

STATISTICAL SUMMARY OF GROUNDWATER QUALITY DATA: 1986-1988
AND PROPOSED GROUNDWATER CLASSIFICATION
FOR THE MAJOR GROUNDWATER BASINS IN OKLAHOMA

Technical Report
90-1

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INTRODUCTION

Within Oklahoma, 23 major groundwater basins have been identified, with many more unidentified minor groundwater basins. Groundwater supplies approximately 60 percent of the total water used in Oklahoma for such purposes as irrigation, public water supply and industry. Increasing population and improving economic conditions in the state will further increase demands for good quality groundwater. Therefore, it is of vital interest to the state to protect the quality of groundwater.

Quality of 21 of the state's major groundwater basins has been monitored since 1983. Water quality samples have been collected and analyzed for 19 inorganic constituents. In 1986 a major reorganization of the groundwater quality monitoring network was undertaken.

Water quality standards are one method of protecting the existing quality of the state's groundwater resources. Surveys of other states' quality standards show that both numeric and narrative standards are used. When numeric standards have been adopted, states most frequently have selected federal primary and secondary drinking water standards (Tables 1 and 2).

In the 1986 standards, the Oklahoma Water Resources Board (Board) established numeric groundwater standards for 36 organic constituents. Numeric standards for inorganic constituents have not yet been established by the Board.

Previously, groundwater classification have been based on beneficial use of the groundwater within the individual basins, a cumbersome system, not well suited to all of Oklahoma's groundwater basins. A classification system should be flexible enough to be used for the protection of an aquifer, as well as in remediation of that aquifer. Such a system would incorporate data obtained from the groundwater quality monitoring network and apply to all groundwater basins within Oklahoma.

The 1983-1985 data were statistically compared to the 1986-1988 data. This report provides the results of this comparison and supplements the Oklahoma Water Resources Board's Technical Report 89-2 (Thomas and Glover, 1989) which contains the raw data for 1986-1988. This report also proposes a new groundwater

classification system for use in conjunction with the State's groundwater standards and in the permitting process.

GROUNDWATER QUALITY SAMPLING NETWORK

In 1983, the Board established a groundwater quality monitoring network for the major groundwater basins. The state's purpose of this network was to provide groundwater quality data for the major groundwater basins. However, this objective has expanded so that the network now provides statistically valid ambient groundwater quality data for inorganic constituents. These data will be used to assess the water quality of the basins and to assist in the development of numeric groundwater standards for Oklahoma.

In 1986, the network was evaluated for accuracy of well locations and completions in the designated aquifer. Wells on which driller's well logs were unavailable or those found to be completed in an aquifer other than the designated aquifer, were dropped from the network. In 1989, the network was re-evaluated for accuracy, and a vulnerability assessment was completed for each well.

TABLE 1. Federal Primary Drinking Water Standards
For Inorganic Constituents,
Maximum Contaminant Levels (MCLs)*

Constituents	MCL (mg/L)
Arsenic	0.05
Barium	5.00
Cadmium	0.01
Chromium (total)	0.05
Fluoride	4.00
Lead (at source)	0.05
Mercury	0.002
Nitrate (as N)	10.00
Nitrite (as N)	1.00
Nitrate + Nitrite	10.00
Selenium	0.01
Silver	0.05

* From USEPA, Office of Drinking Water, Drinking Water Regulations and Health Advisories.

The evaluations performed in 1986 and 1989 included modifications in sample collection procedures and quality control. Today all water samples are collected at the wellhead using appropriate sampling procedures (USEPA, 1985, Scalf, et al, 1981 and USEPA, 1977). A project quality assurance plan is under development.

The network consists of approximately 184 domestic, irrigation, stock and municipal water wells which are sampled annually during July and August. Depth, screened interval, construction, location and potential sources of contamination have been determined on each well. During the 1986 evaluation of the network, many of the wells' depths and screened intervals could not be documented, so such wells were dropped from the network.

TABLE 2. Federal Secondary Drinking Water Standards
For Inorganic Constituents,
Secondary Maximum Contaminant Levels (SMCLs)*

Constituent	SMCL (mg/L)
Aluminum	0.05
Chloride	250.00
Copper	1.00
Fluoride	2.00
Iron	0.30
Manganese	0.05
pH	6.5 - 8.5
Sulfate	250.00
Total Dissolved Solids (TDS)	500.00
Zinc	5.00

* From USEPA, Office of Drinking Water, Drinking Water Regulations and Health Advisories.

GROUNDWATER QUALITY DATA

As mentioned earlier, many of the wells were dropped from the network in early 1986 because it was impossible to determine well depth and screened interval. Therefore, the validity of the water quality data collected from those wells during that time became suspect.

In 1987, a review of the 1983-1985 water quality data was conducted by the Board (Gopal, 1987). This report determined that

due to inadequate well construction information, the data would provide only a general overview of the water quality for the state.

Because of the changes in some water well sites in the network, the 1983-1985 water quality data represent a distinct data population from the 1986-1988 water quality data. Although some of the 1983-1985 data were obtained from questionable aquifer sources, there was the possibility that the data were statistically useful.

The Wilcoxon Rank Sum Test For Two Independent Variables was conducted on the two data sets. This test statistic is a non-parametric test for data that may be non-normally distributed. The Wilcoxon rank sum test was used to determine if the two data sets were statistically of the same data population (Gilbert, 1987). If the two data sets could be demonstrated to be of the same population, then the 1983-1985 data could be used with a reasonable degree of confidence.

The Wilcoxon Rank Sum Test was performed on each constituent for each aquifer. The test compares the raw data for a constituent from the 1983-1985 data set against those of the 1986-1988 data set. The test statistic obtained is then compared to a standard value taken from a test statistic table (Gilbert, 1987). The test statistic demonstrated that many of the constituents for each aquifer were not of the same data population at a 95 percent level of confidence. This means that the 1983-1985 groundwater quality data could not be statistically confirmed as coming from the same aquifers as the data obtained after 1985.

The means, medians, standard deviations, ranges and frequency distribution of the constituents for each data set were also analyzed as a further check on the compatibility of the data sets. It was determined for the purpose of setting groundwater standards or drawing conclusions about the ambient quality of a specific aquifer, that the 1983-1985 data should not be utilized. However, it should be kept in mind that the 1983-1985 data still are useful, particularly for evaluation of water quality complaints within a groundwater basin.

The groundwater quality data obtained from 1986-1988 are the only data that were considered in the comparison to the drinking water or groundwater standards for the state. Three years of data are not considered adequate for drawing definitive conclusions regarding the quality of a particular aquifer. Also, seasonal

variability of groundwater quality has not yet been evaluated to determine if significant variations exist from season to season.

Drinking water standards, as established by the Environmental Protection Agency (USEPA) and adopted by the Oklahoma State Department of Health, are numeric standards established for potable water delivered to the consumer. Therefore, these standards may not be representative of the water quality within the aquifer. Prior to 1988 water samples from public water supply systems were rarely collected at the wellhead, but rather from the distribution system, so they may represent a composite sample of multiple wells.

Summaries of the 1986-1988 groundwater quality data collected from the Board's monitoring network and locations of individual sampling sites (Figures 1 and 2) are located in Appendix A. The summary table for each of the major groundwater basins monitored by the network contains the number of samples, mean, median, standard deviation, range of sample results, 96 percent confidence interval and the drinking water standard for the appropriate constituents.

In many of the aquifers, some of the constituents could not be detected in the water samples collected and submitted for analysis. In the summary tables, the constituents that could not be detected were assigned the detection limit value for the mean, median, range and confidence interval.

The 96 percent confidence interval means that, based on random variations of the water quality at a particular well, there is a 96 percent probability that a constituent will be within the confidence interval (Sanders, et al., 1987, Gilbert, 1987 and Spiegel, 1961). The 96 percent confidence interval was chosen primarily because statistic tables did not contain values for a 95.5 percent (two standard deviations) confidence interval about the mean. Further, the 96 percent confidence interval is sufficiently broad to incorporate much of the normal variability of the constituents, but not so broad as to prevent detection of significant outliers.

Comparing the upper 96 percent confidence limit to the drinking water standards illustrates the differences between the two values. For some constituents, such as zinc, the confidence limits are as much as several orders of magnitude lower than the drinking water standard. For other constituents, such as total dissolved solids, the confidence limits exceed the drinking water

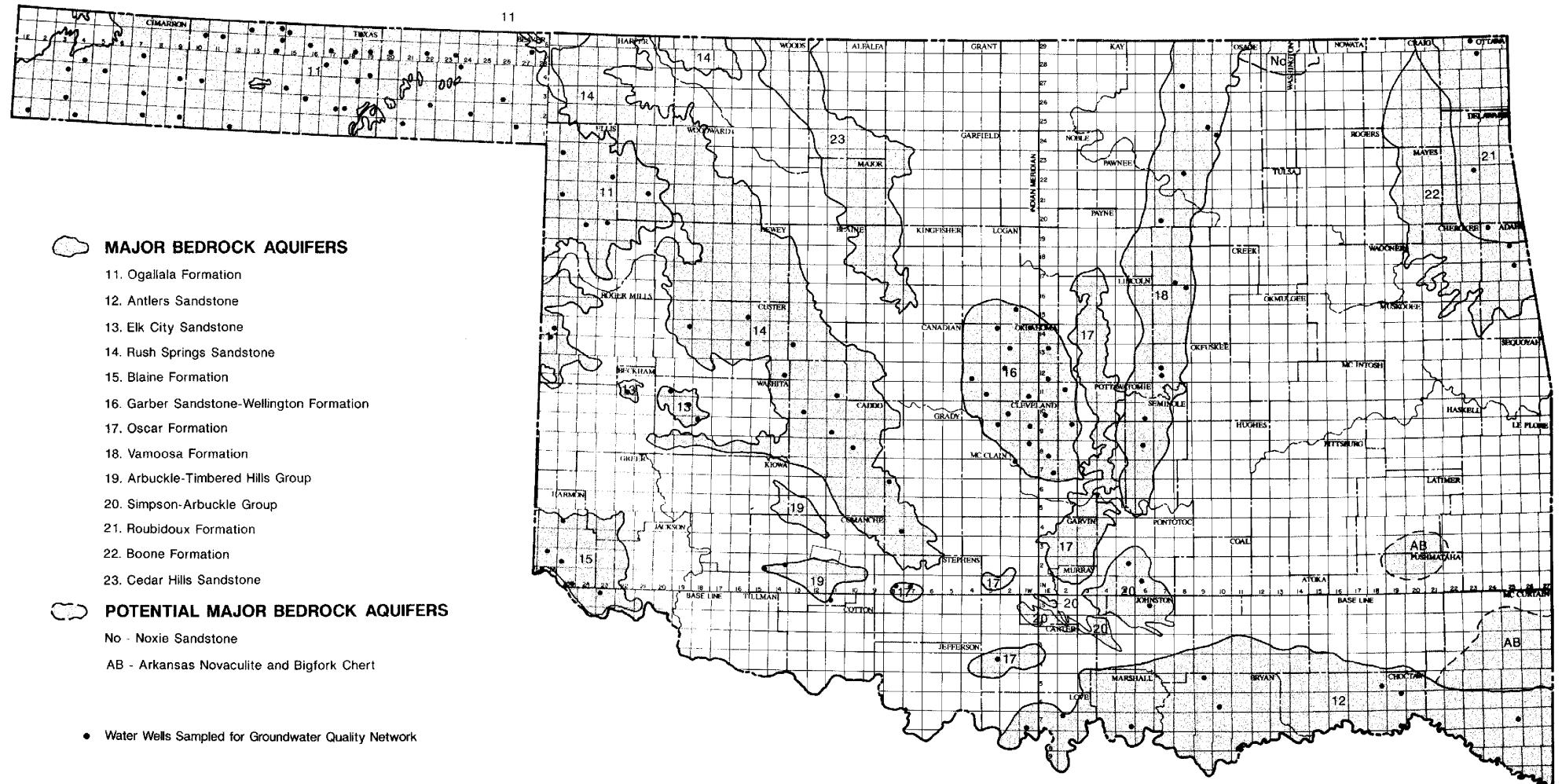


Figure 1. Annual Groundwater Quality Sampling Network, Bedrock Aquifers 1986 - 1988

Map Drawn By
OKLAHOMA WATER RESOURCES BOARD

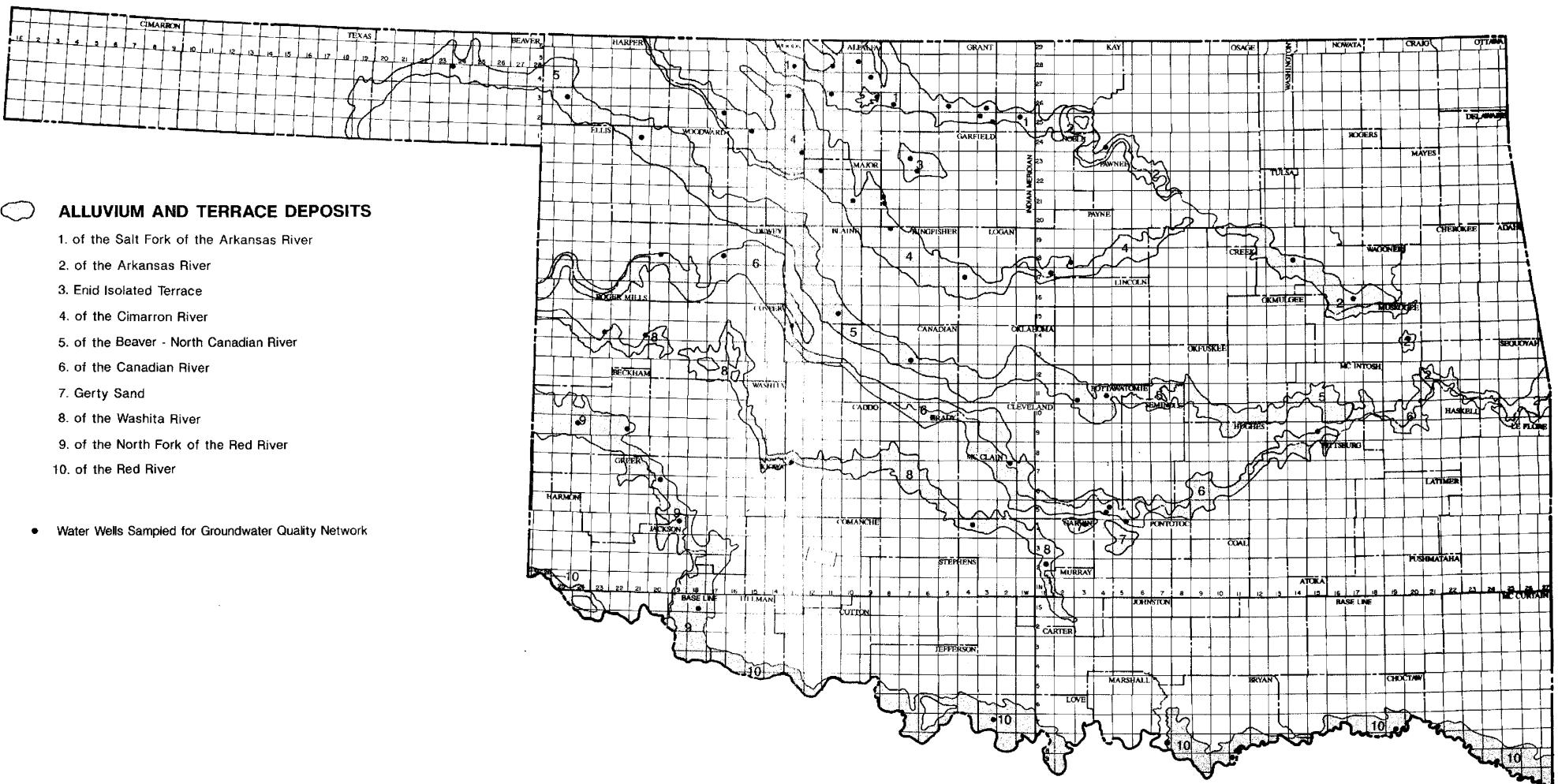


Figure 2. Annual Groundwater Quality Sampling Network, Alluvium and Terrace Aquifers 1986 - 1988

standard (Appendix A). The concentrations of the constituents are also quite variable among the groundwater basins.

In the development of inorganic groundwater standards, the considerable variability of the constituents must be taken into account. Inorganic groundwater standards should, therefore, be aquifer-specific. Seasonal variability must also be evaluated prior to development of standards. The monitoring network should be further expanded to provide a more representative sampling of the different groundwater basins. Approximately 100 water wells will be added to the network in 1990 to assist in accomplishing better coverage of the basins. Also, stratified random sampling will be considered for some of the groundwater basins with large geographic extent to better reflect possibly significant water quality variations within the basin.

GROUNDWATER CLASSIFICATION IN OKLAHOMA

Classification of groundwaters consists of the systematic grouping of water and/or host earth materials in which the water occurs into classes based on common properties. Classification may be initiated for the purpose of clarifying the variety of conditions under which groundwater exists in nature, or for the more formal purpose of determining to which waters specific standards and regulations apply (Flemel, 1986). A classification system also focuses limited resources on the protection and restoration of vulnerable aquifers, provides a basis for coordinating groundwater management activities at different levels of government and guides the development of groundwater standards, groundwater management, source controls and remedial actions (USGS, 1986).

The hydrogeology and land uses of groundwater basins vary considerably in Oklahoma. Classification provides the ability to manage and protect the resource according to existing and expected uses.

Classification according to specific hydrogeologic characteristics would be difficult due to the extreme variability of aquifer characteristics, even within individual groundwater basins.

PROPOSED GROUNDWATER CLASSIFICATION SYSTEM

The primary goal is to provide an effective classification system which is both protective of the basin or subbasin and reactive to contamination. The classification system should permit maximum utilization of the resource, but still provide adequate protection. Above all, the system should be a practical tool to effectively manage the resource for multiple uses and to assure environmental goals are achieved. The proposed classification system (a modified version of the USEPA system) described below should accomplish these tasks (Figure 3).

The USEPA has been advocating a three-tiered classification of groundwaters based on their respective value and vulnerability to contamination. At present, USEPA recommends only use of this or similar classification systems. However, in the future, USEPA may begin requiring states to use a more formal classification system in programs requiring federal/state coordination.

Special Resource Groundwaters - Class I

Special resource groundwaters are those of unusually high value. These groundwaters are of exceptional quality, are ecologically or environmentally important or are necessary to maintain an outstanding resource. Examples of types of groundwater which could be considered Special Resource Groundwaters are:

1. Boiling Springs State Park;
2. City of Ada Public Water Supply (recharge to spring);
3. Chickasaw National Recreation Area (recharge to springs);
4. Sole Source Aquifers (future state-defined).

EPA's criteria on special groundwaters include those which are "ecologically vital" and "irreplaceable" sources of drinking water (USEPA, 1986). "Ecologically vital" is defined as "groundwater supplying a sensitive ecological system that supports a unique habitat." "An irreplaceable" source of drinking water is defined as "serving a substantial population, and if delivery of comparable quality and quantity of water from alternative sources in the area would be economically infeasible or precluded by institutional constraint." In addition to these two criteria for designation of special resource groundwaters, the Board could also consider future state-defined sole source groundwater basins or subbasins.

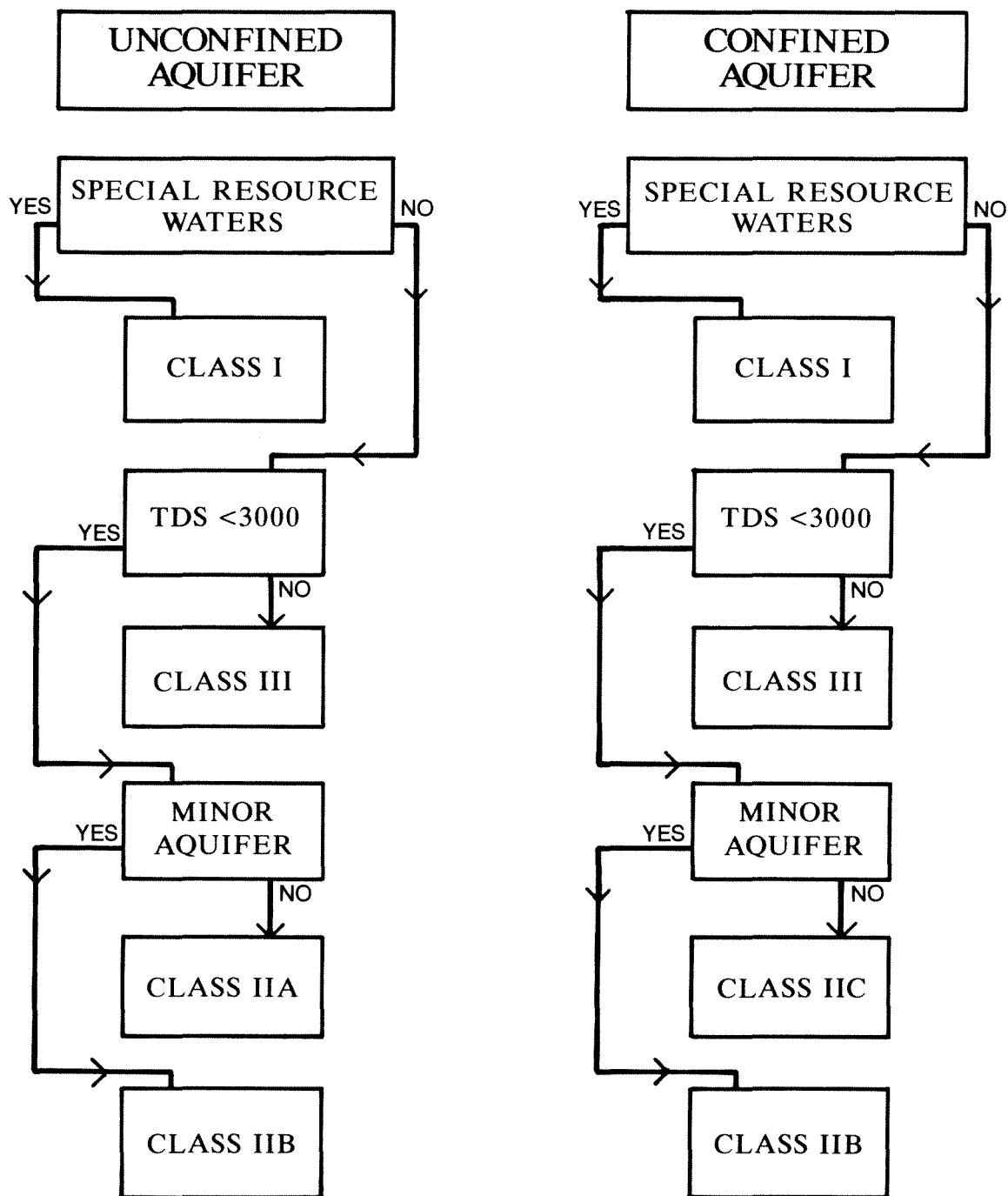


Figure 3. Proposed groundwater classification system for Oklahoma.

General Resource Groundwaters - Class II

General resource groundwaters are those capable of being used as a drinking water supply with conventional treatment methods, as well as having the potential for being used for agricultural, industrial, recreational and other beneficial uses. These groundwaters have a mean total dissolved solids (TDS) concentration of less than 3,000 mg/L. This class of groundwater is further divided into subclasses as follows:

- II(A) This subclass includes all major, unconfined groundwater basins or subbasins with a TDS concentration of less than 3,000 mg/L.
- II(B) This subclass includes all minor, confined or unconfined, groundwater basins or subbasins with a TDS concentration of less than 3,000 mg/L.
- II(C) This subclass includes all major, confined groundwater basins or subbasins with a TDS concentration of 3,000 mg/L.

General resource groundwaters are, at a minimum, those groundwaters which are being put to beneficial use by reason of having suitable quality, local demand and a TDS of less than 3,000 mg/L. This concentration was selected as a division between general resource and limited use groundwaters because an aquifer with a TDS of 3,000 mg/L or greater would partially meet the requirements needed to apply for an aquifer exemption under the rules and regulations of the underground injection control program for Class V injection wells. Also, in Oklahoma, groundwater with a TDS exceeding the recommended concentration is generally not used as a drinking water supply.

Limited Use Groundwaters - Class III

Limited use groundwaters are those which have naturally poor quality and would require extensive treatment for drinking water purposes. These waters have a mean TDS concentration of greater than or equal to 3,000 mg/L.

There are groundwater basins or subbasins where current water quality is naturally poor and is generally unacceptable as a drinking water supply. These groundwaters are of poor quality due to naturally occurring geologic and hydrologic processes in the

area. Limited use groundwaters have the potential for being put to use as a source of drinking water, so they must be protected for that eventuality.

General resource groundwaters could eventually become degraded due to leakage or migration of naturally occurring contaminants from a limited use aquifer. It is uncertain whether groundwaters which have lost their ability to serve as a general resource should be considered for limited use. Many of the groundwater subbasins that have become degraded have done so as a result of man's activities. From a technical point of view, prior use as a general resource groundwater implies that there are no natural impediments to use, and therefore, human remedial actions or natural recovery processes may eventually return such contaminated groundwaters to a usable condition. From a political or economic point of view, many of the general use aquifers that become contaminated by man's activities are seldom completely restored. Consideration must be given, therefore, to designating these subbasins as limited use groundwaters.

Vulnerability Categories Within Classes

Vulnerability mapping for the state will be an integral part of the groundwater classification system. An aquifer vulnerability index could be used for mapping to delineate the different sensitivities within each basin and integrated with the three classes of groundwater. The aquifer vulnerability index will be designed to meet the needs of the state. A vulnerability index would include information on depth to water, soil media, existing land use and other elements deemed necessary for a comprehensive vulnerability assessment of the state's groundwater resources. The vulnerability mapping could be divided into a minimum of three ranges corresponding to slightly sensitive (ss), moderately sensitive (ms) and very sensitive (vs). The vulnerability range will be combined with the aquifer class (Figure 4) resulting in a complete aquifer classification, such as Class II(A)(vs) for a general resource groundwater that is a major, unconfined aquifer with a TDS less than 3,000 mg/L and is potentially very sensitive to contamination.

SUMMARY

The groundwater quality data obtained from the groundwater monitoring network from 1983 - 1985 were determined to be

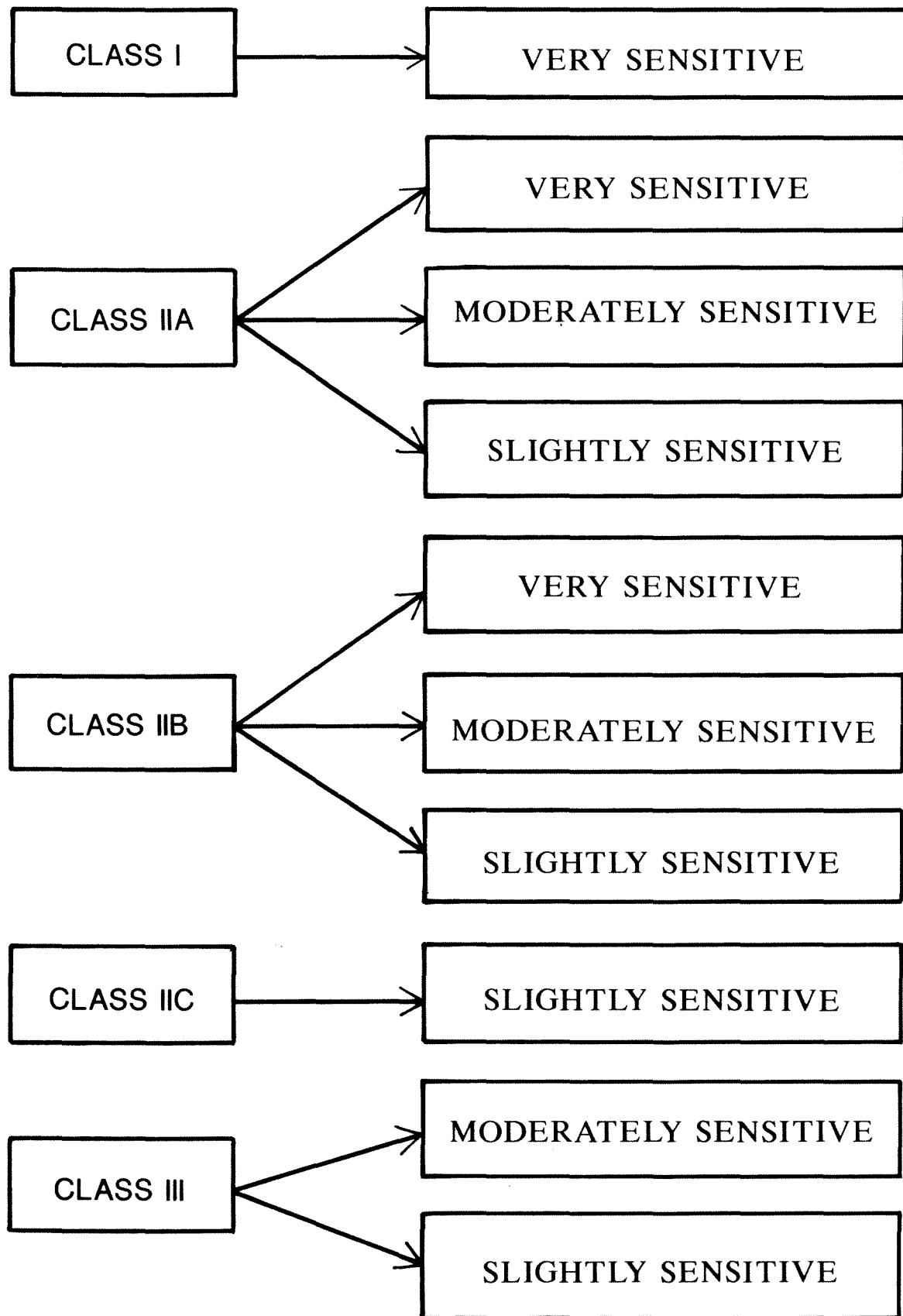


Figure 4. Proposed groundwater classification system in conjunction with vulnerability designations.

statistically invalid for use in the development of groundwater standards or determining ambient groundwater quality for the major groundwater basins. The three years (1986-1988) of groundwater quality data now provide a statistically valid data base for evaluation of groundwater basins. Three years of data, however are not considered adequate to arrive at a statistically valid trend analysis of the data.

The majority of the inorganic constituents in major groundwater basins have significantly higher or lower concentrations than those given for the primary and secondary drinking water standards. Therefore, when evaluating the condition of an aquifer, the ambient water quality (the 96 percent confidence interval) should be the criterion used rather than in conjunction with drinking water standards. Potential anthropogenic sources of contamination have been avoided as much as possible in the development of the monitoring network. Numeric standards, based on ambient water quality, will protect groundwater by the detection and remediation of anthropogenic contamination.

Numeric standards for the inorganic constituents may be established upon better understanding of the seasonal variability of these constituents and when a more comprehensive monitoring network is in place. Numeric goals for the groundwater basins are recommended until adequate data is obtained.

A comprehensive classification system can be an effective tool for optimizing groundwater protection efforts. Such a groundwater classification system would permit the development of a differential protection strategy for each aquifer class. The protection strategy could include water quality standards, permitting and enforcement activities designed specifically for the different groundwater classes.

The classification system has the advantage of equal applicability to major, as well as minor, groundwater basins within the state. A uniform classification system is most desirable to effectively protect and manage the State's groundwater resources.

Numeric, narrative or technology based standards could be applied according to groundwater class. Also, waste discharge permits would be able to take into consideration the sensitivity and use of the particular groundwater basin or subbasin. Enforcement and remediation activities should also benefit from the groundwater classification by allowing the state to direct its limited resources toward the more sensitive basins or subbasins.

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APPENDIX A

**Summary of Groundwater Quality Data
for Major Groundwater Basins
in Oklahoma: 1986-1988**

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE SALT FORK OF THE ARKANSAS RIVER A & T DEPOSITS,
PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	31	551.16	451.00	346.90	91.00-1248.00	91.00 - 1262.30	500.00
ALKALINITY MG/L	32	250.17	279.50	130.38	< 7.50- 424.00	7.50 - 517.45	
ARSENIC UG/L	29	2.76	2.50	1.39	< 5.00- 10.00	5.00 - 5.61	50.00
BARIUM UG/L	32	149.56	143.50	90.61	20.00- 301.00	20.00 - 335.31	1000.00
CADMIUM UG/L	32	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	30	72.37	72.00	36.71	9.00- 156.00	9.00 - 147.62	
CHLORIDE MG/L	31	44.73	29.00	45.80	< 5.00- 219.00	5.00 - 138.61	250.00
CHROMIUM UG/L	32	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	31	6.15	2.50	9.95	< 5.00- 41.00	5.00 - 26.54	1000.00
FLUORIDE MG/L	32	0.34	0.31	0.14	0.11- 0.62	0.05 - 0.63	4.00
IRON UG/L	30	154.47	101.50	130.49	20.00- 462.00	20.00 - 421.97	300.00
LEAD UG/L	32	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	31	30.87	24.00	23.13	3.00- 81.00	3.00 - 78.28	
MANGANESE UG/L	28	28.36	11.00	35.23	< 5.00- 128.00	5.00 - 100.59	50.00
NITRATE MG/L	30	4.51	1.85	4.55	< 0.25- 16.10	0.25 - 13.84	10.00
SELENIUM UG/L	31	2.90	1.25	3.18	< 2.50- 10.00	2.50 - 9.43	10.00
SODIUM MG/L	30	46.00	44.00	34.11	< 5.00- 119.00	5.00 - 115.93	
SULFATE MG/L	31	110.52	56.00	133.29	< 10.00- 440.00	10.00 - 383.77	250.00
ZINC UG/L	30	27.92	1.25	101.56	< 2.50- 560.00	2.50 - 236.12	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ARKANSAS RIVER A & T DEPOSITS, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	19	286.00	214.00	193.55	91.00- 671.00	91.00 - 682.78	500.00
ALKALINITY MG/L	19	154.20	95.00	133.22	< 7.50- 407.00	7.50 - 427.30	
ARSENIC UG/L	19	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	17	88.47	102.00	33.45	48.00- 150.00	19.89 - 157.05	1000.00
CADMIUM UG/L	19	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	19	44.32	25.00	42.54	6.00- 118.00	6.00 - 131.53	
CHLORIDE MG/L	18	23.42	11.00	28.97	< 5.00- 95.00	5.00 - 82.80	250.00
CHROMIUM UG/L	18	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	18	7.28	2.50	10.74	< 5.00- 39.00	5.00 - 29.30	1000.00
FLUORIDE MG/L	17	0.27	0.20	0.23	< 0.05- 0.97	0.05 - 0.75	4.00
IRON UG/L	17	104.24	52.00	113.31	13.00- 409.00	13.00 - 336.53	300.00
LEAD UG/L	19	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	18	8.17	5.50	7.50	1.00- 28.00	1.00 - 23.54	
MANGANESE UG/L	17	23.53	2.50	45.04	< 5.00- 143.00	5.00 - 115.87	50.00
NITRATE MG/L	18	1.82	0.85	2.19	< 0.25- 7.40	0.25 - 6.30	10.00
SELENIUM UG/L	18	1.72	1.25	1.39	< 2.50- 6.00	2.50 - 4.56	10.00
SODIUM MG/L	18	30.89	21.00	22.40	< 5.00- 67.00	5.00 - 76.81	
SULFATE MG/L	18	23.94	5.00	25.00	< 10.00- 66.00	10.00 - 75.18	250.00
ZINC UG/L	18	110.36	32.50	194.00	< 2.50- 799.00	2.50 - 508.05	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ENID ISOLATED TERRACE DEPOSITS, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	6	385.67	354.50	60.37	307.00- 436.00	261.91 - 509.42	500.00
ALKALINITY MG/L	6	183.00	149.00	48.63	129.00- 255.00	83.31 - 282.69	
ARSENIC UG/L	6	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	6	383.67	325.00	80.00	307.00- 490.00	219.67 - 547.66	1000.00
CADMIUM UG/L	6	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	6	65.00	60.00	10.88	51.00- 79.00	42.69 - 87.31	
CHLORIDE MG/L	6	55.50	40.50	22.41	37.00- 87.00	9.56 - 101.44	250.00
CHROMIUM UG/L	6	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	6	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	1000.00
FLUORIDE MG/L	6	0.24	0.20	0.06	0.18- 0.32	0.13 - 0.36	4.00
IRON UG/L	6	40.17	15.25	47.13	< 5.00- 130.00	5.00 - 136.79	300.00
LEAD UG/L	6	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	6	11.67	10.00	2.42	9.00- 15.00	6.70 - 16.63	
MANGANESE UG/L	6	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
NITRATE MG/L	6	10.48	10.40	2.67	5.60- 12.80	5.01 - 15.96	10.00
SELENIUM UG/L	5	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	6	38.67	35.00	5.09	33.00- 45.00	28.24 - 49.09	
SULFATE MG/L	6	26.50	15.50	19.04	< 10.00- 49.00	10.00 - 65.54	250.00
ZINC UG/L	5	39.55	1.25	76.62	< 2.50- 176.00	2.50 - 196.62	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE CIMARRON RIVER A & T DEPOSITS, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	26	502.54	433.00	239.87	175.00-1002.00	10.81 - 994.27	500.00
ALKALINITY MG/L	29	208.17	205.00	78.69	90.00-390.00	46.86 - 369.49	
ARSENIC UG/L	25	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	27	262.74	240.00	146.29	57.00- 553.00	57.00 - 562.63	1000.00
CADMIUM UG/L	27	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	26	71.54	65.00	32.56	28.00- 139.00	4.79 - 138.29	
CHLORIDE MG/L	25	54.32	40.00	45.44	< 5.00- 175.00	5.00 - 147.46	250.00
CHROMIUM UG/L	25	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	26	12.63	2.50	24.82	< 5.00- 89.00	5.00 - 63.51	1000.00
FLUORIDE MG/L	26	0.33	0.32	0.14	0.12- 0.58	0.05 - 0.61	4.00
IRON UG/L	26	209.23	71.00	239.80	23.00- 868.00	23.00 - 700.82	300.00
LEAD UG/L	27	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	25	19.40	17.00	10.86	8.00- 51.00	8.00 - 41.67	
MANGANESE UG/L	24	26.96	2.50	70.34	< 5.00- 341.00	5.00 - 171.16	50.00
NITRATE MG/L	29	7.96	6.70	4.81	< 0.25- 16.20	0.25 - 17.82	10.00
SELENIUM UG/L	25	1.78	1.25	1.47	< 2.50- 6.00	2.50 - 4.80	10.00
SODIUM MG/L	26	53.56	45.00	35.28	< 5.00- 133.00	5.00 - 125.87	
SULFATE MG/L	24	34.88	33.00	33.88	< 10.00- 154.00	10.00 - 104.34	250.00
ZINC UG/L	25	54.60	17.00	112.43	< 2.50- 513.00	2.50 - 285.09	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE N. CANADIAN RIVER A & T DEPOSITS, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	18	512.83	369.50	307.84	161.00-1123.00	161.00 - 1143.90	500.00
ALKALINITY MG/L	18	214.22	197.50	105.66	56.00- 409.00	56.00 - 430.82	
ARSENIC UG/L	17	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	16	142.09	113.00	85.84	< 5.00- 331.00	5.00 - 318.06	1000.00
CADMUM UG/L	18	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	18	64.17	48.00	41.37	2.00- 132.00	2.00 - 148.98	
CHLORIDE MG/L	18	46.39	35.00	39.73	< 5.00- 115.00	5.00 - 127.84	250.00
CHROMIUM UG/L	18	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	16	9.34	2.50	16.89	< 5.00- 55.00	5.00 - 43.97	1000.00
FLUORIDE MG/L	17	0.56	0.57	0.33	0.12- 1.25	0.12 - 1.23	4.00
IRON UG/L	17	256.32	39.00	329.04	< 5.00- 891.00	5.00 - 930.85	300.00
LEAD UG/L	18	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	17	19.07	14.00	14.66	< 0.50- 48.00	0.50 - 49.13	
MANGANESE UG/L	17	73.79	2.50	110.93	< 5.00- 335.00	5.00 - 301.21	50.00
NITRATE MG/L	18	3.86	2.25	3.79	< 0.25- 11.10	0.25 - 11.64	10.00
SELENIUM UG/L	17	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	17	57.06	32.00	58.43	< 5.00- 204.00	5.00 - 176.83	
SULFATE MG/L	17	85.49	34.00	105.04	< 10.00- 281.00	10.00 - 300.81	250.00
ZINC UG/L	17	34.43	7.00	48.55	< 2.50- 156.00	2.50 - 133.94	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE CANADIAN RIVER A & T DEPOSITS, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	15	554.27	314.00	608.88	85.00-2166.00	85.00 - 1802.47	500.00
ALKALINITY MG/L	15	194.20	222.00	95.35	31.00- 312.00	31.00 - 389.67	
ARSENIC UG/L	16	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	14	97.71	64.00	69.94	16.00- 260.00	16.00 - 241.09	1000.00
CADMIUM UG/L	15	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	15	82.33	64.00	83.80	6.00- 299.00	6.00 - 254.13	
CHLORIDE MG/L	14	16.00	7.25	16.06	< 5.00- 41.00	5.00 - 48.92	250.00
CHROMIUM UG/L	14	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	14	4.50	2.50	5.12	< 5.00- 18.00	5.00 - 14.99	1000.00
FLUORIDE MG/L	15	0.32	0.42	0.17	< 0.05- 0.49	0.05 - 0.67	4.00
IRON UG/L	15	49.80	32.00	47.07	< 5.00- 148.00	5.00 - 146.29	300.00
LEAD UG/L	16	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	15	32.53	23.00	36.94	2.00- 142.00	2.00 - 108.25	
MANGANESE UG/L	15	3.53	2.50	4.00	< 5.00- 18.00	5.00 - 11.74	50.00
NITRATE MG/L	15	6.03	2.90	6.70	0.80- 22.10	0.80 - 19.76	10.00
SELENIUM UG/L	14	1.52	1.25	1.00	< 2.50- 5.00	2.50 - 3.57	10.00
SODIUM MG/L	15	29.20	20.00	23.76	11.00- 100.00	11.00 - 77.92	
SULFATE MG/L	15	135.33	34.00	244.48	< 10.00- 813.00	10.00 - 636.51	250.00
ZINC UG/L	15	35.52	12.00	53.35	< 2.50- 182.00	2.50 - 144.89	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE GERTY SAND, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	9	397.44	475.00	198.05	140.00- 601.00	140.00 - 803.46	500.00
ALKALINITY MG/L	9	287.33	324.00	179.43	52.00- 509.00	52.00 - 655.16	
ARSENIC UG/L	8	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	9	172.78	123.00	136.67	10.00- 360.00	10.00 - 452.95	1000.00
CADMIUM UG/L	9	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	9	37.11	14.00	39.62	2.00- 90.00	2.00 - 118.32	
CHLORIDE MG/L	9	24.22	16.00	21.86	< 5.00- 61.00	5.00 - 69.04	250.00
CHROMIUM UG/L	9	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	8	12.75	2.50	14.06	< 5.00- 43.00	5.00 - 41.58	1000.00
FLUORIDE MG/L	9	0.31	0.20	0.21	< 0.05- 0.61	0.05 - 0.75	4.00
IRON UG/L	8	87.25	37.50	121.76	15.00- 383.00	15.00 - 336.86	300.00
LEAD UG/L	9	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	9	9.44	8.00	5.61	1.00- 16.00	1.00 - 20.96	
MANGANESE UG/L	8	5.13	2.50	4.89	< 5.00- 14.00	5.00 - 15.15	50.00
NITRATE MG/L	9	1.64	0.70	1.90	< 0.25- 5.00	0.25 - 5.53	10.00
SELENIUM UG/L	8	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	9	96.89	58.00	89.48	12.00- 223.00	12.00 - 280.31	
SULFATE MG/L	8	13.75	5.00	12.54	< 10.00- 32.00	10.00 - 39.47	250.00
ZINC UG/L	9	152.81	125.00	146.87	< 2.50- 389.00	2.50 - 453.89	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE WASHITA RIVER A & T DEPOSITS, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	12	683.92	700.00	262.53	63.00- 1077.00	145.73 - 1222.11	500.00
ALKALINITY MG/L	12	357.75	364.00	124.92	134.00- 550.00	101.67 - 613.83	
ARSENIC UG/L	12	3.83	2.50	3.12	< 5.00- 11.00	5.00 - 10.23	50.00
BARIUM UG/L	12	157.33	137.50	97.91	13.00- 329.00	13.00 - 358.06	1000.00
CADMIUM UG/L	13	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	12	105.83	77.50	49.01	50.00- 194.00	5.36 - 206.31	
CHLORIDE MG/L	13	63.96	34.00	56.27	< 5.00- 158.00	5.00 - 179.32	250.00
CHROMIUM UG/L	13	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	12	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	1000.00
FLUORIDE MG/L	12	0.35	0.33	0.05	0.27- 0.43	0.25 - 0.44	4.00
IRON UG/L	12	177.79	68.50	219.87	< 5.00- 750.00	5.00 - 628.53	300.00
LEAD UG/L	13	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	
MAGNESIUM MG/L	12	39.08	30.00	20.74	14.00- 74.00	14.00 - 81.61	
MANGANESE UG/L	13	348.12	393.00	284.63	< 5.00- 782.00	5.00 - 931.60	50.00
NITRATE MG/L	12	2.11	0.36	3.61	< 0.25- 10.00	0.25 - 9.51	10.00
SELENIUM UG/L	12	1.56	1.25	1.08	< 2.50- 5.00	2.50 - 3.78	10.00
SODIUM MG/L	13	78.31	61.00	72.20	13.00- 215.00	13.00 - 226.31	
SULFATE MG/L	12	113.17	46.00	146.55	< 10.00- 490.00	10.00 - 413.59	250.00
ZINC UG/L	12	11.46	1.25	15.20	< 2.50- 51.00	2.50 - 42.62	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE NORTH FORK OF THE RED RIVER A & T DEPOSITS,
PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	14	939.36	678.00	565.08	457.00-2025.00	457.00 - 2097.77	500.00
ALKALINITY MG/L	13	273.38	267.00	49.27	212.00- 379.00	172.38 - 374.39	
ARSENIC UG/L	14	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	13	84.23	77.00	62.05	20.00- 180.00	20.00 - 211.44	1000.00
CADMUM UG/L	13	1.62	1.25	1.32	< 2.50- 6.00	2.50 - 4.32	10.00
CALCIUM MG/L	13	114.08	91.00	84.07	41.00- 312.00	41.00 - 286.42	
CHLORIDE MG/L	13	45.42	37.00	37.07	< 5.00- 127.00	5.00 - 121.42	250.00
CHROMIUM UG/L	12	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	14	14.11	2.50	17.04	< 5.00- 43.00	5.00 - 49.03	1000.00
FLUORIDE MG/L	14	0.75	0.63	0.45	0.18- 1.55	0.18 - 1.67	4.00
IRON UG/L	13	46.12	26.00	39.21	< 5.00- 136.00	5.00 - 126.49	300.00
LEAD UG/L	13	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	14	36.64	29.00	20.82	12.00- 72.00	12.00 - 79.32	
MANGANESE UG/L	13	3.27	2.50	1.20	< 5.00- 10.00	0.81 - 5.73	50.00
NITRATE MG/L	13	10.32	10.60	6.29	1.40- 21.70	1.40 - 23.20	10.00
SELENIUM UG/L	13	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	14	78.07	73.50	25.53	41.00- 110.00	25.74 - 130.40	
SULFATE MG/L	14	270.57	129.00	309.78	33.00- 874.00	33.00 - 905.63	250.00
ZINC UG/L	14	99.04	3.63	148.41	< 2.50- 368.00	2.50 - 403.27	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE RED RIVER A & T DEPOSITS, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	15	1134.27	286.00	1525.52	131.00-4743.00	131.00 - 4261.58	500.00
ALKALINITY MG/L	16	284.69	192.00	218.02	34.00- 674.00	34.00 - 731.62	
ARSENIC UG/L	16	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	15	111.87	63.00	110.04	12.00- 352.00	12.00 - 337.45	1000.00
CADMIUM UG/L	16	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	14	91.36	44.00	138.29	16.00- 551.00	16.00 - 374.85	
CHLORIDE MG/L	15	166.23	18.00	263.68	< 5.00- 823.00	5.00 - 706.78	250.00
CHROMIUM UG/L	15	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	15	13.53	2.50	20.18	< 5.00- 73.00	5.00 - 54.91	1000.00
FLUORIDE MG/L	14	0.42	0.43	0.26	< 0.05- 0.76	0.05 - 0.95	4.00
IRON UG/L	15	708.40	258.00	1004.91	12.00-3421.00	12.00 - 2768.46	300.00
LEAD UG/L	15	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	16	40.06	15.50	39.54	2.00- 98.00	2.00 - 121.13	
MANGANESE UG/L	14	45.18	2.50	57.89	< 5.00- 151.00	5.00 - 163.86	50.00
NITRATE MG/L	16	0.99	0.75	0.81	< 0.25- 2.50	0.25 - 2.65	10.00
SELENIUM UG/L	15	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	15	177.27	25.00	230.87	< 5.00- 694.00	5.00 - 650.55	
SULFATE MG/L	15	311.47	33.00	639.01	< 10.00-1955.00	10.00 - 1621.44	250.00
ZINC UG/L	15	12.80	1.25	21.45	< 2.50- 83.00	2.50 - 56.76	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE OGALLALA AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	121	406.95	377.00	119.07	212.00- 708.00	162.86 - 651.04	500.00
ALKALINITY MG/L	116	199.47	194.50	29.54	148.00- 291.00	138.91 - 260.04	
ARSENIC UG/L	121	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	122	84.17	54.50	69.19	17.00- 292.00	17.00 - 226.00	1000.00
CADMUM UG/L	126	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	120	55.28	53.00	18.11	12.00- 97.00	18.15 - 92.40	
CHLORIDE MG/L	120	33.65	23.00	29.96	< 5.00- 135.00	5.00 - 95.06	250.00
CHROMIUM UG/L	119	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	123	6.50	2.50	8.73	4.00- 42.00	4.00 - 24.39	1000.00
FLUORIDE MG/L	123	1.10	0.95	0.66	0.15- 2.70	0.15 - 2.45	4.00
IRON UG/L	123	143.86	62.00	236.76	< 5.00- 1501.00	5.00 - 629.22	300.00
LEAD UG/L	124	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	124	23.24	23.50	8.66	5.00- 39.00	5.48 - 41.00	
MANGANESE UG/L	122	2.91	2.50	1.80	< 5.00- 13.00	5.00 - 6.60	50.00
NITRATE MG/L	121	2.87	2.60	1.61	< 0.25- 8.40	0.25 - 6.17	10.00
SELENIUM UG/L	117	1.42	1.25	0.77	< 2.50- 5.00	2.50 - 3.00	10.00
SODIUM MG/L	121	36.87	31.00	21.06	< 5.00- 111.00	5.00 - 80.05	
SULFATE MG/L	117	64.44	60.00	40.83	< 10.00- 194.00	10.00 - 148.14	250.00
ZINC UG/L	124	26.44	1.25	59.12	< 2.50- 327.00	2.50 - 147.64	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ANTLERS SANDSTONE AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	16	353.56	221.00	267.37	58.00 - 891.00	58.00 - 901.68	500.00
ALKALINITY MG/L	18	217.58	156.50	154.88	< 7.50 - 485.00	7.50 - 535.09	
ARSENIC UG/L	18	< 5.00	< 5.00	0.00	< 5.00 - 5.00	5.00 - 5.00	50.00
BARIUM UG/L	16	32.44	14.50	34.26	< 5.00 - 120.00	5.00 - 102.68	1000.00
CADMUM UG/L	18	< 2.50	< 2.50	0.00	< 2.50 - 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	16	13.97	8.00	13.68	< 0.50 - 40.00	0.50 - 42.00	
CHLORIDE MG/L	16	24.53	17.00	18.85	< 5.00 - 69.00	5.00 - 63.16	250.00
CHROMIUM UG/L	17	3.00	2.50	2.06	< 5.00 - 11.00	5.00 - 7.23	50.00
COPPER UG/L	17	15.15	2.50	26.45	< 5.00 - 101.00	5.00 - 69.37	1000.00
FLUORIDE MG/L	16	0.36	0.19	0.34	< 0.05 - 1.03	0.05 - 1.07	4.00
IRON UG/L	17	382.71	53.00	588.69	< 5.00 - 1718.00	5.00 - 1589.52	300.00
LEAD UG/L	18	< 22.50	< 22.50	0.00	< 22.50 - 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	18	4.99	2.50	4.59	< 0.50 - 14.00	0.50 - 14.39	
MANGANESE UG/L	16	22.94	13.00	30.38	< 5.00 - 124.00	5.00 - 85.21	50.00
NITRATE MG/L	16	0.58	0.13	1.26	< 0.25 - 3.90	0.25 - 3.16	10.00
SELENIUM UG/L	17	< 2.50	< 2.50	0.00	< 2.50 - 2.50	2.50 - 2.50	10.00
SODIUM MG/L	16	103.66	44.00	103.19	< 5.00 - 288.00	5.00 - 315.19	
SULFATE MG/L	16	34.19	21.50	35.42	< 10.00 - 130.00	10.00 - 106.80	250.00
ZINC UG/L	17	12.69	7.00	18.01	< 2.50 - 54.00	2.50 - 49.61	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ELK CITY SANDSTONE AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	12	479.75	413.50	147.44	285.00- 699.00	177.50 - 782.00	500.00
ALKALINITY MG/L	12	303.75	269.50	70.64	213.00- 412.00	158.94 - 448.56	
ARSENIC UG/L	12	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	12	420.67	397.50	198.21	61.00- 680.00	14.33 - 827.00	1000.00
CADMIUM UG/L	12	2.19	1.25	1.70	< 2.50- 10.00	2.50 - 5.66	10.00
CALCIUM MG/L	12	73.25	69.00	29.77	23.00- 112.00	12.22 - 134.28	
CHLORIDE MG/L	12	34.88	26.00	25.70	< 5.00- 77.00	5.00 - 87.56	250.00
CHROMIUM UG/L	12	8.13	2.50	10.18	< 5.00- 50.00	5.00 - 28.99	50.00
COPPER UG/L	11	11.86	2.50	17.38	< 5.00- 47.00	5.00 - 47.49	1000.00
FLUORIDE MG/L	12	0.41	0.40	0.08	0.26- 0.50	0.26 - 0.56	4.00
IRON UG/L	11	15.64	19.00	12.05	< 5.00- 50.00	5.00 - 40.33	300.00
LEAD UG/L	12	20.94	11.25	17.53	< 22.50- 100.00	22.50 - 56.86	50.00
MAGNESIUM MG/L	12	22.67	21.50	4.92	16.00- 31.00	12.57 - 32.76	
MANGANESE UG/L	11	2.95	2.50	1.01	< 5.00- 10.00	0.88 - 5.03	50.00
NITRATE MG/L	11	7.42	8.50	3.08	2.00- 10.60	1.11 - 13.72	10.00
SELENIUM UG/L	11	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	12	41.67	29.50	26.70	13.00- 88.00	13.00 - 96.40	
SULFATE MG/L	12	25.92	5.00	30.32	< 10.00- 83.00	10.00 - 88.07	250.00
ZINC UG/L	11	17.61	10.00	18.20	< 2.50- 49.00	2.50 - 54.92	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE RUSH SPRINGS SANDSTONE AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	30	621.80	441.00	573.71	227.00-2636.00	227.00 - 1797.91	500.00
ALKALINITY MG/L	30	220.00	209.50	52.03	87.00- 303.00	113.35 - 326.65	
ARSENIC UG/L	29	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	30	157.83	168.50	109.16	12.00- 400.00	12.00 - 381.62	1000.00
CADMUM UG/L	27	1.50	1.25	1.30	< 2.50- 8.00	2.50 - 4.16	10.00
CALCIUM MG/L	28	87.57	78.00	43.61	22.00- 198.00	22.00 - 176.98	
CHLORIDE MG/L	29	19.29	14.00	15.79	< 5.00- 54.00	5.00 - 51.65	250.00
CHROMIUM UG/L	28	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	30	6.67	2.50	7.61	< 5.00- 37.00	5.00 - 22.26	1000.00
FLUORIDE MG/L	31	0.29	0.26	0.17	< 0.05- 0.61	0.05 - 0.64	4.00
IRON UG/L	31	353.71	73.00	603.30	14.00-2412.00	14.00 - 1590.47	300.00
LEAD UG/L	28	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	31	27.42	17.00	23.71	5.00- 86.00	5.00 - 76.02	
MANGANESE UG/L	30	14.45	2.50	37.50	< 5.00- 173.00	5.00 - 91.32	50.00
NITRATE MG/L	30	6.10	3.00	6.47	< 0.25- 26.10	0.25 - 19.38	10.00
SELENIUM UG/L	32	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	31	30.84	24.00	22.78	11.00- 115.00	11.00 - 77.55	
SULFATE MG/L	31	214.00	67.00	409.45	< 10.00-1523.00	10.00 - 1053.38	250.00
ZINC UG/L	29	72.66	54.00	75.47	< 2.50- 280.00	2.50 - 227.37	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE BLAINE AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	10	3494.00	3008.50	2716.45	417.00-7704.00	417.00 - 9062.72	500.00
ALKALINITY MG/L	10	200.20	185.00	34.97	158.00- 260.00	128.51 - 271.89	
ARSENIC UG/L	10	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	10	34.05	11.00	39.25	< 5.00- 96.00	5.00 - 114.51	1000.00
CADMIUM UG/L	10	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	10	433.60	473.50	266.17	66.00- 728.00	66.00 - 979.24	
CHLORIDE MG/L	9	466.89	134.00	694.58	12.00-2062.00	12.00 - 1890.77	250.00
CHROMIUM UG/L	10	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	9	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	1000.00
FLUORIDE MG/L	10	0.51	0.49	0.08	0.39- 0.62	0.35 - 0.67	4.00
IRON UG/L	10	34.40	20.50	29.62	< 5.00- 90.00	5.00 - 95.13	300.00
LEAD UG/L	10	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	10	86.35	61.25	62.53	14.00- 165.00	14.00 - 214.54	
MANGANESE UG/L	9	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
NITRATE MG/L	10	10.68	8.90	2.75	7.60- 15.90	5.05 - 16.31	10.00
SELENIUM UG/L	9	5.83	6.00	3.26	< 2.50- 11.00	2.50 - 12.51	10.00
SODIUM MG/L	10	365.40	75.00	504.39	32.00-1302.00	32.00 - 1399.41	
SULFATE MG/L	10	1187.20	1575.50	784.76	54.00-1948.00	54.00 - 2795.95	250.00
ZINC UG/L	9	1.67	1.25	1.25	< 2.50- 5.00	2.50 - 4.23	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE GARBER-WELLINGTON AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	47	286.30	287.00	114.46	76.00- 541.00	51.66 - 520.93	500.00
ALKALINITY MG/L	49	196.47	219.00	93.54	< 7.50- 411.00	4.71 - 388.23	
ARSENIC UG/L	49	3.10	2.50	4.21	< 5.00- 32.00	5.00 - 11.74	50.00
BARIUM UG/L	50	322.10	257.00	193.19	18.00- 691.00	18.00 - 718.13	1000.00
CADMIUM UG/L	50	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	47	42.13	49.00	21.92	1.00- 71.00	1.00 - 87.05	
CHLORIDE MG/L	49	19.85	16.00	14.31	< 5.00- 76.00	5.00 - 49.19	250.00
CHROMIUM UG/L	47	2.74	2.50	1.68	< 5.00- 14.00	5.00 - 6.18	50.00
COPPER UG/L	50	21.43	2.50	50.83	< 5.00- 323.00	5.00 - 125.63	1000.00
FLUORIDE MG/L	49	0.21	0.20	0.10	< 0.05- 0.46	0.02 - 0.41	4.00
IRON UG/L	50	166.82	35.00	432.05	< 5.00- 2267.00	5.00 - 1052.53	300.00
LEAD UG/L	51	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	47	20.43	22.00	10.21	1.00- 37.00	1.00 - 41.36	
MANGANESE UG/L	48	5.05	2.50	7.58	< 5.00- 44.00	5.00 - 20.60	50.00
NITRATE MG/L	50	2.07	0.80	2.82	< 0.25- 12.10	0.25 - 7.86	10.00
SELENIUM UG/L	49	2.68	1.25	6.25	< 2.50- 34.00	2.50 - 15.50	10.00
SODIUM MG/L	48	26.05	16.50	26.87	< 5.00- 121.00	5.00 - 81.14	
SULFATE MG/L	48	14.90	5.00	24.59	< 10.00- 100.00	10.00 - 65.31	250.00
ZINC UG/L	49	15.61	1.25	29.69	< 2.50- 173.00	2.50 - 76.47	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE OSCAR AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	10	808.70	629.00	342.88	360.00-1298.00	105.80 - 1511.60	500.00
ALKALINITY MG/L	10	368.30	359.00	44.13	298.00- 418.00	277.84 - 458.76	
ARSENIC UG/L	9	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	9	224.56	63.00	303.97	13.00- 858.00	13.00 - 847.68	1000.00
CADMIUM UG/L	10	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	10	90.60	70.50	36.53	58.00- 162.00	15.71 - 165.49	
CHLORIDE MG/L	10	56.80	49.50	30.60	13.00- 94.00	13.00 - 119.54	250.00
CHROMIUM UG/L	10	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	9	4.11	2.50	4.83	< 5.00- 17.00	5.00 - 14.02	1000.00
FLUORIDE MG/L	10	0.38	0.31	0.15	0.19- 0.63	0.07 - 0.70	4.00
IRON UG/L	10	299.50	25.50	343.32	< 5.00- 883.00	5.00 - 1003.32	300.00
LEAD UG/L	10	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	9	41.44	36.00	19.40	26.00- 84.00	1.67 - 81.22	
MANGANESE UG/L	10	31.35	2.50	34.87	< 5.00- 91.00	5.00 - 102.84	50.00
NITRATE MG/L	10	2.16	0.13	3.30	< 0.25- 8.40	0.25 - 8.92	10.00
SELENIUM UG/L	9	1.89	1.25	1.92	< 2.50- 7.00	2.50 - 5.82	10.00
SODIUM MG/L	10	102.00	34.50	100.35	17.00- 259.00	17.00 - 307.73	
SULFATE MG/L	10	218.90	64.00	206.93	< 10.00- 497.00	10.00 - 643.10	250.00
ZINC UG/L	9	8.86	8.00	7.00	< 2.50- 19.00	2.50 - 23.21	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ADA-VAMOOSA AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	19	477.42	405.00	188.69	117.00- 917.00	90.60 - 864.24	500.00
ALKALINITY MG/L	20	258.05	260.00	73.18	33.00- 352.00	108.04 - 408.06	
ARSENIC UG/L	20	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	19	64.11	53.00	36.90	27.00- 174.00	27.00 - 139.76	1000.00
CADMIUM UG/L	20	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	19	39.74	27.00	33.99	2.00- 110.00	2.00 - 109.42	
CHLORIDE MG/L	18	35.67	35.00	29.41	< 5.00- 102.00	5.00 - 95.95	250.00
CHROMIUM UG/L	20	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	18	3.03	2.50	2.24	< 5.00- 12.00	5.00 - 7.62	1000.00
FLUORIDE MG/L	19	0.46	0.36	0.31	< 0.05- 1.17	0.05 - 1.10	4.00
IRON UG/L	18	41.61	25.00	43.86	< 5.00- 160.00	5.00 - 131.52	300.00
LEAD UG/L	20	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	18	15.28	7.50	13.40	< 0.50- 36.00	0.50 - 42.75	
MANGANESE UG/L	19	17.08	2.50	20.28	< 5.00- 66.00	5.00 - 58.65	50.00
NITRATE MG/L	19	0.73	0.13	1.01	< 0.25- 3.10	0.25 - 2.80	10.00
SELENIUM UG/L	20	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	19	87.97	74.00	64.29	< 5.00- 217.00	5.00 - 219.76	
SULFATE MG/L	19	76.11	36.00	83.38	< 10.00- 315.00	10.00 - 247.04	250.00
ZINC UG/L	18	10.90	1.25	13.74	< 2.50- 47.00	2.50 - 39.08	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ARBUCKLE-SIMPSON GROUP, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	5	457.40	451.00	94.18	335.00- 600.00	264.34 - 650.46	500.00
ALKALINITY MG/L	5	344.40	295.00	94.83	256.00- 472.00	149.99 - 538.81	
ARSENIC UG/L	5	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	5	54.00	55.00	6.04	48.00- 62.00	41.61 - 66.39	1000.00
CADMIUM UG/L	5	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	5	90.40	91.00	15.95	72.00- 115.00	57.71 - 123.09	
CHLORIDE MG/L	5	12.30	2.50	13.59	< 5.00- 30.00	5.00 - 40.15	250.00
CHROMIUM UG/L	5	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	5	6.20	2.50	8.27	< 5.00- 21.00	5.00 - 23.16	1000.00
FLUORIDE MG/L	5	0.32	0.30	0.24	0.11- 0.71	0.11 - 0.81	4.00
IRON UG/L	5	160.30	113.00	166.50	< 5.00- 380.00	5.00 - 501.63	300.00
LEAD UG/L	5	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	5	33.00	37.00	20.15	11.00- 53.00	11.00 - 74.31	
MANGANESE UG/L	5	5.20	2.50	6.04	< 5.00- 16.00	5.00 - 17.58	50.00
NITRATE MG/L	5	6.27	0.70	9.61	< 0.25- 22.40	0.25 - 25.98	10.00
SELENIUM UG/L	5	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	5	11.10	2.50	11.97	< 5.00- 27.00	5.00 - 35.63	
SULFATE MG/L	5	23.00	5.00	24.66	< 10.00- 51.00	10.00 - 73.55	250.00
ZINC UG/L	5	1097.60	383.00	1392.48	48.00-3320.00	48.00 - 3952.18	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ARBUCKLE-TIMBERED HILLS GROUP, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	8	874.75	553.00	591.86	309.00-1828.00	309.00 - 2088.07	500.00
ALKALINITY MG/L	8	285.25	274.00	113.11	129.00- 472.00	53.37 - 517.13	
ARSENIC UG/L	7	3.86	2.50	3.59	< 5.00- 12.00	5.00 - 11.22	50.00
BARIUM UG/L	8	74.38	23.00	74.02	< 5.00- 210.00	5.00 - 226.12	1000.00
CADMIUM UG/L	7	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	7	6.14	7.00	4.38	1.00- 14.00	1.00 - 15.11	
CHLORIDE MG/L	8	229.38	86.00	238.51	60.00- 694.00	60.00 - 718.32	250.00
CHROMIUM UG/L	7	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
COPPER UG/L	7	4.64	2.50	3.66	< 5.00- 20.00	5.00 - 12.15	1000.00
FLUORIDE MG/L	8	6.99	5.51	3.93	2.44- 12.80	2.44 - 15.04	4.00
IRON UG/L	7	138.57	110.00	128.15	15.00- 376.00	15.00 - 401.29	300.00
LEAD UG/L	7	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	
MAGNESIUM MG/L	7	2.36	2.00	1.97	< 0.50- 6.00	0.50 - 6.39	
MANGANESE UG/L	7	2.86	2.50	0.94	< 5.00- 10.00	5.00 - 10.00	50.00
NITRATE MG/L	7	< 0.25	< 0.25	0.00	< 0.25- 0.25	0.25 - 0.25	10.00
SELENIUM UG/L	8	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	8	296.75	205.00	215.50	98.00- 650.00	98.00 - 738.53	
SULFATE MG/L	8	106.38	73.50	78.23	< 10.00- 235.00	10.00 - 266.75	250.00
ZINC UG/L	8	5.28	1.25	7.08	< 2.50- 21.00	2.50 - 19.79	5000.00

SUMMARY OF GROUNDWATER QUALITY DATA FOR THE ROUBIDOUX AQUIFER, PERIOD 1986-88

PARAMETER	NUMBER OF SAMPLES	MEAN	MEDIAN	STD DEV	RANGE	96% CONFID INTERVAL (BASED ON MEAN)	DRINKING WATER STANDARDS
TDS MG/L	13	366.15	330.00	209.95	107.00- 761.00	107.00 - 796.56	500.00
ALKALINITY MG/L	13	199.23	141.00	106.57	55.00- 390.00	55.00 - 417.71	
ARSENIC UG/L	13	< 5.00	< 5.00	0.00	< 5.00- 5.00	5.00 - 5.00	50.00
BARIUM UG/L	13	40.65	31.00	31.04	< 5.00- 100.00	5.00 - 104.28	1000.00
CADMIUM UG/L	12	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
CALCIUM MG/L	13	37.31	27.00	21.30	11.00- 70.00	11.00 - 80.98	
CHLORIDE MG/L	12	40.08	22.50	45.01	< 5.00- 167.00	5.00 - 132.35	250.00
CHROMIUM UG/L	12	3.46	2.50	3.32	< 5.00- 14.00	5.00 - 10.26	50.00
COPPER UG/L	12	11.29	2.50	12.94	< 5.00- 35.00	5.00 - 37.82	1000.00
FLUORIDE MG/L	12	1.00	0.63	0.91	0.13- 3.00	0.13 - 2.87	4.00
IRON UG/L	12	1004.67	380.50	1149.89	187.00-3733.00	187.00 - 3361.93	300.00
LEAD UG/L	13	< 22.50	< 22.50	0.00	< 22.50- 22.50	22.50 - 22.50	50.00
MAGNESIUM MG/L	13	10.77	8.00	9.62	1.00- 28.00	1.00 - 30.49	
MANGANESE UG/L	13	18.65	11.00	18.90	< 5.00- 51.00	5.00 - 57.40	50.00
NITRATE MG/L	12	< 0.25	< 0.25	0.00	< 0.25- 0.25	0.25 - 0.25	10.00
SELENIUM UG/L	13	< 2.50	< 2.50	0.00	< 2.50- 2.50	2.50 - 2.50	10.00
SODIUM MG/L	12	50.04	16.50	57.50	< 5.00- 199.00	5.00 - 167.92	
SULFATE MG/L	13	42.69	5.00	59.67	< 10.00- 155.00	10.00 - 165.01	250.00
ZINC UG/L	13	449.81	112.00	526.97	< 2.50-1455.00	2.50 - 1530.10	5000.00