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AN EVALUATION OF HYDROTHERMAL RESOURCES OF NORTH DAKOTA

Contract No. DE-FC07-79ID12030

Phase II Final Technical Report

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DISCLAIMER

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INTRODUCTION

This is the final technical report of Phase II of our activities under cooperative agreement DOE-FC07-79ID12030 which was executed March 7, 1979.

Phase I of this agreement (March 7, 1979 to March 7, 1980) consisted of an evaluation of potential hydrothermal aquifers based on the North Dakota Geological Survey's records of oil and gas wells drilled in the state. The Phase I study assembled a computer library system (WELLFILE) of the oil and gas well data, and used this data to construct a geothermal gradient map of North Dakota and summarize the characteristics of potential hydrothermal aquifers (Figure 1) (Harris and others, 1980).

Most of the oil and gas wells drilled in North Dakota have been drilled in the western two-thirds of the state, and most of these wells have had Paleozoic rock units as their objective. Consequently, the oil and gas well data contained in WELLFILE is concentrated geographically in the western two-thirds of the state and stratigraphically in Paleozoic rocks.

Our Phase II activities have dealt with three main topical areas: geothermal gradient and heat-flow studies, stratigraphic studies, and water quality studies. Geographically, our efforts have been concentrated in areas of interest indicated by our Phase I study, and stratigraphically they have been concentrated on Mesozoic and Cenozoic rocks (Figure 2).

The geothermal gradient and heat-flow studies involved running temperature logs in groundwater observation holes in areas of interest indicated by the Phase I study; and locating, obtaining access to, and casing "holes-of-convenience" to be used as heat-flow determination sites.

The stratigraphic and water quality studies involved two main efforts. First, WELLFILE was updated and expanded. Second, a computer library system

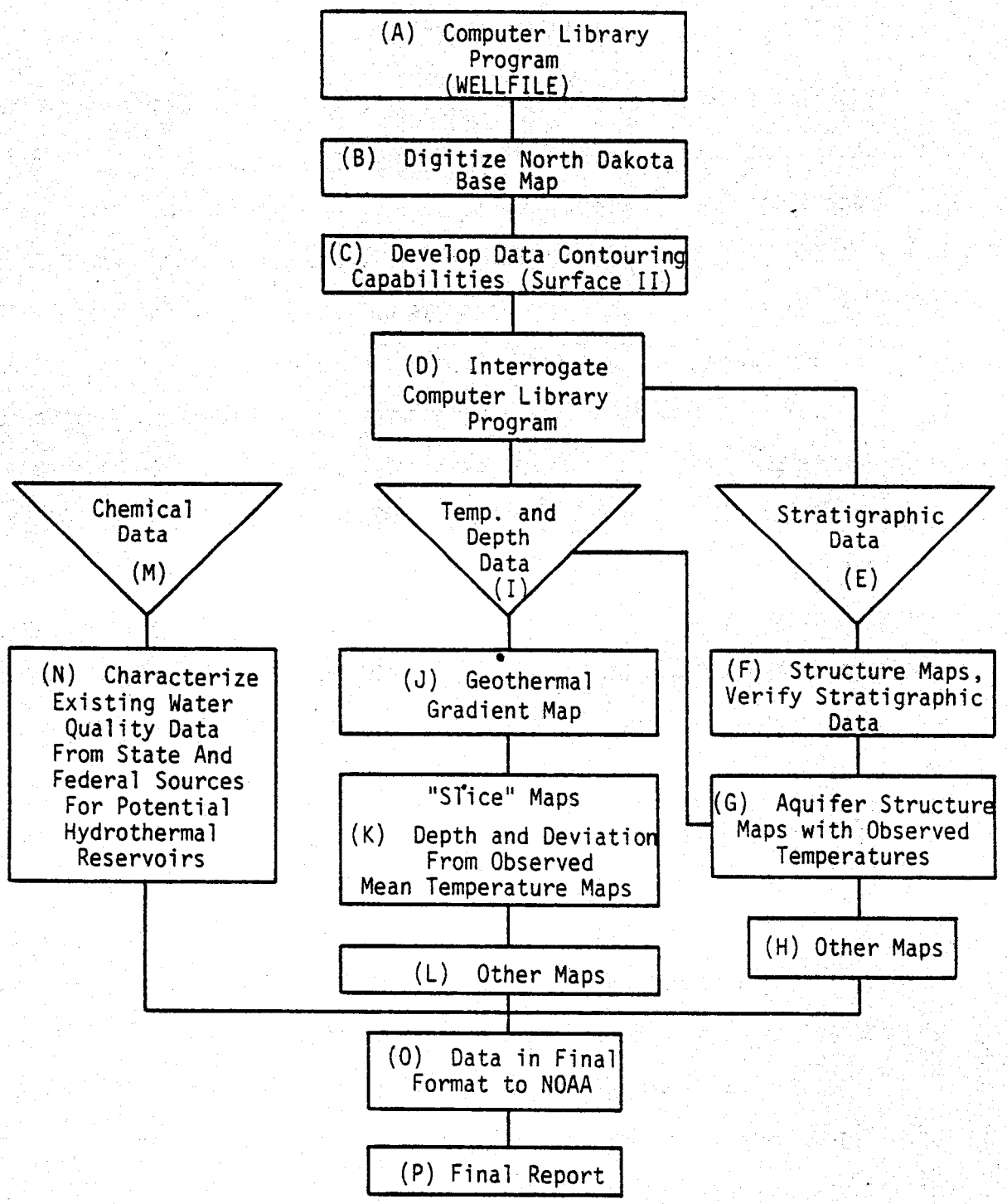


FIGURE 1 - STEPWISE PROCEDURE FOLLOWED FOR THE PHASE I STUDY

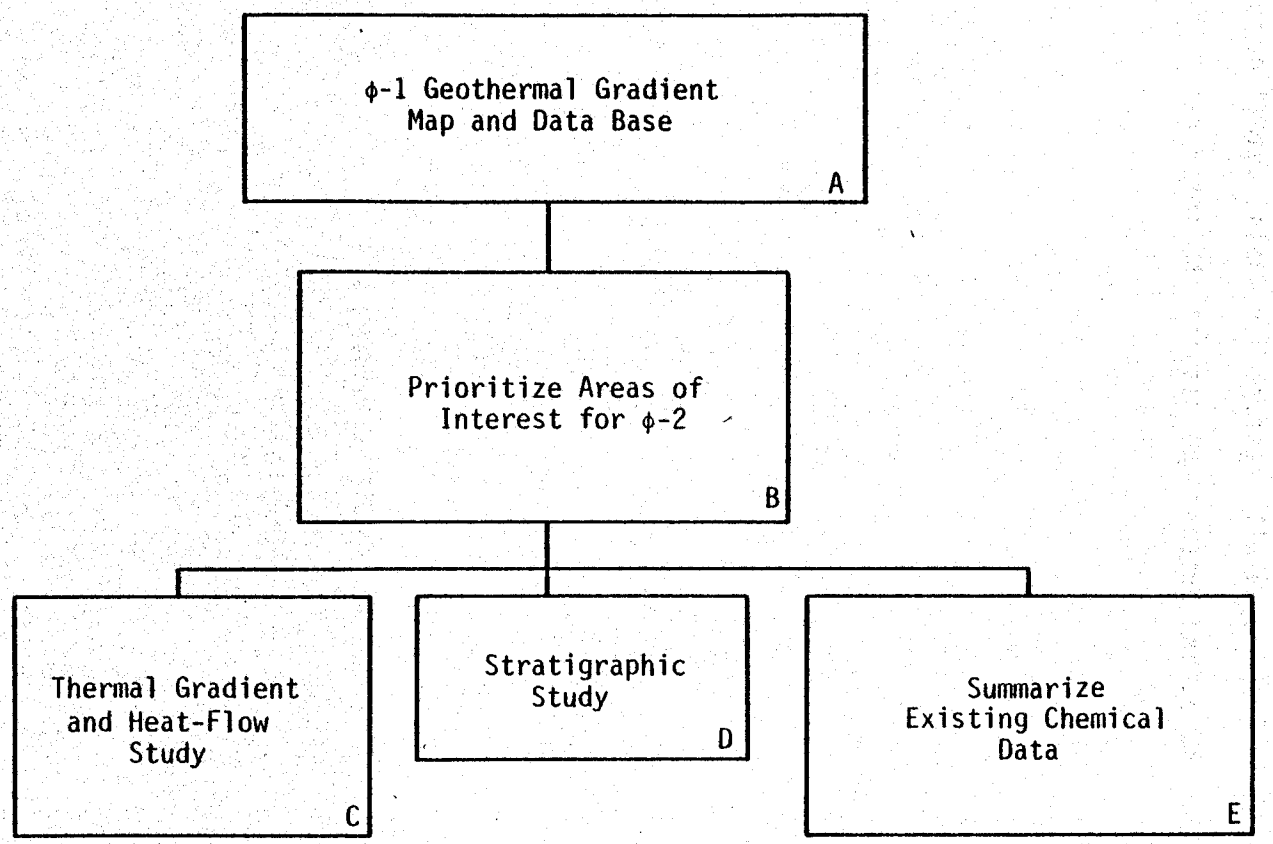


FIGURE 2 - MAIN TASKS INVOLVED IN THE PHASE II STUDY

(WATERCAT) was assembled for all water wells drilled in the state. WATERCAT combines data from the United States Geological Survey Water Resources Division's (USGSWRD) WATSTOR and GWSI computer libraries; and includes physical, stratigraphic, and water quality data.

In the following report we will restate our goals, detail our methods of reaching those goals, and present the results and interpretations of our study.

GOAL

The object of this study is to evaluate the hydrothermal resources of North Dakota. This evaluation is based on existing data on file with the North Dakota Geological Survey (NDGS) and other state and federal agencies, and field and laboratory studies we have conducted. The principal sources of data used during the Phase II study were WELLFILE, the computer library of oil and gas well data developed during our Phase I study, and WATERCAT, a computer library system of water well data assembled during our Phase II study. A field survey of the "shallow" geothermal gradients present in selected groundwater observation holes was conducted. Laboratory determinations of the thermal conductivity of core samples is being done to facilitate heat-flow calculations on those "hole-of-convenience" we have cased.

DATA BASES

WELLFILE

The WELLFILE computer library system manages data obtained from about 8,000 oil and gas wells drilled in North Dakota. These data are filed with the North Dakota Geological Survey.

Location, legal, production, and stratigraphic data, as well as the availability and storage location of cores and samples, are stored for each well. Well location information includes county, township, range, section, and quarter-quarter-quarter description (Figure 3), as well as the footages from north-south and east-west section lines. Legal data include owner-operator, N.D.G.S. well number, N.D.G.S. permit number, permitted date, completion or abandoned date, and A.P.I. number. Production data include well status, producing horizon, perforated interval, and initial production. Stratigraphic data include reference elevations, total depth, deepest formation penetrated, selected formation "tops" and kinds of geophysical logs run. Cores cut in the well are identified by formation and by the footage of top and bottom of the cored interval. Sampled intervals are identified by footages. Core and sample storage location are listed for the cores and samples available in the North Dakota Geological Survey's Wilson M. Laird Core and Sample Library.

Two data subsets are maintained separately from the WELLFILE library. These are considered working files, currently used for special projects and N.D.G.S. internal data management. If desired, these subsets can be added to WELLFILE.

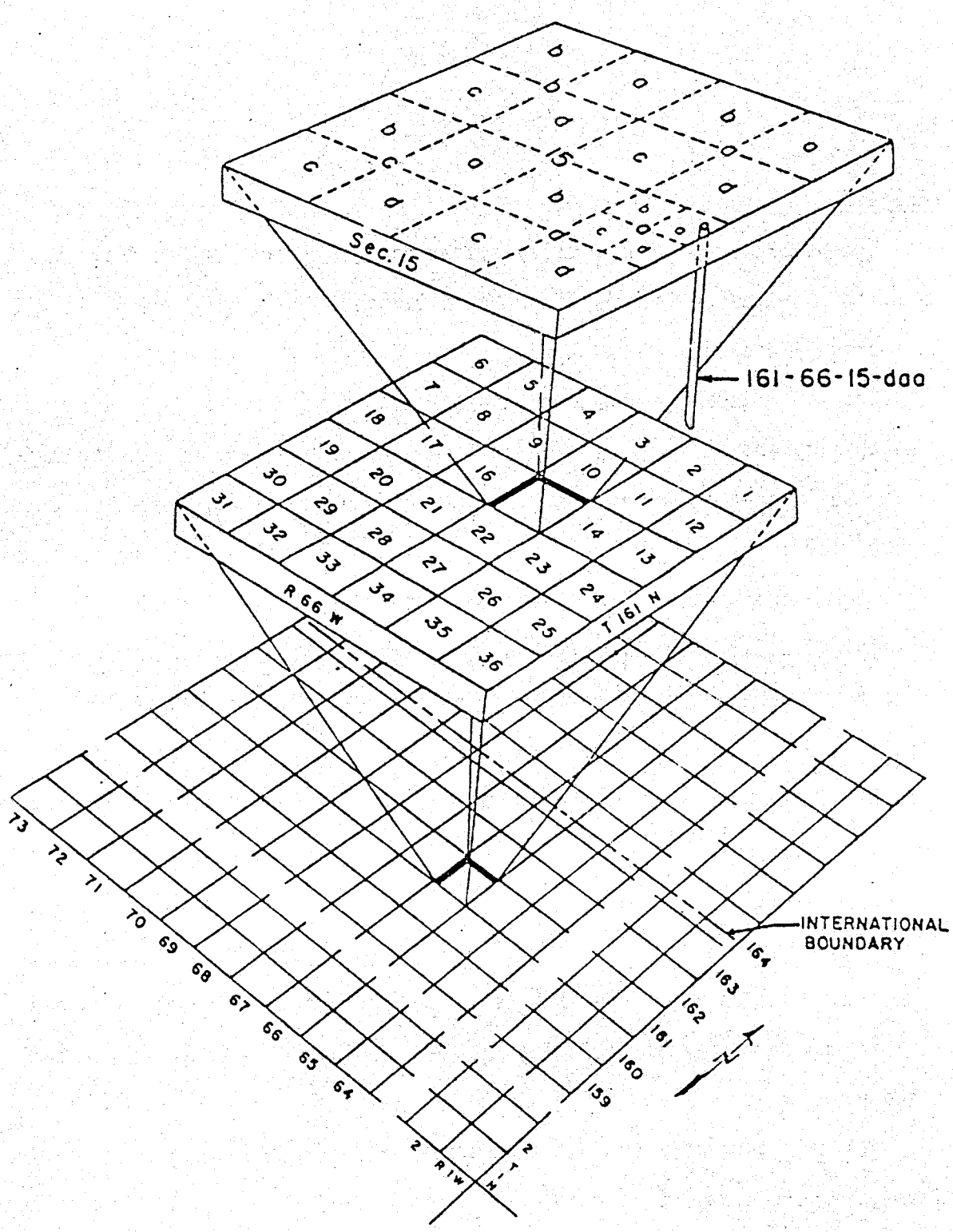


FIGURE 3 - THE LAND OFFICE GRID SYSTEM COARSE LEVEL (LOGSCL) COORDINATE SYSTEM

The first data subset contins water-quality information from analyses performed on water recovered during drill stem tests. N.D.G.S. well number, well location, formation tested, footages of the tested interval, pH, resistivity, and the concentration of major ion species are stored in the subset.

The second data subset contains production statistics from oil and gas wells. This is an internal file and is used only by the N.D.G.S. staff for geologic and engineering studies.

The WELLFILE system is updated as information from newly drilled wells is made public.

A detailed description of the data sources, data elements, system maintenance, and validation techniques is contained in Appendix A. The WELLFILE Data Guide and Coding Guide is included in Appendix B.

WATERCAT

The WATERCAT computer library system manages data from groundwater observation, domestic, and stock wells inventoried by the United States Geological Survey, Water Resources Division (U.S.G.S.W.R.D.) and the North Dakota State Water Commission (N.D.S.W.C.). The library contains information on about 41,000 wells drilled in North Dakota. The source of this data is the U.S.G.S.W.R.D.'s water-well inventory and water-quality files (WATSTOR and GWSI). These two source files were reformatted and combined into our location-oriented library system.

Information stored in WATERCAT includes location, physical, stratigraphic, and water quality data, as available, for each well on file. Location data includes county, township, range, section, quarter-quarter-quarter, and latitude and longitude. Physical data includes total depth, well depth, casing depth, and casing diameter. Stratigraphic data includes the footage of the top of the producing horizon, name of the producing horizon, lithology of the

producing horizon, and the surface elevation. Water quality data include temperature, specific conductance, pH, and the concentration of major ion species.

WATERCAT has one data subset. Temperature and depth data, measured in groundwater observation wells, is maintained as a project file. Information in this subset includes well location, date measured, and temperature-depth values at five- or ten-metre depth intervals. These data are intended to provide accurate, shallow, geothermal gradient data and accurate aquifer water temperature data. It is anticipated that the WATERCAT system will be updated annually.

A detailed discussion of the data sources, data elements, system maintenance, and validation techniques is contained in Appendix A. The WATERCAT Data Guide and Coding Guide is included in Appendix C.

TASKS

Geothermal Gradient and Heat-Flow Studies

This task (Figure 4) involved locating, obtaining access to, and running temperature logs in suitable groundwater observation holes and in "holes-of-convenience", drilled by other agencies or interests, that we cased as heat-flow determination sites. Separate discussions of the procedures followed and our results follow for the geothermal gradient studies and the heat-flow studies.

Geothermal Gradient Studies

Our Phase II temperature logging was geographically limited to those areas of above average geothermal gradient (greater than 30°C/km), indicated by our Phase I study, and the extreme eastern edge of the state, where no oil or gas well data was available (Figure 5). Priority areas for temperature logging were assigned on this basis (Figure 6) and work was concentrated in priority areas one and two. As the field season progressed, it was possible to log most groundwater observation wells in priority area four as well.

Locating suitable groundwater observation wells was accomplished by interrogating WATERCAT for all observation wells in those counties of interest. This resulted in a listing of cased wells, sorted by location, that enabled our field crew to easily locate suitable wells. The North Dakota State Water Commission (NDSWC) and the United States Geological Survey Water Resources Division (USGSWRD) granted access to the wells and temperature logging was conducted from mid-May through early November.

Coding forms and computer storage structures were designed, and all temperature-depth observations have been assembled in a data subset of WATERCAT (Appendices A and C).

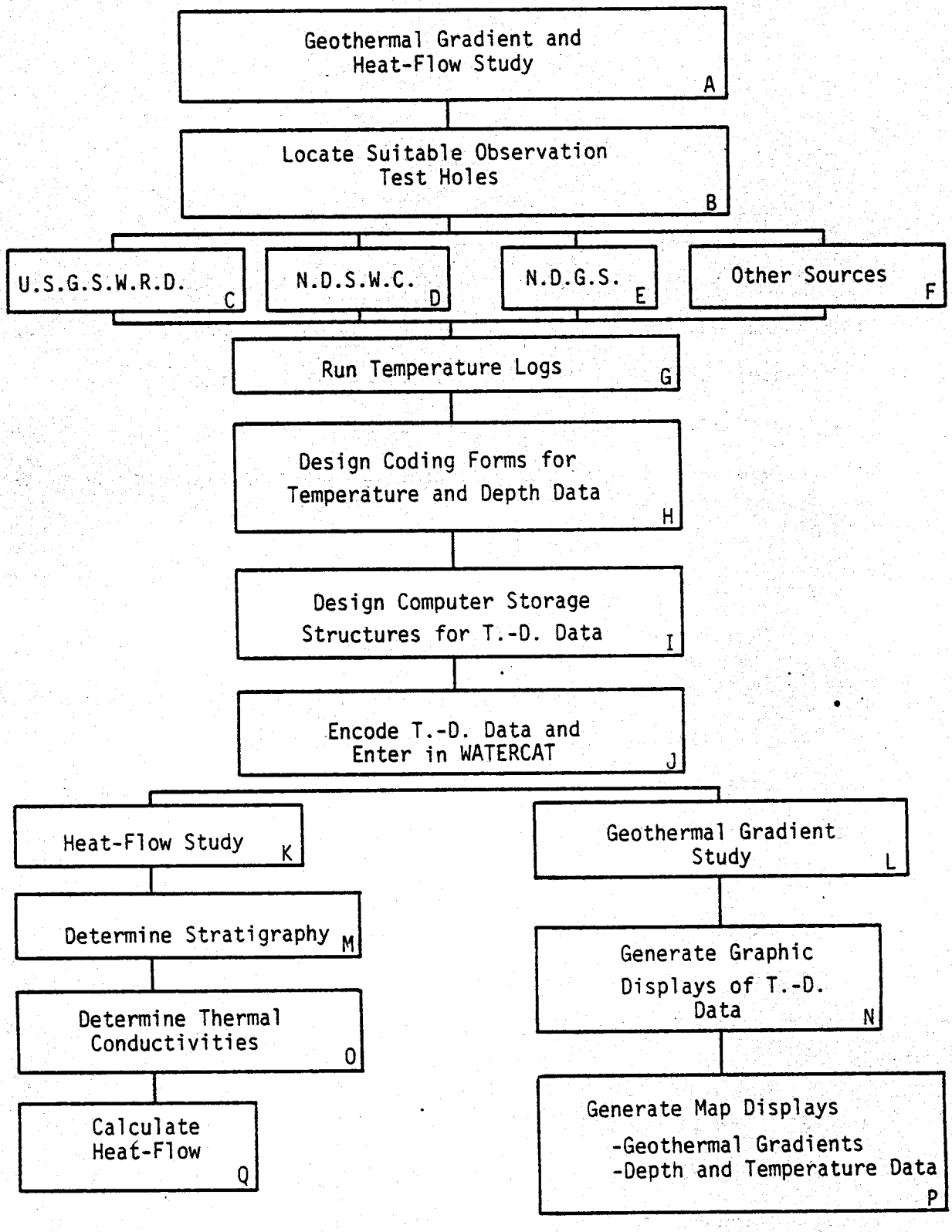


FIGURE 4 - STEPWISE PROCEDURE TO ACCOMPLISH GEOTHERMAL GRADIENT AND HEAT FLOW STUDIES TASK

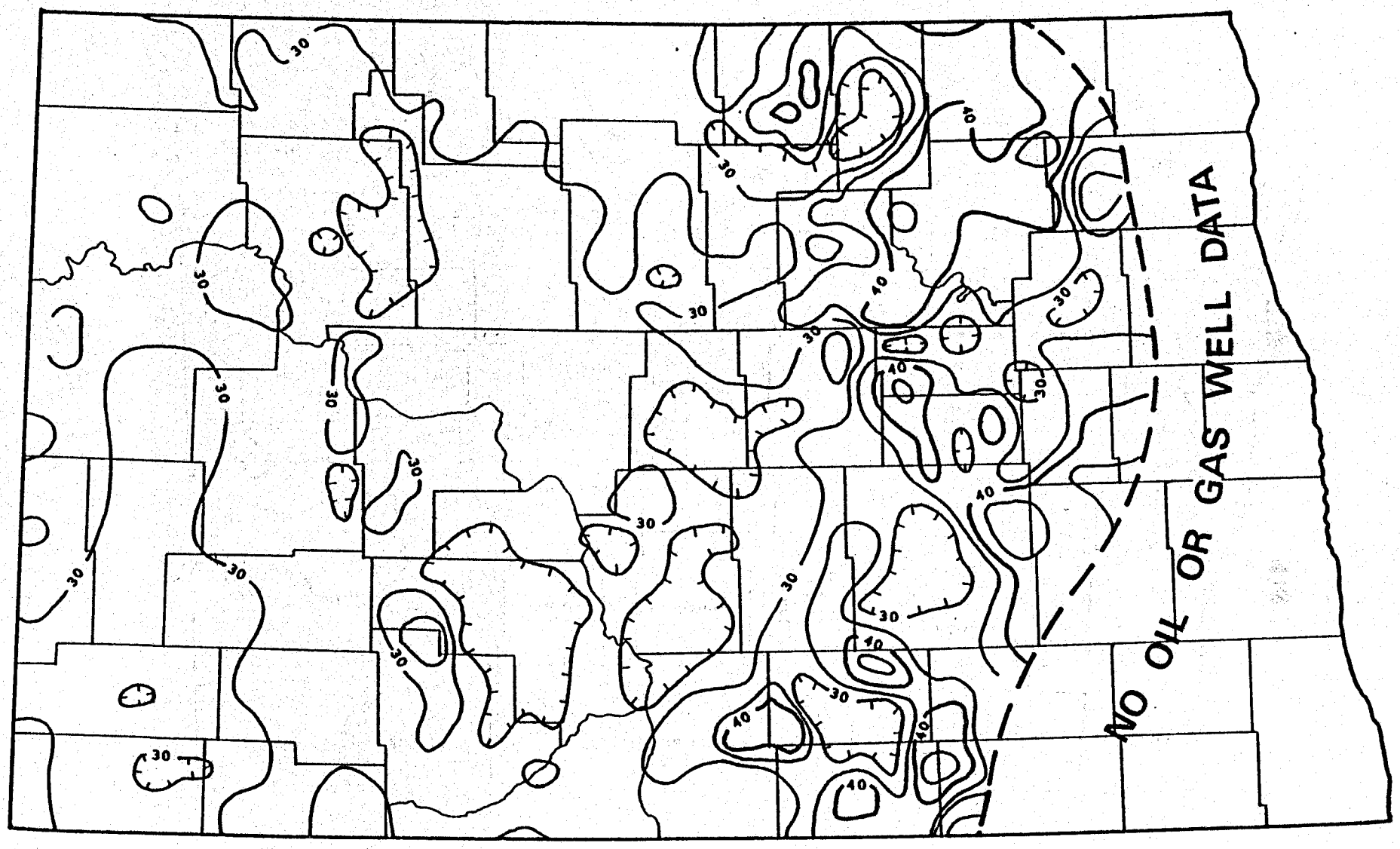


FIGURE 5 - PHASE I GEOTHERMAL GRADIENT MAP OF NORTH DAKOTA (CI = 5°C/KM)

FIGURE 6 - PRIORITY AREAS OF INTEREST FOR PHASE II TEMPERATURE LOGGING

The apparatus used for temperature logging consists of a thermistor probe, a cable reel, and a digital volt-ohm-meter. A calibration curve was determined in the laboratory for the thermistor circuit (±.03°C). Field operations involve lowering the probe down the borehole, allowing the thermistor to reach equilibrium, and measuring the resistance of the thermistor circuit. The digital volt-ohm-meter was used to measure the thermistor resistance, and temperatures were calculated from the calibration curve (±.01°C).

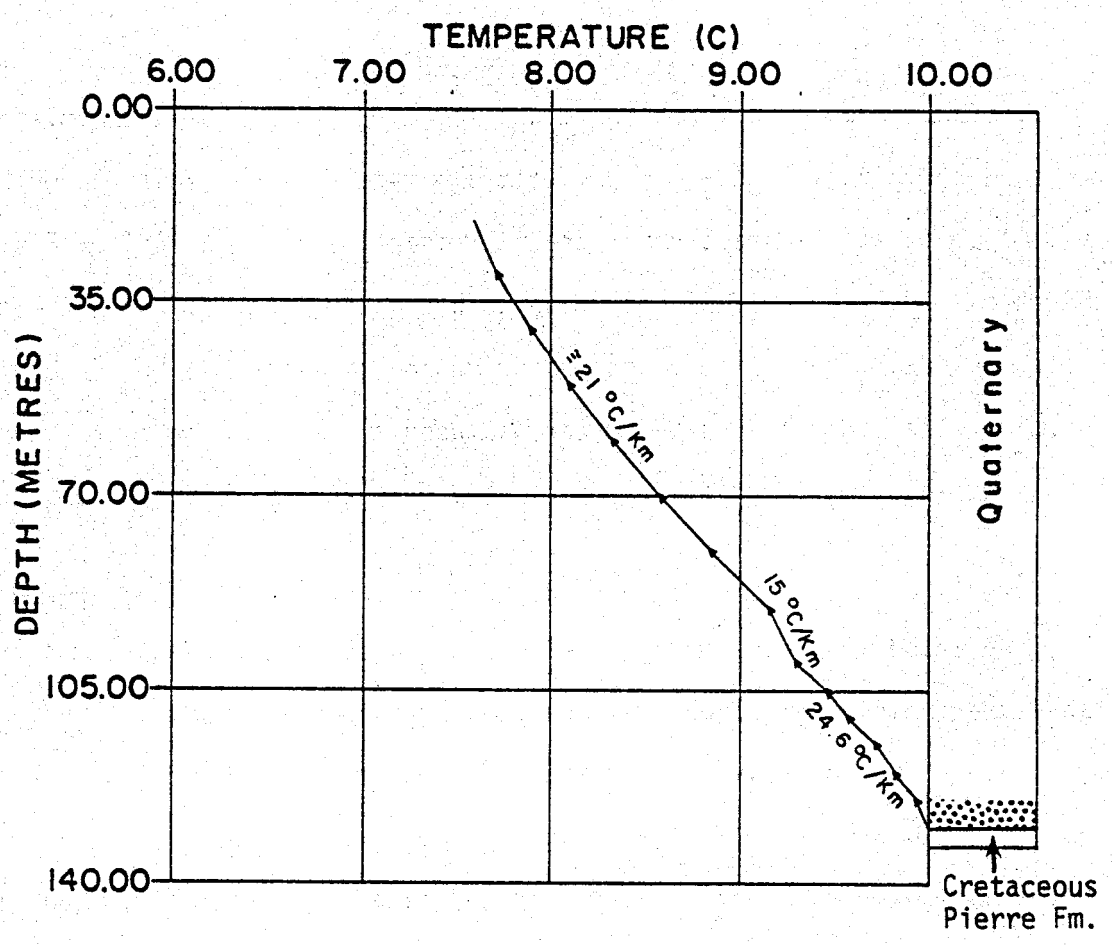
Results

The Phase II geothermal gradient study measured temperatures at five- or ten-metre intervals in about 241 groundwater observation wells in priority areas one, two, and four. This temperature-depth data is stored in WATERCAT and can be summarized graphically and in map form.

Graphical display of the temperature-depth data is accomplished with machine-generated, temperature profiles. A catalog of temperature profiles, for all wells with temperature logs, is maintained to provide potential users with specific local information. Figure 7 shows an example of a machine-generated temperature profile. The plotting routine automatically scales the abscissa and ordinate to accommodate the temperature and depth range encountered. Temperature profiles prove most useful when combined with a geologic description of the well. We are in the process of adding a lithologic data column to each temperature profile. This information will be stored in digital form and be machine-plotted with the temperature profile.

Map summaries of the temperature-depth data include a "shallow" geothermal gradient map and slice maps, showing expected temperatures at selected depths.

Our "shallow" geothermal gradient map (Figure 8) shows machine-contoured, site-average, geothermal gradients calculated in the depth interval of 30 to



Location - La Moure Co., T-133N, R-66W, Section 23, DDD
Date drilled - 10/15/74
Total depth - 134 m (440 ft.)
Surface elevation - 591 m (1940 ft.)
Temp. log run - 08/30/80

FIGURE 7 - AN EXAMPLE OF A MACHINE-GENERATED TEMPERATURE PROFILE

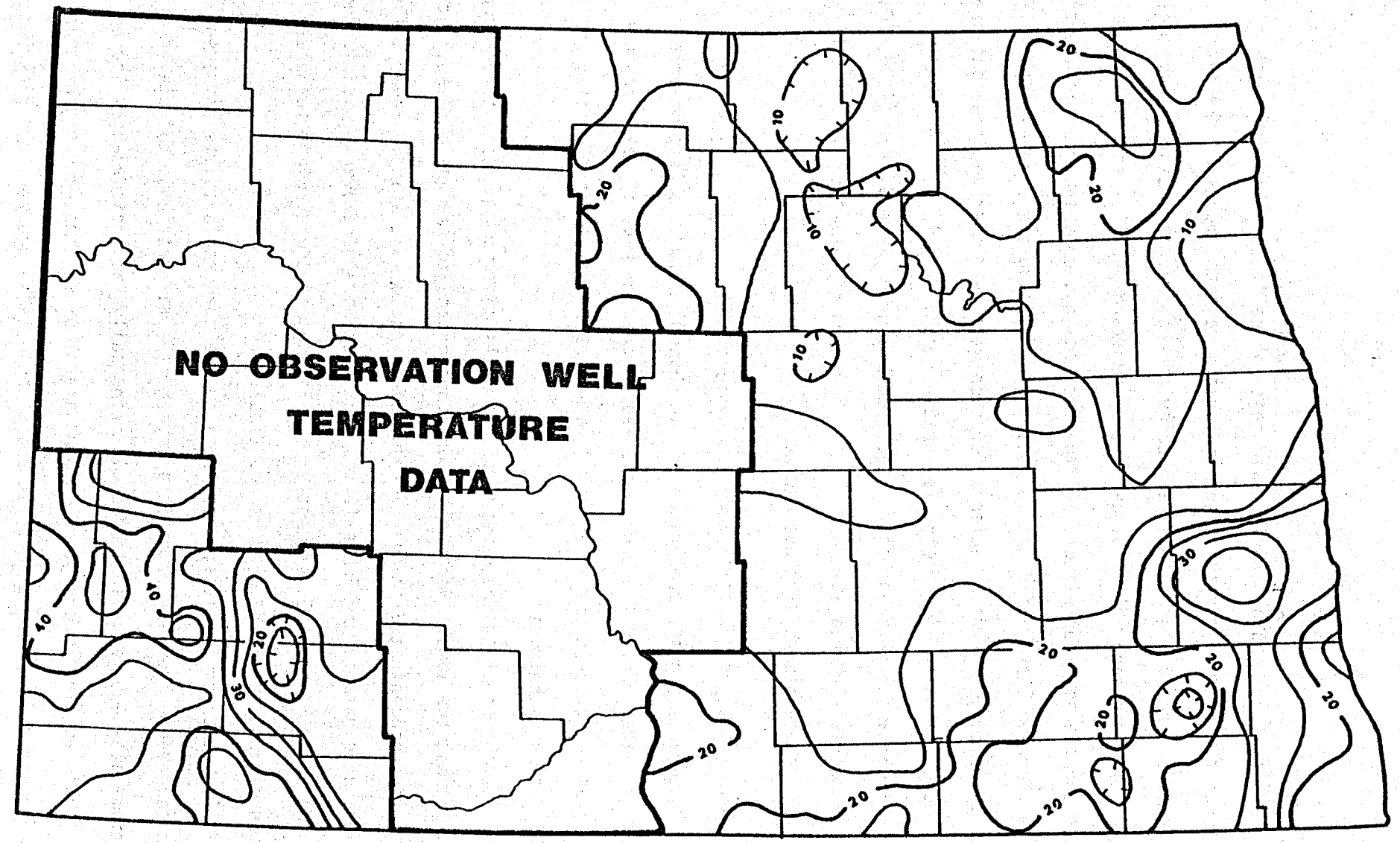


FIGURE 8 - PRELIMINARY "SHALLOW" GEOTHERMAL GRADIENT MAP OF NORTH DAKOTA (CI = 5°C/KM)

100 metres. This depth interval was chosen since it is below the depth of seasonal temperature variation and includes a maximum amount of the data collected. Interval gradients were calculated between adjacent temperature observations in each well. Since some temperature profiles show isothermal zones and the spurious effects of imperfect casing, only interval gradient values between 8 and 80°C/km were used in calculating the site-averages. The site-average, geothermal gradients for each well were then machine-contoured to produce the "shallow" geothermal gradient map.

Slice maps have been constructed from measured temperatures at 30, 50, and 80 metres (Figures 9, 10, and 11). These machine-contoured maps show the expected temperatures at these depths.

Phase I vs. Phase II Geothermal Gradient Maps

Figure 12 shows a comparison of our Phase I and Phase II geothermal gradient data. The differences observed in the two sets of data can be attributed to at least three factors: well control, depth of the data, and calculation techniques.

The distribution and density of the wells contributing data to the two maps is not the same. More wells contributed data to the Phase I map, but they were concentrated in the western two-thirds of the state. Fewer wells contributed data to the Phase II map, but they were more evenly distributed in the areas mapped. Consequently, the "shape" of the gradient features shown can not be expected to be identical.

The depth of the data, used to calculate the gradients, is different for each map. The Phase I map displays geothermal gradients calculated from bottom-hole-temperatures recorded in principally Paleozoic rocks. These Paleozoic aquifers are regional groundwater flow systems, and higher than average gradients result in those areas where these aquifers are closer to the surface.

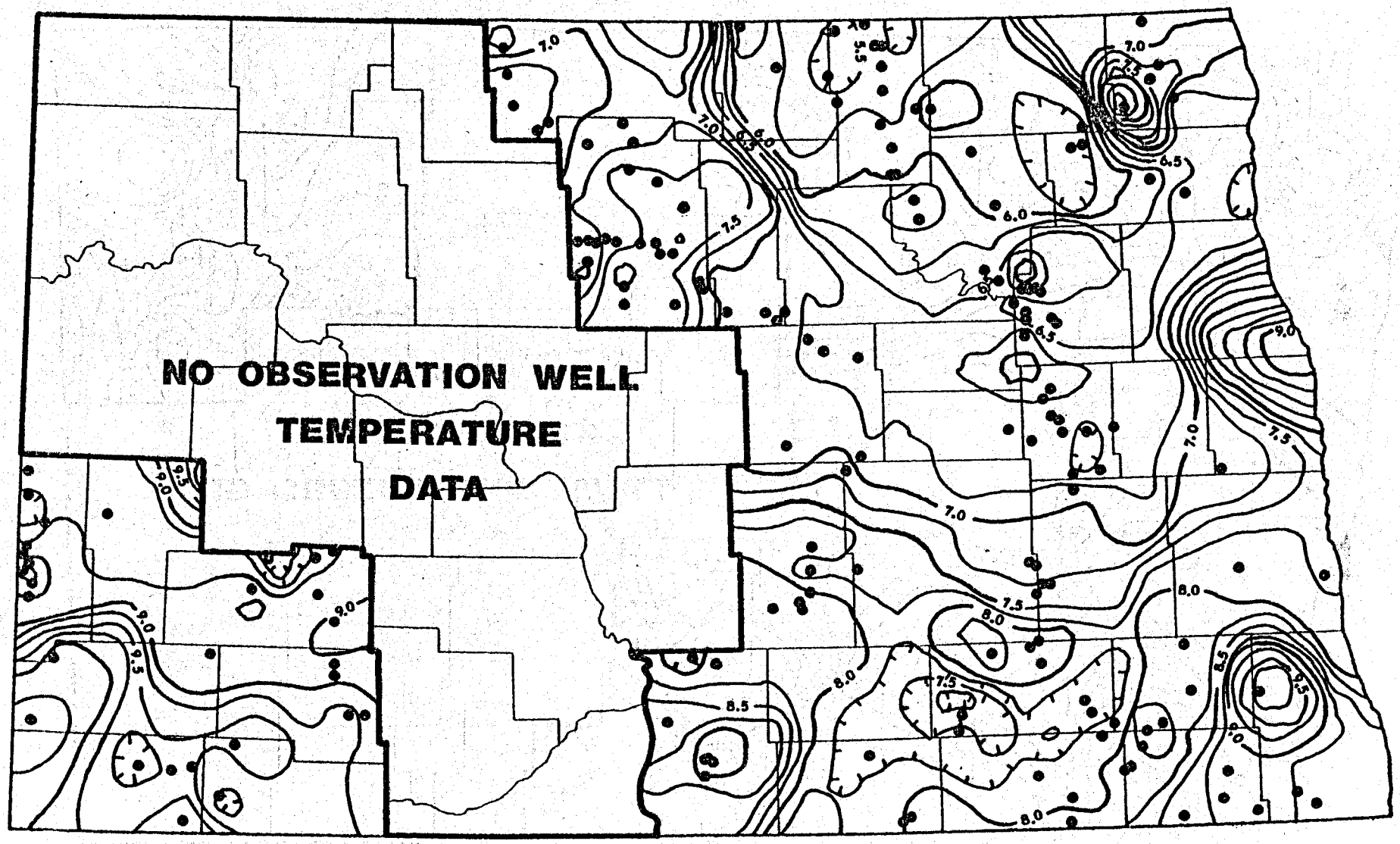


FIGURE 9 - "SLICE" MAP SHOWING EXPECTED TEMPERATURES AT 30 METRES (CI=.25°C)

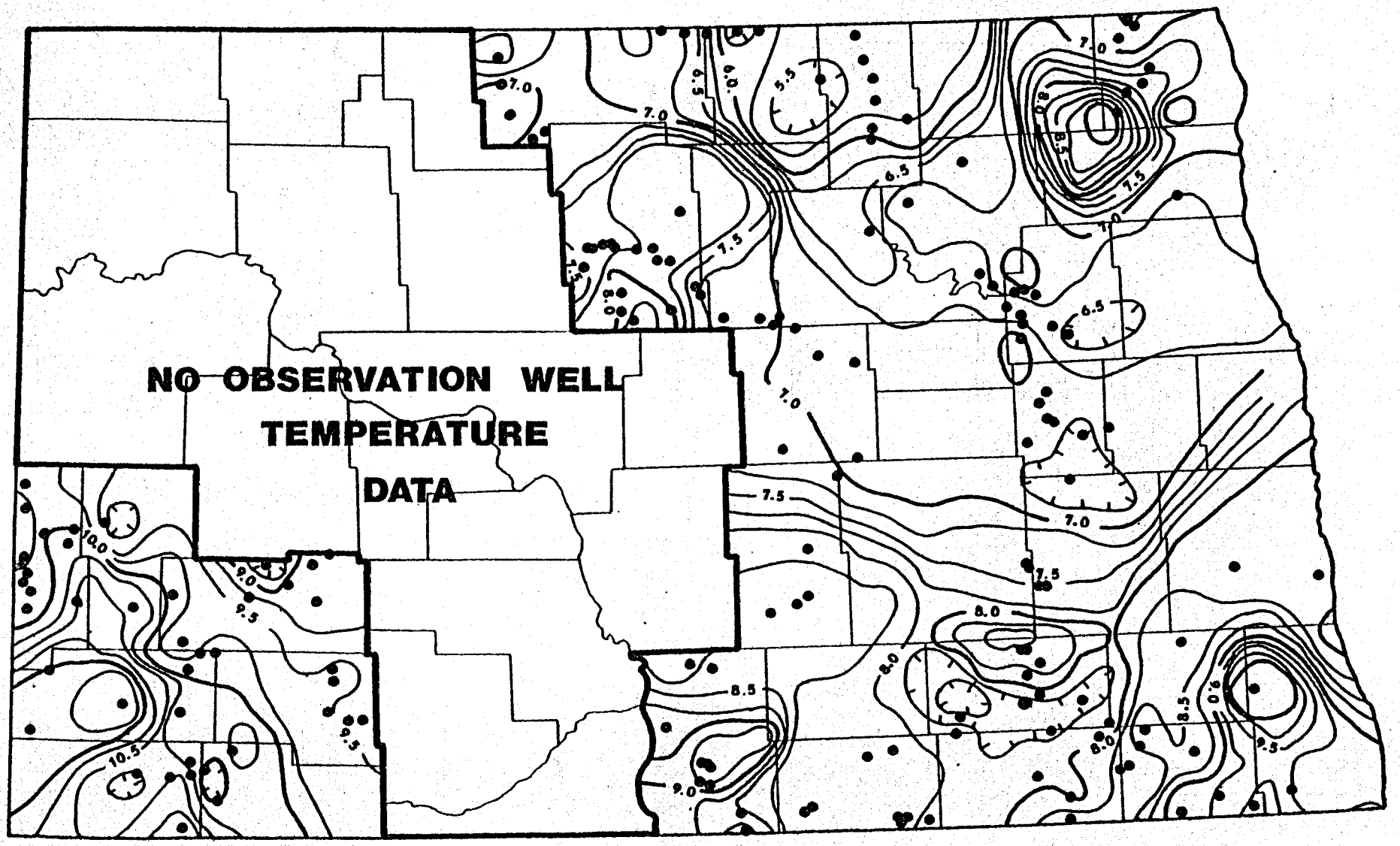


FIGURE 10 - "SLICE" MAP SHOWING EXPECTED TEMPERATURES AT 50 METRES (CI=.25°C)

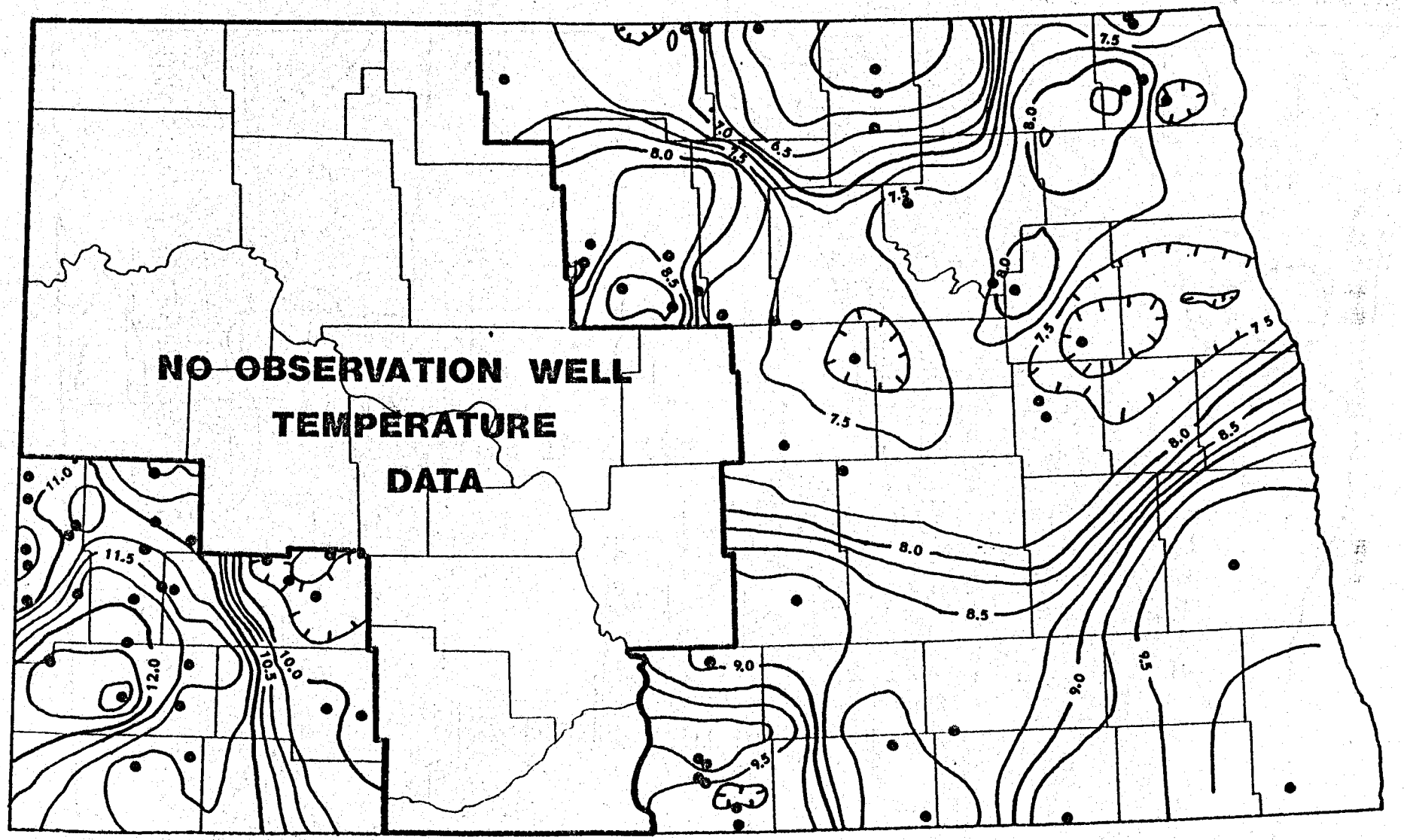


FIGURE 11 - "SLICE" MAP SHOWING EXPECTED TEMPERATURES AT 80 METRES (CI=.25°C)

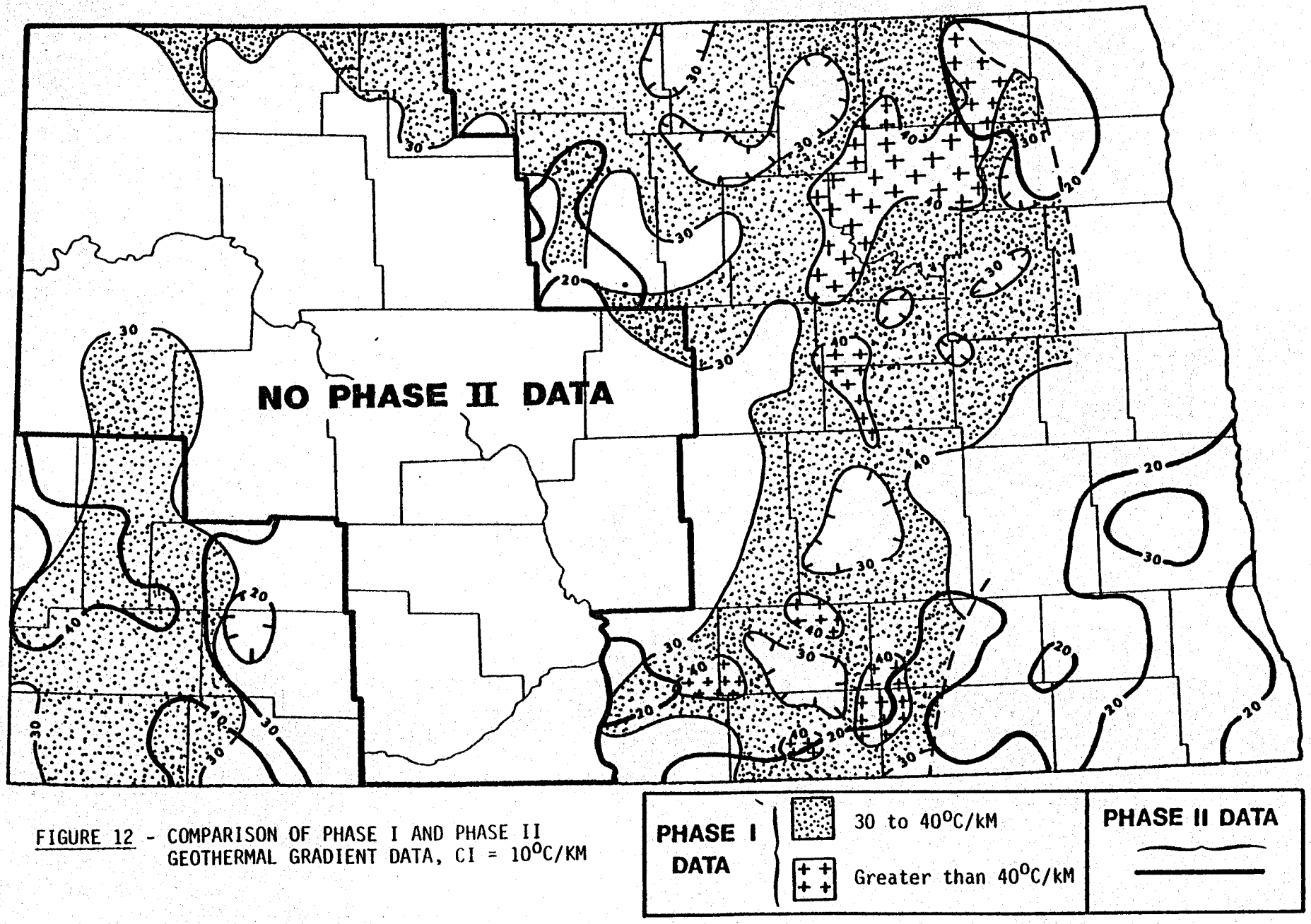


FIGURE 12 - COMPARISON OF PHASE I AND PHASE II GEOTHERMAL GRADIENT DATA, CI = 10°C/KM

The Phase II geothermal gradient map displays site averages of interval gradients from wells located in three geologic settings: shallow, local groundwater systems in Quaternary sediments; shallow, local groundwater systems in Quaternary sediments, in hydraulic communication with deeper regional aquifer systems; and shallow, regional and subregional groundwater systems in Tertiary rocks.

The shallow, local groundwater systems in Quaternary sediments are found in the northeastern one-half of the state. Gradients calculated from temperature logs run on wells in this setting are low (10 to 20°C/km).

In some areas these shallow, local groundwater systems are in hydraulic communication with deeper, Cretaceous and older regional groundwater systems. In these areas the warmer water from the deeper aquifers results in higher temperatures and consequently, higher gradients. This "leakage" also results in higher piezometric heads and poorer water quality.

The techniques used for calculating the gradients on the two maps was different. The Phase I map is based on gradients calculated from oil and gas well bottom-hole-temperature and total depth using the following expression:

$$\text{Grad.}(^{\circ}\text{C/km}) = \frac{\text{BHT}(^{\circ}\text{F}) - 40^{\circ}\text{F}}{\text{Total Depth (Feet)}} \quad (1823)$$

This calculation assumes a linear geothermal gradient from total depth to surface, and a mean annual surface temperature of 4.4°C (40°F). Neither of these assumptions is absolutely correct, but the linear gradient is least correct.

Shallow geothermal gradients were calculated by averaging the interval gradients, between adjacent temperature observations, in each well logged. Isothermal zones in aquifers and water movement behind poorly cemented casing caused spurious gradient profiles. In order to eliminate these effects, only

interval gradients between 8 and 80°C/km were used in calculating the site average. Only temperature observations in the depth interval of 30 to 100 metres were used. Temperatures measured shallower than 30 metres are influenced by seasonal temperature fluctuations and recharge in shallow aquifers. In order to maximize the amount of data available, only observed temperatures shallower than 100 metres were used.

A linear projection of most shallow gradient profiles intercepts the ground surface at temperatures of from 5-10°C. Thus, the assumed 4.4°C (40°F) surface temperature used for the Phase I map is not correct. On the other hand, if shallow well gradients are calculated from a single temperature observation and an assumed surface temperature of 4.4°C (40°F), the resulting gradients would be higher than they actually are.

It is our conclusion that both the Phase I and Phase II gradient maps are useful. The Phase I map is useful for indicating areas of relatively higher geothermal gradients to Paleozoic aquifers. The Phase II map is useful for indicating the relative geothermal gradient to Quaternary and Tertiary aquifers. The slice maps and geothermal gradient profiles provide expected and actual temperatures present in shallow aquifers. This information has proven to be invaluable in satisfying requests by potential users for site-specific information.

Heat-Flow Studies

Existing Heat-Flow Data

The heat flow measurements completed prior to this project are summarized in Figure 13. It is difficult to reliably measure the thermal conductivity of drilling cuttings from sedimentary rocks. This problem leads to the variable results shown. Consequently, even though some of these measurements show standard errors less than ten percent, the absolute value of the heat flow

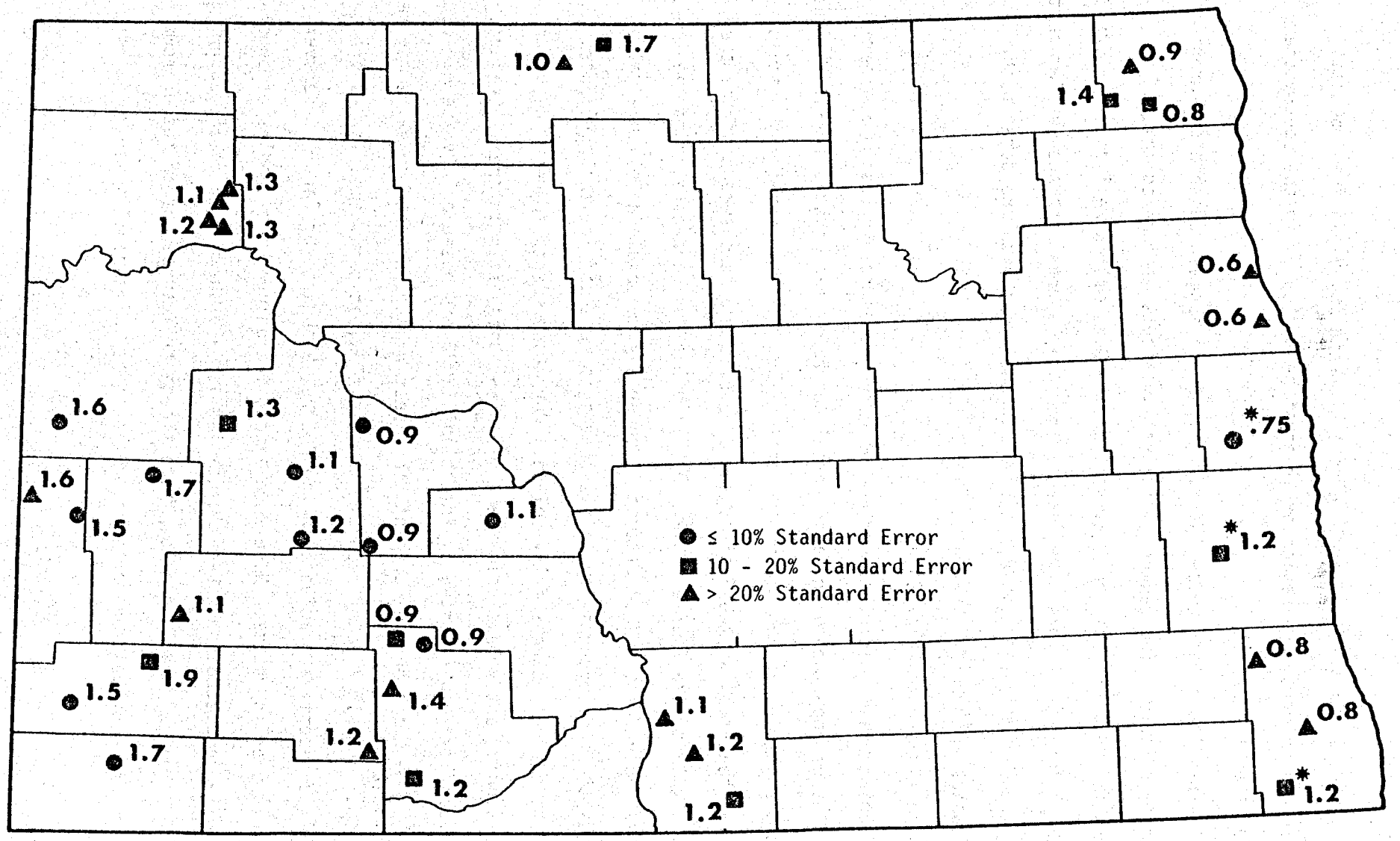


FIGURE 13 - HEAT FLOW VALUES DETERMINED IN NORTH DAKOTA; DATA SHOWN IN HFU = 1 x 10^{-6} CAL/CM^2SEC; ALL VALUES FROM SCATTOLINI, 1978 EXCEPT THOSE MARKED BY * WHICH ARE FROM ZABEL, 1979

reported is not very reliable. The general trend suggested from the data, however, is evident; the region of greatest heat flow is in the southwestern part of the state.

The results of the Phase I study (Figure 5) suggest quite a different heat flow pattern. The region of largest gradients is located toward the eastern fringe of the oil and gas well data. Our shallow well data (Figure 8), though incomplete at this time, seems more in agreement with the earlier heat flow data of Scattolini (1978), and not inconsistent with the data in the southeastern corner of the state (Zabel, 1979).

Additional Heat-Flow Data

During Phase II of this project, we were successful in casing and cementing two holes of opportunity in east-central North Dakota (Figures 14 and 15) which penetrate the Cretaceous Pierre formation. Determining a value for the terrestrial heat flow at these sites would require the measurement of the thermal conductivity of the Pierre Shale. Drilling cuttings and core, from the Pierre, are available to us and an attempt is under way to obtain a reliable value for its thermal conductivity. This proves to be a difficult experimental problem, not yet successfully solved. Our measurements suggest the value to be significantly less than the 4 $\frac{\text{m cal}}{\text{cm sec}^{\circ}\text{C}}$ used often in the literature. The heat flow data reported by Scattolini (1978) is based on a value of about 3.4 $\frac{\text{m cal}}{\text{cm sec}^{\circ}\text{C}}$ and our measurements this past winter suggest the value may be even smaller. In lieu of reporting a heat flow, at this time, it has proven useful to determine gradients in the Pierre, Niobrara, or Carlile wherever possible over the state. Nine such sites, including the two holes of opportunity we completed, have been identified and are shown (Figure 16) superimposed on the "shallow" gradient data. Note the general agreement in the extreme eastern and southwestern portions of the state. Figure 17 superimposes the

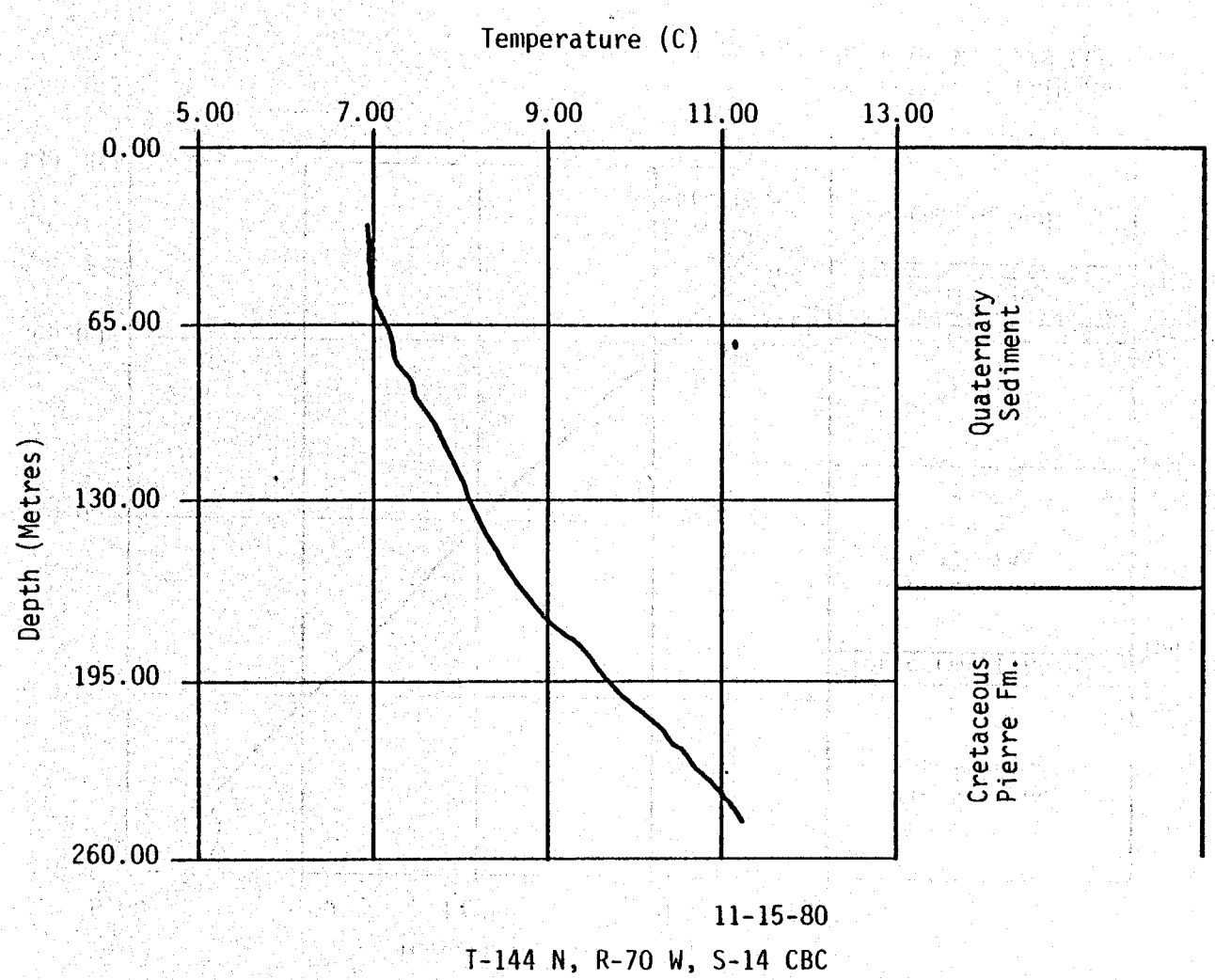


FIGURE 14 - TEMPERATURE PROFILE OF THE KIDDER COUNTY HEAT FLOW SITE

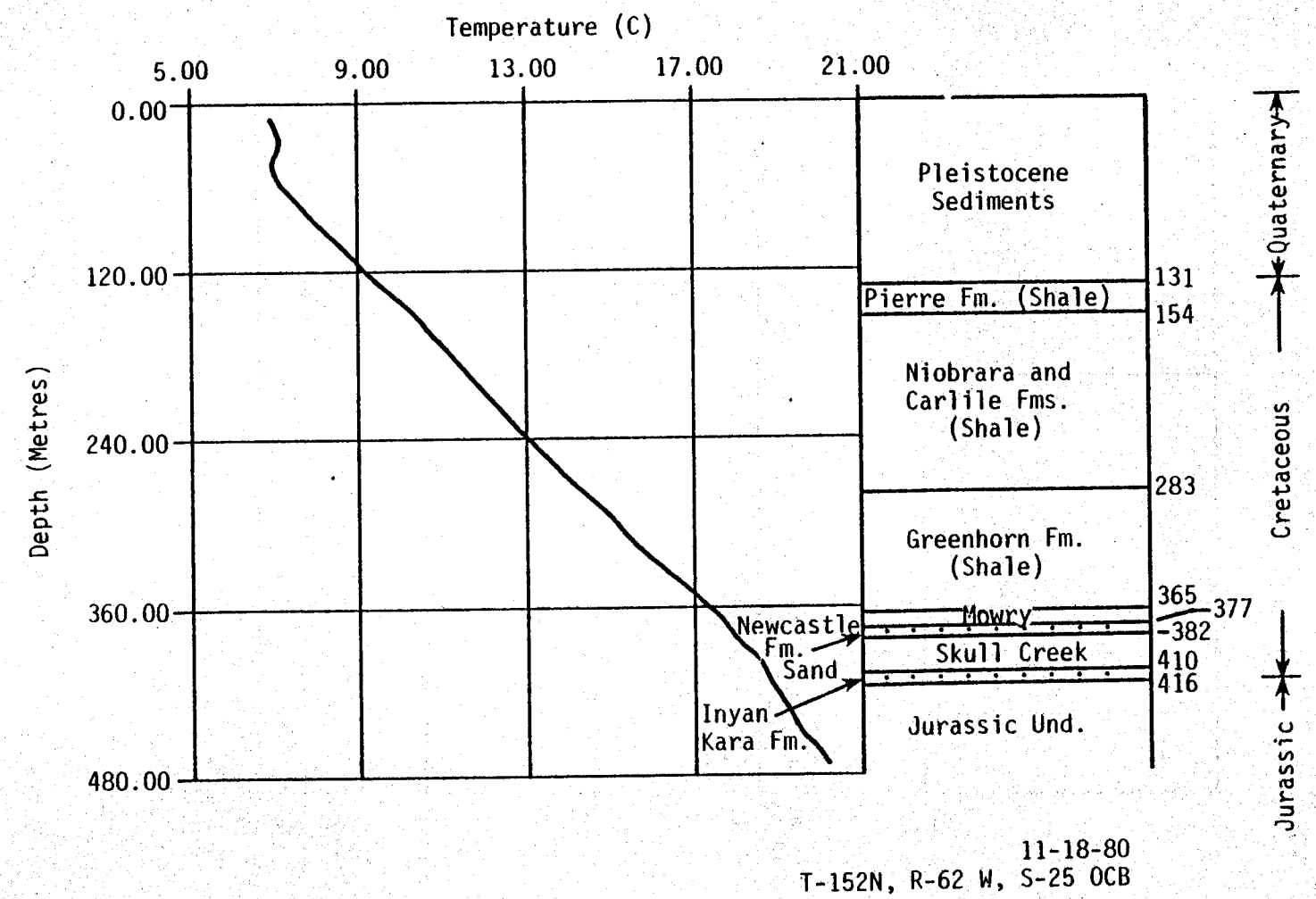


FIGURE 15 - TEMPERATURE PROFILE OF THE RAMSEY COUNTY HEAT FLOW SITE

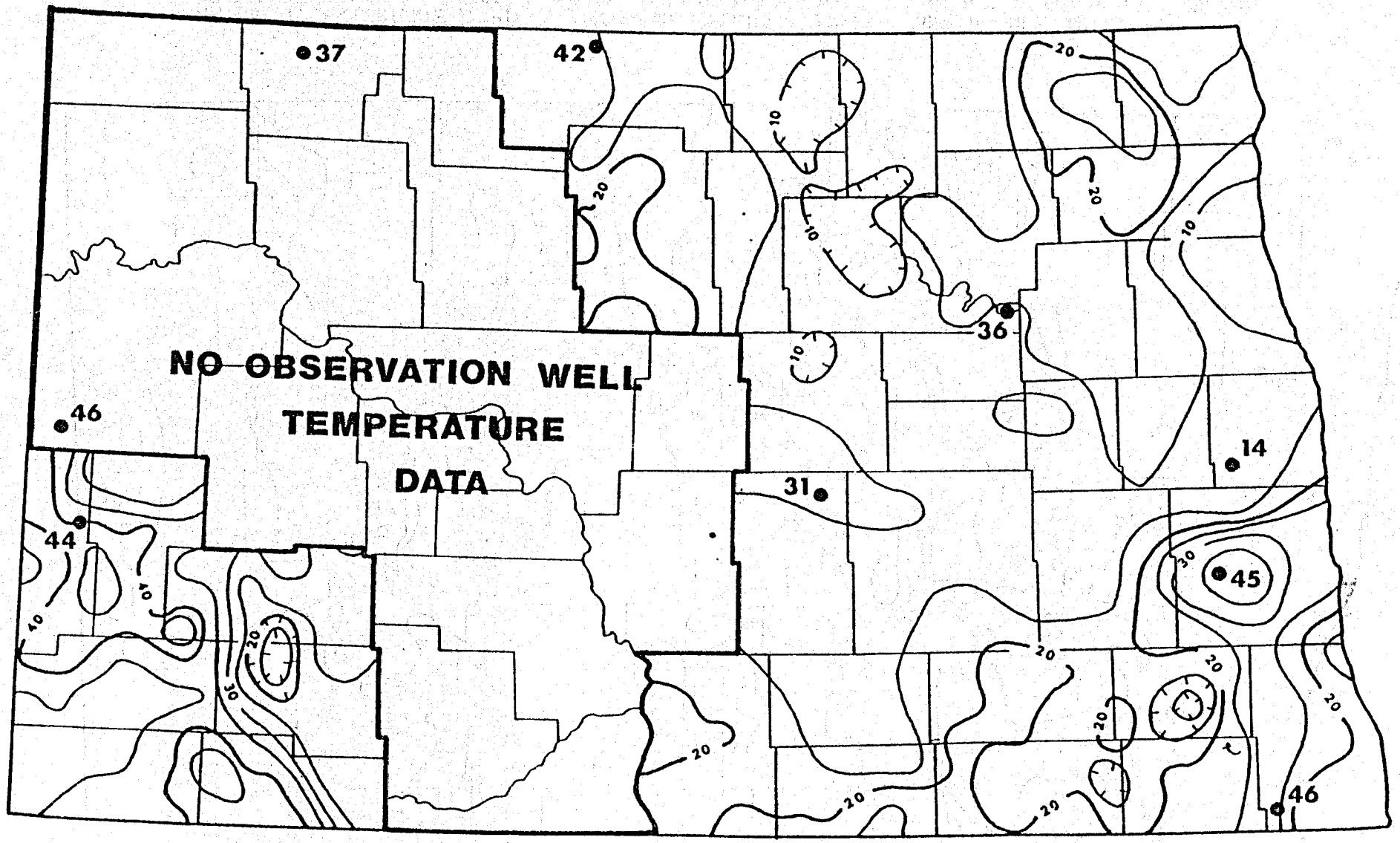


FIGURE 16 - GRADIENTS IN THE CRETACEOUS PIERRE FORMATION SUPERIMPOSED ON THE PRELIMINARY "SHALLOW" GEOTHERMAL GRADIENT MAP OF NORTH DAKOTA (CI = 5°C/KM)

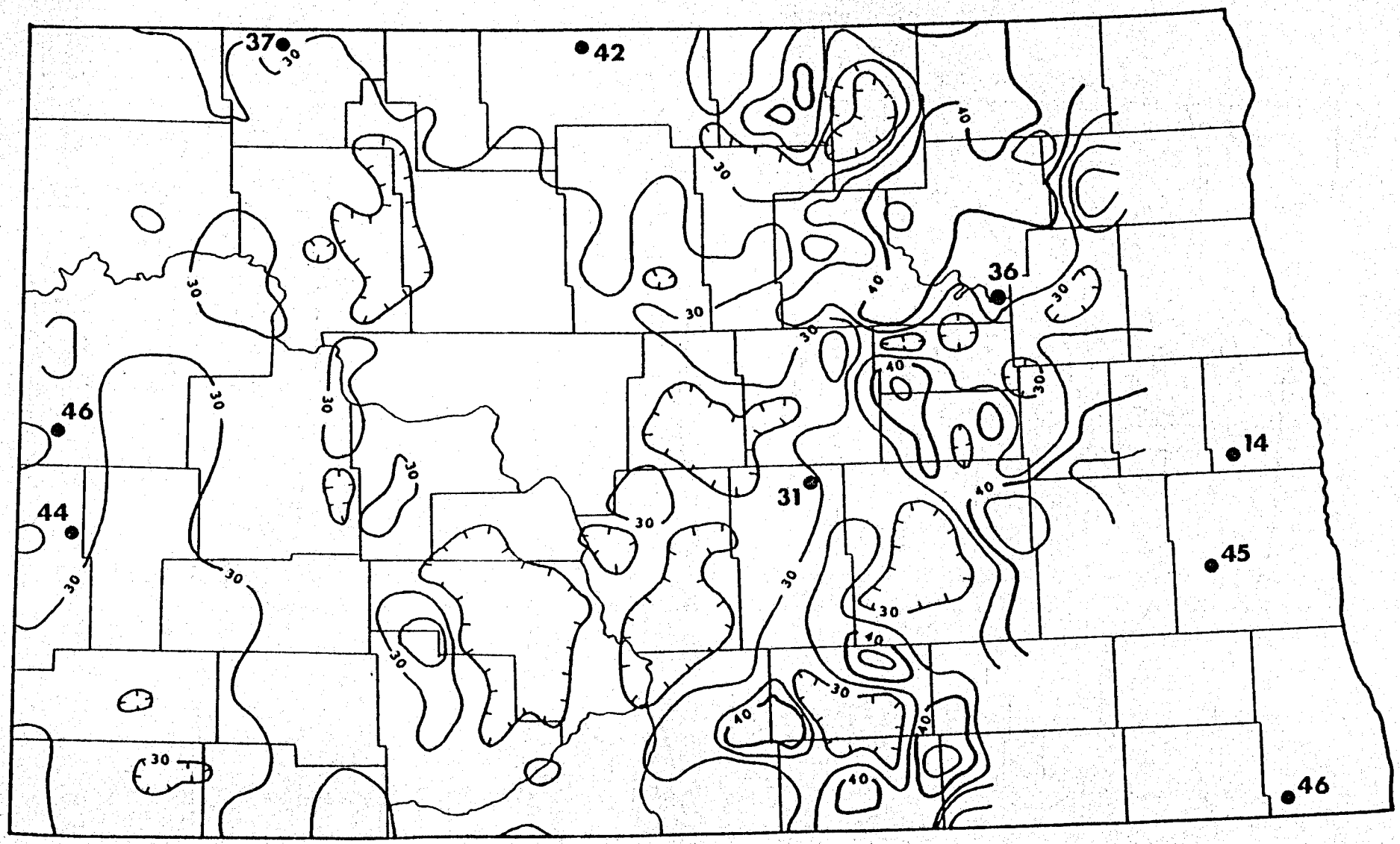


FIGURE 17 - GRADIENTS IN PIERRE FORMATION SUPERIMPOSED ON OIL AND GAS WELL BOTTOM HOLE TEMPERATURE BASED GRADIENT MAP OF NORTH DAKOTA (GRADIENTS IN $^{o}C/KM$, CI = $5^{o}C/KM$)

Cretaceous shale gradients on our Phase I gradient map, based on oil and gas well data. Here the agreement in the western part of the state is not as good, but turns out to be almost exact, for the two holes of opportunity, in east-central North Dakota. This relationship is thought to be governed by the depth of the oil and gas well data, which in the area of agreement is only slightly greater than the depth of the Cretaceous Shales. Figure 18 shows the temperature profile for a site in Golden Valley County, North Dakota, with a gradient through the Pierre of 44°C/km. Note the variation in gradient below the Mowry. Since the oil and gas well data from the western portion of the state is based on bottom-hole-temperatures at depths of 2500-4300 m, the thermal conductivity of the materials below the Cretaceous is reflected as a smaller average gradient.

Summary

The results of our examination of the gradients through the Cretaceous shales indicate the general heat flow pattern over the state, and at the same time help us to interpret both the oil and gas well, and the shallow water well gradient data. This field season we will attempt to gain access to several additional holes of opportunity drilled into or through the Pierre Shale. Gradients measured in the Pierre from sites distributed over the state would then enable us to generate a heat flow map based on a reliable value for the thermal conductivity of the Pierre shale.

Stratigraphic Studies

The goal of this task is to construct geologic maps of potential hydrothermal aquifers in the state.

Phase I Stratigraphic Studies

The Phase I study collected stratigraphic data from oil and gas wells drilled in North Dakota and assembled that data in the computer library

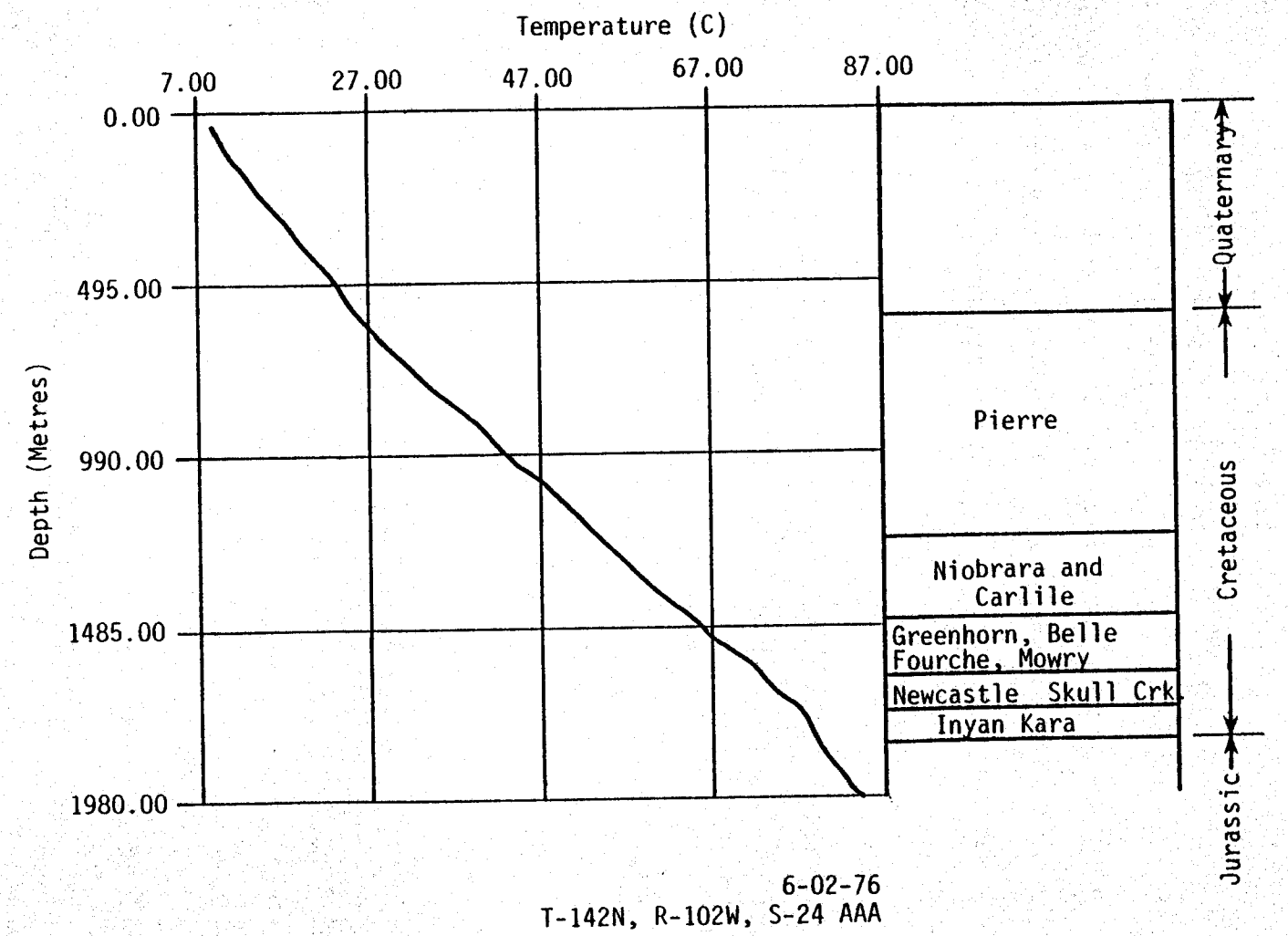


FIGURE 18 - TEMPERATURE PROFILE OF A WELL IN GOLDEN VALLEY COUNTY, NORTH DAKOTA

WELLFILE. This data has enabled us to construct structural maps on fourteen selected formations and an isopach map of the Mississippian Madison Formation (Appendix E).

Phase II Stratigraphic Studies

Our Phase II stratigraphic studies (Figure 19) involved identifying potential Mesozoic and Cenozoic aquifers and compiling additional stratigraphic data, in order to evaluate these aquifers. All Mesozoic and Cenozoic aquifers were of interest, but emphasis was placed on the Cretaceous Inyan Kara Formation.

The data bases used for our Phase II stratigraphic study consisted of WELLFILE and WATERCAT (Appendices A, B, and C).

WELLFILE was updated and expanded so it now accommodates 47 formation tops. Data from new wells, being added to the system, includes the footages of the new formation tops.

WATERCAT contains a stratigraphic identification of the aquifers producing water. These identifiers are compatible with the stratigraphic identifiers used in WELLFILE, but are based on stratigraphic data contained in the original U.S.G.S. source tapes. The geographic distribution of this data isn't satisfactory for producing machine-contoured maps of the state. The U.S.G.S. stratigraphic data has been collected over about the last twenty years, and a certain amount of confusion in the stratigraphic nomenclature is found. For instance, in the southeastern part of North Dakota, the Cretaceous Newcastle Sand is considered part of the Cretaceous Inyan Kara Formation. As a result, the quality of the stratigraphic data contained in WATERCAT will not permit structural mapping of aquifers at this time. We will be logging all suitable groundwater observation wells, in the western half of North Dakota, this field season. This project will use our small diameter gamma-ray tool

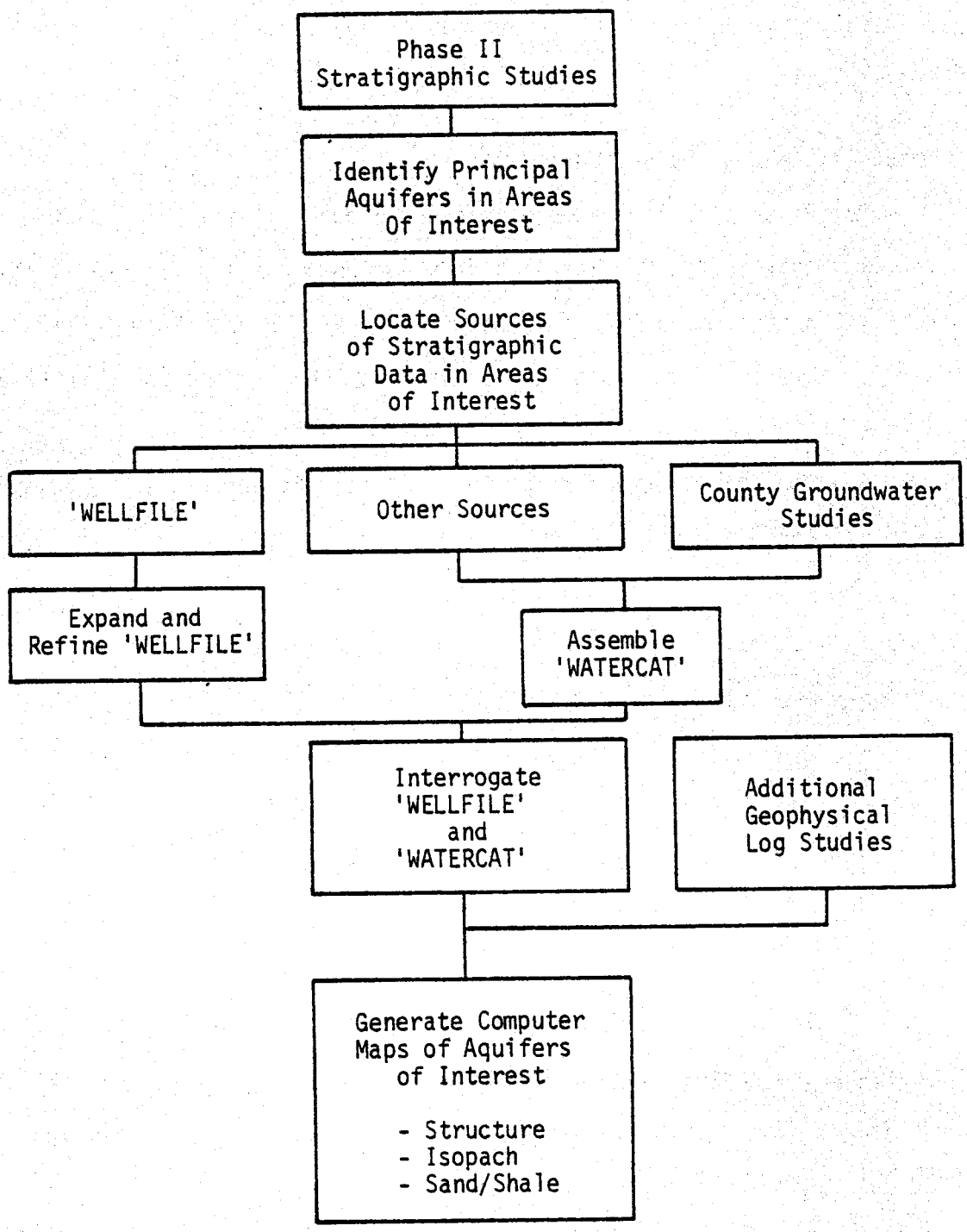


FIGURE 19 - STEPWISE PROCEDURE USED FOR PHASE II STRATIGRAPHIC STUDIES

and the work will be done in cooperation with a Teritary stratigraphic study being conducted by the N.D.G.S. Formation tops, interpreted from these logs, will be stored in WATERCAT. The addition of reliable stratigraphic data to WATERCAT should enable us to generate the needed structural maps.

Two other studies are providing information that will ultimately be useful in evaluating the hydrothermal resources of Mesozoic and Cenozoic aquifer systems.

Dr. Walter Moore, University of North Dakota Geology Department, has worked for the past two years, in cooperation with the N.D.G.S., on a study of the Cretaceous Inyan Kara Formation. His study utilized geophysical logs, on file with the N.D.G.S., and produced several cross-sections and an isopach map of the Inyan Kara Formation in North Dakota. Although unpublished, the results of his study are available through the N.D.G.S.

The U.S.G.S.W.R.D. has been involved in regional aquifer studies for several years. Dr. Ray Butler, of their Bismarck office, has been working with Mesozoic and Cenozoic aquifer systems in the region. The U.S.G.S. expects the results to be available during the third quarter of 1981. Their study will produce structural and isopach maps of major aquifer systems, as well as hydrologic and geochemical models and maps.

It is hoped that we will be able to include the results of these studies in the user-oriented data summary planned for Phase III.

Cretaceous Inyan Kara Formation

Structural, isopach, and sand/shale ratio maps were constructed, for the Cretaceous Inyan Kara Formation, during the Phase II study. All available geophysical logs, in the N.D.G.S. log library, penetrating this formation were studied, and the data was entered in WELLFILE.

Our structural map (Figure 20) shows that the Inyan Kara Formation is present throughout most of the state. The elevation of the formation ranges from about 100 metres, in the east, to about -1,000 metres, in the west. Our structural map was constructed by contouring the township-average elevations of the top of the Inyan Kara Formation. Figure 21 shows the location of townships contributing well control to the map.

Major structural features, evident on the map, include the Williston Basin and the Nesson Anticline. The basin configuration, the tendency for contour lines to describe concentric circles, can be seen in the western one-half of the state. This basin configuration is interrupted, in northwestern North Dakota, by the southward projection of th Nesson Anticline into the basin. The anticline is clearly shown by the -800 metre contour line.

The Inyan Kara isopach map (Figure 22) was constructed by recording formation thickness from all logs penetrating the unit, and contouring the township-average thickness values. Figure 23 shows the location of townships contributing well control to the map. The thickness of the Inyan Kara Formation ranges from about 30 metres, in the east, to more than 150 metres, in the center of the Williston Basin, and shows a tendency to thin in the area of the Nesson Anticline.

A sand/shale ratio map (Figure 24) was constructed for the Inyan Kara Formation. The footages of sand and shale were recorded from each geophysical log penetrating the formation, and entered in WELLFILE. The summation of sand footage was divided by the summation of shale footage for each well; and the township-average of these ratios was mapped. Figure 25 shows the location of those townships contributing data to the map. A ratio of one means equal footages of sand and shale. A ratio of two means twice as much sand footage, compared to the shale footage, is present. These ratios, when used with the

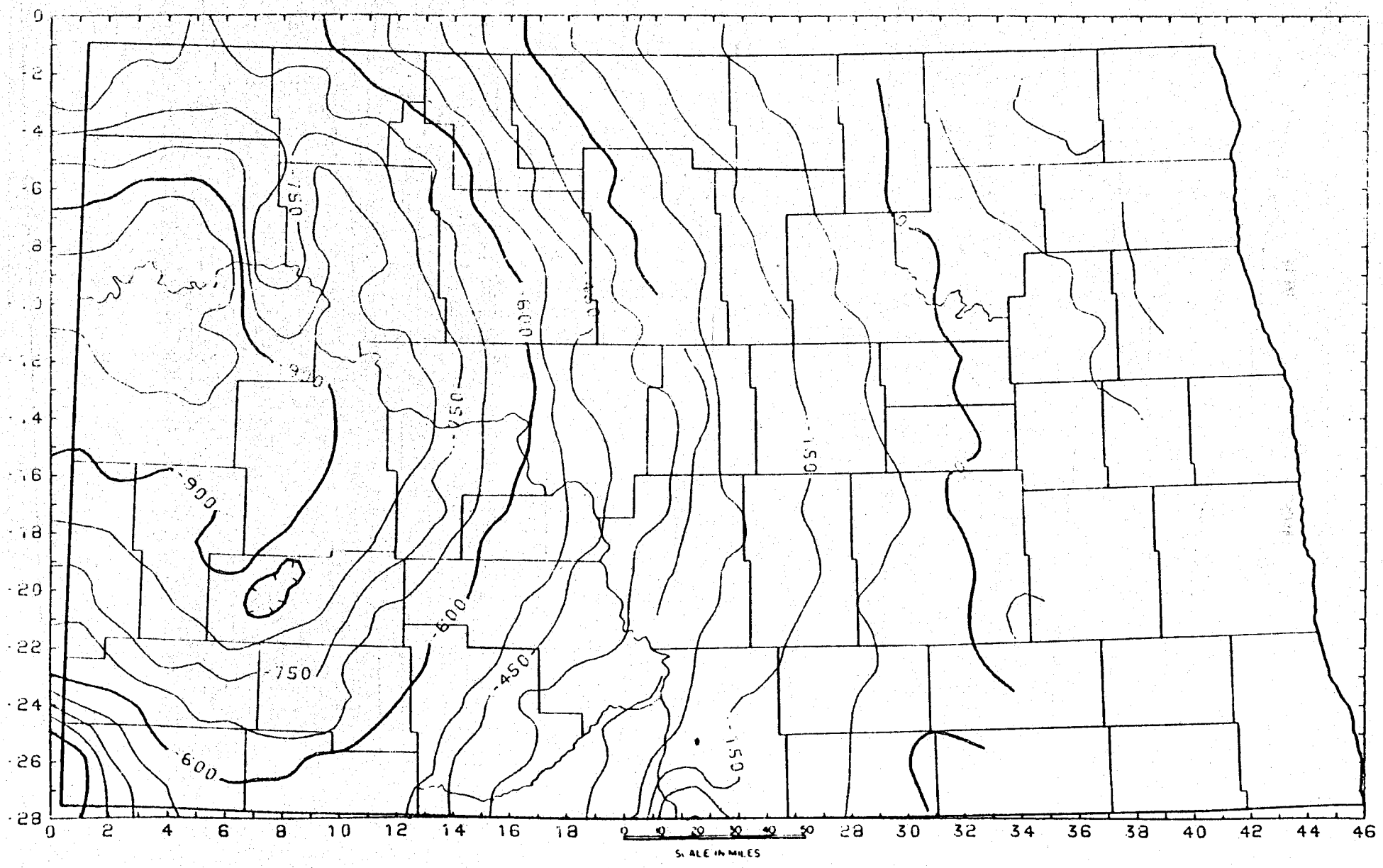


FIGURE 20 - STRUCTURE MAP ON TOP OF THE CRETACEOUS INYAN KARA FORMATION. CONTOUR INTERVAL IS 75 METRES

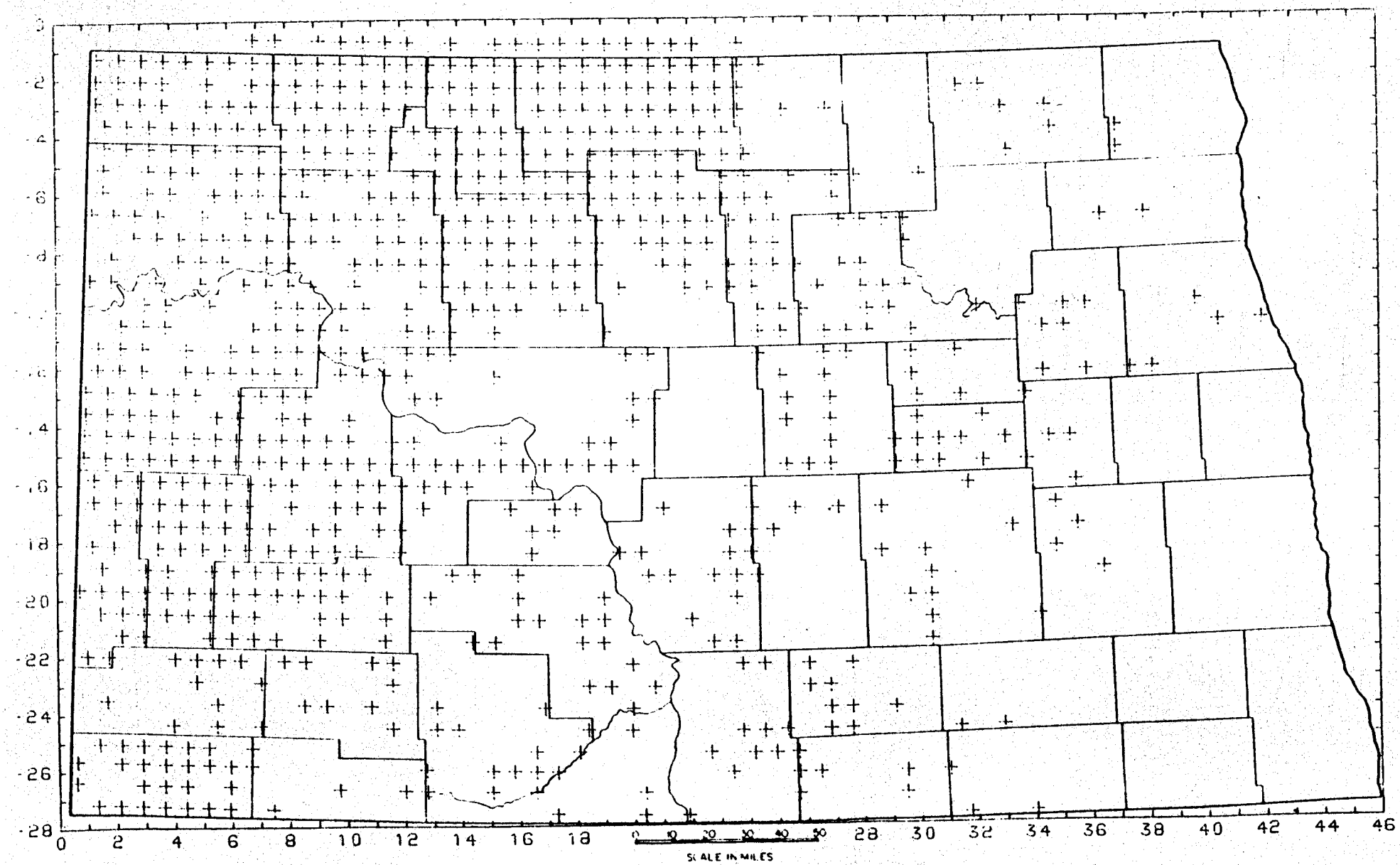


FIGURE 21 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL FOR THE CRETACEOUS INYAN KARA FORMATION STRUCTURE MAP

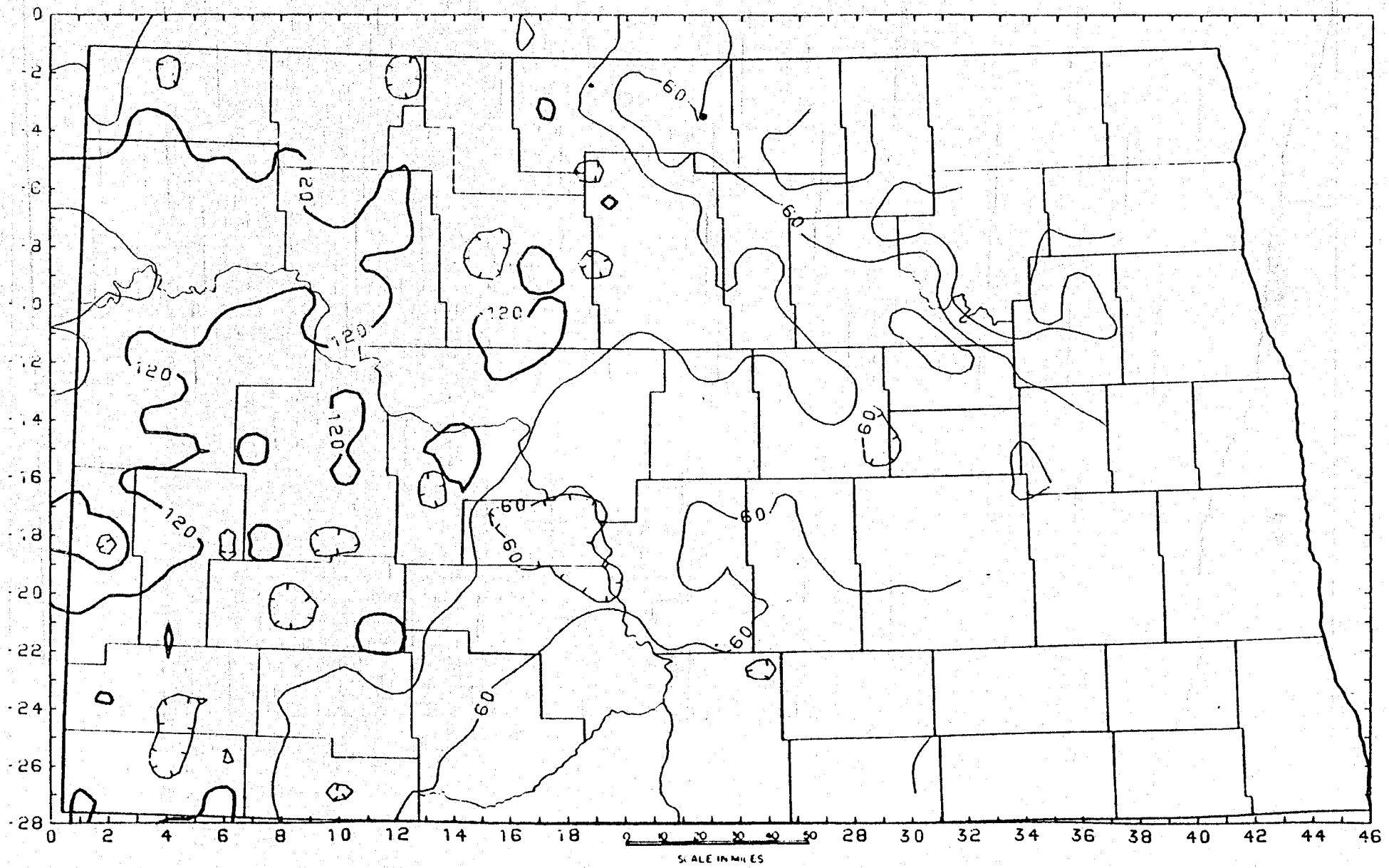


FIGURE 22 - ISOPACH MAP, THICKNESS OF THE CRETACEOUS INYAN KARA FORMATION; CONTOUR INTERVAL IS 30 METRES

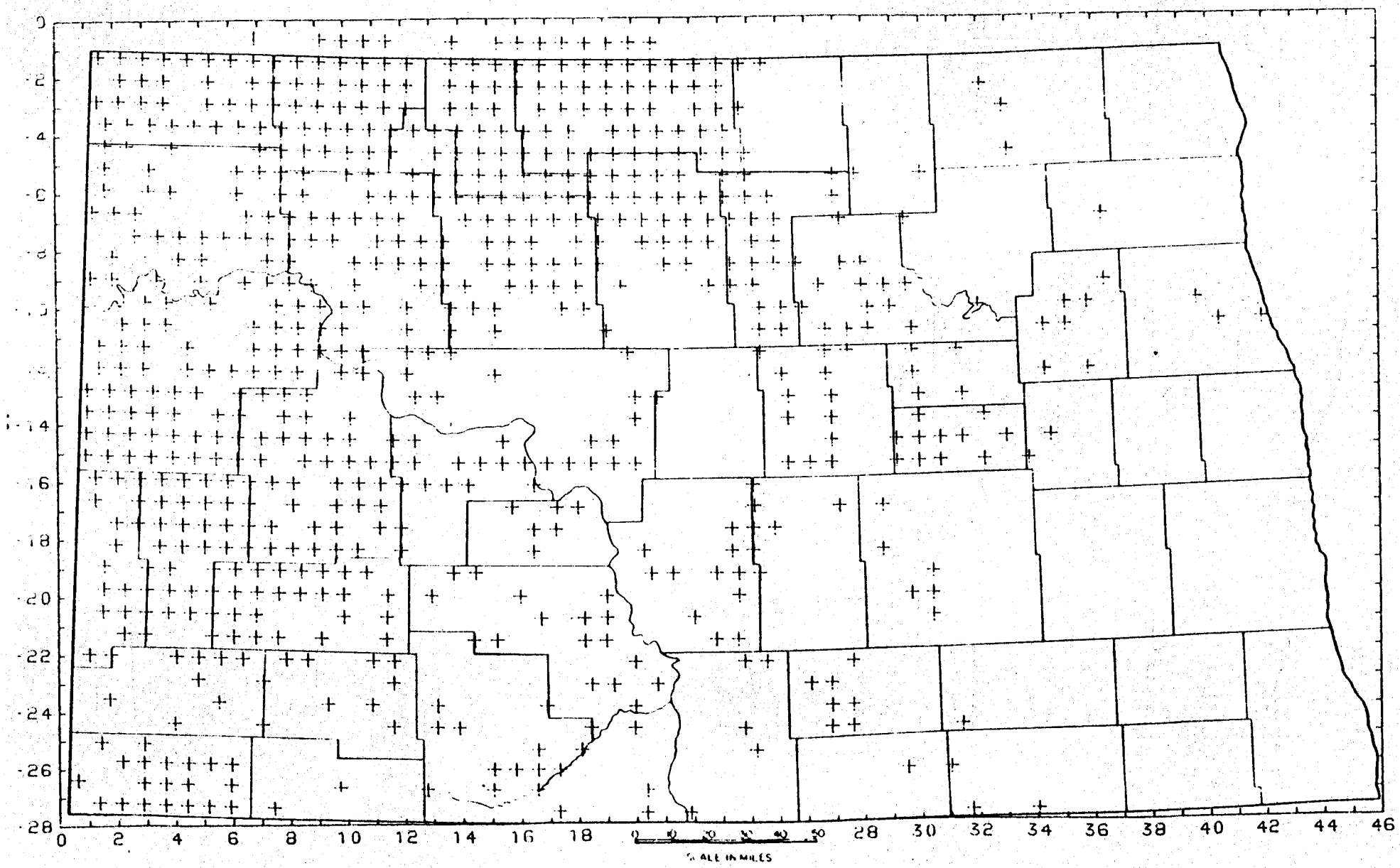


FIGURE 23 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL FOR THE CRETACEOUS INYAN KARA FORMATION ISOPACH MAP

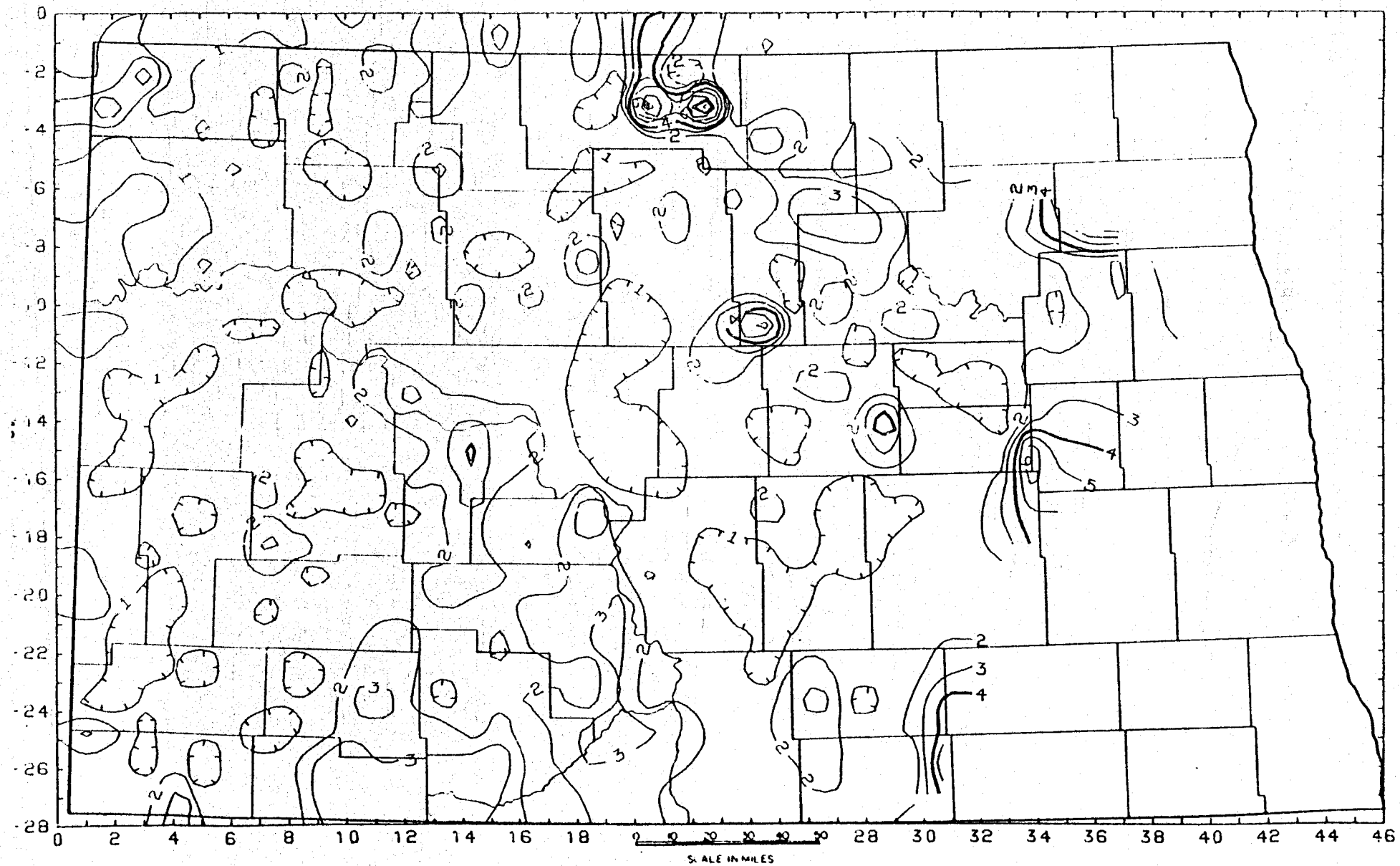


FIGURE 24 - SAND/SHALE RATIO MAP FOR THE CRETACEOUS INYAN KARA FORMATION; CONTOUR INTERVAL IS 1

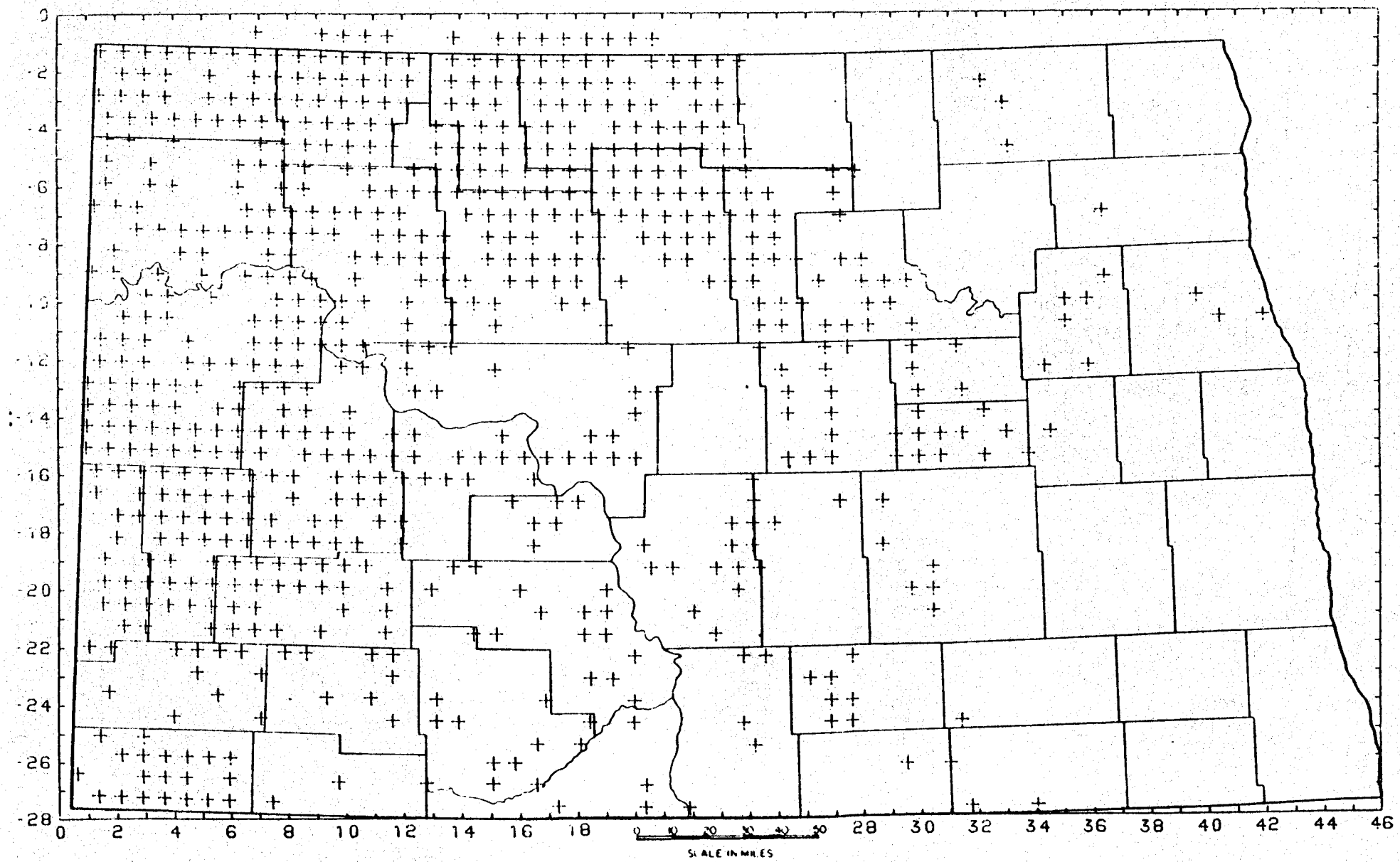


FIGURE 25 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL FOR THE CRETACEOUS INYAN KARA FORMATION SAND/SHALE RATIO MAP

isopach map, will give a total footage value for sand and shale at that location. For example, if the sand/shale ratio is two and the isopach map shows 90 metres of sediment; we can expect 60 metres of sand and 30 metres of shale.

The areas where the sand/shale ratio is greater than two indicate areas of significant sand accumulation. The location of these sand-rich areas is related to the location of source areas for clastic sediment and the environment of deposition during the Early Cretaceous.

Sediments of the Inyan Kara Formation are thought to have been deposited in a marine and marginal marine environment as Cretaceous seas transgressed from the west and southwest toward the east (Hansen, 1955). The transgressing sea reworked sand deposited by preexisting river systems, and deposited, in a nearshore environment, the sand transported into the marine environment.

The terrestrial sources of sand are thought to be the eroded rocks, of Jurassic to Precambrian age, over which the Cretaceous sea advanced, as well as sources, mainly Precambrian in age, to the north, east, and south.

The sand/shale ratio map shows concentrations of sand in the south-central, east, and north-central parts of the state. The accumulations are interpreted to be proximal to sources of terrestrial sand and/or preexisting river deposits.

Water Quality Studies

The goal of this task is to summarize existing water quality data for potential hydrothermal aquifers in the state.

Phase I Water Quality Studies

The Phase I study summarized water quality data from chemical analyses performed on water recovered during oil and gas well drill-stem tests. This information is part of the oil and gas well data on file with the N.D.G.S. Most oil and gas wells have Paleozoic or Mesozoic rocks as their drilling

objective. Consequently, most of the water quality data collected during Phase I was from Paleozoic and Mesozoic aquifers.

Phase II Water Quality Studies

Our Phase II water quality study (Figure 26) involved identifying potential Mesozoic and Cenozoic aquifers and compiling additional water quality on these aquifers. As in our stratigraphic study, emphasis was placed on the Cretaceous Inyan Kara, Fox Hills, and Hell Creek Formations.

The data bases used for our Phase II water quality study consisted of WELLFILE and WATERCAT (Appendices A, B, and C).

The Phase I water quality data, contained in WELLFILE, was expanded and updated. Water analyses not included in the Phase I study and recent water analyses were entered into the system. The updated Phase I water quality data is contained in Appendix F.

WATERCAT contains the results of chemical analyses performed on the water produced by selected water wells in North Dakota. The geographic distribution of this data is not satisfactory to produce water quality maps for most aquifers. In addition, the variable quality of the stratigraphic control on this data results in a chaotic map presentation. Consequently, only tabular summaries of the water quality data are presented in this report. Appendix G lists the water quality data available in WATERCAT for the Tertiary Fort Union Group, Tongue River, Sentinel Butte, Cannonball, and Ludlow Formations, as well as the Cretaceous Hell Creek, Fox Hills, and Inyan Kara Formations.

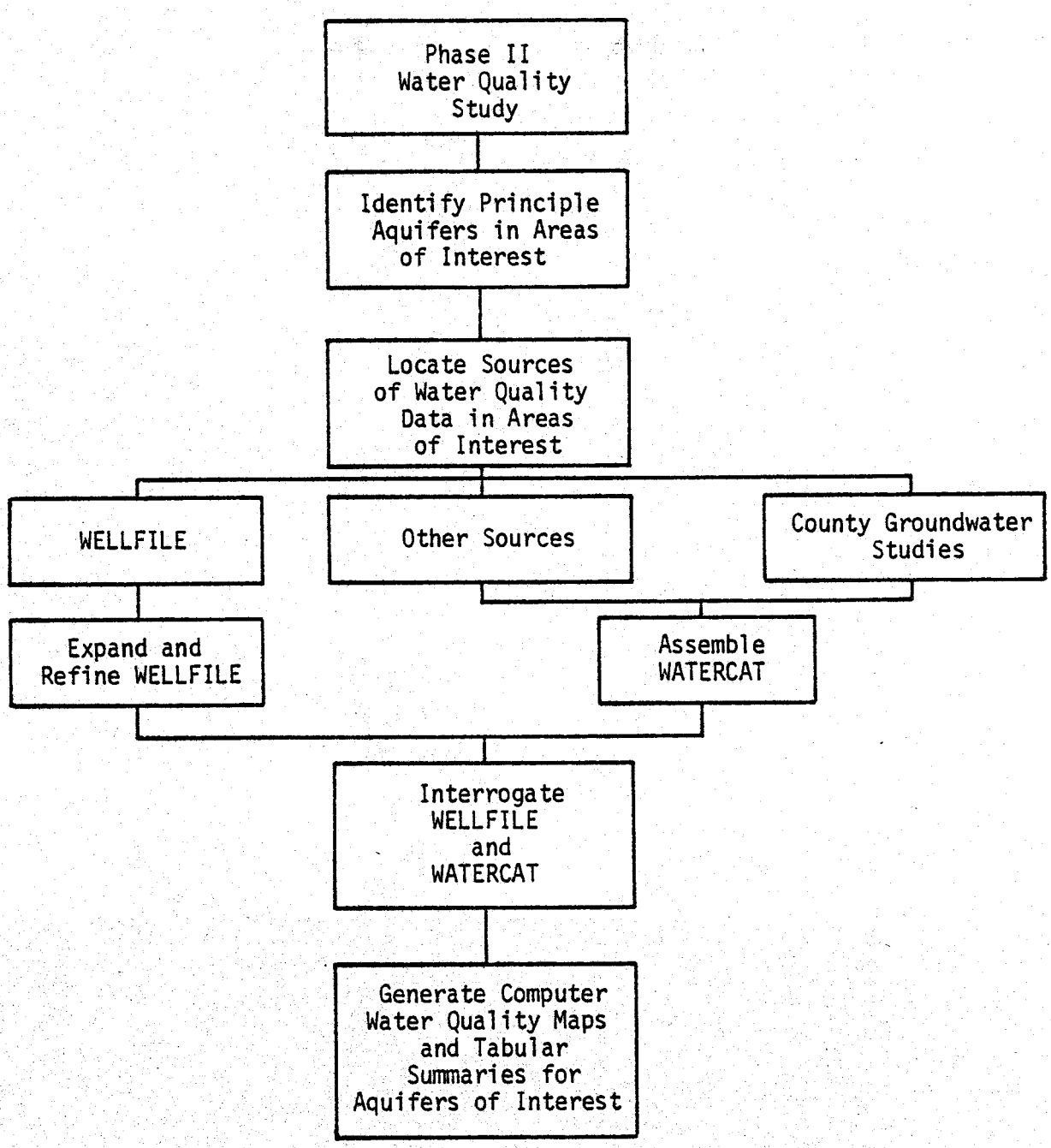


FIGURE 26 - STEPWISE PROCEDURE USED FOR PHASE II WATER QUALITY STUDIES

COMPUTER BASE MAP SUBTASK

Philosophy

The data management systems described here manage a large volume of data, most of which have been obtained from the measurements of natural systems. These data can be numerically analyzed to produce summaries and compilations. However, the true value of the data base lies in its geographical associations, which are best shown by maps. The objective of the Base Map Subtask is to make possible rapid, more accurate, computer-drawn maps, with the flexibility to meet user demands.

Computer mapping programs require a pair of coordinates, (X, Y), to represent the location of the data value. The problem of the Subtask becomes one of providing accurate coordinates for each data collection point on file in the system. Because the descriptions of the site locations can be provided in several systems and with varying degrees of accuracy, the Base Map system must be very flexible. Also, it must be possible to process political and study area boundaries through the system. Finally, the system must be as computer-efficient as is reasonably possible.

Development

The N.D.G.S. Coordinate System, and its development, are discussed in detail in Appendix A. A general overview of the system is provided here.

The N.D.G.S. Coordinate System is an internal coordinate system; that is, it is not one of the many available systems, such as the latitude-longitude system. Conversions to and from external systems, such as these, should be possible with program development. The N.D.G.S. coordinate system is, instead, a grid network laid over a map of the state of North Dakota. The

grid coordinate points of other reference systems are also recorded. The reference points used include, but are not limited to, township corners, latitude-longitude intersections, and intersections of reference lines of the North Dakota State Plane system. The system coordinates for any point within the state are calculated by interpolating from the nearest available reference point.

The initial set of reference points were obtained by digitizing the township corners of a standard 1:500,000 scale map of the state. Political boundaries were not entered. Although the system came on-line rapidly, maps produced by it required an overlay of county lines to be meaningful. Overlays were available only for a few map scales, limiting the flexibility of the system. The task of this phase of the project was to upgrade the system to a higher degree of accuracy and to provide a catalog of political boundaries. Reference points for the latitude-longitude and State Plane systems were to be digitized for future conversion system development. The upgraded version was to be compatible with the software of the initial version. Furthermore, the new system was to allow the entry of new reference points or lines at will.

Accuracy of the system was improved by using county maps at a scale of 1 inch to a mile (1:63,360). Although section corners are clearly marked on these maps, township corners were again used as reference points. Section corener references can be added later as needed. County lines, latitude-longitude intersections, and State Plane intersections were also recorded, as were reference points for final assembly of the maps into an integrated whole.

The county maps used for this Subtask are available, and can be used again to enter new points or lines into the system. This flexibility is important whenever a data point or area cannot be referenced adequately to a point on file.

The quality of the system depends on the quality of the reference maps and the digitizing and assembly processes. The maps are blueline maps distributed by the North Dakota State Highway Department. They are subject to an unknown amount of drafting error. This error, and errors introduced in printing of the maps are noticable when the maps are assembled into an integrated whole. No attempt was made to determine the extent of these errors or eliminate them. Instead, the error was "spread" to the degree possible over the line of fit between maps.

The digitizer used has a claimed precision of 0.001 inch, the smallest increment recorded. Informal tests of actual digitizing accuracy show an average of about +/-0.008 inch. A map can be returned to the digitizing table with an accuracy of about +/-0.010 inch. A section line on the map is about 0.008 inch wide. The largest incompatibility of fit between two maps noted to data is about 0.080 over a line of about 28 inches. Most lines in common between maps match in length to within about 0.015 inches over 15 to 20 inches.

All four corners were digitized for each township, providing up to four values for each corner. The value entered into the reference table is the mean of all values, unless one or more are eliminated due to obvious error.

The final step in this phase of development, which is still in progress, is the compilation of the digitized data into an integrated whole. The process has three parts: verification, annotation, and assembly.

The file of digitized coordinates and associated indixing values has been compared to what was expected. Errors and loss of data are corrected, often without a second digitizing session for the map. The file of records is expanded to include plain-language annotation of each record, so that what each coordinate represents is clearly identified. Finally, each point is rotated and translated, in the Cartesian coordinates system, into a new coordinate

system that integrates the values for all the maps into a unified whole. The values for the various reference tables, such as for township corners or state outline, are extracted and integrated into the software of the initial system.

Applications

Most applications of this system apply to the production of maps, or to the analysis of data in a geographic sense. An example of the first is the posting of values on a map base for hand-contouring. Machine-contouring is also used extensively. An example of the latter would be a resource inventory, such as the tonnage of coal within a certain area. Descriptive figures, such as an outline of a study area, are also possible. This report contains several examples of maps prepared using the initial version of this system.

Status

The initial version of this system is operational. Annotation and verification are completed for the new version. Assembly is in progress and should be completed by July, 1981.

Recommendations

This Subtask will be completed when the new version is operational, with new township corners and political boundaries in reference files. The data are available for developing programs to convert to and from latitude-longitude and State Plane coordinate systems. Section corner reference points can be added to the system. Other reference lines, such as city or park boundaries, rivers, lakes, and reservations, can also be added as needed.

SUMMARY

Our Phase I study developed and implemented WELLFILE, a computer library system based on oil and gas well data contained in N.D.G.S. files (Appendices A and B). WELLFILE is an easily accessable data base that can be interrogated to summarize, in map form or listings, the depth, thickness, water quality, and temperature of potential hydrothermal aquifers. Most of the data in WELLFILE is concentrated in Paleozoic aquifers. Consequently, our Phase II study developed WATERCAT, a computer library system based on water well data collected by the U.S.G.S.W.R.D. (Appendices A and C). WATERCAT is compatable with and supplements the data in WELLFILE. Most of the data in WATERCAT is concentrated in Mesozoic and Cenozoic aquifers, with potable water, stratigraphically above the Pierre Formation.

Paleozoic Aquifers

The Phase I study summarized the available data in WELLFILE (Harris and others, 1980). Our Phase II study updated and expanded the stratigraphic and water quality data contained in WELLFILE (Appendices E and F).

The Mississippian Madison Formation is typical of most Paleozoic aquifers. A detailed evaluation of the hydrothermal potential of the Madison Formation was given in our Phase I final technical report (Harris and others, 1980). The Madison Formation, and other Paleozoic aquifers, are low to medium geothermal resources, but their great depth and poor water quality will probably preclude their development as significant hydrothermal aquifers in North Dakota.

Mesozoic Aquifers

Our Phase II study concentrated on developing structural, isopach, and sand/shale ratio maps of the Cretaceous Inyan Kara Formation. All available oil and gas well logs were studied and the new data was incorporated into WELLFILE.

No reliable temperature data is available for this formation, but its depth, thickness and water quality can be summarized. The Inyan Kara Formation is a widespread aquifer of moderate depth. Figure 27 shows that it ranges from less than 400 metres deep in the east to more than 1,700 metres deep in the central part of the Williston Basin. Figure 28 shows that the thickness varies from less than 30 metres in the east to more than 150 metres in the west. Figure 29 shows the location of significant accumulations of sand in the Inyan Kara Formation. These areas, with sand/shale ratios greater than two, are located in the south-central, south-east, north-east, and north-central parts of North Dakota. The available water quality data is summarized, in table form, in Appendices F and G. In general, the total dissolved solids in the formation water range from about 2,000 mg/l in the south-east part of the state to about 14,000 mg/l in the western part of the state. In some local areas total dissolved solids as high as 50,000 mg/l can be expected, due to the injection of oil well brines or the vertical movement of groundwater from underlying aquifers. The Inyan Kara Formation is a widespread aquifer of moderate depth and moderate water quality. It is likely to be an important hydrothermal aquifer in eastern North Dakota.

Two other Mesozoic, potential hydrothermal aquifers, the Fox Hills and Hell Creek Formations, will be evaluated during our Phase III study. Water quality data for these formations is contained in Appendix G.

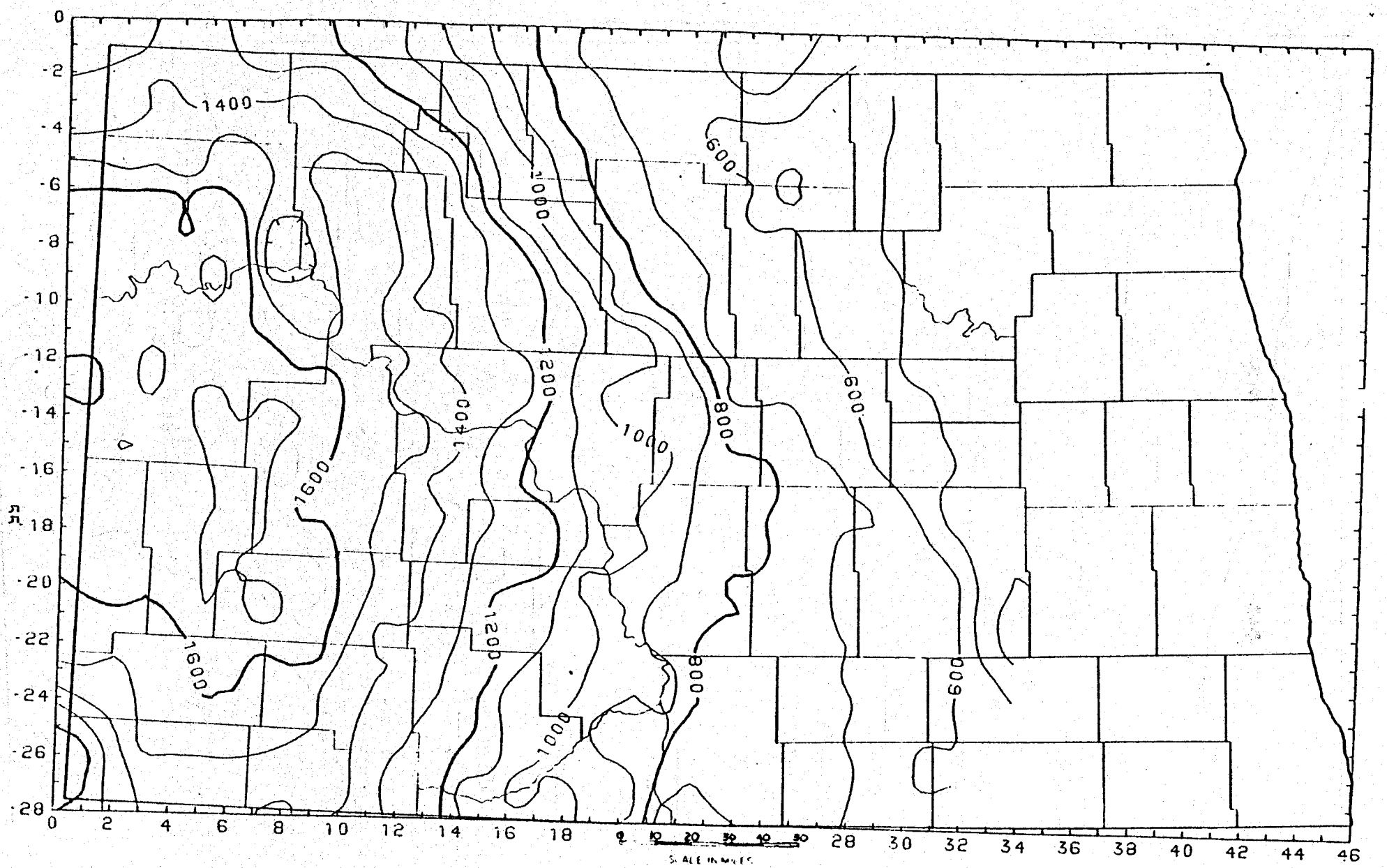


FIGURE 27 - DEPTH TO THE CRETACEOUS INYAN KARA FORMATION; CONTOUR INTERVAL IS 100 METRES

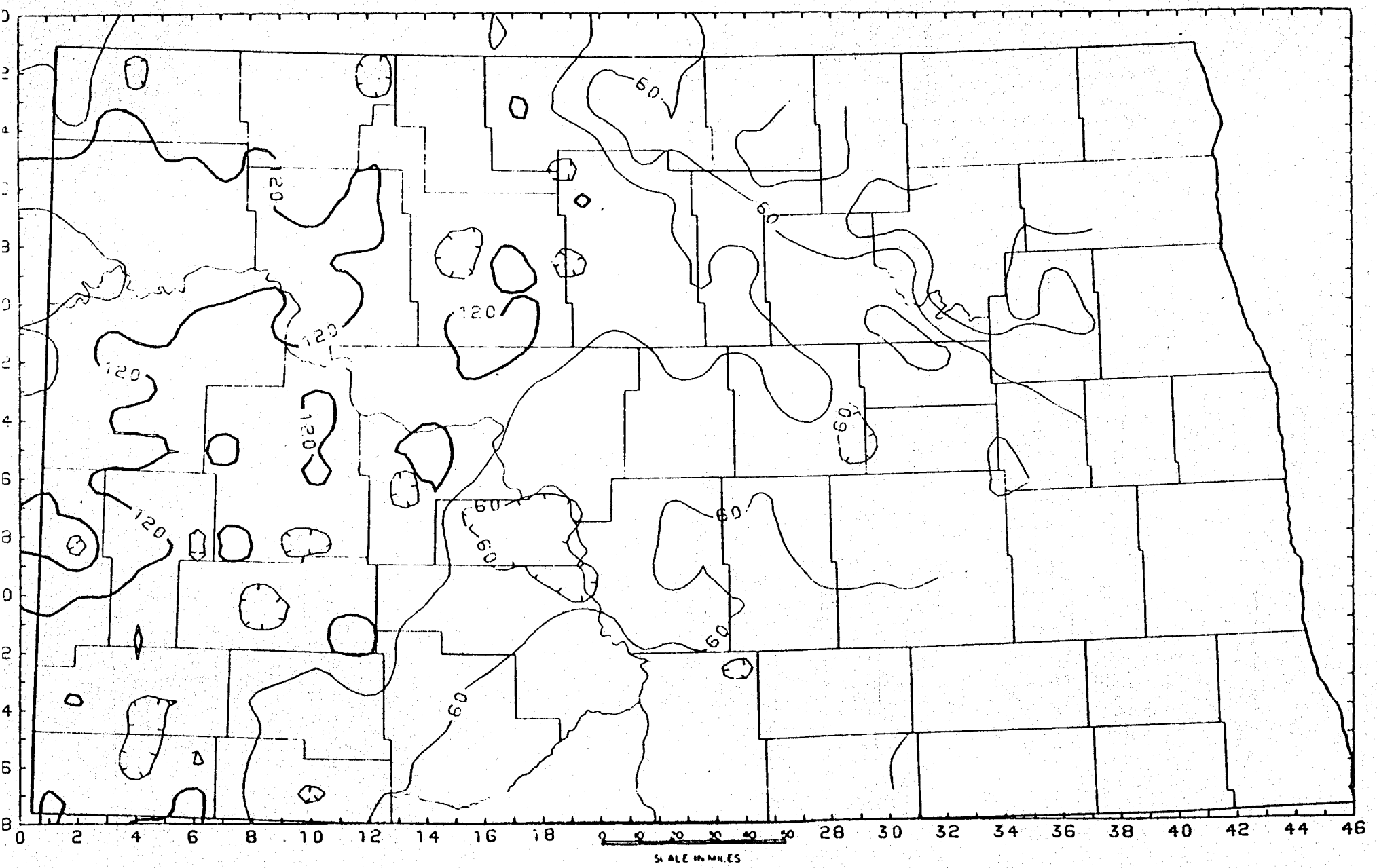


FIGURE 28 - THICKNESS OF THE CRETACEOUS INYAN KARA FORMATION:
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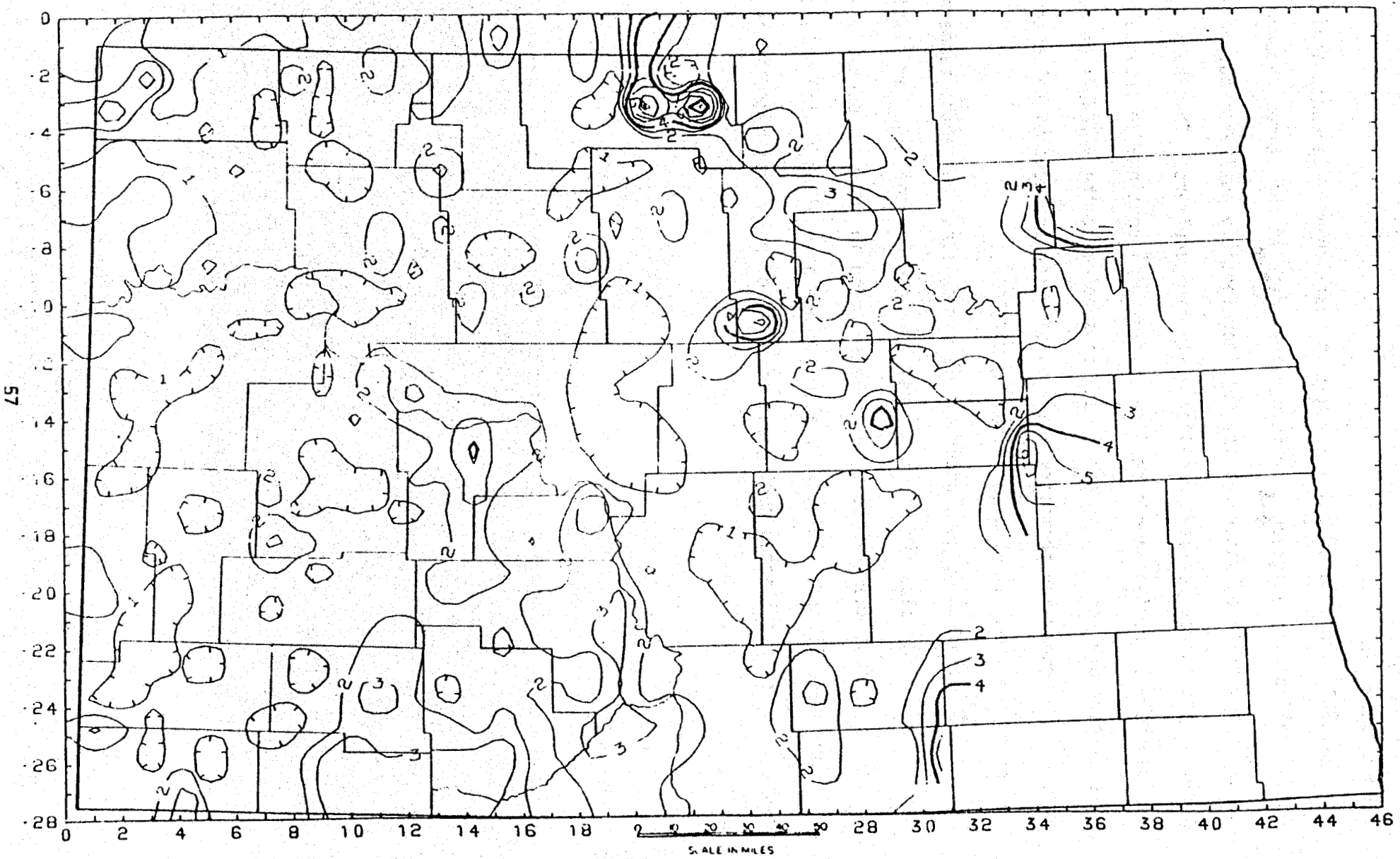

FIGURE 29 - SAND/SHALE RATIO MAP FOR THE CRETACEOUS INYAN KARA FORMATION: CONTOUR INTERVAL IS 1

Cenozoic Aquifers

WATERCAT contains useful water quality data on most Cenozoic aquifers, but no reliable stratigraphic or temperature data at this time. Appendix G contains a listing of water quality data for Tertiary aquifers, but no water quality listing has yet been made for Quaternary aquifers. The Phase II and III geothermal gradient and heat flow studies will continue to provide reliable temperature and stratigraphic data to supplement the WATERCAT data. We also plan to run water chemistry analyses of water produced by selected wells to verify the chemical data contained in WATERCAT.

A U.S.G.S.W.R.D. study, underway, is summarizing the depth, temperature, and water quality data for all major Mesozoic and Cenozoic aquifer systems. This information, when released, will be included in future reports.

Our Phase III activities will also include assembling a user-oriented catalog, of data collected during our studies, of potential hydrothermal aquifers.

REFERENCES

Hansen, Dan E., 1955, Subsurface Correlations of the Cretaceous Greenhorn-Lakota Interval in North Dakota: North Dakota Geological Survey Bulletin Number 29, 45 pages.

Harris, Kenneth L., Winczewski, L.M., Umphrey, H.R., Anderson, Sidney B., 1980, An Evaluation of Hydrothermal Resources of North Dakota, Phase I Final Technical Report: University of North Dakota Engineering Experiment Station Bulletin Number 80-03-EES-02, 176 pages.

Scattolini, R., 1978, Heat Flow and Heat Production Studies in North Dakota; Grand Forks, North Dakota, University of North Dakota, unpublished PhD dissertation, 264 pages.

Zabel, D., 1979, The Determination of Terrestrial Heat Flow in Southeastern North Dakota: Grand Forks, North Dakota, University of North Dakota, unpublished Ms. thesis, 29 pages..

APPENDICES

APPENDIX A

Computer Management of Geologic and Petroleum Data at the North Dakota Geological Survey

April, 1981

Kenneth L. Harris
Laramie M. Winczewski
Howard R. Umphrey

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FUNDING SOURCES AND ACKNOWLEDGEMENTS

Funding for the study "An Evaluation of the Hydrothermal Resources of North Dakota" (Harris and others, 1980), which assembled and implemented WELLFILE and WATERCAT, was provided by the United States Department of Energy, Division of Geothermal Energy, through a cooperative agreement (DOE/ID/12030) with the North Dakota Geological Survey.

Funding for the development of the GEOSTOR data management system and the implementation of the SEAM prototype, COALBASE, was provided by the Surface Environment and Mining Research Group (SEAM) of the USDA Forest Service, Intermountain Forest and Range Experiment Station.

Dr. Lee Gerhard, North Dakota State Geologist, provided financial support during the development and implementation stages of these systems. The North Dakota Geological Survey also purchased the SURFACE II graphics package used by the system.

The Department of Geology, University of North Dakota, provided financial and computer support to several individuals during this project.

The cooperation of the United States Geological Survey, Water Resources Division, in providing computer tapes of North Dakota water well data for WATERCAT is acknowledged. Ray Butler, geologist-hydrologist with the USGS, was extremely helpful in this regard.

Laramie Winczewski, University of North Dakota Geology Department, developed the GEOSTOR concept and implemented it in COALBASE. He also developed the base map coordinate system, and devoted a great deal of time and effort to the development of WELLFILE.

Howard Umphrey, Data Processing analyst with the North Dakota Geological Survey, designed the computer storage structures and programs necessary for

WELLFILE and WATERCAT. Three computer programmers, Duane Boeck, Glen Christy, and Bernadette Franzen, have worked with Howard on various phases of system development.

Sidney B. Anderson, Chief of Subsurface section, North Dakota Geological Survey, assembled a computer oil well library in 1976 that was incorporated, in part, into WELLFILE.

Brad Wartman and Gary Winbourn, University of North Dakota Geology Department, managed phases of the validation of stratigraphic data in WELLFILE and WATERCAT. Brad also helped digitize the base maps used in our graphics system.

The initial encoding of data, validation, and modification processes were tedious and time-consuming tasks. The following students contributed their efforts: Laura Anderson, Brent Anderson, Alan Gatheridge, Collette Howell, Linda Johnson, Rose Kalal, Anthony Kalar, Doug Kenelly, Rob Kerian, Neil Korsmo, Lanelle Martin, Mike Scott, Dan Walker, and Joy Umphrey. Their help is gratefully acknowledged.

PURPOSE OF THIS REPORT

This report describes the data management system used by the North Dakota Geological Survey. Factors governing the design, development, and implementation techniques that were used are also discussed.

Considerable interest has been expressed in the philosophical and technical aspects of this data management system. The documentation presented in this report describes the system in detail and provides guidelines for the development of similar systems. The needs of potential users will differ from our design requirements, but the GEOSTOR design philosophy is flexible, and can meet most of the needs of a map-oriented data management system.

GENERAL DESIGN CONSIDERATIONS

The GEOSTOR Concept

Computer management of geologic and petroleum data at the North Dakota Geological Survey is based on the GEOSTOR concept. GEOSTOR is a design philosophy used to approach the development of a computer data management system for data that derive an essential usefulness from being mapped. The GEOSTOR concept is embodied in ten generalized principles which, if seriously considered in the early phases of system design, should provide the foundation for development of a useful system. The principles are listed in Table 1. The principles and their application to system design are discussed in detail in Winczewski (1980a).

The GEOSTOR Principles

Map-Oriented Data

Any data that can be presented in spatial relationship to one another are considered map oriented data. The spatial relationships are presented on surface maps, contour maps, cross sections, and horizontal slices. Any value so mapped is considered to be representative of an area or volume adjacent to it. Therefore, accurate positioning of the data point in three-dimensional space is very important if accurate and useful maps are to be produced.

User First

This principle is not unique to the design of map-oriented systems. The ease with which a user can enter, use, and exit the system is important if

TABLE 1

THE GEOSTOR PRINCIPLES

1. GEOSTOR principles apply to the design of systems for the management of map-oriented data.

2. The needs of, or the demands on, the user, as data collector or data analyst must be considered above that of the machine.

3. Each item expected to be retrieved on a regular basis should be defined as a data element, i.e., a pigeonhole to be filled with a value. Generalized supplementary data elements should be made available for unexpected items.

4. The user should be able to enter description, remarks, or comments with little or no restriction.

5. The data elements, supplementary elements, and comments should be grouped into a data structure exploiting the natural associations among the variables or the anticipated recall demand on them.

6. A separate, custom-designed data structure should be prepared for each natural association of variables.

7. All data structures for a collecting site should be keyed to that site and its location data elements.

8. Each collecting site should have two identifiers. The first should be unambiguous, preferably assigned by the system. The second should be one assigned by the user and easily recognized by him.

9. The quality of maps and cross-sections produced from map-oriented data depends heavily on the quality of the location values used in all phases of processing, from data collection, through coordinate conversion, to final map production.

10. Except for rare cases, justified by very high demand, the processing of the retrieved values should be performed outside the retrieval system.

the system is to have wide attraction. Potential users must be consulted at all stages of design and testing of the system. The system must fit their needs, or it will not be used.

User access to the system can be controlled in two ways. If the system is interactive, with menu-driven operations, the system can be made self-operational. However, writing efficient programs to carefully guide the user through the system is difficult and expensive. The flexibility of this style of operation is also limited; changes in the system or data base can require wholesale revision of the guidance programs.

The second access method is the use of a system operator, a programmer who prepares the user's requests. This method has the advantage of maintaining the security and integrity of the data base, while simultaneously placing little demand on the user to learn the system. The disadvantage is the potential bottleneck that can occur if demand for the system expands beyond the resources of the operator. We do, however, recommend this method.

Data Elements

A data element is an individually retrievable item. It is a 'pigeonhole' within which a value can be placed and controlled by the system. Data elements can be predefined, with the user restricted to fitting his data within them. Alternatively, data elements can be entirely user-defined, enhancing flexibility, but increasing the work for the user. A combination of system and user-defined elements is recommended.

Unlimited Comments

Many natural scientists prefer to fully describe their observations in free-form. It is unlikely that even a system designed in close cooperation

with potential users will define sufficient data elements to meet the needs of all users under any situation. Comments can fill the gap, but specific retrievals from generalized comments are difficult. Comments are also difficult to handle in a computer data-management system. Comments are important, however, because they will be used to store more than data; they will hold interpretations, hunches, hedges, and items to assist the scientist's memory.

Data Structures

The data elements must be arranged in patterns of associations. These associations will reflect natural relationships among the data, such as among a date and its three elements of day, month, and year. Furthermore, properly designed structures will enhance efficient use of the system if the structures anticipate patterns of recall.

Customized Data Structures

A data structure should be constructed for each class of data encountered. A data class is a group of data elements that are sufficiently related to be frequently searched and retrieved together. Several classes of data may be collected at a single site. For example, a test-hole may provide lithologic data, groundwater data, and engineering data. Each data class should be segregated into separate data structures, and used as separate data bases or subsets of data bases.

Collecting Site Umbrella

Because several classes of data can be collected at a single site, they should be linked together under the identifier for the site and/or its location description. This technique provides an index to all the classes of data available for a site or area. A common initial data 'fishing' request

is of the form: "What do we have for this location (area)?" The system should be able to respond with a list of sites and the classes of data filed for each site.

The Collecting Site Identifiers

A data collecting site, such as a well or outcrop, should be identified in at least two ways. The first is an internal ID, preferable unambiguously assigned by the system. The second consists of one or more additional literal IDs, familiar to the user. These should all be cross-referenced to themselves, as well as to the geographical location of the site.

The Map Trap

Map-oriented data derive much of their value from being mapped. The Map Trap discussion concerns the quality of the spatial relationships among the data points, as provided by the data-management system. The principle is called a 'trap' because it is so easy to neglect this very important aspect of system design. The neglect is a considerable risk, because if the user cannot trust the accuracy of points plotted on maps produced by the system, the system will not be used. In short, the system must not put the well on the wrong side of the road. Even if great care is taken to accurately survey the site in the field, the accuracy of the representation of that site relative to others in the area can only decrease with each conversion and interpolation process before a final map is printed. The degradation of quality is not unique to computer-processed maps; human errors are easily introduced during manual plotting of maps. We recommend that location conversion needs be assessed early in the design stage. The needed conversion programs must be searched for, tested, modified, and in some cases, designed in-house. This pitfall cannot be stressed enough. The user needs to be

able to believe the map. He must be assured that, at each step of map preparation and data processing, the degradation of quality of spatial relationships is well within his tolerances.

Separate Processing Preferred

The data management system should be used as a librarian, not as an analyst. Management and analysis programs should be kept separate so each can be individually maintained and improved. The efficiency and flexibility of the system as a whole is then enhanced.

SPECIFIC DESIGN CRITERIA

In addition to the general design considerations already discussed, regulatory and research needs of the North Dakota Geological Survey had to be met by the data management system. Regulatory data are derived from drilling permit applications received by the Industrial Commission and records of production data maintained by the Survey. Geologic data are obtained during drilling and from projects sponsored by the Survey. Cores, samples, and copies of wireline logs are stored with the Survey. Production data submitted to the Survey over the life of a well require continuous updating of records. The automated preparation of state-required production data reports is a benefit of this system.

Research conducted by the Survey uses data obtained from regulated drilling activity, as well as from public and private sources. The characteristics of these data are as diverse as are the applications of it. The data-management system must be flexible enough to accept many kinds of data and manage them efficiently to fill a wide spectrum of needs.

The volume of data managed by the system will grow with time. Likewise, the demand on the system is expected to increase as users discover its potential. Since applications will be highly variable, the system must satisfy varied retrieval requests for many kinds of data. It is necessary that the system can be expanded to handle larger volumes of data without major revisions.

The system is expected to be a valuable tool for producing maps. Conversion of location descriptions from the legal description to computer mapping coordinates must be automatic. Appropriate graphics programs should be linked to the system.

DATA BASES

Three computer library systems are used by the North Dakota Geological Survey. They are WELLFILE, which contains oil and gas well data; WATERCAT, which contains water well data; and COALBASE, which contains coal exploration data. All three systems are GEOSTOR-based and use a location-oriented organizational scheme. The types of data elements selected for storage, however, differ from system to system.

WELLFILE

The WELLFILE computer library system manages data obtained from about 8,000 oil and gas wells drilled in North Dakota. These data are filed with the North Dakota Geological Survey. Information from newly drilled wells is added to the file as soon as it is made public.

Location, legal, production, and stratigraphic data, as well as the availability and storage location of cores and samples are stored for each well. Well-location information includes county, township, range, section, and quarter-quarter-quarter description (Figure 1), as well as the footages from north-south and east-west section lines. Legal data include owner-operator, N.D.G.S. well number, N.D.G.S. permit number, permitted date, completion or abandoned date, and A.P.I. number. Production data include well status, producing horizon, perforated interval, and initial production. Stratigraphic data include reference elevations, total depth, deepest formation penetrated, selected formation "tops" and kinds of geophysical logs run. Cores cut in the well are identified by formation and by the footage of the top and bottom of the cored interval. Sampled intervals are identified

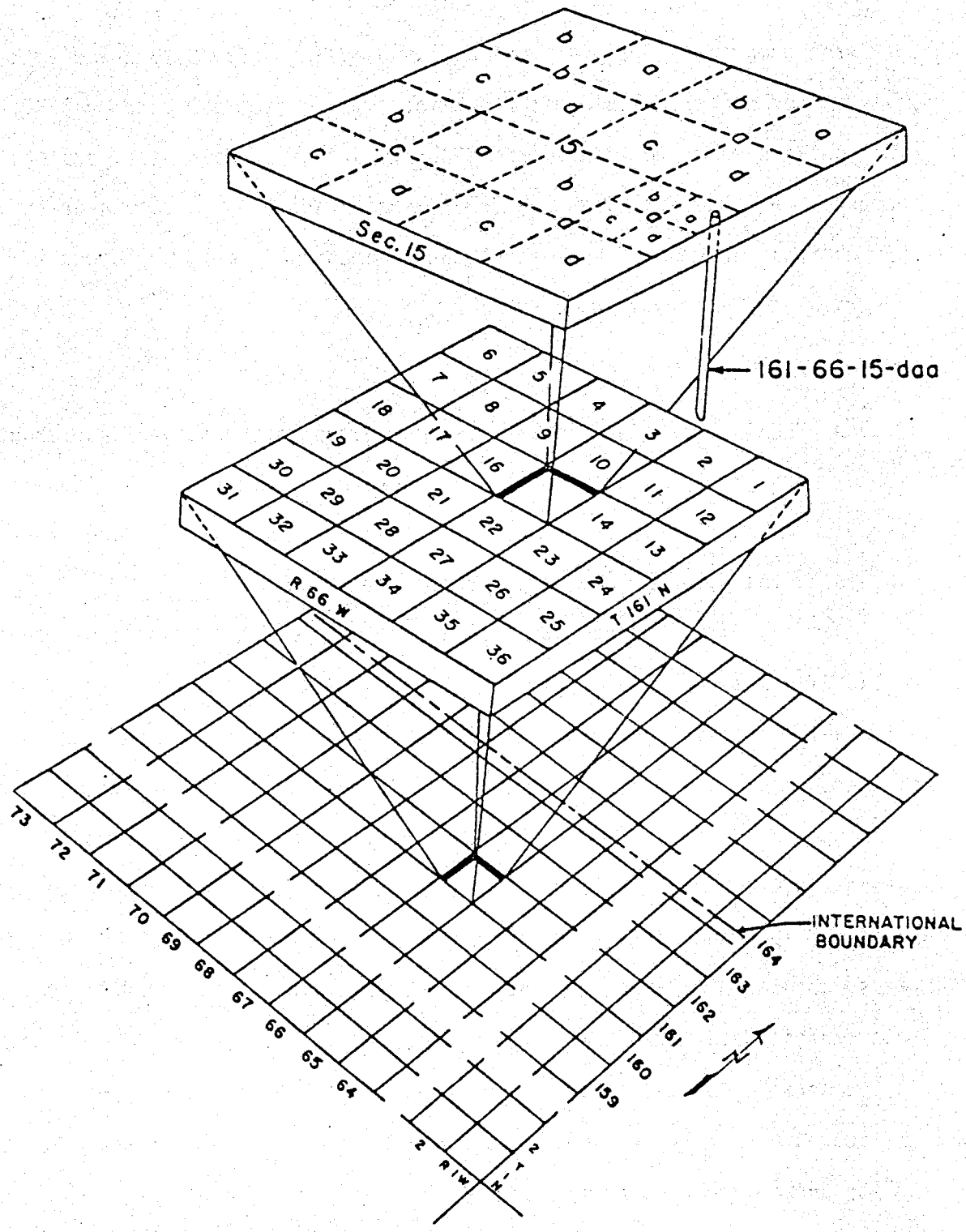


FIGURE 1 - THE LAND OFFICE GRID SYSTEM COARSE LEVEL (LOGSCL) COORDINATE SYSTEM

by footages. Core and sample storage location are listed for the cores and samples available in the North Dakota Geological Survey's Wilson M. Laird Core and Sample Library.

Two data subsets are maintained separately from the WELLFILE library. These are considered working files, currently used for special projects and N.D.G.S. internal data management. If desired, these subsets can be added to WELLFILE.

The first data subset contains water-quality information from analyses performed on water recovered during drill stem tests. N.D.G.S. well number, well location, formation tested, footages of the tested interval, pH, resistivity, and the concentration of major ion species are stored in the subset.

The second data subset contains production statistics from oil and gas wells. This is an internal file and is used only by the N.D.G.S. staff for geologic and engineering studies.

WATERCAT

The WATERCAT computer library system manages data from groundwater observation, domestic, and stock wells inventoried by the United States Geological Survey, Water Resources Division (U.S.G.S.W.R.D.) and the North Dakota State Water Commission (N.D.S.W.C.). The library contains information on about 41,000 wells drilled in North Dakota. The source of this data is the U.S.G.S.W.R.D.'s digitized water-well inventory and water-quality files (WATSTORE and GWSI). These two source files were reformatted and combined into our location-oriented library system.

Information stored in WATERCAT includes location, physical, stratigraphic, and water quality data, as available, for each well on file. Location data include county, township, range, section, quarter-quarter-quarter, and latitude and longitude. Physical data include total depth, well depth, casing

depth, and casing diameter. Stratigraphic data include the footage of the top of the producing horizon, name of the producing horizon, lithology of the producing horizon, and the surface elevation. Water quality data include temperature, specific conductance, pH, and the concentration of major ion species.

WATERCAT has one data subset. Temperature and depth data, measured in groundwater observation wells, is maintained as a project file. Information in this subset includes well location, date measured, and temperature-depth values at five- or ten-metre depth intervals. These data are intended to provide accurate, shallow, geothermal gradient data and accurate aquifer water temperature data.

COALBASE

The COALBASE data base consists of shallow test-hole lithologic data associated with Tertiary coal deposits in North Dakota. The data were obtained from public and private sources. Contributors include the coal operators of North Dakota, federal resource assessment and environmental impact studies, and academic and state research projects.

The records for each site contain essential indexing and location data, with or without interpreted lithologic columns. Some of the columns are based on outcrop descriptions, but most use test-hole data. Significant strata have been identified for many of the over 1,600 sites on file. The data elements for this system are shown in Table 2 and Table 3. The data structure is shown in Table 4.

Although COALBASE is a part of the data of the North Dakota Geological Survey, it is not managed by Statistical Analysis System (Barr and others, 1979), which operates on WELLFILE and WATERCAT. COALBASE uses the SEAM Prototype of GEOSTOR. Because the Prototype is fully described in Winczewski (1980b,c) only a brief description is included here.

TABLE 2

COALBASE: NON-STRATUM DATA ELEMENTS

Internal ID

Site ID

Date Drilled
- Day
- Month
- Year

Method of Drilling Code

Data Records
- Driller or Sample Log
- Natural Gamma Log
- Gamma Denisty Log
- Self Potential Log
- Resistivity Log
- Caliper Log
- Samples Saved
- Other Data Records

Units of Elevation, Depth, and Thickness

Reference Elevation of the Site

Total Depth of Record

Depth to Bedrock

Number of Strata

Data Owner

Data Storage Location(s)

Non-Stratum Comments

Non-Stratum Non-Decimal Supplementary Values

Non-Stratum Decimal Supplementary Values

Non-Stratum Character Supplementary Values

TABLE 2, (Cont.)

Location:	Land Office Grid System, Coarse Level (LOGSCL) Section Number Township Number Range Number Quartering Codes (4)
Location:	Land Office Grid System, Fine Level (LOGSFL) E/W Distance and Code N/S Distance and Code
LOGSFL Origin:	Land Office Grid System, Fine Level Section Number Township Number Range Number
Location:	LOGSFL Coordinates
Location:	NDGS Coordinates
Location:	Latitude and Longitude
Location:	State Plane Coordinates
Location:	UTM Coordinates
Location:	Arbitrary Grid Coordinates

TABLE 3

COALBASE: STRATUM DATA ELEMENTS

Stratum Number

Depth to Top of Stratum

Thickness of Stratum

Elevation to Top of Stratum

Datatype Code

Stratum Name Data

- Namecode 1 - Name of Stratum
- Namecode 2 - Number of Strata of that Name
- Namecode 3 - Which Stratum of that Name
- Stratum Name Abbreviation
- Correlation Code
- ID of Person Naming Stratum

Datatype Symbol

Free-Style Stratum Description

Stratum Non-Decimal Supplementary Value

Stratum Decimal Supplementary Value

Stratum Character Supplementary Value

TABLE 4

COAL BASE DATA STRUCTURE

Indexing Level (High) (Low)		
Group Codes	External Use	
Internal ID Site ID Location Descriptions Reference Elevation Other non-stratum values Non-stratum comments Non-stratum supplementary values	Non-Stratum Values	DATA STRUCTURE
Depth to top of stratum 1 Elevation of top of stratum 1 Other stratum 1 values Stratum 1 comments Stratum 1 supplementary values Depth to top of stratum 2 Elevation to top of stratum 2 Other stratum 2 values Stratum 2 comments Stratum 2 supplementary values * * * Depth to top of stratum n Elevation of top of stratum n Other stratum n values Stratum n comments Stratum n supplementary values	Stratum Values	

A publication is in preparation describing the COALBASE data base, how it was compiled, and how the lithologic columns were interpreted.

DATA ELEMENTS

WELLFILE

Table 5 lists the data elements that were selected for the WELLFILE computer library of oil and gas well data. These data elements were selected for their usefulness in describing the spatial relationships of stratigraphic data, evaluating geothermal resources of the state, providing information on a well, and summarizing frequently requested data. The WELLFILE Data Guide and Coding Guide can be found in Appendix B.

Location data elements are essential to indexing. They must describe the well site location accurately enough to map well parameters at a scale of 1:63,360 (1 inch = 1 mile).

Legal description data elements provide easy access to more detailed information contained in the various files maintained by the N.D.G.S. These elements are used to summarize permitting information and well status.

Production data elements provide a summary of the well's production tests and qualitative production information. They can also be used to evaluate the production history of wells and fields.

Stratigraphic data elements provide reference elevations and formation tops to produce geologic maps of rock units and other parameters for stratigraphic interpretation.

Sample data elements provide an index to the types of samples available, stratigraphic significances of those samples, and storage location in the N.D.G.S.'s Wilson M. Laird Core and Sample Library.

Water chemistry data elements are maintained in a data subset linked to WELLFILE by N.D.G.S. well number. This subset consists of the results

TABLE 5

WELLFILE; DATA ELEMENTS

Data Elements	Description
I. LOCATION DATA ELEMENTS	
A. County	-County in which the wellsite is located. Identified by the third, fourth, and fifth digits of the ten digit API number (ex. ---XXX-----)
B. Land Office Grid System (LOGS) Location	
1. Coarse Level (LOGSCL)	-Township, range, section, and quarter-quarter-quarter description of the location of the well site (ex. T152N, R56W, CBAD)
2. Fine Level (LOGSFL)	-Wellsite location described as being a footage distance from a north-south and an east-west section lines (ex. 660FNL, 660FWL)
II. LEGAL DESCRIPTION DATA ELEMENTS	
A. Well Operator	-Name of the operator of the oil or gas well (ex. Wild Goose Gas Co.)
B. Well Name	-Name of the oil or gas well (ex. #1 S.B. ANDERSON)
C. NDGS Well Number	-Sequential file number for the oil or gas well; may or may not be the same as NDGS permit number
D. NDGS Permit Number	-Sequential number issued when oil or gas wells are permitted; may or may not be the same as NDGS well number
E. NDGS Permit Cancelled	-Date that NDGS permit was cancelled; indicates that well was not drilled
F. Well Status	-Well was an oil well, gas well, single completion, dual completion, dry and abandoned, or junked and abandoned, etc.
1. Completion Date	-The date the well was completed
2. Abandoned Date	-The date the well was abandoned

TABLE 5, Continued

Data Elements	Description
G. American Petroleum Institute Number (API)	-This ten digit number identifies the oil or gas well as having been drilled in a state and county. It also identifies the well as being the nth well drilled in the county. (ex. A A B B B C C C C C) A = State B = County C = Number of wells in county
III. PRODUCTION DATA ELEMENTS	
A. Field Name or Wildcat	-Identifies the oil or gas well as being located either in a field or a wildcat well
B. Producing Formation	-The name of the formation producing hydrocarbons
C. Perforated Interval	-The overall footage interval perforated in the well
D. Initial Production (IP)	-The results of an initial production test run on the well
1. Gas	-Gas produced in IP test. Volume given in MCF, with a 10^X multiplier, per day
2. Oil	-Oil produced in IP test. Volume given in barrels-of-oil-per-day (BPD)
3. Water	-Water produced in IP test. Volume given in BPD
4. Condensate	-Condensate produced in IP test. Volume given in BPD
5. Gas-oil Ratio (GOR)	-Amount of gas produced with oil. Expressed as (N:1); "N" cubic feet of gas per barrel of oil
6. Choke Diameter	-The diameter of the choke used in the initial production test. Expressed as (N:64) inches
IV. STRATIGRAPHIC DATA ELEMENTS	
A. Reference elevations	-Surface reference elevations
1. Kelly Bushing (KB)	-The elevation (feet) of the Kelly Bushing, principal elevation reference for geophysical logs

TABLE 5, Continued

Data Elements	Description
2. Derrick Floor (DF)	-The elevation of the derrick floor, secondary elevation reference for geophysical logs
3. Ground Level (GL)	-The elevation of the ground surface, tertiary elevation reference for geophysical logs
B. Total Depth Drilled (TD)	-The depth of the well, total depth drilled in well
C. Deepest formation penetrated	-The name of the formation penetrated at total depth
D. Bottom-hole-temperature (BHT)	-Temperature reported on geophysical log at total depth (^{o}F)
E. Geophysical logs run	-Abbreviations of downhole geophysical logs run, sample logs, and drilling time logs run on well
F. Formation tops	-Depth (log footage) of the top of selected formations. Space is available for 47 formation tops
V. SAMPLE DATA ELEMENTS	
A. Sample type	-Type of samples available from well
1. Core	-Core was cut, and is available
2. Core chips	-Core was cut, and core chips are available
3. Cuttings	-Cutting samples are available
4. Side-wall-cores	-Side-wall-cores are available
B. Formation	-Identifies the formations from which cores and core chips are available
C. Footage	-Upper and lower footages of cored and sampled intervals
D. Storage location	-Identifies the storage location, in the N.D.G.S. Wilson M. Laird Core and Sample Library, of available cores and samples
VI. WATER CHEMISTRY DATA SUBSET	-A file of the results of tests and analyses performed on water recovered from drill stem tests is maintained in a data subset separate from, but used with WELLFILE

TABLE 5, Continued

Data Elements	Description
A. N.D.G.S. Well Number	-Sequential file number assigned to oil and gas wells, may or may not be the same as N.D.G.S. permit number. Links the data subset to WELLFILE
B. Formation Tested	-The name of the formation tested for which water chemistry data is available
C. Footage Interval Tested	-Log footage of the top and bottom of the sampled interval
D. Ion Concentrations	-Results of formation water analysis
1. Cations	-Concentration of Na^{+}, Ca^{++}, and Mg^{++} in mg/l, and Fe^{++} in mg/l x 100
2. Anions	-Concentration of Cl^{-}, $SO_4^{=}$, HCO_3^{-}, and $CO_3^{=}$ in mg/l
E. pH	-Reported pH from formation water analysis
F. Resistivity and test temperature	-Reported resistivity of formation water and test temperature

of chemical analyses performed on formation water recovered during drill stem tests, and provides the information necessary to characterize the water quality of tested formations.

WATERCAT

Table 6 lists the data elements included in the WATERCAT computer library of water well data. WATERCAT data elements were assembled from the U.S.G.S.W.R.D. computer library WATSTORE and GWSI files. These data elements are keyed to location number, and were selected for their usefulness in describing the spatial relationships of aquifer systems, describing the water quality of aquifer systems, and evaluating the hydrothermal resources. The WATERCAT Data Guide and Coding Guide can be found in Appendix C.

Location data elements describe the well site location accurately enough to map well, stratigraphic, chemical, and temperature parameters at a scale of 1:63,360 (1 inch = 1 mile).

Well description data elements were selected to evaluate the availability and suitability of groundwater observation wells for temperature logging, necessary to characterize aquifer water temperatures and near-surface geothermal gradients.

Stratigraphic data elements provide reference elevations and formation tops necessary to produce geologic maps of aquifer systems. Aquifer thickness and lithology can also be described.

Chemical data elements characterize the water quality of sampled aquifers.

A temperature and depth data subset was assembled to store data gathered during the temperature logging of groundwater observation wells. This information is intended to verify and expand the aquifer temperature data stored in WATERCAT.

TABLE 6

WATERCAT; DATA ELEMENTS

Data Elements	Description
I. LOCATION DATA ELEMENTS	
A. Location Number	-A fifteen digit number used as a file number for WATERCAT well data
1. Latitude of well site	-Latitude of the well site is given in degrees, minutes, and seconds in the first six digits of the location number for the well
2. Longitude of well site	-Longitude of the well site is given in degrees, minutes, and seconds in the seventh through the thirteenth digits of the location number for the well
3. Well number at that location	-The fourteenth and fifteenth digits of the location number identify the well number at that location
B. County	-The county in which the well site is located is identified by a three digit, standard API number
C. Land office grid system location, coarse level (LOGSCL)	-Township, range, section, and quarter-quarter-quarter description of the location of the well site (ex. T156N, R49W, S.32, ACB)
II. DATA SOURCE DATA ELEMENTS	
A. United States Geological Survey, Water Resources Division	-All data in this system is derived from the computer library systems maintained by the U.S.G.S.W.R.D., specifically WATSTOR and GWSI systems
B. Well owner or agency	-Identifies the well owner or agency that drilled the well
III. WELL DATA ELEMENTS	
A. Completion date	-Date well was completed
B. Casing depth	-Depth (feet x 100) to which casing was installed in well

TABLE 6, Continued

Data Elements	Description
C. Casing diameter	-Diameter (inches x 100) of casing installed in well
D. Site use	-Well was drilled as an observation well, stock well, water well, etc.
E. Water use	-Water is used for commercial, public, domestic, irrigation, etc.
IV. STRATIGRAPHIC DATA ELEMENTS	
A. Surface elevation	-Ground surface elevation at well site
B. Total depth	-Total depth drilled at well site
C. Well depth	-Depth at which well was completed
D. Producing formation	-Name of formation in which the well was completed. Formation abbreviations are the same as those used in WELLFILE
1. Top of producing formation	-Footage of the top of the producing formation (feet x 100)
2. Bottom of producing formation	-Footage of the bottom of the producing formation (feet x 100)
3. Lithology of the producing formation	-Lithology and lithologic modifier describe rock unit producing water (ex. sand, gravelly)
V. CHEMICAL DATA ELEMENTS	
A. Water temperature	-Temperature of the water produced by the well as reported by the source agency (^{o}C)
B. Specific conductance	-Specific conductance of the water produced by the well (μmho/cm)
C. pH	-pH of the water produced by the well
D. Concentrations of selected chemical constituents	-Results of water chemistry analyses performed on water produced by the well
1. Cations	-Concentration of Na^{+}, Ca^{++}, Mg^{++}, and K^{+} in mg/l and Mn^{++}, Fe^{++}, and B^{++} in μg/l
2. Anions	-Concentrations of Cl^{-}, $SO_4^{=}$, HCO_3^{-}. NO_3^{-}, and F^{-} in mg/l

TABLE 6, Continued

Data Elements	Description
3. Other	-Concentration of SiO_2 and total dissolved solids in mg/l
E. Hardness	-Concentration of Ca^{++} and Mg^{++} expressed as equivalent $CaCO_3$ in mg/l
F. Sodium-adsorption ratio (SAR)	-Relative activity of Na^{+} ions in exchange reactions with soil
VI. TEMPERATURE-DEPTH DATA SUBSET	
A. Location number	-A twelve digit number used as a file number for subset data files. Also used to link subset data files to WATERCAT data files
1. Land office grid system location coarse level (LOGSCL)	-township, range, section, and quarter-quarter-quarter description of the location of the well site (ex. T156N,R49W, S32, ABC)
2. Well number at that location	-The eleventh and twelfth digits of the location number identify the well number at that location
B. Date measured	-The month, day, and year on which the temperature log was run
C. Temperature-depth observations	-Temperature measured and the depth of the observation, repeated as many times as required to record all observations for a well
1. Depth	-The depth of a temperature measurement in metres
2. Resistance	-Resistance in ohms, of the thermistor circuit when at equilibrium at observation depth
3. Temperature	-Temperature calculated from laboratory determined calibration curve for thermistor circuit (±.03°C)

GEOGRAPHY AND THE SYSTEM

A prime use of the N.D.G.S. GEOSTOR-based retrieval system is the preparation of maps from the data bases. The production of a map requires the posting of data values at locations that correctly reflect the relative geographic positions of the sites from which data were collected. Manually posting values on a map is time-consuming, an inefficient use of human resources, and it can be expensive. Furthermore, manual operations are subject to human error. If many maps are to be produced in a short time, additional human resources must be procured, or the number of maps or the amount of data per map must be reduced. These need not be the only acceptable solutions.

Computer-assisted map preparation can meet such overloads and grow with the needs of the users. However, such programs faithfully replicate any errors built into the system. Therefore, programs must be designed and written with great care. Moreover, reference values used by the conversion programs of the system must be as accurate as possible (Winczewski, 1980a, p. 14).

The N.D.G.S. Coordinate System

The N.D.G.S. Coordinate System is a set of programs and reference values for converting the legal or other description of a site into coordinates suitable for use by computer mapping programs. The N.D.G.S. System is based upon interpolation of an (X,Y) coordinate from the coordinate of the nearest reference point, which is provided in a table. The table is prepared by laying a square grid (Cartesian coordinate system) over a suitable base map. The coordinates of appropriate reference points are recorded by a process called digitizing. Lines, such as county boundaries, which make maps meaningful, can also be digitized as a series of points.

The reference points digitized for the N.D.G.S. Coordinate System are township corners. The system can be expanded to use section corners for reference. The original digitizing program also included political boundaries, such as county lines, as well as the points of intersection of latitude and longitude, and reference intersections of the North Dakota State Plane Coordinate System. Programs have not been prepared to use the latitude/longitude and state plane references.

The conversion program reads the legal description for the site. The reference table is searched for the references for its township. If section corner references are on file, the coordinate for the site is interpolated from the coordinates for the nearest section corner. Otherwise, the interpolation is based on the nearest township corner. All interpolations assume sections are square and 5,280 feet on a side, and that townships are similarly ideal.

The scale of the map providing the digitized reference points places a limit on the extent to which a map area can be 'blown up' by the computer mapping program. If the reference map is digitized with care, a map produced from its reference coordinates can be enlarged to double a dimension in any direction. Further enlargement would begin to show random digitizing errors, and smooth curved lines will appear as a series of straight line segments. Ideally, the base map should be of as small a scale as practical.

Initially, the geothermal project required a general-purpose base for the preparation of generalized maps at a scale of about 1:2,000,000. The need was immediate, so a simplified prototype system was based upon a 1:500,000 township map of the state of North Dakota. The system quickly became operational and has been adequate for most applications.

The prototype base, on which the state of North Dakota is approximately 106 cm by 68 cm (3.5 ft by 2.2 ft), could not be used for detailed mapping

projects. The most practical level of detail was a base with a scale of one inch to a mile (1:63,360). The base is derived from blue-line highway maps available from the North Dakota State Highway Department. Over 100 individual sheets, each representing a county or part of a county, were digitized, converted to a single coordinate system, and 'pieced together'. The new base should be usable for the production of maps of up to two inches per mile. Further enlargements are not recommended. Instead, such detailed mapping should be based on maps digitized specifically for the purpose.

The N.D.G.S. Coordinate System is flexible and is easily adapted to unusual applications. The user is not restricted to defining the location only in terms of a legal description. He may take the reference map, from which the 1:63,360 base was developed, plot his points, and digitize them. The system will translate those coordinates into the master system, making the new locations, and their data, completely compatible with all previous data. This data entry method is advantageous whenever a legal description is difficult to determine, as it is in some remote areas without obvious section line fences. Furthermore, the method allows the user to easily define study areas, watersheds, and other areas which can be legally described only with great difficulty.

This flexibility, along with the use of tangible paper reference maps, is important to a geologist not accustomed to computer operations. He may be more willing to use a system that accepts data from a paper map. He is not required to convert his location descriptions to meaningless numbers for the benefit of a computer. The accuracy of the mapping system and reference table is a function of the quality of the blue-line highway maps, as well as the care with which they were digitized and integrated. The interpolation algorithm assumes ideal sections and townships. Maps produced from the base should not be enlarged much beyond the original reference scale. The table

of reference points and line segments can be quite large, in computer terms. If the coordinates are calculated when the new site is entered into the data base, and the coordinates stored with the new data, repeated calculations can be avoided.

LOGSFL Coordinate System

The LOGSFL coordinate system is a special-purpose system for small-scale detailed mapping, whenever a detailed map is not available for the area. The system uses a grid coordinate system originating at a nearby section corner (Figure 2). Grid units are feet from that origin. The system assumes that all sections are oriented north-south and exactly 5,280 feet on a side. Townships are also assumed to be ideal. The grid system must not overlay a tier correction line, where north-south township boundaries are offset. These assumptions can be critical to the use at a detailed mapping scale. The system is available, however, if a good base map at the proper scale is not available. The LOGSFL system is fully described in Winczewski (1980b).

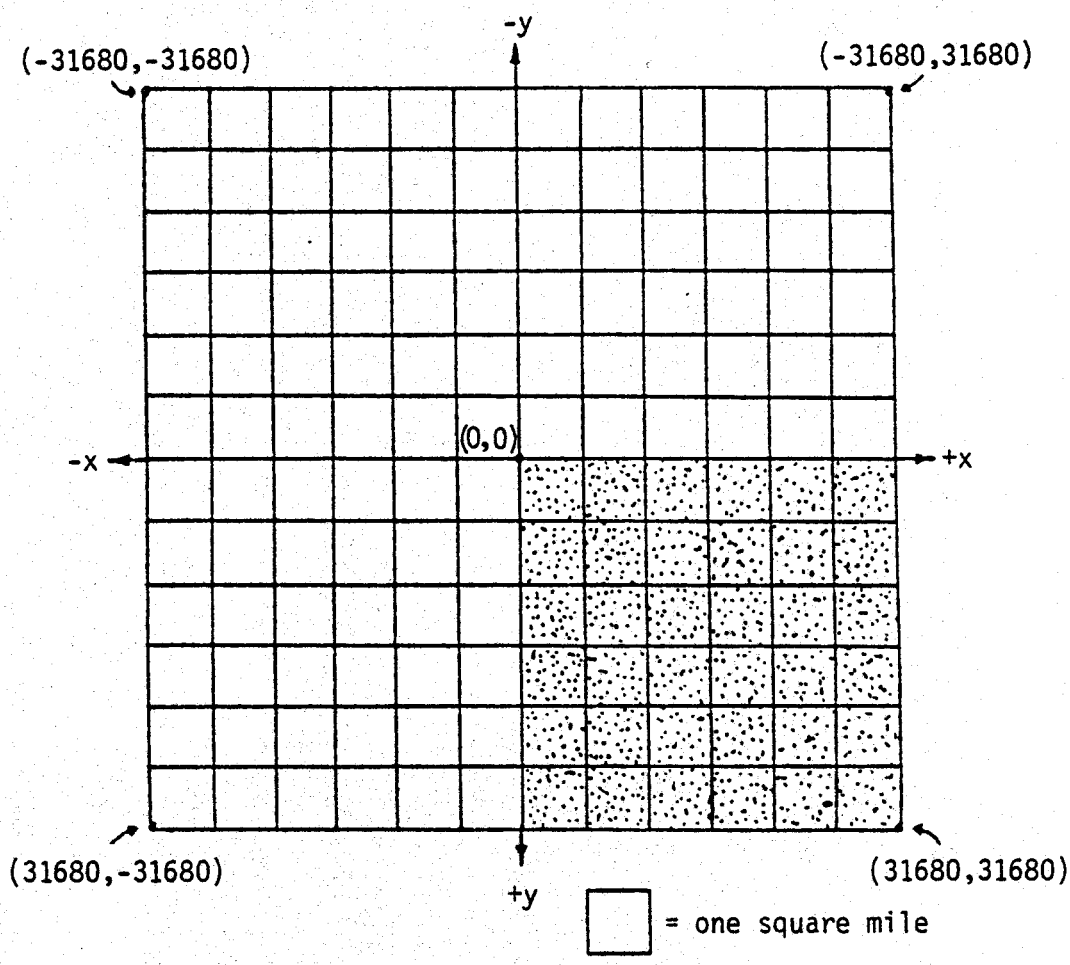


FIGURE 2 - THE LAND OFFICE GRID SYSTEM FINE LEVEL COORDINATE SYSTEM

(The origin (0,0) is located at the northwest corner of any section specified by the user. The stippled area, within which all (y,x) coordinates are positive, is the area normally used. The balance of the grid, containing at least one negative value per coordinate, is the reserve capacity of the system.)

HARDWARE AND SOFTWARE SUPPORT

The N.D.G.S. data management systems are supported by the computer facilities of the University of North Dakota Computer Center. An IBM 370/158 is the mainframe computer used by the Center. During the development stages of our data management system an OS/VS1 operating system was used by the Center. The Center now uses an OS/VS2 (MVS-SE) operating system, improving the speed of the system.

Off-line storage available through the Computer Center includes both disk and tape drive devices. Sixteen IBM 3350 disk drives (200 Megabytes each) and four IBM 3330 disk drives (100 Megabytes each) are available. Because of the expense of storing data on disk, most of our data are stored on tape.

A CALCOMP, three-color, 48-inch drum plotter is available for map production.

Interactive software used during the developmental stages of our systems was Virtual Systems Personal Computing (VSPC) (International Business Machines Corporation, 1977). The Computer Center has replaced VSPC with OBS WYLBUR (On Line Business Systems Incorporated, 1980). WYLBUR is used for text editing, disk file management, and remote job entry.

The supportive software is Statistical Analysis System (SAS) (Barr and others, 1979). SAS has proven to be a very versatile system suited to disk and tape file management. It also provides efficient data sorting and listing. SAS has its own coding language and offers a variety of statistical routines. Furthermore, SAS is easy to learn and use.

The SAS system and its language are the primary software support for the N.D.G.S. data management system. When necessary, FORTRAN is used for

numerical processing. Character manipulation is usually performed with SNOBOL language (Griswald and others, 1971). Tape and disk file maintenance is performed with IBM Standard Utilities.

Data are displayed as listings and plots. The SURFACE II Graphics System (Sampson, 1978) supports most of the graphics needs of the Survey. SURFACE II, developed and maintained by the Kansas Geological Survey, produces high quality pen plots. Within it are options for producing transects, contour maps, posted data, block diagrams, and stereo plots. Draft maps can be produced on a printer.

Printed output can be routed directly to the Survey's IBM System Six word processing system. The system is linked to a jet-ink printer for high quality printed output.

HOW THE SYSTEM IS USED

WELLFILE

Work began in 1976 on developing an oil and gas well computer library system. This system contained location, legal, production, and core and sample data on about 4,000 wells drilled in North Dakota. The data base was coded, key punched, and assembled under the direction of Sidney B. Anderson, N.D.G.S. Chief, Subsurface section.

WELLFILE was designed to supplement and expand the data of this earlier system, assembling the entire data base in an efficient, location-oriented computer library system. Stratigraphic, bottom-hole-temperature, water quality, and more detailed location data were added to the existing data base. In addition, missing wells and wells with N.D.G.S. well numbers greater than 4,000 were coded, key punched, and compiled into the WELLFILE system. Initial data entry was accomplished by the use of coding forms and batch entry of the data on keypunched computer cards. WELLFILE is currently updated monthly, to add newly permitted wells, using interactive terminal and batch entry of key punched data.

Verification

Verification of the data in WELLFILE is a continuing process, as the system is applied to various tasks and projects. Initial verification includes mapping and listing of the data elements to identify anomalous map areas and data values. For example, the elevations of all formation tops may be posted on a North Dakota base map and machine contoured. The posting process helps identify wells that might be mislocated. Because the subcrop area of the Pennsylvania Minnelusa Formation is known from previous work, a

Minnelusa top posted outside the area of known subcrop is suspect. The data point can be identified and checked against the source file. The machine-contouring process can identify erroneous reference elevations, formation tops, and locations. These appear on contour maps as "postholes" and "telephone poles" (Figure 3). An anomalous data point can be identified, checked against source data, and corrected.

Listings of data elements can also be useful in identifying erroneous data. For instance, a listing of all bottom-hole-temperatures, in numerical order, will immediately locate values that are anomalously high or low.

Modifications that are necessary to correct WELLFILE data are entered as new data for that well, overwriting previous values. The SAS language and system are well suited for data modification.

Data Retrieval

Data retrieval is accomplished by requesting the necessary information in the desired format from the N.D.G.S. Data Processing Analyst. It is desirable to limit access to the WELLFILE tapes and thereby limit the confusion during verification and modification. All software necessary for the various retrieval formats is managed by one person who accesses the system through an interactive terminal using SAS programs.

As indicated previously, the data retrieved may be displayed in a variety of formats. Listings of any alphanumeric data stored in WELLFILE may be generated. Data elements can be sorted and listed in the most convenient format for the user. For example, a listing of all cores in storage from McKenzie County might be needed. The cores available should be sorted by formation and well location and listed. Listed information should include the N.D.G.S. well number, the exact footage cored, and the storage location in the Wilson M. Laird Core and Sample Library (Figure 4). As listings of WELLFILE data are

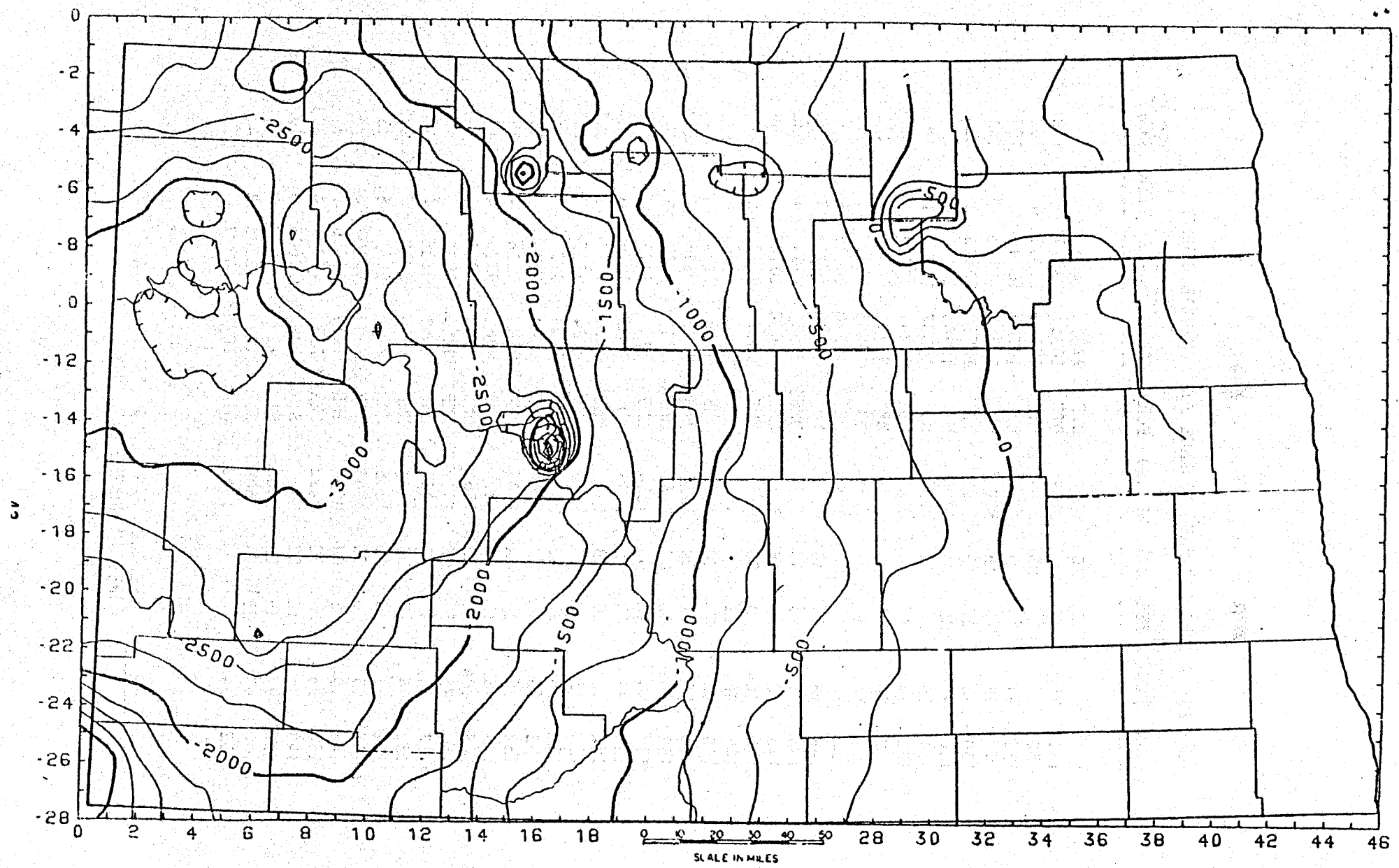


FIGURE 3 - WELLFILE; VERIFICATION OF STRATIGRAPHIC DATA USING A MACHINE-CONTOURED TEST MAP

SAMPLES IN CORE LIBRARY STORAGE FOR MCKENZIE COUNTY

Location						Footage		Storage	
TOWN	RANGE	SEC	QTR	WELLNO	FORM	UPPER	LOWER	TIER	SHELF
152	94	17	DC	1254	DTF	9264	9315		
152	96	3		2169	DTF	10317	10340	5	102
152	96	3	DB	2967	DTF	10313	10340	6	102
152	94	7		1343	DW	10700	10795	1	157
148	98	13	AB	527	MB	11225	11292	4	141
150	96	27	AB	1405	MB	10759	10822	8	224
150	97	35	CA	1606	MB	10945	10960	4	3
151	95	5	CB	2820	MB	10587	10653	1	133
152	94	7		1343	MB	10340	10399	1	329
152	94	17	DC	1254	MB	9070	9130	2	233
152	96	3		2169	MB	10278	10317	2	101
152	96	3	DB	2967	MB	10238	10313	5	102
148	98	13	AB	527	MM	10490	10493	4	140
148	98	13	AB	527	MMFA	9795	9994	4	138
148	98	13	AB	527	MMFA	10050	10107	4	139
148	104	28	CB	956	MMFA	9337	9469	5	94
149	96	12	DC	33	MMFA	9533	9588	4	15
150	96	5	CC	1412	MMFA	9166	9194		
151	95	31	DD	1572	MMFA	9292	9396	7	230
152	94	6	CB	1262	MMFA	8735	9177	5	34
152	94	17	DC	1254	MMFA	8949	8975	8	232
152	95	18	AD	1295	MMFA	9057	9276	6	257
152	95	20	CB	1065	MMFA	9110	9178	6	255
152	95	20	CB	1065	MMFA	9184	9337	7	255
152	96	27	AC	2593	MMFA	9113	9172	4	160
152	96	34	AC	2144	MMFA	9190	9239	3	105
152	96	34	BA	1995	MMFA	9182	9216	4	189
148	98	13	AB	527	MMR	9683	9795	4	137
148	104	28	CB	956	MMR	9240	9337	4	94
150	96	5	CC	1412	MMR	9265	9320		
152	94	6	CB	1262	MMR	8661	8735	4	34
152	94	17	DC	1254	MMR	8934	8949	7	232
152	95	18	AD	1295	MMR	9044	9057	5	257
152	95	20	CB	1065	MMR	9041	9110	8	93
148	104	28	CB	956	ORR	12795	13006	7	94
150	96	5	CC	1412	PENNM	7581	7630	4	303
149	96	12	DC	33	SI	12623	12683	3	16
150	97	35	CA	1606	SI	12670	12923	2	4
150	97	35	CA	1606	SI	13190	13305	3	4
152	94	7		1343	SI	10840	10877		

FIGURE 4 - WELLFILE; PART OF A LISTING OF AVAILABLE CORES IN McKENZIE COUNTY

are requested, the necessary SAS programs are prepared to accomplish the task.

Postings of data elements stored in WELLFILE, on a North Dakota base map, can be accomplished within the accuracy of our location descriptions and digitized base maps. The values posted on the map may be the raw WELLFILE data or manipulated WELLFILE data. For example, it may be desirable to post, on a 1:1,000,000 North Dakota base map, the average elevation of the top of the Mississippian Madison Formation for each township in the state. To accomplish this, it is necessary to calculate the elevation of the top of the Madison in all wells that penetrate that formation. Sorting the elevations by township and range identifies those values to be averaged into a posted value for each township.

Machine contouring of posted data is also a display option. Rapid validation and interpretation of large amounts of data can be accomplished in this way. For example, it may be useful to produce a machine-contoured map of all bottom-hole-temperatures reported in wells that bottom in the Madison Formation. This can be accomplished by sorting WELLFILE for all wells reporting the Madison as the deepest formation penetrated. A list of bottom-hole-temperature and location information will provide the information necessary to post and machine-contour the map (Figure 5).

Sorting and listing programs can easily provide data subsets that can be subjected to statistical analysis or other manipulations. All data elements in WELLFILE are stored in English units or units that are commonly used in the oil industry. The actual units used with the data in storage are not particularly important, because unit conversions can be easily performed at the time the data set is being prepared for display.

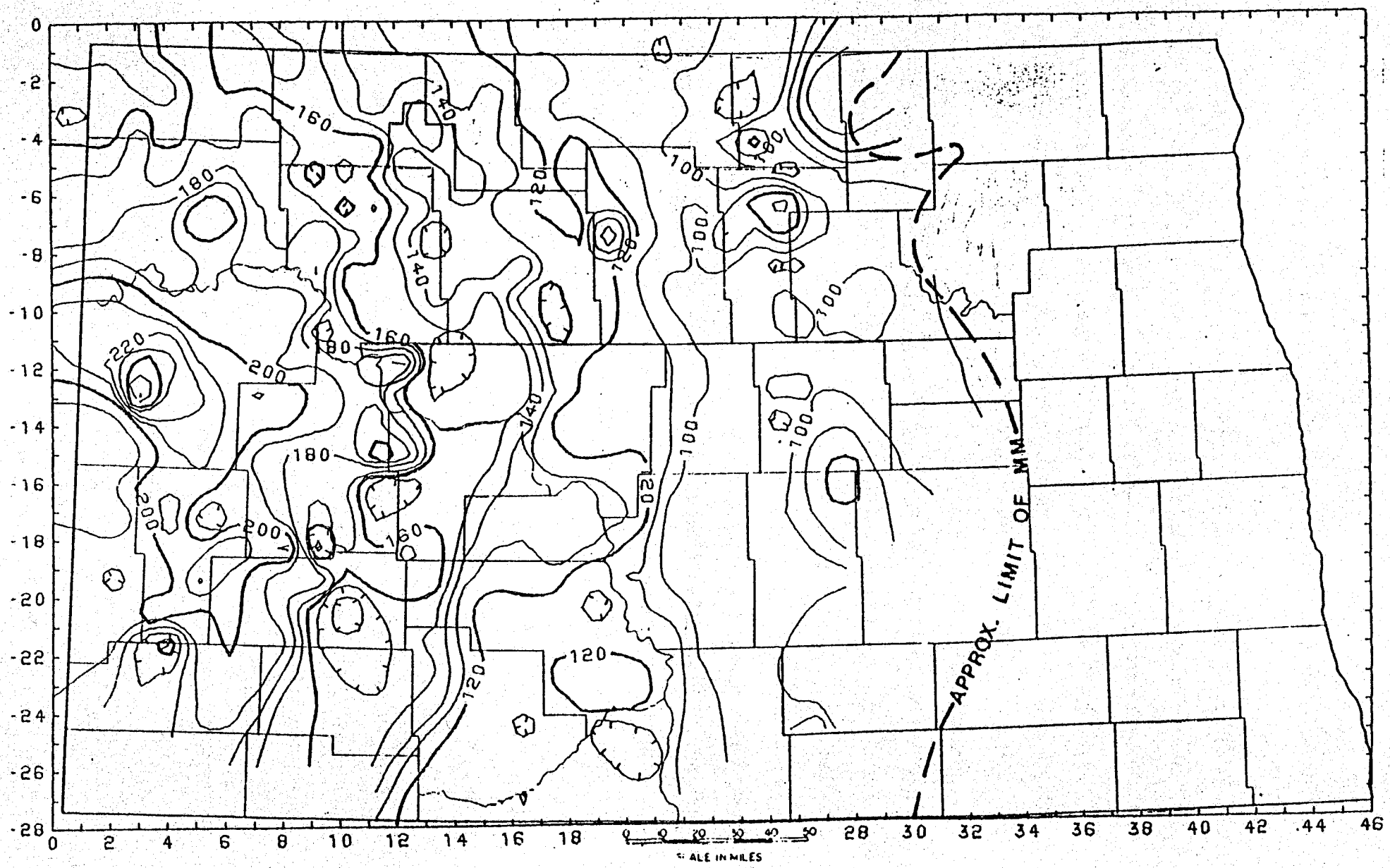


FIGURE 5 - WELLFILE; A MACHINE-CONTOURED ISOTHERMAL MAP OF THE MISSISSIPPIAN MADISON FORMATION

WATERCAT

WATERCAT is a location-oriented computer library system which manages information on more than 41,000 water wells and groundwater observation wells from two U.S.G.S.W.R.D. computer library systems, WATSTORE and GWSI. The two source libraries provide physical, stratigraphic, and water quality data from wells drilled in North Dakota over about the last twenty years. WATERCAT was assembled during July, 1980, and will be updated annually.

Verification

Verification of the data in WATERCAT will be a continuing process as information for the system is applied to various projects. Initial verification consists of mapping and listing data elements to identify anomalous map areas and data values. The procedure used is the same as that outlined for WELLFILE. Modifications to correct WATERCAT data elements are entered through an interactive terminal and SAS programs overwrite the incorrect values.

Data Retrieval

Data retrieval is accomplished by requesting the necessary information in the desired format from the N.D.G.S. Data Processing Analyst. As with WELLFILE, it is desirable to limit access to the WATERCAT tapes and thereby limit the confusion during verification and modification of the data. All software necessary for the various retrieval formats is then managed by one person who accesses the system through an interactive terminal.

Data retrieval and display capabilities are exactly the same as those available for WELLFILE. Most commonly used displays include listings, postings, machine-contoured maps, and graphical displays of the data elements.

Listings can be made of all or any part of the data elements contained in WATERCAT. These data elements may be sorted and listed in any convenient way. An example is a listing of all wells producing water from the Cretaceous

Inyan Kara Formation, for which we have available the results of chemical analyses of the water produced. The wells can be sorted by county, township, range, and section, and listed with the results of the water analyses (Figure 6).

Postings of any of the raw or manipulated data elements can be produced. For example, a posting of the location of all wells on record that produce water from the Pleistocene Elk Valley aquifer might be desired. For this posting, a 1:500,000 scale base map of Cavalier, Pembina, Walsh, Grand Forks, Steele, and Trail counties would be convenient (Figure 7).

A machine-contoured map of any posted data can be produced. For instance, a machine-contoured map of the total dissolved solids recorded for all wells, with water chemistry data, from the Cretaceous Hell Creek Formation may be desired. The user again may choose the most convenient scale for a base map on which to display the data.

Graphical presentations of data elements can also be produced. An example of this display option is the graphic display of our temperature and depth data subset of WATERCAT. A graph of the measured temperature versus the depth of measurement can be produced for each well in the data subset. These geothermal gradient profiles are automatically scaled in degrees Celsius versus depth in metres and labeled with the location of the well and the date of measurement (Figure 8).

Sorting and listing programs can easily provide data subsets that can be subjected to statistical analysis or other manipulations. All data elements in WATERCAT are stored in the units used in the U.S.G.S.W.R.D. source tapes. Data element units can easily be converted to any desired units at the time a data set is being prepared for display.

CRETACEOUS INYAN KARA FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-053-08AAB	4300	8	6	230	40	16	9	1000	13	455	1200	410	2	2890	76
129-054-02AAC	4100	8	6	330	10	14	7	960	14	440	1200	370	1	2800	63
129-054-18BBD	4500	8	5	580	60	15	9	1000	14	477	1200	390	1	2880	75
129-055-13BCC	3890	8	8	1400	60	19	6	880	13	344	1200	360	1	2670	74
129-056-30DDD	4600	8	8	710	40	18	7	1100	17	527	1300	430	1	3160	75
129-057-14CCC	3900	8	6	850	80	27	35	790	13	357	920	470	3	2450	210
129-057-30DCC	3740	8	8	480	40	21	8	810	12	403	900	440	1	2410	84
129-058-22ADD	3970	8	8	3100	80	19	6	880	13	547	660	620	3	2490	70
129-060-06CCA	2870	8	6	2200	60	96	29	510	23	190	1200	85	1	2050	360
129-060-28CCB	3150	8	6	430	60	37	12	670	12	210	1300	100	1	2250	140
129-061-31BCA3	4020	8	8	40	60	16	6	870	13	420	700	640	1	2470	64
129-063-25BBB	2640	7	11	4100	220	210	60	330	21	190	1200	67	1	2000	770
129-063-34BBB	4830	8	6	1800	20	13	7	1100	21	575	160	1300	1	2900	62
129-064-20BBB	3880	8	6	5100	60	25	14	810	21	781	200	770	14	2260	120
129-065-35DBD	4000	8	9	1300	.	18	8	900	17	891	210	810	2	2420	77
129-071-15AAB	2650	8	9	1400	60	93	31	460	11	188	1100	71	1	1870	360
129-073-21CDB	2800	7	13	3600	160	290	76	330	20	180	1200	180	.	2210	1000
130-048-31DCD1	6060	8	6	.	.	33	16	1390	16	307	1450	1020	7	4090	150
130-052-29DAA	4230	8	8	.	.	15	8	970	20	334	1290	414	12	2900	70
130-053-06DDD	4250	8	8	440	10	18	7	980	17	461	1200	370	6	2850	75
130-053-28DDB	4310	8	8	500	40	16	7	970	11	460	1200	400	1	2860	70
130-054-29ABA	4000	8	8	1800	620	17	7	900	15	377	1100	370	1	2620	70
130-055-13ACB1	3950	8	7	580	40	20	6	920	15	323	1200	370	0	2710	74
130-055-32ADD1	4390	8	8	130	30	35	8	960	13	294	1300	490	1	2970	120
130-056-06ABB1	4630	8	6	60	40	14	6	1100	16	888	790	620	11	3010	60
130-056-35AAB1	3810	8	9	0	40	22	6	840	13	357	1100	360	8	2540	80
130-057-02ABC	3500	8	8	990	50	25	8	820	18	315	1100	330	1	2470	96
130-057-35AAB	4090	8	8	0	20	11	6	940	14	576	870	540	4	2690	50
130-058-06AAA	4140	8	7	940	90	18	6	930	17	585	790	600	1	2670	70
130-058-25CBD	4000	8	9	60	10	15	8	890	17	574	730	580	1	2550	70
130-059-23CBD	580	7	30	2500	1000	90	26	8	3	337	55	16	4	401	330
130-059-26CAC	630	7	32	900	1200	95	27	9	3	370	61	4	3	419	350

FIGURE 6 - WATERCAT; PART OF A LISTING OF WELLS COMPLETED IN THE CRETACEOUS INYAN KARA FORMATION WITH CHEMICAL ANALYSES OF THE WATER PRODUCED

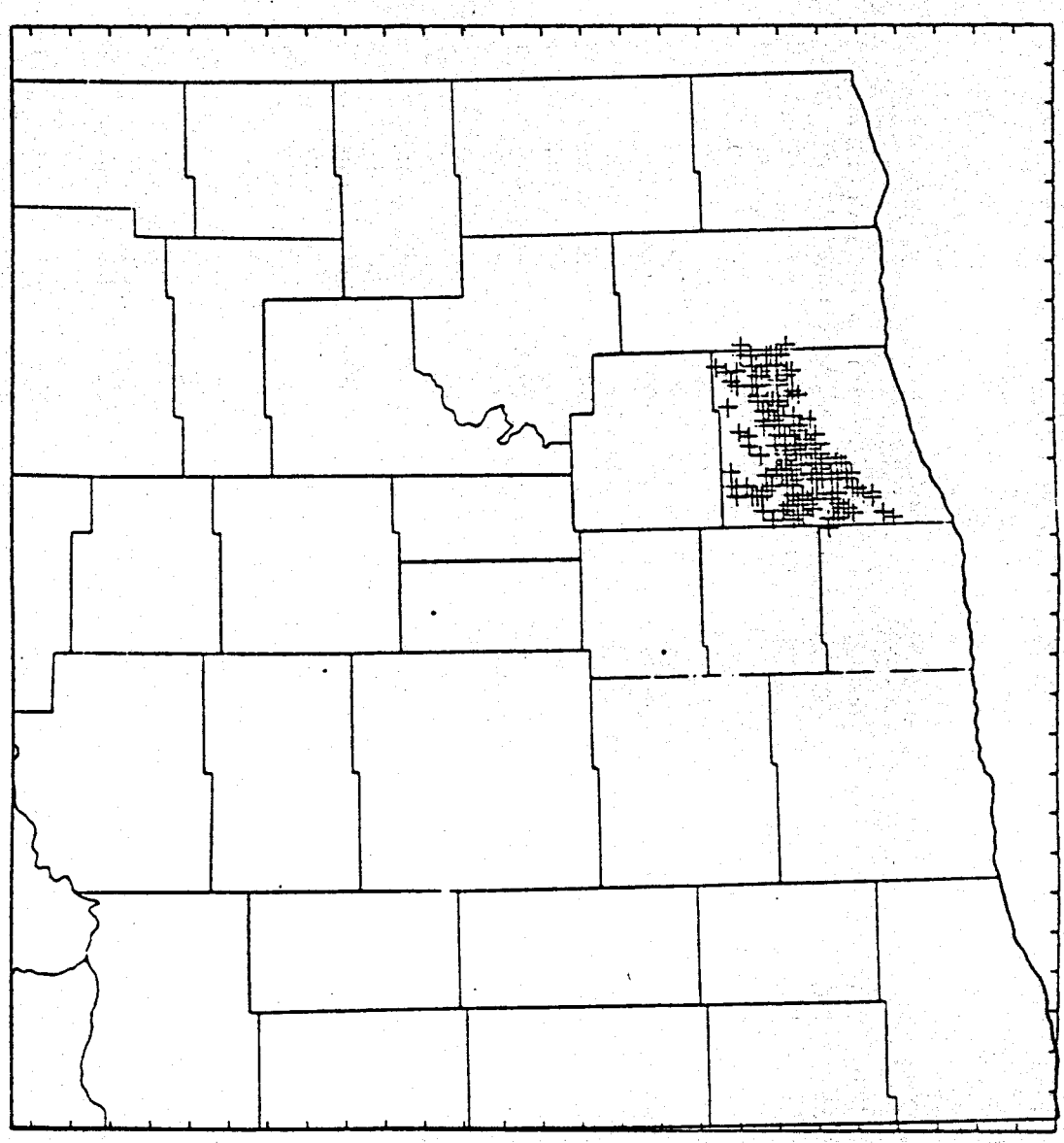


FIGURE 7 - WATERCAT; A POSTING OF WELLS PRODUCING WATER FROM THE PLEISTOCENE ELK VALLEY AQUIFER

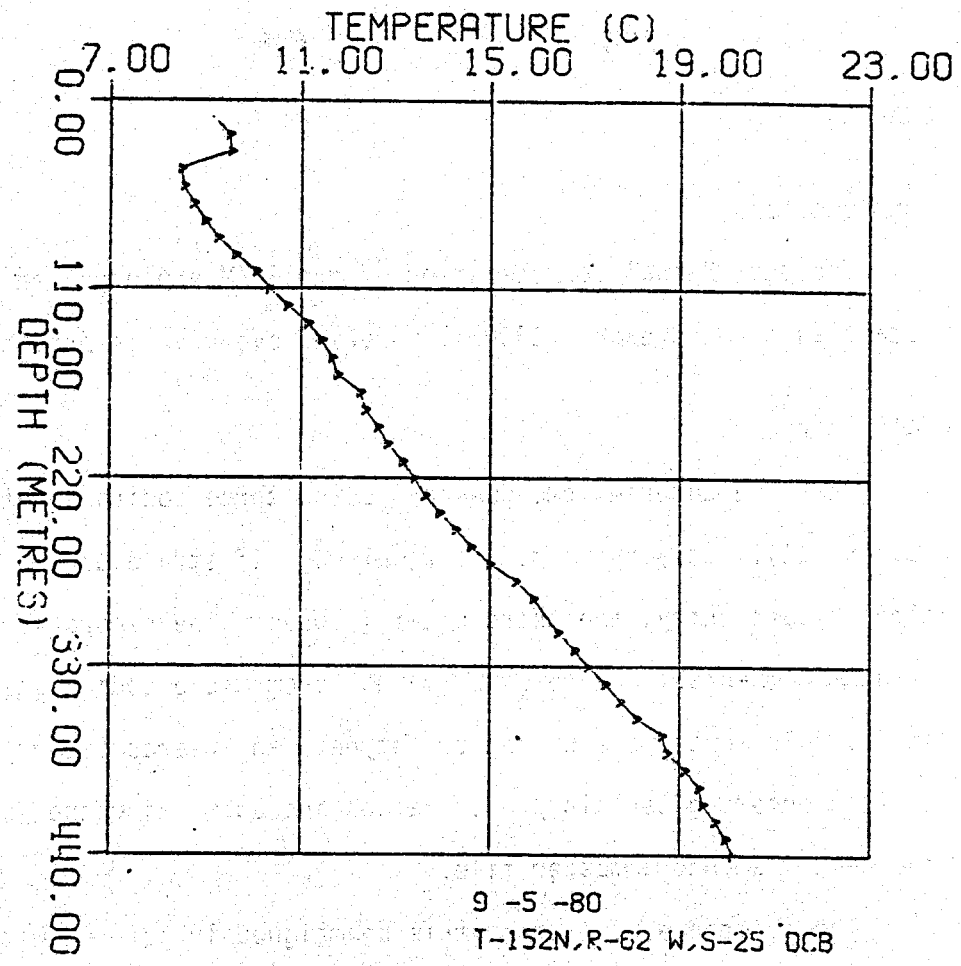


FIGURE 8.- WATERCAT; A GEOTHERMAL GRADIENT PROFILE FROM THE TEMPERATURE-DEPTH DATA SUBSET

COALBASE

Introduction

The User Manual for operation of the SEAM prototype on the COALBASE data base is Winczewski (1980b). A brief overview is provided here.

Data Entry

Data are entered into COALBASE using three coding sheets (Figures 9, 10, and 11). Only the first is required. If strata are to be defined at time of data entry, the third sheet is used. The second is used for non-stratum comments. The records (cards) from these coding sheets are loaded into a file accessible by the prototype. An interactive program guides the user in entering certain preset values and submitting the job to process the new data into a master file.

The substance of a stratum is unambiguously defined with a Datatype Code (Table 7). The user can define his own codes. A stratigraphic marker is defined as a stratum of zero thickness with a code for geologic contact. Any stratum, or sequence of adjacent strata, can be identified with a name code, which is required by some of the retrieval options.

Data Verification and Modification

After the master file has been written, a series of interactive programs is available to guide the user into viewing any or all of his data. Data values can be added, changed, or deleted under the interactive guidance of these programs. Examples of modification sessions are provided in Appendix D. The strength of the prototype is its ability to easily allow changes in strata boundaries. User-defined data elements can be defined and loaded interactively.

SITE ID _____ DATA ENCODER _____ DATE _____ PAGE ____ OF ____

Coding Sheet 'A', for Non-Stratum Data

Record 1: Marker for non-stratum data

ε	ε	ε	ε
1			

Record 2: Site Identification, Location Description, Group Codes

Site Identification

1

LOGSCL Location Description

17	20	23	25
Township	Range	Section	Quarters

LOGSFL Location Description

29	33	34	38
Feet from	N/S line	Feet from	E/W line

Group Codes

40	45	50	55	60	65	70	75

Record 3: Elevation, depth, date, method, records, presets

Units of elevation, depth and thickness (F or M)

1

Reference elevation of site (top of hole or column)

2

Total Depth

10

Depth to Bedrock

17

Date Drilled

24	26	28
Day	Month	Year

Method of Drilling

30
Code

Logs or samples

Driller Log	Natural Gamma Log	Gamma Density Log	Self Potential Log	Resistivity Log	Caliper Log	Samples Saved	Other Records
31	32	33	34	35	36	37	38

Presets

Data Owner	Data Storage	Comments
45	47	49

FIGURE 9 - COALBASE, CODING SHEET 'A'. THIS FORM IS USED TO ENCODE ALL NON-STRATUM DATA OTHER THAN COMMENTS

Site ID _____ Page _____ Of _____

Coding Sheet 'B', for Non-Stratum Comments

Note: Additional 'B' sheets may be used, if needed

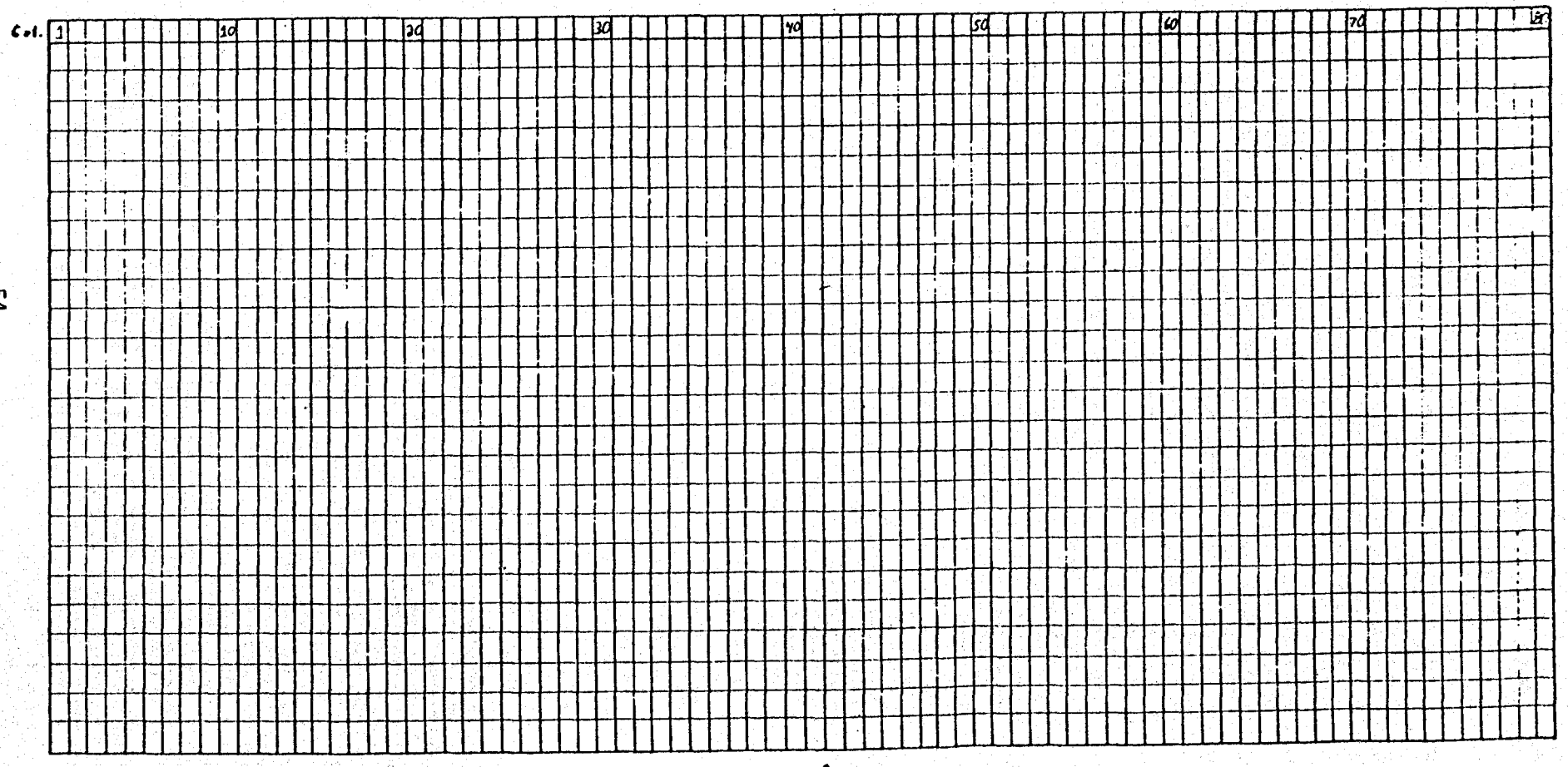


FIGURE 10 - COALBASE, CODING SHEET 'B'. THIS FORM IS USED TO ENCODE NON-STRATUM COMMENTS

Site ID: _____ Page _____ Of _____

Coding Sheet 'C', for Strata Data

$ $ $ $
1

Note: To continue stratum description, leave columns 1-20 blank; Additional 'C' sheets may be used, if needed

Depth to Top of Stratum	Datatype Code	Stratum Name			Stratum Description
		I	II	III	
Col. 1	8	13	17	19	21

FIGURE 11 - COALBASE, CODING SHEET 'C'. THIS FORM IS USED TO ENCODE ALL STRATUM DATA

TABLE 7

COALBASE: SOME EXAMPLES OF DATATYPE CODES

Code	Description	Symbol
100	Topsoil, Undifferentiated	TSTSUD
135	Topsoil, Sandy Clay Loam	TSLM.-
300	Fill, Undifferentiated	FFFFFF
777	Geologic Contact	CONTCT
1220	Lignite, Undifferentiated	CCCCLG
1221	Lignite, With Pyrite or Marcasite	CCLGPY
1310	Limestone	++++LS
1331	Ironstones, As Nodules	++IR@@
1610	Fossil Bed, Petrified Wood	####PW
2000	Clay, Undifferentiated	----UD
2004	Clay, Bentonitic	--BENT
2010	Clay, Carbonaceous	----CC
2011	Clay, Slightly Carbonaceous	-----C
2051	Claystone	----ST
2500	Shale, Undifferentiated	====UD
2510	Shale, Clay-Rich	=====--
2552	Shale, Sandy, Slightly Carbonaceous	===..C
2600	Clay, Silty	----::
2891	Clay, Silty, Slightly Sandy	---::.
3000	Silt, Undifferentiated	::::UD
3100	Silt, Clayey	::::--
3900	Silt, Sandy	:::::..

TABLE 7, Cont.

Code	Description	Symbol
3935	Silt, Slightly Sandy, Foss. (Plant)	:::.FP
3990	Silt, Sandy, Clayey	::..--
4000	Sand, Undifferentiated	....UD
4050	Sand, Indurated	....IN
4051	Sandstone	....ST
4070	Sand, Salt and Pepper	....SP
4100	Sand, Silty	....::
4111	Sand, Silty, Slightly Carbonaceous	...::C
4200	Sand, Very Fine	1
4221	Sand, Very Fine, Slightly Lignitic	...1LG
4300	Sand, Fine	2
4305	Sand, Fine, Slightly Silty	....2:
4400	Sand, Medium	3
4500	Sand, Coarse	4
4600	Sand, Very Coarse	5
5000	Granules, Undifferentiated	,,,,UD
5200	Pebbles, Undifferentiated	%%%%UD
5300	Pebbles, Very Small	%%%%%1
5400	Pebbles, Small	%%%%%2
5500	Pebbles, Medium	%%%%%3
5600	Pebbles, Large	%%%%%4
5700	Gravel, Undifferentiated	8888UD
6000	Cobbles, Undifferentiated	0000UD
7000	Boulders, Undifferentiated	()()UD
9999	No Data	NODATA

Data Retrieval

Conditional data retrieval can be entirely interactive; for lengthy searches, the preparation of the retrieval request is interactive, with the retrieval run offline. Figure 12 shows an example of a retrieval request and the result. Table 8 shows the retrieval options. Special options are available for the retrieval of elevations of tops, names of strata, thicknesses of strata, overburden or interburden, or for processing data of coal splits or partings. Mapping coordinates and missing values are supplied upon request.

Advantages and Disadvantages of the SEAM Prototype

The SEAM Prototype is mostly interactive and allows the user easy access to his data without learning much about computer operations. The programs are menu-driven, and are capable of detecting important errors in requests, or inconsistencies in the data caused by changes. The system is large but is of modular design for installation on small computers. The programs are in the public domain.

Because the SEAM Prototype is a FORTRAN-based system and uses only sequential files, it is slow and inefficient compared to what might be possible to design. It is quite limited in the amount of data that can be made available interactively at an efficient rate of operation. It is not maintained or supported by the designers, but it can be modified easily.

The SEAM Prototype only retrieves values from the coal data base. The processing of the values, such as mapping or statistical analysis, must be done by external programs.

The SEAM Prototype is FORTRAN-based, mostly interactive and of modular design for use on minicomputers. The experience gained in the design and operation of the SEAM Prototype was applied to advantage in the design of the SAS-based system.

The Retrieval Request

YOU ARE RETRIEVING

STRATUM	ITEM	SUB-ITEM	DESCRIPTION
NON-STRATUM	45	1	NDGS Y-COORDINATE
NON-STRATUM	45	1	NDGS X-COORDINATE
ALL STRATA	84	1	THICKNESS OF STRATUM

----------IF----------

ANY STRATUM	DATATYPE CODE	EQ	4051
		(Note: 4051 = 'Sandstone')	

AND

ANY STRATUM	DEPTH TO TOP OF STRATUM	LT	90

BOTH TESTS APPLY TO A STRATUM SIMULTANEOUSLY

RETRIEVE ONLY FOR QUALIFYING STRATA? (Y OR N)

The Result

THE RETRIEVED VALUES ARE:

DESCRIPTION	VALUE
INTERNAL ID	8
SITE ID	DEMO SITE EIGHT
NDGS Y-COORDINATE	88888
NDGS X-COORDINATE	99999
THICKNESS OF STRATUM	8.7

FIGURE 12 - COALBASE: AN EXAMPLE OF A DATA RETRIEVAL

TABLE 8

COALBASE: RETRIEVAL OPTIONS

The retrieval options are:

1. VALUE - retrieval of the value of data element(s) for the test conditions specified;
2. TOP - retrieval of the elevation of the top of a stratum of a specified name. If more than one strata are of the name, the value retrieved will be that of the uppermost one;
3. THICKNESS -
   a. OF - a requested stratum. If more than one strata are of that name, the value retrieved will be the sum of thickness of all the strata of that name;
   b. ABOVE - to the reference elevation, the top of the uppermost or bottom of lowermost stratum of the requested name;
   c. BELOW - to the total depth of record, the top of the uppermost or bottom of lowermost stratum of the requested name;
   d. BETWEEN - the tops of uppermost and/or bottoms of the lowermost strata of the requested names;
   e. SPLIT/PARTING - where 'split' is the primary datatype (lithology) of multiple strata of the same requested name, and 'parting' is the non-primary datatype(s):
      i) ELEVATION - of top of each split/parting;
      ii) DEPTH - to top of each split/parting;
      iii) THICKNESS - of each split/parting;
      iv) SUM THICKNESS OF - all splits/partings;
      v) NUMBER - of split/parting strata

The special options have particular application to geological research and to surface mine planning or operation. The 'TOP' option is used to retrieve values for a structural contour map of the surface of the requested stratum. The 'THICKNESS OF' option serves similarly for isopac mapping, or coal resource calculations. The 'THICKNESS ABOVE' option provides values for measurements of overburden thickness for the coal. The 'THICKNESS BETWEEN' serves the same for interburdens. Special problems of multiple strata of same name are handled within the 'SPLIT/PARTING' options.

The SEAM Prototype data management system is public information and available for the cost of duplication and mailing. It is a somewhat specialized system, less flexible and expandable than the SAS-based system, but it can be installed on almost any computer.

HISTORY OF SYSTEM DESIGN AND DEVELOPMENT

Approximately five years ago, the North Dakota Geological Survey attempted to put all of its data associated with petroleum regulation and geology into a computer system. Data from about 4,000 wells were entered into a system based on the PL/I language. Although the system was operational, it was cumbersome to use and did not really serve the needs of the Survey. In 1978, a project supported by SEAM was begun for the purpose of modeling coal stratigraphy in North Dakota. The project needed a means of managing a large volume of geologic data. The system to manage those data evolved into the SEAM Prototype, which operates on COALBASE.

In 1979 the N.D.G.S. entered into a cooperative agreement with the Department of Energy, Division of Geothermal Energy to evaluate the geothermal resources of North Dakota. The first phase of the study was to be based on data from the N.D.G.S.'s oil and gas wellfiles. Because efficient management of the data collected was necessary, and because there were now more than 7,000 oil and gas wells on file, a GEOSTOR-based system was chosen to manage the data collected by the DOE study.

With the experience of the SEAM project available to guide system development, system design and development was undertaken. The DOE project did not restrict the system language to FORTRAN, as did SEAM. The filing and retrieval powers of SAS were quickly discovered, and SAS was chosen to support the N.D.G.S. data management system.

Problems Encountered

Many of the problems inherent in a FORTRAN-based system were solved with the use of SAS. Auxiliary programs for checking of input data, or translation

of data were written in the languages of SAS, FORTRAN, PL/I, and SNOBOL.

A means was needed for converting the legal description of the well site into a coordinate suitable for use by a mapping program. The 1:500,000 base map system, described above, was developed in coordination with the SEAM project. As discussed, the scale of this system is adequate for most applications, but more detailed mapping requires a smaller scale base map. This problem is being solved with the new 1:63,360 scale base under development.

Finally, a good map contouring program was needed. The SYMAP system (Dougenik and Sheehan, 1975) was available locally, but provided only printed maps. The SURFACE II package (Sampson, 1978) was purchased by the North Dakota Geological Survey to be the primary mapping system. Considerable installation problems were encountered, but now high quality pen-plotted maps are possible.

Both skilled computer scientists and geologists skilled in computers are essential to the successful development of a system such as this.

The availability of suitable supportive hardware, and skilled people to assist in the installation and operation of a system of this size, has been and will continue to be a problem. Operation of the N.D.G.S. data management system is of low priority on the main frame computer. Therefore, delays in processing or availability of peripheral devices are constantly encountered. Much of the processing must be performed late at night or on weekends, placing an extra strain on Survey personnel.

Strengths of the Present System

The primary strength of the present system is its ability to handle a large volume of diverse data and produce results for a wide variety of request conditions. The system is able to grow with the volume of data, accept new data bases, and still retain its flexibility. It is run by people who are skilled in making SAS perform intricate tasks perhaps not envisioned by the SAS designers.

REFERENCES

Barr, Anthony J., Goodnight, James H., Sall, John P., Blair, William H., Chilko, Daniel M., 1979, SAS - Statistical Analysis System: SAS Institute Incorporated, Raleigh, North Carolina, 494 pages.

Dougenik, J.A., and Sheehan, D.D., 1975, SYMAP Users Reference Manual (5th edition): Bedford, Massachusetts, 175 pages.

Griswald, R.E., Poage, J.F., Polonsky, I.P., 1971, SNOBOL 4: Bell Telephone Laboratories Incorporated, Englewood Cliffs, New Jersey, 256 pages.

Harris, Kenneth L., Winczewski, Laramie M., Umphrey, Howard R., Anderson, Sidney B., 1980, An Evaluation of Hydrothermal Resources of North Dakota; Phase I Final Technical Report: University of North Dakota Engineering Experiment Station Bulletin Number 80-03-EES-02, 176 pages.

International Business Machines Corporation, 1977, V.S. Personal Computing: White Plains, New York, 174 pages.

On Line Business Systems Incorporated, 1980, OBS WYLBUR Reference Manual: San Francisco, California, 203 pages.

On Line Business Systems Incorporated, 1980, OBS WYLBUR Users Guide: San Francisco, California, 136 pages.

Sampson, J.A., 1978, SURFACE II Graphics System: Kansas Geological Survey, Lawrence, Kansas, 240 pages.

Winczewski, Laramie M., 1980a, GEOSTOR: An Approach to the Management of Map-Oriented Data; Part I: An Introduction to GEOSTOR: University of North Dakota Engineering Experiment Station Bulletin Number 80-08-EES-05A, 41 pages.

Winczewski, Laramie M., 1980b, GEOSTOR: A Location-Oriented Data Management System; Part II: Users Manual-SEAM Prototype: University of North Dakota Engineering Experiment Station Bulletin Number 80-08-EES-05B, 136 pages.

Winczewski, Laramie M., Umphrey, Howard R., Franzen, Bernadette, and Lindem, Alfred C. III, 1980c, GEOSTOR: A Location-Oriented Data Management System; Part III: Technical Manual - SEAM Prototype: University of North Dakota Engineering Experiment Station Bulletin Number 80-08-EES-05C, 82 pages.

APPENDIX B

CODING GUIDE

WELLFILE DATA GUIDE AND CODING GUIDE

K.L. Harris
North Dakota Geological Survey
November, 1978
Revised February, 1981

TABLE OF CONTENTS

CODED DATA

I. NONRECURSIVE DATA		SPACE/FORM
CARD 1		
WELL NUMBER:	Log file number, may or may not be the same as permit number (see Attachment 1)	I6
CARD COUNTER:	Number all cards for the well sequentially	I2
PERMIT NUMBER:	Drilling permit number may or may not be the same as permit number (see Attachment 1)	I6
CHANGE OF RECORD COUNTER:	Changes in well records are numbered sequentially	I1
A.P.I. NUMBER:	10 digit number which identifies well as to state, county, and sequential number within county. The third, fourth, and fifth digits give county number (see Attachment 2)	(I2,I3,I5)
LOCATION:		
LOGSCL:	Township, range, section, and quarter of quarter to four levels (see Attachment 3)	2I3,I2,A4
LOGSFL:	Feet from a north-south line and an east-west line of the form 1020 N 620 E	2(I4,A1)
ELEVATION: (in feet)		
G.L.:	Elevation of ground level	I4
K.B.:	Elevation of the Kelly Bushing	I4
D.F.:	Elevation of the derrick floor	I4
TOTAL DEPTH:	Maximum depth drilled (in feet)	I5
DEEPEST FORMATION:	Name of Formation at total depth (see Attachment 4)	A5
BHT:	Bottom hole temperature, measured at total depth (°F)	I3
PERMIT CANCELLED:	Date the permit was cancelled (Jan. 10, 1971; 01 10 71)	3(I2) / 78

I. NONRECURSIVE DATA

		SPACE/FORM
CARD 2		
WELL NUMBER:	Log file number	I6
CARD COUNTER:	Sequentially numbered cards	I2
OPERATOR:	Full name, if possible, of the operator(s) of the well	A36
WELL NAME:	Full name, if possible, of the well	A36
		80
CARD 3 and 4		
WELL NUMBER:	Log file number	I6
CARD COUNTER:	Sequentially numbered cards	I2
WELL STATUS:	Initial and final status of the well (see Attachment 5)	2(A2)
DATE:		
COMPLETED:	Date of the completion of the well of the form January 10, 1971; 01 10 71	3(I2)
ABANDONED:	Enter date the well was plugged or abandoned	3(I2)
FIELD NAME:	Name of gas or oil field in which well is located or indicate well is a Wildcat	A16
INITIAL PRODUCTION:	The results of the initial production test are presented as follows:	
GAS PRODUCTION:	MCFPD produced in initial production test. Volume given in MCF with a 10^X multiplier	I4,I1
OIL PRODUCTION:	BOPD produced in initial production test	I4
WATER PRODUCTION:	BWPD produced in initial production test	I4
CONDENSATE PRODUCTION:	BCPD produced in initial production test	I4
GAS-OIL RATIO:	Enter "N" from gas-oil ratio expressed as (N:1) "N" cubic ft. of gas per barrel of oil	I5

I. NONRECURSIVE DATA | SPACE/FORM

CARD 3 and 4, CONT.

CHOKE:	Diameter of choke used in initial production test. Enter numerator of choke size in 64ths of an inch	I2
PRODUCING INTERVAL:	Description of producing horizon follows:	
PRODUCING FORMATION:	Name of producing Formation (see Attachment 4)	A5
PERFORATED INTERVAL:	Enter depth of top and bottom of overall perforated interval	2(I5)
MULTIPLE COMPLETION:	Enter (2) for double, (3) for triple. Information on each additional completion is entered on an additional card 3 (see page 2 of coding form)	I1
		80

CARD 5

Logs run, sample types, Formations, footages, and storage locations. Sample format repeats until all samples are listed.

WELL NUMBER:	Log file number	I6
CARD COUNTER:	Sequentially numbered cards	I2
LOGS:	List logs run; left justify; 1 log/4 spaces; (-) indicates compound logs (ex: IES-GR) (see Attachment 6 for abbreviations used)	9(A4)
SAMPLE TYPE:		I1

Core - - - - - - - - - Enter (1)
Core Chips - - - - - Enter (2)
Cuttings - - - - - - Enter (3)
SWC - - - - - - - - - Enter (4)

FORMATION:	Enter name of formation sampled for core or core chips only (see Attachment 4)	A5
FOOTAGE:	Upper and lower limits of core(s) or samples	2(I5)
STORAGE LOCATION:	Enter up to three storage locations for sampled interval. Row (I4) and tier (I2)	3(I4,I2)
ADDITIONAL SAMPLES:	If additional samples are recorded enter (1). Code additional samples on Card 5	I1
		79

I. NONRECURSIVE DATA

SPACE/FORM

CARDS 6, 7, 8, and 9

Code samples as on Card 4. Additional samples can be coded on cards 5A, 5B, 5C . . . .

```
I6
I2
2(I1,A5,2(I5),
3(I4,I2))
I1
77
```

II. RECURSIVE DATA

		SPACE/FORM
CARDS 10 through 16		
WELL NUMBER:	Log file number	I6
CARD COUNTER:	Sequentially numbered cards	I2
FM AND DEPTH:	Enter the depth of each of the Formations listed	7(A5,I5)
		78

DST Water Chemistry Data
CARDS A through E

Chemical characteristics of water recovered by drill stem tests

WELL NUMBER:	Log file number	I6
TESTED INTERVAL:		
FORMATION:	Enter the name of the formation sampled (see Attachment 4)	A5
FOOTAGE:	Upper and lower limits of sampled interval	2(I5)
ION CONCENTRATIONS:	(mg/1 or ppm)	
CATIONS:		
Ca, Mg, Na	- Enter concentration in mg/1 or ppm	3(I6)
Fe	- Enter concentration in mg/1 or ppm x 100	I6
ANIONS:		
(CO_3, HCO_3, SO_4, Cl)	- Enter concentration in mg/1 or ppm	4(I6)
pH:	Enter pH x 100	I4
RESISTIVITY:	Resistivity and temperature of water measured	
RESISTIVITY:	Enter resistivity of the Formation fluid x 100	I4
TEMPERATURE:	Enter the temperature of the Formation fluid at the time of the resistivity measurement	I3
		80

CHANGES IN WELL STATUS OR RECORD

Cards 1 through 7, as needed, are repeated for renewed drilling (OWDD), recompletion, change of ownership, etc. The permit number (on Card 1) and change-in-record-counter are coded as follows:

_ _ 4 0 6 2 _

Permit Number — change-in-record-counter

Well 4062 is sold

_ _ 4 0 6 2 1

Well 4062 is recompleted

_ _ 4 0 6 2 2

Well 4062 is drilled deeper

_ _ 4 0 6 2 3

ATTACHMENTS

ATTACHMENT 1

HISTORICAL RELATIONSHIP BETWEEN WELLFILE NUMBERS AND PERMIT NUMBERS

WELLFILE NUMBER		PERMIT NUMBER
1 – 507	+16 =	17 – 523
508		No Permit
509 – 518	+15 =	524 – 533
519		No Permit
520		No Permit
521 – 567	+13 =	534 – 580
568 – 695	+14 =	582 – 709
696		No Permit
697 – 870	+13 =	710 – 883
871		No Permit
872 – 6187	+12 =	884 – 6199
6188 – 6199		No Wells
6200 – Present	=	6200 – Present

ATTACHMENT 2

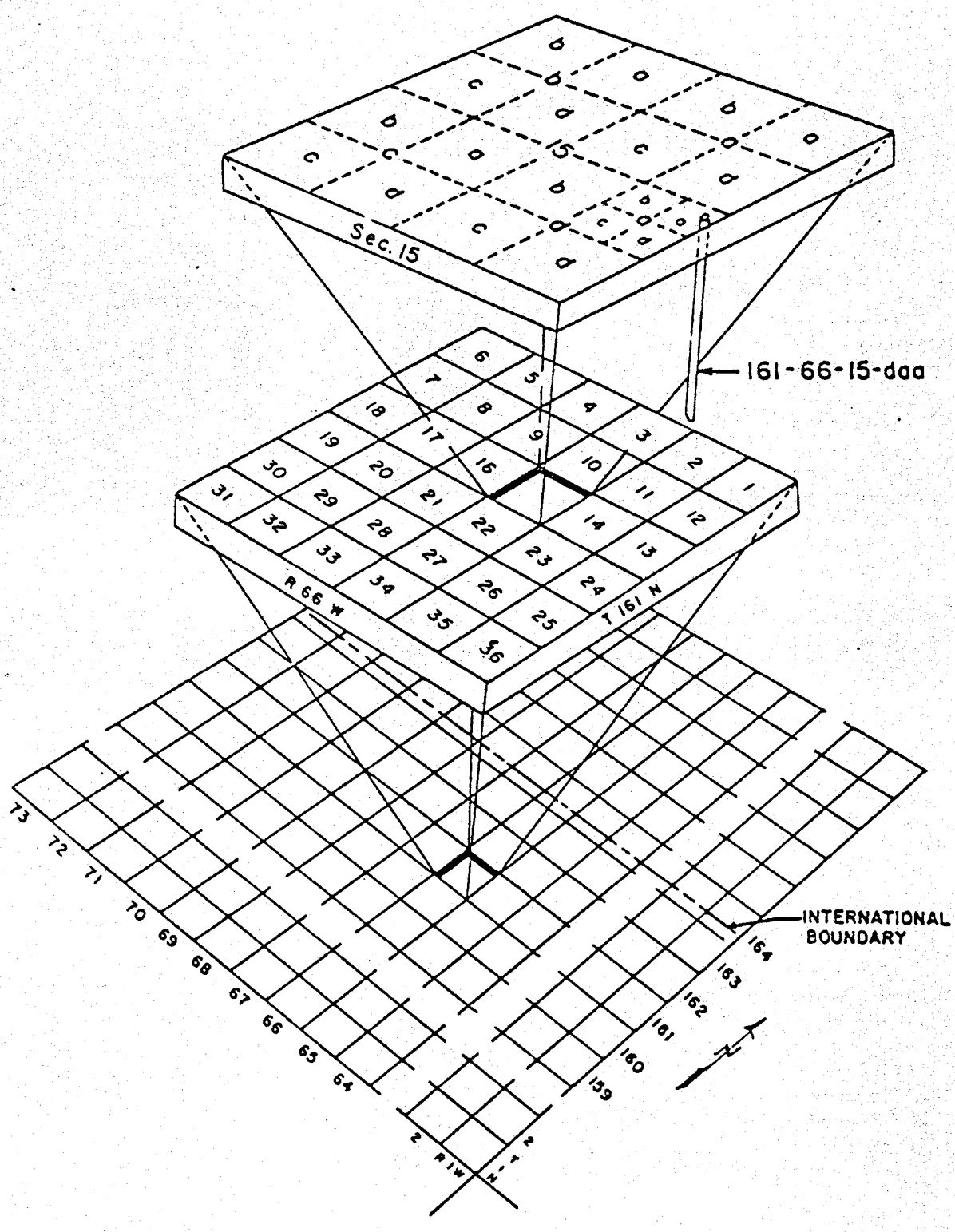
API STANDARD COUNTY NUMBERS FOR NORTH DAKOTA

COUNTIES

	State	County		State	County
Adams----------	33	001	Mountrail-------	33	061
Barnes---------	33	003	Nelson----------	33	063
Benson---------	33	005	Oliver----------	33	065
Billings-------	33	007	Pembina---------	33	067
Bottineau------	33	009	Pierce----------	33	069
Bowman---------	33	011	Ramsey----------	33	071
Burke----------	33	013	Ransom----------	33	073
Burleigh-------	33	015	Renville--------	33	075
Cass-----------	33	017	Richland--------	33	077
Cavalier-------	33	019	Rolette---------	33	079
Dickey---------	33	021	Sargent---------	33	081
Divide---------	33	023	Sheridan--------	33	083
Dunn-----------	33	025	Sioux-----------	33	085
Eddy-----------	33	027	Slope-----------	33	087
Emmons---------	33	029	Stark-----------	33	089
Foster---------	33	031	Steele----------	33	091
Golden Valley--	33	033	Stutsman--------	33	093
Grand Forks----	33	035	Towner----------	33	095
Grant----------	33	037	Traill----------	33	097
Griggs---------	33	039	Walsh-----------	33	099
Hettinger------	33	041	Ward----------	33	101
Kidder---------	33	043	Wells-----------	33	103
La Moure-------	33	045	Williams--------	33	105
Logan----------	33	047			
McHenry--------	33	049			
McIntosh-------	33	051			
McKenzie-------	33	053			
McLean---------	33	055			
Mercer---------	33	057			
Morton---------	33	059			

ATTACHMENT 3

LOGSCL LOCATION GUIDE



SYSTEM OF LOCATING WELLS AND TEST HOLES

ATTACHMENT 4

FORMATION ABBREVIATION LIST
FOR
WELLFILE - Oil and Gas Well Data
WATERCAT - Water Well Data

Era/System/Series/Fm./Other	NDGS Abbrev.
Unknown Material	UNK
Bedrock (Basement)	BRK
Cenozoic (und.)	CZ
Quaternary (und.)	Q
Holocene (und.)	H
Oahe Fm.	HO
fluvial sediment	HF
lacustrine sediment	HL
eolian sediment	HE
Pleistocene (und.)	PL
Coleharbor Group (und.)	PLC
fluvial sediment	PLF
lacustrine sediment	PLL
eolian sediment	PLE
glacial sediment	PLG
local aquifers (PLJIM, see attached Pleistocene aquifer list)	PL___
Tertiary (und.)	T
Pliocene (und.)	TPLC
Miocene (und.)	TMC
Oligocene (und.)	TOC
White River Group (und.)	TWR
Brule Fm.	TWRB
Chadron Fm.	TWRC

Era/System/Series/Fm./Other	NDGS Abbrev.
Eocene (und.)	TEC
Golden Valley Fm.	TGV
Paleocene (und.)	TPAC
Fort Union Group (und.)	TFU
"Tongue River"	TTR
Sentinel Butte Fm.	TSB
Kinneman Creek Intv.	TSBKC
Underwood Intv.	TSBU
-"B"	TSBUB
-"C"	TSBUC
-sand	TSBUS
Hagel Intv.	TSBH
Bullion Creek Fm.	TBC
Tavis Creek Intv.	TBCTC
Coal Lake Coulee Intv.	TBCCC
Weller Slough Intv.	TBCWS
Hensler Intv.	TBCHE
Slope Fm.	TS
Cannonball Fm.	TC
Ludlow Fm.	TL
Mesozoic (und.)	MZ
Cretaceous (und.)	K
Upper Cretaceous (und.)	KU
Hell Creek Fm.	KHC
Montana Group (und.)	KMON
Fox Hills Fm.	KFH
Pierre Fm.	KP
Judith River Sdstn	KPJR
Eagle Sdstn	KPE
Colorado Group (und.)	KCOL
Niobrara Fm.	KN
Carlile Fm.	KC
Greenhorn Fm.	KG

Era/System/Series/Fm./Other	NDGS Abbrev.
Graneros Shale	KGR
Belle Fourche Fm. (Graneros)	KBF
Lower Cretaceous (und.)	KL
Dakota Group (und.)	KDAK
Mowry Fm. (Graneros)	KM
Newcastle Fm. (Graneros)	KNWC
Skull Creek Fm. (Graneros)	KSC
Inyan Kara Fm. (Dakota, Fall River, and Lakota Fms.)	KIK
Jurassic (und.)	J
Morrison Fm.	JM
Swift Fm.	JSW
Sundance Fm.	JS
Rierdon Fm. (Sundance)	JR
Piper Fm. (Sundance)	JP
Triassic (und.)	TR
Spearfish Fm.	TRS
Paleozoic (und.)	PZ
Permian (und.)	P
Minnekahta Fm.	PM
Opeche Fm.	PO
Broom Creek Fm. (U. Minnelusa Gp.)	PBC
Pennsylvanian (und.)	PN
Minnelusa Group	PNM
Amsden Fm.	PNA
Tyler Fm.	PNT
Mississippian (und.)	M
Big Snowy Group (und.)	MBS
Heath Fm.	MH
Otter Fm.	MO
Kibbey Fm.	MK
Kibbey Sdstn.	MKSS
Kibbey Ls.	MKLS
Kibbey Silt	MKSI

Era/System/Series/Fm./Other	NDGS Abbrev.
Madison Group (und.)	MM
Poplar Intv.	MMP
Ratcliffe Intv.	MMR
Midale Subintv.	MMRM
Frobisher Alida Intv.	MMFA
Rival Subintv.	MMFAR
State "A"	MMFAA
Tilston Intv.	MMT
Bottineau Intv. (Lodgepole)	MMB
Madison Base	MB
Bakken Fm.	MBK
Devonian (und.)	D
Three Forks Fm.	DTF
Jefferson Group (und.)	DJ
Birdbear Fm. (Nisku)	DB
Duperow Fm.	DD
Manitoba Group (und.)	DM
Souris River Fm.	DSR
Dawson Bay Fm.	DDB
Elk Point Group (und.)	DEP
Prairie Fm.	DP
Winnepegosis Fm.	DW
U. Winnepegosis Fm.	DWU
L. Winnepegosis Fm. (Ashern)	DWL
Ashern Fm.	DA
Silurian (und.)	S
Interlake Fm.	SI
Silurian-Ordovician (und.)	SO
Stonewall Fm. (U. Bighorn Gp.)	SOS
Ordonician (und.)	O
Big Horn Group (und.)	OBG

Era/System/Series/Fm./Other	NDGS Abbrev.
Stony Mountain Fm.	OSM
U. Stony Mountain Fm. (Gunton)	OSMU
L. Stony Mountain Fm. (Stout.)	OSML
Gunton Mbr.	OG
Stoughton Mbr.	OS
Red River Fm.	ORR
Winnipeg Group (und.)	OW
Roughlock Fm.	OWR
Icebox Fm.	OWI
Black Island Fm.	OWBI
Cambrian (und.)	C
Deadwood Fm.	CD
Precambrian (und.)	PC

PLEISTOCENE ABBREVIATIONS AND ROCK UNITS

Abbrev.	Rock Unit	Abbrev.	Rock Unit
PL '	Pleistocene Series	PLCLF'	Colfax Aq.
PL '	Pleistocene	PLCLM'	Columbus Aq.
PLACL'	Apple Creek Aq. L.	PLCRL'	Cherry Lake Aq.
PLACU'	Apple Creek Aq. U.	PLCRN'	Carrington Aq.
PLANC'	Antelope Creek Aq.	PLCRT'	Courtnay Aq.
PLBAN'	Bantel Aq.	PLCTT'	Cattail Aq.
PLBDC'	Braddock Aq.	PLDGL'	Douglas Aq.
PLBF '	Buffalo Creek Aq.	PLDNB'	Denbigh Aq.
PLBFU'	U. Buffalo Ck. Aq.	PLDRL'	Deer Lake Aq.
PLBHC'	Bald Hill Creek Aq.	PLDYL'	Dry Lake Aq.
PLBLM'	Belmont Aq.	PLE '	Dune Deposits
PLBMK'	Bismarck Aq.	PLEAS'	Eastman Aq.
PLBNL'		PLECL'	Erick Lake Aq.
PLBRC'	Burnt Creek Aq.	PLEDB'	Edinburg Aq.
PLBRG'	Brightwood Aq.	PLEDG'	Edgeley Aq.
PLBRL'	Burlington Aq.	PLEGL'	Englevale Aq.
PLBUT'	Butte Aq.	PLELD'	Ellendale Aq.
PLBVC'	Beaver Creek Aq.	PLELK'	Elk Valley Aq.
PLCBK'	Cutbank Creek Aq.	PLELM'	Elm Creek Aq.
PLCLE'	Central Eddy Aq.	PLEMR'	Emerald Aq.

Abbrev.	Rock Unit
PLESM'	Esmond Aq.
PLF '	Bur. Glac. Fluvial Dep.
PLF '	Buried Outwash Dep.
PLF '	Buried Valley Deposits
PLF '	Esker Dep.
PLF '	Kame Terrace Dep.
PLF '	Outwash Dep.
PLF '	Terrace Dep.
PLFAI'	Fairmount Aq.
PLFDV'	Fordville Aq.
PLFOR'	Forest River Aq.
PLFRG'	Fargo Aq.
PLFRM'	Fort Mandan Aq.
PLG '	Crevasse Dep.
PLG '	Glacial Drift
PLG '	Ice Contact Dep.
PLG '	Kame Deposits
PLG '	Till Deposits
PLGAL'	Galesburgh Aq.
PLGAR'	Garrison Aq.
PLGDF'	Grand Forks Aq.
PLGLE'	Glenco Chl. Aq.
PLGLO'	Goldwin Aq.
PLGLP'	Guelph Aq.
PLGLV'	Glenview Aq.
PLGOO'	Goodman Creek Aq.
PLGRE'	Grendra Aq.
PLHAM'	Hamar Aq.
PLHAN'	Hankinson Aq.
PLHEA'	Heart River Aq.
PLHID'	Hidden Wood Lake Aq.
PLHIL'	Hillsboro Aq.
PLHMT'	Hamilton Aq.
PLHNO'	Horse Nose Butte Aq.
PLHOF'	Hofflund Aq.
PLHOM'	Homer Aq.
PLHSU'	Horseshoe Valley Aq.
PLICE'	Icelandic Aq.
PLINK'	Inkster Aq.
PLJIM'	Jamestown Aq.
PLJON'	Johnson Lake
PLJRV'	James River Aq.
PLJUA'	Juanita Lake Aq.
PLKAR'	Karlsrume Aq.
PLKEN'	Kenmare Aq.
PLKFR'	Knife River Aq.
PLKIL'	Killdeer Aq.
PLKLG'	Kilgore Aq.
PLL '	Beach Deposits
PLL '	Delta Dep.

Abbrev.	Rock Unit
PLL '	Lacustrine Dep.
PLLED'	Leeds Aq.
PLLGL'	Long Lake Aq.
PLLGN'	Lignite City Aq.
PLLHT'	Little Heart Aq.
PLLKS'	L. Souris Aq.
PLLKS'	Lake Souris Aq.
PLLMD'	Little Muddy Aq.
PLLMR'	Lamoure Aq.
PLLN '	Lake Nettie Aq.
PLLNL'	Lake Nettie Aq. L.
PLLNU'	Lake Nettie Aq. U.
PLLSL'	Lost Lake Aq.
PLMAD'	Maddock Aq.
PLMAN'	Manfred Aq.
PLMAR'	Marshtonmoor Pln. Aq.
PLMCI'	McIntosh Aq.
PLMCK'	McKenzie
PLMCV'	McVille Aq.
PLMDA'	Medina Aq.
PLMDF'	Medford Aq.
PLMER'	Mercer Aq.
PLMID'	Midway Aq.
PLMIL'	Milnor Chl. Aq.
PLMIN'	Minnewaukan Aq.
PLMIS'	Missouri River
PLMMR'	Mount Morian Aq.
PLMRT'	Martin Aq.
PLMUN'	Munich Aq.
PLNAP'	Napoleon Aq.
PLNBU'	North Burleigh Aq.
PLNEW'	Newton Aq.
PLNHL'	North Hill Aq.
PLNOR'	Nortonville Aq.
PLNRK'	New Rockford Aq.
PLNT '	Minot Aq.
PLNWC'	NW. Burried Channel Aq.
PLNWE'	N.W. Eddy Aq.
PLOAK'	Oakes Aq.
PLOBR'	Oberon Aq.
PLOTT'	Ottertail Aq.
PLPAG'	Page Aq.
PLPBD'	Pembina Delta Aq.
PLPBR'	Pembina River Aq.
PLPIP'	Pipestem Creek Aq.
PLPLE'	Pleasant Lake Aq.
PLPOP'	Poplar Aq.
PLPWC'	Painted Woods Ck. Aq.
PLPWL'	Painted Woods Lake Aq.
PLRAN'	Random Creek Aq.

Abbrev.	Rock Unit
PLRAY'	Ray Aq.
PLRIV'	Riverdale Aq.
PLRKR'	Rocky Run Aq.
PLROS'	Rosefield Aq.
PLRSL'	Rusland Aq.
PLRUS'	Russel Lake Aq.
PLRYD'	Ryder Aq.
PLSBL'	Strawberry Lake Aq.
PLSDP'	Sand Prairie Aq.
PLSFD'	S. Fessenden Aq.
PLSHD'	Shields Aq.
PLSHL'	Shell Aq.
PLSHL'	South Hill Aq.
PLSIB'	Dibley Chnl. Aq.
PLSID'	Sidney Slough Aq.
PLSIM'	Sims Aq.
PLSJM'	St. James Aq.
PLSKJ'	Skjermo
PLSNK'	Snake Creek Aq.
PLSOO'	Soo Channel Aq.
PLSOV'	Souris Valley Aq.
PLSPR'	Spring Creek Aq.
PLSPT'	Spiritwood Aq.
PLSQR'	Square Butte Ck. Aq.
PLSTB'	Strasburgh Aq.
PLSTR'	Streeter Aq.
PLSUN'	Sundre Buried Chnl. Aq.
PLSVM'	Seven Mile Coulee Aq.
PLSYC'	Sheyenne Chnl. Aq.
PLSYD'	Sheyenne Delta Aq.
PLSYD'	Sheyenne Delta Aq.
PLSYD'	Sydney Aq.
PLSYN'	Sheyenne Village Aq.
PLTOK'	Tokio Aq.
PLTOL'	Tolgen Aq.
PLTOM'	Thompson Aq.
PLTOW'	Tower City Aq.
PLTRN'	Trenton Aq.
PLTRT'	Turtle Lake Aq.
PLVAL'	Valley City Aq.
PLVNG'	Vang Aq.
PLVOL'	Voltaire Aq.
PLWAG'	Wagonsport Aq.
PLWAH'	Wahpeton Aq.
PLWAR'	Warwick Aq.
PLWDS'	Windsor Aq.
PLWEL'	Weller Slough Aq.
PLWFC'	Wolf Creek Aq.
PLWFG'	West Fargo Aq.
PLWIM'	Wimbledon Aq.
PLWIS'	Wishek Aq.
PLWNG'	Wing Chnl. Aq.
PLWR '	Wildrose Aq.
PLWTE'	White Shield Aq.
PLWWR'	West Wildrose Aq.
PLYNK'	Yanktonai Ck. Aq.
PLZEE'	Zeeland Aq.

ATTACHMENT 5

WELL STATUS CODES

Map Symbol	Code	Status
	99	Dry Hole
	88	Location
	10	One oil, no gas completions
	01	No oil, one gas completion
	20	Two oil, no gas completions (three or more indicated by number near location)
3	30	
	02	No oil, two gas completions (three or more indicated by number near location)
3	03	
	11	One oil, one gas completion (two oil and one gas indicated by "21" near location)
21	21	
	AP	Abandoned Producer
	OW	Observation Well
	SW	Service Well
	IW	Injection Well
	JW	Junked Well
	TA	Temporarily Abandoned
	IS	Injection and Service
T	T	Tight Hole
	OP	Other Production
S	ST	Stratigraphic Test
M	MN	Mineral Exploration
	DA	Dry Abandoned
	PA	Plugged and Abandoned

ATTACHMENT 6

LOG TYPES AND SYMBOLS

Log	Symbol
Electrical Logs:	
Conductivity Laterolog	CLL
Contact Log	CON
Continuous Dipmeter	CDM
Continuous Dipmeter Digital	CDD
Dip Log	DIP
Dipmeter	DM
Drill Pipe Log	DP
Dual Induction	DI
Dual Laterolog	DLL
Electrical Survey	ES
Focused Resistivity	FOC
Forxo	FRX
Guard	GRD
Induction Electrical	IES
Induction Log	IL
Limestone	LS
Laterolog	LL
Laterolog 3	LL3
Laterolog 7	LL7
Micro Laterolog	MLL
Microlog (Guard)	ML

Log	Symbol
Electrical Logs, Cont.	
Micro Survey	MS
Mini Focused	MIF
Minilog	MIL
Proximity	PRX
Spontaneous Potential	SP
Acoustical Logs:	
Acoustic, Acoustilog	ACS
Acoustic Amplitude	AMP
Borehole Compensated Acoustic	BCA
Borehole Compensated Sonic	BHC
Cement Bond	BND
Fracture Finder Microseismogram	FFM
Integrated Sonic	ISN
Sonic	SON
Sonic Picture Study	SPS
Seismic Reference Survey	SRS
Velocity	VEL
Radioactivity Logs:	
Casing Collar Locator	CCL
Chlorine Log (Spectral, Spectrograph)	CHL
Compensated Neutron Formation Density	CNL
Density, Densilog, Gamma-Gamma Denisty	DEN
Formation Density	FD
Formation Density Compensated	FDC

Log	Symbol
Radioactivity Logs, Cont.	
Gamma Ray	GR
Gamma Ray-Neutron	GRN
Isotron	ISO
Neutron	NEU
Neutron-Epithermal Neutron	NEN
Neutron-Gamma	NEG
Neutron Lifetime Log	NLL
Neutron Thermal Neutron	NTN
Radioactive Tracer	TR
Radioactivity (Radiation)	RAD
Sidewall Neutron Porosity	SNP
Thermal Decay Time Log	TDT
Miscellaneous Logs:	
Caliper	CAL
Completion (Csg. Col. Loc. and Perf. Record)	COM
Deviation Survey	DS
Directional Survey	DIR
Experimental Log	EXP
Fluid (Formation Tester)	FT
Formation Analysis Log	FAL
Formation Interval Tester	FIT
Movable Oil Plot	MOP
Multiple Fluid Sampler	MFS
Nuclear Magnetism Log	NML

Log	Symbol
Miscellaneous Logs, Cont.	
Permeability	PRM
Synergetic Log	SYG
Temperature	TM
Temperature Differential	TMD
Water Location Survey	WTR
Sample/Drilling Logs:	
Mud Log, Litholog Log, Drill Log	MDL
Mud Log, Chromatograph	MLC
Paleo Log	BUG
Drilling Time Log	DTL
Geolograph	GLG

ATTACHMENT 7

ALPHABETICAL LISTING OF LOG SYMBOLS

Symbol	Log
ACS	Acoustic, Acoustilog
AMP	Acoustic Amplitude
BCA	Borehole Compensated Acoustic
BHC	Borehole Compensated Sonic
BND	Cement Bond
BUG	Paleo Log
CAL	Caliper
CCL	Casing Collar Locator
CDD	Continuous Dipmeter Digital
CDM	Continuous Diameter
CHL	Chlorine Log (Spectral, Spectograph)
CLT	Conductivity Laterolog
CNL	Compensated Neutron Formation Density
COM	Completion (Csg. Col. Loc. and Perf. Record)
CON	Contact Log
DEN	Density, Densilog, Gamma-Gamma Density
DI	Dual Induction
DIL	Dual Induction Laterolog
DIP	Dip Log
DIR	Directional Survey
DLL	Dual Laterolog

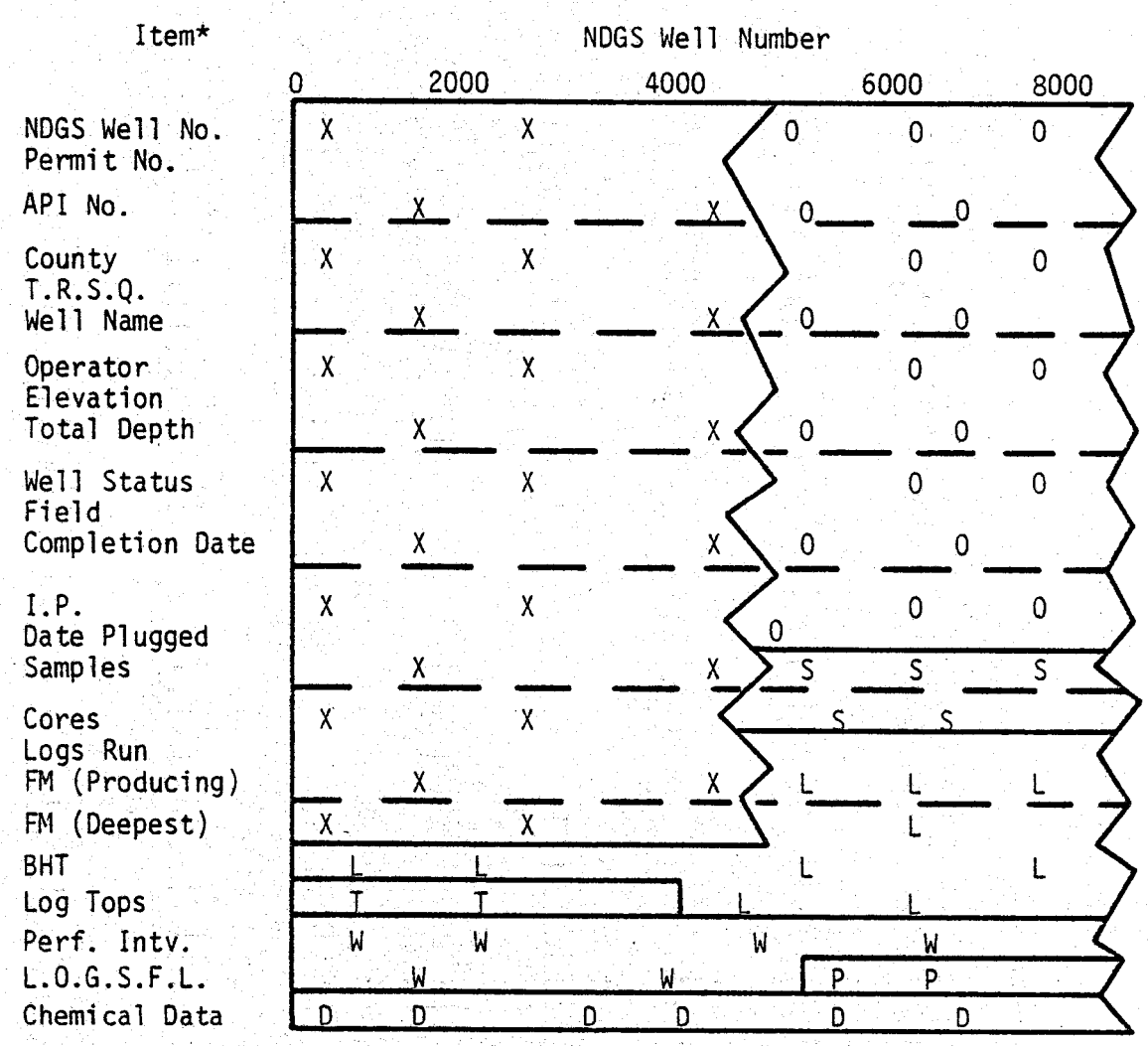
Symbol	Log
DM	Dipmeter
DP	Drill Pipe Log
DS	Deviation Survey
DTL	Drilling Time Log
ES	Electrical Survey
EXP	Experimental Log
FAL	Formaltion Analysis Log
FD	Formation Density
FDC	Formation Density Compensated
FFM	Fracture Finder Microseismogram
FIT	Formation Interval Tester
FOC	Focused Resistivity
FRX	Forxo
FT	Fluid (Formation Tester
GLG	Geolograph
GR	Gamma Ray
GRD	Guard
GRN	Gamma Ray Neutron
IES	Induction Electrical
ISN	Integrated Sonic
IL	Induction Log
ISO	Isotron

Symbol	Log
LL	Laterolog
LL3	Laterolog 3
LL7	Laterolog 7
LS	Limestone
MDL	Mud Log
MFS	Multiple Fluid Sampler
MIF	Mini Focused
MIL	Minilog
ML	Microlog
MLC	Mud Log, Chromatograph
MML	Microlaterolog
MOP	Movable Oil Plot
MS	Micro Survey
NEG	Neutron-Gamma
NEN	Neutron-Epithermal Neutron
NEU	Neutron
NLL	Neutron Lifetime Log
NML	Nuclear Magnetism Log
NTN	Neutron Thermal Neutron
PRX	Proximity
PRM	Permeability
RAD	Radioactivity (Radiation)

Symbol	Log
SNP	Sidewall Neutron Porosity
SON	Sonic
SP	Spontaneous Potential
SPS	Sonic Picture Study
SRS	Seismic Reference Survey
SYG	Synergetic Log
TDT	Thermal Decay Time Log
TM	Temperature
TMD	Temperature Differential
TR	Radioactive Tracer
VEL	Velocity
WTR	Water Location Survey

ATTACHMENT 8

SOURCES OF CODED INFORMATION

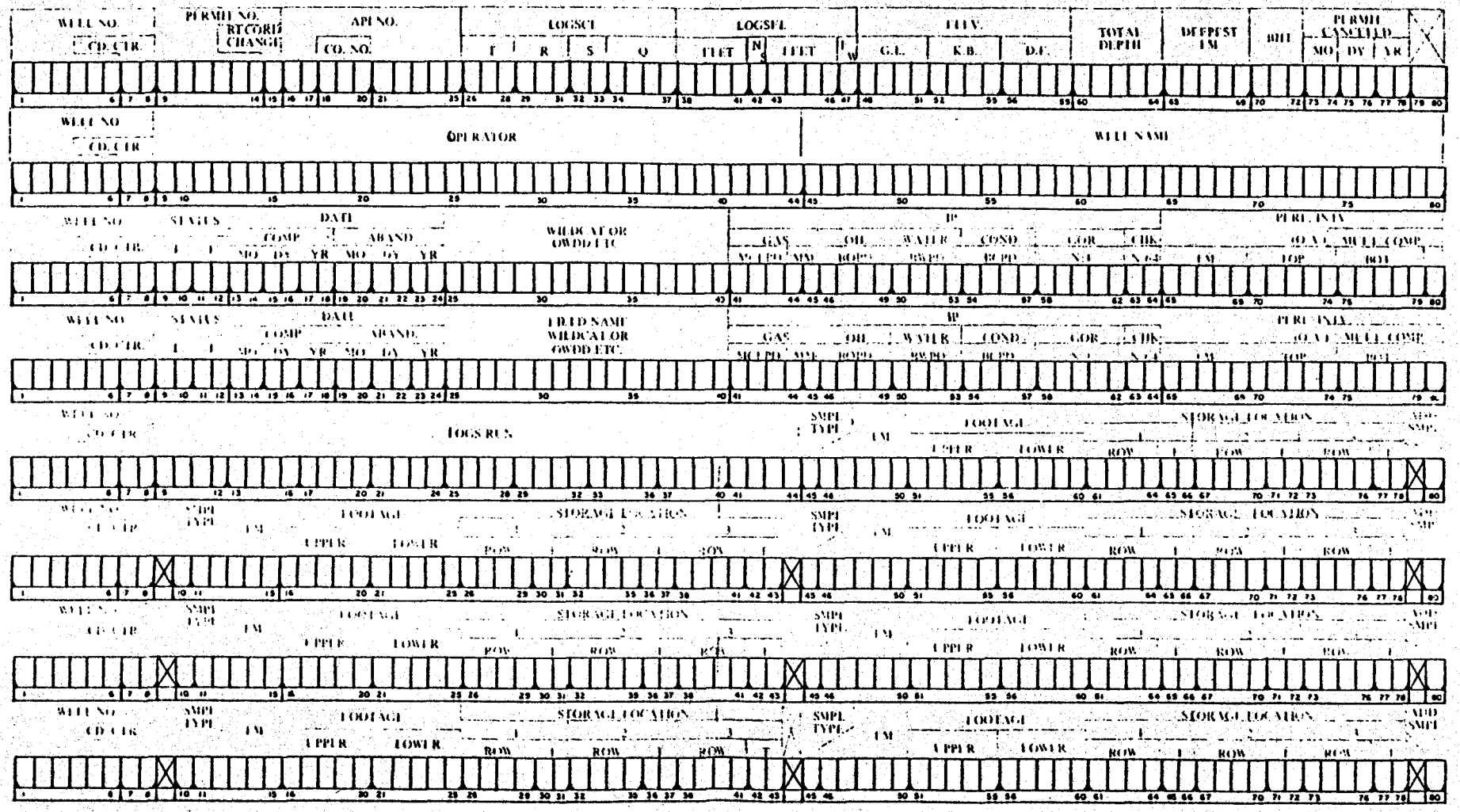


* See Coding Guide for explanation of abbreviations.

SOURCES

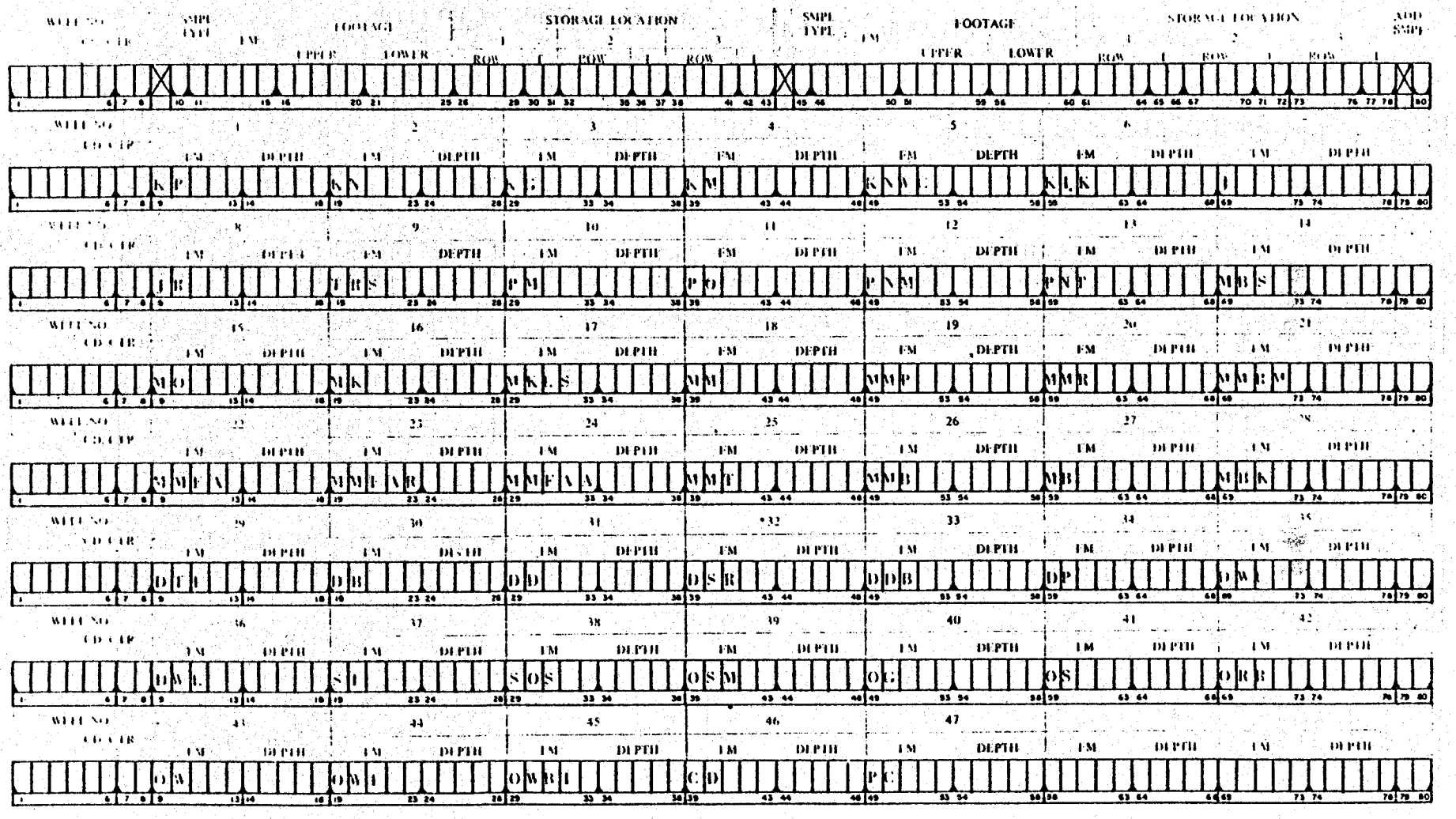
Preexisting Digitized Well Data (NDGS, Open File)----------	X
Circular File (NDGS, Open File)----------	O
Sample and Core Files (NDGS, Open File)----------	S
Log File (NDGS, Open File)----------	L
Permit Book (NDGS, Open File)----------	P
Well File (NDGS, Legal File)----------	W
Tops File (NDGS, Open File)----------	T
Drill Stem Test File (NDGS, Open File)----------	D

ATTACHMENT 9 - CODING FORMS



WELLFILE Coding Form, Page 1; Location, Name, Production, Logs, and Cores

ATTACHMENT 9, Continued



WELLFILE Coding Forms, Page 2;
Samples, Cores, and Formation Tops

ATTACHMENT 9, Continued

PROGRAM	DATE	CLASS IDENTIFICATION	PUNCHING INSTRUCTIONS	PAGE OF
PROGRAMMER	USER ACCT NUMBER			CARD STOCK

WELL NUMBER	TESTED INTV.			CONCENTRATION (PPM, Mg/l)								pH x100	Resistivity	
	FM	TOP	BOT.	Ca	Mg	Na	Fe(x100)	CO_3	HCO_3	SO_4	Cl		ρ x1000	°F
1 6	7 11	12 16	17 21	22 27	28 33	34 39	40 45	46 51	52 57	58 63	64 69	70 73	74 77	78 80

WELL NUMBER	TESTED INTV.			CONCENTRATION (PPM, Mg/l)								pH x100	Resistivity	
	FM	TOP	BOT.	Ca	Mg	Na	Fe(x100)	CO_3	HCO_3	SO_4	Cl		ρ x1000	°F
1 6	7 11	12 16	17 21	22 27	28 33	34 39	40 45	46 51	52 57	58 63	64 69	70 73	74 77	78 80

WELL NUMBER	TESTED INTV.			CONCENTRATION (PPM, Mg/l)								pH x100	Resistivity	
	FM	TOP	BOT.	Ca	Mg	Na	Fe(x100)	CO_3	HCO_3	SO_4	Cl		ρ x1000	°F
1 6	7 11	12 16	17 21	22 27	28 33	34 39	40 45	46 51	52 57	58 63	64 69	70 73	74 77	78 80

WELL NUMBER	TESTED INTV.			CONCENTRATION (PPM, Mg/l)								pH x100	Resistivity	
	FM	TOP	BOT.	Ca	Mg	Na	Fe(x100)	CO_3	HCO_3	SO_4	Cl		ρ x1000	°F
1 6	7 11	12 16	17 21	22 27	28 33	34 39	40 45	46 51	52 57	58 63	64 69	70 73	74 77	78 80

WELL NUMBER	TESTED INTV.			CONCENTRATION (PPM, Mg/l)								pH x100	Resistivity	
	FM	TOP	BOT.	Ca	Mg	Na	Fe(x100)	CO_3	HCO_3	SO_4	Cl		ρ x1000	°F
1 6	7 11	12 16	17 21	22 27	28 33	34 39	40 45	46 51	52 57	58 63	64 69	70 73	74 77	78 80

WELLFILE Coding Forms, Page 3; DST Water Chemistry Data

APPENDIX C

WATERCAT DATA GUIDE AND CODING GUIDE

February, 1981

K.L. Harris

TABLE OF CONTENTS

TABLE OF CONTENTS, Con't.

PAGE

ATTACHMENTS, Con't.

WATERCAT DATA ELEMENTS

The sources of the data elements stored in WATERCAT are two U.S.G.S.W.R.D. computer library systems, WATSTORE and GWSI. Selected data elements from these two source libraries are stored in WATERCAT. Table 1 describes the data elements selected for storage.

TABLE 1

WATERCAT DATA ELEMENTS

I. Location Data Elements

A. Location Number:

The location number is a fifteen digit number, used for well identification. It consists of the latitude and longitude of the well site and indicates the well number at that site.

ex: A A B B C C A A A B B C C D D

Latitude Longitude Well Number

where: A = Latitude or longitude in degrees

B = Latitude or longitude in minutes

C = Latitude or longitude in seconds

D = Well number at this site

B. County:

The county in which the well site is located is identified by a three digit, standard API number. Attachment 1

contains a list of API county numbers for North Dakota.

C. Land Office Grid System, Coarse Level (LOGSCL):

Indicates the township, range, section, and quarter-quarter-quarter description of the well site. Attachment 2 illustrates the well site location scheme used.

ex: 1 3 5 - Ø 9 2 - Ø 3 C C D

T135N R92W Sec 3 CCD

II. Data Source Data Elements

All of the data contained in the WATERCAT library system are from two U.S.G.S.W.R.D. computer library systems, WATSTORE and GWSI. The U.S.G.S.W.R.D. libraries identify the sources of their data by well owner or the agency that drilled the hole.

ex: U.S.G.S. (NDSWC 4562)

III. Well Data Elements

A. Completion Date:

Indicates the date that the well was completed.

ex: Ø1JUL67

1 July 1967

B. Casing Depth:

Indicates the depth to which casing was installed in the well (feet x 100).

C. Casing Diameter:

Indicates the diameter of the casing that was installed in the well (inches x 100).

D. Site Use:

Indicates the purpose for which the well was drilled. The abbreviations used for site use are listed in Attachment 3.

E. Water Use:

Indicate the use of the water produced from the well. The abbreviations used for water use are listed in Attachment 3.

IV. Stratigraphic Data Elements

A. Surface Elevation:

Indicates the elevation of the surface of the ground at the well site (feet x 100).

B. Total Depth:

Indicates the total depth drilled at the well site (feet x 100).

C. Well Depth:

Indicates the depth at which the well was completed (feet x 100).

D. Producing Formation:

Indicates the name of the formation in which the well was completed. Formation abbreviations used are consistent with those used in WELLFILE. Attachment 4 lists formation abbreviations used.

1. Top of producing aquifer: Indicates the top of the producing aquifer (feet x 100).

2. Bottom of producing aquifer: Indicates the bottom of the producing aquifer (feet x 100).

3. Lithology of the producing aquifer: Indicates the major lithology and lithologic modifier of the aquifer producing water. Attachment 5 lists the abbreviations used.

V. Chemical Data Elements

A. Water Temperature:

Records the temperature of the water produced by the well, as reported by the source agency (^{o}C).

B. Specific Conductance:

Reports the specific conductance of the water produced by the well (μmho/cm).

C. pH:

Indicates the pH of the water produced by the well.

D. Concentrations of Selected Chemical Constituents:

Presents the results of chemical analyses performed on the water produced by the well.

1. Cations: The selected cations and the units of the measure of concentration are: Na^{+} (mg/l), Ca^{++}(mg/l), Mg^{++}(mg/l), K^{+}(mg/l), Mn^{++}(μg/l), Fe^{++}(μg/l), and B^{+++}(μg/l).

2. Anions: The selected anions and the units of the measure of concentration are: Cl^{-}(mg/l), $SO_4^{=}$(mg/l), HCO_3^{-}(mg/l), NO_3^{-}(mg/l), and F^{-} (mg/l).

3. Other: Also listed for each chemical analysis are the concentration of SiO_2(mg/l) and the total dissolved solids (mg/l).

4. Date Sampled: Indicates the date that the well was sampled for chemical analysis.

E. Hardness:

The hardness is the concentration of the Ca^{++} and Mg^{++} ions expressed as equivalent Calcium Carbonate (mg/l). Water hardness values greater than 150 mg/l are considered very hard, and values less than 60 mg/l are considered soft.

F. Sodium-Adsorption Ratio:

The sodium-adsorption ratio expresses the relative activity of the Na^{+} ions in exchange reactions with soil.

VI. Temperature-Depth Data Subset

The temperature-depth data subset consists of temperatures measured at various depths in suitable groundwater observation holes. This information supplements the U.S.G.S.W.R.D. data and is intended to provide accurate temperature measurements of formation water and near surface geothermal gradient data.

A. Coding Guide:

1. Location Number: The twelve digit location number is used as a file number for the subset as well as a data link to WATERCAT. The location number consists of the LOGSCL location of the well site and a well number for wells drilled at that site.

	1											12
ex:	1	3	6	0	5	2	2	5	A	C	B	1

T136N R52W Sec25 ACB Well Number

a. Land Office Grid System, Coarse Level Location (LOGSCL):

Indicates the township, range, section, and quarter-quarter-quarter in which the well site is located (right justify in spaces 1-11 on the coding form). See Attachment 2 for LOGSCL location scheme.

b. Well Number:

This is a well number for possible multiple wells drilled at this site (space 12 on coding form).

2. Date Measured: Indicates the month, day, and year that the temperature log was run (right justify in spaces 13-18 on coding form).

	13					18
ex:	Ø	8	2	1	8	Ø
	Month		Day		Year	

3. Temperature-Depth Observations: The temperature measured and the depth of the temperature measurment are recorded. Additional temperature-depth observations are entered as required to record all observations for a well.

a. Depth:

The depth of a temperature measurement is recorded to the nearest tenth of a metre (right justify in spaces 19-23 on the coding form).

	19					23
ex:	Ø	1	Ø	Ø	·	5
	Depth					

b. Resistance:

The equilibrium resistance of the thermistor circuit is recorded in ohms (right justify in spaces 24-28 on the coding form).

	24				28
ex:	Ø	1	9	5	6
	Resistance				

c. Temperature:

The calculated temperature (± .01°C) is recorded (right justify in spaces 29-33 on the coding form). A laboratory determined calibration curve, for each thermistor, is used to convert resistance to temperature. Calibration accuracy is ±.03 °C.

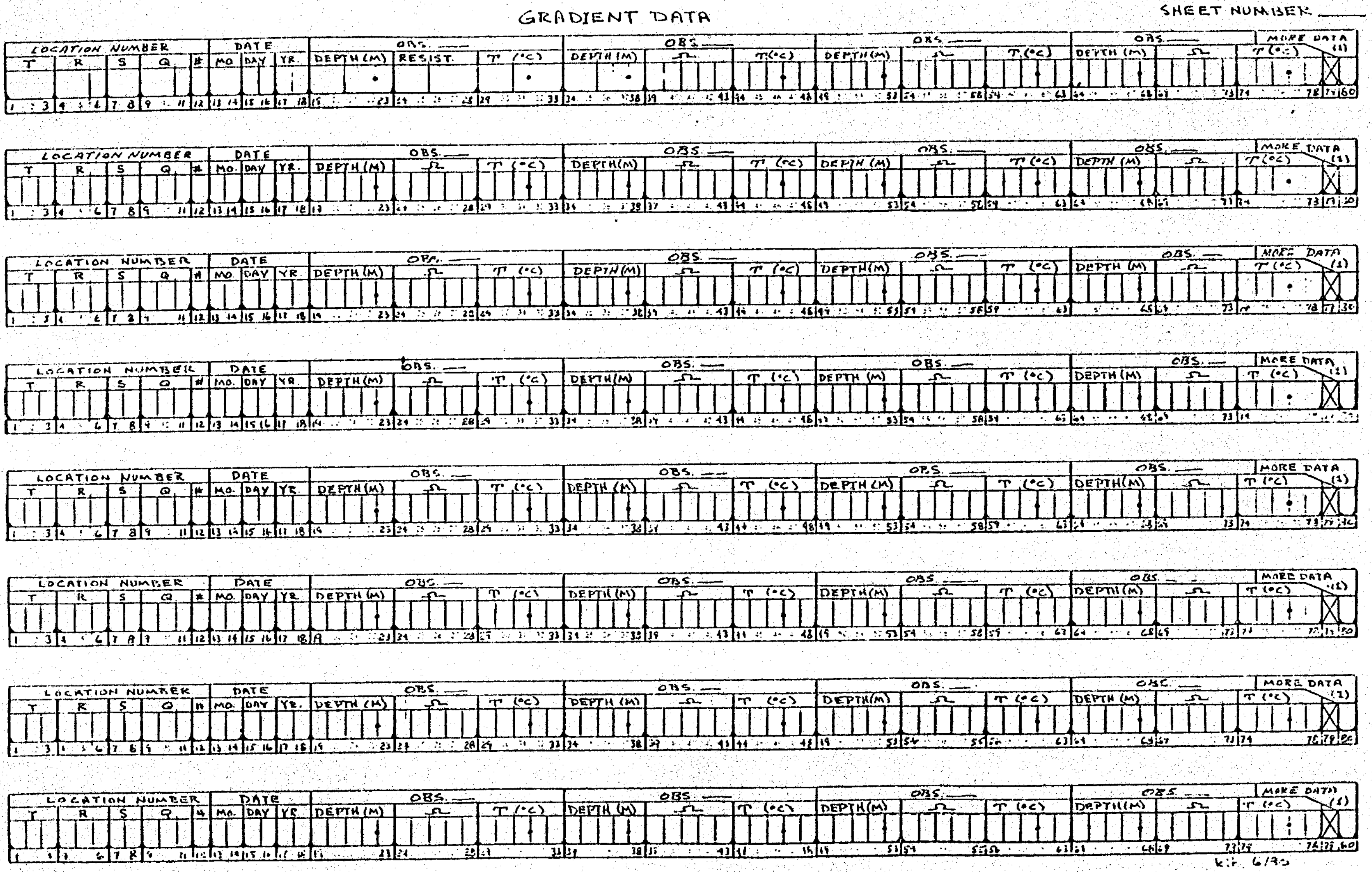
	29				33
ex:	Ø	2	Ø	· 5	1
			Temperature		

d. Additional Data Cards:

More than one data card will be necessary to record all observations on most wells. A (1) in space 80 on the data card indicates that more temperature-depth observations follow on another card. Be sure to fill in the location number and date on all additional data cards.

B. Coding Form:

Figure 1 shows the coding form used for the temperature-depth data subset.



GRADIENT DATA

SHEET NUMBER ____

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	RESIST.	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

LOCATION NUMBER					DATE			OBS. ___			OBS. ___			OBS. ___			OBS. ___			MORE DATA (1)	
T	R	S	Q	#	MO.	DAY	YR.	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	DEPTH (M)	Ω	T (°C)	☒	
1 3	4 6	7 8	9 11	12	13 14	15 16	17 18	19 23	24 28	29 33	34 38	39 43	44 48	49 53	54 58	59 63	64 68	69 73	74 78	79	80

k.r. 6/80

FIGURE 1 - WATERCAT T-D SUBSET CODING FORM

ATTACHMENTS

ATTACHMENT 1

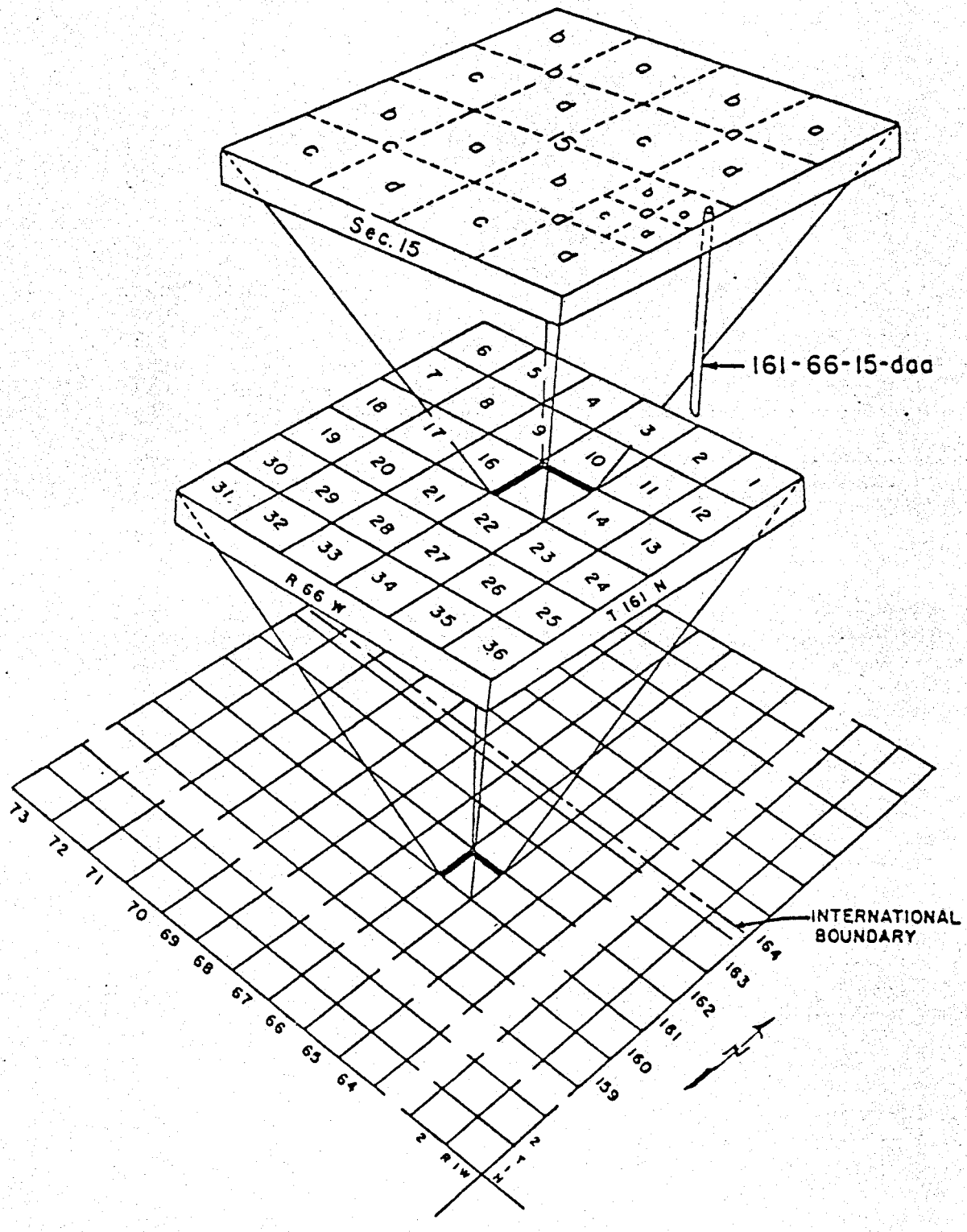
API STANDARD COUNTY NUMBERS FOR NORTH DAKOTA

COUNTIES

	State	County		State	County
Adams----------	33	001	Mountrail-------	33	061
Barnes---------	33	003	Nelson----------	33	063
Benson---------	33	005	Oliver----------	33	065
Billings-------	33	007	Pembina---------	33	067
Bottineau------	33	009	Pierce----------	33	069
Bowman---------	33	011	Ramsey----------	33	071
Burke----------	33	013	Ransom----------	33	073
Burleigh-------	33	015	Renville--------	33	075
Cass----------	33	017	Richland--------	33	077
Cavalier-------	33	019	Rolette---------	33	079
Dickey---------	33	021	Sargent---------	33	081
Divide---------	33	023	Sheridan--------	33	083
Dunn----------	33	025	Sioux----------	33	085
Eddy----------	33	027	Slope----------	33	087
Emmons---------	33	029	Stark----------	33	089
Foster---------	33	031	Steele----------	33	091
Golden Valley--	33	033	Stutsman--------	33	093
Grand Forks----	33	035	Towner----------	33	095
Grant----------	33	037	Traill----------	33	097
Griggs---------	33	039	Walsh----------	33	099
Hettinger------	33	041	Ward----------	33	101
Kidder---------	33	043	Wells----------	33	103
La Moure-------	33	045	Williams--------	33	105
Logan----------	33	047			
McHenry--------	33	049			
McIntosh-------	33	051			
McKenzie-------	33	053			
McLean---------	33	055			
Mercer---------	33	057			
Morton---------	33	059			

ATTACHMENT 2

LOGSCL LOCATION GUIDE



SYSTEM OF LOCATING WELLS AND TEST HOLES

ATTACHMENT 3

SITE USE AND WATER USE ABBREVIATIONS

The following lists include abbreviations commonly used in U.S.G.S.W.R.D. and N.D.S.W.C. publications describing their water well data. The most commonly used abbreviations in WATERCAT are underlined.

Abbreviation	Meaning
Site Use:	
A	anode
C	standby supply
D	drain
E	geothermal (dry rock)
G	seismic
H	heat reservoir (closed system
M	mine
O	observation
P	oil or gas test
R	recharge
S	repressurization
T	test well
U	unused
W	withdrawal of water
X	waste disposal
Z	destroyed
Water Use:	
A	air conditioning
B	bottling
C	commercial
D	dewater
E	power
F	fire
H	domestic
I	irrigation
J	industrial (cooling)
K	mining
M	medicinal
N	industrial
P	public supply
Q	aquaculture

ATTACHMENT 3, Con't.

Abbreviation	Meaning
Water Use, Con't.	
R	recreation
S	stock
T	institutional
U	unused
Y	desalination
Z	other

ATTACHMENT 4

FORMATION ABBREVIATION LIST
FOR
WELLFILE - Oil and Gas Well Data
WATERCAT - Water Well Data

Era/System/Series/Fm./Other	NDGS Abbrev.
Unknown Material	UNK
Bedrock (Basement)	BRK
Cenozoic (und.)	CZ
Quaternary (und.)	Q
Holocene (und.)	H
Oahe Fm.	HO
fluvial sediment	HF
lacustrine sediment	HL
eolian sediment	HE
Pleistocene (und.)	PL
Coleharbor Group (und.)	PLC
fluvial sediment	PLF
lacustrine sediment	PLL
eolian sediment	PLE
glacial sediment	PLG
local aquifers (PLJIM, see attached Pleistocene aquifer list)	PL___
Tertiary (und.)	T
Pliocene (und.)	TPLC
Miocene (und.)	TMC
Oligocene (und.)	TOC
White River Group (und.)	TWR
Brule Fm.	TWRB
Chadron Fm.	TWRC

Era/System/Series/Fm./Other	NDGS Abbrev.
Eocene (und.)	TEC
Golden Valley Fm.	TGV
Paleocene (und.)	TPAC
Fort Union Group (und.)	TFU
"Tongue River"	TTR
Sentinel Butte Fm.	TSB
Kinneman Creek Intv.	TSBKC
Underwood Intv.	TSBU
-"B"	TSBUB
-"C"	TSBUC
-sand	TSBUS
Hagel Intv.	TSBH
Bullion Creek Fm.	TBC
Tavis Creek Intv.	TBCTC
Coal Lake Coulee Intv.	TBCCC
Weller Slough Intv.	TBCWS
Hensler Intv.	TBCHE
Slope Fm.	TS
Cannonball Fm.	TC
Ludlow Fm.	TL
Mesozoic (und.)	MZ
Cretaceous (und.)	K
Upper Cretaceous (und.)	KU
Hell Creek Fm.	KHC
Montana Group (und.)	KMON
Fox Hills Fm.	KFH
Pierre Fm.	KP
Judith River Sdstn	KPJR
Eagle Sdstn	KPE
Colorado Group (und.)	KCOL
Niobrara Fm.	KN
Carlile Fm.	KC
Greenhorn Fm.	KG

Era/System/Series/Fm./Other	NDGS Abbrev.
Graneros Shale	KGR
Belle Fourche Fm. (Graneros)	KBF
Lower Cretaceous (und.)	KL
Dakota Group (und.)	KDAK
Mowry Fm. (Graneros)	KM
Newcastle Fm. (Graneros)	KNWC
Skull Creek Fm. (Graneros)	KSC
Inyan Kara Fm. (Dakota, Fall River, and Lakota Fms.)	KIK
Jurassic (und.)	J
Morrison Fm.	JM
Swift Fm.	JSW
Sundance Fm.	JS
Rierdon Fm. (Sundance)	JR
Piper Fm. (Sundance)	JP
Triassic (und.)	TR
Spearfish Fm.	TRS
Paleozoic (und.)	PZ
Permian (und.)	P
Minnekahta Fm.	PM
Opeche Fm.	PO
Broom Creek Fm. (U. Minnelusa Gp.)	PBC
Pennsylvanian (und.)	PN
Minnelusa Group	PNM
Amsden Fm.	PNA
Tyler Fm.	PNT
Mississippian (und.)	M
Big Snowy Group (und.)	MBS
Heath Fm.	MH
Otter Fm.	MO
Kibbey Fm.	MK
Kibbey Sdstn.	MKSS
Kibbey Ls.	MKLS
Kibbey Silt	MKSI

Era/System/Series/Fm./Other	NDGS Abbrev.
Madison Group (und.)	MM
Poplar Intv.	MMP
Ratcliffe Intv.	MMR
Midale Subintv.	MMRM
Frobisher Alida Intv.	MMFA
Rival Subintv.	MMFAR
State "A"	MMFAA
Tilston Intv.	MMT
Bottineau Intv. (Lodgepole)	MMB
Madison Base	MB
Bakken Fm.	MBK
Devonian (und.)	D
Three Forks Fm.	DTF
Jefferson Group (und.)	DJ
Birdbear Fm. (Nisku)	DB
Duperow Fm.	DD
Manitoba Group (und.)	DM
Souris River Fm.	DSR
Dawson Bay Fm.	DDB
Elk Point Group (und.)	DEP
Prairie Fm.	DP
Winnepegosis Fm.	DW
U. Winnepegosis Fm.	DWU
L. Winnepegosis Fm. (Ashern)	DWL
Ashern Fm.	DA
Silurian (und.)	S
Interlake Fm.	SI
Silurian-Ordovician (und.)	SO
Stonewall Fm. (U. Bighorn Gp.)	SOS
Ordonician (und.)	O
Big Horn Group (und.)	OBG

Era/System/Series/Fm./Other	NDGS Abbrev.
Stony Mountain Fm.	OSM
U. Stony Mountain Fm. (Gunton)	OSMU
L. Stony Mountain Fm. (Stout.)	OSML
Gunton Mbr.	OG
Stoughton Mbr.	OS
Red River Fm.	ORR
Winnipeg Group (und.)	OW
Roughlock Fm.	OWR
Icebox Fm.	OWI
Black Island Fm.	OWBI
Cambrian (und.)	C
Deadwood Fm.	CD
Precambrian (und.)	PC

PLEISTOCENE ABBREVIATIONS AND ROCK UNITS

Abbrev.	Rock Unit	Abbrev.	Rock Unit
PL '	Pleistocene Series	PLCLF'	Colfax Aq.
PL '	Pleistocene	PLCLM'	Columbus Aq.
PLACL'	Apple Creek Aq. L.	PLCRL'	Cherry Lake Aq.
PLACU'	Apple Creek Aq. U.	PLCRN'	Carrington Aq.
PLANC'	Antelope Creek Aq.	PLCRT'	Courtnay Aq.
PLBAN'	Bantel Aq.	PLCTT'	Cattail Aq.
PLBDC'	Braddock Aq.	PLDGL'	Douglas Aq.
PLBF '	Buffalo Creek Aq.	PLDNB'	Denbigh Aq.
PLBFU'	U. Buffalo Ck. Aq.	PLDRL'	Deer Lake Aq.
PLBHC'	Bald Hill Creek Aq.	PLDYL'	Dry Lake Aq.
PLBLM'	Belmont Aq.	PLE '	Dune Deposits
PLBMK'	Bismarck Aq.	PLEAS'	Eastman Aq.
PLBNL'		PLECL'	Erick Lake Aq.
PLBRC'	Burnt Creek Aq.	PLEDB'	Edinburg Aq.
PLBRG'	Brightwood Aq.	PLEDG'	Edgeley Aq.
PLBRL'	Burlington Aq.	PLEGL'	Englevale Aq.
PLBUT'	Butte Aq.	PLELD'	Ellendale Aq.
PLBVC'	Beaver Creek Aq.	PLELK'	Elk Valley Aq.
PLCBK'	Cutbank Creek Aq.	PLELM'	Elm Creek Aq.
PLCLE'	Central Eddy Aq.	PLEMR'	Emerald Aq.

Abbrev.	Rock Unit
PLESM'	Esmond Aq.
PLF '	Bur. Glac. Fluvial Dep.
PLF '	Buried Outwash Dep.
PLF '	Buried Valley Deposits
PLF '	Esker Dep.
PLF '	Kame Terrace Dep.
PLF '	Outwash Dep.
PLF '	Terrace Dep.
PLFAI'	Fairmount Aq.
PLFDV'	Fordville Aq.
PLFOR'	Forest River Aq.
PLFRG'	Fargo Aq.
PLFRM'	Fort Mandan Aq.
PLG '	Crevasse Dep.
PLG '	Glacial Drift
PLG '	Ice Contact Dep.
PLG '	Kame Deposits
PLG '	Till Deposits
PLGAL'	Galesburgh Aq.
PLGAR'	Garrison Aq.
PLGDF'	Grand Forks Aq.
PLGLE'	Glenco Chl. Aq.
PLGLO'	Goldwin Aq.
PLGLP'	Guelph Aq.
PLGLV'	Glenview Aq.
PLGOO'	Goodman Creek Aq.
PLGRE'	Grendra Aq.
PLHAM'	Hamar Aq.
PLHAN'	Hankinson Aq.
PLHEA'	Heart River Aq.
PLHID'	Hidden Wood Lake Aq.
PLHIL'	Hillsboro Aq.
PLHMT'	Hamilton Aq.
PLHNO'	Horse Nose Butte Aq.
PLHOF'	Hofflund Aq.
PLHOM'	Homer Aq.
PLHSU'	Horseshoe Valley Aq.
PLICE'	Icelandic Aq.
PLINK'	Inkster Aq.
PLJIM'	Jamestown Aq.
PLJON'	Johnson Lake
PLJRV'	James River Aq.
PLJUA'	Juanita Lake Aq.
PLKAR'	Karlsrume Aq.
PLKEN'	Kenmare Aq.
PLKFR'	Knife River Aq.
PLKIL'	Killdeer Aq.
PLKLG'	Kilgore Aq.
PLL '	Beach Deposits
PLL '	Delta Dep.

Abbrev.	Rock Unit
PLL '	Lacustrine Dep.
PLLED'	Leeds Aq.
PLLGL'	Long Lake Aq.
PLLGN'	Lignite City Aq.
PLLHT'	Little Heart Aq.
PLLKS'	L. Souris Aq.
PLLKS'	Lake Souris Aq.
PLLMD'	Little Muddy Aq.
PLLMR'	Lamoure Aq.
PLLN '	Lake Nettie Aq.
PLLNL'	Lake Nettie Aq. L.
PLLNU'	Lake Nettie Aq. U.
PLLSL'	Lost Lake Aq.
PLMAD'	Maddock Aq.
PLMAN'	Manfred Aq.
PLMAR'	Marshtonmoor Pln. Aq.
PLMCI'	McIntosh Aq.
PLMCK'	McKenzie
PLMCV'	McVille Aq.
PLMDA'	Medina Aq.
PLMDF'	Medford Aq.
PLMER'	Mercer Aq.
PLMID'	Midway Aq.
PLMIL'	Milnor Chl. Aq.
PLMIN'	Minnewaukan Aq.
PLMIS'	Missouri River
PLMMR'	Mount Morian Aq.
PLMRT'	Martin Aq.
PLMUN'	Munich Aq.
PLNAP'	Napoleon Aq.
PLNBU'	North Burleigh Aq.
PLNEW'	Newton Aq.
PLNHL'	North Hill Aq.
PLNOR'	Nortonville Aq.
PLNRK'	New Rockford Aq.
PLNT '	Minot Aq.
PLNWC'	NW. Burried Channel Aq.
PLNWE'	N.W. Eddy Aq.
PLOAK'	Oakes Aq.
PLOBR'	Oberon Aq.
PLOTT'	Ottertail Aq.
PLPAG'	Page Aq.
PLPBD'	Pembina Delta Aq.
PLPBR'	Pembina River Aq.
PLPIP'	Pipestem Creek Aq.
PLPLE'	Pleasant Lake Aq.
PLPOP'	Poplar Aq.
PLPWC'	Painted Woods Ck. Aq.
PLPWL'	Painted Woods Lake Aq.
PLRAN'	Random Creek Aq.

Abbrev.	Rock Unit
PLRAY'	Ray Aq.
PLRIV'	Riverdale Aq.
PLRKR'	Rocky Run Aq.
PLROS'	Rosefield Aq.
PLRSL'	Rusland Aq.
PLRUS'	Russel Lake Aq.
PLRYD'	Ryder Aq.
PLSBL'	Strawberry Lake Aq.
PLSDP'	Sand Prairie Aq.
PLSFD'	S. Fessenden Aq.
PLSHD'	Shields Aq.
PLSHL'	Shell Aq.
PLSHL'	South Hill Aq.
PLSIB'	Dibley Chnl. Aq.
PLSID'	Sidney Slough Aq.
PLSIM'	Sims Aq.
PLSJM'	St. James Aq.
PLSKJ'	Skjermo
PLSNK'	Snake Creek Aq.
PLSOO'	Soo Channel Aq.
PLSOV'	Souris Valley Aq.
PLSPR'	Spring Creek Aq.
PLSPT'	Spiritwood Aq.
PLSQR'	Square Butte Ck. Aq.
PLSTB'	Strasburgh Aq.
PLSTR'	Streeter Aq.
PLSUN'	Sundre Buried Chnl. Aq.
PLSVM'	Seven Mile Coulee Aq.
PLSYC'	Sheyenne Chnl. Aq.
PLSYD'	Sheyenne Delta Aq.
PLSYD'	Sheyenne Delta Aq.
PLSYD'	Sydney Aq.
PLSYN'	Sheyenne Village Aq.
PLTOK'	Tokio Aq.
PLTOL'	Tolgen Aq.
PLTOM'	Thompson Aq.
PLTOW'	Tower City Aq.
PLTRN'	Trenton Aq.
PLTRT'	Turtle Lake Aq.
PLVAL'	Valley City Aq.
PLVNG'	Vang Aq.
PLVOL'	Voltaire Aq.
PLWAG'	Wagonsport Aq.
PLWAH'	Wahpeton Aq.
PLWAR'	Warwick Aq.
PLWDS'	Windsor Aq.
PLWEL'	Weller Slough Aq.
PLWFC'	Wolf Creek Aq.
PLWFG'	West Fargo Aq.
PLWIM'	Wimbledon Aq.
PLWIS'	Wishek Aq.
PLWNG'	Wing Chnl. Aq.
PLWR '	Wildrose Aq.
PLWTE'	White Shield Aq.
PLWWR'	West Wildrose Aq.
PLYNK'	Yanktonai Ck. Aq.
PLZEE'	Zeeland Aq.

ATTACHMENT 5

LITHOLOGY AND LITHOLOGIC MODIFIER ABBREVIATIONS

The following lists include abbreviations commonly used in U.S.G.S.W.R.D. and N.D.S.W.C. publications describing their water well data. The most commonly used abbreviations in WATERCAT are underlined.

Lithology:

Abbreviation	Lithology
B	sedimentary rock (und.)
CHLK	chalk
D	dolomite
F, SHLE, Sh	shale
G, GRVL, GV, GRAVEL	gravel
L, LS, LM	limestone
1, LIG, LG, COAL, LGNT	lignite
O	organic
P, Cl, CLAY	clay
Q, St., SILT	silt
R, SAND AND GRVL, SDGL	sand and gravel
S, SAND, Sd	sand
T, Tl, Ti, TILL	till
V, SNDS, SS	sandstone
W, SLTS	siltstone
X	silty sand
Y	clayey gravel
Z	other

ATTACHMENT 5, Con't.

Modifiers:

Abbreviation	Modifier
1, VFN, V.FINE	very fine-grained
2, FINE, FINE GRAINED, FN	fine-grained
3, MEDIUM, MED, MD	medium-grained
4, COARSE, CS, CORSE, CRS, CRSE	coarse-grained
5, V.CRSE, V.CRS, VCSE	very coarse-grained
6, CLAY, CLAYEY	clayey
7, SILTY	silty
8, SANDY, SDY, SNDY	sandy
9, GRVLY, GRAVELLY, GRVL	gravelly
C	calcareous
D, DENSE	dense
FAIRLY CLEAN	moderately sorted
FR	from
GOOD, CLEAN	well sorted
H	hard
I, INTERBEDDED, LAYERS, LENS, LENSES	interbedded
J, FRACTURED	jointed or fractured
OX	oxidized
POORLY SORTED, MIXED, DIRTY	poorly sorted
S, SOFT	soft
SL	slightly
SLOT	screened
U	unconsolidated

ATTACHMENT 5, Con't.

Modifiers, Con't.:

Abbreviation	Modifier
V, INDURATED, SEMICONSOLIDATED	semiconsolidated
WATER, MUD, QUICKSAND	saturated
WITH LIGNITE	lignite fragments
Y, SHALY	shaley

APPENDIX D

EXAMPLES OF COALBASE DATA MODIFICATION SESSIONS

```
RUN NS2

 DO YOU WANT A LISTING OF VALUES? (Y OR N)
?Y


NON-STRATUM VALUES FOR SITE ID DEMO ONE          INTERNAL ID      10

  DATE DRILLED: DAY -  6   MONTH -  7   YEAR - 1980

  SURFACE OR REFERENCE ELEVATION:  3000.00 F

  DEPTH TO BEDROCK:     8.0F

  TOTAL DEPTH (NOT MODIFIABLE HERE):   80.00 F

  METHOD OF DRILLING CODE: 2

  DATA RECORDS:
       DRILLER LOG:              YES
       NATURAL GAMMA LOG:        NO
       GAMMA DENSITY LOG:        NO
       SELF-POTENTIAL LOG:       NO
       RESISTIVITY LOG:          NO
       CALIPER LOG:              NO
       SAMPLES SAVED:            YES
       OTHER RECORDS - CODE: ' '


 ENTER        TO DO
 -----        ---------------------------------
   1          CHANGE DATE DRILLED
   2          CHANGE UNITS (FEET/METERS)
   3          CHANGE REFERENCE ELEVATION
   4          CHANGE DEPTH TO BEDROCK
   5          CHANGE METHOD OF DRILLING CODE
   6          CHANGE DATA RECORDS
   7          PERFORM OTHER PROCESSING
?3
```

```
   SURFACE OR REFERENCE ELEVATION:  3000.00 F
  DO YOU WISH TO CHANGE THE VALUE?  (Y OR N)
?Y

  ENTER THE NEW ELEVATION VALUE WITH DECIMAL POINT:
?3100.

   THE NEW REFERENCE ELEVATION IS:  3100.00 F
   IS THE VALUE CORRECT?  (Y OR N)
?Y

   DO YOU WISH TO MAKE THE CHANGE PERMANENT? (Y OR N)
?Y


  DO YOU WANT A LISTING OF VALUES? (Y OR N)
?N


  ENTER        TO DO
  -----        ---------------------------------
    1          CHANGE DATE DRILLED
    2          CHANGE UNITS (FEET/METERS)
    3          CHANGE REFERENCE ELEVATION
    4          CHANGE DEPTH TO BEDROCK
    5          CHANGE METHOD OF DRILLING CODE
    6          CHANGE DATA RECORDS
    7          PERFORM OTHER PROCESSING
?6

    DATA RECORDS:
         DRILLER LOG:              YES
   DO YOU WISH TO CHANGE THE VALUE?  (Y OR N)
 ?N
         NATURAL GAMMA LOG:        NO
   DO YOU WISH TO CHANGE THE VALUE?  (Y OR N)
 ?Y

   ENTER THE NEW VALUE AS 'Y' OR 'N':
 ?Y

     THE NEW VALUE IS:
         NATURAL GAMMA LOG:        YES
    IS THE VALUE CORRECT?  (Y OR N)
 ?Y

    DO YOU WISH TO MAKE THE CHANGE PERMANENT? (Y OR N)
 ?Y

   ANY MORE CHANGES TO 'DATA RECORDS'? (Y OR N)
 ?N
```

```
 DO YOU WANT A LISTING OF VALUES? (Y OR N)
?Y

NON-STRATUM VALUES FOR SITE ID DEMO ONE          INTERNAL ID      10

  DATE DRILLED: DAY -  6   MONTH -  7   YEAR - 1980

  SURFACE OR REFERENCE ELEVATION:  3100.00 F

  DEPTH TO BEDROCK:     8.0F

  TOTAL DEPTH (NOT MODIFIABLE HERE):   80.00 F

  METHOD OF DRILLING CODE: 2

  DATA RECORDS:
       DRILLER LOG:                YES
       NATURAL GAMMA LOG:          YES
       GAMMA DENSITY LOG:          NO
       SELF-POTENTIAL LOG:         NO
       RESISTIVITY LOG:            NO
       CALIPER LOG:                NO
       SAMPLES SAVED:              YES
       OTHER RECORDS - CODE:

  ENTER        TO DO
  -----        ------------------------------
    1          CHANGE DATE DRILLED
    2          CHANGE UNITS (FEET/METERS)
    3          CHANGE REFERENCE ELEVATION
    4          CHANGE DEPTH TO BEDROCK
    5          CHANGE METHOD OF DRILLING CODE
    6          CHANGE DATA RECORDS
    7          PERFORM OTHER PROCESSING
?7
```

```
   YOU ARE PROCESSING NON-STRATA DATA OF
 INTERNAL ID:        10   SITE ID: DEMO ONE

 DO YOU WANT A LISTING OF ALL NON-STRATA VALUES?
 (Y OR N)
?N


 WHEN 'N.N SECS' APPEARS ON THE SCREEN,

 ENTER          TO LIST OR CHANGE
 ------------   ------------------------------
 RUN LOCA       LOCATION VALUES
 RUN COMM       COMMENT RECORDS
 RUN SUPP       SUPPLEMENTARY VALUES
 RUN NS1        SITE ID, OWNER OR STORAGE VALUES
 RUN NS2        ALL OTHER NON-STRATA VALUES
 RUN SITE       EXIT TO OTHER PROCESSING
STOP
TIME 1.7 SECS
```

```
RUN STRAT


   YOU ARE PROCESSING STRATA DATA OF
 INTERNAL ID:        10   SITE ID: DEMONSTRATION 1

 ENTER          TO DO
 -----          --------------------------
  1             PROFILE OF THE STRATA DATA
  2             SEE A STRATIGRAPHIC COLUMN
  3             LIST ALL THE STRATA VALUES
  4             MODIFY VALUES OF A STRATUM OR
                  EXIT TO OTHER PROCESSING
?1


       PROFILE OF THE STRATA

 ID   DEPTH  LITHOLOGY  ELEVATION  THICKNESS    NAME
 1     0.  F   TSLM.-     3000.00F      3.00F SOIL A
 2     3.00F   TSLM:-     2997.00F      5.00F SOIL B
 3     8.00F   ----UD     2992.00F      2.00F
 4    10.00F   ....UD     2990.00F      6.00F
 5    16.00F   CCCCLG     2984.00F      2.00F COAL 1
 6    18.00F   ----UD     2982.00F      1.00F COAL 1
 7    19.00F   CCCCLG     2981.00F      1.00F COAL 1
 8    20.00F   ----UD     2980.00F      2.00F COAL 1
 9    22.00F   CCCCLG     2978.00F      2.00F COAL 1
10    24.00F   ----UD     2976.00F      4.00F
11    28.00F   ::::UD     2972.00F      4.00F
12    32.00F   ....UD     2968.00F      7.00F
13    39.00F   CCLGPY     2961.00F     10.00F COAL 2
14    49.00F   --BENT     2951.00F      9.00F
15    58.00F   ::::UD     2942.00F      5.00F
16    63.00F   ....UD     2937.00F      9.00F
17    72.00F   ....IN     2928.00F      3.00F
18    75.00F   ----CC     2925.00F      1.00F
19    76.00F   ...1:C     2924.00F      4.00F
20    80.00F   BOTTOM     2920.00F      0.  F
```

```
  YOU ARE PROCESSING STRATA DATA OF
INTERNAL ID:       10   SITE ID: DEMONSTRATION 1

ENTER          TO DO
-----          ---------------------------
 1             PROFILE OF THE STRATA DATA
 2             SEE A STRATIGRAPHIC COLUMN
 3             LIST ALL THE STRATA VALUES
 4             MODIFY VALUES OF A STRATUM OR
                 EXIT TO OTHER PROCESSING
?2


          STRATIGRAPHIC COLUMN
INTERNAL ID:       10   SITE ID: DEMONSTRATION 1

STRATA:  40; TOTAL DEPTH:    80.00 F

 ENTER THE NUMBER OF FEET/METERS PER TERMINAL LINE
       ENTRY MUST HAVE A DECIMAL POINT
?2.

   DEPTH  SYMBOL  ELEVATION  THICKNESS    NAME
    0.  F TSLM.-    3000.00F      3.00F SOIL A
          TSLM.-
   3.00F  TSLM:-    2997.00F      5.00F SOIL B
          TSLM:-
          TSLM:-
   8.00F  ----UD    2992.00F      2.00F
          ----UD
  10.00F  ....UD    2990.00F      6.00F
          ....UD
          ....UD
          ....UD
  16.00F  CCCCLG    2984.00F      2.00F COAL 1
          CCCCLG
  18.00F  ----UD    2982.00F      1.00F COAL 1
  19.00F  CCCCLG    2981.00F      1.00F COAL 1
  20.00F  ----UD    2980.00F      2.00F COAL 1
          ----UD
  22.00F  CCCCLG    2978.00F      2.00F COAL 1
          CCCCLG
  24.00F  ----UD    2976.00F      4.00F
          ----UD
          ----UD
```

```
28.00F ::::UD    2972.00F      4.00F
       ::::UD
       ::::UD
32.00F ....UD    2968.00F      7.00F
       ....UD
       ....UD
       ....UD
39.00F CCLGPY    2961.00F     10.00F COAL 2
       CCLGPY
       CCLGPY
       CCLGPY
       CCLGPY
       CCLGPY
49.00F --BENT    2951.00F      9.00F
       --BENT
       --BENT
       --BENT
       --BENT
58.00F ::::UD    2942.00F      5.00F
       ::::UD
       ::::UD
63.00F ....UD    2937.00F      9.00F
       ....UD
       ....UD
       ....UD
       ....UD
72.00F ....IN    2928.00F      3.00F
       ....IN
75.00F ----CC    2925.00F      1.00F
76.00F ...1:C    2924.00F      4.00F
       ...1:C
       ...1:C
80.00F BOTTOM    2920.00F      0.  F
```

```
  YOU ARE PROCESSING STRATA DATA OF
INTERNAL ID:       10   SITE ID: DEMONSTRATION 1

ENTER          TO DO
-----          ---------------------------
 1             PROFILE OF THE STRATA DATA
 2             SEE A STRATIGRAPHIC COLUMN
 3             LIST ALL THE STRATA VALUES
 4             MODIFY VALUES OF A STRATUM OR
                 EXIT TO OTHER PROCESSING
?4

WHEN 'TIME N.N SECS' APPEARS ON THE SCREEN,
  ENTER            TO DO
  --------------   ---------------------------
  RUN VALUE        PROCESS STRATA VALUES
  RUN BOUND        CHANGE STRATA BOUNDARIES
  RUN COMM         PROCESS COMMENTS
  RUN SUPP         PROCESS SUPPLEMENTARY VALUES
  RUN SITE         EXIT TO OTHER PROCESSING


STOP
TIME 0.9 SECS
```

RUN VALUE

YOU ARE PROCESSING STRATA DATA OF
INTERNAL ID: 10 SITE ID: DEMONSTRATION 1

ENTER	TO DO
1	PROFILE OF THE STRATA DATA
2	MODIFY VALUES OF A STRATUM
3	EXIT TO OTHER PROCESSING

?1

PROFILE OF THE STRATA

ID	DEPTH	LITHOLOGY	ELEVATION	THICKNESS	NAME
1	0. F	TSLM.-	3000.00F	3.00F	SOIL A
2	3.00F	TSLM:-	2997.00F	5.00F	SOIL B
3	8.00F	----UD	2992.00F	2.00F	
4	10.00F	....UD	2990.00F	6.00F	
5	16.00F	CCCCLG	2984.00F	2.00F	COAL 1
6	18.00F	----UD	2982.00F	1.00F	COAL 1
7	19.00F	CCCCLG	2981.00F	1.00F	COAL 1
8	20.00F	----UD	2980.00F	2.00F	COAL 1
9	22.00F	CCCCLG	2978.00F	2.00F	COAL 1
10	24.00F	----UD	2976.00F	4.00F	
11	28.00F	::::UD	2972.00F	4.00F	
12	32.00F	....UD	2968.00F	7.00F	
13	39.00F	CCLGPY	2961.00F	10.00F	COAL 2
14	49.00F	--BENT	2951.00F	9.00F	
15	58.00F	::::UD	2942.00F	5.00F	
16	63.00F	....UD	2937.00F	9.00F	
17	72.00F	....IN	2928.00F	3.00F	
18	75.00F	----CC	2925.00F	1.00F	
19	76.00F	...1:C	2924.00F	4.00F	
20	80.00F	BOTTOM	2920.00F	0. F	

```
  YOU ARE PROCESSING STRATA DATA OF
 INTERNAL ID:       10   SITE ID: DEMONSTRATION 1

 ENTER          TO DO
 -----          ---------------------------
  1             PROFILE OF THE STRATA DATA
  2             MODIFY VALUES OF A STRATUM
  3             EXIT TO OTHER PROCESSING
?2


 ENTER THE STRATUM NUMBER OF THE STRATUM
  FOR WHICH YOU WILL BE CHANGING VALUES;
  ENTER A '0' TO ESCAPE:
 321
? 16

 STRATUM   DEPTH DTCODE  NAME  DATA  CC  ABBRV  ELEVATION   THICKNESS  SYMBOL
   16     63.00F   4000     0  1  1  NO          2937.00F       9.00F  ....UD

 ENTER          TO DO
 -----          ---------------------------
  1             CHANGE DTCODE/SYMBOL
  2             CHANGE NAME DATA/CC/ABBRV
  3             EXIT TO OTHER PROCESSING
?2


  YOU ARE PROCESSING STRATUM NAME DATA;
 DO YOU WANT A LIST OF STRATUM NAMES ON FILE (Y OR N)
?Y

NAME1  ABBREV  DESCRIPTION
  -1    ERROR
   0
 5555  INTRBN  THE INTERBURDEN
 7001  SAND A
 7002  SAND B
 7003  SAND C  SAND BED C
 8001  COAL A
 8002  COAL B
 8003  COALAB
 8005  COAL 1
 8006  COAL 2
 9991  SOIL A
 9992  SOIL B
```

```
 THE VALUES ARE:
NAME1 NAME2 NAME3  ABBREV  CC  OLD ID  NEW ID
    0     1     1          NO     555       0

  DO YOU WANT TO CHANGE THE VALUES? (Y OR N)
?Y

 ENTER THE NEW NAME1 (CODE FOR STRATUM NAME);
   ENTER A '0' TO DELETE STRATUM NAME VALUES:
 4321
?7003

 TO HOW MANY CONSECUTIVE STRATA
   WILL THE NEW NAME1 APPLY?
 21
? 2

 ENTER CC, THE CORRELATION CODE:
?Y1


 THE VALUES ARE:
NAME1 NAME2 NAME3  ABBREV  CC  OLD ID  NEW ID
 7003     2     1  SAND C  Y1               0

 ARE THE VALUES CORRECT?  (Y OR N)
?Y

 DO YOU WANT TO MAKE THE CHANGES PERMANENT? (Y OR N)
?Y


   YOU ARE PROCESSING STRATA DATA OF
 INTERNAL ID:       10   SITE ID: DEMONSTRATION 1

 ENTER          TO DO
 -----          ---------------------------
  1             PROFILE OF THE STRATA DATA
  2             MODIFY VALUES OF A STRATUM
  3             EXIT TO OTHER PROCESSING
?1
```

PROFILE OF THE STRATA

ID	DEPTH	LITHOLOGY	ELEVATION	THICKNESS	NAME
1	0. F	TSLM.-	3000.00F	3.00F	SOIL A
2	3.00F	TSLM:-	2997.00F	5.00F	SOIL B
3	8.00F	----UD	2992.00F	2.00F	
4	10.00F	....UD	2990.00F	6.00F	
5	16.00F	CCCCLG	2984.00F	2.00F	COAL 1
6	18.00F	----UD	2982.00F	1.00F	COAL 1
7	19.00F	CCCCLG	2981.00F	1.00F	COAL 1
8	20.00F	----UD	2980.00F	2.00F	COAL 1
9	22.00F	CCCCLG	2978.00F	2.00F	COAL 1
10	24.00F	----UD	2976.00F	4.00F	
11	28.00F	::::UD	2972.00F	4.00F	
12	32.00F	....UD	2968.00F	7.00F	
13	39.00F	CCLGPY	2961.00F	10.00F	COAL 2
14	49.00F	--BENT	2951.00F	9.00F	
15	58.00F	::::UD	2942.00F	5.00F	
16	63.00F	....UD	2937.00F	9.00F	SAND C
17	72.00F	....IN	2928.00F	3.00F	SAND C
18	75.00F	----CC	2925.00F	1.00F	
19	76.00F	...1:C	2924.00F	4.00F	
20	80.00F	BOTTOM	2920.00F	0. F	

YOU ARE PROCESSING STRATA DATA OF
INTERNAL ID: 10 SITE ID: DEMONSTRATION 1

ENTER	TO DO
1	PROFILE OF THE STRATA DATA
2	MODIFY VALUES OF A STRATUM
3	EXIT TO OTHER PROCESSING

?3

YOU ARE PROCESSING STRATA DATA OF
INTERNAL ID: 10 SITE ID: DEMONSTRATION 1

ENTER	TO DO
1	PROFILE OF THE STRATA DATA
2	SEE A STRATIGRAPHIC COLUMN
3	LIST ALL THE STRATA VALUES
4	MODIFY VALUES OF A STRATUM OR EXIT TO OTHER PROCESSING

?4

WHEN 'TIME N.N SECS' APPEARS ON THE SCREEN,

ENTER	TO DO
RUN VALUE	PROCESS STRATA VALUES
RUN BOUND	CHANGE STRATA BOUNDARIES
RUN COMM	PROCESS COMMENTS
RUN SUPP	PROCESS SUPPLEMENTARY VALUES
RUN SITE	EXIT TO OTHER PROCESSING

STOP
TIME 2.5 SECS

Example 1: Increasing the Thickness of Stratum 13

```
RUN BOUND

   YOU ARE PROCESSING STRATA DATA OF
 INTERNAL ID:        10   SITE ID: DEMONSTRATION 1

 ENTER          TO DO
 -----          ---------------------------
  1             PROFILE OF THE STRATA BOUNDS
  2             MODIFY STRATA BOUNDARY VALUES
  3             EXIT TO OTHER PROCESSING
?1

        PROFILE OF THE BOUNDARY VALUES
```

STRATUM	DEPTH TOP	DEPTH BTM	ELEV. TOP	THICKNESS	ABBREV
1	0. F	3.00F	3000.00F	3.00F	TSLM.-
2	3.00F	8.00F	2997.00F	5.00F	TSLM:-
3	8.00F	10.00F	2992.00F	2.00F	----UD
4	10.00F	16.00F	2990.00F	6.00F	....UD
5	16.00F	18.00F	2984.00F	2.00F	CCCCLG
6	18.00F	19.00F	2982.00F	1.00F	----UD
7	19.00F	20.00F	2981.00F	1.00F	CCCCLG
8	20.00F	22.00F	2980.00F	2.00F	----UD
9	22.00F	24.00F	2978.00F	2.00F	CCCCLG
10	24.00F	28.00F	2976.00F	4.00F	----UD
11	28.00F	32.00F	2972.00F	4.00F	::::UD
12	32.00F	39.00F	2968.00F	7.00F	....UD
13	39.00F	49.00F	2961.00F	10.00F	CCLGPY
14	49.00F	58.00F	2951.00F	9.00F	--BENT
15	58.00F	63.00F	2942.00F	5.00F	::::UD
16	63.00F	72.00F	2937.00F	9.00F	....UD
17	72.00F	75.00F	2928.00F	3.00F	....IN
18	75.00F	76.00F	2925.00F	1.00F	----CC
19	76.00F	80.00F	2924.00F	4.00F	...1:C
20	80.00F	80.00F	2920.00F	0. F	BOTTOM

```
  YOU ARE PROCESSING STRATA DATA OF
 INTERNAL ID:       10   SITE ID: DEMONSTRATION 1

 ENTER          TO DO
 -----          --------------------------
  1             PROFILE OF THE STRATA BOUNDS
  2             MODIFY STRATA BOUNDARY VALUES
  3             EXIT TO OTHER PROCESSING
?2

 ENTER          TO DO
 -----          --------------------------
  1             DELETE A STRATUM
  2             ADD A STRATUM/CHANGE BOUNDARIES
  3             EXIT TO OTHER PROCESSING
?2

 ENTER          TO DO
 -----          --------------------------
  1             CHANGE BOUNDS OF AN OLD STRATUM
  2             DEFINE A NEW STRATUM
  3             EXIT TO OTHER PROCESSING
?1


 ENTER THE STRATUM NUMBER OF THE STRATUM
   YOU WANT TO CHANGE THE BOUNDARIES;
  ENTER A '0' TO ESCAPE:
 321
?13


 STRATUM NUMBER 130 IS NOT AMONG THE DATA
```

```
  ENTER THE STRATUM NUMBER OF THE STRATUM
    YOU WANT TO CHANGE THE BOUNDARIES;
   ENTER A '0' TO ESCAPE:
 321
? 13

  STRATUM  DEPTH TOP  DEPTH BTM  ELEV. TOP  THICKNESS   ABBREV
     13       39.00F     49.00F   2961.00F     10.00F   CCLGPY

   IS THIS THE STRATUM TO BE CHANGED? (Y OR N)
?Y


   ENTER THE NEW DEPTH TO THE TOP OF THE STRATUM
     WITH A DECIMAL POINT:
?39.00


   ENTER THE NEW DEPTH TO THE BOTTOM OF THE STRATUM
     WITH A DECIMAL POINT:
?49.50


   THE VALUES ARE:

  STRATUM  DEPTH TOP  DEPTH BTM  ELEV. TOP  THICKNESS   ABBREV
     13A      39.00F     49.50F   2961.00F     10.50F   CCLGPY

   ARE THE VALUES CORRECT? (Y OR N)
?Y


  DO YOU WANT TO CONTINUE THE CHANGE? (Y OR N)
?Y
```

THE NEW
PROFILE OF THE BOUNDARY VALUES

STRATUM	DEPTH TOP	DEPTH BTM	ELEV. TOP	THICKNESS	ABBREV
1	0. F	3.00F	3000.00F	3.00F	TSLM.-
2	3.00F	8.00F	2997.00F	5.00F	TSLM:-
3	8.00F	10.00F	2992.00F	2.00F	----UD
4	10.00F	16.00F	2990.00F	6.00F	....UD
5	16.00F	18.00F	2984.00F	2.00F	CCCCLG
6	18.00F	19.00F	2982.00F	1.00F	----UD
7	19.00F	20.00F	2981.00F	1.00F	CCCCLG
8	20.00F	22.00F	2980.00F	2.00F	----UD
9	22.00F	24.00F	2978.00F	2.00F	CCCCLG
10	24.00F	28.00F	2976.00F	4.00F	----UD
11	28.00F	32.00F	2972.00F	4.00F	::::UD
12	32.00F	39.00F	2968.00F	7.00F	....UD
13A	39.00F	49.50F	2961.00F	10.50F	CCLGPY
(FORMER STRATUM 14 IS DELETED.					
14	49.50F	58.00F	2950.50F	8.50F	MISSNG
15	58.00F	63.00F	2942.00F	5.00F	::::UD
16	63.00F	72.00F	2937.00F	9.00F	....UD
17	72.00F	75.00F	2928.00F	3.00F	....IN
18	75.00F	76.00F	2925.00F	1.00F	----CC
19	76.00F	80.00F	2924.00F	4.00F	...1:C
20	80.00F	80.00F	2920.00F	0. F	BOTTOM

DO YOU WANT TO MAKE THE CHANGE PERMANENT? (Y OR N)
?Y

Note: Further processing integrates the change into the master file. The values of stratum 14 can be restored using the 'VALUE' program.

Example 2: Adding a 'Marker Stratum'.

```
  YOU ARE PROCESSING STRATA DATA OF
INTERNAL ID:        10   SITE ID: DEMONSTRATION 1

ENTER          TO DO
-----          ---------------------------
 1             PROFILE OF THE STRATA BOUNDS
 2             MODIFY STRATA BOUNDARY VALUES
 3             EXIT TO OTHER PROCESSING
?1
```

PROFILE OF THE BOUNDARY VALUES

STRATUM	DEPTH TOP	DEPTH BTM	ELEV. TOP	THICKNESS
1	0. F	3.00F	3000.00F	3.00F
2	3.00F	8.00F	2997.00F	5.00F
3	8.00F	10.00F	2992.00F	2.00F
4	10.00F	16.00F	2990.00F	6.00F
5	16.00F	18.00F	2984.00F	2.00F
6	18.00F	19.00F	2982.00F	1.00F
7	19.00F	20.00F	2981.00F	1.00F
8	20.00F	22.00F	2980.00F	2.00F
9	22.00F	24.00F	2978.00F	2.00F
10	24.00F	28.00F	2976.00F	4.00F
11	28.00F	32.00F	2972.00F	4.00F
12	32.00F	39.00F	2968.00F	7.00F
13	39.00F	49.00F	2961.00F	10.00F
14	49.00F	58.00F	2951.00F	9.00F
15	58.00F	63.00F	2942.00F	5.00F
16	63.00F	72.00F	2937.00F	9.00F
17	72.00F	75.00F	2928.00F	3.00F
18	75.00F	76.00F	2925.00F	1.00F
19	76.00F	80.00F	2924.00F	4.00F
20	80.00F	80.00F	2920.00F	0. F

```
   YOU ARE PROCESSING STRATA DATA OF
 INTERNAL ID:       10   SITE ID: DEMONSTRATION 1

 ENTER          TO DO
 -----          ---------------------------
  1             PROFILE OF THE STRATA BOUNDS
  2             MODIFY STRATA BOUNDARY VALUES
  3             EXIT TO OTHER PROCESSING
?2

 ENTER          TO DO
 -----          ---------------------------
  1             DELETE A STRATUM
  2             ADD A STRATUM/CHANGE BOUNDARIES
  3             EXIT TO OTHER PROCESSING
?2

 ENTER          TO DO
 -----          ---------------------------
  1             CHANGE BOUNDS OF AN OLD STRATUM
  2             DEFINE A NEW STRATUM
  3             EXIT TO OTHER PROCESSING
?2


   ENTER THE NEW DEPTH TO THE TOP OF THE STRATUM
     WITH A DECIMAL POINT:
?49.00


   ENTER THE NEW DEPTH TO THE BOTTOM OF THE STRATUM
     WITH A DECIMAL POINT:
?49.00


   THE VALUES ARE:

  STRATUM  DEPTH TOP  DEPTH BTM  ELEV. TOP  THICKNESS   ABBREV
     0A      49.00F     49.00F   2951.00F      0.  F    NEW* 1

   ARE THE VALUES CORRECT? (Y OR N)
?Y


  DO YOU WANT TO CONTINUE THE CHANGE? (Y OR N)
?Y
```

THE NEW
PROFILE OF THE BOUNDARY VALUES

STRATUM	DEPTH TOP	DEPTH BTM	ELEV. TOP	THICKNESS	ABBREV	
1	0. F	3.00F	3000.00F	3.00F	TSLM.-	
2	3.00F	8.00F	2997.00F	5.00F	TSLM:-	
3	8.00F	10.00F	2992.00F	2.00F	----UD	
4	10.00F	16.00F	2990.00F	6.00F	....UD	
5	16.00F	18.00F	2984.00F	2.00F	CCCCLG	
6	18.00F	19.00F	2982.00F	1.00F	----UD	
7	19.00F	20.00F	2981.00F	1.00F	CCCCLG	
8	20.00F	22.00F	2980.00F	2.00F	----UD	
9	22.00F	24.00F	2978.00F	2.00F	CCCCLG	
10	24.00F	28.00F	2976.00F	4.00F	----UD	
11	28.00F	32.00F	2972.00F	4.00F	::::UD	
12	32.00F	39.00F	2968.00F	7.00F	....UD	
13	39.00F	49.00F	2961.00F	10.00F	CCLGPY	
13A	49.00F	49.00F	2951.00F	0. F	NEW* 1	(CHANGE
14	49.00F	58.00F	2951.00F	9.00F	--BENT	
15	58.00F	63.00F	2942.00F	5.00F	::::UD	
16	63.00F	72.00F	2937.00F	9.00F	....UD	
17	72.00F	75.00F	2928.00F	3.00F	....IN	
18	75.00F	76.00F	2925.00F	1.00F	----CC	
19	76.00F	80.00F	2924.00F	4.00F	...1:C	
20	80.00F	80.00F	2920.00F	0. F	BOTTOM	

DO YOU WANT TO MAKE THE CHANGE PERMANENT? (Y OR N)
?Y

Note: Further processing integrates the change into the master file. The values for stratum 13A can be added using the 'VALUE' program.

APPENDIX E

UPDATED PHASE I STRATIGRAPHIC DATA

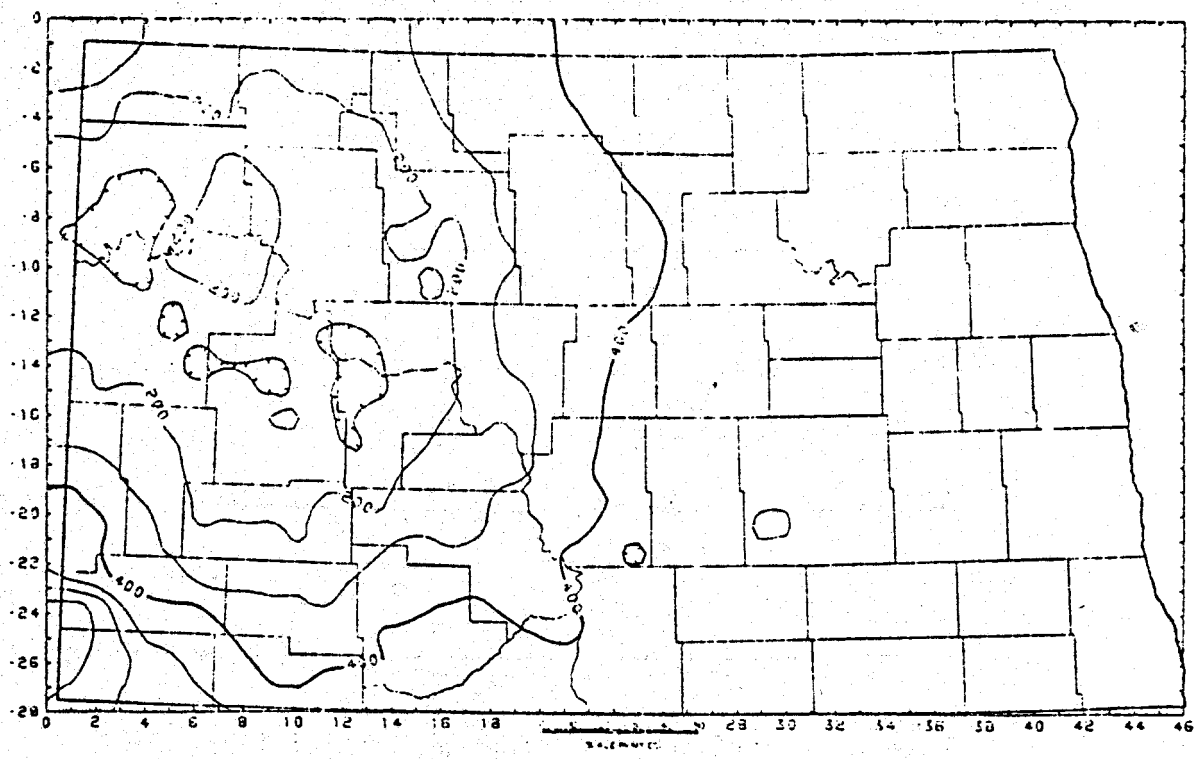


FIGURE 1 - STRUCTURE MAP ON THE TOP OF THE CRETACEOUS PIERRE FORMATION (KP): CONTOUR INTERVAL IS 100 METRES

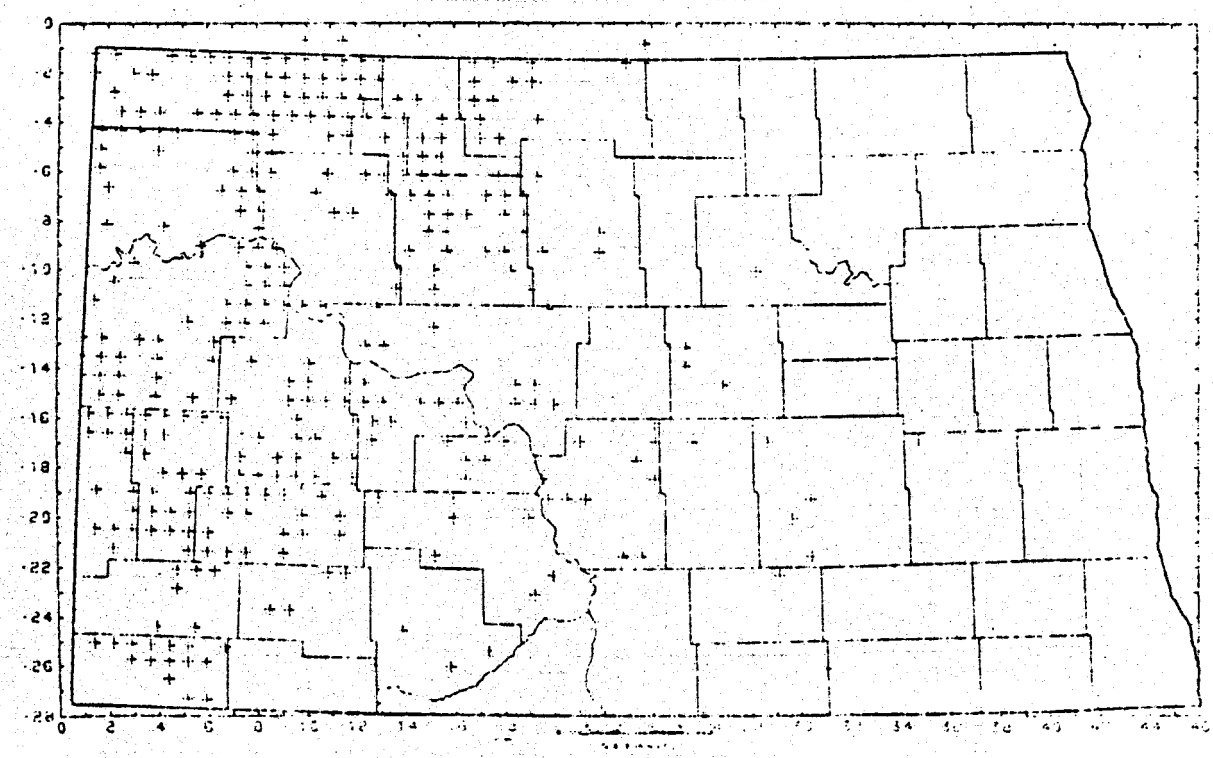


FIGURE 2 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE CRETACEOUS PIERRE FORMATION STRUCTURE MAP

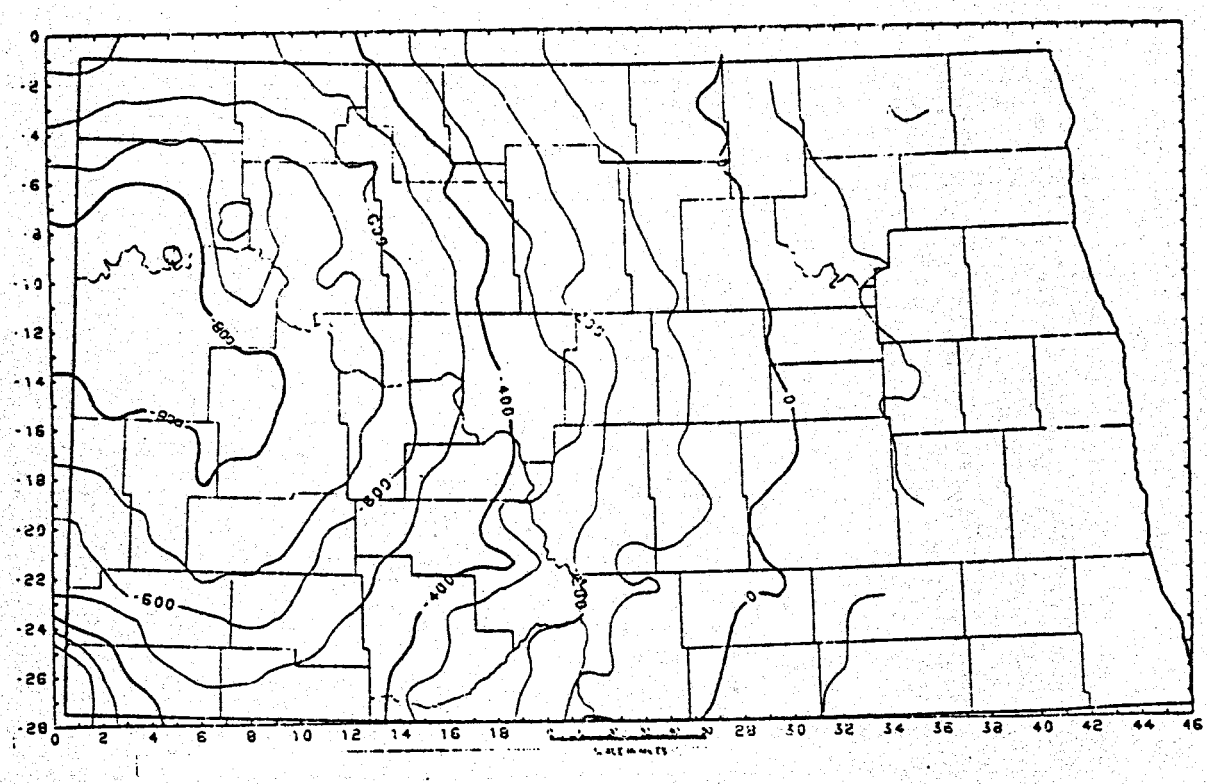


FIGURE 3 - STRUCTURE MAP ON TOP OF THE CRETACEOUS MOWRY FORMATION (KM); CONTOUR INTERVAL IS 100 METRES

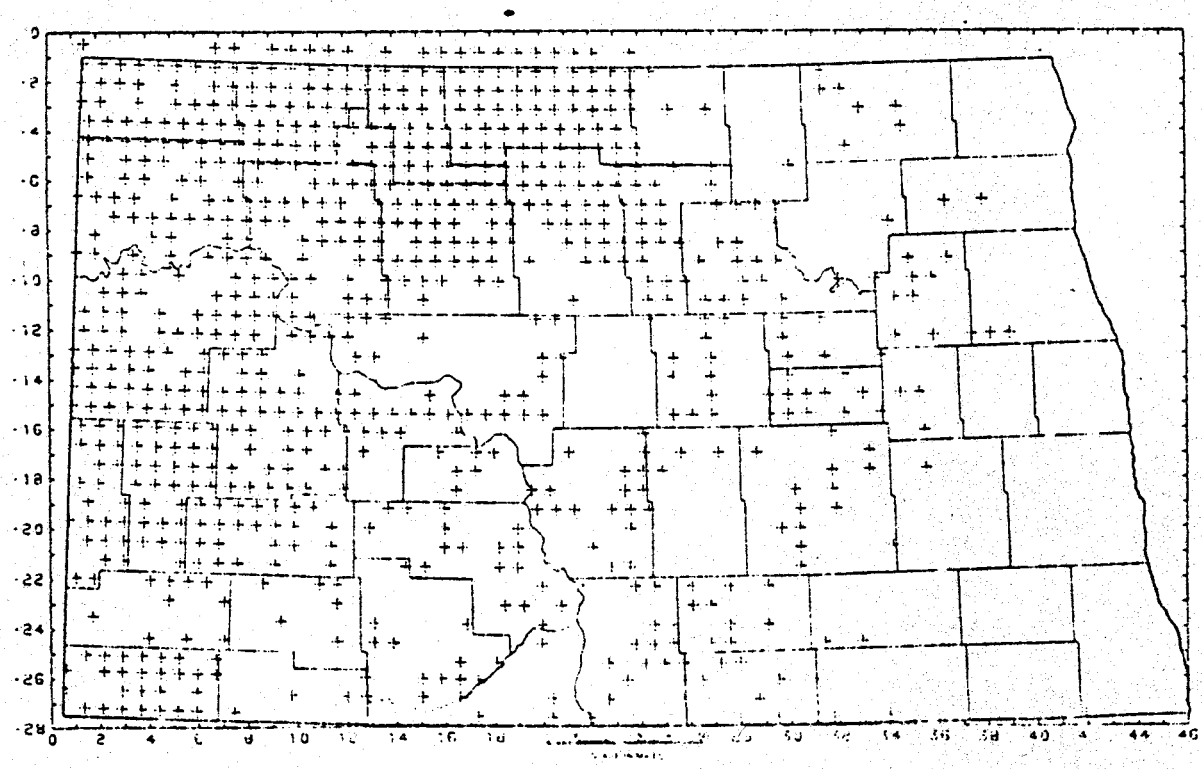


FIGURE 4 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE CRETACEOUS MOWRY FORMATION STRUCTURE MAP

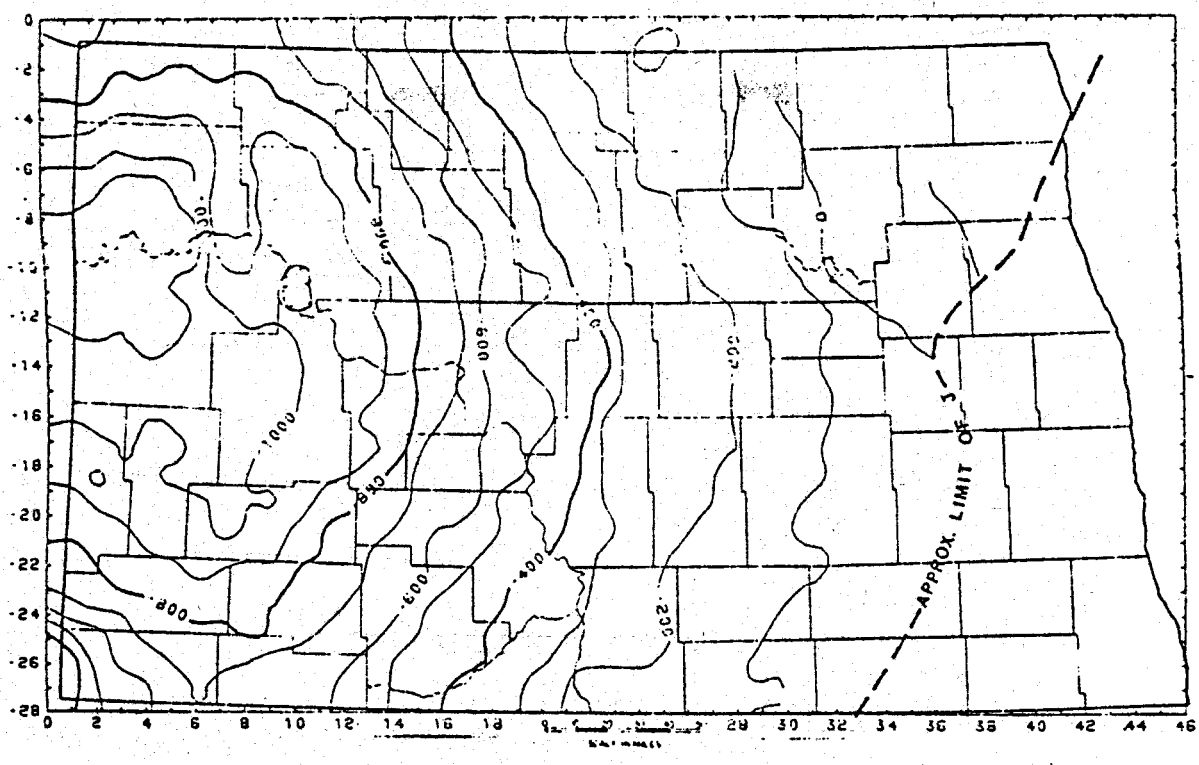


FIGURE 5 - STRUCTURE MAP ON THE TOP OF THE JURASSIC SYSTEM (J); CONTOUR INTERVAL IS 100 METRES

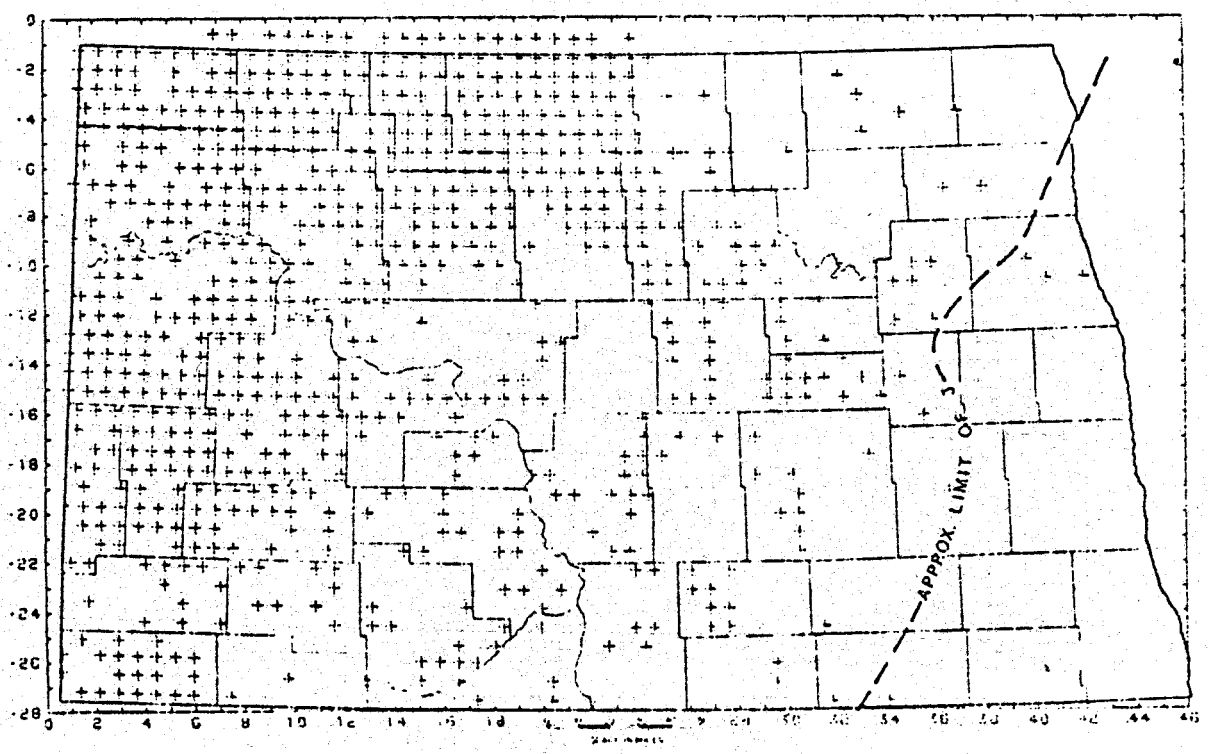


FIGURE 6 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE JURASSIC SYSTEM STRUCTURE MAP

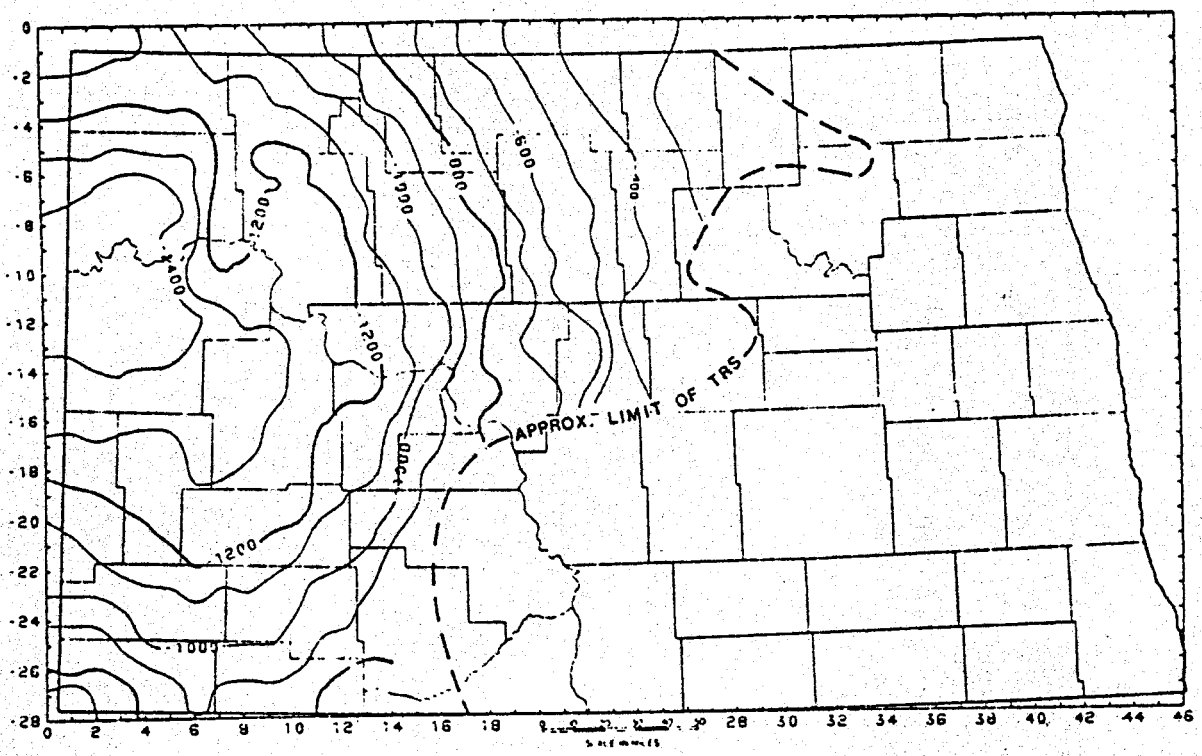


FIGURE 7 - STRUCTURE MAP ON THE TOP OF THE TRIASSIC SYSTEM (TRS); CONTOUR INTERVAL IS 100 METRES

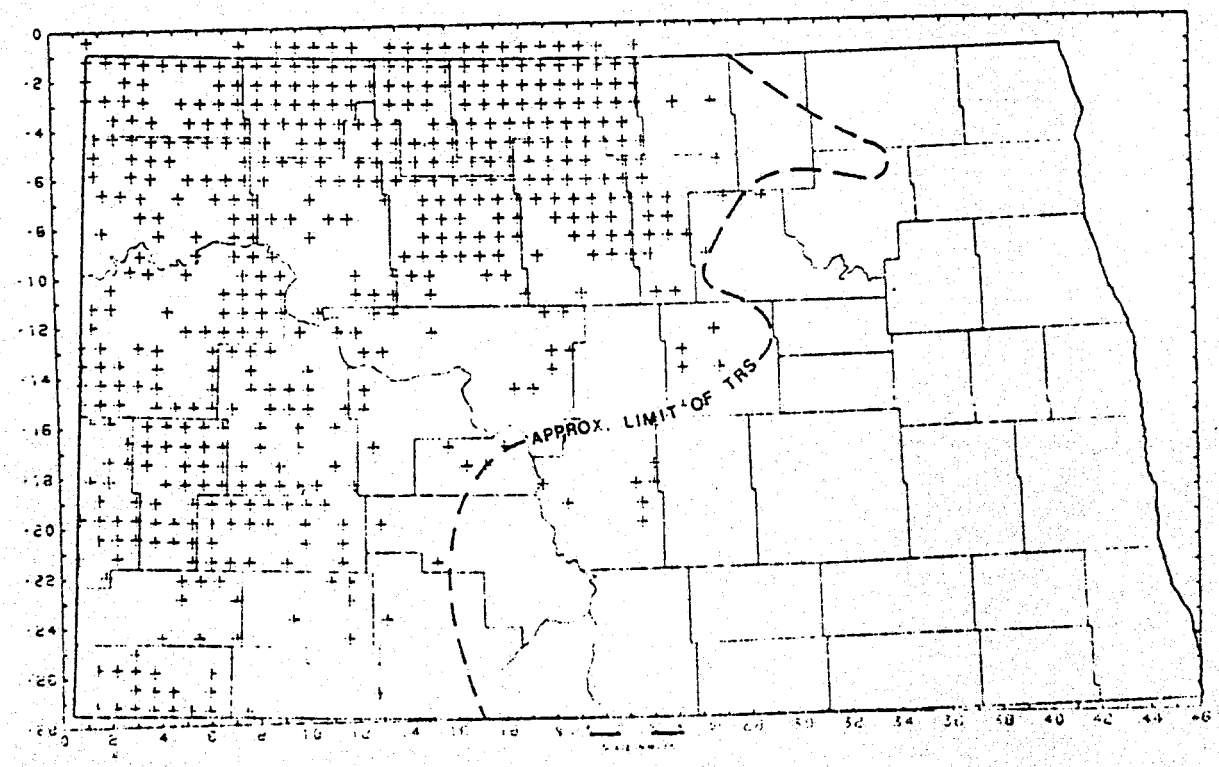


FIGURE 8 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE TRIASSIC SYSTEM STRUCTURE MAP

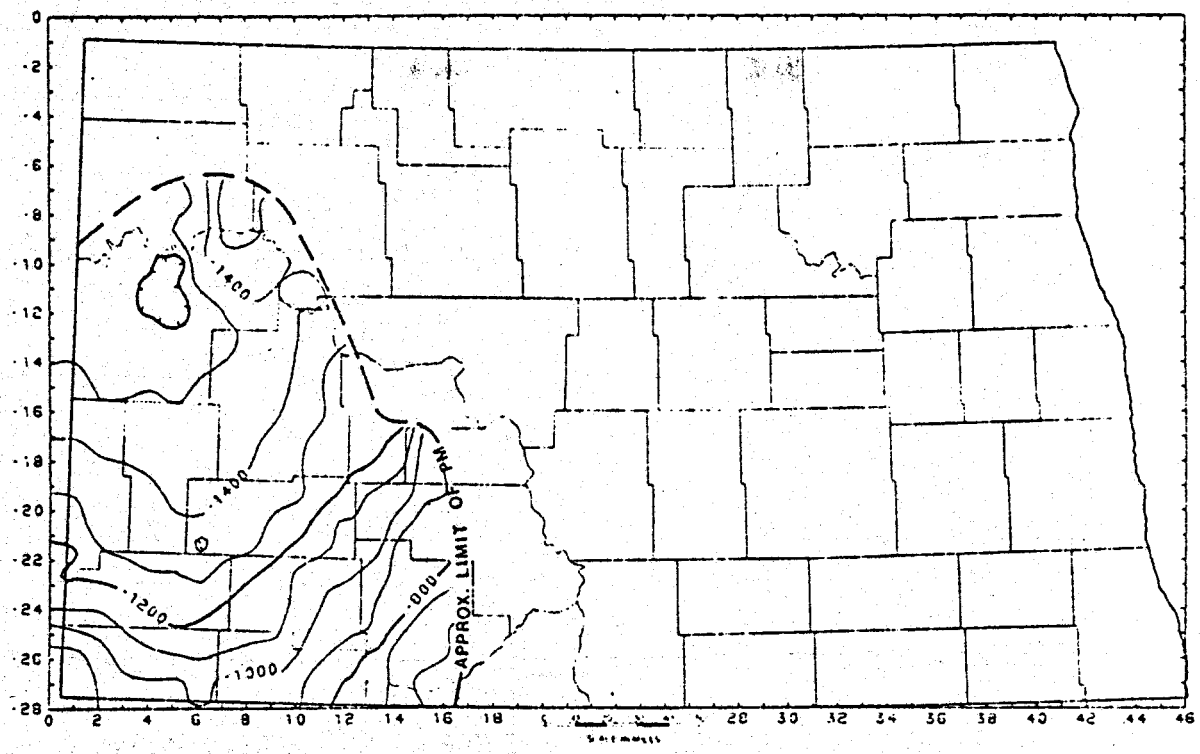


FIGURE 9 - STRUCTURE MAP ON THE TOP OF THE PERMIAN MINNEKAHTA FORMATION (PM); CONTOUR INTERVAL IS 100 METRES

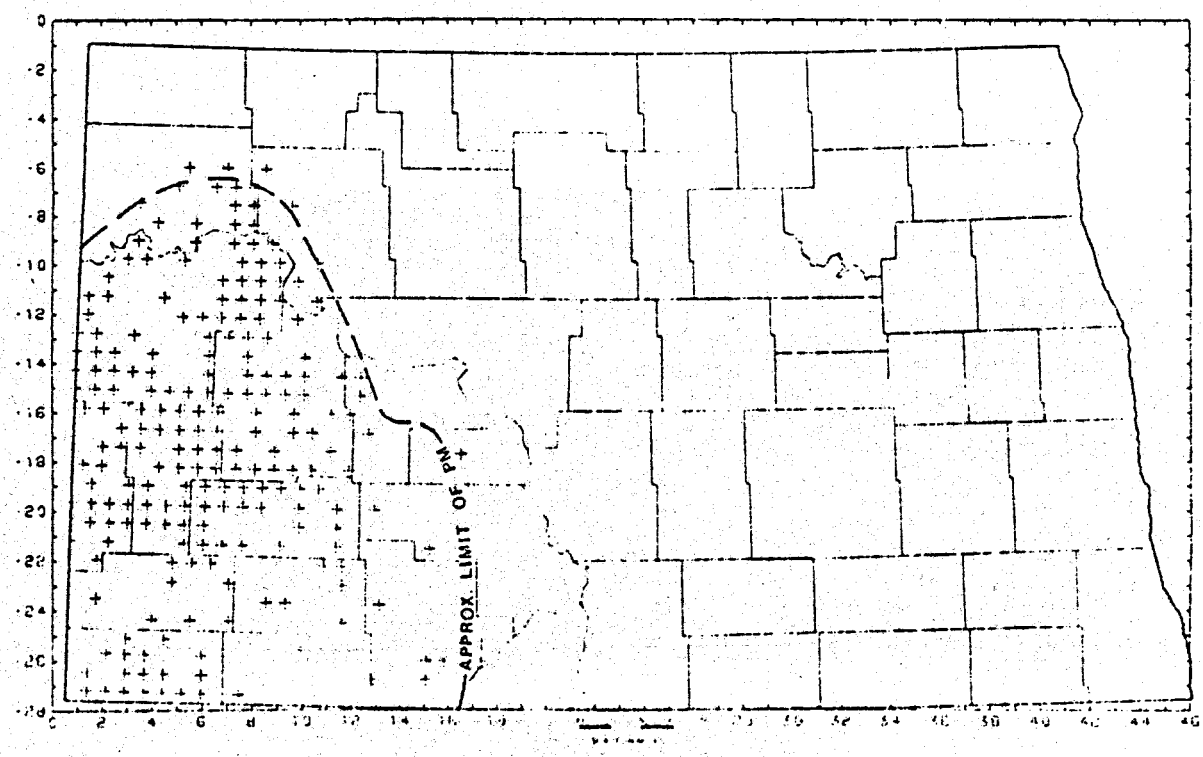


FIGURE 10 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE PERMIAN MINNEKAHTA FORMATION STRUCTURE MAP

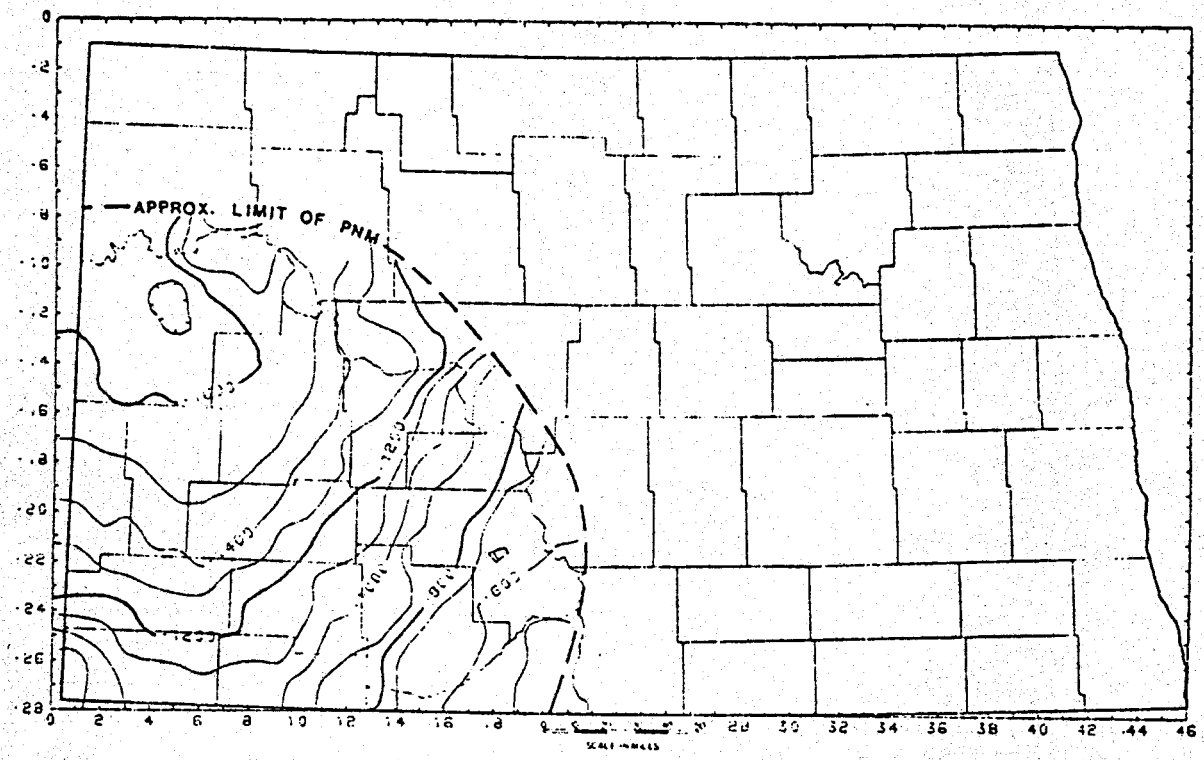


FIGURE 11 - STRUCTURE MAP ON THE TOP OF THE PENNSYLVANIAN MINNELUSA FORMATION (PNM); CONTOUR INTERVAL IS 100 METRES

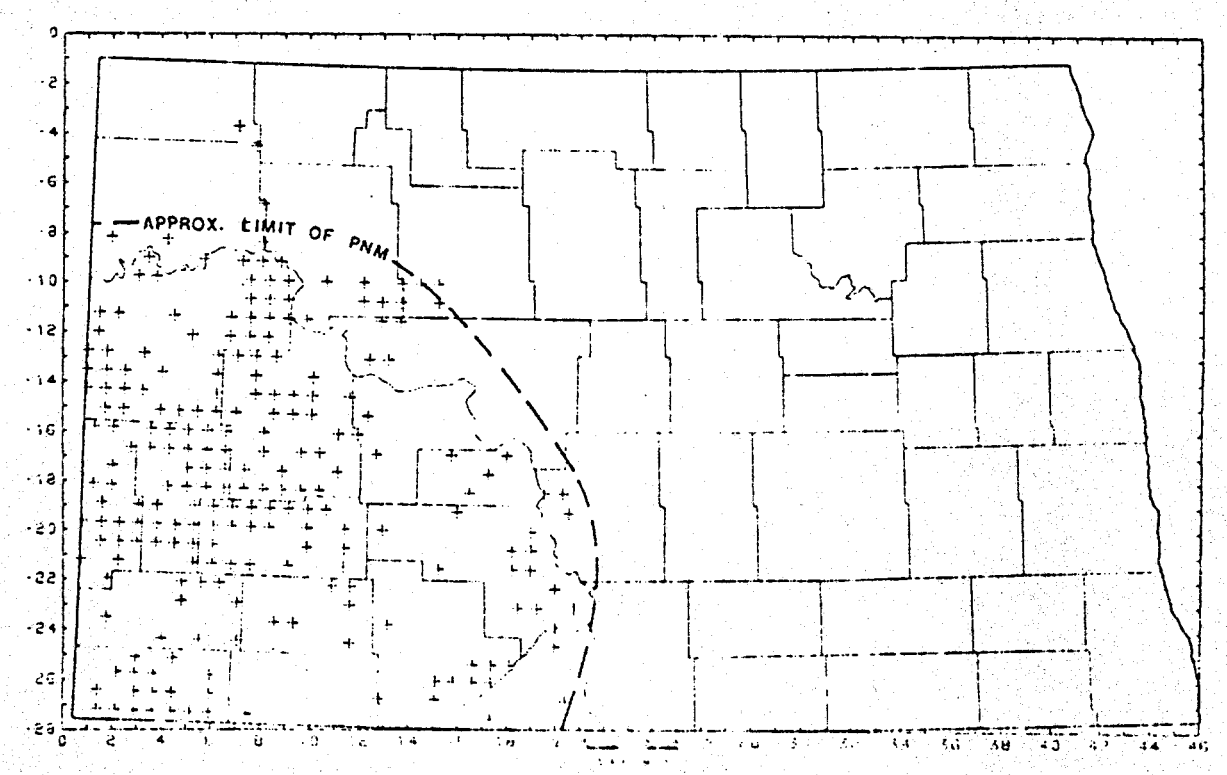


FIGURE 12 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE PENNSYLVANIAN MINNELUSA FORMATION STRUCTURE MAP

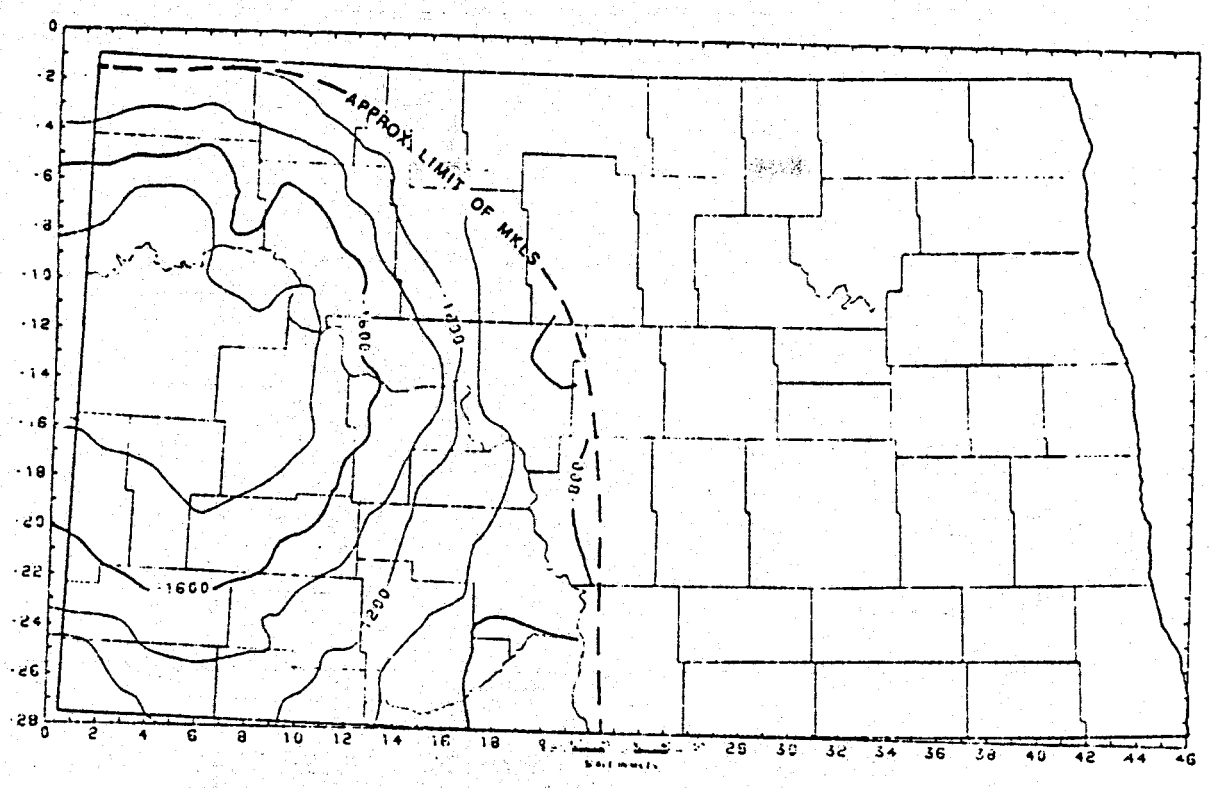


FIGURE 13 - STRUCTURE MAP ON THE TOP OF THE MISSISSIPPIAN KIBBEY LIMESTONE (MKLS); CONTOUR INTERVAL IS 200 METRES

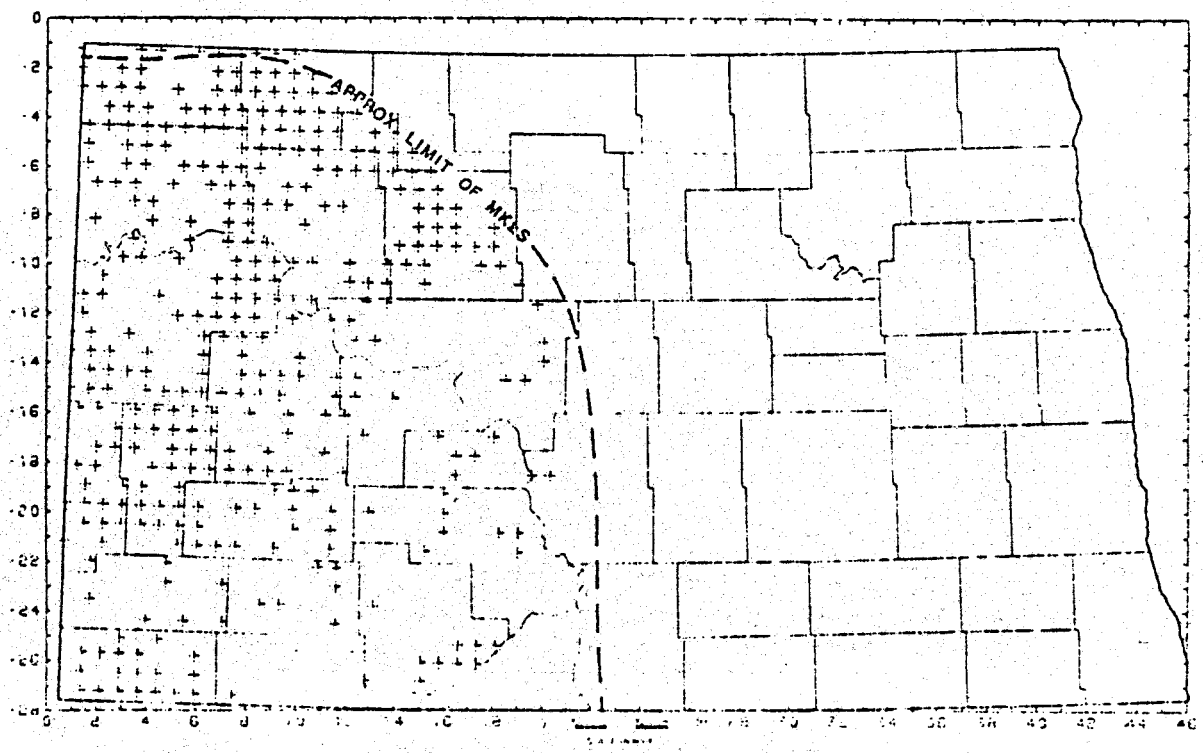


FIGURE 14 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE MISSISSIPPIAN KIBBEY LIMESTONE STRUCTURE MAP

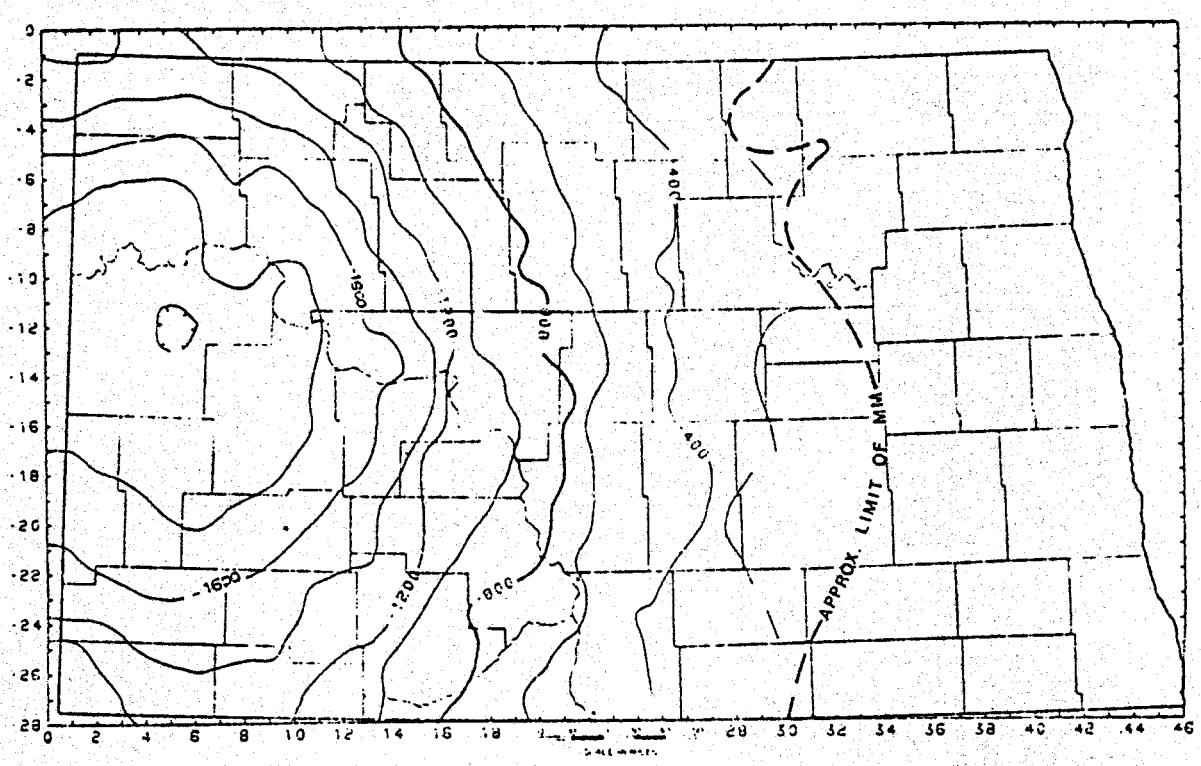


FIGURE 15 - STRUCTURE MAP ON THE TOP OF THE MISSISSIPPIAN MADISON FORMATION (MM); CONTOUR INTERVAL IS 200 METRES

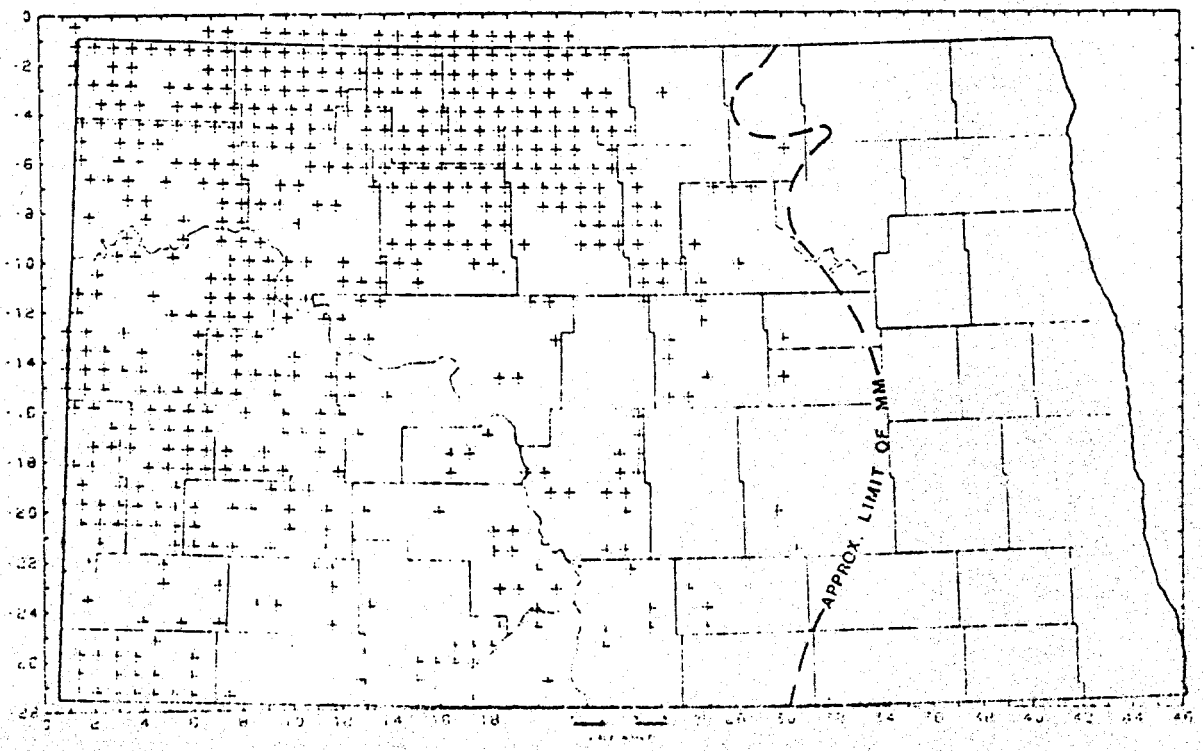


FIGURE 16 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE MISSISSIPPIAN MADISON FORMATION STRUCTURE MAP

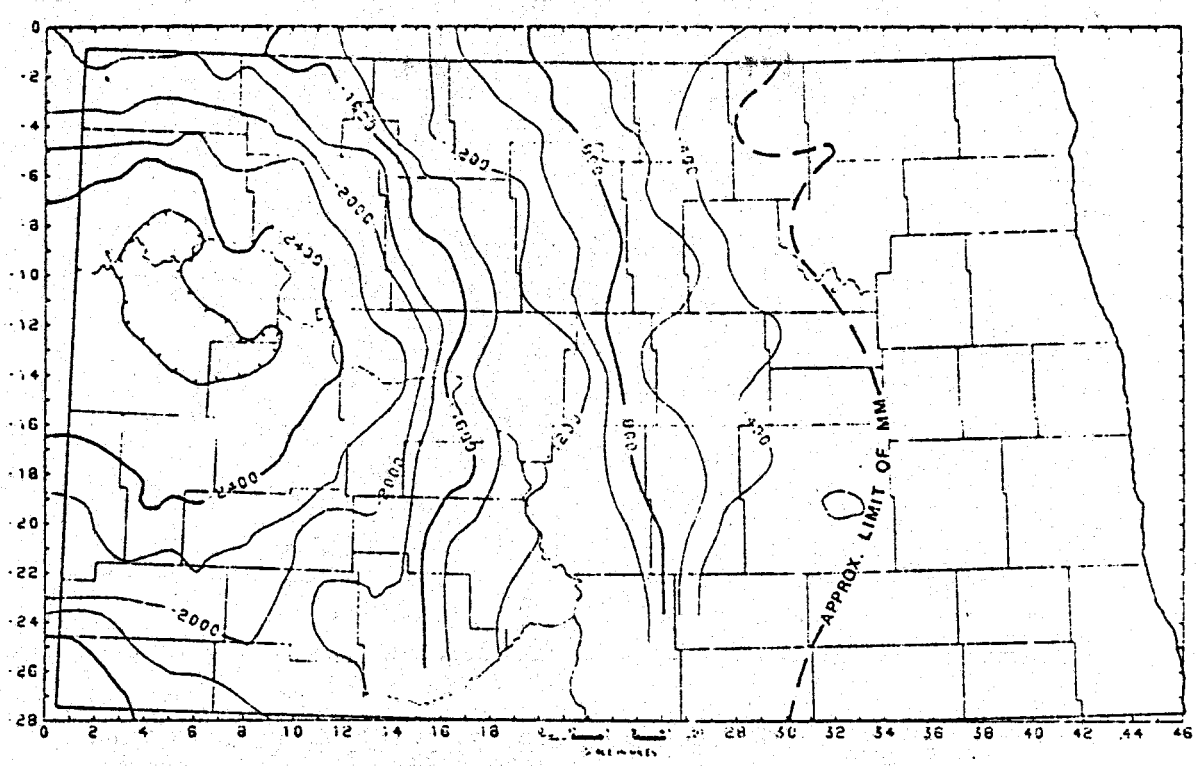


FIGURE 17 - STRUCTURE MAP ON THE BASE OF THE MISSISSIPPIAN MADISON FORMATION (MB); CONTOUR INTERVAL IS 200 METRES

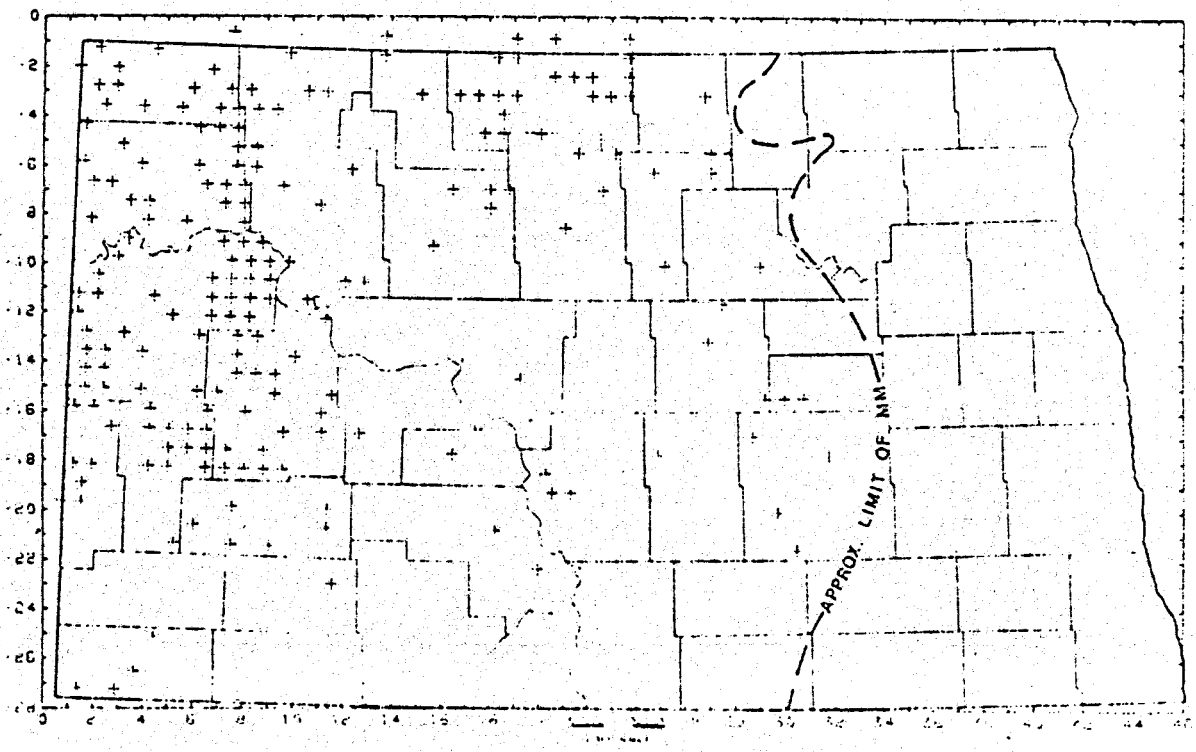


FIGURE 18 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE BASE OF THE MISSISSIPPIAN MADISON FORMATION STRUCTURE MAP

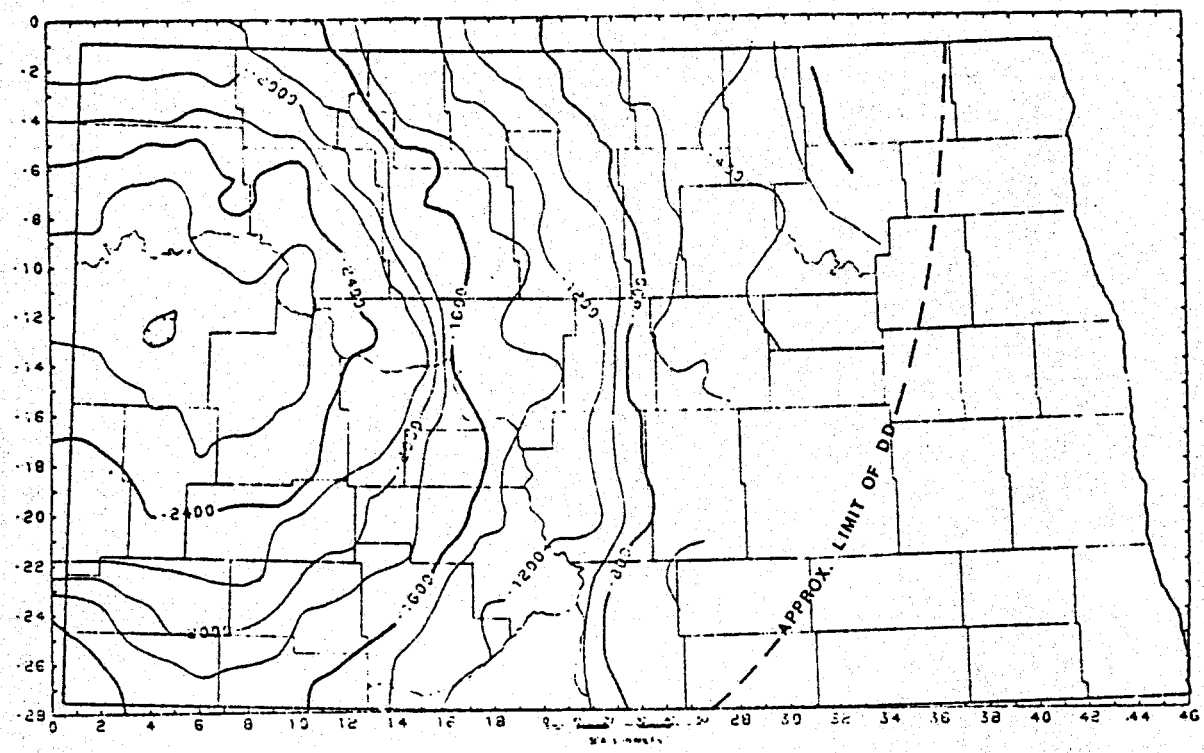


FIGURE 19 - STRUCTURE MAP ON THE TOP OF THE DEVONIAN DUPEROW FORMATION (DD); CONTOUR INTERVAL IS 200 METRES

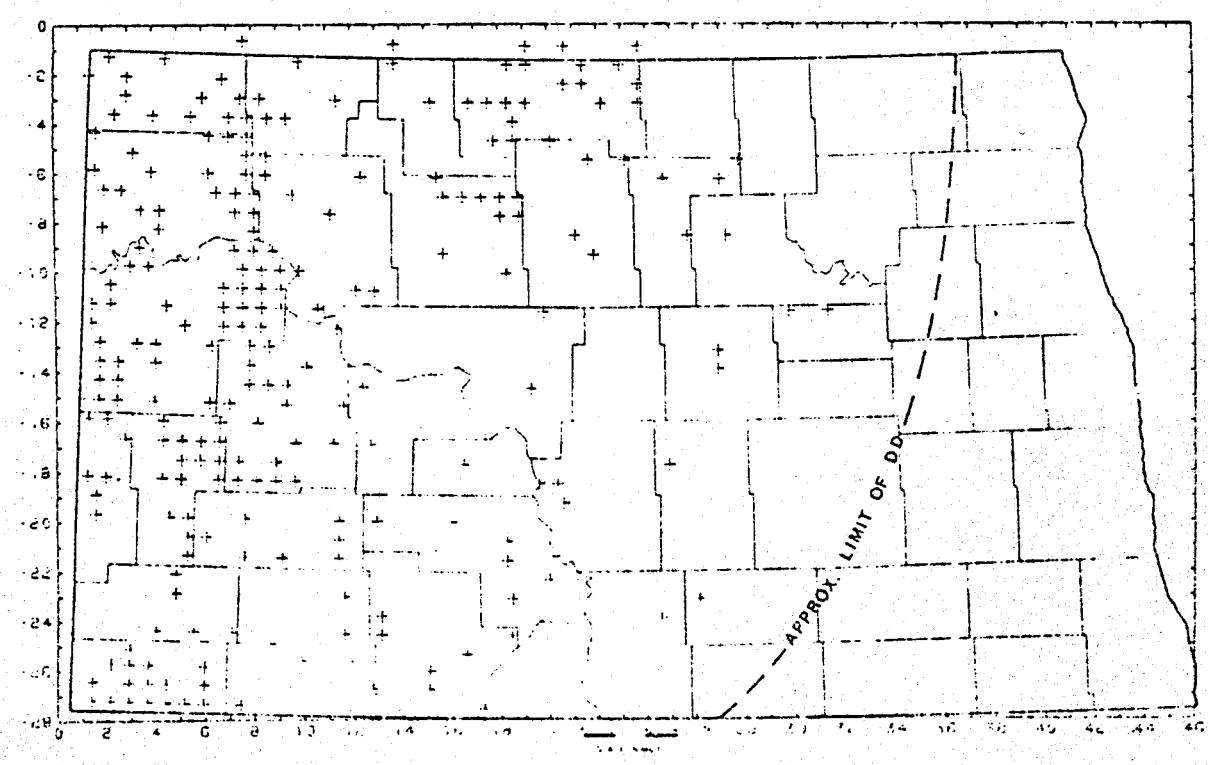


FIGURE 20 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE DEVONIAN DUPEROW STRUCTURE MAP

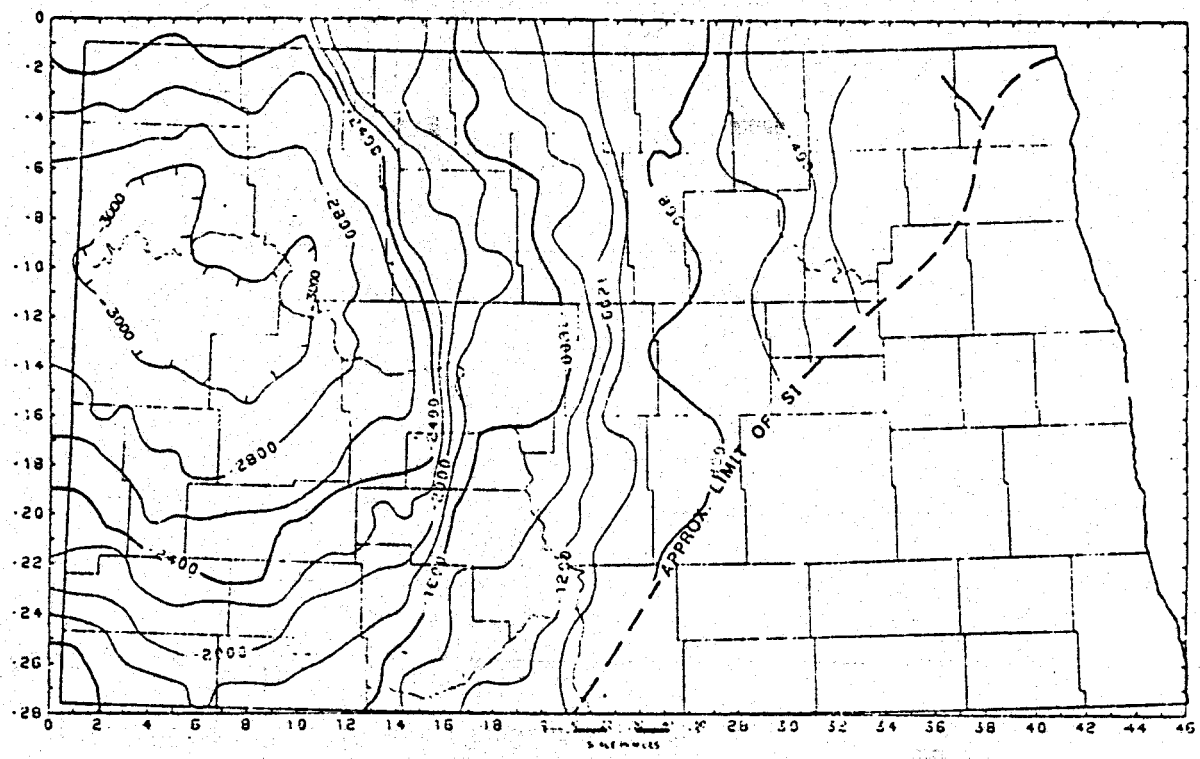


FIGURE 21 - STRUCTURE MAP ON THE TOP OF THE SILURIAN INTERLAKE FORMATION (SI); CONTOUR INTERVAL IS 200 METRES

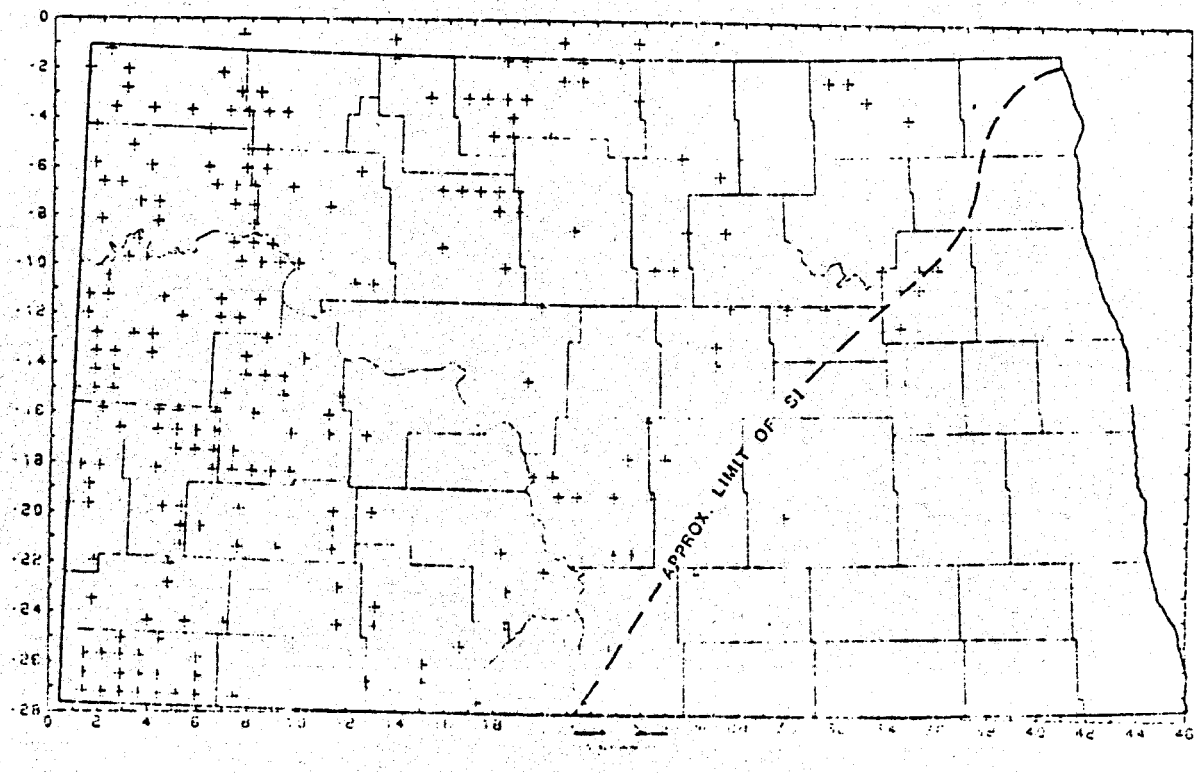


FIGURE 22 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE SILURIAN INTERLAKE FORMATION STRUCTURE MAP

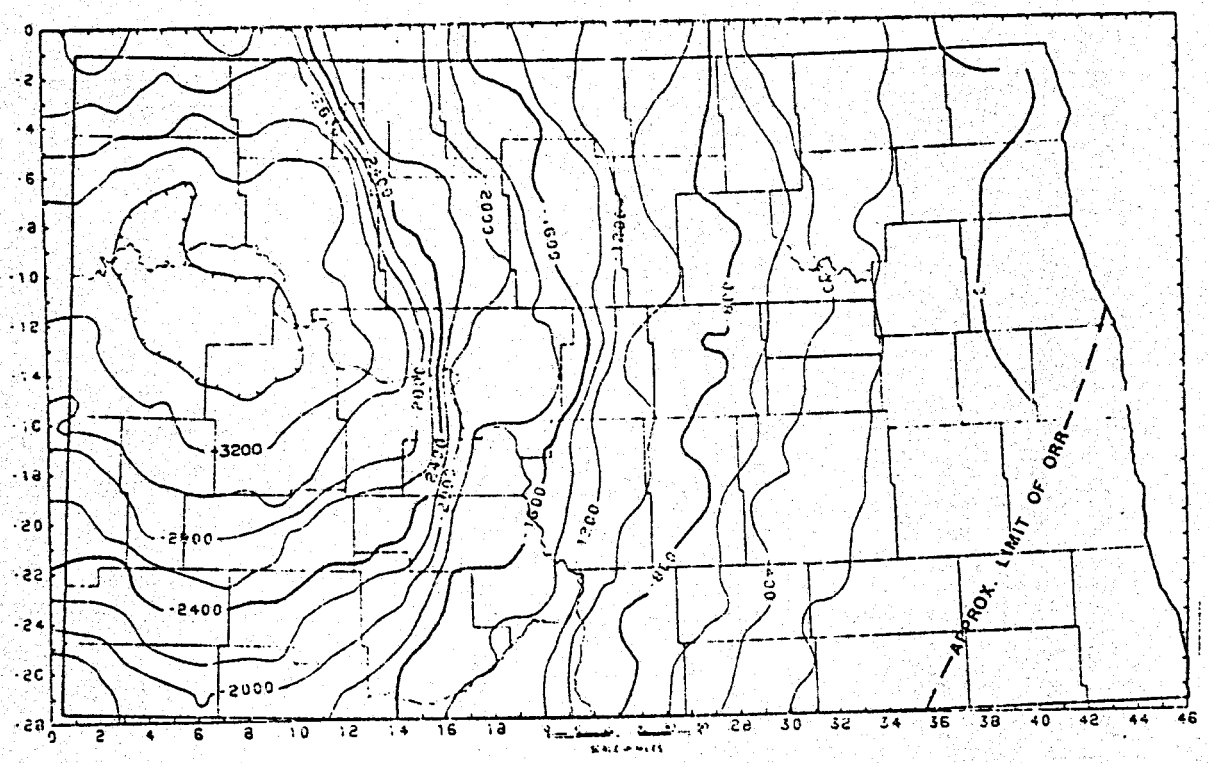


FIGURE 23 - STRUCTURE MAP ON THE TOP OF THE ORDOVICIAN RED RIVER FORMATION (ORR); CONTOUR INTERVAL IS 200 METRES

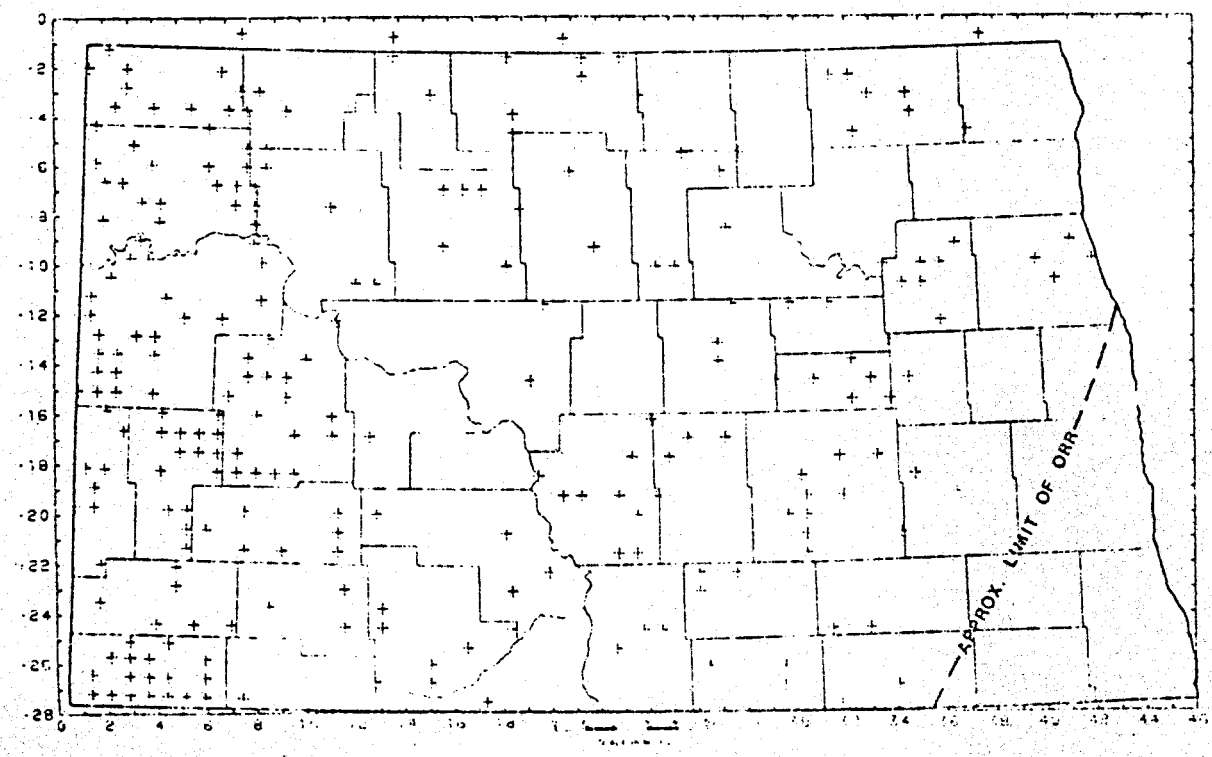


FIGURE 24 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE ORDOVICIAN RED RIVER FORMATION STRUCTURE MAP

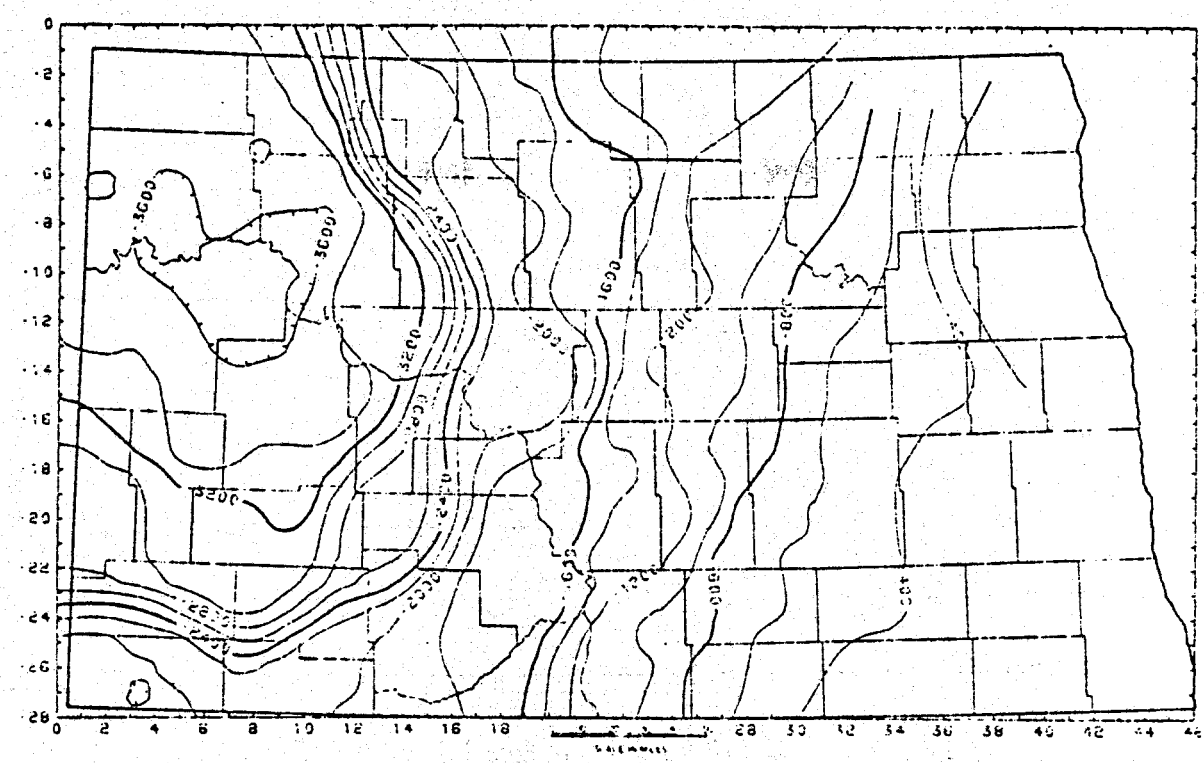


FIGURE 25 - STRUCTURE MAP ON THE TOP OF THE CAMBRIAN DEADWOOD FORMATION (CD); CONTOUR INTERVAL IS 200 METRES

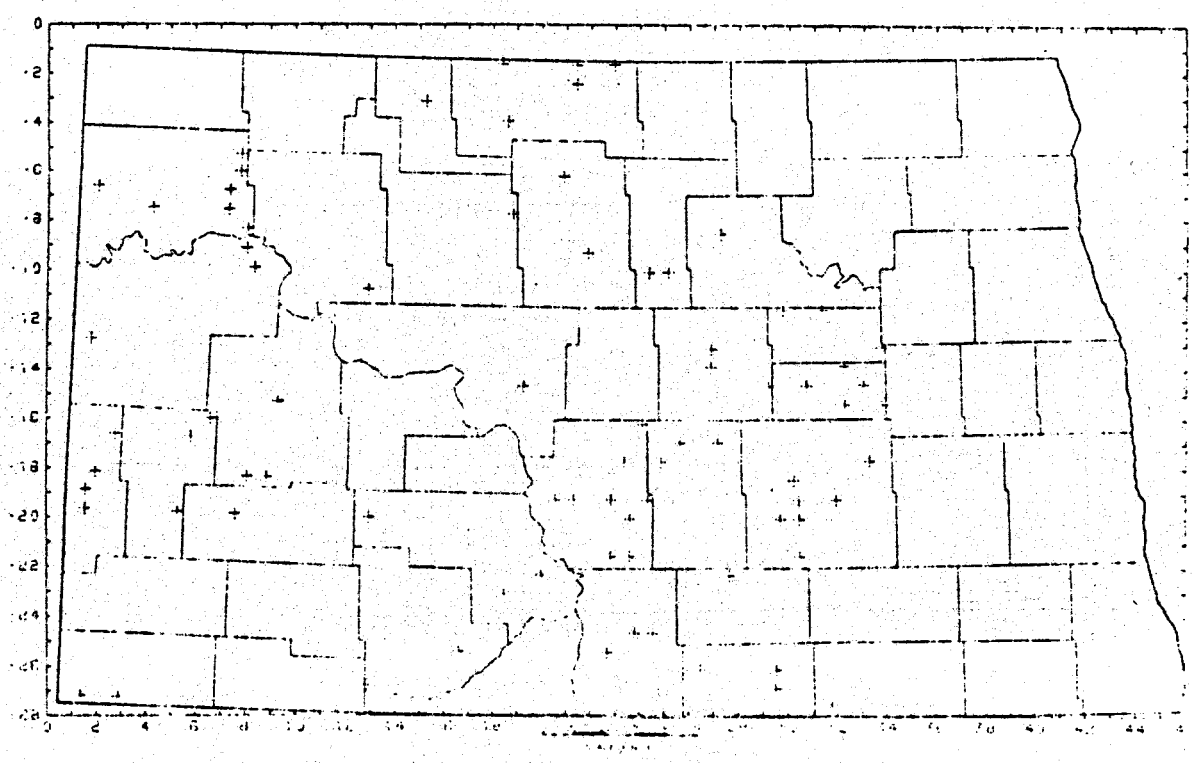


FIGURE 26 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE CAMBRIAN DEADWOOD FORMATION STRUCTURE MAP

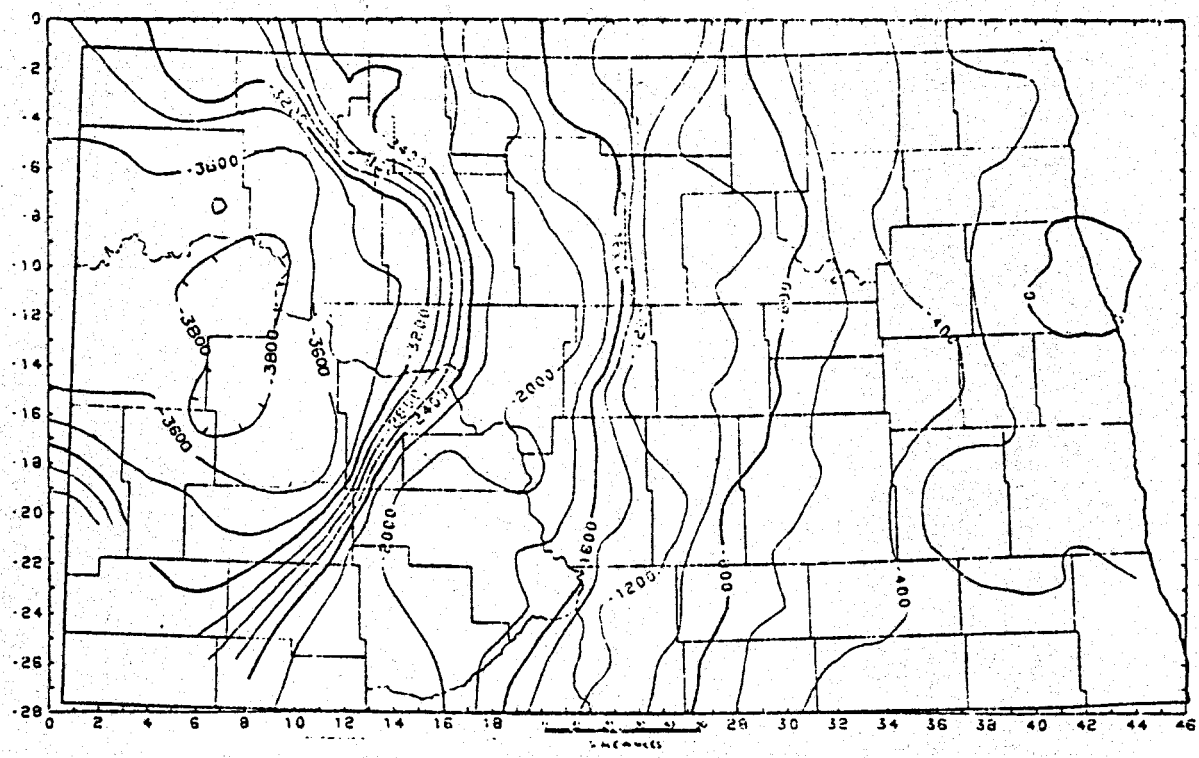


FIGURE 27 - STRUCTURE MAP ON THE TOP OF THE PRECAMBRIAN (PC); CONTOUR INTERVAL IS 200 METRES

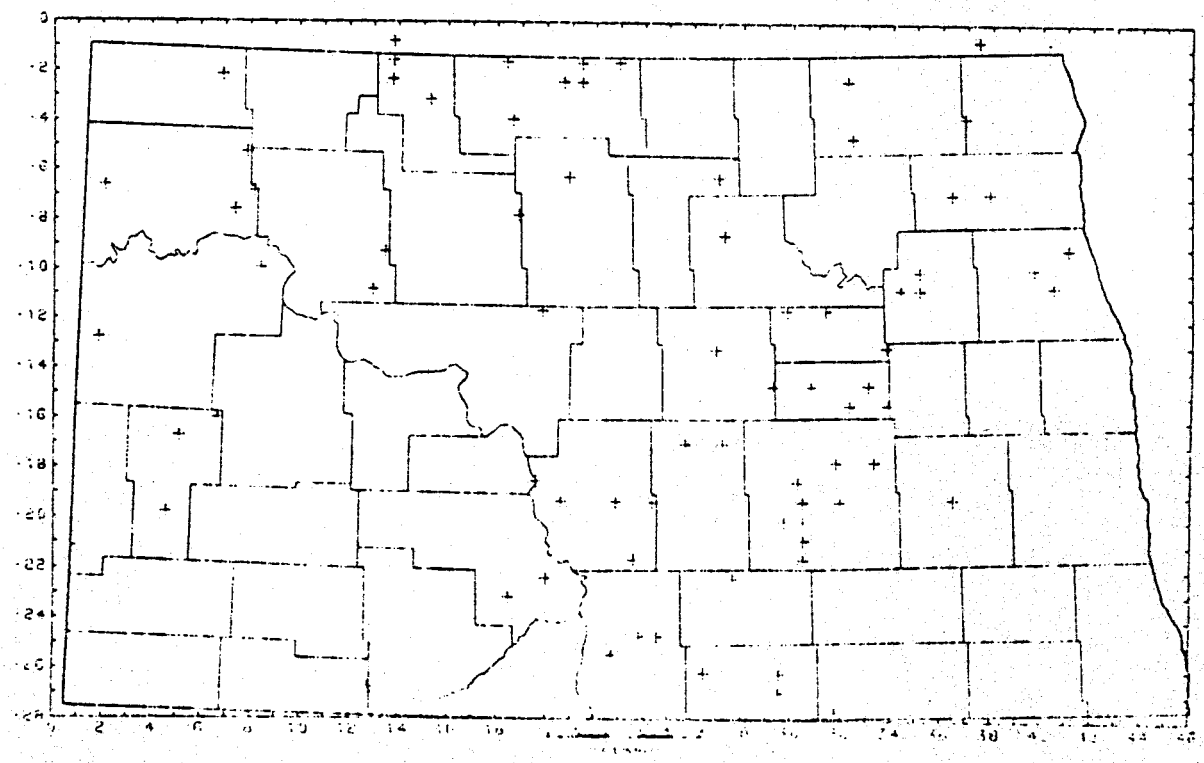


FIGURE 28 - POSTING OF TOWNSHIPS CONTRIBUTING WELL CONTROL TO THE PRECAMBRIAN STRUCTURE MAP

APPENDIX F

UPDATED PHASE I WATER QUALITY DATA

The following table lists the chemical data contained in WELLFILE which consists of the results of analyses of water recovered from oil and gas well drill stem tests.

A brief explanation of the table headings is necessary.

WELLNO - N.D.G.S. Well Number

T-R-S - Location of well, township. range, and section

FORM - , D, DB, etc. - The abbreviation of the formation tested. See Appendix "B" for a complete listing of the abbreviations used. (____ = blank, Formation is unknown.)

TOP - Top of tested interval (footage).

BOTTOM - Bottom of tested interval (footage).

CA, MG, NA - The concentration of these cations in mg/l or ppm.

FE - The concentration of this cation in mg/l or ppm x 100.

CO3, HCO3, SO4, CL - The concentration of these anions in mg/l or ppm.

pH - The pH of the tested fluid x 100.

RESIST and F - The resistivity of the Formation fluid (ρ x 1000) at the tested temperature (^{o}F).

TDS - Total dissolved solids in tested Formation fluid.

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
6322	130-091-07		8355	8419	12224	1580	52300	840		140	1300	110000	681	53	77	177552
7240	131-104-04				3006	1459	28700	200		305	1510	49580	685	89	77	84562
94	133-065-12				169	47	481			293	1045	238	745		77	2273
4570	133-098-05		4776	4830	38	8	4893			1525	43	6720	790	560	68	13227
4578	133-098-06		4790	4825	38	24	4605			1660	48	6240	780	590	68	12615
4565	134-098-31		4816	4881	14	6	5387			1370	73	7500	790	520	68	14350
1541	138-095-06		8665	8720	13000	1400	76300			144	853	144000	610	47	68	235697
7127	139-096-30				13828	365	76800	320		330	1410	149600	647	45	77	242336
1587	139-100-10				132	61	9631			1230	835	13936	760	290	68	25825
3813	139-102-02				380	58	3572			270	984	5468	740	640	68	10732
3750	139-102-13				15	2	489		50	710	183	179	920	5600	68	1628
3939	139-102-15				1210	154	5869			214	860	10880				19187
3829	139-102-23		9029	9038	3080	920	6598			245	870	17650	640	240	68	29363
4640	140-059-09				452	180		32		268	1350	189	740			2439
151	140-080-18		7729	7763	1558	175	8046			1295	2872	12800	790	290	68	26746
4592	140-080-18		7729	7763	1558	175	8046			1295	2875	12800	790	290	68	26749
7403	141-100-07		9326	9362	4609	608	31200	110		738	1880	56210	702	87	77	95246
7403	141-100-07		9375	9410	4008	486	29800	1030		629	800	52129	701	94	77	87862
6618	141-101-22		9153	9159	1133	110	9407			488	1125	16000	740	260	68	28263
6618	141-101-22		9218	9230	850	141	8248			476	1000	13900	740	280	68	24615
7499	142-100-26				4409	486	31700	80		256	900	58596	708	78	77	96348
6474	143-100-05				23368	4326	87019			159	240	197000	600	56	68	312112
4488	145-092-28				7182	413	36698			281	481	70000	680	82	77	115055
7579	145-104-24				5812	122	24800	1000		506	1100	47802	724	107	77	80152
22	146-081-10				1008	215	20849			380	8606	28000	730	150	68	59058
7162	146-104-14				15631	1337	49180	692		537	1350	108766	669	48	77	176808
7162	146-104-14			13026	608	69E3	180	4550	180	732	40	135158	1038	47	77	206444
4304	146-104-33		11570	11624	16400	6561	108698	11700		644	1360	214420	560	38	77	348200
4304	146-104-33		12640	12752	36000	7290	87469	15100		195	1600	218680	500	38	77	351385
4304	146-104-33		12766	12826	41200	8991	82317	16200		127	3400	223650	470	37	77	359847
6994	147-096-13				77350	4376	37100	12800		101	20	237050	462	47	77	356125
6663	147-104-03				8670	818	109600			146	864	184400	630	46	68	304498
7166	147-104-22				11824	2553	99500	780		268	580	174020	612	41	77	288753

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
7366	151-094-06				18036	3768	81900	500		409	490	169400	610	42	77	274008
41	152-096-26		9175	9225	1343	217	121697			189	7625	185000	580	53	68	316071
4633	153-058-08					100		170		672	128	223	780			1125
2665	153-094-30				1660	204	12748	-		365	692	22473	720	190	68	38142
1335	153-094-32				1207	264	17600			330	1730	28900	720			50031
78	153-095-16				752	168	18234			620	1658	28362	660	170	68	49794
919	153-095-33				148	110	340			535	1012	49	770	4690	68	2194
1226	154-095-31				309	262	1529			535	835	2742	730	1140	68	6212
7570	155-094-09				11764	1165	114000				765	193826	460	46	68	321520
79	155-095-07		4590	4998	27	1	3418		146	1560	852	3615	890	780	68	9619
165	155-096-01		4599	4647	19	8	3620		240	1500	522	4050				9959
7712	155-098-21				9018	365	104500	200		207	1270	185040	778	43	77	300402
647	156-095-18		4825	5105	21	3	3235		37	1880	650	3420	840	850	68	9246
44	156-095-33		8641	8671	6423	6243	92098			305	613	171000	660	52	68	276682
4618	156-103-17		9533	9570	28371	2096	87871			171	390	191700	580		68	310599
32	157-095-12		8361	8394	12900	1538	99440			205	789	180000	620	50	68	294872
32	157-095-12		8486	8544	8841	1125	114696			110	1064	195000	610	52	68	320836
32	157-095-12		11561	11665	1735	173	126186			110	215	198000	680	52	68	326419
7279	158-082-01		4315	4360	3407	1094	109600	700		220	3200	180800	656	41	77	298328
7709	158-083-28		5042	5068	8016	1823	100200	180		348	1350	178872	639	40	77	290611
4081	159-084-05				12	7				1401	75	1818	800			3313
5239	161-079-32		3462	3490	3407	705	30793	21200		195	4878	52116	670	90	73	92306
2214	161-092-03		10146	10147	7520	1390	110000	80			325	186000	630	1207	60	305236
3030	162-092-22		4288	4384	15	8	4500		72	1549	143	5900	820	650	68	12187
1549	162-092-24		6330	6352	4260	206	79700			222	2660	129000	650	51	68	216048
1549	162-092-24		6357	6368	1320	154	12200			900	4810	17600	770	224	68	36984
6401	163-087-10		8690	8855	20320	2163	92855			49	226	191000	560	60	68	306613
6401	163-087-10		9257	9364	15748	2472	103258			85	528	200000	620	60	68	322091
1530	163-092-24		5932	5978	5680	1100	77200			247	2080	129000	710	49	68	215307
1530	163-092-24		6031	6060	1450	36	10600			420	5860	14700	680	233	68	33066
1530	163-092-24		6061	6093	1930	206	21600			348	5140	33600	600	136	68	62824
1742	163-092-34		6259	6273	3170	352	28600			300	2780	48600	730	106	68	83802
7773	163-094-06				11423	1580	97700	700		207	930	170391	669	42	77	282238

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
6	163-095-27		0				84					7			91	91
7515	163-096-32				10822	608	39400	900		744	90	81726	1067	70	77	133399
7515	163-096-32		3330	3390	20240	1216	48800	2190		159	1250	112566	703	126	77	184253
864	164-080-35				2480	924	1555	2050		54	2980	7250				15264
381	164-080-36				2786	870		150		108	3635	64537	730	1080	77	71938
3859	135-083-34	C	7882	7950	2270	380	33992			230	2605	55500	780	93	68	94977
4218	152-095-01	CD	14166	14308	8640	3596	47580			710	430	98430	690	66	68	159386
6436	163-087-05	CD	9490	9528	11684	14E3	76233			134	414	192000	540	50	68	294679
6436	163-087-05	CD	9532	9596	21336	3090	58556			122	760	145000	520	64	68	228864
6436	163-087-05	CD	9535	9550	559	62	994			98	185	2580	680	135	68	4478
3448	130-107-12	D	7750	7803	677	103	17773			317	1800	27400	800	155	77	48070
3798	131-106-32	D	8042	8102	517	99	6024			586	2650	8200	740	390	77	18076
644	139-068-05	D	3199	3216	1026	464	3429			660	2526	6210	700	520	68	14315
1202	152-094-06	D			20240	1503	101815			100	162	197064	580	46	68	320884
1748	152-094-06	D	10747	10768	6435	2065	33803			135	124	69376	550	86	68	111938
1370	152-094-07	D			20614	1466	91523			25	142	181800	520	46	68	295570
4240	152-094-07	D	10693	10891	41804	790	59216			143	346	167560	570	269		269859
1567	152-095-12	D	10334	10351	22770	5605	87513				168	191490	500	51	68	307546
1495	153-094-32	D			21480	2400	100851				84	200500	450	47	68	325315
1495	153-094-32	D	10349	10366	21285	3245	103215				144	206220	460	51	68	334109
1231	155-096-02	D	10279	10460	49920	11E3	24307			220	353	157560	600	50	68	243380
1231	155-096-02	D	10279	10460	49920	11E3	22692			230	492	154960	600	50	68	239314
1982	155-096-12	D	10500	10501	36400	1980	129955	73000		110	120	264000	485	505		433295
182	156-095-16	D	10267	10304	49995	5605	67938			475	208	209166	600	51	68	333387
1385	156-095-16	D	10485	10530	56840	9440	56666			355	110	215213	550	46	68	338624
2501	156-095-30	D	10316	10391	20640	2900	106555			30	291	209100	530	48	68	339516
1534	156-096-26	D			17150	2990	35658			146	338	98000	690	710	68	154282
1514	156-096-34	D	10271	10329	54880	6490	65506			185	217	216800	430	48	68	344078
1514	156-096-34	D	10388	10428	41160	5900	68354			230	285	195120	500	48	68	311049
355	158-094-18	D	9920	9945	56050	6380	62051				142	213384	400	50	68	338007
355	158-094-18	D	9920	9975	55100	5800	62892				165	211292	400	50	68	335249
355	158-094-18	D	10120	10220	55100	6380	65855				144	217568	400	50	68	345047
6684	161-085-02	D			31930	2817	75619			232	295	182000	600	55	68	292893

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
6684	161-085-02	D	6664	6728	25750	3756	79837			134	300	185000	620	65	68	294777
3859	135-083-34	DB	6038	6070	7840	1100	63597			60	2901	113000	680	57	68	188498
4280	135-103-18	DB	9690	9734	13320	3420	90085			60	259	172300	610	48	68	279444
4130	138-105-09	DB	9898	9918	13453	1853	66413			75	341	131350	610	53	68	213485
2584	145-101-16	DB	11020	11100	23925	2004	84951			37	179	179000	580	45	77	290096
793	149-091-22	DB	10326	10388	12000	1342	73934			162	1740	137808	610	52	68	226986
607	149-093-24	DB	10850	11062	18200	4514	83753			355	626	173880	550	47	68	281328
607	149-093-24	DB	10850	11062	250	79	1045			224	1187	1279	500	1750	68	4064
4095	151-096-34	DB	11060	11088	25816	2071	77542			75	209	171125	600	48	68	276838
2373	152-095-01	DB	10380	10450	25650	2850	82098			85	310	180050	600	48	68	291043
3086	152-095-01	DB	10487	10565	24700	3400	87191			60	412	187800	520	48	68	303563
7741	156-094-28	DB	10664	10691	24800	1880	82700				260	182000	500	49	68	291640
1385	156-095-16	DB	10090	10150	27048	3304	79949			270	362	180386	600	46	68	291319
4618	156-103-17	DB	10494	10560	22306	1731	93911			315	439	189073	610	307		307775
1517	162-071-16	DB	3393	3400	3430	1593	60325			110	3766	100920	740	66	68	170144
2010	163-102-07	DB	8006	8049	33165	4130	87977			75	570	205960	590	48	68	331877
528	157-089-25	DBD	8967	9051	48925	6090	64111			186	245	202924	520	47	68	322481
528	157-089-25	DBD	9103	9177	40375	4930	57849			112	402	174682	500	48	68	278350
3160	137-095-20	DD	9895	9952	26970	5600	63376			75	526	161370	550	53	68	257917
4130	138-105-09	DD	10102	10192	19089	1962	67837			160	901	143375	670	52	68	233324
1678	139-101-02	DD	10766	10798	38417	2820	78635				122	197400	500	49	68	317394
3927	139-101-21	DD	10541	10601	33200	4100	66834	4		37	228	173600	570	51	68	277999
3927	139-101-21	DD	10631	10686	33200	3250	79662			37	100	191000	610	51	68	307249
3044	143-092-27	DD	10033	10126	32300	5700	81330			1575	341	198050	720	50	68	319296
2853	143-101-05	DD	11209	11245	48222	3762	75500			85	99	208000	470	42	77	335668
5887	144-092-08	DD	10540	10600	1282	1307	135466			195	520	221000	530	58	68	359770
7265	144-100-30	DD			39679	2431	54300	1200		98	270	163452	564	45	77	260242
3492	146-090-25	DD	10070	10121	16017	2380	60052			122	950	131000	680	53	68	210521
6894	146-103-05	DD	11118	11153	51904	6199	65700			183	1510	208800	514	44	77	334296
6832	146-103-09	DD	11170	11240	14600	1750	105400			159	633	173500	530	52	68	296042
4304	146-104-33	DD	11048	11163	52000	12E3	65182	7400		195	1020	227200	590	37	77	357821
4304	146-104-33	DD	11204	11281	35600	19E3	70265	11200		161	1100	227200	590	37	77	353878
413	147-093-05	DD	10883	10898	25840	2552	32831			34	311	103554	480	60	68	165122

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
2400	148-096-10	DD	11555	11607	48450	4560	75319			145	112	215033	560	51	68	343619
793	149-091-22	DD	10712	10724	1026	93	4210			104	1926	7099	630	500	68	14458
1744	149-095-07	DD	11470	11520	50490	5310	73536			390	182	217884	530	51	68	347792
1744	149-095-07	DD	11577	11628	47520	4720	77484			670	232	216800	620	50	68	347426
1744	149-095-07	DD	11633	11658	46530	4130	77477			305	208	213548	600	50	68	342198
1744	149-095-07	DD	11657	11691	51975	4425	72164			560	184	215716	600	49	68	345024
2750	149-096-36	DD	11281	11320	47232	4872	76353			108	139	215384	500	50	68	344088
7209	149-104-21	DD			27655	1459	90300	5200		146	690	195200	600	44	77	315502
7209	149-104-21	DD	10998	11008	50100	3890	68200	4400		580	3800	204000	594	46	77	330614
2494	151-094-19	DD	11262	11405	52320	3480	79008			185	112	224400	540	51	68	359505
4095	151-096-34	DD	11416	11450	47268	3270	70449			170	119	201650	600	51	68	322926
2373	152-095-01	DD	10562	10640	35150	3420	82764			135	385	199465	590	49	68	321319
2373	152-095-01	DD	10674	10706	57950	5130	65969			280	220	218925	600	50	68	348474
2373	152-095-01	DD	10724	10778	45600	4350	77407			865	139	212160	700	51	68	340521
3086	152-095-01	DD	10658	10744	19950	3420	99276			37	444	198050	510	49	68	321177
3086	152-095-01	DD	10747	10780	57000	5700	63376				109	215150	470	51	68	341335
2967	152-096-03	DD	10748	10950	35900	2725	45683			170	316	141600	640	53	68	226394
2967	152-096-03	DD	10748	10950	35900	2725	45683			170	316	141600	640	53	68	226394
2226	153-094-18	DD	11150	11278	56050	3400	70831			425	132	218000	600	50	68	348838
2841	153-094-29	DD	10799	10817	61500	4800	62062			204	104	218348	520	48	68	347018
2841	153-094-29	DD	10858	10933	43500	4200	78084			278	53	209456	560	47	68	335571
2665	153-094-30	DD	10920	10975	24460	1740	94158			100	176	193400	640	52	68	314034
2839	153-094-30	DD	10921	10979	57500	3600	69575			224	122	219336	530	48	68	350357
1495	153-094-32	DD	10710	10785	14694	1344	100287			100	555	184140	570	49	68	301120
2602	153-095-06	DD	10266	10332	28000	6804	89884	12600		81	1150	207320	450	38	77	333365
1679	153-096-10	DD	10615	10668	44055	3540	79225			185	97	210296	560	47	68	337398
2375	155-096-10	DD	10151	10236	56050	5700	67053			230	120	219000	770	51	68	348153
2487	155-096-12	DD	10266	10484	63000	6000	61187			10	72	223288	440	49	68	353557
1729	155-096-13	DD	10152	10277	50304	3944	81635			200	166	226260	500	49	68	362509
1729	155-096-13	DD	10424	10490	62370	5900	63618			245	102	225472	540	50	68	357707
2438	155-096-13	DD	10211	10291	43200	3480	79770			137	126	209456	520	49	68	336169
2515	155-096-14	DD	10129	10305	55000	4500	61752			196	96	205504	510	49	68	327048
2515	155-096-14	DD	10322	10352	43607	146	90183			183	192	208119	581	342		342430

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
2147	155-096-23	DD	10376	10465	58900	2850	69659			205	78	219800	540	51	68	351492
2409	155-096-23	DD	10131	10208	57000	8550	62627			635	230	221844	570	50	68	350886
1385	156-095-16	DD	10330	10420	54880	6490	70154			280	122	216550	550	46	68	348476
2092	156-095-17	DD	10311	10370	58410	7080	62385			270	128	219968	560	52	68	348241
2092	156-095-17	DD	10464	10465	36135	3540	87023			185	268	208184	530	52	68	335335
2149	156-095-18	DD	10299	10350	57915	5900	64444				110	219000	580	52	68	347369
254	156-095-19	DD	10286	10346	4465	580	111908				272	182004	400	48	68	299229
2344	156-095-19	DD	10314	10440	28215	2950	95964			75	300	206280	560	48	68	333784
2583	156-095-20	DD	10349	10423	15744	2088	100602			39	537	188700	520	46	68	307710
2555	156-096-23	DD	10304	10356	35520	4350	90737			205	206	215220	650	50	68	346238
2555	156-096-23	DD	10461	10508	23040	3190	103983			120	363	210120	650	49	68	340816
2555	156-096-23	DD	10479	10556	58080	6090	69513			340	118	227460	610	51	68	361601
1514	156-096-34	DD	10456	10504	47040	4425	76335			295	216	213548	480	48	68	341859
1820	156-096-35	DD	10160	10449	6500	660	39629			200	923	73755	690	75	68	121667
4618	156-103-17	DD	10705	10750	55037	8475	58448			253	178	212290	550		68	334681
392	157-085-21	DD	7607	7645	1388	314	5010			355	3136	8580	580	410	68	18783
1002	157-094-10	DD	10271	10328	54321	4060	63186			315	131	205138	640	49	68	327151
1745	157-095-21	DD	10082	10205	58410	5900	66134			355	174	222220	550	50	68	353193
1745	157-095-21	DD	10205	10400	58410	6195	64837			295	156	221136	550	50	68	351029
1689	158-081-07	DD	5788	5845	31360	4720	75735			120	344	185744	500	47	68	298023
355	158-094-18	DD	10155	10220	55100	6380	65855				144	217568	400	50	68	345047
4665	158-095-06	DD	10178	10188	59000	4600	60700				50	211400	480	50	68	335750
3983	158-095-16	DD	9980	10274	56800	8100	62844				71	221000	550	48	68	348815
3983	158-095-16	DD	9995	10105	17460	1640	83963			295	560	164600	780	47	68	268518
3983	158-095-16	DD	10110	10164	14720	1200	72519			60	770	140800	700	50	68	230069
3983	158-095-16	DD	10176	10212	17640	1960	85856			110	396	169000	720	48	68	274962
3983	158-095-16	DD	10230	10250	18540	1860	90982			75	435	178200	690	47	68	290092
3983	158-095-16	DD	10284	10329	19280	1960	90560			25	405	179200	600	47	68	291430
2182	158-095-21	DD	10143	10190	53450	5300	68263			195	200	215060	540	50	68	342468
2182	158-095-21	DD	10195	10274	64350	5300	64057			365	120	227820	550	50	68	362012
4514	158-095-24	DD	10105	10140	55000	14E3	444963				69	208600	550	54	68	723032
4390	158-095-27	DD	10027	10065	44180	11E3	69000			18	247	215840	480	339		339977
3899	158-095-28	DD	10076	10129	42250	3545	74648			120	225	200000	560	50	68	320788

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
3899	158-095-28	DD	10236	10271	55900	4100	61476				122	205600	510	52	68	327198
265	158-095-35	DD	10046	10084	39250	5596	69605			145	185	192906	550	46	68	307687
7087	163-095-18	DD	8175	8240	2004	24	81200	1060	3451	20747	4900	15680	1015	46	77	128017
2010	163-102-07	DD	8403	8446	28215	5015	88948			170	440	201320	590	50	68	324108
1679	153-096-10	DDB	11038	11069	79200	5900	45088			355	172	226556	570	50	68	357271
1679	153-096-10	DSR	10980	11015	81180	5900	49105			295	141	236312	560	51	68	372933
3827	162-078-20	DSR	4952	5005	11063	1558	87931			75	913	159029	740	49	68	260569
793	149-091-22	DTF	10045	10100	2000	52	31355			230	6698	46980	630	100	68	87315
4304	146-104-33	DW	11624	11674	23600	16E3	76038	9500		136	800	205190	600	39	77	321897
5279	157-076-34	DW	5079	5129	8016	1556	90788	16900		61	1003	158120	550	44	73	259713
5498	157-082-01	DW	6765	6821	31872	4228	79525			183	460	199000	610	52	68	315268
5281	158-075-16	DW	4784	4814	1964	511	28862	51100		610	5548	45380	650	105	73	83386
5283	158-077-34	DW	5240	5289	6613	632	87783	11100		171	1480	147839	630	52	74	244629
5277	162-077-11	DW			5691	1143	82403	7600		293	1903	138976	583	49	72	230485
4655	162-078-31	DW	5333	5365	7068	425	90712			185	1400	152650	720	42	68	252440
7087	163-095-18	DW	9377	9407	802	61	3030	80		104	1300	5200	834	505	77	10498
511	134-096-24	KIK			14	2	3014		133	1730	1099	2705	870	900	68	8697
4485	136-101-09	KIK	5384	5424	351		5246			875	252	8023	740		68	14747
3339	139-101-12	KIK			625	75	18841	35000		430	910	30000	615	190	74	51231
2680	158-081-07	KIK	2730	2785	8	4	1624		108	964	329	1600	850	160	68	4637
3148	158-081-07	KIK	2700		11		1847		48	1122	351	1900	820	149	68	5279
2792	159-082-36	KIK	2688	2750	24	107	1920			1025	268	2520	640	1070	77	5864
6001	160-084-21	KIK			462	113	7348	920		736	3744	9196	750			21608
893	161-079-21	KIK	2192	2203	9	2	1411		96	575	477	1398	860	1800	68	3968
2782	161-082-14	KIK	2520	2580	52	41	2489			1074	440	3096	680	900	77	7192
1764	162-095-29	KIK	4615	4625	21	2	3296			2125	306	3666	770	840	68	9416
924	164-078-32	KIK			18	4	1760		58	918	343	1900		5	1	5001
165	155-096-01	KIK			405	55	4840			989	2005	6250	760	730	68	14544
50	155-096-14	KIK	4750	4925	67	29	6710			805	1099	9274	760	400	68	17984
954	155-096-15	KIK	4502	4920	19	9	3331		43	1990	807	3395	890	850	68	9594
73	156-095-10	KIK			18	6	4055	1550		1492	557	4900	855	618	68	11044
43	132-078-08	M			104		637	200		216	839	422	830	3300	79	2220
1835	133-072-20	M	2720	2738	495	171	1051			220	3550	249	810	1700	68	5736

CHEMICAL DATA

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WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1835	133-072-20	M	2981	3019	554	236	983			255	2750	1008	810	1550	68	5786
4130	138-105-09	M	8640	8701	14726	1744	107393			205	460	185000	670	47	68	309528
3146	139-101-01	M	8008	8034	4650	1232	63930				760	109890	420	58	68	180462
6780	151-089-24	M	9675	9780	43610	4860	73390			170	170	204570	570	42	68	326770
6780	151-089-24	M	10760	10863	19238	1459	105400	153		79	140	193600	479	43	77	319918
184	157-094-06	M	8272	8312	13056	1740	100511			207	274	182886	600	46	68	298674
5281	158-075-16	M	3010	3056	4890	2091	72467			244	2196	124795	630	48	73	206683
5183	158-081-33	M	4595	4622	6607	2430	98222			410	1422	169000	590	47	68	278091
231	158-094-08	M	8187	8217	12288	1856	98058			210	328	178040	630	46	68	290780
237	158-094-23	M	8340	8394	1751	482	92467				4256	144000		242	68	242956
460	158-094-30	M	8196	8233	12672	1392	98437			151	313	177996	620	46	68	290961
482	158-094-30	M	8214	8236	12672	1740	102854			215	268	185820	600	46	68	303569
7577	160-086-15	M	5465	5495	9619	972	92000	5300		1587		166844	880	44	77	271075
5518	161-085-10	M			8702	1112	103109			61	570	181000	580	50	68	294554
5518	161-085-10	M			8702	1112	103109			61	570	181000	580	50	68	294554
2996	161-096-25	M	7554	7594	12228	1856	110459			166	971	196612	630	46	68	322292
3729	162-085-19	M	3010	3056	4890	2091	72467	5900		244	2196	124795	630	48	68	206742
1794	163-086-03	M	4444	4460	2830	680	49900			132	3940	81000	740	68	68	138482
1794	163-086-03	M	4448	4480	2520	570	42300			132	3160	69000	730	84	68	117682
6749	163-087-03	M			16232	1459	79400	540		220	920	152800	678	44	77	251036
5834	163-087-12	M			8702	1946	105291			329	584	187000	600	50	68	303852
5834	163-087-12	M			9618	834	103070			329	570	187000	610	50	68	301421
793	149-091-22	MB	9974	10054	2080	73	33382			160	7020	50112	630	96	68	92827
607	149-093-24	MB	10530	10712	80	82	269			425	426	234	710	6000	68	1516
2996	161-096-25	MB	7906	7940	12864	1508	106954			198	465	191672	590	46	68	313661
1522	137-100-15	MH	8086	8103	7500	660	56121			166	532	101270	570	60	68	166249
2923	137-100-15	MH			4020	972	45669				527	80000	540	70	68	131188
2923	137-100-15	MH			4020	972	45669				527	80000	540	70	68	131188
3733	138-101-24	MH			3660	350	29764			245	764	52700	660	99	68	87483
5028	139-098-03	MH	8070	8112	16400	1215	95799	29900		112	1300	179630	410	41	77	294755
2909	139-100-04	MH	8203	8221	13000	840	73544			44	739	138320	540	51	68	226487
2395	139-100-06	MH	8124	8136	12144	1339	59290	2		100	307	116560	590	56	68	189740
2486	139-100-08	MH			14000	1500	83318	10000		60	250	160000	515	51	78	259228

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
518	139-100-09	MH			10668	6699	52353			55	1260	118200	530	61	68	189235
518	139-100-09	MH	8240		6650	1276	28007			195	705	58053	540	93	68	94886
518	139-100-09	MH	8245	8247	11020	1392	55273			205	1674	107460	530	58	68	177024
518	139-100-09	MH	8245	8287	12100	1580	64200			110	674	124500	450	1134	71	203164
518	139-100-09	MH	8287		616	244	5778			695	1498	9204	710	41	68	18035
3146	139-101-01	MH	8008	8034	4650	1232	63930				760	109890	420	58	68	180462
2928	139-101-03	MH	8237	8266	11200	1320	54791			264	452	107692	590	58	68	175719
3643	139-101-12	MH	8024	8052	9911	928	59176			245	459	111038	690	58	68	181757
1789	139-101-14	MH			11590	644	66898				315	106182	340	5	98	185629
1789	139-101-14	MH	7947	7960	1280	143	10600			438	1410	17800	550	232	68	31671
4009	139-101-20	MH			1836	256				321	820	53352	720	79	75	56585
3761	139-102-02	MH	7668	7710	13080	1300	99129	9		49	824	179200	680	48	68	293582
3761	139-102-02	MH	7768	7710	15240	1280	96415			85	766	178800	640	49	68	292586
3790	139-102-10	MH	7618	7655	12000	1280	94177			100	1045	169400	650	49	68	278002
3790	139-102-10	MH	7692	7750	9530	750	52685	5		185	551	99800	650	62	68	163501
3829	139-102-23	MH			501		3731			278	781E3	5893	9720	6	68	791206
4027	139-102-25	MH			9023	759	37249			79	558	75260	610	209		122928
4027	139-102-25	MH			301	30	1886			232	760	2840	740	122	68	6049
4077	139-102-27	MH	7800	7830	16544	1744	60641			60	284	127650	640	55	68	206923
613	140-099-31	MH	8249	8254	14250	1624	72846			164	314	141984	500	53	68	231182
613	140-099-31	MH	8254	8266	15700	417	71609			166	339	139104	500	51	68	227335
613	140-099-31	MH	8338	8356	15800	417	71436			54	305	139104	480	51	68	227116
919	153-095-33	MH	7430	7483	14400	1464	108865			78	414	197316	450	46	68	322537
1536	138-099-25	MK	8172	8192	3600	120	104500			120	3860	165000	740	44	68	277200
1508	139-101-10	MK	8178	8222	451	100	21503			365	4387	30809	1043	150	68	57615
613	140-099-31	MK	8513	8553	8300	915	90412			44	397	156492	480	49	68	256560
1267	152-096-17	MK	7933	8019	4950	1560	83187			60	743	141036	640	51	68	231536
796	159-094-29	MK	6987	7027	4300	671	65290			112	1235	109296	600	57	68	180904
4280	135-103-18	MKSS	8011	8030	190	57	4598		24	490	6592	2420	840	630	68	14371
3160	137-095-20	MKSS	7750	7808	7254	896	81324			60	367	140580	600	51	68	230481
4642	140-102-30	MKSS	8172	8220	380	480	35889			120	2250	55700	720	95	68	94819
1469	149-096-25	MKSS	8345	8464	7742	1160	110193			85	454	186664	590	46	68	306298
882	151-095-08	MKSS	8062	8152	4465	522	103258			102	2161	167040	530	47	68	277548

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1111	152-095-01	MKSS	7697	7766	6534	1020	804			54	804	166260	500	48	68	175476
1101	153-095-28	MM	8872	8926	12276	1800	103519			305	874	185820	600	46	68	304594
1101	153-095-28	MM	8926	8951	15246	1800	92326			135	698	174040	600	47	68	284245
1575	129-106-09	MM	6855	6869	568	89	1800			355	1778	2523	680	1000	68	7113
6322	130-091-07	MM	6220	6310	7375	389	32900	450		333	1500	63500	695	74	77	106002
6322	130-091-07	MM	6310	6220	13627	1580	50600	500		137	1050	112000	687	51	77	178999
1446	130-103-34	MM	7319	7395	1137	177	14000			390	2786	21840	690	200	68	40330
2677	130-107-03	MM	6820	6821	386	67	690			281	1461	702	810	2200	77	3587
43	132-078-08	MM	3569	3599	689	287	3767	200		257	4732	4228	775	556	79	13962
6413	133-092-21	MM			6515	668	40300	45		194	1800	78540	697	63	77	128017
6413	133-092-21	MM	6968	7058	7836	1325	85500	150		531	950	155950	640	43	77	252094
511	134-096-24	MM	7830	7900	551		7206		264		10558	3870	1100	420	68	22449
511	134-096-24	MM	7885	7958	475		4678		155	160	4166	4707	1010	600	68	14341
511	134-096-24	MM	8023	8110	2470	754	17668			525	1477	32426	660	150	68	55320
3859	135-083-34	MM	5112	5148	6000	1640	72384			220	2329	125200	730	54	68	207775
1464	135-100-16	MM	8648	8694	1270	109	29200			180	2870	45500	570	110	68	79129
2805	135-101-09	MM	7890	7909	369	30	9616			490	6057	10820	710	300	68	27382
2805	135-101-09	MM	8465	8487	15552	1566	105030			95	384	193648	560	46	68	316275
2805	135-101-09	MM	8655	8677	330	32	910			340	1106	1067	660	2080	68	3785
2805	135-101-09	MM	8676	8760	998	64	4981			340	2881	7312	730	470	68	16576
4280	135-103-18	MM	8686	8734	209	80	813			230	984	997	800	2300	68	3313
1926	136-093-35	MM	7819	7884	6138	1475	118672			185	1100	197288	650	47	68	324858
1926	136-093-35	MM	7902	7922	9999	1593	102531			145	620	179944	640	47	68	294832
6243	137-092-26	MM	7710	7752	11623	2431	96000	3700		320	293	180480	612	40	77	291184
3160	137-095-20	MM	8310	8357	16740	2352	94296			195	869	181170	610	49	68	295622
3160	137-095-20	MM	8362	8450	13990	1792	78128			135	1246	149490	620	52	68	244781
3160	137-095-20	MM	8511	8600	7626	896	45804			280	2634	84645	690	70	68	141885
3160	137-095-20	MM	8605	8680	14508	1792	90722			160	619	170280	610	50	68	278081
1574	137-099-15	MM	9045	9085	266	42	1478			295	950	2000	740	1400	68	5031
1396	137-100-14	MM			15250	2850	63919			170	251	133600	710	52	68	216040
1541	138-095-06	MM	8485	8532	5840	828	40500			168	1990	73800	680	70	68	123126
850	138-098-15	MM	9080	9170	969	52	5053			475	2814	7308	660	460	68	16671
657	138-099-09	MM	7672	7717	10494	2006	115392			135	950	201624	610	49	68	330601

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
657	138-099-09	MM	7884	7900	9108	2596	113211			255	1200	197288	580	47	68	323658
849	138-100-34	MM	8985	9032	18050	2320	105795			135	428	201492	610	46	68	328220
849	138-100-34	MM	9157	9170	1330	116	21289			280	3363	32886	650	140	68	59264
849	138-100-34	MM	9168	9192	874	58	9530			415	1544	15034	660	260	68	27455
4091	138-102-10	MM	9016	9042	1200	109	8288			500	1749	13644	690	280	68	25490
3695	138-103-11	MM	8736	8796	16678	1450	98654			60	672	185377	630	49	68	302891
3695	138-103-11	MM	8739	8796	16678	1450	98654			60	672	185377	630	49	68	302891
3695	138-103-11	MM	8964	8990	362	46	2055			380	1132	2888	700	1050	68	6863
3695	138-103-11	MM	9178	9210	362	35	1459			270	1123	2007	700	1420	68	5256
4525	138-104-16	MM	8952	8972	490	78	2072			290	1175	3260	700	980	68	7365
4525	138-104-16	MM	9182	9198	500	60	2302			290	950	3740	700	910	68	7842
4130	138-105-09	MM	8795	8890	364	49	1713			380	1313	2239	730	1200	68	6058
4130	138-105-09	MM	9096	9120	273	33	1071			270	905	1406	730	1840	68	3958
7127	139-096-30	MM	8838	8901	13828	365	76800	260		330	1410	149600	647	45	77	242336
4250	139-097-17	MM	8788	8848	24400	11E3	94829	14600		166	1700	213710	530	38	77	345886
4250	139-097-17	MM	8915	8965	14000	5589	72266			420	2300	150520	650	45	77	245095
4224	139-098-10	MM	8985	9041	16579	1700	102463			122	360	192000	600	43	77	313224
4224	139-098-10	MM	9110	9130	4215	442	53618			281	3100	89000	720	58	77	150656
2117	139-099-16	MM	9018	9046	9900	1534	116828			170	1060	201310	630	49	68	330802
2117	139-099-16	MM	9150	9275	15246	1652	111736			145	1060	203274	620	49	68	333113
2117	139-099-16	MM	9344	9370	6930	1062	84177			170	2340	143372	640	52	68	238051
375	139-100-04	MM			130	17	2163			486	1950	1904	760	6		6650
375	139-100-04	MM	9418	9451	2790	495	68189			220	5926	107060	570	60	68	184680
375	139-100-04	MM	9434	9451	238	35	2877			500	1510	3556	740	810	68	8716
522	139-100-04	MM			139	48	9631			1075	723	14083	690	290	68	25699
522	139-100-04	MM	9415	1422	430	37	8199			940	1587	11798	680	320	68	22991
522	139-100-04	MM	9415	9422	1700	366	18478			720	5382	28188	640	160	68	54834
2577	139-100-04	MM	9415	9422	608	342	17063			190	1114	27460	610	170	68	46777
291	139-100-09	MM	9378	9466	44	20	554		37	685	300	328	810	4100	68	1968
291	139-100-09	MM	9388	9466	223	35	1950			1220	1490	1696	760	1250	68	6614
291	139-100-09	MM	9401	9666	273	38	1645			500	974	2122	740	1250	68	5552
291	139-100-09	MM	9402	9466	1665	319	2583			365	1325	6670	730	530	68	12927
291	139-100-09	MM	9404	9430	242	55	2857			510	1550	3556	740	810	68	8770

CHEMICAL DATA

1=(mg/l, ppm) · 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
291	139-100-09	MM	9469	9508	818	122	2693			510	1370	4650	730	700	68	10163
291	139-100-09	MM	9601	9666	273	38	1645			500	2122	974	740	1250	68	5552
625	139-100-09	MM			130	12	2544			389	2625	2013	765	7		7713
794	139-100-09	MM	9425	9435	8400	2697	1470	16800		610	1010	24140	550	430	68	38495
448	139-100-10	MM	9390	9403	6745	2204	1336			380	868	19560	540	230	68	31093
598	139-100-10	MM	9240	9291	17100	2320	106890			742	351	201204	550	46	68	328607
598	139-100-10	MM	9444	9476	1748	139	25386			440	5283	38502	660	130	68	71498
738	139-100-15	MM			139	17	2677			542	3000	1904	770	7		8279
739	139-100-16	MM			139	17	2677			542	3000	1904	770	8		8279
795	139-100-16	MM			1330	112	1370	180		418	955	6580	620	10		10767
1855	139-101-02	MM			81	46	1352			770	300	1694	760	1700	68	4243
4325	139-101-03	MM			11928	2538	99280			170	1275	180600	640	46	68	295791
1508	139-101-10	MM			380	12	1773	2000		270	625	2900	690	1460	74	5980
1508	139-101-10	MM	9300		380	12	1773	2000		270	625	2900	690			5980
2725	139-101-10	MM	9349	9402	1862	209	8358			305	786	16038	670	270	68	27558
3268	139-101-10	MM	9110	9132	2006	134	5887			245	765	12314	680	320	68	21351
3268	139-101-10	MM	9328	9349	865	82	11551			295	834	18800	630	230	68	32427
1789	139-101-14	MM			277	17	1642			261	611E3	1763	6730	185		615098
3761	139-102-02	MM	8929	8935	295	41	1647			245	930	2353	760	1320	68	5511
3928	139-102-03	MM			351	30	4727			267	1017	7100	710	13	68	13492
4268	139-102-08	MM	9040	9059	400	80	3465			355	1022	5325	740	650	68	10647
3573	139-102-11	MM	8844	8869	21160	2890	96444			205	254	194320	600	46	68	315273
3573	139-102-11	MM	9260	9280	280	42	1445			255	720	2167	700	1350	68	4909
3939	139-102-15	MM	8974	8979	1210	154	5869			214	860	10880		19		19187
4012	139-102-22	MM	8861	8877	725	80	5838			120	1765	9150	760	400	68	17678
3829	139-102-23	MM			351		1587			303	844	2272	730	11	68	5357
3829	139-102-23	MM			351		1587			303	844	2272	730	5		5357
4019	139-102-26	MM			858	58	1655			270	1918	2668	720	1050	68	7427
4359	139-103-05	MM	9240	9310	863	132	7515			305	1256	12400	750	290	77	22471
4627	139-103-05	MM	9146	9194	4200	420	25887			130	3200	46150	720	110	68	79987
4627	139-103-05	MM	9172	9205	2200	300	14659			255	2075	25700	690	170	68	45189
7461	139-103-09	MM			106	18	792			145	330	1134	630	2680	68	2525
4150	140-097-34	MM			17000	1955	83929			159	207	165000	640	43	77	268250

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
613	140-099-31	MM	9488	9499	860	49	18591			415	3761	27324	660	160	68	51000
2768	140-100-04	MM	9816	9856	499	70	4868			330	678	7904	730	49	68	14349
4642	140-102-30	MM			401	61	2921			464	1174	4260	730	690	68	9281
4339	140-103-20	MM	9150	9220	899	118	6458			329	1362	10700	740	335	77	19866
6325	140-103-36	MM	8851	8871	18715	4137	91823			268	613	186200	600	48	68	301756
6325	140-103-36	MM	9060	9080	1152	136	6287			464	1469	10780	660	370	68	20288
4467	140-105-21	MM	8946	8986	14800	2080	106954			170	168	197000	610	48	68	321172
824	141-091-08	MM	7794	7869	1560	268	19573			342	5124	29754	640	160	68	56621
7463	142-100-03	MM			4810	1216	38500	50		452	510	72474	708	69	77	117963
6936	142-100-06	MM			6012	2674	52200	130		378	840	97146	694	51	77	159251
7465	142-100-32	MM			2204	292	22000	40		342	650	37933	774	102	77	63421
7514	142-100-33	MM			2325	486	22000	80		342	650	39167	695	100	77	64971
2894	142-103-24	MM	9413	9486	4000	600	77543			145	3226	125970	660	53	68	211484
2894	142-103-24	MM	9498	9594	3600	720	44460			415	3667	74100	670	73	68	126962
2826	143-090-01	MM	8112	8173	5600	1320	116315			180	1886	191672	580	46	68	316973
3044	143-092-27	MM	8407	8508	15744	2320	104698			234	512	195600	550	46	68	319108
3044	143-092-27	MM	8470	8508	16512	2668	101874			224	487	193644	520	46	68	315409
3044	143-092-27	MM	8527	8597	16200	3400	100487			25	573	193150	560	46	68	313835
2853	143-101-05	MM	9543	9588	4512	855	57818			345	3325	97000	670	52	77	163855
2853	143-101-05	MM	9773	9818	5076	1026	54290			415	639	95000	640	54	77	156446
3199	144-092-16	MM	8689	8763	16554	2352	84164			185	718	165330	600	50	68	269303
2689	144-099-21	MM	9910	9952	12800	1080	113071			224	271	199875	610	47	68	327321
2788	144-099-33	MM	10126	10149	11712	1044	107883			315	397	189696	630	46	68	311047
2798	144-100-09	MM	9968	10058	9328	928	110802			305	332	189696	610	46	68	311391
4419	144-102-14	MM	9315	9360	4607	825	88984			244	2263	146000	670	51	77	242923
734	145-091-17	MM	8709	8721	19392	2668	98954			246	233	192660	550	48	68	314153
2821	145-099-03	MM	9981	10049	17088	1508	104619			222	338	195624	560	46	68	319399
2584	145-101-16	MM	9550	9554	12650	1670	103153			159	270	186000	660	45	77	303902
2584	145-101-16	MM	9569	9571	12650	1670	101870			195	272	184000	670	45	77	300657
2678	145-101-23	MM	9462	9517	15400	167	112022			171	477	200000	700	42	77	328237
1516	146-082-32	MM	5797	5841	745	77	4329			255	4465	4778	760	530	68	14649
1516	146-082-32	MM	6139	6165	9408	2596	101184			220	900	179494	710	46	68	293802
826	146-091-11	MM	8568	8610	37000	6710	79776			270	227	207756	520	46	68	331739

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
6894	146-103-05	MM	9290	9405	10421	1459	105800			146	1450	193600	592	44	77	312876
6966	146-104-36	MM			12024	972	108800	400		1739	450	193600	810	41	77	317589
413	147-093-05	MM	8930	8950	33250	7830	79033			575	416	202924	540	49	68	324028
413	147-093-05	MM	9012	9040	20140	2320	80540				429	166314	380	48	68	269743
413	147-093-05	MM	9121	9148	30400	1624	74838				439	173636	100	47	68	280937
2848	147-093-08	MM	9104	9127	38500	5400	82318			310	192	210516	560	47	68	337236
2848	147-093-08	MM	9192	9245	20000	4200	96924			205	546	196612	570	46	68	318487
2230	147-096-36	MM	10007	10039	14454	1888	105009			120	680	192480	630	51	68	314631
6532	147-101-15	MM	9330	9440	11684	6682	96813			122	560	181000	630	59	68	296861
6532	147-101-15	MM	9468	9560	10160	4764	93234			122	752	170000	580	59	68	279032
6663	147-104-03	MM	9270	9370	9740	584	113900			85	864	184400	570	46	68	309573
2352	148-095-18	MM	9510	9575	37620	4720	85537			205	196	212000	580	48	68	340278
2352	148-095-18	MM	9894	10005	17622	1770	99159			315	470	188760	640	47	68	308096
2400	148-096-10	MM	9402	9456	36100	3400	88010			205	300	209200	620	51	68	337215
2400	148-096-10	MM	9614	700	20900	2052	101967			255	860	199460	650	51	68	325494
2400	148-096-10	MM	9614	9700	20900	2052	101967			255	860	199460	650	51	68	325494
793	149-091-22	MM	8553	8583	2920	512	126274			210	363	201042	580	46	68	331321
793	149-091-22	MM	8840	8940	3080	610	114492			88	3313	181332	500	46	68	302915
793	149-091-22	MM	8995	9001	18050	2900	92499			278	281	182700	610	49	68	296708
793	149-091-22	MM	8999	9036	7700	1342	105012			200	744	178848	620	46	68	293846
1469	149-096-25	MM	9400	9463	32830	3835	86098			120	253	201818	570	46	68	324954
3089	150-079-14	MM	5128	5115	7790	2280	101474			396	920	176040	540	47	68	288900
3089	150-079-14	MM	5128	5175	7600	2166	99109			414	1087	171590	570	47	68	281966
1309	150-094-20	MM	9205	9350	15444	2040	87552			440	845	167440	640	48	68	273761
2383	150-094-30	MM	9291	9329	14630	1600	96961			890	760	179032	680	47	68	293873
1798	150-095-02	MM	9384	9447	17028	2006	92477			500	750	177776	670	48	68	290537
1542	150-095-06	MM			14000	1520	83893			475	173	158200	720	50	68	258261
1716	150-095-09	MM	9080	9142	35770	4130	77869			60	392	195120	450	47	68	313341
1716	150-095-09	MM	9320	9372	15680	1888	93995			355	339	177776	550	47	68	290033
1792	150-095-15	MM	9304	9363	14652	1888	96794			660	545	179944	630	47	68	294483
1792	150-095-15	MM	9474	9534	15642	1888	96255			500	450	181028	620	47	68	295763
2032	150-095-15	MM	9300	9366	14454	1888	94177			245	570	175780	690	48	68	287114
1938	150-095-16	MM	9246	9302	13266	2596	80261			135	1130	153928	600	49	68	251316

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1938	150-095-16	MM	9319	9354	15642	1888	92755			245	680	175608	620	47	68	286818
1938	150-095-16	MM	9352	9433	19800	10E3	32210				1200	119240	420	63	68	182480
1459	150-095-18	MM	9082	9149	33320	4012	88609			245	307	206960	600	46	68	333453
1459	150-095-18	MM	9270	9327	14504	2006	96721			575	605	179920	670	46	68	294331
1854	150-096-17	MM	9518	9564	16038	2006	92633			305	324	176692	640	47	68	287998
1849	150-096-29	MM	9457	9520	15642	1888	94816			490	388	178860	670	46	68	292084
1849	150-096-29	MM	9526	9550	15642	1770	96366			405	292	181028	680	46	68	295503
1606	150-097-35	MM	9560	9627	18620	2242	85982			414	555	171456	560	47	68	279269
6780	151-089-24	MM	7800	7857	12374	1962	100237			305	580	186000	610	65	68	301458
1746	151-096-08	MM	9380	9435	18612	2242	106231			415	510	202708	620	48	68	330718
1305	151-096-34	MM	9192	9243	32670	4200	84480			185	393	199962	590	46	68	321890
1305	151-096-34	MM	9312	9423	17325	2700	101294			195	663	194166	650	46	68	316343
1305	151-096-34	MM	9375	9405	16830	2550	101453			315	430	193200	630	46	68	314778
1305	151-096-34	MM	9426	9493	19305	3000	98444			355	512	194166	660	46	68	315782
920	151-097-11	MM	9310	9408	18050	2320	102690			284	480	196578	600	46	68	320402
920	151-097-11	MM	9440	9500	16150	2900	105643			170	500	199512	600	46	68	324875
1202	152-094-06	MM			20989	1692	101798			49	125	198970	520	47	68	323623
1202	152-094-06	MM			17600	3604	8307			102		333000	590	46	68	362613
1262	152-094-06	MM			14300	2000	72860			185	284	143200	720	52	68	232829
1265	152-094-06	MM			21900	1700	92225			110	131	185800	690	46	68	301866
1432	152-094-06	MM	8877	8991	15680	1770	98541			390	803	184080	700	46	68	301264
1279	152-094-07	MM			13350	1450	66842			185	329	130600	680	53	68	212756
1342	152-094-07	MM			10092	1256	52280			160	476	101640	710	61	68	165904
1370	152-094-07	MM			14300	1450	78297			160	280	150000	660	50	68	244487
1417	152-094-07	MM			8188	686	99296			25	317	169400	690	47	68	277912
1512	152-094-08	MM			30464	2626	85792			135	288	193600	630	50	68	312905
1254	152-094-17	MM			17898	1828	85414			245	222	168440	660	48	68	274047
1254	152-094-17	MM	8944	8975	17622	2800	100102			176	603	193200	640	47	68	314503
1254	152-094-17	MM	9055	9130	18810	2400	95751			196	615	187404	640	47	68	305176
1398	152-094-17	MM			19992	800	93740			195	276	181980	640	47	68	296983
1499	152-094-17	MM			16946	1028	91193			185	358	173272	670	48	68	282982
1440	152-094-18	MM			19040	1028	106974			270	262	201340	640	46	68	328914
1468	152-094-18	MM			18100	4000	86581			195	165	177000	720	47	68	286041

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1111	152-095-01	MM			18100	2300	78009			170	214	158800	690	49	68	257593
1144	152-095-01	MM			20560	2056	85657			230	166	174240	690	48	68	282909
1250	152-095-01	MM			12850	3700	68180			135	284	138400	660	52	68	223549
1255	152-095-01	MM			20182	2398	87696			205	185	177714	690	47	68	288380
1323	152-095-01	MM			14280	2280	71182			185	372	141328	720	53	68	229627
1350	152-095-01	MM			13800	2550	72346			170	194	143200	730	50	68	232260
1352	152-095-01	MM			14661	1142	73485			205	276	142296	710	52	68	232065
1372	152-095-01	MM			12380	1256	67783			185	407	129712	740	53	68	211723
1571	152-095-02	MM			19230	1256	88701			205	198	174240	690	48	68	283830
1711	152-095-02	MM			20182	1941	87567			205	194	176176	690	48	68	286265
2035	152-095-02	MM			16755	2170	84222			230	298	165528	690	48	68	269203
2480	152-095-02	MM			19992	2284	65078			170	25	142296	680	51	68	229845
1114	152-095-05	MM			15488	1256	93109			245	407	174240	700	470	68	284745
1474	152-095-05	MM			12186	1485	68793			160	354	131648	720	53	68	214626
1862	152-095-05	MM			17618	1941	90602			270	337	176176	690	46	68	286944
1088	152-095-06	MM			16262	1713	82512			330	218	160688	670	49	68	261723
1088	152-095-06	MM	9053	9063	14208	812	83503			205	255	156000	700	48	68	254983
1162	152-095-06	MM			16184	1598	92238			185	354	175200	670	47	68	285759
2030	152-095-06	MM			18973	1599	89662			270	272	176176	670	46	68	286952
1218	152-095-07	MM			18005	2284	91306			245	177	179080	660	46	68	291097
1360	152-095-07	MM			11616	1485	61554			465	539	118096	730	56	68	193755
1504	152-095-07	MM			16946	342	86196			280	235	163600	670	49	68	267599
1601	152-095-07	MM			14280	1598	77622			183	635	149080	640	50	68	243398
4013	152-095-07	MM			17326	1028	95181			280	358	180040	670	46	68	294213
1310	152-095-08	MM			18850	2056	92676			270	210	181984	700	46	68	296046
1312	152-095-08	MM			18392	1941	87175			195	337	172304	670	47	68	280344
1419	152-095-08	MM			17517	2398	87258			205	210	172304	690	47	68	279892
1555	152-095-08	MM			16843	2056	85015			255	386	166496	710	48	68	271051
1557	152-095-08	MM			18198	1713	92141			185	177	179080	680	46	68	291494
1558	152-095-08	MM			18779	1941	102992			185	227	197472	680	46	68	321596
1596	152-095-08	MM			17618	2056	83401			245	190	165528	680	48	68	269038
1846	152-095-11	MM	8555	9060	23760	2950	95412			255	508	197288	620	47	68	320173
1846	152-095-11	MM	9052	9108	24750	3245	88759			355	344	189700	650	46	68	307153

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1344	152-095-12	MM			21520	2160	71751			230	156	154800	640	49	68	250617
1351	152-095-12	MM			20950	2850	87728			230	131	177200	660	47	68	289089
1567	152-095-12	MM			20940	3420	91381			160	135	187800	650	46	68	303836
2034	152-095-12	MM			25320	2280	74149			120	303	165528	670	50	68	267700
1277	152-095-16	MM			20563	2284	89650			245	226	181016	690	46	68	293984
1181	152-095-17	MM			21490	1713	85931			295	251	175208	690	47	68	284888
1200	152-095-17	MM			18973	3198	90441			270	345	181984	690	49	68	295211
1241	152-095-17	MM			15101	1941	67062			195	251	135520	720	51	68	220070
1284	152-095-17	MM			16456	2170	81364			205	186	160688	690	49	68	261069
1331	152-095-17	MM			15875	1827	54368			135	94	117128	750	56	68	189427
1361	152-095-17	MM			19554	1827	94256			245	382	184888	690	46	68	301152
1488	152-095-17	MM			18005	1827	92878			270	325	180048	710	46	68	293353
1256	152-095-18	MM			24006	3426	93577			255	206	196504	630	46	68	317974
1295	152-095-18	MM			17618	2741	94064			245	259	183920	640	46	68	298847
1423	152-095-18	MM	9210	9234	26880	2784	88236			315	319	191360	580	46	68	309894
1562	152-095-18	MM			19040	1598	91497			255	341	179080	660	46	68	291811
948	152-095-19	MM			15994	1370	56539	9		220	428	119060	640	56	68	193611
948	152-095-19	MM	9229	9269	28512	3120	87775			264	217	194622	520	46	68	314510
1156	152-095-19	MM			25362	1941	76566			230	94	168432	640	48	68	272625
1327	152-095-19	MM			25132	1142	85333			255	263	179080	650	48	68	291205
1065	152-095-20	MM			25749		1941			245	123	176176	650	46	68	204234
1143	152-095-20	MM			21706	1126	88344			205	198	177693	680	47	68	289272
1242	152-095-20	MM			27685	1941	92226			255	337	196504	670	46	68	318948
1285	152-095-20	MM			26717	2741	93682			145	370	199408	640	46	68	323063
1289	152-095-20	MM			22845	1599	85165			205	210	176176	640	47	68	286200
1316	152-095-20	MM			24974	2284	82701			160	280	178112	670	46	68	288511
1433	152-095-20	MM			16456	1599	54873			295	205	118096	710	56	68	191524
1193	152-095-29	MM			27878	2512	83293			230	144	184888	640	48	68	298945
1246	152-095-29	MM			28846	2170	89255			205	478	194568	650	46	68	315522
1317	152-095-29	MM			25168	2284	94439			220	309	196504	660	46	68	318924
1330	152-095-29	MM			23813	2170	94224			295	37	193600	660	46	68	314139
1066	152-095-30	MM	9276	9295	26740	3000	90396			200	331	195132	570	46	68	315799
2661	152-095-32	MM			24974	2056	90642			205	202	189728	670	46	68	307807

CHEMICAL DATA

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WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
147	152-096-15	MM	9066	9110	21200	1952	92654			246	194	185832	610	46	68	302078
1267	152-096-17	MM	9001	9060	18216	2520	100533			185	506	194166	650	46	68	316126
1267	152-096-17	MM	9143	9245	18216	2880	100456			255	403	195132	630	46	68	317342
1085	152-096-24	MM	9264	9356	20988	1920	97483			280	365	192666	550	46	68	313702
41	152-096-26	MM	9083	9116	29300	2840	88348			176	412	196000	580	53	68	317076
2645	153-094-21	MM	9454	9548	13600	1920	102186			220	665	186660	640	46	68	305251
1282	153-094-32	MM			13709	1827	75160			195	272	145200	710	51	68	236363
1319	153-094-32	MM			16755	2056	85050			270	235	166496	700	49	68	270862
1335	153-094-32	MM	8912	9000	21120	2900	88487			245	230	182000	660	46	68	294982
1335	153-094-32	MM	8912	9000	3120	435	16531			49	273	31875	840	145	68	52283
2316	153-094-32	MM			10662	1713	60107			220	384	116160	710	189		189246
1269	153-094-33	MM			20754	1828	68270			75	238	147136	690	51	68	238301
1563	153-094-33	MM			13800	2850	89424			170	218	170400	720	47	68	276862
1886	153-094-33	MM	9289	9360	19404	1770	94868			280	404	185364	670	47	68	302090
786	153-095-06	MM	8356	8394	29450	2320	24958			34	352	97092	500	65	68	154206
542	153-095-07	MM	8718	8776	16400	1830	35446			15	378	88740	620	66	68	142809
78	153-095-16	MM	8914	8963	20200	1220	91833			308	212	180612	610	46	68	294385
283	153-095-16	MM	8867	8907	12508	2784	98623			248	221	182004	530	48	68	296388
283	153-095-16	MM	8868	8904	3069	767	48405			145	1280	81300	670	71	68	134966
1084	153-095-20	MM	9166	9201	16236	1680	90792			170	630	173106	520	47	68	282614
397	153-095-25	MM	9105	9171	16720	2320	89309			318	382	173636	570	50	68	282685
3167	153-095-31	MM	8728	8935	14550	1910	86617			270	216	164600	670	50	68	268163
3167	153-095-31	MM	8728	8935	14550	1910	86617			270	216	164600	670	50	68	268163
919	153-095-33	MM	8960	9020	13490	1856	106871			160	524	193644	600	46	68	316545
1131	153-095-35	MM	9036	9139	15642	1920	93575			292	573	177018	550	46	68	289020
1131	153-095-35	MM	9118	9139	15840	1920	91363			224	453	174084	530	47	68	283884
1679	153-096-10	MM	8890	8943	15680	2124	94112			185	532	178600	530	46	68	291233
1152	153-098-30	MM	8823	8909	12078	1440	106910			405	686	189732	450	46	68	311251
4891	154-082-31	MM	5522	5540	9784	340	102950			458	1103	176150	660	42	68	290785
2930	154-083-08	MM	5684	5709	8200	1920	100917			290	978	174876	610	47	68	287181
2930	154-083-08	MM	5748	5778	8300	1980	105041			239	744	181792	580	46	68	298096
2816	154-092-12	MM	8606	8680	31488	4756	88327			214	262	205504	580	49	68	330551
2816	154-092-12	MM	8821	8998	19200	2552	97613			162	285	191672	530	46	68	311484

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1135	154-095-07	MM	9036	9139	15084	2040	97211			234	642	181908	550	46	68	297119
128	154-095-16	MM	8570	8604	12940	1380	97660			230	302	177200	720	46	68	289712
6068	154-095-18	MM	8240	8320	13270	1240	91500	50		186	625	178700	661	41	77	285522
305	154-095-33	MM			25840	3248	80344			156	220	178866	540	48	68	288674
674	154-095-34	MM	8377	8416	15580	1740	61584			54	315	127368	530	57	68	206641
1333	154-096-36	MM	8502	8515	22572	3360	87976			230	244	185120	610	46	68	299502
474	155-090-24	MM	7887	7920	5700	1856	17053			280	1852	40271	570	130	68	67012
7570	155-094-09	MM	9090	9201	15979	1456	97000			154	372	290709	620	46	68	405670
3227	155-094-16	MM	8743	8852	16491	1692	94098			330	397	178770	650	47	68	291778
603	155-095-05	MM			13138	1598	81054			255	263	152586	700	48	68	248894
719	155-095-05	MM	8413	8419	10472	1370	73713			305	294	135828	730	50	68	221982
87	155-095-06	MM			9114	1405	71762			256	420	135000	710	60	68	217957
87	155-095-06	MM	8410	8446	8378	2170	56908			195	453	108480	780	58	68	176584
216	155-095-06	MM	8406	8454	4760	456	33121			450	809	59980	780	87	68	99576
223	155-095-06	MM	8532	8566	8758	1142	55086			415	477	103200	790	60	68	169078
347	155-095-06	MM	8417	8462	9520	1720	59329			390	453	112800	750	56	68	184212
376	155-095-06	MM	8325	8362	13140	2060	81873			220	290	155200	710	49	68	252783
709	155-095-06	MM	8440	8466	6912	870	57385			535	294	102752	630	59	68	168748
709	155-095-06	MM	8520	8543	10282	1370	65986			340	392	123480	730	54	68	201850
710	155-095-06	MM	8502	8530	5332	1256	37695			195	766	70560	780	75	68	115804
66	155-095-07	MM	8503	8516	14239	1038	75270			315	215	143980	580	50	68	235057
86	155-095-07	MM	8512	8545	13518	1599	93375			185	272	172300	730	47	68	281249
439	155-095-07	MM	8466	8476	10280	1480	70383			390	412	130536	710	52	68	213481
439	155-095-07	MM	8502	8524	13520	2520	80562			205	289	155200	710	48	68	252296
475	155-095-07	MM	8498	8505	13320	2160	81535			365	294	155200	700	48	68	252874
721	155-095-07	MM	8428	8435	12760	2060	78943			245	281	150000	700	48	68	244289
490	155-095-08	MM	8490	8497	12756	1942	83125			205	284	156120	700	50	68	254432
937	155-095-08	MM	8474	8629	9520	1942	64563			255	303	121720	730	54	68	198303
970	155-095-17	MM	8444	8458	13700	1720	87539			170	246	164000	710	49	68	267375
1031	155-095-17	MM	8397	8410	15552	1972	99524			245	646	186160	640	46	68	304099
60	155-095-18	MM	8473	8488	13900	2060	99977			245	363	184400	680	47	68	300945
138	155-095-18	MM	8464	8476	12940	1940	89732			270	275	166600	690	48	68	271757
281	155-095-18	MM	8454	8472	18468	2056	86526			205	292	171800	660	48	68	279347

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
593	155-095-18	MM	8468	8474	13900	1720	94588			245	247	175600	670	47	68	286300
1494	155-095-28	MM	8378	8388	14112	1888	95825			230	594	177708	690	46	68	290357
75	155-096-01	MM	8487	8520	13490	1740	89975			258	291	167360	540	47	68	273114
165	155-096-01	MM	8370	8408	12756	1598	95514			185	282	174242	710	47	68	284577
352	155-096-01	MM	8444	8484	12376	2170	94800			185	4272	174240	700	47	68	288043
399	155-096-01	MM	8399	8435	11620	2280	89891			185	208	165600	650	48	68	269784
496	155-096-01	MM	8395	8430	8568	1714	64384			160	426	119060	760	55	68	194312
575	155-096-01	MM	8320	8328	10280	1480	81741			230	343	148200	660	50	68	242274
3844	155-096-01	MM	8452	8492	22320	1840	85895			185	326	177000	690	49	68	287566
161	155-096-02	MM	8350	8390	13708	1941	93759			205	254	174240	730	47	68	284107
261	155-096-02	MM	8402	8424	11044	1714	85471			305	482	155840	730	49	68	254856
570	155-096-02	MM	8278	8398	10852	2170	79094			230	342	147140	740	50	68	239828
640	155-096-02	MM	8284	8348	13518	1713	96940			230	252	178120	730	47	68	290773
789	155-096-02	MM	8350	8376	12186	1828	78867			220	314	148180	690	49	68	241595
300	155-096-10	MM	8325	8362	6660	920	45354			245	652	83800	720	67	68	137631
310	155-096-10	MM	8351	8405	9900	1828	54766			380	514	106720	700	58	68	174108
143	155-096-11	MM	8397	8426	16128	1740	96989			176	302	182886	580	46	68	298221
202	155-096-11	MM	8392	8426	536	214	118804			295	10600	176820	650	46	68	307269
202	155-096-11	MM	8392	8428	10660	1560	72609			230	369	135000	730	52	68	220428
267	155-096-11	MM	8300	8338	4560	1142	37154			295	725	68000	750	77	68	111876
445	155-096-11	MM	8419	8448	12940	1942	81843			351	289	154400	680	48	68	251765
648	155-096-11	MM	8262	8441	14860	1820	83839			230	250	160600	680	48	68	261599
386	155-096-12	MM	8420	8052	12000	1820	75178			280	455	142000	730	50	68	231733
412	155-096-12	MM	8428	8466	12948	1942	84635			220	312	158760	720	49	68	258817
562	155-096-13	MM	8400	8420	2574	720	51057			160	2298	83619	550	73	68	140428
562	155-096-13	MM	8507	8676	6280	1020	46411			1015	5555	84672	750	67	68	144953
50	155-096-14	MM	8348	8429	10000	3400	90000	2000			180	170000	630	275		273600
653	155-096-14	MM	8422	8629	8568	1256	60232			295	482	111200	730	56	68	182033
5623	155-096-14	MM	8294	8375	12560	2970	84868			280	304	161400	700	48	68	262382
954	155-096-15	MM	8290	8316	12380	1714	84691			550	290	157000	700	48	68	256625
1895	155-096-22	MM	8248	8298	14058	2242	98845			315	665	183200	620	45	68	299325
106	156-095-03	MM	8414	8428	208	165	120379			450	14450	175608	760	49	68	311260
136	156-095-03	MM	8417	8427	13490	1624	95570			162	263	175728	500	46	68	286837

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
146	156-095-04	MM	8374	8390	13680	2204	93291			740	294	173880	550	46	68	284089
146	156-095-04	MM	8374	8390	12757	1370	97623			170	440	176722	700	46	68	289082
198	156-095-08	MM	8456	8699	4760	456	33839			1135	578	60860	770	86	68	101628
210	156-095-09	MM	8397	8424	14820	1972	77887			680	261	151524	570	49	68	247144
210	156-095-09	MM	8397	8424	12186	800	98335			245	311	175200	740	47	68	287077
243	156-095-09	MM	8406	8440	17480	1972	95794			185	317	184096	500	46	68	299844
379	156-095-09	MM	8410	8440	12760	1480	95720			245	264	174200	690	47	68	284669
514	156-095-09	MM	8395	8476	1190	314	10852			1270	680	18520	770	220	68	32826
595	156-095-09	MM	8422	8445	10092	1714	74688			270	406	137600	720	51	68	224770
294	156-095-10	MM	8427	8453	17100	2552	74865			454	262	152716	550	51	68	247949
294	156-095-10	MM	8430	8575	1285	286	15655			1305	644	26020	780	160	68	45195
404	156-095-10	MM	8500	8526	10480	1820	85160			280	329	154800	710	49	68	252869
67	156-095-14	MM	8510	8707	5140	1370	36336			1185	714	67920	760	82	68	112665
67	156-095-14	MM	8512	8540	13680	13E3	2088			342	376	169452	530	48	68	199238
249	156-095-14	MM	8556	8576	6290	1260	89751			140	2112	151600	540	51	68	251153
51	156-095-15	MM	8317	8473	12756	2170	93818			270	230	173280	750	47	68	282524
53	156-095-15	MM	8448	8468	12376	2512	94860			220	285	175200	730	47	68	285453
54	156-095-15	MM	8410	8450	14470	800	85606			245	268	159640	710	49	68	261029
56	156-095-15	MM	8450	8485	13300	1508	93301			185	259	171544	540	47	68	280097
1045	156-095-15	MM	8469	8475	11804	2284	79609			305	298	149940	700	50	68	244240
42	156-095-16	MM	8490	8512	13680	1856	94991			342	282	175728	530	48	68	286879
42	156-095-16	MM	8490	8512	12380	2060	91902			120	266	169400	630	47	68	276128
42	156-095-16	MM	8512	8537	6839	907	98943			330	1600	166000	620	52	68	274619
163	156-095-16	MM	8438	8478	12560	1480	94146			245	287	171400	700	47	68	280118
181	156-095-16	MM	8522	8542	11044	2170	83311			255	302	154000	670	49	68	251082
182	156-095-16	MM	8389	8390	15200	1624	82936			660	265	158976	580	48	68	259661
182	156-095-16	MM	8415	8484	10860	1600	83994			170	458	153000	670	49	68	250082
443	156-095-16	MM	8444	8480	10472	1484	79579			220	372	145200	750	50	68	237327
790	156-095-16	MM	8432	8474	12360	1600	93521			255	322	170400	700	47	68	278458
1014	156-095-16	MM	8425	8455	12940	1380	50017			205	474	103600	690	60	68	168616
152	156-095-17	MM	8470	8516	13518	1828	84152			160	266	158760	690	49	68	258684
204	156-095-17	MM	8420	8452	8940	1720	72091			160	457	131600	660	53	68	214968
296	156-095-17	MM	8448	8506	11804	1714	78977			270	332	147300	700	50	68	240397

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
325	156-095-17	MM	8443	8475	13824	1740	94431			245	441	174720	640	47	68	285401
388	156-095-17	MM	8449	8496	12566	2284	85633			245	428	160520	700	47	68	261676
4382	156-095-17	MM	8548	8570	16968	2144	77619			120	340	155680	610	49	68	252871
269	156-095-18	MM	8420	8456	11044	2056	83474			205	345	153920	750	49	68	251044
479	156-095-18	MM	8470	8496	10472	1598	75598			305	350	139360	730	50	68	227683
500	156-095-18	MM	8454	8465	13518	1941	91551			230	403	170360	740	47	68	278003
647	156-095-18	MM	8472	8507	12186	2170	85083			245	301	158760	700	49	68	258745
1035	156-095-18	MM	8430	8742	61	9	3372			1905	679	3727	820	760	68	9753
1075	156-095-18	MM	8482	8488	12756	1714	88721			245	289	164060	700	47	68	267785
153	156-095-19	MM	8484	8530	11614	2284	91791			205	315	168444	710	47	68	274653
268	156-095-19	MM	8461	8500	9900	1484	79661			305	407	144240	730	50	68	235997
405	156-095-19	MM	8427	8459	11420	1380	91894			205	344	165600	710	48	68	270843
405	156-095-19	MM	8532	8550	6474	800	49248			465	543	89080	760	66	68	146610
1039	156-095-19	MM	8457	8487	10852	1484	78804			280	374	144640	720	49	68	236434
102	156-095-20	MM	8510	8526	11804	1713	93991			490	287	170360	750	47	68	278645
131	156-095-20	MM	8520	8600	10092	1142	76273			195	408	138420	780	51	68	226530
289	156-095-20	MM	8548	8595	12566	1942	83336			195	277	156120	690	49	68	254436
311	156-095-20	MM	8538	8580	8760	1380	68046			280	431	124000	740	54	68	202897
324	156-095-20	MM	8562	8600	7044	1828	50664			390	614	95260		155		155800
80	156-095-21	MM			10092	1828	66961			1600	406	125240	720	53	68	206127
424	156-095-21	MM	8507	8488	8000	1140	65572			405	523	118000	750	55	68	193640
429	156-095-21	MM	8476	8503	13138	1256	95103			230	254	173280	740	47	68	283261
444	156-095-21	MM	8507	8514	13140	1280	98783			270	262	179000	700	46	68	292735
219	156-095-22	MM	8474	8510	6854	1276	89432			205	290	153460	700	49	68	251517
428	156-095-22	MM	8545	8566	14820	1740	92924			315	277	173636	540	47	68	283712
428	156-095-22	MM	8545	8566	14440	1740	94820			540	272	176364	550	47	68	288176
168	156-095-28	MM	8627	8663	11800	1380	85758			280	294	156800	720	49	68	256312
190	156-095-28	MM	8620	8675	11040	1600	73814			340	346	137600	700	50	68	224740
191	156-095-28	MM	8610	8670	8568	1714	60372			295	281	112900	730	57	68	184130
417	156-095-28	MM	8600	8626	11800	2056	86941			270	297	160600	670	48	68	261964
788	156-095-28	MM	8602	8615	12560	1600	95071			245	256	173200	720	47	68	282932
183	156-095-29	MM	8564	8610	12376	914	79			195	352	147300	700	49	68	161216
192	156-095-29	MM	8628	8670	9520	1260	72288			245	376	131600	730	52	68	215289

CHEMICAL DATA

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WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
218	156-095-29	MM	8504	8532	11800	1484	89950			245	280	163600	650	48	68	267359
351	156-095-29	MM	8500	8545	12756	1484	84022			270	299	156120	730	49	68	254951
391	156-095-29	MM	8570	8604	12000	1820	95305			220	290	173200	720	47	68	282835
480	156-095-29	MM	8532	8570	9900	2284	71527			280	379	134060	730	51	68	218430
69	156-095-30	MM	8463	8490	12756	1828	103932			195	403	187800	640	46	68	306914
101	156-095-30	MM	8468	8516	10472	1942	74415			280	446	138480	730	51	68	226035
137	156-095-30	MM	8460	8500	12186	1828	84566			205	286	157000	710	49	68	256071
414	156-095-30	MM			11234	1714	76740			205	331	142880	700	50	68	233104
418	156-095-30	MM	8486	8526	12376	1828	99939			230	306	181020	700	46	68	295699
812	156-095-30	MM	8456	8476	13320	1714	104720			170	253	189800	640	46	68	309977
55	156-095-31	MM	8460	8490	12756	2056	86325			145	316	161400	720	48	68	262998
119	156-095-31	MM	8450	8480	10282	1256	68437			170	430	127000	760	53	68	207575
189	156-095-31	MM	8426	8436	7236	1028	56397			340	1292	101640	730	60	68	167933
189	156-095-31	MM	8426	8469	7616	1713	55650			245	799	103576	770	60	68	169599
272	156-095-31	MM	8393	8438	11234	1828	71613			230	351	133180	750	51	68	218436
331	156-095-31	MM	8442	8487	12566	1714	79763			195	282	149940	730	50	68	244460
442	156-095-31	MM	8500	8560	12948	1598	82401			195	267	154360	730	49	68	251769
159	156-095-32	MM	8434	8472	7616	1142	49656			425	719	92620	790	64	68	152178
169	156-095-32	MM	8423	8456	10660	1720	75686			295	334	140200	690	51	68	228895
169	156-095-32	MM	8423	8456	11234	1828	70254			245	337	133180	760	52	68	217078
187	156-095-32	MM	8450	8481	10092	1598	65172			255	399	122600	720	54	68	200116
214	156-095-32	MM	8508	8550	9710	2170	76565			330	397	141120	770	50	68	230292
433	156-095-32	MM	8554	8566	11996	1828	86692			245	321	157800	750	48	68	258882
679	156-095-32	MM	8537	8542	12948	1370	82851			220	286	154360	730	49	68	252035
741	156-095-32	MM	8501	8506	12376	1598	81412			245	393	151700	700	48	68	247724
841	156-095-33	MM	8594	8601	12760	1380	94743			255	257	172400	700	47	68	281795
309	156-095-35	MM	8415	8449	18810	1624	88219			258	415	173636	540	47	68	282962
309	156-095-35	MM	8416	8445	25800	1708	43146				346	116928	470	60	68	187928
59	156-096-25	MM	8520	8540	12756	1828	100079			195	236	181980	700	46	68	297074
225	156-096-25	MM	8486	8521	10852	2170	89789			280	353	163600	720	48	68	267044
688	156-096-25	MM	8485	8726	27	5	3926			1710	515	4744	790	690	68	10927
185	156-096-35	MM	8300	8328	12160	1826	100460			340	359	181332	550	46	68	296477
185	156-096-35	MM	8380	8409	9900	1942	74400			245	454	137460	730	51	68	224401

CHEMICAL DATA

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WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
870	156-096-35	MM	8372	8379	11234	2284	84709			255	313	156820	720	49	68	255615
982	156-096-35	MM	8372	8605	2476	914	22822			425	515	41620	740	120	68	68772
45	156-096-36	MM	8472	8500	13138	2056	87035			185	286	163170	720	48	68	265870
113	156-096-36	MM	8366	8404	13680	1740	91079			186	314	169452	540	47	68	276451
113	156-096-36	MM	8366	8404	13328	3198	79568			195	383	155240	730	49	68	251912
323	156-096-36	MM	8416	8457	11044	1598	90395			245	349	161400	730	48	68	265031
420	156-096-36	MM	8448	8469	12566	2398	97353			170	284	179080	700	46	68	291851
497	156-096-36	MM	8395	8415	12756	1598	82649			185	331	154360	49	730	68	251879
497	156-096-36	MM	8484	8516	10538	1180	79355			120	350	144160	620	50	68	235703
2567	157-075-01	MM	2972	2992	2100	930	35650			78	5078	57630	660	89	68	101466
2567	157-075-01	MM	3036	3057	2650	1230	53281			68	4350	87210	710	65	68	148789
2610	157-075-10	MM	3012	3052	2352	667	44883			58	5290	71400	680	74	68	124650
2610	157-075-10	MM	3122	3138	2832	1044	56470			132	4451	91800	680	63	68	156729
2956	157-079-33	MM	4008	4020	4400	1320	75443			288	2526	125970	600	53	68	209947
883	157-080-21	MM	4362	4382	912		15740		168	37	9612	18583	1070	190	68	45052
392	157-085-21	MM	6016	6116	8455	1972	98393			355	989	171540	550	49	68	281704
1503	157-087-17	MM	6668	6681	17700	3340	94900			600	427	186000	680	46	68	302967
175	157-094-05	MM	8227	8244	12000	1940	100570			195	407	181600	680	46	68	296712
307	157-094-05	MM	8239	8290	11920	2300	102282			170	357	185200	740	46	68	302229
129	157-094-06	MM	8264	8304	11800	1940	102551			170	293	184400	690	46	68	301154
184	157-094-06	MM	8272	8312	13056	1740	100511			207	274	182886	600	46	68	298674
367	157-094-06	MM	8213	8263	10660	1480	83992			145	334	152400	690	49	68	249011
415	157-094-06	MM	8268	8308	4760	1260	43592			145	810	78652	760	71	68	129219
493	157-094-06	MM	8224	8253	10860	1720	90337			195	349	163200	690	48	68	266661
554	157-094-06	MM	8268	8289	10380	1040	86875			135	165	155200	720	49	68	253795
245	157-094-07	MM	8270	8297	11540	2180	102462			160	441	184400	730	46	68	301183
502	157-094-07	MM	8281	8289	10960	2200	100007			160	227	179800	680	46	68	293354
513	157-094-07	MM	8229	8240	11424	1941	99334			170	444	178664	670	46	68	291977
978	157-094-07	MM	8278	8286	11740	2180	99715			120	359	180600	710	46	68	294714
1030	157-094-08	MM	8298	8538	9320	1380	73681			355	484	133600	820	50	68	218820
1116	157-094-08	MM	8238	8245	12120	2420	98268			230	190	179800	680	46	68	293028
1092	157-094-18	MM	8257	8277	11040	1260	96853			195	387	172200	780	47	68	281935
1093	157-094-18	MM	8255	8264	12120	1270	98575			160	275	176900	670	46	68	289300

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1191	157-094-18	MM	8210	8231	11420	2280	98575			185	262	178600	690	46	68	291322
1253	157-094-18	MM			10780	1962	83602			185	350	153380	700	49	68	250259
1253	157-094-18	MM	8159	8259	10780	1962	83602			185	350	153380	700	49	68	250259
724	157-094-30	MM	8264	8272	11995	1827	91932			230	318	167984	690	47	68	274286
612	157-094-31	MM	8284	8318	13068	3120	96688			240	386	180930	550	46	68	294432
612	157-094-31	MM	8284	8318	12186	1599	92760			160	346	168954	670	47	68	276005
822	157-094-31	MM	8336	8537	3175	692	26177			475	930	47050	750	110	68	78499
1032	157-094-31	MM	8321	8327	11805	1599	93291			245	476	168954	710	48	68	276370
1032	157-094-31	MM	8321	8327	11805	1599	93291			245	476	168954	710	48	68	276370
82	157-095-01	MM	8242	8290	13248	266	102182			188	266	185820	570	46	68	301970
82	157-095-01	MM	8242	8290	12350	2204	90736			410	441	167670	550	47	68	273811
114	157-095-01	MM	8292	8331	9901	2284	82884			355	461	151476	730	49	68	247361
299	157-095-01	MM	8226	8254	6660	1380	61326			195	660	109800	670	57	68	180021
350	157-095-01	MM	8260	8276	11800	1820	98357			110	314	177600	650	46	68	290001
398	157-095-01	MM	8265	8300	3998	679	36131			170	811	64086	750	83	68	105875
398	157-095-01	MM	8265	8300	3944	808	32606			185	325	59280	730	89	68	97148
419	157-095-01	MM	8254	8499	3560	580	29844			1295	474	52920	760	98	68	88673
855	157-095-01	MM	8282	8302	11920	1740	99140			145	270	178800	690	46	68	292015
256	157-095-02	MM	8275	8320	13248	2204	100671			185	269	184842	610	46	68	301419
256	157-095-02	MM	8275	8320	13248	2204	100671			185	269	184842	610	46	68	301419
1062	157-095-02	MM	8267	8290	9720	1380	67659			145	227	169920	610	49	68	249051
1477	157-095-09	MM	8332	8361	12544	1888	96224			120	395	175760	650	49	68	286931
1165	157-095-10	MM	8285	8292	12186	1485	100540			160	367	180606	690	46	68	295344
93	157-095-11	MM	8258	8294	7800	1260	72019				490	128200	400	53	68	209769
366	157-095-11	MM	8208	8274	4960	1020	42588			195	821	76720	730	72	68	126304
811	157-095-11	MM			2980	405	28490			755	433	49640	730	100	68	82703
913	157-095-11	MM	8171	8242	100	30	5732			905	535	8100	860	470	68	15402
971	157-095-11	MM			9330	1256	79154			185	527	141766	710	51	68	232218
1027	157-095-11	MM			11805	1713	105614			185	415	188374	700	46	68	308106
1027	157-095-11	MM	8202	8268	144	127	594			135	280	1256	680	2620	68	2536
32	157-095-12	MM	8312	8350	35590	6920	40321			185	425	144920	650	50	68	228361
32	157-095-12	MM	8312	8350	14652	2160	103075			240	490	190710	550	46	68	311327
62	157-095-12	MM	8258	8290	1485	171	16623			585	494	28062	810	160	68	47420

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
681	157-095-12	MM	8289	8297	11420	2060	99681			135	341	179600	670	670	68	293237
606	157-095-13	MM	8265	8271	10960	1260	88372			305	270	159000	570	48	68	260167
606	157-095-13	MM	8265	8271	7045	799	62985			60	334	111666	740	57	68	182889
649	157-095-13	MM	8260	8268	12864	1624	96512			205	274	176040	620	46	68	287519
649	157-095-13	MM	8260	8268	12864	1624	96512			205	274	176040	620	46	68	287519
876	157-095-13	MM	8291	8298	13660	1384	90480			160	235	167500	690	47	68	273419
1018	157-095-13	MM	8279	8287	11805	1370	96133			135	334	172838	730		68	282615
301	157-095-14	MM	8240	8272	171	80	692			390	272	1175	820	2520	68	2780
365	157-095-14	MM	8238	8271	11220	1700	97349			160	321	174600	750	47	68	285350
473	157-095-14	MM	8238	8244	11805	1713	96741			145	319	174780	680	46	68	285503
1043	157-095-14	MM	8162	8227	11360	1962	92083			135	379	167500	690	47	68	273419
315	157-095-23	MM	8270	8310	329	45	1623			525	1070	2120	740	1280	68	5712
315	157-095-23	MM	8276	8290	12314	1732	101753			145	275	183500	690	46	68	299719
928	157-095-23	MM	8251	8261	3040	680	28041			465	1118	49520	720	99	68	82864
1077	157-095-23	MM			2500	580	19427			1365	5658	34800	760	130	68	64330
751	157-095-24	MM	8251	8257	12314	1732	93770			135	183	171260	660	47	68	279394
946	157-095-24	MM	8260	8268	12120	1380	102087			170	318	182600	710	298		298675
989	157-095-24	MM	8269	8276	11736	1732	97531			185	251	175960	680	47	68	287395
990	157-095-24	MM	8263	8271	12672	2640	98729			270	457	181908	550	46	68	296676
552	157-095-25	MM	8257	8266	11995	1827	95052			145	328	172838	700	47	68	282185
552	157-095-25	MM	8257	8266	14046	1154	90481			185	235	167500	700	47	68	273601
626	157-095-25	MM	8228	8239	9720	1020	43875			7	601	87400	560	66	68	142623
666	157-095-25	MM	8220	8230	11995	1370	95430			220	568	171868	700	46	68	281451
935	157-095-25	MM	8247	8253	11995	1713	95273			37	425	172838	660	47	68	282281
1047	157-095-25	MM	8191	8196	11424	1599	93626			185	310	168954	700	47	68	276098
744	157-095-26	MM	8238	8418	3660	580	28645			425	412	51800	700	100	68	85522
1029	157-095-26	MM			11424	1485	91397			230	428	165070	710	48	68	270034
1029	157-095-26	MM	8230	8236	11210	1596	91628			234	546	165282	570	48	68	270496
1078	157-095-26	MM	8214	8221	11805	1485	95971			170	423	172838	710	47	68	282692
257	157-095-35	MM	8300	8328	12566	1370	94658			205	334	171868	680	47	68	281001
257	157-095-35	MM	8300	8328	11928	2192	90913			170	170	167500	700	47	68	272873
77	157-095-36	MM	8323	8372	13056	1508	96516			212	280	176040	600	46	68	287612
290	157-095-36	MM	8282	8310	13248	1392	96509			196	280	176040	620	46	68	287665

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
507	157-095-36	MM	8300	8309	13056	1624	96302			210	293	176040	590	46	68	287525
507	157-095-36	MM	8300	8309	13056	1624	96302			210	293	176040	590	46	68	287525
770	157-095-36	MM	8269	8281	12000	1720	90899			170	425	166042	660	47	68	271256
909	157-095-36	MM	8284	8291	11920	1740	95913			175	5	174000	690	47	68	283753
1973	158-077-13	MM	3325	3348	2574	1268	36937			100	1640	63956	730	83	68	106475
2652	158-078-13	MM	3343	3363	2160	552	45288			63	5910	70890	690	76	68	124863
2708	158-080-05	MM	4242	4272	5200	1200	88434			168	2030	147510	590	51	68	244542
3396	158-080-05	MM	6742	6755	8360	1482	114444			205	445	195190	670	49	68	320126
3396	158-080-05	MM	6743	6755	8360	1482	114444			205	445	195190	670	49	68	320126
2670	158-080-06	MM	4201	4212	5184	1334	96117			118	1178	160380	620	48	68	264311
2803	158-080-06	MM	4278	4333	5376	1450	97780			335	1825	163020	590	48	68	269786
3151	158-080-08	MM	4246	4264	4940	1480	95649			340	1955	158950	580	49	68	263314
2554	158-081-06	MM	4514	4525	6528	1392	105315			132	1051	177200	630	47	68	291618
2614	158-081-06	MM	4528	4543	5600	1320	90477			305	184	153000	630	49	68	250886
2614	158-081-06	MM	4554	4574	6200	1260	108393			330	112	181560	620	46	68	297855
1689	158-081-07	MM	4512	4539	6076	1770	91889			270	1644	156275	550	47	68	257924
2696	158-081-07	MM			5962	1568	92566			317	959	162000	640	52	68	263372
3194	158-081-07	MM	4499	4512	5194	1298	74472			390	2311	125913	620	53	68	209578
2663	158-081-08	MM	4519	4529	6700	1458	106789			305	889	180000	730	50	68	296141
4127	158-081-13	MM	4576	4583	6500	1260	104939			270	895	176220	610	47	68	290084
4127	158-081-13	MM	4589	4595	6500	1260	103628			310	807	174240	560	47	68	286745
2633	158-081-19	MM	4558	4573	5500	1140	87822			224	2043	146880	650	50	68	243609
2617	158-082-02	MM	4559	4572	6200	1440	103338			365	1287	173400	640	47	68	286030
3145	158-082-03	MM	4583	4603	5520	1480	85088			340	1856	143760	560	49	68	238044
2835	158-082-10	MM	4564	4581	6700	1620	101323			400	974	171912	590	47	68	282929
2926	158-082-13	MM	4560	4580	7600	840	104307			366	962	175864	610	47	68	289939
3116	158-082-15	MM	4600	4620	6840	1596	101146			362	1246	171639	570	47	68	282829
1876	158-087-22	MM	6161	6202	4455	826	117643			145	1194	190784	650	46	68	315047
1876	158-087-22	MM	6224	6250	10791	1652	100268			295	843	177776	620	46	68	291625
1844	158-091-10	MM	7680	7724	4356	1003	121641			145	1200	197288	640	47	68	325633
416	158-093-15	MM	8312	8364	3135	870	67381			255	4181	108784	550	62	68	184606
416	158-093-15	MM	8367	8400	6745	1073	105675			305	1506	176774	520	48	68	292078
441	158-094-05	MM	8238	8263	12120	1500	98156			160	185	177000	690	46	68	289121

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
484	158-094-05	MM	8240	8260	9720	1260	84346			245	444	150506	690	49	68	246521
629	158-094-05	MM	8197	8217	11920	1500	102041			185	205	182600	710	46	68	298451
804	158-094-05	MM	8240	8249	11614	1713	101396			170	360	181578	680	46	68	296831
340	158-094-06	MM	8185	8240	11360	3116	99657			170	328	182560	680	46	68	297191
393	158-094-06	MM	8204	8245	12376	1827	94650			205	354	172838	690	47	68	282250
510	158-094-06	MM	8183	8234	12186	1142	101825			185	362	181578	710	46	68	297278
628	158-094-06	MM	8218	8236	11800	1820	102176			110	275	183520	670	46	68	299701
662	158-094-06	MM	8200	8253	12320	1740	104224			160	461	187200	730	46	68	306105
728	158-094-06	MM	8106	8145	11540	1620	102324			160	380	102324	720	46	68	218348
728	158-094-06	MM	8106	8205	11540	1620	102324			160	380	182600	720	46	68	298624
238	158-094-07	MM	8116	8156	9240	2420	77769			220	315	143000	710	50	68	232964
238	158-094-07	MM	8116	8158	9240	2420	77769			220	315	143000	710	50	68	232964
312	158-094-07	MM	8158	8194	11740	1620	102003			175	175	182600	650	46	68	298313
339	158-094-07	MM	8200	8240	11740	1740	95712			185	230	173200	570	47	68	282807
346	158-094-07	MM	8170	8210	8568	1256	75642			170	579	134970	700	52	68	221185
452	158-094-08	MM	8226	8246	13276	1154	100530			195	250	181620	710	46	68	297025
506	158-094-08	MM	8205	8217	12314	1846	96647			170	251	175960	690	47	68	287188
314	158-094-10	MM	8193	8246	11360	1740	97273			195	135	175000	570	47	68	285703
209	158-094-17	MM	8141	8180	10780	2080	98040			160	360	176000	730	47	68	287420
285	158-094-17	MM	8158	8211	12314	1846	89315			160	220	164680	700	47	68	268535
753	158-094-17	MM	8195	8400	6160	1260	49607			830	552	90200	760	65	68	148609
99	158-094-18	MM	8121	8176	11904	1972	97610			244	286	177018	580	47	68	289034
99	158-094-18	MM	8122	8260	6283	1256	55795			685	581	100014	720	61	68	164614
99	158-094-18	MM	8160	8218	13300	1740	96089			366	330	176364	550	46	68	288189
132	158-094-18	MM	8098	8228	4240	1040	38649			245	550	69600	720	78	68	114324
176	158-094-18	MM	8111	8150	8860	1960	81480			135	260	146800	730	50	68	239495
215	158-094-18	MM	8195	8254	11420	1720	99267			185	311	178000	690	46	68	290903
282	158-094-18	MM	8086	8127	5570	776	57380			145	731	100000	740	60	68	164602
326	158-094-18	MM			14360	1300	99995			185	244	183150	660	47	68	299234
326	158-094-18	MM	8117	8169	11043	1599	97225			220	311	173810	700	46	68	284208
345	158-094-18	MM	8084	8140	10960	700	92963			160	180	164600	720	48	68	269563
355	158-094-18	MM	8049	8120	10100	1280	90361			170	359	161200	700	48	68	263470
148	158-094-19	MM	8142	8216	10860	1720	97696			195	316	174784	680	47	68	285571

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
148	158-094-19	MM	8150	8186	10960	1500	90296			170	195	162800	710	48	68	265921
195	158-094-19	MM	8182	8240	10780	1620	97587			220	260	174000	670	47	68	284467
250	158-094-19	MM	8162	8225	11920	1384	97361			185	235	175020	700	47	68	286105
581	158-094-19	MM	8186	8198	11740	2078	97896			255	275	177840	700	46	68	290084
523	158-094-20	MM	8206	8216	558	162	13328			465	1150	20900	790	21	68	36563
523	158-094-20	MM	8208	8216	558	162	13328			465	1150	20900	790	210	68	36563
650	158-094-20	MM	8225	8233	11920	1840	98307			220	220	177800	680	46	68	290307
703	158-094-20	MM	8208	8217	12120	1840	100981			195	617	182000	700	46	68	297753
894	158-094-20	MM	8262	8503	54	16	3718			1645	550	4515	710	72	68	10498
906	158-094-29	MM	8291	8297	12000	1940	99365			185	336	179800	790	46	68	293626
964	158-094-29	MM	8263	8269	12180	1720	101363			185	280	182600	690	46	68	298328
199	158-094-30	MM	8222	8276	12540	1624	54023			92	499	109830	530	58	68	178608
199	158-094-30	MM	8226	8236	11920	1620	101804			175	190	182600	660	46	68	298309
454	158-094-30	MM	8250	8295	8940	1140	109340			255	321	187400	690	46	68	307396
482	158-094-30	MM	8214	8236	12672	1740	102854			215	268	185820	600	46	68	303569
667	158-094-30	MM	8218	8228	12180	2160	96959			135	440	177000	780	47	68	288874
809	158-094-30	MM	8256	8263	12180	2060	101901			205	292	184400	690	46	68	301038
135	158-094-31	MM	8287	8336	12380	2160	101531			185	286	178800	780	46	68	295342
186	158-094-31	MM	8271	8300	8860	220	25975			100	165	56200	750	94	68	91520
368	158-094-31	MM	8260	8274	12320	2080	99796			175	125	181600	680	46	68	296096
400	158-094-31	MM	8306	8346	1540	700	108987			170	235	172600	720	47	68	284232
487	158-094-31	MM	8235	8247	12000	1820	100078			170	280	180600	690	46	68	294948
498	158-094-31	MM	8228	8274	11100	1140	102345			205	145	180600	710	46	68	295535
729	158-094-31	MM	8226	8243	12890	2078	94344			205	255	174080	710	47	68	283852
729	158-094-31	MM	8228	8243	12890	2078	94344			205	255	174080	710	47	68	283852
749	158-094-31	MM	8206	8225	4425	1185	40243			85	215	73150	720	75	68	119303
488	158-094-32	MM	8255	8273	11420	1820	98903			185	359	177694	670	46	68	290381
908	158-094-32	MM	8222	8476	760	920	97154			280	433	153400	700	49	68	252947
908	158-094-32	MM	8222	8478	760	920	97154			280	433	153400	700	49	68	252947
495	158-095-01	MM	8148	8255	8930	1276	87015			135	1279	152716	500	48	68	251351
495	158-095-01	MM	8160	8195	12320	1620	99499			145	150	179800	700	46	68	293534
726	158-095-01	MM	8150	8184	12186	1370	102056			85	509	182548	680	46	68	298754
726	158-095-01	MM	8160	8195	12672	2400	99142			170	453	181908	550	46	68	296745

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
783	158-095-01	MM			960	1120	72757			1695	453	4980	750	680	68	81965
1016	158-095-11	MM	8078	8154	12186	1941	101555			185	321	183520	710	46	68	299708
1051	158-095-11	MM			3998	571	37180			940	655	65058	760	81	68	108402
228	158-095-12	MM			10853	1142	105804			170	231	185462	680	46	68	303662
576	158-095-12	MM			11995	1485				195	11513	189346	700	46	68	214534
627	158-095-12	MM	8185	8193	11234	1713	100608			160	443	179636	680	46	68	293794
905	158-095-12	MM	8178	8192	11995	1713	100956			205	326	181578	680	46	68	296773
108	158-095-13	MM	8188	8218	11740	1500	101542			120	135	181600	700	46	68	296637
156	158-095-13	MM	8136	8225	377	90	3155			280	236	5460	750	710	68	9598
157	158-095-13	MM	8152	8178	11424	1485	102071			220	375	181578	710	46	68	297153
158	158-095-13	MM			11160	1840	103567			170	487	184400	610	46	68	301624
158	158-095-13	MM	8102	8246	7620	1380	73359			160	497	130200	710	52	68	213216
276	158-095-13	MM	8139	8250	10960	1740	103239			230	235	183400	720	46	68	299804
509	158-095-13	MM	8182	8220	10960	1620	97352			185	230	175000	690	47	68	285347
717	158-095-14	MM	8634	8650	6283	1142	57969			245	1074	102926	750	60	68	169639
800	158-095-14	MM			4570	1256	39675			1015	679	71854	770	76	68	119049
800	158-095-14	MM	8265	8283	12566	1370	109729			170	288	195170	700	46	68	319293
130	158-095-23	MM	8246	8295	11995	1256	104973			195	347	186432	720	46	68	305198
212	158-095-23	MM	8246	8295	11805	1256	109578			170	326	193230	700	46	68	316365
574	158-095-23	MM	8309	8319	9139	1713	90429			160	459	160216	730	49	68	262116
641	158-095-23	MM	8326	8336	12120	1740	99540			160	218	179800	720	46	68	293578
241	158-095-24	MM	8234	8276	11920	1960	96636			135	251	175600	700	47	68	286502
252	158-095-24	MM	8194	8280	7426	1370	68682			205	823	122346	730	54	68	200852
253	158-095-24	MM	8261	8307	10860	1380	88371			160	345	159200	790	48	68	260316
319	158-095-24	MM	8136	8204	7616	1256	63528			185	598	114578	690	56	68	187761
332	158-095-24	MM	8180	8230	10100	1480	87825			160	456	157220	690	49	68	257241
154	158-095-25	MM	8372	8400	11740	1840	96051			185	250	174000	700	47	68	284066
233	158-095-25	MM	8200	8242	14440	1500	94269			185	275	175020	680	47	68	285689
259	158-095-25	MM	8266	8336	11540	1500	96864			175	135	174000	710	47	68	284214
266	158-095-25	MM			12000	1940	76190			405	506	143800	660	50	68	234841
266	158-095-25	MM	8260	8300	11420	1940	100516			165	282	180600	670	46	68	294923
423	158-095-25	MM	8304	8335	11220	1140	95403			205	288	170000	790	47	68	278256
423	158-095-25	MM	8365	8395	16720	2088	93717			135	319	179912	530	46	68	292891

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
466	158-095-25	MM	8274	8316	12864	1856	99400			149	300	181185	590	46	68	295754
466	158-095-25	MM	8274	8316	12864	1856	99400			149	300	181185	590	46	68	295754
298	158-095-26	MM	8278	8335	12864	1508	97994			188	277	177996	630	46	68	290827
298	158-095-26	MM	8278	8335	12864	1508	97994			188	277	177996	630	46	68	290827
356	158-095-26	MM	8300	8350	6100	920	57758			160	640	102000	810	60	68	167578
537	158-095-26	MM	8268	8301	12864	1508	99901			173	299	180930	610	46	68	295675
541	158-095-26	MM	8304	8332	12864	1508	100221			206	280	181419	590	46	68	296498
541	158-095-26	MM	8304	8332	12864	1508	100221			206	280	181419	590	46	68	296498
556	158-095-26	MM	8277	8448	5140	1140	44191			840	668	79600	810	70	68	131579
677	158-095-27	MM	8276	8511	4189	1142	40979			1025	716	72826	800	75	68	120877
118	158-095-35	MM			2475	571	220281			1365	690	36024	760	120	68	261406
453	158-095-35	MM	8276	8308	8940	800	78505			170	464	138800	770	51	68	227679
471	158-095-35	MM	8328	8356	9040	2078	73230			185	460	134560	700	52	68	219553
127	158-095-36	MM	8306	8344	12000	1820	105789			170	292	189400	660	46	68	309471
213	158-095-36	MM	8293	8332	12180	1820	104785			160	258	188200	700	46	68	307403
353	158-095-36	MM	8346	8390	12500	1740	100913			170	198	182600	690	46	68	298121
421	158-095-36	MM	8249	8274	10662	1485	94085			145	334	167984	710	47	68	274695
447	158-095-36	MM	8271	8290	7620	1380	72075			170	514	128200	750	53	68	209959
781	158-095-36	MM	8330	8360	10662	1370	91883			220	484	164100	690	48	68	268719
847	158-095-36	MM	8312	8340	5520	800	47985			270	756	85400	820	68	68	140731
2960	159-080-31	MM	4229	4248	5568	1508	95783			356	2340	160056	600	48	68	265611
3009	159-081-30	MM	4547	4562	5376	1160	77977			298	2158	131404	620	52	68	218373
2976	159-081-31	MM	4510	4523	5472	1276	74561			318	2304	126524	620	53	68	210455
2471	159-081-33	MM	4492	4521	6528	1620	102518			270	1425	173194	720	47	68	285555
5986	159-082-35	MM	4547	4557	6600	1680	102196			410	1450	172900	560	47	68	285236
2792	159-082-36	MM	4500	4543	6400	4131	98946			312	520	175370	450	41	77	285679
1843	159-088-32	MM	6534	6584	5346	1239	111680			120	1332	184280	620	47	68	303997
796	159-094-29	MM	7669	7705	5100	610	114621			120	1667	186300	600	46	68	308418
796	159-094-29	MM	7878	7900	11900	1586	109400			190	762	193752	610	46	68	317590
796	159-094-29	MM	7965	7982	5700	1037	114741			58	1728	188784	620	46	68	312048
796	159-094-29	MM	8015	8040	11424	1485	102715			220	407	182548	710	46	68	298799
796	159-094-29	MM	8080	8100	17400	1708	101912			132	510	192510	630	46	68	314172
823	159-094-29	MM	7905	7965	2375	549	119182			78	3679	186876	500	46	68	312739

CHEMICAL DATA

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WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
823	159-094-29	MM	7970	8009	7220	1098	107477			102	1469	180612	530	46	68	297978
823	159-094-29	MM	8013	8029	3135	610	118401			88	2687	187920	530	46	68	312841
828	159-094-32	MM	8044	8295	6920	1160	57578			415	808	103600	750	59	68	170481
966	159-094-32	MM	8079	8088	6336	1080	108779			170	1515	180930	610	46	68	298810
1449	159-094-32	MM			11360	2080	102750			185	200	184000	690	46	68	300575
2790	159-094-34	MM	4500	4543	6400	4131	98946			312	520	175370	450	41	77	285679
2054	160-078-17	MM	3429	3446	2970	767	40819			170	5000	66666	710	820	68	116392
1910	160-079-04	MM	3382	3403	4405	1210	33214			135	2400	60704	690	94	68	102068
1910	160-079-04	MM	3448	3470	2772	885	40393			170	4100	66666	690	86	68	114986
962	160-080-05	MM	3640	3652	3990	1160	26683			170	2861	49389	620	100	68	84253
962	160-080-05	MM	3912	3924	3800	1508	47733			205	3354	82152	610	71	68	138752
2899	160-083-22	MM	4518	4540	6200	1800	94849			336	1733	161044	610	48	68	265962
4534	160-083-27	MM	4520	4550	6500	2400	90655			270	775	157600	640	50	68	258200
2995	160-083-30	MM	4662	4696	7680	2320	105031			366	1028	177840	550	46	68	294265
2995	160-083-30	MM	4906	4920	6912	1624	99177			312	1099	168948	560	47	68	278072
7227	160-084-32	MM	4900	4927	17635	1702	61900	510		92	1710	128800	672	49	77	211844
7227	160-084-32	MM	4951		15832	1823	59500	450		140	1740	121600	680	51	77	200640
7227	160-084-32	MM	4951	4952	11423	1702	85100	1510		177	2010	161600	667	44	77	262027
995	160-089-23	MM	6160	6213	8170	1566	104851			102	1001	179952	600	47	68	295642
995	160-089-23	MM	6322	6412	9785	1798	107593			440	652	187776	600	46	68	308044
1660	160-092-01	MM	7222	7253	8232	1534	95983			145	1228	166098	530	48	68	273220
2071	160-094-03	MM	7600	7647	10890	1880	113732			135	1020	199346	630	47	68	327003
2071	160-094-03	MM	7782	7800	10494	1888	107201			170	1060	188544	640	46	68	309357
2194	160-094-29	MM	7937	7955	10692	1711	106984			205	360	188540	630	47	68	308492
2646	160-094-29	MM	7933		11000	1440	108468			149	315	190650	660	46	68	312022
2646	160-094-29	MM	7933	7933	11000	1440	108468			149	315	190650	660	46	68	312022
5716	160-096-13	MM	7787	7806	2198	83	100498			111	500	162000	640	57	68	265390
2777	161-078-17	MM	3341	3358	2832	783	41478			110	4337	68023	700	77	68	117563
2705	161-078-19	MM	3329	3355	2620	360	42668			112	4234	68310	670	77	68	118304
2424	161-078-20	MM	3322	3336	2746	499	52407			98	3988	84150	740	69	68	143888
2457	161-078-20	MM	3313	3348	2880	986	57708			120	4750	93408	720	64	68	159852
1592	161-079-15	MM	3465	3490	3332	1475	50394			160	4000	83388	800	68	68	142749
1656	161-079-16	MM	3443	3498	9504	1652	44852			415	1550	89430	620	66	68	147403

CHEMICAL DATA

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WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
893	161-079-21	MM	3476	3509	4845	1276	48166			100	2663	84564	610	68	68	141614
1996	161-079-23	MM	3368	3390	5049	1239	50478			75	2000	88888	650	70	68	147729
2289	161-079-25	MM	3308	3324	6336	1357	52159			255	1480	94380	650	66	68	155967
1526	161-079-27	MM	3361	3380	3185	1121	52247			120	3798	86621	730	64	68	147092
2090	161-079-28	MM	3396	3462	2277	501	28921			65	3300	47627	670	115	68	82691
2187	161-080-01	MM	3438	3456	5346	1121	42620			110	2450	76596	720	75	68	128243
524	161-081-19	MM	4041	4048	1348	302	6141			425	3037	10250	620	350	68	21503
524	161-081-19	MM	4072	4125	5510	1972	92435			295	1360	156900	530	49	68	258472
524	161-081-19	MM	4092	4120	2565	696	13576			380	2959	25104	580	180	68	45280
524	161-081-19	MM	4114	4120	4940	1566	83103			362	1516	140160	530	53	68	231647
524	161-081-19	MM	4531	4557	5130	1856	65228			270	2675	112968	540	57	68	188127
2271	161-081-30	MM	4092	4129	5148	1357	75584			440	2350	127660	640	57	68	212539
2300	161-081-30	MM	4080	4112	5148	1298	80460			425	2050	135240	580	55	68	224621
2877	161-082-09	MM	4218	4236	6400	1800	102216			270	1596	172900	610	47	68	285182
2782	161-082-14	MM	4104	4122	4800	2187	109434			254	390	183180	570	41	77	300245
1058	161-082-15	MM	4142	4147	2273	689	15702			137	3132	27860	680	173	68	49793
1058	161-082-15	MM	4152	4158	3789	1020	27554			99	3214	49750	660		68	85426
1058	161-082-15	MM	4152	4168	4210	1530	49237			77	3037	85570	640	72	68	143661
1058	161-082-15	MM	4159	4167	3473	1071	29982			115	3004	53233	650	100	68	90878
2813	161-082-23	MM	4124	4145	5376	1566	100992			274	1021	168940	570	47	68	278169
2813	161-082-23	MM	4142	4145	5376	1566	100992			274	1021	168940	570	47	68	278169
2320	161-082-25	MM	4151	4167	5742	1534	98262			355	800	165400	580	49	68	272093
2320	161-082-25	MM	4182	4202	5890	2052	100341			270	1120	170200	630	48	68	279873
2343	161-082-25	MM			5700	1557	97443			256	965	164000	690	51	68	269921
2343	161-082-25	MM	4098	4111	5760	1740	104893			170	1001	176220	670	47	68	289784
2343	161-082-25	MM	4098	4112	5760	1740	104893			170	1001	176220	670	47	68	289784
6624	161-085-01	MM	4941	5000	6283	1409	107989			220	1020	186000	620	58	68	302921
3571	161-086-08	MM			9020	1820	105960			279	583	184250	630	41	68	301912
3838	161-086-16	MM	5294	5309	399	112	4653			7	11	5146	490	1191	76	10328
3838	161-086-16	MM	5294	5909	8000	1361	107019			429	530	182470	490	41	77	299809
1487	161-087-09	MM	5524	5553	9604	1652	93000			365	983	164320	630	48	68	269924
1487	161-087-09	MM	5555	5577	10976	2006	103347			365	522	184080	620	46	68	301296
1487	161-087-09	MM	5622	5640	4606	885	37601			170	2805	66560	650	82	68	112627

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1487	161-087-09	MM	5784	5807	10584	2124	102215			284	565	182000	600	46	68	297772
1083	161-090-11	MM	6155	6215	4356	840	34537			380	3486	60636	660	88	68	104235
945	161-090-28	MM	6530	6590	646	186	56664			234	2588	87042	610	660	68	147360
945	161-090-28	MM	6689	6741	1292	209	111541			254	959	174084	610	46	68	288339
1082	161-090-30	MM	6530	6590	3663	780	49978			220	3506	83130	600	68	68	141277
1082	161-090-30	MM	6817	6844	6237	1260	59653			305	2572	104646	600	59	68	174673
1082	161-090-30	MM	6882	6910	10890	1800	105125			355	868	185820	600	46	68	304858
2214	161-092-03	MM			7280	1320	110000	1030			335	186000	630			304945
836	161-092-06	MM	6890	6900	2300	976	90628			85	4918	143028	600	50	68	241935
836	161-092-06	MM	6960	6978	2600	488	85823			220	4877	134676	600	51	68	228684
836	161-092-06	MM	7245	7275	9200	1464	97041			136	1383	169128	600	47	68	278352
4759	161-092-35	MM	7261	7309	8480	1871	126767			425	5500	211580	500	38	77	354623
4759	161-092-35	MM	7261	7309	8480	1895	118215	7		478	4100	199510	500	39	77	332678
2996	161-096-25	MM	7648	7677	12096	1972	108846			210	384	194636	600	46	68	318144
2722	161-098-13	MM	7288	7390	4608	580	83453			96	2708	136620	620	51	68	228065
3827	162-078-20	MM	3865	3900	5002	1269	71737			120	2362	121389	740	54	68	201879
1435	162-079-04	MM	3295	3302	2573	696	27336			120	3955	27336	750	110	68	62016
3004	162-079-08	MM	3292	3309	3168	957	46884			120	4181	77558	8670	70	68	132868
3309	162-079-18	MM	3402	3412	3561	1354	52274			120	3983	87870	720	67	68	149162
2842	162-079-20	MM	3356	3388	3034	673	44321			168	4037	72618	730	74	68	124851
2740	162-079-30	MM	3393	3441	3200	1008	52313			44	3580	86625	650	66	68	146770
1670	162-080-06	MM	3522	3547	3332	1239	40191			195	3560	68761	640	82	68	117278
1588	162-080-17	MM	3538	3556	2499	620	25884			145	3741	43311	700	110	68	76200
1629	162-081-23	MM	3607	3620	4410	2242	46422			425	2377	83942	600	68	68	139818
916	162-081-26	MM	3636	3648	3515	928	32701			112	3255	56898	530	92	68	97409
916	162-081-26	MM	3692	3704	3040	928	49687			108	4378	81432	530	69	68	139573
1637	162-082-34	MM	4032	4042	5390	1652	99160			270	1420	166098	620	47	68	273990
1761	162-082-36	MM	3834	3843	5742	1711	50637			100	2165	91598	690	65	68	151953
1761	162-082-36	MM	4027	4035	5148	1711	99821			280	1312	166936	610	47	68	275208
1450	162-084-09	MM	4590	4610	3504	783	38846			365	3671	65480	730	81	68	112649
2729	162-085-22	MM	4730	4761	7600	1440	103440			285	1100	176220	640	47	68	290085
2484	162-090-09	MM	5802	5835	4032	928	65887			110	3292	108976	700	59	68	183225
985	162-090-16	MM	5830	5870	1782	276	14915			135	3831	24059	620	180	68	44998

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
2922	162-090-17	MM	5852	5884	2100	360	19182			230	4201	31120	710	150	68	57193
1554	162-091-04	MM	6110	6128	5782	1180	57169			255	2288	100016	670	60	68	166690
1461	162-091-05	MM	6155	6188	3293	661	33020			220	3247	56160	690	92	68	96601
1485	162-091-05	MM	6094	6108	1803	307	17774			234	4736	27872	790	170	68	52726
1535	162-091-05	MM	6078	6104	5586	1298	57514			195	603	101802	690	62	68	166998
1535	162-091-05	MM	6078	6104	5586	1298	57514			195	630	101802	690	62	68	167025
1580	162-091-06	MM	6081	6110	5292	1121	113123			230	728	186448	630	46	68	306942
1593	162-091-06	MM	6095	6140	774	101	3640			2700	3540	3180	680	595	68	13935
1687	162-091-06	MM	6081	6110	5292	1121	113123			230	728	186448	630	46	68	306942
1639	162-091-07	MM	6142	6174	5292	1062	109712			205	731	181028	640	46	68	298030
1639	162-091-07	MM	6142	6174	5292	1062	109712			205	731	181028	640	46	68	298030
1500	162-091-08	MM	6116	6161	3920	649	70267			390	3633	114304	690	60	68	193163
1878	162-091-08	MM	6108	6140	3564	885	57447			295	4100	94300	770	63	68	160591
3545	162-091-08	MM	6142	6179	2565	513	30300			220	5400	48660	600	100	68	87658
3431	162-091-35	MM			5600	1191	114306			195	860	188860	480	40	77	311012
2562	162-092-03	MM	6236	6263	7872	1392	107894			255	894	183600	640	46	68	301907
2474	162-092-12	MM	6237	6260	4876	880	123539			550	660	200940	720	47	68	331445
1847	162-092-22	MM	6348	6372	4356	106	89230			245	1800	144180	580	50	68	239917
1429	162-095-20	MM	7026	7032	11300	1820	104400			108	344	186000	650	41	68	303972
2970	162-101-20	MM	7022	7039	9024	1580	141527			98	756	196612	580	46	68	349597
6555	162-103-03	MM	6811	6950	14490	1740	63653			43	1111	128050	670	59	68	209087
1669	163-078-11	MM			720	194	4550			240	5090	5100	810	548	68	15894
1237	163-079-20	MM	3269	3292	4158	1080	47105			245	3198	80661	740	70	68	136447
1281	163-080-05	MM	3314	3340	1820	552	14665			145	3572	24730	760	180	68	45484
2119	163-080-19	MM	4519	4529	5634	2006	121674			340	900	204260	590	46	68	334814
438	163-080-21	MM	3394	3404	2613	841	24508			108	4033	41840	570	120	68	73943
438	163-080-21	MM	3401	3421	1976	314	14603			240	3712	24058	660	180	68	44903
438	163-080-21	MM	3417	3421	2945	870	42595			152	4444	70082	550	78	68	121088
993	163-081-12	MM	3396	3406	2653	672	23477			135	3646	40098	640	130	68	70681
1510	163-081-24	MM	3465	3475	1901	271	12888			440	3658	21078	710	210	68	40236
1353	163-082-04	MM	3692	3702	2030	570	18313			245	3984	30420	750	148	68	55562
911	163-082-31	MM	3730	3750	2090	464	19344			110	4119	31785	640	140	68	57912
3162	163-083-05	MM	3789	3821	3540	900	39605		72	37	3457	67320	860	77	68	114931

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
3770	163-083-16	MM	3828	3855	4290	1220	45560			100	2526	79500	730	70	68	133196
2283	163-083-23	MM	3953	3964	1782	283	12670			120	3500	20870	740	210	68	39225
2283	163-083-23	MM	3968	3988	3168	649	36292			280	3300	60880	600	88	68	104569
1436	163-083-25	MM	3995	4014	4800	1392	80811			355	2430	135200	650	51	68	224988
1436	163-083-25	MM	4010	4024	4320	1334	68115			270	2765	114400	680	56	68	191204
3914	163-084-26	MM	4240	4265	5640	1420	98770			85	1129	165600	680	48	68	272644
1794	163-086-03	MM	4526	4558	7400	1700	101700			204	1000	174000	640	43	68	286004
1539	163-086-13	MM	4399	4415	2450	3009	46495			110	2320	83048	710	72	68	137432
5557	163-086-13	MM			9618	2780	99804			256	560	183000	600	50	68	296018
5557	163-086-13	MM			9618	2780	99804			256	560	183000	600	50	68	296018
5708	163-086-13	MM			9160	1946	90946			268	584	166000	620	50	68	268904
5708	163-086-13	MM			9160	1946	90946			268	584	166000	620	50	68	268904
5587	163-087-01	MM			9618	3058	100568			171	540	185000	620	50	68	298955
5587	163-087-01	MM			9618	3058	100568			171	540	185000	620	50	68	298955
5634	163-087-01	MM			10076	834	107430			171	516	190000	630	50	68	309027
5634	163-087-01	MM			10076	834	107430			171	516	190000	630	50	68	309027
5565	163-087-02	MM			10076	1112	105683			220	516	188000	610	50	68	305607
5565	163-087-02	MM			10076	1112	105683			220	516	188000	610	50	68	305607
5485	163-087-12	MM			9618	1390	93534			220	510	169000	610	50	68	274272
5485	163-087-12	MM			9618	1390	93534			220	510	169000	610	50	68	274272
5603	163-087-12	MM			10076	1390	100579			244	530	181000	630	50	68	293819
5603	163-087-12	MM			10076	1390	100579			244	530	181000	630	50	68	293819
1080	163-088-11	MM	5030	5055	2376	432	112574			230	2646	177018	550	46	68	295276
1490	163-088-31	MM	5819	5840	9996	1770	104493			365	596	183270	610	46	68	300490
2800	163-089-13	MM	5150	5162	7872	1508	90786			280	1497	157092	600	49	68	259035
2800	163-089-13	MM	5243	5302	9216	1972	107295			610	633	186732	550	46	68	306458
974	163-089-22	MM	5180	5247	760	220	2029			670	3782	1936	710	860	68	9397
974	163-089-22	MM	5306	5336	6840	1276	58133			510	2069	103668	600	62	68	172496
974	163-089-22	MM	5307	5357	3990	928	98237			365	2257	159414	620	49	68	265191
974	163-089-22	MM	5308	5342	3230	638	34022			755	3918	56724	620	92	68	99287
1552	163-090-18	MM	5713	5735	1470	208	11200			1140	3480	17400	770	231	68	34898
1076	163-090-22	MM	5506	5530	2257	360	24143			270	4074	39120	602	120	68	70224
1076	163-090-22	MM	5531	5555	594	60	1701			160	3819	939	660	1150	68	7273

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
1076	163-090-22	MM	5587	5602	594	72	1642			160	3572	1066	660	1150	68	7106
1837	163-090-28	MM	5694	5719	574	71	1972			240	4050	1138	700	1000	68	8045
1837	163-090-28	MM	5719	5739	554	106	2245			200	4300	1463	700	1000	68	8868
1837	163-090-28	MM	5755	5766	7425	1534	77959			205	1570	136580	580	55	68	225273
1501	163-091-17	MM			2200	613	37900			1020	4040	61200	780	83	68	106973
1501	163-091-17	MM	5878	5912	8820	1298	108436			185	1080	185744	630	46	68	305563
1501	163-091-17	MM	6041	6056	7840	2124	101385			230	808	175716	690	47	68	288103
1872	163-091-22	MM	5920		10890	1888	98073			255	404	175600	660	46	68	287110
1492	163-091-23	MM	5903	5913	7300	1450	73200			162	1510	129000	660	49	68	212622
1492	163-091-23	MM	5903	5916	640	48	2290			720	4060	1500	810	913	68	9258
1950	163-091-24	MM	5841	5851	9504	1593	99072			170	1000	173440	610	46	68	284779
1648	163-091-28	MM	5940	5950	6664	870	112738			425	598	187532	740	46	68	308827
2548	163-092-02	MM	6160	6178	8428	1534	107081			295	573	183958	520	46	77	301869
1540	163-092-17	MM	6028	6058	3720	595	102000			162	1540	165000	650	48	68	273017
1540	163-092-17	MM	6075	6091	4800	1270	93600			180	661	156000	640	45	68	256511
1540	163-092-17	MM	6095	6111	2190	413	15300			1320	3010	25800	620	167	68	48033
1640	163-092-17	MM	6065	6096	2979	424	14282			390	4893	33488	690	140	68	56456
1700	163-092-20	MM	6083	6118	5684	1062	74078			490	1649	125913	580	54	68	208876
1700	163-092-20	MM	6160	6178	8526	1652	108499			270	627	186638	520	46	68	306212
1700	163-092-20	MM	6160	6178	8526	1652	108499			270	627	186638	520	46	68	306212
1799	163-092-20	MM	5737	5744	47520	5900	75218			450	330	216800	590	49	68	346218
1530	163-092-24	MM			3400	789	87100			234	2240	141000	700	49	68	234763
1742	163-092-34	MM			8700	789	110900			186	476	186000	620	43	68	307051
2412	163-093-19	MM	6303	6356	1663	314	18314			475	4900	28217	830	160	68	53883
1703	163-094-12	MM	6191	6221	5880	1357	107324			245	1220	178860	530	47	68	294886
3617	163-095-03	MM	6250	6287	7574	1283	101045			220	912	172198	680	47	68	283232
3617	163-095-03	MM	6376	6479	6409	813	71920			85	1978	123136	660	54	68	204341
7087	163-095-18	MM			6212	1459	59200	150		288	650	102368	642	41	77	170179
7087	163-095-18	MM	6300	6342	6012	729	94400	310		134	3800	160000	695	44	77	265078
7087	163-095-18	MM	6300	6424	7615	1094	100100			372	2110	174400	670	42	77	285691
7087	163-095-18	MM	6400	6324	8216	122	98600	1010		201	4000	164800	667	44	77	275949
4691	163-095-29	MM	6503	6521	7890	1210	102912			160	450	175800	590	47	68	288422
2688	163-098-10	MM	6453	6493	8600	1200	105390			81	1122	180400	610	46	68	296793

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
2688	163-098-10	MM	6453	6499	8600	1200	105390			81	1122	180400	610	46	68	296793
2010	163-102-07	MM	6580	6607	29700	4130	86418			145	710	197280	600	48	68	318383
2010	163-102-07	MM	6660	6693	35640	4720	84074			110	650	205960	580	47	68	331154
2010	163-102-07	MM	6726	6760	36630	5015	83032			195	480	207040	610	48	68	332392
2010	163-102-07	MM	6773	6828	8316	590	13807				5350	96480	120	29	68	124543
2010	163-102-07	MM	6967	6991	4653	944	62972			120	2450	106240	610	60	68	177379
2010	163-102-07	MM	6967	6997	3861	649	63909			355	2650	105140	680	60	68	176564
2010	163-102-07	MM	7160	7180	30690	4425	76841			75	440	185360	620	49	68	297831
884	164-077-33	MM	2980	2987	3323	1238	54698			258	2946	91540	640	62	68	154003
994	164-081-33	MM	3525	3537	3990	1334	35614			112	3046	63570	600	90	68	107666
3749	164-084-35	MM	3998	4015	3620	700	45303			170	3288	75800	760	72	68	128881
317	156-095-20	MM	8479	8517	3998	799	38421			205	851	67920	810	80	68	112194
215	158-094-18	MM	8284	8318	12186	1599	92760			185	311	178000	5690	7046		285041
413	147-093-05	MMB	10360	10390	37050	1160	11097				387	85772	200	62	68	135466
7614	148-096-10	MMB	9845	9872	4809	486	114600	2400		280	4300	180414	670	43	77	304913
2148	155-095-07	MMB	10316	10365	48400	12E3	62800	7300		269	608	217000	450	44	68	341300
2148	155-095-07	MMB	10456	10529	50300	18E3	46300	15200		433	743	210000	450	48	68	325428
528	157-089-25	MMB	7580	7675	7410	1856	70348			415	1721	125520	540	54	68	207270
1186	153-094-32	MMFAR			13708	1484	62051			185	382	123904	740	55	68	201714
223	155-095-06	MMFAR	8458	8488	10100	2160	65774			195	418	125200	750	54	68	203847
4716	155-096-11	MMFAR			29925	2309	68034			79	581	164370	540	265		265298
4716	155-096-11	MMFAR	8332	8365	7218	1276	46090			153	1490	86480	690	0	68	142707
979	157-095-14	MMFAR	8246	8255	11614	1713	98192			135	272	176722	670	46	68	288648
1067	157-095-23	MMFAR	8271	8276	12180	1380	96333			170	332	173820	650	47	68	284215
77	157-095-36	MMFAR	8323	8372	13860	1920	96135			220	383	177996	550	46	68	290514
65	158-095-13	MMFAR	8150	8194	14155	1624	53386			145	354	111780	550	59	68	181444
1764	162-095-29	MMFAR	7064		9520	1734	104873			185	344	183300	630	46	68	299956
1764	162-095-29	MMFAR	7064	7065	9520	1156	105354			185	342	182360	630	46	68	298917
4268	139-102-08	MMR	8808	8844	18468	4796	104890			110	357	208120	570	46	68	336741
6861	139-106-10	MMR	8687	8891	4896	2943	103955			634	1105	178000	760	56	68	291533
6894	146-103-05	MMR	9170	9230	13627	1459	107600	7600		146	700	196800	544	42	77	320408
7206	146-104-29	MMR	9270	9371	9419	243	93000	720	1470	15011	900	168000	990	47	77	288050
7292	146-105-36	MMR			17635	2674	114000	17300		317	580	215880	607	41	77	351259

CHEMICAL DATA

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WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
6625	147-104-11	MMR	9038	9045	12400	1050	108500			134	184E3	593	620	46	68	307077
6625	147-104-11	MMR	9038	9095	12700	1170	95800			85	481	174500	610	46	68	284736
7614	148-096-10	MMR	9095	9180	26853	1944	94700	4900		146	900	198918	600	42	77	323510
7570	155-094-09	MMR	8570	8635	11175	1282	107000			76	733	301952	600	46	68	422218
499	158-095-35	MMR	8168	8186	2280	1020	21890			305	1078	39800	830	120	68	66373
6696	162-103-02	MMR	6631	6690	21400	2920	93800			110	711	183400	620	51	68	302341
6555	162-103-03	MMR	6596	6654	11592	2320	107145			49	593	192075	600	47	68	313774
4429	162-103-35	MMR	6968	6989	10400	4131	99636	19000		351	1240	183180	650	41	77	299128
2894	142-103-24	MMRM	9289	9360	18400	2040	104178			30	538	198780	550	41	68	323966
2584	145-101-16	MMRM	9423	9428	28600	3006	86135				232	192000	440	45	77	309973
2230	147-096-36	MMRM	9780	9992	20233	2124	103078			120	700	200400	610	49	68	326655
7741	156-094-28	MMRM	8760	8863	18000	1530	96800			83	528	180000	610	48	68	296941
1549	162-092-24	MMRM			5200	910	107700			180	1160	177000	660	45	68	292150
1532	162-095-09	MMRM	6695	6725	5600	728	73200			342	2300	123000	700	52	68	205170
1794	163-086-03	MMRM	4351	4418	2600	461	18900			192	1920	33600	750	146	68	57673
1872	163-091-22	MMRM	5920	5921	10890	1888	98073			255	404	175600	660	46	68	287110
1648	163-091-28	MMRM	5940	5950	6664	870	112738			425	598	187532	740	46	68	308827
4691	163-095-29	MMRM	6462	6485	6830	1210	99293			145	656	168200	600	48	68	276334
2702	163-096-08	MMRM	6346	6373	6700	1020	98904			234	1257	166320	590	48	68	274435
2688	163-098-10	MMRM	6569	6614	5600	890	80891			142	2028	135550	650	51	68	225101
3749	164-084-35	MMRM	3868	3896	2760	700	40268			120	4156	65900	710	81	68	113904
3268	139-101-10	O	12708	12754	59031	2820	69042					219170	510	50	68	350063
3268	139-101-10	O	13456	13515	22488	4512	80445				377	176750	460	53	68	284572
151	140-080-18	O			2801	485	52358			105	2757	85000	690	70	68	143506
6920	141-104-25	O	12000	12250	21643	486	93700	440		476	930	182400	750	45	77	299639
1231	155-096-02	OG	12570	12610	2304	604	11774			37	311	187200	560	46	68	202230
485	129-104-16	ORR	9176	9221	1235	186	14558			720	2375	2375	630	200	68	21449
485	129-104-16	ORR	9270	9332	2565	580	24645			510	2856	41840	660	120	68	72996
485	129-104-16	ORR	9335	9346	2280	464	27152			415	1358	46024	600	110	68	77693
485	129-104-16	ORR	9350	9402	2280	464	29124			330	1296	49162	600	100	68	82656
485	129-104-16	ORR	9400	9460	4370	1102	36157			380	1518	65375	530	81	68	108902
3261	129-106-15	ORR	8289	8308	2061	226	58615			205	3691	91910	660	64	68	156708
3261	129-106-15	ORR	8322	8394	2420	220	67385			195	5028	105040	610	59	68	180288

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
6322	130-091-07	ORR	8307	8330	17836	2188	88500	8700		24	275	180000	560	44	77	288910
6322	130-091-07	ORR	8355	8414	21643	2552	89400	790		159	215	188000	596	44	77	301977
6322	130-091-07	ORR	8378	3416	4449	741	29300	140		390	1630	52620	691	85	77	89131
6322	130-091-07	ORR	8378	8416	5471	668	31000	100		403	15400	57582	702	80	77	110525
2677	130-107-03	ORR	8346	8348	893	203	13227			403	2304	20640	820	191	77	37670
7240	131-104-04	ORR	9870	9910	4810	608	53700	1860		220	3100	91200	674	61	77	153657
7241	131-104-29	ORR			1202	486	24300	270		195	2200	38400	666	110	77	66786
7383	133-103-28	ORR			4810	365	59000	800		256	4900	97790	624	54	77	167129
7383	133-103-28	ORR	10320		13230	1483	76600	5550		195	650	152970	610	44	77	245184
511	134-096-24	ORR	10199	10300	28400	1392	20363			490	2136	83680	700	75	68	136461
511	134-096-24	ORR	10318	10375	544E3	4060	64790			560	667	188280	630	50	68	802057
3859	135-083-34	ORR	6918	6961	7640	1420	66056			60	1235	118600	680	56	68	195011
3859	135-083-34	ORR	7023	7060	9460	1960	79163			60	708	144000	680	50	68	235351
4280	135-103-18	ORR	10816	10845	6860	3880	55966			37	504	109380	640	58	68	176627
4134	137-092-15	ORR	10216		60449	5450	59591			60	179	214600	580	53	68	340329
1620	139-090-27	ORR	10346	10387	18620	3245	100733			60	537	197353	450	47	68	320548
1678	139-101-02	ORR	12176	12223	44976	2820	72301				61	199280	460	51	68	319438
3268	139-101-10	ORR	12070	12086	41400	2575	67145				123	184240	530	56	68	295483
3268	139-101-10	ORR	12072	12118	14055	1128	102437			85	370	185840	520	48	68	303915
3927	139-101-21	ORR	12041	12092	18180	1526	66070			195	543	138014	670	52	68	224528
7012	141-100-30	ORR	12312	12342	77900	2900	31900				156	202000	510	46	68	314856
7012	141-100-30	ORR	12460	12492	974	8180	78000			73	1040	151000	620	54	68	239267
3044	143-092-27	ORR	12068	12157	85500	9200	39918				110	239600	480	55	68	374328
2853	143-101-05	ORR	12785	12920	1692	342	64897			781	2220	102000	680	52	77	171932
6508	144-104-01	ORR			39779	2734	74500	23900		510	160	201600	558	43	77	319522
6531	144-104-12	ORR			43888	3160	71900	4390		61	40	198800	512	45	77	317893
2584	145-101-16	ORR	13205	13280	15125	1336	33384			610	1050	81000	700	69	77	132505
6308	145-103-07	ORR			50100	3829	69100	4950		143	7	209600	549	45	77	332829
5975	145-103-18	ORR			48096	4011	72300	2510		116	17	210800	575	44	77	335365
6014	145-103-19	ORR			55310	3160	66600	5330		55	10	212800	506	45	77	337988
6544	145-103-29	ORR			47795	4011	70200	1030		104	38	205200	472	45	77	327358
6655	145-104-12	ORR			50000	3707	73900	5110		247	8	209200	534	45	77	337113
7206	146-104-29	ORR			80	49	766	40		677	10	840	875	1750	77	2422

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter³ x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
7200	146-105-36	ORR			31463	122	78300	8000		116	1020	175560	565	44	77	286661
7580	148-102-04	ORR	13471	13563	53306	2431	58700	8800		104	34	187353	544	46	77	302016
793	149-091-22	ORR	13075	13170	3400	183	36711			220	4798	59508	630	90	68	104820
7306	149-102-35	ORR	13416		56112	3282	50100	5400		153	22	191208	506	43	77	300931
7478	149-102-35	ORR	13504		52505	5348	54800	1800		153	170	191979	552	43	77	304973
6780	151-089-24	ORR	12010	12089	81700	7900	40040			130	170	229610	530	47	68	359550
1231	155-096-02	ORR	12810	12876	7880	3940	6871				124	35900	630	160	68	54715
1403	155-096-15	ORR	12710	12735	32340	9735	8853				788	98677	250	70	68	150393
1403	155-096-15	ORR	12710	12885	65660	5310	55471			355	25	217000	620	46	68	343821
1403	155-096-15	ORR	12945	12985	79380	5310	42805			795	54	221464	770	46	68	349808
4990	156-084-22	ORR	9055	9115	49000	5880	62690			60	145	200400	590	49	68	318175
6223	156-086-15	ORR	10216	10243	65731	6321	46300	10400		198	32	218880	515	45	77	337566
1385	156-095-16	ORR	13292	13360	102E3	8260	29649			415	34	249890	570	46	68	390168
1514	156-096-34	ORR	13046	13120	75460	7670	41530			450		219678	480	51	68	344788
7054	156-102-14	ORR			43300	4133	58100	15900			90	191940	432	45	77	297722
1745	157-095-21	ORR	12904	12955	98010	8260	29522			390		242816	530	57	68	378998
430	158-094-17	ORR	3704	3717	279	248	11810			132	5564	15252	660	240	68	33285
355	158-094-18	ORR	12195	12295	23560	4408	84159			72	287	184096	500	48	68	296582
355	158-094-18	ORR	12432	12474	38950	11E3	2181				1185	147486	150	38	68	200822
2009	158-095-16	ORR	12742	12790	11682	1888	90147			425	1330	163994	700	48	68	269466
4514	158-095-24	ORR	12896	13011	78000	4200	44055				23	218200	570	61	68	344478
390	160-067-24	ORR	3520	3540	1620	853	25352			136	5389	40400	630	120	68	73750
390	160-067-24	ORR	3575	3602	1620	770	25397			96	5876	39895	620	120	68	73654
6624	161-085-01	ORR	8370	8510	14420	2817	86672			134	360	170000	640	60	68	274403
4655	162-078-31	ORR	5964	6041	6266	1106	89140			179	1185	143070	680	44	68	240946
6293	162-080-03	ORR	10216	10243	65731	6321	46300			198	32	218880	515	45	77	337462
434	163-068-27	ORR	3704	3717	477	272	14117			152	5604	19190	630	200	68	39812
2010	163-102-07	ORR	10492	10550	32670	4720	84445			100	600	201320	590	50	68	323855
2010	163-102-07	ORR	10550	10585	29700	4425	90287			75	560	204260	590	51	68	329307
515	129-063-11	OW	1840		46	22	1165			220	1582	648	710	2250	68	3683
1231	155-096-02	OW	13470	13510	1920	230	7959			450	519	15700	720	1024	68	26778
1514	156-096-34	OW	13762	13792	21364	2478	85656			164	322	176814	480	48	68	286798
4655	162-078-31	OW	6570	6604	4712	626	81440			61	1279	134900	630	44	68	223018

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
511	134-096-24	PNM	7610	7660	2660		24511		360		8692	35564	1080	130	68	71787
4989	135-082-11	PNM	3902	3918	824	210	6086			49	3225	9050	640	380	68	19444
3859	135-083-34	PNM	4615	4634	2360	1200	66493			60	2714	108200	630	58	68	181027
4280	135-103-18	PNM	7365	7400	400	91	8769			330	2666	12340	810	310	68	24596
1508	139-101-10	PNM	7452	7500	2471	708	119679			49	1081	190210	660	46	68	314198
613	140-099-31	PNM	8019	8066	7400	1525	106386				410	181332	380	47	68	297053
4642	140-102-30	PNM	7410	7445	2100	580	117392			185	775	185800	730	46	68	306832
1469	149-096-25	PNM	7770	7843	706	742	122537			512	3852	189280	640	46	68	317629
1716	150-095-09	PNM	7315	7374	568	566	125866			315	7473	191102	500	46	68	325890
1665	137-100-15	PNT	8123	8128	6800	1140	48686			174	600	89908	620	65	68	147308
4224	139-098-10	PNT	7985	8023	3316	408	51270			134	2800	84000	450	68	77	141928
4224	139-098-10	PNT	8045	8058	3990	578	60092			98	3900	98500	460	55	77	167158
2395	139-100-06	PNT	8124	8136	9600	1320	45989	2		174	380	91390	570	65	68	148853
2309	139-100-07	PNT	8155	8170	12400	1560	60243			152	365	119054	570	55	68	193774
2486	139-100-08	PNT	8281	8292	13200	2160	63329			204	350	126958	580	53	68	206201
518	139-100-09	PNT	8271	8278	14000	1320	63312			112	328	125970	570	54	68	205042
2426	139-100-17	PNT	8244	8261	13600	1560	67200			200	341	131898	570	52	68	214799
4325	139-101-03	PNT	8152	8165	10390	1485	58222			255	770	114802	630	56	68	185924
4357	140-103-13	PNT	7818	7912	9235	4111	66029			170	290	129858	610	53	68	209693
3859	135-083-34	S	6497	6571	4270	820	30023			160	2117	54600	770	97	68	91990
4130	138-105-09	S	10390	10440	691	109	9187			255	1033	14800	700	270	68	26075
3044	143-092-27	S	11316	11373	21400	3400	98199			25	314	199000	570	48	68	322338
3044	143-092-27	S	11668	11735	30400	5100	88700			25	227	205400	530	49	68	329852
2584	145-101-16	S	12336	12386	23100	1837	89443			73	214	184000	730	45	77	298667
6839	150-104-11	S	11720	11840	24950	2188	89800	760		582	90	191360	687	41	77	308978
3387	152-094-07	S	11805	11854	26128	1618	95427			24	152	198016	570	47	68	321365
341	152-094-21	S	12175	12271	5510	638	103257			196	1768	169452	540	48	68	280821
341	152-094-21	S	12413	12460	26800	1972	99964			146	227	207108	500	46	68	336217
2841	153-094-29	S	11933	12007	21500	2400	101002			274	145	200564	580	47	68	325885
2841	153-094-29	S	12007	12065	28000	1680	99340			156	136	207480	580	47	68	336792
2665	153-094-30	S	12004	12058	13248	1850	66745			48	518	131376	610	53	68	213785
1679	153-096-10	S	11814	11887	30690	3245	94472			170	234	209212	620	47	68	338023
2148	155-095-07	S	11606	11823	15444	2242	107713			535	480	199340	670	50	68	325754

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
2148	155-095-07	S	11609	11763	15642	2124	107019			365	500	198360	660	50	68	324010
161	155-096-02	S	11441	11526	12600	2124	67600			600	636	132000	680	49	68	215560
1231	155-096-02	S	11441	11526	7776	406	31814			108	694	63400	690	85	68	104198
1231	155-096-02	S	11566	11616	17856	4292	64190			390	556	142480	740	54	68	229764
1231	155-096-02	S	11566	11632	16240	1200	99703			465	382	185470	720	46	68	303460
1231	155-096-02	S	11628	11680	20640	4640	84550			490	349	179920	700	48	68	290589
1231	155-096-02	S	11696	11766	26880	7830	79271			185	207	192400	690	46	68	306773
1231	155-096-02	S	11960	12011	31680	2900	88531			145	354	200720	600	46	68	324330
1231	155-096-02	S	11990	12050	29568	2552	93012			185	160	203000	650	46	68	328477
2438	155-096-13	S	11558	11713	18240	2320	110111			185	393	194600	650	49	68	325849
2515	155-096-14	S	11764	11436	17280	4060	108978			72	356	210200	640	49	68	340946
1403	155-096-15	S	11616	11658	19110	4720	94898				229	193780	480	46	68	312737
1403	155-096-15	S	12279	12390	45570	7375	53686				122	184851	450	46	68	291604
1895	155-096-22	S	11524	11574	27720	3540	95152				240	205960	440	46	68	332612
1385	156-095-16	S	11785	11870	26950	5310	89420			110	141	200925	560	46	68	322856
1385	156-095-16	S	11910	11960	27440	3540	92231			110	199	200925	550	46	68	324445
1385	156-095-16	S	11982	12020	23030	2065	97348			270	373	196494	560	46	68	319580
1636	156-095-17	S	11702	11886	25650	5985	90599				240	202400	380	50	68	324874
1636	156-095-17	S	11926	11996	26235	5015	96217			120	230	209212	530	47	68	337029
2092	156-095-17	S	11750	11900	15345	2360	108169			120	650	200328	520	50	68	326972
2149	156-095-18	S	11702	11890	13860	1792	109097			120	780	197380	610	49	68	323029
2501	156-095-30	S	11703	11900	16896	2088	111145			110	402	207060	560	49	68	337701
2173	156-095-31	S	11603	11857	13840	2124	110947			120	600	201300	600	49	68	328931
2173	156-095-31	S	11627	11720	13662	1888	109755			110	740	198360	600	49	68	324515
1745	157-095-21	S	11490	11552	29205	2950	96677			100	172	209212	560	49	68	338316
1745	157-095-21	S	11590	11685	29700	3540	94337			120	252	208128	580	47	68	336077
355	158-094-18	S	11375	11445	19380	348	108927			92	467	202924	500	47	68	332138
2009	158-095-16	S	11424	11473	12276	1062	119634			60	200	209166	590	47	68	342398
2009	158-095-16	S	12258	12342	19988	2596	102433			255	620	200328	630	49	68	326220
4514	158-095-24	S	11555	11588	26500	2700	90957			37	51	195000	580	51	68	315245
4323	158-095-26	S	12226	12264	27128	2424	91445				106	196040	460	48	68	317143
4323	158-095-26	S	12306	12348	26936	1616	98198				135	203740	410	48	68	330625
4434	158-095-35	S	11514	11544	27500	2700	88026			60	99	192200	610	51	68	310585

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
2675	159-079-34	S	2603	2658	580	276	10374			160	5934	13362	700	240	68	30686
2675	159-079-34	S	5975	6056	6600	1140	93211			142	1142	157850	620	49	68	260085
4670	161-080-01	S	5853	5913	6480	1260	99629			37	800	168200	590	47	68	276406
4655	162-078-31	S	5466	5495	5213	322	70679			359	2596	117150	700	48	68	196319
793	149-091-22	SI	12626	12771	3700	976	51063			230	5395	84042	610	70	68	145406
793	149-091-22	SI	12770	12855	70	13	74			102		217	670	9999	68	476
7570	155-094-09	SI	13530	13617	11764	1165	114000				765	193826	460	46	68	321520
2219	161-079-06	SI	5895	5912	6138	1003	82970			230	1640	140420	610	55	68	232401
6243	137-092-26	TRS	5750	5868	8317	790	20200			146	1700	51600	745	88	77	82753
6243	137-092-26	TRS	5868	5750	8317	790	20200	150		146	1700	51600	745	88	77	82755
1606	150-097-35	TRS	7540	7641	7252	1416	113747			68	510	191994	570	46	68	314987
2128	160-079-02	TRS	3342	3412	4059	885	27183			220	2340	49836	600	110	68	84523
3779	161-078-09	TRS	3178	3204	4670	810	47439			85	2641	81800	660	69	68	137445
2094	161-079-03	TRS	3327	3352	7326	1003	49402			168	2100	90340	910	66	68	150339
2113	161-079-07	TRS	3408	3434	5472	986	49337			44	2156	87042	690	66	68	145037
1611	161-079-09	TRS	3360	3394	5684	1298	45924			54	2165	83049	530	68	68	138174
2160	161-079-18	TRS	3419	3441	5346	1003	51700			100	2340	90344	620	67	68	150833
3440	161-079-20	TRS	3438	3449	2484	636	29043		50	37	3930	48410	850	100	68	84590
3440	161-079-20	TRS	3438	3452	7360	1503	50790			75	1971	94248	700	65	68	155947
893	161-079-21	TRS	3403	3411	6745	1392	52100			58	1786	95004	520	63	68	157085
1607	161-079-21	TRS	3403	3411	6840	1334	51761			74	1771	94482	550	63	68	156262
1675	161-079-21	TRS	3381	3417	6370	1593	52045			85	1753	94850	500	64	68	156696
1675	161-079-21	TRS	3436	3444	7309	1466	54495			100	1647	99990	700	65	68	165007
1675	161-079-21	TRS	3454	3462	7309	1241	53609			185	1576	97970	830	65	68	161890
1675	161-079-21	TRS	3458		7496	1692	51949			280	1630	96960	850	65	68	160007
1755	161-079-21	TRS	3419	3405	5622	1128	53370			60	2158	93930	660	67	68	156268
3354	161-079-21	TRS	3402	3432	5060	1241	52649			120	2440	91910	680	68	68	153420
1996	161-079-23	TRS	3322	3390	5445	1180	50386			60	1800	89430	650	71	68	148301
2090	161-079-28	TRS	3368	3383	5940	1121	62400		121	37	2500	108020	830	60	68	180139
2168	161-079-28	TRS	3410	3424	7128	1534	52169			100	1700	96240	660	63	68	158871
3827	162-078-20	TRS	3086	3160	2092	389	20697			185	4082	33641	780	130	68	61086
2709	162-079-20	TRS	3344	3360	4900	780	52147			34	2265	89688	620	70	68	149814
2842	162-079-20	TRS	3273	3285	4456	719	43886			98	2757	75582	740	72	68	127498

CHEMICAL DATA

1=(mg/l, ppm) 2=(mg/l, ppm)x100 3=pH x 100 4=ohms/meter^3 x 1000

WELLNO	T-R-S	FORM	TOP	BOTTOM	Ca(1)	Mg(1)	Na(1)	Fe(2)	CO3(1)	HCO3(1)	SO4(1)	Cl(1)	PH(3)	RES(4)	°F	TDS(1)
2842	162-079-20	TRS	3277	3282	4895	870	49309			136	2323	85462	580	67	68	142995
2842	162-079-20	TRS	3277	3289	5060	902	51238			49	2313	88880	640	64	68	148442
2111	162-079-30	TRS	3392	3402	5742	1062	50390			60	2150	89360	660	66	68	148764
2195	162-079-31	TRS	3410	3425	6633	1357	31929			25	1475	63840	500	87	68	105259
3088	162-079-31	TRS	3369	3415	5568	986	48298			76	2176	85575	720	67	68	142679
2455	162-080-15	TRS	3407	3437	4085	1026	33318			100	4300	58380	720	89	68	101209
1588	162-080-17	TRS	3450	3468	4165	944	32424			100	2754	58045	690	90	68	98432
1489	162-080-22	TRS	3440	3430	5684	1239	45836			100	2212	82680	710	72	68	137751
1629	162-081-23	TRS	3585	3610	4900	1475	45699			135	2265	81710	550	69	68	136184
916	162-081-26	TRS	3550	3566	5225	1102	47798			54	2861	84042	500	68	68	141082
3342	163-078-19	TRS			2983	64				138	6300	45647				55132
4052	163-079-07	TRS	3190		4329	866	48631			49	2125	83600	570	69	68	139600
4052	163-079-07	TRS	3190	3191	4329	866	48631			49	2125	83600	570	69	68	139600
2084	163-079-35	TRS	3143	3190	3317	620	47003			220	3350	77578	680	74	68	132088
438	163-080-21	TRS	3260	3280	3753	1073	38641			145	3175	66944	550	81	68	113731
1259	163-081-01	TRS	3377	3397	3663	840	33147			68	3313	56511	670	90	68	97542
1130	164-081-36	TRS	3334	3351	4257	900	39526			75	2889	68949	580	78	68	116596

APPENDIX G

PHASE II WATER QUALITY DATA FOR TERTIARY AND CRETACEOUS AQUIFERS

The following table lists the chemical data contained in WATERCAT (Appendix "C") for the formations listed below. This data was obtained from the U.S.G.S.W.R.D. computer library systems WATSTORE and GWSI.

A brief explanation of the table headings follows:

T-R-S-Q - The location of the well, township, range, section, and quarter-quarter-quarter.

SPCND - Specific Conductance (μmho/cm).

PH - pH of water recovered.

SIO2 - Concentration of SiO_2 (mg/l).

FE and MN - Concentration of Fe^{++} and Mn (mg/l).

CA, MG, NA, and K - Concentration of Ca^{++}, Mg^{++}, Na^{+}, and K^{+} (mg/l).

HCO3, SO4, CL, and NO3 - Concentration of HCO_3^{-}, $SO_4^{=}$, Cl^{-}, and NO_3 (mg/l).

DISLD - Total dissolved solids (mg/l).

HARDX - Water hardness (equivalent Calcium Carbonate) (mg/l).

Aquifer	Page

TERTIARY FORT UNION GROUP

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
143-080-35DAA	565	8	8	80	240	82	27	1	4	310	70	6	1	352	320
143-080-35DAD	759	8	18	130	.	109	27	4	4	428	46	1	0	420	385
143-080-36CBB	488	8	9	150	.	76	17	1	4	271	41	3	0	285	261
147-087-12BAB	2920	9	7	.	.	7	1	732	3	1110	286	154	1	1840	22
148-086-09AAA	2680	8	13	940	.	6	3	720	3	1360	437	2	1	1860	29
148-086-13BCC	2410	8	15	100	.	170	70	330	9	769	659	52	89	1770	712
149-084-02DBD	1890	8	17	560	.	12	3	467	3	771	351	5	0	1250	42
149-085-19CDC	2380	7	12	2200	.	141	87	362	11	526	1020	9	2	1910	710
149-089-23CCC	1750	8	20	.	.	178	121	61	7	646	445	5	43	1220	940
149-090-11ADA	2010	9	8	.	.	2	1	510	2	885	316	3	0	1320	11
150-081-31CAC	2640	8	13	220	.	8	1	656	2	1220	253	127	1	1670	23
150-083-20CCC	2480	8	26	3000	.	174	90	322	10	741	858	8	0	1860	805
150-089-26BCC	3350	8	10	220	.	10	6	812	4	1020	947	12	0	2330	49

TERTIARY TONGUE.RIVER FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
132-090-14AAB2	2600	.	7	100	100	10	3	610	3	639	820	3	1	1780	37
133-092-05BAA	1720	8	9	340	.	2	1	451	2	1090	17	27	1	1080	10
133-094-04DAA	1920	8	.	700	.	6	3	457	2	738	374	11	3	1250	26
134-094-32AAA	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
134-096-32ADD	1790	8	.	0	.	5	2	434	2	808	272	5	2	1160	22
135-089-22CDD	1350	.	7	1300	20	3	0	340	1	666	160	16	1	874	9
135-090-23BBB2	2170	9	7	260	20	7	2	526	4	870	405	6	1	1410	23
135-093-01BCB	1440	8	7	1100	.	18	6	329	3	643	248	3	0	935	70
135-097-28DAA	2040	8	.	.	.	.	.	.	.	528	452	7	0	1320	20
138-095-23DBA6	1450	.	.	2800	.	.	.	80	.	.	.	.	250	1160	660
139-099-04BDC	3200	.	.	400	.	.	.	.	.	647	1030	30	0	1930	680
140-096-28DDC	3180	7	.	1000	.	.	.	.	.	608	828	32	92	2070	610
140-096-29DDD1	2320	7	.	7900	.	.	.	.	.	380	726	6	0	1510	810
141-085-27DDD	2280	8	7	2000	.	7	3	611	3	1560	2	17	1	1440	32
141-093-16AAA1	9740	8	3	8100	640	100	75	2400	12	860	5000	8	0	8030	560
143-091-19AAA1	2830	9	0	40	40	33	12	660	7	1320	420	12	1	1850	130
143-093-09BCB	3140	9	9	80	20	4	3	870	4	2100	10	14	1	2090	23
144-091-30AAA2	2400	9	10	40	30	17	16	610	7	1440	150	14	1	1580	110
144-097-26CBD1	2780	9	8	510	0	2	2	770	4	1930	8	10	1	1800	16
145-091-05DDD2	2960	9	19	60	0	7	5	780	4	2060	6	26	1	1910	38
146-082-21CCC	1320	9	19	900	0	3	1	350	2	762	74	0	1	863	12
147-091-26CCD	2950	7	20	0	620	374	123	229	10	746	1290	21	26	2460	1400
147-091-29BCA	3650	8	7	90	40	8	4	973	4	2400	9	159	1	2350	35
147-097-06ABB	2830	8	8	400	40	3	1	772	3	2050	1	17	1	1820	14
148-093-04CAB1	4250	8	17	0	20	6	2	1100	3	1180	1300	6	1	3050	24
148-093-04CBD	3680	9	10	230	60	10	6	1000	4	2230	12	85	1	2370	50
151-080-24CBC	2700	8	18	1100	0	6	6	660	3	1330	380	19	1	1750	38
152-080-29AAD	2200	8	19	2000	100	42	11	670	4	1200	490	79	3	1910	150
155-081-11CCC	1050	8	28	870	100	75	32	110	6	475	160	8	1	656	320
155-081-11CCD	1600	8	28	1800	80	63	23	280	5	551	390	19	1	1080	250
155-083-23BBB	470	7	10	0	270	40	20	36	11	218	68	11	1	305	180
155-096-17ADC	1900	8	30	1600	100	84	79	340	9	.	660	7	.	1540	540

TERTIARY TONGUE RIVER FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
155-096-21BCB1	1800	8	20	30	130	64	48	320	9	.	610	5	.	1370	360
155-096-21BCB2	1650	8	17	10	110	85	63	250	8	.	550	7	.	1290	470
155-096-28CBD	1990	7	10	160	60	42	27	470	6	.	430	5	.	1460	220
163-097-34ADD	1300	8	19	100	0	66	26	210	6	811	8	57	7	800	270

TERTIARY TONGUE RIVER LUDLOW FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-091-19BAA	935	8	11	100	20	41	14	147	4	409	147	2	0	568	162
129-093-28ABB2	1950	8	10	80	.	24	22	422	4	643	462	24	26	1310	150
129-095-08BCC	1050	8	10	4500	10	64	68	76	11	487	197	4	0	675	439
129-095-13BBD	1830	8	11	0	40	195	90	113	5	362	749	33	31	1410	856
129-095-18BBA1	1120	8	14	0	90	71	48	129	10	651	126	4	1	725	375
129-095-18BBA2	1150	8	14	0	90	87	40	127	10	649	129	4	0	731	380
129-095-30CBC	1060	8	11	0	10	41	26	167	10	458	194	3	1	680	209
129-096-02DDC2	1840	8	13	380	50	81	56	278	14	566	550	2	0	1270	433
129-096-12DCD2	909	8	15	0	60	94	59	24	4	535	65	18	2	547	476
129-096-13BBB3	1480	8	16	0	100	80	139	50	6	519	298	68	43	957	774

TERTIARY SENTINEL BUTTE FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
132-092-15BCB	876	8	.	420	.	.	.	.	.	353	153	0	.	613	337
132-092-28DCD	3700	.	.	.	.	.	.	.	.	376	1350	0	.	2420	49
134-101-35BCC	690	8	17	1600	60	40	17	100	2	436	30	1	1	425	170
135-091-06DAA	3300	8	.	1200	.	.	.	.	.	444	1030	11	.	2150	1190
135-095-32BCA	1300	9	.	.	.	.	.	275	.	.	.	.	.	1040	80
135-097-04ADB	1350	8	13	570	100	38	18	304	3	558	232	26	1	1300	169
135-098-32DAD1	4010	7	11	80	10	420	520	62	6	574	2700	16	35	4060	3200
135-101-16CBA	2050	8	6	7100	250	69	36	370	6	707	560	3	1	1410	320
136-098-33CCD	2390	8	9	730	160	36	10	580	5	954	580	4	1	1700	130
139-097-34ACA2	1270	8	.	200	.	.	.	.	.	352	241	26	24	824	350
139-098-17CCD	2300	9	15	100	20	3	3	550	4	1010	300	7	.	1450	19
139-099-04DBC1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
140-095-08AAA	601	8	25	1100	330	72	20	28	4	285	93	1	1	386	260
140-096-28ADA	2310	8	.	1000	.	.	.	.	.	784	407	4	0	1500	24
140-098-10DDD	1600	9	6	140	20	7	3	370	11	.	340	3	.	1090	31
141-093-02ABB	3770	8	11	5200	60	32	22	874	7	1290	1050	3	3	2650	170
141-093-14ABA	2590	8	10	620	30	11	4	691	3	1850	10	10	1	1670	45
141-093-16AAA2	2140	9	13	1100	40	4	2	550	3	1400	11	10	1	1340	18
141-094-02BBA	2320	8	14	3900	20	66	30	471	6	745	702	3	3	1670	290
141-094-34AAA	5330	8	7	310	80	23	15	1400	5	1310	1900	8	1	4030	120
141-094-34DAD	4530	9	7	470	40	19	11	1100	7	1220	1400	11	7	3210	93
141-097-23ABD	2220	8	14	80	20	137	130	183	11	672	325	113	231	1480	880
141-097-32AAB	784	8	18	0	130	72	40	46	3	322	130	14	18	500	350
142-091-12DD	2560	8	10	0	30	5	1	700	2	1750	19	51	1	1660	17
142-092-10BBC	2780	8	7	500	50	14	5	750	4	1980	19	14	13	1800	54
142-092-10BCC2	2710	8	22	0	10	26	24	641	6	1370	436	23	2	1860	160
142-092-34BBB	2760	8	8	170	20	7	16	712	4	1550	338	7	1	1880	83
142-093-09BBA	3320	8	15	0	20	24	19	800	6	1150	910	5	1	2370	140
142-094-19DDD	6190	8	15	470	140	238	298	1020	15	735	3430	10	34	5430	1800
142-095-02BCB	1980	8	14	250	20	62	53	353	7	741	515	2	1	1370	370
142-095-04CCD	1540	8	17	0	70	74	70	210	6	630	385	2	1	1080	470
142-095-27BCC	745	8	19	0	100	36	22	101	3	371	82	11	10	468	180

TERTIARY SENTINEL BUTTE FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
142-095-33DCC	5770	8	15	740	250	330	176	1080	7	1630	2440	82	1	4940	1500
142-096-36CCB	4250	7	12	0	0	367	241	337	90	464	2000	130	226	3630	1900
142-097-24CCB	4910	8	11	0	50	355	419	235	89	902	1530	315	681	4080	2600
142-099-03DCC	680	8	11	100	20	57	36	44	6	393	61	4	8	422	290
142-099-10DDD	565	8	10	0	60	53	26	31	3	318	46	6	2	334	240
142-100-01BDC	5230	7	11	100	160	120	100	1100	13	1060	2200	18	7	4100	710
143-087-18BCC	3000	6	48	730	6200	480	170	43	8	.	2000	4	.	2820	1900
143-091-11CBA	996	7	13	5700	350	123	55	19	8	445	207	0	1	652	530
143-091-18BAD	795	8	2	230	30	14	12	147	8	276	174	0	3	504	84
143-091-19AAA3	2530	8	8	0	140	140	58	390	10	590	940	3	3	1850	590
143-092-03BAA1	1080	8	6	310	30	11	6	240	4	547	138	0	3	679	54
143-092-08CCC2	557	8	25	290	450	72	17	17	4	275	53	11	1	336	250
143-092-20DBB	929	8	19	220	10	2	1	224	2	483	105	0	1	593	8
143-092-22AAD	751	7	14	100	90	90	25	15	2	263	142	1	7	426	330
143-093-03CCB	1350	8	19	130	50	24	13	296	3	674	175	3	1	878	110
143-093-18ACB	987	8	24	4500	140	64	18	146	3	445	183	1	1	666	230
143-093-31ACD	3110	8	23	0	50	6	3	779	4	1190	651	4	1	2080	27
143-093-33BCC	5260	8	4	10000	320	235	74	1070	12	941	2270	81	1	4220	890
143-094-21CCA1	3530	8	20	800	60	29	19	835	7	1130	1040	5	3	2520	150
143-094-21CCA2	2870	8	17	0	10	109	58	534	6	808	1020	7	3	2150	510
143-094-34BAD	748	8	21	70	10	63	39	32	2	309	79	27	9	425	320
143-096-10DCB	767	8	9	730	10	60	30	65	3	341	125	13	1	476	270
143-096-21BDD	548	7	14	90	10	64	22	22	2	294	65	0	3	337	250
143-096-27DBB	3440	9	18	500	20	30	23	821	4	1240	843	13	1	2390	170
143-097-09CDD	870	8	11	0	10	75	30	80	2	426	124	8	11	551	310
143-097-20DCD	571	8	8	100	520	28	18	69	7	252	104	0	4	363	140
144-089-35AAD	1350	8	11	210	20	97	100	64	3	695	180	17	39	854	650
144-091-11BCA1	2650	8	10	880	30	7	6	632	5	1230	423	1	2	1690	40
144-092-04DBB	2520	7	13	100	520	390	150	56	11	554	1200	17	3	2110	1600
144-092-10ADC1	2700	8	.	6000	.	.	.	.	.	1260	230	27	0	.	.
144-093-03CCC	410	8	11	10	10	33	35	5	1	50	46	1	.	159	230
144-093-17ADA	2760	8	9	160	60	20	11	670	5	1160	560	5	2	1870	95
144-094-07DAA1	2310	9	3	540	10	5	2	570	3	1040	370	1	1	1510	22

TERTIARY SENTINEL BUTTE FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
144-094-10DAA	800	7	9	20	100	26	19	150	5	491	69	3	.	526	140
144-094-12CCC	4900	8	10	40	200	58	36	1100	12	80	1800	7	.	3070	300
144-094-34BAB2	3030	8	11	410	20	11	9	710	6	743	1000	6	1	2120	64
144-097-08DBD	911	7	16	1300	480	37	27	124	4	299	220	1	1	580	200
144-099-30AAB	3800	8	9	5400	730	180	130	610	8	1080	1300	8	1	2790	980
144-100-13DBD	2950	9	6	210	0	2	2	730	3	1220	590	3	2	1970	12
145-091-05DDD3	565	8	11	20	280	36	19	64	4	270	83	4	1	356	170
145-091-11CDD2	2490	8	9	0	300	51	34	516	11	795	694	0	1	1710	270
145-091-16CCC	2520	7	.	620	.	.	.	.	.	328	1100	19	4	.	.
145-091-20AAA1	2380	8	10	480	80	4	2	630	2	1570	18	68	1	1510	19
145-091-20AAA2	1630	7	.	7400	.	.	.	7	.	400	480	4	0	.	.
145-092-22DAA1	1760	8	18	200	20	7	7	414	4	691	372	0	1	1170	46
145-092-25AAC	5220	8	14	700	100	415	288	591	12	760	2640	47	211	4600	2200
145-092-25ADC2	3030	8	8	420	40	6	4	756	4	1290	624	6	1	2050	32
145-092-25BAA1	4710	8	21	0	40	92	190	805	6	1120	1660	75	129	3530	1000
145-093-04DDD	1740	8	12	170	220	54	35	300	10	560	480	3	1	1180	280
145-093-21CDD	1850	8	18	0	0	1	4	453	2	758	355	0	1	1220	20
145-093-22DCA	1830	8	12	200	280	17	5	441	2	796	334	3	1	1210	61
145-093-26BAD	1980	8	11	0	10	10	7	499	3	1060	218	0	1	1290	54
145-093-27DBC	1980	8	10	190	0	11	12	490	3	1040	281	3	1	1330	77
145-093-29CDB1	2250	8	11	0	10	19	6	571	3	1130	305	0	1	1490	71
145-093-30CDD1	2210	8	11	0	10	14	12	563	3	1140	293	0	1	1480	84
145-093-32BBB1	2930	9	10	2500	30	7	5	729	4	1070	680	4	2	2000	38
145-093-32BBB2	10000	7	16	3900	250	283	494	1820	14	728	5210	239	251	8690	2700
145-094-06CCC1	698	8	10	110	180	16	12	130	2	350	86	3	1	433	89
145-094-10ABB1	2270	9	10	0	10	14	8	565	2	1000	409	1	1	1530	69
145-094-10ABB2	7630	7	15	1300	350	366	553	992	14	267	4290	103	424	6890	3200
145-094-10CCB	2220	8	12	0	10	21	6	565	2	1100	322	2	3	1500	78
145-094-15DDD1	2190	9	8	680	20	3	4	530	2	900	410	3	1	1430	23
145-094-19CCC	933	9	7	170	0	2	3	220	1	430	71	2	1	565	17
145-094-20DDB2	5820	7	21	50	110	319	326	789	21	749	2250	309	450	4860	2100
145-094-26AAA3	1775	.	20	340	310	50	31	540	7	688	820	4	.	1810	250
145-094-26AAA4	2690	.	39	6800	380	83	71	420	13	418	1100	6	.	1950	500

TERTIARY SENTINEL BUTTE FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
145-094-26BBB	1750	8	20	140	10	12	6	409	3	763	301	2	1	1140	56
145-094-26BDD	2110	8	18	540	10	4	3	500	3	713	524	0	1	1410	22
145-094-27ACC	2060	8	14	560	0	3	2	530	3	1230	210	2	.	1380	15
145-094-27CAA	2230	8	10	390	100	23	15	500	5	820	530	5	1	1500	120
145-095-23AAD	482	8	14	80	50	15	14	72	4	287	33	0	0	295	95
145-096-12DAA	818	8	13	0	30	73	27	70	3	277	181	14	17	535	290
145-096-14BBA	596	8	25	0	10	62	26	28	12	327	36	7	13	370	260
145-096-21DDD	2920	8	8	120	100	8	3	730	4	1230	590	6	1	1980	32
145-097-15CAD	341	7	13	180	0	13	7	51	2	176	25	0	8	206	63
145-097-22DCC	1050	7	13	780	190	12	10	217	5	456	167	3	1	654	71
146-091-08CAA	2860	8	8	0	350	206	120	357	5	705	1180	12	1	2240	1000
146-091-13BCA1	893	8	16	6700	50	64	36	84	7	433	150	2	1	580	310
146-091-20DDD	1230	8	11	0	10	91	37	129	5	420	322	4	3	810	380
146-091-21DCD	4260	8	9	0	80	27	17	1050	6	937	1660	4	3	3240	140
146-091-22BBA	2200	9	5	620	30	2	1	550	2	863	401	0	1	1450	7
146-092-27DDD	407	8	10	0	180	34	13	37	3	220	38	3	1	248	140
146-092-30DAA	470	7	15	100	30	24	16	52	2	249	44	0	1	278	130
146-092-32CDD	810	8	13	50	40	53	33	66	5	275	107	25	65	504	270
146-093-03CDD	2130	8	15	50	0	2	0	530	2	1150	8	180	.	1310	7
146-093-17CBB	745	7	15	3100	420	85	38	26	4	374	126	0	3	485	370
146-093-20ADD	220	7	17	1200	60	26	8	9	5	99	25	12	4	157	98
146-093-20CBC	670	8	16	4300	10	58	37	37	4	312	113	4	1	428	300
146-093-20CCA	655	7	16	1300	320	48	32	49	3	324	70	4	19	403	250
146-093-22ADD	174	7	19	6200	140	6	4	24	2	65	32	6	1	133	32
146-093-24DCC1	421	8	24	14000	130	29	16	34	2	113	113	0	1	290	140
146-093-26CBB	887	7	23	220	400	47	45	62	13	53	191	32	189	630	300
146-093-27CCC	1030	8	12	40	300	95	44	73	6	340	300	5	1	705	420
146-093-28AAA2	909	8	14	100	800	100	44	40	5	450	150	2	1	579	430
146-093-28DDB1	733	8	18	530	10	35	15	105	5	312	131	2	1	467	150
146-093-29CCC	212	7	22	4200	140	13	6	20	2	78	27	10	1	145	59
146-093-34CCC	433	8	9	80	100	49	19	16	4	180	71	10	11	278	200
146-094-24DDD2	442	8	14	120	190	26	16	53	2	249	46	2	3	285	130
146-094-25AAA	950	8	12	200	60	14	7	210	4	420	150	6	1	616	64

TERTIARY SENTINEL BUTTE FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
146-094-25ABA	706	8	16	410	300	64	27	55	4	360	87	6	1	438	270
146-095-07DDB2	2010	8	18	70	20	99	64	311	7	532	728	3	1	1500	510
146-095-10ABA1	3680	8	18	30	20	137	126	647	7	762	1620	31	3	2970	860
146-095-22DCA	2080	8	23	200	20	25	34	449	7	819	510	2	1	1460	200
146-095-30DDD	1030	8	23	570	20	8	5	226	3	471	149	2	1	656	40
146-096-13ADA	1580	9	10	6700	100	8	3	368	2	599	296	7	1	1020	33
146-096-24CBB	1890	8	12	1300	10	15	12	441	5	742	407	4	1	1270	87
146-096-36AAA	895	8	11	80	20	40	24	138	6	448	113	4	1	559	200
146-097-25AAC1	1950	9	12	300	20	3	2	472	2	771	338	1	1	1230	13
146-097-26AAD	685	8	15	30	10	61	43	28	13	356	77	8	11	432	330
147-093-03DBB	4060	9	26	160	.	9	11	1060	4	1510	920	11	3	2880	68
147-093-29DCA	3240	8	6	80	0	5	4	903	3	2360	5	31	1	2120	27
147-095-13CCC2	2120	9	15	250	20	2	0	522	2	1100	10	150	1	1280	6
147-095-24AAC	2070	8	15	0	20	2	0	519	2	1110	100	82	1	1290	6
147-095-26BBB1	2270	8	16	200	20	3	2	564	2	1170	19	189	1	1380	15
147-096-36DCB	1600	8	3	390	50	6	3	390	2	813	160	6	1	995	26
147-097-05AAA	3060	8	2	0	10	4	2	841	4	2220	4	21	1	1970	17
148-092-06BDB	888	7	13	0	20	69	50	59	5	491	120	2	2	563	380
148-092-23CCA	1530	8	13	2400	100	95	44	200	5	566	400	6	1	1050	420
148-093-10CCC	3880	8	15	390	220	87	40	860	5	930	1500	8	1	2980	380
148-093-14CDC	5270	8	17	430	160	17	12	1300	4	1190	1900	8	1	3860	92
148-094-13BBD	1090	8	24	1000	520	118	64	43	2	497	212	5	1	716	560
148-094-20DDD	1490	8	23	440	.	74	28	250	5	581	378	2	2	1050	300
148-096-17CCD	3080	8	9	40	50	8	0	821	3	2090	0	62	1	1940	21
148-096-18ABC	3230	8	7	180	40	5	3	881	4	2360	0	16	1	2080	23
148-096-22BCB	3210	8	6	0	40	4	2	876	3	2320	0	19	1	2060	19
148-096-23BBB	3160	8	7	0	10	4	2	867	3	2360	0	22	1	2070	19
148-096-35BCC	719	8	13	90	670	105	24	22	5	471	21	0	2	426	360
148-097-04DBA	2750	8	9	0	0	4	1	736	4	1970	1	19	1	1750	15
148-097-09DBD	2180	8	14	0	20	3	2	552	2	1150	3	154	1	1320	13
148-097-10CAA	2940	8	8	80	40	4	2	803	3	2110	0	25	1	1890	19
148-097-12ABA	3200	8	6	80	40	5	3	878	4	2330	28	13	1	2090	22
148-097-17DAA	2380	8	15	0	200	3	1	587	3	1150	5	231	1	1430	9

TERTIARY SENTINEL BUTTE FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
148-097-33BCC	2890	8	10	0	20	3	1	737	3	1760	3	148	1	1780	11
154-096-04AAB	2040	8	23	850	220	83	70	390	9	.	700	7	.	1630	500
160-090-15DCC	2200	8	23	80	10	5	2	590	3	960	440	8	.	1550	21
160-090-21DDD1	2050	9	8	60	10	6	2	540	3	.	290	12	.	1370	23
160-090-21DDD2	1560	7	23	200	240	100	40	240	8	.	420	5	.	1160	420
160-090-23BBA	2620	8	22	60	10	27	4	650	3	.	650	9	.	1870	86
162-093-30DDD	3200	8	17	70	30	19	6	840	8	862	1100	10	.	2430	72
162-093-30DDD1	3050	9	7	80	.	30	2	770	3	.	520	25	.	2090	83
162-094-10AAA1	2500	9	8	150	10	3	2	710	4	1420	140	47	.	1740	18
162-094-26BBB	4600	8	9	60	30	20	7	1200	5	.	1500	17	.	3450	81

TERTIARY SENTINEL BUTTE TONGUE RIVER FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
139-095-02AAB3	1070	.	.	2200	.	.	.	.	.	.	.	.	.	856	595
143-084-28CCC2	1050	8	27	400	.	103	32	97	4	485	186	3	1	693	388
143-087-19BBB2	1950	6	17	1500	330	390	68	40	6	.	1100	11	.	1800	1300
155-096-21CDC1	2060	8	9	100	40	4	3	730	4	1800	54	54	.	1750	22
155-096-21CDC2	1520	8	11	0	10	58	47	250	11	396	560	11	.	1150	340
162-093-17CCC1	2800	8	10	90	20	3	1	700	3	1380	130	35	.	1670	14

TERTIARY CANNONBALL FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-092-06DDC	3190	8	9	320	20	29	21	738	6	642	1210	2	0	2340	159
129-096-01DAD2	2690	8	11	0	120	228	105	298	13	485	1160	29	14	2100	1000
130-092-22CBB	1780	8	8	1700	10	4	2	457	2	924	207	7	0	1150	17
131-098-07BCC	1440	8	5	530	20	8	8	380	3	861	85	17	0	955	52
131-098-23DAD1	1760	9	10	40	20	19	16	431	2	642	426	1	2	1250	104
133-089-32BDA	2360	8	11	2800	20	115	68	366	6	519	876	9	.	1710	568
133-089-34BAB	1620	9	.	960	.	.	.	.	.	.	418	13	.	946	10
134-089-22BDD	2150	8	12	50	120	2	1	538	1	1260	3	92	.	1290	12
151-077-34BA	.	.	.	1800	.	93	89	210	7	444	530	13	.	.	520
153-079-30AAA3	1400	8	9	150	40	4	1	350	2	728	51	43	1	860	12
153-080-25CDC	710	8	12	480	0	5	0	170	2	335	100	3	1	459	13

TERTIARY LUDLOW FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-091-07AAA2	2270	9	9	0	20	9	5	527	3	716	529	3	2	1470	44
129-091-08CCC	1790	8	10	50	20	7	2	422	3	590	418	5	1	1170	27
129-092-26CCB	3660	8	9	70	30	159	82	659	13	747	1490	29	8	2820	734
129-093-08CBB2	1760	8	8	140	30	5	3	432	2	942	170	13	1	1110	27
129-093-28ABB3	1670	8	8	480	10	4	1	419	2	886	151	10	1	1060	15
129-094-17BBC2	1610	8	8	280	30	13	4	401	2	947	68	17	0	1000	51
129-094-29BBB	2750	8	8	1300	10	9	7	674	4	875	759	4	0	1900	53
129-095-02DAD	2140	8	8	0	30	7	3	516	3	770	435	9	0	1370	27
129-095-06BCC	1620	8	8	0	10	4	2	407	2	903	130	11	1	1030	18
129-095-11CCC1	1600	8	8	680	10	8	43	408	2	989	166	23	0	1170	196
129-095-13BCD	3420	8	8	0	30	14	6	804	3	727	1180	13	1	2390	59
129-095-30AAB	2070	8	6	0	240	18	15	476	5	764	468	26	2	1410	106
129-096-06DAA	1660	8	9	200	10	8	0	422	2	858	156	14	1	1050	22
129-096-18CDD	3320	8	8	380	60	10	6	811	4	807	1090	7	0	2340	48
129-096-20AAA	1830	9	6	140	20	4	4	459	3	797	257	16	1	1180	27
129-096-25BAD	1350	8	9	0	50	75	44	173	10	415	412	7	1	937	368
129-096-26CAA	2050	8	8	0	20	5	3	496	3	832	391	10	2	1330	25
129-096-33AAA1	2350	8	8	0	20	5	3	572	3	808	547	11	1	1550	24
129-097-11DAC	2750	9	8	360	30	6	3	655	3	759	781	10	2	1880	27
129-097-15AAB	2180	8	8	0	20	4	2	538	2	860	407	10	1	1410	19
129-098-07DDA	1520	8	8	2400	20	7	7	391	1	955	35	6	0	955	49
129-098-30DCC	3550	8	8	2600	130	12	8	890	3	1230	980	9	2	2530	65
129-099-04CBB	1630	8	11	100	20	2	1	393	1	724	213	30	1	1020	9
129-100-07DAA	2570	8	8	0	20	1	2	606	2	721	679	8	1	1690	10
129-100-21DBA	2550	8	8	240	40	5	3	609	3	787	685	4	1	1730	26
129-100-25DAA2	1710	8	9	1100	20	8	8	425	1	834	207	16	1	1110	55
129-100-26ADA	1630	8	11	50	10	2	1	400	1	745	219	21	1	1030	8
129-101-07CCC	1580	9	11	440	10	3	1	392	1	697	203	24	0	1010	11
129-101-27BBB	1600	9	12	320	10	3	0	390	1	689	208	22	1	1010	7
129-102-11CAA	1550	9	11	300	10	3	1	378	1	666	186	12	2	955	11
129-102-27AAA	1590	9	11	40	20	2	0	386	1	647	249	11	1	1030	6
129-102-28BAD	2240	8	9	300	20	3	1	539	1	693	570	8	1	1500	14

TERTIARY LUDLOW FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-103-10DCC	1590	9	9	400	20	3	1	387	1	700	232	4	1	1020	10
129-103-23BDD	302	10	1	520	40	3	1	44	4	64	8	2	1	130	10
129-104-08DDD	2060	9	8	160	20	2	1	505	1	792	367	5	1	1330	12
129-105-02CAA	1290	8	11	370	20	2	0	308	1	581	180	1	2	807	4
130-092-27BBA2	1820	8	7	0	30	14	6	452	6	944	183	20	2	1180	61
130-098-17DAA	1940	8	8	830	20	8	7	481	2	877	303	7	0	1270	51
130-098-21CCC2	1590	9	9	0	30	4	4	405	2	932	66	17	1	1010	29
130-098-26BAC	1580	8	9	0	30	7	2	396	2	938	58	18	0	989	27
130-099-17AAA1	1610	9	7	220	10	15	7	399	2	719	222	5	5	1060	65
130-099-17AAA2	2280	8	6	0	10	27	24	499	5	604	716	7	1	1610	165
130-103-34DDD	1590	9	11	440	10	3	1	379	1	705	207	7	2	994	10
131-091-10CCC	1780	8	9	320	10	4	2	468	2	1130	33	50	1	1160	19
131-091-13CCB	1870	8	10	160	20	3	2	473	2	1150	42	50	1	1170	17
131-093-21AAA1	1600	8	9	40	30	10	4	408	2	1030	23	20	1	991	40
131-093-21AAA2	1630	8	7	440	40	7	4	407	4	960	62	17	1	1000	32
131-094-20CBC3	1590	8	8	0	20	20	3	405	2	970	44	16	1	1010	64
131-099-04DAA	1450	8	9	1700	30	7	5	362	1	767	146	6	0	933	37
131-099-25BBB1	1640	.	3	40	400	5	6	420	5	968	63	6	1	1040	36
131-100-24ABB	1050	8	9	100	50	25	15	198	7	454	192	3	2	678	125
131-102-02DDA	1710	8	13	80	10	1	0	409	1	743	240	26	0	1070	3
131-102-13CCC2	2470	9	9	450	20	8	3	558	2	452	832	7	1	1660	33
131-103-08CAC1	1740	9	12	0	10	2	1	428	1	722	248	10	1	1110	8
131-105-18DCC	1820	9	9	180	10	3	0	444	1	701	322	7	1	1170	9
131-106-03DAA	2500	8	12	100	80	46	22	541	5	825	681	6	4	1720	206
131-106-04DCC	869	8	13	0	20	32	15	149	4	390	138	11	2	558	143
132-096-22ABC1	2040	8	9	300	10	2	2	538	3	1350	34	17	1	1300	16
132-097-07CAB3	1500	8	10	1100	30	26	2	374	2	882	104	16	1	997	75
132-097-07CAB4	2050	9	8	620	10	2	1	540	2	1340	14	8	1	1300	9
132-099-32DDC1	2600	9	9	2500	20	18	30	595	3	954	598	15	1	1790	169
132-099-32DDC2	1130	8	15	500	80	92	61	79	7	441	286	3	5	767	482
132-100-35DDD	1810	8	12	0	10	4	1	447	1	908	179	37	0	1130	15
132-102-24BBB1	1620	8	11	500	50	11	12	427	2	1020	54	4	1	1060	76
133-097-34BBB	2040	9	3	70	.	2	2	538	2	1200	23	14	1	1260	12

TERTIARY LUDLOW FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
138-105-05DAA	2550	9	8	30	40	17	9	650	5	.	850	4	.	1940	79
138-105-07CCC	2160	7	12	10	60	230	140	360	18	.	1100	3	.	2350	1200
138-105-22BCB	3250	8	8	300	70	41	19	730	8	.	1100	4	.	2340	180
138-106-01AAA	4250	8	8	10	80	43	100	950	22	.	1800	5	.	3250	520
138-106-02AAA	3200	7	22	130	2000	480	450	130	21	.	2500	10	.	4010	3100
139-105-07DCC2	1760	8	8	200	20	8	5	510	3	.	150	22	.	1280	40
139-105-08AAA	1960	9	10	340	100	12	0	540	16	.	69	26	.	1370	32
139-105-18DDD	2200	8	8	80	40	10	5	520	5	.	530	63	.	1490	47
139-105-20CCC	3200	8	8	20	30	29	14	700	5	.	950	8	.	2090	130
139-105-21AAA1	1860	10	1	10	20	5	2	430	3	.	440	16	.	1220	20
139-105-21AAA2	3010	8	8	150	10	14	6	660	3	.	1300	15	.	2190	59
139-105-28CCC	3500	8	6	10	70	23	21	800	7	.	1300	6	.	2420	150
139-105-30DCC2	2800	8	11	30	40	31	20	630	9	.	890	6	.	2000	160
139-106-13CCB	2100	8	7	60	30	10	6	500	9	.	290	10	.	1360	47
139-106-23BBB	2600	8	9	10	40	18	10	610	6	.	640	7	.	1770	86
139-106-25CCC	1275	7	15	330	290	97	89	34	7	.	310	34	.	741	610
139-106-27AAB	3100	6	12	1000	1700	390	260	77	10	.	1800	16	.	2690	2100
139-106-34DDD1	2000	7	10	2300	80	120	71	330	12	.	640	3	.	1540	600
139-106-34DDD2	770	7	10	190	130	83	39	6	4	.	120	3	.	428	370
140-105-06BBB2	2720	8	7	40	20	11	41	590	4	.	770	15	.	1740	200
140-105-17AAA	2250	8	9	150	40	8	4	460	3	.	260	15	.	1260	36
140-105-27BBB	2380	8	8	90	20	.	.	110	4	.	500	5	.	1130	61
140-105-30CCC4	2700	9	2	30	30	.	.	130	3	.	790	7	.	1300	27
140-105-30CCC5	3250	8	10	1100	60	21	13	750	5	.	1000	7	.	2220	110
140-106-02DDC	2000	8	8	280	30	7	19	470	5	.	76	25	.	1260	96
140-106-23AAA	2250	8	9	510	40	11	8	550	4	.	160	20	.	1370	61
140-106-36BCC	1450	8	9	20	10	5	3	390	3	.	230	11	.	971	24
141-056-04BBB	5610	8	18	.	.	450	213	500	20	346	1860	605	80	3920	2000
141-057-15CBB	1430	8	21	.	.	212	56	29	8	517	398	10	2	990	760
141-105-03BBB	2200	9	8	10	20	5	5	600	4	.	850	13	.	1730	33
141-105-05BBB1	3500	8	9	140	10	21	16	800	4	.	920	6	.	2310	120
141-105-07AAA	4000	11	2	30	0	11	7	880	6	.	1400	11	.	2570	56
141-105-07DDD1	7000	7	20	150	1000	87	240	2400	15	.	5000	8	.	8560	1200

TERTIARY LUDLOW FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
141-105-07DDD2	4080	7	14	1200	360	48	22	800	3	.	1200	340	.	2660	210
141-105-09AAA	1930	8	13	300	80	13	7	490	5	.	54	21	.	1200	63
141-105-09BBB	2600	8	8	70	10	6	4	590	2	.	680	10	.	1630	33
141-105-14DDA	1850	8	2	2500	60	10	6	460	5	.	170	27	.	1210	51
141-105-17ADC	3475	6	8	40	20	14	9	800	4	.	1100	6	.	2360	73
141-105-20BBB	3750	8	11	40	20	20	11	840	4	.	960	5	.	2430	96
141-105-20CCC1	2950	8	3	120	60	27	36	550	5	.	1000	22	.	1900	220
141-105-20CCC2	3600	8	10	40	60	19	13	750	6	.	970	5	.	2320	100
141-105-21AAA1	2300	8	6	10	30	6	10	490	3	.	700	40	.	1500	56
141-105-21AAA2	3300	8	8	30	40	16	9	750	3	.	1000	8	.	2200	78
141-105-29ADD1	3750	8	8	150	30	27	13	900	4	.	1200	6	.	2700	120
141-105-29ADD2	4000	8	8	30	30	23	15	950	4	.	1200	6	.	2790	120
141-105-29ADD3	3800	8	8	30	30	23	13	920	5	.	1200	5	.	2760	110
141-105-32DCC	2700	8	7	110	30	14	63	.	3	.	990	14	.	1330	290
141-105-36AAA1	3400	9	0	190	50	12	46	650	8	.	1400	25	.	2290	220
141-105-36AAA2	4900	8	6	30	230	180	250	600	16	.	2400	31	.	3750	1500
143-061-14DAD	624	8	24	.	.	69	29	13	10	284	76	5	19	385	290

TERTIARY LUDLOW HELL CREEK

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-091-07AAA1	1770	9	8	120	40	5	2	443	2	975	24	58	1	1080	18
129-093-08CBB1	1870	8	8	90	50	5	2	471	2	1140	14	67	1	1160	20
129-094-17BBC1	2270	8	4	0	30	11	6	525	4	851	489	9	1	1470	54
129-096-02DCC3	1610	8	9	0	.	3	9	391	3	889	101	12	1	1000	46
129-096-02DDC1	1560	8	8	2000	10	7	0	410	2	927	69	14	1	994	17
129-096-13AAD	1720	9	6	0	30	3	3	422	2	929	50	43	2	1050	20
129-098-09BDD	1580	8	11	200	10	0	2	394	1	768	149	31	3	990	8
129-098-32ADB	1570	8	5	180	10	11	6	411	2	950	66	25	1	1020	54
129-100-13DDA	2950	8	9	460	40	30	25	654	4	962	816	7	3	2030	176
129-100-19AAA	1770	9	8	1100	60	17	5	455	2	855	239	6	2	1190	65
129-100-25DAA1	1650	9	4	1300	10	4	0	389	1	672	220	22	1	1010	10
129-101-32BCD	1660	8	10	320	10	3	1	411	3	744	258	14	1	1070	12
129-102-14CDD	1590	9	2	4400	10	3	1	391	1	676	212	22	1	1000	10
129-103-13ADA	2360	8	10	200	40	4	1	579	1	793	604	4	1	1610	15
130-091-09BAB	1890	8	10	280	10	5	2	484	2	1180	49	48	1	1190	18
130-092-27BBA3	1670	9	7	90	50	6	2	422	3	977	13	0	1	990	23
130-097-35BCB1	1670	8	10	320	80	8	6	442	3	1040	91	12	1	1090	45
130-098-21CCC1	1760	9	8	320	30	4	1	466	1	989	132	12	1	1160	13
130-099-15BCC	712	8	11	120	10	31	18	103	5	362	79	3	1	432	152
131-091-15CCC	1860	8	9	80	30	5	2	489	2	1170	99	1	1	1200	19
131-094-20CBC2	2020	8	10	680	10	8	7	516	2	1250	9	65	2	1270	50
131-100-09CCD	1730	8	13	240	10	2	2	416	1	783	212	44	1	1090	12
131-100-23DBA	1660	8	12	300	10	2	0	415	1	789	179	35	1	1040	7
131-100-29BBB1	1680	8	13	620	30	9	4	425	2	767	277	5	0	1140	39
131-100-29BBB2	2030	8	10	170	30	13	9	482	3	617	576	3	1	1430	70
131-102-07DDD1	1890	8	8	230	20	3	1	465	3	779	165	133	2	1190	11
131-102-11DDC	1900	8	12	0	140	106	76	240	6	675	450	56	1	1280	579
131-102-13CCC1	2120	8	7	0	30	11	10	486	2	647	576	9	0	1430	68
132-097-07CAB2	2110	8	8	0	40	8	4	546	3	1250	144	15	1	1390	36
132-100-14ADB	2280	8	7	180	20	32	11	500	5	634	668	4	1	1550	124
132-101-10DDD	1750	8	8	1100	30	9	7	428	5	629	427	9	6	1220	51
132-102-09DDD	2080	8	8	440	20	5	2	482	1	538	626	3	1	1400	23

TERTIARY LUDLOW HELL CREEK

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
132-102-09DDD	1700	9	9	880	40	3	1	407	1	471	444	3	2	1130	11
132-102-12CCC	4120	7	19	680	200	566	259	227	6	419	2320	44	86	3730	2480
132-102-18BAA	2430	9	8	360	20	4	3	561	1	492	799	4	1	1640	21
132-104-09CDD	3330	7	15	.	.	485	274	53	37	727	1900	8	1	3160	2340
132-105-08BBD	3390	9	3	200	20	4	6	848	2	982	799	3	1	2300	36
133-098-14AAA	2200	9	10	190	0	4	1	590	2	1450	9	13	1	1400	13
134-103-30BB	2800	9	6	20	60	7	5	650	3	709	830	5	1	1880	36
134-105-05AAA	1690	9	5	0	40	3	2	390	1	616	320	12	1	1060	16
134-105-25ADD	3500	8	6	100	70	23	18	830	3	923	1200	6	2	2540	130
134-106-27DBD	2800	9	4	230	40	7	6	660	2	897	710	5	3	1870	41
135-101-26BAA	2000	9	9	270	20	3	2	530	1	1300	3	24	3	1250	13
136-098-31ABB	2070	9	6	400	10	3	3	540	2	1390	6	14	4	1290	19
136-100-31DDC2	2950	9	0	100	40	6	15	670	9	553	1000	22	1	2000	78
136-102-05DBB	1600	9	12	.	.	1	1	430	2	930	63	12	.	1020	5
136-102-08ACC	1500	9	9	.	.	2	0	410	2	900	100	5	.	1010	6
136-102-17BDD	1410	9	10	.	.	0	1	400	2	880	88	5	.	974	4
136-103-19CDC	1600	9	6	170	0	2	1	400	3	827	160	8	1	1020	9
136-105-01AAD	1550	9	2	460	60	3	3	370	2	617	200	12	1	967	20
136-105-26ACA	1800	9	10	230	40	3	3	400	1	608	260	17	1	1060	20
137-101-19BBD	1800	8	16	.	.	1	0	470	2	1250	8	1	.	1140	2
137-101-32CCB	1640	9	7	100	20	2	1	430	1	930	79	9	1	1040	8
137-101-33CCA	1600	8	11	.	.	1	0	410	2	1010	27	2	.	990	4
137-101-34CCA	1550	8	11	.	.	1	1	410	2	1050	7	1	.	991	6
137-103-01ACA	1700	9	10	.	.	1	1	440	2	850	210	7	.	1130	6
137-104-29ADA	2050	9	6	310	10	3	2	510	2	677	490	8	1	1380	17
138-100-07AAA1	2250	9	11	770	40	2	1	540	2	1300	1	11	1	1280	10
138-102-03BBC	1850	9	11	.	.	1	1	470	2	1170	5	1	.	1100	6
138-102-06ADD	.	9	11	.	.	2	1	490	2	960	220	9	.	1250	11
138-102-07CAC	1800	9	10	.	.	2	1	450	2	900	220	7	.	1180	11
138-102-08BBC	1900	9	11	.	.	2	2	470	2	930	210	9	.	1210	12
138-102-18CBB	1900	9	10	.	.	2	1	470	2	900	260	7	.	1220	11
138-102-19ACD	1850	9	1	.	.	2	1	450	2	880	220	9	.	1160	9
138-102-20ADA	.	9	11	.	.	2	1	440	2	1080	41	2	.	1070	8

TERTIARY LUDLOW HELL CREEK

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
138-103-25DBA	.	9	12	.	.	2	1	420	2	770	250	7	.	1110	8
139-101-17CDA	1550	9	9	460	0	2	2	410	2	791	140	33	3	1030	10
139-102-10DBD1	2000	8	10	.	.	3	4	480	2	990	220	4	.	1240	24
139-102-10DBD2	1700	8	12	.	.	1	1	700	4	1720	8	2	.	1580	7
139-102-20ABB	2160	9	7	140	10	3	2	530	2	860	390	13	1	1410	16
139-102-21CAB	.	8	10	.	.	2	1	490	2	1000	200	2	.	1240	9
139-102-33CBB	1950	9	10	.	.	2	1	480	2	930	190	10	.	1180	8
140-102-17CCA	2050	8	12	.	.	2	0	510	2	112	170	3	.	784	8
140-102-27ACB2	.	9	14	.	.	1	0	410	2	900	71	29	.	1020	4
140-105-30CCC2	3100	10	1	40	10	5	20	700	6	.	1000	20	.	2130	95
141-101-02BBB	2020	8	10	.	.	2	1	570	3	1490	9	1	.	1340	8
142-100-25DDA	2180	9	13	120	10	3	3	580	2	1410	4	12	1	1370	19
143-102-09CBB1	.	8	10	.	.	2	1	560	3	1470	9	2	.	1310	8
143-102-21DDD	2300	9	11	.	.	2	0	600	3	1460	15	2	.	1400	6
144-100-24BBD2	2400	9	12	170	20	3	6	610	3	1450	5	21	1	1450	32
144-102-05CCB	2030	8	10	.	.	0	1	560	2	1230	110	2	.	1340	6
144-102-05DBA	2050	8	10	.	.	0	1	550	2	1250	90	4	.	1320	6
144-102-16BBB	1720	8	9	.	.	0	0	580	2	1320	110	1	.	1400	3
144-102-24DDD	1620	9	14	250	10	2	1	420	1	874	77	56	1	1040	8

CRETACEOUS HELL CREEK FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-088-31DDA	2150	8	15	240	140	62	22	425	4	593	666	6	.	1490	244
129-090-29ACA	2050	8	9	0	140	11	3	479	3	590	577	3	.	1380	39
129-099-04ABA2	1620	9	10	860	30	2	1	400	1	685	214	29	2	1030	8
129-102-01ADD	1550	9	12	240	30	2	1	381	1	687	196	16	1	981	11
130-084-31AAA1	4260	8	7	150	70	120	49	900	6	495	1900	83	28	3340	500
130-086-28CCC2	1900	.	16	380	50	4	1	480	1	810	260	39	1	1220	14
130-101-25ADD	3740	8	11	70	40	22	12	923	8	1150	1140	6	1	2690	106
130-102-13DCD	2930	8	13	120	20	60	37	600	14	893	863	0	1	2030	301
130-103-29CBB	2120	8	10	200	30	4	1	519	1	783	447	5	1	1400	17
130-104-15CAC	1660	9	11	320	10	2	2	393	1	610	285	2	2	1060	14
131-080-33ADD	1320	8	24	200	110	44	18	245	5	546	227	14	.	861	184
131-081-31DBC	1730	8	16	120	10	5	0	430	1	969	104	30	.	1070	14
131-081-33ACA	2420	8	17	260	10	12	2	592	3	984	479	18	.	1610	40
132-087-27ADA	1800	.	14	610	30	3	1	440	1	921	98	78	1	1100	12
132-101-12CCC	1450	9	9	440	20	13	6	349	1	559	256	14	0	960	57
132-105-16BDB	1720	9	11	240	20	3	3	425	1	736	259	3	0	1100	20
133-089-04DAD	2100	.	9	360	90	3	1	530	1	1140	2	100	1	1250	11
134-080-30CCD	2200	8	38	100	.	.	126	482	.	96	498	99	.	.	.
134-081-06DAB1	3180	8	27	680	50	12	4	750	2	820	900	12	1	2120	45
134-083-05CCD1	1530	8	27	20	10	2	0	380	1	700	260	0	1	1020	6
134-083-05CCD2	1640	8	24	40	0	2	0	400	1	740	270	5	1	1070	5
134-084-03AAD	2020	8	11	230	60	3	1	490	1	620	550	1	1	1380	9
135-083-32CBB2	3870	9	10	1300	60	13	4	980	3	1140	1200	14	1	2790	50
135-086-15DDD1	2680	8	12	110	20	3	2	660	3	1300	15	260	1	1620	14
136-081-07DDC2	2230	9	14	150	20	4	1	560	2	1070	110	130	1	1380	15
136-082-07CCC2	2130	8	8	290	0	3	6	530	2	1160	23	140	3	1300	33
137-080-35CAD	4030	9	17	0	.	41	14	1000	6	1050	1400	3	1	3070	160
137-081-25CAB	2500	8	15	90	20	7	8	610	2	870	690	0	2	1760	49
137-083-06CDD2	3400	.	12	310	10	6	1	720	3	1210	6	440	.	1790	19
137-083-06CDD3	2500	.	12	150	0	3	1	570	2	1210	23	160	.	1380	11
137-086-03AAD2	2400	9	12	60	20	3	1	670	2	1270	4	220	.	1580	10
137-089-09ABA1	2480	9	11	220	40	2	1	600	2	1120	7	230	0	1460	9

CRETACEOUS HELL CREEK FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
138-080-08ABA1	2090	8	18	5300	2700	130	67	320	6	850	450	61	0	1480	600
138-080-28AAA1	890	8	12	1100	310	110	35	52	6	480	130	1	2	587	420
138-081-09ABB2	2300	9	11	50	10	3	1	590	2	1270	3	200	.	1440	11
138-090-28DCB	2080	8	5	300	0	12	4	560	2	1460	8	10	1	1330	47
139-081-09AAA2	3100	9	8	50	0	9	2	800	3	1150	6	500	.	1960	30
139-081-09AAA3	2800	9	11	110	20	5	2	680	2	1070	10	410	.	1680	21
139-081-36DDA1	1530	8	25	7200	.	150	45	150	7	850	150	26	0	980	560
139-081-36DDA2	3460	8	17	20	.	7	1	800	3	1170	6	580	1	2000	22
139-083-12DBA2	2600	8	11	50	20	4	1	720	2	1220	4	330	.	1720	14
139-085-30AAB2	3450	9	9	1900	160	7	2	800	5	1090	5	590	1	2000	26
139-085-30AAB3	1700	.	23	1600	510	74	30	280	7	807	240	4	1	1060	310
139-086-34ADC	1040	8	25	1900	120	84	24	130	3	540	140	3	1	680	310
139-088-22DCB	3340	8	5	2000	570	26	12	830	5	1530	650	4	1	2290	110
139-088-34BCC2	2550	9	10	190	0	3	1	640	1	1110	4	240	.	1540	11
139-088-34BCC4	4700	8	7	330	50	11	8	1100	2	1400	1200	6	.	3030	59
139-089-08DDC	1000	.	23	3500	50	52	27	140	3	558	62	1	1	588	240
139-089-27BCC	1160	8	17	3500	110	53	26	180	4	580	170	0	1	742	240
139-090-14BBD	2060	8	2	140	10	3	1	560	2	1420	0	6	2	1290	13
140-084-08DCD	2130	8	7	150	20	5	3	540	4	1070	280	8	0	1390	23
140-084-33CCC	2460	9	11	80	40	4	2	650	4	1490	34	88	1	1570	17
140-085-03DDD	2670	8	10	190	0	3	3	640	3	1240	1	290	1	1590	20
140-085-09DBD	2520	8	10	870	40	3	3	680	4	1770	17	22	3	1620	18
140-085-20BDA1	2490	8	10	680	0	3	4	680	4	1750	24	20	1	1610	21
140-085-28BCD1	2440	8	11	40	0	2	2	640	4	1530	32	71	2	1540	15
140-085-30AAA	2470	8	12	40	10	2	3	660	3	1620	7	66	1	1570	17
140-086-12BCB	1690	9	7	720	20	2	2	420	4	730	280	2	1	1100	12
140-089-15DCC	2130	8	17	40	50	100	54	360	11	1110	330	7	1	1430	470
140-089-36ADD1	2250	.	24	5500	140	140	75	410	12	721	980	2	1	2010	660
141-089-20CB	2750	8	9	1800	.	4	1	750	2	1880	3	33	2	1760	14
141-090-19CCD	2320	10	2	300	20	3	2	542	9	650	10	191	1	1340	12
141-095-08BCD	5910	7	12	90	80	661	546	421	8	399	4090	1	287	6230	3900
141-095-17ACC	788	8	14	140	10	7	10	172	4	371	125	1	1	523	56
141-097-10CDA	561	8	14	50	10	16	12	103	4	298	58	4	0	357	89

CRETACEOUS HELL CREEK FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
144-091-23DBB	2360	8	10	9	0	3	1	620	2	1580	8	74	.	1500	10
145-095-22DAD1	1870	8	11	1100	50	3	2	480	3	1060	12	106	1	1150	13
147-095-04BBA	3210	8	10	580	20	5	2	837	3	1730	15	323	1	2050	18
148-096-15AAA	2310	8	14	90	30	4	0	580	2	1240	0	192	1	1410	11
151-075-15CBA	1490	8	16	330	740	75	27	230	7	611	250	44	3	954	300
151-075-23BCC	1700	8	21	580	300	74	23	290	10	704	160	140	3	1070	280
151-076-02CBC2	.	.	.	900	.	.	5	580	3	660	74	320	1	.	20
151-076-02CBC3	.	.	.	1000	.	.	7	630	4	910	120	420	1	.	29
151-076-03DDA	.	.	.	1400	.	.	5	560	3	705	270	73	1	.	20
151-076-07DDC3	2200	9	11	710	40	5	3	520	2	917	1	230	1	1270	24
151-076-07DDC4	2000	8	10	80	20	5	3	500	2	973	89	90	1	1220	25
151-076-10AAA	1550	8	7	620	0	2	1	440	2	977	7	110	1	1060	8
151-077-29ADD	2500	8	6	250	20	5	6	590	3	1030	2	370	1	1490	36
152-076-05CAC	2300	8	10	290	10	6	1	670	3	846	3	540	1	1660	19
152-077-30DDA3	3200	8	12	20	0	8	5	710	3	769	0	650	1	1790	39
152-079-13DDD2	3000	9	12	100	0	8	3	740	3	936	690	74	1	2020	33
152-079-13DDD3	4000	8	11	150	70	8	4	800	3	859	10	710	1	2020	34
152-080-05DAA	2500	8	7	690	10	6	1	710	3	1160	3	420	1	1730	20
153-077-15ADD	2400	8	6	420	10	4	1	590	3	978	5	360	1	1460	15
153-079-30AAA2	4000	9	4	150	40	4	4	780	3	1140	7	480	1	1930	26
153-080-22CDB	2500	8	7	420	0	5	3	680	2	1160	3	410	1	1690	22
154-078-31BAA2	4030	8	9	210	50	10	5	890	3	756	110	880	1	2310	47
154-079-30AAC	2300	8	7	670	20	5	2	550	2	1130	190	83	3	1410	19
154-079-36CAC	3500	8	19	2500	60	74	26	630	6	858	2	690	1	1880	290
155-080-10DCD	4000	8	16	860	60	38	13	790	7	742	7	910	1	2150	150
155-080-14AAA	4100	8	6	210	20	8	5	870	4	842	10	890	1	2210	39
155-080-17BBD	3250	8	7	480	20	6	1	730	3	983	3	580	1	1820	17
155-080-17CAC	4200	8	6	670	60	8	2	870	4	829	3	900	1	2210	27

CRETACEOUS HELL CREEK-FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-096-04DCB	1580	9	11	700	70	5	0	397	1	735	120	55	0	989	14
129-096-12DBB	1840	8	11	320	40	4	1	455	3	852	45	165	1	1110	15
129-096-13ACA	1880	9	11	40	10	2	0	460	2	884	7	180	.	1100	6
129-096-13ADD	1550	8	11	200	0	2	1	393	1	789	101	47	2	966	9
129-096-13BBB1	1590	8	11	280	0	2	2	400	1	794	66	71	0	970	12
129-096-13BDD1	1530	8	11	480	0	2	1	390	1	853	70	44	1	947	10
129-098-31ABB	1540	8	10	260	.	1	3	376	1	708	194	24	1	977	15
129-103-35BBB	1600	9	12	300	10	3	1	375	1	646	235	16	2	999	12
129-104-34ADA	1650	9	12	140	20	3	0	396	1	683	254	14	1	1050	10
130-098-04DBB	1730	8	12	0	10	3	2	418	2	897	11	129	1	1030	15
130-098-04DCC	1760	8	11	140	10	2	1	438	1	892	4	138	1	1050	11
131-094-20CBC1	1930	8	10	260	50	6	2	504	3	888	44	237	1	1250	25
131-099-22CCC1	2260	8	8	1600	40	7	3	518	6	601	668	6	1	1520	32
131-099-22CCC2	1880	8	9	320	10	2	1	498	2	1200	48	7	2	1200	8
131-100-26ABA	1870	9	11	420	20	4	2	435	2	782	93	120	1	1100	19
131-103-21DBC	1980	9	6	400	10	5	1	459	3	488	551	5	0	1320	19
131-104-28AAA2	1490	9	12	760	20	3	1	366	1	663	209	4	1	951	12
131-105-23CDD	1760	9	9	160	0	2	0	435	1	767	242	7	2	1120	5
132-097-07CAB1	1790	8	12	2800	30	5	1	451	2	877	175	54	1	1140	19
132-102-28AAA	1730	8	12	50	.	82	150	43	14	580	130	88	.	1070	820
132-103-20BBB	2230	8	9	360	20	7	3	510	6	435	766	3	2	1530	29
133-099-02CBB	1920	9	9	750	10	2	2	480	1	891	150	80	2	1200	12
133-099-32BBA	1830	9	9	410	40	2	3	450	1	830	180	64	3	1160	16
133-103-23BDC	1600	9	4	290	10	1	1	410	6	814	65	8	1	995	6
133-105-30CCC	2570	9	6	240	0	6	2	610	2	700	720	10	1	1730	22
133-106-13ADB2	2400	9	32	80	40	4	5	570	2	678	660	8	1	1640	31
133-106-34AAA	2220	9	5	40	20	3	3	530	2	788	500	9	1	1450	22
133-106-34BAA	1960	9	9	60	0	3	1	460	1	.	430	5	.	.	11
134-104-24DDD1	1800	9	11	250	10	3	3	400	3	653	150	110	.	1050	19
134-105-09BAA	1420	9	5	270	20	2	2	330	1	527	230	23	3	885	14
134-105-26BAA	1480	9	8	210	10	2	1	360	2	623	220	9	2	944	7
135-102-03CDB	1780	9	7	130	20	2	2	420	2	712	220	66	1	1100	12

CRETACEOUS HELL CREEK-FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
135-102-19DAA	1910	9	8	350	0	2	2	460	4	822	56	170	1	1150	12
136-100-31DDC1	1920	9	13	80	10	5	1	470	4	742	220	57	.	1230	14
136-102-11DAC	1600	8	16	.	.	1	0	410	2	710	220	25	.	1070	2
136-102-15ACC	1700	9	10	130	20	2	1	420	1	730	140	88	2	1060	9
136-102-20BBD	1550	9	14	.	.	1	0	410	2	700	220	28	.	1050	4
136-102-21DBD	1610	9	14	.	.	1	1	400	2	730	220	22	.	1060	6
136-103-14ADA	1650	8	12	.	.	1	0	410	2	720	220	18	.	1060	4
136-103-23ADB	1600	8	13	.	.	2	0	400	1	690	220	21	.	1050	6
136-103-24ABD	1600	8	14	.	.	1	0	400	2	730	220	22	.	1060	4
136-104-12BAD	1670	9	7	80	10	2	2	390	4	593	300	25	1	1060	14
137-101-29CCA	1600	9	14	.	.	2	0	410	2	850	110	19	.	1020	6
137-101-30ABC	1610	9	10	120	20	2	0	390	1	710	180	27	1	1000	5
137-101-30BBC	1590	9	14	.	.	1	0	400	2	860	110	15	.	1000	2
137-102-06CBD	1600	9	11	.	.	1	1	420	2	750	240	7	.	1090	7
137-103-12BAB	1600	9	15	.	.	0	1	400	2	620	280	31	.	1070	7
137-105-10ABB	2020	9	10	210	0	6	1	500	1	770	370	18	1	1310	19
138-102-34DDA	1600	9	11	100	20	1	1	410	1	650	210	28	1	1030	5
138-106-25DDA	1780	9	9	80	20	2	2	420	1	717	280	21	3	1120	10
139-102-02DCA	1650	9	16	.	.	1	1	420	2	730	220	39	.	1100	5
139-102-14DBD	.	9	16	.	.	1	0	410	2	733	210	41	.	1070	3
139-102-17CAC2	1700	9	10	1100	40	2	1	410	1	660	250	32	1	1080	8
139-105-13BBC	1840	9	10	340	0	3	1	440	1	760	270	24	4	1160	11
140-100-28CAB	1670	9	11	230	0	2	2	410	2	794	160	34	0	1050	13
140-101-35DAD	1690	9	15	40	0	4	1	410	2	.	120	68	.	.	13
140-102-06DCC	1750	9	10	140	20	1	0	430	1	680	260	37	1	1120	4
140-102-10DDA	.	9	9	.	.	3	1	480	2	590	500	8	.	1340	12
140-102-18DCC	1800	9	9	100	10	3	2	420	1	670	260	44	4	1100	13
140-102-22DBD	1700	9	13	230	0	3	1	410	1	668	220	56	1	1080	13
140-102-22DCD	1720	9	14	40	0	1	0	410	1	.	220	50	.	.	4
140-102-26ACC	.	.	17	.	.	4	0	440	0	740	220	38	.	1130	10
140-102-26BBB	1670	9	14	0	0	3	0	410	1	677	220	41	.	1060	8
140-102-26BCA	1680	9	14	140	20	3	1	410	1	730	190	37	1	1060	9
140-102-27ACB1	1700	9	14	.	.	1	0	440	2	780	170	42	.	1110	5

CRETACEOUS HELL CREEK-FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
140-102-34AAD	1700	9	15	.	.	1	0	400	2	710	240	31	.	1080	3
140-103-02CDC	1790	9	10	230	20	2	2	440	1	710	220	65	2	1130	15
140-104-12ADB	1670	9	11	130	10	2	1	430	2	666	300	38	3	1140	8
140-104-15BBD	1820	9	10	100	10	2	1	430	2	674	310	38	3	1150	7
140-105-14ABA	1890	9	10	330	0	4	1	450	2	708	320	37	1	1210	12
140-105-30CCC1	2060	9	7	40	20	13	19	570	3	728	640	31	1	1680	110
140-106-25CBB1	2170	9	11	80	20	4	2	530	1	790	430	23	1	1410	15
141-100-30ACA	1600	9	10	210	0	2	1	410	2	765	170	37	2	1050	9
141-101-02AAC	1700	8	15	.	.	0	0	440	2	890	150	40	.	1090	0
141-101-21BCB	1700	8	16	.	.	2	0	430	.	760	200	33	.	.	8
141-101-21CAC	.	9	13	.	.	2	0	410	2	740	190	38	.	1070	5
142-101-33DBA	2400	9	15	.	.	0	0	460	2	820	190	35	.	1150	1
142-102-04BCB	.	8	11	.	.	3	0	570	3	1500	12	2	.	1370	8
143-102-01BBD	.	8	15	.	.	1	0	470	2	870	140	48	.	1140	3
143-102-29AAD	.	9	16	.	.	2	5	450	2	750	250	44	.	1180	27
143-105-33BAB	2050	9	13	730	20	4	1	450	1	834	190	40	1	1140	11
144-099-14ABB	1550	9	13	270	10	2	1	430	1	969	7	84	2	1050	8
144-100-24BBD1	1720	9	15	420	0	3	0	450	2	.	29	78	.	.	7
144-102-27DCC	.	8	14	.	.	2	0	470	2	890	160	56	.	1180	4
144-102-29BBA	.	8	13	.	.	2	0	440	2	810	170	49	.	1110	4
144-102-35CCB	.	8	12	.	.	2	1	430	2	790	160	66	.	1110	12
145-074-08AAA	1450	8	29	1700	0	26	13	300	6	644	140	79	3	918	120
145-077-04ABC	2100	8	12	420	120	19	6	500	3	883	410	13	3	1400	74
145-077-04DAB	2150	8	12	460	60	8	3	550	3	915	460	13	0	1500	34
145-077-09BBB	2100	8	13	380	40	30	11	520	5	973	400	10	1	1470	120
145-077-09DDD	1900	8	19	3000	60	11	5	480	3	941	280	17	0	1290	48
145-077-16CAA	2250	9	10	150	20	8	2	590	2	796	600	10	3	1630	30
145-077-22BAA	1750	8	11	1000	20	7	4	420	3	852	240	15	3	1130	34
146-077-29DBB	1700	8	13	750	10	6	2	430	2	996	7	85	1	1040	22
147-074-04BDD	1850	7	22	13000	240	140	73	210	8	905	340	6	1	1260	650
147-075-20ADC	1910	7	26	20000	260	140	51	240	10	786	430	16	0	1320	560
148-077-02DDD2	2700	9	13	3000	100	10	6	570	5	867	150	270	1	1480	50
149-075-15ABB	2200	8	18	650	10	6	1	560	3	741	540	51	3	1560	20

CRETACEOUS HELL CREEK-FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
150-074-08CDB	2090	8	53	210	0	8	2	490	6	796	240	120	3	1340	29
150-074-14BBB	4000	8	20	240	60	18	7	880	10	523	850	470	10	2530	74
150-075-35BBD	3010	8	45	1500	160	22	5	730	7	848	950	13	4	2210	74

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-077-17ADA	2650	8	25	4700	790	293	128	220	15	977	825	14	.	2030	1260
129-078-11DCC	1870	7	15	0	250	74	54	299	9	763	422	20	.	1270	407
129-081-01BAB	2520	8	12	2100	40	11	3	610	5	905	600	13	1	1720	38
129-087-10BBC	2000	.	10	220	20	3	1	470	1	907	2	220	1	1170	10
129-089-24DDD2	2000	8	10	0	20	23	5	473	2	725	508	3	.	1390	77
130-071-20DDD	1080	8	43	80	140	68	44	74	12	378	170	13	2	613	350
130-076-34DCD	3510	8	12	3600	200	78	32	669	12	204	1240	229	.	2380	325
130-077-01CCC	1500	8	31	.	.	80	64	196	11	545	395	10	.	1060	462
130-081-31BBB2	1440	8	17	0	10	7	0	340	1	577	254	0	.	918	18
130-083-25CBC	2590	8	15	0	20	16	4	617	1	820	739	5	.	1810	56
130-083-28DCD1	2030	9	.	690	.	.	.	.	.	.	595	9	.	1200	32
130-083-28DCD2	2530	9	.	2100	.	.	.	.	.	.	846	21	.	1540	46
130-083-28DCD3	1710	8	.	400	.	.	.	432	.	726	330	10	.	1110	15
130-084-36ABA	2470	8	13	1200	80	7	1	540	2	675	410	130	0	1450	22
130-085-17DAA1	2200	.	16	1200	30	3	1	510	2	875	3	270	1	1250	12
130-086-28CCC1	2130	9	11	0	10	4	2	510	3	874	30	249	0	1270	16
130-089-32DDA	2600	.	9	40	20	3	1	600	2	847	2	410	1	1460	9
130-089-33CCB	3180	8	6	140	30	185	125	421	11	663	1320	13	.	2410	975
130-099-04BAA	4500	7	.	.	.	.	.	.	14	.	.	.	.	.	.
131-067-35ACC	990	7	20	1100	1500	140	56	36	8	456	260	9	0	757	580
131-071-07BBB2	610	8	20	0	100	44	19	61	6	313	50	5	1	370	190
131-072-02CCC2	400	8	15	240	240	40	12	28	6	237	21	3	1	246	150
131-072-14BBB2	420	8	19	0	100	35	18	19	6	224	7	3	1	219	160
131-073-35BCC	1180	8	19	480	120	39	20	170	11	514	120	11	2	650	180
131-087-06BCB	1770	8	10	100	40	4	2	425	1	742	291	13	.	1130	21
131-088-01AAD	1750	.	.	.	.	.	.	.	.	.	.	.	.	1140	10
131-089-30AAA	2330	8	10	980	40	4	1	550	3	880	10	330	.	1370	12
131-090-04CAA	1040	8	11	360	10	61	21	143	13	415	212	1	.	668	240
132-068-02DDD2	840	8	26	80	200	92	51	17	6	397	120	6	1	527	440
132-068-22CDA	1850	8	16	190	560	180	110	120	12	479	590	40	87	1390	900
132-069-05BCD	1670	8	19	420	1400	97	26	250	11	485	370	95	0	1110	350
132-070-22BBB1	800	8	22	210	220	26	11	140	7	373	86	4	2	498	110

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
132-071-01DDD2	950	8	18	40	20	39	18	150	9	416	98	18	3	573	170
132-072-22CCC2	555	8	25	0	460	61	21	17	6	292	37	2	2	318	240
132-073-02DDD2	610	8	45	0	300	68	24	37	7	322	91	3	1	441	270
132-073-04BBB2	1690	8	22	350	720	14	4	340	7	667	210	8	7	941	50
132-073-04CAB	4120	8	11	60	180	190	250	470	15	852	1100	190	570	3220	1500
132-073-08CBC	4520	7	21	170	50	320	240	580	23	499	2500	64	33	4030	1800
132-073-28BAB	1650	7	15	690	400	200	88	78	12	683	460	6	0	1200	860
133-047-17CCC1	869	8	21	60	260	77	36	67	7	490	66	16	2	535	340
133-047-20BAA1	1090	8	21	850	320	84	83	35	5	456	250	7	2	713	550
133-047-20DDD1	2890	8	16	3200	30	370	140	170	12	341	1500	41	3	2430	1500
133-078-09CCC	1200	8	17	0	60	32	25	220	6	599	163	8	.	770	184
133-082-05ABC	2300	8	17	270	30	6	1	590	2	1170	170	100	1	1480	18
133-082-05DBA	2120	8	21	380	20	79	30	410	7	1170	130	96	1	1350	320
133-082-15ACD2	2730	8	16	860	40	7	2	670	8	1130	530	42	1	1840	24
133-082-29CDD1	2240	8	16	90	10	3	4	560	2	1150	230	74	1	1470	26
133-082-31DDA	2150	8	16	220	10	4	2	530	2	1100	240	37	1	1380	17
133-082-32BAD	2270	8	16	0	0	5	1	570	2	1130	200	93	1	1450	17
133-085-12AAD	2270	8	17	920	0	3	1	559	2	1130	6	224	.	1380	12
133-088-14DAC	1640	7	.	11000	.	.	.	.	.	391	456	11	.	1170	680
134-075-08DCB	1070	7	49	6400	630	126	54	37	11	408	264	2	.	753	538
134-077-18CCB	1260	8	19	280	10	30	16	243	4	494	237	4	.	800	142
134-079-07BCB	1750	8	27	40	260	32	15	370	5	720	350	5	1	1160	140
134-079-20AAB	1150	8	15	150	260	36	32	190	6	470	240	7	0	757	220
134-080-16DAA	1930	8	24	0	20	14	7	450	4	880	310	10	1	1260	64
134-080-17DDD	1940	8	19	200	80	19	7	440	5	910	300	10	1	1250	76
134-080-23BAB	1940	8	15	490	240	12	8	450	3	840	350	5	1	1260	62
134-081-06DAB2	2700	8	26	20	40	9	4	680	3	890	700	41	3	1910	41
134-081-08DAD1	2540	8	25	310	40	25	11	600	3	800	690	4	4	1760	110
134-081-08DAD2	2520	8	25	80	30	7	4	610	2	760	750	2	3	1780	32
134-081-30BCD2	2490	8	17	20	10	5	1	610	3	1100	320	69	1	1570	18
134-082-01AAC	1800	8	22	90	50	3	3	470	2	1000	140	44	3	1180	20
134-082-01ACA	1420	8	24	400	50	3	3	360	1	730	160	9	1	928	20
134-082-35DAA	2370	8	16	60	0	5	6	570	2	1110	240	82	1	1490	36

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
134-082-36DCD	2800	.	14	2500	50	5	2	640	2	1080	470	49	1	1720	18
134-083-05DCC	1610	8	22	610	100	26	11	360	2	800	230	4	1	1060	110
134-083-17CCC	1600	8	25	920	160	22	9	350	3	680	280	16	1	1050	93
134-083-17DDB1	1950	8	24	190	140	140	68	250	7	800	460	27	1	1370	630
134-083-17DDB2	1530	8	25	1300	60	66	35	250	5	710	270	5	1	1010	310
134-083-23CAD	1410	7	26	5800	500	140	60	100	6	600	310	14	1	960	600
134-083-26BBA	2110	8	23	270	20	70	33	420	5	1050	300	30	1	1400	310
134-083-32AAA1	2280	8	24	360	120	20	8	520	3	1070	210	90	1	1410	82
134-083-32AAA2	1790	8	22	3600	60	110	47	250	7	670	470	4	1	1250	470
134-084-01CDC1	773	8	24	2100	620	70	28	56	4	330	150	3	1	502	290
134-084-01CDC2	862	8	19	3100	520	90	43	39	4	360	190	3	1	570	400
134-084-03ADC	2240	8	13	170	10	4	3	520	2	960	250	90	1	1370	20
134-084-03CBA	2100	8	9	370	10	3	3	470	1	600	540	5	0	1340	20
134-084-11DDD	730	8	20	2100	540	67	27	51	4	340	120	2	1	462	280
134-084-17DBD	1610	8	24	1300	100	14	4	380	2	720	270	2	1	1060	52
135-075-12DBB	533	8	43	0	20	7	38	45	7	220	90	9	.	348	174
135-076-19CCC	1150	8	40	.	.	11	12	249	6	567	151	3	1	755	77
135-076-19CCC	1170	.	40	.	.	18	7	254	5	561	166	1	0	778	73
135-076-19CCC	1210	8	44	640	140	32	17	230	5	570	190	7	3	811	150
135-079-10AAB1	2900	9	9	40	40	7	2	690	3	1110	5	420	1	1730	27
135-080-30AAB	1310	8	28	40	10	110	33	150	8	560	260	5	0	873	410
135-080-32DDA	1770	8	16	640	50	6	3	430	2	800	300	0	1	1150	26
135-080-33DDA	2080	8	27	100	140	70	26	400	6	720	510	7	1	1410	280
135-081-03BCC	1070	8	22	1500	1200	160	41	21	8	460	240	2	1	725	570
135-081-04BAB	998	8	30	1100	480	120	29	62	7	410	210	4	1	668	420
135-081-24DDD	1760	8	12	100	10	8	5	420	2	800	270	9	3	1140	40
135-082-30CBB	1310	8	14	40	80	17	6	290	3	550	230	3	1	836	67
135-083-31BCD	1450	7	.	940	60	16	7	320	2	670	230	0	1	.	69
135-083-32CBB1	3110	9	8	0	40	6	2	750	2	1160	470	160	1	2000	24
135-084-04DCC	1930	8	25	1000	40	31	15	430	5	950	280	6	1	1270	140
135-084-09CCD	2330	8	14	7400	220	130	55	380	6	660	790	4	1	1710	550
135-084-16AAA1	919	8	24	1700	340	130	35	35	2	550	73	1	1	576	470
135-084-16AAA2	889	8	15	2900	220	110	40	33	5	520	88	3	1	555	440

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
135-084-16AAA3	933	8	15	4500	540	120	41	34	4	530	100	3	1	586	470
135-084-16AAA4	1480	8	19	1200	80	32	12	330	3	830	150	9	1	969	130
135-084-16AAA5	990	8	17	5700	300	130	38	41	4	570	110	3	1	632	480
135-084-16AAA6	969	8	16	2600	300	120	41	40	5	550	110	4	1	611	470
135-084-16AAA7	995	8	15	4500	140	79	30	110	4	560	100	3	1	624	320
135-084-16AAA8	904	8	23	2700	40	130	33	27	3	560	69	2	1	568	460
135-084-16AAA9	1020	8	22	3800	240	110	28	93	3	610	89	2	1	654	390
135-084-16AAB	1320	8	18	3300	560	37	16	280	5	700	150	6	1	869	160
135-084-16ABA	1950	8	25	1400	160	70	28	370	6	830	410	5	1	1330	290
135-084-16ABB	1620	8	24	5700	200	97	48	230	6	700	360	1	1	1120	440
135-084-21DDD2	1920	8	25	1600	20	45	21	400	5	760	420	8	1	1300	200
135-084-21DDD3	1040	8	23	3300	140	47	20	170	4	470	180	3	1	685	200
135-084-23AAB	2170	8	.	300	20	4	1	530	1	930	370	17	3	.	13
135-084-26DAA1	1880	8	26	1800	20	110	45	290	5	620	550	5	1	1350	400
135-084-26DAA2	1700	8	25	2700	40	110	55	220	7	680	420	4	1	1180	500
135-084-26DAA3	1270	8	22	5000	80	110	50	120	5	480	320	3	1	875	480
135-090-23BBB1	2250	9	10	300	80	3	1	567	3	1080	20	167	0	1370	12
136-075-14AAA	764	7	39	1600	130	33	12	129	5	380	103	1	.	515	130
136-079-05CCC	2990	8	12	130	20	7	3	720	3	1210	140	340	1	1830	29
136-079-07BAD1	2070	8	12	370	20	4	1	490	2	630	550	4	3	1380	13
136-081-06BBB	2570	8	28	500	80	84	27	510	8	1000	510	63	1	1730	320
136-081-07AAA	980	.	29	1700	400	77	24	88	12	467	88	1	1	553	290
136-081-07BBB	2640	8	27	120	120	62	18	570	6	1010	490	76	1	1750	230
136-081-07DDC1	1620	9	10	190	20	2	3	400	1	380	130	7	1	775	19
136-081-13DBD	2420	8	18	1200	100	59	27	500	4	750	750	0	8	1740	260
136-081-16BBB	1800	8	28	440	250	140	46	230	7	590	520	7	1	1270	540
136-081-16CDD	1350	8	25	190	100	70	23	220	4	490	310	9	1	905	270
136-081-31ABB	1420	8	21	120	260	37	12	290	5	560	300	5	1	950	140
136-081-32ABD	1050	8	14	11000	1600	150	49	22	7	450	250	0	3	729	580
136-082-07CCC1	2840	8	11	460	10	5	4	690	2	1200	0	380	4	1710	30
136-082-08AAB	2560	8	18	420	30	8	2	660	3	1380	25	210	0	1610	26
136-082-22BBC	1980	8	15	400	0	4	0	500	2	1060	130	61	3	1240	10
136-082-22DAA	1450	8	28	150	1000	110	38	170	9	550	320	21	1	969	430

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDN(1)
136-083-01CCC	2170	8	13	190	60	5	2	550	2	1120	89	110	1	1350	21
136-083-10CDA	2190	8	12	90	0	6	2	540	2	810	530	0	1	1490	21
136-083-10CDD	421	8	8	800	130	41	15	29	2	260	10	0	2	236	160
136-083-19ADB1	2150	8	11	40	0	4	1	550	2	1150	61	140	1	1340	12
136-083-22BDD2	2110	8	11	180	20	5	12	500	2	740	570	0	0	1470	62
136-083-22BDD3	2980	8	13	900	90	37	16	720	4	1070	830	1	1	2150	160
136-083-22CCB	1760	8	11	160	30	3	1	440	1	810	300	0	1	1160	13
136-083-26DDC	9090	8	14	310	80	400	980	1200	10	930	6400	150	170	9790	5000
136-083-32CDD1	2310	7	17	44000	400	230	170	130	9	710	960	6	1	1920	1300
136-084-20DBA	1240	8	23	1300	80	77	33	160	5	540	210	24	1	803	330
136-084-21BDC	2350	8	13	140	10	5	0	590	2	1150	150	120	1	1450	12
136-084-30DAA	1220	8	18	120	240	48	27	200	4	510	230	10	1	792	230
136-084-31ADD1	2120	8	19	380	10	4	1	530	2	1160	3	130	0	1290	16
136-084-31ADD2	1160	8	21	3500	10	68	34	150	4	450	270	4	1	777	310
136-084-33DDD	1500	8	10	870	40	4	0	380	1	780	200	0	3	989	10
136N081W16CCC	1070	8	26	40	820	100	29	100	6	420	250	4	1	722	370
136N081W16CCD	931	8	33	60	400	88	29	84	6	430	160	3	1	618	340
137-080-07CAD	2490	8	16	20	0	4	2	610	2	1010	380	87	0	1610	18
137-081-10BAA	957	8	23	350	400	70	38	110	5	510	140	1	1	641	330
137-081-24ADB	2310	8	16	200	20	6	0	580	2	1170	300	23	2	1510	15
137-081-28CBC1	1220	8	26	2000	110	39	15	230	3	520	230	0	1	803	160
137-081-28CCD	1810	8	31	20	60	66	21	360	6	790	320	24	1	1220	250
137-082-36DDD	2580	8	20	580	40	19	8	610	4	1260	300	66	1	1650	81
137-083-06CDD1	3800	.	15	100	10	5	1	740	3	1200	7	490	.	1860	17
137-083-07BBB1	2610	8	23	220	80	40	17	570	4	990	460	120	1	1730	170
137-084-22ACD1	2190	8	12	160	140	3	1	560	2	1210	200	30	3	1410	10
137-085-06CCD	2900	8	25	860	10	80	39	600	7	1120	720	5	1	2030	360
137-085-17CDB	2490	8	19	1200	60	61	26	510	6	990	520	4	1	1640	260
137-086-03AAD1	2600	9	11	40	10	3	1	720	2	1210	5	330	.	1710	11
137-086-28DCD	733	8	11	530	220	64	34	41	7	360	89	13	1	439	300
137-086-34BAB	1550	9	8	110	10	2	2	370	2	660	240	4	1	985	14
137-087-12CDA	2230	9	6	190	20	4	2	560	2	1090	290	8	1	1440	16
137-088-21DDC	950	.	1	40	20	4	6	220	2	339	62	22	.	566	34

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
138-080-06ADD	830	8	15	2000	1000	71	20	77	3	320	160	13	1	521	260
138-080-06BCA1	1880	8	16	1200	1400	130	55	250	5	940	260	47	1	1230	550
138-080-06BCA2	2750	8	13	100	0	5	2	670	2	1150	8	360	1	1630	20
138-080-06BCC	1540	8	21	2400	520	120	66	170	7	850	180	27	1	1020	570
138-080-30CDD	1860	8	15	100	10	32	15	370	4	600	330	63	66	1190	140
138-080-31DBB	2200	8	13	40	10	5	2	530	4	950	260	98	3	1390	18
138-081-01CBD	1350	8	19	210	20	31	13	280	5	620	210	16	1	881	130
138-081-01CCA	1230	8	28	250	580	87	37	140	7	550	200	29	0	800	370
138-081-09ABB1	4600	.	16	1100	30	8	3	970	3	1100	3	890	1	2440	32
138-081-09ABB4	2230	9	5	60	40	3	2	560	2	1140	220	36	1	1420	17
138-081-12DAB	1370	7	21	12000	100	98	52	150	5	960	5	11	1	827	460
138-081-15DDC	1710	9	9	170	0	13	24	420	2	820	190	18	3	1110	130
138-081-17DDA	2170	8	10	230	10	4	1	550	4	1220	4	140	3	1330	15
138-081-20BAA	2050	8	9	140	0	4	1	520	3	1180	79	63	1	1280	15
138-081-25ADB	1540	8	15	100	10	22	10	340	4	510	280	70	1	994	94
138-081-30ABB	726	8	11	60	80	77	33	26	4	330	76	13	41	444	330
138-081-32ADA	2260	8	10	40	0	5	1	560	3	990	380	16	3	1480	17
138-081-35ABA	2180	8	22	1100	170	39	13	460	5	940	120	210	1	1340	150
138-082-04BDD1	2800	8	11	40	0	20	7	670	10	1160	1	390	1	1690	78
138-082-05BCA	2830	8	12	60	0	5	1	690	7	1230	3	360	1	1690	18
138-082-05DBC	2860	8	13	190	10	5	12	700	6	1230	2	380	1	1730	61
138-082-08DDD	2920	8	11	560	20	7	2	700	5	1250	5	390	1	1740	27
138-082-20DDD	2440	8	9	190	30	6	5	630	8	1090	400	23	2	1640	32
138-082-30CBD	2340	8	10	170	30	4	1	610	8	1120	260	59	1	1540	16
138-082-34DAB	2620	8	9	230	20	5	2	650	8	990	580	11	1	1780	21
138-083-14ABB	2850	8	10	80	0	4	2	690	4	1270	13	350	1	1720	15
138-083-22ABA	2900	8	12	570	10	4	1	700	4	1190	17	380	1	1720	14
138-083-22BDB	3100	8	12	0	10	4	1	740	4	1230	18	420	1	1820	15
138-083-26ACC	2680	8	12	110	20	3	2	660	3	1300	15	260	1	1620	14
138-083-26CDB	2340	9	10	110	10	3	1	580	3	1030	330	38	0	1510	13
138-084-01ABC	4300	7	19	380	80	77	58	1000	9	1750	1200	2	1	3230	430
138-084-10ABB	2520	8	8	570	10	3	1	630	4	1470	5	140	1	1540	12
138-084-25AAA	3350	8	11	260	10	7	2	820	5	1020	960	2	3	2330	27

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
138-084-27CCC2	1250	8	9	20	20	12	7	280	3	630	140	5	3	779	59
138-085-01CAA	2340	9	9	680	20	2	3	590	4	1360	54	82	1	1450	18
138-085-10CAB	1920	9	3	1300	20	3	1	490	2	1060	150	3	2	1210	12
138-085-20BBD	2320	8	8	110	40	7	2	570	4	1130	330	3	1	1500	28
138-085-22BAD	1790	9	4	310	10	3	1	440	1	880	220	3	1	1140	10
138-085-26CDD	1470	9	6	130	20	3	0	360	1	640	220	3	1	936	10
138-086-11DDB	1460	.	25	2100	80	10	5	350	2	740	180	2	1	953	43
138-086-13CCC	1560	8	18	480	80	19	8	360	3	820	190	3	1	1010	82
138-086-17CDD	1600	8	18	1600	170	23	10	370	3	840	200	5	1	1050	99
138-086-17DDC	826	8	21	100	20	94	40	33	3	510	51	4	0	500	400
138-086-20BAB	2740	8	22	2900	40	60	29	610	6	1170	600	12	1	1920	270
138-086-20BBB	2150	8	18	270	20	46	23	470	5	1070	290	9	1	1390	210
138-086-21BCB	1640	8	16	150	320	90	43	250	6	820	280	5	1	1100	400
138-086-26CCC	3020	8	23	190	0	96	46	630	8	1140	850	13	1	2230	430
138-086-26CDD1	2140	8	9	270	40	35	15	500	4	920	470	4	5	1500	150
138-086-35BBC	3020	8	23	350	10	96	44	650	8	1130	800	9	1	2190	420
138-086-36AAB1	2510	8	13	640	20	3	2	640	4	1310	310	10	3	1660	18
138-087-03DBB	3120	8	24	2100	90	110	47	620	9	1140	870	7	1	2250	470
138-087-28BBC2	2390	9	8	140	120	2	2	600	2	1090	360	5	3	1550	14
138-087-34CBA	2210	8	9	0	80	2	2	560	2	1210	210	7	3	1410	12
138-089-13CBB	2990	8	8	80	120	3	4	750	2	1230	640	6	1	2030	23
138-089-32CBB2	1940	8	9	290	100	3	1	500	2	1240	65	10	1	1210	11
138-089-35BAA	2000	8	6	90	120	12	6	520	2	1290	82	10	1	1280	56
139-080-31CAA	1140	8	16	560	1500	120	41	82	4	450	260	16	1	764	470
139-080-31CDD	910	8	16	60	460	98	35	63	4	480	100	13	1	567	390
139-081-04BDA1	3710	8	11	70	30	17	8	930	4	1140	1200	24	.	2760	76
139-081-04BDA2	3360	8	18	190	0	6	2	810	3	1290	3	500	1	1980	23
139-081-09AAA1	3250	8	19	240	10	6	2	850	3	1300	4	560	.	2090	24
139-081-09AAA4	8000	8	10	40	210	78	50	2000	7	960	3800	24	.	6450	400
139-081-15CBB	3020	8	9	190	70	8	3	750	2	1150	660	16	5	2040	32
139-081-16BCC	3350	8	8	100	10	1	1	800	2	1310	1	500	1	1970	8
139-081-16CDB	2730	8	11	20	20	5	2	650	2	1200	13	350	1	1630	22
139-081-22ACC	2710	8	10	370	0	6	2	680	2	1240	320	94	1	1740	21

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
139-081-25CBB	1920	8	17	620	100	95	49	310	6	910	280	51	8	1270	440
139-081-25CCC	1690	8	17	210	2400	190	67	130	6	840	300	10	1	1140	750
139-081-26ACA	1530	8	21	4600	860	130	43	180	5	730	260	11	5	1020	500
139-081-28CDC	1250	8	12	80	70	150	43	81	5	570	240	7	1	820	550
139-081-30ADA	1680	8	17	250	160	100	2	310	4	720	220	83	1	1090	260
139-081-30BBB	887	8	14	1000	600	100	27	62	9	420	140	5	1	567	360
139-081-30DDA	2520	8	10	120	10	4	2	610	3	1200	7	260	1	1500	17
139-081-36CCD	1870	8	19	1200	100	110	47	280	5	920	290	37	1	1250	470
139-081-36DAB	1270	8	16	1800	1700	130	43	110	8	750	120	6	5	812	500
139-082-08BCC	2790	8	14	20	0	5	1	690	4	1300	5	330	1	1690	16
139-082-15ADA	3070	8	18	390	0	6	9	760	7	1290	1	420	1	1860	51
139-082-21AAB	4580	8	11	20	10	15	10	1100	5	1210	1500	11	5	3260	79
139-082-23DCB	3060	8	12	230	40	8	2	730	7	1190	1	450	1	1810	30
139-082-24CCA	3200	8	13	140	0	6	2	770	8	1280	2	470	1	1910	24
139-082-25ADD	1170	7	18	5400	280	120	32	100	8	560	110	60	1	731	430
139-082-25BBD	1630	8	16	6300	700	170	60	140	4	720	340	25	1	1120	670
139-083-12DBA1	2800	9	12	60	20	4	1	750	2	1220	4	370	.	1800	15
139-083-12DBA3	2300	9	9	30	20	4	2	600	2	1040	380	22	.	1540	19
139-083-24DDB	4380	9	9	20	10	13	7	1100	5	1090	1500	8	0	3210	61
139-083-28DAD	2550	8	7	40	20	4	4	620	2	1100	410	34	5	1650	26
139-084-27BBC	1980	9	7	80	10	3	2	500	2	1090	110	45	1	1240	15
139-085-03DCC	2190	8	8	1600	20	2	2	570	2	1180	230	5	1	1430	12
139-085-06CDD	2480	8	6	140	60	11	7	630	3	1450	220	13	5	1610	57
139-085-06DDD1	1650	8	10	260	620	70	48	260	6	560	440	19	5	1140	370
139-085-06DDD2	1020	8	10	100	200	88	28	92	5	370	190	18	45	659	340
139-085-18DCD	1640	8	25	220	160	89	26	290	5	780	300	2	1	1120	330
139-085-21AAD	2420	9	8	0	20	3	1	620	2	1230	310	4	1	1580	12
139-085-21ADC	2240	9	8	400	10	3	1	570	3	1160	290	6	0	1480	12
139-085-21BAC	2800	.	8	3700	80	5	3	700	3	1320	380	6	1	1830	26
139-085-21BDB	1670	10	3	260	40	2	1	400	4	380	190	11	0	1020	10
139-085-22BCB	2740	9	9	4100	100	4	3	700	3	1320	410	5	1	1810	21
139-085-24BAB	2190	9	12	590	20	2	1	570	3	1140	260	7	1	1440	12
139-085-30AAB1	3450	9	9	1900	160	7	2	800	5	1090	5	590	1	2000	26

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDN(1)
139-086-27BAA	1500	8	18	6100	520	50	18	280	4	640	290	3	1	990	200
139-086-35BCC	1320	8	17	1100	220	22	13	290	3	650	190	4	1	863	110
139-086-35BDA	1460	8	13	1200	520	140	32	170	4	560	350	14	1	1000	480
139-086-35CBC	1250	8	14	1800	360	80	19	200	3	590	190	12	1	813	280
139-086-35CCC	1575	.	28	2600	70	16	5	370	2	856	160	3	.	1010	60
139-087-01BCB	2100	9	9	190	10	2	1	520	2	1000	290	2	3	1350	8
139-087-08BAB	2270	9	11	190	40	3	1	590	3	1330	170	7	1	1470	10
139-087-11DCD	2340	8	8	380	40	2	3	590	4	990	450	2	2	1570	15
139-087-16CDB	1310	8	8	480	780	79	57	160	5	510	320	3	1	886	430
139-087-18ABC2	2400	9	8	90	20	9	22	620	4	1430	160	15	3	1580	110
139-087-23BBB	2120	9	6	320	20	4	1	560	3	1310	18	14	1	1330	12
139-087-26ADB	2170	8	13	90	10	2	1	590	3	1510	7	13	1	1400	8
139-088-06DDD	3790	8	19	2000	60	210	94	670	11	960	1500	3	8	3000	910
139-088-15CCC	3400	8	25	0	80	140	73	630	10	1000	1200	5	1	2580	650
139-088-25BAD	3330	8	21	60	80	110	57	630	11	1150	930	8	2	2340	510
139-088-25BCC	3110	8	24	1200	0	90	50	630	9	1070	910	5	1	2250	430
139-088-28DDA	4240	8	21	1800	70	130	57	910	7	1300	1400	6	1	3180	560
139-088-31BBC1	2060	8	27	920	40	28	10	490	6	1020	280	6	2	1350	110
139-088-31BBC2	3460	8	24	2500	70	47	22	800	6	1310	890	6	1	2450	210
139-088-34BCC1	2400	.	4	20	5	4	1	730	3	880	7	390	.	1770	16
139-088-34BCC3	2600	.	9	180	60	3	3	630	2	1300	290	10	1	1610	18
139-089-22ADA	2540	8	10	20	50	17	20	700	3	1880	96	4	1	1780	130
139-089-26CCD2	3990	8	17	1700	120	260	110	650	12	1130	1600	6	3	3200	1100
139-090-12DAA	3160	8	8	140	30	6	3	790	4	970	1000	5	.	2300	28
140-062-02CCC	1240	8	23	490	180	70	40	150	9	493	210	52	1	799	340
140-062-16DDD	1690	8	23	130	20	26	23	340	8	601	240	110	1	1070	160
140-062-23AAB	1110	8	22	20	120	65	24	150	7	478	160	41	0	706	260
140-062-23ABB	1110	8	23	1400	60	63	25	150	7	468	160	44	1	706	260
140-062-27CCC1	1430	8	21	1400	160	24	10	300	7	519	210	76	1	907	100
140-062-27CCC2	1060	8	19	0	10	140	46	28	7	406	250	13	1	704	540
140-081-18ABD	1370	8	15	5100	1600	110	43	160	4	600	280	12	1	928	450
140-081-21CBC	1870	8	18	1700	100	190	77	160	6	1020	260	26	4	1250	790
140-081-29ACC	2780	8	10	60	0	5	1	660	2	1190	4	350	1	1630	18

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
140-082-01DAD	1080	8	14	40	1100	50	30	160	4	560	140	5	1	686	250
140-084-35CCC	1960	8	9	1400	.	5	6	490	4	1100	180	4	3	1260	38
140-085-18BBC	2630	9	7	420	120	5	4	690	3	1750	38	24	1	1670	30
140-088-16ADB1	2900	9	4	0	10	2	3	750	3	1630	56	35	1	1860	19
140-089-36ADD2	2800	.	16	5500	60	100	44	260	7	791	330	1	1	1150	430
140-090-12DCC	966	8	12	20	0	110	38	48	4	330	160	1	110	646	430
140-090-17ACB	2680	8	2	90	10	4	2	730	2	1870	9	31	2	1710	17
140-090-20DBA1	2800	8	11	20	70	6	1	760	2	2020	7	38	1	1820	20
140-090-21BCB1	2500	8	19	0	40	55	23	530	6	890	630	8	1	1720	230
140-090-21BCB2	9760	8	10	.	100	490	670	1500	7	630	6500	4	1	9500	4000
140-090-32BDD	2310	8	21	360	20	3	2	600	4	1450	72	12	1	1460	18
140-090-33ACD	2390	8	2	100	10	7	1	620	2	1250	280	5	1	1540	22
140-090-34AAA	1830	8	20	100	40	62	23	340	4	660	440	3	1	1220	250
140-090-35BBA	2970	8	14	2100	70	13	7	760	5	1550	500	0	1	2070	62
141-089-36DCD	2930	8	18	2000	60	140	80	500	11	817	1100	3	3	2260	680
141-095-06CCD	1970	9	9	0	10	10	10	501	2	1060	197	9	1	1290	64
141-096-29CCC	2470	8	13	1200	0	22	4	550	6	897	260	220	3	1530	70
141-097-06BAD	1040	8	13	80	40	95	32	77	3	279	137	0	187	682	370
142-084-24BBA	2820	9	8	320	.	4	1	684	2	1170	5	343	0	1670	16
142-092-08BBB	1440	8	17	130	10	5	10	361	2	832	127	3	1	946	53
143-095-32ACB	2660	8	27	200	50	5	3	708	4	1870	13	10	1	1730	22
143-095-34ACD	2550	8	28	340	20	4	2	673	3	1790	11	9	1	1640	18
143-097-24DBB	779	8	16	120	10	22	15	146	3	439	74	5	2	500	120
144-089-35AAD	2460	9	11	290	20	4	0	590	2	1160	3	210	1	1420	10
145-075-09BBB1	1280	9	20	410	20	5	1	320	1	653	88	34	1	830	14
145-078-05BBB	2700	9	11	20	100	13	5	570	3	901	23	360	1	1460	53
146-074-08DCB1	1500	9	42	140	40	3	3	390	3	874	110	15	1	1010	21
146-074-08DCB2	1500	8	43	120	20	4	2	390	3	873	110	16	1	1010	16
146-074-21CCC	1500	8	25	180	120	61	26	250	6	716	200	17	1	940	260
146-076-33DAA	1680	8	30	3300	40	50	16	330	7	601	330	40	3	1110	190
146-077-11ADB	1600	8	26	180	560	45	14	400	6	788	100	220	1	1200	170
146-077-20CDB	2290	8	13	480	10	7	0	590	3	952	3	340	1	1430	19
146-077-21BBB	1900	8	11	200	20	6	3	540	4	993	4	250	1	1340	27

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
146-077-30DAB	1900	8	12	120	20	5	2	470	2	915	31	170	1	1150	20
146-090-20CCC	2260	8	14	240	.	2	1	564	2	1100	3	214	2	1370	9
146-092-29DDC1	1100	8	17	0	20	92	37	81	2	311	124	36	181	725	380
146-094-05CBD	2890	8	10	0	40	5	3	732	3	1660	10	206	1	1790	24
146-094-08DAC1	4070	8	19	0	180	219	103	694	10	1060	1480	17	46	3110	970
146-094-08DAD	3590	8	11	40	40	7	3	913	3	1980	10	274	1	2220	27
146-094-35ABA	729	7	13	940	350	86	38	20	2	284	172	2	1	476	370
146-095-03DCB	2100	8	14	30	0	2	1	527	2	1160	0	154	1	1280	8
147-075-03CCC1	2200	8	25	400	140	52	20	440	9	669	520	66	1	1470	210
147-094-26BCB	2350	8	12	0	0	3	1	596	2	1230	2	214	1	1440	9
147-094-34BAD	2230	8	15	100	0	2	1	560	2	1190	4	181	1	1360	9
147-095-12CAD	2900	8	11	530	10	3	1	736	3	1560	100	129	1	1760	13
147-095-14AAA	2880	8	11	0	10	3	2	745	3	1570	94	136	1	1770	16
147-095-14CBB1	3860	8	13	2200	30	226	130	625	8	870	1650	7	1	3090	1100
147-097-05BDB	2900	8	8	60	10	3	2	802	3	2080	7	22	1	1880	14
148-076-09DDC	2910	8	21	380	0	7	2	650	3	1160	2	380	1	1640	24
148-077-02DDD1	2000	9	10	1000	90	9	4	540	4	940	340	33	1	1430	40
148-095-31CCA	2020	8	14	220	10	2	2	500	2	1130	14	124	1	1230	12
148-095-32DBD	2660	8	11	100	10	3	2	703	3	1690	0	139	1	1700	14
148-095-35BDD	3110	8	8	250	10	4	3	859	3	2300	0	24	1	2040	22
148-096-06DCA	3280	8	7	0	10	3	3	911	3	2480	0	24	1	2180	18
148-096-09ABD	2140	8	13	0	10	3	0	535	2	1200	11	138	1	1310	7
148-096-11BB	3060	8	10	0	30	4	5	771	2	1690	7	249	1	1890	32
148-097-20CAD	2140	8	14	60	20	2	1	556	2	1170	4	150	1	1310	7
148-097-22CDC	2060	9	14	290	10	2	0	512	2	1140	0	122	4	1250	6
148-097-27BCB	3180	8	8	100	20	4	3	860	4	2300	4	16	1	2050	23
148-097-28ACB	2900	8	9	20	40	3	2	798	3	2110	1	41	1	1900	14
148-097-30ADA	2030	8	15	0	0	3	1	514	2	1140	5	119	1	1240	9
148-097-33ABB	1980	8	15	90	20	2	0	500	2	1150	6	120	0	1220	5
149-072-07DDD	1310	8	41	240	.	3	1	337	3	730	61	41	1	850	10
149-092-22CDC	772	8	6	1800	190	45	32	81	4	359	134	0	1	482	240
149-093-02ACB	2230	8	15	540	0	2	0	557	3	1100	329	4	1	1460	6
149-093-05CDC	2620	8	16	200	0	3	1	656	1	1140	531	4	2	1780	12

CRETACEOUS FOX HILLS FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
149-093-08DCC	3010	8	18	300	60	3	3	743	2	1120	710	2	3	2040	18
150-076-21BBB	4000	8	20	80	160	15	3	960	7	576	1	1200	1	2490	49
150-077-05DDD	2200	8	10	0	10	5	8	580	3	1050	10	310	1	1450	45
150-080-08BBB	739	8	14	0	0	90	40	11	4	359	120	3	3	462	390
151-076-07DDC1	3800	9	20	20	40	11	6	850	4	640	11	920	1	2170	51
151-076-07DDC2	3000	9	14	380	80	5	4	650	3	725	0	530	1	1620	28
151-077-01BCC	3000	8	7	330	10	8	4	680	3	744	4	680	1	1760	36
152-077-11CCD	.	.	.	430	.	2	10	1100	7	459	32	1100	2	.	46
152-077-21CDD	.	.	.	380	.	5	11	1100	8	444	26	1300	2	.	58
152-077-30DDA1	4200	9	14	230	40	13	4	890	4	687	6	960	3	2250	50
152-077-30DDA2	4500	8	12	330	70	10	8	800	4	724	7	820	1	2040	57
152-079-13DDD1	4330	8	23	480	60	11	7	950	4	737	3	1000	1	2390	55
153-072-03DDD	1110	8	45	4300	.	2	1	279	3	588	101	5	1	747	9
153-077-34ACD	4000	8	17	330	0	12	4	970	5	632	5	1200	1	2530	46
153-079-30AAA1	4800	8	11	210	40	9	1	840	3	991	8	680	1	2070	27
154-075-04AAA1	2700	9	31	40	10	6	2	570	4	892	3	370	5	1460	25
154-075-21CDD1	1300	9	38	130	0	4	1	340	2	818	5	27	1	847	15
154-075-21CDD2	700	9	19	80	0	4	2	180	1	397	13	3	1	454	15
154-078-31BAA1	4610	8	21	60	80	15	4	1200	4	626	3	1400	1	2960	52
155-075-03ADD	1300	8	15	440	40	8	1	300	3	721	100	4	1	790	26
155-075-15BBB	2700	9	25	120	0	6	1	590	3	949	53	310	3	1480	18
155-075-23ABB	650	8	20	270	80	19	6	120	4	373	39	1	2	397	74
155-080-15AAA	5680	8	17	580	60	17	10	1200	6	585	3	1600	1	3160	84
155-080-19CCB2	4900	8	6	860	40	10	3	960	3	764	7	1100	1	2470	36
156-071-05AAA	479	8	17	20	320	52	15	25	5	285	16	1	1	274	190
156-071-17CDA	1320	8	18	60	100	46	11	260	7	648	180	15	1	858	160
156-073-12CCC	1420	9	44	80	20	4	2	340	3	690	120	26	2	907	16
156-075-22CCC	3500	9	20	870	160	7	3	710	4	834	4	600	1	1780	31
156-077-22CCC	1030	9	14	0	0	3	1	260	1	612	12	28	1	648	12
157-076-22DCC	1310	8	16	270	80	20	5	300	3	731	58	51	4	819	69
158-079-13CCC	5210	8	12	40	90	10	10	1200	5	690	7	1400	1	3030	64

CRETACEOUS INYAN KARA FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
129-053-08AAB	4300	8	6	230	40	16	9	1000	13	455	1200	410	2	2890	76
129-054-02AAC	4100	8	6	330	10	14	7	960	14	440	1200	370	1	2800	63
129-054-18BBD	4500	8	5	580	60	15	9	1000	14	477	1200	390	1	2880	75
129-055-13BCC	3890	8	8	1400	60	19	6	880	13	344	1200	360	1	2670	74
129-056-30DDD	4600	8	8	710	40	18	7	1100	17	527	1300	430	1	3160	75
129-057-14CCC	3900	8	6	850	80	27	35	790	13	357	920	470	3	2450	210
129-057-30DCC	3740	8	8	480	40	21	8	810	12	403	900	440	1	2410	84
129-058-22ADD	3970	8	8	3100	80	19	6	880	13	547	660	620	3	2490	70
129-060-06CCA	2870	8	6	2200	60	96	29	510	23	190	1200	85	1	2050	360
129-060-28CCB	3150	8	6	430	60	37	12	670	12	210	1300	100	1	2250	140
129-061-31BCA3	4020	8	8	40	60	16	6	870	13	420	700	640	1	2470	64
129-063-25BBB	2640	7	11	4100	220	210	60	330	21	190	1200	67	1	2000	770
129-063-34BBB	4830	8	6	1800	20	13	7	1100	21	575	160	1300	1	2900	62
129-064-20BBB	3880	8	6	5100	60	25	14	810	21	781	200	770	14	2260	120
129-065-35DBD	4000	8	9	1300	.	18	8	900	17	891	210	810	2	2420	77
129-071-15AAB	2650	8	9	1400	60	93	31	460	11	188	1100	71	1	1870	360
129-073-21CDB	2800	7	13	3600	160	290	76	330	20	180	1200	180	.	2210	1000
130-048-31DCD1	6060	8	6	.	.	33	16	1390	16	307	1450	1020	7	4090	150
130-052-29DAA	4230	8	8	.	.	15	8	970	20	334	1290	414	12	2900	70
130-053-06DDD	4250	8	8	440	10	18	7	980	17	461	1200	370	6	2850	75
130-053-28DDB	4310	8	8	500	40	16	7	970	11	460	1200	400	1	2860	70
130-054-29ABA	4000	8	8	1800	620	17	7	900	15	377	1100	370	1	2620	70
130-055-13ACB1	3950	8	7	580	40	20	6	920	15	323	1200	370	0	2710	74
130-055-32ADD1	4390	8	8	130	30	35	8	960	13	294	1300	490	1	2970	120
130-056-06ABB1	4630	8	6	60	40	14	6	1100	16	888	790	620	11	3010	60
130-056-35AAB1	3810	8	9	0	40	22	6	840	13	357	1100	360	8	2540	80
130-057-02ABC	3500	8	8	990	50	25	8	820	18	315	1100	330	1	2470	96
130-057-35AAB	4090	8	8	0	20	11	6	940	14	576	870	540	4	2690	50
130-058-06AAA	4140	8	7	940	90	18	6	930	17	585	790	600	1	2670	70
130-058-25CBD	4000	8	9	60	10	15	8	890	17	574	730	580	1	2550	70
130-059-23CBD	580	7	30	2500	1000	90	26	8	3	337	55	16	4	401	330
130-059-26CAC	630	7	32	900	1200	95	27	9	3	370	61	4	3	419	350

CRETACEOUS INYAN KARA FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
130-061-25ACA	2920	8	6	2300	60	90	38	520	29	194	1200	95	1	2080	380
130-062-15ADB	1800	8	11	5000	180	200	54	330	35	199	1200	71	1	2010	720
130-062-15CBB	4890	8	7	350	20	34	6	1000	24	470	200	1200	2	2710	110
130-063-20DDC	4530	8	7	100	20	18	7	970	21	700	160	1100	1	2640	75
130-065-11CAB	2570	8	8	2900	220	230	64	290	25	190	1200	79	1	2000	840
130-084-13AAD	2030	8	.	300	.	.	.	514	.	773	485	0	.	1220	24
131-047-07DAD	2880	9	7	.	.	8	5	650	10	486	464	364	5	1790	42
131-048-28AAA	3560	8	7	.	.	32	29	778	14	327	784	578	4	2400	200
131-051-31DBA	4350	8	7	.	.	12	6	990	18	478	1180	443	12	2910	55
131-052-32CCC	4290	8	7	.	.	14	4	1020	21	544	1170	443	6	2950	50
131-053-10DDC1	5500	8	7	480	0	9	7	1100	7	565	1300	420	1	3160	50
131-054-17BAA	4000	8	9	270	40	23	8	870	15	318	1200	350	1	2650	91
131-054-26ABD2	4000	8	8	1500	60	20	7	910	17	374	1100	370	1	2640	80
131-055-03CDD	4000	8	8	120	20	20	4	880	15	437	950	470	0	2570	67
131-056-23CBB1	4000	8	8	130	20	17	7	890	17	459	980	440	1	2600	70
131-057-12CDC	4000	8	8	60	40	14	4	920	17	529	880	490	6	2620	50
131-057-30ADD	3800	8	8	1200	60	26	6	830	18	299	1100	320	0	2470	89
131-058-11BAA	4500	8	9	1700	20	18	4	970	20	643	750	640	1	2760	62
131-060-27ABA	5780	8	7	1400	200	47	13	1300	22	310	1900	590	1	4040	170
131-061-23DDC	3390	8	7	470	40	62	16	680	24	270	1200	200	1	2330	220
131-062-15ACB	5000	8	7	190	10	24	10	1000	26	582	160	1200	1	2720	100
131-062-30DCC	4910	8	7	80	20	21	12	1000	23	620	160	1200	1	2740	100
131-064-22AAA	4640	8	8	100	40	38	13	910	25	570	33	1200	2	2520	150
132-047-08ABD	1590	8	8	.	.	10	5	357	13	544	245	98	1	1000	45
132-047-08ACB	1670	8	8	.	.	8	10	380	7	734	150	104	1	1030	63
132-049-12DAA1	2420	8	21	.	.	34	10	506	6	424	558	220	2	1570	127
132-050-06DCB	5800	8	7	.	.	30	18	1250	21	315	1230	970	0	3680	150
132-051-05CCD	4390	8	6	.	.	15	4	1060	34	649	1170	465	3	3080	54
132-052-19CBB1	4460	8	7	.	.	5	7	1010	10	546	1200	405	0	2930	40
132-054-09DAC	3900	8	6	590	60	22	5	870	15	338	1100	380	1	2590	75
132-054-09DCA	4000	8	.	150	10	.	.	.	.	.	.	.	.	.	.
132-054-13ABB	4000	8	8	80	60	24	4	870	16	325	1200	360	1	2660	77
132-054-31BAB1	.	8	8	130	10	24	3	860	15	317	1100	390	4	2570	74

CRETACEOUS INYAN KARA FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
132-055-09ACB	4000	8	8	1100	20	18	5	990	18	610	1100	420	1	2870	64
132-056-07DDB	3990	8	3	890	60	17	5	930	19	513	1100	420	3	2760	62
132-056-08CAC	3900	8	5	190	40	27	6	810	17	268	1200	310	1	2520	92
132-056-34CCC	3800	8	8	1700	20	23	6	820	18	321	1200	310	1	2550	80
132-057-06DCC	5000	8	9	370	10	14	9	1200	24	805	680	890	4	3240	70
132-057-15DDD	3900	8	8	790	40	27	7	830	17	309	1200	340	1	2590	96
132-058-20DDC	4250	8	8	120	20	12	5	960	17	666	780	600	1	2720	50
132-060-17DAA	3000	8	9	290	40	47	10	600	21	210	1200	85	1	2080	160
132-063-12AAA	5340	8	9	220	40	20	11	1100	26	750	25	1400	1	2970	95
132-063-29BBB	5060	8	7	0	40	28	12	1100	26	700	10	1400	2	2940	120
132-076-07BBC	3460	8	13	840	160	118	74	617	11	207	1440	232	.	2610	597
133-053-16DDD	4500	8	7	1800	0	71	13	790	28	278	1100	420	1	2570	230
133-054-09DAA	5000	8	7	670	40	38	9	910	23	380	1100	470	1	2760	130
133-055-16CCA	5500	8	8	580	10	21	6	1000	19	540	1100	420	1	2860	77
133-055-20CBB	3760	8	6	100	60	20	7	830	14	310	1200	280	1	2520	77
133-056-26ABB	4500	8	8	80	60	25	8	820	18	303	1200	280	1	2520	94
133-056-32BBD	4500	8	8	1700	180	27	5	840	18	292	1300	260	0	2610	89
133-058-19CCD	3120	8	4	80	40	20	8	680	14	200	1200	94	1	2120	82
133-058-22DDD1	4000	9	8	2500	60	36	7	840	15	233	1400	240	1	2670	120
133-059-02BCD	3050	7	8	100	20	19	3	670	19	218	1200	97	.	2130	62
133-059-11AAB1	4300	8	6	890	0	15	7	1100	22	605	290	1200	0	2950	68
133-059-11AAB2	4180	8	7	940	100	45	12	870	25	230	1200	500	3	2780	160
133-059-14CBB	3710	8	6	130	0	16	5	790	17	358	960	380	1	2370	59
133-059-22ADD	2560	8	9	890	20	19	7	660	19	236	1200	94	1	2130	78
133-059-23BCC	3080	8	3	350	20	20	4	630	15	176	1100	95	5	1970	68
133-059-27ADD	4670	8	4	1300	20	15	8	980	20	541	440	990	5	2740	71
133-060-19BAA	4890	8	5	380	0	14	10	1100	22	681	140	1200	26	2860	76
133-060-24CCC1	5410	8	6	230	0	15	8	1200	23	604	180	1400	3	3140	70
133-060-34ACB	3040	8	7	380	60	35	10	620	21	215	1200	96	1	2100	130
133-061-01DBD	800	7	26	850	570	100	33	35	6	434	93	15	.	525	390
133-061-03BBC	4860	8	6	190	0	16	6	1100	24	764	100	1200	1	2840	66
133-061-18ACB	2270	8	7	2500	160	210	67	290	33	190	1200	80	1	1990	800
133-063-05ADD	2690	8	7	7900	140	240	75	280	27	198	1200	92	1	2030	910

CRETACEOUS INYAN KARA FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
133-065-11DAC	2600	8	8	10000	120	320	97	180	23	193	1300	81	1	2120	1200
134-053-23ADC	5000	8	7	40	20	10	7	1100	5	325	1300	580	1	3190	54
134-054-28BBA	4000	8	7	350	20	40	7	900	24	348	1000	510	1	2670	130
134-055-03BBC	3900	8	7	1500	70	61	9	760	33	253	1100	360	1	2470	190
134-055-07BAB	4030	8	8	480	.	37	4	889	19	322	1060	505	1	2690	110
134-056-13ABA	4000	8	6	2500	60	30	6	880	18	264	1300	340	1	2720	100
134-056-14AAB	3900	8	7	150	70	30	9	850	20	285	1200	390	1	2660	110
134-056-28CDD1	3800	8	8	5000	.	27	4	886	21	310	1260	362	0	2740	82
134-056-28CDD2	3900	8	7	1500	60	31	6	840	19	263	1300	300	1	2640	100
134-058-33BBA	4000	8	9	950	80	52	10	880	24	239	1200	500	1	2800	170
134-059-02AAA	3100	8	9	890	20	33	12	680	33	257	1200	130	1	2230	130
134-060-01DCA	3030	8	5	620	60	60	22	580	26	205	1200	120	1	2120	240
134-060-20DDA1	4780	8	4	2100	10	16	10	970	23	725	120	1100	2	2610	80
134-061-06DCA	2710	8	6	3300	80	230	69	280	32	187	1200	97	0	2010	860
134-062-34CAA	2530	8	5	8000	200	240	75	240	30	152	1200	95	1	1970	910
134-063-10DDD	9140	8	7	6400	60	59	23	1900	38	700	16	2700	1	5100	240
134-065-26CDC	2640	8	8	8800	160	320	97	190	23	192	1300	90	1	2140	1200
135-053-17ABB	4400	8	6	460	40	7	7	980	7	358	1000	550	1	2750	46
135-054-10CAD	4000	8	7	270	60	38	11	870	24	313	1100	490	1	2700	140
135-055-02BCB	3500	8	8	1200	80	130	28	620	48	229	1200	340	1	2490	440
135-056-10DDB	3700	8	8	1400	50	47	8	770	22	257	1200	310	1	2500	150
135-057-12BBC	3600	8	9	1100	80	75	15	730	29	261	1100	390	1	2480	250
135-058-07ACC	3100	8	7	3700	100	120	36	510	44	217	1200	160	1	2190	450
135-059-23CDD	3080	8	6	860	120	52	15	620	25	202	1200	130	0	2150	190
136-054-03CCC	4600	8	7	2700	80	87	18	850	31	228	1300	490	1	2900	290
136-054-17DDB	3500	8	7	920	60	130	30	680	49	224	1300	360	1	2680	450
136-054-33CBB	4400	8	8	2200	40	51	10	830	28	252	1200	430	1	2690	170
136-055-01BDC	4600	8	9	480	20	69	14	880	30	247	1200	510	1	2840	230
136-055-27BBC	3900	7	9	2900	80	120	34	620	44	128	1200	300	1	2400	440
136-056-02CDD	4700	7	10	1400	80	180	54	720	46	215	1300	540	1	2960	670
136-056-21DCC	4550	7	7	580	80	28	7	940	29	468	350	1000	1	2600	100
136-057-04DCB	4950	8	11	330	60	87	20	930	33	208	1200	720	1	3110	300
136-057-19DBD	4990	8	8	250	10	30	11	1000	30	529	280	1200	1	2830	120

CRETACEOUS INYAN KARA FORMATION

1=mg/l 2=ug/l 3=umho/cm

T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
136-058-12DAD	3600	8	9	150	20	36	12	770	24	280	1200	300	0	2500	140
136-058-30BAB	3350	7	10	2500	80	200	75	450	43	199	1300	230	1	2410	810
136-058-35DAD1	5300	8	6	400	10	21	14	1100	27	657	110	1300	1	2910	110
145-066-01CDD	4490	8	7	.	.	8	6	1000	40	553	1160	431	5	2930	45
146-065-32DAD	.	.	.	.	.	.	.	31	.	403	.	.	.	.	150
146-069-15CDC	4320	9	10	520	.	4	2	1050	3	672	1150	349	2	2950	18
148-070-13BAA	4210	8	10	60	.	5	1	982	3	466	1290	325	7	2860	18
149-050-31BBC	5842	8	.	.	.	342	258	1022	25	260	1271	94	1	3536	600
149-050-33BBB	5770	8	.	.	.	254	86	900	.	281	1050	1150	33	3754	900
149-051-24CDD	4940	7	18	.	.	302	128	776	12	300	2030	484	2	3900	1280
149-052-21CCD	8060	7	1	.	.	298	116	1360	52	19	1560	1860	22	5300	1220
150-050-32CBC	2400	8	20	.	.	152	119	158	25	307	285	206	547	1670	870
150-051-08DDD	7070	8	25	.	.	326	104	1160	27	325	1410	1460	26	4700	1240
150-051-18BAA	7190	8	24	.	.	328	127	1110	33	345	1210	1620	10	4640	1340
150-051-26ADC	6900	8	23	.	.	222	70	1220	34	228	1570	1220	0	4480	840
150-051-31BAB	4280	8	16	.	.	296	173	102	543	952	630	478	352	1450	4100
150-051-33CCC	6210	8	7	.	.	230	77	1070	39	238	1420	1210	1	4180	890
150-051-34AAA	6970	7	18	.	.	316	120	.	.	226	1480	1680	0	5020	1280
151-051-03BBB	6170	8	19	.	.	226	82	1120	34	252	1530	1170	2	4320	900
151-052-06BCC	3250	8	17	.	.	253	70	414	19	406	988	368	1	2330	920
151-055-12DDD1	658	8	21	.	.	90	23	16	4	328	63	16	4	399	318
152-050-20AAA	1310	8	20	.	.	125	90	46	3	544	253	47	2	855	683
152-051-04BCC	8810	8	17	.	.	270	101	1550	40	278	1450	1990	0	5560	1090
152-051-08CCC	386	7	8	.	.	51	12	7	5	139	61	9	14	241	178
152-051-34CCC	6370	8	31	.	.	208	88	1100	22	258	1400	1170	4	4150	880
152-054-09DCC	6260	8	5	.	.	150	62	1260	33	278	1330	1260	3	4250	628
152-054-14DDC	561	8	19	.	.	52	29	22	6	225	103	3	6	351	250
152-056-02BAA	3810	8	20	.	.	384	173	310	11	414	1310	382	139	2030	1670
154-064-34DCB1	.	.	.	60	.	12	5	.	.	840	1100	830	4	3770	50
154-064-34DCB2	.	.	.	.	.	12	5	.	.	870	1100	880	1	3770	51
154-064-34DCC	.	.	.	.	.	8	7	.	.	750	1100	880	1	3870	50
156-054-19DDA	6210	8	7	3400	.	49	24	1370	18	642	1200	1030	25	4050	220
160-054-31CCC	20700	8	10	0	90	309	143	4410	44	285	1090	6600	2	12800	1360

CRETACEOUS INYAN KARA FORMATION

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T-R-S-Q	SPCND(3)	PH	SIO2(1)	FE(2)	MN(2)	CA(1)	MG(1)	NA(1)	K(1)	HCO3(1)	SO4(1)	CL(1)	NO3(1)	DISLD(1)	HARDX(1)
161-055-15BCD1	9930	8	9	3100	90	136	46	2030	32	291	560	2890	0	5860	53[illegible]
163-056-11BBB	41700	7	6	8100	230	1190	442	8830	150	184	2300	15900	1	28900	479[illegible]