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DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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Report of Investigations 84-21

GROUND-WATER OCCURRENCE IN EAGLE RIVER, ALASKA

By
James A. Munter

STATE OF ALASKA
Department of Natural Resources
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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CONTENTS

	Page
Abstract	1
Introduction	1
Acknowledgments	1
Hydrogeologic setting	2
Water use in Eagle River	8
Water-supply potential	10
Alluvial-fan aquifers	10
Confined aquifer system	11
Future water demand and water supply	14
Conclusions	15
References cited	15

FIGURES

Figure 1. Location map of study area ... 3
2. Map of hydrogeologic terranes in Eagle River ... 4
3. Hydrogeologic cross section A-A' ... 6
4. Hydrogeologic cross section B-B' ... 7
5. Metered and estimated water use by major community water systems in Eagle River in 1983 ... 9
6. Annual precipitation at Anchorage Weather Service Meteorological Office, Anchorage International Airport ... 13
7. Histogram showing construction year of wells in which water levels were measured in 1983 and were compared with levels reported by drillers ... 13

TABLES

Table 1. Description of map units used in figure 2 ... 5
2. Population and water-demand projections in Eagle River ... 14

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ABSTRACT

Rapid population growth in Eagle River has caused a variety of water-supply and distribution problems. A shallow alluvial-fan aquifer in the area is widely available, but is only lightly stressed. Four deeper, previously unrecognized, confined aquifers have also been identified. A 1983 survey of water levels in 100 domestic wells in the confined system showed that water levels were generally higher than reported by drillers, except near major pumping wells where 10 to 15 ft of water-level decline has occurred. Water-level increases are attributed to several recent years of above-average precipitation in the area. Average water use in Eagle River in 1983 was about 970 gallons per minute (gpm), and average potential yield of all aquifers is estimated to be 1,850 gpm. Current water-supply problems stem from inadequate water production, storage, and distribution facilities. Future large-scale development of the confined aquifer system would result in significant and widespread effects on present users.

INTRODUCTION

Because of rapidly increasing population and a scattered distribution of productive aquifers, the community of Eagle River has water-supply problems. Inquiries from developers, planners, water managers, and the public regarding the location and extent of developable ground water and the effects of existing and anticipated ground-water pumpage have not been adequately answered.

This document is an updated version of a paper presented at the annual meeting of the Alaska Section of the American Water Resources Association (entitled "Managing Water Resources for Alaska's Development 1984") held November 10-11, 1983, at Chena Hot Springs Resort near Fairbanks, Alaska (Munter, 1983). It presents the preliminary results of a detailed hydrogeologic examination of the study area shown in figure 1. Additional unpublished data are available for inspection at the DGGS office on Fish Hatchery Road in Eagle River.

ACKNOWLEDGMENTS

I thank numerous employees of the Municipality of Anchorage for providing opportunities for data collection, for allowing ready access to previously collected data, and for engaging in rewarding dialogs concerning Eagle River's water supply. Assistance from the engineering firms cited in the text is also appreciated. Significant contributions were made by Roger Allely and Larry Dearborn of DGGS. Larry Dearborn, Bill Long and Bill Barnwell (DGGS), along with Rick Illian of the Anchorage Water and Wastewater Utility (AWWU) reviewed versions of this manuscript.

HYDROGEOLOGIC SETTING

The community of Eagle River lies at the base of the west front of the Chugach Mountains, in the valleys of Meadow Creek and Eagle River, and in the glaciated lowlands of Knik Arm of Cook Inlet (fig. 1). This diverse geologic environment has resulted in a correspondingly diverse assemblage of aquifers. A map of hydrogeologic terranes that serves as a guide to general ground-water conditions in different areas of Eagle River is shown in figure 2. Hydrogeologic terranes are defined as three-dimensional geologic units with distinctive water-bearing characteristics. Detailed descriptions of map units are presented in table 1. A surficial-geologic map (Schmoll and others, 1971) and data from approximately 420 water-well logs from drillers were used to construct the map. The logs consist of descriptions of materials encountered during drilling and well-construction information such as casing depth, static-water level, and well yield.

DGGS contracted test drilling at a central location in the study area (fig. 2). The results of the drilling and the analyses of other well logs are presented in two cross sections (figs. 3 and 4).

Cross section A-A' (fig. 3) shows the three thickest and most extensive confined aquifers identified in the area. Detailed data on the middle aquifer at the site of the DGGS test well (fig. 3) and on the lower aquifer at the site of a well drilled by the AWWU (fig. 3, AWWU well A-1) show that the aquifers consist of alternating layers of silty glacial sediments and relatively silt-free sands and gravels. Typically, individual water-producing strata are thin and require careful well-construction methodologies.

Water-level data show that potentiometric surfaces for the three lowest confined aquifers are within 20 ft of each other, and that ground water flows downward in most of the mapped confined-aquifer area. A small upward gradient exists from the lower aquifer to the middle aquifer near well AWWU A-1, probably because of water-level declines caused by heavy pumping of the middle aquifer. Small gradients between the confined aquifers provide indirect evidence that the confining beds between aquifers are leaky or that the aquifers are physically connected by coarse-grained glacial sediments, or both. Pumping a well in the middle aquifer at 300 gpm for 24 hr caused the water level in the upper aquifer to drop 2 ft, as observed in two wells within 500 ft of the pumping well (F. Damron, CH2M Hill, written commun., 1983). This response provides direct evidence that significant hydraulic connection exists between the aquifers.

Cross section B-B' (fig. 4) illustrates that the potentiometric surface of the upper aquifer is about 20 ft above the top of that aquifer at some locations. Wells constructed in these areas have a low tolerance for water-level decline because these wells usually require a 10- to 15-ft column of water under static conditions to ensure total pump submergence during pumping. Ten to 15 ft of water-level decline from 1983 levels could significantly reduce the ability of some wells to provide water. Deepening these wells may not be a reliable method of obtaining additional water because the confined aquifers are commonly thin and because deeper aquifers may not exist. Similar conditions exist in the eastern part of the study area, where some wells

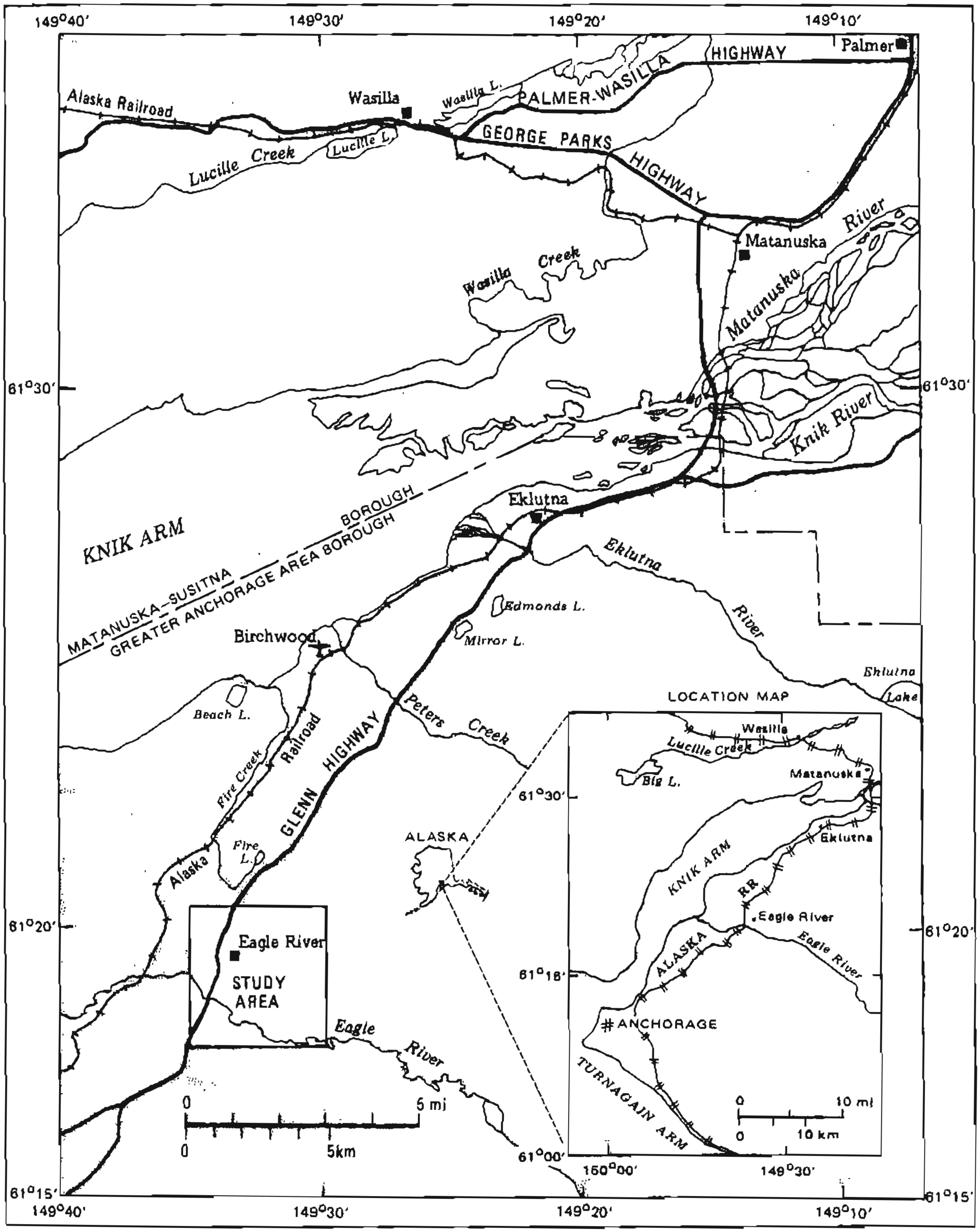


Figure 1. Location map of study area.

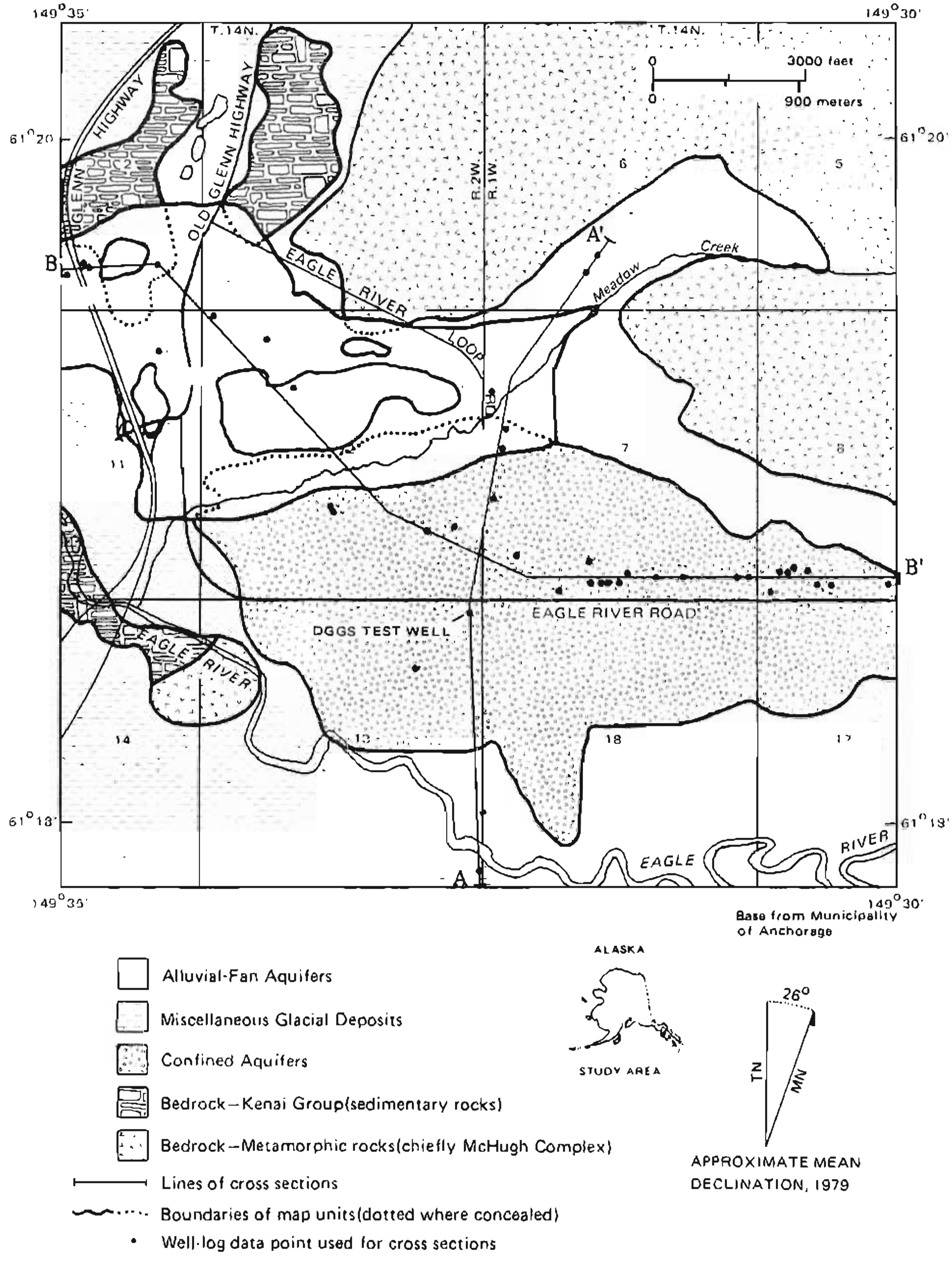


Figure 2. Hydrogeologic terranes in Eagle River (see table 1 and text for explanation of map units.

Table 1. Description of map units in figure 2.

Map unit	Description
Alluvial-fan aquifer	Quaternary surficial deposit that consists of gravel and sand, with cobbles and boulders common, and minor silt. Thickness ranges from a few feet to about 70 ft. Source areas of fan material probably include both adjacent bedrock areas and Pleistocene glaciers in Knik Arm. Most ground water is under water-table conditions, but locally confined or semiconfined aquifers exist. Well yields range up to 500 gpm. Unit boundaries modified from Schmoll and others (1971).
Miscellaneous glacial deposits	Quaternary deposit that includes till, thin alluvium overlying glacial deposits, glaciolacustrine deposits, and colluvium derived from or interbedded with glacial deposits. Water-bearing sand and gravel deposits are typically thin, shallow, and discontinuous. Reported well yields are commonly not more than a few gallons per minute. Some wells obtain water from underlying bedrock. Unit boundaries modified from Schmoll and others (1971).
Confined aquifer	Quaternary unit that represents an area where wells may penetrate one or more confined aquifers that consist of sand and gravel with small to moderate amounts of silt; silty intervals are common where the aquifer is thick. Aquifers may be old, buried alluvial fans or glacial outwash, or both. Thickness of aquifers ranges from a few feet to about 90 ft, and aquifer depth ranges from 50 to 470 ft. Aquifers are confined by silty till and glaciolacustrine or glaciomarine deposits. Several wells yield about 300 gpm.
Bedrock (Kenai Group)	Kenai Group rocks of Oligocene or Miocene age (Wolfe and others, 1966) are within about 50 ft of land surface and consist of relatively flat-lying beds of siltstone, sandstone, and coal. Lithification of clastic rocks varies from very friable to well cemented. Reported well yields in study area are typically a few gallons per minute or less.
Bedrock (metamorphic rocks)	Rocks of McHugh Complex and a less extensive unnamed formation (Zenone and others, 1974) are within about 50 ft of land surface. McHugh Complex consists of deformed and chaotically juxtaposed sequences of metaclastic and metavolcanic rocks of Jurassic or Cretaceous age, or both (Clark, 1973). Nearly all wells obtain water from fracture systems in bedrock. Reported well yields are a few gallons per minute or less.

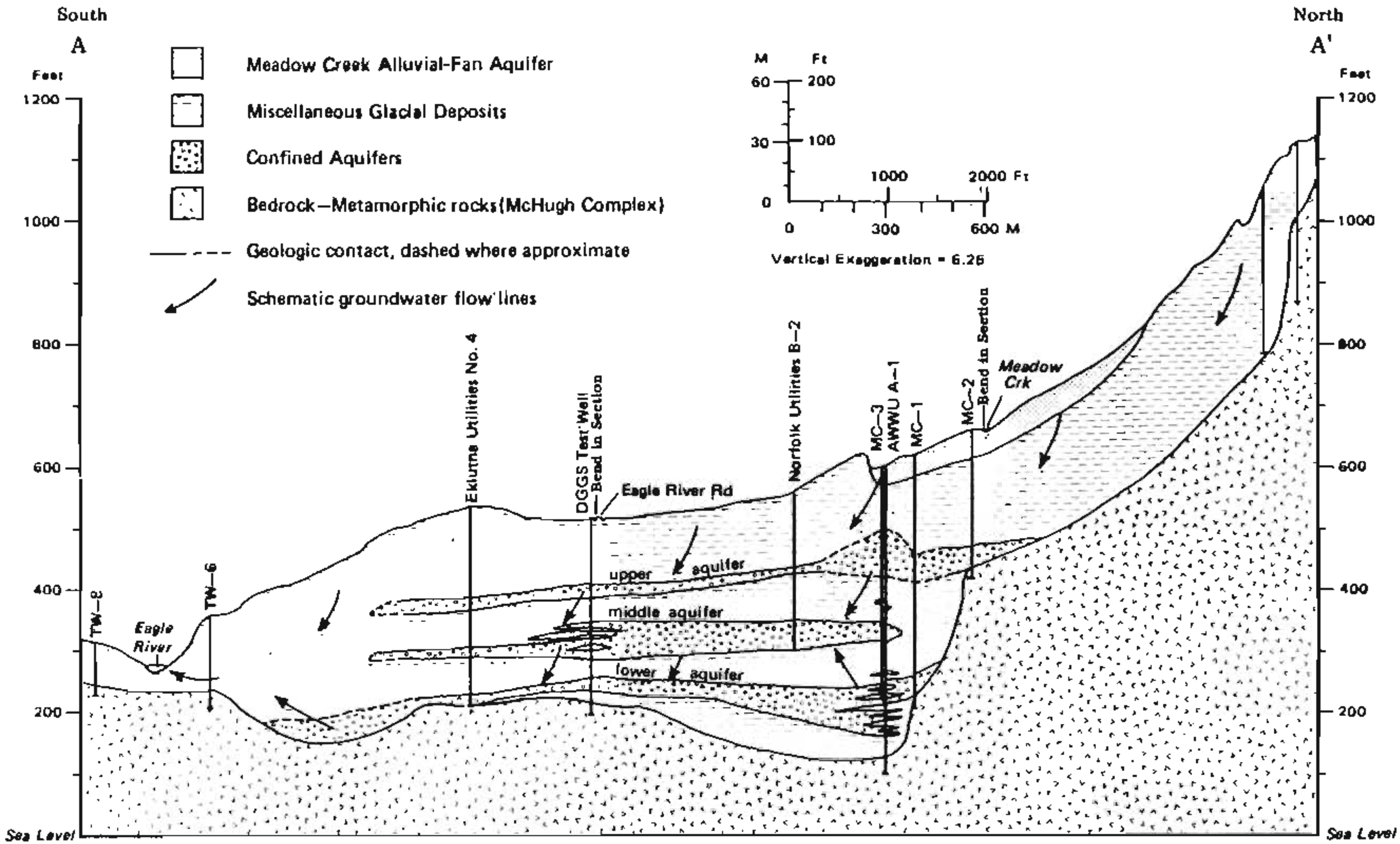


Figure 3. Hydrogeologic cross section A-A' (see fig. 2 for location of section).

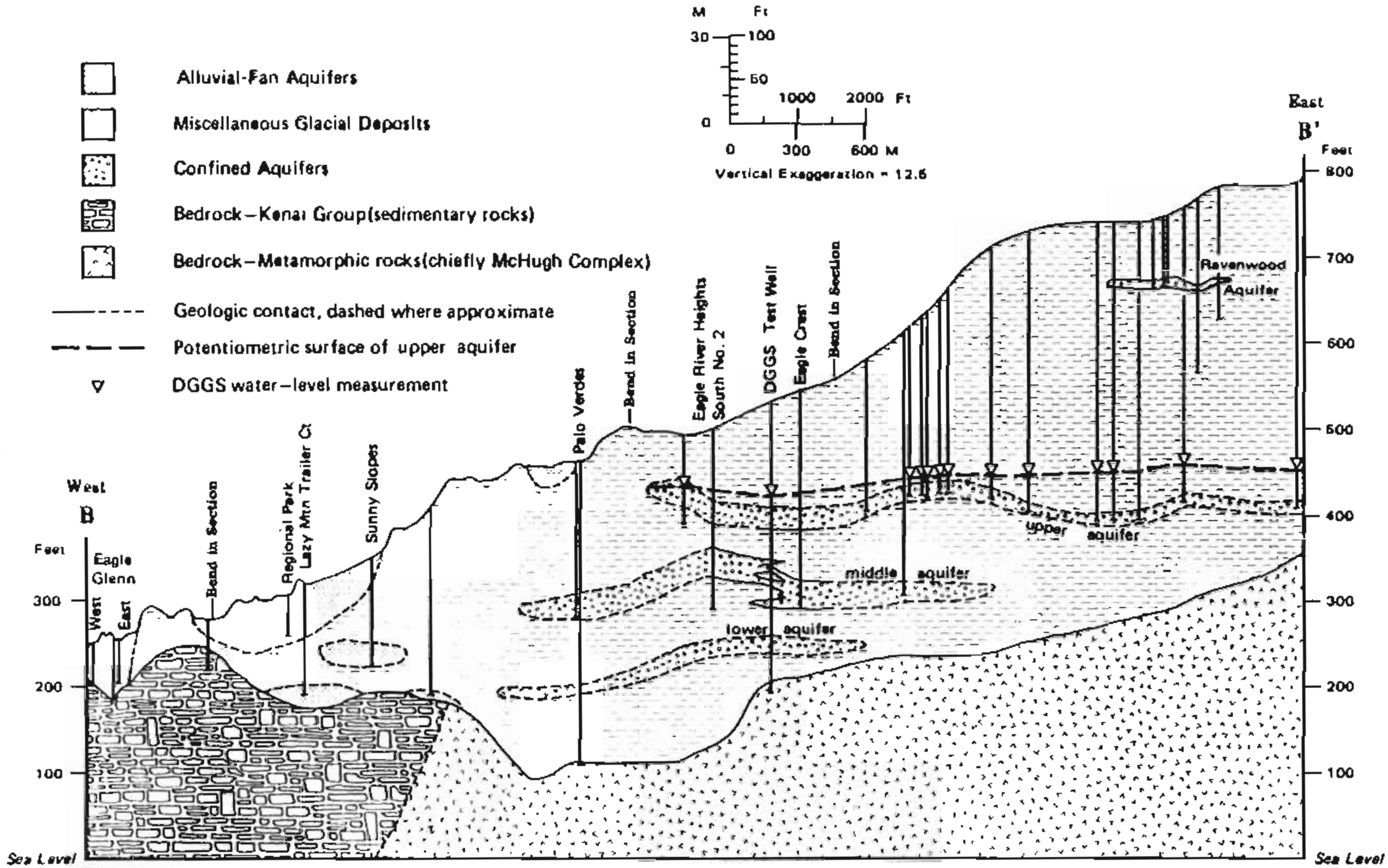


Figure 4. Hydrogeologic cross section B-B' (see fig. 2 for location of section).

drilled into the Ravenwood aquifer (fig. 4) have less than 20 ft of available drawdown, and the presence of a deeper aquifer cannot be relied on.

The alluvial-fan aquifer includes both the surficial alluvial-fan deposits and older, buried alluvial sands and gravels that occur in the same area (cross section B-B', fig. 4). The alluvial-fan aquifer is surrounded by till and other glacial deposits. The eastern portion of the aquifer is underlain by silty glacial sediments, and the western part by siltstones, sandstones, and lignites of the Kenai Group. Deep sands and gravels of the alluvial-fan aquifer were encountered in the Sunny Slopes well and the Lazy Mountain Trailer Court well (fig. 4). The irregular bedrock topography in the area and the irregular distribution of glacial sediments preclude mapping the deep sands and gravels with the existing data base.

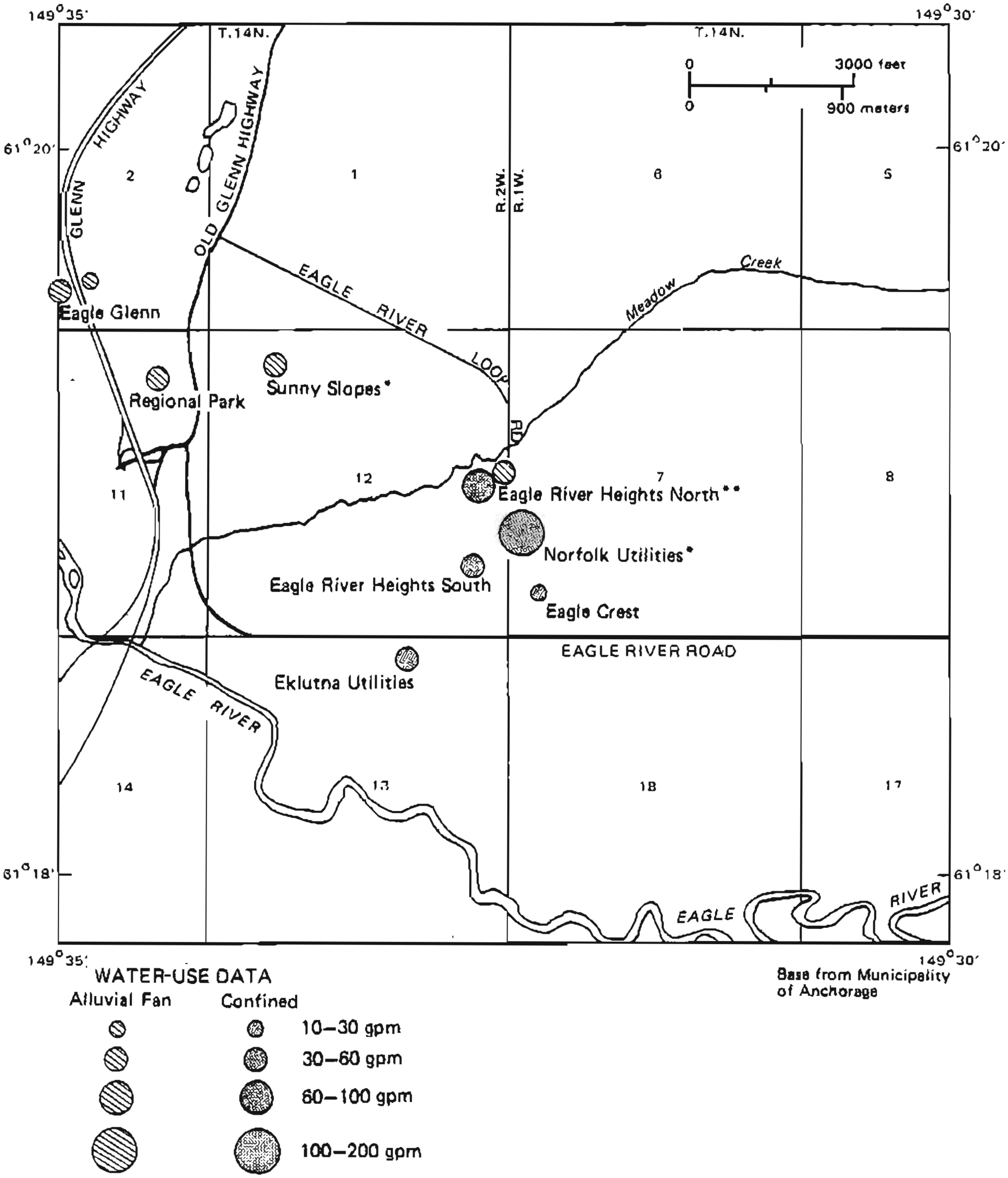
WATER USE IN EAGLE RIVER

Average continuous-supply rates of metered water use and water-use estimates in Eagle River for 1983 are presented in figure 5. Only water-distribution systems that deliver more than an average of 10 gpm are included. Water-use data for systems for which pumping records are not available were estimated by multiplying the number of residential household consumers by 400 gallons per day (gpd) per household, the average rate of consumption during parts of 1983 and 1984 at five water-distribution systems in Eagle River with known average pumping rates and number of households served.

The population of the study area was estimated at 11,665 as of July 1, 1983, an increase of 49 percent from 1982 (A.L. Van Domelen, Municipality of Anchorage, written commun., 1983, 1984). A survey of 300 households in the Eagle River-Chugiak area indicates that the average number of people per household for all nongroup types of housing in 1983 was 3.38 (Van Domelen, oral commun., 1984). Dividing this number into 400 gpd per household results in a water-use figure of 120 gpd per person for 1983. Thus, the average rate of water use in the Eagle River study area for 1983 is estimated to be 970 gpm, or 1.4 million gpd (mgd). The water-use data and estimates shown in figure 5 total about 470 gpm, or about 48 percent of the total estimated usage. The remaining 500 gpm is withdrawn from an estimated 1,000 to 1,500 private wells and a few small neighborhood water systems.

On the basis of distribution of known wells in the study area and the location and pumping rates of major water-supply wells, an average of 47 percent of the estimated water consumption in 1983 in the study area, or 460 gpm, is withdrawn from the confined-aquifer system. About 30 percent, or 290 gpm, is withdrawn from the alluvial-fan aquifers. The remaining 23 percent (220 gpm) is withdrawn from areas mapped as shallow bedrock or miscellaneous glacial deposits.

Of the estimated 47 percent pumped from the confined aquifer system, about 32 percent of the water comes from the middle aquifer, 13 percent from the upper and Ravenwood aquifers, and 2 percent from the lower aquifer.



* Water use is estimated from number of households served x 400 gpd.

** Breakdown between confined and alluvial-fan sources is estimated from total production data.

Figure 5. Metered and estimated water use by major community water systems in Eagle River

WATER-SUPPLY POTENTIAL

Alluvial-fan Aquifers

The estimated water-supply potential described herein from the alluvial-fan aquifers is based solely on the potential yield of several existing well systems. Drawdown in individual production wells is the limiting factor in producing water at sites of alluvial-fan aquifers in Eagle River because a) the wells are typically shallow with small amounts of available drawdown and b) well interference among the various wells in the aquifers is not a major consideration.

DGGS and AWWU tested the alluvial-fan aquifer at the Eagle River Heights North well field, and DGGS concluded that a pumping rate of 200 to 300 gpm could be sustained by the aquifer for an extended time. Two shallow wells that were drilled at the site between 1971 and 1973 appear to have become encrusted with iron precipitates, necessitating well rehabilitation or redrilling. On the basis of both the aquifer-test results and existing water-use data, the alluvial-fan-aquifer yield at this site appears to be about 200 gpm greater than the 1983 rate of extraction.

DGGS assisted with a test of the alluvial-fan aquifer at the Eagle Glenn well field (Munter and Dearborn, 1984). Although pumping rates exceeded 500 gpm for a brief time, aquifer boundaries limit long-term aquifer yields to significantly lower rates. Pumping at an annual average rate of about 90 gpm has resulted in a stabilized drawdown of about 8 ft in 1984 at a 2-in.-diam observation well in the well field. With about 14 ft of drawdown originally available in the well field, an average sustained yield of about 150 gpm should be attainable.

Two separate aquifer evaluations were conducted by local engineering firms at the Sunny Slopes water system: one in 1970 (Dickinson, Oswald and Partners, Consulting Engineers) and the other in 1981 (Beyer Engineering). The 1970 test projected sustainable yields of 350 gpm, based on low-rate (170 to 190 gpm) aquifer tests; the 1981 test projected a yield of 500 gpm. The reported static-water level was 1 ft higher in 1981 than in 1970, despite continuous supply to the Sunny Slopes subdivision in the interim. Because of the short duration and low rate of previous aquifer tests, a conservative estimate of long-term aquifer yield at Sunny Slopes is about 250 gpm, or about 200 gpm above the current rate of production (fig. 5).

In summary, alluvial-fan aquifers appear to be capable of producing a minimum of 475 gpm more than is being withdrawn from existing wells; the estimated total yield is about 650 gpm. Additional supplies from the alluvial-fan aquifers could be obtained by developing new wells, building infiltration galleries, or pumping existing wells at higher rates during wetter times of the year (May through October). The potential yield of these aquifers is unknown, but is probably greater than 690 gpm, with possible seasonal variations in maximum yield.

Confined-aquifer System

Methods of determining the potential yield of the confined-aquifer system are different than those used to determine the yield of the alluvial-fan aquifers. The effects of large ground-water withdrawals from the confined system propagate to greater distances because a) the confined aquifers extend over larger areas, b) the general hydraulic behavior of confined aquifers favors widespread drawdown propagation, and c) the confining units that separate individual aquifers are 'leaky' enough to transmit the effects of pumping vertically from one aquifer to another. Because of the large potential for propagation of drawdown, the impact of further development of water resources on users with prior water rights is an important consideration. The potential yield of the confined-aquifer system depends on the amount of water-level decline that is deemed acceptable throughout the aquifers, not on drawdown limitations of individual production wells. Specifically, highly productive wells may be physically capable of producing more water and causing more drawdown than would be considered acceptable by managers and users of the confined-aquifer system. Consideration of acceptable amounts of drawdown are significantly influenced by the current hydrologic status of the confined-aquifer system.

To determine the present hydrologic status of the confined aquifers, DGGS successfully measured the water level in 100 domestic wells in 1983; none of the wells were perforated, screened, or left open to more than one confined aquifer. Of the 100 DGGS-measured water levels, 87 could be directly compared with water levels reported by drillers. In 92 percent of these comparisons, the DGGS-measured water level was higher than the water level at time of well development. The average water-level increase was 7.1 ft, with a standard deviation of 5.6 ft. Generally, the shallowest aquifers showed the highest change and the most net increase in water level. Water-level data collected near Eagle River Loop Road indicate that the nonpumping water levels of the middle aquifer dropped about 12 ft from 1978 to 1983 (R & M Consultants, 1979; Smith and Robertson & Associates, 1983). This is probably a direct result of large rates of ground-water extraction from the middle aquifer.

To determine the reason for higher static water levels in early 1983 than in the past, several factors were considered:

1. The datum for a water-level measurement from a driller may have been the top of the well casing, which is commonly about 2 ft above the ground.

2. Common drilling, developing, and testing techniques may result in measured water levels by drillers that are lower than water levels representative of static conditions.

3. The existing data set of drillers' logs was collected over a period of many years and during all seasons of the year, which introduces biases to statistical analyses of water-level data.

4. The accuracy of drillers' water-level-measuring techniques and equipment are undocumented.

5. The survey results may reflect an actual increase in ground-water levels that was caused by an increase in the rate of recharge after construction of most wells.

Figure 6 shows annual precipitation at Anchorage International Airport, and figure 7 shows a well-construction histogram. Precipitation events in Eagle River are somewhat different than those in Anchorage, but the annual trends are similar. Figure 6 shows that the period from 1979 to 1982 was abnormally wet in Anchorage; figure 7 shows that most wells in the survey were drilled between 1975 and 1977, near the end of a long period of below-average precipitation in Anchorage. Thus, the statistical results of the water-level survey probably reflect a real rise in water levels in the confined aquifers because precipitation increased after most wells were drilled (option 5, above). This is not inconsistent with the previous observation of 12 ft of water-level decline since 1978 near major pumping wells along the Eagle River Loop Road, because most DGGS water-level measurements were made 0.5 to 1.5 mi east of the pumping wells, where the effects of historic pumping were not large. Seven water-level measurements in middle aquifer wells in T. 14 N., R. 2 W., sec. 12 showed an average increase of 1 ft above that reported by drillers, which suggests that historic pumping has affected water levels in the western part of the confined-aquifer system. The data indicate, however, that fluctuations of natural aquifer recharge on water levels had more effect on the upper and Ravenwood aquifers (in the eastern part of the confined aquifer system) than did aquifer-system pumping at historic rates through 1983 in that area.

Several wells in the upper aquifer may be significantly affected if water levels in the upper or Ravenwood aquifers drop 10 to 15 ft from 1983 levels. Natural fluctuations in water level may be a significant contributor to this.

To summarize, about 10 to 15 ft of drawdown appears to have occurred through 1983 near existing pumping centers; the eastern part of the aquifer system had imperceptible change. Assuming a direct proportionality between pumping rate and drawdown, a doubling of existing withdrawal would result in a drawdown of about 20 to 30 ft near existing pumping centers, with small drawdowns in the eastern part of the aquifer system. The effect of such water use on most existing users would probably be slight. Some users with relatively low tolerances for water-level decline may experience difficulty when pumping increases and the area returns to average or below-average precipitation, which will cause declines below the 1983 water levels.

As previously discussed, estimates of the potential yield of the confined-aquifer system depend on the amount of water-level decline that is deemed acceptable; this has not been defined. Therefore, only an approximation of the potential yield of the aquifer system can be made. For this analysis, doubling 1983 use (from an estimated 470 gpm to 940 gpm) is suggested as a lower limit of potential supply from the confined-aquifer system; this assumes that increased pumpage is areally distributed similarly to historic pumpage. Therefore, the sum of the potential yield of the confined-aquifer system (940 gpm), the alluvial-fan aquifers (650 gpm), and the current estimated pumpage from miscellaneous glacial and bedrock sources (220 gpm) is 1,850 gpm (2.67 mgd).

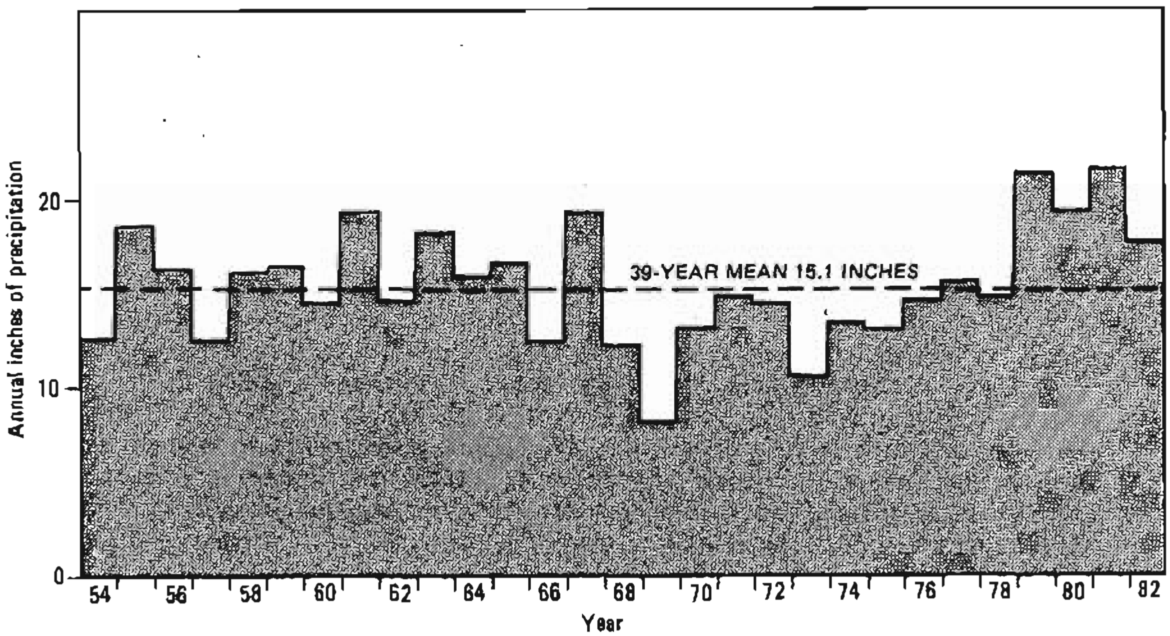


Figure 6. Annual precipitation at Anchorage Weather Service Meteorological Office, Anchorage International Airport.

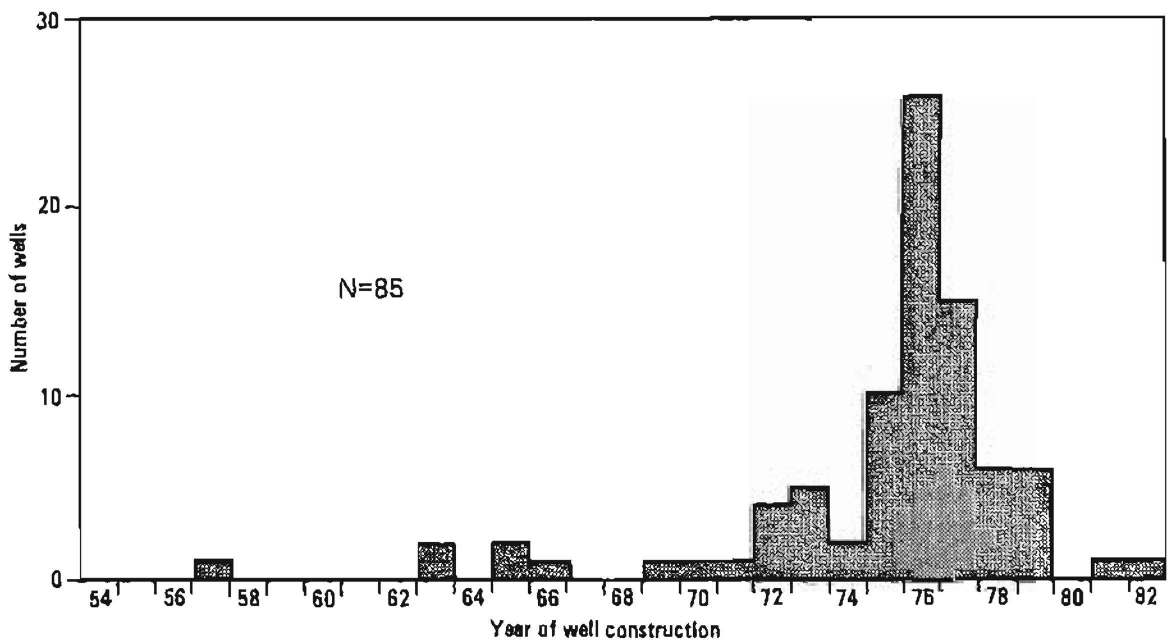


Figure 7. Histogram showing construction year of wells in which water levels were measured in 1983 and compared with levels reported by drillers.

The potential sustainable yield of the Eagle River aquifer of 1,850 gpm is considered a conservative estimate of available supplies. Kinney and Eklutna Utilities, Inc. (1981) compiled estimates of well yields in Eagle River and concluded that 4,725 gpm of water could be developed. The more conservative estimate of 1,850 gpm is used in this report because many wells described by Kinney and Eklutna Utilities (1981) have either not been adequately tested or would cause serious interference problems if pumped at the proposed rates.

FUTURE WATER DEMAND AND WATER SUPPLY

Table 2 shows population projections for the study area through the year 2005 (Van Domelen, written commun., 1983) and average water-demand projections. Population projections were not extrapolated further because of unresolved zoning issues. A comparison of the population projections with population estimates (p. 8) reveals that Eagle River in 1983 had a population that was projected to occur in 1986. Such a large discrepancy suggests that the population projections in table 2, which are the most current projections available (Van Domelen, oral commun., 1984), are not reliable for estimating future water-supply problems.

Table 2. Population and water-demand projections in Eagle River.

Year	Projected population[a]	Estimated average water demand[b] (gpm)
1981	7,461	620
1982	7,779	650
1983	9,251	770
1984	10,453	870
1985	10,855	900
1990	14,068	1200
1995	17,732	1500
2000	22,953	1900
2005	25,123	2100

[a]From transportation districts 46-48, which encompass an area slightly larger than the study area shown in figure 1 (Van Domelen, written commun, 1983).
[b]Using 120 gpd per person.

Construction has begun on a project to import water to Eagle River by the fall of 1985 (Municipality of Anchorage, 1984). Initially, the Eklutna Water Project calls for construction of a pipeline to deliver water from Anchorage to Eagle River. Then, plans call for extending the pipeline to Eklutna Lake and building a treatment plant to provide water from the lake to both Eagle River and to Anchorage as early as 1988.

CONCLUSIONS

The system of alluvial-fan and confined aquifers that has been identified in Eagle River is, under 1983 conditions, lightly stressed in most areas. Ten to 15 ft of historic drawdown has occurred near major pumping wells in the confined-aquifer system. The impact of further development of the alluvial-fan aquifers is expected to be minor, whereas the impact of large-scale development of the confined-aquifer system will be significant and widespread, particularly during periods of below-average precipitation and in wells that tap the confined-aquifer system in areas where the amount of available drawdown is small.

The total long-term average rate of potential aquifer yield is conservatively estimated at 1,850 gpm (2.67 mgd). More water could be developed from the alluvial-fan aquifers. Unfortunately, the most recent population projections do not realistically reflect recent high growth rates and are not reliable for estimating the timing of future water-supply problems.

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