STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

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December 1989

Report of Investigations 89-3
A PLAN FOR MANAGING GROUND-WATER
QUALITY DATA IN ALASKA
in cooperation with the Alaska
Department of Environmental Conservation

by
J.A. Munter

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

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CONTENTS

TABLES

A PLAN FOR MANAGING GROUND-WATER QUALITY DATA IN ALASKA

by
J. A. Munter[1]

ABSTRACT

Collection of ground-water quality data in Alaska has increased substantially in recent years, creating a demand for efficient data management, storage, and retrieval. This report presents a plan to computerize ground-water quality data in a cost-effective way according to minimum standards for data completeness. The plan objective is to promote industry-wide data collection and storage methods which will make reliable data more accessible to present and future users. The plan relies primarily on the National Water Information System (NWIS) of the U.S. Geological Survey (USGS) for hardware and software support, with funding from the state under a cooperative program. Initial data input is likely to be complex and cumbersome; however, enhanced data reporting by data generators will streamline the process. Microcomputer databases with appropriate parameter fields can be transferred to the NWIS database. Data retrieval can be performed by request to USGS or via modem onto paper, diskette, or magnetic tape, using an extensive library of user-friendly NWIS retrieval software. Eventually, data entry and retrieval is envisioned to be performed by microcomputer and NWIS-supplied software anywhere in the state. Responsibility for data verification must be shared by the USGS and the source agency for the data. Interagency participation and discussion will be vital in the continuing effort to develop and refine an integrated ground-water quality data management system.

INTRODUCTION

Ground-water data are collected in Alaska by state, federal, and local agencies. These data are used (1) in compliance monitoring of solid waste landfills, public drinking water systems, wastewater disposal systems, and coal mines; (2) for investigations of ground-water contamination; and (3) in evaluation of areawide ground-water conditions. Many of these data are not now stored or generally available for systematic retrieval by agency or private-sector users.

The importance of comprehensive ground-water data management has been recognized recently at the national level by the U.S. Environmental Protection Agency (EPA, 1987), because numerous EPA programs tend to generate large quantities of data that cannot be readily shared. Since many EPA programs in Alaska have been delegated to the Alaska Department of Environmental Conservation (DEC, 1989), the State has become a major collector of water-quality data. The State of Alaska also has a well-defined public mandate in AS 41.08.017(a) to collect and manage water data:

> Systematic collection, recording, evaluation, and distribution of data on the quantity, location and quality of

[1]Division of Geological and Geophysical Surveys, P.O. Box 772116, Eagle River, Alaska 99577.

> water of the state in the ground, on the surface of the ground, or along the coasts, are in the public interest and necessary to the orderly domestic and industrial development of the state.

This report presents a plan for managing ground-water quality data in Alaska that will make these data more useful, both in their original, specific application and in broader, future applications. These are compatible functions, because routine turnover of personnel commonly requires that new staff review historical data in order to deal effectively with current issues in projects and programs. Well-managed data also assist government, industry, and researchers in a variety of activities ranging from regional assessments to site-specific investigations at or near earlier data collection sites.

A ground-water quality data management system is defined as a scheme for collecting data according to core standards of completeness and reliability and for processing data according to criteria for verification, access, retrieval and analysis, within constraints imposed by agency mandates, available funding, and the condition of historic data. The scope of the system includes all historic data, subject to a determination of their completeness and reliability.

A major portion of this report integrates the plan for ground-water quality data with other existing ground-water database systems. This integration is necessary because (1) most wells provide a variety of ground-water data; and (2) integration of several types of ground-water data is usually necessary to solve ground-water problems or issue facility permits.

Use of any statewide interagency ground-water data management system requires the general consensus and cooperation of numerous data gatherers in Alaska. This plan should therefore be considered flexible and subject to change as implementation proceeds and working knowledge is gained. Agencies or industries affected by changes suggested in this report may want to meet periodically to review and refine data management practices where appropriate.

ACKNOWLEDGMENTS

The author thanks Bill Ashton and Douglas Redburn of DEC, Toby Hegdahl of EPA, and Mike Lilly and Dan Hawkins of the University of Alaska for their thoughtful reviews of the manuscript, and EPA for approving project funds.

REVIEW OF GROUND-WATER DATA MANAGEMENT SYSTEMS

Ground-water data, whether collected only once (such as location, altitude, or construction of a well) or periodically (such as for water level or water quality), may be classified into eight components:

1. Site location and use information;
2. Hydrogeologic information;
3. Well construction and development information;
4. Periodic and continuous water-level data;
5. Aquifer-test data;

6. Field or laboratory determinations of water-quality parameters;
7. Field or laboratory quality assurance and quality control (QA/QC) information; and
8. Water (including wastewater) extraction or injection information (collectively known as water-use data).

Of these eight components, comprehensive computerized data systems currently exist and are routinely used in Alaska for components 1, 2, 3, 4, and 8. The first three components are commonly referred to as well-log data.

Well-log and Water-use Data Systems

The water rights program of the Alaska Department of Natural Resources (DNR) Division of Land and Water Management (DLWM) is a major source of water data in Alaska. Drillers submit well logs directly to DLWM, and water users submit well logs with water rights applications; DLWM enters water rights information and cursory well-log data into DNR's Land Administration System (LAS). DLWM assigns latitude, longitude, township, range, section, and fourth-quarter-section identifiers to water data sites and periodically transfers well logs to the Division of Geological and Geophysical Surveys (DGGS) within DNR; DGGS enters water-use data into the LAS and publishes annual summaries.

DGGS also receives well logs from drillers, the Municipality of Anchorage (MOA), and other agencies in DGGS project areas, and uses its computerized well-log tracking system (WELTS) to store cursory well-log data. Well logs are manually filed in numerical order by unique WELTS-assigned index number. The WELTS system is designed to be an intermediate filing system, pending comprehensive entry of well-log data into the U.S. Geological Survey's Ground-Water Site Inventory (GWSI) system. During calendar year 1989, data from 1,183 wells were entered into GWSI through WELTS. An accumulation of 6,114 DGGS well logs awaited entry into GWSI as of November 21, 1989. Funding limitations preclude more rapid data entry.

Through its GWSI system, USGS checks incoming well logs for previously entered, duplicate logs, determines and verifies location, maintains a location-based, manual filing system, and enters virtually all log data into GWSI.

Water-well or monitoring-well logs received by DEC through any of several programs are filed manually in case files, facility files, or archived files at various DEC offices and not routinely transmitted to DLWM, DGGS, or USGS. No computerized indexing or tracking system exists at DEC for well logs.

Water-level Data Systems

Periodic water-level measurements are made at numerous observation wells in Alaska. Data from most of these wells are stored in the USGS Daily Values file, and the remainder are on file at DGGS. Data from 225 wells monitored during 1984 have been published (Still and Brunett, 1987). Some data are also published in annual USGS data reports.

Aquifer-test Data Systems

Aquifer-test data are not widely computerized in Alaska. The GWSI system, however, does have the capability for storing a variety of data generated from short-term well-yield tests or long-term aquifer tests.

Water-quality Data Systems

Sources of water-quality data in Alaska were reviewed by Munter (1987) and Maynard (1988), who contacted 39 data-collecting agencies or programs and located data in 228 reports and in various computer and manual filing systems. Major data sources in Alaska are listed in table 1 and summarized below.

In its QWDATA file, the USGS maintains a ground-water-quality database on a Prime minicomputer at Anchorage for approximately 1,700 sites. These data are periodically updated to the USGS national WATSTORE system at Reston, Virginia, and to the EPA national STORET system at Research Triangle Park, North Carolina. The USGS calls its centralized nationwide network of well-log, water-quality, water-use, and water-level data the National Water Information System (NWIS).

Sites of actual or potential ground-water contamination managed by the U.S. Air Force in Alaska utilize the Installation Restoration Program Information Management System (IRPIMS). This database system, developed during 1988 by a contractor for the Air Force, contains ground-water quality data from 1988 fieldwork. Data are not compatible for STORET input without additional programming (D. Dietzel, USAF/OEHL Brooks AFB, Texas, oral commun., 1988).

The DEC Drinking Water Program maintains a computerized database (using Revelation software) containing information from 1,551 public water systems (as of February 1988) which use ground water for part or all of their supply (Maynard, 1988). Locations of points of water intake for these systems are not computerized and, in some cases, are not obtainable from DEC records. As of December 13, 1988, the STORET system contained water quality data from 673 sample locations obtained from the Drinking Water Program (Bill Bogue, EPA, written commun., 1988). These data include an unknown number of treated, surface-water, and mixed surface- and ground-water samples.

The DEC solid waste program maintains manual files of ground-water quality data for about 30 solid waste facilities in Alaska. Although these are not computerized at DEC, data collected by MOA Solid Waste Services and USGS (under cooperative programs with facility operators) are computerized.

Ambient trend monitoring data are collected by MOA at 85 shallow wells. Data collected by the USGS at 48 of these wells sampled during 1985 and 1986 are stored in the WATSTORE and STORET systems. All monitoring data are anticipated to be stored in an MOA database system currently nearing completion (Marc Little, MOA, oral commun., December 1988).

Numerous investigations have been conducted in Alaska at sites of actual or potential ground-water contamination; these investigations typically involve several DEC programs. At DEC, only data from the Anchor Point,

Table 1. Major sources of ground-water quality data in Alaska.

Agency	Program	Location(s)	Principal database system
Federal			
U.S. Geological Survey	Water Resources Div. (Alaska Dist.)	Anchorage	NWIS, WATSTORE
U.S. Environmental Protection Agency	Alaska Operations	Anchorage	STORET
U.S. Fish & Wildlife Service	National Wildlife Refuges	Anchorage	STORET
U.S. Department of Defense (Air Force)[a]	Installation Restoration Program	Elmendorf AFB, Anchorage	IRPIMS
State			
Alaska Department of Environmental Conservation:	Laboratory	Douglas	PCSTORET
	Oil Pollution Control	Anchorage, Juneau, Soldotna, Fairbanks	various
	Public Water Systems	Anchorage, Juneau, Fairbanks	Revelation
	Solid Waste	Anchorage, Fairbanks	none
	Wastewater	Anchorage	none
	Leaking Underground Storage Tanks (LUST)	Anchorage, Juneau, Fairbanks	none
	Hazardous Waste	Juneau	none
Alaska Department of Fish and Game	Fish Hatcheries (FRED Div.)	various	none
Alaska Division of Mining	Surface Mining	Anchorage	none
Alaska Division of Geological and Geophysical Surveys	Water Resources	Eagle River, Fairbanks	INFOS II (WELTS)
University of Alaska	Water Resource Center	Fairbanks	UA Computer Network
Local Governments[a]			
Municipality of Anchorage:	Water Quality	Anchorage	Clipper
	On-site Services	Anchorage	Clipper

[a] Does not include solid waste, public water-supply, or other data available through listed state programs.

Sterling, and Peters Creek investigations have been computerized. The databases use commercially available software packages.

An additional source of ground-water quality data (not reported in Munter [1987] or Maynard [1988]) is the Leaking Underground Storage Tank (LUST) program operated by DEC in cooperation with EPA. Investigations were conducted during 1988 at 43 sites in Alaska, commonly resulting in collection of ground-water data (S. Osborn, DEC, oral commun., 1988). These data are not systematically computerized. Also absent from previous inventories is a database developed for ground-water quality data collected in the hills surrounding Fairbanks (Weber, 1985). This study discusses database compilation problems and methodologies which would be applicable statewide.

Table 2 summarizes the degree to which existing statewide databases include various ground-water data components; only the NWIS system is capable of storing many of the components in a thorough manner. Although NWIS stores aquifer-test data incompletely, it does a far more thorough job of storing this data component than do other databases. Additional details of NWIS and STORET databases are discussed on pp. 9 and 10.

A common feature of databases discussed in this report is that each contains a site identifier or location description, or both. An understanding of the process by which identifiers are assigned is critical, because the type of identifier used (1) affects the speed and cost of data entry and retrieval and (2) determines the usefulness of data to the user.

The WELTS database and most commercially available PC software databases use either arbitrarily assigned well names and numbers or parcel-based location descriptions (lot, block, subdivision). Arbitrarily assigned identifiers simplify data entry (the Revelation database uses this type of identifier) but are not very useful for areawide data retrieval, because they do not specify latitude and longitude of the well. Parcel-based location descriptions also simplify entry, because they have sometimes been pre-assigned by local governments or DEC field offices for other purposes. Although computerized geographic information systems utilizing parcel-based location data are available, disadvantages of parcel-based location descriptions in statewide application include:

1. Subdivisions in different boroughs may have the same name.
2. Parcel names within a borough may change with time.
3. New subdivisions are constantly being created.
4. Parcel names are highly non-uniform in format.
5. Well locations within large parcels are vague.
6. Multiple wells within a single parcel require separate distinguishing identifiers.
7. Parcel base maps (plat maps) can be proprietary.
8. Parcel base maps require frequent updating.

LAS and NWIS are currently the only databases in which well locations are determined by land-survey system (section-township-range) and latitude and longitude; this is a relatively laborious process which requires technical training and verification of results. The system, however, enables a user to easily retrieve data by referring to any regular or irregular map polygon. Selected data sets can be readily transferred to mapping, statistical, or graphics software--although conversion of data to rectilinear coordinates may be necessary.

Table 2. Summary of data-storage capabilities of existing statewide ground-water databases. Descriptions indicate degree to which components are included in each database.

	Ground-water data components							
Database	Site information	Hydrogeologic data	Well construction data	Water level data	Aquifer test data	Water quality parameters	QA/QC	Water use data
LAS (DNR)	T	I	I	N	N	N	N	T
WELTS (DGGS)	I	S	S	N	N	N	N	N
NWIS (USGS):								
GWSI	T	T	T	I	I	I	N	S
QWDATA	T	N	N	N	N	T	T	N
DAILY VALUES	T	N	N	T	N	N	N	N
WATER USE	T	N	N	N	N	N	N	T
STORET (EPA) (including PCSTORET)	I	I	I	N	N	T	T	N
Revelation (DEC Drinking Water Program)	I	N	N	N	N	I	S	S

T = Thoroughly
I = Intermittently or incompletely
S = Seldom or superficially
N = Not at all

Some data in STORET were copied from WATSTORE and contain site identifiers and location descriptions similar to those in the NWIS system. STORET also contains data obtained from the DEC Drinking Water Program, entered using arbitrary site identifiers and latitude-longitude coordinates that are less precise than the NWIS data.

USE OF GROUND-WATER DATA MANAGEMENT SYSTEMS

The key concept underlying a comprehensive ground-water data management system is that it is less expensive and more useful to enter and store ground-water data properly than to search through old and often incomplete records, recollect the data, or make guesses or assumptions about historic conditions that cannot be verified. Without a management system, entire data sets or critical auxiliary information such as well location may be lost. Also, data archived in obscure locations among volumes of other information is effectively lost for many purposes. Ground-water data have long-term value that can be eroded by inadequate data management practices.

Because many sites where ground-water data are collected have regulatory lifespans longer than the tenure of many regulatory staff members, it is particularly important to have information readily available to new personnel. Ready access to data is also important as investigations evolve from initial assessment to areawide or long-term evaluations. For areawide or long-term evaluations, the process of obtaining and verifying historic data may be prohibitively expensive or only marginally successful if an effective data management system has not been operating.

Practical applications for ground-water data include ground-water resource evaluation, facility siting, permitting and permit compliance evaluation, potability or industrial use determination, spill response, assessment and cleanup, long-term contaminant detection monitoring, responding to public concerns or inquiries, and substantiating enforcement actions and lawsuits.

The size of Alaska and the diversity of its data-using community dictate that most practical applications of the data will be distributed throughout the state and performed on personal computers. Therefore, ease of access to the data management system and PC-compatible data are essential.

DESIGN OF AN INTERAGENCY GROUND-WATER QUALITY DATA MANAGEMENT SYSTEM

Criteria

The following criteria were used in the conceptual design of a ground-water quality data management system. The system should:

(1) build on existing data-handling capabilities wherever possible;
(2) be capable of quick and inexpensive implementation (at least in selected areas) with flexibility for future expansion;
(3) provide a framework for retention of information which cannot immediately be fully processed;
(4) establish linkages between computer and manual files that will ensure permanent access to original paper records;
(5) handle a wide spectrum of ground-water quality data;
(6) observe minimum standards for data completeness and quality;
(7) furnish reasonable access for any agency, business, or public user;
(8) facilitate editing and updating by data-collection personnel;
(9) incorporate quality assurance procedures;
(10) designate unique identification numbers for each data site, wherever possible; and
(11) allow retrieval of data in a format suitable for geographic information system (GIS) applications.

Most of these criteria are fundamental data storage and verification functions, functions which do not now occur on a large scale in Alaska. Regardless of the database ultimately selected, widespread implementation of these functions will cause increased effort and cost in some segment(s) of the data collecting, processing, and using community. Database selection must therefore be based on a balance which will meet the system criteria listed above, minimize associated costs, and assign responsibility to the most appropriate segment of the data gathering or using community.

Review of Database Options

Computer software suitable for use as a ground-water quality database falls into two categories: commercially available software such as INFO, INFOS II, Powerbase, dBASE III+, Revelation, RBase, Clipper, CONDOR, or LOTUS

1-2-3, which are purchased and custom-developed to handle whatever data fields the user specifies; or nationally or regionally available software systems that have already been developed specifically for ground-water quality data management.

Commercially available software systems are used in Alaska to manage PWS data, WELTS, two MOA databases, and DEC databases for Anchor Point, Sterling, and Peters Creek areas as well as DEC enforcement tracking and project management functions. Although commercially available systems have the flexibility for local or decentralized applications, they can be expensive and time-consuming to initiate on a statewide scale. Minnesota started planning this type of system more than three years ago and has yet to begin implementation (S. Maeder, Minnesota State Planning Agency, St. Paul, MN, oral commun., 1988).

Primary centralized ground-water data systems in use are NWIS (USGS) and STORET (EPA). Although STORET is a centralized database located outside of Alaska, a version capable of operating on a microcomputer (PCSTORET) is now being developed (R. Peterson, EPA, Seattle, WA, oral commun., 1988). PCSTORET may provide considerable flexibility in creating a decentralized data processing network responsive to local needs.

Because STORET does not have parameter fields for handling common well-log data components, EPA Region X (which includes Alaska) has also developed a monitoring-well and aquifer-characteristics database using dBASE III+ (M. Gubitosa, EPA, written commun., 1988). This database contains many fields from GWSI, along with other non-GWSI fields added by EPA staff. EPA Region X is in the process of entering well-log data from up to 6,000 monitoring wells located in Washington, Oregon, and Idaho into the database.

Overview of STORET

The STORET system consists of a mainframe computer and support staff located in North Carolina, a Client Services Branch located in Washington, D.C., PCSTORET software (obtainable from the EPA Region X Office in Seattle), a local microcomputer or user terminal, a telephone and modem, and (optional) a printer. According to Blake-Coleman and Dee (1987), EPA recommends STORET to manage ground-water quality data on a nationwide basis because:

1. STORET is a well-established system with proven capability for storing and analyzing environmental monitoring data.
2. STORET is widely available. Over 40 states, numerous federal agencies, research institutes, local governments, and interstate commissions have direct access to the system. Most users can obtain reports from small portable telecommunication terminals located in their offices.
3. STORET is well known to many persons who would be entering ground-water data, due to its widespread use in analyzing surface-water data; any new costs would therefore relate mainly to personnel and software rather than hardware.
4. STORET is versatile and has many available functions that are useful for ground-water data interpretation:

a. Extensive analytical software aids the user in manipulating ground-water data statistically. Specifically, use of STORET enables the user to:

   -- determine short- and long-term trends in ground-water quality;
   -- determine individual facility performance; and
   -- generalize about hydrologic settings, waste treatment, or disposal.

b. Additional software enables users to present ground-water data visually with graphics and maps.

5. STORET routinely loads all water-quality data from the WATSTORE database onto the STORET database, thus providing easy access to USGS water-quality data on one database.
6. STORET provides free training and operational aid from EPA's User Assistance Group.

Detailed information on data input and retrieval methodologies and capabilities can be found in various manuals. STORET and PCSTORET are not particularly user-friendly, and substantial training is required in order to enter or retrieve data. Menu-driven software is expected to be available during 1989 (N. Dee, EPA, oral commun., 1988; R. Peterson, EPA, oral commun., 1989). Despite widespread use of STORET in other states and its practical availability to anyone with a PC, modem, and user access rights, it is not widely known or used in Alaska.

It should also be noted that comparison of selected data currently stored in the QWDATA file with data stored in STORET (as of November 1988) revealed several instances where data did not match. It appears that (1) modification of 'site ID's' (described below in NWIS) made prior to 1988 by USGS has not been properly transferred to EPA, (2) some data were never transferred at all, and (3) some sites contain incorrect county codes. The irregularities are sufficiently numerous that the data currently contained in STORET for Alaska should be considered questionable with regard to completeness and accuracy.

Overview of NWIS

During 1987, USGS decentralized its database from the mainframe Amdahl computer in Reston, Virginia, to a nationwide network of Prime minicomputers located in district offices. The Alaska District Prime minicomputer, located in Anchorage, is accessible throughout the state via modem and telephone. Ground-water quality data are computerized by project personnel, laboratory staff in Denver, Colorado, or centralized data entry staff in Anchorage. All files are reviewed by the database manager prior to entry into the database. Original water-quality records are manually filed with well logs by township, range, and section.

NWIS uses over 3,300 parameter codes obtained from EPA in order to facilitate eventual transfer of data to STORET. Also, USGS assigns unique 15-digit numbers ('site ID's') to each ground-water data site. Site ID's are sometimes referred to as 'station numbers.' Site ID is also used by STORET as a unique site identifier known as the Primary Station Code. Primary characteristics of NWIS are summarized here from P.J. Still, USGS (written commun., 1989):

1. NWIS is a well-established system with proven capability for storage, analysis, and retrieval of water-quality data.
2. NWIS is available in 50 states and some territories and accessible by numerous federal, state, and local agencies, consultants, and the general public. Users may obtain data through telecommunication terminals in their offices or from Survey offices in each state.
3. NWIS is well known by federal, state and local agencies in Alaska, as well as private consultants and general public involved in water-quality data collection and interpretation activities.
4. NWIS is versatile and has many functions available for interpreting ground-water quality data:

   a. Water-quality data can be added, modified, or deleted from the database on a real-time basis.
   b. Data stored in GWSI, such as well construction, ownership, site usage, water levels, and aquifer descriptions, are readily available to the user.
   c. Daily water levels are available through the Survey's Automated Data Processing System (ADAPS).
   d. Water-quality data can be retrieved in various formats suitable for inclusion as tables in professional reports.
   e. Water-quality data can be retrieved by individual parameter or group of parameters, individual or multiple sites, state, county, geographic location (polygons based on latitude and longitude), hydrologic unit, and in conjunction with surface-water quality data.
   f. Graphics software programs are available for:

X,Y plots	Box plots	Regression plots
Stiff diagrams	Piper diagrams	Flat file output
Time series plots	Statistics plots	Detection limits table
	Summary statistics table	

A key factor distinguishing NWIS from STORET is that NWIS currently uses interactive 'conversational' routines that allow input and output of data to be performed with minimal use of specialized computer commands.

Suggested Minimum Ground-water Quality Data Elements

In order to match design criteria listed earlier for a ground-water quality data management system with an appropriate computer and software package, a list of minimum suggested data elements is presented here. This list is intended for use by all ground-water quality data collectors in Alaska. Such a list may encompass a wide range of thoroughness, from a rudimentary set of data elements (table 3) to a relatively extensive list. The elements listed in table 3, in addition to a few other data fields, form the core of existing databases for the Anchor Point, Sterling, and Peters Creek areas.

The major difficulty in using databases constructed from only rudimentary data elements is that location descriptions can be vague and inadequate (see table 4, for example). Without personal knowledge of the area, database users would be unable to identify sample locations, and data would be rendered practically unusable. Available maps of the Sterling area showing sampling locations are incomplete and imprecise, and changes in property ownership have the effect of making location descriptions by owner's name unreliable.

Table 3. Rudimentary ground-water quality data elements.

Element	Description
Location	Physical description of well or sampling site, usually sufficient to allow approximate determination of well site after consulting existing maps, sampler, local tax assessor, or local property owners
Source of data	Owner, data collecting agency, or lab or sample identification
Date	Date sample was taken
Parameters measured	Chemicals for which analyses are made
Concentrations or values	Values determined by parameter measurements, indicating unit of measure

Table 4. Location codes and descriptions for data sites in the Sterling area database.

Location code	Description	Location code	Description
1	Well # 0	17	Enid Craig residence
2	Well # 1	18	Short Stop Deli
3	Well # 2	19	Ebnet residence
4	Well # 3	20	Hildreth residence
5	Well # 4	21	Johnson residence
6	Well # 5	22	Artesian Sp. at Birch's Hardware
7	Well # 6	23	Pistilli residence
8	Union Chemicals Pit	24	Ellison's rental at Chumley's
9	Sterling Weigh Station	25	Vasilie residence
10	Water Puddle at AEI shop	26	Showalter residence
11	Union's Pond (upper)	27	Gilbertson residence
12	Sterling Elementary School	28	Jensen residence
13	Franzman residence	29	Parrish residence
14	Truck 4	30	Ahlfors residence
15	General Effluent Lead Pond	31	Ellison residence
16	Pedersen residence	32	field or transport blank

To ensure usability of data across ground-water related programs, EPA recently proposed 22 minimum data elements to be noted during data collection (table 5; EPA, 1988). Subject to availability of time and funding, this list is suggested for use in Alaska by all agencies or programs that collect or require collection of ground-water data. However, in view of time and funding limitations, it is likely that data containing fewer than these 22 elements will sometimes be collected. To ensure preservation of data for possible use by others, the core group of 13 data elements in table 6 is suggested for use during collection of ground-water quality data in Alaska. The unifying theme of the core group is that all the elements can be readily determined by existing ground-water data collection programs in Alaska.

Table 5. Proposed minimum set of data elements to ensure usability of data across ground-water related programs (from EPA, 1988).

Latitude - The angular distance north or south from the Equator measured through 90 degrees. The length of a degree varies from 68.074 statute miles at the equator to 69.407 at the poles because of the flattened configuration of the Earth. A second is approximately 100 ft long.

Longitude - The angular distance, in degrees, due east or west from the prime meridian that runs from north to south pole and passes through Greenwich, England. The length of a degree varies from 69.65 statute miles at the Equator to zero at the poles. The length of a second is a little over 100 ft at the equator and about 78 ft at the 40-degree latitudinal parallel which passes through the approximate middle of the United States.

Method of measure for latitude/longitude - The method used to determine latitude/longitude such as surveyed or determined from USGS topographic maps.

Source agency for latitude/longitude data - The agency that reported the data.

State Federal Information Processing Standard Code (FIPS) - Established standard 2-digit number representing state where well or spring is located.

County Federal Information Processing Standard Code (FIPS) - An established standard 3-digit number of the county or county equivalent where well or spring is located.

Altitude - Altitude of land surface at the well or spring above or below mean sea level, in feet (National Geodetic Vertical Datum).

Well/spring and facility identification - A permanent, nonduplicatable identification to be developed for each well or spring that, where applicable, establishes a tie or linkage between the well or spring and the facility on which it is located.

Use of well - The principal use of a well or spring or purpose for which the well was constructed (the former always holds precedence over the latter)

Depth of well at completion - Elevation of completion depth of well above or below mean sea level, in feet (National Geodetic Vertical Datum).

Depth to top of open interval - Depth to point where opening begins, in feet below land surface.

Depth to bottom of open interval - Depth to the bottom of the open interval, in feet below land surface.

Location of well log - Physical location of the well log, such as agency name and address where the log is located.

Type of well log - Physical description of the rock cuttings of the different formations penetrated, such as the driller's log; or a continuous recording of the electrical, radioactive, acoustic, or other properties of the penetrated formations.

Source agency for sample data - The agency that reported the data.

Sample date - The date on which the sampling event occurred.

Sample identification - An identification to be developed to uniquely identify each sample take; it may include several factors, such as sampling purpose, field conditions, field protocol.

Parameter measured - The specific chemical for which an analysis is made.

Concentration/value - The numerical value (concentration or quantity) detected by the parameter test (in standard units).

Confidence factor - An element that can include field and laboratory quality assurance, and other factors that provide the degree of confidence the data source has in the value reported.

Depth to water - Water level at well or spring, in feet, below land surface.

Measurement quantification - A method of quantification of a parameter (lab or field methodology).

Table 6. Suggested core group of data elements for ground-water quality data collection in Alaska.

Data element	Description
Sample Source	The source of water at the point of capture (a well, a spring, or surface water, or some mixture of the three) must be known.
Location	Location of the source should be determined to at least the nearest second-order aliquot portion of a section (40 acres), and to at least the nearest 10 seconds of latitude and longitude. If possible, locations should be determined to at least the nearest fourth-order aliquot portion of a section (2.5 acres) and to at least the nearest second of latitude and longitude, and the legal description of the property on which the water source is located should be determined. Sketch maps or narrative descriptions relative to local landmarks can be included.
Method of locating	The methods used to determine location should be documented. Indicate whether surveyed, or source and scale of map(s).
Owner of well	The owner of the land on which the well is drilled, with any well identifier in common use.
Use of well	The principal use of a well or spring or the purpose for which the well was constructed (the former always holds precedence over the latter).
Source of sample data	The agency or responsible party for data collection, including sample collector's name.
Sample date and time	Date and time of sampling.
Parameter measured	A physical or chemical characteristic for which a determination is made.
Analytical method	Method by which a parameter is measured, including field filtering, treating, or storing and preserving methods.
Field data	Methods used to obtain, filter, treat, store, and preserve samples.
Concentration or value	Numerical value determined by the parameter measurement, including units of measure.
Confidence factor	An element that can include field and laboratory quality assurance, and other factors that provide the degree of confidence the data source has in the value reported.
Sample identification number	Unique number assigned to each sample to link field, lab, and database information.

Minimum Standards for Entering Data into Existing Databases

Currently, data entered into WELTS, LAS, NWIS, and STORET are required to meet certain minimum standards. The least restrictive of these is WELTS. Virtually any record relating to ground-water data may be assigned a WELTS index number and entered. Data sites are assigned a status indicator (table 7) and manually filed in numerical order by WELTS number and status (except status 'S' logs, which are filed by the township-range-section method).

Table 7. WELTS status indicators for ground-water data.

Status	Meaning
S	Data have been Sent to USGS for entry and have returned
U	Data waiting to be sent to the USGS
G	Data have Gone to the USGS
H	Data Held at DGGS pending receipt of further well information
X	Data not suitable for USGS entry
P	Data temporarily held in a DGGS Project file
V	Data pertain to a Village and lack suitable location information for entry into GWSI

In order for data to be entered into the water-use data files of LAS, the water user must be identified, the amount of water and the time period during which it was used must be known, and the location of the source must be known to the nearest second-order aliquot part of a section (40 acres) and the nearest 10 seconds of latitude or longitude.

In order for data to be entered into the Daily Values, GWSI, or QWDATA files of NWIS, header information must first be input. Header information is linked by the computer to the GWSI, QWDATA, and Daily Values data files. Mandatory fields for inputting header information are listed in table 8. Although well locations are assigned fourth-order aliquot locations (2.5 acres), well locations must be known with confidence only to the nearest third-order aliquot portion of a section (10 acres) in order to be entered into the database. In order for automatically recorded water levels to be included in the Daily Values file, they must be accurate to within ±2% of actual levels as measured from ground surface. In order for data to be entered into the QWDATA file, data fields listed in table 9 must be known.

Table 8. List of mandatory fields required by the USGS for entering header information into NWIS.

Latitude	District code	Agency use
Longitude	Local number	Station type
Agency code	Site ID	Data reliability
State FIPS code	Use of site	Site type
County FIPS code	Use of water	

Table 9. List of mandatory fields required by the USGS for entering data into the QWDATA file.

Contributing agency or lab
Analytical method
Date of sampling
Parameter measured
Concentration or value
Method of obtaining, filtering, treating, storing and preserving the sample

In order for data to be put into STORET, knowledge of the location of the sampling station must be known to the nearest degree of latitude (one degree of latitude is about 70 miles) and longitude (one degree of longitude is about 34 miles at Anchorage). In addition, the reporting agency, hydrologic unit (obtainable from a USGS hydrologic unit map of Alaska), station type, date sampled, analytical method, parameter measured, and concentration or value of the parameter must be known.

INTEGRATION OF EXISTING GROUND-WATER DATABASES

Existing databases are operated by different agencies, generally with different objectives. It is unrealistic, therefore, to expect that a single all-purpose database will satisfy all applications. Rather, data may be collected, analyzed, and stored using standard techniques which will allow sharing of data among agencies, either through printout, floppy diskette, modem and telephone, or hardwire connection.

One of the best methods of identifying and retrieving data is to use a standard geographic coordinate system such as latitude-longitude, state plane, or universal transverse Mercator. Using a current list of all available ground-water databases, an investigator should be able to retrieve all data for any region of interest. A second method of identifying and retrieving data is by unique well-site identifier. This method is more useful in some instances because common sites of data collection (water use, well log, and water quality, for example) can be easily identified, and closely spaced wells can be easily distinguished.

Unfortunately, no single type of site identifier is currently in universal use in Alaska. The two most common types of site identifiers in Alaska are the WELTS index number (about 17,900 sites) and the NWIS site ID (about 16,700 sites). About 11,000 to 12,000 sites have both WELTS and NWIS site identifiers. Substantial numbers of monitoring wells, public water system supply wells, and single-family water-supply wells have neither type of site identifier. Because the location information described in table 6 has not been determined for several thousand WELTS data sites, the NWIS site ID is suggested for use as the primary interagency site identifier in Alaska. The primary drawback associated with use of the NWIS site ID is that assignment of site ID's is a relatively laborious process, considering the potential volume of statewide data that could be presented for site ID assignment. As a practical matter, however, assignment of site ID's can proceed with relative speed in selected areas of the state where the importance of relating different databases to one another is high.

Development of a Ground-water Quality Data System

The two major functions associated with developing an interagency ground-water database are software development (programming) and data input and verification. Both STORET and the QWDATA file of the NWIS contain in excess of 3,300 parameter fields for nearly every conceivable piece of information related to water-quality data. In addition, GWSI contains about 400 parameter fields for site location and use, well construction and development, hydrogeologic, and aquifer test information. The QWDATA and GWSI systems are both modified frequently in order to keep pace with user requirements. Construction of similar databases using commercially available software would likely require at least several years of intense work with minimal probabilities for achieving an improved product. For this reason, existing federal software is suggested for use as the primary repository for ground-water data in Alaska.

Database Software

The QWDATA file of the NWIS is suggested for use as the primary ground-water quality database in Alaska. This system is considered superior to the STORET system for most applications for the following reasons:

1. The QWDATA file is closely tied to the GWSI system, whereas the STORET system does not adequately handle well and aquifer data. Creation of a database similar to EPA's monitoring well and aquifer characteristics database for use in conjunction with STORET appears to be an unnecessary duplication of GWSI.
2. The QWDATA file currently contains more up-to-date information about USGS data collection sites than does STORET. Existing data in STORET reported to be from the USGS are of questionable completeness and accuracy.
3. The QWDATA file is managed by experienced Alaska database managers using established procedures. The STORET system is not widely used in Alaska.
4. The source agency for data entered in the QWDATA file can be designated, as in the STORET system.
5. The USGS in Anchorage is contacted routinely by data users in Alaska; this indicates the long-term efficiency of using the USGS program for a comprehensive data repository.
6. The USGS maintains an existing location-based manual filing system for ground-water quality records. Use of the STORET system would require creation of a new filing system.
7. The USGS can enter into cooperative programs with any state or local agency, adding federal resources to matching state or local funding and thereby increasing the total size of the data processing effort.
8. The USGS currently has cooperative agreements with numerous agencies that use surface-water data, thus providing a complementary environment for a ground-water database.

9. STORET would be automatically updated with ground-water data from Alaska through the efforts of the USGS and EPA headquarters offices, making the data available to PCSTORET and STORET users.

10. NWIS is currently accessible via modem and telephone throughout most of Alaska, and further decentralization to local microcomputer work stations is anticipated. Eventually, data entry could take place in the office generating the original data.

11. NWIS currently uses a menu-driven data entry and retrieval system, greatly reducing the training time required to effectively use the database.

In cases where quality of data collected by agencies or private firms may not be up to NWIS standards (for example, where accurate well location or sample treatment information may not be known), four options would be available:

1. Use the STORET system.

2. Create a separate 'cooperator's file' within the USGS system. This file would be established with all normal QWDATA parameter fields but would not be updated to the regular QWDATA database.

3. Use the QWDATA file for data entry but permanently flag the data with an 'estimated' designation, denoting the absence of some key piece of information, which could be identified by researching the manual files.

4. Using commercially available software:

   (a) upload data to items 1, 2, or 3 listed above; or
   (b) establish a statewide list of viable ground-water quality databases to direct potential users to database managers.

If data exist for which neither NWIS nor STORET is suitable, yet preservation of information is desirable, databases using commonly available software should be constructed, with at least the minimum data elements listed in table 6. Existing databases deficient in parameter fields for one or more of the data elements listed in table 6 should be revised to include these elements, or all ground-water quality data should be transferred to some other database.

Data Verification and Input

The major impediment to implementation of a ground-water quality database is that personnel are not currently available to assemble, verify, or computerize ground-water quality data. Major cost categories are: (1) copying, transferring, unfiling and refiling paper records; (2) coordinating interagency efforts; (3) training data entry staff; (4) verifying key components of data that reside separately from the main analytical report; and (5) actual data entry time. Verifying key components of data includes obtaining and evaluating field notes, laboratory methods, and quality assurance procedures (for each lab providing data), and determining latitudes and longitudes of data collection sites. This data entry task is probably the most costly of all. Because the USGS is principally responsible for the integrity of its database, and USGS data entry personnel follow an extensive set of data entry procedures, it is suggested that data entry tasks be performed by a relatively small number of specialists who are responsible to all projects and programs.

Priorities would be established through the funding process. Initially, existing historic or new data would likely be photocopied and sent to USGS offices for entry into NWIS. Eventually, data entry should occur where data are collected by using PC-compatible versions of NWIS data-entry software or commercially available software with NWIS-compatible parameter fields for machine transfer. This would be contingent on data collectors using standard data entry techniques. Such a system would make effective use of a relatively small number of data management individuals, promote statewide consistency, have a low impact on ongoing project or program activities, and allow project or program managers to have primary control and responsibility for the content of databases.

In order to fully utilize NWIS as a comprehensive database, methods for transferring and verifying data from existing computer databases are required. Logically, this should be accomplished using automated data transferral techniques. This may be impossible, however, because of the diversity of existing databases, the absence of key information in existing databases (see tables 6 and 8), and the requirement for maintaining a system of unique site identifiers in NWIS. Each agency or program with a computer database is encouraged to place a high priority on transferring data to NWIS and confirming the continuing reliability of NWIS data. In order to accomplish this, agency or program staff would be required to expand their databases to include data fields listed in tables 6 and 8 and to exercise appropriate verification of the data or send paper copies of data to DGGS or USGS.

Input of data to NWIS can be facilitated in Alaska by requiring submittal of a data diskette in a format suitable for NWIS entry as a deliverable for every significant government contract or enforcement action which involves ground-water work. This would place primary responsibility for data entry costs with responsible parties and reduce substantial agency costs for data entry. Costs incurred by the private sector to comply with such a clause may be negligible since some contractors already use computer data management systems. The major benefits from such a system would be a uniform industry-wide method of reporting ground-water quality data and overall efficiency from privatization of the data entry function. Private firms may choose to enter into contractual agreements with DGGS or USGS to provide data entry services.

The State of Washington has selected WATSTORE and STORET for use as a centralized database and has decentralized data input functions to local governments. The local governments use menu-driven software developed by private companies on personal computers to enter data similar to that listed in tables 6 and 8. The data were intended to be uploaded electronically onto the USGS database, but concerns over data quality have prevented this and caused a re-evaluation of where these data should ultimately reside (M. Blair, Washington Dept. of Ecology, Seattle, WA, oral commun., 1988). If Alaska pursues decentralized data entry and a centralized data repository, safeguards to ensure data quality will need to be established to avoid the type of dilemma facing Washington.

Quality Assurance and Quality Control

A key feature of the system described in this report is that all sites where ground-water data are collected would have unique identifiers assigned or verified by USGS. Additionally, USGS would be responsible for assigning or verifying latitude and longitude of sites and checking for duplicate sites. Centralization of the verification function is essential to ensure data quality. To facilitate centralization, information must be efficiently routed between field offices and the USGS. Methods similar to those currently used by DGGS and USGS to transfer well logs could be used. Electronic transfer of information (FAX machine or computer files) may be advantageous in the future. No matter what data entry scheme is used, verification of information contained in the database should be performed by both a database manager and a project or program manager.

As previously noted, PWS data are difficult to use, because locations of water sources are not adequately described. A way to improve this situation is to encourage all PWS owners to file for water rights through education, application assistance, or increased enforcement of Alaska Statute 46.15.180--which states that users of significant quantities of water (greater than 500 gallons per day) must obtain a water use permit or be guilty of a class A misdemeanor. Data from water-use permit applications would enter DNR's existing water data management system. Well-log data could be given priority for entry into GWSI, and DEC's water-quality data could be entered into the QWDATA file.

Any scheme for standardizing data management will require enhanced data reporting by public and private laboratories. Lab reports should list specific analytical methods, NWIS/STORET parameter codes, selected field data, and quality assurance and quality control information from the sampling program.

Cost-effectiveness

Although a rigorous analysis of the cost-effectiveness of implementing this plan is beyond the scope of this report, pertinent key concepts can be reviewed here.

First, the cost of comprehensively managing data is a small percentage of the cost of data collection. The cost of data collection for most projects can be divided into six components: (1) developing a quality assurance project plan; (2) drilling wells; (3) collecting samples; (4) analyzing water samples and blanks; (5) evaluating and interpreting data; and (6) comprehensively documenting and computerizing data. The latter component is usually performed to some degree for all projects and performed almost completely for some projects for regulatory and efficiency reasons. Considering potential statewide implementation, the supplemental cost of using NWIS to manage data is probably only a few percent of the total data acquisition cost.

Second, a comprehensive data management system will be useful for an indefinite period of time. Because ground-water quality problems can persist for centuries, review and evaluation of all extant data can be expected to occur repeatedly in some areas. Use of a data management system for this purpose is likely to result in significant long-term economic gains.

Third, a comprehensive data management system can reduce total data collection costs by helping to eliminate wasteful, duplicative, or inadequate data collection. Public acceptance of regulatory decisions at sites of ground-water contamination is dependent on public confidence in data gathering and interpretation methods. The quality assurance principles inherent in NWIS data-entry procedures may serve to verify that data are collected that all parties can trust. This can lead to faster and more efficient recognition and resolution of problems than would otherwise occur.

Data Dissemination

The NWIS database is intended to be the primary repository of high-quality water data. Although data can be accessed on a real-time basis by anyone with the necessary communications link to the Prime computer in Anchorage, most user needs are probably best served by data retrievals on printouts, floppy diskettes, or magnetic tapes. Data on diskettes or tapes would be in standard ASCII flat files with field length and type listings for easy loading onto a data user's computer. Initially, users could provide their own data manipulation software (such as SAS, SPSS, or Autocad) or retrieve data with NWIS software via modem or at the USGS Anchorage Office. The USGS will provide customized data retrieval for a nominal fee. NWIS retrieval software is expected to be available eventually for use on personal computers. Steps should be taken to make this software available to database users in Alaska.

Demonstration Projects

A small-scale demonstration project was conducted to test the viability of the NWIS system for storing data collected by the state. At the Usibelli Coal Mine near Healy, Alaska, DGGS collected water from 4 wells during 1988. Water analyses were performed at the DGGS laboratory in Fairbanks. Well logs were entered into GWSI, and the water-quality data entered in the QWDATA file. A sample printout of the data is shown as table 10; other printout formats are possible. The most time-consuming data-entry task was the identification of specific laboratory methodologies used for each analysis. This identification was required for assignment of proper parameter codes, which, in turn, allow users of the data to understand how the data were obtained. NWIS was found to perform satisfactorily for the small-scale demonstration project.

The next suggested step for evaluating NWIS is a large-scale demonstration project, to be divided into five phases:

Phase I Establish a QW unit under USGS direction to verify and enter ground-water quality data.

Phase II Select a geographic project area and assemble, review, and evaluate available historic data for entry into NWIS. Forward to the QW unit data that meet minimum criteria for completeness and reliability (tables 6 and 8).

Phase III Develop comprehensive guidelines that determine the suitability of data for entry into NWIS. Portions of the guidelines will be unique to each laboratory supplying data.

Phase IV Establish standard information collection and routing procedures for new data that becomes available in the project area, so that these data may be computerized or additional information can be collected to allow computerization.

Phase V Using a relatively complete suite of water-quality and well-log data for an area, produce graphs, charts, maps, or cross sections for use by environmental decision makers. Close cooperation with decision makers is required at the onset of the demonstration project to ensure development of useful products. Phase V could entail the use of commercially available software (such as SAS, Autocad, or SPSS) or application of existing NWIS data-retrieval software, or both.

SUMMARY AND CONCLUSIONS

A review of current ground-water data management in Alaska reveals the absence of a systematic, statewide, interagency method of dealing with ground-water quality data. The absence of such a system results in lost data, incompletely collected data, and inefficient and inadequate technical analyses for environmental decision-making. In light of the characteristically long duration of public interest in areas with ground-water quality problems, implementation of a comprehensive system for long-term preservation of and access to ground-water quality information is justified.

The development of a ground-water quality database system consists of two primary components: determining data storage locations and techniques, and determining data retrieval and dissemination techniques. Statewide data storage has traditionally been a centralized function, using a large computer, and has resulted in cumbersome methodologies for data retrieval. Conversely, data storage and retrieval on a project-by-project basis in recent years has been rapid, flexible, and responsive to local needs; but this decentralization has also prevented easy and thorough access to data by new or different users. Current advancements in decentralizing key functions of the NWIS databases promise to maintain the quality, thoroughness, and breadth of a central repository while providing quickness, flexibility, and responsiveness for local applications.

No matter what database is used, costs will be incurred for equipment, for training data-entry and supervisory personnel, for copying, verifying, and inputting data, and for developing data retrieval and dissemination techniques and procedures. Because of its extensive development and its widespread use in Alaska for well-log and surface-water data, the NWIS system is probably the lowest-cost alternative for use as a ground-water quality database.

The NWIS system, as it is envisioned to function two or three years hence, is expected to meet the 11 system design criteria listed on p. 8 more readily than systems relying on STORET or commercially available software packages. For situations in which other databases are used, the suggested core group of data elements in table 6 should be entered, and data from these databases may subsequently be transferred to the NWIS system.

Implementation of this plan will require interagency cooperation to distribute costs, responsibilities and benefits appropriately, and to promote industry-wide standards for data collection techniques, documentation, and storage. Periodic revision of the plan may be necessary as data management experience is gained.

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Table 10. Sample printout of ground-water quality data retrieval from NWIS demonstration project at Usibelli Coal Mine, Healy, Alaska, 1988.

GROUND-WATER QUALITY DATA

USIBELLI MINE AREA

STATION NUMBER	LOCAL IDENT-I-FIER	DATE	TIME	AGENCY COL-LECTING SAMPLE (CODE NUMBER) (00027)	AGENCY ANA-LYZING SAMPLE (CODE NUMBER) (00028)	TEMPER-ATURE WATER (DEG C) (00010)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH (STAND-ARD UNITS) (00400)
635351148552702	FC01200704DCDA3 002	07-20-88	1805	1/ 9702	9702	4.0	3320	6.70
635427148544201	FC01200703BBDC1 001	05-24-88	1650	9702	9702	2.5	1560	6.40
		07-18-88	1450	9702	9702	4.0	1540	6.70
		09-07-88	1415	9702	9702	1.5	1640	6.00
635427148553401	FC01200704ABDD1 003	05-25-88	1000	9702	9702	1.0	415	6.70
		07-18-88	1700	9702	9702	2.0	504	7.00
		09-07-88	1650	9702	9702	2.0	445	6.40
635419148565701	FC01200705ADAD1 001	05-25-88	1710	9702	9702	5.0	4010	6.30
		07-19-88	1200	9702	9702	3.5	7840	6.20
		09-08-88	1000	9702	9702	2.5	6900	6.40

STATION NUMBER	DATE	ALKA-LINITY WAT WH TOT IT FIELD MG/L AS CACO3 (00419)	ACIDITY (MG/L AS CACO3) (00435)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)
635351148552702	07-20-88	1720	71	360	52	57	660	15	76	64
635427148544201	05-24-88	352	67	310	65	36	160	4	52	19
	07-18-88	356	147	220	56	19	190	6	64	20
	09-07-88	380	278	210	46	22	190	6	63	28
635427148553401	05-25-88	188	32	130	36	9.1	5.6	0.2	6	45
	07-18-88	232	56	160	43	13	8.6	0.3	8	48
	09-07-88	205	83	120	31	9.5	6.7	0.3	7	56
635419148565701	05-25-88	478	129	1000	190	130	790	11	62	10
	07-19-88	666	224	1500	280	190	890	10	56	16
	09-08-88	650	302	1000	250	90	960	14	67	11

STATION NUMBER	DATE	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BARIUM, DIS-SOLVED (UG/L AS BA) (01005)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE) (01010)	BORON, DIS-SOLVED (UG/L AS B) (01020)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)
635351148552702	07-20-88	170	24	0.60	6.8	<4	240	<1000	<10	<1
635427148544201	05-24-88	250	85	0.60	9.0	<4	400	<1000	1700	<1
	07-18-88	240	72	0.80	5.3	4	400	<1000	1500	<1
	09-07-88	200	87	0.80	7.9	<4	240	<1000	2800	2
635427148553401	05-25-88	3.8	21	1.0	9.3	9	420	<1000	450	17
	07-18-88	3.8	22	1.4	11	<4	360	<1000	500	<1
	09-07-88	3.5	26	1.2	8.6	20	140	<1000	290	40
635419148565701	05-25-88	1600	62	4.4	10	10	1400	<1000	1500	<1
	07-19-88	1700	72	6.2	12	5	1100	<1000	1400	<1
	09-08-88	1700	63	6.1	10	10	1300	<1000	2900	5

1/ ALASKA

Table 10.--Continued

GROUND-WATER QUALITY DATA

USIBELLI MINE AREA--Continued

STATION NUMBER	DATE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COBALT, DIS-SOLVED (UG/L AS CO) (01035)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)	ALUM-INUM, DIS-SOLVED (UG/L AS AL) (01106)
635351148552702	07-20-88	2	20	<10	350	50	120	32	<20	300
635427148544201	05-24-88	4	30	130	47000	110	1200	26	210	300
	07-18-88	3	40	150	43000	110	1200	40	230	300
	09-07-88	3	40	<10	38000	110	1300	28	100	300
635427148553401	05-25-88	<1	8	10	13000	<30	660	12	<20	200
	07-18-88	<1	<1	20	12000	<30	780	17	<20	200
	09-07-88	<1	2	810	7700	<30	580	10	<20	200
635419148565701	05-25-88	4	410	130	58000	180	11000	140	300	300
	07-19-88	5	270	20	59000	170	7300	120	340	200
	09-08-88	1	340	<10	43000	210	8300	110	200	300

STATION NUMBER	DATE	ALKA-LINITY WAT.WH. GRAN T. FIELD CACO3 (MG/L) (29813)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER DAY) (70302)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	PHOS-PHORUS, DIS-SOLVED (MG/L AS PO4) (71888)	ELEV. OF LAND SURFACE DATUM (FT. ABOVE NGVD) (72000)	DEPTH OF WELL, TOTAL (FEET) (72008)
635351148552702	07-20-88	1700	1040	0.0	1.41	<0.20	5.4	1850	361.50
635427148544201	05-24-88	350	631	0.0	0.85	<0.20	<0.05	1300	33.00
	07-18-88	350	617	0.0	0.83	<0.20	<0.05	1300	33.00
	09-07-88	370	585	0.0	0.79	<0.20	<0.05	1300	33.00
635427148553401	05-25-88	190	133	0.0	0.18	0.06	<0.05	1350	28.80
	07-18-88	230	153	0.0	0.21	0.01	<0.05	1350	28.80
	09-07-88	200	145	0.0	0.19	<0.20	<0.05	1350	28.80
635419148565701	05-25-88	450	2790	0.0	3.77	<0.20	<0.05	1300	95.00
	07-19-88	640	3220	0.0	4.36	<0.20	<0.05	1300	95.00
	09-08-88	640	3080	0.0	4.17	<0.20	<0.05	1300	95.00