SWF District Copy [redacted]

PASCO COUNTY, FLORIDA

SOLID WASTE RESOURCE RECOVERY FACILITY

APPLICATION FOR

POWER PLANT SITE CERTIFICATION

VOLUME IV - LANDFILL/ASHFILL

SUBMITTED BY
THE PASCO COUNTY
BOARD OF COUNTY COMMISSIONERS

NOVEMBER 1987

PREPARED BY
CAMP DRESSER & McKEE INC.

environmental engineers, scientists, planners & management consultants **CDM**

[redacted]

FDEP- Siting Coordination

Memo

To: Robert Butera

From: Erica Herring

CC: Kim Ford

Date: 12/28/00

Re: Pasco County RRF Site Certification Application Volume IV

Return Receipt Requested by Jan. 22, 2001

Please copy and return the enclosed site certification application to my office on or before Jan. 22, 2001. This is an original and the **only copy** that I have. My mailing address is: 2600 Blair Stone Road MS 48, Tallahassee, Florida 32399-2400.

If you need additional information please feel free to contact Hamilton Oven at 850-487-0472.

RECEIVED
DEC 29 2000
Department of ... Protection
SOUTHWEST DISTRICT
BY ______

PASCO COUNTY, FLORIDA

SOLID WASTE RESOURCE RECOVERY FACILITY

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SOLID WASTE RESOURCE RECOVERY FACILITY
APPLICATION FOR POWER PLANT SITE CERTIFICATION

VOLUME IV - LANDFILL/ASHFILL

FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION
CONSTRUCTION/OPERATIONS PERMIT APPLICATION
FOR THE PASCO COUNTY
HAYS ROAD SANITARY LANDFILL/ASHFILL

Prepared for:

PASCO COUNTY BOARD OF COUNTY COMMISSIONERS
7530 Little Road
New Port Richey, Florida 33553

Prepared by:

CAMP DRESSER & McKEE INC.
One Tampa City Center, Suite 1750
Tampa, Florida 33602

SEPTEMBER 1987

between operator and property owner by which the closing and long-term care of the facility may be affected.

Response:
Long-term maintenance and closure will be performed by the current owner (Pasco County, Florida). No agreement for lease or transfer of property is necessary since the county intends to retain possession beyond the closure period. Proof of county ownership is evidenced by the Warranty Deed and Order of Taking found in Technical Appendix B.

8. **Proof of publication of notice of application for the proposed activity in a newspaper of general circulation.**

Response:
This permit will be included in the publication of Notice of Application for the Power Plant Site Certification Application.

III. SPECIFICATION ATTACHMENT ITEMS

Items will be presented as they appear in FDER Form 17-7.130(1).

SECTION 1 - FOUNDATION ANALYSIS

Response:
An analysis of the geological stratification of the Pasco County Hays Road Landfill/Ashfill was performed by Jammal & Associates. This foundation analysis can be found in Attachment 2, Section 5.4, page 38. As part of the hydrogeological investigation, 92 SPT borings, 4 deep and 4 shallow groundwater monitoring wells, and 57 piezometers were installed. Over 7.5 miles of ground surface was investigated using ground penetrating radar (GPR) and was also evaluated in the grid pattern indicated on sheet numbers 2 and 3 of the boring location plan in Attachment 2.

SECTION 2 - EVIDENCE THAT THE FACILITY IS IN CONFORMANCE WITH LOCAL ZONING

Response:

Technical Appendix C contains a letter from the Pasco County Zoning Director indicating that the proposed facility is exempt from local zoning.

SECTION 3 - FACILITY DESIGN

3A. **Map or aerial photograph of the area not more than one year old showing land use and zoning within one mile of the facility.**

Response:

Aerials of the site are provided on Sheets, 2, 3, 4, and 5 in Attachment 1, including topographic contours for the site and the area within one mile of the Hays Road Landfill site boundary. The aerial on Sheet 2 was flown in November 1986 and has a 1-inch equals 1,000-foot scale. The aerial on Sheets 3, 4, and 5 was flown in September 1986 and has a 1-inch equals 200-foot scale. Land use and zoning designations within one mile of the Hays Road Landfill are delineated on Sheet 2.

3B. Plot Plan.

3B(1) Dimensions and Legal Description of the Site.

Response:

The dimensions and legal description of the site are shown on Sheet 6 in Attachment 1. The legal description indicates the entire site acreage to be 810.26 acres, more or less. Approximately 59.23 acres have been designated for a Class III landfill. Approximately 751.03 acres are included in the power plant siting act submittal for the Class I landfill/ashfill and the resource recovery facility. The Class III landfill will be permitted separately at a later date.

3B(2) Location and Depth of Soil Borings.

Response:

The location and depth of the soil borings are presented on Sheet 7 of Attachment 1.

3B(3) Plan for Disposal Areas.

Response:

Sheet 9 of Attachment 1 shows the plan for disposal areas. The minimum elevation of the secondary liner is 48 feet msl. As can be seen on Sheet 7, the existing ground surface is located near 48 feet msl over most of the area to be landfilled.

3B(4) Fencing or Other Measures to Restrict Access.

Response:

Access will be controlled at all times. Vehicles entering the landfill will be required to stop at the scale house for weighing or approval before proceeding. Access or containment barriers will include a locking access gate at the Hays Road entrance to the landfill, and an eight-foot high chain link fence with two strands of barbed wire along the top completely enclosing the Class I landfill area as shown on Sheet 8 of Attachment 1.

3B(5) Cross Sections Showing Original and Proposed Fill Elevations.

Response:

Original and proposed final fill elevations are identified on the landfill cross sections shown on Sheet 15 of Attachment 1.

SECTION 4 - LANDFILL PERFORMANCE AND DESIGN STANDARDS

4A Liner Performance.

4A(1) Material Type (soil synthetic, other).

Response:
The design concept proposed employs a double liner/leachate collection system. The secondary liner/leachate collection system acts as a backup to the primary liner as well as providing a means of leak detection of the primary liner.

A geotechnical/hydrogeologic study over the site was performed relating to implementation of a Class I sanitary landfill/ashfill. Because of the site's topographic, geologic, and hydrogeologic conditions, the study addressed in detail the potential for sinkhole activity over the project sites.

Both the primary and the secondary liner will be a 60 mil thick high density polyethylene material or equivalent that meets the minimum requirements of the National Sanitation Foundation Standard Number 54, Flexible Membrane Liners (November 1983). High density polyethylene (HDPE) was selected as the liner material for several reasons. HDPE contains no additives or fillers which can leach out and cause deterioration over time. Most importantly, HDPE is resistant to a wide range of chemicals including acids, bases, salts, alcohols, amines, oils, heavy metals and hydrocarbons.

4A(2) Adequate Base Support.

Response:
A clay layer 5 to 10 feet below the ground surface and 5 to 15 feet thick was identified by Jammal & Associates over about 250 acres of the 810-acre site (See Sheets 2 and 3 in Attachment 2). The proposed landfill was configured to stay

within this area of a subsurface clay layer. The clay layer adds support and mitigates the degree of differential settlement. Section 5.4 of Attachment 2 discusses this and other advantages to limiting the landfill to the area found to contain this subsurface clay layer.

Landfill settlement considerations are discussed in Section 5.4 of the Jammal & Associates report (1987, Attachment 2). Consolidation test results are recorded on Plates 9-16 and settlement estimates are shown on Sheet 1 in Appendix B of the report. Total settlement of the landfill under the maximum landfill height of 100 feet is anticipated to be 13 to 15 inches. Under the height of 75 feet, distortion plus consolidation is estimated to be 11 to 13 inches. Total settlement at the toe of the slope is estimated at 2 to 3 inches. The critical area for differential settlement is between the toe and the high point of the 1V:4H slope (330 feet). The maximum differential settlements over this distance should be 10 to 12 inches. Given a tolerance of 10 percent material elongation, the liner can withstand a 12-inch deflection if the radius is equal to or greater than 2.2 feet. The 330-foot radius between the toe and the high point of the slope is much greater than 2.2 feet, thus the liner settlement design is very conservative.

As part of the Jammal & Associates report (Attachment 2), the future sinkhole potential over the landfill/ashfill area was investigated. Study of the existing site conditions and the various factors associated with sinkhole formation showed the potential for sinkhole formation over the landfill area to be slight. See Section 5.9 of Attachment 2 for further details.

4A(3) Planned Installation Adequate to Cover All Surrounding Earth.

Response:

Sheet 8 of Attachment 1 illustrates the extent of the synthetic liner placement. As shown on Sheet 9, the installation of this liner will be in phases. All seams will be hot welded with parent materials to prevent the introduction of foreign adhesives. Corners will be constructed with separate side pieces, rather than wrapped around. Disposal waste will be contained in each cell by surrounding berms. The liner in each cell will completely cover the base of the cell and the inside slope of the berm. The liner will be anchored at the top of the berms. See Sheet 16 of Attachment 1 for a liner anchor detail. Any penetration of the liner by the leachate collection system will be wrapped, with protective liner boots constructed of the liner material. Boots will be seamed to the liner to assure a contiguous surface.

4A(4) Equivalency to Design Standards.

Response:

The synthetic liner material will meet the specifications for permability and strength as required in FDER 17-7.050(4)(a). The proposed liner material (HDPE) is highly chemically resistant to leachate degradation. Performance in a leachate environment will be tested using the EPA 9090 materials test for chemical degradation. Additional materials test data will be provided by the manufacturer including tensile strength, burst strength, impact puncture strength, friction pullout and permeability.

4B Liner Quality Control Plan.

4B(1) Specifications.

Response:

Liner specifications are provided in Technical Appendix F including a Liner Quality Control Plan.

TECHNICAL APPENDIX E

GROUNDWATER MONITORING PLAN SUPPLEMENT

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

NORTHWEST DISTRICT
BRANCH OFFICE

WIN TOWERS OFFICE BUILDING
500 BLAIR STONE ROAD
ALLAHASSEE, FLORIDA 32301

BOB GRAHAM
GOVERNOR

VICTORIA J. TSCHINKEL
SECRETARY

APPLICATION FOR MONITORING PLAN APPROVAL
(Existing Sources)

INSTRUCTIONS: Submit four copies of this application and four copies of supporting information such as laboratory reports, maps and other documents to the appropriate District Office.

PART I - General Information

In compliance with Florida Administrative Code Rule 17-4.245(6)(c)2., the undersigned installation owner applies for approval from the Department for the monitoring criteria on the following property owned by:

Pasco County
Corporation or Owner's Name ______ Permit No. ______

Hays Road Landfill Monitoring Wells
Installation Name ______ SIC Code ______

Nearest City: Port Richey
Street Address, City, Zip, County ______ 82°33'30"N 28°22'05"W Latitude Longitude

___1/4 ___1/4 ___1/4 of 24,25,26 T24S R17E
Section, Township, Range

OWNER OR AUTHORIZED REPRESENTATIVE (If representative, attach letter of authorization.)

Pasco County
Name and Official Title (Print or Type)

7530 Little Road, New Port Richey, Florida 33553 ______ (813) 847-8132
Street, City, State Zip ______ Telephone Number

Signature: George W. Ellsworth ______ Date: ______

PART II - Content of Monitoring Plan

Pursuant to Rule 17-4.245(6)(d), the plan shall contain findings, recommendations and plans for ground water monitoring derived from site specific information. For the type of information to be considered in the development and assessment of the plan, see page two of this form. In any case, the following items must be included:

1. Location(s) of proposed well(s) to sample natural unaffected background water quality and the intermediate and compliance well(s) in the down gradient direction.

2. Construction details of the monitor well(s), including type of casing material, diameter of casing, depth of casing and location of screens.

3. A water sampling and chemical analysis procedure which can determine the natural unaffected background quality of the ground water, and the quality of the receiving ground water in the downgradient intermediate and compliance wells.

The following information is the type generally required for detailed assessment of the most complex plans, with less complex cases not needing this degree of evaluation:

1. Hydrogeological, physical and chemical data for the site, including:

   a. Direction and rate of ground water flow, and background ground water quality;

   b. Porosity, horizontal and vertical permeability for the aquifer(s) and the depth to, and lithology of, the first confining bed(s);

   c. Vertical permeability, thickness, and extent of any confining beds;

   d. Topography, soil information and surface water drainage systems surrounding the site;

2. Waste disposal rate and frequency, chemical composition, method of discharge, pond volume, spray-field dimension, or other applicable site specific information;

3. Toxicity of waste;

4. Present and anticipated wastewater volume, seepage rate to the receiving ground water, physical, chemical, microbiological (whichever is applicable) characteristics of the leachate;

5. Disposal system water balance;

6. Present and reasonably expected future pollution sources located within one mile radius of the site;

7. Inventory depth, construction details, and cones of depression of water supply wells and monitor wells located within one mile radius of the site or potentially affected by the discharge;

8. Site specific economic and feasibility considerations;

9. Chronological information on water levels in the monitor wells and water quality data on water supplies collected from the water supply and monitor wells;

10. Type and number of waste disposal facilities within the installation;

11. Chronological information on surface water flows and water quality upstream and downstream from the site;

12. Construction and operation details of disposal facilities;

13. History of construction and land development in the vicinity of the site.

A monitoring program instituted under some other state, federal, or local government regulation or permit may be substituted (or referenced if contained in an existing department permit) if such program is in substantial compliance with Part II.

APPLICATION FOR MONITORING
PLAN APPROVAL
(SUPPLEMENT)

FOR THE

HAYS ROAD LANDFILL
PASCO COUNTY, FLORIDA

CONTENTS

1.0 INTRODUCTION

1.1 BACKGROUND

The existing landfill serving the western part of Pasco County is near capacity. Favorable portions of the Hays Road Site are being developed into a Class I sanitary/ash landfill to serve the future needs of Western Pasco County. A resource recovery plant is being constructed in the southern portion of the site. It is anticipated that both raw refuse and ash from the resource recovery plant will be disposed at the lined landfill. The landfill height is anticipated to be about 75 feet.

1.2 PURPOSE AND SCOPE

This report is in support of an Application for Monitoring Plan Approval [DER Form 17-1.216(1)] for the Hays Road Class I Landfill site. Chapter 2.424(b), Florida Administrative Code (FAC), requires groundwater monitoring for facilities which discharge to the groundwater. The information requested is presented in a configuration and numbering system similar to page 2 of the form. The majority of information is contained in Attachment 2, Geotechnical and Hydrogeologic Investigation Proposed Landfill Site - Hays Road, Pasco County, Florida (Jammal & Associates, April 1987) and the answers are referenced therein.

2.0 HYDROGEOLOGY

2.1 HYDROGEOLOGIC FRAMEWORK

The principal formations in Pasco County are a series of limestones and dolostones mantled by relatively thin sand and clay deposits. The surficial sands and clays are undifferentiated with the lower portion of the deposits generally assigned to the Hawthorn Formation. The Hawthorn Formation, which is generally composed of clays, sand and dolosilt, is relatively thin in the eastern part of the county and may be absent in some areas, particularly in the northern part of Pasco County.

The uppermost limestone in northwest Pasco County is the Tampa Limestone, or in areas where not present, the Suwannee Limestone. Most domestic and many irrigation wells produce from the lower Suwannee Limestone. The Ocala Group and the Avon Park Formation are composed of limestone and dolostone with dolostone becoming more prevailing with depth. Most large production wells produce from the lower Ocala Group and/or the dolostone of the Avon Park Formation.

In general, the soil materials at the Hays Road site consist of a varying thickness of sand (less than 10% fines) overlying clayey materials also of varying thickness and consistency, which in turn overlie either significantly weathered limestone with clay or more intact weathered limestone. The preferred area for the landfill shows at least 5 feet of intact and nearly continuous clayey semi-confining unit material separating the surficial aquifer from the limestone of the Floridan aquifer. Detailed site specific information is contained in Chapters 4 and 5 of the Jammal report (April, 1987), Attachment 2.

2.2 AQUIFER SYSTEMS

Two distinct water-bearing geologic units, or aquifer systems, capable of supplying economical quantities of water to wells, occur in the western portion of Pasco County. The uppermost of the two is the surficial aquifer system, comprised of the permeable portions of the unconsolidated deposits overlying the limestones. The limestone formations form the deeper Floridan aquifer, an artesian and sometimes unconfined aquifer system which underlies most of central Florida.

The surficial aquifer system is apparently relatively thin in western Pasco County and may be absent or discontinuous in some areas. The transmissivity, or ability to transmit water, of the water table aquifer is dependent upon the permeability of the aquifer deposits and the saturated thickness. In areas where the surficial sand deposits are thin, the transmissivity of the unit typically is comparatively less than in areas where the deposits are thicker. The surficial aquifer system in western Pasco County is seldom used for a water supply source primarily because the deeper Floridan aquifer supplies greater quantities of higher quality water to wells.

The surficial or water table aquifer system is recharged primarily by precipitation and subsequent infiltration to the saturated zone. Water is discharged from the aquifer by evapotranspiration, seepage to lakes and streams and by vertical leakance to underlying aquifers.

The top of the Floridan aquifer system in Pasco County is represented by either the Miocene Tampa Limestone or where absent, the Oligocene Suwannee Limestone. The top of the Floridan aquifer occurs at an altitude of near mean sea level (msl) in northwest Pasco County. The aquifer becomes progressively more deeply buried beneath the surficial clastic deposits southward.

The Suwannee Limestone is a very permeable, productive zone of the Floridan aquifer. Most domestic and many irrigation wells produce from the lower part of the Suwannee Limestone. The Ocala Group is highly permeable over much of the area and yields large quantities of water to wells. The underlying Avon Park Formation contains a fractured, cavernous zone near the top which yields large quantities of water to wells.

Groundwater flow in the Floridan aquifer system in Pasco County moves generally westward toward the Gulf of Mexico from the "Pasco High" centered in the eastern part of the county. The "Pasco High" represents an area of highest altitude in the vicinity of the potentiometric surface of the Floridan aquifer.

Based on available publications, the transmissivity of the Floridan aquifer in this area of Pasco County is highly variable; varying from about 40,000 to 130,000 $ft.^2$/day. The natural leakance rate through the semi-confining clayey unit in this area of Pasco County varies from about 5×10^{-3} to $5 \times 10^{-4}/day^{-1}$.

3.0 DISPOSAL SYSTEM ASSESSMENT

The following information is presented in the same numerical order as the items contained on page 2 of the Application for Monitoring Plan Approval.

1. Hydrogeological, physical and chemical data for the site.

   a. The altitude of the surficial aquifer is shown at the end of the wet season for September 6, 1986, and for the dryer period of November 13, 1986 in Figures 2-20 and 2-21, respectively (Volume I). The direction of groundwater flow is from the higher water table elevations toward lower water table elevations. Groundwater conditions in the surficial aquifer are discussed in Section 4.2 of the Jammal & Associates report (April, 1987), Attachment 2. It appears that the water table is from 5 to 18 feet below land surface in the favorable landfill area with the water table being 10 to 12 feet below present surface over the majority of the above area.

      The lowest measured points on the water table surface occurred along the north and northeast margin of the site. Water table elevations of less than +30 feet above msl were measured in wells in these areas. Geologic data, discussed above, suggests that the clay deposits covering the limestone may be missing in areas along the northern site boundary.

      Water levels in wells at the site indicate that the water table surface above the Hawthorn clay deposits ranged in altitude from about +30 to +40 feet above msl. Based on the potentiometric surface maps of the underlying Floridan aquifer prepared by SWFWMD (Plate 2, Appendix A, Jammal & Associates, April 1987, Attachment 2), the difference in head between the Floridan and overlying water table aquifer is relatively small, approximately 5 feet on an average.

No tests of the surficial aquifer at the site were performed. The upper fine sands are expected to have a permeability of about 10 to 20 feet/day.

The average linear velocity (seepage velocity) for the Floridan aquifer was calculated using the following formula (Freeze and Cherry, 1979; Fetter, 1980).

$$\bar{v} = \frac{-Kdh}{ndl} \qquad K = \frac{T}{b}$$

where:

$\bar{v}$ = average linear velocity (ft/day)

K = hydraulic conductivity (ft/day)

$\frac{dh}{dl}$ = hydraulic gradient (ft/day)

n = effective porosity

T = transmissivity (ft^2/day)

b = thickness of aquifer (ft)

The steepest hydraulic gradient perpendicular to the September 6, 1986 groundwater contours was about 1 foot decline in 50 feet. Assuming an effective porosity of N = 0.20, the average linear velocity is:

$$\bar{v} = \frac{20}{0.20} \; \frac{1}{50} = 2 \text{ feet/day}$$

The hydraulic gradient of the Floridan aquifer determined from the potentiometric surface (water level) in the monitor wells at the site was 1 foot in 826 feet from readings taken on November 13, 1986 (Jammal & Associates, April 1987, Table 4, Attachment 2). This compares favorably with the gradient interpreted from USGS potentiometric surface maps for the area. The direction of groundwater flow in the upper Floridan aquifer at the site is to the northwest.

The nearest pump test sites were 5 miles to the east at the Cross Bar Ranch Well Field where transmissivity values ranged from 50,000 to 115,000 ft^2/day (Hutchinson, 1985, Figure 5). Jammal & Associates (April 1987, Attachment 2) state that the transmissivity in this area is highly variable, varying from about 40,000 to 130,000 ft^2/day. A transmissivity of 150,000 ft^2/day is used in calculations for the Hays Road site for a worst case velocity determination.

No values for the effective porosity of the upper Floridan aquifer in the vicinity of the site could be found. An effective porosity of 0.05 for the Floridan aquifer is used in the G-1 Rule as adopted by the Florida Department of Environmental Regulation. The thickness of the upper Floridan aquifer in the vicinity of the site is estimated to be about 800 feet (Ryder, 1985, Figure 10). Therefore:

$$K = \frac{T}{b} = \frac{150,000}{800} = 187.5 \text{ ft/day}$$

and:

$$\bar{v} = \frac{-Kdh}{ndl} = \frac{187.5}{.05} \times \frac{1}{826} = 4.54 \text{ ft/day}$$

Water quality analyses have been performed for the onsite monitor wells. The results of the analyses (Appendix A) show no violation of primary and secondary drinking water standards (Chapter 17-22.104, FAC). The surficial aquifer water may be slightly acidic, high in dissolved iron, and have a high color.

b. See Item 1.a. above for available information on aquifer porosity and permeability.

The top of the first semi-confining unit is very irregular. The clay to sandy clay of strata 8 and 9, and the more clayey portions of the clayey sand of strata 7 make up the semi-confining unit (Sections 5.2 and 5.7, Jammal & Associates, April 1987, Attachment 2).

c. The clayey semi-confining unit was present and fairly consistent in physical properties in the area classified as favorable (proposed area to be landfilled). The highly plastic clays of strata 8 and 9 are considered essentially impermeable to vertical movement of water. However, there appear to be minor inconsistencies and seams of secondary seepage that allow some vertical movement of groundwater.

The thickness in the favorable area varies from 5 to 15 feet with a thickness of 6 to 8 feet in most cases. The average vertical permeability is approximately 7.2×10^{-5} cm/sec.

d. The project site is situated in a relatively flat section of the Pamlico Terrace of the Gulf Coastal Lowlands physiographic province with greater relief to the east and northeast. Numerous lakes and ponds are found south of the site and the relatively large/linear Crews Lake is located about 1.5 miles to the east of the site. The topography and physiographic settings are further discussed in Sections 1.3 and 2.1, respectively, of the Jammal & Associates report (April 1987, Attachment 2).

Section 3.1 of the Jammal & Associates report (April 1987, Attachment 2) discusses the test drilling program during evaluation of the Hays Road site. The results of the soil borings are presented as soil profiles on Sheets 5 through 11 and discussed in Section 4.1.

In the northern portion of the project site, a relict drainage ditch 5 to 8 feet deep is present. It appears to have been dry for a considerable length of time.

The Hays Road site has no surface water bodies within the landfill construction area. Several small limestone-solution, sinkhole related depression areas are located west of the power line easement that bisects the property and do not lie within an area where construction is planned.

There is no distinct drainage pattern, since the surface material is generally very permeable and most rainfall infiltrates directly into the sandy soil. The existing surface water runoff flows toward closed shallow depressions. The overland flow occurs downgradient, generally via sheet flow. It is envisioned that the stormwater management system will, to the greatest extent possible, retain this general flow regime. This will permit the development of the project with a minimal amount of disruption to the existing environment.

2. Pasco County currently generates an estimated 660 tons per day of solid waste, or approximately 240,000 tons per year. This is expected to increase to approximately 1,160 tons per day or 425,000 tons per year in the year 2010. The East Pasco Sanitary Landfill, east of Dade City, is the only active sanitary landfill site presently serving Pasco County. The Hays Road Landfill will serve the 70% of the population that lives in western Pasco County. See Section 3.7.1 of Volume I for further information on the types and quantities of solid waste.

3. Hazardous wastes, as defined by the U.S. Environmental Protection Agency (EPA) and identified by FDER in Chapter 17-30, FAC, may not be disposed of at the landfill. The small amounts of solvents and household chemicals contained in typical community solid wastes are

not hazardous because they form such a tiny fraction of the total mass of wastes. The overall toxicity of the solid waste should be low.

4. The characteristics of the leachate generated are not known. The indicator parameters selected for the groundwater quality analyses should detect any leachate reaching the groundwater by water quality changes.

   The volume of water infiltrating the landfilled solid waste area is discussed in the following paragraph (Item 5).

5. Disposal System Water Balance. Site Water Budget and Area Uses are discussed in Section 2.3.3 of Volume I. Water infiltrating the solid waste/ash landfilled area will be intercepted by the leachate collection system for treatment and disposal.

6. There are no known existing or expected future pollution sources located within one mile of the site.

7. Information on wells located within one mile of the site is located in Section 2.3.3 of Volume I and Appendix 10.8 of this volume.

8. The Hays Road site was recommended for the construction of a new sanitary landfill for the following reasons:

   - A sanitary landfill at this location should not have any adverse environmental impacts and can be constructed and operated to minimize any impacts upon adjacent land use.

   - A sanitary landfill can be constructed at this site with very minimal potential impacts to groundwater quality.

   - The Hays Road site has a lower annual disposal cost (between $3.00 to $6.00 per ton) than the East Pasco landfill site, primarily because of the higher transportation cost associated with the East Pasco site.

9. Groundwater conditions are described in Section 4.2 of the Jammal & Associates summary report (April 1987, Attachment 2). Measurements are given on Table 3, and groundwater elevation contour maps are included on Sheets 12 and 13. All of the monitor wells can be used to obtain background water quality, as the landfill facility is not in operation. See Item 1.a. above for background water quality data.

10. The waste disposal facilities will consist of an electrical power generating plant which will burn solid waste as fuel and a sanitary landfill co-located at the site. The lined landfill will be utilized for disposal of incinerator residue and bypass solid waste.

11. There are no streams or other surface water flows present at the site.

12. The design, construction and operation plans of the solid waste resource recovery facility, and the sanitary landfill are contained in Appendix 10.6 of this volume.

13. The immediate surrounding land use at the Hays Road site is primarily non-residential, with chicken and tree farms and undeveloped lands on the southern and eastern site boundaries. There is sparse mobile home development on the western and northern boundaries along First Avenue and Bluebird Lane, respectively. The Shady Hills Civic Association recreational complex is located north of the site. A Florida Power Corporation 230 KV transmission line passes through and a substation is located in a residential development north of the site. The natural barriers present on the site, and the access to the site by Hays Road will minimize contact with nearby residents.

4.0 MONITOR WELL SYSTEM

4.1 LOCATION OF MONITOR WELLS

A series of four monitor well clusters have been installed at selected locations around the perimeter of the site as illustrated in Figure 4-1. Each monitor well cluster consists of a surficial aquifer well and a Floridan aquifer well. The surficial monitor wells are designated 2MW1 to 2MW4 while the Floridan monitor wells are designated 4MW1 to 4MW4.

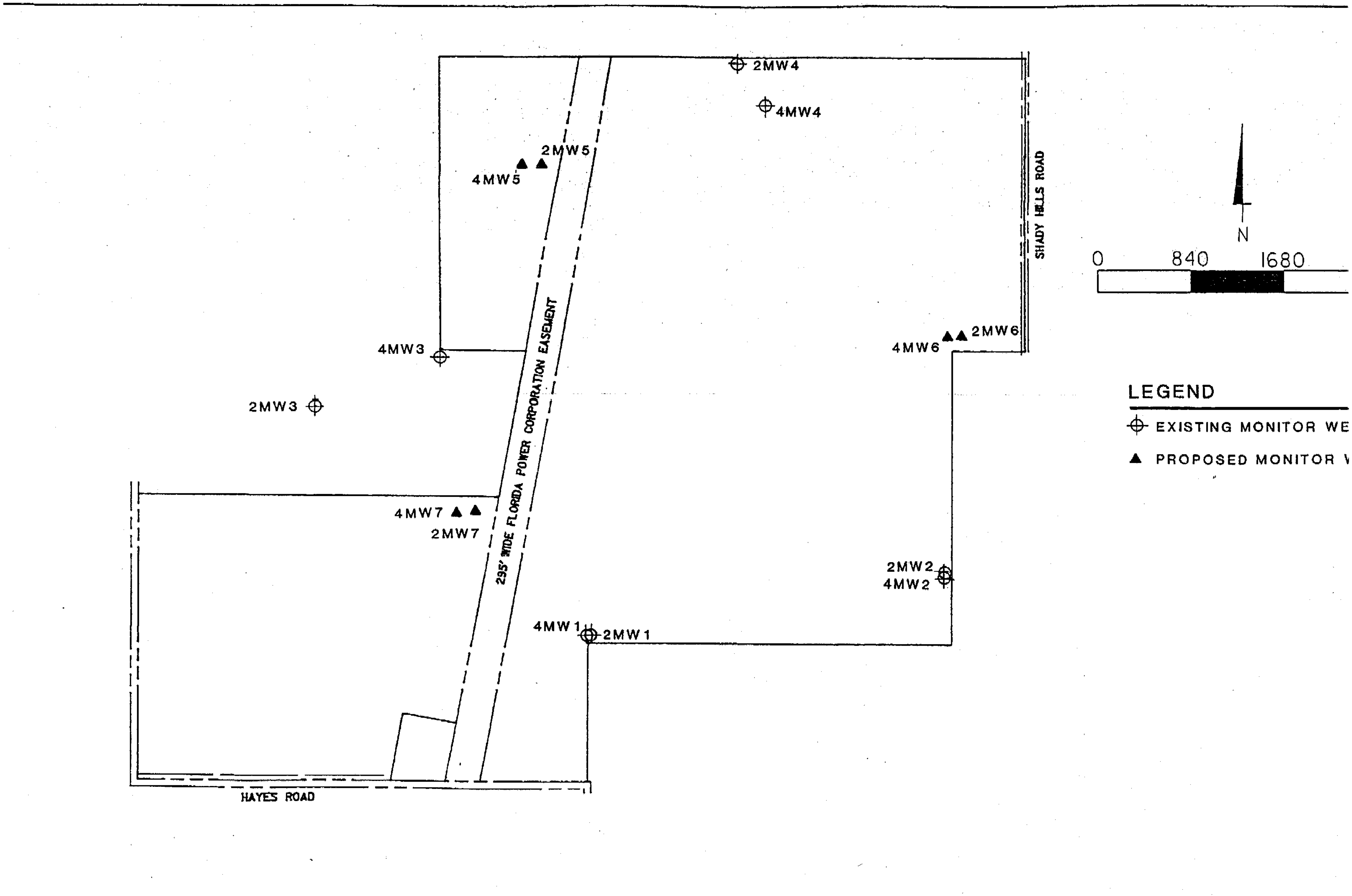
It is recommended that three additional monitor well clusters be constructed in locations which are shown as monitor well clusters 5, 6 and 7 as shown in Figure 4-1. These monitor wells would be used as compliance wells. The background water quality monitor wells would be monitor well 2MW1 for the surficial aquifer and 4MW1 for the Floridan aquifer. The remaining surficial aquifer monitor wells 2MW2 to 2MW4 and Floridan aquifer monitor wells 4MW2 to 4MW4 will be used as compliance wells.

4.2 MONITOR WELL CONSTRUCTION

The surficial aquifer monitor wells are installed generally just above the semi-confining clayey materials. In general, the casings of the deep monitor wells were set and grouted several feet into competent limestone and then an open hole for monitoring the Floridan aquifer was drilled into the limestone.

The well construction details for each of the shallow and deep monitor wells are included in Appendix E, on Plates 1 through 5 of the Jammal & Associates report (April 1987, Attachment 2). Sections 3.3 and 6.2 of the Jammal & Associates report (April 1987) contain further information on monitor well construction.

When construction of the groundwater monitoring system is complete, the following information will be submitted to the Florida Department of Environmental Regulation for all groundwater monitoring wells:



Pasco County Resource Recovery Program
Monitor Wells

FIG

Well identification	Driller's log
Latitute/longitude	Total depth of well
Aquifer monitored	Casing diameter
Screen type and slot size	Casing type and length
Screen length	Direction of groundwater flow in screened zone
Elevation at top of pipe	Well construction permit numbers
Elevation at land surface	Site map showing well location
Elevation at top and bottom of construction zone (screen)	

5.0 GROUNDWATER MONITORING

5.1 SAMPLING PROCEDURES

Upon completion of construction, all new monitor wells will be sampled for the Primary and Secondary Drinking Water parameters included in Chapter 17-22, Florida Administrative Code, Public Drinking Water Systems. The specific parameters to be considered are the Primary [17-22.104(1)] and Secondary [17-22.104(2)] Drinking Water Standards listed in Part II, Quality Standards, Analytical Methods, Sampling.

All groundwater monitor wells will be sampled quarterly at a minimum for the indicator parameters determined from initial water quality analyses. However, additional sample(s) and parameter(s) may be required during the permit period based upon the results or trends of the indicator parameter analyses. Also water levels (ft. msl) will be reported.

Samples from the monitor wells will be taken after a minimum of 3 to 5 well volumes of water have been removed and temperature and conductivity have stabilized. Water samples must be drawn from the aquifer since water which has been stationary and exposed to the atmosphere within the casing will not have the same chemistry as that in the aquifer. The field testing, sample collection and preservation and laboratory testing, including quality control procedures, will comply with Chapter 17-4.246 and 17-3.401, FAC.

Approved methods as published by FDER or as published in Standard Methods, ASTM or EPA methods shall be used. Approved methods for chemical analyses are summarized in the Federal Register, December 1, 1976 (41FR52780), except that turbidity will be measured by the Nephelometric Method.

The groundwater monitoring analyses will be reported on FDER form 17-1.215(2), Quarterly Report on Ground Water Monitoring. The results will be submitted to FDER no later than the fifteenth (15th) day of the month immediately following the end of the sampling period.

If a monitor well becomes damaged or inoperable, FDER will be notified immediately and a detailed written report will follow within fourteen (14) days indicating the problem that has occurred and remedial measures that have been taken to prevent recurrence. All monitoring well design and replacement will be approved by FDER before installation.

6.0 BIBLIOGRAPHY

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Freeze, R.A. and Cherry, J.A. 1979. Groundwater. Prentice-Hall, Inc. New Jersey.

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Jammal & Associates, Inc. April 17, 1987. Summary Report, Geotechnical/ Hydrogeologic Study, Proposed Class I Sanitary/Ash Landfill Site--Hays Road, Pasco County, Florida.

Ryder, P.D. 1985. Hydrology of the Floridan Aquifer System in West-Central Florida. U.S. Geological Survey Open File Report 84-611.

United States Department of Agriculture

Soil Conservation Service

401 S.E. 1st Ave. Rm. 248
Gainesville, FL 32601

Subject: SOI-GPR-Hays Road Site

RECEIVED
SEP 18 1986

Date: September 16, 1986

To: Paul Pilney
Resource Soil Scientist
SCS, Bushnell, FL

File code:

It has come to my attention that there has been some misunderstanding of the results contained in my letter dated July 24, 1986, pertaining to the GPR investigation of the Hays Road site. This letter supersedes the letter dated July 24, 1986, and provides clarification of critical points.

Due to scale limitations, the computer plotted location map contained in the previous letter was not intended to be accurate. The purpose of placing subsurface features on this map was to identify possible lineament features at the site. More detailed locations of subsurface features should be accessed from the radar tapes. To avoid any further confusion, the exact locations of subsurface anomalies due to karstic process which have been identified on the radar tapes are included in tabular form in this report. Error is ± 10 feet.

Another copy of the radar tape is enclosed. Along the top margin are the location markers. In addition, I have identified subsurface anomalies with an "A". Those anomalies which I believe would yield interesting data if drilled are marked with a "**". The horizontal scale of the radar tape is variable, depending on the horizontal speed of the antenna. I, therefore, strongly suggest that GPR be used to exactly locate any subsurface anomalies prior to further investigatory drilling.

On the enclosed tapes, I have highlighted in red the interface between sand and clayey stratum as best I can. The graphic recorder used in this investigation prints radar signals in 16 shades of gray. The darker the signal the more contrasting the interface being measured. The apparent density of this signal on the tape varies. This is a result of one or more of the following conditions:

1. Change in soil moisture content of the overlying sand.

2. Change in amount (%) of clay in the fine earth fraction of the confining layer.

3. Change in minerology of the confining layer.

In general, darker signals will be apparent at the interface of dry sand and material with a high proportion of montmorillonite clays. Where the signal is weak or obscured, I have dashed the line.

The subsurface anomalies identified on the radar tape are a result of karstal processes. Paleo-sinkholes are one feature of a karst topography. These subsurface anomalies have occurred in recent (approx. 15,000 b.p.) geologic history. Not all paleo-sinkholes can be classified as having been catastrophic collapses, such as the one experienced in 1982 in Winter Park. The anomalies identified on the radar tapes are most likely a result of one of the following sequences:

1. The gradual subsidence or sudden collapse of the ground surface into an underground cavity, and subsequent inundation by Holocene sands.

2. The gradual contortion of overlying clayey strata as a result of solution of underlying limestone.

It is my belief that most of the anomalies apparent on the GPR tape can be attributed to the second hypothesis. At the Hays Road site, the karstified limestone is mantled by variable thicknesses of sand and clay. Radar penetration is limited due to the high electrical conductivity of the clay which dissipates the radar signal. However, ongoing karst processes have deformed the overburdened strata by gradual subsidence. Consequently, the radar profile of the clay layer reveals karstic features associated with the underlying limestone. In addition, I believe the hyperbolic features outlined in dashed red lines represent domed intrusions of strata 10 into the upper 10 meters of soil. Further investigation will either prove or disprove this hypothesis.

I hope this has helped in clarifying some of the points presented in the previous letter.

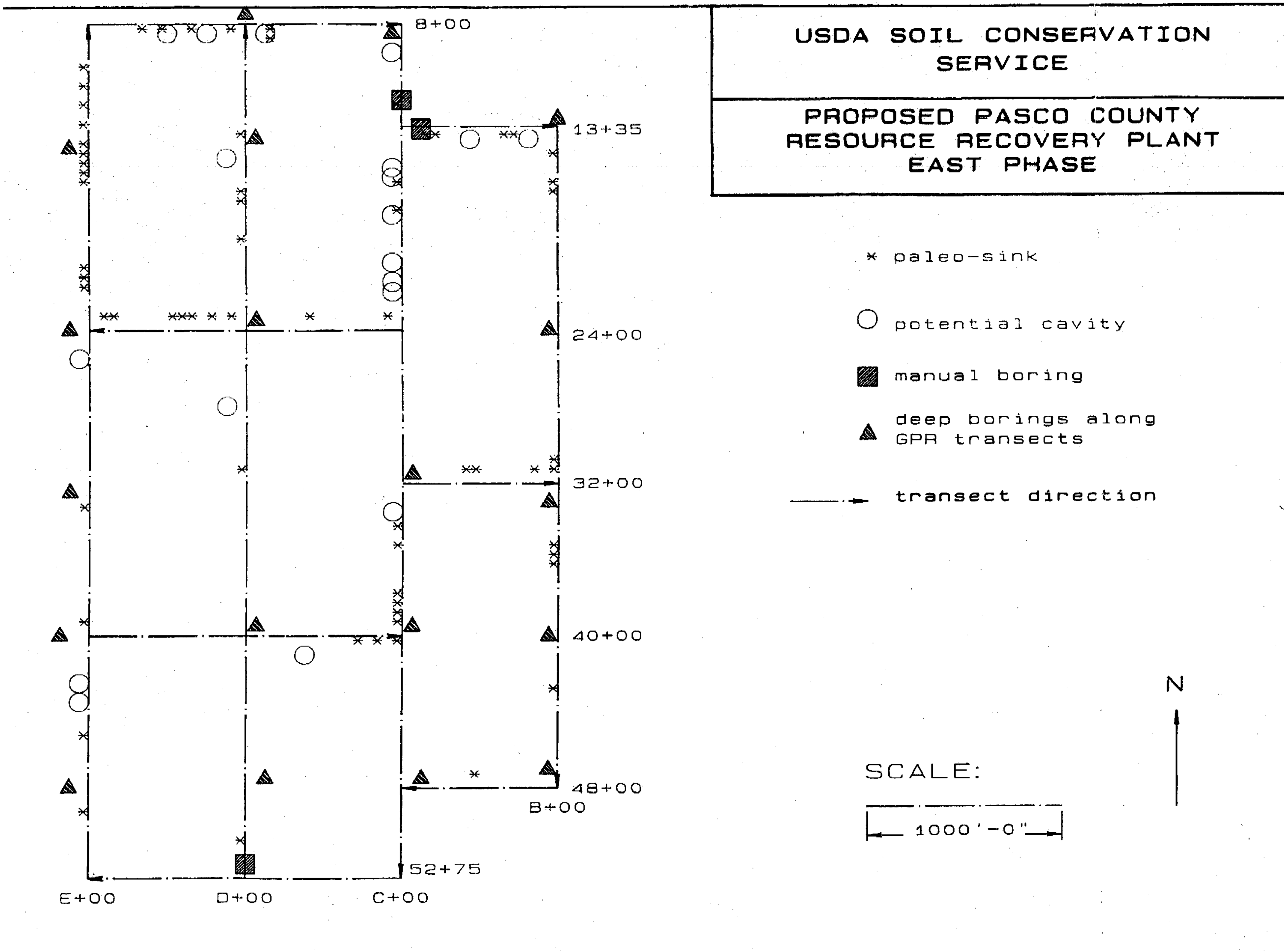
If I can be of further assistance, no not hesitate to call. Please distribute this report to appropriate parties.

G W Schellentrager

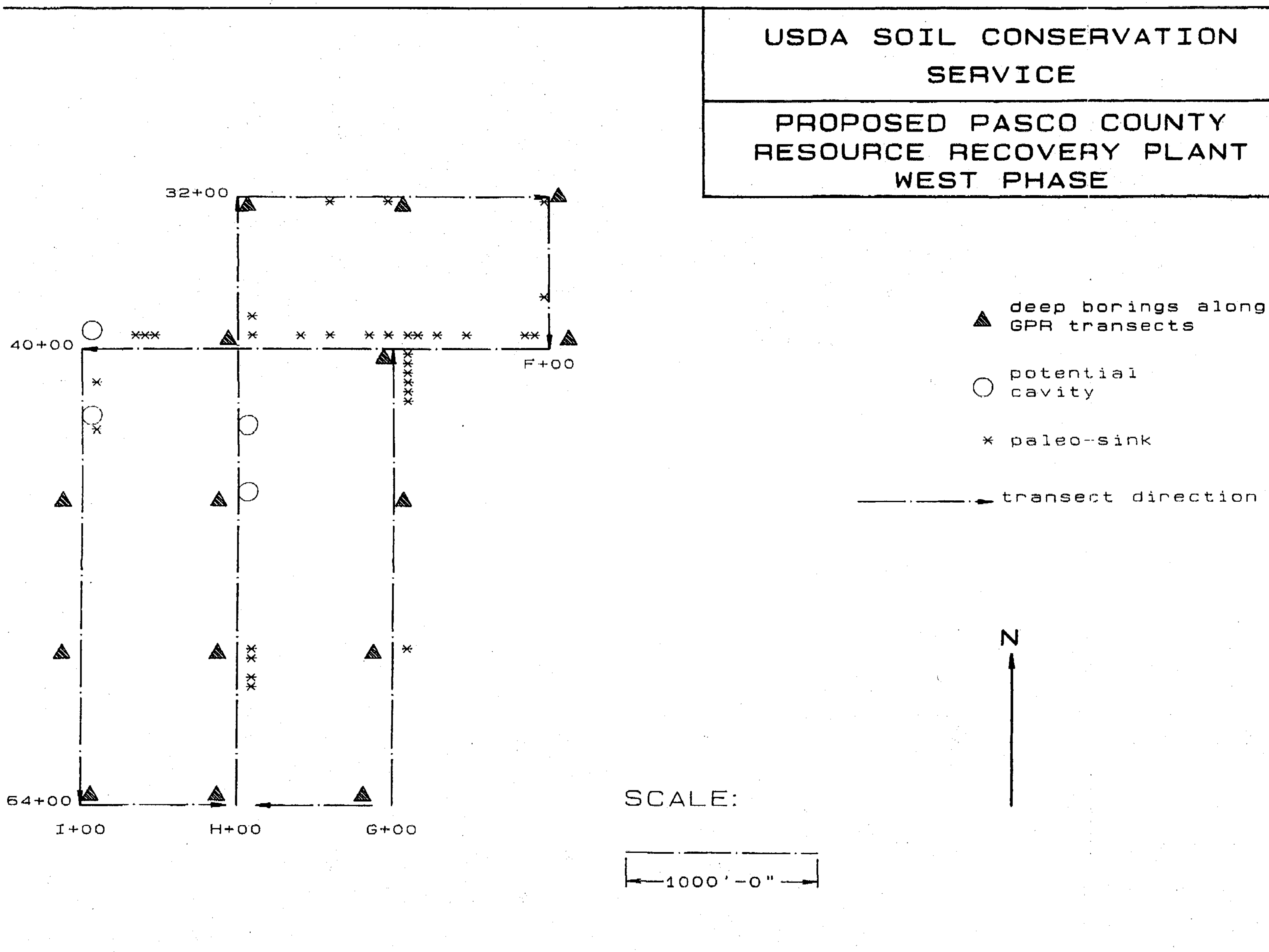
Gregg W. Schellentrager
Soil Specialist (GPR)

Enclosure

cc: Elmer Sauer w/o encl
Mortensen, Jammal & Assoc.



USDA SOIL CONSERVATION SERVICE
PROPOSED PASCO COUNTY RESOURCE RECOVERY PLANT EAST PHASE
8+00
13+35
24+00
32+00
40+00
48+00
B+00
52+75
E+00
D+00
C+00
* paleo-sink
potential cavity
manual boring
deep borings along GPR transects
transect direction
SCALE:
1000'-0"
N


USDA SOIL CONSERVATION SERVICE
PROPOSED PASCO COUNTY RESOURCE RECOVERY PLANT WEST PHASE
32+00
40+00
64+00
F+00
I+00
H+00
G+00
deep borings along GPR transects
potential cavity
* paleo-sink
transect direction
N
SCALE:
1000'-0"

HAYS RD. SITE: SUBSURFACE ANOMALIES[1]

transect E:
49+10
42+80
43+40
44+50**
44+90
46+50
39+50
33+80
24+80
21+00
20+50
19+90**
10+90*
11+90
12+70
13+50
14+20**
14+90
15+30**
15+60
15+80

transect 8+00:
D+100 **
D+210
D+310
D+420
D+440
D+550
C+640
C+720**

transect C:
15+50**
15+90
12+40
9+30
17+10
18+10
19+30**
20+00
20+40
21+50
21+90
23+20
34+70
35+50**
38+00*
38+50
39+40
39+60
39+90

transect D:
13+90**
19+70**
17+30
17+10
31+20
28+10
51+80

transect 13+35:
B+140**
B+220
B+240
B+460
B+510
B+590

transect B:
14+40
15+90
16+20
30+80
31+50
35+30
35+60
36+10
43+10

transect 48+00:
B+440

transect 40+00:
C+110
C+210**
C+480
C+10**

transect 32+00:
B+80
B+140
B+440
B+500

transect 24+00:
C+80**
C+510
D+100
D+200
D+300**
D+350
D+380
D+650
D+750

potential lack of dense clay:
C 46+10 to 47+10
C 50+00 to 49+50
52+75 C+100 to C+300

*: secondary drilling site
**: primary drilling site
1: expected error is (+) or (-) 10 feet

September 30, 1986
Project No. 85-30267

TO: Camp Dresser & McKee, Inc.
555 Winderley Place
Maitland, Florida 32751

Attention: Mr. Dan Morrical, P.E.

SUBJECT: GPR Testing and Discussion with USDA
Proposed Pasco County Landfill-Hays Road Site
Pasco County, Florida

Dear Mr. Morrical:

As you know, I met with Mr. Greg Schellentrager with the USDA on September 15, 1986, at my office here in Tampa. Briefly, at the meeting we discussed some of our comments and concerns regarding the initial letter that he forwarded to all parties concerned on July 24, 1986, pertaining to the GPR investigation at the Hays Road landfill site. I discussed with Mr. Schellentrager several of my concerns which primarily included some scaling mistakes, stationing errors that we had discovered and some other discrepancies that we noted in our review of the actual GPR tapes and comparing them to his letter and computer plot which summarized the results of his initial evaluation. At the outcome of our meeting, Mr. Schellentrager agreed to resubmit a letter to all parties concerned clarifying the discrepancies.

Also, at our meeting, I discussed our concern relative to some verbage he utilized in his July 24th letter; specifically where he talked about "paleo-sinks" and "potential cavities". I mentioned to him that these were strong or extreme terms, when considering the very generalized nature of the results associated with GPR investigations. I felt it was not appropriate at this time, to utilize these terms unless actual ground truth test borings were performed to justify those descriptions. Instead, I suggested that features which he felt were potential concern areas be termed "subsurface anomalies"; he agreed. Afterwards, I asked him if he could identify, on another set of tapes, those "subsurface anomalies" that he would like to see drilled during our Phase II borings; in other words, identify those features on the tape which he feels would probably produce some discontinuity during the drilling process.

Last week, I received the revised letter from Mr. Schellentrager. A copy of this letter is attached. He has included a table of "subsurface anomalies", where on that table, he has identified primary drilling sites and secondary drilling sites. In order to accurately locate these "subsurface anomalies" in the field, it was decided to utilize the GPR machine out in the field to relocate these positions for purposes of ground truth test borings.

As recently discussed with Mr. Dick Schlemmer in your Clearwater office, the GPR locating of these Phase II test boring areas will be conducted on Friday, October 3, 1986, at the site. Talking with Mr. Tietz yesterday, he will be at the site also at 8:00 to 8:30 in the morning. The Phase II boring locations will be staked on Friday. We recommend that the locations that he has selected as being primary and secondary drilling sites, be ground truth tested during our Phase II boring program, to properly address the issue and effectively utilize the GPR data. Approximately twenty (20) test boring locations are planned in our Phase II investigation.

Along with the letter from Mr. Schellentrager, I was suppose to receive the new radar tapes from the initial GPR investigation at the site. On these tapes Mr. Schellentrager was going to locate areas of inconsistent clay confining unit and areas of continuous clay confining unit. Inadvertently, these tapes were sent to Mr. Tietz instead. I am in the process right now of obtaining them from Mr. Tietz.

We plan to proceed with our Phase II drilling program on Monday, October 6th. On Friday, I plan to attend the meeting at the site with Mr. Schellentrager and Mr. Tietz to locate the

Phase II test borings. Surveyors can tie down these new locations as well as the monitoring well locations later next week.

As a separate note, one of the deep wells that we had installed at the Pasco County landfill site was vandalized and filled with sand. The 4-inch PVC pipe was damaged and broken. This necessitated drilling a new deep well adjacent to the previous one that we just installed. Also, regarding the wells, they should all be developed this week; therefore, next week sometime they would be available for water quality sampling.

If you have any questions about this letter, please give me a call. If not, we will probably see you on Friday, October 3rd at the site.

Sincerely,

JAMMAL & ASSOCIATES, INC.

Richard A. Mortensen, P.E.
Tampa Regional Manager

RAM/bp
1191M

Attachment: Letter from USDA dated September 16, 1986

cc: Mr. Bob Hauser
Mr. Dick Schlemmer

United States Department of Agriculture

Soil Conservation Service

401 S.E. First Ave. Rm. 248
Gainesville, FL 32601

Subject: SOI-GPR Investigation of Proposed Pasco County Landfill - Hays Road Site

Date: July 24, 1986

To: Paul Pilney
Resource Soil Scientist
SCS, Bushnell, FL

File Code: 430-13

Enclosed are the tapes of GPR investigation conducted on 29 May '86 at the proposed Pasco County Landfill Site. The tape has been depth scaled at the beginning of the first transect and all transects have been identified. Depth scale error should be expected to be ± 5 inches.

Due to the massive amount of data collected, I have not traced the confining clay layer throughout the entire tape. However, you will find that I have identified the clay signal at the beginning of transect E 52+75. Additionally, I have highlighted an observed paleo-sink feature for reference at E 44+50 and a potential cavity/limestone layer at E 43+50 and E 42+50. If there are any questions concerning specific portions of the tape, I will be glad to discuss them with interested parties.

Along the top margin of the tape you will find symbols which I have used to identify subsurface features consistent with a karst landscape. A "x" is used to identify a paleo-sink, a "o" is used to identify a potential cavity/limestone surface and a "⊗" is used to identify a paleo-sink of major contrasting features. A "∇" has been used to identify locations of borings conducted by Jammal & Associates, Inc.

The radar results correspond remarkably well to the boring data generated by Jammal & Associates, Inc. Some variations may be expected. These may be grouped in two categories: (i) sampling errors, and (ii) in-site soil conditions.

(i) Sampling errors most often may be attributed to depth-scaling radar imagery from borings not taken directly beneath the radar antenna path. The GPR images only those subsurface features which pass beneath it. In a karst area such as the Hays Rd. site, soil and geologic structures change rapidly over a horizontal distance. Consequently, boring conducted 50 to 100 feet away from the radar's path (such as transect E 52+75 to E 8+00) may exhibit some deviation from the radar record.

(ii) Ground-Penetrating Radar actually detects and records changes in soils electromagnetic properties. The rate and subsequently depth of penetration of a radar signal is governed by an electromagnetic property called the dielectric constant by the following equation:

$$d(m) = tp(ns) \left(\frac{0.15}{\sqrt{\varepsilon_R}} \right)$$

where: d(m) is distance to interface in meters
t(ns) is the two-way travel time to the interface in nanoseconds (ns)
ε_R is the relative dielectric constant of the medium.

From this equation you can see that any increase in relative dielectric constant will decrease the depth of penetration at a set travel time. Soils do not have homogenous dielectric properties. The conductivity and subsequent dielectric constant of earthen materials increases with moisture content, the concentrations of salts in solution, and the amount and type of clay in the matrix. Consequently, a uniform depth scale applied to a non-uniform soil medium may be misleading. However, with our current state of knowledge of electromagnetic wave propagation in earthen materials, we must accept this error.

Sinkhole prediction, as is earthquake prediction, is a risky business. Only minimal degrees of accuracy have yet to be attained. However, by studying the underlying formations of rock and clay, we may observe the recent history of sinkhole occurrence in an area.

Over time, in a humid climate such as Florida, underlying highly soluble limestone is dissolved. Gradually, caverns form and fractures widen. The overlying sand and clay materials begin to contort and conform with the underlying limestone surface. It is these type of features which we attempted to observe with GPR in order to ascertain the degree of Karstal processes of an area.

On the enclosed site maps you will see areas which I have observed to indicate paleo (or ancient) sinks and potential cavity/limestone surface areas. While the radar signals representing paleo-sinks are obvious, those representing cavities/limestone surface would require further ground truth observations in order to confirm their presence.

I hope this information has been of some use to you. If you have any further questions, do not hesitate to call.

Gregg W. Schellentrager
Soil Specialist (GPR)

cc: w/o encl:Elmer Sauer
w/encl: D. Morrical, C.D.M.

TECHNICAL APPENDIX G

LEACHATE DEPTH CALCULATIONS

PAS7C.6/8
11/12/87

REFERENCE: EPA SW-869 APRIL 1983, LANDFILL AND SURFACE IMPOUNDMENT PERFORMANCE EVALUATION

For a liner system designed w/a slope α;

$$h_{max} = \frac{L}{2N}\left[\sqrt{\frac{e}{Ks} + TAN^2\alpha} - TAN\alpha\right]$$

where: L = Length of spacing between drainlines

N = Porosity

Ks = Permeability

e = Rate of Impingement (use 1/2 x average annual rainfall)

α = Slope

h_{max} = Maximum head

Assume:

Porosity = N = 0.34

Permeability = K_{si} = 7.76×10^{-3} cm/s, 22 ft./day

Rate of Impingement = e = 1/2 of 53.95 in/yr

= 2.20×10^{-6} cm/sec

Slope = α = 2% = 1.146°

h_{max} = 12" = 30.48 cm

Calculation:

$$30.48 = \frac{L}{2(0.34)}\left[\sqrt{\frac{2.20 \times 10^{-6}}{7.76 \times 10^{-3}} + TAN^2(1.146)} - TAN(1.146)\right]$$

$$30.48 = \frac{L}{2(0.34)}[0.00614]$$

3371_{cm} = L = 110′ maximum spacing between drainlines

USE 2% SLOPE W/100′ PIPE SPACING

NOTE: 53.95" Avg. Annual Rainfall for Brooksville, 1950-80

ATTACHMENT 1

PLANS

ATTACHMENT 2

SOILS AND GEOTECHNICAL REPORT

SUMMARY REPORT
GEOTECHNICAL/HYDROGEOLOGIC STUDY
PROPOSED CLASS I SANITARY/ASH
LANDFILL SITE - HAYS ROAD
PASCO COUNTY, FLORIDA

JAMMAL & ASSOCIATES, INC. Consulting Engineers

MEMBER
Associated Soil and Foundation Engineers, Inc.
American Consulting Engineers Council
National Society of Professional Engineers
Florida Institute of Consulting Engineers
American Society for Testing and Materials
American Concrete Institute

6313 Benjamin Road, Suite 101, Tampa, Florida 33614 Telephone (813) 886-1075

JAMMAL & ASSOCIATES, INC. Consulting Engineers

April 17, 1987
Project No. 85-30267

TO: Camp, Dresser, & McKee, Inc.
1321 U.S. 19 South, Suite 601
Clearwater, Florida 33546

Attention: Mr. Lou Tortora, P.E.

SUBJECT: SUMMARY REPORT
Geotechnical/Hydrogeologic Study
Proposed Class I Sanitary/Ash
Landfill Site - Hays Road
Pasco County, Florida

Dear Mr. Tortora:

Please find enclosed herein our summary report which includes the results of our geotechnical/hydrogeologic study of the proposed Class I sanitary/ash landfill site off of Hays Road in northwest Pasco County.

Thank you for this opportunity to be of service to you and Pasco County on this significant and challenging project. If you have any questions during your review of the report, please do not hesitate to give either Mr. S.E. Jammal or myself a call.

Sincerely,

JAMMAL & ASSOCIATES, INC.

Richard A. Mortensen, P.E.
Vice President

S. E. Jammal, P.E.
President

RAM/bp:1498M

Attachment: Summary Report

Geotechnical Engineers, Hydrogeologic Consultants & Materials Testing Engineers
6313 Benjamin Road, Suite 101 ■ Tampa, Florida 33634 ■ Telephone (813) 886-1075
Principal Office: Winter Park, Florida ■ Regional Offices: West Palm Beach, Ormond Beach, Ocala, Florida

TABLE OF CONTENTS

GEOTECHNICAL AND HYDROGEOLOGIC INVESTIGATION
PROPOSED LANDFILL SITE - HAYS ROAD
PASCO COUNTY, FLORIDA

1.0 INTRODUCTION

1.1 Purpose and Scope of Geotechnical and Hydrogeologic Study

The primary purpose of our geotechnical/hydrogeologic study over the selected or proposed landfill site (Hays Road Site) was to address some of the permitting requirements setforth in Chapters 17-4 and 17-7 of the Florida Administrative Code (F.A.C.) relating to the geotechnical and hydrogeological aspects of implementation of a Class I sanitary/ash landfill. In addition, because of the site's topographic, geologic and hydrogeologic conditions, it was our intention to address in detail the future potential for sinkhole activity over the project site and to discuss soils and groundwater data relevant to this phenomenon.

Our initial study or evaluation of the Hays Road site was submitted to Camp, Dresser & McKee, Inc. in our report dated August 17, 1985 (Project No. 86-30225). In that report four (4) potential landfill sites were investigated, three in northwest Pasco County and one in eastern Pasco County. The results suggested that the Hays Road site was the most favorable of the three sites in northwest Pasco County for implementation of a sanitary/ash landfill, in terms of the geologic and hydrogeologic conditions and implications. The results of our preliminary study were based on our review of available literature, topographic, geologic and hydrogeologic maps of the site, and a very limited test boring program.

The primary objectives of our final level evaluation of the Hays Road site, as presented herein, was to collect adequate subsurface soil and groundwater information over the project site in order to provide geotechnical and hydrogeologic input and recommendations in each of the following areas:

1. Identify favorable areas over the project site for implementation of a sanitary/ash landfill.
2. Identify favorable areas on-site for acquisition of daily sand cover material.

3. Identify favorable areas on-site for implementation of the stormwater management disposal system.

4. Identify and evaluate the soil stratigraphy and upper limestone conditions over the project site. Determine and evaluate the thickness, integrity and permeability of the semi-confining clayey unit separating the shallow watertable aquifer from the deeper Floridan Aquifer. Identify areas of favorable and unfavorable semi-confining unit conditions.

5. Identify and evaluate the groundwater conditions, flow directions and gradients over the project site. Identify and evaluate the potentiometric levels of the Floridan Aquifer. Discuss Floridan Aquifer recharge potential over the project site. Discuss groundwater considerations relating to the design and construction of the landfill.

6. Determine and evaluate the compressibility characteristics of the subsurface materials in order to address the settlement potential and magnitudes of the landfill mass under the anticipated landfill heights.

7. Discuss and evaluate the ground penetrating radar (GPR) data collected over the project site by the United States Department of Agriculture (USDA). Discuss the impacts of this data on the project and the corresponding ground truth test boring results, specifically drilled in GPR concern areas identified by USDA.

8. Discuss final clayey cover material considerations, on-site sources and implications, and potential off-site needs.

9. Evaluate and discuss the potential for future sinkhole activity over the proposed landfill site. Discuss the potential risks of future sinkhole activity. Discuss potential sinkhole sizes and depths. Discuss, in general, sinkhole related processes and mechanisms.

10. Perform a literature well inventory within a 2 mile radius of the project site, considering data collected from the Southwest Florida Water Management District (SWFWMD) and the United States Geological Survey (USGS).

11. Generate and design the necessary groundwater quality monitoring well network for the proposed landfill facility in general accordance with Chapter 17-4. Provide proposed groundwater monitoring well construction details.

1.2 Project Description and Location

The proposed sanitary/ash landfill site studied herein is shown located on the Pasco County Site Location Map included on Sheet 1. On Sheet 1 the proposed landfill site is shown with respect to local county roads, existing wellfields in Pasco County, and location with respect to township, section and range. The area studied herein encompasses approximately 810 acres and has been termed the Hays Road Site.

We understand that it is proposed to develop the favorable portions of the site studied herein into a Class I sanitary/ash landfill. It is anticipated that, adjacent to or just south of the landfill, a resource recovery plant will be constructed. It is anticipated that both raw refuse and ash generated from the resource recovery plant will be disposed of at the proposed landfill site. Because of the physiographic setting of the site a lined landfill is anticipated. The landfill height is anticipated on the order of 75 to 100 feet.

1.3 Topography and Site Description

The project site is shown located on recent aerial topographic maps prepared for our use by Camp, Dresser & McKee, Inc. The scale of these aerial topographic maps is 1"=200'. The aerial topographic maps are included as Sheets 2, 3 and 4. The topographic maps present approximately one foot ground elevation contour intervals over the entire project site. The site boundaries are also shown located on the maps.

In general, the ground surface over the project site varies from low elevations in the vicinity of +35 feet MSL to higher elevations on the order of +55 feet MSL. Over the southwestern and western portions of the site, and also in the northeastern portions of the site, several closed circular depressional areas are present and evident on the site aerial topographic map. Over the southeastern and central portions of the project site, the ground elevations are, in general, fairly consistent, varying from +45 to +52 feet MSL. In general, over the southeastern and central portions of the site, no significant depressional areas are evident.

In the northern portion of the project site, a relict drainage ditch is present, as evident on the aerials. This ditch varies from approximately 5 to 8 feet lower than the surrounding grade on either side of the ditch. It appears, based on visual observations of the ditch, that it has been dry for a considerable length of time. During our study of the project site, no water was observed in this ditch. In any event, this feature is very distinct and is evident on nearly all maps of the site.

A Florida Power Corporation easement, approximately 295 feet wide, runs generally north-south through the entire project site. The easement is identifiable on the aerial topographic maps (Sheets 2-4). A small outparcel that includes the Florida Power Substation is located on the south end of the site, just off Hays Road.

At the time of our field investigation, the majority of the project site, which was formerly a pine tree farm, was cleared by the previous landowner of nearly all the pine trees. Some pine trees remain in the northeastern portion of the site, as evident on the aerials. Over the majority of the site east of the power easement, generally underbrush, weed growth, and tree trunks are present. West of the Florida Power easement, in general, the site is near its natural state, which primarily consists of sparse to moderate tree growth and underbrush.

In the southwestern portion of the project site, west of the Florida Power easement, several of the closed circular depressional areas contain standing water. These depressional areas and water elevations are identifiable on the topographic maps provided on Sheets 2-4.

In the northern portion of the site, a concrete block house-like structure is present and is somewhat visible on the aerial topographic map. Near this structure an old deep water well is present. No information was available about this well. Aside from this abandoned structure, it does not appear that the site was developed for other purposes, other than tree farming or pastureland.

2.0 REGIONAL GEOLOGY AND HYDROGEOLOGY

2.1 Physiographic Setting

The proposed Pasco County landfill site is located within the Gulf Coastal Lowlands physiographic province along the west coast of Florida. In this portion of Pasco County, the Gulf Coastal Lowlands province is bounded on the east by the Brooksville Ridge, a distinct north-south trending sand ridge reaching altitudes of about 300 feet above mean sea level (MSL). To the west of the ridge, land surface elevations decline to MSL along the gulf coast. Two major erosional terraces, the Pamlico Terrace and the Wicomico Terrace, occur between the Brooksville Ridge and the coast. The Wicomico Terrace is marked on its seaward face by a break in land surface slope at an altitude of around +100 feet MSL. Farther west, a distinct break in slope again occurs, at an altitude of +25 feet MSL, delineating the seaward scarp of the Pamlico Terrace. The proposed Pasco County landfill site is situated within the Pamlico Terrace, westward from the Wicomico scarp.

The project site is situated in a relatively flat section of the Pamlico Terrace. More rugged topography with greater local relief occurs to the east and northeast. Relief within the project site ranges from about 20 to 30 feet in the southwestern portion and about 10 feet throughout the remainder of the project area.

Numerous lakes and ponds exist to the south of the proposed landfill site. This area is drained primarily by Buckhorn Creek and the Pithlachascotee River. The major surface water feature in the vicinity of the project site is Crews Lake, a linear, northeast-trending lake located about 1.5 miles to the east.

2.2 Regional Geology

The principal geologic formations in Pasco County are comprised primarily of a thick sequence of limestones and dolostones. The uppermost limestone formation identified in northwest Pasco County is the Tampa Limestone, or in areas where the Tampa is not present, the Suwannee Limestone.

The surface of the limestones is mantled throughout the county by interbedded deposits of sand and clay which may range in thickness up to as much as 250 feet within Pasco County. The lower portion of the sand and clay deposits in Pasco County are generally assigned to the Hawthorn Formation, a deposit comprised primarily of clays. According to available data, the Hawthorn Formation is absent in areas north of Pasco County, is relatively thin in the eastern portion of the county, and thickens appreciably to the south towards Tampa Bay. The Hawthorn Formation is overlain by deposits of quartz sand which form the present land surface.

A brief description of the various geologic and hydrogeologic units and their stratigraphic position within Pasco County is presented on Tables 1 and 2. The table does not differentiate the Hawthorn Formation from the contemporaneous deposits of the Tampa Limestone, owing to the similar lithology of each unit. That differentiation is made, as shown on the geologic cross section presented on Figures 1 and 2. An interpretation of geologic formations serving as the basis for the cross-section is presented on Tables 1 and 2.

2.3 Groundwater Systems

Two distinct water-bearing geologic units, or aquifers, able to supply economical quantities of water to wells occur within the western portion of Pasco County. The uppermost of the two is the water table aquifer, comprised of the permeable portions of the unconsolidated deposits overlying the limestones. The limestone formations are generally considered to form the skeleton of the deeper Floridan Aquifer, an artesian and sometimes unconfined aquifer system which underlies most of central Florida.

The water table aquifer is recharged primarily by precipitation and subsequent infiltration to the saturated zone. Water is discharged from the aquifer by evapotranspiration, seepage to lakes and streams and by vertical leakance to underlying aquifers.

The water table aquifer is apparently relatively thin in western Pasco County and according to some studies may be absent or discontinuous in some areas. The transmissivity, or ability to transmit water, of the water table aquifer is dependent upon the permeability of the aquifer deposits and the saturated thickness. In areas where the surficial sand deposits are thin, the transmissivity of the unit typically is comparatively less than in areas where the deposits are thicker.

The upper water table aquifer in western Pasco County is seldom used for a water supply source primarily because deeper aquifers supply greater quantities of better quality water to wells. Consequently, hydraulic characteristics of the water table aquifer are not well documented in Pasco County.

The regionally extensive Floridan Aquifer is the main water supply source throughout most of Florida. In Pasco County, the Floridan Aquifer is considered to consist of the Miocene, Oligocene and Eocene age rocks, primarily limestones and dolostones. As shown on the geologic cross-section (Figure 2), the top of the Floridan Aquifer in Pasco County is represented by either the Miocene Tampa Limestone or the Oligocene Suwannee Limestone. According to some studies, the top of the Floridan Aquifer occurs at an altitude of near mean sea level in northwest Pasco County. The aquifer becomes progressively more deeply buried beneath the surficial clastic deposits with distance southward. The increasing depth to the top of the Floridan Aquifer in the southerly direction reflects the regional dip of the upper Eocene and younger beds from the axis of the Ocala Uplift farther to the north.

Groundwater flow in the Floridan Aquifer in Pasco County moves generally westward towards the Gulf of Mexico from the well known "Pasco High" centered in the eastern part of the county. The "Pasco High" represents an area of highest altitude of the potentiometric surface of the Floridan Aquifer. The elevation of the potentiometric surface in this area is generally about

+80 to +90 feet MSL. Groundwater moves from the "Pasco High" downgradient to discharge areas along the gulf coast. The elevation of the potentiometric surface is generally less than +10 feet MSL along the coast. The general westward flow is locally perturbed by discharge from numerous springs situated near the coast. Larger springs, such as Weeki Wachee, discharge copious quantities of groundwater from the Floridan Aquifer. Smaller springs and local seepage areas discharge water from the aquifer as base flow to the river drainage systems in southern Pasco County. A recent potentiometric surface of the upper Floridan Aquifer map, showing the site location, levels and regional flow directions, is included on Plate 2 in Appendix A.

Based on available publications, the transmissivity of the Floridan Aquifer in this area of Pasco County is highly variable; varying from about 40,000 to 130,000 $ft.^2/day$. The natural leakance rate through the semi-confining clayey unit in this area of Pasco County, in general, varies from about 5×10^{-3} to $5 \times 10^{-4}/day^{-1}$. Based on the map on Plate 2 in Appendix A, the potentiometric surface of the Floridan Aquifer in September 1986 in the general site vicinity of the proposed landfill was on the order of about +35 to +37 feet MSL.

2.4 General Sinkhole Related Processes and Mechanisms

Sinkholes in Florida are the result of the geologic and hydrologic setting of the Florida Peninsula. The entire state is underlain to various depths with limestones and dolostones which are susceptible to dissolution from groundwater. Depending on factors such as the extent of dissolution, depth from land surface to the top of limestone, the hydrogeology of the area, the extent of recharge to the limestone from unconsolidated sediments that overlie the limestone, and the amount of circulation within the limestone, sinkholes may be experienced to varying degrees of frequency and severity. The extent of the sinkhole occurrence, then, depends on the particular geologic and hydrogeologic conditions of the area in question.

Where extensive subsurface chemical weathering and dissolution of limestone has taken place during geologic times, a reduction of subsurface limestones has slowly occurred, resulting in downward movement or deformation of the surface of the ground. Where such solution becomes a dominant process in land development it results in the production of a unique type of topography that is commonly referred to or described as Karst topography. Karst is a comprehensive term applied to areas underlain by water soluble rocks such as dolostones. These areas possess a topography particular to and dependent upon underground solution activity and the diversion of surface waters to the underground. Karst topography is abundant within the central portion of the State of Florida and is particularly evident within the western-central Gulf Coast counties.

The geologic and hydrogeologic conditions that are a prerequisite for the optimum development of Karst may be summarized as follows:

1) Soluble limestone at or near ground surface,

2) The limestone should be dense, highly jointed, and thin bedded,

3) Major entrenched valleys exist in a position such that groundwater can emerge into surface streams,

4) The region should have a moderate to abundant rainfall.

Subsidence (including sinkholes) in faulted recharge areas is common where the features listed below are prevalent. No one feature is mandatory, but the greater number present, the greater the subsidence susceptibility.

1) shallow, flat-lying aquifers encompassing large areas,

2) seasonal fluid level fluctuations (e.g. piezometric levels),

3) Pliocene or younger bedding,

4) clay interbeds,

5) fine grained aquifers,

6) groundwaters contain low chloride and carbonate levels, and/or are acidic,

7) near surface solution and erosion of underlying limestone,

8) little dolomitization of the limestones, and

9) topography diverts infiltration towards the faults.

By comparison, faulted areas with poor subsidence susceptibility,

1) contain significant cementation of the intergranular structure and/or a high degree of sand packing, hence low porosity and permeability.

2) may have experienced preconsolidation from a previous period of deep burial, or

3) experience little solution activity.

In northern and central Florida sinkholes have resulted from numerous breeches in the confining beds overlying the artesian aquifers. Thus, water is free to move downward to these aquifers through fractures and the permeable sand bottoms of sinkholes (if the watertable is higher than the potentiometric surface). This is the primary method of recharge. Where the water table is considerably higher than the potentiometric surface, recharge may also be accomplished by slow percolation through low permeability beds. The infiltrating recharge waters are especially active in areas where clastics typically overlying the Tertiary limestones were never deposited, have been stripped away, or are relatively thin. Researchers indicate that initial flow causes pronounced solution particularly in the upper zones, because of the shorter flow lines involved, greater circulation, and higher reactive ion concentrations.

Potentiometric surface maps have been prepared by the Florida Department of Natural Resources (and local SWFWMD) to determine areas of recharge, discharge, and direction and rate of groundwater movement. Groundwater moves from high pressure to low pressure zones in a direction perpendicular to the pressure contour lines. Potentiometric mounds, (referred to as "highs"), usually indicate areas of recharge to the aquifer. Potentiometric depressions or troughs, (referred to as "lows"), usually indicate areas of discharge from the aquifer. Recharge and discharge thus may take place anywhere from the high to the low where hydrogeologic conditions are favorable. Thus, there is no single point of recharge or discharge.

Groundwater in the central part of Florida moves outward in all directions under the influence of an elongated potentiometric high which extends approximately from central Lake County to southern Highlands County. This is generally referred to as the "Polk high". A smaller potentiometric high in Pasco County, commonly referred to as the "Pasco high", is also recognized. Water entering the aquifer in central Florida in general, is less mineralized than water already in the aquifer. Water entering is low in mineral content because the overlying sands and clays generally are less soluble than the limestones of the Floridan Aquifer. Therefore, in recharge areas the mineral content of the water should increase as the water moves through the aquifer until it becomes saturated with calcium and bicarbonate. Using only the mineral content to indicate areas of recharge could be misleading because water entering the aquifer in some areas could be more highly charged with carbon dioxide than in other areas.

A review of the literature indicates lack of consensus or uniformity in classifying sinkholes. Basically, however, there are two major types or classes of sinkholes, namely; a collapse sinkhole and a ravelled sinkhole. Sinkholes in Florida fall in both of the above classes, however, ravelled sinkholes are the most common, and typical in Pasco County as well as surrounding areas.

A collapse sinkhole is the result of collapse of the roof of a cavity within the limestone. This collapse is followed by a drop down of the overlying unconsolidated sediments which were supported by the limestone roof. Collapse sinkholes are normally steep sided, rocky and abruptly descending forms. This implies a structural break or collapse of the limestone and, hence, is referred to as a "collapse sinkhole". There is wide acceptance of the usage of collapse sinkhole to suggest this type of sinkhole and mechanism. Figure 3 is an illustration of the collapse sinkhole type and mechanism.

A ravelling sinkhole is often referred to as a solution sink, erosion sink, soil condition sink and less frequently, doline sink. This type of sinkhole originates within limestones containing openings or cavities at the interface of the limestone and the overlying unconsolidated sediments. This type of sinkhole initially developes slowly where soil from the overburden materials gradually erode into openings present within the limestone. Slow, long-term, continual erosion and ravelling of soil materials into the limestone, develop a cavity or a dome within the overburden, which, under favorable hydrogeologic conditions, can continue to enlarge and work upward towards land surface. The action of water percolating downward to the limestone enhances the development of such a dome within the unconsolidated sediments. As the dome or cavity within the unconsolidated material enlarges, a point is reached where the soil which overlies the dome can no longer bridge the opening, and, under favorable conditions, the material above begins to collapse and fall into the underlying opening. Figure 4 is an illustration of the mechanism of a ravelled sinkhole. Ravelled sinkholes range from funnel shaped depressions that open upward to pan or bowl shaped.

Ravelled sinkholes are formed in environments with some or all of the following physical characteristics:

- Limestones which contain openings and are overlain by unconsolidated sediments. Overburden sediments may range from a few feet to 150 feet in thickness.

- Cavity systems must be present in the limestone and must extend upward to be in contact with overlying sediments.

- The elevation of the water table must be higher than the potentiometric surface elevation of the Floridan Aquifer.

- There must be breeching of the limestone into the cavernous zone creating a point of high recharge to the artesian aquifer.

- There must be a sufficiently large cavity or opening within the limestone capable of receiving the eroded unconsolidated materials from above.

It has been established that sinkholes, as experienced in Florida, are the result of geologic and hydrogeologic processes. The relationship of these processes to the formation of sinkholes has received some appreciable attention in the past recent years and the State of Florida has been mapped for areas with varying degrees of sinkhole potential. Four zones varying from very little to no risk in terms of sinkhole potential to high risk areas of sinkhole potential have been delineated, as illustrated on Figure 5. This figure was adapted from information published by the Florida Bureau of Geology. It can provide a qualitative and meaningful early comparative indication of the potential for sinkhole development for various geographic regions of the State and can be used as an early guide in the formulation of a sinkhole potential opinion. An assessment of the site specific sinkhole potential is provided later in the report.

3.0 FIELD AND LABORATORY INVESTIGATION

3.1 Test Drilling Program

As previously mentioned, during the preliminary evaluation of the Hays Road site, thirteen (13) Standard Penetration Test (SPT) borings were advanced to the limestone level over the project site in order to obtain, in general, adequate site coverage. These test borings are designated "B". The approximate locations of these thirteen (13) test borings are included on the boring location plan presented on Sheets 2-4. These thirteen (13) borings are the only test borings that were not surveyed-in, in terms of location and ground elevation. These boring locations are shown approximately on the boring location plans.

For our final level study of the Hays Road site, the test drilling program basically was broken down into two phases. Phase I consisted of drilling SPT borings down to the limestone level on a grid system. In general, the Phase I borings were spaced approximately 800 feet apart over the site, and as close as 400 feet apart in the area that was anticipated to be the primary location of the landfill.

For the Phase I drilling program, fifty-seven (57) SPT test borings were drilled to the limestone level. The approximate locations of these borings as surveyed-in by the project surveyor, Atwood and Associates, Inc., are shown on Sheets 2-4. At each of the the fifty-seven (57) Phase I test boring locations, a shallow 2-inch diameter PVC pipe, hacksaw cut screen, piezometer was installed in a auger borehole that was advanced adjacent to the SPT boring location. This temporary piezometer was installed to measure shallow groundwater levels during our study. These shallow piezometers were, in nearly all instances, installed to a depth just above the first clayey material layer.

During the Phase II test boring program, an additional eighteen (18) SPT borings were drilled at selected and surveyed-in locations indicated on Sheets 2-4. These eighteen (18) test borings, as will be discussed later, were drilled in areas identified as suspect anamoly locations by USDA considering their interpretation of the ground penetrating radar (GPR) survey. In addition, during the Phase II drilling program, four (4) SPT borings were drilled to the limestone level at the four (4) deep groundwater monitoring well locations selected during our study.

In general, the designation of the borings drilled during the Phase I and II test boring programs correspond to the coordinate of the grid system that we established over the project site. Upon completion of all the SPT borings that encountered clayey material and/or the limestone bedrock surface, the borehole was grouted up to the ground surface upon completion, in accordance with SWFWMD requirements. In general, all the SPT borings were performed in general accordance with ASTM D-1586. All the test borings performed on this project were performed using men and drill rigs from the Tampa Regional Office of Jammal & Associates, Inc. A degreed geologist was utilized in the field with the drill crews to coordinate field operations and to log the test borings.

At selected locations in several of the test borings, relatively undisturbed Shelby tube samples were collected of the semi-confining clayey unit material. Approximately 3-inch diameter Shelby tube samples were collected, at the approximate locations indicated on the soil profiles.

The results of all the test borings performed during the preliminary study and Phase I and II program are shown illustrated as soil profiles on Sheets 5-11. All the test borings are plotted according to ground elevation as determined by the project surveyor, with the exception of the thirteen (13) preliminary study test borings, which were estimated. Pertinent drilling notes are also included along the soil boring profiles.

3.2 Ground Penetrating Radar (GPR) Survey

At the request of Pasco County and Camp, Dresser & McKee, Inc., the United States Department of Agriculture (USDA) was retained to perform a ground penetrating radar (GPR) survey over the proposed Hays Road landfill site. The initial GPR survey was conducted by USDA at the project site on May 29, 1986, with observation from Jammal & Associates, Inc. The GPR survey grid lines are shown on the boring location plans and aerial topographic maps included on Sheets 2-4. Heavy dashed lines indicate the path of the GPR survey. The GPR survey lines were established by Jammal & Associates, Inc. Approximately 39,800 lineal feet of GPR survey testing was performed over the project site, (approximately 7.5 miles).

After the initial GPR testing results were reviewed and discussed, it was decided by all parties concerned to utilize the GPR equipment in locating selected and specific potential anamoly or concern locations in the field to be test drilled during the Phase II field program. Therefore, on October 3, 1986, the GPR equipment was brought back to the site to locate approximately eighteen (18) potential anamoly locations, for ground truth testing purposes. All eighteen (18) of the potential anamoly locations were test drilled during the Phase II drilling program. The potential anamoly drilling locations were selected by the soil scientist, Mr. Gregg Schellentrager, interpreting the GPR data for USDA. The term "anomaly" as discussed herein and defined by Webster's Dictionary refers to something that is different, abnormal or peculiar. An "anomaly" does not necessarily have an adverse impact on the proposed landfill.

Tape results of the initial GPR testing performed along the grid lines illustrated on Sheets 2-4, are available for review upon request from the USDA/SCS office in Gainesville, Florida. The specific results at the eighteen (18) suspect anamoly locations selected by USDA, are included in Appendix C. On each of the eighteen (18) plates included in Appendix C is a copy of the initial GPR survey result that was collected on May 29, 1986, at a fast speed, and also the GPR result from the October 3, 1986 survey that was conducted at a somewhat slower speed to more accurately locate and define the suspect anamoly. Also on each plate is the resulting Phase II ground truth test boring. The test results included in Appendix C are discussed later in this report.

3.3 Installation of Groundwater Monitoring Wells

To assist in evaluating the groundwater levels over the project site, four (4) deep groundwater monitoring wells and four (4) shallow groundwater monitoring wells were installed at the approximate locations indicated on Sheets 2-4. In general, the four (4) deep groundwater monitoring wells were sealed several feet within the limestone surface and were open-hole drilled into the limestone. In general, the shallow groundwater monitoring wells were installed just above the semi-confining clayey materials at each of the shallow well locations. In general, the groundwater monitoring well locations, which basically consist of four (4) well pairs, each with a shallow and a deep groundwater monitoring well, were selected to obtain adequate site coverage and are located, in general, near the perimeter of the project site.

The monitoring wells that were installed for our study were positioned in the field at the approximate locations approved by Camp, Dresser & McKee, Inc. and The Department of Environmental Regulation (DER), specifically, Mr. Gardner Strasser. The intent of these well locations was to utilize them as part of the permanent groundwater monitoring plan for the landfill. The well construction details for each of the shallow and deep monitoring wells installed for this study are included in Appendix E, on Plates 2-5. In addition, on each of these plates the corresponding soil boring profile from the test boring performed at the deep well location is also illustrated. The well construction details were approved by DER prior to well installation. Upon completion of each well, it was developed by pumping and/or air surging until the water produced was reasonably clear and clean. Ground elevations were determined at each well location by the project surveyor, Atwood and Associates, Inc.

3.4 Soil Physical Property Testing and Classification

To assist in visual classification of the soil samples and evaluating soil engineering properties relevant to our study, a series of full grain size analyses, minus No. 200 sieve washes, and liquid and plastic limit tests were conducted. The results of all these tests are included on the soil profiles on Sheets 5-11. The grain size distribution curves are included in Appendix B. The soil samples were classified utilizing procedures in general accordance with the Unified Soil Classification System. The soils were grouped into different strata according to the soil legend included on the soil profile sheets.

The strata break lines included on the soil profiles represent approximate boundaries between different soil or rock material types. The actual transition between soil or rock conditions not considered important to our evaluations were abbreviated or omitted for clarity.

3.5 Consolidation and Permeability Testing

In order to evaluate the consolidation potential of the subsurface clayey deposits under the anticipated landfill heights and loadings, it was necessary to perform a limited amount of consolidation tests. Selected 3-inch diameter Shelby tube samples of the clayey confining unit materials were utilized for consolidation testing. The approximate location of each of the eight (8) consolidation tests that were performed are shown at the appropriate sample depth on the soil profiles. In general, we believe that the consolidation tests are spread adequately over the proposed landfill area and represent the more plastic clayey materials that could exhibit significant consolidation settlement. The consolidation test curves are included in Appendix B. The physical soil properties of each consolidation sample are also included on the consolidation test curve result in Appendix B. The consolidation test results were utilized in our settlement evaluation discussed later.

In order to evaluate the permeability of the semi-confining clayey unit material over the proposed landfill site, some of the Shelby tube samples of the clayey material were selected for permeability testing. The permeability testing was conducted utilizing falling head testing techniques on a sample cut into a consolidometer. The sample was loaded to the approximate insitu effective overburden pressure. The results of the permeability tests are included at the appropriate depth on the soil profiles. Because the permeability tests were conducted on the clayey sample that was utilized for consolidation testing, the permeability test result is also included on the consolidation test curve result included in Appendix B. The results of the permeability testing of the semi-confining clayey unit materials will be discussed later in this report.

4.0 SITE SPECIFIC SUBSURFACE CONDITIONS

4.1 Soil Stratigraphy

As previously mentioned, the results of the soil borings are presented as soil profiles on Sheets 5-11. Also included on the soil profile sheets are the results of the laboratory testing of selected physical properties of selected soil types. In addition, pertinent drilling notes relevant to our study and evaluation are also included on the soil profiles. Standard Penetration Test "N" values and a legend which describes the soils encountered and the Unified Soil Classification designation are included on the soil profile sheets.

In general, the soil materials over the project site consist of a varying thickness of sandy material (Strata 3, 4, 5 and 6) overlying clayey materials of varying thickness and consistency (Strata 2, 7, 8 and 9), which in turn overlie either significantly weathered upper limestone material with clay (Stratum 10) or the more intact weathered limestone materials (Stratum 11).

The upper sandy materials of Strata 3, 4, and 5 generally contain less than 10% fines passing the No. 200 sieve. Strata 3 and 4 materials are the lighter colored sands at the project site and vary from fine sand to slightly silty fine sand. Strata 5 is comprised of the dark brown slightly silty fine sands to silty fine sands. Stratum 5 has the appearance of some organic staining. In general, the upper fine sands (Strata 3, 4, and 5) vary in thickness and in depth considerably depending on the location on-site. The thickness of the upper sands varies from as little as 1 to 2 feet to as deep as 70 to 90 feet. The grainsize analysis results indicate that the upper fine sands are poorly graded with low fines content (clay and silt fraction). In general, over the project site, the topsoil materials are on the order of 1 foot thick and are basically either Stratum 1, which is black organic debris, or Stratum 3, which is gray slightly silty fine sand with traces of roots.

In general, the upper fine sands (Strata 3, 4, and 5) vary in relative density from loose to medium dense. Some very loose zones (SPT "N" values of less than 4) were indicated in a few borings. Some drilling fluid circulation was lost in a few of the test borings within the upper sand strata, indicating zones of secondary permeability. The locations of the drilling fluid circulation losses are indicated at the appropriate depth on the soil profiles. The significance of the drilling fluid circulation losses is discussed later.

Beneath the fine sands of Strata 3, 4, and 5, slightly clayey sands to clayey sand materials of Strata 6 and 7 were generally encountered. These materials are generally the transition materials from the upper sands to the lower more plastic clayey materials. The thickness and presence of the Strata 6 and 7 materials varies considerably over the project site. In most borings, these materials are absent. The results of laboratory tests on selected Strata 6 and 7 soil samples are included on the soil profiles or in Appendix B. In general, the materials of Strata 6 have generally between 10% and 20% fines, and the materials of Strata 7 have generally less than 35% fines, passing the No. 200 sieve. The results of liquid and plastic limit tests performed on the more clayey materials of Stratum 7 indicate that the clayey sands are of low plasticity.

Either beneath the sandy materials of Strata 3, 4, and 5 or beneath the slightly clayey sand materials of Strata 6 and 7, the more plastic clayey materials of Strata 8 and 9 are present. Both of these materials are classified as sandy clay to clay and exhibit, in general, moderate to high plasticity. The difference between Strata 8 and 9 materials is essentially coloring, with Stratum 8 being more of a mottled colored material and Stratum 9 being more of a pure greenish-gray to green clayey material. The depth, thickness and presence of the clayey materials of Strata 8 and 9 are highlighted on the soil profiles on Sheets 5-11. These materials are shaded in for easy identification purposes. At several of the boring locations, a dark gray to black silty to sandy clay (Stratum 2) material was encountered. This material is also a moderately to highly plastic clay; however, it was noticeably black and organic-stained. The clayey materials of Strata 8 and 9 and the darker colored clays of Stratum 2 are, in our opinion, the major components of the semi-confining unit clayey material which underlies the project site. In all but a few of the test borings, the clayey materials of Strata 8 and 9 were discovered.

Based on the results of liquid and plastic limit tests performed on selected Strata 8 and 9 materials, the plasticity of these materials varies significantly from moderately to extremely plastic. In general, liquid limit values of the Strata 8 and 9 materials varied from 50% to 150%; in general, the liquid limit was in the vicinity of 80% to 120%. Minus No. 200 sieve washes indicate that the fines content of the Strata 8 and 9 material was generally in excess of 50%. In general, the natural moisture content of the Strata 8 and 9 materials is in excess of the plastic limit.

Based on SPT "N" values, in general, the consistency of the cohesive materials of Strata 8 and 9 varies from stiff to very stiff. Several very loose and soft zones were identified and are indicated on the soil profiles. In general, these locations correspond to zones that displayed either "WH", "WR" or "WK" drilling notations. In these zones, either the weight of the drill rod (WR), weight of the rod plus the hammer (WH) or the weight of the rod plus kelly (WK) fell under its own weight because of the extremely soft or loose clayey conditions. At some locations identified on the soil profiles, drilling fluid circulation losses were experienced while drilling through these soft clayey materials.

Observing some of the clayey samples taken from the soil borings classified as Strata 8 or 9, it was evident that seams of sand and zones of secondary seepage were present. Thin hairline seams and lines of iron or rust color were evident in most of the clayey samples observed from Strata 8 and 9. These zones indicate that water is probably very slowly moving down through some discontinuities in the clayey materials.

As previously mentioned, significant consolidation testing and vertical permeability testing was performed on selected clayey samples from Strata 8 and 9. The results of these tests are included in Appendix B.

Beneath the clayey materials of Strata 8 and 9, in general, highly weathered limestone with traces of clay (Stratum 10) or more competent weathered limestone (Stratum 11) was encountered. The presence and consistency of the extremely weathered portions of the limestone (Stratum 10) are indicated on the soil profiles. In general, Stratum 10 was classified as white to light brown calcareous silty clay with varying amounts of limestone fragments and traces of the green clay of Stratum 9. Stratum 10 was not encountered at all the borings locations. Stratum 11 was considered the upper unit of the Floridan Aquifer. This stratum was generally comprised of white to light gray weathered limestone and was found in nearly all the boring locations. In general, Stratum 10 materials overlaid more competent weathered limestone (Stratum 11). As noted on the soil profiles, significant drilling fluid circulation losses were reported when encountering Stratum 10 or 11 materials. At several boring locations, evidence of very loose or solutioning conditions was discovered with the indication of "WK", "WH" or "WR" adjacent to the soil profile. Based on SPT "N" values, the consistency and integrity of the extremely weathered limestone material (Stratum 10) and the more competent weathered limestone of Stratum 11, varied considerably throughout the depth of rock penetrated at each boring location.

It is important to note the following items with regard to the site specific soil conditions discovered over the project site during this study:

1. As expected, the soil and rock conditions over the project site are extremely variable in thickness, material type, elevation of occurrence, and consistency or relative density; for example, boring D+100-8 and boring D-8, performed along the northern portion of the project site about 100 feet apart. The boring results for these two borings are presented on Sheet 5; these results illustrate the potential variability of soil conditions within a short distance.

2. It is important to note the thickness and occurrence of the semi-confining unit clayey materials of Strata 8 and 9 at individual boring locations; especially within the favorable area proposed for the landfill discussed later.

3. It is important to note the presence of weight of hammer (WH), weight of rod (WR), and weight of kelly (WK), that occurred at several of the boring locations throughout the project site. The depth and thickness of these extremely loose zones that were discovered during drilling operations is indicated on the soil profiles. These areas are indicative of solutioning or ravelling activity.

4. It is important to note the depths and locations of minor and major losses of drilling fluid circulation. At nearly all the boring locations, there were some drilling fluid circulation losses reported. The approximate depth and degree of circulation loss is indicated on the soil profiles at the corresponding depth. Drilling fluid circulation losses noted above the limestone materials of Strata 10 and 11, indicate zones of secondary permeability within the upper unconsolidated deposits. The significance of these losses is discussed later in Section 5.9.

5. It is important to note that the consistency and physical properties of the clayey materials of Strata 8 and 9 within the landfill area are fairly consistent and uniform, based on the liquid and plastic limit tests, SPT "N" values and other laboratory data.

4.2 Groundwater Conditions

As previously mentioned, a series of shallow temporary piezometers were installed at the Phase I boring locations throughout the site. Land surface elevations were determined at each piezometer location by the project surveyor. The depth to groundwater was measured in each piezometer and the resulting depth measurements were transposed to elevations, referenced to mean sea level (MSL).

Groundwater measurements were taken in each piezometer on September 6, 1986 and again on November 13, 1986. The results of these measurements are presented on Table 3. Groundwater elevation contour maps for each date are included on Sheets 12 and 13.

On September 6, 1986, measured depths to the groundwater surface ranged from less than one-half foot in a low-lying portion of the site to over 20 feet in one of the higher areas. The average depth to the groundwater surface was about 11 feet. Of the 57 installed piezometers, 13 were dry at the time of measurement on September 6th. The average depth to water and the range of depths reflect measurements taken in 44 of the piezometers. The average elevation of the groundwater surface was about +36.5 feet MSL on September 6, 1986; and ranged, from a low of about +28.8 feet MSL in C+300-4, located in the extreme northern portion of the project site, to a high of +44.4 feet MSL in C-13+35, located in the north-central area.

The groundwater contour maps over the project site for each date were generated by Camp, Dresser & McKee, Inc. from our September 6th and November 13th measurements. The contour maps were drawn using a one-foot contour interval by interpolation

It is important to note the following items with regard to the site specific soil conditions discovered over the project site during this study:

1. As expected, the soil and rock conditions over the project site are extremely variable in thickness, material type, elevation of occurrence, and consistency or relative density; for example, boring D+100-8 and boring D-8, performed along the northern portion of the project site about 100 feet apart. The boring results for these two borings are presented on Sheet 5; these results illustrate the potential variability of soil conditions within a short distance.

2. It is important to note the thickness and occurrence of the semi-confining unit clayey materials of Strata 8 and 9 at individual boring locations; especially within the favorable area proposed for the landfill discussed later.

3. It is important to note the presence of weight of hammer (WH), weight of rod (WR), and weight of kelly (WK), that occurred at several of the boring locations throughout the project site. The depth and thickness of these extremely loose zones that were discovered during drilling operations is indicated on the soil profiles. These areas are indicative of solutioning or ravelling activity.

4. It is important to note the depths and locations of minor and major losses of drilling fluid circulation. At nearly all the boring locations, there were some drilling fluid circulation losses reported. The approximate depth and degree of circulation loss is indicated on the soil profiles at the corresponding depth. Drilling fluid circulation losses noted above the limestone materials of Strata 10 and 11, indicate zones of secondary permeability within the upper unconsolidated deposits. The significance of these losses is discussed later in Section 5.9.

between data points representing the locations of the measured piezometers. Distinct local highs in the groundwater surface are apparent on the contour maps. The highs are marked by elevations of the water surface greater than +40 feet MSL. Two saddle configurations of the groundwater surface separate the localized highs as well as areas of lower elevations in the west-central and northeast portions of the site.

Given the groundwater surface configuration as mapped from the September 6th measurements, groundwater movement within the site is essentially radial from the three local highs to adjacent areas of lower water surface elevations. Superposition of groundwater drainage divides on the high indicates that the largest portion of the site drains groundwater towards the area of low groundwater elevations in the central portion of the area and to the west of the Florida Power easement. In the eastern portion of the site groundwater apparently moves from the two major highs in the northern and southern areas toward a depression in the groundwater surface in the northeast part of the site. The extreme northern and southern portions of the site appear to drain off-site.

Depth to groundwater surface measurements recorded in the on-site piezometers on November 13, 1986 are indicated on Table 3. At some piezometers, the groundwater surface had receeded below the depth of the pipe and, thus, no water level measurements were recorded. In other cases, the piezometers were found to have been physically destroyed or were not able to be located in the field and no measurements were possible. Sheet 13 is less detailed than Sheet 12 and is provided for information purposes only. Of the piezometers located along the groundwater highs on-site, only one, piezometer E-48, was deep enough to intercept the groundwater surface on this date of measurement. The remaining 11 piezometers suitable for measurement were located off the groundwater highs in areas where water elevations were recorded at +37 feet MSL and lower in September.

A general trend of declining water levels is apparent at the 12 piezometers measured in November. Three piezometers indicated a rise in water levels, especially piezometer A-13+35 which showed an increase of 4.3 feet from the September measurement. A small increase in water level was noted at piezometers C+300-4 and A-24 of 0.1 and 0.5 feet, respectively. The remaining nine piezometers recorded recessions of the groundwater surface of between 0.8 and 3.6 feet. The average measured decline was about 1.6 feet.

4.3 Groundwater Recharge Potential

Most of Pasco County provides some recharge to the regional groundwater system. The exceptions are areas along the coast and along the western margin of the Green Swamp area in the eastern part of the County. These areas are discharge areas for the Floridan Aquifer. According to researchers, the most effective recharge area for the Floridan Aquifer is the northwest portion of Pasco County where annual recharge is estimated at greater than 15 inches per year. Groundwater recharge rates throughout the central portion of the County are estimated to range between 5 and 15 inches per year on average. The lack of a well-defined surface drainage network in an area of abundant rainfall is evidence of groundwater recharge potential. Apparently, the primary surface drainage mechanism is internal to the groundwater system which serves to convey water to discharge areas along the gulf coast.

The majority of the test borings drilled within the boundaries of the project site penetrated several feet of high plasticity clays overlying the limestone surface. In an idealized hydrogeolgic model, the clay bed acts to retard the vertical interchange of water from the surficial sand deposits to the underlying limestones. Groundwater elevation data collected from on-site observation wells suggest that the clay beds are either discontinuous within the site,locally breached, or contain seams or zones of secondary seepage.

The surficial sand aquifer, which intercepts and stores excess precipitation, is relatively thin or non-existant in portions of the project site. With the top of the clay representing the base of the watertable aquifer, measurements at the observation wells indicate that the watertable aquifer is generally on the order of 5 feet thick or less when the measurements were taken in September. As September typically represents the end of the rainy season when groundwater elevations are highest, the surficial aquifer in this portion of Pasco County may not be perennial.

Four deep monitoring wells were installed into the upper portion of the Floridan Aquifer within the project site. Water level measurements taken in November of 1986 (Table 4) indicate elevations of the potentiometric surface ranged from +29.2 to +34.5 feet MSL, and averaged about +31.5 feet MSL. These measured values are in good agreement with recent potentiometric surface maps for the area published by the U.S. Geological Survey and SWFWMD (Plate 2, Appendix B). These maps suggest a typical end-of-wet-season elevation of about +30 to +35 feet MSL for the site and near vicinity. The available aquifer maps indicate higher potentiometric surface elevations in the southeastern part of the site. The hydraulic gradient is toward lower elevations to the northwest and west.

The three major local highs identified during this study on the groundwater surface may be indicative of areas where the clay beds at the base of the water table aquifer are most effective in inhibiting recharge to the underlying limestones. The groundwater highs do not necessarily correlate with topographic highs on the land surface where thicker sand deposits would normally be anticipated. The area of low groundwater elevations in the west-central portion of the site correlates with a topographic high on the land surface. Consequently, the watertable is deeper in this area, tending to approach the elevation of the potentiometric surface of the Floridan Aquifer. The north and northeast portions of the site exhibit similar characteristics. Assuming uniform distribution of rainfall across the project site immediately preceding the measurements taken in September, the most effective recharge areas to the Floridan Aquifer within the project site are identified by the depressions in the watertable surface as shown on Sheets 12 and 13.

5.0 EVALUATIONS AND CONCLUSIONS

5.1 Subsurface Conditions and Basis for Landfill Area Site Selection

The area within the shaded-in limits on Sheets 2 and 3 on the aerial topographic maps (approximately 267 acres), we have identified as being favorable or suitable for location of a lined sanitary or ash landfill. The limits of the favorable area for implementation of the landfill were based on our interpretation and evaluation of all the test boring data available from Phases I and II and also on the GPR data collected by USDA. We understand that a synthetic liner system will be constructed under all areas to be land filled. We agree that the landfill should be lined with a leachate collection system.

Generally speaking, favorable areas outlined include areas where test borings:

a. showed at least five (5) feet or more of intact and nearly continuous clayey semi-confining unit material (Strata 8 or 9 as described on the soils legend);

b. were in general conformance with the trend of the neighboring soil stratigraphy;

c. lacked significant evidence or indicators of internal soil erosion in the overburden soils, and/or the propagation of this feature upward;

d. in general, showed the typical results, that is, sand over clay over limestone; or with some acceptable deviation from this soil profile.

It is important to note that favorable areas were also selected considering the site topography. Consistency in topography and the lack or avoidance of depressional areas characterize the favorable areas. Of the 267 acres, approximately 200 of the acres showed more consistency in several of the qualifications mentioned above. In other words, the clayey semi-confining unit over the 200 acres is generally greater than five (5) feet in thickness and less subsurface anomalies are present in the soil profiles.

The USDA's interpretation of the GPR data includes the identification of some potential subsurface anomalies within the favorable areas we have identified. The results of the majority of our Phase II test borings suggest that the feature shown on the GPR tapes included in Appendix C is not an anomaly of major consequence or not an anomaly at all in our opinion. Based on the Phase II boring results performed at the selected potential subsurface anomalies identified with GPR by USDA, we are of the opinion that the minor anomalies, which were interpreted within the favorable landfill area, should not adversely impact the landfill with the design concept as planned. The GPR data and the ground truth test borings are discussed in a later section.

5.2 Semi-Confining Unit Presence and Permeability

The clayey semi-confining unit separating the upper shallow aquifer system from the deeper Floridan Aquifer was present and fairly consistent in physical properties in nearly all the test borings performed within the favorable area outlined on Sheets 2 and 3. The clayey semi-confining unit is primarily comprised of the highly plastic clays of Strata 8 and 9, and the more clayey portions of Stratum 7. The highly plastic and intact portions of Strata 8 and 9 are considered essentially impermeable to vertical groundwater movement. However, through minor inconsistencies and seams of secondary seepage within the semi-confining unit, some vertical movement of groundwater is occurring. As previously mentioned, the thickness of the semi-confining unit varies over the favorable area from approximately 5 to 15 feet in thickness. In most instances, the thickness of the semi-confining unit is in the range of 6 to 8 feet. The semi-confining unit discovered over the favorable area of the landfill should significantly inhibit direct vertical groundwater movement from the upper sand aquifer to the deeper Floridan Aquifer.

From our observation of the clayey samples and some evidence of vertical seepage down through clayey portions, we are of the opinion that the semi-confining unit over the favorable area of the landfill site, although apparently consistently present, is somewhat leaky. Essentially, we believe that this is the case based on the shallow groundwater conditions discovered over the project site and based on the significant iron staining and small zones of secondary permeability discovered within intact highly plastic, clayey samples. We believe that over the majority of the favorable landfill area that some slow vertical movement down through the semi-confining unit is taking place through the small inconsistencies and vertical and somewhat circuitous paths made over the years through the clay layers. It is important to note that our test borings did not show significant signs of weathering or upward ravelling of the semi-confining unit, nor direct areas of recharge through breaches in the semi-confining unit over the favorable landfill area. Therefore, over the favorable landfill area vertical recharge should be lower than the surrounding areas.

As previously mentioned, the results of the vertical permeability tests performed over the landfill area on selected Shelby tube samples of the semi-confining unit clayey materials are presented on the consolidation test result curves in Appendix B and also are shown on the soil profiles on Sheets 5-11. The vertical permeability of the semi-confining unit clayey materials varies from a high of approximately 2.3×10^{-4} centimeters per second to a low of 1.2×10^{-8} centimeters per second. The variability is attributable to the fine secondary seams of seepage. Based on the data collected, the average vertical permeability of the semi-confining unit clayey materials is on the order of 7.2×10^{-5} centimeters per second. Essentially, these values show that the semi-confining unit clayey materials are nearly impermeable to vertical groundwater movement. The very low to low vertical permeability test results on the clayey materials suggests favorable conditions regarding implementation of a lined landfill.

5.3 Groundwater Design Considerations

Based on the results of groundwater level measurements included on Table 3 and Sheets 12 and 13, it appears that the groundwater table depth over the favorable landfill area varies from approximately five (5) feet to as much as eighteen (18) feet deep. In general, over the majority of the central portion of the favorable landfill area, the groundwater depth is indicated on the order of 10 to 12 feet below present grades. We anticipate that the groundwater levels measured herein could be as much as 3 to 5 feet higher at certain locations under natural conditions on an interim basis (short-term during wet seasons). Considering the groundwater table depth information collected and the depth of clayey materials, it is possible that some areas of the favorable area could be cut to accommodate landfilling. Also, after liner installation and some landfill construction, the post-development groundwater levels beneath the landfill area should be more favorable for cutting because less recharge will be occurring. We recommend that no areas be considered for major cutting (in excess of 2 feet) that show clayey materials, Strata 7, 8, or 9, within 10 feet of present grades. This is recommended primarily because of the potential for temporary perched groundwater during sustained wet periods. Although some cutting is possible, it is our opinion that only minimal cutting should be considered primarily because of the variability in the elevation of the top of the clay. We recommend that the proposed landfill primarily achieve capacity by being filled above present grades.

5.4 Landfill Settlement Considerations

We have had the opportunity to review the preliminary landfill plan layout, proposed height data and the proposed typical north-south and east-west cross-sections through the landfill. The proposed landfill site plan is shown on Sheet 1 in Appendix B. Based on the plans provided, the landfill height is anticipated on the order of 75 to 100 feet above general present grades. Little cutting is anticipated. From general present grade to about a height of 75 feet, the net slope of the sides of the landfill is planned on the order of 1V:4H. From a height of 75 feet to a height of 100 feet, the net slope of the landfill sides is considerably flatter at about 1V:35H. Based on the preliminary plans, the landfill is planned primarily just above, at, or just below, general site grades over the favorable area selected. The base elevation of the landfill, in general, is compatible with our recommendations.

Based on the consolidation test data available, in general, distortion (sand) plus consolidation (clay) total settlements of the landfill under the maximum landfill height of 100 feet are anticipated to be on the order of 13 to 15 inches. Under the landfill height of about 75 feet at the top of the 1V:4H slope (elevation +125 ft. MSL), total settlements, distortion plus consolidation are anticipated to be on the order of 8 to 13 inches. Total settlements at the toe of 1V:4H slope are estimated on the order of 2 to 3 inches. Settlement estimates are shown on Sheet 1 in Appendix B.

Differential settlements will be primarily dependent on the uniformity of the clayey semi-confining unit, the differences in landfill heights across a typical cross-section through the landfill and construction sequencing. Based on the proposed landfill cross-sections, it appears that the most critical area for differential settlement is between the toe (elevation +50 feet MSL) and the high point (elevation +125 feet MSL) of the 1V:4H slope over an average distance of about 330 feet. Considering the total settlements above, the maximum differential settlements over the 1V:4H slope (a distance of about 330 feet with a landfill height difference of 75 feet) should be on the order of 10 to 12 inches.

We are assuming that the anticipated liner materials and leachate collection systems will be able to take the gradual differential settlements over the sections mentioned above. We understand that Camp, Dresser & McKee, Inc. will forward the settlement results to the liner manufacturer for their review. If this is not the case, we should be contacted for additional evaluation.

5.5 GPR Data and Ground Truth Test Borings

As discussed in Section 3.2, we have included in Appendix F the original letter from USDA to Pasco County discussing the Ground Penetrating Radar (GPR) test results performed over the Hays Road site; this letter is dated July 24, 1986. Because this letter and attachments contained several inaccuracies including scaling mistakes, stationing and plotting errors, and other discrepancies, we met with USDA at our office on September 15, 1986 to discuss these concerns. As a result of our meeting of September 15, 1986, USDA reinterpreted then resubmitted their evaluation of the initial GPR test results over the Hays Road site in a letter to the County dated September 16, 1986. This letter is also included in Appendix F. Also included in Appendix F is our letter to Camp, Dresser & McKee discussing our September 15th meeting with Mr. Gregg Schellentrager of USDA, as well as other concerns relating to the USDA interpretation of the GPR data.

We have included in Appendix C the results of the Ground Penetrating Radar (GPR) testing and ground truth test borings performed at the eighteen (18) potential subsurface anomaly locations identified by USDA in their letter of September 16, 1986. The ground truth testing of these potential anomaly locations was performed during our Phase II drilling program. The definition of an "anomaly" was presented in Section 3.2. The results of the ground truth test borings are shown adjacent to the GPR results on the Plates included in Appendix C. Each plate is discussed below.

<u>Plate 1:</u> Some minor anomaly was indicated in the test boring at location B+150-13+35, primarily a total loss of drilling fluid circulation at a depth of about 30 feet and a soft zone at a depth of approximately 35 feet. Significant intact clay (Stratum 9) was discovered over the weathered limestone and above these features. These features are considered below the effective depth of GPR equipment and below clays that would somewhat impair the GPR signal. Because of the favorable relative density and consistence of the overburden soils above a depth of 30 feet, this is not considered a significant subsurface anomaly or an area of concern for the anticipated landfill.

<u>Plate 2:</u> At location C-15+45, some minor anomaly was noted at a depth of 25 feet in a total loss of drilling fluid circulation at the top of the clay. However, at least 5 feet of intact clay was found over the limestone. Because of the favorable relative density and consistency of the overburden soils above this minor feature, this does not represent a significant subsurface anomaly, nor should this adversely impact the proposed landfill.

<u>Plate 3:</u> At location C-19+35, some anomaly was noted at a depth of approximately 30 to 34 feet in total loss of drilling fluid circulation and extremely loose clayey materials of Stratum 2. This condition is considered somewhat of a small anomaly; however, considering the thickness of the clayey materials of Strata 2 and 9 and the thickness and relative density of the overburden sands, this should not adversely impact the landfill.

<u>Plate 4:</u> At location C-35+58, some anomaly was discovered in the form of a drilling fluid circulation loss at a depth of approximately 43 feet and some loose conditions were discovered between the depth of 50 to 55 feet within the clayey materials of Stratum 8. Also, a seam of highly weathered limestone (Stratum 10) was discovered at a depth of 33 to 38 feet. These conditions are not considered significant anomalies and should not adversely impact the proposed landfill because of the favorable relative density, consistency and depth of the overburden soils.

<u>Plate 5:</u> Essentially, the soil conditions discovered at this potential anomaly location C-38+05, do not represent an anomaly. The discovered conditions are typical of the soil stratigraphy anticipated over the favorable area.

<u>Plate 6:</u> At location C+105-24, the boring results do not represent an anomaly. The discovered conditions are typical of what is anticipated over the favorable area of the landfill.

<u>Plate 7:</u> At location C+210-40 a small anomaly was noted in the presence of Stratum 11 limestone at a depth of 24 to 28 feet between layers of Stratum 9. In addition, some very loose zones were discovered over deeper Stratum 11 between the depths of 37 to 42 feet. This is considered a minor anomaly, however, should not adversely impact the proposed landfill, because of the favorable relative density, consistency and depth of the overburden soils.

Plate 8: At location C+750-8, we do not believe that the test boring shows an anomaly at this location. The stratigraphy is typical of the favorable area.

Plate 9: At location D-13+90, a significant zone of soft material was discovered between the depths of approximately 35 to 60 feet below ground. The material was primarily soft clays of Stratum 8. We do consider this an anomaly; however, we believe that this condition is isolated (based on the other site boring data) and should not adversely impact the proposed landfill, because of the favorable relative density and thickness of the upper sands.

Plate 10: At location D-19+40, some anomaly was noted at a depth of approximately 30 to 40 feet deep, in the presence of extremely soft clayey materials of Stratum 9 and drilling fluid circulation losses. This represents a minor anomaly, however, should not adversely impact the proposed landfill considering the favorable presence of approximately 10 feet of intact clay above the soft conditions, and the relative density and thickness of the upper sands.

Plate 11: At location D+100-8, this was somewhat of an anomaly as the boring was advanced to a depth of approximately 100 feet and no clayey material of Strata 8 or 9 was discovered. However, the sands to a depth of 100 feet are medium-dense to dense, and no drilling circulation losses were reported. As evident on Sheet 2, this location is outside the favorable area for the landfill, primarily because of the borings in the vicinity of this boring which do show some other subsurface variabilities.

Plate 12: At location D+295-24, we do not think that the conditions at this boring location show an anomaly, as the conditions are typical of what is anticipated over the favorable area.

<u>Plate 13:</u> At location E-11+90, some minor anomaly was discovered at depths of approximately 30 and 35 feet in the form of drilling fluid circulation losses and soft clays of Stratum 9. In addition, some additional soft clay was discovered over the weathered limestone of Stratum 11. Considering the depth to limestone, thickness and general consistency of the clays and the favorable relative density and thickness of the overburden sands, these conditions should not adversely impact the proposed landfill.

<u>Plate 14:</u> At location E-14+40, although the presence of the clayey materials and weathered limestone appeared at a relatively shallow depth, this is not considered an anomaly. This condition should not adversely impact the proposed landfill because of the favorable relative density and consistency of the overburden soils.

<u>Plate 15:</u> At location E-15+30, some anomaly was discovered at a depth of approximately 50 to 59 feet (below the range of the GPR equipment) in the form of very weathered limestone of Stratum 10. However, approximately 10 feet of intact Stratum 9 was discovered above it, underlying dense to very dense overburden sands. This condition does represent a minor anomaly; however, should not adversely impact the proposed landfill because of the above items relative to the depth and condition of the overburden soils.

<u>Plate 16:</u> At location E-16+20, some small anomaly was noted at a depth of approximately 25 feet in the form of minor circulation losses and soft clayey conditions, and an additional soft zone was discovered over the weathered limestone of Stratum 11. This represents a minor anomaly, however, considering the thickness of the clay and relative density of the overburden sands, this should not adversely impact the proposed landfill.

<u>Plate 17:</u> At location E-20+80, some minor soft conditions were discovered at the bottom of Stratum 9 overlying the weathered limestone of Stratum 10; however, this is somewhat typical. This represents a very minor anomaly and should not adversely impact the proposed landfill because of the favorable depth, relative density and consistency of the overburden soils.

<u>Plate 18:</u> At location E-45+60, this boring does not represent an anomaly. This soil stratigraphy is typical of what is anticipated under the favorable area of the landfill.

Considering all of the Phase I and Phase II test boring data and the GPR tests results discussed and provided herein, we believe that the presence of anomalies under the landfill is a possibility. Major anomalies under the favorable landfill area that could adversely impact the landfill are unlikely, considering the extensive GPR testing and test drilling performed over the favorable area. We are of the opinion that the favorable area for the landfill outlined on Sheets 2 and 3 is appropriate.

5.6 Favorable Areas of Site for Daily Sand Cover

The following areas on-site (outside the limits of the "favorable" landfill area) should be considered the better areas on-site to acquire and access daily sand cover material. In general, the fine sands to slightly fine sands of Strata 3, 4, 5 and 6 are suitable as daily cover material.

- The area north and northeast of the dry drainage ditch and east of the powerline easement, in the vicinity of borings D+400-4, C+300-4, B-3, B-4, A+400-4, B-2, A-13+35, and B-1. In this area, in general, based on the boring results, at least 20 feet of fine sand to slightly silty fine sand (less than 15 percent fines passing the No. 200 sieve) is present. Significantly deeper deposits of fine sand are present in the area of borings

D+400-4 and C+300-4; as much as 50 to 60 feet of fine sand to slightly silty fine sand. The shallow groundwater level is in the vicinity of +30 to +35 feet MSL, or about 10 to 25 feet below the ground surface depending upon the ground elevation.

° In the southwestern portion of the site, in the vicinity of borings I+400-44 and I-48. In this area a topographic high sandy knoll is present. Based on the boring results in this area (approximately 15 acres) as much as 13 to 18 feet of fine sand to slightly silty fine sand is present. Based on the shallow groundwater data collected from the two piezometers in this area, the groundwater level is in the vicinity of elevation +40 to +45 feet MSL or approximately 10 to 15 feet below the ground surface depending on the general elevation.

° In the western central portion of the site, west of the power line right-of-way, in the vicinity of borings G-32, B-8, F-32, F-40, and G-40. In this area a topographic high sandy knoll is present. Based on the boring results in this area (approximately 15 acres) as much as 15 to 20 feet of fine sand to slightly silty fine sand is present. Based on the shallow groundwater data recently collected from the piezometers in the area, the groundwater level is in the vicinity of elevation +30 to +35 feet MSL or approximately 10 to 20 feet below the ground surface depending on the ground elevation.

It is important to note that the upper sandy materials of Strata 3, 4, 5 and 6 within the favorable area for the landfill are also suitable for daily sand cover. However, care should be exercised in accessing the sand materials in the landfill area to maintain the necessary cover and clearance over the natural clayey materials. After areas have been selected to acquire sand cover, additional test borings, prior to excavation, are warrented at closer spacings to confirm the availability of sandy materials.

5.7 Final Cover Material Considerations

Regarding final cover clayey material, because of the following items below, we are of the opinion that the acquisition of offsite clayey material will be necessary for construction of the final clay cover (cap) over completed portions of the landfill. We do not recommend excavating clayey semi-confining unit materials from areas around landfill.

a. The predominant clay materials of Strata 8 and 9 are, in general, highly plastic and upon excavation, drying, and compaction may crack or fissure due to dessication. This could cause a "leaky" final cover.

b. Stratum 7, clayey sand (which would be suitable final cover material) is not an abundant material type over the non-landfill areas of the site.

c. In general, the clayey material excavated would be below shallow perched groundwater levels; thus, some difficulty in excavation would be associated with dewatering and the drying of near-saturated clayey material.

d. In general, over the non-landfill areas of the site, when the clayey material is closer to the surface (easy access), in turn the top of the limestone is shallower.

e. On-site clayey materials, Strata 8 and 9, and the more clayey portions of Stratum 7 make up the semi-confining unit separating the two aquifer systems. In general, the semi-confining unit is on the order of 5 to 10 feet over the site; with the thicker and more consistent confining unit being under areas identified as "favorable" for siting the landfill. Thus, the remaining areas have generally a lesser quality semi-confining unit.

5.8 Favorable Areas of Site For Stormwater Disposal

At this time, no preliminary stormwater management plans are available; however, we are providing our general thoughts relative to this matter. Considering the natural low depressional areas located, in general, in the northeast and southwest portions of the site, it is reasonable to ultimately direct treated stormwater towards these lower areas. Detention/retention facilities could be constructed adjacent to selected depressional areas that could provide ultimate discharge after some pretreatment. In the northeast and southwest areas of the site, a significant thickness of upper sand aquifer (Strata 3, 4, 5 and 6) is present to promote positive horizontal exfiltration from new stormwater detention/retention basins. If possible, the primary stormwater management features should be planned in these areas.

The groundwater data provided herein should be utilized in the design and selection of control levels in the retention/detention ponds. Although no permeability testing was performed on the sand strata, we anticipate that permeability values on the order of 10 to 20 feet/day would be appropriate for the materials of Strata 3 and 4, and 1 to 7 feet/day for Strata 5 and 6 materials. After preliminary stormwater plans are available, some permeability testing of the sands and additional test borings should be performed.

5.9 Future Sinkhole Potential Over Landfill Area

The proposed Pasco County landfill site and adjacent areas exhibit Karst features typical of west central Florida. The land surface is a gently rolling terrain dotted by numerous topographically-closed depressions. Within the boundaries of the project site, land surface depressions are more common in the western portion and especially in the southwest corner where apparently perennial ponds occur.

Although numerous sinkholes and other Karst-related features exist within the project site and near vicinity, the standard penetration test borings drilled for this investigation did not encounter significant voids in the underlying limestones. This fact, and the general configuration of most of the on-site land surface depressions suggest that sinkholes in the area are primarily caused by areal solution of the limestone surface and subsequent progressive subsidence of the land surface over a relatively long period of time.

Researchers described this type of Karst process forming specific types of features known as limestone-solution sinkholes. Researchers attribute this process to areas where a relatively thin cover of overburden is overlying a limestone surface that is jointed and fractured. Researchers report that in general, the northern portion of west central Florida, including northwest Pasco County, is characterized by the occurrence of shallow, broad sinkholes that develop progressively over fairly long periods of time. The subsidence rate observable at the land surface occurs roughly at the same rate as the dissolving of the limestone by aggressive recharge waters.

Sinkholes and resultant Karst topographic features of the land surface have been intermittently active during the various geologic periods subsequent to deposition of the carbonate bedrocks. During the Pleistocene Age, the sea level has risen and fallen relative to current datum as water was stored and released in glacial and interglacial periods. It is commonly believed that the most recent maximum sea level regression occurred about 18,000 years ago when sea level was approximately 300 feet or more below today's level.

The Karst processes operating in west central Florida must have been more active in the past during low sea level stands. The drowned Karst features along the present coast line and offshore are solid evidence of past intense solution erosion of the region's limestone foundation. It is very likely that most of the sinkholes in the region were formed in the past and that these processes have slowed considerably with the onset of a transgressive, or rising sea which is continuing today.

An assessment of the potential for formation of new sinkholes within the proposed favorable landfill area is presented in this report, based on the geomorphologic history of the region, together with evaluations of site-specific geologic and hydrogeologic data collected during the project investigation. Data collected and utilized in our assessment consisted of:

1. Geologic logs prepared from test borings drilled throughout the project site.

2. Groundwater elevations measured in installed observation wells.

3. Ground penetrating radar (GPR) surveys.

4. Review of type, occurrence and distribution of existing sinkholes and related features within the project site boundaries.

5. Land surface fracture trace/lineament map of the area and vicinity that was developed for the Pasco County Public Works Department by FDOT, a portion of which was traced over the USGS map illustrated on Sheet 3 in Appendix D.

Geologic logs of the numerous test borings drilled within the project site indicate that:

1. The surface of the limestone bedrock, likely the Tampa Limestone, is fairly rugged in relief. This surface marks a lithologic change between the Miocene carbonates of the Tampa or Suwannee Limestone and the predominant clay lithology of the overlying Miocene Hawthorn Formation.

2. The Hawthorn Formation is apparently present throughout most of the site overlying the limestone surface. The Hawthorn here is comprised of deposits of very plastic clays.

3. The Pleistocene to Recent Age quartz sand deposits are relatively thin and generally medium-dense throughout the site.

4. The Hawthorn clay deposits, while apparently continuous throughout most of the site, may be missing in the extreme northern portion along the north property boundary.

Measured water levels in wells installed throughout the site, indicate that the water table surface above the Hawthorn clay deposits ranged in altitude from about +30 to +40 feet above MSL. Based on the potentiometric surface maps of the underlying Floridan Aquifer prepared by SWFWMD (Plate 2, Appendix A), the difference in head between the Floridan and overlying water table aquifer is relatively small, on the order of 5 feet as an average.

The lowest measured points on the water table surface occurred along the north and northeast margin of the site. Water table elevations of less than +30 feet above MSL were measured in wells in these areas. Geologic data, discussed above, suggests that the clay deposits covering the limestone may be missing in areas along the northern site boundary. A very similar hydrogeologic feature was noted at the Cross Bar Ranch well field, located about three to four miles due east. Reseachers attributed the feature to a pinching-out of the primary confining bed over the Floridan Aquifer in a south-to-north direction through the well field.

The September 6, 1986 water level measurements also indicate that excess precipitation recharging the upper sand watertable aquifer within the project area builds groundwater mounds in the central part of the site, as indicated on the watertable contour maps, Sheets 12 and 13. The map data and groundwater contours suggest that groundwater throughout most of the site moves east and west towards areas of lower water table elevation.

Geoelectric signatures generated from the GPR surveys identified interpreted potential geologic anomalies at certain locations along the survey lines. Some locations were drilled by Standard Penetration Test (SPT) methods to correlate the GPR signatures with actual geologic logs and samples. The SPT data indicate that the GPR responses may reflect density differences in the sedimentary beds overlying the limestone surface. The SPT data did not indicate noticable voids and cavities, either in the sand and clay deposits or in the underlying limestones.

The topographic map of the project site indicates numerous, small surface depressions within the project site. Two distinct types, or forms, of depressions are noted: small, rounded depressions with relatively steep slopes, mainly in the southwest corner of the site, and; very shallow, gently-sloping depressions occurring primarily in the interior portion of the site. Most of the land surface depressions within the site are of the latter category. These depressions are generally very shallow, perhaps two to three feet deep on average and relatively broad, ranging up to several acres in area.

Within the proposed landfill area, a linear relationship between land surface depressions and other geomorphic features was not particularly noted during review of aerial photographs and U.S. Geological Survey 7-1/2 minute quadrangle maps. Other major lineament features were not observed in the immediate vicinity of the proposed landfill, as evident on Sheet 3 in Appendix D.

Given the above considerations, the predominant sinkhole-forming process operating at the proposed project site appears to be very slow dissolution of calcium carbonate at the surface of the limestone bedrock. The result is the occurrence of very shallow depressions forming over very long periods of time. The primary hydrogeologic factors controlling the process are: 1.) the existence of a nearly continuous clay layer covering the limestone surface throughout the interior or favorable portion of the site, and 2.) the small head difference between the water table and Floridan Aquifer. Collected data suggests that active recharge to the Floridan Aquifer limestones, a prerequisite for formation of new sinkholes, occurs away from the project favorable boundaries. The clay deposits of the Hawthorn Formation apparently form an effective aquatard, or semi-confining bed, throughout nearly all of the favorable area.

In view of the apparent site conditions and the various factors associated with sinkhole formation, we consider the potential sinkhole related risks to the integrity of the proposed landfill to be slight over the favorable area identified on Sheets 2 and 3. The apparent hydraulic gradient driving water to the Floridan Aquifer limestones is relatively small throughout the site and the potential for erosion or ravelling of the unconsolidated deposits into limestone voids is low. The noticable lack of significant cavities in the limestones penetrated at test boring locations further reduces the potential for significant sinkhole risk to the landfill. In addition, with construction of the liner and landfill, Floridan Aquifer natural recharge will be significantly reduced in the landfill area, reducing the natural potential for sinkhole activity in the landfill area, and slowing solutioning processes identified at the greater depths in some of the deep SPT borings in the favorable area.

Sinkholes formed by catastrophic collapse of caverns in the limestone are considered to be uncommon in the project area. The relatively thin overburden covering the limestone formations, together with the apparent small head difference between the water table and potentiometric surface are two factors supporting the formation of surface depressions as a slow on-going process directly related to solution activity at the limestone surface. Sinkholes of this type tend to develop slowly, over long periods of time and may be typically on the order of 1 to 3 feet deep near the center and 10 to 20 feet in diameter. The potential to generate catastrophic, short-period failure sinkholes is considered to be very low.

6.0 GROUNDWATER QUALITY MONITORING PROGRAM

6.1 Well Inventory

To satisfy DER requirements discussed at one of our earlier meetings with them, a water supply well inventory was conducted within a one mile radius of the proposed Hays Road site boundaries. In addition, wells located within a two mile radius of the site were also located. Computer printouts of consumptive use permits (CUPS) and well construction lists for the area were obtained from the Southwest Florida Water Management District (SWFWMD). Also, a list of monitoring wells within the two mile radius that are still used by the United States Geological Survey (USGS) was also obtained. The USGS well locations, as well as the SWFWMD CUPS well locations, are shown approximately located on the USGS map (Sheet 1) and on a recent 1" = 1,000' aerial of the area (Sheet 2) included in Appendix D. The pertinent well inventory data collected from USGS and SWFWMD, as well as the well construction listing of wells within the one mile radius which could not be plotted because no locations are provided, are also included within the well inventory data section in Appendix D.

It is important to note that near the existing concrete structure in the northern portion of the site, a deep abandoned well casing is present. It is imperative that this well be abandoned properly and grouted to the ground surface in accordance with SWFWMD requirements before the landfill is put into operations. Other than this old abandoned well, no other wells were found on the project site, based on available data and our reconnaissance of the site.

Based on the CUPS data collected from SWFWMD, it appears that only one major water supply well is located with the one mile radius of the project site. This well is labelled Number 5 and is shown located on Sheet 1 and Sheet 2 in Appendix D. This well is located approximately one mile from the northern border of the site and is significantly upgradient (Floridan Aquifer) of the landfill. Pertinent data relative to this well is provided in Appendix D. Based on data collected from SWFWMD and USGS, it does not appear that there are any other major permitted water supply wells within a one mile radius of the project site.

Based on the data collected on the SWFWMD well construction list, there appears to be a significant number of smaller water supply wells located within a one mile radius of the project site. In addition, it appears that there are significant small water wells located west and south of the site, or in other words, downgradient of the landfill area. It is important to note, that there is no County water available within 1 mile around the site. Therefore, it should be assumed that all residences, businesses, etc. within a 1-mile radius of the landfill site (and more) have a small potable water supply well, based on the extensive well construction list.

6.2 Groundwater Monitoring Plan

To assess the shallow and deep aquifer background water quality at the proposed Hays Road landfill site, a series of four well pairs, as previously discussed, were installed at selected locations around the perimeter of the site. In particular, these well pairs consisted of a shallow and a deep well installed in accordance with DER regulations. The four well pair locations are shown illustrated on Sheet 1 and Sheet 2 in Appendix D and also on the aerial topographic maps provided on Sheets 2, 3, and 4. Basically, the shallow groundwater monitoring wells are designated 2MW1 to 2MW4. The 2 as the prefix in the well designation corresponds to the diameter in inches of the well. The number following the lettering MW is the well number designation. Likewise, for the four deep groundwater monitoring wells, the 4 prefix represents a 4-inch diameter well and the number after the MW designation corresponds to the well number. For purposes of assessing the background water quality at the project site, four shallow and four deep groundwater monitoring wells were installed. We understand that water quality sampling from these wells to establish background parameters will be conducted by Camp, Dresser & McKee, Inc.

The construction details for the four shallow and four deep groundwater monitoring wells that were installed to assess background water quality at the project site are included on Plates 2-5 in Appendix E. As previously discussed, the well details were approved by DER prior to installation.

It is recommended that for the long-term monitoring program, for the proposed landfill, and assuming that the landfill is sited within the favorable area outlined on Sheets 2 and 3, that three (3) additional well pairs be installed for groundwater quality monitoring purposes. The three additional well pair locations designated 5, 6 and 7 are shown approximately located on Sheets 1 and 2 in Appendix D and also on the aerial topographic maps provided on Sheets 2, 3, and 4. Essentially, these additional groundwater monitoring wells are located approximately 100 feet away from the edge of the proposed landfill area. The proposed well construction details for the shallow and deep groundwater monitoring wells, which are similar to the existing wells previously installed, are included on Plate 1 in Appendix E.

We understand, based on conversations with Camp, Dresser & McKee, Inc., that CDM will be providing the recommended well sampling frequency that will be necessary during operation of the landfill. In addition, CDM will also be recommending the parameters that will be required during the testing process. As a minimum, we recommend that initially all the wells be sampled and analyzed for the State primary organic and inorganic drinking water parameters, as well as the State secondary drinking water standards. We anticipate that some additional parameters will be required by DER and Pasco County. Also, as a minimum, we recommend that quarterly sampling be performed at each of the well locations during the initial five years of the landfill operation. If tested parameters show concerns, then the testing frequency will need to be adjusted.

6.3 Other Well Considerations

We understand that a water supply well (about 1.0 mgd) will be necessary as a back-up (emergency situations) to accommodate water demands at the adjacent resource recovery plant. It is anticipated that the primary water source will be piped in reclaimed treated domestic wastewater. We strongly recommend that this well be located at the southwestern-most point of the project site to minimize the impact on future site sinkhole potential. In addition, the well should be designed with our input after more details become available, and the well should be constructed under close inspection.

7.0 TABLE AND FIGURES

TABLE 1 1/

GEOLOGIC FORMATIONS

Age		Formation	Lithology	Quality of water	Use
Recent and Pleistocene		Undifferentiated sand and clay	Interbedded sand and clay up to 250 feet thick.	Objectionable concentration of iron and high organic color are common.	Only a few small domestic wells.
Miocene		Tampa Limestone	White to gray, sandy, fossiliferous limestone.	Generally satisfactory for domestic supplies without treatment.	Most domestic and many irrigations wells produce water from the basal Suwannee Limestone. Some wells in southwestern Pasco County produce water from the Tampa Limestone if the Suwannee Limestone contains salty water.
Oligocene		Suwannee Limestone	Fossiliferous, yellow to white, fine-grained limestone. Hard at bottom.		
Eocene	Ocala Group	Crystal River Formation	Soft, chalky, white to tan coquinoid limestone.	Not well known but probably similar to water from Suwannee Limestone in most of area.	Only a few wells produce water from local cavities.
	Ocala Group	Williston Formation			
	Ocala Group	Inglis Formation	Hard, fossiliferous, brown to gray dolomitic limestone.	Contains more sulfate than water from overlying formations but probably does not exceed public health limits in most of area.	Most wells that produce more than 1,000 gpm penetrate the Inglis Formation and/or part of the hard brown dolomitic section of the Avon Park and Lake City Limestones.
		Avon Park Limestone	Soft to hard, fossiliferous, brown limestone with dark brown beds of dolomitic limestone. Some sapropel.		
		Lake City Limestone			

[1]The classification and nomenclature of rock units in this report conform to the usage of the Florida Geological Survey and also, except for the Ocala Group and its subdivisions, with those of the U. S. Geological Survey.

1/Taken from Wetterhall (1964).

TABLE 2 3/

HYDROGEOLOGIC FRAMEWORK

System	Series	Stratigraphic unit	General lithology	Major lithologic unit	Hydrogeologic unit	Geologic process	Age estimates of boundaries, in million years[1]
Quaternary	Holocene Pleistocene	Surficial sand, terrace sand, phosphorite	Predominantly fine sand; interbedded clay, marl, shell, limestone, phosphorite.	Sand	Surficial aquifer		
Tertiary	Pliocene	Undifferentiated deposits[2]	Clayey and pebbly sand; clay, marl, shell, phosphatic.	Clastic deposits	Confining bed — INTERMEDIATE AQUIFER AND CONFINING UNITS	Fluctuations of sea level with consequent high water tables and deposition in low-lying areas alternating with low water tables and accelerated weathering of soluble rocks.	2
	Miocene	Hawthorn Formation	Dolomite, sand, clay, and limestone; silty, phosphatic.	Carbonate and clastic deposits	Aquifer — INTERMEDIATE AQUIFER AND CONFINING UNITS		5
		Tampa Limestone	Limestone, sandy, phosphatic, fossiliferous; sand and clay in lower part in some areas.	Carbonate deposits	Confining bed		
	Oligocene	Suwannee Limestone	Limestone, sandy limestone, fossiliferous.	Carbonate deposits	FLORIDAN AQUIFER SYSTEM — Upper Floridan aquifer	Exposure and weathering Carbonate deposition	24
	Eocene	Ocala Limestone	Limestone, chalky, foraminiferal, dolomitic near bottom.	Carbonate deposits	Confining bed / Upper Floridan aquifer	Exposure and weathering	38
		Avon Park Formation	Limestone and hard brown dolomite; intergranular evaporite in lower part in some areas.	Carbonate deposits	FLORIDAN AQUIFER SYSTEM Upper Floridan aquifer Middle confining unit	Carbonate deposition	
		Oldsmar Formation	Dolomite and limestone, containing intergranular gypsum in most areas.	Carbonate and evaporite deposits	Lower Floridan aquifer		
	Paleocene	Cedar Keys Formation	Dolomite and limestone with beds of anhydrite.	Carbonate and evaporite deposits	Sub-Floridan confining unit	Exposure and weathering Carbonate deposition	55 63

1/ Geologic Times Chart, 1984.

2/ Includes all or parts of Caloosahatchee Marl, Bone Valley Formation, Alachua Formation, and Tamiami Formation.

3/Taken from Sinclair, et al (1985)

TABLE 3

GROUNDWATER MEASUREMENTS
(September 6, 1986/November 13, 1986)

Observation Well No.	Land Surface Elevation (ft above msl)	Depth to 1/. Water (ft)	Groundwater Elevation (ft above msl)	Water Level 2/. Change (ft)
D+400-4	45.6	16.6/17.8	29.0/27.8	- 1.2
C+300-4	46.4	17.6/17.5	28.8/28.9	+ 0.1
A+400-4	49.7	16.7/33.0	33.0/ --3/.	--
F-8	50.2	7.2/ --	43.0/ --	--
D-8	50.2	13.0/ --	37.2/ --	--
C-8	48.7	12.6/ --	36.1/ --	--
E-16	47.6	4.4/ --	43.2/ --	--
D+400-12	48.2	5.6/ --	42.6/ --	--
C-13+35	49.6	5.2/ --	44.4/ --	--
B-13+35	43.0	7.5/ --	35.5/ --	--
A-13+35	49.0	18.1/13.8	30.9/35.2	+ 4.3
F-20	44.8	4.1/ --	40.7/ --	--
A+400-20	43.1	13.2/ --	29.9/ --	--
E-24	46.9	13.7/ --	33.2/ --	--
D-24	49.4	11.8/ --	37.6/ --	--
D-16	45.6	-- / --	-- / --	--
C+400-12	48.5	-- / --	-- / --	--
D+400-20	46.9	11.2/ --	35.7/ --	--
C+400-20	50.4	-- / --	-- / --	--
B+400-20	48.8	-- / --	-- / --	--
B-24	49.8	-- / --	-- / --	--
F-24	45.6	6.5/ --	39.1/ --	--
A-24	52.0	20.3/19.8	31.7/32.2	+ 0.5
H-32	45.0	-- / --	-- / --	--
G-32	48.9	17.9/18.8	31.0/30.1	- 0.9
E-32	50.8	18.1/19.1	32.7/31.7	- 1.0
F-32	47.8	16.8/17.6	31.0/30.2	- 0.8
D+400-28	48.6	12.0/ --	36.6/ --	--
C+400-28	50.2	13.1/ --	37.1/ --	--
C-32	50.6	13.9/ --	36.7/ --	--
H-40	46.0	-- / --	-- / --	--
G-40	47.4	14.5/ --	32.9/ --	--
F-40	45.5	13.1/ --	32.4/ --	--
E-40	44.2	-- / --	-- / --	--

Table 3 (Cont'd)

D+400-36	46.5	-- / --	-- / --	--
D-40	49.7	-- / --	-- / --	--
C+400-36	50.6	-- / --	-- / --	--
C-40	51.8	-- / --	-- / --	--
B-40	52.1	-- / --	-- / --	--
I+400-44	60.0	19.2/ --	40.8/ --	--
I-48	54.9	14.5/ --	40.4/ --	--
H-48	46.7	7.0/ --	39.7/ --	--
G-48	35.7	0.4/ 1.7	35.3/34.0	- 1.3
E-48	47.1	4.4/ 8.0	42.7/39.1	- 3.6
D+400-44	48.0	11.5/ --	36.5/ --	--
D-48	48.8	11.1/ --	37.7/ --	--
C+400-44	50.9	11.1/ --	39.8/ --	--
C-48	49.2	11.4/ --	37.8/ --	--
B-48	50.2	11.8/ --	38.4/ --	--
I-56	40.5	4.9/ 7.0	35.6/33.5	- 2.1
H-56	45.2	5.0/ --	40.2/ --	--
G-56	44.2	6.9/ --	37.3/ --	--
E+400-56	43.4	7.0/ --	36.4/ --	--
I-64	41.3	5.8/ --	35.5/ --	--
H-64	45.2	9.8/11.3	35.4/33.9	- 1.5
G+100-64	42.4	5.6/ 7.5	36.8/34.9	- 1.9
F-64	43.7	8.1/ --	35.6/ --	--

1/. First value is 9/6/86 measurement, second value is 11/13/86.

2/. Measured change from 9/6/86 to 11/13/86.

3/. -- indicates no water level measurement, piezometer dry.

TABLE 4

PHASE 1
PASCO COUNTY LANDFILL
BORING LOGS

Boring Number	Ground Elev. +Ft. MSL	GWT Elev. +Ft./MSL	Top of Clay +Ft. MSL	Top of Limestone +Ft. MSL
D+400-4	45.6	29.0/27.8	-24.5	-32.5
C+300-4	46.4	28.8/28.9	-12.5	-21.5
B-4	43.5	---	20.5	6.5
A+400-4	49.7	33./-	27.0	18.0
F-8	50.2	43.0/dry-7'	43.0	33.0
B-5	47.2	---	34.0	29.0
D-8	50.2	37.2/dry-12'	38.0	34.0
C-8	48.7	36.1/dry-13'	35.0	17.5
B-3	41.5	---	- 7.0	-15.0
B-2	44.3	---	16.0	-11.0
B-7	32.5	---	29.5	21.5
E-16	47.6	43.2/dry-5'	45.5	35.5
D+400-12	48.2	42.6/dry-5'	44.5	27.5
D-16	45.6	dry-10'/dry-8.5'	37.5	28.5
C+400-12	48.5	dry-10'/dry-9'	36.0	31.0
[illegible]-13+35	49.6	44.4/dry-5'	48.0	22.5
B-13+35	43.0	35.5/dry-7'	37.5	4.0
A-13+35	49.0	30.9/35.2	25.0	2.0 (est.)
F-20	44.8	40.7/dry-5'	38.5	30.0
*D+400-20	46.9	35.7/dry-13'	34.0	25.0
C+400-20	50.4	dry-15'/dry-14'	35.0	11.0
B+400-20	48.8	dry-6'/dry-6'	41.0	37.0
A+400-20	43.1	29.9/dry-17'	22.5	6.0
*F-24	45.6	39.1/damaged	41.5	17.0
E-24	46.9	33.2/dry-14'	28.0	- 5.0 (est.)
D-24	49.4	37.6/dry-13'	36.5	26.5
B-6	46.5	---	42.0	34.0
B-24	49.8	dry-18'/dry-17'	31.0	17.0
*A-24	52.0	31.7/32.2	28.5	17.0
B-1	44.2	---	-19.0	-35.0 (est.)
*H-32	45.0	dry-13'	32.0	22.0
G-32	48.9	31.0/30.1	27.5	20.5
B-8	48.0	---	30.0	18.0
F-32	47.8	31.0/30.2 damaged	25.5	19.5
E-32	50.8	32.7/31.7	16.0	-45.0 (est.)

TABLE 4 (cont'd)

PHASE 1
PASCO COUNTY LANDFILL
BORING LOGS

Boring Number	Ground Elev. +Ft. MSL	GWT Elev. +Ft./MSL	Top of Clay +Ft. MSL	Top of Limestone +Ft. MSL
D+400-28	48.6	36.6/dry-15'	31.0	26.5
B-9	46.3	---	38.0	22.0
C+400-28	50.2	37.1/dry-13'	32.0	18.0
C-32	50.6	36.7/dry-14'	36.0	23.0
B-10	51.7	---	33.5	28.5
H-40	46.0	dry-15'/damaged	40.0	19.0
G-40	47.4	32.9/damaged	33.5	17.5
*F-40	45.5	32.4/damaged	16.5	-20.0 (est.)
E-40	44.2	dry-10'/dry-9'	32.0	12.0
D+400-36	46.5	dry-8'/dry-8'	28.0	12.0 (est.)
D-40	49.7	dry-10'/dry-10'	38.0	19.0
C+400-36	50.6	dry-18'dry-16'	28.0	8.0 (est.)
C-40	51.8	dry-5'/dry-5'	49.5	40.0
B-40	52.1	dry-10'/dry-8'	42.0	40.0
I+400-44	60.0	40.8/dry-19'	35.0	26.0 (est.)
I-48	54.9	40.4/dry-14'	41.5	3.0 (est.)
[illegible]-48	46.7	39.7/damaged	38.5	22.5
G-48	35.7	35.3/34.0 damaged	26.0	17.0
B-13	48.0	---	39.5	31.0
*E-48	47.1	42.7/39.1	20.5	- 5.0 (est.)
D+400-44	48.0	36.5/dry-13'	40.5	15.0 (est.)
D-48	48.8	37.7/dry-11'	36.5	23.5
C+400-44	50.9	39.8/dry-11'	37.0	32.0
B-12	49.0	---	39.5	32.5
C-48	49.2	37.8/dry-13'	36.0	17.0
*B-48	50.2	38.4/dry-12'	35.5	20.0
B-11	52.3	---	34.0	28.0
I-56	40.5	35.6/33.5	33.0	25.0
H-56	45.2	40.2/damaged	41.5	31.0
G-56	44.2	37.3/dry-7'	40.5	32.0
E+400-56	43.4	36.4/couldn't find	15.0	7.5
I-64	41.3	35.5/dry-11'	36.5	25.0
H-64	45.2	35.4/33.9	31.5	17.0
G+100-64	42.4	36.8/34.9	34.5	24.5
F-64	43.7	35.6/couldn't find	30.0	15.0

NOTES: * anomaly or judgement applied
- no piezometer installed
dry - 10' no groundwater level to 10 feet deep
groundwater elevations 9-6-86/11-13-86

PHASE 2
PASCO COUNTY LANDFILL
BORING LOGS*

Boring Number	Ground Elev. +Ft. MSL	GWT Elev. +Ft./MSL	Top of Clay +Ft. MSL	Top of Limestone +Ft. MSL
B+150-13+35	47.8	-	26.0	5.0
C-15+45	49.7	-	26.0	19.0
C-19+35	48.8	-	25.5	5.0
C-35+58	52.6	-	26.5	-13.5
C-38+05	51.7	-	29.5	8.0
C+105-24	48.1	-	35.0	26.0
*C+210-40	50.2	-	32.0	27.0
C+750-8	49.4	-	39.5	35.5
C-13+90	45.6	-	10.5	-14.5
D-19+40	46.5	-	30.0	- 1.5
*D+100-8	49.9	-	-50.0 (est.)	-60.0 (est.)
D+295-24	48.5	-	34.0	26.0
E-11+90	47.0	-	17.0	-21.0
E-14+40	45.8	-	40.0	22.0
E-15+30	45.9	-	5.0	-13.0
[illegible]-16+20	45.5	-	27.5	5.5
E-20+80	44.4	-	32.0	21.5
E-45+60	46.0	-	36.5	30.0
E-52	45.5	-	31.5 (est.)	31.0
A-44	53.0	-	19.0	17.0
F+600-26	48.9	-	43.5	32.0
C-8N	48.1	-	40.5	29.0

*No shallow piezometers were installed in these borings, all borings were grouted upon completion.

TABLE 4 (cont'd)

GROUNDWATER LEVELS IN MONITORING WELLS*

Elevations (+ Ft. MSL)

2MW1	dry-10' (below +36.2)
4MW1	32.9
2MW2	35.0
4MW2	34.5
2MW3	dry-10' (below +36.7)
4MW3	29.5
2MW4	dry-19' (below +32.3)
4MW4	29.2

*Readings taken 11-13-86

1138M

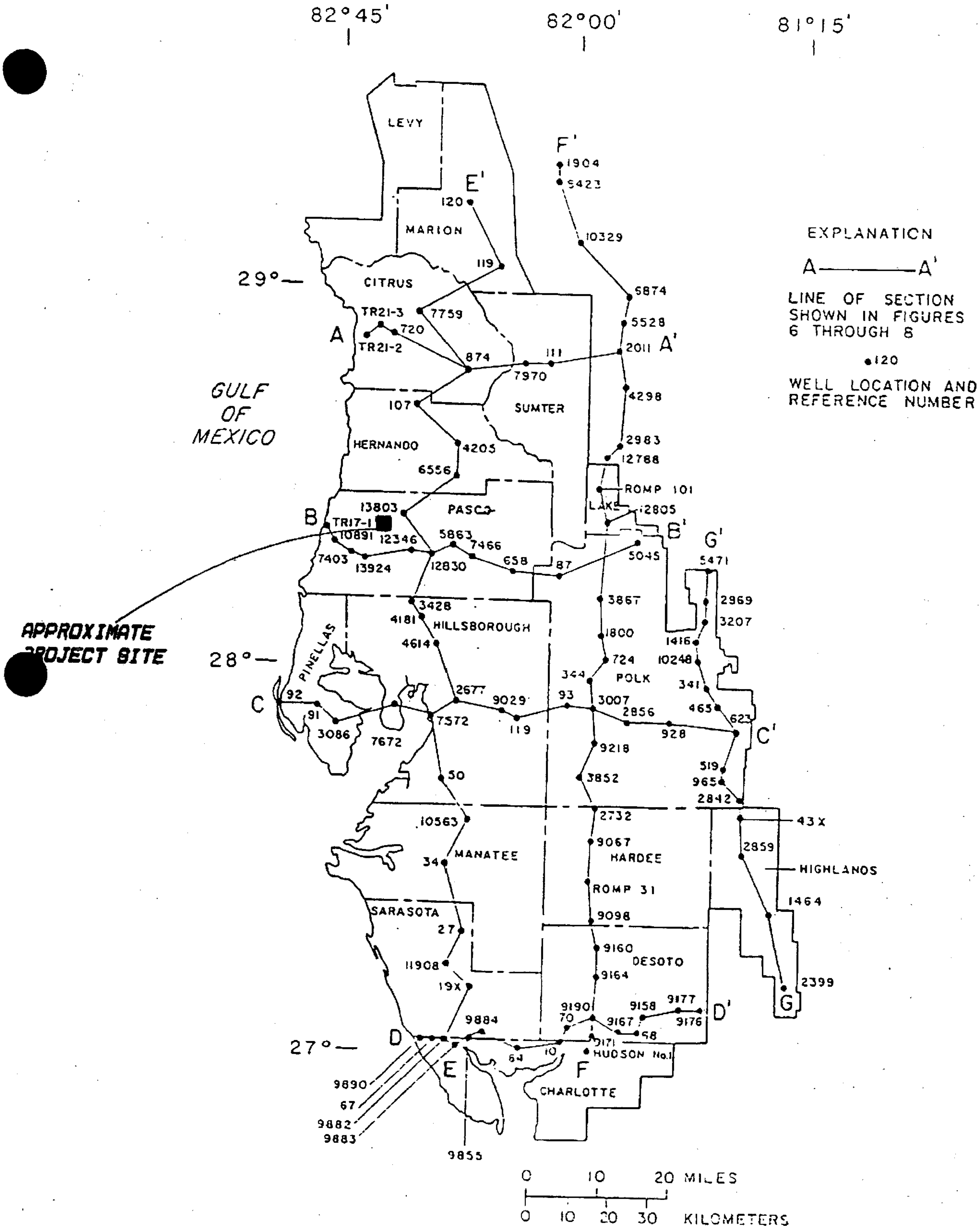


FIGURE 1 LOCATIONS OF GEOLOGIC SECTIONS

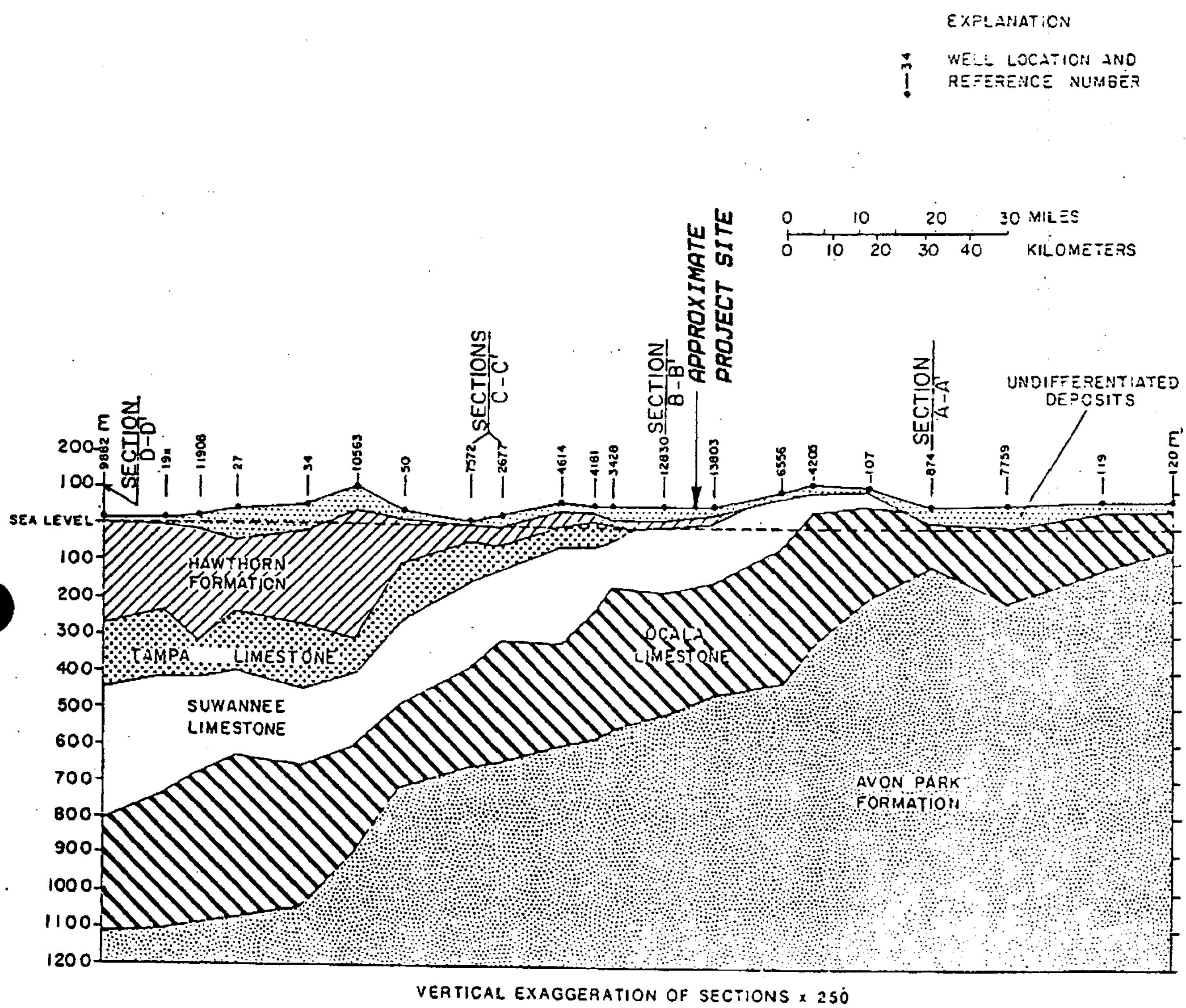


FIGURE 2 NORTH-SOUTH GEOLOGIC CROSS-SECTION

TECHNICAL APPENDIX G

LEACHATE DEPTH CALCULATIONS

REFERENCE: EPA SW-869 APRIL 1983, LANDFILL AND SURFACE IMPOUNDMENT PERFORMANCE EVALUATION

For a liner system designed w/a slope α;

$$h_{max} = \frac{L}{2N}\left[\sqrt{\frac{e}{Ks} + TAN^2\alpha} - TAN\alpha\right]$$

where:
- L = Length of spacing between drainlines
- N = Porosity
- Ks = Permeability
- e = Rate of Impingement (use 1/2 x average annual rainfall)
- α = Slope
- h_{max} = Maximum head

Assume:

Porosity = N = 0.34

Permeability = K_{si} = 7.76×10^{-3} cm/s, 22 ft./day

Rate of Impingement = e = 1/2 of 53.95 in/yr

= 2.20×10^{-6} cm/sec

Slope = α = 2% = 1.146°

h_{max} = 12" = 30.48 cm

<u>Calculation</u>:

$$30.48 = \frac{L}{2(0.34)}\left[\sqrt{\frac{2.20 \times 10^{-6}}{7.76 \times 10^{-3}} + TAN^2(1.146)} - TAN(1.146)\right]$$

$$30.48 = \frac{L}{2(0.34)}\,[0.00614]$$

3371_{cm} = L = 110′ maximum spacing between drainlines

USE <u>2%</u> SLOPE W/<u>100′</u> PIPE SPACING

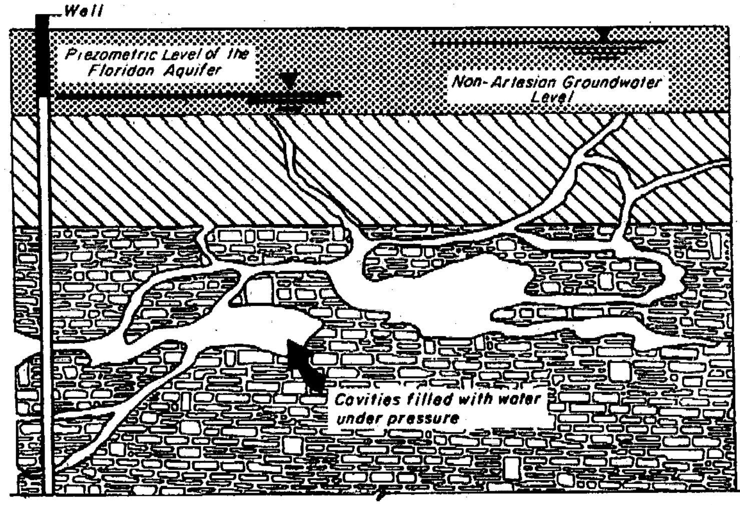
NOTE: 53.95" Avg. Annual Rainfall for Brooksville, 1950-80

ATTACHMENT 1

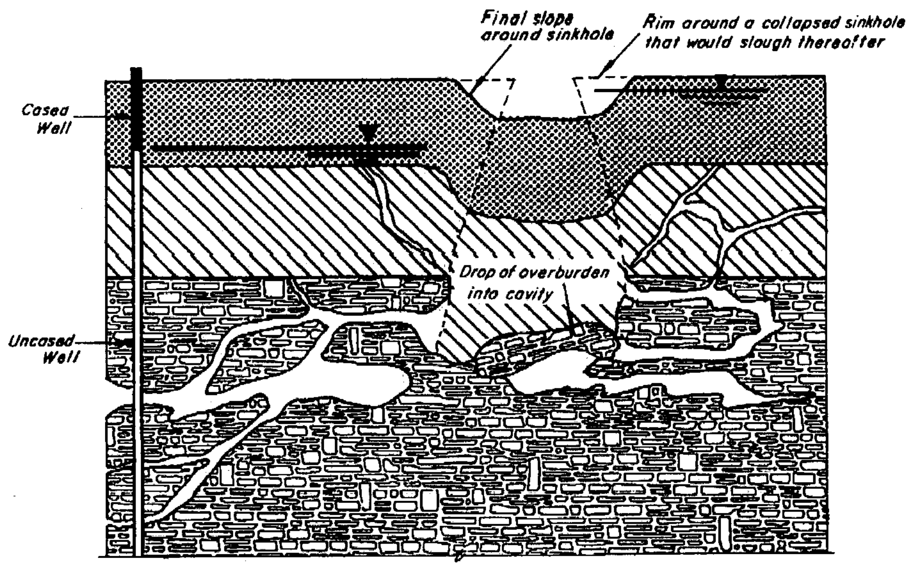
PLANS

ATTACHMENT 2

SOILS AND GEOTECHNICAL REPORT



Condition Before Collapse



Condition After Collapse

<u>Collapse Sinkhole</u>: Collapse sinkholes are the result collapse of roofs of cavities within the limestone that lies the surface followed by a drop-down of the ove unconsolidated sediment that was supported by the lime roof. This implies a structural break or collapse limestone and hence is referred to as a "Collapse Sink There is a wide spread acceptance of the usage of Co Sinkhole to suggest this type of mechanism.

FIG
Illustration of Lim
Cavity C

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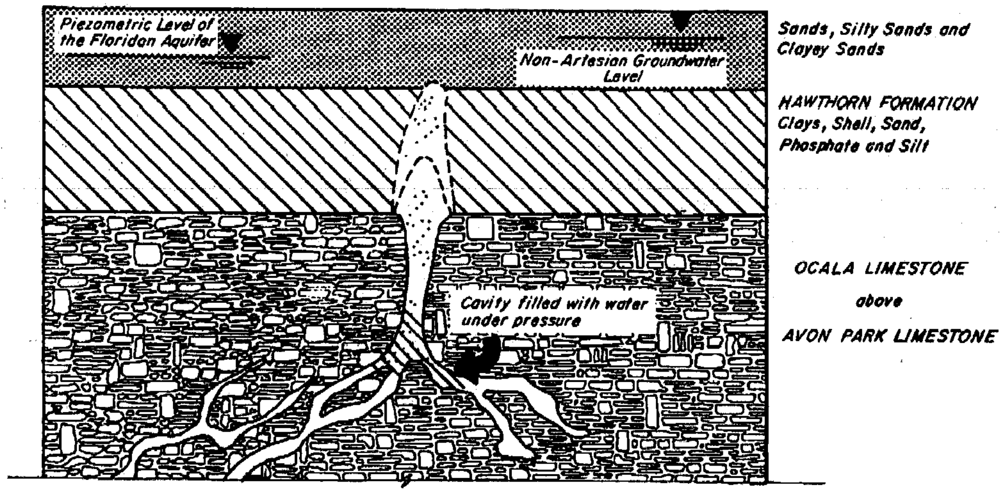
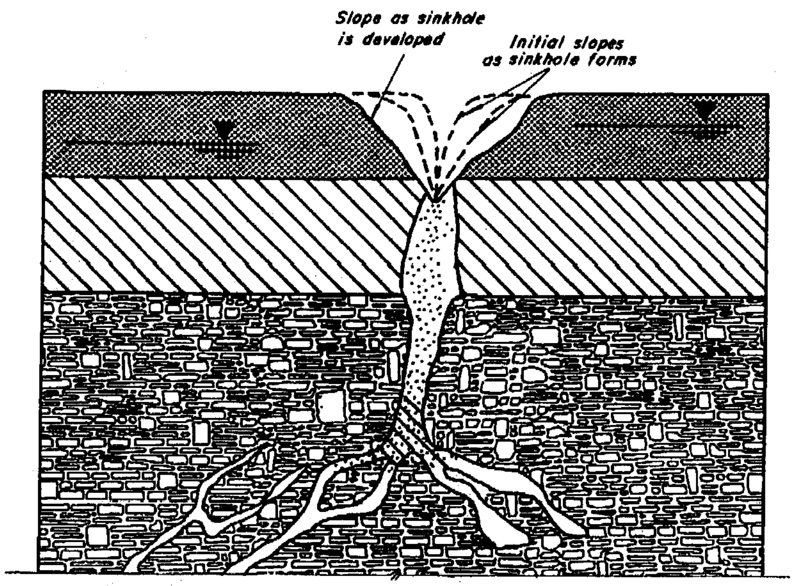


Condition Before Sinkhole



Condition After Sinkhole

Ravelled Sinkholes: This type of sinkhole is often referred to as "Sol Sink", "Erosion Sink", "Soil Condition Sink", and less frequently "D Sink". This type of sinkhole originates within the unconsolidated sedi that overlie limestones containing openings or cavities near the interfa the limestone and the overlying unconsolidated sediment. This ty sinkhole develops as soil from the overburden material erodes into ope present within the limestone beneath. Such continual erosion of soil ma into the limestone develop ravelling or a cavity or a dome withi overburden which under favorable hydrogeologic conditions can con to enlarge and work itself upward towards the surface of the ground presence of water circulating from near the surface of the ground t limestone enhances the development of such a dome within the u solidated sediment and it is almost a pre-requisite for the developme such a sinkhole. As the dome or cavity within the unconsolidated ma enlarges, the soil that overlies the dome can no longer bridge the op and under favorable conditions the material above begins to collapse a into the underlying opening. In the Geotechnical Engineering Profe and Practice, "Ravelled Sinkhole", to describe this type of mechanis become popular within the past few years and will be used here opposed to "Solution Sink", "Erosion Sink", "Soil Condition Sink" or a "D Sink".

FIGU

Illustration of Rav
Col

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In certain regions, solution becomes a dominant process in landform development resulting in a unique type of topography to which the name Karst has been applied. Most of the notable Karst areas are in regions where limestones underlie the surface although in some localities the rocks are dolomitic limestones or dolomites. Limestones are abundant in their distribution; hence it might be expected that Karst topography would also be widespread. In actuality, significant development of Karst features is restricted to a relatively small number of localities. Some of the important areas are in western Yugoslavia, southern France, southern Spain, Greece, northern Yucatan, Jamaica, northern Puerto Rico, western Cuba, southern Indiana, parts of Tennessee, Virginia, Kentucky and central Florida. In any of the above areas, numerous Karst features are found, but in none are all the possible individual forms to be seen, as they exhibit varying stages of Karst development and different types of geologic structures.

The geologic and hydrologic conditions necessary for the optimum development of Karst can be summarized as follows:

1) Soluble rock (limestone) at or near the surface.

2) The limestone should be dense; highly jointed, and thin bedded.

3) Major entrenched valleys exist in a position such that ground water can emerge into surface streams.

4) The region should have moderate to abundant rainfall.

Florida possesses the above-mentioned conditions only in part and consequently has only moderately well-developed Karst. Limestones are not highly indurated or dense and therefore possess some degree of mass permeability, however, Florida limestones are highly fractured and do possess moderate vertical differential permeability to concentrate water movement. If a rock is highly porous and permeable throughout, rainfall will be absorbed en masse and move through the whole of the rock resulting in no differential solution.

Florida also does not have major entrenched valleys into which ground water can emerge and drain off; however, the artesian aquifer accomplishes a similar result. In this case water entering the system moves down gradient discharging through springs or eventually into the Atlantic Ocean or Gulf of Mexico. The rate of movement in this system is very slow and this decreases the amount of solution taking place.

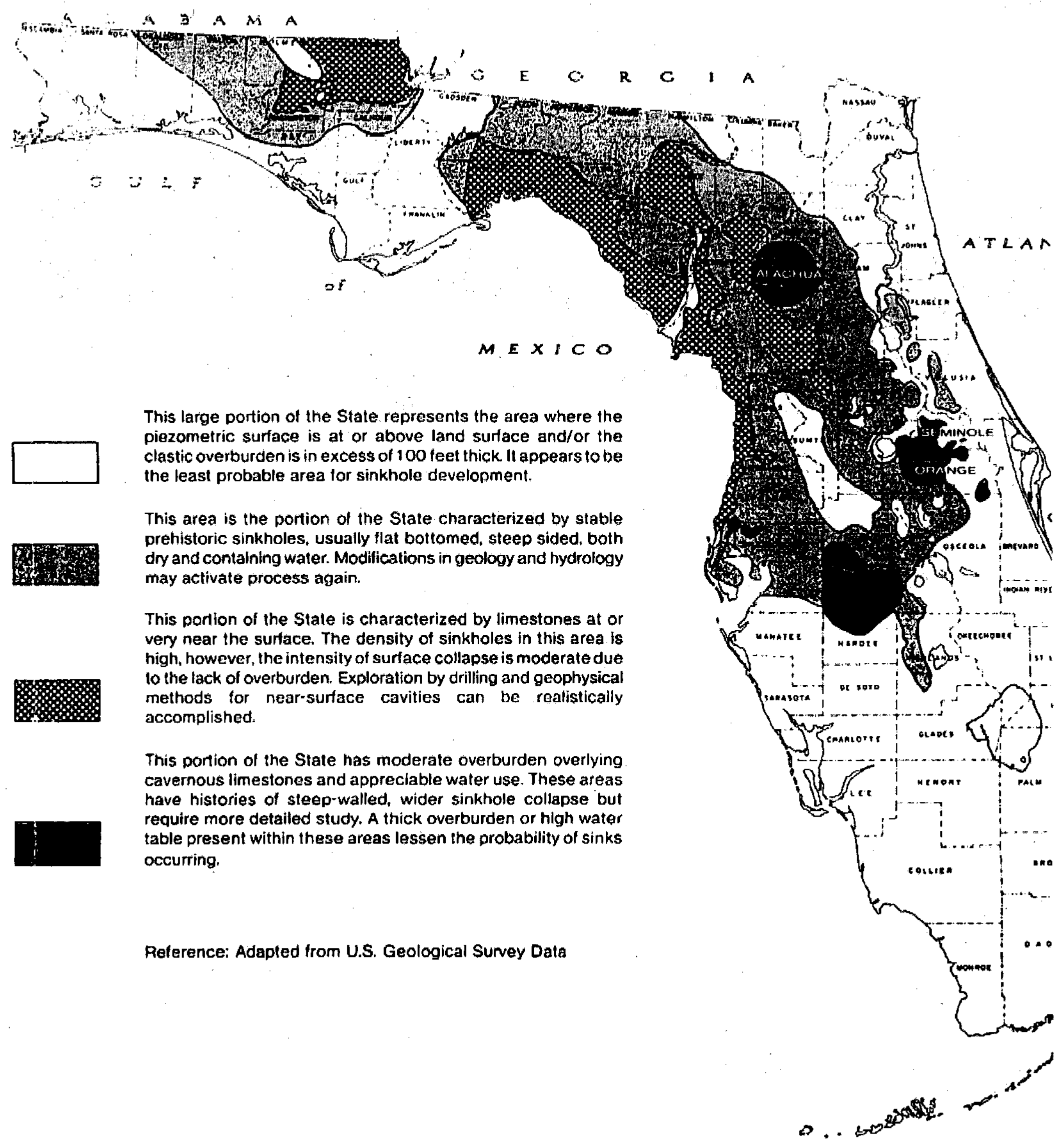
Thus Florida is an area that fulfills in part the conditions for optimum Karst development and reflects this in having a moderately developed Karst topography characterized by one Karst feature, sinkholes. The sinkhole is the most common and widespread topographic form in a Karst terrain.

It is most difficult to classify sinkholes because of the many variations that they exhibit and the varying local usage of terms applied to them. Fundamentally, however, they are of two major types, those that are produced by collapse of the limestone roof above an underground void and those that are developed slowly downward by solution beneath a soil mantle without physical disturbance of the rock in which they are developing. These two types have been referred to as collapse sinks and solution sinks or dolines. Collapse sinks are normally steep-sided, rocky and abruptly descending forms while dolines range from funnel-shaped depressions broadly open upward to pan or bowl-shaped. Sinkholes of Florida fall in both of the above categories, however, more commonly they constitute a third type.

Florida sinkholes are most commonly formed in an environment with the following physical characteristics:

1. Limestones overlain by unconsolidated sediments less than 100 feet thick.
2. Cavity systems present in the Limestone.
3. Water table higher than the potentiometric surface.
4. Breaching of the Limestone into the cavernous zone creating a point of high recharge of the artesian aquifer.

Under these circumstances water moving down into the Limestone may take large amounts of sediments into the cavernous system creating a void in the overlying sediments. These sediments are generally incompetent and will reflect at the surface as either a structural sag or as catastrophic collapse.



FIGU
Sinkhole
Areas in

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