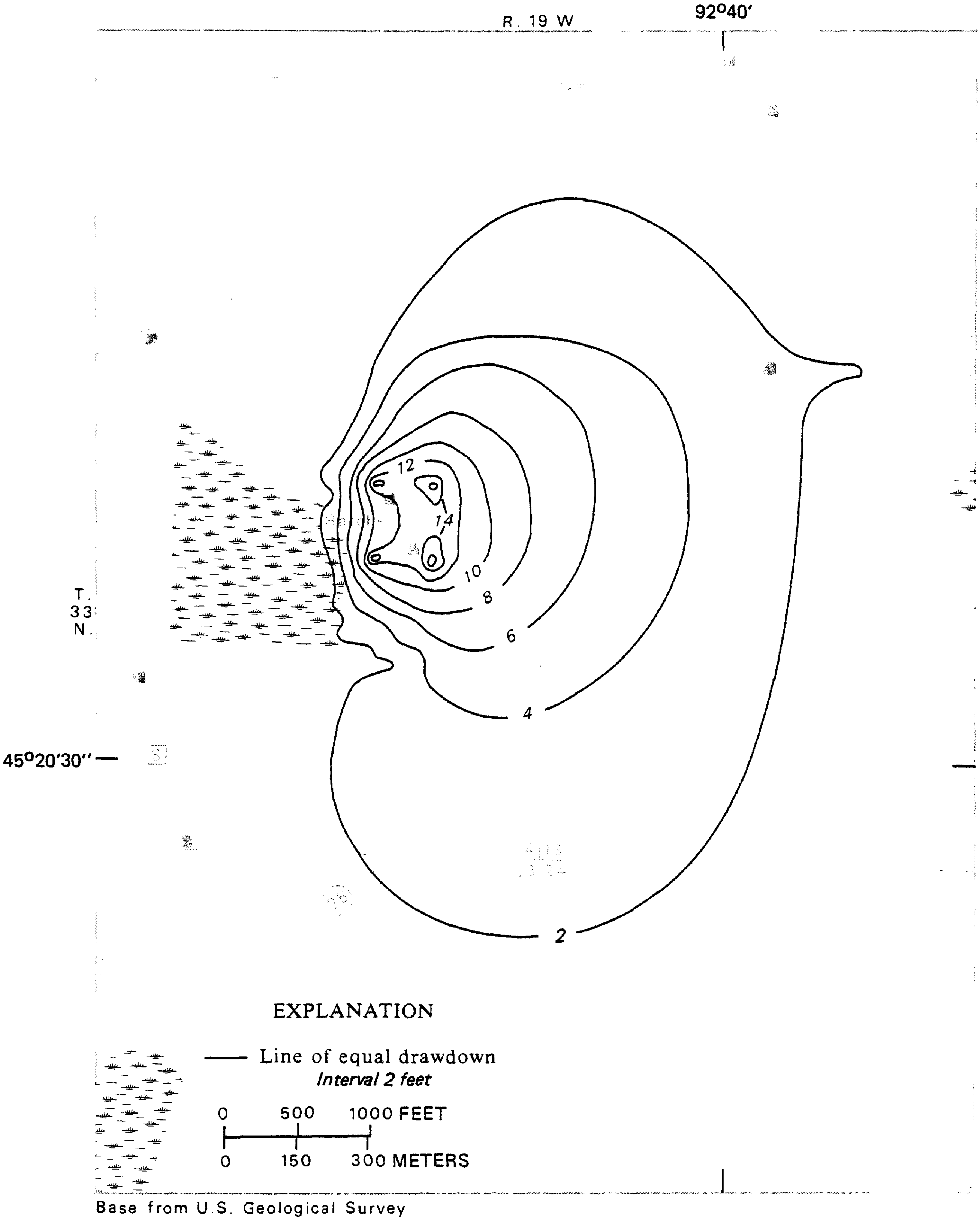


Figure 4. Estimated drawdown caused by withdrawing 1,600 gal/min for 10 years from the sand-and-gravel and upper sandstone aquifers at the Nevin station.



Base from U.S. Geological Survey
1:48,000 quadrangles

Figure 5. Estimated drawdown caused by withdrawing 1,600 gal/min for 10 years from the limited sand-and-gravel and sandstone aquifers at the Osceola station.

Table 4. Chemical analysis of water from selected fish-propagation stations.

(CHEMICAL ANALYSES IN MILLIGRAMS PER LITRE, EXCEPT IRON AND MANGANESE WHICH ARE GIVEN IN MICROGRAMS PER LITRE)

SOURCE OF SAMPLE	DATE	DIS-SOLVED SILICA (SIO2)	TOTAL IRON (FE)	TOTAL MAN-GANESE (MN)	DIS-SOLVED CALCIUM (CA)	DIS-SOLVED MAG-NE-SIUM (MG)	DIS-SOLVED SODIUM (NA)	DIS-SOLVED PO-TAS-SIUM (K)	BICAR-BONATE (HCO3)	DIS-SOLVED SULFATE (SO4)	DIS-SOLVED CHLO-RIDE (CL)	DIS-SOLVED FLUO-RIDE (F)	DIS-SOLVED NITRITE PLUS NITRATE (N)	DIS-SOLVED SOLIDS (SUM)	LOSS ON IGNI-TION	SPEC-IFIC COND-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)
BRULE FISH-REARING STATION																		
SURFACE WATER INFLOW TO RACEWAYS	5-14-74	11	160	0	A12	A 3.2	2.4	0.4	56	5.1	2.8	A0.2	0.13	74	18	107	7.4	- -
GROUND WATER INFLOW TO RACEWAYS	5-14-74	9.9	20	0	A15	A 4.1	3.3	.8	80	4.5	.5	A .2	.00	112	34	135	8.3	- -
OUTFLOW FROM RACEWAYS	5-14-74	11	160	17	A14	A 3.7	2.5	.4	61	4.6	2.0	A .2	.19	110	34	113	7.2	- -
CRYSTAL SPRINGS FISH-REARING STATION																		
GROUND WATER INFLOW TO RACEWAYS	4-17-74	15	110	10	25	14	1.9	1.2	156	5.7	.6	.1	.03	B152	--	246	7.6	8.0
GROUND WATER INFLOW TO RACEWAYS	4-17-74	17	110	10	28	14	2.9	1.2	156	8.1	1.1	.1	.24	B167	--	257	7.7	7.5
OUTFLOW FROM RACEWAYS	4-17-74	13	140	120	25	12	3.3	1.1	145	6.1	.7	.1	.03	B144	--	228	7.6	8.5
HAYWARD FISH-REARING STATION																		
GROUND WATER INFLOW TO RACEWAYS	5-14-74	17	90	17	A21	A 6.0	2.6	.4	94	5.2	3.1	A .2	.83	160	58	175	7.4	- -
OUTFLOW FROM RACEWAYS	5-14-74	18	70	17	A21	A 6.0	2.6	.5	95	4.9	3.0	A .2	.80	138	28	174	7.6	- -
LAKEWOOD FISH-REARING STATION																		
GROUND WATER INFLOW TO RACEWAYS	4-16-74	12	110	10	25	13	2.6	1.4	150	8.3	1.2	.4	.29	B168	--	256	7.9	12.5
OUTFLOW FROM RACEWAYS	4-16-74	12	120	10	30	13	2.6	1.4	153	8.0	1.1	.4	.30	B150	--	261	7.5	10.5
LANGLADE FISH-REARING STATION																		
SURFACE WATER INFLOW TO RACEWAYS	4-16-74	8.9	180	10	22	11	2.0	1.1	117	5.6	1.0	.3	.17	B136	--	200	7.7	4.0
OUTFLOW FROM RACEWAYS	4-16-74	9.0	210	20	26	11	2.0	1.2	117	5.6	3.2	.3	.17	B131	--	200	7.6	4.5
NEVIN FISH HATCHERY																		
GROUND WATER INFLOW TO RACEWAYS	8-5-74	15	--	--	60	31	3.0	1.6	310	13	4.4	-	2.4	B299	--	509	8.0	11.0
GROUND WATER INFLOW TO RACEWAYS	8-5-74	17	--	--	69	35	5.9	1.2	325	22	14	.0	4.4	B368	--	588	- -	10.5
OSCEOLA FISH HATCHERY																		
GROUND WATER INFLOW TO RACEWAYS	5-13-74	24	20	0	A45	A18	5.0	.9	210	19	8.5	A .3	2.7	310	130	396	7.9	9.5
OUTFLOW FROM RACEWAYS	5-13-74	21	30	0	A43	A17	5.0	1.1	207	17	8.7	A .3	2.4	284	124	393	7.6	- -
ST. CROIX FALLS FISH HATCHERY																		
GROUND WATER INFLOW TO RACEWAYS	5-13-74	25	60	0	A37	A12	5.4	.9	148	13	21	A .3	2.9	260	100	347	7.1	8.5
OUTFLOW FROM RACEWAYS	5-13-74	25	10	0	A36	A13	8.1	1.3	160	11	13	A .3	2.5	262	68	326	7.4	9.0

A-TOTAL CONCENTRATION; B-DISSOLVED SOLIDS(RESIDUE@180°C) of the saturated thickness. Drawdown distribution is shown in figure 5. The shape of the drawdown cone is due to the St. Croix River, just west of the station, which provides recharge.

WATER QUALITY

The chemical analyses of water from selected salmonid fish-propagation stations (table 4) indicate characteristics of current supplies. Comparison of the inflow and outflow at eight stations shows that fish-rearing operations cause little change in water quality.

SUMMARY AND CONCLUSIONS

Supplemental water supplies from surface-water sources are available at 7 of the 12 salmonid fish-propagation stations. Ground water is available from the sand-and-gravel aquifer at all stations and from sandstone aquifers at 7 of the 12 stations.

Development of supplemental supply from the sand-and-gravel aquifer at the Bayfield, Brule, Hayward, Nevin, Osceola, St. Croix Falls, and Thunder River stations would be inadequate for needs. At the Crystal Springs, Hayward, Lakewood, Langlade, and Thunder River stations, supplemental supply from the bedrock aquifer is not available. Supplemental supply from the bedrock aquifer at the St. Croix Falls stations would probably be inadequate for needs. Adequate supplemental supplies at the Hayward station are not available from either ground- or surface-water sources. Supplemental supplies from ground-water and(or) surface-water sources at other stations are adequate for needs.

Because of planned early development, the drawdown caused by continuously pumping 1,600 gal/min for 10 years from the sand-and-gravel aquifer at the Crystal Springs and Langlade stations and the sand-and-gravel and sandstone aquifers at the Nevin and Osceola stations was modeled. Estimated drawdowns ranged from 6 percent of the saturated thickness at Nevin and Osceola stations to 35 percent of the saturated thickness at the Langlade station.

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