see file Pocket 11 for sac end.

Battelle
Project Management Division
505 King Avenue
Columbus, Ohio 43201-2693

Technical Information Center

Jerry Pearing
U.S. Nuclear Regulatory Commission
Mail Stop 623-SS
Washington, DC 20555

January 17, 1986

Dear Mr. Pearing:

Five reports are enclosed in response to your request to Andrew Avel of the DOE/Salt Repository Project Office for EA references.

Enclosed are:

ONWI-411
ONWI-498
BMI/ ONWI-512 - LN 3372
BMI/ ONWI-564 - LN 3733
And the draft report, Expected Near-Field Thermal Performance for Nuclear Waste Repositories at Potential Salt Sites - LN 2961

The sixth report you have requested will be delivered from the GPO printing office to our site in a week or two (ONWI-553) and will be sent to you as soon as it arrives.

I hope these items satisfy your needs at this time.

Sincerely,

Robert Baker
Manager,
Technical Information Center

WM Record File 106

WM Project 16
Docket No.
PDR ✓
LPDR ✓

Distribution:
JPearing
(Return to WM, 623-SS) nto

rec'd 1-31-86

8605070422 860117
PDR WASTE
WM-16 PDR

Encls located in WM DCC.

Visitors' Entrance: 1375 Perry Street, Columbus, Ohio
Telephone (614) 424-7359 — Telex 24-5454

1312

Attachment II rec'd With ltr. to Pearring dated 1/17/86 106

Parsons Brinckerhoff / PB-KBB

BPMD-ESF-1185
March 25, 1985

Data Requirements for Freeze Wall Design

As a result of the unconsolidated, variably cemented soil-like sediments of the Ogallala and portions of the Dockum Formations, there is the potential for large volumes of water in-flow during shaft construction. Therefore, ground freezing is planned to facilitate shaft sinking. Due to the sensitivity and complexity of ice wall development, a comprehensive field and laboratory investigation is required for a confident freeze wall design. The depth and design characteristics of the freeze wall will be based on the site-specific data obtained in the EDBH program, and may be subject to change from the conditions presently assumed for Preliminary Design. Specific data requirements are as follows:

- Soil sampling in accordance with ASTM standards (samples at 5-ft intervals or at each soil change, whichever is less), including disturbed and undisturbed methods, as appropriate.

- Continuous rock core, as appropriate

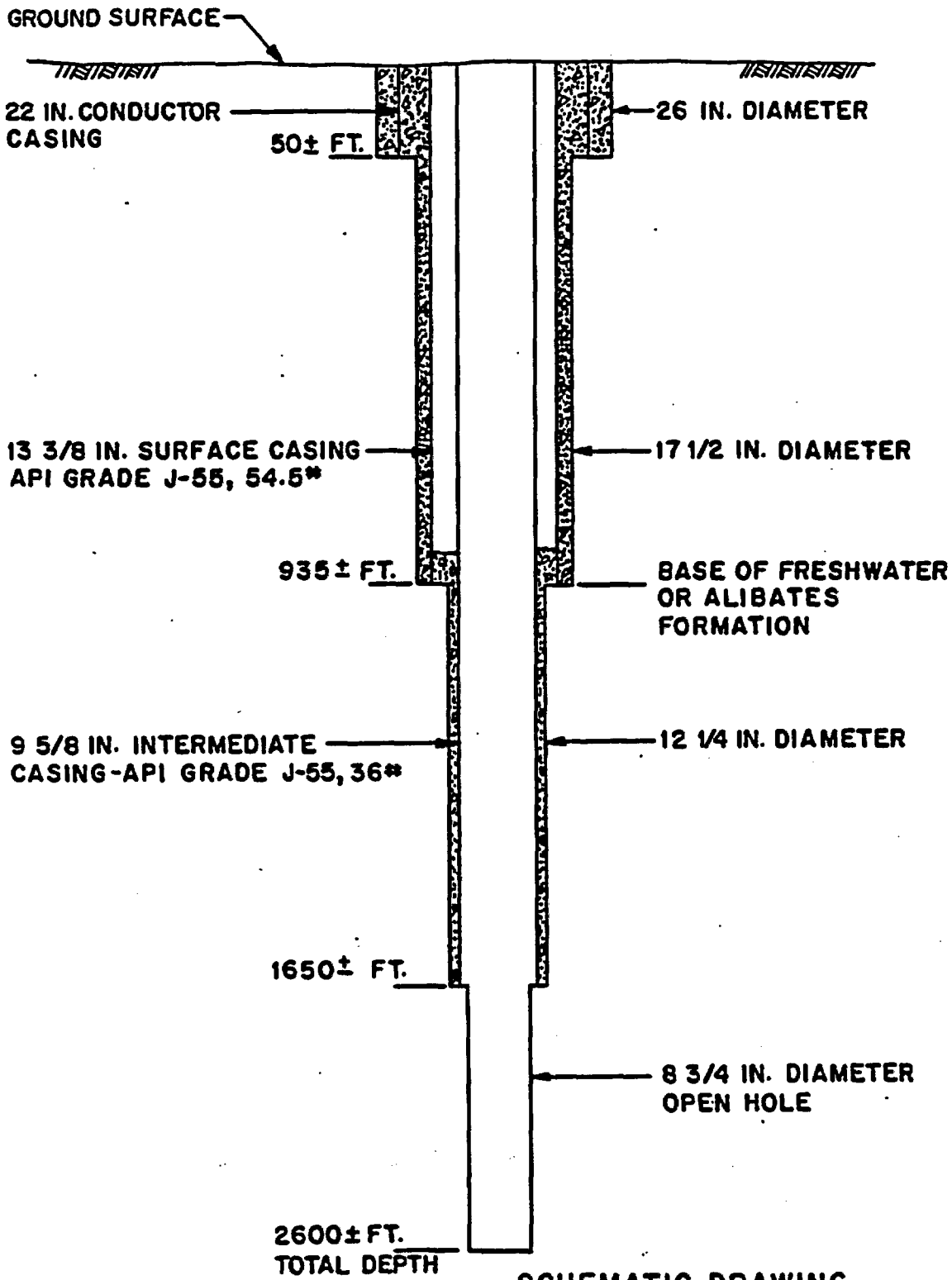
- Detailed materials and drilling log decription, including lithologic and Unified Soils Classification; drilling & sampling conditions, etc.

- In-situ hydrologic testing, including:
  - permeability/hydraulic conductivity,
  - water levels (i.e., potentiometric levels)
  - hydrostatic pressure
  - water flow velocity
  - ground water gradient (flow direction)
  - earth and ground water temperature.

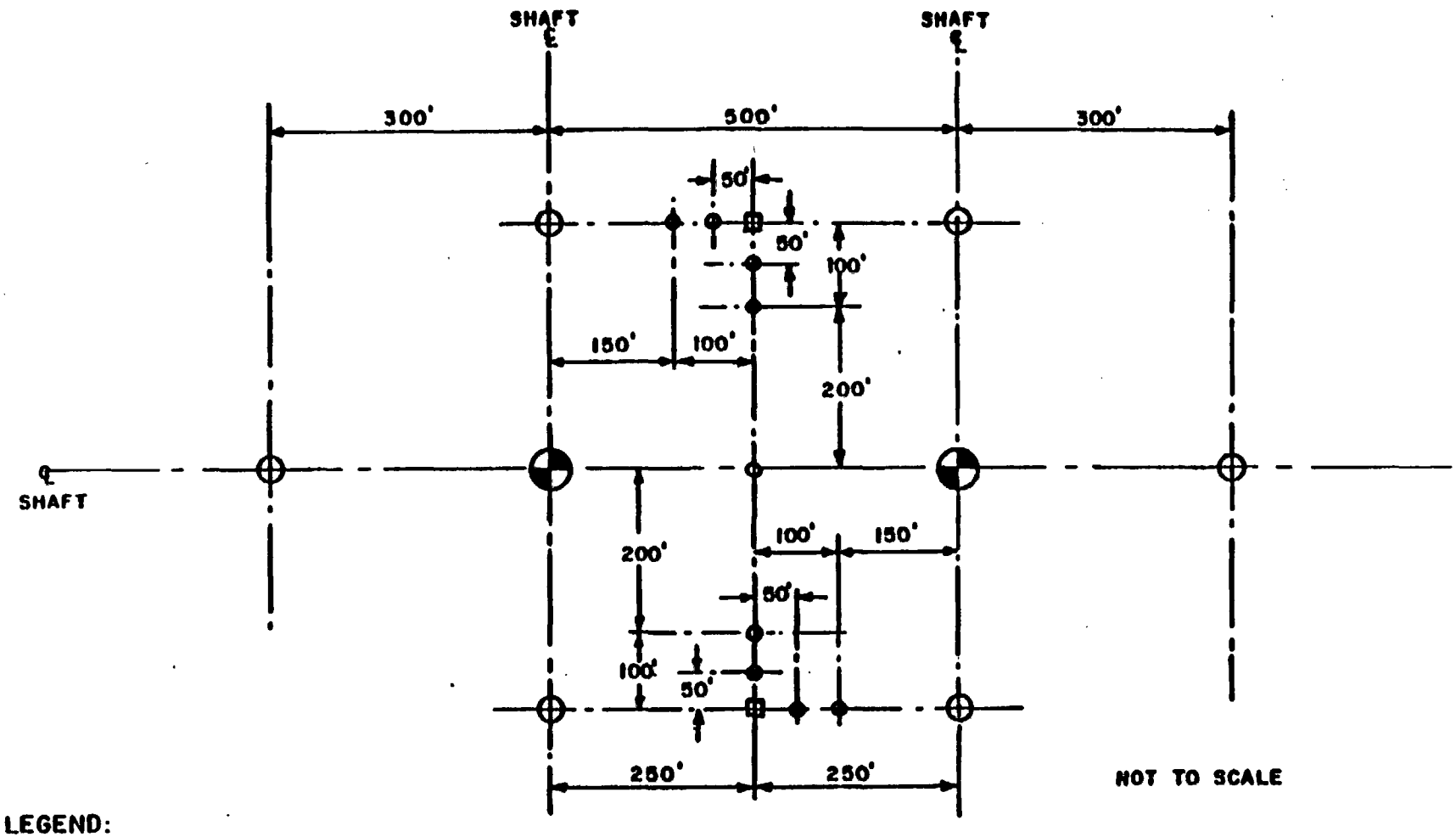
- Definition of aquifer/aquitard zones

- Geophysical logs to supplement borehole sampling and testing operations (full suite of logs).

- Laboratory testing requirements as follows:
  - Standard index tests (including grain size distribution, moisture content, bulk and dry density, porosity, etc.)
  - Soil and ground water chemistry
  - Unconfined and triaxial strengths
  - Freeze point of ground water
  - Instantaneous frozen strength at varying temperatures
  - Time-dependent strength of frozen ground, including creep characteristics
  - Specific heat and thermal conductivity



SCHEMATIC DRAWING OF ENGINEERING DESIGN BOREHOLES
STONE & WEBSTER ENGINEERING CORP.

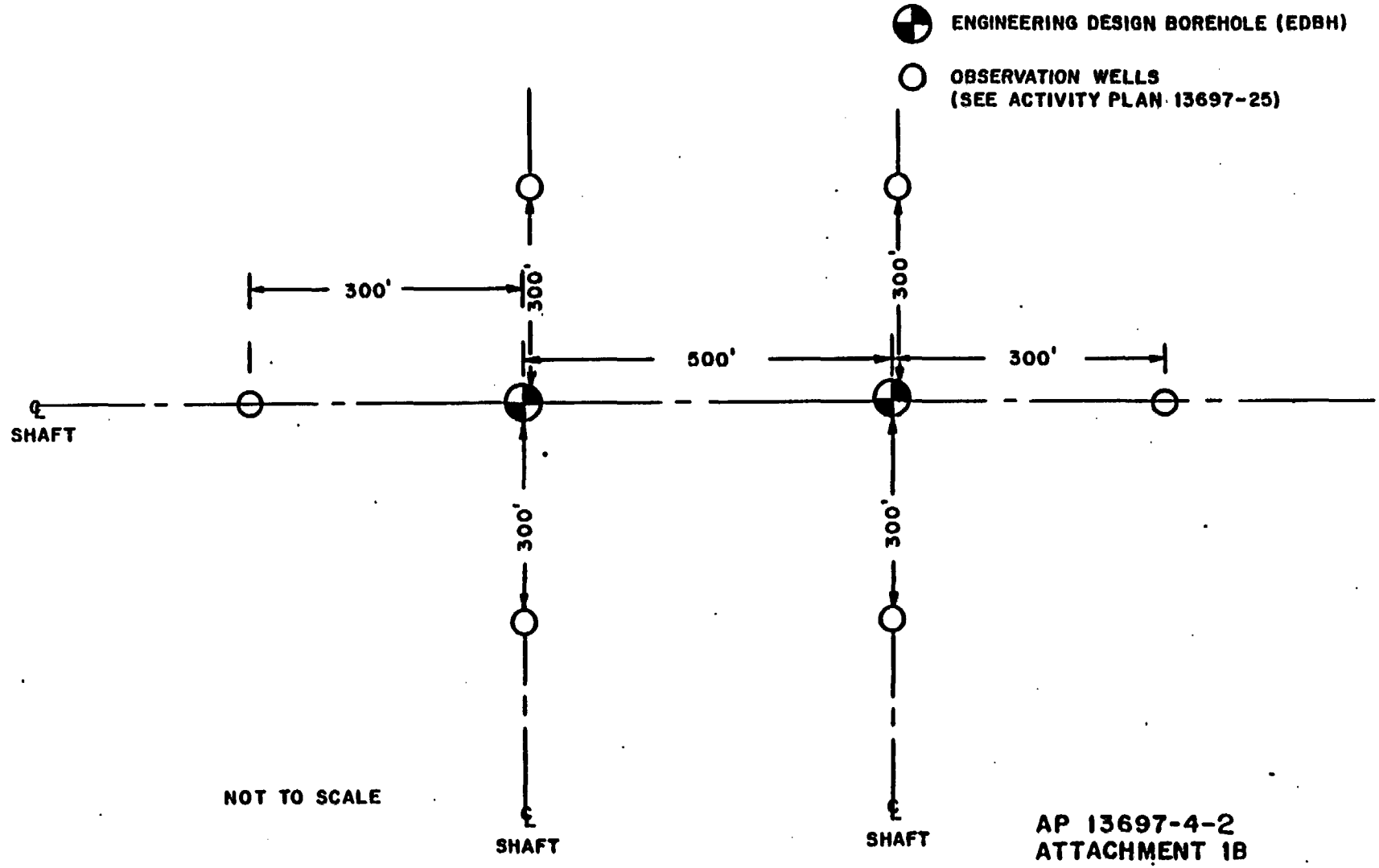


LEGEND:

- PUMPING WELLS
- PUMP TEST MONITORING WELLS
- ENGINEERING DESIGN BOREHOLE (EDBH)
- EXPLORATORY SHAFT MONITORING WELLS

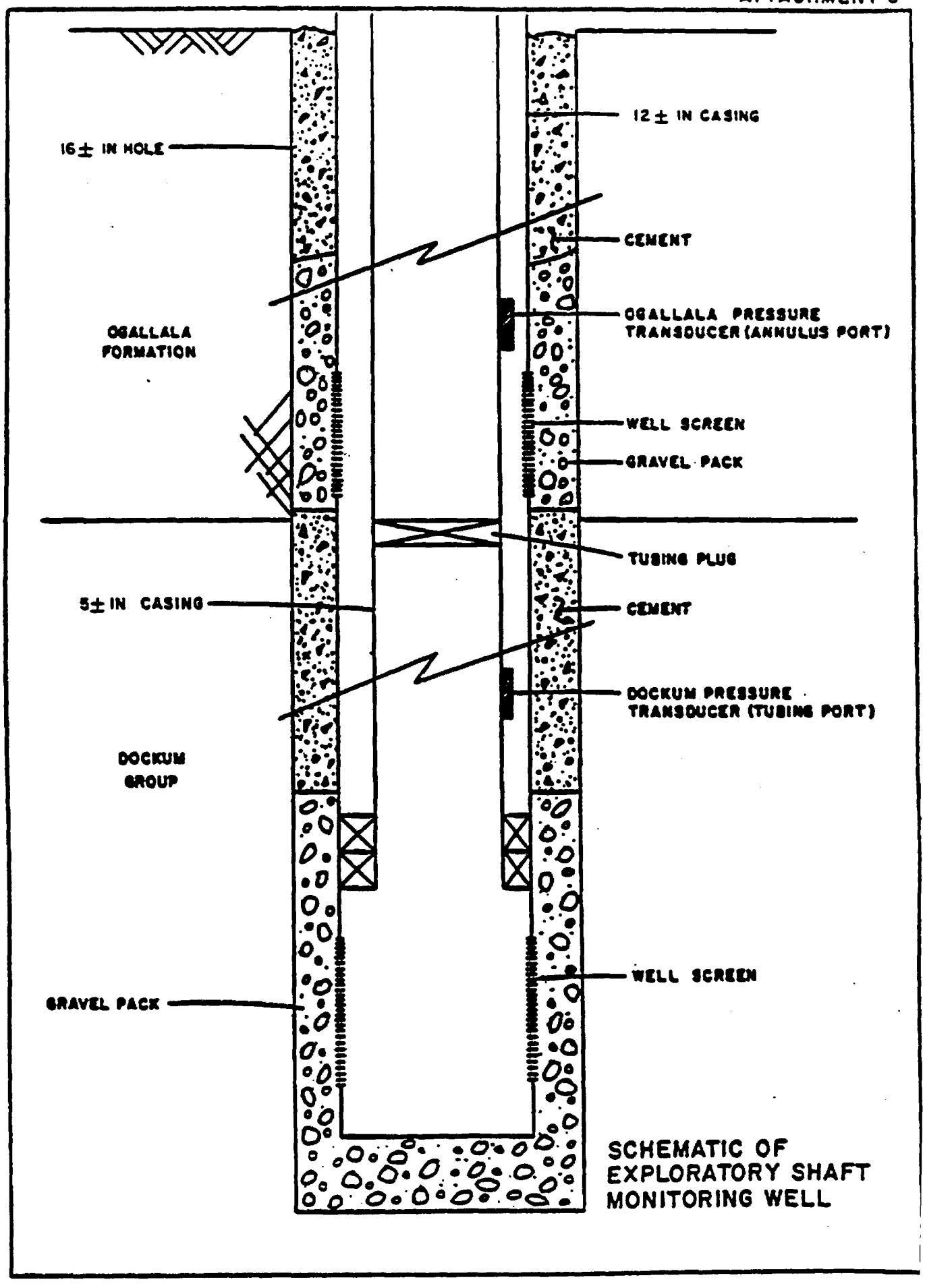
AP 13697-25-0
ATTACHMENT 2

LOCATION OF OBSERVATION WELLS
PERMIAN BASIN, TEXAS

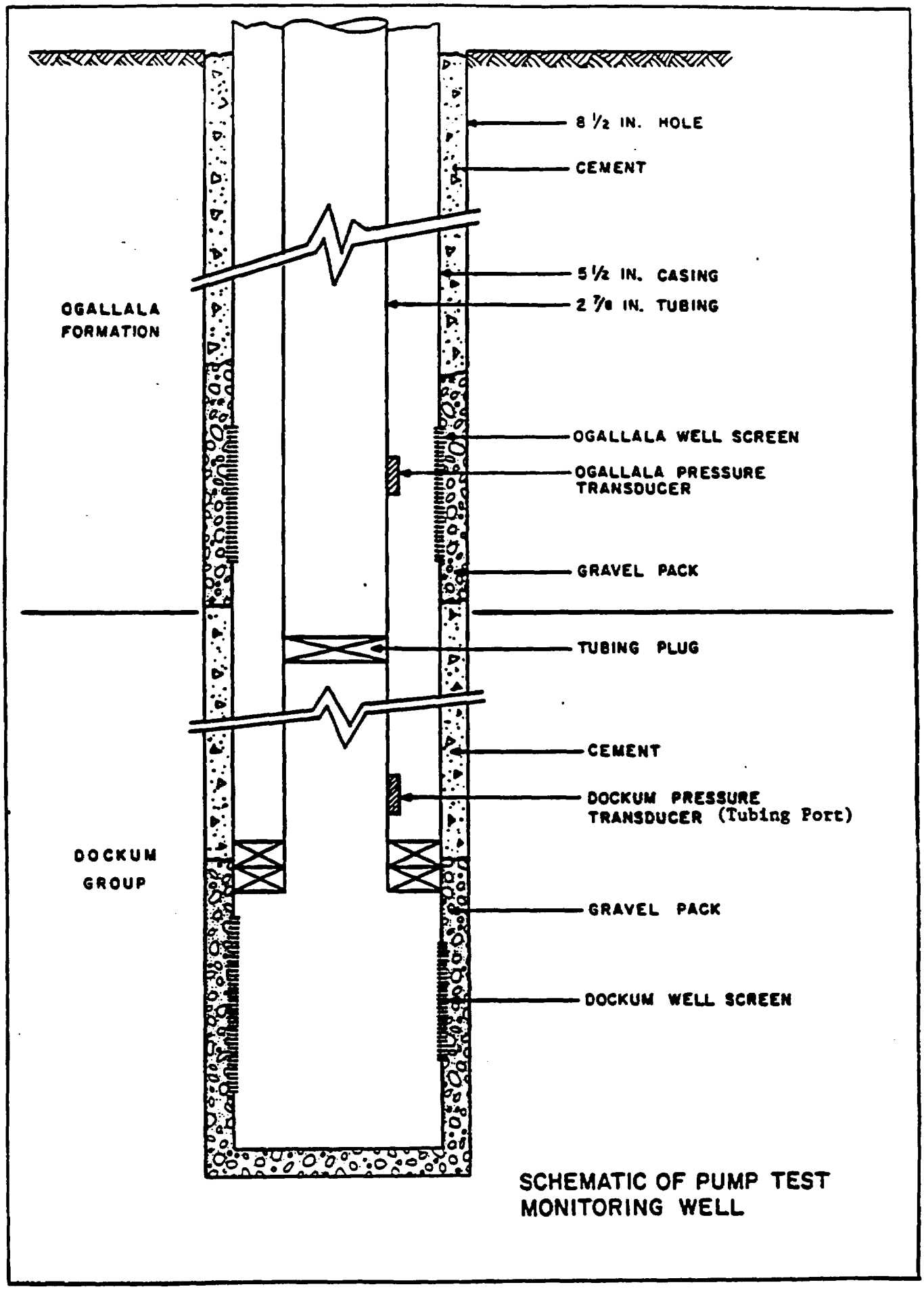


AP 13697-4-2
ATTACHMENT 1B

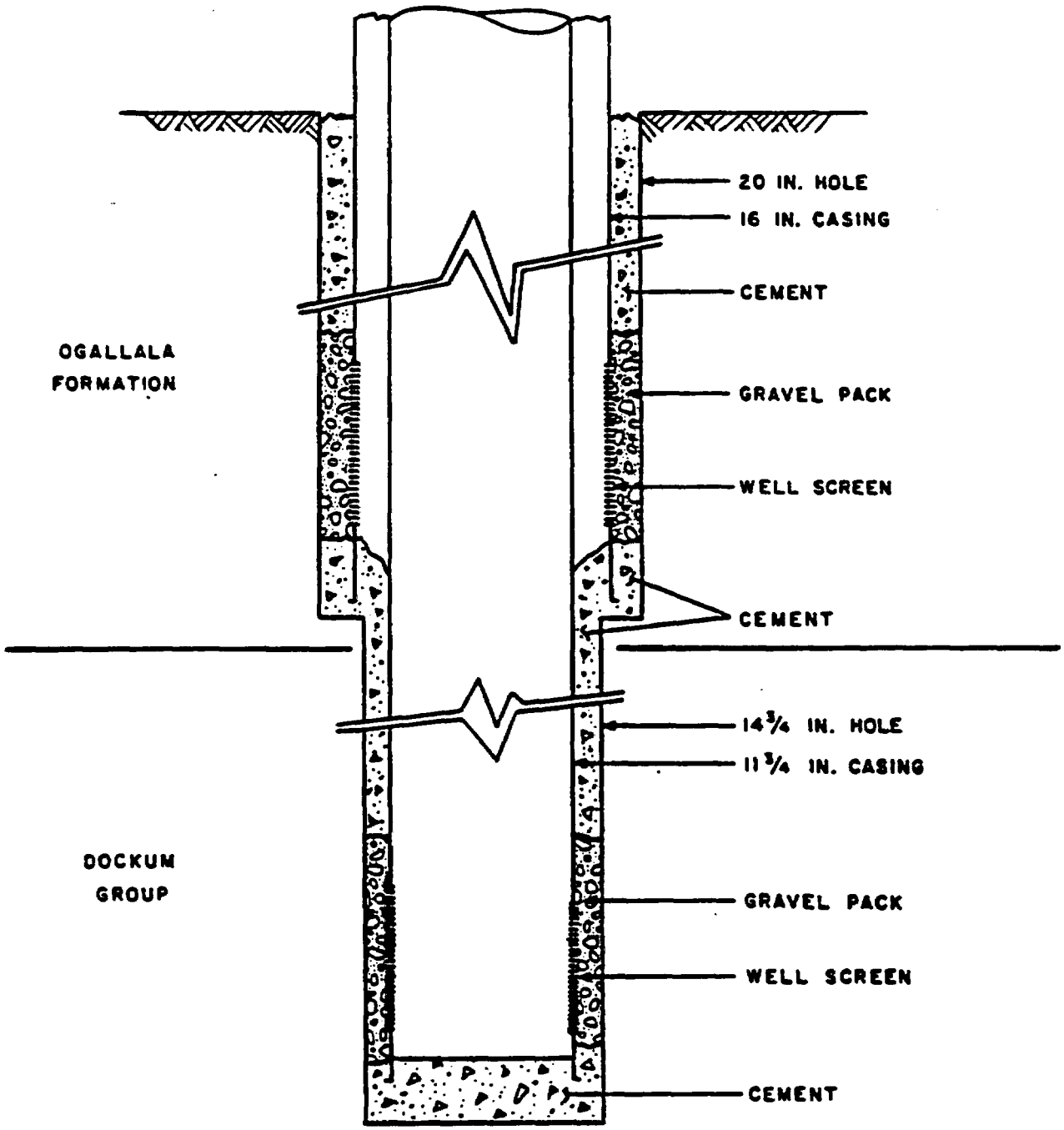
LOCATION OF EDBHs
PERMIAN BASIN TEXAS



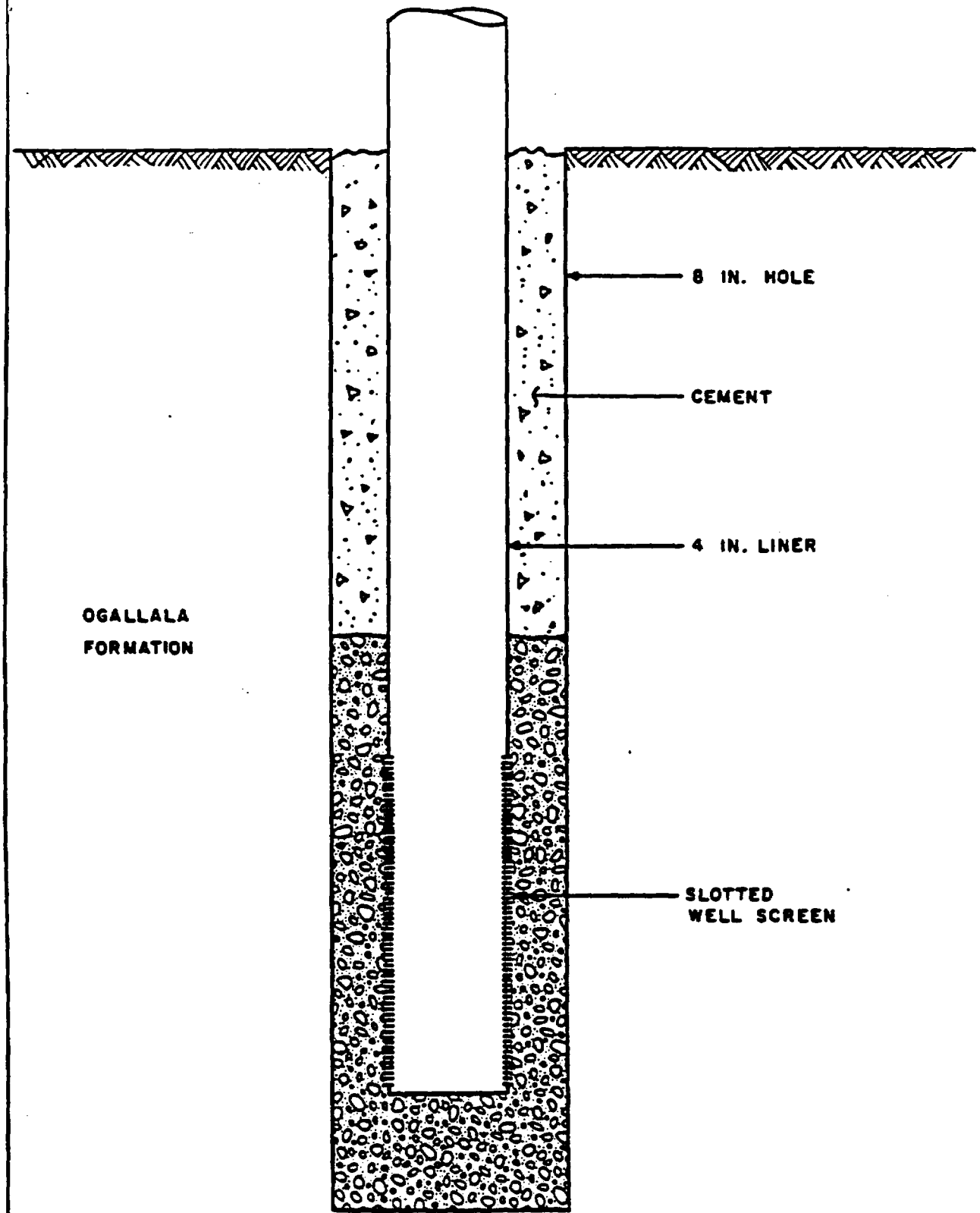
SCHEMATIC OF EXPLORATORY SHAFT MONITORING WELL



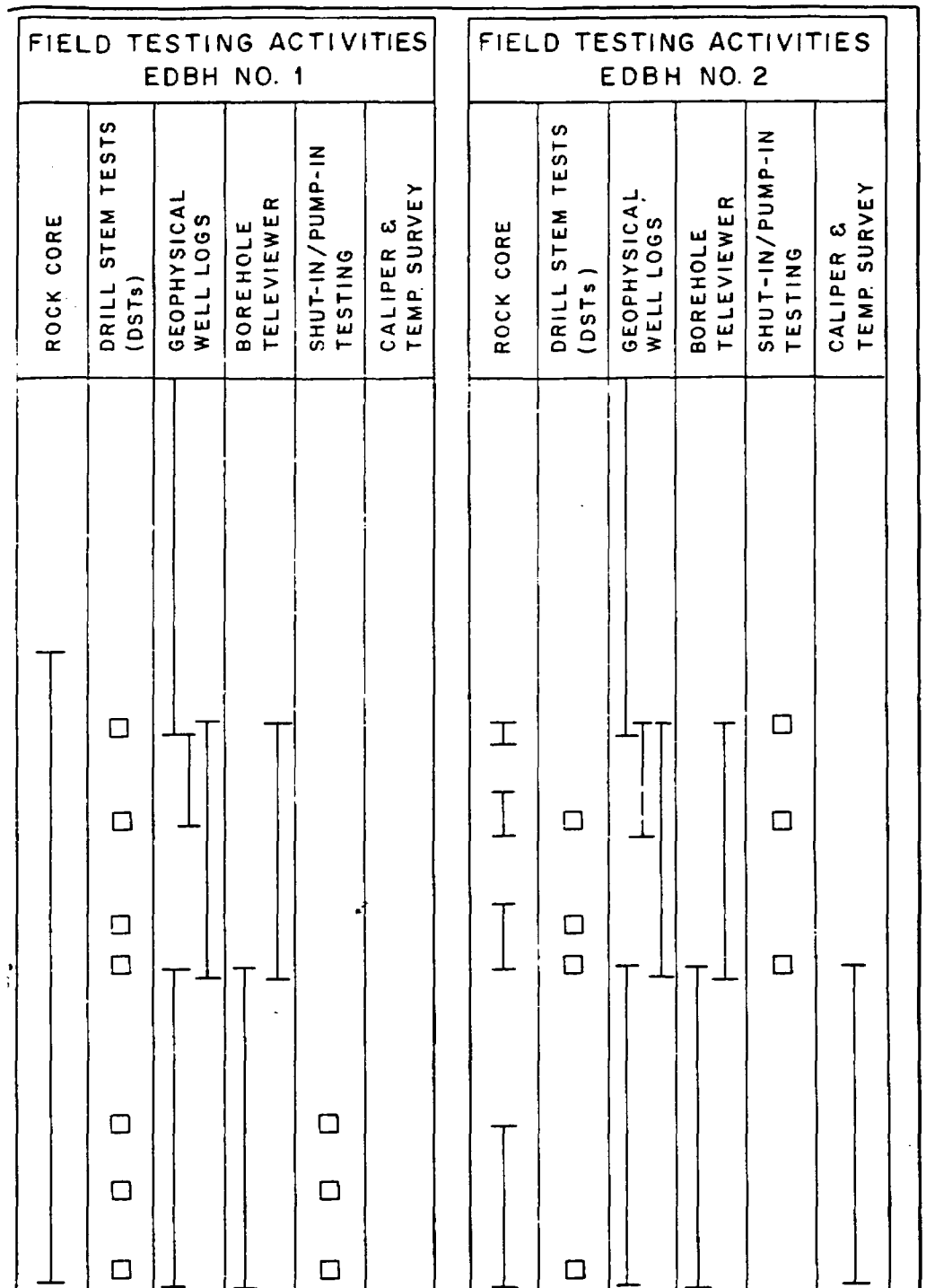
SCHEMATIC OF PUMP TEST MONITORING WELL

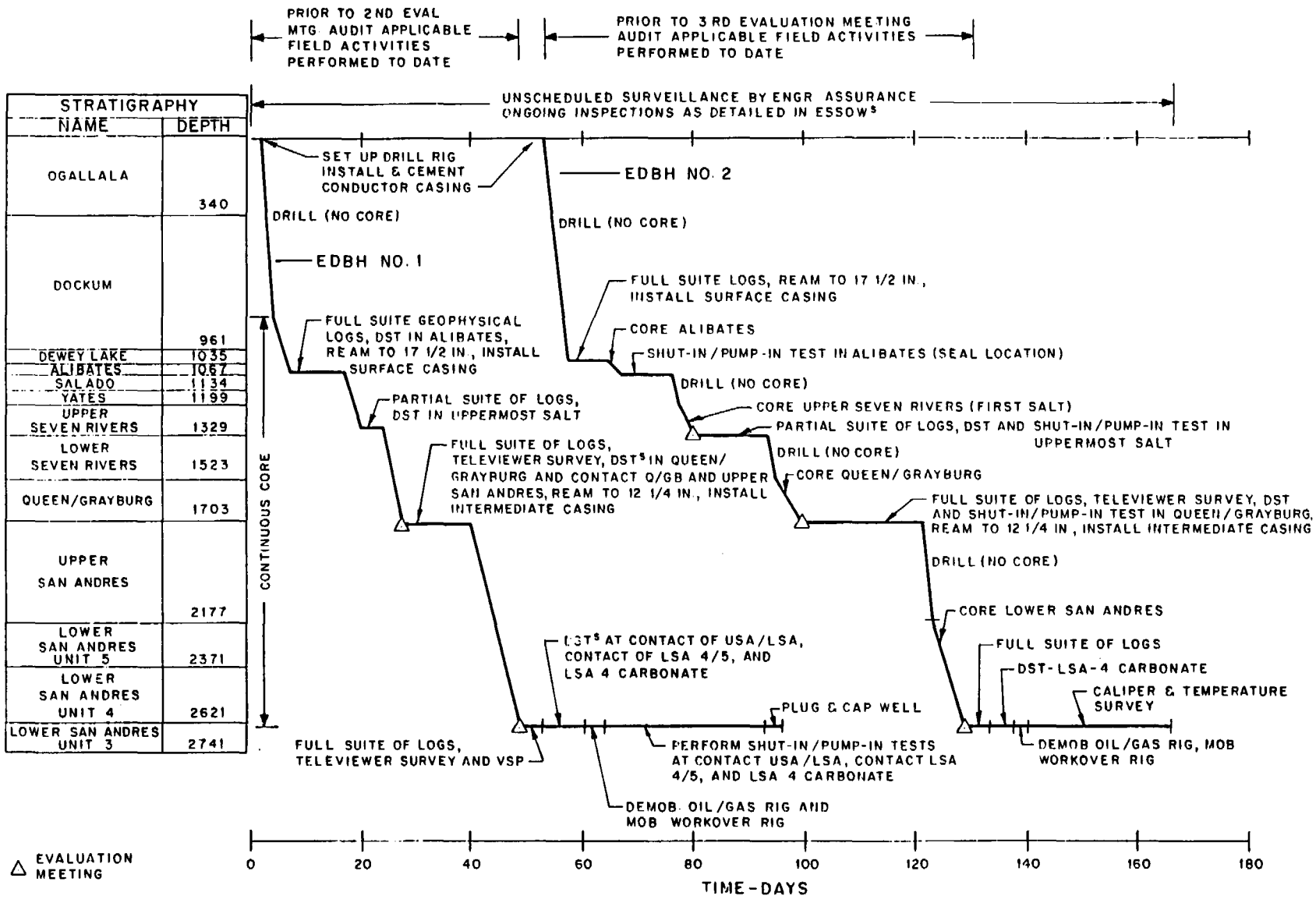


SCHEMATIC OF PUMPING WELL



SCHEMATIC OF EXPLORATORY SHAFT AND REPOSITORY FACILITY MONITORING WELLS


FIELD TESTING ACTIVITIES
EDBH NO. 1
ROCK CORE
DRILL STEM TESTS (DSTs)
GEOPHYSICAL WELL LOGS
BOREHOLE TELEVIEWER
SHUT-IN/PUMP-IN TESTING
CALIPER & TEMP. SURVEY
FIELD TESTING ACTIVITIES
EDBH NO. 2
ROCK CORE
DRILL STEM TESTS (DSTs)
GEOPHYSICAL WELL LOGS
BOREHOLE TELEVIEWER
SHUT-IN/PUMP-IN TESTING
CALIPER & TEMP. SURVEY


PRIOR TO 2ND EVAL MTG AUDIT APPLICABLE FIELD ACTIVITIES PERFORMED TO DATE
PRIOR TO 3RD EVALUATION MEETING AUDIT APPLICABLE FIELD ACTIVITIES PERFORMED TO DATE
UNSCHEDULED SURVEILLANCE BY ENGR ASSURANCE ONGOING INSPECTIONS AS DETAILED IN ESSOWS
STRATIGRAPHY
NAME
DEPTH
OGALLALA
340
DOCKUM
961
DEWEY LAKE
1035
ALIBATES
1067
SALADO
1134
YATES
1199
UPPER SEVEN RIVERS
1329
LOWER SEVEN RIVERS
1523
QUEEN/GRAYBURG
1703
UPPER SAN ANDRES
2177
LOWER SAN ANDRES UNIT 5
2371
LOWER SAN ANDRES UNIT 4
2621
LOWER SAN ANDRES UNIT 3
2741
CONTINUOUS CORE
SET UP DRILL RIG INSTALL & CEMENT CONDUCTOR CASING
EDBH NO. 2
DRILL (NO CORE)
EDBH NO. 1
DRILL (NO CORE)
FULL SUITE LOGS, REAM TO 17 1/2 IN., INSTALL SURFACE CASING
FULL SUITE GEOPHYSICAL LOGS, DST IN ALIBATES, REAM TO 17 1/2 IN., INSTALL SURFACE CASING
CORE ALIBATES
SHUT-IN/PUMP-IN TEST IN ALIBATES (SEAL LOCATION)
DRILL (NO CORE)
PARTIAL SUITE OF LOGS, DST IN UPPERMOST SALT
CORE UPPER SEVEN RIVERS (FIRST SALT)
PARTIAL SUITE OF LOGS, DST AND SHUT-IN/PUMP-IN TEST IN UPPERMOST SALT
FULL SUITE OF LOGS, TELEVIEWER SURVEY, DSTS IN QUEEN/GRAYBURG AND CONTACT Q/GB AND UPPER SAN ANDRES, REAM TO 12 1/4 IN., INSTALL INTERMEDIATE CASING
DRILL (NO CORE)
CORE QUEEN/GRAYBURG
FULL SUITE OF LOGS, TELEVIEWER SURVEY, DST AND SHUT-IN/PUMP-IN TEST IN QUEEN/GRAYBURG, REAM TO 12 1/4 IN., INSTALL INTERMEDIATE CASING
DRILL (NO CORE)
CORE LOWER SAN ANDRES
DSTS AT CONTACT OF USA/LSA, CONTACT OF LSA 4/5, AND LSA 4 CARBONATE
FULL SUITE OF LOGS
DST-LSA-4 CARBONATE
CALIPER & TEMPERATURE SURVEY
PLUG & CAP WELL
FULL SUITE OF LOGS, TELEVIEWER SURVEY AND VSP
PERFORM SHUT-IN/PUMP-IN TESTS AT CONTACT USA/LSA, CONTACT LSA 4/5, AND LSA 4 CARBONATE
DEMOB OIL/GAS RIG, MOB WORKOVER RIG
DEMOB OIL/GAS RIG AND MOB WORKOVER RIG
△ EVALUATION MEETING
0
20
40
60
80
100
120
140
160
180
TIME-DAYS

Attachment II

ONWI
Office of Nuclear Waste Isolation

BATTELLE Project Management Division

Project Number

Internal Distribution

J. E. Hanley
J. E. Gould
G. E. Heim
M. H. Farzin
R. S. Kingsley
D. E. Miall
A. Stewart
Engineering Files

Date June 1, 1984

To John Treadwell

From F. Djahanguiri

Subject History of Shaft Freezing and Its Application to the Salt Repository Project

Summary

A review of the literature indicates that the technique of ground freezing is more than 100 years old and has been applied to consolidation of saturated sediments during sinking of mine shafts, driving mine drifts, tunnels, and during foundation excavation in civil and nuclear projects. In recent years improvements and hence the cost effectiveness of frozen ground engineering and refrigeration technology have opened up new applications for ground freezing. This technical memo highlights the history of the ground freezing technology in mining-related projects. Although ground freezing and grouting can in some instances be complimentary techniques, there is no detailed discussion of grouting in this memo.

A review of Tables 1 and 2 indicates that ground freezing technique is a feasible and economical technique provided it is engineered properly. Since its application in mining projects, many shafts and mines have become economical and have been saved from flooding. Otherwise Canada's potash industry may not have come into existence making the price of potash and agricultural products much higher than it is today, at least in North America.

In summary, ground freezing technology is a feasible, practical, and economical technique, and sufficient experience and expertise exist today to apply it to shafts in the Permian Basin and Richton Dome. In the Paradox Basin where the geology and hydrology are different, repository shafts can be grouted. In fact, grouting and freezing techniques are applicable practically to any site and primarily to sedimentary formations provided sufficient information on geology, hydrology, soil, rock, and geochemistry of water-

bearing sediments is available. These techniques have been successfully applied in sinking deep potash shafts in Canada and Europe and could equally well be applied to shaft sinking in a salt repostiory.

Introduction

A review of the literature on ground freezing for subsurface construction indicates that ground freezing was first applied to mine shaft construction in 1883 during sinking for the Archibald mine in Schneidlinger, Germany. The first ground freezing in North America was carried out in 1888 to sink a shaft for Chapin Mining Company in Iron Mountain, Michigan, and the first ground freezing of shaft in a potash mine was carried out in 1886 by Jessenitz Company in Mecklenburg, Germany.

Shaft Freezing Technology and Its Application to Repository Shafts

Ground freezing is a unique technique applied to penetration of water-bearing formations in civil, nuclear and mining projects. There are two well-known companies in West Germany, Deilmann-Haniel Gmbh and Thyssen Schachbau Gmbh, which have been active in applying ground freezing techniques to major mining projects on a world-wide basis. Ground freezing is applied mainly in sedimentary rock formations (bedded) primarily in sinking of shafts for evaoporites (salt, potash, trona) and carbonacious rocks (coal), where sinking is carried out through water-bearing layers of limestone, sandstone, and water saturated cap rocks (i.e., domal salt), unconsolidated sediments overlying competent rock, and flowing sands. Today sufficient experience in design and application of ground freezing techniques exists so that the risk of flooding shafts during shaft freezing and sinking is minimized. Geologic and hydrologic conditions of thee strata overlying any sedimentary formation would require special techniques for ground and water control during shaft sinking. The easily soluble materials such as salt and potash require the linings of these shafts to be virtually watertight to assure long-term and

safe operation. Ground freezing, grouting, lining design, and operation have been perfected, so it is possible to sink large-diameter shafts through deep water-bearing aquifers successfully, and make the shafts completely watertight.

A typical example of a shaft freezing project is Thyssen's Boulby (Yorkshire, England) mine's shaft No. 1 where a 5.5-m-diameter shaft was sunk through the Bunter sandstone (water-bearing sandstone with mudstone interbeds) (Figures 1 and 2). Between 610 and 945 m an ice wall was created around the ground to be excavated, and a steel lining was used to protect the shaft wall. Shaft No. 2 was sunk using the grouting and tubbing method. These two shafts were situated 100 m apart, but because of the nature of the ground, different ground stabilization techniques (freezing and grouting) were used. The use of these different techniques was necessary to overcome the high-pressure saline water in the Bunter sandstone. In the potash-producing province of Saskatchewan, 16 out of the 17 potash shafts sunk have been completed using the freezing technique (Figures 3, 4, and 5). In six of these shafts, major water problems were encountered resulting in shaft flooding. The very first shaft was conventionally sunk (i.e., without ground freezing); it was abandoned due to flooding when the depth of the shaft reached 550 m after nearly eight years of construction. In 13 of the shafts in the area, special cast iron or ductile iron tubbings with wall thickness up to 90 mm were utilized to seal the major water horizons. One of the shafts was lined with concrete throughout the entire depth, with a thickness of close to 3 m, in the Blairmore Formation. Ground freezing is a unique technique that has helped to minimize risk of flooding of the shafts during sinking in Canadian potash mines (province of Saskatchewan).

Like other techniques, this technique is still evolving. In the early days ground freezing suffered from problems such as delays and huge cost overruns; prior to 1965 most failures in ground freezing projects were due to lack of knowledge about the freezing technology. The technology improved dramatically between 1965 and 1975 in the areas of heat and moisture transfer in the

ground and the mechanism of freezing, frozen, and thawing soils. Advances have also been made in developing lighter, more efficient protable refrigeration machinery. Table 1 lists the major shaft freezing projects in North America. The world-wide ground freezing (shaft) projects reported by Thyssen are presented in Table 2. Note that almost 98 percent of shaft freezing projects in North America have been completed for salt and potash mines. At present, Thyssen (Mulheim) and Deilmann-Haniel (Dortmund), both from West Germany, are joint ventured and are the main contractors for design and construction of the salt repository in Gorleben (salt dome) for the West German nuclear waste program. Two shafts are 7.50 meter in finished diameter (10.36 m OD) and will be sunk using ground freezing techniques. The depth of each shaft will be 1,300 m and the freezing depth will be 600 m. Drilling of freeze holes will begin in May 1984 and take four months. The estimated pre-freeze period will be six months.

The total refrigeration capacity will be 2.5 million kilo calories per hour. The diameter of the freeze hole circle will be 17.39 m, and the holes will be spaced 1.31 m apart. A total of 38 to 42 freeze holes per shaft is planned. The estimated time for shaft sinking is five to six years. The shaft liners will be double walled and the annular space will be filled with bitumen (asphaltic base material). Thyssen Mining Construction, Inc., an American subsidiary of Thyssen of West Germany, is a joint partner with PB/KBB who are under contract to ONWI for designing an exploratory shaft for a salt repository; indirectly Thyssen will be utilizing their years of ground freezing experience in the salt repository program in the U.S.A.

A recent draft report prepared by Parsons Brinckerhoff/PB/KBB for ONWI titled "Two Shaft Study - ES - 137-01", dated April 1984 has been reviewed. Figures 6, 7, and 8 represent generalized stratigraphy related to the study for Permian (Texas) and Paradox (Utah) salt basins, and Richton Dome. The exploratory shaft proposed for the Paradox Basin will be sunk by grouting. (For instance, the 6.7-m-diameter Shaft No. 1 (production shaft) at Cane

Creek potash mine (Paradox Formation, Utah) was sunk to a depth of 854 m in 1961. The sinking of this shaft through limestone beds required grouting which was carried out successfully.) The diameter of the repository shafts almost equals the diameter of shafts which have been frozen in Canada. The increase in the diameter of these shafts is not a problem; only the number of freeze holes and refrigeration capacity will have to be increased to accomodate the shaft diameter increases during freezing operations (Figures 9 and 10). Since 1981 many shafts have been completed in North America which did not require ground freezing, and grouting has commonly been used to seal water-bearing strata during shaft sinking.

The most recent ground freezing has been reported from Britain at the Selby coal field. At Britain's Selby Coal mining project which will be the biggest mining enterprise in Europe, driving of two parallel drifts and sinking of five pairs of shafts in Selby Coal district required extensive ground freezing and grouting. The project was successfully carried out by a consortium of companies (Forkay Ltd., Thyssen Ltd., and Cementation Mining Ltd. of England). The stratigraphy encountered from the surface down consisted of glacial lake deposits, Bunter sandstone, upper Permian marl, upper magnesian limestone, lower magnesian limestone, lower Permian marl, basal Permian sands, and coal measures. During shaft sinking, freezing of water-bearing Bunter sandstone, magnesian limestone, and the basal Permian sands was necessary; and freezing was required for driving parallel drifts. The freezing at the five mines and drifts was done by Forkay, Ltd. of England. The most interesting part of the Selby freezing project is the application of the freezing technique in the basal sands on the drifts. It is believed that freezing of basal sand is a new development by itself.

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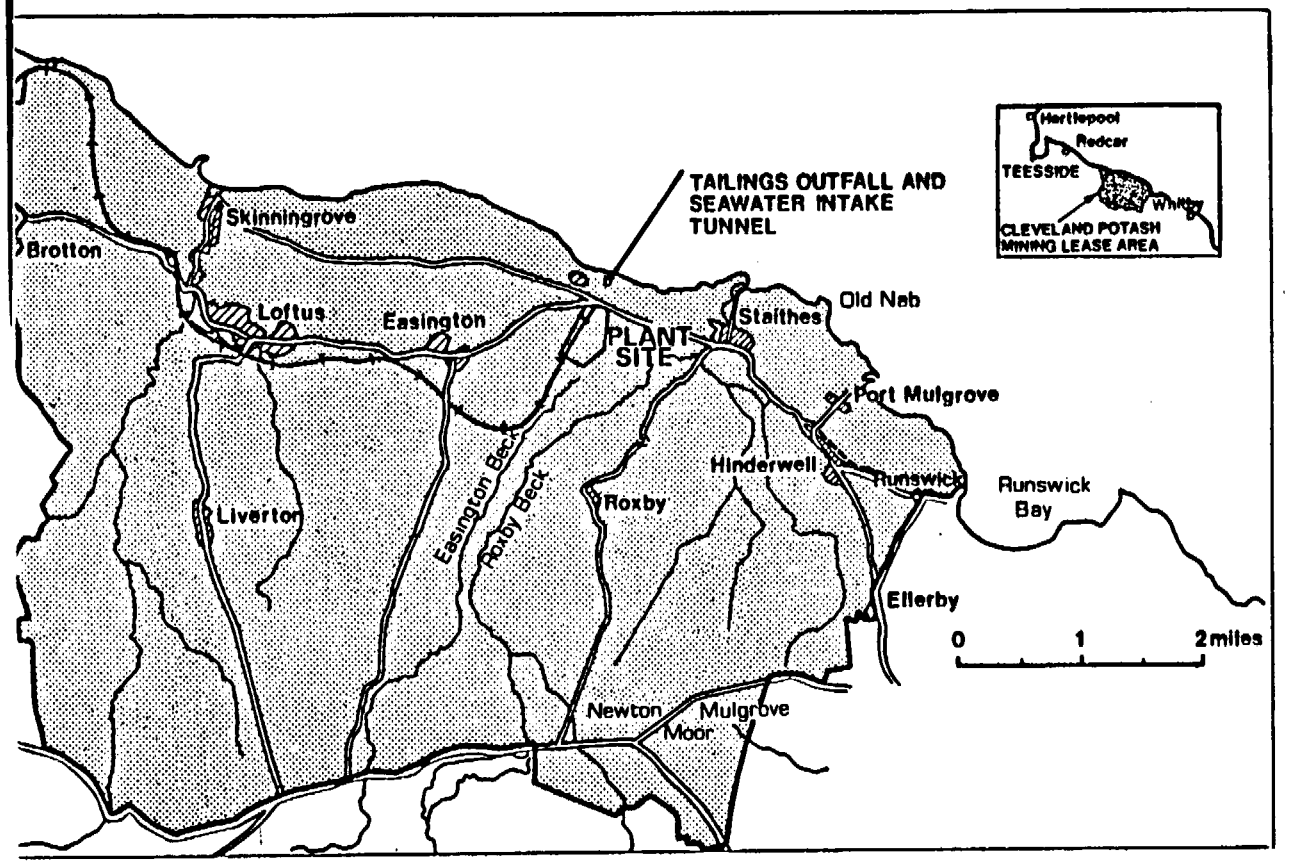


Location map showing mining lease area and plant site.

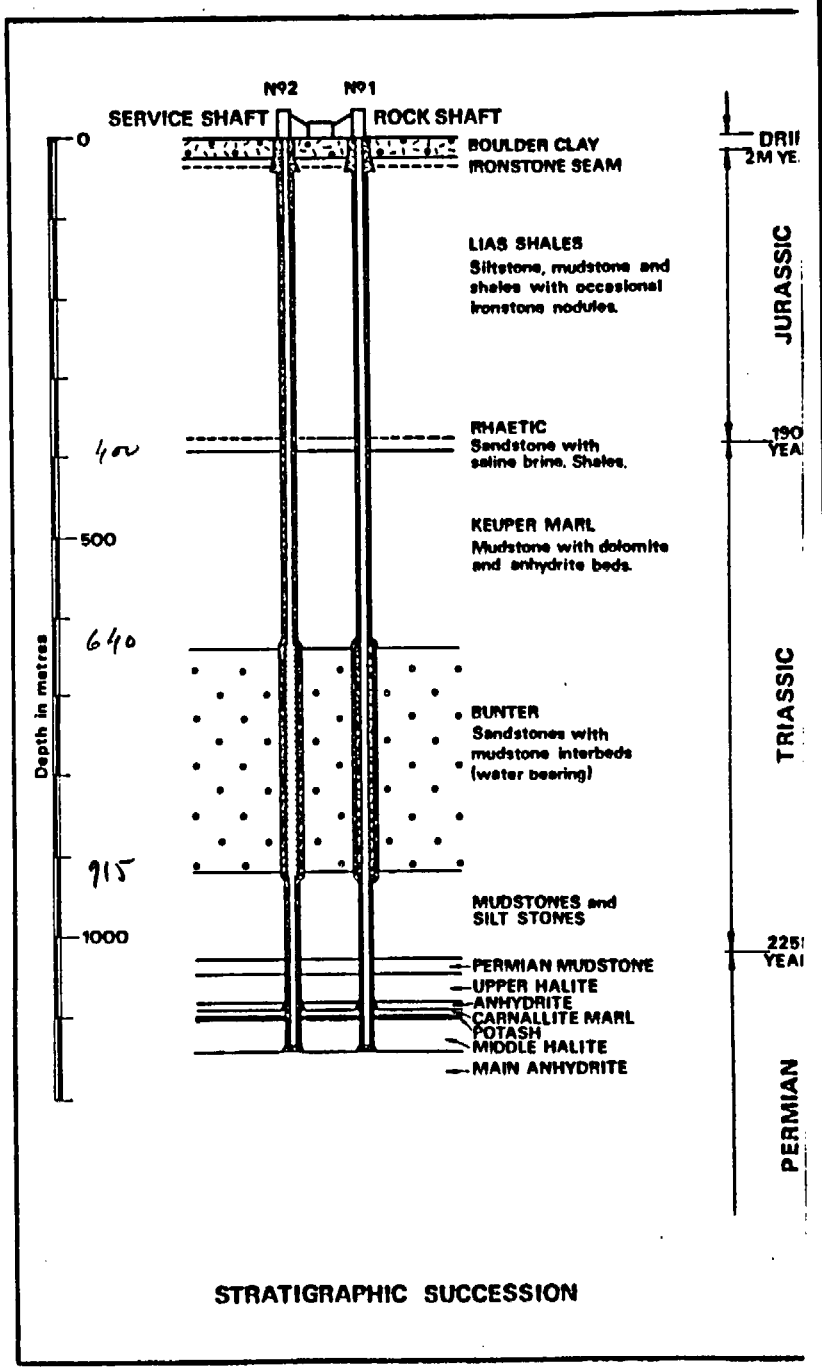
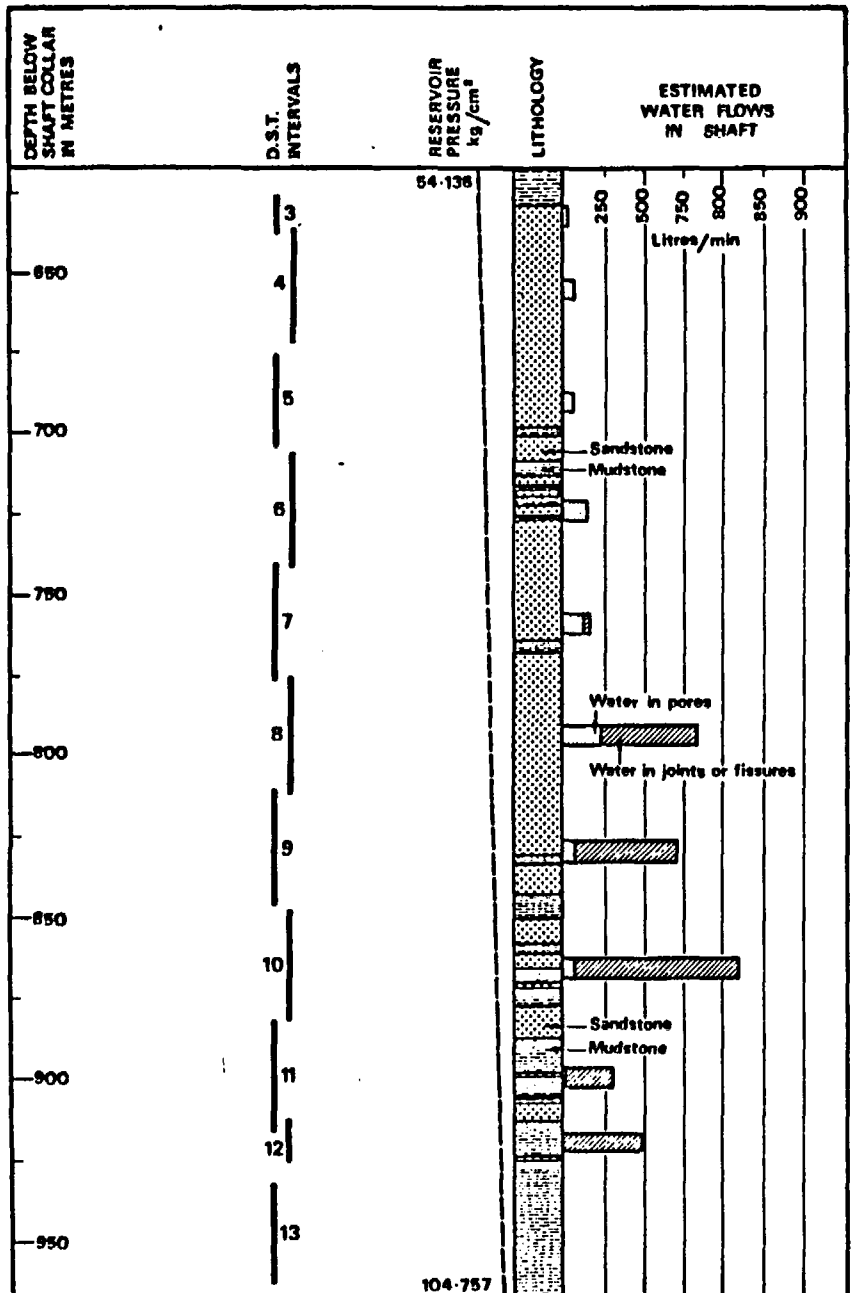
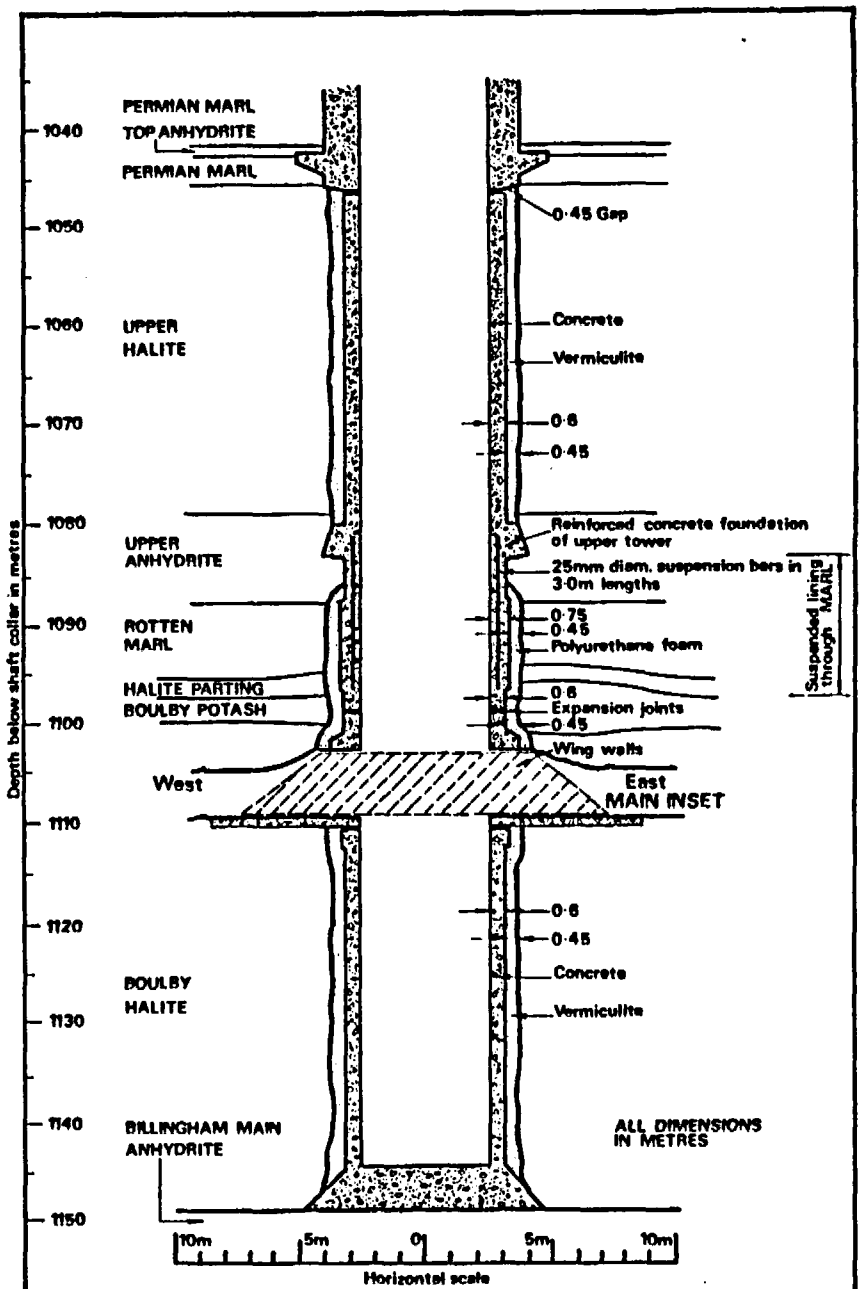


Figure 1. Shaft Freezing and Sinking at the Boulby Potash Mine, Cleveland, England

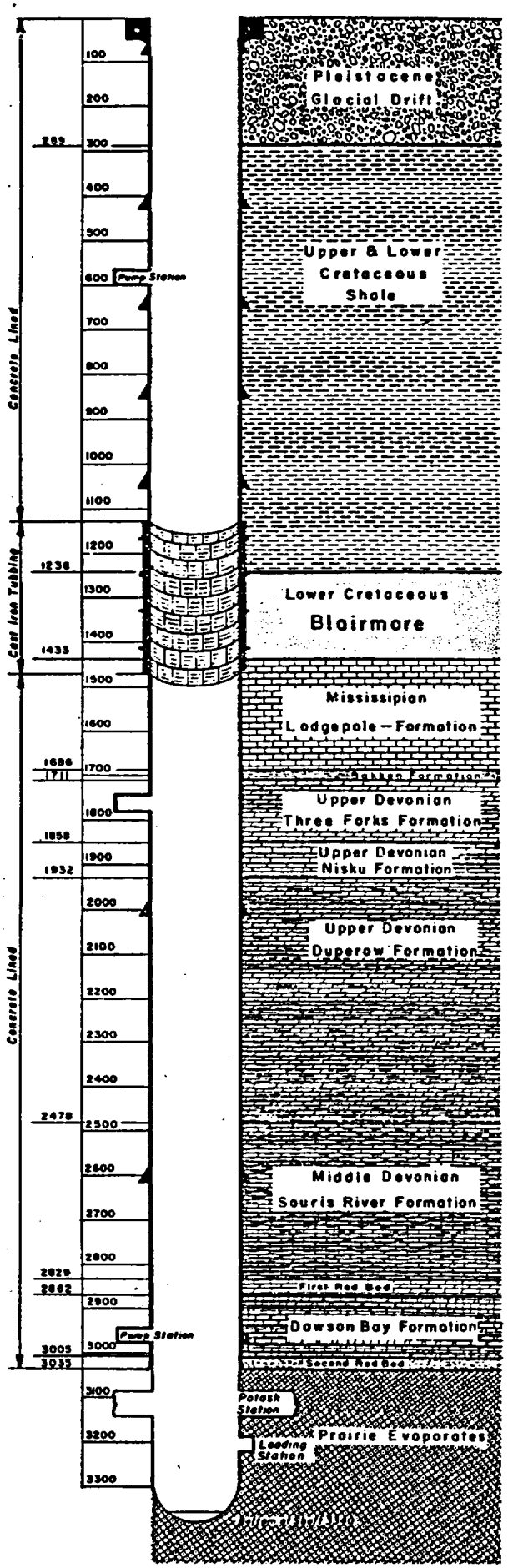


BUNTER SANDSTONE HYDROLOGY SHOWING D.S.T. INTERVALS AND THE ESTIMATED WATER FLOW

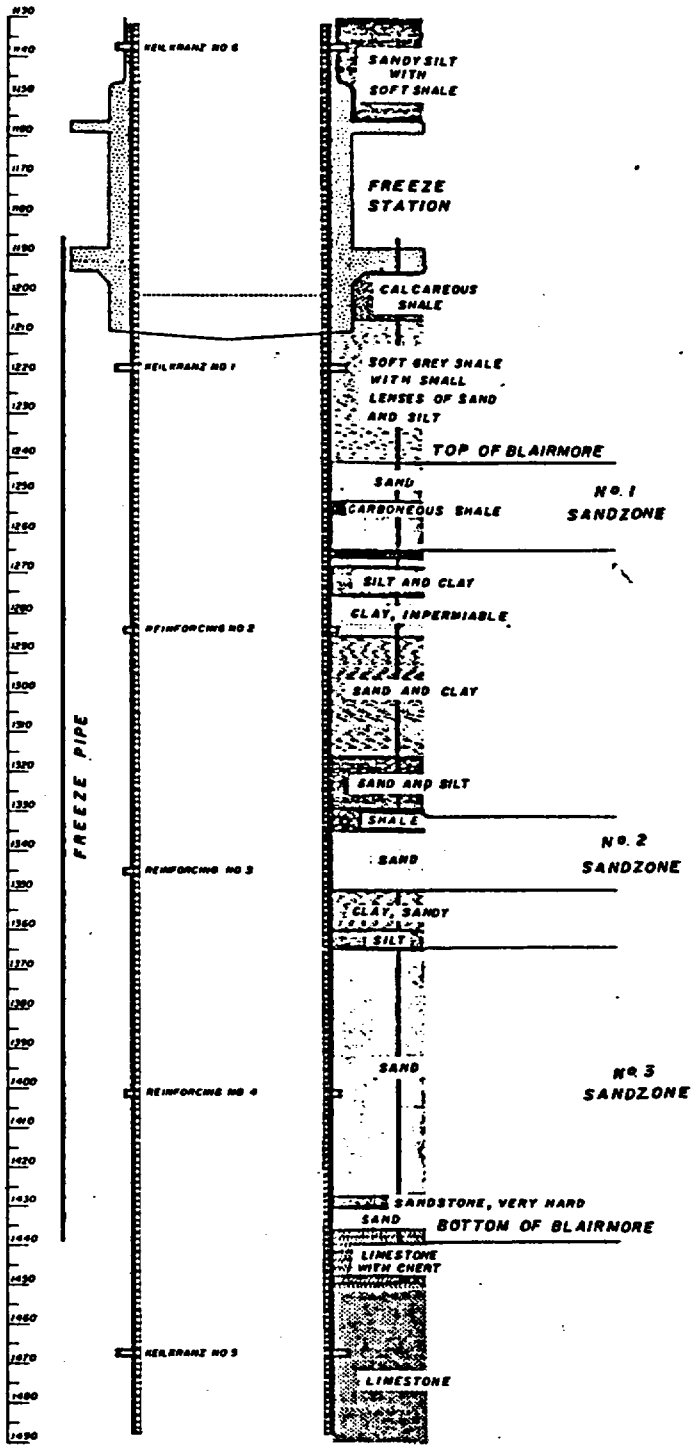


EVAPORITE SECTION SHOWING THE LITHOLOGY AND THE LINING DESIGN

Figure 2. Detailed Hydrology of Bunter Sandstone and Lithology and and Lining Design of Evaporate Section--Boulby Potash Mines

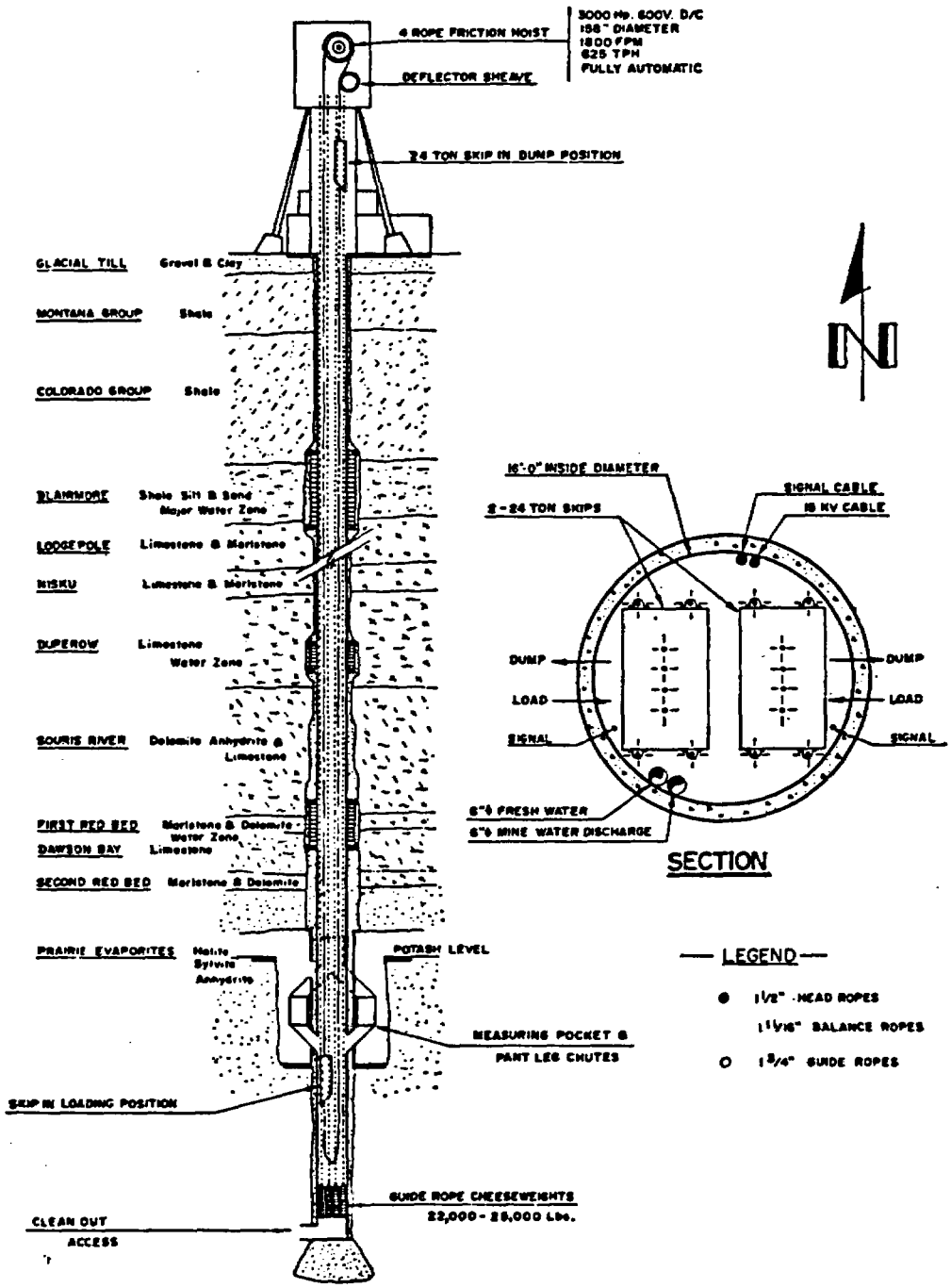


-Geological Section of Yarbo No. 1 Shaft.



—Section showing Freeze Chamber and Tubbing Column.

Figure 3. International Minerals and Chemicals Corporation, Esterhazy/Sask., Canada



No. 1 Production Shaft.

Figure 4. Potash Corporation of Saskatchewan's Sylvite Mine, Rocanville, Saskatchewan, Canada

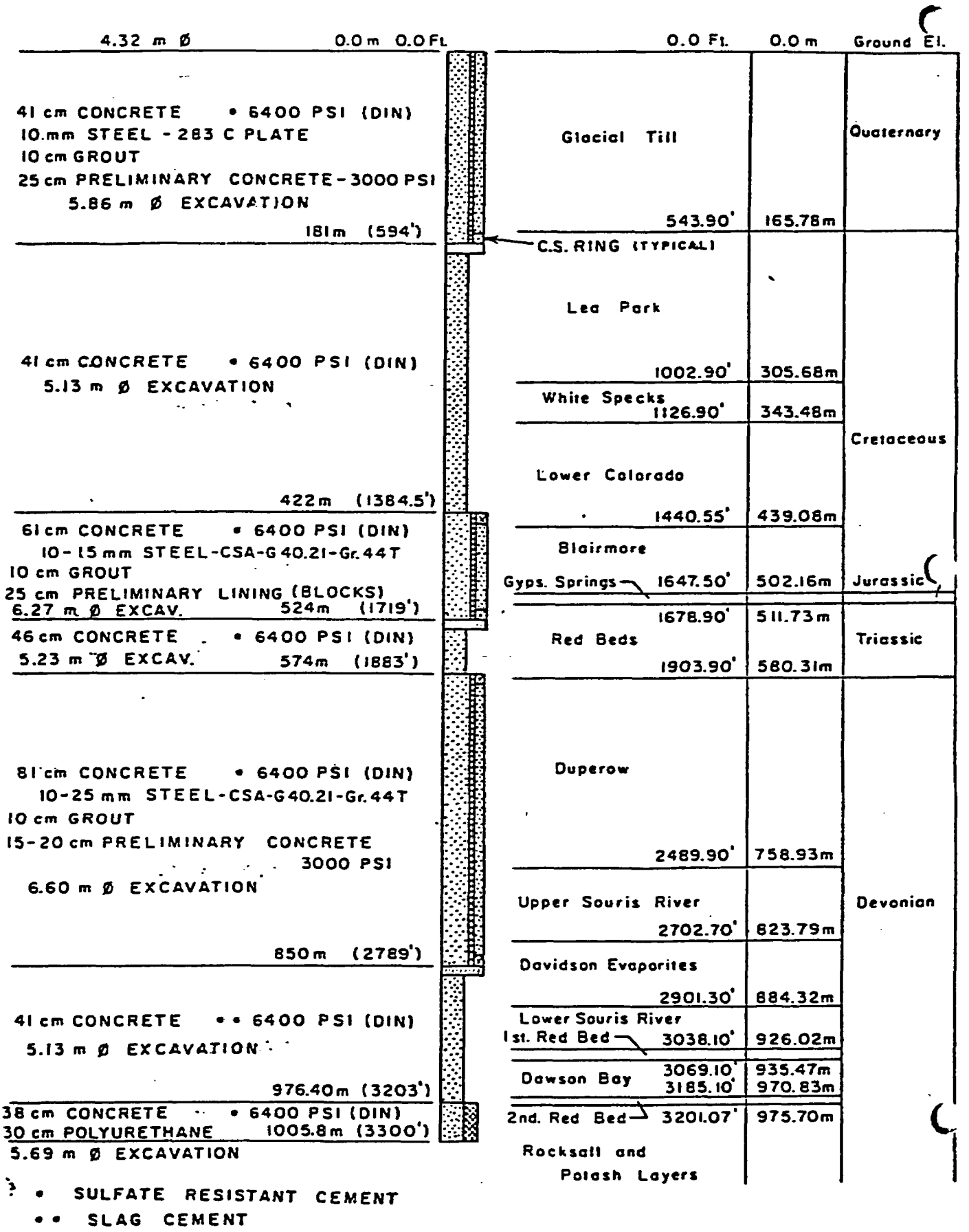
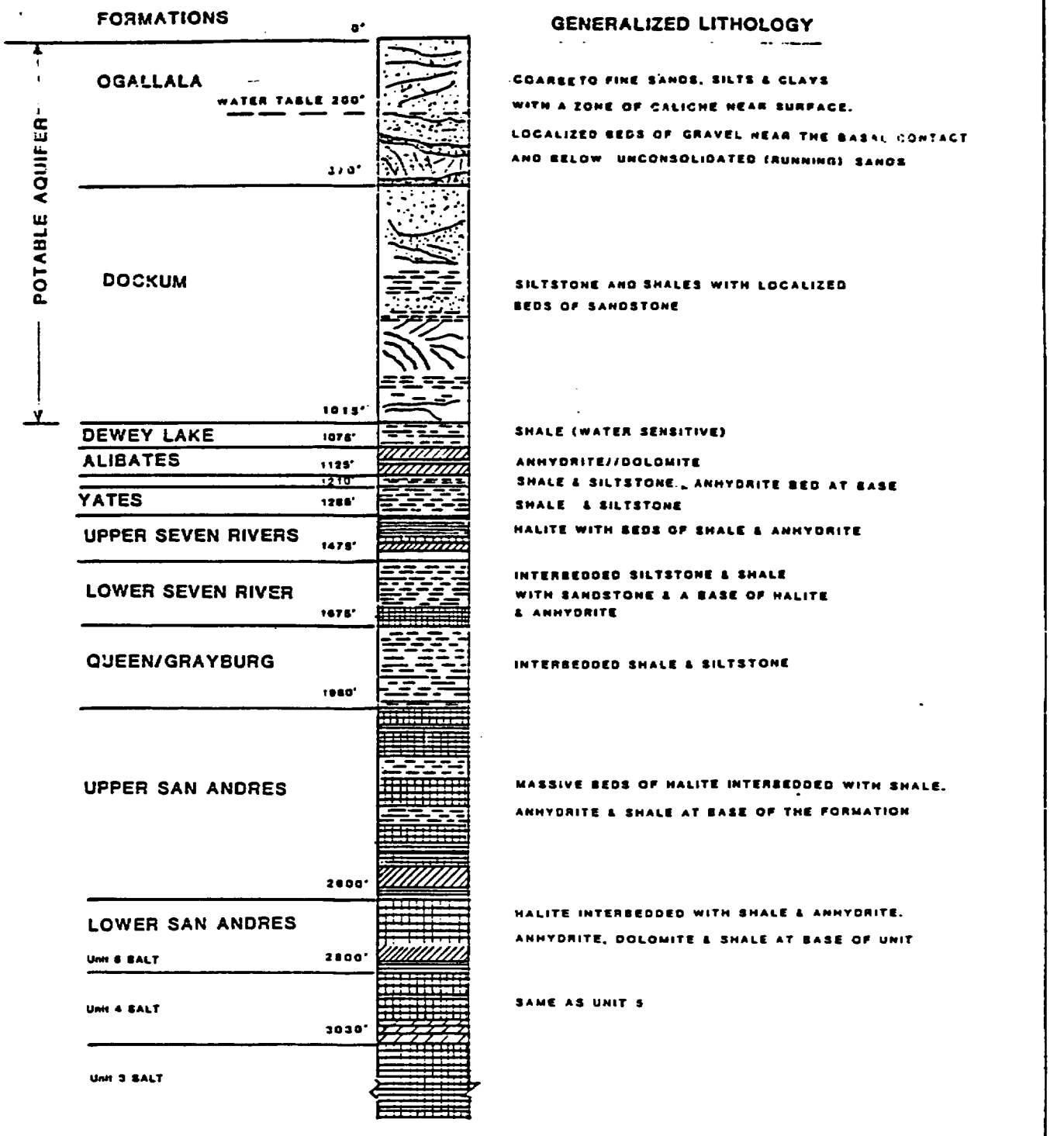


Figure 5. Potash Corporation of Saskatchewan's Lanigan Mine, Saskatchewan, Canada



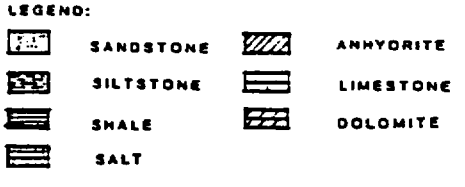


Figure 6. Generalized Stratigraphy, Two Shaft Study Permian Basin, Texas, Deaf Smith County

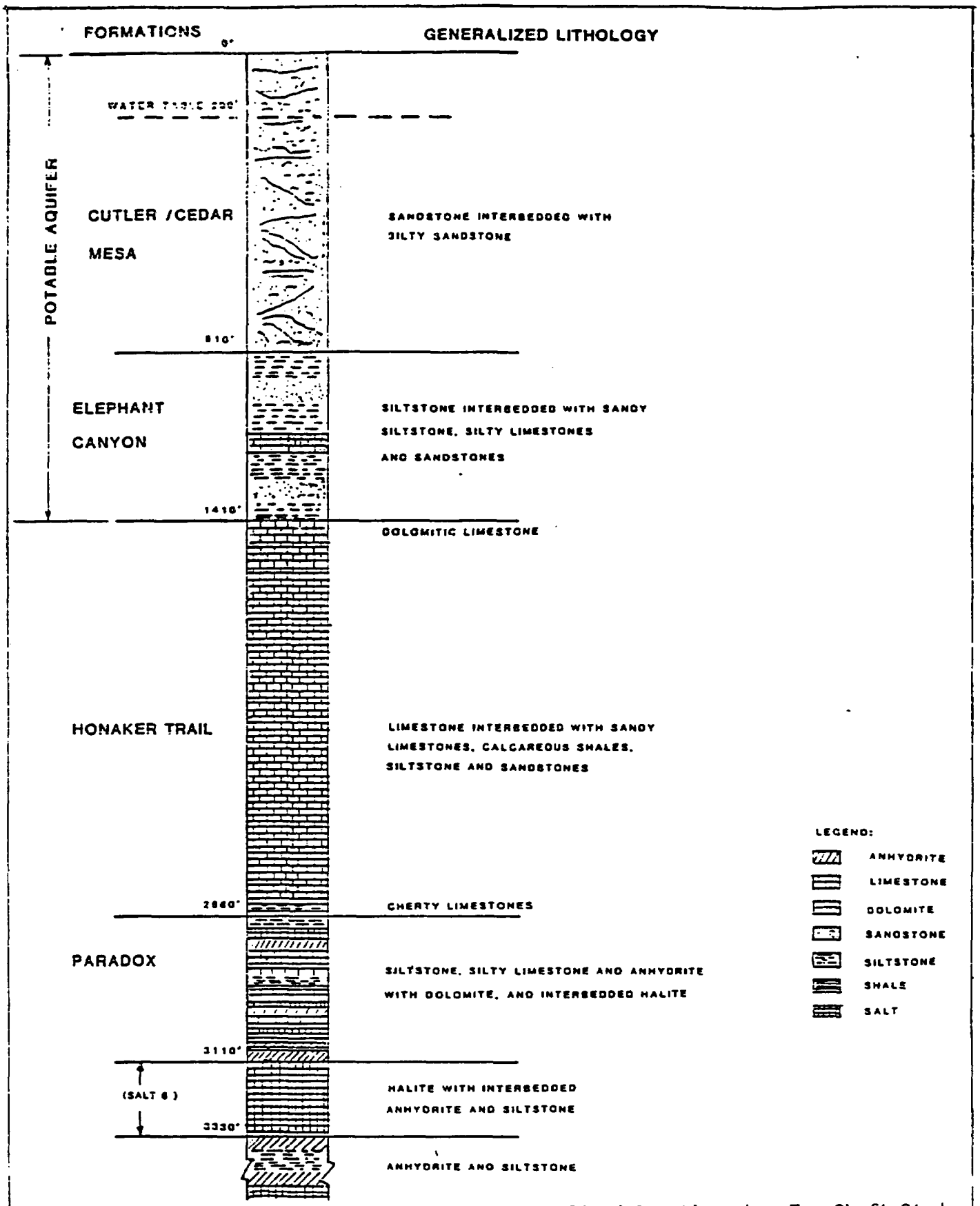
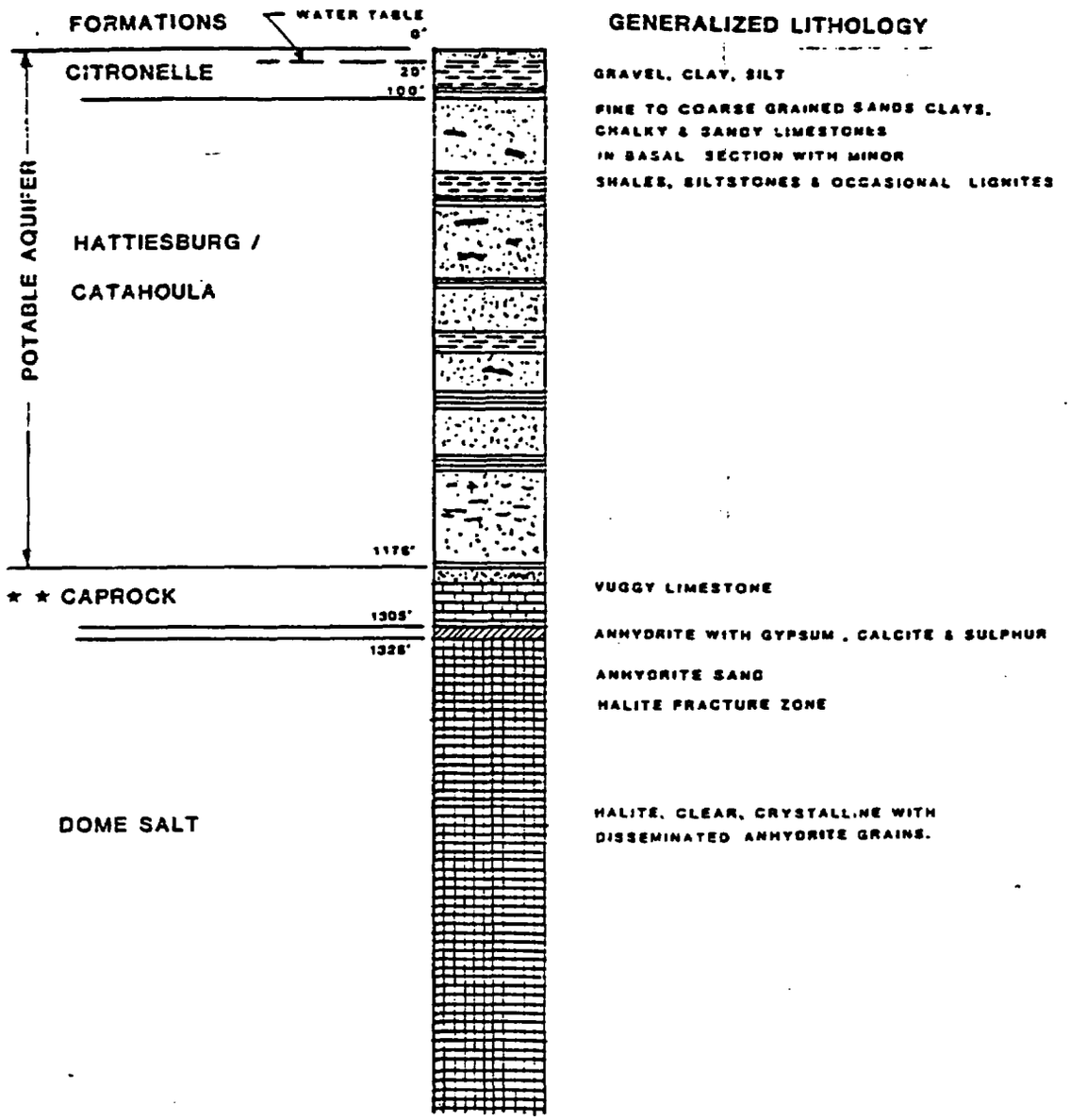


Figure 7. Generalized Stratigraphy, Two Shaft Study Paradox Basin, Utah, Davis County



STRATIGRAPHY

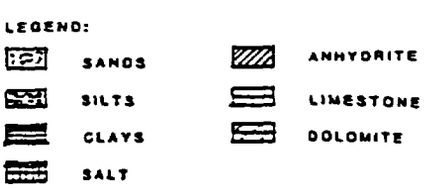
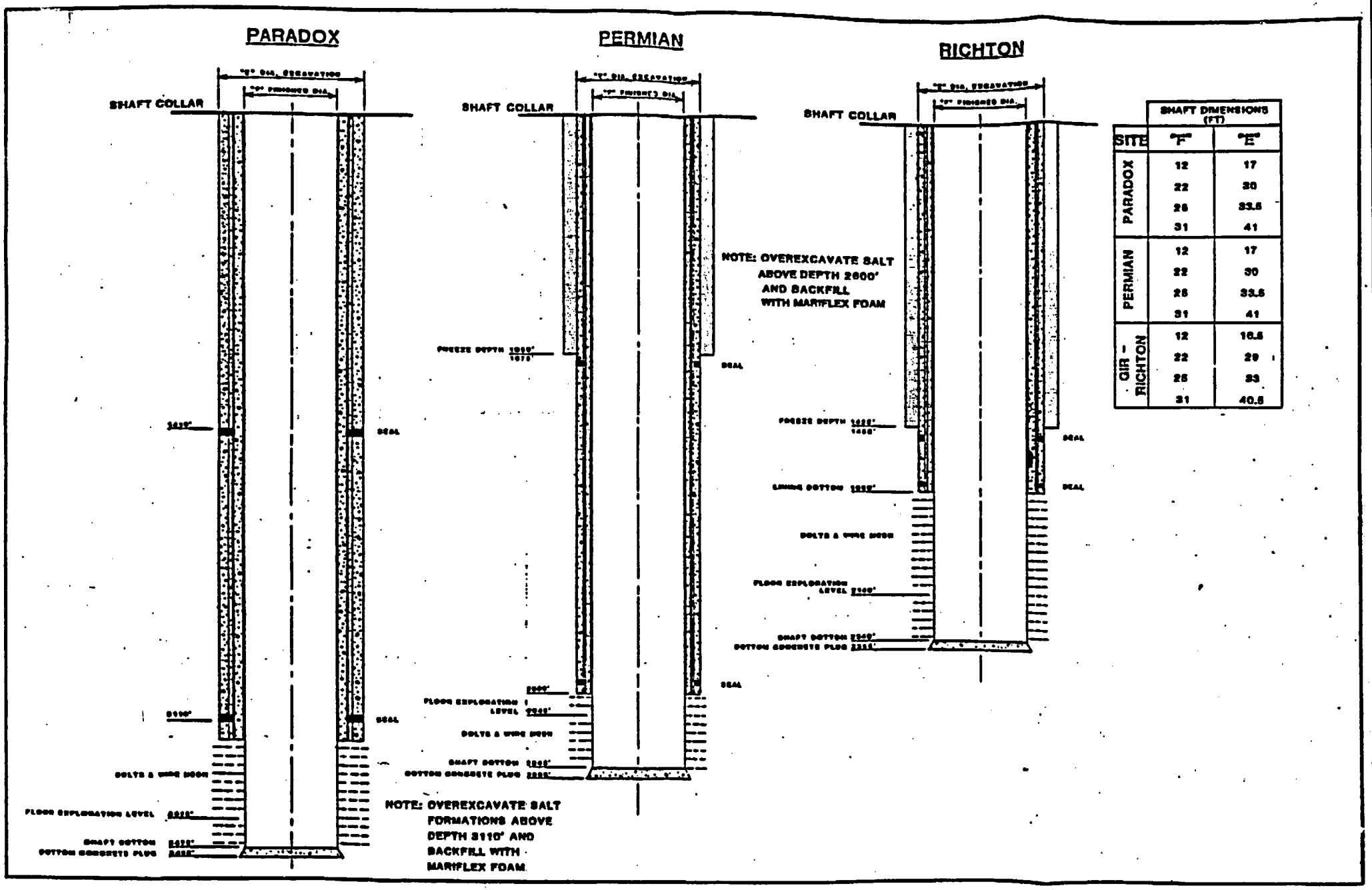
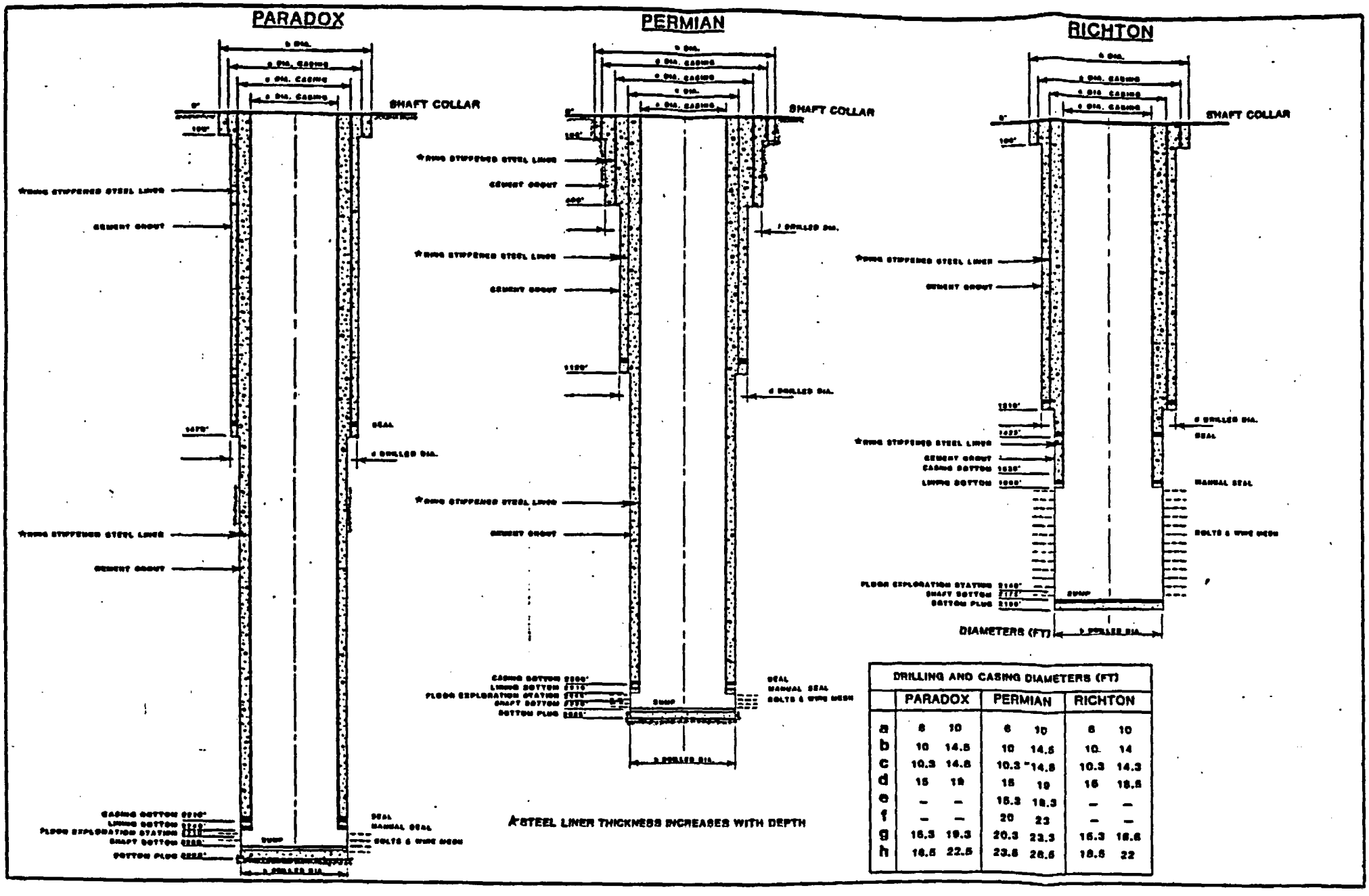


Figure 8. Generalized Stratigraphy, Two Shaft Study Gulf Interior Region, Miss., Richton Dome



SITE	SHAFT DIMENSIONS (FT) "F"	"E"
PARADOX	12	17
	22	30
	25	33.5
	31	41
PERMIAN	12	17
	22	30
	25	33.5
	31	41
GIR - RICHTON	12	16.5
	22	29
	25	33
	31	40.5

Figure 9. Two Shaft Study, Conventional Sinking by Drilling and Blasting



DRILLING AND CASING DIAMETERS (FT)						
	PARADOX		PERMIAN		RICHTON	
a	8	10	6	10	8	10
b	10	14.5	10	14.5	10	14
c	10.3	14.8	10.3	14.8	10.3	14.3
d	15	19	15	19	15	18.5
e	–	–	15.3	18.3	–	–
f	–	–	20	23	–	–
g	16.3	19.3	20.3	23.3	16.3	18.6
h	18.5	22.5	23.6	26.6	18.5	22

Figure 10. Two Shaft Study, Casing Arrangement

TABLE 1. NORTH AMERICAN MINE SHAFT GROUND FREEZING

Mine	Location	Year Started/ Ended	Shaft Dimensions (M)	Shaft Depth (M)	Freeze Depth (M)	Type of Formation	Remarks	Contractor
Chapin Mining Co.	Iron Mt., MI	1888	4 x 5		30	Glacial Till		
Morton (Myles Salt Co.)	Louisiana	1901/'03	4.9	228	761	Domal Salt		
Potash Corp. of America	Carlsbad, NM	1952	4.6	233	107	Bedded Potash		
Potash Corp. of America	Sask., Canada	1955	4.9	1,051	914	Bedded Potash		
International Minerals & Chemical Corp.	Esterhazy, Sask., Can.	1957	5.5	1,030	0-70 363-437	Bedded Potash		Thyssen of Canada
Morton (Weeks Island)	Louisiana	1958	5.5	243	76			
Duval Corporation	Carlsbad, NM	1963	4.26 & 3.65	305&279	128	Bedded Potash		
International Minerals	Esterhazy, Sask., Can.	1963/'67	5.64	1,021	468	Bedded Potash	Glacial till, Blairmore Wet dolomites and salt Freezing 0 to 473 M Grouting 473 to 915 M	Cementation of Canada
PCS*(Allan Potash Mines #1)	Sask., Canada	1964	4.9	1,089	625	Bedded Potash		Thyssen of Canada
PCS (Allan Potash Mines #2)	Sask., Canada	1964	4.9	1,089	625	Bedded Potash		Thyssen of Canada
PCS (Alwinsal Potash of Can. #1)**	Canada	1964	5.5	1,004	527	Bedded Potash		Thyssen of Canada
Noranda Mines Ltd. #1	Canada	1965/'68	4.9	1,052	591	Bedded Potash	Glacial till, Blairmore Wet dolomites and salt Freezing 0 to 548 M Grouting 548 to 915 M	Thyssen/Cementation of Canada
Noranda Mines Ltd. #2	Canada	1965/'68	4.9	1,052	591	Bedded Potash	Glacial till, Blairmore Wet dolomites and salt. Freezing 0 to 548 M Grouting 548 to 915 M	Thyssen/Cementation of Canada
Cominco Ltd.	B.C., Canada	1965/'68	4.9 & 5.64	1,089	684	Bedded Potash	Glacial till, Blairmore Wet dolomites and salt Freezing 0 to 610 M Grouting 610 to 915 M	Thyssen/Cementation of Canada
Potash Corp. of America	Sask., Canada	1967/'69	5.5	1,068	548	Bedded Potash	Glacial till, Blairmore Wet dolomites and salt Freezing 0 to 548 M Grouting 548 to 915 M	Cementation of Canada
PCS (Sylvite #1)	Canada	1967	4.9	1,021	461	Bedded Potash		Thyssen of Canada
PCS (Sylvite #2)	Canada	1967	4.9	1,000	469	Bedded Potash		Thyssen of Canada
Cargill, Inc.	Louisiana, Belle-isle	1969/'71	4.9	378	70	Domal Salt	Ground frozen to 70 M Conventional sinking in salt dome thereafter.	
Cargill, Inc.	Louisiana, Belle-isle	1973/'76	4.9	478	76	Domal Salt	Extensive ground investigation, ground frozen to 76 M.	Cementation of Canada
PCS (Alwinsal #2)**	Canada	1974	4.26	1,004	527	Bedded Potash		Thyssen of Canada
Amax Coal Co.	Illinois	1974	6.09	228	38	Coal		
Diamond Crystal	Louisiana	1975	2.44	470	70	Domal Salt		
Island Creek Coal Co.	Kentucky	1975	6.09	122	54	Coal		
Morton Salt Co.	Louisiana	1977	5.5	381	64	Domal Salt		Frontier Kemper & Deilmann-Haniel
Peabody Coal Co.	Illinois	1978	6.09	122	53	Coal		
Selco Mining Corp.	Quebec, Can.	1979	3.65	61	61			
White County Coal Corp.	Illinois	1979	6.7x9.8, 6	335	41	Coal		
Domtar, Inc.	Goderich, Ont.	1980	6.09	518	61	Bedded Salt	Involves freezing to 107 M and grouting to 229 M.	Cementation of Canada
Les Mine Salin	Mad. Is., Can.	1980	6.70	122	43	Bedded Salt		
Turris Coal Co.	Illinois	1981	5.5, 6.09 & 7.3	87	64	Coal		
Asarco Exploration	Timmons, Ont.	1981	3.65	174	43	Glacial Till		
Repository								
Gorleben	West Germany	1984	7.5	1,300	600	Domal Salt		Thyssen & Deilmann-Haniel
Permian	Texas, U.S.A.	?	6.7, 7.6, & 9.4	871	320	Bedded Salt		
Richton	Mississippi, U.S.A.	?	6.7, 7.6, & 9.4	718	434	Domal Salt		
Paradox	Utah, U.S.A.	?	6.7, 7.6, & 9.4	1,060	-	Bedded Salt		

*PCS: Potash Corporation of Saskatchewan

**The PCS's Lanigan Mine was originally built, owned, and operated by Alwinsal Potash of Canada, Ltd.

TABLE 2. SHAFT FREEZING AND SINKING PROJECTS COMPLETED BY THYSSEN WORLDWIDE

	Commencement	Name of Plant/Shaft	Finished Diameter M	Frozen Length M	Final Depth M	Owner	Country	Remarks
1	1905	Friedrich Thyssen 5	5,5	150	500	Gewerkschaft Deutscher Kaiser (D)	W. Germany	
2	1907	Lohberg 1	6,3	415	890	Gewerkschaft Lohberg (D)	W. Germany	
3	1907	Lohberg 2	6,3	415	750	Gewerkschaft Lohberg (D)	W. Germany	
4	1908	Prosper 7	6,25	90	90	Arenberg'sche AG f. Bergbau und Hüttenbetrieb, Essen (D)	W. Germany	
5	1910	August Thyssen	4,0	210	390	Saar- und Mosel-Bergwerksges. (D)	W. Germany	
6	1910	Wilhelmine	4,5	30	170	Bergbauges. Wilhelmine (D)	W. Germany	
7	1911	Wehofen 1	6,3	330	600	Gewerkschaft Rhein 1 (D)	W. Germany	
8	1911	Arenberg – Fortsetzung 1	6,25	90	90	Arenberg'sche AG f. Bergbau und Hüttenbetrieb, Essen (D)	W. Germany	
9	1911	Carlsglück	4,5	30	170	Bergbauges. Carlsglück (D)	W. Germany	
10	1911	Alicenhall	4,5	50	200	Bergbauges. Alicenhall (D)	W. Germany	
11	1911	Zwartberg 1	5,25	560	560	Sé. An. pour l'Exploitation de la Concession Charbonnière des Liègeois en Campine (B)	Belgium	
12	1911	Zwartberg 2	5,25	560	560	Sé. An. pour l'Exploitation de la Concession Charbonnière des Liègeois en Campine (B)	Belgium	
13	1912	Oranje-Nassau 3	6,0	160	240	Mij. tot Exploitatie van Limburgse Steenkolenmijnen, Heerlen (NL)	Netherlands	
14	1913	Oranje-Nassau 4	4,5	210	240	Mij. tot Exploitatie van Limburgse Steenkolenmijnen, Heerlen (NL)	Netherlands	
15	1919	Beeckerwerth 1	6,4	160	583	Gewerkschaft Friedr. Thyssen (D)	W. Germany	

	Commencement	Name of Plant/Shaft	Finished Diameter M	Frozen Length M	Final Depth M	Owner	Country	Remarks
16	1919	Beeckerwerth 2	6,4	160	380	Gewerkschaft Friedr. Thyssen (D)	W. Germany	
17	1922	Friedrich Thyssen 8	6,2	85	700	Gewerkschaft Friedr. Thyssen (D)	W. Germany	
18	1922	Walsum 1	6,2	340	850	Gewerkschaft Walsum (D)	W. Germany	
19	1922	Walsum 2	6,5	340	833	Gewerkschaft Walsum (D)	W. Germany	
20	1930	Gneisenau 4	7,6	70	500	Harpener Bergbau AG (D)	W. Germany	
21	1930	Königsborn 5	6,5	20	188	Klöckner Werke AG (D)	W. Germany	
22	1931	Faulquemont 1	6,5	520	720	Société des Charbonnages de Faulquemont (F)	France	
23	1931	Faulquemont 2	6,5	509	720	Société des Charbonnages de Faulquemont (F)	France	
24	1935	Schwimmerschächte Hohenwarthe (4 Stück)	13,0	110	78	Preuß. Neubauamt Magdeburg (D) (Kanalbau)	W. Germany	
25	1936	Rumeln	5,3	168	517	Bergwerksgesellschaft Diergardt-Mevissen (D)	W. Germany	
26	1937	Emil Mayrisch 1	6,5	465	875	Eschweiler Bergwerks-Verein (D)	W. Germany	
27	1937	Emil Mayrisch 2	6,5	475	875	Eschweiler Bergwerks-Verein (D)	W. Germany	
28	1941	Andreas 4	5,0	200	464	Bergwerksverwaltung Oberschlesien	W. Germany	
29	1941	Junghannschacht	5,77	50	210	Bergwerksverwaltung Oberschlesien	W. Germany	
30	1941	Rossenray 1	7,2	365	970	Bergwerke Essen-Rossenray AG, Essen (D)	W. Germany	

	Commencement	Name of Plant/Shaft	Finished Diameter M	Frozen Length M	Final Depth M	Owner	Country	Remarks
31	1941	Rossenray 2	7,2	375	905	Bergwerke Essen-Rossenray AG, Essen (D)	W. Germany	
32	1948	St. Charles IV	6,0	255	680	Houillères du Bassin de Lorraine; Groupe de Petite-Roselle (F)	France	
33	1951	Franzschacht	6,0	84	640	Eschweiler Bergwerks-Verein (D)	W. Germany	
34	1954	Niederberg III	5,5	230	500	Niederrheinische Bergwerks AG, Neukirchen (D)	W. Germany	
35	1958	Nordlicht-West	7,25	90	680	Arenberg Bergbauges. mbH, Hauptverwaltung Essen (D)	W. Germany	
36	1958	Warndtschacht	7,5	348	750	Saarbergwerke AG, Saarbrücken (D)	W. Germany	
37	1959	Niederberg IV	5,5	290	510	Niederrheinische Bergwerks AG, Neukirchen (D)	W. Germany	
38	1960	Kellingley No. 1	7,32	195	791	National Coal Board, London (GB)	England	
39	1960	Kellingley No. 2	7,32	195	768	National Coal Board, London (GB)	England	
40	1960	Staffhorst	6,75	260	1100	Barbara Erzbergbau AG, Düsseldorf (D)	W. Germany	
41	1960	Yarbo	5,5	597	1030	International Minerals & Chemical Corporation, Esterhazy/Sask. (CDN)	Canada	
42	1962	Lohberg 3	6,5	450	910	Hamborner Bergbau AG, Duisburg (D)	W. Germany	
43	1963	Niederberg V	7,4	240	820	Niederrheinische Bergwerks AG, Neukirchen (D)	W. Germany	
44	1964	Allan 1	4,88	625	1089	Allan Potash Mines, Allan/Sask. (CDN)	Canada	
45	1964	Allan 2	4,88	625	1089	Allan Potash Mines, Allan/Sask. (CDN)	Canada	

	Commencement	Name of Plant/Shaft	Finished Diameter M	Frozen Length M	Final Depth M	Owner	Country	Remarks
46	1964	Alwinsal 1 (Lanigan)	5,5	527	1004	Alwinsal Potash of Canada, Lanigan/Sask. (CDN)	Canada	
47	1965	Noranda 1	4,88	591	1052	Noranda Mines Ltd., Colonsay/Sask. (CDN)	Canada	
48	1965	Noranda 2	4,88	591	1052	Noranda Mines Ltd., Colonsay/Sask. (CDN)	Canada	
49	1967	Sylvite 1 (PCS)	4,88	461	1022	Sylvite of Canada Ltd., Rocanville/Sask. (CDN)	Canada	
50	1967	Sylvite 2 (PCS)	4,88	469	1000	Sylvite of Canada Ltd., Rocanville /Sask. (CDN)	Canada	
51	1969	Boulby Mine No. 1	5,5	600–930	1149	Cleveland Potash Ltd., (GB)	England	
52	1971	Leonie 1	5,0	185	190	Eisenwerk-Ges. Maximilians-hütte mbH, Sulzbach-Rosenberg (D)	W. Germany	
53	1974	Alwinsal 2 (Lanigan)	4,27	527	1006	Alwinsal Potash of Canada, Lanigan/Sask. (CDN)	Canada	
54	1977	Lauterbach	7,0	220	950	Saarbergwerke AG, Saarbrücken (D)	W. Germany	
55	1977	Fulpmes	7,0	105	180	Österreichische Bundesbahn, Wien (A)	Austria	
56	1978	Stillingfleet No. 1	7,32	165	722	National Coal Board, London (GB)	England	
57	1978	Stillingfleet No. 2	7,32	165	722	National Coal Board, London (GB)	England	
58	1979	Whitemoor No. 1	7,32	307	964	National Coal Board, London (GB)	England	
59	1979	Whitemoor No. 2	7,32	307	964	National Coal Board, London (GB)	England	
60	1979	Polsum 2	8,0	98,5	652	Ruhrkohle AG, Essen (D)	W. Germany	

	Commencement	Name of Plant/Shaft	Finished Diameter M	Frozen Length M	Final Depth M	Owner	Country	Remark
61	1982	Hünxe	8,0	328	1350	Ruhrkohle AG, Essen (D)	W. Germany	
62*	1983	Gorleben 1	7,5	270	900	Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe m.b.H. (DBE)	W. Germany	
63*	1983	Gorleben 2	7,5	270	810	Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe m.b.H. (DBE)	W. Germany	

*Ground Freezing projects for West German Nuclear Waste Program.

PCS = Potash Corporation of Saskatchewan

Concurred in draft by WF Jebb 3/17/86
Approved:_____Date_____
FC Hood, QAD Manager

TEKE

Battelle
Project Management Division

Project Number_____

Attachment III

Internal Distribution
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Date March 18, 1986

To Distribution

From H. P. Nunes

Subject ESF DESIGN COORDINATOR MEETING MINUTES
PARSONS BRINCKERHOFF/PB-KBB, FLUOR, ONWI, SRPO
MARCH 4-6, 1986, HOUSTON, TEXAS

A meeting was held at the Parsons Brinckerhoff/PB-KBB (PB/PB-KBB) offices, Houston, Texas, to resolve design approach differences between the ESF and Repository A/E design firms of Fluor Engineers, Inc. and PB/PB-KBB. The meeting lasted 2 1/2 days with discussions between the A/E's focusing on the following topics:

a. Shaft seals should be based on an 100 year design life with maintenance being permitted.

b. Dry shaft definitions.

c. Programmatic geological term definition.

d. Shaft liner design configuration.

e. Bitumen, chemical, and pikotage seal design, installation and performance.

f. Design basis approach.

g. Agenda for Columbus, Ohio, design approach coordination meeting, March 18-19, 1986.

The results of this coordination effort produced a number of key agreements:

a. Geological term definitions for aquifer, aquitard, and aquiclude [Attachment 1].

b. Generic shaft liner configuration [Attachment 2].

c. Dry shaft definition [Attachment 3].

Additional data needs were identified with action items assigned to support the Columbus, Ohio, meeting:

a. Seismic design factor (ONWI).

b. Translation of German design document: "Asphalt as a Sealant in Shaft Construction" (ONWI).

c. Scope of work statement for Fluor report on design and construction - basic approach for conventionally mined shafts (ONWI).

d. Report on WIPP chemical seal usage experience (ONWI).

e. Freeze hole grouting-Corps of Engineers data (SRPO).

Attached for information is the Columbus, Ohio, Coordination Meeting Agenda (Attachment 4) and the Houston, Texas, attendance sheet (Attachment 5).

From a subjective standpoint, ONWI was key in maintaining the thrust to reach common agreement between the two A/E's. While at times each A/E presented very discreet arguments in support of their design position, it appeared that no agreements would be reached other than by third party arbitration. The joint positions presented here were major accomplishments for this coordination effort.

HPN:epp

QA-86-224

An <u>AQUIFER</u> is defined as a water-bearing stratum or sequence of strata that has the capability to store groundwater and the potential to yield water to wells or open excavations in useable quantities, or in quantities requiring control, respectively.

* An <u>AQUITARD</u> is a stratum or sequence of strata of relatively low permeability which retards the flow (or migration) of water.

* An <u>AQUICLUDE</u> is a stratum which is essentially impermeable and prevents the flow (migration) of groundwater between aquifers.

* Definitions generally paraphrased from <u>Construction Dewatering: A Guide to Theory & Practice</u>, J. Patrick Powers, 1981.

ATTACHMENT 2

HOUSTON
3-5-86

0'

ENVIRONMENTAL SEAL CONCERN

PRIMARY CONCRETE LINER
BITUMEN - SINGLE STEEL SHEET W/ REINFORCED CONCRETE
(SUBJECT TO SEISMIC EVALUATION)

ALI BATES 1100 ± (NOT BELOW 1200')

IF WATER

STEEL SANDWICH W/GROUT
OR + CHEMICAL SEAL REDUNDANT

ALT FOR CONSIDERATION ~ TUBBING OR COMBINATION THEREOF

OR

REINFORCED CONCRETE ONLY
WITHOUT WATER.

2400 ±

NOTE: PICTAGE OPTIONAL FOR SHORT SECTIONS OF WATERTIGHT (INC. TUBBING) LINING

ATTACHMENT 3

DRY SHAFT DEFINITION

MARCH 6, 1986

Allowable Inflows

Surface to approximately 1100 Ft. (Steel + Concrete + Bitumen Lining)	=	Zero Inflow
Approximately 1100 Ft. to Shaft Bottom	=	0.2 GPM

No Point Source Inflow to Exceed 0.1 GPM in This Zone.

Condensation Would be Additional to Above Inflow Rates.

ATTACHMENT 4

PROPOSED AGENDA
ESF/REPOSITORY INTEGRATION MEETING
COLUMBUS, OHIO
MARCH 18-19, 1986

March 18, 1986

Design Value - Status Report (ONWI)	30 Minutes
ESF-Licensing Approach (PB/PB-KBB)	30 Minutes
Shaft Design Guide (Fluor)	60 Minutes
FDC - Title [illegible] Revision 6 (ONWI)	30 Minutes
ESF - Title [illegible] Design Schedule (PB/PB-[illegible])	30 Minutes
Lunch	
Appendix "E" Update (ONWI)	30 Minutes
Review of German Shaft Guidelines (PB/PB-KBB)	60 Minutes
Loading Assumptions and Design Approach for Shaft Liner (PB/PB-KBB) (Fluor)	60 Minutes 60 Minutes
Seismic Approach (PB/PB-KBB) (Fluor)	30 Minutes 30 Minutes

PROPOSED AGENDA
ESF/REPOSITORY INTEGRATION MEETING
COLUMBUS, OHIO
MARCH 18-19, 1986
(CONTINUED)

March 19, 1986

Freeze Depth (Fluor)	30 Minutes
EDBH - Status Report (ONWI)	30 Minutes
Proposed Seal Locations (Fluor)	30 Minutes
Lunch	
ESF - Title II Design Value Needs (PB/PB-KBB)	30 Minutes
ESF - Future Testing Potential (SRPO/ONWI)	30 Minutes
Draft Meeting Minutes (ONWI/PB/Fluor)	60 Minutes

ATTACHMENT 5

ESF/REPOSITORY INTEGRATION MEETING
HOUSTON

3/4/86

NAME	AFFILIATION	PHONE
William F Jobb	ONWI	424-4572
IVAN COTTLE	"	614 424 5258
ROBERT S. SAUNDERS	MKE	208 386 5434
WITOLD, J. OSTROWSKI	MKE	303 988 8039
DICK SNELL	FLWOR	714 975-5038
Maurice Grieves.	P.B.	415 274 4500
BILL BROWN	FLUOR	714 975-5069
Pen Whiton	MKE	208 382-5267
Sigi Poppen	PB/PB-KBB	713-531-6069
Gunter Matthes	PB/PB-KBB	303-431 4311
Harry Glaser	PB/PB-KBB.	713-531-6069.
MAHMOOD B. MIRZA	PB/PB-KBB	" " "
Randy Lentell	PB/PB-KBB (WCC)	713-531-6069
STEVE WEBSTER	DOE/SRPO	FTS 976-5916
MANNY COMAR	ONWI	614-424-4952
B.R. Chytrowski	ONWI	(614) 424-6504
H.P. NUNES	ONWI	614-424-7604
BOB JANOWSKI	PB/PB-KBB	713 531 6069
DEBRICK WAGG	WESTON/Jacobs	301-963-6843

Attachment IV

Battelle
Project Management Division

Distribution: J. Fitch, C. Kuntz, A. Razem, K. Oschman, O. Swanson, M. Ferrigan, J. Powell, H. Kalia, J. S. Treadwell, W. Carbiener, ONWI Files, FOD Files, CN Files (2), LB J. A. Sherwin, B. J. Solomon, V. Lepardo (Fluor), J. Fitch (Fluor)

VC No. FOD-SRPO-184
Page 1 of 6
Date March 17, 1986
WBS No.
WP No.
Distribution:
Program Manager
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Technical Department Manager
All Participants

DOCUMENTATION OF VERBAL COMMUNICATION

Subject: Data Integration Meeting

Recorded By Owen E. Swanson OES Date and Time March 12-13, 1986

Participants (name, organization, telephone)
SWEC - T.J. Lamb, D.H. Corkum, A.O. Gokce, E.M. Washer, Heather Atwood, Larry Picking
Woodward-Clyde/Fluor - Peter Solberg; MKE/Fluor - K. K. Bhattachwayya; PB/PB-KBB(TMCI) - S.A.G. Poppen; Woodward-Clyde (PB/PB-KBB) - Randy Lentell; SRPO - J. Powell, M. Ferrigan; ONWI - O.E. Swanson, K.P. Oschman, Allan Razem, C. Kuntz

____ Telephone Conversation
____ Incoming
____ Outgoing

X Meeting
____ Columbus
X SWEC Offices, Boston

Item	Description of Discussion	Action Responsibility
SUMMARY	The purpose of the meeting between the ESF and Repository AEs, SRPO, ONWI and SWEC was to accomplish the items listed on the Agenda prepared following the February 25-26, 1986, meeting in Columbus between the ESF AE, ONWI and SWEC.	
1.	A. Review and Approval of Detailed Stratigraphy - "Hypothetical J. Friemel Core Log at ESF Location" Dockum through LSA#3	

Concurrence of Other Participant:

Signed by [illegible] 3/13/86

[illegible] 3/13/86

[illegible] DOE/SRPO 3/13/86

[illegible] 3/13/86

Approved for Release:

[illegible]
Responsible Manager
ONWI-029-86-67

BPMD-292-1 (8/85)

In draft

Battelle
Project Management Division

VC No. _____
Page 2 of 6
Date March 17, 1986

DOCUMENTATION OF VERBAL COMMUNICATION (Continued)

Item	Description of Discussion (Continued)	Action Responsibility
	- Accomplishments o The hypothetical log was reviewed, accepted and signed by all parties for Dockum through LSA #3 o Depths to top of formations are consistent throughout the stratigraphic depictions, the hydrostratigraphic units described, and the synthetic geophysical logs. - Further actions to be accomplished: o PB/PB-KBB will computerize the 1" - 10' (variable) hypothetical core log of J. Friemel at ESF location and produce an actual 1" - 10' finished product. o Ogallala stratigraphy and soils parameters for both Ogallala and Dockum formations will be finalized during the core meeting at Austin the week of March 17 or March 24 (TBD). o SWEC will provide a generalized description to fill in areas where conventional drilling or loss of core recovery precluded derivation of descriptions utilizing J. Friemel data. This informatioan will be provided to PB/PB-KBB by about March 24, 1986, or earlier, upon receipt from SWEC. o C. Kuntz will provide the last page of the log to PB/PB-KBB which was not ready for this meeting but will be by March 17, 1986. o C. Kuntz will, in the Dockum formation, break out the water bearing unit (Santa Rosa) from the units within Dockum above and below.	

DOCUMENTATION OF VERBAL COMMUNICATION (Continued)

Item	Description of Discussion (Continued)	Action Responsibility
	B. Review and Approval of Geophysical Logs - Accomplishments: 5 logs have been produced by SWEC at 1" = 10' based on J. Friemel formation tops (consistent with hypothetical core logs at ESF). Logs have been compressed, or expanded to accommodate (geometric) thickness variations. These five have been accepted and signed by all parties. (1) CCR-computed grammaray (2) NPH-neutron porosity (3) RHOB-bulk density (4) DT-internal transit time (5) Cali-Caliper - Further Actions o An additional 11 logs are to be utilized at the EDBHs, but 5 of these are not susceptible to synthesis and will not be produced by SWEC for this exercise. o The 6 to be produced (but not for 60 days) are: (1) Temperature - although J. Friemel log is of very questionable value and will not be used, a gradient will be presented with 81°F at repository depth decreasing by 1.1°F/100 up to the base of the Dockum. (2) SP - 1st 1100' only (below water table) (3) SGR - gamma spectrometer (4) Dual induction laternal log (5) Borehole deviation - to be shown only as a log to be available in EDBHs (6) microresistivity	

DOCUMENTATION OF VERBAL COMMUNICATION (Continued)

Item	Description of Discussion (Continued)	Action Responsibility
	There are 5 logs which were not available from J. Friemel and will not be synthesized - (1) Mechanical properties log - a synthetic log in itself, this would be beyond the potential of the computer. (2) Dip meter fracture log - The log has not worked in the past, J. Friemel gave misleading results in salt, bedding planes, if horizontal were ok but inclined fractures could be 90 percent off if salt filled. A new tool is being considered for actual EDBH applications. (3) Casing potential. (4) Bore hole televiewer. (5) Vertical seismic profit (VSP) C. Status of Graphic Log The log, scale 1" = 50' was approved with the need for the following: - C. Kuntz/ONWI will revise the 1" = 50' chart to reflect Dockum through LSA #3 and fill the blank columns as requested by PB/PB-KBB. This action should be accomplished by April 1, 1986, and the shaft inflow filled in by ONWI following completion of SWEC calculations, due April 1,1986.	
2.	Review and Approval of Proposed Programmatic Design Rock Mechanics Matrix - Accomplishments o The matrix values were rounded to accommodate programmatic convention by K. Oschman and results accepted by all. o 5 corrections made by K. Oschman during his review were presented and accepted.	

DOCUMENTATION OF VERBAL COMMUNICATION (Continued)

Item	Description of Discussion (Continued)	Action Responsibility
	o Strength values (cohension and friction) were reviewed by all participants to assure consistency in approach and agreement of parameters. These were accepted by all. - Actions o Dockum parameters will be derived at the core meeting. A. Review and Approval of Proposed Programmatic Design Hydro-Matrix - Accomplishments o All values presented were reviewed and accepted by all (these included the recent work by D. Markley and H. Atwood) for the Ogallala, Dockum, Queen/Grayburg and LSA 4 Carbonate. o These parameters (matrix and design value sheets) were accepted by all for the units listed. - Actions o The matrix values for the Dewev Lakes, Alibates, Salado, Yates, Upper/Lower Seven Rivers, Upper San Andres and Lower San Andres 5 will be provided by L. Picking/SWEC by April 1 as they complete calculations of water inflow (B below). B. Status of Calculation of Water Inflow into Shaft - Accomplishments - Work by SWEC is in progress - Actions - to be completed by April 1, 1986, by SWEC - the values used to do calculations will allow completion of the remaining matrix sections (formations listed above). o A follow-on meeting is required to review and approve the water inflow and the remaining matrix sections.	
4.	Discuss Seismic Design Criteria (See Attachment 1) The value of 0.2g was accepted for surface ground acceleration by all. This is a conservative value for SSE.	

Battelle
Project Management Division

VC No. _____
Page 6 of 6
Date March 17, 1986

DOCUMENTATION OF VERBAL COMMUNICATION (Continued)

Item	Description of Discussion (Continued)	Action Responsibility
5.	Status of Mineralogy Summary Scheduled for completion by March 21, 1986, by SWEC. The proposed format attached is fine with exception of a total Dockum presentation. This will be split into 3 units, above, and below Santa Rosa, and Santa Rosa (principal water bearing unit). The mineralogy values are keyed to the Rock Mechanics Matrix.	
6.	Status of Frozen Soil Strength Literature Review - Draft due from WCC by March 27, 1986. It was suggested that the WCC author attend the core/sample visit to TBEG to allow hands-on correlation of sample/core to frozen soil properties.	
7.	Plan TBEG trip to finalize Ogallala Stratigraphy and Engineering Properties - Action - PB/PB-KBB will develop a list of soils properties requirements and foundation design recommendations prior to the trip for Ogallala and Dockum as appropriate. - Potential attendees - o SWEC Soil Engineer - Tom Chang o SWEC - Dave Corkum o ONWI - Jebb/Swanson - C. Kuntz/K. Oschman o PB/PB-KBB - R. Lentel, S. Poppen, G. Mathes o Fluor - TBD o TBEG - 1 probable (Steve Senni) o SRPO - TBD - Potential dates March 20, 21, 1986	
8.	The proposed SRP information sheets were distributed and discussed.	

AGENDA

Data Integration Meeting

March 12 and 13, 1986

SWEC Offices, Boston

1.	Stratigraphy	
	A. Review and Approval of Detailed Stratigraphy	C. Kuntz (ONWI)
	B. Review and Approval of Geophysical Logs	T. Lamb (SWEC)
	C. Status of Graphic Log	C. Kuntz (ONWI)
2.	Review and Approval of PB's Rock Mechanics Data Matrix Tables	K. Oschman (ONWI)
3.	Hydrology	
	A. Review and Approval of PB's Hydrologic Chart	R. Lentell (PB)
	B. Status of Calculation of Water Inflow into Shaft	L. Picking (SWEC)
4.	Discuss Seismic Design Criteria	(ONWI/SWEC)
5.	Status of Mineralogy Summary	D. Corkum (SWEC)
6.	Status of Frozen Soil Strength Literature Review	K. Oschman (ONWI)
7.	Plan TBEG Trip to finalize Ogallala and Dockum Stratigraphy and Engineering Properties	All
8.	Closure	All
	A. Summarize Meeting	
	B. Develop Action Items and Completion Schedule	
9.	Freeze Design holes	

DATA INTEGRATION MEETING

March 12-13, 1986

T. J. Lamb	Project Geotechnical Engr.	SWEC
D. H. Corkum	Assoc. Geologist	SWEC
O. E. Swanson	Surface Testing	ONWI
K. P. Oschman	Engineering Geologist	ONWI
A. O. Gokce	Associate Geologist	SWEC
E. M. Washer	Project Manager	SWEC
K. K. Blattachwayya	P. E. Geotechnical	MKE/Fluor
J. R. Fitch	Project	Fluor
Peter Solberg	Geologist	Woodward-Clyde/Fluor
Heather Atwood	Assoc. Geologist	SWEC
Allan Razem	Geohydrologist	ONWI
Larry Picking	Hydrogeologist	SWEC
P. M. Ferrigan	Geophysicist	DOE/SRPO
J. Powell	Engineer	DOE/SRPO
C. S. Kuntz	Geologist	ONWI
S.A.G. Poppen	Mining Engineer	PB/PB-KBB(TMCI)
Randy Lentell	Senior Project Geologist	Woodward-Clyde (PB/PB-KBB)

ATTACHMENT 1

JAH-86-028

Battelle
Project Management Division

Distribution:
SJ Basham
OE Swanson
WE Newcomb
JA Hileman
Geophysics Files
AC Funk
M Ferrigan/SRPO (3)
JS Treadwell

Permian Files
LB
ONWI Files
VC Log
GEO Log

VC No. GEO-86-92
Page 1 of 2
Date March 4, 1986
WBS No. 1.3.3.2.2
WP No. ----------
Distribution:
Program Manager
WBS Manager
Technical Department Manager
All Participants

RECEIVED MAR 1986 SITE CHARACTERIZATION PROJECT OFFICE

DOCUMENTATION OF VERBAL COMMUNICATION

Subject: Seismic Design Criteria for PB/PB-KBB

Recorded By James Hileman Date and Time March 4, 1986, 3:15 p.m.

Participants (name, organization, telephone)

James Hileman, ONWI, 7534
Mike Ferrigan, SRPO, 5916

X Telephone Conversation
____ Incoming
X Outgoing
____ Meeting
____ Columbus

Item	Description of Discussion	Action
	At this stage of investigation, a peak-value of 0.2 gravity as described in the Deaf Smith County Draft EA is probably the most reasonable value for seismic design. The value of 0.14 gravity given in drafts for the final EA is a mean-value estimate that does not allow for any data uncertainty. No site-specific data are yet available to influence the seismic design. Presumably the 0.2 gravity value will be used to anchor the high-frequency end of a standard (NRC) pseudo-response spectrum and thereby provide the necessary acceleration, velocity and displacement values as functions of frequency. A 0.14 gravity value is derived by assuming a magnitude 6.3 earthquake occuring on faults that are about 55 kilometers distant from the site and	

Concurrence of Other Participant:

Signed by James A Hileman 3/5/86
(name) (date)

✓ Verbal Mike Ferrigan to Jim Hileman 3/4/86
(name) (date)

____ Not Available _____
(reason)

Approved for Release:

Responsible Manager

Ray Solem for OES 3/7/86
Field Operations Office

ONWI-021-86-060

BPMD-292 (3/85)

DOCUMENTATION OF VERBAL COMMUNICATION (Continued)

Item	Description of Discussion	Action
	using the Nuttli and Herrmann (1981) attenuation relationship. A similar value is obtained for a magnitude 5.3 earthquake within 10 kilometers of the site. The 0.14 value is arbitrarily raised to 0.2 to account for uncertainty, but such a value is consistent with upper values in Schnabel and Seed's (1973) attenuation curves and with a multiplicative factor of 1.5 for the 87th percentile as used by Campbell (1982). The magnitude 6.3 earthquake may be challenged as too small because of recent studies of the Meers Fault in Oklahoma. Larger maximum earthquakes have been estimated for the Meers fault by some investigators, but the Meers fault is part of a northern frontal fault system along the Amarillo-Wichita Uplift. The eventual impact, if any, that these considerations may have on seismic design criteria for a Deaf Smith County site are sufficiently unclear that revising the peak-gravity estimate at this time does not seem warranted. JAH:ylh	

Attachment V

VERMA

AGENDA

ESF/REPOSITORY INTEGRATION MEETING

COLUMBUS, OHIO

March 18-19
(Start 8:30 a.m.)

March 18-19, 1986

Data Base Design Values - Summary of Boston Meeting & Houston Meeting	ONWI - Fluor PB/PB-KBB
Freezing Depth - Based on agreed data base	Fluor PB/PB-KBB
Seismic Approach to Shaft Design	Fluor PB/PB-KBB
Loading Assumptions and Design Approach for Shaft Lining	PB/PB-KBB Fluor
ESF - Licensing Approach	PB/PB-KBB Fluor
EDBH - Status Report & Freeze Design Holes	ONWI
Appendix "E" Update	ONWI
ESF Future Testing Potential	ONWI PB-Fluor
General Shaft Design Guidelines	PB-Fluor
Open Discussion	

1945C

Teke

APPENDIX E

Attachment V

GENERIC REQUIREMENTS FOR EXPLORATORY SHAFT FACILITY (ESF) DESIGN, CONSTRUCTION AND OPERATIONS

SECTION A. ESF SCOPE AND DEFINITIONS

2. To provide engineered components and component designs which can be incorporated into the repository as permanent features. These components shall be designed to repository grade requirements, criteria, and constraints (designated RG in Section C). These ESF components shall include ~~but are not limited to~~ the following and shall be designed and constructed to repository quality assurance (QA) requirements:

   a. LINER (includes UNDERGROUND concrete, steel, grout, and shaft station~~s~~ ACCESS)
   b. EXCAVATION (the opening, including disturbed zone)
   c. OPERATIONAL SEALS
   d. SHAFT PLUGS (~~shaft bottom seal~~ STRUCTURE)
   e. GROUND SUPPORT (roof bolts, shotcrete, etc.)

3. To provide subsurface exposure of host rock and geologic features for in-situ site characterization.

The design, ~~shall ensure that~~ ~~further~~ construction, and operations SHALL ~~do~~ not compromise the long-term isolation and containment capabilities of the repository and that construction of the ESF will not preclude the acquisition of adequate information for site characterization; i.e.,

1. The ESF design and construction shall consider the long-term sealing needs of the repository.

2. The ESF design and construction shall consider the need to obtain significant and unique information about site properties during shaft sinking.

WORKSHOP 3/11 — 3/13/86
LAS VEGAS, NV

FUNCTIONAL REQUIREMENTS

6. Those engineered ESF components and component designs which are incorporated into the repository shall meet the requirements of 10CFR60 (GR2.2/FR/1). Compliance with the requirements of 10CFR60 will be demonstrated in the License Application.

PERFORMANCE CRITERIA

6. a. For those ESF components and component designs which will be incorporated into the repository as engineered barriers, the following criterion applies. Compliance will be demonstrated in the license application.

Assuming anticipated processes and events, the release rate of any radionuclide from the engineered barrier system, excluding shaft and borehole seals, following the containment period shall not exceed 1 part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure or such other fraction of the inventory as may be approved or specified by the Commission, provided, that this requirement does not apply to any radionuclide which is released at a rate less than 0.I percent of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay. (GR2.2/PO/1a)

b. ESF shafts, boreholes and their seals shall be designed so that they do not become pathways that compromise the repository's ability to meet the performance objectives of 10CFR60. Demonstration of compliance with this criteria will be provided in the License Application.

Attachment I Nunes

RECEIVED
MAR 1 0 1986
QA DEPARTMENT

SCOPE OF WORK

Title: Licensing Guide: Repository Shaft Design

Objective: Define the approach to be used for design and construction of licensed repository shafts. This approach will be used to support the ESF design, repository ACD, and preparation of the license application.

Strategy: Using the quality assurance criteria of 10 CFR 50, Appendix B, develop specific guidance for repository shaft design and construction in order that they are licensable.

Background: Traditional industry practices for conventional mine shaft design and construction have never been applied to meet NRC licensing requirements. In the absence of specific NRC guidance, it is assumed that quality assurance requirements of 10 CFR 50, Appendix B, can be used to approximate the NRC licensing approach. In essence, these regulations require that a suitable quality assurance program be applied to the design, construction, fabrication, and testing of the system to be licensed. The concept of quality control is also included as part of the QA program.

Approach

1. Define the basic conventional mining approach used for shaft design and construction.

2. Classify the types of repository shafts, including the ESF, according to safety function.

3. Compare conventional mining approach with the requirements of 10 CFR 50, Appendix B.

4. Prepare annotated outline of licensing guide.

5. Prepare draft licensing guide.

Input Data

1. 10 CFR 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Reprocessing Plants.

2. 10 CFR 60, Disposal of High-Level Radioactive Waste in Geologic Repositories; Licensing Procedures (See esp. part 60.131(b), Structures, Systems, and Components Important to Safety; and part 60.134, Design of Seals for Shafts and Boreholes).

3. Repository Subsystem Design Requirements - Interim issue, 9/10/85 (shaft functional design criteria).

4. SCP-CDR (description of repository shaft design).

5. (Fluor) Quality Assurance Practices Report, March 1985.

Task Descriptions

Task 1: Conventional Design Approach

Fluor shall define the basic approach used for design and construction of conventional mined shafts of the type applicable to proposed repository conditions (i.e., appropriate diameter, depth, geology, etc.). The basis for this definition shall be to apply current state-of-the-art mining practices without modification or enhancement to meet NRC licensing requirements. This definition shall be used as a reference for comparison with proposed techniques that are needed to meet licensing constraints. The definition shall address, as a minimum, the following items:

a. Quality control.

b. Design, construction, and performance testing techniques.

c. Scope includes shaft lining, structural support, shaft collar, seals, shaft wall/liner performance instrumentation, and hoisting components.

d. Differences in design and construction techniques that result from differences in shaft function.

The rationale for the conventional shaft design and construction approach shall be documented. Fluor shall submit the results of this task to SRPO/ONWI for review and approval.

Task 2: Shaft Safety Classification

Based on the SCP-CDR, Fluor shall classify the repository and ESF shafts and shaft components according to their safety function. The criteria for safety function shall be as defined by the NRC regulations in 10 CFR 60, i.e., important to safety or waste isolation. Based on this derived classification, the prospective shaft licensing guide shall include requirements for each shaft classification. The shaft classification shall be supported by appropriate safety analyses. Fluor shall submit the results of this task to SRPO/ONWI for review and approval.

Task 3: Comparison with QA Requirements

Fluor shall compare the conventional approach for shaft design and construction (Task 1) with each of the 18 criteria of 10 CFR 50, Appendix B. A separate comparison shall be made for each shaft component classification (Task 2). The comparisons shall indicate, as a minimum, the following conditions for each QA criteria:

a. The degree to which conventional shaft component design and construction techniques meet 10 CFR 50, Appendix B requirements.

b. A determination of whether compliance is dependent on administrative, technical, or other constraints (i.e., can conventional shaft techniques be brought into compliance with NRC QA requirements by changing administrative procedures, etc., or is there a technical constraint inherent in the nature of the repository shaft concept).

c. An assessment of whether conventional shaft design and construction techniques used for the exploratory shaft facility can be made to comply with NRC QA requirements. (This determination should be based on coordination with the ESF architect-engineer and construction manager.)

Fluor shall provide the results of this task to SRPO/ONWI for review and approval.

Task 4: Annotated Outline

Based on the comparison of conventional shaft component design and construction techniques with NRC QA requirements (Task 3), Fluor shall develop an annotated outline of the shaft design licensing guide. The objective of the design licensing guide is to serve as an interim regulatory guide, in lieu of an NRC version, for repository shaft design and construction. This outline shall be the basis for detailed development of the licensing guide (Task 5) and shall define the types of information, rationale, approach, etc., to be used in the guide. Fluor shall submit the annotated outline to SRPO/ONWI for review and approval.

Task 5: Draft Licensing Guide

Based on SRPO's approval of the annotated outline (Task 4) and the QA comparisons (Task 3), Fluor shall develop a draft repository shaft design licensing guide. The guide shall address the following approaches, as a minimum, for each shaft component classification:

a. Certifying compliance with performance requirements

b. Design quality control

c. Construction quality control, including performance testing

d. Operational testing/inspection requirements

e. Sealing (operating and postclosure) requirements

f. Roles of shaft design A/E and construction manager.

In addition, the licensing guide shall address these same approaches as they could be applied to the design and construction of the ESF. The roles that the ESF design A/E and construction manager should perform in order to comply with NRC licensing requirements shall also be defined in terms of recommendations.

Fluor shall submit the draft repository shaft licensing guide and ESF recommendation to SRPO/ONWI for review and approval.

Milestones

1.	Fluor to provide definition of conventional shaft design approach to SRPO	4/1/86
2.	Fluor to provide shaft safety classification to SRPO	4/14/86

3.	SRPO approval of shaft safety classifications	4/30/86
4.	Fluor to provide shaft design/QA requirements comparison to SRPO	6/20/86
5.	Fluor to provide annotated outline of shaft licensing guide	7/7/86
6.	SRPO approval of design/QA comparison and annotated outline	7/31/86
7.	Fluor to provide draft shaft design licensing guide to SRPO	9/30/86

SRPO/ONWI Reviews

SRPO and ONWI will review Fluor submittals. The following constraints are imposed on Fluor's scope of work:

a. Task 3 (shaft design/QA requirements comparison) cannot begin until SRPO has approved the results of Task 2 (shaft safety classification).

b. Task 5 (draft design licensing guide) cannot begin until SRPO has approved the results of Tasks 3 (shaft design/QA requirements comparison) and 4 (annotated outline).

Text

Attachment V

TITLE II ESF FUNCTIONAL DESIGN CRITERIA

- PRESENT STATUS
- GENERAL ASPECTS
- SPECIFIC DETAILS
- REMAINING EFFORTS

TITLE II FUNCTIONAL DESIGN CRITERIA

PRESENT STATUS

- COMPLETED DRAFT
- DOE-HQ COMMENTS REQUESTED
- CURRENTLY BEING REVIEWED BY OTHER PROJECT PARTICIPANTS

TITLE II ESF FUNCTIONAL DESIGN CRITERIA

GENERAL ASPECTS

- FORMAT AND COMPOSITION DERIVED FROM TITLE I REV. 5
  - GENERAL CRITERIA PRESENTED BEFORE SPECIFIC
- EMPHASIZES COMPONENT FUNCTION AND DESIGN RATHER THAN COMPONENT FUNCTION ONLY (TITLE I)
- PROVIDES ADDITIONAL DETAILS TO BOUND THE DESIGN YET GIVES THE AE DESIGN LATITUDE

TITLE II ESF FUNCTIONAL DESIGN CRITERIA

SPECIFIC DETAILS

- INCORPORATES PB/PB-KBB AND PR COMMENTS FROM TITLE I FDC
- INCLUDES CRITERIA FOR DECOMMISSIONING
- EXPANDS CRITERIA FOR LICENSABILITY

TITLE II ESF FUNCTIONAL DESIGN CRITERIA

REMAINING EFFORTS

- INCORPORATE REVIEW COMMENTS
- INCLUDE ESF GENERIC REQS. (APPENDIX E) WHEN APPROV
- RESOLVE RELATIONSHIP WITH SYSTEM DESIGN SPEC. AND ANY FORMAT IMPACTS

Attachment V

bcc: W.L. Brown (2)
J.K. Clark
H. Koza
P.W. McKie, MKE
W.R. Mowry
P. Richter
R.D. Snell
PIC
RF

FLUOR TECHNOLOGY, INC.
ADVANCED TECHNOLOGY DIVISION

3333 MICHELSON DRIVE
IRVINE, CALIFORNIA 92730
TELEPHONE (714) 553-5000
TELEX 18-2294

March 14, 1986

Reference: Nuclear Waste Repository in Salt
Contract DE-AC02-83WM46656
Fluor Contract 839704

Letter No: FIDC-694C
PSWBS No: 1.3.4.1

U. S. Department of Energy
Salt Repository Project Office
505 King Avenue
Columbus, Ohio 43201

Attention: Mr. R. B. Lahoti, Chief
Engineering and Technology

Gentlemen:

Repository Shaft Design Guide

Fluor has been directed to prepare a Repository Shaft Design Guide to define the approaches to be used for the design and construction of licensed repository shafts using the quality assurance requirements in 10CFR50 Appendix B. These approaches are to be used to support the ESF design, the repository ACD design, and for preparation of the license application.

Revision 6 of the Title II Functional Design Criteria for an Exploratory Shaft Facility in Salt (Feb. 1986) requires the repository architect-engineer to provide technical guidance for the integration of the exploratory shafts into the repository shaft system. We propose that the work be accomplished in three separate reports, i.e., Basic Design Approach, Seismic Design Analysis, and Constructability.

The Basic Design Approach task will start immediately with the goal of providing technical guidance to PB/PB-KBB in May 1986. This task will be accomplished in the following steps:

1. Identify repository and ESF shaft design concerns for structures, systems, and components that will potentially influence repository licensing.

2. Define the design approach to be used in the design of the components identified above.

3. Obtain agreement on the design approaches between the two A & E's and submit for SRPO approval.

4. Define the safety classification and the Q.A. requirements for the shaft components.

The guidance provided to PB/PB-KBB in May 1986 will be prepared based on the current design and available site knowledge. This work may have to be updated with a refinement of the inputs.

The Seismic Design Analysis task has already started. The following steps are required to provide a preliminary seismic design basis and related engineering parameters (step 4) by July 1986. Completion of the steps 5 through 8 will depend on the availability of site specific data and the complexity of the analysis:

1. Convene eminent consultants to advise on analysis details.

2. Prepare first draft of definitive shaft design criteria document. This document will be revised and updated as analysis and design activities progress.

3. Develop preliminary site profile and related foundation engineering properties for dynamic analysis.

4. Provide preliminary definition of design basis earthquake and related engineering parameters.

5. Perform preliminary site response computer calculations.

6. Provide preliminary assessment of the effect of site response on shaft components as currently arranged.

7. Modify shaft design, as required.

8. Repeat steps 2 through 6 with more definitive and final information. Repeat these steps as required until all information is finalized based on site specific, documented activities and data. In the process of analysis and design iteration, the definitive shaft design criteria document will also be revised and updated.

While steps 1 through 7 listed above are arranged sequentially, considerable overlap will exist among several of the activities with several occurring concurrently.

FLUOR

Mr. R. B. Lahoti
U. S. Department of Energy
Columbus, Ohio

March 14, 1986
FIDC-694C
Page 3

We recommend that shaft construction techniques, quality assurance practices, and contractor performance be investigated in a separate study to be conducted by Fluor/MKE. This study should include a survey of available contractors and recently constructed shafts to assess the industries performance in constructing licensable repository shafts. We will provide our recommendations on how this task should be accomplished the week of March 24, 1986.

Very truly yours,

T O Mallonee

T. O. Mallonee
Project Manager

WLB
TOM:WLB:dmm

cc: S. J. Basham, ONWI
J. R. Fitch, Fluor/Columbus
L. A. Parys, DOE
D. K. Robinette, DOE
V. J. Rutkauskas, ONWI
Project Control Room, DOE
Engineering Records Center, ONWI
Attachment 9-1, No. 2 (Technical)