FORM NRC-2
(7-77)
10 CFR 40

Approved by GAO
R0203

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR SOURCE MATERIAL LICENSE

Pursuant to the regulations in Title 10, Code of Federal Regulations, Chapter 1, Part 40, application is hereby made for a license to receive, possess, use, transfer, deliver or import into the United States, source material for the activity or activities described.

1. *(Check one)*
   - [X] *(a)* New license
   - [ ] *(b)* Amendment to License No. _____
   - [ ] *(c)* Renewal of License No. _____
   - [ ] *(d)* Previous License No. _____

2. NAME OF APPLICANT
   Arizona Public Service Company

3. PRINCIPAL BUSINESS ADDRESS
   411 Central Avenue
   Phoenix, AZ 85004

4. STATE THE ADDRESS(ES) AT WHICH SOURCE MATERIAL WILL BE POSSESSED OR USED
   Peterson In Situ Extraction Research and Development Site (see Section 2.0 of attached License Application Report)

5. NAME OF PERSON TO BE CONTACTED CONCERNING THIS APPLICATION
   Mr. Bob Ward, Manager Safety and Environmental Affairs, Nuclear Assurance Corporation

6. TELEPHONE NO. OF INDIVIDUAL NAMED IN ITEM 5
   (303) 741-0447

7. DESCRIBE PURPOSE FOR WHICH SOURCE MATERIAL WILL BE USED
   Source material will be derived from Research and Development (R&D) in situ testing procedures employed to evaluate the feasibility of the in situ extraction process. Material produced will be transferred to an existing nearby uranium mill for standardized processing.

8. STATE THE TYPE OR TYPES, CHEMICAL FORM OR FORMS, AND QUANTITIES OF SOURCE MATERIAL YOU PROPOSE TO RECEIVE, POSSESS, USE, OR TRANSFER UNDER THE LICENSE

(a) TYPE	*(b)* CHEMICAL FORM	*(c)* PHYSICAL FORM *(Including % U or Th.)*	*(d)* MAXIMUM AMOUNT AT ANY ONE TIME *(kilograms)*
NATURAL URANIUM	Uranyl Peroxide $UO_4 \cdot 2H_2O$; and Ammonium Diurante	Slurry 50% Solids by Weight	4,536 kilograms
URANIUM DEPLETED IN THE U-235 ISOTOPE			
THORIUM (ISOTOPE)			

(e) MAXIMUM TOTAL QUANTITY OF SOURCE MATERIAL YOU WILL HAVE ON HAND AT ANY TIME *(kilograms)*
4,536 kilograms

9. DESCRIBE THE CHEMICAL, PHYSICAL, METALLURGICAL, OR NUCLEAR PROCESS OR PROCESSES IN WHICH THE SOURCE MATERIAL WILL BE USED, INDICATING THE MAXIMUM AMOUNT OF SOURCE MATERIAL INVOLVED IN EACH PROCESS AT ANY ONE TIME, AND PROVIDING A THOROUGH EVALUATION OF THE POTENTIAL RADIATION HAZARDS ASSOCIATED WITH EACH STEP OF THOSE PROCESSES
   Alkaline Leach with oxidant to be used in in situ pilot scale testing to recover uranium from the underground mineralized zone. Due to low uranium concentration in the raw material, there should be insignificant external radiation exposure hazard associated with the processes (see sections 3.0, 4.0 and 5.0 of attached License Application Report)

10. LIST THE NAMES AND ATTACH A RESUME OF THE TECHNICAL QUALIFICATIONS INCLUDING TRAINING AND EXPERIENCE OF APPLICANT'S SUPERVISORY PERSONNEL AND THE PERSON RESPONSIBLE FOR THE RADIATION SAFETY PROGRAM (OR OF APPLICANT IF AN INDIVIDUAL)
    See section 3.0 of attached License Application Report

11. DESCRIBE THE EQUIPMENT AND FACILITIES WHICH WILL BE USED TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE OR PROPERTY AND RELATE THE USE OF THE EQUIPMENT AND FACILITIES TO THE OPERATIONS LISTED IN ITEM 9. INCLUDE: *(a)* RADIATION DETECTION AND RELATED INSTRUMENTS (including film badges, dosimeters, counters, air sampling, and other survey equipment as appropriate. The description of radiation detection instruments should include the instrument characteristics such as type of radiation detected, window thickness, and the range(s) of each instrument).
    See section 6.0 of attached License Application Report

    (b) METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED IN *(a)* ABOVE, INCLUDING AIR SAMPLING EQUIPMENT (for film badges, specify method of calibrating and processing, or name supplier).
    See section 6.0 of attached License Application Report

16655

8007220073

11(c). VENTILATION EQUIPMENT WHICH WILL BE USED IN OPERATIONS WHICH PRODUCE DUST, FUMES, MISTS, OR GASES, INCLUDING PLAN VIEW SHOWING TYPE AND LOCATION OF HOOD AND FILTERS, MINIMUM VELOCITIES MAINTAINED AT HOOD OPENINGS AND PROCEDURES FOR TESTING SUCH EQUIPMENT

No dry recovered substances will be involved (see section 3.0 of attached License Application Report).

12. DESCRIBE PROPOSED PROCEDURES TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE AND PROPERTY AND RELATE THESE PROCEDURES TO THE OPERATIONS LISTED IN ITEM 9. INCLUDE: (a) SAFETY FEATURES AND PROCEDURES TO AVOID NONNUCLEAR ACCIDENTS, SUCH AS FIRE, EXPLOSION, ETC., IN SOURCE MATERIAL STORAGE AND PROCESSING AREAS.

See section 6.0 of attached License Application Report

(b) EMERGENCY PROCEDURES IN THE EVENT OF ACCIDENTS WHICH MIGHT INVOLVE SOURCE MATERIAL.

See section 6.0 of attached License Application Report

(c) DETAILED DESCRIPTION OF RADIATION SURVEY PROGRAM AND PROCEDURES.

See sections 4.0 5.0, and 6.0 of attached License Application Report

13. WASTE PRODUCTS: *If none will be generated, state "None" opposite (a), below. If waste products will be generated, check here* ☒ *and explain on a supplemental sheet:*

(*a*) Quantity and type of radioactive waste that will be generated.
(*b*) Detailed procedures for waste disposal.

See sections 3.0 and 4.0 of attached License Application Report

14. IF PRODUCTS FOR DISTRIBUTION TO THE GENERAL PUBLIC UNDER AN EXEMPTION CONTAINED IN 10 CFR 40 ARE TO BE MANUFACTURED, USE A SUPPLEMENTAL SHEET TO FURNISH A DETAILED DESCRIPTION OF THE PRODUCT, INCLUDING:

(*a*) PERCENT SOURCE MATERIAL IN THE PRODUCT AND ITS LOCATION IN THE PRODUCT.
(*b*) PHYSICAL DESCRIPTION OF THE PRODUCT INCLUDING CHARACTERISTICS, IF ANY, THAT WILL PREVENT INHALATION OR INGESTION OF SOURCE MATERIAL THAT MIGHT BE SEPARATED FROM THE PRODUCT.
(*c*) BETA AND BETA PLUS GAMMA RADIATION LEVELS (*Specify instrument used, date of calibration and calibration technique used*) AT THE SURFACE OF THE PRODUCT AND AT 12 INCHES.
(*d*) METHOD OF ASSURING THAT SOURCE MATERIAL CANNOT BE DISASSOCIATED FROM THE MANUFACTURED PRODUCT.

CERTIFICATE

(*This item must be completed by applicant*)

15. *The applicant, and any official executing this certificate on behalf of the applicant named in Item 2, certify that this application is prepared in conformity with Title 10, Code of Federal Regulations, Part 40, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.*

BY: Myron K. Beck
(*Signature*)

Dated June 5, 1980

Myron K. Beck
(*Print or type name*)

Manager, Uranium & Coal Development
(*Title of certifying official authorized to act on behalf of the applicant*)

WARNING: 18 U.S.C. Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

SUPPORTIVE INFORMATION
FOR
APPLICATION
FOR
SOURCE MATERIAL LICENSE

PETERSON IN SITU URANIUM EXTRACTION PROJECT
Converse County, Wyoming

By
Arizona Public Service Company
June, 1980

16655

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

Figures

LIST OF TABLES

Tables

1.0 PROPOSED ACTIVITIES

1.0 PROPOSED ACTIVITIES

1.1 INTRODUCTION

Arizona Public Service Company (APS) proposes to evaluate the technical, economic and environmental factors involved with in situ extraction of uranium at an area generally known as the Peterson Project, Converse County, Wyoming. Nuclear Assurance Corporation (NAC) will act as operator of the project for APS. The proposed Research and Development (R&D) Site is located in the SE¼ SW¼ Sec. 26 and NE¼ NW¼ Sec. 35, T34N, R73W in the southern Powder River Basin.

From September, 1979, until the present time, APS-NAC have performed hydrological field tests, metallurgical analyses, and process engineering design studies to assess the feasibility of in situ testing at the proposed R&D Site. From the information derived, APS-NAC desire to further evaluate in situ extraction techniques.

1.2 PROJECT OBJECTIVES

The test will evaluate the feasibility of in situ extraction of uranium ore from beneath the R&D Site, and develop reclamation techniques applicable to a commercial operation. These goals will be achieved by:

(1) Developing a wellfield pattern(s) that will allow efficient and economical recovery of uranium, but will minimize the chance of lixiviant excursion away from the mineralization.

(2) Identifying leach solution chemicals and oxidizers that are amenable to in situ leaching, processing and ground water restoration.

(3) Identifying the volumes and compositions of process effluent and restoration waste products.

(4) Determining sound procedures to dispose of these wastes for commercial operations.

1.3 GENERALIZED DESCRIPTION OF IN SITU EXTRACTION PROCESS

APS-NAC propose to perform an R&D test during which uranium will be leached from a limited volume of subsurface ore-bearing sandstone from multiple wells located in up to four wellfield patterns within a one acre (0.4 hectare) area. A uranium extraction facility having a maximum circulation capacity of 100 gpm (gallons per minute (6.3 liters/second)(lps)), or less, will process uranium enriched solution pumped from the wells. Small solar evaporation ponds will be used to contain process wastes. It is estimated that the test will be completed within one year.

The leaching process is accomplished by injecting an oxidant-charged leach solution (lixiviant) through wells to the mineralized zone. The natural uranium precipitation process that deposited the uranium in the host sandstone is reversed when the lixiviant contacts the uranium. The metal becomes soluble and mobile, and the resulting uranium enriched liquor is pumped from recovery wells to a surface processing plant where the uranium is extracted by conventional uranium recovery techniques. After being rejuvenated, the lixiviant is recycled to the mineralized zone to dissolve additional uranium.

After the ore zone is depleted of recoverable uranium, restoration techniques will be initiated to restore the baseline ground water quality. Reagents and mobilized ionic species remaining in the leach zone will be removed from the ground water, and the water quality will be restored to a level consistent with the potential uses for which the ground water was suitable prior to testing. The baseline ground water quality for the potentially affected aquifers at the R&D Site has been established and is described herein.

1.4 PROJECT SCHEDULE

The proposed construction of the R&D facilities is scheduled to begin during August, 1980. It is the desire of APS-NAC to complete the major construction before severe winter weather. The R&D test is scheduled to start during March, 1981, or when spring weather permits. The leaching tests will be performed over a three to four month period with aquifer restoration encompassing approximately the subsequent eight to nine months. The R&D test is scheduled to be completed within one year from the start of leaching.

1.5 REGULATORY COMPLIANCE

The test will conform with the requirements of the U.S. Nuclear Regulatory Commission (NRC), Wyoming Department of Environmental Quality (WDEQ), Wyoming State Engineer and U.S. Environmental Protection Agency (EPA). A complete list of agencies contacted for permits and approvals is provided in Section 4.6 of this report.

1.6 CONTRIBUTORS TO APPLICATION REPORT

Arizona Public Service Company acts as project manager for the R&D in situ uranium extraction project. As project manager, APS determines policy, makes decisions and sets goals for project performance. As operator of the project, Nuclear Assurance Corporation is responsible for project implementation through the day to day management of project developmental activities and the acquisition and interpretation of technical information. In addition, NAC provides recommendations to APS on the scope and feasibility of the proposed program.

NAC assumed the primary role in the acquisition of technical information required for this application and in assembling the application report. The work was accomplished by both NAC staff and subcontractors to NAC. International Environmental Consultants (IEC), Golden, Colorado, performed the studies on topography, soils, ecology, meteorology, and radiology. Envirosphere Company, Golden, Colorado, had primary responsibility for the hydrology studies, and were supported by NAC with their work. Ortloff Minerals Services Corporation, Golden, Colorado, performed process engineering design studies, and Hazen Research, Inc., Golden, Colorado, conducted geochemistry/metallurgical studies. In addition to the work performed by these subcontractors, NAC compiled the sections on adjudication file, land use, archaeology, geology, operational plan and reclamation.

2.0 THE SITE

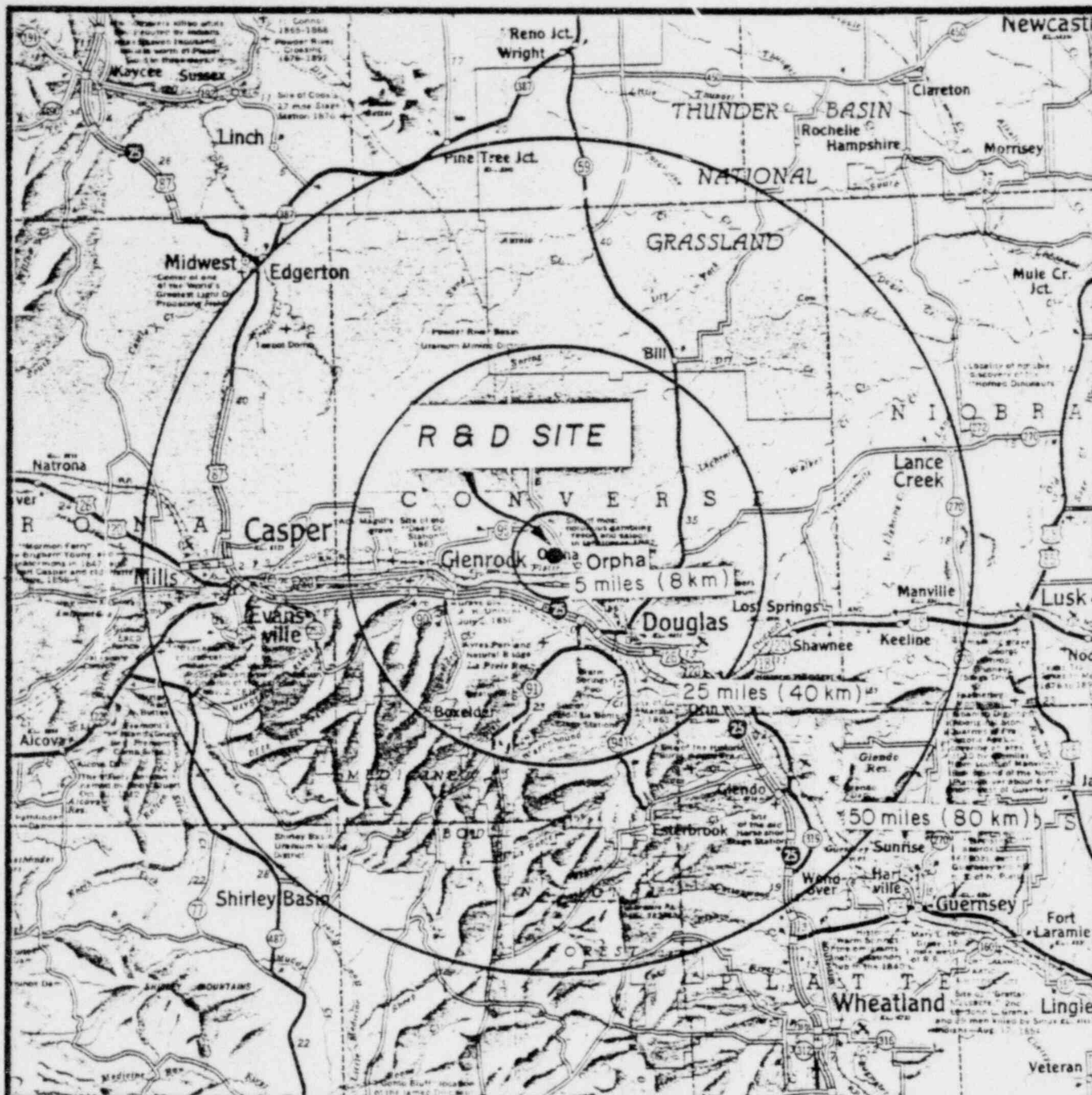
2.0 THE SITE

2.1 SITE LOCATION AND LAYOUT

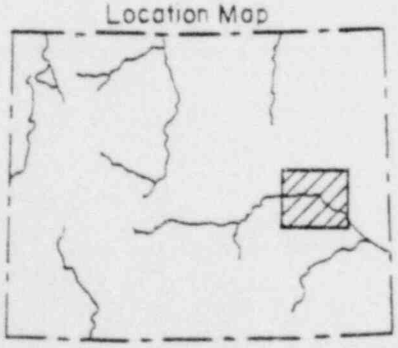
Arizona Public Service Company controls the uranium mineral rights underlying privately and state owned surface lands within the North Platte River drainage in the southern Powder River Basin, Converse County, Wyoming. The area for which APS controls the uranium mineral rights is commonly referred to as the Peterson Project. The proposed R&D Site lies within the overall Project and is located about midway between Douglas and Glenrock, Wyoming, approximately 16 road miles (26 kilometers (km)) from each town (Figure 2.1). Orpha, an unincorporated community, is located approximately four miles (6 km) east-southeast of the Test Site. The R&D Site is generally located within SE¼ SW¼ Sec. 26 and NE¼ NW¼ Sec. 35, T34N, R73W (Figures 2.2 and 2.3).

The R&D Site encompasses approximately 41.3 acres (17 hectares) within the Peterson Project. Within this area only about 4.5 acres (1.8 hectares) will be subject to intense activity. Of this disturbed area the wellfield area will include 1.4 acres (0.56 hectares), solar evaporation ponds 1.3 acres (0.52 hectares), process plant and office area 1.2 acres (0.48 hectares), and topsoil stockpile area 0.6 acre (0.24 hectare). In addition, the existing access road connecting County Highway 27 with the Test Site must be improved. Land disturbances related to road improvements will involve approximately 9 acres (3.6 hectares).

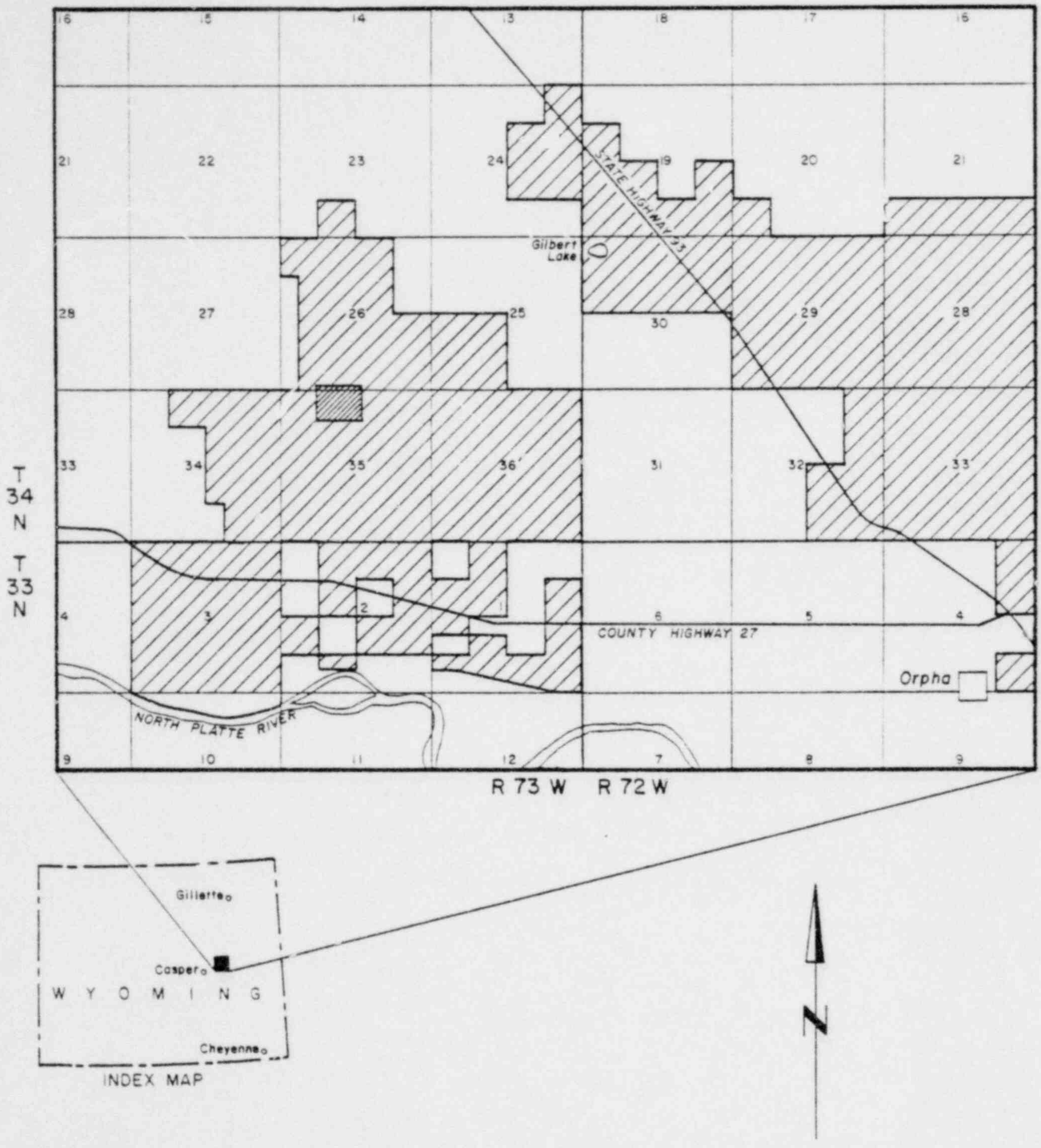
Arizona Public Service Company controls all of the uranium mineral rights immediately adjacent to the Test Site. The surface land use rights are leased by APS, however, the surface lands on and immediately adjacent to the Test Site are owned by Hildebrand, Inc., Douglas, Wyoming. Oil and gas leases within the site boundary are owned by Coquina Oil Corporation, Diamond Shamrock Corporation-Getty Oil Company-Chorney Oil Company, and Jerry Chambers Oil Producer. Additional legal estates of record within one half mile (0.8 km) of the Test Site boundary include two surface land owners, one surface lessee, two uranium mineral owners, one uranium mineral lessee, four



Taken from the Wyoming Highway Commission Map 1979



ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	REGIONAL SITE LOCATION & ACCESS	
	PREPARED BY: B. Ward	DATE: Feb. 15, 1980
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED:	DATE:
	DRAWN BY: J.E.G. 3-12-80	
	SCALE: (Approx.) 1" = 18.5 miles	FIGURE NO. 2.1
	CONTOUR INTERVAL: N/A	

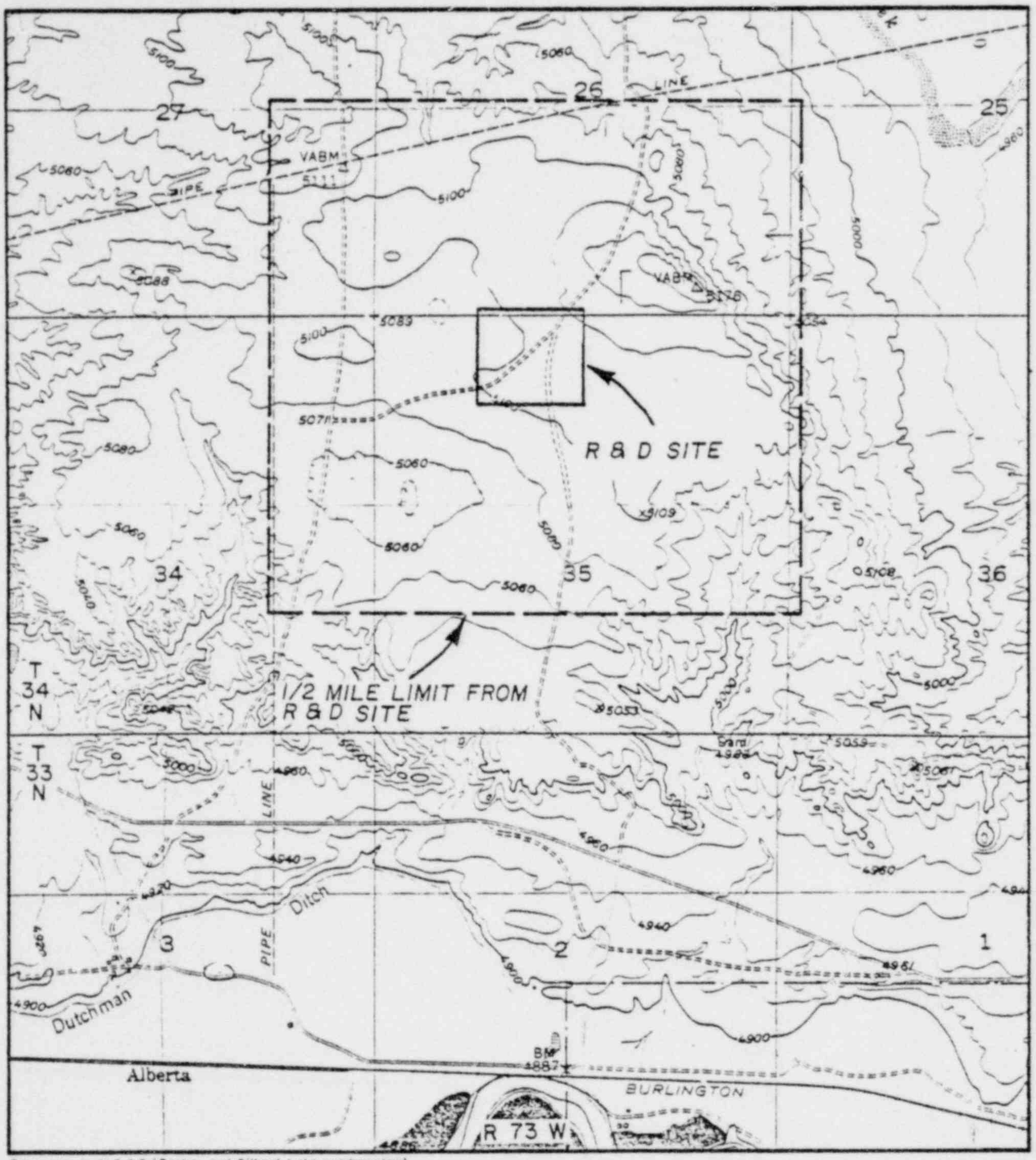


LEGEND

R & D Site

Peterson Project

ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	LOCAL SITE LOCATION	
	PREPARED BY: B.W.	DATE: Feb. 15, 1980
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED:	
	DRAWN BY: A.M. (2-20-80)	
	SCALE: 1" = 1 mile	FIGURE No.
	CONTOUR INTERVAL: N/A	2.2



Base map by U.S.G.S. (Orpha and Gilbert Lake quadrangles)

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

NUCLEAR ASSURANCE CORPORATION
GRAND JUNCTION, COLORADO

R & D SITE

PREPARED BY: B.W.	DATE: Feb. 15, 1980
REVISED:	
DRAWN BY: A.M. (2-21-80)	
SCALE: 1" = 2000'	FIGURE No. 2.3
CONTOUR INTERVAL: 20'	

oil and gas lessees, one coal lessee and two pipeline easements. All owners of legal estates of record within one-half mile (0.8 km) of the Test Site boundary have been informed of the proposed R&D test.

Access to the vicinity of the site is provided by Interstate 25, a major north-south highway across Wyoming. The R&D Site may be reached by leaving Interstate 25 at either Douglas or Glenrock, Wyoming. From Douglas, State Highway 93 may be traveled northwesterly to its junction with County Highway 27 near Orpha. From this point, approximately 5 miles (8 km) of gravel and sand surfaced roads lead to the Test Site. From Glenrock, County Highway 27 may be directly traveled to the R&D Site.

2.2 LAND USE

The lands contained within the R&D Site have historically been used for cattle and sheep grazing. In addition to cattle grazing, the land currently is being used by APS for uranium exploration. If results of the R&D test are favorable, future use of the land will include commercial scale uranium in situ extraction. Following this activity the land will be returned to a condition suitable for cattle and sheep grazing. If commercial scale extraction does not follow the proposed R&D test, the land will be reclaimed for cattle and sheep grazing use after testing. In this event the reclamation plan that will be implemented is presented in Section 4.0.

The currently undisturbed nature of the Test Site and present condition of the land is apparent from Figures 2.4 and 2.5. Only a few ranches are located in the area, with the nearest ranch about two miles (3 km) away. These ranches are primarily located in the North Platte River valley. Crop production is pursued in the valley and cattle and sheep grazing elsewhere. The nearest small community, Orpha, is approximately four miles (6 km) east-southeast of the Test Site.

2.3 POPULATION DISTRIBUTION

Within a 50 mile (80 km) radius of the Test Site, Casper (pop. 75,000 est.), Douglas (pop. 8,800 est), and Glenrock (pop. 3,100 est. (Converse County

FIGURE 2.4 — Proposed Process Plant (on left) and Wellfield Area (on right) looking from south-southeast (on left) to south-southwest (on right) from Hydrologic Test Well PW-1.

Figure 2.5 — Proposed Solar Evaporation Pond Area (looking east-northeast from Hydrologic Test Well PW-1)

Planning Office)), Wyoming, are the largest cities (Figure 2.1). Only a few small towns and communities are present including Midwest, Edgerton, Bill, Shirley Basin, Glendo, Orpha, Orin, Shawnee, Lost Springs and Manville, Wyoming. Nearly all of the towns listed above are located along corridors provided by Interstate 25 and U.S. Highways 18 and 20.

Within five miles (8 km) of the Test Site approximately ten families are living on ranches. All except two of the ranches are located south of County Highway 27 within the North Platte valley. The remaining two ranches are each located about five miles (8 km) from the site in northwesterly and northeasterly directions, respectively. Approximately four families are living at Orpha. The low distribution of population near the Test Site is attributed to the more desirable building sites available in the North Platte valley relative to the upland pasture areas.

2.4 ARCHAEOLOGICAL, SCENIC, CULTURAL AND NATURAL LANDMARKS

No historic or archaeological remains or scenic or natural landmarks are known to exist by APS-NAC at the site. If significant cultural or paleontological evidence are exposed during any excavation or other similar work at the site, such activity will be delayed until a qualified person has examined the evidence. APS-NAC have requested the Offices of State Archaeologist and State Historic Preservation to review the R&D Site relative to the need for cultural clearances. The response of the Wyoming Recreation Commission was that archaeological, but not historical surveys, should be performed at the site (Appendix A). The Office of the State Archaeologist performed a site survey during April, 1980. No cultural resources were located during this survey and archaeological clearance is recommended by the Office of the State Archaeologist (Appendix A).

2.5 TOPOGRAPHY

The R&D Site is located in the midst of a fairly level plateau that ranges in elevation from a low of about 5,100 feet (1,555 meters(m)) near the site, to about 5,300 feet (1,615 m), four miles (6 km) north of the site. The elevation of the R&D Site varies from a low of 5,092 feet (1,552 m) on the southwestern corner to a high of 5,126 feet (1,562 m) on the northeastern corner. The relief of the R&D Site is quite gentle, uniformly sloping from the high northeastern corner to the lower elevations on the western side of the site. The slope varies from zero to six percent. Topographic contours of the R&D Site are shown in Figure 2.6.

2.6 SOILS

A soils survey was performed on the R&D Site during November, 1979. To provide the required baseline information, the soils were mapped, sampled and described. In addition to the characterization of baseline conditions, the data have been used to formulate a sound program of topsoil removal and replacement, and revegetation on the R&D Site (Section 4.0).

METHODS

The soils on the R&D Site were mapped in detail from field observations. Soil series phases were used as basic mapping units. The soils survey conformed to the standards of the National Cooperative Survey as outlined in the U.S. Department of Agriculture (USDA) Handbooks 18, 60 and 436. The survey also conformed to the recommended procedures of WDEQ Land Quality Division (LQD) Guideline Nos. 1 and 3.

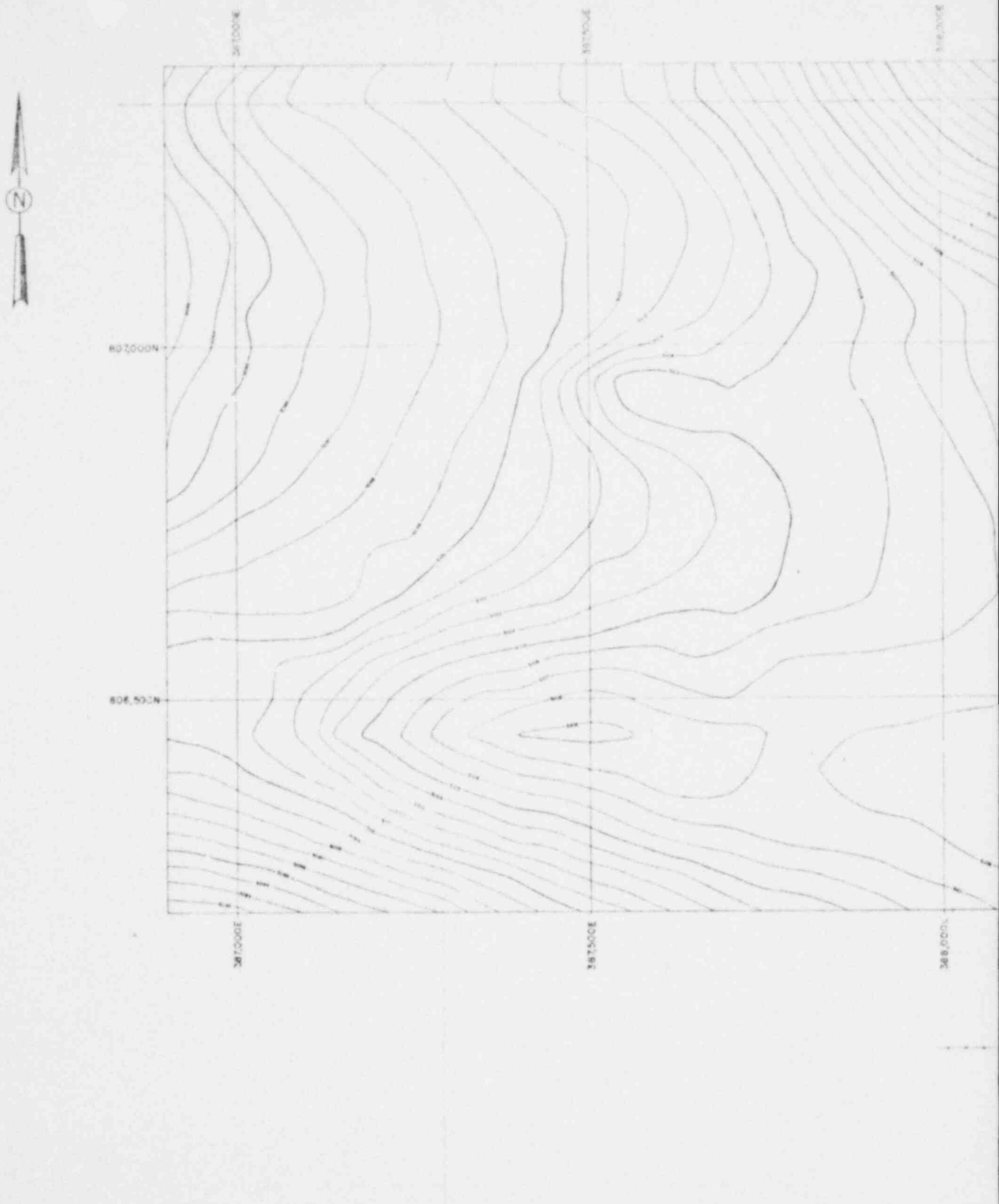
ANALYTICAL RESULTS

Laboratory analytical results for chemical and physical characteristics are presented in Appendix B. Representative samples from each soil series phase were selected for laboratory analysis to determine their suitability for use in reclamation as recommended by WDEQ-LQD Guideline No. 1. The analytical results are used to provide a portion of the soil series descriptions.

SOILS SERIES AND DISTRIBUTION

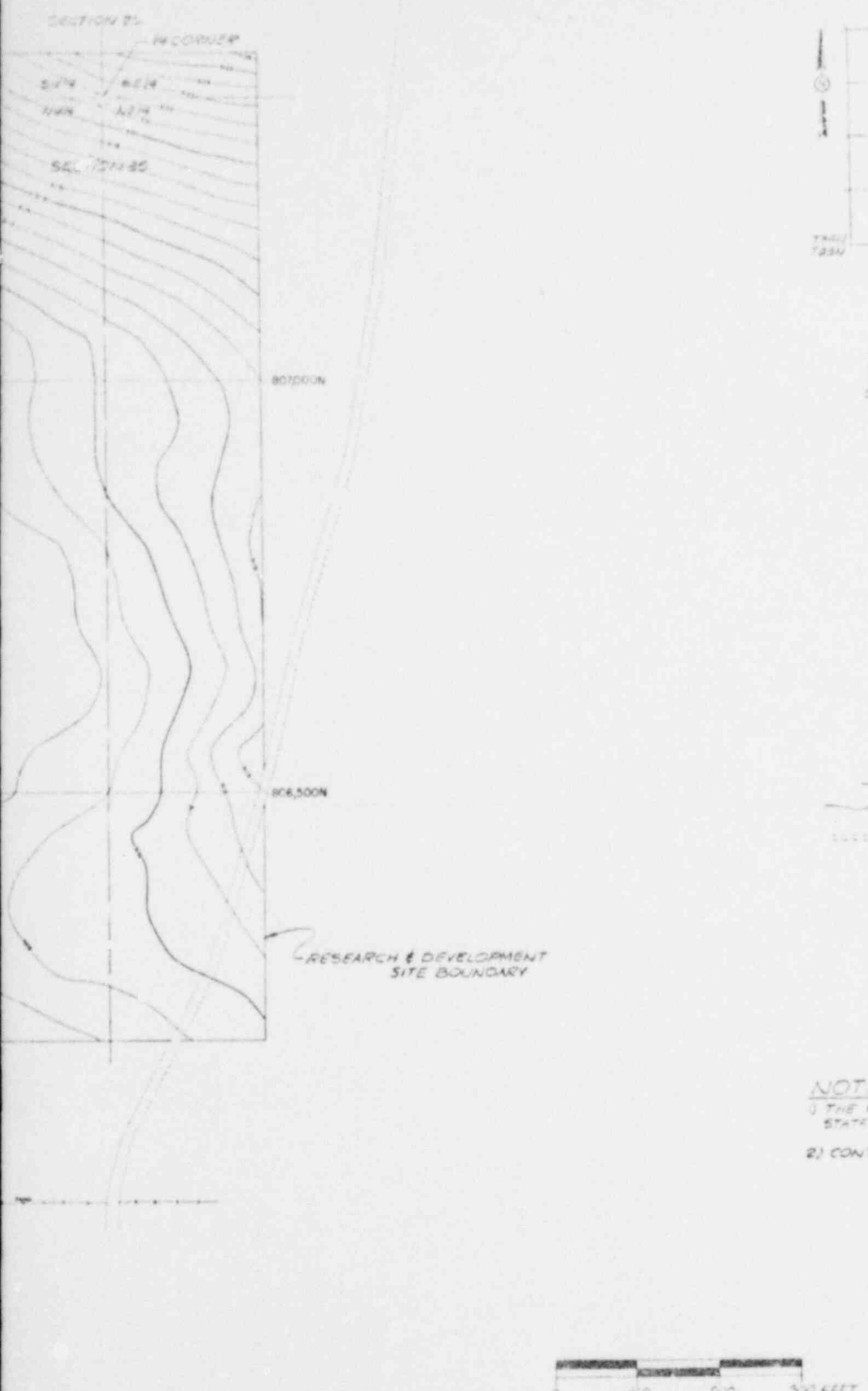
Two primary soils series phases were found in the study area: Fort Collins sandy loam, a deep soil; and Tassel sandy loam, a shallow soil. Both of these series occur frequently in nearby areas and throughout northeastern Wyoming.

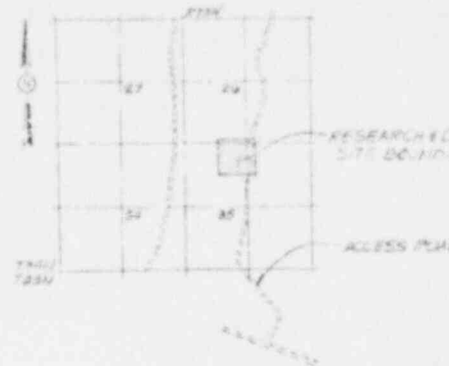
A B



REV	DATE	REVISION	CH	APP	REV	DATE	REVISION	CH	APP
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				

A B





LOCATION MAP

0 4000 8000 12000 FEET

LEGEND

EXISTING CONTOURS

EXISTING ROADS

NOTES

1) THE COORDINATES USED ARE AS PER WYOMING STATE COORDINATE SYSTEM

2) CONTOUR INTERVALS = 1'

NUMBER	REFERENCE DRAWINGS	NOTICE			DATE
		THIS DRAWING HAS NOT BEEN PUBLISHED BUT RATHER HAS BEEN PREPARED BY THE ORTLOFF MINERALS SERVICES CORPORATION FOR USE BY THE CLIENT NAMED IN THE TITLE BLOCK SOLELY IN RESPECT OF THE CONSTRUCTION, OPERATION AND MAINTENANCE OF THE FACILITY NAMED IN THE TITLE BLOCK AND SHALL NOT BE USED FOR ANY OTHER PURPOSE OR FURNISHED TO ANY OTHER PARTY WITHOUT THE EXPRESS CONSENT OF THE ORTLOFF MINERALS SERVICES CORPORATION	SCALE		
			DRAWN		
			CHECKED		
			PROCESS		
			STRUCT.		
			INSTR.		
			ELECT.		
			MECH.		
			APP.		

ARIZONA PUBLIC SERVICE COMPANY

PHOENIX, ARIZONA

ORTLOFF MINERALS SERVICES CORPORATION

PRE-TESTING CONTOUR MAP

PETERSON IN-SITU URANIUM EXTRACTION PROJECT

PROJECT NO. 88900

FIGURE NO. 2.6

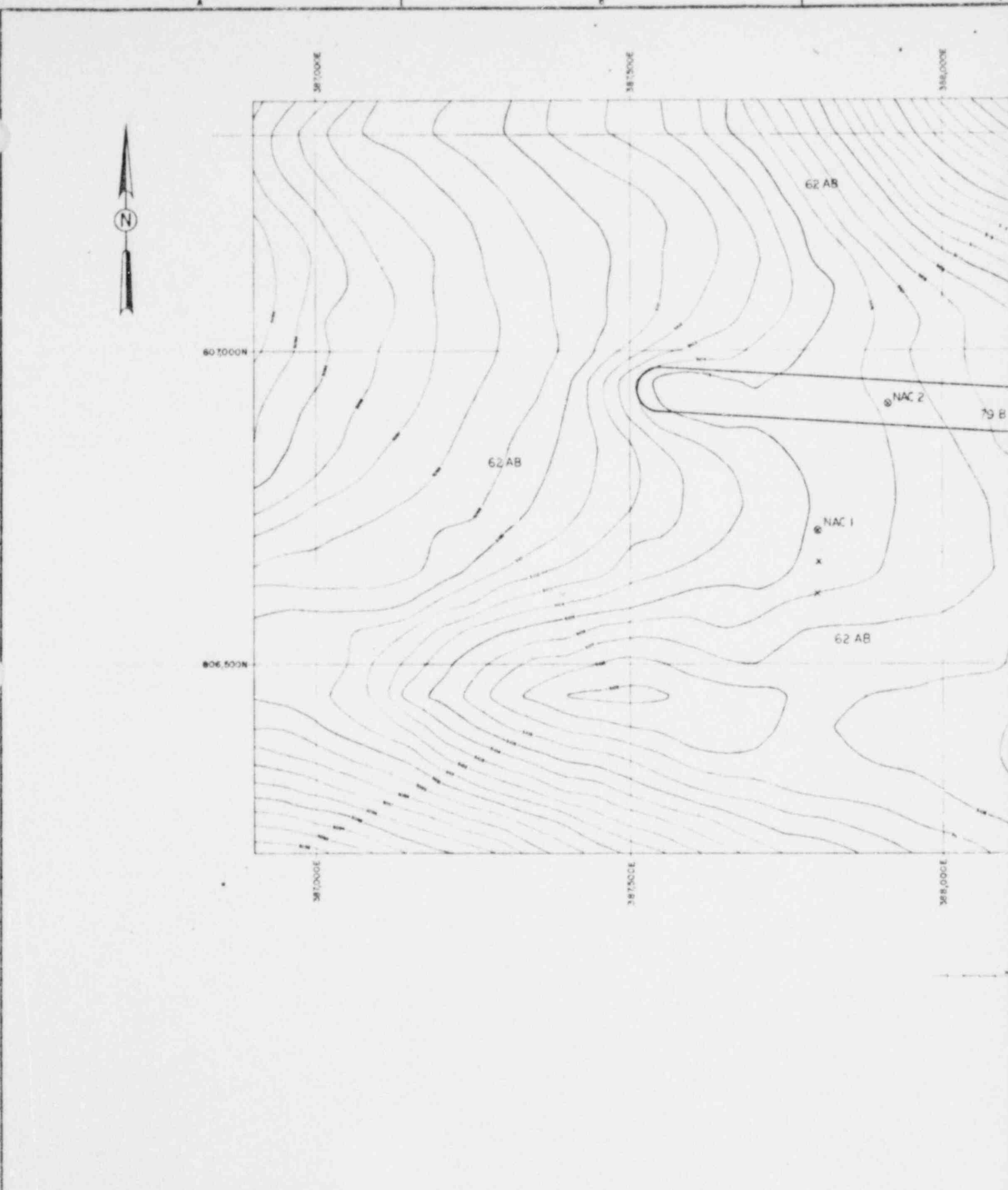
Figure 2.7 is the soils map of the R&D Site. The map indicates the mapping unit boundaries and the sample locations for both the chemical analyses and the profile description within each unit. A legend and description of each mapping unit is provided in Appendix B. Th descriptions provide a summary of the important characteristics useful in determining the suitability of the soils for reclamation. The representative soil profile descriptions for the R&D Site are also contained in Appendix B.

Fort Collins series soils are deep with fair to good suitability as a plant growth medium. The depth of topsoil material ranges from about 40 inches (102 centimeters (cm)) to approximately eight feet (2.4 m). The Fort Collins soils have fine textured loamy surface horizons that are rich in organic matter, and they are well-drained with medium runoff and moderate to moderately rapid permeability. Fort Collins soi s are non-saline and non-alkaline to depths of approximately eight feet (2.4 m). Wind and water erosion hazard is moderate, and tilth at optimum moisture content is good to very good. The potential for compaction of undisturbed soils is low, and the soil structure has good stability against wet slumping. Crusting potential of Fort Collins soils upon drying is low, and the available water holding capacity is moderately high or about 2.0 inches/foot (17 cm/m). Effective rooting depth may be greater than about 50 inches (127 cm).

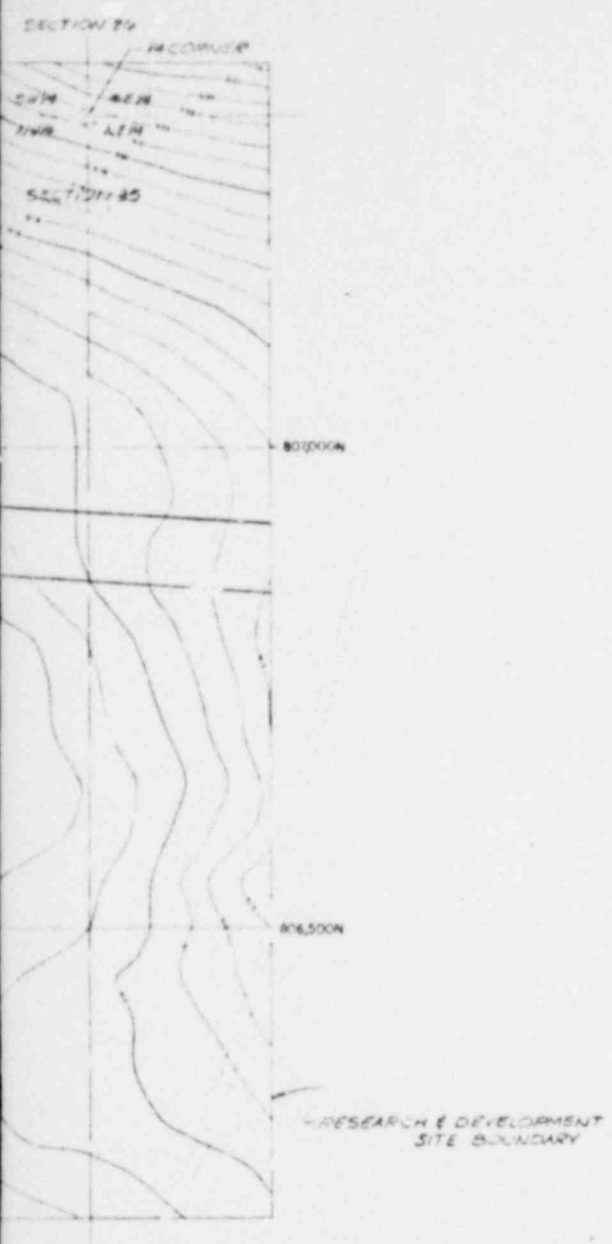
Tassel series soils include shallow well-drained soils with medium runoff and moderately rapid permeability. These soils are non-saline and non-alkaline, and wind and water erosion hazard is moderate. Tilth at optimum moisture content is fair to good, and the potential for compaction of undisturbed soils is moderate to low. The soil structure has fair stability when wet. The potential of Tassel soils for crusting upon drying is low to moderate, and the available water holding capacity is moderate or about 1.8 inches/foot (15 cm/m). Effective rooting depth is commonly ten to fifteen inches (25 to 38 cm).

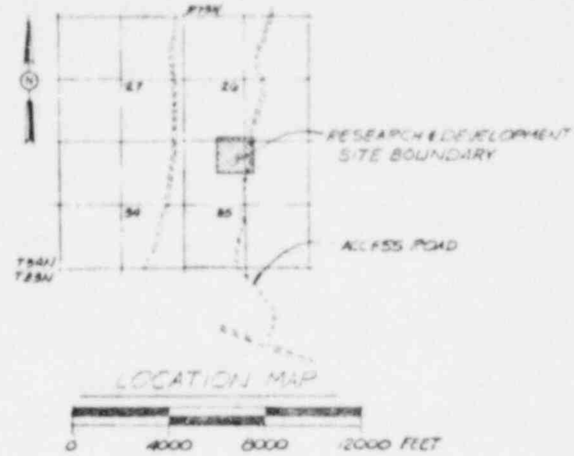
SUMMARY

Salvage depth for suitable topsoil material has been addressed in the mapping unit descriptions. The estimated average depth of topsoil material



REV	DATE	REVISION	DR/CK	APP	REV	DATE	REVISION	DR/CK	APP	NUMBER





LOCATION MAP

LEGEND

EXISTING CONTOURS

EXISTING ROADS

SOIL UNIT

62 AB	FORT COLLINS SANDY LOAM, 0 TO 6% SLOPES
79 B	TASSEL SANDY LOAM, 3 TO 6% SLOPES

⊗ SAMPLE LOCATIONS (NAC 1, NAC 2)

× BACK HOE PITS

NOTES

1) THE COORDINATES USED ARE AS PER WYOMING STATE COORDINATE SYSTEM

2) CONTOUR INTERVALS = 1'

0 100 200 300 FEET

REFERENCE DRAWINGS

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

INTERNATIONAL ENVIRONMENTAL CONSULTANTS
GOLDEN, COLORADO

SOILS DISTRIBUTION ON TEST SITE

PETERSON IN-SITU URANIUM EXTRACTION PROJECT

PROJECT No 85900

FIGURE No 2.7

R&D Site is 56 inches (142 cm). This material is rated fair to good as a plant growth medium. Adequate amounts of suitable topsoil material are available on the R&D Site to mitigate disturbances with proper removal, handling and replacement methods.

2.7 ECOLOGY

VEGETATION

Peterson Project

The Peterson Project area is located in an ecological transition zone between the northern desert shrub type toward the west, dominated by big sagebrush types, and the shortgrass plains toward the east (Department of Interior, 1979), dominated by many species of grasses. The sagebrush types are termed the Cold Desert Formation by Oosting (1956) and Sagebrush Steppe by Kuchler (1964). The shortgrass plains are described in detail by Weaver and Clements (1929). In the shortgrass plains sagebrush types dominate, but grasses are very abundant, forming grasslands. These types dominate in nearly all of the upland portions of the Project area. Some riparian types occur in the bottomlands. Riparian cottonwood forests occur along the North Platte River in the southern Project areas and extend up the Sage Creek valley into the Project.

The vegetation has been influenced by many factors. The most important have been grazing, fire, climate (especially precipitation), soils and topography. The advent of fire control and heavy grazing by domestic herbivores has allowed sagebrush to dominate the vegetation at the expense of pure grassland. Soils and topography are key elements in the development of the less abundant communities of the lowlands.

R&D Site

The R&D Site is dominated by sagebrush shrubland (Artemesia tridentata) (c.f. Dorn, 1977, and Beetle, 1977, re. nomenclature) on the northern portion, with sagebrush less abundant on the southern and southeastern portions of the site. The Test Site has been very heavily grazed, and no seed heads of grasses were evident in the fall of 1979. The vegetation of the site is typical of the surrounding upland area.

Sagebrush Type. The sagebrush type is dominated by sagebrush whose height ranges from 12 to 18 inches (30 to 46 cms). The cover in this type varies from 20 to 40 percent although about half of the sage is dead and has no foliage at all. Grasses are interspersed with the sagebrush and have a cover ranging to 20 percent. The dominant grasses include: blue grama (Boutelous gracilis), sedge (Carex sp.) and western wheatgrass (Agropyron smithii). Prickly pear cactus (Opuntia polyacantha), though not abundant, occurs in patches as much as three feet (1 m) in width. Lichen cover ranges between one and five percent and is interspersed among the other plants.

Sagebrush-Grassland Type. The sagebrush-grassland dominates on the southern and southeastern portions of the R&D Site and includes the same species of plants. Sagebrush cover, however, is less evident. The type grades imperceptibly into the sagebrush type and possesses a greater grass cover. In addition to the grasses mentioned above, other common grasses include: june grass (Koeleria cristata), needle-and-thread (Stipa comata), and Indian rice grass (Oryzopsis hymenoides). Prior to grazing, the grassland cover probably exceeded 20 percent. Exact cover is difficult to determine owing to the heavy overgrazing of the site.

WILDLIFE

As stated previously in the description of vegetation, the R&D Site contains sagebrush and sagebrush-grassland habitats. Several additional habitats occur in surrounding areas within the Peterson Project and include: grassland, bottomland grassland, bottomland sagebrush, cottonwood woodland, agricultural, silver sage and wet rush meadow. Not all of these are distinct wildlife habitats since wildlife species generally occupy habitats on the basis of their physiognomic appearance rather than their specific species composition. From the above lists of vegetation types, six wildlife habitats may be distinguished including: sagebrush, grassland, cottonwood woodland, agricultural, wet rush meadow and bottomland shrub. The sagebrush-grassland vegetation type would be expected to contain wildlife species representative of its two component vegetation types. Where moisture conditions are better, specimens of sagebrush and its associated shrub species grow taller and denser, and new shrub species may be present. These taller shrub associations resulting from better moisture conditions constitute the bottomland shrub wildlife habitat.

Wildlife species mentioned below as characteristic of sagebrush or grassland habitat types may be expected on and are considered characteristic of the Test Site. Other species, more characteristic of surrounding habitats, may be expected to occur occasionally on the Test Site, while in transit.

Mammels

The Converse Planning Unit provides habitat for 64 species of mammals (BLM, 1977). Species most characteristic of the sagebrush and grassland habitats which may be present on the Test Site in varying degrees of admixture include: Desert Cottontail, White-tailed Jack Rabbit, Black-tailed Jack Rabbit, Least Chipmunk, Black-tailed Prairie Dog, Northern Pocket Gopher, Deer Mouse, Sagebrush Vole, Coyote, Red Fox, Badger, Mule Deer, and Pronghorn. Cottonwood woodland and wet rush meadow hatitats would be most likely to provide additions to the list of mammal species characteristic of the upland Test Site. Species likely to be added include: Vagrant Shrew, Prairie Vole, Muskrat, Raccoon, Long-tailed Weasel, Mink, Striped Skunk, and White-tailed Deer. On rocky outcrop microhabitats, likely additional species include Ord's Kangaroo Rat and Bushy-tailed Woodrat. On a November, 1979, reconnaissance visit to the site environs, Mule Deer, Pronghorn, Muskrat, and roadkilled White-tailed Jack Rabbits were seen. Striped Skunk and Beaver sign were also observed. Three groups of mammals considered further herein are: prey and predator species; big game species; and sensitive, threatened or endangered species.

Prey and Predator Species of Mammals. Important small prey species are primarily in the orders Lagomorpha (pikas, rabbits and hares) and Rodentia (squirrels, gophers, rats, mice, Beaver and Porcupine). Small prey species which could occur on the Test Site include: Nuttall's Cottontail, Desert

Cottontail, White-tailed Jack Rabbit, Black-tailed Jack Rabbit, Least Chipmunk, Thirteen-lined Ground Squirrel, Black-tailed Prairie Dog, White-tailed Prairie Dog, Northern Pocket Gopher, Olive-backed Pocket Mouse, Deer Mouse and Northern Grasshopper Mouse. In the immediate vicinity of the Peterson Project, Nuttall's Cottontail and White-tailed Prairie Dog are not expected to be common. Map 7 in the Eastern Powder River Coal ES (BLM, 1978) shows no prairie dog towns on either the Test Site or within the Peterson Project. No prairie dogs were observed on the site reconnaissance visit; however, prairie dogs are not expected to be active in early November when this visit occurred. The roadkilled White-tailed Jack Rabbits seen on this visit were along State Highways 93 (two individuals) and 95 (one individual), and Interstate 25 (one individual).

Larger prey species of importance are in the order Artiodactyla (deer, Pronghorn and other hollow-horned ruminants). Pronghorn are typical of the habitats found on the Test Site and throughout the region. The habitat on and in the immediate vicinty of the Test Site is not optimum for Mule Deer. Within the area, Mule Deer can be expected to occur most frequently along Sage Creek and along the North Platte River. These two species are discussed further under big game mammals. Occasional White-tailed Deer can be expected along the North Platte River. There are no known wild horses or burros within the planning unit (BLM, 1977).

Members of the order Carnivora (including wolves and dogs, bears, raccoons, weasels and cats) and man are the primary mammalian predators on both large and small species. Man has eliminated most of the large carnivores while maximizing populations of carnivore prey species for his own use. Because of man's management practices, adequate food sources are available for carnivores that remain. These food sources may be wild or domestic animals; but when they are domestic stock, obvious conflicts arise. The larger carnivores, such as Coyotes, Foxes and Bobcats, are mobile and may occasionally occur in and around the site. Weasels, Badgers and Skunks are other possible predators on and near the R&D Site.

Big Game Mammals. The big game mammals in east-central Wyoming are: Elk, Mule Deer, White-tailed Deer, Pronghorn and Mountain Sheep. The relative importance of various areas surrounding and including the site can best be obtained from Wyoming Game and Fish Department (WGFD) hunt harvest figures for a given species. While these figures do not reflect actual populations, they do give an indication of relative population in a given area over several years or in a given year over several areas.

White-tailed Deer occur primarily in forested, mountainous and riparian areas and are not likely to occur on the Test Site. Within the region, this species is most likely to occur along the North Platte River.

Big Horn Sheep require rugged mountainous terrain. Forty-two big horns were transplanted into the Laramie Peak area in 1964, about 50 miles (80 km) south of the site. During 1965 and 1966, 57 additional sheep were released. However, there is no appropriate habitat for this species on the Test Site.

A herd of about 600 Elk has maintained a stable population level in the Laramie Mountains over the last several years (BLM, 1977). Elk are occasionally seen in the lowlands of Wyoming, indicating that they are beginning to use the plains again. Because of the 30 mile (48 km) distance to the nearest Elk range, Elk are likely to be extremely rare within the R&D Site. Individuals that are present would be away from optimum habitat and be wanderers, or present because of extreme population increase. Because Elk herds are closely managed for hunting, such a population expansion is unlikely.

Mule Deer are an important game species in Converse County. Scattered populations inhabit the northern prairie parts of the county, but the main concentration of the herd occupies the foothills of the Laramie Mountains in the southern part of the county. In addition to providing excellent year-round habitat, this foothills area provides abundant forage (especially mountain mahogany) for winter use by large populations of Mule Deer. Although it is not considered prime habitat, the northern two-thirds of Converse County provides year-long range for small populations of deer in draws where cover and water are available, especially along pine covered ridges and riparian areas. Major forage plants in these areas are big sagebrush, rubber rabbitbrush and a variety of forb species. Map 6 in the

Eastern Powder River Coal ES shows year-long deer range in the western one-half of T34N, R73W, just west of the Test Site. However, WGFD field personnel believe the drainage of Sage Creek and the North Platte River constitute crucial winter range for local Mule Deer populations (Helms and Trebelcock, pers. comm.). Based on data contained in the mining and reclamation plans for existing and proposed mine sites within the eastern Powder River Basin, the average density of deer inhabiting the region is three per square mile ($1.2/km^2$). During the November, 1979, reconnaissance visit along Interstate 25, two Mule Deer plus one roadkilled deer were seen about five miles (8 km) west of Glenrock and another roadkilled individual was about 18 miles (29 km) west of Glenrock.

Mule Deer are relatively intolerant of human activity and will leave not only the immediate activity site but also a surrounding buffer zone. The width of this buffer zone varies with the intensity of mining activity, the degree of human intrusion in the area and the degree of topographic shielding available in the area. Conflicts between energy developmental activities and Mule Deer are already occurring in northern Converse County. The town of Douglas has grown from approximately 1,500 people to approximately 10,000 people within the last four or five years (Helms and Trebelcock, pers. comm.). Both Helms and Trebelcock felt that the rapidly increasing local human population poses the major threat to Mule Deer populations through poaching and harassment. Because most of the area in the vicinity of the Peterson Project is year-round range, they felt the loss of habitat for this species was much less important by comparison.

Pronghorn are an important game species of the plains. Year-long Pronghorn range in Converse County includes the Test Site as shown in Map 6 of the Eastern Powder River Coal ES (BLM, 1978). It consists of rolling sagebrush-grassland typical of the best Pronghorn range in Wyoming. The year-long range provides forage, water and cover, and the habitat is considered to be in good condition and stable. During winter months, Pronghorn concentrate in parts of the range where there is low snow cover and abundant forage. The valleys of Sage Creek and the North Platte River are considered by Helms and Trebelcock (pers. comm.) to be important wintering areas for Pronghorn as well as Mule Deer. Based on data from existing and proposed mine sites in the eastern Powder River Basin, average Pronghorn density in the area is 20.8

animals per square mile ($8/km^2$) (BLM, 1978). During the site reconnaissance, Pronghorn were seen in every wildlife habitat within the area except cottonwood woodland and wet rush meadow. Occasional lone Pronghorn were seen, but most observations of Pronghorn on the Peterson Project were of herds ranging in size from 59 to 81 individuals. Pronghorn were particularly noted along the ridges south and west of Sage Creek, in the valley and flatter northeastern side of Sage Creek, and in strip-cropped fields north of County Road 27 and west of Sage Creek.

Habitat management for Pronghorn involves some of the same features as discussed for Mule Deer. Adequate water supplies are apparently already available for the present Pronghorn population. The rehabilitation of mine sites with shrub and forb species will benefit Pronghorn as well as Mule Deer.

Sensitive, Threatened or Endangered Species. The Wyoming mammals considered nationally endangered (USF&WS, 1977) are the Black-footed Ferret and the Northern Rocky Mountain Wolf, a subspecies of the Gray Wolf. In addition, the Spotted Bat, Meadow Jumping Mouse and Wolverine are considered rare in the state by the WGFD. Neither the wolf nor the Wolverine is likely on the Test Site. Remnant populations of both species remain only in the more remote and inaccessible parts of the state, if anywhere. The Spotted Bat is rare everywhere, and its habitat is too little known to predict its presence at any one place. The Meadow Jumping Mouse is at the edge of its range and habitat in Wyoming, where it largely is ecologically replaced by the Western Jumping Mouse. Specimens of this species have been recorded only south of the North Platte River and in the far northeastern corner of the state (Long, 1965). Its presence in the moist drainage valleys near the site is possible, but not likely.

The Mountain Lion is considered uncommon in Wyoming; and even though its populations are believed to be stable or increasing, it is a high priority species (WGFD, 1977). It is known to occur in extreme southern Converse County in the Laramie Mountains (BLM, 1977), but could occur in the areas surrounding the site.

The Swift Fox is also considered a high priority species by the WGFD. Its presence in eastern portions of the state has been verified but data regarding its population density, distribution and status are inadequate (WGFD, 1977). Only five specimens are known from the entire state (Long 1965).

The Black-footed Ferret is rare and elusive. The Test Site is within its range and habitat, so far as these are known (Keenlyne, 1977). Within the eastern Powder River Basin, two sightings, both in Campbell County, have been classified by Clark (1977) as positive (BLM, 1978). There have been no Black-footed Ferret sightings in the vicinity of the Peterson Project (Helms and Trebelcock, pers. comm.). Present U.S. Fish and Wildlife Service (USF&WS) thinking on this species ties it strongly to prairie dog colonies. The WGFD is administratively following this reasoning. Thus, the presence of large and/or numerous praire dog colonies on the site would make the presence of a ferret possible. However, there are no prairie dog colonies known within the Peterson Project including the R&D Site, at this time (January, 1980). Because of their elusive nature and the low probability of their presence, Black-footed Ferrets are not likely to conflict with operations at the Test Site.

Birds

The Converse Planning Unit is considered to provide habitat for 280 species of birds (BLM, 1977). Based on range maps in Robbins et. al. (1966), an additional ten species might be added to the BLM list. Not all of these species are likely to remain on the site because the habitats they require are not present. However, any of the species could be seen on the site and all should be considered when making field identifications of birds. Many species would be expected to stop briefly or fly over to nearby areas which provide different habitats, such as the riparian habitat along the North Platte River. Further, not all of the 290 potentially possible species of birds are likely at all times of the year. Some (41.4 percent) only breed in the area and spend the winter elsewhere; others (5.5 percent) may winter in the area but breed elsewhere; and still others (21.4 percent) only migrate through the area from more southern wintering grounds to more northern breeding grounds. Only 31.7 percent of the 290 potentially possible species in the area of the site remain there throughout the year.

Non-raptor species that are particularly characteristic of the habitats found on the R&D Site include: Horned Lark, Brewer's Sparrow, Sage Grouse, Sage Sparrow, Western Meadowlark, Sage Thrasher, Loggerhead Shrike, Green-tailed Towhee, Lark Bunting, Vesper Sparrow and Mourning Dove. These species are listed in the expected order of their general abundance. The additional habitats which are off the R&D Site but within the surrounding area can be expected to markedly increase the bird species diversity within the project area. The cottonwood woodland, with its unique components of deciduous thickets, trees and water, can be expected to have both the greatest numbers and greatest variety of birds. Gilbert Lake also represents a unique local habitat. Species breeding there such as Mallards, Teal, Killdeer and Spotted Sandpipers may also breed in quiet backwater areas along the North Platte River. The bottomland shrub habitat can be expected to draw species from both cottonwood riparian and sagebrush habitats. Agricultural and wet rush meadow habitats probably attract several species not found in the surrounding sagebrush based habitats. During the site reconnaissance, Horned Larks were the only species commonly encountered. Mallards, Redheads, a White-winged Scoter, American Kestrel, a Loggerhead Shrike, a Black-billed Magpie, Pine Siskins, Tree Sparrows and a Black-capped Chickadee were also recorded on or adjacent to the Test Site.

Raptor species tend to hunt over a variety of habitats rather than being restricted to specific habitats. Prey is taken wherever the vegetation is sufficiently open to allow visibility and access. However, raptor species do exhibit considerable specificity in nesting sites. Species which might be observed anywhere within the Peterson Project include: Golden Eagle, Ferruginous Hawk, American Kestrel, Red-tailed Hawk and Prairie Falcon. In summer, Swainson's Hawk, and in winter, Rough-legged Hawk, should be added to this list of likely species. Close to the river, Bald Eagles and Osprey can also be expected. Bald Eagles, Golden Eagles and Rough-legged Hawks were observed during the site reconnaissance. These species will be discussed in greater detail below.

Because they are of particular interest and importance, three groups will be singled out from the potential species for further discussion. These are game birds; raptors; and sensitive, threatened or endangered species.

Game Birds. Game bird species are of popular interest and are managed to provide an important recreational activity for hunters. Waterfowl, grouse, pheasants and allies, and Mourning Doves constitute potential game species groups in the area.

The North Platte River provides the best habitat for waterfowl in Converse County. The abundant inlets, sloughs and islands provide nesting, feeding and resting areas for waterfowl. The duck harvest has been relatively stable since 1970, while numbers of Canada Geese harvested have steadily increased. Almost all the birds harvested in the county are taken along the North Platte River (BLM, 1977). Mallards were seen repeatedly along the river during the November, 1979, reconnaissance visit. Gilbert Lake provides additional waterfowl habitat. Canada Geese nested on the lake in the summer of 1979 (Helms, pers. comm.). Gilbert Lake can also be expected to attract numbers of migrating waterfowl, shorebirds and other water birds. Helms and Trebelcock (pers. comm.) mentioned Cormorants, Canada Geese, Coots and Mergansers as species which use this lake. During the site reconnaissance, a pair of Redheads and a male White-winged Scoter were observed on Gilbert Lake. A large flock of Canada Geese in a triple V was observed flying high past Gilbert Lake in early afternoon.

Sage Grouse require a year-round source of free water. Breeding centers on traditional leks, which are typically in flat, sparsely vegetated areas with good visibility, and surrounded by sagebrush dominated communities. Nests are usually found within two miles (3.2 km) of the lek in ten to fifteen inch (25 to 38 cm) high sagebrush (Patterson, 1952). Sagebrush provides both food and cover for the birds. Summer diets also include large numbers of insects. The BLM has identified no problems in water supply or sagebrush cover for Sage Grouse habitat in Converse County. Good grouse populations are supported, especially in the northern part of the county (BLM, 1977). There is a possible, but undetermined, conflict with domestic stock that may affect the amount of forbs available for Sage Grouse food.

The R&D Site is within year-long grouse habitat (BLM, 1977; overlay). As shown on Map 7, 25 grouse leks, or strutting grounds, have been identified in the eastern Powder River Basin (BLM, 1978). Seven of these leks are north of the North Platte River in Converse County. One of these is on the northeastern side of State Highway 93 and northwest of Gilbert Lake. It appears to be approximately one to one and one-half miles (1.6 to 2.4 km) northwest of the most northern Peterson Project boundary, and approximately three and one-half miles (5 km) north of the R&D Site (BLM, 1978). Helms and Trebelcock (pers. comm.) located this lek in Sections 13 and 14 north northwest of Gilbert Lake. Helms has seen Sage Grouse at Gilbert Lake and he believes they probably winter in the dense sage along Sage Creek. Trebelcock flew an aerial grouse survey in the spring of 1979 to look for Sage Grouse leks. His survey included the Peterson Project area. Although he recorded no grouse activity, he felt his traverses were too wide, and that the survey should be repeated (pers. comm.).

The Sage Grouse harvest in Converse County fluctuates from year to year, depending on population status. From a low brood year in 1971 when no harvest took place, the population increased to a stable level by 1975 and 210 birds were harvested (BLM, 1977). Based on data from existing and proposed mine sites within the eastern Powder River Basin, regional Sage Grouse densities are 5-25 pairs per 100 acres (40 hectares) (BLM, 1978). BLM habitat management plans for Sage Grouse include the protection of leks from disturbance by developmental activities such as drilling and construction during the critical period from March through June. Use of proper seed mixtures including shrubs and forbs in rehabilitation of mined areas will also benefit Sage Grouse populations.

Pheasants and their allies have been introduced (Ring-necked Pheasant, Chukar, Gray Partridge) or reintroduced (Wild Turkey) in various areas in the state. The species most likely to be encountered in the vicinity of the R&D Site are Gray Partridge, Wild Turkey and Ring-necked Pheasant. Gray Partridge have been released just east of the Peterson Project (Helms, pers. comm.). This species occupies a variety of habitat types and could be encountered occasionally anywhere within the Peterson Project, including the R&D Site. Scattered populations exist within Converse County and 15, 6 and 32 birds were harvested in 1972, 1973 and 1975, respectively (BLM, 1977). Wild Turkey habitat in Converse County is found in the eastern portion of the Laramie Range and in areas of deciduous riparian woodland. Populations in the county increased between 1971 and 1976, with particularly high brood counts in 1972 and 1973. Wild Turkey could be found in the North Platte River bottomlands at the southern extreme of the Peterson Project. Occasional pheasants are found in the North Platte River bottomlands, particularly near agricultural areas (Loeper and Helms, pers. comm.).

Mourning Doves are found throughout the region including the R&D Site. They require free water and are most abundant around agricultural areas. Doves can be expected to congregate along the North Platte River and around Gilbert Lake for water in the early morning and late evening. During the remainder of the day, they probably radiate out from these focal points to forage in all habitats, but concentrate in the agricultural areas southeast of the R&D Site. The only data for dove populations in the county are statistics from hunting. County harvest figures for Converse County in 1973, 1974 and 1975 were 591, 2,409 and 1,609, respectively.

Raptors. Raptors serve as sensitive indicators of environmental disturbance because they are at the top of their food chains and intolerant of intrusion near their nests. Hawks and owls are the two groups generally considered as raptors.

Sixteen species of hawks are potentially present in the area. Of these, the Rough-legged and Harlan's Hawks and the Bald Eagle spend winter only in the area; the Swainson's Hawk spends summer only in the area; and the Osprey migrates through. At least some individuals of the remaining 11 species are present in the area all year.

Wintering species and, to a greater extent, migrating species are not attached to a specific geographic spot as breeding birds are. Thus, so long as adequate habitat exists, the loss of one spot or another is not critical to them. The R&D Site and most of the Peterson Project contain no regionally unique raptor wintering habitat. However, the North Platte River does provide a regionally unique wintering habitat, particularly for Bald Eagles and Osprey. Because of warm water from the Dave Johnston Power Plant, the North Platte River remains open from the power plant to just above Douglas, Wyoming. This section of the river is the only open stretch of water in the area (Loeper). As a result, Bald Eagles, Osprey and even Golden Eagles concentrate along this stretch of river (Helms and Trebelcock, pers. comm.).

Bald Eagles may stay along the river as late as April. Three Bald Eagles were seen in the area during the November, 1979, reconnaissance. Two were within sight of the power plant, and one was south of the Peterson Project. One half to one dozen Osprey are normally seen along the river in fall and in spring (Helms and Trebelcock, pers. comm.). Helms saw an Osprey holding a fish and sitting on a fence post due south of the R&D Site and on the north side of County Road 27. Golden Eagle numbers increase locally during winter as they concentrate and feed along the river (Helms and Trebelcock, pers. comm.). During the site reconnaissance, one juvenile Golden Eagle was at the south end of the Peterson Project adjacent to the river. On 7 November, 1979, along a nine mile (15 km) stretch of County Road 27 east from the R&D Site entrance, six Golden Eagles were observed, only one of which was a full adult bird. Other wintering hawks may be found throughout the region, opportunistically concentrating wherever prey species are particularly abundant. During the site reconnaissance, two Rough-legged Hawks were observed, both in the vicinity of Orpha. The only other raptor species observed during the reconnaissance visit was the American Kestrel, which was generally common in the vicinity of the Peterson Project.

Especially among raptors, breeding failure can be caused by interruption of breeding activity. Further, breeding birds are psychologically tied to the nest site until the young have fledged. Therefore, breeding raptors are most susceptible to human disruption. On the R&D Site, no suitable raptor nesting habitat exists. Within the entire area, trees provide the only good potential nesting sites. Trees are concentrated along Sage Creek valley and the North Platte River. Away from these stream valleys, only three trees occur on the entire Peterson Project. Two of these are small and have inadequate crotch structures for nests. The remaining cottonwood is large and could be an appropriate nesting site. During the reconnaissance visit it did not contain an intact raptor nest, although there was scattered debris in the top of this tree, perhaps from a very old nest. From about one mile (1.6 km) north of County Road 27 to the North Platte River, Sage Creek valley contains evidence of raptor nesting. During the fall reconnaissance, four large nests were seen in this stretch of the creek valley. The steep topography providing the high vantage required for ground nests of such raptor species as the Ferruginous Hawk is absent or only marginally present on the Peterson Project. Marsh Hawks do not require a nest site atop a high vantage point, and good nesting habitat for this species is present in the upper Sage Creek valley.

Nine species of owls are potentially present on the site. Seven are permanent residents (Screech, Great Horned, Long-eared, Short-eared, Barn, Saw-whet, and Pygmy Owls); one is a summer resident (Burrowing Owl); and one is a winter resident (Snowy Owl). The Screech Owl often nests in cavities along streams. Long-eared and Great Horned Owls nest in trees, and Short-eared Owls nest on the ground. The Long-eared Owl nests in denser vegetation and is least likely to occur on the site. The Barn Owl nests on cliffs and in buildings. The Burrowing Owl nests in ground burrows, usually in association with prairie dog towns. Within the Converse Planning Unit, active nests of Golden Eagles, Swainson's Hawks, Ferruginous Hawks (BLM, 1977) and Great Horned Owls (UNC Teton, 1979) have been observed. None are known within the Peterson Project.

Sensitive, Threatened or Endangered Species. Species which are on the federal threatened and endangered list (USF&WS, 1977) and on the list of potential species for the site are: Bald Eagle, Peregrine Falcon and Whooping Crane. Bald Eagles, which winter along the North Platte River, have been discussed previously. Peregrine Falcons are probably permanent residents in the region, but not near the R&D Site. There are records of Whooping Crane migration during 1977 through Wyoming (Keenlyne, 1977). This species might pass over the site, but there is no appropriate habitat present.

The WGFD (1977) has prepared a list of species considered rare in the state. This list includes the Peregrine Falcon and Whooping Crane discussed above, and also the Least Tern, Purple Martin, Brown-capped Rosy Finch, Scrub Jay, Burrowing Owl and Columbian Sharp-tailed Grouse. Burrowing Owls might be expected to be found near prairie dog towns. Least Terns are potential breeders along the North Platte River. The status of these two species in the local vicinity of the site is unknown.

Several additional species may be considered sensitive. Of the 53 species on the Audubon Blue List (Arbib, 1976), 36 (68 percent) are on the list of potential species for the site. Those species which are likely to breed on or near the site include: Swainson's Hawk, Ferruginous Hawk, Marsh Hawk, American Kestrel, Sage Grouse, Upland Sandpiper, Burrowing Owl, Short-eared Owl, Common Nighthawk, Mountain Bluebird, Loggerhead Shrike and Vesper Sparrow. None of these species is threatened or endangered, but their populations appear to be nationally declining. The Golden Eagle is included in the Bald Eagle Act (16 US Code 668-668D) because it cannot generally be distinguished from immature Bald Eagles. It is therefore protected from disturbance of its nesting site even though the species is not considered threatened or endangered.

Reptiles and Amphibians

There are 11 species of reptiles and seven species of amphibians which potentially occur on the site (BLM, 1977). None of these is on the federal list of threatened and endangered species (USF&WS, 1977). Two species, the Western Smooth Green Snake and the Pale Milk Snake are on the Wyoming state list of rare species (WGFD, 1977). Inadequate data exist on the status and distribution of populations of these species within Wyoming.

The seven amphibian and two turtle species require moist to wet habitats. Such habitats do not occur on the R&D Site. The nearby ephemeral playa lakes provide breeding habitat for less aquatic amphibians such as toads. The remaining reptile species include two lizards and seven snakes. The local abundance and distribution of these species are unknown.

Fishes

The Test Site is dry and provides no aquatic habitat. The Peterson Project includes or is immediately adjacent to the aquatic habitats of Gilbert Lake, North Platte River, intermittent stretches of Sage Creek and ephemeral playa pools. The Converse County section of the North Platte River was a near biological desert until about 1957 when abatement of municipal sewage and industrial waste pollution yielded effective results. Fish stocking, which began in 1959, includes Brown Trout, Rainbow Trout and Channel Catfish. The North Platte River is currently considered a Class 3 stream and a recreational fishing area (BLM, 1977; overlays). The river provides a Class A recreational area, contrasting with a Class C rating elsewhere in the Project vicinity. Gilbert Lake probably contains a fish population, however the species present are unknown. Sage Creek is not a perennial stream and probably contains no fish.

Seven species of fish on the list of rare species in Wyoming (WGFD, 1977) that occur or once occurred in the North Platte River drainage include: Shovelnose, Sturgeon, Goldeye, Hornyhead Chub, Sturgeon Chub, Suckermouth Minnow and Common Shiner. There are no recent data which indicate that any of these species still occur in the North Platte Drainage.

2.8 METEOROLOGY

CLIMATOLOGICAL DATA SOURCES

At present there is no official meteorological reporting station in the immediate vicinity of the R&D Site. Regional data are available, however, from Casper, Wyoming, which is situated approximately 40 miles (64 km) west of the proposed Test Site. Both Casper and the Test Site are situated in rolling hill country east of the continental divide at comparable altitudes. The Natrona County International Airport, where Casper data are collected, is at an elevation of 5,338 feet (1,627 m). The elevation of the Test Site is approximately 5,100 feet (1,554 m).

Additional unofficial climatological data are available from recent studies conducted at the TVA-United Nuclear Morton Ranch Project and the Rocky Mountain Energy Corporation Bear Creek Project each located north of the Test Site about 15 miles (24 km) and 25 miles (40 km), respectively.

Other sources of data and climatological discussions include the Climate of Wyoming (Lowers, 1960); Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1941-1970 (Climatography of the United States No. 81 (Wyoming), NOAA, 1973); the Converse County Unit Resource Analysis

(BLM, 1976); and Holzworth, 1972. Data summarized in these studies are available for Glenrock (16 miles (26 km) west-southwest of the site), Douglas (16 miles (26 km) southeast of the site) and Dull Center (40 miles (64 km) northeast of the site).

The data appear to be sufficient to characterize meteorological conditions in the area of the Test Site.

TEMPERATURE, PRECIPITATION AND HUMIDITY

The climate of the Test Site is generally classified as semi-arid and cool. However, seasonal variations are considerable. Table 2.1 shows monthly and annual mean temperatures for Casper, Glenrock, Douglas and Dull Center. The mean annual temperature in the area is 45.4°F to 47.4°F (7.5°C to 8.5°C). The mean monthly temperature in January, the coldest month, at Glenrock is 25.8°F (-3.4°C); the mean monthly temperature for July is 71°F (21.6°C). The highest temperature reported at Casper was 104°F (40°C) in July, 1954. The extreme low reported at Casper was -40°F (-40°C) in January, 1970 and 1972.

Table 2.2 shows monthly and annual precipitation for Casper, Glenrock, Douglas and Dull Center. The average annual precipitation in the area is 11.2 to 13.5 inches (26.9 to 32.4 cm). The wettest month is May (mean precipitation at Glenrock is 2.34 inches (5.6 cm)), while the driest month is December (mean precipitation at Glenrock is 0.41 inches (1.0 cm)). More detailed information including monthly and annual extremes and snowfall data for Casper, Wyoming, are presented in Table 2.3.

Although annual average precipitation is comparatively small, there is considerable variability in rainfall from year to year. A minimum annual precipitation of 7.34 inches (17.6 cm) was reported at Casper in 1960, while a maximum of 16.24 inches (39.0 cm) was reported in 1941 (local climatological data for Casper). Wide seasonal and annual variations in the amounts of precipitation are often the result of spring and summer thunderstorm activity. Several heavy thunderstorms during a year can produce 25 to 50 percent of the annual precipitation. For this reason, a short-term precipitation record at the site would not provide a reliable estimate of the

TABLE 2.1: Monthly and Annual Mean Temperature for Representative Stations.

	Casper[1]		Glenrock[1]		Douglas[2]		Dull Center[2]	
	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F	Degrees C	Degrees F	Degrees C
January	23.2	- 4.9	25.8	- 3.4	24.2	- 4.3	23.1	- 4.1
February	26.8	- 2.9	29.4	- 1.4	25.8	- 3.4	27.6	- 2.4
March	31.0	- 0.6	33.7	0.9	33.8	1.0	32.2	0.1
April	42.7	5.9	45.1	7.3	44.4	6.1	44.5	6.9
May	52.7	11.5	54.8	12.7	54.8	12.7	54.3	12.4
June	61.9	16.6	63.5	17.5	63.4	17.4	63.4	17.4
July	71.0	21.8	72.1	22.3	71.0	21.7	72.7	22.6
August	69.6	20.9	70.6	21.4	69.2	20.7	71.0	21.7
September	58.7	14.8	59.9	15.5	59.4	15.2	59.7	15.4
October	47.7	8.7	49.1	9.5	48.0	8.9	48.7	9.3
November	33.9	1.1	36.5	2.5	34.4	1.3	34.8	1.6
December	26.2	- 3.2	29.0	- 1.7	28.2	- 2.1	26.4	- 3.1
Annual	45.4	7.4	47.4	8.6	46.4	8.0	46.5	8.1

Source: 1) NOAA, 1973, (Period, 1941-1970).

2) BLM, Converse County Unit Resource Analysis (period, 1931-1960).

TABLE 2.2: Monthly and Annual Precipitation Normals for Representative Stations.

	Casper[1]		Glenrock[1]		Douglas[2]		Dull Center[2]	
	Inches	Centimeters	Inches	Centimeters	Inches	Centimeters	Inches	Centimeters
January	.5	1.3	.5	1.3	.4	1.0	.2	.5
February	.5	1.3	.4	1.1	.5	1.0	.3	.8
March	.9	2.3	.9	2.3	.8	2.0	.6	1.5
April	1.5	3.7	1.6	4.0	1.8	4.6	1.5	3.8
May	1.9	4.9	2.3	5.9	2.3	5.8	2.3	5.8
June	1.4	3.7	2.3	5.9	1.8	4.6	2.2	5.6
July	1.0	2.4	1.0	2.7	1.3	3.3	1.5	3.8
August	.6	1.5	.8	2.0	1.1	2.8	1.2	3.1
September	.9	2.2	1.0	2.6	1.1	2.8	.9	2.3
October	.9	2.3	1.0	2.6	1.1	2.8	.8	2.0
November	.7	1.7	.6	1.4	.6	1.5	.4	1.0
December	.5	1.2	.4	1.0	.6	1.5	.3	.8
Annual	11.22	28.5	12.91	32.8	13.5	34.3	12.2	31.0

Source: 1) NOAA, 1973 (Period, 1941-1970).

2) BLM, Converse County Unit Resource Analysis (period, 1931-1960).

TABLE 2.3 Monthly Means and Extremes of Precipitation, Casper, Wyoming.

Month	Average Inches Monthly	Max. Monthly Inches	Max. Monthly Year	Min. Monthly Inches	Min. Monthly Year	Max. 24 Hr. Period Inches	Max. 24 Hr. Period Year	Snow, Ice Pellets: Mean Inches Monthly	Snow, Ice Pellets: Max. Monthly Inches	Snow, Ice Pellets: Max. Monthly Year	Snow, Ice Pellets: Max. 24 Hr. Period Inches	Snow, Ice Pellets: Max. 24 Hr. Period Year
January	0.50	0.99	1972	T	1952	0.53	1972	9.0	19.2	1972	9.7	1972
February	0.50	1.01	1955	0.15	1957	0.40	1956	9.7	23.8	1952	10.4	1952
March	0.91	2.43	1954	0.25	1953	1.00	1958	14.2	32.9	1954	14.6	1954
April	1.45	3.86	1973	0.20	1952	1.57*	1964	13.7	56.3	1973	16.5	1973
May	1.94	5.59	1971	0.30	1966	2.07	1952	1.7	23.9	1950	14.1	1950
June	1.44	3.75	1967	0.03	1956	1.67	1969	0.3	3.0	1969+	3.0	1969+
July	0.95	3.05	1951	0.11	1971	1.33	1951	0.0	0.0		0.0	
August	0.57	1.52	1972	0.02	1950	0.88	1972	T	T	1964	T	1964
September	0.87	3.28	1973	0.07	1956	2.01	1973	0.9	8.8	1965	4.5	1965
October	0.92	2.49	1962	T	1965	2.49	1962	4.7	13.1	1971	8.2	1970
November	0.68	1.30	1956	0.07	1965	0.54	1955	9.2	19.9	1956	9.7	1956
December	0.49	1.04	1955	0.30	1952	0.47	1970	8.8	17.8	1967	8.2	1953
Annual	11.22	5.59*	May 1971	T	Oct. 1965+	2.49	Oct. 1962	72.2	56.3	Apr. 1973	16.5	Apr. 1973

T = Trace (<0.01 inches). + also, on earlier dates, years, months

Length of record: 30 years (1941-1970) for means; 23 years for extremes

* 5.75" was reported in April, 1941, for maximum monthly precipitation. 3.09" was recorded in April, 1941, for a 24-hour period.

Source: NOAA, 1973

general precipitation pattern. Precipitation records published by the Wyoming State Climatologist (Lowers, 1960) and National Oceanic and Atmospheric Administration (NOAA) (1973) indicate that data shown in Tables 2.2 and 2.3 are representative of the long-term pattern over the east-central portions of the state.

Snowfall averages about 72 inches (172.8 cm) at Casper annually. A maximum of 116.8 inches (280.3 cm) was reported during the 1972-73 season, and a minimum of 33.6 inches (80.6 cm) was reported during the 1941-42 season.

Table 2.4 provides the monthly and annual mean daily variations in relative humidity at Casper which may be considered representative of the site. Although the absolute moisture of the air is normally quite low, cool temperatures keep the relative humidity at moderate levels, particularly during the winter.

WIND SPEED AND DIRECTION

Table 2.5 shows the annual wind direction-wind speed joint frequency distribution for Casper, Wyoming, obtained from the National Climatic Center Star Program for the period January, 1967, through December, 1971. Figure 2.8 presents the annual wind rose for Casper based on this distribution. Table 2.6 provides a summary of mean wind speeds and prevailing wind directions by month for the period 1941-70. Both sets of data indicate the most frequent winds, on an annual basis, are from the southwest. The mean wind speed is 13.1 miles per hour (21 km/hr), with winds during the months of December and January averaging over 16 miles per hour (26 km/hr).

Figure 2.9 presents wind direction frequency distributions collected at the Bear Creek Project for 1977 (Air Quality Permit to Modify Bear Creek Expansion CT-32, Rocky Mountain Energy Company, August, 1978). Although one may anticipate variations during a single year's monitoring program, general similarities between the short-term and the long-term Casper wind data are evident with prevailing winds from the west-southwest and adjacent sections.

TABLE 2.4: Monthly and Annual Mean Variations in Relative Humidity, Casper, Wyoming.

Month	Mean Relative Humidity* By Time of Day (LST)			
	05	11	17	23
January	67	58	61	68
February	70	57	56	70
March	72	54	48	69
April	76	50	45	70
May	77	44	39	68
June	78	42	36	66
July	71	33	26	56
August	65	30	23	51
September	69	38	32	61
October	69	46	42	65
November	70	55	58	67
December	68	59	62	68
Annual	71	47	44	65

*9-year record

Source: NOAA, 1973

TABLE 2.5: Annual Wind Speed - Wind Direction Joint Frequency Distribution for Casper, Wyoming (1967-1971).

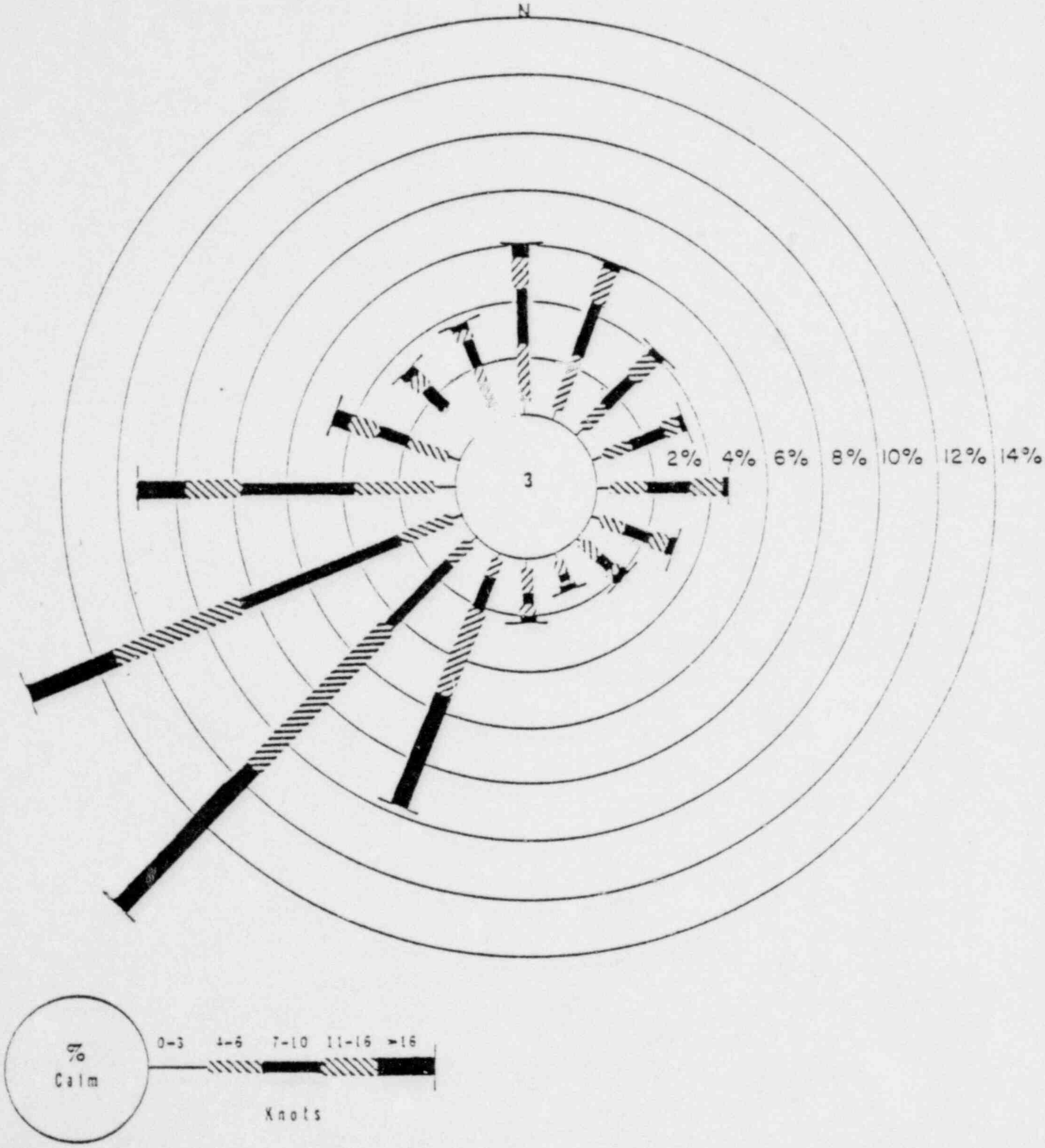
	SPEED (KTS)						
Direction	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	TOTAL
N	0.005290	0.018564	0.018085	0.011371	0.002809	0.001028	0.057146
NNE	0.003657	0.017674	0.019729	0.015002	0.003836	0.001022	0.060925
NE	0.003008	0.012741	0.015276	0.010412	0.001713	0.000274	0.043425
ENE	0.002638	0.010207	0.013769	0.006645	0.000617	0.000000	0.033875
E	0.003860	0.013495	0.016235	0.010344	0.002261	0.000137	0.046332
ESE	0.002510	0.[illegible]00111	0.010138	0.005823	0.000822	0.000069	0.028473
SE	0.002190	0.007672	0.005960	0.002124	0.000411	0.000000	0.018357
SSE	0.001823	0.005823	0.002846	0.000548	0.000137	0.000000	0.011276
S	0.003296	0.008631	0.004453	0.004042	0.001918	0.000411	0.022730
SSW	0.002216	0.006576	0.013015	0.031785	0.026784	0.014797	0.095174
SW	0.002958	0.009933	0.029593	0.067475	0.050418	0.022537	0.182944
WSW	0.004476	0.019455	0.057063	0.053706	0.022469	0.009864	0.167032
W	0.007816	0.027812	0.043020	0.021236	0.009659	0.005275	0.114617
WNW	0.004172	0.014865	0.012399	0.009796	0.004247	0.001165	0.046644
NW	0.003126	0.011782	0.010070	0.006302	0.002398	0.000411	0.034089
WNW	0.004271	0.016372	0.010001	0.004727	0.001028	0.000343	0.036741
TOTAL	0.057337	0.210713	0.281751	0.261337	0.131525	0.057337	

Total Relative Frequency of Observations = 1.000000

Total Relative Frequency of Calms Distributed Above = 0.027881

Source: NOAA (Star Program), 1973

FIGURE 2.8: Wind Rose for Casper, Wyoming for the Period 1967 through 1971, Annual Average Conditions



Source: NOAA (Star Program), 1973

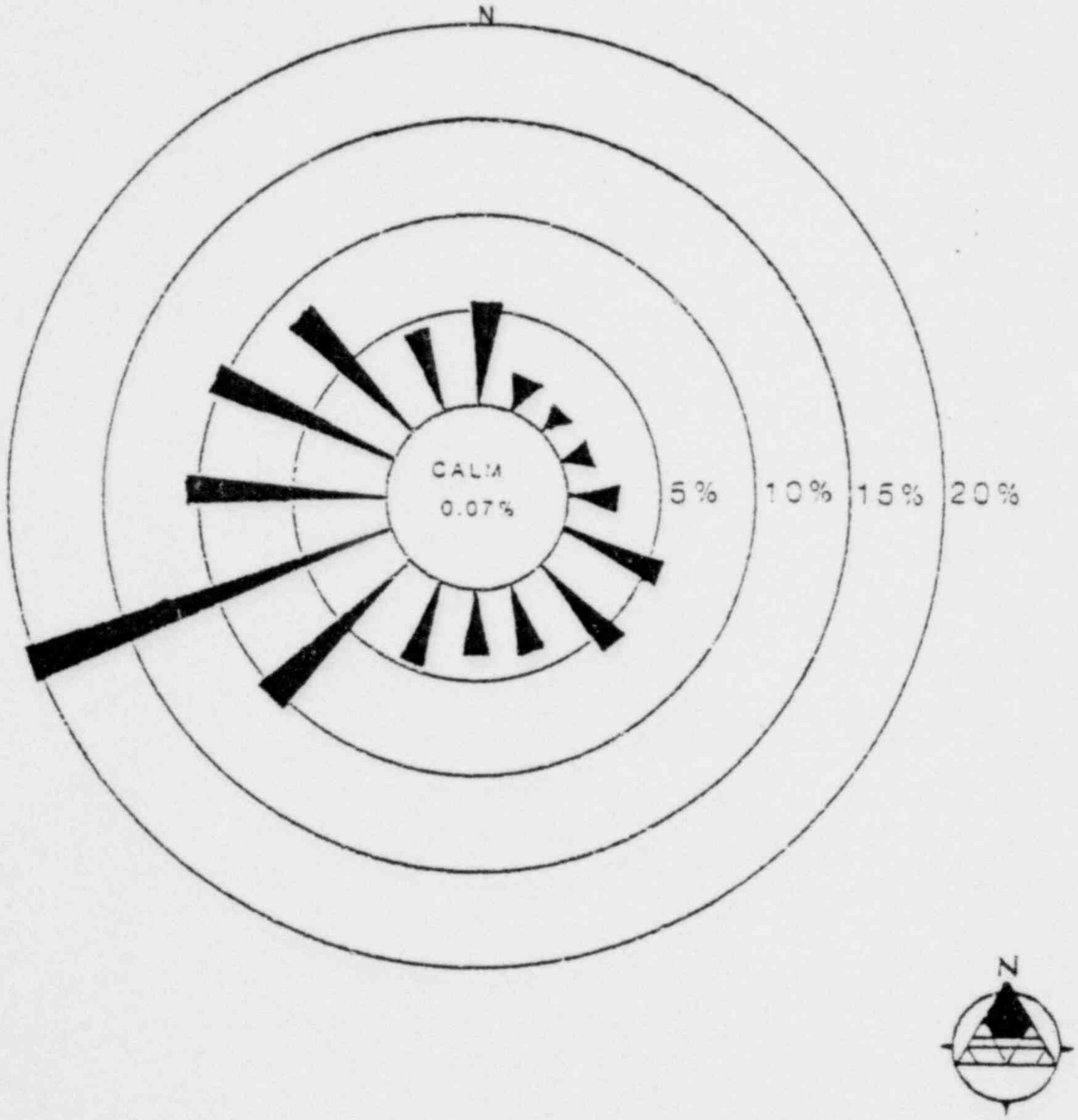
TABLE 2.6: Summary of Mean Wind Speed Prevailing Direction and Fastest Mile by Month for Casper, Wyoming.

Month	Mean Speed(MPH)	Prevailing Direction	Fastest Mile Speed (MPH)	Fastest Mile Bearing (Degrees)	Fastest Mile Year
January	16.9	SW	58	20	1954
February	15.1	SW	58	23	1957
March	14.1	SW	81	25	1956
April	13.0	WSW	54	25	1967
May	11.8	WSW	58	32	1959
June	11.1	WSW	52	36	1959
July	10.0	WSW	52	21	1973
August	10.4	SW	50	25	1954
September	11.3	WSW	53	32	1965
October	12.4	SW	55	25	1954
November	14.7	SW	49	25	1970
December	16.3	SW	63	20	1955
Year	13.1	SW	81	25	Mar. 1956

Length of Record: 23 years for mean speed and prevailing direction; 20 years for fastest mile

Source: NOAA, 1973

FIGURE 2.9: Wind Frequency Distribution 1977, for the Bear Creek Mill Expansion, Converse County, Wyoming.



Source: RMEC, Bear Creek, 1978

SIGNIFICANT WEATHER FACTORS

There are no significant mountain ranges to the east and north of the Test Site. Therefore, arctic air masses can move over the area, perhaps several times a month, particularly in winter. The arctic air masses can be accompanied by blizzard conditions, strong northerly winds, abrupt temperature changes, and falling snow. As a general rule, the cold arctic air masses modify rapidly after they reach Wyoming (Lowers, 1960). The water content of winter snow is low because of the cold temperatures at which it usually occurs. Also, the very dry, strong westerly and southwesterly winds that follow winter storms tend to clear the snow from the ground within several days.

The Test Site lies in an area where, based on the data for 1953 through 1962 provided by Thom (1963), the mean annual frequency of tornadoes is 0.4 in the one-degree square of latitude and longitude. Using those data and applying Thom's methods (Thom, 1963), the probability of a tornado striking a point in any year within this one-degree square is calculated at 0.00032, and the recurrence interval (R = 1/P) is about 3,100 years.

During the spring and summer, thunderstorms are frequent in Wyoming. As a rule, the related precipitation only amounts to a few hundredths of an inch. However, several heavy local storms occur each year which can be expected to produce one or two inches (2.5 to 5 cm) of rain in a single day. On some occasions from three to five inches (7.5 to 12.5 cm) of rain have fallen in 24 hours (Lowers, 1960). The maximum precipitation reported to have fallen within 24 hours at Casper was 3.09 inches (7.8 cm) in April, 1941. Lowers (1960) indicates that the principal damage from thunderstorms in the state results from hailstones, however, most hailstorms pass over the open rangeland where damage is minimal.

Strong winds that are related to thunderstorm activity in the spring and summer and intense arctic outbreaks in the winter can occur. The strongest winds reported at Casper were 81 mph (130 km/hr) in March, 1956. Based on Thom's computations (1968), the mean recurrence interval for wind speeds 30 feet above the ground is estimated for the Test Site area as follows:

Maximum Speed (mph)	65	70	85	90	100
Maximum Speed (km/hr)	105	113	137	145	161
Recurrence Interval (years)	2	10	25	50	100

Table 2.7 presents the estimated maximum precipitation at any given location on the R&D Site (point precipitation) for specific durations and recurrence intervals using technical procedures outlined by Hershfield (1961) and Miller (1964).

2.9 RADIOLOGY

A radiological survey of background gamma radiation was performed at the R&D Site in November, 1979. In addition, laboratory testing of soil samples was performed to determine concentrations of radium-226 and uranium. The gamma radiation survey was conducted on a grid system with readings taken at 125 foot (38 m) intervals. Measurements were taken at 112 locations. The readings were taken at a height of three feet (1 m) above the ground surface.

Samples of the Fort Collins and Tassel soils identified at the R&D Site were collected for analysis of radium-226 and natural uranium. Care was taken to obtain samples which were truly representative of existing conditions and to handle the samples so as to prevent contamination before they reached the laboratory. In the laboratory the samples were composited to depths of six feet (2 m) and 18 inches (0.5 m), respectively, to the bedrock material. Testing of the samples was then completed. Descriptions of the laboratory procedures are given in Appendix C.

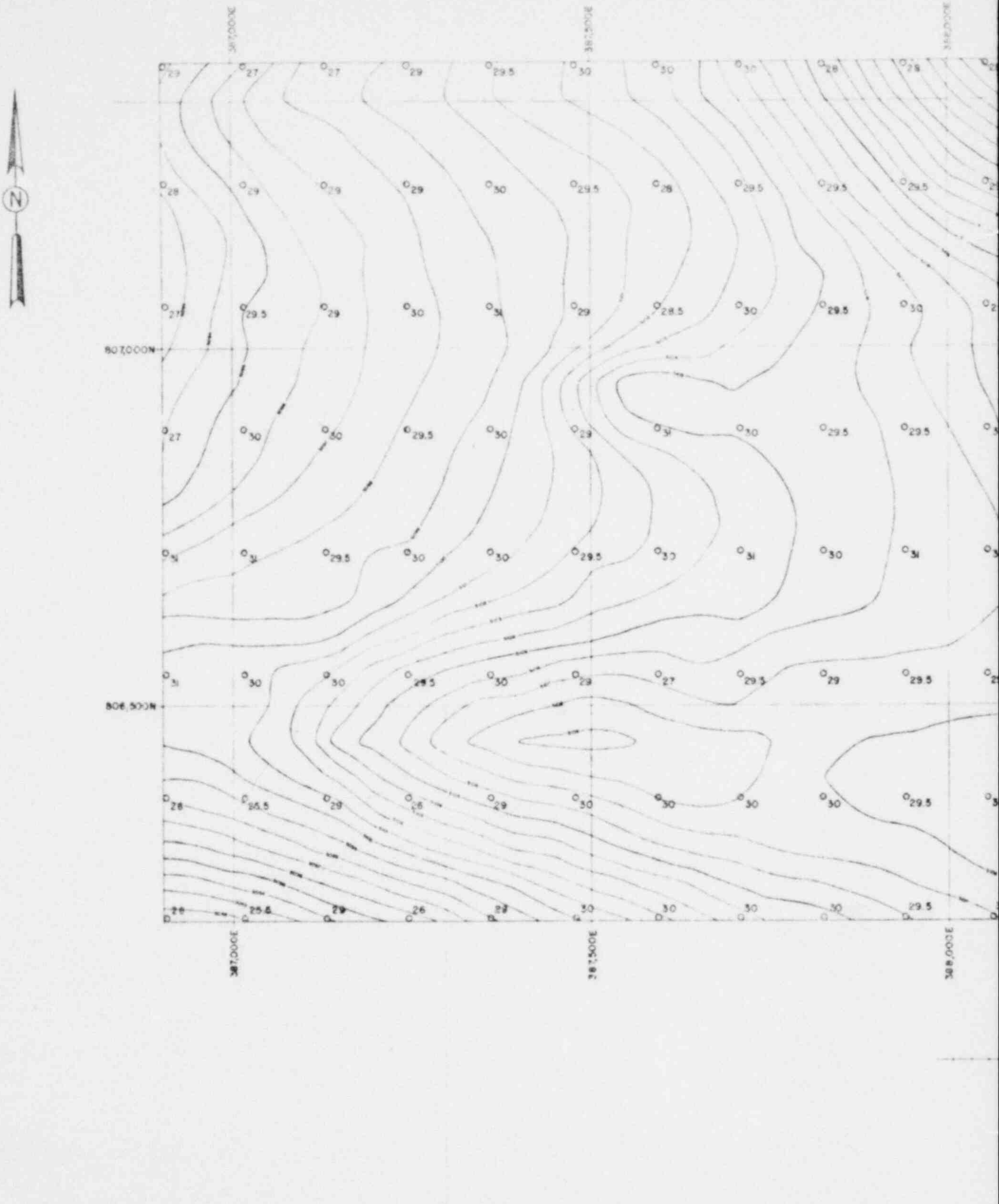
GAMMA RADIATION SURVEY

The dosage was measured utilizing a Ludlum Model 12 micro Roentgen (R) instrument with a Model 44-2 high energy gamma scintillator 1" x 1" NaI (Tl) detector. The dosage measurements for the R&D Site are presented in Figure 2.10. A statistical summary of the data is presented in Table 2.8. The range of activities is from 26 to 31 micro R/hour with a mean of 29.11 micro R/hour and a standard deviation of 1.35 micro R/hour.

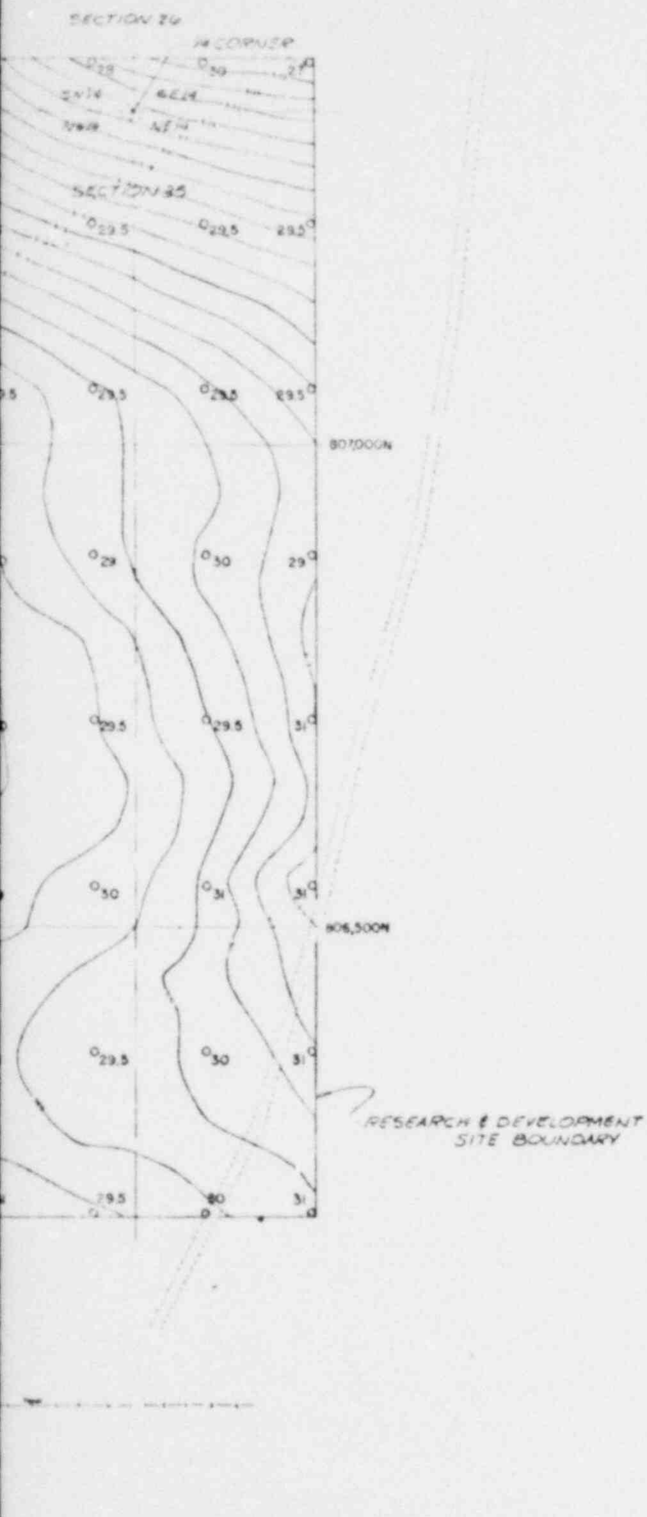
TABLE 2.7: Estimated Maximum Point Precipitation (Inches) for Selected Durations and Recurrence Intervals for the Peterson Property.

	Recurrence Interval (Years)				
Duration	2	10	25	50	100
1 hour	.9	1.4	1.8	2.0	2.3
12 hour	1.5	2.4	2.8	3.2	3.6
24 hour	1.7	2.8	3.2	3.6	4.0
2 day	1.8	3.0	3.6	4.0	4.5
7 day	2.5	3.9	4.5	5.4	5.8
10 day	2.8	4.1	5.0	5.6	6.4

Sources: Hershfield, 1961; Miller, 1964.



REV	DATE	REVISION	DR CH	APP	REV	DATE	REVISION	DR CH	APP



0 100 200 300 FEET

LOCATION MAP

0 4000 8000 12000 FEET

LEGEND

EXISTING CONTOURS

EXISTING ROADS

GAMMA RADIATION SAMPLING POINT AND BASELINE VALUE (MICRO R/HR)

NOTES

1) THE COORDINATES USED ARE AS PER WYOMING STATE COORDINATE SYSTEM

2) CONTOUR INTERVALS = 1'

REFERENCE DRAWINGS

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

INTERNATIONAL ENVIRONMENTAL CONSULTANTS
GOLDEN, COLORADO

GAMMA RADIATION ON TEST SITE

PETERSON IN-SITU URANIUM EXTRACTION PROJECT

PROJECT NO. 85900

FIGURE NO. 2.10

Background gamma scintillation measurements were also taken at Douglas and Glenrock, Wyoming. The measurements ranged from 24 to 26 micro R/hour at Douglas and 22 to 24 micro R/hour at Glenrock. As shown by Figure 2.10, the measurements taken at the Test Site are only slightly above the two background sites.

TABLE 2.8 Scintillator Survey - Statistical Summary.

Sample Population (N)	112
Mean ($\tilde{X}$)	29.11 micro R/hour
Variance	1.81 micro R/hour
Standard Deviation	1.35 micro R/hour

These data compare favorably with those gathered for other R&D in situ projects in the Wyoming area. In order to compare the data, the measurements presented in this report were converted to counts per second (cps). The data in the open literature could not be converted to micro R/hour as the calculation is dependent upon the geometry and calibration of the detector which was not known.

The background activities measured at Douglas and Glenrock ranged from 55 cps to 65 cps. Site survey readings reported in the literature ranged from 50 cps to 75 cps. Readings ranging from 65 to 75 cps were reported for the Test Site. The slight variation of the data gathered for this survey versus that in the literature may be due to the differences in geometry, instrument efficiency and distance from the ground for each point measured. There were no anomalies detected in the readings. An anomalous measurement is considered to be twice the background level.

RADIOCHEMICAL ANALYSIS OF SOILS

The soils data presented in Table 2.9 for natural uranium and radium-226 indicate no unusual activities. The soils collected were of the two upland types defined in Section 2.6, herein. Sample No. NAC #1 Fort Collins was collected from an existing trench, while Sample No. NAC #2 Tassel was collected from a trench excavated at the time of the survey.

TABLE 2.9: Natural Uranium and Radium-226 in Soils.

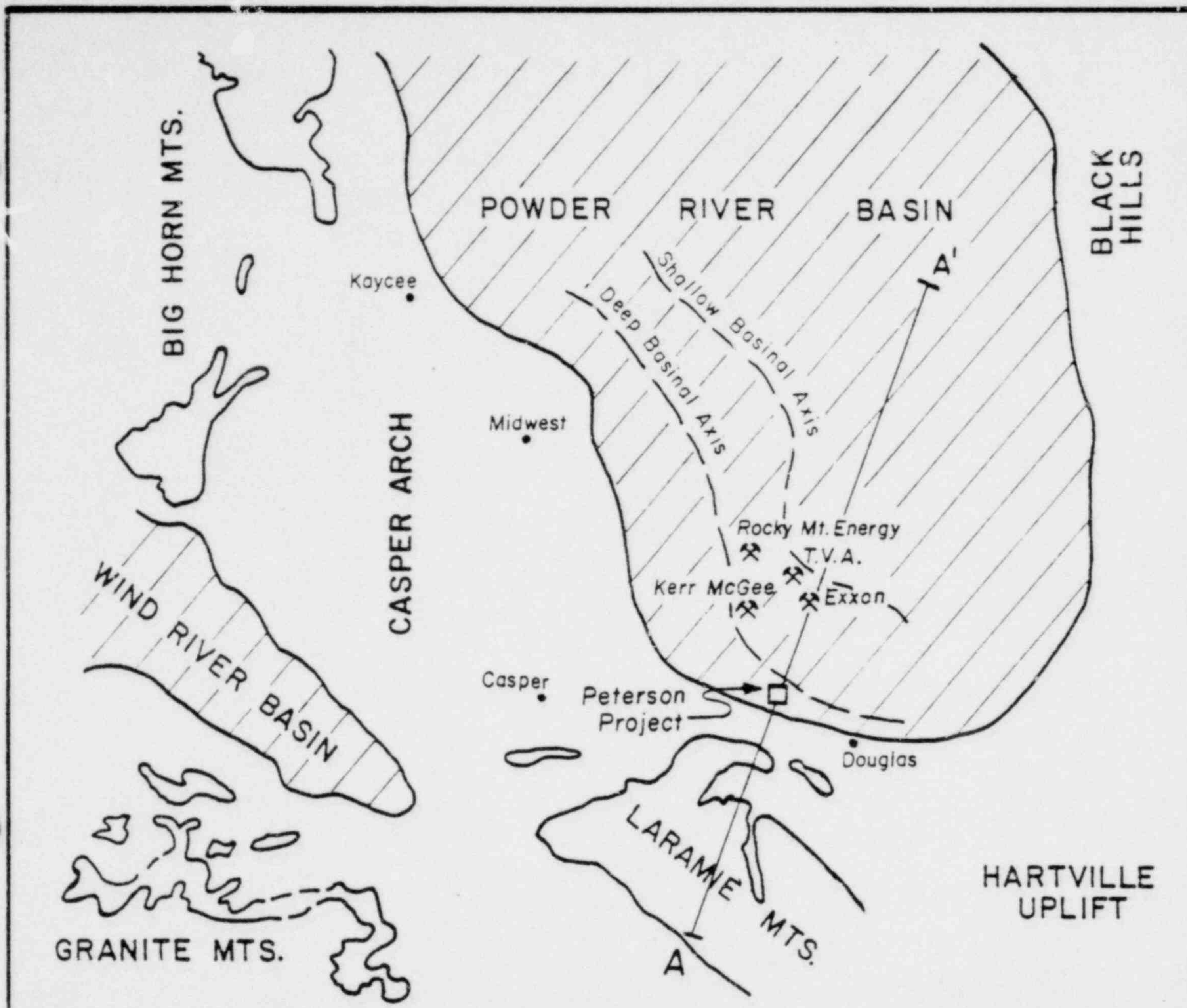
Sample Identification	Date Collected	Natural Uranium ug/gm	Radium-226 pCi/gm (dry)
NAC #1 Fort Collins	11/7/79	1.90	1.6 ± 0.6
NAC #2 Tassel	11/7/79	0.46	2.2 ± 0.5
		$\bar{X}$ = 1.18	$\bar{X}$ = 1.9 ± 0.6

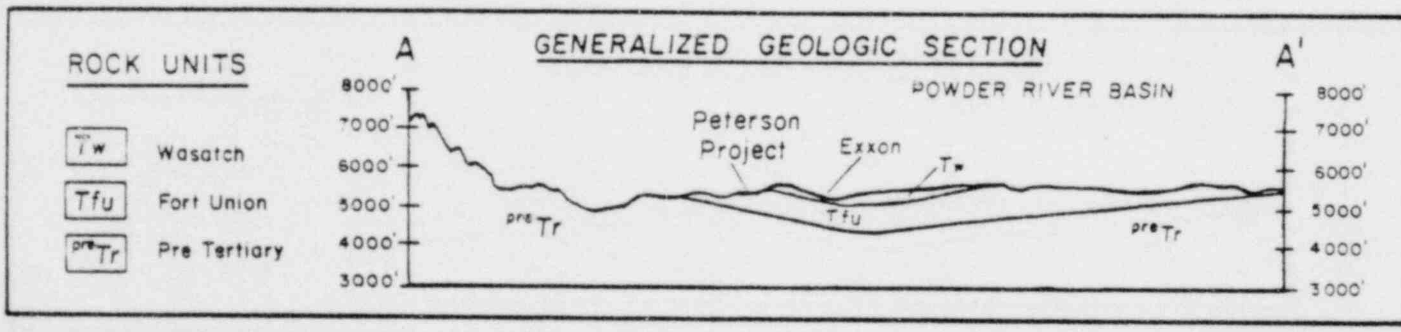
2.10 GEOLOGY

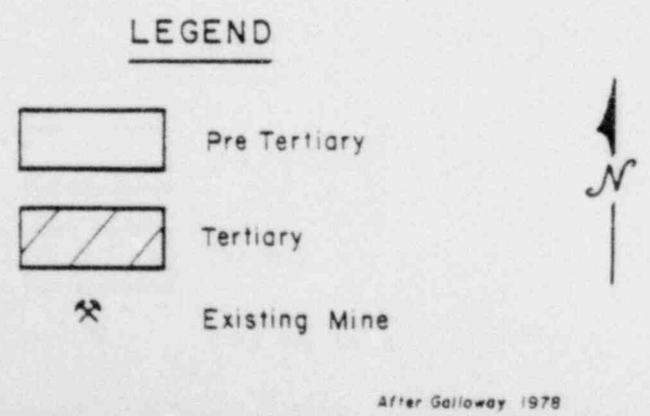
REGIONAL GEOLOGY

The R&D Site is located near the southern margin of the Powder River Basin, a large structural and physiographic basin which is almost completely surrounded by structural highlands which predate the Tertiary sedimentary rocks within the depression. The basin is bounded on the south by the Laramie Range and the Hartville Uplift, on the east by the Black Hills and on the west by the Big Horn Mountains and Casper Arch. Toward the north the Powder River drains a large portion of the basin through a low structural saddle (Figure 2.11).

The basin is underlain by continental sedimentary rocks of the Eocene Wasatch and underlying Paleocene Fort Union Formations. These units crop out as a band around the periphery of the basin and dip gently basinward. Older rock units of Cretaceous and Paleozoic Age occur in discontinuous outcrops around the margins of the basin. Consolidated post-Wasatch units are generally grouped into the White River Formation of Oligocene Age. The White River Formation is generally limited to erosional remnants in the Pumpkin Buttes area near the center of the basin and along the eastern and southern margins of the basin.







ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	REGIONAL GEOLOGIC FEATURES		
	PREPARED BY: B. J. Hoover	DATE: Feb. 25, 1980	
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED:	DATE:	
	DRAWN BY: J. E. Gronwall	DATE: Feb. 27, 1980	
	SCALE: 1:1,500,000	FIGURE NO. 2.11	
	CONTOUR INTERVAL: N/A		

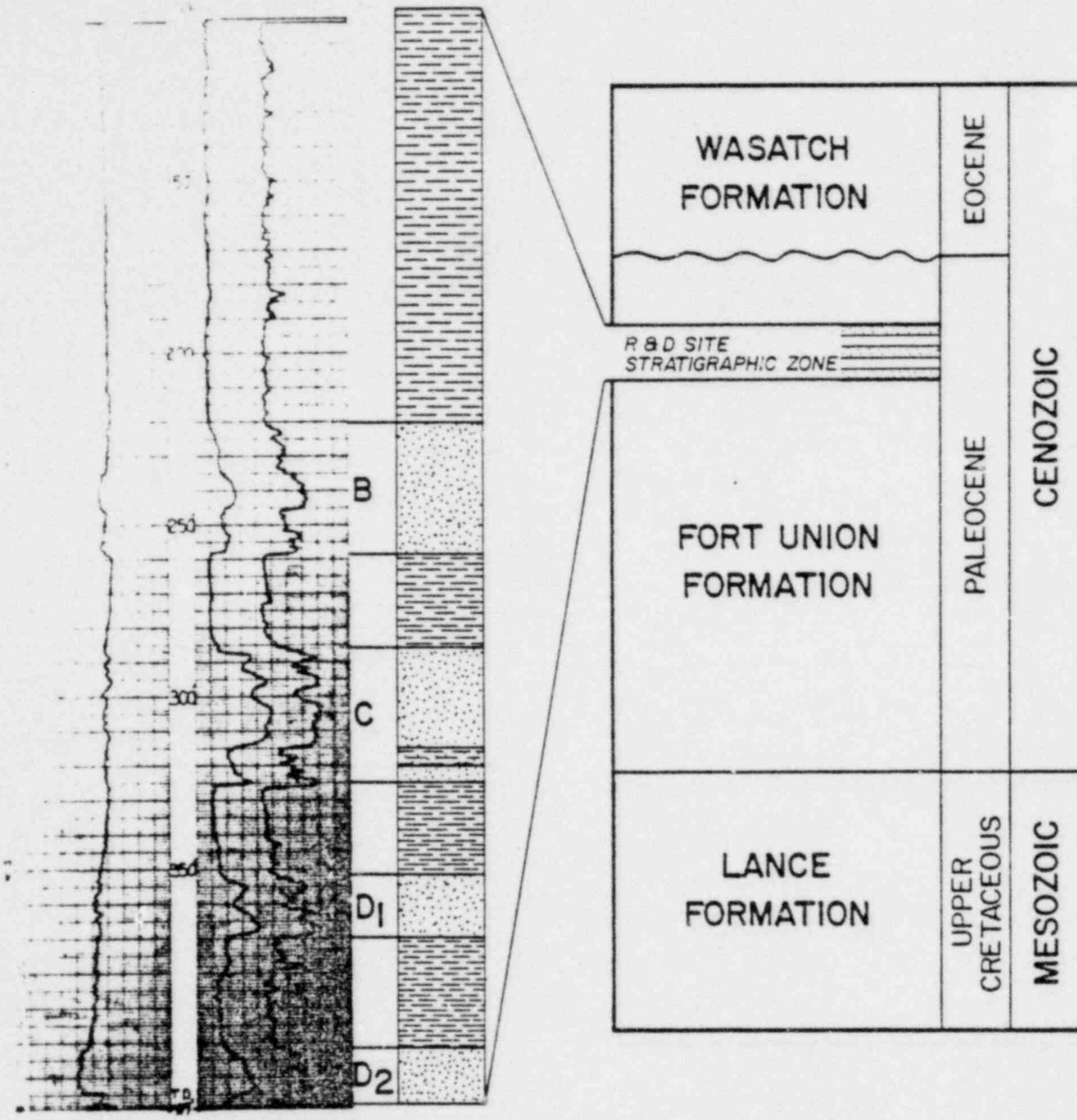
The southern portion of the Powder River Basin, including the Test Site, has been structurally stable since at least early Wasatch time. The dips of the beds in the Wasatch Formation throughout the area range from less than 1.0 degree to as much as 2.5 degrees basinward on the southern, eastern and western fringes. Portions of the Fort Union Formation dip basinward from less than 1.0 degree to, locally, as high as 20.0 degrees.

Structurally, the basin is a north-south oriented asymmetrical syncline with the projected axis trending through the Peterson Project. The depositional axis of the basin trends in a generally northerly direction and is, in part, slightly offset to the east of the axial trace as measured in the "basement" of pre-Cretaceous rocks. The position of the basin's axis has influenced the position and depositional pattern of the sedimentary rocks in the area since pre-Tertiary time.

STRATIGRAPHY

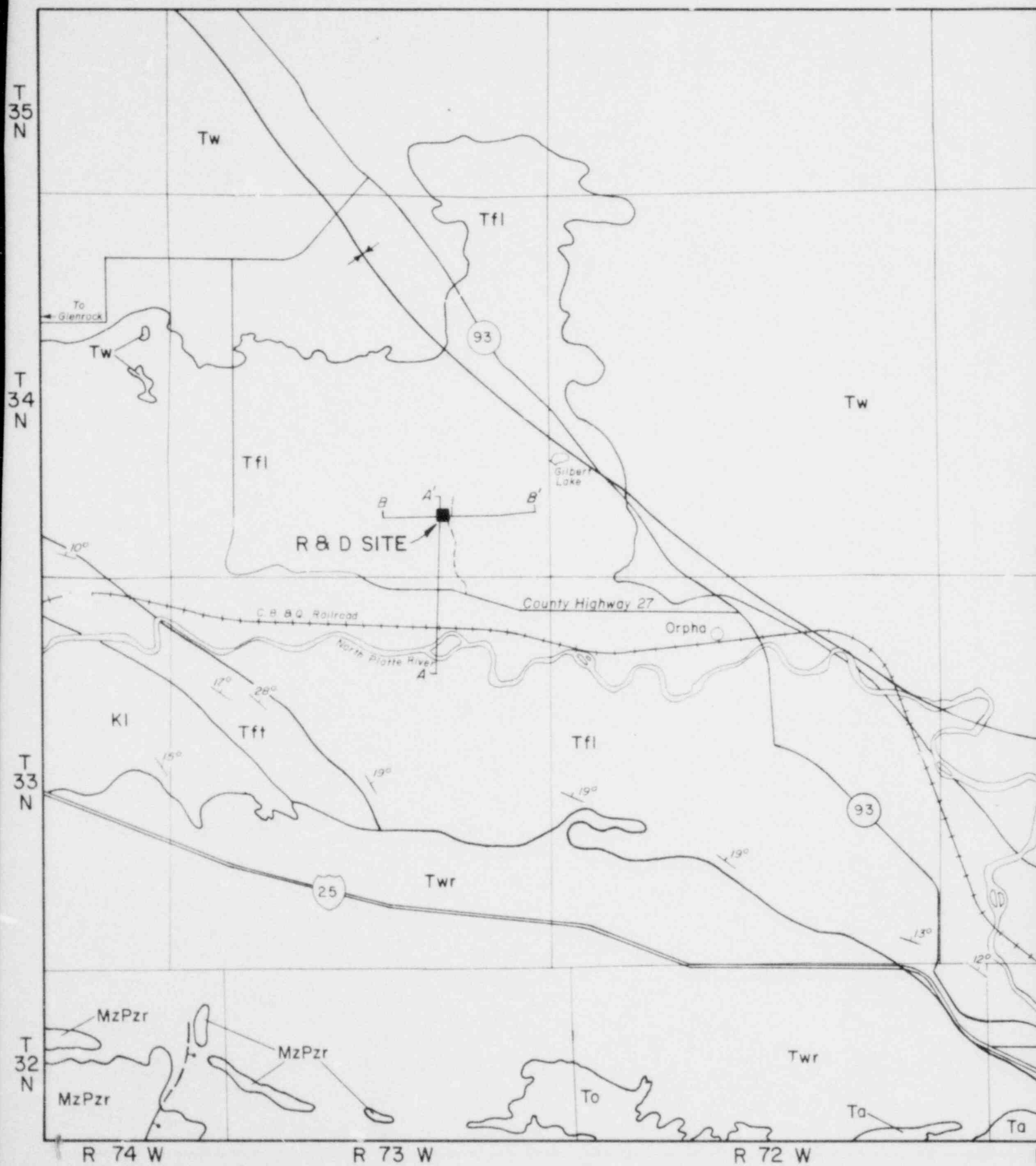
The stratigraphy of the surface rocks of the Powder River Basin and the R&D Site is summarized below. Figure 2.12 presents a stratigraphic column for the basin. A geologic map of the vicinity of the R&D Site is given in Figure 2.13. Geologic sections showing the geology in the near vicinity of the site are shown in Figures 2.14 and 2.15. Details of the geology of the R&D Site are given in Figure 2.16.

1. Lance Formation. The Lance Formation, of Cretaceous Age, is the oldest unit that crops out in the vicinity of the Test Site. Because the Lance Formation is not known to host appreciable uranium deposits in the immediate area and lies at a depth approximately 3,000 to 4,000 feet (915 to 1,220 m) below the land surface at the site, a detailed description is not given for this unit. The Lance Formation is approximately 3,000 feet (915 m) thick in the vicinity of the site and comprises thinly bedded, brown to gray sandstones and shales. The uppermost portion of the unit contains numerous thin coal seams and dark carbonaceous beds representing a marginal marine depositional environment.

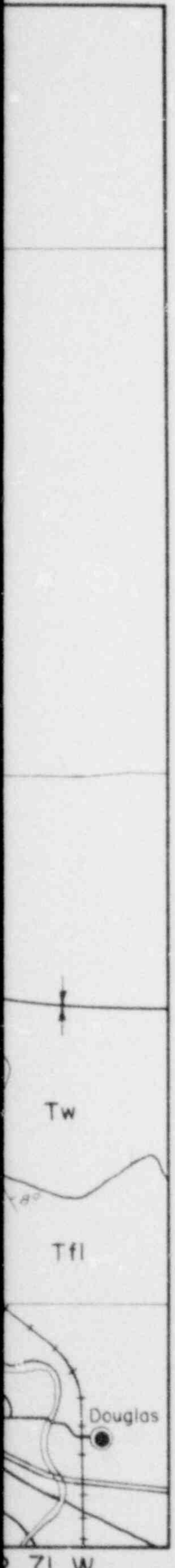


TYPICAL LOG RESPONSE

ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	GENERALIZED STRATIGRAPHIC COLUMN	
	PREPARED BY: B.J. Hoover	DATE: Feb. 27, 1980
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED:	
	DRAWN BY: A.E.M. (2-27-80)	
	SCALE: (LOG) 1" = 50'	FIGURE No. 2.12
	CONTOUR INTERVAL: N/A	



After Denson and Horn (1975)



LEGEND

CENOZOIC	TERTIARY	PLIOCENE & U. MIOCENE	To	OGALLALA FORMATION — *Poorly cemented calcareous claystone, siltstone, sandstone and conglomerate of fluviatile origin.*
				Unconformity
CENOZOIC	TERTIARY	LOWER MIOCENE	Ta	ARIKAREE FORMATION — *Very fine grained, poorly bedded sandstone containing trace amounts of magnetite; some siltstone and limestone predominately of eolian and volcanic origin.*
				Disconformity
CENOZOIC	TERTIARY	OLIGOCENE	Twr	WHITE RIVER FORMATION — *Interbedded tuffaceous siltstone and conglomerate, of eolian and fluviatile origin.*
				Unconformity
CENOZOIC	TERTIARY	LOWER EOCENE	Tw	WASATCH FORMATION — *Conglomeratic to fine-grained arkosic sandstone, siltstone, carbonaceous shale, and coal, all of fluviatile and paludal origin.*
				Unconformity
CENOZOIC	TERTIARY	PALEOCENE	Tfl	FORT UNION FORMATION — LEBO MEMBER — *Very fine grained-conglomeratic sandstone interbedded with siltstone, claystone, carbonaceous shale, and coal; all of fluviatile and paludal origin.*
CENOZOIC	TERTIARY	PALEOCENE	Tft	TULLOCK MEMBER — *Very fine to conglomeratic interbedded sandstone, siltstone, shale, carbonaceous shale and thin coal beds of fluviatile and paludal origins.*
PALEOZOIC & MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	Kl	LANCE FORMATION — *Dark shale and massive lenticular concretionary sandstone with thin coal beds in lower half.*
PALEOZOIC & MESOZOIC		PERMIAN TO CAMBRIAN	MzPzr	*Sedimentary rocks: Shale, siltstone, sandstone, conglomerate anhydrite, dolomite, and limestone of continental and marine origin.*

Contact

Fault

Syncline

10° Strike & dip of beds

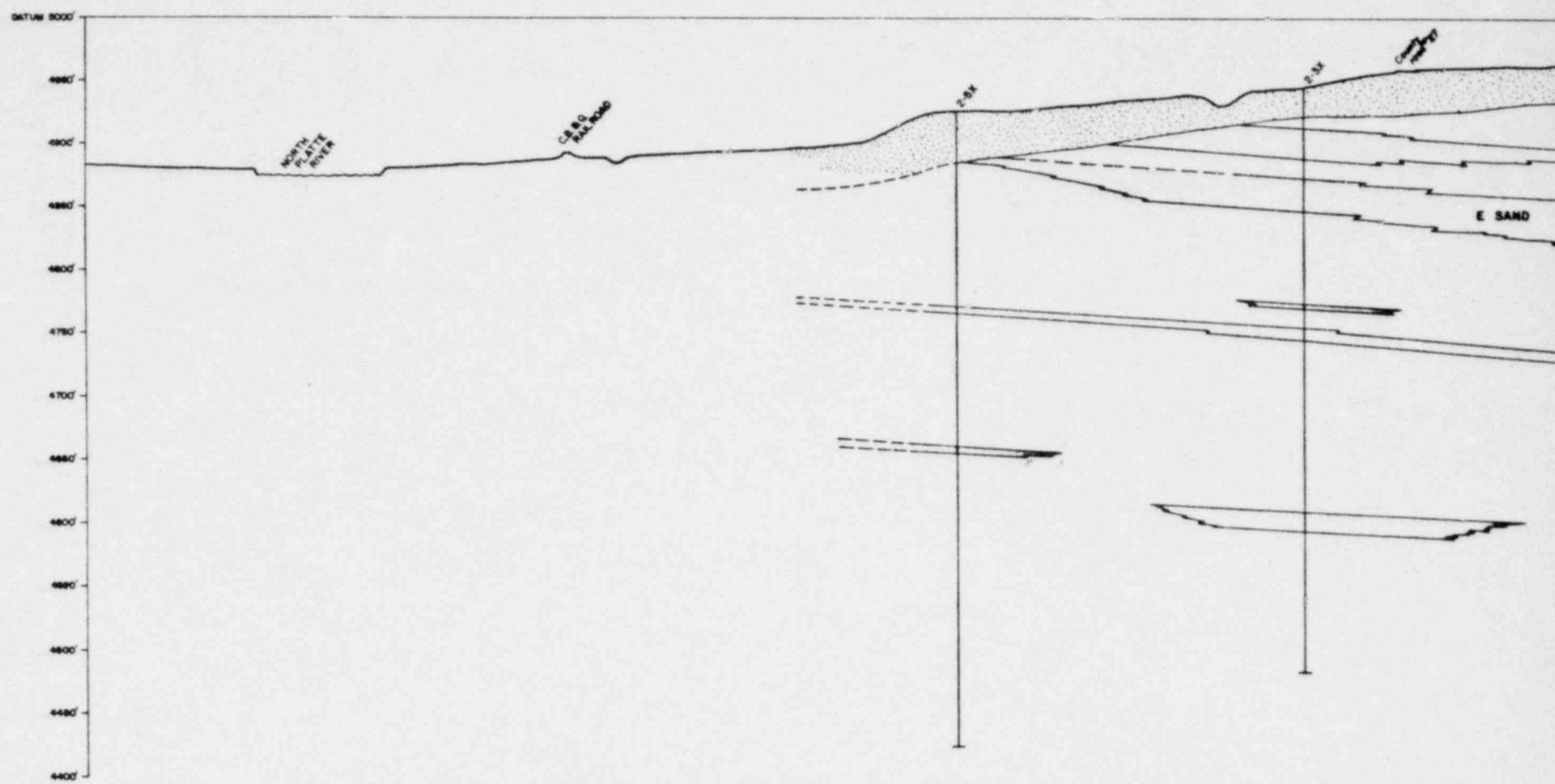
A A′ Cross section location (Section C-C′ is within the R&D site. See cross section C-C′ for location)

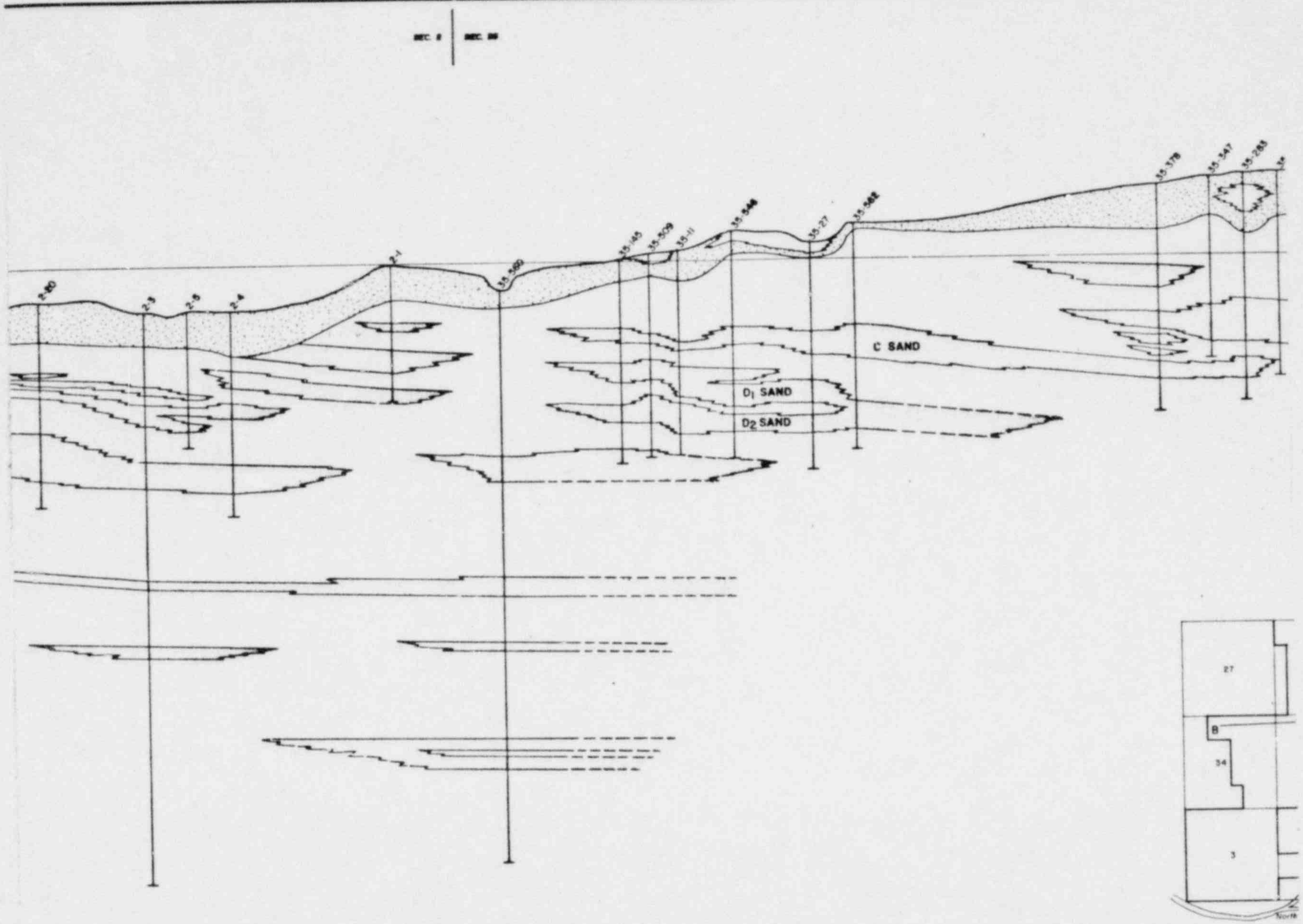
N

ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	VICINITY GEOLOGIC MAP	
	PREPARED BY: B. J. Hoover	DATE: Feb. 25, 1980
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED:	
	DRAWN BY: A. Mayhew	DATE: Feb. 29, 1980
	SCALE: 1" = 2 miles	FIGURE No. 2.13
	CONTOUR INTERVAL: N/A	

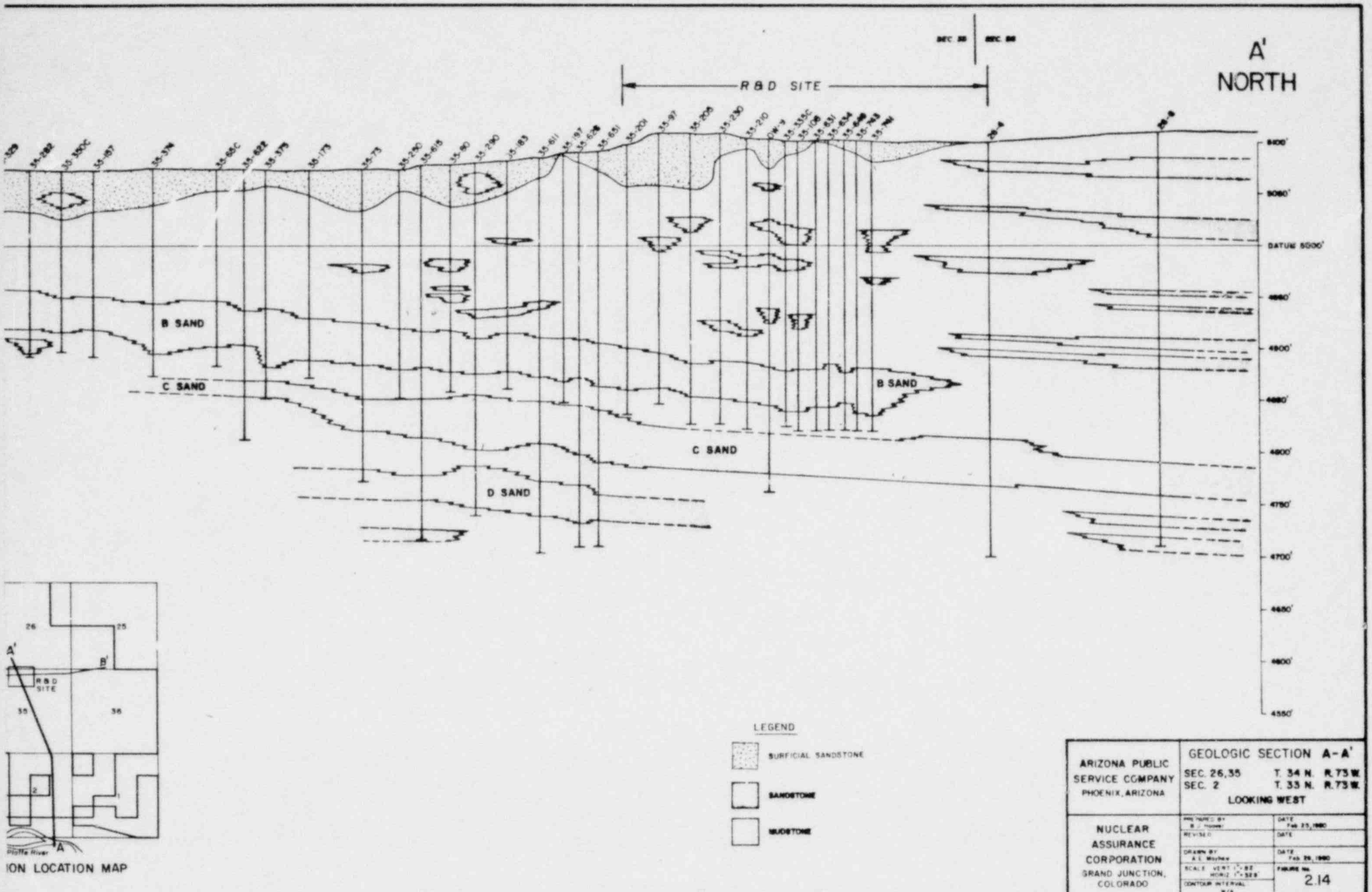
A

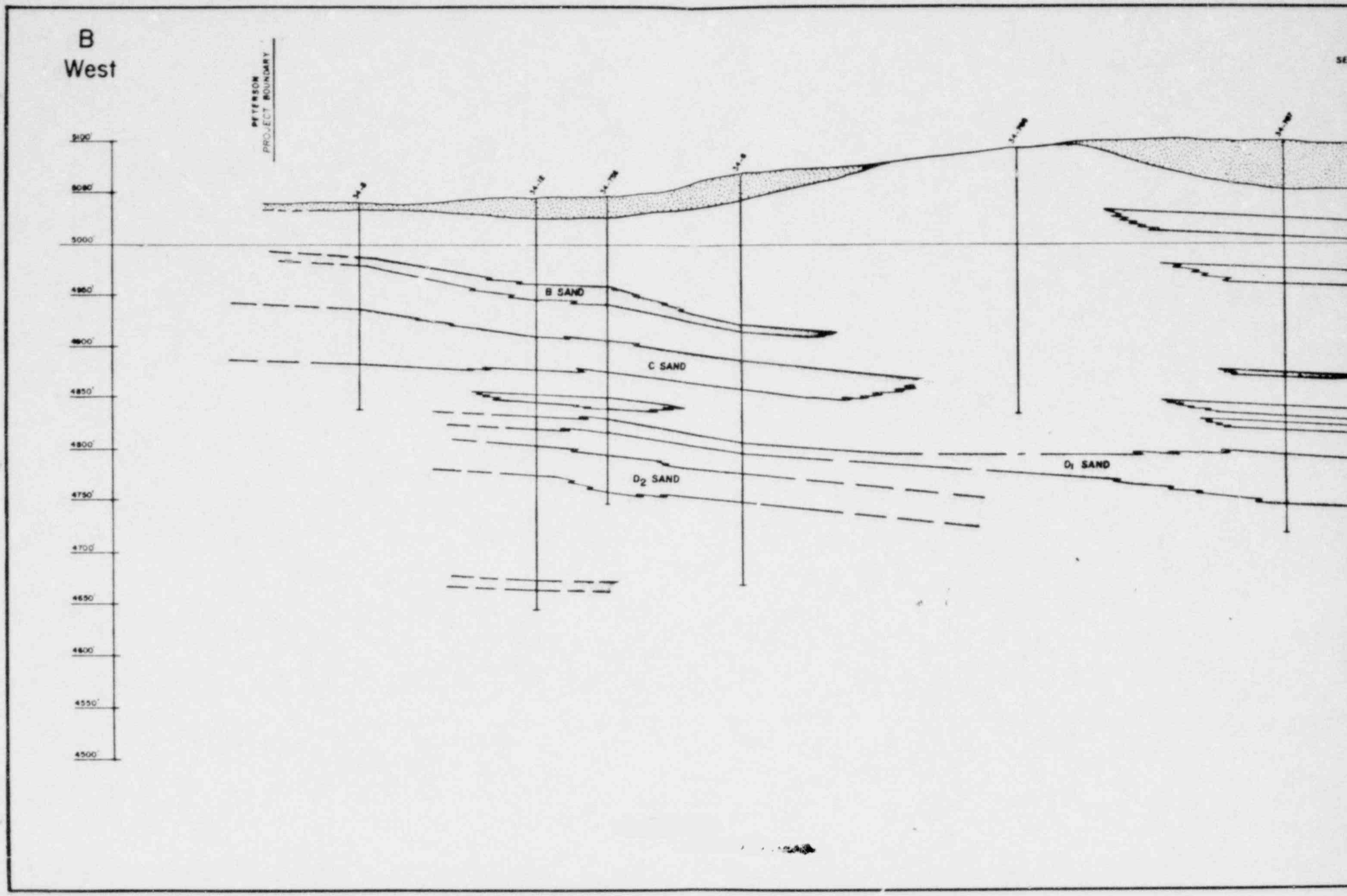
SOUTH

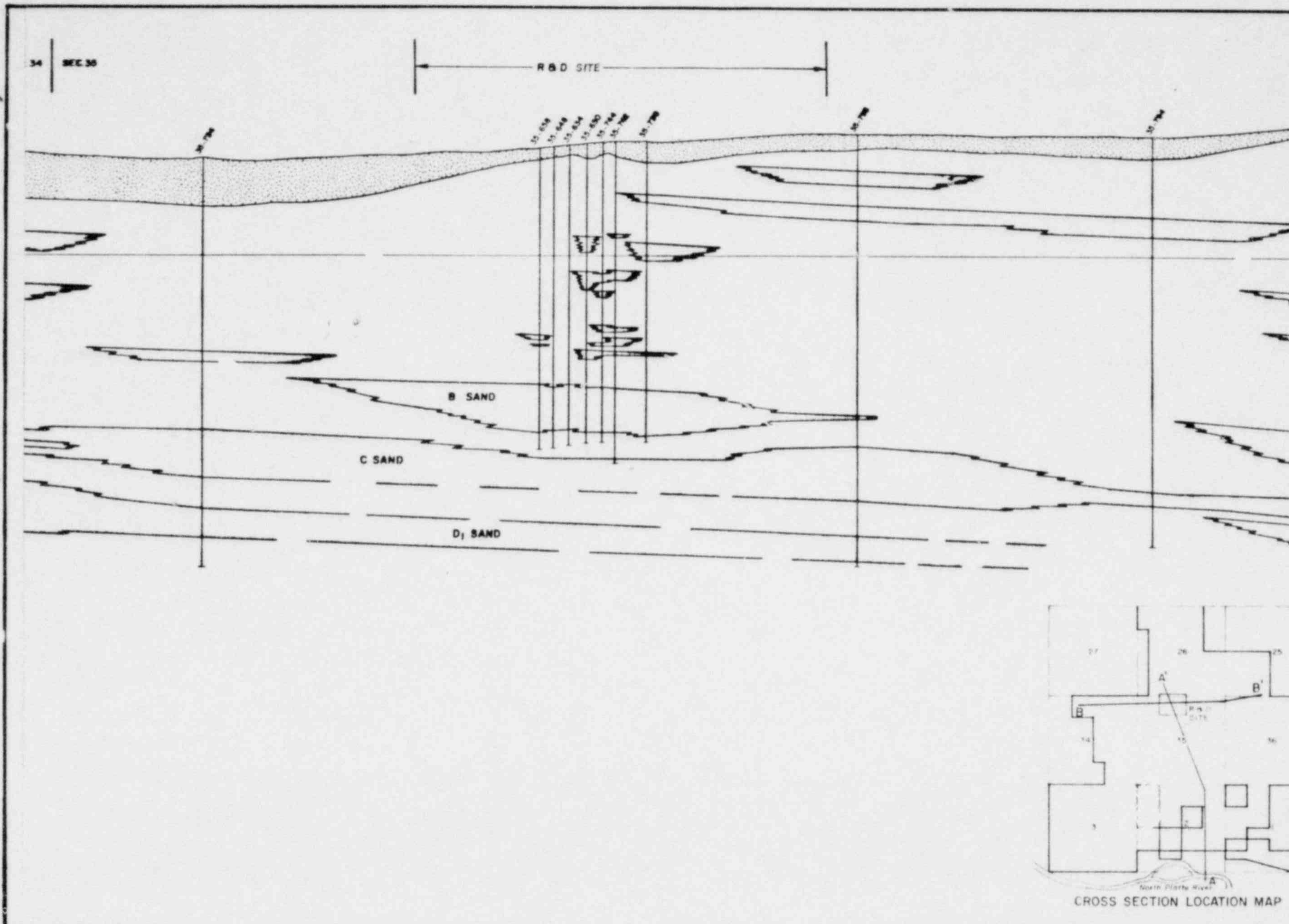

DATUM 5000'
4900'
4800'
4750'
4700'
4600'
4500'
4400'
NORTH PLATTE RIVER
C.B.&Q. RAIL ROAD
2-6X
2-5X
E SAND



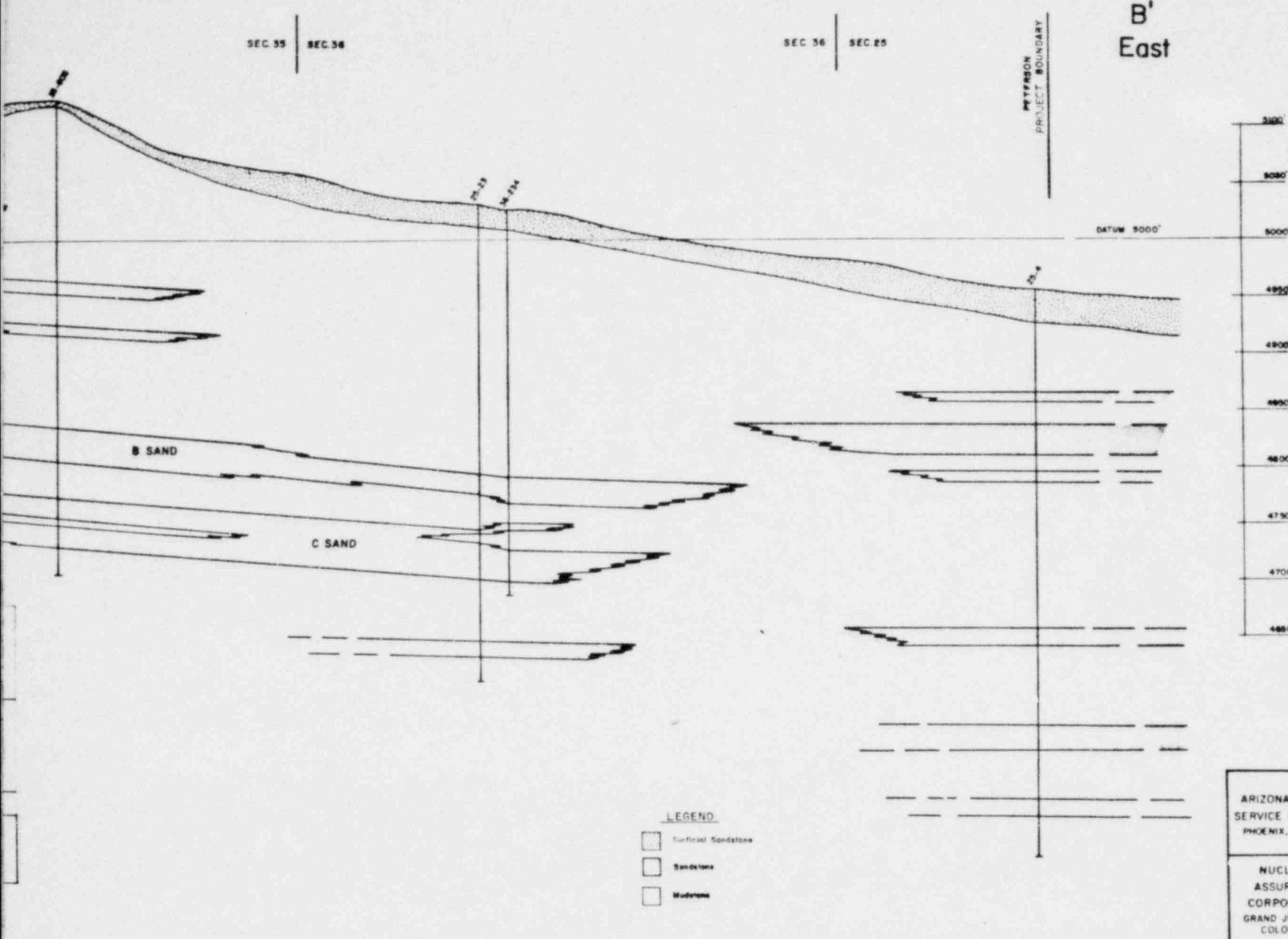
CROSS SECTI


A'
NORTH
R&D SITE
B SAND
C SAND
D SAND
DATUM 5000'
LEGEND
SURFICIAL SANDSTONE
SANDSTONE
MUDSTONE
ION LOCATION MAP
ARIZONA PUBLIC
SERVICE COMPANY
PHOENIX, ARIZONA
GEOLOGIC SECTION A-A'
SEC. 26,35 T. 34 N. R. 73 W.
SEC. 2 T. 33 N. R. 73 W.
LOOKING WEST
NUCLEAR
ASSURANCE
CORPORATION
GRAND JUNCTION,
COLORADO
2.14


B
West
PETERSON
PROJECT BOUNDARY
5100'
5050'
5000'
4950'
4900'
4850'
4800'
4750'
4700'
4650'
4600'
4550'
4500'
B SAND
C SAND
D2 SAND
D1 SAND



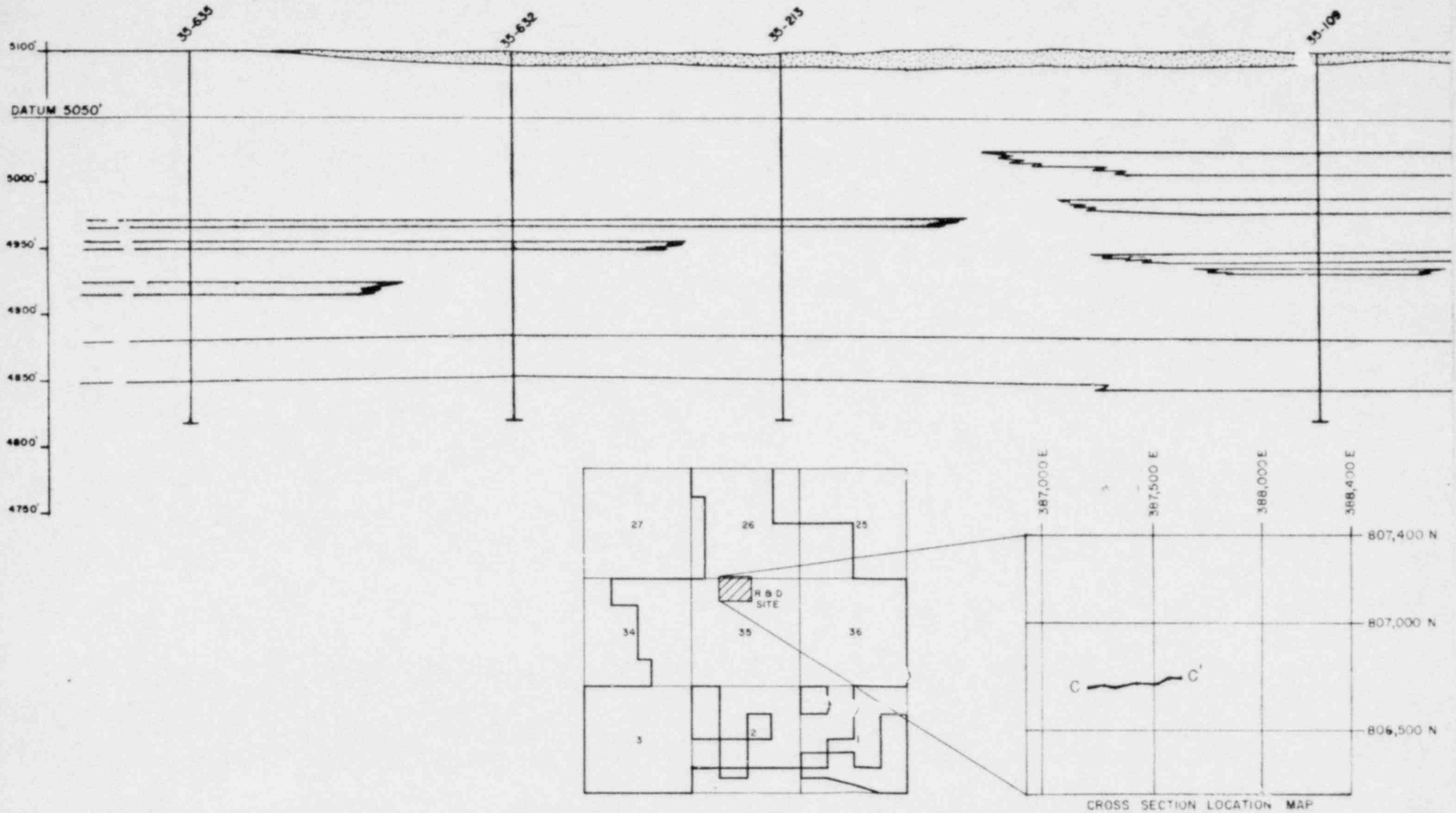
CROSS SECTION LOCATION MAP

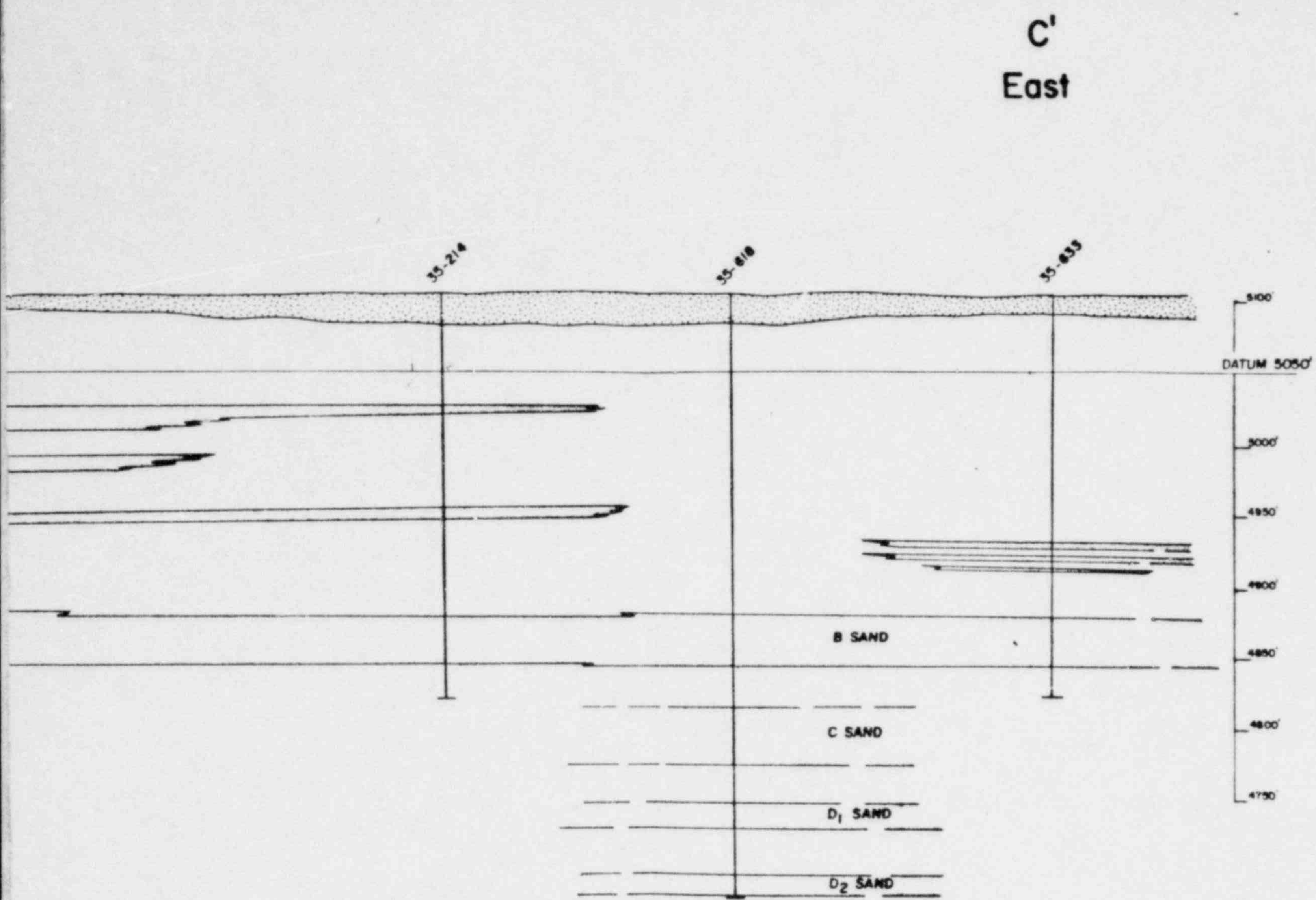


ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	GEOLOGIC SECTION B-B' SEC. 25, 34, 35, 36 T. 34 N. R. 73 W. LOOKING NORTH
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	PREPARED BY B.J.H. — DATE Feb 25, 1980; REVISED — DATE; DRAWN BY J.E.G. — DATE Feb 26, 1980; SCALE VERT 1"=82' HORIZ 1"=328'; CONTOUR INTERVAL N/A — FIGURE NO. 2.15

C

West


35-635
35-632
35-213
35-109
5100'
DATUM 5050'
5000'
4950'
4900'
4850'
4800'
4750'
27
26
25
34
35
36
3
2
1
R & D SITE
387,000 E
387,500 E
388,000 E
388,400 E
807,400 N
807,000 N
806,500 N
C
C'
CROSS SECTION LOCATION MAP



LEGEND

- Surficial Sandstone
- Sandstone
- Mudstone

ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	GEOLOGIC SECTION C-C' SEC 35 T 34N. R73W. LOOKING NORTH	
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	PREPARED BY B.J. Hoover	DATE Feb 25, 1980
	REVISED	DATE
	DRAWN BY J.F. Gronwell	DATE Feb 27, 1980
	SCALE VERT 1" = 82' HORIZ 1" = 20.5'	FIGURE NO. 2.16
	CONTOUR INTERVAL N/A	

2. Fort Union Formation. The Paleocene Fort Union Formation is represented in the southern Powder River Basin by approximately 3,000 (915 m) feet of poorly consolidated clastic continental sediments. This unit conformably overlies the Cretaceous Lance Formation and, in the local area of interest, mainly consists of gray, white, pinkish and pale orange, flat-bedded, fine grained, clay-rich sandstones and interbedded mudstones. Silty claystones and very thin coal or lignitic stringers occur as minor stratigraphic constituents.

The paleo-rivers, capable of transporting sand, were also laden with mud which at high water stages was carried out to the flood plain to settle as layers of overbank silt or crevasse splay deposits. The well defined and commonly occurring crossbedding within the sandstone deposits of the Fort Union Formation strongly indicates that many, if not all, of the coarser clastic units are point-bar deposits.

Heavy mineral studies and analyses of crossbedding and grain size distribution strongly infer that the source area for the clastic sediments contained within the Fort Union Formation is in the central and northern portions of the Laramie Range. Additionally, it is noted by several writers that the thick coal seams observed in the central and northern portions of the Powder River Basin thin or completely disappear toward the south. Therefore, the supply of detrital material was greater and the energy level of deposition was higher toward the south.

Sandstones of the Fort Union Formation are the main host rocks for the uranium ore on the Test Site.

3. Wasatch Formation. The Wasatch Formation, of early Eocene Age, attains a thickness of approximately 1,000 feet (305 m) within the basin and unconformably overlies the Fort Union Formation. The unit consists of clays and siltstones containing abundant, thick lenses of coarse, crossbedded, arkosic, poorly sorted sandstone. Thin beds of coal or carbonaceous shale are common in some areas.

Interstitial calcite locally cements the sand grains into concretionary masses of various sizes and shapes. In addition to calcite, other cementing materials in sandstone lenses of the Wasatch Formation are hematite, limonite, manganese oxides, pyrite and barite.

The Wasatch Formation is the main uranium host unit in the central part of the Powder River Basin. However, in the area immediately surrounding and to the north of the Peterson Project, the Wasatch Formation has been mostly removed by erosion. Only small scattered outcrops of the Wasatch Formation are present in the vicinity.

SITE GEOLOGY

Beneath the R&D Site, the Fort Union Formation comprises interbedded mudstones, siltstones and clays with minor crossbedded sandstone "channels" representing an extensive meandering or braided stream system. The arkosic sandstones are gray to red, fine to very coarse grained, poorly sorted, crossbedded and cherty. Minor to very abundant pyrite and carbonaceous material are present in most of the unaltered channel deposits.

The channel deposits beneath and adjacent to the Test Site are very sinuous, and in general trend in a north-northeasterly direction. The major Fort Union fluvial systems in the southern and central portions of the Powder River Basin attain widths up to 15 miles (24 km). Considering the much smaller size of the individual channels on the Peterson Project relative to the major Fort Union drainage systems hosting the Highland deposit to the north, it is probable that the Peterson Project channels are subsidiary or represent tributaries to a larger system. The uranium deposits beneath the site exhibit most of the geologic and morphic characteristics of the sandstone type geochemical frontal systems or roll fronts that form the major uranium ore bodies in the State of Wyoming. The geochemical frontal cells approximately follow the general course and direction of the paleo-stream system described above. Beneath the Peterson Project, ore occurrence has been identified in four separate sand units designated B, C, D and E sands. However, only the B sand is known to contain ore beneath the R&D Site.

The B sand lies at a depth of 220 to 260 feet (66 to 78 m) beneath the surface. This sand is saturated by ground water and is referred to elsewhere, herein, as the B Aquifer. The ore in the B sand ranges from 5 to 15 feet (1.5 to 4.5 m) thick within a total sand thickness of approximately 40 feet (12 m) beneath the Test Site. The effective porosity of this sand unit is about 27 percent.

Approximately 170 feet (51 m) of mudstone overlies the B sand and separates it from a shallow sand unit. This sand unit occurs at depths up to approximately 40 to 50 feet (12 to 15 m) below the land surface and is unsaturated. At a depth of about 180 feet (54 m) a thin (10 to 20 ft) (3 to 6 m) discontinuous barren sand occurs within the mudstone. This sand unit is the shallowest saturated sand unit detected beneath the site.

The B sand is separated from the C sand below by a mudstone unit ranging from 25 to 30 feet (7.5 to 9 m) thick. Likewise, the C sand is separated from the D sand below by another mudstone ranging from 15 to 20 feet (4.5 to 6 m) thick. The thicknesses of the C and D sands average approximately 40 and 45 feet (12 and 15 m), respectively, beneath the Test Site. Although the C and D sands are ore bearing elsewhere on the Project, they are barren beneath the Test Site and are not included within the proposed scope of testing. Figures 2.14 to 2.16 demonstrate the wide lateral continuity of the mudstones which act as confining layers beneath the area.

No major folds or faults have been detected within the R&D Site and Peterson Project areas during previous subsurface investigations conducted by APS-NAC. The dip of the Fort Union beds at the Test Site is about 2.0 to 2.5 degrees in a generally northeasterly direction.

2.11 HYDROLOGY

WATER RIGHTS

Records on file in the Office of the Wyoming State Engineer indicate that there are no adjudicated surface water rights within ½ mile (0.8 km) of the R&D Site boundary. A small ephemeral pond used for stock watering when water is present exists just west of the R&D Site in a natural playa depression. No water right of record exists for this water body.

With the exception of hydrologic test wells constructed by APS-NAC and described herein, no wells are registered with the Wyoming State Engineer's Office within ½ mile (0.8 km) of the site boundary. A well inventory in the field confirmed the absence of wells. Well permit numbers for the hydrologic test wells constructed by APS-NAC are provided in Table 2.10, herein.

SURFACE WATER

The R&D Site is located out of any major or minor stream channels at the head of an unnamed drainage, which is eventually tributary to the North Platte River. The North Platte River is located about 1.5 miles (2.4 km) south of the site while Sage Creek is approximately 1 mile (1.6 km) toward the east. Surface drainage from the site does not flow in the direction of Sage Creek.

Surface runoff occurs from snowmelt and high intensity thunderstorms that are frequent during the period from April to July. The relatively low annual precipitation of about 13 inches (33 cm), the relatively permeable sediments underlying many reaches of stream channels, and the closeness of the R&D Site to the drainage divide contribute to the ephemeral flow in streams near the site. The ground water near the R&D Site is under confined conditions and is too deep to contribute to the flow of the unnamed drainage that drains the site.

GROUND WATER

Regional Occurrence

Within the vicinity of the Peterson Project, major water-bearing units, in order of increasing age and depth are (1) Quaternary Alluvium, (2) Wasatch Formation, (3) Fort Union Formation, and (4) Lance Formation. The Quaternary Alluvium is an aquifer in the North Platte River valley south of the Project.

North and east of the Peterson Project the Wasatch Formation is an aquifer, however, scattered Wasatch deposits on the Project appear to be unsaturated. The Lance Formation is an aquifer beneath the Project, but it is geologically and hydrologically separated from the ore sands beneath the site by a few thousand feet of strata. Beneath and adjacent to the Peterson Project the Fort Union Formation is the primary aquifer.

The Fort Union aquifer generally crops out within and adjacent to the Test Site boundary, and the outcrops likely form part of the recharge area for the aquifer. Regionally, the Fort Union aquifer can yield up to 150 gpm (9.5 lps) from adequate thicknesses of fine-grained sandstones. Regional ground water quality is mostly of the sodium bicarbonate and sodium sulfate types with total dissolved solids concentrations commonly ranging from 500 to 1,500 mg/l (milligrams/liter) (Hodson et al, 1973).

Local Occurrence

Beneath the R&D Site, within the leaching zone, ground water occurs within the Fort Union aquifer. Three of the major ore bearing strata known to contain water have been designated in descending order the B Aquifer, C Aquifer and D Aquifer. A relatively thin, lenticular saturated sandstone occurs above the B Aquifer at the Test Site and has been designated Shallow Aquifer. Above this aquifer are several shallower lenticular sandstone layers, however, field tests indicate that these strata are unsaturated. The proposed R&D test will be performed within the B Aquifer.

The ground water that is present is not used for domestic, stock water, or other uses beneath and within ½ mile (0.8 km) of the site boundary. The reasons for this lack of use are not readily apparent although the relatively great depth (180 feet) (55 m) to the first occurrence of ground water, the relatively poor quality of the water as documented elsewhere herein, and the lack of development of this area probably are contributing factors.

Ground water in the aquifers penetrated by wells at the R&D Site is under confined conditions. Although water rises above the tops of the respective aquifers, artesian flows are not present from wells drilled at the site or from exploratory drill holes elsewhere on the Peterson Project. The piezometric levels of the ground water below the land surface at the R&D Site for the various aquifers are approximately: (1) Shallow Aquifer - 98 feet (29 m); (2) B Aquifer - 136 feet (41 m); (3) C Aquifer - 124 feet (37 m); and (4) D Aquifer - 150 feet (45 m).

Piezometric water level surfaces representing water levels in wells completed in the various aquifers at the R&D Site have not been visually depicted herein. For the Shallow, C and D Aquifers only one data point exists which precludes the construction of a significant map. Data for static water levels measured in monitor wells penetrating these aquifers as well as monitor wells penetrating the B Aquifer have been given in Appendix F. These data indicate that the B Aquifer piezometric water level surface is relatively level within the immediate area of the wellfield. For example, the most recent water level data show that only a 0.5 foot (0.15 m) variation exists. Thus a water level contour map would show only a single contour. From the available data ground water flow may be inferred generally toward the northwest and west at the site.

The average hydraulic gradient of the piezometric surface is assumed to be about .005 based on water level data included in Appendix F. The hydraulic conductivity is 1.03 ft/day (7.7 gpd/ft^2/7.48 gal/ft^3) (0.3 m/day) using data obtained from the hydrologic test described in a later section. The porosity has previously been estimated to be 27 percent. Therefore:

$$\text{Ground Water Velocity at Wellfield} = \frac{\text{(hydraulic conductivity)(hydraulic gradient)}}{\text{porosity}}$$

$$= \frac{(1.03\ \text{ft/day})(.005)}{.27}$$

$$= (.019\ \text{ft/day})(365\ \text{days/year})$$

$$= 6.94\ \text{ft/yr}\ (2\ \text{m/yr})$$

Aquifer Characteristics

Several aquifer tests were performed on the B Aquifer at the R&D Site. The tests included a 3.5-hour step-drawdown test of the pumping well to establish well efficiency and long term well yield, a 50-hour pumping/recovery test to estimate aquifer characteristics, and a 4.5-hour pumping test to verify the confidence level of data collected during the 50-hour test. The following discussion presents well characteristics, wellfield layout, test procedures, data analyses and test results.

Well Construction. Eleven wells comprise the wellfield used for the aquifer tests at the R&D Site. Well completion data for these wells are provided in Table 2.10. With the exception of Well OW-7 all wells were drilled with mud to the top of the producing aquifer. Wells were then cased and cemented to the surface. Next, the producing aquifer interval was drilled, taking great care during drilling to insure the least amount of formation well bore damage. Well screen was then telescoped through the surface casing to the depth of the producing aquifer. Figure 2.17 shows the well construction technique and materials.

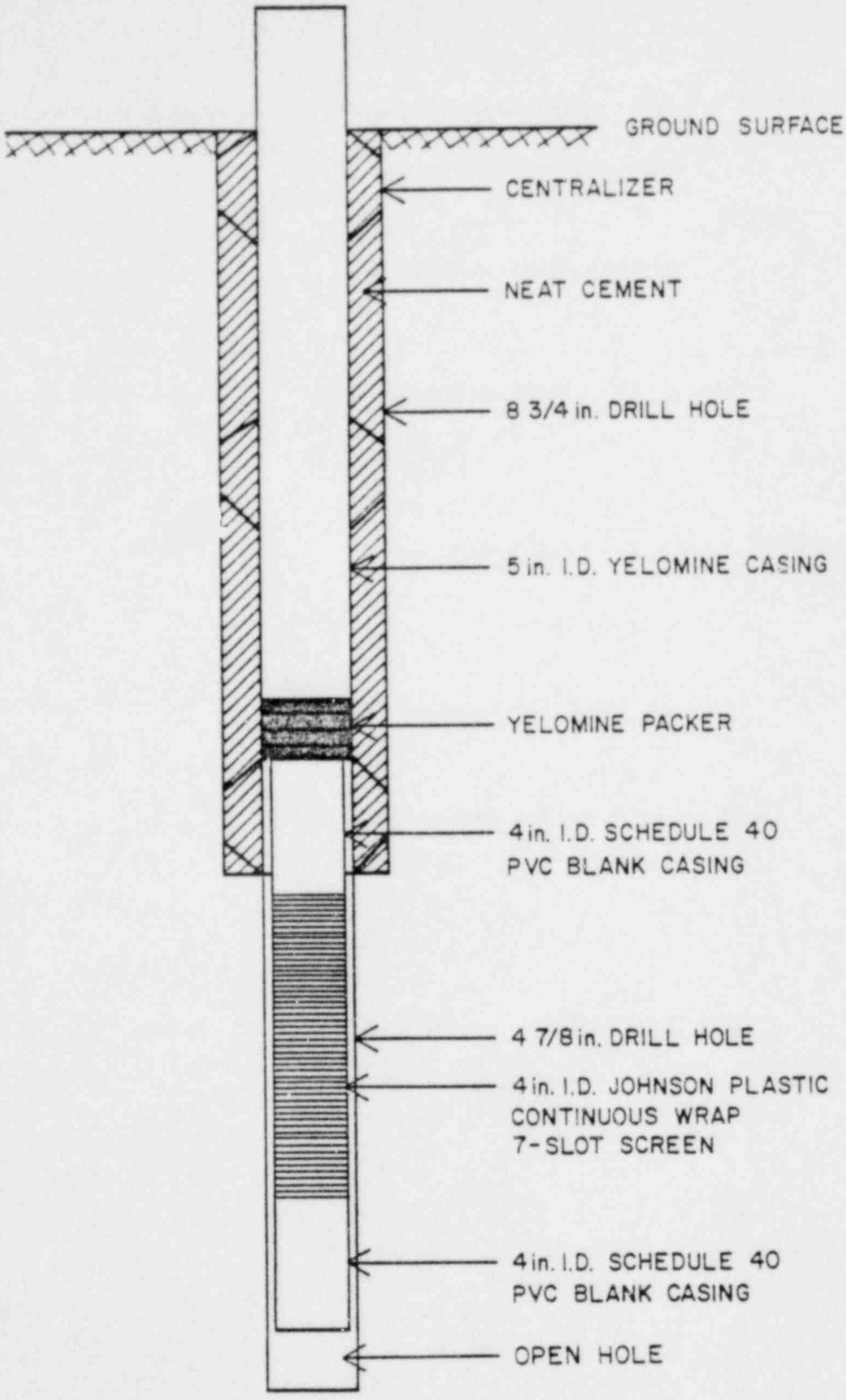
Well OW-7 was constructed by an alternative technique so as to be able to determine the shallowest occurrence of ground water beneath the site during drilling. The well was drilled using air methods to detect the first indication of ground water. Ground water was not encountered until a depth of 180 feet (55 m). Drilling progressed until the bottom of the Shallow Aquifer was reached at about 200 feet (61 m) in depth. The well was completed with 2-inch (5 cm) I.D. PVC casing, slotted with a hacksaw through the aquifer interval. The open interval was gravel packed, and the annulus above the aquifer was filled with soil and drill cuttings to the surface since only unsaturated natural material occurs.

All wells were completed through the entire producing zone. Well development was accomplished by washing the hole with clean water, air lifting, and pumping the well.

TABLE 2.10
COMPLETION DATA

Well[(1)] Number	Wyoming Permit #	Completion Date	Coordinates x	Coordinates y	Surface Elev. ft. (M.P.Elev.ft.)	Casing[(2)] Depth, ft. (Elev.ft.)	Top of Packer Depth, ft. (Elev.ft.)	Screen[(3)] Interval Depth, ft. (Elev.ft.)	Total Depth, ft. (Elev.ft.)	Static[(4)] Water Level Depth, ft. (Elev.ft.)	Sand Interval Screened
PW-1A	49694	10-22-79	387,499.66	806,678.89	5103.9 (5105.4)	205 (4898.9)	200 (4903.9)	220-255 (4883.9-4848.9)	265 (4838.9)	140.9 (4964.5)	B
PW-1	49701	11-3-79	387,500.58	806,704.80	5103.7 (5105.5)	209 (4894.7)	openhole	openhole	265 (4838.7)	145.5 (4959.9)	B
OW-1	49695	10-24-79	387,481.13	806,776.24	5102.4 (5103.9)	209 (4893.4)	200 (4902.4)	220-264 (4882.4-4838.4)	265 (4837.4)	140.1 (4963.8)	B
OW-2	49696	10-23-79	387,594.84	806,646.64	5105.3 (5107.2)	211 (4894.3)	204 (4901.3)	220-260 (4885.3-4845.3)	270 (4835.3)	143.0 (4964.2)	B
OW-3	49697	11-6-79	387,421.83	806,616.34	5104.8 (5106.2)	211 (4893.8)	200 (4904.8)	215-255 (4889.8-4849.8)	265 (4839.8)	141.8 (4964.4)	B
OW-4	49698	11-2-79	387,363.52	806,865.96	5100.5 (5101.6)	212 (4888.5)	---(5) ---	217-257 (4883.5-4843.5)	260 (4840.5)	140.0 (4961.6)	B
OW-5	49699	10-8-79	387,474.66	806,678.67	5103.8 (5105.2)	191 (4912.8)	177 (4926.8)	211-251 (4892.8-4852.8)	260 (4843.8)	139.2 (4966.0)	B
OW-6	49700	10-19-79	387,480.16	806,663.33	5103.8 (5105.3)	212 (4891.8)	206 (4897.8)	218-254 (4885.8-4849.8)	265 (4838.8)	139.6 (4965.7)	B
OW-7	51105	12-5-79	387,498.15	806,666.76	5103.7 (5105.9)	180 (4923.7)	--- ---	180-200 (4923.7-4903.7)	200 (4903.7)	95.3 (5008.4)	sand above B
OW-8	49702	10-23-79	387,527.67	806,689.43	5104.0 (5105.3)	335 (4769.0)	330 (4774.0)	340-381 (4764.0-4723.0)	395 (4709.0)	153.0 (4952.[illegible])	D
OW-9	49703	11-7-79	387,480.70	806,703.87	5103.3 (5104.6)	274 (4829.3)	263 (4840.3)	283-323 (4820.3-4780.3)	340 (4763.3)	125.9 (4978.7)	C

(1) See Figure 2.18 for well locations.
(2) Casing is 5"I.D. Yelomine with a 8 3/4" hole diameter, except for OW-7 which consists of 2"I.D. Schedule 40 PVC with a 4 7/8" hole diameter.
(3) Screen is 4"I.D. Johnson plastic continuous wrap 7-slot with a 4 7/8" hole diameter, except OW-7 which consists of hacksaw slotted 2"I.D. (gravel packed) Schedule 40 PVC with a 4 7/8" hole diameter.
(4) Water level measurements obtained on November 13, 1979.
(5) The screen assembly was partially damaged during installation. The packer was removed but the damaged screen was left in the hole.



GENERALIZED WELL COMPLETION DIAGRAM

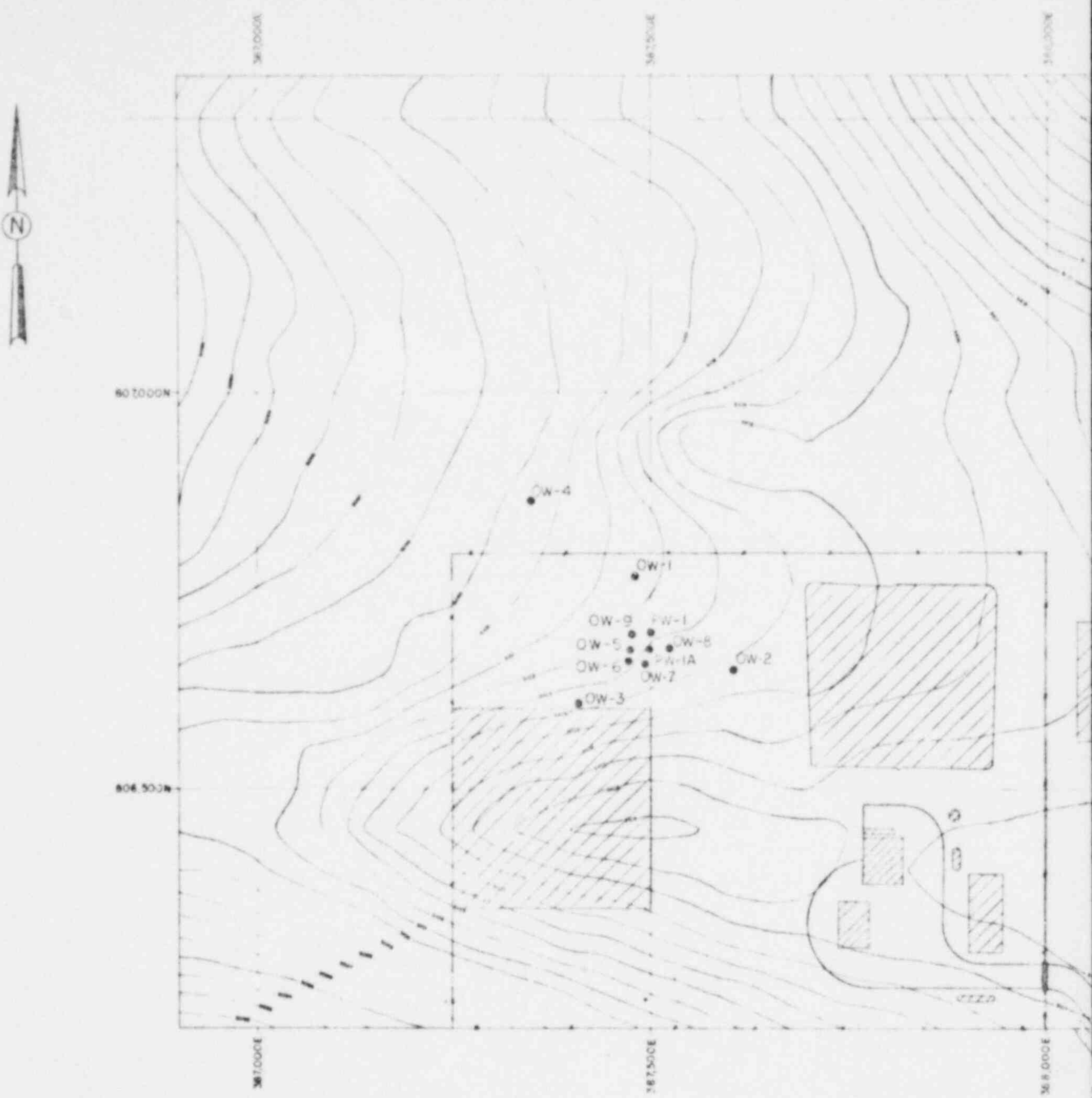
FIGURE 2.17

Wellfield Layout. The wellfield layout used for the aquifer test is shown by Figure 2.18. Geohydrologic sections across the wellfield are presented in Figures 2.19 and 2.20. Wells PW-1A, PW-1, and OW-1 to OW-6 were completed in the B Aquifer in a configuration that allows optimum determination of aquifer characteristics such as anisotropy, hydraulic boundaries, and the radius of influence of pumping. Wells OW-7, OW-9 and OW-8 were located in the Shallow Aquifer, C Aquifer and D Aquifer, respectively, to determine the presence or absence of leakage between aquifers and to collect water samples from these aquifers.

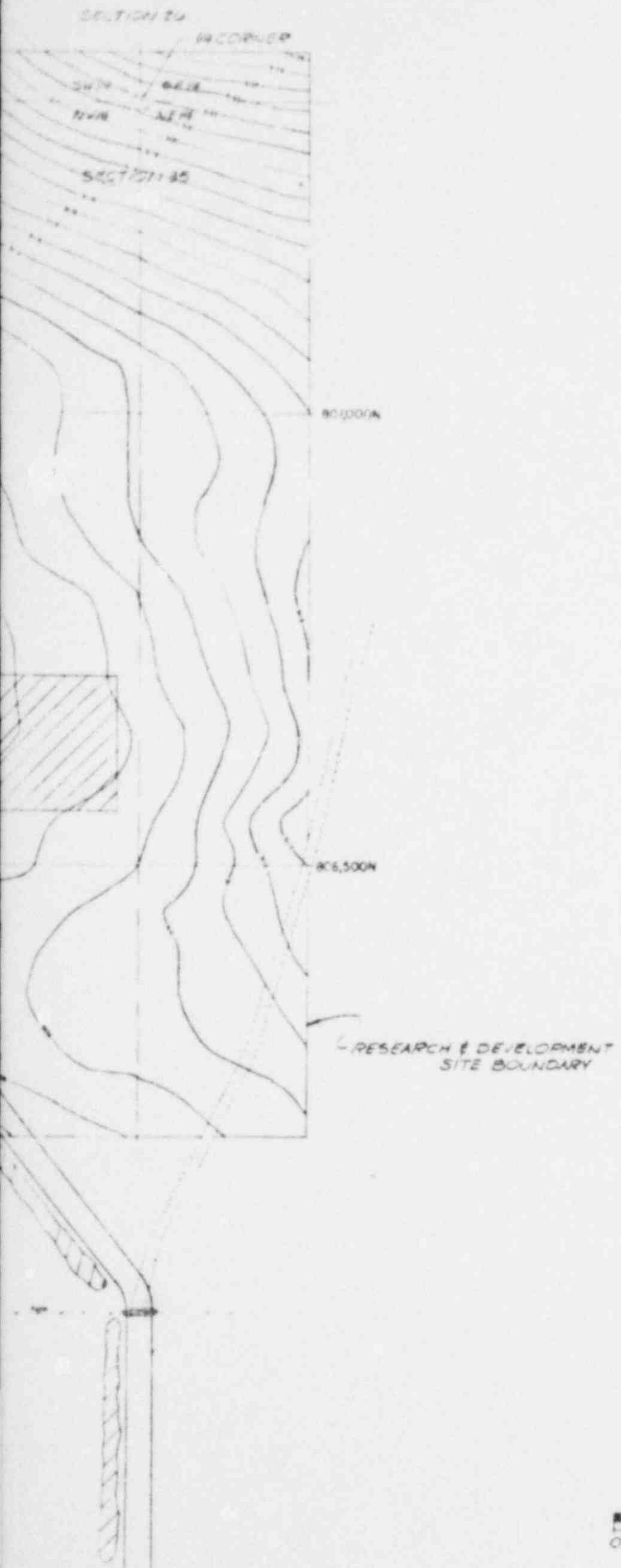
Aquifer Test Procedures. During the aquifer tests a 5 HP submersible pump was set just above the top of the packer in Well PW-1A (Table 2.10). A 2-inch (5 cm) I.D. galvanized riser pipe extended from the pump to the well head where a gate valve used to adjust the rate of discharge and a cumulative flow meter were attached. Discharge was measured with the cumulative flow meter which was calibrated against a container of known volume prior to the test. A stopwatch was used to determine the rate of discharge.

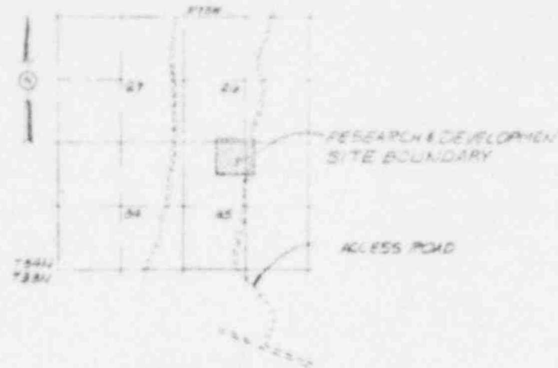
The B Aquifer pumping test began at 8:35 a.m. on November 13, 1979, and continued for approximately 50-hours until November 15, 1979. The average pumping rate was 5.7 gpm (0.4 lps). An initial pumping period of about 26.5-hours was followed by measurement of water level recovery for about 23.5-hours. Water levels were monitored throughout the entire 50-hour period according to a predetermined schedule. Measurements were made with both electrical water level measuring devices and Stevens Type F recorders. The pumping test field data including water level readings, time of water level measurements, and discharge rates are presented in Appendix D.

Using similar procedures to those described above, a 3.5-hour step-drawdown test was performed on November 16, 1979, and a 4.5-hour pumping test was performed on January 17, 1980. Field data for these tests are also included in Appendix D. The 4.5-hour test was run to verify that a decline in pumping rate experienced during the 50-hour test did not mask any possible effects of leakage to the B Aquifer from adjacent strata. This test was run at a constant discharge rate of 5 gpm (0.3 lps). During this test, water levels were monitored only in Wells PW-1A, OW-2, OW-6 and OW-7. Recovery data from this test were not required for the desired analyses.



REV	DATE	REVISION	DR CH	APP	REV	DATE	REVISION	DR CH	APP





LOCATION MAP

0 4000 8000 12000 FEET

LEGEND

EXISTING CONTOURS

EXISTING ROADS

● OW-1 OBSERVATION WELL

● PW-1 PUMPING WELL

NOTES

1) THE COORDINATES USED ARE AS PER WYOMING STATE COORDINATE SYSTEM

2) CONTOUR INTERVALS = 1'

SCALE

0 100 200 300 FEET

NUMBER	REFERENCE DRAWINGS

NOTICE

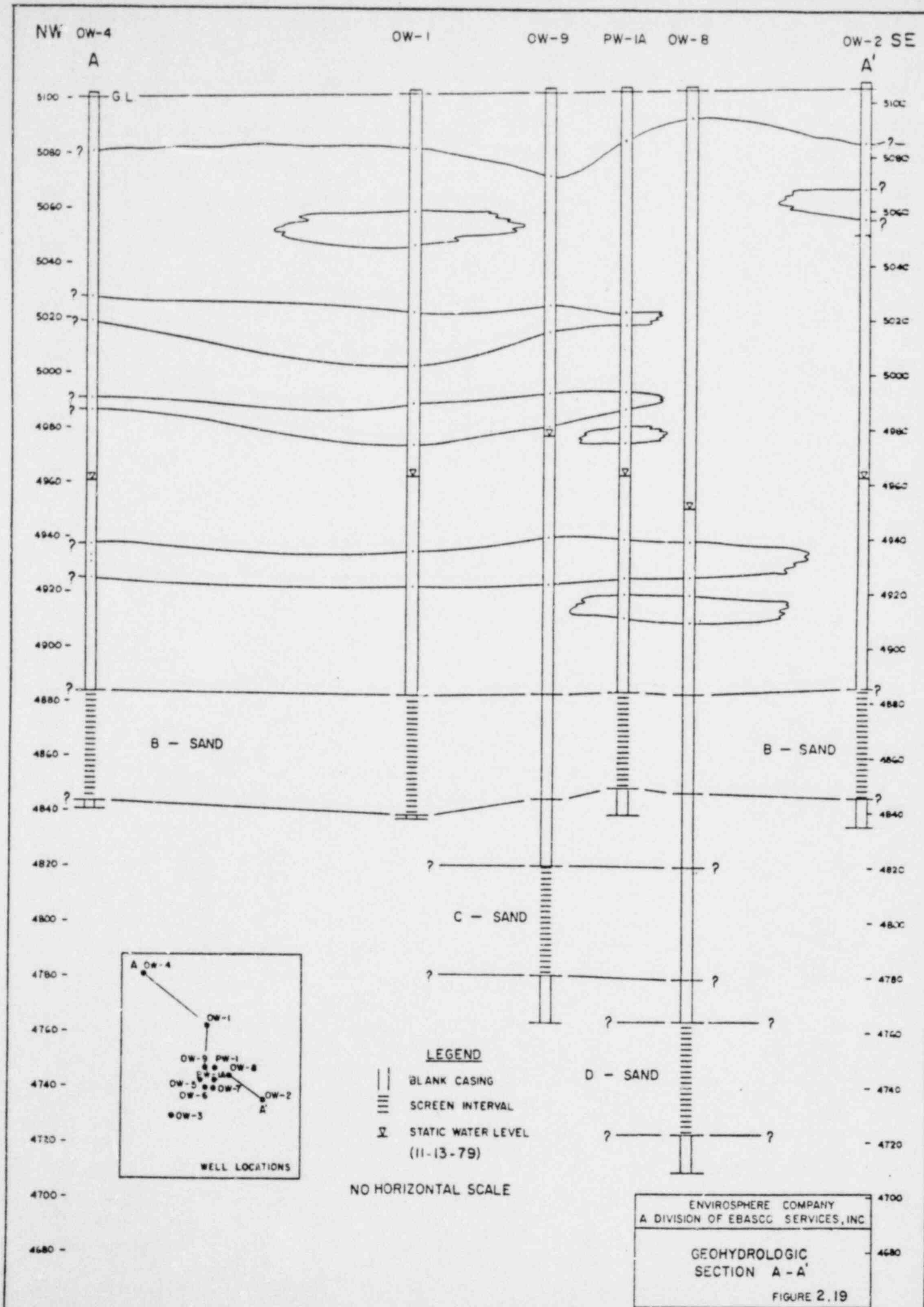
SCALE		DATE
DRAWN	JCP	2-17-80
CHECKED		
PROCESS		
STRUCT		
INSTR		
ELECT		
DESIGN		
APP		

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

ENVIROSPHERE COMPANY
GOLDEN, COLORADO

AQUIFER TEST WELL LOCATIONS
PETERSON IN-SITU URANIUM EXTRACTION PROJECT

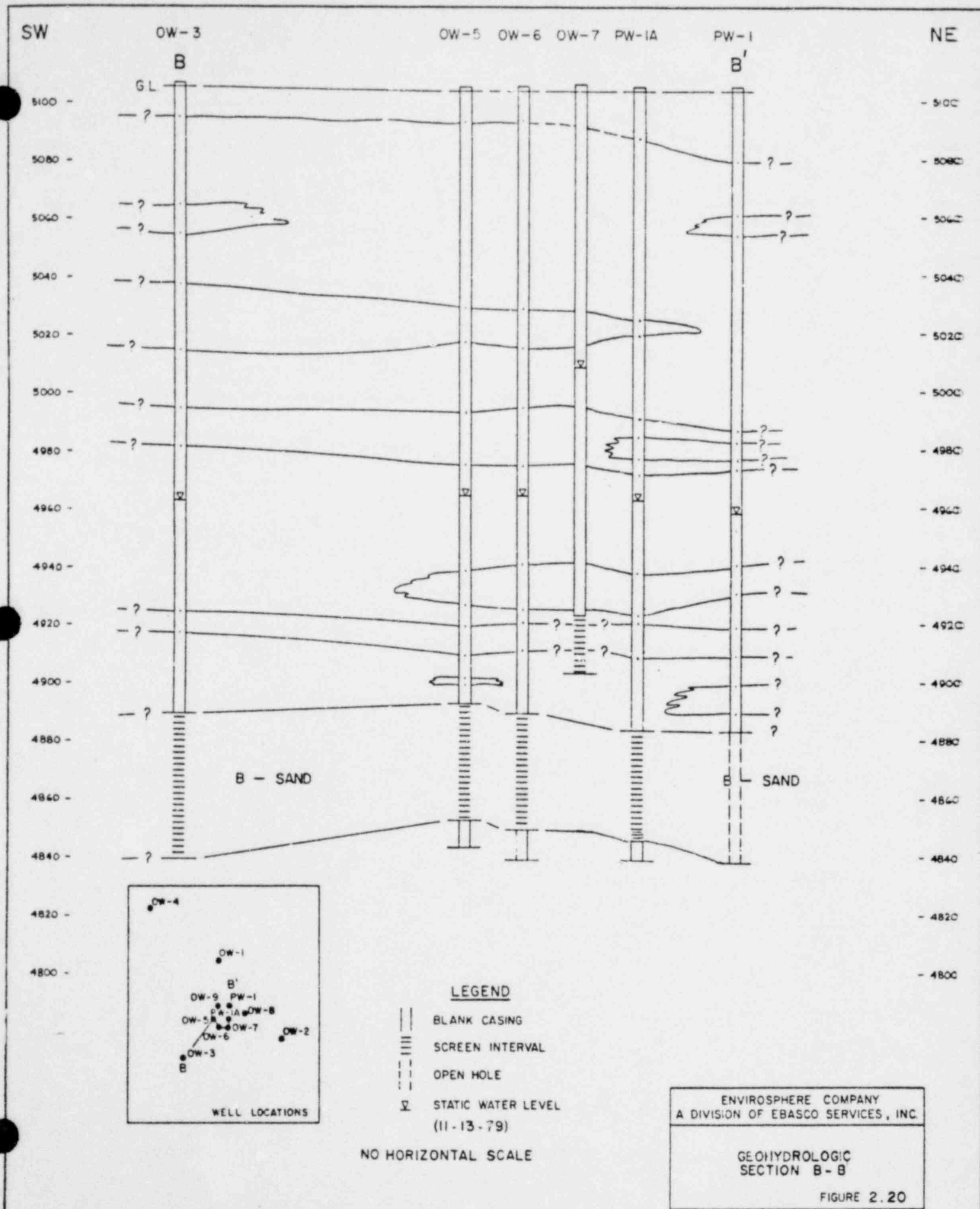
PROJECT No 88900 | FIGURE No 2.18 | REV



ENVIROSPHERE COMPANY
A DIVISION OF EBASCO SERVICES, INC.

GEOHYDROLOGIC SECTION A - A'

FIGURE 2.19


SW
NE
OW-3
OW-5
OW-6
OW-7
PW-1A
PW-1
B
B'
G.L.
5100
5080
5060
5040
5020
5000
4980
4960
4940
4920
4900
4880
4860
4840
4820
4800
?
B – SAND
B – SAND
OW-4
OW-1
B'
OW-9
PW-1
PW-1A
OW-8
OW-5
OW-6
OW-7
OW-2
OW-3
B
WELL LOCATIONS
LEGEND
BLANK CASING
SCREEN INTERVAL
OPEN HOLE
STATIC WATER LEVEL
(11-13-79)
NO HORIZONTAL SCALE
ENVIROSPHERE COMPANY
A DIVISION OF EBASCO SERVICES, INC.
GEOHYDROLOGIC
SECTION B-B
FIGURE 2.20

Aquifer Test Results

From the results of the aquifer tests, the basic hydrologic properties of the B Aquifer have been calculated. In addition, the calculations involved the determination of anisotropy in the horizontal plane, the presence of hydrologic boundaries, and the determination of potential hydraulic connection between the B Aquifer and adjacent strata. Graphical representation and treatment of the field data are given in Appendix D. The results of the aquifer test on November 13-15, 1979, are summarized in Table 2.11.

Table 2 11 shows transmissivity values ranging from 242 to 372 gpd/ft (3.0 to 4 6 m^2/day) with a mean value of 315 gpd/ft (3.9 m^2/day). The values are reasonably consistent for both pumping and recovery phases. The values for storativity range from 1.8×10^{-5} to 3.7×10^{-4}, with a mean value of 1.0×10^{-4} (Table 2.11). The storativity values are about twice as high for recovery data as for drawdown data. Because of the declining production rate during the pumping test, the recovery data are believed to be more reliable than the drawdown data for ascertaining formation properties. In general, recovery data are much less sensitive to fluctuations in discharge rate than are drawdown data and more accurately represent the aquifer response to the average pumping rate.

Hydraulic conductivity values range from 5.4 to 8.8 gpd/ft^2 (0.22 to 0.35 m/day), with a mean value of .7 gpd/ft^2 (0.31 m/day). Corresponding permeabilities range from 326 to 531 millidarcies, with a mean of 464 millidarcies.

Table 2.11 also gives the transmissivity and storativity calculated from distance-drawdown data. For each observation well, the drawdown at the end of the pumping period was plotted versus distance from the pumped well on full-logarithmic paper (Appendix D), and the data were matched to a theoretical type curve (Walton, 1962). The calculated transmissivity and storativity are consistent with the other reported values.

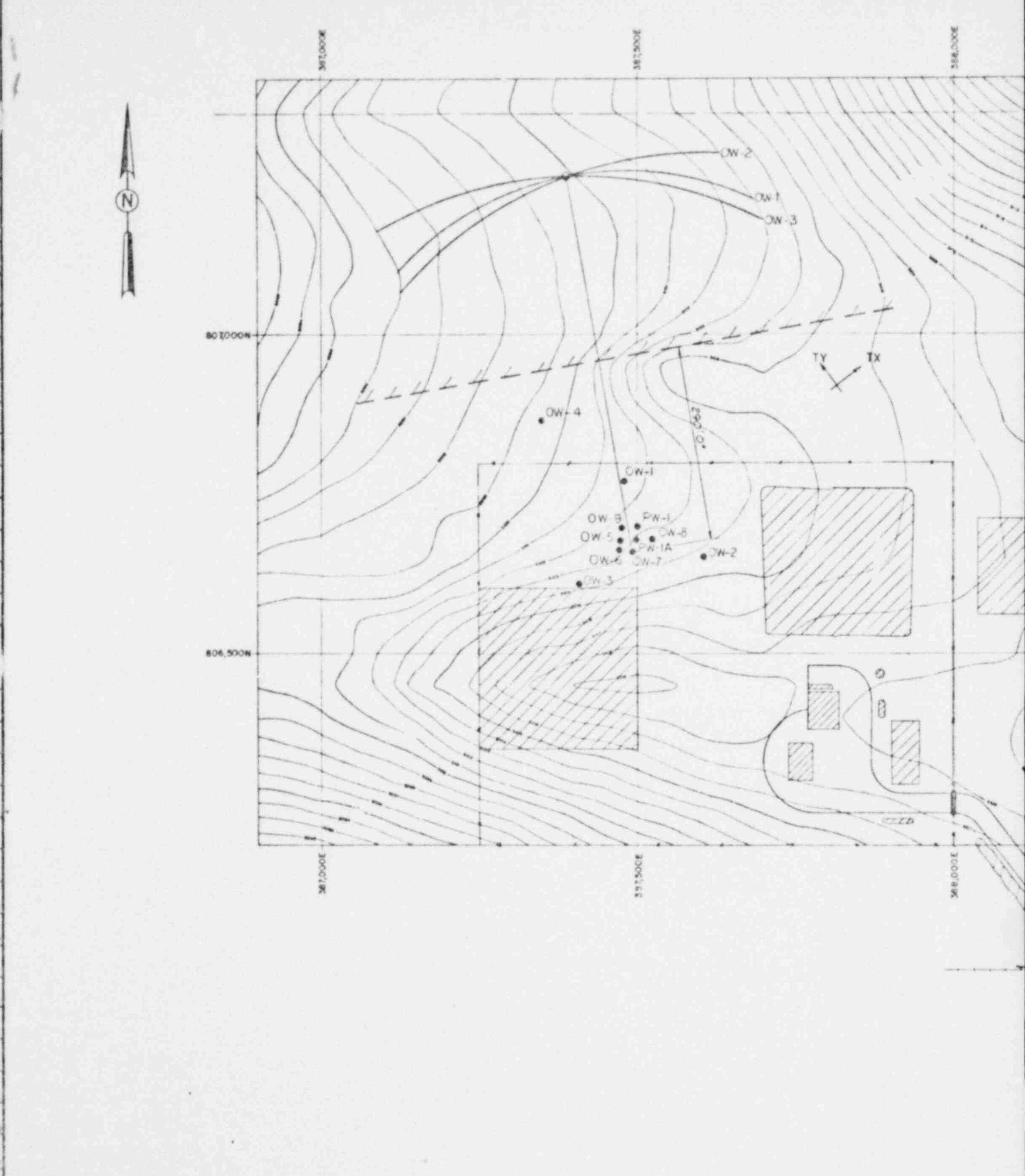
During the pumping test a negative boundary was detected. It is represented graphically (Appendix D) by an approximate doubling of the rate of drawdown late in the test. This boundary is shown in Figure 2.21 and was computed by

TA[illegible]2.11
SUMMARY OF AQUIFER TEST ANALYSES
AQUIFER TEST OF 11/13-15/79
(26.5 hours pumping, 23.5 hours recovery)

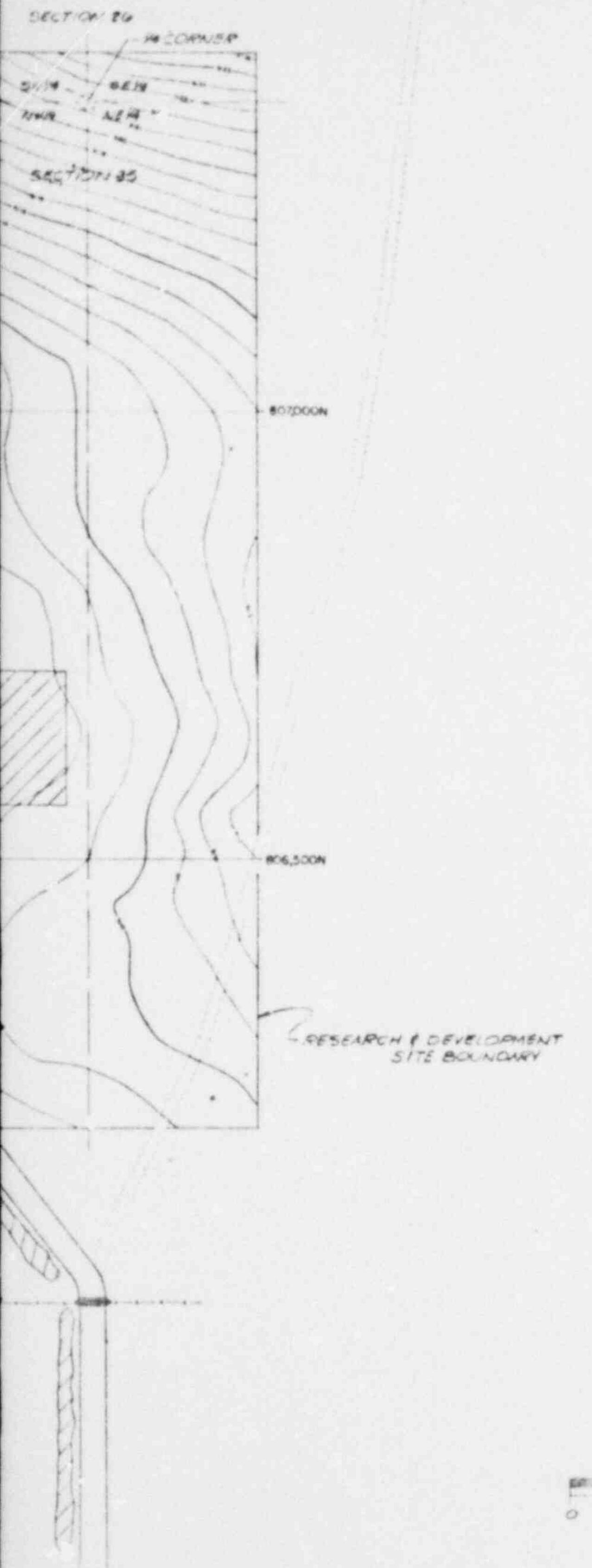
Observation Well Number	Distance From Pumped Well (ft)	Type of Analysis (1)	Transmissivity (gpd/ft)	Storativity	Distance From Hypothetical Image Well (ft)	Formation Thickness (ft)	Hydraulic Conductivity (gpd/ft^2)	Equivalent Permeability (2) (md)
OW-1	99.1	SL TD	358	$4.7x10^{-5}$	809			
		SL RR	358					
		SL TR	363	$1.1x10^{-4}$	491			
		FL TD	284	$8.0x10^{-5}$	767			
		FL TR	327	$1.2x10^{-4}$	464			
		Means	338	$8.9x10^{-5}$	663	44	7.7	464
OW-2	100.5	SL TD	338	$5.2x10^{-5}$	842			
		SL RR	367					
		SL TR	367	$8.7x10^{-5}$	576			
		FL TD	272	$7.5x10^{-5}$	875			
		FL TR	284	$1.3x10^{-4}$	670			
		Means	326	$8.6x10^{-5}$	741	40	8.2	495
OW-3	99.8	SL TD	342	$3.9x10^{-5}$	1033			
		SL RR	327					
		SL TR	314	$7.8x10^{-5}$	652			
		FL TD	297	$5.4x10^{-5}$	1145			
		FL TR	284	$1.0x10^{-4}$	602			
		Means	313	$6.8x10^{-5}$	858	40	7.8	470
OW-4	231.4	FL TR	242	$2.0x10^{-4}$	324	45	5.4	326
OW-5	25.0	SL TD	372	$2.6x10^{-5}$	1280			
		SL RR	334					
		SL TR	320	$1.5x10^{-4}$	546			
		FL TD	311	$6.3x10^{-5}$	984			
		FL TR	297	$2.1x10^{-4}$	449			
		Means	327	$1.1x10^{-4}$	815	40	8.2	495
OW-6	24.9	SL TD	367	$4.4x10^{-5}$	1017			
		SL RR	334					
		SL TR	289	$2.9x10^{-5}$	399			
		FL TD	327	$7.5x10^{-5}$	892			
		FL TR	272	$3.7x10^{-4}$	352			
		Means	318	$1.3x10^{-4}$	665	36	8.8	531
All		Full-logarithmic Distance-Drawdown	344	$1.8x10^{-5}$	---	41	8.4	507
		Mean Values	315	$1.0x10^{-4}$	---	41	7.7	464

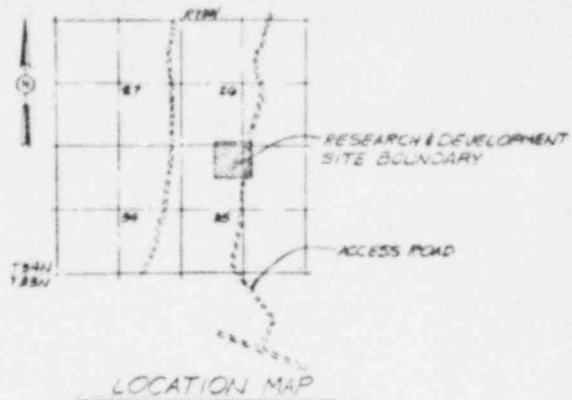
(1) SL = Semi-logarithmic (Cooper-Jacob); FL = Full-logarithmic (Theis); TD = Time-drawdown; TR = Time-recovery; RR = Residual recovery

(2) md = millidarcys, @ 12°C



REV.	DATE	REVISION		APP.	REV.	DATE	REVISION		APP.
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				





LOCATION MAP

0 4000 8000 12000 FEET

LEGEND

EXISTING CONTOURS
EXISTING ROADS
HYPOTHETICAL IMAGE WELL
● OW 1 OBSERVATION WELL
● PW 1 PUMPING WELL
OW 2 LOCUS OF POINTS FROM INDICATED WELL
APPARENT BARRIER BOUNDARY
PRINCIPLE DIRECTIONS OF ANISOTROPY

NOTES

1) THE COORDINATES USED ARE AS PER WYOMING STATE COORDINATE SYSTEM.

2) CONTOUR INTERVALS = 1'

0 100 200 300 FEET

REFERENCE DRAWINGS		ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	LOCATION OF NEGATIVE BOUNDARY PETERSON IN-SITU URANIUM EXTRACTION PROJECT
		ENVIROSPHERE COMPANY DENVER, COLORADO	PROJECT NO. 85900 — FIGURE NO. 2.21 — REV.

using the Law of Times (Walton, 1962) based upon data from the B Aquifer monitor wells. The average recovery data from Wells OW-1, OW-2 and OW-3 indicate that the calculated boundary is approximately 290 feet (87 m) from the pumping Well (PW-1A) and normal to a line through Well PW-1A oriented N 10° W. This computed boundary approximately coincides with the thinning of the B Aquifer northwest of the hydrologic test location. A decrease in average grain size of the B sand is also a likely contributing factor. The lower transmissivity and hydraulic conductivity values calculated for Well OW-4 may reflect the relatively close proximity of this well to the boundary.

The B Aquifer anisotropy in the horizontal plane was determined by the method of Papadopoulos as described by Walton (1970). From the calculations, it was determined that the most reliable estimates of anisotropy result from the analyses of data from Wells OW-1, OW-2 and OW-3. Based on the average recovery data from these wells, the major transmissivity is 364 gpd/ft (4.5 m^2/day) in a direction N 50° E. The minor transmissivity is 236 gpd/ft (2.9 m^2/day). The average transmissivity from this analysis is 292 gpd/ft (3.6 m^2/day), and the storage coefficient is 1.1×10^{-4}. The ratio of major to minor transmissivity is about 1:1.5, indicating a rather weak anisotropy in the horizontal plane. The directions of the major and minor axes of anisotropy are illustrated in Figure 2.21.

The data from the 50-hour pumping test were analyzed to determine if a possible hydraulic connection between the B Aquifer and adjacent aquifers exists. Because a declining pumping rate was experienced during the 50-hour test, it could not be conclusively determined from that test data if there was an absence of leakage from the adjacent aquifers.

In order to demonstrate a lack of leakage to the B Aquifer, a second 4.5-hour pumping test was performed. During this test Well PW-1A was pumped at a lower rate of 5 gpm (0.3 lps). The pumping rate remained constant throughout the first part of the test with some fluctuation in the latter part. The data for this test, especially the first 90 minutes, were best fit by the nonleaky type curve (Walton, 1962) (Appendix D).

During the tests only 0.2 foot (6.1 cm), 0.25 foot (7.6 cm), and 0.1C foot (3 cm) variations in water levels were observed in Wells OW-7, OW-8 and OW-9, respectively. It is highly probable that the slight changes are caused by a combination of barometric pressure fluctuations and changes in pore pressure caused by changes in pressure within the B Aquifer during pumping. These slight changes do not suggest leaky conditions and demonstrate that the claystones above and below the B Aquifer appear to behave as competent confining layers.

During the hydrologic study, other lines of evidence became apparent which support an absence of leakage to the B Aquifer. These are:

1. There is a significant difference in potentiometric head among the various aquifers at the Test Site. Substantial leakage between the B Aquifer and adjacent aquifers would tend to produce an equivalence in head between the two strata.

2. There is a significant difference in water quality between the B Aquifer and other aquifers at the Test Site suggesting that the waters of the various aquifers do not mix.

3. If leakage is present, the water levels in the observation wells should have stabilized very rapidly in response to induced leakage to the B Aquifer. This phenomenon was not observed during the field test.

The radius of influence resulting from the 26-hour pumping period is estimated to be more than 4,000 feet (1,200 m). However, drawdowns of five feet (1.5 m), or greater, occurred within a radius of 750 feet (225 m) from the pumping well.

WATER QUALITY

Ground water samples were collected at the Test Site from the B Aquifer, C Aquifer, D Aquifer and Shallow Aquifer to determine baseline ground water quality beneath the hydrologic test wellfield. The water quality data are used to establish suitable uses of the water in the test wells and to begin the accumulation of data to be used to define upper control limits for leach solution excursion detection (see Section 3.0) if some of these wells are used as monitor wells. From one to four water samples have been obtained from each test well.

Two sampling methods were used at the Test Site. The primary method used a pump lowered into the well casing to a depth immediately above the packer (Table 2.10). Then two casing volumes of water were pumped from the well before the sample was taken. The second method involved bailing water from the well and was used primarily on Well OW-7 which is cased with a small diameter pipe that would not accommodate the available pump.

Field measurements were taken for pH, specific conductance and temperature. The samples were put in containers with the proper preservatives and shipped to the laboratory. At the laboratory the samples were preserved and analyzed according to WDEQ-LQD Guideline No. 4 (revised 12/12/77).

The results of the chemical analyses are given in Table 2.12. Table 2.13 is a summary of published and unpublished recommended water quality standards for various water uses.

The mean concentrations of each chemical parameter for the Shallow, B, C and D Aquifers were compared to the recommended water quality criteria. Based on this comparison, it appears that the concentrations of several chemical parameters in the water exceed drinking water standards in all of the aquifers sampled. Chemical parameters exceeding drinking water standards in the waters tested include chromium, iron, lead, manganese, sulfate, total dissolved solids, gross alpha and radium-226. However, not all of these parameters occur in elevated concentrations in all of the aquifers. In particular, water in the B Aquifer exceeds recommended drinking water standards for chromium, iron, manganese, sulfate, total dissolved solids, gross alpha and radium-226. Therefore, it appears that the ground water in all of the aquifers tested would not be recommended for human consumption.

TABLE 2.12
WATER QUALITY DATA
(mg/l unless specified otherwise)

Well Number	Date of Sample	Al	NH_4	As	Ba	Be	HCO_3	B	Cd	Ca	CO_3	Cl	Cr
PW-1	11/16/79	7.7	0.13	0.008	<0.5	<0.01	340	0.1	<0.01	69	0	13	<0.03
	1/16/80	13	0.43	0.014	0.6	<0.01	340	<0.1	<0.01	67	0	21	0.11
PW-1A	11/9/79	<0.5	0.11	<0.002	<0.5	<0.01	340	0.1	<0.01	61	0	13	<0.03
	11/14/79	<0.5	0.11	<0.002	<0.5	<0.01	340	0.1	<0.01	58	0	13	<0.03
	12/1/79												
	1/17/80	<0.6	0.23	0.006	0.4	<0.01	350	<0.1	<0.01	64	0	16	0.10
OW-1	11/12/79	2.4	0.11	<0.002	<0.5	<0.01	340	0.1	<0.01	52	0	14	<0.03
	1/16/80	0.6	0.34	0.009	0.6	<0.01	360	0.1	<0.01	55	0	14	0.10
OW-2	11/5/79	<0.5	0.14	0.002	<0.5	<0.01	340	0.1	<0.01	70	0	15	<0.03
	1/18/80	<0.6	0.34	0.004	0.2	<0.01	340	0.1	<0.01	72	0	16	0.09
OW-3	11/7/79	<0.5	0.05	<0.002	<0.5	<0.01	360	0.1	<0.01	62	0	16	<0.03
	1/18/80	0.6	0.23	0.012	0.4	<0.01	500	0.1	<0.01	74	0	17	0.10
OW-4	11/16/79	1.5	0.13	0.004	<0.5	<0.01	300	0.1	<0.01	118	0	33	<0.03
	1/15/80	10	0.48	0.021	0.9	<0.01	290	0.1	<0.01	98	0	26	0.12
OW-5	11/8/79	<0.5	0.05	<0.002	<0.5	<0.01	340	0.1	<0.01	55	0	14	<0.03
	1/16/80	<0.6	0.26	0.006	0.3	<0.01	190	<0.1	<0.01	19	0	15	0.10
OW-6	1/16/80	<0.6	0.63	0.006	0.6	<0.01	440	<0.1	<0.01	70	0	17	0.09
OW-7	1/15/80(5)												
	1/16/80	6.0	0.30	0.021	0.6	<0.01	260	0.1	0.01	57	0	24	0.25
OW-8	11/9/79	<0.5	0.18	0.002	<0.5	<0.01	230	0.1	<0.01	21	0	8	<0.03
	1/16/80	<0.6	0.36	0.004	0.3	<0.01	290	0.1	<0.01	18	0	6	0.10
OW-9	11/9/79	1.5	0.16	<0.002	<0.5	<0.01	220	0.1	<0.01	10	0	8	<0.03
	1/16/80	<0.6	0.38	0.009	0.2	<0.01	200	<0.1	<0.01	11	0	6	0.11

TABLE 2.12
WATER QUALITY DATA
cont'd

Well Number	Date of Sample	Co	Lab Conductivity(1)	Cu	Fl	Hardness	Fe	Pb	Li	Mg	Mn	Hg	Mo
PW-1	11/16/79	<0.05	1340	0.03	0.6	312	7.33	0.106	0.01	25	0.27	<0.00004	0.013
	1/16/80	<0.05	1240	0.22	0.4	322	8.1	0.084	0.06	28	0.18	0.00007	<0.005
PW-1A	11/9/79	<0.05	1260	<0.02	0.2	317	0.19	<0.005	<0.01	23	0.09	<0.00004	0.010
	11/14/79	<0.05	1300	<0.02	0.3	317	0.19	<0.005	<0.01	25	0.09	<0.00004	0.010
	12/1/79												
	1/17/80	<0.05	1290	<0.02	0.4	319	0.3	<0.005	0.04	26	0.08	0.00007	0.007
OW-1	11/12/79	<0.05	1210	0.02	0.3	277	1.43	0.044	<0.01	22	0.10	<0.00004	0.008
	1/16/80	<0.05	1230	0.04	0.4	281	0.9	0.023	0.04	23	0.10	0.00005	0.006
OW-2	11/5/79	<0.05	1430	<0.02	0.2	366	0.40	<0.005	<0.01	31	0.10	<0.00004	0.013
	1/18/80	<0.05	1380	0.10	0.4	351	0.6	0.006	0.04	30	0.10	<0.00005	0.007
OW-3	11/7/79	<0.05	1320	<0.02	0.2	347	0.91	<0.005	<0.01	22	0.14	<0.00004	0.013
	1/18/80	<0.05	1330	0.63	0.3	376	1.9	0.130	0.06	31	0.18	<0.00005	0.065
OW-4	11/16/79	<0.05	2140	0.30	0.4	634	1.53	0.136	<0.01	51	0.10	<0.00004	0.013
	1/15/80	<0.05	1630	0.05	0.5	472	11	1.25	0.06	37	0.16	<0.00005	0.006
OW-5	11/8/79	<0.05	1260	0.02	0.2	292	0.27	0.006	<0.01	22	0.09	<0.00004	0.012
	1/16/80	<0.05	808	<0.02	0.5	92	0.2	<0.005	0.03	8.8	<0.01	<0.00005	<0.005
OW-6	1/16/80	0.05	1290	<0.02	0.3	361	0.5	<0.005	0.04	29	0.08	0.00007	<0.005
OW-7	1/15/80(5)												
	1/16/80	<0.05	1140	0.02	0.5	270	6.7	0.069	0.03	23	0.08	0.00007	<0.005
OW-8	11/9/79	<0.05	582	0.02	0.7	124	0.47	0.006	<0.01	8.1	0.05	<0.00004	0.014
	1/16/80	<0.05	575	<0.02	0.6	90	0.4	<0.005	0.03	7.7	0.03	<0.00005	<0.005
OW-9	11/9/79	<0.05	503	0.02	0.6	64	1.12	0.024	<0.01	4.7	0.07	<0.00004	0.013
	1/16/80	<0.05	515	<0.02	0.6	56	0.4	0.009	0.02	5.5	0.08	0.00005	<0.005

TABLE 2.12
WATER QUALITY DATA
cont'd

Well Number	Date of Sample	Ni	NO_3	NO_2/NO_3	Lab pH(2)	K	Se	Na	SO_4	TDS (@180°C)	V	Zn	Field Conductivity(1)
PW-1	11/16/79	<0.05	<0.04	<0.04	7.6	9.2	<0.005	175	432	909	0.050	0.27	950
	1/16/80	<0.05	<0.05	<0.05	8.0	10	<0.005	200	427	904	0.040	0.31	980
PW-1A	11/9/79	<0.05	<0.04	<0.04	7.7	7.9	<0.005	163	425	864	0.009	0.36	
	11/14/79	<0.05	<0.04	<0.04	7.5	7.6	<0.005	161	426	884	<0.005	0.41	
	12/1/79												980
	1/17/80	<0.05	0.09	0.09	8.0	8.3	<0.005	180	455	900	<0.005	0.11	1000
GW-1	11/12/79	<0.05	<0.04	<0.04	7.6	7.3	0.005	154	332	777	0.008	0.51	850
	1/16/80	<0.05	<0.05	<0.05	8.1	7.4	<0.005	165	392	821	<0.005	0.16	825
GW-2	11/5/79	<0.05	<0.04	<0.04	7.6	8.5	0.005	210	521	974	<0.005	0.56	1050
	1/18/80	<0.05	<0.05	<0.05	8.1	10	<0.005	190	484	964	0.005	0.09	950
GW-3	11/7/79	<0.05	<0.04	<0.04	7.0	8.0	<0.005	157	360	895	<0.005	0.44	1050
	1/18/80	<0.05	<0.05	<0.05	7.6	12	<0.005	190	384	981	0.010	0.30	1000
GW-4	11/16/79	<0.05	<0.04	<0.04	7.7	14	<0.005	253	1020	1610	0.009	5.15	1350
	1/15/80	<0.05	<0.05	<0.05	7.9	13	<0.005	200	659	1190	0.031	0.37	1110
GW-5	11/8/79	<0.05	<0.04	<0.04	7.7	7.6	0.005	157	414	628	0.019	0.44	820
	1/15/80	<0.05	0.16	0.16	8.3	6.7	<0.005	125	228	488	<0.005	0.19	550
GW-6													1000
	1/15/80	<0.05	0.19	0.19	7.5	8.6	<0.005	160	394	957	0.005	1.12	925
GW-7	1/15/80(5)												800
	1/16/80	0.12	0.30	0.30	8.0	9.0	<0.005	160	390	755	0.023	0.07	650
GW-8	11/9/79	<0.05	0.12	0.12	7.2	4.5	<0.005	94	104	361	<0.005	0.24	830
	1/16/80	<0.05	0.16	0.16	7.4	5.4	<0.005	105	57	372	<0.005	0.04	800
GW-9	11/9/79	<0.05	<0.04	<0.04	7.5	3.6	0.024	87	84	309	0.006	0.47	350
	1/16/80	<0.05	0.14	0.14	8.0	3.4	<0.005	100	91	323	<0.005	0.17	350

TABLE 2.12
WATER QUALITY DATA
cont'd

Well Number	Date of Sample	Field pH(2)	Field Temperature(3)	U	Gross Alpha(7)	Dissolved Ra226(7)	Cation Equiv.	Anion Equiv.	Charge Balance(6)	Formation
PW-1	11/16/79	6.6	12				13.34	15.07	6.1	B-sand
	12/1/79			0.41	1100±100	119±14				
	1/16/80	7.6	13.5	.19	620±30	94±10	14.60	15.05	1.5	
PW-1A	11/9/79						12.22	14.79	9.5	B-sand
	11/14/79						12.14	14.81	9.9	
	12/1/79	6.6	11.5	.072	340±20	56±7				
	1/17/80	7.5	13	.057	300±20	68±7	13.37	15.66	7.9	
OW-1	11/12/79	5.5	12.0				11.85	12.88	4.2	B-sand
	12/2/79			.056	110±12	69±7				
	12/2/79			.052	240±20	59±7				
	1/16/80	7.6	13.5	.077	360±20	85±8	11.99	14.45	9.3	
OW-2	11/5/79	5.7	12.5				15.39	16.84	4.5	B-sand
	12/2/79			.12	480±20	70±7				
	1/18/80	(4)	13	.073	350±20	62±7	14.58	16.10	5.0	
OW-3	11/7/79	5.6	12.0				11.93	13.85	7.4	B-sand
	12/2/79			.041	78±10	4.5±1.9				
	1/18/80	(4)	13	.063	110±12	11.4±3.1	14.81	16.68	5.9	
OW-4	11/16/79	5.8	11.5				21.44	27.08	11.6	B-sand
	12/2/79			.45	740±30	34±5				
	1/15/80	7.4	10	.64	950±40	62±7	16.96	19.20	6.2	
OW-5	11/8/79	6.4	12.5				11.74	14.59	10.8	B-sand
	12/1/79			.042	145±10	19±4				
	1/16/80	7.9	11	.014	27±4	7.5±2.4	7.27	8.28	6.5	
OW-6	12/1/79	7.0	12	.038	310±20	23±4				
	1/16/80	7.3	12	.051	175±15	30±5	13.92	15.89	6.6	B-sand
OW-7	1/15/80(5)	7.25	11							
	1/16/80	7.4	10	.011	15±5	0.5±1.2	11.92	13.06	4.6	A-sand
OW-8	11/9/79	5.4	13				5.92	6.16	2.0	D-sand
	12/2/79			<0.002	7.7±2.3	0.5±0.9				
	1/16/80	7.4	13.0	.003	3.4±1.7	1.0±0.5	6.24	6.11	1.1	
OW-9	11/9/79	5.3	12				4.76	5.58	7.9	C-sand
	12/1/79			.007	15±3	0.6±0.4				
	1/16/80	7.6	12	.009	14±3	0.8±0.4	5.44	5.34	0.9	

(1) µmhos/cm
(2) Standard pH units - field measurements prior to 2/1/80 unreliable due to equipment malfunction
(3) °C
(4) Meter inoperable
(5) Sample not reliable - bailer lost in borehole
(6) $\left|\frac{\text{cation equiv.} - \text{anion equiv.}}{\text{cation equiv.} + \text{anion equiv.}}\right| \times 100$
(7) Picocuries per liter ± counting error

Table 2.13

RECOMMENDED WATER QUALITY CRITERIA

(See Footnotes at the End of Table)

PARAMETER	IRRIGATION	LIVESTOCK	AQUATIC LIFE	PUBLIC WATER SUPPLY
Alkalinity			Not more than 25% reduction from natural level (4)	Naturally occurring 400 mg/l as $CaCO_3$ (4)
Aluminum	5.0-20. mg/l (1)			
Ammonia			.02 mg/l unionized (4)	.5 mg/l (1)
Arsenic	.10 mg/l no range (1), (4)	0.2 mg/l (1),(11)	1.0 mg/l (10)	.05 mg/l(4),(8),(10)
Barium				1.0 mg/l (4),(8)
Beryllium	.1 mg/l (1),(4)	6000 mg/l (10)	.01-1.1 mg/l (4) (soft of or hard water)	
Bicarbonate			40-180 mg/l (10)	0-150 mg/l (10)
BOD				
Boron	.75-2.0 mg/l crops (1),(4)	5.0 mg/l (1)		1.0 mg/l (4) (8)
Cadmium	.01 mg/l (1)	.05 mg/l	.0004-.012 mg/l (4)	.0[illegible] mg/l (4),(8)
Chloride	100 mg/l (10)	2000 mg/l(11) 1500 mg/l (10)		250 mg/l (1)
Chlorine	0-50 mg/l (10)		.002-.01 mg/l (4)	0-2.0 mg/l (10)
Chromium	.1 mg/l (1)	1.0 mg/l (1)	.1 mg/l (4)	.05 mg/l (4)(8)
Cobalt	.05 mg/l (1)	1.0 mg/l (1)	1.0 mg/l (10)	.1-.25 mg/day (10)
Color				75 pcu (15 color units)(2),(4)
Copper	.2 mg/l (1)	.5 mg/l (1)	.1 x 96-hr LC50(4) .1-.2 mg/l	1.0 mg/l (4)
Cyanide			.005 mg/l (4)	.2 mg/l (1)
Detergents			.2 mg/l (1)	
Dissolved Oxygen			min. 5 mg/l (4)	
Dissolved Solids	2000-5000 or (11) 500-1000 mg/l(10)	5000 mg/l (11) 2500 mg/l (10)	2000 mg/l (10)	500 mg/l (12) 250 mg/l (4)
Fluoride	1.0 mg/l (1)	2.0 mg/l (1)	1.5 mg/l (10)	1.4-2.4 mg/l (1),(8) Depends on temp.
Fluorine		2.0 mg/l		

Table 2.13 (Continued)

PARAMETER	IRRIGATION	LIVESTOCK	AQUATIC LIFE	PUBLIC WATER SUPPLY
Foaming Agents				.5 mg/l (1)
Hardness	Industrial only 120-5000 @ $CaCO_3$			
Hydrogen Sulfide			.002 mg/l (1)	.05 mg/l (2)
Iron	5 mg/l (1)		1.0 mg/l (4)	.3 mg/l (4)
Lead	5.0 mg/l (1)	.1 mg/l (1)	.01x96-hr LC50(4) .03 mg/l (1)	.05 mg/l (4),(8)
Lithium	.075-crops 2.5 mg/l (1)			5 mg/l (1)
Manganese	0.2 mg/l (1)	10.0 mg/l (10)	1.0 mg/l (10)	.05 mg/l (4)
Mercury(inorganic)		.001 mg/l (1) recommendation	.05 ug/l (1)	
Molybdenum	.01 mg/l (1)			
Nickel	.2 mg/l (1)		.01x96-hr LC50(4)	1.0 mg/l (10)
Nitrates		100 mg/l (1)	(as N) 4.2-.9 mg/l (10)	(as N) 10 mg/l (4),(8)
Nitrilotriacetate				
Nitrites		10.0 mg/l (1)		1.0 mg/l (1)
Oil				
Oil & Grease	10 mg/l (10)	10 mg/l (10)	0-0.1x96-hr LC50 10 mg/l (4)	None (4)
Odor				3-Threshold odor #(2) None (1)
pH	4.5-9.0 (4)	6.0-9.0 (11)	6.5-9.0 (4)	6.5-8.5 (2) 5.0-9.0 (4)
Phenolic Compounds			.1 mg/l (1)	
Phenols	40-50 mg/l (10)		.001 mg/l (4)	.001 mg/l (4)
Phthalate Esters			.003 mg/l (4)	
Phosphate	6-50 mg/l (10)			
Polychlorinated Biphenyls			.001 ug/l (4)	

Table 2.13 (Continued)

PARAMETER	IRRIGATION	LIVESTOCK	AQUATIC LIFE	PUBLIC WATER SUPPLY
Radioactivity				5-15 pCi/l (9)
Salinity		3000 mg/l (10)		500 mg/l (10)
Selenium	.02 mg/l (1)	.05 mg/l (1)	.01x96-hr LC50(4)	.01 mg/l (4),(8)
Silver			.1x96-hr LC50(4)	.05 mg/l (4),(8)
Sodium		2000 mg/l (7)		No limit (1)
Sulfate	200 mg/l (10)	3000 mg/l (11) 500 mg/l (10)		250 mg/l (1),(2)
Sulfide			.002 mg/l (1)	
Suspended Solids	240 mg/l (10)		25-80 mg/l (10)	.1 mg/l (10)
Temperature (4)				
Turbidity			200 Units (4),(10)	1-5 Units (9)
Vanadium	.1 mg/l (1)	.1 mg/l (1)		
Zinc	2 mg/l (1)	25.0 mg/l (1)	.01x96-hr LC50(4)	5.0 mg/l (4)

Modified After: Teton-Nedco R&D In Situ Testing License Application, WDEQ Land Quality Division, July, 1979.

Table 2.13 (Continued)

Footnotes

(1) Committee of Water Quality Criteria, 1972, Water Quality Criteria, Environmental Studies Board: National Academy of Science-National Academy of Engineering, Washington, D.C.

(2) Environmental Protection Agency, March 31, 1977, National Secondary Drinking Water Standards (40 CFR Part 143) Proposed Regulations: Federal Register, Volume 42, No. 62, p. 17143-17146.

(3) U.S. Public Health Service, March 6, 1962, Drinking Water Standards (42 CFR, Ch. 1, Part 72): Federal Register 2152.

(4) Environmental Protection Agency (not published as of July, 1976), Quality Criteria for Water: Washington, D.C.

(5) Environmental Protection Agency, (undated), Comparison of NTAC, NAS, and Proposed EPA Numerical Criteria for Water Quality: Washington, D.C., 12 pp.

(6) Environmental Protection Agency, July 9, 1976, Promulgation of Regulations on Radionuclides (40 CFR, Ch. 1, Part 141): Federal Register, Vol. 41, No. 133, p. 28402-28409.

(7) Wyoming Department of Agriculture, April 9, 1973, Division of Laboratories (table not published).

(8) Environmental Protection Agency, National Interim Primary Drinking Water Regulations, Federal Register, Vol. 40 p. 59566-59574.

(9) Environmental Protection Agency, 1977, National Interim Primary Drinking Water Regulations, EPA-570/9-76-003.

(10) McKee & Wold (ed.), 1963, Water Quality Criteria (2nd ed.): Resources Agency of CA, State Water Quality. Control Board Publication No. 30-A.

(11) Wyoming Department of Environmental Quality, Dec. 12, 1977, Land Quality Division Guideline #4: LQD, Hathaway Bldg., Cheyenne, Wyoming.

(12) Environmental Protection Agency, March 1, 1977, National Secondary Drinking Water Regulations (40 CFR Part 143): Federal Register Vol. 42, No. 62.

In addition, based upon the current data, the water appears only marginally suited for livestock or for agricultural use. The contributing chemical parameters in these use categories are aluminum, chromium, iron, sulfate, lead and zinc. Waters in the Shallow and B Aquifers would likely not be used for either livestock watering or irrigation.

3.0 OPERATIONAL PLAN

3.0 OPERATIONAL PLAN

3.1 GENERAL DISCUSSION

The proposed activity at the R&D Site is a pilot test, and not a commercial in situ extraction operation. Therefore, the pilot test has been designed to accomplish two things:

1. Perform research and development into the feasibility of in situ extraction of uranium.

2. Demonstrate restoration of the aquifer.

The plan outlined herein is based on the best information and projections currently available to APS-NAC. The intent of this plan and application is to allow for adequate flexibility to facilitate research into all viable aspects of commercial development and aquifer restoration within the limitations of existing regulations.

EXPECTED LIFE OF OPERATIONS

The operation of the pilot plant and wellfield is scheduled to start during March, 1981, and last approximately one year. The initial three to four months will involve leaching operations and data compilation needed to evaluate the potential commercial operations. The final eight to nine months will be used to demonstrate ground water restoration. If restoration is demonstrated in less time, the R&D test will be terminated earlier than expected, and the commercial license application may be submitted.

The construction of site facilities must begin prior to March, 1981. Because the R&D operation will not be winterized, it will be operated during the warmer spring and summer seasons of 1981. Construction must begin by late summer, 1980, to take maximum advantage of the warm weather months during 1981. Since plant construction will require 60 to 90 days, APS desires to start site preparation no later than August, 1980. A start up by this date should allow construction to be completed before severe winter weather. Therefore, the plant will be ready for operation as soon as weather permits in spring, 1981.

ORGANIZATION AND TECHNICAL QUALIFICATIONS

Arizona Public Service Company acts as owner and project manager for the R&D in situ uranium extraction project. As project manager, APS determines policy, makes decisions and sets goals for project performance. As operator of the project, Nuclear Assurance Corporation is responsible for project implementation through the day to day management of project development activities, the acquisition and interpretation of technical information, and provides recommendations to APS on the scope and feasibility of the proposed program.

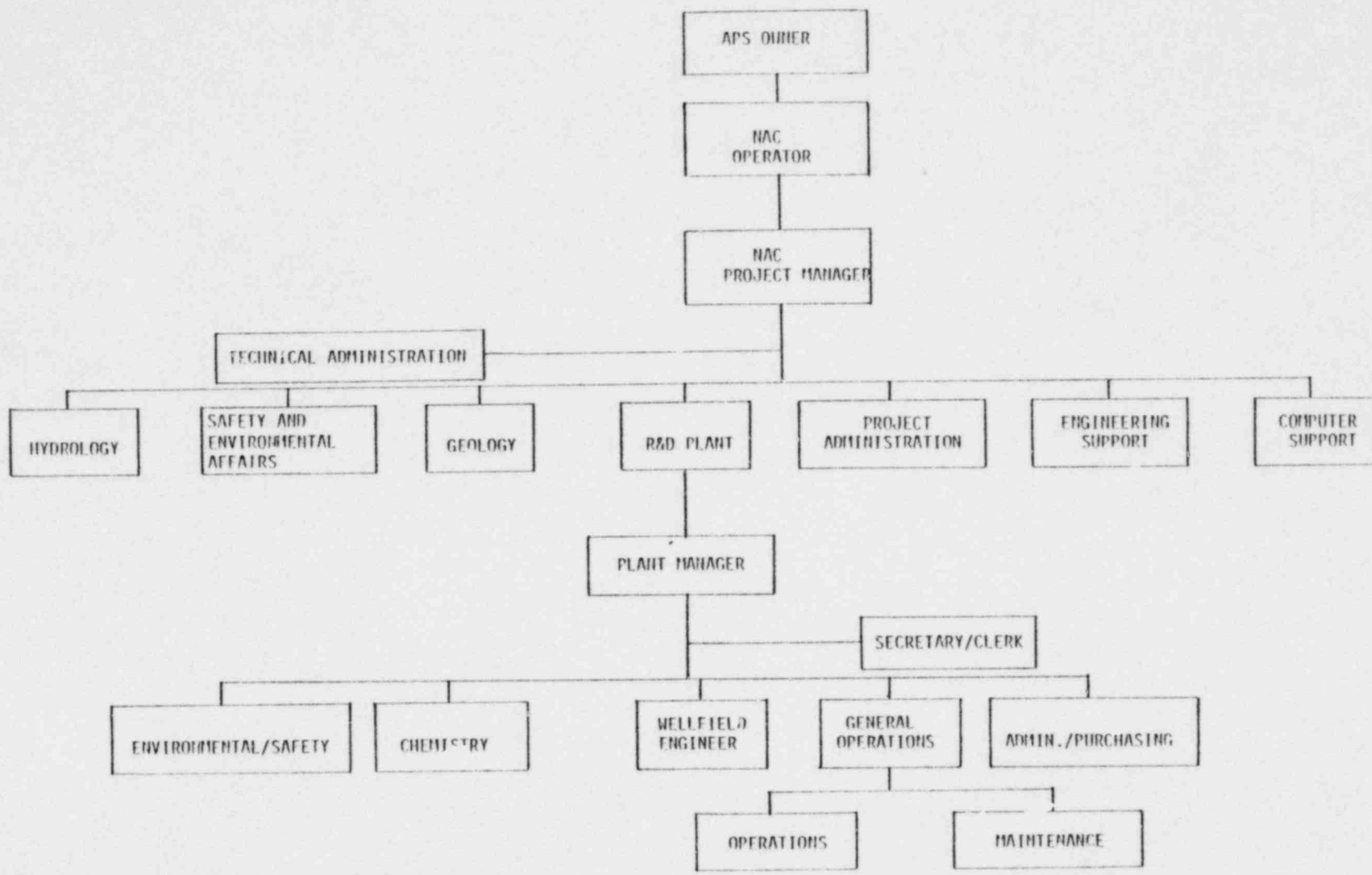
The APS-NAC organizational chart for the proposed project is provided by Figure 3.1. The chart indicates that the NAC project manager is directly responsible for overall project operations and interacts directly with APS management. The plant manager located at the site is responsible for everyday operations and reports directly to the NAC project manager. Numerous professional personnel having a wide range of expertise will be available to support the project and plant managers.

Mr. Jim Krebs has been designated as the NAC project manager for the R&D test. Mr. Krebs is responsible for field operations, technical support activities, project planning and economic analyses. Prior to joining NAC in November, 1979, Mr. Krebs has four years operational experience with in situ extraction projects and has held titles of Chief Mill Engineer, Operations Superintendent and Process Engineer. Mr. Krebs holds B.S. and M.S. degrees in Metallurgical Engineering from the Colorado School of Mines.

Personnel in intermediate management positions will generally have a degree in science or engineering and working experience. In lieu of a degree, these

FIGURE 3.1

ORGANIZATIONAL CHART
FOR
R&D TEST



personnel will have demonstrated several years of pertinent experience. On site general operations personnel will have had several months industrial experience, some of which is in the area of wellfield or metallurgical plant operations.

A specific health and safety training course will be given to personnel regarding the handling of equipment, plant layout and operation, and chemical hazards. In addition, radiation hazards will be discussed with personnel.

The radiation monitoring and protection program will be implemented by the plant Environmental/Safety Supervisor under the guidance of the Plant Manager and Safety and Environmental Affairs Manager. The design of the radiation monitoring program may initially be performed by a qualified consultant.

EQUIPMENT LIST

The extraction area at an in situ operation is for all practical purposes the wellfield. The general types of equipment needed to operate the wellfield consist of:

1. Cased water wells
    a. Recovery wells with submersible pumps, pump columns and related electrical equipment.
    b. Injection wells equipped to allow introduction of fluids under pressure.
    c. Wells constructed to allow operation in either of the above modes.
2. Surface equipment in the wellfield including pipes, valves and instrumentation.
3. Electrical supply generators at the plant.

In the area of the surface process plant, several additional pieces of equipment will be present. These include:

1. Pumps for transferring solutions within process plant
2. Adsorption and elution columns
3. Various solution tanks within process plant
4. Agitators and mixers
5. Reverse osmosis unit
6. Water supply tank
7. Chemical storage tanks
8. Propane storage tank
9. Air compressor

In addition, solar evaporation ponds, an office/lab, warehouse, sanitary leach field and potable water supply well will be constructed. The office/lab and warehouse will likely comprise one or more trailer modules attached to each other to satisfy space requirements. The office/lab will likely require three modules (each 12 feet by 60 feet), and the warehouse may require only one module. Small trucks, automobiles, truck mounted water well drill rigs and perhaps a small hydraulic crane will be used at the site.

MINING OPERATIONS IN THE AREA

Currently there are no underground, open pit, or in situ extraction operations known within a radius of approximately five miles (8 km) from the Test Site.

PROTECTION OF OTHER RESOURCES

The proposed extraction activity will not require special provisions to protect other resources in the permitted area. The extraction process is highly selective for uranium. Subsurface physical disturbance is very small and surface disturbances are short-term.

If present in the deeper strata, oil and gas can be recovered after extraction operations cease by using standard industry techniques and procedures. Based on current knowledge, any other minerals potentially occurring beneath the site in commercial quantities will not be adversely affected.

Ground water in the producing aquifers will become an integral part of the operation. The ground water chemistry in the immediate area of the wellfield will be temporarily altered during operations by circulating chemically prepared ground water through the in situ uranium bearing strata (aquifer). A major function of the R&D test will be to demonstrate that the future use of the ground water in the extraction area is not precluded due to the chemical extraction of uranium.

The proposed activities will not require the dewatering of the producing aquifers. Therefore, large quantities of ground water will not be lost to future use.

The land surface will be temporarily removed from other use during the extraction operations. However, upon termination of the operations the land will be returned to a condition equal to or better than its present condition.

3.2 PROPOSED LEACH CHEMISTRY

The leach solution or lixiviant to be used for dissolution and recovery of uranium at the R&D Site will be formation water to which sodium and carbonate species have been added. An oxidizer, either hydrogen peroxide or oxygen, will also be added to aid in the dissolution process.

Theoretically, uranium dissolution is a two step process involving an oxidation step and a dissolution step. The reactions representing these steps at a neutral pH are:

Oxidation: $$UO_2 + H_2O_2 \rightleftharpoons UO_3 + H_2O$$

$$UO_2 + \tfrac{1}{2} O_2 \rightleftharpoons UO_3$$

(solid) (in solution) (at solid surface) (in solution)

Dissolution: $$H_2O + UO_3 + 2HCO_3^- \rightleftharpoons UO_2(CO_3)_2 \cdot 2H_2O^{-2}$$

$$CO_3^{=} + UO_3 + 2HCO_3^- \rightleftharpoons UO_2(CO_3)_3^{-4} + H_2O$$

The principal uranyl carbonate complex ions formed as illustrated above are uranyl dicarbonate ($UO_2(CO_3)_2 \cdot 2H_2O^{-2}$, or UDC); and uranyl tricarbonate ($UO_2(CO_3)_3^{-4}$, or UTC). The relative abundance of each is a function of pH and total carbonate strength.

Various cations can be used to carry carbonates and bicarbonates in solution, but for economic reasons sodium or ammonium systems are normally used for in situ extraction. Sodium systems are rather selective for uranium, and sodium is a naturally occuring ground water constituent. In addition, sodium does not usually have a strong loading/elution interaction with clay minerals in the ore.

Ammonium systems are useful where clay swelling might prevent the use of sodium; however, ammonium ions load on clays, displacing the natural cation. Also, ammonium is not naturally occurring in ground water.

In addition to the complexing agent, either sodium or ammonium bicarbonate, an oxidant is added to the injected solution to carry out the oxidation reactions shown above. Although several oxidants could be used, the common choices are hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2). Both of these oxidants revert to naturally occurring substances.

At the R&D Site, a sodium bicarbonate lixiviant will be used. The sodium bicarbonate will be used at a strength of 2.0 to 5.0 grams per liter with 0.3 to 1.5 grams per liter H_2O_2, or oxygen equivalent, added. From the results of the leaching tests, APS-NAC may determine that it will be desirable to use an ammonium bicarbonate lixiviant. However, prior approval from the WDEQ-LQD and NRC would be obtained before using ammonium bicarbonate.

3.3 PROCESSING

GENERAL PROCESS DESCRIPTION

As mentioned previously, the R&D plant will utilize a sodium bicarbonate solution containing an oxidant to solubilize the uranium underground. The uranium bearing solution will then be recovered, and the uranium will be extracted in the processing plant. The plant process will utilize the following steps:

A. Loading of uranium complexes onto an ion exchange resin.

B. Reconstitution of the leach solution by addition of NaOH, CO_2, and H_2O_2 or O_2.

C. Elution of uranium complexes from the resin using an NaCl/$NaHCO_3$ eluant.

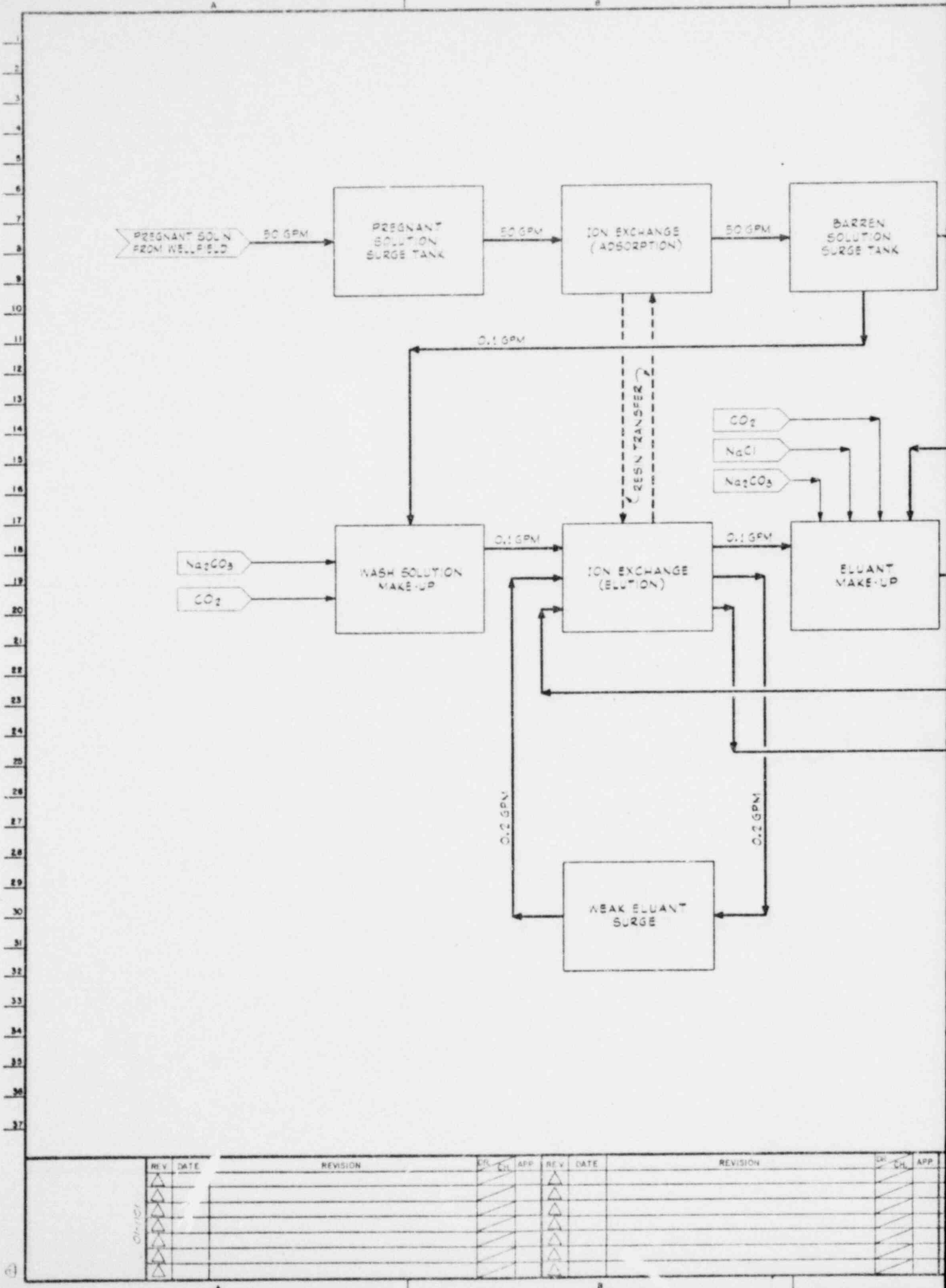
D. Precipitation of the uranium using HCl, H_2O_2 and NaOH.

The process flow sheet for the above steps is shown in Figure 3.2. The anticipated R&D process plant layout is shown in Figure 3.3. The plant will be designed to operate at a maximum capacity of 50 gpm (3.2 lps).

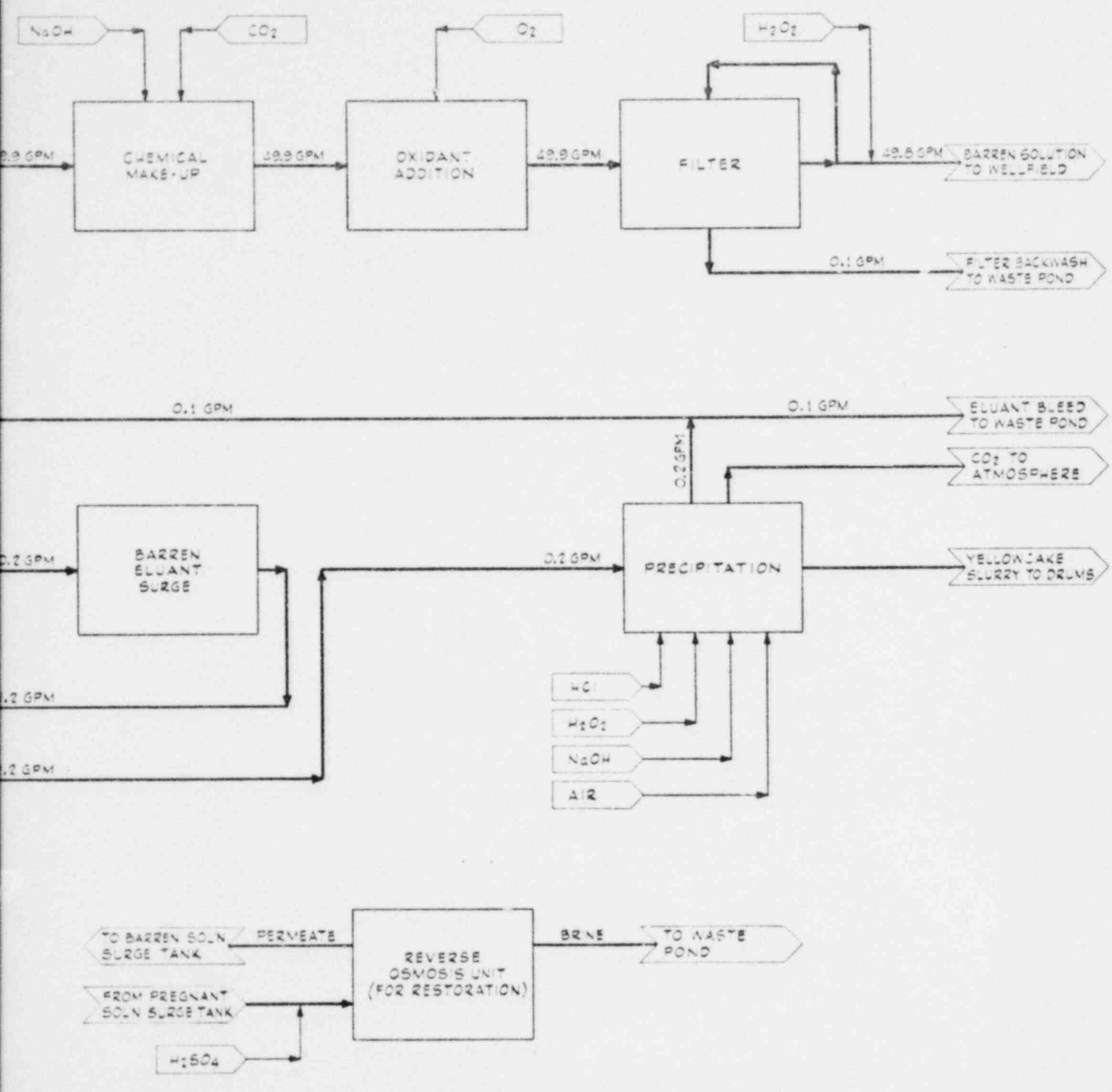
PROCESS DETAILS

Ion exchange will take place in multi-stage, upflow moving bed columns. Uranium bearing leach solution will enter the bottom of the column. As it passes upward, the uranium will be loaded on the resin. Periodically a volume of resin will be withdrawn from the loading column and transferred into the elution vessel. After the resin is eluted, it will then be placed back into the adsorption system.

The ion exchange process that will be used consists of the adsorption of a uranium complex ion on a strong base ion exchange resin followed by the elution of the uranium complex ion by a strong salt solution. The eluant to be used will be a combination of 0.75 to 1.0 Molar (M) sodium chloride and 0.1 to 0.2 M sodium bicarbonate. The loading and elution processes can be represented by the following reactions:



A
B
PREGNANT SOL'N FROM WELLFIELD
50 GPM
PREGNANT SOLUTION SURGE TANK
50 GPM
ION EXCHANGE (ADSORPTION)
50 GPM
BARREN SOLUTION SURGE TANK
0.1 GPM
RESIN TRANSFER
CO2
NaCl
Na2CO3
Na2CO3
CO2
WASH SOLUTION MAKE-UP
0.1 GPM
ION EXCHANGE (ELUTION)
0.1 GPM
ELUANT MAKE-UP
0.2 GPM
0.2 GPM
WEAK ELUANT SURGE
REV
DATE
REVISION
CH
APP
REV
DATE
REVISION
CH
APP



NUMBER	REFERENCE DRAWINGS

NOTICE
THIS DRAWING HAS NOT BEEN PUBLISHED BUT RATHER HAS BEEN PREPARED BY THE ORTLOFF MINERALS SERVICES CORPORATION [illegible] ORTLOFF MINERALS SERVICES CORPORATION

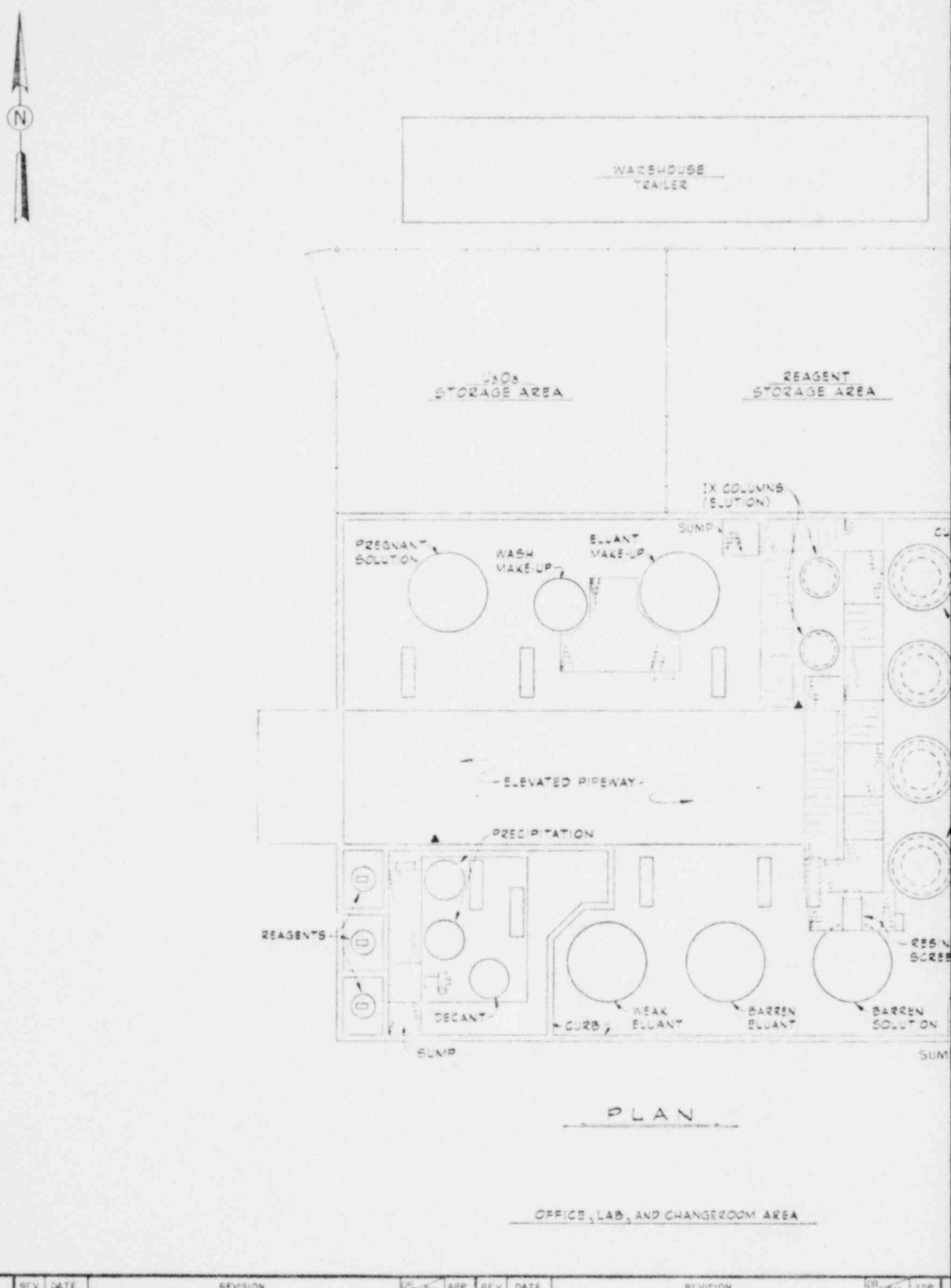
SCALE	——	DATE
DRAWN	SRC	4 82
CHECKED		
PROCESS		
STRUCT.		
INSTR.		
ELECT.		
MECH.		
APP.		

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

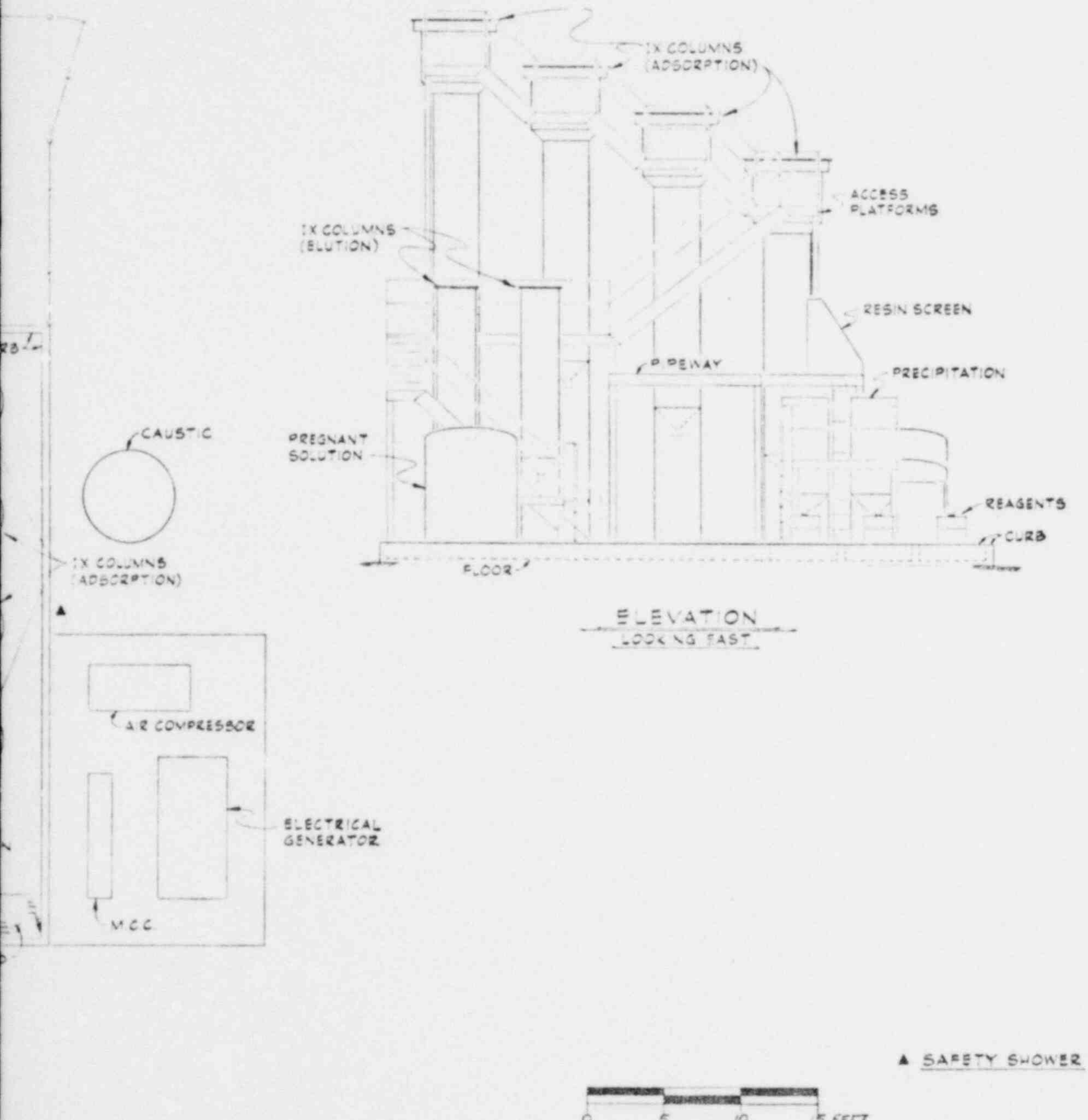
ORTLOFF MINERALS SERVICES CORPORATION

PROCESS FLOWSHEET
PETERSON IN-SITU URANIUM EXTRACTION PROJECT

PROJECT NO.	FIGURE NO.	REV.
88900	3.2	



REV.	DATE	REVISION	DR. / CH.	APP	REV.	DATE	REVISION	DR. / CH.	APP



NUMBER	REFERENCE DRAWINGS

SCALE		DATE
DRAWN	SEC	7/1/80
CHECKED		
PROCESS		
STRUCT.		
INSTR.		
ELECT.		
MECH.		
APP.		

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

ORTLOFF MINERALS SERVICES CORPORATION

PROCESS PLANT LAYOUT
PETERSON IN-SITU URANIUM EXTRACTION PROJECT

PROJECT NO. 88900 | FIGURE NO. 3.3 | REV.

Loading: $2\ RCl + UO_2(CO_3)_2^{-2} \rightleftharpoons R_2\ UO_2\ (CO_3)_2 + \quad 2\ Cl^-$

(resin, Cl-form) (uranyl dicarbonate ion) (loaded resin) (exchanged ion

Elution: $R_2\ UO_2\ (CO_3)_2 + 2Cl^- + CO_3^{=} \rightleftharpoons 2\ RCl + \quad UO_2\ (CO_3)_3^{-4}$

(loaded resin) (eluant) (stripped resin) (uranyl tri-carbonate ion)

The elution reaction will be carried out in two stages, however, the reaction is the same for both. During the elution process, the first half of the pregnant (uranium-rich) eluate will be transferred to the precipitation tank. The second half of the eluate volume, which is lower in uranium content, will be stored in the weak eluant storage tank to be used in the first half of the next cycle.

After the uranium has been removed from the resin, the stripped resin will be rinsed with a dilute sodium bicarbonate solution. The rinse will remove the high chloride eluant physically entrained in the resin and will partially convert the resin to bicarbonate form. In this way chloride build up in the leach solution can be reduced.

PRECIPITATION

The pregnant eluate in the precipitation tank will be acidified with hydrochloric acid to destroy the uranyl carbonate complex ion, and air will be sparged through the solution to assist in removal of the resulting CO_2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \rightleftharpoons UO_2^{++} + \underset{\text{(gas)}}{3CO_2\uparrow} + 3H_2O$$

Hydrogen peroxide will then be added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \rightleftharpoons UO_4 \cdot 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry will be allowed to settle, and the clear solution will be decanted. Part of the decant solution will go back to the eluant make-up tank while the remainder will go to the evaporation ponds. The thickened slurry will then be transferred to plastic-lined drums, tightly sealed, and stored in a secured area in the process plant (Figure 3.3). The product eventually will be shipped to a licensed milling or converting facility.

PROCESS WASTES

The operation of the process plant will result in three sources of liquid wastes. These are: 1) filter backwash, 2) eluant bleed, and 3) reverse osmosis brine (Figure 3.2). Since this is a research and development operation, the composition of the process wastes may vary as efforts are made to improve the process. However, the currently anticipated compositions of the liquid wastes are given in Table 3.1. The wastes will be discharged into lined solar evaporation ponds. The total amount of solution wastes from the process plant (items 1 and 2, above) are not expected to exceed four (4) percent of the pregnant solution recovered from the wellfield.

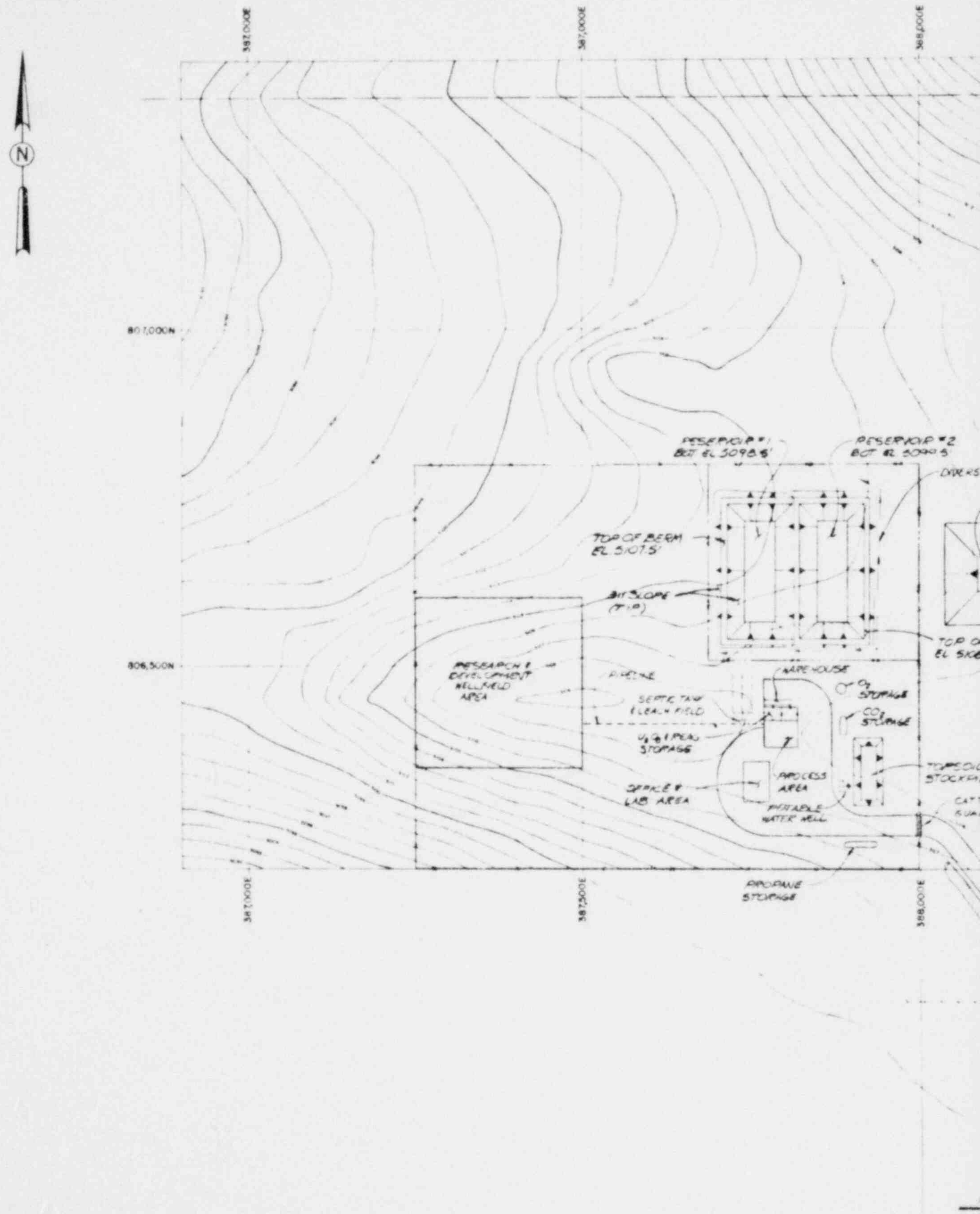
3.4 SITE FACILITIES

The process plant, office/lab, warehouse, solar evaporation ponds, topsoil stockpile, and wellfield have been located in the south-central and south-eastern portions of the R&D Site (Figure 3.4 and large scale drawing in Appendix G). The siting of these facilities was accomplished so as to minimize the amount of earth work required for construction. Total surface disturbance within the site boundary is estimated to be approximately 4.5

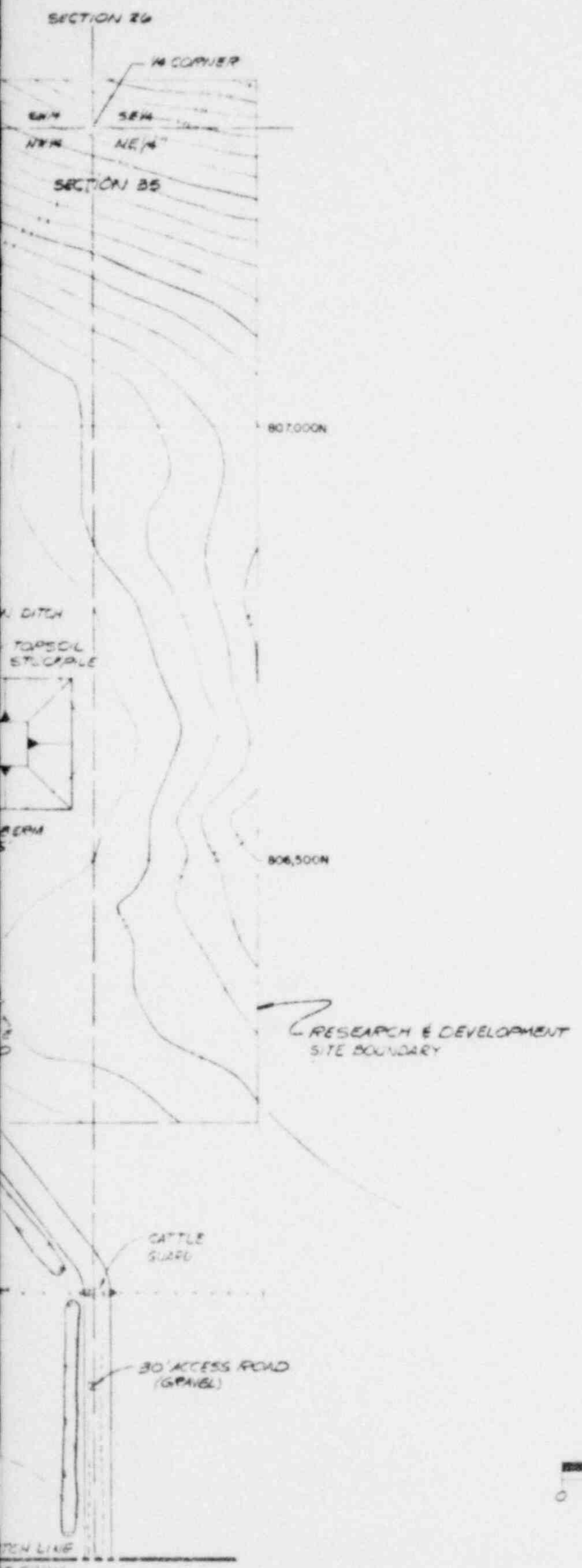
TABLE 3.1

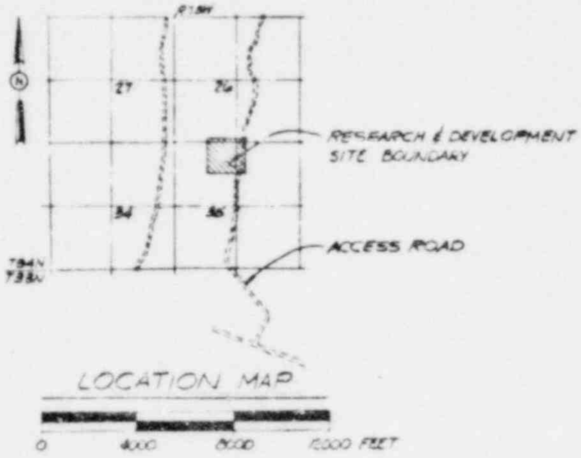
Estimated Flow Rates and Composition of Liquid Wastes (mg/l, except as noted)

Parameter	Filter Backwash	Eluant Bleed	Reverse Osmosis Brine
Flow Rate (gpm)	0.1	0.1	5 - 10 (intermittent)
Ca	50 - 80	50 - 100	150 - 250
$CaCO_3$ (solids)	1-5 (percent by weight)	-	-
Cl	200 - 400	25,000 - 35,000	1,500 - 2,000
CO_3/HCO_3	2,000 - 3,000	<10	0
Na	1,100 - 1,300	25,000 - 30,000	3,200 - 3,500
SO_4	250 - 1000	10,000 - 15,000	9,000 - 12,000
U_3O_8	<2	<50	50 - 100



REV	DATE	REVISION		APP	REV	DATE	REVISION		APP	NUMBER
△					△					
△					△					
△					△					
△					△					
△					△					
△					△					
△					△					





LOCATION MAP

LEGEND

- EXISTING CONTOURS
- SHEEP TIGHT FENCE (TYPE I, SEE NOTE Nº3)
- DEEP TIGHT FENCE (TYPE II, SEE NOTE Nº3)
- EXISTING ROADS
- PROPOSED ROADS
- EMBANKMENT SLOPE
- TOPSOIL STOCKPILE

NOTES:

1) THE COORDINATES USED ARE AS PER THE WYOMING STATE COORDINATE SYSTEM.

2) CONTOUR INTERVALS = 1'

3) FENCES ARE TO BE AS PER WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY-LAND QUALITY DIVISION GUIDELINE #10 FENCING.

0 100 200 300 FEET

REFERENCE DRAWINGS

SCALE	
DRAWN	
CHECKED	
PROCESS	
STRUCT.	
ARCH.	
ELECT.	
MECH.	
APP.	

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

ORTLOFF MINERALS SERVICES CORPORATION

SITE FACILITY LAYOUT
PETERSON INSITU URANIUM EXTRACTION PROJECT

PROJECT NO.	FIGURE NO.	REV.
83900	3.4	

acres (1.8 hectares). In addition, it will be necessary to improve the existing access road connecting the Test Site with County Highway 27. Modifications to this road will result in the disturbance of about 9 acres (3.5 hectares) of land, less than one-half of which is new land disturbance.

PROCESS PLANT

The solution processing equipment will be placed on a 40 by 50 foot (12 by 15 m) concrete pad (Figure 3.3). A curb around the perimeter of the pad will prevent potential run off and chemical solutions from leaving the pad. Sumps are provided to collect any solutions that accumulate, and a pump and piping system will carry the liquids to the solar evaporation ponds. Two equal sized gravel surfaced areas each 20 by 25 feet (6 by 7.5 m) are provided adjacent to the plant for drummed reagent and U_3O_8 storage.

The proposed operational schedule calls for operations to begin during the spring season and continue through summer and fall. Currently there are no plans to construct a process plant building for protection from winter weather. The concrete foundation has been designed, however, to accommodate a building if one becomes necessary.

At least one foot (30 cm) of topsoil will be removed from the process plant site prior to construction. This soil will be placed on the small stockpile just east of the office and lab area (Figure 3.4). The soil will be broadcast seeded at a rate of 12 lb/acre (13.4 kg/hectare) of western wheatgrass and 12 lb/acre (13.4 kg/hectare) of thickspike wheatgrass, or equivalent seed mixture.

SUPPORT FACILITIES

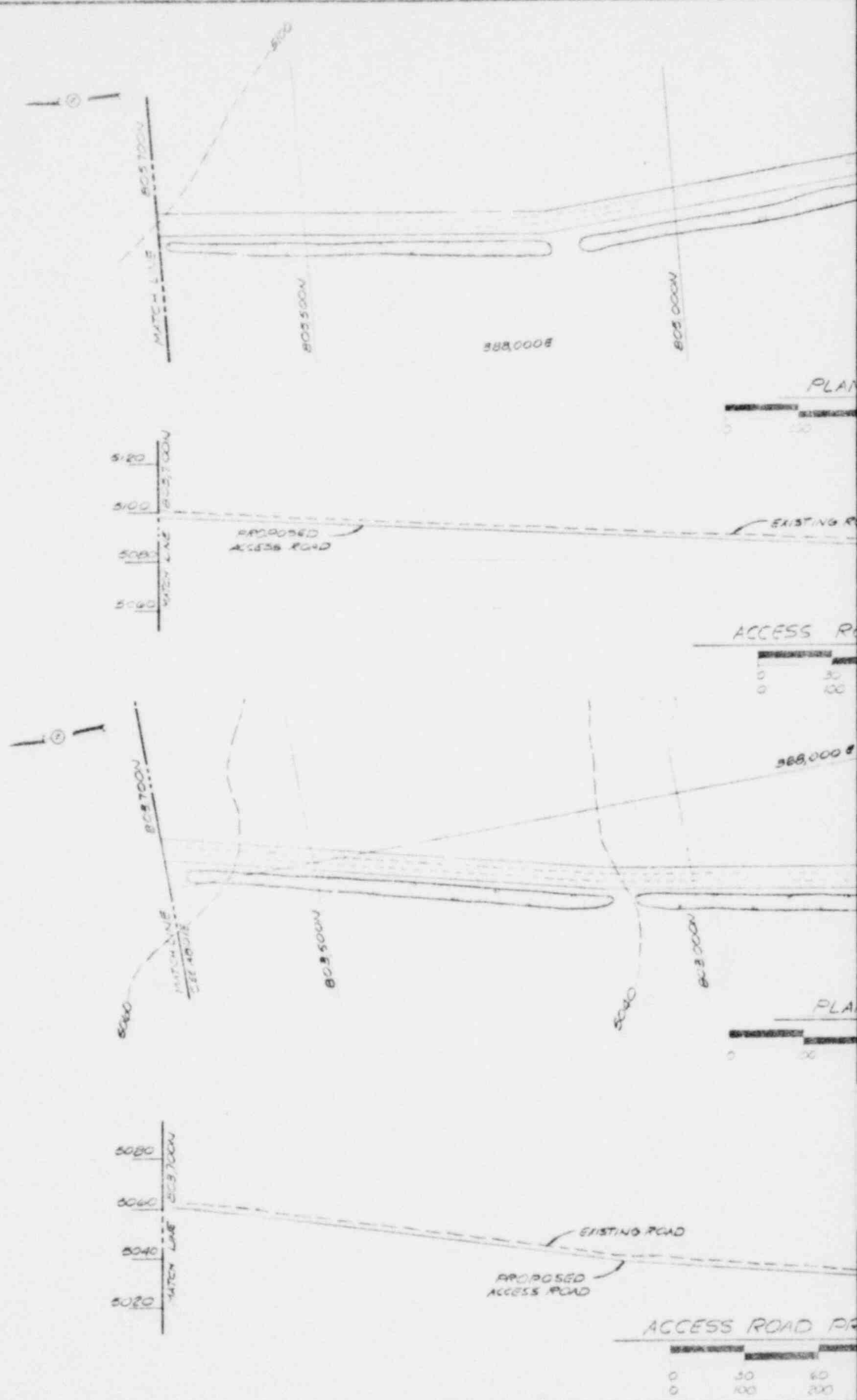
Support facilities will include office/lab, warehouse, water supply well, sanitary leach field, chemical storage facilities, fence, access road and parking area (Figure 3.4). The office/lab will consist of two or three house trailers attached as a single unit approximately 36 by 60 feet (11 by 18 m) (each modular component 12 by 60 feet (3.6 by 18 m)). In addition to the office and chemistry laboratory, a change room will be housed in this unit. A separate warehouse trailer will be located adjacent to the north side of the process plant.

A water supply well will be located in the area of the topsoil stockpile adjacent to the parking area. The well will supply potable drinking water as well as satisfy process water requirements. The total depth of the water supply well is estimated to be about 450 feet (135 m), with production from the next aquifer (E Aquifer) beneath the D Aquifer. If this proposed source of water below the production zone receiving strata does not prove satisfactory, the well will be deepened or relocated. Details of this well completion will be forwarded to the Wyoming State Engineer's Office.

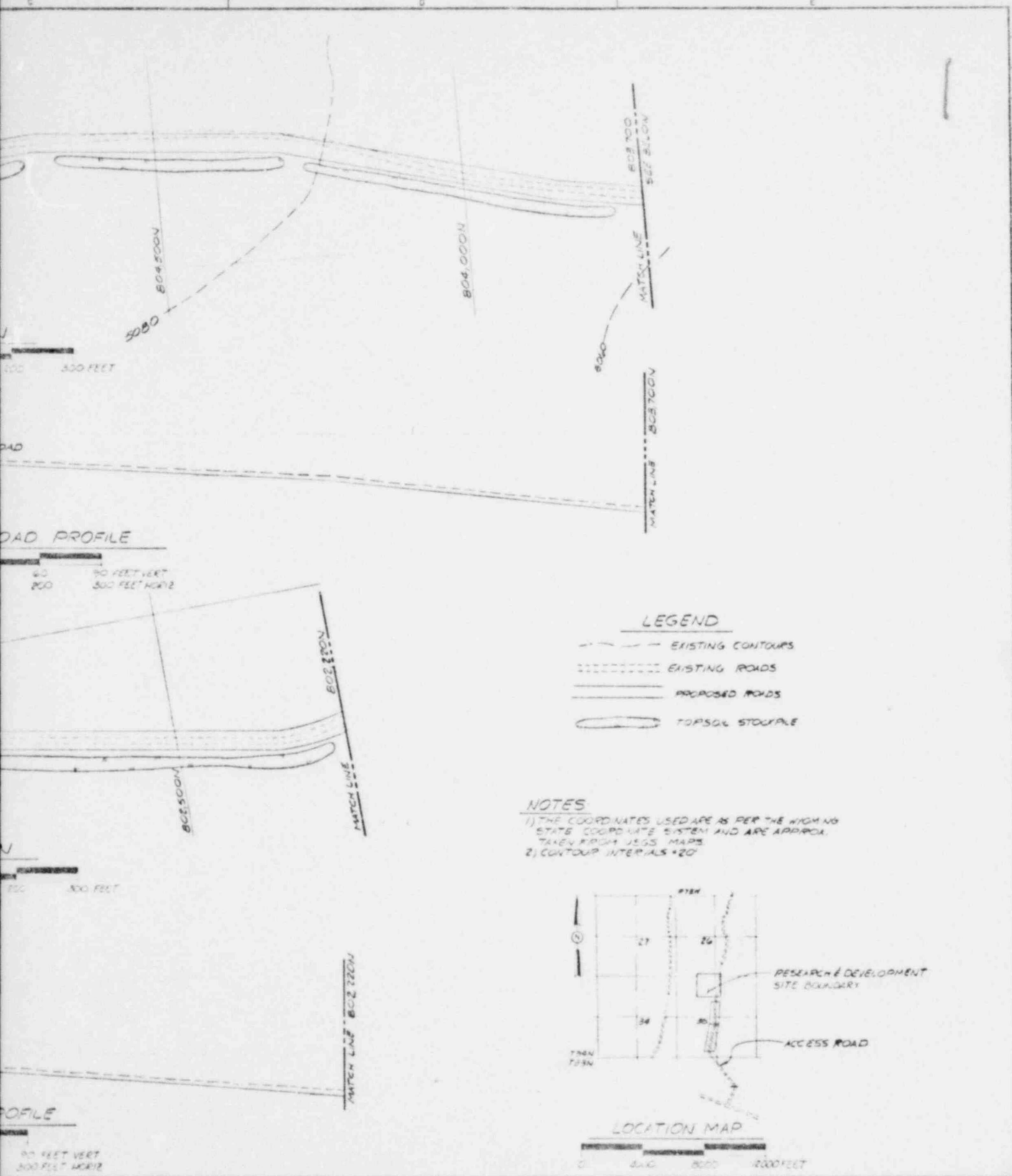
Shower, lavatory and sewage wastes will be disposed of in an on-site sanitary leach field adjacent to and northwest of the process plant. Approval of the septic system will be obtained from the WDEQ-Water Quality Division (WQD). Chemical laboratory wastes will be piped to the solar evaporation ponds. Trash and garbage will be collected in suitable containers and hauled to an approved sanitary landfill for disposal.

A sheep tight fence (Type I) (WDEQ - LQD Guideline No. 10) will be placed around the perimeter of the area of operations on the Test Site (Figure 3.4). A deer tight fence (Type II) will be placed around the solar evaporation ponds.

An access road approximately one mile (1.6 km) in length will be required. To minimize land disturbance, the existing road will be used, however, improvements will be required to accommodate increased traffic (Figures 3.5 and 3.6). One foot (30 cm) of topsoil will be removed and windrowed into low berms along side the road. This stockpile area will be broadcast seeded at a rate of 12 lb/acre (13.4 kg/hectare) with western wheatgrass and 12 lb/acre (13.4 kg/hectare) with thickspike wheatgrass, or equivalent seed mixture. This temporary disturbance will encompass a strip about 50 feet wide along one side of the road. A gravel surfaced road 24 feet wide is planned. Cattle guard crossings will be placed at the existing fence line just south of the Test Site and at the Test Site entrance. All other access roads are existing.



REV	DATE	REVISION	DR. CH.	APP	REV	DATE	REVISION	DR. CH.	APP
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				



NUMBER	REFERENCE DRAWINGS

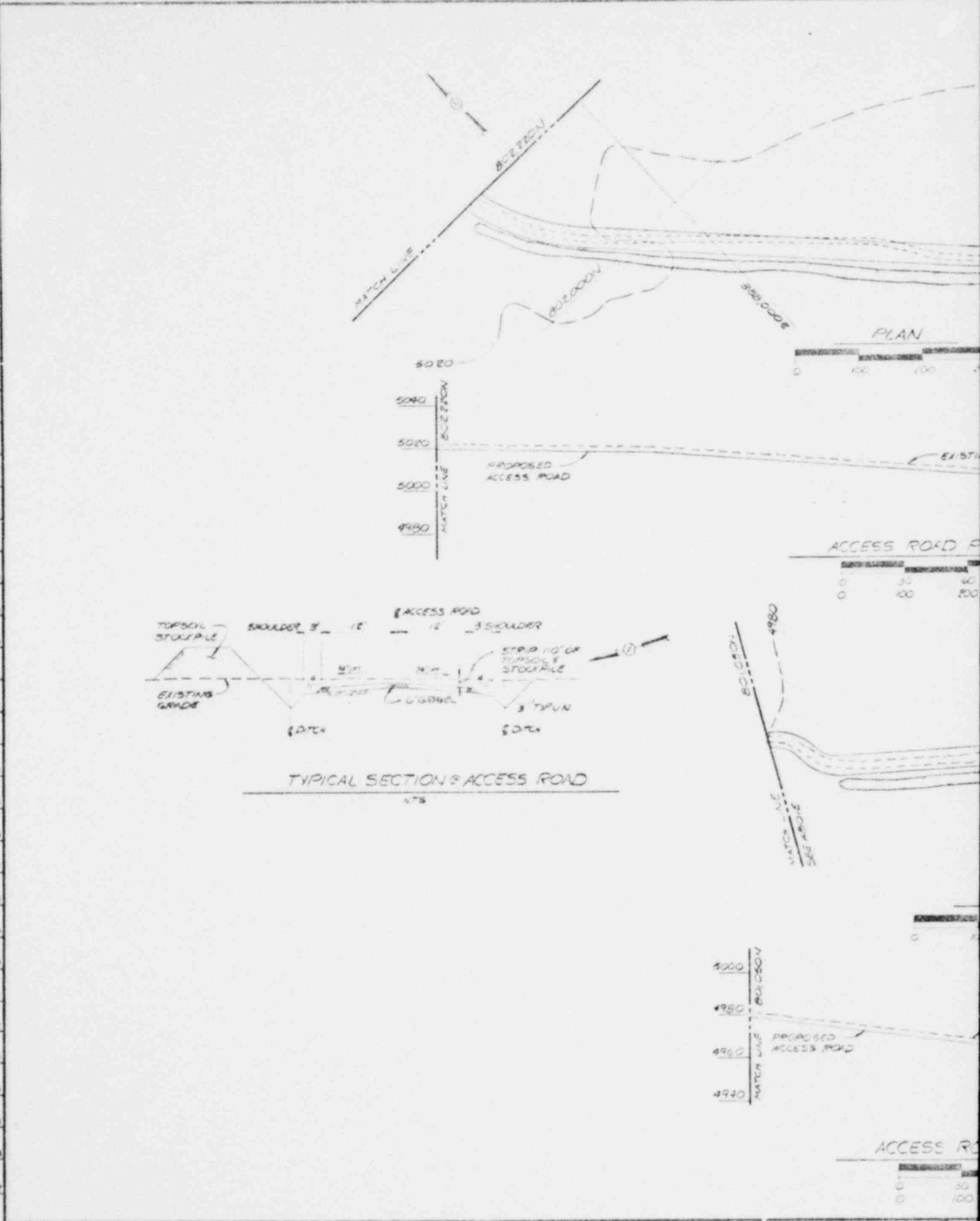
SCALE	NOTED	DATE
DRAWN		1/80
CHECKED		
PROCESS		
STRUCT.		
INSTR.		
ELECT.		
MECH.		
APP.		

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

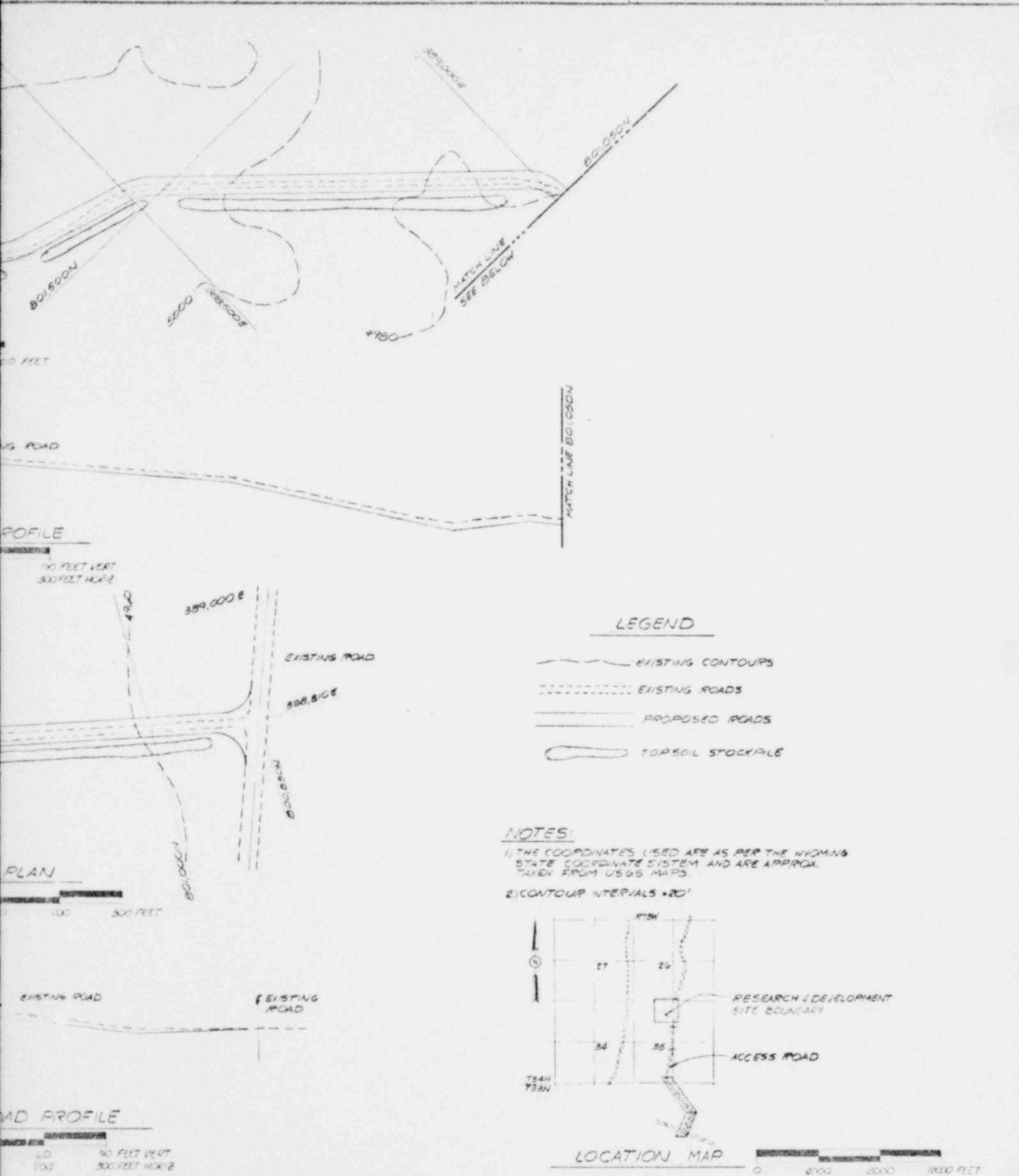
ORTLOFF MINERALS SERVICES CORPORATION

ACCESS ROAD
PETERSON IN SITU URANIUM EXTRACTION PROJECT

PROJECT NO. 88900 | FIGURE NO. 3.5 | REV.



REV	DATE	REVISION	DR / CH	APP	REV	DATE	REVISION	DR / CH	APP
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				



NUMBER	REFERENCE DRAWINGS

NOTICE: THIS DRAWING HAS NOT BEEN PUBLISHED, BUT RATHER HAS BEEN PREPARED BY THE ORTLOFF MINERALS SERVICES CORPORATION FOR USE BY THE CLIENT NAMED IN THE TITLE BLOCK SOLELY IN RESPECT OF THE CONSTRUCTION, OPERATION AND MAINTENANCE OF THE FACILITY NAMED IN THE TITLE BLOCK AND IS NOT TO BE USED FOR ANY OTHER PURPOSE OR FURNISHED TO ANY OTHER PARTY WITHOUT THE EXPRESS CONSENT OF THE ORTLOFF MINERALS SERVICES CORPORATION.

	NOTED	DATE
SCALE	NOTED	
DRAWN	JRP	7-9-80
CHECKED		
PROCESS		
STRUCT.		
INSTR.		
ELECT.		
MECH.		
APP.		

ARIZONA PUBLIC SERVICE COMPANY
PHOENIX, ARIZONA

ORTLOFF MINERALS SERVICES CORPORATION

ACCESS ROAD
PETERSON IN-SITU URANIUM EXTRACTION PROJECT

PROJECT No. 88900 | FIGURE No. 3.6 | REV.

No power lines are anticipated as power will be generated on-site. Communication lines will be constructed as this service becomes available.

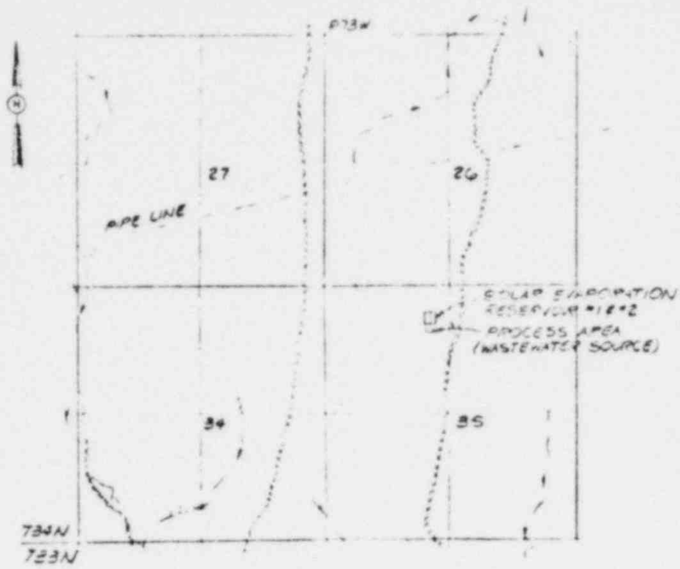
There are no streams or ditches running through the R&D Site. However, erosion control procedures will be utilized as necessary to mitigate any excess surface erosion in the wellfield area, along the access road, and for diversion around the topsoil stockpiles and solar evaporation ponds.

SOLAR EVAPORATION PONDS

Two adjacent solar evaporation ponds will contain the waste solutions produced during both leaching and restoration processes (see later discussion and Figure 3.2). There will be no discharge from the ponds. The location of the evaporation ponds is shown on Figure 3.4. Design details of the ponds are presented in Figure 3.7 (large scale drawing of Figure 3.7 in Appendix G).

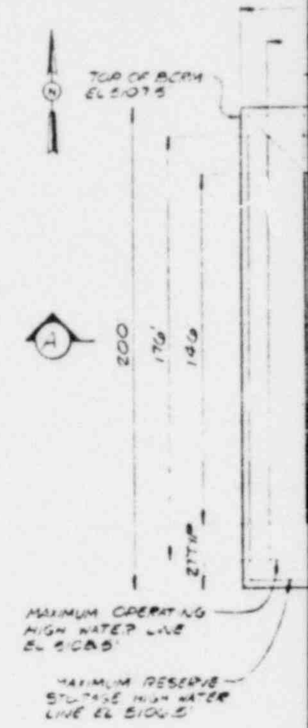
The runoff from the drainage area above the ponds will be diverted around the ponds. The drainage area encompasses approximately 16.07 acres (6.5 hectares), and the design capacity of the diversion ditch is based on the volume of runoff from 10(-year 24-hour storms on two consecutive days. This volume of runoff has been calculated to be 76.5 cubic feet per second (cfs) (2.1 m^3/sec) (Appendix E). This runoff will be diverted around the solar evaporation ponds.

If the process plant operates as planned at a design capacity of 50 gpm (3.2 lps) with a 4 percent bleed for 90 days, the total volume of solution discharged from the process plant to the ponds will be 259,200 gallons (985,000 liters) or 0.80 acre-feet (985 m^3). The estimated pond capacity required for ground water restoration is approximately 0.63 acre-feet (777 m^3) (see Section 4.0). Therefore, the required capacity of the ponds for the R&D test is 1.43 acre-feet (1,750 m^3) if net evaporation is neglected. The total design capacity below free board for each pond is 2.1 acre-feet (2,600 m^3). Therefore, either pond is capable of containing all the waste solutions generated by the process plant in the event repairs become necessary to either pond.



LOCATION MAP

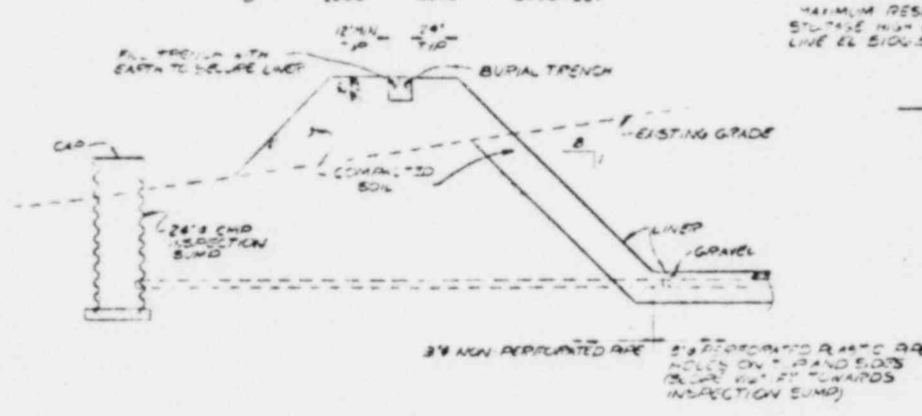
0 2000 4000 6000 FEET



SOLAR

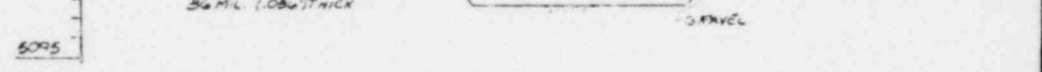
RESERVOI

RESERVOIR



INSPECTION SUMP DETAIL

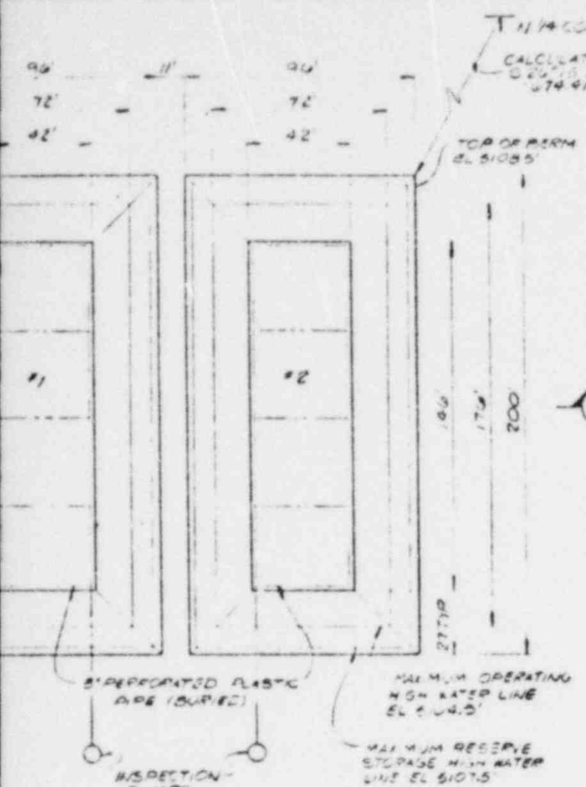
NTS



SECTION (A)

I, JERRY A. JELINEK OF ARVADA, COLORADO, PROFESSIONAL ENGINEER DULY REGISTERED IN THE STATE OF WYOMING HEREBY CERTIFY ON THIS 15 DAY OF FEBRUARY, 1980 THIS DRAWING WAS MADE UNDER MY DIRECT SUPERVISION.

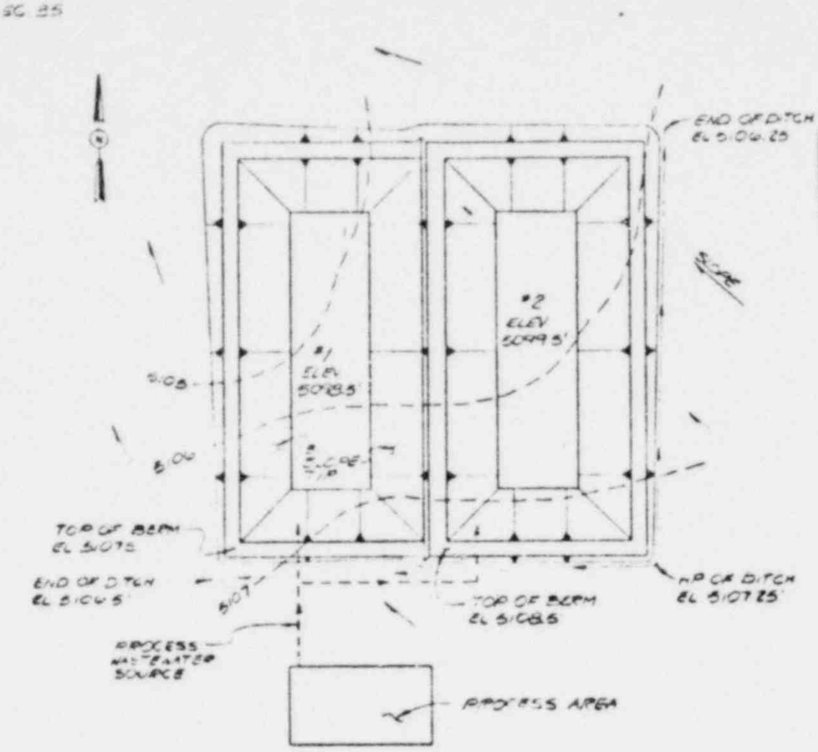
LICENSE NO. 1136



EVAPORATION RESERVOIRS #1 & #2

#1 AREA AT MAXIMUM OPERATING LEVEL .291 ACRES
CAPACITY AT MAXIMUM OPERATING LEVEL 10.4 ACRE-FEET
#2 AREA AT MAXIMUM OPERATING LEVEL .291 ACRES
CAPACITY AT MAXIMUM OPERATING LEVEL 10.4 ACRE-FEET

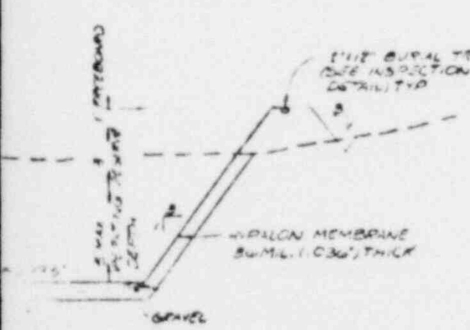
0 40 80 120 FEET



DRAINAGE DETAILS

0 50 100 150 FEET

CAPACITY TABLE								
RESERVOIR #1				RESERVOIR #2				
WATER DEPTH	AREA ACRES	AVERAGE ACRES	CAPACITY AC-FT	WATER DEPTH	AREA ACRES	AVERAGE ACRES	CAPACITY AC-FT	
0	.141			0	.141			WASTEWATER STORAGE 10.4 AC-FT EACH RESERVOIR
		.154	154			.154	.154	
1	.167			1	.167			
		.182	.182			.182	.182	
2	.196			2	.196			
		.211	211			.211	.211	
3	.226			3	.226			
		.242	242			.242	.242	
4	.258			4	.258			
		.275	.275			.275	.275	
5	.291			5	.291			RESERVE STORAGE 10.6 AC-FT EACH RESERVOIR
		.309	309			.309	.309	
6	.326			6	.326			
		.345	345			.345	.345	
7	.363			7	.363			
		.382	382			.382	.382	
8	.401			8	.401			
TOTAL CAPACITY #1			21	TOTAL CAPACITY #2			21	
TOTAL CAPACITY RESERVOIR #1 & #2 42 ACRE-FEET								



MAP TO ACCOMPANY APPLICATION FOR

SOLAR EVAPORATION RESERVOIRS

APPLICANT

ARIZONA PUBLIC SERVICE COMPANY

PHOENIX, ARIZONA

PETERSON IN SITU URANIUM EXTRACTION PROJECT

FIGURE No. 3.7

The construction of the two ponds will involve the excavation of approximately 7,300 yd^3 (5,600 m^3) of earthen material. Except for approximately the upper two feet (60 cm) of topsoil, this material will be used for berm construction. Earthen material used for berm construction will be compacted to a density of 90 percent maximum density as determined by the modified American Association of State Highway Officials (AASHO) (ASTM D1557-70) test method. The ponds will have approximately 3:1 side slopes and will maintain at least one foot (30 cm) of free board when filled to capacity (4.2 acre-feet) (5,200 m^3).

Prior to construction, two feet (60 cm) of topsoil will be removed from the pond site. This material will be stockpiled to the east of the pond area and broadcast seeded at a rate of 12 lb/acre (13.4 kg/hectare) with western wheatgrass and 12 lb/acre (13.4 kg/hectare) of thickspike wheatgrass, or equivalent seed mixture. If an excess of topsoil remains within the excavation zone of the pond area, it will be used for constructing the base of the pond berms and for spreading across the outer faces of the berms. The berms will be broadcast seeded as described above. Using this procedure, the topsoil can be easily recovered and will be the last material that will be replaced during reclamation. A gamma radioactivity survey will be performed following this topsoil replacement during reclamation.

Following preparation of the berms and pond floors a leak detection system will be installed. The system will consist of 3 inch (7.6 cm) diameter PVC pipe slotted on the top and sides and installed around the perimeter of the pond floors. The pipe will be imbedded in a gravel sand at an elevation 6 to 12 inches (15 to 30 cm) below the pond base. The pipe will slope at 1/16 inch per foot so that its lowest elevation will occur at the corner of the pond nearest the inspection sump. An unperforated pipe will connect the piping system to the base of the inspection sump located on the outer side of the berms (Figure 3.7). The inspection sump will have a diameter of approximately 24 inches (61 cm) and will be covered with a removable cap at the top. A separate leak detection system will be installed for each pond.

After the leak detection system is installed, the pond bottoms will be finish-graded and covered with a 36 mil (.036 inch) (.09 cm) thick impervious

Hypalon liner, or equivalent. The liners will be formed to the pond contours and will be anchored at the top of the berms in backfilled trenches.

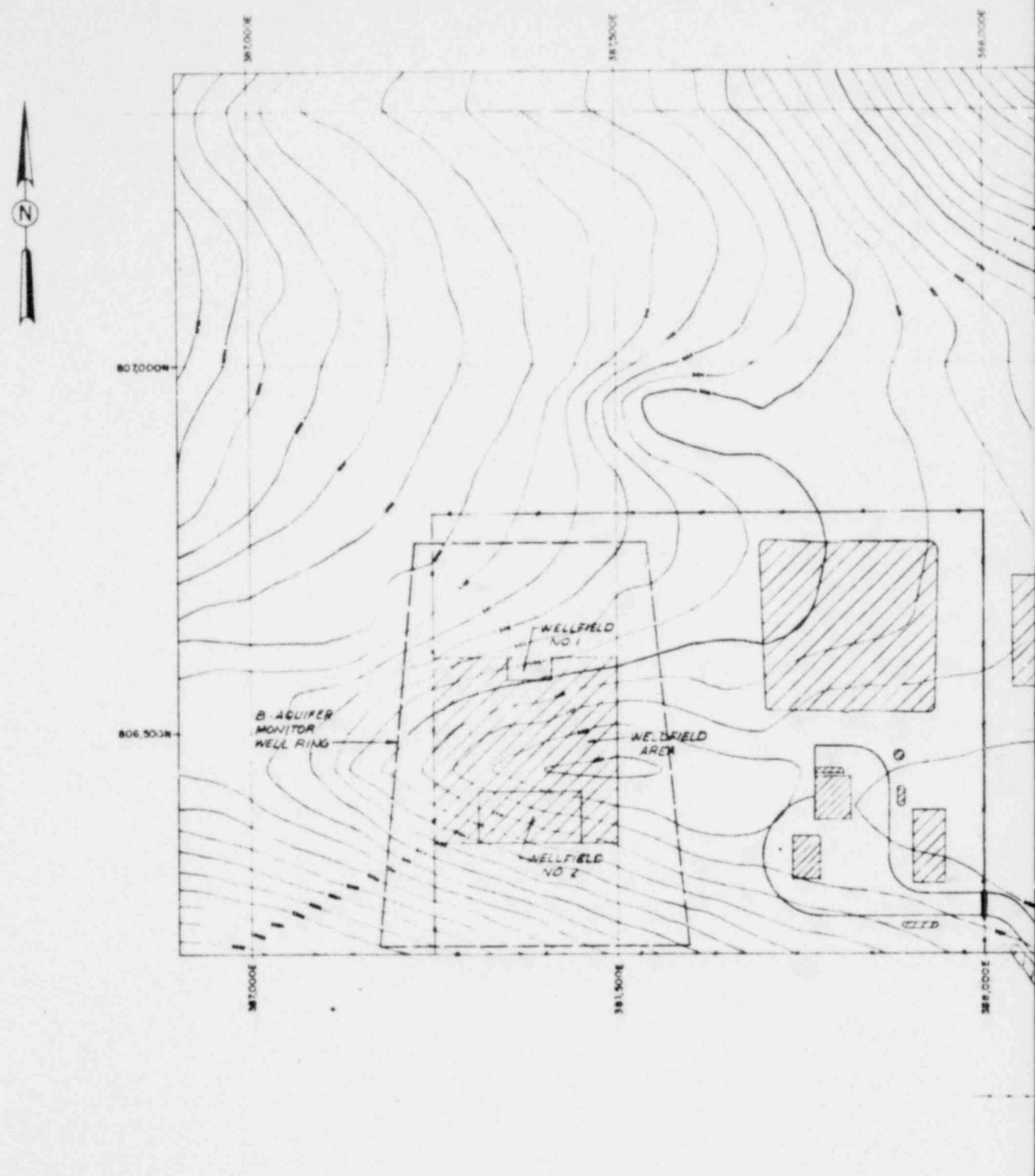
During testing operations, the leak detection system inspection sumps will be checked at two week intervals to insure that the pond liner is not leaking. Liquid effluent wastes being discharged to the ponds will be sampled at the same frequency. The effluent waste solutions will be analyzed for calcium (Ca), chloride (Cl), sodium (Na), sulfate (SO_4), uranium (U_3O_8), alkalinity, specific conductance and pH. If water is detected in the inspection sump, this sample will be analyzed for the same constituents to attempt to determine if the water in the stand pipe may be derived from leakage of liquid wastes. It is expected that the inspection sump will be dry. If pond leakage is detected, however, the water in the leaking pond will be transferred to the adjacent pond, and the leak will be repaired.

3.5 WELLFIELD

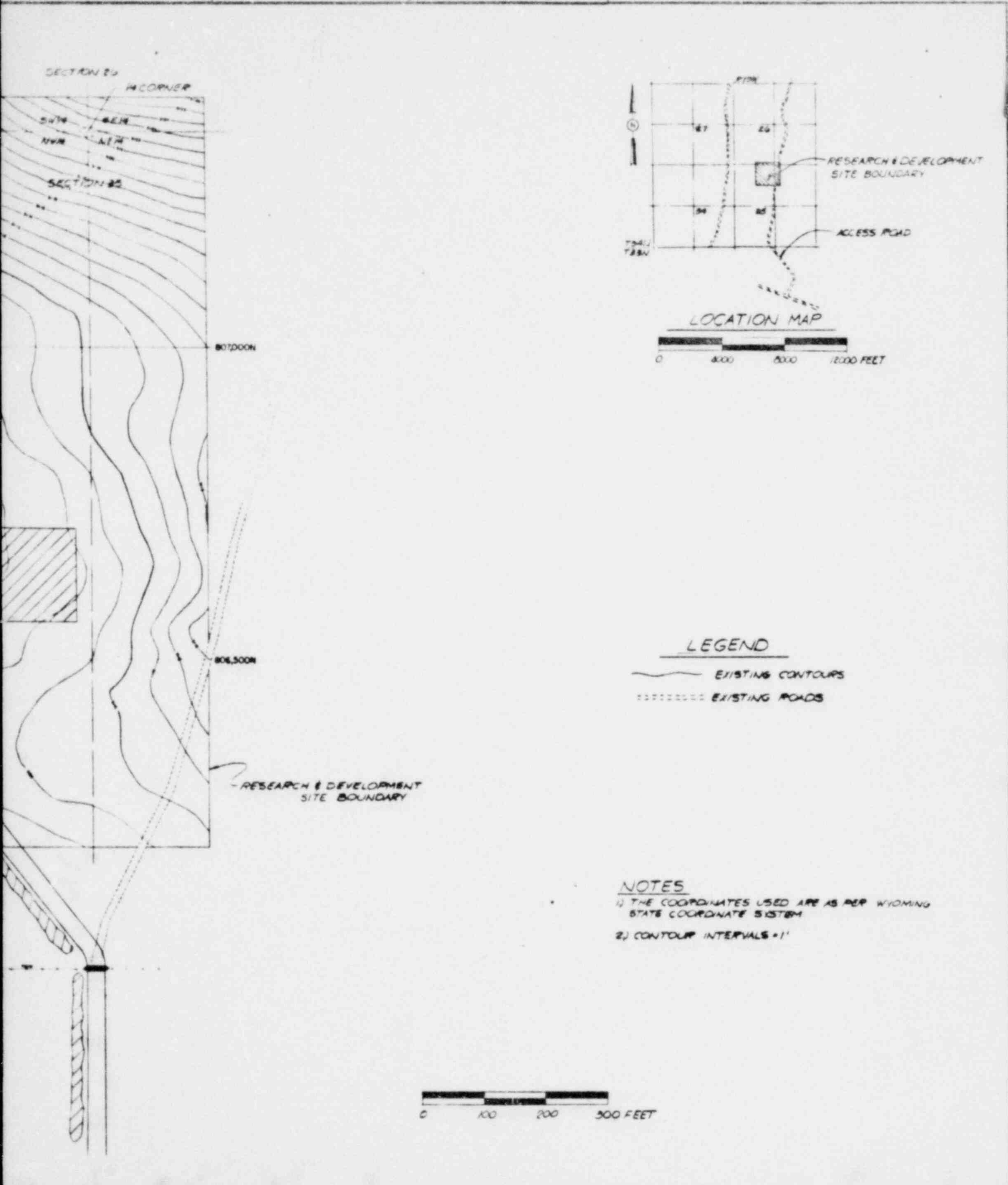
A wellfield area of approximately one and one half acres (0.6 hectares) has been designated just west of the process plant (Figure 3.4). Within this area two wellfields will be constructed on a smaller area not to exceed one acre (0.4 hectare). Injection and recovery wells in both wellfields will be open to the B Aquifer. The B Aquifer production zone ranges between approximately 220 and 260 feet (66 and 78 m) in depth below the land surface. The injection and recovery wells will be selectively screened at the ore depth within this interval. The generalized well locations are given in Figure 3.8. The geologic rock units comprising the producing zone (B Aquifer) have been previously delineated in Figures 2.14, 2.15 and 2.16. A significant factor in the final siting of the wells within the area designated on Figure 3.4 will be the ore distribution encountered during the drilling of the initial wells.

WELLFIELD PATTERN

Within the wellfield area, two separate wellfields will be tested. Within each wellfield, two five-spot patterns will be placed adjacent to each other so that two injection wells are shared by the two five-spot patterns in each



REV	DATE	REVISION	DR / CH	APP	REV	DATE	REVISION	DR / CH	APP
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				
△					△				



ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	LOCATION OF WELLFIELDS
NUCLEAR ASSURANCE CORPORATION	PETERSON IN-SITU URANIUM EXTRACTION PROJECT
PROJECT No 88900	FIGURE No 3.8

REFERENCE DRAWINGS

DRAWN K.P.

wellfield (Figure 3.9). If only a single five-spot pattern is considered, four injection wells will form a square around the recovery well. However, for the overall wellfield six injection wells will be constructed in a rectangular configuration with dimensions as shown below. Although initially designated as injection and recovery wells, all of the wells will be capable of functioning for either purpose throughout the test.

The exact dimensions of the wellfields may vary depending on conditions encountered in the field. Current plans are for injection wells at one wellfield to be spaced on a 35 by 35 foot (10.5 by 10.5 m) square for a single pattern (two adjacent patterns are 35 by 70 feet) (10.5 by 21 m). This wellfield will be called Wellfield No. 1. Injection wells in the second wellfield will be spaced on a 70 by 70 foot (21 by 21 m) square (two adjacent patterns are 70 by 140 feet) (21 by 42 m). This wellfield will be called Wellfield No. 2.

If new investigations are found desirable during the operation of the wellfields, APS-NAC may desire to construct an additional pattern within the one acre (0.4 hectare) area limitation. The anticipated pattern would likely be the five-spot array, however, the exact dimensions would depend upon the desired information to be obtained.

Monitor wells open to the B Aquifer will be placed as shown on Figures 3.8 and 3.9. If the placement of the well patterns justifies, a few wells in the hydrologic test wellfield may also be used for B Aquifer monitor wells. In addition to the B Aquifer, monitor wells will be placed in the C Aquifer and Shallow Aquifer (Figures 3.9 and 3.10). All monitor wells constructed will be completed and developed prior to leach solution injection.

WELL COMPLETION

Several well completion procedures and casing materials may be used during the pilot test. The well construction methods that will receive greatest attention are shown in Figures 3.11, 3.12 and 3.13. As these well construction methods are used, summaries of the well completion data for each well will be forwarded to the Wyoming State Engineer so as to maintain acceptable documentation of project activities.

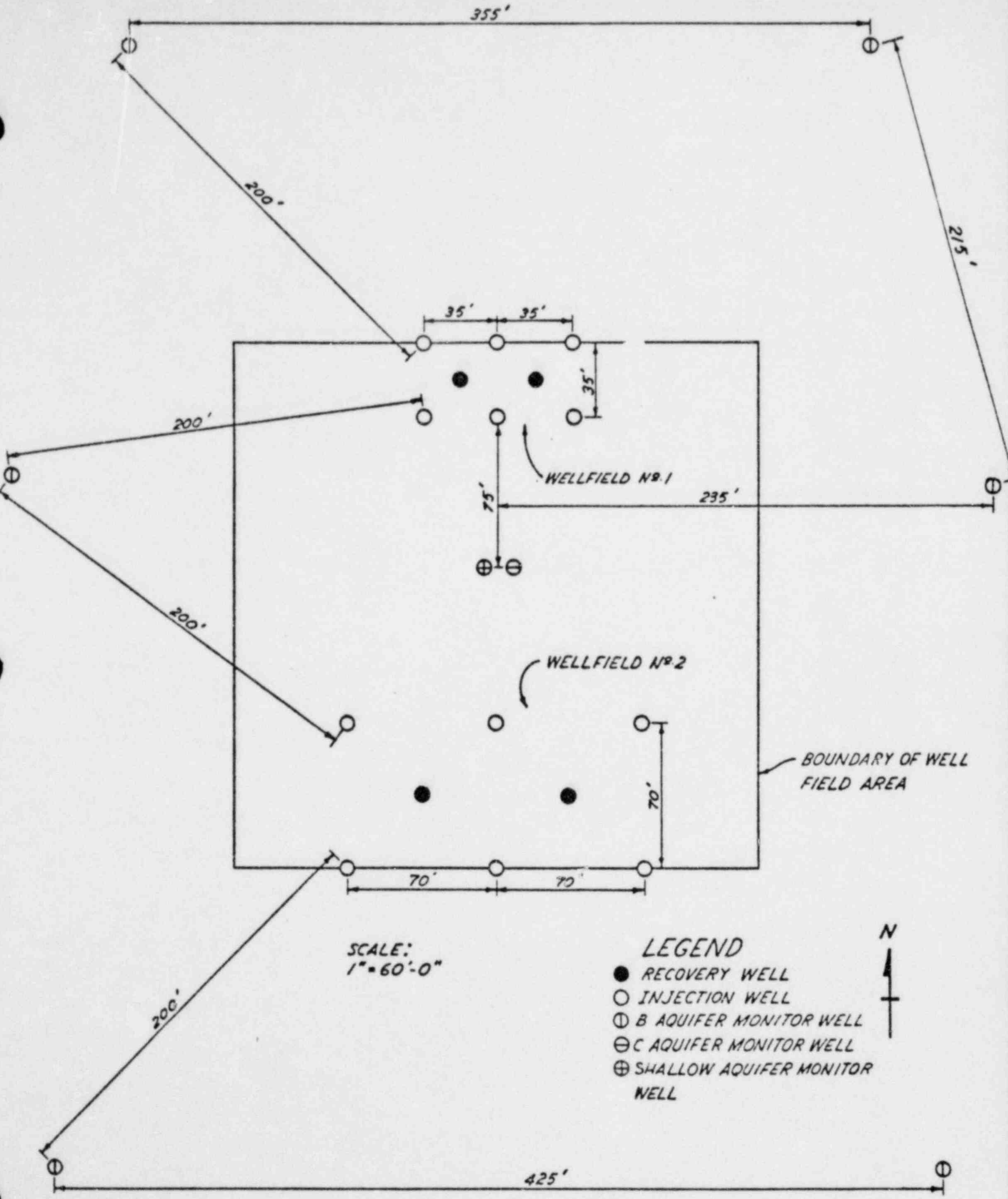
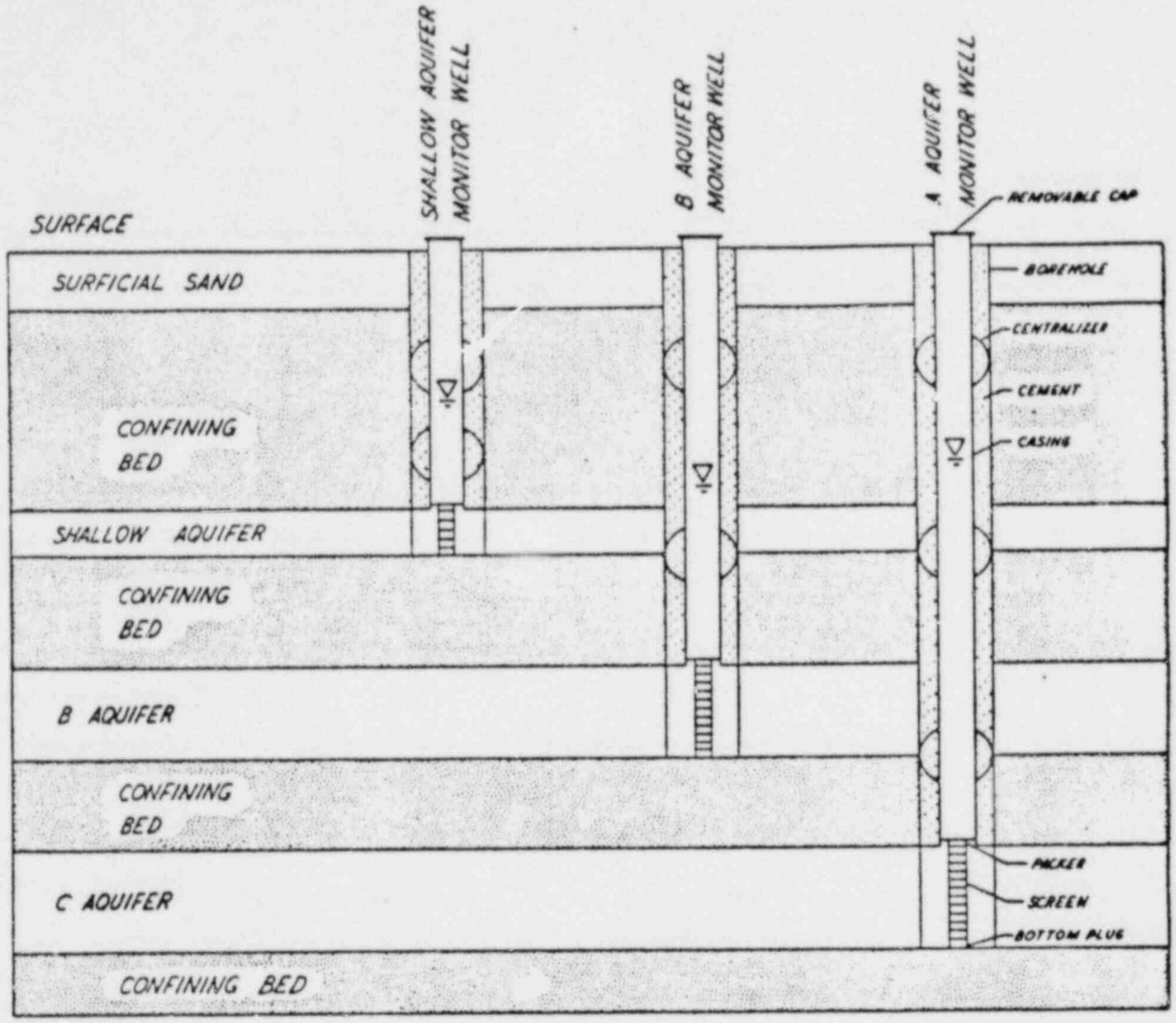


FIGURE 3.9

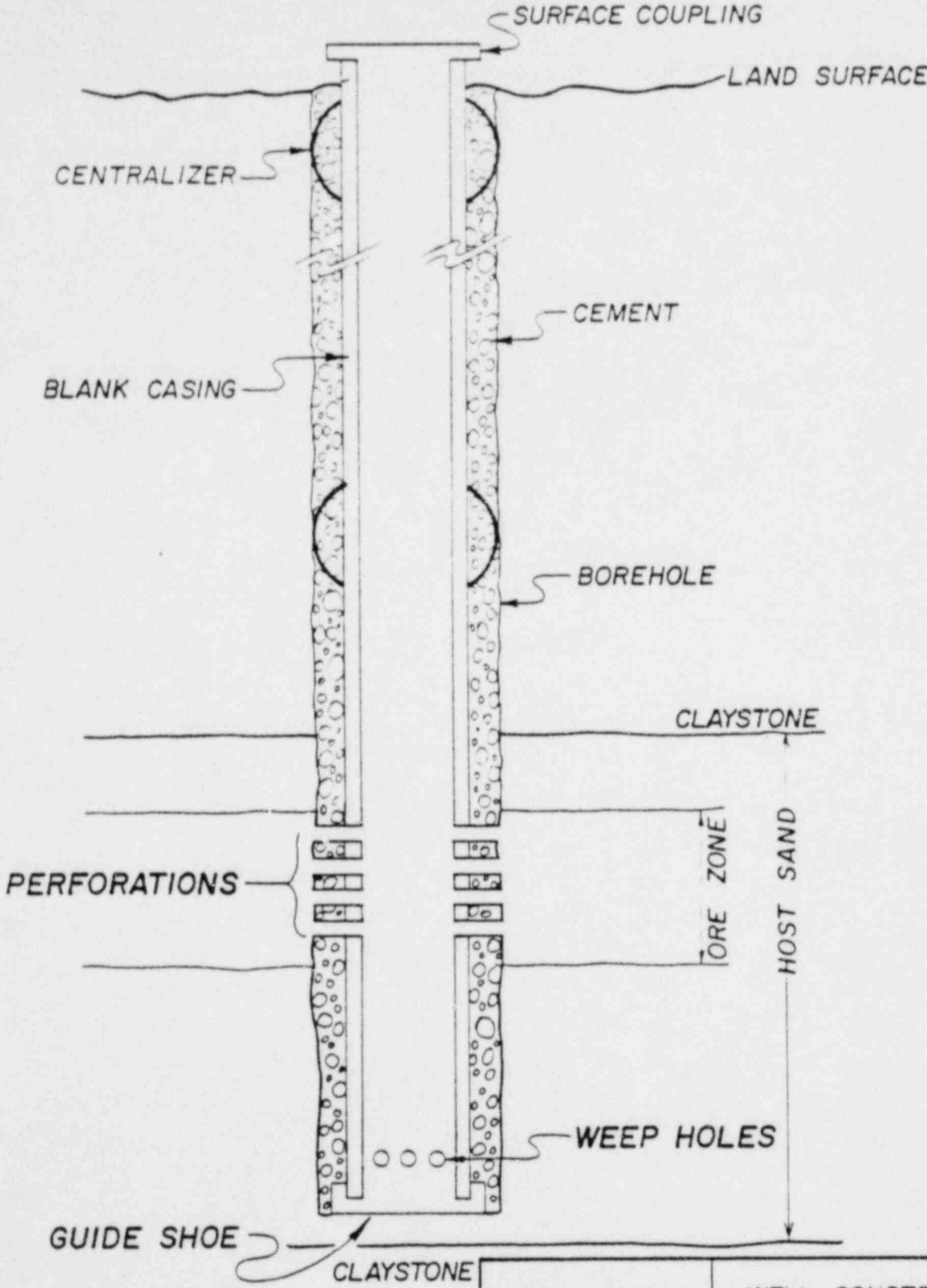
WELLFIELD LAYOUT



SCHEMATIC
NOT TO SCALE

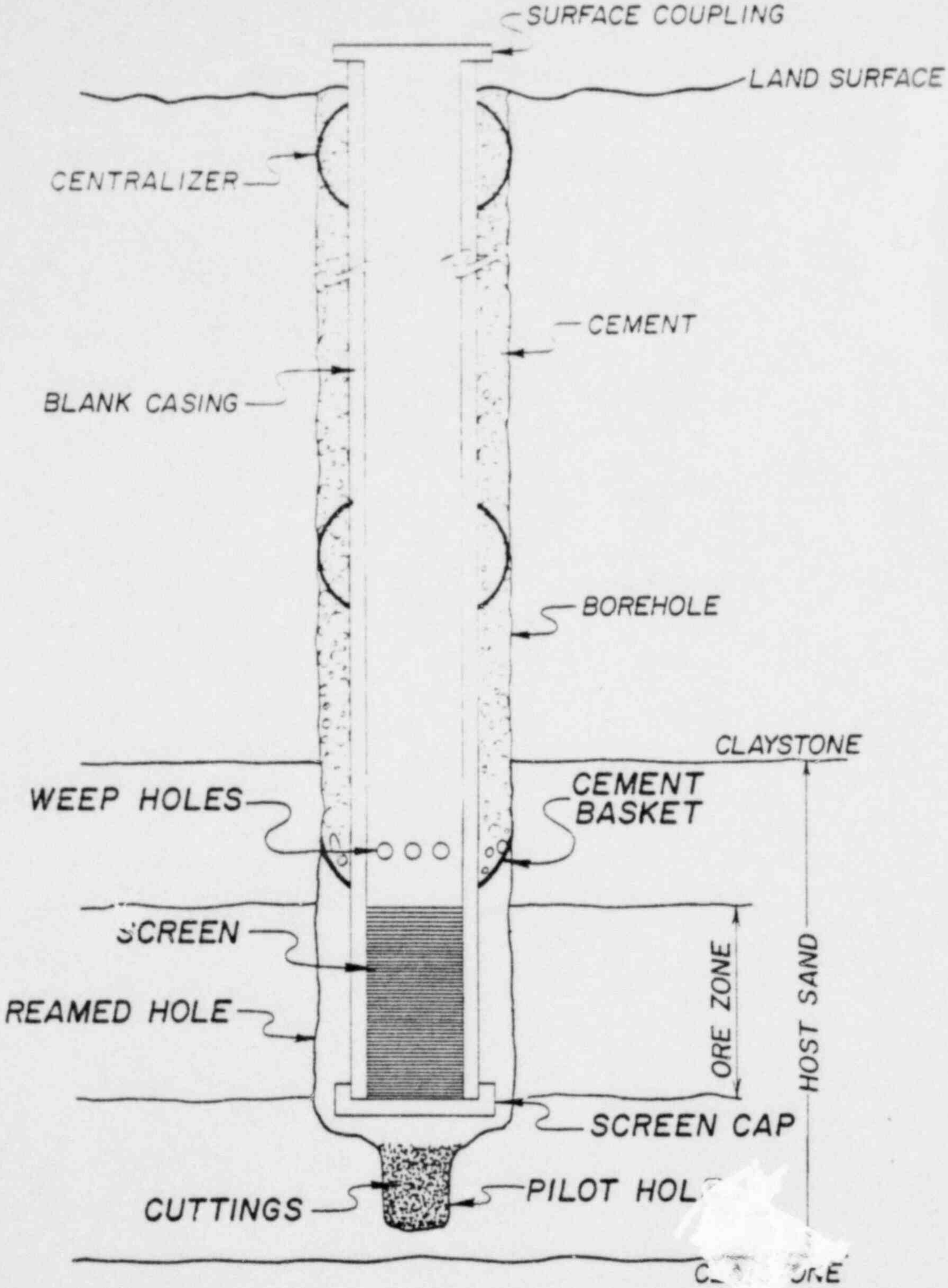
NOTE:
WELL CONSTRUCTION METHOD Nº 2 SHOWN; METHOD Nº 3 MAY ALSO BE USED.
∇ STATIC WATER LEVEL

FIGURE 3.10
MONITOR WELL DESIGN



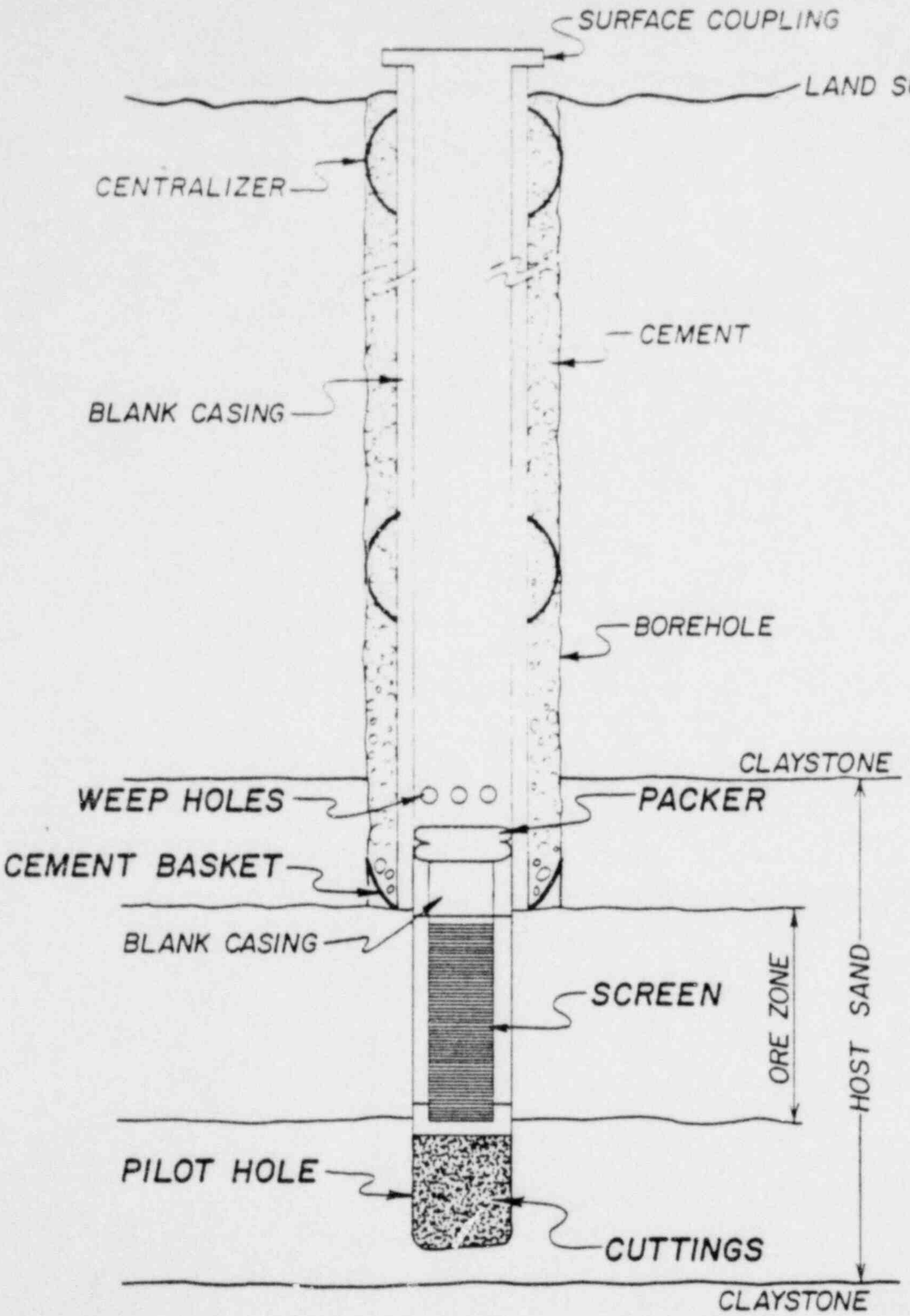
Not to scale

ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	WELL CONSTRUCTION METHOD No. 1	
	PREPARED BY B. Fullerton	DATE Feb. 15, 1980
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED	
	DRAWN BY A. Mayhew	DATE Feb. 22, 1980
	SCALE N/A	FIGURE No. 3.11
	CONTOUR INTERVAL N/A	



Not to scale

ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	WELL CONSTRUCTION METHOD No. 2	
	PREPARED BY B. Fullerton	DATE Feb. 15, 1980
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED	
	DRAWN BY A. Mayhew	DATE Feb. 22, 1980
	SCALE N/A	FIGURE No. 3.12
	CONTOUR INTERVAL N/A	



Not to scale

ARIZONA PUBLIC SERVICE COMPANY PHOENIX, ARIZONA	WELL CONSTRUCTION METHOD No. 3	
	PREPARED BY B. Fullerton	DATE Feb. 15, 1980
NUCLEAR ASSURANCE CORPORATION GRAND JUNCTION, COLORADO	REVISED	
	DRAWN BY A. Mayhew	DATE Feb. 22, 1980
	SCALE N/A	FIGURE No. 3.13
	CONTOUR INTERVAL N/A	

The well construction methods are not necessarily numbered herein in order of preference. Method No. 1 (Figure 3.11) involves the perforation of blank casing after it is cemented in the ground. This method involves the drilling of a pilot hole and then geophysically logging this hole. The hole would next be reamed to the optimum diameter and casing set and cemented in the hole. Next an abrasive water jet or mechanical technique would perforate the casing in the producing interval, and the well would likely be developed by air lifting and pumping.

Method No. 2 (Figure 3.12) also involves the drilling and logging of a pilot drill hole and subsequent reaming of this hole. A string of casing with a length of screen attached at the lower end would be lowered into the hole. A cement basket will be attached to the blank casing just above the screen. Cement will be pumped down the inside of the casing to a plug just above the screen, out weep holes at the base of the casing, and will be directed by the cement basket back to the surface through the annulus. Subsequently, the residual cement and plug will be drilled out, and the well will be developed.

Method No. 3 (Figure 3.13) involves drilling a pilot hole through the ore zone, logging the hole, and reaming the hole to the top of the ore zone. Casing will then be set in the reamed hole and cemented in place. Next the residual cement will be drilled out, and drilling will continue through the production zone. Then screen will be telescoped through the casing and selectively set opposite the producing zone. Well development will again be accomplished by air lifting and pumping. Upon completion of well development, the wells will be ready for injection or recovery of leach solution.

Several types of casing may be used, however, preference will be given to CPVC (Yelomine) or fiberglass construction materials. The diameter of a typical well may likely range between 4 to 6 inches (10 to 15 cm).

Monitor wells will likely be constructed by either Method No. 2 or Method No. 3, above. It is possible that the monitor wells will utilize Schedule 40, PVC for casing material.

MECHANICAL INTEGRITY

Before leach solution injection begins, field testing of the injection and recovery wells will be performed by pressure-packer tests or other acceptable methods to demonstrate mechanical integrity of the well casing. Initially, the pressure-packer test will be used. This test will involve the setting of packers inside the casing at the top and bottom and creating pressure in the casing between the packers.

Specifically, the upper packer will be set a short distance below the well head, and the lower packer will be placed directly above the well screen. Compressed air will be discharged under pressure into the well casing between the two packers until no more than 90 pounds per square inch (psi) is reached. This well head pressure will be used to insure that bottom hole pressure in the wells does not exceed 200 psi. This value is chosen because it represents the lowest pressure rating for casing materials that will be used. When this approximate pressure is achieved, the well will be shut in, and the psi reading on the pressure gauge will be recorded every 30 seconds for a ten minute period. If the pressure remains constant, the well casing will be determined to be mechanically sound.

If the pressure does not remain constant, the well casing may be checked for cracks or holes by down hole TV or other methods. When possible, the well will be repaired, and the packer test will be repeated. If the well casing leakage cannot be repaired or corrected, the well will be plugged and reclaimed as described in Section 4.1 of this application report.

The NRC will be provided with a report that describes all mechanical integrity tests and their results after this testing is complete and before leach solution injection. In addition, NRC will be notified when all the wells initially failing tests have been repaired or plugged.

Initially, the testing of all wells for mechanical integrity is proposed. However, through the use of the mechanical integrity tests it is intended to demonstrate to NRC that the well contruction materials and techniques used will result in a very high confidence level as to the mechanical integrity of the wells. Therefore APS-NAC intend to ultimately propose an alternate plan that would not require the testing of all wells for mechanical integrity.

LEACH SOLUTION CIRCULATION

Initially, formation water will be pumped from the recovery wells in the well field area and transferred through a pipeline to the process plant. At this point chemicals and an oxidizer will be added to the formation water, and the resulting leach solution will be returned to the wellfield injection wells. Following injection, the pregnant solution will be pumped from the recovery wells and transferred back to the process plant. After processing and chemical make-up, the leach solution will be recirculated as described. The solution will be circulated with a bleed of waste solutions to the solar evaporation ponds. This solution bleed will be maintained by pumping more solution from the B Aquifer than is injected. Therefore, the underground process will be operating in a positive hydraulic cone of depression in which solutions surrounding the pumping wells will be drawn inward toward those wells.

LEACH SOLUTION EXCURSION

Detection

As previously discussed, monitor wells will be located in the producing zone (B Aquifer) around the perimeter of the wellfield area. A total of six monitor wells will be located in the B Aquifer, one well in the C Aquifer below, and one well in the Shallow Aquifer above (Figures 3.9 and 3.10).

Prior to start-up of leaching, baseline water quality in each of the monitor wells will be established. The data will be used for calculating excursion parameter upper control limits and establishing the occurrence of potential excursions as defined in the following section. The baseline quality and control limits will be based on sampling each well on at least three separate occasions within a two week period prior to start-up of leaching. The samples collected will be analyzed for the excursion parameters listed in the following section. Before the collection of each water quality sample, water levels will be recorded.

During extraction operations, a water sample from each monitor well will be collected once every two weeks. The concentrations of the excursion parameters will be determined and compared to the upper control limits as described in the following section. Water levels will be recorded prior to obtaining water samples as described above and reviewed for indications of excursions.

Chemical analyses will be performed in the on-site laboratory. Standard methods will be used for excursion parameter analyses.

Excursion Parameters

The proposed leach solution will be composed of $NaHCO_3$ - Na_2CO_3. The mineral to be extracted contains uranium. Oxidation of uranium ore is generally accompanied by an increase in sulfate concentrations. Chloride will likely increase because of a gradual buildup inherent in the leaching process. The total dissolved solids (conductivity) within the producing zone is also expected to increase. Therefore, the chemical species that will be excursion parameters for the R&D test will be:

Sodium (Na)
Chloride (Cl)
Specific Conductance
Sulfate (SO_4)
Uranium (U_3O_8)

Upper control limits (UCL) will be defined for all the excursion parameters in all monitor wells before start-up of leaching. The upper control limits will be an important factor in defining the occurrence of an excursion during the test.

Upper control limits as defined herein are chemical parameter values with a 20 percent chance (probability) of representing natural ground water quality. These values will be determined by selecting the factor from a Cumulative Student t Distribution (Percentage Point) (Meyer, 1975) for a sample size of 1 and a probability of .8. The value given in the Cumulative Student t Distribution Table is 1.38. This value will be multiplied by the population standard deviation and the answer added to the population mean. The resulting chemical parameter value (UCL) has a 20 percent chance of representing natural ground water quality. Based upon these statistics, the UCL for each excursion parameter should be observed 20 percent of the time (1 sample out of every 5) when sampling monitor wells.

The probability that two excursion parameters will simultaneously exceed their respective UCL will be .04 (.20 x .20). This result should be observed 4 percent of the time when sampling monitor wells. Likewise, the probability that two consecutive samples will have any two excursion parameters exceed their respective UCL will be .16% (.04 x .04).

Consequently, if two consecutive samples have any two excursion parameters (they do not have to be the same two parameters) exceeding their UCL, then it is likely than an excursion will exist.

The proposed monitor wells discussed previously will be constructed in advance of the leaching operations to be able to document upper control limits for the excursion parameters in each well. Since data are not currently available, the information will be provided to the NRC before start-up of leaching.

Based upon the above analysis, the following excursion detection procedures will be used:

1. Monitor wells will be sampled once every two weeks. The static water level will be recorded before pumping at least two casing volumes prior to a sample collection.

2. If any two parameters from a well exceed their respective UCL, an additional sample will be collected from this well within 24 hours. In addition, the static water level measurements will be compared to previous readings for significant variations.

3. If this latter sample behaves similarly, an excursion will be detected.

4. The NRC will be notified that an excursion has occurred, and the excursion parameter concentrations and the well(s) in excursion status will be reported.

If an excursion is detected, the following procedures will be implemented:

1. Reorder the wellfield balance and change the well functions to an equilibrium determined to be consistent with the experience gained at the site. Sample the affected well at least once per week and analyze for the excursion parameters.

2. After six weeks of excursion status increase the solution bleed to a level determined from the operating experience. If the excursion is occurring in the Shallow Aquifer, reduce injection pressure head to a level below the static water level of the Shallow Aquifer.

3. After nine weeks, increase the bleed again as dictated by operating conditions.

4. After 12 weeks, begin restoration if the water quality at the affected well exceeds recommended standards and criteria for the use of category of the water (Table 2.13).

An excursion will be corrected when two consecutive weekly samples from the excursion well show less than two excursion parameters above their respective UCL.

4.0 RECLAMATION

4.0 RECLAMATION

4.1 AQUIFER RESTORATION

WATER QUALITY CRITERIA

Based on currently available ground water quality information collected at the hydrologic test site, it appears that ground water in the B Aquifer is not suitable for human consumption. Section 2.11 provides a list of several chemical parameters whose concentration levels exceed recommended drinking water standards. In addition, the water appears to be only marginally suitable for livestock and wildlife watering and crop irrigation. The water quality sampling of monitor wells to establish baseline conditions prior to leaching will determine if the water fits these latter use categories.

Based on the data contained herein, the ground water restoration program is designed to attempt to return the water quality of the affected zones to a chemical quality consistent with the present water quality. If the water is subsequently shown to be suitable for watering livestock or crop irrigation, it will be returned to a quality consistent with the standards for these use categories. Based on the currently documented poor water quality of the B Aquifer, water use categories should not be a determining factor for restoration.

Restoration criteria for individual chemical parameters in specific water use categories are not provided herein because: (1) current information indicates that the water is not suitable or only marginally suitable for any use category, and (2) specific data are not yet available for the monitor wells to define the quality of water beneath the wellfield. When the data become available, they will be reviewed to determine any potential water use. If the water fits a use category, the NRC will be provided with a list of chemical parameters and their recommended concentration levels to be used as restoration criteria. If no criteria concentration value is listed for a particular parameter or water use as determined by water quality standards or criteria (Table 2.13), the recommended restoration concentration level will be the mean baseline concentration plus 20 percent of the mean baseline concentration.

If the results of the pre-leaching water quality sampling show that the water does not fit any use category, the water quality standards and criteria for specific water use will not be considered for restoration. In this instance, restoration will be based on the statistical mean for individual parameters calculated from baseline samples plus 20 percent of the mean baseline concentration.

Restoration will be achieved when the average concentration of chemical parameters analyzed from samples collected from randomly selected injection, recovery, and monitor wells is equal to or less than the criteria levels, as determined above. It is APS' understanding that when the water quality of the affected zone meets the set criteria, the requirements pursuant to the definition of restoration provided by Wyoming Statute 35-11-103 (f)(iii) have been met.

Before ground water restoration begins, the NRC will be notified so that a representative may be sent to the site to ensure that restoration efforts meet all conditions specified by this application report.

RESTORATION METHOD

APS proposes to initially select Wellfield No. 1 (overall dimensions 35 by 70 feet) (10.5 by 21 m) for demonstration of restoration. Wellfield No. 2 (70 by 140 feet) (21 by 42 m) will be incorporated into the commercial scale wellfield for additional leaching if all of the ore is not recovered during the R&D test. If commercial operations are not feasible, Wellfield No. 2 will be restored following restoration of Wellfield No. 1. If the project proves feasible, APS intends to submit the commercial Source Material License application following restoration of Wellfield No. 1.

The initial method to be used for ground water restoration will be ground water sweep. If additional treatment is necessary, a reverse osmosis unit will be used to filter the contaminants out of the discharge water. This improved ground water will be recycled through injection wells into the affected zones and recovered by pumping. The fresh water recycle approach will very likely be used in combination with ground water sweep.

As indicated above, the dimensions of the well pattern to be restored will be about 35 by 70 feet (10.5 by 21 m). The ore thickness averages approximately eight feet, and the formation porosity is about 27 percent. Assuming an average leaching sweep of 20 percent in the three dimensions, the volume of ground water contained in one pattern pore volume in the B Aquifer is:

$$\text{Volume} = .27(35 + .20(35))\ (70 + .20(70))\ (8 + .20(8))\ ft^3$$

$$= 9{,}145\ ft^3$$

$$= .21\ \text{acre-ft/pore volume}\ (259\ m^3\text{/pore volume})$$

Because applicable field data have not yet been obtained, it is currently estimated that as many as 10 pore volumes of ground water may have to be flushed through the wellfield pattern to accomplish ground water restoration. A net withdrawal of ground water of 3 pore volumes during the ground water sweep phase is estimated, or a total of 0.63 acre-feet (777 m^3). During the clean water recycle phase, a maximum of 7 pore volumes will consist of a brine stream resulting from the operation of the reverse osmosis unit. The solar evaporation ponds have been designed to contain the 2.1 acre-feet (2,560 m^3) of water discharged during restoration.

Depending upon information and experience gained during ground water restoration testing, alternative methods may be implemented to improve ground water restoration.

After completion of ground water restoration, APS-NAC will collect water samples from the leached zones once every four weeks over a period of four months to determine if the concentrations of the chemical parameters of the ground water have stabilized. When chemical stabilization is achieved, and after such stabilization is agreed to by the Wyoming Department of Environmental Quality and U.S. Nuclear Regulatory Commission, ground water restoration shall be deemed completed.

Subsequent to the completion of ground water restoration, all injection and recovery well casings will be filled with a bentonite slurry to a level seven feet (2.1 m) below the land surface. Next, a plug will be placed at least seven feet (2.1 m) below the land surface, and the hole above the plug will be filled with cement to within two feet (60 cm) from the land surface. The well casing will then be cut off at least two feet (60 cm) below land surface, and the remaining hole will be filled with soil. Any well not reclaimed in this manner will remain as a water well and will be permitted with the Wyoming State Engineer.

The Wyoming State Engineer will be given the location of the wellfield areas and the range of depths of the production zones prior to bond release.

4.2 SURFACE RECLAMATION

After ground water restoration is completed, the land surface of the R&D Site will be reclaimed. The reclamation will be performed on all disturbed areas of the site including the wellfield, building areas, ponds and roads.

In the wellfield area, the water wells will be abandoned as described in the previous section. The land will then be scarified and prepared for seeding.

The solar evaporation ponds will be allowed to dry out. The dried solid residue remaining on the floor of the ponds and liners will be surveyed for gamma radioactivity. If from this survey and the periodic monitoring of process plant effluents the U. S. Nuclear Regulatory Commission and/or Wyoming Department of Environmental Quality determine that a significant (twice background concentration levels) radioactive waste is present, arrangements may be made to remove the residue and pond liners and dispose of them at a licensed tailings facility or other approved location. If commercial operations are conducted on the Peterson Project, the waste residues and liners will be disposed of in that commercial tailings disposal facility. Following removal of the liners, a gamma radioactivity survey will be performed on the earthen material beneath, and any contaminated material will be removed.

If the pond materials are not found to be significantly radioactive, the pond liners will be folded into the floor of the pond along with other miscellaneous debris from the site including the process plant foundation. The pond area will then be regraded with the stockpiled material. Due to the small size of the disturbed area (primarily the pond site), the final contour of the affected area should be essentially the same as the original contours. Therefore, Figure 2.6 is referenced as the final contour map.

The process plant will be dismantled and removed from the site. Office and warehouse trailers and other support equipment will also be removed. Miscellaneous debris and the process plant foundation if not contaminated by significant gamma radioactivity will be broken into segments and disposed of in the pond area.

Before recovering the area with topsoil, a gamma radiation survey using equipment and procedures similar to those described in Section 2.9 will be performed on all disturbed areas. The scintillometer used for the survey will be calibrated against baseline values from unaffected lands as shown on Figure 2.10. If gamma radiation is detected at levels significantly higher than shown in Figure 2.10, the contaminated material will be removed to a licensed tailings disposal facility.

Following removal of the facilities, the access road and building site will be ripped and retopsoiled with at least one foot (30 cm) of topsoil. The evaporation pond area will be regraded with at least the two feet (60 cm) of topsoil stockpiled during the project. The topsoil will be regraded approximately parallel to the existing contours.

The off site access road will be ripped or scarified to relieve compaction before retopsoiling. At the request of the surface land owner, this road will be left for his use.

The following revegetation program will take place once the topsoil has been replaced, contoured and spread in satisfactory fashion, and the area is ready for planting. Planting will be completed either before mid-May or in the fall after mid-October in order to utilize the most advantageous soil moisture conditions. Seed will generally be drilled into the soils and the areas subsequently mulched, preferably with native hay, or straw if hay is not available. The following mixture and amount of percent live seed (PLS) is recommended:

Prairie sand reed (two pounds per acre) (2.2 kg/hectare).
Indian rice grass (two pounds per acre) (2.2 kg/hectare).
Green needle grass (two pounds per acre) (2.2 kg/hectare).
Sheep fescue (one pound per acre) (1.1 kg/hectare).
Slender wheatgrass (one pound per acre) (1.1 kg/hectare).
Streambank wheatgrass (one pound per acre) (1.1 kg/hectare).
Thickspike wheatgrass (one pound per acre) (1.1 kg/hectare).
Western wheatgrass (one pound per acre) (1.1 kg/hectare).
Sweet clover (one pound per acre) (1.1 kg/hectare).

Following planting, the mulch will be spread and anchored to the disturbed area.

4.3 BONDING

AMOUNT

A Research and Development License Performance Bond will be submitted to the WDEQ - Land Quality Division prior to start-up of operations. The amount of the bond will be based on the estimated cost of reclamation as follows:

	Unit Cost	Total Cost
Ground water restoration	--	\$20,000
Well plugging (24 wells)	\$300/well	7,200
Building and equipment removal	--	3,000
Backfilling and grading pond area (10,400 yd^3)	\$0.50/yd^3	5,200
Scarifying wellfield and on-site access road (2.0 acres)	\$250/acre	500
Retopsoiling building, pond and on-site access road areas (1,900 yd^3)	\$0.75/yd^3	1,400
Seed mix (4 acres)	\$75/acre	300
Planting (4 acres)	\$50/acre	200
Mulch (2 tons/acre) and spreading (4 acres)	\$350/acre	1,400
Total		\$39,200

RELEASE

The Research & Development License Performance Bond shall be released by the WDEQ - Land Quality Division to APS when at least 12 aquifer pore volumes of ground water have been circulated through all wellfields installed or when the ground water restoration goals have been achieved; and when the surface reclamation plan (Section 4.0) is completed in its entirety.

It is APS' understanding that the ground water restoration criteria and the bond release procedures used for this R&D operation in no way serve as a precedent for any future commercial scale Source Material License application. An application for a commercial scale operation will stand on its own merits.

Before bond release APS will submit a written report to the NRC and WDEQ-LQD to:

1. Summarize operational scheduling with respect to environmental decisions.

2. Summarize all environmental monitoring data collected in conjunction with the R&D test.

3. Summarize restoration procedures and report the results achieved using the restoration methods attempted.

4. Document the extent and success of ground water restoration.

5.0 MONITORING PROGRAMS

5.0 MONITORING PROGRAMS

5.1 PREOPERATIONAL SURVEYS

HYDROLOGICAL

The importance of the establishment of ground water quality baseline concentration levels prior to the in situ extraction operation is recognized by APS-NAC. Therefore, a ground water sampling program has been initiated at the R&D Site. Currently, water quality data are available for the hydrologic test wells as described in Section 2.11, herein. Because additional wells will be constructed for the R&D test, the baseline sampling program will be extended to these wells. The preoperational ground water sampling program is described in detail in Section 3.5 - Wellfield.

AIR QUALITY

There is currently no preoperational air quality monitoring program requirement directed specifically toward R&D in situ tests.

ECOLOGICAL

There is currently no preoperational vegetation and wildlife monitoring program requirement for R&D in situ tests. However, descriptions of vegetation and wildlife at the site are included in Section 2.7, herein.

Soils were sampled and tested as described in Section 2.6 and Appendix B, herein.

RADIOLOGICAL

A preoperational radiological survey has been performed at the Test Site. The details of the survey are provided in Section 2.9, herein.

5.2 OPERATIONAL MONITORING

SOLAR EVAPORATION PONDS

The monitoring system for the solar evaporation ponds has been discussed in detail in Section 3.4, herein. The system includes periodic monitoring of effluent collection sumps that are part of a seepage collection system beneath the pond liners and periodic sampling of effluent entering the pond from the process plant.

RADIOLOGICAL

The following radiological monitoring program is considered adequate in view of the relatively low releases and the estimated relatively short duration of the R&D test operations. At least three sampling sites will be designated on the Test Site. Two of these will be representative of the working areas in the process plant area. Sampling will occur on a quarterly basis and will include measurements of radium-226, radon-222, uranium and particulates.

Soils will be sampled at the same sites on an annual basis and will include measurements of radium-226 and uranium.

During reclamation, radiological monitoring will be performed as described in Section 4.2, herein.

WELLFIELD

Wellfield monitoring procedures will define an area of containment for leachate injected during the R&D test. A detailed description for the monitoring surveillance technique for corrective actions in the event of leachate migration or for restoration is given in Sections 3.5 and 4.1.

During the operations, monitor wells will be established in the producing aquifer and also in the shallow and deep aquifers immediately above and below the producing aquifer. The monitor wells will be sampled every two weeks during wellfield operations. Upper control limits for chemical parameters in the monitor wells will be established to indicate a deviation in ground water chemistry from the baseline concentrations. Corrective actions are proposed, herein, in the event that an excursion is detected. Procedures for monitoring water quality during restoration are outlined. Postmining water quality monitoring will be performed to document that restoration has been achieved. Required reporting will be to both the NRC and WDEQ.

6.0 ACCIDENTS

6.0 ACCIDENTS

Accidents during the operation of the R&D test will be minimized through: (1) the proper design, manufacture, and operation of the process equipment; (2) adherence to known solution mining procedures; and (3) incorporation of a quality assurance program designed to establish and maintain safe operations in accordance with NRC Regulatory Guide 3.5. APS-NAC recognize that NRC and MSHA (Mine Safety and Health Administration) will maintain surveillance over the project and its individual safety systems by conducting periodic inspections and by requiring reports of effluent releases and deviations from normal operations.

6.1 SURFACE ACCIDENTS

FAILURE OF CHEMICAL STORAGE

Leach and eluant solutions will be stored in welded or bolted steel tanks under atmospheric pressure. The likelihood of rupture of a tank that is vented to the atmosphere is small. It is more likely that the tank would develop a small leak. If a leak were to occur, fluids released at the process plant site would be caught on the concrete pad, drained to sumps and then be diverted to the solar evaporation ponds.

Propane, oxygen (O_2), and carbon dioxide (CO_2) will be stored on site in pressurized tanks. Rupture of the external piping to these storage tanks would not result in a significant release of gases because a drop in pressure would automatically close the excess-flow valve on the tanks.

PIPELINE FAILURES

The rupture of a trunkline, an injection well feeder line, or a production well collection line would result in either barren or pregnant leach solution contaminating the soil near the break. The maximum volume that reasonably would be expected to be released from a trunkline rupture is estimated to be 1,500 gallons (50 gpm times 30 minutes of release) (5,900 liters). The potential for such a failure is considered to be very unlikely.

To minimize the volume of fluid that could be lost due to a pipeline rupture, the piping systems will be equipped with automatic high-pressure and low-pressure shutdown systems. The pressure controls will also include alarms to attract the operator's attention should a malfunction or abnormal operating pressure occur.

If fluid were released by a pipeline rupture, the localized area potentially affected by the leach solution would be surveyed. Any contaminated material would be transferred to the solar evaporation ponds, and the contaminated area would be reclaimed.

FIRES AND EXPLOSIONS

The fire and explosion hazard of the uranium process plant will be minimal. The plant will not use flammable liquids in the uranium extraction processes. Gases such as propane will be stored in pressure tanks a safe distance away from the process building. Flammable fuels will also be stored away from areas of activity. Because the uranium in the process plant will be in solution, adsorbed on ion exchange resin, or in the form of yellowcake slurry, an explosion would not appreciably disperse the uranium. Spilled liquids or slurries would be confined to sumps and pumped to the solar evaporation ponds.

To be prepared for potential fires, adequate fire extinguishers will be located throughout the operation so as to quickly contain any fire. In addition, the fresh water make-up tank will supply water under pressure for fire hoses stored at strategic locations ready for emergency use.

SOLAR EVAPORATION POND LEAKAGE

The leak detection system for the solar evaporation ponds has been previously described in Section 3.0. Should a leak develop, the contents of the leaking pond and process effluents will be pumped into the second pond while the leak is repaired. Contamination of underlying materials would be confined to soil and strata directly beneath the pond. If the contamination is determined to be radioactive, the materials will be disposed of during reclamation as described in Section 4.0.

6.2 SUBSURFACE ACCIDENTS

WELL CASING FAILURE

If a well casing cracks, leach solution from an injection well or pregnant solution from a recovery well could seep into and contaminate aquifers overlying or underlying the producing zone. The amount of solution that could seep through a crack is potentially very small for the R&D test. Because of the small volume of solution being handled, any loss of solution would be readily noticed. If a crack was not detected for seven days, however, the maximum volume of solution escaping from an injection well would be 30,000 gallons (3.0 gpm times 7 days) (114,000 liters) and from a recovery well would be 121,000 gallons (12 gpm times 7 days) (460,000 liters). This is a worst case estimate and assumes that the crack is large enough and the overlying aquifer is permeable enough to allow the total fluid flow from the well to infiltrate the aquifer.

To detect a casing failure, monitor wells will be completed in the aquifers above and below the producing zone aquifer. The water levels and water quality of water in these wells will be analyzed bi-monthly to check for leach solution excursions.

LEAKAGE THROUGH OLD EXPLORATION HOLES

Leakage of leach solution between aquifers through old exploration holes is considered very unlikely at the Test Site. Only a few wells penetrate deeper than the B Aquifer within several hundred yards of the wellfield area. At the low aquifer pressures which will be induced by in situ extraction, the drilling mud column is believed to be an effective seal against fluid movement between various aquifer units penetrated by the drilling. Additional sealing has occurred by the rapid swelling and bridging of the isolated mudstones between the aquifer units. Aquifer tests performed at the site have demonstrated that [illegible] hydraulic communication exists between aquifers at the site. In the event that leakage between aquifers does occur through old drill holes, the old holes responsible for the leakage will be re-entered and replugged. Wells completed in the contaminated aquifer would then be pumped to reduce to acceptable levels the concentration of any contaminating fluids.

WELLFIELD EXCURSIONS

Wellfield excursions are considered as potentially normal events during operation. Therefore, they have been previously discussed in Section 3.0. The proposed degree of monitoring and corrective actions are believed to be sufficient to result in minimal effects on the aquifer units.

6.3 TRANSPORTATION ACCIDENTS

YELLOWCAKE TRANSPORTATION

An accident involving vehicles transporting the yellowcake slurry from the process plant to an existing uranium mill could result in the spillage of some yellowcake. The likelihood of such a spill is considered low because the slurry will be transported over county and state highways where vehicle traffic is light. The effects of such a spill would be minimal because only a few drums containing yellowcake slurry would be transported at any given time. If a spill occurred, a dust would not disperse because the yellowcake is wet. Soils contaminated by the spill would be removed and processed through a mill to recover the yellowcake. All areas disturbed would be reclaimed as described in Section 4.0.

SHIPMENT OF CHEMICALS

The operation of the process plant will require the periodic shipment of process chemicals and fuel to the site. The shipment of solid sodium bicarbonate and carbonate presents almost no risk of injury to individuals. The handling of other chemicals and fuels is also expected to present minimal effects.

6.4 ACCIDENT PREVENTION

Due to the type of equipment used and design of in situ extraction processes the potential for serious accidents using this extraction technique is considered to be much smaller than for other types of uranium mining and milling operation. The usual hazards associated with open pit or underground mining are not present. For example, no heavy equipment is used, no dust is generated, no blasting is required and fall of ground is not present. Within the process plant, the major equipment items having moving or rotating parts are pumps and small submerged agitators. The injury frequency rate for existing in situ operations is believed to be less than at conventional mines and mills.

The wellfield and plant equipment will be operated by experienced operators. A training program will be given to all personnel to describe the hazards associated with operation of all equipment. NRC and MSHA regulations will be followed relative to equipment maintenance.

Because the process plant, wellfield and chemical storage areas will be in the open air, the need for ventilation equipment is limited. If radioactive dusts, mists, fumes or gases accumulate in the office or warehouse areas adequate ventilation systems will be installed.

The site will be fenced as described in Section 3.0. The site will also be posted with appropriate signs to keep out unauthorized visitors and to caution the general public regarding radiation areas. Entrances to the site will have gates which will be locked except during operating periods or when access is required.

Adequate protective clothing, safety showers, and wash facilities will be maintained on site to provide for safe handling of chemicals and packaging of yellowcake slurry into drums.

In addition to the regular NRC and MSHA health and safety inspections, APS-NAC management and safety supervisory personnel will frequently inspect the Test Site to identify and rectify potential health and safety hazards.

Diligent inspections and the use of accepted industrial working procedures will be used to prevent accidents resulting especially from the storage, distribution and use of chemical reagents.

Insofar as possible, the design of surface facilities and equipment will be specified and constructed to withstand, without failure, foreseeable weather extremes.

Source material will be stored in a location and manner to avoid foreseeable possibilities of most extreme accidents. Only small (5 to 10 drums) quantities of yellowcake will be stored on the site at any one time. The yellowcake will be packaged for storage and transportation in compliance with U.S. Department of Transportation regulations.

7.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

7.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

Several federal, state and local agencies are directly and indirectly involved promulgating, administering, and enforcing laws and regulations related to in situ extraction operations. APS will apply for licenses, permits and approvals from:

Federal

1. Source Material License for R&D Operation - U.S. Nuclear Regulatory Commission.
2. Miner Training and Operating Plan - Mine Safety and Health Administration.

State

3. R&D In Situ Mining License - WDEQ - Land Quality Division.
4. Air Quality Permit to Construct - WDEQ - Air Quality Division.
5. Waste Water Evaporation Ponds Permit to Construct - WDEQ - Water Quality Division.
6. Permit to Construct Sanitary Wastes Facility - WDEQ - Water Quality Division.
7. Permit to Construct Evaporation Ponds - Office of the Wyoming State Engineer.
8. Water Well Permits - Office of the Wyoming State Engineer.
9. Registration of Activity - Radiological Division of Wyoming Public Health Department.
10. Semi-Public Water Supply Approval - Wyoming Public Health Department.
11. Informal Review - Wyoming Office of Industrial Siting.

Local

12. Development Plan - Converse County Planning Department.

13. Surface Access and Use Agreements - Private Land Owners.
14. Approval to Use Landfill - Douglas, Wyoming

There will be no discharge of waste waters from the project activities to natural drainage systems. Therefore, it is not necessary to obtain the WDEQ-EPA NPDES permit.

During the collection of the baseline environmental data for this report, representatives of all of the above agencies were contacted and consulted. This report reflects the concerns of these agencies in so far as their concerns are understood. In addition to the above agencies, the following agencies were contacted for information:

1. U.S. Geological Survey
2. U.S. Bureau of Land Management
3. U.S. Department of Agriculture, Soil Conservation Service
4. Commissioner of Public Lands
5. Wyoming Recreation Commission
6. Wyoming Game and Fish Commission
7. Converse County Engineer
8. Converse County Clerk
9. Converse County Assessor

8.0 SELECTED REFERENCES

8.0 SELECTED REFERENCES

Allred, W. 1943. Wyoming antelope - life history and wartime management. Trans. N. Am. Wildl. Conf. 8:117-122.

American Ornithologists Union (AOU). 1957. Check-list of North American birds. Baltimore, The Land Baltimore Press, Inc. 691 p.

American Ornithologists Union (AOU). 1976. Thirty-third supplement to the AOU check-list of North American birds. Auk 93:875-879.

American Ornithologists Union (AOU). 1977. Corrections and additions to the Thirty-third supplement to the AOU check-list of North American birds. Auk 94:10.

Arbib, R. 1976. The blue list for 1977. American Birds 30: 1031-1039 pp.

Bailey, A.M., and R.J. Niedrach. 1965. Birds of Colorado. 2 Vols. Denver Museum of Natural History. 895 p.

Beetle, A.A. 1977. Grasses of Wyoming. Agriculture Experimental Station, Laramie, Wyoming: 1-154 pp.

Bent, A.C. 1937. Life histories of North American birds of prey. Part I. Smithsonian Institution, United States National Museum Bulletin 167.

BLM. 1976. Unit resource analysis. Converse County Planning Unit. Unpublished. Interrupted pagination.

BLM. 1977. Unit resource analysis and management framework plan. Converse Planning Unit. Unpublished. Interrupted pagination.

BLM. 1979. Final environmental statement. Proposed development of coal resources in the Eastern Powder River Basin, Wyoming. U.S. Department of the Interior. Washington D.C. Interrupted pagination.

Burt, W.H. and R.P. Grossenheider. 1952. A field guide to the mammals. Houghton Mifflin Company, Boston. 200 p.

Clark, T.W. 1977. Black-footed Ferrets and prairie dogs in Wyoming: 5 yr (1973-77) summary of research. Unpublished paper, Idaho State University, Pocatello, Idaho.

Dorn, R.D. 1977. Manual of the vascular plants of Wyoming. Garland Publishing, Inc., New York. 1-1498. 2 Vols.

HASL-300 Procedures Manual. Health and Safety Laboratory. New York, New York.

Helms, Bill. 1979. Biologist. District 7, Wyoming Game and Fish Department, Lusk, Wyoming. Personal Interview.

Hedsen, W.G., R.R. Pear and S.A. Druse. 1973. Water Resources of the Powder River Basin and Adjacent Areas, Northeastern Wyoming. U.S. Geological Survey Hydrological Investigations Atlas HA-465, Washington, D.C.

Herschfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 2 to 100 years. U.S. Weather Bureau Technical Paper 40, Washington, D.C.

Holzworth, G.C. 1972. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. Environmental Protection Agency. Office of Air Programs Research Triangle Park, N.C.

Keelyne, K.D. 1977. Endangered or threatened species in Wyoming. Special Report Number 3. Wyoming Coal Coordinator. Mimeo. 48 p.

Interior, Department of. 1979. Proposed development of coal resources in the Eastern Powder River Basin, Wyoming. U.S. Department of the Interior. Interruptea pagination. 2 Vols.

Kuchler, A.W. 1964. Potential natural vegetation of the coterminous United States. American Geographical Society. Special Publication No. 36. 138 p. + 116 photos.

Loeper, Dick. 1979. District Conservationist. Douglas Field Office, Soil Conservation Service, Douglas, Wyoming. Personal interview.

Long, C.A. 1965. The mammals of Wyoming. University of Kansas Publs., Museum of Natural History. 14:493-758.

Lowers, A.R. 1960. Climates of the states - Wyoming. Climatography of the United States No. 60-48. U.S. Department of Commerce. Washington, D.C.

Meyer, S.L. 1975. Data Analysis for Scientists and Engineers. John Wiley and Sons, Inc.

Miller, J.G. 1964. Two to ten days precipitation for return periods of 2 to 100 years in the contiguous United States. U.S. Weather Bureau Technical Paper 49, Washington, D.C.

NOAA (National Oceanic and Atmospheric Administration). 1973. Environmental data service. Climatography of the United States No. 81 (by state). Monthly normals of temperature, precipitation, and heating and cooling degree days 1941-70. U.S. Department of Commerce, Asheville, N.C.

NOAA (National Oceanic and Atmospheric Administration). 1976. Environmental data service. LCD for Casper, Wyoming. U.S. Department of Commerce, Asheville, N.C.

NOAA (National Oceanic and Atmospheric Administration). 1973. Environmental data service. Star program for Casper, Wyoming. U.S. Department of Commerce, Asheville, N.C.

Oosting, H.J. 1956. The study of plant communities. 2d edition. W.H. Freeman and Company, San Francisco. 440 p.

Patterson, R.L. 1952. The Sage Grouse in Wyoming. Wyoming Game and Fish Commission. Sage Books, Inc., Denver.

Peterson, R.T. 1961. A field guide to western birds. Houghton Mifflin Company, Boston. 366 p.

Robbins, C.S., B. Bruun, H.S. Zim, and A. Singer. 1966. Birds of North America. Golden Press, New York. 340 p.

Rocky Mountain Energy Corporation. 1978. Air quality permit to modify Bear Creek expansion CT-32. RMEC.

Stebbins, R.C. 1954. Amphibians and reptiles of western North America. McGraw-Hill Book Company, Inc., New York. 536 p.

Thom. H.C.S. 1963. Tornado probabilities. Monthly Weather Review, 92.

Thom, H.C.S. 1968. New distributions of extreme winds in the United States. Journal of the Structural Division, Proceedings of the American Society of Civil Engineers, 94(7).

Trebelcock, Bob. 1979. Game Warden. District 7, Wyoming Game and Fish Department, Douglas, Wyoming. Personal Interview.

UNC Teton Exploration Drilling, Inc. 1979. Application for an R&D Testing License for a uranium in situ operation. Application to Wyoming Department of Environmental Quality. Interrupted pagination.

United States Department of Agriculture. 1969. Diagnosis and improvement of saline and alkali soils. USDA Handbook No. 60. Washington, D.C.

United States Department of Agriculture. 1962. Soil survey manual. USDA Handbook No. 19. Washington, D.C.

United States Department of Agriculture. 1975. Soil Taxonomy. USDA Handbook No. 436. Washington, D.C.

United States Department of Interior. 1974. Earth Manual: Bureau of Reclamation. U.S. Government Printing Office, Washington, D.C. 810 p.

United States Fish and Wildlife Service. 1977. Endangered and threatened wildlife and plants. Federal Register 42 (135):36420-36431.

Walpole, R.E. and S.H. Myers. 1972. Probability of Statistics for Engineers and Scientists: MacMillian Publishing Company, N.Y. 506 p.

Walton, W.C. 1970. Ground Water Resource Evaluation. McGraw-Hill, New York.

Walton, W.C. 1962. Selected Analytical Methods for Well and Aquifer Evaluation. Illinois State Water Survey Bulletin 49, Urbana.

Weaver, J.E. and F.E. Clements. 1929. Plant ecology. McGraw-Hill Book Company, New York. 520 p.

Wyoming Game and Fish Department. 1977. Current status and inventory of wildlife in Wyoming. Cheyenne, WGFD. 133 p.

APPENDIX A

ARCHAEOLOGICAL REVIEW

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Wyoming Recreation Commission

604 EAST 25TH STREET CHEYENNE, WYOMING 82002

JAN L. WILSON
Director
777-7695

January 30, 1980

Bob Ward
Nuclear Assurance Corporation
8312 E. Otera Circle
Englewood, Colorado 80112

RE: Peterson Property, In Situ Uranium Mining

Dear Mr. Ward:

Thank you for the opportunity to review and comment on this project.

I have enclosed recommendations concerning archeological and historical clearance of the project and concur with them.

At such time as a cultural resources inventory can be reviewed by this office, a determination concerning cultural clearance can be made by the State Historic Preservation Officer (SHPO).

If you have any questions, please feel free to contact this office.

Sincerely,

John F. Carlson, Chief
Resources Division and
Deputy SHPO

FOR:

Jan L. Wilson, Director and
State Historic Preservation Officer

JFC:klm
Encls.

WYOMING RECREATION COMMISSION

STATE HISTORIC PRESERVATION OFFICE

REVIEW AND COMPLIANCE

Interdisciplinary Staff Comments

Archeology • History • Historical Architecture • Recreation Planning

TO: John Carlson, Chief

FROM: Gregory D. Kendrick, Survey Historian GK

DATE: January 30, 1980

RE: Nuclear Assurance Corporation, in situ uranium mining, Peterson Property

The area is in proximity to the Bozeman and Oregon-California Trails. An archeological inventory is therefore recommended for the 40 acres.

WYOMING RECREATION COMMISSION

STATE HISTORIC PRESERVATION OFFICE

REVIEW AND COMPLIANCE

Interdisciplinary Staff Comments

Archeology • *History* • *Historical Architecture* • *Recreation Planning*

TO: John F. Carlson, Chief

FROM: Thomas K. Larson, Associate State Archeologist

DATE: January 22, 1980

RE: Nuclear Assurance Corporation, in situ uranium mining, Peterson Property

An archeological inventory is recommended for the 40 acres mentioned prior to the mitigation of the proposed project.

CULTURAL RESOURCE INVENTORY OF THE NUCLEAR ASSURANCE CORPORATION PETERSON PROPERTY NEAR DOUGLAS WYOMING

By

David Eckles

Prepared For:

Nuclear Assurance Corporation

Submitted By

Office of the Wyoming State Archeologist
Wyoming Recreation Commission
Department of Anthropology
University of Wyoming
Laramie,Wyoming 82071

Project Number: WY-1-80
Antiquities Permit Number: 79-WY-031

April 1980

INTRODUCTION

On April 6, 1980 David Eckles and Dan Hayes of the Office of the Wyoming State Archeologist conducted an archeological reconnaissance survey of the Peterson Property in Converse County, Wyoming. The Nuclear Assurance Corporation requested a cultural inventory of this property in order to comply with state and federal antiquities legislation. Proposed disturbance involves drilling for uranium, construction of an evaporation pond, on-site offices and processing facilities and access roads.

The purposes of this survey were to: 1) locate and record cultural resourses in the project area; 2) evaluate their significance and eligibility for nomination to the National Register of Historic Places, and; 3) if necessary, develope a plan for the mitigation of sites should they be adversely impacted.

The location of the project area is indicated in Figure 1. The legal location is as follows:

T34N,R73W
Section 35, NE/NW
Converse County, Wyoming

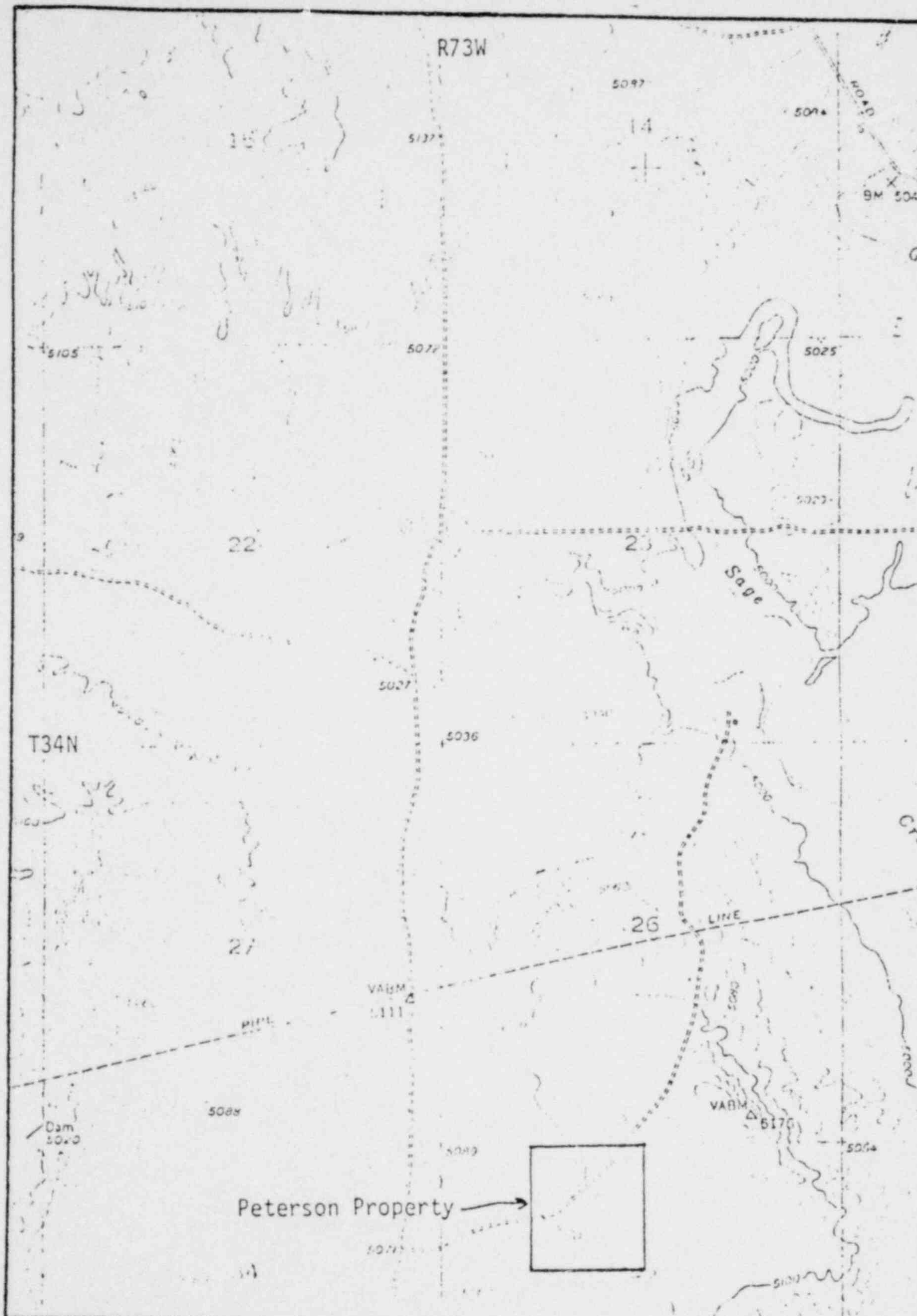


Figure 1. Map showing the location of the Nuclear Assurance Peterson Property surveyed by the OWSA.
Project # WY-1-80, Nuclear Assurance Corporation.
USGS Topographic map, 7.5' series, Gilbert Lake Quad.
Converse County, Wyrming.
4-6-80.

GENERAL SETTING

The project area is located about 10 miles northwest of Douglas, Wyoming and 2 miles north of the North Platte River. It is situated in an area of moderately rolling hills in a bluff area above the river. A playa is about ¼ mile from the project area. The soils consists of a silty, sandy and gravelly mixture. Vegetation consists of big sage, needle-and-thread grass, wild rye, blue gramma, and prickly pear.

METHODOLOGY

The project area was surveyed on foot in fair weather conditions. Crew members were spaced 30 meters apart and walked east-west transects. A zig-zag pattern was used in order to maximize coverage and to check areas of suspected site occurence.

SURVEY RESULTS

No cultural resources were located during this survey. Therefore archeological clearance is recommended with the stipulation that, if subsurface cultural remains are found during construction activities the appropriate state and federal agencies should be contacted immediately.

APPENDIX B

SOILS DATA

APPENDIX B
SOILS DATA

APPENDIX B.1 SOILS STUDIES FIELD AND DATA ANALYSES PROCEDURES

Field Studies

Field observations were primarily obtained from several spade and core-auger holes which were dug at random across the Test Site in each mapping unit delineation to a depth of five feet (1.6 m) or bedrock. In addition, several backhoe pits were excavated to depths up to 15 feet (4.6 m) to examine deeper strata, obtain soil samples and write profile descriptions. Other observations were made of associated parent material, vegetation and topographic location.

A mapping unit is comprised of a single soil series phase. Slope phases A and B were mapped indicating relatively level positions. These mapping units indicate a single soil type with less than 15 percent inclusions of other soil and/or land type.

Field mapping of soils was done directly on high quality color aerial photos of 1" = 1,000' scale. High intensity mapping was employed. Vegetation, topography, and the spade and auger holes were used to determine mapping unit boundaries. Reference was made to available Soil Conservation Service (SCS) soil series descriptions and ranges of characteristics to maintain a high degree of correlation with other SCS surveys in Converse County. Local SCS personnel were contacted to obtain existing maps and legends for nearby areas. The SCS was also consulted to verify soil identifications and interpretations. This survey maintained consistency with recent soil surveys conducted for uranium mine permits in the Highland area.

Sampling and Profile Description

A representative profile from each of the two soil series phases was sampled and described in detail. The representative profile was selected on the basis of median characteristics for parent material, physiography, physical characteristics and vegetation type. Each profile was sampled and described by horizon to a depth of 60 inches (152 cm) or bedrock. Surface and subsoil horizons were sampled at intervals of one foot or less.

A one quart (0.9 liter) sample from each soil horizon, subdivided horizon or contrasting layer was collected and air dried. This sample was then divided with a portion submitted for laboratory analysis and the remainder retained for additional tests if necessary. These samples were analyzed for the essential parameters listed in WDEQ-LQD Guideline No. 1.

Each horizon or contrasting layer was described in detail using standard SCS 232 forms. The following soil properties were evaluated in the field.

1. Type of horizon (A^1, $B2^t$, C^{ca}, etc.).
2. Relative depth and thickness of horizons.
3. Color (dry, moist).
4. Structure.
5. Consistence (dry, moist, wet).
6. Percent coarse fragments.
7. Depth and abundance of roots.
8. Clay films.
9. Visible secondary calcium carbonate or lime.
10. Effervescence with 0.1 N HCl.
11. Horizon boundary.

General observations were also noted for each site including: slope, landform, parent material, evidence of salt or sodium, internal and surface drainage and general vegetation type.

The range of characteristics noted for major horizons was derived from field observations and SCS soil series descriptions.
The range for major characteristics such as texture, depth and reaction was also provided.

Series Description

The soil series descriptions are site-specific to the R&D Site. The descriptions present the taxonomic classification, physiographic setting, physical and chemical characteristics, location, range of characteristics, drainage and permeability of each soil series. Series descriptions were obtained from representative soil pits which were also sampled. The series descriptions have been correlated with their respective laboratory results. These descriptions provide the fundamental technical information for each soil series phase (see Appendix B.3).

Mapping Unit Descriptions

The mapping unit descriptions focus on the physiographic setting, inclusion of other soil or land types, and topsoil suitability and depth. It is assumed that soils within a mapping unit may occupy the full range of characteristics for primary and included soil types.

The mapping unit descriptions also include a summarization of topsoil suitability and average depth. The soil and parent material is rated using Table 1 of WDEQ-LQD Guideline No. 3. The estimated average depth represents mean values for suitable topsoil material (see Appendix B.2).

APPENDIX B.2

SOIL MAPPING UNIT DESCRIPTIONS

62AB - Fort Collins sandy loam, 0 to 6 percent slopes

Fort Collins soils have formed on relatively level upland fans and drainages in deep, moderately coarsely textured, calcareous, sandstone alluvium. Slopes are nearly level to gently undulating. Small areas of Cushman sand loam, a moderately deep (20 to 40 inches) (51 to 102 cm) Fort Collins-like soil has been mapped as an inclusion in this unit. The Cushman series occurs as the transitional soil on the boundary between the Fort Collins and Tassel mapping units, but the area is too small to require separate delineation.

Fort Collins soils have sandy loam textures and moderately fine granular structure in the A horizon; sandy clay loam textures and moderate to strong, prismatic and subangular blocky structure in the $B2^{t}$ horizon; and sandy loam C^{ca} horizons which lack structure. A $B3^{ca}$ horizon may or may not be present. The Fort Collins series, as mapped by the SCS in this area, has less than 35 percent fine sand or coarser in the USDA textural classification. Depth to bedrock is greater than 40 inches (102 cm). These soils are rated good for topsoil material to an estimated average depth of 60 inches (152 cm) on the R&D Site.

79B - Tassel sandy loam, three to six percent slopes

The Tassel soils have formed residually over sandstone and sandy shale bedrock. They often have been found in association with very shallow soils and rock outcrops along ridgetops. Slopes of this unit in the permit area are gently undulating. Small areas of Cushman sandy loam, the moderately deep Fort Collins-like soil, were mapped as inclusions along the boundary with Fort Collins soils because the area where they were found was too small to map separately.

Tassel soils are sandy loam or light sandy clay loam throughout their depth. They have from 18 to 35 percent clay between 10 inches (25 cm) and bedrock.

They have weak structure in the surface horizon. Depth to bedrock is 15 to 20 inches (38 to 51 cm) in the permit area. The estimated average depth of suitable topsoil material is 18 inches (46 cm).

APPENDIX B.3

SOIL SERIES DESCRIPTIONS

Fort Collins Series

The Fort Collins series is comprised of deep, well-drained soils developed in calcareous alluvial fan and valley-filling fan sediments. Slopes are zero to six percent. Average annual precipitation is 10 to 13 inches (25 to 33 cm). These soils have moderate to moderately rapid permeability and medium runoff.

Taxonomic Classification: Ustollic Haplargid, fine-loamy, mixed, mesic.

Typical Profile: Al (0-3") - Light, yellowish brown (10 YR 6/4) sandy loam, yellowish brown (10 YR 5/4) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; many fine and very fine roots; neutral (pH 6.9); clear, smooth boundary.

$B2^t$ (3-12") - Brown (10 YR 5/3) sandy clay loam, dark brown (10 YR 4/3) moist; moderate, medium prismatic structure parting to strong, medium subangular blocky; hard, firm, slightly sticky and slightly plastic; thin, almost continuous clay films on horizontal and vertical ped faces and lining pores; many fine and very fine roots; neutral (pH 7.1); clear, smooth boundary.

$B3^{ca}$ (12-24") - Very pale brown (10 YR 7/3) sandy loam, pale brown (10 YR 6/3) moist; weak, medium prismatic structure parting to moderate, medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; thin, discontinuous clay films on vertical and horizontal peds and lining root pores; common fine and very fine roots; strongly effervescent; few soft medium masses, seams and threads of lime, mildly alkaline (pH 7.4); gradual, smooth boundary.

C^{ca} (24-60") - Very pale brown (10 YR 7/4) sandy loam, light yellowish brown (10 YR 6/4) moist; massive; loose, nonsticky and nonplastic; few fine and medium roots to 40 inches (102 cm); strongly to violently effervescent; common fine and medium seams and threads of lime; mildly to moderately alkaline (pH 7.5 to 8.1).

Range in Characteristics:

A Horizon

Texture: sandy loam to light sandy clay loam.

Reaction: neutral to mildly alkaline.

Thickness: Two to five inches (5 to 13 cm).

$B2^t$ Horizon

Texture: heavy sandy loam to sandy clay loam.

Reaction: neutral to mildly alkaline.

Thickness: eight to fifteen inches (20 to 38 cm).

$B3^{ca}$ Horizon

May or may not be present; if so, it has similar characteristics as the $B2^t$ horizon.

C^{ca} Horizon

Texture: sandy loam to sandy clay loam.

Reaction: mildly to moderately alkaline.

Thickness: two to six feet (0.6 to 1.8 m).

Tassel Series

The Tassel series is comprised of shallow, well-drained soils with moderately rapid permeability and medium runoff. They have developed residually from soft, calcareous sandstone and are found on hillcrests, escarpments and ridges. Slopes are three to six percent. Average annual precipitation is 10 to 13 inches (25 to 33 cm).

Taxonomic Classification: Ustic Torriorthent, loamy, mixed (calcareous) mesic, shallow.

Typical Profile: A1 (0-3") - Light, yellowish brown (10 YR 6/4) sandy loam, yellowish brown (10 YR 5/4) moist; weak, fine granular structure; soft, very friable, nonsticky and nonplastic; common fine and medium roots; slightly effervescent; neutral (pH 7.3); clear, smooth boundary.

C^{ca} (3-18") - Very pale brown (10 YR 8/3) sandy loam, very pale brown (10 YR 7/3) moist; massive; loose, nonsticky and nonplastic; common fine and very fine roots to ten inches (25 cm); strongly effervescent; common fine seams and threads of lime; mildly alkaline (pH 7.7).

Range in Characteristics:

A Horizon

Texture: loamy sand to sandy loam.
Reaction: neutral to mildly alkaline.
Thickness: one to four inches (2.5 to 10 cm).

C^{ca} Horizon

Texture: sandy loam (10 to 18 percent clay).
Reaction: mildly to moderately alkaline.
Thickness: nine to sixteen inches (23 to 41 cm).

Appendix B.4: SOIL ANALYSES - December, 1979

Profile #/Soil Series	pH (paste)	E.C. mmhos/cm	Ca meq/l	Mg meq/l	Na meq/l	SAR	O.M. %	Sat. %	Texture	Sand %	VFS %	Silt %	Clay %
Fort Collins													
#1/ 0-3	6.9	1.4	10.0	4.3	1.0	0.4	2.9	41.0	SL	15	46	25	14
3-12	7.1	0.7	5.1	2.0	0.6	0.3	2.7	44.4	SCL	10	47	21	22
12-24	7.4	0.8	5.0	2.5	0.6	0.3	1.6	40.3	SL	5	50	27	18
24-42	8.1	1.3	1.6	2.7	6.3	4.3	0.5	36.6	SL	12	47	22	19
42-60	7.5	7.2	20.4	43.7	25.8	4.6	0.5	36.2	SL	13	48	21	18
Tassel													
#2/ 0-3	7.3	1.1	8.5	2.7	0.8	0.3	1.9	29.1	SL	44	33	13	10
3-18	7.7	0.7	3.1	2.7	1.7	1.0	0.7	31.3	SL	38	36	11	15

APPENDIX C

RADIOLOGY LABORATORY PROCEDURES

APPENDIX C

RADIOLOGY LABORATORY PROCEDURES

Sample Preparation

The sample of soil was ground to 60 mesh and homogenized. Appropriate aliquots of the homogenized sample were taken and treated as follows for analysis:

1. Radium-226: an aliquot of 100 grams (gm) was taken and placed in a four ounce counting container for analysis.

2. Natural Uranium: A ten gm aliquot of sample was leached with dilute nitric acid, boiled, filtered and analyzed.

Analytical Procedures

In the determination of chemical constituents, precautions must be taken to obtain a sample that is truly representative of existing conditions and to handle it in such a way that it does not deteriorate or become contaminated. Care must also be exercised to insure that the analyses are representative of the actual composition of the sample. The analytical procedures were derived from HASL Procedures Manual.

The prepared sample was counted for radium-226 utilizing a Ge(li) detector which is coupled to a computerized gamma spectrophotometer. The results were calculated with the aid of the computer which identified and quantitized the radium-226 peak at 0.186MeV.

The leachate from the prepared sample was evaporated to dryness and ashed until a white residue remained. A fluor mixture was added and fused at 900° C. The resulting pellet was then read for fluorescence and converted to micrograms of uranium by comparing against uranium solutions of varying concentrations.

Analytical Instrumentation

The gamma spectrometer consists of a Northern Scientific Model 636 multichannel pulse height analyzer equipped with a Data General Nova Computer, teletype and X-Y Recorder, and a solid state Ge(Li) detector. The computer based gamma spectrometry system is used for all gamma counting. The system uses the software from Northern Scientific to search for, identify and quantize the peaks of interest.

The Jarrel Ash Fluorometer has been specifically designed for the analysis of solid and liquid samples containing uranium minerals and products.

The Ludlum Model 12 micro R Instrument is designed to obtain optimum performance with a high efficiency gamma scintillator detector. The detector is a 1" x 1" NaI(Tl) scintillator. The survey instrument has a micro range of 0 to 1,000.

APPENDIX D

HYDROLOGY FIELD DATA AND GRAPHICAL ANALYSES

APPENDIX D

50-HOUR AQUIFER TEST

11/13 - 15/79

PUMPING TEST FIELD DATA

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: N/A

DISTANCE FROM PUMPED WELL: N/A

ELEVATION OF MEASURING POINT: 5105.4 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0835			140.89			Static
1979	0902			140.90			levels
	0910			140.93			
	0916			140.90			
	0924			140.91			
	0935			140.90			
	0955			140.90			
	1010			140.90		20	Pump on
	1015	5		198.3	57.4		
	1017	7		198.3	57.4	8	
	1020	10				8	
	1022	12		198.4	57.5		
	1026	16		198.3	57.4	7	
	1028	18				7	
	1029	19		198.3	57.4	7	
	1033	23					
	1035	25		198.3	57.4		
	1037	27				7	
	1038	28		198.3	57.4		
	1042	32				7	
	1043	33		198.3	57.4		
	1050	40		198.3	57.4		
	1051	41				7	
	1101	51				7	
	1102	52		198.3	57.4		
	1110	60		198.3	57.4		
	1112	62				6.6	
	1113	63				7	
	1114	64		198.3	57.4		
	1123	73				7	
	1124	74		198.3	57.4		
	1130	80				7	
	1132	82		198.3	57.4		
	1140	90				6.8	
	1143	93		198.4	57.5		
	1150	100				6.8	
	1152	102		198.35	57.45		
	1200	110				6.8	
	1202	112		198.3	57.4		
	1208	118				6.3	
	1210	120				6.4	
	1211	121		198.35	57.45		
	1245	155				6.4	
	1247	157		198.35	57.45		

PROJECT: NAC Peterson PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A OBSERVATION WELL: N/A

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	1312	182		198.35	57.45	6.2	
	1314	184					Leak in valve
	1325	195					
	1334	204				<6	
	1336	206		198.35	57.45	6.2	Adjust discharge
	1410	240				6.3	
	1411	241		198.3	57.4		
	1511	301		198.3	57.4		
	1512	302				6.1	
	1611	361		198.3	57.4	6.2	Adjust discharge
	1612	362				6.1	
	1620	370					Pump surging
	1624	374				6.0	
	1625	375		198.35	57.45		
	1630	380		198.30	57.4	5.9	
	1814	484		198.3	57.4		
	1816	486				5.9	
	1819	489				5.9	
	1830	500				5.7	
	1838	508					Adjust discharge
	1840	510					Discharge stopped, valve problem
	1905	535					
	1925	555		198.3	57.4	5.6	
	1930	560		198.3	57.4	5.7	
	2010	600		197.6	56.7	5.6	
	2130	680		194	53.1	5.4	Adjust discharge
	2210	720		1[illegible].9	56.0	5.5	
	2216	726		196.9	56.0	5.5	
	2317	787		198.3	57.4	5.5	
11/14	0009	839		198.3	57.4		
	0010	840				5.5	
	0114	904		198.3	57.4	5.5	
	0216	966		195.7	54.8	5.1	Adjust discharge
	0316	1026		198.3	57.4	5.4	
	0415	1085		198.2	57.3	5.4	
	0525	1155		198.3	57.4	5.4	
	0611	1201		198.3	57.4	5.4	
	0720	1270		198.3	57.4	5.4	
	0817	1327		198.4	57.5	5.3	
	0909	1379		198.4	57.5		
	0910	1380				5.3	
	1030	1460		198.4	57.5		

PROJECT: NAC Peterson PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A OBSERVATION WELL: N/A

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1033	1463				5.3	
	1055	1485		198.4	57.5	5.3	
	1100	1490					Pump off
	1101	1491	1	195.8	54.9		Recovery
	1102	1492	2	178.3	37.4		
	1103	1493	3	174.7	33.8		
		1493.5	3.5	171.0	30.1		
	1104	1494	4	168.9	28.0		
		1494.5	4.5	167.2	26.3		
	1105	1495	5	166.1	25.2		
		1495.5	5.5	164.9	24.0		
	1106	1496	6	164.3	23.4		
	1107	1497	7	163.3	22.4		
	1108	1498	8	162.3	21.4		
		1498.5	8.5	161.5	20.6		
	1109	1499	9	160.9	20.0		
		1499.5	9.5	160.3	19.4		
	1110	1500	10	159.9	19.0		
		1501.5	11.5	158.3	17.4		
	1112	1502	12	157.9	17.0		
	1113	1503	13	157.5	16.6		
		1503.5	13.5	157.1	16.2		
	1114	1504	14	156.7	15.8		
	1115	1505	15	156	15.1		
	1116	1506	16	155.7	14.8		
		1506.5	16.5	155.25	14.35		
	1117	1507	17	155	14.1		
	1118	1508	18	154.8	13.9		
	1119	1509	19	154.5	13.6		
	1120	1510	20	154.4	13.5		
	1125	1515	25	153.5	12.6		
	1126	1516	26	153.1	12.2		
	1128	1518	28	152.8	11.9		
	1129	1519	29	152.6	11.7		
	1140	1530	40	151.7	10.8		
	1145	1535	45	151.35	10.45		
	1150	1540	50	151.1	10.2		
	1155	1545	55	150.9	10.0		
	1201	1551	61	150.7	9.8		
	1213	1563	73	150.4	9.5		
	1221	1571	81	150.2	9.3		
	1225	1575	85	150.0	9.1		
	1240	1590	100	149.8	8.9		
	1304	1614	124	149.35	8.45		
	1348	1658	168	148.9	8.0		

PROJECT: NAC Peterson PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A OBSERVATION WELL: N/A

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1410	1680	190	148.6	7.7		
	1433	1703	213	148.8	7.9		
	1506	1736	246	148.2	7.3		
	1607	1797	307	147.8	6.9		
	1700	1850	360	147.5	6.6		
	1819	1929	439	147.1	6.2		
	1922	1992	502	146.8	5.9		
	2005	2035	545	146.75	5.85		
	2102	2092	602	146.5	5.6		
	2201	2151	661	146.3	5.4		
	2325	2235	745	145.9	5.0		
	2400	2270	780	145.8	4.9		
11/15	0207	2397	907	145.6	4.7		
	0407	2517	1027	145.1	4.2		
	0626	2656	1166	144.9	4.0		
	0831	2781	1291	144.6	3.7		
	0859	2809	1319	144.6	3.7		
	0955	2865	1375	144.5	3.6		
	1056	2926	1436	144.4	3.5		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-1
DISTANCE FROM PUMPED WELL: 99.1 ft

ELEVATION OF MEASURING POINT: 5103.9 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0838			140.17			Static
1979	0848			140.69			levels
	0858			140.04			
	0906			140.02			
	0916			140.23			
	0926			140.19			
	0935			140.01			
	0947			140.00			
	0951			140.12			
	1010			140.12			Pump on
	1021	11		141.21	1.09		
	1050	40		143.33	3.21		
	1110	60		144.34	4.22		
	1120	70		144.34	4.22		
	1130	80		144.67	4.55		
	1140	90		144.88	4.76		
	1150	100		144.92	4.80		
	1200	110		144.17	4.05		
	1210	120		145.01	4.89		
	1240	150		146.00	5.88		
	1310	180		146.07	5.95		
	1340	210		146.40	6.28		
	1410	240		146.62	6.50		
	1510	300		147.28	7.16		
	1610	360		147.73	7.61		
	1710	420		148.26	8.14		
	1825	495		148.61	8.49		
	1918	548		148.86	8.74		
	2013	603		149.14	9.02		
	2217	727		149.86	9.74		
	2320	790		149.94	9.82		
11/14	0017	847		150.25	10.13		
	0110	900		150.58	10.46		
	0212	962		150.67	10.55		
	0310	1020		150.75	10.63		
	0413	1083		151.2	11.08		
	0520	1150		151.4	11.28		
	0615	1205		151.8	11.68		
	0710	1260		151.9	11.78		
	0812	1322		152.0	11.88		
	0909	1379		152.03	11.91		
	1023	1453		152.31	12.19		
	1055	1485		152.38	12.26		

PROJECT: NAC Peterson   PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A   OBSERVATION WELL: OW-1

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1100	1490		152.44	12.32		Pump off
	1130	1520	30	150.85	10.73		Recovery
	1135	1525	35	150.25	10.40		
	1140	1530	40	150.34	10.22		
	1145	1535	45	150.22	10.10		
	1150	1540	50	150.04	9.92		
	1155	1545	55	150.00	9.88		
	1200	1550	60	149.75	9.63		
	1205	1555	65	149.66	9.54		
	1210	1560	70	149.60	9.48		
	1215	1565	75	149.52	9.40		
	1220	1570	80	149.44	9.32		
	1225	1575	85	149.29	9.17		
	1230	1580	90	149.15	9.03		
	1240	1590	100	149.00	8.88		
	1250	1600	110	148.89	8.77		
	1300	1610	120	148.66	8.54		
	1340	1650	160	148.2	8.08		
	1408	1678	188	148.0	7.88		
	1430	1700	210	147.7	7.58		
	1505	1735	245	147.5	7.38		
	1610	1800	310	147.8	7.68		
	1707	1857	367	146.65	6.53		
	1827	1937	447	146.3	6.18		
	1922	1992	502	146.1	5.98		
	2005	2035	545	145.8	5.68		
	2100	2090	600	145.7	5.58		
	2205	2155	665	145.4	5.28		
	2325	2235	745	145.1	4.98		
11/15	0005	2275	785	145..0	4.88		
	0215	2405	915	145.2	5.08		
	0413	2523	1033	144.4	4.28		
	0635	2665	1175	144.0	3.88		
	0835	2785	1295	143.8	3.68		
	0905	2815	1325	143.8	3.68		
	1003	2873	1383	143.7	3.58		
	1103	2933	1443	143.4	3.28		
11/16	1000	4310	2820	141.6	1.48		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-2

DISTANCE FROM PUMPED WELL: 100.5 ft

ELEVATION OF MEASURING POINT: 5107.2 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0835			143.04			Static
1979	0846			143.04			levels
	0853			143.03			
	0859			143.02			
	0907			143.03			
	0912			143.02			
	0923			143.03			
	0930			143.01			
	0937			143.00			
	0941			142.98			
	0955			142.98			
	1003			142.98			
	1009			143.00			
	1010			143.00			Pump on
	1011	1		143.06	.06		
	1012	2		143.06	.06		
	1013	3		143.03	.03		
		4.5		143.14	.14		
		5.5		143.17	.17		
	1016	6		143.29	.29		
	1017	7		143.46	.46		
	1018	8		143.50	.50		
	1019	9		143.65	.65		
	1020	10		143.78	.78		
	1025	15		144.42	1.42		
	1026	16		144.54	1.54		
	1028	18		144.75	1.75		
	1029	19		144.84	1.84		
	1030	20		144.96	1.96		
	1031	21		145.00	2.00		
	1032	22		145.08	2.08		
	1036	26		145.54	2.54		
	1037	27		145.62	2.62		
	1040	30		145.79	2.79		
	1042	32		145.90	2.90		
	1044	34		145.99	2.99		
	1049	39		146.35	3.35		
	1051	41		146.35	3.35		
	1053	43		146.49	3.49		
	1055	45		146.52	3.52		
	1057	47		146.59	3.59		
	1103	53		146.84	3.84		
	1108	58		147.01	4.01		
	1119	69		147.31	4.31		

PROJECT: NAC Peterson | PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A | OBSERVATION WELL: OW-2

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	1130	80		147.55	4.55		
	1140	90		147.82	4.82		
	1150	100		147.94	4.94		
	1200	110		148.11	5.11		
	1210	120		148.27	5.27		
	1220	130		148.45	5.45		
	1240	150		148.71	5.71		
	1310	180		149.05	6.05		
	1336	206		149.41	6.41		
	1340	210		149.42	6.42		
	1410	240		149.67	6.67		
	1510	300		150.18	7.18		
	1610	360		150.61	7.61		
	1710	420		151.05	8.05		
	1818	488		151.46	8.46		
	1912	542		151.67	8.67		
	2025	615		152.12	9.12		
	2220	730		152.57	9.57		
	2327	797		152.90	9.90		
11/14	0012	842		153.10	10.10		
	0017	847		152.9	9.9		
	0117	907		153.38	10.38		
	0210	960		153.50	10.50		
	0312	1022		153.80	10.80		
	0410	1080		154.04	11.04		
	0525	1155		154.29	11.29		
	0610	1200		154.45	11.45		
	0711	1261		154.65	11.65		
	0807	1317		154.83	11.83		
	0907	1377		155.00	12.00		
	1002	1432		155.00	12.00		
	1100	1490		155.12	12.12		Pump off
		1492.5	2.5	155.13	12.13		Recovery
	1105	1495	5	155.12	12.12		
		1497.5	7.5	155.05	12.05		
	1110	1500	10	154.91	11.91		
		1502.5	12.5	154.75	11.75		
	1115	1505	15	154.57	11.57		
		1507.5	17.5	154.40	11.40		
	1120	1510	20	154.21	11.21		
	1125	1515	25	153.86	10.86		
	1130	1520	30	153.59	10.59		
	1135	1525	35	153.30	10.30		
	1140	1530	40	153.07	10.07		
	1145	1535	45	152.87	9.87		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-2

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1150	1540	50	152.69	9.69		
	1200	1550	60	152.38	9.38		
	1210	1560	70	152.11	9.11		
	1220	1570	80	151.88	8.88		
	1240	1590	100	151.52	8.52		
	1300	1610	120	151.22	8.22		
	1315	1625	135	151.1	8.1		
	1330	1640	150	150.93	7.93		
	1420	1690	200	150.49	7.49		
	1510	1740	250	150.12	7.12		
	1600	1790	300	149.83	6.83		
	1620	1810	320	149.7	6.70		
	1650	1840	350	149.53	6.53		
	1740	1890	400	149.29	6.29		
	1830	1940	450	149.07	6.07		
	1920	1990	500	148.88	5.88		
	2010	2040	550	148.75	5.75		
	2015	2045	555	148.65	5.65		
	2105	2095	605	148.60	5.60		
	2150	2140	650	148.43	5.43		
	2240	2190	700	148.26	5.26		
	2330	2240	750	148.10	5.10		
11/15	0005	2275	785	148.00	5.00		
	0009	2279	789	147.97	4.97		
	0213	2403	913	147.59	4.59		
	0248	2438	948	147.51	4.51		
	0338	2488	998	147.38	4.38		
	0419	2529	1039	147.30	4.30		
	0431	2541	1051	147.27	4.27		
	0521	2591	1101	147.15	4.15		
	0611	2641	1151	147.05	4.05		
	0701	2691	1201	146.95	3.95		
	0751	2741	1251	146.86	3.86		
	0822	2771	1281	146.80	3.80		
	0838	2787	1297	146.77	3.77		
	0842	2791	1301	146.73	3.73		
	0932	2841	1351	146.65	3.65		
	1022	2891	1401	146.56	3.56		
	1112	2941	1451	146.47	3.47		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-3

DISTANCE FROM PUMPED WELL: 99.8 ft

ELEVATION OF MEASURING POINT: 5106.2 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	1010			141.80			Pump on
1979		1.5		141.89	.09		
	1014	4		142.19	.39		
		6.5		142.59	.79		
	1019	9		142.97	1.17		
		11.5		143.30	1.50		
	1024	14		143.63	1.83		
		16.5		143.92	2.12		
	1029	19		144.16	2.36		
		21.5		144.39	2.59		
	1034	24		144.61	2.81		
	1039	29		144.95	3.15		
	1044	34		145.24	3.44		
	1049	39		145.52	3.72		
	1054	44		145.74	3.94		
	1059	49		145.95	4.15		
	1104	54		146.14	4.34		
	1109	59		146.31	4.51		
	1119	69		146.61	4.81		
	1129	79		146.85	5.05		
	1139	89		147.09	5.29		
	1149	99		147.28	5.48		
		106.5		147.42	5.62		
	1204	114		147.56	5.76		
	1209	119		147.63	5.83		
	1219	129		147.79	5.99		
	1229	139		147.93	6.13		
	1239	149		148.06	6.26		
	1249	159		148.19	6.39		
	1305	175		148.5	6.7		
	1308	178		148.54	6.74		
	1318	188		148.64	6.84		
	1328	198		148.73	6.93		
	1348	218		148.92	7.12		
	1408	238		149.12	7.32		
	1428	258		149.31	7.51		
	1448	278		149.48	7.68		
	1508	298		149.62	7.82		
	1528	318		149.76	7.96		
	1548	338		149.91	8.11		
	1608	358		150.04	8.24		
	1648	398		150.28	8.4		
	1715	425		150.5	8.7		
	1720	430		150.55	8.75		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-3

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	1740	450		150.68	8.88		
	1830	500		150.96	9.16		
	1845	515		151.03	9.23		
	1850	520		151.04	9.24		
	1855	525		151.01	9.21		
	1900	530		150.99	9.19		
	1910	540		151.00	9.20		
	1920	550		151.05	9.25		
	2010	600		151.34	9.54		
	2050	640		151.50	9.70		
	2108	658		151.6	9.8		
	2142	692		151.66	9.86		
	2147	697		151.68	9.88		
	2212	722		151.85	10.05		
	2237	747		151.92	10.12		
	2327	797		152.09	10.29		
11/14	0017	847		152.36	10.56		
	0107	897		152.57	10.77		
	0126	916		152.65	10.85		
	0245	995		152.78	10.98		
	0249	999		152.78	10.98		
	0339	1049		152.96	11.16		
	0429	1099		153.15	11.35		
	0519	1149		153.29	11.49		
	0554	1184		153.5	11.7		
	0610	1200		153.56	11.76		
	0700	1250		153.72	11.92		
	0750	1300		153.84	12.04		
	0840	1350		153.99	12.19		
	0910	1380		154.08	12.28		
	0915	1385		154.2	12.40		
	0930	1400		154.26	12.46		
	1000	1430		154.33	12.53		
	1030	1460		154.41	12.61		
	1100	1490		154.49	12.69		Pump off
	1105	1495	5	154.49	12.69		Recovery
		1497.5	7.5	154.48	12.68		
	1110	1500	10	154.36	12.56		
		1502.5	12.5	154.18	12.38		
	1115	1505	15	154.07	12.27		
		1512.5	22.5	153.32	11.52		
	1125	1515	25	153.26	11.46		
	1135	1525	35	152.26	10.46		
	1145	1535	45	151.91	10.11		

PROJECT: NAC Peterson PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A OBSERVATION WELL: OW-3

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1150	1540	50	151.77	9.97		
	1200	1550	60	151.57	9.77		
	1215	1565	75	150.92	9.12		
	1233	1583	93	150.52	8.72		
	1305	1615	125	150.02	8.22		
	1323	1633	143	149.75	7.95		
	1347	1657	167	149.53	7.73		
	1359	1669	179	149.41	7.61		
	1419	1689	199	149.23	7.43		
	1519	1749	259	148.8	7.0		
	1619	1809	319	148.45	6.65		
	1626	1816	326	148.42	6.62		
	1726	1876	386	148.12	6.32		
	1826	1936	446	147.85	6.05		
	1926	1996	506	147.63	5.83		
	2021	2051	561	147.47	5.67		
	2024	2054	564	147.46	5.66		
	2124	2114	624	147.24	5.44		
	2224	2174	684	147.06	5.26		
	2324	2234	744	146.88	5.08		
11/15	0014	2284	794	146.74	4.94		
	0017	2287	797	146.73	4.93		
	0117	2347	857	146.59	4.79		
	0217	2407	917	146.41	4.61		
	0317	2467	977	146.24	4.44		
	0417	2527	1037	146.12	4.32		
	0426	2536	1046	146.07	4.27		
	0526	2596	1106	145.93	4.13		
	0626	2656	1166	145.78	3.98		
	0726	2716	1226	145.68	3.88		
	0844	2794	1304	145.52	3.72		
	0847	2797	1307	145.51	3.71		
	0947	2857	1367	145.40	3.60		
	1047	2917	1427	145.30	3.50		
	1124	2954	1464	145.24	3.44		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-4

DISTANCE FROM PUMPED WELL: 231.4 ft

ELEVATION OF MEASURING POINT: 5101.6 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0945			138.1			
1979	1010						Pump on
	1400	230		140.15	2.05		
	1641	391		141.95	3.85		
	1738	448		142.42	4.32		
	1746	456		142.50	4.40		
	1835	505		142.83	4.73		
	1903	533		143.05	4.95		
	1928	558		143.24	5.14		
	2025	615		143.59	5.49		
	2125	675		143.99	5.89		
	2128	678		143.99	5.89		
	2225	735		144.29	6.19		
	2333	803		144.62	6.52		
11/14	0021	851		144.82	6.72		
	0150	940		145.40	7.30		
	0241	991		145.59	7.49		
	0315	1025		145.74	7.64		
	0417	1087		145.86	7.76		
	0520	1150		146.12	8.02		
	0545	1175		146.40	8.30		
	0617	1207		146.50	8.40		
	0720	1270		146.70	8.60		
	0817	1327		146.91	8.81		
	1005	1435		147.25	9.15		
	1010	1440		147.25	9.15		
	1028	1458		147.29	9.19		
	1053	1483		147.39	9.29		
	1100	1490		147.39	9.29		Pump off
	1112	1502	12	147.44	9.34		Recovery
	1132	1522	32	147.47	9.37		
	1155	1545	55	147.48	9.38		
	1233	1583	93	147.32	9.22		
	1300	1610	120	147.20	9.10		
	1330	1640	150	147.04	8.94		
	1333	1643	153	147.0	8.90		
	1420	1690	200	146.63	8.53		
	1440	1710	220	146.46	8.36		
	1515	1745	255	146.19	8.09		
	1640	1830	340	145.5	7.40		
	1722	1872	382	145.19	7.09		
	1829	1939	449	144.72	6.62		
	1928	1998	508	144.36	6.26		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-4

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	2030	2060	570	144.03	5.93		
	2037	2067	577	144.01	5.91		
	2108	2098	608	143.86	5.76		
	2206	2156	666	143.58	5.48		
	2333	2243	753	143.23	5.13		
11/15	0022	2292	802	143.05	4.95		
	0031	2301	811	142.98	4.88		
	0214	2404	914	142.65	4.55		
	0432	2542	1052	142.26	4.16		
	0438	2548	1058	142.25	4.15		
	0630	2660	1170	141.95	3.85		
	0717	2707	1217	141.87	3.77		
	0850	2800	1310	141.68	3.58		
	0856	2806	1316	141.67	3.57		
	0908	2818	1328	141.64	3.54		
	1003	2873	1383	141.53	3.43		
	1107	2937	1447	141.39	3.29		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-5
DISTANCE FROM PUMPED WELL: 25.0 ft

ELEVATION OF MEASURING POINT: 5105.2 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0945			139.33			Static
1979	0951			139.31			levels
	0958			139.25			
	1008			139.22			
	1010			139.22			Pump on
		1.75		139.89	0.67		
	1013	3		141.66	2.44		
	1015	5		143.73	4.51		
	1017	7		144.50	5.28		
	1020	10		145.36	6.14		
	1023	13		145.82	6.60		
	1027	17		146.60	7.38		
	1028	18		146.88	7.66		
	1031	21		147.13	7.91		
	1033	23		147.40	8.18		
	1037	27		147.62	8.40		
	1041	31		147.90	8.68		
	1046	36		148.23	9.01		
	1050	40		148.37	9.15		
	1056	46		148.67	9.45		
	1102	52		148.83	9.61		
	1106	56		148.97	9.75		
	1111	61		149.11	9.89		
	1122	72		149.40	10.18		
	1130	80		149.61	10.39		
	1142	92		149.80	10.58		
	1150	100		149.95	10.73		
	1201	111		150.13	10.91		
	1210	120		150.24	11.02		
	1241	151		150.65	11.43		
	1309	179		150.96	11.74		
	1337	207		151.21	11.99		
	1415	245		151.52	12.30		
	1514	304		151.90	12.68		
	1610	360		152.5	13.28		
	1710	420		152.74	13.52		
	1811	481		153.13	13.91		
	1857	527		152.61	13.39		
	1908	538		152.93	13.71		
	2010	600		153.44	14.22		
	2209	719		153.85	14.63		
	2317	787		153.98	14.76		
11/14	0009	839		154.47	15.25		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-5

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	0112	902		154.72	15.50		
	0214	964		154.90	15.68		
	0314	1024		155.00	15.78		
	0413	1083		155.25	16.03		
	0520	1150		155.45	16.23		
	0616	1206		155.70	16.48		
	0713	1263		155.75	16.53		
	0814	1324		156.0	16.78		
	0907	1377		156.07	16.85		
	1024	1454		156.31	17.09		
	1055	1485		156.27	17.05		
	1100	1490		156.27	17.05		Pump off
		1490.25	0.25	156.27	17.05		Recovery
		1490.5	0.5	156.29	17.07		
	1101	1491	1	156.21	16.99		
		1491.5	1.5	156.08	16.86		
	1102	1492	2	155.88	16.66		
		1492.5	2.5	155.67	16.45		
	1103	1493	3	155.50	16.28		
		1493.5	3.5	155.29	16.07		
	1104	1494	4	155.12	15.90		
		1494.5	4.5	154.96	15.74		
	1105	1495	5	154.73	15.51		
	1106	1496	6	154.38	15.16		
	1107	1497	7	154.04	14.82		
	1108	1498	8	153.75	14.53		
	1109	1499	9	153.50	14.28		
	1110	1500	10	153.25	14.03		
	1111	1501	11	152.96	13.74		
	1112	1502	12	152.75	13.53		
	1113	1503	13	152.5	13.28		
	1114	1504	14	152.33	13.11		
	1115	1505	15	152.12	12.90		
	1116	1506	16	151.96	12.74		
	1117	1507	17	151.79	12.57		
	1118	1508	18	151.62	12.40		
	1119	1509	19	151.46	12.24		
	1120	1510	20	151.33	12.11		
	1121	1511	21	151.17	11.95		
	1122	1512	22	151.06	11.84		
	1123	1513	23	150.94	11.72		
	1124	1514	24	150.88	11.66		
	1125	1515	25	150.75	11.53		
	1126	1516	26	150.62	11.40		
	1127	1517	27	150.54	11.32		

PROJECT: NAC Peterson PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A OBSERVATION WELL: OW-5

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1128	1518	28	150.46	11.24		
	1129	1519	29	150.38	11.16		
	1130	1520	30	150.29	11.07		
	1135	1525	35	149.96	10.74		
	1140	1530	40	149.62	10.40		
	1145	1535	45	149.42	10.20		
	1150	1540	50	149.21	9.99		
	1155	1545	55	149.04	9.82		
	1200	1550	60	148.83	9.61		
	1211	1561	71	148.52	9.30		
	1221	1571	81	148.33	9.11		
	1232	1582	92	148.10	8.88		
	1242	1592	102	147.94	8.72		
	1302	1612	122	147.62	8.40		
	1341	1651	161	147.10	7.88		
	1415	1685	195	146.80	7.58		
	1438	1708	218	146.5	7.28		
	1508	1738	248	146.3	7.08		
	1610	1800	310	145.8	6.58		
	1703	1853	363	145.7	6.48		
	1820	1930	440	145.3	6.08		
	1923	1993	503	145.0	5.78		
	2006	2036	546	144.9	5.68		
	2104	2094	604	144.7	5.48		
	2203	2153	663	144.6	5.38		
	2325	2235	745	144.6	5.38		
11/15	0001	2271	781	144.1	4.88		
	0210	2400	910	143.7	4.48		
	0410	2520	1030	143.3	4.08		
	0627	2657	1167	143.4	4.18		
	0837	2787	1297	142.9	3.68		
	0901	2811	1321	142.9	3.68		
	0958	2868	1378	142.8	3.58		
	1101	2931	1441	142.7	3.48		
11/16	1002	4312	2822	140.8	1.58		

PROJECT: NAC Peterson PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A OBSERVATION WELL: OW-6

DISTANCE FROM PUMPED WELL: 24.9 ft

ELEVATION OF MEASURING POINT: 5105.3 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0840			139.72			Stati`
1979	0904			139.65			level
	0915			139.62			
	0918			139.66			
	0930			139.62			
	0937			139.61			
	0947			139.63			
	0953			139.63			
	0959			139.61			
	1007			139.61			
	1010			139.61			Pump on
	1011	1		139.76	0.15		
		2.75		140.81	1.20		
		4.25		142.40	2.79		
	1016	6		143.51	3.90		
		8.5		144.60	4.99		
	1021	11		145.20	5.59		
	1025	15		145.79	6.18		
		17.5		146.30	6.69		
	1029	19		146.64	7.03		
	1032	22		146.86	7.25		
	1035	25		147.02	7.41		
	1040	30		147.45	7.84		
	1045	35		147.76	8.15		
	1049	39		147.87	8.26		
	1055	45		148.15	8.54		
	1100	50		148.42	8.81		
	1105	55		148.67	9.06		
	1110	60		148.74	9.13		
	1121	71		148.95	9.34		
	1129	79		149.20	9.59		
	1140	90		149.40	9.79		
	1151	101		149.67	10.06		
	1200	110		149.74	10.13		
	1211	121		149.90	10.29		
	1240	150		150.33	10.72		
	1311	181		150.62	11.01		
	1335	205		150.82	11.21		
	1415	245		151.2	11.59		
	1515	305		151.65	12.04		
	1610	360		152.00	12.39		
	1707	417		152.39	12.78		
	1813	483		152.67	13.06		
	1855	525		152.43	12.82		

PROJECT: NAC Peterso.. PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A OBSERVATION WELL: OW-6

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	1910	540		152.66	13.05		
	2008	598		153.11	13.50		
	2210	720		153.54	13.93		
	2316	786		153.65	14.04		
11/14	0010	840		154.11	14.50		
	0110	900		154.35	14.74		
	0215	965		154.3	14.69		
	0315	1025		154.6	14.99		
	0411	1081		154.91	15.30		
	0523	1153		155.05	15.44		
	0615	1205		155.2	15.59		
	0715	1265		155.4	15.79		
	0813	1323		155.55	15.94		
	0905	1375		155.73	16.12		
	1025	1455		155.94	16.33		
	1055	1485		156.02	16.41		
	1100	1490		156.00	16.39		[illegible] on Recovery
		1490.25	0.25	156.20	16.59		
		1490.5	.50	155.94	16.33		
		1490.75	.75	155.90	16.29		
	1101	1491	1	155.90	16.29		
		1491.25	1.25	155.77	16.16		
		1491.5	1.50	155.68	16.07		
		1491.75	1.75	155.59	15.98		
	1102	1492	2	155.48	15.87		
		1492.5	2.5	155.35	15.74		
	1103	1493	3	155.33	15.72		
		1493.5	3.5	155.21	15.60		
	1104	1494	4	155.12	15.51		
		1494.5	4.5	155.05	15.44		
	1105	1495	5	154.92	15.31		
	1106	1496	6	154.76	15.15		
		1496.5	6.5	154.63	15.02		
	1107	1497	7	154.55	14.94		
	1108	1498	8	154.22	14.61		
		1498.5	8.5	154.19	14.58		
	1109	1499	9	153.91	14.30		
	1110	1500	10	153.67	14.06		
	1112	1502	12	153.20	13.59		
	1114	1504	14	152.73	13.12		
	1116	1506	16	152.37	12.76		
	1118	1508	18	152.06	12.45		
	1120	1510	20	151.74	12.13		
	1122	1512	22	151.49	11.88		

PROJECT: NAC Peterson | PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A | OBSERVATION WELL: OW-6

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1124	1514	24	151.25	11.64		
	1126	1516	26	151.10	11.49		
	1128	1518	28	150.84	11.23		
	1130	1520	30	150.75	11.14		
	1135	1525	35	150.32	10.71		
	1140	1530	40	150.00	10.39		
	1145	1535	45	149.81	10.20		
	1150	1540	50	149.53	9.92		
	1155	1545	55	149.31	9.70		
	1200	1550	60	149.19	9.58		
	1210	1560	70	148.94	9.33		
	1224	1574	84	148.57	8.96		
	1231	1581	91	148.39	8.78		
	1241	1591	101	148.31	8.70		
	1259	1609	119	148.01	8.40		
	1340	1650	160	147.44	7.83		
	1417	1687	197	147.00	7.39		
	1436	1706	216	146.8	7.19		
	1510	1740	250	146.6	6.99		
	1608	1798	308	146.3	6.69		
	1705	1855	365	146.1	6.49		
	1821	19[illegible]	441	145.7	6.09		
	1925	1995	505	145.35	5.74		
	2008	2038	548	145.10	5.49		
	2105	2095	605	145.0	5.39		
	2204	2154	664	144.9	5.29		
	2326	2236	746	144.8	5.19		
11/15	0003	2273	783	144.5	4.89		
	0212	2402	912	144.2	4.59		
	0412	2522	1032	143.7	4.09		
	0630	2660	1170	143.4	3.79		
	0839	2789	1299	143.4	3.79		
	0903	2813	1323	143.2	3.59		
	0959	2869	1379	143.1	3.49		
	1104	2934	1444	143.1	3.49		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-8

DISTANCE FROM PUMPED WELL: 29.9 ft

ELEVATION OF MEASURING POINT: 5105.3 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0840			152.98			Static
1979	0850			152.98			levels
	0903			152.96			
	0916			152.96			
	0919			152.95			
	0934			152.94			
	0946			152.94			
	0952			152.95			
	1005			152.95			
	1010			152.95			Pump on
		12.5		152.98			
	1034	24		152.94			
	1046	36		152.95			
	1100	50		152.92			
	1111	61		152.89			
	1116	66		152.88			
	1132	82		152.86			
	1137	87		152.85			
	1215	125		152.88			
	1245	155		152.83			
	1314	184		152.82			
	1410	240		152.81			
	1513	303		152.81			
	1610	360		152.82			
	1670	420		152.80			
	1825	495		152.92			
	1925	555		152.85			
	2020	610		152.80			
	2227	737		152.97			
	2324	794		152.8			
11/14	0115	905		152.75			
	0214	964		152.75			
	0310	1020		152.75			
	0410	1080		152.73			
	0520	1150		152.75			
	0615	1205		152.73			
	0705	1255		152.75			
	0810	1320		152.79			
	0905	1375		152.75			
	1025	1455		152.75			
	1100	1490					Pump off
	1139		39	152.73			Recovery
	1200		60	152.74			

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-8

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1219		79	152.72			
	1240		100	152.8			
	1300		120	152.7			
	1344		164	152.95			
	1413		193	152.9			
	1440		220	152.9			
	1509		249	152.9			
	1610		310	152.7			
	1716		376	152.7			
	1835		455	152.8			
	1928		508	152.9			
	2009		549	152.70			
	2108		608	152.8			
	2205		665	152.7			
	2321		741	152.8			
11/15	0004		784	152.7			
	0205		905	152.8			
	0406		1026	152.8			
	0624		1164	152.8			
	0829		1289	152.7			
	0906		1326	152.7			
	0955		1375	152.7			
	1102		1442	152.7			
11/16	0950		2810	152.7			

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: PW-1

DISTANCE FROM PUMPED WELL: 25.9 ft

ELEVATION OF MEASURING POINT: 5105.4 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/13	0833			145.5			Static
1979	0843			145.83			levels
	0853			145.48			
	0903			145.62			
	0913			145.50			
	0921			145.56			
	0931			145.53			
	0940			145.58			
	0950			145.54			
	1010			145.54			Pump on
	1034	24		145.54	0.00		
	1110	60		145.89	0.35		
	1120	70		145.86	0.32		
	1130	80		146.01	0.47		
	1140	90		146.04	0.50		
	1150	100		146.04	0.50		
	1200	110		146.04	0.50		
	1210	120		146.06	0.52		
	1240	150		146.12	0.58		
	1310	180		146.11	0.57		
	1340	210		146.17	0.63		
	1410	240		146.18	0.64		
	1510	300		146.25	0.71		
	1610	360		146.34	0.80		
	1710	420		146.40	0.86		
	1830	500		146.56	1.02		
	1913	543		146.61	1.07		
	2019	609		146.63	1.09		
	2213	723		146.80	1.26		
	2325	795		146.92	1.38		
11/14	0012	842		146.95	1.41		
	0115	905		147.03	1.49		
	0210	960		147.08	1.54		
	0312	1022		147.1	1.56		
	0410	1080		147.2	1.66		
	0522	1152		147.3	1.76		
	0610	1200		147.4	1.86		
	0713	1263		147.4	1.86		
	0808	1318		147.4	1.86		
	0911	1381		147.51	1.97		
	1027	1457		147.58	2.04		
	1055	1485		147.62	2.08		
	1100	1490					Pump off

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: PW-1

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/14	1134	1524	34	147.5	1.96		Recovery
	1206	1556	66	147.51	1.97		
	1250	1600	110	147.4	1.86		
	1345	1655	165	147.5	1.96		
	1415	1685	195	147.5	1.96		
	1435	1705	215	147.4	1.86		
	1510	1740	250	147.4	1.86		
	1605	1795	305	147.4	1.86		
	1714	1864	374	146.7	1.16		
	1837	1947	457	146.75	1.21		
	1927	1997	507	146.7	1.16		
	2010	2040	550	146.7	1.16		
	2105	2095	605	146.7	1.16		
	2201	2151	661	146.7	1.16		
	2320	2230	740	146.7	1.16		
11/15	0003	2273	783	146.7	1.16		
	0206	2396	906	146.6	1.06		
	0411	2521	1031	146.7	1.16		
	0625	2655	1165	146.8	1.26		
	0831	2781	1291	145.5	-0.04		
	0901	2811	1321	145.5	-0.04		
	1000	2870	1380	145.5	-0.04		
	1100	2430	1440	145.5	-0.04		
11/16	1003	4313	2823	147.4	1.86		

PUMPING TEST

GRAPHICAL ANALYSES

50-HOUR AQUIFER TEST
11/13-15/79
SUMMARY OF DATA ANALYSES

Semi-Logarithmic Data Plots

$T = 264\ Q/\Delta s$, $S = Tt_o/4790\ r^2$, $r_i = r\sqrt{t_i/t_p}$

T = transmissivity, gpd/ft

Q = pumping rate, gpm

Δs = drawdown per logarithmic cycle of time, ft

S = storativity

t_o = intersection of time-drawdown line with zero drawdown axis, min

r = distance from observation well to pumped well, ft

r_i = distance from observation well to hypothetical image well (barrier boundary analysis), ft

t_i = time at which deviation of drawdown curve due to barrier boundary equals drawdown observed at time t_p before boundary deviation is observed

Full-Logarithmic Data Plots

$T = 114.6\ QW(u)/s$, $S = Tut/2693\ r^2$, $r_i = r\sqrt{t_i/t_p}$

Match point coordinates: (u, W(u)) type curve
(t,s) data curve

Other parameters defined previously

Semi-Logarithmic Data Plots

Observation Well	r	Analysis[1]	Δs	t_o	T	S[2]	t_i	t_p	r
OW-1	99.1	TD	4.2	6.2	358	4.7(-5)	1900	28.5	809
		RR	4.2		358				
		TR	4.15	13.8	363	10.6(-5)	1500	61	491
OW-2	100.5	TD	4.45	7.5	338	5.2(-5)	1300	18.5	842
		RR	4.1		367				
		TR	4.1	11.5	367	8.7(-5)	2500	76	576
OW-3	99.8	TD	4.4	5.5	342	3.9(-5)	1500	14	1033
		RR	4.6		327				
		TR	4.8	11.8	314	7.8(-5)	1600	37.5	652
OW-5	25.0	TD	4.05	0.21	372	2.6(-5)	1600	.61	1280
		RR	4.5		334				
		TR	4.7	1.4	320	15.0(-5)	10000	21	546
OW-6	24.9	TD	4.1	0.36	367	4.4(-5)	2000	1.2	1017
		RR	4.5		334				
		TR	5.2	3.0	289	2.9(-5)	2000	7.8	399

(1) TD-time drawdown, RR-residual recovery, TR-time recovery

(2) 4.7(-5) = 4.7×10^{-5}

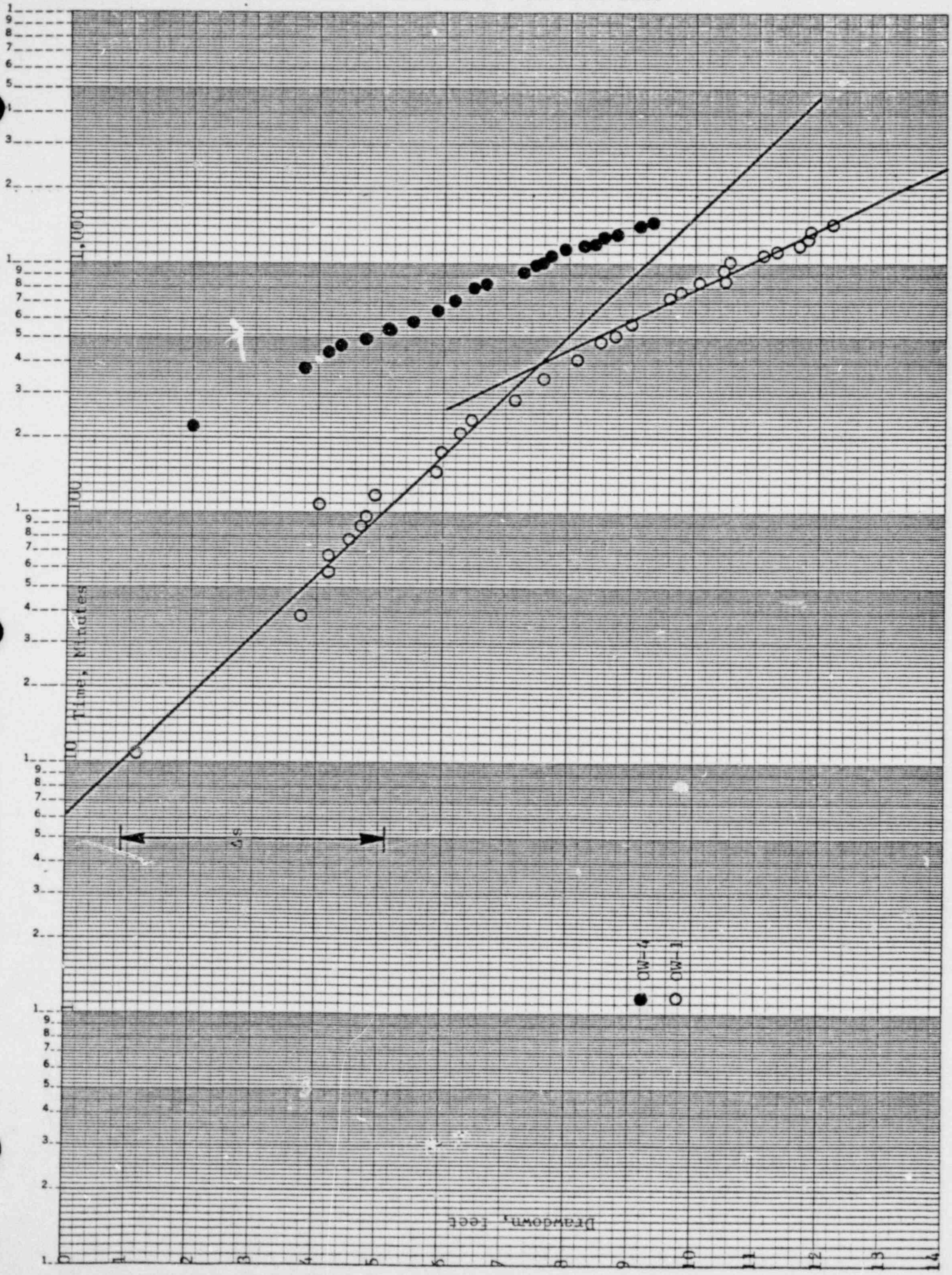
Full-Logarithmic data plots

Observation Well	r	Analysis[1]	s	t	W	u	T	S[2]	t_i	t_p	r_i
OW-1	99.1	TD	2.3	745	1	.01	284	8.0(-5)	3950	66	767
		TR	2.0	1000	1	.01	327	12.3(-5)	4600	210	464
OW-2	100.5	TD	2.4	750	1	.01	272	7.5(-5)	5000	66	875
		TR	2.3	1230	1	.01	284	12.8(-5)	6000	135	670
OW-3	99.8	TD	2.2	485	1	.01	297	5.4(-5)	2000	15.2	1145
		TR	2.3	940	1	.01	284	10.0(-5)	8000	220	602
OW-4	231.4	TR	2.7	1170	1	.1	242	19.6(-5)	280	143	324
OW-5	25.0	TD	2.1	340	1	.001	311	6.3(-5)	9600	6.2	984
		TR	2.2	117	1	.01	297	20.6(-5)	10000	31	449
OW-6	24.9	TD	2.0	38.5	1	.01	327	7.5(-5)	10000	7.8	892
		TR	2.4	227	1	.01	272	37.0(-5)	3600	18	352

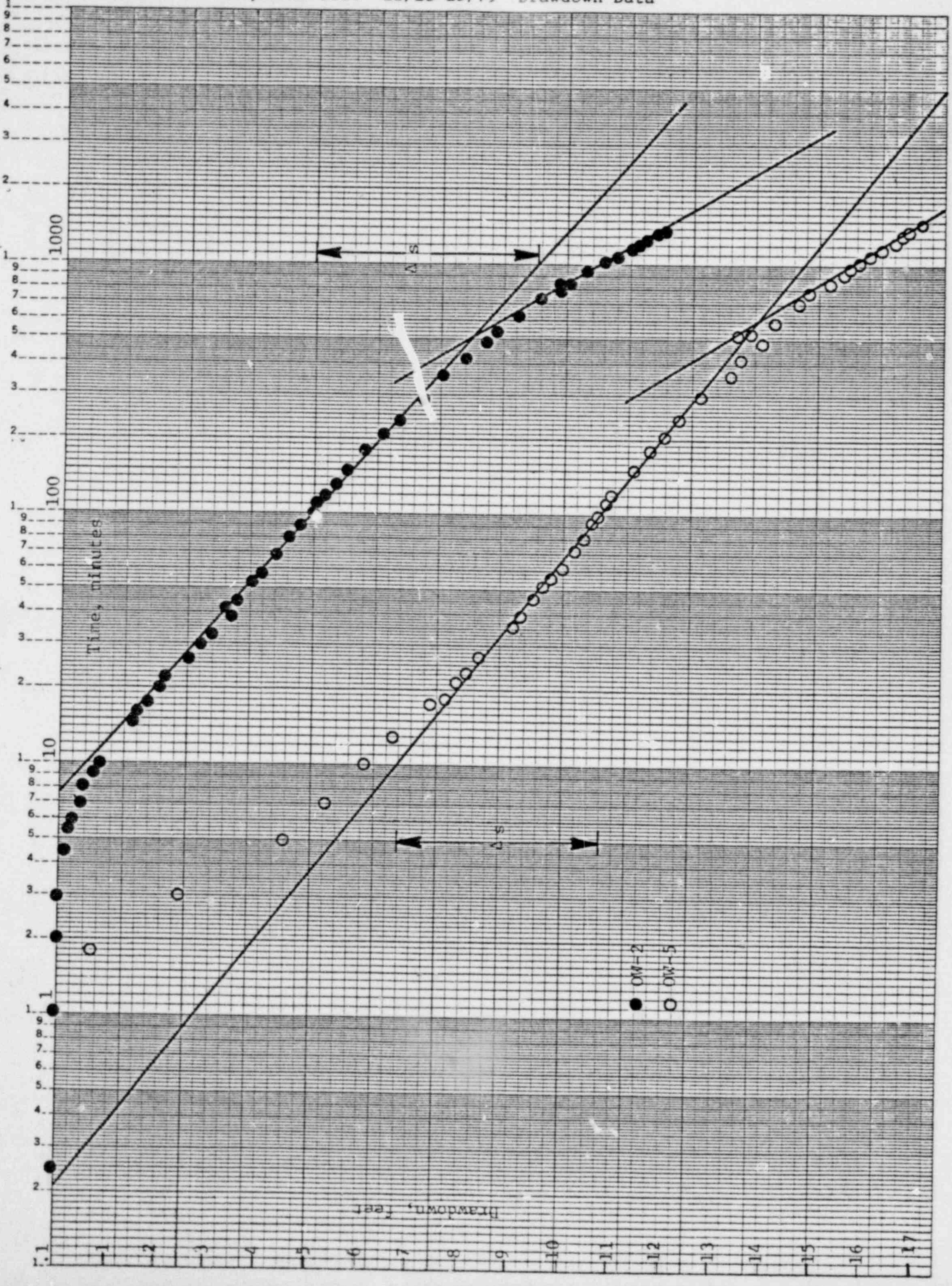
(1) TD-time drawdown, RR-residual recovery, TR-time recovery

(2) $4.7(-5) = 4.7 \times 10^{-5}$

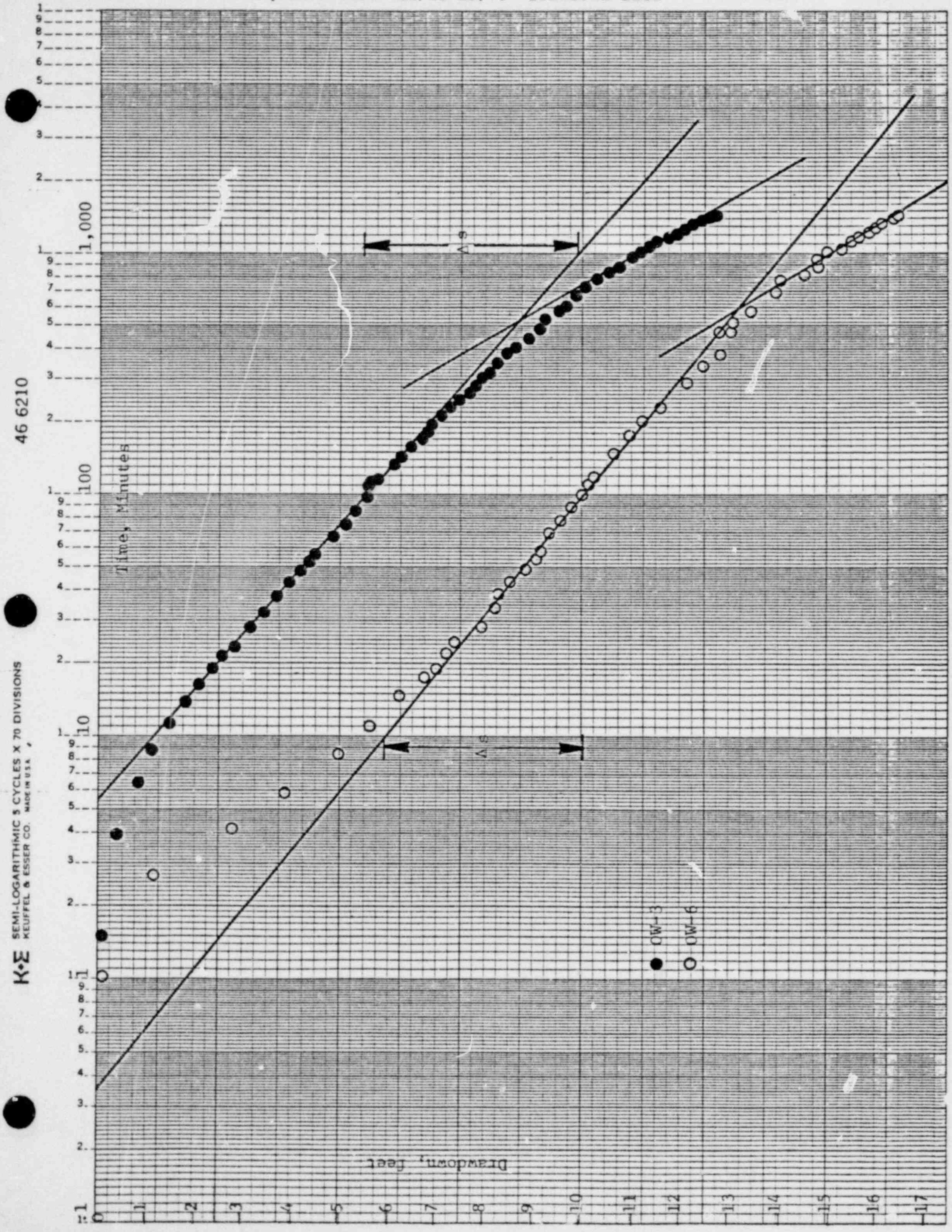
Aquifer Test 11/13-15/79 Drawdown Data

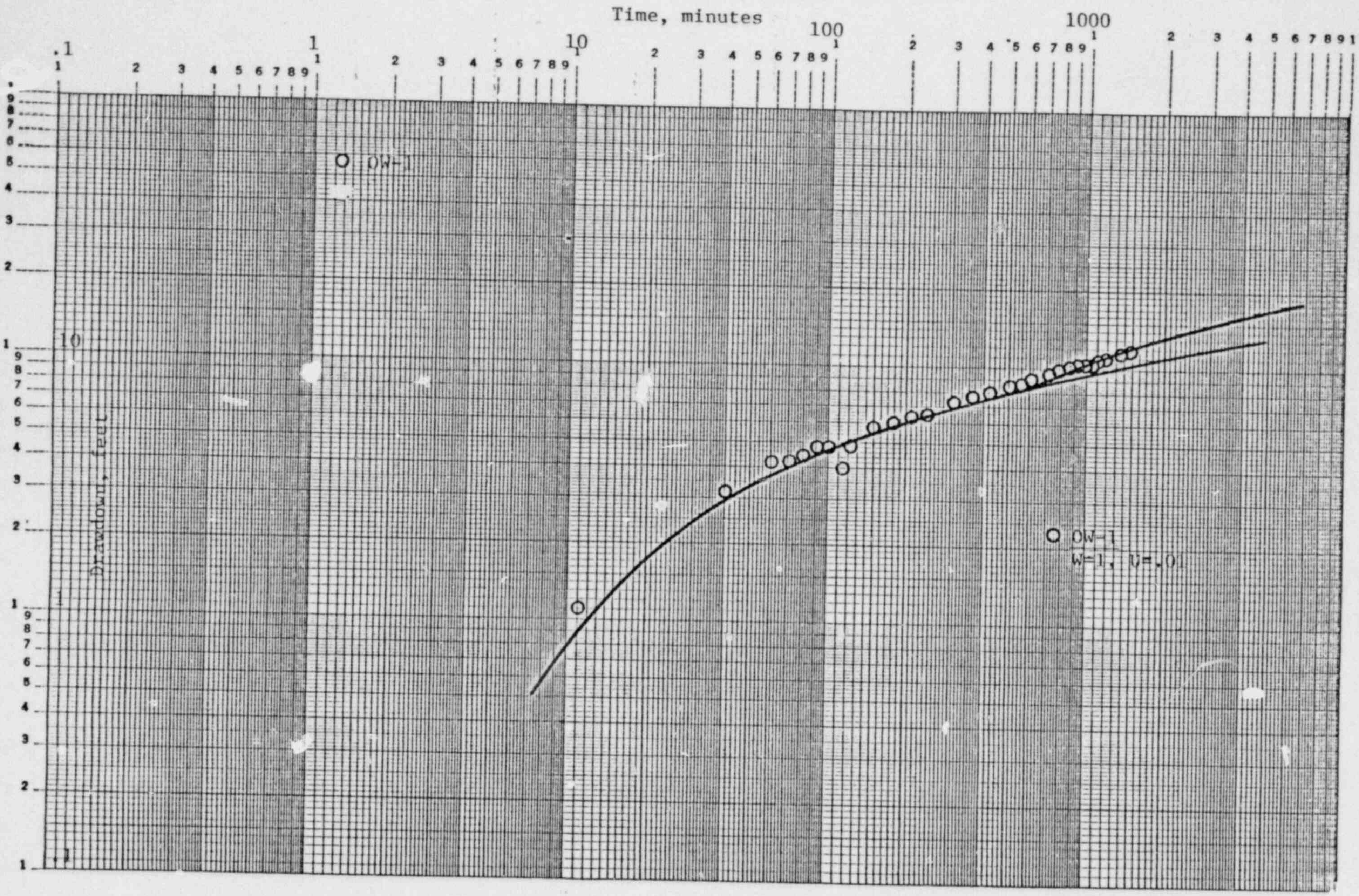


Aquifer Test 11/13-15/79 Drawdown Data



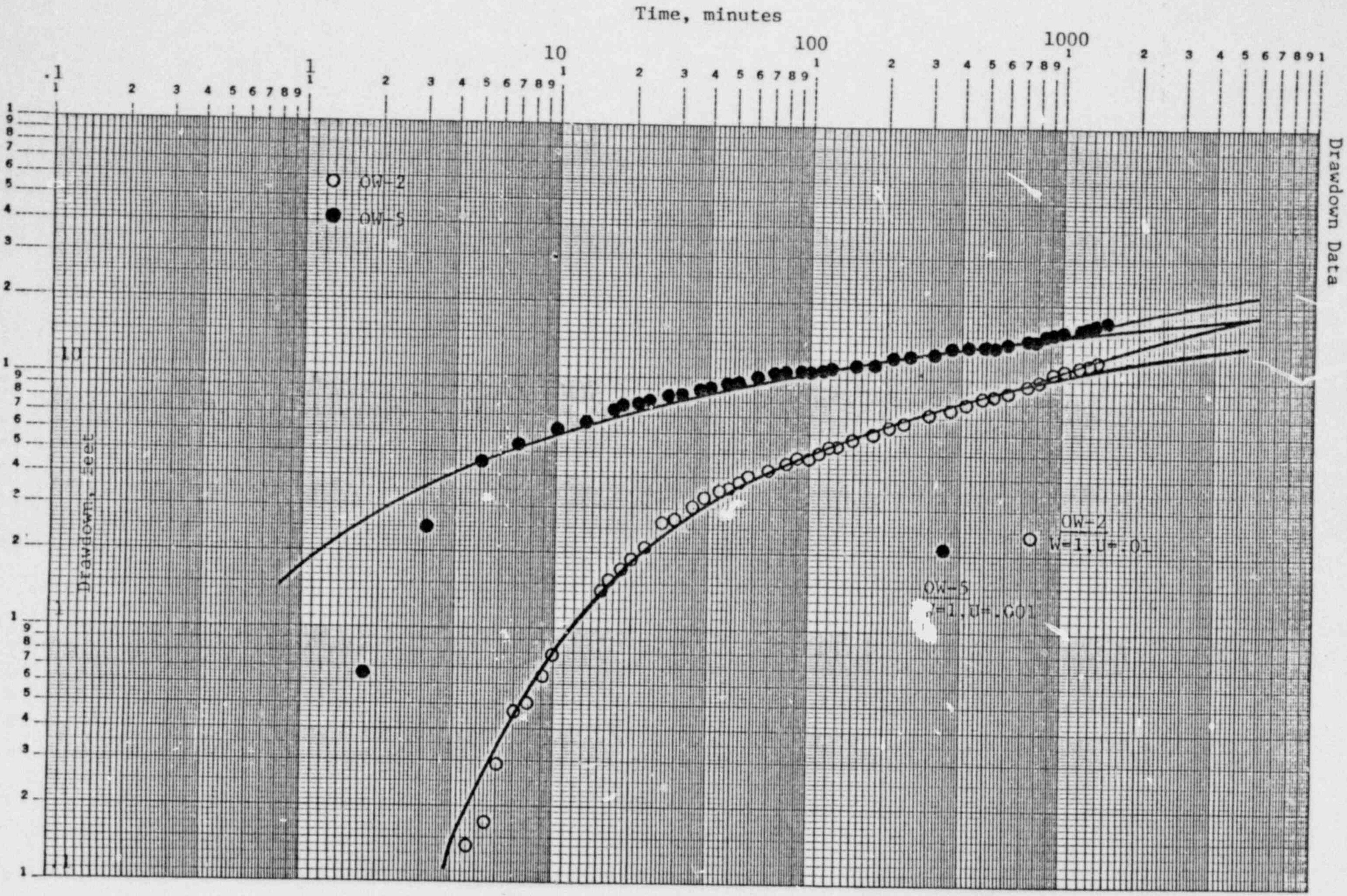
Aquifer Test 11/13-15/79 Drawdown Data





Drawdown Data

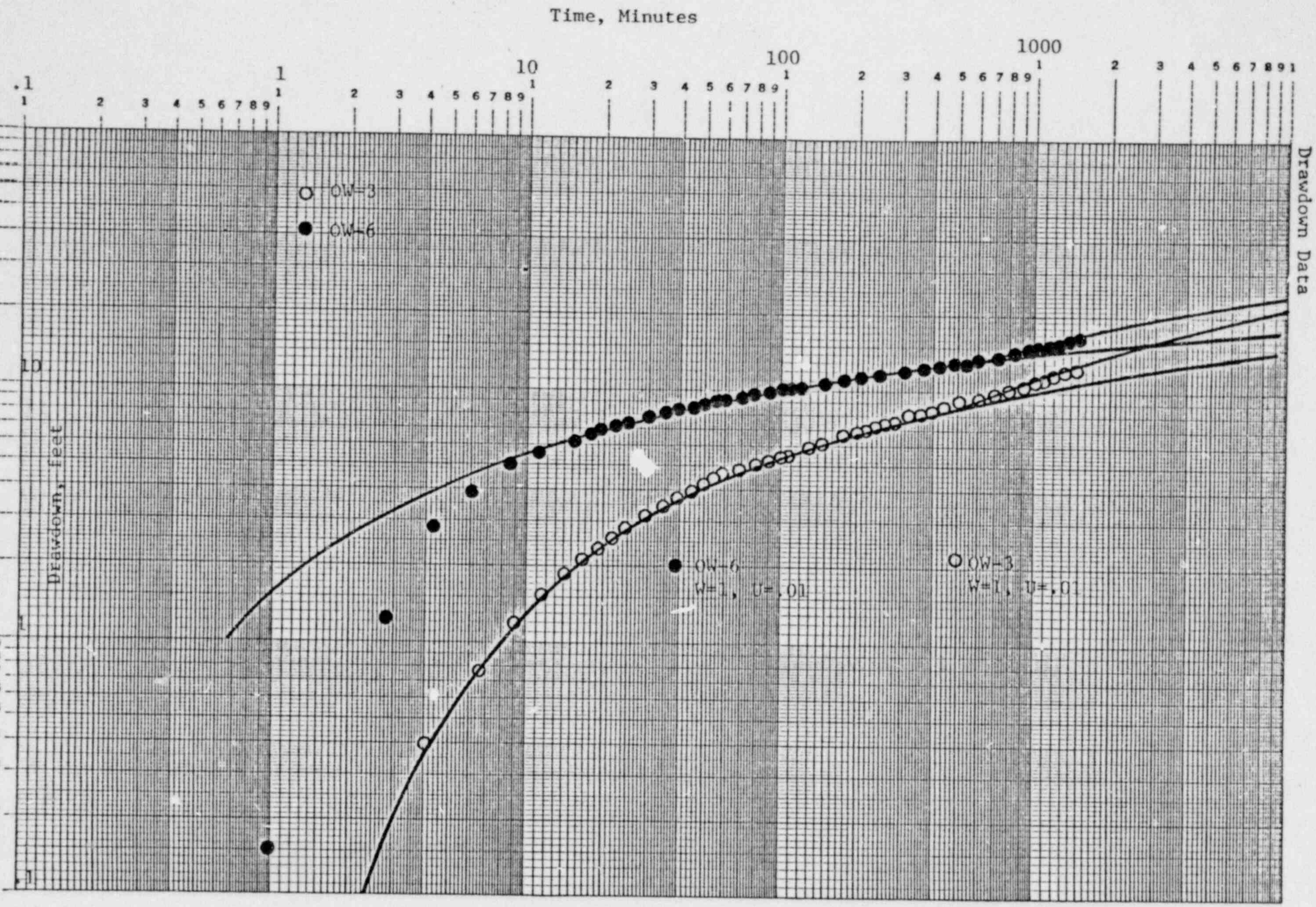
Aquifer Test 11/13-15/79



Aquifer Test 11/13-15/79

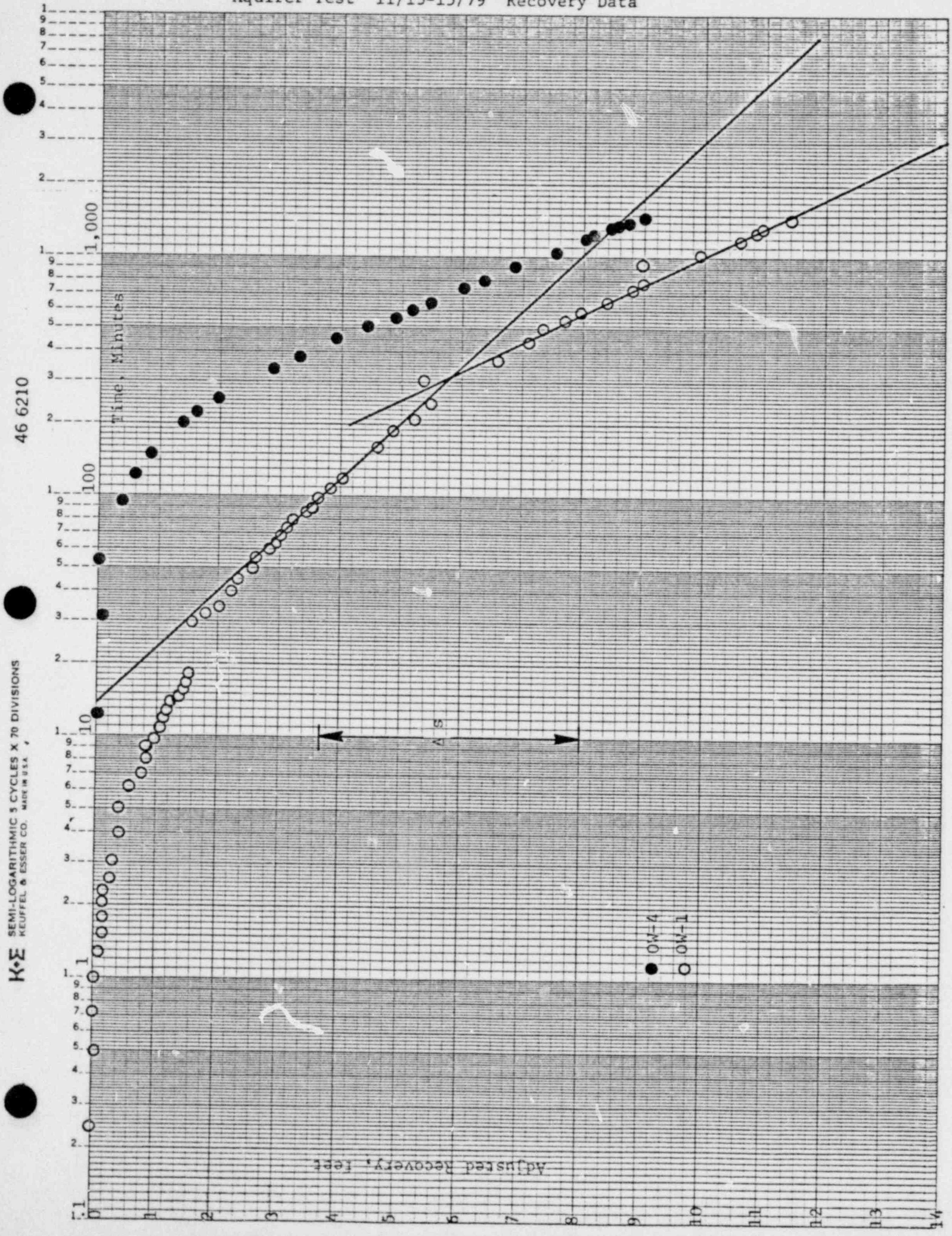
K•E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7522

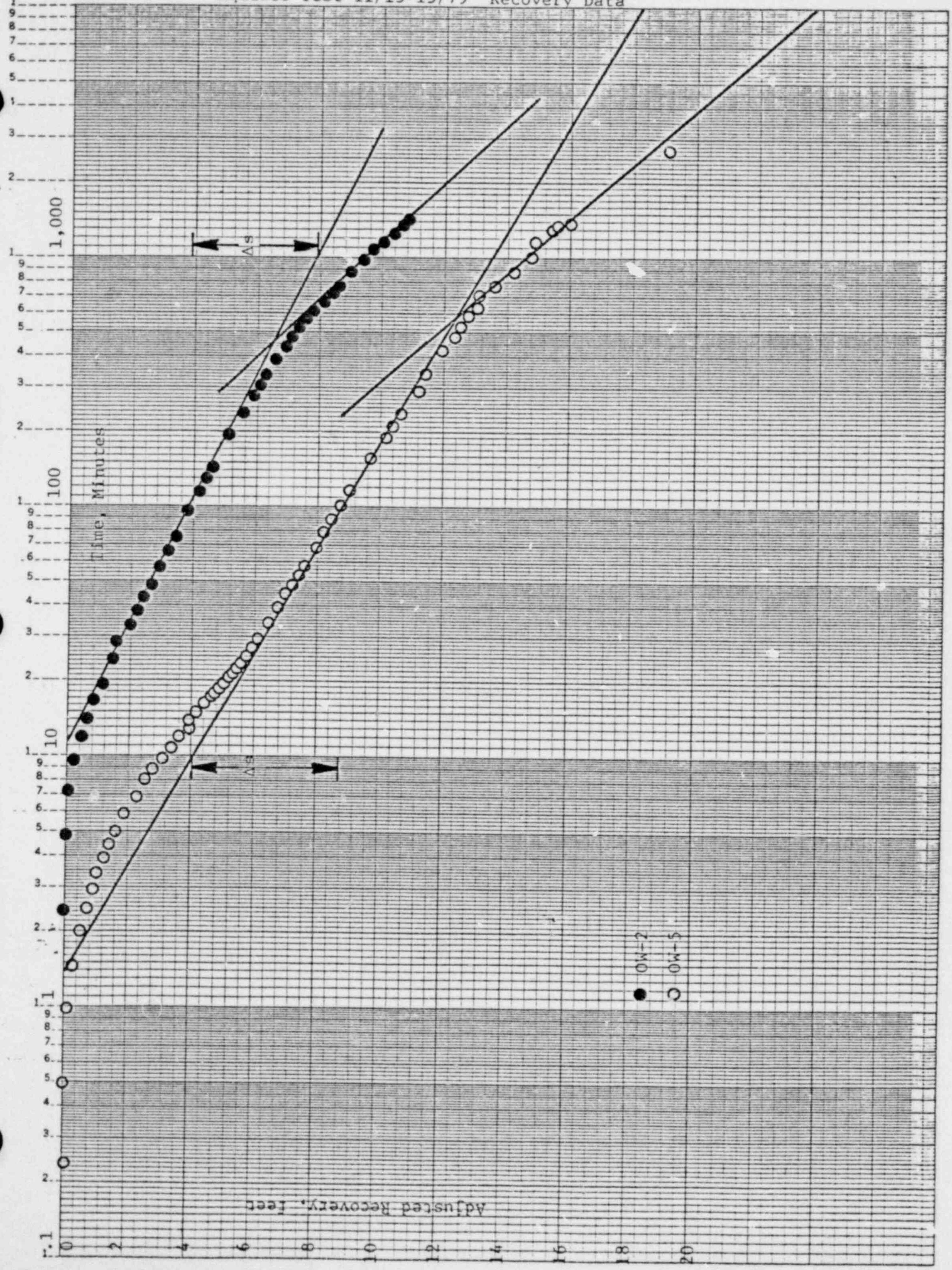


Aquifer Test 11/13-15/79

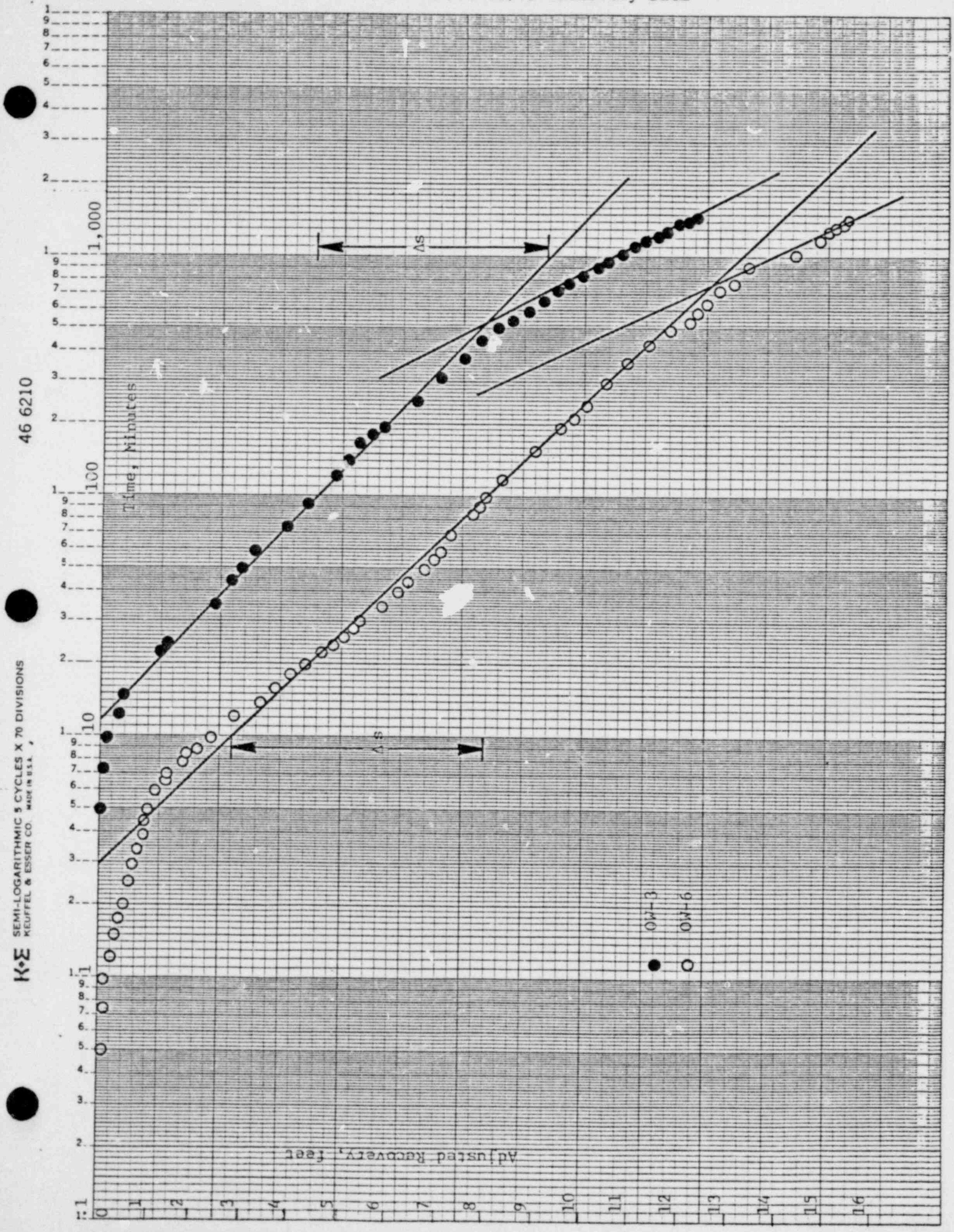
Aquifer Test 11/13-15/79 Recovery Data



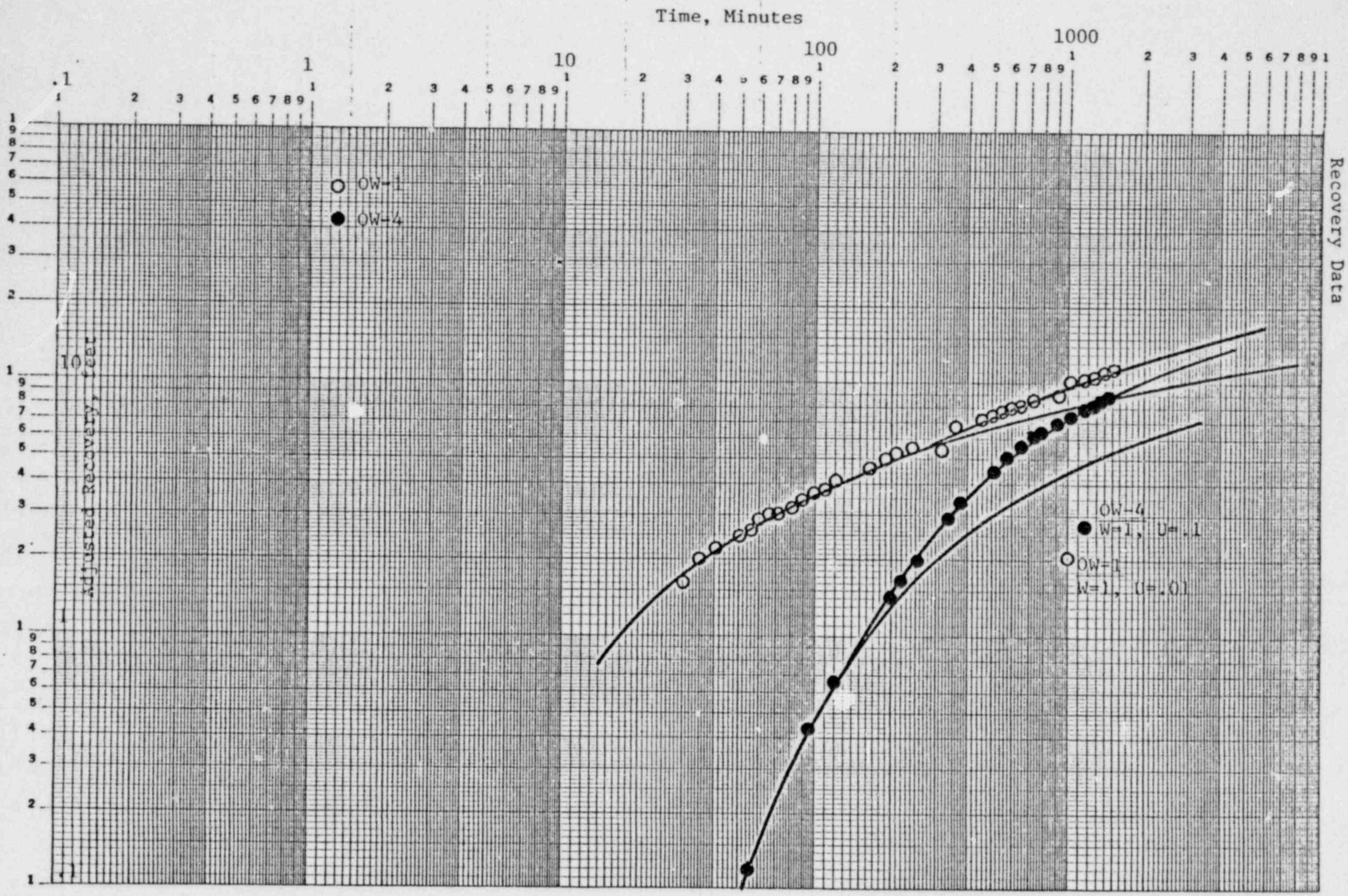
Aquifer Test 11/13-15/79 Recovery Data



Aquifer Test 11/13-15/79 Recovery Data



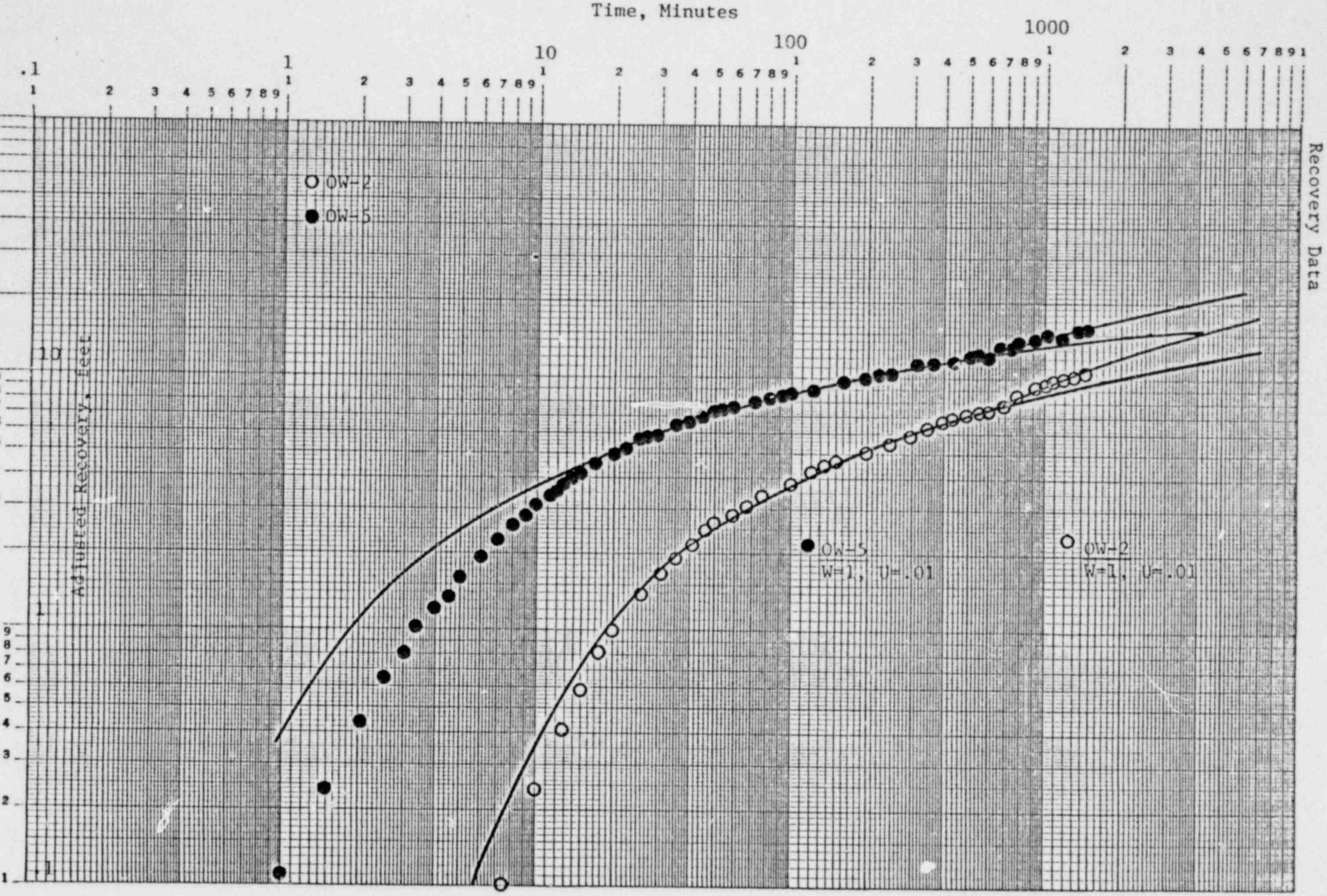
K+E LOGARITHMIC 3 x 5 CYCLES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 7522



Aquifer Test 11/13-15/79

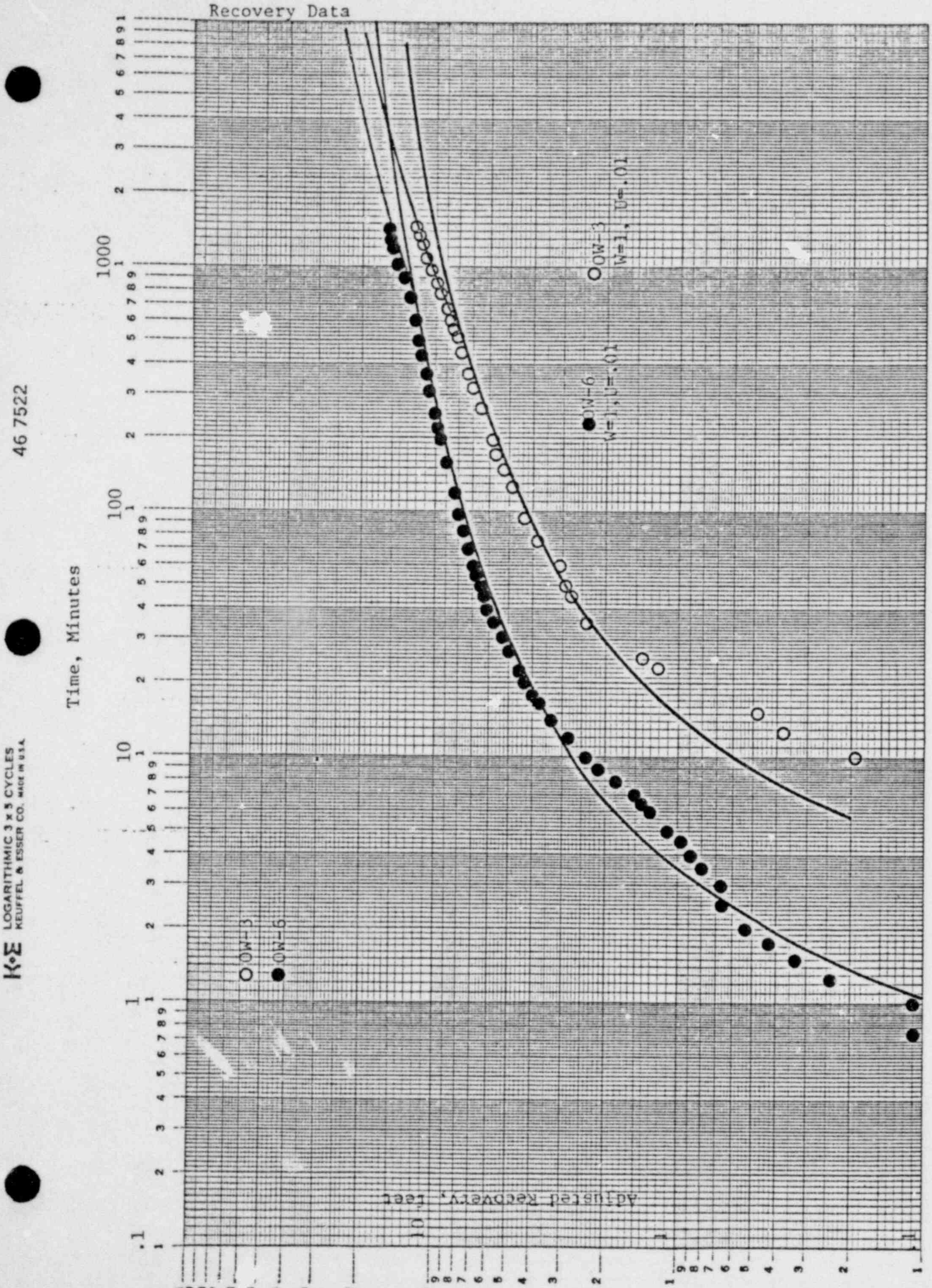
K·E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7522

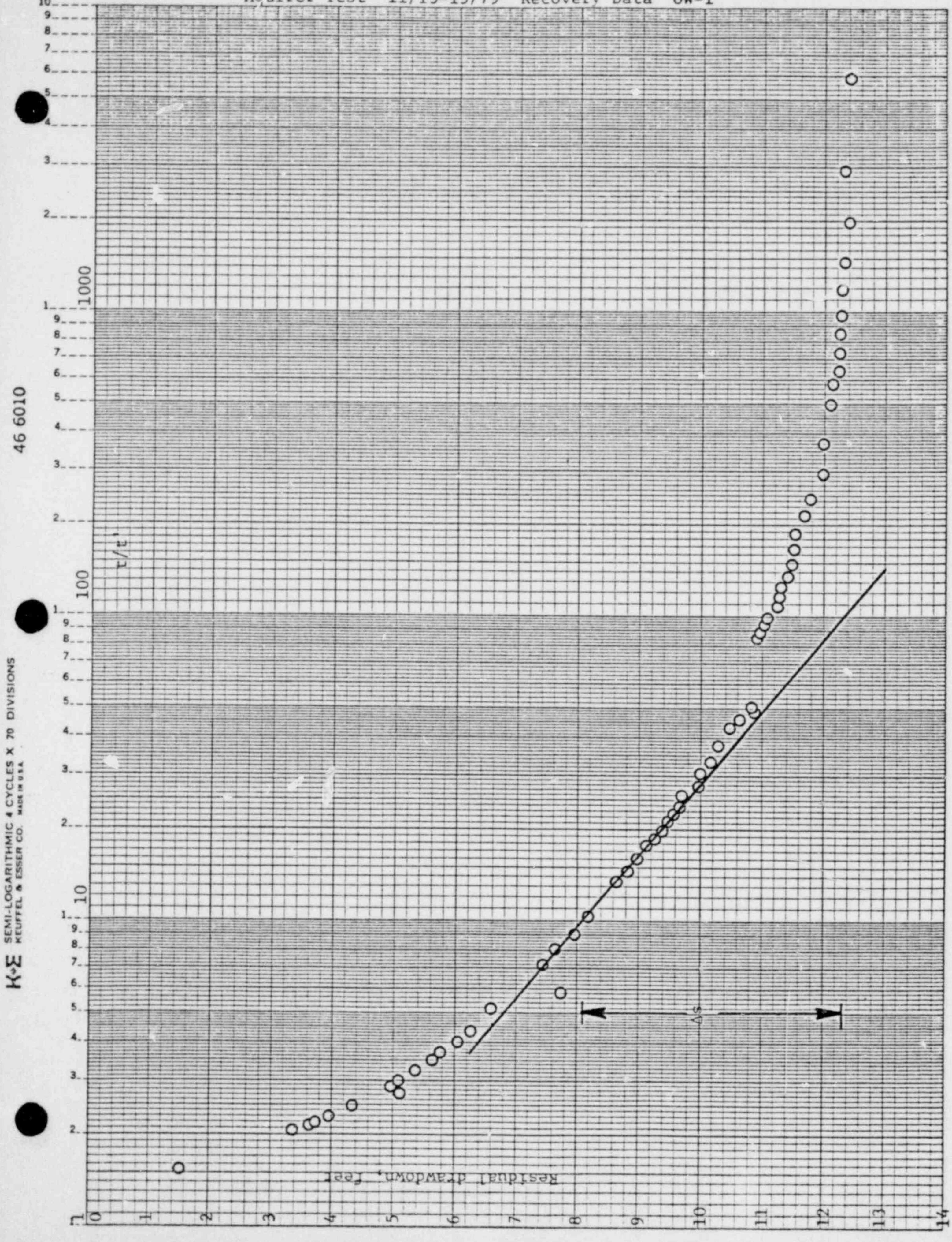


Aquifer Test 11/13-15/79

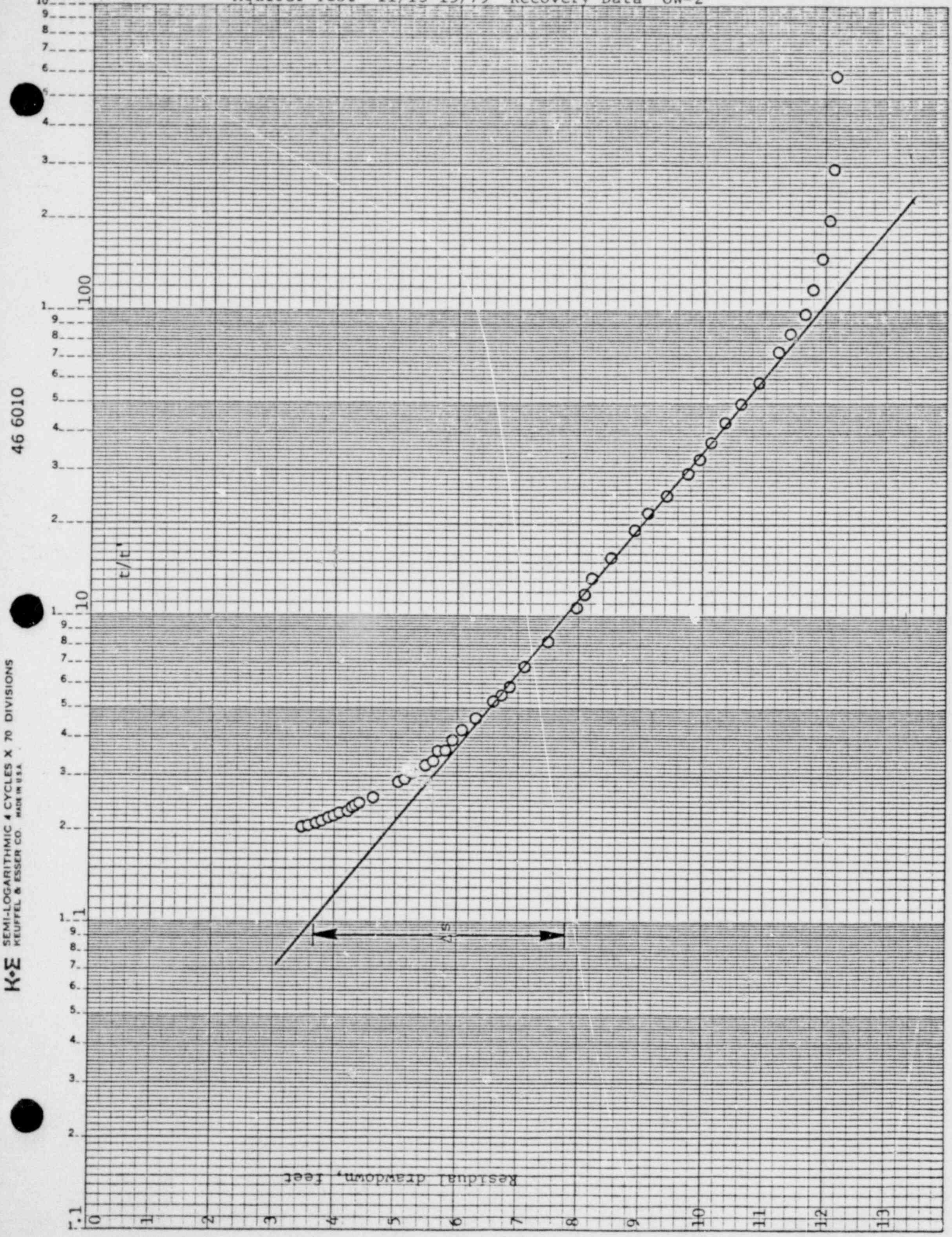
Aquifer Test 11/13-15/79



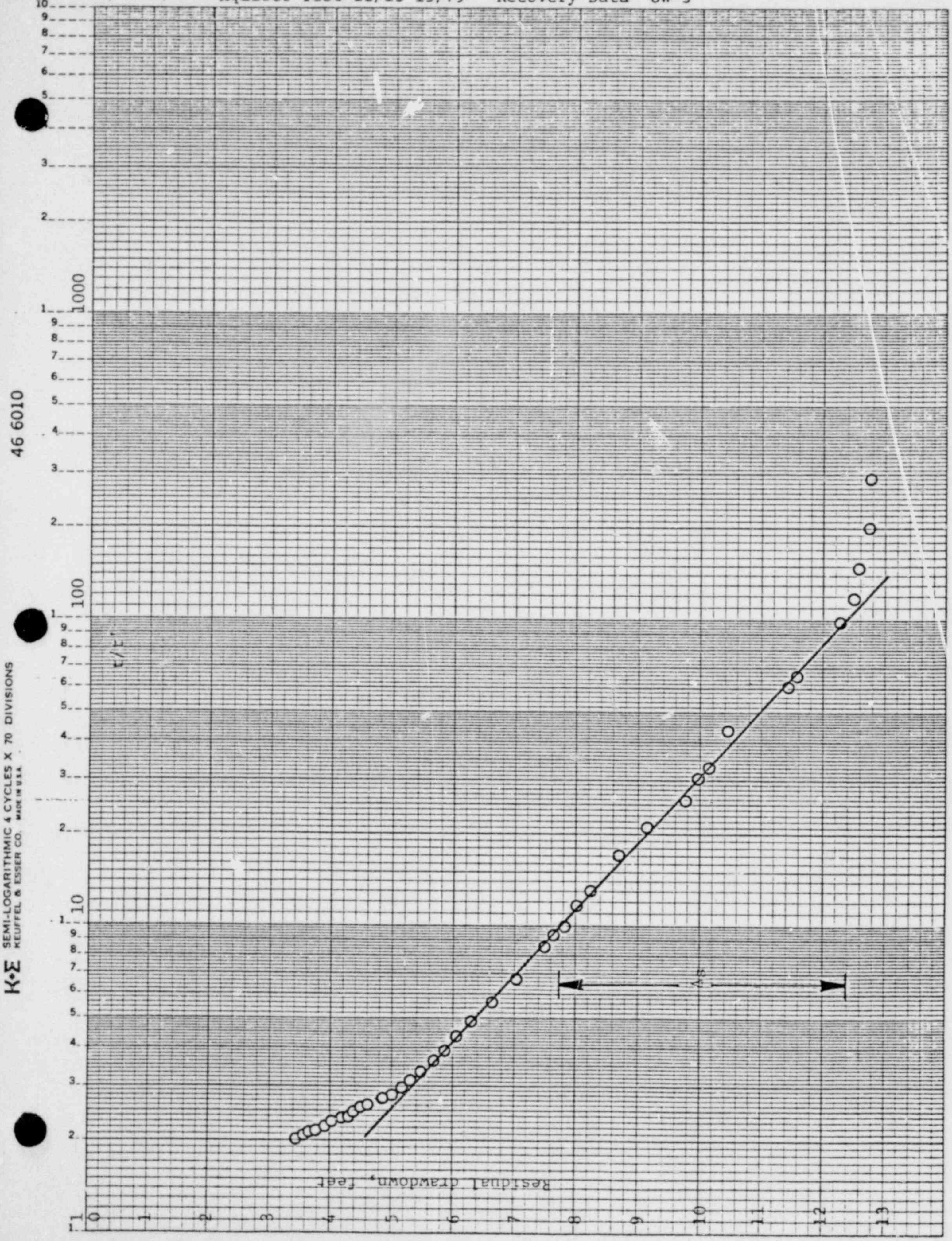
Aquifer Test 11/13-15/79 Recovery Data OW-1



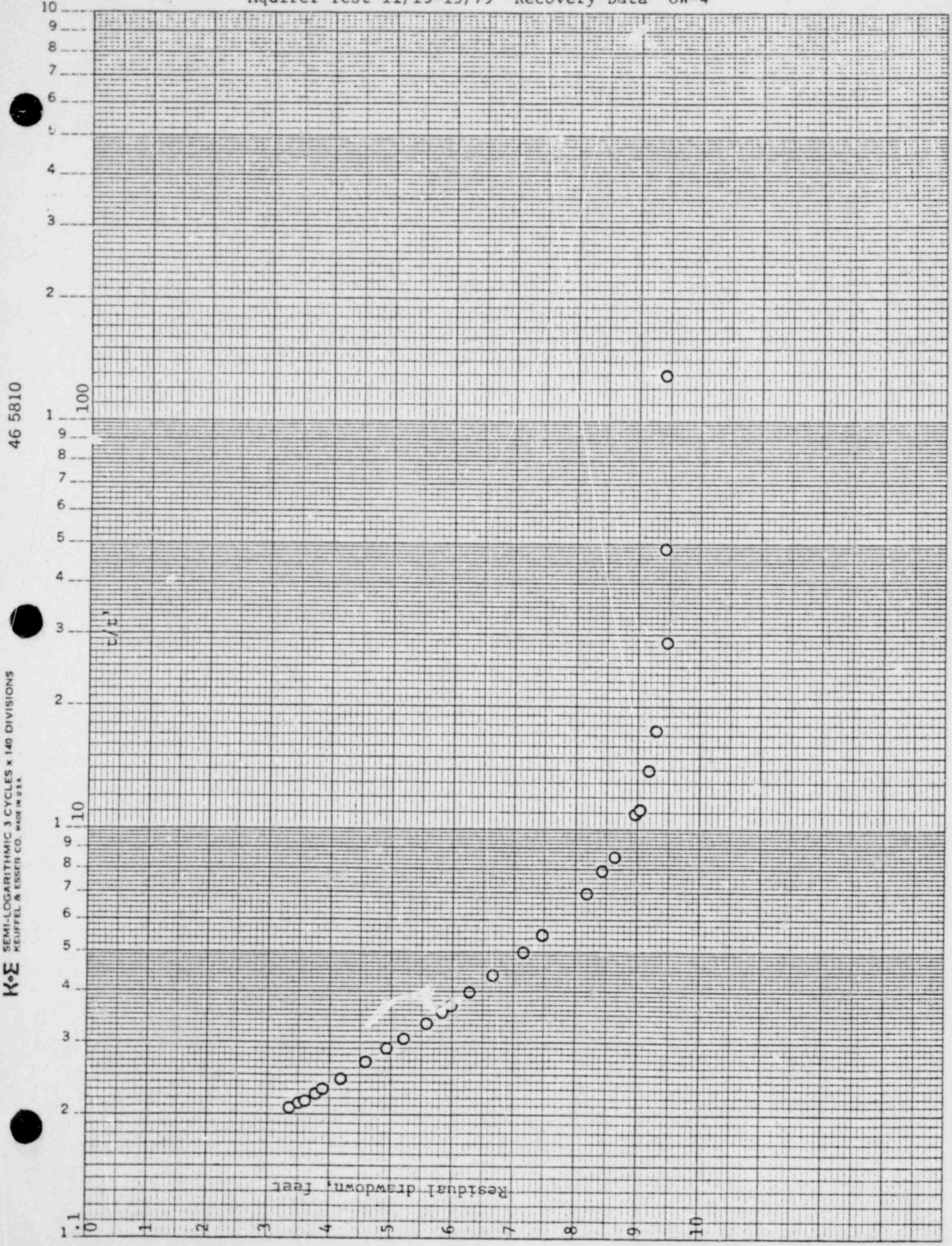
Aquifer Test 11/13-15/79 Recovery Data OW-2



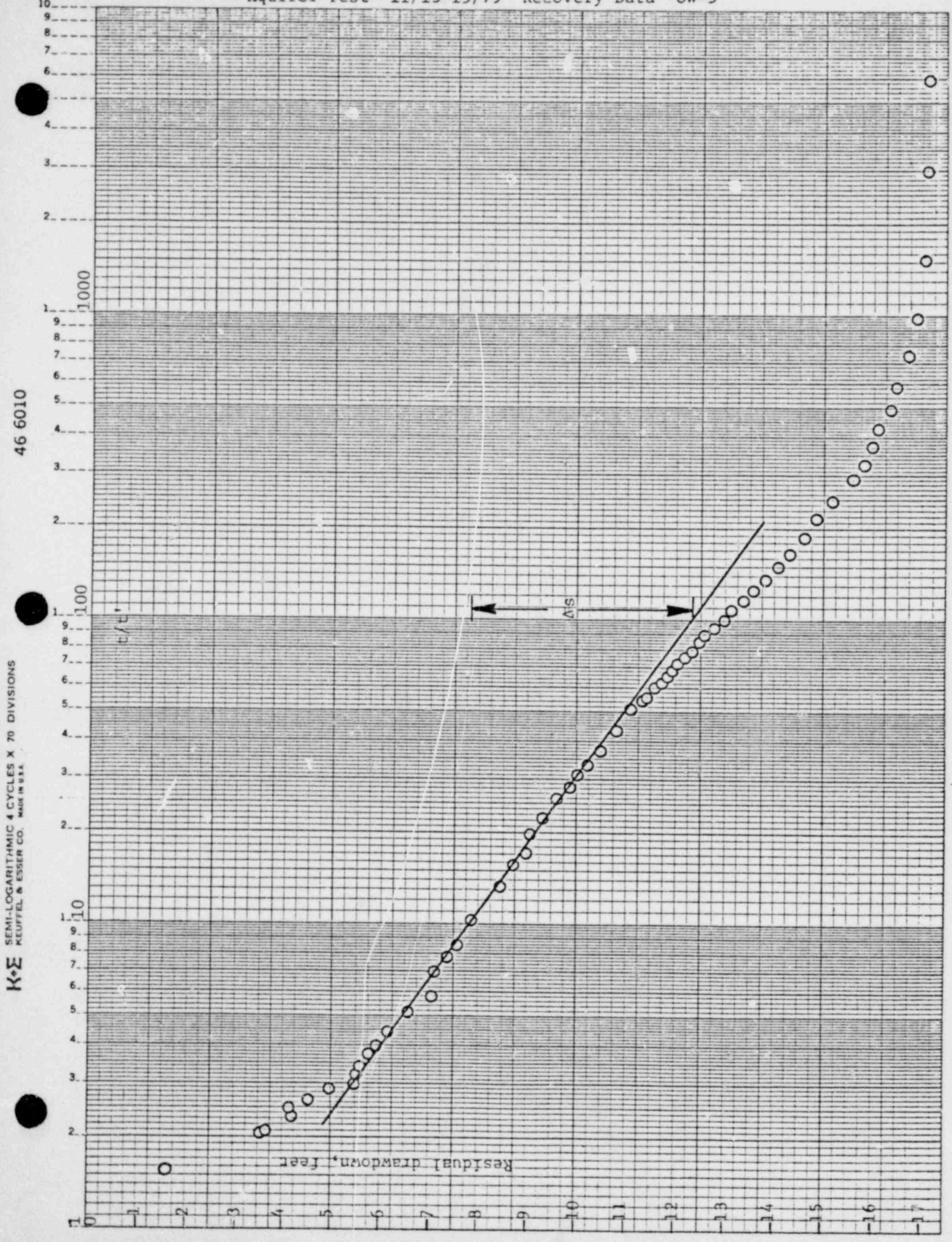
Aquifer Test 11/13-15/79 Recovery Data OW-3



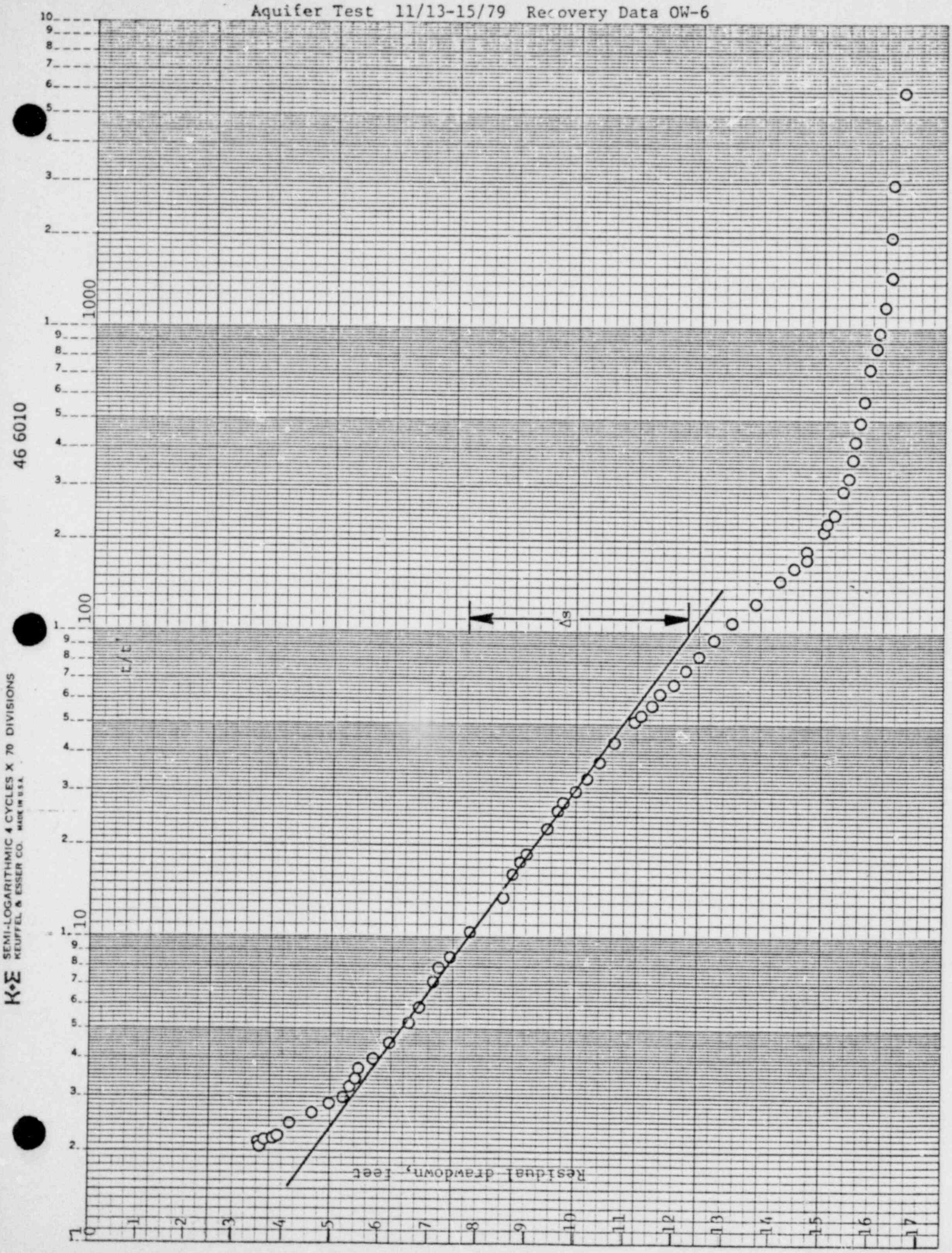
Aquifer Test 11/13-15/79 Recovery Data OW-4



Aquifer Test 11/13-15/79 Recovery Data OW-5

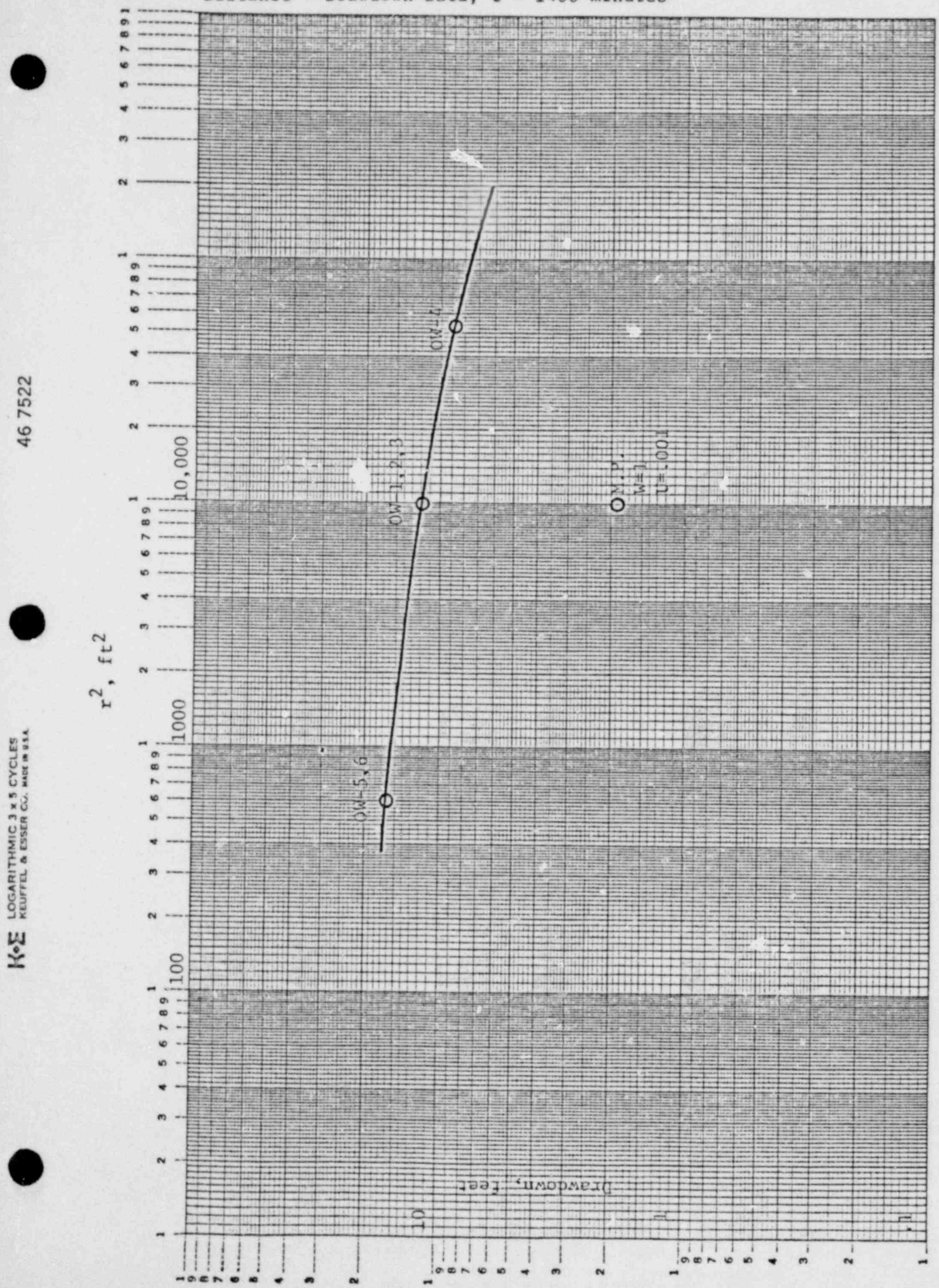


Aquifer Test 11/13-15/79 Recovery Data OW-6



Aquifer Test 11/13-15/79

Distance - Drawdown Data, t = 1400 minutes



APPENDIX D

WELL PW-1A STEP-DRAWDOWN TEST

11/16/79

PUMPING TEST FIELD DATA

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: N/A

DISTANCE FROM PUMPED WELL: N/A

ELEVATION OF MEASURING POINT: 5105.3 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/16	0956			142.7			
1979	1058			142.6			
	1100					3.2	Pump on
	1103	3		157.2	14.6		
	1105	5		156.9	14.3		
	1106					2.0	
	1108	8		156.9	14.3		
	1109					1.97	
	1113	13		156.8	14.2		
	1115					2.0	
	1116	16		156.85	14.25		
	1124					2.0	
	1125	25		157.0	14.4		
	1129					2.0	
	1130	30		157.15	14.55		
	1139	39		157.3	14.7		
	1140					2.0	
	1141	41		157.4	14.8		
	1144	44		157.4	14.8		
	1149	49		157.5	14.9		
	1151					2.0	
	1154	54		157.58	14.98		
	1155					2.0	
	1156	56		157.6	15.0		
	1159	59		157.65	15.05		
	1200						Step
	1203					3.9	
	1205	65		163.2	20.6		
	1206	66		164.1	21.5		
		66.5		165.0	22.4		
	1207	67		165.6	23.0		
		67.5		165.8	23.2		
	1208	68		166.0	23.4		
		68.5		166.2	23.6		
	1209	69		166.4	23.8		
		69.5		166.8	24.2		
	1210	70		167.0	24.4		
		70.5		167.3	24.7		
	1212					3.8	
	1216	76		169.1	26.5		
	1217	77		169.2	26.6		
		77.5		169.4	26.8		
	1218	78		169.5	26.9		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: N/A

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/16	1220					3.75	
	1221					3.75	
		81.5		170.0	27.4		
	1222	82		170.1	27.5		
	1225	85		170.4	27.8		
	1226					3.75	
	1230	90		170.65	28.05		
	1231					3.75	
	1235	95		170.9	28.3		
	1237					3.75	
	1242	102		171.1	28.5		
	1244					3.75	
		104.5		171.2	28.6		
		106.5		171.25	28.65		
	1248					3.75	
		108.5		171.3	28.7		
	1250	110		171.33	28.73		
	1255	115		171.4	28.8		
	1259					3.75	
		119.5		171.5	28.9		
	1300						Step
	1302					5.6	
		122.5		175.8	33.2		
	1303	123		176.6	34.0		
		123.5		177.0	34.4		
	1304	124		177.6	35.0		
	1305	125		178.1	35.5		
		125.5		179.3	36.7		
	1306	126		179.7	37.1		
		126.5		180.3	37.7		
	1307	127		180.5	37.9		
		127.5		180.85	38.25		
		127.8		181.1	38.5		
	1308	128		181.6	39.0		
		128.5		181.9	39.3		
	1309	129		182.2	39.6		
		129.5		182.5	39.9		
	1310	130		182.75	40.15		
	1312					5.6	
		132.5		184.2	41.6		
	1313	133		184.4	41.8		
	1319					5.5	
	1320	140		185.85	43.25		
	1324	144		186.[illegible]	44.0		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: N/A

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/16	1326					5.6	
	1328	148		187.2	44.6		
	1333	153		187.5	44.9		
	1342	162		188.0	45.4		
	1344					5.6	
	1346	166		188.3	45.7		
	1351	171		188.6	46.0		
	1353					5.6	
	1354	174		188.6	46.0		
	1400	180		188.9	46.3	5.55	Step
	1402					10.5	
	1404	184		198.3	55.7		
	1405	185		198.5	55.9		
		185.5		198.5	55.9		
	1406	186		198.6	56.0		
		186.5		198.6	56.0		
	1407	187		198.6	56.0		
	1408	188		198.65	56.05		
		188.5		198.7	56.1		
	1409	189		198.75	56.15		
		189.5		198.75	56.15		
	1410	190		198.75	56.15		
	1412	192		198.5	55.9	6.8	Rate decrease
	1413	193		198.5	55.9	6.7	
	1417	197		198.5	55.9	6.5	
	1420	200					Shut down

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-5

DISTANCE FROM PUMPED WELL: 25.0 ft

ELEVATION OF MEASURING POINT: 5105.2 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/16	1100			140.9			Pump on
1979	1101	1		141.1	.2		
	1102	2		141.3	.4		
	1103	3		141.4	.5		
	1104	4		141.6	.7		
	1105	5		141.8	.9		
	1106	6		141.9	1.0		
	1107	7		142.0	1.1		
	1108	8		142.2	1.3		
	1109	9		142.3	1.4		
	1110	10		142.4	1.5		
	1115	15		142.8	1.9		
	1120	20		142.8	1.9		
	1125	25		142.9	2.0		
	1130	30		143.1	2.2		
	1135	35		143.2	2.3		
	1140	40		143.3	2.4		
	1145	45		143.4	2.5		
	1150	50		143.5	2.6		
	1155	55		143.6	2.7		
	1200	60		143.6	2.7		Step
	1201	61		143.6	2.7		
	1202	62		143.6	2.7		
	1203	63		143.6	2.7		
	1204	64		143.6	2.7		
	1205	65		143.8	2.9		
	1206	66		143.9	3.0		
	1207	67		144.1	3.2		
	1208	68		144.2	3.3		
	1209	69		144.3	3.4		
	1210	70		144.5	3.6		
	1215	75		144.9	4.0		
	1220	80		145.3	4.4		
	1225	85		145.6	4.7		
	1230	90		145.8	4.9		
	1235	95		145.9	5.0		
	1240	100		146.0	5.1		
	1245	105		146.2	5.3		
	1250	110		146.4	5.5		
	1255	115		146.4	5.5		
	1300	120		146.5	5.6		Step
	1301	121		146.6	5.7		
	1302	122		146.6	5.7		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-5

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
11/16	1303	123		146.8	5.9		
	1304	124		146.8	5.9		
	1305	125		146.9	6.0		
	1306	126		147.0	6.1		
	1307	127		147.2	6.3		
	1308	128		147.4	6.5		
	1309	129		147.5	6.6		
	1310	130		147.6	6.7		
	1315	135		148.0	7.1		
	1320	140		148.4	7.5		
	1325	145		148.8	7.9		
	1330	150		149.1	8.2		
	1335	155		149.3	8.4		
	1340	160		149.5	8.6		
	1345	165		149.6	8.7		
	1350	170		149.7	8.8		
	1355	175		149.9	9.0		
	1400	180		150.0	9.1		Step
	1401	181		150.0	9.1		
	1402	182		150.0	9.1		
	1403	183		150.1	9.2		
	1404	184		150.4	9.5		
	1405	185		150.4	9.5		
	1406	186		150.6	9.7		
	1407	187		150.8	9.9		
	1408	188		150.8	9.9		
	1409	189		150.9	10.0		
	1410	190		151.0	10.1		
	1415	195		151.2	10.3		
	1420	200		151.4	10.5		

PUMPING TEST GRAPHICAL ANALYSES

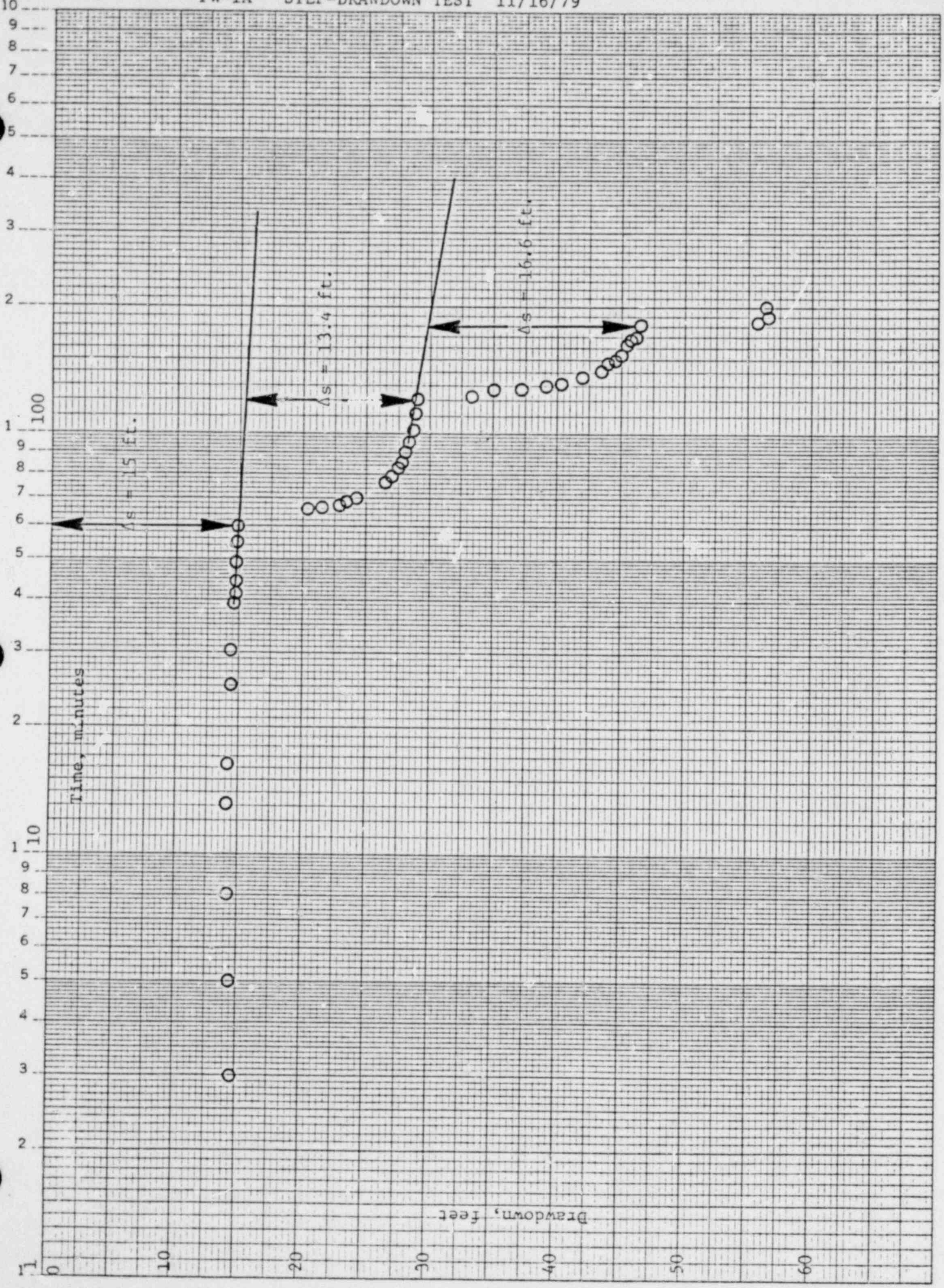
PW-1A STEP-DRAWDOWN TEST
11/16/79

Step	Q(gpm)	ΔQ(cfs)	Δs(ft)	s(ft)	Q(cfs)	s/Q
1	2	.00445	15.0	15.0	.00445	3371
2	3.75	.00390	13.4	28.4	.00835	3401
3	5.6	.00412	16.6	45.0	.01247	3609

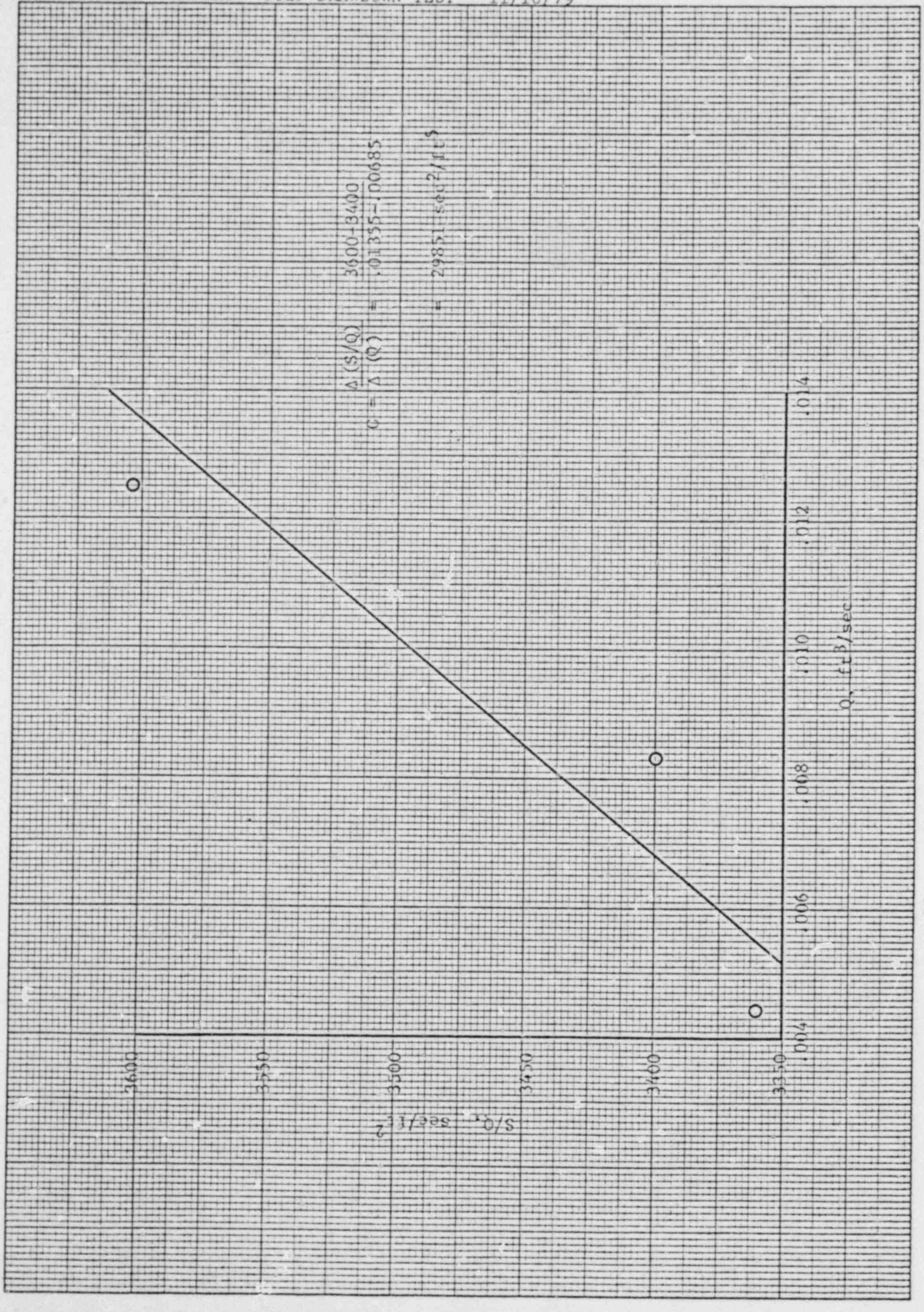
Well-loss coefficient, C, is given by the slope of a linear plot of s/Q vs. Q. Well loss at a pumping rate Q is then given by:

$$s_w = CQ^2$$

PW-1A STEP-DRAWDOWN TEST 11/16/79



PW-1A STEP-DRAWDOWN TEST 11/16/79



APPENDIX D

4.5 HOUR PUMPING TEST

1/17/80

PUMPING TEST FIELD DATA

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: N/A

DISTANCE FROM PUMPED WELL: N/A

ELEVATION OF MEASURING POINT: 5105.3 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
1/17	0803			137.02			Static
1980	0809			137.03			levels
	0814			137.02			
	0828			137.03			
	0833			137.61			New
	0839			137.59			M-scope
	0842						Pump on
	0845					4.6	
	0846	4		164.35	26.76		
	0848					5.0	
	0850	8		166.66	29.07		
	0856					5.1	
	0857	15		168.75	31.16		
	0903					5.0	
	0905	23		169.82	32.23		
	0912					5.0	
	0917	35		170.33	32.74		
	0921					5.0	
	0927	45		171.07	33.48		
	0928					5.0	
	0936	54		171.29	33.70		
	0938					5.0	
	0942	60				5.0	
	0948	66		171.85	34.26		
	1002					5.0	
	1005	83		172.37	34.78		
	1020	98		174.26	36.67		
	1024					5.4	
	1029					5.4	
	1042					5.5	
	1046	124		170.00	32.41		
	1056					4.5	
	1102	140		171.22	33.63		
	1121	159		170.52	32.93		
	1124					4.6	
	1142	180		171.09	33.50		
	1218	216		170.82	33.23		
	1252	250		170.69	33.10		
	1253	251				4.4	
	1312	270					Pump quit

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-2
DISTANCE FROM PUMPED WELL: 100.5 ft

ELEVATION OF MEASURING POINT: 5107.2 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
1/17	0753			139.32			Static
1980	0805			139.34			levels
	0814			139.27			
	0826			139.30			
	0837			139.32			
	0842						Pump on
	0849	7		139.59	.27		
	0855	13		139.91	.59		
	0859	17		140.34	1.02		
	0907	25		140.86	1.54		
	0914	32		141.22	1.90		
	0924	42		141.67	2.35		
	0933	51		142.05	2.73		
	0946	64		142.45	3.13		
	1002	80		142.84	3.52		
	1014	92		143.04	3.72		
	1040	118		143.59	4.27		
	1058	136		143.86	4.54		
	1119	157		144.01	4.69		
	1138	176		144.08	4.76		
	1215	213		144.36	5.04		
	1248	246		144.60	5.28		

PROJECT: NAC Peterson PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-6

DISTANCE FROM PUMPED WELL: 24.9 ft

ELEVATION OF MEASURING POINT: 5105.3 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
1/17	0753			137.56			
1980	0802			137.56			
	0810			137.56			
	0818			137.57			
	0830			137.56			
	0838			137.56			
	0842						Pump on
	0843	1		137.68	.12		
	0844	2		138.12	.56		
	0845	3		138.77	1.21		
	0846	4		139.01	1.45		
	0847	5		139.38	1.82		
	0848	6		139.73	2.17		
	0849	7		140.02	2.46		
	0850	8		140.24	2.68		
	0851	9		140.56	3.00		
	0852	10		140.77	3.21		
	0853	11		140.99	3.43		
	0855	13		141.40	3.84		
	0857	15		141.69	4.13		
	0859	17		141.99	4.43		
	0901	19		142.26	4.70		
	0903	21		142.44	4.88		
	0906	24		142.75	5.19		
	0909	27		142.94	5.38		
	0912	30		143.19	5.63		
	0916	34		143.39	5.83		
	0920	38		143.57	6.01		
	0924	42		143.86	6.30		
	0928	46		144.05	6.49		
	0932	50		144.26	6.70		
	0937	55		144.39	6.83		
	0942	60		144.55	6.99		
	0947	65		144.70	7.14		
	0952	70		144.85	7.29		
	0957	75		145.00	7.44		
	1002	80		145.14	7.58		
	1012	90		145.42	7.86		
	1022	100		145.72	8.16		
	1032	110		146.02	8.46		
	1042	120		146.07	8.51		
	1057	135		146.25	8.69		
	1112	150		146.24	8.68		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-6

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
1/17	1127	165		146.17	8.61		
	1142	180		146.23	8.67		
	1202	200		146.42	8.86		
	1222	220		146.53	8.97		
	1242	240		146.64	9.08		
	1312	270		146.74	9.18		

PROJECT: NAC Peterson

PROJECT NO.: NAC 3440.001

PUMPED WELL: PW-1A

OBSERVATION WELL: OW-7

DISTANCE FROM PUMPED WELL: 12.2 ft

ELEVATION OF MEASURING POINT: 5105.9 ft

Date	Time	t (min)	t' (min)	Depth to Water (ft)	Drawdown (ft)	Q (gpm)	Notes
1/17	0758			98.54			Static
1980	0812			98.43			levels
	0825			98.33			
	0832			98.34			
	0838			98.37			
	0842						Pump on
	0852	10		98.37			
	0901	19		98.36			
	0910	28		98.36			
	0919	37		98.36			
	0930	62		98.36			
	0944	48		98.36			
	1028	106		98.35			
	1124	162		98.34			
	1221	219		98.36			
	1255	253		98.34			

PUMPING TEST GRAPHICAL ANALYSES

4.5-HOUR PUMPING TEST
1/17/80
SUMMARY OF DATA ANALYSES

See Appendix B-1 for formulas and explanation of symbols.

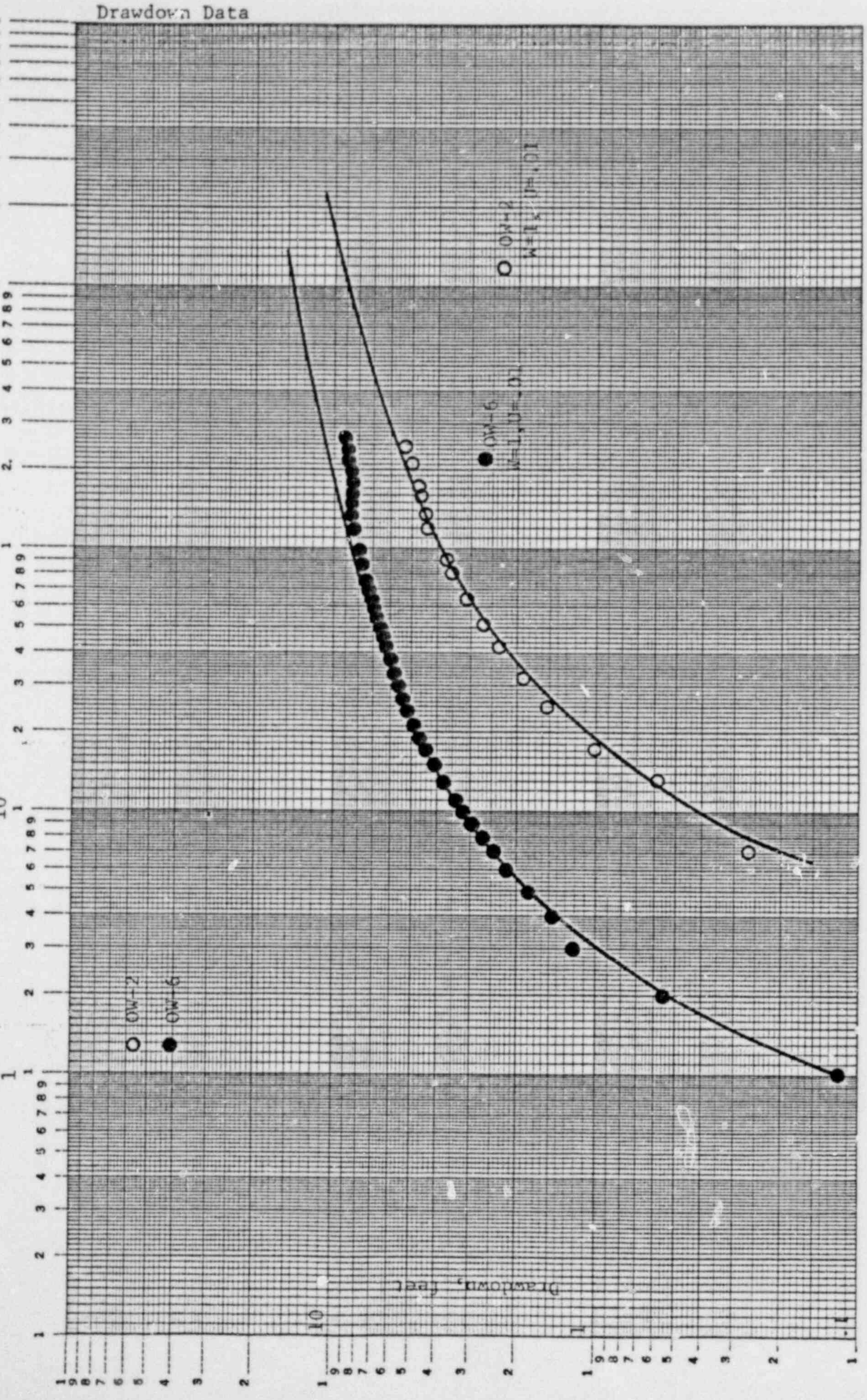
Full-logarithmic data plots

Time-drawdown analyses

Observation Well	r	s	t	W	u	T	S
OW-2	100.5	2.3	1170	1	.01	249	.00011
OW-6	24.9	2.7	220	1	.01	212	.00028

Aquifer Test 1/17/80

Drawdown Data



APPENDIX E

SURFACE WATER RUNOFF CALCULATIONS

APPENDIX E

SURFACE WATER RUNOFF CALCULATIONS

The method used to determine runoff estimates for design of the diversion ditch adjacent to the east side of the solar evaporation ponds is the Rational Method. The method is described on page 305 of Introduction to Hydrology by Warren Viessman, T. E. Harbaugh, and John W. Knapp.

The method is summarized in the following equation:

$$q_p = CiA$$

where

q_p = peak rate of flow in c.f.s.
C = coefficient of runoff
i = design rainfall intensity in inches per hour for a given frequency and for a duration equal to the time of concentration of the basin
A = area in acres.

Values of C are tabulated in the literature and are a function of the soil type and watershed cover. The runoff resulting from 24-hour, 100 year storms occurring on consecutive days was used for the diversion ditch design. Due to the small nature of this drainage area, runoff from the first 24-hour storm was assumed to have passed prior to the second 24-hour, 100 year storm. For ditch design, it was assumed one storm had passed leaving the ground saturated. A C value of 0.85 was used, herein, due to the assumed saturated ground conditions.

The time of concentration T_c from which the design rainfall intensity is determined is the time it takes for water to travel from the most distant point of a watershed to the watershed outlet. A formula to describe this factor is:

$$T_C = \frac{L^{1.15}}{7{,}700\ H^{0.38}}$$

where

T_C = time concentration in hours

L = length of the watershed along the mainstream from the outlet to the most distant ridge in feet

H = the difference in elevation between the watershed outlet and the most distant ridge in feet.

Applying the above method to the Test Site, the following results are obtained:

L = 1,750 feet

H = 70 feet

$$T_C = \frac{1750^{1.15}}{(7{,}700)\ (70)^{0.38}} = .141 \text{ hour} = 8.5 \text{ minutes}$$

NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, was used to determine the intensity of a five minute storm in this area. The precipitation from a one hour duration 100-year storm in this area is described as:

$$y_{100} = .671 + .757\ [(X_3)\ (X_3/X_4)]\ -\ 0.003Z$$

where

y_{100} = 100-year one-hour estimate value

X_3 = 100-year six-hour value

X_4 = 100-year 24-hour value

Z = point elevation in hundreds of feet

Using values from the Atlas, the following variables are used:

X_3 = 2.55 inches

X_4 = 3.4 inches

Z = 51 inches

therefore

$$y_{100} = .671 + .757 [(2.55)(\frac{2.55}{3.4})] - (0.003)(51)$$

$$y_{100} = 1.97 \text{ inches in 24 hours}$$

A correction factor of .29* was used to adjust the y_{100} value of 1.97 inches for a one-hour storm to a value applicable to a 5 minute storm. Therefore, the 5-minute, 100 year rainfall is .57 inches (1.97 inches x .29 inches). The design intensity for a time of concentration of 8.5 minutes is 5.6 inches/hour.

The area of the watershed was measured to be 16.07 acres. The calculated value of q_p is:

$$\begin{aligned} q_p &= CiA \\ &= (.85)(5.6)(16.07) \\ &= 76.5 \text{ cfs } (2.1 \text{ m}^3/\text{sec}) \end{aligned}$$

The diversion ditch that has been designed to accommodate this peak rate of flow is V-shaped, 3 feet deep, and with 2:1 side slopes.

* See NOAA Atlas 2, p. 16, Table 12.

APPENDIX F

WATER LEVEL DATA

APPENDIX F

WATER LEVEL DATA

HYDROLOGIC TEST WELLS

	January 15, 1980		March 6, 1980	
Well Number	Depth to Water (feet)	Elevation of Static Water Level (feet)	Depth to Water (feet)	Elevation of Water Level (feet)
PW-1A	136.3	4969.1	136.0	4969.5
PW-1	136.5	4969.1	136.3	4969.3
OW-1	135.2	4968.7	134.9	4969.0
OW-2	138.2	4969.0	137.9	4969.3
OW-3	137.3	4968.9	136.9	4969.3
OW-4	135.4	4966.2	132.6	4969.0
OW-5	136.1	4969.2	135.8	4969.4
OW-6	136.6	4968.7	136.3	4969.0
OW-7	95.3	5110.63	98.5	5007.4
OW-8	150.6	4954.7	150.2	4955.1
OW-9	124.2	4980.5	124.4	4980.2

APPENDIX G

ILLUSTRATIONS