WATTS BAR NUCLEAR PLANT

YARD HOLDING POND MODIFICATIONS

ENGINEERING REPORT

May, 1989

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I. INTRODUCTION

The yard holding pond at Watts Bar Nuclear Plant (WBN) is used primarily as a holding pond for cooling water retention when the Tennessee River flow is not sufficient for dissipation of waste heat and, also as a centralized collection point for various waste streams and yard drainage prior to its ultimate release to the Tennessee River as described in the WBN National Pollutant Discharge Elimination System - Permit No. TN 0020168. Underneath a section of the yard holding pond, an underground barrier (UB) was constructed to protect buried piping in the unlikely event of soil liquefaction during a large earthquake. The UB was constructed by excavating a trench to bedrock and backfilling with compacted earthfill. Some crushed stone was used in the bottom portion of the UB. Following construction of the UB and return of the east end of the yard holding pond to service, groundwater seepage near the intake pumping station was discovered. To isolate the east end of the pond a temporary dike was constructed in May, 1987. Monitoring of the seepage and other water levels in the area identified a correlation of seepage rate with the level of water in the east end of the yard pond. Following a technical review it is concluded that a clay liner is required to reduce seepage in the east end of the pond. Isolated zones of crushed stone used for dewatering purposes (sumps, etc.) during construction of the UB are believed to be a possible cause of the excessive pond seepage. Thus, TVA is proposing to modify the east end of the yard holding pond as described in this report.

II. DESCRIPTION OF SITE GEOLOGY AND HYDROLOGY

The following information for site geology and hydrology is summarized from the WBN Environmental Statement.

Geology

Geological studies of the bedrock at the site show that it is overlain by approximately 40 feet of unconsolidated terrace deposits laid down by the Tennessee River when flowing at a higher level. Drilling and excavations have shown that the upper half of the terrace deposits consist of sandy, silty clay. The lower half is more granular, consisting of sand, pepples, cobbles, and small boulders of quartz or quartzitic sandstone embedded in a sandy clay matrix.

Beneath the terrace cover are the interbedded limestone and shales of the Conasauga Formation of Middle Cambrian Age. Stratigraphically, the Conasauga is overlain to the southeast by 2,500 to 3,000 feet of massive limestone and dolomite of the Knox Group and is underlain to the northwest by 800 to 1,200 feet of sandstone and shale of the Rome Formation. During the geologic past, folding and faulting compressed the Conasauga Formation between the more competent overlying Knox and underlying Rome Formations with the result that the thin-bedded limestones and shales of the Conasauga are complexly folded, crumpled, contorted, sheared, and broken by small faults.

The Conasauga Formation at the site is relatively unfossiliferous and has no known areas of unique paleontologic significance.

Hydrology

Ground water at Watts Bar is derived principally from precipitation which, over the past 30 years of record, has averaged 52.9 inches per year. Because the shales and limestones of the Conasauga Formation are essentially impervious, the bedrock at the site is a poor aquifer. The majority of the ground water flows through the overlying terrace deposits toward Chickamauga Lake. Water level readings made in the exploration holes show that the water table stands approximately 20 feet above rock in the terrace material.

The ground water elevation near the east end of the yard holding pond has been closely monitored since August, 1987. During this period the ground water elevation has ranged from approximately 684 to 694.

III. DESCRIPTION OF YARD HOLDING POND

The yard holding pond consists of a natural valley diked off to elevation 714.0, a skimmer structure, and a discharge control weir. The dikes are constructed of compacted earth fill. The skimmer is designed to retain floating solids and liquid debris that do not settle to the bottom of the pond. The discharge control weir is designed to handle a 100-year rainfall from the drainage area in addition to the normal contents of the pond.

The yard holding pond has direct or indirect interfaces with the following plant features:

- Equipment and Floor Drains
- Makeup Water Treatment Plants
- Diffuser Backflow
- Alum Sludge Ponds
- Essential Raw Cooling Water
- Yard Drainage System
- Metal Cleaning Waste Ponds
- Low Volume Waste Treatment Pond

The pond is designed to prevent floating debris and oil and grease from entering Chickamauga Reservoir. The limiting water quality parameters are suspended solids, oil and grease discharges and total residual chlorine. The only treatment done in the pond is to allow for sedimentation. The various waste streams will not have a detrimental effect on the proposed clay liner.

will cover the pond bottom east of the temporary dike as shown in Figure 3. The clay liner will not be needed in a narrow zone (approximately 40 feet wide) adjacent to the east toe of the temporary dike. This is because this zone was not disturbed during the UB construction. The exact limits of this undisturbed zone will be determined during construction of the clay liner. The clay liner will also be placed on a portion of the inside side slope (as shown in Figure 3) that was disturbed during construction of the UB (see Figure 2 for the barrier location).

The temporary dike will be removed after construction of the clay liner is completed. A clay liner under the area of the temporary dike is not required because this area was not disturbed during the construction of the UB.

The clay liner will be constructed with fine grained earth fill obtained from an onsite borrow source (Borrow Area 16). To maintain the pond capacity the area to be covered with the liner will be excavated to the depth necessary to accomodate the clay liner.

<u>Design</u>

Figures 4 and 5 show details of the liner. (See Appendix A for the notes referenced on the figures).

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Design

Figures 4 and 5 show details of the liner. (See Appendix A for the notes referenced on the figures).

The liner is designed to provide a coefficient of permeability no greater than 7.3×10^{-6} cm/sec (see State of Tennessee Department of Health and Environmental Division of Water Pollution Control Wastewater Treatment Section, August 1987). The design is based on laboratory permeability test data for remolded specimen's of the proposed liner earthfill. Also, consideration is given to laboratory permeability test data for block samples taken from the underground barrier located in the pond. Soil test data is presented in Appendix B. Permeability test data shows that the design permeability value (7.3×10^{-6} cm/sec) can be achieved by:

1. compacting the earthfill to at least 100 percent of the maximum dry density and

2. placing and compacting the earthfill on the wet side of the optimum moisture content.

Protection Against Cracking

Protective measures are provided to prevent wetting and drying cycles (caused by raising/lowering the pond level during plant operation) from causing desiccation cracking in the clay liner. A 6-inch thick soil cover will be placed over the portion of the clay liner located in the bottom of the pond. The 12-inch thick rock blanket placed on the side slopes for erosion protection will also provide side slope protection against desiccation cracking.

Filter Protection

A filter is provided to protect the clay liner against piping (hydraulic erosion of fine particles) in the areas where gravel zones are encountered in the foundation (see Figures 4 and 5). Figure 5 shows the details of the filter which consists of 1032 crushed stone and a geotextile.

Slope Stability

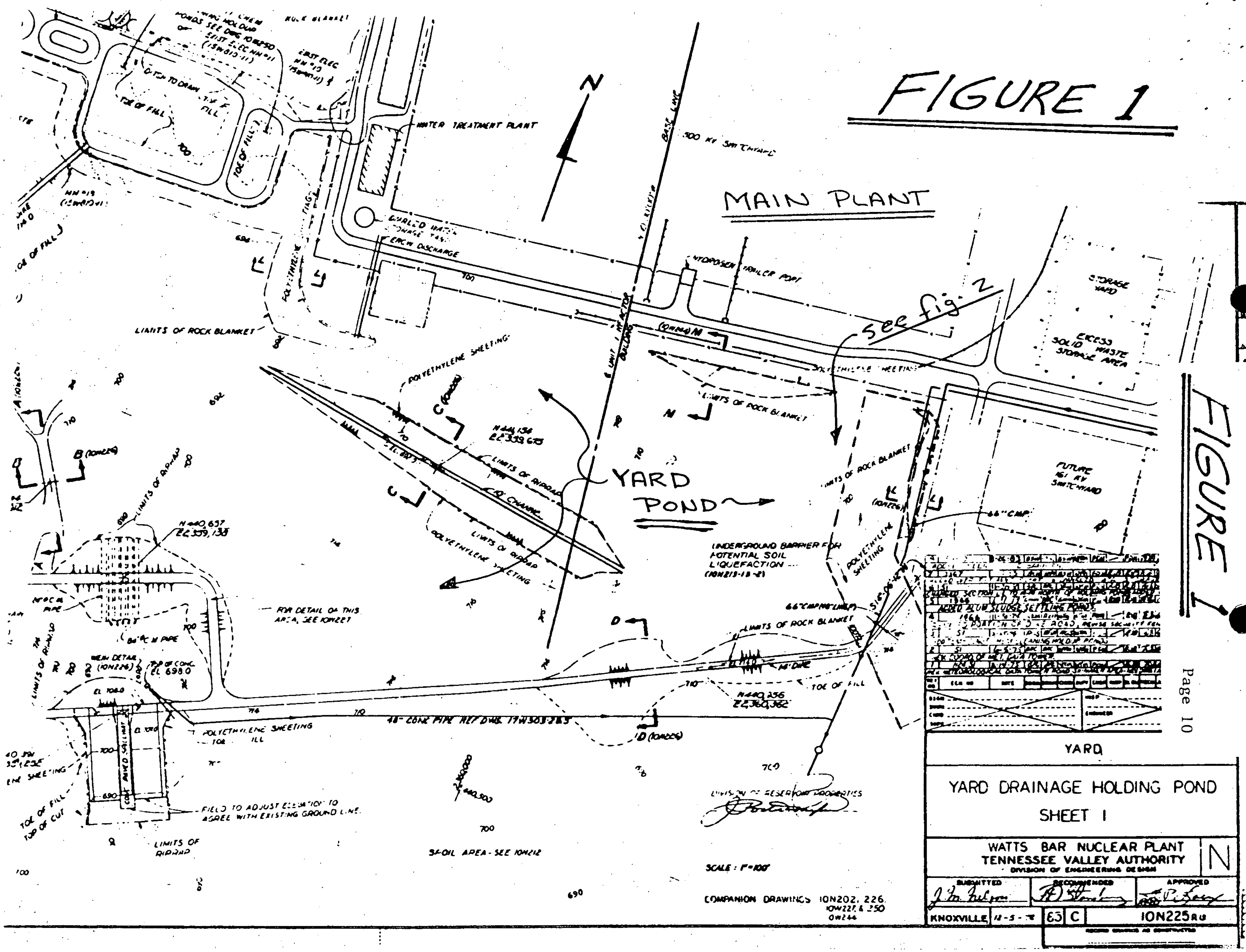
The side slopes of the clay liner will be no steeper than 3:1. This will require some flattening of portions of the existing slopes in the area of the pond to be lined with clay. A slope stability analysis shows that 3:1 slopes are stable.

V. SUMMARY

TVA proposes to modify the yard holding pond by installing a 2-foot thick clay liner in the east end of the pond. The clay liner is designed to provide a coefficient of permeability no greater than 7.3×10^{-6} cm/sec. To assure that the design permeability is achieved, appropriate construction techniques and procedures will be used to install the liner. Also, quality control will be emphasized to verify and document that the liner is properly installed.

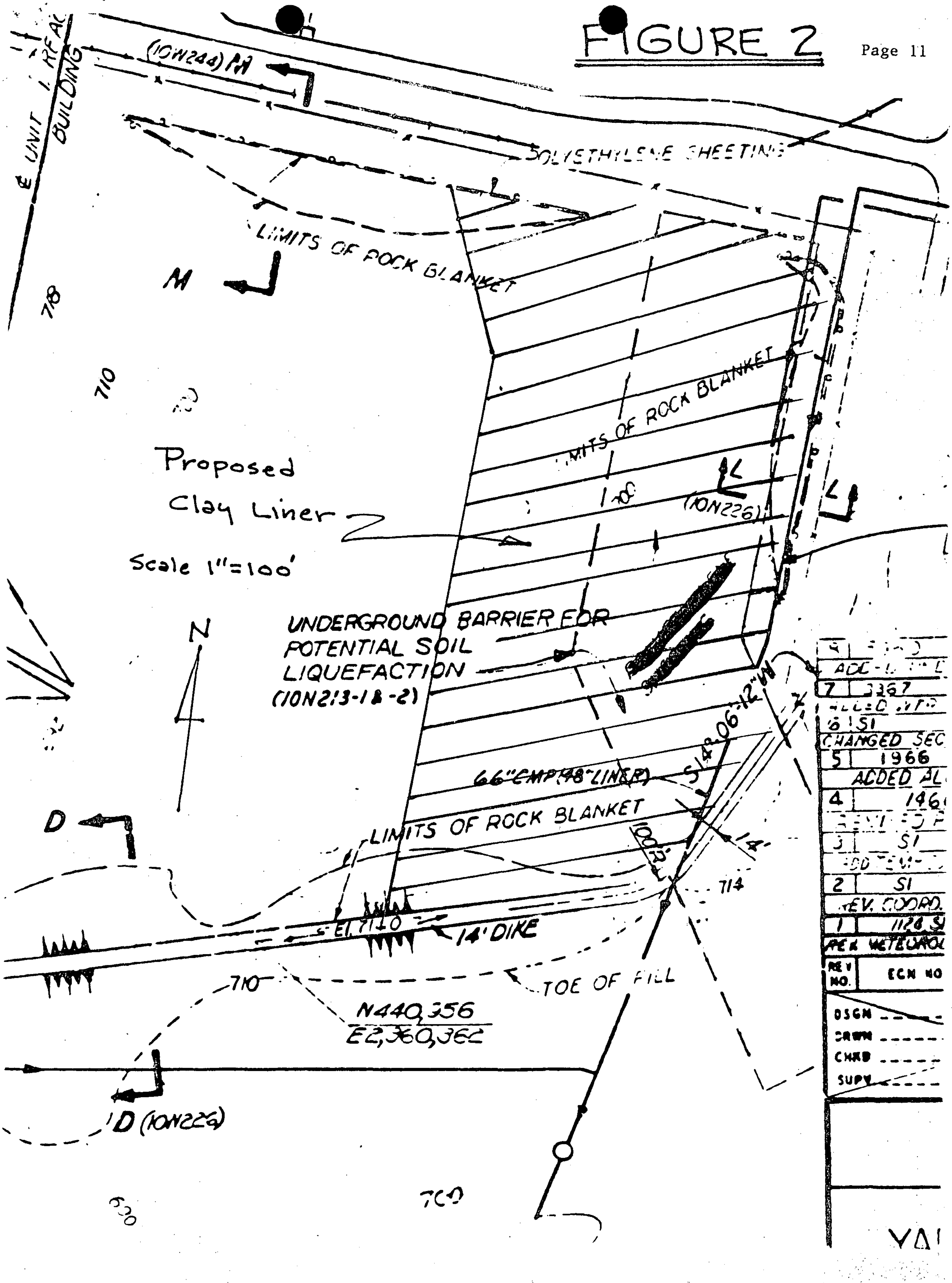
FIGURES

FIGURE 1



N
MAIN PLANT
YARD POND
see fig. 2
WATER TREATMENT PLANT
500 KV SWITCHYARD
BASE LINE
HYDROGEN TRAILER PORT
STORAGE YARD
EXCESS SOLID WASTE STORAGE AREA
FUTURE 161 KV SWITCHYARD
LIMITS OF ROCK BLANKET
POLYETHYLENE SHEETING
LIMITS OF RIPRAP
UNDERGROUND BARRIER FOR POTENTIAL SOIL LIQUEFACTION (10N213-13-21)
FOR DETAIL OF THIS AREA, SEE 10N227
48" CONC PIPE REF DWG 17W303-283
FIELD TO ADJUST ELEVATION TO AGREE WITH EXISTING GROUND LINE
SPOIL AREA - SEE 10N212
SCALE: 1"=100'
COMPANION DRAWINGS 10N202, 226, 10W227, & 250
YARD
YARD DRAINAGE HOLDING POND
SHEET 1
WATTS BAR NUCLEAR PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
10N225

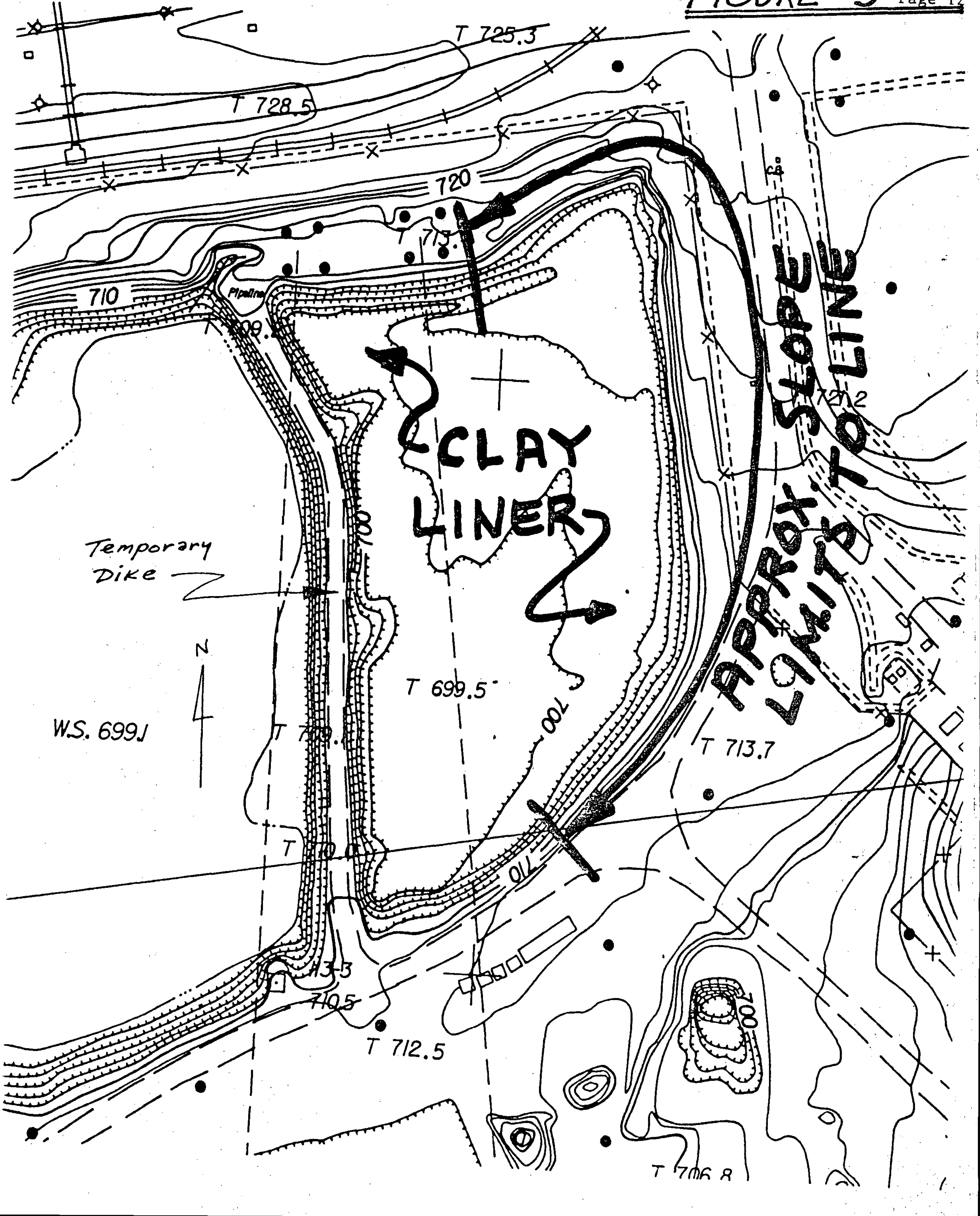
FIGURE 2

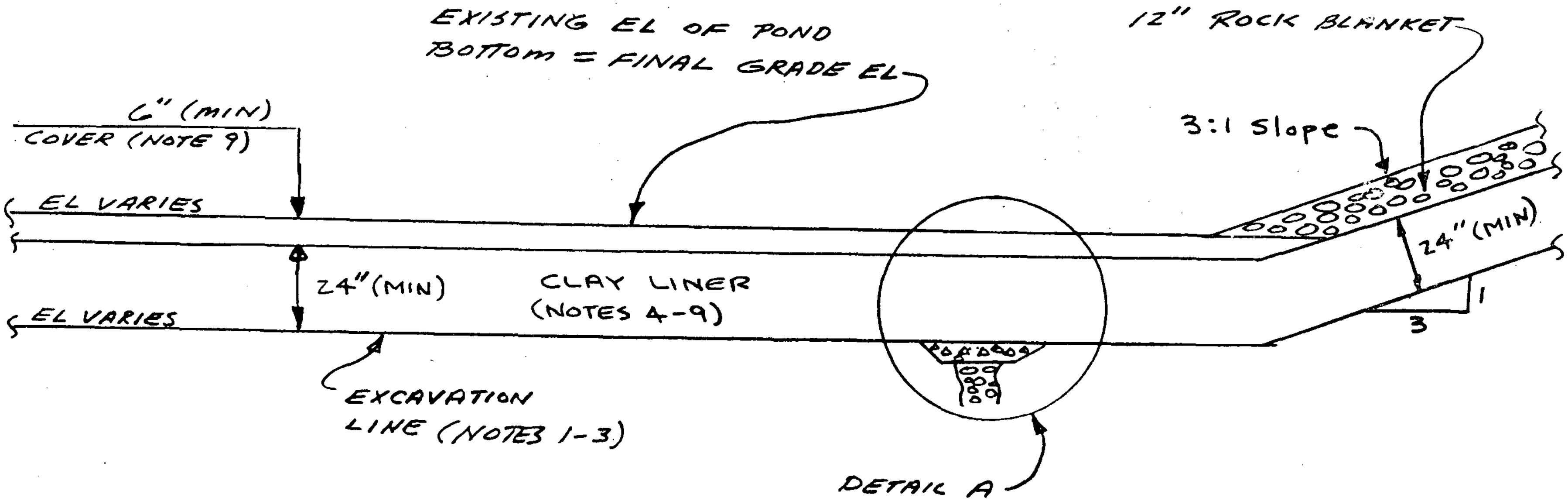


℄ UNIT 1 REAC BUILDING
(10W244) PH
POLYETHYLENE SHEETING
LIMITS OF ROCK BLANKET
M
718
710
Proposed
Clay Liner
Scale 1"=100'
N
LIMITS OF ROCK BLANKET
L
(10N226)
L
UNDERGROUND BARRIER FOR
POTENTIAL SOIL
LIQUEFACTION
(10N213-18-2)
S14°06'12"W
66"CMP(48"LINER)
LIMITS OF ROCK BLANKET
D
100'R
14'
714
EL 710
14' DIKE
710
TOE OF FILL
N440,356
E2,360,362
D (10N229)
700
690
7 3367
6 SI
CHANGED SEC
5 1966
ADDED AL
4 196
3 SI
2 SI
REV. COORD.
1 1128 S
REV NO.
ECN NO
DSGN
DRWN
CHKD
SUPV

SCALE 1"=100'

FIGURE 3



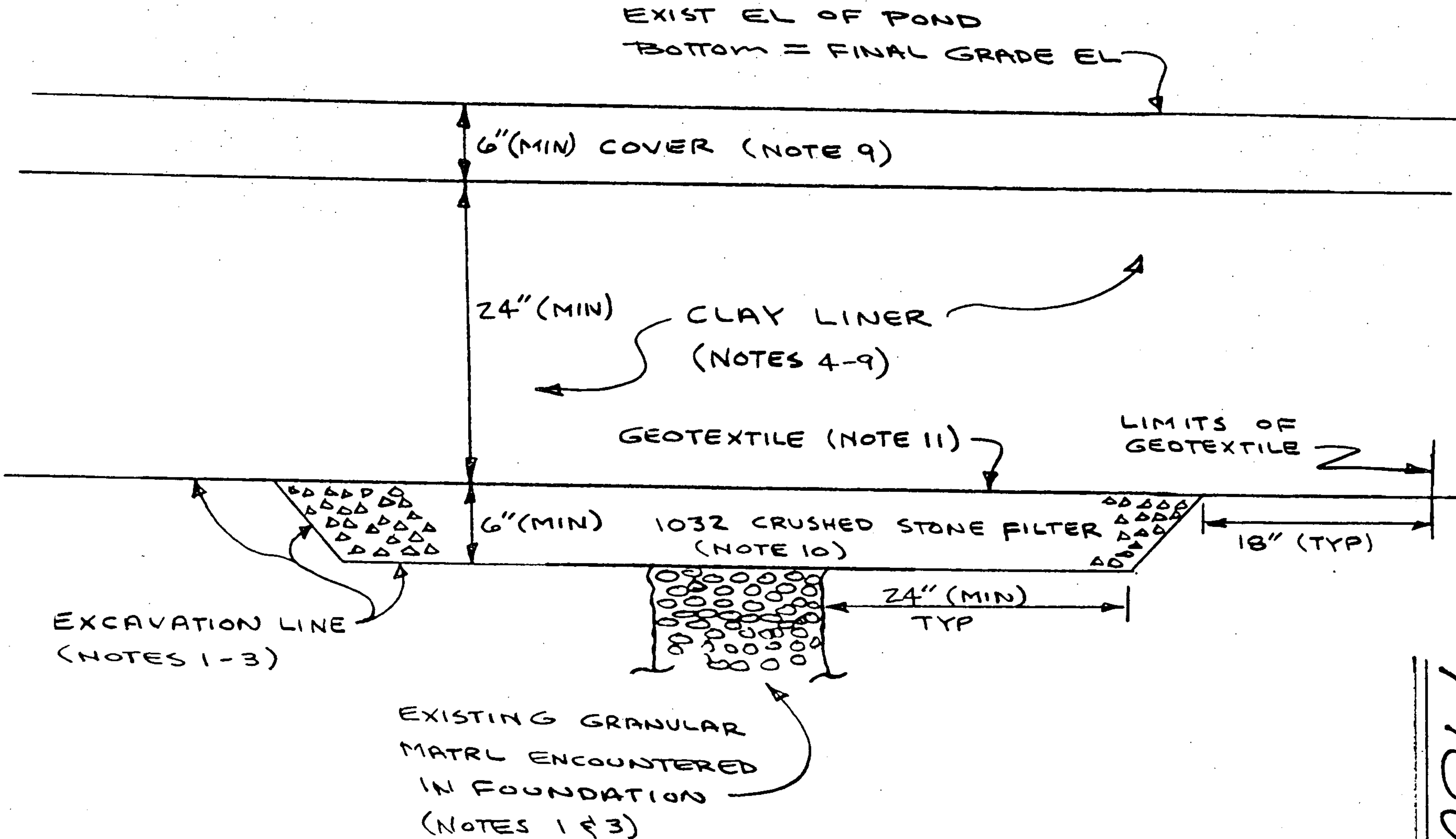


WBN YARD POND REPAIR

TYPICAL SECTION - POND BOTTOM

FIGURE 4

Page



WBN YARD POND REPAIR
DETAIL A

FIGURE 5

Page

APPENDIX A

APPENDIX A

WBN YARD POND REPAIR (CLAY LINER)
CONSTRUCTION REQUIREMENTS

EXCAVATION

1. The existing pond bottom shall be excavated to a minimum depth of 30 inches to accomodate a 24-inch thick compacted clay liner and a 6-inch thick soil cover (see figure 4). In areas where granular materials (ie pervious soils) are encountered the excavation depth shall extend an additional 6 inches to accomodate the 1032 crushed stone filter (see figure 5).

2. For the side slope areas to be covered by the clay liner the minimum excavation depth shall be 24 inches (30 inches where granular materials are encountered). The existing rock blanket shall be removed and stockpiled prior to excavating side slope areas for the clay liner.

3. Excavation depths shall be verified by a qualified inspector at 50 ft grid intervals. During the excavating phase significant effort shall be made to visually locate all the areas where granular materials are encountered in the foundation. The dimensions and plant coordinates for each granular material location shall be documented and submitted to NE. The required accuracy for these measurements is ± 1 ft.

EARTHFILL

4. All earthfill construction shall be in accordance with the WBN INSTRUCTION titled "BACKFILL" (WBN-CPI-8.1.8-C-101) with the following additions and exceptions.

5. Earthfill for constructing the clay liner shall be obtained from Borrow area 16. Borrow area 16 soils information (compaction curves, etc.) are contained in WBN-CPI-8.1.8-C-101. Only fine grained soils (ie CH,CL,MH,ML classification) shall be used to construct the liner.

6. The clay liner shall be constructed in lifts. See section 6.3.10 of WBN-CPI-8.1.8-C-101. The maximum loose lift thickness shall be in accordance with par. D of section 6.3.10 of WBN-CPI-8.1.8-C-101. Any rocks larger than 3 inches in diameter shall be removed from each lift prior to compacting the lift.

7. The clay liner shall be compacted to at least 100 percent of maximum dry density (ASTM D698). Allowable moisture content during placement and compaction shall be between 1% dry of optimum and 3% wet of optimum moisture content. However, to ensure that most of the liner is constructed on the wet side of optimum, the mean value of all the moisture content tests shall fall between optimum and 3% wet of optimum. In place dry density tests shall routinely be conducted at the rate of 1 for every 750 CY of earthfill placed. At least one test shall be performed each day that earthfill is placed. Additional density tests shall be conducted where deemed necessary by the inspector or NE engineer to verify compaction and moisture contents.

APPENDIX A (con't)

8. The clay liner shall be compacted with tamping (sheepsfoot) rollers. However, the surface of the liner shall be sealed with smooth drum rollers or rubber tired equipment. Power tampers(e.g.,air tampers, whackers) shall be used to construct the liner around structures and in other areas too confined for rollers to operate.

9. Drying cracks (desiccation cracks) occuring during construction of the liner shall be treated and prevented in accordance with section 6.3.14 of WBN-CPI-8.1.8-C-101. The 6-inch cover shall be placed on completed portions of the clay liner as quickly as possible to prevent desiccation cracking. The cover may be constructed with the excavated material from the pond bottom. Compaction control tests are not required for the cover. However, when placed the cover material shall be sufficiently wet to not cause drying in the clay liner. The surface of the cover shall be sealed with smooth drum rollers.

10. The 1032 crushed stone filter shall in general conform to section 6.4 of WBN-CPI-8.1.8-C-101. The gradation shall conform to specified limits provided in Appendics D & E of WBN-CPI-8.1.8-C-101. Relative density tests are not required. However the crushed stone shall be compacted in 6 inch lifts with a small vibratory roller (such as a bomag BW35 or BW605) making approximately 5 passes per lift. Larger vibratory rollers may be used where the working area permits.

GEOTEXTILE

11. The geotextile fabric shall have an AOS(apparent opening size) equal to or finer than the U.S. No. 120 standard sieve. The minimum strength properties shall be as follows.

	MIN VALUE	ASTM DESIGNATION
GRAB	130 lbs	D1682
PUNCTURE	40 lbs	D751-68
BURST	210 psi	D751-68
TEAR	40 lbs	D1117

The geotextile shall be placed over the entire surface of the compacted 1032 stone filter. The edges of the fabric shall be overlapped a minimum of 18 inches. During placement of the initial lift of the clay liner over the fabric, construction equipment shall not be operated directly on the fabric. Also special care shall be exercised to avoid tearing the fabric.

APPENDIX B

APPENDIX B

SOILS DATA

Compaction Curves

The family of compaction curves for the Borrow Area 16 soils are shown in Figure B1.

Permeability Tests

Laboratory permeability testing was performed for the Borrow Area 16 soils and some of the underground barrier soils located in the pond bottom. Some testing was also performed to investigate desiccation cracking and its effects on permeablility.

Borrow Area 16

The results of the laboratory permeability tests for Borrow Area 16 are provided in Table B2. As indicated in the table this testing is separated into 3 groups.

Group 1

These test results show the relationship between permeability and remolding moisture content. All the specimens were remolded to 95 percent maximum dry density. As expected the results show that the permeability value can be minimized by placing and compacting the soils on the wet side of optimum moisture content.

Group 2

These test results show permeability values for specimens remolded at 100 percent maximum dry density and optimum moisture content. The data shows that increasing compaction from 95 percent (Group 1) to 100 percent maximum density (Group 2) causes a significant decrease in permeability at optimum moisture content (6.2×10^{-6} cm/sec decreased to 5.3×10^{-7} cm/sec and 2.2×10^{-6} cm/sec decreased to 5.1×10^{-7} cm/sec).

Group 3

The purpose of this testing was to investigate the effects on permeability of succesive wetting/drying cycles i.e., investigate potential for and effects of dessication cracking. The test results in general show that the wetting/drying cycles cause some increase in permeability for the class I (CL) soils. However, the data in general does not show any increase in k for the class II (ML) soils.

Underground Barrier

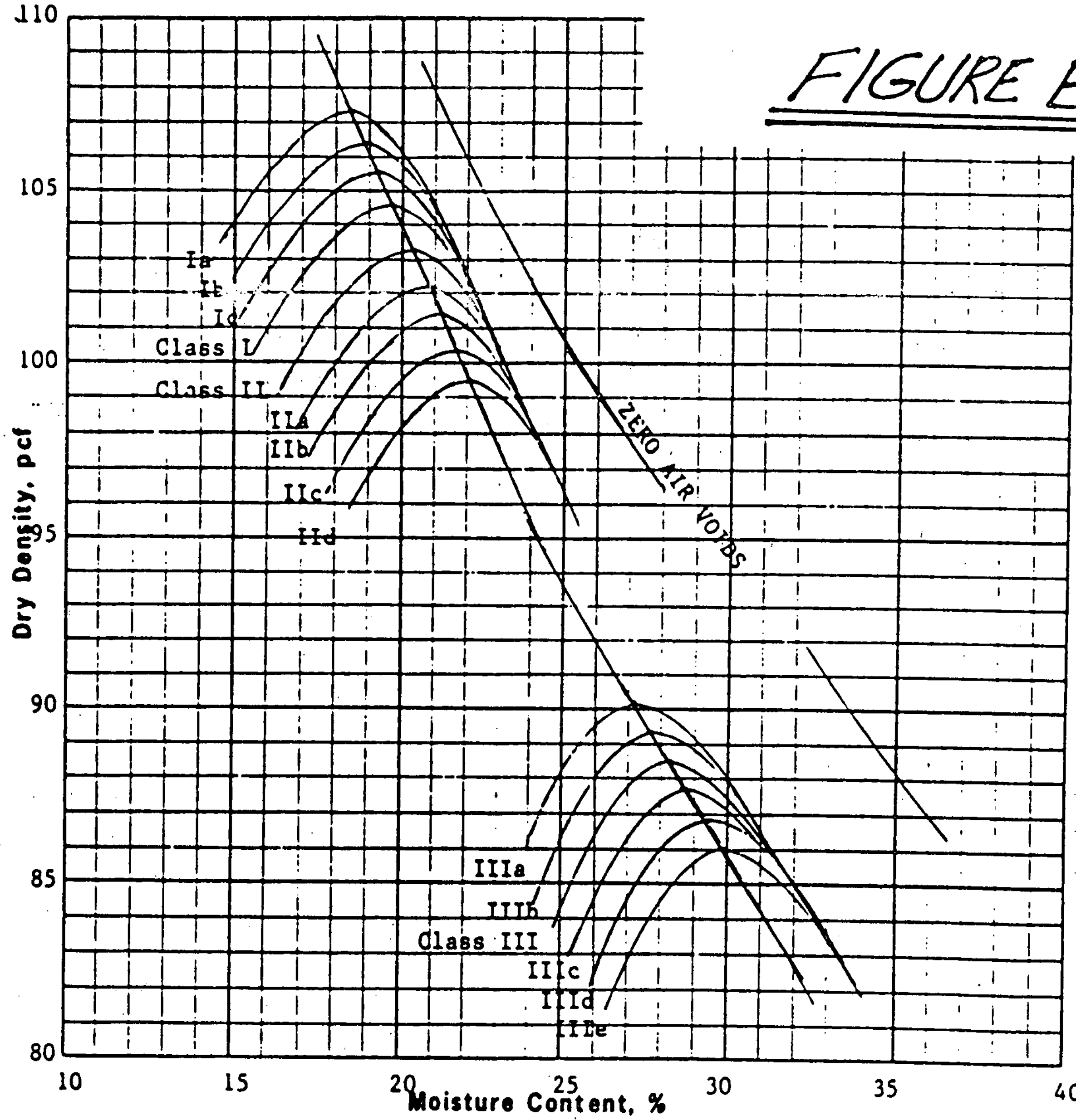
Permeability testing was performed on undisturbed block samples taken from the existing pond bottom. These samples were obtained from the top of the compacted underground barrier (shown in Figure 2) located in a portion of the east end of the pond. The top of the barrier is the bottom of the pond in the area in which it lies.

These test results provide an indication of the permeability that can be expected for a clay liner constructed with the Borrow Area 16 soils. This is because the block samples consist of compacted low plasticity clays and silty clays similar to the Borrow Area 16 soils. A review of construction control test results show that the block samples consist of soils compacted to at least 100 percent maximum dry density. The moisture content during placing and compacting the soil was within 3 percent of the optimum moisture content. These same construction controls will be used for the proposed clay liner except that the earthfill will be placed and compacted only on the wet side of optimum moisture to improve permeability.

The test results in Table B1 show a permeability value less than 1×10^{-7} cm/sec for both undisturbed and remolded block sample specimens. Therefore, the permeability of the proposed clay liner after installation may well be below the design permeability.

Dye testing was also performed on the block samples to evaluate the potential for desiccation cracking. This testing was performed both in the field and in the laboratory. The test results in general show that desiccation cracking should not be a problem for these soils if a 6 inch thick soil cover is provided over the clay liner.

FIGURE B1



Soil Class	Gravel %	Sand %	Silt %	Clay %	Specific Gravity	LL %	PI %	Optimum Moisture, %	Maximum Density, pcf
I-CL	0	27	37	36	2.70	36	13	19.8	104.5
II-ML	0	19	45	36	2.73	37	11	20.3	103.2
III-MH	0	16	28	56	2.78	60	13	28.2	88.5

Plus No. 4 Specific Gravity, S S D	--
Plus No. 4 Absorption, %	--

Remarks:

Project Watts Bar Nuclear Plant

Feature Borrow Area 16

ASTM Designation D 698A

Date Tested

COMPACTION TEST (FAMILY OF CURVES)

Table 2

WATTS BAR NUCLEAR PLANT

CLAY LINER DESICCATION AND SOIL PERMEABILITY

BLOCK SAMPLES

Block Sample*	1(T)	1(B)	2(T)	2(B)	3(T)	3(B)	4(T)	4(B)	5(T)	5(B)
Symbol	ML/CL	ML/CL	ML/CL	CL	CL	CL	CL	CL	CL	CL/ML
Moisture Content, percent	21.9	21.9	21.4	20.7	18.9	19.5	21.1	19.8	15.8	19.5
Dry Density, lb/ft^3	104.8	103.4	104.5	104.8	108.7	106.9	105.4	105.4	106.8	105.5
Specific Gravity	2.71	2.71	2.72	2.68	2.70	2.71	2.71	2.69	2.70	2.73
Mechanical and Hydrometer Analysis										
Gravel, percent	0	0	0	0	2	3	1	0	2	2
Sand, percent	20	16	16	17	21	27	30	19	22	30
Silt, percent	40	41	43	42	39	37	43	41	39	40
Clay, percent	40	43	41	41	38	33	26	40	37	28
Atterberg Limits										
Liquid Limit, percent	45	44	45	47	37	34	36	42	37	31
Plastic Limit, percent	28	27	27	25	21	21	23	25	20	22
Plasticity Index, percent	17	17	18	22	16	13	13	17	17	9
Shrinkage Limit, percent	22	25	23	24	15	16	23	19	15	18
Permeability, cm/sec										
Undisturbed	$5.2x10^{-8}$	$5.0x10^{-8}$	$9.0x10^{-8}$	$4.7x10^{-8}$						
Remolded	$3.0x10^{-8}$		$4.2x10^{-8}$							

* (T) = Top portion of the block sample. (B) = Bottom Portion of the block sample.

27334.4

TABLE B1

Table 3

WATTS BAR NUCLEAR PLANT

CLAY LINER DESICCATION AND SOIL PERMEABILITY

BORROW AREA 16

Soil Class	Test Series	Soil Symbol	Shrink Limit %	Dispers Charac %	OMC %	Max. Dry Density lb/ft^3	Permeability, cm/sec: Gr 1, Moisture Content (%) at +3.0	+1.5	OMC	-1.5	-3.0	Gr 2 OMC	Gr 3, After Each Drying Cycl 1	2	3
I	S-1	CL	19.4	11.1	19.8	104.5	1.2×10^{-6}	4.2×10^{-6}	6.2×10^{-6}	7.4×10^{-6}	7.6×10^{-6}	5.3×10^{-7}	5.8×10^{-6}	5.3×10^{-6}	6.3×10^{-6}
	S-2												3.2×10^{-6}	2.5×10^{-6}	2.5×10^{-6}
	S-3												1.9×10^{-5}	2.6×10^{-5}	3.2×10^{-5}
	S-4												5.3×10^{-6}	3.6×10^{-5}	5.5×10^{-5}
II	S-1	ML	19.0	11.1	20.3	103.2	2.7×10^{-6}	7.1×10^{-6}	2.2×10^{-5}	3.2×10^{-5}	3.9×10^{-5}	5.1×10^{-7}	1.5×10^{-6}	1.6×10^{-6}	2.0×10^{-6}
	S-2												7.5×10^{-6}	8.1×10^{-6}	6.9×10^{-6}
	S-3												3.3×10^{-5}	3.1×10^{-5}	2.4×10^{-5}
	S-4												5.3×10^{-5}	2.5×10^{-5}	2.7×10^{-5}

NOTE: Gr 1 = 1.4-in. dia specimens remolded to 95% of max. dry density at varying moisture contents from +3% to -3% from optimum moisture content (OMC).

Gr 2 = 1.4-in. dia specimens remolded to max. dry density at optimum moisture content (OMC).

Gr 3 = 2.8-in. dia specimens remolded to 95% of max. dry density at optimum moisture content (OMC).

A27334.5

TABLE B2