TVA/RG/EQS-92-8

ENVIRONMENTAL ASSESSMENT

DEVELOPMENT OF BY-PRODUCT DISPOSAL FACILITIES

CUMBERLAND FOSSIL PLANT

FLUE GAS DESULFURIZATION GYPSUM AND FLY ASH

PREPARED BY FOSSIL FUELS

COMBUSTION BY-PRODUCT MARKETING AND MANAGEMENT SECTION

MAY 1992

ENVIRONMENTAL ASSESSMENT

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CUMBERLAND FOSSIL PLANT

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1.0 Introduction

The Cumberland Fossil Plant (CUF) is located in Stewart County, Tennessee, and began commercial operation in 1972 (Figure 1.0). This is the Tennessee Valley Authority's newest fossil (coal-burning) steam electric generating plant.

Under current operating conditions, the plant burns approximately seven million tons of coal annually. By-products from the combustion of coal are fly ash, approximately 428,000 tons annually, and bottom ash, approximately 115,000 tons annually.

The current ash disposal area consists of a 245 acre pond complex into which fly ash and bottom ash are sluiced hydraulically. Part of the large pond which has filled with ash has had internal dikes raised so that ash from the active portion of the pond could be dredged into the diked areas. This process has effectively extended the life of the active pond which is now only about 70 acres. Because of structural limitations associated with the outer dikes, no further dike raising is planned.

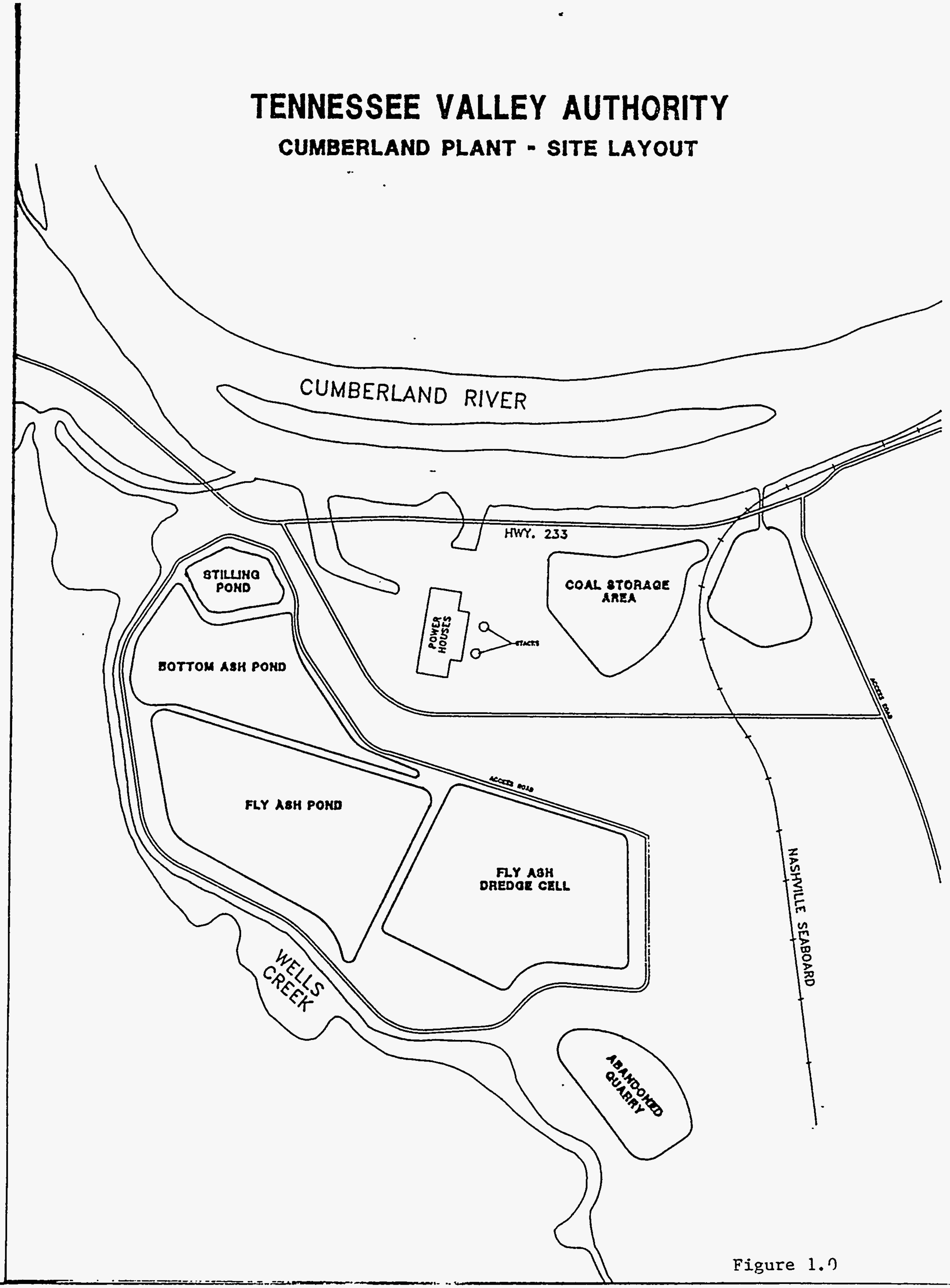

TENNESSEE VALLEY AUTHORITY
CUMBERLAND PLANT - SITE LAYOUT
CUMBERLAND RIVER
HWY. 233
STILLING POND
COAL STORAGE AREA
POWER HOUSES
BOTTOM ASH POND
FLY ASH POND
FLY ASH DREDGE CELL
NASHVILLE SEABOARD
WELLS CREEK
ABANDONED QUARRY

Figure 1.0

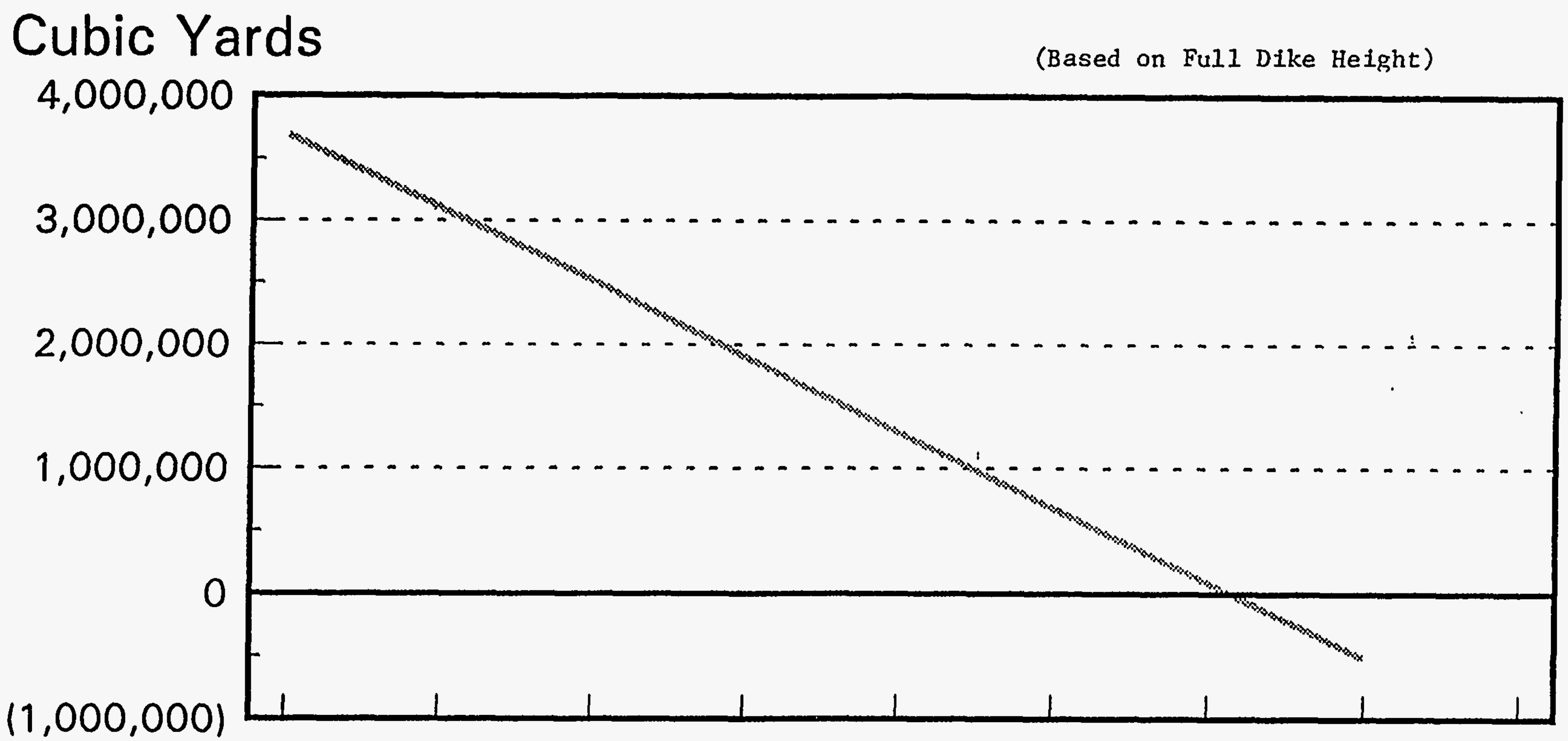
Some seepage along the toe of the active ash pond area dikes has occurred and TVA has chosen to remediate the seeps by lowering the water level in the active pond and pressure grouting. The success of the grouting program has been evaluated and it has been determined that the pond level can be raised to elevation 384 msl to provide additional storage capacity through October 1994 without further corrective action. If the full design capacity of the pond can be utilized, the plant will have ash storage capacity in the existing pond complex to last through the year 1996 based on historic ash production.

Based on historical load and projected ash production rates (Figure 2.0), a study was initially undertaken to identify feasible alternatives for marketing, utilization and disposal of ash by-products. As a result of the Clean Air Act Amendments of 1990, TVA now also proposes to reduce SO_2 emissions at CUF to 1.2 lb/10^6 Btu or less in 1995. The two most viable options to achieve this reduction are a switch to low-sulfur coal (Eastern or Powder River Basin [PRB] coal) or the installation of flue gas desulfurization (FGD), also called scrubbers. Switching to PRB coal or use of FGD will significantly influence planning for ash capacity. These options are discussed in detail in another environmental assessment document entitled SO_2 Compliance, Cumberland Fossil Plant, June 1991.

The EA on SO_2 Compliance concludes that FGD will result in more environmental impacts than low-sulfur coal. The additional impacts are primarily due to the generation of FGD by-product material which must be managed and associated impacts. The SO_2 compliance EA also concludes

CUMBERLAND FOSSIL PLANT

Fly Ash and Bottom Ash Storage Pond Volume



FISCAL YEAR	1990	1991	1992	1993	1994	1995	1996	1997	
	3,690,000	3,097,780	2,515,192	1,897,387	1,290,699	685,700	87,460	(513,358)	

SRS 2/29/92

Figure 2.0

that neither FGD or low-sulfur coal use constitute a major federal action significantly affecting the quality of the human environment. The analysis done for this EA confirms that conclusion. Scrubbers are currently being proposed as the compliance strategy for CUF. Scrubbers would not begin to continuously generate by-product materials until 1995 at the earliest. Regardless of the SO_2 compliance strategy chosen for CUF, continuous operation of the plant requires that capacity for ash must be planned for in the same timeframe. This assessment therefore considers and plans for handling both ash and FGD material in the event that scrubbers are constructed. The implications for by-product management of switching to low-sulfur coal will also be considered in this assessment.

1.1 Fly Ash Generation and By-Product Characteristics

Under current operating conditions, CUF is projected to continue producing approximately 428,000 tons of fly ash per year. As discussed earlier, this material is currently handled by being sluiced to the 70 acre active area of the ash pond where it settles out. The discharge from this pond goes to the plant stilling pond before discharging to the

Cumberland River through NPDES Permit TN 0005789 outfall 001 (see Figure 3.0). Periodic dredging of ash into cells constructed on inactive portions of the ash pond have allowed continued sluicing into the active portion of the pond without developing any additional offsite ash storage areas. However, after 1996, all available ash storage capacity for wet ash will be filled in this area and new capacity must be provided.

The fly ash currently generated at CUF meets or exceeds the quality criteria necessary to successfully market the material in the ready-mix concrete industry and for most other uses and is classified as a "Class F" fly ash. However, the current method of wet handling precludes marketing for most uses. This is discussed in much greater detail in the report entitled "Cumberland Steam Plant Long Range Utilization and Disposal Plans for Combustion By-Products" (reference 1). Toxicity testing of the fly ash by the recent TCLP testing procedure also indicates that the ash is nonhazardous (Table 1.0). Use of this material consistent with current state of Tennessee regulations related to fly ash and bottom ash (Rule 1200-1-7-.02(1)(c)1.(ii)) and with TVA's Environmental Assessment for Coal Combustion By-Product Marketing/Utilization (reference 2) therefore will not result in any significant impacts to groundwater, surface water or other environmental media.

CUMBERLAND STEAM PLANT
COAL COMBUSTION BY-PRODUCT HANDLING SCHEME

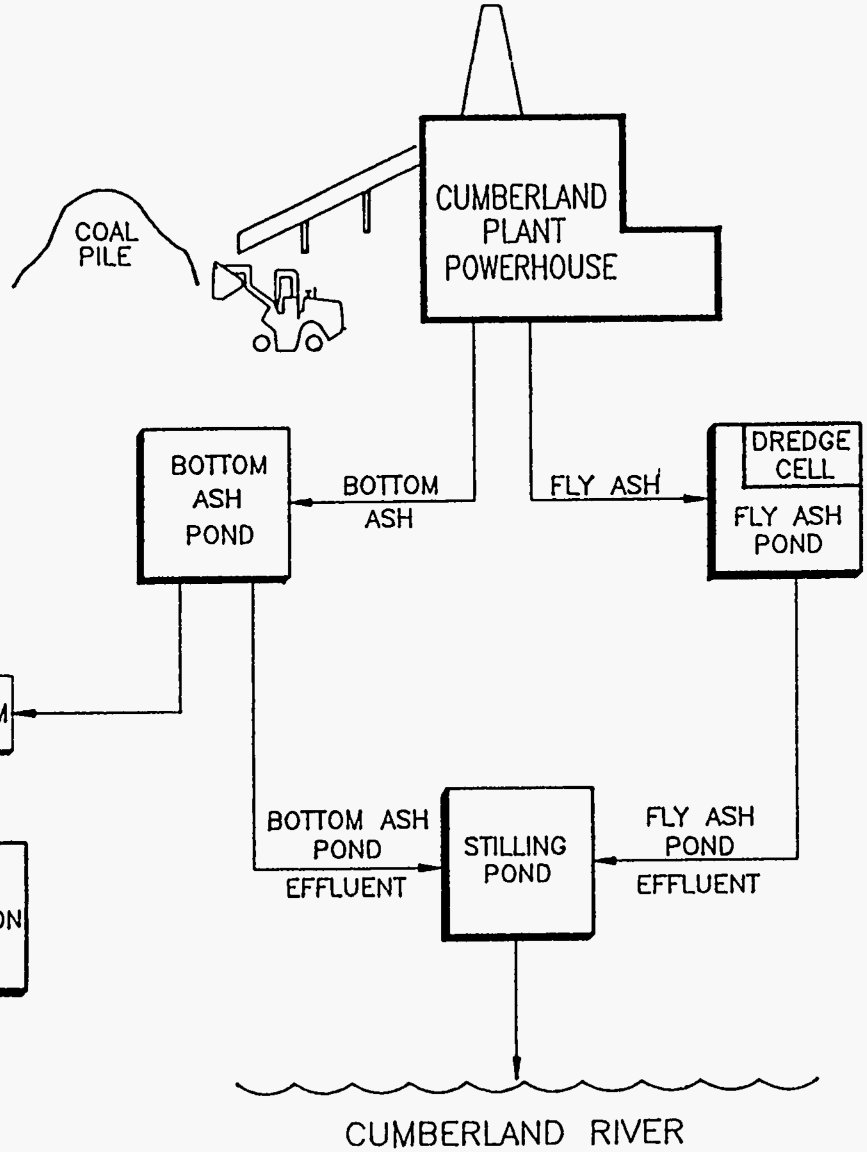


Figure 3.0

TABLE 1.0

Comparison of Western Kentucky and PRB Coal Ash

Toxicity Characteristic Leaching Procedure (TLCP) Analysis

	TCLP Results (mg/l)				
Parameter	W. KY Bottom Ash[1]	W. KY Fly Ash[1]	PRB Fly Ash[2]	PRB Bottom Ash[2]	Regulatory Limit (mg/l)
As	<0.05	<0.21	<00.005	<0.005	5.0
Ba	0.38	0.21	29	0.25	100.0
Cd	<0.01	<0.06	<00.03	<0.03	1.0
Cr	<0.01	1.03	<00.02	<0.02	5.0
Pb	<0.05	<0.05	<00.1	<0.1	5.0
Hg	<0.0005	<0.0005	<00.0008	<0.0008	0.2
Se	<0.01	<0.10	00.018	<0.005	1.0
Ag	<0.01	<0.01	<00.1	<0.01	5.0

1. Average for six samples collected at Cumberland during a 5-day period.

2. Based on one sample of PRB coal ash.

A switch to eastern low-sulfur coal would not result in any significant changes in ash production rates or ash characteristics (chemical and toxicity).

If SO_2 emissions at CUF are reduced by converting to burning PRB coal, some changes in ash handling and ash characteristics will likely result. Since PRB coal contains less ash than coal currently being burned at CUF (approximately 5-6 percent versus 8.6 percent in current coal supplies), less ash would be produced per ton of coal burned. However, PRB coal also has a lower BTU value and more would have to be burned to maintain current electric generation levels, thus total ash production would be expected to remain about the same as current levels. The fly ash resulting from PRB coal would have a greater market potential than ash currently being generated. PRB coal ash has a higher calcium content and would be classified as a "Class C" ash which is more desirable as a concrete additive. Because of the cementitious properties of Class C fly ash it would be difficult to handle the material by wet sluicing. This would increase the likelihood for conversion to dry fly ash handling if this option is chosen. Conversion to dry fly ash handling also enhances marketability of the by-product because it is collected in a physical state which is readily loaded for transport either by truck or by train, and reduces the amount of land required for development since more ash can be stacked per acre of land than can be ponded.

Representative data on the chemical characteristics of PRB coal ash from other utilities currently burning PRB coal are in Table 1.0. These data indicate that PRB coal ash is also nonhazardous and thus the same requirements for utilization would apply.

1.2 Bottom Ash Generation and By-Product Characteristics

If there are no operational changes at CUF, bottom ash production is projected to continue to be approximately 115,000 tons per year. Bottom ash is currently handled by sluicing to a portion of the active ash pond area. Pyrite reject material from the coal crushing operation at the plant is codisposed in this waste stream. The presence of pyritic material in the bottom ash makes the bottom ash undesirable for many market applications (reference 1). However, if a market were pursued for bottom ash from CUF, separation of the pyritic material could be achieved with plant system modifications.

Data on the chemical characteristics, including TCLP analyses for CUF bottom ash are included on Table 1.0. Because CUF bottom ash is nonhazardous and nontoxic, utilization of this material consistent with state regulations and TVA's EA on by-product marketing/utilization (reference 2) can be pursued without risk of any significant adverse environmental impacts on groundwater, surface water or other environmental media. Bottom ash generated from combustion of eastern low-sulfur coal would be essentially identical to bottom ash currently generated at CUF.

Based on comparisons of PRB coal fly ash analyses and analyses of existing fly ash at CUF, bottom ash generated from combustion of PRB coal would be similar in chemical and physical characteristics to bottom ash currently being produced at CUF, and it is anticipated that the quantity produced on an annual basis would not differ significantly from current production levels. Test burns of PRB coal will be conducted at CUF if this compliance strategy is selected, and sampling will be done in order to confirm the ash characterization.

Since bottom ash tends to be coarser and heavier than fly ash, bottom ash can be reclaimed from the pond with dragline equipment. If new areas are developed for fly ash storage, bottom ash could continue to be handled in a portion of the existing ash pond. The material would periodically be draglined out of the pond and stacked around the perimeter of the pond. Bottom ash could also be handled by collection in dewatering bins and dry stacked or marketed.

1.3 FGD Sludge Generation and By-product Characteristics

Installation of scrubbers for meeting SO_2 reduction at CUF will result in production of a new by-product, FGD gypsum. Due to the size of the units at CUF, scrubbers will produce approximately 1.2 million cubic yards of FGD gypsum on an annual basis.

Scrubbers remove SO_2 from the flue gases in steam electric plants by injecting a slurry of pulverized limestone ($CaCO_3$) mixed with water as a fine mist. The $CaCO_3$ reacts with the SO_2 to form calcium sulfite ($CaSO_3$) which is forced-oxidized and converted to calcium sulfate, or gypsum ($CaSO_4$). Carbon dioxide is released as a gas during the process. Since limestone is not chemically pure, small amounts of other compounds are also present in the FGD gypsum, primarily chlorides and some partially reacted CaCO3 in the form of calcium sulfite, as well as trace amounts of some metals such as iron, potassium, magnesium, sodium and silica in the form of silicates. Representative chemical data and toxicity data on FGD gypsum from other TVA facilities is included in Table 2.0.

FGD gypsum is chemically the same as gypsum which occurs naturally and is mined in many parts of the world for a number of commercial applications. In this country the primary use of gypsum is in the wallboard industry. The feasibility of utilizing the material produced at CUF for commercial applications is discussed in reference 1. Because of the large quantity of material which will be produced at CUF if scrubbers are installed, and due to the location of CUF, a high-volume commercial market is not readily available for this material. However, marketing and utilization of scrubber sludge has been assessed in TVA's EA on by-product marketing/utilization (reference 2), and so long as the material is utilized in a manner consistent with that document, no significant

TABLE 2.0

Chemical and TCLP Data on FGD Gypsum

Parameter	Widows Creek Scrubber/Sludge mg/l	Paradise Scrubber/Sludge mg/l
Arsenic	11.0	<1.0
Selenium	4.0	3.0
Cadmium	8.4	10.0
Lead	<1.0	1.0
Chromium	6.0	4.0
Barium	10.0	17.0
Silver	<10.0	<10.0
Mercury	<0.2	<0.2

Typical Chemical Analysis

Elements/Parameter	Widows Creek Scrubber/Sludge	Paradise Scrubber/Sludge
Calcium Sulfate	57-74%	80-85%
Calcium Carbonate	6-11%	5-8%
Magnesium Carbonate	2-3%	1-5%
Fly Ash	15-31%	8-10%
pH	6-8	6-8

groundwater, surface water or other environmental impacts will occur. If scrubbers are installed at CUF, retrofit equipment can be installed to process up to 10 percent of the gypsum to produce a material which will meet industry specifications for wallboard. The material could be utilized for wallboard production if a market were developed in the future.

2.0 Alternatives Considered for By-Product Storage

Providing fly ash storage capacity is the most critical need since CUF will run out of storage capacity in 1996. SO_2 reduction would probably not change the fly ash handling mode or result in production of a new waste stream if eastern low-sulfur coal is burned. However, because SO_2 reduction employing PRB coal or scrubbers will either change the fly ash handling mode or result in production of a new waste stream, this environmental assessment evaluates environmentally and economically sound alternatives which can accommodate either scenario. The environmental effects associated with handling the by-products of current coals and eastern low-sulfur coals are similar and are therefore not discussed in this section as a separate option.

Since the results of market surveys presented in reference 1 did not indicate any strong market opportunities for any of the by-products from CUF, by-product marketing is not a major consideration in selecting the alternatives considered. However, marketing will be pursued in the future if opportunities develop. This leads to consideration of three basic alternatives for by-product handling: if scrubbers are chosen, the by-product materials will be 1) wet FGD gypsum stacking, wet bottom ash and wet fly ash or 2) wet FGD gypsum stacking, wet bottom ash and dry fly ash; if PRB coal is chosen, the by-product materials will be 3) dry fly ash and no FGD gypsum stacking. Switching to eastern low-sulfur coal would not impact current waste disposal operations at CUF and is not considered critical path for the purpose of this document. No action is not considered a viable alternative for consideration in this document since the plant would not be able to continue operation if no provisions are made for waste disposal. Since bottom ash handling is a relatively small-volume stream, its handling considerations are not critical to the decisionmaking and is not discussed in detail. From an environmental standpoint, bottom ash does not present any management needs over and above those considered for fly ash and FGD gypsum.

Once the by-product handling mode is defined, the life of the storage facility must be considered and enough capacity must be provided to meet the desired storage life. In general, TVA plans by-product storage facilities for a 20-year life. Because of the expense of permitting and developing such facilities and because of the long lead time required to site and permit them, a long life is desirable to help spread out the cost recovery for the facility. In this case, 20 years of fly ash generation will require approximately 10 million cubic yards of capacity and 20 years of scrubber sludge generation will require about 24 million cubic yards of storage capacity.

2.1 Alternative 1--Wet FGD Gypsum Stacking, and Wet Fly Ash Handling

A number of different methods for handling these materials in a wet state are discussed in detail in reference 1. From an operational and economic standpoint, the most feasible method currently available for handling of wet FGD gypsum is by the rim ditch stacking method. In rim ditch stacking, a facility is developed which usually consists of three or more cells. The cells are diked impoundments into which the FGD gypsum is sluiced for settling and clarification of process water before the water is recirculated into the process loop or discharged. Two cells are used alternately for dewatering of gypsum, and one cell is used for water clarification. During the initial stages, gypsum is allowed to accumulate in the first cell until a sufficient quantity is available to develop a series of ditches. The first cell is then dewatered so that ditches can be developed and material is sluiced into the second cell. Sluicing continues to alternate between these two cells as material is alternately deposited and ditches are raised. In this manner a stack gradually develops. The ultimate height of the stack is dependant on the size of the original footprint of the area developed, subsurface conditions, and the side slopes of the stack. Generally, side slopes of 3 horizontal to 1 vertical (3:1) are maintained to ensure stability. In order to provide capacity for the desired 20-year life at CUF the area needed for development is approximately 132 acres. This would allow for development of three cells, 3:1 side slopes on the stacked material and an ultimate height of 165 feet.

In order to continue to handle fly ash wet at CUF, the most economically and operationally feasible option is to reclaim material from existing or new dredge cells within the inactive ash pond area and haul the reclaimed material to a new area where it would be stacked. This would require no changes in the basic operational processes at CUF. Fly ash would continue to be sluiced into the active portion of the ash pond, and this area would periodically be dredged using a floating hydraulic dredge to move material into dredge cells where the material would dewater by gravity drainage until dry enough to handle with conventional earth-moving equipment. The stacking area would be diked to control erosion and runoff, and would require a sedimentation basin for runoff water. Depending on the location of this new area, the sedimentation basin could either be pumped back to the existing ash pond for ultimate discharge of the water or the discharge could be permitted separately. An offsite stacking area of approximately 125 acres would be required to accommodate the desired 20-year life of this facility.

Comingling of wet fly ash and wet FGD gypsum has also been considered, but while only one storage facility would be developed for such an operation, comingling would eliminate any possibility of reclaiming either material in the future if markets did develop for these materials.

2.2 Alternative 2--Wet FGD Gypsum and Dry Fly Ash Handling

This alternative would require the same amount of acreage for FGD gypsum as presented in Alternative 1. Conversion to dry ash handling would necessitate major equipment and operational changes to the ash handling system at CUF. A detailed discussion of these changes is presented in section 5.0 of reference 1.

There are several advantages associated with conversion to dry fly ash collection at CUF. Although the initial capital cost of conversion is high, it would allow CUF to take advantage of the market opportunities that do exist for fly ash utilization in the vicinity of CUF which would offset a portion of the cost. CUF consistently produces fly ash with low carbon content and excellent fineness which is desirable in ready mix concrete. A market for up to 50,000 tons per year of fly ash is projected for CUF in the ready mix market and another 125,000 tons per year for light weight aggregate in concrete block manufacturing if dry fly ash collection is installed. Sale of material would not only generate revenue but would also reduce the amount of material which is landfilled.

Even if marketing could not be achieved, dry fly ash collection would allow fly ash to be transported directly to the stacking area, eliminating the messy and time-consuming step of dredging, dewatering and reclaiming material out of dredge cells. Dredge cells also have greater potential for groundwater impacts. Studies of dry ash stacking facilities at other TVA facilities (references 3, 4 and 5) indicate that if developed properly, dry fly ash stacks generate little or no leachate and have very little potential for contamination of groundwater resources. In order to provide capacity for the desired 20-year life at CUF, the area needed for development is approximately 95 acres. This would allow for development of a stack with 3:1 side slopes and an ultimate height of 210 feet.

2.3 Alternative 3--PRB Coal, Dry Fly Ash Collection

Although ash resulting from combustion of PRB coal for SO_2 reduction could be handled with the existing wet system if some equipment and operational changes were made, because of the highly cementitious properties of PRB coal ash, this material is usually handled dry. When handled wet, this material tends to plug piping, especially in the event of an emergency shutdown, which can lead to costly repairs. It probably would not be feasible to dredge PRB ash from the pond once it had settled, because it could set like cement in the pond bottom.

Dry collection of PRB coal ash would be handled in the same manner as that described in Alternative 2, but PRB coal ash would be much easier to market because of its enhanced pozzolonic characteristics. Since scrubbers would not be needed if PRB coal is burned, only ash storage would need to be provided. Therefore, a total of only 125 acres of storage would need to be developed for by-product disposal.

3.0 Preferred Alternative

The preferred alternative to ensure that facilities are planned for all by-products which will potentially be generated at CUF is to plan facilities to handle wet FGD gypsum and dry fly ash. If scrubbers are installed at CUF, scrubber material would be handled in a wet rim ditch stack. However, regardless of whether scrubbers or low-sulfur coal are used for SO_2 compliance, conversion to dry fly ash handling is preferred. This has several advantages over retaining the existing wet mode of ash handling.

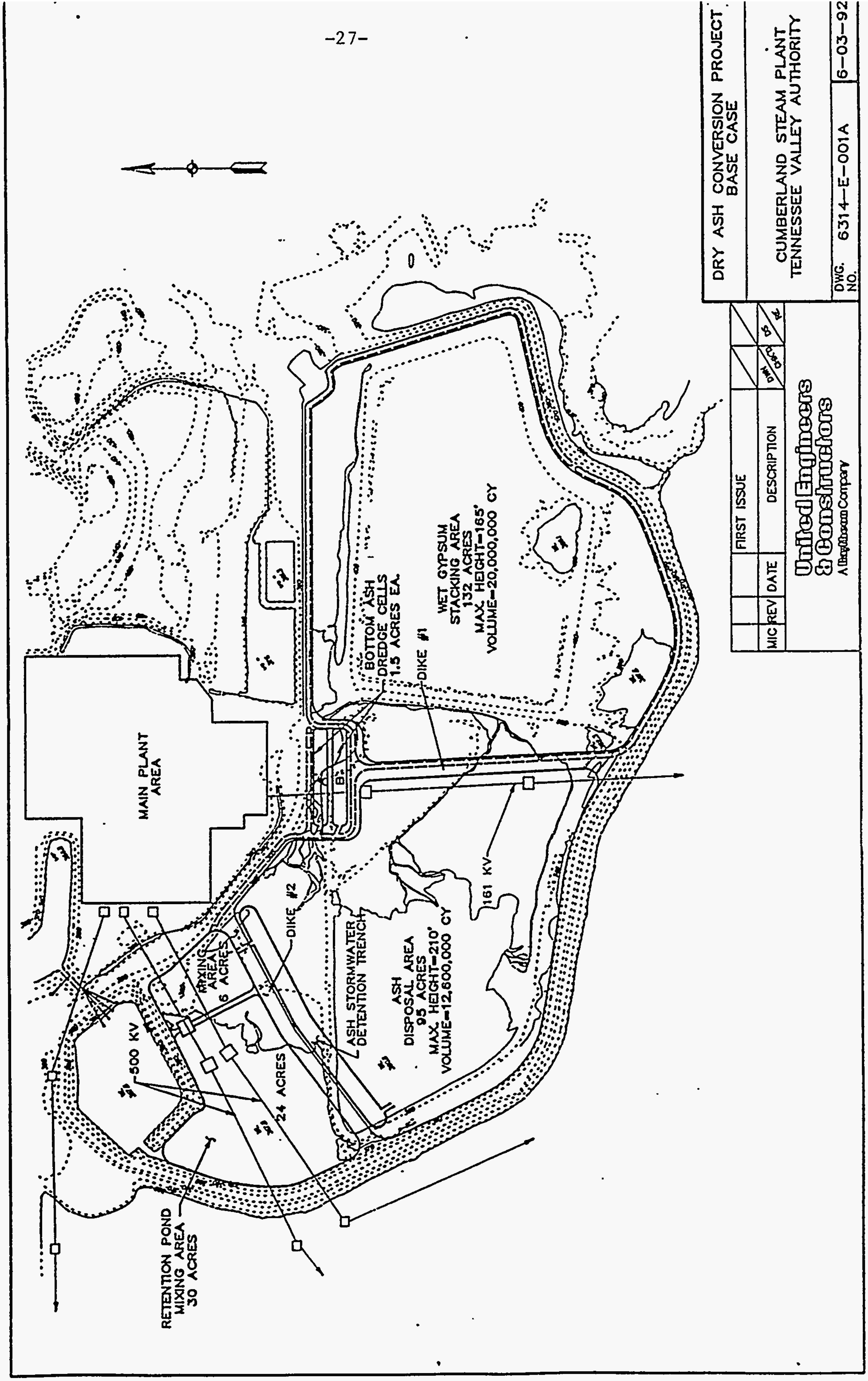
Conversion to dry fly ash collection will allow the flexibility to handle ash from PRB coal in the most economical manner if this compliance strategy is selected. Whether or not PRB coal is burned, dry fly ash collection will facilitate movement of material into markets, offsite stacking areas or placement of material in limited onsite areas (such as on inactive areas of the ash pond). Studies at other TVA sites where dry fly ash collection has been installed also demonstrate that dry fly ash stacking has less potential for groundwater impacts than do other ash management strategies.

A number of different sites were evaluated for their suitability as waste disposal areas. These sites are discussed in detail in reference 1 and are addressed is the next section. From both an economic and an environmental perspective the preferred site for development of the dry ash stacking facility and the FGD rim ditch stacking area is to develop these facilities on inactive portions of the ash pond complex. A conceptual plan showing the layout of these facilities is illustrated in Figure 4.0.

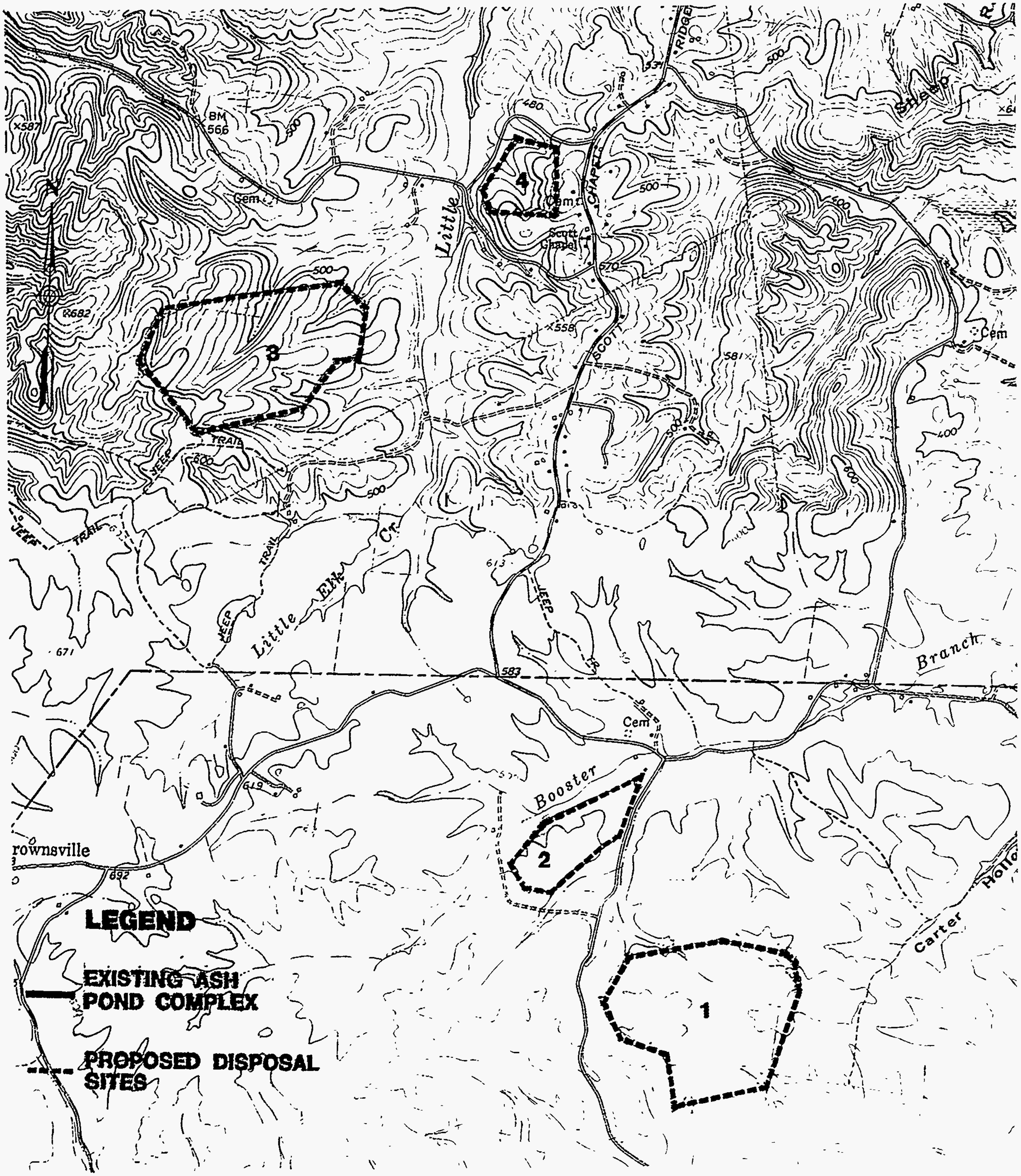
4.0 Environmental Evaluation

4.1 Sites Considered

A number of potential sites were investigated both on and off the plant reservation to assess their suitability for development as FGD gypsum and ash storage facilities (Figures 5.0 and 6.0). A more complete discussion of each of these sites is presented in reference 1. A table summarizing the acreage and storage capacity for each of the ten offsite areas considered is presented in Table 3.0. In addition to these areas, development of inactive portions of the ash pond were also considered.


DRY ASH CONVERSION PROJECT
BASE CASE
CUMBERLAND STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DWG. NO. 6314-E-001A
6-03-92
MIC REV DATE
FIRST ISSUE
DESCRIPTION
United Engineers & Constructors
A Raytheon Company
MAIN PLANT AREA
BOTTOM ASH DREDGE CELLS 1.5 ACRES EA.
WET GYPSUM STACKING AREA 132 ACRES MAX. HEIGHT-165' VOLUME-20,000,000 CY
DIKE #1
DIKE #2
161 KV
500 KV
ASH STORMWATER DETENTION TRENCH
ASH DISPOSAL AREA 95 ACRES MAX. HEIGHT-210' VOLUME-12,600,000 CY
MIXING AREA 6 ACRES
24 ACRES
RETENTION POND MIXING AREA 30 ACRES

.Figure 4



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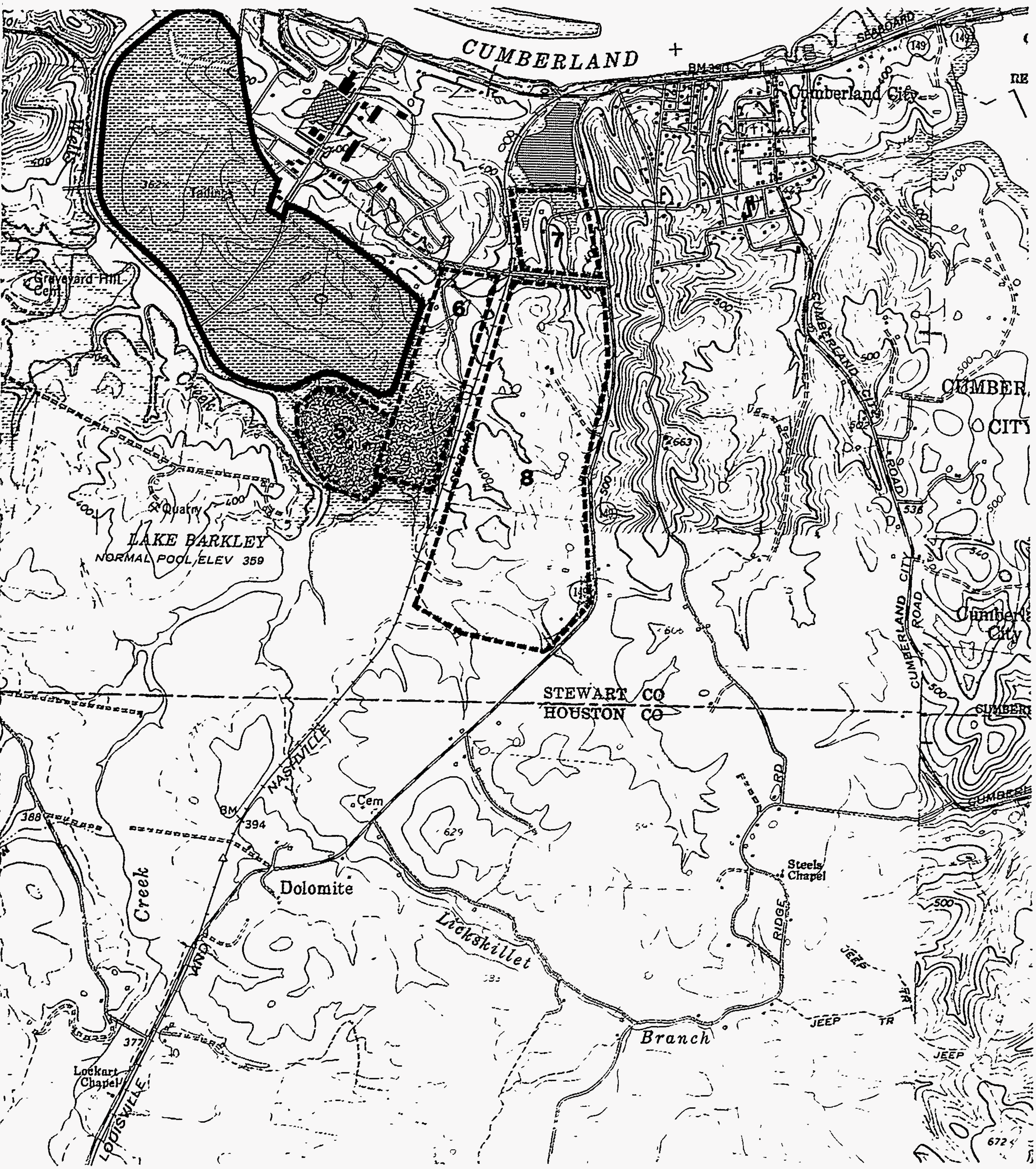

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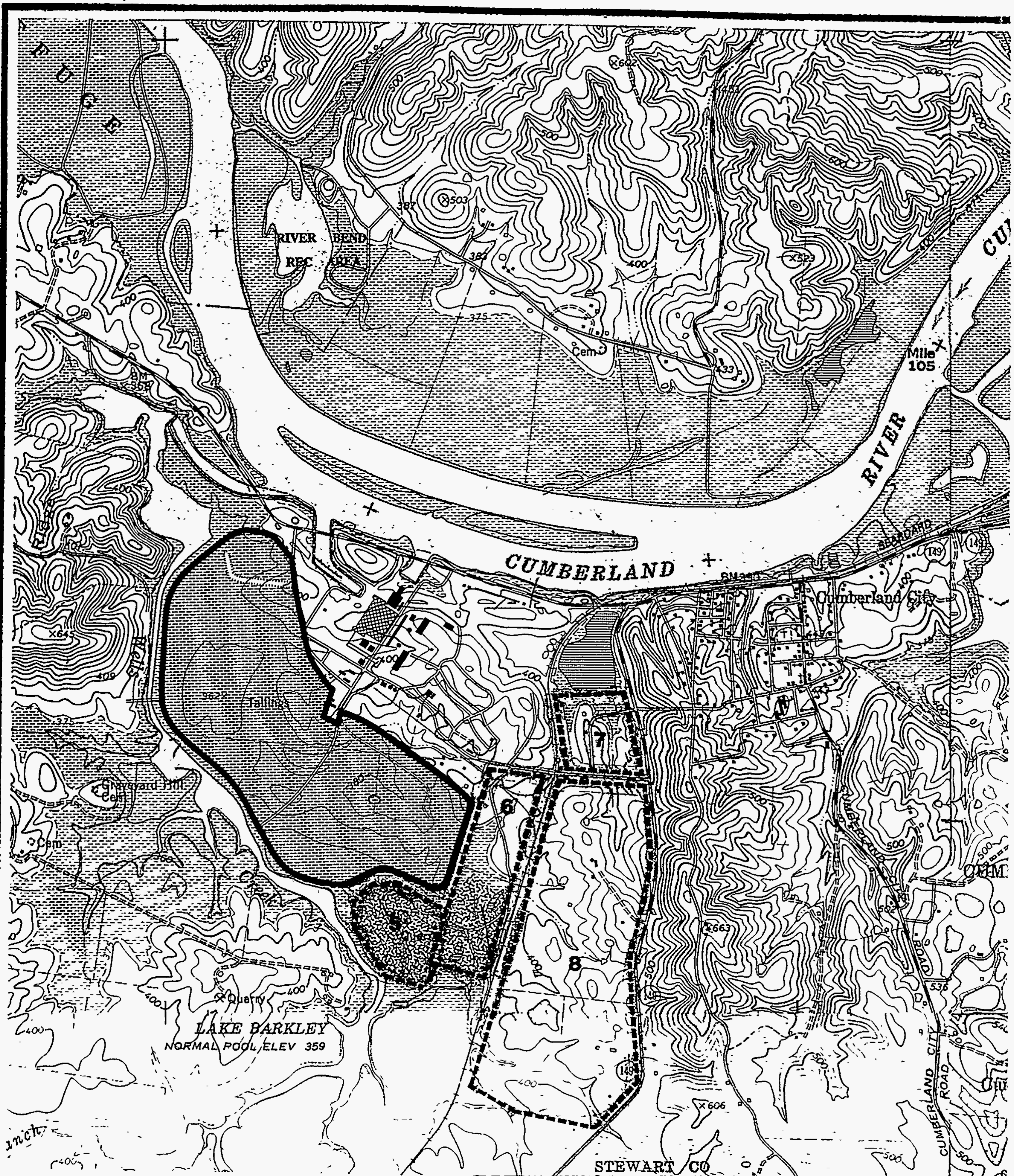
CHECKED BY:	
APPROVED BY:	

CUMBERLAND FOSSIL PLANT

DISPOSAL SITE LOCATION MAP

FIGURE 5.0



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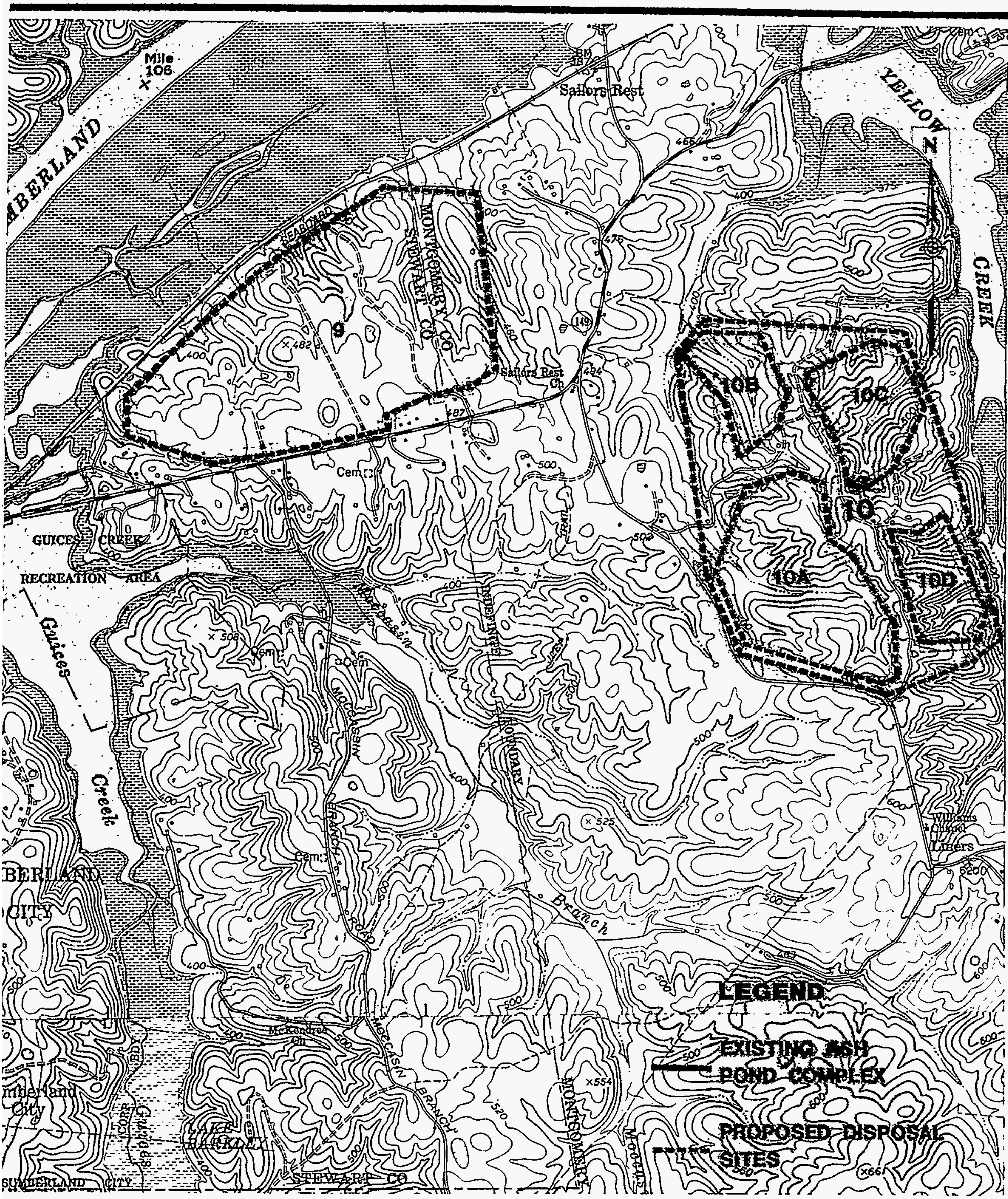

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CUMBERLAND FOSSIL PLANT

DISPOSAL SITE LOCATION MAP

FIGURE 6.0

Of the new potential offsite storage areas identified, all but two were ruled out for in-depth consideration because they either lacked adequate storage capacity to accommodate by-product storage for the required 20 years of generation, were characterized by wetland habitat and thus would be difficult to develop or permit, were too far from the plant to allow for economical movement of material to the site or were unsuitable or undesirable for a combination of these and other reasons. The two offsite areas which were deemed potentially suitable for development are sites 8 and 10. The existing ash pond complex was also judged to be potentially suitable for development of stacking areas.

In order to more fully assess the suitability of sites 8 and 10 from an engineering and environmental standpoint, LAW Engineering was contracted to conduct onsite explorations of both sites to develop information on the general nature of subsurface soil, rock and groundwater conditions in the site areas. The reports of these investigations are included in

TABLE 3.0

Offsite Storage Areas Considered

Disposal Site Location	Acres	Storage Capacity Cubic Yards	Distance From Plant (Road Miles)	Waste Stream Potential
1	111	11,538,796	6.0	1,2
2	34	1,442,979	5.6	2
3	114	21,203,958	4.8	1,2
4	21	1,165,595	3.5	2
5	38	2,000,000**	1.14	3
6	61	2,629,737**	0.49	2,3
7	29	2,290,722	0.85	2,3
8	234	10,642,466	0.85	1,3
9	339	8,385,451	2.75	1,3
10A	124	14,874,358	4.3	1
10B	35	2,886,815	4.6	1,2
10C	55	5,580,808	4.8	1,2
10D	40	1,593,648	5.2	1,2

**Obtained from TVA Civil Engineering Report

1. Scrubber Sludge/Gypsum
2. Fly Ash
3. Poorly Suited for Disposal

Note: Assumption Used In Calculating Site Storage Capacities
Cnute quad sheets were used for all volume calculations.

⌂ Low elevations were filled to the maximum elevation of the site with mounding allowed in appropriate areas.

⌂ An approximate 200' buffer zone was allowed for all perennial surface waters and property boundaries. This allowance accounts for buffers to water, sedimentation ponds as well as for other drainage features that will utilize land area other than fill material.

⌂ Top cap 2-3% slope for drainage for final fill was not included in volume calculations.

Appendix I and II of this document. Surveys were also conducted on each site to assess the presence of threatened and endangered species, wetlands and floodplains, archaeological and cultural resources, prime farmland and other site characteristics which must be considered from an environmental perspective. More complete discussion of these considerations for each site are discussed in the sections that follow.

In considering development of facilities on inactive portions of the ash pond complex, many of the issues which are of concern for offsite areas or so-called "greenfield" sites do not apply. Since this area has been used for many years as an ash storage facility, there are no threatened or endangered species present, archaeological or cultural resources, or prime farm lands. Therefore, the engineering aspects of development on the ash pond complex involving dike stability, required clearances below high voltage transmission lines which cross the site, and potential changes in the characteristics of surface water discharges are the types of issues which must be considered for this site. The sections which follow discuss the environmental consequences of developing sites 8, 10, and the inactive area of the ash pond for the preferred alternative.

4.2 Water Resources

4.2.1 Wetlands and Floodplains

Although parts of the ash pond complex may at one time have been within the 100-year floodplain, all portions of the area are now isolated from the floodplain by virtue of diking around the area. No wetlands exist within this area.

All of Site 8 is outside of the 100-year floodplain area. Three small springs exist within the site as well as one or two small farm ponds; however, there are no significant wetlands on this site.

Site 10 is also well outside of the 100-year floodplain area and there are no perennial springs or streams on the site. One small farm pond exists on the site, but does not contain any wetlands.

Based on this information there would be no significant impacts to wetlands or to floodplains due to development of any of the three sites considered, which is consistent with the requirements of Floodplain Management Executive Order Nos. 11988 and 11990.

4.2.2 Surface Water Resources

Construction activities associated with development on any of the sites considered have the potential of impacting surface water bodies due to erosion and sedimentation. Best management erosion and sedimentation controls would be used to minimize these impacts.

No significant surface water resources exist on any of the three sites considered. Site 10 contains no perennial surface water features other than a small manmade farm pond which was formed by diking to retain rainfall runoff within a small draw on a portion of the property.

The farm ponds on Site 8 appear to occur in natural depressions on the site which are probably indicative of sinkhole activity. At least one of the springs which originate on Site 8 was observed to disappear into the ground in several locations and reappear at some distance further down the swale which also is indicative of fractures and developed Karst features (Appendix I).

The ash pond complex itself, including inactive portions, is considered a waste water treatment facility and is regulated under Tennessee NPDES Permit No. 0005789 which discharges to the Cumberland River through outfall 001. Conversion to dry ash collection would result in elimination of approximately 20 million gallons per day of fly ash and bottom ash sluice water of the total 27 million gallons which is currently routed to the pond. This ash sluice water provides treatment for numerous other low volume waste streams which receive cotreatment in the ash pond. These low volume waste streams involve flows of approximately 2 million gallons per day and include boiler blow down, air preheater washes, deionizer regeneration, coal pile runoff and metal cleaning wastes. In order to assess the effects of loss of ash sluice water for cotreatment of these waste streams and ultimate effects on the ability of the ash pond discharge to meet NPDES permit requirements, a preliminary study was conducted to simulate chemical changes in the ash pond under these conditions. The results of this study is presented in Appendix III. Further modeling studies will be conducted to assist in the design of chemical treatment systems and to support permitting for the liquid waste streams at CUF if conversion to dry ash collection is pursued.

Development of an FGD rim ditch on Site 8 or on the inactive portions of the ash pond complex would be designed to allow for recycling of all liquid wastewater back into the process water loop. However, the facility would be operated open loop unless required to operate closed loop in the future. Although closed loop operation could have environmental benefits by reducing the total discharge volume, compliance with the applicable NPDES permit limits for open loop is expected to adequately protect the environment.

Under open loop operation the facility would discharge approximately 7500 gallons per minute of decant liquid from the stack. This discharge would be routed through the existing NPDES permitted outfall for the ash pond discharge. However, if a rim ditch were developed on Site 10, it might be desirable to permit a discharge from Site 10 directly to the Cumberland River rather than pumping back to CUF. If a permitted discharge from Site 10 were necessary, it would have to be in compliance with all applicable state water quality criteria, and would have to be permitted through NPDES. If the supernatant did not meet these requirements without treatment, treatment would have to be provided. However, experience with other scrubber facilities at TVA's Widows Creek and Paradise Fossil Plants indicate that the supernatant could probably be discharged without treatment.

Development of a dry ash stacking facility on any of the three sites will also require development of a runoff pond to control runoff from working surfaces of the ash stack. The runoff pond will allow any eroded ash to settle out so that it is not discharged with accumulated rainfall. If the ash stack is developed either on Site 8 or on inactive portions of the ash pond complex the runoff pond would probably be routed into the remaining active portion of the ash pond. Development of the ash stack on Site 10 would probably require discharge directly to the river from that site. This waste stream could also be comingled with the discharge from the FGD rim ditch stack so that only one permitted discharge would be necessary. Based on knowledge of runoff from other ash stacking facilities, this discharge is expected to meet any applicable NPDES discharge requirements without treatment.

4.2.3 Aquatic Ecology

Since there are no significant surface water features on either Site 8 or 10 (only small springs are present on Site 8) there would be no significant impacts to aquatic ecology on the sites themselves due to development. Development of either site might; however, result in NPDES permitted discharges to the Cumberland River. However, these discharges would have to meet effluent limitations prior to discharge. Therefore, it is not anticipated that these discharges would result in any significant impacts to aquatic ecology. Ongoing studies of effluent toxicity are being conducted at CUF and will continue as a condition of the NPDES permit for the facility. Based on results to date, indications are that the source of limited toxicity occurring is due largely to fly ash sluice water. The conversion to dry fly ash should minimize these impacts.

Stacking of ash and scrubber sludge on the inactive portions of the ash pond complex will not result in any additional impacts to aquatic ecology since any discharges will be through the existing permitted discharge point and will continue to meet all applicable discharge requirements.

The three springs which occur on Site 8 have the potential to contain aquatic resources which would be impacted if site development utilized the site as a whole. However, current Tennessee Division of Solid Waste Management (DSWM) regulations (Rule 1200-1-7-.04(3)(a)4, Buffer Zone Standards for Siting New Landfills) require facilities to be located, designed, constructed, operated, and maintained such that the fill areas are, at a minimum, 200 feet from the normal boundaries of springs, streams, lakes and other bodies of water (except . . . wet weather conveyance . . .). Although waiver provisions do exist to allow for alternate siting standards, according to DSWM personnel, the DSWM would be very unlikely to grant a waiver from this requirement. In order to develop Site 8 with adequate buffer zones around all three springs, the total area which could be developed within the 230 acre site would be reduced to two areas of 55 and 65 acres, respectively, with a total storage volume for only approximately eight years of scrubber and ash production. This significant reduction in area makes other sites more attractive for the proposed development.

4.2.4 Hydrogeologic Resources

The hydrogeologic conditions of Sites 8 and 10 are discussed in detail in Appendix I and II. Cumberland Fossil Plant is located near the center of the Wells Creek Formation, a roughly circular structure approximately two miles in diameter. This unique geologic setting is characterized by exposed Knox Dolomite and bedrock of the Stones River Group within the central portion of the structure. Around the periphery, a series of more recent sedimentary strata are exposed in parallel bands. The outermost and uppermost of these include the Fort Payne formation and the St. Louis Limestone which are the dominant surface strata in this part of Tennessee. The rock within the central portion of the feature are highly fractured in a random pattern to a depth of several thousand feet. Beyond the central portion of the structure, a radial and longitudinal fracture pattern has been mapped extending several miles in all directions. Although there is some conjecture about the origin of this feature, it appears that it most likely developed as the result of the impact of a meteor. Site geology specific to CUF is also discussed in reference 6, an application of the DRASTIC model to sites in the vicinity of the plant.

Although the ash pond complex at CUF is located within the center of the Wells Creek Formation, the pond has not experienced any sinkhole development or evidence of discontinuity in the pond bottom. The ash deposits within inactive portions of the pond are many feet thick and stacking facilities for dry ash and FGD rim ditch stacking can be developed on top of these deposits without any significant risk to groundwater resources. Since the ash pond itself will eventually need to be closed and reclaimed in the future, stacking of the ash and scrubber sludge on top of this facility can also serve as a means of closing out inactive portions of the existing pond complex. As these stacks are raised, their slopes will be contoured, dressed with at least two feet of earthen cover and revegetated. Studies at other TVA sites indicate that the dry stacked ash material will reduce rainfall infiltration and can effectively lower the hydraulic gradient beneath the stack to serve as the cover material for closure of inactive ash ponds (references 7 and 8).

The FGD stack will be a wet stack and therefore will remain essentially saturated in the lower portions of the stack. This stacking area will be engineered to include design features that may be required, such as an underdrain system, liners, and/or a geologic buffer to control leachate migration or for stack stability.

Due to the geology of Site 8 it is likely that development of facilities in this area would require liners and leachate collection systems in addition to a minimum of three feet of geologic buffer. Unfortunately, onsite borings indicate that soils are very shallow at this site and development would require excavation of approximately 2.2 million cubic yards of rock on the 65 acre area and 3.74 million cubic yards on the 55-acre area, including over-excavation of at least three feet to to allow for construction of the geologic buffer. Borrow material from another location would have to be brought to the site in order to construct diking and the geologic buffer. The Tennessee DSWM could also require the filling or treatment of fractures, cavities and seams with grouting and/or dental concrete, or other suitable material for development of the site for waste disposal. Because of the uncertainties which exist due to geologic conditions at Site 8, the cost of site development is very difficult to estimate. However, conservative economic analyses indicate that development of the limited areas within this site that can be permitted for waste disposal (due to the location of the springs and the required buffer zones for springs) do not make development of this site economically feasible at the present time. If development of Site 8 is proposed, an offsite borrow area would need to be identified and the impacts of its use further assessed.

Site 10 is located just outside of the Wells Creek Formation and site investigations indicate that soil overburden within the area range from approximately 24 feet to in excess of 60 feet. Cuts 30 to 40 feet deep can be made in the higher elevations of the property. The site contains enough suitable acreage to develop for both ash stacking and FGD rim ditch stacking for the desired 20-year storage life. Both facilities could probably be developed on the site with geologic buffers alone and no liners or leachate collection due to the depth of the onsite soils. However, if the DSWM required liners or leachate collection, these additional measures would be incorporated into the design of the scrubber facility.

4.3 Terrestrial Ecology

Development of the inactive portions of the ash pond complex will not affect any terrestrial habitats since the area is essentially void of any terrestrial life.

Site 10 vegetation generally consists of deciduous hardwood trees dominated by oaks with occasional evergreens, primarily cedars. There is evidence of past logging activities at the site. Scattered cleared areas are generally grass covered and are used for grazing (Appendix IV). No unique or critical habitats appear to be present on the site.

Site 8 is characterized by scattered clumps of deciduous hardwood trees and cedars, but most of the site has been cleared and is devoted to pasture for livestock.

No unique or critical habitats exist on the site. Development on any of the three sites would not result in losses of any important terrestrial habitat.

4.4 Threatened and Endangered Species

Surveys of Sites 8 and 10 did not reveal the occurrence of any federally or state listed threatened or endangered plant or animal species (Appendix IV). The inactive ash pond complex likewise does not support habitat suitable for or used by any threatened or endangered species due to its long use for ash storage. Therefore, development of any of the sites considered would not result in impacts to threatened or endangered species.

4.5 Archaeological and Cultural Resources

No significant archaeological or cultural resources are present on either Site 8 or on the inactive portions of the ash pond. A small log house exists near the center of the Site 10 area but is not a unique structure. This building could easily be moved to a new site if its preservation were necessary. There would therefore be no loss of significant archaeological or cultural resources resulting from development of any of the three areas under consideration.

4.6 Air Quality

Construction of FGD by-product facilities on any of the sites under consideration will result in temporary fugitive dust emissions from clearing and/or grading during site preparation. Gasoline and diesel-fueled equipment and vehicles used in construction would emit minor amounts of combustion pollutants, such as particulate matter (PM), carbon monoxide (CO), and nitrogen oxides (NOx). Fugitive dust and equipment emissions will vary daily depending on the level of construction activity, specific operations, soil type, and meteorological conditions. These air quality impacts will be minimized in accordance with normal construction best management practices (BMP).

If tree trimmings and other vegetative debris cleared from the site are disposed of by open burning, additional small amounts of PM and CO will be released. Any open burning will be conducted in accordance with applicable State and local regulations.

Air quality impacts from material conveyed via pipelines are expected to be minimal. Material will be hydraulically conveyed to the new FGD pond by pipe. Thus any air emissions from transport will be negligible. All material will be handled and ponded wet, so fugitive dust emissions from such operations will be minimal. When the gypsum stack reaches its capacity, the material will be covered with at least two feet of suitable soil and revegetated. With proper BMP measures, FGD wet gypsum stack operations should not significantly impact air quality.

Construction of the dry fly ash stack area will similarly result in temporary fugitive dust and equipment emissions from clearing and/or grading. The open-burning restrictions cited above will also apply.

Air quality impacts from the dry-stacking operation are potentially greater than for the FGD wet gypsum stack operation. Dry ash will be pneumatically transferred from the power plant to surge bins and storage silos. The ash will be separated from the transfer air by integral cyclone/bag filter collectors. Bag filters are generally considered to be state-of-the-art control devices and will reduce emissions to a very low level.

There will be a potential increase in particulate emissions associated with the conversion of the wet fly ash sluicing and ponding system to a dry fly ash pneumatic conveying system which includes new storage silos, a combined ash fill area and the trucking of the fly ash to this disposal area. It is anticipated that this increase in dust emissions would be completely offset by emissions reductions in the existing coal handling and storage facilities, and therefore, a Prevention of Significant Deterioration of Air Quality (PSD) permit would not be required. If required, the PSD permitting process could take up to two years to complete.

Preliminary calculations have been performed which show that the new emissions from the fly ash handling and disposal system can be completely offset by the installation of baghouse collectors on the existing coal handling and storage facilities at CUF.

Unloading from the silos to haul trucks will involve pugmill-type conditioner unloaders. Conditioning will reduce dust emissions by mixing ash and water to produce a moist product suitable for transport in haul trucks. Conditioned fly ash will be transported from storage silo to stack, then placed, and compacted using fuel-burning equipment. In order to minimize dusting, exposed ash surfaces will be held to the minimum feasible to support stacking operations. The moisture content of the ash being compacted will range from 18 to a maximum 20 percent moisture by weight. Because of the moisture content and compaction of the ash, dusting should be held to minimum. Water equipment will be used as necessary to further minimize dusting of haul roads and exposed ash surfaces.

Closure of the dry ash stack will include a minimum of 24 inches of soil cover and vegetation to prevent air quality impacts resulting from wind erosion of the ground surface. With proper operation and maintenance, dry fly ash stacking operations should not significantly impact air quality. In addition to these minor impacts, if Site 10 were developed for dry fly ash stacking and the material were transported to the site using trucks, minor amounts of combustion pollutants would continue to be emitted from these vehicles for the life of the facility. However, by comparison, development of these facilities on either Site 8 or on the existing ash pond complex would result in fewer air impacts.

4.7 Socioeconomic Impacts

Operation of both the dry ash stack and the FGD rim ditch will probably result in a minimal number of additional jobs at CUF, probably no more than five new employees since these facilities do not require onsite personnel for more than one normal eight hour daily shift. Therefore, there will not be any significant increase in traffic, housing or services as a result of these additional employees.

Development of Site 8 would result in the relocation of one family residence, but because of its close proximity to CUF and to a nearby county industrial park development it is likely that future development of this property for commercial, industrial or manufacturing usage would occur with or without this project. The proximity of the site to the plant and industrial park and the associated visual impacts of these areas would probably make Site 8 undesirable for residential development, parks or other facilities where aesthetics are important.

Site 10 is more suitable for development in a number of diverse ways, as housing, parkland, business or industrial, but, because of the topography of the site and the availability of other undeveloped sites in the county more suitable for development, it is likely that the site will remain as woodland and pasture in the foreseeable future if the site is not utilized for CUF by-product storage. Only three or four residences would be affected as a result of development of this site, and one short segment of paved county road and several dirt roads leading to these residences would be permanently closed for development. However, because of the location of this site over four miles from CUF and the necessity to construct pipelines and/or haul roads to transport material to the site, development of this site could disrupt the residents of Cumberland City which lies directly between CUF and Site 10.

Development of facilities on the existing ash pond complex would therefore result in the least impact on the community.

4.8 Other Impacts

The development of FGD and/or dry ash stacking facilities on any of the sites considered are not expected to have significant impacts on prime farmland or to significantly increase noise levels. The development of Site 10 could have minor impacts on transportation patterns in the area depending on routing of sluicing lines and pump stations to the site. Transportation would not be impacted by development of Site 8 or the existing ash pond complex. Visual impacts of stack development would be greatest on Sites 8 and 10, but will be minimized by covering and revegetating the side slopes as the stacks are developed.

Although Site 10 is suitable for development of these facilities, its location over four miles from the plant site present difficulties in moving the material to the site. FGD material would be sluiced through a pipeline, and dry ash would be transported by truck or pneumatically conveyed through a pipeline. Construction of the pipelines or haul roads would involve acquisition of rights-of-way to the site and additional operational and maintenance costs. The high operational and maintenance costs associated with the pipelines, haul roads and operating a facility more than four miles from the plant reservation make this site less desirable from an economic and operational standpoint than a site closer to the CUF.

5.0 Probable Unavoidable Environmental Consequences

Based on assessments of potential impacts to each environmental medium considered, there does not appear to be any significant environmental impacts that can not be avoided with proper design and construction of the proposed sites in accordance with TVA's own internal requirements and additional requirements which will be imposed through Tennessee's DSWM in order to permit the proposed facilities.

6.0 Conclusions

Development of the proposed dry fly ash stacking facility and FGD rim ditch stack on inactive portions of the existing ash pond complex at CUF in accordance with Tennessee DSWM and NPDES requirements will result in fewer environmental impacts than would development on either of the other two sites considered. In addition, development on the existing ash pond complex can be achieved more economically than development on either Site 8 or Site 10. Sites 8 and 10 were ruled from further consideration based primarily on these factors even though it is possible that they could be developed without significant environmental impacts if required for future projects.

It is concluded that the most economically desirable option is the preferred option (use of FGD, conversion to dry fly ash collection, and stacking of both wastes within the existing ash pond complex). Although the environmental impacts of utilizing low-sulfur coal are less than with FGD, the impacts are being minimized and would not be a major federal action significantly affecting the quality of the human environment and therefore the preparation of an environmental impact statement is not required.

7.0 Permits Required

Development of the dry fly ash stacking facility and the FGD rim ditch stack will require solid waste disposal permits from the Tennessee

Division of Solid Waste Management. Because of the proximity of the two facilities proposed on the inactive areas of the existing ash pond, it may be possible to permit both facilities in one permit or as two distinct facilities.

Modifications to the existing NPDES permit will need to be submitted to account for changes in the quality and quantity of water discharges from CUF. Modification to the ash pond complex will also require a waste water treatment facility construction approval from the state.

Since the only air quality impacts will be minimal and of a temporary nature during construction it is not anticipated that any change in existing air permits for CUF will be required. However, a construction permit from the Tennessee Air Pollution Control Devision will be required for the dry ash handling and disposal system.

References

1. KBK Enterprises, Inc., "Cumberland Steam Plant - Long Range Utilization and Disposal Plans for Combustion By-Products," February, 1991.

2. TVA Power Production, "Environmental Assessment for Coal Combustion By-Product Marketing/Utilization and Listing of Approved Uses" and Finding of No Significant Impact. Memorandum from M. Paul Schmierbach to William H. Thompson dated February 16, 1990.

3. Young, S. C., 1989, "Leachate Generation from Dry Stacked Fly Ash at the Bull Run Fossil Plant, Part I, Field Experiments," Report No. WR28-1-49-102, Tennessee Valley Authority, Norris, TN.

4. Young, S. C., 1989, "An Assessment of the Phase II Fly Ash Dry Stacking at the Bull Run Fossil Plant," Report No. WR28-1-49-104, Tennessee Valley Authority, Norris, TN.

5. Lindquist, K. F. and S. C. Young, 1989, "Colbert Dry Stack Groundwater Evaluation," Report No. WR28-1-37-103, Tennessee Valley Authority, Norris, TN.

6. Foust, D. D. and L. Beard, 1990, "Cumberland fossil Plant Drastic Application," Report No. WR28-1-46-104, Tennessee Valley Authority, Norris, TN.

7. Lindquist, K. F. and C. E. Bohac, 1989, "Shawnee Groundwater Assessment - Phase I," Report No. WR28-1-35-110, Tennessee Valley Authority, Norris, TN.

8. Lindquist, K. F. and C. E. Bohac, 1991, "Shawnee Groundwater Assessment - Phase II," (In preparation).

Appendix I

Report of Preliminary Hydrogeologic Assessment – Site 8

LAW ENGINEERING

GEOTECHNICAL, ENVIRONMENTAL
& CONSTRUCTION MATERIALS
CONSULTANTS

June 3, 1991

Mr. J. Steven Baugh
2N 83A Blue Ridge Place
1101 Market Street
Chattanooga, Tennessee 37402-2801

Subject: Report of Preliminary Hydrogeologic Assessment
Ash/Scrubber Sludge Disposal Site
Cumberland Fossil Fuel Plant
Cumberland City, Tennessee
Law Project Number 56301442.01

Gentlemen:

As authorized, Law Engineering has completed a preliminary hydrogeologic evaluation of the subject site. The purpose of this work was to define the general nature of subsurface soil, rock and water conditions in the site area for use in site selection and the planning of a number of waste disposal facilities. This report presents a brief review of our understanding of the project, a description of site topographic and subsurface conditions, and an evaluation of those conditions relative to the requirements of the proposed facilities.

We have appreciated the opportunity to conduct this study for you. If you have any questions regarding this report, or if we can be of further assistance, please feel free to contact us at your convenience.

Sincerely,

LAW ENGINEERING, INC.

James W. Niehoff, PE
Principal Engineer

M. Whitt Walker, PG
Principal Geologist

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1.0 INTRODUCTION

The Tennessee Valley Authority is currently seeking a site for future waste disposal needs for its Cumberland Fossil Fuel Plant located near Cumberland City, Tennessee. Under consideration in this study is a 230 acre parcel of land located to the east of the plant (see Figure 1). Although plans are preliminary at this time, it is expected that the site will be developed to handle fly ash and SO_2 scrubber sludge. The purpose of this preliminary study was to conduct research on the proposed site, perform a limited subsurface exploration and provide some direction relative to further site study, if warranted. At the time this study was authorized, the Tennessee Valley Authority neither owned the property, nor held an option on it. As a result, we were granted access only to the northern two thirds of the site.

It should be noted that this report is based largely on the work of others. Sources of data and descriptions of geologic features, while not always specifically referenced in the text, are listed and acknowledged in the Bibliography.

2.0 SCOPE OF THE STUDY

The purpose of this study was to generally define the geologic/hydrogeologic setting of the site for use in evaluating the suitability of the site relative to the Tennessee Department of Health and Environment regulations and for use in preliminary design studies. The scope of the evaluation has included the following activities:

2.0.1 Map and Literature Search: Geologic and topographic maps of the area were examined for evidence of fracture zones, sinkholes, other karstic features and areal drainage patterns. Available literature concerning the area including state reports, soil surveys, ground-water level data, etc., were also collected and reviewed.

2.0.2 Site Reconnaissance: Accessible portions of the site were visited by a LAW hydrogeologist and geotechnical personnel for the purpose of observing surface conditions and planning for subsequent soil test borings and observation well (piezometer) installations. The reconnaissance included a search for sinks, springs, rock outcrops, and other characteristics of geologic or hydrogeologic significance.

2.0.3 Geotechnical Exploration/Piezometer Installation: Six soil test borings were advanced to bedrock refusal at locations within the authorized portion of the site (see Figure 1). Locations were selected to represent the typical geologic and ground-water conditions over the site. Soil sampling included both undisturbed (Shelby Tube) samples for natural hydraulic conductivity determinations and bulk (composite) samples for standard Proctor compaction tests, recompacted hydraulic conductivity tests and soil classification. The borings were extended so that each hole penetrated into the saturated zone (i.e., below the water table).

Bedrock materials were cored in each boring to permit an evaluation of its composition and continuity. Piezometers were installed in each borehole to permit the measurement of stabilized water levels beneath the site.

Test boring records indicating the classification of the soil overburden and the nature of the bedrock are presented in the Appendix. The soil and rock samples retrieved were examined and field logs were prepared by a registered geologist at the time the borings were drilled. The finished logs represent our interpretation of conditions based upon the field classifications and upon the results of laboratory tests.

3.0 GENERAL SITE INFORMATION

3.1 SITE LOCATION

The proposed disposal site site is located in Stewart County, Tennessee, approximately 1/2 mile southwest of Cumberland City and 1/2 mile southeast of the Cumberland Fossil Fuel Plant. The site is roughly rectangular in shape with dimensions of approximately 2000 feet in the east-west direction and 5500 feet in the north-south direction. It is bounded to the west by a Seaboard Coastline Railroad spur line, to the east by State Route 149 and by undeveloped land to the north and south.

3.2 GENERAL SITE DESCRIPTION

The subject site is predominantly occupied by open pasture and isolated wooded areas. A limited number of structures and residences are also located within the parcels comprising the site. Topographically, the site is located on the western flank of a north-south trending ridgeline dissected by swales which drain in north-south and east-west directions. Three springs were identified in the field and on the USGS quadrangle sheet for the area. One begins in the north central portion of the parcel and flows to the north. A second begins near the center of the parcel and flows in a northwesterly direction. This spring was observed to dissapear into the ground in several locations and reappear at some distance further down the swale. The largest spring was noted within the southern portion of the site flowing from east to west near the southern boundary.

Throughout the parcel, a number of surface depressions were noted which are interpreted to be associated with karst activity. Although most of these depressions were observed to be less than 50 feet across, a large feature 400 to 500 feet in diameter was noted on the USGS quadrangle sheet within the southern portion of the site. As this was located in a wooded area in a portion of the site not made accessible to us during this phase of study, no on-site observations of this feature were made.

4.0 GEOLOGY

4.1 GENERAL

The proposed site lies at the periphery of a large geologic feature known as the Wells Creek Structure. The Wells Creek Structure is roughly circular in shape with a diameter of approximately 2 miles. Within the central portion of the structure, Knox Dolomite and bedrock of the Stones River Group are exposed. Around the periphery, a series of more recent sedimentary strata are exposed in parallel bands. The outer-most and upper-most of these include the Fort Payne Formation and the St. Louis Limestone which are the dominant surface strata in this part of Tennessee. The rock within the central portion of the feature are highly fractured in a random pattern to a depth of several thousand feet. Beyond the central portion of the structure, a radial and longitudinal fracture pattern has been mapped extending several miles in all directions. Although there is some disagreement among several experts, it appears that the structure most likely developed as the result of the impact of a meteor.

4.2 SUBSURFACE CONDITIONS

The borings conducted within the accessible portions of the site initially encountered a relatively thin layer of soil overburden material composed of a soft to hard silty clay with fragments of weathered limestone, shale and chert. Hydraulic conductivity tests conducted on undisturbed and remolded samples of the overburden soil resulting in the following results:

Boring Number	Depth Range	Sample Type	Hydraulic Conductivity
B-1	0' - 14'	Remolded	8.3×10^{-8} cm/sec
B-1	2' - 4'	Undisturbed	4.1×10^{-6} cm/sec
B-3	2' - 4'	Undisturbed	8.3×10^{-4} cm/sec
B-4	0' - 20'	Remolded	3.8×10^{-8} cm/sec
B-4	2' - 4'	Undisturbed	1.0×10^{-7} cm/sec
B-6	2' - 4'	Undisturbed	1.4×10^{-7} cm/sec

As may be noted, the hydraulic conductivity of remolded samples was typically found to be considerably lower than that of undisturbed materials. Copies of all laboratory data are attached in the Appendix.

Refusal to the drilling augers was encountered at depths ranging from 5.7 feet in boring B-5 to 23.5 feet in boring B-4. The refusal material was cored in each of the boreholes to identify its composition and continuity. The cores retrieved generally consisted of light to moderately weathered interbedded limestone and shale. Bedding planes were found to dip at angles of 45 degrees to 90 degrees from the horizontal. Slots and soil filled joints were penetrated within the bedrock in several of the boreholes. Based upon our observation of the composition of the cores and upon our review of geologic maps, we interpret that the majority of the site is underlain by rock of the Stones River Group and the Hermitage Formation of Ordivician age. Geologic mapping also indicates the presence the Osgood Formation, Brassfield Limestone and other undifferentiated rock of Silurian age. A fault trending in a north-south direction within the site limits is indicated near the eastern boundary of the property. A geologic map of the site area is presented as Figure 2 in the Appendix. Cross sections representing site and regional subsurface conditions are presented on Figures 3 and 4.

4.3 GROUND WATER

Ground water was measured in the boreholes at the time of drilling and after an extended stabilization period. In general, the near surface ground-water patterns appear to be a subdued replica of the surface topography. Water typically lies at depths of 10 to 25 feet below the ground surface. Springs occur where the ground-water level approaches the ground surface elevation. Although our preliminary exploration was not of sufficient scope to accurately define hydrogeologic patterns, it is believed that the ground-water system at the site is made up of a composite two media system. Ground-water flow in this system will be primarily by way of the interconnected pores within the low permeabilty overburden medium. In addition, the underlying fractured bedrock is part of the system. Flow within the bedrock will be in a downgradient direction towards the areas intersected by the ground surface and discharging as springs, or if the flow volume is high enough, as streams. Fracture orientations and concentrations will dictate flow directions and gradients within this part of the system on a more localized scale.

5.0 EVALUATION

A number of factors are of consequence in the siting of a disposal facility. Of particular importance are:

- o Major topographic characteristics which influence the degree of grading necessary for development.

- o The thickness and character of overburden materials which have an impact on the type of equipment necessary for site grading, the availability of fill soils for dike construction, and the presence of natural geologic buffers necessary for the protection of ground water.

- o Bedrock conditions underlying the site which can affect structural stability and ground-water flow directions.

- o The depth to the water table and the presence of springs which influence grading depths and buffer zones.

During the course of our study, information was gathered relative to each of these factors to aid in the evaluation of the site for its projected purpose. The following sections present a summary of our evaluation of these factors relative to the subject site.

5.1 FOUNDATION CONDITIONS

Based upon our observations of the site, published data, and the result of borings conducted as part of this study, it appears that the bedrock underlying this site has been subjected to significant thrusting in the past as the result of the impact of a meteor or other subsurface phenomenon. As a result, the rock is moderately fractured and faulted and bedding planes dip toward the east at angles of 45 to 90 degrees. The orientation of bedding planes and the composition of the exposed material has apparently promoted solutioning of the limestone segments of the bedrock. Soil filled voids, slots and seams were found in two of the borings conducted. Additionally, numerous small to large surface depressions were noted throughout the site. Waste disposal facilities constructed within this site will need to be designed to consider the possibility of localized subsidence associated with subsurface erosion, and compression/deformation of weak soils and rock.

5.2 TOPOGRAPHY/GRADING CONSIDERATIONS

The site is dominated by a north-south trending ridgeline dissected by swales. Some of these swales support springs. In accordance with TDHE regulations, a buffer of at least 200 feet must be maintained between the waste impoundment facility and any perennial spring.

Plans for development of this site are preliminary at this time. However, conceptual designs involve significant excavation of the ridge and placement of fill along the lower, western portion of the parcel. Based upon the thickness of the overburden soil and the presence of shallow rock, it is anticipated that a grading plan which contemplates cuts in excess of 10 feet will need to consider the excavation of shale and limestone bedrock. As the bedrock is characterized by slots and open seams, the bedrock surface cannot be considered a geologic buffer under TDHE regulations. To provide the proper buffer, the rock would need to be overexcavated to a depth of at least 3 feet. Depending upon the presence of open voids, cavities, and seams, treatment of the surface of the bedrock will likely be necessary. This may involve the filling of voids with dental concrete or other suitable material. Further treatment of underlying voids may be required depending upon their size and effect on structural support capability. Following proper preparation of the rock surface, a minimum 3 feet of fill having a permeability of 1×10^{-6} cm/sec would be necessary.

An alternative to the above would involve raising the level of the waste impoundment structures to minimize the requirements for excavation. Treatment of voids and slots could still be required with this plan if they presented a significant risk of structural instability or groundwater contamination. Such treatment would likely involve some form of grouting. The overburden soil within this site was found to have a significant range in hydraulic conductivities. In general, it appears that the soil does not meet TDHE criteria for a geologic buffer in its current condition. As a result, it may be necessary to excavate and recompact the upper 3 feet of soil as part of the construction process.

As the soil overburden layer is relatively thin within this site, it is likely that off-site borrow material would be necessary for either of these two options.

5.3 ADDITIONAL STUDY

This preliminary study was intended to characterize the general subsurface conditions across the proposed site. Due to the variability in rock type across the site, fracture patterns associated with the Wells Creek Structure, and karstic features, extensive additional subsurface exploration would be required prior to proceeding with design and construction. The most important issues which would need to be addressed include:

- The characteristics of near-surface and deep groundwater flow.

- The extent of bedrock fracturing, solution activity and the potential for future local and general ground subsidence.

- The availability of off-site soil borrow material.

6.0 SUMMARY

In summary, the subject site is characterized by a thin layer of overburden soil, underlain by fractured bedrock. Constraints to site development include buffer requirements adjacent to springs, limitations to excavation depths resulting from shallow bedrock, and limited availability of borrow materials for use in the construction of dikes and mass fills. Consideration must also be given to the potential for the development of sinkholes which appear to be prevalent within the site limits.

7.0 REFERENCES

Tiedemann, Herbert A., et al., "Geologic Map of the Cumberland City Quadrangle, Tennessee", State of Tennessee Department of Conservation Division of Geology, 1968.

Tiedemann, Herbert A., et al., "Geologic Map of the Needmore Quadrangle, Tennessee", State of Tennessee Department of Conservation Division of Geology, 1968.

Wilson, C. W. Jr., and Sterns, R. G., "Geology of the Wells Creek Structure", Tennessee Division of Geology Bulletin Number 68, 1968.

Wilson, Charles W., Jr., and Sterns, Richard G., "Circumferential Faulting Around Wells Creek Basin, Houston and Stewart Counties, Tennessee - A Manuscript by J.M. Safford and W.T. Lander, Circa 1895", State of Tennessee Department of Conservation Division of Geology, 1966.

Marcher, Melvin V., "Geology of the Dover Area, Stewart County, Tennessee", State of Tennessee Department of Conservation and Commerce Division of Geology, 1962.

APPENDIX

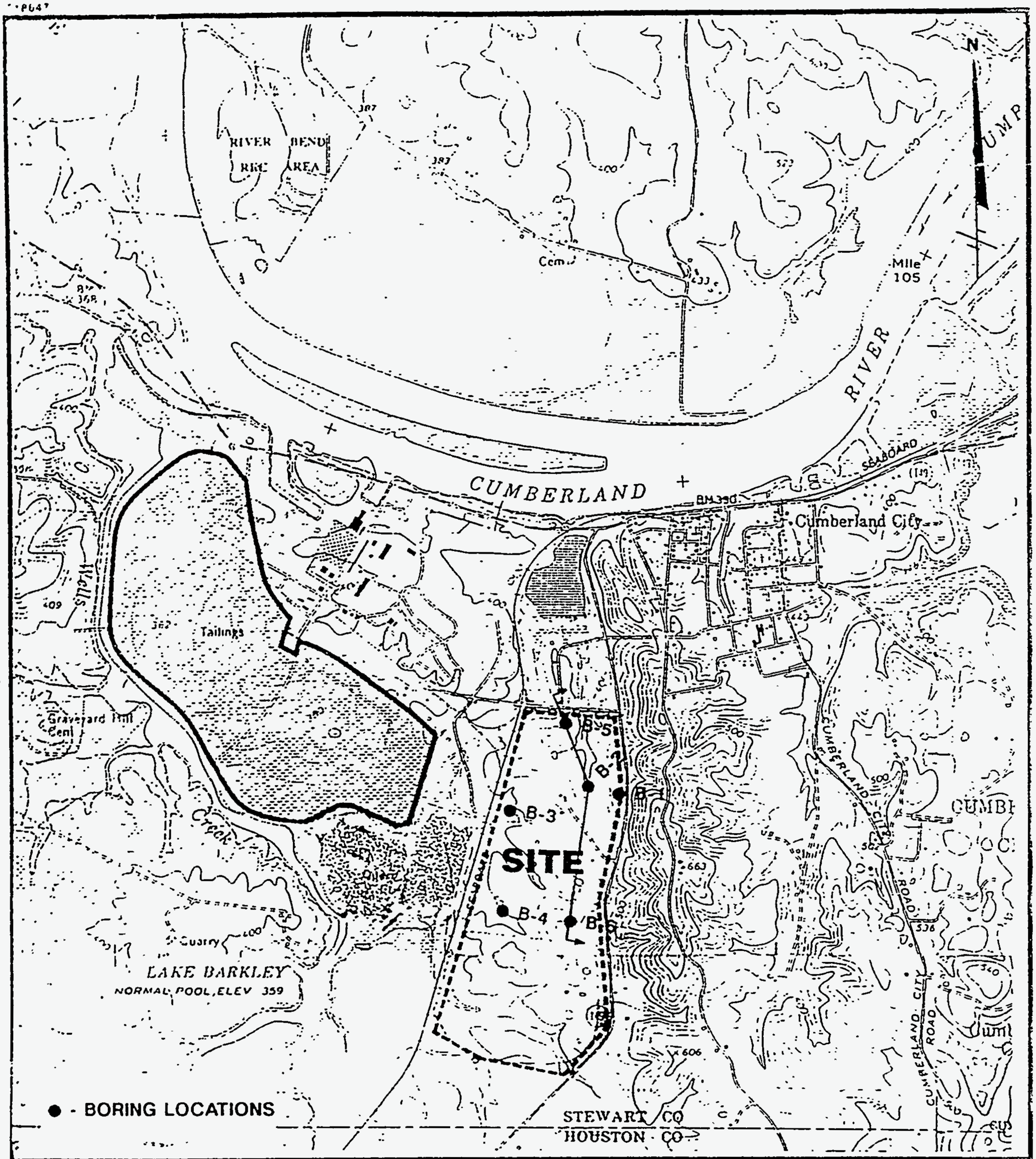

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FIGURE 1 - SITE LOCATION MAP

CUMBERLAND FOSSIL PLANT
CUMBERLAND CITY, TENNESSEE

Project No.	Scale	Date
56301442.01	1"=2000'	APRIL, 1991

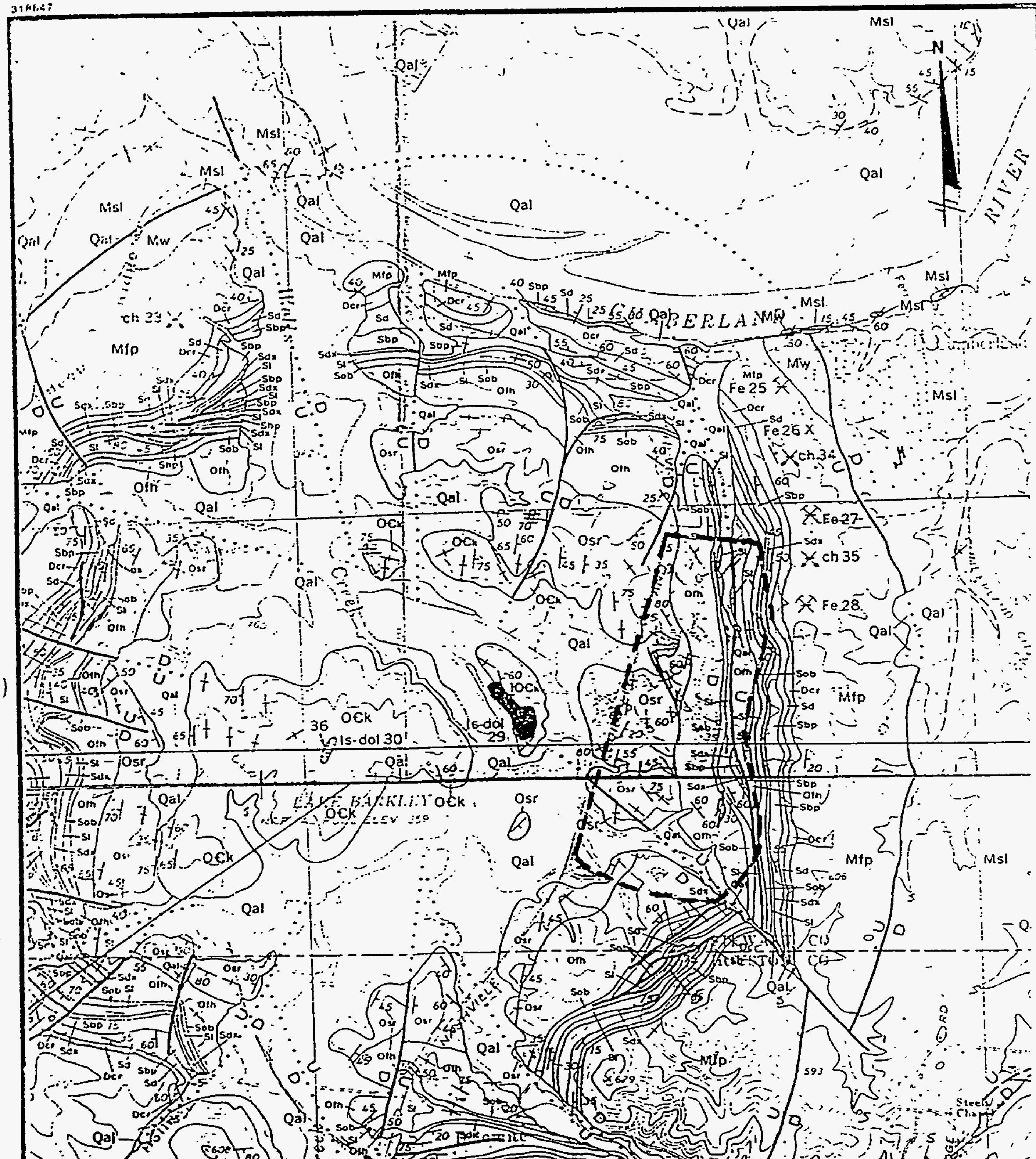

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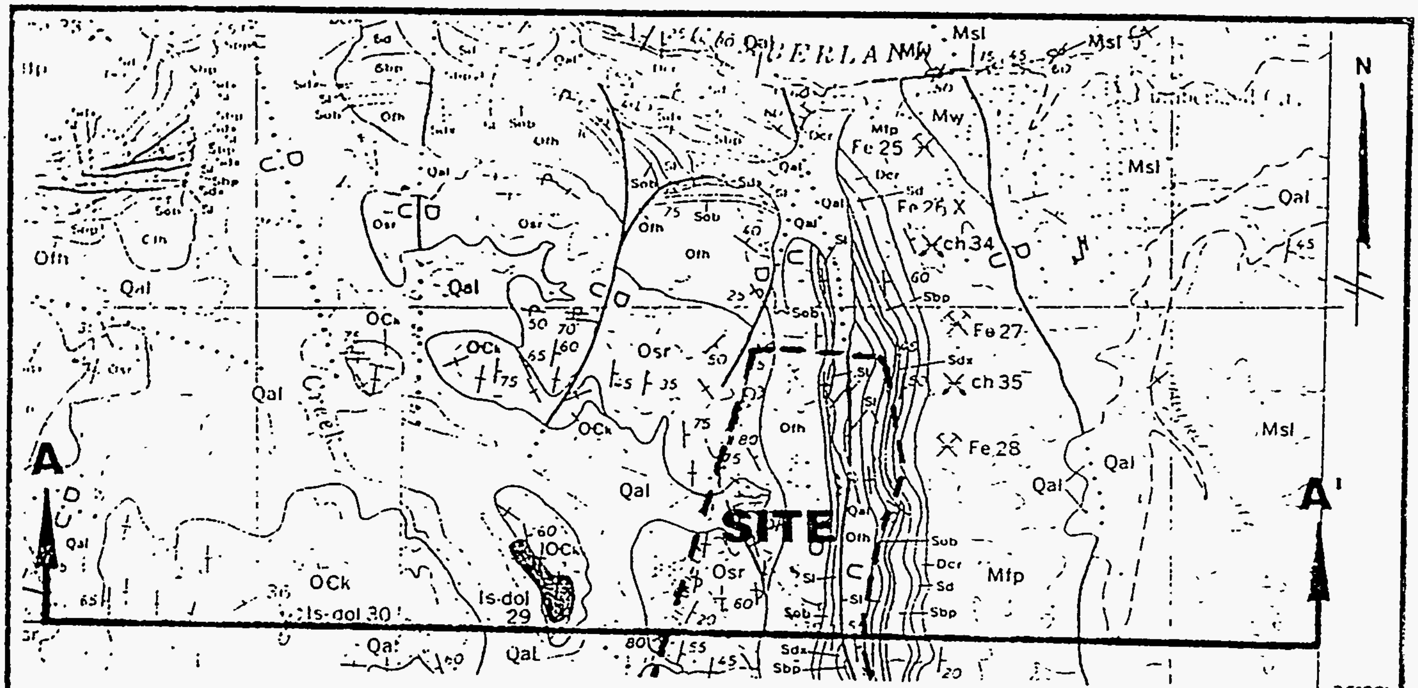
FIG. 2 - SITE LOCATION WITH RESPECT TO STRUCTURAL GEOLOGIC FEATURES

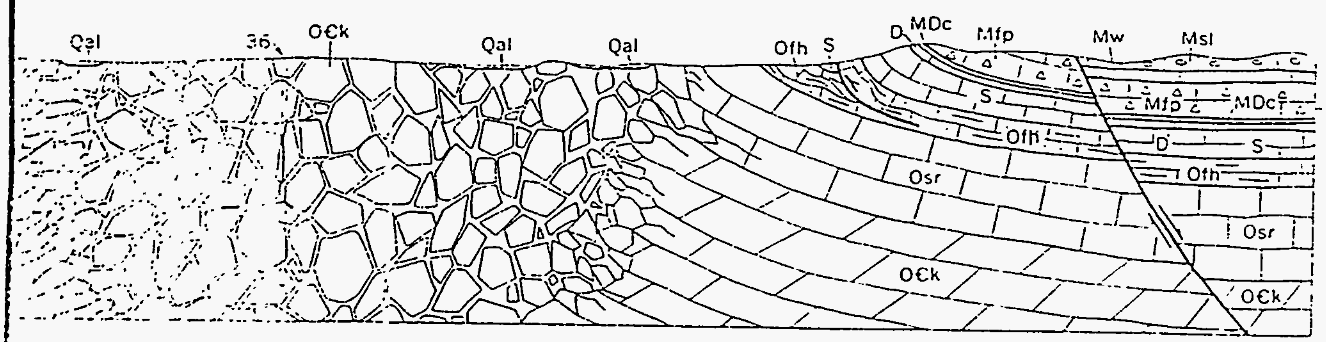
CUMBERLAND FOSSIL PLANT
CUMBERLAND CITY, TENNESSEE

Project No.	Scale	Date
56301442.01	1"=2000'	APRIL, 1991

316647



PLAN



SECTION A - A'

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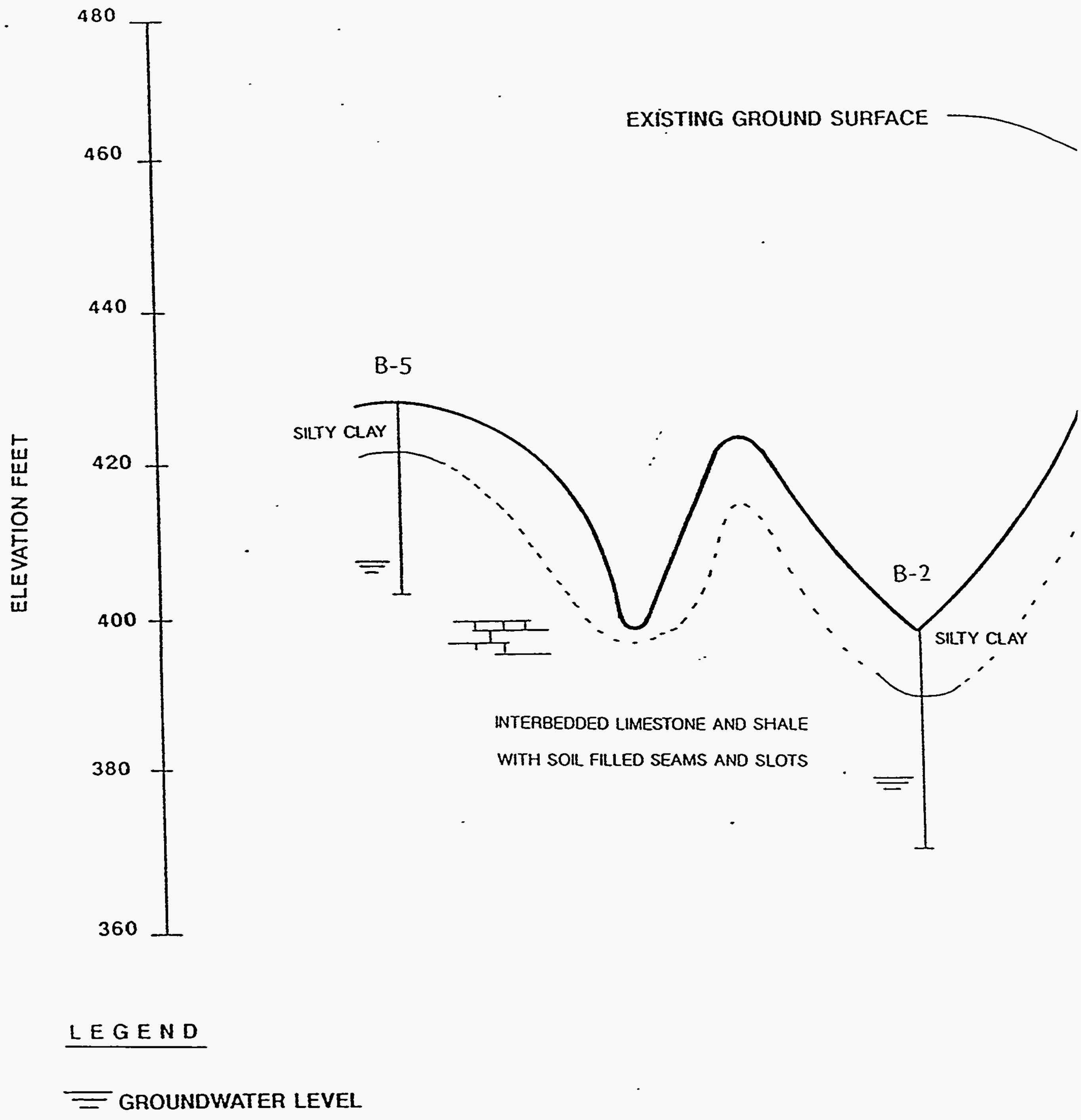
FIG. 3 · ABBREVIATED GEOLOGIC CROSS-SECTION OF THE SITE AREA		
CUMBERLAND FOSSIL PLANT CUMBERLAND CITY, TENNESSEE		
Project No. 56301442.01	Scale 1"=2000'	Date APRIL, 1991



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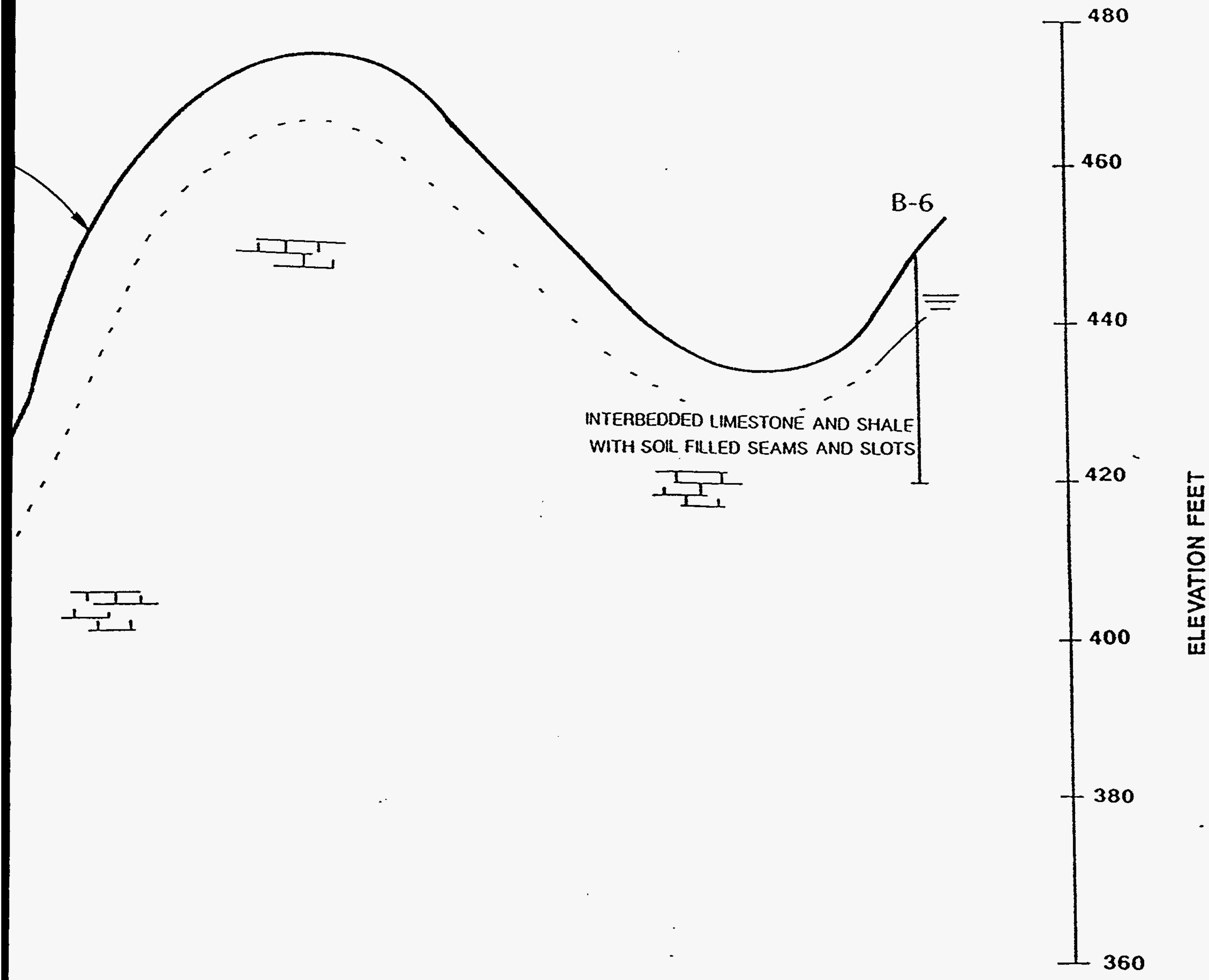
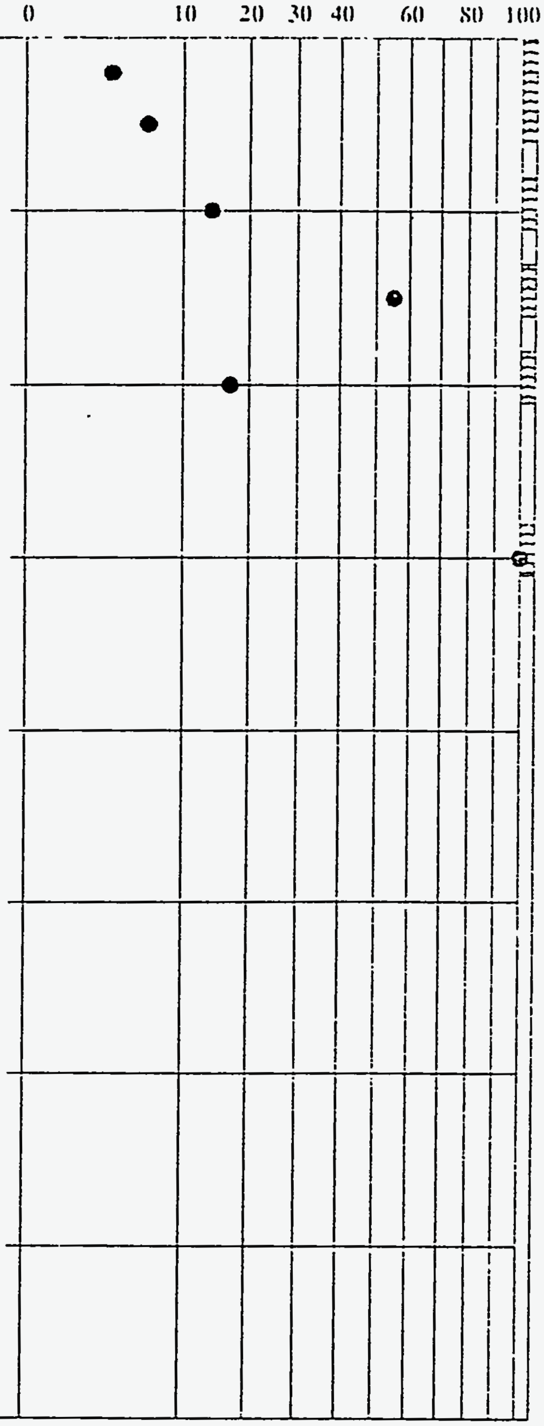


NGINEERING ta, Georgia Environmental Consultants	FIGURE 4 CROSS-SECTION THROUGH SITE CUMBERLAND FOSSIL PLANT		
	SCALE 1"=20 (V) 1"=3000'(H)	PROJECT NO. 56301442.01	DATE JUNE, 1991

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION - BLOWS PER FOOT		
0	TOPSOIL				
	SOFT TO VERY STIFF BROWN SILTY CLAY INTERLAYERED WITH WEATHERED LIMESTONE, SHALE AND CHERT			3 6 14 55 17	
14.8	AUGER REFUSAL AT 14.8 FEET MODERATELY WEATHERED FINE GRAINED WITH COARSE CALCITE CRYSTALS INTERBEDDED WITH EXTENSIVELY WEATHERED SHALE CORE FROM 14.8 FEET TO 24.8 FEET (BEDDING 45 DEGREES) LIGHTLY WEATHERED FINE GRAINED LIMESTONE WITH COARSE CALCITE CRYSTALS CORE FROM 24.8 FEET TO 34.8 FEET (BEDDING 45 DEGREES)			50/4"	REC. 95% ROD. 40% REC. 45% ROD. 13% REC. 87% ROD. 85% REC. 98% ROD. 98%
34.8	CORING TERMINATED AT 34.8 FEET				



REMARKS:

AS-BUILT PIEZOMETER DESCRIPTION: 36.55 FT. OF 1 1 1/2" PVC PIPE. SCREENED INTERVAL 23.0 FT. TO 34.0 FT. BACKFILLED WITH AUGER CUTTINGS.

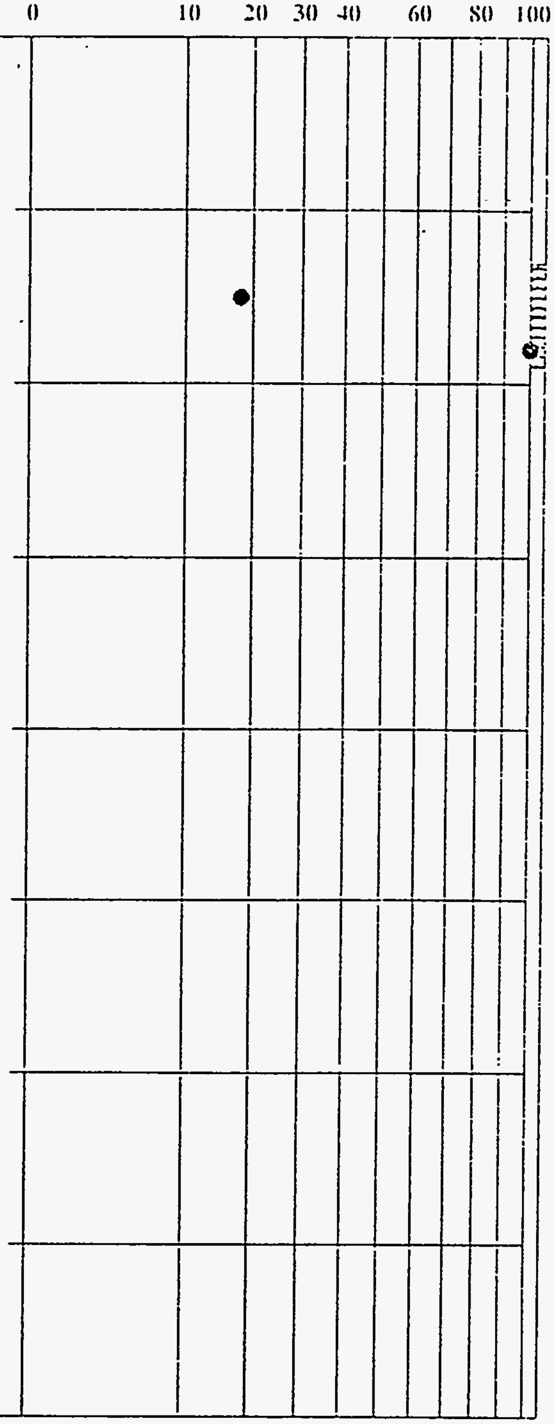
SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-1
DATE DRILLED	April 9, 1991
PROJECT NUMBER	563014402.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS PER FOOT		
0.0	TOPSOIL				
1.0	VERY STIFF TO VERY HARD CLAY WITH SOME CHERT FRAGMENTS			18	
9.5	AUGER REFUSAL AT 9.5 FEET MODERATELY TO EXTENSIVELY WEATHERED SANDY ARGILACEOUS LIMESTONE INTERBEDDED WITH SHALE CORE FROM 9.5 FEET TO 22.7 FEET (BEDDING 45 DEGREES) MODERATELY WEATHERED SANDY ARGILACEOUS LIMESTONE INTERBEDDED WITH SHALE (SLICKENSIDES EVIDENT AT APPROXIMATELY 27.0 FEET)			35/2"	REC. 47% RQD. 31% REC. 64% RQD. 22%
	CORE FROM 22.7 FEET TO 29.5 FEET (BEDDING 45 DEGREES)				REC. 100% RQD. 100% REC. 83% RQD. 34% REC 100% RQD. 64%
29.5	CORING TERMINATED AT 29.5 FEET				



REMARKS:

AS-BUILT PIEZOMETER DESCRIPTION: 26.3 FT. OF 1 1/2" PVC PIPE. SCREENED INTERVAL 19.0 FT. TO 24.0 FT. BACKFILLED WITH AUGER CUTTINGS.

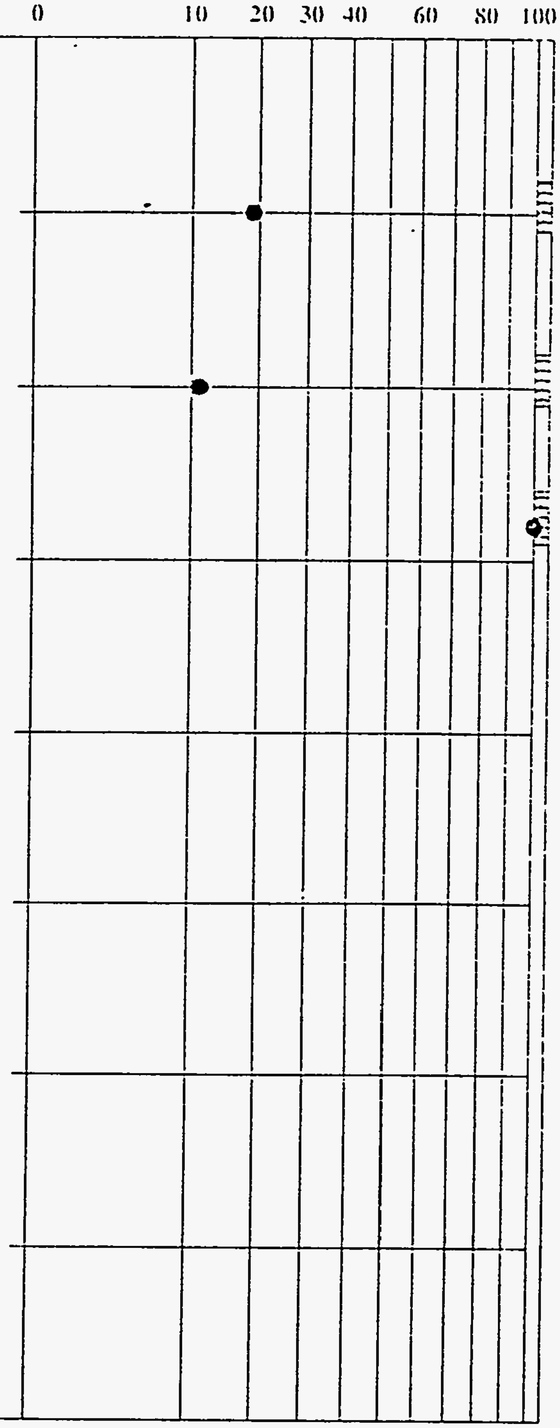
SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-2
DATE DRILLED	April 9, 1991
PROJECT NUMBER	563014402.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS PER FOOT		
0.0					
0.7	TOPSOIL				
	STIFF TO VERY STIFF SLIGHTLY SANDY, SILTY CLAY			19	
				11	
14.0	AUGER REFUSAL AT 14.0 FEET			20/0"	REC. 94% ROD. 85%
	LIGHT TO MODERATELY WEATHERED FINE GRAINED LIMESTONE INTERBEDDED WITH SHALE CORE FROM 14.0 FEET TO 34.0 FEET EXTENSIVELY WEATHERED SHALE FROM 28.5 FEET TO 29.0 FEET (BEDDING 45 DEGREES)				REC. 89% ROD. 40%
					REC 98% ROD 67%
					REC. 76% ROD. 52%
34.0	CORING TERMINATED AT 34.0 FEET				



REMARKS:

AS-BUILT PIEZOMETER DESCRIPTION: 35.25 FT. OF 1 1/2" PVC PIPE. SCREENED INTERVAL 29.0 FT. TO 34.0 FT. BACKFILLED WITH AUGER CUTTINGS.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

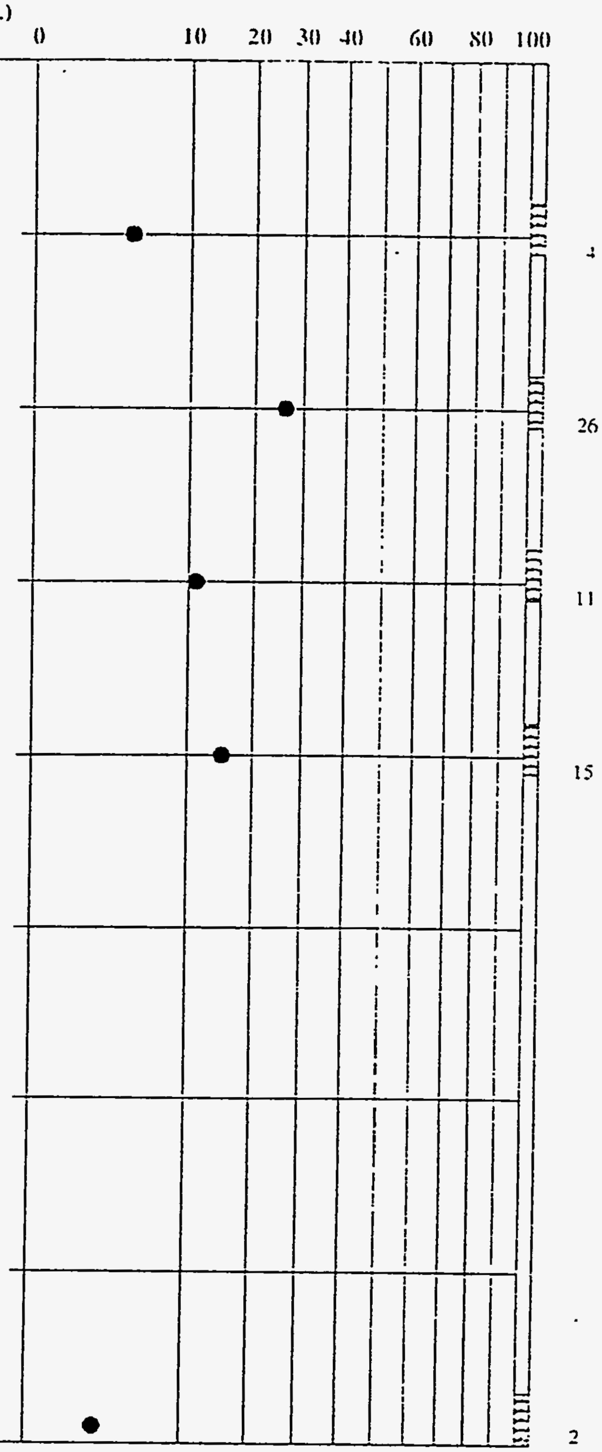
SOIL TEST BORING RECORD

BORING NUMBER	B-3
DATE DRILLED	April 10, 1991
PROJECT NUMBER	563014402.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
0.0	TOPSOIL	
3.0	SOFT TO VERY STIFF CLAY WITH CHERT AND OXIDE NODULES	
23.5	AUGER REFUSAL AT 23.5 FEET CORED TO 28.5 FEET NO RECOVERY	
28.5	VERY SOFT BROWN CLAY	

● PENETRATION - BLOWS PER FOOT



REMARKS:

AS-BUILT PIEZOMETER DESCRIPTION:
68.75 FT. OF 1 1/2" PVC PIPE. SCREENED INTERVAL 61.0 FT. TO 66.0 FT. BACKFILLED WITH AUGER CUTTINGS.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-4
DATE DRILLED	April 10, 1991
PROJECT NUMBER	563014402.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 1 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS PER FOOT (0 10 20 30 40 60 80 100)		
	VERY SOFT BROWN CLAY			2	
46.5	AUGER REFUSAL AT 46.5 FEET MODERATELY TO EXTENSIVELY WEATHERED FINE GRAINED LIMESTONE WITH STYOLITES AND THIN SHALE PARTINGS CORE FROM 46.5 FEET TO 57.5 FEET (BEDDING 45 DEGREES)				REC. 49% ROD. 38% REC. 100% ROD. 0% REC. 40% ROD. 0% REC. 97% ROD. 95% REC. 100% ROD. 96%
66.5	CORING TERMINATED AT 66.5 FEET				

REMARKS:
AS-BUILT PIEZOMETER DESCRIPTION: 68.75 FT OF 1 1/2" PVC PIPE. SCREENED INTERVAL 61.0 FT. TO 66.0 FT. BACKFILLED WITH AUGER CUTTINGS.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-4
DATE DRILLED	April 10, 1991
PROJECT NUMBER	563014402.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 2 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS PER FOOT (0 10 20 30 40 60 80 100)	
0.0	TOPSOIL			
1.0	BROWN SILTY CLAY			
5.7	AUGER REFUSAL AT 5.9 FEET		50/6"	
	SLIGHTLY WEATHERED SHALE INTERBEDDED WITH FINE TO MEDIUM GRAINED LIMESTONE CORE FROM 5.75 FEET TO 25.75 FEET (BEDDING 90 DEGREES)			REC. 97% RQD. 78%
				REC. 98% RQD. 98%
				REC. 100% RQD. 100%
				REC. 100% RQD. 100%
				REC. 100% RQD. 94%
25.8	CORING TERMINATED AT 25.8 FEET			

REMARKS:

AS-BUILT PIEZOMETER DESCRIPTION: 28.0 FT. OF 1 1/2" PVC PIPE. SCREENED INTERVAL 20.0 FT. TO 25.0 FT. BACKFILLED WITH AUGER CUTTINGS.

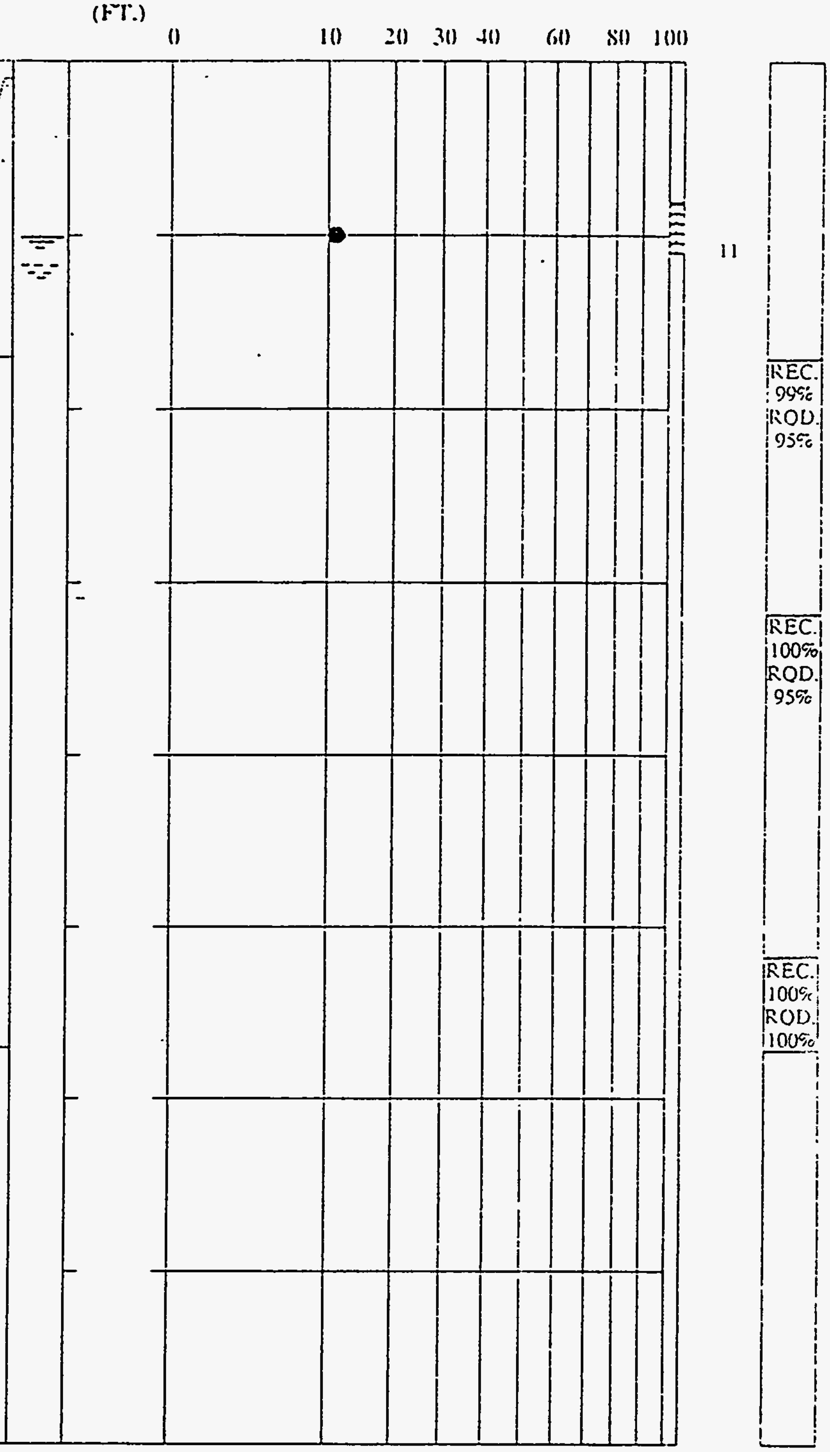
SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-5
DATE DRILLED	April 11, 1991
PROJECT NUMBER	563014402.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS PER FOOT	
0.0 – 0.5	TOPSOIL			
0.5 – 8.5	STIFF BROWN SILTY CLAY		11	
8.5 – 28.5	AUGER REFUSAL AT 8.5 FEET LIGHT TO MODERATELY WEATHERED INTERBEDDED FINE TO MEDIUM GRAINED LIMESTONE AND SHALE (BEDDING 45 DEGREES)			REC. 99% RQD. 95% REC. 100% RQD. 95% REC. 100% RQD. 100%
28.5	CORING TERMINATED AT 28.5 FEET			



REMARKS:

AS-BUILT PIEZOMETER DESCRIPTION: 30.85 FT. OF 1 1/2" PVC PIPE. SCREENED INTERVAL 23.0 FT. TO 28.0 FT. BACKFILLED WITH AUGER CUTTINGS.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-6
DATE DRILLED	April 11, 1991
PROJECT NUMBER	563014402.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1	

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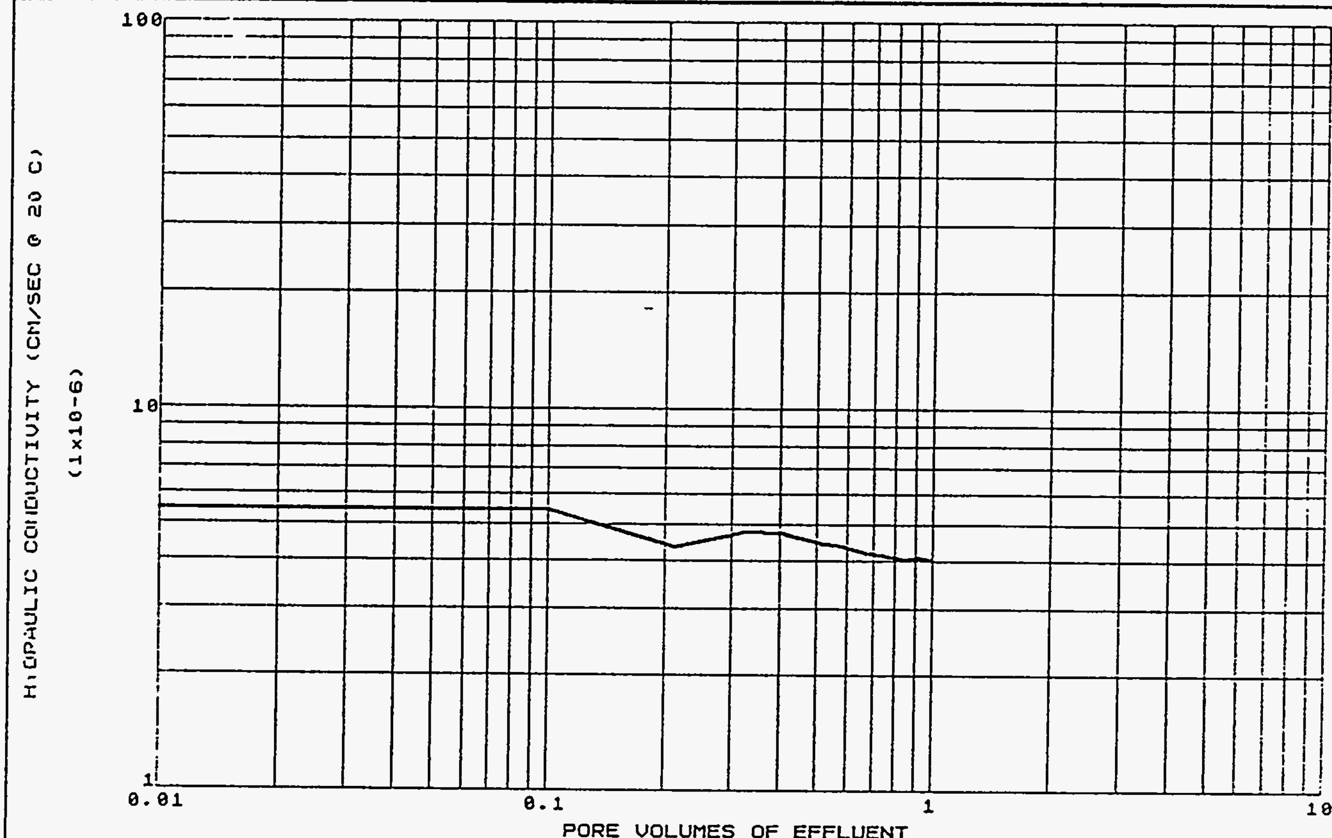
CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 30, 1991
TESTED BY JM HJ MO PAGE 4
PROJECT Cumberland City Fossil Plant
TEST METHOD Corps of Engrs EM1110-2-1906.



LAB NO.	01040					
SAMPLE IDENTIFICATION	B-1 UD 2'-4'					
RECEIPT DATE	4/16/91					
TEST COMPLETION DATE	4/24/91					
SAMPLE TYPE	Undist					
INITIAL WATER CONTENT (% BY DRY WEIGHT)	25.6					
DRY UNIT WEIGHT (PCF)	105.9					
PERCENT COMPACTION IF REMOLDED	N/A					
ONE PORE VOLUME (CC)	79					
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	4.1E-06					

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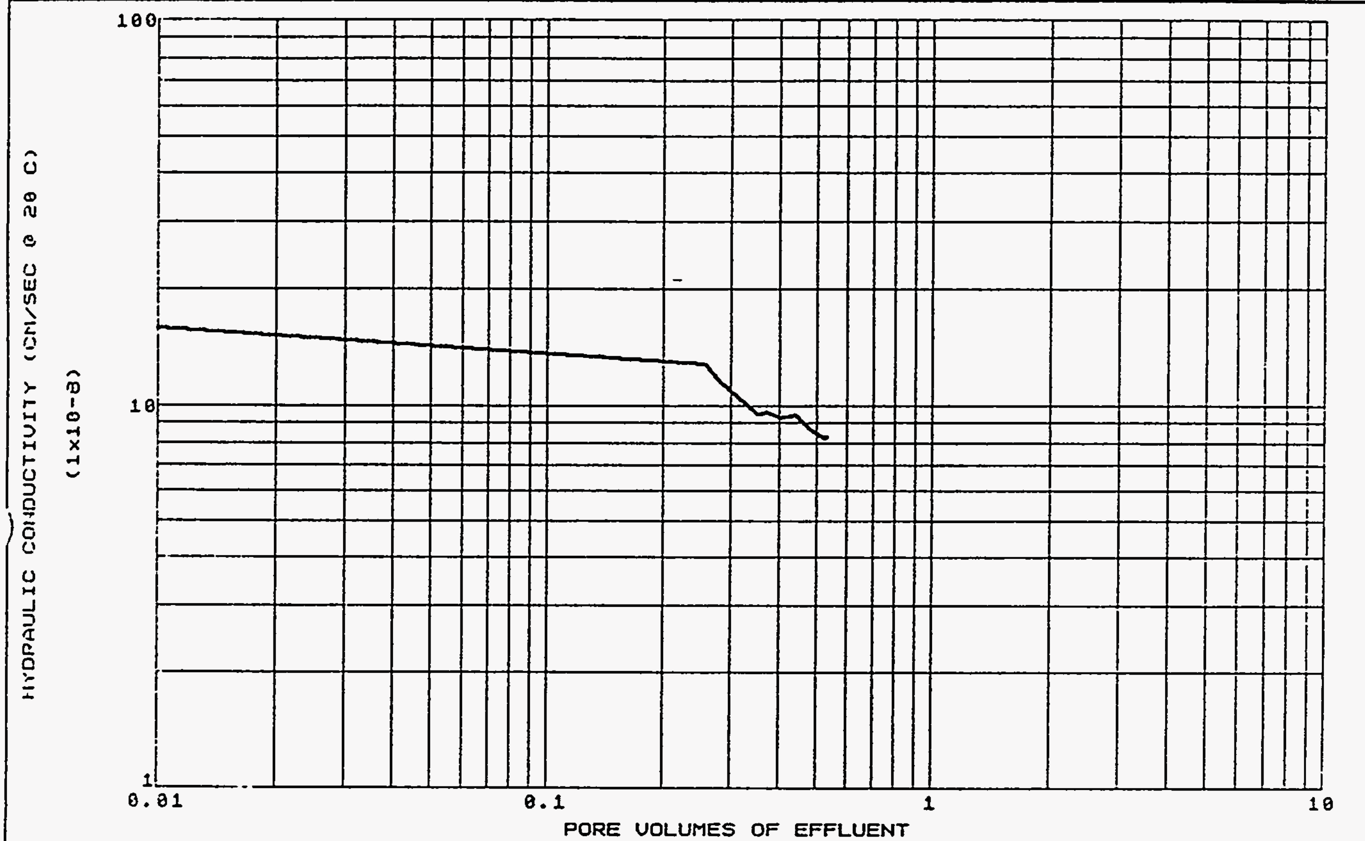
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE May 6, 1991
TESTED BY JM HJ MO PAGE 1
PROJECT Cumberland City Fossil Plant
TEST METHOD Corps of Engrs EM1110-2-1906.



LAB NO.	01037					
SAMPLE IDENTIFICATION	B-1 Bag 0'-14'					
RECEIPT DATE	4/16/91					
TEST COMPLETION DATE	5/3/91					
SAMPLE TYPE	Remold					
INITIAL WATER CONTENT (% BY DRY WEIGHT)	21.4					
DRY UNIT WEIGHT (PCF)	101.0					
PERCENT COMPACTION IF REMOLDED	94.4					
ONE PORE VOLUME (CC)	89					
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	8.3E-08					

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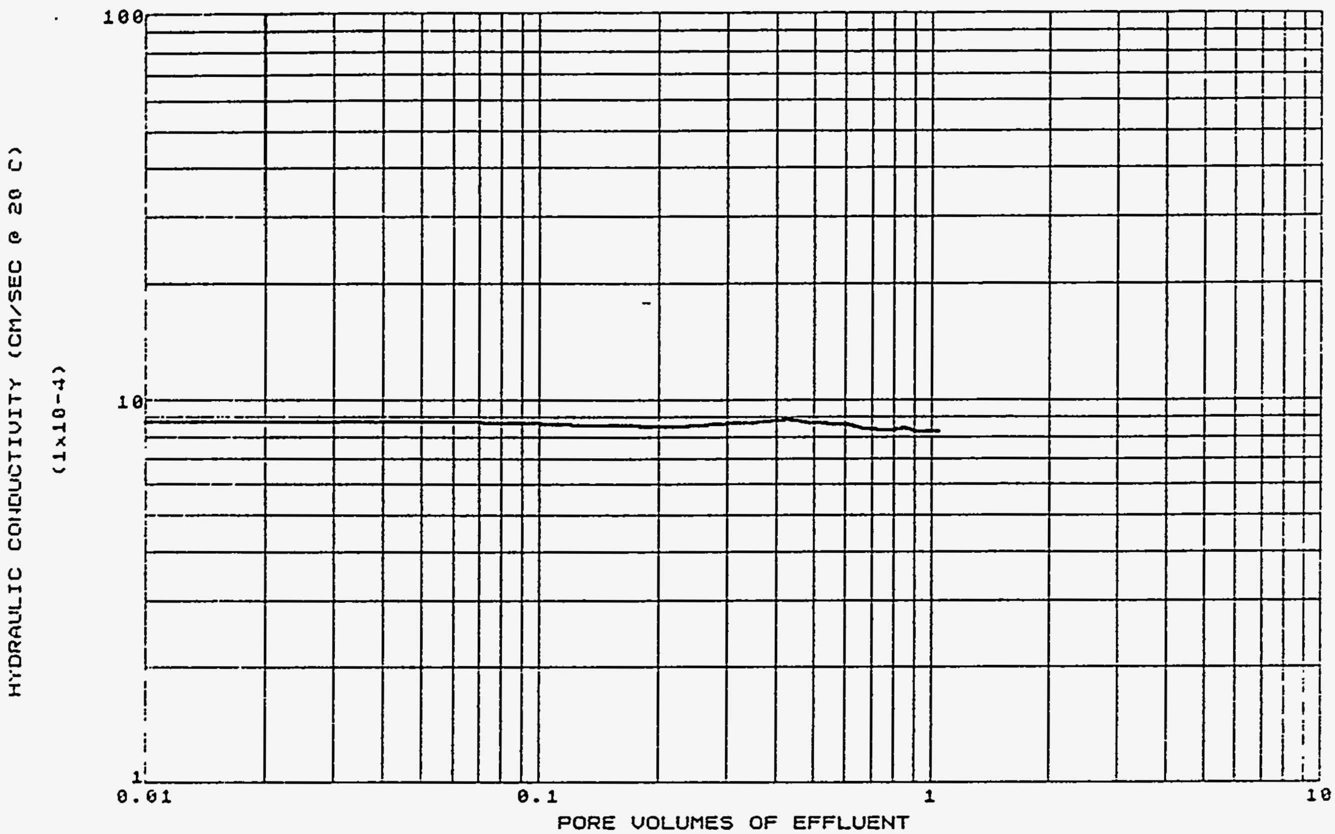
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 30, 1991
TESTED BY JM HJ MO PAGE 5
PROJECT Cumberland City Fossil Plant
TEST METHOD Corps of Engrs EM1110-2-1906.



LAB NO.	01041					
SAMPLE IDENTIFICATION	B-3 UD 2'-4'					
PECEIPT DATE	4/16/91					
TEST COMPLETION DATE	4/24/91					
SAMPLE TYPE	Undist					
INITIAL WATER CONTENT (% BY DRY WEIGHT)	20.9					
DRY UNIT WEIGHT (PCF)	105.0					
PERCENT COMPACTION IF REMOLDED	N/A					
ONE PORE VOLUME (CC)	88					
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	8.3E-04					

REMARKS: Blocky sample condition.

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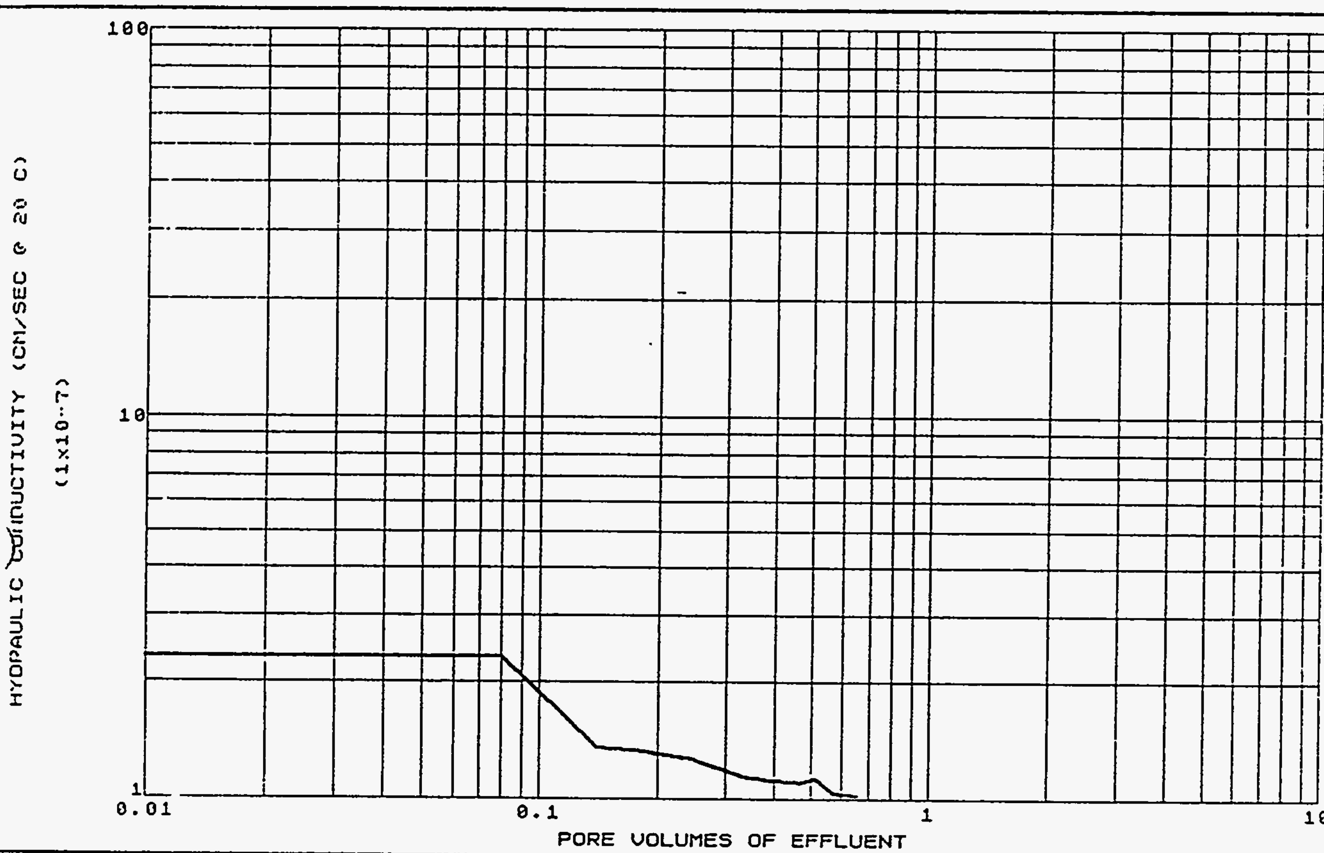
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 30, 1991
TESTED BY JM HJ MO PAGE 6
PROJECT Cumberland City Fossil Plant
TEST METHOD Corps of Engrs EM1110-2-1906.



LAB NO.	01042				
SAMPLE IDENTIFICATION	B-4 UD 2'-4'				
RECEIPT DATE	4/16/91				
TEST COMPLETION DATE	4/30/91				
SAMPLE TYPE	Undist				
INITIAL WATER CONTENT (% BY DRY WEIGHT)	26.5				
DRY UNIT WEIGHT (PCF)	98.4				
PERCENT COMPACTION IF REMOLDED	N/A				
ONE PORE VOLUME (CC)	96				
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	1.0E-07				

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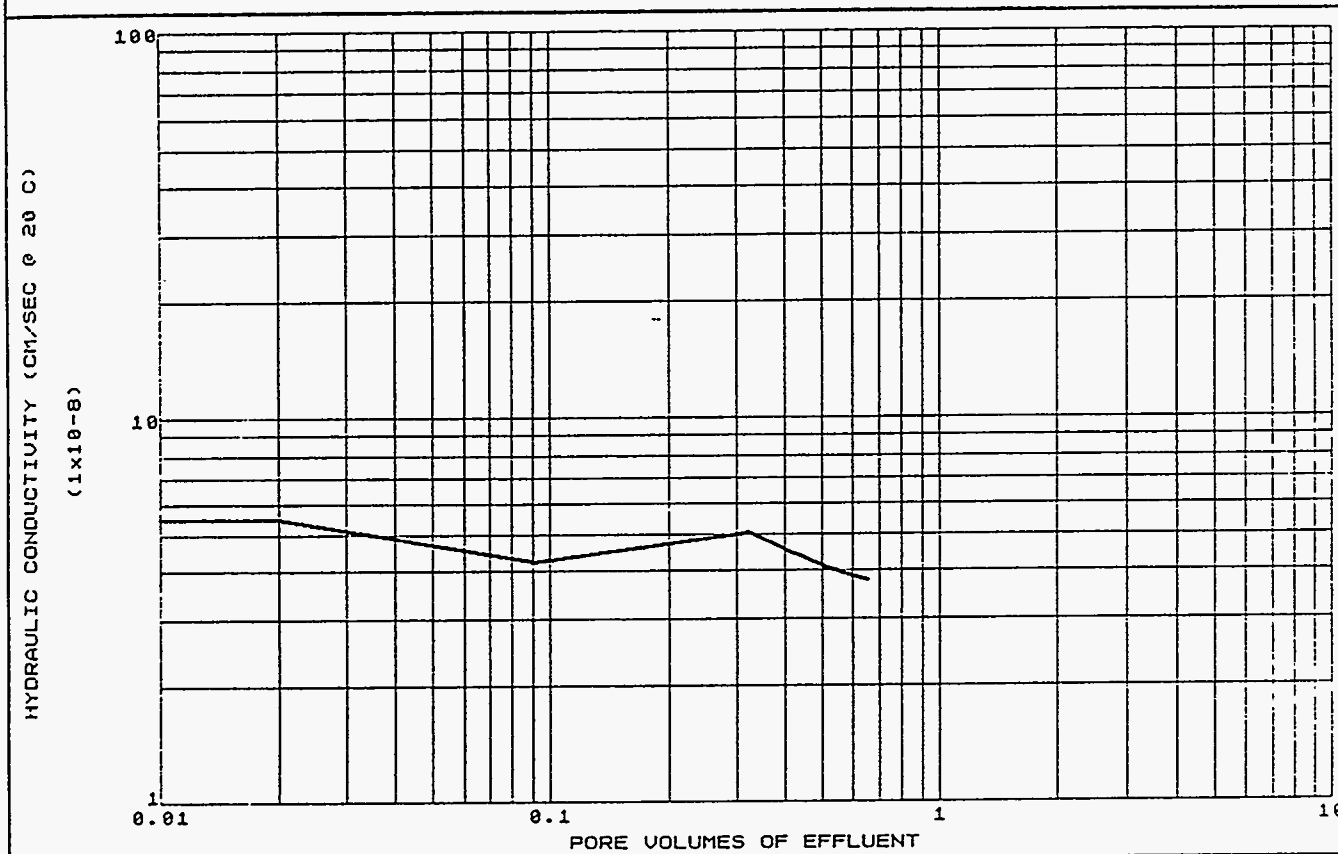
CLIENT	Law Engineering, Inc.	JOB NO.	41-10101
	396 Plasters Avenue	DATE	May 6, 1991
	Atlanta, Georgia 30324	TESTED BY	JM HJ MO
CLIENT JOB NO./P.O.#	56301442.01	PAGE	2
		PROJECT	Cumberland City Fossil Plant
		TEST METHOD	Corps of Engrs EM1110-2-1906.



LAB NO.	01038					
SAMPLE IDENTIFICATION	B-4 Bag 0'-20'					
RECEIPT DATE	4/16/91					
TEST COMPLETION DATE	5/3/91					
SAMPLE TYPE	Remold					
INITIAL WATER CONTENT (% BY DRY WEIGHT)	18.2					
DRY UNIT WEIGHT (PCF)	106.5					
PERCENT COMPACTION IF REMOLDED	96.8					
ONE PORE VOLUME (CC)	81					
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	3.8E-08					

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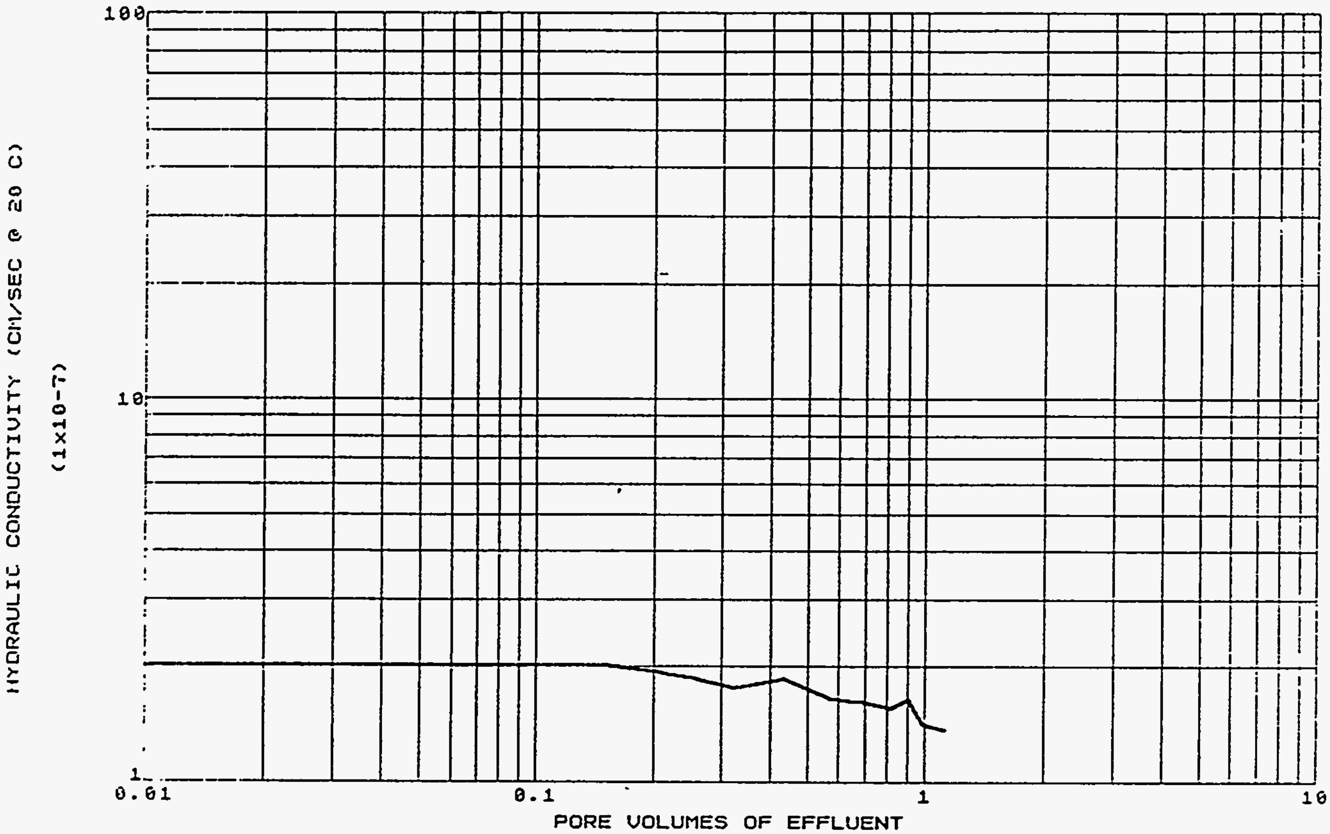
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 30, 1991
TESTED BY JM HJ MO PAGE 7
PROJECT Cumberland City Fossil Plant
TEST METHOD Corps of Engrs EM1110-2-1906.



LAB NO.	01043					
SAMPLE IDENTIFICATION	B-6 UD 2'-4'					
RECEIPT DATE	4/16/91					
TEST COMPLETION DATE	4/30/91					
SAMPLE TYPE	Undist					
INITIAL WATER CONTENT (% BY DRY WEIGHT)	27.4					
DRY UNIT WEIGHT (PCF)	104.2					
PERCENT COMPACTION IF REMOLDED	N/A					
ONE PORE VOLUME (CC)	83					
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	1.4E-07					

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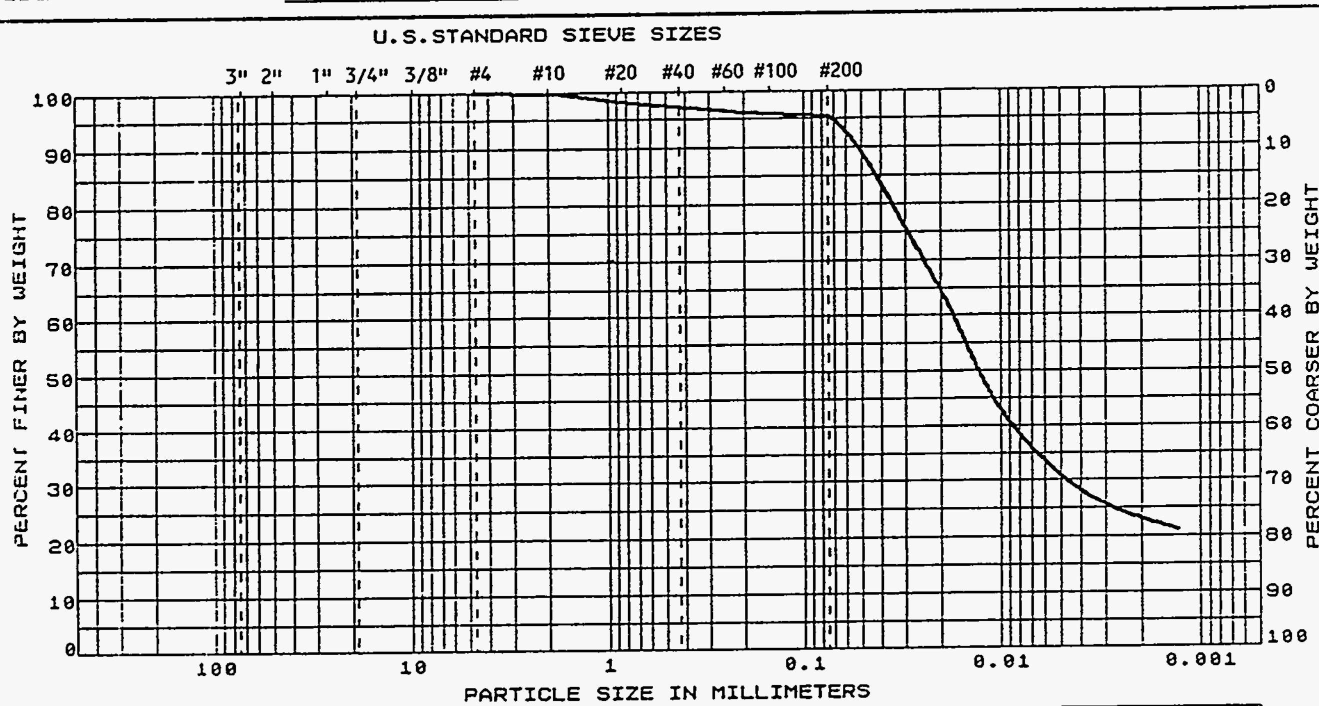
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101
LAB NO. 01040
PROJECT Cumberland City Fossil Plant
SAMPLE ID B-1UD 2'-4'

DATE April 23, 1991
PAGE 7



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING	HYDROMETER	
SIEVE NO.	SIEVE SIZE (MILLIMETERS)		PERCENT PASSING	PARTICLE DIAMETER (MILLIMETERS)
3"	75		86.4	0.050
2"	50		64.3	0.020
1-1/2"	37.5		31.0	0.005
1"	25		23.5	0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
No.4	4.75	100.0		
No.10	2.00	99.8		
No.20	0.850	98.2		
No.40	0.425	97.2		
No.60	0.250	96.5		
No.100	0.150	95.9		
No.200	0.075	95.5		

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%) ______
EFFECTIVE SIZE (mm) ______
COEFFICIENT OF UNIFORMITY ______
COEFFICIENT OF CURVATURE ______
LIQUID LIMIT ______
PLASTIC LIMIT ______
PLASTICITY INDEX ______
CLASSIFICATION ()
WATER CONTENT (%) 25.6
DRY DENSITY (PCF) 105.9
SPECIFIC GRAVITY ______
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) ______
TEST PROCEDURES: ASTM D422.

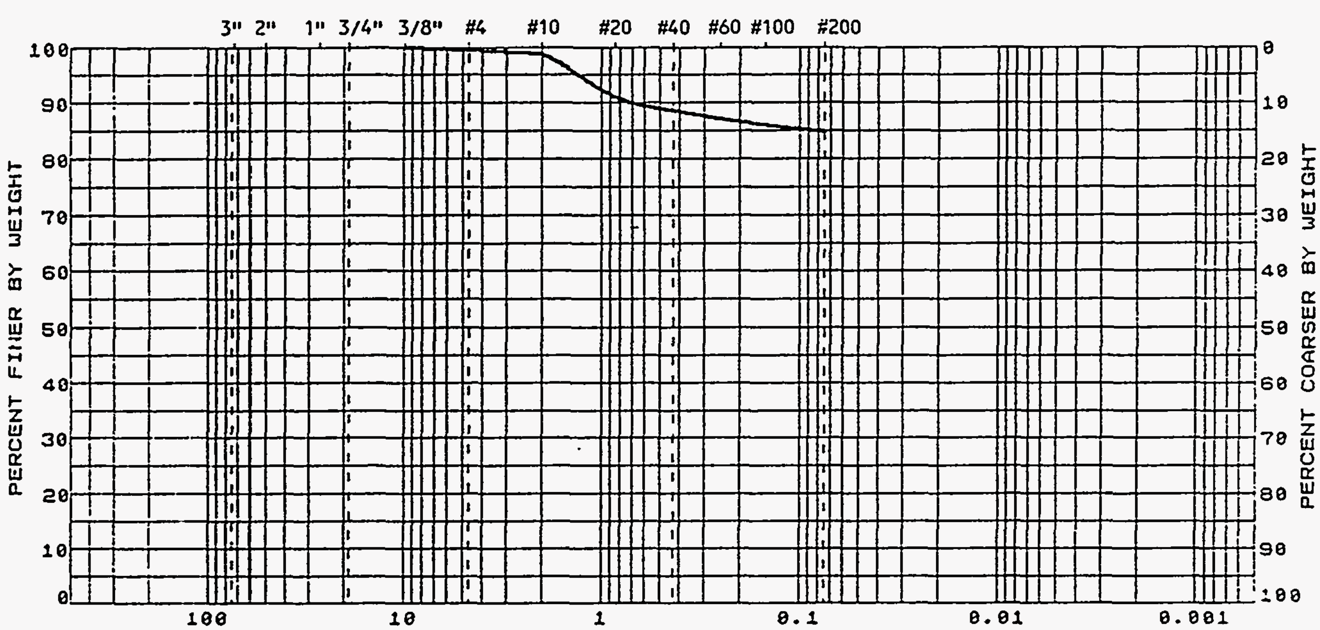
LAW ENVIRONMENTAL, INC.
M. A. O'Kelly

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 23, 1991
LAB NO. 01031 PAGE 1
PROJECT Cumberland City Fossil Plant
SAMPLE ID B-1S-3 5'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING	HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)		PARTICLE DIAMETER (MILLIMETERS)
3"	75		0.050
2"	50		0.020
1-1/2"	37.5		0.005
1"	25		0.002
3/4"	19		0.001
1/2"	12.5		
3/8"	9.5	100.0	
No.4	4.75	99.5	
No.10	2.00	98.8	
No.20	0.850	91.2	
No.40	0.425	88.6	
No.60	0.250	87.2	
No.100	0.150	86.1	
No.200	0.075	84.9	

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()

WATER CONTENT (%)
DRY DENSITY (PCF)
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

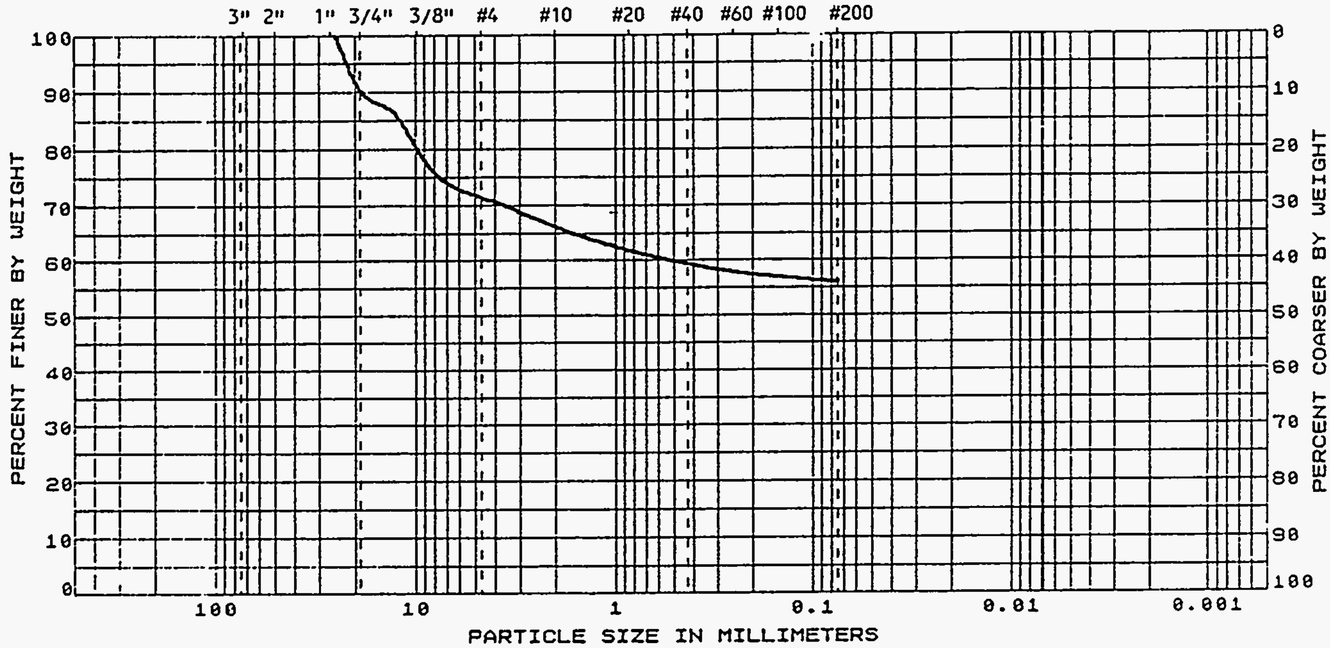
LAW ENVIRONMENTAL, INC.
M. A. O'Kelly

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 23, 1991
LAB NO. 01032 PAGE 2
PROJECT Cumberland City Fossil Plant
SAMPLE ID B-2S-1 7'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

SIEVE NO.	SIEVE SIZE (MILLIMETERS)	PERCENT PASSING		HYDROMETER PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25	100.0		0.002
3/4"	19	90.6		0.001
1/2"	12.5	86.2		
3/8"	9.5	79.3		
No.4	4.75	71.5		
No.10	2.00	66.2		
No.20	0.850	61.9		
No.40	0.425	59.4		
No.60	0.250	57.9		
No.100	0.150	57.0		
No.200	0.075	56.1		

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()

WATER CONTENT (%)
DRY DENSITY (PCF)
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

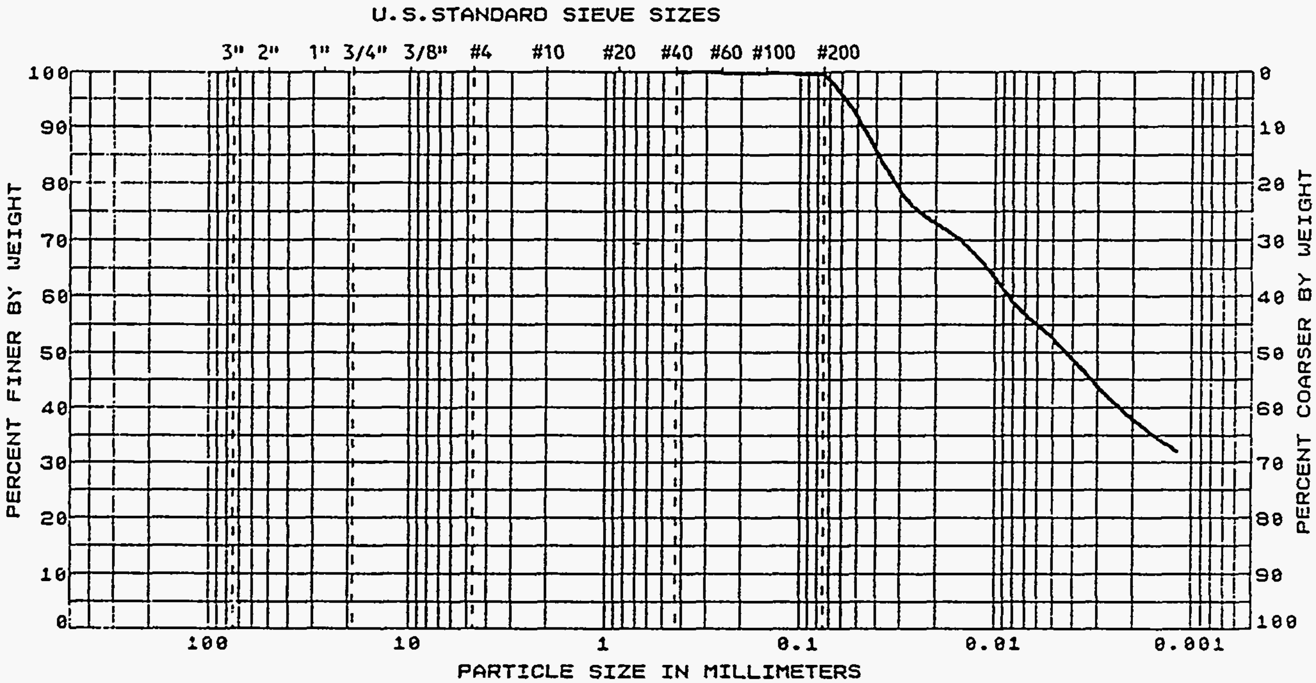
LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101　DATE April 23, 1991
LAB NO. 01041　PAGE 8
PROJECT Cumberland City Fossil Plant
SAMPLE ID B-3UD 2'-4'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75		90.4	0.050
2"	50		73.1	0.020
1-1/2"	37.5		52.3	0.005
1"	25		38.5	0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
No.4	4.75			
No.10	2.00			
No.20	0.850			
No.40	0.425	100.0		
No.60	0.250	99.8		
No.100	0.150	99.6		
No.200	0.075	99.4		

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.
REMARKS: Blocky sample condition.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()

WATER CONTENT (%) 20.9
DRY DENSITY (PCF) 105.0
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.
M.H. O'Kelly

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

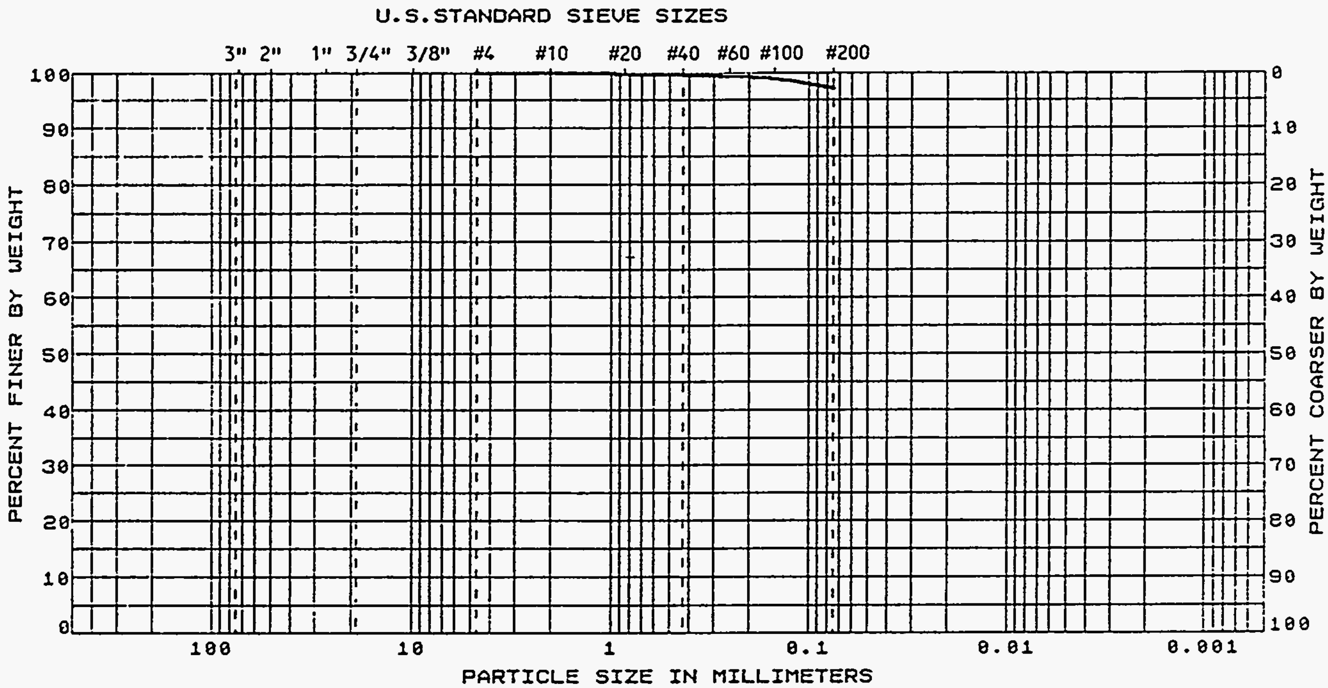
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 23, 1991

LAB NO. 01033 PAGE 3

PROJECT Cumberland City Fossil Plant

SAMPLE ID B-3S-2 10'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING	HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)		PARTICLE DIAMETER (MILLIMETERS)
3"	75		0.050
2"	50		0.020
1-1/2"	37.5		0.005
1"	25		0.002
3/4"	19		0.001
1/2"	12.5		
3/8"	9.5		
No.4	4.75	100.0	
No.10	2.00	99.9	
No.20	0.850	99.8	
No.40	0.425	99.6	
No.60	0.250	99.3	
No.100	0.150	98.9	
No.200	0.075	97.1	

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY:JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()
WATER CONTENT (%)
DRY DENSITY (PCF)
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

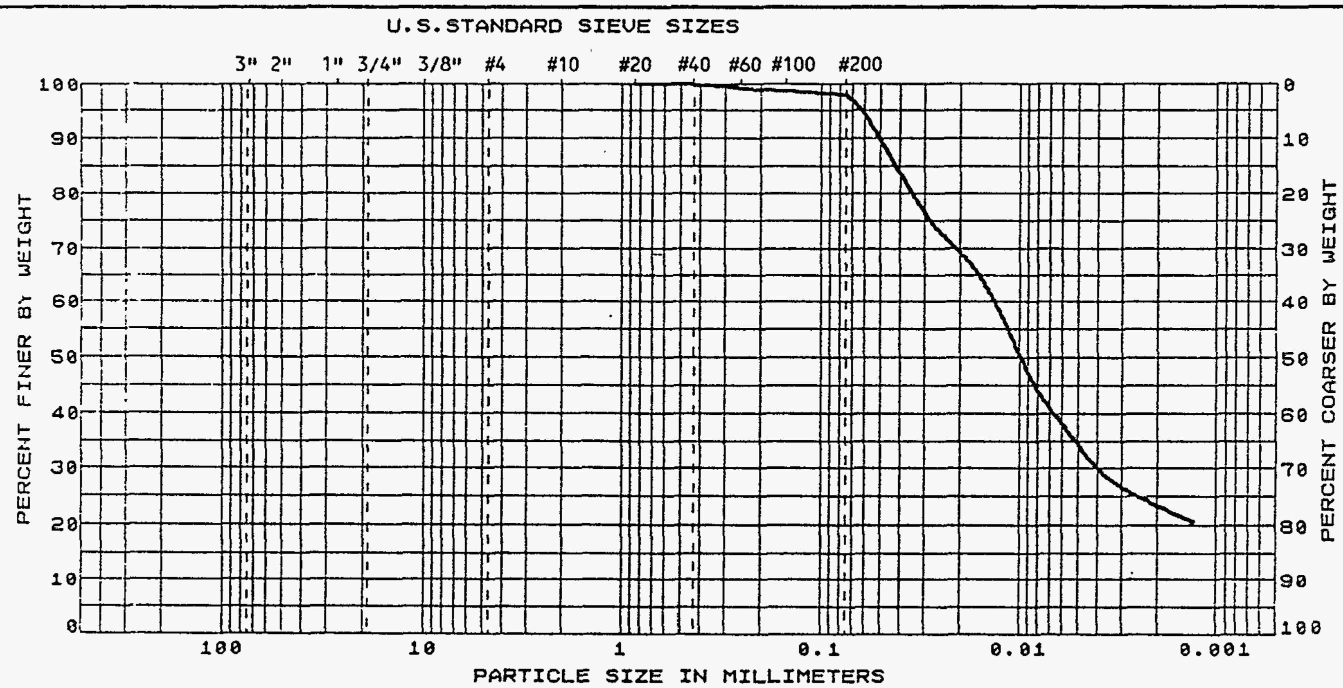
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 23, 1991

LAB NO. 01042 PAGE 9

PROJECT Cumberland City Fossil Plant

SAMPLE ID B-4UD 2'-4'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75		88.5	0.050
2"	50		69.2	0.020
1-1/2"	37.5		34.2	0.005
1"	25		23.8	0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
No.4	4.75			
No.10	2.00			
No.20	0.850	100.0		
No.40	0.425	99.8		
No.60	0.250	99.1		
No.100	0.150	98.5		
No.200	0.075	97.9		

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ( )

WATER CONTENT (%) 26.5
DRY DENSITY (PCF) 98.4
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.

M.H. O'Kelly

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

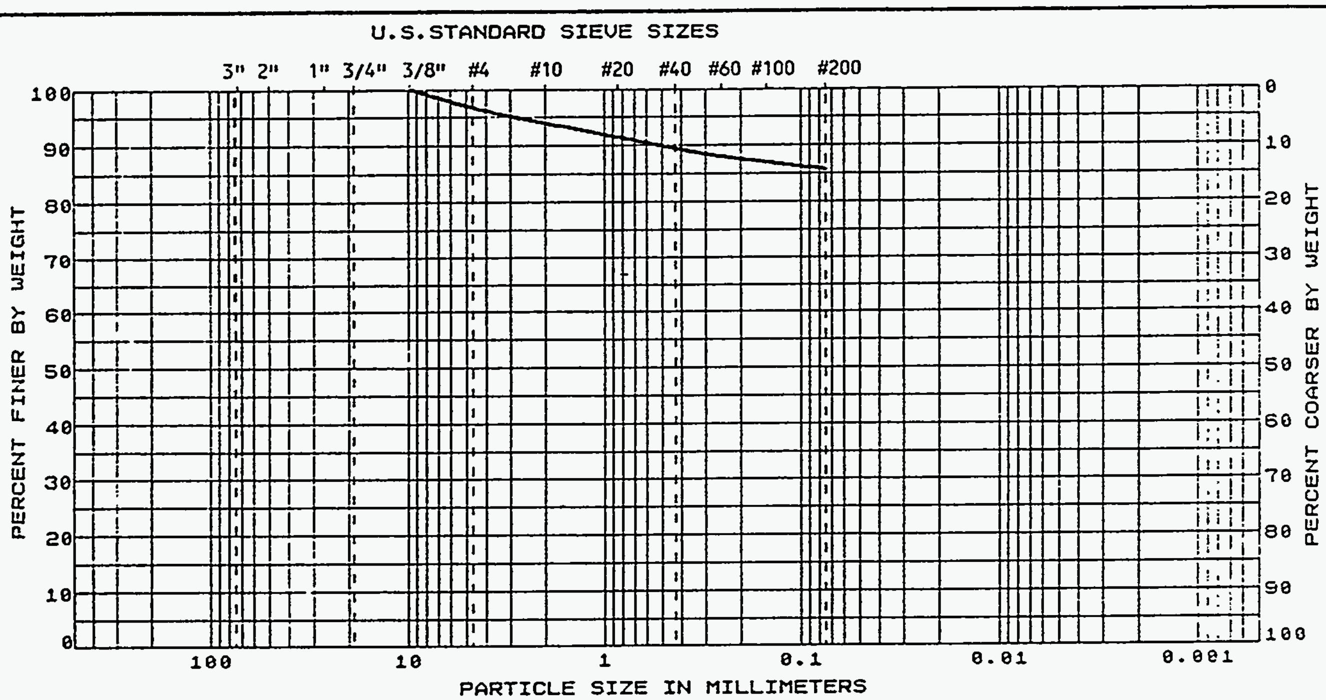
PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101
LAB NO. 01034
PROJECT Cumberland City Fossil Plant
SAMPLE ID B-4S-4 20'

DATE April 23, 1991
PAGE 4



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S. STANDARD SIEVE SIZE: SIEVE NO.	SIEVE SIZE (MILLIMETERS)	PERCENT PASSING	HYDROMETER PARTICLE DIAMETER (MILLIMETERS)
3"	75		0.050
2"	50		0.020
1-1/2"	37.5		0.005
1"	25		0.002
3/4"	19		0.001
1/2"	12.5		
3/8"	9.5	100.0	
No.4	4.75	96.9	
No.10	2.00	94.1	
No.20	0.850	91.6	
No.40	0.425	89.5	
No.60	0.250	88.1	
No.100	0.150	87.1	
No.200	0.075	85.8	

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()

WATER CONTENT (%)
DRY DENSITY (PCF)
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.

M.H. O'Kelley

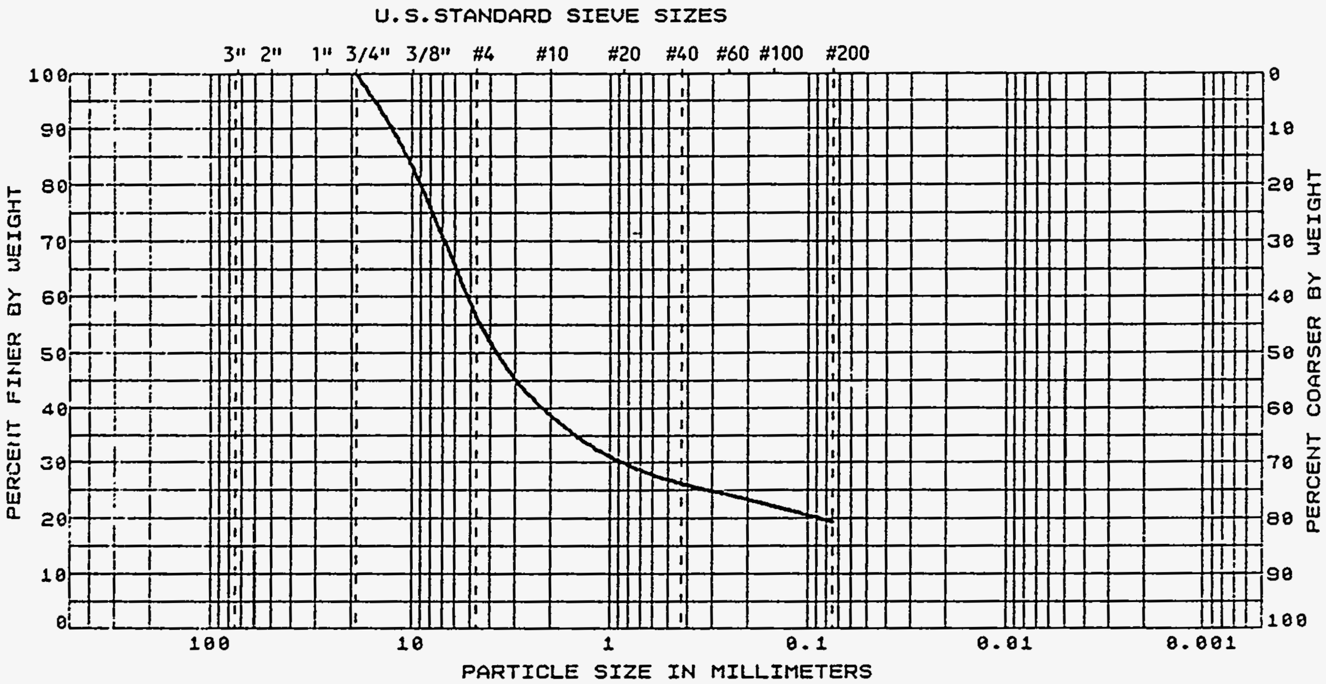
LAW ENVIRONMENTAL, INC.

300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 23, 1991
LAB NO. 01035 PAGE 5
PROJECT Cumberland City Fossil Plant
SAMPLE ID B-5S-1 5'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING	HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)		PARTICLE DIAMETER (MILLIMETERS)
3"	75		0.050
2"	50		0.020
1-1/2"	37.5		0.005
1"	25		0.002
3/4"	19	100.0	0.001
1/2"	12.5	90.0	
3/8"	9.5	81.8	
No.4	4.75	56.8	
No.10	2.00	38.6	
No.20	0.850	30.0	
No.40	0.425	26.2	
No.60	0.250	24.2	
No.100	0.150	22.3	
No.200	0.075	19.4	

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()

WATER CONTENT (%)
DRY DENSITY (PCF)
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.

M.H. O'Kelly

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

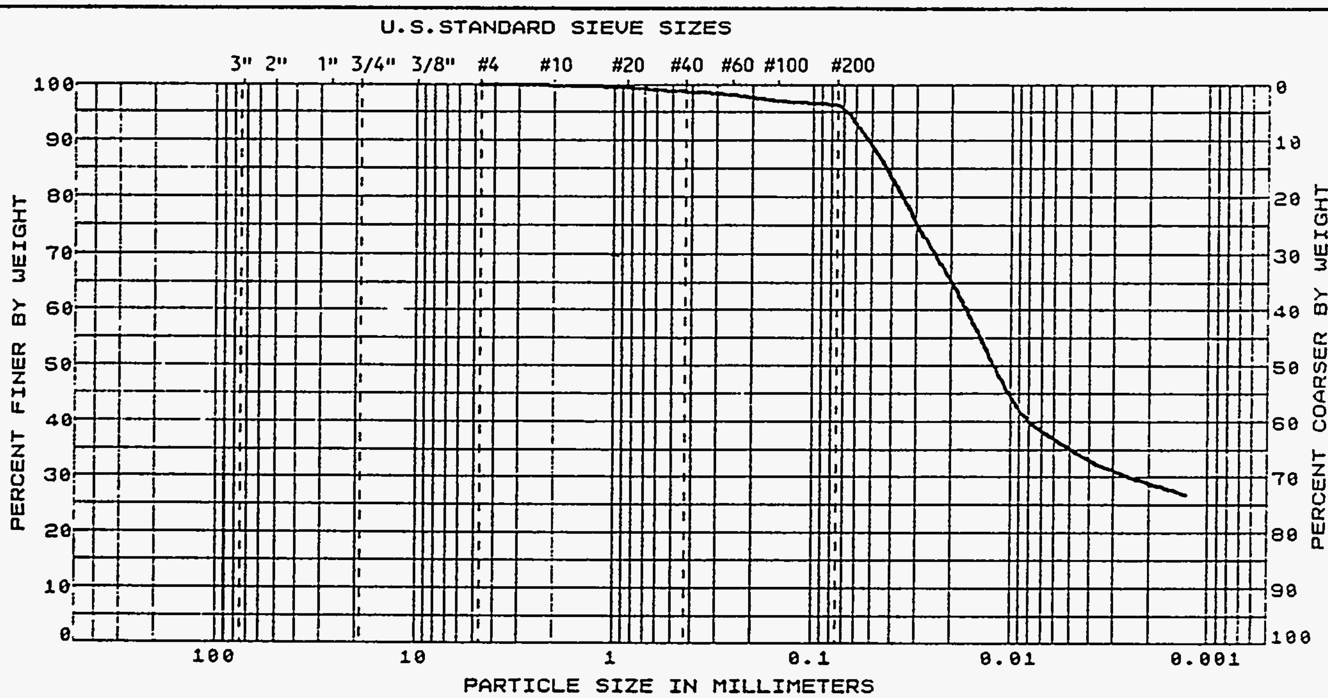
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 23, 1991

LAB NO. 01043 PAGE 10

PROJECT Cumberland City Fossil Plant

SAMPLE ID B-6UD 2'-4'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75		87.0	0.050
2"	50		65.0	0.020
1-1/2"	37.5		35.0	0.005
1"	25		29.1	0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
No.4	4.75	100.0		
No.10	2.00	99.8		
No.20	0.850	99.4		
No.40	0.425	98.7		
No.60	0.250	98.1		
No.100	0.150	97.1		
No.200	0.075	96.4		

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()

WATER CONTENT (%) 27.4
DRY DENSITY (PCF) 104.2
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.

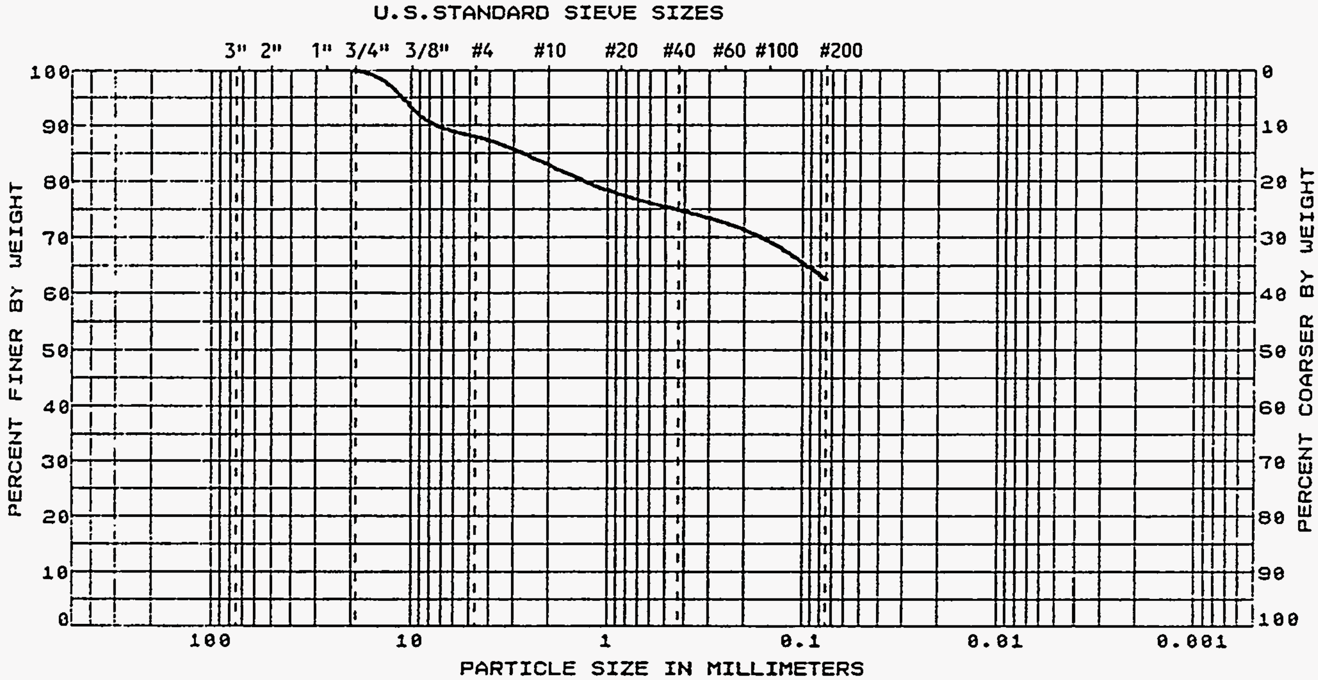
M. A. O'Kelly

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE April 23, 1991
LAB NO. 01036 PAGE 6
PROJECT Cumberland City Fossil Plant
SAMPLE ID B-6S-1 5'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	CO.	MEDIUM	FINE	

SIEVE NO.	SIEVE SIZE (MILLIMETERS)	PERCENT PASSING	HYDROMETER PARTICLE DIAMETER (MILLIMETERS)	
3"	75		0.050	
2"	50		0.020	
1-1/2"	37.5		0.005	
1"	25		0.002	
3/4"	19	100.0	0.001	
1/2"	12.5	97.1		
3/8"	9.5	92.7		
No.4	4.75	88.1		
No.10	2.00	83.0		
No.20	0.850	77.6		
No.40	0.425	74.8		
No.60	0.250	72.5		
No.100	0.150	69.3		
No.200	0.075	62.5		

REMARKS: TABULATED HYDROMETER VALUES ARE COMPUTER INTERPOLATED FROM A LINEAR DATA PLOT. PLOTTED VALUES MAY BE MORE ACCURATE FOR THE 0.050 mm PARTICLE DIAMETER.

TESTED BY: JM HJ MO

POROSITY (%)
EFFECTIVE SIZE (mm)
COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
CLASSIFICATION ()

WATER CONTENT (%)
DRY DENSITY (PCF)
SPECIFIC GRAVITY
HYDRAULIC CONDUCTIVITY (cm/sec - 20C)
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.

M. A. OKelley

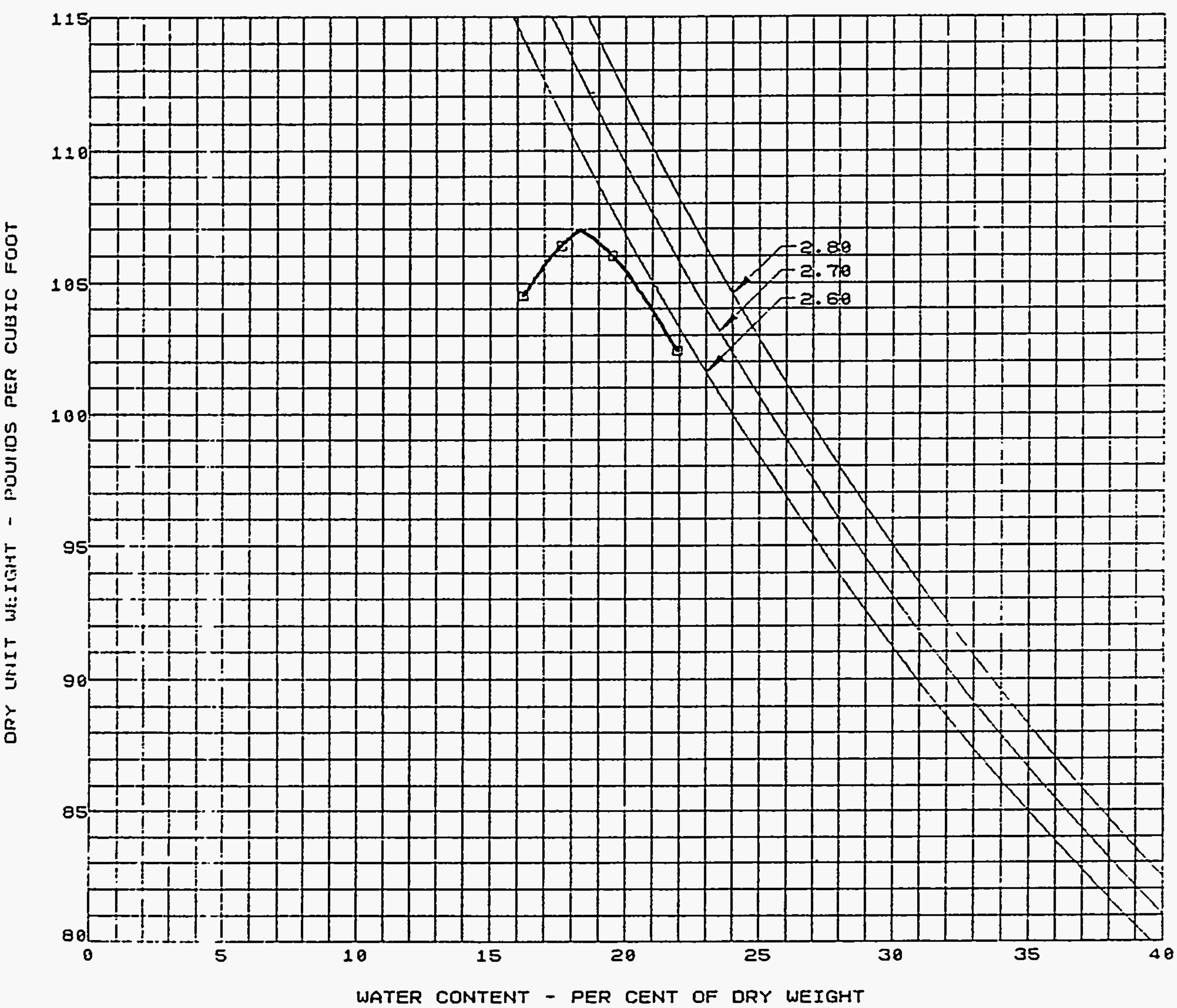
LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

COMPACTION TEST

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-10101
DATE April 22, 1991
LAB NO. 01037
PAGE 1
BORING NO. B-1
CLIENT JOB NO./P.O.# 56301442.01
SAMPLE NO. Bag
PROJECT Cumberland City Fossil Plant
DEPTH 0'-14'
LOCATION
SOIL DESCRIPTION Brown Clayey, Sandy Silt
METHOD OF TEST ASTM D698-A
TESTED BY JM HJ MO

MAXIMUM DENSITY (PCF) 107.0
OPTIMUM MOISTURE CONTENT (%) 18.3



LAW ENVIRONMENTAL, INC.
M.A. O'Kelly

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

COMPACTION TEST

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

CLIENT JOB NO./P.O.# 56301442.01

PROJECT Cumberland City Fossil Plant

LOCATION

METHOD OF TEST ASTM D698-A

MAXIMUM DENSITY (PCF) 110.0

JOB NO. 41-10101 DATE April 22, 1991

LAB NO. 01038 PAGE 2

BORING NO. B-4

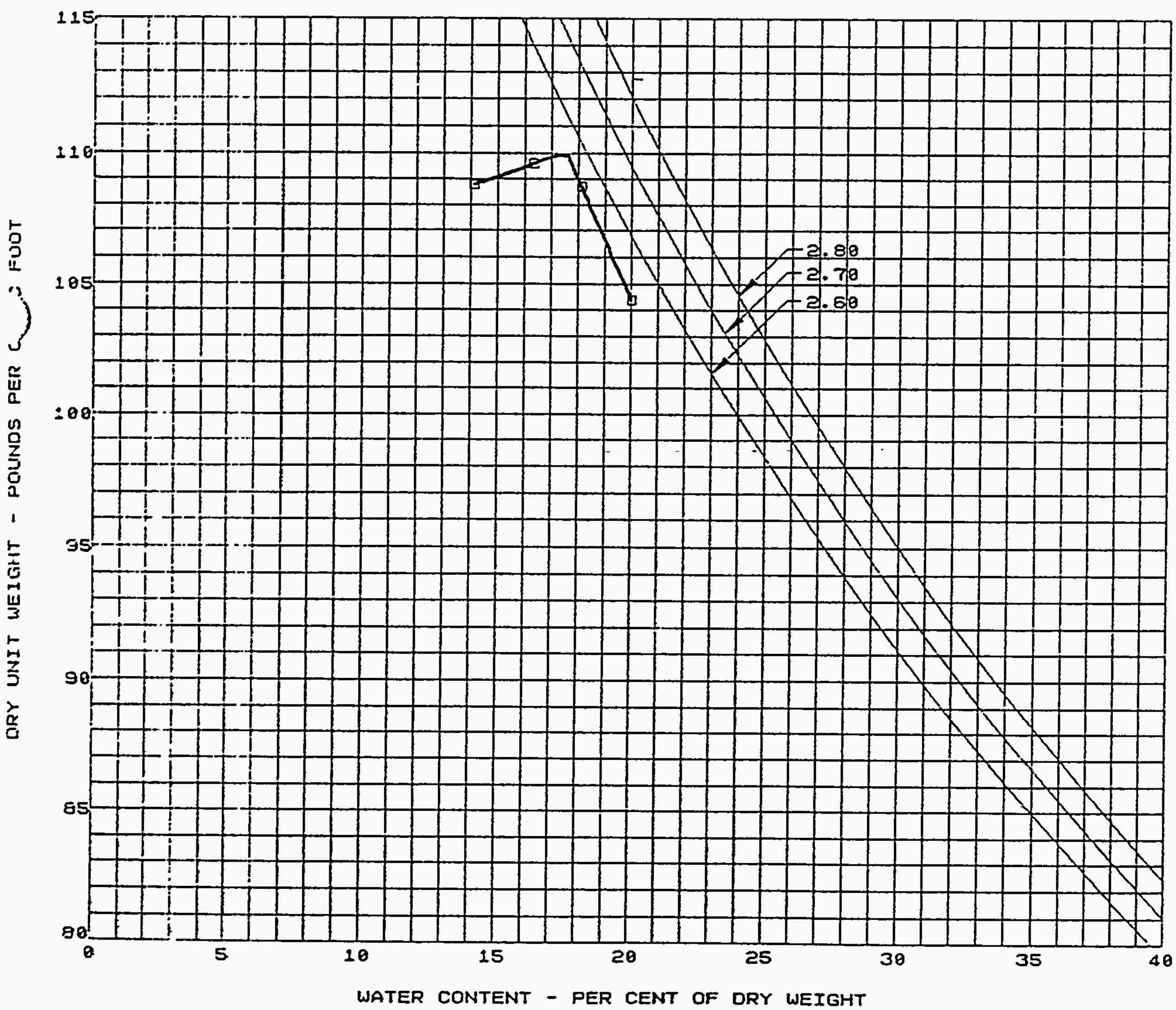
SAMPLE NO. Bag

DEPTH 0'-20'

SOIL DESCRIPTION Brown Clayey, Sandy Silt

TESTED BY JM HJ MO

OPTIMUM MOISTURE CONTENT (%) 17.5



LAW ENVIRONMENTAL, INC.

M. A. O'Kelley

Appendix II

Report of Preliminary Hydrogeologic Assessment - Site 10

LAW ENGINEERING

LAW ENGINEERING
GEOTECHNICAL, ENVIRONMENTAL
& CONSTRUCTION MATERIALS
CONSULTANTS

June 12, 1991

Mr. J. Steven Baugh
Tennessee Valley Authority
2N 83A Blue Ridge Place
1101 Market Street
Chattanooga, Tennessee 37402-2801

Subject: Report of Preliminary Hydrogeological Assessment
Proposed Disposal Site
Cumberland Fossil Fuel Plant
Site No. 10
Montgomery County, Tennessee
Law Project Number 417.91199.04 (Nashville)
Law Project Number 563.01442.01 (Atlanta)

Dear Mr. Baugh:

As authorized, Law Engineering has conducted a preliminary hydrogeological assessment of the subject site. The purpose of this assessment was to define the general nature of subsurface soil, rock and ground water conditions in the site area for use in site selection and planning a number of waste disposal facilities. This report presents a brief review our understanding of the project, a description of site topography and subsurface conditions, and an evaluation of those conditions relative to applicable requirements for the proposed facilities.

We appreciate the opportunity to complete this study for you. If you have any questions regarding this report, or if we can be of further assistance, please feel free to contact us at your convenience.

Sincerely,

LAW ENGINEERING, INC.

Alfred L. Futrell, Jr., P.E., P.G.
Principal Geotechnical Engineer

James W. Niehoff, P.E.
Principal Engineer

ALF/JWN/dlm (env/719904.06)

445 METROPLEX DRIVE — NASHVILLE, TN 37211
P.O. BOX 111299 — NASHVILLE, TN 37222-1299
615/832-0513 — FACSIMILE. 615/832-0983

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1.0 INTRODUCTION

The Tennessee Valley Authority is currently seeking a site for future waste disposal needs for its Cumberland Fossil Fuel Plant located near Cumberland City, Tennessee. Under consideration in this study is an approximate 450 acre parcel of land, designated as Site Number 10. Site Number 10 is located approximately 4 miles east of the plant, as indicated on Figure 1. Although plans are preliminary at this time, it is expected that the site will be developed to handle fly ash and sulfur dioxide scrubber sludge.

The purpose of this preliminary study was to conduct a reconnaissance on the proposed site, perform a limited subsurface exploration and provide recommendations relative to further site study, if warranted.

2.0 SCOPE OF STUDY

The purpose of this study was to generally define the site geologic/hydrogeologic setting for use in evaluating the suitability relative to the Tennessee Department of Conservation Division of Solid Waste Management (DSWM) regulations and for use in preliminary design studies. The scope of the study included the following activities:

2.1 MAP AND LITERATURE SEARCH

Geologic and topographic maps of the area were examined for evidence of fracture zones, bedrock geology, sinkholes and other karstic features, and areal drainage patterns. Available literature concerning the area, including state reports, soil surveys, ground water level data, water well surveys etc., were also collected and reviewed.

2.2 SITE RECONNAISSANCE

Accessible portions of the site were visited by LAW hydrogeological and geotechnical personnel for the purpose of observing surface conditions and planning for subsequent soil test borings and observation well (piezometer) installations. The reconnaissance included a search for sinks, springs, rock outcrops, and other characteristics of geologic or hydrogeologic significance.

2.3 GEOTECHNICAL EXPLORATION/PIEZOMETER INSTALLATION

Nine soil test borings were advanced to bedrock refusal or predetermined termination depths at locations within the site (see Figure 1). Locations were selected in an attempt to define the typical geologic and ground water conditions over the site. The test borings included the following:

1. Soil sampling which included both undisturbed (Shelby Tube) samples for natural hydraulic conductivity determinations and bulk (composite) samples for standard Proctor compaction tests, recompacted hydraulic conductivity tests and soil classification.

2. Bedrock materials cored at three boring locations to permit an evaluation of its composition and continuity.

3. Piezometers installed in five of the boreholes to permit the measurement of stabilized water levels beneath the site.

4. Each of the boreholes/wells was grouted with Portland cement approximately 7 days after completion.

Test boring records indicating the classification of the soil overburden and the nature of the bedrock are presented in the Appendix. The soil and rock samples retrieved were examined and field logs were prepared by a registered geologist at the time the borings were drilled. The finished logs represent our interpretation of the subsurface conditions based upon the field classifications and upon the results of laboratory tests on selected field samples.

3.0 GENERAL SITE INFORMATION

3.1 SITE LOCATION

The proposed disposal site is located in Montgomery County, Tennessee, approximately 3 miles southeast of Cumberland City and 4 miles southeast of the Cumberland Fossil Fuel Plant. The site is roughly rectangular in shape with dimensions of approximately 4,000 feet in the east-west direction and 5,500 feet in the north-south direction. It is bounded by undeveloped land on all sides.

3.2 GENERAL SITE DESCRIPTION

Our geologist/engineer, Mr. Alfred L. Futrell, Jr., conducted a field reconnaissance during the drilling phase of this project. The field observations were used to identify key land forms, surface drainage patterns, and to site locations for the soil test borings.

Based upon our review of available topographic information and our observations, the site is dominated by a north-south trending ridge line. This ridge line extends approximately through the center of the site. Available published geologic data indicates the topographic features in this region of Tennessee are a result of erosion of a former plateau, to form numerous ridges and intervening valleys. The site topography appears to be consistent with the published data and we believe represents an erosional remnant of a former plateau. Apparently, this plateau was eroded, particularly on the east side, by Yellow Creek and its tributaries and to a lesser extent on the west side. Maximum site relief is on the order of approximately 150 to 200 feet between the ridge line, and the base of intermittent streams on both the east and west sides of the site. Slopes are generally on the order of about 3 or 4 horizontal to one vertical, but are occasionally steeper, particularly near the southeast site corner.

Site vegetation generally consists of deciduous hardwood trees, particularly dominated by oaks with occasional evergreens dominated by cedars. Evidence of past logging activities was noted near the east and southeast site areas. At the time of our reconnaissance, some active logging was occurring near the east central site area. Scattered cleared areas were primarily located near the northwest site area. These areas were generally grass covered and appeared to be used for cattle grazing.

A paved road (Sexton Road) traverses the central and western portions of the site. Sexton Road loops through the site from the west-central site boundary to the south-central site boundary. Structures along Sexton Road include an occupied residence near the central portion of the site and a vacant residence near the west-central site area. Several out buildings, such as barns, were also noted around each residence.

Site drainage appeared to be directed both eastward and westward from the ridge to intermittent streams which flow off site to Yellow Creek. These stream beds were dry at the time of our reconnaissance. It should be noted that this study was conducted one to two days after significant rainfall.

A man-made pond was observed near the west-central site area. This pond was created by a dike on the west end, and had several feet of standing water. The pond appeared to be fed by surface runoff rather than an actively flowing spring or stream.

No obvious sinkholes, or other natural depressions were observed. A single large depressed area was noted near the west central site area. This area is mapped as being an iron mine which was active approximately 140 years ago.

4.0 GEOLOGY

4.1 GENERAL

The proposed site lies at the extreme periphery of a large geologic feature known as the Wells Creek Structure. The Wells Creek Structure is roughly circular in shape with a diameter of approximately 2 miles. Beyond the central portions of the structure, a radial and longitudinal fracture pattern has been mapped extending several miles in all directions. The nearest of these faults is mapped as terminating near the western site boundary.

The outer-most and upper-most strata of the Basin Structure include the Warsaw Limestone and the St. Louis Limestone. These are the dominant near-surface strata beneath Site 10, based on a review of the Tennessee Division of Geology, Needmore Quadrangle Map.

The Warsaw is typically a highly jointed or fractured, blueish gray, granular limestone with interbedded shale, capped with a layer of calcareous sandstone. The overlying St. Louis is typically a light olive to dark gray, very fine to medium grained, medium to thick bedded, fossiliferous limestone containing numerous chert stringers and nodules. Both formations weather in-place to form a relatively thick layer of residual soil which can range from 80 or more feet thick to less than 20 feet thick. The soil is typically a yellow to reddish-brown clay with abundant chert.

It is not uncommon for relatively thick zones of chert (i.e., 1 to 3 feet thick) to be located within the clayey soil overburden formed by the two rock units described above. In general, this chert is progressively less weathered and more dense with increasing depth below the ground surface. As a result, the soil/rock interface can be very irregular, and is often difficult to delineate based on limited soil test drilling. Solution weathering along vertical joints and bedding planes in the rock may exacerbate the irregular soil/rock profile.

4.2 SUBSURFACE CONDITIONS

Subsurface conditions were explored by drilling a total of nine soil test borings within the site at the approximate locations indicated on Figure 1. The test boring locations were estimated by our engineer who paced distances along Sexton Road from known topographic landmarks.

Soil was sampled and tested for consistency by means of standard penetration tests conducted in general accordance with ASTM 1586.

Soil samples were visually examined in the field by a geologist, and logs indicating soil type and consistency were prepared.

In general, the soil overburden within the site area was found to range from approximately 24 feet to in excess of 60 feet. Soil overburden thickness generally appeared to be deeper in areas of higher surface elevation, particularly along the ridge line where the overburden ranged from 42 feet to in excess of 60 feet. Borings B-107 and B-109 were drilled in lower site areas adjacent to intermittent stream beds (wet weather conveyances) and encountered soil overburden thicknesses ranging from 24 to 43 feet.

The soil overburden generally consisted of residual soils. These residual soils were generally stiff to very stiff, tan to reddish-brown, lean to fat clay with abundant chert gravel. In some instances, the chert gravel was predominant, and the soil was classified as a clayey chert gravel.

Hydraulic conductivity tests were conducted on undisturbed and remolded samples of the overburden soil. The data obtained is summarized below:

Boring Number	Depth Range	Sample Type	Hydraulic Conductivity
B-101	0-30 ft.	Remolded	1.4×10^{-8} cm/sec
B-104	3.5-4.5 ft.	Undisturbed	2.0×10^{-6} cm/sec
B-105	0-15 ft.	Remolded	9.8×10^{-8} cm/sec
B-107	11-13 ft.	Undisturbed	1.1×10^{-7} cm/sec
B-108	0-10 ft.	Remolded	7.5×10^{-8} cm/sec

The hydraulic conductivity of the remolded samples was typically found to be considerably lower than that of undisturbed materials. Copies of all laboratory data are included in the Appendix.

Refusal materials were explored in Borings B-105, B-107 and B-108. Refusal materials were sampled by rock coring techniques to characterize their composition and continuity. Refusal consisted of limestone bedrock. This bedrock was generally a moderately hard, medium gray siliceous (cherty) limestone. The rock quality was fair to good at most of the boring locations. This limestone material is interpreted to represent the St. Louis Limestone Formation of the Mississippian Age.

4.3 GROUND WATER

Borings B-101, B-102, B-103, B-104, and B-105 were fitted with a slotted PVC pipe for measurement of stabilized ground water levels. Additionally, Borings B-106, B-107, B-108, and B-109 were left open to permit post-drilling ground water measurements. In general, borings which were drilled by hollow stem auger methods were dry at the time of our drilling activities. Several of the borings were drilled using a wash drilling process which utilized drilling water. High water levels were initially measured in these boreholes. However, the water dropped over a period of several days. We interpret these water levels to be a result of drilling water introduced to the borehole. We also note, that in several of the boreholes, circulation of the drill water was lost, apparently through openings in the bedrock.

5.0 EVALUATION

A number of factors are of consequence in the siting of a disposal facility. Of particular importance are:

- Major topographic characteristics which influence the degree of grading necessary for development.
- The thickness and character of overburden materials which have an impact on the type of equipment necessary for site grading, the availability of fill soils for dike construction and cover, and the presence of natural geologic buffers necessary for the protection of ground water.
- Bedrock conditions underlying the site which can affect structural stability and ground water flow directions.
- The depth to the water table and the presence of springs which influence grading depths and buffer zones.

During the course of our study, information was gathered relative to each of these factors to aid in the evaluation of the site for its projected purpose. Based on our review of these features, we believe the proposed site generally appears to be suitable for development of a disposal facility. Site development will require a site acceptability permit to be issued by the DSWM. Favorable characteristics of the site include the relatively low permeability of the soils encountered, the thick soil overburden that is present and the relatively deep depth to ground water. The following paragraphs present a summary of the information obtained.

5.1 HYDROGEOLOGIC CONSIDERATIONS

Based on the available data, and our previous experience with similar geologic conditions, we believe the first ground water aquifer at this site will typically be discontinuous perched water zones near the soil/rock interface or possibly within dense, chert gravel layers. Typically, flow gradients for this aquifer mirror the surface topography. We anticipate that run-off will be high and infiltration will be relatively low due to the hilly surface topography present at the site, resulting in relatively low yields for this aquifer.

This first aquifer is typically not suited as a potable water source, most often due to its low yield. A review of Tennessee Division of Water Supply records for the Needmore quadrangle indicates domestic water supply wells in the area have aquifer depths ranging from 130 to 300 feet, and yields of 1 to 2 gallons per minute.

5.2 TOPOGRAPHY/GRADING CONSIDERATIONS

We understand that a "hollow fill" type design will be used for waste disposal trenches at this site. In general, we believe that cuts 30 to 40 feet deep can be made in the higher elevations of the property. Cuts in excess of these depths may encounter discontinuous perched water zones or significant quantities of hard chert gravel that may be difficult to excavate. Cut depths should be limited to about 15 feet or less in the lower site elevations to protect wet weather springs, which while not observed, are likely seasonable present, and to allow proper surface drainage.

According to a DSWM letter to TVA, dated January 31, 1991, "the liner and geologic buffer required will be 3 feet in total thickness with a maximum hydraulic conductivity of 1×10^{-6} cm/sec". Based on preliminary laboratory test data, we believe that the on-site soils, particularly when remolded should meet or exceed these values. We do note, however, that in some locations the in-place soil does not meet these requirements, and that construction of a recompacted liner would be required.

5.3 ADDITIONAL STUDY

This preliminary study was intended to characterize the general subsurface conditions across the proposed site. Additional subsurface exploration would be required prior to proceeding with design and construction. The most important issues which would need to be addressed include:

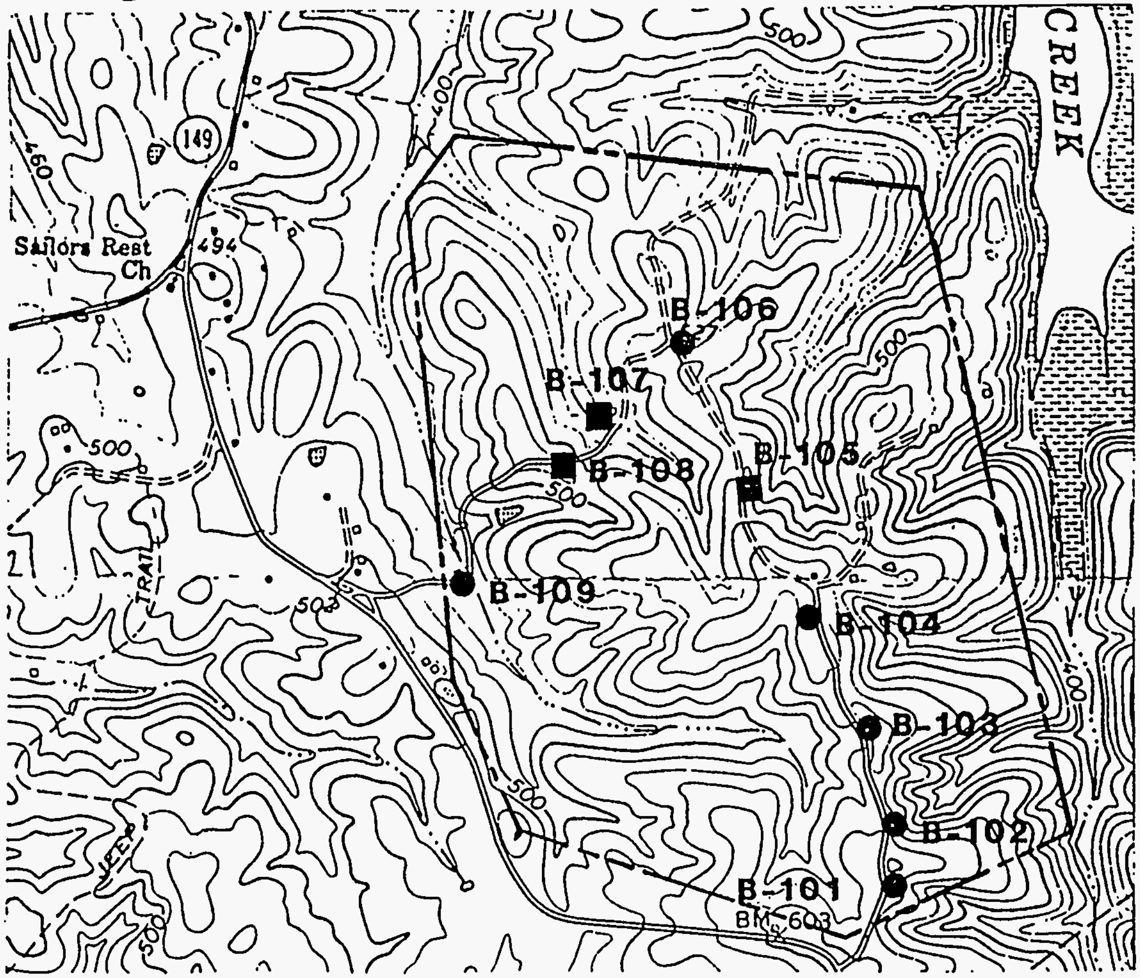
- The characteristics of near-surface and deep ground water flow.

- Additional soil borings and permeability testing accomplished to confirm preliminary findings.

- A more detailed survey of local water supplied, including interviews with local residents concerning springs and supply wells.

APPENDIX

LAW ENGINEERING, INC.



LEGEND

● B-101 SOIL TEST BORING

■ B-105 SOIL TEST BORING WITH ROCK CORING

SOURCE: U.S.G.S. TOPOGRAPHIC MAP
NEEDMORE, TENNESSEE QUADRANGLE
PHOTOREVISED 1983

BORING LOCATION PLAN

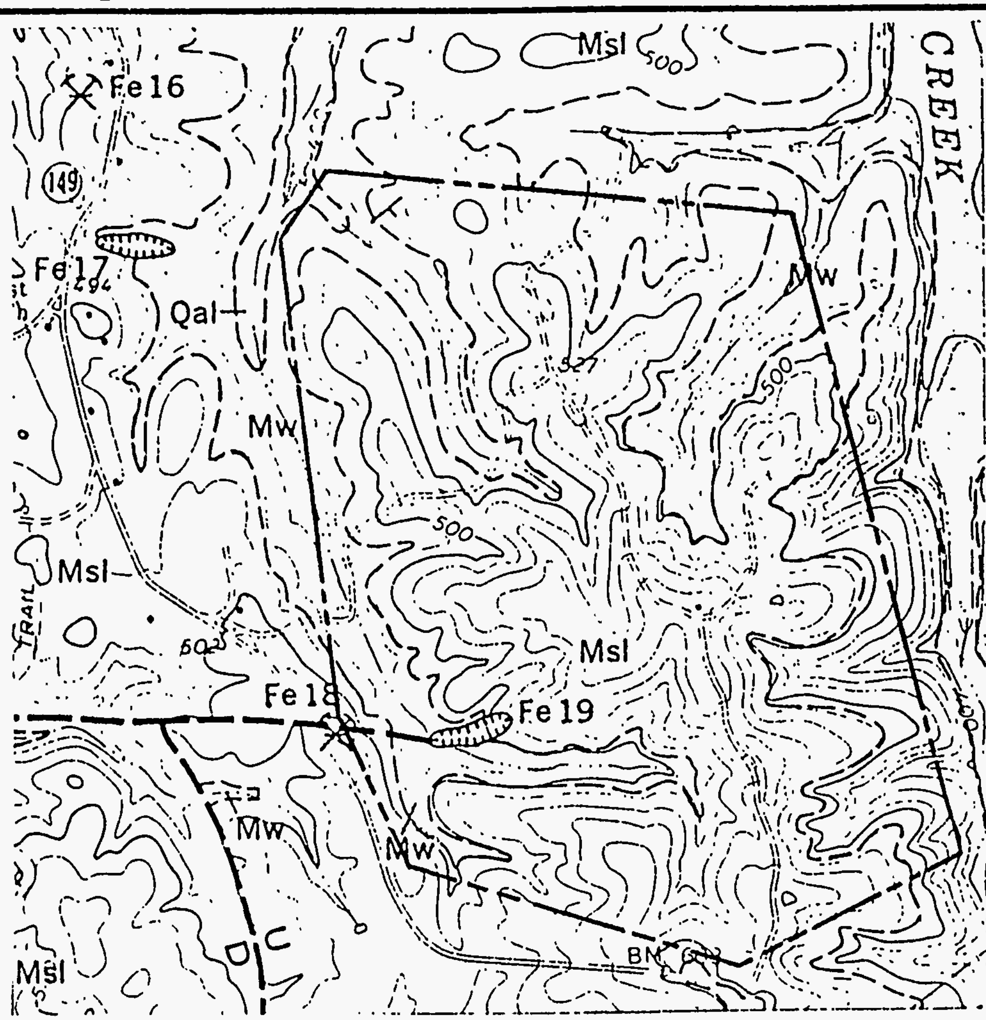
SCALE: NONE	APPROVED BY:	DRAWN BY D.E.H.
DATE: 5-2-91		REVISED

CUMBERLAND FOSSIL PLANT
CUMBERLAND CITY, TENNESSEE

LAW ENGINEERING, INC.

DRAWING NUMBER
FIGURE 1

8½ X 11 PRINTED ON NO. 1000H CLEARPRINT®



Msl

St. Louis Limestone

Upper part is limestone, light-gray to dark brownish-gray, very fine- to medium-grained, thin- to medium-bedded, fossiliferous, locally oolitic. Distinguished from lower part of St. Louis by yielding, upon weathering, "cannonballs" of concentric, spherical, medium-gray chert, walnut- to grapefruit-size, in a rubble of angular fragments and blocks of dense chert. Near the top bumpy ovoidal masses of mottled brown and cream chert are prominent. Large colonies of the coral "*Lithostrotion*" are common in middle part. Thickness about 120 feet.

Lower part is calcarenite, medium to dark brownish-gray, fine- to medium-grained, poorly sorted, very thin- to medium-bedded, fetid odor, fossiliferous. Distinguished from underlying Warsaw Limestone by brownish color, fetid odor, the presence of the coral "*Lithostrotion*," and the presence of blocks and masses of rounded and banded porous chert. Thickness about 60 feet.

Mw

Warsaw Limestone

Calcarenite, light- to dark-gray, fine to coarse-grained, with a white to light-gray chalky matrix, medium- to very thick-bedded, crossbedded, fossil-fragmental; some oolitic beds near top of formation; contains beds of brownish-gray to yellowish-brown, silty, fine-grained dolomite. Gradational with Fort Payne below and with St. Louis above. Two beds of siltstone, containing very fine-grained quartz sand, are present near the middle and top of the formation. Formation weathers to angular plates and blocks of coarsely porous, granular, fossiliferous chert. Thickness 100 to 140 feet.

SOURCE: TENNESSEE DIVISION OF GEOLOGY
GEOLOGIC MAP
NEEDMORE QUADRANGLE
DATED 1968

N

SITE GEOLOGY

SCALE: NONE

DATE: 6-12-91

APPROVED BY:

DRAWN BY D.E.H.

REVISED

CUMBERLAND FOSSIL PLANT
CUMBERLAND CITY, TENNESSEE

LAW ENGINEERING, INC.

DRAWING NUMBER
FIGURE 2

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0								
	0.1	Very stiff, tan, FAT to LEAN CLAY with abundant chert gravel							
				12		23			
				14		19			
				14		25			
				12		26			Dry on 4/30/91
				16		28			Set 1 1/2-inch PVC observation well to 60.0 feet, hand-slotted screen, lower 10 feet
				16		30			
	32.0	Very stiff to hard, LEAN to FAT CLAY, with abundant chert gravel, grading to clayey chert gravel.							
				12		32			
				10		21			
				8		34			
				12		45			

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

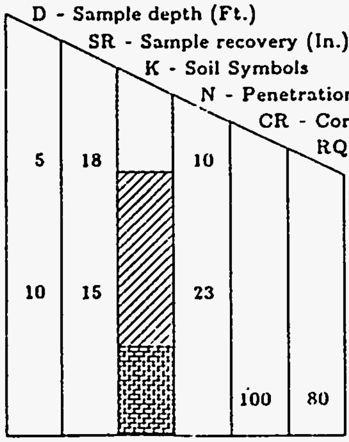
TEST BORING RECORD

BORING NUMBER B-101
DATE DRILLED April 11, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
				14		49			
	60.5	BORING TERMINATED AT 60.5 FEET		12		26			

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation



SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
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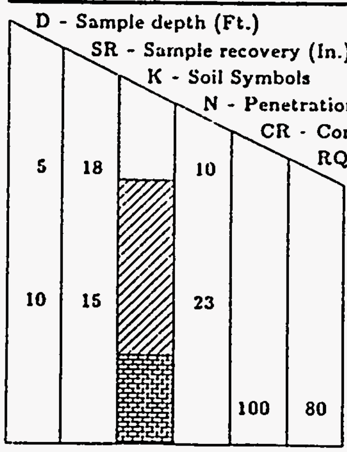
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-101
DATE DRILLED April 11, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 2 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0	Hard to very hard brown LEAN CLAY with abundant chert gravel							
						60			
						49			
	15.0	Very stiff reddish brown LEAN CLAY with black mineral oxide staining							∇
				15		22			Set 1 1/2-inch PVC observation well to 60.0 feet, hand-slotted screen, lower 10 feet
	25.0	Stiff to very stiff tan LEAN CLAY with abundant chert gravel, grading to clayey chert gravel							
				12		27			
				14		12			
									▼ 4/23/91
	45.0	Firm, reddish-brown, FAT CLAY, with trace of chert gravel							
				14		6			
									▼ 4/30/91



- D - Sample depth (Ft.)
- SR - Sample recovery (In.)
- K - Soil Symbols
- N - Penetration (Blows/Ft.)
- CR - Core Recovery (percent)
- RQD - Rock Quality Designation

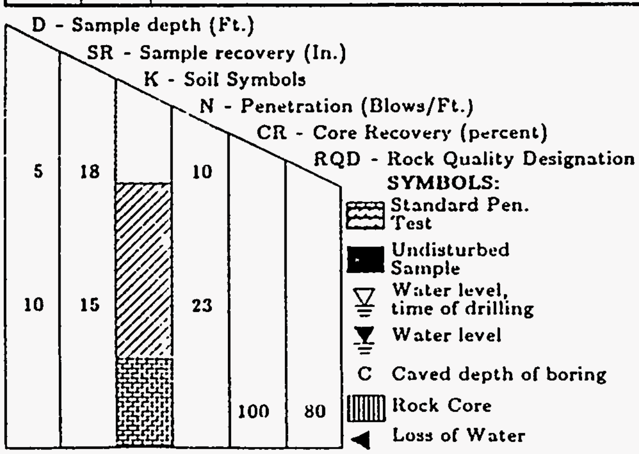
SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- ∇ Water level, time of drilling
- ▼ Water level
- C Caved depth of boring
- Rock Core
- ◄ Loss of Water

TEST BORING RECORD

BORING NUMBER	B-102
DATE DRILLED	April 22, 1991
PROJECT NUMBER	563.01442.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 1 OF 2	

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
									4/30/91
	60.5	BORING TERMINATED AT 60.5 FEET		13		6			



TEST BORING RECORD

BORING NUMBER B-102
DATE DRILLED April 22, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 2 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0	Soft, brown, LEAN CLAY with rock fragments (FILL)		9		.4			
	2.0	Very stiff, reddish-brown to tan LEAN CLAY with abundant chert gravel							Dry at time of boring and 24 hours Dry on 4/30/91
				11		19			
				8		26			Set 1 1/2-inch PVC observation well to 55.0 feet, hand-slotted screen, lower 10 feet
				13		18			
	35.0	Firm to stiff, reddish-brown to tan FAT CLAY with weathered and porous chert gravel							
				18		7			
				20					
				5		10			

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

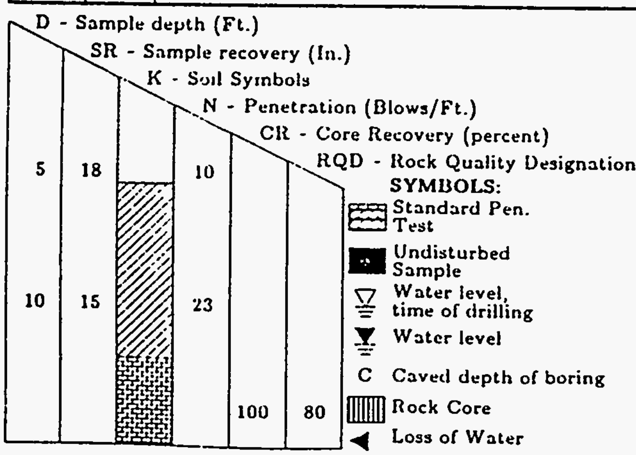
SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-103
DATE DRILLED April 22, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	55.0	REFUSAL AT 55.0 FEET BORING TERMINATED		0		*			*50/0



TEST BORING RECORD

BORING NUMBER	B-103
DATE DRILLED	April 22, 1991
PROJECT NUMBER	563.01442.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 2 OF 2	

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0								
	0.2	TOPSOIL							
		Stiff to hard, tan to reddish brown, LEAN CLAY with abundant chert gravel.		15		9			
				12					
				12		45			
				8		17			
	25.0								4/26/91
		Stiff to very stiff, reddish-brown to tan, FAT CLAY, with abundant chert gravel, grading to clayey chert gravel.							
				10		14			
									4/30/91
				12		13			Set 1 1/2-inch PVC observation well to 57.5 feet, 4/30/91 hand-slotted screen, lower 10 feet
				6		16			

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-104
DATE DRILLED April 23, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	60.5	BORING TERMINATED AT 60.5 FEET		16		17			

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
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TEST BORING RECORD

BORING NUMBER B-104
DATE DRILLED April 23, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 2 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0								
	0.7	TOPSOIL							
		Hard, reddish-brown, LEAN CLAY with abundant chert gravel, grading to clayey chert gravel		14		6			Dry at time of boring
									Dry on 4/30/91
				8		41			Bag sample obtained at 0.0 to 15.0 feet
				16		32			
	25.0	Stiff, reddish-brown, FAT CLAY, with chert gravel							Set 1 1/2-inch PVC observation well to 60.0 feet, hand-slotted lower 10 feet.
				6		14			
				14		16			
	42.0	SAMPLER REFUSAL AT 42.0 BEGIN CORING		6					
		Moderately hard, light gray fossiliferous to crystalline, slightly porous limestone with chert bands					97	60	
							17	0	
							96	83	
							100	100	
							67	54	
									100%

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23	100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-105
DATE DRILLED April 23, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD		REMARKS
										Cavity from 53.7 to 54.7 Cavity from 55.6 to 58.6 Cavity below 62.0
							40	0		
							20	0		
	62.0	CORING TERMINATED at 62.0 FEET								

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER	B-105
DATE DRILLED	April 23, 1991
PROJECT NUMBER	563.01442.01
PROJECT	CUMBERLAND FOSSIL PLANT
PAGE 2 OF 2	

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0								
	0.9	TOPSOIL							
	2.0	Firm, brown, clayey SILT		16		8			
		Very stiff, tan, LEAN CLAY with abundant chert gravel							Dry on 4/30/91
				15		27			
	15.0	Stiff to very stiff reddish-brown FAT CLAY with chert gravel							
				16		17			C
				10		16			
				8		10			
	43.4	REFUSAL AT 43.4 FEET BORING TERMINATED							

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

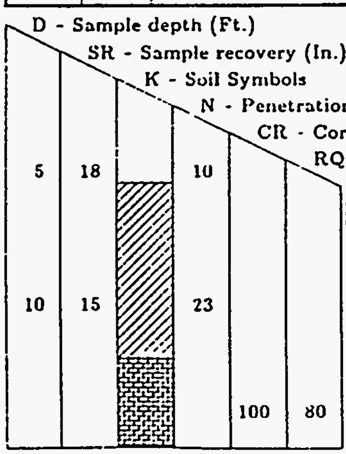
SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-106
DATE DRILLED April 24, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0								
	0.3	TOPSOIL							
		Firm to soft brown clayey SILT to LEAN CLAY with some chert gravel		6		8			
	10.5	Firm, reddish-brown FAT CLAY		0		4			
				17					
				16		8			
	23.5	REFUSAL AT 23.5 FEET BEGIN CORING Moderately hard, medium to light gray, limestone, fossiliferous below 29.5 feet. Fractured, with chert bands from 33.5 to 35.0 feet.					98	95	5/7/91
							93	50	
							100	100	
	43.5	CORING TERMINATED AT 43.5 FEET							



SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-107
DATE DRILLED April 25, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0								
	0.3	TOPSOIL		14		11			
	2.0	Stiff, brown, LEAN CLAY, [illegible]							
		Hard to stiff, reddish-brown to tan FAT CLAY, with abundant chert gravel, grading to clayey chert gravel							
				14		32			
				12		22			
				16		23			
				14		11			
	50.0			12		26			
		REFUSAL AT 50.5 BEGIN CORING Moderately hard, medium to dark gray, fine grained to coarsely crystalline limestone with stylolites					87	73	◄ 100%
							93	84	

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-108
DATE DRILLED April 25, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
		throughout healed vertical fracture from 59.0 to 63.1 feet					99	98	5/7/91
	70.5	CORING TERMINATED AT 70.5 FEET							

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-108
DATE DRILLED April 25, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 2 OF 2

LAW ENGINEERING

ELEV.	STRATUM DEPTH	VISUAL SOIL DESCRIPTION	D	SR	K	N	CR	RQD	REMARKS
	0.0								
	0.8	TOPSOIL							
		Stiff brown LEAN CLAY to silt		18		4			
									Dry on 5/7/91
				16		12			C
	15.0	Stiff to firm brown LEAN CLAY with chert gravel and coarse sand.							
				11		9			
									100% (Loss of Water)
				13		8			
									(Water level, time of drilling)
	30.0	Very soft, brown, sandy CLAY		13		*			*Weight of rods caused rod drop from 39.0 to 43.5 feet
	43.5	REFUSAL AT 43.5 BORING TERMINATED							

D - Sample depth (Ft.)
SR - Sample recovery (In.)
K - Soil Symbols
N - Penetration (Blows/Ft.)
CR - Core Recovery (percent)
RQD - Rock Quality Designation

D	SR	K	N	CR	RQD
5	18		10		
10	15		23		
				100	80

SYMBOLS:
- Standard Pen. Test
- Undisturbed Sample
- Water level, time of drilling
- Water level
- C Caved depth of boring
- Rock Core
- Loss of Water

TEST BORING RECORD

BORING NUMBER B-109
DATE DRILLED April 30, 1991
PROJECT NUMBER 563.01442.01
PROJECT CUMBERLAND FOSSIL PLANT
PAGE 1 OF 1

LAW ENGINEERING

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

COMPACTION TEST

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-10101 DATE April 22, 1991

LAB NO. 01039 PAGE 3

BORING NO. B-101

CLIENT JOB NO./P.O.# 56301442.01

SAMPLE NO. Bag

PROJECT Cumberland City Fossil Plant

DEPTH 0'-30'

LOCATION

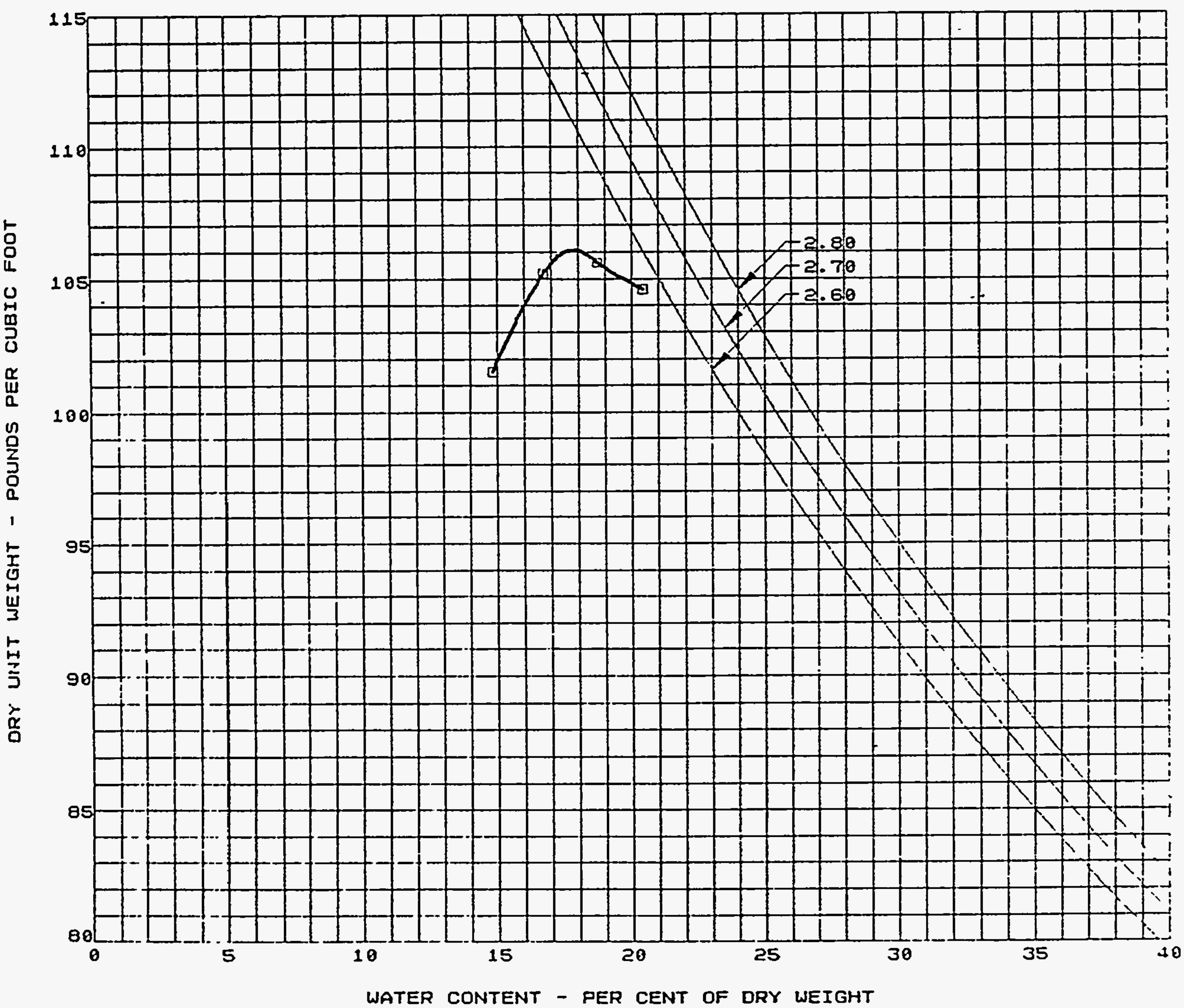
SOIL DESCRIPTION Tan Sandy,Clayey Silt w/some Grvl.

METHOD OF TEST ASTM D698-A

TESTED BY JM HJ MO

MAXIMUM DENSITY (PCF) 106.1

OPTIMUM MOISTURE CONTENT (%) 17.8



LAW ENVIRONMENTAL, INC.

M.H. OKelley

COMPACTION TEST

LAW ENGINEERING TESTING COMPANY.

DATE 5/7/91

JOB NAME Cumberland Fossil Plant

JOB NUMBER 563.01442.01

CLIENT

CONTRACTOR

BORING NUMBER B-105

SAMPLE NUMBER

DEPTH 0-15 feet

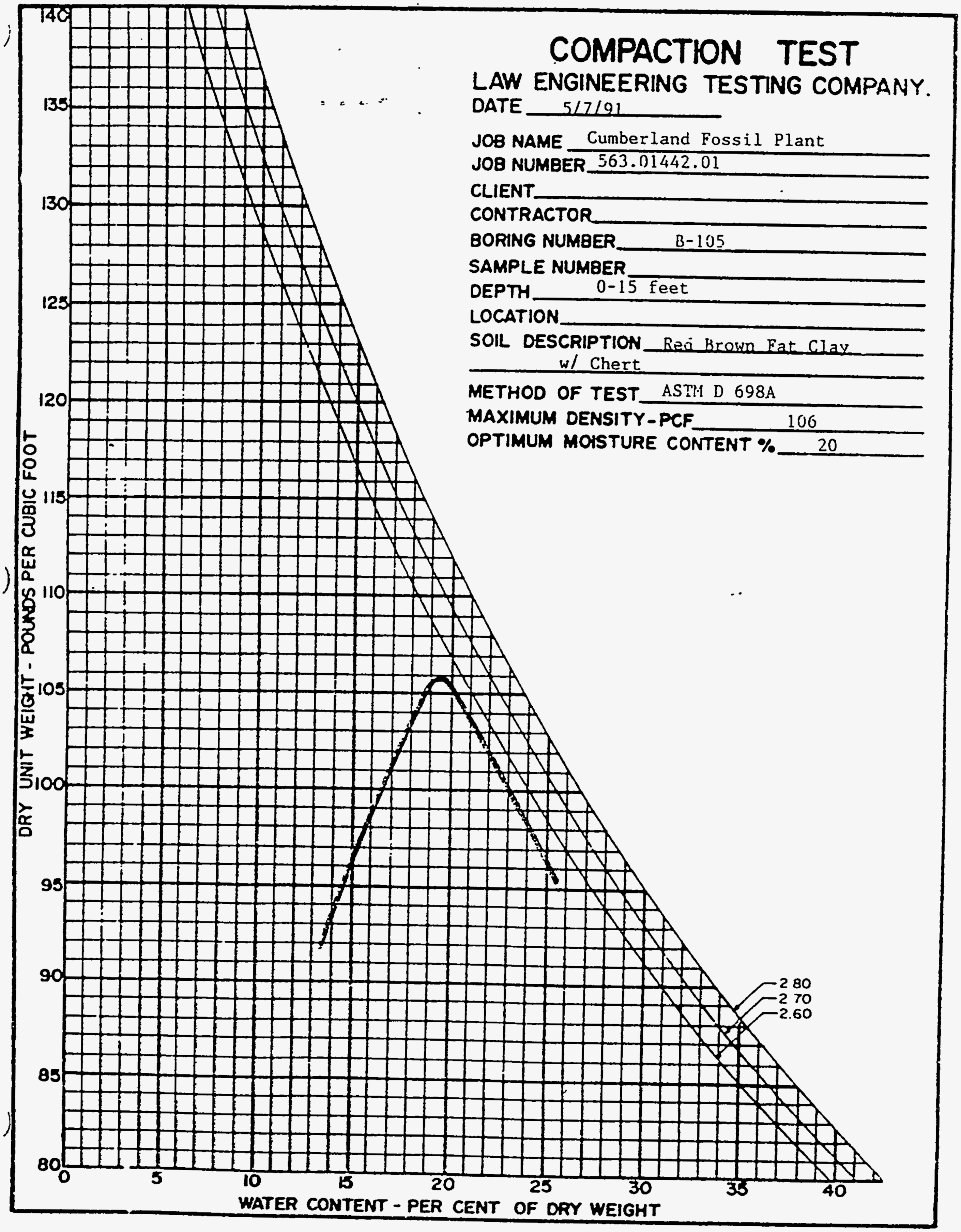
LOCATION

SOIL DESCRIPTION Red Brown Fat Clay w/ Chert

METHOD OF TEST ASTM D 698A

MAXIMUM DENSITY-PCF 106

OPTIMUM MOISTURE CONTENT % 20



COMPACTION TEST

LAW ENGINEERING TESTING COMPANY.

DATE 5/7/91

JOB NAME Cumberland Fossil Plant

JOB NUMBER 563.01442.01

CLIENT

CONTRACTOR

BORING NUMBER B-108

SAMPLE NUMBER 0-10 feet

DEPTH

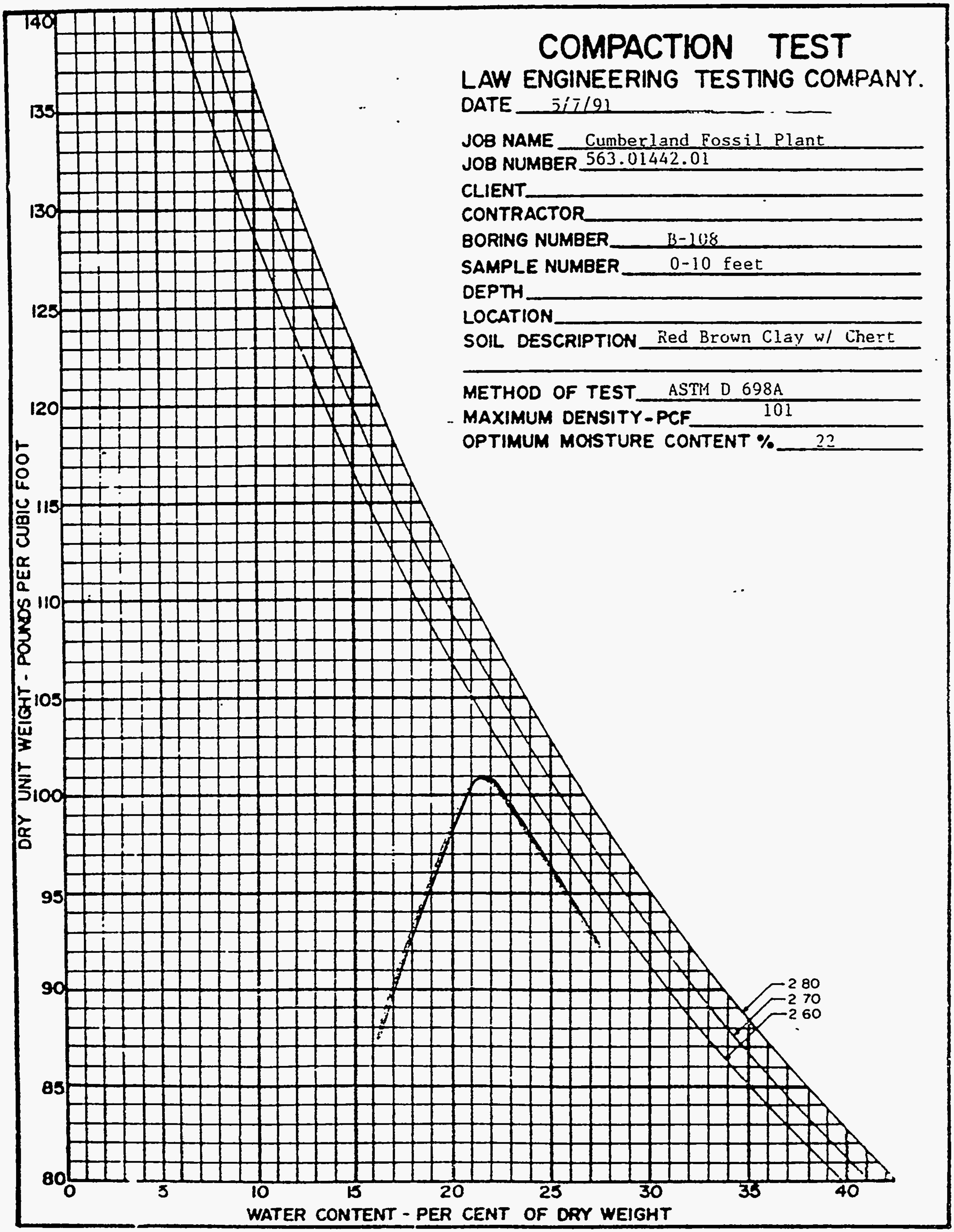
LOCATION

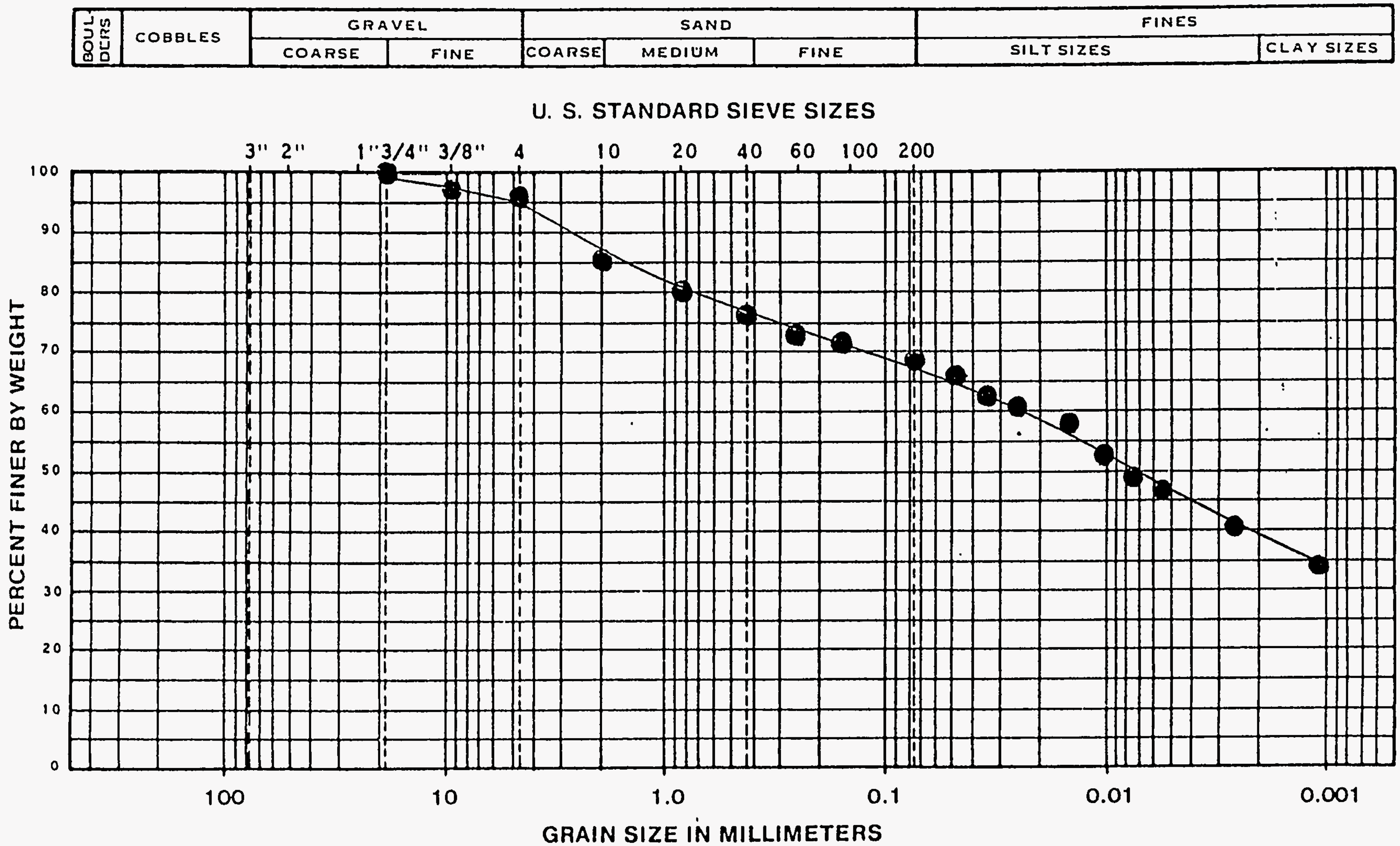
SOIL DESCRIPTION Red Brown Clay w/ Chert

METHOD OF TEST ASTM D 698A

MAXIMUM DENSITY-PCF 101

OPTIMUM MOISTURE CONTENT % 22



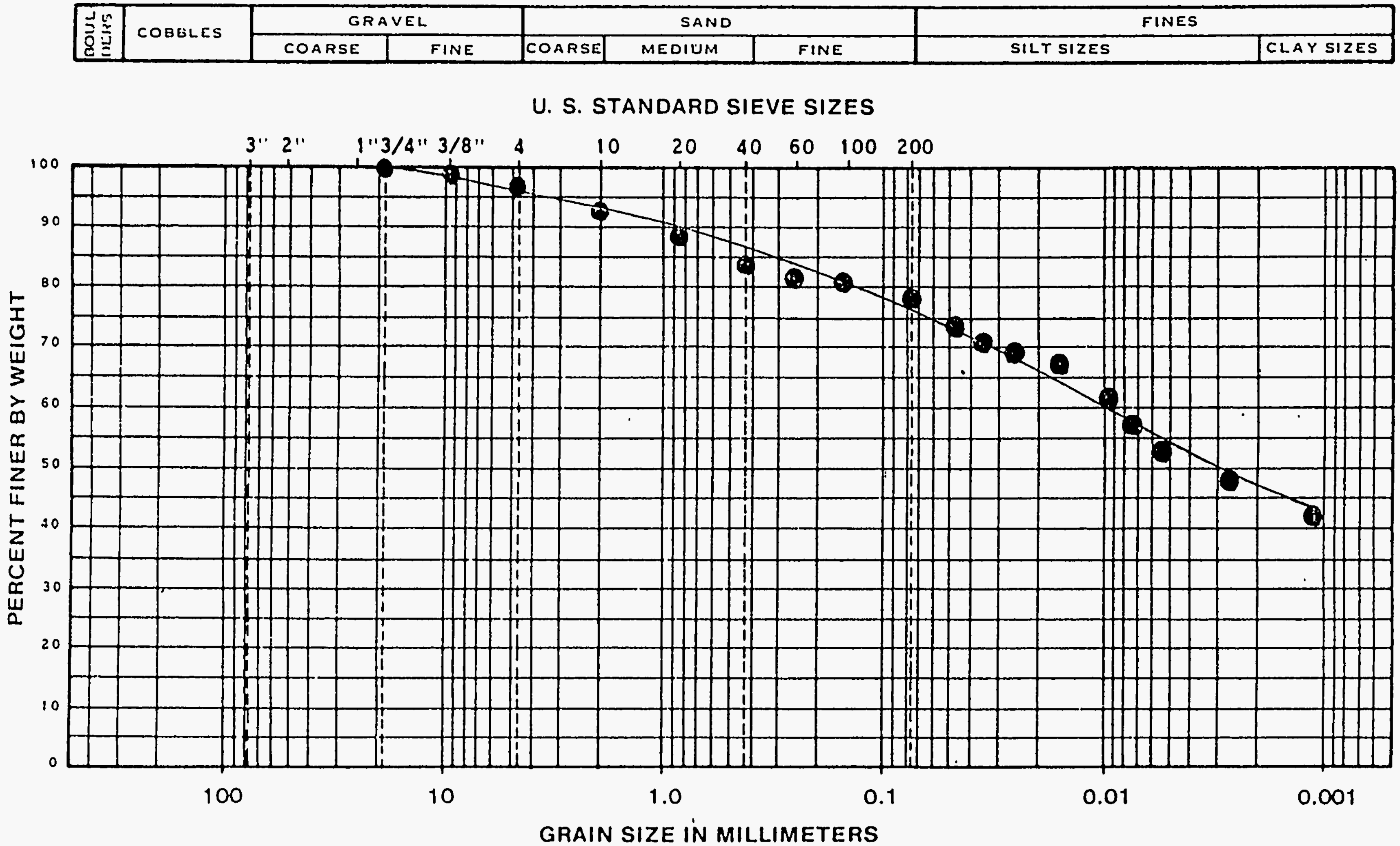


Law Engineering Testing Company

Grain Size Distribution

BORING NO	DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-105	0'-15'	19.9	57	22	35	Medium brown clay with chert
JOB NO 417.9119. 04						

1400001



Law Engineering Testing Company

Grain Size Distribution

BORING NO	DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-108	0'-10'	22.1	64	23	41	Reddish-brown clay with chert
JOB NO						
17.91199-04						

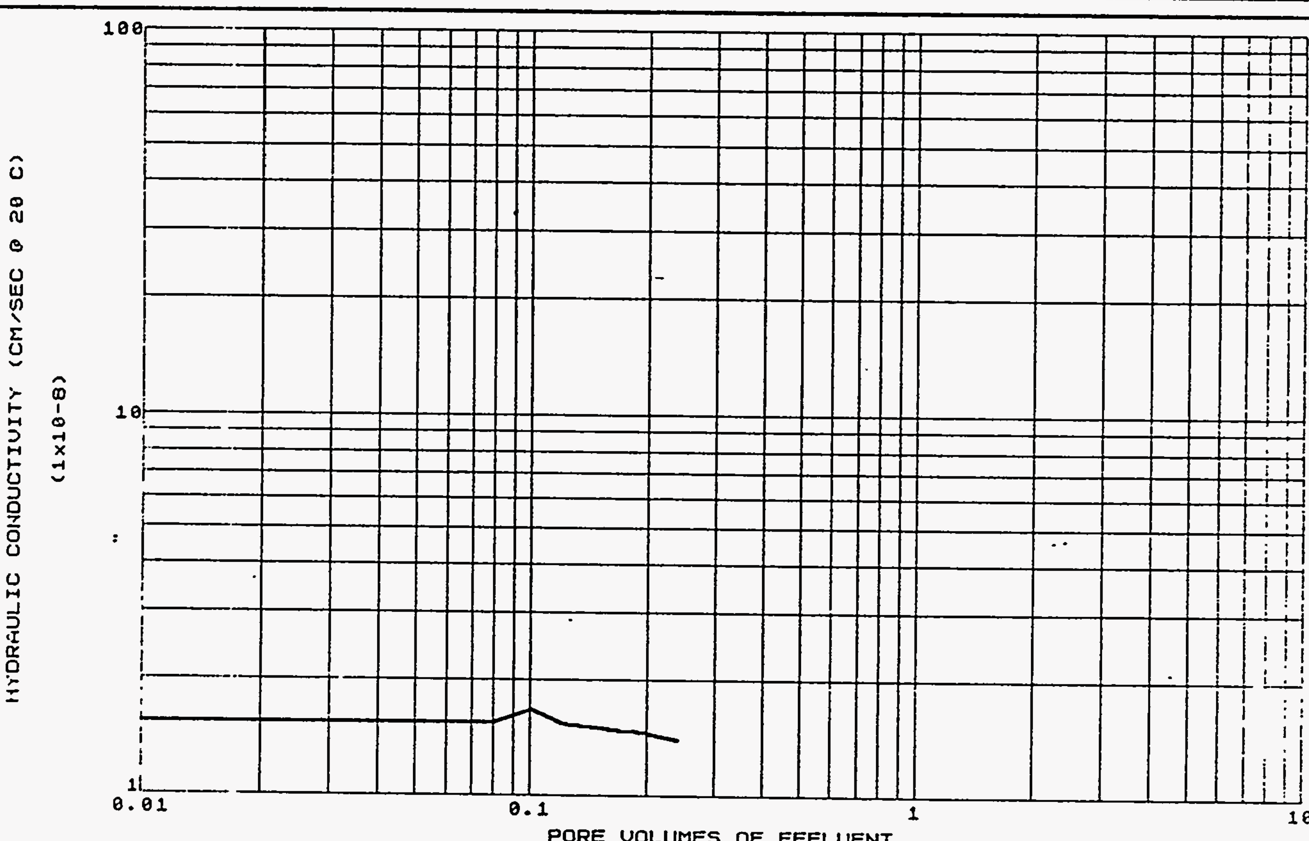
1400001

LAW ENVIRONMENTAL, INC.
300 CHASTAIN CNTR BLVD, SUITE 315
KENNESAW, GEORGIA 30144
404-425-7879

HYDRAULIC CONDUCTIVITY

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324
CLIENT JOB NO./P.O.# 56301442.01

JOB NO. 41-10101 DATE May 6, 1991
TESTED BY JM HJ MO PAGE 3
PROJECT Cumberland City Fossil Plant
TEST METHOD Corps of Engrs EM1110-2-1906.



LAB NO.	01039					
SAMPLE IDENTIFICATION	B-101 Bag 0'-30'					
RECEIPT DATE	4/16/91					
TEST COMPLETION DATE	5/3/91					
SAMPLE TYPE	Remold					
INITIAL WATER CONTENT (% BY DRY WEIGHT)	19.5					
DRY UNIT WEIGHT (PCF)	101.9					
PERCENT COMPACTION IF REMOLDED	96.0					
ONE PORE VOLUME (CC)	88					
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	1.4E-08					

LAW ENVIRONMENTAL, INC.
M.A. O'Kelly

HYDRAULIC CONDUCTIVITY

Job Number: 1461000904
Job Name: Cumberland City Landfill
Date: 5-20-91

Boring Number:	B-104
Sample Type:	UD
Sample Depth (ft.):	3.5 - 4.5
Initial Water Content (%):	22.9
Wet Unit Weight (pcf):	122.2
Dry Unit Weight (pcf):	99.4
Compaction (%):	N/A
Hydraulic Conductivity (cm/sec. @ 20 C)	**2.0 x 10^{-6} cm/sec**

Reviewed by: DDB
Date: 5-20-91

HYDRAULIC CONDUCTIVITY

Job Number: 1461000904
Job Name: Cumberland City Landfill
Date: 5-20-91

Boring Number:	B-105
Sample Type:	BAG
Sample Depth (ft.):	0 - 15
Initial Water Content (%):	22.8
Wet Unit Weight (pcf):	122.4
Dry Unit Weight (pcf):	99.7
Compaction (%):	94.1%
Hydraulic Conductivity (cm/sec. @ 20 C)	**9.8×10^{-8}**

Reviewed by: DDB
Date: 5-20-91

HYDRAULIC CONDUCTIVITY

Job Number: 1461000904
Job Name: Cumberland City Landfill
Date: 5-20-91

Boring Number:	B-107
Sample Type:	UD
Sample Depth (ft.):	11 - 13
Initial Water Content (%):	22.5
Wet Unit Weight (pcf):	123.5
Dry Unit Weight (pcf):	100.9
Compaction (%):	N/A
Hydraulic Conductivity (cm/sec. @ 20 C)	**1.1×10^{-7} cm/sec**

Reviewed by: DDB
Date: 5-20-91

HYDRAULIC CONDUCTIVITY

Job Number: 1461000904
Job Name: Cumberland City Landfill
Date: 5-20-91

Boring Number:	B-108
Sample Type:	BAG
Sample Depth (ft.):	0 - 10
Initial Water Content (%):	23.2
Wet Unit Weight (pcf):	117.3
Dry Unit Weight (pcf):	95.2
Compaction (%):	94.3%
Hydraulic Conductivity (cm/sec. @ 20 C)	**7.5×10^{-8} cm/sec**

Reviewed by: DDB
Date: 5-20-91

Appendix III

Cumberland Fossil Plant

Removal of Ash Sluice Waters From Ash Pond

Determination of Potential Impact on Ash Pond Effluent

TENNESSEE VALLEY AUTHORITY

Division of Water Resources

CUMBERLAND FOSSIL PLANT (CUF)

DETERMINATION OF POTENTIAL IMPACT ON FINAL EFFLUENT FROM REMOVAL OF ASH SLUICE WATERS FROM ASH POND

FINAL REPORT

Prepared by

Water Quality Branch

Chattanooga, Tennessee

August 1991

TABLE OF CONTENTS

I. INTRODUCTION

The planned addition of scrubbers at Cumberland Fossil Plant (CUF) requires evaluation of dry ash handling. Proposed operational changes include: (a) dry stacking fly ash; (b) wet sluicing bottom ash to a dewatering tank and reusing the sluice water; (c) continuing to combine the low-volume wastewaters in a diked-off section of the existing bottom ash pond; (d) continuing to discharge Air Preheater Cleaning Wastes to a diked-off section of the ash pond for treatment; and (e) installing scrubber system. The proposed plant layout for these changes is shown in Figure 1.

It was stated that the scrubber system would be closed-loop and have no discharge. This report is based on that assumption. However, an 8-inch rainfall event such as CUF has experienced in the past could generate 25 to 30 million gallons (MG) of runoff just from the 145 acre gypsum stacking area shown in Figure 1. Some provision should be made for handling this large volume of potentially alkaline wastewater.

The Development Document for Effluent Limitations Guidelines and Standards for the Steam-Electric Category [1] allows for ash pond treatment for low-volume wastewaters (LVW). The theory behind this treatment method is that the physical/chemical nature of the ash pond environment will treat those wastes as well as conventional treatment methods.[1] The alkaline ash ponds at CUF have provided the treatment processes (neutralization, sedimentation, skimming, alkaline precipitation, and adsorption on ash) that effectively treat the LVW. All of the LVW now receive some degree of cotreatment in the ash pond prior to discharge with the ash sluice water.

When the ash sluice waters are segregated from the LVW, NPDES regulations <u>may require</u> that each LVW stream be treated separately prior to discharge. Therefore, two alternatives were evaluated. The first alternative was segregation of LVW from the fly and bottom ashes except for inclusion of fly ash dry stack runoff with the LVW. With this alternative each waste stream may require treatment to meet NPDES effluent limitations. Even if NPDES regulations allow combining the LVW for treatment without ash sluice water, the combined LVW may require additional treatment to meet NPDES effluent limitations.

Table 1 lists the normal NPDES effluent limitations for LVW including chemical cleaning wastes and coal pile runoff [1]. In addition, the pH of LVW and metal cleaning waste discharges shall be within the range of 6.0 to 9.0. The current ash pond effluent limitations are: pH minimum = 6.0 units, oil & grease = 15/20 mg/L average, and total suspended solids (TSS) = 30 mg/L average. The parameters which may be difficult to meet in the future are pH and TSS. CUF has also had some problems with chronic toxicity in the final ash pond effluent. The cause of the toxicity is unknown at this time and is being investigated by TVA and EPA. The potential impacts of the proposed changes on acute or chronic toxicities of any discharges were not evaluated in this study.

The second alternative was combining all of the LVW with the bottom ash sluice water and recycling all of the wastewater for use in the bottom ash handling system. This alternative appears to be very similar to current operations from a regulatory viewpoint. However, the proposed systems shown in Figure 1 may not provide adequate treatment to meet NPDES limitations for discharge of the combined wastewater because of the greatly increased hydraulic loading. This would not be a problem if the quantities of water consumed by the bottom ash handling system equal or exceed the quantity of LVW. This may be feasible based on daily average flows. However, some LVW flows are dependent on precipitation and generate large volumes in a short time.

Little flow or characterization data exists for these LVW at CUF. Therefore, Water Resources was asked on July 15, 1991 to evaluate the probable impact of the proposed changes on the surface water quality at CUF, emphasizing compliance with the NPDES permit limitations for the ash/low-volume wastes pond. The requested completion date was August 1, 1991. The short time frame for this project mandates that limited sampling be done. Therefore, historical data or assumptions about normal operations will be used when actual monitoring data does not exist.

II. EXISTING CONDITIONS

A. Plant Layout

The existing plant layout is shown in Figure 2. Currently fly ash and bottom ash are each sluiced directly to their respective ponds. The fly ash pond then discharges into the bottom ash sluice pond at approximately the point indicated by the arrow on Figure 2. The coalyard pond, boiler cleaning waste (BCW) pond, and air preheater cleaning waste (APCW) each discharge to the trench on the perimeter of the fly ash dredge area. This trench discharges by gravity to the present fly ash pond except when the discharge pipes are closed. The station sump discharge and demineralizer regenerant LVW are discharged directly to the bottom ash sluice pond at the same point as the ash sluice water without prior treatment. Pyrites and other coal reject materials are currently landfilled on site.

The following LVW are discharged to the coalyard pond before being discharged to the fly ash pond: coalyard runoff, barge unloader sump discharge, coal transfer station sump discharge, car wash, south yard drainage, water treatment plant wastes, and roof drainage.

Actual capacities of individual treatment or storage units were not available. Available information about each unit is as follows:

1. Coalyard Runoff Pond - Visual estimation of the capacity of the coalyard runoff pond is 7 MG at a depth of 6 feet. The coalyard drainage pond has 3 pumps each with a capacity of 3.6 MGD. These pumps are float-activated. If one pump does not prevent the water level in the pond from continuing to rise, the second, and then the third pump is activated. Thus during normal operations the discharge flow is 3.6 MGD but during a very heavy rainfall the discharge flow could be as high as 10.8 MGD. The capacity of all three pumps could handle the runoff from a 4.5 to 5 inch rainfall event, but not that of the historical maximum 8 inch rainfall.

2. Metal Cleaning Waste Pond - Estimation of the boiler cleaning waste pond is 3 MG at a depth of 7 feet. Currently only the chemical Boiler Cleaning Waste (BCW) is discharged into this pond for treatment.

3. Station Sump Discharge - Pumps are float-controlled. The size of the sump and the pump capacities were not determined during this study.

4. Demineralizer Regenerant Sump - Pumps are float-controlled. The size of the sump and the pump capacities were not determined during this study. The discharge flow from this sump into the bottom ash pond was approximately 1 gallon per second or 3,000 to 4,000 gallons per hour.

5. Bottom Ash Pond - This pond now receives approximately 26 MGD each of bottom ash sluice water and the discharge of approximately 26 MGD from the fly ash pond. This pond then discharges into the stilling pool where the final discharge (NPDES No. 001) to the condenser cooling water channel is located.

B. Low-Volume Wastes (LVW)

1. Station Sump Discharge
Discharge is intermittent but frequent enough that the flow of 1.298 million gallons per day (MGD) from the NPDES permit application may be assumed to be fairly constant on a daily basis. Primary constituents of concern are believed to be oil and grease and suspended solids.

2. Demineralizer Regenerant Sump Discharge
Discharge is intermittent. The demineralizer regenerant (DI) LVW are first directed to the demineralizer regenerant sump. If the plant does not need any condensate makeup water, the demineralizers will receive little use and will not be regenerated as often. There are three different demineralizer regenerant cycles.

a. The Cochrane system has 8 trains which are regenerated on an average of two per week. Each Cochrane regeneration cycle creates approximately 40,000 gallons of wastewater at flows ranging from 30 to 210 gallons per minute (GPM) over an 8 to 10 hour period. During this cycle the wastewater ranges in quality from condensate rinses to several thousand gallons of 4 percent sodium hydroxide, 4 percent sulfuric acid, and 0.5 percent ammonium hydroxide.
b. The LADI cation/anion system has 3 trains and an average of one train is regenerated every 11-17 hours. This cycle creates over 26,000 gallons of wastewater ranging from 100 to 400

GPM over a 3 hour period. During this cycle the wastewater ranges in quality from condensate rinses to several thousand gallons of 4 percent sodium hydroxide and 1.5 to 6 percent sulfuric acid. The acid and caustic phases are normally done simultaneously so some neutralization probably occurs in the DI sump.

c. The LADI mixed-bed system is regenerated on an average of one train per week and generates approximately 7,000 gallons of wastewater over 3 hour period ranging from 15 to 90 GPM over a 3 hour period. During this cycle the wastewater ranges in quality from condensate rinses to approximately 280 gallons of sodium hydroxide and sulfuric acid. The acid and caustic phases are normally done simultaneously so some neutralization probably occurs in the DI sump.

d. Therefore, the combined DI discharge will vary significantly from day to day depending on how many and which systems are being regenerated. However, the daily average flow of 0.147 MGD from the NPDES permit application is probably fairly close over periods of a week or more. The acid storage tank also drains to this sump if there is a spill or leak. Primary constituents of concern are believed to be acids, alkalies, and ammonia.

3. Coalyard Runoff

Quantity and quality are dependant on precipitation. Flow will range from zero to over 4 MGD. It is directed to the coalyard runoff pond primarily for solids removal and possible neutralization by other LVW. Primary constituents of concern are acidity, suspended solids, and metals.

4. South Yard Drainage and Roof Drainage

Quantity and quality are dependant on precipitation. Flow will range from zero to over 14 MGD. Quality should be similar to that of the precipitation with the addition of solids picked up from the surfaces by the runoff. It is directed to the coalyard runoff pond. Primary constituent of concern is suspended solids.

5. Barge Unloader Sump Discharge, Coal Transfer Station Sump Discharge, and Car Wash

The two coal transfer sumps are float-controlled. The discharge is primarily daily washdown with raw river water. Discharge is intermittent but frequent enough that the flow of 0.062 MGD from the NPDES permit application may be assumed to be daily and fairly constant. The car wash is only raw river water. All three are directed to the coalyard runoff pond by way of the coalyard drainage ditch. Primary constituent of concern is suspended solids.

6. Water Treatment Plant Wastes

Backwash is normally automatic and is based on pressure drop across the filter. Backwash is discharged to a sump with pumps which are float-controlled. Discharge is intermittent but the flow may be assumed to be daily and fairly constant. The discharge is to the coalyard runoff pond. Primary constituents of concern are suspended solids and aluminum.

7. Metal Cleaning Wastes

a. Boiler Cleaning Wastes (BCW) occur approximately once each 5 years and are directed to the dedicated treatment pond. There the BCW is treated with sodium hydroxide to remove the metals in the waste. When the iron and copper concentrations in the waste are less than 1.0 mg/L the BCW is pumped to the trench which circles the dredge pond and discharges to the fly ash pond. Because this waste stream is treated before discharge from the metal cleaning waste pond, its impact is assumed to be negligible on the other LVW.

b. Air Preheater Cleaning Wastes (APCW) occur approximately once each 3 months. The total volume of APCW is 11 to 22 million gallons (MG) over a 30 to 72 hour period. The first 2 to 4 MG is acidic and high in metals as shown in Table 2[3]. The remainder of the APCW is similar to river water but exceeds the NPDES limitation of 1.0 mg/L of iron. All the APCW are discharged with fly ash sluice water directly to the trench which circles the dredge pond. The mixture is retained for 15 days, sampled and then discharged to the fly ash pond when the iron and copper concentrations in the waste are less than 1.0 mg/L. Primary constituents of concern are suspended solids and metals.

C. Flows

The estimated average and maximum daily flows of the LVW are summarized in Table 3. The current average LVW flows without the future dry ash disposal area runoff total approximately 2 MGD. The flows for the car wash, filter plant backwash, and boiler cleaning waste are unknown. However, it is assumed that their flows are insignificant in comparison to the other LVW such as the DI waste and the station sump. The current total ash pond discharge is approximately 54 MGD. If it is assumed that the bottom ash sluice and the fly ash sluice are approximately equal, then each averages 26 MGD.

III. Proposed Conditions

A. Plant Layout

As stated in the Introduction proposed operational changes include: (a) dry stacking fly ash; (b) wet sluicing bottom ash to a dewatering tank and reusing the sluice water; (c) continuing to combine the low-volume wastewaters in a diked-off section of the existing bottom ash pond; (d) continuing to discharge Air Preheater Cleaning Wastes to a diked-off section of the ash pond for treatment; and (e) installing scrubber system. The proposed plant layout for these changes is shown in Figure 1.

It was stated that the scrubber system would be closed-loop and have no discharge.

B. Low-Volume Wastes

If feasible the plant does not want to change the way LVW are currently handled. Therefore, all LVW would have approximately the same quantity and quality and follow similar flow paths to the current ones. The primary change would be redirection of the station sump and DI sump discharges directly to the proposed Emergency Sluicing Area.

This Emergency Sluicing Area (ESA) is intended to provide the capability to wet sluice ash during emergency shutdown of a unit. It is also intended under the proposed course of action to serve as a LVW treatment pond. If this area is assumed to be 10 acres by approximately 5 feet deep, it will contain approximately 16.3 MG.

The Coalyard Pond, BCW Pond, and APCW discharges would all continue to be directed to the same trench around the new Wet Gypsum Stacking Area. They would then discharge to a channel around the new ash disposal area near the perimeter dike and flow into the ESA. Runoff from the new ash disposal area would also enter the ESA. The final discharge of the combined LVW and fly ash stack runoff would be through the stilling pool by way of the existing final ash pond discharge weirs.

Dry fly ash stack runoff is assumed to have the same chemical characteristics as the existing fly ash sluice pond discharge. Its flows are assumed to be directly related to precipitation with 100 percent runoff from the 125 acre area. The scrubber system is assumed to be closed-loop with no discharge.

Continuing to handle APCW in this fashion will require that the capability to periodically wet sluice fly ash with the

APCW must be retained. Otherwise, the 1986 demonstration is no longer applicable and the APCW must be treated to meet NPDES limitations.

The second alternative is that the bottom ash sluice water would also be directed to the ESA for chemical neutralization of the LVW. Under this alternative the LVW would be recycled with the bottom ash sluice water. The final discharge would be reduced to a blowdown stream or a discharge during heavy rainfall events.

C. Flows

Because no operational changes are planned for the LVW other than routing them to the ESA, the flows listed in Table 3 will be unchanged. If the bottom ash sluice is combined with the LVW in the ESA, the combined flows during a 2" rainfall increase to 39 MGD. With an 8" rainfall the flows into the ESA increase to 47 MGD without the bottom ash sluice and 73 MGD with the bottom ash.

IV. METHODS

A. Field Sampling

Limited samples were collected on July 18-19, 1991, from the ash ponds and each of the low-volume waste streams currently discharged to the ash ponds. LVW samples were collected from: filter plant backwash sump, barge unloading sump, transfer station B sump, station sump, coalyard runoff pond, and demineralizer regenerant (DI) sump. Grab samples were taken from the respective sumps and ponds for all LVW except for the DI waste.

A composite of the demineralizer regenerant sump discharge was collected at the end of the pipe to the bottom ash pond sluice channel on July 19. The Cochrane system and one of the LADI trains were regenerated on July 19. The samples were collected at times to coincide approximately with the discharge of the strong chemical regenerant solutions (acid, caustic, ammonia) to the DI sump. The final composite sample consisted of equal volumes of 3 caustic and 3 acidic samples.

Samples were not collected of the all the influent streams to the coalyard runoff pond. These include: undiluted coalyard runoff, south yard drainage, and roof drains. These LVW and untreated boiler chemical cleaning waste and APCW were not sampled because they were not available during the sampling period.

Samples were also collected of the fly ash pond effluent, bottom ash pond influent, and the final ash pond effluent.

Samples were analyzed for pH, conductivity, temperature, and salinity with a calibrated Hydrolab H2O. Alkalinity and acidity, where measured, were titrated in the field. Analyses for: total suspended solids, oil & grease, total dissolved solids, sulfate, ammonia, and total metals were done by the Environmental Chemistry Laboratory. The total metals include the following: aluminum, arsenic, barium, boron, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, selenium, sodium, and zinc. The DI composite was analyzed for ammonia and sodium because the Cochrane system regeneration includes ammonium hydroxide and sodium hydroxide phases.

B. Mixing Major LVW

In order to evaluate the effects of the proposed changes in ash waste disposal on final effluent quality, portions of different waste streams were mixed in proportions to simulate four possible scenarios. Of all the LVWs, only the Station Sump (SS) and Demineralizer Regenerant (DI) are routinely discharged directly to the ash pond. Portions of these wastes were used in all four mixtures. The metal cleaning wastes are discharged periodically and since they were not available at the time of sampling, they were excluded from this portion of the study. All the remaining LVWs flow into the coalyard runoff (CYR) pond before being discharged. Since the discharge pumps are float-activated, there may or may not be a discharge on any given day. Therefore, two of the mixtures reflect the zero-flow discharge while two mixtures reflect discharge with one pump operating at its 3.6 MGD capacity. Since it has not yet been determined if the bottom ash sluice water (BA) will be mixed with the other wastes prior to recirculation, bottom ash water, collected directly from a sluice line, was used in two mixtures. The four mixtures were thus comprised as follows:

CUF-13	SS + DI
CUF-14	SS + DI + CYR
CUF-15	SS + DI + BA
CUF-16	SS + DI + CYR + BA

The relative proportion of each waste used in each mixture was determined from their expected flows. This is summarized in Table 4. Equilibrium pH, alkalinity and acidity were determined for each mixture in the Environmental Engineering Unit Operations Laboratory (EUOL) while the Environmental Chemistry Lab analyzed for the same suite of parameters as those listed in the Field Sampling section above.

C. Computer Modeling - MINTEQ

Equilibrium concentrations of selected parameters in these four waste mixtures were modeled with the chemical speciation code MINTEQA2[4]. One objective was to determine if the effluent water quality of the different mixtures would be within NPDES permit limitations. Another objective was to compare the results with the lab data obtained from the actual sample mixtures.

Before these four mixtures could be modeled on the computer, equilibrium concentrations of selected constituents of each waste stream needed to be determined. Total metals and sulfate concentrations were obtained from laboratory analyses, where available. Total carbonate concentrations were calculated from alkalinity values (after ammonia concentrations were subtracted). Details on the derivation on these inputs to the model are in the Appendix.

Three additional mixtures were modeled (but not made in the lab) with MINTEQ according to the same procedure in order to simulate other likely waste discharge scenarios. MIX A accounts for a discharge from the fly ash dry stack runoff pond after a 2-inch storm event in 24 hours mixing with the SS and DI wastes and an increased volume in CYR waste. It is assumed that the first flush from the coal pile after a storm event will create a runoff much stronger than the CYR sample obtained on July 18. Because no coal pile runoff data are available from Cumberland, average data from Colbert Fossil Plant's coal pile runoff collected in 1976-77[6] (Table 5) were used in MIX B and MIX C. MIX B was otherwise the same as MIX A; bottom ash waste was included in MIX C. The relative proportion of each waste used in each mixture is summarized in Table 4.

V. Results and Discussion

A. Low-Volume Wastes

The raw data from the sampling done on July 18 and 19 are contained in Appendix 1. The data indicate that the primary source of potential noncompliance with NPDES limitations is the DI because of the concentrated acids and caustics in this waste stream. The other expected problem waste stream was the coalyard runoff. The maximum flows expected during heavy rainfall events may also result in difficulty meeting the TSS limitations.

1. DI

The DI regeneration procedures described earlier result in several thousand gallons of concentrated acids and bases being discharged with essentially no treatment at this time. Based on the limited sampling done for this study it appears that the bases are stronger than the acids because the pH of the DI composite was very high. The remainder of this report assumes that the DI composite was representative of the average DI discharge. However, to truly evaluate the DI waste intensive sampling over a week's time of each backwash, rinse, etc. would be necessary. Another alternative would be to work with the manufacturers of each DI system to determine what the normal waste characteristics and required treatment may be.

2. Coalyard Runoff

The quality of the water in the coalyard runoff pond was relatively neutral. This may be due to the lack of recent rainfall which probably resulted in the contents of the coalyard runoff pond consisting primarily of the neutral LVW such as the coal transfer sump discharges and the filter plant backwash. The mixtures made in the EUOL and some computer models used the coalyard pond data. However, for a more conservative representation of conditions during rainfall events MIX B and MIX C use data from undiluted coalyard runoff at Colbert Fossil Plant as discussed in the Methods section. These data are contained in Table 5 and show that coalyard runoff may be a significant source of acidity and metals[4].

This study could not determine the change in coalyard runoff characteristics with rainfall events of various sizes. We believe that coalyard runoff may show a "first flush" effect where the initial runoff after a dry period is more concentrated than at the end. The intensity and size of this concentrated "first flush" would be dependent on several factors including: the antecedent rainfall, the size and intensity of the current rainfall, and the storage capacity and geometry of the coalyard stack. To determine the actual coalyard runoff characteristics at CUF would require intensive sampling during several rainfall events of varying sizes. Our conservative assumption was that all of the coalyard runoff would be similar in chemical characteristics to the data obtained from Colbert. The mean rainfall event for the Colbert data was approximately 2 inches.

3. Metal Cleaning Wastes

Untreated BCW and APCW were not available to be sampled. However, NPDES regulations require that these wastes be treated to meet iron and copper concentrations of 1.0 mg/L before mixing with any other waste stream unless an equivalent treatment demonstration is completed. Therefore the assumption was made that these two wastes will be treated before they combine with the other LVW and thus will have little if any impact on the compliance of the final effluent. If the plant does not choose to retain the capability to wet sluice fly ash with the APCW, then this waste may require some other type of chemical neutralization.

B. Computer Generated Data

Because some significant LVW streams could not be sampled computer modeling of the most probable mixtures was done to predict the characteristics of the combined wastes. The equilibrium pH and alkalinity of each mixture determined at the time the mixtures were made (Field), by Environmental Chemistry Lab, and predicted by MINTEQ are summarized in Table 4. Predicted acidities for MIX B and MIX C are also included (formulas are in the Appendix).
Note that MINTEQ in effect, treated these as closed systems. In order to reflect an open system, atmospheric CO_2 needs to be set in equilibrium with the water.

Equilibrium concentrations of seven other parameters predicted by the model are compared with the Lab analyses of the mixtures in Table 6.

The DI waste water was the most difficult to model due to its high ionic strength (0.5 vs 0.01 for the other waste streams) and high ammonia concentration (390 mg/l). However, the assumed sodium concentration of 3700 mg/l proved to be very close to the observed amount of 3500 mg/l. Sodium levels of the other waste streams were not measured, but the predicted concentrations of the mixtures were within a reasonable margin of error of the observed levels.

For each mixture modeled with MINTEQ, runs were made where solids were prevented from precipitating and where solids were allowed to precipitate. The primary parameter of interest is the equilibrium pH, NOT the specific solids which may or may not fall out of the system. The model was not calibrated for the speciation of solids likely to precipitate. Some of the solids which were allowed to form might not be kinetically possible (their formation rates are too slow) for the conditions at CUF. Therefore, the pH predicted for cases when precipitation was allowed represent an "extreme case" analysis for pH.

Alkalinity and pH are the two most important parameters in this exercise. Alkalinity is a measure of the buffer capacity while pH is the primary factor influencing dissolution or precipitation of metals. Alkalinities and pHs measured soon after mixing had the least time to equilibrate. Therefore, field values of these parameters were expected to most likely represent the model runs without solids precipitating. The mixtures sent to the Lab for analysis had more time to react. Therefore, the Lab results were expected to be closest to the model predictions with solids precipitating. As seen in Table 4, these results are confirmed in samples CUF-13 and CUF-14, but are less apparent in CUF-15 and CUF-16. Note that the latter samples had more time to react before testing. When CUF-14 was tested three days after mixing, its pH and alkalinity approached the values observed by Environmental Chemistry Laboratory and predicted by MINTEQ with solids precipitating (these values are in parentheses in Table 4). Also, if MINTEQ predicted more calcite to precipitate than would normally occur, the carbonate in calcite would not be included in the alkalinity calculations.

Sulfate levels are important indicators of water quality. The secondary drinking water standard for sulfate is 250 mg/l. The observed sulfate concentrations compared very favorably with those predicted by MINTEQ.

Sulfate and sodium concentrations do not appear to be affected by solids precipitating, while calcium and magnesium appear to be affected only in the mixture that had a pH greater than 9.5 (Table 6). The observed levels of calcium and magnesium were closer to those in the runs without solids than with solids precipitating.

The data support the importance of the high-volume bottom ash sluice water in neutralizing the other waste streams. Without bottom ash waste, equilibrium pH may range from as high as 10 to as low as 4. During periods of little or no rainfall, pHs tend to be in the 8 to 10 range. The first flush from the coalyard runoff after a large rainfall (>1"/24 hours) can be expected to depress the final pH to as low as 4 even when mixed with a larger volume of high pH wastes from fly ash runoff and DI waste.

C. Flows

Because no operational changes are planned for the LVW other than routing them to the ESA, the flows listed in Table 3 will be unchanged. The 13 MGD resulting from a 2" rainfall would only have a 30 hour retention time in a 16.3 MG pond even with perfect plug flow. Any short-circuiting would result in significantly shorter retention times and possible TSS concentrations greater than 30 mg/L. If the bottom ash sluice is combined with the LVW in the ESA, the combined flows during a 2" rainfall increase to 39 MGD and a retention time of only 10 hours. With an 8" rainfall the flows into the ESA increase to 47 MGD without the bottom ash sluice and 73 MGD with the bottom ash. These heavier rainfalls will increase the hydraulic loading on the ESA and cause probable TSS concentrations greater than the 30 mg/L limitation.

VI. CONCLUSIONS

A. The limited sampling did not adequately characterize the variations with time of the coalyard runoff and the DI waste streams. Additional data would be needed if individual treatment systems are required.

B. If the LVW are discharged untreated to the ESA without the bottom ash sluice, the strength of the coalyard runoff and the DI waste streams together with their intermittent nature will make pH values less than 6.0 and greater than 9.0 units likely on an intermittent basis. Large rainfall events may also result in TSS concentrations greater than 30 mg/L.

C. If the LVW are discharged untreated to the ESA with the bottom ash sluice, the effluent pH values should normally be between 6.0 and 9.0 units. However, heavy rainfalls may still result in pH violations and the additional hydraulic loading will probably result in TSS concentrations greater than 30 mg/L.

D. If the combined LVW and bottom ash sluice can be recycled with little or no discharge, the required quality will primarily be determined by the needs of the recycling system not by regulatory limitations.

E. It may be operationally difficult to wet sluice fly ash with the APCW 4 times each year. Therefore, an alternative treatment scheme should be evaluated. These could include: in-line neutralization, directing the first 2-4 MG to the BCW pond for treatment, or demonstrating that only time and aeration in the trench are required to remove the iron and copper.

VII. RECOMMENDATIONS

A. Conduct long-term flow measurements to better determine to actual flows under varying conditions.

B. Conduct intensive sampling of the coalyard runoff and the DI waste streams to determine how their chemical characteristics vary with time and rainfall.

C. Evaluate the chemical and hydraulic characteristics of combined LVW, including APCW, and bottom ash sluice to determine if it is feasible to recycle 100 percent of the combined waste streams.

D. If LVW cannot be recycled with the bottom ash, evaluate alternative LVW treatment systems. Examples are:

   1. Direct all of the LVW including the DI and the station sump into the coalyard runoff pond for mixing and chemical neutralization when necessary. Reroute the coalyard runoff pond discharge directly to the ESA.

   2. Evaluate the feasibility of storing some of the alkaline LVW, such as the DI, in the Metal Cleaning Pond to use as needed to neutralize the acidic LVW. This could reduce the cost of treatment chemicals.

   3. Evaluate alternative treatment schemes for the APCW, including: in-line neutralization, directing the first 2-4 MG to the BCW pond for treatment, or demonstrating that only time and aeration are required to remove the iron and copper.

VIII. REFERENCES

1. Development Document for Effluent Limitations Guidelines and Standards and Pretreatment Standards for the Steam Electric Point Source Category, United States Environmental Protection Agency, EPA-440/1-82/029, November 1982.

2. Manual for Management of Low-Volume Wastes from Fossil-Fuel-Fired Power Plants, Electric Power Research Institute, EPRI CS-5281, July 1987.

3. "Air Preheater Cleaning Wastes - In-situ Demonstration of Equivalent Treatment in Cumberland Fossil Plant Ash Pond", TVA Water Quality Branch, June 1986.

4. Allison, J. D., D. S. Brown, and K. J. Novo-Gradac. "MINTEQA2/PRODEFA2, A Geochemical Assessment Model for Environmental Systems: Version 3.0 User's Manual." Environmental Research Laboratory, Athens, Georgia, 1990.

5. Snoeyink, V. L. and D. Jenkins. Environmental Chemistry, John Wiley & Sons, New York, 1980.

6. Cox, D. B., T-Y. J. Chu, and R. J. Ruane. "Characterization of Coal Pile Drainage." U. S. Environmental Protection Agency, Washington, D. C. EPA-600/7-79-051. 1979.

7. "Groundwater and Leachate Quality". July 1991, Tennessee Valley Authority Water Quality Department input to John Sevier Groundwater Assessment. Memorandum from C. E. Bohac to J. M. Boggs, "John Sevier Groundwater Assessment". July 10, 1991.

TABLES

Table 1

BAT EFFLUENT LIMITATIONS

(mg/L)

Parameter	Low Volume Waste: Maximum for Any 1 Day	Low Volume Waste: Average of Daily Values for 30 Consecutive Days	Chemical Metal Cleaning Waste: Maximum for Any 1 Day	Chemical Metal Cleaning Waste: Average of Daily Values for 30 Consecutive Days	Coal Pile Runoff: Maximum for Any Time
TSS	100.0	30.0	100.0	30.0	50
Oil and grease	20.0	15.0	20.0	15.0	NA
Copper	NA	NA	1.0	1.0	NA
Iron	NA	NA	1.0	1.0	NA

NA - Not applicable.

Source: Reference 2

Table 2
Air Preheater Cleaning Waste
Cumberland Fossil Plant

Sample Number	Date	Sample Time CST	Elapsed Time hours	Time Represented Per Sample	Volume/ Sample MG	pH units	Total Iron mg/L	Total Iron lbs.	Dissolved Iron mg/L	Dissolved Iron lbs.	Ferrous Iron mg/L	Ferrous Iron lbs.	Total Copper mg/L	Total Copper lbs.	Dissolved Copper mg/L	Dissolved Copper lbs.
CCW-2A/H	3/29	0830-1200	0-4	4	1.250	1.9-4.3	2260.00	23560.50	2220.00	23143.50	1600.00	16680.00	3.30	34.40	2.90	30.23
CCW-2I/P	3/29	1230-1600	4-8	4	1.250	4.0-6.2	187.00	1949.47	161.00	1678.42	160.00	1668.00	.08	.83	.02	.21
* CCW-2Q/X	3/29	1630-2000	8-12	4	1.250	6.2-6.6	57.25	596.83	32.10	334.64	35.00	364.88	.07	.78	< .01	< .10
CCW-2Q/X(1)	3/29	1630-2000	8-12	4	N/A	6.2-6.6	54.40	--	33.10	--	35.00	--	.01	--	< .01	--
CCW-2Q/X(2)	3/29	1630-2000	8-12	4	N/A	6.2-6.6	60.10	--	31.1	--	Broken	--	.14	--	< .01	--
CCW-2Y/3A	3/29	2100-2400	12-16	4	1.250	6.0-6.7	57.60	600.48	15.60	162.63	17.00	177.22	.02	.21	< .01	< .10
CCW-3B/E	3/30	0100-0400	16-20	4	1.250	6.6-7.0	18.80	195.99	.97	10.11	2.20	22.94	< .01	< .10	< .01	< .10
CCW-3F/I	3/30	0500-0800	20-24	4	1.250	6.9-7.1	14.50	151.16	1.24	12.93	1.30	13.55	.01	.10	< .01	< .10
CCW-3J/K	3/30	0900-1200	24-28	4	1.250	7.2-7.5	14.10	146.99	< .01	< .10	.82	8.55	< .01	< .10	< .01	< .10
CCW-3L	3/30	1600	32.0	4	1.250	7.50	17.50	182.44	< .01	< .10	.70	7.30	< .01	< .10	< .01	< .10
CCW-3M	3/30	2000	36.0	4	1.250	7.50	13.20	137.61	< .01	< .10	.68	7.09	.28	2.92	.01	.10
			Total	36.00	11.25			27521.48		25342.55		18949.52		39.56		31.17
		Flow-weighted Average					293.33		270.10		201.97		.42		.33	

* Concentrations are averages of the two duplicate samples listed immediately below it.

Source: Reference 3

Table 3

Estimated Daily Low-Volume Waste Flows

WASTE STREAM	Average Flow, MGD	2" Rain Flow, MGD	Maximum Flow, MGD
-Relatively Constant Sources			
Barge Unloader Sump and Transfer Station B	0.062	0.062	0.062
Station Sump	1.298	1.298	1.298
Car Wash	unknown	unknown	unknown
Demineralizer Regenerants	0.147	0.147	0.147
Filter Plant Backwash	unknown	unknown	unknown
Subtotal	1.507	1.507	1.507
-Sources Dependant on Precipitation*			
Coal Pile Runoff (20 ac.)	0.086	1.086	4.3
Roof Drains (5.2 ac.)	0.022	0.282	1.1
South Yard Drainage (62 ac.)	0.261	3.368	13.5
Subtotal	0.369	4.736	18.9
-Proposed New Source			
Dry Ash Disposal Area (125 ac.)	0.530	6.78	27
Approximate Totals	2.4	13.0	47
-Infrequent Sources			
Air Preheater Cleaning Waste**	10		
Boiler Cleaning Waste	unknown		

* These flows are primarily based on precipitation and an assumption of 100 percent runoff. The average flows are based on 57 inches of precipitation per year divided by 365 days per year. The 2" and 8" Rainfall flows are based on those rainfalls in 24 hours.

** The APCW discharge is 11 to 22 MG over a 30 to 70 hour period per cleaning with 4 cleanings per year. Because fly ash sluice water must be coponded with the APCW, the total volume per cleaning is probably 35 to 70 MG. The average daily flow of 10 MGD is based on the rate of APCW discharged during the 1986 in-situ study[3].

Table 4. Cumberland Fossil Plant

Equilibrium pH and Alkalinity of Various waste stream mixtures.

Mixture	Waste Streams (a)	Parameter	Field	Lab	Minteq w/o solids	Model w/solids
CUF-13	.9 SS + .1 DI	pH	9.88	9.7	10.05	9.77
		alk. (mg/L CaCO3)	440	310	323	220
CUF-14	.26 SS + .03 DI	pH	9.4 (8.1)(b)	9.0	9.3	7.8
	+ .71 CYR	alk.	154 (85)	88	153	92
CUF-15	.05 SS + .005 DI	pH	9.0	9.0	8.0	7.9
	+ .95 BA	alk.	95	90	90	85
CUF-16	.04 SS + .005 DI	pH	8.84	8.8	8.1	7.85
	+ .12 CYR +.84 BA	alk.	98	90	93	87
MIXA	.1 SS + .01 DI	pH				8.93
	+ .4 CYR + .5 FLY	alk.				6
MIXB	.1 SS + .01 DI	pH			5.64	4.03
	+ .4 COLCYR	alk.			17	0
	+ .5 FLY	acd. (mg/L CaCO3)			192	213
MIXC	.03 SS + .004 DI	pH			6.5	6.3
	+ .15 COLCYR +	alk.			58	47
	.65 BA + .17 FLY	acd.			132	143

(a) Wast Stream Key (Assumed Flows, MGD):
SS = Station sump (1.3); DI = Demineralizer regenerant (.15);
CYR = Coalyard runoff (3.6, in MIXA-5.4); COLCYR = Colbert coalyard runoff (5.4);
BA = Bottom ash sluice (26); FLY = Fly ash dry stack runoff (6.8).

(b) Values in ( ) 3 days later.

Table 5. Colbert Coalpile Runoff
Water Quality Data

Date	pH (SU)	Acidity (CaCO$_3$) (mg/L)	Conductivity (µmhos/cm)	Cl (mg/L)	SO$_4$ (mg/L)	D. Sol. (mg/L)	S. Sol. (mg/L)	Fe (mg/L)	Mn (mg/L)	SiO$_2$ (mg/L)	Cu (mg/L)	Zn (mg/L)	Cr (mg/L)
11- 3-76	3.1	1600	3000	19	2900	3400	180	470	3.2	28	0.20	3.0	< 0.011
11-27-76	2.6	1300	3000	120	4000	3100	38	340	2.5	45	0.23	2.0	0.005
12- 2-76	2.6	2100	4500	44	3300	5000	130	480	10.0	1	0.46	3.7	0.006
12-16-76	2.6	1300	3400	260	2500	3900	260	390	3.7	45	0.28	2.1	0.010
12-22-76	2.5	860	3000	170	2100	2900	270	280	2.4	32	0.10	1.1	< 0.005
12-28-76	2.6	1000	3100	170	1900	3100	250	320	3.0	38	0.10	1.2	< 0.005
3- 2-77	2.5	920	3300	190	2200	3300	680	300	3.2	27	0.07	1.3	< 0.005
3- 7-77	2.6	700	2700	120	1800	2300	280	23	1.8	23	0.09	1.2	< 0.005
3-14-77	2.5	1200	2600	15	1900	270	460	270	2.3	40	0.14	1.8	< 0.005
4- 6-77	2.4	2500	6400	660	6200	8200	72	590	12.0	45	0.26	3.7	< 0.005
4-26-77	2.3	4800	2200	340	4100	5100	420	480	4.6	41	0.12	2.8	< 0.005
6-21-77	2.4	1500	6000	470	3700	6300	340	310	5.0	-	0.12	5.1	0.009

Date	Al (mg/L)	Ni (mg/L)	Ca (mg/L)	Mg (mg/L)	Pb (mg/L)	Hg (mg/L)	Ba (mg/L)	As (mg/L)	Cd (mg/L)	Se (mg/L)	Ti (mg/L)	Be (mg/L)	Sb (mg/L)	Rainfall (cm)
11- 3-76	56	0.40	210	46	< 0.01	0.0031	< 0.1	0.046	< 0.001	< 0.001	< 1.0	< 0.01	0.3	3.25
11-27-76	38	0.28	230	38	< 0.01	0.0072	< 0.1	0.018	< 0.001	< 0.001	< 1.0	< 0.01	0.3	8.28
12- 2-76	50	0.46	340	81	< 0.01	0.0032	< 0.1	0.006	0.003	< 0.001	< 1.0	< 0.01	< 0.1	4.24
12-16-76	60	0.31	340	89	< 0.01	-	< 0.1	-	0.002	-	< 1.0	-	< 0.1	1.47
12-22-76	22	0.24	250	45	< 0.01	< 0.0043	< 0.1	0.015	0.002	< 0.001	< 1.0	0.03	< 0.1	2.69
12-28-76	34	0.26	[illegible]	50	< 0.01	[illegible]	< 0.1	-	0.003	-	< 1.0	< 0.01	< 0.1	2.18
3- 2-77	39	0.15	320	51	< 0.01	0.0020	< 0.1	0.027	0.001	0.001	< 1.0	< 0.01	< 0.1	1.85
3- 7-77	26	0.20	110	31	< 0.01	0.0014	< 0.1	0.014	0.001	0.002	< 1.0	< 0.01	< 0.1	9.42
3-14-77	38	0.40	140	22	< 0.01	0.0005	< 0.1	0.031	< 0.001	0.006	< 1.0	< 0.01	-	6.30
4- 6-77	20	0.46	400	130	< 0.01	0.0019	0.5	0.011	< 0.001	0.001	< 1.0	0.02	0.5	8.97
4-26-77	92	0.49	720	78	< 0.01	0.0030	< 0.1	0.019	< 0.001	< 0.001	< 1.0	0.01	0.4	5.16
6-21-77	-	0.40	520	120	< 0.01	0.0025	-	-	< 0.001	< 0.001	< 1.0	< 0.01	-	-

Source: Reference 6

Table 6. Cumberland Fossil Plant
Waste Stream Mixtures
Equilibrium Concentrations - MINTEQ Predictions
with and without solids preciptating compared with Environmental Chemistry Lab analyses

SAMPLE		CUF-13			CUF-14			CUF-15			CUF-16			Mix A	Mix B	Mix C
		MINTEQ		LAB	MINTEQ		LAB	MINTEQ		LAB	MINTEQ		LAB	MINTEQ	MINTEQ	MINTEQ
Parameter	Units	Without Solids	With Solids		Without Solids	With Solids		Without Solids	With Solids		Without Solids	With Solids		With Solids	With Solids	With Solids
Total Suspended Solids	mg/L			220			100			24			18			
Total Dissolved Solids	mg/L			1200			640			210			210			
Sulfate in Water	mg/L	707	707	720	353	353	390	102	102	75	117	117	100	377	478	220
Total Alkalinity	mg/L	323	220	310	153	92	88	90	95	90	93	87	90	6	0	47
Arsenic, Total in Water	µg/L			2			<1			<1			<1			
Barium, Total in Water	µg/L			30			30			50			70			
Boron, Total in Water	µg/L			<50			940			150			260			
Chromium, Total in Water	µg/L			13			2			6			3			
Lead, Total in Water	µg/L			11			2			2			<1			
Nickel, Total in Water	µg/L			25			10			4			3			
Selenium, Total in Water	µg/L			12			5			3			2			
Zinc, Total in Water	µg/L			80			20			<10			<10			
Aluminum, Total in Water	µg/L	752	14	300	218	<1	160	2121	<1	<0.1	1873	<1	0.1	2	1135	<1
Iron, Total in Water	µg/L	1761	<1	1600	515	<1	920	4729	<1	1100	4179	<1	1000	<1	<1	<1
Manganese, Total in Water	µg/L			110			13			27			50			
Copper, Total in Water	µg/L	238	55	520	71	71	160	22	22	5.2	20	20	5.6	24	24	15
Calcium, Total in Water	mg/L	38	1	38	78	55	87	39	35	40	46	41	45	85	143	75
Magnesium, Total in Water	mg/L	6	<1	6.9	9	9	8.7	6	6	20	7	7	10	6	7	7
Cadmium, Total in Water	µg/L			0.6			<0.1			560			410			
Ca and Mg Hardness Calc	mg/L[a]			123			253			121			135			
Ammonia Nitrogen	mg/L			44			13			2.1			2.1			
Sodium	mg/L	419	419	370	175	175	140	65	65	18	67	67	22	70	42	46
pH Value	pH	10.0	9.8	9.7	9.3	7.8	9.0	8.0	7.9	9.0	8.1	7.9	8.8	8.9	4.0	6.3

a. as $CaCO_3$

FIGURES

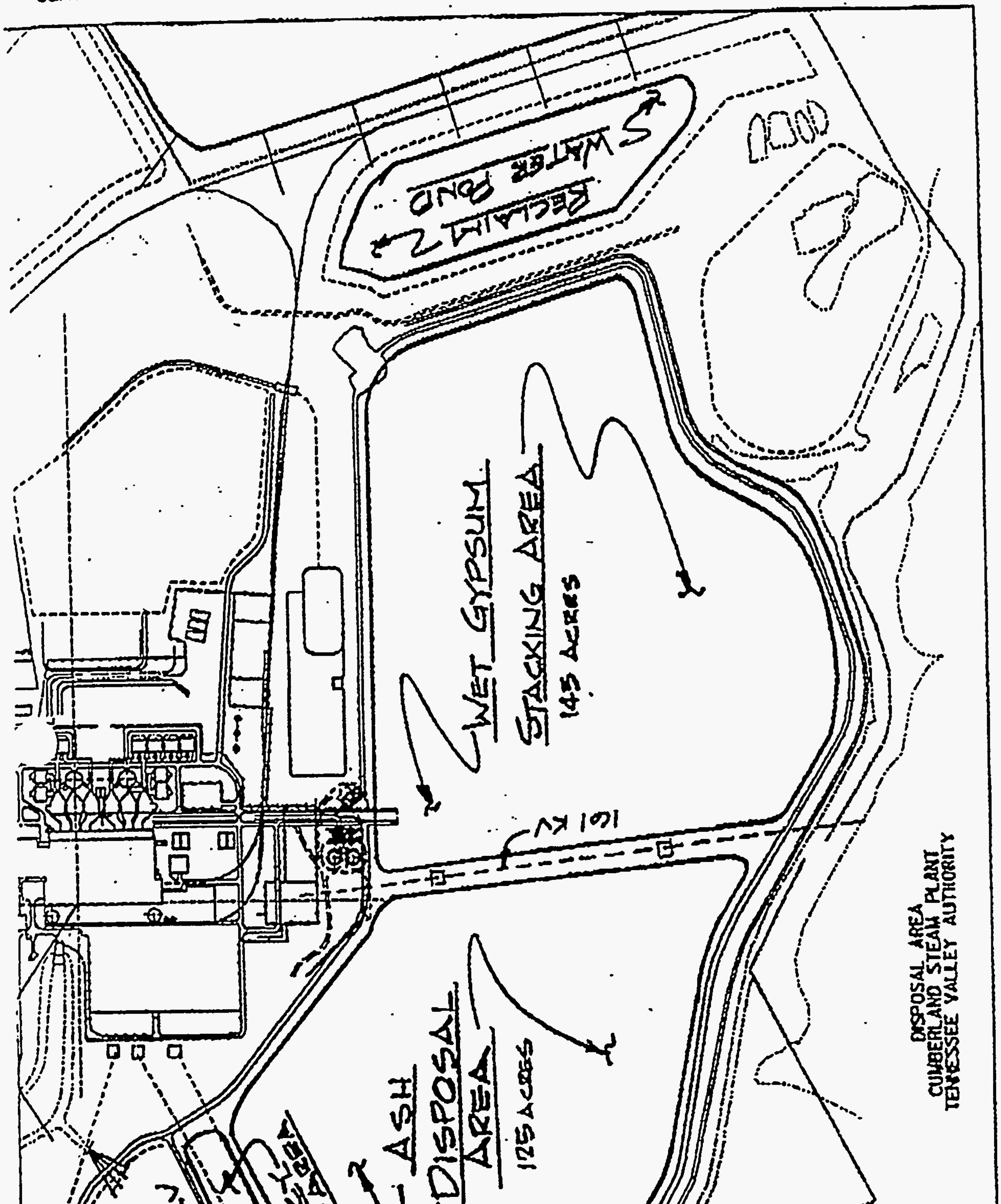

RECLAIM WATER POND
WET GYPSUM STACKING AREA
145 ACRES
161 KV
ASH DISPOSAL AREA
125 ACRES
500 KV
DISPOSAL AREA
CUMBERLAND STEAM PLANT
TENNESSEE VALLEY AUTHORITY

FIGURE 1

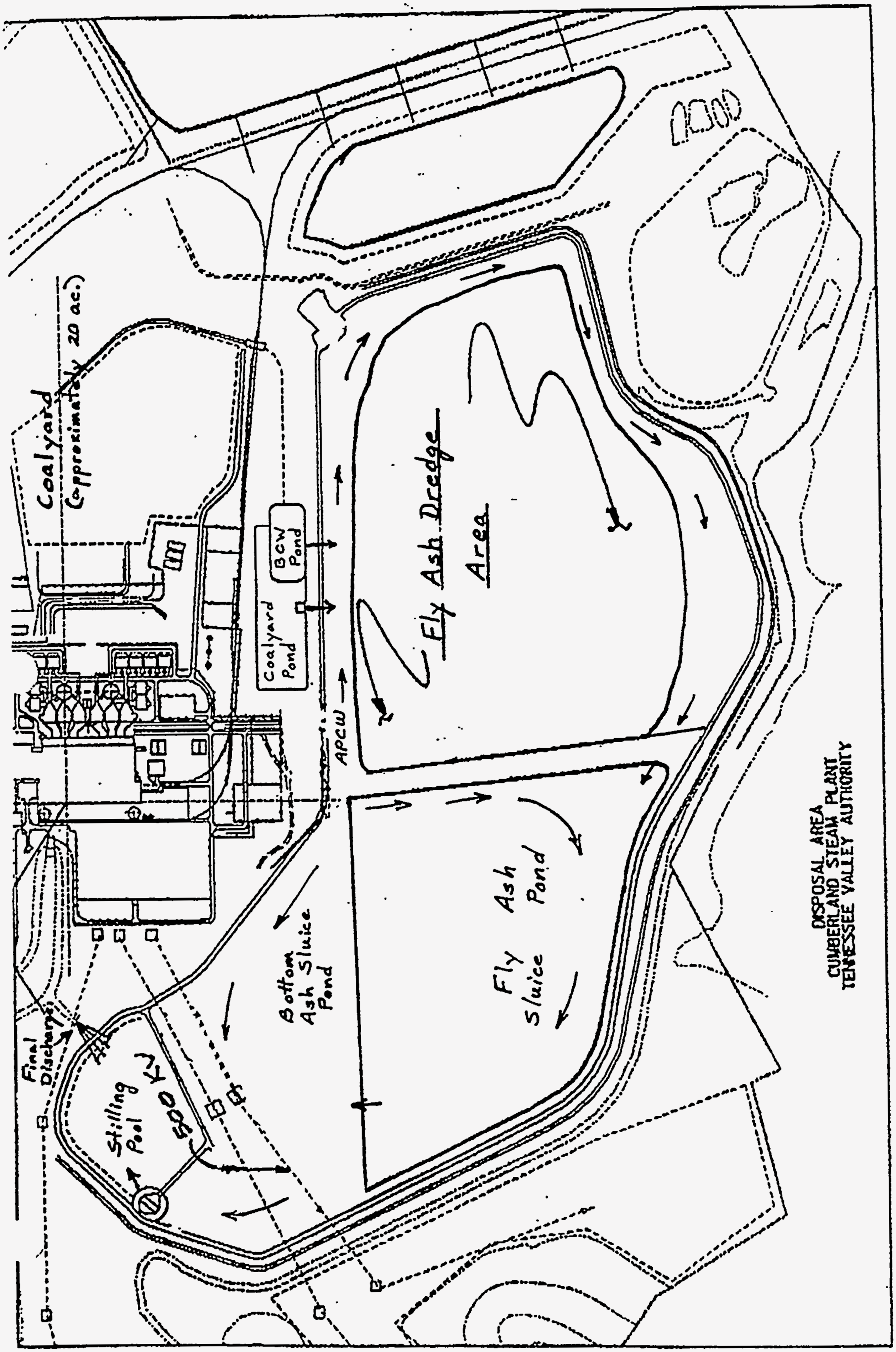

Coalyard
(approximately 20 ac.)
BCW Pond
Coalyard Pond
APCW
Fly Ash Dredge Area
Fly Ash Sluice Pond
Bottom Ash Sluice Pond
Final Discharge
Stilling Pool
DISPOSAL AREA
CUMBERLAND STEAM PLANT
TENNESSEE VALLEY AUTHORITY

FIGURE 2

APPENDIX

Derivation of Inputs to MINTEQ Model

The total carbonate concentrations were determined by the following formulas:

$$C_{T,CO3} = \frac{\text{Alkalinity} - [OH-] + [H+]}{(\alpha_1 + 2\alpha_2)}$$

where, $\alpha_1 = \{([H+]/K_1) + 1 + (K_2/[H+])\}^{-1}$

and $\alpha_2 = \{([H+]^2/K_1K_2) + 1 + ([H+]/K_2)\}^{-1}$

where, K_1 and K_2 are dissociation constants for carbonic acid with values of 1E-6.3 and 1E-10.3, respectively[5].

All concentrations are in moles per liter except alkalinity which is in equivalents per liter. With the pH fixed, MINTEQ determined the total hydrogen concentration in each of the four waste streams. (Lab results from the sample obtained from the bottom ash pond channel were used for the bottom ash (BA) waste stream in the modeling exercises even though bottom ash sluice water collected directly from a sluice line was used to make mixtures CUF-15 and CUF-16.) Sodium concentrations were assumed in order to balance the ionic charges in each sample because the laboratory results were not available at the time of modeling.

The equilibrium concentrations from these runs were used to calculate the initial concentrations for the mixtures according to the same proportions in Table 4. These values were run in MINTEQ once without allowing solids to precipitate and once with allowing solids to precipitate.

The alkalinities and acidities predicted by MINTEQ were calculated as follows:

Total alkalinity (eq/l) = $C_{T,CO3}(\alpha_1 + 2\alpha_2) + \alpha_1 C_{T,NH3} + [OH-] - [H+]$;

Total acidity (eq/l) = $C_{T,CO3}(\alpha_1 + 2\alpha_0) + [H+] - [OH-]$,

where, $C_{T,CO3}$ = equilibrium concentration predicted by MINTEQ (moles/l) and

$C_{T,NH3}$ = ammonia nitrogen concentration determined by Environmental Chemistry Laboratory (moles/l)[5].

umberland Fossil Plant
·pecial Study

Field Data

ate	Lab ID	Time cst	Salinity ppt	Hydrolab Temp. °C	S Cond mmhos/cm	pH S.U.	pH	Field Alk. mg/L CaCO	Eng. Acidity 8.3	Acidity 10.5	Sample
'/18/91	CUF-1	11:06	0.7	31	1.279	10.61	10.9	210	0	0	Fly ash pond eff.
	CUF-2						7.1	76	8	94	Barge Sump
	CUF-3						7.4	81	10	90	Intake (Raw)
	CUF-4						7.2	81	6	86	Filter Plant Backwash
	CUF-5	14:20	0.4	31.5	0.726	7.93					Coalyard Runoff - Surface
		14:24	0.5	26.5	0.907	6.87					" " - Bottom (6.5 ft)
		14:28	0.4	30.3	0.730	7.90	7.8	100	10	120	" " - 3 ft
	CUF-6	16:06	0.3	32.1	0.559	9.00	9.1	76	0	52	Final Ash Pond Eff.
	CUF-7	10:52	0.1	34.1	0.238	7.10	7.7	86	10	85	Bottom Ash Pond Channel (BAPC)
	CUF-8						7.8	92	5	85	Transfer Station B
	CUF-9						7.5	80	6	92	Station Sump
	CUF-10						7.5	81	5	90	Station Sump Dup.
'/19/91	CUF-11	15:00				11.73	11.5	2740	0	0	DI Comp.
	CUF-12	14:08									DI NH3
	DI Waste	9:00	27.6	35.5	42.800	11.95		used in composite			Cochran 4% caustic
		9:09	40.1	36.8	59.800	11.98					'
	BAPC	9:19	0.4	35	0.846	11.11					app. 100 m from sluice discharge
		9:40 - 10:53	no DI discharge								
	Sluice	9:40	0.1	34.8	0.249	8.11	8.3	80	0	163	Bottom ash
	BAPC	10:26	0.1	34.8	0.269	8.07					
	DI Waste	10:57	43.1	36	63.800	11.94		used in composite			Cochran - 0.5% ammonia, LADI - acid and caustic
	BAPC	11:11	0.7	35.3	1.370	11.23					
	DI Waste	11:17	10.8	35.7	18.300	2.36		used in composite			" "
	BAPC	11:26	0.4	35.4	0.730	6.92					
	DI Waste	11:35	7.5	33.8	13.100	2.06		used in composite			" "
	BAPC	11:45	0.2	36.2	0.494	6.22					
	DI Waste	14:08	1.9	35.4	3.450	8.90		used in composite			Cochran - rinse and backwash
	BAPC	14:18	0.2	35.8	0.398	7.90					
	DI Waste	14:45	27.1	38.2	42.100	1.80					Cochran - 4% acid
	BAPC	14:50	0.2	34.5	0.440	4.50					
	DI Waste	15:00	24	41.7	37.600	1.90		used in composite			" "

'/23/91 Waste Stream Mixtures

Waste stream	Station Sump	DI Comp Waste	Coal yard Runoff	Bottom ash Sluice
Assumed flow (MGD)	1.3	0.15	0/3.6	26

Mixture	Station Sump Ratio	ml	DI Comp Ratio	ml	Coal yard Ratio	ml	Bottom ash Ratio	ml	pH	Alk.	Total Assumed Flow (MGD)	Total Ratio (MGD)
CUF-13	0.9	1800	0.1	200	0	0	0	0	9.88	440	1.45	1
CUF-14	0.26	520	0.03	60	0.71	1420	0	0	9.39	150	5.05	1
CUF-15	0.05	100	0.005	10	0	0	0.95	1890	9.00	95	27.45	1.005
CUF-16	0.04	85	0.005	10	0.12	230	0.84	1675	8.84	98	31.05	1.005

Lab Sample Number. 91Z13805 .. Project Leader :Carmen L Keane

Sample comments :CUMBERLAND FOSSIL PLANT CUF-1
Sample type/matrix :WATER - ASH POND Fly Ash Effluent
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date .910719 Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	2	mg/L
70300	Filterable Residue	940.	mg/L
00945	Sulfate in Water	460.	mg/L
01105	Aluminum, Total in Water	7200.	ug/L
01002	Arsenic, Total in Water	3.	ug/L
01007	Barium, Total in Water	310.	ug/L
01022	Boron, Total in Water	11000.	ug/L
01027	Cadmium, Total in Water	< 0.1	ug/L
00916	Calcium, Total in Water	230.	mg/L
01034	Chromium, Total in Water	160.	ug/L
01042	Copper, Total in Water	< 10.	ug/L
01045	Iron, Total in Water	40.	ug/L
01051	Lead, Total in Water	< 1.	ug/L
00927	Magnesium, Tot in Water	3.1	mg/L
01055	Manganese, Tot in Water	6.0	ug/L
01067	Nickel. Total in Water	< 1.	ug/L
01147	Selenium, Total in Water	18.	ug/L
01092	Zinc, Total in Water	< 10.	ug/L
46570	Ca and Mg Hardness Calc.	587	mg/L CaCO3

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Lab Sample Number :91/13806 Project Leader :Carmen L. Keane

Sample comments :CUMBERLAND FOSSIL PLANT CUF-2
Sample type/matrix :WATER - ASH POND
Sample collected by :CHARLIE MCENTYRE Barge Sump
Sample collection date :910718
Sample login date :910719 Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	5300.	mg/L
70300	Filterable Residue	480.	mg/L
00556	Oil and Grease in Water	< 5.	mg/L
00945	Sulfate in Water	360.	mg/L
01105	Aluminum, Total in Water	18000.	ug/L
01002	Arsenic, Total in Water	15.	ug/L
01007	Barium, Total in Water	280.	ug/L
01022	Boron, Total in Water	870.	ug/L
01027	Cadmium, Total in Water	4.9	ug/L
00916	Calcium, Total in Water	120.	mg/L
01034	Chromium, Total in Water	73.	ug/L
01042	Copper, Total in Water	90	ug/L
01045	Iron, Total in Water	42000	ug/L
01051	Lead, Total in Water	63.	ug/L
00927	Magnesium, Tot in Water	10.	mg/L
01055	Manganese, Tot in Water	450	ug/L
01067	Nickel, Total in Water	110.	ug/L
01147	Selenium, Total in Water	16.	ug/L
01092	Zinc, Total in Water	600.	ug/L
46570	Ca and Mg Hardness Calc.	341	mg/L CaCO3

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Lab Sample Number :91/13807 Project Leader :Carmen L. Keane

Sample comments :CUMBERLAND FOSSIL PLANT CUF-3
Sample type/matrix :WATER - ASH POND Raw Intake
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719 Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	17.	mg/L
70300	Filterable Residue	130.	mg/L
00556	Oil and Grease in Water	< 5.	mg/L
00945	Sulfate in Water	33.	mg/L
01105	Aluminum, Total in Water	280.	ug/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	30.	ug/L
01022	Boron, Total in Water	< 50.	ug/L
01027	Cadmium, Total in Water	0.2	ug/L
00916	Calcium, Total in Water	30.	mg/L
01034	Chromium, Total in Water	< 1	ug/L
01042	Copper, Total in Water	< 10.	ug/L
01045	Iron, Total in Water	350.	ug/L
01051	Lead, Total in Water	1.	ug/L
00927	Magnesium, Tot in Water	5.9	mg/L
01055	Manganese, Tot in Water	93.	ug/L
01067	Nickel, Total in Water	2.	ug/L
01147	Selenium, Total in Water	< 1.	ug/L
01092	Zinc, Total in Water	< 10.	ug/L
46570	Ca and Mg Hardness Calc.	99.	mg/L CaCO3

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Lab Sample Number :91/13808   Project Leader :Carmen L Keane

Sample comments :CUMBERLAND FOSSIL PLANT   **CUF-4**
Sample type/matrix :WATER - ASH POND   **Filter Plant Backwash**
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719   Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	520.	mg/L
70300	Filterable Residue	120.	mg/L
00556	Oil and Grease in Water	< 5.	mg/L
00945	Sulfate in Water	34.	mg/L
01105	Aluminum, Total in Water	43000.	ug/L
01002	Arsenic, Total in Water	7.	ug/L
01007	Barium, Total in Water	110	ug/L
01022	Boron, Total in Water	90.	ug/L
01027	Cadmium, Total in Water	0.6	ug/L
00916	Calcium, Total in Water	31.	mg/L
01034	Chromium, Total in Water	14	ug/L
01042	Copper, Total in Water	20.	ug/L
01045	Iron, Total in Water	13000	ug/L
01051	Lead, Total in Water	42	ug/L
00927	Magnesium, Tot in Water	6.8	mg/L
01055	Manganese, Tot in Water	1500.	ug/L
01067	Nickel, Total in Water	21	ug/L
01147	Selenium, Total in Water	2	ug/L
01092	Zinc, Total in Water	70.	ug/L
46570	Ca and Mg Hardness Calc.	105.	mg/L CaCO3

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Lab Sample Number :91/13809 .. Project Leader :Carmen L Keane

Sample comments .CUMBERLAND FOSSIL PLANT CUF-5
Sample type/matrix ·WATER - ASH POND - Coalyard Runoff
Sample collected by CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719 Sample received by lab :910719
Sample account number 4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	4	mg/L
70300	Filterable Residue	480.	mg/L
00556	Oil and Grease in Water	< 5.	mg/L
00945	Sulfate in Water	200.	mg/L
01105	Aluminum, Total in Water	< 50.	ug/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	30.	ug/L
01022	Boron, Total in Water	1500.	ug/L
01027	Cadmium, Total in Water	0.4	ug/L
00916	Calcium, Total in Water	94.	mg/L
01034	Chromium, Total in Water	< 1	ug/L
01042	Copper, Total in Water	< 10.	ug/L
01045	Iron, Total in Water	< 10.	ug/L
01051	Lead, Total in Water	1.	ug/L
00927	Magnesium, Tot in Water	10.	mg/L
01055	Manganese, Tot in Water	57.	ug/L
01067	Nickel, Total in Water	2.	ug/L
01147	Selenium, Total in Water	< 1.	ug/L
01092	Zinc, Total in Water	< 10.	ug/L
46570	Ca and Mg Hardness Calc	276	mg/L CaCO3

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Lab Sample Number :91/13810 Project Leader :Carmen L Keane

Sample comments :CUMBERLAND FOSSIL PLANT **CUF-6**
Sample type/matrix :WATER - ASH POND **Final Ash Pond Effluent**
Sample collected by .CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719 Sample received by lab .910719
Sample account number :4273-767000-1

Alt IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	3	mg/L
70300	Filterable Residue	400.	mg/L
00945	Sulfate in Water	220.	mg/L
01105	Aluminum, Total in Water	2400.	ug/L
01002	Arsenic, Total in Water	< 1	ug/L
01007	Barium, Total in Water	100.	ug/L
01022	Boron, Total in Water	4700.	ug/L
01027	Cadmium, Total in Water	0.1	ug/L
00916	Calcium, Total in Water	86.	mg/L
01034	Chromium, Total in Water	53.	ug/L
01042	Copper, Total in Water	< 10	ug/L
01045	Iron, Total in Water	80.	ug/L
01051	Lead, Total in Water	< 1.	ug/L
00927	Magnesium, Tot in Water	3.7	mg/L
01055	Manganese, Tot in Water	11	ug/L
01067	Nickel, Total in Water	2.	ug/L
01147	Selenium, Total in Water	15.	ug/L
01092	Zinc, Total in Water	< 10.	ug/L
46570	Ca and Mg Hardness Calc	230.	mg/L CaCO3

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Lab Sample Number :91/13811   Project Leader :Carmen L. Keane

Sample comments   :CUMBERLAND FOSSIL PLANT   CUF-7
Sample type/matrix   :WATER - ASH POND   Bottom Ash Pond Channel
Sample collected by   :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date   :910719   Sample received by lab :910719
Sample account number   :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	170.	mg/L
70300	Filterable Residue	170.	mg/L
00556	Oil and Grease in Water	< 5.	mg/L
00945	Sulfate in Water	70.	mg/L
01105	Aluminum, Total in Water	2200.	ug/L
01002	Arsenic, Total in Water	2.	ug/L
01007	Barium, Total in Water	90	ug/L
01022	Boron, Total in Water	100.	ug/L
01027	Cadmium, Total in Water	< 0.1	ug/L
00916	Calcium, Total in Water	39.	mg/L
01034	Chromium, Total in Water	4.	ug/L
01042	Copper, Total in Water	10.	ug/L
01045	Iron, Total in Water	4900.	ug/L
01051	Lead, Total in Water	6.	ug/L
00927	Magnesium, Tot in Water	6.2	mg/L
01055	Manganese, Tot in Water	130.	ug/L
01067	Nickel, Total in Water	6.	ug/L
01147	Selenium, Total in Water	< 1.	ug/L
01092	Zinc, Total in Water	20	ug/L
46570	Ca and Mg Hardness Calc	123	mg/L CaCO3

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Lab Sample Number :91/13813 - Project ~~Leader~~ ~~Carmen~~ L. Keane

Sample comments :CUMBERLAND FOSSIL PLANT CUF-9
Sample type/matrix :WATER - ASH POND Station Sump
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719 Sample received by lab :910719
Sample account number :4273-767000-1
Laboratory comments :LARGE PRESENCE OF OIL

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	130.	mg/L
70300	Filterable Residue	90.	mg/L
00556	Oil and Grease in Water	18000.	mg/L
00945	Sulfate in Water	78.	mg/L
01105	Aluminum, Total in Water	1000.	ug/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	50.	ug/L
01022	Boron, Total in Water	60.	ug/L
01027	Cadmium, Total in Water	1.6	ug/L
00916	Calcium, Total in Water	34.	mg/L
01034	Chromium, Total in Water	7.	ug/L
01042	Copper, Total in Water	110.	ug/L
01045	Iron, Total in Water	1700.	ug/L
01051	Lead, Total in Water	48.	ug/L
00927	Magnesium, Tot in Water	4 9	mg/L
01055	Manganese, Tot in Water	210.	ug/L
01067	Nickel, Total in Water	6.	ug/L
01147	Selenium, Total in Water	31.	ug/L
01092	Zinc, Total in Water	140	ug/L
46570	Ca and Mg Hardness Calc	105.	mg/L CaCO3

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Lab Sample Number :91/13971   Project Leader :Carmen L. Keane

Sample ID Information :CUF-9 OILY LAYER   **Station Sump**
Sample comments :CUMBERLAND FOSSIL PLANT
Sample type/matrix :WATER - ASH POND
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910722   Sample received by lab :910719
Sample account number :4273-767000-1
Laboratory comments :1gOIL SEP FROM WAT&ANALYZ

Alt. IDC	Analysis Performed	result	units
01108	Aluminum, Total in Sed	56.	mg/Kg
01003	Arsenic, Tot in Sediment	< 2.5	mg/Kg
01008	Barium, Tot in Sediment	< 0.25	mg/Kg
01023	Boron, Total in Sediment	18.	mg/Kg
01028	Cadmium, Tot in Sediment	< 0.12	mg/Kg
00917	Calcium, Tot in Sediment	78.	mg/Kg
01029	Chromium, Total in Sed	3.2	mg/Kg
01043	Copper, Tot in Sediment	4.8	mg/Kg
01170	Iron, Total in Sediment	59.	mg/Kg
01052	Lead, Total in Sediment	3.2	mg/Kg
00924	Magnesium, Total in Sed	18.	mg/Kg
01053	Manganese, Total in Sed	6.2	mg/Kg
01068	Nickel, Tot in Sediment	4.2	mg/Kg
01148	Selenium, Total in Sed	< 2.5	mg/Kg
01093	Zinc, Total in Sediment	5.5	mg/Kg

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Lab Sample Number :91/13814 Project Leader :Carmen L. Keane

Sample comments :CUMBERLAND FOSSIL PLANT CUF-10
Sample type/matrix :WATER - ASH POND Station Sump Dup.
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719 Sample received by lab .910719
Sample account number :4273-767000-1
Laboratory comments :LARGE PRESENCE OF OIL

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	43.	mg/L
70300	Filterable Residue	230.	mg/L
00556	Oil and Grease in Water	1500.	mg/L
00945	Sulfate in Water	27.	mg/L
01105	Aluminum, Total in Water	500.	ug/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	40.	ug/L
01022	Boron, Total in Water	50.	ug/L
01027	Cadmium, Total in Water	0.6	ug/L
00916	Calcium, Total in Water	30.	mg/L
01034	Chromium, Total in Water	< 1.	ug/L
01042	Copper, Total in Water	40.	ug/L
01045	Iron, Total in Water	880.	ug/L
01051	Lead, Total in Water	26.	ug/L
00927	Magnesium, Tot in Water	4.9	mg/L
01055	Manganese, Tot in Water	100.	ug/L
01067	Nickel, Total in Water	4.	ug/L
01147	Selenium, Total in Water	2.	ug/L
01092	Zinc, Total in Water	40.	ug/L
46570	Ca and Mg Hardness Calc	95	mg/L CaCO3

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Lab Sample Number :91/13972 Project Leader :Carmen L. Keane

Sample ID Information :CUF-10 OILY LAYER Station Sump Dup.
Sample comments :CUMBERLAND FOSSIL PLANT
Sample type/matrix :WATER - ASH POND
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910722 Sample received by lab .910719
Sample account number :4273-767000-1
Laboratory comments :1gOIL SEP FROM WAT&ANALYZ

Alt. IDC	Analysis Performed	result	units
01108	Aluminum, Total in Sed	73.	mg/Kg
01003	Arsenic, Tot in Sediment	< 2.5	mg/Kg
01008	Barium, Tot in Sediment	< 0.25	mg/Kg
01023	Boron, Total in Sediment	14.	mg/Kg
01028	Cadmium, Tot in Sediment	0.38	mg/Kg
00917	Calcium, Tot in Sediment	70.	mg/Kg
01029	Chromium, Total in Sed	4.2	mg/Kg
01043	Copper, Tot in Sediment	2.8	mg/Kg
01170	Iron, Total in Sediment	14	mg/Kg
01052	Lead, Total in Sediment	3.8	mg/Kg
00924	Magnesium, Total in Sed	19.	mg/Kg
01053	Manganese, Total in Sed	6.2	mg/Kg
01068	Nickel, Tot in Sediment	5.8	mg/Kg
01148	Selenium, Total in Sed	< 2.5	mg/Kg
01093	Zinc, Total in Sediment	2.2	mg/Kg

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Lab Sample Number :91/13815 Project Leader :Carmen L. Keane

Sample comments :CUMBERLAND FOSSIL PLANT CUF-11
Sample type/matrix :WATER - ASH POND DI Composite
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719 Sample received by lab :910719
Sample account number :4273-767000-1
Laboratory comments :STRONG AMMONIA ODOR

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	370.	mg/L
70300	Filterable Residue	11000.	mg/L
00556	Oil and Grease in Water	< 5.	mg/L
00945	Sulfate in Water	6600.	mg/L
01105	Aluminum, Total in Water	760.	ug/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	110.	ug/L
01022	Boron, Total in Water	110.	ug/L
01027	Cadmium, Total in Water	1.2	ug/L
00916	Calcium, Total in Water	92.	mg/L
01034	Chromium, Total in Water	38	ug/L
01042	Copper, Total in Water	1700.	ug/L
01045	Iron, Total in Water	6000	ug/L
01051	Lead, Total in Water	< 1.	ug/L
00927	Magnesium, Tot in Water	17.	mg/L
01055	Manganese, Tot in Water	250.	ug/L
01067	Nickel, Total in Water	250	ug/L
01147	Selenium, Total in Water	240	ug/L
01092	Zinc, Total in Water	40.	ug/L
46570	Ca and Mg Hardness Calc.	300	mg/L CaCO3
00610	Ammonia Nitrogen	390	mg/L
00929	Sodium, Total in Water	3500.	mg/L
00403	pH value	12.1	pH Units

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Lab Sample Number :91/13816 Project Leader :Carmen L. Keane

Sample comments :CUMBERLAND FOSSIL PLANT CUF-12
Sample type/matrix :WATER - ASH POND DI Ammonia Wash
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910719 Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00610	Ammonia Nitrogen	120.	mg/L

Lab Sample Number :91/14102   Project Leader :Carmen L. Keane

Sample ID Information :CUF-13 COMPOSITE
Sample comments :CUMBERLAND FOSSIL PLANT
Sample type/matrix :WATER - ASH POND
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910723   Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	220.	mg/L
70300	Filterable Residue	1200.	mg/L
00945	Sulfate in Water	720.	mg/L
00410	Total Alkalinity	310	mg/L
01002	Arsenic, Total in Water	2.	ug/L
01007	Barium, Total in Water	30.	ug/L
01022	Boron, Total in Water	< 50	ug/L
01034	Chromium, Total in Water	13.	ug/L
01051	Lead, Total in Water	11.	ug/L
01067	Nickel, Total in Water	25.	ug/L
01147	Selenium, Total in Water	12.	ug/L
01092	Zinc, Total in Water	80.	ug/L
01105	Aluminum, Total in Water	300.	ug/L
01045	Iron, Total in Water	1600.	ug/L
01055	Manganese, Tot in Water	110.	ug/L
01042	Copper, Total in Water	520.	ug/L
00916	Calcium, Total in Water	38	mg/L
00927	Magnesium, Tot in Water	6.9	mg/L
01027	Cadmium, Total in Water	0.6	ug/L
46570	Ca and Mg Hardness Calc	123.	mg/L CaCO3
00610	Ammonia Nitrogen	44.	mg/L
00929	Sodium, Total in Water	370	mg/L
00403	pH Value	9.7	pH Units

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Lab Sample Number :91/14103 Project Leader :Carmen L. Keane

Sample ID Information :CUF-14 COMPOSITE
Sample comments :CUMBERLAND FOSSIL PLANT
Sample type/matrix .WATER - ASH POND
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910723 Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	100.	mg/L
70300	Filterable Residue	640.	mg/L
00945	Sulfate in Water	390.	mg/L
00410	Total Alkalinity	88	mg/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	30.	ug/L
01022	Boron, Total in Water	940.	ug/L
01034	Chromium, Total in Water	2.	ug/L
01051	Lead, Total in Water	2	ug/L
01067	Nickel, Total in Water	10.	ug/L
01147	Selenium, Total in Water	5.	ug/L
01092	Zinc, Total in Water	20.	ug/L
01105	Aluminum, Total in Water	160.	ug/L
01045	Iron, Total in Water	920.	ug/L
01055	Manganese, Tot in Water	13.	ug/L
01042	Copper, Total in Water	160.	ug/L
00916	Calcium, Total in Water	87.	mg/L
00927	Magnesium, Tot in Water	8 7	mg/L
01027	Cadmium, Total in Water	< 0.1	ug/L
46570	Ca and Mg Hardness Calc.	253.	mg/L CaCO3
00610	Ammonia Nitrogen	13.	mg/L
00929	Sodium, Total in Water	140	mg/L
00403	pH value	9.0	pH Units

Lab Sample Number :91/14104 Project Leader :Carmen L. Keane

Sample ID Information :CUF-15 COMPOSITE
Sample comments :CUMBERLAND FOSSIL PLANT
Sample type/matrix :WATER - ASH POND
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910723 Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	24.	mg/L
70300	Filterable Residue	210.	mg/L
00945	Sulfate in Water	75.	mg/L
00410	Total Alkalinity	90	mg/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	50.	ug/L
01022	Boron, Total in Water	150.	ug/L
01034	Chromium, Total in Water	6.	ug/L
01051	Lead, Total in Water	2.	ug/L
01067	Nickel, Total in Water	4.	ug/L
01147	Selenium, Total in Water	3.	ug/L
01092	Zinc, Total in Water	< 10.	ug/L
01027	Cadmium, Total in Water	< 0.1	ug/L
01045	Iron, Total in Water	1100.	ug/L
01055	Manganese, Tot in Water	27.	ug/L
00927	Magnesium, Tot in Water	5.2	mg/L
00916	Calcium, Total in Water	40.	mg/L
01042	Copper, Total in Water	20	ug/L
01105	Aluminum, Total in Water	560	ug/L
46570	Ca and Mg Hardness Calc.	121.	mg/L CaCO3
00610	Ammonia Nitrogen	2.1	mg/L
00929	Sodium, Total in Water	12	mg/L
00403	pH value	9.0	pH Units

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Lab Sample Number :91/14105 — Project Leader :Carmen L. Keane

Sample ID Information :CUF-16 COMPOSITE
Sample comments :CUMBERLAND FOSSIL PLANT
Sample type/matrix :WATER - ASH POND
Sample collected by :CHARLIE MCENTYRE
Sample collection date :910718
Sample login date :910723 — Sample received by lab :910719
Sample account number :4273-767000-1

Alt. IDC	Analysis Performed	result	units
00530	Non-Filterable Residue	18.	mg/L
70300	Filterable Residue -	210.	mg/L
00945	Sulfate in Water	100.	mg/L
00410	Total Alkalinity	90	mg/L
01002	Arsenic, Total in Water	< 1.	ug/L
01007	Barium, Total in Water	70.	ug/L
01022	Boron, Total in Water	260.	ug/L
01034	Chromium, Total in Water	3.	ug/L
01051	Lead, Total in Water	< 1.	ug/L
01067	Nickel, Total in Water	3	ug/L
01147	Selenium, Total in Water	2.	ug/L
01092	Zinc, Total in Water	< 10	ug/L
01027	Cadmium, Total in Water	0.1	ug/L
01045	Iron, Total in Water	1000.	ug/L
01055	Manganese, Tot in Water	50.	ug/L
00927	Magnesium, Tot in Water	5.6	mg/L
00916	Calcium, Total in Water	45	mg/L
01042	Copper, Total in Water	10	ug/L
01105	Aluminum, Total in Water	410.	ug/L
46570	Ca and Mg Hardness Calc.	135.	mg/L CaCO3
00610	Ammonia Nitrogen	2.1	mg/L
00929	Sodium, Total in Water	22.	mg/L
00403	pH value	8.8	pH Units

Appendix IV

Wetlands and Protected Species Survey and

Followup Protected Plant Survey – Site 10

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

11 April 1990

Mr. Jim Niehoff
Law Engineering
396 Plasters Avenue
Atlanta, Georgia 30324

Dear Mr. Niehoff:

Subject: **Wetland Determination and Protected Species Survey**
Tennessee Valley Authority
Montgomery County, Tennessee
Law Environmental Project No. 55-1551

Law Environmental is pleased to submit this report to Law Engineering regarding the jurisdictional wetland determination and preliminary protected species survey conducted on the proposed scrubber sludge facility site near Cumberland City, Tennessee. This report documents the methodology used to determine the extent of jurisdictional wetlands and to assess potential habitat for protected species, and the subsequent results of our investigations.

BACKGROUND

It is our understanding that Law Engineering was contracted by Tennessee Valley Authority (TVA) to conduct preliminary work on site suitability for a proposed scrubber sludge facility site in Montgomery County, Tennessee. The subject site consists of approximately 350 acres located south of Tennessee Highway 149 and west of Yellow Creek.

Mr. Harwell E. Coale, Ecologist and Mr. Haynes E. Currie, Botanist, with Law Environmental, visited the subject site on 28 and 29 March 1991 to determine the extent of jurisdictional wetlands, and identify potential protected species habitat.

METHODS

Jurisdictional Wetlands

Jurisdictional wetlands are defined by 33 CFR Part 328.3(b) and are protected by Section 404 of the Clean Water Act (33 USC 1344), which is administered and enforced by the

U.S. Army Corps of Engineers (USACE). Data obtained during the site visit was supplemented by evaluations of the U.S. Geological Survey (USGS) 7.5 minute quadrangle Needmore, Tennessee topographic map, U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) Montgomery, County soil survey maps, and NHAP false-color infrared aerial photography prepared by the USGS, EROS Data Center.

Wetlands depicted by these resources were evaluated in the field using the Routine On-site Determination Method described as defined in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands[1]. This multi-parameter approach requires positive evidence of three criteria.

- Hydrophytic vegetation
- Hydric soil
- Wetland hydrology

Areas exhibiting evidence of all three of the above criteria were classified as jurisdictional wetlands.

Protected Species

Protected species are plants and animals classified as endangered or threatened by the U.S. Fish and Wildlife Service (USFWS), the Tennessee Department of Conservation and Environment, or the Tennessee Wildlife Resources Agency. Species classified as endangered or threatened are protected as specified in the Federal Endangered Species Act of 1973 (16 USC 1531 to 1543), the Tennessee Rare Plant Protection and Conservation Act of 1985, and the Tennessee Non-game and Endangered or Threatened Wildlife Species Conservation Act of 1974.

An in-house literature and background review was conducted for protected species potentially occurring in Montgomery and adjacent Tennessee counties. This literature search included the review of Endangered and Threatened Species of the Southeast United States[2], and personal communications with the TVA Regional Heritage Program.

Following this literature review, a site reconnaissance was conducted to locate areas that

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[1]Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and USDA Soil Conservation Service, Washington, D.C. Cooperative Technical publication. 77 pp. plus appendices.

[2]U.S. Fish and Wildlife Service. 1989. Endangered and Threatened Species of the Southeastern United States. Region 4, Atlanta, Georgia.

may provide potential habitat for protected plant and animal species.

RESULTS

Jurisdictional Wetlands

Areas on the 350-acre site subject to Section 404 jurisdiction were identified in the field and consisted primarily of intermittent streams. The approximate locations of jurisdictional streams are depicted in Figure 1. Although intermittent streams were the only areas observed to be subject to Section 404 jurisdiction, there may be limited jurisdictional wetland areas associated with these streams in some places that were not detected during the preliminary pedestrian survey. Stream and wetland boundaries should be delineated in the field and verified by the USACE, Nashville District to determine the exact extent of Section 404 jurisdictional areas on the project site prior to final planning and site development.

Protected Species

Plants

Many of the north-facing slopes on the project site support mature eastern deciduous forests. The dominant tree species observed in these sites were American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), yellow-poplar (*Liriodendron tulipifera*), white oak (*Quercus alba*), Northern red oak (*Quercus rubra*), and hickories (*Carya* spp.). Common understory trees include hop-hornbeam (*Ostrya virginiana*), sourwood (*Oxydendrum arboreum*), and redbud (*Cercis canadensis*). A common shrub species observed in these habitats was spicebush (*Lindera benzoin*). The observed herbaceous layer was abundant and highly diverse. Common herbaceous plants identifiable in early spring were prairie trillium (*Trillium recurvatum*), pennywort (*Obolaria virginica*), hound's tongue (*Cynoglossum* spp.), sedges (*Carex* spp.), toothwort (*Dentaria* spp.), May-apple (*Podophyllum peltatum*), Solomon's seal (*Polygonatum* spp.), meadow rue (*Thalictrum thalictroides*), creeping phlox (*Phlox stolonifera*), chickweed (*Stellaria media*), agrimony (*Agrimonia* spp.), and doll's eye (*Actaea pachypoda*).

Two state-threatened plant species, golden seal (*Hydrastis canadensis*) and Wyandote beauty (*Synandra hispidula*) are known to occur near the subject site. North-facing mixed-mesic hardwood forest occurs on the site and provides potential habitat for these two plant species (Figure 1). Neither of these plant species would have been detectable during the onsite visit 28-29 March 1991; however, both species are readily detectable during their flowering periods during early May. A follow-up site visit during this time is recommended to check for the presence of these species.

Animals

The TVA Regional Heritage Program indicated the presence of two federally-listed animals, the gray bat (*Myotis grisescens*) and the Indiana bat (*Myotis sodalis*) in the area near the project site. These species generally are associated with cave habitat; however, no caves were observed during the on-site pedestrian survey. Therefore, development of the project site is not expected to negatively impact these two species.

RECOMMENDATIONS

Jurisdictional wetland boundaries should be field delineated and followed by a boundary verification by the USACE. After USACE verification, arrangements should be made to have a metes-and-bounds survey conducted on the wetland boundaries to accurately determine Section 404 permitting requirements.

A follow up protected species survey should be conducted in early May to determine the presence of the two threatened plant species mentioned above.

If you have any questions regarding this report, please do not hesitate contacting Mr. Harwell E. Coale III or Dr. Richard W. Whiteside at (404) 421-3400.

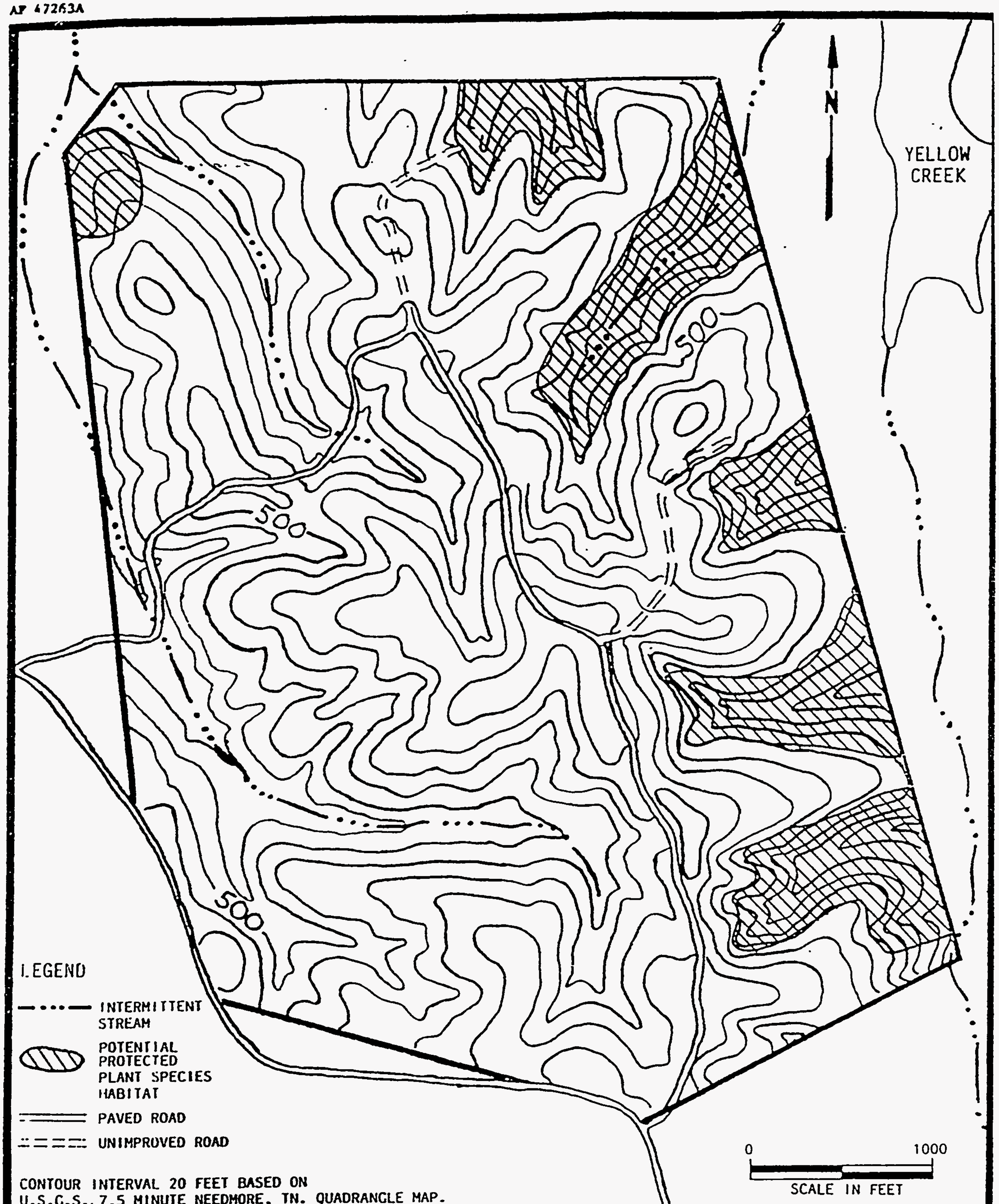
Sincerely,

Harwell E. Coale III
Ecologist

Richard W. Whiteside, Ph.D.
Principal Environmental Scientist

HEC/RWW

AF 47263A



TVA SITE MONTGOMERY COUNTY, TENNESSEE	LAW ENVIRONMENTAL INC.	JURISDICTIONAL STREAMS AND POTENTIAL PROTECTED PLANT SPECIES HABITAT JOB NO. 55-1551 FIGURE 1

LAW ENVIRONMENTAL, INC.

112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

5 July 1991

Mr. Jim Niehoff
Law Engineering
396 Plasters Avenue
Atlanta, Georgia 30324

Dear Mr. Niehoff:

Subject: **Follow-up Protected Plant Survey**
Tennessee Valley Authority
Montgomery County, Tennessee
Law Environmental Project No. 55-1551

Law Environmental is pleased to submit this report to Law Engineering regarding the follow-up protected plant survey conducted on the proposed scrubber sludge facility site near Cumberland City, Tennessee.

During our preliminary protected species survey, as reported on 11 April 1991, potential habitat was found on the project site for two plant species, golden seal (*Hydrastis canadensis*) and Wyandote beauty (*Synandra hispidula*). These species are listed as threatened by the State of Tennessee. As neither of these species was detectable during our 28 and 29 March 1991 survey, we recommended a follow-up survey be conducted later in the season to better determine whether these species are present within the project boundaries.

At your request, Mr. Haynes E. Currie, Project Botanist, revisited the site on 1 July 1991 to conduct a pedestrian survey for these two plant species. No individuals of either of these two species were detected on the proposed project site during this follow-up visit. Therefore, we do not expect that this project will impact either of these two species or any other federal or state protected species.

Law Environmental appreciates the opportunity to conduct this most important work for Law Engineering. If you have any questions concerning this follow-up survey, please contact Mr. Haynes E. Curric or Dr. Richard W. Whiteside at (404) 421-3400.

Sincerely,

for Haynes E. Currie
Project Botanist

Richard W. Whiteside, Ph.D.
Principal Environmental Scientist

HEC:RWW/bjp