FINAL REPORT

PHASE I GROUNDWATER MONITORING WORKPLAN

September, 1995

Prepared for
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El Dorado, Arkansas

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1.0 INTRODUCTION

In compliance with the terms of Consent Administrative Order (CAO) LIS-95070, El Dorado Chemical Company (EDC) submits this Groundwater Monitoring Work Plan (GWMP). As stipulated in Paragraph 18 of the Order and Agreement of the CAO, EDC is to submit the GWMP no later than 90 days from the effective date of the CAO. The CAO became effective on June 9, 1995. Therefore, this GWMP is submitted within the 90 day time frame.

This GWMP addresses the following potentially affected areas of the EDC facility:

- Process Wastewater Treatment System (PWTS) including,
- Lake Lee,
- Lake Kildeer,
- Plant Drain System;
- Nitric Acid Concentrator area; and
- Product Loading and Unloading areas.

These areas are suspected to be potential sources of release for the following constituents:

- Nitrate;
- Sulfate;
- Lead; and
- Chromium.

Definition of the groundwater quality is proposed to be conducted in two phases. Phase I will consist of preliminary delineation of horizontal and vertical extent of potentially affected areas using direct-push technology and groundwater sampling and analysis. Additionally, groundwater quality in upgradient areas will be evaluated. Phase II will be designed based on the Phase I findings and will consist of construction of a groundwater monitoring network. A workplan will be prepared and submitted to the Water Division of the Arkansas Department of Pollution Control and Ecology (ADPC&E) prior to any Phase II field activities.

2.0
OBJECTIVES OF THE GROUNDWATER MONITORING PLAN

The principal objective of this GWMP is to assess groundwater quality with respect to nitrate, sulfate, lead, and chromium within the immediate proximity of the areas of concern (AOCs) as outlined in Paragraph 18 of the CAO. Preliminary delineation of the horizontal and vertical extent of any detected target constituents in these AOCs will be the focus of the Phase I investigation. The methods employed by the GWMP will enhance the understanding of hydrogeologic conditions and groundwater quality in the AOCs.

3.0
FACILITY DESCRIPTION

3.1 FACILITY LOCATION

The EDC Facility is located at 4500 North West Avenue in El Dorado, Union County, Arkansas. EDC's production and support facilities are near the center of an approximately 1,340 acre property consisting of 34 tracts. Approximately 150 acres are used for the actual plant operations (i.e. Production Area). The approximate center of the Production Area is located at Latitude 33° 15′ 53″ North, Longitude 94° 41′ 16″ West and are generally contained in the southeast 1/4 of Section 6 and the northeast 1/4 of Section 7, Township 17 South, Range 15 West. Figure 1 shows the location and approximate boundaries of the EDC property, the topography of the area, and area drainage patterns.

3.2 REGIONAL GEOLOGIC AND HYDROGEOLOGIC SETTING

The EDC facility lies within the Gulf Coastal Plain Province in southern Arkansas. Heath (1988) has broadly characterized this province as a relatively undissected low-lying plain underlain by complexly interbedded sands, silts, and clays which thicken progressively toward the coast and toward the Mississippi River. Sediments within the sequence are, for the most part, unconsolidated or non-lithified. The sediments range in age from Quaternary (youngest) to Triassic. The sediments occur as continuous, distinguishable units across most of the Gulf Coastal Plain Province.

Structurally, depositional dip was basinward in a generally southern to southeasterly direction. Growth fault development at depth enhances the basinward dip of the sediment accumulations across the region. A graben structure (a down-thrown faulted block of sediments) is located approximately seven miles south of the facility. The fault planes which form the graben strike northwest-southeast.

Table 1 shows the age relationships of the various formations found in the subsurface of the region. Also shown are the approximate thicknesses of the formations and descriptions of the lithologic character of the sediments.

Broom, et. al. (1984) have characterized the regional hydrogeology in a study of salt water contamination of groundwater in Union County, Arkansas. The regional hydrogeologic description presented here is based largely on their work. Additionally, two studies

(Fitzpatrick, et. al., 1990 and McWreath, et. al., 1991) which simulated the response to pumping stresses in the Sparta Sands are also cited in description of the regional hydrogeologic setting. The major regional aquifers and confining units of the region are presented in Figure 2. The following discussions are limited to the principal aquifers used for potable water supplies within the immediate vicinity of the study area: the Cockfield aquifer, the Greensand aquifer, and the El Dorado aquifer.

3.2.1 Cockfield Aquifer

The Tertiary-aged Cockfield formation (part of the Claiborne Group) crops out over most of Union County. This formation consists predominantly of sands, silts, and carbonaceous (calcitic) clays with minor amounts of interbedded lignite and gypsum. The formation can contain lenticular beds of lignitic sands in some areas. The formation thickness is approximately 200 feet in most of the county. A thin veneer of quaternary-aged alluvial sediments overlay the Cockfield formation along the Ouachita River and its tributaries.

Recharge to the Cockfield aquifer is local. Groundwater occurs under water table, or unconfined, conditions; however, locally semi-confined conditions have been demonstrated to exist in areas where the clay content of the sediments is high. Water table configuration within the aquifer generally exhibits a subdued reflection of the local topography with flow toward surface drains (i.e., the valleys of the principal streams).

Water levels in wells range in depth from near land surface in low-lying areas to as much as 50 feet on the largest hills and ridges. Discharge is primarily base flow to streams with lesser amounts of evapotranspiration.

Falling head tests on undisturbed samples collected from the Cockfield formation revealed coefficient of vertical permeability values ranging from 1.0×10^{-3} cm/sec for sandy materials to 5.0×10^{-8} cm/sec for the more clay rich sediments. This wide range of permeability values is the result of the variable character of the sediments. Lithologic investigations have shown that the Cockfield formation is highly variable in clay content with some areas being predominantly clay and other areas being predominantly sand. Subsequently, the horizontal hydraulic conductivity of the aquifer, when considered as a whole, should be expected to be greater than the aquifer's vertical hydraulic conductivity. Areas of high clay content tend to perch groundwater on a local scale. Further, clay horizons can generate conditions termed semi-confined when the clayey material overlies more permeable zones and hydrostatic head is driven by recharge areas at higher elevations.

Domestic use of groundwater from the Cockfield aquifer has decreased considerably in recent years. Prior to the 1920s, the Cockfield aquifer was the primary source of groundwater for both domestic and industrial use. Rural water supply systems developed in the late 1960s greatly reduced the number of wells producing from the Cockfield aquifer (Broom, et. al., 1984).

3.2.2 Cook Mountain Formation

The Cook Mountain formation underlies the Cockfield formation in all areas of the region except where the younger sediments have been removed by erosion. The formation consists of low permeability clays and silty clays with lesser amounts of very fine sands. The formation acts as a lower confining unit (aquitard) for the Cockfield aquifer and an upper confining unit for the underlying aquifer.

Thickness of the confining unit is variable from approximately 50 feet to as much as 200 feet across the region. In the vicinity of the EDC facility, the thickness of the clays comprising the confining unit is estimated to be between 75 and 100 feet (McWreath, et. al., 1991).

Vertical hydraulic conductivity of the confining unit was estimated by Fitzpatrick, et. al. (1990) to range from 1×10^{-7} cm/sec to 1×10^{-10} cm/sec. The estimates are based on the results of their calibrated regional finite-difference model. Horizontal hydraulic conductivity of the Cook Mountain confining unit was established by the calibrated model to be 3.18×10^{-9} cm/sec. Therefore, both the vertical and horizontal hydrologic flow components are retarded by this formation.

3.2.3 Sparta Sand

The Tertiary-aged Sparta Sand is the main source of municipal and industrial water supplies throughout the region. Heavy pumping stresses placed on the aquifer in the past decades have created large cones of depression within the potentiometric surface surrounding the pumping centers. One such cone of depression is centered around El Dorado, Arkansas. Large quantities of groundwater withdrawn from the aquifer have altered, and in some cases reversed, flow directions in the aquifer (McWreath, et. al., 1991).

The overall drawdown within the Sparta aquifer has reversed the pre-development trend of upward flow across the Cook Mountain confining unit to the younger sediments. Vertical hydraulic gradients between the near surface Cockfield aquifer and the Sparta aquifer have been reversed as a result of the historical pumpage. Leakage from the Cockfield aquifer is downward across the Cook Mountain confining unit and into the Sparta Sand (McWreath, et. al., 1991). McWreath, et. al.'s model estimated that between 0.05 to 0.1 inches of water per year leak vertically across the Cook Mountain confining unit and into the upper portion of the Sparta aquifer (Greensand Aquifer).

In Union County, the Sparta aquifer is hydrogeologically separated into three zones based on lithologic character and water production capacities. These zones, in descending order, are the Greensand aquifer, the Sparta Sand confining bed, and the El Dorado aquifer. The El Dorado aquifer is the most heavily used portion of this hydrostratigraphic sequence.

3.2.3.1 <u>Greensand Aquifer</u>

The Greensand aquifer occupies the upper portion of the Sparta Sand. The aquifer consists of fine-grained to very fine-grained glauconitic sands with lesser amounts of silts and clays. Groundwater within the aquifer is under confined conditions. Confining units are the Cook Mountain confining unit above and a clay-rich horizon of the Sparta Sand below.

The structural top of the aquifer in the vicinity of El Dorado ranges from mean sea level (msl) to 50 feet below msl, yet the potentiometric surface in tightly cased wells can rise as high as 100 feet above msl in some areas. The aquifer thickness in the Union County area is approximately 200 feet (Leidy and Taylor, 1992). The regional flow direction within the aquifer is south-southeast (Broom, et. al., 1984).

The Greensand aquifer is generally less productive than the deeper El Dorado aquifer. The aquifer is used as a potable water supply, but less extensively than the deeper, more productive aquifer.

Recharge to the aquifer is via precipitation and from streams flowing across areas of outcrop. To a lesser extent, the aquifer can receive recharge from leakage across confining beds when the vertical hydraulic gradient is toward the aquifer.

3.2.3.2 <u>Sparta Sand Confining Bed</u>

In separate investigations by Fitzpatrick, et. al (1990) and McWreath, et. al. (1991), the Sparta Sand has been treated as a single aquifer for the purposes of finite-difference modeling of the effects of pumping stresses. However, as stated by Broom, et. al. (1984), sufficient evidence exists to support the conceptualization that in Union County, Arkansas a predominantly marine clay horizon in the middle portion of the Sparta Sand serves as a confining unit. Hydraulic conductivity, both horizontal and vertical, is low in comparison to the overlying and underlying sediments. This zone serves as a confining bed between the upper and lower portions of the Sparta Sand and allows them to function separately as individual aquifers. McWreath, Nelson, and Fitzpatrick (1991) support the designation of this clay horizon as a confining unit on a local scale. The confining bed is between 50 and 150 feet thick in the Union County subsurface. (McWreath, et. al., 1991).

3.2.3.3 El Dorado Aquifer

The El Dorado aquifer is more productive and, thus, more heavily targeted for placement of high yield wells. Both the City of El Dorado, EDC , and other industries have wells completed in this aquifer.

The structural top of the aquifer in the vicinity of the EDC facility is approximately 350 feet below msl. Thickness of the aquifer in this area is approximately 200 feet (Broom, et. al., 1984).

3.3 AREAS OF POTENTIAL CONCERN

In September, 1992, the Superfund Branch of the Hazardous Waste Division of the ADPC&E conducted a preliminary assessment of the EDC facility. The investigation was completed under the authority of CERCLA and SARA with the overall objective of determining if additional CERCLA/SARA actions at the facility are warranted.

An on-site and off-site reconnaissance were completed by the ADPC&E on September 9 - 10, 1992. A report of the preliminary assessment was issued by the ADPC&E on September 30, 1992 and later revised on October 27, 1992. Based on the findings of the preliminary assessment, the ADPC&E identified the plant's wastewater treatment system and Lake Lee as potential areas of concern.

In March of 1994, a multi-media inspection (MMI) of the EDC facility was conducted by the ADPC&E. As part of the MMI, personnel from the Water Division of the ADPC&E conducted an inspection of the process wastewater treatment system and the EDC facility in general. The inspection included a groundwater monitoring data review which revealed that nitrate in groundwater had been detected at levels greater than the maximum contaminant level (MCL). Also, sulfate had been detected at levels greater than the secondary MCL (SMCL). The MCL and SMCL for nitrate and sulfate are 10 ppm and 250 ppm, respectively (EPA, 1993).

On March 29, 1994, Water Division personnel reported the findings of the inspection and recommendations for actions to be taken by EDC. This information was detailed in a memorandum to the enforcement coordinator (Mr. Harry Elliott) of the MMI task force.

Based on the findings of the September, 1992 preliminary assessment and the March, 1994 MMI, a CAO was negotiated between EDC and the ADPC&E. Paragraph 18 of the Order and Agreement specifically cited the following to be potential AOCs with respect to groundwater quality:

- Process Wastewater Treatment System (PWTS) including,
- Lake Lee,
- Lake Kildeer,
- Plant Drain System;
- Nitric Acid Concentrator area; and
- Product Loading and Unloading areas.

The AOCs addressed in the CAO are suspected to be potential sources of release for nitrate, sulfate, lead, and chromium. The following discussion gives a brief overview and description of these areas.

The plant drainage system is comprised of four components:

- Discharges from the PWTS through NPDES Outfall 001;
- Discharges of stormwater/wastewater under heavy rainfall conditions through NPDES Outfall 002;
- Discharges of effluent from the sanitary sewer collection and treatment system through NPDES Outfall 003, and
- Discharges of stormwater collected around the ammonium nitrate manufacturing and loading/unloading areas through NPDES Outfall 004.

The PWTS receives flows from the following equipment within the EDC's facility's production area:

- Three weak nitric acid plants;
- Two ammonium nitrate plants;
- One sulfuric acid plant;
- One natural gas fired boiler;

- One nitric acid concentrator; and
- One strong nitric acid plant with associated oxygen plant.

A schematic showing the arrangement of the plant drainage and discharge (including the PWTS) is given as Figure 3. Figure 3 also shows the sanitary sewer treatment system and the NPDES regulated stormwater discharge outfalls.

NPDES Outfall 001 discharges the processed wastewater and stormwater from EDC's acid manufacturing and ammonium nitrate manufacturing operations. Inlets to the system receive flows released continuously from cooling towers, boiler blowdowns, and manufacturing areas where there is potential for spills (both indoor and outdoor). Flows enter the process sewer system and flow by gravity to a pumping station located on the south side of the acid manufacturing area. At this point, the wastewater is pumped from a stainless steel collection basin and into a limestone ($CaCO_3$) neutralization basin. Flow from the neutralization basin is via gravity into Lake Lee (also referred to as the day pond). Lake Lee is a one-acre pond equipped with one aerator. Under high rainfall conditions, wastewater mixed with stormwater from the acid manufacturing area can bypass the neutralization pit and flow directly to Lake Lee. Lake Lee also receives direct flow from the ammonium nitrate plants, boiler blowdown, and zeolite regeneration backwash. These three sources are mixed by the aerator in Lake Lee.

From Lake Lee, flow is directed through a pipe to Lake Kildeer in the south-central portion of the EDC property. Lake Kildeer is a fifty-acre (±) finishing treatment pond which allows retention time for biological treatment. Discharge from Lake Kildeer is via Outfall 001 to an unnamed tributary of Haynes Creek.

Normally, all stormwater flows are treated with the process wastewater; however, when stormwater volumes exceed the capacity of the pipe from Lake Lee to Lake Kildeer, the excess flow is directed through an overflow pipe from Lake Lee and is discharged through Outfall 002 into the tributary of Haynes Creek. This overflow pipe is necessary for levee protection for Lake Lee.

Sanitary wastewater is collected and treated by a separate system at the EDC facility. The wastewater is collected and transferred via gravity flow to an Imhoff sanitary treatment plant located approximately ¼ mile south of the manufacturing area. After treatment, effluent is discharged to the unnamed tributary of Haynes Creek at a location downstream of the other outfalls.

Stormwater which falls in the vicinity of ammonium nitrate manufacturing and loading/unloading areas is collected in storm sewers and is directed to an 18" diameter polyethylene sewer pipe which carries the flow along the western and southern sides of the production area. Discharge from this pipe is directly to Lake Lee. The water is aerated prior to discharge to Lake Kildeer. When runoff exceeds the capacity of this system, overflow is directed through Outfall 004 and into the unnamed tributary of Haynes Creek.

Figure 4 shows the location of the following:

- Nitric Acid Concentrator area;
- Loading and Unloading areas;
- Lake Lee;
- Lake Kildeer; and
- the unnamed tributary of Haynes Creek.

4.0
PROPOSED GROUNDWATER INVESTIGATION

Definition of groundwater quality conditions in the AOCs at the EDC facility is proposed to be conducted in a phased approach. Phase I of the investigation will consist of a strategic implementation of direct-push and sampling technology targeted at the principal AOCs. Additionally, this technology will be used in unaffected, upgradient areas to establish background concentrations of the target constituents.

Based on the groundwater elevation and groundwater quality data obtained during Phase I, a groundwater monitoring network will be designed and implemented at the facility during Phase II. The monitoring well network will consist of two-inch diameter PVC monitoring wells. Construction of the wells will be in conformance with ASTM methodology and placement of the wells will be in conformance with applicable EPA technical guidance (EPA, 1992).

The Cockfield aquifer has been defined as the first water bearing zone that can be used as a source of potable groundwater. Accordingly, the Phase I investigation will focus on water quality conditions in this aquifer. The uppermost saturated zone within the Cockfield formation will be considered as part of the aquifer.

4.1 PREVIOUS ON-SITE INVESTIGATIONS

Five hydrogeologic investigations focused on shallow groundwater conditions have been completed at four locations at the EDC facility. Generally, these investigations confirm the information regarding shallow groundwater as given in the preceding discussion of regional geologic and hydrogeologic settings. The information obtained during these investigations has been used to facilitate planning this phased approach to development of a facility-wide groundwater monitoring network. The investigations are summarized below.

4.1.1 McClelland Engineers - 1980 Investigation

McClelland Engineers completed an investigation in the west-central portion of the EDC property. The investigation was conducted in December of 1980 (McClelland Engineers, 1980). The stated investigation objectives were to:

1. Determine general soil stratigraphy at the site in relation to groundwater characteristics;

2. Establish the thickness and character of the existing soil strata;

3. Establish the permeability of significant strata; and

4. Install wells for long-term monitoring of groundwater quality.

The study concluded that the landfill site was underlain by deposits of the Claiborne Group. At the site, the "upper approximately 10 to 15 feet consists of reworked alluvial deposits; whereas the underlying beds are relatively unaltered from the original depositional character." The cover over the burial area was found to range from 2 to 2.5 feet in thickness in four borings. The cover soils were reported to consist predominantly of gray and tan sandy clay with the percentage of sand varying from 6 to 37 percent.

At the site, "moderately variable stratigraphy and cross-bedding should be anticipated." In four widely spaced borings around the landfill site, McClelland noted significant variation in strata. The borings for monitor well installations were advanced by a combination of dry auger and wash-rotary drilling methods and were completed to depths ranging from 20 to 40 feet. The Plan of Borings (Plate 1 of the report) indicates that four borings, (i.e., B-A, B-B, B-C and B-D) were completed for monitor well installations. However, the text indicates that two additional borings, C-1 and C-2, were completed to different depths in proximity to boring B-C. The report contains boring logs for Borings A, B, C, and D but not for C-1 or C-2. Also, there are no monitor well installation diagrams or other information to indicate where and how the screens and casings were set in these wells. The annulus between the casing and the soil was reported to have been backfilled with a free-draining gravel.

Groundwater was encountered in the borings at depths ranging from 7.5 to 21 feet below ground surface (bgs). In each boring, the water level was observed to rise rapidly. The recorded amount of rise ranged from 3.5 feet (Boring C-2 completed to 10 feet total depth) to 16.5 feet (Boring B-C completed to 40 feet total depth). McClelland interpreted the water level information to represent, "a 'perched' condition rather than a major groundwater aquifer. However, to fully evaluate the groundwater hydrology, it would be necessary to obtain specific water well data in the area."

From the information presented, WC suggests that the groundwater encountered was in a confined or semi-confined unit(s) which may indeed be above the uppermost regional aquifer. However, these conclusions are preliminary. The water level information for Borings B-C, C-1 and C-2 are particularly difficult to interpret because of lack of topographical data. The water levels in B-C (completed at 40 feet total depth) and C-2 (completed at 10 feet total depth) both rose to 4.5 feet bgs. However, the water level in Boring C-1 (completed to 20 feet total depth) rose only to 14 feet bgs.

McClelland reported that the cover in the burial area apparently possesses vertical permeability values in the order of 1.0×10^{-7} to 1.0×10^{-6} cm/sec. The natural clays which are assumed to underlie the cover possess vertical permeabilities in the order of 5.0 to 10^{-7} to 1.0 to 10^{-8} cm/sec. WC infers from the McClelland report and general geologic conditions of the region that the clay layers may not be continuous across the entire area; the overall vertical permeability value for the area as a whole should not exceed approximately 1×10^{-7} to 5×10^{-7} cm/sec. In areas where sand interbedding is prevalent, the overall horizontal permeability value may locally approach 1.0×10^{-5} to 1.0×10^{-4} cm/sec.

4.1.2 McClelland Engineers - 1981a Investigation

McClelland Engineers (1981a) completed an investigation in the Lake Kildeer Area in June, 1981. The studies were conducted to provide the following:

- General subsurface stratigraphy and definition of the first aquifer;
- Determination of the degree of contamination, if any, of the first aquifer and soils resulting from seepage losses from the impoundment;
- An estimation of the seepage losses based on groundwater seepage analysis and a water balance for existing and proposed reservoir levels.

The study concluded that the site was underlain by deposits of the Claiborne Group. A total of 12 borings were completed with depths ranging from 18 to 100 feet bgs using a combination of dry auger and wash-rotary methods. Casagrande-type piezometers were installed in six of the borings (Borings A through F). These were reported to consist of 2-inch diameter closed-end PVC casing with a slotted screen tip approximately 3 to 4 feet in length. The annulus between the casing and the soil was backfilled with a graded, free-draining sand. Above the slotted screen, the annulus was sealed by placing a layer of bentonite pellets. The upper portion of the annulus was sealed with grout to prevent infiltration of surface water.

Six monitor wells were also installed in Borings 1, 2, 2A, 3, 4 and 5. The monitor wells were reportedly installed in a similar manner as the Casagrande piezometers. However, the wells incorporated 4-inch diameter casings, 5-foot slotted screen lengths and 2-foot sand traps. A plan of the borings, boring location coordinates, boring ground surface elevations and Boring Logs are presented in the report. Information on screen placement is indicated on the Boring Logs. According to the Plan of Borings:

- Piezometer F and Monitor Well 1 were completed in a former borrow area located adjacent to the north of the Lake;
- Piezometer A was completed near the northeast corner of the Lake;
- Piezometer E was completed north of the northern end of the dam;
- Piezometer D and Monitor Wells 2, 2A, and 5 were completed east and downstream of the dam;
- Piezometer C was completed south of the southern end of the dam;
- Monitor Well 3 was completed east of the accessory dike on the southern side of the Lake;
- Monitor Well 4 was completed near the end of the western end of the accessory dike on the southern side of the Lake; and
- Piezometer B was completed near the western end of the accessory dike on the southern side of the Lake.

McClelland divided the deposits encountered in these borings into three strata as follows:

> "STRATUM I: Stiff to very stiff tan and gray sandy clay (CL) was encountered at or near the ground surface over a portion of the site to depths of up to approximately 15 ft. The permeability of this stratum is estimated to be in the order of 1.0 x 10^{-7} centimeters per second.
>
> STRATUM II: Medium dense to dense gray clayey sand and silty sand (SC and SM) was encountered beneath Stratum I or at the ground surface over most of the site to depths of up to approximately 50 ft. The thickness of this stratum is greatest on the

south side of the Impoundment Pond and beneath the embankment (approximately 30 to 50 ft.) and least on the north and west sides of the pond (approximately 0 to 20 ft). Measured permeability values were found to vary widely over the range of 1.3×10^{-4} to 5.8×10^{-7} centimeters per second; and

STRATUM III: Laminated stiff to very stiff gray silty clay (CL and CH) and light gray fine sand (SM was encountered as the basal unit beneath Strata I and II). This stratum was encountered generally below EL 160 to 170 on the northwest sides of the impoundment, below EL 130 on the south side and below EL 90 to 100 in the valley bottom below the dam. Measured permeabilities range from 9.5×10^{-5} to 7.0×10^{-9} centimeters per second. Vertical permeabilities are substantially less than horizontal permeabilities in this laminated zone."

It is not clear from the report whether the Strata described above should be treated as one or more water bearing zones. The wells and piezometers have their screens set in Stratum II (Wells, 1, 3, 4 and 5 and Piezometers B, C and D) and in Stratum III (Well 2 and Piezometers A, E and F). Well 2A is apparently screened in shallow fill material. Also, two borings were overdrilled with respect to where the piezometer or well screens were set. Well 4 was drilled to 60 feet bgs and its screen was set at 27 feet bgs. Similarly, Piezometer C was drilled to 100 feet bgs and its screen was set at 38 feet bgs. There are no details in the report concerning how the deeper portions of these borings were filled before the piezometer and well were set.

McClelland concluded that regional groundwater flow in the first aquifer was from the north-northwest to the south-southeast.

Chemical analytical data for soil or groundwater samples were not included in the report obtained by WC. McClelland concluded, based on this data, that, "little if any contamination of either the soil or groundwater was evidenced in the chemical analyses."

Based on seepage analyses and a water balance, McClelland estimated that underseepage losses from Lake Kildeer range from 300 gallons per day with a lake surface elevation of 165 feet above mean sea level (msl) to 700 gallons per day with a lake water surface elevation of 175 above msl. Details of the seepage loss estimates are not provided in the report but it is noted that, "considerably higher or lower seepage quantities could actually be experienced."

WC anticipates that the seepage losses from Lake Kildeer will substantially alter the configuration of water table contours in the immediate vicinity of the impoundment. A "mounding" effect may be observed in this area, particularly when the lake surface elevation is high and seepage is anticipated to be at a maximum.

4.1.3 McClelland Engineers - 1981b Investigation

McClelland Engineers (1981b) completed an investigation of the Lake Lee area in November, 1981. The report noted, "Since no subsurface investigation was conducted prior to construction of the collection pond, the question has arisen as to potential contamination of the 'uppermost aquifer'." The objective of this investigation was to address that potential.

Four borings were completed to depths ranging from 40 to 60 feet using a combination of dry auger and wash-rotary methods. The boring locations were selected to provide three downgradient (Borings 1, 2 and 3) and one upgradient (Boring 4) locations. The report does not indicate that monitor wells were installed. Monsanto Company representatives collected water samples immediately on the first encounter of water in each boring. These water samples were tested for pH, sulfate, nitrate-nitrogen and ammonia-nitrogen. A variable head aquifer test was also performed on Boring 3.

The report concluded that Lake Lee was underlain at depth by deposits of the Claiborne Group. These were encountered at elevations below 162 to 164 feet above msl within the pond area and below 147 feet above msl downstream of the pond. Fill or alluvium was encountered above the Claiborne deposits. McClelland divided the deposits encountered in these borings into four strata as follows:

> "Stratum I: Fill consisting of very stiff to firm tan gray and brown sandy clay (CL) with some gravel encountered at the ground surface to depths of 5 to 17 feet (generally to EL 166 to 170 within the pond area). The mass permeability of this stratum is in the order of 7×10^{-7} to 5×10^{-8} cm per second;
>
> Stratum II: Soft to stiff gray with tan sandy clay (CL) was encountered beneath the fill to depths of approximately 15 to 20 ft. This stratum contains some silty sand pockets and seams and consequently possesses a horizontal permeability in the order of 5.0×10^{-6} and 1×10^{-5} cm per second. This stratum represents geologically recent alluvial deposition;

Stratum III: Very stiff brown and dark gray clay (CL to CH) with light gray silt and fine sand partings and seams was encountered beneath the alluvial zone to the completion depths of 40 ft. in Borings 1, 2 and 4 and to a depth of 49 ft. in Boring 3. Numerous sand seams and layers were encountered below depths of 35 ft. in Boring 3 and 32.5 ft. in Boring 4. The mass vertical permeability of this stratum is in the order of 5×10^{-8} to 1×10^{-7} cm per second. In the deeper zone more frequent sand seams are encountered and the mass vertical permeability could approach 1×10^{-5} and 1×10^{-4} cm per second; and

Stratum IV: Dense light find sand (SN to SP) with occasional clayey seams was encountered beneath Stratum III in Boring 3 at a depth of 49 ft. The coefficient of permeability is estimated to be 1.0×10^{-3} cm per second for this sand stratum."

Static groundwater levels in the four borings ranged from 4 feet bgs in Boring 3 to 24.5 feet bgs in Boring 1. The groundwater flow direction roughly paralleled the ground surface and sloped downward towards the southeast. McClelland concluded that the water bearing zone encountered did not represent the uppermost aquifer. The uppermost aquifer was interpreted as being in the Stratum IV sands encountered below 115 msl.

The analyses of water samples from the four borings had sulfate in the range of 399 to 1020 mg/L, nitrate in the range of 3.2 to 66.2 mg/L, ammonia in the range of <1 to 27 mg/L and pH in the range of 4.3 to 5.6. From these values, McClelland concluded that "contamination of the shallow groundwater system is taking place." McClelland further concluded that this shallow groundwater most likely discharged by seepage into the nearby surface water drainage system. The amount of seepage discharge was estimated to be 5 to 15 gallons per day, although McClelland noted that there were many assumptions and considerable uncertainty in this estimate. McClelland also concluded that there was a low potential for the groundwater to migrate vertically through Stratum III and into the uppermost aquifer.

WC notes that water in the upgradient Boring 4 had a sulfate level (530 mg/L) at levels similar to the downgradient Borings 2 (399 mg/L) and 3 (650 mg/L). Also, no formal sampling and analyses plan was indicated, therefore making the data suspect.

In 1985, a second investigation was completed in the Lake Lee area. This investigation was undertaken in support of EDC's RCRA Part B Permit Application, which was subsequently withdrawn. A formal report of this investigation was not prepared; however, it was summarized and referenced in the Groundwater Protection section of the Part B Permit Application (EDC, 1986). The investigation involved borings and monitor well or piezometer installations by MCI Consulting Engineers, Inc. The information presented in borings logs is contradictory and WC has not interpreted subsurface conditions from these boring logs. The boring logs apparently have been used to also document installation of 1-inch diameter piezometers. It is not clear if these logs correlate in any way to the monitor wells.

However, there are installation diagrams for four monitoring wells around Lake Lee (Well IDs L-1 through L-4) installed in 1985 indicating that the monitor wells were constructed of 2-inch diameter threaded PVC riser pipe and PVC screen with 0.010-inch slot size. The total depth of the wells is 20 feet for Well L-2, L-3 and L-4 and 25 feet for Well L-1. The screens are reportedly 5 feet in length and the annular space between the screen and soil is backfilled with sand. A bentonite pellet seal was placed above the sand pack and the remainder of the boring was grouted with bentonite/cement grout. A potentiometric map which accompanies the logs and well installation diagrams indicates the groundwater flow direction is towards the northeast, which contradicts the information presented in the McClelland (1981b) report.

4.1.4 Grubbs, Garner & Hoskyn - 1992 Investigation

Grubbs, Garner & Hoskyn (1992) completed an investigation of the existing Class III Landfill in September, 1992. The primary purposes of this study were to define site stratigraphy and to determine groundwater depth and movement. Three borings were completed to depths ranging from 20 to 25 feet bgs using dry auger methods. Monitor wells were installed in each of the three borings. Monitor wells were constructed of 2-inch diameter PVC risers and screen with 0.010-inch machine cut slots. The annulus between the screen and soil was backfilled with 10/20 sand and a bentonite pellet seal was placed on top of the sand pack. The remaining annular space was then filled to near the ground surface with cement/bentonite grout. Well completion details are shown on the boring logs.

EDC personnel have stated that the Grubbs, Garner & Hoskyn (GGH) Report has the designations for Borings and Monitor Wells 1 and 3 reversed from EDC's understanding of the monitor well designations. Therefore, this report follows the monitor well designation understood by EDC. In direct quotes, WC will stay with the GGH report as written, but will insert the EDC designations in parentheses. In WC text, the wells will be designated so that Monitor Well 1 is located east of Landfill Area 1 and Monitor Well 3 is located south of Landfill Area 5.

The Class III Landfill site was found to be underlain by deposits of the Claiborne Group. Based on available mapping, GGH projected that the base of the Cockfield and the top of the

Cook Mountain Formation will be at a depth of about 100 feet bgs at the site; and that the thickness of the Cook Mountain clays is in the order of 150 to 200 feet at the EDC site. WC notes that other geologists investigating this area of Union County have estimated that the Cook Mountain clay is probably no more than 75 to 100 feet thick in the vicinity of the EDC plant site.

GGH summarized the stratigraphy encountered in borings at the site as follows:

> "Stratum I: Loose to medium-dense brown, tan and gray clayey silt and silty fine sand to fine sandy silt was encountered at the ground surface to depths of 2 to 4 ft.;
>
> Stratum II: Stiff to very stiff gray and yellowish tan clay and sandy clay with silty sand seams was encountered beneath Stratum I to depths of 13 to 20 ft. The more clayey portions of this stratum were found to possess vertical hydraulic conductivities in the range of 3×10^{-9} to 5×10^{-9} cm/sec. Due to the presence of intermittent sand seams, horizontal hydraulic conductivities are substantially greater than these recorded vertical conductivities;
>
> Stratum III: Medium dense to dense tan and gray silty fine sand was encountered beneath Stratum II in Monitoring Wells 2 and 3 (EDC Well 1) to the boring completion depths. Grain size analyses indicated hydraulic conductivities ranging from 4×10^{-4} to 8×10^{-4} cm/sec. Review of this and previous studies indicates that this sand stratum is present over most of the existing and old landfill sites; and
>
> Stratum IV: Very stiff, dark brown clay was encountered beneath Stratum III in Monitoring Well 1 (EDC Well 3) to the boring completion depth. A coefficient of permeability of 5×10^{-9} cm/sec was obtained. This clay stratum was also encountered in Boring 3 of the previous study. Apparently, this predominantly clay unit is confined to the northeastern portion of the existing landfill."

GGH provided a potentiometric surface map using groundwater elevation data obtained from the three recently installed wells at the Existing Landfill and groundwater elevation data from the four older wells installed at the old Monsanto Landfill. However, GGH noted that the groundwater elevations in Wells B-A and B-C-2 at the old landfill were considered to represent "perched" conditions in association with near surface sand units at those wells. Thus, groundwater surface elevations from these two wells were excluded in the preparation of the GGH potentiometric surface map.

The potentiometric surface map prepared by GGH indicates that shallow groundwater flow is generally to the southeast beneath the Monsanto Landfill and generally to the south beneath the existing Class III Landfill. WC notes that this flow direction is toward the valley of the unnamed tributary that crosses the EDC property on the south side of the Production Area.

WC notes that the groundwater monitoring network around the Class III landfill has been approved by the Solid Waste Division of the ADPC&E. Accordingly, this GWMP anticipates no further investigation in this area of the facility. This information has been presented here only to demonstrate the hydrogeologic conditions which may be encountered in various areas at the site.

4.2 PROPOSED METHODS OF INVESTIGATION

4.2.1 Well Point Program

A well point program will be utilized as the initial phase of the investigation. Well points will be installed using a Hydropunch. The Hydropunch consists of a direct-push sampling device mounted on an all terrain vehicle (ATV). An expendable aquifer sampling implant is pushed to the desired depth and a real-time water sample is collected. Groundwater levels are determined by using a digital manometer. The following discussion details equipment, materials and procedures employed by this investigative method.

Drilling equipment consists of a hydraulic, direct-push drill mounted on an ATV. Steel probe rods (1" outer diameter and 1/2" inner diameter) are hydraulically pushed and hammered to the desired depth with an expendable well point attached to the leading end of the probe rods. Upon achieving the desired depth, perforated 3/8" polyethylene tubing is placed down the inner circumference of the probe rods. Next, the polyethylene tubing is threaded into the expendable well point. With the well point acting as an anchor for the perforated tubing, the probe rods are uncoupled from the expendable well point and hydraulically removed from the ground.

If purgeable water is present, a section of 3/8" silicon tubing is attached to the polyethylene tubing and groundwater samples are withdrawn using a variable speed, peristaltic pump after three full well volumes have been purged, if possible.

If purgeable water is not present, a sand pack consisting of environmental grade 10/20 silica sand will be placed to one foot above the perforated section of the polyethylene tubing. After confirming the depth of the sand pack, the remainder of the borehole will be sealed using a granular bentonite seal. A section of 2" diameter Schedule 40 PVC surface casing will next be placed at the surface and grouted using a cement/powdered bentonite mixture. The polyethylene tubing will be sealed using laboratory grade film to avoid down-hole contamination. The temporary wells will be allowed to stand for a period of one to five days. Following this period, groundwater samples will be collected with a peristaltic pump as described above.

All reuseable down-hole equipment (i.e., probe rods, water level indicators, etc.) will be decontaminated prior to each use as follows:

- brush with mixture of potable water and non-phosphate soap;
- rinse with potable water;
- rinse with distilled water; and
- air dry.

4.2.2 Hydropunch Locations and Depths

Groundwater samples will be collected at the thirty-five hydropunch locations proposed on Figure 4. These locations have been selected based on the locations of the areas of concern described in the CAO. The locations shown on Figure 4 are approximate locations only. Actual locations may vary slightly due to accessibility restrictions caused by surface obstructions, subsurface obstructions, steep topography, or heavy vegetation.

Most of the AOCs cited in Paragraph 18 of the CAO are in close proximity to one another and are within a relatively small portion of the EDC facility. The PWTS, the nitric acid concentrator units, the loading and unloading areas, and most of the plant drainage system are located within the portion of the facility referred to as the production area. The AOCs are so closely spaced that their areas of influence actually overlap one another. WC proposes that thirteen groundwater sampling locations in this portion of the plant be placed along the periphery of the production area. The locations proposed on Figure 4 generally surround the production area and are reasonably close to the AOCs. The sampling locations shown will provide a good preliminary indication of groundwater quality conditions for the production area as a whole.

Due to the unknown locations of subsurface utilities and product transfer lines within the production area, health and safety risk factors for field personnel preclude the possibility of extensive hydropunch operations within this area. Four of the thirteen hydropunch locations of the production area have been shown inside the periphery sampling previously described.

These locations have been proposed based on preliminary determinations of subsurface infrastructure locations only. If absolute certainty pertaining to the locations of subsurface obstructions cannot be obtained at these locations, WC will not attempt to complete these borings. In that case, additional hydropunch locations would be selected around the periphery of the production area. Spacing of these locations will be sufficient to define shallow groundwater quality on a preliminary basis.

Ten locations have been proposed immediately adjacent to Lake Kildeer. These locations will be adequate to determine any potential impact that the impoundment has on the surrounding groundwater.

Three locations have been proposed in the area southeast of Lake Kildeer. Two of these locations are very near the topographic drainage channels. These three locations are proposed to help define the areal extent of any impacted groundwater in the vicinity of Lake Kildeer, if present. Groundwater flow in this area is expected to be to the southeast based on previous investigations (McClelland Engineers, 1981a).

Five locations have been proposed in the area between the production area and Lake Kildeer. Again, these locations are intended to help define the lateral extent of any detected constituents and to assist in determination of the groundwater flow pattern in this portion of the facility.

Four locations have been selected in an area along the northern portion of the EDC property. This area is expected to be upgradient from plant activities and, therefore, potentially unaffected by potential site releases. The groundwater data obtained from the four upgradient sites can be used to establish baseline values in natural groundwater for the constituents of concern and can be used to assist in determination if releases have occurred in the downgradient direction(s). These four hydropunch sites will be completed first to limit the possibility of cross-contamination of the upgradient, background sampling.

Depths of the installation are anticipated to be variable based on topographic elevations at the proposed hydropunch locations. Furthermore, the nature of the sediments within the Cockfield formation (and subsequently the saturated zones) can vary substantially in the horizontal direction. Based on literature review concerning the regional hydrogeology and on conditions encountered during previous hydrogeologic investigations conducted at the site, WC anticipates that saturated soils will be encountered at depths of thirty feet or less. Accordingly, the hydropunch installations will be completed at approximately this depth. If suitable groundwater samples cannot be obtained at this depth, additional installations will be constructed to greater depths. Also, installation of the expendable sampling points may be at shallower levels depending on subsurface conditions actually encountered.

4.2.3 Groundwater Level Measurements and Sample Collection

Measurements to the surface of the groundwater will be conducted after allowing sufficient time for stabilization of the potentiometric head and prior to purging and sampling. A wooden stake or metal rod will be driven into the ground adjacent to each boring location. Water level measurements will be referenced to the top of the wooden stakes/rods. Subsequent surveys of the sampling locations (as described below) will include determination of the elevations at the points of reference. Thus, preliminary determinations of groundwater elevations will be possible. Groundwater elevation data from the Phase I investigation will be used to assist in designing the Phase II groundwater monitoring well network.

If possible, existing shallow wells and piezometers will be used for collection of supplemental groundwater elevation data. Currently, there are installations in the west-central portion of the EDC property, near Lake Lee, and near Lake Kildeer. Although construction details for these installations are not precisely known, some useful information regarding groundwater elevations may be obtainable. Water level measurements and depth of wells will be recorded using a decontaminated water level indicator. Due to the lack of monitoring well construction diagrams, existing wells and piezometers will not be used for collection of groundwater samples.

Groundwater samples will be collected from each hydropunch location following measurement of the stabilized head. Samples will be collected from the temporary well points using a peristaltic pump as described above. Three full well volumes will be purged prior to collection of the samples. Samples will be collected in laboratory-supplied sample containers, preserved (as appropriate), labeled, and stored on ice for transport to the analytical laboratory. All samples will be documented in field notes. Strict chain-of-custody procedures will be employed at all times.

Blind field duplicate samples will be collected at a rate of one per twenty groundwater samples, or portion thereof (five percent minimum). At least one of the blind duplicates will be collected from the anticipated upgradient area; the remaining duplicates will be collected from downgradient locations. All duplicate samples will be handled and documented in the same manner as the other groundwater samples.

Two equipment rinsate samples will be collected during the course of the investigation. Equipment rinsate samples will be collected by pouring laboratory-supplied analyte-free water over and through decontaminated probe rods. The rinsate samples will be collected following completion of installations in the anticipated downgradient direction in areas which are suspected to contain detectable levels of the target constituents.

4.2.4 Laboratory Analyses

All samples will be analyzed for the following target constituents: nitrate plus nitrite (nitrate), sulfate, total lead, and total chromium.

Analytical methods, containers, preservatives and holding times are as follows:

- Nitrate - EPA 9200, 250 mL plastic, 4°C, 2 days
- Sulfate - EPA 9038, 250 mL plastic, 4°C, 28 days
- Lead - EPA 7421, 250 mL plastic, pH < 2.0 - $HN0_3$ and 4°C, 6 months
- Chromium - EPA 7190, 250 mL plastic, pH < 2.0 - HNO_3 and 4°C, 6 months

4.2.5 Monitoring Network Survey

Following completion of the sampling point installations, a survey will be conducted to establish horizontal and vertical locations of the sampling points. At a minimum, the survey will consist of the following:

- horizontal definition of all sampling points with respect to an established plant coordinate system;
- vertical definition of ground surface elevation (with respect to mean sea level) at each sampling location; and
- vertical definition of elevations of reference points (with respect to mean sea level) as established during groundwater level measurements.

Additionally, any existing wells or piezometers used for measurement of groundwater elevations will be included in the survey. The horizontal and vertical locations of points used to reference the measurements (typically the top of casing) will be established.

Survey activities will be conducted under the supervision of an Arkansas Registered Land Surveyor. A detailed plat showing the precise locations of the borings will be prepared by the surveyor.

4.2.6 Borehole Abandonment

Following completion of the survey, all temporary sampling points will abandoned by the following methods:

- remove any temporary 2" PVC surface casings;
- remove 3/8" polyethylene tubing; and
- grout boreholes to grade using portland cement and 3% to 5% powdered bentonite mixture.

4.3 PROPOSED PHASE I INVESTIGATION SCHEDULE

Upon approval of this Phase I Workplan by the ADPC&E, WC will initiate investigation activities. The estimated times required for the various tasks of this investigation are listed below:

- subcontractor notification, scheduling, and mobilization - 14 to 21 days
- boring completion and groundwater sampling - 7 to 9 days
- survey - 3 to 5 days
- sample analyses - 7 to 10 days
- analytical data review - 3 to 4 days
- draft report preparation - 14 to 21 days
- peer review - 3 to 5 days
- final report preparation and submittal - 5 to 7 days.

WC anticipates that the Phase I investigation can be completed within 12 weeks of the date the workplan is approved.

5.0
SUMMARY REPORT

Following the completion of the groundwater sampling activities described above, WC will prepare a summary report detailing field activities and analytical results. At a minimum, the report will consist of the following components:

- field investigation procedures and results;
- hydropunch well details;
- analytical data summary;
- groundwater elevation data summary;
- data evaluation;
- quality assurance and quality control data evaluation;
- conclusions; and
- recommendations for Phase II activities.

Phase II monitoring well installations will be based on the results of the Phase I investigation. The recommended number, location, and depth of installations will be detailed in the Summary Report. The recommendations presented in the Summary Report will contain details of the Phase II work and will be submitted as a Phase II workplan for approval by the ADPC&E.

6.0 REFERENCES

Broom, M.E., T.F. Kraemer and W.V. Bush (1984). A Reconnaissance Study of Saltwater Contamination in the El Dorado Aquifer, Union County, Arkansas. U.S. Geological Survey, Water-Resources Investigations Report 84-4012. 47 p.

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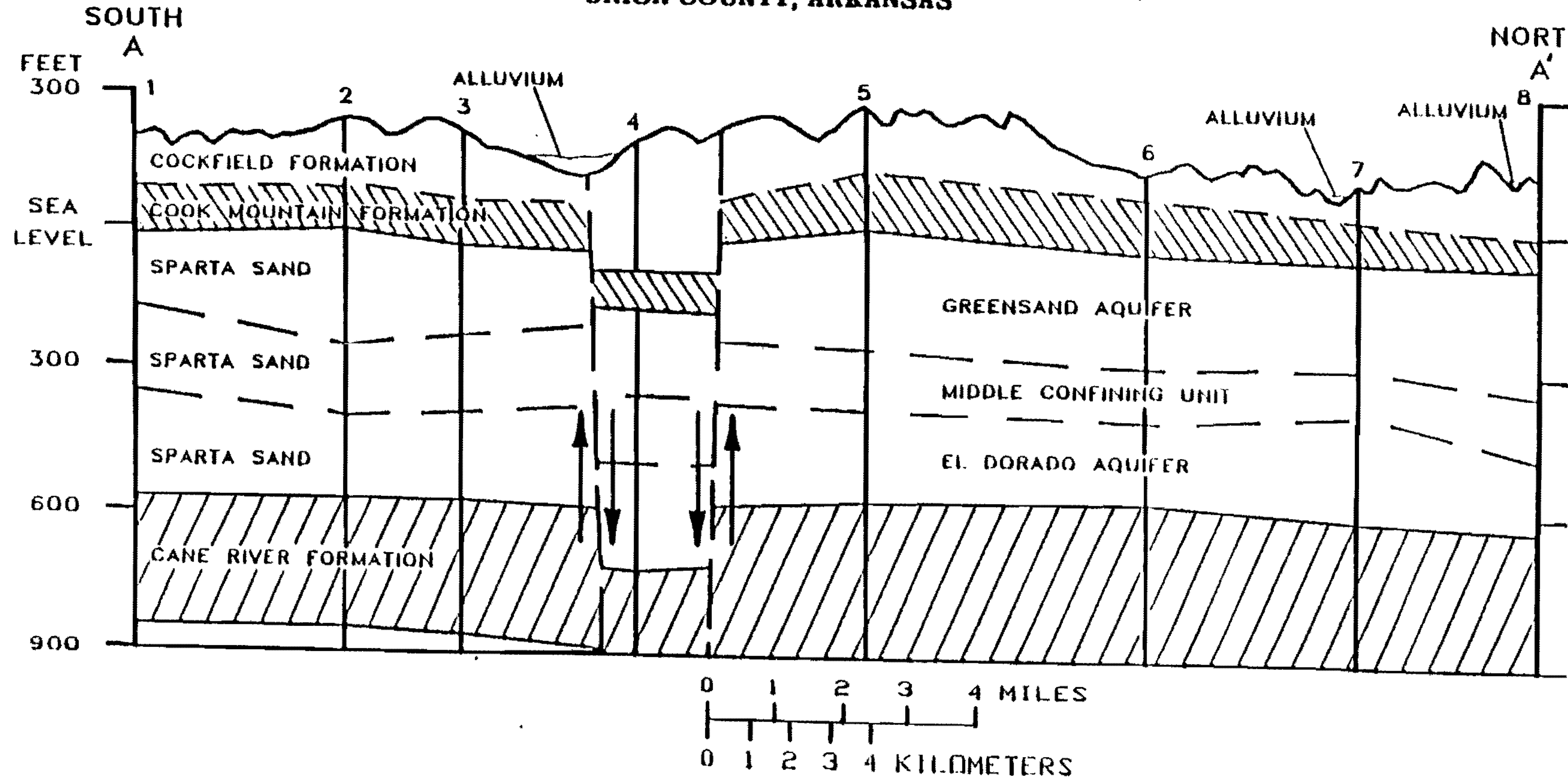
SOUTH–NORTH HYDROGEOLOGIC SECTION THROUGH THE CENTER OF UNION COUNTY, ARKANSAS



VERTICAL EXAGGERATION X35
(TRACE OF SECTION SHOWN ON FIGURE 4.)

From Leidy and Taylor, 1992.

EL DORADO CHEMICAL CO.
EL DORADO, ARKANSAS

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists
Little Rock, Arkansas

SCALE:
DRAWN BY: CRS
DATE: 8-23-95
CHKD. BY: MDB
DATE: 8-23-95

HYDROGEOLOGIC SECTION

FILE NO. 95B165
FIG. NO. 2

EL DORADO CHEMICAL CO.
EL DORADO, ARKANSAS

Woodward-Clyde Consultants
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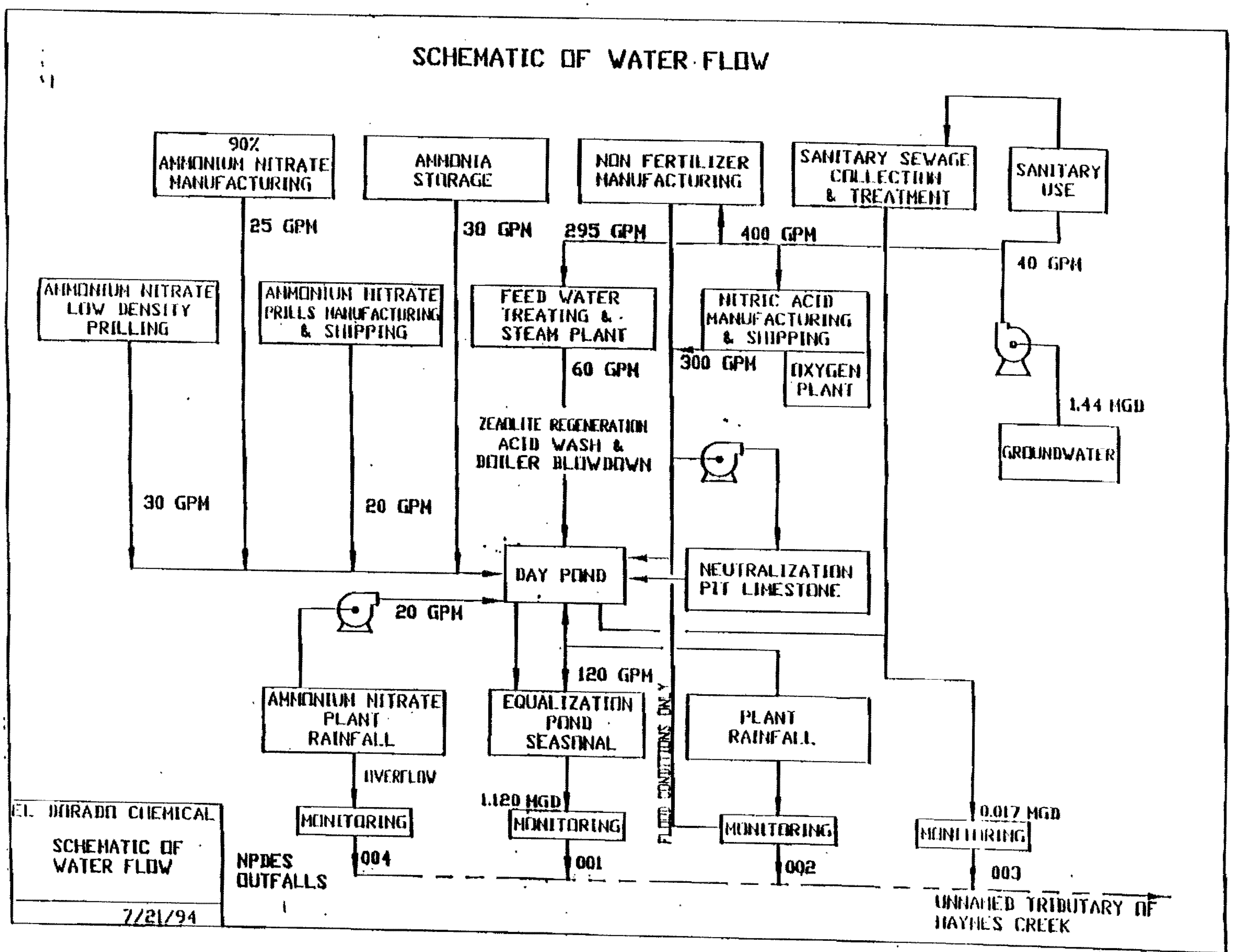
Baton Rouge, Louisiana

SCALE: NTS
DRAWN BY: CRS
CHKD. BY: MDB
DATE: 8-23-95
DATE: 8-23-95

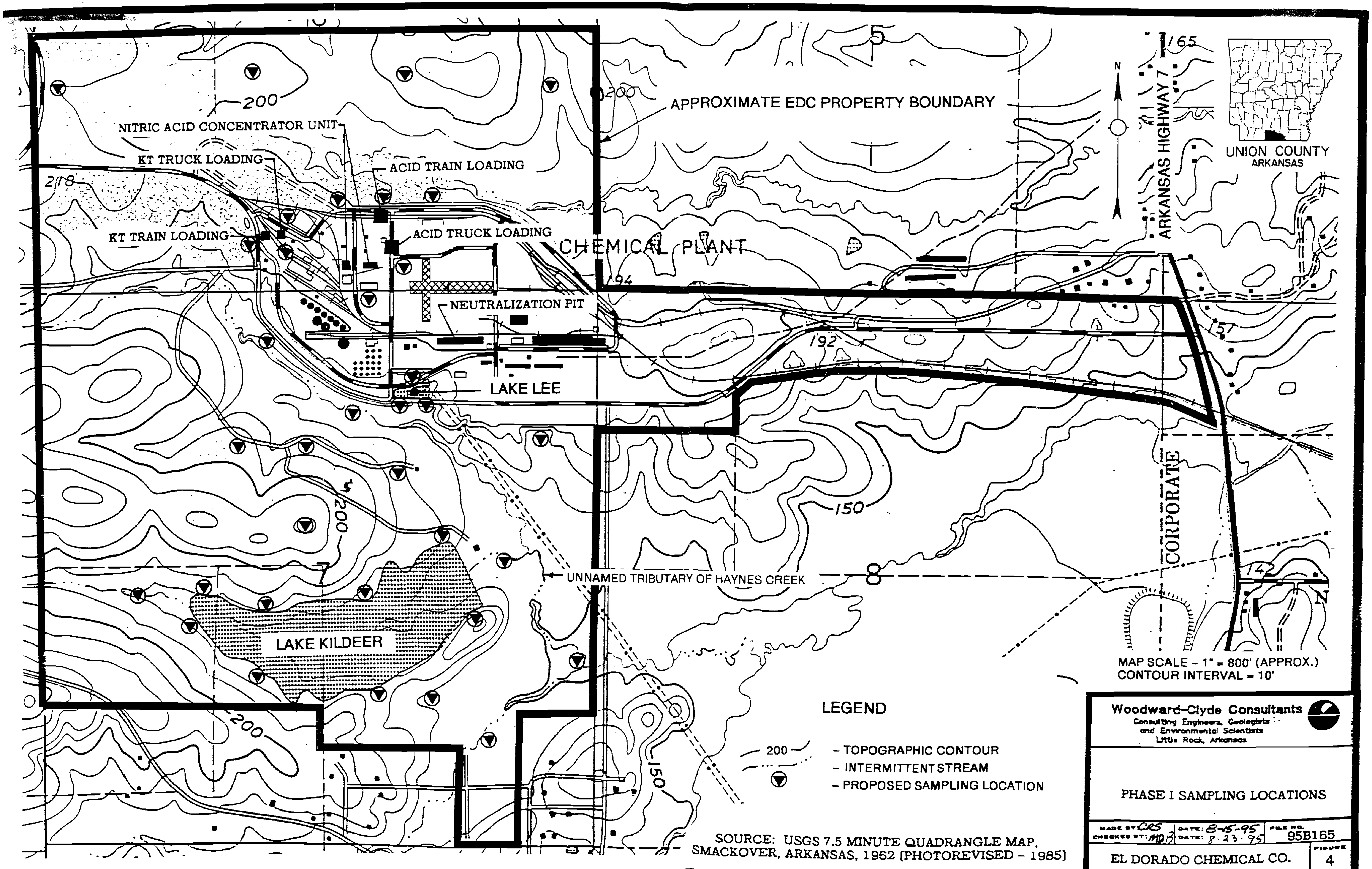
PLANT DRAINAGE AND DISCHARGE DIAGRAM

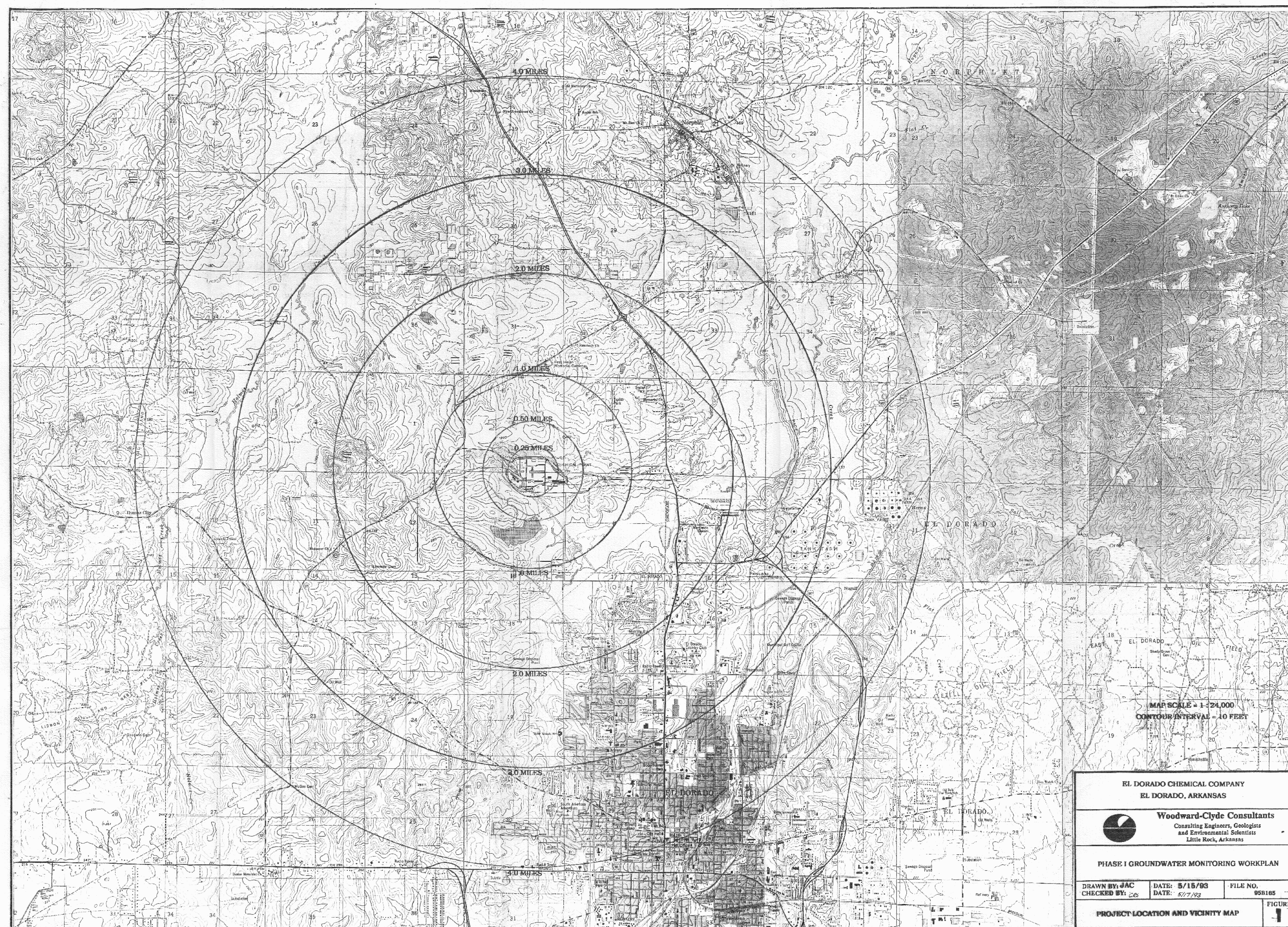
FILE NO 95B165

FIG. NO 3



Prepared by El Dorado Chemical Company


APPROXIMATE EDC PROPERTY BOUNDARY
NITRIC ACID CONCENTRATOR UNIT
KT TRUCK LOADING
ACID TRAIN LOADING
KT TRAIN LOADING
ACID TRUCK LOADING
CHEMICAL PLANT
NEUTRALIZATION PIT
LAKE LEE
UNNAMED TRIBUTARY OF HAYNES CREEK
LAKE KILDEER
ARKANSAS HIGHWAY 7
CORPORATE
N
UNION COUNTY
ARKANSAS
200
218
194
192
157
150
142
165
5
8
MAP SCALE - 1" = 800' (APPROX.)
CONTOUR INTERVAL = 10'
LEGEND
200 - TOPOGRAPHIC CONTOUR
- INTERMITTENT STREAM
- PROPOSED SAMPLING LOCATION
SOURCE: USGS 7.5 MINUTE QUADRANGLE MAP, SMACKOVER, ARKANSAS, 1962 [PHOTOREVISED - 1985]
Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists
Little Rock, Arkansas
PHASE I SAMPLING LOCATIONS
MADE BY: CRS DATE: 8-15-95
CHECKED BY: MDB DATE: 8-23-95
FILE NO. 95B165
EL DORADO CHEMICAL CO.
FIGURE 4



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Consulting Engineers, Geologists
and Environmental Scientists
Little Rock, Arkansas

PHASE I GROUNDWATER MONITORING WORKPLAN

DRAWN BY: JAC CHECKED BY: CRS	DATE: 5/15/93 DATE: 5/17/93	FILE NO. 95B165

PROJECT LOCATION AND VICINITY MAP — FIGURE 1