# GROUND WATER STUDY - LAKE LEE
# MONSANTO AGRICULTURAL PRODUCTS COMPANY
# EL DORADO, ARKANSAS

*  *  *

R e p o r t
t o

MONSANTO AGRICULTURAL PRODUCTS COMPANY
El Dorado, Arkansas

*  *  *

by
M c C L E L L A N D  E N G I N E E R S,  I N C.
Geotechnical Consultants
Little Rock, Arkansas

November 1981

**McClelland engineers, inc. / geotechnical consultants**
P.O. Box 5239 / 10501 Stagecoach Road, Little Rock, Arkansas 72215
Tel. 501 / 455-2536

November 12, 1981
LR81-365

Monsanto Agricultural Products Company
Post Office Box 231
El Dorado, Arkansas 71730

ATTENTION: Mr. Larry Adams
Engineering Supervisor

SUBJECT: Ground Water Study - Lake Lee
Monsanto Agricultural Products Company
El Dorado, Arkansas

## INTRODUCTION

Presented herein is the report of the ground water study performed for the existing Monsanto Company waste water collection pond referred to as Lake Lee. This study was conducted under Monsanto Company Purchase Order No. EL 11746 dated November 9, 1981. Our work was performed generally as outlined in our proposal letter of November 4, 1981.

The existing Lake Lee waste water collection pond covers approximately one acre at the plant site and has been in service for several years. It is our understanding that the pond contains acid, sulphate and nitrate contaminated water. 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 study is to assess the potential through a multi-phase program as follows: a) a field investigation consisting of four (4) sample borings and ground water level observations; b) a laboratory testing program planned following completion of the field studies;

and c) an engineering analysis of the data compiled in the field and laboratory studies.

## FIELD INVESTIGATION

General subsurface stratigraphy and ground water conditions were determined in four (4) sample borings drilled to depths of 40 to 61 ft. The approximate boring locations are indicated on the Plan of Borings, Plate 1. These boring locations were selected in an effort to provide three downgradient (Borings 1 through 3) and one upgradient (Boring 4) measurement. Logs of the borings, presenting soil descriptions and field and laboratory test results, are presented as Plates 2 through 5. A key to the terms and symbols used on the log forms is included as Plate 6.

Samples were obtained from Borings 1 through 4 using a 3-in. diameter thin-wall tube sampler forced hydraulically into the soil strata. Samples were extruded from the samplers in the field, and the shear strengths were estimated using a calibrated hand penetrometer. Estimated cohesion values are plotted on the log forms, in tons per sq ft, as small circles enclosing an "x". Following the field testing and visual classification, all samples were placed in appropriate containers to prevent loss in moisture during transfer to the laboratory.

The borings were advanced in part by dry auger procedures to enable evaluation of ground water conditions at the site. The recorded water levels are noted on the lower right portion of each log form. A variable-head test was conducted for Boring 3 to establish approximate permeability of the alluvial stratum. The field permeability value was computed using emperical formulae developed by the U. S. Navy Bureau of Yards and Docks and data obtained from the

variable-head test. The computed permeability value is discussed in the CONCLUSIONS section of this report.

## LABORATORY TESTING

The physical properties and permeability characteristics of the subsurface strata and the chemical properties of the ground water were evaluated in our laboratory by tests performed on selected representative specimens. Discussions of test procedures and data presentation are included in the following paragraphs.

### Permeability Tests

Falling-head permeability tests were performed on selected, undisturbed specimens to establish the permeability of the various strata. In the falling-head test, the soil specimen is placed in a permeameter to prevent flow around the sides of the specimen, and a permeable medium is placed on the top and bottom of the specimen. De-aired water is then allowed to flow under gravity through the specimen of known cross-sectional area until a specified head loss occurs. Computations are then performed to determine the coefficient of permeability. The computed permeability values are presented on the appropriate log forms and are also tabulated on the Summary of Classification Tests Data sheet, Plate 7.

### Classification Tests

Classification tests were performed on the permeability test specimens and other selected specimens. Classification tests performed include Plastic and Liquid Limit tests and mechanical grain-size analyses. The Plastic and Liquid Limit test and moisture content test results are plotted on the log forms using the scale and symbols contained in the log form legend. The percentage of soil

passing the No. 200 sieve is tabulated in the "Minus Number 200" column on the log forms. The classification test results are also tabulated on Plate 7.

Chemical Analyses

Water samples were collected by a Monsanto Company representative immediately upon encountering ground water in each boring. Each sample was tested in the Monsanto Company laboratory for sulphate, nitrate-nitrogen ammonia-nitrogen and pH. The test results are tabulated in the CONCLUSIONS section of this report.

## GENERAL SITE AND SUBSURFACE CONDITIONS

### Site Features

The existing Lake Lee collection pond is located on gently to moderately sloping terrain on the south side of the main plant facility. The top of the levee is approximately at El 183, and the ground surface downstream of the levee is approximately at El 164. The water surface level within the pond varies over several feet dependent upon the runoff but during our field studies was at El 178.1.

### Site Geology

The project site is underlain at depth by deposits of the Tertiary Age Claiborne Group. The Claiborne Group represents a transitional, depositional stage between the underlying Deltaic Wilcox and the overlying Marine Jackson sediments. All of the Claiborne sediments are near-shore deposits consisting of interbedded clay, sand and silt. At the Lake Lee site, these Claiborne Group deposits were encountered below El 162 to 164 within the pond area and below El 147 downstream of the pond.

Alluvium of recent age underlies the stream valleys in Union County. The alluvium generally consists of sandy clay, poorly sorted sand and possibly gravel. In major stream valleys, the thickness may approach 35 to 40 ft. At the pond site, the alluvium thickness is only in the order of 5 to 12 ft.

General Soil Conditions

The deposits encountered at the project site may be subdivided into four (4) basic 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 ft (generally to El 166 to 170 within the pond area). The mass permeability of this stratum is in the order of $5 \times 10^{-7}$ to $5 \times 10^{-8}$ 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 $5.0 \times 10^{-6}$ to $1 \times 10^{-5}$ 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 $5 \times 10^{-8}$ to $1 \times 10^{-7}$ cm per second. In the deeper zone more frequent sand seams are encountered, and the mass horizontal permeability could approach $1 \times 10^{-5}$ to $1 \times 10^{-4}$ cm per second; and

Stratum IV: Dense light gray fine sand (SM 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 $1.0 \times 10^{-3}$ cm per second for this sand stratum.

To assist in discussion and visualization of subsurface stratigraphy, one (1) Generalized Soils Profile was prepared and is shown as Plate 8. In using the Profile, it should be understood that the subsurface stratigraphy between

borings was inferred from conditions encountered within the borings. Variations in stratigraphy and soil conditions should be anticipated. Additionally, the natural transition between alluvial soil types is generally gradual, and the indicated boundaries cannot be considered as precise.

Ground Water Level

As noted on the log forms, ground water was encountered in the sample borings below depths of 4 to 24.5 ft. As would be anticipated, this upper ground water surface roughly parallels the existing ground surface. This upper ground water surface slopes from approximately El 170 near Boring 4 to approximately El 160 in Boring 3.

CONCLUSIONS

It is our understanding that implementation of a ground water monitoring program may be required for the existing Lake Lee collection pond unless a low potential for ground water contamination can be established. According to federal regulations, monitoring requirements may be waived if the owner or operator can demonstrate that there is a low potential for migration of hazardous wastes or hazardous waste constituents from the facility via the uppermost aquifer to water supply wells or to surface water. This potential is discussed in detail in the following paragraphs.

The results of chemical analyses of water samples collected from the borings are as follows:

| Boring No. | Depth (ft) | $SO_4$* | $NO_3$-N* | $NH_3$-N* | pH |
|---|---|---|---|---|---|
| 1 | 25 | 1020 | 5.9 | less than 1 | 4.6 |
| 2 | 20 | 399 | 14.5 | 27 | 5.1 |
| 3 | 15 | 650 | 66.2 | 8 | 4.3 |
| 4 | 15 | 530 | 3.2 | 2 | 5.6 |

*Concentrations are in mg/liter.

We must conclude from the chemical analyses that contamination of the shallow ground water system is taking place. The highest $NO_3$-N level was recorded in Boring 3 located at intermediate location between the pond and the surface drainage system for the area.

The ground water encountered at shallow depths in the borings represents the top zone of saturation (the water table). We feel, however, that this zone does not represent the uppermost aquifer. An aquifer is defined as a soil or rock formation that yields water to wells. This shallow alluvial zone can provide only a very small yield for shallow wells and is, consequently, not utilized in the general plant area. Production wells extend into the deep Claiborne Group sands.

Although contamination of this upper alluvial zone poses little or no threat to ground water supplies, some potential exists for migration of waste constituents into the nearby surface drainage system. Based on a horizontal permeability in the alluvial zone of $5 \times 10^{-6}$ to $1 \times 10^{-5}$ cm per second, we estimate seepage flow into the surface drainage system at 5 to 15 gallons per day. Due to the degree of assumptions required in this computation, actual flow may vary from the estimated amount. Observation of site conditions indicates that actual flow is less than those estimated values.

The sand encountered below El 115 apparently represents the uppermost aquifer. Migration of waste constituents from the pond into this aquifer would require seepage through the very stiff brown and dark gray clay of Stratum III. Since this stratum is essentially impervious to vertical seepage, we feel that a low potential exists for migration of waste constituents to this aquifer and water supply wells.

In summary, a low potential exists for contamination of the uppermost aquifer and water supply wells; however, a slight potential exists for contamination of surface water. Nitrate and sulphate contaminated water flow into surface waters should not exceed approximately 5 gallons per day. Chemical analyses of this surface water could be used to provide a means of assessing the extent of contamination, if any.

We have appreciated the opportunity to be of service to you on this phase of the project. If there are any questions or comments with regard to the conclusions presented herein, please contact us.

McCLELLAND ENGINEERS, INC.

Richard E. Ackley, P.E.

John P. Hoskyn, P.E.

REA/JPH/jab

Copies Submitted: Monsanto Agricultural Products Co. (3)

# LOG OF BORING NO. 2

LAKE LEE
MONSANTO AGRICULTURAL PRODUCTS COMPANY
EL DORADO, ARKANSAS

TYPE: Auger to 20 ft - Wash LOCATION: See Plate 1

| DEPTH, FT | SYMBOL | SAMPLES | DESCRIPTION OF MATERIAL | BLOWS PER FT | UNIT DRY WT LB/CU FT | COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70) | - No. 200, % |
|---|---|---|---|---|---|---|---|
| | | | SURF. EL: 182.5 | | | | |
| | | | Very stiff to firm tan and gray with brown sandy clay (FILL) | | | | |
| | | | -with gravel and organic matter | | | | |
| | | | -clay at 3.5 ft | | | | |
| 5 | | | -more clayey and less gravel below 4.5 ft | | | | |
| 10 | | | | | | | |
| 15 | | | Firm gray fine sandy clay | | | | |
| | | | -with silty sand pockets and seams | | | | |
| 20 | | | Very stiff brown clay with light gray silty fine sand partings | | | | |
| 25 | | | | | | | |
| | | | -dark gray below 27 ft | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

NOTE: SCALE CHANGE

COMPLETION DEPTH: 40 ft
DATE: 11/4/81

DEPTH TO WATER IN BORING: 16 ft DATE: 11/4/81

McCLELLAND ENGINEERS

PLATE 3

# LOG OF BORING NO. 1

LAKE LEE
MONSANTO AGRICULTURAL PRODUCTS COMPANY
EL DORADO, ARKANSAS

TYPE: Auger to 25 ft - Wash

LOCATION: See Plate 1

| DEPTH, FT | SYMBOL | SAMPLES | DESCRIPTION OF MATERIAL | BLOWS PER FT | UNIT DRY WT LB/CU FT | COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70) | % - No. 200, % |
|---|---|---|---|---|---|---|---|
| | | | SURF. EL: 182.7 | | | | |
| | | | Very stiff to stiff gray with tan and brown sandy clay (FILL) | | | | |
| | | | -with some gravel and organic matter | | | | |
| | | | -with gray and red clay at 2.5 ft | | | | |
| 5 | | | | | | | |
| | | | -more clayey with no gravel below 6 ft | | | | |
| 10 | | | | | | | |
| 15 | | | | | | | |
| | | | Firm gray with tan fine sandy clay | | | | |
| 20 | | | -with silty sand pockets and seams | | | | |
| | | | Stiff gray and brown clay | | | | |
| 25 | | | -with light gray silty fine sand seams | | | | |
| | | | Very stiff brown clay | | | | |
| 30 | | | -with numerous light gray and tan fine sand and silt partings and seams | | | | |
| | | | -with dark gray below 29.5 ft | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

NOTE: SCALE CHANGE

COMPLETION DEPTH: 40 ft
DATE: 11/3/81

DEPTH TO WATER IN BORING: 24.5 DATE: 11/3/81

McCLELLAND

PLATE

# LOG OF BORING NO. 3

LAKE LEE
MONSANTO AGRICULTURAL PRODUCTS COMPANY
EL DORADO, ARKANSAS

TYPE: Auger to 17 ft - Wash

LOCATION: See Plate 1

SURF. EL: 163.8

| DEPTH, FT | DESCRIPTION OF MATERIAL |
|---|---|
| 5 | Very stiff tan clayey silt (FILL)<br>-with organic matter and some fine sand<br>-with some crushed stone below 1.5 ft |
| 10 | Soft to stiff gray with tan sandy clay (MOIST)<br>-more clayey below 9.5 ft<br>-with some sand seams below 14.5 ft |
| 15 | |
| 20 | Very stiff dark gray clay<br>-with light gray silty fine sand seams and partings<br>-mostly gray below 20 ft<br>-cemented layer at 21 ft |
| 25 | |
| 30 | |
| 35 | Interbedded very stiff dark gray clay and light gray fine sand |
| 40 | |
| 50 | Dense light gray fine sand<br>-with occasional clay seams |
| 60 | NOTE: Encountered water at 15 ft - rose to 5.4 ft after 15 min.-rose to 4 ft after 1 hr. |

NOTE: SCALE CHANGE

BLOWS PER FT

UNIT DRY WT LB/CU FT

COHESION, TON/SQ FT
0.2 0.4 0.6 0.8 1.0 1.2 1.4

PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT
10 20 30 40 50 60 70

% - No. 200, %

COMPLETION DEPTH: 61.0 ft
DATE: 11/4/81

DEPTH TO WATER IN BORING: See Note
DATE: 11/4/81

McCLELLAND ENGINEERS

PLATE 4

# LOG OF BORING NO. 4

LAKE LEE
MONSANTO AGRICULTURAL PRODUCTS COMPANY
EL DORADO, ARKANSAS

TYPE: Auger LOCATION: See Plate 1

SURF. EL: 181.8

| DEPTH, FT | DESCRIPTION OF MATERIAL |
|---|---|
| | Stiff brown sandy clay (FILL) -with organic matter and gravel |
| | Loose tan and gray clayey sand (FILL) -with sandy clay seams |
| 5 | Very stiff to firm tan and gray sandy clay (FILL) -with some organic matter and gravel |
| | Stiff dark gray and gray clay and silty clay (FILL) |
| 10 | |
| | Soft gray sandy clay |
| 15 | |
| | Soft light gray with red sandy clay |
| 20 | Very stiff brown clay -with light gray silty fine sand partings and seams -mostly dark gray with some silt and fine sand partings below 23 ft |
| 25 | |
| 30 | -with numerous sand seams and layers below 32.5 ft |
| 35 | |
| 40 | NOTE: Water at 11 ft after 15 minutes |

NOTE: SCALE CHANGE

BLOWS PER FT

UNIT DRY WT LB/CU FT

COHESION, TON/SQ FT
0.2 0.4 0.6 0.8 1.0 1.2 1.4

PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT
10 20 30 40 50 60 70

% - No. 200

COMPLETION DEPTH: 40 ft
DATE: 11/4/81

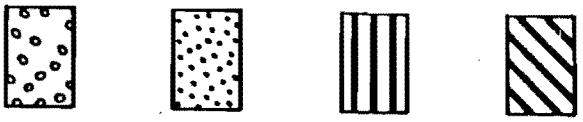
DEPTH TO WATER IN BORING: See Note
DATE: 11/4/81

McCLELLAND ENGINEERS

PLATE 5

# SYMBOLS AND TERMS USED ON BORING LOGS

## SOIL TYPES
(SHOWN IN SYMBOL COLUMN)



Gravel | Sand | Silt | Clay

Predominant type shown heavy

## SAMPLER TYPES
(SHOWN IN SAMPLES COLUMN)

Shelby Tube | Piston | Split Spoon | No Recovery

## TERMS DESCRIBING CONSISTENCY OR CONDITION

**COARSE GRAINED SOILS** (major portion retained on No. 200 sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

| DESCRIPTIVE TERM | RELATIVE DENSITY |
|---|---|
| Loose | 0 to 40% |
| Medium dense | 40 to 70% |
| Dense | 70 to 100% |

**FINE GRAINED SOILS** (major portion passing No. 200 sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests.

| DESCRIPTIVE TERM | UNCONFINED COMPRESSIVE STRENGTH TON/SQ FT |
|---|---|
| Very soft | less than 0.25 |
| Soft | 0.25 to 0.50 |
| Firm | 0.50 to 1.00 |
| Stiff | 1.00 to 2.00 |
| Very stiff | 2.00 to 4.00 |
| Hard | 4.00 and higher |

Note: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

## TERMS CHARACTERIZING SOIL STRUCTURE

**Slickensided** – having inclined planes of weakness that are slick and glossy in appearance.

**Fissured** – containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.

**Laminated** – composed of thin layers of varying color and texture.

**Interbedded** – composed of alternate layers of different soil types.

**Calcareous** – containing appreciable quantities of calcium carbonate.

**Well graded** – having wide range in grain sizes and substantial amounts of all intermediate particle sizes.

**Poorly graded** – predominantly of one grain size, or having a range of sizes with some intermediate size missing.

Terms used in this report for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

# SUMMARY OF CLASSIFICATION TESTS

PROJECT: Lake Lee SITE: Monsanto Company El Dorado, Arkansas

| SAMPLED FROM | LOCATION DEPTH, FT. | WATER CONTENT PERCENT (NATURAL) | L.L. | P.L. | P.I. | MECHANICAL ANALYSIS PERCENT FINER 3 IN. | 3/4 IN. | 3/8 IN. | NO. 4 | NO. 10 | NO. 40 | NO. 200 | PERMEABILITY, $k_v$ Cm/SEC | CLASSIFICATION UNIFIED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | 9.5-10 | 17.3 | 35 | 14 | 21 | - | 100 | 96 | 92 | 89 | 86 | 55 | $2.0\times10^{-8}$ | CL |
| | 29.5-30 | 20.9 | 41 | 15 | 26 | - | - | - | - | 100 | 99 | 73 | $2.2\times10^{-7}$ | CL |
| B-2 | 19--19.5 | 26.7 | 44 | 16 | 28 | - | - | - | - | 100 | 96 | 82 | | CL |
| | 29.5-30 | 24.8 | 34 | 19 | 15 | - | - | - | 100 | 97 | 87 | 76 | $3.8\times10^{-7}$ | CL |
| | 4.5-5 | 11.0 | 30 | 17 | 13 | - | 100 | 95 | 87 | 79 | 69 | 49 | | SC |
| | 9.5-10 | 20.3 | 28 | 16 | 12 | - | - | - | - | 100 | 99 | 84 | $1.7\times10^{-7}$ | CL |
| | 14.5-15 | 20.9 | Nonplastic | | | - | - | - | - | - | 100 | 54 | $1.0\times10^{-5}$ | ML |
| B-4 | 13.5-14 | 25.3 | 30 | 15 | 15 | - | - | - | - | - | 100 | 77 | $4.3\times10^{-7}$ | CL |
| | 29.5-30 | 22.2 | 26 | 24 | 2 | - | - | - | 100 | 99 | 94 | 85 | $1.0\times10^{-7}$ | ML |