REQUEST FOR AG-3 AGRICULTURAL AND RESIDENTIAL CONDITIONAL USE
GREEN MEADOWS MUNICIPAL SOLID WASTE DISPOSAL & RECYCLING FACILITY
Amended Application for July 9, 2019 Submittal

APPENDIX XI

Letter Report on Groundwater Pollution Potential

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July 31, 2019

Mr. Ben Well
Atlantic Waste Services, Inc.
125-B Pine Meadow Drive
Pooler, Georgia 31322

Subject: **Preliminary Opinion of Groundwater Pollution Potential**
Green Meadows Dairy Farm
Screven County, Georgia
IES Project No. 1000-1210-019

Dear Mr. Wall:

Innovative Engineering Strategies, LLC (IES) is pleased to provide this preliminary opinion of groundwater pollution potential for the Green Meadows Dairy Farm property currently owned by United Ag, LLC. As stated in the previous letter dated June 18, 2019, should the subject property receive Conditional Use zoning in the existing Screven County Agricultural and Residential (AG-3) Zoning District for a solid waste disposal facility (landfill), then it is our understanding a comprehensive Site Assessment Report (SAR) will be prepared in accordance with "Circular 14: Criteria for Performing Site Acceptability Studies for Solid Waste Landfills in Georgia," as required by the Georgia Solid Waste Management Act of 1990, as amended (Act). Following approval of the SAR and issuance of site limitations by the Georgia Environmental Protection Division (EPD), the applicant will be required to have a qualified groundwater scientist assist in preparation of the facility's Design & Operation (D&O) Plans.

The following pages of this letter include a description of the unconfined aquifer, confined aquifer, potential of unconfined and confined aquifers as sources of drinking water and a limited pathway analysis regarding our preliminary understanding of site-specific hydrogeology and well construction of potential receptors. **Based upon this initial and limited assessment, it is extremely unlikely a Subtitle D municipal solid waste (MSW) landfill, required to be designed and constructed in accordance with state and federal requirements (a "modern landfill"), will contaminate the groundwater in the Upper Floridan Aquifer, where nearby agricultural and drinking water wells are assumed to be constructed.**

For purposes of continuity with IES letter dated June 18, 2019, figures prepared for this letter will begin with Figure number 7.

1.0 Description of Unconfined Aquifer

The unconfined aquifer at the proposed site is the uppermost aquifer. Groundwater elevations were observed by Whitaker Laboratory, Inc. (Whitaker) to be approximately ±15 feet to greater than 30 feet below ground surface at the time of drilling in May 2019 (See Appendix A of IES letter dated June 18, 2019). Figure 7 illustrates the assumed direction of groundwater flow in the unconfined aquifer from the conceptual landfill footprint. This direction of groundwater flow is assumed to be consistent with ground surface topography, flowing easterly towards Brady Branch and southerly to an onsite existing surface water pond at slopes between 2% and 5%.

The following is excerpted from the Groundwater Resources Table in the USGS Scientific Investigations Report (SIR) 2011-5048: "Groundwater Conditions and Studies in Georgia, 2008-2009" (See Appendix A):

> The surficial aquifer system in Georgia consists of unconsolidated sediments and residuum and are generally unconfined. In the coastal area of the Coastal Plain, however, at least two semiconfined aquifers have been identified. Wells installed in the surficial aquifer system typically range in depth between 11 and 300 feet below ground surface (bgs). The typical range of yield for these wells is between 2 and 25 gallons per minute (gpm), but may exceed 75 gpm.
>
> Water-level fluctuations in the surficial aquifer system are caused mainly by variations in precipitation, evapotranspiration, and natural drainage or discharge... Water levels generally rise rapidly during wet periods and decline slowly during dry periods. Prolonged droughts may cause water levels to decline below pump intakes in shallow wells, particularly those located on hilltops and steep slopes, resulting in temporary well failures. Usually, well yields are restored by precipitation (Clarke, 2003).

1.1 Description of Confined Aquifers

Confined aquifers were not encountered during Whitaker's initial field subsurface exploration in May 2019. Confined aquifers beneath the uppermost aquifer system consist of the Upper and Lower Floridan aquifer systems.

The following is excerpted from the Groundwater Resources Table in the USGS Scientific Investigations Report (SIR) 2011-5048: "Groundwater Conditions and Studies in Georgia, 2008-2009" (See Appendix A):

> The Upper and Lower Floridan aquifers in Georgia, consists of limestone, dolomite, and calcareous sand and is generally confined. Wells installed in the Floridan aquifer typically range in depth between 40 and 900 feet below ground surface (bgs). The typical range of yield for these wells is between 1,000 and 5,000 gallons per minute (gpm), but may exceed 11,000 gpm.

> In and near outcrop areas, the Floridan aquifers are semiconfined, and water levels in wells tapping the aquifers fluctuate seasonally in response to varia-tions in recharge rate and pumping. Near the coast, where the aquifers are confined, water levels primarily respond to pumping, and fluctuations related to recharge are less pronounced (Clarke and others, 1990).

Based upon a study performed by the United States Geological Survey (USGS) Scientific Investigations Report 2010-5158, the depth to the top of the Upper Floridan Aquifer in the vicinity of the proposed site is estimated between 180 and 250 feet below ground surface (ft bgs); See Figure 8a. The depth to the first permeable zone in the Upper Floridan Aquifer in the vicinity of the proposed site is estimated between 200 and 270 ft bgs; See Figure 8b. The depth to the base of the Upper Floridan Aquifer in the vicinity of the proposed site is estimated between 340 and 410 ft bgs; See Figure 8c. Based upon the contouring in these Figures, the direction of groundwater flow in the confined Upper Floridan Aquifer is southerly.

1.3 Potential of Unconfined and Confined Aquifers as Sources of Drinking Water

Based upon correspondence with a local well driller who installs domestic and agricultural wells in the area, the domestic wells in this area of Screven County, Georgia are wells terminated within the Upper Floridan aquifer approximately ±200 feet below ground surface; the agricultural water wells are terminated approximately ±300 feet below ground surface.

2.0 LIMITED PATHWAY ANALYSIS

The purpose of this section, using limited information, is to preliminarily evaluate how leachate might percolate downward from the waste burial areas to the water table and then migrate offsite to potential human receptors.

2.1 Description of Inter-Relationships Between the Vadose Zone, the Uppermost Aquifer and Deeper Aquifers

See Figure 9 for the schematic cross-sectional diagram showing the relationship of the groundwater aquifers for the general area of where the proposed site is located. Figure 9 is excerpted from a USGS Scientific Investigations Report 2010-5158 entitled "Revised Hydrogeologic Framework of the Floridan Aquifer System in the Northern Coastal Area of Georgia and South Carolina" dated 2010.

As previously discussed, the vadose zone and uppermost aquifer for the proposed site is above a Miocene confining unit overlaying the Upper Floridan Aquifer.

2.2 Calculated Ground-Water Flow Velocities

For most Coastal Plain soil sites where the uppermost aquifer is a porous media, the calculation for horizontal groundwater flow velocities should be based on the Darcy Equation:

$$V = \frac{K \Delta h}{n \Delta l}$$

where:

V = linear velocity (feet/day)
K = hydraulic conductivity (feet/day)
n = effective porosity (%)
$\frac{\Delta h}{\Delta l}$ = hydraulic gradient (based on the potentiometric map of the uppermost aquifer)

To calculate effective porosity, n, the following equation is used:

$$n = 1 - \frac{SG_{BULK\ DENSITY}}{SG_{SOIL\ PARTICLE}}$$

where:

n = effective porosity (%)
$SG_{BULK\ DENSITY}$ = specific gravity of bulk density of soil sample
$SG_{SOIL\ PARTICLE}$ = specific gravity of soil particle = 2.66

Conservatively, the largest bulk density measured in the laboratory from Whitaker's initial investigation in May 2019 was used for this preliminary calculation. According to the laboratory analysis in Appendix A of the IES letter dated June 18, 2019, the bulk composite sample from boring B-3 was measured to have a bulk density of 109.8 pcf, or a specific gravity of 1.76 (109.8 pcf ÷ 62.4 pcf H_2O). Using the equation above, the effective porosity, n, is calculated to be 0.34 or 34%.

The estimated maximum and average horizontal hydraulic conductivity in surficial soils calculated from the USDA Web Soil Survey referenced in Appendix C of the IES letter dated June 18, 2019 are 1.40×10^{-3} cm/sec and 3.08×10^{-4} cm/sec, respectively. This is equal to 3.97 and 0.87 feet/day, respectively.

The estimated maximum and average hydraulic gradients ($\Delta h/\Delta l$) measured using topographic contours (assuming shallow, unconfined aquifer mirror contours of ground surface) in Figure 7 are 0.05 ft/ft and 0.02 ft/ft, respectively.

Therefore, for preliminary purposes only and using Darcy's Law equation above, the estimated maximum and average linear velocities are calculated to be 0.58 and 0.05 feet/day.

As stated earlier, a more-detailed and thorough analyses will be required by Georgia EPD during the permitting process to evaluate groundwater flow velocities in the unconfined aquifer. This initial and preliminary calculation was performed using limited information and therefore is subject to change as more data is collected at the site.

2.3 Groundwater Pollution Potential

This section is to address groundwater pollution potential of sites in their natural state. Pollutants in groundwater generally tend to be removed or reduced in concentration with time and with distance traveled. Mechanisms such as attenuation include: filtration, soprtion, chemical processes, microbiological decomposition and dilution. As a part of the EPD-required Site Assessment Report, sorptive capacity (cation exchange capacity) will be measured in undisturbed samples collected at varying depths from site suitability borings.

The Hydrological Atlas Number 20, of the Georgia Geological Survey, was utilized to determine the nearest proximity of groundwater pollution susceptibility areas to the site. The atlas shows the site within an average susceptibility area with a DRASTIC rating between 141 and 181, as shown on Figure 10. The DRASTIC rating is based upon several factors, such as depth to water, sorption above the water table, aquifer permeability, water table gradient, horizontal distance, thickness of unconsolidated media at two-media sites, recharge, aquifer media, impact of vadose zone, hydraulic conductivity, soil media, and topography. Again, the DRASTIC pollution susceptibility methodology only considers sites in their natural state and does not take into account engineered sites having liner and leachate collection systems.

According to the Hydrologic Atlas 20 and as shown on Figure 10, the proposed landfill site is not located in a significant recharge area. The overall pollution potential for the landfill was estimated using the LeGrand concept for loose granular materials extending 100 feet or more below the ground surface (typical Coastal Plain sites) as described in Circular 14 (Rating Chart excerpt shown on Figure 11). The following values are for the flow most typical of site and were calculated to develop a total LeGrand score, as follows:

- Depth to groundwater beneath landfill – 20 foot average (2.5 points)
- Soil sorption – maximum sorption for composite liner with leachate collection system (6 points)
- Aquifer permeability – "clayey sand" permeability rating for composite liner with leachate collection system (3 points)
- Gradient – maximum of 5 percent with favorable flow direction (4.8 points)
- Distance to receptor – Approximately 1,900 feet from the proposed landfill footprint to Brady Branch, which is the closest down-gradient receptor (9.5 points)

Modern landfills are required to be designed with a composite liner and a leachate collection system. With these engineering controls, the total score for the LeGrand calculation for the nearest drinking water receptor is 25.8 points, which is considered "approaching impossible" pollution potential. Listed below in Table 1 is a summary indicating different scenarios using the LeGrand calculation, and as identified in Figure 11:

Table 1: Summary of LaGrand calculation for Groundwater Pollution Potential

Scenario	**Without Composite Liner & Leachate Collection System "NATURAL STATE"**	**With Composite Liner & Leachate Collection System**
Nearest down-gradient receptor: Brady Branch	23.9 Possible, but not likely	25.8 Approaching impossible
Nearest down-gradient residential receptor	24.9 Possible, but not likely	26.8 Approaching impossible

For sites having an "imminent" (LaGrand rating between 0-4 points) or "probable" (LaGrand rating between 4-8 points) pollution potential in their natural state, Georgia EPD recommends they have their pollution potential reduced through design engineering. Since the "natural state" scenarios (i.e., unlined landfills) for the Green Meadows Dairy Farm site score an unlikely possibility of groundwater pollution potential to offsite receptors in the surficial, unconfined aquifer, there is even lesser potential for a modern landfill (with a composite liner and leachate collection system) to adversely impact groundwater in the underlying confined Upper Floridan Aquifer.

Should there ever be a release from the proposed landfill as a result of a leak in the composite liner, the LaGrand calculation predicts an "approaching impossible" potential for groundwater pollution at the Green Meadows Dairy Farm site because of the site-specific factors affecting the ability of natural attenuation to occur.

The United States Environmental Protection Agency (US EPA) defines **natural attenuation** as "a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants" (US EPA, 1999)

According to the US EPA, natural attenuation reduces potential risk posed by site contaminants in three (3) ways:

(1) Transformation of contaminant(s) to a less toxic form through destructive processes such as biodegradation or abiotic transformations;
(2) Reduction of contaminant concentrations whereby potential exposure levels may be reduced; and
(3) Reduction of contaminant mobility and bioavailability through sorption onto the soil or rock matrix.

Harry E. LeGrand, who created the groundwater pollution potential rating system currently being used by Georgia EPD, wrote in "A Standardized System for Evaluating Waste-Disposal Sites: A Manual to Accompany Description and Rating Charts" regarding un-lined, pre-Subtitle D landfills:

> The soil zone is the pivotal zone for most contaminants. Infiltration of water from precipitation tends to carry contaminants downward into the groundwater flow system. Biodegradation, sorption and other processes of weakening of contamination occur in the soil zone, and thus there is a strong tendency for many contaminants to be retarded in the movement of subsurface water. The chemical and biological character of contaminants and the texture, permeability and thickness of the soil zone are important features affecting the rate of movement of contaminants…
>
> Permeability is an important characteristic because it controls the rate of movement of water and its contaminants. The permeability of some clays may be hundreds times less than that of some sands… Differences of permeability in the horizontal field, although common, are in many cases more gradual than in the vertical field. It is significant that water and the leached material in it will tend to make preferred paths, flowing readily through permeable zones and shunning or flowing with difficulty through relatively impermeable materials.
>
> The water table has an important influence on ground water contamination, not because of any specific magical contamination control, but because it is a distinctive marker between the unsaturated and saturated zones. In the unsaturated zone, above the water table, attenuation of most contaminants in sands, silts and clays is especially effective, and many studies have shown that the thicker the unsaturated zone, or the deeper the water table the more effective is the attenuation.

Based upon the initial and limited information available, the subsurface conditions at the Green Meadows Dairy Farm site are favorable for natural attenuation to occur. The groundwater table of the unconfined aquifer was observed deeper than 15 feet below ground surface (ft bgs) in May 2019, and deeper than 30 ft bgs in the upland portions. These depths do not indicate a shallow water table, therefore the unsaturated (vadose) zone is suitable for natural attenuation processes to reduce contaminants (Georgia Geologic Survey, 1992). The natural sandy clays and clayey sands which underlay the site have the ability to absorb contaminants and retard velocities due to low soil permeability. Lastly, the horizontal distance to offsite receptors is favorable for natural attenuation to occur because locations are greater than minimum State requirements to residential wells (500 feet) and separated by the State-required undisturbed buffer of 200 feet for potential mitigation purposes, minimizing concern of groundwater pollution in the uppermost aquifer.

2.4 Description of the Inter-Relationship Between Groundwater Flow Directions and Potential Receptors

Horizontal directions of groundwater flow in the surficial unconfined aquifer are shown on Figure 7. These assumed groundwater flow directions generally follow the natural topography; that is, flowing easterly towards Brady Branch and southerly towards the existing onsite surface water pond. Potential receptors are located down-gradient of the proposed site to the south on the other side of Brady Branch. Locations of these receptors are shown in Figure 7.

Of the estimated 22 offsite potential residential receptors located within 0.5 mile of the proposed site's boundary, 13 are down-gradient and all on the other side of Brady Branch to the south and its tributary to the southwest. No offsite residential receptors are located within 0.5 mile of the proposed landfill footprint. The remaining offsite potential residential receptors located within 0.5 miles of the property boundary are located hydraulically up-gradient or lateral gradient of the site. These potential receptors are identified in Figure 7.

The approximate horizontal distances between the nearest potential receptors are indicated on Figure 7. As mentioned earlier in Section 1.3, it is our understanding domestic wells and irrigation wells in the vicinity of the site were installed at depths ±200-300 feet below ground surface. Based on the limited hydraulic conductivity data (laboratory vertical and USDA Web Soil Survey horizontal), the horizontal direction of groundwater flow through the unconfined aquifer is greater than the potential for vertical migration through the uppermost aquifer and through the lower confining units, making it less likely the deeper drinking water wells within proximity to the proposed site will be affected by potential pathways in groundwater flow.

2.5 Estimated Travel Time for Leachate to Reach Potential Receptors

As shown in Section 2.2, the maximum and average linear groundwater flow velocities for the surficial, unconfined aquifer are calculated from Darcy's Law to be 0.58 and 0.05 feet/day. The nearest hydraulically down-gradient receptor is approximately ±5,200 feet from the proposed conceptual footprint (See Figure 7) located on the other side of Brady Branch. Using the conservative, maximum flow velocity, the estimated travel time for groundwater to flow horizontally from the proposed waste disposal boundary to this potential receptor is approximately 24.6 years. This preliminary estimate is not an adequate measure of travel time to potential receptors and should not be used for mitigation because of the following actual limitations to this estimate:

1. The actual travel time is expected to be much longer than this estimate because of the vertical and diagonal pathway to the actual well intake elevation of unscreened casing bottom, estimated to be ±200 feet below ground surface into a confining unit; the travel time vertically by gravity alone through each underlying strata or confining unit cannot be calculated although it is understood this vertical pathway takes far more time than the horizontal pathway through the surficial unconfined aquifer; each subsequent vertical strata with varying densities further filters the groundwater before it reaches this deeper elevation;

2. Surface water and natural depressions or drainage ways can intercept discharged groundwater between future waste limits and property boundary;

3. The actual travel time is expected to be longer than this preliminary estimate because of the anticipated longer horizontal travel distance. This distance is anticipated to be longer due to the actual horizontal groundwater flow direction, which is not linear;

4. The actual pathway of the theoretical contaminant will likely not ever reach the potential receptor because of the likely considerable dilution and natural attenuation processes and the intrinsic chemical properties that would retard transport under actual conditions; and

5. The actual travel time is expected to be much longer than this preliminary estimate because the waste disposal unit is required to have a liner and leachate collection system.

6. More information is needed from a more-detailed site investigation required by Georgia EPD prior to issuance of site limitations.

In conclusion, in the unlikely occurrence of a failure in the required liner and leachate collection system, the estimated travel time of a theoretical contaminant is anticipated to be much greater than 16.1 years.

2.6 Wellhead Protection Area

The Georgia Environmental Protection Division (EPD) is required to "develop a Wellhead Protection Plan for every well, well field of spring which is used as source for a community public water systems owned by and/or serving municipalities, counties, and authorities from nearby pollution sources." (Georgia Rule 391-3-5-.40-[2]).

EPD defines a **Wellhead protection area** as "an area of potential ground water recharge around a well which should be protected from surface and subsurface sources of man-made pollution in order to protect the quality of drinking water supplies." (Georgia Rule 391-3-5-.02-[140]).

Every wellhead protection area consists of two (2) zones: the Control Zone and the Management Zone. The **Control Zone** is the area where the owner is required to "control all activities so there are minimal sources of potential pollution in the immediate vicinity of the well bore." (Georgia Rule 391-3-5-.40-[4]-[a]) This area is typically a 15-ft radius from the wellhead and is required for sources "of public water supply for community water systems owned by and/or serving municipalities, counties, or authorities." (Georgia Rule 391-3-5-.40-[5])

The **Management Zone** is the area where, "within this zone, certain potential pollution sources are prohibited or certain activities must be performed in accordance with the rules… The size and shape of the management zone will vary according to aquifer type, aquifer hydraulic conductivity, pumpage rate, hydrologic province, and proximity to recharge." (Georgia Rule 391-3-5-.40-[4]-[b]) Because Screven County is designated as a "Coastal Plain" aquifer type, by default the **Inner-Management Zone** is a 250-ft radius from the wellhead. If the owner can document the aquifer type is within a confining unit, then the Inner-Management Zone is only a 100-ft radius from the wellhead. The **Outer-Management Zone** by default is a one-mile radius, however, can be anywhere between 100-ft to several miles depending upon well construction and the geology of the wellhead protection area.

EPD cannot issue any new permits for municipal solid waste (MSW) landfills if the proposed site is within the inner and outer management zone of existing public water supply wells and springs. The same is true for land application systems (LAS) of wastewater or sludge for which the Green Meadows Dairy farm is currently operating under Permit No. GAG940027. Based upon recent correspondence with Georgia EPD, the Green Meadows Dairy Farm site is not within an inner or outer management zone of any wellhead protection area. Therefore, the subject sites meets this criteria.

2.7 Mitigation of Geologic and/or Natural Hazards

Based on the preliminary information presented in the IES letter dated June 18, 2019, there are no geologic and/or natural hazards in the site area which would warrant special mitigation or design criteria other than all containment structures and surface water control systems shall be designed to resist the maximum horizontal acceleration of lithified earth material for the site.

3.0 Conclusion

The United States Environmental Protection Agency (US EPA) now requires all municipal solid waste landfills to be designed with leachate collection systems and composite liners (i.e., Subtitle D criteria). The two (2) components of the composite liner system consists of a *lower* component and a *higher* component. The lower component is a minimum of 2 feet of soil material compacted to a hydraulic conductivity of no more than 1 x 10^{-7} centimeters/second (cm/sec). The upper component is a minimum 30-mil flexible membrane liner (FML) installed in direct contact with the lower component. If high-density polyethylene (HDPE) is used, a minimum thickness of 60 mils is required. Lastly, a leachate collection system is designed and constructed to maintain less than a 30-cm (approximately 1-foot) depth of leachate over the liner.

The required composite liner system significantly retards any potential leak, as opposed to using just one of its components. In a US EPA Seminar Publication on the "Design, Operation, and Closure of Municipal Solid Waste Landfills," it states:

> "The geomembrane liner (GML) minimizes the exposure of the compacted soil liner to leachate, thus significantly reducing the volume of leachate reaching the soil liner. Reducing membrane penetration is vital to controlling the escape of leachate into ground water. One way to reduce membrane penetration is to institute a comprehensive quality assurance program... The hydraulic conductivity of the compacted soil liner is an important factor in leakage control. For example, a 1-square-centimeter hole in a geomembrane with 12 inches of liquid head can have a leakage rate as high as 3,300 gallons per day. The presence of a compacted soil liner with a conductivity of 10^{-7} centimeters per second underneath the geomembrane can reduce this rate to 0.2 gallons per day. Even if the conductivity changes to 10^{-6} centimeters per second, the leakage rate still would be less than 4 gallons per day, providing a dramatic improvement over the use of a geomembrane alone."

The preliminary field investigation in May 2019 performed by Whitaker Laboratory, Inc. encountered natural soil lenses of sandy CLAY (CL) and clayey SAND (SC) underlying the existing Green Meadows Dairy Farm site in the uppermost aquifer. Vertical hydraulic conductivity of the bulk samples collected ranged between 4.4 and 5.4 x 10^{-8} cm/sec, which is approximately two times less permeable than the state and federal requirements for constructed soil liners at modern landfills.

LaGrand's rating method discussed in this letter confirms how unlikely groundwater pollution will occur in the uppermost aquifer. There are no significant groundwater recharge areas within two (2) miles of the site and the site is not in a management area of a wellhead protection zone.

Based upon research of recent information provided to us by Georgia EPD, our review did not find any Subtitle D municipal solid waste landfill cells (with composite liner and leachate collection systems) that had documented releases to groundwater not associated with contiguous pre-Subtitle D disposal areas, gas migration issues, or data evaluation and/or interpretation issues. A summary of our research is included in Appendix B of this letter.

Therefore, based upon this initial and limited assessment, it is extremely unlikely a Subtitle D municipal solid waste (MSW) landfill, required to be designed and constructed in accordance with state and federal requirements (a "modern landfill"), will contaminate the groundwater in the Upper Floridan Aquifer, where nearby agricultural and drinking water wells are assumed to be constructed.

Should you have any questions, or need any additional information, do not hesitate to contact me.

Sincerely,
INNOVATIVE ENGINEERING STRATEGIES, LLC

Michael W. Biers, P.E.
Georgia Professional Engineer No. 36066

3.0 References Cited

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LeGrand, Henry E., 1983, A Standardized System for Evaluating Waste-Disposal Sites: A Manual to Accompany Description and Rating Charts.

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United States Geologic Survey (USGS), 2017, 7.5-Minute Series Quadrangle Map, for Sylvania South, Hunters, Dover and Oliver.

United States Environmental Protection Agency, 1994, Design, Operation, and Closure of Municipal Solid Waste Landfills, Seminar Publication EPA/625/R-94/008.

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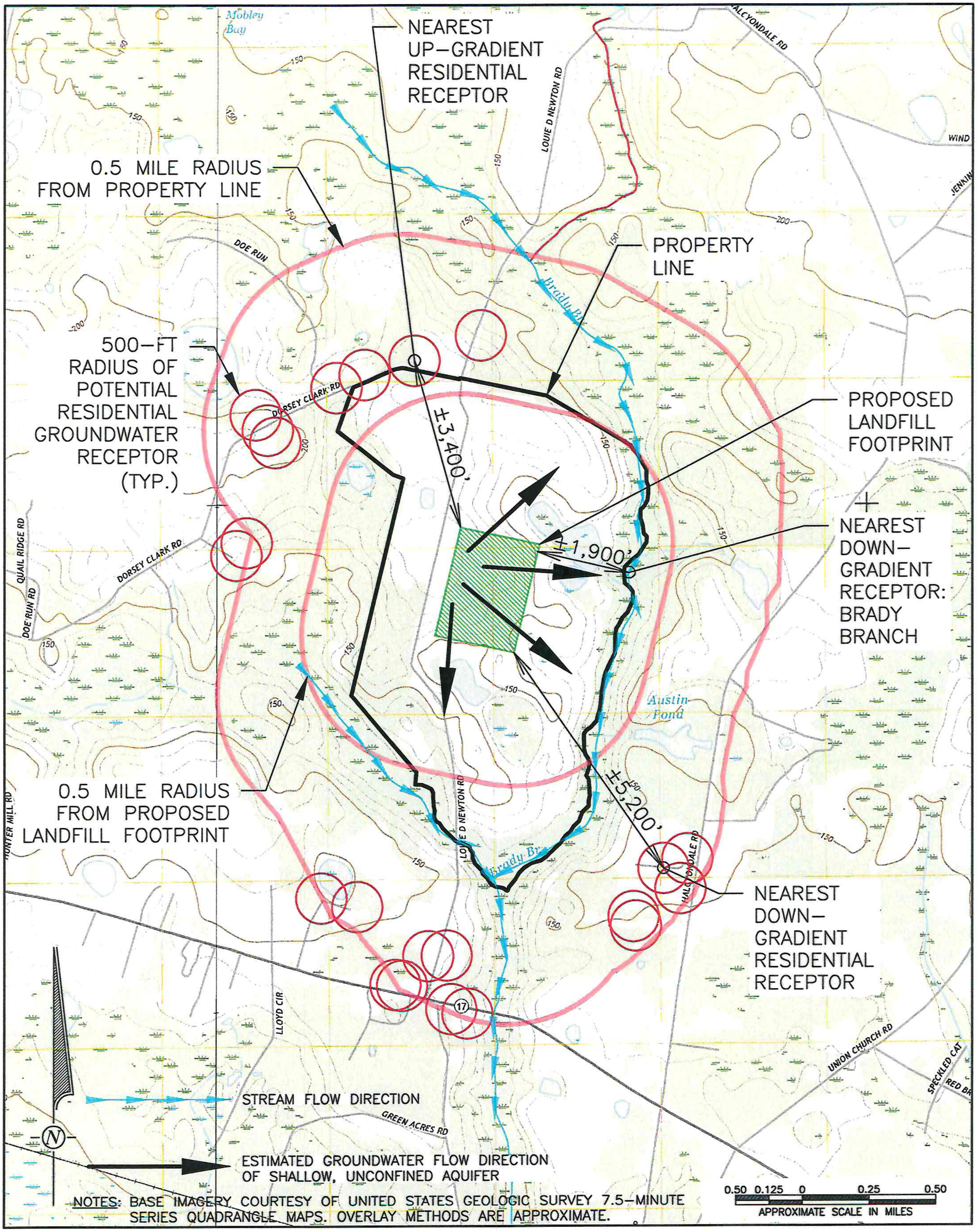
FIGURES



ATLANTIC WASTE SERVICES, INC.

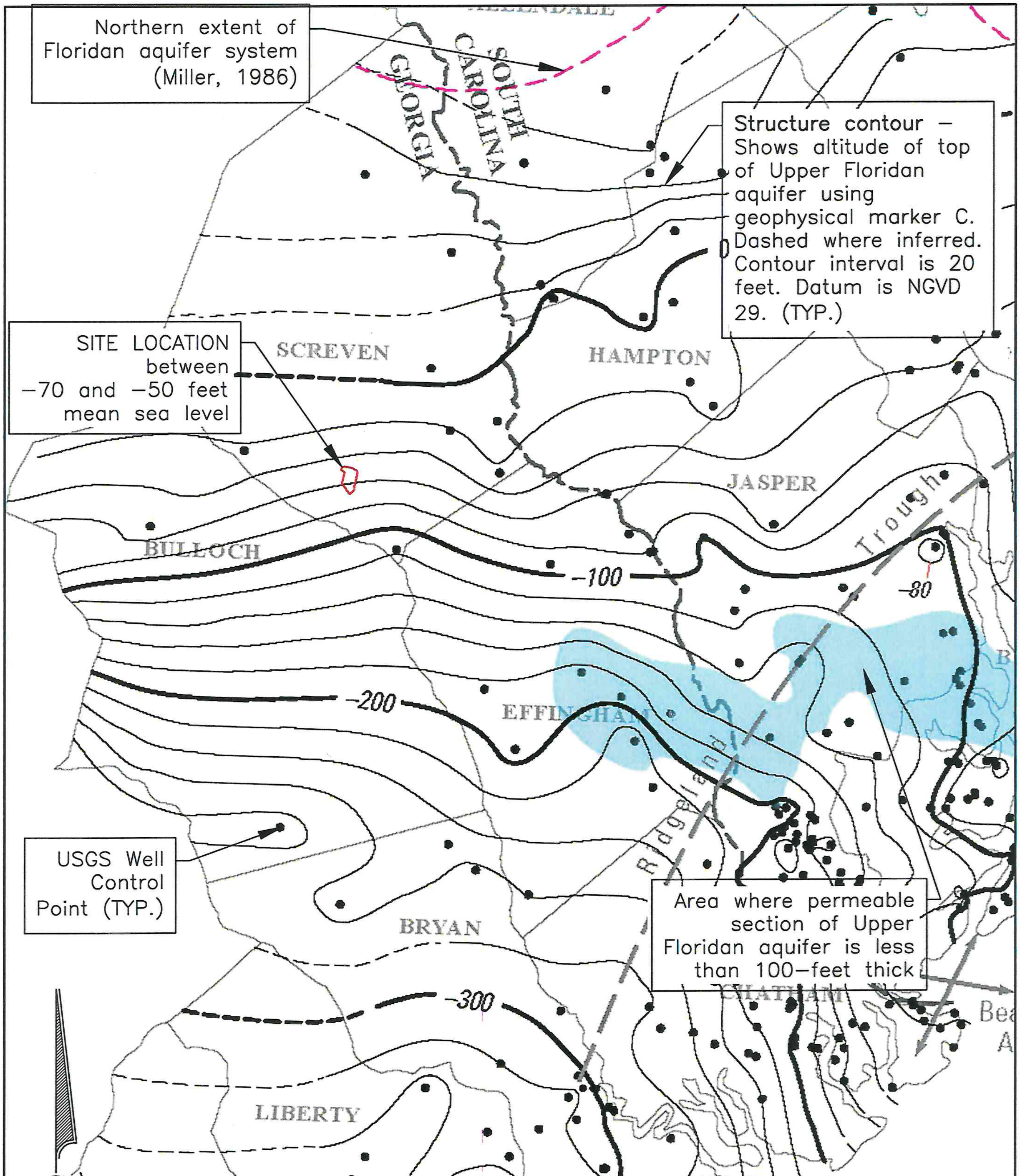
PROPOSED LANDFILL IN SCREVEN COUNTY, GEORGIA

PRELIMINARY OPINION OF GROUNDWATER POLLUTION POTENTIAL

PROXIMITY TO OFFSITE GROUNDWATER RECEPTORS

FIGURE 7

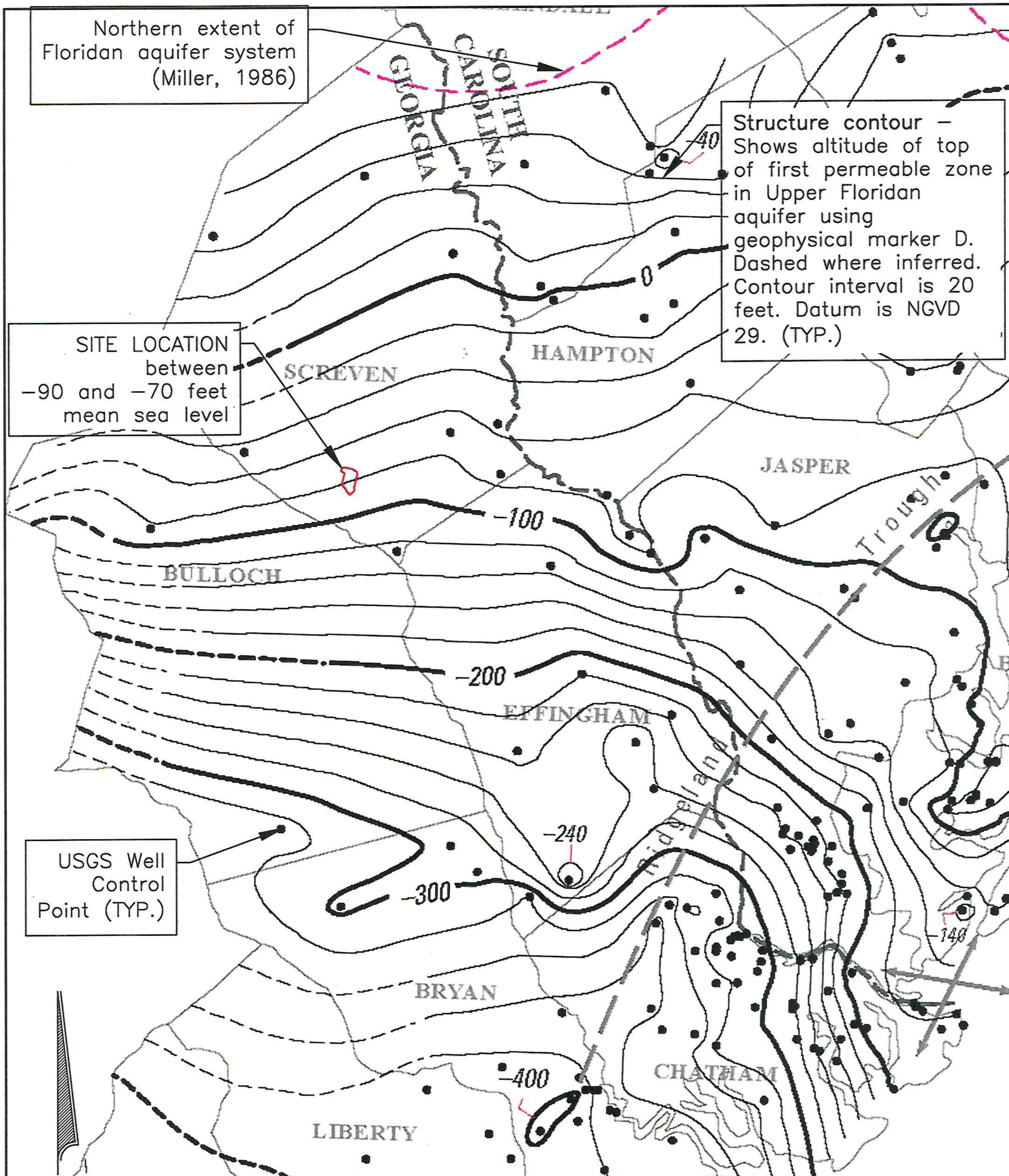
IES PROJECT NO: 1210-019-01 DRAWING: 1210-019 pathway.dwg DATE: 06-25-19



NOTES: BASE IMAGERY COURTESY OF UNITED STATES GEOLOGICAL SURVEY ((USGS) SCIENTIC INVESTIGATIONS REPORT (SIR) 2010-5158 "REVISED HYDROGEOLOGIC FRAMEWORK OF THE FLORIDAN AQUIFER SYSTEM IN THE NORTHERN COASTAL AREA OF GEORGIA AND ASDJACENT PARTS OF SOUTH CAROLINA," FIGURE 26: ALTITUDE OF THE UPPER FLORIDAN AQUIFER SYSTEM. OVERLAY METHODS ARE APPROXIMATE.

ATLANTIC WASTE SERVICES, INC.	PRELIMINARY OPINION OF GROUNDWATER POLLUTION POTENTIAL	FIGURE
PROPOSED LANDFILL IN SCREVEN COUNTY, GEORGIA	PROXIMITY TO TOP OF UPPER FLORIDAN AQUIFER	8a

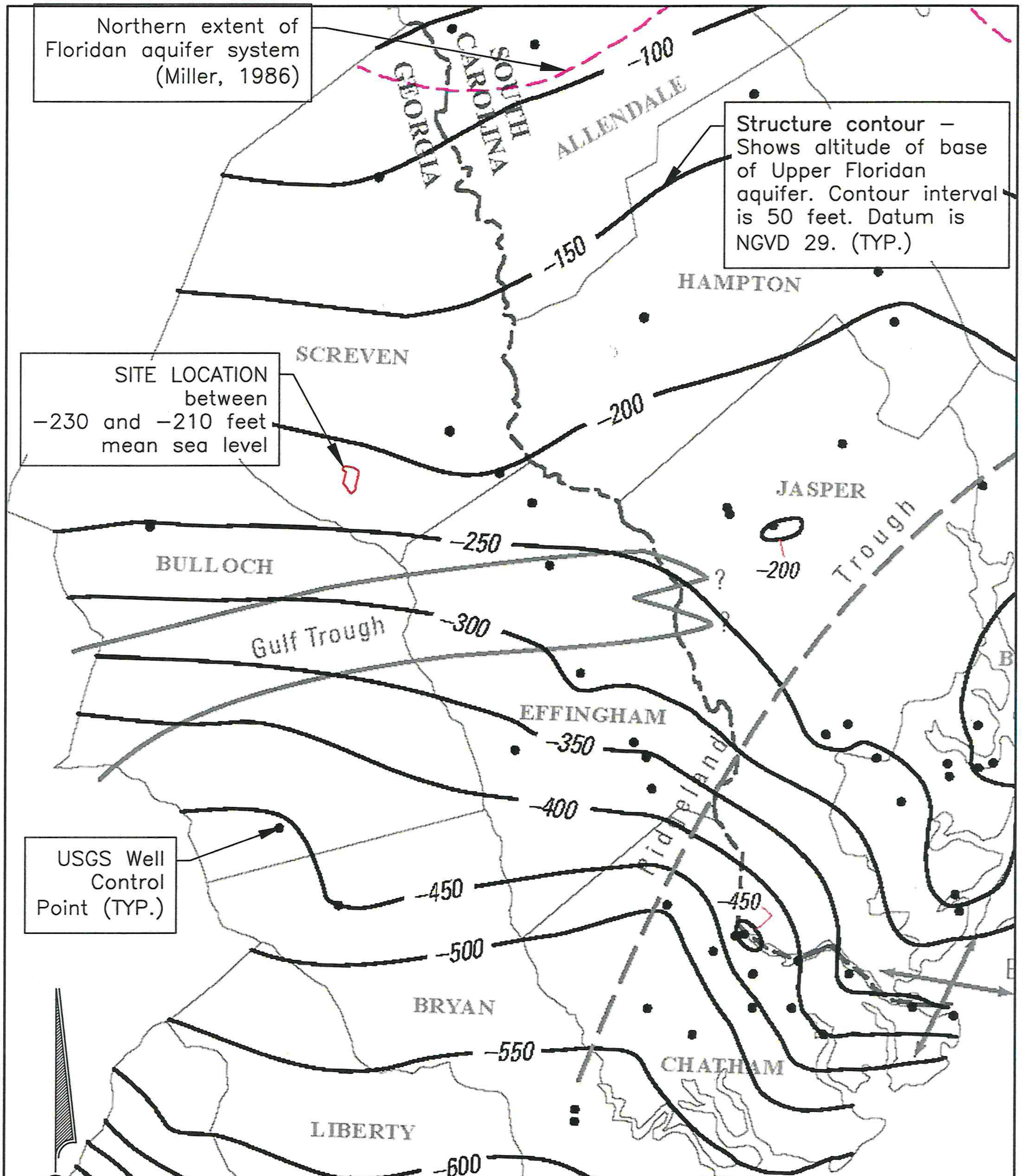
IES PROJECT NO: 1210-019-01 DRAWING: 1210-019 pathway.dwg DATE: 06-25-19



NOTES: BASE IMAGERY COURTESY OF UNITED STATES GEOLOGICAL SURVEY ((USGS) SCIENTIC INVESTIGATIONS REPORT (SIR) 2010–5158 "REVISED HYDROGEOLOGIC FRAMEWORK OF THE FLORIDAN AQUIFER SYSTEM IN THE NORTHERN COASTAL AREA OF GEORGIA AND ASDJACENT PARTS OF SOUTH CAROLINA," FIGURE 27: ALTITUDE OF THE TOP OF OF THE UPPER EOCENE ROCKS IN THE UPPER FLORIDAN AQUIFER SYSTEM. OVERLAY METHODS ARE APPROXIMATE.

ATLANTIC WASTE SERVICES, INC.	PRELIMINARY OPINION OF GROUNDWATER POLLUTION POTENTIAL	FIGURE
PROPOSED LANDFILL IN SCREVEN COUNTY, GEORGIA	PROXIMITY TO TOP OF FIRST PERMEABLE ZONE IN UPPER FLORIDAN AQUIFER	8b

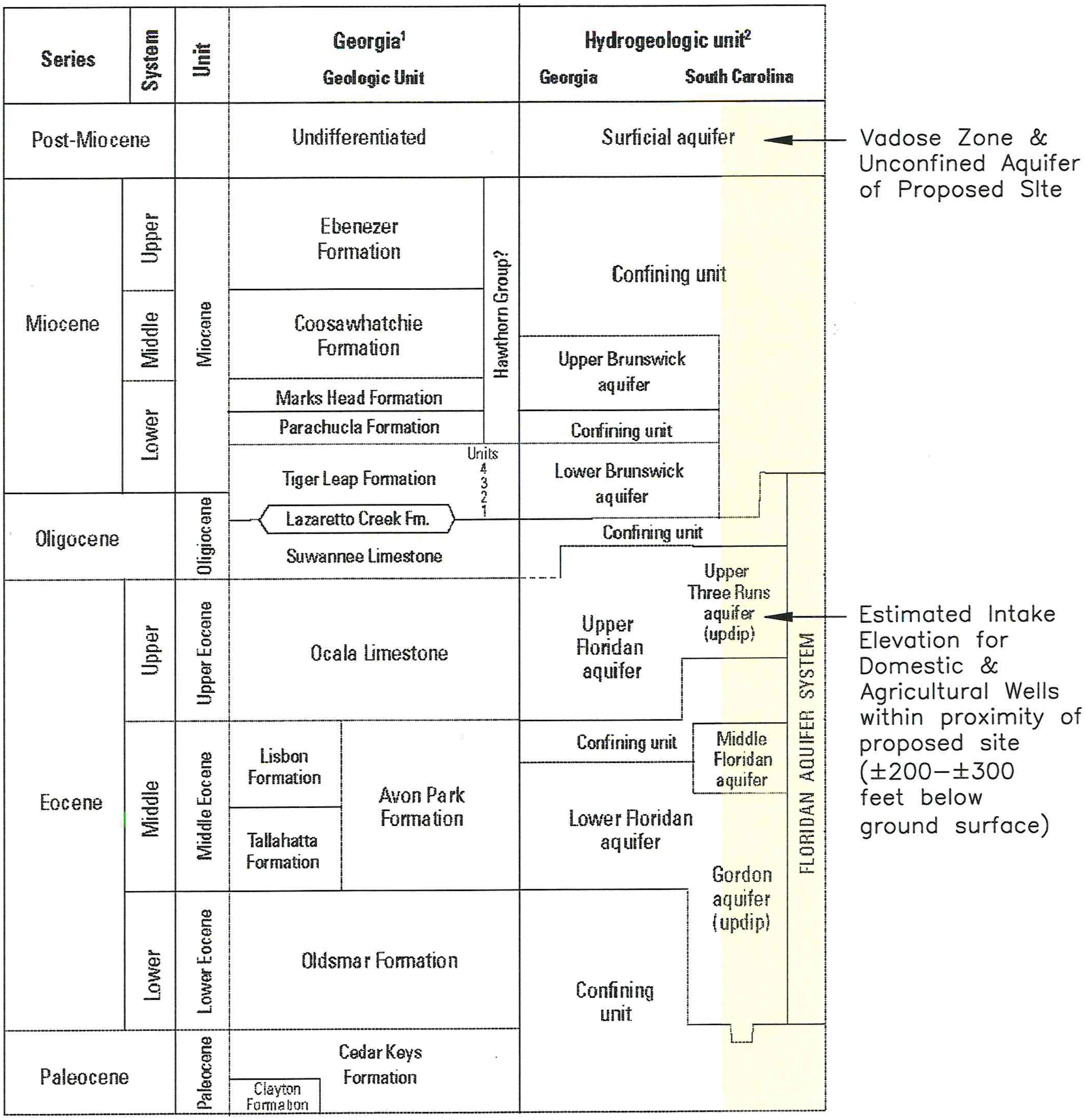
IES PROJECT NO: 1210–019–01 DRAWING: 1210–019 pathway.dwg DATE: 06–25–19



NOTES: BASE IMAGERY COURTESY OF UNITED STATES GEOLOGICAL SURVEY ((USGS) SCIENTIC INVESTIGATIONS REPORT (SIR) 2010-5158 "REVISED HYDROGEOLOGIC FRAMEWORK OF THE FLORIDAN AQUIFER SYSTEM IN THE NORTHERN COASTAL AREA OF GEORGIA AND ADJACENT PARTS OF SOUTH CAROLINA," FIGURE 28: ALTITUDE OF THE BASE OF THE UPPER FLORIDAN AQUIFER SYSTEM. OVERLAY METHODS ARE APPROXIMATE.

ATLANTIC WASTE SERVICES, INC.	PRELIMINARY OPINION OF GROUNDWATER POLLUTION POTENTIAL	FIGURE
PROPOSED LANDFILL IN SCREVEN COUNTY, GEORGIA	PROXIMITY TO THE BASE OF THE UPPER FLORIDAN AQUIFER	8c

IES PROJECT NO: 1210-019-01 DRAWING: 1210-019 pathway.dwg DATE: 06-25-19



[1]Modified from Weems and Edwards, 2001; Miller, 1986; Randolph and others, 1991; Clarke and Krause, 2000

[2]Modified from Miller, 1986; Clarke and others, 2004; Randolph and others, 1991; Weems and Edwards, 2001

[3]Modified from Edwards, 2001; Self-Trail and Bybell, 1997; Falls and others, 1997; Miller, 1986

NOTES: BASE IMAGERY COURTESY OF UNITED STATES GEOLOGICAL SURVEY ((USGS) SCIENTIC INVESTIGATIONS REPORT (SIR) 2010–5158 "REVISED HYDROGEOLOGIC FRAMEWORK OF THE FLORIDAN AQUIFER SYSTEM IN THE NORTHERN COASTAL AREA OF GEORGIA AND ADJACENT PARTS OF SOUTH CAROLINA," FIGURE 3: GEOLOGIC AND HYDROGEOLOGIC UNITS OF NORTHERN COASTAL AREA OF GEORGIA AND PARTS OF SOUTH CAROLINA.

ATLANTIC WASTE SERVICES, INC.

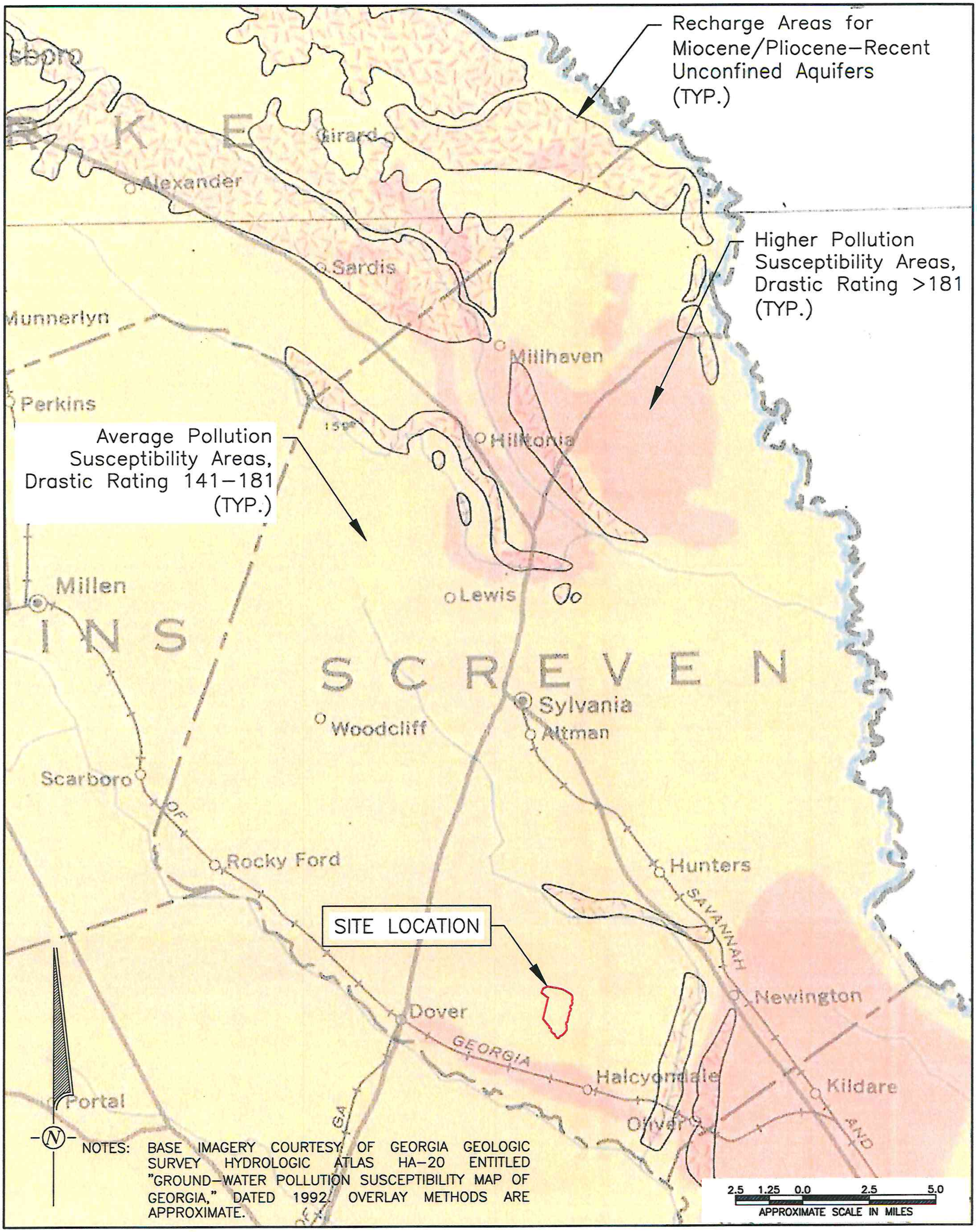
PROPOSED LANDFILL IN SCREVEN COUNTY, GEORGIA

PRELIMINARY OPINION OF GROUNDWATER POLLUTION POTENTIAL

RELATIONSHIP BETWEEN THE VADOSE ZONE AND DEEPER AQUIFERS

FIGURE 9

IES PROJECT NO: 1210–019–01 DRAWING: 1210–019 pathway.dwg DATE: 06–25–19



ATLANTIC WASTE SERVICES, INC.

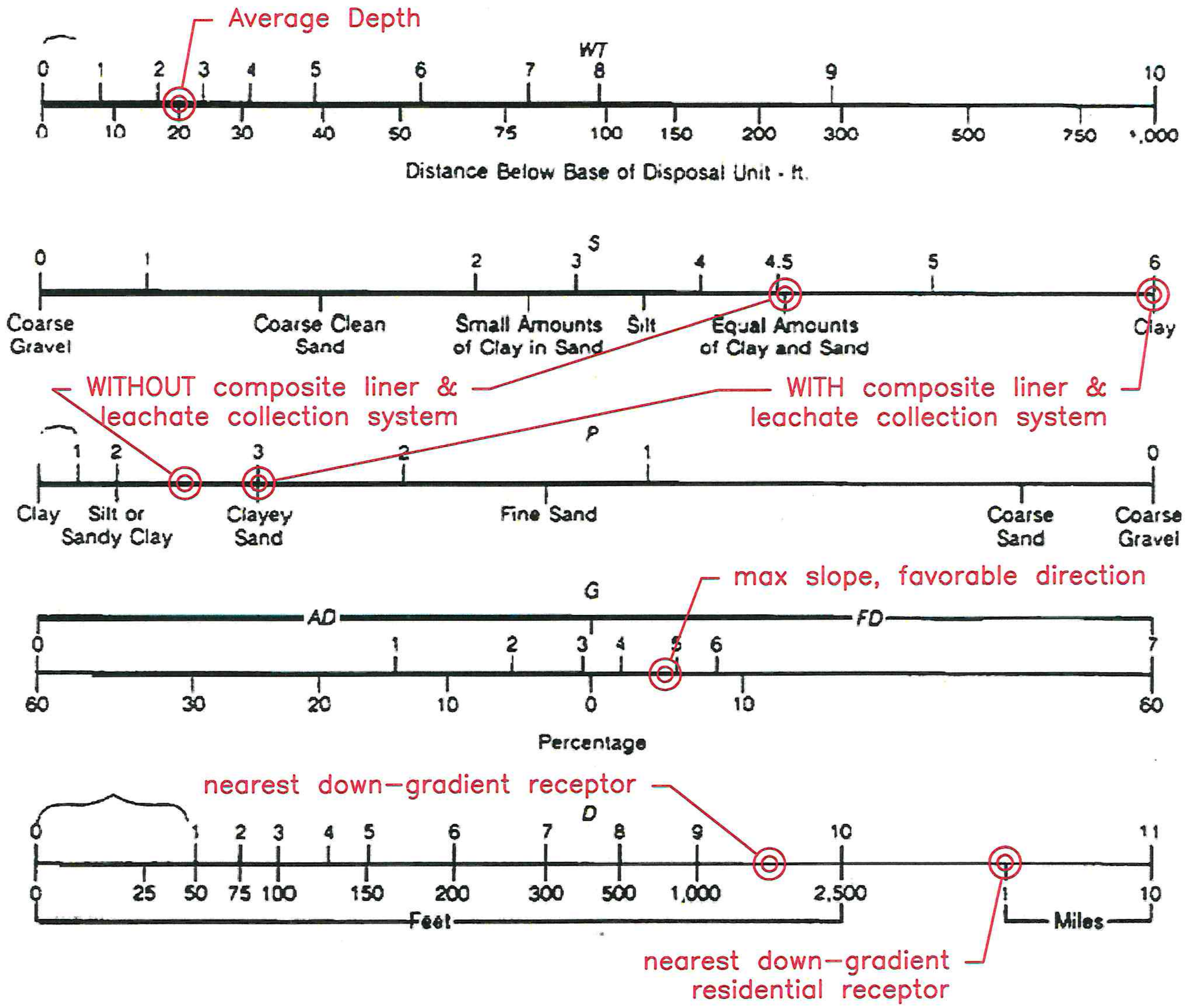
PROPOSED LANDFILL IN SCREVEN COUNTY, GEORGIA

PRELIMINARY OPINION OF GROUNDWATER POLLUTION POTENTIAL

PROXIMITY TO GROUNDWATER HIGHER POLLUTION SUSCEPTIBILITY AREAS

FIGURE 10

IES PROJECT NO: 1210–019–01 DRAWING: 1210–019 pathway.dwg DATE: 06–25–19



The scales for the various factors are labeled as follows: WT, water table; S, sorption; P, permeability; G, gradient; and D, distance. On all scales the point values are indicated by the upper scale; the brackets indicate unacceptable ranges for any factor, except the two brackets on the gradient scale, one labeled AD, which is for an adverse direction of flow (toward point of water use), and one FD, which is for a favorable direction of flow. (From LeGrand, 1964).

NOTES: BASE IMAGERY COURTESY OF GEORGIA ENVIRONMENTAL PROTECTION DIVISION (EPD) CIRCULAR 14: CRITERIA FPR PERFORMING SITE ACCEPTABILITY STUDIES FOR SOLID WASTE LANDFILLS IN GEORGIA, "FIGURE 3: RATING CHART FOR SITES IN LOOSE GRANULAR MATERIALS," DATED 1997. IMAGE OVERLAY METHODS ARE APPROXIMATE

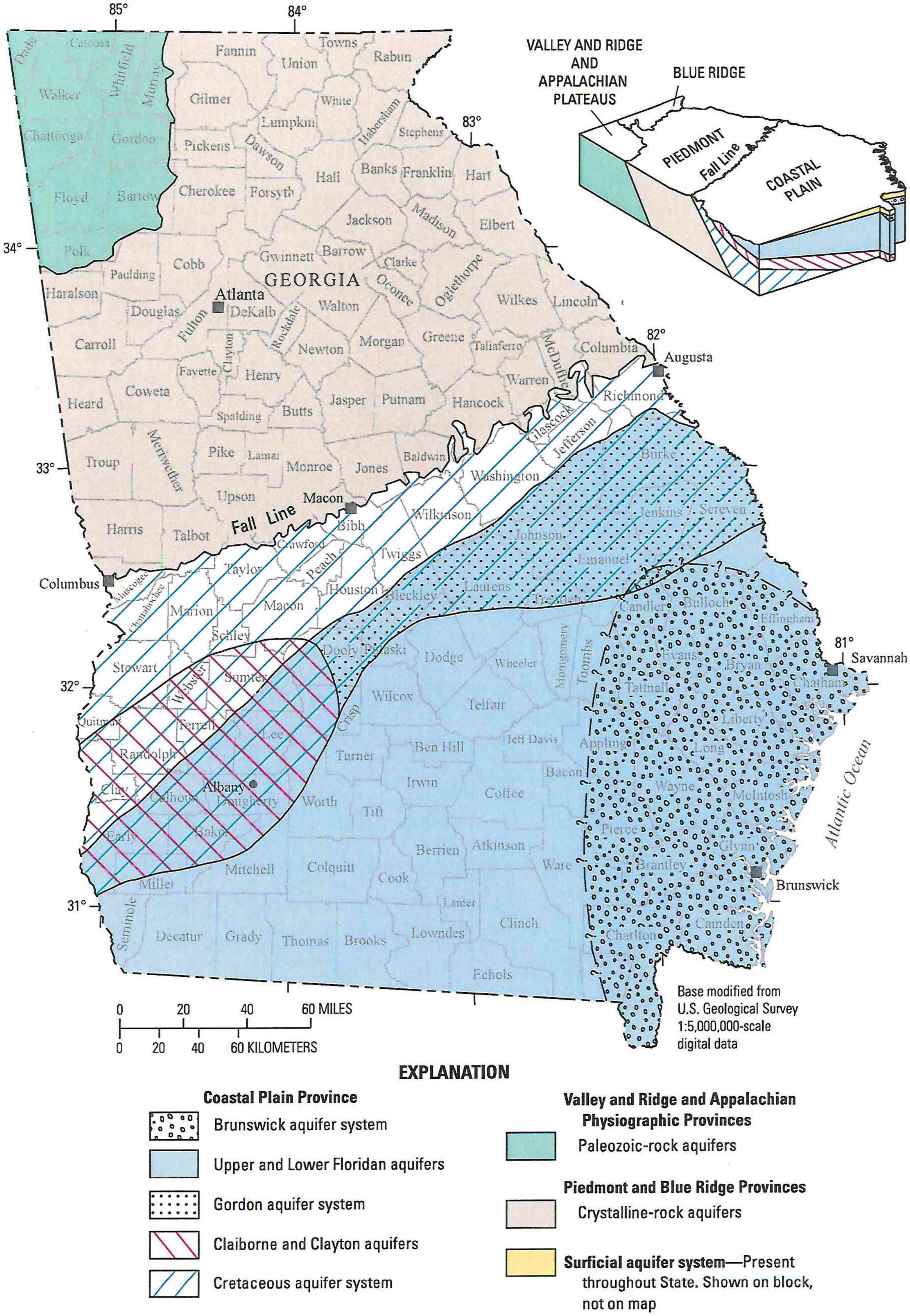
ATLANTIC WASTE SERVICES, INC. / PROPOSED LANDFILL IN SCREVEN COUNTY, GEORGIA	PRELIMINARY OPINION OF GROUNDWATER POLLUTION POTENTIAL / LAGRAND RATING CHART FOR SITES IN LOOSE GRANULAR MATERIALS	FIGURE 11

IES PROJECT NO: 1210-019-01 DRAWING: 1210-019 pathway.dwg DATE: 06-25-19

APPENDIX A

Excerpt from:

United States Geologic Survey (USGS), 2011, Groundwater Conditions and Studies in Georgia, 2008-2009, Scientific Investigations Report Study SIR 2011-5048.



Areas of use of major aquifers in Georgia (modified from Clarke and Pierce, 1985).

Groundwater Resources

Aquifer and well characteristics in Georgia [modified from Clarke and Pierce, 1985; Peck and others, 1992; ft, foot; gal/min, gallon per minute]

Aquifer name	Aquifer description	Well characteristics		
		Depth (ft)	Yield (gal/min)	
		Typical range	Typical range	May exceed
Surficial aquifer system	Unconsolidated sediments and residuum; generally unconfined. However, in the coastal area of the Coastal Plain, at least two semiconfined aquifers have been identified	11–300	2–25	75
Brunswick aquifer system, including upper and lower Brunswick aquifers	Phosphatic and dolomitic quartz sand; generally confined	85–390	10–30	180
Upper and Lower Floridan aquifers	Limestone, dolomite, and calcareous sand; generally confined	40–900	1,000–5,000	11,000
Gordon aquifer system	Sand and sandy limestone; generally confined	270–530	87–1,200	1,800
Claiborne aquifer	Sand and sandy limestone; generally confined	20–450	150–600	1,500
Clayton aquifer	Limestone and sand; generally confined	40–800	250–600	2,150
Cretaceous aquifer system	Sand and gravel; generally confined	30–750	50–1,200	3,300
Paleozoic-rock aquifers	Sandstone, limestone and dolomite; generally confined	15–2,100	1–50	3,500
Crystalline-rock aquifers	Granite, gneiss, schist, and quartzite; confined and unconfined	40–600	1–25	500

Hydrologic response	Remarks
Water-level fluctuations are caused mainly by variations in precipitation, evapotranspiration, and natural drainage or discharge. In addition, water levels in the City of Brunswick area are influenced by nearby pumping, precipitation, and tidal fluctuations (Clarke and others, 1990). Water levels generally rise rapidly during wet periods and decline slowly during dry periods. Prolonged droughts may cause water levels to decline below pump intakes in shallow wells, particularly those located on hilltops and steep slopes, resulting in temporary well failures. Usually, well yields are restored by precipitation (Clarke, 2003).	Primary source of water for domestic and livestock supply in rural areas. Supplemental source of water for irrigation supply in coastal Georgia.
In the coastal area, the aquifers may respond to pumping from the Upper Floridan aquifer as a result of the hydraulic connection between the aquifers. Elsewhere, the water level mainly responds to seasonal variations in recharge and discharge. In Bulloch County, unnamed aquifers equivalent to the upper and lower Brunswick aquifers are unconfined to semiconfined and are influenced by variations in recharge from precipitation and by pumping from the Upper Floridan aquifer; in the Wayne and Glynn County area, the aquifers are confined and respond to nearby pumping (Clarke and others, 1990; Clarke, 2003).	Not a major source of water in coastal Georgia, but considered a supplemental water supply to the Upper Floridan aquifer.
In and near outcrop areas, the aquifers are semiconfined, and water levels in wells tapping the aquifers fluctuate seasonally in response to variations in recharge rate and pumping. Near the coast, where the aquifers are confined, water levels primarily respond to pumping, and fluctuations related to recharge are less pronounced (Clarke and others, 1990).	Supplies about 50 percent of groundwater in Georgia. The aquifer system is divided into the Upper and Lower Floridan aquifers. In the Brunswick area, the Upper Floridan aquifer includes two freshwater-bearing zones—the upper water-bearing zone and the lower water-bearing zone. In the Brunswick area and in southeastern Georgia, the Lower Floridan aquifer includes the brackish-water zone, the deep freshwater zone, and the Fernandina permeable zone (Krause and Randolph, 1989). The Lower Floridan aquifer extends to more than 2,700 ft in depth and yields high-chloride water below 2,300 ft (Jones and Maslia, 1994).
Water levels are influenced by seasonal fluctuations in recharge from precipitation, discharge to streams, and evapotranspiration (Clarke and others, 1985).	Major source of water for irrigation, industrial, and public-supply use in east-central Georgia.
Water levels are mainly affected by precipitation and by local and regional pumping (Hicks and others, 1981). The water level is generally highest following the winter and spring rainy seasons, and lowest in the fall following the summer irrigation season.	Major source of water for irrigation, industrial, and public-supply use in southwestern Georgia.
Water levels are affected by seasonal variations in local and regional pumping (Hicks and others, 1981).	Major source of water for irrigation, industrial, and public-supply use in southwestern Georgia.
Water levels are influenced by variations in precipitation and pumping (Clarke and others, 1983, 1985).	Major source of water in east-central Georgia. Supplies water for kaolin mining and processing; includes the Providence aquifer in southwestern Georgia, and the Dublin, Midville, and Dublin–Midville aquifer systems in east-central Georgia.
Water levels are affected mainly by precipitation and local pumping (Cressler, 1964).	Not laterally extensive. Limestone and dolomite aquifers are the most productive. Storage is in regolith, primary openings, and secondary fractures and solution openings in rock. Springs in limestone and dolomite aquifers discharge at rates of as much as 5,000 gal/min. Sinkholes may form in areas of intensive pumping.
Water levels are affected mainly by precipitation and evapotranspiration, and locally by pumping (Cressler and others, 1983). Precipitation can cause a rapid rise in water levels in wells tapping aquifers overlain by thin regolith.	Storage is in regolith and fractures in rock.

APPENDIX B
SUMMARY OF RESEARCH OF GEORGIA EPD'S FILES

Based upon the list provided by EPD of Landfill Permits and the types [(D)SL – Pre Subtitle D Liner Sanitary Landfill and (D)MSWL – Post Subtitle D Liner Municipal Solid Waste Landfill) and the records list of ACM activities, there are only six (6) permit numbers with the "D(MSWL)" nomenclature in its suffix that have ACM records. Evaluation of the records for these sites indicates that no MSWL lined cells have releases that are related leakage through a composite liner system. Some sites have incorrect documentation confusing Pre Subtitle D and Post Subtitle D Cells where releases have been documented from the Pre Subtitle D areas; some have incorrect evaluations of leachate releases which are actually due to excessive turbidity impacts, coincident landfill gas impacts, and or incorrect statistical evaluations or other data evaluations. Following are excerpts from EPD files.

018-008D(MSWL) - Republic Services - Pine Ridge Recycling (MSWL)
Review of the EPD information on notes related to ACM activities indicates:

8/23/2012 letter sent to the facility regarding the N=33 sampling event; GWC-7 SSI (based on submitted info believe they only use background, they don't say in the report what they used but the statistical analysis in the back of the report looks like it is background) that exceeded the EPA RSL for 1,1 Dichloroethane (5.26 ug/L) facility also told to address the reported SSIs for Ba; *note - the facility could redo the Statistical Calculations to address SSI over the RSL but they would need to formally set that and have it approved as their

9/19/2012 received by the Directors office on 10/10/2012; demonstration submitted for SSIs for Barium @ GWC-4, GWC-7, GWC-8 and GWC-9. Kruskal-Wallace tested identified SSIs but were not identified with a non-parametric Confidence interal test. In addition, according to the ASD there has never been an exceedance of Ba. ASD approved for Ba @ GWC-4, GWC-7, GWC-8 and GWC-9

9/27/2012 received 1,1 DCA @ GWC-7, noted in the 2nd gwmr no longer SSI; discussion with D. Stewart they are going to evaluate the information and make a decision regarding the submittal

1/18/2013 Facility retracted the the ACM workplan and milestone schedule; the letter was attached to the retracted work plan and milestone schedule and sent to the GW Cor. File

044-047D(MSWL) - WMI-Live Oak #2(SL)
Review of the EPD information on notes related to ACM activities indicates:

WMI-Live Oak #1 closed 12/1/2004 Permit No. 044-035D(SL)
WMI-Live Oak #2 closed 12/1/2004

No ACM info for WMI-Live Oak #2, all ACM records for WMI-Live Oak #2 state SEE COMMENTS UNDER 044-035D(SL). Duplicate entries discontinued by new staff assigned to project.

069-015D(MSWL) - Hall County - Candler Road (SR 60)
Review of the EPD information on notes related to ACM activities indicates:

1/2/2018 noted in asd schedule request that county allowed/encouraged to implement icm while gathering methane data,

3/15/2018 dissolved ch4 found in gwc-5a 1600 - requested site provide schedule for completion of evaluation or begin ACM. 60 days to provide schedule

105-014D(MSWL) - Murray County - US 411 Westside Site 2 MSWL
Review of the EPD information on notes related to ACM activities indicates:

5/29/2008 Request site go into assessment monitoring for metals SSIs and lead > MCL. They may also choose to do an alternate demonstration by sampling using low-flow methods to bring turbidity down. Response due 30 days from receipt of letter.

107-015D(MSWL) - Newton County - Lower River Road HE & VE
Review of the EPD information on notes related to ACM activities indicates:

Permit No. 107-015D(MSWL) is for the combined site permit which incorporated the Phase #1 pre subtitle D Sanitary Landfill [old Permit No 107-013D(SL)] and the Phase #2 MSWL Permit No 107-015D(MSWL) under the active permit number. All ACM activities are related to releases from the Phase #1 and C&D landfills not the Subtitle D lined Phase #2 MSWL.

121-018D(MSWL) - Richmond County - Deans Bridge Road Phase III MSWL
Review of the EPD information on notes related to ACM activities indicates:

Permit No. 121-018D(MSWL) for the Phase III MSWL was issued 6/30/2004. Three other permit numbers existed prior to issuance of permit 121-018D(MSWL) for the Phase III MSWL: 121-015D(SL) for Phase 2A closed 10/8/1993; 121-016D(SL)-(2B) for Phase 2B closed 10/8/1993; permit 121-016D(SL) issued 8/23/1993 for Phase 2C.

10/16/2008 ACM was requested for 121-015D(SL) for Phase 2A in a letter regarding 2nd 2007 groundwater monitoring report.

Three entries for Permit No. 121-018D(MSWL for 3/1/2010, 3/18/2011 and 6/30/2011) are incorrectly entered for the Phase III MSWL and fit the chronology for the Phase 2A site ACM and should have been recorded for the 121-015D(SL) as are all other entries from 10/16/2008 through 5/30/2017.

There are several other sites with "D(SL)" in the permit number indicating they are Pre Subtitle D Liner Sanitary Landfills, but are listed as an "MSWL" in the Facility Name. All of these sites were designated (D)MSWLs at some period after the initial permit was issued suggesting they were constructed with Post Subtitle D Composite Liners when in fact they were originally constructed Pre Subtitle D standards (D)SL indicated some modification to the site that included MSWL features as a follow on to pre Subtitle D features. The timelines for the releases indicate they were detected shortly after construction of the Subtitle D Lined cells and often many years (a decade or more) after the initial construction. The releases occurred from the Pre Subtitle D areas.

032-004D(SL) - Clinch County - Smith Road Phase 1 ~~MSWL~~

Site Closed 4/8/1994 pre Subtitle D; Not conforming to MSWL Liner

044-048D(SL) - BFI - Hickory Ridge ~~(MSWL)~~

No ACM; interim corrective action – gas extraction implemented 7/2/2001 through 12/31/2005.

058-010D(SL) - Forsyth County - Hightower Road Phase 4 ~~MSWL~~

Hightower Road Phase 4 closed 12/20/1997

ACM Entries for Hightower Road Phase 4 from 10/1/2002 through 3/2/2006 are redundant of entries for Hightower Road Phase 3 which has entries for the period from 11/18/1997 through 6/30/2017. Duplicate entries made by new staff assigned to project.

067-032D(SL) - BFI - Richland Creek Road ~~MSWL~~

Investigation initiated 5/4/1998

071-005D(SL) - Haralson County - US 78 Bremen (Site #2) ~~MSWL~~

US 78 Bremen (Site #2) closed 1/3/2000

In conclusion, our review did not find any Subtitle D Lined Cells that had documented releases that were not associated with contiguous pre Subtitle D constructed Cells, gas migration issues, or data evaluation and/or interpretation issues.