A SYSTEMATIC APPROACH TO THE SITE CHARACTERIZATION AND REMEDIAL DESIGN OF CONTAMINATED GROUND WATER

By

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A SYSTEMATIC APPROACH TO THE SITE CHARACTERIZATION AND REMEDIAL DESIGN OF CONTAMINATED GROUND WATER

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Introduction

In the past especially, numerous institutions were guilty of disposal and/or containment practices of materials that if released into the ground water system would constitute contamination. The result of these practices has led to the contamination of many of the ground water resources presently or formerly used for domestic and other water sources. More recently and as a result of public awareness both state and federal agencies have begun to enforce more stringent rules and regulations for the proper disposal and/or containment of these potential contaminant sources (Oklahoma State Department of Health, 1986; 42 U.S.C. 9601 et seq). Also, wide sweeping laws have been instituted to require remediation of previously contaminated ground waters (Public Law 99-499; Public Law 94-580).

Although normally financed by the firm(s) responsible for the contamination, most of the actual site characterization and remediation design is carried out by the consulting engineering/hydrogeologic firms. This type of activity is both expensive and very technical in nature. Due to the expenses involved there is considerable concern that the work be completed as quickly and as accurately as is possible. These two concerns, of course, must be balanced since quite often the rapidly completed operation is often lacking in quality. A job of poor quality may actually cost the client more in the long run than one that is carefully thought out and implemented over a rather long time frame.

It is apparent to those in the engineering and hydrogeologic consulting fields that realistic procedures for this type of activity are only now being established. Some general and even some specific guidelines were early established in an attempt to assure that site characterization and eventual remediations were maintained within the bounds of known hydrogeologic technologies (National Water Well Association, 1986; Ford and Turina, 1985). What was lacking even ten (10) years ago, however, was the required practical experience in site characterization and remediation on which to establish sound clean up guidelines. This experience is now being acquired by those professionals actively involved with these types of activities.

It is clear to the field hydrogeologist today that many of the early guidelines were not always practical. Most often the case was that the early guidelines were established as a result of narrowly defined hydrogeologic characteristics. These may have, for example, been developed solely on the basis of early experiences in a single geologic situation. When situations arose in different hydrogeologic situations the guidelines were not always appropriate.

Field work today is actively establishing the working procedures and criteria on which sound decisions may be made regarding widely ranging hydrogeologic situations (Kent and Overton, 1987; Environmental Protection Agency, 1985; Bredehoeft, 1964; Broadhead, 1981; Farmer, et.al., 1982; Greenhouse and Harris, 1983; Hart and Davis, 1981; MacFarlane, et.al., 1983; Satpathy and Kanungo, 1976). It is paramount that the present guidelines be continuously revised to incorporate these new experiences and that new guidelines, both state and federal, be flexible enough to adapt to situations not previously encountered.

Enough experience has now been attained to direct the hydrogeologist or other professional in the proper approach to ground water contamination characterization and remediation design. It is necessary to approach such activities in a systematic manner. Such a systematic approach may be visualized in the form of a flow chart such as presented in Figure 1. It should be well understood, however, that flexibility in any work plan is critically important. The flow chart presented here is

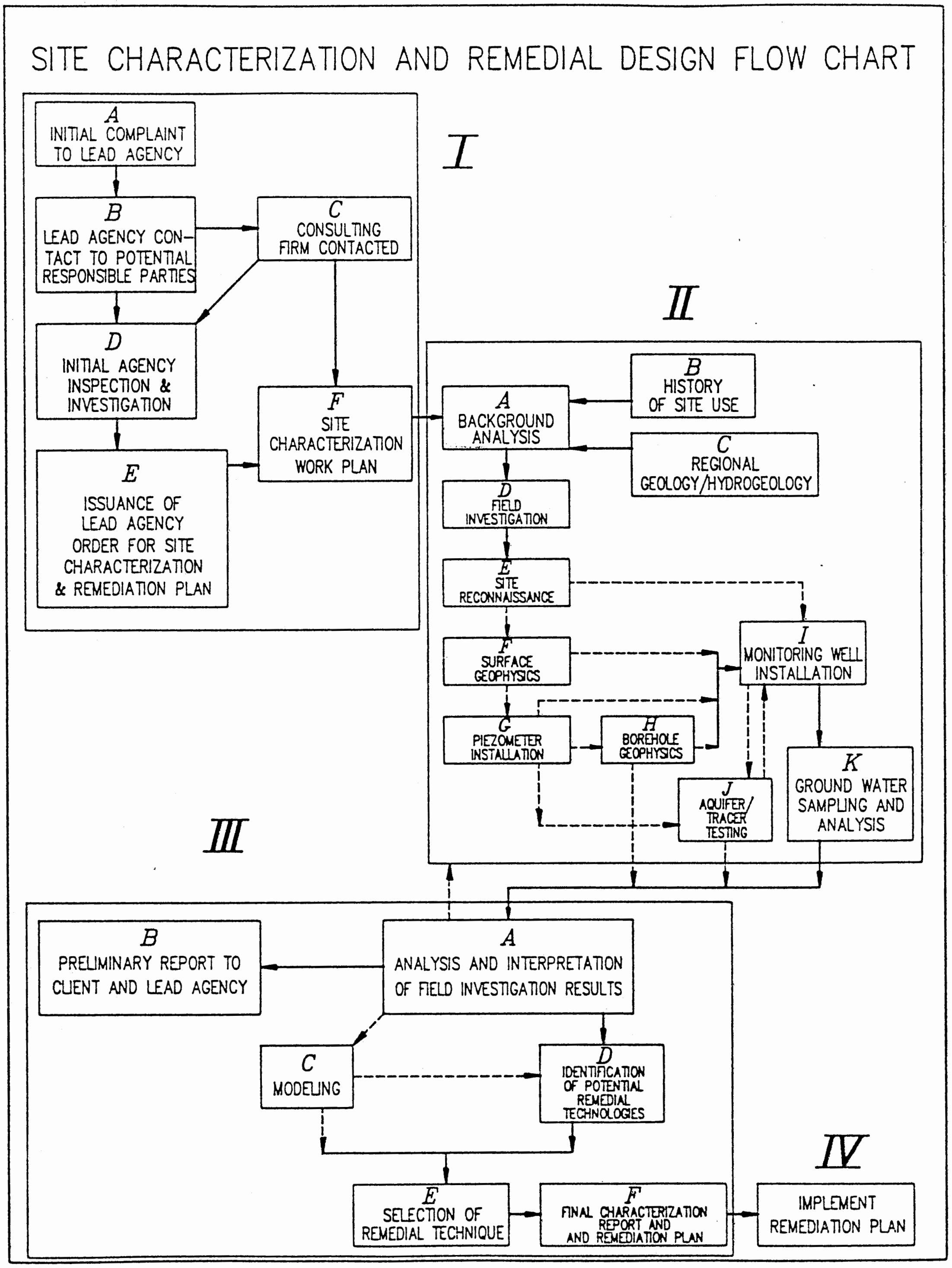


Figure 1. Site Characterization and Remedial Design Flow Chart

highly generalized and must be incorporated into any project only to the extent that its components are applicable. Each step of the process must be critically analyzed based on results of previous findings and where necessary adjustments in the work plans must be quickly adopted where the results will be most beneficial to the client and objective(s) of the analyses. This study is designed to demonstrate a systematic approach and illustrate the need for flexibility. The flow chart presented as Figure 1 will be used in Chapter II to lead the reader through such a systematic approach.

Purpose of Investigation

Once a lead agency, state or federal, has mandated that an institution characterize a potentially contaminated site and produce a remedial action plan, a hydrogeologic consulting firm must provide a proposed work plan to the client and/or lead agency. This plan most often will be required to delineate the specific tasks to be undertaken to carry out the activities required of the order. In addition, the consultant will usually be asked to both rationalize each task and provide a cost estimate at least to the client. The purpose of this study is to demonstrate a systematic approach to the characterization of a contaminant plume and its final remediation design. A specific case study will be presented to demonstrate the proper utilization of appropriate hydrogeologic techniques within the framework of an actual field experience as negotiated through a state mandated Consent Order.

This study is intended to present a detailed approach to ground water contaminant plume identification and remediation design within a complex geologic environment. Although professionals are expected to continuously fulfill such obligations, full understanding of the applicability of these approaches is far from complete.

Location of Study Area

The area chosen as a case study for this investigation comprises a portion of the former Union Carbide (Umetco Minerals Corporation) vanadium processing plant and adjoining properties to the south (see Figure 2).

The vanadium processing plant is located approximately seven (7) miles southeast of the City of Hot Springs, Arkansas on the north side of U.S. Highway 270 (see Figure 3). The facility occupies portions of Sections 16, 17, 20 and 21 of Township 3 South, Range 18 West. The entire area is located in the Lake Catherine 7.5 minute quadrangle.

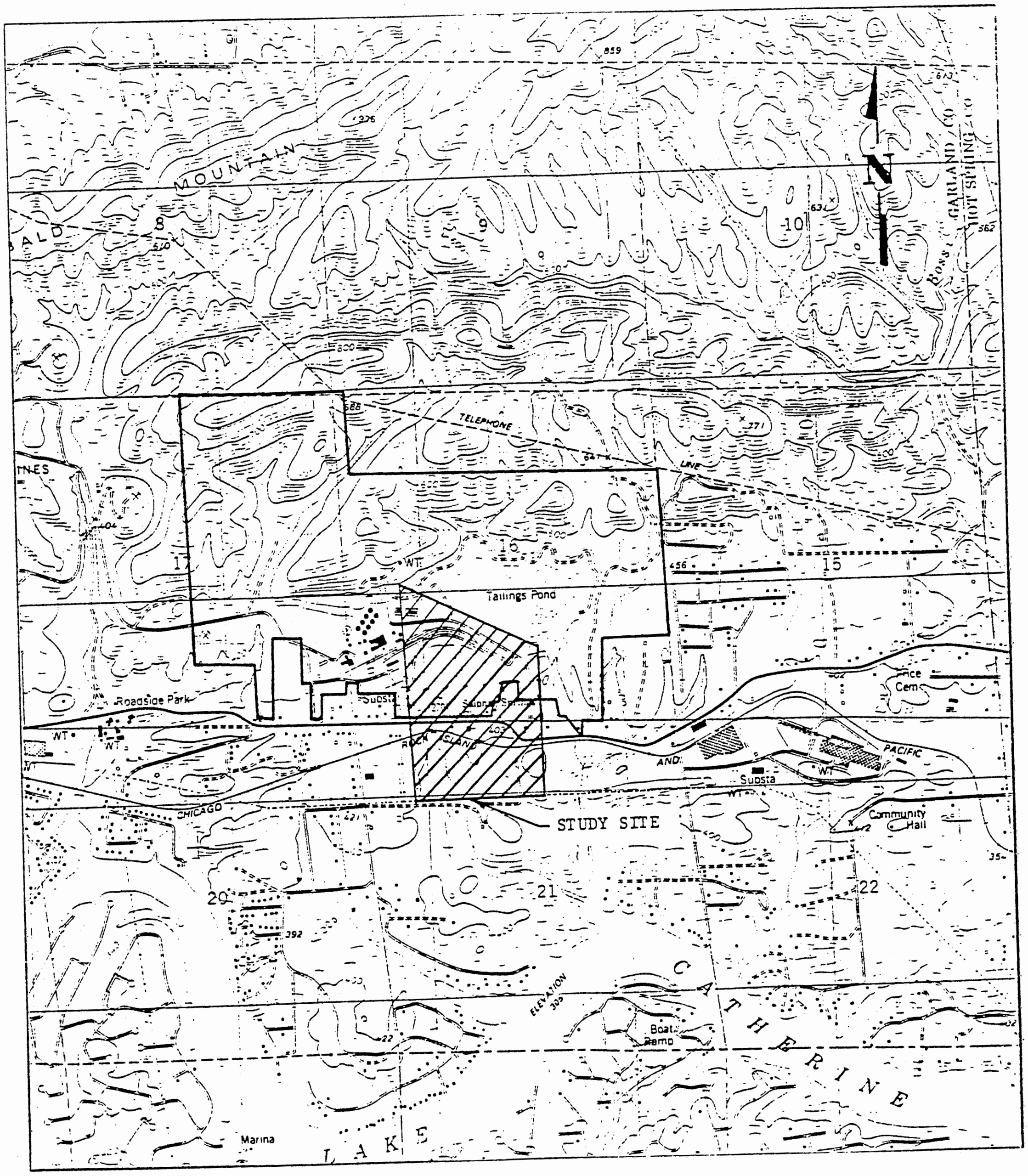


Figure 2. Study Site

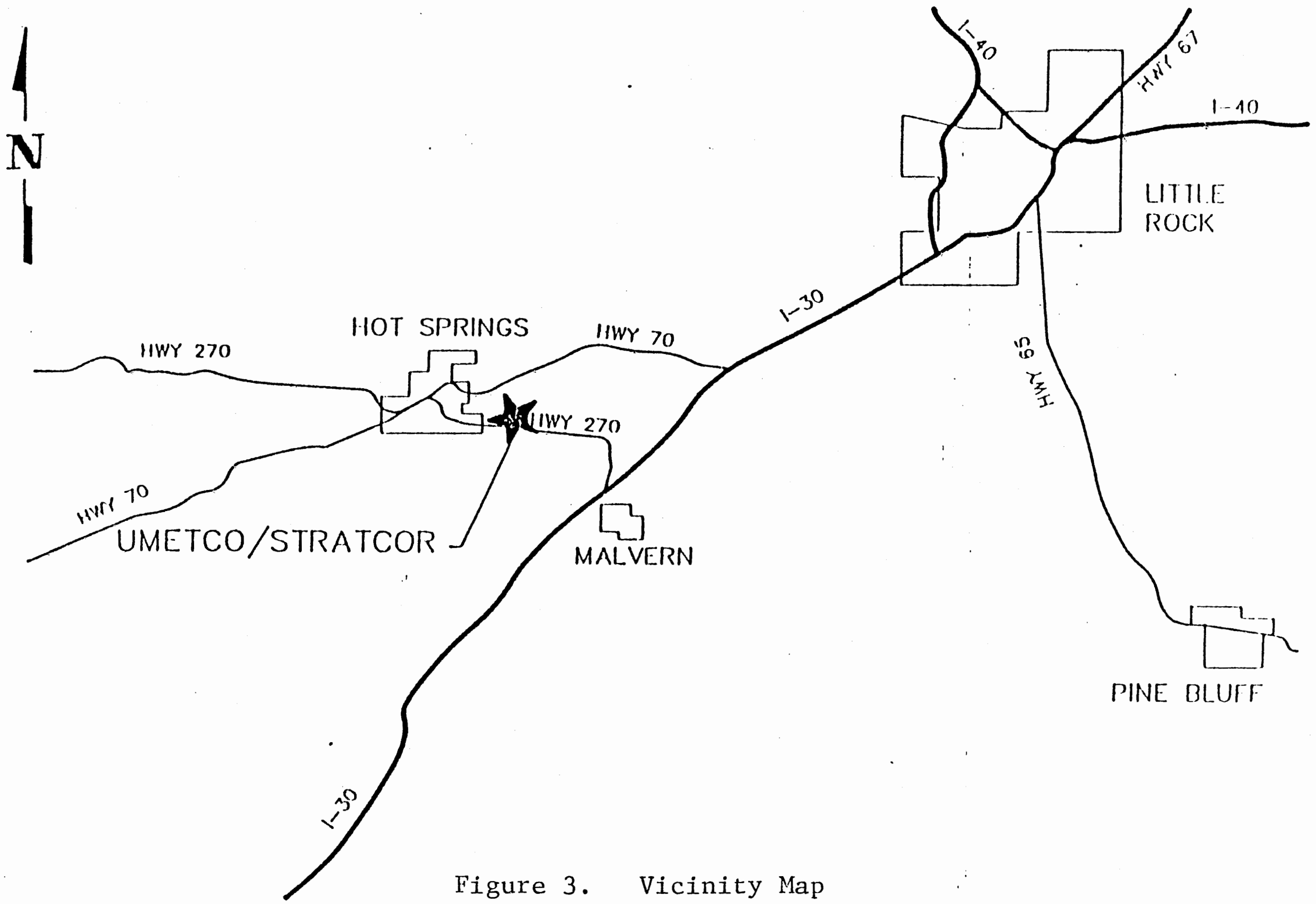


Figure 3. Vicinity Map

CHAPTER II

APPLICATION OF A SYSTEMATIC APPROACH

Introduction

The need for a systematic approach to site characterization and, where necessary, remediation design is easily rationalized on the basis of the importance of these activities both financially to the client and environmentally. In many instances the contaminants have reached and are having negative impacts on domestic water supplies causing, at the least, economic hardships for many families and activities. The client is usually faced with a substantial cost for remediation even when the clean up is relatively simple and of short duration. Longer durations and more complex situations can be devastating to the responsible parties involved in remediation.

The following paragraphs attempt to describe the major components of a systematic approach proposed in this study and as outlined in Figure 1. It should be again stated that flexibility must be an integral part of any site characterization and remedial design. The hydrogeologist must be prepared to critically review his work plan and make revisions when necessary. It is readily realized that the systematic approach discussed in this document and outlined in Figure 1 may often be revised to fit specific case situations. The overall integrity of the approach, however, will remain intact.

Systematic Approach

For the readers convenience each component of the flow chart presented in Figure 1 and to be discussed below will be depicted by the corresponding Section and box number to which it relates. The flow chart is divided into four (4) components for ease of discussion. A figure will be presented representing each Section prior to its discussion. Section I is presented as Figure 4.

Section I: Initial Activities

Section I is presented as Figure 4. This section describes the initial activities from the time a complaint is registered with a lead agency through the development of a site characterization work plan.

Section I-A: Initial Complaint and Contacts

The most common situation in which an institution is found to be contaminating a ground water resource is the result of a complaint filed usually by a neighbor who

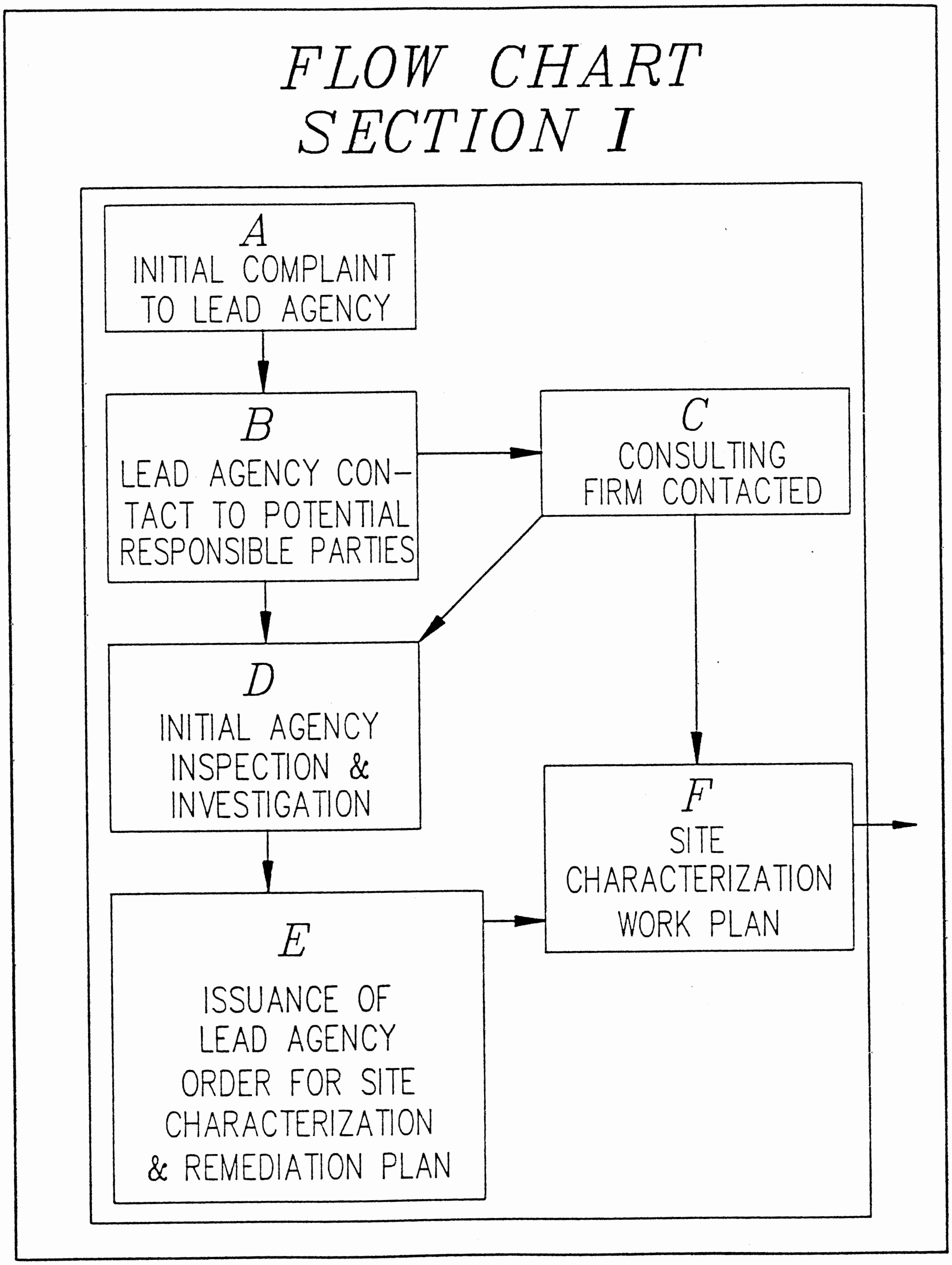


Figure 4. Flow Chart: Section I

feels his ground water has been contaminated. Most often, this neighbor will complain to a state agency such as the State Department of Health, the Department of Resources or some similar agency. In some instance the complaint will be filed directly with or referred to a federal agency, such as the Environmental Protection Agency.

Section I-B: Lead Agency Contact to Potential Responsible Parties

Following the initial complaint the lead agency will normally visit the site to meet with the parties filing the complaint. This is usually followed by contacts to all parties within the area that are likely to be potentially responsible parties if contamination is found to be present.

Section I-D: Initial Agency Inspection and Investigation

The lead agency will normally then conduct an initial investigation of the complaint. This often involves only a walk over of the area and a water sample analysis of the potentially contaminated water supply. If the water sample(s) prove to be contaminated, the agency officials will again contact potentially responsible parties (PRP´s) or institutions and ask their cooperation in delineating the probable source(s) of contamination. Once the source(s) have been narrowed to the satisfaction of the state agency, negotiations between the potentially responsible persons or institutions and the lead agency will begin.

Section I-C: Hiring A Consulting Firm

In most cases the targeted responsible person(s) or institution(s) do not have the necessary expertise for detailed ground water evaluation within its immediate corporate structure. The responsible parties most often will contact an engineering/hydrogeology consulting firm that is familiar with ground water contamination problems and their remediation. This firm may be brought in as early as the initial walk over investigation by the lead agency or as late as following the issuance of an agency order. The consulting firm, however, should be present during all field activities and during all meetings at which technical discussions take place.

Section I-E: Order To Investigate

Following negotiations between the responsible parties and the lead agency the agency will often issue some form of order to require the responsible parties to characterize the ground water resources and if necessary to present a plan for remediation. This order, often a Consent Order drafted by the lead agency`s legal department and binding in court, will require that each stage of the investigation conform to both accepted hydrogeologic operating technologies and a previously agreed upon schedule of performance. This order will also spell out specific penalties for non-compliance to either the intent of the order or to failures to adhere to the schedule of events established in the order.

Section I-F: Site Characterization Work Plan

The consulting firm is normally given the task of producing a work plan that is acceptable to both the client and the lead agency. This work plan must be detailed enough to specifically address all requirements of data gathering identified in the order. It is also important that the consultant identify specific techniques that will be utilized to accomplish the tasks identified in the plan and to rationalize their inclusion.

The client will also require that the consultant provide a cost estimate for the proposed activities. These cost estimates may or may not be required of the lead agency. Although the work plans are normally filed with the lead agency, they are usually open to revision. Where revision is felt to be necessary the consultant should propose these revisions to the client, including modified cost estimates; then, upon the clients approval, the revisions should be made in writing to the lead agency. It is good practice to request and obtain approval of these modifications from the lead agency prior to continuing the project. It might also be necessary to meet with the agency personnel to recommend or explain the proposed modifications. The consultant must be prepared at all times to explain any proposed modifications to the original work plan and be able to demonstrate the necessity.

The possible components of the work plan and the actual field activities to be carried out are extensive. A basic set of components are addressed here. It must be emphasized that the possible sequencing of these components may vary somewhat from the flow chart presented in Figure 1. Dashed lines on the flow chart represent junctures where the next step will be based on the best professional judgment of the ground water scientist. The steps which are most often followed are described below.

Section II: Field Analyses/Data Collection

The portion of the flow chart represented by Section II is presented in Figure 5. This section represents the various forms of data collection, including; documents searches, personnel interviews, field analyses and analytical chemical analyses.

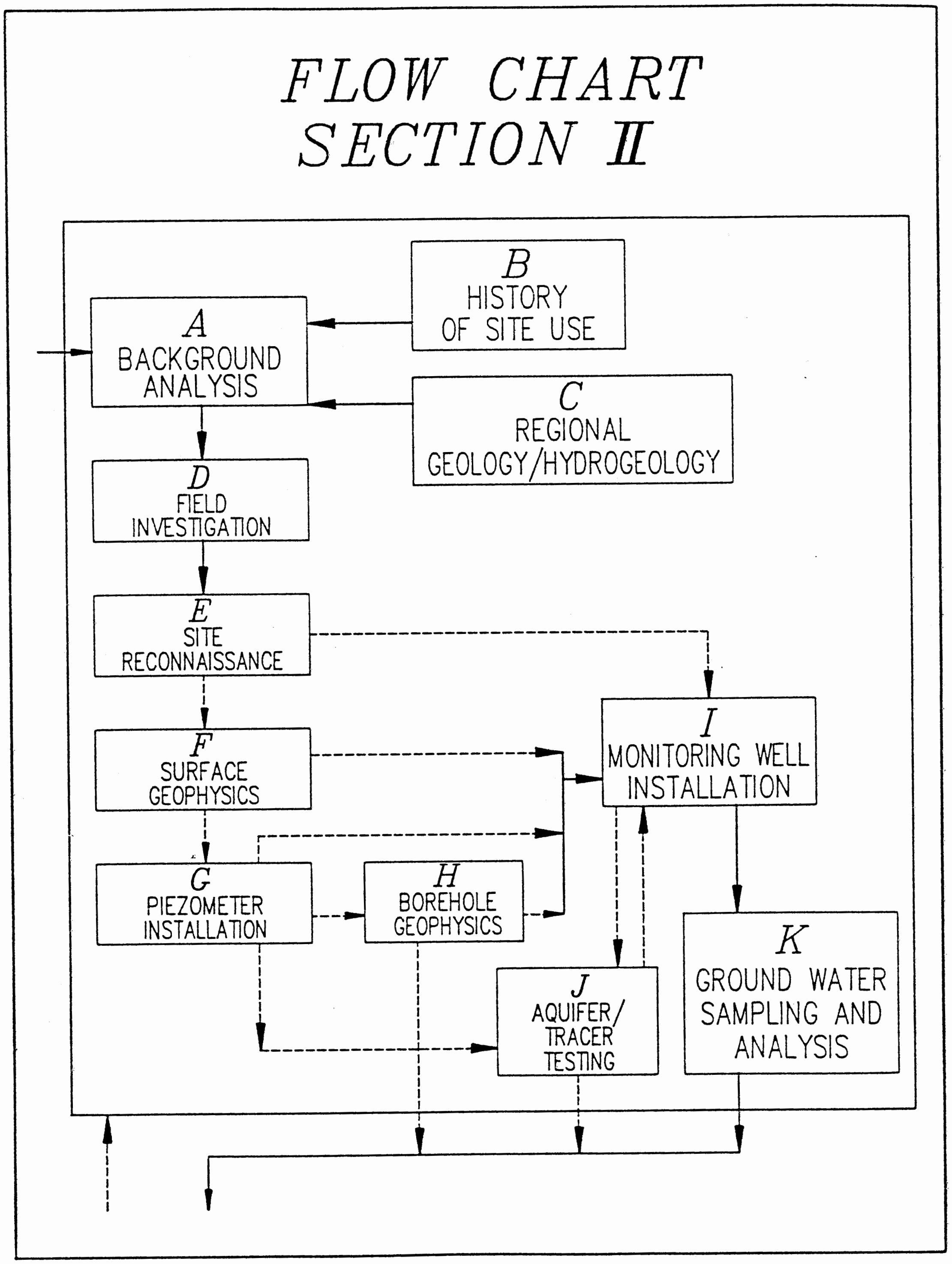


Figure 5. Flow Chart: Section II

Section II-A: Background Information Retrieval

Background information is vital to the consultant. In order to attain a full understanding of the regional setting of the site and the processes that have occurred that led to ground water contamination the consultant must spend some time researching previously published documents and interviewing officials familiar with previous site activities.

Two broad forms of information are desired; the the history of site utilization (Section II-B) and the regional geology/hydrogeology (Section II:C). The regional geology and hydrogeology may be obtained from numerous sources, such as, the libraries of the Geology Commission, State agencies, or major university libraries. These documents will provide necessary data to describe the regional geologic environment, hydrogeology, hydrology and climatology surrounding the site under investigation. In many instances ground water chemical analyses are available for the general area and may be used for background purposes.

The history of site utilization will incorporate several items. Both the present and past operations of the site should be identified along with the production or utilization of any materials that might be a contributor to ground water contamination. Dates of production or utilization of these potential contaminants should be established where possible. In addition, former techniques for containment and/or transport should be established. The consultant should also address the regulatory history of the site in order to understand both previous problems at the site and the regulatory procedures leading to the present Order and requirements for site characterization.

Section II-D: Field Investigation

Field investigations must be tailored to fit the needs of the specific concerns posed by the Order, including the hydrogeologic environment which is expected to exist after regional analyses have been completed. Figure 1 identifies a scenario that may be followed along with various modifications to fit the specific needs of the project. Again, it must be pointed out that the consultant should be willing to evaluate his situation at the completion of each task and to modify his activities accordingly. Since flexibility is vitally important the decision of specific flow paths to be followed must be left the the judgment of the professional ground water scientist. This flexibility is denoted within the flow chart by dashed lines and leaves several options open to the professional.

Section II-E: Site Reconnaissance The first step in any field investigation is to conduct a site reconnaissance. This should involve every field technician to be used at the project site. All information earlier retrieved from both regional analyses and site histories should be made available and be assimilated by the necessary technicians for review during the site reconnaissance. It is important to have a knowledgeable representative of the client to be present to answer questions.

The site reconnaissance should include a tour of the entire affected facility, a discussion of any portions of the site that might be dangerous or off limits to the field team, a discussion of safety procedures to be included as standard operating procedures and an identification of known limits of contamination in the surrounding area. Specific geologic, hydrogeologic or hydrologic points of interest should be pointed out to the investigating team. The site investigation team should spend a few moments at the conclusion of the reconnaissance to discuss specific points of concern and any contradictions identified to that point.

In order to acquire immediate information about the specific area in which the site is located, an area well survey should be conducted where possible. This may not be possible in every instance due to the sensitivity of the situation within the community. Where hostilities are present or may potentially occur, it is prudent to forego this component of analysis. As a substitute, often drill logs and pumping test data for drilled domestic wells within the community are available within the appropriate state agency.

The area well survey should include the identification and evaluation of all wells within a predetermined radius of the study site (usually one mile). The survey should be conducted by a team led by a hydrogeologist. The team should measure the water levels of each well identified (both abandoned and in active use), determine the field pH and specific conductivity of each well and sample the well for laboratory analysis. Samples must be taken with care and every precaution not to cross contaminate samples must be followed. The samples should be prepared and packaged for transport to a reputable, independent laboratory for analysis. Each well location should be precisely located on a topographic map for future reference. In some instances the well location and elevation might need to be surveyed.

In association with the well survey, the project geologist should direct an outcrop survey within the area. Each exposed outcrop should be identified and measured. This information will be valuable at a later date and should be tied in to cross-sections developed from borehole logs.

Section II-F: Surface Geophysics Preliminary to subsurface investigations (test drilling, piezometer, monitoring well installation) it is often prudent to incorporate surface geophysics where possible. If the form of contamination lends itself to geophysical analyses, for example where chlorides are a component of the contamination, it is often possible to identify much of the plume geometry quickly and relatively inexpensively. The use of geophysics will not preclude subsurface excavations and test drilling, however, the time involved and number of excavations necessary can often be reduced drastically by their inclusion.

It might be possible to narrow the actual plume geometry significantly by the use of such techniques as D.C. Resistivity, magnatometer or E.M. Conductivity. It must be pointed out, however, that where contaminant plumes are very deep or where surface features cause interferences to occur, surface geophysics may not be useful. Also, it is important to realize that these tools used alone are not sufficient to characterize a specific site. Other techniques, such as trench excavation, piezometer and/or monitoring well installations, should also be included.

Section II-G: Installation Of Piezometers The ground water level (piezometric surface) and the direction of ground water movement within the affected area are generally determined as early as is possible. Some generalization of this can be obtained from the regional hydrogeologic analyses and area well survey but local variations must be discovered in the field. The utilization of piezometers is somewhat similar to the use of surface geophysics discussed above. These wells may be installed in an attempt to reduce the uncertainty and the number of monitoring wells to be required. Piezometer installation and their periodic monitoring will reveal important information about specific zones to be screened and the precise movement of the ground water at the site. Piezometers may be installed quickly and relatively cheaply to obtain this necessary data.

As the boreholes are advanced, the hydrogeologist should be present to sample log each borehole. A field book should be maintained to record not only the sample interpretations but other information that might be utilized at a later date. Such information as date, time drilling began and ceased, difficulties in the drilling operation, weather conditions, methods of drilling and the type of drilling rig utilized in completion and development must be recorded. The hydrogeologist must be able to identify all lithologies and hydrologic conditions penetrated and be able to chose with confidence the correct zones to be screened and developed as piezometers.

During the drilling operation the hydrogeologist should collect samples of the materials penetrated for possible laboratory analysis. This analysis should include the basic engineering properties of the materials, such as Atterberg limits, proctor density, and soils classification. These analyses should be performed by a reputable engineering laboratory.

Piezometers are usually narrow diameter wells advanced and completed for the sole purpose of measuring water levels and constructing conceptual potentiometric surface maps. These maps can then be utilized to further design a monitoring well system that can be used to determine more precisely the character of the contaminant plume at the project site. The number and the locations of piezometers will vary significantly from one project to another. Most often nested piezometers will be required to determine the piezometric surface of several different geologic units at the site. These nested piezometers may occupy the same borehole or separate boreholes may be drilled for each piezometer of the nest.

In some situations, especially where domestic or other wells are already available within the general area, the piezometer step may not be necessary. Adequate information about the piezometric surface may already be available. Another alternative sometimes employed when considerable information about the ground water regime is available is to construct piezometers as if they were monitoring wells. These may then be submitted to the lead agency at a later date as monitoring wells. This is sometimes utilized when piezometers are required by the lead agency as a prior step to monitoring well installation regardless of the level of data already available for decision making. This later approach, if successful, could save the client a considerable amount of investment. It must be cautioned, however, that not all the piezometers will always be accepted as monitoring wells and some new monitoring wells may still need to be installed. This risk should be explained to the client prior to initial piezometer installation.

Section II-H: Borehole Geophysics Borehole geophysics are often employed during the completion of piezometers (or monitoring wells) in an attempt to gain additional knowledge of the site's hydrogeology. This is especially important where little information about the region is available or where the hydrogeology proves to be exceptionally heterogeneous. In many complex geologic environments it is recommended that borehole geophysics be employed to supplement existing data.

Upon reaching the desired depths of each excavation, borehole geophysics can be utilized to increase the amount and precision of data from the site. Borehole geophysics interpretations will allow the hydrogeologist to correct his sample logs and extend the data base with confidence.

A wide variety of borehole geophysical logs exist, but only a few are commonly utilized for ground-water and shallow geologic purposes. These are identified under two categories; nuclear and electrical. The nuclear logging techniques commonly employed include natural gamma, gamma-gamma (density) and neutron. Often these three are employed as a composite to facilitate interpretation. The electrical logs constitute a broader grouping. They commonly include several resistivity logs, spontaneous potential and caliper.

Section II-I: Monitoring Well Installation Data collected to this point in the investigation will be vitally important in the determination of the number and location of monitoring wells and the locations of screens. The primary objective of monitoring well installation is to determine the chemical character of the target aquifer(s). It may be necessary to monitor these wells periodically over a period of months or years to determine the seasonal variations in the ground water chemistry involved at the site.

The number of wells to be installed will vary considerably from one site to another in much the same way as discussed earlier for piezometer installation. The determination of the number of wells and the location of screens will depend on the nature of the contaminant and the hydrogeologic circumstances involved. Very complex geologic situations might require a nested monitoring well design to sample several discrete levels. A rather simple geologic situation may require only a single well at each location. The reader is referred to EPA´s RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (EPA, 1986) as a concise state of the art guide to the sitting and sampling of monitoring wells.

In order to determine the number and locations of monitoring wells, the hydrogeologist must have a clear understanding of the ground-water system at the site. This will include each of the required analyses and resulting maps or cross-sections, but will usually require additional information such as surface and borehole geophysical logging, potentiometric surface delineation and flow net analysis. Only with these techniques can the hydrogeologist be relatively assured of an adequate understanding of the ground-water situation at the site.

Section II-J: Aquifer Testing It is generally necessary to conduct some form of aquifer testing in order to determine the general physical characteristics of the aquifer. This data will be important when attempting to model the aquifer(s) and when designing the remediation techniques for aquifer clean up.

There are numerous aquifer testing techniques that might be employed. Each technique, however, must be used in its proper situation. Slug tests can be used to determine the transmissivity and storage coefficient immediately adjacent to a piezometer or monitoring well. Multiple well aquifer tests, on the other hand, may be employed to determine the general physical characteristics of an aquifer within the cone of depression generated when pumping a well.

In addition to the several tests that may be performed there are many techniques for data interpretation. The specific techniques that should be employed will depend on the hydrogeologic and monitoring well (or piezometric well) situation present at the site. A point that should be taken into consideration as early as piezometer or monitoring well installation is the consideration of techniques used to conduct the aquifer tests. If the hydrogeologist, for example, desires to pump a well and measure drawdowns in several adjacent wells, the pumping well must be constructed with sufficient diameter to accommodate the pumping apparatus available.

Section II-K: Ground Water Sampling And Analysis

The final field step in site characterization is the sampling and analysis of monitoring wells. Generally, the parameters to be sampled for are specifically delineated in the lead agency Order. The hydrogeologist must be aware of the proper protocol for sampling and transport of samples. He must be very aware of the possibility of cross contamination and follow guidelines exactly to eliminate such occurrences.

All samples should be transported to a reputable independent laboratory for analysis. Each sample should be accompanied with a completed chain of custody form. This form will identify the sample, the sampler(s) and the specific parameters to be tested.

Section III: Analysis of Field Results and Development of a Remediation Plan

The tasks to be completed in Section III are presented as Figure 6. These include the various forms of data interpretation and analysis, the development of preliminary reports and finally the development and presentation of a remediation plan for agency approval.

Section III-A: Analysis And Interpretation Of Field Investigation Results

Upon completion of all prescribed field analyses, the hydrogeologist is faced with the task of data reduction and interpretation. This will involve the generation of drilling logs and well completion forms, the interpretation of surface and borehole geophysical logs, analysis and work up of aquifer test data, the construction of potentiometric surfaces and the interpretation of chemical analyses from the sampled wells. Of course much of this interpretation will have already been complete in order to advance to earlier steps. Analysis and interpretation should be advanced as quickly as possible but not too quickly as to reduce quality of results. Professional drafting services should

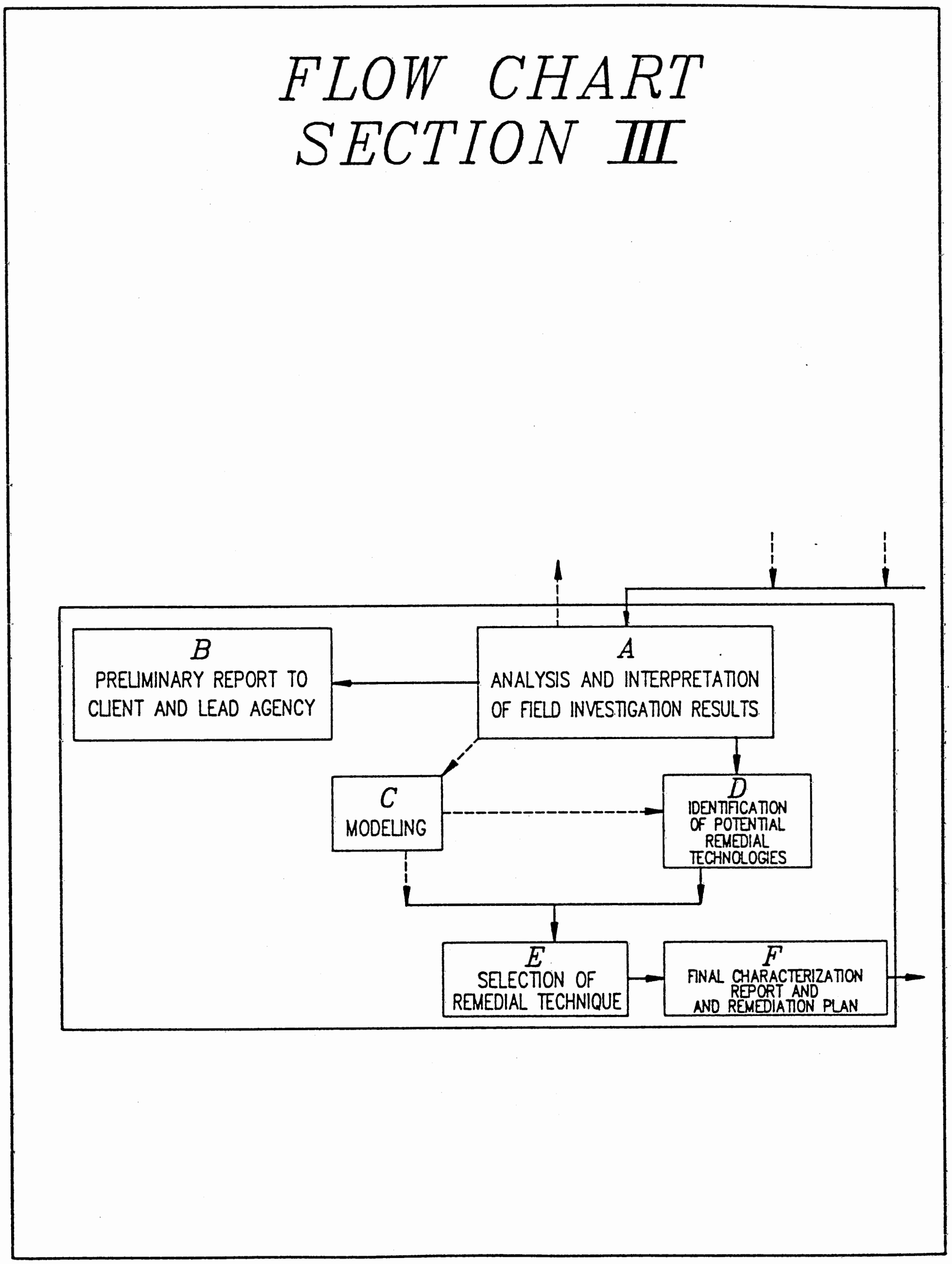


Figure 6. Flow Chart: Section III

be utilized to present results in the most appropriate form where possible.

Section III-B: Preliminary Report

Once the field analyses are complete, it is normal to provide the client and the lead agency, where necessary, with a preliminary report of findings. This will serve to keep the client informed of findings and progress and will inform the lead agency of results of the field activities. Often a meeting between the lead agency, the client and consulting firm will be arranged to discuss the results and perhaps to develop a direction for further analysis. If the lead agency or the client is not satisfied with the quantity or quality of results, it may request that further field analyses be conducted before beginning the remedial design stage of the project. This may necessitate a revision of the Order issued by the lead agency to provide sufficient time for additional field activities.

Section III-C: Modeling

Once all parties have agreed that the field analyses are complete and are satisfied with field results, the development of a remedial design for the site may begin. Ground water modeling is recommended where applicable to assist the hydrogeologist in designing the specific remediation techniques. Modeling will provide the hydrogeologist with a prediction of the direction and rate of movement of any contaminant moving through the aquifer.

Because of the need to analyze contamination of ground-water resources, many mathematical models have been developed to simulate ground-water flow and solute transport (Wilson and Miller, 1978; Konikow and Bredehoeft, 1978; Pricket and Lonnquist, 1971; Trescott, 1975). These models serve a dual purpose: first, to simulate and predict the development of ground-water contamination plumes; and second, to assist in solving the problems of ground-water remediation. Three types of mathematical models have been developed to meet these objectives. These methods are the nomograph, the analytical model and the numerical model. The first two of these methods are most suitable for the groundwater scientist working without a substantial background in modeling techniques. Both the nomograph and the analytical model are straight forward and relatively simple to use, and they provide the scientist with significant information.

Section III-D: Identification Of Potential Remedial Techniques

Upon completion of the modeling exercise the hydrogeologist should be aware of the specific problems and circumstances surrounding the site. With this knowledge available, the hydrogeologist will be able to identify a range of remediation techniques that might be employed at the site. These may range from no action to very sophisticated pumping and treating scenarios.

In addition to identifying specific remediation scenarios, the hydrogeologist must be able to estimate the ability of each scenario to adequately remediate the site. These techniques must be compared on the basis of their abilities to remediate the site, their levels of technical expertise required and the costs of each scenario. The hydrogeologist should select one or more scenarios to present to the client and then to the lead agency as a recommended remediation activity.

Section III-E: Selection of Final Remediation Technique

Based on the specific hydrogeologic situation and the type(s) of contamination present at the site and taking into account the level of technical expertise required and the costs involved, a final remediation program is developed and presented to the client and then to the lead agency. Most often the client will have been directly involved with the actual evaluation of the remediation techniques.

Section III-F: Final Report with Remediation Plan

A final report will be prepared for presentation to the lead agency. This report will restate the findings of the field analyses and discuss the range of remediation techniques considered. The final remediation program will be presented along with a schedule of activities required to complete remediation. This will normally require a meeting between the lead agency, the client and the consulting firm for explanation purposes and perhaps to answer question regarding some parts of the proposed project.

Section IV: Remedial Plan Implementation

Once the remedial activity plan has been fully accepted by all parties, the ground water scientist will initiate remediation (see Figure 7). This may involve the utilization of drilling firms, engineering expertise or other professionals. Most often the ground water scientist is in a position of overseeing the progress of the project. Progress reports may be required either by the client or the lead agency. These reports should be prepared by the project hydrogeologist.

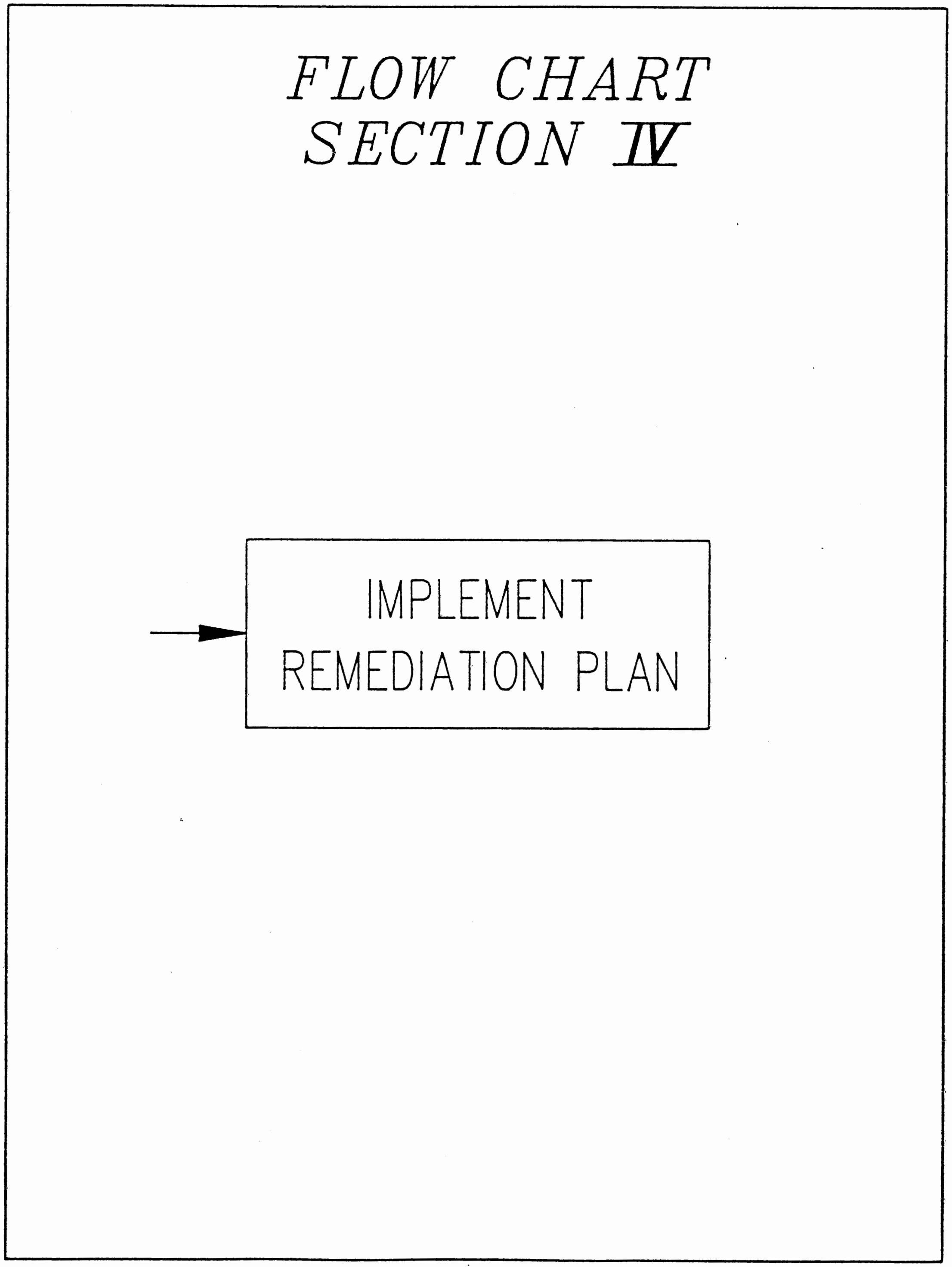


Figure 7. Flow Chart: Section IV

CHAPTER III

PRESENTATION OF CASE STUDY

Background

In 1967 the Mining and Metals Division of Union Carbide Corporation began operating a plant to process ores to produce vanadium by-products and other mineral concentrates near Sulphur Springs, Arkansas (see Figure 3). The plant is presently being operated by U.S. Vanadium Corporation. Ores and mineral were mined largely by open-pit methods at two nearby sites; the Sulphur Springs Intrusive and the Magnet Cove Intrusive. In addition to the nearby ore and mineral sources, feed stocks were obtained from from other sources. An example is oil refinery residues from Venezuelan crudes.

Ores are transported to the plant, dried, ground, and roasted in the presence of sodium chloride. The roasted ore is water leached to remove a soluble vanadium compound, V_2O_5. The leached ore is washed free of soluble product in a series of thickeners and pumped to a tailings pond where solids are retained.

The gas discharge from the roaster is scrubbed in three stages to remove particulates, HCl, chlorides and other materials. The three stages consist of a strong acid scrub, weak acid scrub, and a basic scrub to reduce the contaminants in the effluent gas stream to negligible amounts.

The vanadium is recovered from the leach solution by a solvent extraction process. The solvent, after extracting the vanadium, is stripped by an aqueous solution and recycled to the extraction process. The vanadium is then precipitated from the strip solution and a final product is prepared. The solvent extraction raffinate (water leach solution after removal of the vanadium) enters a series of decant ponds to remove any small quantities of solvent which may have become entrained. The outfall from the decant ponds go to lime neutralization and thence to the tailings pond.

The liquid effluent released consists of wash water discharged with the barren solids from the last washing thickener, raffinate from the extraction process, and solution from the acid and basic gas scrubbers. Acidic effluents are discharged through an acid neutralizing step. Chloride from the salt roast process is discharged in the plant effluent. The process is designed to provide maximum recycle of all chloride containing streams in order to minimized chloride release.

Holding ponds were installed as early as 1966 to permit controlled release to Lake Catherine as permitted by the Arkansas Department of Pollution Control and Ecology (ADPC&E). Design of the effluent disposal system was based on limiting the chloride release to a level that would result in a monthly average maximum chloride increase above background in the Ouachita River below Remmel Dam equal to 10 percent of the U.S. Drinking Water Standards.

In February of 1985 chlorides were detected by a nearby resident in her domestic well (this well is generally referred to as the Duty well. A complaint was filed with the ADPC&E. The site was investigated by ADPC&E staff in March of 1985 and a Consent Administrative Order (LIS 85-075) was agreed to by Umetco Minerals Corporation (Umetco) and the ADPC&E in April of 1986. The plan of action was initiated immediately to investigate subsurface anomalism, utilizing a phased approach to include the following components:

1. Review of existing data,
2. Phase I field investigation - geophysical survey,
3. Phase II field investigation - monitoring well installation,
4. Contamination evaluation report,
5. Remedial alternative study,
6. Initiate final plan of action.

Regional Analyses

Geology

<u>Regional Stratigraphy</u> The typical stratigraphic section of the Ouachita Mountains consists of more than 50,000 feet of Paleozoic rocks. The lithology of the section is primarily composed of shale, sandstone, novaculite, chert and conglomerate, with minor amounts of limestone, subgraywacke, and siltstone. The formations range in age from Ordovician to Permian. The formations relevant to this study are the Arkansas Novaculite (Devonian to Mississippian Age) and the Stanley Shale Formation (Mississippian Age) (see Figure 8).

The Arkansas Novaculite is divided into lower, middle, and upper divisions. The lithology of the lower division is comprised of massive white to gray and black novaculite. The middle division is characterized by thin-bedded, black to dark gray chert interbedded with thin beds of dark gray to black shale. The rocks of the upper division consist of thin to medium bedded, white, locally calcareous novaculite.

The Stanley Shale Formation is composed of medium to dark gray shale with some thick beds of medium to dark gray and olive gray, fine grained sandstone. The base of the formation is characterized by a light gray, fine grained, quartzose sandstone interbedded with dark gray shale. This lower unit is the Hot Springs Sandstone

AGE	FORMATION	THICKNESS (FEET)	LITHOLOGY
MIssissippian	Stanley Shale	6,000- 12,000	Shale, bluish-black to black, fissile, and greenish quartzitic compact fine-grained sandstone; containes novaculite conglomerate and several beds of acidic vitric tuff near base. Lower part of shale locally is slaty.
	Hot Springs Sandstone Member	0 - 200	Sandstone, fine to medium grained, gray quartzitic, hard, laminated, novaculite-pebble conglomerate at base.
Mississippian And Devonian	Arkansas Novaculite	230 - 950	Upper member: Novaculite, massive, light gray to bluish-black, calcareous. Middle member: Novaculite, thin-bedded, dark, and interbedded black clay shale. Lower member: Novaculite, dense, massive, white.

Figure 8. Generalized Geologic Column

member.

Regional Structural Geology The study site is located in the eastern portion of the Mazarn Basin (see Figure 9). The Mazarn basin is a synclinorium; bounded on the north by the northeast trending Zig Zag Mountains and on the south by the east-west trending Trap Mountains. The rocks were folded, faulted, and locally intensely fractured during late Pennsylvanian-early Permian orogeny (Purdue and Miser, 1923).

Regional Geologic History The geologic history of the Ouachita Mountains is a result of three (3) geologic events: (1) the formation of a long narrow geosyncline, in which a great thickness of sediments were deposited, (2) the deformation of these rocks into a complexly folded and thrust faulted anticlinorium, and (3) a long period of epirogenic uplift and erosion.

The geosyncline formed in two distinct phases that lasted throughout most of the Paleozoic Era. During the first phase, approximately 7,000 feet of fine-grained sediments were deposited in the slowly sinking geosyncline. During the second phase the geosyncline sank very rapidly, geologically, and approximately 39,000 feet of predominantly clastic sediments were deposited.

Orogenic movements began during Atoka time and continued through middle Pennsylvanian time. Tremendous compressive forces formed the rocks into a complexly

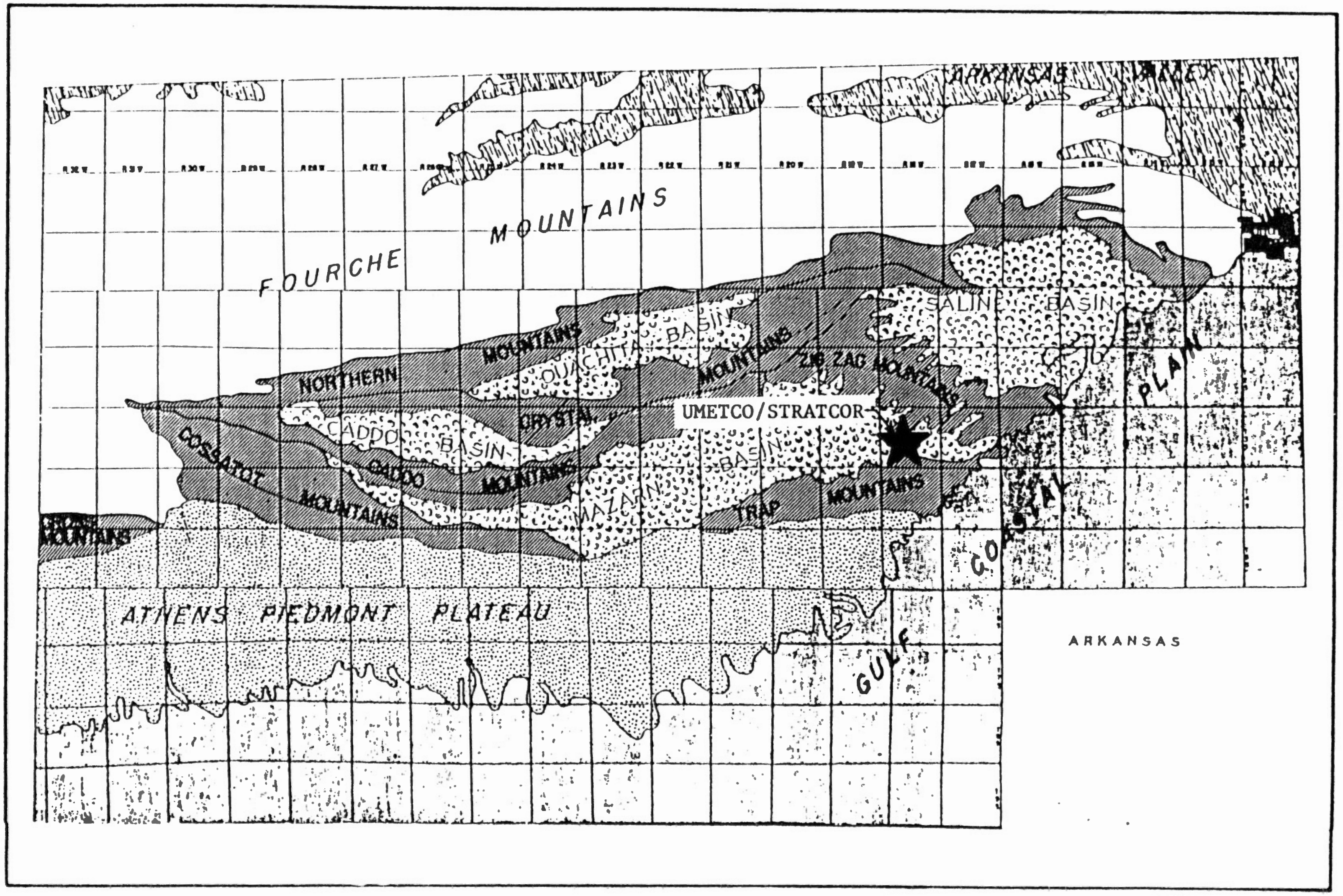


Figure 9. Physiographic Province Map of the Ouachita Mountains (Source: Purdue and Miser, 1923)

folded and thrust faulted anticlinorium.

The Ouachita Mountain area has been rising as a result of epirogenic uplift since the climax of orogenic deformation in middle Pennsylvanian time. Erosion kept pace with the uplift and reduced the area to a peneplane by the end of the Mesozoic era.

The Paleozoic rocks were intruded by alkalic plutons of early late Cretaceous Age. There are two major plutons near the study area. The Magnet Cove complex is located approximately three mile to the east of the site, and the Potash Sulfur Springs intrusive body approximately one mile west of the study area. The Potash Sulfur Springs intrusive is shown on Figure 10. Numerous dikes and sills occur in the bedrock between the two intrusives.

Differential rates of erosion during the post-Cretaceous erosional event have resulted in a topography with a moderate relief of about 535 feet. Resistant beds of novaculite and sandstone form the highlands where elevations as much as 840 feet are attained. In contrast, the valleys are underlain by less resistant shale, resulting in a gently rolling low relief topography. The lowest elevation is 305 feet at Lake Catherine. The differential erosion has emphasized the fold pattern of southwest plunging anticlines and synclines.

The Stanley Shale has been weathered to significant depths. However, the thickness of the weathered zone is related to the rate of erosion. Zones of weathering range

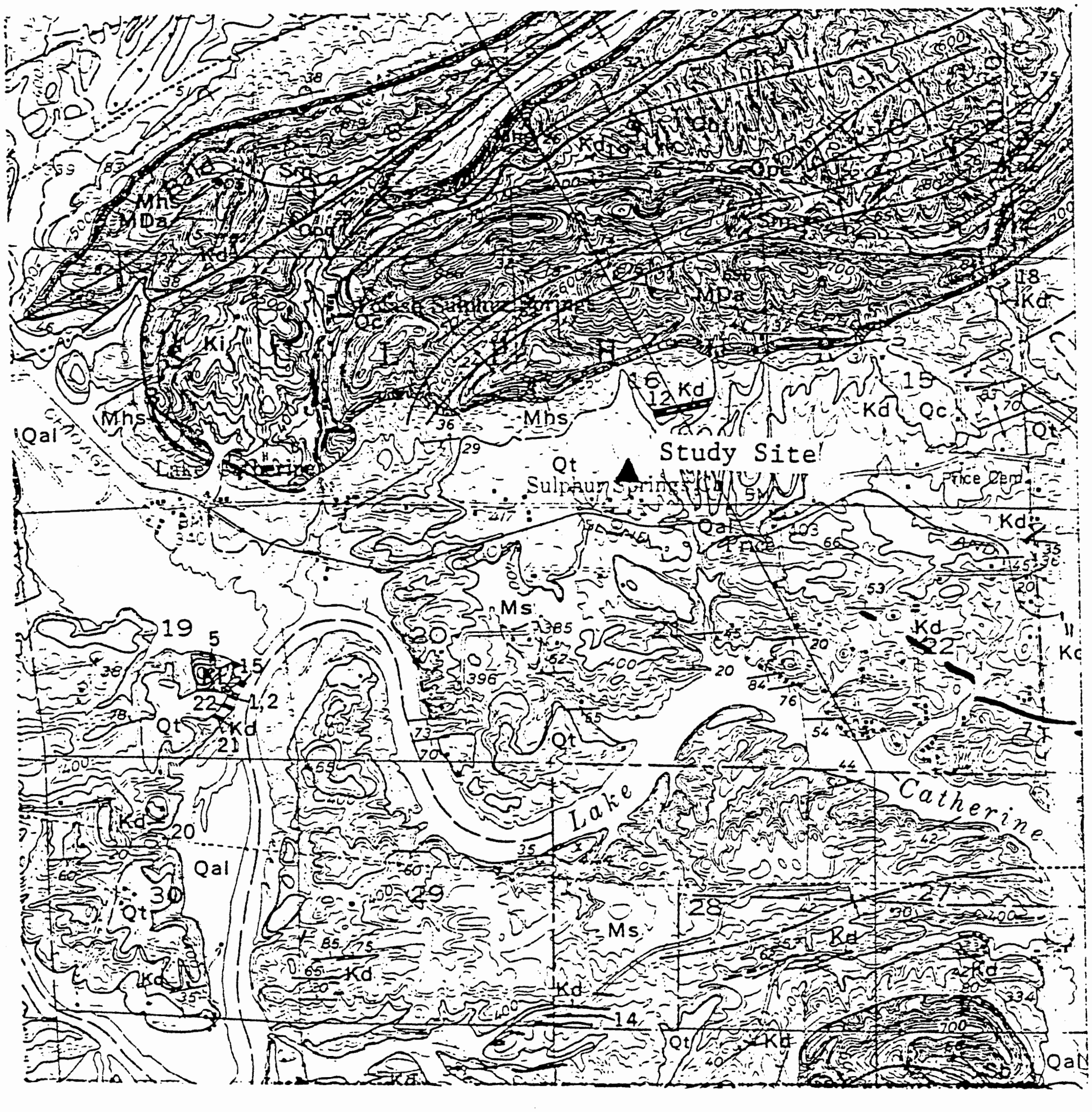


Figure 10. Area Geologic Map (Source: Danilchik and Haley, 1964)

from 20 feet in some localities, to thin or non-existent in others.

The development of major stream systems during the Pleistocene Period resulted in the deposition of fluviatile deposits. In the Mazarn Basin, these deposits are represented by dissected relics adjacent to and elevated above the present level of the Ouachita River and associated lakes system.

Alluvial fans were deposited penecontemporaneously with the fluviatile deposits. Clastics for the fans were derived from highlands bordering the Ouachita River. The clastics were transported along narrow, high gradient channels during periods of heavy rainfall and deposited as fan shaped deposits over the broad, flat, and unconfined valley floor.

Regional Surface Water Hydrology

A major drainage divide between the Arkansas and Red River basins is formed along the Ouachita Mountain section between Township 2 North and Township 1 South. The northern portion of the mountains is in the Arkansas River basin and is drained principally by the Fourche LaFave River and its tributaries. The southern part of the section is in the Red River basin is drained by the Ouachita River and its tributaries (see Figure 11).

The location of streams in the Ouachita Mountains is dependent upon the regional geologic structure. In

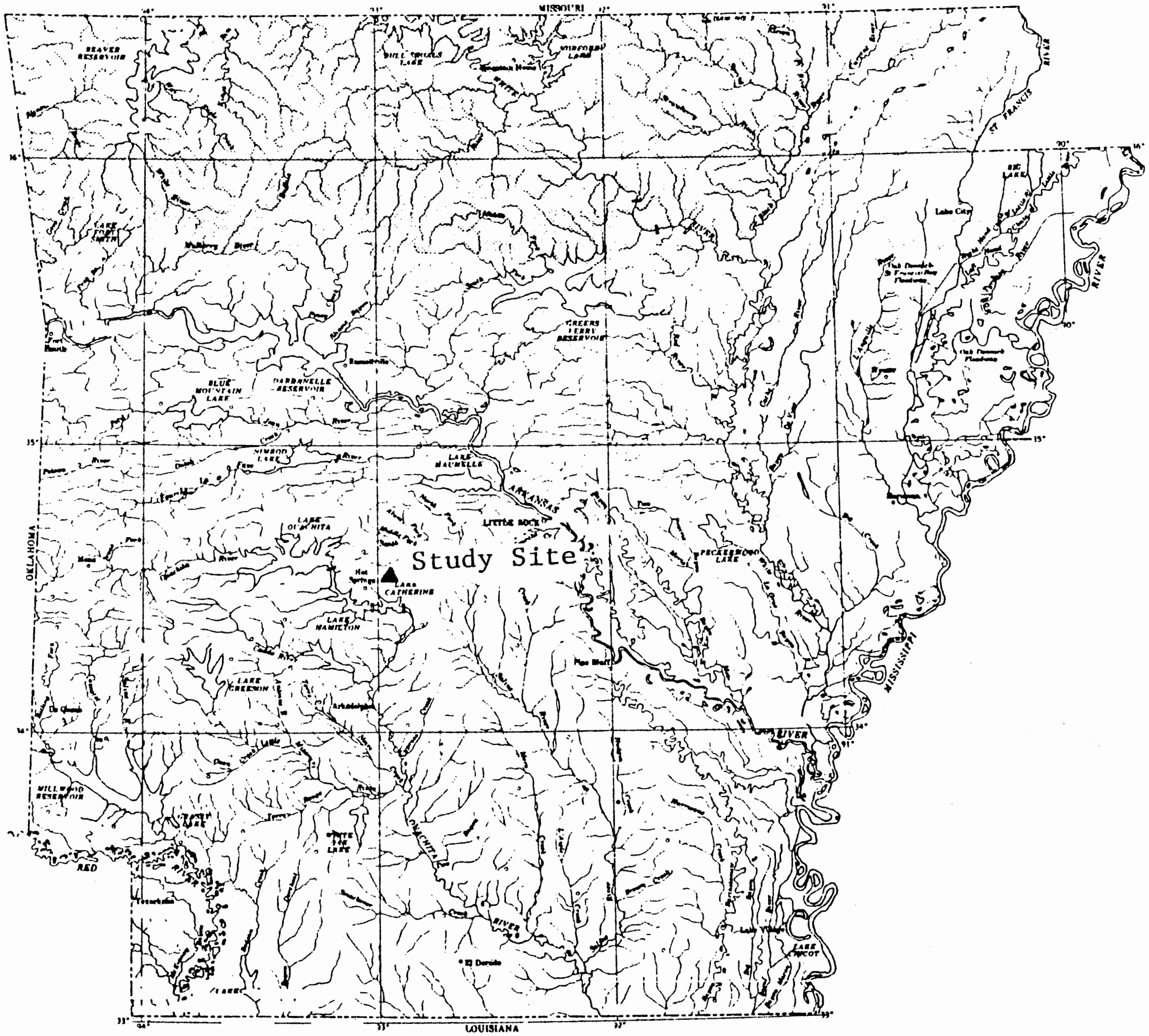


Figure 11. Surface Drainage of Arkansas

general, the streams flow parallel to the east-west trending ridge lines and valleys for long distances. However, many streams in all parts of the section have at some point, cut their course transverse to the ridges.

Several reservoirs have been constructed in the Ouachitas for water supply, conservation, flood control, recreation, power production, or combinations of these purposes. The reservoir nearest to the study site is Lake Catherine (see Figure 2).

Regional Hydrogeology

All the rock formations within the Ouachita Mountains will yield at least some water to wells and springs, depending upon the extent of faulting, fracturing and jointing within the rock, and the type of sedimentary rock present. The primary porosity of all but the youngest sedimentary rocks has been destroyed by consolidation from deep burial, deformation pressures, or both. Ground water, then, primarily occurs in secondary openings such as joints, fractures and separations along bedding planes. Much of this secondary porosity has also been destroyed by fracture filing, with quartz a major constituent. The availability of ground water at any point depends upon the degree to which the strata has been "broken-up" by orogenic processes and the degree of fracture filling that has taken place. However, limited supplies of ground water are available at most locations because secondary openings still occur in almost all rocks in the section.

According to Miser and Purdue (1929), the formations which contain the least water are the Missouri Mountain Shale, the Polk Creek Shale and the Brownstone Marl. The Crystal Mountain Sandstone, the Bigfork Chert and the Arkansas Novaculite apparently yield the greatest amounts of water. Of these, the Bigfork Chert contains the most water. This is the result of the uniform shattering within the formation, its considerable thickness, and the relatively large area over which it crops out.

Usable ground water resources are most frequently found on the flanks of anticlines, in synclinal valleys, and off the noses of plunging anticlines. Differential movement between sandstone and shale beds during folding commonly forms fractures and bedding plane separations near the contact between these beds. When these areas are exposed to recharge on the flanks of anticlines ground water can accumulate in significant amounts.

Most wells in the Ouachita Mountains are less than 100 feet deep, but wells with the highest yields generally range between 100 and 635 feet in depth. The static water level is generally less than 20 feet below the ground surface, and artesian wells are not uncommon (Albin, 1965). Seasonal water level fluctuations generally are less than 10 feet, however, larger fluctuations are common in abnormally wet or dry years. These fluctuations are due in part to the small storage capacities in the water yielding zones, and because of recharge from infiltration of precipitation.

According to Albin (1965), aquifer tests at 10 locations in the Ouachita Mountains show that the coefficient of transmissivity generally is less than 1,000 gallons per day per foot (gpd per foot) of aquifer thickness and may be less than 50 gallons per day per foot of aquifer thickness. Specific capacities of most wells range from 0.1 to 1.0 gallon per minute per foot of drawdown after 90 minutes of pumping.

The chemical make-up of ground water in the Ouachita Mountains is primarily a mix of calcium and sodium bicarbonate and is chemically suitable for most domestic and farm uses. However, Albine (1965) reports "some ground water samples from the region are high in calcium-magnesium hardness and contained iron (Fe), manganese (Mn), chloride (Cl), nitrate (NO_3) or dissolved solids in excess of concentrations recommended for water supplies by the U.S. Public Health Service" (1962, p.7).

Regional Climatology

The study site is located in the southern portion of the Ouachita Mountains in west central Arkansas. The climate in this region is normally influenced by continental air masses. However, the proximity of the Gulf of Mexico allows warm, moist, tropical air to frequently dominate the area in the summer and, to a lesser extent, in the spring and fall. Interactions between tropical and continental air masses in the spring and fall frequently produce locally heavy rainfall. This results in a bimodal seasonal precipitation distribution for the region, with the larger peak in the spring.

Mean annual precipitation in the region varies between 50 and 55 inches, with peak values centered in the Bonnerdale, Arkansas vicinity south of Hot Springs. Average annual lake evaporation ranges between 44 and 48 inches, increasing from east to west.

Although the climate of the Ouachita Mountains is not significantly different from that of the lowlands to the south and east, the temperatures tend to be lower, and to have greater extremes. Significant temperature variations occur in the mountain region, between highland and valley stations.

Regional temperatures often exceed 100 degrees F. in the late summer, usually occurring when the area is under the influence of dry, continental air from the southwest. In the winter, arctic outbreaks can cause temperatures below zero degrees F. However, these periods of extreme cold are short-lived.

Field Investigations

Site Reconnaissance

Site reconnaissance for the study area was accomplished prior to geophysical investigation. These analyses, along with the geophysical analyses, were incorporated into reports submitted to the ADPC&E as Components 1 and 2 of the investigation and as required by the Consent Order. The purpose of these reconnaissance and geophysical investigations was to make a preliminary determination of the existence and extent of ground water contamination.

Existing drill hole records were utilized to upgrade the U.S. Geological Survey map (Danilchik and Haley, 1964) depicting the extent of alluvial deposits within the study area. These records were supplemented with aerial photograph analysis and field checking of data. Static water levels in accessible domestic wells and some existing monitoring wells were measured and a preliminary conceptual potentiometric map was constructed. Geophysical investigations were conducted by Excalibur International Consultants Ltd., Mississauga, Ontario, Canada. The area in proximity to the East and West Effluent Ponds and south to and including the Marney road were traversed using three geophysical systems. These were; a Self Potential System, Type TN-6, manufactured by Geophysical Engineering Products, Inc., an Electromagnetic

System, Geonics EM 34-3XL, operated at a constant 10 meter coil spacing and a Bison Earth Resistivity System, Model 2350.

Monitoring Well Installation

Monitoring Well Locations and Depths

The locations of monitoring wells installed during field investigation are shown on Figure 12. The preliminary locations were selected to verify geophysical interpretations, delineate the east and west plume boundaries, and determine if possible sub-surface contamination exist south of the boundaries established by the geophysical survey. The final locations were chosen based on these guidelines in addition to property access, location of underground and overhead utilities, ground surface conditions and the results of initial borehole logs and monitoring wells analytical analyses.

The depths selected for the wells were dependent upon which of three (3) zones were to be monitored. These zones are:

- Alluvial Fan Sediments
- Fluviatile Sediments
- Stanley Shale Formation

The wells were numbered utilizing the system as described below. The wells are numbered U-87-1.1A through UO-88-15.2. The well designations ending in a one (1),

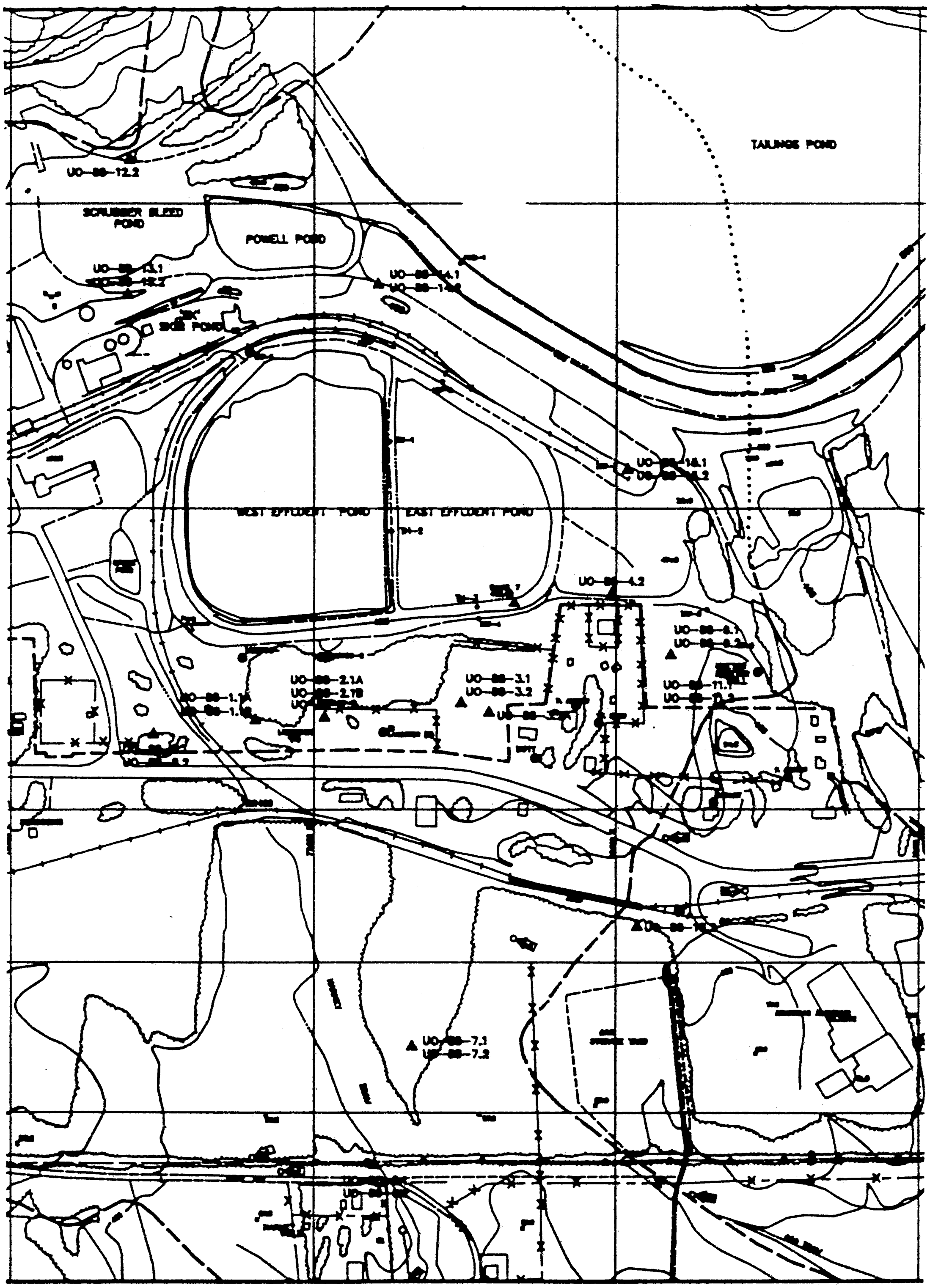


Figure 12. Location of Monitoring Wells

such as UO-87-1.1A or UO-87-3.1, represent wells screened in the alluvial/fluviatile formations, whereas well designations ending in a two (2) represent wells screened in the Stanley Shale Formation, for example UO-87-10.2. Two sets of wells are designated as "A" and "B". The wells designated with an "A" are screened in the alluvial fan sediments and the wells designated with a "B" are screened in the fluviatile deposits. Well number UO-87-5.1 proposed to be screened in the alluvium was not installed because of the absence of alluvium at the proposed well location.

Drilling

As part of the required investigation, initial monitoring wells were installed in both the alluvial material (ten wells) and the Stanley Shale (six wells). At a later date four (4) alluvial wells and seven (7) Stanley Shale wells were installed. One Stanley Shale well was advanced to 190 feet (UO-88-3.2A). The drilling logs and well completion records are presented in Appendices A and B respectively.

A truck mounted CME 75 drill equipped for hollow stem auger and air rotary drilling was used to advance the initial 16 well borings. The hollow stem auger drilling method (6.25 inches ID and 10.25 inches OD) was used to penetrate the alluvial sediments for the wells screened in the alluvial fan and fluvial materials. The hollow stem auger provided boring wall support enabling construction of the well inside the hollow stem auger.

The Stanley Shale wells (deeper wells) were installed by using the hollow stem auger to drill through the alluvial deposits and affecting a seal with the Stanley Shale by shallow penetration of the weathered clay of that formation. Upon penetrating two feet into the Stanley Shale, the auger was extracted and one foot of bentonite pellets were used to fill the void. The auger was then pressed back into this bentonite to affect the seal. Further penetration of the Stanley Shale was by air rotary to a depth of approximately 20 feet below the Alluvial-Stanley Shale contact. The well was then constructed, again using the hollow stem auger to support the alluvial materials. The exception to this was monitoring well UO-87-8.2, which penetrates only 14.5 feet of the Stanley Shale Formation because an impenetrable (with available equipment) quartz zone was encountered. The well was completed just above this impenetrable zone.

The final eleven wells were installed within the alluvium and Stanley Shale Formations using a truck mounted Mayhew 1000 drill equipped for air and wash rotary drilling. A 12 1/4 inch diameter boring was advanced for those wells penetrating the alluvium in order to install a surface casing in order to provide a seal for the upper zone; then, the borehole was advancement into the Stanley Shale. The Stanley Shale Formation was drilled using a 6

1/2 inch diameter drill bit. Borings not intended to penetrate beyond the alluvial deposits or borings completed in locations where the alluvial deposits were absent were advanced as 7 7/8 inch diameter borings.

Samples from the alluvial material in the boring were taken at five (5) foot intervals. Stanley material was sampled by continually collecting drill cuttings flushed from the hole during penetration.

The sampled materials were evaluated in the field by visual means to determine soil and rock characteristics. The information was recorded in a field log by the on-site hydrogeologist. This data was later transferred to individual drill logs and are presented here as Appendix A. The samples were then packaged, labeled, and placed in storage at the site.

Well Installation

The monitoring wells were constructed using commercially manufactured, flush jointed, four (4) inch inside diameter, Schedule 40, polyvinylchloride (PVC) casing and screen. The wells were constructed using standard well completion techniques as described by EPA's RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (EPA, 1986) where applicable. Figure 13 represents a typical monitoring well as installed at the study site. Well completion records are presented in

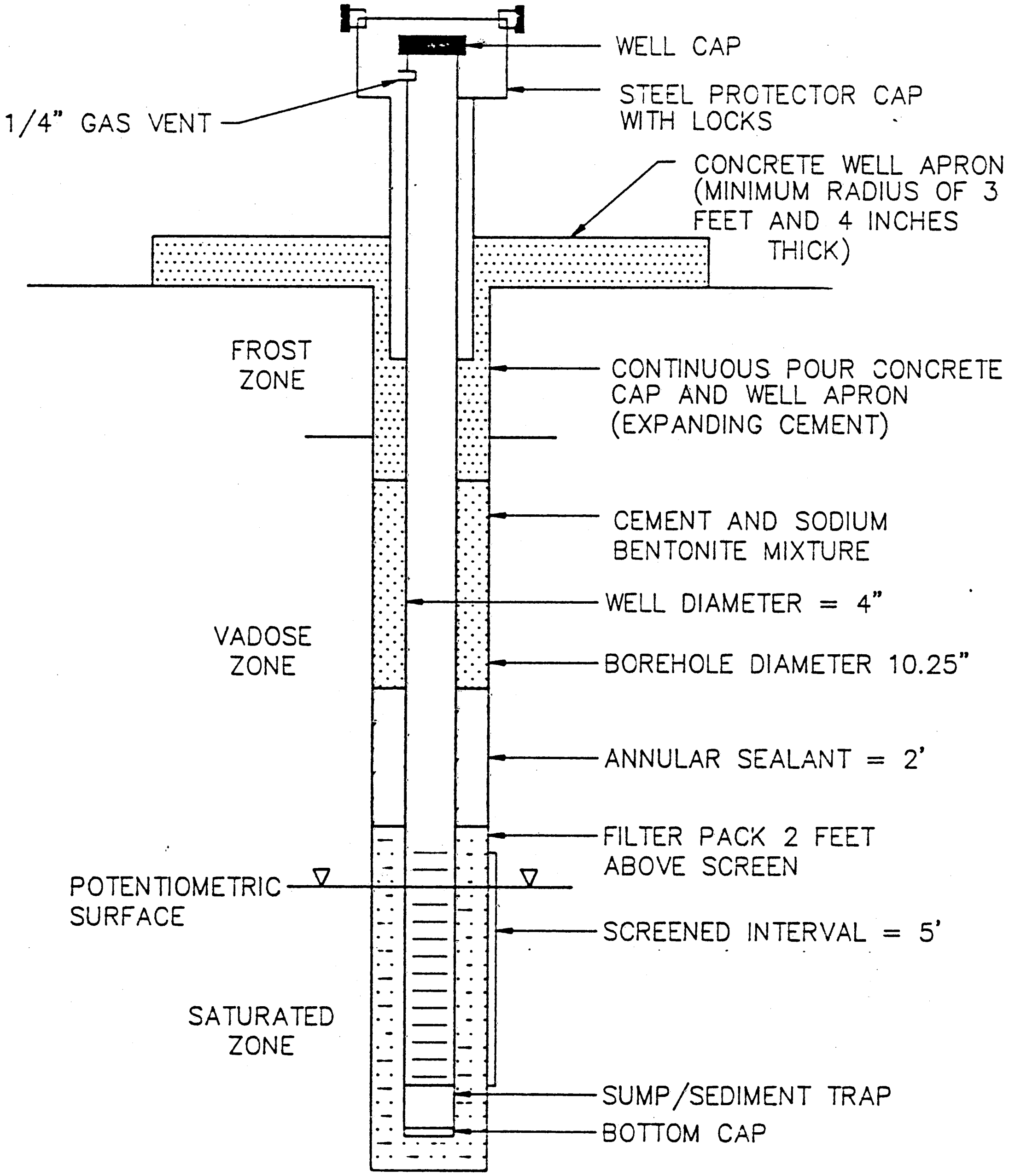


Figure 13. Monitoring Well-Cross Section

Appendix B.

Solid casing was used from the top of the well screens to a minimum of one (1) foot above the ground surface. The bottom of the well was capped with a sump cup to collect any fine grained sediment. All casing and screen material was steam cleaned prior to installation.

Monitoring well filter packs were constructed of well rounded, clean quartz gravel. Within the initial wells drilled and using the hollow stem auger the gravel was placed by dropping the material between the casing and the inside of the hollow stem auger and slowly raising the auger and allowing the gravel to fill the borehole to a distance of two (2) feet above the top of the screen (see Figure 13). However, heaving sands in the fluviatile zone prevented conventional well installation practices from being utilized at some locations. As a result, wells UO-87-1.1B and UO-87-3.1 were installed utilizing a four (4) layer wrapping of geotechnical fabric (MIARFI 140N) around the screen and casing to two (2) feet above the screen. Specifications for the fabric are shown in Appendix C. Other materials are also available to replace conventional filter pack where necessary.

The additional wells installed were constructed using filter pack of well rounded clean 10-20 quartz sand. The gravel was placed by either dropping the material directly down the borehole or by tremie pipe. The method selected was based on field conditions. The sand was dropped directly down the borehole on wells less than 20 feet in depth which were not filled with ground water. The filter pack was placed with a tremie pipe in those wells exceeding 20 foot in depth or where shallow ground water occurred.

A sufficient amount of bentonite pellets were used to affect a two (2) foot annular seal above the sand filter. However, problems with the bentonite pellets bridging between the inside of the hollow stem auger and the PVC well casing were experienced in completing wells with heaving sands and/or where the well screen was over ten feet below the top of the water table. An alternate method was used where these problems were encountered. A two (2) foot layer of well graded sand was allowed to settle out above the filter pack. It was believed that this sand layer would be more easily emplaced and still function adequately as a barrier between the grout and the filter pack.

In order to determine the adequacy of this approach, a study to explore and confirm the feasibility of using the well graded sand in lieu of the bentonite pellets was administered by an independent soils testing laboratory. The results of their investigation are presented in Appendix D, and suggest that the sand does function adequately as a barrier to grout which may move downward into the sand. The use of this approach in actual well construction indicated that the described techniques and well construction methods were successful and is substantiated by the following observations:

- No bridging between the PVC well casing and the interior of the hollow stem auger was observed.

- No significant increase in pH or calcium was noted in any sand sealed well.

The remaining annular space was sealed to the surface with a bentonite/cement grout. The bentonite/cement grout was prepared using water from the City of Hot Springs' water system and placed in the borehole using a tremie pipe to within three (3) feet of the ground surface. The remainder of the well was sealed by constructing a four (4) inch apron of concrete which extends a minimum of three feet from the outer edge of the casing. The well casing was provided with a flanged cap to prevent the entrance of foreign material. A one-quarter inch vent hole was placed in the casing to provide an avenue for the escape of gas and allow for the equilibration of water levels. The casing was covered by a steel security cover, set three (3) feet into the concrete apron and annular space while the concrete was still wet. Locks were installed to prevent tampering.

Well Development

The well development procedures utilized were dependent on the zone to be developed and the anticipated rate of recharge. The procedures utilized were compressed air, bailing, downhole pumping, or a combination of these methods. The methods utilized for each well are shown in Table 1. The wells were developed until the water was clear and free of sediment.

Sampling and Analysis Plan

A sampling and analysis plan for the observation wells at the site was outlined in a letter to ADPC&E on January 29, 1987. The following sections describe the techniques utilized and includes procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain-of-custody control as specified in EPA's technical enforcement guidance document (EPA, 1986). Sample analysis was performed by three (3) different laboratories; U.S. Vanadium's on site laboratory, American Interplex and Sorrells Research Laboratory both of Little Rock, Arkansas.

Water Level Measurement Techniques

Water levels were measured using a SINCO Model 51453 water level indicator. Using the water level indicator, the depth to ground water from the top of each well casing was measured. The measurements were recorded on either a field data sheet or a water level recording form. The elevation of the well water level was calculated using the data shown in Table 2.

TABLE 1

WELL DEVELOPMENT PROCEDURES

Well	Compressed Air	Bailing	Downhole Pumping	Screened Interval
U0-87-1.1A	*	*		Alluvial Fan
U0-87-1.1B	*	*		Fluvial
U0-87-2.1A	*	*		Alluvial Fan
U0-87-2.1B	*	*		Fluvial
U0-88-2.2		*	*	Stanley
U0-87.3.1		*	*	Fluvial
U0-87-3.2			*	Stanley
U0-88-3.2A		*	*	Stanley
U0-87-4.1		*		Alluvial Fan
U0-87-6.1		*	*	Alluvial Fan
U0-87-6.2		*	*	Stanley
U0-87-7.1		*	*	Alluvial Fan
U0-87-7.2			*	Stanley
U0-87-8.1		*	*	Alluvial Fan
U0-87-8.2			*	Stanley
U0-87-9.1		*	*	Alluvial Fan
U0-87-9.2			*	Stanley
U0-87-10.2			*	Stanley
U0-88-11.1				Alluvial Fan
U0-88-11.2		*	*	Stanley
U0-88-12.2			*	Stanley
U0-88-13.1		*	*	Alluvial Fan
U0-88-13.2		*	*	Stanley
U0-88-14.1		*	*	Alluvial Fan
U0-88-14.2		*	*	Stanley
U0-88-15.1		*	*	Alluvial Fan
U0-88-15.2		*	*	Stanley

TABLE 2

MONITORING WELL SPECIFICATIONS

Well	Coordinates		Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Casing Stickup (Feet)	Well Depth From Ground Surface (Feet)
	North	East				
U0-87-1.1A	27295	76789	404.41	405.76	1.35	23.0
U0-87-1.1B	27308	76793	404.55	406.01	1.46	36.0
U0-87-2.1A	27294	77029	404.74	406.34	1.60	26.0
U0-87-2.1B	27293	77037	404.82	406.37	1.55	38.0
U0-88-2.2	27286	77020	405.05	406.47	1.42	58.0
U0-87-3.1	27342	77492	411.80	413.18	1.38	50.0
U0-87-3.2	27344	77499	411.88	413.39	1.51	73.0
U0-88-3.2A	27304	77588	413.36	414.52	1.16	190.0
U0-87-4.1	27706	77964	422.74	422.74	1.84	30.0
U0-87-6.1	25813	77217	378.73	380.32	1.59	12.5
U0-87-6.2	25819	77215	378.90	380.30	1.40	32.0
U0-87-7.1	26238	77326	385.92	387.11	1.79	21.0
U0-87-7.2	26234	77318	385.98	387.36	1.38	46.0
U0-87-8.1	27237	76459	405.89	407.67	1.78	19.0
U0-87-8.2	27240	76468	405.84	407.26	1.42	51.5
U0-87-9.1	27491	78185	412.74	414.52	1.78	30.0
U0-87-9.2	27498	78183	412.83	414.52	1.69	55.6
U0-87-10.2	26625	78079	388.78	390.55	1.77	31.0
U0-88-11.1	27470	78377	403.04	404.59	1.55	5.5
U0-88-11.2	27459	78410	403.64	405.58	1.94	38.5
U0-88-12.2	29207	76342	472.57	473.93	1.36	32.0
U0-88-13.1	28684	76473	437.71	439.06	1.35	9.5
U0-88-13.2	28686	76464	438.32	439.75	1.43	35.0
U0-88-14.1	28675	77181	441.06	442.42	1.36	22.0
U0-88-14.2	28665	77205	440.08	441.29	1.21	55.7
U0-88-15.1	28124	78050	426.72	428.20	1.48	22.0
U0-88-15.2	28131	78037	427.23	428.74	1.51	53.0

Well Evacuation

Generally, the water standing in a monitoring well does not represent formation ground water quality. Therefore, prior to sample collection, the standing water in each well and in the filter pack was removed to a minimum of three (3) volumes so that formation water would recharge the well filter pack and casing. The succeeding paragraphs describe the step-by-step procedures followed and the equipment utilized in evacuating the monitoring wells.

The amount of water evacuated from each monitoring well was based on the hydraulic recharge of the well. A minimum of three casing volumes were evacuated from high yield wells. Low yield wells were purged until the well was dry. Low yielding wells are defined as those that would not adequately recharge within a three hour period.

The quantity (gallons) of water standing in the wetted well casing can be calculated by multiplying the gallons of water per foot (0.653 gallons/foot for a four inch I.D. casing) times the length of wetted casing bore. Water quantities evacuated from each well were measured by collecting the discharge in a container with a known volume.

The following techniques were used for well evacuation, and were selected dependent on the hydraulic characteristics and/or depth of the well. Because of the

31 to 190 foot depths and low recharge of most of the Stanley Shale screened wells, the standing water in the well was removed with a clean down hole submersible pump or polytetrafluoroethylene (PTFE) bailer with a new polypropylene rope (more recently dedicated bladder pumps have been installed in each monitoring well). Low recharge wells screened in the alluvium (UO-87-1.1A, UO-87-1.1B, UO-87-2.1A and UO-87-2.1B) were evacuated using a clean polytetrafluoroethylene (PTFE) bailer and new polypropylene rope. Because of the depth or because of high recharge rates, the remainder of the alluvial screened wells were evacuated with a clean downhole submersible pump.

Sample Withdrawal

The techniques used to collect ground water samples were designed to minimize the physical alteration, or the chemical make-up of the sample in the withdrawal process. Decontaminated PTFE sampler/bailers were used. A clean pair of new disposable gloves were worn each time a sample was collected.

After well evacuation and recovery has occurred, a decontaminated PTFE sampler was lowered into the well and withdrawn a sufficient number of times to rinse the sampler and sample containers. The sample was then withdrawn from the well and containerized in a new one gallon plastic bottle which had been rinsed using water from the well to be sampled. Each sample container was labeled with the sample number, date, time, sampler(s) and analyses required. Each sample was field tested for temperature, specific conductance and pH and recorded on the field data sheet. The pH and specific conductivity meter were calibrated prior to field measurements and recorded in the appropriate instrument calibration log.

Equipment and procedures that minimize sample agitation and reduce contact with the atmosphere during sample transfer were used. This was accomplished by first slowly lowering the sampler into the well. After retrieval from the well the water samples were slowly transferred to the sample containers to further minimize agitation and aeration. New polypropylene cord was used for each sample event and for each well.

The samples were taken to the chosen laboratory or laboratories for analysis. After each use the bailers were taken to the on-site laboratory, disassembled and thoroughly decontaminated using deionized water, non-phosphate detergent and disposable bailer brushes. The bailers were then reassembled and placed in a dedicated plastic storage case ready for further use.

Sample Preservation and Handling

Collected samples were filtered and preserved according to specifications received from the receiving laboratory. Filtering and sample preservation was conducted at the on-site laboratory. A chain-of-custody record was completed by sampling and analysis personnel for each sample.

Sample Transport Procedures

An accurate written record which can be used to trace possession and handling of a water sample from the point of collection through laboratory analysis is extremely important.

Each sample was identified using the well sample number system described above. Additional information recorded on the sample container consisted of;

- date and time of collection
- name of sampler(s)
- required analyses.

The samples were taken immediately to the on-site laboratory for filtering and, when required, preservation. Samples which were transported off-site were placed in a refrigerated transportation case along with a completed chain-of-custody form.

When transferring the possession of samples, the transferee was required to sign and record the date and time on the chain-of-custody record. Each person who took custody of the samples was required to fill in the appropriate section(s) of the chain-of-custody form. To prevent an undue proliferation of custody records, the number of custodians were minimized.

Analytical Procedures

The samples were analyzed for the following parameters at the receiving laboratory:

Parameters	Analytical Method	Reference
Ca	215.1	2
Na	273.1	2
Cl	407A	1
V	286.1	2
SO_4	375.4 or 375.3	2
$NH_4(N)$	350.2	2
pH	150.1	2

[1] Standard Methods for Examination of Water and Wastewater, 15th edition.

[2] EPA Methods for Chemical Analysis of Water and Waste. EPA- 600\4-79-020, March 1979.

Bottom of Plume Identification

In an attempt to identify the bottom of the contaminant plume two (2) means were employed; monitoring well installation and surface geophysics. It was believed that surface geophysics alone would be inadequate to identify the vertical extent of the contaminant plume due to the complex geology involved and the existence of considerable metal features in the immediate area.

It was decided that an attempt to determine plume depth would be made by advancing a deep borehole (later to be completed as a monitoring well, UO-88-3.2A) with intensive field logging of the cuttings. In addition, packers were installed every 20 feet, the testing interval purged with clean water and a sample collected for on-site laboratory analysis prior to continuing the borehole advancement. Due to the attitude of the Stanley Shale Formation and the fractured nature of these deposits seating of the packers was suspect.

Three locations were chosen for surface geophysical analysis based on previous sample analysis. D.C. Resistivity was employed. Analysis of the D.C. Resistivity was made using previously installed monitoring wells as control.

Aquifer Testing

A multiple-well aquifer test and ten (10) slug tests were conducted at the study site. The aquifer test began on August 8, 1988 and was concluded on August 11, 1988. The slug tests were administered in August of 1988 for three (3) Stanley Shale wells and in February and March of 1989 for seven (7) alluvial wells.

The multiple-well aquifer test was conducted in the Stanley Shale Formation using monitoring well UO-88-2.2 as the discharge (pumping) well and monitoring wells UO-87-3.2 and UO-87-8.2 were used as observation wells. These wells are all screened within the Stanley Shale Formation. In addition, wells UO-87-2.1B and UO-87-1.1B (screened within the fluvial deposits) were monitored in order to identify communications between the Stanley Shale and overlying deposits.

Monitoring well UO-88-2.2 was pumped with a submersible pump at approximately one-half gallon per minute. Water level measurements were taken at scheduled intervals for the discharge well and the two observation wells (UO-87-2.1B and UO-87-1.1B).

Slug tests were conducted in three (3) Stanley Shale screened monitoring wells; UO-87-7.2, UO-88-13.2 and UO-88-15.2. In addition slug tests were carried out in seven alluvial screened monitoring wells; UO-87-1.1A, UO-87-2.1B, UO-87-4.1, UO-87-7.1, UO-87-8.1, UO-88-14.1 and UO-88-15.1. These Stanley Shale tests were accomplished by first measuring the static water levels over a period of time then inserting a prefabricated tubular "slug" into the well to be tested and allowing the water level to return to static. Each well was allowed to equilibrate for a minimum of 72 hours prior to slug removal. The static water level with slug inserted was then measured just prior to an "instantaneous" removal of the slug. Water levels were measured at scheduled intervals as the well recovered.

Slug tests were performed in the alluvium wells by obtaining a static water level then calculating the volume of water necessary to fill the well casing to the top of the well. This amount of water was quickly added to the well and water levels were measured at scheduled intervals as the well returned to its static water level.

The data generated from these two aquifer tests were reduced using standard hydrologic methods. Curve fitting using the Theis methodology for the aquifer test and the Papadapulos methodology for the slug tests was employed to determine transmissivities and storage coefficients. Hydraulic conductivities were then calculated.

Field Investigation Results

Site Geology

During preliminary analyses a geologic model for the site was developed depicting geologic history of alluvial deposition over a weathered and eroded paleosurface of the Stanley Shale. The alluvial deposits are shown to consist of fluviatile (terrace) gravel deposition overlain by alluvial fan deposits.

As part of the overall investigation 27 monitoring wells were installed at the locations shown in Figure 12. The logs of these boreholes are presented in Appendix A. As shown in Table 2, thirteen (13) of the wells penetrated into the Stanley Shale formation. The remaining 14 wells were completed in the alluvial fan or fluviatile sediments. Twelve (12) of the 14 alluvial boreholes penetrated the entire thickness of the alluvium. Monitoring wells UO-87-1.1A and UO-87-2.1A were completed in the alluvial fan deposits.

The logs of the boreholes were used to construct several cross-sections in the area of investigation. The plan view and the cross-sections are presented as Figures 14 through 17. Cross-section A-A′ (see Figure 15) transits east to west across the investigated area. Cross-sections B-B′ and C-C′ (see Figures 16 and 17) transit generally north to south across the area of investigation. The water levels measured on August 16, 1988 are depicted on the cross-sections, and will be discussed below.

Quaternary Alluvial Sediments

The differences in lithologic character of the alluvium in the upper part of the deposits from that of the lower part is best shown on cross-sections A-A′ and B-B′ (see Figures 15 and 16). The upper portion of the alluvium is believed to be analogous to the alluvial fan deposit described earlier. This is substantiated by the well-boring logs, which indicate the presence of angular, poorly sorted clastics composed primarily of sandy, silty, clayey gravels. The lower portion of the alluvial formation is interpreted as a fluviatile gravel deposit. It is believed that the well boring logs largely substantiate this interpretation because of the presence of granule and gravel size clastics admixed with silty sands.

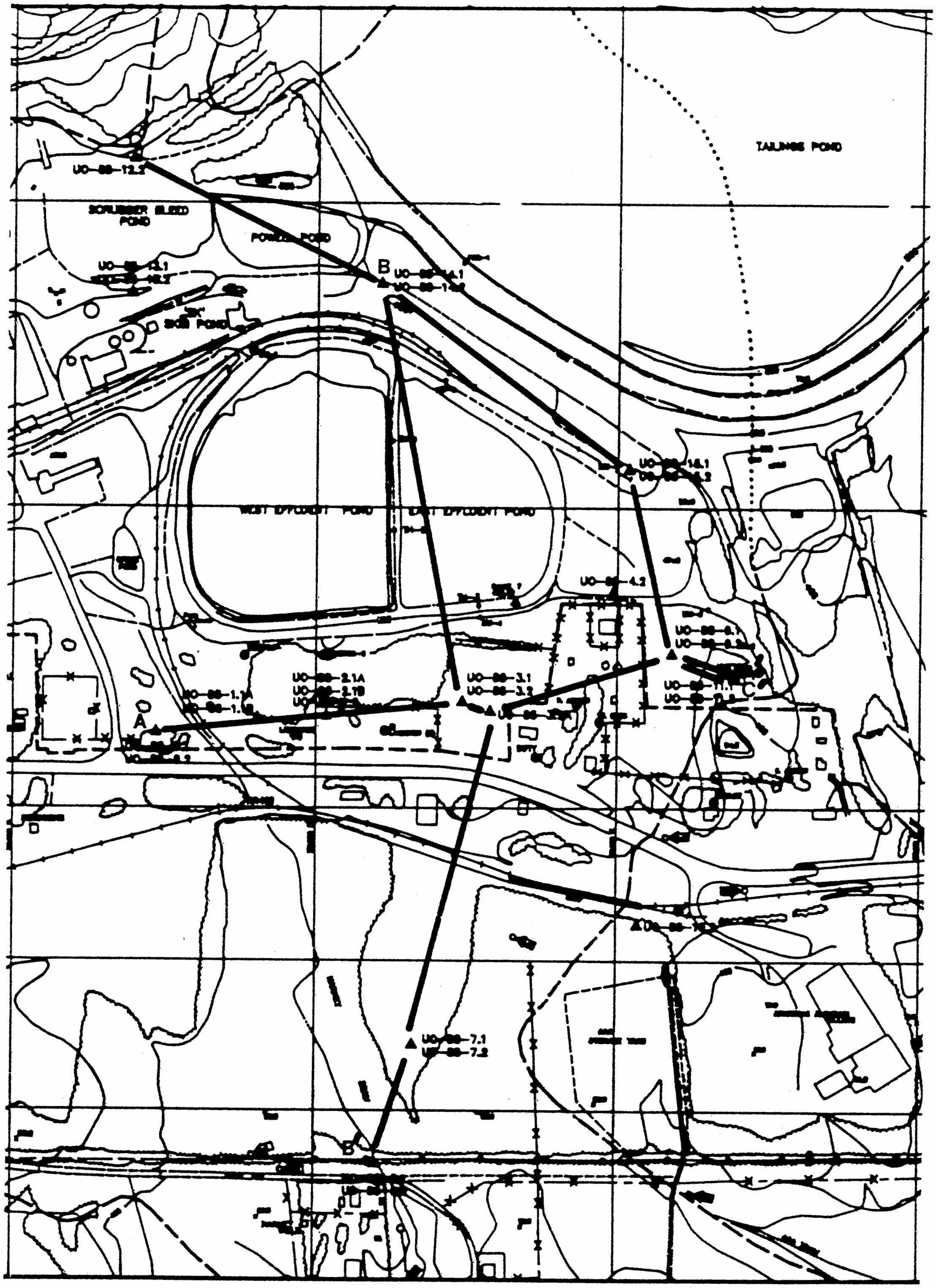
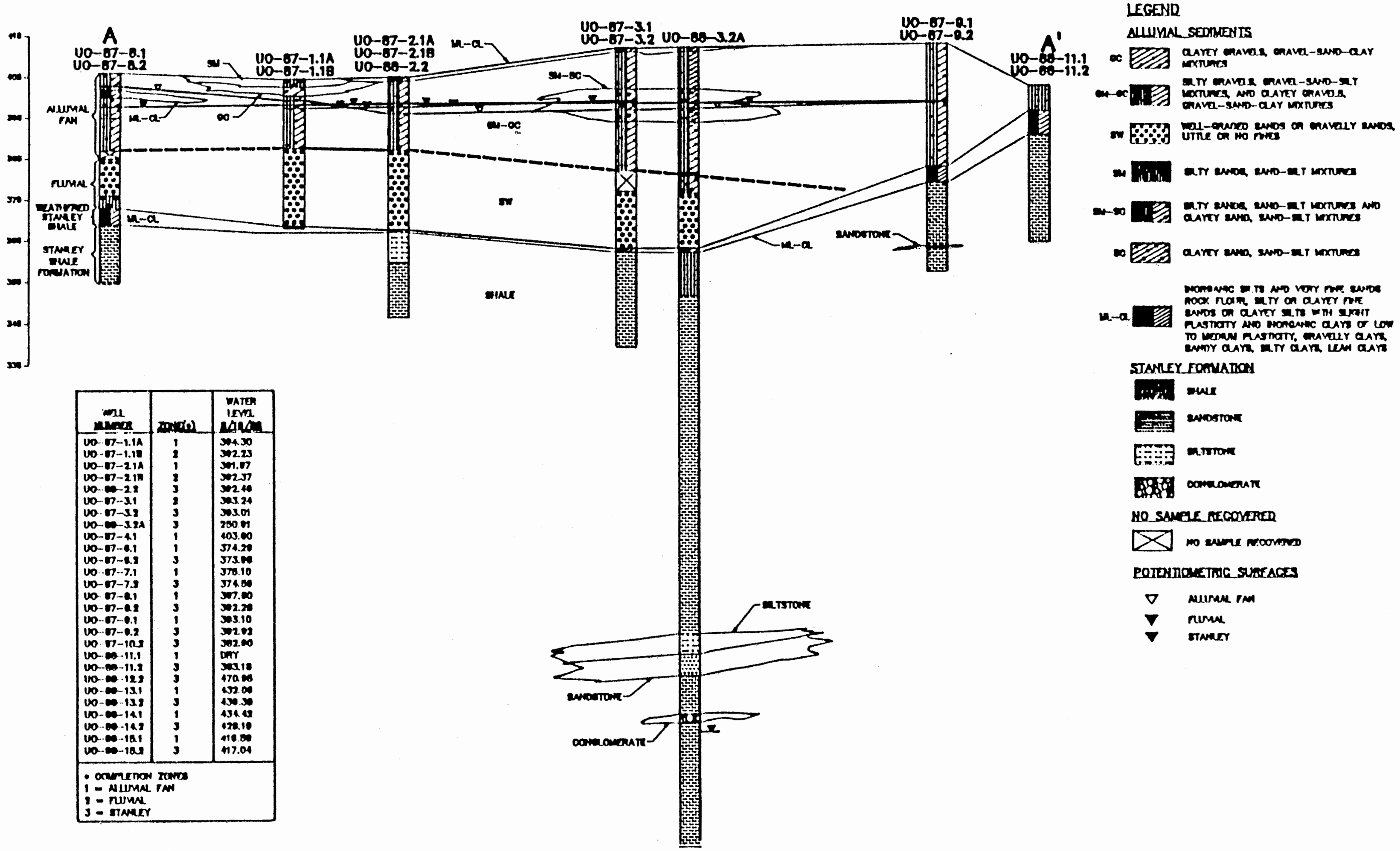


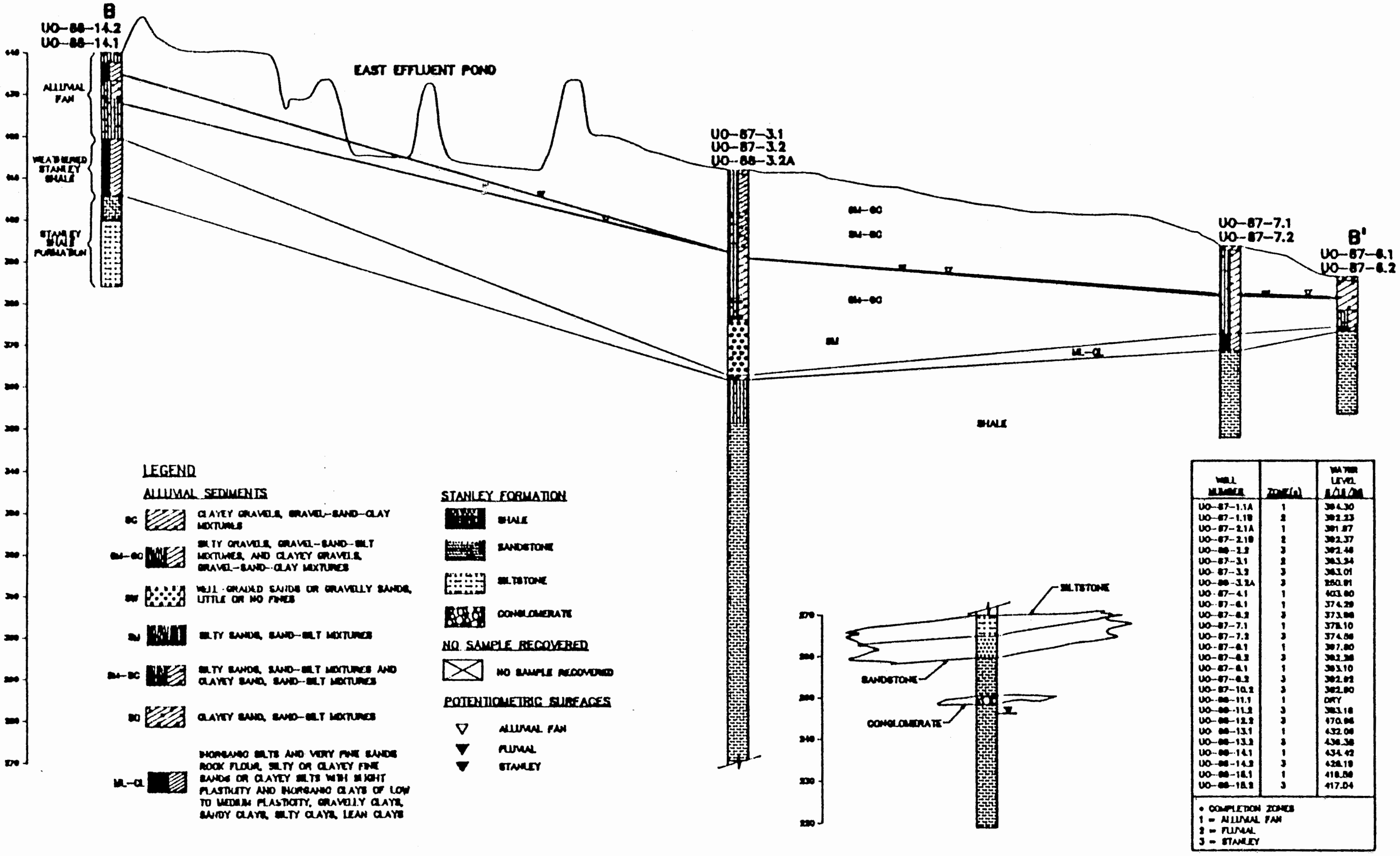
Figure 14. Plan View of Cross-Sections



WELL NUMBER	ZONE(s)	WATER LEVEL 8/18/88
UO-87-1.1A	1	394.30
UO-87-1.1B	2	392.23
UO-87-2.1A	1	391.87
UO-87-2.1B	2	392.37
UO-88-2.2	3	392.40
UO-87-3.1	2	393.24
UO-87-3.2	3	393.01
UO-88-3.2A	3	260.91
UO-87-4.1	1	403.80
UO-87-6.1	1	374.29
UO-87-6.2	3	373.98
UO-87-7.1	1	376.10
UO-87-7.2	3	374.56
UO-87-8.1	1	397.80
UO-87-8.2	3	392.28
UO-87-9.1	1	393.10
UO-87-9.2	3	392.92
UO-87-10.2	3	392.90
UO-88-11.1	1	DRY
UO-88-11.2	3	393.18
UO-88-12.2	3	470.96
UO-88-13.1	1	432.06
UO-88-13.2	3	430.30
UO-88-14.1	1	434.42
UO-88-14.2	3	428.19
UO-88-15.1	1	418.59
UO-88-15.2	3	417.04

• COMPLETION ZONES
1 – ALLUVIAL FAN
2 – FLUVIAL
3 – STANLEY

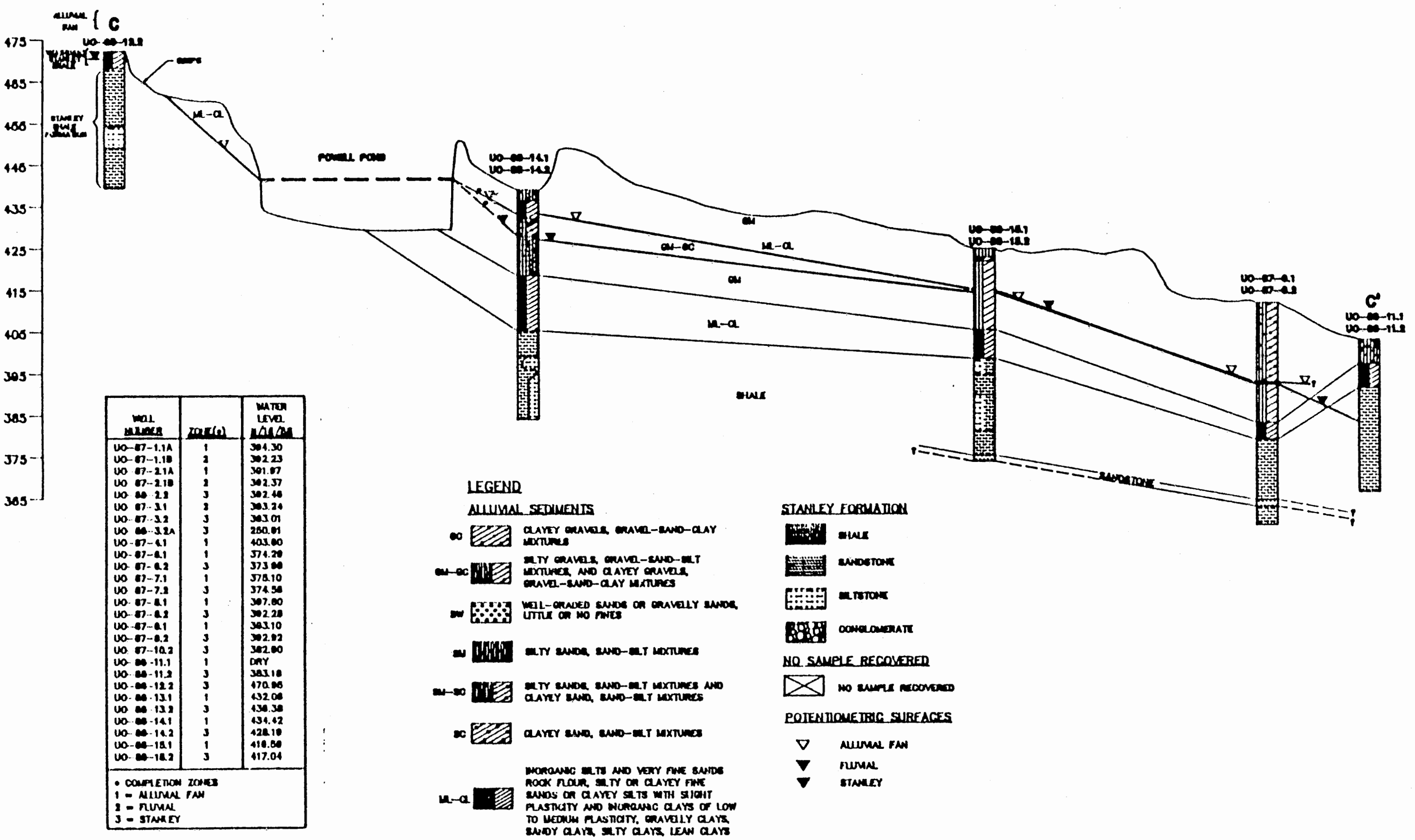
Figure 15. Cross Section A-A^1



WELL NUMBER	ZONE(s)	WATER LEVEL 8/01/88
UO-87-1.1A	1	384.30
UO-87-1.1B	2	382.23
UO-87-2.1A	1	381.87
UO-87-2.1B	2	382.37
UO-88-2.2	3	382.48
UO-87-3.1	2	383.34
UO-87-3.2	3	383.01
UO-88-3.2A	3	250.91
UO-87-4.1	1	403.80
UO-87-6.1	1	374.29
UO-87-6.2	3	373.88
UO-87-7.1	1	378.10
UO-87-7.2	3	374.68
UO-87-8.1	1	387.80
UO-87-8.2	3	382.38
UO-87-9.1	1	383.10
UO-87-9.2	3	382.92
UO-87-10.2	3	382.80
UO-88-11.1	1	DRY
UO-88-11.2	3	383.18
UO-88-12.2	3	470.96
UO-88-13.1	1	432.08
UO-88-13.2	3	436.38
UO-88-14.1	1	434.42
UO-88-14.2	3	428.19
UO-88-16.1	1	418.58
UO-88-16.2	3	417.04

• COMPLETION ZONES
1 = ALLUVIAL FAN
2 = FLUVIAL
3 = STANLEY

Figure 16. Cross Section B-B^1



WELL NUMBER	ZONE(s)	WATER LEVEL 8/16/88
UO-87-1.1A	1	394.30
UO-87-1.1B	2	392.23
UO-87-2.1A	1	391.07
UO-87-2.1B	2	392.37
UO-88-2.2	3	392.48
UO-87-3.1	2	393.24
UO-87-3.2	3	393.01
UO-88-3.2A	3	260.01
UO-87-4.1	1	403.80
UO-87-6.1	1	374.20
UO-87-6.2	3	373.88
UO-87-7.1	1	378.10
UO-87-7.2	3	374.58
UO-87-8.1	1	397.60
UO-87-8.2	3	392.28
UO-87-9.1	1	393.10
UO-87-9.2	3	392.92
UO-87-10.2	3	392.00
UO-88-11.1	1	DRY
UO-88-11.2	3	393.18
UO-88-12.2	3	470.06
UO-88-13.1	1	432.06
UO-88-13.2	3	438.38
UO-88-14.1	1	434.42
UO-88-14.2	3	428.10
UO-88-15.1	1	418.60
UO-88-15.2	3	417.04

• COMPLETION ZONES
1 = ALLUVIAL FAN
2 = FLUVIAL
3 = STANLEY

Figure 17. Cross Section C-C^1

According to the geologic model developed in the preliminary model, the fluviatile gravel deposit is mainly confined to the paleostream channel. This would explain the absence of fluviatile sediments in wells UO-87-6.1, UO-87-7.1 and UO-87-9.1 of cross-section A-A′ as well as its total absence from cross-section C-C′ (see Figure 17).

Cross-section B-B′ indicates that the southern boundary of fluviatile sequence occurs between boreholes UO-87-3.1 and UO-87-7.1. The log of well boring UO-87-6.1 suggests reworking of the alluvial fan sediments by the intermittent stream in Marney Draw. The cross-section indicates that the entire alluvial sequence thins to the south from UO-87-3.1 to UO-87-6.1. Cross-section C-C′ does not indicate the presence of the fluviatile sequence. This absence may be explained by differential erosion after deposition. This cross-section indicates the presence of alluvial fan materials in all except the UO-88-12.2 locations. However, these materials pinch out to the south and are absent in UO-87-10.2, again, the likely result of differential erosion processes.

The data from this investigation was used to construct an isopach map of the alluvium south of the East and West Effluent Ponds (see Figure 18). This map indicates a southward thickening of the alluvium to a point in the general vicinity of UO-87-3.1. This thickening is explained, in part, by the presence of the fluviatile gravel deposited in the Ouachita River paleochannel. The

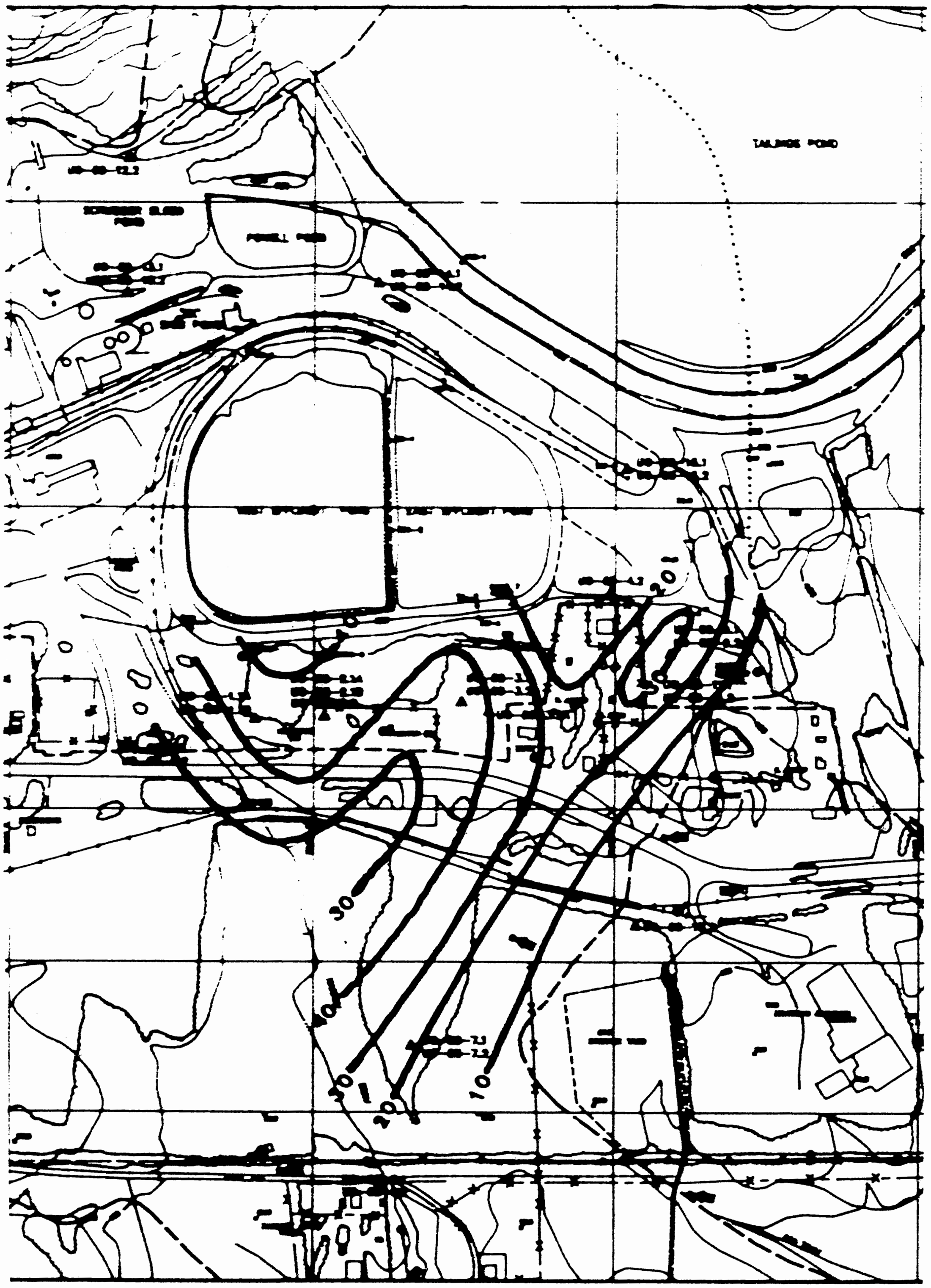


Figure 18. Alluvial Isopach Map

greatest recorded thickness of alluvium encountered in the investigation was 49 feet at well boring UO-87-3.1. In well UO-87-6.1, where there has been reworking and erosion of the alluvium by the intermittent stream in Marney Draw, the alluvium is only 12 feet in thickness.

Stanley Shale Formation

Data on the character and structure of the Stanley Shale Formation was obtained from 13 of the well borings of the investigation. The drilling logs indicate that the Stanley Shale is characterized by medium to dark gray shale and siltstone with milky quartz filling some fractures. With the exception of UO-88-3.2A the average penetration of the Stanley Shale is 20 feet beneath the weathered zone. Thin sandstone beds were -encountered in well UO-87-9.2 and thin conglomerate beds were encountered in well UO-87-6.2. At a much deeper level, however, both a well developed sandstone and conglomerate were encountered in the UO-88-3.2A boring.

The logs of the boreholes which penetrated the entire thickness of the alluvium and/or the Stanley Shale Formation were used to revise a paleosurface contour map of of the Stanley Shale topography that was earlier developed by Union Carbide staff geologists (see Figure 19). This map provides further definition of the paleosurface of the Stanley and the paleochannel discussed earlier. This is indicated by the depression which

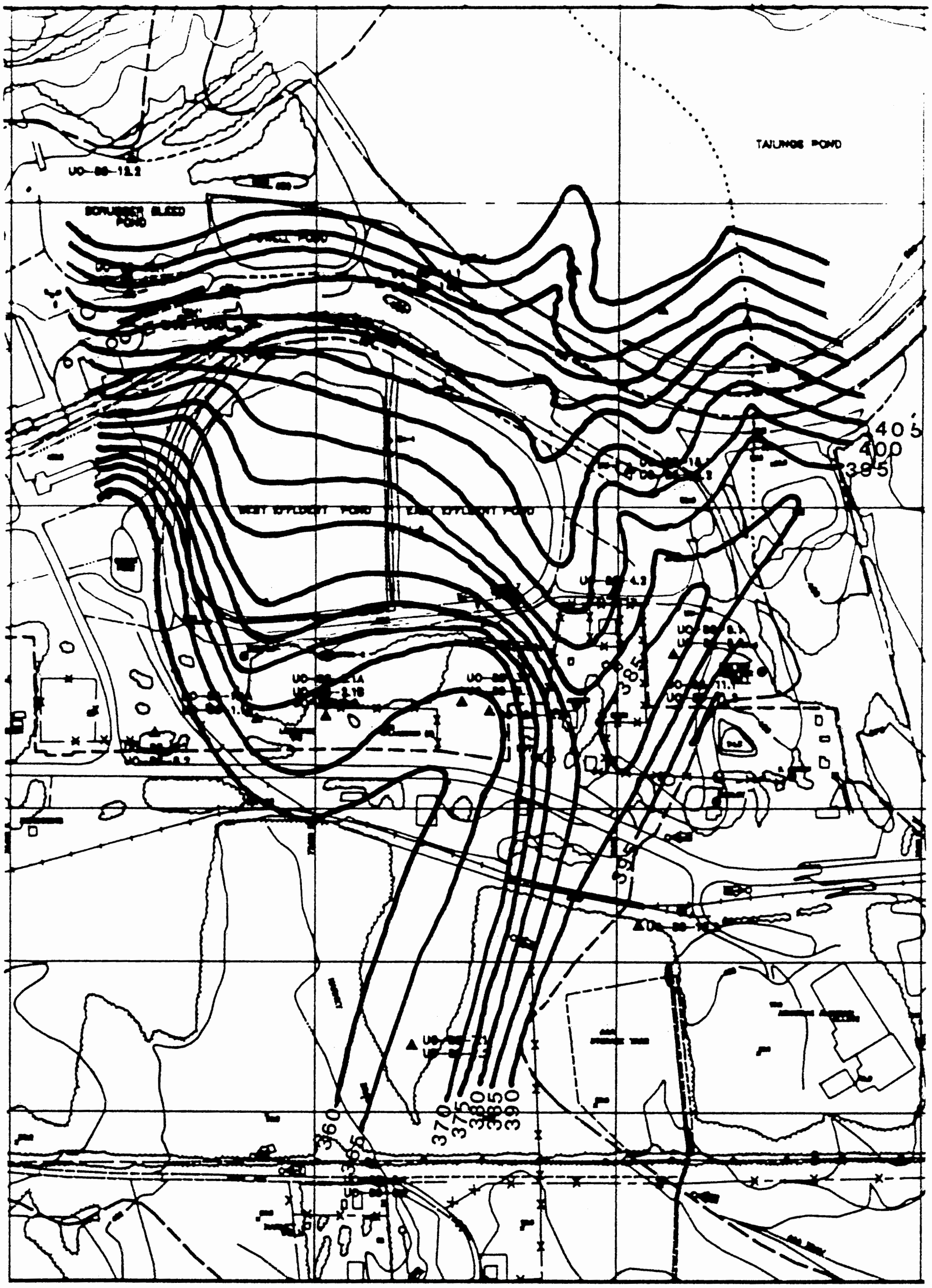


Figure 19. Structural Contour Map: Top of Stanley Shale Formation (Source: Owens, 1986)

extends to just north of boreholes UO-87-3.1 and UO-87-3.2. However, lack of data does not allow definition of the southwestern boundary of the paleochannel.

The presence of a topographic depression in the Stanley Shale was confirmed by well borings UO-88-3.2A, UO-87-9.1 and UO-87-9.2. This depression appears to be the result of erosion from the eastern most stream valley depicted on the Stanley Shale paleosurface.

Site Surface Water Hydrology

The area investigated is characterized by intermittent streams on the east and west sides of the site. The upper reaches of the stream′s natural courses have been altered by physical construction required by the plant structures and supporting facilities. The surface drainage flows generally in a southerly direction, towards lake Catherine. The locations of the drainage streams are shown on Figure 20.

In the eastern portion of the study area, surface water drainage has been modified to the north by the tailings dam and a catchment pond referred to as the Intermediate Pond and associated containment systems. The East and West Effluent Ponds also affect the flow of surface runoff. The affected surface runoff is re-channeled to the natural drainage and passes through Outfall 002 which is monitored under NPDES permit number AR 0000523. The runoff then flows southerly toward Lake Catherine.

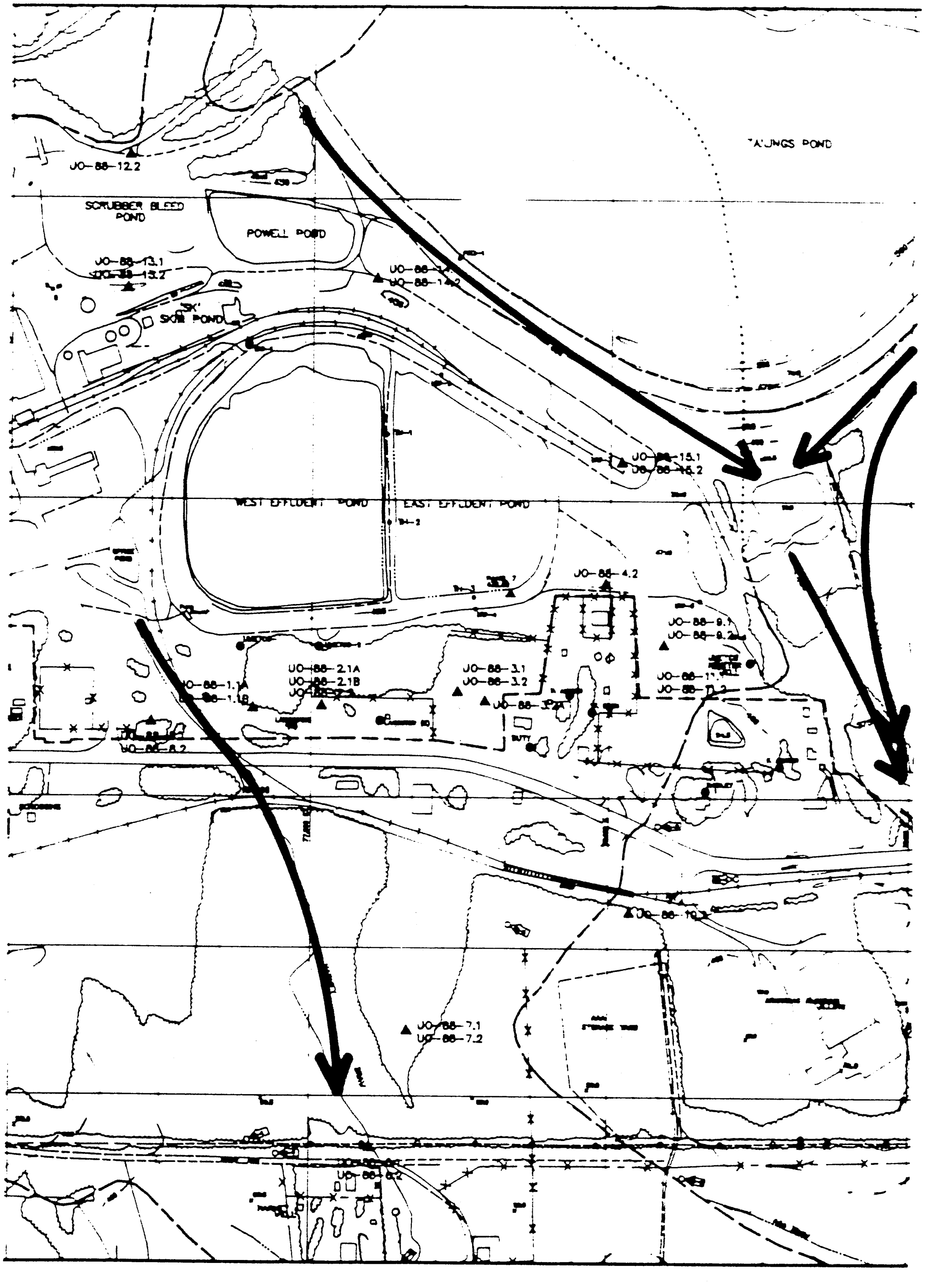


Figure 20. Site Surface Drainage

The plant structures on the west side of the study area have also changed the natural drainage. The surface runoff here is collected by a system of ditches and is channeled to a holding pond referred to as the Office Pond. After collection in the Office Pond, the runoff is pumped to one of the Effluent Ponds and is discharged in accordance with NPDES permit AR 0000523 through Outfall 001.

South of the plant collection system, runoff flows naturally through original drainage down Marney Draw.

Site Ground Water

Water levels were measured for each of the 27 monitoring wells on several occasions. This series of measurements began soon after development of the wells was completed and after each well had been allowed to fully recover. A significant amount of data has then been generated regarding the normal fluctuations of the ground-water at this site. These measurements are presented in Appendix E and summarized in Table 3.

Water level measurement periods through August 16, 1988 were used as the basis for this presentation and constitute the raw data used for ground-water evaluations. Water level measurements for four (4) months, two wet seasons (January and February) and two dry seasons (July and August) have been plotted to show conceptual potentiometric surfaces for both the alluvium and the

TABLE 3

WATER LEVEL MEASUREMENT SUMMARY

WELL NUBMER	ZONE(*)	12/31/87	01/04/88	01/06/88	01/08/88	01/14/88	01/22/88	02/11/88	02/16/88
U0-87-1.1A	1	400.06	396.01	397.66	397.56	396.41	399.46	399.41	399.16
U0-87-1.1B	2	397.41	398.21	399.81	399.66	398.26	397.93	397.67	397.18
U0-87-2.1A	1	396.64	396.39	396.24	396.04	396.09	396.09	395.96	395.64
U0-87-2.1B	2	398.37	398.47	397.82	397.72	397.27	397.82	397.58	397.17
U0-87-3.1	2	399.88	399.78	399.23	399.18	398.73	399.30	398.85	398.59
U0-87-3.2	3	399.69	399.29	399.09	399.29	398.50	399.08	398.60	398.36
U0-87-4.1	1	412.84	412.49	412.14	411.94	411.29	412.13	411.54	410.73
U0-87-6.1	1	376.42	376.27	375.92	375.37	375.52	375.52	374.70	374.43
U0-87-6.2	3		377.20	376.70	376.10	376.20	376.40	375.22	374.89
U0-87-7.1	1	381.91	381.56	380.91	379.76	380.01	380.02	378.02	377.38
U0-87-7.2	3	381.96	381.51	381.16	380.16	380.16	380.26	378.52	377.95
U0-87-8.1	1	403.17	402.87	402.87	402.77	403.32	402.96	402.79	402.76
U0-87-8.2	3	398.76	398.36	397.96	397.91	397.36	397.91	397.74	397.16
U0-87-9.1	1	401.12	399.72	399.22	399.07	399.07	400.07	399.03	398.43
U0-87-9.2	3	401.32	399.67	399.12	398.92	397.97	400.15	398.91	398.27
U0-87-10.2	3	387.75	387.25	386.95	386.80	386.96	387.18	386.69	386.46

* COMPLETION ZONES
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

TABLE 3 (Continued)

WELL NUBMER	02/23/88	05/06/88	05/11/88	05/13/88	05/16/88	05/24/88	06/03/88	06/08/88
U0-87-1.1A	399.18	397.26	396.74	396.46	396.09	395.64	397.21	396.03
U0-87-1.1B	397.29	394.90	394.37	394.12	393.86	393.41	393.51	393.29
U0-87-2.1A	395.85	393.73	393.34	393.19	393.00	392.84	393.54	392.74
U0-87-2.1B	397.22	394.86	394.35	394.10	393.87	393.57	393.32	393.27
U0-88-2.2								
U0-87-3.1	398.75	396.41	395.68	395.45	395.09	394.28	393.88	392.46
U0-87-3.2	398.53	396.22	395.73	395.97	394.85	394.04	393.54	393.88
U0-88-3.2A								
U0-87-4.1	410.46	407.18	406.17	405.92	405.59	405.40	404.01	403.95
U0-87-6.1	375.74	374.10	374.12	373.27	373.42	372.78	374.09	373.81
U0-87-6.2	376.49	374.37	374.44	373.58	373.70	372.95	374.65	373.99
U0-87-7.1	380.33	376.10	376.13	374.75	375.01	373.96	377.56	375.69
U0-87-7.2	380.33	376.80	376.87	375.79	375.96	375.06	378.06	376.51
U0-87-8.1	402.78	400.01	399.41	399.22	398.82	399.07	399.12	399.37
U0-87-8.2	397.34	394.97	394.42	394.14	393.94	393.55	393.56	393.35
U0-87-9.1	399.05	396.21	395.45	395.32	394.79	394.22	393.72	394.14
U0-87-9.2	399.04	396.01	395.17	394.94	394.73	394.00	393.62	393.75
U0-87-10.2	386.77	385.03	384.50	384.27	383.96	381.25	384.40	381.05

* COMPLETION ZONES
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

TABLE 3 (Continued)

WELL NUMBER	06/13/88	07/05/88	07/11/88	07/14/88	07/18/88	08/03/88	08/16/88
U0-87-1.1A	395.17	396.37	395.91	397.36	396.89	395.74	394.30
U0-87-1.1B	392.81	393.35	393.07	393.87	393.38	392.73	392.23
U0-87-2.1A	392.26	393.12	392.60	394.22	393.04	392.42	391.97
U0-87-2.1B	392.79	393.37	393.15	390.70	393.16	392.81	392.37
U0-88-2.2						392.92	392.46
U0-87-3.1	393.54	393.99	393.99	399.70	393.50	393.77	393.24
U0-87-3.2	393.39	393.73	393.71	394.37	393.16	393.48	393.01
U0-88-3.2A						239.73	250.91
U0-87-4.1	403.64	403.92	403.96	404.74	404.87	404.74	403.60
U0-87-6.1	373.66	374.51	373.66	374.74	374.46	374.32	374.29
U0-87-6.2	373.73	374.60	373.79	375.22	374.41	374.40	373.98
U0-87-7.1	375.36	376.53	375.19	377.61	376.16	375.91	375.10
U0-87-7.2	376.07	327.42	376.17	378.41	376.83	376.71	374.56
U0-87-8.1	398.36	400.32	399.29	401.70	400.69	393.16	397.80
U0-87-8.2	392.87	393.49	393.07	393.95	394.35	398.11	392.28
U0-87-9.1	393.37	393.77	393.64	395.20	393.13	393.72	393.10
U0-87-9.2	393.23	393.71	393.57	395.16	393.12	393.52	392.92
U0-87-10.2	383.38	384.67	383.82	385.37	384.36	383.60	382.90
U0-88-11.1						DRY	DRY
U0-88-11.2						376.39	383.18
U0-88-12.2		472.13	471.74	472.45	472.24	471.62	470.95
U0-88-13.1		433.25	432.77	433.66	433.22	432.35	432.06
U0-88-13.2		436.65		436.86	436.89	436.22	436.38
U0-88-14.1		434.94	434.62	435.00	434.70	433.80	434.42
U0-88-14.2		428.47	428.61	428.72	428.93	428.29	428.19
U0-88-15.1		417.60	417.02	418.56	418.01	416.65	416.59
U0-88-15.2		417.74	417.52	418.31	417.89	417.52	417.04

* CONPLETION ZONES
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

Stanley Shale formations. These maps are presented as Figures 21 through 28.

Alluvial Ground-Water

The conceptual potentiometric surface maps (see Figures 21 and 24) representing the alluvial deposits indicate a general east-west trend of the equipotential lines pattern. This pattern, however, is modified on the east by the expected margin of the alluvial materials as depicted by the dark line extending roughly north to south on each figure. East of the contact, the Stanley Shale outcrops and the alluvium is absent.

As may be seen by the alluvial equipotential lines, the water table near the southern (downgradient) side of the East and West Effluent Ponds range from 405 to 410 feet elevation. The water table near UO-87-6.1, in the lower portion of the maps, is at approximately 375 feet elevation, while the water table in the vicinity of the Scrubber Bleed and Powell ponds on the northern margins of the study area is approximately 435 feet in elevation. The hydraulic gradient over this area ranges from one (1) foot of ground water change per 40 feet of horizontal distance in the upper portion of the area to one (1) foot of ground water change per 50 feet of horizontal distance in the southern portion near Marney Road. Between the downgradient edge of the East and West Effluent ponds and

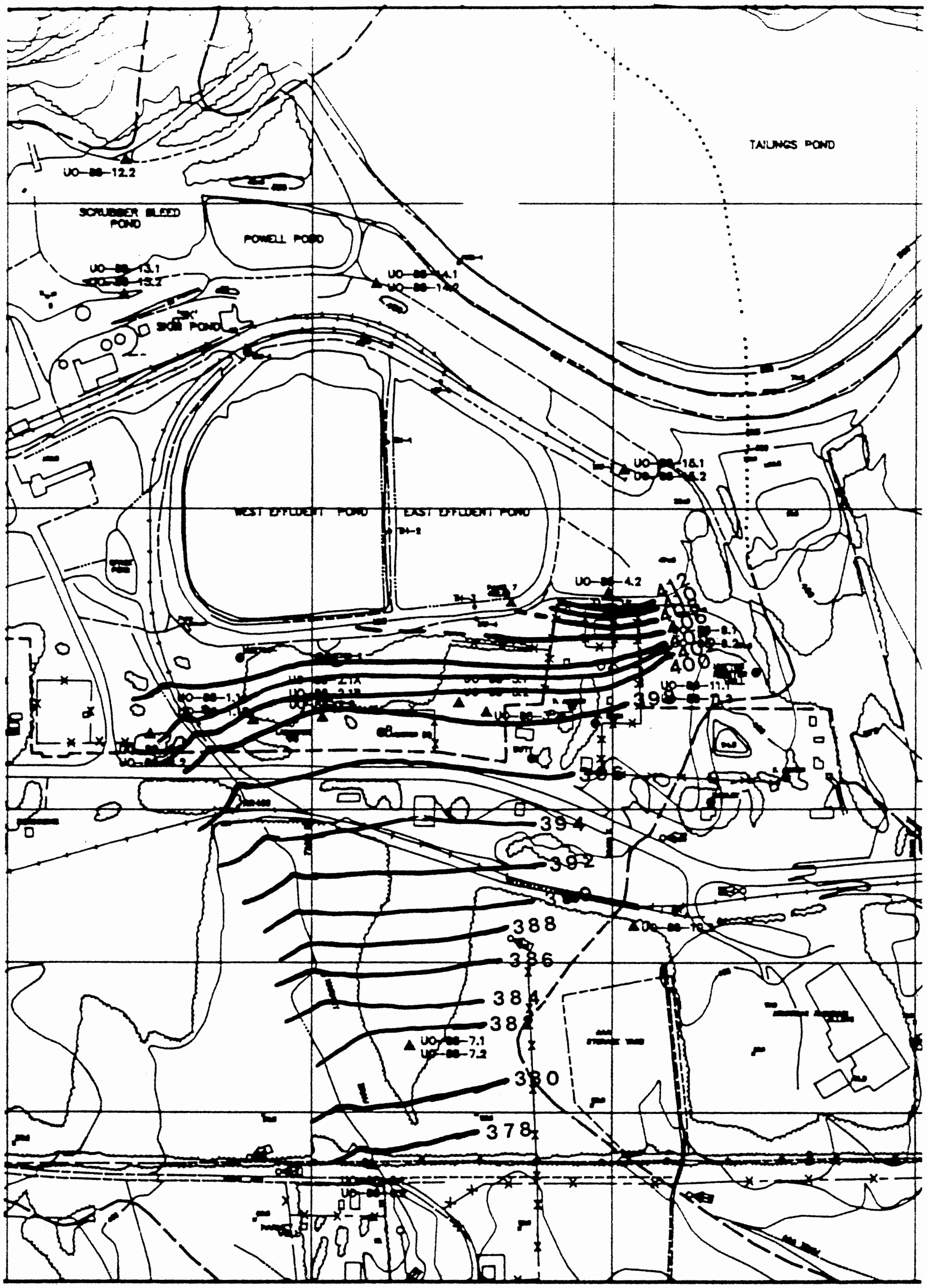


Figure 21. Conceptual Potentiometric Surface: Alluvium (1-6-88)

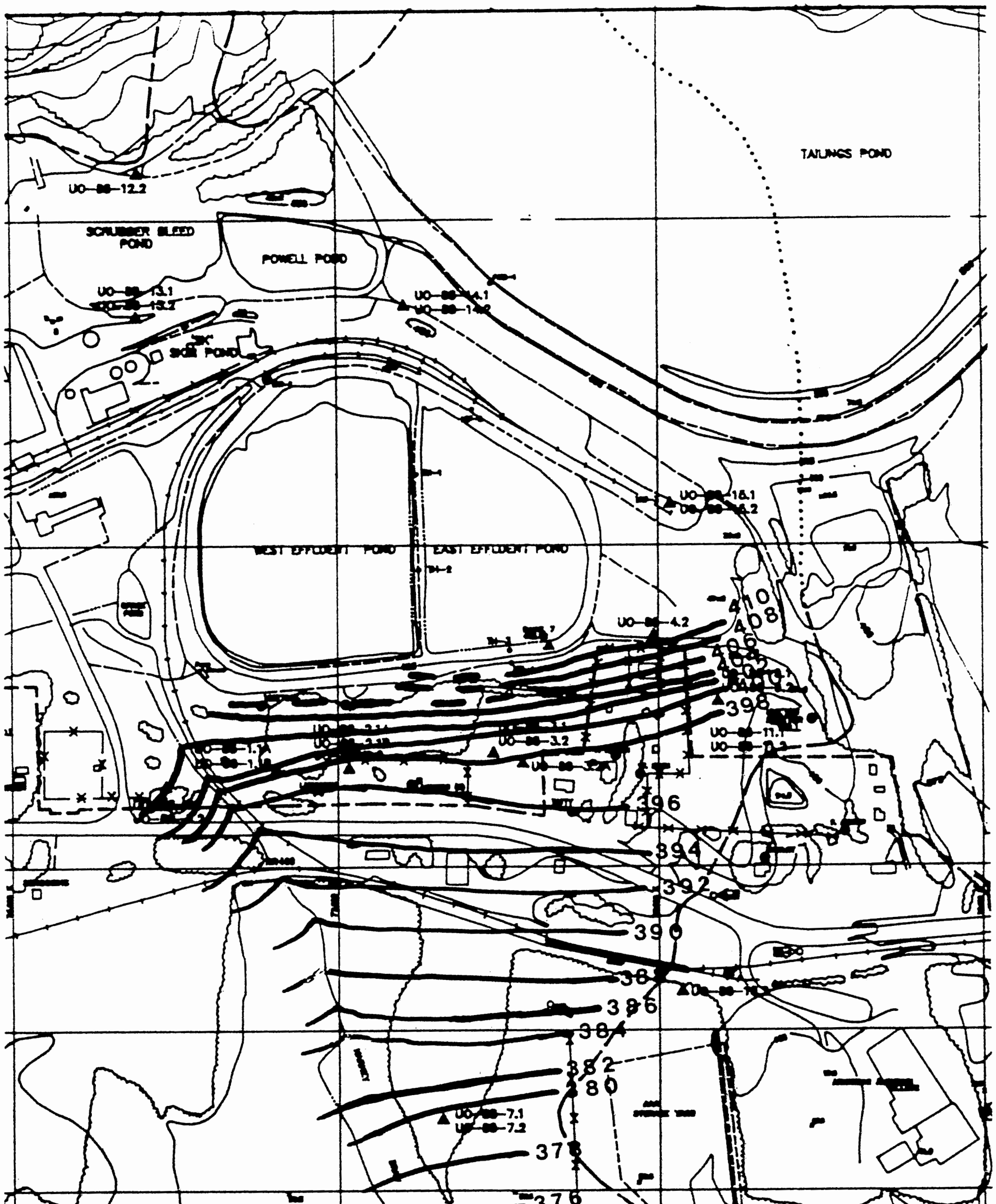


Figure 22. Conceptual Potentiometric Surface: Alluvium (2-11-88)

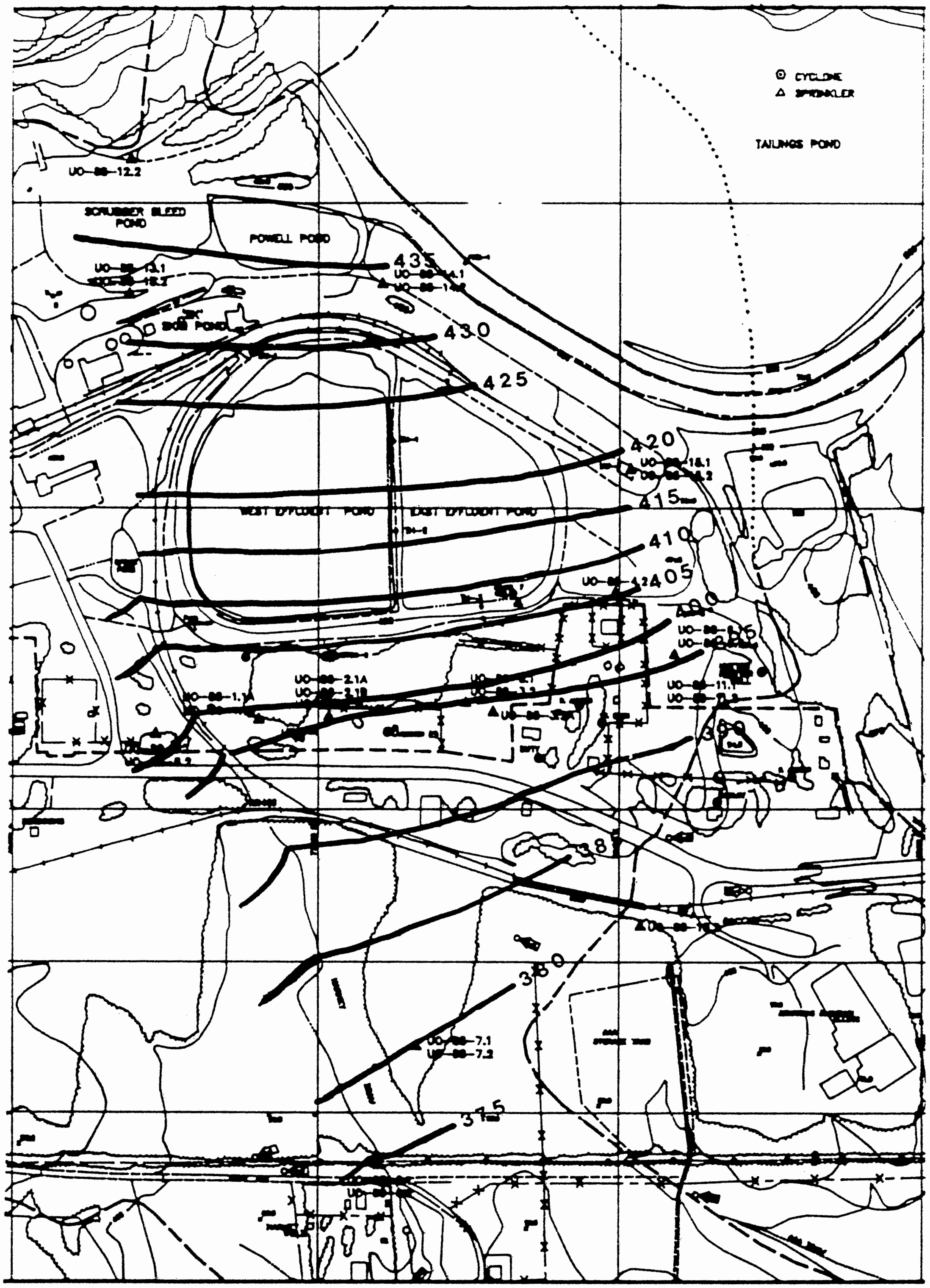


Figure 23. Conceptual Potentiometric Surface: Alluvium (7-14-88)

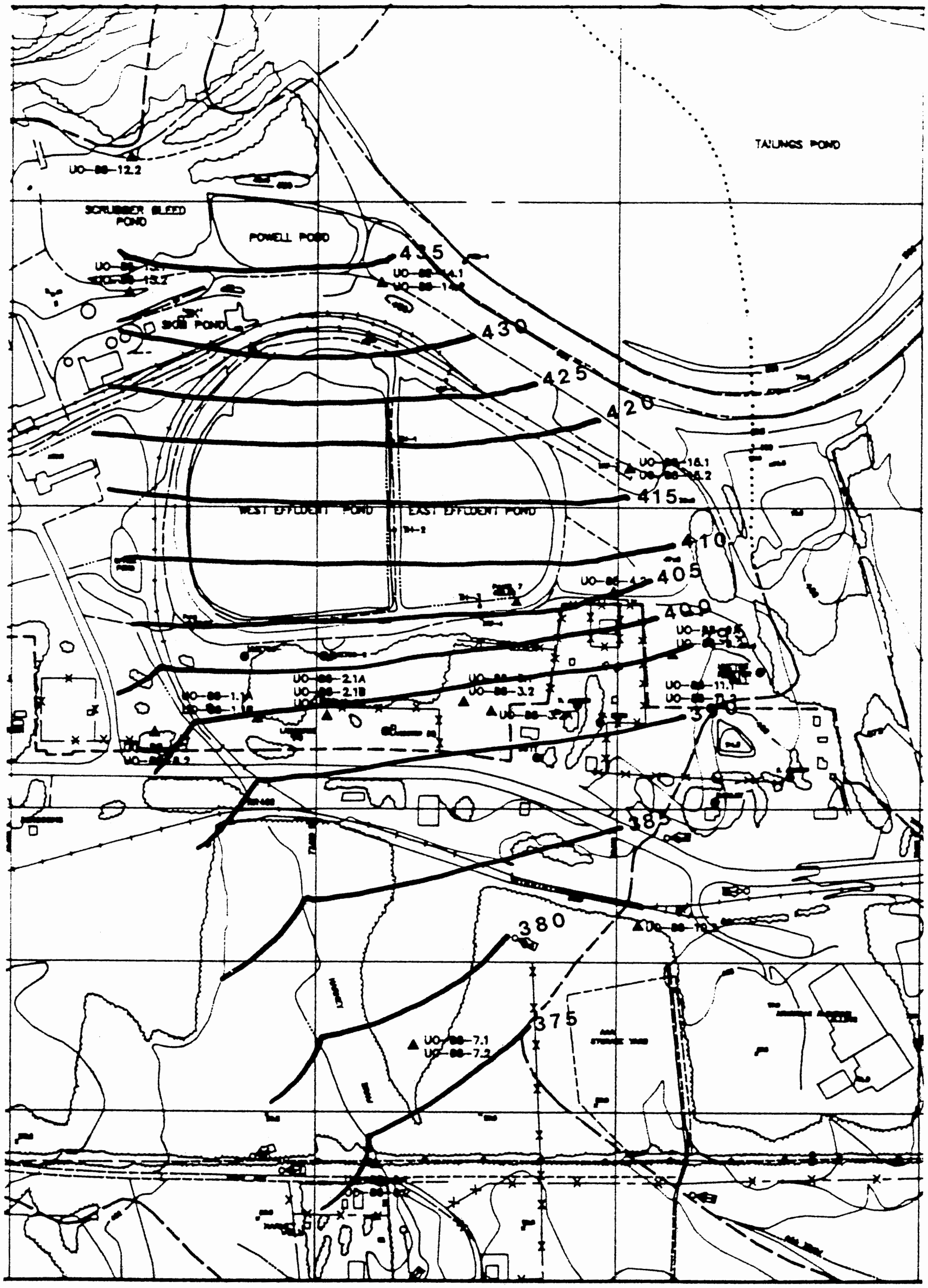


Figure 24. Conceptual Potentiometric Surface: Alluvium (8-16-88)

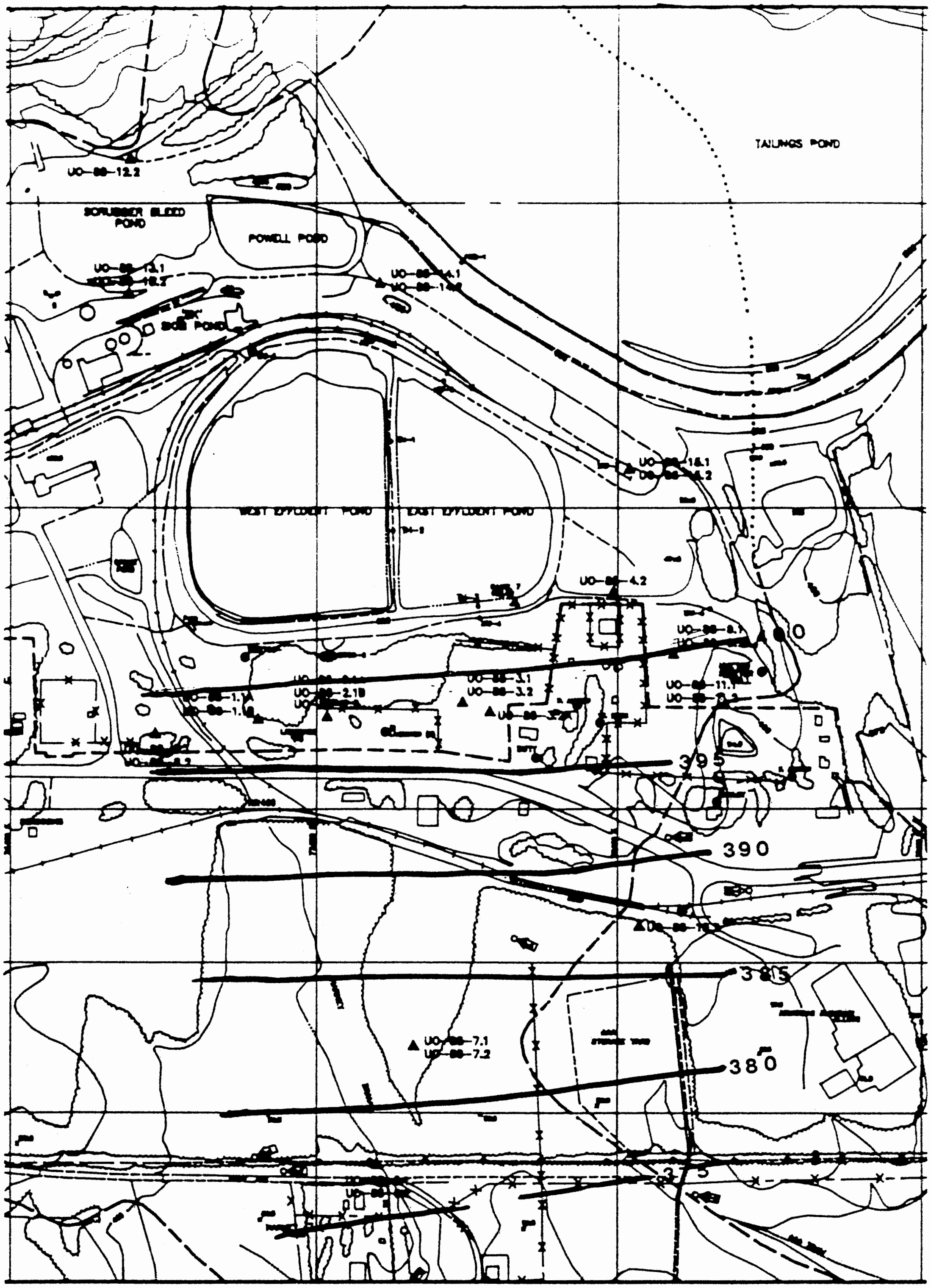


Figure 25. Conceptual Potentiometric Surface: Stanley Shale (1-6-88)

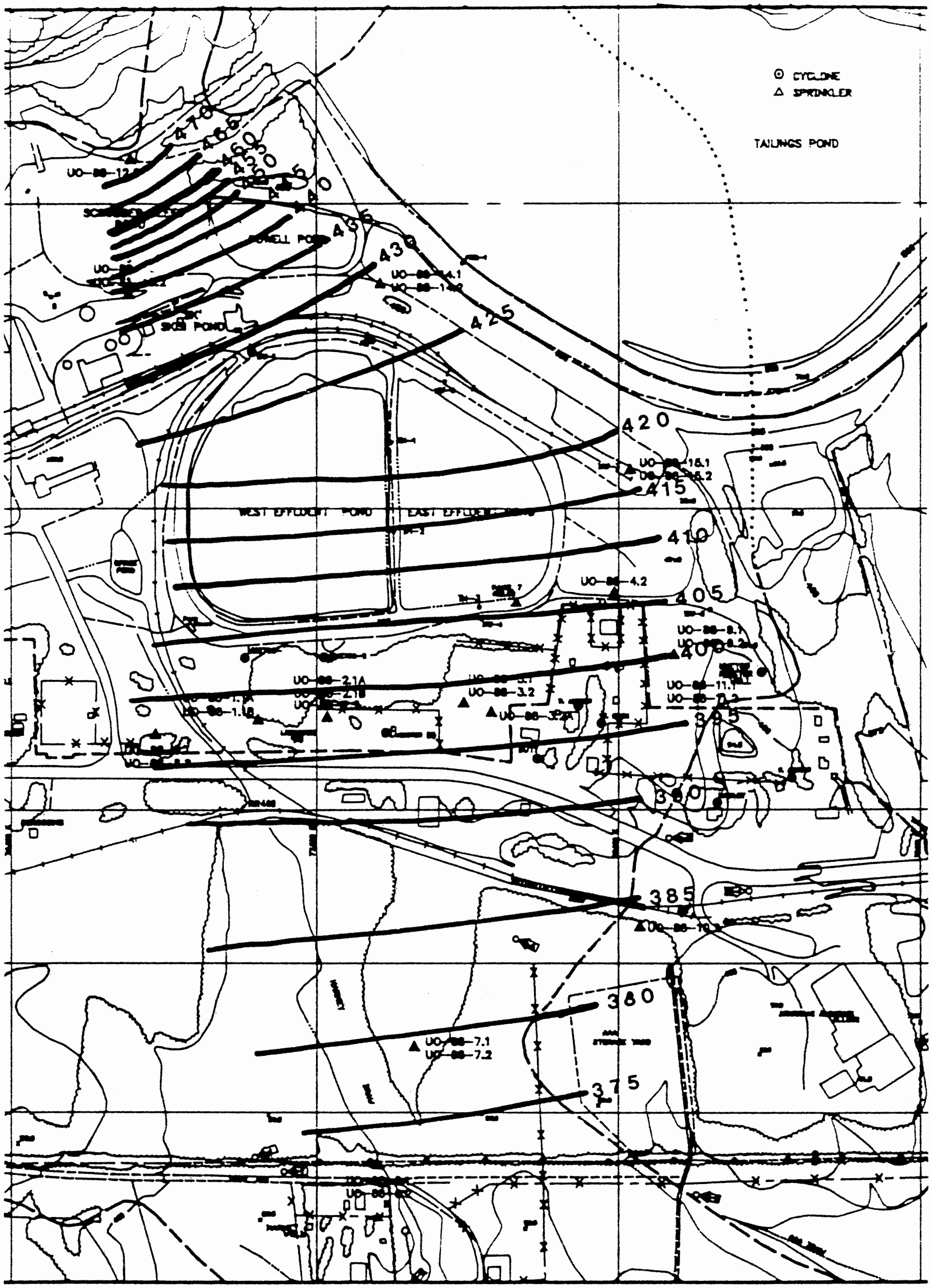


Figure 26. Conceptual Potentiometric Surface: Stanley Shale (2-11-88)

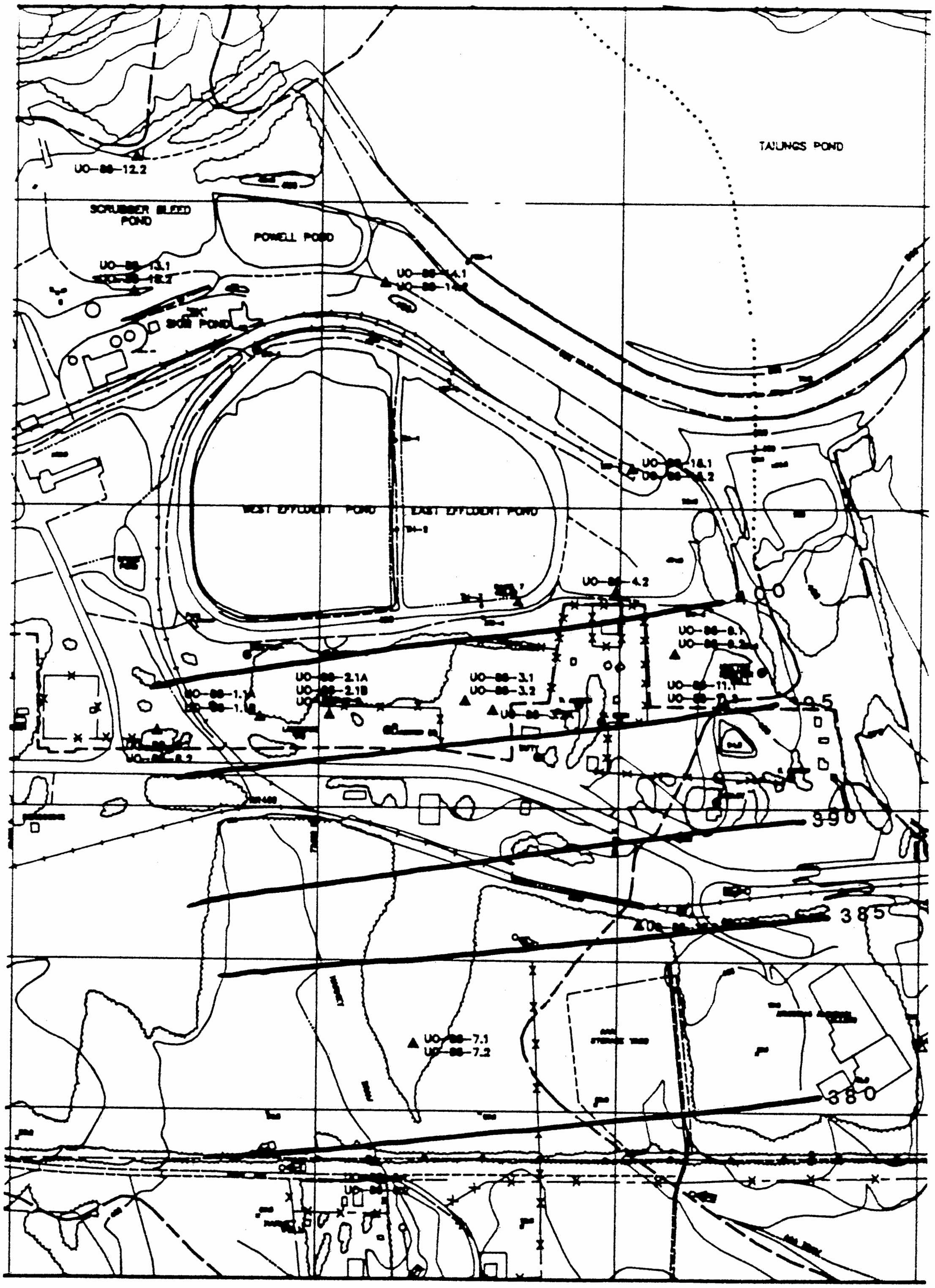


Figure 27. Conceptual Potentiometric Surface: Stanley Shale (7-14-88)

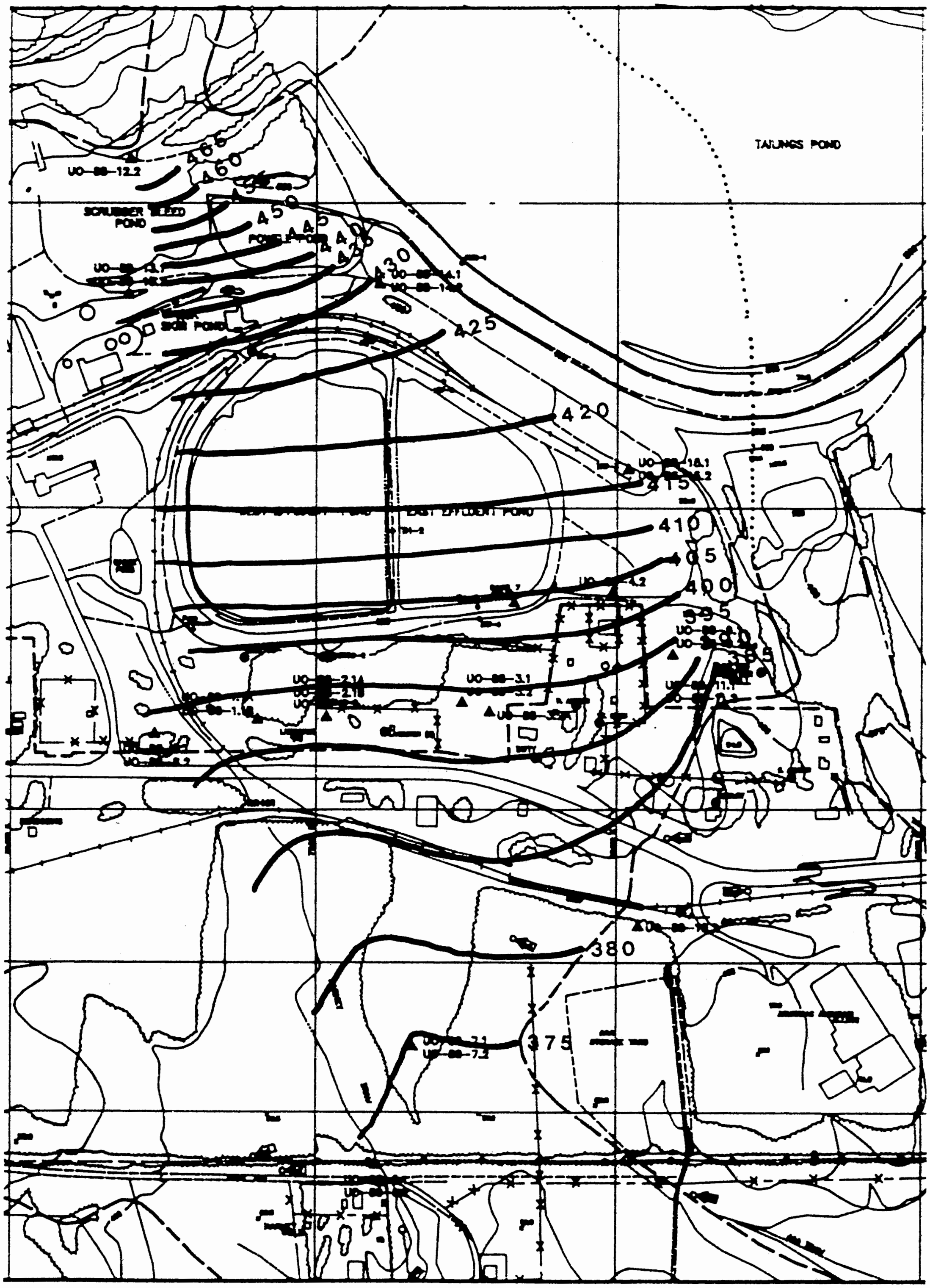


Figure 28. Conceptual Potentiometric Surface: Stanley Shale (8-16-88)

the State Highway 270 the hydraulic gradient is approximately one (1) foot of ground water change per 20 feet of horizontal distance.

As may be inferred from the alluvial potentiometric surface maps , there are indications of a slight ground water mound upgradient from monitoring wells UO-87-3.1, UO-87-4.1 and UO-87-9.1. This is inferred by the steeper gradient in that area, and especially in the vicinity of UO-87-2.1A. This same phenomenon is not inferred above the monitoring wells installed in the western portion of the investigation area (UO-87-8.1/8.2). If a mound does exist at the site it would be logical to assume that the source of these waters would be the East and West Effluent Ponds located directly upgradient and adjacent to the monitoring wells.

The East Effluent Pond was drained of all fluids during the Spring of 1986 (the exact date of this evacuation is presently not available). As precipitation accumulated after initial pumping, it was likewise evacuated. In addition, all sediments were removed from this pond in the Fall of 1986. During September and October of 1987, the East Effluent Pond was lined using a 1E-7 cm/sec clay and a sub-drain system was installed to assure that any contained fluids do not migrate to the ground water system.

The East Pond has not been a source for possible mounding waters in the recent past and a mound does not seem to be present except near the southeastern margin of the West Effluent Pond. Figure 19 indicates that a structural high exists on the top of the Stanley Formation in the vicinity of well UO-87-4.1 while paleotopographic lows appear to exist in the Stanley Formation at wells UO-87-3.1 and UO-87-9.1. Therefore, well location UO-87-4.1 is approximately nine feet higher topographically than the wells at UO-87-3.1 and UO-87-9.1. A low recharge rate was observed in well UO-87-4.1 during well development and sampling which could indicate low alluvial permeability in this area. Based on these observations the inferred mound is likely not to exist.

There is a great deal of variation in the hydraulic gradients over the water level measurement period due to several precipitation events and a long dry period through much of the summer months and the varying impacts these had on the wells monitored. In an attempt to identify possible relationships between precipitation events and water levels in the monitoring wells, water level and precipitation hydrographs for each well have been prepared. These are presented individually in Appendix F. The precipitation data was obtained from the National Park Service at Hot Springs, Arkansas. This station is the official U.S. Meteorological reporting station nearest to the study site and is located approximately seven (7) miles to the northwest of the study site.

As may be seen from the hydrographs, wells completed in both the alluvial fan and fluviatile (UO-87-1.1B and UO-87-2.1B) zones respond to precipitation events. However, the hydrographs indicate that the alluvial fan wells appear to respond much more quickly than wells completed in the fluviatile zone. The slower response to precipitation events in the fluviatile sequence indicates that the paleochannel recharge is probably not within the boundaries of the study site.

Comparison of the ground water elevations in well pairs UO-87-1.1A/UO-87-1.1B and UO-87-2.1A/UO-87-2.1B (see Table 3) indicate a normally upward vertical component of groundwater movement from the fluviatile sequence to the alluvial fan sediments in this area. However, this vertical component can be reversed by rapid recharge of the alluvial fan deposits by precipitation events.

Table 3 and cross-section A-A´ (Figure 15) indicate that the fluvial ground-water movement is subdued in wells UO-87-3.1 and UO-87-9.1. It is believed that these wells are near the boundary of the paleochannel which probably bends toward the southeast as it approaches this area.

Stanley Shale Formation Ground-Water

The conceptual potentiometric surface maps for the Stanley Shale Formation are also shown in Figures 25 through 28. These maps represent the same water level measurement events (see Table 3) as discussed above for the monitoring wells screened in the alluvium.

The overall pattern for the equipotential lines represented on these maps indicates that the ground-water movement is to the south, much the same as for the overlying alluvium deposits, and is consistent over the area under analysis. Unlike the alluvial patterns discussed previously, the surface water features in the western portion of the site do not seem to affect the potentiometric surface for the Stanley Shale, suggesting that at least partially confined conditions are present. The suggested partially confined conditions are further substantiated by the cross-sections, which indicate that the potentiometric surface of the Stanley Shale Formation is generally higher than that of the alluvial fan or fluviatile zones over most of the study area. Exceptions, as discussed earlier, are likely related to recharge from precipitation events of the shallower alluvial sediments.

The potentiometric surface represented in the Stanley Shale Formation ranges from just over 470 feet in elevation at UO-88-12.2 to as low as 375 feet in elevation at UO-87-6.2. The shallow Stanley Shale screened wells located between UO-87-8.2 and UO-87-9.2 are relatively uniform with respect to each other in potentiometric level. This suggests that recharge is generally of a regional nature and that this area is affected somewhat uniformly by this recharge.

In an attempt to identify the base of the plume a deeper well (UO-88-3.2A) was advanced at a point approximately 50 feet east-southeast of monitoring well UO-87-3.2. The potentiometric level in this deeper well is much lower than for the adjacent monitoring well (UO-87-3.2) screened in the same formation, 250.9 versus 393.01 elevations on August 16, 1988. This well was advanced by first drilling to the base of the alluvial deposits and setting an eight (8) inch PVC surface casing. The surface casing was installed to assure that any contaminants present in the alluvium are not allowed to reach the underlying Stanley Shale during further borehole advancement. The borehole was then advanced by increments through the surface casing. The first increment was to drill a 6.5 inch borehole approximately 20 feet past the screened interval of monitoring well UO-87-3.2. At this point a four (4) inch rathole was bored to approximately 20 feet below the 6.5 inch borehole bottom. This hole was then thoroughly cleaned of all fluids and a packer was set approximately ten (10) feet above the bottom of the borehole as a seal to prevent upper level fluids from reaching the borehole bottom. The lower ten (10) foot interval of the borehole was again evacuated through the drill stem inserted into the packer. The borehole was allowed to recover to a point that a water sample could be taken for analysis. This sample was immediately transported to the STRATCOR on-site laboratory and analyzed for chlorides. If significant chlorides were detected the next 20 foot interval was drilled out to 6.5 inches and the procedure repeated.

During the drilling of this deeper borehole it was noted that the intensity of fractures, based on the ease of or difficulty of drilling and the quantity of pyrite and quartz fillings that was recovered, did not diminish with depth. In addition two (2) very hard formations, one of sandstone and one of conglomerate, were encountered. Based on these observations and the belief that the packers were not sufficient to retard upper ground water movement from the sealed portion of the borehole, it was decided to halt excavation at 190 feet and complete the well.

Following well completion, attempts were made to develop the deep well. Since the well recovers very slowly full development took several weeks. Samples were taken during the August, 1988 sampling event and the level of chlorides was near background levels.

The even spacings of the equipotential lines on the various maps is indicative of a rather uniform regional recharge to the ground water in the Stanley Shale, and partially confined conditions. Unlike the alluvial maps discussed earlier, there is little variation in hydraulic gradient of the August water levels across most of the study area. During the July period, however, a slight steepening of gradient to the south of the East and West Effluent ponds is evident. The general gradient over the area from the upgradient side of the East and West Effluent ponds is approximately one (1) foot change in gradient over 53 feet of horizontal distance. Upgradient of the East and West Effluent ponds the potentiometric surface steepens to one (1) foot of gradient change to only 15 feet of horizontal distance. This corresponds closely to a significant topographic relief change and the presence of the paleochannel in that general area.

The hydrographs presented in Appendix F, again, compare the precipitation events to the water level measurements for the monitoring wells completed in the Stanley Shale Formation (well designations ending in 2). These graphs suggest that although the ground water in the Stanley Shale Formation may be directly affected by precipitation recharge, the impact is less conspicuous than for the alluvium screened wells previously discussed. It is likely that any primary means of direct recharge to the Stanley Shale from precipitation is through fracture porosity, which is also characteristic of this formation.

Aquifer Testing

As discussed earlier, a multiple-well aquifer test and ten (10) slug tests were conducted at the study site. The aquifer test was begun on August 8, 1988 whereas the slug tests were conducted on August 23, 24, and 25, 1988 and on

February 28, March 1, 2 and 3, 1989. The data and graphical results of these tests are shown in Appendix G. The aquifer test results were reduced to transmissivity (T) and storage coefficients (S) using the Theis time/drawdown curve matching methodology (Kruseman and DeRidder, 1983). From these results, it was possible to calculate hydraulic conductivities (K) using the water column of the well bore as the aquifer thickness (K = T/M). The aquifer test utilized monitoring well UO-88-2.2 as the discharging (pumping) well and monitoring wells UO-87-3.2 and UO-87-8.2 as observation wells in the Stanley Shale Formation. Drawdowns for monitoring wells UO-87-8.2 and UO-87-3.2 were monitored during the period that monitoring well UO-88-2.2 was being pumped. Using the Jacob method, the resulting T value was 7.6E5 gpd/ft and an S value of 9.0E-5 cm/sec was calculated. The K value for this well was calculated under two different assumptions. The first assumption was that the aquifer under analysis was confined. This assumption is based on results of borehole logging and an S value less than 1.0E-4 (S < 1.0E-4). The K value resulting from this assumption was found to be 1.8 cm/sec. The second assumption was that the aquifer under investigation was unconfined. This assumption is based on the very similar water levels between monitoring wells screened in the Stanley Shale and those screened in the overlying alluvium. The K value resulting from this assumption was found to be 7.1E-1 cm/sec.

Using the Theis method of analysis, the resulting T value was 6.35E5 gpd/ft and an S of 6.8E-5 was determined. Again, calculating K based on the two assumptions (confined and unconfined conditions) values of 1.5 cm/sec and 6.5E-1 cm/sec respectively were calculated.

A weathered shale (clay) was found to exist between the Stanley Shale and the overlying alluvial deposits (fluviatile and alluvial fan). It is, then, important to calculate an in-situ permeability of this partially confining clay barrier. The Hantush type curve method was employed using data generated from the UO-87-8.2 drawdown measurements. The following equation was used:

$$p' = \frac{Tm'(r/B)^2}{r^2}$$

where: p' = Permeability of confining bed

T = transmissivity

m' = thickness of confining bed

r/B = Hantush type curve function

r = radius of discharge well

The resulting permeability for the partially confining bed was found to be 3.22E-4 cm/sec. This is several magnitudes lower than the permeabilities calculated for the Stanley Shale aquifer using the Theis and the Jacob methods reported above. Due to data restrictions a similar analysis of the confining bed using the UO-87-3.2 drawdown data was not possible.

Slug tests were conducted in three (3) Stanley Shale screened monitoring wells; UO-87-7.2, UO-88-13.2 and UO-88-15.2. As discussed earlier each test was accomplished by instantaneously removing a solid "slug" from the well and measuring drawdowns until the well was at least 90 percent recovered to the measured static level.

The data for the slug tests are also presented in Appendix G. The slug test results were reduced to transmissivity (T) using the approach defined by Cooper, Bredehoeft and Papadapulos (1967). From these results, it was possible to calculate hydraulic conductivities (K) for the immediate area of each monitoring well.

The permeabilities for these three (3) locations, as may be seen from the test results, are quite uniform. The calculated K values ranged from 9.66E-4 cm/sec at UO-87-7.2 to 6.0E-5 cm/sec at UO-88-15.2.

Slug tests were also conducted in seven (7) alluvial screened monitoring wells. A slug was added to these wells as discussed earlier. Water levels were measured at scheduled intervals until the well had reached at least 90 percent recovery to static water level.

The data for these slug tests are also shown in Appendix G. The permeabilities for these seven (7) wells, as may be seen from the test results, vary generally from east to west across the study site. The calculated K values range from 5.64E-4 cm/sec at UO-88-14.1 to 1.88E-5 cm/sec at UO-88-15.1.

Alluvial Sample Results

Several sampling events were conducted at available monitoring wells recently installed at the site, the first event occurred between January 3 and January 29, 1988 and included only the 16 wells installed at that time. The last event took place between August 17 and August 22, 1988 and includes all 27 wells installed at that time.

Laboratory sample results (Appendix H) in wells screened in the alluvium indicate two somewhat different patterns of ground-water chemical constituents. Alluvial (alluvial fan and fluviatile) wells in the eastern portion of the study area consistently showed elevated concentrations of calcium and chloride, whereas alluvial fan monitoring wells (UO-87-1.1A and UO-87-2.1A) in the western portion of the study area showed a greater tendency for elevated sodium and sulfate along with chloride. Fluvial wells (UO-87-1.1B and UO-87-2.1B) in the western portion of the study area indicate only background water quality conditions similar to those found in monitoring well UO-87-8.1.

Isoconcentration maps were prepared for five (5) of the analyzed parameters; chlorides, sodium, sulfate, calcium and nitrogen/ammonia. These are presented as Figures 29 through 33. Each of the parameters may be depicted as possible plumes within the alluvium deposits that generally follows the ground water flow patterns depicted by the conceptual potentiometric surface maps discussed earlier. The chloride isoconcentrations seem to be bifurcating near their down gradient terminus into two plumes that correspond well with the plumes identified through geophysical analyses. It is possible that these plumes are not as continuously uniform as the isoconcentration map suggests but rather constitute a sequence of slugs moving through the system.

Three of the isoconcentration maps (sodium, sulfate and nitrogen/ammonia) conform with the two western plumes denoted by geophysical analyses. Only the sulfate plume seems to be contributing any measurable contamination to the other plumes. The isoconcentration depicting calcium, however, is more strongly associated with the two eastern plumes.

Stanley Sampling Results.

As in the wells screened in alluvium and discussed earlier, the wells screened in the Stanley Shale Formation seem to fit two predominant chemical patterns (see Appendix H). The deep monitoring wells located in the eastern and northwestern portions of the study area show a propensity for elevated chloride and calcium. On the

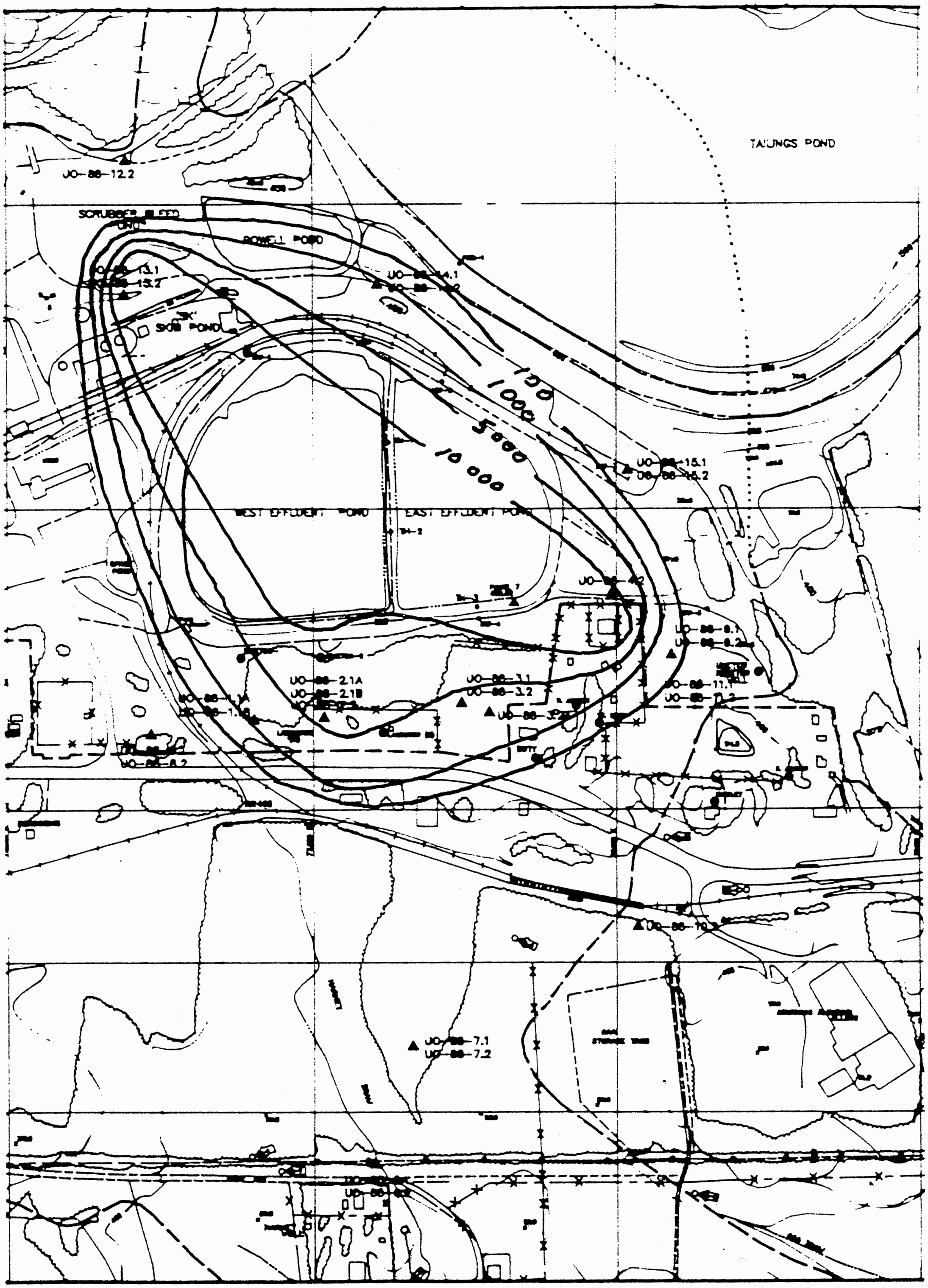


Figure 29. Chloride Isoconcentration Map: Alluvium (8-16-88)

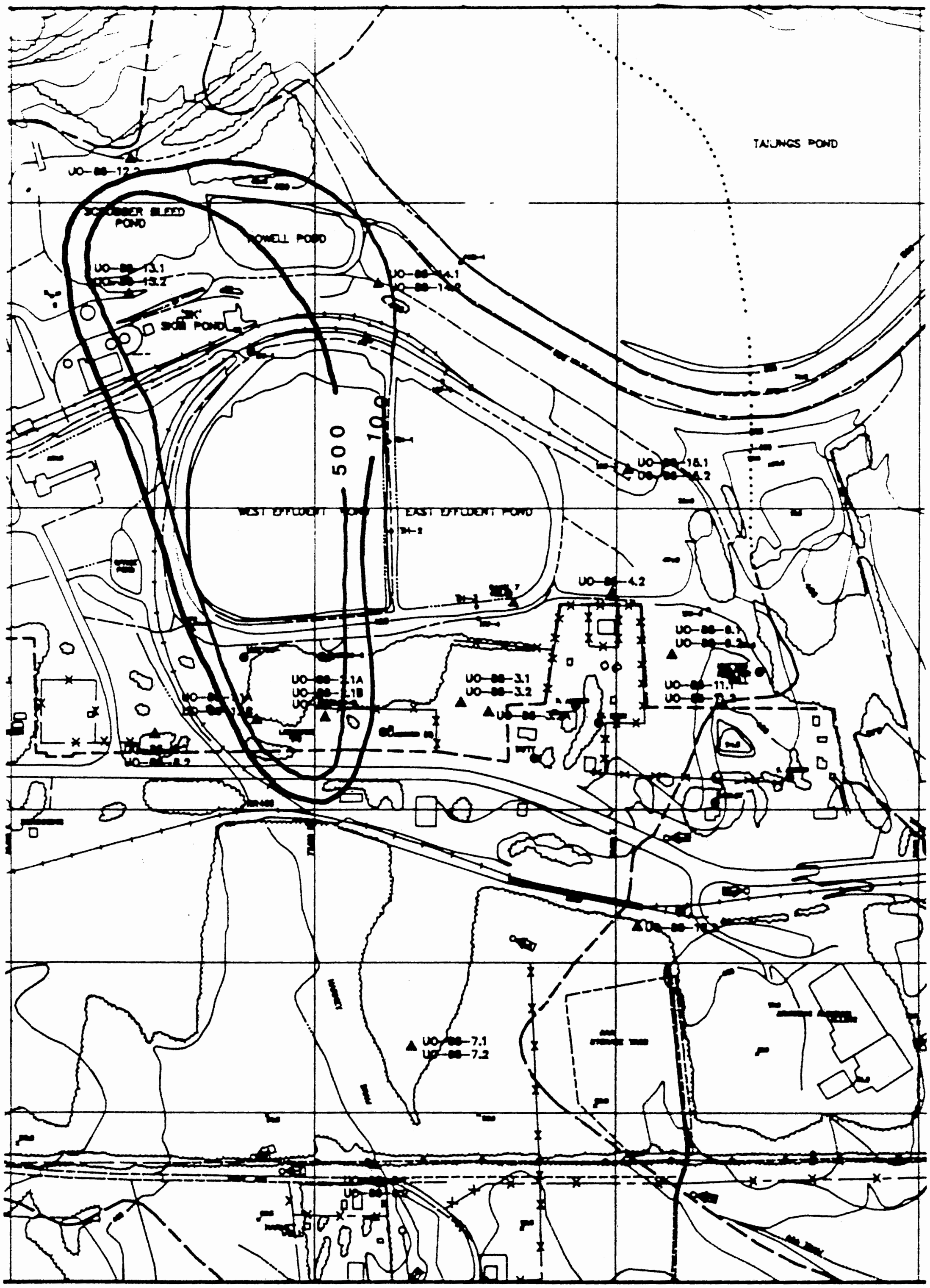


Figure 30. Sodium Isoconcentration Map: Alluvium (8-16-88)

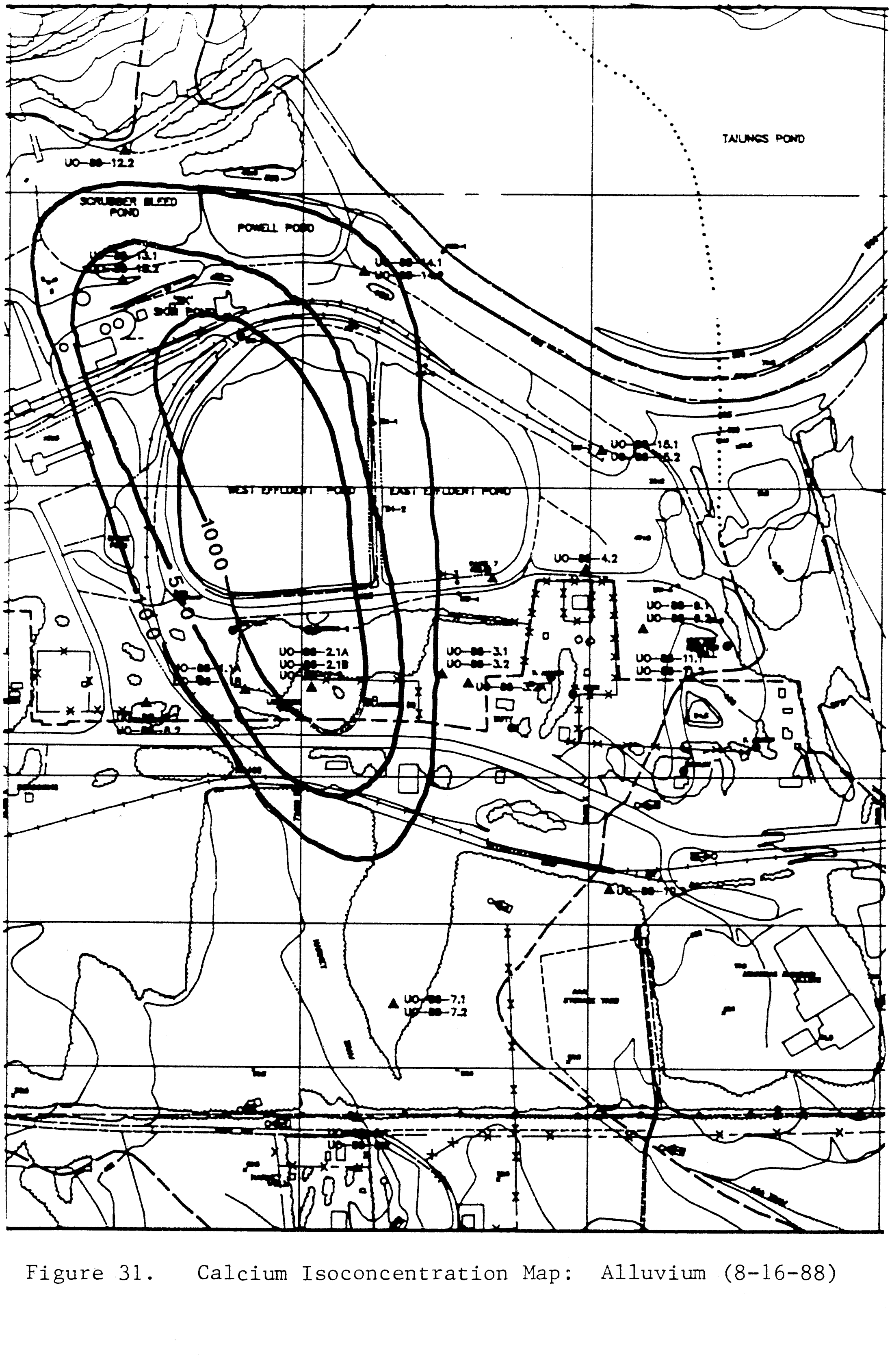


Figure 31. Calcium Isoconcentration Map: Alluvium (8-16-88)

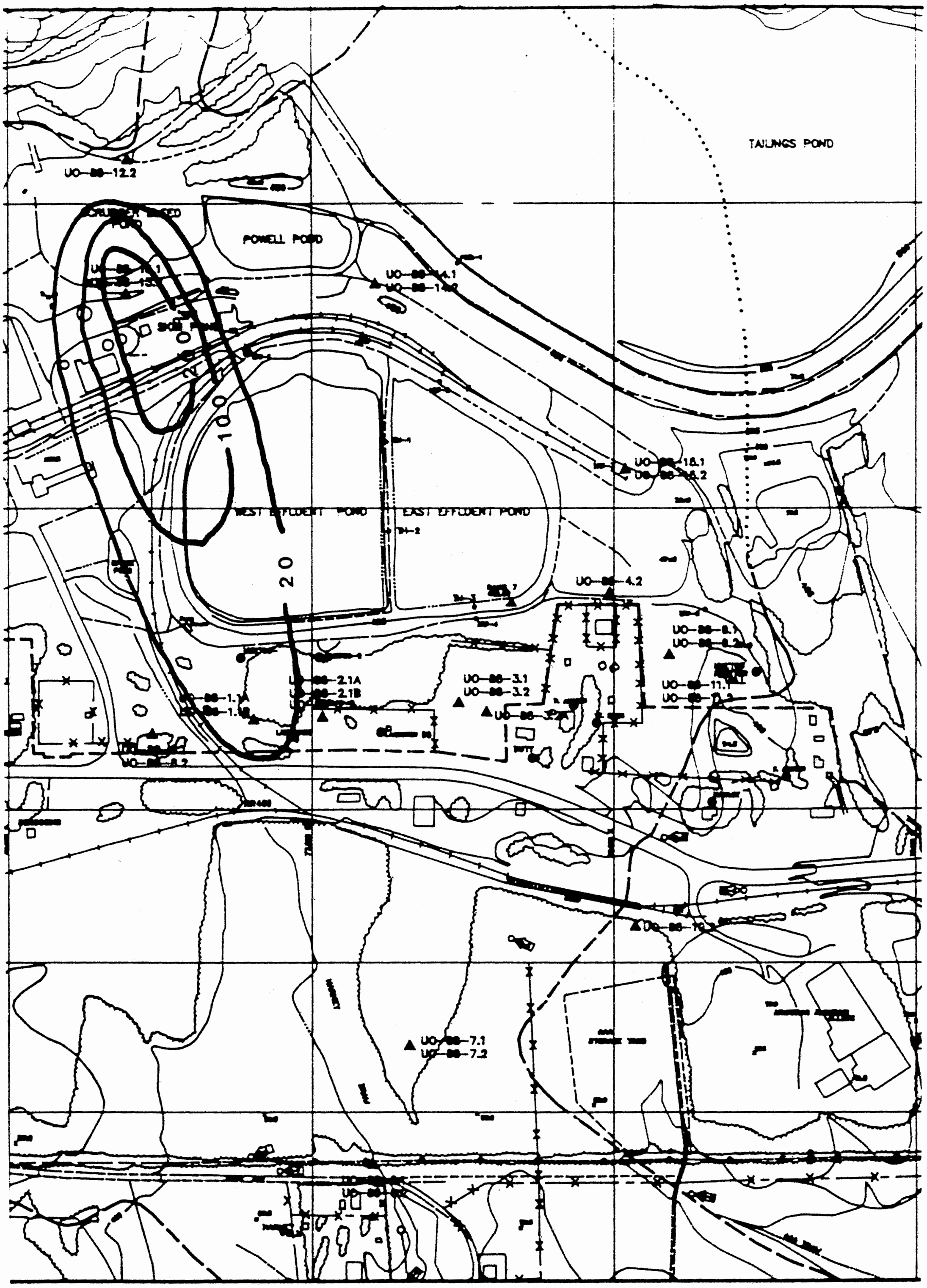


Figure 32. Nitrogen/Ammonia Isoconcentration Map: Alluvium (8-16-88)

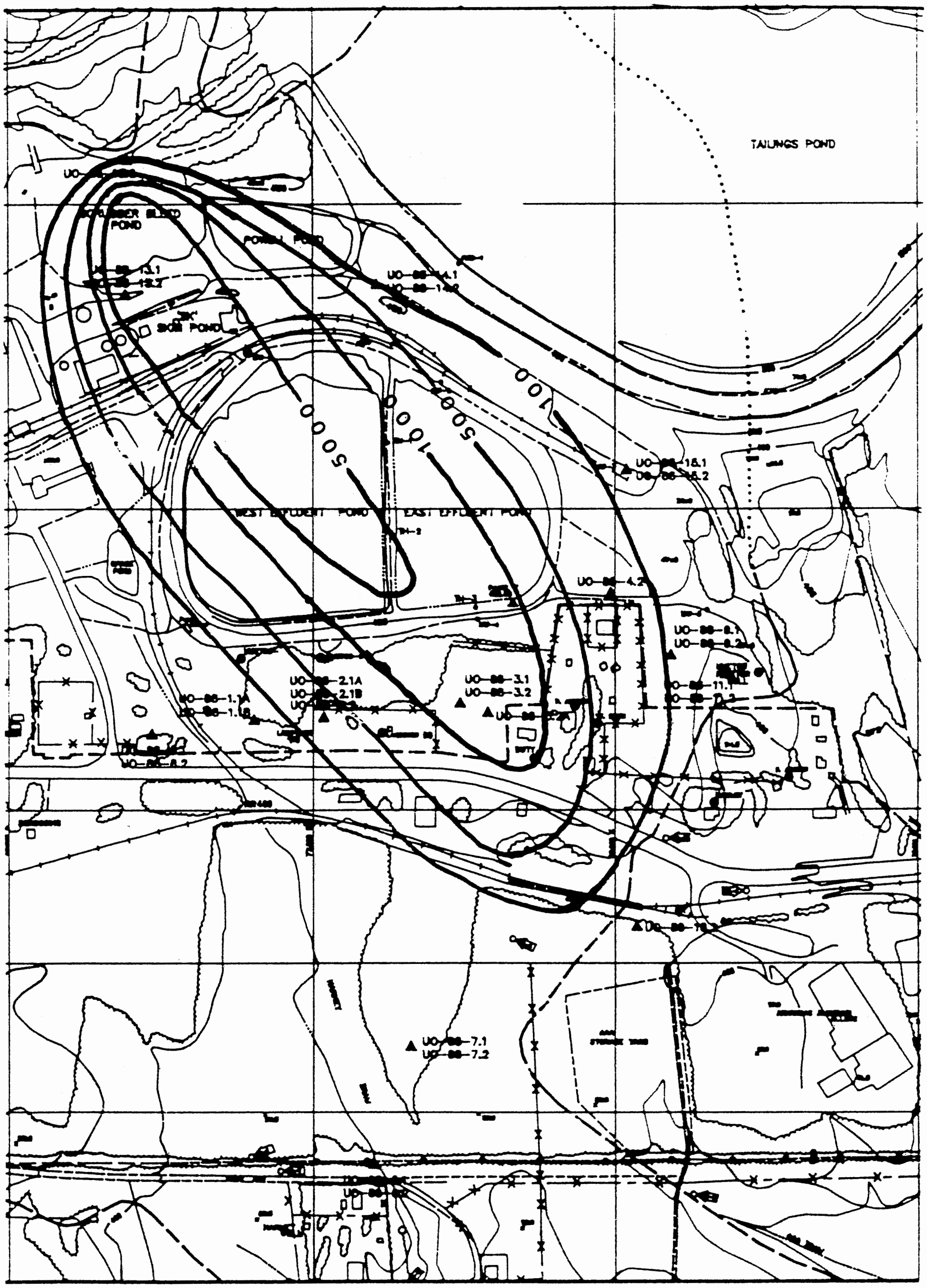


Figure 33. Sulfate Isoconcentration Map: Alluvium (8-16-88)

other hand, the deeper wells in the western portion of the study area do not tend to be represented by any elevated constituents.

Each chemical constituent analyzed can again be contoured using data from the Stanley Shale screened wells. The resulting patterns are shown on isoconcentration maps of chloride, sodium and calcium (see Figures 34 through 36). These patterns closely approximate the overall ground water flow for the study area.

Summary of Field Investigation Findings

The primary objective of the field investigation was to determine if remedial activities are warranted and if so to provide a basis for necessary remedial activity planning. In order to achieve this greater objective four activities were addressed; 1) confirm and/or further delineate the geophysical interpretations indicating ground-water plumes, 2) collect data on the water chemistry from the aquifers intercepted, 3) test for the presence of an aquiclude by well tests and water chemistry, and, 4) provide future observation sites to collect data on ground-water. The results of these activities are summarized in the following paragraphs.

In order to achieve these objectives a series of 27 monitoring wells were installed at the study site (see Figure 12). These wells were installed into the three

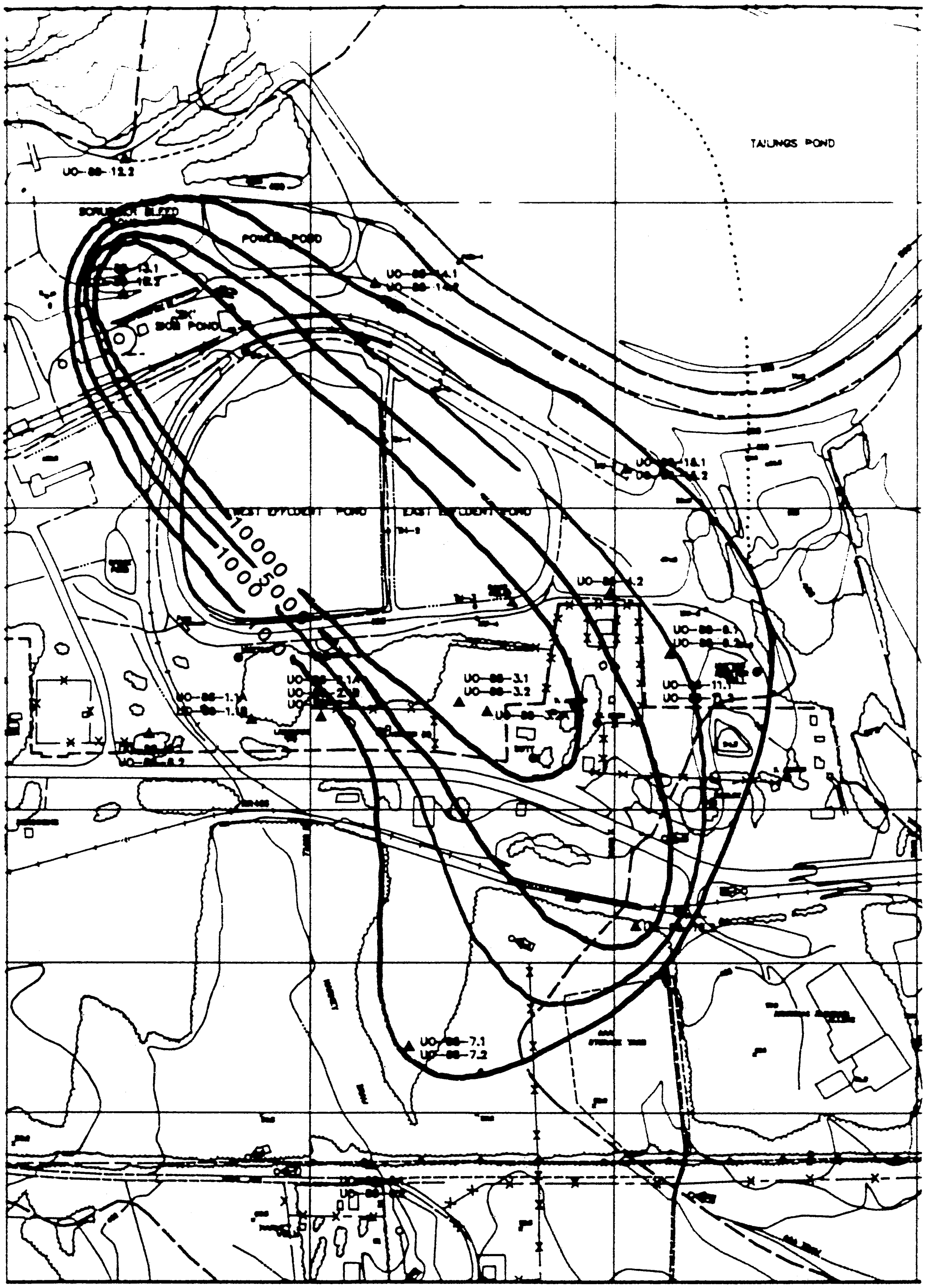


Figure 34. Chloride Isoconcentration Map: Stanley Shale (8-16-88)

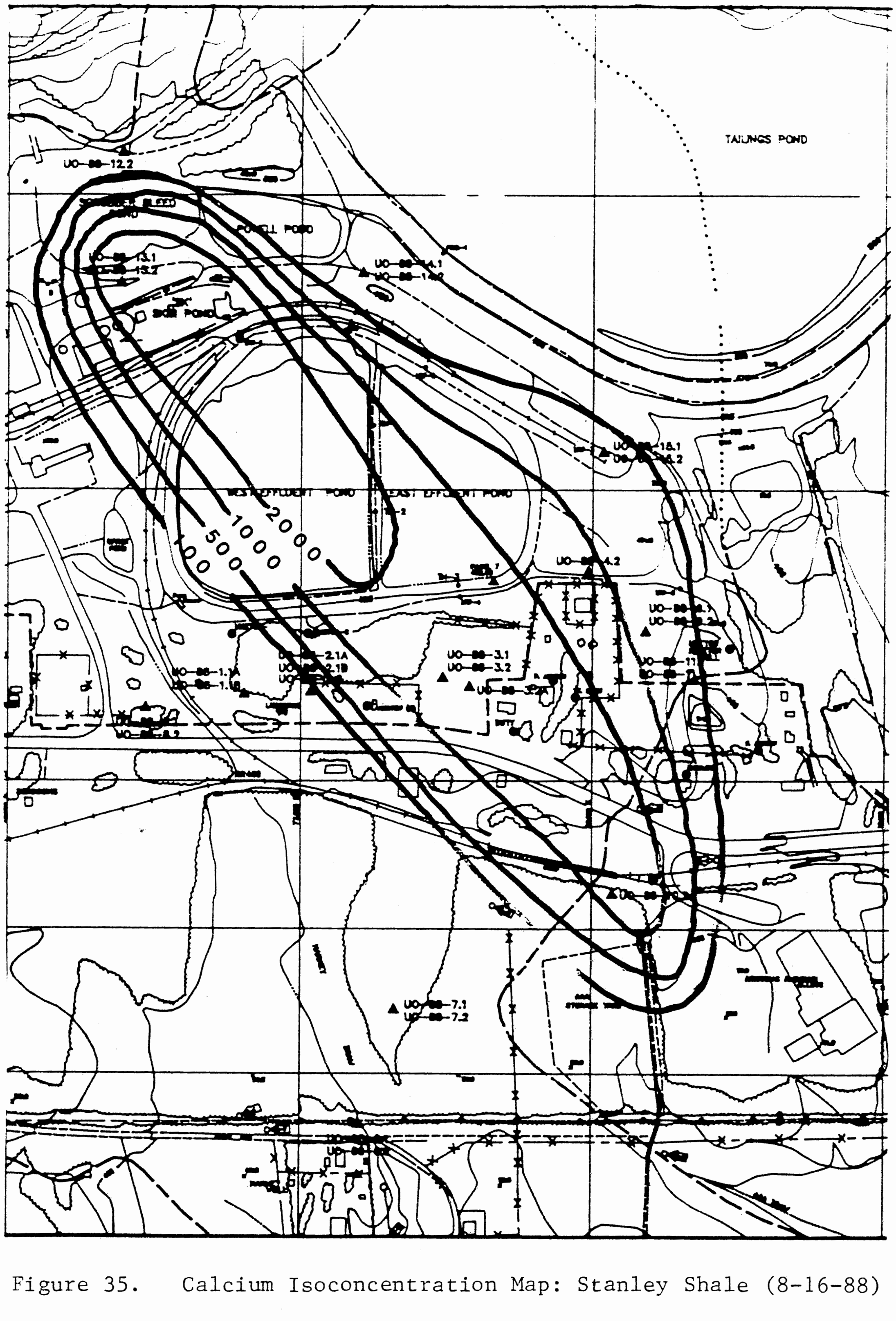


Figure 35. Calcium Isoconcentration Map: Stanley Shale (8-16-88)

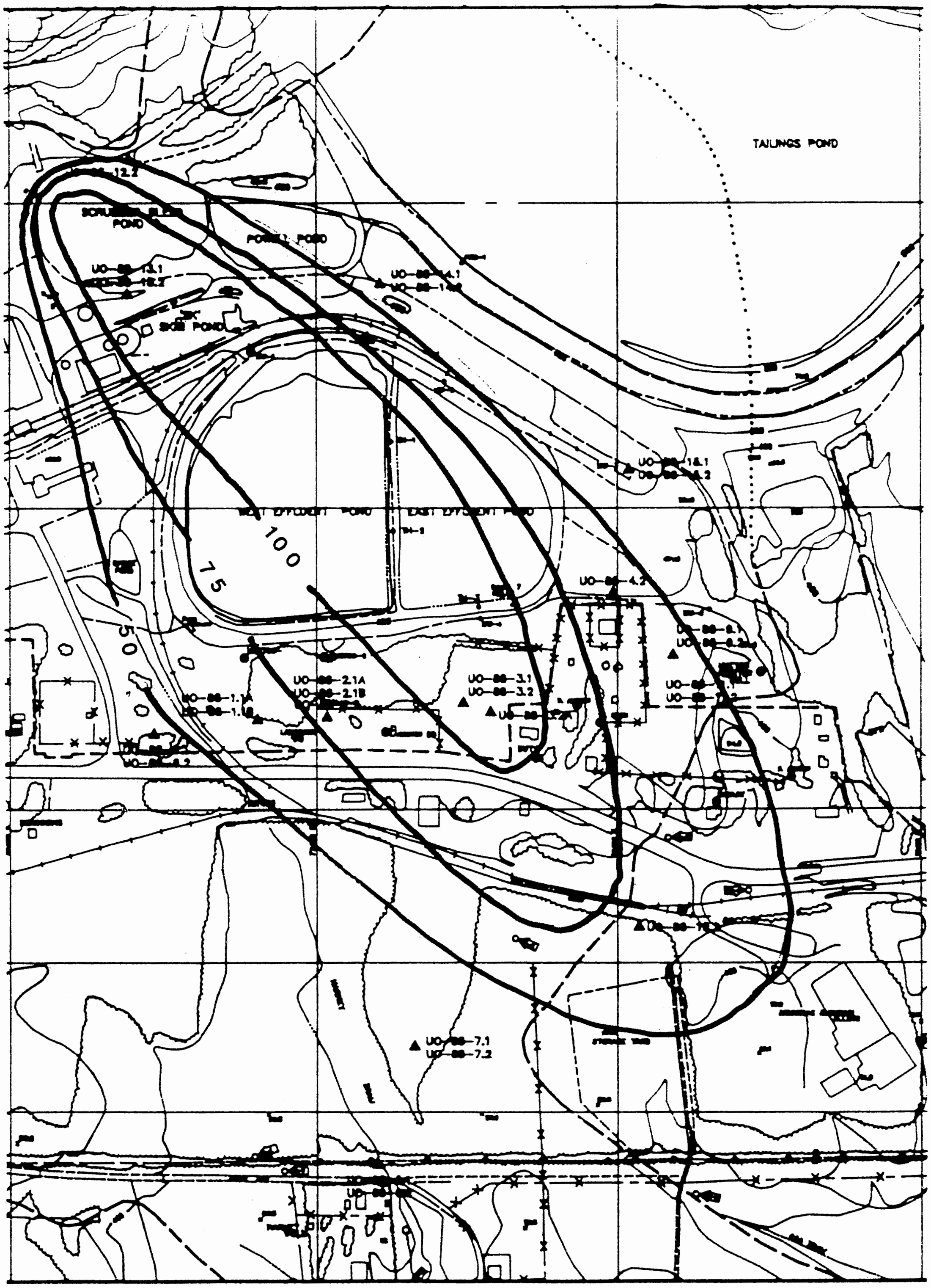


Figure 36. Sodium Isoconcentration Map: Stanley Shale (8-16-88)

geologic formations of concern; alluvial fan, fluviatile and Stanley Shale Formation (see Appendices A and B). Locations and design of the first 16 of these monitoring wells were initially developed by Umetco personnel. Additional wells were added following review of drilling logs, and other tests conducted within the initial wells. Installation of these monitoring wells and their development has been completed. These wells are presently available and are being used to collect on-going ground water data for the site.

Identification of Contaminant Sources

The East and West Effluent Ponds were identified as potential sources of contamination in Consent Order LIS 85-075. However, additional field investigations that were completed north of the East and West Effluent Ponds indicated additional potential sources of groundwater contamination. These sources are the two Scrubber Bleed Ponds, Powell´s Pond, and the SX Raffinate (Skim) Pond.

East Effluent Pond

The East Effluent Pond was used as a holding reservoir for salt roast off-gas neutralization effluent that contain calcium and chloride. In the spring of 1986 the pond was drained of all fluids. As precipitation accumulated after drainage, it was evacuated. In the fall of 1986 all sediments were removed from the pond. During

September and October of 1987 the pond was lined with a 1E-7 cm/sec or less clay liner and a sub-drain system was installed to assure that the structural integrity of the liner will not be damaged by groundwater fluctuations. The East Effluent Pond, then, has not been a source for groundwater contamination for approximately three years.

West Effluent Pond

The West Effluent Pond has been a storage pond for solvent extraction neutralization effluent. The effluent from the pond is characterized by sodium, sulfate and ammonia (N). The Effluent is discharged into Lake Catherine through outfall 001 in accordance with the NPDES Permit ARD000523. The West effluent Pond has a storage capacity of approximately 50 million gallons. The SX Raffinate (Skim) Pond is a possible source of groundwater contamination upgradient of the West Effluent Pond.

Elevated concentrations of sulfate and ammonia (N) have been detected south and down gradient to the ponds. This suggests that the pond leakage has entered the groundwater system.

Scrubber Bleed Ponds

The Scrubber Bleed Ponds were utilized to collect unreacted limestone. These ponds contained associated liquids high in calcium chloride from the mill off-gas neutralization system. The residues, or sludges, are a potential source of the chloride ions. The residues in both ponds were excavated in February 1988 by UMETCO. U.S. Vanadium is currently using the East Scrubber Bleed Pond in their current salt roasting operation.

The depth of the ponds vary, however, both ponds penetrate both alluvial sediments and the Stanley Shale Formation. Monitor wells UO-88-13.1 and UO-88-13.2 indicate elevated chlorides in both formations.

Powell's Pond

Powell's Pond is used for additional settling of solids from the overflow of the Scrubber Bleed Ponds. The estimated capacity of the pond is approximately 6 million gallons. The sediments and liquids have the same chemical characteristics as the Scrubber Bleed Pond residues. The location of the pond relative to the chloride plume suggests that the pond is also contributing to groundwater contamination.

SX Raffinate (Skim) Pond

The SX Skim Pond is a small pond east of the SX building. The pond is an elevated earthen constructed pond with a concrete baffle structure at the east end. Effluent streams from the Ammonia Meta Vanadate (AMV) crystallizer and solvent extraction SX raffinate are mixed in this pond and tramp organic reagent is recovered. If required, the pH of the effluent can be adjusted using anhydrous ammonia. The effluent is then piped from the SX pond to the West Effluent Pond.

Wells UO-88-13.1 and UO-88-13.2 north of the pond have shown elevated concentrations of sulfate and ammonia (N) in groundwater. The SX Raffinate (Skim) Pond is a probable source of this contaminant. The contamination plume trends down gradient from these wells and flows beneath the West Effluent Pond. The West Effluent Pond contains the same chemical makeup as the SX Raffinate (Skim) Pond. Based on the isoconcentration maps for sulfate and sodium, the West Effluent Pond is also a potential source of contamination.

Contaminant Concentrations and Plume Boundaries

Analytical results have been obtained for groundwater samples collected from the monitoring wells installed in the Component 3 investigation. The first event occurred between January 3 and January 29, 1988 and included only the 16 wells installed at that time. The last event was between May 3 and May 10, 1989, and included the eleven additional wells installed at the study site during the summer of 1988, as well as the original Component 3 wells. Using data obtained from the alluvial screened monitoring wells collected in August 1988, isoconcentration maps were prepared for five (5) of the analyzed parameters: chlorides, sodium, sulfate, calcium, and nitrogen/ammonia. Isoconcentration maps for the Stanley Formation were also prepared at that time for chloride, calcium, and sodium. These maps were presented in Figures 34 through 36. These maps indicate that the alluvial plume is oriented primarily in a southerly direction, whereas the Stanley plume is represented by a southeasterly orientation.

Contaminates from the Scrubber Bleed Ponds and Powell′s Pond are primarily calcium and chloride. The East Effluent Pond was also a potential contributor of calcium and chloride prior to sediment removal in 1986 and re-lining in 1987. In contrast, the main contaminates emanating from the West Effluent Pond and the SX Raffinate (Skim) Pond are sodium, sulfate, and ammonia (N).

Alluvial Contaminant Concentrations and Plume Boundaries

The analytical results of groundwater samples taken from monitoring wells screened in the alluvium indicate two separate patterns of ground-water chemical constituents. Alluvial fan and fluviatile screened wells in the eastern portion of the study area consistently indicate elevated concentrations of calcium and chloride. In contrast, analytical data from groundwater samples taken from the alluvial fan screened monitoring wells (UO-87-1.1A and UO-87-2.1A) in the western portion of the study area indicated elevated sodium and sulfate along with chloride. In addition, the monitor wells screened in the fluvial zone (UO-87-1.1B and UO-87-2.1B) located in the western portion of the study area indicate only background water quality conditions.

The alluvial isoconcentration maps show that the calcium plume closely resembles the chloride plume. In contrast, these same maps indicate a close similarity between sodium, sulfate, and ammonia (N) concentrations, and are represented by a more western variation of the plume.

The northern boundary of the alluvial chloride/calcium plume has been delineated by: 1) the analytical results of monitoring wells UO-88-12.2, UO-88-13.1, UO-88-14.1, and UO-88-15.1, and 2) the northern most boundary of the alluvial fan deposits. The eastern boundary is located west of a line between monitoring wells UO-88-15.1 and UO-88-11.1. As discussed above, the chloride concentrations along the western boundary of the plume are confined to the alluvial fan deposits. At monitoring well UO-87-1.1B the vertical extent of the plume is confined to the uppermost 17 feet as indicated by the thickness of the alluvial fan deposits at that location. The western boundary is defined by analytical chemical data of groundwater samples taken from UO-.pa 88-8.1. This evidence is supported by analyses of water obtained from a domestic well located at Route 6, Box 944A, which is located approximately 800 feet west of UO-87-8.1.

Stanley Contaminate Concentrations and Plume Boundaries

The analytical results of groundwater samples taken from monitoring wells screened in the Stanley Formation indicate two different groundwater chemistry patterns. Stanley screened wells in the eastern portion of the study area indicated elevated concentrations of calcium and chloride (UO-87-3.2 and UO-87-9.2). In contrast, Stanley screened wells located in the western portion of the study area revealed that the groundwater in this area is represented by considerably lower calcium and chloride concentrations (UO-87-8.1 and UO-88-2.2).

The northern boundary of the Stanley plume has been delineated by the analytical results of groundwater samples taken from monitoring wells UO-88-12.2, UO-88-13.2, and UO-88-15.2. The eastern boundary of the plume is located in the vicinity of UO-88-11.2. As discussed above, the western boundary of the plume is defined by the analytical results of monitoring wells UO-87-8.1 and UO-88-2.2.

Southern Boundary of Alluvial and Stanley Contamination

The southern or down gradient boundary of contamination can be defined by both direct and indirect evidence obtained since the submission of the Component 4 Report. Direct evidence is provided by analytical data from samples collected from groundwater seepage and stream surface water, down gradient monitor wells, and area domestic wells. Indirect evidence is provided by the results of computer modeling. This data indicates that the southern contamination boundary does not extend to Lake Catherine.

Seepage and stream sampling have been conducted on several occasions during periods of low precipitation. These samples were taken in and along two unnamed streams which flow on the eastern and western boundaries of the study area and along flanking slopes where groundwater seeps have been identified (See Figure 37). Appendix I presents the chemical results of samples collected on each occasion. During periods of low precipitation, stream flow is primarily the result of ground water discharge. Therefore, stream water quality is directly influenced by groundwater chemistries. The sampling of groundwater seepage points, and strategic stream locations has allowed the contributing ground and resulting stream water qualities to be determined. The sampling program supports Umetco's belief that groundwater is surfacing at numerous points, and provides direct evidence of the presence or absence of the contamination plume. The main

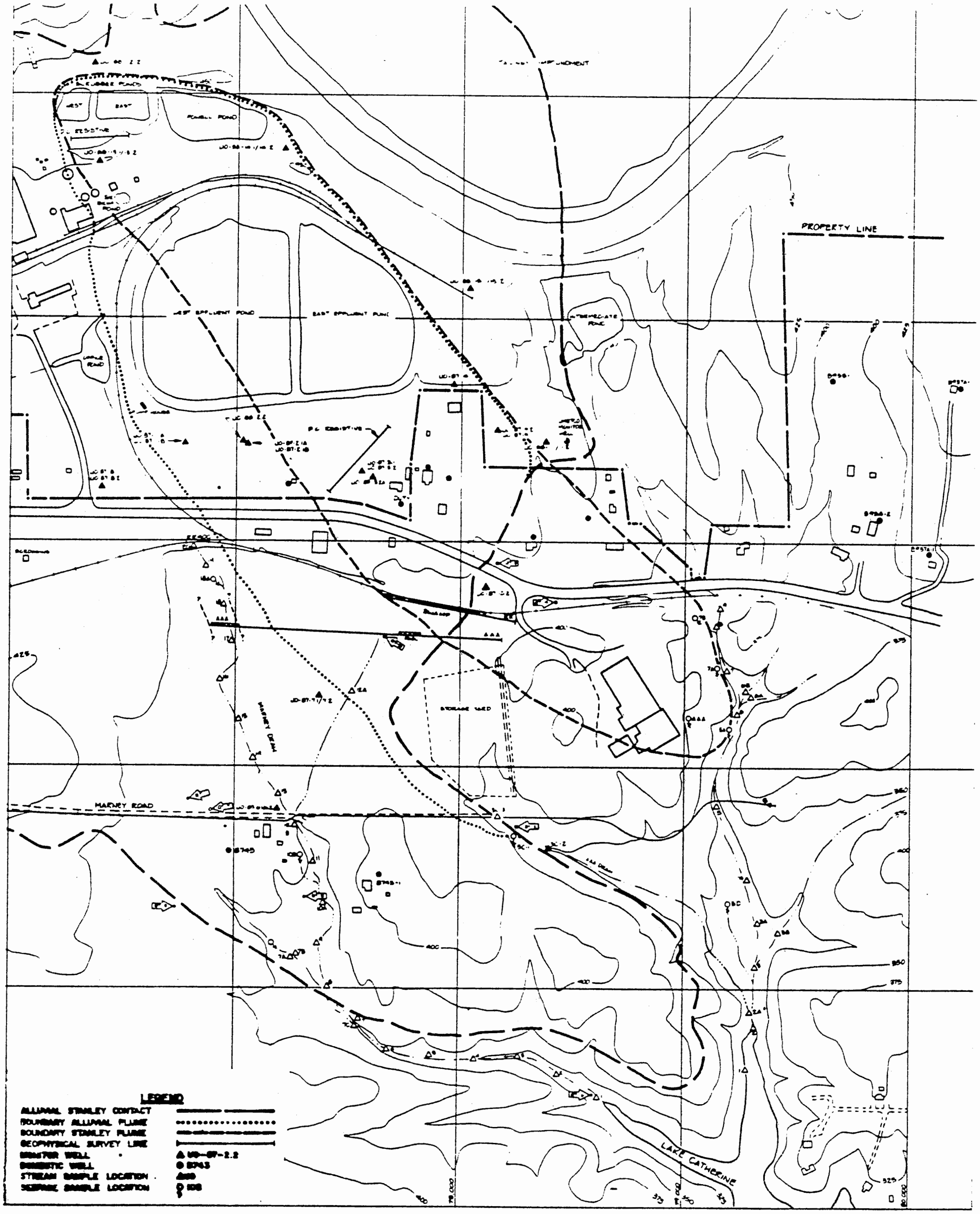


Figure 37. Stream and Seepage Sampling Locations

water course also receives waters from a number of tributaries that are believed to be representative of background water quality.

Samples were collected for analysis along an unnamed stream and its tributaries located along the east boundary of the study area (East Stream). The major source of surface water flow is from surface runoff with some groundwater seepage from the Quaternary alluvium. The major tributaries located on the east side of the East Stream are sampled at points 6A, 6B, and 3B. These tributaries drain a portion of the basin with headwaters stretching approximately one mile to the east.

Water quality of sampled stream waters varies from sampling point 9, where the stream discharges beneath Highway 270, to where the stream finally discharges into Lake Catherine. This variability is directly the result of groundwater and tributary discharges into the stream. Some discharges have been found to be high in chlorides, and as a result increase stream chloride levels, whereas other discharges are found to be so low as to dilute stream waters. Surface water samples taken on July 11, 1986 at location 9 and 8 indicate an average chloride concentration of 159 ppm. Groundwater seepage from the Stanley is contributing to the surface water flow of the East stream at sample point 7A. The analytical results for chlorides from samples taken at this location indicate 1,818 ppm. This results in a slight increase in the chloride content of the stream at location 7.

Analytical results from a tributary at sample points 6A and 6B indicate an average of 24 ppm. At sample location number 6 the chloride concentration decreases to 122 ppm. As a result of dilution from the representative background quality tributary at sample location 5A, the analytical results of a Stanley groundwater seep indicate elevated chlorides (1,285 ppm on 4-5-89). The effect of the Stanley seepage from 5A on the chloride concentration in the East stream is shown by the analytical results at sample location 5, 4, and 3A, which show increased chlorides. The chloride concentrations decrease again due to dilution at sample location 3 as a result of the influence of the tributary at sample location 3B.

The analytical results of alluvial groundwater seepage along East stream tributaries indicate elevated chlorides at sample points 3C-1, 3C-2, and 3C-3. Sample points 3D and 2A indicates that this seepage is influencing the East stream by slightly elevating chloride levels.

If the sulfate and chloride concentrations in the stream decreases or remain constant over this interval, then seepage contribution to the stream are very low in chloride and sulfate constituents and/or flow additions are negligible. The sampling data, taken during different seasons during a three year period, substantiates Umetco´s belief that the chloride and sulfate concentrations decrease between sample locations 5 and 2 in the East Stream. Between these two locations no surface water flow enters the main water course during periods of low precipitation. As a result, the only sources of water contribution to stream flow between these two locations during these periods would be groundwater seepage.

Samples were collected for analyses along an unnamed stream located along the western boundary of the study area (West stream). Groundwater discharge is contributing to the flow of the West Stream between sample locations 20 and 13, as well as location 12A. The source of this groundwater discharge is from the Quaternary alluvium. The alluvium has been found to be approximately twelve (12) feet thick in the vicinity of sample point 12 (UO-87-6.2).

Seepage from sample point 10B on the West Stream has been analyzed for methylene blue active substance (MBAS) and other sewage indicators. MBAS is the brightener found in laundry detergents and does not occur naturally. Thus, the presence of MBAS is often used as an indicator of the presence of sewerage. Other indicators are phosphates and fecal coliform. These results are tabulated below:

Analyte	Units	Concentration Found
Methylene Blue Active Substance	mg/l	0.17
Phosphate	mg/l	0.1
Fecal Coliform	#/100 ml	1
TDS	mg/l	1029

Sewage also contains chloride and sulfate. Adjacent to this seepage abundant trash has been observed including old car batteries, and empty containers of numerous commercial products.

An abandoned domestic well was located south of well location UO-87-7.1 and UO-87-7.2 and southeast of well location UO-87-6.1 and UO-87-6.2. This well is a structurally sound, hand excavated well. The measured depth was 33 feet and the collar elevation is approximately 400 feet above MSL. The bottom of the well is the same elevation as the screened interval in wells UO-87-6.1 and UO-87-7.1. This well was sampled and analyzed for the same chemical constituents as required by the Consent Order. The results are tabulated below and are considered to be within background levels. The patterns of groundwater discharge into the West Stream are similar to those encountered in the East Stream, particularly between locations 6 and 2. These patterns provide direct evidence of the plume boundary.

DOMESTIC WELL B743-1

ANALYTE	mg/liter
Chloride	9.6
Sodium	2.3
Sulfate	6.5
Calcium	1.6
Ammonia (N)	0.04
Vanadium	<0.03

NOTE: Sampling after Component 4 Submission.

The southern boundary of the alluvial contamination, based on data previously discussed, is believed to be on the east; the alluvial Stanley shale contact, the south, a nose around sample points 3C-1, 3C-2, and 3C-3; west, north of well 7.1 and between samples locations 20 and 12 and along the west stream.

The Southern extent of the Stanley Shale contamination is believed to be the locations of seepage points 5A, 7B and 7A. The location of these seepage points also lines up along with the flow direction of the Stanley Shale plume (See Figures 34 through 36).

Two D.C. Resistivity geophysical lines were run to provide additional information on the depth of contamination into the Stanley Shale. The locations of these lines are shown on Figure 37. This analysis was performed by B & F Engineering, Inc. personnel the geophysical data indicates that the chloride contamination is approximately 50 feet into the Stanley formation at these locations. This analysis was completed subsequent to the submission of the Component 4 Report.

COMPUTER MODEL SIMULATION

Introduction

Computer model simulations have become important tools to assist in remediation design for groundwater contamination sites in recent years. These simulations, especially the analytical and numerical programs, have allowed the groundwater scientist to more effectively predict the results of specific remediation scenarios. These programs additionally allow for a more precise locating of remediation facilities when these facilities are warranted.

The representative model, when based on adequate and accurate data, will allow the groundwater scientist to identify plume geometries beyond the extent of available monitoring well restraints. The use of models, then, is predicated on the availability of adequate groundwater and lithologic formation data. It is necessary to have available borehole data, potentiometric surface measurements, groundwater sample results and adequate aquifer test results for the affected area of the study site. The greater the availability of these data sets the more representative will be the modeling results.

Following completion of model calibration the modeler is able to simulate specific aquifer remediation scenarios. These may range from no action through numerous forms of groundwater depletion and recharge. Each scenario to be simulated will incorporate those hydrogeologic characteristics on which the flow and solute model portions of the model were calibrated. Resulting outputs, then, may be compared to assist in the determination of the most appropriate remedial technologies and their physical placement.

Model Selections

There exist today numerous models from which the groundwater scientist may select. The majority of these models will provide the groundwater scientist with an adequate simulation of the site. The model must be selected on the basis of its applicability to the situation as well as the modelers familiarity to the model and its ease of application. Not all the available models have been well documented nor do all have available a user-friendly preprocesser that will allow the modeler easy access and rapid data input or modification. It is also important to note that several different levels of model sophistication are available. More specifically, both analytical and numerical models are readily available to the groundwater scientist.

The groundwater scientist should always begin with the simpler and more easily utilized model(s) where possible. A first attempt at modeling, then, should be made with an analytical model rather than the numerical models. If the analytical model proved adequate for the level of simulation required it would not be necessary to employ the time requirements needed for numerical modeling. In very complex geologic situations, however, analytical models usually do not prove to be satisfactory. A numerical model would then be necessary to simulate those environments.

For the modeling project discussed in this report initial attempts were made to utilize an analytical model. The model chosen was one in the series of "Plume" models that are available to groundwater scientists today. The specific model utilized was the FPlume version of the Wilson-Miller Analytical Model developed at Oklahoma State University by Kent, LeMaster and Witz. This modified version of the Wilson-Miller analytical model has incorporated a greater flexibility to input by becoming more user friendly. The model allows the groundwater scientist to, among other things, regulate the size of the source area and to input a volume flow rate and source concentration. Aquifer saturated thickness, porosity, velocity, dispersion, retardation and decay are kept at constant rates throughout the study area. This later limiting factor, however, makes it difficult to simulate an extremely heterogeneous environment such as would occur in many alluvial situations.

Results of the analytical model were unsatisfactory for the site under study. Although the flow portion of the model was calibrated reasonably well it was not possible to calibrate the solute portion of the model to simulate known chemical parameters at the site.

A numerical model was chosen to complete model simulations at the study site. The model selected was the

Modified U.S.G.S. Solute Transport Model (MOCNRC) version of the Konikow and Bredehoeft model. The model was purchased by B & F Engineering, Inc. from the International Ground Water Modeling Center, Holcomb Research Institute, Butler University in Indianapolis, Indiana. The selected numerical model incorporates a wider flexibility in input parameters to allow for a more detailed evaluation of complex hydrogeologic environments.

The Konikow and Bredehoeft computer model was developed to calculate transient changes in the concentration of a nonreactive solute in flowing groundwater. The computer program solves two (2) simultaneous partial differential equations. One equation is the groundwater flow equation, which describes the head distribution in the aquifer. The second is the solute-transport equation, which describes the chemical concentration in the system. By coupling the flow equation with the solute-transport equation, the model can be applied to both steady state and transient flow situations.

The purpose of the simulation model is to compute the concentration of a dissolved chemical species in an aquifer at any specified place and time. Changes in chemical concentration occur within a dynamic groundwater system primarily due to four (4) distinct processes: 1) corrective transport; 2) hydrodynamic dispersion; 3) fluid sources; and 4) reactions. The Konikow and Bredehoeft model assumes that no reactions occur that affect the concentration of the species of interest, and that gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.

Hydrogeologic Data Requirements for the Model

There are five (5) major data input sets for the Konikow and Bredehoeft model. The data sets are: starting head, storage coefficients, transmissivity, recharge and pumping wells. Where one or more of these data sets are unknown, average values may be substituted for data inputs. For the Umetco study site only storage coefficients and recharges were calculated and averaged across the site.

Piezometric Surface

Starting head represents the water level or the piezometric surface measured when the well was first completed and then on a continual basis to aid in model calibration. Piezometric surface measurements made in August, 1988 were used in these modeling efforts.

Storage Coefficient

Beginning storage coefficient values were derived from aquifer test calculations at the site. Storage coefficient is a tensor for this model. A tensor is used in numerical modeling to adjust model calibration and assure that a minimum of known hydrogeologic parameters are modified during that process. It is not uncommon to have storage coefficient values significantly higher than those recorded during field investigations.

Transmissivity

The transmissivity may vary from one area to another within an aquifer. The Konikow and Bredehoeft model allows the option of internal calculation of transmissivities on a node to node basis by inputting hydraulic conductivity and aquifer thickness matrices. Aquifer thickness is additionally derived by inputting a bottom of aquifer contour matrix along with the piezometric surface matrix discussed above.

Recharge Rates

Estimates of recharge and discharge are required to simulate the flow of groundwater. Recharge rates can be entered into the model in several ways: 1) constant head, the piezometric surfaces of the constant head nodes do not change during the simulations; 2) injection wells, this is a form of artificial recharge where a fluid is injected into the aquifer; 3) constant flux, the fluid is flowing into a node at a specific rate; and 4) recharge matrix, a volume of fluid entering a node due to the potentiometric gradient.

Pumping Wells

The last major data input is pumping and/or injection wells. Wells are assigned to locations identified as sources and simulation by injection is employed. Recovery wells are pumped to simulate aquifer remediation in certain instances. The model is capable of handling multiple pumping periods of variable length.

Numerical Model Calibrations

Calibration is necessary for any type of simulation. Calibration is normally performed in two phases: 1) comparison of an analytical solution to a numerical solution; and 2) comparison of field data with predictions made by the model.

A comparison of analytical and numerical model results was not possible for the UMETCO study site. As discussed earlier, the site geology consisted of a too complex situation for analytical modeling to be fully successful. Therefore, reliable analytical results were not available for comparison.

The Konikow-Bredehoeft Model was calibrated utilizing data generated during field investigations at the study site. These included; borehole logs, slug testing, aquifer testing and chemical sample analyses of installed monitoring wells. It must be realized that model simulations do not produce exact replicas of the actual environments under analysis. The modeler normally cannot entirely duplicate actually recorded field measurements throughout the study area. The best one may hope for is an approximation of those parameters over the majority of the site. It is the modelers task to attain the most representative approximation within the limits of known and assumed hydrogeologic parameters. For the modeling attempted here a mode grid matrix was overlain on the study site and oriented with the axis of the contaminant plume. This grid is presented in Appendix J.

Alluvial Calibration

It is not known to what extent groundwaters are in communication between the alluvial deposits and the Stanley Shale Formation. It is believed that over most of the affected area leaky confined conditions prevail. It is assumed that only where the paleo-channel has removed the weathered shales above the Stanley is there direct communication between the two (2) deposits. The alluvial component of the system, then, was modeled separately from the Stanley Shale Formation.

The model of the alluvium was initially calibrated to simulate groundwater flow conditions. The period of calibration began with the initial construction of holding ponds at the site and continued to the present. This constituted a period of approximately 18 years. The flow portion of the model was calibrated to minimize mounding and dewatering of the groundwater resource and to maintain as near as possible known hydrogeologic parameters as inputs.

Solute transport was calibrated after completion of flow calibrations as discussed above. Solute transport calibration is a further fine tuning of the calibration effort and is completed by attempting to match known concentrations at selected monitoring well locations. This final calibration step assures the modeler that as near as accurate representation of the site as possible has been attained. Final calibration results are shown in Appendix J.

Stanley Shale Calibrations

Calibrations for the Stanley Shale followed the same format as outlined for the alluvial materials above. The hydrogeologic parameters were modified to fit the specific conditions identified for that formation. Calibration results are here presented in Appendix J.

Simulation of Selected Remediation Scenarios

Selected Scenarios

The alluvial deposits and the Stanley Shale Formation were modeled separately as discussed earlier. For each unit modeled three scenarios were chosen for analysis. In each of the three (3) scenarios the initial step is the remediation of identified sources. It is assumed that contaminants at the sources identified earlier were removed from the site and that each source is lined with an accepted low permeability liner to assure that these source will no longer contribute to groundwater contamination.

Following the remediation of contamination sources the model simulation monitored concentration change over the affected area for five (5) years and ten (10) years respectively. During these time periods normal groundwater flow and, as a result, contaminant dilution was allowed to occur. The final scenario involves the simulated installation of five (5) groundwater recovery wells, two below the Scrubber Bleed and Powell Ponds and three below the Effluent Ponds. These recovery wells were pumped at two (2) gpm for a period of ten (10) years. The three recovery wells located downgradient of the Effluent ponds are located along the southern Umetco property boundary. Attempts were made to increase the number of recovery wells in each of the two (2) locations. Any increase above the number reported resulted in a total dewatering at the well sites and therefore computer termination at that point of the model simulation.

Scenario Simulation Results

Alluvial Deposits The results of the three (3) alluvial scenarios are presented as Figures 38 through 40. A comparison of the model results after the remediation of identified sources and groundwater monitoring for periods of five (5) years and ten (10) years (see Figures 38 and 39) indicates that natural dilution is reducing the highest concentrations appreciably. The 10,000 ppm contour on these two maps has not only decreased in overall extent but exhibits downgradient migration. This indicates that over a period of time downgradient migration will eventually flush the contaminants from the system.

The third remediation scenario includes the installation of five (5) recovery wells. These wells are evacuated at a rate of two (2) gpm over the ten (10) year period following sources remediation. A comparison of Figures 39 and 40 indicates that only minor differences in resulting concentrations exist. The highest level of concentration, greater than 10,000 ppm, is eliminated due to pumping, whereas a small area at this level will still remain when pumping is not included as part of remediation. The overall plume, however, remains little changed due to this groundwater recovery.

It must be recognized that by placing the recovery wells near and slightly downgradient of the identified

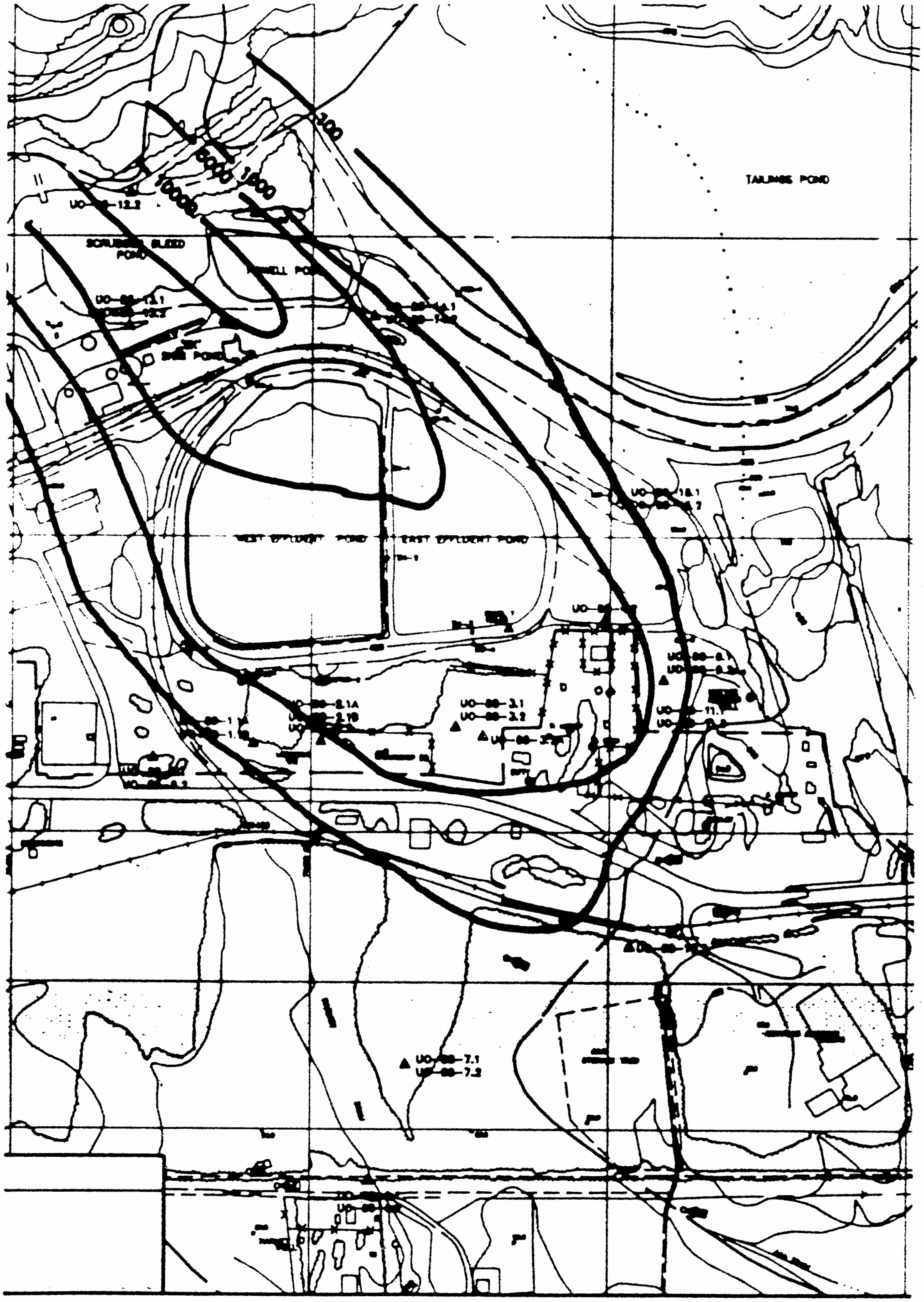


Figure 38. Sources Remediation with Normal Groundwater Flow for Five Years (Alluvium)

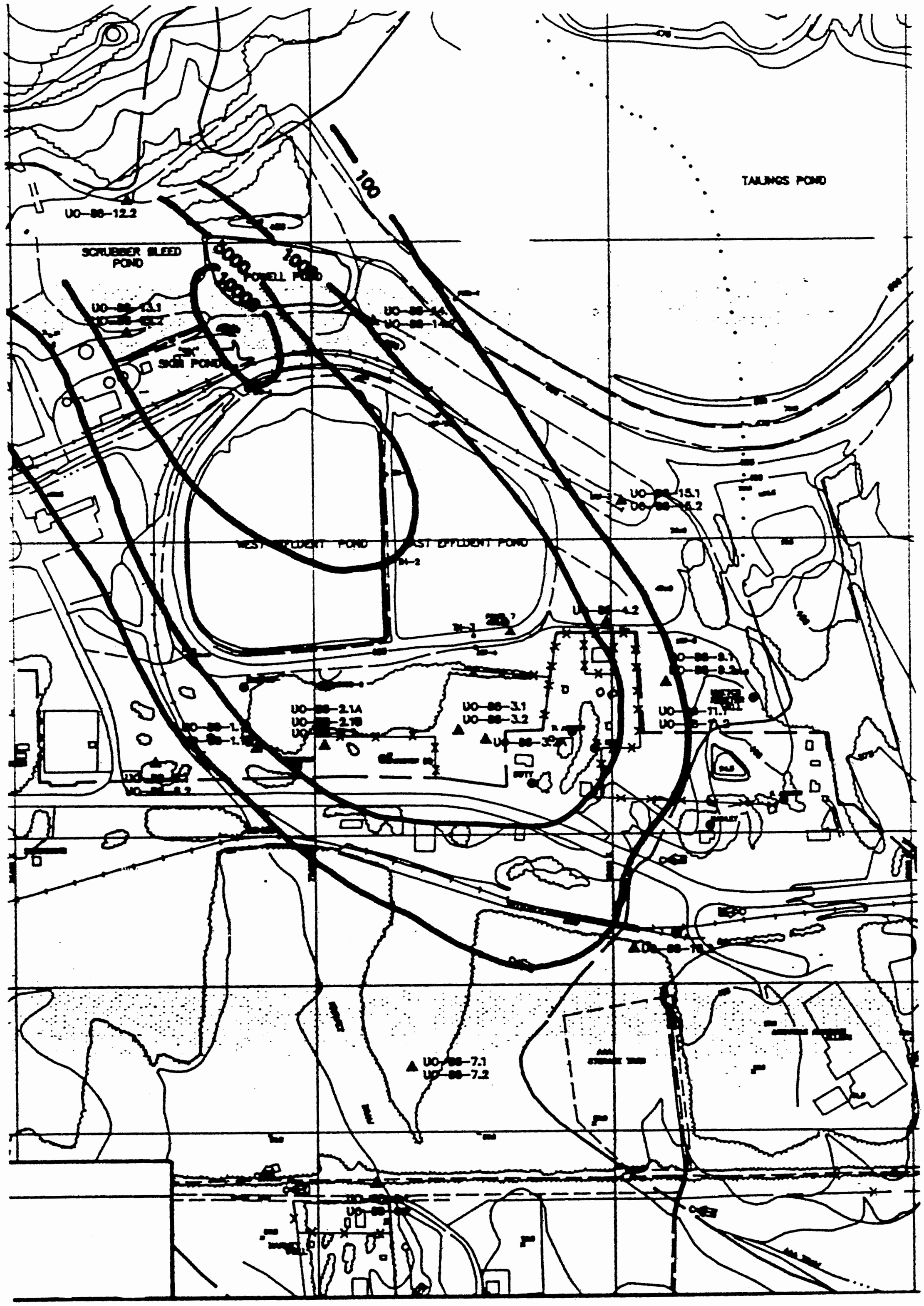


Figure 39. Sources Remediation with Normal Groundwater Flow For Ten Years (Alluvium)

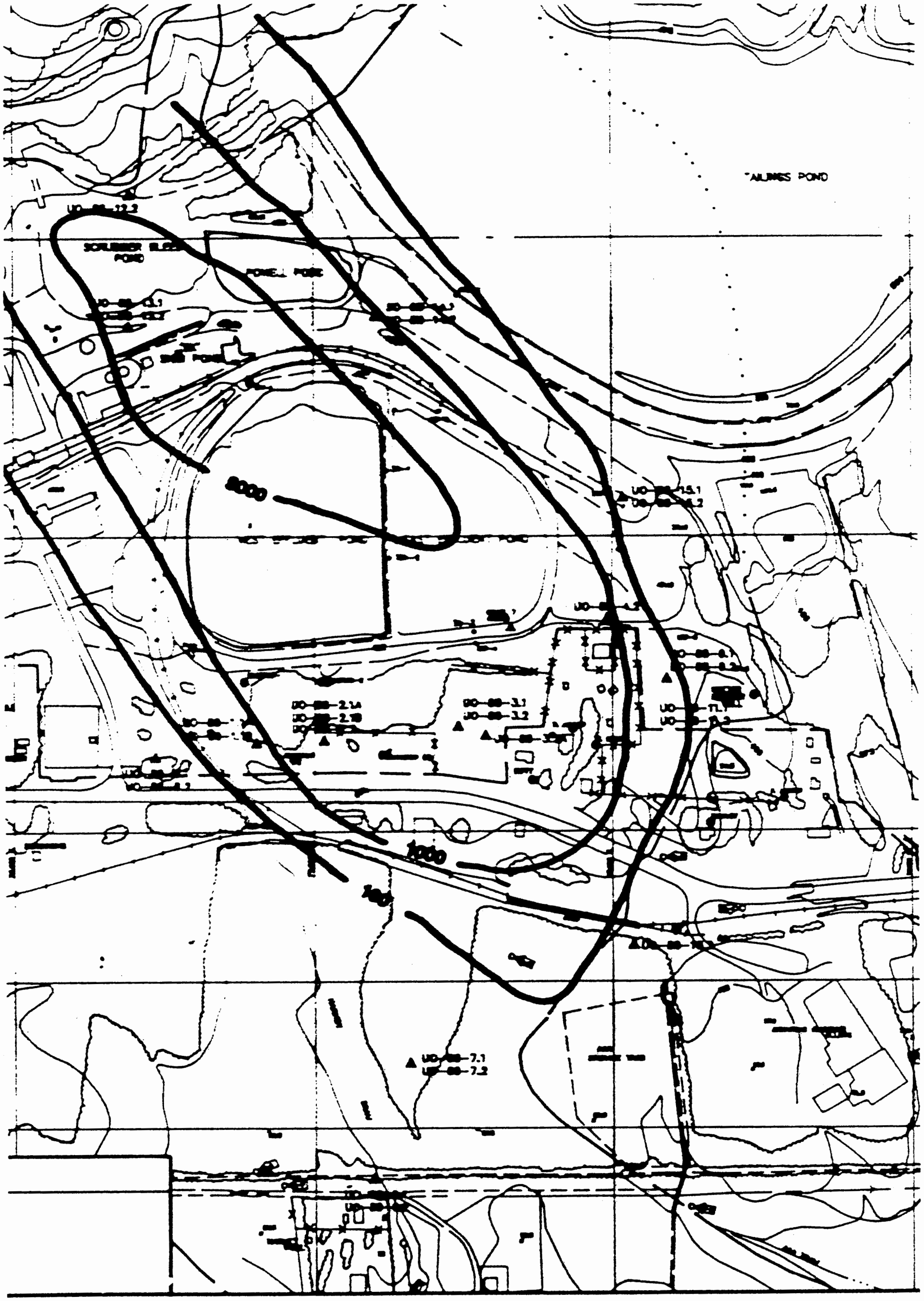


Figure 40. Sources Remediation with Recovery Wells (Alluvium)

sources full groundwater remediation will be slow to occur. Those groundwaters already having migrated downgradient will not be appreciably pulled back upgradient to the recovery wells. This groundwater will continue to move downgradient and be influenced by continued dilution. Recovery wells near contamination sources that have been previously remediated will result in a significant reduction of the highest contaminant concentrations.

Stanley Shale Formation The results of the three (3) Stanley Shale scenarios are presented in Figures 41 through 43. The final solute transport calibration which closely replicates the current situation at the site is presented in Appendix J. Figures 41 and 42 represents remediation of identified sources with scheduled monitoring of existing monitoring wells for five (5) years and ten (10) years respectively.

The change in plume geometry and overall levels of contaminants present may be realized by comparing the solute transport calibration (see Appendix J) with Figures 41 and 42, contamination plumes following sources remediation. Two important differences may be noted. The first is a distinct reduction in maximum chloride levels simulated and the second is an expansion of the overall plume dimensions. Both these results are due to the dilution of existing contaminated groundwaters coupled

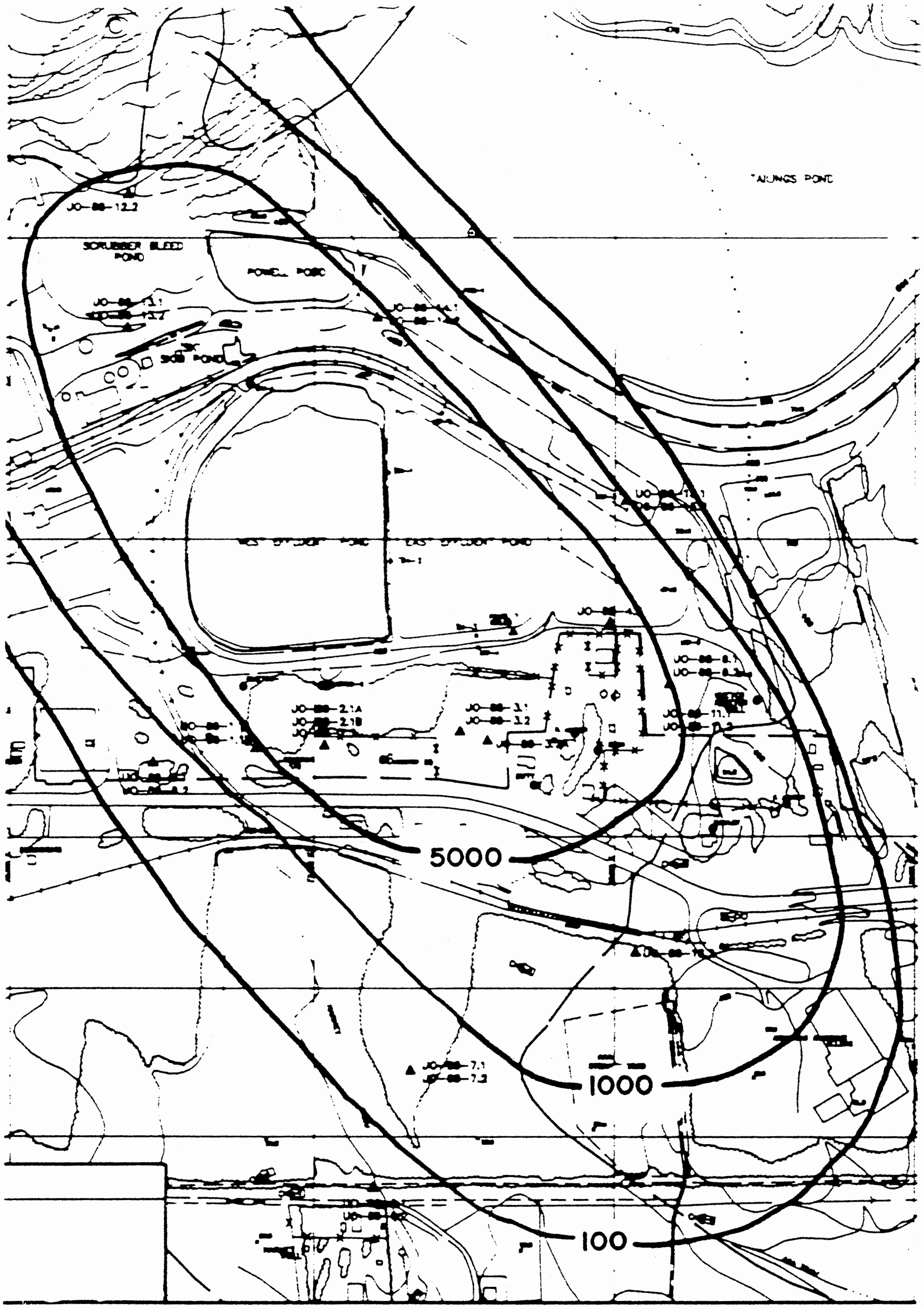


Figure 41. Sources Remediation with Normal Groundwater Flow for Five Years (Stanley Shale)

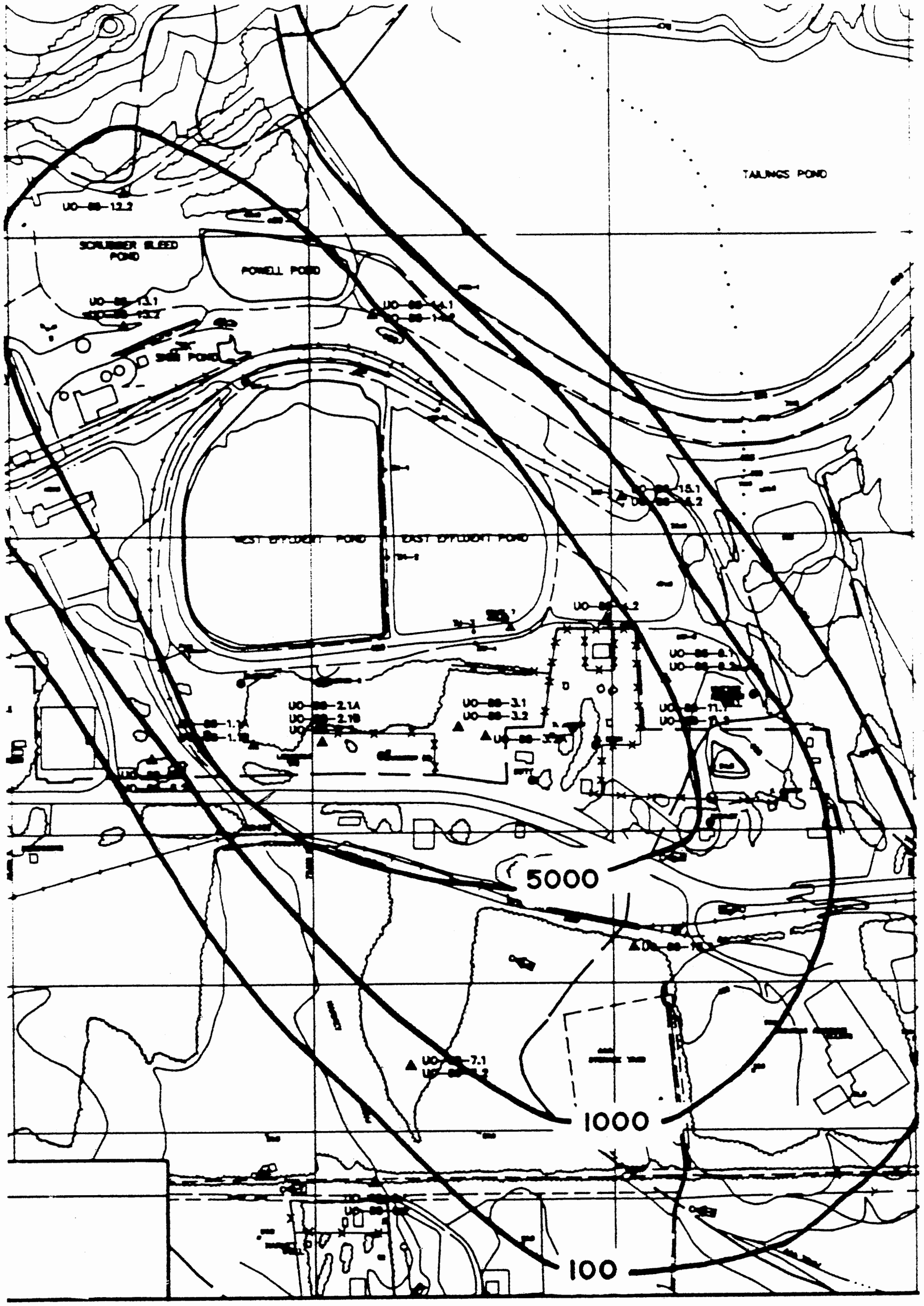


Figure 42. Sources Remediation with Normal Groundwater Flow for Ten Years (Stanley Shale)

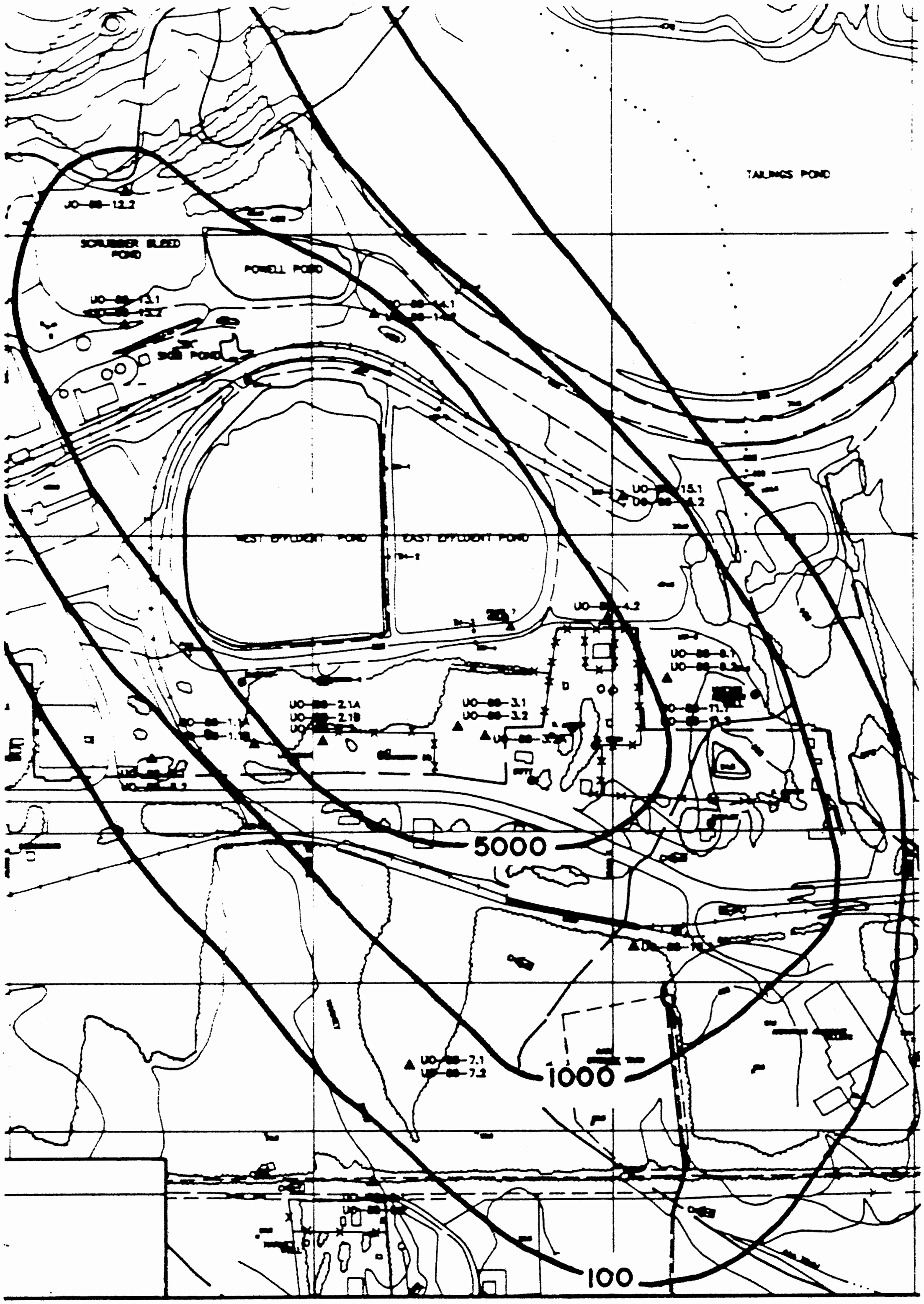


Figure 43. Sources Remediation with Recovery Wells (Stanley Shale)

with the slow movement of the contaminant body through the system.

Figure 43 represents the results not only of sources remediation but also the installation and pumping of five (5) recovery wells at the site. Recovery wells are located downgradient of the Scrubber Bleed and Powell Ponds, two (2) wells, and the effluent ponds, three (3) wells. The three (3) recovery wells located downgradient of the effluent ponds are located along Highway 270, the southern boundary of Umetco's property.

A comparison of Figures 41 and 42 indicates that similar changes would occur as a result of pumping that were reported for source remediation without the installation of recovery wells. A further comparison should be made between the two scenarios reported as Figure 42, sources remediation and monitoring for ten (10) years, and Figure 43, source remediation and the installation of groundwater recovery wells pumped at two (2) gpm for ten (10) years. The only significant difference between these two scenarios is a somewhat narrower 5,000 ppm contoured area for the recovery well pumping approach.

Again, it must be recognized that recovery wells near the sources will not fully remediate groundwaters that have migrated downgradient of those locations. Initially higher concentrations, will however, exhibit marked decreases due to this recovery well configuration.

Summary of Modeling Results

Groundwater model simulation is one in a series of tools employed to aid the investigator in appropriate remediation alternative identification. The alluvial aquifer was modeled separately from the Stanley Shale aquifer even though the Stanley Shale is a leaky aquifer with some communication with the alluvium. For each modeled aquifer three scenarios were investigated through numerical model simulations. The three scenarios included sources remediation of known potential contaminant sources in each instance. Two scenarios involved only groundwater monitoring after sources remediation. The third incorporated strategically sited recovery wells within the Umetco or U.S. VANADIUM property boundaries. The recovery wells were placed near the identified sources in order to arrest the higher concentrations and allow for dilution to assist in full long term plume remediation.

The most revealing results suggest that although source concentrations may be significantly reduced the overall plume of chloride contamination will be little affected by the installation of recovery wells and continuous evacuation of groundwaters. Long term dilution of groundwater contaminants following sources remediation, then, is as viable an alternative as recovery well installation and evacuation.

IDENTIFICATION OF POTENTIAL REMEDIAL ACTIVITIES

The objective of remedial action is to improve the groundwater quality within the boundaries of the identified plume, and contain further contamination using existing cost effective technology compatible with site groundwater characteristics.

A summary of data and conclusions obtained from the field investigations was utilized as a basis in identifying remedial technologies. Development of new or untested technology was not considered in attempting to provide a remedial solution. The following discussion of remedial action alternatives does not necessarily depict the final remedial plan proposed by Umetco Minerals Corporation. At the time of this writing the remedial action plan is in draft form. Probable revisions will be made prior to final submission.

Summary of Findings

The following list summarizes the conclusions and applications of data from field investigations and computer modeling which were used as a basis for developing potential remedial technologies:

1) The identified potential sources of groundwater contamination are the West Effluent Pond, the Scrubber Bleed Ponds, Powell′s Pond, and the SX Raffinate (Skim) Pond.

2) The Quaternary alluvium is characterized by an unconfined groundwater system exhibiting relatively low permeabilities.

3) The Stanley Formation is a partially or leaky confined groundwater system characterized by fracture porosity.

4) No vanadium contamination was detected in tested groundwaters. The contaminants (chloride, sulfate, ammonia (N), calcium, and sodium) exhibit different geochemical characteristics, with chlorides exhibiting the greatest mobility and ammonia (N) the least mobility within the groundwater system.

5) Computer modeling results suggest that remediation of sources followed by normal groundwater movements does result in a reduction of chloride concentrations over time.

6) Computer modeling results suggest that remediation of sources followed by the installation and pumping of groundwater recovery wells do not significantly reduce chloride concentrations beyond those reported without the recovery wells.

7) The contamination boundaries have been defined by analytical data samples from the groundwater monitoring system, groundwater seepage and stream surface water, and area domestic wells. These boundaries are consistent with the computer generated models.

8) All occupied dwellings located within the affected area have an alternate source of domestic water.

Identification of Remedial Technologies

Table 4 presents a list of the potential technologies which could be implemented in various combinations to remediate the study area. Each technology is applicable for a specific function as part of a remedy and, as such, represents a portion of the potential remedial action which may be necessary to fulfill the remedial objectives.

Table 4

LIST OF REMEDIAL TECHNOLOGIES CONSIDERED

A. Alternate Domestic Water Supplies

B. Groundwater Monitoring

C. Remediation of Primary Sources

  1. Sediment Excavation from Ponds

  2. Lining of Ponds

D. Recovery and permitted discharge of Contaminated Ground Water

Alternate Domestic Water Supplies

The provision of alternate water supplies in the affected areas is a remedial technology which may not directly mitigate a contaminant problem, but can be utilized in support of the identified response technologies.

Groundwater Monitoring

The groundwater monitoring system was installed in the Component 3 and supplemental investigations. The sampling and analysis plan has been developed and was included in the Component 4 report. The existing system could be utilized to monitor the contaminant plume.

Remediation of Identified Sources

The remediation of identified source(s) would require the implementation of a combination sediment removal and lining of the facilities with a material sufficient to effectively contain leakage of pond contents into the ground water system. There are five (5) potential sources of ground water contamination that could be considered for remediation: Scrubber Bleed Ponds, Powell's Pond, West Effluent Pond and the SX Raffinate Pond.

Recovery and Permitted Discharge of Contaminated Ground Water

The recovery of contaminated ground water could be accomplished by the installation of strategically placed recovery wells. The recovered ground water would be returned to a holding pond for discharge through NPDES permit AR000523, Outfall 001.

Identification of Remedial Alternatives

Table 5 presents a list of potential remedial alternatives which could be implemented to remediate the site.

Table 5

LIST OF REMEDIAL ALTERNATIVES

1) No Action
2) No Action with Groundwater Monitoring.
3) Limited Action with Groundwater Monitoring
4) Remediation of Primary Sources without Groundwater Monitoring
5) Remediation of Primary Sources with groundwater monitoring.
6) Remediation of Primary sources and groundwater recovery from the Stanley Shale formation on Umetco/Stratcor property.
7) Remediation of identified sources and groundwater recovery from the Quaternary Age Alluvium on Umetco/Stratcor property.
8) Remediation of identified sources and groundwater recovery from the Stanley Shale Formation and Quaternary Age Alluvium on Umetco/Stratcor property.

Screening of Remedial Alternatives

This section presents a screening of the remedial alternatives identified above, these alternatives will be screened on the basis of cost, public health and environmental effects and engineering feasibility. Efforts have been made to identify and quantify potential items that may affect the scope and cost of each remedy, if implemented. For those items which can not be quantified at this level, certain assumptions will be presented.

Screening Criteria

In order to reduce the number of potential alternatives to a group of practical implementable alternatives, the National Contingency Plan (40 CFR, Part 300.68g), has established three broad criteria to be used in the initial screening of alternatives. These criteria are presented, in part, below:

1. Cost. For each alternative, the cost of installing or implementing the remedial action must be considered, including operation and maintenance costs. The screening cost estimates are developed to provide comparative estimates for alternatives with relative accuracy so that cost decisions between alternatives will be sustained as the accuracy of the cost estimates improves beyond the screening process. An option that far exceeds the costs of others evaluated and that does not provide substantially greater public health or environmental benefit should usually be excluded from further consideration.

2. Effects on Health and Environment. The effects of each alternative should be evaluated in two ways: (i) whether the action itself or its implementation has any adverse environmental effects; and (ii) for source control remedial actions, whether the action

is likely to achieve adequate control of source material, or for offsite remedial actions, whether the action is likely to effectively mitigate and minimize the threat of harm to public health, welfare or the environment. If an alternative has significant adverse effects, it should be excluded from further consideration. Only those alternatives that effectively contribute to protection of public health, welfare, or the environment should be considered further.

3. Acceptable Engineering Practices. Alternatives must be feasible for the location and conditions of the release, applicable to the problem, and represent a reliable means of addressing the problem.

Comparative construction costs were estimated for each remedial alternative option or technology. Rough estimates of continuing operation, maintenance, and monitoring costs were developed where necessary for alternative comparison and screening. Cost estimates are "order-of-magnitude" costs based upon current market conditions. (Note: Actual costs are not included in this document due to privacy concerns.)

The screening process for the alternatives developed for the Umetco/Stratcor site was based on a listing of the technical and environmental advantages and disadvantages of each alternative followed by an estimate of cost of implementation.

Screening of Remedial Alternatives

The six remedial alternatives listed above are discussed with regard to screening criteria, and summarized. The cost criteria is shown here as the estimate total cost of the alternate.

No Action Alternative

The no action alternative means that the site would remain in its present condition with no remediation of identified sources or removal of contaminated groundwater.

Costs:

($0.00)

Engineering Feasibility:

No engineering activities would be associated with this alternative.

Public Health and Environmental Effects

Umetco has made arrangements to furnish a central water supply to homes located near the site for those residences which had utilized individual water wells in the past. It is believed that groundwater flow is surfacing prior to reaching Lake Catherine. Studies were conducted subsequent to the submission of the Component 4 Report which indicate that the groundwater seepage enters unnamed tributaries at low concentrations. These tributaries discharge into Lake Catherine.

Summary

The advantage of this alternative is that it would result in no further expenditure of effort or capital for clean up of the site. Groundwater would continue to enter Lake Catherine through seepage into tributaries.

No Action Alternative with Groundwater Monitoring

The no action alternative means that the site would remain in its present condition with no remediation of identified sources or removal of contaminated ground water. Groundwater monitoring utilizing the existing monitoring system would be conducted on a semi-annual basis for a period of 7 years. The groundwater monitoring would detect plume movement and chemical concentrations. These results would be maintained on file.

Costs:

($0.00)

Engineering Feasibility:

No additional engineering activity would be associated with the no action alternative with groundwater monitoring utilizing the existing well system.

Public Health and Environmental Effects

Umetco has made arrangements to furnish a central water supply to homes located near the site for those residences which had utilized individual water wells in the past. It is believed that groundwater flow is surfacing prior to reaching Lake Catherine. Studies were conducted subsequent to the submission of the Component 4 Report which indicate that the groundwater seepage enters unnamed tributaries at low concentrations. These tributaries discharge into Lake Catherine. Groundwater monitoring utilizing the existing monitoring system would be conducted for a period of 7 years. The groundwater monitoring would detect plume movement and chemical concentration. The monitoring results will be maintained on file.

Summary

In addition to no further expenditure of effort and capital, this alternative would provide data to monitor contaminant plume movement. This alternative, however, would not remove contamination sources or contaminated groundwater.

Limited Action Alternative with Groundwater Monitoring

A central water supply to nearby homes located near the site has been provided. This action was accomplished by extending a water line from the City of Hot Springs along U.S. Highway 270 to several homes in the affected area. At present there are no domestic users of groundwater downgradient of the potential contaminant sources. Additional municipal water supply connections could be made available if areas down gradient of the site are further developed. The groundwater monitoring would detect plume movement and chemical concentrations.

Costs:

($0.00)

Engineering Feasibility:

No further engineering activity would be associated with this alternative.

Public Health and Environmental Effects:

Umetco has made arrangements to furnish a central water supply to homes located near the site for those residences which had utilized individual water wells in the past. It is believed that groundwater flow is surfacing prior to reaching Lake Catherine. Studies were conducted subsequent to the submission of the Component 4 Report which indicate that the groundwater seepage enters unnamed tributaries at low concentrations. These tributaries discharge into Lake Catherine.

Summary

The advantages of this alternative are: 1) limited expenditure of effort and capital; 2) reduced chance of public contact with the contaminated groundwater; and 3) monitoring of plume movement. This alternative, however, would not remove contamination sources or groundwater.

Remediation of Identified Sources Without Groundwater Monitoring

The sediments removed from the identified source(s) would be transported to a permitted landfill. This method would require an estimated 70,000 cubic yards of landfill space. The sources would then be lined with a material sufficient to effectively contain leakage into the ground water.

Costs

($0.00)

Engineering Feasibility:

The removal and disposal of sludges is feasible using existing technologies. The reconstruction of ponds and lining with materials suitable to retard the movement of contaminates into the groundwater system has been demonstrated to be feasible. Soil materials suitable for lining of the ponds have been identified within the immediate proximity of the site location.

Locations both on site and off site are available for disposal of sludge material.

Public Health and Environmental Effects

This alternative will result in some minor public health and environmental effects in the form of noise and dust generation during source remediation. This will be the result of the excavation of sediments from the identified sources and the lining of the sources. Adverse effects resulting from the reactivation of the sources will be minimal. This alternative would not provide data on plume movement.

This alternative will also result in positive environmental effects. Continuing leaching of contaminants from the sources will be eliminated. Although the sediments will not be destroyed by landfilling, the wastes will be contained and isolated.

Summary

The advantages of this alternative are: 1) control of further contamination by source remediation ; 2) it is technically feasible; 3) reduction of long term environmental risks; 4) isolation of contaminants and control of leaching and erosions. This alternative would require long term maintenance, land use control. In addition to these disadvantages, this alternative does not monitor the movement of the plume.

Remediation of Identified Sources with Groundwater Monitoring

In addition to the remedial actions described above, this alternative would include groundwater monitoring. The existing monitoring well system would be monitored semi-annually for two (2) years. At the end of that time period analytical results would be reviewed to determine the effectiveness of natural remediation of contaminants.

Costs

($0.00)

Engineering Feasibility:

The removal and disposal of sludges is feasible using existing technologies. The reconstruction of pond and lining with materials suitable to retard the movement of contaminates into the groundwater system has been demonstrated to be feasible. Soil materials suitable for lining of the ponds have been identified within the immediate proximity of the site location.

Locations both on site and off site are available for disposal of sludge material.

Public Health and Environmental Effects

This alternative will result in some public health and environmental effects in the form of noise and dust generation during source remediation. This will be the result of the excavation of sediments from the identified source area(s) and the lining of the sources. Adverse effects resulting from the reactivation of the sources will be minimal.

This alternative will also result in positive environmental effects. Continuing leaching of contaminants from the sources will be eliminated. Although the sediments will not be destroyed by landfilling, the wastes will be contained and isolated. The semi-annual monitoring of the existing well system would allow UMETCO to monitor the contaminate plume.

Summary

In addition to the advantages described above, this alternative would monitor the movement of the contaminant plume. The disadvantages of this alternative are the costs associated with long-term maintenance, land use control, and groundwater monitoring.

Remediation of Identified Sources and Groundwater Recovery From the Stanley Shale Formation On Umetco/Stratcor Property

This alternative would consist of the remedial actions described above, and would include the extraction of contaminated ground water from the Stanley Shale Formation on property owned by Umetco and/or Stratcor. The extraction of groundwater shall be conducted for a period of seven (7) years or would cease when analyzed parameters at selected monitoring locations indicate that further groundwater quality improvements is statistically improbable.

Costs

($0.00)

Engineering Feasibility

Groundwater recovery by recovery wells is a proven remedial technology. Access for the locations of the wells, collection lines, and utilities on Umetco property is readily available. The engineering feasibility of the remediation of identified sources is the same as discussed above.

Public Health and Environmental Effects

This alternative has positive public health and environmental effects by removing contaminants from the groundwater and preventing the continued migration of the contaminant plume.

Summary

In addition to the advantages described above (sources remediation and groundwater monitoring), this alternative would include attempted remediation of contaminated groundwater from the Stanley Shale Formation. This alternative does not attempt remediation of contaminated alluvial groundwater.

Remediation of Identified Sources and Groundwater From the Quaternary Age Alluvium on Umetco/Stratcor Property

This alternative would consist of the remedial actions described above, and would include the extraction of contaminated ground water from the Quaternary Age alluvium on Umetco and/or Stratcor property. The extraction of groundwater shall be conducted for a period of seven (7) years or would cease when analyzed parameters at selected monitoring locations indicate that further groundwater quality improvement is statistically improbable.

Costs

($0.00)

Engineering Feasibility

Groundwater extraction by recovery wells are a proven remedial technology. The locations of the wells, collection lines, and utilities for each of these technologies is technically feasible. The engineering feasibility of the remediation of identified sources is discussed above.

Public Health and Environmental Effects

This alternative has positive public health and environmental effects by removing contaminants from the groundwater and preventing the continued migration of the contaminant plume.

Summary

In addition to the advantages described above, this alternative would include attempted remediation of contaminated groundwater from the Quaternary age alluvium. This alternative does not attempt remediation of contaminated Stanley Formation groundwater.

Remediation of Identified Sources and Groundwater From the Stanley Shale Formation and Quaternary Age Alluvium on Umetco Property

This alternative would consist of implementation of the remedial technologies described above. The extraction of groundwater shall be conducted for a period of seven (7) years or would cease when analyzed parameters at selected monitoring locations indicate that further groundwater quality improvement is statistically improbable.

Costs

($0.00)

Engineering Feasibility

Groundwater extraction by recovery wells drains are proven remedial technologies. The locations of the wells, collection lines, and utilities for each of these technologies is technically feasible.

Public Health and Environmental Effects

This alternative has positive public health and environmental effects by removing contaminants from the groundwater and preventing the continued migration of the contaminant plume.

Summary

Summary

In addition to the advantages described above, this alternative would include attempted remediation of contaminated groundwater from both the Stanley Formation and the Quaternary age alluvium.

Selection of Remedial Technique

Based on the review of remediation technologies and the screening of alternatives it is possible to identify an alternative that is both cost effective and technologically feasible and that would best the stated objectives of remediation. It is felt that sources remediation must be incorporated into any final remediation plan. The superiority of recovery wells over natural clean up processes, however, is less clear. Although the costs are not exceedingly high for recovery well installation and operation, it is felt that the resulting benefits of such activities may not warrant their inclusion into the plan at this time.

It is recommended, then, that the final remediation plan include the following:

a) remediation of all identified sources;

b) monitor existing monitoring wells and identified stream and seepage locations on a semi-annual basis;

c) Report semi-annual analytical results to ADPC&E within 30 days of receipt of all results;

d) At the end of five (5) years monitoring, a re-evaluation of the plume based on all analytical results will be made to ADPC&E. The evaluation will incorporate any necessary recommendations to assure that the objectives of remediation are being met.

CHAPTER IV

SUMMARY

An ever increasing number of hydrogeologists are today involved in field evaluations of contaminated ground water resources. A systematic approach to site characterization and remedial design of contaminated ground waters is argued in this document.

Although numerous attempts have been presented to offer guidance to the field hydrogeologist attempting to work with ground water contamination problems, only recently has sufficient field experience been attained to provide adequate field procedures applicable to a wide variety of hydrogeologic situations. Commonly, guidance for the field hydrogeologist, and in some cases state or federal regulations, was best applied to unique hydrogeologic situations. Applying these to other localities often proved to be inadequate.

A case study that incorporates activities from initial complaint through final remediation design is presented to demonstrate a systematic approach to site characterization and remediation. The chosen site for demonstration was one that exhibited fairly complex geologic and hydrogeologic characteristics. This example well emphasized the point that work plans must be continuously reviewed and, where necessary, revised during site characterization.

The hydrogeologist is most often employed by a client that has been identified as at least a potential contaminator of a ground water resource. In some instances the hydrogeologist will be hired by the lead agency to direct or conduct the specified evaluations and remediation. A systematic approach to site characterization and remediation design is important to both the lead agency involved and to the client of the hydrogeologist. The lead agency is interested in a timely and complete remediation of the ground water resource. The client is also interested in a timely and complete remediation but is also interested in minimizing costs of the project. In order to assure that the concerns of each party are satisfied a systematic approach to site characterization and remediation is necessary.

Figure 1 presents a flow chart outlining such an approach as indicated above. Although each component may be repositioned and in some special cases components may be added or deleted, the overall integrity of the approach remains intact. The basic premise of the presented approach is the utilization of hydrogeologic techniques in their proper sequencing by qualified technicians within the context of a specific hydrogeologic situation. This is contrary to previous guidance which sometimes advocated utilization of techniques that were successful elsewhere regardless of their appropriateness to the project at hand. This is now possible due to the recently acquired experiences of a wide variety of hydrogeologists working in many hydrogeologic environments. These experiences are the direct result of state and federal legislations that have required the analysis and where necessary the remediation of many of the nations ground water resources.

In order to apply appropriate techniques to specific situations that the hydrogeologist might encounter in the field, it will be necessary to evaluate each step of the operation and be flexible enough to revise earlier developed work plans accordingly. Numerous data gathering techniques, may be or should be employed by the hydrogeologist to characterize a potentially contaminated site. Each of these techniques will provide the hydrogeologist with additional data that must be interpreted and assimilated with previously acquired data. Each acquired data set will potentially reveal some aspect of the situation not previously expected. Incorporating these revelations into the work plans dictates a flexible, systematic approach. This flexibility, however, must be acceptable to the lead agencies and clients involved with each project. It then becomes the role of the hydrogeologist early in the project to educate both the client and the lead agency of the necessity of flexibility in site characterization and remedial design.

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APPENDIX A

DRILLING LOGS

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 3 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE 10-29-87 | STARTED 8:00 am | COMPLETED 5:30 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 | HOLE NO. 1.1B

6. TYPE DRILL RIG
CME 75

5. DRILLING AGENCY
DISC

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" I.D. Hollow Stem Auger

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
27308N 76793E

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
36.5'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 8 | DISTURBED 8 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Dr. Jerry Overton/Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

UO-87
HOLE NO. 1.1B

PROJECT UMETCO

ELEVATION TOP OF HOLE 404.55

SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	0 – 2	Sand, silty, minor gravel, brown	SM	Bag 1 0-2'		Dry 0 to 2'
402.55	2	Sand, silty, clayey with increasing gravel content with depth	GC			Dry to moist 2' to 4'
400.55	4	Clay, silty, sandy, gravelly, gravel 0.25" diameter	GM-GC	Bag 2 4' to 5'		Cutting dry due to heat produced by hard drilling
396.55	8	Alluvial gravel, clayey, gravel primarily novaculite up to 1" diameter, brown to red, clay content increasing with depth		Bag 3 9' to 10' Bag 4 14' to 15'		
387.55	17	See next page	SW			
	18					

DRILLING LOG (Cont. sheet)

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

UO-87
HOLE NO. 1.1B

PROJECT UMETCO

ELEVATION TOP OF HOLE 404.55

SHEET 3
OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USCS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Sand, gravelly, clayey, tan				
	19			Bag 5 19' to 20'		
	20					
	21					
	22					
	23					
	24			Bag 6 24' to 25'		
	25					
	26					
	27					
	28					
	29			Bag 7 29' to 30'		
	30					
	31					
	32					
	33					
	34					
	35					
368.55	36		ML-CL			--Bag 8 36' to 36.5'
	36.5					Total depth of hole 36.5'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF 3 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE | STARTED | COMPLETED
10-29-87 | 7:30 am | 10:00 am

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER
7-2439-0101

HOLE NO.
2.1A

6. TYPE DRILL RIG
CME 75-

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" I.D. Hollow Stem Auger

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
27294N 77029E

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
404.74

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
26'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 5 | DISTURBED 5 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	HOLE NO. 2.1A
PROJECT UMETCO	ELEVATION TOP OF HOLE 404.74	SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Sand, silty, clayey, dark brown	ML-CL	Bag 1 0-6"		
403.74	1	Clay, silty, sandy, gravelly	GM-GC			
	2					
	3					
	4			Bag 2 4' to 5'		
	5					
	6					
	7					
396.74	8	Gravel, clayey, silty, sandy, gravel sandstone and novaculite, angular, average 0.25" diameter				
	9			Bag 3 9' to 10'		Drilling slow and difficult 8' to 16', took 40 minutes.
	10					
	11					
	12					
	13					
	14			Bag 4 14' to 15'		
	15					
388.74	16	Clay, silty, sandy, gravelly gravel angular, 0.25" to 1.0" diameter				
	17					
	18					

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	HOLE NO. 2.1A
PROJECT UMETCO	ELEVATION TOP OF HOLE 404.74	SHEET 3 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	19			Bag 5 19' to 20'		Pulled bit at 21', water on bit
384.74	20	Gravel, clayey, silty, sandy, brown.	GC			
	21					
	22					
	23					
	24			Bag 6 24' to 25'		
	25					
378.74	26					Total depth of hole 26'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 3 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigaion

2. DATE HOLE — STARTED 10-22-87 11:30am — COMPLETED 10-23-87 10:00am

3. JOB NUMBER 77-2439-0101 — HOLE NO. 2.1B

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

5. DRILLING AGENCY
DISC

6. TYPE DRILL RIG
CME 75-

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" I.D. Hollow Stem Auger

9. LOCATION (coordinates or station)
27293N 77037E

10. LOCATION SKETCH (reference to design baseline and/or monuments)

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION — DURING DRILLING — AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
404.82

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
38'

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 8 — DISTURBED 8 — UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

22. SAMPLES SENT TO LAB FOR TESTING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UU-87-2.1B HOLE NO.
PROJECT UMETCO	ELEVATION TOP OF HOLE 404.82	SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Sand, clayey, silty, brown	ML-CL	Bag 1 0-6"	▥▨	
403.82	1	Sand, very fine-fine, silty, clayey, granule and gravel, tan to brown, gravel average diameter 0.25" to 0.5"	GM-GC		⁞▨	
400.82	4	Sand, fine, silty, clayey, gravelly, brown		Bag 2 4' to 5'	⁞▨	
396.82	8	Gravel, sandy, clayey, gravel composed of sandstone and novaculite fragments.		Bag 3 9' to 10' Bag 4 14' to 15'	⁞▨	Took 45 minutes to advance 8' to 18 '
386.82	18					

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87-2.1B HOLE NO.
PROJECT UMETCO	ELEVATION TOP OF HOLE 404.82	SHEET 3 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Sand, gravelly, silty, clayey, gravel 0.25" to 1.0 " diameter average novaculite			○	
	19		SW	Bag 5 19' to 20'	○	
	20				○	
	21				○	
	22				○	
	23				○	
	24			Bag 6 24' to 25'	○	
	25				○	
	26				○	
	27				○	
376.82	28	Sand, medium to coarse, silty, gravelly, tannish-brown			○	
	29			BAG 7 29'to 30'	○	
	30				○	
	32				○	NOTE: Scale change at 32'
	34				○	
				BAG 8	○	34' to 35' NOTE: Scale change at 36'
	36				○	
	37				○	
367.32		Clay, gray, plastic	ML-CL	BAG 9	▥ ▨	*37.5' to 38'
366.82	38					Total depth of hole 38'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 4 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE

	STARTED	COMPLETED
10-20-87	9:00 am	4:00 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 HOLE NO. 3.1

6. TYPE DRILL RIG
CME 75

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" I.D. Hollow Stem Auger

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
27342N 77492E

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION DURING DRILLING ____ AFTER ____ HRS
date ____
time ____
elev ____

13. ELEVATION TOP OF HOLE
411.80

14. DIRECTION OF HOLE
☐ VERTICAL ☐ INCLINED ____° FROM VERTICAL
____ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
50

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN

	DISTURBED	UNDISTURBED
8	8	0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

21. SOIL SAMPLING (If applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

22. SAMPLES SENT TO LAB FOR TESTING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 3-1
PROJECT UMETCO	ELEVATION TOP OF HOLE 411.80	SHEET 2 OF 4 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Clay, silty, sandy, brown	ML-CL	Bag 1 0-6"		
410.80	1	Clay, silty, sandy, gravelly, red gravel granule size to 0.5" diameter	GM-GC			
	2					
	3					
	4			Bag 2 4' to 5'		
	5					
	6					
	7					
	8					
	9			Bag 3 9' to 10'		
401.80	10	Clay, sandy to sand, clayey, sand fine to medium, minor amounts of gravel, tan	SM-SC			
	11					
	12					
	13					
	14			Bag 4 14' to 15'		
	15					
	16					
	17					
	18					

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87-3.1 HOLE NO.
PROJECT UMETCO	ELEVATION TOP OF HOLE 411.80	SHEET 3 OF 4 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	19 20 21 22 23 24	Gravel, silty, sandy, clayey, tan gravel 0.25" to 0.5" average diameter	GM-GC	Bag 5 19' to 20' Bag 6 24' to 25'		Drilling slow and difficult Pulled bit at 20' to check condition of bit. Bit worn but usable.
386.80	25 26 27 28 29	Clay, silty, sandy, gravelly, brown		Bag 7 29' to 30'		
381.80	30 31 32 33 34	No cuttings, likely same as 35' to 49'				Drilling time approximately 2 minutes 30' to 35'
376.80	35 36	Sand, medium to coarse, gravelly, gravel 0.25" to 0.5" average diameter	SW			

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	U0-87-3.1 HOLE NO.
PROJECT UMETCO	ELEVATION TOP OF HOLE	SHEET 4 OF 4 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	37					
	38					
	39			Bag 8 39' to 40'		
	40					
	41					
	42					
	43					
	44			Bag 9 44' to 45'		
	45					
	46					
	47					
	48					
362.80	49	Clay, stiff, gray	ML-CL			
361.80	50					Total depth of hole 50'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE 11-21-87 | STARTED 8:30 am | COMPLETED 11-25-87 12:15 pm

3. JOB NUMBER 7-2439-0101 | HOLE NO. 3.2

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

5. DRILLING AGENCY
DISC.

6. TYPE DRILL RIG
CME 75-

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
5.75" Diameter Tri-Cone Rockbit

9. LOCATION (coordinates or station)
27344N 77499E

10. LOCATION SKETCH (reference to design baseline and/or monuments)

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
411.89

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______ ° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
51'

16. DEPTH DRILLED INTO ROCK
22'

17. TOTAL DEPTH OF HOLE
73'

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 4 | DISTURBED 4 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

22. SAMPLES SENT TO LAB FOR TESTING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 3.2
PROJECT UMETCO	ELEVATION TOP OF HOLE 411.88	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	10 20 30 40	Interval not logged 0 to 49'				See log of boring 3.1 located within 10' Hollow stem auger 0 to 51'
362.88	50	Clay, gray, plastic	ML-CL	Bag 1 49'-51'	▥ ▨	Note scale change at 49'
360.88	52 54 56 58 60 62 64 66 68 70 72	Shale, dark gray to black, milky quartz from fractures and joints 51' to 58' and 66' to 71'	Shale	Bag 2 54'-55' Bag 3 58' to 60' Bag 4 64'-65' Bag 5 69'-70'	▤	Air drilling 51' to 73'
338.88						Total depth of hole 73'

HOLE NO.

DRILLING LOG

S&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE
9-4-87
STARTED
8:00 am
COMPLETED
5:15 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER
7-2439-0101
HOLE NO.
4.1

6. TYPE DRILL RIG
CME 75

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" ID Hollow Stem Auger

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Mike Ruffin - Driller
Floyd Summerhill - Driller's Helper

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 27706 E 77964

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION
DURING DRILLING
AFTER ________ HRS
date
time
elev

13. ELEVATION TOP OF HOLE
420.90

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED
________° FROM VERTICAL
________ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
30'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN
8
DISTURBED
8
UNDISTURBED
0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Dr. Jerry Overton

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 4.1
PROJECT UMETCO	ELEVATION TOP OF HOLE 420.90	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	2 4	Sandy, gravelly alluvium, large novaculite fragments (to 4" diameter) medium to well rounded, some sandstone fragments	GM-GC	Bag 1 0-1' Bag 2 4'-5'		Dry to slightly damp 0 to 5'
415.90	6 8 10 12 14	Sandy, gravelly alluvium with increased clay content, red to gray		Bag 3 9'-10' Bag 4 14'-15'		Easily remolded, damp to moist with moisture increasing to 15'
405.90	16 18 20	Sandy, gravelly alluvium, increasing clay content 15' to 21'		Bag 5 19'-20'		Moisture increasing 15' to 21'
399.90	22 24	Clay, dark red, shale fragments yellow	ML-CL	Bag 6 24'-25'		Dry 21' to 25'
395.90	26 28	Shale, gray to tan, very hard	Shale	Bag 7 29'-30'		Dry 25' to 30'
390.90	30					Total depth of hole 30'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE STARTED 11-10-87 11:40 am COMPLETED 1:45 pm

3. JOB NUMBER 7-2439-0101 HOLE NO. 6.1

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

5. DRILLING AGENCY
DISC.

6. TYPE DRILL RIG
CME 75

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" ID Hollow Stem Auger

9. LOCATION (coordinates or station)
N 25813 E 77217

10. LOCATION SKETCH (reference to design baseline and/or monuments)

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION DURING DRILLING AFTER ____ HRS
date ____
time ____
elev ____

13. ELEVATION TOP OF HOLE
378.73

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ____° FROM VERTICAL
____ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
12.5'

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 3 DISTURBED 3 UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

22. SAMPLES SENT TO LAB FOR TESTING

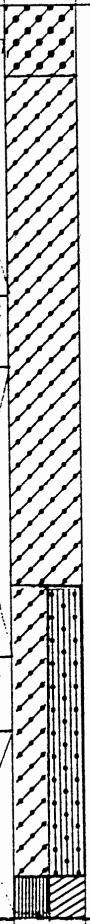
23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 6.1
PROJECT UMETCO	ELEVATION TOP OF HOLE 378.73	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Silt, Sandy, Clayey, Brown	SC	Bag 1 0-6"		
377.73	1 2 3 4 5 6 7	Sand, clayey, gravelly, light gray to tan	GC	Bag 2 4' to 5'		
370.73	8 9 10 11	Gravel, sandy, clayey, light gray to tan	GC-GM	Bag 3 9' to 10'		
366.73	12	Clay, gray	ML-CL			
366.23						Total depth of hole 12.5'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE	STARTED	COMPLETED
12-2-87	11:30 am	4:50 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER	HOLE NO.
7-2439-0101	6.2

6. TYPE DRILL RIG
CME 75

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
5.75" diameter Tri-cone rockbit

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 25819 E 77215

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
378.90

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
12'

16. DEPTH DRILLED INTO ROCK
20.3'

17. TOTAL DEPTH OF HOLE
32.3'

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED	UNDISTURBED
4	4	0

22. SAMPLES SENT TO LAB FOR TESTING

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (If applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 6.2
PROJECT UMETCO	ELEVATION TOP OF HOLE 378.90	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	6	Interval not logged 0-12'				See log of boring 6.1 located within 10' Hollow stem auger 0 to 13'
366.90	12	Clay, gray	ML-CL			Note scale change at 12' Air drilling 13' to 32.3'
365.90	14 16	Shale, dark gray to black, gravel layers approximately 3" thick at 13', 18', 21', and 27'	Shale	Bag 1 13' to 18'		
	18 20 22			Bag 2 18' to 23'		
	24 26			Bag 3 23' to 28'		
	28 30			Bag 4 28' to 32.3'		
346.90	32					Total depth of hole 32.3'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE 11-6-87 | STARTED 10:05 am | COMPLETED 1:00 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 | HOLE NO. 7.1

6. TYPE DRILL RIG
CME 75-

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" ID Hollow Stem Auger

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 26238 E 77326

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ________ HRS
date ________
time ________
elev ________

13. ELEVATION TOP OF HOLE
385.92

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________° FROM VERTICAL
________ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
21'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 4 | DISTURBED 4 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 7.1
PROJECT UMETCO	ELEVATION TOP OF HOLE 385.92	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Silt, sandy, brown	SC			
384.92	1	Clay, sandy, gravelly, red	GC-GM			
	2					
	3					
381.92	4	Clay, silty, sandy, gravelly, red				
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
372.92	13	Sand, clayey, gravelly, tan				Note scale change 13' to 21'
	15					
	17					
	19					
364.92	21					Total depth of hole 21'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE
12-8-87
STARTED
4:00 pm
COMPLETED
12-10-87
2:20 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER
7-2439-0101

HOLE NO.
7.2

6. TYPE DRILL RIG
CME 75-

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
5.75" Diameter Tri-cone rock bit

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 26234 E 77318

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
385.98

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
25'

16. DEPTH DRILLED INTO ROCK
21'

17. TOTAL DEPTH OF HOLE
46'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED	UNDISTURBED
4	4	0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 7.2
PROJECT UMETCO	ELEVATION TOP OF HOLE 385.98	SHEET OF SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
364.98	5 10 15 20	Interval not logged 0 to 21'				See log of 7.1 located within 10' Hollow stem auger 0 to 21'
360.98	25	Clay, gray and shale, gray, weathered	ML-CL		▥▨	Hollow stem auger 21' to 25'
339.98	30 35 40 45	Shale, gray to black, fractures and joints contain quartz	Shale	Bag 1 25'-30' Bag 2 30' - 35' Bag 3 35' - 40' Bag 4 40' - 46'	▤	
						Total depth of hole 46'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE 10-9-87 | STARTED 8:00 am | COMPLETED 1:00 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 | HOLE NO. 8.1

6. TYPE DRILL RIG
CME 75 -

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" ID Hollow Stem Auger

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
27237N 76459E

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
405.89

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
19'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 5 | DISTURBED 5 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	HOLE NO. 8.1
PROJECT UMETCO	ELEVATION TOP OF HOLE 405.89	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	1 2 3	Gravel, sandy, clayey, brown	GC	Bag 1 0-6"	▨	0 to 4' likely fill material on top of swampy area represented by 4' to 5.5'
401.89	4 5	Clay, silty, sandy, gray, wood fragments	ML-CL	Bag 2 4' to 5'	▥▨	
400.39	6 7 8 9 10 11 12 13 14 15 17	Gravel, silty, sandy, tan, gravel rounded, 0.25 to 1.0" diameter	GM	Bag 3 9' to 10' Bag 4 14'-15' Bag 5 18-19'	▥	Note scale change at 15' Pulled bit at 15', water on bit Gravel content increasing 15' to 19'
386.89	19					Total depth of hole 19'

HOLE NO.

DRILLING LOG

S&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE | STARTED 12-11-87 2:00 pm | COMPLETED 12-12-87 4:00 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101

HOLE NO. 8.2

6. TYPE DRILL RIG CME 75 -

5. DRILLING AGENCY Disc.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
5.75" Diameter Tri-cone rock bit

7. NAMES OF DRILLER AND CREW
Steve Schrum - Forman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
27240N 76468E

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
405.84

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
33'

16. DEPTH DRILLED INTO ROCK
18.5'

17. TOTAL DEPTH OF HOLE
51.5'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 4	DISTURBED 4	UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 8.2
PROJECT UMETCO	ELEVATION TOP OF HOLE 405.84	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	5 10 15	Interval not logged 0 to 19'				See log of 8.1 located within 10' Hollow stem auger 0 to 19'
386.84	20	No cuttings - see remarks				Hollow stem auger 19' to 33'
384.84	25	Sand, gravelly, tan gravel 0.25" to 0.5" diameter	SW	Bag 1		19' to 21' interval likely continuation of 16'-19' interval logged in 8.1
375.84	30	Sand, silty	SM			30' to 33' cuttings very thin mud
372.84	35	Clay, gray	ML-CL			
368.84	40 45	Shale, dark gray to black	Shale	Bag 2 37-42 Bag 3 42-48 Bag 4 48-51.5		Air drilling 37' to 51.5' Encountered extremely hard quartz zone at 51.5, driller could not penetrate
354.34	50					
						Total depth of hole 51.5'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE 9-3-87 | STARTED 9:30 am | COMPLETED 4:00 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 | HOLE NO. 9.1

6. TYPE DRILL RIG
CME 75

5. DRILLING AGENCY
DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
6.25" I.D. Hollow Stem Augers

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Mike Ruffin - Driller
Floyd Summerhill - Driller's Helper

9. LOCATION (coordinates or station)
N 27491 E 78186

10. LOCATION SKETCH (reference to design baseline and/or monuments)

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER 20.5 HRS
date 9-4-87
time 12:35 pm
elev 20.3

13. ELEVATION TOP OF HOLE
412.74

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
NA

16. DEPTH DRILLED INTO ROCK
NA

17. TOTAL DEPTH OF HOLE
30'

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 6 | DISTURBED 6 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

21. SOIL SAMPLING (If applicable)
☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".
☒ Soils FIELD classified in accordance with the Unified Soil Classification System
☐ Soils LAB classified

22. SAMPLES SENT TO LAB FOR TESTING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

24. LOGGED BY
Dr. Jerry Overton

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

HOLE NO. UO-87 9-1

PROJECT UMETCO

ELEVATION TOP OF HOLE 412.74

SHEET OF SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		0 to 2" sandy top soil, dry 2" - 5' alluvial/fluvial gravels of sandstone and novaculite, novaculite increases 5' to 9'.		Bag 1		Dry 0 to 9'
	2					
	4		GM-GC	Bag 2		
	6					
	8					
403.74		Clay, gravelly, sandy, silty, brown w/red clay, noduler, gravel primarily novaculite		Bag 3		Damp 9' to 11'
	10					
401.74		Clay, sandy, gravelly, brown, gravel primarily novaculite				Damp to moist 11' to 26'
	12					
	14			Bag 4		
	16					
395.74		Clay, gravelly, brown with gray clay noduler, novaculite fragments				
	18			Bag 5		
392.74	20	Clay, gravelly, sandy, brown with gray clay noduler, novaculite fragments				
	22					
	24			Bag 6		
386.74	26	Clay, gravelly, red to light brown, novaculite and sandstone fragments				Moist to wet 26' to 30'
	28					
382.74	30					Total depth of hole 30'

HOLE NO.

DRILLING LOG

S&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE STARTED 11-17-87 2:13 pm | COMPLETED 11-20-87 1:30 pm

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 | HOLE NO. 9.2

6. TYPE DRILL RIG
CME 75

5. DRILLING AGENCY
DISC

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
5.75" diameter Tri-cone Rock Bit

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 27498 E 78183

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
412.83

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
30'

16. DEPTH DRILLED INTO ROCK
25.6'

17. TOTAL DEPTH OF HOLE
55.6'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 4 | DISTURBED 4 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

UO-87
HOLE NO. 9.2

PROJECT UMETCO

ELEVATION TOP OF HOLE 412.83

SHEET OF SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
	5 10 15 20 25	Interval not logged 0 to 30'				See log of boring 9.1 located within 10' Hollow stem auger 0 to 34'
382.83	30 32	Clay, silty, gray	ML-CL		▥ ▨	Note scale change at 30'
378.83	34 36 38 40	Shale, dark gray to black, milky quartz from fractures and joints	Shale		▤	Air drilling 34' to 55.6
	42 44 46 48			BAG 1	▤	42' - 43'
363.33	50	Sandstone, light gray, very hard	sand-stone	BAG 2	░	49' - 50'
361.83	52	Shale, dark gray to black	Shale		▤	Note scale change at 52'
357.23	55.6			Bag 3 54-55'	▤	Total depth of hole 55.6'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO
Subsurface Contamination Investigation

2. DATE HOLE 12-387 | STARTED 2:15 pm | COMPLETED 12-4-87 9:50 am

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 | HOLE NO. 10.2

6. TYPE DRILL RIG CME 75

5. DRILLING AGENCY DISC.

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
5.75' Diameter tri-cone rock bit

7. NAMES OF DRILLER AND CREW
Steve Schrum - Foreman
Glenn Nesbitt - Driller

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
26625N 78079E

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
388.75

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
9'

16. DEPTH DRILLED INTO ROCK
22'

17. TOTAL DEPTH OF HOLE
31'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN 4 | DISTURBED 4 | UNDISTURBED 0

19. TOTAL NO. CORE BOXES
NA

20. TOTAL CORE RECOVERY FOR BORING
NA

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
Wil Hawkins

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-87 HOLE NO. 10.2
PROJECT UMETCO	ELEVATION TOP OF HOLE 388.88	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Clay, silty, sandy, brown	ML-CL	Bag 1	▨	Hollow stem auger 0 to 9'
386.78	2 4 6 8	Clay, sandy, tan, cohesive			▨	
379.78	10 12 14	Shale, clayey, gray, dry	Shale	Bag 2 10' to 15'	▤	Air drilling 9' to 31'
372.78	16	Shale, clayey, gray, saturated		Bag 3 15' to 20'	▤	
370.78	18 20 22 24 26 28 30	Shale, dark gray to black		Bag 4 20' to 25' Bag 5 25' to 31'	▤	
357.78						Total depth of hole 31'

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO

2. DATE HOLE
STARTED 6-12-88
COMPLETED 6-12-88

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER
7-2439-0101

HOLE NO.
UO-88-12.2

6. TYPE DRILL RIG
Mayhew 1000

5. DRILLING AGENCY
Foundation Testing Laboratories

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
7 7/8 inch Tri-cone

7. NAMES OF DRILLER AND CREW
Neil Waddell, Randy Godwin,
Danny Jarmon, Chuck Jones

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 29208 E 76342

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
472.57

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
0

16. DEPTH DRILLED INTO ROCK
33'

17. TOTAL DEPTH OF HOLE
33'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED 6 | UNDISTURBED NA

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (If applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
WDH

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	HOLE NO. UO-88-12.2
PROJECT UMETCO 7-2439-0101	ELEVATION TOP OF HOLE 472.57	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
		Clay, silty, sandy, tan	ML-CL	BAG 1 0 TO 5'	▨	
468.57	4.0	Shale, silty, tan-gray, very weathered		BAG 2 5' to 10'	▤	
462.57	9.5	Shale, silty, grayish-black, weathered, thin siltstone beds 12' to 14'.		BAG 3 10' to 15'	▤	
457.57	15.0	Shale, silty, gray		BAG 4 15' to 20'	▤	Water at 18'
454.57	18.0	Siltstone, gray, iron stained cuttings large-up to 1.5" diameter		BAG 5 20' to 25'	▦	
449.57	23.0	Shale, silty, black		BAG 6 25' to 33'	▤	Fractures at 28' and 29'
439.57	33.0					

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF 2 SHEETS

1. PROJECT
UMETCO

2. DATE HOLE

	STARTED	COMPLETED
	6-13-88	6-13-88

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER
7-2439-0101

HOLE NO.
UO-88-13.1

6. TYPE DRILL RIG
Mayhew 1000

5. DRILLING AGENCY
Foundation Testing Laboratories

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
7 7/8 inch Tri-cone

7. NAMES OF DRILLER AND CREW
Neil Waddell,
Randy Godwin,
Chuck Jones

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 28684 E 76473

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION

	DURING DRILLING	AFTER ______ HRS
date		
time		
elev		

13. ELEVATION TOP OF HOLE
437.71

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED
______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
9.5

16. DEPTH DRILLED INTO ROCK
0

17. TOTAL DEPTH OF HOLE
9.5'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN

	DISTURBED	UNDISTURBED
	0	NA

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
WDH

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 528 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-88-13.1 HOLE NO.
PROJECT UMETCO 7-2439-0101	ELEVATION TOP OF HOLE 437.71	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
437.71		Fill - gravel, silty, sandy, brown	GM		▥	Cuttings dry
433.71	4.0	Clay, Silty, gravelly, brown	GM- GC		▥ ▨	Cuttings moist at 4' Cuttings wet at 7'
430.71	7.0	Clay, tan	ML- CL		▥ ▨	
428.21	9.5					

HOLE NO.

DRILLING LOG

S&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF SHEETS

1. PROJECT
UMETCO

2. DATE HOLE | STARTED 6-10-88 | COMPLETED 6-16-88

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER 7-2439-0101 | HOLE NO. UO-88-13.2

6. TYPE DRILL RIG
Mayhew 1000

5. DRILLING AGENCY
Foundation Testing Labortories

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
12.25 inch Tri-cone
6.25 inch Tri-cone

7. NAMES OF DRILLER AND CREW
Neil Waddell, Randy Godwin
Danny Jarmon, Chuck Jones

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 28686 E 76464

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ____ HRS
date ____
time ____
elev ____

13. ELEVATION TOP OF HOLE
438.32

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ____° FROM VERTICAL
____ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
13.5

16. DEPTH DRILLED INTO ROCK
21.5

17. TOTAL DEPTH OF HOLE
35'

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED 7 | UNDISTURBED NA

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
WDH

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

UO-88-13.2
HOLE NO.

PROJECT UMETCO 7-2439-0101

ELEVATION TOP OF HOLE 438.32

SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
434.32	4.0	Fill - gravel, silty, sandy, brown	GM	BAG 1 0 to 5'		Cuttings dry
431.32	7.0	Clay, silty, gravelly, brown	GM-GC	BAG 2 5' to 10'		Cuttings moist at 4' Cuttings wet at 7'
428.82	9.5	Clay, tan	ML-CL			
424.82	13.5	Clay, shaley, tan	ML-CL	BAG 3 10' to 15'		
409.32	29.0	Shale, silty, gray		BAG 4 15' to 20' BAG 5 20' to 25' BAG 6 25' to 30'		Cuttings dry 13.5' to 23' Cuttings moist 23' to 25' Cuttings wet at 25'
406.32	32.0	Siltstone, gray		BAG 7 30' to 35'		Cuttings wet
403.32	35.0	Interbedded siltstone & shale, gray, thin sandstone bed at 32.5 tan to red, quartzitic, milky quartz in fractures				

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT: UMETCO

2. DATE HOLE: STARTED 6-9-88 | COMPLETED 6-9-88

4. PURPOSE OF HOLE (monitoring well, test boring, etc.): Monitoring Well

3. JOB NUMBER: 7-2439-0101 | HOLE NO. UO-88-14.1

6. TYPE DRILL RIG: Mayhew 1000

5. DRILLING AGENCY: Foundation Testing Laboratories

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S): 7 7/8 inch Tri-cone

7. NAMES OF DRILLER AND CREW:
Neil Waddell,
Randy Godwin

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station): N 28675 E 77181

11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ____ HRS
date ____
time ____
elev ____

13. ELEVATION TOP OF HOLE: 441.06

14. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____° FROM VERTICAL ____ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN: 22

16. DEPTH DRILLED INTO ROCK: 0

17. TOTAL DEPTH OF HOLE: 22

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5 | UNDISTURBED NA

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY: WDH

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	U0-88-14.1 HOLE NO.
PROJECT UMETCO 7-2439-0101	ELEVATION TOP OF HOLE 441.06	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
441.06		Fill - gravel, quartzitic, and silt, gray	GM	BAG 1 0 to 5'	⁞	
438.06	2.5	Clay, silty, red, plastic	ML-CL	BAG 2 5' to 10'	▥▨	Cuttings moist
434.06	7.0	Clay, gravelly-gravel primarily novaculite and sandstone	GM-GC	BAG 3 10' to 15'	⁞▨	
430.06	11.0	Gravel, silty, primarily novaculite, siltstone, and sandstone	GM	BAG 4 15' to 20'	⁞	Cuttings average 1/16" to ½" diameter, cuttings dry
420.56	20.5	Clay, silty, gray, plastic	ML-CL	BAG 5 20-22'	▥▨	Cuttings moist
419.00	22.0					

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 3 SHEETS

1. PROJECT: UMETCO

2. DATE HOLE — STARTED: 6-9-88 — COMPLETED: 6-14-88

3. JOB NUMBER: 7-2439-0101 — HOLE NO.: UO-88-14.2

4. PURPOSE OF HOLE (monitoring well, test boring, etc.): Monitoring Well

5. DRILLING AGENCY: Foundation Testing Laboratories

6. TYPE DRILL RIG: Mayhew 1000

7. NAMES OF DRILLER AND CREW:
Neil Waddell,
Randy Godwin,
Chuck Jones

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S):
12.25 inch Tri-cone
6.25 inch Tri-cone

9. LOCATION (coordinates or station): N 28665 E 77205

10. LOCATION SKETCH (reference to design baseline and/or monuments)

11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL

12. WATER LEVEL ELEVATION — DURING DRILLING ______ — AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE: 440.08

14. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL ______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN: 34

16. DEPTH DRILLED INTO ROCK: 21.7

17. TOTAL DEPTH OF HOLE: 55.7

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: 7 — UNDISTURBED: NA

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

22. SAMPLES SENT TO LAB FOR TESTING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

24. LOGGED BY: WDH

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 757-2366	UO-88-14.2 HOLE NO.
PROJECT UMETCO 7-2439-0101	ELEVATION TOP OF HOLE 440.08	SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
440.08		Fill, gravel-quartzitic, silty gray	GM			
437.58	2.5	Clay, silty, red, plastic	ML-CL			Cuttings moist
433.08	7.0	Clay, gravelly-gravel composed primarily of sandstone and novaculite	GM-GC			
429.08	11.0	Gravel, silty, gravel composed primarily of sandstone and novaculite	GM			Cuttings average 1/16" to ½" diameter, cuttings dry
419.58	20.5	Clay, silty, gray to red brown, very plastic	ML-CL	BAG 1 20' to 25' BAG 2 25' to 30' BAG 3 30' to 35'		Cuttings moist
406.08	34.0	Shale, silty, gray to tan, iron stained, weathered				Cuttings dry

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-88-14.2 HOLE NO.
PROJECT UMETCO 7-2439-0101	ELEVATION TOP OF HOLE 440.08	SHEET 3 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
				BAG 4 35' to 40'		
400.08	40.0	Interbedded siltstones and shales gray to black, iron stains, quartz filled fractures		BAG 5 40' to 45'	▨	
				BAG 6 45' to 50'	▨	
				BAG 7 50' to 55.7'	▨	
384.38	55.7					

38
40
42
44
46
48
50
52
54

HOLE NO.

DRILLING LOG

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1 OF 2 SHEETS

1. PROJECT
UMETCO

2. DATE HOLE | STARTED 6-11-88 | COMPLETED 6-11-88

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER
7-2439-0101

HOLE NO.
UO-88-15.1

6. TYPE DRILL RIG
Mayhew 1000

5. DRILLING AGENCY
Foundation Testing Laboratories

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
7 7/8 inch Tri-cone

7. NAMES OF DRILLER AND CREW
Neil Waddel, Randy Godwin,
Danny Jarmon, Chuck Jones

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 28123 E 78050

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
426.72

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
22

16. DEPTH DRILLED INTO ROCK
0

17. TOTAL DEPTH OF HOLE
22

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED 0 | UNDISTURBED NA

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
WDH

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)	S&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	UO-88-15.1 HOLE NO.
PROJECT UMETCO 7-2439-0101	ELEVATION TOP OF HOLE 426.72	SHEET 2 OF 2 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
426.72		Fill, gravel, silty, sandy	GM			
424.72	2	Clay, silty, red	ML			Cutting moist
423.72	3	Gravel, clayey, silty, brown	GM-GC			Cuttings moist
405.72	21	Clay, silty, gray and brown	ML-CL			
404.72	22					

HOLE NO.

DRILLING LOG

E&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

SHEET 1
OF 3 SHEETS

1. PROJECT
UMETCO

2. DATE HOLE | STARTED 6-11-88 | COMPLETED 6-15-88

4. PURPOSE OF HOLE (monitoring well, test boring, etc.)
Monitoring Well

3. JOB NUMBER
7-2439-0101

HOLE NO.
UO-88-15.2

6. TYPE DRILL RIG
Mayhew 1000

5. DRILLING AGENCY
Foundation Testing Laboratories

8. SIZE AND TYPE OF SAMPLER AND/OR BIT(S)
12.25 inch Tri-cone
6.25 inch Tri-cone

7. NAMES OF DRILLER AND CREW
Neil Waddell, Randy Godwin,
Danny Jarmon, Chuck Jones

10. LOCATION SKETCH (reference to design baseline and/or monuments)

9. LOCATION (coordinates or station)
N 28131 E 78037

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
MSL

12. WATER LEVEL ELEVATION | DURING DRILLING | AFTER ______ HRS
date ______
time ______
elev ______

13. ELEVATION TOP OF HOLE
427.23

14. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______° FROM VERTICAL
______ BEARING ref. to magnetic north

15. THICKNESS OF OVERBURDEN
27

16. DEPTH DRILLED INTO ROCK
26

17. TOTAL DEPTH OF HOLE
53

22. SAMPLES SENT TO LAB FOR TESTING

18. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED 10 | UNDISTURBED NA

19. TOTAL NO. CORE BOXES

20. TOTAL CORE RECOVERY FOR BORING

23. SPECIAL FIELD TEST CONDUCTED (list with brief summary of results)

21. SOIL SAMPLING (if applicable)

☐ Blows per foot: Number required to drive 1 3/8" splitspoon with 140 lb. hammer falling 30".

☒ Soils FIELD classified in accordance with the Unified Soil Classification System

☐ Soils LAB classified

24. LOGGED BY
WDH

25. DRILL LOG CHECKED BY

HOLE NO.

DRILLING LOG (Cont. sheet)

B&F ENGINEERING, INC.
928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366

HOLE NO. UO-88-15.2

PROJECT UMETCO 7-2439-0101

ELEVATION TOP OF HOLE 427.23

SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
427.23		Fill - gravel, silty, sandy	GM	BAG 1 0 to 5'		
425.23	2	Clay, silty, red	ML			Cuttings moist
424.23	3	Gravel, clayey, silty, brown	GM-GC	BAG 2 5' to 10' BAG 3 10' to 15' BAG 4 15' to 20'		Cuttings moist
407.23	20	Clay, silty, gray to tan brown	ML-CL	BAG 5 20' to 25' BAG 6 25' to 30'		
400.23	27	Interbedded siltstone and shale, tan to brown, very weathered	☒			Cuttings moist
396.23	31	Shale, tan brown, weathered	☒	BAG 7 30' to 35'		Cuttings moist
392.23	35	Shale, black, iron stained	☒			Borehole began to produce water

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36

DRILLING LOG (Cont. sheet)	B&F ENGINEERING, INC. 928 AIRPORT RD., HOT SPRINGS, ARK. 71913 767-2366	U0-88-15.2 HOLE NO.
PROJECT UMETCO 7-2439-0101	ELEVATION TOP OF HOLE 427.23	SHEET 3 OF 3 SHEETS

ELEV. a	DEPTH b	DESCRIPTION c	USC USGS d	SAMPLE INTERVAL e	GRAPHIC LOG f	REMARKS (Blow count, pull information, % core recovery, significant observations)
391.23		Interbedded siltstone and shale, grayish black		BAG 8 35' to 40' BAG 9 40' to 45'	▨	
382.23	45	Shale, silty, black		BAG 10 45' to 53'	▨	Cuttings dusty
	51.5	Sandstone, quartzitic, w/thin siltstone and shale stringers			▨	Quartz filling of fractures
374.23	53					

38 40 42 44 46 48 50 52

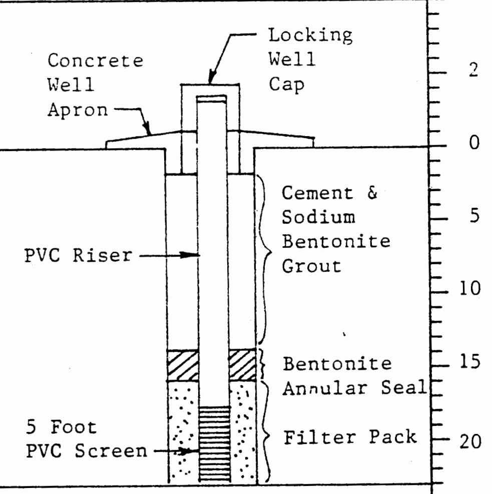
APPENDIX B

MONITORING WELL INSTALLATION RECORDS

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS	Graphic Log
404.41	0	sand, clayey, silty, brown	sm	
403.41	1	Sand, silty, clayey, gravelly, red, gravel-average diameter 0.25", angular	GC	
398.41	6	Gravel, sandy, clayey, silty, red, gravel-average diameter 0.25" to 0.5"	GM-GC	
398.41	15	Gravel, sandy, clayey, silty, gravel-average diameter 1.0"	GC	
381.41	23			

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-1.1A

Job Name/Number Umetco 7-2439-0101

Coordinates N27295.91 E76789.56

Installation Date 10-14-87

Drilling Method Hollow Stem Auger

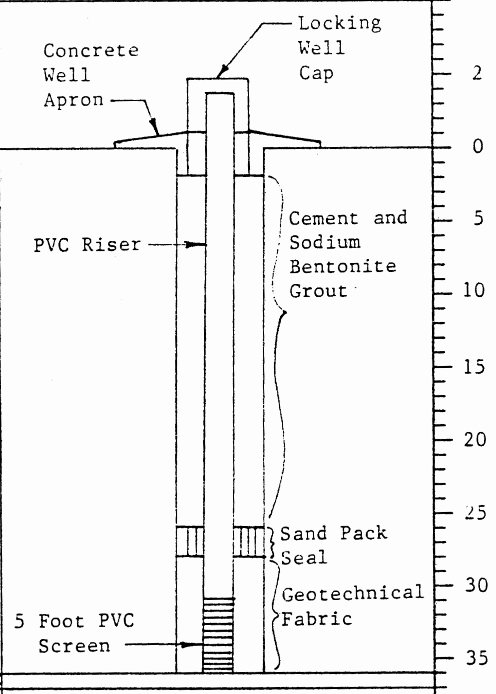
Drilled By Disc Logged By WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS	Graphic Log
404.55	0	sand, silty, some gravel, brown	SM	
402.55	2	sand, silty, clayey, gravelly	GC	
400.55	4	Clay, silty, sandy, gravelly, gravel 0.25" diameter	GM-GC	
396.55	8	Alluvial gravel, clayey, gravel novaculite up to 1.0" diameter, brown to red		
387.55	17	Sand, gravelly, clayey, tan	SW	
368.55	36	Clay, stiff, grain	ml-cl	

Well Completion Detail



B&F ENGINEERING, INC.

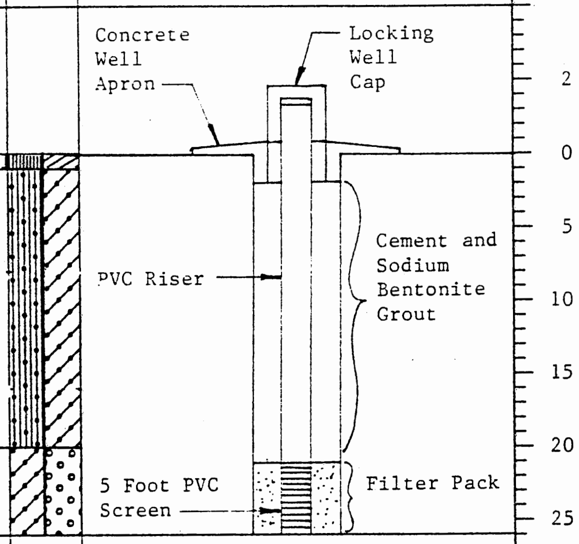
928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-1.1B
Job Name/Number Umetco 7-2439-0101
Coordinates N27308.14 E76793.14
Installation Date 10/29/87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By JVO/WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
404.74	0	Sand, silty, clayey, dark brown	ml-c
403.74	1	Clay, silty, sandy, gravelly	GM-GC
396.74	8	Gravel, clayey, silty, sandy, gravel-sandstone & novaculite anguler, average 0.25" diameter	
388.74	16	Clay, silty, sandy, gravelly, gravel anguler, average 0.25" diameter	
384.74	20	Gravel, clayey, silty, sandy, brown	GC
378.74	26		



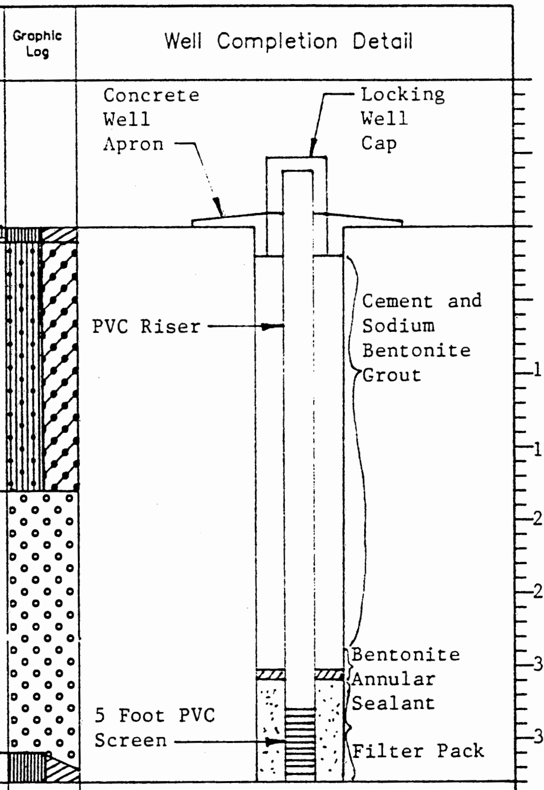
B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record 2.1A
Job Name/Number Umetco 7-2439-0101
Coordinates N27294.44 E77029.17
Installation Date 10/21/87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
404.82	0	sand, clayey, silty, brown	ml-cl
403.82	1.0	Sandy, V. fine to fine, silty, clayey, gravelly, tan to brown	GM-GC
400.82	4.0	Sand, fine, silty, clayey, gravelly, brown	
396.82	8.0	Gravel, sandy, clayey, gravel composed of sandstone & novaculite fragments	
386.82	18.0	Sand, gravelly, silty, clayey, gravel 0.25" to 1.0" diameter, novaculite	SW
376.82	28.0	Sand, medium to coarse, silty, gravelly, tannish-brown	
367.32	37.5	clay, gray, plastic	ml-cl
366.82	38.0		



B&F ENGINEERING, INC.

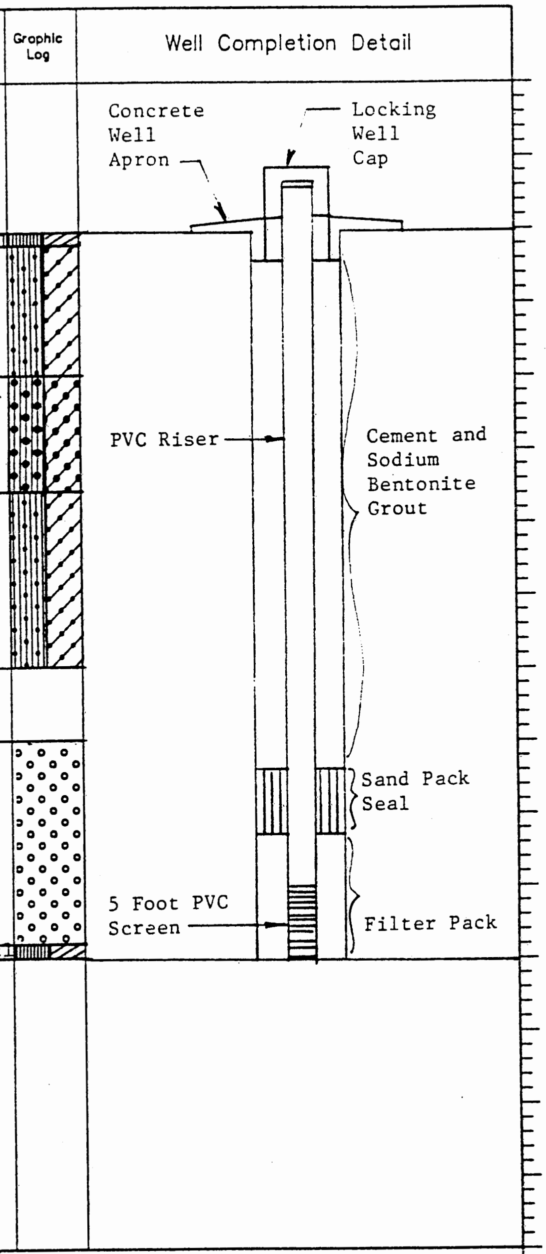
928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-2.1B
Job Name/Number Umetco 7-2439-0101
Coordinates N27293.77 E77037.47
Installation Date 10/23/87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
411.80	1	clay, silty, sandy, brown	ml-c
		Clay, silty, sandy, gravelly, red gravel granule to 0.5" diameter	GM-GC
401.80	10	Clay, sandy to sand, clayey, sand fine to medium, minor amounts of gravel, tan	SM-SC
392.80	18	Gravel, silty, sandy, clayey, tan gravel 0.25" to 0.5" average diameter	GM-GC
386.80	25	Clay, silty, sandy, gravelly, brown	
381.80	30	No cuttings, likely same as 35'-49'	
376.80	35	Sand, medium to coarse, gravelly Gravel 0.25" to 0.5" average diameter	SW
362.80	49	clay, stiff, grain	ml-cl
361.80	50		



B&F ENGINEERING, INC.

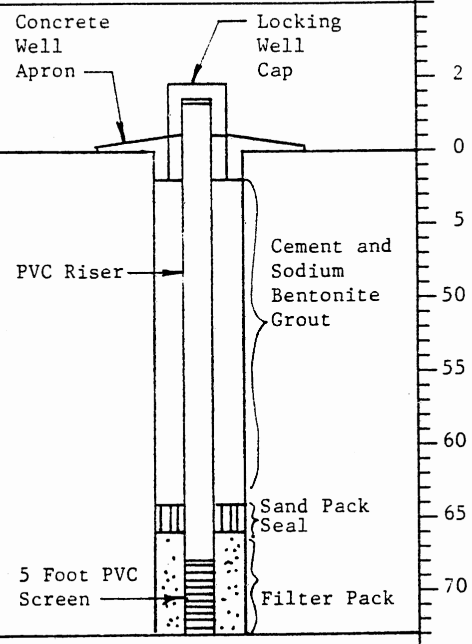
928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-3.1
Job Name/Number Umetco 7-2439-0101
Coordinates N27342.20 E77492.66
Installation Date 11-2-87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS	Graphic Log
411.88	0	Interval not logged 0-49' See log of 3.1		
362.88	49	Clay, gray, plastic 49-51'	ML-C	
360.88	51	Shale, dark gray to black, milky quartz in fractures 51' to 58' and 66' to 71'	Shale	
338.88	73			

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

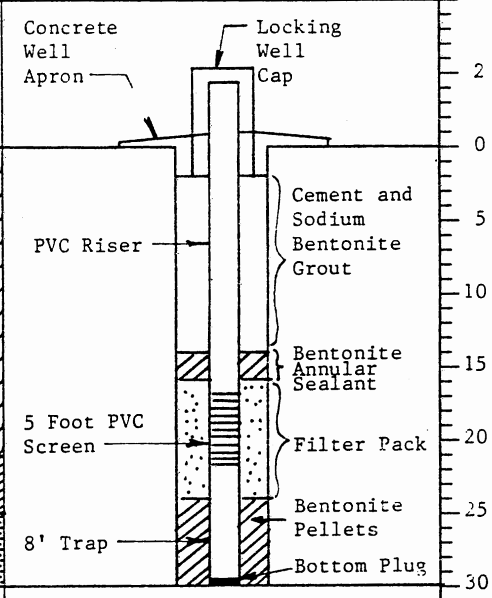
Monitoring Well Record UO-87--3.2
Job Name/Number Umetco 7-2439-0101
Coordinates N27344.56 E77499.08
Installation Date 12-1-87
Drilling Method Air Rotary
Drilled By Disc Logged By WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS	Graphic Log
420.90	0	sandy, gravelly, alluvium, large novaculite fragments to 4" diameter, medium to well rounded, some sandstone fragments	GM-GC	
415.90	5	Sandy, gravelly alluvium with increased clay content, red to gray		
405.90	15	Sandy gravelly alluvium, increasing clay content 15' to 21'		
399.90	21	Clay, dark red, shale fragments, yellow	ML-CL	
395.90	25	Shale, gray to tan, very hard	Shale	
390.90	30			

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

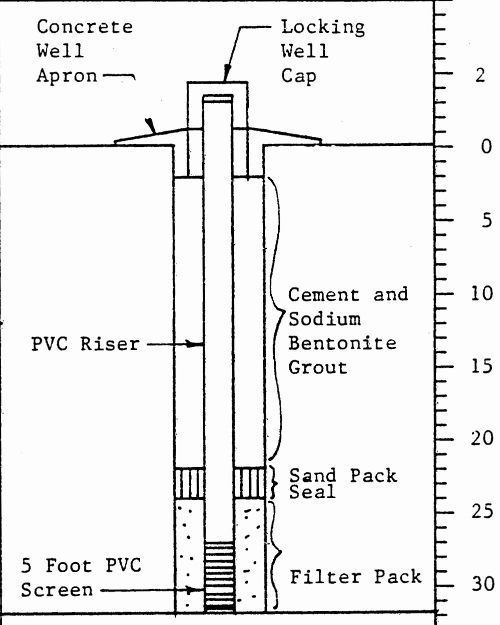
Monitoring Well Record UO-87-4.1
Job Name/Number Umetco 7-2439-0101
Coordinates N27706.27 E77964.45
Installation Date 9/4/87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By JVO

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS	Graphic Log
378.90	0	Interval not logged 0-12' See log 6.1		
366.90	12	Clay, gray	ml-c	
365.90	13	Shale, dark gray to black gravel layers approximately 3" thick at 13', 18', 21' and 27'	Shale	
346.90	32			

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-6.2

Job Name/Number Umetco 7-2439-0101

Coordinates N25819.62 E77215.88

Installation Date 12-3-87

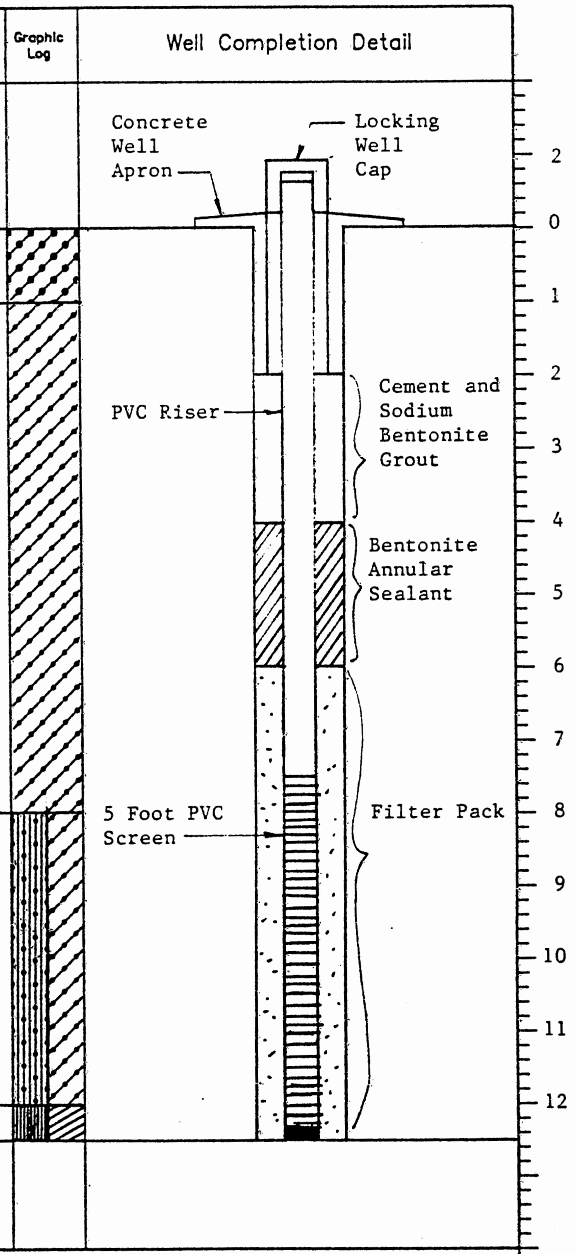
Drilling Method Air Rotary

Drilled By Disc Logged By WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
378.73	0	Silty, sandy, clayey top-soil, brown	SC
377.73	1	Sand, clayey, gravelly, Light gray to tan	GC
370.73	8	Gravel, sandy, clayey, light gray to tan	GM-GC
366.73	12	Clay, gray	ML-CL
366.23	12.5		



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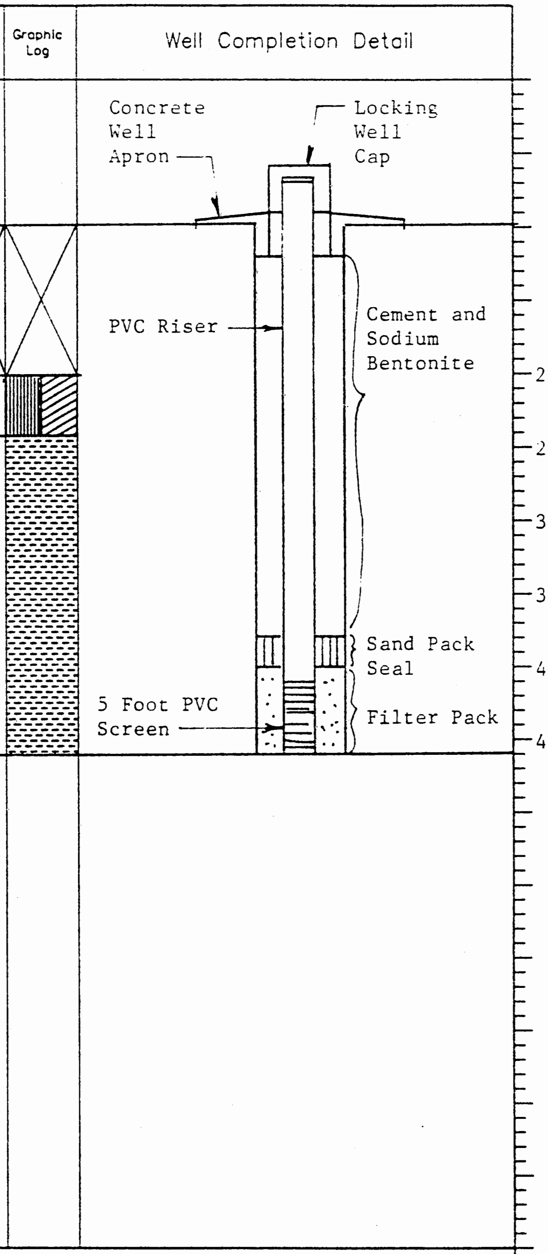
928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-6.1
Job Name/Number Umetco 7-2439-0101
Coordinates N25813.54 E77217.36
Installation Date 11/10/87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
385.98	0	Interval not logged 0-21' See log of 7.1	
364.98	21	Clay, gray, & shale, gray weathered	ML-CL
360.98	25	Shale, gray to black, fractures and joints contain quartz	Shale
339.98	46		



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

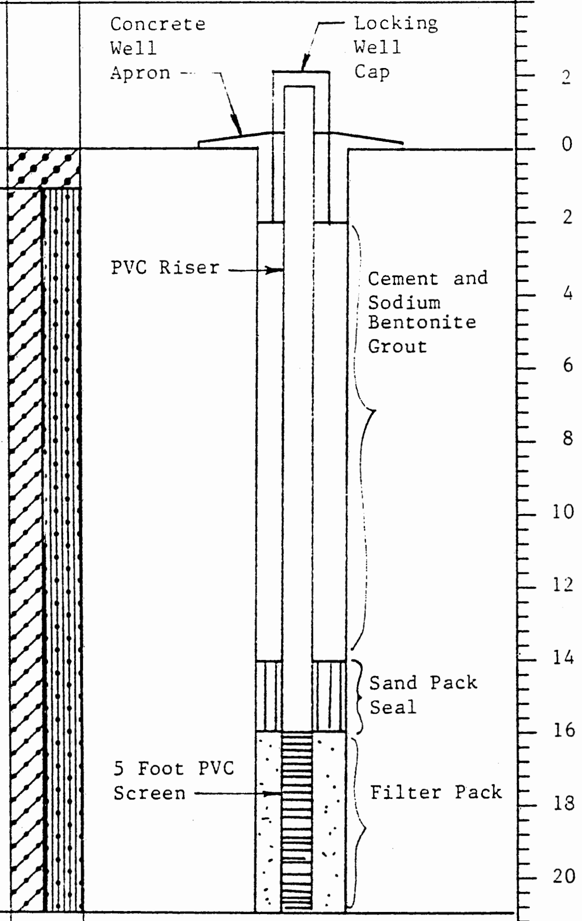
Monitoring Well Record UO-87-7.2
Job Name/Number Umetco 7-2439-0101
Coordinates N26234.13 E77318.10
Installation Date 12/10/87
Drilling Method Air Rotary
Drilled By Disc Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
385.92	0	Silt, sandy, brown	SC
384.92	1	Clay, sandy, gravelly, red	GC-GM
381.92	4	Clay, silty, sandy, gravelly, red	
372.92	13	Sand, clayey, gravelly, tan	
364.92	21		

Graphic Log

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-7.1

Job Name/Number Umetco 7-2439-0101

Coordinates N26238.57 E77326.26

Installation Date 11-6-87

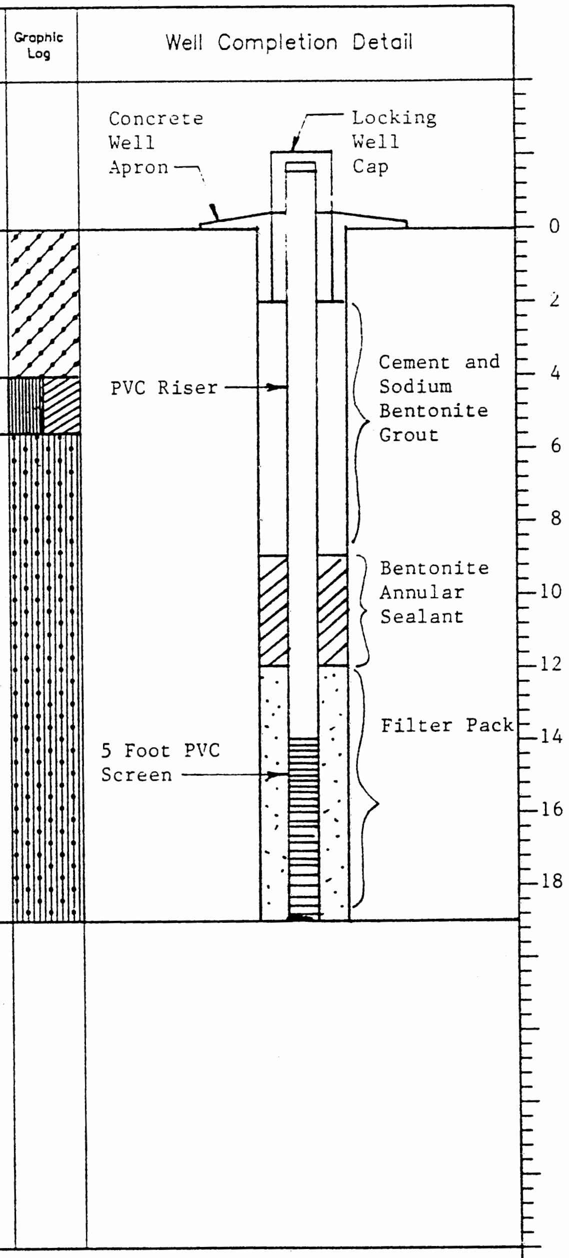
Drilling Method Hollow Stem Auger

Drilled By Disc Logged By WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
405.89	0	Gravel, sandy, clayey, brown	GC
401.89	4.0	Clay, silty, sandy, gray, wood fragments	ML-CL
400.39	5.5	Gravel, silty, sandy, tan, gravel rounded, 0.25" to 0.5" diameter	GM
386.89	19		



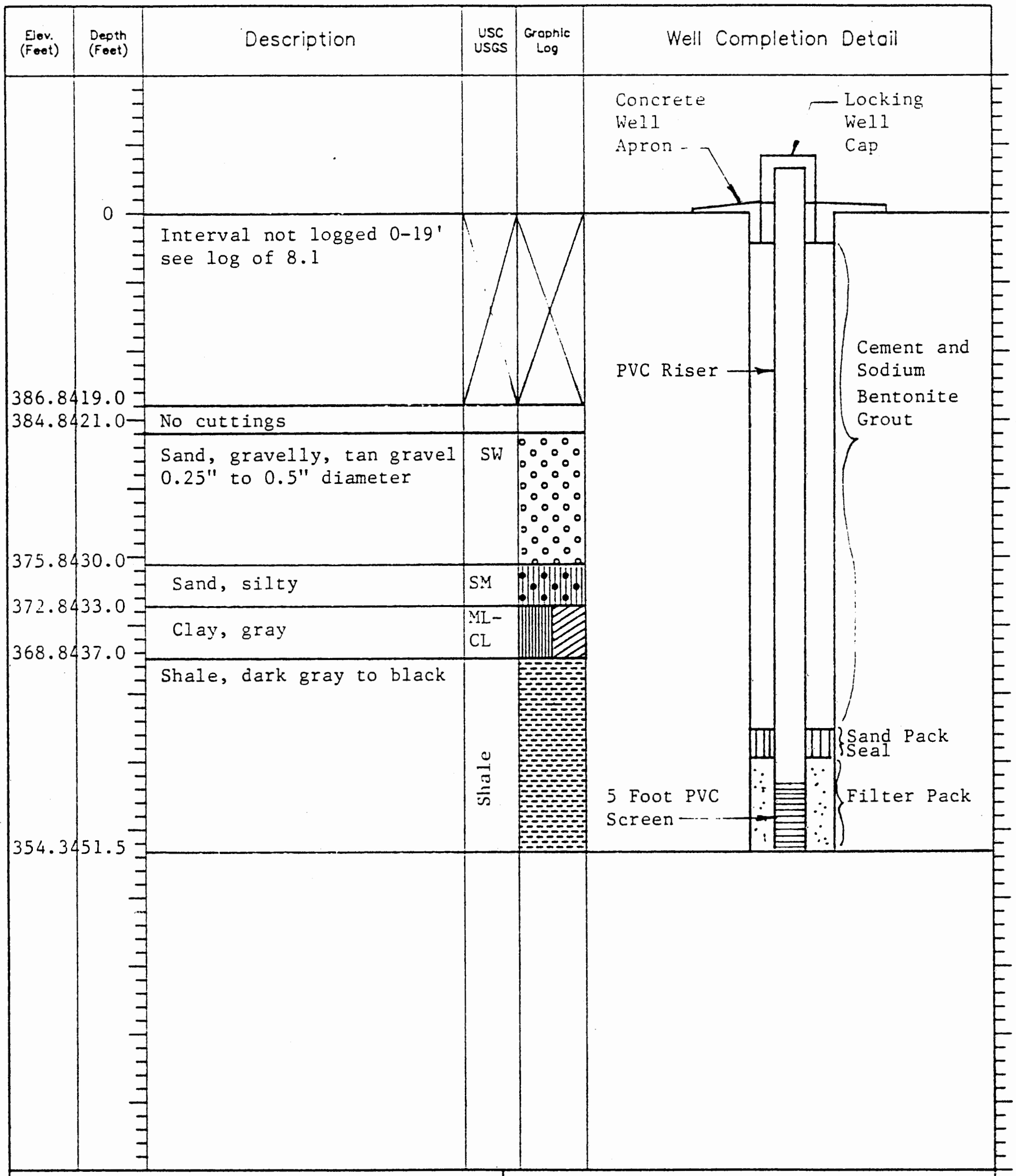
B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-8.1
Job Name/Number Umetco 7-2439-0101
Coordinates N27237.57 E76459.41
Installation Date 10-9-87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD



Elev. (Feet)	Depth (Feet)	Description	USC USGS	Graphic Log
	0	Interval not logged 0-19' see log of 8.1		
386.84	19.0	No cuttings		
384.84	21.0	Sand, gravelly, tan gravel 0.25" to 0.5" diameter	SW	
375.84	30.0	Sand, silty	SM	
372.84	33.0	Clay, gray	ML-CL	
368.84	37.0	Shale, dark gray to black	Shale	
354.34	51.5			

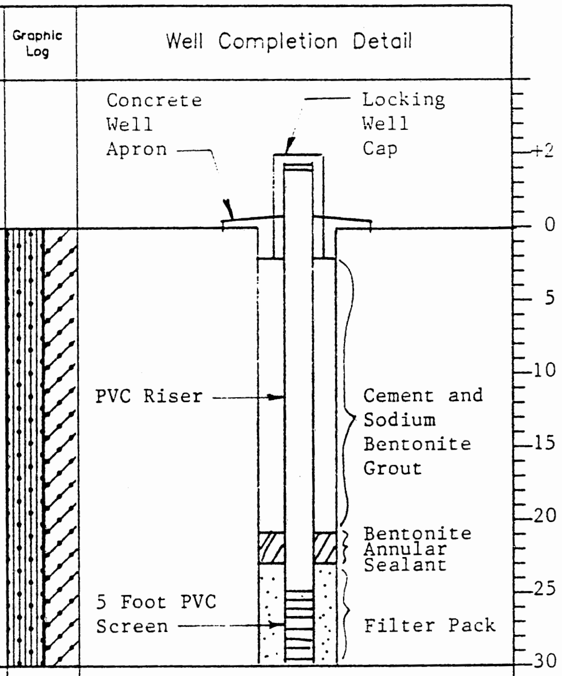
B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-8.2
Job Name/Number Umetco 7-2439-0101
Coordinates N27240.33 E76468.99
Installation Date 12-15-87
Drilling Method Air Rotary
Drilled By Disc Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
412.74	0	0-2" Sandy topsoil 2"-5' Allnvial/fluvial gravels of sandstone and novaculite	GM-GC
403.74	9	Clay,gravelly, sandy, silty	
401.74	11	Clay, sandy, gravelly, brown, gravel primarily novaculite	
395.74	17	Clay, gravelly, clay nodules, brown, gravel primarily novaculite	
392.74	20	Clay, gravelly, sandy, brown, with gray clay nodule , novaculite fragments	
386.74	26	Clay, gravelly, red-brown novaculite & sandstone fragments	
382.74	30		



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928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

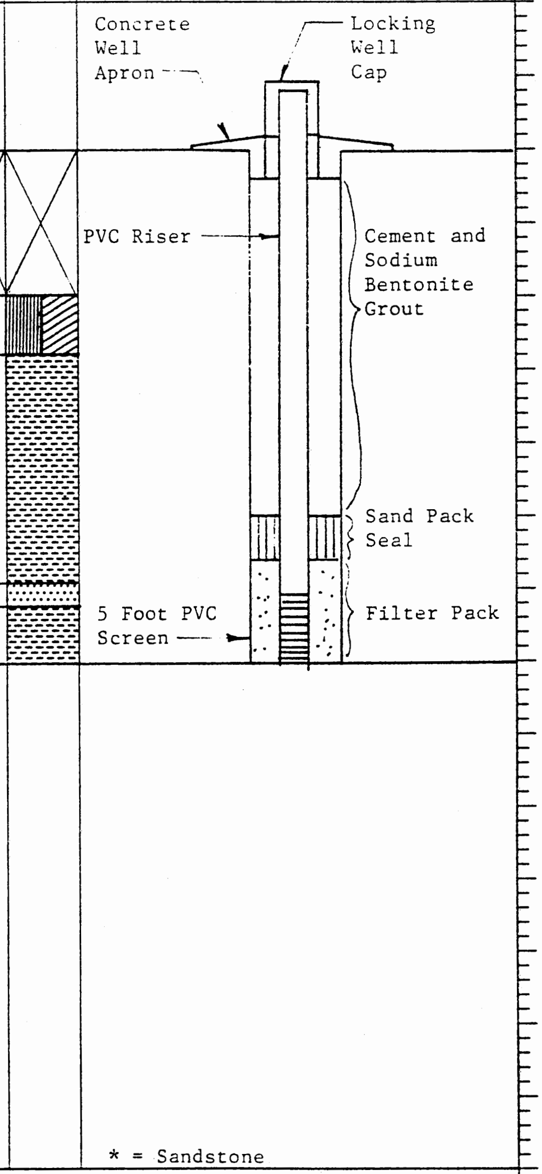
Monitoring Well Record UO-87-9.1
Job Name/Number Umetco 7-2439-0101
Coordinates N27491.19 E78185.66
Installation Date 9/3/87
Drilling Method Hollow Stem Auger
Drilled By Disc Logged By JVO
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
412.83	0	Interval not logged, see log of boring 9.1	
282.83	30.0	Clay, silty, gray	ML-CL
378.83	34.0	Shale, dark gray to black, milky quartz from fractures and joints	Shale
363.33	49.5	sandstone, light gray, very hard	*
361.83	51.0	Shale, dark gray to black	Shale
357.23	55.6		

Graphic Log

Well Completion Detail



* = Sandstone

B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-9.2
Job Name/Number Umetco 7-2439-0101
Coordinates N27498.23 E78183.21
Installation Date 11/20/87
Drilling Method Air Rotary
Drilled By Disc Logged By WDH

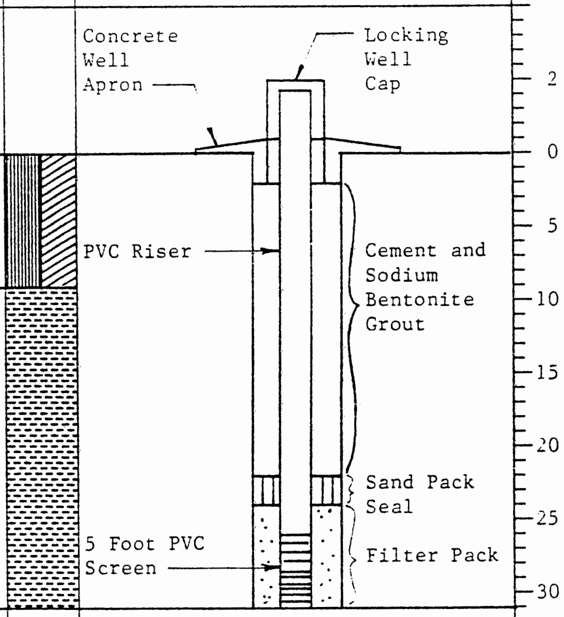
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
388.78		Clay, silty, sandy, brown	ML-
386.78	2	Clay, sandy, tan, cohesive	CL
379.78	9	Shale, clayey, gray, dry	Shale
372.78	16	Shale, clayey, gray, saturated	
370.78	18	Shale, dark gray to black	
357.78			

Graphic Log

Well Completion Detail



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928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-87-10.2

Job Name/Number Umetco 7-2439-0101

Coordinates N26625.20 E78079.84

Installation Date 12/7/87

Drilling Method Air Rotary

Drilled By Disc Logged By WDH

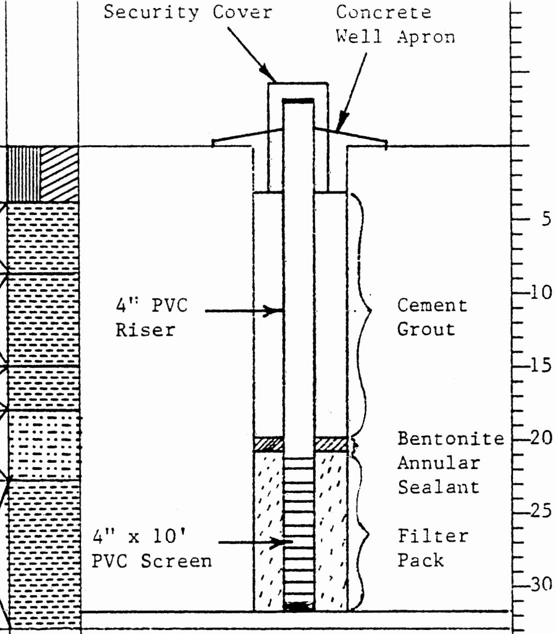
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
472.57	0	Clay, silty, sandy, tan	ML-CL
468.57	4.0	Shale, silty, tan-gray, very weathered	
462.97	9.5	Shale, silty, grayish black, weathered, thin siltstone beds 12' to 14'	
457.57	15.0	Shale, silty, gray	
454.57	18.0	Siltstone, gray, iron stained	
449.57	23.0	Shale, silty, black	
439.57	33.0		

Graphic Log

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-88-12.2

Job Name/Number UMETCO 7-2439-0101

Coordinates N 29208 E 76342

Installation Date 6-12-88

Drilling Method Air Rotary

Drilled By FTL Logged By WDH

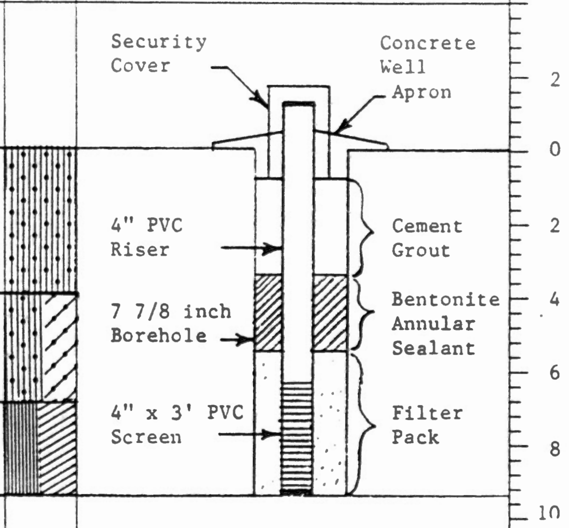
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
437.71	0	Fill, gravel, silty, sandy; brown	GM
433.71	4.0	Clay, silty, gravelly, brown	GM-GC
430.71	7.0	Clay, tan	ML-CL
428.21	9.5		

Graphic Log

Well Completion Detail



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928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-88-13.1
Job Name/Number UMETCO 7-2439-0101
Coordinates N 28684 E 76473
Installation Date 6-13-88
Drilling Method Air Rotary
Drilled By FTL Logged By WDH

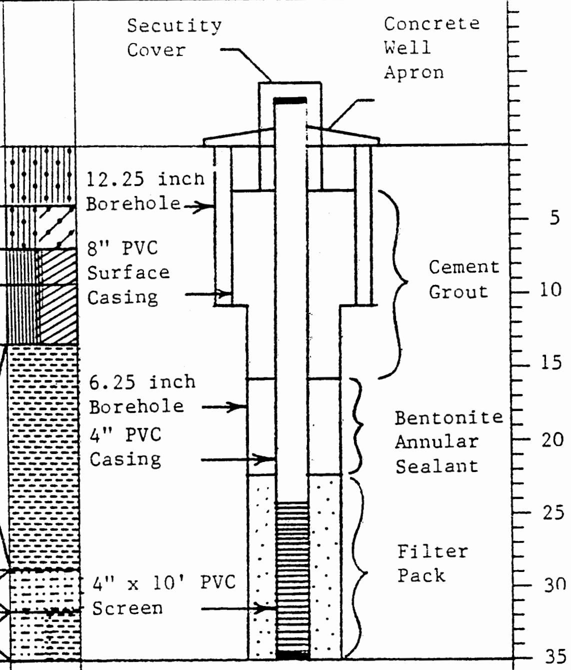
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
438.32	0	Fill - gravel, silty, sandy, brown	GM
434.32	4.0	Clay, silty, gravelly, brown	GM-GC
431.32	7.0	Clay, tan	ML-CL
428.82	9.5	Clay, shale, tan	ML-CL
424.82	13.5	Shale, silty, gray	
409.32	29.0	Siltstone, gray	
406.32	32.0	Interbedded siltstone and Shale	
403.32	35.0		

Graphic Log

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-88-13.2

Job Name/Number UMETCO 7-2439-0101

Coordinates N 28686 E 76464

Installation Date 6-16-88

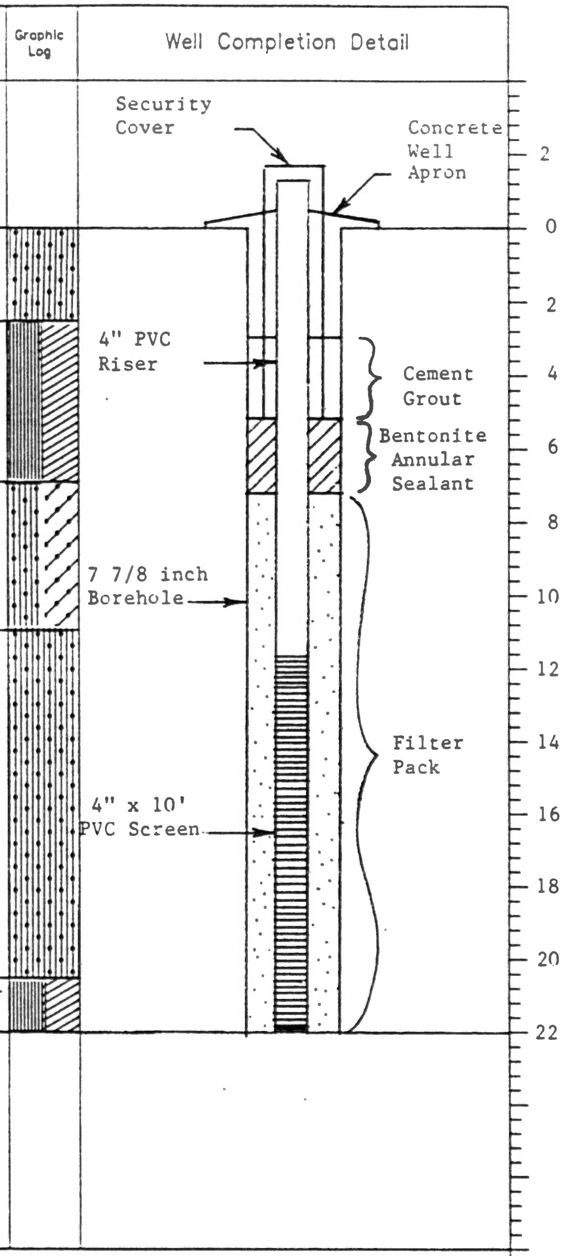
Drilling Method Air Rotary

Drilled By FTL Logged By WDH

Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
441.06	0	Fill - gravel, quartzitic and silt, gray	GM
438.06	2.5	Clay, silty, red, plastic	ML-CL
434.06	7.0	Clay, gravelly-gravel preimarily novaculite and sandstone	GM-GC
430.06	11.0	Gravel, silty, primarily novaculite, siltstone, and sandstoen	GM
420.56	20.5	Clay, silty, gray, plastic	ML-CL
419.06	22.0		



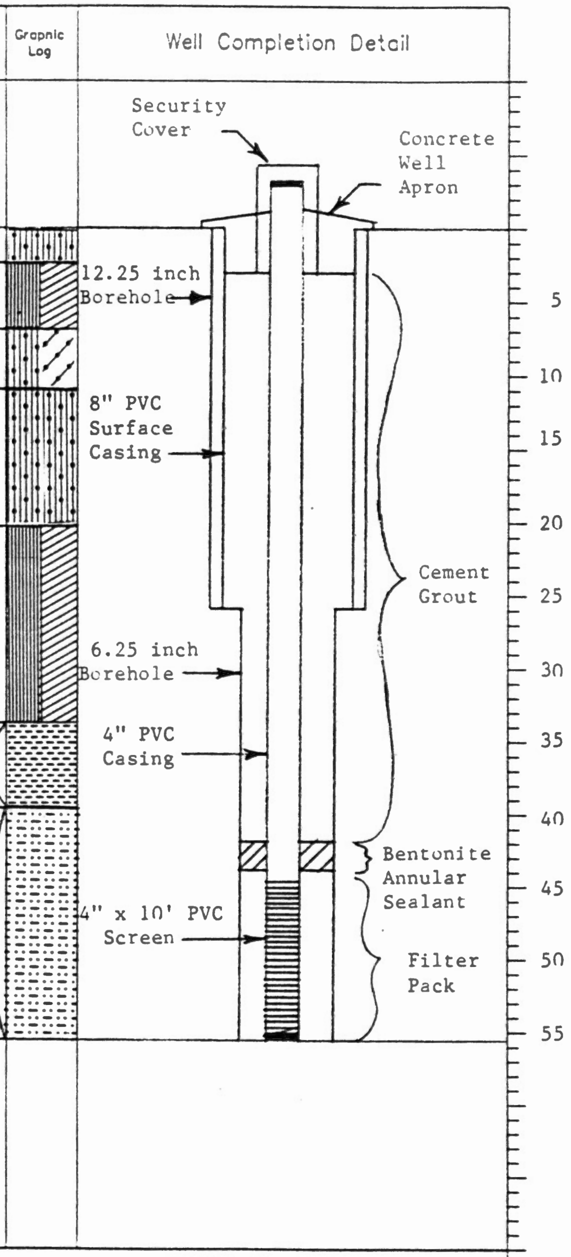
B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-88-14.1
Job Name/Number UMETCO 7-2439-0101
Coordinates N 28675 E 77181
Installation Date 6-9-88
Drilling Method Air Rotary
Drilled By FTL Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
440.08	0	Fill gravel, silty, gray	GM
437.58	2.5	Clay, silty, red, plastic	ML-CL
433.08	7.0	Clay, gravelly, gravel compossed primarily of sandstone & novaculite	GM-GC
429.08	11.0	Gravel, silty, gravel composed primarily of novaculite and sandstone	GM
419.58	20.5	Clay, silty, gray to red brown, very plastic	ML-CL
406.08	34.0	Shale, silty, gray to tan, iron stained, weathered	
400.08	40.0	Interbedded siltstones and shales, gray to black, iron stains, quartz filled fractures	
384.38	55.7		



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

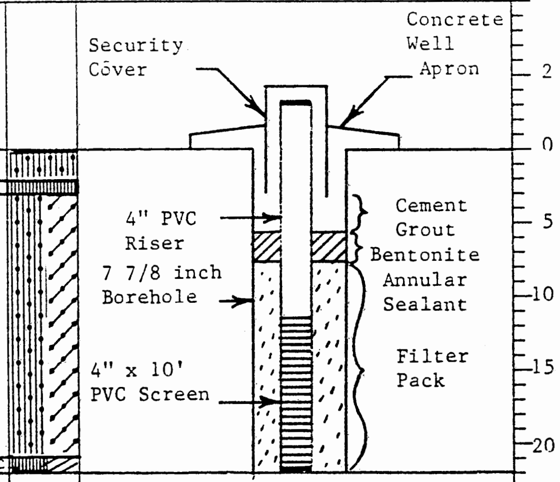
Monitoring Well Record U0-88-14.2
Job Name/Number UMETCO 7-2439-0101
Coordinates N 28665 E 77205
Installation Date 6-14-88
Drilling Method Air Rotary
Drilled By FTL Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
426.72	0	Fill, gravel, silty, sandy	GM
424.72	2	Clay, silty red	ml
423.72	3	Gravel, clayey, silty, brown	GM-GC
405.72	21	Clay, silty, gray, brown	ml-c
404.72	22		

Graphic Log

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

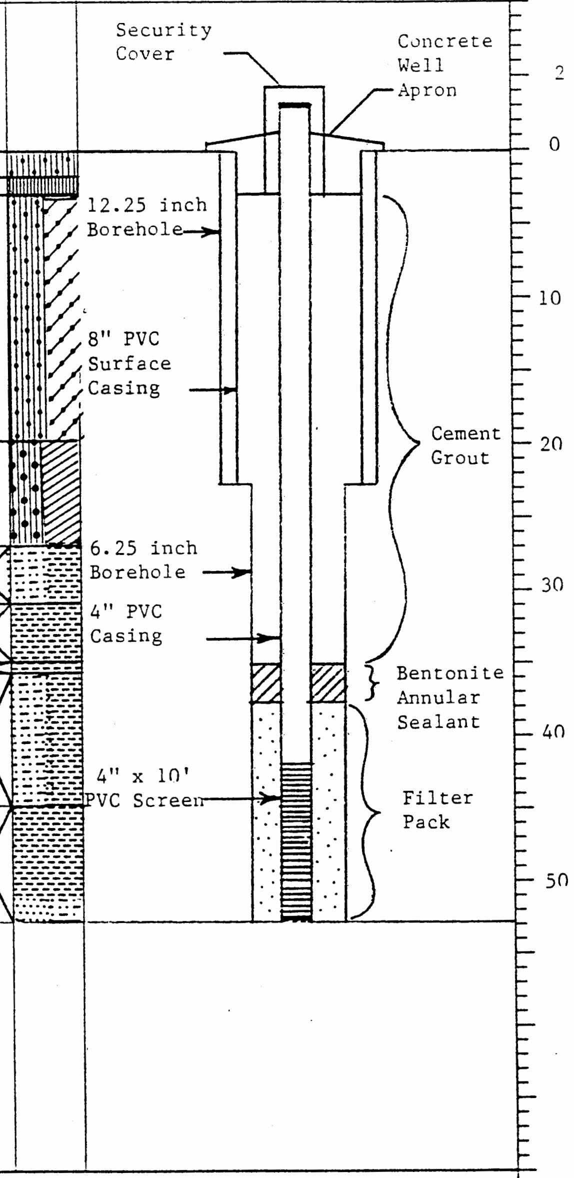
Monitoring Well Record UO-88-15.1
Job Name/Number UMETCO 7-2439-0101
Coordinates N 28123 E 78050
Installation Date 6-11-88
Drilling Method Air Rotary
Drilled By FTL Logged By WDH
Page 1 of

MONITORING WELL INSTALLATION RECORD

Elev. (Feet)	Depth (Feet)	Description	USC USGS
427.23	0	Fill, gravel, silty, sandy	GM
425.23	2	Clay, silty, red	ML
424.23	3	Gravel, clayey, silty, brown	GM-GC
407.23	20	Clay, silty, gray to tan brown	ML-CL
400.23	27	Interbedded siltstone and shale, tan to brown, very weathered	
396.23	31	Shale, tan-brown, weathered	
392.23	35		
391.23	36	Shale, black, iron stained	
		Interbedded siltstones and shales, grayish black	
382.23	45	Shale, silty, black	
375.73	51.5	Sandstone, quartzitic, with thin siltstone & shale stringers	
374.23	53		

Graphic Log

Well Completion Detail



B&F ENGINEERING, INC.

928 AIRPORT ROAD
HOT SPRINGS, ARKANSAS 71913
(501) 767-2366

Monitoring Well Record UO-88-15.2
Job Name/Number UMETCO 7-2439-0101
Coordinates N 28131 E 78037
Installation Date 6-15-88
Drilling Method Air Rotary
Drilled By FTL Logged By WDH

Page 1 of

APPENDIX C

MARFI FABRIC SPECIFICATIONS

MIRAFI®
CONSTRUCTION FABRICS

Typical Properties

Typical property values are statistical means (averages) of test data generated by Mirafi Inc's quality assurance testing. Where direction is not specified, the typical value represents the lower value of the two principal fabric directions.

MIRAFI® CONSTRUCTION FABRICS TYPICAL PROPERTY VALUES

The product specifications are average values. For minimum certified values contact your local Mirafi Representative or the Mirafi Technical Department at 1-800-438-1855.

			DRAINAGE OR EROSION CONTROL		STABILIZATION		SEDIMENTATION CONTROL ENVIROFENCE	ASPHALT OVERLAY
PROPERTY	UNIT	TEST METHOD	140N	700X	500X	600X	(100X)	900N
Weight	oz/sy	ASTM D-3776-79	4.5	6.5	4	6	2.5	4
Thickness	mils	ASTM D-1777-64	60	19	23	30	17	50
Grab Strength	lb	ASTM D-1682-64	120	400 x 250	200	300	100	115
Grab Elongation	%	ASTM D-1682-64	55	35 (max)	30 (max)	35 (max)	30	60
Modulus (10% Elongation)	lb	ASTM D-1682-64	N/A	N/A	115	140	N/A	N/A
Trapezoid Tear Strength	lb	ASTM D-1117-80	50	110 x 55	115	120	65	N/A
Mullen Burst Strength	psi	ASTM D-3786-80[1]	210	490	400	>600	210	N/A
Puncture Strength	lb	ASTM D-3787-80[2]	70	130	85	130	N/A	N/A
Abrasion Resistance	lb	ASTM D-3884-80[3] & D-1682-64	N/A	155	50	100	N/A	N/A
Coef. of Permeability, k	cm/sec	CFMC-GET-2	0.2	0.015	0.002	0.01	0.0009	N/A
Water Flow Rate	gal/min/sf	CFMC-GET-2	285	60	35	50	40	N/A
Air Flow Rate	cf/min/sf	ASTM D-737-75	225	115	N/A	N/A	N/A	290
Equivalent Opening Size (EOS)	US Standard Sieve	COE CW 02215-77	100-	70-100	20-45	20-45	20	N/A
Open Area	%	COE Method	N/A	4.3	N/A	N/A	N/A	N/A
Retention Efficiency (Suspended Solids)	%	Virginia DOT VTM-51	N/A	N/A	N/A	N/A	75	N/A
Slurry Flow Rate	gal/min/sf	Virginia DOT VTM-51	N/A	N/A	N/A	N/A	0.5	N/A
Gradient Ratio	—	COE CW 02215-77	<3	<3	N/A	N/A	N/A	N/A
Ultraviolet Radiation Stability	%	ASTM G-26/ D-1682-64[4]	N/A	90	30	90	90	N/A
Asphalt Retention	oz/sf	Texas DOT Item 3099	N/A	N/A	N/A	N/A	N/A	3.5
Shrinkage from Asphalt	%	Texas DOT Item 3099	N/A	N/A	N/A	N/A	N/A	<6

[1] Diaphragm Bursting Tester

[2] Tension Testing Machine with ring clamp; steel ball replaced with a 5/16 inch diameter solid steel cylinder centered within the ring clamp

[3] ASTM D-1682 as above after abrasion as required by ASTM D-3884 Rotary Platform Double Head Method rubber-base abrasive wheel equal to CS-17 Calibrase by Taber Instrument Co. 1 kg load per wheel, 1000 revolutions

[4] ASTM D-1682 as above after 250 cycles in Xenon-arc Weatherometer Type BH or Type C apparatus as described in ASTM G-26. One cycle consists of 102 minutes of light only, followed by 18 minutes of light with water spray.

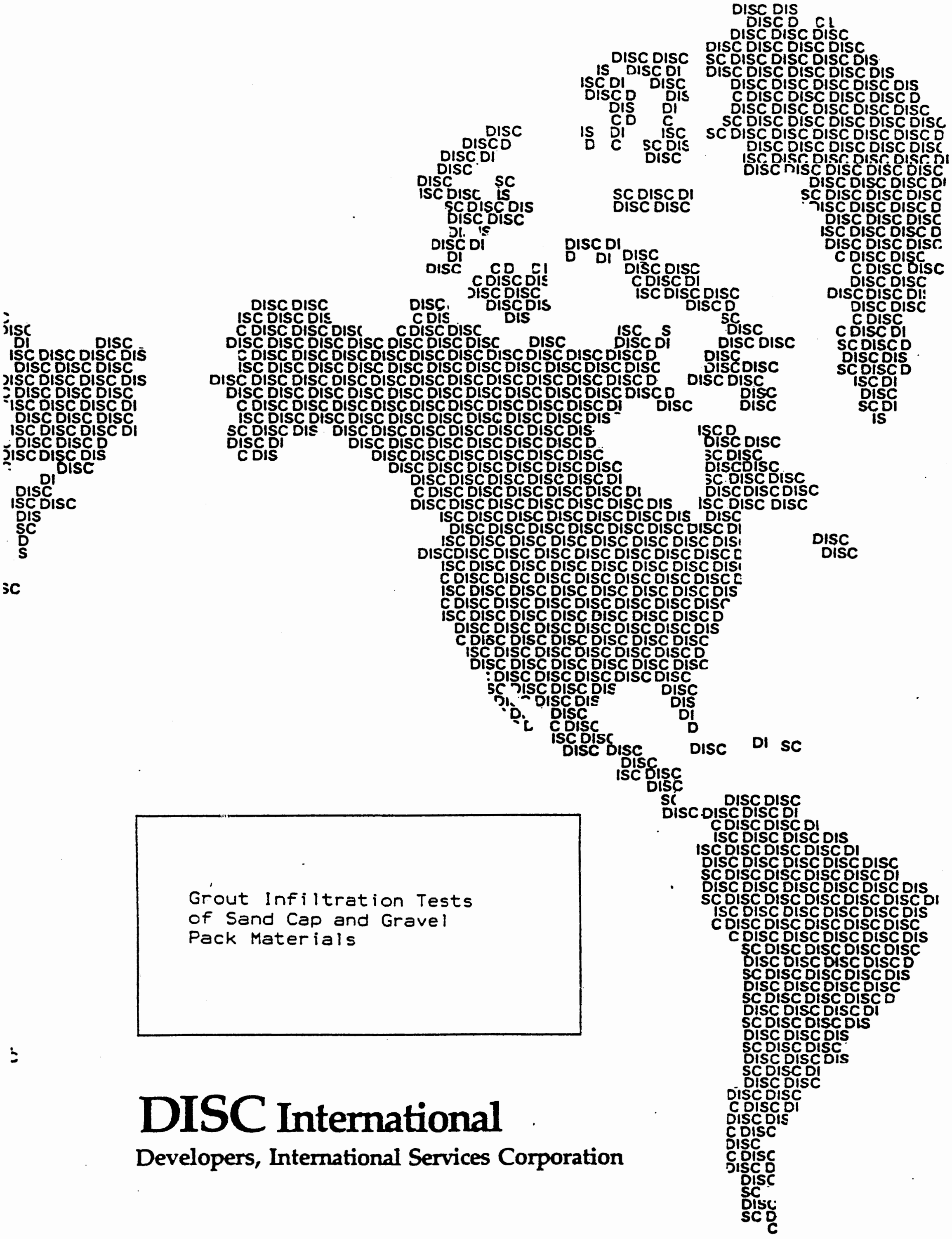
MIRAFI®

For further information contact your local Mirafi Representative, or call toll free 800-438-1855. In Hawaii, Alaska or North Carolina call 704-523-7477. In Canada call 613-632-2788. Telex 216903 MRFI.

A member of the DOMINION TEXTILE group

APPENDIX D

DISC INTERNATIONAL SAND STUDY RESULTS



Grout Infiltration Tests of Sand Cap and Gravel Pack Materials

DISC International

Developers, International Services Corporation

DISC ARKANSAS

- CONSULTANTS
- LABORATORIES
- ENGINEERS
- GEOLOGISTS

P.O. Box 34997
Memphis, Tennessee
38134
(901) 382-6060

18 November 1987
Job No. 2124
Serial No. T-243

UMETCO Minerals Corporation
Post Office Box 943
Hot Springs, Arkansas 71901

Attention: Mr. R. R. Evans

Reference: Grout Infiltration Test of Sand Cap and Gravel Pack Materials

Gentlemen:

In October 1987 DISC performed grout infiltration tests on aggregates proposed for well pack materials. Sand cap and gravel pack proposed for well pack materials were subjected to tests to determine how far cement-bentonite grout would penetrate the aggregate under conditions similar to those which would be encountered during the installation of a typical monitoring well. Attached are photographs showing the test apparatus and actual penetration of grout into the gravel well pack material. Laboratory tests results are presented to show the aggregate gradations, the depth of grout penetration, and other pertinent data.

The penetration tests on sand and gravel were conducted in a four inch diameter PVC pipe mounted with a pressure guage, regulator, and exhaust valve as shown in the attached photographs. A ten inch layer of well pack aggregate was placed in the bottom of the chamber and saturated with water. A layer of cement-bentonite grout was mixed to a consistency that would be used in the field, and was then applied to the top of the aggregate. The test chamber was sealed and a pressure of 28 psi was applied to the grout mixture for approximately four hours. The 28 psi pressure simulates a forty foot head of grout on the materials. After 24 hours had elapsed, the chamber was then stripped and the penetration of the grout into the aggregate was measured.

The grout penetrated the gravel well pack material to a depth of 5.0 inches and the sand well pack material to a depth of 0.125 inches.

Permeability tests were performed on the sand well pack material just beyond the penetration of the grout in the test chamber and compared to the results from permeability tests of the same aggregate not exposed to the grout test. Permeability of the sand was 3.0 X 10 E-1 cm/sec before and after the penetration test. The permeability of gravel was estimated to be 1 cm/sec. The gravel that was not penetrated by grout was not cemented and is estimated to have the same permeability. Results of laboratory tests are presented on Attachment Numbers 1 and 2.

If there are any questions, please advise.

Respectfully submitted

DISC International

Robert Briggs

Robert Briggs
Laboratory Manager

John Walton

John L. Walton, Sr., P.E.
Vice-President

Attachments (3)

JLW/eng42

ATTACHMENT 1

TEST RESULTS OF GRAVEL WELL PACK MATERIAL

Sieve Analysis

Mesh Size	Gravel % Finer
5/16	100
No. 4	88
No. 8	36
No. 16	05
No. 30	02
No. 50	01
No. 100	00
No. 200	00

Grout Penetration in the gravel well pack material was 5.0 inches. The grout pressure was 28 pounds per square inch, simulating a 40 foot head of grout. The permeability of the gravel well pack material was estimated to be 1 cm/sec before and after the grout penetration test.

ATTACHMENT 2

TEST RESULTS OF SAND WELL PACK MATERIAL

Sieve Analysis

Mesh Size	Gravel % Finer
5/16	100
No. 4	100
No. 8	99
No. 16	95
No. 30	75
No. 50	21
No. 100	01
No. 200	00

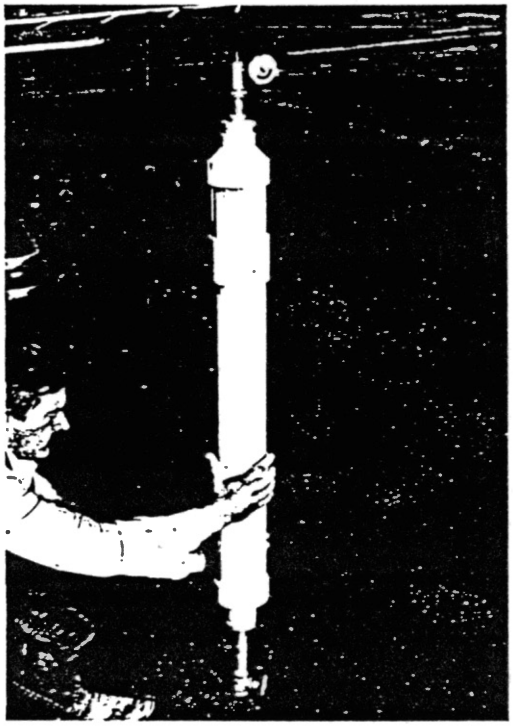
Permeability Tests:

Sand Control (k)	3.0 X 10 E-1
Sand from Pressure Chamber (k)	3.0 X 10 E-1

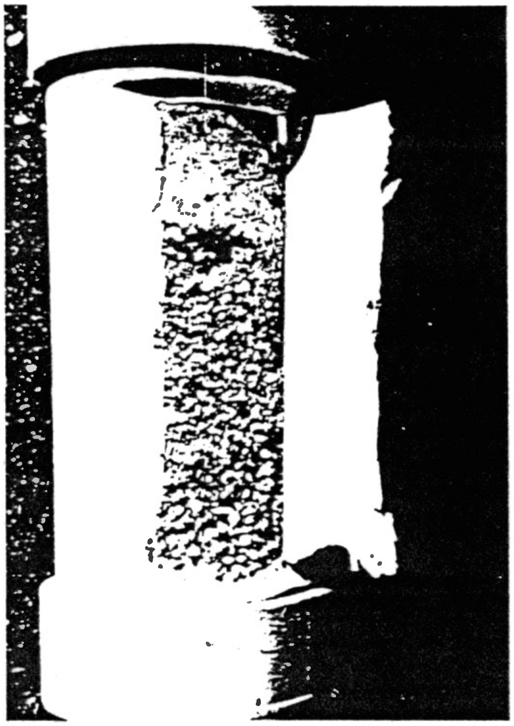
Grout Penetration in the sand well pack material was 0.125 inches. The grout pressure was 28 pounds per square inch, simulating a 40 foot head of grout.

ATTACHMENT 3

PHOTOGRAPHS



TEST APPARATUS



GROUT PENETRATION
IN GRAVEL WELL PACK

APPENDIX E

WATER LEVEL DATA

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	12-31-87	T.C.	5.7	400.06				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	12-31-87	T.C.	8.6	397.41				
UO-87 2.1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	12-31-87	T.C.	9.7	396.64				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	12-31-87	T.C.	8.0	398.37				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	12-31-87	T.C.	13.3	399.88				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	12-31-87	T.C.	13.7	399.69				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	12-31-87	T.C.	9.9	412.84				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	12-31-87	T.C.	3.9	376.42				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	12-31-87	T.C.	----	----				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	12-31-87	T.C.	5.8	381.91				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	12-31-87	T.C.	5.5	381.96				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	12-31-87	T.C.	4.5	403.17				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	12-31-8	T.C.	8.5	398.76				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	12-31-8	T.C.	13.4	401.12				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	12-31-8	T.C.	13.2	401.32				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	12-31-8	T.C.	2.8	387.75				

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	1-4-88	T.C.	9.75	396.01				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	1-4-88	T.C.	7.80	398.21				
UO-87 2.1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	1-4-88	T.C.	9.95	396.39				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	1-4-88	T.C.	7.90	398.47				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	1-4-88	T.C.	13.40	399.78				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	1-4-88	T.C.	14.10	399.29				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	1-4-88	T.C.	10.25	412.49				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	1-4-88	T.C.	4.05	376.27				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	1-4-88	T.C.	3.10	377.20				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	1-4-88	T.C.	6.15	381.56				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	1-4-88	T.C.	5.85	381.51				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	1-4-88	T.C.	4.80	402.87				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	1-4-88	T.C.	8.90	398.36				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	1-4-88	T.C.	14.80	399.72				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	1-4-88	T.C.	14.85	399.67				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	1-4-88	T.C.	3.30	387.25				

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	1-6-88	TC/DH	8.10	397.66				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	1-6-88	TC/DH	6.20	399.81				
UO-87 2.1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	1-6-88	TC/DH	10.10	396.24				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	1-6-88	TC/DH	8.55	397.82				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	1-6-88	TC/DH	13.95	399.23				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	1-6-88	TC/DH	14.30	399.09				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	1-6-88	TC/DH	10.60	412.14				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	1-6-88	TC/DH	4.40	375.92				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	1-6-88	TC/DH	3.60	376.70				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	1-6-88	TC/DH	6.80	380.91				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	1-6-88	TC/DH	6.20	381.16				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	1-6-88	TC/DH	4.80	402.87				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	1-6-88	TC/DH	9.30	397.96				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	1-6-88	TC/DH	15.30	399.22				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	1-6-88	TC/DH	15.40	399.12				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	1-6-88	TC/DH	3.60	386.95				

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	1-8-88	TC/DH	8.20	397.56				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	1-8-88	TC/DH	6.35	399.66				
UO-87 2·1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	1-8-88	TC/DH	10.30	396.04				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	1-8-88	TC/DH	8.65	397.72				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	1-8-88	TC/DH	14.00	399.18				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	1-8-88	TC/DH	14.10	399.29				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	1-8-88	TC/DH	10.80	411.94				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	1-8-88	TC/DH	4.95	375.37				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	1-8-88	TC/DH	4.20	376.10				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	1-8-88	TC/DH	7.95	379.76				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	1-8-88	TC/DH	7.20	380.16				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	1-8-88	TC/DH	4.90	402.77				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	1-8-88	TC/DH	9.35	397.91				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	1-8-88	TC/DH	15.45	399.07				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	1-8-88	TC/DH	15.60	398.92				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	1-8-88	TC/DH	3.75	386.80				

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	1-14-88	WDH/RE	9.35	396.41				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	1-14-88	WDH/RE	7.75	398.26				
UO-87 2-1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	1-14-88	WDH/RE	10.25	396.09				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	1-14-88	WDH/RE	9.10	397.27				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	1-14-88	WDH/RE	14.45	398.73				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	1-14-88	WDH/RE	14.90	398.50				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	1-13-88	WDH/RE	11.45	411.29				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	1-14-88	WDH/RE	4.80	375.52				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	1-14-88	WDH/RE	4.10	376.20				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	1-14-88	WDH/RE	7.70	380.01				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	1-14-88	WDH/RE	7.20	380.16				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	1-14-88	WDH/RE	4.35	403.32				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	1-14-88	WDH/RE	9.90	397.36				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	1-14-88	WDH/RE	15.45	399.07				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	1-14-88	WDH/RE	16.55	397.97				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	1-14-88	WDH/RE	3.56	386.96				

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	1-22-88	WDH	6.30	399.46				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	1-22-88	WDH	8.08	397.93				
UO-87 2.1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	1-22-88	WDH	10.25	396.09				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	1-22-88	WDH	8.55	397.82				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	1-22-88	WDH	13.88	399.30				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	1-22-88	WDH	14.32	399.08				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	1-22-88	WDH	10.61	412.13				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	1-22-88	WDH	4.80	375.52				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	1-22-88	WDH	3.90	376.40				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	1-22-88	WDH	7.69	380.02				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	1-22-88	WDH	7.10	380.26				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	1-22-88	WDH	4.71	402.96				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	1-22-88	WDH	9.35	397.91				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	1-22-88	WDH	14.45	400.07				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	1-22-88	WDH	14.37	400.15				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	1-22-88	WDH	3.34	387.18				

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10/14/87	404.41	405.76	24.35	1.35	23.0	2/11/88	TS/BH	6.35	399.41				
UO-87 1.1B	10/29/8	404.55	406.01	37.46	1.46	36.0	2/11/88	TS/BH	8.34	397.67				
UO-87 2.1A	10/21/8	404.74	406.34	27.60	1.60	26.0	2/11/88	TS/BH	10.38	395.96				
UO-87 2.1B	10/23/87	404.82	406.37	39.55	1.55	38.0	2/11/88	TS/BH	8.79	397.58				
UO-87 3.1	11/2/87	411.80	413.18	51.38	1.38	50.0	2/11/88	TS/BH	14.33	398.85				
UO-87 3.2	12/1/87	411.89	413.39	74.51	1.51	73.0	2/11/88	TS/BH	14.79	398.60				
UO-87 4.1	9/4/87	420.90	422.74	31.84	1.84	30.0	2/11/88	TS/BH	11.20	441.54				
UO-87 6.1	11/10/8	378.73	380.32	14.09	1.59	12.5	2/11/88	TS/BH	5.62	374.7				
UO-87 6.2	12/3/87	378.90	380.30	33.40	1.40	32.0	2/11/88	TS/BH	5.08	375.22				
UO-87 7.1	11/6/87	385.92	387.71	22.79	1.79	21.0	2/11/88	TS/BH	9.69	378.02				
UO-87 7.2	12/10/8	385.98	387.36	47.38	1.38	46.0	2/11/88	TS/BH	8.84	378.52				
UO-87 8.1	10/9/87	405.89	407.67	20.78	1.78	19.0	2/11/88	TS/BH	4.88	402.79				
UO-87 8.2	12/15/87	405.84	407.26	52.92	1.42	51.5	2/11/88	TS/BH	9.52	397.74				
UO-87 9.1	9/3/87	412.74	414.52	31.78	1.78	30.0	2/11/88	TS/BH	15.49	399.03				
UO-87 9.2	11/20/8	412.83	414.52	57.29	1.69	55.6	2/11/88	TS/BH	15.61	398.91				
UO-87 10.2	12/7/87	388.75	390.55	32.77	1.77	31.0	2/11/88	TS/BH	3.86	386.69				

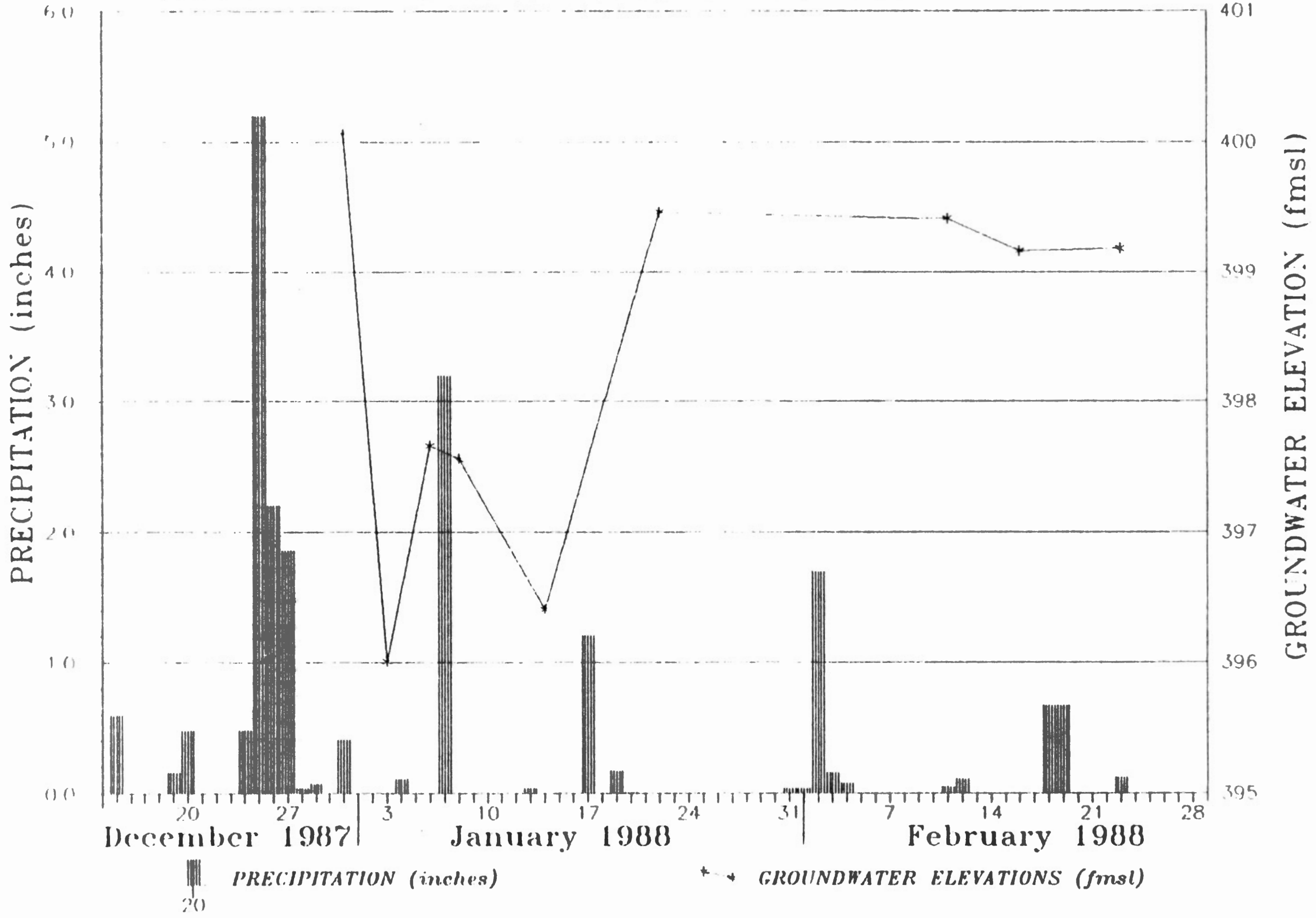
WELL INFORMATION							WATER LEVELS								
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	5/6/88	EVANS HAWKINS	8.50	397.26				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	5/6/88	EVANS HAWKINS	11.11	394.90				
UO-87 2.1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	5/6/88	EVANS HAWKINS	12.61	393.73				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	5/6/88	EVANS HAWKINS	11.51	394.86				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	5/6/88	EVANS HAWKINS	16.77	396.41				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	5/6/88	EVANS HAWKINS	17.17	396.22				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	5/6/88	EVANS HAWKINS	15.56	407.18				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	5/6/88	EVANS HAWKINS	6.22	374.10				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	5/6/88	EVANS HAWKINS	5.93	374.37				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	5/6/88	EVANS HAWKINS	11.61	376.10				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	5/6/88	EVANS HAWKINS	10.56	376.80				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	5/6/88	EVANS HAWKINS	7.66	400.01				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	5/6/88	EVANS HAWKINS	12.29	394.97				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	5/6/88	EVANS HAWKINS	18.31	396.21				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	5/6/88	EVANS HAWKINS	18.51	396.01				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	5/6/88	EVANS HAWKINS	5.52	385.03				

WELL INFORMATION							WATER LEVELS							
Well Number	Installation Date	Ground Surface Elevation (Ft. MSL)	Reference Point Elevation (Ft. MSL)	Total Depth from Ref. Pt. (Feet)	Stickup (Feet)	Depth from Ground Surface (Feet)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft.MSL)	Date	Measured by	Depth from Reference Point (Feet)	Water Surface Elevation (Ft. MSL)
UO-87 1.1A	10-14-87	404.41	405.76	24.35	1.35	23.0	5/11/88	WDH	9.02	396.74				
UO-87 1.1B	10-29-87	404.55	406.01	37.46	1.46	36.0	5/11/88	WDH	11.64	394.37				
UO-87 2.1 A	10-21-87	404.74	406.34	27.60	1.60	26.0	5/11/88	WDH	13.00	393.34				
UO-87 2.1B	10-23-87	404.82	406.37	39.55	1.55	38.0	5/11/88	WDH	12.02	394.35				
UO-87 3-1	11-2-87	411.80	413.18	51.38	1.38	50.0	5/11/88	WDH	17.50	395.68				
UO-87 3-2	12-1-87	411.89	413.39	74.51	1.51	73.0	5/11/88	WDH	17.66	395.73				
UO-87 4.1	9-4-87	420.90	422.74	31.84	1.84	30.0	5/11/88	WDH	16.57	406.17				
UO-87 6.1	11-10-87	378.73	380.32	14.09	1.59	12.5	5/11/88	WDH	6.20	374.12				
UO-87 6.2	12-3-87	378.90	380.30	33.40	1.40	32.0	5/11/88	WDH	5.86	374.44				
UO-87 7.1	11-6-87	385.92	387.71	22.79	1.79	21.0	5/11/88	WDH	11.58	376.13				
UO-87 7.2	12-10-87	385.98	387.36	47.38	1.38	46.0	5/11/88	WDH	10.49	376.87				
UO-87 8.1	10-9-87	405.89	407.67	20.78	1.78	19.0	5/11/88	WDH	8.26	399.41				
UO-87 8.2	12-15-87	405.84	407.26	52.92	1.42	51.5	5/11/88	WDH	12.84	394.42				
UO-87 9.1	9-3-87	412.74	414.52	31.78	1.78	30.0	5/11/88	WDH	19.07	395.45				
UO-87 9.2	11-20-87	412.83	414.52	57.29	1.69	55.6	5/11/88	WDH	19.35	395.17				
UO-87 10.2	12-7-87	388.75	390.55	32.77	1.77	31.0	5/11/88	WDH	6.05	384.50				

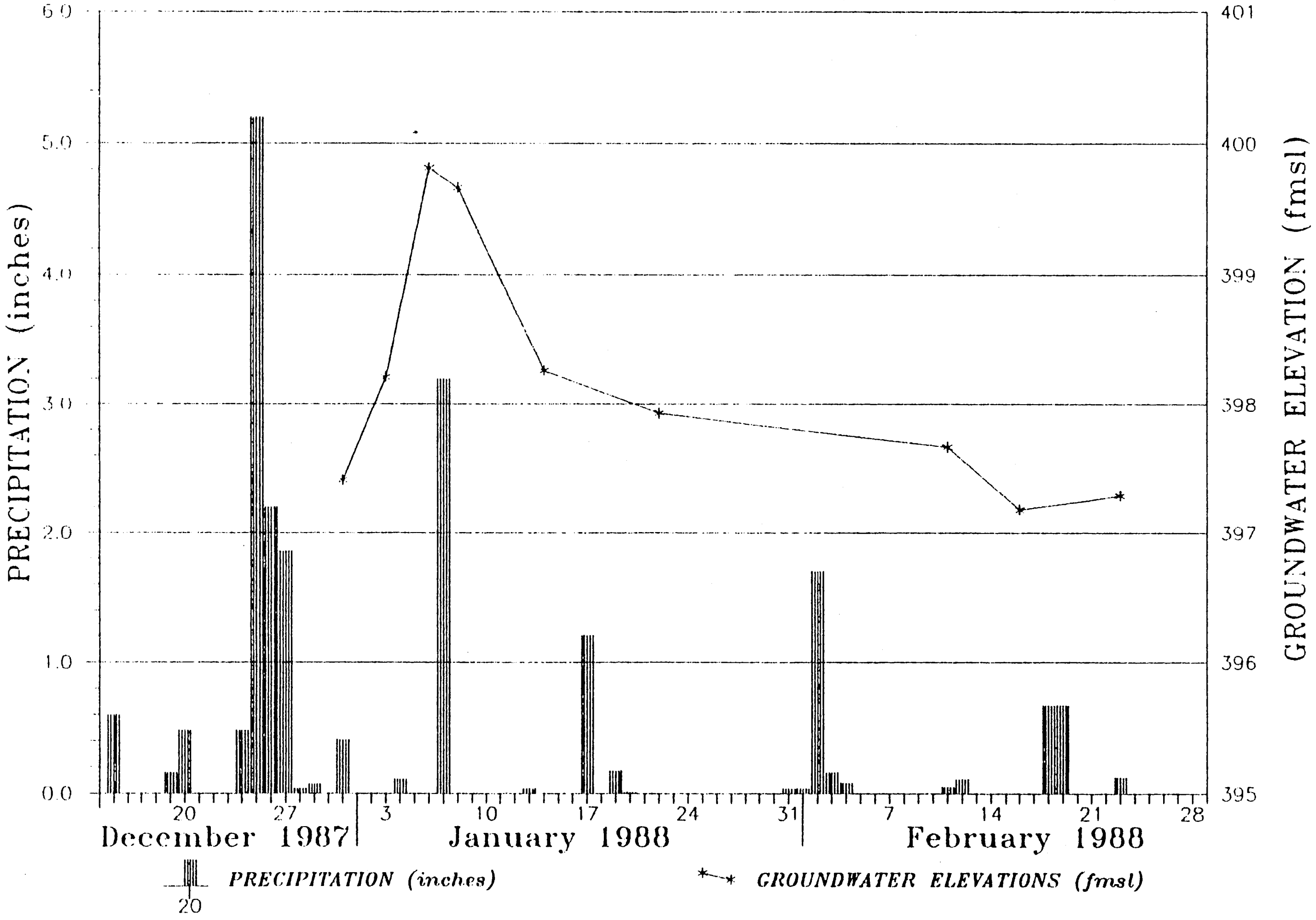
APPENDIX F

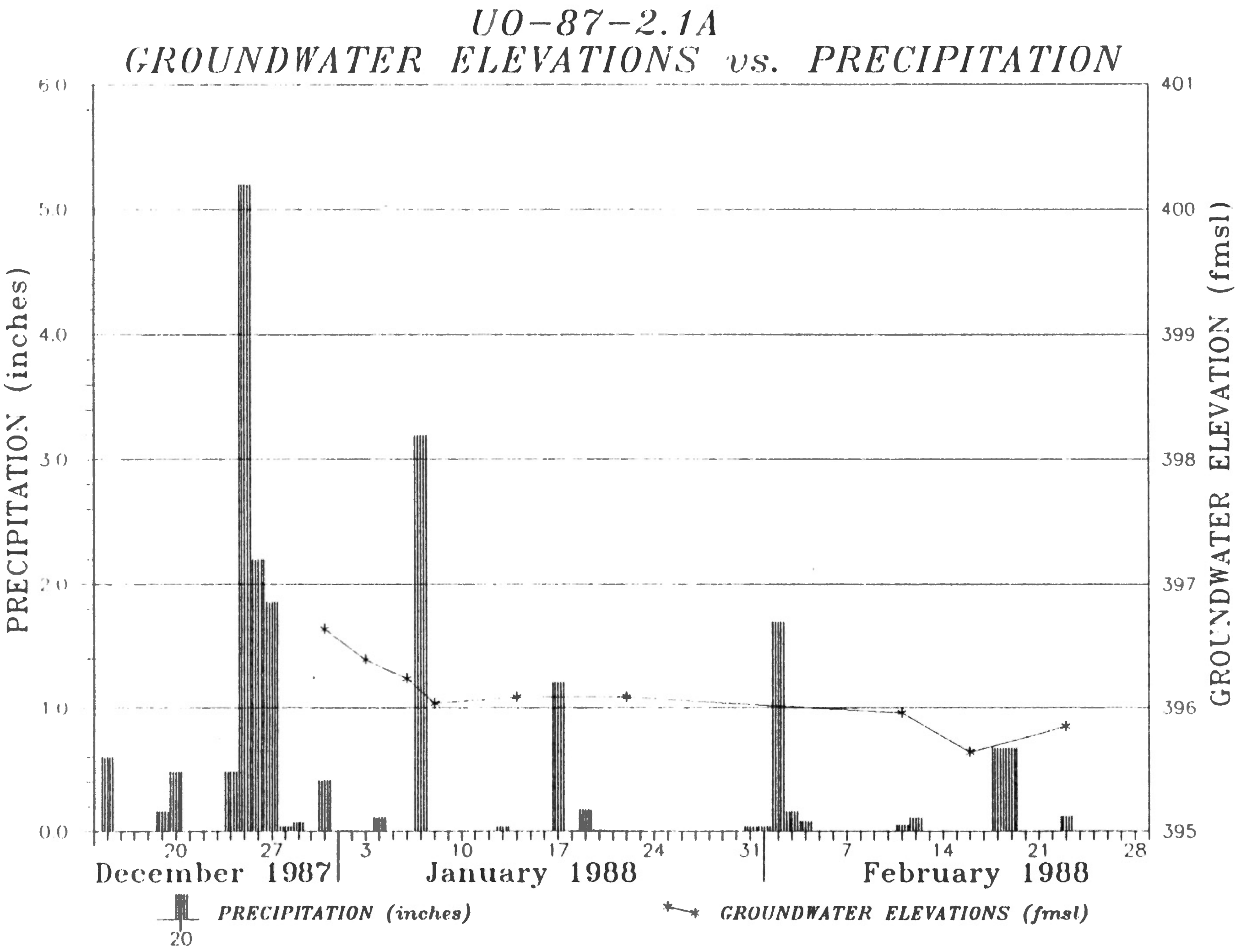
HYDROGRAPHS

UO-87-1.1A
GROUNDWATER ELEVATIONS vs. PRECIPITATION

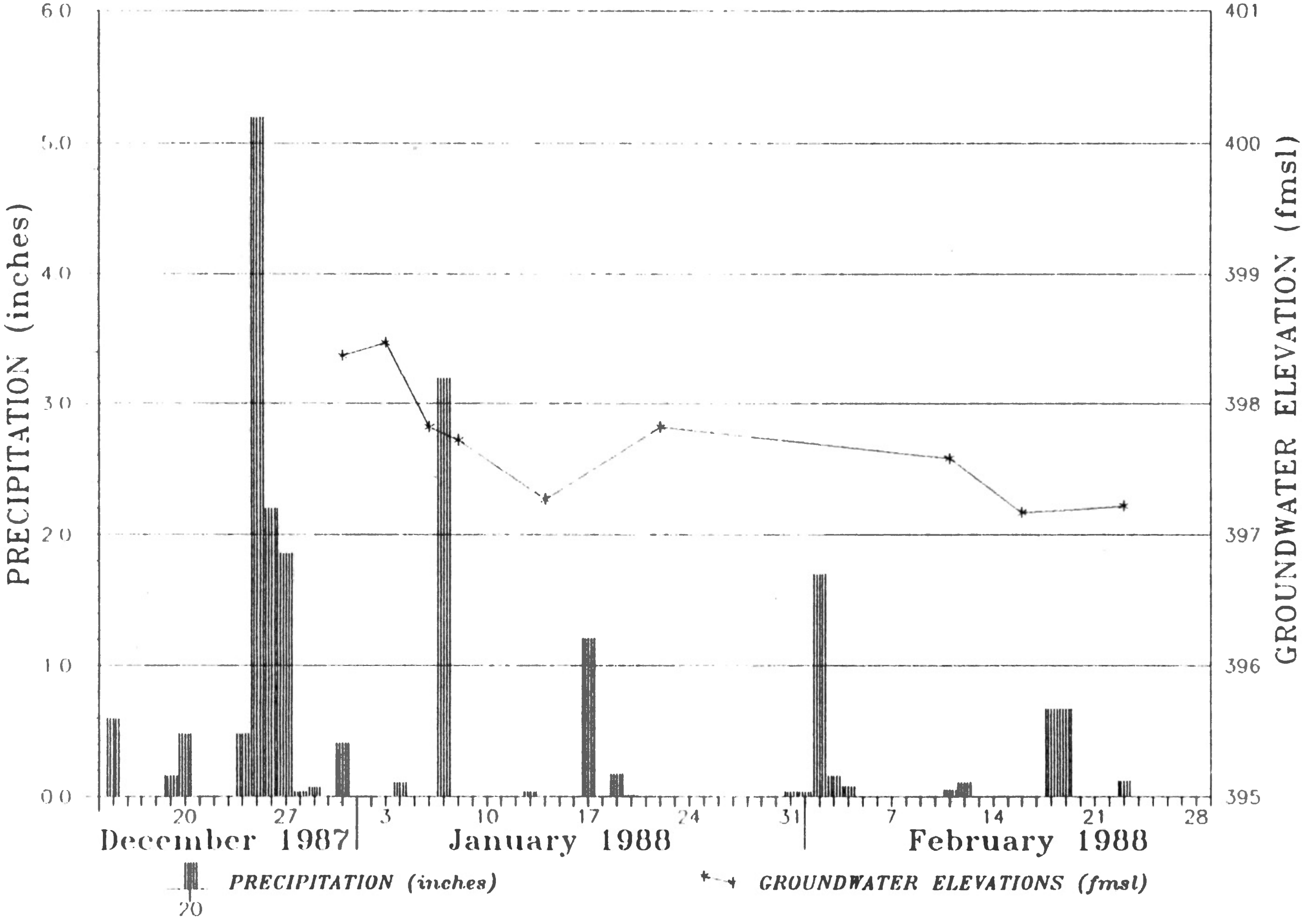


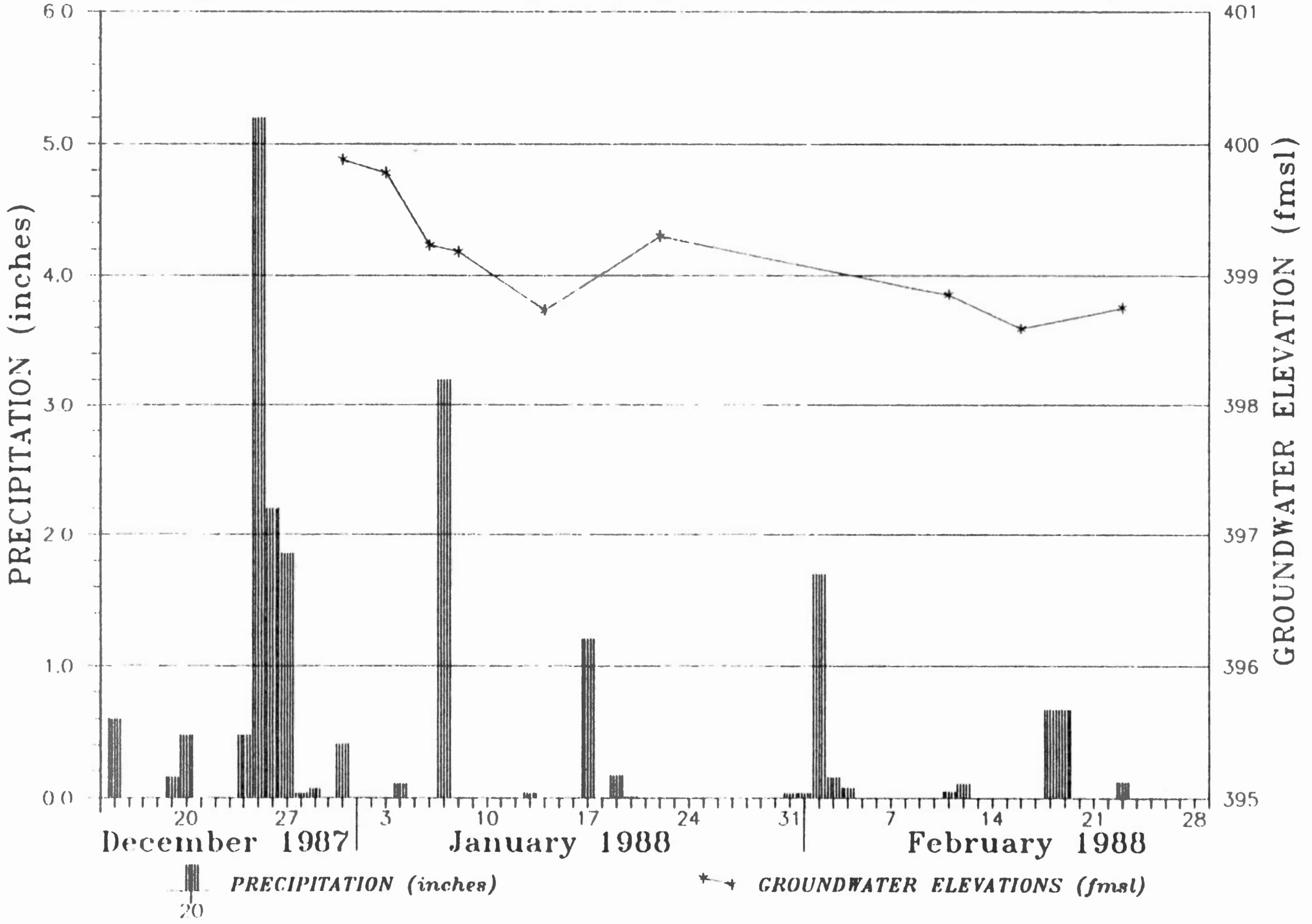
UO-87-1.1B
GROUNDWATER ELEVATIONS vs. PRECIPITATION



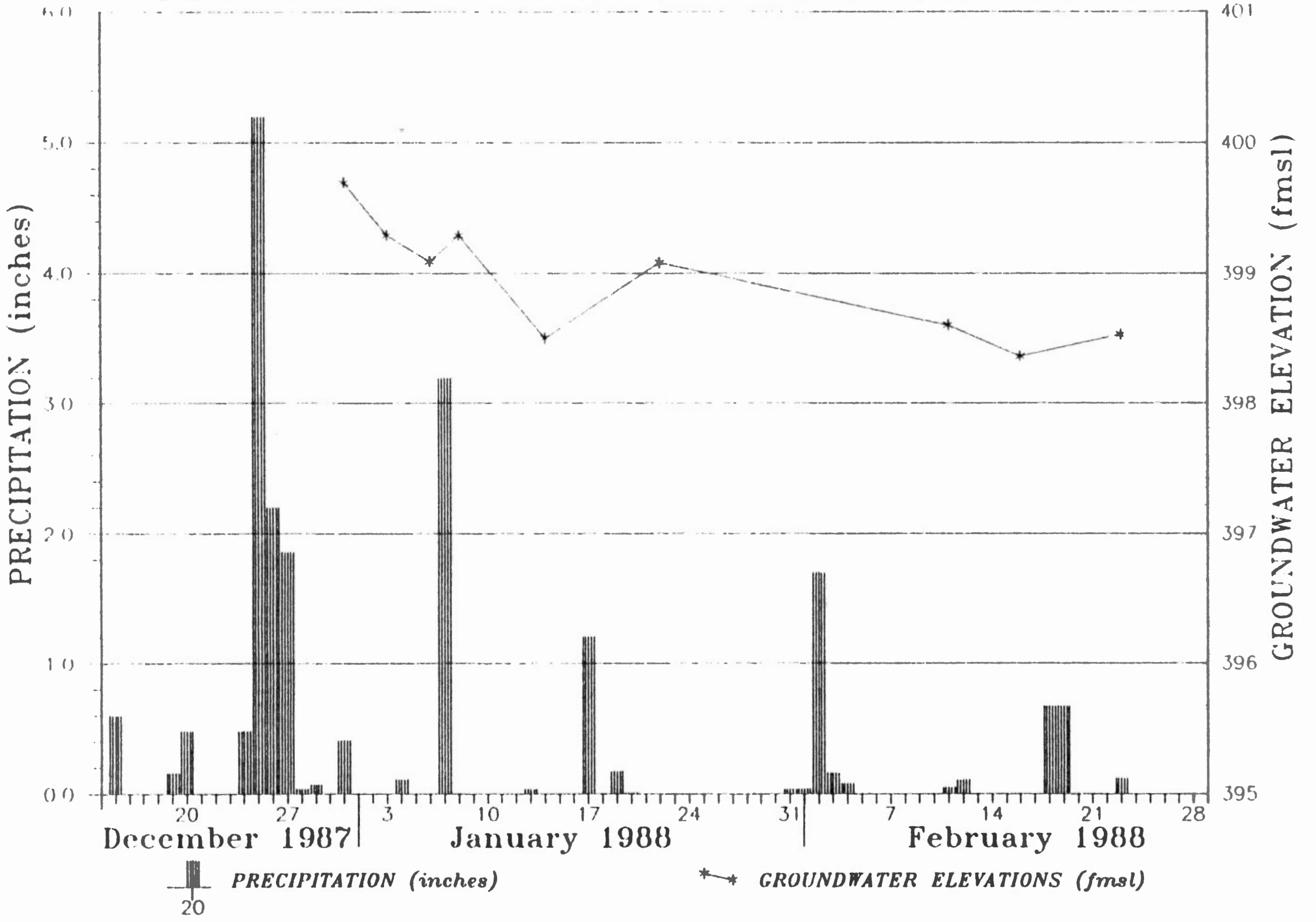

UO-87-2.1A
GROUNDWATER ELEVATIONS vs. PRECIPITATION
PRECIPITATION (inches)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
GROUNDWATER ELEVATION (fmsl)
401
400
399
398
397
396
395
20
27
3
10
17
24
31
7
14
21
28
December 1987
January 1988
February 1988
20
PRECIPITATION (inches)
GROUNDWATER ELEVATIONS (fmsl)

U0-87-2.1B
GROUNDWATER ELEVATIONS vs. PRECIPITATION



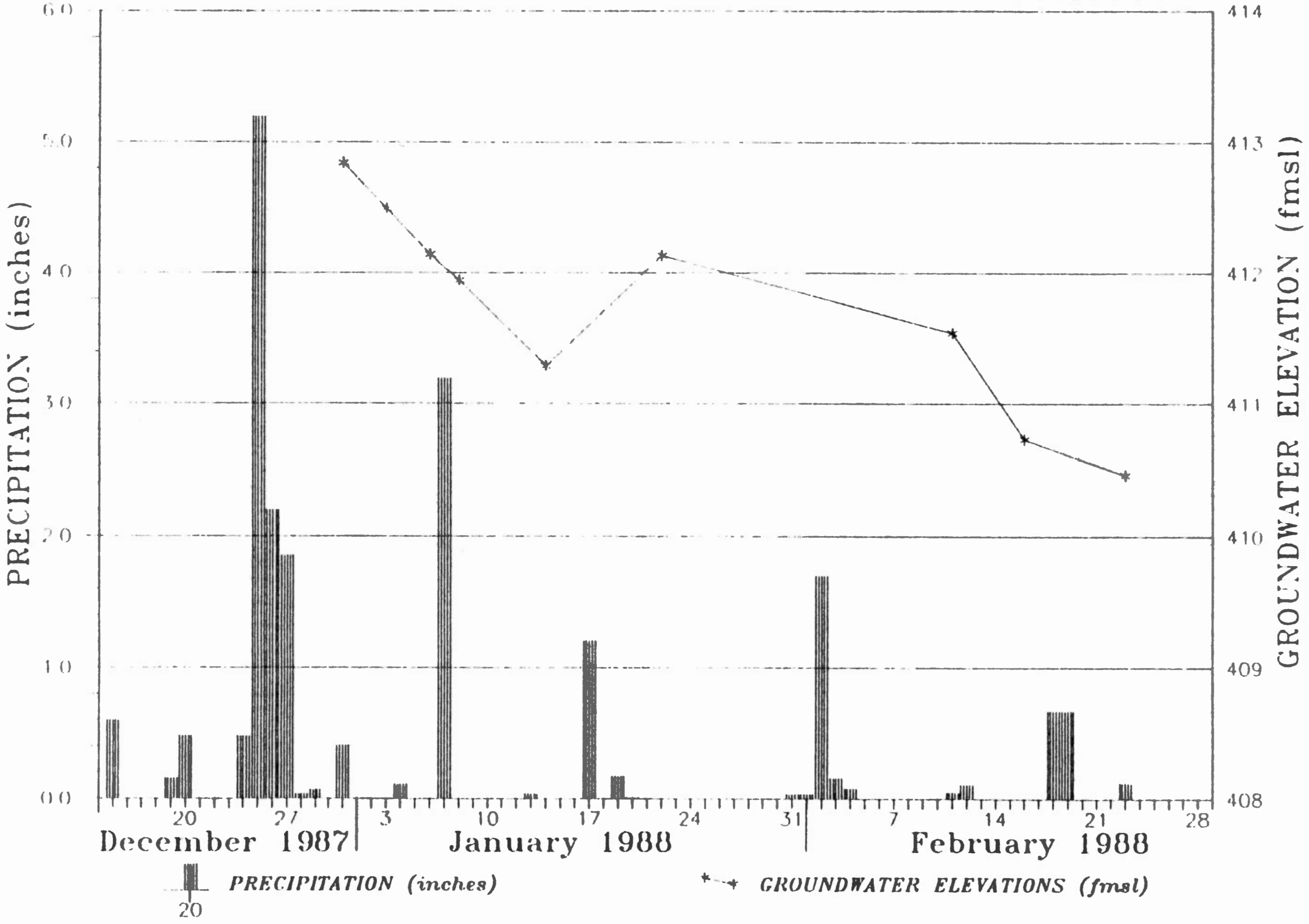


UO-87-3.1
GROUNDWATER ELEVATIONS vs. PRECIPITATION

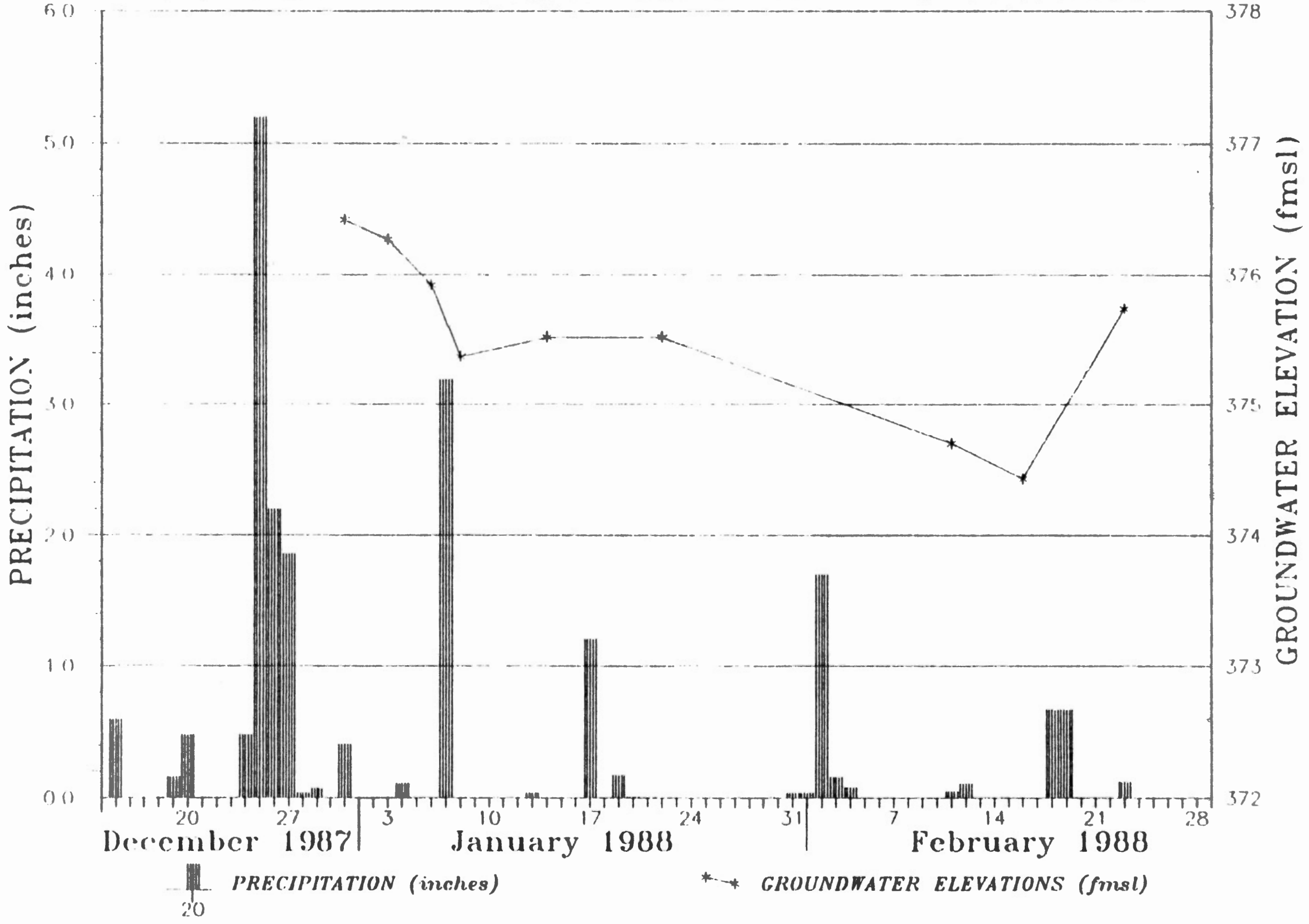


UO-87-3.2
GROUNDWATER ELEVATIONS vs. PRECIPITATION

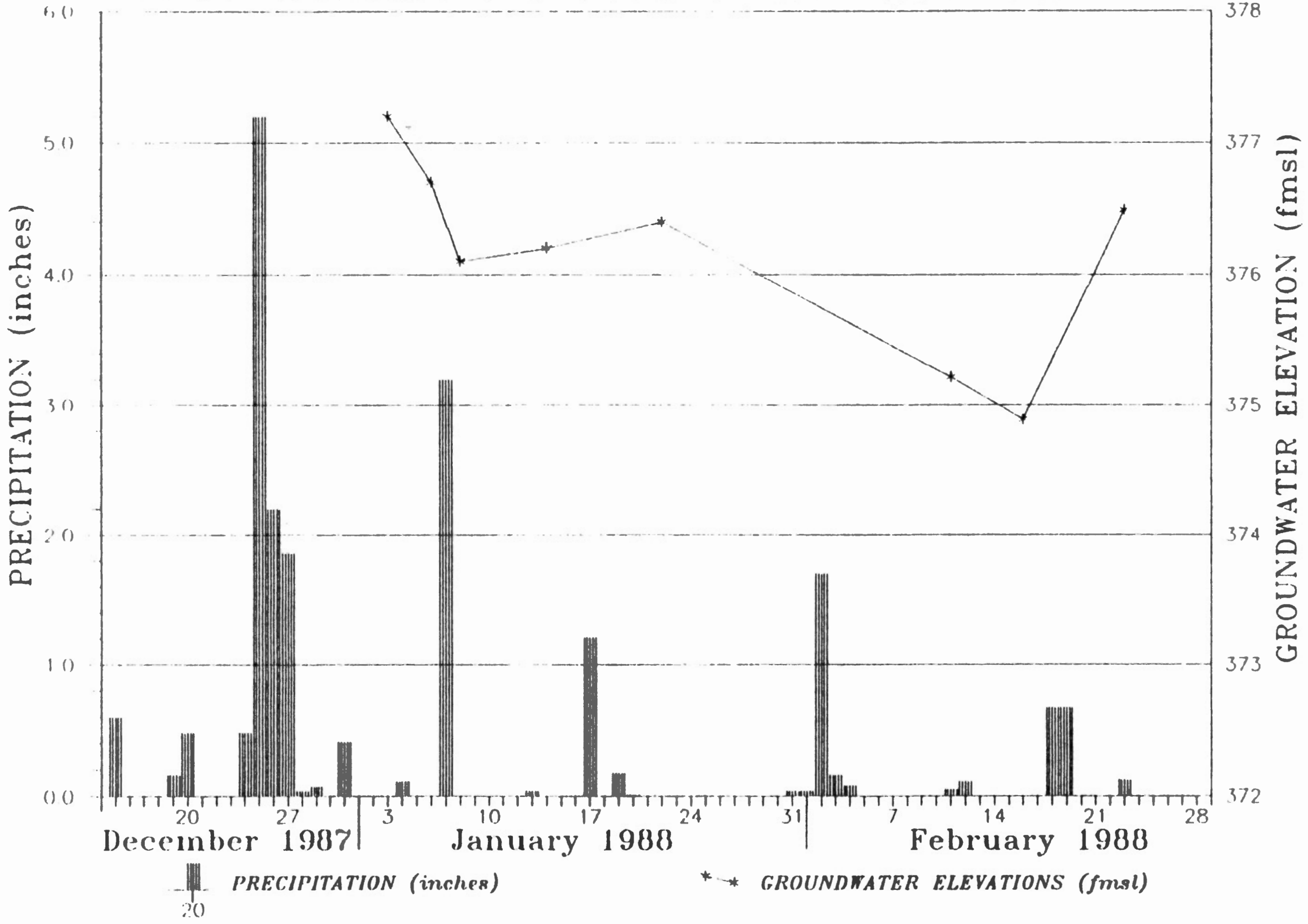
UO-87-4.1
GROUNDWATER ELEVATIONS vs. PRECIPITATION



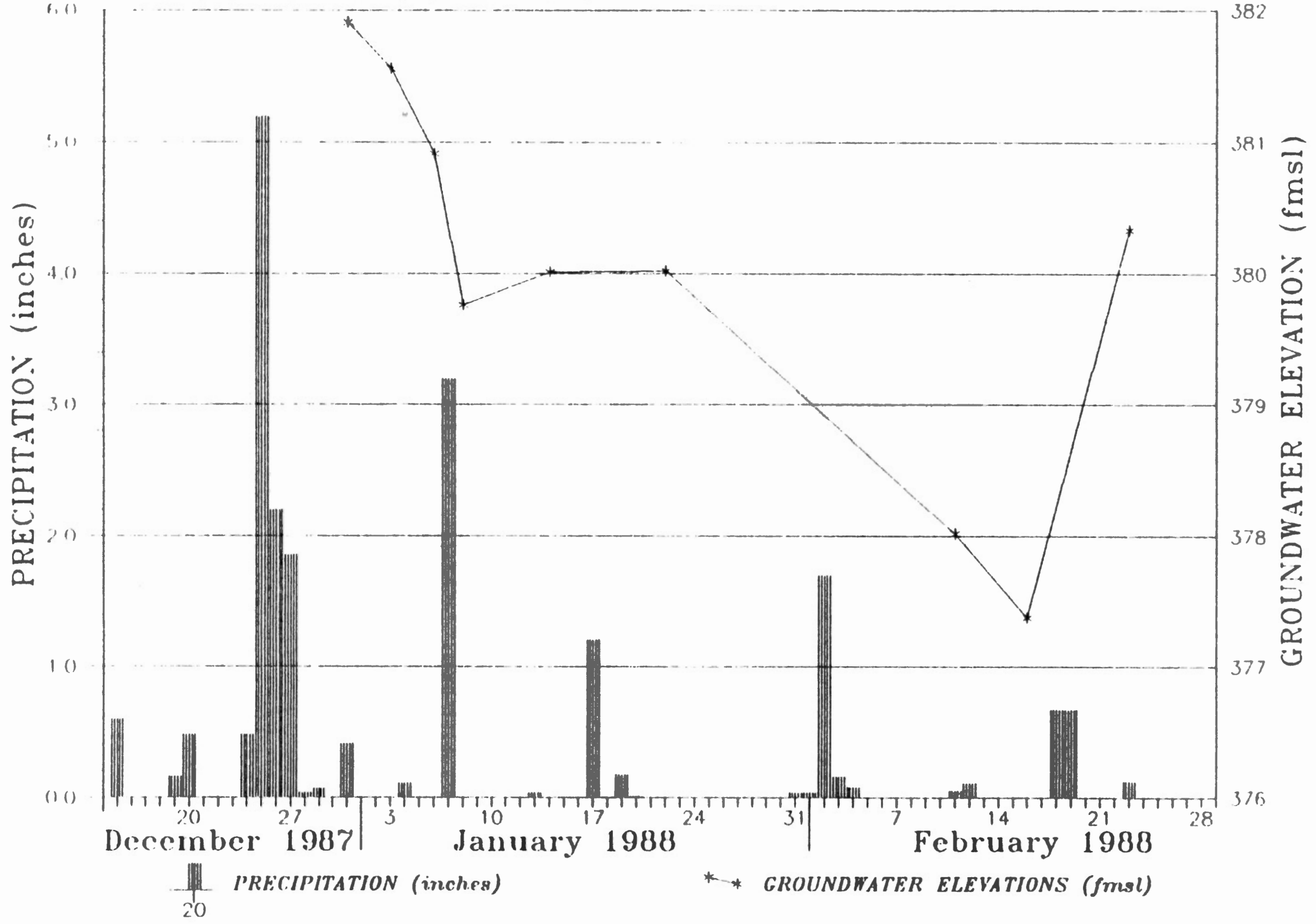
UO-87-6.1
GROUNDWATER ELEVATIONS vs. PRECIPITATION

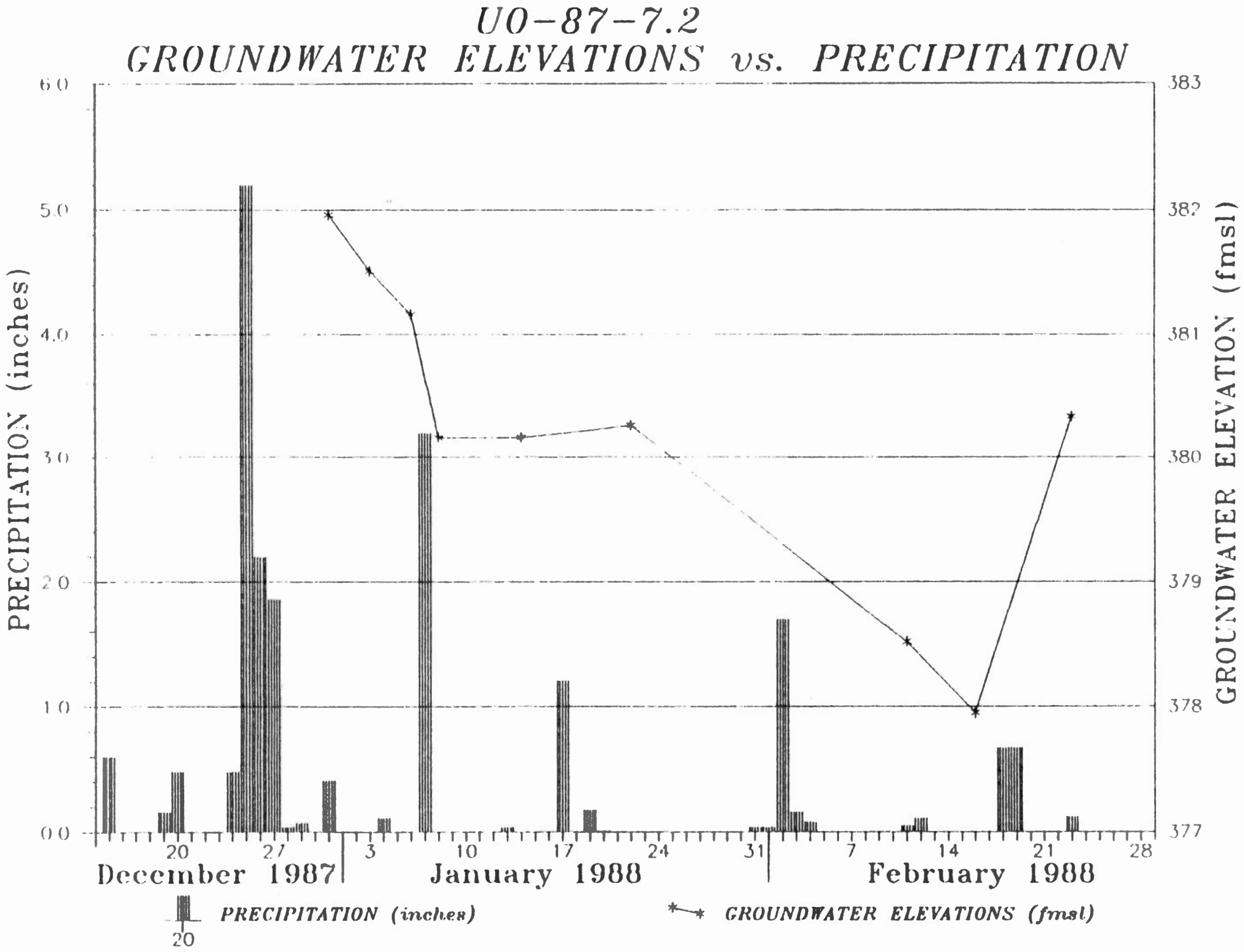


UO-87-6.2
GROUNDWATER ELEVATIONS vs. PRECIPITATION

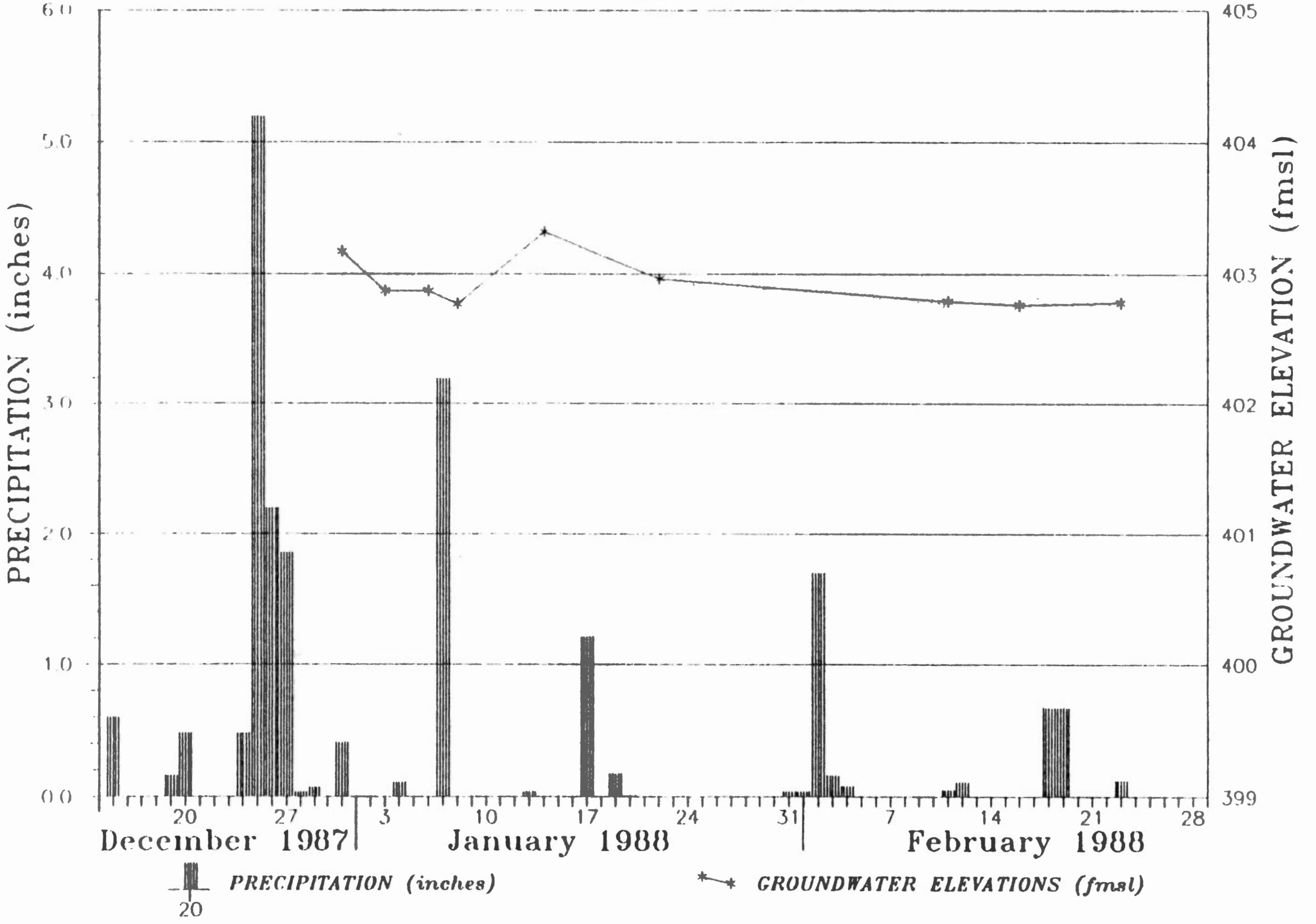


UO-87-7.1
GROUNDWATER ELEVATIONS vs. PRECIPITATION

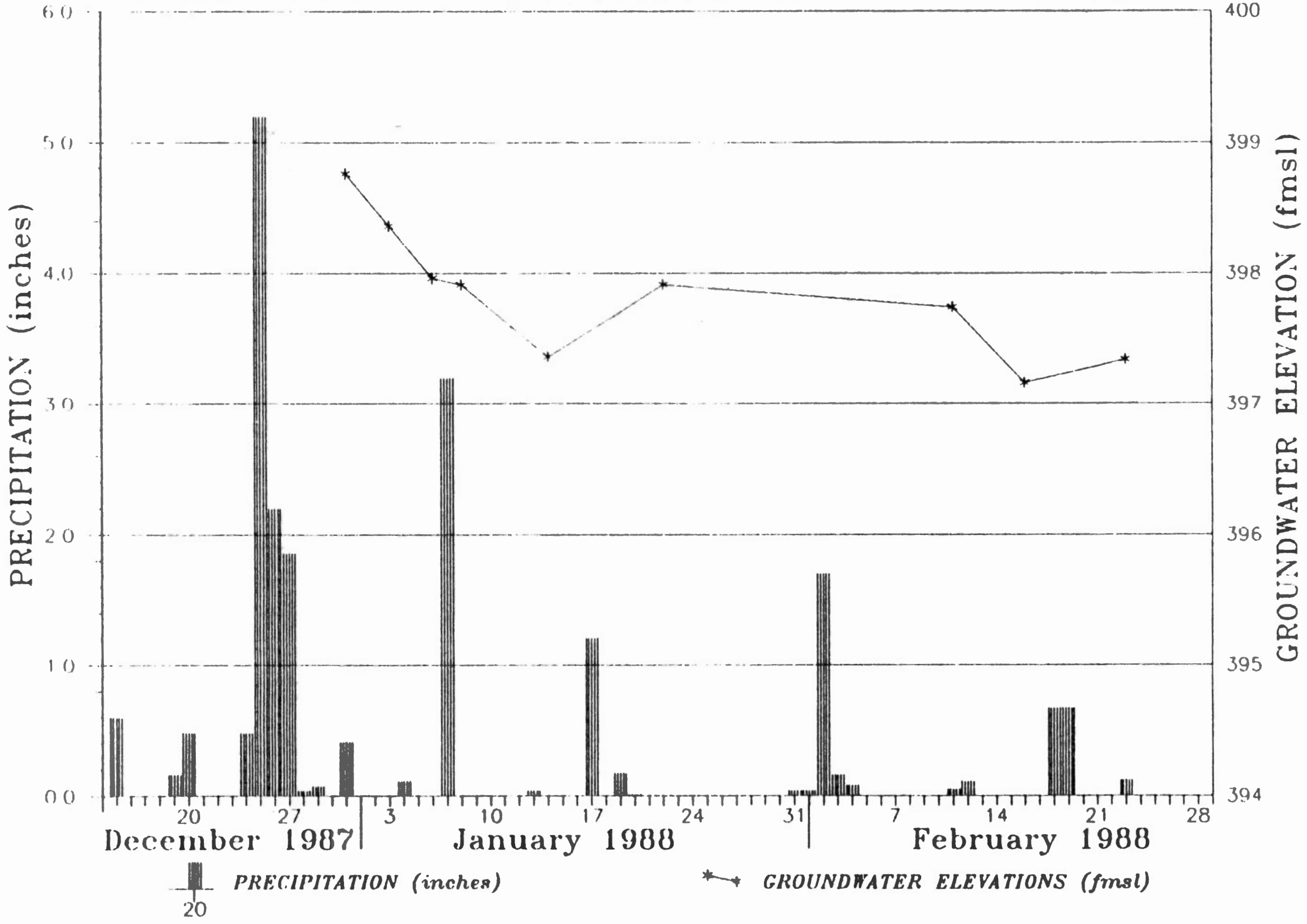



UO-87-7.2
GROUNDWATER ELEVATIONS vs. PRECIPITATION
PRECIPITATION (inches)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
GROUNDWATER ELEVATION (fmsl)
383
382
381
380
379
378
377
20
27
3
10
17
24
31
7
14
21
28
December 1987
January 1988
February 1988
PRECIPITATION (inches)
GROUNDWATER ELEVATIONS (fmsl)
20

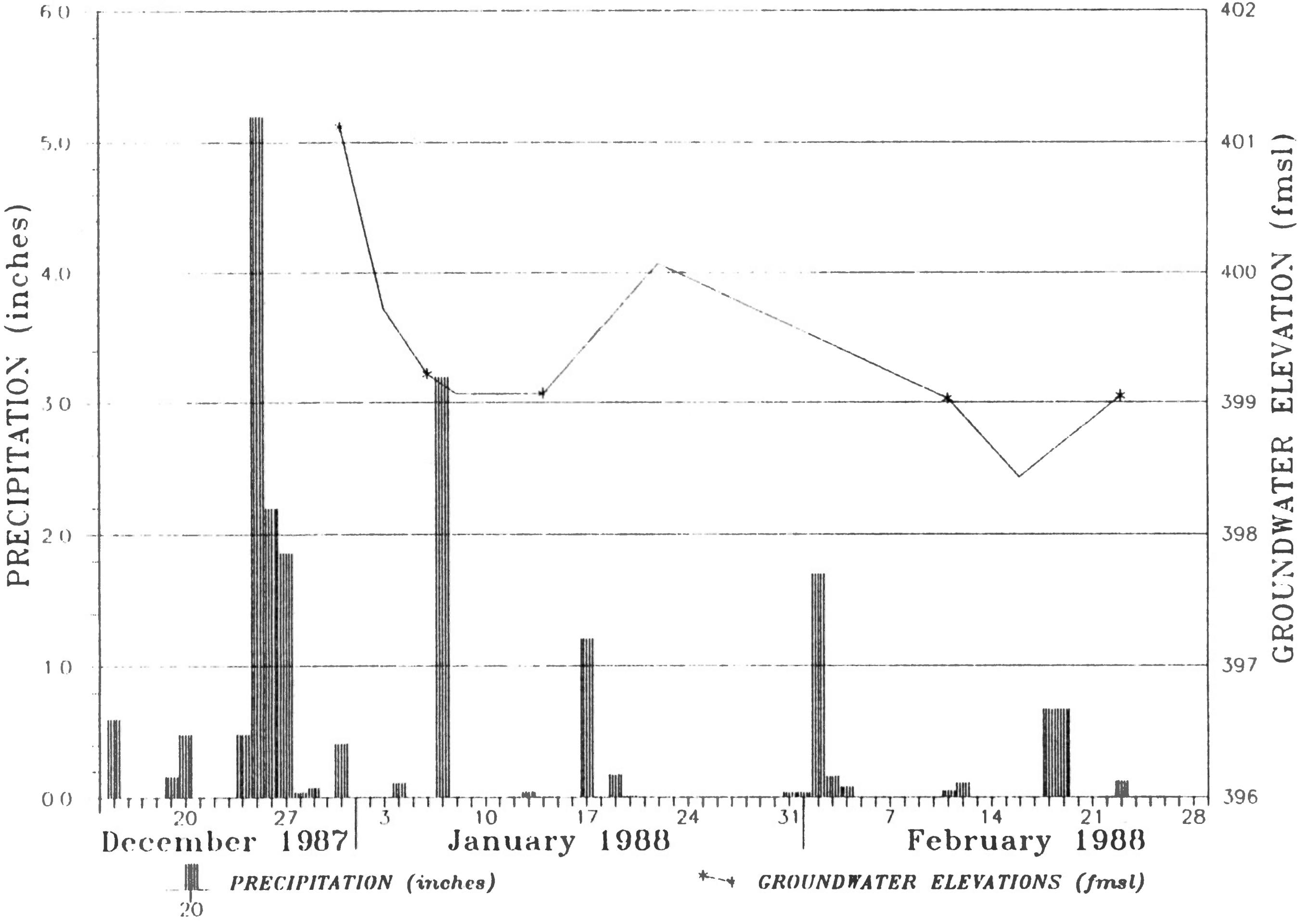
UO-87-8.1
GROUNDWATER ELEVATIONS vs. PRECIPITATION



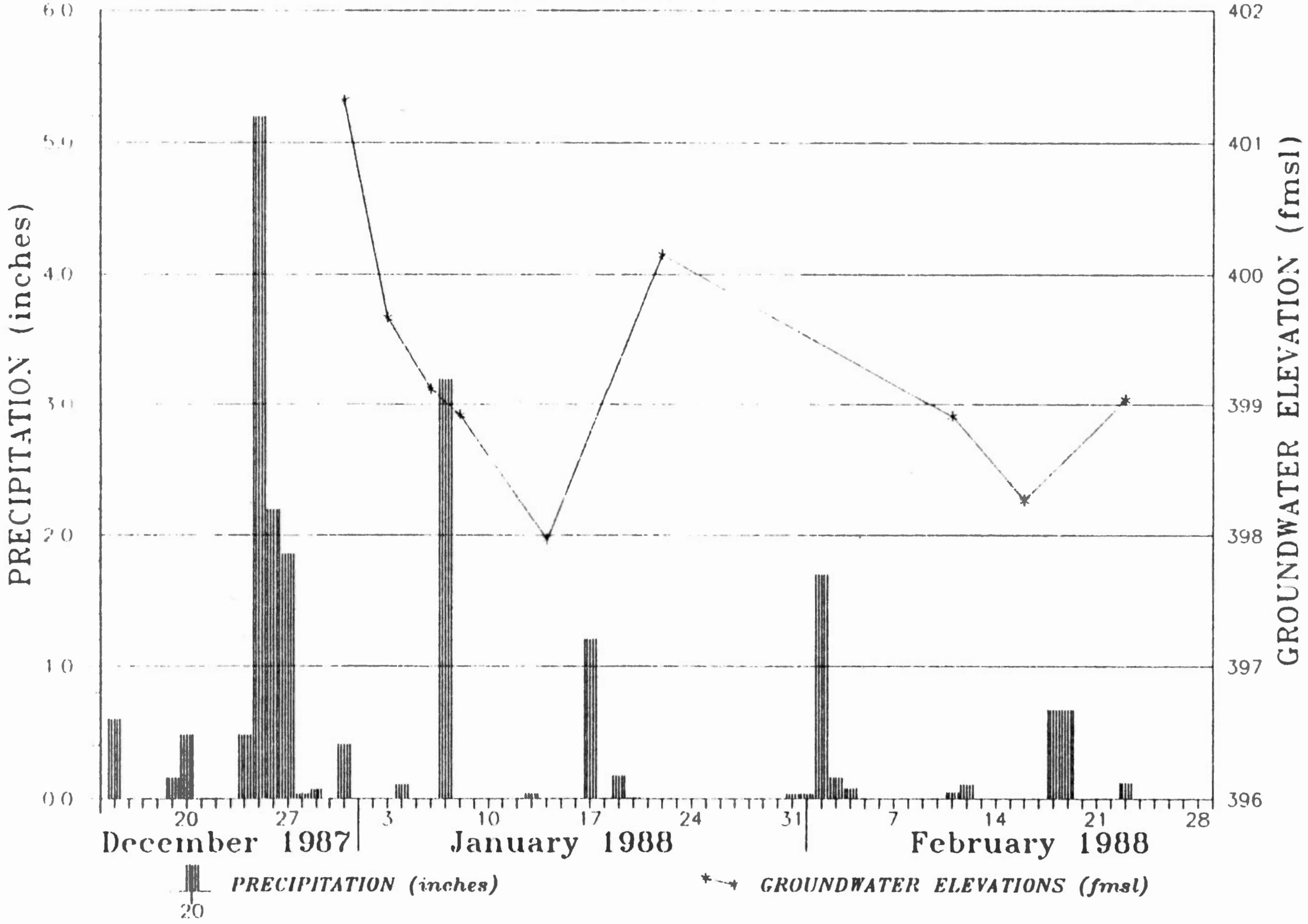
UO-87-8.2
GROUNDWATER ELEVATIONS vs. PRECIPITATION



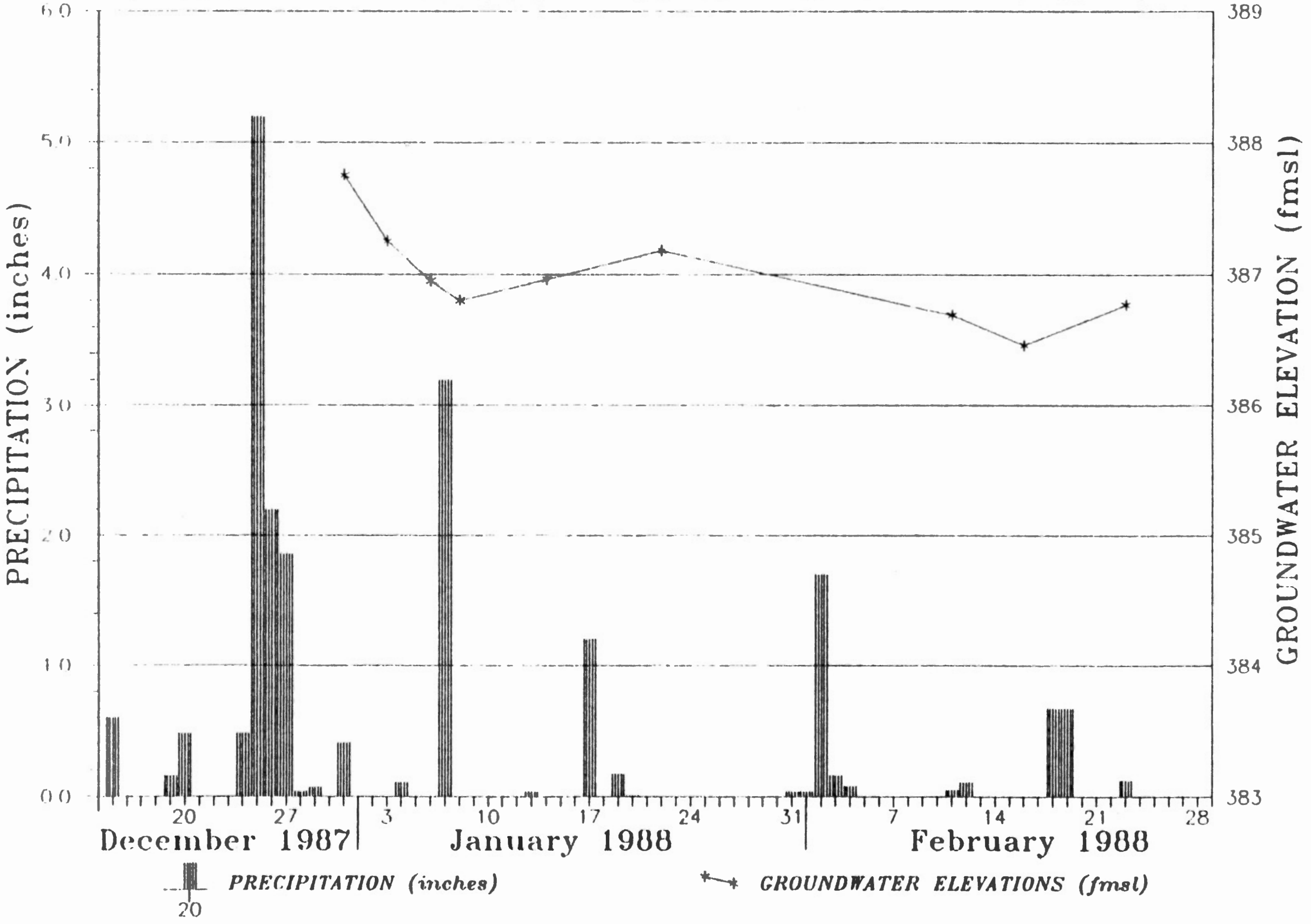
UO-87-9.1
GROUNDWATER ELEVATIONS vs. PRECIPITATION



UO-87-9.2
GROUNDWATER ELEVATIONS vs. PRECIPITATION



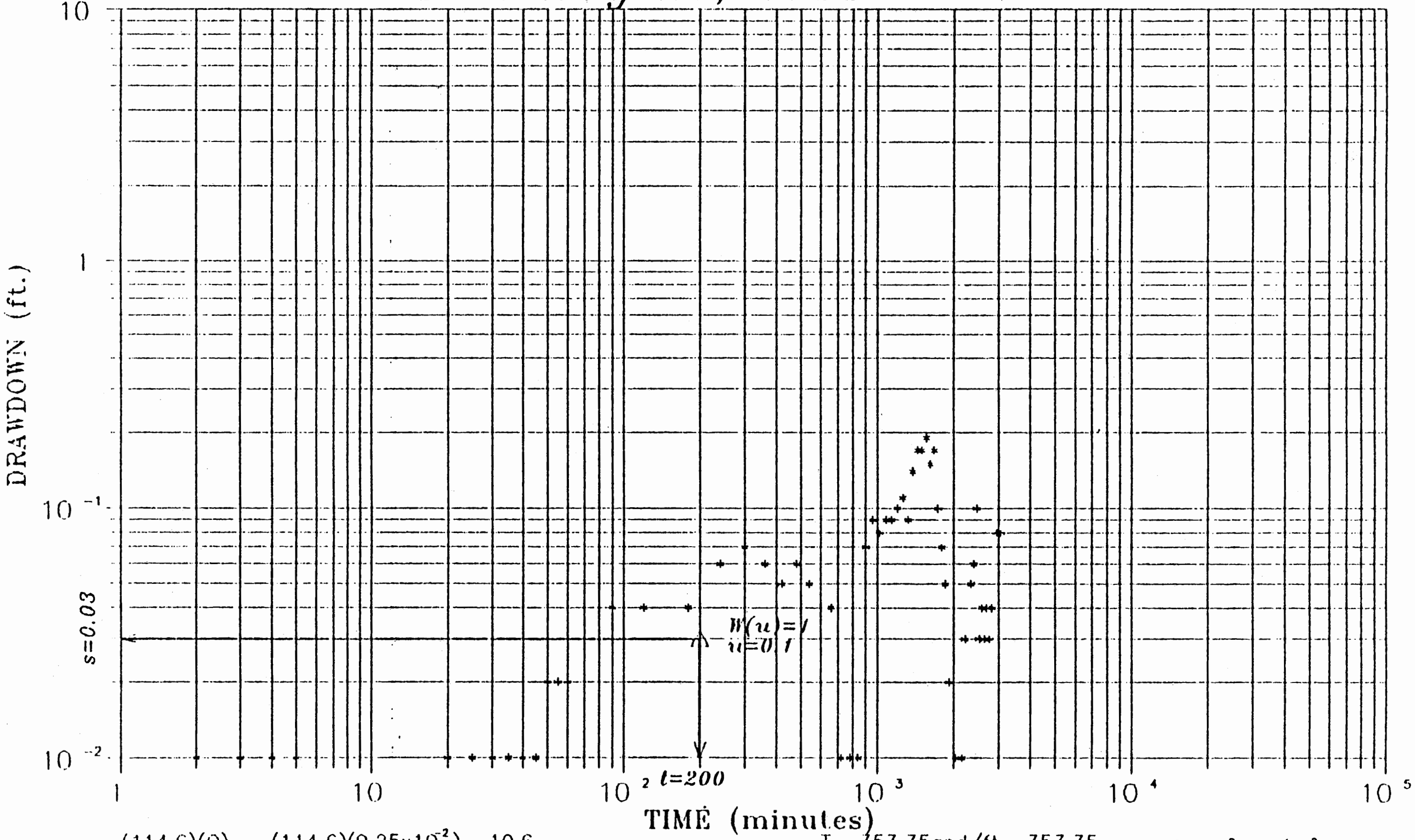
UO-87-10.2
GROUNDWATER ELEVATIONS vs. PRECIPITATION



APPENDIX G

AQUIFER TEST RESULTS

TIME/DRAWDOWN ANALYSIS (Theis)
MW U0-87-3.2 (Observation Well)
February 29, 1988

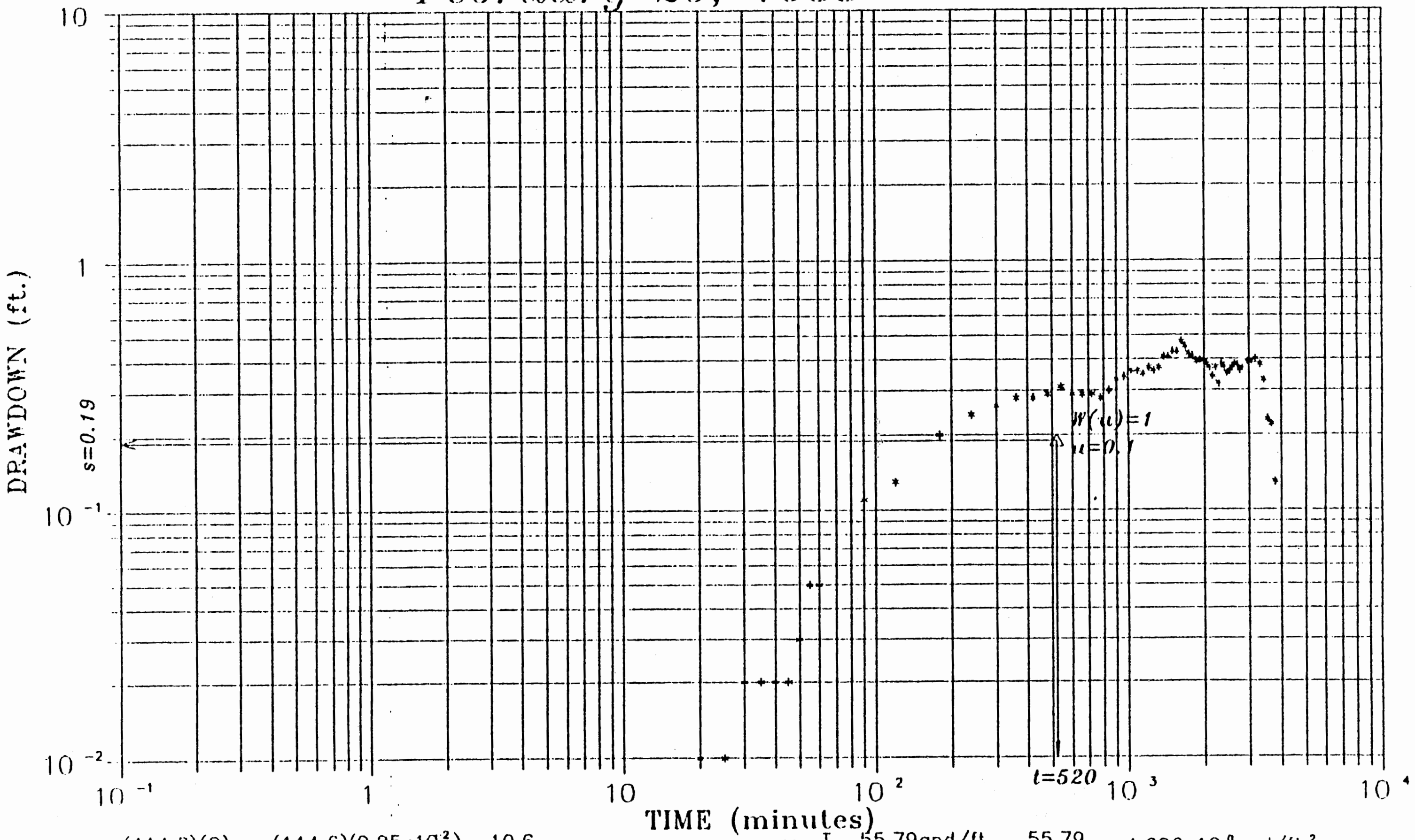


$T = \frac{(114.6)(Q)}{s} = \frac{(114.6)(9.25\times10^{-2})}{0.03} = \frac{10.6}{0.03} =$ 353.35gpd/ft

$K = \frac{T}{M} = \frac{353.35\text{gpd/ft}}{73-15.35\text{ft}} = \frac{353.35}{57.65} =$ 6.13×10^{0}gpd/ft^2 $=$ 2.89×10^{-4}cm/sec

$S = \frac{Ttu}{2693r_o^2} = \frac{(353.35)(200)(.1)}{(2693)(700)^2} = \frac{7067}{1.32\times10^{+9}} = 5.35\times10^{-6}$

TIME/DRAWDOWN ANALYSIS (Theis)
MW U0-87-9.1 (Observation Well)
February 29, 1988

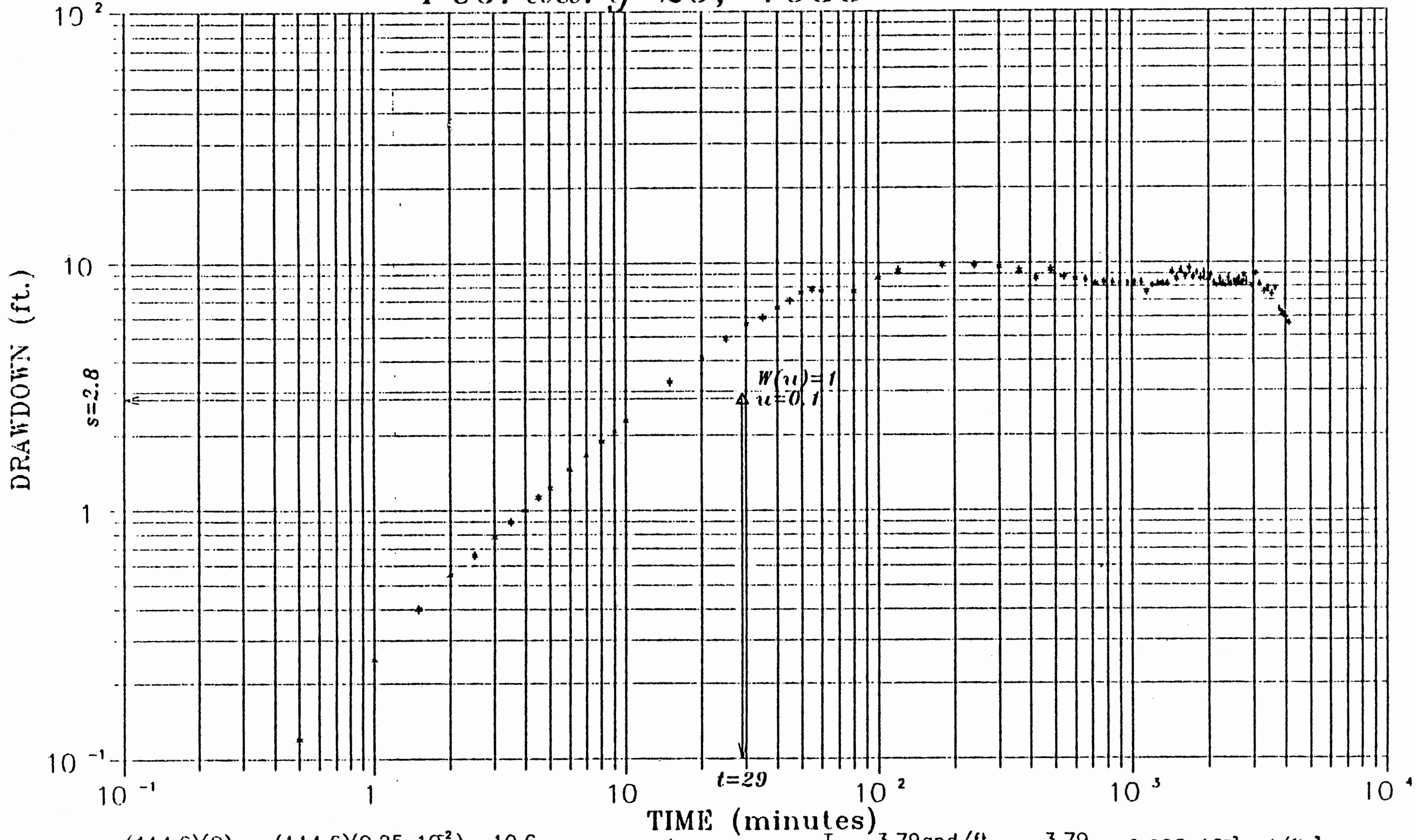


$T = \frac{(114.6)(Q)}{s} = \frac{(114.6)(9.25\times10^{2})}{0.19} = \frac{10.6}{0.19} = 55.79$ gpd/ft

$K = \frac{T}{M} = \frac{55.79\text{gpd/ft}}{30-16.38\text{ft}} = \frac{55.79}{13.62} = 4.096\times10^{0}$ gpd/ft^{2} $= 1.93\times10^{4}$ cm/sec

$S = \frac{Ttu}{2693r_0^2} = \frac{(55.79)(520)(.1)}{(2693)(10)^2} = \frac{2901.08}{2.69\times10^{+5}} = 1.08\times10^{-2}$

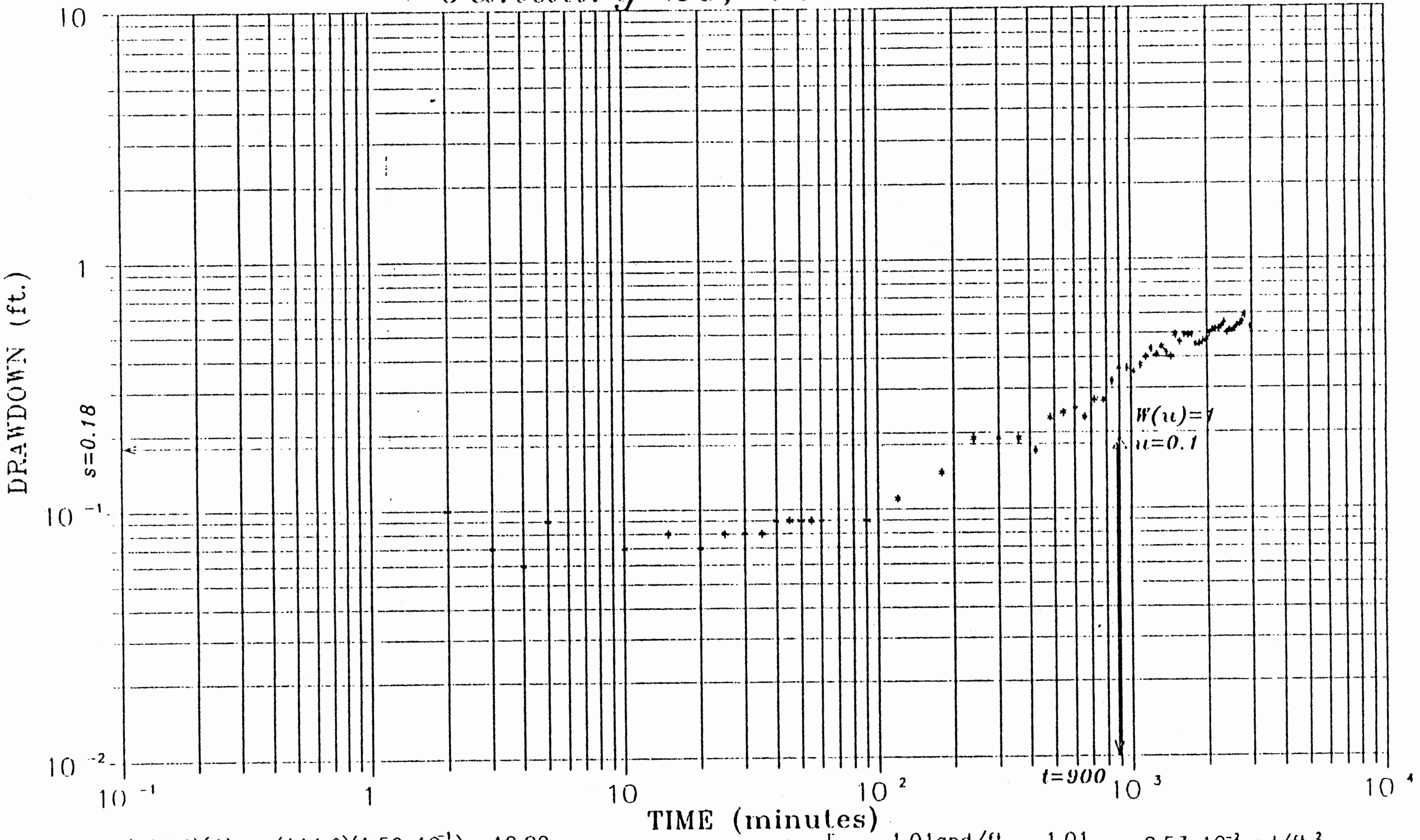
TIME/DRAWDOWN ANALYSIS (Theis)
MW U0-87-9.2 (Production Well)
February 29, 1988



$T = \frac{(114.6)(Q)}{s} = \frac{(114.6)(9.25x10^{2})}{2.8} = \frac{10.6}{2.8} = 3.79 gpd/ft$

$K = \frac{T}{M} = \frac{3.79 gpd/ft}{55.6 -- 16.52 ft} = \frac{3.79}{39.08} = 9.698x10^{-2} gpd/ft^{2} = 4.58x10^{-6} cm/sec$

TIME/DRAWDOWN ANALYSIS (Theis)
MW U0-87-9.2 (Observation Well)
January 26, 1988

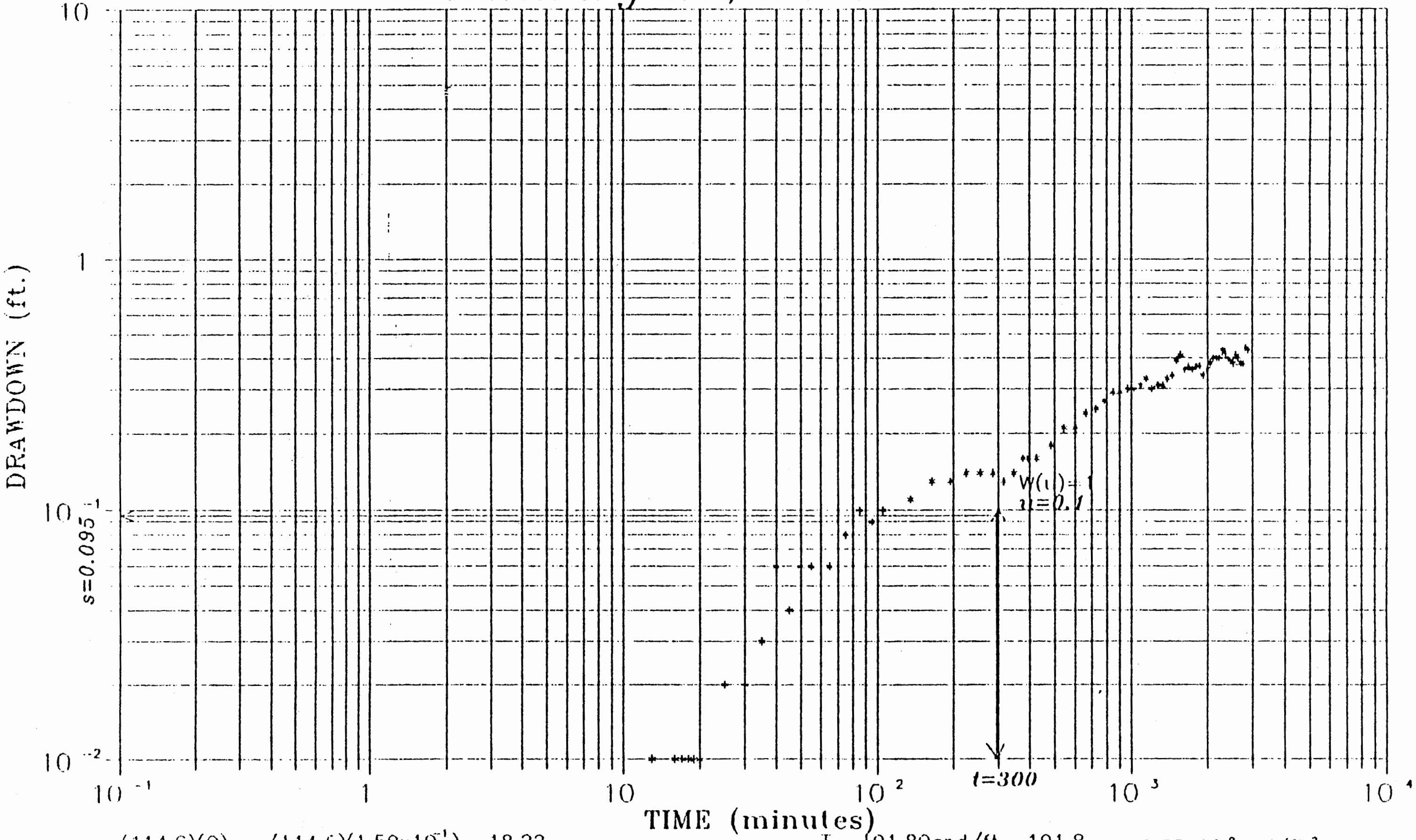


$T = \frac{(114.6)(Q)}{s} = \frac{(114.6)(1.59x10^{-1})}{0.18} = \frac{18.22}{0.18} =$ 1.01gpd/ft

$K = \frac{T}{M} = \frac{1.01gpd/ft}{55.6-15.65ft} = \frac{1.01}{39.95} = 2.53x10^{-2}gpd/ft^2$
$= 1.19x10^{6}cm/sec$

$S = \frac{Ttu}{2693r_0^2} = \frac{(1.01)(900)(0.1)}{(2693)(700)^2} = \frac{90.9}{1.32x10^{+9}} = 6.89x10^{-8}$

TIME/DRAWDOWN ANALYSIS (Theis)
MW U0-87-3.1 (Observation Well)
January 26, 1988

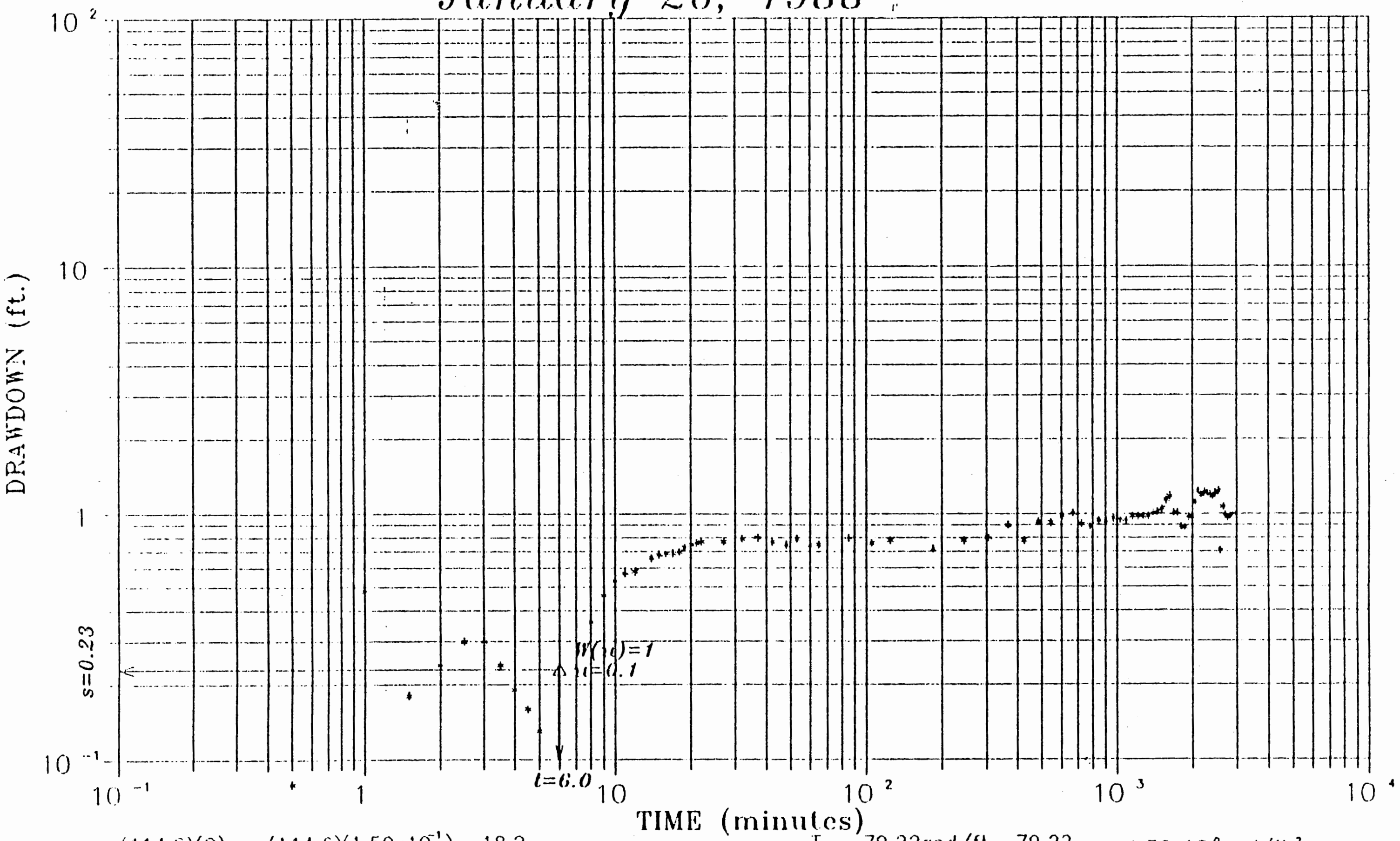


$T = \frac{(114.6)(Q)}{s} = \frac{(114.6)(1.59\times10^{-1})}{0.095} = \frac{18.22}{0.095} =$ 191.8gpd/ft

$K = \frac{T}{M} = \frac{191.80\text{gpd/ft}}{34.94-14.34\text{ft}} = \frac{191.8}{20.60} =$ 9.28×10^{0}gpd/ft^2 = 3.96×10^{-4}cm/sec

$S = \frac{Ttu}{2693r_0^2} = \frac{(191.8)(300)(0.1)}{(2693)(6.64)^2} = \frac{5754}{1.19\times10^{5}} = 4.84\times10^{-2}$

TIME/DRAWDOWN ANALYSIS (Theis)
MW U0-87-3.2 (Production Well)
January 26, 1988



$T = \frac{(114.6)(Q)}{s} = \frac{(114.6)(1.59\times10^{-1})}{0.23} = \frac{18.2}{0.23} =$ 79.22gpd/ft

$K = \frac{T}{M} = \frac{79.22\text{gpd/ft}}{73-14.92\text{ft}} = \frac{79.22}{58.03} =$ 1.36×10^{0}gpd/ft^2 $= 6.44\times10^{-5}$cm/sec

MW UO-87-3.2
TIME/DRAWDOWN DATA
(Production Well)
January 26, 1988

	TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
(STATIC)	0	14.92	0.00
	0.5	15.00	0.08
	1	15.40	0.48
	1.5	15.10	0.18
	2	15.16	0.24
	2.5	15.22	0.30
	3	15.22	0.30
	3.5	15.16	0.24
	4	15.11	0.19
	4.5	15.08	0.16
	5	15.05	0.13
	8	15.28	0.36
	9	15.38	0.46
	10	15.45	0.53
	11	15.49	0.57
	12	15.50	0.58
	14	15.58	0.66
	15	15.60	0.68
	16	15.61	0.69
	17	15.61	0.69
	18	15.62	0.70
	19	15.65	0.73
	20	15.67	0.75
	21	15.68	0.76
	22	15.69	0.77
	27	15.69	0.77
	32	15.71	0.79
	37	15.72	0.80
	42	15.69	0.77
	48	15.67	0.75
	53	15.71	0.79
	60	15.66	0.74
	65	15.67	0.75
	85	15.72	0.80
	105	15.68	0.76
	125	15.70	0.78
	185	15.64	0.72
	245	15.70	0.78
	305	15.72	0.80
	365	15.82	0.90
	425	15.70	0.78
	485	15.85	0.93
	545	15.84	0.92
	605	15.90	0.98
	665	15.93	1.01
	725	15.83	0.91
	785	15.81	0.89

MW UO-87-3.2
TIME/DRAWDOWN DATA
(Production Well)
January 26, 1988

TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
845	15.86	0.94
905	15.85	0.93
965	15.88	0.96
1025	15.87	0.95
1085	15.86	0.94
1145	15.90	0.98
1205	15.90	0.98
1265	15.90	0.98
1325	15.90	0.98
1385	15.93	1.01
1445	15.94	1.02
1505	15.97	1.05
1565	16.06	1.14
1625	16.10	1.18
1685	15.93	1.01
1745	15.93	1.01
1805	15.81	0.89
1865	15.80	0.88
1925	15.89	0.97
1985	15.89	0.97
2045	16.04	1.12
2105	16.16	1.24
2165	16.11	1.19
2225	16.15	1.23
2285	16.14	1.22
2345	16.12	1.20
2405	16.10	1.18
2465	16.13	1.21
2525	16.16	1.24
2585	15.63	0.71
2645	15.99	1.07
2705	15.91	0.99
2765	15.89	0.97
2825	15.90	0.98
2885	15.92	1.00

MW UO-87-3.1
TIME/DRAWDOWN DATA
(Observation Well)
January 26, 1988

	TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
(STATIC)	0	14.34	0.00
	0.5	14.34	0.00
	1	14.34	0.00
	1.5	14.34	0.00
	2	14.34	0.00
	2.5	14.34	0.00
	3	14.34	0.00
	3.5	14.34	0.00
	4	14.34	0.00
	4.5	14.34	0.00
	5	14.34	0.00
	5.5	14.34	0.00
	6.5	14.34	0.00
	7.5	14.34	0.00
	8	14.34	0.00
	9	14.34	0.00
	10	14.34	0.00
	11	14.34	0.00
	12	14.34	0.00
	13	14.35	0.01
	14	14.34	0.00
	15	14.34	0.00
	16	14.35	0.01
	17	14.35	0.01
	18	14.35	0.01
	19	14.35	0.01
	20	14.35	0.01
	25	14.36	0.02
	30	14.36	0.02
	35	14.37	0.03
	40	14.40	0.06
	45	14.38	0.04
	50	14.40	0.06
	55	14.40	0.06
	65	14.40	0.06
	75	14.42	0.08
	85	14.44	0.10
	95	14.43	0.09
	105	14.44	0.10
	135	14.45	0.11
	165	14.47	0.13
	195	14.47	0.13
	225	14.48	0.14
	255	14.48	0.14
	285	14.48	0.14
	315	14.47	0.13
	345	14.48	0.14

MW UO-87-3.1
TIME/DRAWDOWN DATA
(Observation Well)
January 26, 1988

TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
375	14.50	0.16
393	14.50	0.16
423	14.50	0.16
483	14.52	0.18
543	14.55	0.21
603	14.55	0.21
663	14.58	0.24
723	14.59	0.25
783	14.61	0.27
843	14.63	0.29
903	14.63	0.29
963	14.64	0.30
1023	14.64	0.30
1083	14.65	0.31
1143	14.67	0.33
1203	14.64	0.30
1263	14.65	0.31
1323	14.65	0.31
1383	14.67	0.33
1443	14.68	0.34
1503	14.73	0.39
1563	14.75	0.41
1623	14.70	0.36
1683	14.71	0.37
1743	14.70	0.36
1803	14.71	0.37
1863	14.71	0.37
1923	14.68	0.34
1983	14.70	0.36
2043	14.72	0.38
2103	14.74	0.40
2163	14.74	0.40
2223	14.74	0.40
2283	14.77	0.43
2343	14.76	0.42
2403	14.74	0.40
2463	14.73	0.39
2523	14.72	0.38
2583	14.75	0.41
2643	14.74	0.40
2703	14.72	0.38
2763	14.72	0.38
2823	14.78	0.44
2883	14.77	0.43

MW UO-87-9.2
TIME/DRAWDOWN DATA
(Observation Well)
January 26, 1988

	TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
(STATIC)	0	15.65	0.00
	1	15.65	0.00
	2	15.75	0.10
	3	15.72	0.07
	4	15.71	0.06
	5	15.74	0.09
	10	15.72	0.07
	15	15.73	0.08
	20	15.72	0.07
	25	15.73	0.08
	30	15.73	0.08
	35	15.73	0.08
	40	15.74	0.09
	45	15.74	0.09
	50	15.74	0.09
	55	15.74	0.09
	60	15.74	0.09
	90	15.74	0.09
	120	15.76	0.11
	180	15.79	0.14
	240	15.84	0.19
	300	15.84	0.19
	360	15.84	0.19
	420	15.82	0.17
	480	15.88	0.23
	540	15.89	0.24
	600	15.90	0.25
	660	15.88	0.23
	720	15.92	0.27
	780	15.92	0.27
	840	15.97	0.32
	900	16.01	0.36
	960	16.01	0.36
	1020	16.00	0.35
	1080	16.02	0.37
	1140	16.05	0.40
	1200	16.08	0.43
	1260	16.06	0.41
	1320	16.09	0.44
	1380	16.07	0.42
	1440	16.05	0.40
	1500	16.14	0.49
	1560	16.11	0.46
	1620	16.14	0.49
	1680	16.14	0.49
	1740	16.14	0.49
	1800	16.10	0.45

MW UO-87-9.2
TIME/DRAWDOWN DATA
(Observation Well)
January 26, 1988

TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
1860	16.10	0.45
1920	16.11	0.46
1980	16.12	0.47
2040	16.15	0.50
2100	16.17	0.52
2160	16.17	0.52
2220	16.17	0.52
2280	16.18	0.53
2340	16.20	0.55
2400	16.15	0.50
2460	16.17	0.52
2520	16.16	0.51
2580	16.17	0.52
2640	16.19	0.54
2700	16.19	0.54
2760	16.21	0.56
2820	16.24	0.59
2940	16.18	0.53

MW UO-87-9.2
TIME/DRAWDOWN DATA
(Production Well)
February 29, 1988

	TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)	pH (Std. Units)
(STATIC)	0	16.52	0.00	
	0.5	16.64	0.12	
	1	16.77	0.25	10.60
	1.5	16.92	0.40	
	2	17.07	0.55	
	2.5	17.18	0.66	
	3	17.30	0.78	
	3.5	17.42	0.90	
	4	17.52	1.00	10.70
	4.5	17.65	1.13	
	5	17.75	1.23	10.65
	6	17.98	1.46	
	7	18.18	1.66	10.65
	8	18.40	1.88	10.65
	9	18.60	2.08	
	10	18.80	2.28	
	15	19.80	3.28	
	20	20.66	4.14	10.65
	25	21.43	4.91	
	30	22.13	5.61	
	33			10.65
	35	22.50	5.98	
	40	23.10	6.58	10.65
	45	23.58	7.06	
	50	24.08	7.56	
	52			10.65
	55	24.32	7.80	
	60	24.21	7.69	
	62			10.80
	80	24.17	7.65	
	100	25.16	8.64	10.80
	120	25.80	9.28	9.60
	157			8.95
	174			8.85
	180	26.35	9.83	
	204			8.80
	232			8.60
	240	26.30	9.78	
	292			8.40
	300	26.13	9.61	
	360	25.81	9.29	
	361			8.20
	415			8.30
	420	25.17	8.65	
	472			8.60
	480	25.89	9.37	
	532			8.05

MW UO-87-9.2
TIME/DRAWDOWN DATA
(Production Well)
February 29, 1988

TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)	pH (Std. Units)
540	25.29	8.77	
592			8.00
600	25.10	8.58	
652			8.15
660	25.06	8.54	
712			8.10
720	24.73	8.21	
772			8.10
780	24.87	8.35	
832			8.15
840	24.80	8.28	
892			8.15
900	24.76	8.24	
952			8.05
960	24.83	8.31	
1012			8.05
1020	24.83	8.31	
1072			8.15
1080	24.83	8.31	
1132			8.10
1140	24.11	7.59	
1192			8.20
1200	24.61	8.09	
1252			8.15
1260	24.74	8.22	
1317			8.15
1320	24.77	8.25	
1377			8.15
1380	24.74	8.22	
1440	25.68	9.16	
1442			7.55
1500	25.10	8.58	7.70
1560	25.75	9.23	7.55
1620	25.30	8.78	7.60
1680	25.95	9.43	7.40
1740	25.24	8.72	7.45
1800	25.64	9.12	7.70
1860	25.11	8.59	7.55
1920	25.62	9.10	7.55
1980	25.02	8.50	7.65
2040	25.43	8.91	7.60
2100	24.82	8.30	7.70
2160	24.60	8.08	7.55
2220	25.07	8.55	7.80
2280	24.72	8.20	7.70
2340	24.58	8.06	7.85
2400	25.06	8.54	7.80

MW UO-87-9.2
TIME/DRAWDOWN DATA
(Production Well)
February 29, 1988

TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)	pH (Std. Units)
2460	24.65	8.13	7.80
2520	24.96	8.44	8.00
2580	24.66	8.14	7.85
2640	25.10	8.58	7.80
2700	24.71	8.19	7.80
2760	25.36	8.84	7.85
2820	24.86	8.34	7.65
2940	24.61	8.09	7.45
3060	25.53	9.01	7.95
3180	24.67	8.15	8.00
3300	24.15	7.63	7.90
3420	24.36	7.84	7.80
3540	23.95	7.43	7.85
3660	24.32	7.80	7.85
3780	22.96	6.44	7.90
3900	22.70	6.18	7.85
4020	22.51	5.99	7.75
4140	22.18	5.66	7.85

MW UO-87-9.1
TIME/DRAWDOWN DATA
(Observation Well)
February 29, 1988

	TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
(STATIC)	0	16.38	0.00
	1	16.38	0.00
	2	16.38	0.00
	3	16.38	0.00
	4	16.38	0.00
	5	16.38	0.00
	10	16.38	0.00
	15	16.38	0.00
	20	16.39	0.01
	25	16.39	0.01
	30	16.40	0.02
	35	16.40	0.02
	40	16.40	0.02
	45	16.40	0.02
	50	16.41	0.03
	55	16.43	0.05
	60	16.43	0.05
	90	16.49	0.11
	120	16.51	0.13
	180	16.58	0.20
	240	16.62	0.24
	300	16.64	0.26
	360	16.66	0.28
	420	16.66	0.28
	480	16.67	0.29
	540	16.69	0.31
	600	16.67	0.29
	660	16.67	0.29
	720	16.67	0.29
	780	16.66	0.28
	840	16.68	0.30
	900	16.71	0.33
	960	16.72	0.34
	1020	16.74	0.36
	1080	16.74	0.36
	1140	16.73	0.35
	1200	16.75	0.37
	1260	16.74	0.36
	1320	16.75	0.37
	1380	16.79	0.41
	1440	16.79	0.41
	1500	16.81	0.43
	1560	16.81	0.43
	1620	16.85	0.47
	1680	16.83	0.45
	1740	16.80	0.42
	1800	16.79	0.41

MW UO-87-9.1
TIME/DRAWDOWN DATA
(Observation Well)
February 29, 1988

TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
1860	16.77	0.39
1920	16.78	0.40
1980	16.77	0.39
2040	16.76	0.38
2100	16.75	0.37
2160	16.72	0.34
2220	16.75	0.37
2280	16.70	0.32
2340	16.76	0.38
2400	16.75	0.37
2460	16.73	0.35
2520	16.74	0.36
2580	16.75	0.37
2640	16.76	0.38
2700	16.76	0.38
2760	16.74	0.36
2820	16.75	0.37
2940	16.77	0.39
3060	16.77	0.39
3180	16.78	0.40
3300	16.76	0.38
3420	16.71	0.33
3540	16.61	0.23
3660	16.60	0.22
3780	16.51	0.13
3900	16.30	-0.08
4020	16.05	-0.33
4140	15.83	-0.55

MW UO-87-3.2
TIME/DRAWDOWN DATA
(Observation Well)
February 29, 1988

	TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
(STATIC)	0	15.35	0.00
	1	15.35	0.00
	2	15.36	0.01
	3	15.36	0.01
	4	15.36	0.01
	5	15.36	0.01
	10	15.35	0.00
	15	15.35	0.00
	20	15.36	0.01
	25	15.36	0.01
	30	15.36	0.01
	35	15.36	0.01
	40	15.36	0.01
	45	15.36	0.01
	50	15.37	0.02
	55	15.37	0.02
	60	15.37	0.02
	90	15.39	0.04
	120	15.39	0.04
	180	15.39	0.04
	240	15.41	0.06
	300	15.42	0.07
	360	15.41	0.06
	420	15.40	0.05
	480	15.41	0.06
	540	15.40	0.05
	600	15.35	0.00
	660	15.39	0.04
	720	15.36	0.01
	780	15.36	0.01
	840	15.36	0.01
	900	15.42	0.07
	960	15.44	0.09
	1020	15.43	0.08
	1080	15.44	0.09
	1140	15.44	0.09
	1200	15.45	0.10
	1260	15.46	0.11
	1320	15.44	0.09
	1380	15.49	0.14
	1440	15.52	0.17
	1500	15.52	0.17
	1560	15.54	0.19
	1620	15.50	0.15
	1680	15.52	0.17
	1740	15.45	0.10
	1800	15.42	0.07

MW UO-87-3.2
TIME/DRAWDOWN DATA
(Observation Well)
February 29, 1988

TIME (minutes)	DEPTH from T.O.C. to WATER LEVEL (feet)	DRAWDOWN (feet)
1860	15.40	0.05
1920	15.37	0.02
1980	15.35	0.00
2040	15.36	0.01
2100	15.33	-0.02
2160	15.36	0.01
2220	15.38	0.03
2280	15.35	0.00
2340	15.40	0.05
2400	15.41	0.06
2460	15.45	0.10
2520	15.38	0.03
2580	15.39	0.04
2640	15.38	0.03
2700	15.39	0.04
2760	15.38	0.03
2820	15.39	0.04
2940	15.43	0.08
3060	15.43	0.08
3180	15.32	-0.03
3300	15.33	-0.02
3420	15.31	-0.04
3540	15.25	-0.10
3660	15.10	-0.25
3780	15.18	-0.17
3900	15.19	-0.16
4020	15.14	-0.21
4140	15.13	-0.22

AQUIFER TEST

DRAW DOWNS *

TIME SINCE PUMPING STARTED tm (MINUTES)	**PUMPING WELL** S UO-88-2.2 R = 0	S UO-87-3.2 R = 460'	S UO-87-8.2 R = 580'	S UO-87-2.1B R = 21'	S UO-87-1.1B R = 240'
1	0.59				
2	1.14				
3	1.93				
4	2.53				
5	3.22				
6	3.46				
7	4.17				
8	4.67				
9	5.13			0.01	
10	5.56			0.01	
12	6.32			0.01	
14	6.98			0.03	
16	7.51			0.04	
18	7.91			0.08	
20	8.27			0.09	0.02
25	9.02			0.17	0.01
30	9.57			0.19	0.01
35	9.99		0.02	0.19	0.01
40	10.32		0.01	0.19	0.01
45	10.58		0.00	0.40	0.01
50	10.76	0.01	0.01	0.40	0.02
60	11.02	0.04	0.01	0.43	0.02
70	11.21	0.03	0.01	0.43	0.02
80	11.37	0.03	0.02	0.43	0.03
90	11.49	0.00	-0.01	0.86	0.03
100	11.58	0.04	-0.01	0.98	0.03
140	11.73	0.08	0.03	1.20	0.05
180	11.77	0.02	0.04	1.41	0.05
200	11.68	0.02	0.05	1.49	0.06
235	11.67	-0.01	0.06	1.53	0.07
270	11.64	-0.06	0.03	1.61	0.06
300	11.49	0.03	0.02	1.65	0.06
360	12.28	0.03	0.03	1.70	0.06
420	12.36	-0.04	0.05	1.76	0.07
480	12.46	-0.01	0.06	1.83	0.08
540	12.48	-0.01	0.06	1.86	0.09
600	12.54	-0.04	0.07	1.93	0.13
660	12.57	-0.06	0.11	1.98	0.16
720	12.57	0.02	0.13	2.01	0.16
780	12.45	0.01	0.15	2.04	0.17
840	12.84	0.00	0.19	2.06	0.19
900	12.62	0.00	0.21	2.09	0.19
1080	12.71	-0.01	0.17	2.12	0.21
1260	12.71	0.00	0.18	2.16	0.22
1440	12.59	0.12	0.18	2.15	0.22
1620	12.69	0.18	0.26	2.21	0.28

DRAW DOWNS *

TIME SINCE PUMPING STARTED tm (MINUTES)	**PUMPING WELL** S UO-88-2.2 R = 0	S UO-87-3.2 R = 460'	S UO-87-8.2 R = 580'	S UO-87-2.1B R = 21'	S UO-87-1.1B R = 240'
1800	12.71	0.15	0.27	2.22	0.30
1980	12.54	0.10	0.26	2.22	0.30
2160	12.85	0.10	0.27	2.19	0.31
2340	12.78	0.18	0.28	2.29	0.36
2520	12.70	0.18	0.32	2.30	0.35
2700	12.60	0.20	0.31	2.30	0.35
2880	12.89	0.23	0.34	2.33	0.37
3060	13.04	0.28	0.37	2.36	0.41
3240	12.97	0.24	0.39	2.38	0.43
3420	12.73	0.23	0.37	2.38	0.42
3600	12.78	0.25	0.37	2.32	0.43
3780	14.24	0.27	0.41	2.48	0.45
3960	14.13	0.34	0.42	2.57	0.46
4140	14.09	0.34	0.42	2.58	0.46
4320	14.03	0.31	0.43	2.59	0.48

* Negative (-) valves indicate that the measured water level was above the static water level measured prior to the start of pumping.

SLUG TEST
UO-88-7.2
DATE: 8-23-88

t TIME (SEC.)	DEPTH TOC TO WATER LEVEL (FEET)	H	H/HO
-1	11.02		
0	13.00	1.98	1
30	12.82	1.80	0.91
41	12.70	1.68	0.85
54	12.63	1.61	0.81
64	12.48	1.46	0.74
77	12.40	1.38	0.70
80	12.36	1.34	0.68
85	12.28	1.26	0.64
93	12.20	1.18	0.60
103	12.11	1.09	0.55
126	12.01	0.99	0.50
131	11.95	0.93	0.47
150	11.89	0.87	0.44
160	11.80	0.78	0.39
175	11.75	0.73	0.37
185	11.71	0.69	0.34
	11.67	0.65	0.33
203	11.61	0.59	0.30
208	11.59	0.57	0.29
245	11.47	0.45	0.23
274	11.41	0.39	0.20
305	11.36	0.34	0.17
335	11.33	0.31	0.16
365	11.30	0.28	0.14
395	11.26	0.24	0.12
428	11.24	0.22	0.11
486	11.20	0.18	0.09
550	11.19	0.17	0.09
605	11.16	0.17	0.07
668	11.15	0.13	0.07
725	11.14	0.12	0.06
784	11.14	0.12	0.06
843	11.14	0.12	0.06
904	11.12	0.10	0.05
964	11.12	0.10	0.05
1024	11.11	0.09	0.05
1324	11.09	0.07	0.04
1624	11.08	0.06	0.03
1924	11.07	0.05	0.03
2224	11.07	0.05	0.03
2524	11.07	0.05	0.03
2824	11.06	0.04	0.02
3124	11.06	0.04	0.02
3424	11.06	0.04	0.02
3724	11.06	0.004	0.02
4324	11.05	0.03	0.02
4924	11.05	0.03	0.02
5524	11.04	0.02	0.01
6124	11.04	0.02	0.01
6724	11.03	0.01	0.01

SLUG TEST
UO-88-13.2
DATE: 8-24-88

t TIME (SEC.)	DEPTH TOC TO WATER LEVEL (FEET)	H	$^{H}/HO$
-1	3.62		
0	6.18	2.56	1
52	5.98	2.36	0.92
65	5.96	2.34	0.91
76	5.89	2.27	0.89
88	5.79	2.17	0.85
92	5.64	2.02	0.80
105	5.58	1.96	0.77
117	5.50	1.89	0.74
127	5.39	1.77	0.69
138	5.29	1.67	0.65
150	5.25	1/63	0.64
159	5.16	1.54	0.60
171	5.02	1.40	0.55
182	4.99	1.37	0.54
193	4.94	1.32	0.52
202	4.89	1.27	0.50
217	4.84	1.22	0.48
228	4.79	1.17	0.46
239	4.76	1.14	0.45
249	4.69	1.07	0.42
300	4.50	0.88	0.34
325	4.40	0.78	0.30
355	4.31	0.69	0.27
385	4.25	0.63	0.25
415	4.19	0.57	0.22
445	4.14	0.52	0.20
505	4.06	0.44	0.17
445	4.00	0.38	0.15
505	3.95	0.33	0.13
565	3.90	0.28	0.11
625	3.86	0.24	0.09
685	3.84	0.22	0.09
745	3.82	0.20	0.08
805	3.80	0.18	0.07
1105	3.74	0.12	0.05
1405	3.73	0.11	0.04
1705	3.71	0.09	0.04
2005	3.69	0.07	0.03
2305	3.69	0.07	0.03
2605	3.69	0.07	0.03
2905	3.69	0.07	0.03
3205	3.68	0.06	0.02
3505	3.67	0.05	0.02
3805	3.67	0.05	0.02
4105	3.67	0.05	0.02
4705	3.66	0.04	0.02
5305	3.66	0.04	0.02
5905	3.66	0.04	0.02
6505	3.66	0.04	0.02
7105	3.66	0.04	0.02
7705	3.66	0.04	0.02
9505	3.66	0.04	0.02

SLUG TEST
UO-88-15.2
DATE: 8-25-88

t TIME (SEC.)	DEPTH TOC TO WATER LEVEL (FEET)	H	H/HO
-1	11.72		
0	13.71	1.99	1
21	13.69	1.97	0.99
30	13.64	1.92	0.97
39	13.62	1.90	0.96
47	13.59	1.87	0.94
59	13.58	1.86	0.94
71	13.56	1.84	0.93
78	13.53	1.81	0.91
89	13.51	1.79	0.09
96	13.49	1.77	0.89
107	13.48	1.76	0.88
177	13.46	1.74	0.87
131	13.43	1.71	0.86
141	13.40	1.68	0.84
151	13.39	1.67	0.84
164	13.37	1.65	0.83
176	13.35	1.63	0.82
214	13.27	1.55	0.78
244	13.24	1.52	0.76
274	13.19	1.47	0.74
304	13.14	1.42	0.71
334	13.10	1.38	0.69
364	13.06	1.34	0.67
424	12.99	1.27	0.64
484	12.91	1.19	0.60
544	12.85	1.13	0.57
604	12.78	1.06	0.57
664	12.73	1.01	0.51
724	12.68	0.96	0.48
784	12.63	0.91	0.46
844	12.58	0.86	0.43
904	12.54	0.82	0.41
964	12.50	0.78	0.39
1264	12.32	0.60	0.30
1564	12.19	0.47	0.24
1864	12.09	0.37	0.19
2164	12.00	0.28	0.14
2464	11.97	0.25	0.13
2764	11.93	0.21	0.11
3064	11.89	0.17	0.09
3364	11.87	0.15	0.08
3964	11.82	0.10	0.05
4564	11.80	0.08	0.04
5164	11.78	0.06	0.03
5764	11.77	0.05	0.03
6364	11.76	0.04	0.02
6964	11.76	0.04	0.02
8764	11.76	0.04	0.02
10564	11.76	0.04	0.02

APPENDIX H

ANALYTICAL RESULTS

ANALYTICAL RESULTS

1-3-88 TO 1-29-88

Well Number Sample Number		Parameters (mg/l)						
	Zone ^{A}	V	Ca	Na	Cl	$NH_3(N)$	SO_4	pH^B
1.1A-8015-1	1	0.1	301	770	1,091	28.0	1,438	6.0
1.1B-8015-1	2	0.1	29	40	67	<0.12	34	7.0
1.1B-8015-2	2	0.1	28	36	61	<0.12	34	7.0
2.1A-8019-1	1	0.2	332	1,900	3,939	4.7	18	4.3
2.1B-8019-1	2	0.1	18	48	14	<0.12	<6	8.3
3.1 -8029-1	2	0.3	910	114	3,333	<0.12	8	6.2
3.2 -8029-1	3	0.4	2,010	139	6,666	<0.12	9	6.6
3.2 -8029-2	3	0.3	2,040	150	6,363	<0.12	10	6.6
4.1 -8013-1	1	0.3	3,320	10.0	11,817	<0.12	20	3.6
6.1 -8028-1	1	6.1	31	42	67	<0.12	141	6.9
6.2 -8028-1	3	0.2	39	41	164	<0.12	7	7.8
7.1 -8028-1	1	0.1	54	20	12	<0.12	16	7.9
7.2 -8028-1	3	0.1	54	14	30	<0.12	9	7.6
8.1 -8029-1	1	0.2	14	4	18	<0.12	<6	5.9
8.2 -8029-1	3	0.3	27	19	6	<0.12	12	7.7
9.1 -8029-1	1	0.3	98	39	212	<0.12	6	11.2
9.2 -8029-1	3	0.4	52	43	1,073	0.12	14	11.2
10.2-8020-1	3	<0.1	1,100	56	3,272	<0.12	12	6.1

A - Completion zones
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

B - pH in standard units

ANALYTICAL RESUTS

2-16-88 TO 2-26-88

Well Number Sample Number		Parameters (mg/l)						
	Zone[A]	V	Ca	Na	Cl	NH_3(N)	SO_4	pH[B]
1.1A-8057-1	1	<0.1	266	390	1,060	28.0	1,390	7.2
1.1B-8057-1	2	<0.1	67	31	109	<0.12	83	7.5
2.1A-8057-1	1	.3	468	1,450	3,515	4.0	1,536	4.6
2.1B-8057-1	2	<0.1	57	26	12	<0.12	<6	8.6
3.1 -8056-1	2	<0.1	960	130	3,394	<0.12	9	6.0
3.2 -8056-1	3	<0.1	1,910	180	5,696	<0.12	23	6.8
4.1 -8056-1	1	.5	3,190	950	12,423	<0.12	17	3.5
6.1 -8055-1	1	3.9	75	180	194	<0.12	396	6.4
6.2 -8055-1	3	<0.1	84	23	79	<0.12	8	7.7
7.1 -8055-1	1	<0.1	53	23	14	<0.12	19	7.4
7.2 -8055-1	3	<0.1	57	19	54	<0.12	8	7.6
8.1 -8056-1	1	<0.1	11	9	18	<0.12	<6	6.0
8.2 -8056-1	3	<0.1	16	15	6	<0.12	101	6.8
9.1 -8057-1	1	*	100	40	*	0.085	*	9.45
9.1 -8057-2	1	*	110	38	*	0.071	*	9.45
9.1 -8057-3	1	*	120	48	*	0.055	*	9.0
9.2 -8057-1	3	*	550	41	*	0.097	*	10.0
9.2 -8057-2	3	*	550	41	*	0.091	*	9.4
9.2 -8057-3	3	*	560	41	*	0.12	*	8.8
10.2-8055-1	3	0.2	1,090	110	3,515	<0.12	13	6.4

A - Completion Zones
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

B - pH in standard units

*Note: Analysis for V, Cl, SO_4 were not conducted due to incomplete laboratory instructions.

ANALYTICAL RESULTS
DATE: 5-16-88 TO 5-23-88

Well Number Sample Number					Parameters (mg/l)			
	ZONE ^{A}	V	Ca	Na	Cl	NH_3(N)	SO_4	pH_B
UO-87-1.1A	1	<0.1	260	760	982	27.0	2,048	6.6
UO-87-1.1B	2	<0.1	21	81	103	<0.12	38	9.0
UO-87-2.1A	1	0.2	440	1,622	3,060	2.5	2,195	4.5
UO-87-2.1B	2	0.1	27	63	14	<0.12	<6	7.9
UO-88-2.2	3							
UO-87-3.1	1	0.1	1,060	116	3,333	<0.12	8	6.0
UO-87-3.2	3	<0.1	2,140	160	6,242	<0.12	8	6.8
UO-87-3.2A								
UO-87-4.1	1	0.2	3,270	940	12,423		19	3.6
UO-87-4.1	1	<0.1	1.2	87	9	<0.12	<6	4.8
UO-87-6.1	1	4.5	28	27	42	<0.12	28	6.5
UO-87-6.2	3	0.1	100	26	297	<0.12	7	7.6
UO-87-7.1	1	0.2	63	32	12	<0.12	13	7.5
UO-87-7.2	3	<0.1	54	21	62	<0.12	8	7.6
UO-87-8.1	1	<0.1	16	6	15	<0.12	<6	5.6
UO-87-8.2	3	<0.1	37	13	4	<0.12	6	8.2
UO-87-9.1	1	<0.1	870	373	255	<0.12	<6	7.0
UO-87-9.2	3	<0.1	770	46	1,733	<0.12	18	9.2
UO-87-10.2	3	0.2	1,150	85	3,697	<0.12	12	6.3
UO-88-11.1	1							
UO-88-11.2	3							
UO-88-12.2	3							
UO-88-13.1	1							
UO-88-13.2	3							
UO-88-14.1	1							
UO-88-14.2	3							
UO-88-15.1	1							
UO-88-15.2	3							

A - Completion zones
    1 = Alluvial Fan
    2 = Fluvial
    3 = Stanley Shale

B - pH in standard units

ANALYTICAL RESULTS
DATE: 6-14-88 TO 6-22-88

Well Number Sample Number		Paramerters (mg/l)						
	ZONE ^{A}	V	Ca	Na	Cl	NH$_3$(N)	SO$_4$	pH^{B}
UO-87-1.1A	1	<1	210	1,550	945	26.0	1,065	5.4
UO-87-1.1B	2	<1	<0.1	58	109	<0.12	37	7.5
UO-87-2.1A	1	<1	460	2,030	3,684	4.2	14	4.4
UO-87-2.1B	2	<1	<0.1	55	9	<0.12	<6	7.9
UO-88-2.2	3							
UO-87-3.1	1	<0.1	2,390	119	3,424	<0.12	<6	5.9
UO-87-3.2	3	<0.1	2,020	179	6,272	<0.12	11	6.8
UO-88-3.2A	3							
UO-87-4.1	1	0.1	1,010	980	12,120	<0.12	7	3.7
UO-87-6.1	1	4.0	35	52	180	<0.12	48	6.4
UO-87-6.2	3	<0.1	81	35	220	<0.12	7	7.7
UO-87-7.1	1	<0.1	53	26	11	<0.12	9	7.5
UO-87-7.2	3	<0.1	70	23	73	<0.12	6	7.5
UO-87-8.1	1	<0.1	12	5	18	<0.12	<6	5.5
UO-87-8.2	3	<0.1	54	13	4	<0.12	<6	7.3
UO-87-9.1	1	0.1	79	35	261	<0.12	<6	6.6
UO-87-9.2	3	<1	780	50	1,842	<0.12	16	8.1
UO-87-10.2	3	0.4	1,040	88	3,757	<0.12	11	6.5
UO-88-11.1	1							
UO-88-11.2	3							
UO-88-12.2	3							
UO-88-13.1	1							
UO-88-13.2	3							
UO-88-14.1	1							
UO-88-14.2	3							
UO-88-15.1	1							
UO-88-15.2	3							

A - Completion zones
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

B - pH in standard units

ANALYTICAL RESULTS
DATE: 7-5-88 TO 7-29-88

Well Number Sample Number		Parameters (mg/l)						
	ZONE [A]	V	Ca	Na	Cl	NH_3(N)	SO_4	pH [B]
UO-87-1.1A	1							
UO-87-1.1B	2							
UO-87-2.1A	1							
UO-87-2.1B	2							
UO-88-2.2	3	0.3	31	95	15	<0.12	7	8.0
UO-87-3.1	1							
UO-87-3.2	3	0.1	166	201	194	0.96	27	11.8
UO-88-3.2A	3							
UO-87-4.1	1							
UO-87-6.1	1							
UO-87-6.2	3							
UO-87-7.1	1							
UO-87-7.2	3							
UO-87-8.1	1							
UO-87-8.2	3							
UO-87-9.1	1							
UO-87-9.2	3							
UO-87-10.2	3							
UO-88-11.1	1							
UO-88-11.2	3	<0.01	89	19	179	<0.12	23	7.7
UO-88-12.2	3	<0.1	<1	20	26	<0.12	68	6.5
UO-88-13.1	1	0.8	5,220	762	14,544	173.0	678	4.3
UO-88-13.2	3	0.2	1,960	159	4,757	<0.12	66	6.9
UO-88-14.1	1	<0.1	180	162	488	<0.12	149	4.7
UO-88-14.2	3	0.2	70	14	73	<0.12	<6	7.2
UO-88-15.1	1	<0.1	38	10	29	<0.12	<6	6.5
UO-88-15.2	3	0.2	114	24	464	<0.12	<6	6.7

A - Completion zones
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

ANALYTICAL RESULTS
DATE: 8-16-88 TO 8-23-88

Well Number Sample Number				Parameters (mg/l)				
	ZONE ^{A}	V	Ca	Na	Cl	NH_3(N)	SO_4	pH^{B}
UO-87-1.1A	1	<0.03	256	673	1,450	36.06	950	5.35
UO-87-1.1B	2	<0.03	21.5	53.7	101	0.48	4	7.48
UO-87-2.1A	1	<0.03	560	2,010	5,750	7.2	1,350	3.93
UO-87-2.1B	2	<0.03	23.3	61.5	16	0.017	91.5	8.71
UO-88-2.2	3	<0.03	13.6	80.7	13.9	0.016	3.9	8.21
UO-87-3.1	1	<0.03	1,020	85.8	3,610	0.034	6.2	5.7
UO-87-3.2	3	0.058	1,420	171	13,200	0.06	16.8	5.85
UO-88-3.2A	3	<0.04	362	320	197.5	2.74	13.1	12.45
UO-87-4.1	1							
UO-87-6.1	1	4.07	24.9	43.4	77.9	0.023	46.6	6.79
UO-87-6.2	3	<0.03	95.1	24	722	0.04	3.8	6.88
UO-87-7.1	1	<0.03	60.1	18.3	9.28	0.30	12.0	7.32
UO-87-7.2	3	<0.03	63.5	17.2	100	0.17	24.9	7.41
UO-87-8.1	1	<0.03	1.58	5.93	57.3	0.082	4.0	5.55
UO-87-8.2	3	<0.03	32.8	10.5	12.9	0.04	14.2	7.35
UO-87-9.1	1	<0.03	91.3	37	260	0.016	4.5	7.15
UO-87-9.2	3	<0.03	362	51.4	2,890	0.18	13.25	8.76
UO-87-10.2	3	<0.03	1,440	73.4	5,360	0.05	16.2	3.90
UO-88-11.1	1	DRY	DRY	DRY	DRY	DRY	DRY	DRY
UO-88-11.2	3	<0.03	83.5	24.3	185	0.023	12.45	6.65
UO-88-12.2	3	<0.03	4.06	20	40.1	0.011	49.0	5.36
UO-88-13.1	1	<0.03	7,780	681	14,500	206	690.0	3.96
UO-88-13.2	3	<0.03	2,000	172	11,000	0.44	60.0	6.69
UO-88-14.1	1	<0.03	492	171	2,420	0.04	177.0	4.54
UO-88-14.2	3	<0.03	40.1	16.6	104	0.03	9.1	7.14
UO-88-15.1	1	<0.03	19.7	28	60.6	0.11	5.1	6.65
UO-88-15.2	3	<0.03	139	34.3	552	0.067	18.5	6.61

A - Completion zones
1 = Alluvial Fan
2 = Fluvial
3 = Stanley Shale

B - pH in standard units

APPENDIX I

STREAM AND SEEPAGE SAMPLE RESULTS

WEST STREAM AND SEEPAGE
SAMPLING CHLORIDE
mg/l

Sample location	1/30/86	2/25/86	6/19/86	2/24/89	3/16/89	4/5/89	4/25/89
20			30	400		24	20
19			32	370			
18A			17	6			
18			61				
17			339	330			
16			41	350			
15			42	340			
14			45	340			
13			49	320			
12A		64				42	DRY
12			45	330		78	68
11			140	330			
10C	12				6	8	*
10B					310	374	382
10A			539	580			
10			354	410			
9			345	400			
8			215	400			
7C			10				
7B			13				
7A			15	10			
7			336	380			
6			321	350		266	388
5			327				
4			324				
3			321	340			
2			318			36	360
1			321	330			

* Sample not analyzed due to detergent content.

EAST STREAM AND SEEPAGE
SAMPLING SULFATE
mg/l

Sample location	2/24/89	3/30/89	4/5/89	4/25/89
9			15	15
8	47			
7B			7	DRY
7A	7		7	9
7	52			
6B	12			
6A			35	29
6	35			
5A			<6	13
5	36		18	15
4	39			
3A				
3B	11		12	12
3C-1		7	7	DRY
3C-2		11	11	10
3C-3		31	15	16
3D			10	9
3	35		15	14
2A	10		9	DRY
2	35			
1				

EAST STREAM AND SEEPAGE
SAMPLING CHLORIDE
mg/l

Sample location	1/30/86	3/8/86	5/9/86	6/4/86	7/11/86	2/24/89	4/5/89	4/25/89
9				114	160		32	24
8				107	158	52		
7B					DRY		72	DRY
7A					1818	1300	1260	1721
7				95	162	80		
6B					30	8		
6A					18		10	30
6				35	122	50		
5A							1285	1327
5				34	142	50	42	56
4				33	142	50		
3A					126			
3B						8	10	16
3C-1							90	DRY
3C-2	238	498	479				368	326
3C-3							576	198
3D							280	326
3				28	120	60	36	50
2A						310	258	DRY
2				43	27	60		
1				14	18			

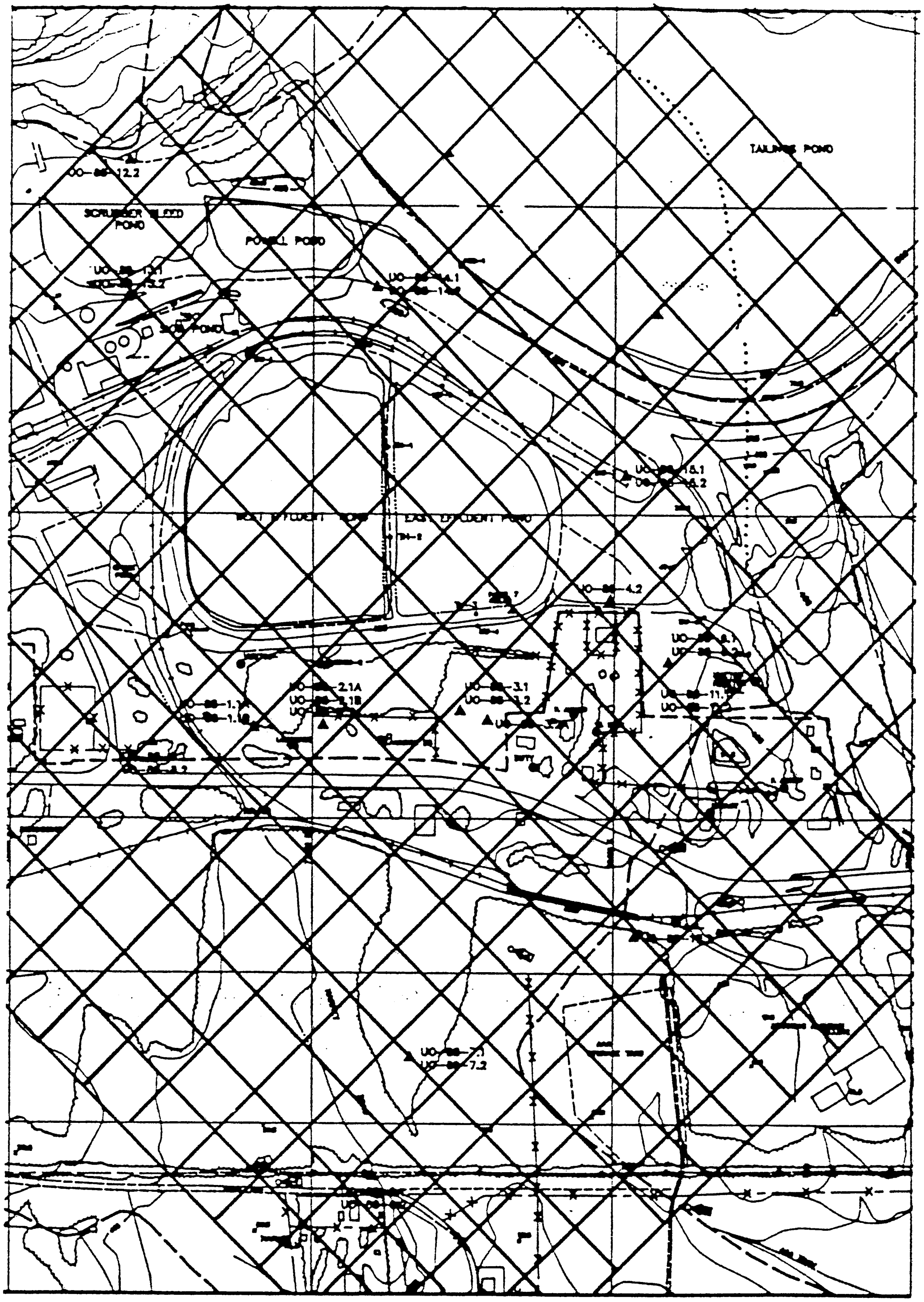
WEST STREAM AND SEEPAGE SAMPLING SULFATE mg/l

Sample location	2/24/89	3/16/89	4/5/89	4/25/89
20	130	6	19	12
19	118			
18A	11			
18				
17	108			
16	113			
15	108			
14	101			
13	98			
12A			7	DRY
12	96		37	25
11	84			
10C		<6	9	*
10B		59	74	38
10A	69			
10	86			
9	76			
8	76			
7C				
7B				
7A	11			
7	64			
6	59		37	35
5				
4				
3	52			
2			40	35
1	59			

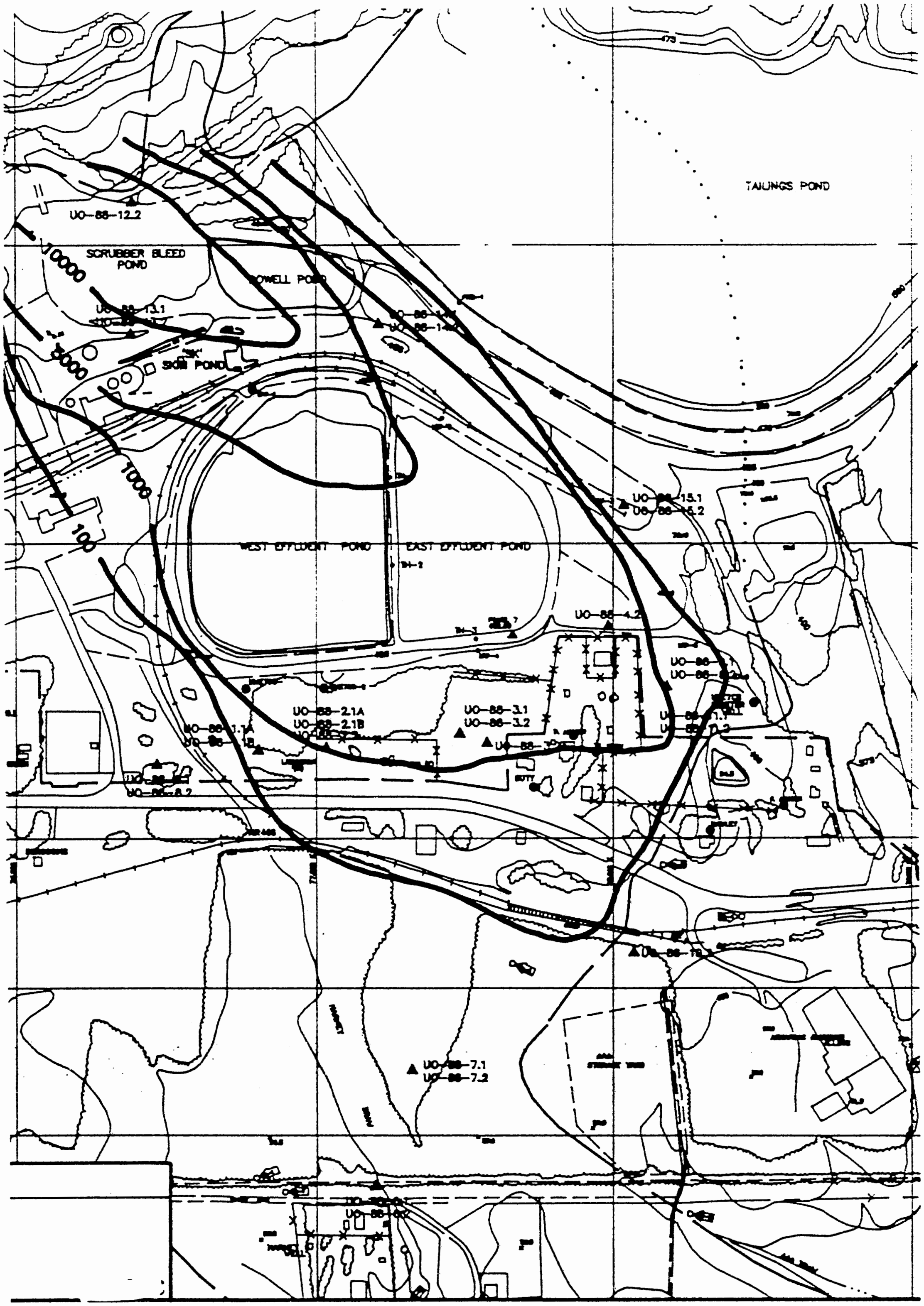
* Sample not analyzed due to detergent content

APPENDIX J

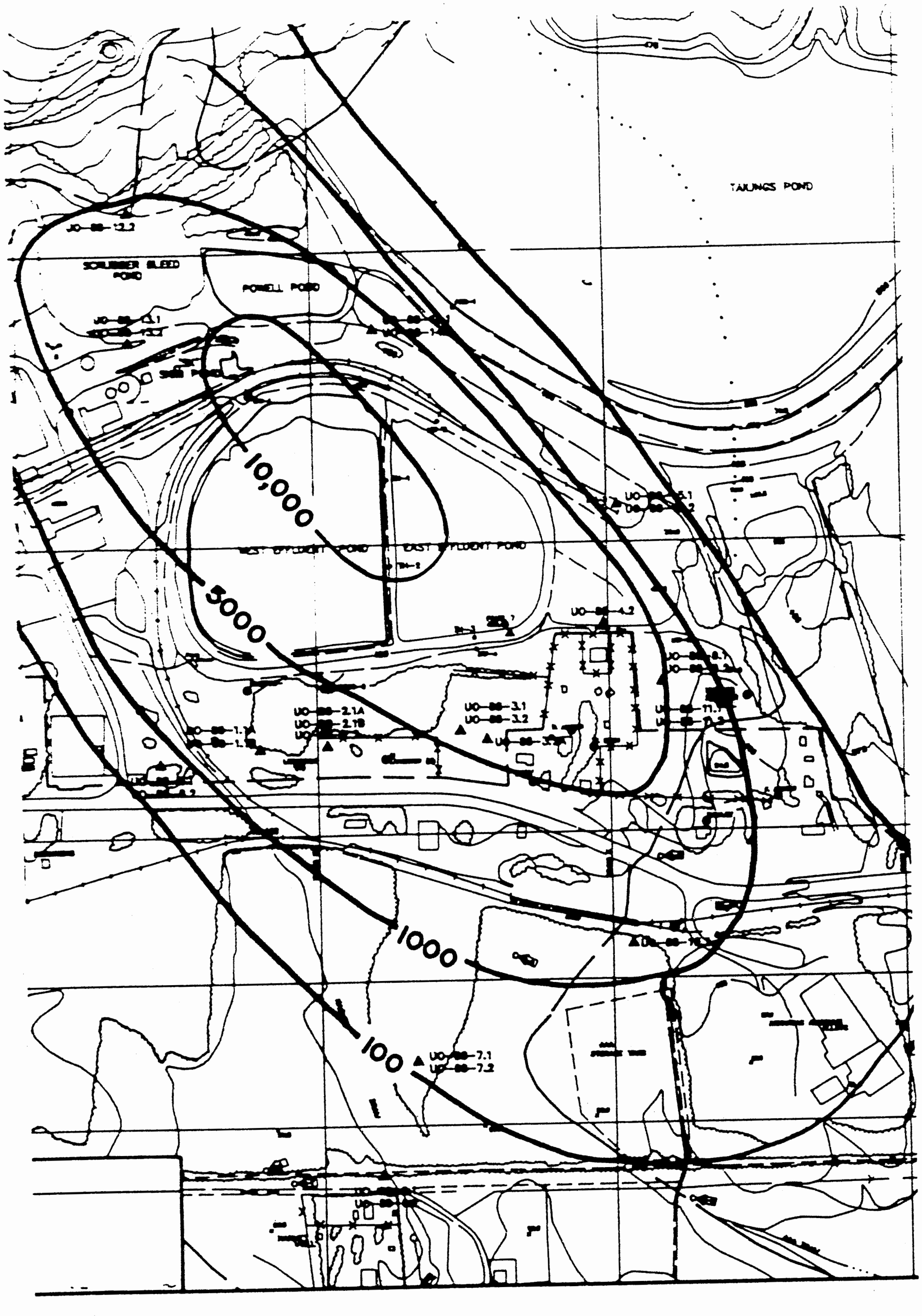
MODELING RESULTS


TAILINGS POND
SCRUBBER BLEED POND
POWELL POND
WEST EFFLUENT POND
EAST EFFLUENT POND
UO—88—12.2
UO—88—2.1A
UO—88—2.1B
UO—88—1.1
UO—88—3.1
UO—88—3.2
UO—88—4.2
UO—88—7.1
UO—88—7.2

Model Grid



Alluvium Model Calibration



Stanley Shale Model Calibration

ALLUVIUM DEPOSITS

PLUME EVOLUTION - 18 YEARS

NUMERICAL MODEL INPUT/OUTPUT
ALLUVIAL DEPOSITS
MODEL EXPLANATION
(MODEL CALIBRATIONS)
PLUME EVOLUTION - 18 YEARS

GENERAL GROUNDWATER PARAMETERS

```
0                    I N P U T     D A T A
0                      GRID DESCRIPTORS

             NX     (NUMBER OF COLUMNS)  =    20
             NY     (NUMBER OF ROWS)     =    20
             XDEL   (X-DISTANCE IN FEET) =   200.0
             YDEL   (Y-DISTANCE IN FEET) =   200.0
0                      TIME  PARAMETERS

             NTIM    (MAX. NO. OF TIME STEPS)        =       5
             NPMP    (NO. OF PUMPING PERIODS)        =       2
             PINT    (PUMPING PERIOD IN YEARS)       =     18.000
             TIMX    (TIME INCREMENT MULTIPLIER)     =      1.00
             TINIT   (INITIAL TIME STEP IN SEC.)     =    .11E+10
0              HYDROLOGIC AND CHEMICAL PARAMETERS

             S        (STORAGE COEFFICIENT)        =        .400000
             POROS    (EFFECTIVE POROSITY)         =        .30
             BETA     (CHARACTERISTIC LENGTH)      =     400.0
             DLTRAT   (RATIO OF TRANSVERSE TO
                      LONGITUDINAL DISPERSIVITY)   =        .03
             ANFCTR   (RATIO OF T-YY TO T-XX)      =      10.000000
0 ***NON-DECAYING SPECIES***
0 ***NON-SORBING SPECIES***
0 ***SIP USED***
0 ***UNCONFINED AQUIFER***
0 ***BOTTOM INPUT***
0                    EXECUTION PARAMETERS

             NITP    (NO. OF ITER. PARAM  - ADIP)  =    4
             TOL     (CONVERGENCE CRITERIA)        =      .0090
             ITMAX   (MAX.NO.OF ITERATIONS)        =   10
             CELDIS  (MAX.CELL DISTANCE PER MOVE
                          OF PARTICLES - M.O.C.)   =     .500
             NPMAX   (MAX. NO. OF PARTICLES)       = 3200
             NPTPND  (NO. PARTICLES PER NODE)      =     4
0                         PROGRAM OPTIONS

             NPNT    (TIME STEP INTERVAL FOR
                      COMPLETE PRINTOUT)     =      5
             NPNTMV  (MOVE INTERVAL FOR CHEM.
                      CONCENTRATION PRINTOUT)  =    0
             NPNTVL  (PRINT OPTION-VELOCITY
                      0=NO; 1=FIRST TIME STEP;
                      2=ALL TIME STEPS)        =    0
             NPNTD   (PRINT OPTION-DISP.COEF.
                      0=NO; 1=FIRST TIME STEP;
                      2=ALL TIME STEPS)        =    0
             NUMOBS  (NO. OF OBSERVATION WELLS
                      FOR HYDROGRAPH PRINTOUT) =    5
             NREC    (NO. OF PUMPING WELLS)    =   39
             NCODES  (FOR NODE IDENT.)         =    2
             NPNCHV  (PUNCH VELOCITIES)        =    0
             NPDELC  (PRINT OPT.-CONC. CHANGE) =    1
```

LOCATION OF PUMPING WELLS
(CONTAMINANT SOURCES)

```
0          LOCATION  OF  PUMPING  WELLS

            X    Y    RATE(IN CFS)    CONC.

           11    2    -.100E-03    50000.00
           12    3    -.100E-03    50000.00
           13    4    -.100E-06    50000.00
           13    5    -.100E-06    50000.00
           11    5    -.100E-05    30000.00
            9    7    -.100E-05    50000.00
            9    8    -.100E-05    50000.00
            9    9    -.100E-05    50000.00
           10    7    -.100E-05    50000.00
           10    8    -.100E-05    50000.00
           10    9    -.100E-05    50000.00
           10   10    -.100E-05    50000.00
           11    6    -.100E-05    50000.00
           11    7    -.100E-05    50000.00
           11    8    -.100E-05    50000.00
           11    9    -.100E-05    50000.00
           12    7    -.100E-05    50000.00
           12    8    -.100E-05    50000.00
           11   10    -.100E-05    50000.00
           11   11    -.100E-05    50000.00
           12    9    -.100E-05    50000.00
           12   10    -.100E-05    50000.00
           12   11    -.100E-05    50000.00
           13    9    -.100E-05    50000.00
           13   10    -.100E-05    50000.00
           13   11    -.100E-05    50000.00
           11    3    -.100E-03    50000.00
           10    6    -.100E-05    50000.00
           12    6    -.100E-05    50000.00
            8    8    -.100E-65    50000.00
           13    8    -.100E-05    50000.00
            8    7    -.100E-05    50000.00
            8    9    -.100E-05    50000.00
            9   10    -.100E-05    50300.00
           13    8    -.100E-05    50000.00
           12   12    -.100E-05    50000.00
           10    2    -.100E-03    50000.00
           10    3    -.100E-03    50000.00
           12    4    -.100E-03    50000.00
7           AREA OF ONE CELL =    4.0000E+04
)           X-Y SPACING:
                200.00
                200.06
```

DATA INPUT MATRICIES

```
1AQUIFER BOTTOM (FT)
         .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0390.0395.0400.0405.0410.0415.0420.0430.0433.0433.0435.0437.0437.0441.0443.0445.0450.0453.0   .0
         .0385.0380.0390.0400.0405.0405.0410.0420.0428.0432.0433.0434.0436.0439.0440.0445.0448.0452.0   .0
         .0380.0375.0380.0390.0395.0397.0400.0410.0420.0428.0430.0432.0435.0437.0440.0442.0446.0450.0   .0
         .0370.0370.0365.6370.0375.0370.0385.0390.0405.0410.0420.0430.0435.0437.0439.0441.0445.0448.0   .0
         .0360.0365.0370.0370.0372.0378.0380.0380.0395.0410.0414.0415.0420.0430.0435.0439.0442.0444.0   .0
         .0350.0355.0357.0362.0365.0370.0375.0385.0395.0400.0410.0412.0415.0417.6438.0430.0437.0440.0   .0
         .0345.0347.0352.0357.0362.0368.0375.0385.0393.0397.0410.0410.0413.0415.0425.0430.0435.0   .0   .0
         .0340.0345.0350.0355.0360.0368.0375.0382.0383.0395.0397.0405.0410.0415.0420.0425.0   .0   .0   .0
         .0340.0345.0350.0355.0360.0368.0375.0380.0385.0390.0397.0397.0405.0407.0412.0   .0   .0   .0   .0
         .0340.0345.0350.0355.0360.0360.0368.0375.0385.0390.0400.0400.0397.0400.0   .0   .0   .0   .0   .0
         .0340.0345.0350.0355.0360.0360.0360.0363.0364.0375.0400.0400.0400.0403.0   .0   .0   .0   .0   .0
         .0340.0345.0350.0355.0360.0360.0365.0365.0370.0380.0395.0397.0390.0   .0   .0   .0   .0   .0   .0
         .0345.0350.0360.0360.0365.0365.0370.0370.0385.0385.0385.0386.0386.0   .0   .0   .0   .0   .0   .0
         .0350.0360.0365.0365.0365.0370.0375.0377.0380.0384.0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0360.0365.0365.0366.0370.0375.0377.0380.0384.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0363.0364.0370.0375.0376.0377.0379.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0364.0370.0371.0372.0373.0374.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0365.0370.0371.0372.0372.0373.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
1WATER TABLE
         0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
         0. 422. 423. 423. 425. 427. 430. 432. 434. 435. 436. 437. 440. 442. 445. 446. 450. 452. 455.   0.
         0. 420. 420. 420. 423. 425. 427. 430. 432. 434. 435. 436. 437. 440. 443. 446. 450. 453. 453.   0.
         0. 418. 417. 418. 420. 420. 423. 427. 430. 432. 434. 435. 436. 440. 442. 445. 446. 450. 452.   0.
         0. 414. 414. 415. 415. 418. 420. 422. 425. 430. 432. 435. 436. 437. 440. 442. 445. 446. 450.   0.
         0. 410. 410. 412. 412. 415. 416. 420. 422. 425. 427. 430. 435. 436. 437. 440. 442. 443. 445.   0.
         0. 407. 407. 407. 408. 410. 415. 416. 418. 420. 425. 427. 430. 435. 435. 436. 437. 440. 442.   0.
         0. 405. 404. 403. 405. 406. 410. 412. 416. 418. 420. 425. 427. 430. 432. 435. 436. 437.   0.   0.
         0. 397. 397. 397. 400. 402. 405. 406. 410. 416. 417. 422. 423. 425. 430. 433. 435.   0.   0.   0.
         0. 393. 393. 393. 394. 395. 397. 400. 405. 410. 413. 415. 419. 422. 425. 430.   0.   0.   0.   0.
         0. 389. 389. 389. 390. 393. 394. 395. 400. 405. 410. 412. 416. 419. 420.   0.   0.   0.   0.   0.
         0. 384. 385. 387. 388. 386. 390. 391. 392. 393. 404. 405. 410. 415. 415.   0.   0.   0.   0.   0.
         0. 380. 383. 384. 385. 386. 388. 388. 390. 392. 395. 400. 405. 410.   0.   0.   0.   0.   0.   0.
         0. 378. 380. 382. 383. 383. 385. 386. 387. 387. 390. 394. 395. 402.   0.   0.   0.   0.   0.   0.
         0. 377. 377. 378. 380. 382. 383. 384. 385. 386. 387.   0.   0.   0.   0.   0.   0.   0.   0.   0.
         0. 376. 377. 377. 378. 378. 380. 382. 383. 385.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
         0. 374. 375. 375. 376. 377. 378. 380.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
         0. 373. 374. 374. 374. 375. 375.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
         0. 372. 373. 373. 373. 374. 374.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
         0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
1AQUIFER THICKNESS (FT)
         .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0 32.0 28.0 23.0 20.0 17.0 15.0 12.0  4.0  2.0  3.0  2.0  3.0  5.0  4.0  3.0  5.0  2.0  2.0   .0
         .0 35.0 40.0 30.0 23.0 20.0 22.0 20.0 12.0  6.0  3.0  3.0  3.0  4.0  4.0  6.0  5.0  5.0  1.0   .0
         .0 38.0 42.0 30.0 30.0 25.0 26.0 27.0 20.0 12.0  6.0  5.0  4.0  5.0  5.0  5.0  4.0  4.0  2.0   .0
         .0 44.0 44.0 50.0 45.0 43.0 50.0 37.0 35.0 25.0 22.0 15.0  6.0  2.0  3.0  3.0  4.0  1.0  2.0   .0
         .0 50.0 45.0 42.0 42.0 43.0 38.0 40.0 42.0 30.0 17.0 16.0 20.0 16.0  7.0  5.0  3.0  1.0  1.0   .0
         .0 57.0 52.0 50.0 46.0 45.0 45.0 41.0 33.0 25.0 25.0 17.0 18.0 20.0 18.0  6.0  7.0  3.0  2.0   .0
         .0 60.0 57.0 51.0 48.0 44.0 42.0 37.0 31.0 25.0 23.0 15.0 17.0 17.0 17.0 10.0  6.0  2.0   .0   .0
         .0 57.0 52.0 47.0 45.0 42.0 37.0 31.0 28.0 33.0 22.0 25.0 18.0 15.0 15.0 13.0 10.0   .0   .0   .0
         .0 53.0 48.0 43.0 39.0 35.0 29.0 25.0 25.0 25.0 23.0 18.0 22.0 17.0 18.0 18.0   .0   .0   .0   .0
         .0 49.0 44.0 39.0 35.0 33.0 34.0 27.0 25.0 20.0 20.0 12.0 16.0 22.0 20.0   .0   .0   .0   .0   .0
         .0 44.0 40.0 37.0 33.0 28.0 30.0 31.0 29.0 29.0 29.0  5.0 10.0 15.0 12.0   .0   .0   .0   .0   .0
         .0 40.0 36.0 34.0 30.0 26.0 28.0 23.0 25.0 22.0 15.0  5.0  8.0 20.0   .0   .0   .0   .0   .0   .0
         .0 33.0 30.0 22.0 23.0 18.0 20.0 16.0 17.0  2.0  5.0  9.0  9.0 14.0   .0   .0   .0   .0   .0   .0
         .0 27.0 17.0 13.0 15.0 17.0 13.0  9.0  8.0  6.0  3.0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0 16.0 12.0 12.0 12.0  8.0  5.0  5.0  3.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0 11.0 11.0  5.0  1.0  1.0  1.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0  9.0  4.0  3.0  2.0  2.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0  7.0  3.0  2.0  1.0  2.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
         .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
```

```
1PERMEABILTY MAP (FT/SEC)
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  6.60E-07  6.60E-07  6.60E-07  9.00E-07  9.80E-07  1.30E-06  1.30E-06  1.47E-06  1.64E-06
     1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06   .00E+00
      .00E+00  6.60E-07  6.60E-07  6.60E-07  8.50E-07  9.80E-07  1.25E-06  1.30E-06  1.40E-06  1.64E-06
     1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06   .00E+00
      .00E+00  6.60E-07  6.60E-07  6.60E-07  7.00E-07  9.80E-07  1.30E-06  1.30E-06  1.64E-06  1.64E-06
     1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06   .00E+00
      .00E+00  6.60E-07  6.60E-07  6.60E-07  9.80E-07  9.80E-07  1.30E-06  1.32E-06  1.64E-06  1.64E-06
     1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.40E-06  1.20E-06   .00E+00
      .00E+00  6.60E-07  6.60E-07  7.00E-07  9.80E-07  1.05E-06  1.30E-06  1.47E-06  1.64E-06  1.64E-06
     1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.64E-06  1.47E-06  1.20E-06  8.00E-07  5.50E-07   .00E+00
      .00E+00  6.60E-07  6.60E-07  8.20E-07  9.80E-07  1.14E-06  1.30E-06  1.55E-06  1.64E-06  1.64E-06
     1.64E-06  1.64E-06  1.64E-06  1.55E-06  1.30E-06  9.80E-07  3.30E-07  3.00E-07  2.50E-07   .00E+00
      .00E+00  6.60E-07  6.60E-07  9.80E-07  9.80E-07  1.20E-06  1.40E-06  1.64E-06  1.64E-06  1.64E-06
     1.64E-06  1.55E-06  1.40E-06  9.80E-07  4.50E-07  3.00E-07  2.60E-07  1.70E-07   .00E+00   .00E+00
      .00E+00  6.60E-07  8.20E-07  9.80E-07  9.80E-07  1.30E-06  1.60E-06  1.64E-06  1.64E-06  1.60E-06
     1.40E-06  1.20E-06  9.00E-07  3.00E-07  2.70E-07  2.00E-07  1.30E-07   .00E+00   .00E+00   .00E+00
      .00E+00  6.50E-07  9.50E-07  9.80E-07  1.14E-06  1.35E-06  1.64E-06  1.60E-06  1.40E-06  1.30E-06
     1.14E-06  7.00E-07  3.30E-07  2.70E-07  1.70E-07  9.00E-08   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  7.00E-07  9.80E-07  9.80E-07  1.14E-06  1.48E-06  1.64E-06  1.40E-06  1.30E-06  9.80E-07
     6.00E-07  3.10E-07  1.90E-07  1.60E-07  5.00E-08   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  7.00E-07  9.80E-07  9.80E-07  1.30E-06  1.60E-06  1.47E-06  1.30E-06  9.80E-07  6.00E-07
     3.10E-07  2.50E-07  1.60E-07  4.00E-08  3.00E-08   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  7.00E-07  9.80E-07  9.80E-07  1.30E-06  1.30E-06  1.30E-06  1.10E-06  7.00E-07  4.00E-07
     3.00E-07  2.30E-07  9.00E-08  4.00E-08   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  9.00E-07  9.80E-07  9.80E-07  1.30E-06  1.30E-06  1.25E-06  9.00E-07  6.00E-07  3.20E-07
     2.70E-07  1.90E-07  9.00E-08  4.00E-08   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  9.00E-07  9.80E-07  9.80E-07  1.30E-06  1.05E-06  9.80E-07  7.00E-07  3.50E-07  3.10E-07
     2.70E-07   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  8.50E-07  9.80E-07  9.80E-07  9.80E-07  9.80E-07  9.00E-07  6.60E-07  3.30E-07  3.10E-07
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  6.60E-07  7.50E-07  9.80E-07  9.80E-07  9.00E-07  8.30E-07  4.60E-07   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  6.60E-07  6.60E-07  6.60E-07  6.60E-07  6.60E-07  6.60E-07   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  6.60E-07  6.60E-07  6.60E-07  6.60E-07  6.60E-07  6.60E-07   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
```

TRANSMISSIVITIES AS CALCULATED FROM INPUT DATA

```
1TRANSMISSIVITY MAP (FT*FT/SEC)
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  2.11E-05  1.85E-05  1.52E-05  1.80E-05  1.67E-05  1.95E-05  1.56E-05  5.88E-06  3.28E-06
      4.92E-06  3.28E-06  4.92E-06  8.20E-06  6.56E-06  4.92E-06  8.20E-06  3.28E-06  3.28E-06   .00E+00
       .00E+00  2.31E-05  2.64E-05  1.98E-05  1.95E-05  1.96E-05  2.75E-05  2.60E-05  1.68E-05  9.84E-06
      4.92E-06  4.92E-06  4.92E-06  6.56E-06  6.56E-06  9.84E-06  8.20E-06  8.20E-06  1.64E-06   .00E+00
       .00E+00  2.51E-05  2.77E-05  2.51E-05  2.10E-05  2.45E-05  3.38E-05  3.51E-05  3.28E-05  1.97E-05
      9.84E-06  8.20E-06  6.56E-06  8.20E-06  8.20E-06  8.20E-06  6.56E-06  6.56E-06  3.28E-06   .00E+00
       .00E+00  2.90E-05  2.90E-05  3.30E-05  4.41E-05  4.21E-05  6.50E-05  4.88E-05  5.74E-05  4.10E-05
      3.61E-05  2.46E-05  9.84E-06  3.28E-06  4.92E-06  4.92E-06  6.56E-06  1.40E-06  2.40E-06   .00E+00
       .00E+00  3.30E-05  2.97E-05  2.94E-05  4.12E-05  4.52E-05  4.94E-05  5.88E-05  6.89E-05  4.92E-05
      2.79E-05  2.62E-05  3.28E-05  2.62E-05  1.15E-05  7.35E-06  3.60E-06  8.00E-07  5.50E-07   .00E+00
       .00E+00  3.76E-05  3.43E-05  4.10E-05  4.51E-05  5.13E-05  5.85E-05  6.35E-05  5.41E-05  4.10E-05
      4.10E-05  2.79E-05  2.95E-05  3.10E-05  2.34E-05  5.88E-06  2.31E-06  9.00E-07  5.00E-07   .00E+00
       .00E+00  3.96E-05  3.76E-05  5.00E-05  4.70E-05  5.28E-05  5.88E-05  6.07E-05  5.08E-05  4.10E-05
      3.77E-05  2.32E-05  2.38E-05  1.67E-05  7.65E-06  3.00E-06  1.56E-06  3.40E-07   .00E+00   .00E+00
       .00E+00  3.76E-05  4.26E-05  4.61E-05  4.41E-05  5.46E-05  5.92E-05  5.08E-05  4.59E-05  5.28E-05
      3.08E-05  3.00E-05  1.62E-05  4.50E-06  4.05E-06  2.60E-06  1.30E-06   .00E+00   .00E+00   .00E+00
       .00E+00  3.45E-05  4.56E-05  4.21E-05  4.45E-05  4.73E-05  4.76E-05  4.00E-05  3.50E-05  3.25E-05
      2.62E-05  1.26E-05  7.26E-06  4.59E-06  3.86E-06  1.62E-06   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  3.43E-05  4.31E-05  3.82E-05  3.99E-05  4.88E-05  5.58E-05  3.76E-05  3.25E-05  1.96E-05
      1.20E-05  3.72E-06  3.04E-06  3.52E-06  1.00E-06   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  3.06E-05  3.92E-05  3.63E-05  4.29E-05  4.48E-05  4.41E-05  4.03E-05  2.84E-05  1.74E-05
      8.99E-06  1.25E-06  1.60E-06  6.00E-07  3.60E-07   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  2.80E-05  3.72E-05  3.33E-05  3.90E-05  3.38E-05  3.64E-05  2.53E-05  1.75E-05  8.00E-06
      4.50E-06  1.15E-06  7.20E-07  8.00E-07   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  2.97E-05  2.94E-05  2.16E-05  2.99E-05  2.34E-05  2.50E-05  1.44E-05  1.02E-05  6.40E-07
      1.35E-06  1.71E-06  8.10E-07  5.60E-07   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  2.43E-05  1.67E-05  1.27E-05  1.95E-05  1.79E-05  1.27E-05  6.30E-06  2.80E-06  1.86E-06
      8.10E-07   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  1.36E-05  1.18E-05  1.18E-05  1.18E-05  7.84E-06  4.50E-06  3.30E-06  9.90E-07  3.10E-07
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  7.26E-06  8.25E-06  4.90E-06  9.80E-07  9.00E-07  8.30E-07  4.60E-07   .00E+00   .00E+00
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  5.94E-06  2.64E-06  1.98E-06  1.32E-06  1.32E-06  6.60E-07   .00E+00   .00E+00   .00E+00
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00  4.62E-06  1.98E-06  1.32E-06  6.60E-07  1.32E-06  6.60E-07   .00E+00   .00E+00   .00E+00
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
       .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
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CONSTANT RECHARGE INPUT

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1DIFFUSE RECHARGE AND DISCHARGE (FT/SEC)
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
  -1.00E-09   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
```

STEADY FLOW PARAMETERS

```
1NODE IDENT.FICATION MAP

       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0    0    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0    0    0    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    1    0    0    0    0    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    1    0    0    0    0    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    1    0    0    0    0    0    0
       0    1    0    0    0    0    0    0    0    0    0    1    1    1    0    0    0    0    0    0
       0    1    0    0    0    0    0    0    0    0    1    0    0    0    0    0    0    0    0    0
       0    1    0    0    0    0    0    0    1    1    0    0    0    0    0    0    0    0    0    0
       0    1    0    0    0    0    0    1    0    0    0    0    0    0    0    0    0    0    0    0
       0    1    0    0    0    0    1    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    1    1    1    3    1    1    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0      NO. OF NODE IDENT. CODES SPECIFIED =  2
0           THE FOLLOWING ASSIGNMENTS HAVE BEEN MADE:
      CODE NO.       LEAKANCE      SOURCE CONC.      RECHARGE
0         1         1.000E+00       .000E+00
0         3          .000E+00       .000E+00
                                                   1.000E-08
1VERTICAL PERMEABILITY/THICKNESS (FT/(FT*SEC))
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00
     1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00  1.00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
     1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00  1.00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00  1.00E+00  1.00E+00   .00E+00  1.00E+00  1.00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
```

BACKGROUND CONCENTRATION MATRIX

```
     *** WARNING ***   RECH.GT.0.0 AT NODE IX =   5, IY =  19
1CONCENTRATION

 NUMBER OF TIME STEPS =       0
        TIME(SECONDS) =   .00000E+00
   CHEM.TIME(SECONDS) =   .00000E+00
   CHEM.TIME(DAYS)    =   .00000E+00
        TIME(YEARS)   =   .00000E+00
   CHEM.TIME(YEARS)   =   .00000E+00
  NO. MOVES COMPLETED =       0

0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0   10.0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000
0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000
0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000     .0000     .0000     .0000
0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
0     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
```

CALIBRATED HEAD DISTRIBUTION

```
1HEAD DISTRIBUTION - KUW
 NUMBER OF TIME STEPS =      1
        TIME(SECONDS) =  5.68037E+08
        TIME(DAYS)    =  6.57450E+03
        TIME(YEARS)   =  1.80000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 422 423 423 425 427 430 432 434 435 436 437 440 442 445 446 450 452 455   0
0   0 420 419 419 421 423 425 427 428 430 434 436 438 441 444 446 449 452 453   0
0   0 418 416 416 417 419 421 423 424 427 430 433 436 440 442 445 448 451 452   0
0   0 414 413 413 414 416 418 420 422 424 427 431 433 437 440 443 446 448 450   0
0   0 410 410 410 411 413 416 418 420 422 425 429 432 434 437 441 444 445 445   0
0   0 407 406 406 408 410 413 415 418 420 423 427 430 433 436 439 440 442 442   0
0   0 405 403 404 406 408 410 413 416 418 422 425 429 432 434 437 438 437   0   0
0   0 397 399 401 403 405 407 410 413 416 419 423 427 429 431 434 435   0   0   0
0   0 393 396 398 400 402 404 407 410 414 417 421 424 425 427 430   0   0   0   0
0   0 389 393 395 397 399 402 404 406 410 414 417 419 422 420   0   0   0   0   0
0   0 384 390 393 395 397 399 401 403 406 409 409 413 417 415   0   0   0   0   0
0   0 380 388 391 393 395 397 398 400 402 403 401 406 410   0   0   0   0   0   0
0   0 378 385 388 390 392 394 395 396 392 395 394 395 400   0   0   0   0   0   0
0   0 377 383 385 388 390 391 391 391 388 387   0   0   0   0   0   0   0   0   0
0   0 376 381 383 386 387 387 387 383 385   0   0   0   0   0   0   0   0   0   0
0   0 374 379 380 380 381 381 380   0   0   0   0   0   0   0   0   0   0   0   0
0   0 373 376 377 374 377 375   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 372 373 373 363 374 374   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
1DRAWDOWN
     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    1    1    2    2    2    3    4    4    1    0    0    0    0    0    1    1    0    0
     0    0    1    2    3    1    2    4    6    5    4    2    0    0    0    0   -1    0    0    0
     0    0    1    2    1    2    2    2    3    6    5    4    3    0    0    0    0   -1    0    0
     0    0    0    2    1    2    0    2    2    3    2    1    3    2    0    0   -1   -1    0    0
     0    0    1    1    0    0    2    1    0    0    2    0    0    2    0   -2   -2   -1    0    0
     0    0    1    0    0   -1    0    0    0    0   -1    0   -1   -1   -1   -1   -1    0    0    0
     0    0   -1   -3   -2   -2   -1   -3   -2    0   -1    0   -3   -3    0    0    0    0    0    0
     0    0   -2   -4   -5   -6   -6   -6   -4   -3   -3   -5   -4   -2   -1    0    0    0    0    0
     0    0   -3   -5   -6   -5   -7   -8   -5   -4   -3   -4   -2   -2    0    0    0    0    0    0
     0    0   -4   -5   -6   -8   -8   -9  -10  -12   -4   -3   -2   -1    0    0    0    0    0    0
     0    0   -4   -6   -7   -8   -8   -9   -9   -9   -7    0    0    0    0    0    0    0    0    0
     0    0   -4   -5   -6   -6   -8   -8   -8   -4   -4    0    0    0    0    0    0    0    0    0
     0    0   -5   -6   -7   -7   -7   -6   -5   -1    0    0    0    0    0    0    0    0    0    0
     0    0   -3   -5   -7   -8   -6   -4    0    0    0    0    0    0    0    0    0    0    0    0
     0    0   -3   -4   -3   -3   -2    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0   -1   -2    0   -1    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0   10    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
     0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

Water Level Change at
End of Calibration *

* NOTE: Negative denotes an increase in head.

CALIBRATED AQUIFER THICKNESS

```
1AQUIFER THICKNESS
      .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0 32.0 28.0 23.0 20.0 17.0 15.0 12.0  4.0  2.0  3.0  2.0  3.0  5.0  4.0  3.0  5.0  2.0  2.0   .0
      .0 35.0 39.4 29.3 21.1 17.8 20.0 16.8  7.5  2.3  1.9  3.2  3.9  5.0  4.7  5.8  4.2  3.8  1.0   .0
      .0 38.0 41.3 36.0 27.0 23.7 24.0 23.1 14.2  6.7  1.9  3.4  3.8  4.7  5.2  4.9  5.6  4.9  2.0   .0
      .0 44.0 43.0 48.0 43.6 40.5 48.0 35.1 31.8 19.3 17.2 10.7  3.5  2.0  2.9  4.0  5.0  3.2  2.0   .0
      .0 50.0 44.6 39.8 41.1 40.9 37.5 37.6 40.0 27.5 15.4 15.0 16.7 14.2  7.2  5.7  4.5  2.7  1.0   .0
      .0 57.0 51.1 49.5 46.3 45.2 42.8 40.3 33.0 25.5 23.5 17.2 18.4 18.4 18.8  8.6 10.1  4.5  2.0   .0
      .0 60.0 55.7 51.7 48.6 45.6 42.2 37.9 30.6 25.2 24.6 15.3 18.7 19.0 19.2 11.5  7.6  2.0   .0   .0
      .0 57.0 54.2 51.0 47.8 44.9 39.4 35.1 31.0 33.1 24.5 26.5 21.6 18.7 16.5 14.0 10.0   .0   .0   .0
      .0 53.0 51.0 48.2 45.0 42.1 36.4 32.0 29.9 28.7 27.0 24.1 26.7 20.1 20.4 18.0   .0   .0   .0   .0
      .0 49.0 48.0 45.4 42.2 39.5 41.7 35.7 31.5 25.0 23.5 16.7 19.4 25.2 20.0   .0   .0   .0   .0   .0
      .0 44.0 45.1 42.9 39.8 37.1 39.2 41.0 40.2 41.9 33.8  8.8 13.3 16.7 12.0   .0   .0   .0   .0   .0
      .0 40.0 42.6 40.6 37.6 34.7 36.6 33.3 34.9 32.4 22.8  6.3  9.0 20.0   .0   .0   .0   .0   .0   .0
      .0 33.0 35.3 28.2 30.5 27.1 29.3 25.2 26.2  6.9  9.6  9.0  9.0 14.0   .0   .0   .0   .0   .0   .0
      .0 27.0 22.9 20.3 23.2 24.7 21.4 16.3 13.7  8.2  3.0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0 16.0 15.7 17.8 19.9 16.8 12.4 10.3  3.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0 11.0 14.7  9.9  4.5  4.5  4.6  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0  9.0  6.2  5.6  2.2  3.6  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0  7.0  3.0  2.0 -9.0  2.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
1TRANSMISSIVITY
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
```

MASS BALANCE CALCULATIONS

```
0  CUMULATIVE MASS BALANCE -- (IN FT**3)

    RECHARGE                      = -5.61221E+06
    INJECTION                     = -3.57977E+05
    PUMPAGE                       =  2.27215E+05
    CUMULATIVE  NET  PUMPAGE      = -5.74297E+06
    WATER RELEASE FROM STORAGE    = -6.79640E+06
    LEAKAGE INTO AQUIFER          = -5.22645E+06
    LEAKAGE OUT OF AQUIFER        =  4.17270E+06
    CUMULATIVE  NET  LEAKAGE      = -1.05375E+06
0        MASS BALANCE RESIDUAL    =  3.17000E+02
         ERROR  (AS PERCENT)      =  7.20443E-03

0  RATE MASS BALANCE -- (IN C.F.S.)

    RECHARGE                      = -9.88000E-03
    LEAKAGE INTO AQUIFER          =  9.20089E-03
    LEAKAGE OUT OF AQUIFER        = -7.34583E-03
    NET LEAKAGE     (QNET)        =  1.85507E-03
    INJECTION                     = -6.30200E-04
    PUMPAGE                       =  4.00000E-04
    NET WITHDRAWAL    (TPUM)      = -1.01102E-02
1           STABILITY CRITERIA --- M.O.C.
```

SUMMARY OF PARTICLE MOVES
NECESSARY FOR CALIBRATION

```
0          THE LIMITING STABILITY CRITERION IS BETA
0          NO. OF PARTICLE MOVES REQUIRED TO COMPLETE THIS TIME STEP  =   18

0  NP       =          1243        IMOV     =             1
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  3.15576E+07
0  NP       =          1243        IMOV     =             2
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  6.31152E+07
0  NP       =          1243        IMOV     =             3
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  9.46728E+07
0  NP       =          1258        IMOV     =             4
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  1.26230E+08
0  NP       =          1258        IMOV     =             5
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  1.57788E+08
0  NP       =          1287        IMOV     =             6
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  1.89346E+08
0  NP       =          1287        IMOV     =             7
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  2.20903E+08
0  NP       =          1319        IMOV     =             8
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  2.52461E+08
0  NP       =          1323        IMOV     =             9
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  2.84018E+08
0  NP       =          1334        IMOV     =            10
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  3.15576E+08
0  NP       =          1335        IMOV     =            11
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  3.47134E+08
0  NP       =          1395        IMOV     =            12
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  3.78691E+08
0  NP       =          1397        IMOV     =            13
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  4.10249E+08
0  NP       =          1432        IMOV     =            14
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  4.41806E+08
0  NP       =          1478        IMOV     =            15
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  4.73364E+08
0  NP       =          1531        IMOV     =            16
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  5.04922E+08
0  NP       =          1533        IMOV     =            17
0     NUMBER OF CELLS WITH ZERO PARTICLES  =     1      IMOV   =     17

   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  5.36479E+08
0  NP       =          1606        IMOV     =            18
   TIM(N)   =   5.68037E+08        TIMV     =   3.15576E+07        SUMTCH =  5.68037E+08
```

CALIBRATED GROUNDWATER CHEMICAL CONCENTRATIONS
FIRST PUMPING PERIOD
(ROUNDED TO NEAREST WHOLE NUMBER)

```
1CONCENTRATION

 NUMBER OF TIME STEPS =     1

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    6    5    5    4    4    0   17   94 78261016014501 4244  578   64    8    5    4    3    0
    0    0    7    6    7    5    5    0   36 262139012012230081 5797  730   56    7    6    6    3    0
    0    0    6    8    8    7    7   -2   92  555 92591387626889 9130  755   35    6    6    6    3    0
    0    0    7    9    9    8    7   -6  209  756 5445 850518766 8989  604   15    5    7    6    3    0
    0    0    8    9    9    9    8   -7  494 1037 4724 764611412 6132  325    2    6    7    6    3    0
    0    0    7    9    9    9    7   13 1168 1855 4383 6249 8397 2915   79    0    8    8    6    3    0
    0    0    5    9   10    9    8   55 1446 2212 3948 5313 6495 3399   72    6    8    8    5    0    0
    0    0    5    9   10    9   10   92 1490 2329 3416 4529 5019 3574   60    9    9    8    0    0    0
    0    0    6   10   10   10   13  117 1178 2188 2904 3829 4622 3588   47    9    9    0    0    0    0
    0    0    8   10   10   10   14  109  639 1620 2015 3212 5009 3673   29    9    0    0    0    0    0
    0    0    8   10   10   10   15   90  580  967 1064 1921 5656 1925   11    9    0    0    0    0    0
    0    0    8   10   10   10   14   63  328  535  531  876 3595  557    9    0    0    0    0    0    0
    0    0    9    9    9   10   12   36  170  258  323  477 1304  151    9    0    0    0    0    0    0
    0    0    9    9    9    9   11   22   89  127   98  254    0    0    0    0    0    0    0    0    0
    0    0    9    9    9    9   10   16   45   60   26    0    0    0    0    0    0    0    0    0    0
    0    0    9    9    9    9    9   12   24    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    8    8    8   11    8    8    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    6    7    7   13    7    3    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =     1
        DELTA T       =  5.68037E+08
        TIME(SECONDS) =  5.68037E+08
   CHEM.TIME(SECONDS) =  5.68037E+08
   CHEM.TIME(DAYS)    =  6.57450E+03
        TIME(YEARS)   =  1.80000E+01
   CHEM.TIME(YEARS)   =  1.80000E+01
  NO. MOVES COMPLETED =    18
```

Change in Chemical Concentrations Through
Plume Evolution (18 Years)

```
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0   -3   -5   -5   -6   -6   -9    7   84 78161014914491 4234  568   53   -2   -4   -5   -7    0
    0    0   -3   -3   -3   -4   -5  -10   26 252138902011230071 5787  719   45   -2   -4   -4   -7    0
    0    0   -3   -1   -1   -2   -3  -13   82  544 92491386526879 9119  744   25   -4   -3   -4   -6    0
    0    0   -2   -1   -1   -1   -2  -16  199  745 5435 849518755 8979  593    4   -4   -3   -4   -6    0
    0    0   -2    0    0   -1   -2  -18  484 1026 4714 763511402 6121  315   -7   -3   -3   -4   -6    0
    0    0   -2    0    0    0   -2    3 1158 1844 4373 6238 8387 2904   69   -9   -2   -2   -4   -6    0
    0    0   -5    0    0    0   -2   44 1435 2202 3937 5303 6484 3388   61   -3   -1   -2   -5    0    0
    0    0   -4    0    0    0    0   81 1480 2318 3405 4518 5008 3563   49   -1   -1   -1    0    0    0
    0    0   -3    0    0    0    2  106 1167 2177 2894 3818 4611 3577   36   -1   -1    0    0    0    0
    0    0   -2    0    0    0    4   98  828 1609 2005 3201 4998 3662   18    0    0    0    0    0    0
    0    0   -1    0    0    0    5   79  570  956 1054 1911 5645 1915    0   -1    0    0    0    0    0
    0    0   -1    0    0    0    4   52  317  524  521  865 3585  546   -1    0    0    0    0    0    0
    0    0    0    0    0    0    2   26  159  248  312  466 1294  140   -1    0    0    0    0    0    0
    0    0    0    0    0    0    0   11   78  117   88  243    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    5   35   49   15    0    0    0    0    0    0    0    0    0    0
    0    0   -1   -1   -1    0   -1    2   13    0    0    0    0    0    0    0    0    0    0    0    0
    0    0   -1   -1   -1    1   -2   -2    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0   -2   -3   -2    3   -3   -6    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

CHEMICAL MASS BALANCE

```
 CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES     =   .00000E+00
        MASS OUT BOUNDARIES    = -2.62521E+08
        MASS PUMPED IN         =  5.26510E+10
        MASS PUMPED OUT        = -2.51628E+06
        INFLOW MINUS OUTFLOW   =  5.23660E+10
        INITIAL MASS STORED    =  6.14520E+08
        PRESENT MASS STORED    =  5.46006E+10
        CHANGE MASS STORED     =  5.39861E+10
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL  = -1.60007E+09
        ERROR  (AS PERCENT)    = -3.03901E+00
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)    = -3.09064E+00
1SOLUTE TRANSPORT REMEDIATION
```

ALLUVIAL DEPOSITS

SOURCES REMEDIATION AND
NATURAL CLEAN UP
5 YEARS

NUMERICAL MODEL INPUT/OUTPUT
ALLUVIAL DEPOSITS
MODEL EXPLANATION
SOURCES REMEDIATED
NATURAL CLEAN UP
(5 YEARS)

GENERAL GROUNDWATER PARAMETERS

```
1     START PUMPING PERIOD NO.  2

  THE FOLLOWING TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:

0             NTIM   =    5
              NPNT   =    5
              NITP   =    4
              ITMAX  =   10
              NREC   =   45
              NPNTMV =    0
              NPNTVL =    0
              NPNTD  =    0
              NPDELC =    1
              NPNCHV =    0
              PINT   =       5.000
              TIMX   =       1.000
              TINIT  = **********

1TIME INTERVALS (IN SECONDS)
     .15000E+09  .15000E+09  .15000E+09  .15000E+09  .15000E+09  .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
      00000       00000       00000       00000       00000       00000       00000       00000       00000       00000
```

LOCATION OF SOURCES

```
0         LOCATION  OF  PUMPING  WELLS

           X    Y   RATE(IN CFS)   CONC.

          11    2     .000E+00       .00
          12    3     .000E+00       .00
          13    4     .000E+00       .00
          13    5     .000E+00       .00
          11    5     .000E+00       .00
           9    7     .000E+00       .00
           9    8     .000E+00       .00
           9    9     .000E+00       .00
          10    7     .000E+00       .00
          10    8     .000E+00       .00
          10    9     .000E+00       .00
          10   10     .000E+00       .00
          11    6     .000E+00       .00
          11    7     .000E+00       .00
          11    8     .000E+00       .00
          11    9     .000E+00       .00
          12    7     .000E+00       .00
          12    8     .000E+00       .00
          11   10     .000E+00       .00
          11   11     .000E+00       .00
          12    9     .000E+00       .00
          12   10     .000E+00       .00
          12   11     .000E+00       .00
          13    9     .000E+00       .00
          13   10     .000E+00       .00
          13   11     .000E+00       .00
          11    3     .000E+00       .00
          10    6     .000E+00       .00
          12    6     .000E+00       .00
           8    8     .000E+00       .00
          13    8     .000E+00       .00
           8    7     .000E+00       .00
           8    9     .000E+00       .00
           9   10     .000E+00       .00
          13    8     .000E+00       .00
          12   12     .000E+00       .00
          10    2     .000E+00       .00
          10    3     .000E+00       .00
          12    4     .000E+00       .00
           8   11     .000E+00       .00
          10   13     .000E+00       .00
          11    4     .000E+00       .00
          13   13     .000E+00       .00
          13    6     .000E+00       .00
          12    4     .000E+00       .00
0
```

HEAD DISTRIBUTION, WATER LEVEL CHANGE AND AQUIFER THICKNESS 5 YEARS AFTER SOURCE REMEDIATION

```
1HEAD DISTRIBUTION - ROW
 NUMBER OF TIME STEPS =        2
        TIME(SECONDS) =   7.25825E+08
        TIME(DAYS)    =   8.40075E+03
        TIME(YEARS)   =   2.30000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 422 423 423 425 427 430 432 434 435 436 437 440 442 445 446 450 452 455   0
0   0 420 419 419 421 423 425 427 427 430 434 436 438 441 444 446 449 452 453   0
0   0 418 416 416 417 418 421 422 423 425 430 433 436 440 442 445 448 451 452   0
0   0 414 413 413 413 415 418 419 421 423 426 430 433 437 440 443 446 449 450   0
0   0 410 409 410 411 413 415 417 419 421 425 428 431 434 437 441 444 445 445   0
0   0 407 406 406 408 410 413 415 417 420 423 427 430 433 436 439 441 442 442   0
0   0 405 403 404 406 408 410 413 415 418 421 425 429 432 435 437 438 437   0   0
0   0 397 399 401 403 405 408 410 413 416 420 424 427 429 432 434 435   0   0   0
0   0 393 397 399 401 403 405 408 411 414 418 422 425 426 428 430   0   0   0   0
0   0 389 394 397 399 401 403 405 408 411 414 418 420 423 420   0   0   0   0   0
0   0 384 391 394 396 399 401 403 405 408 410 410 414 417 415   0   0   0   0   0
0   0 380 389 392 394 397 399 401 402 404 405 402 406 410   0   0   0   0   0   0
0   0 378 386 390 392 394 396 398 399 395 397 394 395 400   0   0   0   0   0   0
0   0 377 384 387 390 392 394 394 393 390 387   0   0   0   0   0   0   0   0   0
0   0 376 382 385 388 389 390 390 383 385   0   0   0   0   0   0   0   0   0   0
0   0 374 380 382 382 383 384 380   0   0   0   0   0   0   0   0   0   0   0   0
0   0 373 377 378 373 378 375   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 372 373 373 363 374 374   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
1DRAWDOWN
       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    0    1    1    2    2    2    3    5    4    1    0    0    0    0    0    1    1    0    0
       0    0    1    2    3    2    2    5    7    7    4    2    0    0    0    0   -1    0    0    0
       0    0    1    2    2    3    2    3    4    7    6    5    3    0    0    0    0   -2    0    0
       0    0    1    2    1    2    1    3    3    4    2    2    4    2    0    0   -1   -1    0    0
       0    0    1    1    0    0    2    1    1    0    2    0    0    2    0   -2   -3   -1    0    0
       0    0    1    0    0   -1    0    0    1    0    0    0   -1   -1   -2   -1   -1    0    0    0
       0    0   -1   -3   -2   -2   -2   -3   -2    0   -2   -1   -3   -3   -1    0    0    0    0    0
       0    0   -3   -5   -6   -7   -7   -7   -5   -3   -4   -6   -5   -3   -2    0    0    0    0    0
       0    0   -4   -7   -8   -7   -8   -9   -7   -5   -3   -5   -3   -3    0    0    0    0    0    0
       0    0   -5   -6   -7  -10  -10  -11  -12  -14   -5   -4   -3   -1    0    0    0    0    0    0
       0    0   -5   -7   -6  -10  -10  -12  -11  -11   -9   -1    0    0    0    0    0    0    0    0
       0    0   -5   -7   -8  -10  -10  -11  -11   -7   -6    0    0    0    0    0    0    0    0    0
       0    0   -6   -8   -9   -9  -10   -9   -7   -3    0    0    0    0    0    0    0    0    0    0
       0    0   -4   -7   -9  -10   -9   -7    0    0    0    0    0    0    0    0    0    0    0    0
       0    0   -4   -6   -5   -5   -5    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    0   -2   -3    1   -2    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    0    0    0   10    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1AQUIFER THICKNESS
      .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0 32.0 28.0 23.0 20.0 17.0 15.0 12.0  4.0  2.8  3.0  2.0  3.0  5.0  4.0  3.0  5.0  2.0  2.0   .0
      .0 35.0 39.4 29.2 20.9 17.6 19.9 16.5  7.2  2.0  1.8  2.7  4.1  5.1  4.8  5.7  4.1  3.6  1.0   .0
      .0 38.0 41.2 35.7 26.6 23.4 23.6 22.5 13.1  5.5  1.5  2.9  4.0  4.8  5.3  4.8  5.8  4.6  2.0   .0
      .0 44.0 42.9 47.7 43.3 40.2 47.6 34.4 30.8 18.0 15.9  9.9  3.3  2.0  3.0  4.1  5.2  3.7  2.0   .0
      .0 50.0 44.4 39.5 40.9 40.6 37.2 37.1 39.2 26.5 14.5 14.4 16.1 14.0  7.3  6.0  5.0  3.5  1.0   .0
      .0 57.0 51.0 49.4 46.3 45.1 42.6 39.9 32.4 24.9 22.9 16.9 18.1 18.2 19.0  9.2 11.0  5.2  2.0   .0
      .0 60.0 55.7 51.9 48.8 45.7 42.2 37.8 30.3 25.0 24.4 15.3 18.8 19.1 19.6 12.0  8.2  2.0   .0   .0
      .0 57.0 54.4 51.5 48.3 45.4 39.8 35.4 31.1 33.1 24.6 26.7 22.2 19.5 16.9 14.3 10.0   .0   .0   .0
      .0 53.0 51.5 49.0 45.9 43.1 37.4 32.9 30.6 29.0 27.6 24.8 27.7 21.0 21.0 18.0   .0   .0   .0   .0
      .0 49.0 46.7 46.5 43.5 40.8 43.1 37.3 32.8 26.0 24.4 17.8 20.4 26.1 20.0   .0   .0   .0   .0   .0
      .0 44.0 46.1 44.2 41.3 38.8 41.0 43.0 42.2 43.9 34.9 10.2 14.3 17.2 12.0   .0   .0   .0   .0   .0
      .0 40.0 43.6 42.0 39.3 36.6 38.8 35.6 37.3 34.5 24.6  7.0  9.4 20.0   .0   .0   .0   .0   .0   .0
      .0 33.0 36.4 29.7 32.3 29.3 31.4 27.7 28.8  9.9 11.7  9.0  9.0 14.0   .0   .0   .0   .0   .0   .0
      .0 27.0 24.2 22.1 25.1 26.8 23.6 19.0 16.4  9.7  3.0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0 16.0 17.6 19.5 21.6 18.9 14.8 13.1  3.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0 11.0 15.8 11.7  7.1  7.2  6.7  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0  9.0  7.0  6.9  1.1  4.8  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0  7.0  3.0  2.0 -6.7  2.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
```

```
1TRANSMISSIVITY
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
     .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
0  CUMULATIVE MASS BALANCE -- (IN FT**3)

     RECHARGE                      = -7.17115E+06
     INJECTION                     = -3.57977E+05
     PUMPAGE                       =  2.90330E+05
     CUMULATIVE  NET  PUMPAGE      = -7.23880E+06
     WATER RELEASE FROM STORAGE    = -8.50121E+06
     LEAKAGE INTO AQUIFER          = -6.67861E+06
     LEAKAGE OUT OF AQUIFER        =  5.41562E+06
     CUMULATIVE  NET  LEAKAGE      = -1.26279E+06
0         MASS BALANCE RESIDUAL    =  3.73000E+02
          ERROR  (AS PERCENT)      =  6.53659E-03

0  RATE MASS BALANCE -- (IN C.F.S.)

     RECHARGE                      = -9.88000E-03
     LEAKAGE INTO AQUIFER          =  9.16694E-03
     LEAKAGE OUT OF AQUIFER        = -7.96375E-03
     NET LEAKAGE     (QNET)        =  1.20319E-03
     INJECTION                     =   .00000E+00
     PUMPAGE                       =  4.00000E-04
     NET WITHDRAWAL    (TPUM)      = -9.48000E-03
1          STABILITY CRITERIA --- M.O.C.
```

Mass Balance Calculations

GROUNDWATER CHEMICAL CONCENTRATIONS
5 YEARS AFTER SOURCE REMEDIATION

```
1CONCENTRATION

 NUMBER OF TIME STEPS =      2

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    5    4    4    3    3    0   34  158 3291 800513441 4567  742  103   10    5    4    2    0
0    0    6    6    5    5    4   -1   65  290 4256 810513652 5277  737   80    7    5    4    2    0
0    0    6    7    7    6    5   -4  122  484 4875 831815728 5289  429   44    5    5    5    2    0
0    0    7    8    8    8    6   -7  240  796 5777 914515611 5664  401   19    4    6    5    2    0
0    0    7    9    9    8    6   -4  499 2369 5952 851010283 5218  398    9    5    6    5    2    0
0    0    7    9    9    9    6   15  639 1718 4936 6979 8446 2294  104    0    6    7    5    2    0
0    0    5    9    9    9    6   60 1153 2269 4318 5927 6551 2717  141    4    8    7    4    0    0
0    0    5    9    9    9    9  116 1262 2242 3708 4955 5293 3224   70    8    8    8    0    0    0
0    0    6    9    9    9   13  372 1248 2105 3121 4163 4776 3418   61    9    9    0    0    0    0
0    0    7    9    9    9   17  152 1053 1804 2374 3299 4720 3281   38    9    0    0    0    0    0
0    6    8    9    9   10   19  133  782 1267 1430 2387 4539 2616   17    8    0    0    0    0    0
0    0    8    9    9   10   18  102  507  828  929 1228 3501  857   10    0    0    0    0    0    0
0    0    9    9    9   10   16   68  328  433  609 1017 1894  264    9    0    0    0    0    0    0
0    0    9    9    9    9   14   44  186  258  261  525    0    0    0    0    0    0    0    0    0
0    0    9    9    9    9   12   28  107  171   97    0    0    0    0    0    0    0    0    0    0
0    0    9    8    8    9   10   20   69    0    0    0    0    0    0    0    0    0    0    0    0
6    0    8    6    6   11    9   14    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    7    7    7   15    8    4    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =      2
         DELTA T         =  7.78600E+06
         TIME(SECONDS)   =  7.25825E+08
    CHEM.TIME(SECONDS)   =  7.25625E+08
    CHEM.TIME(DAYS)      =  8.40075E-03
         TIME(YEARS)     =  2.30000E+01
    CHEM.TIME(YEARS)     =  2.30600E+01
  NO. MOVES COMPLETED    =      1
```

Change in Chemical Concentrations
5 Years After Source Remediation

```
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -4   -5   -5   -6   -6  -11   23  147 3280 799513430 4557  732   92    0   -5   -6   -8    0
0    0   -3   -4   -4   -5   -5  -12   55  279 4246 809413642 5267  726   69   -2   -5   -5   -8    0
0    0   -4   -2   -2   -3   -4  -14  112  473 4864 830815718 5278  419   33   -5   -4   -4   -7    0
0    0   -3   -2   -2   -2   -3  -17 -230  786 5767 913515600 5653  391   -9   -5   -4   -5   -7    0
0    0   -3   -1   -1   -1   -3  -15  488 2359 5941 849910273 5207  388   -1   -4   -3   -5   -7    0
0    0   -3    0    0   -1   -3    5  829 1708 4926 6969 8436 2283   93  -10   -3   -3   -5   -7    0
0    0   -5    0    0    0   -3   50 1143 2258 4307 5916 6540 2707  131   -5   -2   -2   -5    0    0
0    0   -5    0    0    0   -1  105 1252 2231 3697 4944 5283 3214   60   -2   -1   -2    0    0    0
0    0   -4    0    0    0    3  361 1237 2094 3111 4153 4765 3407   51   -1   -1    0    0    0    0
0    0   -3    0    0    0    7  141 1042 1794 2364 3288 4710 3270   28   -1    0    0    0    0    0
0    0   -2    0    0    0    8  122  772 1257 1419 2377 4529 2606    6   -1    0    0    0    0    0
0    0   -1    6    0    0    8   91  496  817  918 1217 3490  846    0    0    0    0    0    0    0
0    0   -1    0    0    0    6   57  317  423  599 1007 1884  253    0    0    0    0    0    0    0
0    0    6    6    0    0    3   33  176  248  250  514    0    0    0    0    0    0    0    0    0
0    0   -1   -1   -1    0    1   18   96  161   86    0    0    0    0    0    0    0    0    0    0
0    0   -1   -1   -1    0    0   10   56    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -2   -2   -2    1   -1    4    0    0    0    0    0    0    0    0    0    0    0    0    0
6    0   -2   -3   -2    4   -2   -5    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

CHEMICAL MASS BALANCE

```
 CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES      =   .00000E+00
        MASS OUT BOUNDARIES     = -3.29856E+08
        MASS PUMPED IN          =  5.26510E+10
        MASS PUMPED OUT         = -3.38099E+06
        INFLOW MINUS OUTFLOW    =  5.23178E+10
        INITIAL MASS STORED     =  6.14520E+08
        PRESENT MASS STORED     =  5.44587E+10
        CHANGE MASS STORED      =  5.38442E+10
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL   = -1.52642E+09
        ERROR  (AS PERCENT)     = -2.89913E+00
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)     = -2.95228E+00
1SOLUTE TRANSPORT REMEDIATION
```

ALLUVIAL DEPOSITS

SOURCES REMEDIATION
NATURAL CLEAN UP
10 YEARS

```
1     START PUMPING PERIOD NO.  2

  THE FOLLOWING TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:

0              NTIM    =     5
               NPNT    =     5
               NITP    =     4
               ITMAX   =    10
               NREC    =    45
               NPNTMV  =     0
               NPNTVL  =     0
               NPNTD   =     0
               NPDELC  =     1
               NPNCHV  =     0
               PINT    =      10.000
               TIMX    =       1.000
               TINIT   = **********

1TIME INTERVALS (IN SECONDS)
     .30000E+09  .30000E+09  .30000E+09  .30000E+09  .30000E+09  .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
```

```
        LOCATION  OF  PUMPING  WELLS

        X    Y   RATE(IN CFS)   CONC.

       11    2    .000E+00        .00
       12    3    .000E+00        .00
       13    4    .000E+00        .00
       13    5    .000E+00        .00
       11    5    .000E+00        .00
        9    7    .000E+00        .00
        9    8    .000E+00        .00
        9    9    .000E+00        .00
       10    7    .000E+00        .00
       10    8    .000E+00        .00
       10    9    .000E+00        .00
       10   10    .000E+00        .00
       11    6    .000E+00        .00
       11    7    .000E+00        .00
       11    8    .000E+00        .00
       11    9    .000E+00        .00
       12    7    .000E+00        .00
       12    8    .000E+00        .00
       11   10    .000E+00        .00
       11   11    .000E+00        .06
       12    9    .000E+00        .00
       12   10    .000E+00        .00
       12   11    .000E+00        .00
       13    9    .000E+00        .00
       13   10    .000E+00        .00
       13   11    .000E+00        .00
       11    3    .000E+00        .00
       10    6    .000E+00        .00
       12    6    .000E+00        .00
        8    8    .000E+00        .00
       13    8    .000E+00        .00
        8    7    .000E+00        .00
        8    9    .000E+00        .00
        9   10    .000E+00        .00
       13    8    .000E+00        .00
       12   12    .000E+00        .00
       10    2    .000E+00        .00
       10    3    .000E+00        .00
       12    4    .000E+00        .00
        8   11    .000E+00        .00
       10   13    .000E+00        .00
       11    4    .000E+00        .00
       13   13    .000E+00        .00
       13    6    .000E+00        .00
       12    4    .000E+00        .00
```

```
1HEAD DISTRIBUTION - ROW
 NUMBER OF TIME STEPS =      2
        TIME(SECONDS) =  8.83613E+08
        TIME(DAYS)    =  1.02270E+04
        TIME(YEARS)   =  2.80000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0
0   0 422 423 423 425 427 430 432 434 435 436 437 440 442 445 446 450 452 455    0
0   0 420 419 419 421 423 425 426 427 430 434 435 438 441 444 446 449 452 453    0
0   0 418 416 416 417 418 421 422 423 425 429 432 436 440 442 445 448 451 452    0
0   0 414 413 413 413 415 418 419 420 422 425 430 433 437 440 443 446 449 450    0
0   0 410 409 410 411 413 415 417 419 421 424 428 431 434 437 441 444 446 445    0
0   0 407 406 407 409 410 413 415 417 420 423 427 430 433 436 440 442 443 442    0
0   0 405 403 404 406 408 411 413 415 418 421 425 429 432 435 437 439 437   0    0
0   0 397 400 402 404 406 408 411 413 416 420 424 427 430 432 435 435   0   0    0
0   0 393 397 400 402 404 406 409 411 414 418 422 425 427 428 430   0   0   0    0
0   0 389 394 397 400 402 404 406 409 412 415 419 421 424 420   0   0   0   0    0
0   0 384 392 395 398 400 402 404 406 409 411 411 415 418 415   0   0   0   0    0
0   0 380 389 393 396 398 400 402 404 406 406 403 407 410   0   0   0   0   0    0
0   0 378 387 391 394 396 398 400 401 397 398 394 395 400   0   0   0   0   0    0
0   0 377 385 388 392 394 395 396 395 391 387   0   0   0   0   0   0   0   0    0
0   0 376 383 386 389 391 392 392 383 385   0   0   0   0   0   0   0   0   0    0
0   0 374 381 383 384 385 386 380   0   0   0   0   0   0   0   0   0   0   0    0
0   0 373 378 379 373 379 375   0   0   0   0   0   0   0   0   0   0   0   0    0
0   0 372 373 373 363 374 374   0   0   0   0   0   0   0   0   0   0   0   0    0
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0
1DRAWDOWN
          0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
          0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
          0     0     1     1     2     2     2     4     5     4     1     1     0     0     0     0     1     1     0     0
          0     0     1     2     3     2     2     5     7     7     5     3     0     0     0     0    -1     0     0     0
          0     0     1     2     2     3     2     3     5     8     7     5     3     0     0     0     0    -2     0     0
          0     0     1     2     1     2     1     3     3     4     3     2     4     2     0     0    -1    -2     0     0
          0     0     1     0     0     0     2     1     1     0     2     0     0     2     0    -3    -4    -2     0     0
          0     0     1     0     0    -1     0     0     1     0     0     0    -1    -1    -2    -1    -2     0     0     0
          0     0    -2    -4    -3    -3    -2    -4    -2     0    -2    -1    -3    -4    -1    -1     0     0     0     0
          0     0    -3    -6    -7    -8    -8    -8    -5    -3    -4    -6    -5    -4    -2     0     0     0     0     0
          0     0    -4    -7    -9    -8    -9   -10    -8    -6    -4    -6    -4    -4     0     0     0     0     0     0
          0     0    -6    -7    -9   -11   -11   -12   -13   -15    -6    -5    -4    -2     0     0     0     0     0     0
          0     0    -5    -8   -10   -11   -11   -13   -13   -13   -10    -2    -1     0     0     0     0     0     0     0
          0     0    -6    -8   -10   -12   -12   -13   -13    -9    -7     0     0     0     0     0     0     0     0     0
          0     0    -7    -9   -11   -11   -11   -11    -9    -4     0     0     0     0     0     0     0     0     0     0
          0     0    -5    -8   -10   -12   -11    -9     0     0     0     0     0     0     0     0     0     0     0     0
          0     0    -5    -7    -7    -7    -7     0     0     0     0     0     0     0     0     0     0     0     0     0
          0     0    -3    -4     1    -3     0     0     0     0     0     0     0     0     0     0     0     0     0     0
          0     0     0     0    10     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
          0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
```

```
1AQUIFER THICKNESS
       .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
       .0 32.0 28.0 23.0 20.0 17.0 15.0 12.0  4.0  2.0  3.0  2.0  3.0  5.0  4.0  3.0  5.0  2.0  2.0   .0
       .0 35.0 39.4 29.2 20.9 17.5 19.8 16.4  7.0  1.6  1.6  2.4  4.2  5.1  4.8  5.7  4.1  3.5  1.0   .0
       .0 36.0 41.2 35.7 26.6 23.3 23.6 22.3 12.8  4.9  1.2  2.5  4.1  4.8  5.4  4.9  5.9  4.6  2.0   .0
       .0 44.0 42.9 47.7 43.3 40.2 47.6 34.3 30.4 17.4 15.4  9.5  3.2  2.0  3.1  4.2  5.4  4.0  2.0   .0
       .0 50.0 44.5 39.6 41.0 40.7 37.3 37.1 39.0 26.1 14.1 14.1 16.0 14.0  7.5  6.2  5.4  4.0  1.0   .0
       .0 57.0 51.2 49.6 46.5 45.4 42.9 40.1 32.4 24.7 22.7 16.8 18.1 18.3 19.3  9.6 11.6  5.8  2.0   .0
       .0 60.0 55.9 52.2 49.2 46.2 42.6 38.1 30.5 25.0 24.3 15.3 18.9 19.3 19.9 12.4  8.7  2.0   .0   .0
       .0 57.0 54.7 52.0 48.9 46.1 40.4 35.9 31.5 33.3 24.8 26.9 22.4 19.9 17.3 14.5 10.0   .0   .0   .0
       .0 53.0 51.9 49.7 46.7 43.9 38.2 33.7 31.2 29.5 27.9 25.2 28.2 21.7 21.5 18.0   .0   .0   .0   .0
       .0 49.0 49.3 47.4 44.5 41.9 44.2 38.4 33.8 26.9 25.0 18.5 21.2 26.9 20.0   .0   .0   .0   .0   .0
       .0 44.0 46.7 45.2 42.5 40.0 42.3 44.3 43.5 45.1 35.9 11.3 15.2 17.7 12.0   .0   .0   .0   .0   .0
       .0 40.0 44.3 43.1 40.6 38.1 40.3 37.2 38.9 36.0 25.9  7.6  9.8 20.0   .0   .0   .0   .0   .0   .0
       .0 33.0 37.2 30.9 33.7 30.9 33.1 29.6 30.6 12.2 13.3  9.0  9.0 14.0   .0   .0   .0   .0   .0   .0
       .0 27.0 25.1 23.5 26.6 28.5 25.4 21.0 18.4 11.3  3.0   .0   .0   .0   .0   .0   .0   .0   .0   .0
       .0 16.0 17.9 20.9 23.1 20.7 16.8 15.3  3.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
       .0 11.0 16.7 13.1  9.0  9.2  8.9  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
       .0  9.0  7.7  8.1  1.6  6.1  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
       .0  7.0  3.0  2.0 -8.6  2.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
       .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
1TRANSMISSIVITY
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
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      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
      .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
```

```
0  CUMULATIVE MASS BALANCE -- (IN FT**3)

    RECHARGE                      = -8.73010E+06
    INJECTION                     = -3.57977E+05
    PUMPAGE                       =  3.53445E+05
    CUMULATIVE  NET  PUMPAGE      = -8.73463E+06
    WATER RELEASE FROM STORAGE    = -1.01113E+07
    LEAKAGE INTO AQUIFER          = -8.14818E+06
    LEAKAGE OUT OF AQUIFER        =  6.77114E+06
    CUMULATIVE  NET  LEAKAGE      = -1.37704E+06
0       MASS BALANCE RESIDUAL     =  3.28500E+02
        ERROR  (AS PERCENT)       =  4.61069E-03

0  RATE MASS BALANCE -- (IN C.F.S.)

    RECHARGE                      = -9.88000E-03
    LEAKAGE INTO AQUIFER          =  9.12569E-03
    LEAKAGE OUT OF AQUIFER        = -6.40685E-03
    NET LEAKAGE     (GNET)        =  7.78837E-04
    INJECTION                     =   .00000E+00
    PUMPAGE                       =  4.00000E-04
    NET WITHDRAWAL    (TPUM)      = -9.48000E-03
1          STABILITY CRITERIA --- M.O.C.
```

```
1CONCENTRATION

 NUMBER OF TIME STEPS =     2

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    5    4    4    3    3   -1   42  182 1581 5133 8744 3811  884  139   14    5    3    1    0
    0    0    6    5    5    4    3   -2   74  312 2392 5716 9759 3877  737   98    6    4    3    1    0
    0    0    5    7    7    6    5   -4  129  638 3691 656710537 4280  657   53    5    5    4    2    0
    0    0    6    8    8    7    5   -5  223 1227 4964 789510781 4661  694   42    4    5    4    2    0
    0    0    6    8    9    8    5    0  420 2146 5649 8721 9766 4788  578   31    4    5    4    2    0
    0    0    6    9    9    8    2   39  653 2501 5241 7227 7887 3067  211    3    5    6    4    2    0
    0    0    4    9    9    9    0  268 1037 2387 4711 6108 6142 2385  165    2    7    7    4    0    0
    0    0    4    9    9    8   13  312 1126 2359 4012 5123 5060 2929  103    6    8    7    0    0    0
    0    0    5    9    9    9   73  690 1225 2202 3313 4179 4735 3167   71    8    8    0    0    0    0
    0    0    6    9    9   10   56  549 1126 1914 2643 3498 4483 3087   48    9    0    0    0    0    0
    0    0    7    9    9   11   94  529  996 1461 1703 2597 4131 2474   29    8    0    0    0    0    0
    0    0    8    9    9   11   36  209  663 1029 1136 1452 3432 1171   13    0    0    0    0    0    0
    0    0    8    9    9   10   23  116  460  624  776 1187 2354  535   10    0    0    0    0    0    0
    0    0    9    9    9   10   18   77  275  440  506  873    0    0    0    0    0    0    0    0    0
    0    0    9    9    9   10   14   51  173  326  244    0    0    0    0    0    0    0    0    0    0
    0    0    8    8    6   10   13   36  135    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    8    8    8   11   11   27    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    7    7    7   16    9    9    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =     2
        DELTA T       =  1.55760E+07
        TIME(SECONDS) =  8.83613E+08
   CHEM.TIME(SECONDS) =  8.83613E+08
   CHEM.TIME(DAYS)    =  1.02270E+04
        TIME(YEARS)   =  2.80000E+01
   CHEM.TIME(YEARS)   =  2.80000E+01
  NO. MOVES COMPLETED =     1

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0   -5   -6   -6   -6   -7  -11   31  172 1571 5123 8733 3801  874  129    3   -5   -7   -8    0
    0    0   -4   -4   -4   -5   -6  -12   64  302 2381 5705 9748 3866  726   88   -3   -5   -6   -8    0
    0    0   -4   -3   -3   -4   -5  -14  119  628 3680 655710527 4270  646   42   -5   -5   -5   -8    0
    0    0   -4   -2   -2   -3   -4  -16  212 1217 4953 788410770 4650  683   32   -5   -4   -5   -8    0
    0    0   -3   -1   -1   -2   -5   -9  409 2136 5639 8711 9756 4778  567   21   -5   -4   -5   -8    0
    0    0   -4   -1   -1   -1   -7   28  643 2490 5231 7217 7877 3057  200   -6   -4   -3   -5   -8    0
    0    0   -6   -1    0   -1   -9  258 1026 2377 4700 6097 6132 2375  154   -8   -3   -3   -6    0    0
    0    0   -5   -1    0   -1    2  302 1115 2348 4002 5113 5049 2919   92   -4   -2   -2    0    0    0
    0    0   -4    0    0   -1   63  679 1214 2191 3303 4169 4725 3157   60   -1   -1    0    0    0    0
    0    0   -3    0    0    0   45  539 1115 1903 2633 3488 4472 3077   38   -1    0    0    0    0    0
    0    0   -3    0    0    0   83  519  966 1451 1692 2586 4120 2463   19   -2    0    0    0    0    0
    0    0   -2    0    0    0   27  199  652 1019 1125 1442 3421 1160    2    0    0    0    0    0    0
    0    0   -2    0    0    0   13  105  450  614  766 1177 2344  524    0    0    0    0    0    0    0
    0    0   -1    0   -1    0    7   67  265  430  496  862    0    0    0    0    0    0    0    0    0
    0    0   -1   -1   -1    0    4   40  162  315  233    0    0    0    0    0    0    0    0    0    0
    0    0   -1   -1   -1    0    2   25  125    0    0    0    0    0    0    0    0    0    0    0    0
    0    0   -2   -2   -1    1    0   17    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0   -3   -3   -2    6    0   -1    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
 CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES      =   .00000E+00
        MASS OUT BOUNDARIES     = -4.51094E+08
        MASS PUMPED IN          =  5.26510E+10
        MASS PUMPED OUT         = -4.34155E+06
        INFLOW MINUS OUTFLOW    =  5.21956E+10
        INITIAL MASS STORED     =  6.14520E+08
        PRESENT MASS STORED     =  5.52735E+10
        CHANGE MASS STORED      =  5.46590E+10
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL   = -2.46338E+09
        ERROR  (AS PERCENT)     = -4.67668E+00
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)     = -4.77573E+00
1SOLUTE TRANSPORT REMEDIATION
```

ALLUVIAL DEPOSITS

SOURCES REMEDIATION
5 RECOVERY WELLS
PUMPED FOR 10 YEARS

```
1     START PUMPING PERIOD NO.  2

  THE FOLLOWING TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:

0             NTIM    =    5
              NPNT    =    5
              NITP    =    4
              ITMAX   =   10
              NREC    =   45
              NPNTMV  =    0
              NPNTVL  =    0
              NPNTD   =    0
              NPDELC  =    1
              NPNCHV  =    0
              PINT    =      10.000
              TIMX    =       1.000
              TINIT   = **********

1TIME INTERVALS (IN SECONDS)
     .31000E+09  .31000E+09  .31000E+09  .31000E+09  .31000E+09  .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .0000
      00000       00000       00000       00000       00000       00000       00000       00000      .00000      .0000
```

```
0         LOCATION  OF  PUMPING  WELLS

           X    Y   RATE(IN CFS)   CONC.

          11    2    .000E+00         .00
          12    3    .000E+00         .00
          13    4    .000E+00         .00
          13    5    .000E+00         .00
          11    5    .000E+00         .00
           9    7    .000E+00         .00
           9    8    .000E+00         .00
           9    9    .000E+00         .00
          10    7    .000E+00         .00
          10    8    .000E+00         .00
          10    9    .000E+00         .00
          10   10    .000E+00         .00
          11    6    .000E+00         .00
          11    7    .000E+00         .00
          11    8    .000E+00         .00
          11    9    .000E+00         .00
          12    7    .000E+00         .00
          12    8    .000E+00         .00
          11   10    .000E+00         .00
          11   11    .000E+00         .00
          12    9    .000E+00         .00
          12   10    .000E+00         .00
          12   11    .000E+00         .00
          13    9    .000E+00         .00
          13   10    .000E+00         .00
          13   11    .000E+00         .00
          11    3    .000E+00         .00
          10    6    .000E+00         .00
          12    6    .000E+00         .00
           8    8    .000E+00         .00
          13    8    .000E+00         .00
           6    7    .000E+00         .00
           8    9    .000E+00         .00
           9   10    .000E+00         .00
          13    8    .000E+00         .00
          12   12    .000E+00         .00
          10    2    .000E+00         .00
          10    3    .000E+00         .00
          12    4    .000E+00         .00
           6   11    .450E-02         .00
          10   13    .450E-02         .00
          11    4    .450E-02         .00
          13   13    .450E-02         .00
          13    6    .450E-02         .00
          12    4    .000E+00         .00
0
```

```
1HEAD DISTRIBUTION - ROW
 NUMBER OF TIME STEPS =      2
        TIME(SECONDS) =  8.83613E+08
        TIME(DAYS)    =  1.02270E+04
        TIME(YEARS)   =  2.80000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 422 423 423 425 427 430 432 434 435 436 437 440 442 445 446 450 452 455   0
0   0 420 419 419 421 422 425 426 427 429 428 434 437 441 444 446 449 452 453   0
0   0 418 416 416 417 418 420 422 422 423 392 430 433 439 442 445 448 451 452   0
0   0 414 413 413 413 415 417 418 419 420 415 426 425 436 440 443 446 449 450   0
0   0 410 409 410 411 412 415 416 418 419 419 425 412 431 437 441 444 446 445   0
0   0 407 406 407 408 410 412 413 416 418 419 424 420 431 436 439 442 443 442   0
0   0 405 403 404 406 408 409 410 414 416 419 423 422 430 435 437 439 437   0   0
0   0 397 400 402 404 405 407 407 411 413 418 422 423 429 432 435 435   0   0   0
0   0 393 397 400 401 403 404 403 408 411 416 421 422 426 423 430   0   0   0   0
0   0 389 394 397 399 401 402 397 405 405 413 418 418 423 420   0   0   0   0   0
0   0 384 392 395 397 399 400 398 402 398 409 411 406 417 415   0   0   0   0   0
0   0 380 389 393 395 397 399 397 400 381 403 402 343 410   0   0   0   0   0   0
0   0 378 387 391 393 395 397 396 398 389 397 394 395 400   0   0   0   0   0   0
0   0 377 385 388 391 393 394 394 394 389 387   0   0   0   0   0   0   0   0   0
0   0 376 383 386 389 390 391 391 383 385   0   0   0   0   0   0   0   0   0   0
0   0 374 381 383 384 385 385 380   0   0   0   0   0   0   0   0   0   0   0   0
0   0 373 378 379 373 379 375   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 372 373 373 364 374 374   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
1DRAWDOWN
         0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
         0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
         0     0     1     1     2     3     2     4     5     5     7     2     0     0     0     0     1     1     0     0
         0     0     1     2     3     2     3     5     8     9    42     5     3     1     0     0    -1     0     0     0
         0     0     1     2     2     3     3     4     6    10    17     9    11     1     0     0     0    -2     0     0
         0     0     1     2     1     3     1     4     4     6     8     5    23     5     0     0    -1    -2     0     0
         0     0     1     0     0     0     3     3     2     2     6     3    10     4     0    -2    -4    -2     0     0
         0     0     1     0     0    -1     1     2     2     2     1     2     5     0    -2    -1    -2     0     0     0
         0     0    -2    -4    -3    -2    -1     0     0     3     0     0     0    -3    -1    -1     0     0     0     0
         0     0    -3    -6    -6    -7    -6    -2    -2     0    -2    -5    -2    -3    -2     0     0     0     0     0
         0     0    -4    -7    -8    -7    -7    -1    -4     0    -2    -5    -1    -3     0     0     0     0     0     0
         0     0    -6    -7    -8   -10    -9    -6    -9    -4    -4    -5     4    -1     0     0     0     0     0     0
         0     0    -5    -8    -9   -10   -10    -8    -9    11    -7    -1    62     0     0     0     0     0     0     0
         0     0    -6    -8    -9   -11   -11    -9   -10    -1    -6     0     0     0     0     0     0     0     0     0
         0     0    -7    -9   -10   -10   -10    -9    -8    -2     0     0     0     0     0     0     0     0     0     0
         0     0    -5    -8   -10   -11   -10    -8     0     0     0     0     0     0     0     0     0     0     0     0
         0     0    -5    -7    -7    -7    -6     0     0     0     0     0     0     0     0     0     0     0     0     0
         0     0    -3    -4     1    -3     0     0     0     0     0     0     0     0     0     0     0     0     0     0
         0     0     0     0     9     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
         0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
```

```
1AQUIFER THICKNESS
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
   .0 32.0 28.0 23.0 20.0 17.0 15.0 12.0  4.0  2.0  3.0  2.0  3.0  5.0  4.0  3.0  5.0  2.0  2.0   .0
   .0 35.0 39.4 29.2 20.9 17.4 19.6 16.1  6.5   .7 -4.2  1.3  3.1  4.9  4.8  5.7  4.1  3.5  1.0   .0
   .0 38.0 41.2 35.7 26.5 23.1 23.2 21.6 11.9  2.8-35.7   .0   .8  4.3  5.3  4.9  5.9  4.7  2.0   .0
   .0 44.0 42.9 47.7 43.2 39.9 47.0 33.3 29.3 15.4  5.3  6.3 -5.2   .5  2.8  4.2  5.4  4.0  2.0   .0
   .0 50.0 44.5 39.6 40.9 40.4 36.6 35.7 37.6 24.1  9.3 10.5 -3.4 11.1  6.9  6.2  5.4  4.0  1.0   .0
   .0 57.0 51.1 49.6 46.4 45.0 41.9 38.2 30.8 22.6 19.4 13.6  8.0 15.6 18.7  9.5 11.6  5.7  2.0   .0
   .0 60.0 55.9 52.2 49.0 45.7 41.3 35.4 28.5 22.6 21.8 12.7 12.2 17.1 19.5 12.4  8.7  2.0   .0   .0
   .0 57.0 54.7 51.9 48.7 45.5 38.8 32.1 29.0 30.5 22.6 24.8 17.9 18.6 17.1 14.5 10.0   .0   .0   .0
   .0 53.0 51.9 49.6 46.5 43.3 36.3 27.7 28.2 25.6 25.9 23.6 25.3 21.0 21.4 18.0   .0   .0   .0   .0
   .0 49.0 49.2 47.3 44.3 41.2 42.0 28.5 30.1 20.5 23.0 17.5 18.3 26.5 20.0   .0   .0   .0   .0   .0
   .0 44.0 46.7 45.1 42.3 39.3 40.3 37.6 39.5 34.0 33.6 10.5  6.0 17.5 12.0   .0   .0   .0   .0   .0
   .0 40.0 44.3 43.0 40.4 37.5 38.5 32.4 35.0 11.3 23.5  6.6-53.5 20.0   .0   .0   .0   .0   .0   .0
   .0 33.0 37.1 30.9 33.5 30.4 31.7 26.3 27.8  3.3 12.2  9.0  9.0 14.0   .0   .0   .0   .0   .0   .0
   .0 27.8 25.0 23.4 26.4 28.1 24.4 19.0 16.8  8.9  3.0   .0   .0   .0   .0   .0   .0   .0   .0   .0
   .0 16.0 17.9 20.9 23.1 20.5 16.2 14.1  3.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
   .0 11.0 16.7 13.0  8.7  9.0  8.5  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
   .0  9.0  7.7  8.0   .9  6.0  1.6   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
   .0  7.0  3.0  2.0 -8.4  2.0  1.0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
1TRANSMISSIVITY
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
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  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00  .00
```

```
0  CUMULATIVE MASS BALANCE -- (IN FT**3)

    RECHARGE                       = -8.73010E+06
    INJECTION                      = -3.57977E+05
    PUMPAGE                        =  7.45390E+06
    CUMULATIVE  NET  PUMPAGE       = -1.63417E+06
    WATER RELEASE FROM STORAGE     = -3.43148E+06
    LEAKAGE INTO AQUIFER           = -8.49187E+06
    LEAKAGE OUT OF AQUIFER         =  6.69433E+06
    CUMULATIVE  NET  LEAKAGE       = -1.79755E+06
0        MASS BALANCE RESIDUAL     =  2.33000E+02
         ERROR  (AS PERCENT)       =  1.64684E-03

0  RATE MASS BALANCE -- (IN C.F.S.)

    RECHARGE                       = -9.88000E-03
    LEAKAGE INTO AQUIFER           =  1.17132E-02
    LEAKAGE OUT OF AQUIFER         = -8.10995E-03
    NET LEAKAGE     (QNET)         =  3.60328E-03
    INJECTION                      =   .00000E+00
    PUMPAGE                        =  2.29000E-02
    NET WITHDRAWAL    (TPUM)       =  1.30200E-02
1           STABILITY CRITERIA --- M.O.C.
```

```
1CONCENTRATION

 NUMBER OF TIME STEPS =      2

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    5    4    4    3    2    0   47  168 2223 6336 4410 2241  745  128   14    5    3    1    0
0    0    6    5    5    4    3    0   81  281 3899 7827 4440 2458  728  100    7    4    3    1    0
0    0    5    7    7    6    4    0  142  525 6459 7407 2283 3214  599   52    4    5    4    2    0
0    0    6    8    8    7    5    2  249  922 6275 7679 6405 4017  543   28    3    5    4    2    0
0    0    6    8    9    8    6   12  424 1938 4843 9139 8902  622  419    3    4    6    4    2    0
0    0    6    9    9    8    6   36  717 2313 4811 6537 7935-3563 -213   -6    6    6    4    2    0
0    0    4    9    9    9    8   80  954 2269 4284 5612 6170 -237  128   17    7    7    4    0    0
0    0    4    9    9    9   11  133 1248 2204 3863 4832 5072 2941  300    7    8    7    0    0    0
0    0    5    9    9    9   14  169 1256 2092 3392 4062 4627 3193  125    7    8    0    0    0    0
0    0    6    9    9    9   18  172 1386 1804 2979 3384 4381 2627   30    9    0    0    0    0    0
0    0    7    9    9   10   19  108 1073 1412 2553 2600 3832  181    0    8    0    0    0    0    0
0    0    6    9    9   10   16   73  413  963 2370 1641 2664 -401  -72    0    0    0    0    0    0
0    0    8    9    9   10   16   56  278  471 1493 1206 1905 -233   -4    0    0    0    0    0    0
0    0    9    9    9   10   14   42  171  271  372  821    0    0    0    0    0    0    0    0    0
0    0    9    9    9    9   13   32  120  212  137    0    0    0    0    0    0    0    0    0    0
0    0    6    8    6    9   12   26   94    0    0    0    0    0    0    0    0    0    0    0    0
0    0    8    8    8   11   10   21    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    7    7    6   17    9    7    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =      2
        DELTA T          =  5.57600E+06
        TIME(SECONDS)    =  8.83613E+08
   CHEM.TIME(SECONDS)    =  8.83613E+08
   CHEM.TIME(DAYS)       =  1.02270E+04
        TIME(YEARS)      =  2.80000E+01
   CHEM.TIME(YEARS)      =  2.80000E+01
  NO. MOVES COMPLETED =      2

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -5   -6   -6   -6   -7  -10   37  158 2212 6326 4399 2231  734  118    3   -5   -7   -8    0
0    0   -4   -4   -5   -5   -6  -10   70  270 3888 7817 4429 2447  718   90   -3   -5   -6   -8    0
0    0   -4   -3   -3   -4   -5  -10  132  515 6448 7397 2273 3203  589   42   -5   -5   -5   -8    0
0    0   -4   -2   -2   -3   -4   -8  238  912 6265 7669 6395 4007  533   18   -6   -4   -5   -8    0
0    0   -3   -1   -1   -2   -4    2  413 1928 4832 9129 8892  612  408   -7   -6   -4   -5   -8    0
0    0   -4   -1   -1   -1   -3   25  706 2302 4801 6526 7924-3573 -224  -16   -4   -3   -5   -8    0
0    0   -6   -1    0   -1   -2   70  943 2258 4274 5602 6160 -247  118    7   -2   -3   -6    0    0
0    0   -5   -1    0   -1    0  123 1238 2193 3852 4821 5061 2930  290   -2   -2   -2    0    0    0
0    0   -4    0    0    0    4  158 1246 2081 3382 4052 4616 3183  115   -3   -1    0    0    0    0
0    0   -3    0    0    0    7  161 1376 1794 2968 3373 4370 2616   19   -1    0    0    0    0    0
0    0   -2    0    0    0    8   97 1063 1401 2542 2589 3822  171  -10   -2    0    0    0    0    0
0    0   -2    0    0    0    8   62  403  953 2360 1631 2654 -411  -83    0    0    0    0    0    0
0    0   -1    0    0    0    6   45  267  460 1482 1195 1894 -243  -15    0    0    0    0    0    0
0    0   -1    0   -1    0    4   32  161  260  362  810    0    0    0    0    0    0    0    0    0
0    0   -1   -1   -1    0    2   21  110  201  127    0    0    0    0    0    0    0    0    0    0
0    0   -1   -1   -1    0    1   16   83    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -2   -2   -1    1    0   11    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -3   -3   -2    6    0   -2    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
 CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES     =   .00000E+00
        MASS OUT BOUNDARIES    = -4.11493E+08
        MASS PUMPED IN         =  5.26510E+10
        MASS PUMPED OUT        = -2.53415E+10
        INFLOW MINUS OUTFLOW   =  2.68980E+10
        INITIAL MASS STORED    =  6.14520E+08
        PRESENT MASS STORED    =  3.76025E+10
        CHANGE MASS STORED     =  3.69879E+10
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL  = -1.00899E+10
        ERROR  (AS PERCENT)    = -1.91637E+01
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)    = -3.83887E+01
1SOLUTE TRANSPORT REMEDIATION


0     TIME VERSUS HEAD AND CONCENTRATION AT SELECTED OBSERVATION POINTS

              PUMPING PERIOD NO.    2
```

STANLEY SHALE FORMATION

PLUME EVOLUTION - 18 YEARS

```
B>type umetcob.lst
1U.S.G.S. METHOD-OF-CHARACTERISTICS MODEL FOR SOLUTE TRANSPORT IN GROUND WATER
0SOLUTE TRANSPORT REMEDIATION
0                      I N P U T     D A T A
0                        GRID DESCRIPTORS

               NX     (NUMBER OF COLUMNS)  =     20
               NY     (NUMBER OF ROWS)     =     20
               XDEL   (X-DISTANCE IN FEET) =   200.0
               YDEL   (Y-DISTANCE IN FEET) =   200.0
0                        TIME  PARAMETERS

               NTIM    (MAX. NO. OF TIME STEPS)         =       5
               NPMP    (NO. OF PUMPING PERIODS)         =       2
               PINT    (PUMPING PERIOD IN YEARS)        =      18.000
               TIMX    (TIME INCREMENT MULTIPLIER)      =       1.00
               TINIT   (INITIAL TIME STEP IN SEC.)      =    .11E-10
0                  HYDROLOGIC AND CHEMICAL PARAMETERS

               S        (STORAGE COEFFICIENT)          =         .500000
               POROS    (EFFECTIVE POROSITY)           =         .40
               BETA     (CHARACTERISTIC LENGTH)        =     1000.0
               DLTRAT   (RATIO OF TRANSVERSE TO
                        LONGITUDINAL DISPERSIVITY)     =         .02
               ANFCTR   (RATIO OF T-YY TO T-XX)        =       10.000000
0 ***NON-DECAYING SPECIES***
0 ***NON-SORBING SPECIES***
0 ***SIP USED***
0 ***CONFINED AQUIFER***
0                        EXECUTION PARAMETERS

               NITP    (NO. OF ITER. PARAM  - ADIP)  =     4
               TOL     (CONVERGENCE CRITERIA)        =      .0090
               ITMAX   (MAX.NO.OF ITERATIONS)        =   10
               CELDIS  (MAX.CELL DISTANCE PER MOVE
                             OF PARTICLES - M.O.C.)  =      .500
               NPMAX   (MAX. NO. OF PARTICLES)       = 3200
               NPTPND  (NO. PARTICLES PER NODE)      =      4
0                         PROGRAM OPTIONS

               NPNT    (TIME STEP INTERVAL FOR
                        COMPLETE PRINTOUT)       =      5
               NPNTMV  (MOVE INTERVAL FOR CHEM.
                        CONCENTRATION PRINTOUT)  =      0
               NPNTVL  (PRINT OPTION-VELOCITY
                        0=NO; 1=FIRST TIME STEP;
                        2=ALL TIME STEPS)        =      0
               NPNTD   (PRINT OPTION-DISP.COEF.
                        0=NO; 1=FIRST TIME STEP;
                        2=ALL TIME STEPS)        =      0
               NUMOBS  (NO. OF OBSERVATION WELLS
                        FOR HYDROGRAPH PRINTOUT) =      5
               NREC    (NO. OF PUMPING WELLS)    =     39
               NCODES  (FOR NODE IDENT.)         =      1
               NPNCHV  (PUNCH VELOCITIES)        =      0
               NPDELC  (PRINT OPT.-CONC. CHANGE) =      1
```

```
0          LOCATION  OF  PUMPING  WELLS

            X    Y   RATE(IN CFS)    CONC.

           11    2   -.300E-03   50000.00
           12    3   -.300E-03   50000.00
           13    4   -.300E-03   50000.00
           13    5   -.300E-03   50000.00
           11    5   -.300E-03   50000.00
            9    7   -.300E-03   50000.00
            9    8   -.300E-03   50000.00
            9    9   -.300E-03   50000.00
           10    7   -.300E-03   50000.00
           10    8   -.300E-03   50000.00
           10    9   -.300E-03   50000.00
           10   10   -.300E-03   50000.00
           11    6   -.300E-03   50000.00
           11    7   -.300E-03   50000.00
           11    8   -.300E-03   50000.00
           11    9   -.300E-03   50000.00
           12    7   -.300E-03   50000.00
           12    8   -.300E-03   50000.00
           11   10   -.300E-03   50000.00
           11   11   -.300E-03   50000.00
           12    9   -.300E-03   50000.00
           12   10   -.300E-03   50000.00
           12   11   -.300E-03   50000.00
           13    9   -.300E-03   50000.00
           13   10   -.300E-03   50000.00
           13   11   -.300E-03   50000.00
           11    3   -.300E-03   50000.00
           10    6   -.300E-03   50000.00
           12    6   -.300E-03   50000.00
            8    8   -.300E-03   50000.00
           13    8   -.300E-03   50000.00
            8    7   -.300E-03   50000.00
            8    9   -.300E-03   50000.00
            9   10   -.300E-03   50000.00
           13    6   -.300E-03   50000.00
           12   12   -.300E-03   50000.00
           10    2   -.300E-03   50000.00
           10    3   -.300E-03   50000.00
           12    4   -.300E-03   50000.00
0           AREA OF ONE CELL =   4.0000E+04
0           X-Y SPACING:
                200.00
                200.00
```

```
1AQUIFER THICKNESS (FT)
      .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0   .0
      .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
1WATER TABLE
     0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
     0. 422. 423. 423. 425. 427. 430. 432. 434. 435. 436. 437. 440. 442. 445. 446. 450. 452. 455.   0.
     0. 420. 420. 420. 423. 425. 427. 430. 432. 434. 435. 436. 437. 440. 443. 446. 450. 453. 453.   0.
     0. 416. 417. 418. 420. 420. 423. 427. 430. 432. 434. 435. 436. 440. 442. 445. 446. 450. 452.   0.
     0. 414. 414. 415. 415. 418. 420. 422. 425. 430. 432. 435. 436. 437. 440. 442. 445. 446. 450.   0.
     0. 410. 410. 412. 412. 415. 416. 420. 422. 425. 427. 430. 435. 436. 437. 440. 442. 443. 445.   0.
     0. 407. 407. 407. 408. 410. 415. 416. 418. 420. 425. 427. 430. 435. 435. 436. 437. 440. 442.   0.
     0. 405. 404. 403. 405. 406. 410. 412. 416. 418. 420. 425. 427. 430. 432. 435. 436. 437. 438.   0.
     0. 397. 397. 397. 400. 402. 405. 406. 410. 416. 417. 422. 423. 425. 430. 433. 435. 436. 437.   0.
     0. 393. 393. 393. 394. 395. 397. 400. 405. 410. 413. 415. 419. 422. 425. 430. 432. 434. 436.   0.
     0. 389. 389. 389. 390. 393. 394. 395. 400. 405. 410. 412. 416. 419. 420. 422. 424. 426. 430.   0.
     0. 384. 385. 387. 388. 388. 390. 391. 392. 393. 404. 405. 410. 415. 415. 417. 419. 422. 425.   0.
     0. 380. 383. 384. 385. 386. 388. 388. 390. 392. 395. 400. 405. 410. 413. 415. 417. 421. 424.   0.
     0. 378. 380. 382. 383. 383. 385. 386. 387. 387. 390. 394. 395. 400. 405. 409. 412. 413. 420.   0.
     0. 377. 377. 378. 380. 382. 383. 384. 385. 386. 387. 393. 395. 400. 398. 400. 412. 413. 420.   0.
     0. 376. 377. 377. 378. 378. 380. 382. 383. 385. 387. 392. 394. 400. 397. 409. 411. 412. 418.   0.
     0. 374. 375. 375. 376. 377. 378. 380. 383. 385. 386. 390. 385. 380. 390. 408. 410. 410. 417.   0.
     0. 373. 374. 374. 374. 375. 375. 378. 382. 384. 385. 383. 380. 385. 389. 408. 410. 410. 416.   0.
     0. 372. 373. 373. 373. 374. 374. 375. 380. 382. 380. 384. 380. 383. 389. 408. 410. 410. 416.   0.
     0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
```

```
1TRANSMISSIVITY MAP (FT*FT/SEC)
    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00
    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+06   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .06E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04
   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04   1.32E-04    .00E+00
    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .03E+00    .00E+00    .00E+00
    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00    .00E+00
```

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1PERMEABILTY MAP (FT/SEC)
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06
   3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06  3.30E-06   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
    .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
0
```

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1DIFFUSE RECHARGE AND DISCHARGE (FT/SEC)
     .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
     .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09
   -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09 -1.00E-09   .00E+00
     .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
     .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
```

```
1NODE IDENTIFICATION MAP

       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    0
       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0      NO. OF NODE IDENT. CODES SPECIFIED =  1
0           THE FOLLOWING ASSIGNMENTS HAVE BEEN MADE:
      CODE NO.      LEAKANCE      SOURCE CONC.      RECHARGE
0        1          1.000E+00      .000E+00
```

```
1VERTICAL PERMEABILITY/THICKNESS (FT/(FT*SEC))
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00  1.00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00  1.00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
      .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00   .00E+00
```

```
1CONCENTRATION

 NUMBER OF TIME STEPS =       0
        TIME(SECONDS) =    .00000E+00
   CHEM.TIME(SECONDS) =    .00000E+00
   CHEM.TIME(DAYS)    =    .00000E+00
        TIME(YEARS)   =    .00000E+00
   CHEM.TIME(YEARS)   =    .00000E+00
  NO. MOVES COMPLETED =       0

0      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000
0      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000
0    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000    10.0000      .0000
0      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000
0      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000      .0000
```

```
1HEAD DISTRIBUTION - ROW
 NUMBER OF TIME STEPS =      1
        TIME(SECONDS) =  5.68037E+08
        TIME(DAYS)    =  6.57450E+03
        TIME(YEARS)   =  1.80000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0
0   0 422 414 412 412 413 415 418 421 424 427 429 430 432 434 437 441 446 455   0
0   0 420 413 411 411 413 415 417 420 424 427 429 430 432 434 437 440 445 453   0
0   0 416 412 410 410 412 414 417 420 423 426 428 430 431 433 436 439 444 452   0
0   0 414 410 409 409 410 413 415 418 422 425 427 429 430 432 435 438 443 450   0
0   0 410 408 407 407 409 411 414 417 420 423 426 427 429 431 434 437 441 445   0
0   0 407 405 405 405 407 409 412 415 419 422 424 426 427 430 432 435 438 442   0
0   0 405 402 402 403 405 407 410 414 417 420 422 424 426 428 430 433 436 438   0
0   0 397 399 400 401 403 405 408 411 414 417 420 422 424 426 428 431 434 437   0
0   0 393 395 397 399 401 403 406 409 412 415 418 420 421 424 426 429 431 436   0
0   0 389 392 395 396 398 401 403 406 409 412 415 417 419 422 424 427 429 430   0
0   0 384 389 392 394 396 399 401 404 407 410 413 415 417 419 422 424 426 425   0
0   0 380 387 390 392 394 397 399 402 404 407 410 412 415 417 420 422 424 424   0
0   0 378 385 388 391 393 395 397 400 402 405 408 410 412 415 418 420 422 420   0
0   0 377 383 387 389 391 393 396 398 400 403 406 408 410 413 416 419 420 420   0
0   0 376 381 385 388 390 392 394 397 399 401 404 406 409 412 415 418 419 418   0
0   0 374 380 384 387 389 391 393 396 398 400 403 405 407 410 414 417 418 417   0
0   0 373 379 383 386 388 390 392 395 397 399 402 404 406 410 414 416 417 416   0
0   0 372 379 383 386 388 390 392 395 397 399 401 403 406 409 413 416 417 416   0
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0
1DRAWDOWN
        0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
        0    0    9   11   13   14   15   14   13   11    9    8   10   10   11    9    9    6    0    0
        0    0    7    9   12   12   12   13   12   10    8    7    7    8    9    9   10    8    0    0
        0    0    5    8   10    8    9   10   10    9    8    7    6    9    9    9    7    6    0    0
        0    0    4    6    6    8    7    7    7    8    7    8    7    7    8    7    7    3    0    0
        0    0    2    5    5    6    5    6    5    5    4    4    8    7    6    6    5    2    0    0
        0    0    2    2    3    3    6    4    3    1    3    3    4    8    5    4    2    2    0    0
        0    0    2    1    2    1    3    2    2    1    0    3    3    4    4    5    3    1    0    0
        0    0   -1   -2    0    0    0   -1    0    2    0    2    1    1    4    5    4    2    0    0
        0    0   -1   -3   -4   -5   -5   -5   -3   -1   -1   -2    0    1    1    4    3    3    0    0
        0    0   -2   -5   -5   -4   -6   -7   -5   -3   -1   -2    0    0   -1   -1   -2   -2    0    0
        0    0   -3   -4   -5   -7   -8   -9  -11  -13   -5   -7   -4   -1   -3   -4   -4   -3    0    0
        0    0   -3   -5   -6   -7   -8  -10  -11  -11  -11   -9   -6   -4   -3   -4   -4   -2    0    0
        0    0   -4   -5   -7   -9   -9  -10  -12  -14  -14  -13  -14  -11   -9   -8   -7   -8    0    0
        0    0   -5   -6   -8   -8   -9  -11  -12  -13  -15  -12  -12   -9  -14  -15   -6   -6    0    0
        0    0   -3   -7   -9  -11  -11  -11  -13  -13  -13  -11  -11   -8  -14   -5   -6   -6    0    0
        0    0   -4   -8  -10  -11  -12  -12  -12  -12  -13  -12  -19  -26  -19   -5   -6   -7    0    0
        0    0   -4   -8  -11  -12  -14  -13  -12  -12  -13  -18  -23  -20  -20   -5   -5   -6    0    0
        0    0   -5   -9  -12  -13  -15  -16  -14  -14  -18  -16  -22  -22  -19   -4   -5   -6    0    0
        0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
0  CUMULATIVE MASS BALANCE -- (IN FT**3)

    RECHARGE                      = -7.36177E+06
    INJECTION                     = -6.47562E+06
    PUMPAGE                       =   .00000E+00
    CUMULATIVE  NET  PUMPAGE      = -1.38374E+07
    WATER RELEASE FROM STORAGE    = -1.45171E+07
    LEAKAGE INTO AQUIFER          = -2.55035E+07
    LEAKAGE OUT OF AQUIFER        =  2.48212E+07
    CUMULATIVE  NET  LEAKAGE      = -6.82324E+05
0       MASS BALANCE RESIDUAL     =  2.57400E+03
        ERROR  (AS PERCENT)       =  1.03696E-02

3  RATE MASS BALANCE -- (IN C.F.S.)

    RECHARGE                      = -1.29600E-02
    LEAKAGE INTO AQUIFER          =  4.48977E-02
    LEAKAGE OUT OF AQUIFER        = -4.36965E-02
    NET LEAKAGE     (QNET)        =  1.20120E-03
    INJECTION                     = -1.14000E-02
    PUMPAGE                       =   .00000E+00
    NET WITHDRAWAL    (TPUM)      = -2.43600E-02
1            STABILITY CRITERIA --- M.O.C.
```

```
0          THE LIMITING STABILITY CRITERION IS BETA
0          NO. OF PARTICLE MOVES REQUIRED TO COMPLETE THIS TIME STEP  =   95

0  NP        =          1547          IMOV     =             1
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  5.97933E+06
0  NP        =          1547          IMOV     =             2
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  1.19587E+07
0  NP        =          1547          IMOV     =             3
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  1.79380E+07
0  NP        =          1547          IMOV     =             4
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  2.39173E+07
0  NP        =          1547          IMOV     =             5
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  2.98967E+07
0  NP        =          1548          IMOV     =             6
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  3.58760E+07
0  NP        =          1548          IMOV     =             7
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  4.18553E+07
0  NP        =          1548          IMOV     =             8
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  4.78347E+07
0  NP        =          1548          IMOV     =             9
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  5.38140E+07
0  NP        =          1549          IMOV     =            10
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  5.97934E+07
0  NP        =          1549          IMOV     =            11
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  6.57727E+07
0  NP        =          1552          IMOV     =            12
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  7.17520E+07
0  NP        =          1552          IMOV     =            13
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  7.77314E+07
0  NP        =          1552          IMOV     =            14
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  8.37107E+07
0  NP        =          1553          IMOV     =            15
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  8.96900E+07
0  NP        =          1566          IMOV     =            16
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  9.56694E+07
0  NP        =          1568          IMOV     =            17
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  1.01649E+08
0  NP        =          1584          IMOV     =            18
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  1.07628E+08
0  NP        =          1584          IMOV     =            19
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  1.13607E+08
0  NP        =          1595          IMOV     =            20
   TIM(N)    =   5.68037E+08          TIMV     =   5.97933E+06          SUMTCH =  1.19587E+08
```

```
0  NP         =        1596          IMOV      =           21
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.25566E+08
0  NP         =        1609          IMOV      =           22
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.31545E+08
0  NP         =        1610          IMOV      =           23
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.37525E+08
0  NP         =        1615          IMOV      =           24
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.43504E+08
0  NP         =        1616          IMOV      =           25
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.49483E+08
0  NP         =        1620          IMOV      =           26
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.55463E+08
0  NP         =        1622          IMOV      =           27
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.61442E+08
0  NP         =        1624          IMOV      =           28
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.67421E+08
0  NP         =        1624          IMOV      =           29
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.73401E+08
0  NP         =        1629          IMOV      =           30
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.79380E+08
0  NP         =        1631          IMOV      =           31
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.85359E+08
0  NP         =        1640          IMOV      =           32
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.91339E+08
0  NP         =        1641          IMOV      =           33
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  1.97318E+08
0  NP         =        1642          IMOV      =           34
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  2.03297E+08
0  NP         =        1642          IMOV      =           35
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  2.09277E+08
0  NP         =        1657          IMOV      =           36
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  2.15256E+08
0  NP         =        1657          IMOV      =           37
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  2.21235E+08
0  NP         =        1658          IMOV      =           38
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  2.27215E+08
0  NP         =        1659          IMOV      =           39
   TIM(N)     =  5.68037E+08         TIMV      =  5.97933E+06          SUMTCH =  2.33194E+08
```

```
0  NP      =          1672      IMOV    =          40
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.39173E+08
0  NP      =          1673      IMOV    =          41
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.45153E+08
0  NP      =          1676      IMOV    =          42
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.51132E+08
0  NP      =          1677      IMOV    =          43
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.57111E+08
0  NP      =          1692      IMOV    =          44
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.63091E+08
0  NP      =          1696      IMOV    =          45
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.69070E+08
0  NP      =          1696      IMOV    =          46
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.75049E+08
0  NP      =          1697      IMOV    =          47
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.81029E+08
0  NP      =          1728      IMOV    =          48
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.87008E+08
0  NP      =          1732      IMOV    =          49
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.92987E+08
0  NP      =          1753      IMOV    =          50
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  2.98967E+08
0  NP      =          1754      IMOV    =          51
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.04946E+08
0  NP      =          1770      IMOV    =          52
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.10925E+08
0  NP      =          1770      IMOV    =          53
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.16905E+08
0  NP      =          1793      IMOV    =          54
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.22884E+08
0  NP      =          1806      IMOV    =          55
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.28863E+08
0  NP      =          1816      IMOV    =          56
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.34843E+08
0  NP      =          1817      IMOV    =          57
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.40822E+08
0  NP      =          1827      IMOV    =          58
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.46801E+08
0  NP      =          1828      IMOV    =          59
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.52781E+08
0  NP      =          1853      IMOV    =          60
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.58760E+08
0  NP      =          1857      IMOV    =          61
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.64739E+08
0  NP      =          1862      IMOV    =          62
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.70719E+08
0  NP      =          1880      IMOV    =          63
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.76698E+08
0  NP      =          1898      IMOV    =          64
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.82677E+08
0  NP      =          1904      IMOV    =          65
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.88657E+08
0  NP      =          1921      IMOV    =          66
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  3.94636E+08
0  NP      =          1921      IMOV    =          67
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  4.00615E+08
0  NP      =          1927      IMOV    =          68
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  4.06594E+08
0  NP      =          1930      IMOV    =          69
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  4.12574E+08
0  NP      =          1940      IMOV    =          70
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  4.18553E+08
0  NP      =          1942      IMOV    =          71
   TIM(N)  =   5.68037E+08      TIMV    =   5.97933E+06      SUMTCH =  4.24532E+08
0  NP      =          1990      IMOV    =          72
```

```
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.30512E+08
0    NP       =          1990      IMOV   =            73
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.36491E+08
0    NP       =          1991      IMOV   =            74
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.42470E+08
0    NP       =          1998      IMOV   =            75
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.48450E+08
0    NP       =          2001      IMOV   =            76
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.54429E+08
0    NP       =          2012      IMOV   =            77
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.60408E+08
0    NP       =          2029      IMOV   =            78
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.66388E+08
0    NP       =          2029      IMOV   =            79
     TIM(N)   =   5.66037E+06      TIMV   =   5.97933E+06        SUMTCH =  4.72367E+08
0    NP       =          2055      IMOV   =            80
     TIM(N)   =   5.66037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.78346E+08
0    NP       =          2076      IMOV   =            81
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.84326E+08
0    NP       =          2078      IMOV   =            82
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  4.90305E+08
0    NP       =          2079      IMOV   =            83
     TIM(N)   =   5.68037E+06      TIMV   =   5.97933E+06        SUMTCH =  4.96284E+08
0    NP       =          2085      IMOV   =            84
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.02264E+08
0    NP       =          2087      IMOV   =            85
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.08243E+08
0    NP       =          2067      IMOV   =            86
     TIM(N)   =   5.68037E+06      TIMV   =   5.97933E+06        SUMTCH =  5.14222E+08
0    NP       =          2097      IMOV   =            87
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.20202E+08
0    NP       =          2124      IMOV   =            88
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.26181E+08
0    NP       =          2124      IMOV   =            89
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.32160E+08
0    NP       =          2159      IMOV   =            90
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.38140E+08
0    NP       =          2164      IMOV   =            91
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.44119E+08
0    NP       =          2167      IMOV   =            92
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.50098E+08
0    NP       =          2172      IMOV   =            93
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.56078E+08
0    NP       =          2175      IMOV   =            94
     TIM(N)   =   5.68037E+06      TIMV   =   5.97933E+06        SUMTCH =  5.62057E+08
0    NP       =          2175      IMOV   =            95
     TIM(N)   =   5.68037E+08      TIMV   =   5.97933E+06        SUMTCH =  5.68036E+08
```

```
1CONCENTRATION

 NUMBER OF TIME STEPS =      1

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    3    5    9   10   31  248  953 3032 7581 9455 5554 3141 1034  332   99   28   11    5    0
0    0    4    5    9   10   22  319 1282 3949 8091 9255 8789 4621 1090  202   31    8    5    4    0
0    0    3    5    9    9   39  481 1797 4285 7433 8848 9362 7364  986  124   14    7    5    3    0
0    0    4    5    9    7   58  709 2564 4971 772510040 9286 7588  817   92   12    7    5    3    0
0    0    4    6    9    6   83 1090 3674 6062 91661061510114 6883  740   86   12    8    6    3    0
0    0    4    6    9    5  121 1287 5302 7630 97911080610464 6797  676   78   12    8    6    3    0
0    0    3    7    9    5  153 2224 6024 8205 98351069010524 7604  670   65   10    8    7    3    0
0    0    3    7    9    7  258 2161 6055 8158 94551033110356 7817  637   51    8    8    7    3    0
0    0    4    7    9   12  351 2515 5535 7674 8761 9730 9947 7532  679   37    7    8    7    2    0
0    0    4    7    9   18  446 2445 4829 6604 7612 8798 9237 6759  509   18    6    8    7    2    0
0    0    4    8   10   27  509 2177 4263 5423 6427 7612 8127 5373  327    3    5    8    7    2    0
0    0    5    8   12   35  498 1905 3490 4485 5385 6241 6584 3945  216   -7    6    9    8    2    0
0    0    6    8   17   38  513 1539 2667 3496 4259 5100 5095 2619   75  -15    6    9    8    2    0
0    0    7    9   14   35  361 1193 2045 2687 3226 4063 3836 1846    2  -15    7    9    8    4    0
0    0    8   10   14   31  171  661 1468 1872 2306 2820 2460 1047  -48  -13    8   10    9    4    0
0    0    8   10   14   26  117  542  934 1194 1510 1865 1477  552  -66   -7    9   10    9    5    0
0    0    9   10   14   24   81  308  508  659  860 1020 1029  285  -57    1   10   10    9    6    0
0    0    9   10   13   30   44  124  191  255  369  406  484  100  -27    8   10   10   10   10    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =      1
        DELTA T       =  5.68037E+08
        TIME(SECONDS) =  5.68037E+08
   CHEM.TIME(SECONDS) =  5.68036E+08
   CHEM.TIME(DAYS)    =  6.57449E+03
        TIME(YEARS)   =  1.80000E+01
   CHEM.TIME(YEARS)   =  1.30000E+01
  NO. MOVES COMPLETED =     95

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -6   -4   -1    0   20  238  942 3022 7571 9445 5543 3131 1023  322   89   17    1   -4    0
0    0   -6   -4   -1    0   11  309 1271 3939 8080 9244 8778 4610 1080  192   20   -2   -4   -5    0
0    0   -6   -4   -1   -1   28  470 1786 4274 7422 8838 9351 7354  975  114    4   -3   -4   -6    0
0    0   -6   -4   -1   -2   48  698 2553 4960 771410030 9275 7578  807   82    2   -2   -4   -6    0
0    0   -6   -3   -1   -4   73 1080 3664 6052 91551060410104 6872  730   75    2   -2   -4   -6    0
0    0   -6   -3   -1   -4  111 1276 5291 7619 97811079510453 6787  666   67    1   -1   -3   -6    0
0    0   -7   -3   -1   -4  143 2214 6013 8194 98251068010513 7594  659   55    0   -2   -3   -6    0
0    0   -6   -3   -1   -2  248 2150 6045 8147 94451032010346 7806  626   40   -1   -2   -3   -6    0
0    0   -6   -2   -1    1  341 2504 5525 7664 8750 9719 9936 7521  668   26   -2   -1   -3   -7    0
0    0   -5   -2   -1    8  435 2435 4819 6594 7602 8788 9227 6749  499    7   -4   -1   -3   -7    0
0    0   -5   -2    0   16  498 2167 4253 5412 6417 7601 8116 5363  317   -6   -4   -1   -2   -7    0
0    0   -5   -2    1   24  487 1895 3479 4474 5375 6231 6574 3935  205  -18   -4   -1   -2   -7    0
0    0   -4   -1    7   27  503 1528 2656 3486 4248 5090 5084 2609   64  -25   -3    0   -1   -7    0
0    0   -3    0    4   24  371 1163 2035 2676 3216 4053 3825 1836   -7  -25   -2    0   -1   -6    0
0    0   -2    0    3   20  161  851 1458 1862 2295 2810 2449 1036  -59  -23   -1    0   -1   -5    0
0    0   -1    0    3   15  106  532  923 1184 1500 1854 1466  542  -77  -18    0    0    0   -4    0
0    0   -1    0    3   13   71  298  497  649  850 1009 1019  275  -67   -9    0    0    0   -4    0
0    0    0    0    2   20   34  113  181  245  358  396  473   89  -38   -2    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
 CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES      =   .00000E+00
        MASS OUT BOUNDARIES     = -1.60167E+08
        MASS PUMPED IN          =  3.66945E+11
        MASS PUMPED OUT         =   .00000E+00
        INFLOW MINUS OUTFLOW    =  3.66785E+11
        INITIAL MASS STORED     =  2.07360E+09
        PRESENT MASS STORED     =  3.92324E+11
        CHANGE MASS STORED      =  3.90251E+11
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL   = -2.34656E+10
        ERROR  (AS PERCENT)     = -6.39485E+00
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)     = -6.43402E+00
1SOLUTE TRANSPORT REMEDIATION
```

STANLEY SHALE FORMATION

SOURCES REMEDIATION
NATURAL CLEAN UP
5 YEARS

```
1     START PUMPING PERIOD NO.  2

  THE FOLLOWING TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:

0             NTIM   =    5
              NPNT   =    5
              NITP   =    4
              ITMAX  =   10
              NREC   =   45
              NPNTMV =    0
              NPNTVL =    0
              NPNTD  =    0
              NPDELC =    1
              NPNCHV =    0
              PINT   =       5.000
              TIMX   =       1.000
              TINIT  = **********

1TIME INTERVALS (IN SECONDS)
     .15000E+09  .15000E+09  .15000E+09  .15000E+09  .15000E+09  .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
```

```
0          LOCATION  OF  PUMPING  WELLS

            X    Y   RATE(IN CFS)   CONC.

           11    2    .000E+00        .00
           12    3    .000E+00        .00
           13    4    .000E+00        .00
           13    5    .000E+00        .00
           11    5    .000E+00        .00
            9    7    .000E+00        .00
            9    8    .000E+00        .00
            9    9    .000E+00        .00
           10    7    .000E+00        .00
           10    8    .000E+00        .00
           10    9    .000E+00        .00
           10   10    .000E+00        .00
           11    6    .000E+00        .00
           11    7    .000E+00        .00
           11    8    .000E+00        .00
           11    9    .000E+00        .00
           12    7    .000E+00        .00
           12    8    .000E+00        .00
           11   10    .000E+00        .00
           11   11    .000E+00        .00
           12    9    .000E+00        .00
           12   10    .000E+00        .00
           12   11    .000E+00        .00
           13    9    .000E+00        .00
           13   10    .000E+00        .00
           13   11    .000E+00        .00
           11    3    .000E+00        .00
           10    6    .000E+00        .00
           12    6    .000E+00        .00
            8    8    .000E+00        .00
           13    8    .000E+00        .00
            8    7    .000E+00        .00
            8    9    .000E+00        .00
            9   10    .000E+00        .00
           13    8    .000E+00        .00
           12   12    .000E+00        .00
           10   12    .000E+00        .00
           10    3    .000E+00        .00
           12    4    .000E+00        .00
            8   11    .000E+00        .00
           10   13    .000E+00        .00
           11    4    .000E+00        .00
           13   13    .000E+00        .00
           13    6    .000E+00        .00
           12    4    .000E+00        .00
```

```
1HEAD DISTRIBUTION - ROW
 NUMBER OF TIME STEPS =      2
        TIME(SECONDS) =  7.25825E+08
        TIME(DAYS)    =  8.40075E+03
        TIME(YEARS)   =  2.30000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0
0   0 422 413 410 410 411 413 415 418 421 424 426 428 430 432 435 439 445 455    0
0   0 420 412 410 409 410 412 415 418 421 423 426 428 430 432 435 439 444 453    0
0   0 418 411 409 409 410 412 414 417 420 423 425 427 429 431 434 438 443 452    0
0   0 414 409 407 408 409 411 413 416 419 422 424 426 428 431 433 437 442 450    0
0   0 410 407 406 406 408 410 412 415 418 421 423 425 427 430 432 436 440 445    0
0   0 407 405 404 405 406 408 411 414 417 419 422 424 426 428 431 434 438 442    0
0   0 405 402 402 403 405 407 409 412 415 418 420 423 425 427 430 432 436 438    0
0   0 397 399 400 401 403 405 408 411 413 416 419 421 423 425 428 431 434 437    0
0   0 393 396 398 399 401 403 406 409 412 414 417 419 421 424 426 429 431 436    0
0   0 389 393 395 397 400 402 404 407 410 413 415 417 420 422 425 427 429 430    0
0   0 384 390 393 396 398 400 403 405 408 411 413 416 418 420 423 425 427 425    0
0   0 380 388 391 394 396 399 401 404 406 409 411 414 416 419 421 423 424 424    0
0   0 378 386 390 392 395 397 399 402 405 407 410 412 415 417 420 422 423 420    0
0   0 377 384 388 391 394 396 398 401 403 406 408 411 413 416 418 420 421 420    0
0   0 376 382 387 390 393 395 397 400 402 405 407 409 412 415 417 419 420 418    0
0   0 374 381 386 389 392 394 396 399 401 404 406 408 411 414 417 418 419 417    0
0   0 373 381 385 389 391 393 396 398 401 403 405 408 410 413 416 418 418 416    0
0   0 372 380 385 388 391 393 395 398 400 403 405 407 410 413 416 418 418 416    0
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0
1DRAWDOWN
        0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
        0     0    10    13    15    16    17    17    16    14    12    11    12    12    13    11    11     7     0     0
        0     0     8    10    14    15    15    15    14    13    12    10     9    10    11    11    11     9     0     0
        0     0     6     9    11    10    11    13    13    12    11    10     9    11    11    11     8     7     0     0
        0     0     5     8     7     9     9     9     9    11    10    11    10     9     9     9     8     4     0     0
        0     0     3     6     6     7     6     8     7     7     6     7    10     9     7     8     6     3     0     0
        0     0     2     3     3     4     7     5     4     3     6     5     6     9     7     5     3     2     0     0
        0     0     2     1     2     1     3     3     4     3     2     5     4     5     5     5     4     1     0     0
        0     0    -1    -2     0     0     0    -1     0     3     1     3     2     2     5     5     4     2     0     0
        0     0    -2    -4    -4    -5    -5    -5    -3    -1     0    -1     0     1     1     4     3     3     0     0
        0     0    -3    -5    -6    -6    -7    -8    -6    -4    -2    -2     0     0    -1    -2    -2    -2     0     0
        0     0    -4    -5    -7    -9    -9   -11   -12   -14    -6    -7    -5    -2    -4    -5    -5    -4     0     0
        0     0    -4    -6    -8    -9   -10   -12   -13   -13   -13   -10    -8    -5    -5    -5    -5    -2     0     0
        0     0    -5    -7    -8   -11   -11   -12   -14   -17   -16   -15   -16   -14   -11   -10    -9    -9     0     0
        0     0    -6    -9   -10   -11   -12   -13   -15   -16   -18   -14   -15   -12   -17   -17    -7    -7     0     0
        0     0    -4    -9   -11   -14   -14   -14   -16   -16   -17   -14   -14   -11   -17    -7    -7    -7     0     0
        0     0    -5   -10   -12   -14   -15   -15   -15   -15   -17   -15   -22   -30   -23    -8    -7    -8     0     0
        0     0    -6   -10   -14   -15   -17   -17   -15   -16   -17   -21   -27   -24   -23    -7    -7    -7     0     0
        0     0    -6   -11   -14   -16   -18   -19   -17   -17   -22   -20   -26   -26   -23    -7    -7    -7     0     0
        0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
[illegible]
```

```
0  CUMULATIVE MASS BALANCE -- (IN FT**3)

    RECHARGE                      = -9.40671E+06
    INJECTION                     = -6.47562E+06
    PUMPAGE                       =   .00000E+00
    CUMULATIVE  NET  PUMPAGE      = -1.58823E+07
    WATER RELEASE FROM STORAGE    = -1.66129E+07
    LEAKAGE INTO AQUIFER          = -3.26602E+07
    LEAKAGE OUT OF AQUIFER        =  3.19270E+07
    CUMULATIVE  NET  LEAKAGE      = -7.33234E+05
0        MASS BALANCE RESIDUAL    =  2.61860E+03
         ERROR  (AS PERCENT)      =  8.19962E-03

0  RATE MASS BALANCE -- (IN C.F.S.)

    RECHARGE                      = -1.29600E-02
    LEAKAGE INTO AQUIFER          =  4.53779E-02
    LEAKAGE OUT OF AQUIFER        = -4.50973E-02
    NET LEAKAGE     (QNET)        =  2.80619E-04
    INJECTION                     =   .00000E+00
    PUMPAGE                       =   .00000E+00
    NET WITHDRAWAL    (TPUM)      = -1.29600E-02
1            STABILITY CRITERIA --- M.O.C.
```

```
1CONCENTRATION

 NUMBER OF TIME STEPS =       2

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    3    5    8   11   49  310 1138 4129 6056 7584 5578 3392 1698  639  209   67   23    8    0
0    0    3    4    8   10   44  391 1639 4774 7195 8388 6864 4179 1615  411   71   11    9    6    0
0    0    3    5    8    9   39  521 2170 5315 7624 9005 8214 5428 1622  270   30    6    6    3    0
0    0    3    4    8    7   38  874 2826 5562 8127 9274 8870 5987 1267  184   19    6    5    3    0
0    0    3    5    8    6   77  871 3558 6262 8728 9811 9195 6034 1106  147   17    7    5    3    0
0    0    3    5    7   10  124 1441 4193 6955 9031 9933 9292 5441 1024  131   15    7    5    3    0
0    0    2    6    7   28  219 2036 4862 7284 9042 9833 9244 5207 1001  116   12    7    5    3    0
0    0    3    6    7   64  367 2571 5242 7447 8823 9574 9069 5310  955   95    9    7    6    3    0
0    0    3    6    8   87  503 3025 5337 7152 8391 9139 8744 5576  852   69    6    7    7    2    0
0    0    3    6   12  109  631 2885 5126 6711 7794 8534 8246 5308  697   39    3    7    6    2    0
0    0    4    6   18  141  721 2805 4763 6045 7039 7796 7329 4857  517   10    1    8    6    2    0
0    0    4    7   21  151  762 2453 4057 5316 6313 6925 6645 3860  327  -12    1    8    7    2    0
0    0    5    6   24  166  735 2065 3410 4350 5254 5996 5445 3023  170  -25    2    8    7    2    0
0    0    8   10   28  173  672 1638 2863 3518 4286 4893 4383 2241   53  -29    3    9    8    3    0
0    0    9   11   34  170  600 1483 2171 2687 3234 3774 3249 1501  -29  -28    5    9    8    4    0
0    0    9   14   39  135  463 1034 1570 1971 2344 2682 2220  851  -84  -21    7   10    9    4    0
0    0   11   17   41  131  358  666  966 1224 1508 1605 1242  367  -82   -8    9   10    9    5    0
0    0   12   17   32   75  164  277  388  520  740  728  425  110  -27    2    9   10    9   10    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =       2
        DELTA T        =  7.78800E+06
        TIME(SECONDS)  =  7.25825E+08
   CHEM.TIME(SECONDS)  =  7.25825E+08
   CHEM.TIME(DAYS)     =  8.40075E+03
        TIME(YEARS)    =  2.30000E+01
   CHEM.TIME(YEARS)    =  2.30000E+01
  NO. MOVES COMPLETED =       2

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -7   -5   -1    1   39  300 1127 4118 6046 7573 5568 3381 1687  628  199   56   13   -1    0
0    0   -7   -5   -2    0   33  380 1628 4764 7184 8378 6853 4168 1605  401   61    1    0   -3    0
0    0   -7   -5   -1   -1   29  510 2159 5305 7613 8995 8204 5418 1611  260   20   -4   -3   -6    0
0    0   -7   -5   -2   -3   27  863 2815 5552 8117 9263 8859 5977 1257  173    8   -4   -4   -7    0
0    0   -7   -5   -2   -3   67  860 3547 6251 8717 9801 9185 6023 1096  137    6   -3   -4   -7    0
0    0   -7   -4   -2    0  113 1431 4182 6944 9020 9922 9282 5431 1013  121    4   -3   -4   -7    0
0    0   -7   -4   -3   17  208 2026 4852 7273 9031 9823 9233 5196  991  105    1   -3   -4   -7    0
0    0   -7   -4   -3   53  357 2560 5231 7437 8812 9563 9058 5300  944   84   -1   -3   -4   -7    0
0    0   -7   -4   -1   76  492 3014 5326 7142 8381 9129 8733 5565  841   58   -4   -2   -3   -8    0
0    0   -6   -4    1   99  620 2874 5116 6700 7783 8524 8235 5297  686   28   -7   -2   -4   -8    0
0    0   -6   -3    7  131  711 2795 4753 6035 7029 7785 7319 4847  506    0   -9   -2   -3   -8    0
0    0   -5   -2   10  141  752 2442 4046 5305 6303 6915 6634 3850  317  -22   -9   -2   -2   -8    0
0    0   -4   -1   13  155  725 2055 3399 4340 5244 5985 5434 3012  160  -35   -8   -1   -2   -8    0
0    0   -2    0   18  162  662 1628 2852 3508 4276 4883 4372 2230   43  -40   -6   -1   -2   -6    0
0    0   -1    1   24  160  589 1472 2160 2676 3223 3764 3239 1490  -39  -39   -5    0   -1   -6    0
0    0    0    3   28  144  452 1023 1559 1961 2334 2672 2209  841  -94  -31   -2    0   -1   -5    0
0    0    1    6   31  120  347  656  956 1213 1498 1595 1231  357  -92  -18    0    0   -1   -5    0
0    0    2    7   22   65  154  266  376  510  729  718  414  100  -38   -7    0    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
 CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES     =   .00000E+00
        MASS OUT BOUNDARIES    = -1.89576E+08
        MASS PUMPED IN         =  3.66945E+11
        MASS PUMPED OUT        =   .00000E+00
        INFLOW MINUS OUTFLOW   =  3.66756E+11
        INITIAL MASS STORED    =  2.07360E+09
        PRESENT MASS STORED    =  3.93533E+11
        CHANGE MASS STORED     =  3.91460E+11
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL  = -2.47040E+10
        ERROR  (AS PERCENT)    = -6.73233E+00
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)    = -6.77411E+00
1SOLUTE TRANSPORT REMEDIATION
```

STANLEY SHALE FORMATION

SOURCES REMEDIATION
NATURAL CLEAN UP
10 YEARS

```
1     START PUMPING PERIOD NO.  2

  THE FOLLOWING TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:

0             NTIM   =    5
              NPNT   =    5
              NITP   =    4
              ITMAX  =   10
              NREC   =   45
              NPNTMV =    0
              NPNTVL =    0
              NPNTD  =    0
              NPDELC =    1
              NPNCHV =    0
              PINT   =      10.000
              TIMX   =       1.000
              TINIT  = **********

1TIME INTERVALS (IN SECONDS)
     .31000E+09  .31000E+09  .31000E+09  .31000E+09  .31000E+09  .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
     .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000      .00000
```

```
0          LOCATION  OF  PUMPING  WELLS

            X    Y   RATE(IN CFS)    CONC.

           11    2    .000E+00         .00
           12    3    .000E+00         .00
           13    4    .000E+00         .00
           13    5    .000E+00         .00
           11    5    .000E+00         .00
            9    7    .000E+00         .00
            9    8    .000E+00         .00
            9    9    .000E+00         .00
           10    7    .000E+00         .00
           10    8    .000E+00         .00
           10    9    .000E+00         .00
           10   10    .000E+00         .00
           11    6    .000E+00         .00
           11    7    .000E+00         .00
           11    8    .000E+00         .00
           11    9    .000E+00         .00
           12    7    .000E+00         .00
           12    8    .000E+00         .00
           11   10    .000E+00         .00
           11   11    .000E+00         .00
           12    9    .000E+00         .00
           12   10    .000E+00         .00
           12   11    .000E+00         .00
           13    9    .000E+00         .00
           13   10    .000E+00         .00
           13   11    .000E+00         .00
           11    3    .000E+00         .00
           10    6    .000E+00         .00
           12    6    .000E+00         .00
            8    8    .000E+00         .00
           13    8    .000E+00         .00
            8    7    .000E+00         .00
            8    9    .000E+00         .00
            9   10    .000E+00         .00
           13    8    .000E+00         .00
           12   12    .000E+00         .00
           10    2    .000E+00         .00
           10    3    .000E+00         .00
           12    4    .000E+00         .00
            8   11    .000E+00         .00
           10   13    .000E+00         .00
           11    4    .000E+00         .00
           13   13    .000E+00         .00
           13    6    .000E+00         .00
           12    4    .000E+00         .00
```

```
1HEAD DISTRIBUTION - ROW
 NUMBER OF TIME STEPS =       2
        TIME(SECONDS) =  8.83613E+08
        TIME(DAYS)    =  1.02270E+04
        TIME(YEARS)   =  2.80000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 422 413 409 409 410 411 414 416 419 422 424 426 429 431 434 438 444 455   0
0   0 420 412 409 408 409 411 414 416 419 422 424 426 428 431 434 438 444 453   0
0   0 418 411 408 408 409 411 413 416 419 421 424 426 428 430 433 437 443 452   0
0   0 414 409 407 407 408 410 412 415 418 420 423 425 427 430 433 436 442 450   0
0   0 410 407 406 406 407 409 411 414 417 420 422 424 426 429 432 435 440 445   0
0   0 407 405 404 404 406 408 410 413 416 418 421 423 425 428 431 434 438 442   0
0   0 405 402 402 403 405 407 409 412 415 417 420 422 424 427 429 432 436 438   0
0   0 397 399 400 401 403 405 408 410 413 416 418 421 423 425 428 431 434 437   0
0   0 393 396 398 400 402 404 406 409 412 414 417 419 421 424 426 429 431 436   0
0   0 389 393 396 398 400 402 405 408 410 413 415 418 420 422 425 427 429 430   0
0   0 384 390 394 396 399 401 404 406 409 411 414 416 419 421 423 426 427 425   0
0   0 380 368 392 395 397 400 402 405 407 410 412 415 417 420 422 424 425 424   0
0   0 378 386 391 394 396 399 401 404 406 409 411 414 416 418 421 423 423 420   0
0   0 377 384 389 392 395 396 400 402 405 408 410 412 415 417 420 421 422 420   0
0   0 376 383 388 392 394 397 399 402 404 407 409 411 414 416 419 420 420 418   0
0   0 374 362 387 391 394 396 398 401 403 406 408 411 413 416 418 420 419 417   0
0   0 373 381 387 390 393 396 398 400 403 405 408 410 413 415 417 419 419 416   0
0   0 372 381 366 390 393 395 398 400 403 405 407 410 412 415 417 419 419 416   0
0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
1DRAWDOWN
       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
       0    0   10   14   16   17   19   18   18   16   14   13   14   13   14   12   12    8    0    0
       0    0    8   11   15   16   16   16   16   15   13   12   11   12   12   12   12    9    0    0
       0    0    6   10   12   11   12   14   14   13   13   11   10   12   12   12    9    7    0    0
       0    0    5    8    8   10   10   10   10   12   12   12   11   10   10    9    9    4    0    0
       0    0    3    6    6    8    7    9    8    8    7    8   11   10    8    8    7    3    0    0
       0    0    2    3    4    4    7    6    5    4    7    6    7   10    7    5    3    2    0    0
       0    0    2    1    2    1    3    3    4    3    3    5    5    6    5    6    4    1    0    0
       0    0   -1   -2    0    0    0   -1    0    3    1    4    2    2    5    5    4    2    0    0
       0    0   -2   -4   -5   -6   -6   -5   -3   -1    0   -1    0    1    1    4    3    3    0    0
       0    0   -3   -6   -7   -6   -7   -9   -7   -4   -2   -2   -1    0   -1   -2   -2   -2    0    0
       0    0   -4   -6   -7  -10  -10  -12  -13  -15   -6   -8   -5   -3   -5   -5   -6   -4    0    0
       0    0   -4   -7   -9  -10  -11  -13  -14  -14  -14  -11   -9   -6   -6   -6   -6   -3    0    0
       0    0   -5   -8  -10  -12  -13  -14  -16  -18  -18  -16  -18  -15  -12  -11  -10   -9    0    0
       0    0   -6  -10  -11  -12  -14  -15  -16  -18  -20  -16  -16  -14  -18  -19   -8   -8    0    0
       0    0   -5  -10  -13  -15  -16  -16  -18  -18  -19  -16  -16  -13  -18   -9   -8   -7    0    0
       0    0   -6  -11  -14  -16  -17  -17  -17  -17  -19  -17  -25  -32  -25   -9   -9   -8    0    0
       0    0   -6  -12  -15  -17  -20  -19  -17  -16  -19  -24  -29  -27  -25   -6   -6   -8    0    0
       0    0   -7  -12  -16  -18  -20  -22  -19  -20  -24  -22  -29  -28  -25   -8   -8   -8    0    0
       0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
0  CUMULATIVE MASS BALANCE -- (IN FT**3)

    RECHARGE                     = -1.14516E+07
    INJECTION                    = -6.47562E+06
    PUMPAGE                      =   .00000E+00
    CUMULATIVE  NET  PUMPAGE     = -1.79273E+07
    WATER RELEASE FROM STORAGE = -1.84920E+07
    LEAKAGE INTO AQUIFER         = -3.98594E+07
    LEAKAGE OUT OF AQUIFER       =  3.92922E+07
    CUMULATIVE  NET  LEAKAGE     = -5.67200E+05
1       MASS BALANCE RESIDUAL    =  2.50400E+03
        ERROR  (AS PERCENT)      =  6.37256E-03

0  RATE MASS BALANCE -- (IN C.F.S.)

    RECHARGE                     = -1.29600E-02
    LEAKAGE INTO AQUIFER         =  4.55013E-02
    LEAKAGE OUT OF AQUIFER       = -4.58935E-02
    NET LEAKAGE     (QNET)       = -3.92157E-04
    INJECTION                    =   .00000E+00
    PUMPAGE                      =   .00000E+00
    NET WITHDRAWAL    (TPUM)     = -1.29600E-02
1          STABILITY CRITERIA --- M.O.C.
```

```
1CONCENTRATION

 NUMBER OF TIME STEPS =      2

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0    2    4    7   13   74  394 1393 3561 5531 6603 5911 4148 2299 1032  358  135   52   18    0
0    0    3    4    7   12   62  497 1951 4717 6817 7712 6818 4169 2275  726  137   28   32   14    0
0    0    2    4    7   11   57  653 2460 5422 7458 8275 7707 5539 2237  516   51    8    9    4    0
0    0    2    4    7   15   63  877 2884 5584 7077 8898 7874 5465 1689  350   32    5    5    3    0
0    0    2    4    7   25   94 1237 3488 6050 8384 9176 8336 5564 1576  255   24    5    4    3    0
0    0    2    4    7   24  146 1604 4127 6441 8688 9350 8465 5459 1421  211   20    5    5    3    0
0    0    2    4    7   32  254 2316 4683 7052 8801 9303 8450 5221 1318  181   16    5    5    3    0
0    0    2    5    7   46  410 2762 5053 7168 8580 9102 8291 5001 1223  146   10    5    5    2    0
0    0    2    5    9   76  480 3010 5197 7043 8267 8735 7901 4915 1102  107    3    5    4    2    0
0    0    3    5   12   99  681 3100 5190 6734 7835 8233 7316 4642  945   68    0    6    6    2    0
0    0    3    5   16  131  800 2913 4848 6243 7189 7639 6712 4141  739   29   -3    6    6    2    0
0    0    3    6   21  157  777 2755 4429 5547 6462 6898 6020 3520  522   -5   -4    7    6    1    0
0    0    4    7   26  202  980 2461 3798 4786 5601 6136 5280 3009  315  -30   -3    8    6    2    0
0    0    6   10   43  232  873 2087 3147 4140 4718 5231 4516 2278  134  -43   -1    8    7    3    0
0    0    8   15   58  250  791 1695 2504 3161 3856 4096 3425 1720    4  -44    1    9    7    3    0
0    0   10   23   75  253  677 1311 1874 2331 2847 2994 2288  868  -78  -34    5    9    8    4    0
0    0   15   35   91  238  539  936 1294 1613 1891 1901 1273  361  -82  -15    8    9    8    4    0
0    0   19   38   77  165  322  302  683  864  921  804  469  111  -19    0    8    9    9    9    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =      2
        DELTA T        =  5.57600E+06
        TIME(SECONDS)  =  8.83613E+08
   CHEM.TIME(SECONDS)  =  8.83613E+08
   CHEM.TIME(DAYS)     =  1.02270E+04
        TIME(YEARS)    =  2.80000E+01
   CHEM.TIME(YEARS)    =  2.80000E+01
  NO. MOVES COMPLETED  =      1

0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
0    0   -7   -6   -2    3   63  383 1382 3551 5520 6592 5901 4137 2288 1022  347  125   42    8    0
0    0   -7   -6   -2    1   52  486 1940 4706 6807 7702 6807 4158 2265  715  127   17   22    3    0
0    0   -7   -6   -2    1   46  642 2450 5412 7448 8265 7696 5529 2226  506   40   -1    0   -6    0
0    0   -7   -6   -2    5   52  867 2874 5573 7067 8888 7863 5454 1679  340   21   -5   -4   -7    0
0    0   -7   -6   -2   14   84 1226 3478 6040 8374 9165 8326 5553 1565  244   14   -4   -5   -7    0
0    0   -7   -5   -3   14  136 1593 4117 6431 8678 9340 8455 5449 1411  200   10   -4   -5   -7    0
0    0   -7   -5   -3   22  244 2306 4673 7041 8790 9293 8439 5210 1308  170    5   -4   -5   -7    0
0    0   -7   -5   -2   35  400 2752 5043 7157 8569 9091 8281 4990 1213  135    0   -4   -4   -7    0
0    0   -7   -5   -1   60  470 3000 5186 7033 8256 8725 7891 4905 1092   97   -6   -4   -5   -8    0
0    0   -7   -5    2   88  671 3090 5180 6724 7825 8222 7305 4632  934   58  -10   -4   -4   -8    0
0    0   -6   -4    5  120  789 2903 4838 6233 7179 7629 6701 4131  729   18  -13   -3   -4   -8    0
0    0   -6   -4   11  146  767 2745 4418 5537 6451 6888 6010 3510  511  -16  -14   -3   -4   -8    0
0    0   -5   -2   15  191  970 2451 3787 4776 5591 6126 5270 2998  304  -40  -13   -2   -3   -8    0
0    0   -3    0   33  221  862 2076 3137 4130 4707 5220 4505 2268  124  -54  -11   -1   -2   -7    0
0    0   -1    4   48  240  781 1665 2494 3150 3845 4086 3415 1710   -6  -55   -8   -1   -2   -6    0
0    0    0   13   65  243  666 1300 1663 2320 2836 2983 2278  857  -89  -44   -5    0   -2   -6    0
0    0    5   24   81  228  529  926 1283 1602 1880 1890 1263  351  -92  -26   -2    0   -1   -5    0
0    0    9   27   66  155  311  491  673  853  911  794  459  101  -30  -10   -1    0    0    0    0
0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
 CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES      =    .00000E+00
        MASS OUT BOUNDARIES     = -2.22285E+08
        MASS PUMPED IN          =  3.66945E+11
        MASS PUMPED OUT         =    .00000E+00
        INFLOW MINUS OUTFLOW    =  3.66723E+11
        INITIAL MASS STORED     =  2.07360E+09
        PRESENT MASS STORED     =  3.94780E+11
        CHANGE MASS STORED      =  3.92706E+11
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL   = -2.59831E+10
        ERROR  (AS PERCENT)     = -7.08091E+00
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)     = -7.12550E+00
1SOLUTE TRANSPORT REMEDIATION
```

STANLEY SHALE FORMATION

SOURCES REMEDIATION
5 RECOVERY WELLS
PUMPED 10 YEARS

```
1     START PUMPING PERIOD NO.  2

  THE FOLLOWING TIME STEP, PUMPAGE, AND PRINT PARAMETERS HAVE BEEN REDEFINED:

0             NTIM   =    5
              NPNT   =    5
              NITP   =    4
              ITMAX  =   10
              NREC   =   45
              NPNTMV =    0
              NPNTVL =    0
              NPNTD  =    0
              NPDELC =    1
              NPNCHV =    0
              PINT   =     10.000
              TIMX   =      1.000
              TINIT  = **********

1TIME INTERVALS (IN SECONDS)
      .31000E+09  .31000E+09  .31000E+09  .31000E+09  .31000E+09  .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
      .00000      .00000      .00000      .00000      .00000      .00000     .00000     .00000     .00000     .00000
```

```
0            LOCATION  OF  PUMPING  WELLS

              X    Y   RATE(IN CFS)    CONC.

             11    2    .000E+00        .00
             12    3    .000E+00        .00
             13    4    .000E+00        .00
             13    5    .000E+00        .00
             11    5    .000E+00        .00
              9    7    .000E+00        .00
              9    8    .000E+00        .00
              9    9    .000E+00        .00
             10    7    .000E+00        .00
             10    8    .000E+00        .00
             10    9    .000E+00        .00
             10   10    .000E+00        .00
             11    6    .000E+00        .00
             11    7    .000E+00        .00
             11    8    .000E+00        .00
             11    9    .000E+00        .00
             12    7    .000E+00        .00
             12    8    .000E+00        .00
             11   10    .000E+00        .00
             11   11    .000E+00        .00
             12    9    .000E+00        .00
             12   10    .000E+00        .00
             12   11    .000E+00        .00
             13    9    .000E+00        .00
             13   10    .000E+00        .00
             13   11    .000E+00        .00
             11    3    .000E+00        .00
             10    6    .000E+00        .00
             12    6    .000E+00        .00
              8    8    .000E+00        .00
             13    8    .000E+00        .00
              8    7    .000E+00        .00
              8    9    .000E+00        .00
              9   10    .000E+00        .00
             13    8    .000E+00        .00
             12   12    .000E+00        .00
             10    2    .000E+00        .00
             10    3    .000E+00        .00
             12    4    .000E+00        .00
              8   11    .450E-02        .00
             10   13    .450E-02        .00
             11    4    .450E-02        .00
             13   13    .450E-02        .00
             13    6    .450E-02        .00
             12    4    .000E+00        .00
0
```

```
1HEAD DISTRIBUTION - ROW
 NUMBER OF TIME STEPS =       2
        TIME(SECONDS) =  8.83613E+08
        TIME(DAYS)    =  1.02270E+04
        TIME(YEARS)   =  2.80000E+01

0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
0   0 422 413 409 409 409 411 413 415 417 418 421 424 427 430 434 438 444 455   0
0   0 420 412 409 408 409 411 413 415 417 417 421 423 427 430 434 438 444 453   0
0   0 418 411 408 408 408 410 412 414 416 415 420 422 426 430 433 437 443 452   0
0   0 414 409 407 407 408 409 411 414 415 416 420 421 425 429 432 436 441 450   0
0   0 410 407 465 406 407 408 410 413 415 416 419 419 424 428 431 435 440 445   0
0   0 407 404 404 404 405 407 409 411 414 416 418 419 423 427 430 434 438 442   0
0   0 465 402 402 403 404 406 407 410 412 415 417 419 422 426 429 432 436 438   0
0   0 397 399 400 401 403 404 405 408 411 413 416 418 421 424 427 430 433 437   0
0   0 393 396 398 399 401 403 403 407 409 412 415 416 420 423 426 429 431 436   0
0   0 389 393 396 398 400 401 400 405 407 411 413 415 418 422 425 427 429 430   0
0   0 384 390 394 396 398 400 400 404 405 409 412 412 417 420 423 425 427 425   0
0   0 380 388 392 395 397 399 400 402 402 408 410 410 416 419 422 424 425 424   0
0   0 378 386 390 393 396 398 399 401 402 407 409 410 414 418 420 422 423 420   0
0   0 377 384 389 392 395 397 398 401 402 406 408 410 413 417 419 421 421 420   0
0   0 376 383 388 391 394 396 398 400 402 405 407 409 413 416 418 420 420 418   0
0   0 374 382 387 391 393 395 397 399 402 404 407 409 412 415 418 419 419 417   0
0   0 373 381 386 390 393 395 397 399 401 404 406 409 412 415 417 419 419 416   0
0   0 372 381 386 390 392 395 397 399 401 404 406 408 411 414 417 419 418 416   0
0   0   0   0   6   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
1DRAWDOWN
         0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
         0     0    10    14    16    18    19    19    19    18    18    16    16    15    15    12    12     8     0     0
         0     0     6    11    15    16    16    17    17    17    18    15    14    13    13    12    12     9     0     0
         0     0     6    10    12    12    13    15    16    16    19    15    14    14    12    12     9     7     0     0
         0     0     5     8     8    10    11    11    11    15    16    15    15    12    11    10     9     5     0     0
         0     0     3     7     6     8     8    10     9    10    11    11    16    12     9     9     7     3     0     0
         0     0     3     3     4     5     8     7     7     6     9     9    11    12     8     6     3     2     0     0
         0     0     2     1     2     2     4     5     6     6     5     8     8     8     6     6     4     1     0     0
         0     0    -1    -2     0     0     1     1     2     5     4     6     5     4     6     6     5     3     0     0
         0     0    -2    -4    -4    -5    -5    -2    -1     1     1     0     3     2     2     4     3     3     0     0
         0     0    -3    -6    -7    -6    -6    -4    -4    -1     0     0     1     1    -1    -2    -2    -2     0     0
         0     0    -4    -6    -7    -9    -9    -8   -11   -11    -4    -6    -1    -1    -4    -5    -5    -4     0     0
         0     0    -4    -7    -9   -10   -10   -11   -11    -9   -12    -9    -4    -5    -5    -6    -6    -3     0     0
         0     0    -5    -7    -9   -12   -12   -12   -13   -14   -16   -14   -14   -13   -12   -10    -9    -9     0     0
         0     0    -6   -10   -11   -12   -13   -13   -15   -15   -18   -14   -14   -12   -18   -18    -8    -7     0     0
         0     0    -5   -10   -12   -15   -15   -15   -16   -16   -17   -14   -14   -12   -18    -8    -8    -7     0     0
         0     0    -6   -11   -14   -15   -16   -16   -15   -16   -17   -16   -23   -31   -24    -9    -8    -8     0     0
         0     0    -6   -11   -15   -17   -19   -18   -16   -16   -18   -22   -28   -26   -25    -8    -8    -8     0     0
         0     0    -7   -12   -16   -17   -20   -21   -18   -18   -23   -21   -27   -27   -24    -8    -8    -7     0     0
         0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
```

```
9  CUMULATIVE MASS BALANCE -- (IN FT**3)

     RECHARGE                    = -1.14516E+07
     INJECTION                   = -6.47562E+06
     PUMPAGE                     =  7.10046E+06
     CUMULATIVE  NET  PUMPAGE    = -1.08268E+07
     WATER RELEASE FROM STORAGE  = -1.14811E+07
     LEAKAGE INTO AQUIFER        = -3.98979E+07
     LEAKAGE OUT OF AQUIFER      =  3.92412E+07
     CUMULATIVE  NET  LEAKAGE    = -6.56672E+05
)        MASS BALANCE RESIDUAL   =  2.38400E+03
         ERROR  (AS PERCENT)     =  5.14427E-03

0  RATE MASS BALANCE -- (IN C.F.S.)

     RECHARGE                    = -1.29600E-02
     LEAKAGE INTO AQUIFER        =  4.56253E-02
     LEAKAGE OUT OF AQUIFER      = -4.57287E-02
     NET LEAKAGE     (QNET)      = -1.03453E-04
     INJECTION                   =   .00000E+00
     PUMPAGE                     =  2.25000E-02
     NET WITHDRAWAL    (TPUM)    =  9.53997E-03
1           STABILITY CRITERIA --- M.O.C.
```

```
1CONCENTRATION

 NUMBER OF TIME STEPS =      2

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    2    4    7   12   58  332 1209 3790 5923 7459 6590 4414 2641 1305  488  181   68   23    0
    0    0    3    4    7   10   50  434 1833 5059 7132 7744 7209 4191 2358  985  239   51   42   16    0
    0    0    2    4    7   10   51  600 2397 5136 7587 7921 8193 3816 2300  849  138   20   11    4    0
    0    0    2    4    7   13   69  795 2912 5437 8022 8277 8272 3566 2274  748   81   11    5    3    0
    0    0    3    4    7   23  106 1008 3297 5907 8037 9584 8248 3146 2575  661   65    4    4    3    0
    0    0    2    4    7   39  175 1364 4061 6361 8417 9647 8844 5487 2633  512   33    2    4    3    0
    0    0    2    5    7   46  245 1751 4757 6861 8819 9512 8834 4971 2362  366   17    3    5    3    0
    0    0    2    5    8   55  316 2242 5306 7012 8670 9260 8504 4739 1942  271   10    4    5    2    0
    0    0    2    5    9   73  428 2168 5448 6802 8562 8886 8072 4734 1694  217    5    5    5    2    0
    0    0    3    5   12   92  541 2256 5712 6399 8418 8355 7345 4076 1526  171    1    5    5    2    0
    0    0    3    5   16  115  620 2123 4784 5761 8387 7734 6804 3936 1337  118   -4    6    6    2    0
    0    0    4    6   21  129  669 2083 4156 5285 8356 6781 6235 3654 1094   49   -9    6    6    1    0
    0    0    4    8   24  168  694 1880 3510 4285 5401 5675 5428 2802  727  -17  -10    7    6    2    0
    0    0    6   10   37  190  699 1717 2921 3506 4050 4660 4358 1363  318  -54   -6    8    7    3    0
    0    0    8   14   50  209  657 1448 2274 2733 3177 3675 3077  851  105  -51    0    9    7    3    0
    0    0   10   21   65  217  560 1146 1672 2027 2349 2630 1952  399   -1  -35    4    9    8    4    0
    0    0   14   31   81  208  472  822 1105 1306 1484 1524 1007  140  -22  -15    7   10    8    4    0
    0    0   18   35   69  146  262  429  505  543  638  598  341   72    4    2    8    9    9    9    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
1CHANGE IN CONCENTRATION

 NUMBER OF TIME STEPS =      2
        DELTA T       =  5.57600E+06
        TIME(SECONDS) =  8.83613E+08
   CHEM.TIME(SECONDS) =  8.83613E+08
   CHEM.TIME(DAYS)    =  1.02270E+04
        TIME(YEARS)   =  2.80000E-01
   CHEM.TIME(YEARS)   =  2.80000E+01
  NO. MOVES COMPLETED =      1

    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0   -7   -6   -2    1   48  321 1199 3780 5912 7448 6579 4403 2630 1295  477  171   58   12    0
    0    0   -7   -6   -2    0   39  424 1823 5049 7122 7734 7199 4180 2347  974  229   41   31    6    0
    0    0   -7   -6   -2    0   41  589 2386 5125 7577 7911 8183 3805 2290  838  128   10    0   -6    0
    0    0   -7   -6   -2    3   58  784 2901 5426 8011 8267 8261 3555 2264  737   70    0   -5   -7    0
    0    0   -7   -5   -2   12   95  997 3286 5896 8027 9573 8237 3135 2565  651   55   -6   -6   -7    0
    0    0   -7   -5   -2   28  164 1353 4050 6351 8406 9636 8834 5477 2623  502   23   -8   -5   -7    0
    0    0   -7   -5   -2   35  235 1740 4746 6850 8809 9501 8824 4960 2352  355    7   -7   -5   -7    0
    0    0   -7   -5   -2   44  306 2231 5296 7001 8660 9250 8494 4728 1932  261    0   -5   -5   -7    0
    0    0   -7   -5    0   62  418 2158 5438 6791 8551 8875 8062 4724 1684  207   -4   -5   -5   -8    0
    0    0   -7   -5    1   81  530 2245 5702 6389 8408 8344 7335 4066 1515  161   -9   -4   -4   -8    0
    0    0   -6   -4    5  104  609 2112 4773 5751 8376 7724 6794 3926 1326  107  -14   -4   -4   -8    0
    0    0   -6   -3   10  118  638 2072 4145 5275 8345 6771 6224 3643 1084   39  -19   -3   -4   -8    0
    0    0   -5   -2   13  157  664 1869 3500 4274 5391 5665 5417 2792  717  -28  -20   -2   -3   -8    0
    0    0   -3    0   27  180  688 1706 2910 3495 4039 4649 4347 1352  307  -65  -16   -2   -2   -7    0
    0    0   -1    3   40  199  647 1438 2264 2722 3167 3664 3066  840   94  -61  -11   -1   -2   -6    0
    0    0    0   10   55  206  569 1136 1661 2017 2339 2619 1942  389  -11  -46   -6    0   -2   -6    0
    0    0    4   21   70  198  461  812 1094 1295 1473 1513  997  130  -32  -26   -2    0   -1   -5    0
    0    0    7   24   58  135  271  419  494  532  628  588  330   61   -5   -8   -1    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
CHEMICAL MASS BALANCE

        MASS IN BOUNDARIES      =    .00000E+00
        MASS OUT BOUNDARIES     = -2.21471E+08
        MASS PUMPED IN          =  3.66945E+11
        MASS PUMPED OUT         = -4.28965E+10
        INFLOW MINUS OUTFLOW    =  3.23825E+11
        INITIAL MASS STORED     =  2.07360E+09
        PRESENT MASS STORED     =  3.89444E+11
        CHANGE MASS STORED      =  3.87371E+11
      COMPARE RESIDUAL WITH NET FLUX AND MASS ACCUMULATION:
        MASS BALANCE RESIDUAL   = -6.35451E+10
        ERROR  (AS PERCENT)     = -1.73173E+01
      COMPARE INITIAL MASS STORED WITH CHANGE IN MASS STORED:
        ERROR  (AS PERCENT)     = -1.97497E+01
1SOLUTE TRANSPORT REMEDIATION
```

Umetco Minerals Corporation

ROUTE 6, BOX 943 • HOT SPRINGS, ARKANSAS 71901

JUN 10 1989

June 9, 1989

Dr. Jerry V. Overton
928 Airport Road
Hot Springs, AR 71914

Dear Jerry:

This letter is authorization to utilize the data generated by Umetco Minerals Corporation during the groundwater investigation at Hot Springs, Arkansas for your thesis work. Umetco Minerals does not assume responsibility and or necessarily support the interpretations made from the data.

The confidentiality of the data requires the restriction as to check-out, reproduction, and inter-library loans as outlined in your letter dated July 20, 1988. These restrictions will apply until released by Umetco Minerals in writing.

Very truly yours,

Evans

R. R. Evans

cdr

2

VITA

DR. JERRY V. OVERTON

Candidate for the Degree of

Master of Science

Thesis: A SYSTEMATIC APPROACH TO THE SITE CHARACTERIZATION AND REMEDIAL DESIGN OF CONTAMINATED GROUND WATER PROJECTS

Major Field: Geology

Biographical:

Personal Data: Born August 19, 1947, Fort Worth, Texas, the son of Leon and Eula Overton.

Education:

Ph.D. University of Oklahoma, 1980, Geography, Area of **Dissertation Title:** "Rural Water Districts: Their Impact on Rural Land Use Change in Oklahoma".

M.S. Oklahoma State University, 1971, Geography.

B.S. Oklahoma State University, 1970, Physical Geography.

Professional Experience:

Private Business:

Project Hydrogeologist, B & F Engineering, Hot Springs Arkansas. June 1987 - Present.

Hydrogeologist, MDK Consultants Inc., Stillwater, Oklahoma. May 1985 - June 1987.

Teaching:

Assistant Professor, Department of Geography, University of Central Arkansas, 1979 - 1984.

Assistant Professor, Department of Social Sciences, Cameron University, 1972 - 1979.

Special Instructor, Department of Geography, University of Oklahoma, Summer 1974.

Instructor, Department of Earth Sciences, Ft. Hays Kansas State College, 1971 - 1972.