PART III, ATTACHMENT 4

GEOLOGY REPORT

Temple Recycling & Disposal Facility

Temple, Bell County, Texas

TCEQ Permit MSW-692B

Owner/Site Operator/Permittee:

City of Temple
201 N. Main
Temple, Texas 76501

Operator:

Waste Management of Texas
9708 Giles Lane
Austin, Texas 78781

STATE OF TEXAS
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Geology
License #10527
12-6-16
LICENSED
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GOLDER ASSOCIATES INC.
Geoscience Firm Registration Certificate Number 50369

INTENDED FOR PERMITTING PURPOSES ONLY

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Project No. 1400336

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1.0 INTRODUCTION

This document is the Geology Report pertaining to the Permit Amendment Application for the expansion of the Temple Recycling and Disposal Facility ("facility" or "site") and has been prepared in accordance with 30 Texas Administrative Code (TAC) §330.63(e). The site is an existing 269 acre Type I municipal solid waste facility owned by the City of Temple, Texas ("City").

By way of this application, the City of Temple proposes to add 191 acres and remove 17 acres from the permitted area of the facility, for a total permitted area of 443 acres (proposed permit MSW-692B). This Geology Report was prepared by Golder Associates Inc. and signed by Christina Higginbotham, P.G., a licensed professional geologist in the State of Texas. This report summarizes available data related to regional and local geology and aquifers in the area of the proposed site expansion in accordance with 30 TAC §330.63(e). Based on a review of this data, and on the results of geotechnical investigations conducted at the site, the proposed site is suitable for use as a municipal solid waste disposal facility.

2.0 REGIONAL PHYSIOGRAPHY AND TOPOGRAPHY

The site is located in east-central Bell County, Texas at 706 Landfill Road, approximately 0.4 miles east of the intersection of Loop 363 and Little Flock Road, shown on Figure III-4-1.

The topographic elevation of Bell County decreases from west to east, within the Blackland Prairie physiographic province. The Balcones Fault Zone (BFZ) (or Balcones Escarpment) passes through the center of Bell County, and trends from the northeast to southwest approximately parallel to the strike of geological units in the area. The fault system has been documented approximately 2 miles northwest of the site (Duffin and Musick 1991). The main tectonic events of the Balcones halted during the Miocene Epoch (5.3 million to 23 million years ago); however, structural adjustments were observed during the Cretaceous (Abbott and Woodruff 1986). The BFZ divides Bell County into two physiographic provinces: the Inner (Tertiary) Gulf Coastal Plain to the east and the Great Rio Grande Plain to the west. The Inner Gulf Coastal Plain physiographic province is further divided into two physiographic regions. These regions are the Rolling Prairie physiographic region to the west and the Blackland Prairie physiographic region to the east. The Blackland Prairie physiographic region is further divided by the BFZ into the White Rock Prairie sub-province to the west and the Taylor Black Prairie sub-province to the east. The site is located in the Taylor Black sub-province. The Taylor Black Prairie is characterized by undulating topography with several series of perennial streams. Regional physiography is shown on Figure III-4-2.

The site is located within the Little Elm Creek Watershed of the Brazos River Basin. The natural surface drainage in the site area is towards two tributaries of Little Elm Creek: Williamson Branch towards the northeast and Unnamed Tributary No. 1 to the south. Drainage features of the site are depressions that generally transport surface water toward the southern and eastern portions of the site. Figure III-4-3 shows site topography based on the 2012 United States Geological Survey (USGS) Temple 7.5 minute quadrangle map.

The distances to local surface water bodies and drainage features are listed below:

Body of Water	Approximate Distance from Site	Direction from Site
Williamson Branch of Little Elm Creek	0.1 mile	Northeast
Little Elm Creek	0.5 mile	North and Northeast
Unnamed Tributary No. 1 of Little Elm Creek	0.2 mile	South
Knob Creek	1 mile	Southwest
Veterans Administrative Lake	1.5 miles	West

Prior to initial development of the site, the maximum elevation of the facility was approximately 610 feet above mean sea level (ft-msl). The maximum current permitted elevation is 759 ft-msl, and will be increased to approximately 835 ft-msl in the proposed expansion. The elevation of deepest excavation (EDE) for the facility is currently approximately 536 ft-msl and will be lowered to approximately 515 ft-msl within the proposed expansion area.

3.0 GEOLOGY

This section includes discussions on regional and local geologic settings, fault areas, seismic impact zones, unstable areas, and erosion potential. The following discussion describes a generalized regional stratigraphic column of the area and in accordance with 30 TAC 330.63(e)(1)(B) includes discussion down to the base of the lowermost aquifer capable of providing usable groundwater. The stratigraphy, including geologic age, lithology, and variations in lithology, thickness, depth, geometry, hydraulic conductivity, and depositional history (as available through current geologic information), are included in the following paragraphs and Table III-4-1. Table III-4-1, Regional Geologic Units and Their Water Bearing Properties, includes the system, series, group, stratigraphic unit, hydrologic unit, approximate maximum thickness in feet, character of rocks, and water bearing properties.

3.1 Regional Geologic Setting

The geology of the City of Temple and surrounding areas consist primarily of Cretaceous age sediments consisting primarily of fine-grained materials deposited in ancient oceans. In the area surrounding the site, Cretaceous sediments are approximately 3,600 feet thick and dip approximately 1° to 2° to the east-southeast (Duffin and Musick 1991).

The Cretaceous system is divided into two series, the Comanchean and the Gulfian. The Comanche series is stratigraphically lower and older than the Gulf and consists of three groups: the Trinity, the Fredericksburg, and the Washita, ordered from oldest to youngest. Each of these groups contains several different formations/stratigraphic units. The Trinity Group includes the Paluxy Formation, Glen Rose (Upper and Lower Members) and Travis Peak which includes the Hensell Sand, Cow Creek Limestone, Hammett Shale (confining unit), Sligo and Hosston Members. Detailed lithology pertaining to these geologic units are found in Table III-4-1. The Upper Trinity aquifer resides in the Paluxy Formation and Upper Glen Rose. The Middle Trinity aquifer resides in the Lower Glen Rose, Hensell Sand and Cow Creek Limestone. The Hammett Shale Member is a confining unit separating the Middle Trinity from the Lower Trinity aquifer. The Lower Trinity aquifer resides in the Sligo Member and Hosston Member. Hydraulic conductivities for the individual Trinity hydraulic units were unable to be obtained by published services, however the Trinity aquifer's hydraulic conductivity ranges from approximately 1 to 31 feet per day (Ryder 1996). The Fredericksburg Group includes the Kiamichi Formation, Edwards Limestone, Comanche Peak Limestone and the Walnut Formation. The Washita Group includes the Buda Limestone, Del Rio Clay (confining unit) and the Georgetown Formation. Detailed lithology pertaining to these geologic units are found in Table III-4-1. The Edwards aquifer and associated limestones, which resides in the Georgetown Formation, Kiamichi Formation, Edwards Limestone, and Comanche Peak Limestone has a hydraulic conductivity that ranges from 0.01 to 30,000 ft/day (mean of 9 ft/day) (Jones 2003). The surface outcrop of the Comanche series is west of the BFZ.

The Gulf series is younger than the Comanche and consists of four groups: the Eagle Ford, the Austin, the Taylor, and the Navarro groups, ordered from oldest to youngest. The Eagle Ford Group is a confining unit. The Austin Group contains the Austin Chalk Aquifer which yields small quantities of fresh water. Hydraulic conductivity values for Austin Chalk aquifer were unable to be obtained. The Navarro/ Taylor Group yields very small quantities of water. Hydraulic conductivity values for the Navarro/Taylor aquifer were unable to be obtained. Detailed lithology pertaining to these geologic units are found in Table III-4-1. The outcrop of the Gulf series is located east of the BFZ.

The stratigraphic units are generally older to the west and younger to the east, strike northeast/southwest, and dip to the east-southeast. The thickness of individual units generally increases to the east towards the deeper portions of the marine basin present during Cretaceous times. The distribution of stratigraphic units has been altered by movement along the BFZ. Most faults have the downthrown blocks to the southeast, but some are antithetic, with the downthrown block to the northwest. The net vertical displacement of the downthrown or southeast blocks is at least 400 feet in portions of Bell County (Duffin and Musick 1991).

Tertiary age sediments (Eocene series), comprising the Midway and Wilcox Groups, crop out east of the Temple area. These sediments consist primarily of sand, silt, and clay, and were deposited as detrital sediments at or near a transgressive shoreline. Hydraulic conductivity of the Wilcox aquifer (undifferentiated) ranges from 2-204 feet per day based on a study just southeast of Bell County by Thorkildsen and Price (1991). The hydraulic conductivity for the Midway aquifer was unable to be obtained from published services. Quaternary age sediments are present in the region and consist of the Pleistocene and Holocene (Recent) Series, ordered from oldest to youngest. These series consist of relatively unconsolidated alluvial floodplain and terrace deposits composed of silt, sand, gravel, and clay from the Brazos River Colorado is south, closer to Austin. The hydraulic conductivity for the Brazos River alluvial aquifer system can be as great as 2,400 feet per day for gravel (Ryder 1996).

3.2 Local Geologic Setting

As shown on Figures III-4-4 and III-4-5, the site is underlain by the Upper Cretaceous age Taylor Group, and is comprised of the Ozan Formation, Wolfe City, and Pecan Gap Chalk. These units are generally considered together as the "Taylor Marl." The Ozan Formation is comprised of a weathered montmorillonitic clay with high shrink/swell potential. The clay is generally hard and occasionally contains shell fragments. Underlying the weathered material is the unweathered Taylor Group, which in the site area consists of a calcareous claystone. The top of this unit is most often encountered between 40 and 50 feet below ground surface (ft-bgs). Below the claystone is an unweathered marl layer. Based on regional data, the base of the Taylor Group in the site area is at a depth of approximately 400 ft-bgs. The weathered-unweathered interface serves as a demarcation for the uppermost water bearing unit in the area, which is located within the weathered portions of the Taylor Group.

The site is located on an outcrop of the Ozan Formation, a unit of Cretaceous sediments deposited in a low-energy marine environment. The Ozan Formation is lithologically a claystone and marl. Mineralogically, the Ozan Formation is made up primarily of montmorillonite followed by lesser amounts of glauconite, phosphate pellets, hematite and pyrite nodules, and calcite (BEG 1992).

Underlying the Taylor Group is the Austin Chalk, which consists of massive beds of chalk and marl with bentonitic seams, glauconite, and pyrite nodules (Brune and Duffin 1983). The Austin Chalk is approximately 200 feet thick. Below the Austin Chalk are the Eagle Ford Group, Buda Limestone, and Del Rio Clay, which have a combined thickness of approximately 150 feet. Underlying those units are the Edwards aquifer and associated limestones. The northern extent of the Edwards aquifer is generally identified as being southwest of Temple, extending to the Lampasas River in southern Bell County.

Table III-4-1: Regional Geologic Units and Their Water Bearing Properties

System	Series	Group	Stratigraphic Unit	Hydrologic Unit	Approximate Maximum Thickness (feet)	Lithology	Water Bearing Properties/ Hydraulic Conductivities	Depositional Environment
Quaternary	Recent		Alluvium	Alluvium and Terrace Deposits	60	Water-stratified deposits of unconsolidated calcareous gravel, sand, silt, and clay, with coarser materials usually concentrated in the lower section.	Yields small to very large quantities of fresh to slightly saline water, chiefly along the Colorado River in eastern Travis County. K= ≤2,400 feet per day for gravel alluvium from the Brazos River (Ryder 1996).	Alluvial
	Pleistocene		Terrace Deposits		60	Water-stratified deposits of unconsolidated calcareous gravel, sand, silt, and clay, with the coarser materials at the base.	Yields very small to moderate quantities of fresh to moderately saline water.	Alluvial
			High gravel		20	Gravel and sand, sometimes mixed with clay from underlying formations.		Alluvial
Tertiary	Eocene	Wilcox	Simsboro Sand Member	Wilcox	200	Fine-to-coarse sand and sandstone, sandy clay, with lenses of limestone and lignite.	Yields small to moderate quantities of fresh to moderately saline water. K= 2-204 ft/day (Thorkildsen and Price 1991).	Detrital sediments at or near a transgressive shoreline.
		Midway		Midway	300	Clay, silt, glauconitic sand, and thin beds of limestone and sandstone with gypsum, phosphatic nodules, and calcareous concretions.	Yields very small quantities of fresh to moderately saline water.	Detrital sediments at or near a transgressive shoreline.

System	Series	Group	Stratigraphic Unit	Hydrologic Unit	Approximate Maximum Thickness (feet)	Lithology	Water Bearing Properties/ Hydraulic Conductivities	Depositional Environment
Cretaceous	Gulf	Navarro		Navarro and Taylor Groups	700	Massive beds of shale and marl with clayey chalk, clay, sand, and some nodular and phosphatic zones.	Yields very small quantities of fresh to moderately saline water.	Sediments deposited in a low-energy marine environment.
		Taylor						Sediments deposited in a low-energy marine environment.
		Austin		Austin Chalk	200	Massive beds of chalk and marl with bentonitic seams, glauconite, pyrite nodules.	Yields small quantities of fresh water.	Sediments deposited in a low-energy open marine shelf environment.
		Eagle Ford		Confining Unit	40	Massive calcareous shale with thin interbeds of silty and sandy, flaggy limestone.	Not known to yield water in Bell County	Marginal (lagoonal) to open marginal marine.
	Comanche	Washita	Buda Limestone		50	Massive, fine-grained, borrowed, shell-fragment limestone. The upper portion is harder and bluff-forming.	Not known to yield water Bell County.	Shallow subtidal and intertidal.
			Del Rio Clay	Confining Unit	60	Clay and marl with gypsum, pyrite, and a few thin siltstone and sandstone beds.	Not known to yield water in Bell County.	Lagoonal
			Georgetown Formation	Edwards and associated limestones	75	Thin interbeds of richly fossiliferous, nodular, massive fine-grained limestone and marl.	Yields small to very large quantities of fresh water, especially from cavernous zones in the Edwards Limestone.	Open-shelf subtidal.

System	Series	Group	Stratigraphic Unit	Hydrologic Unit	Approximate Maximum Thickness (feet)	Lithology	Water Bearing Properties/ Hydraulic Conductivities	Depositional Environment
							K = 0.01 – 30,000 ft/day (mean of 9 ft/day) (Jones 2003).	
		Fredericksburg	Kiamichi Formation		100	Marl, thin limestone seams, clay, and shell aggregates. Not present in Bell County.	NA	Variety of carbonate marine environments (reef, lagoonal, shoal, basinal, and supratidal.
			Edwards Limestone		200	Massive, brittle, vugular limestone and dolomite with nodular chert, gypsum, anhydrite, and solution-collapse features.	Yields small to very large quantities of fresh water, especially from cavernous zones. K = 0.01 – 30,000 ft/day (mean of 9 ft/day) (Jones 2003).	Variety of carbonate marine environments (reef, lagoonal, shoal, basinal, and supratidal).
			Comanche Peak Limestone		50	Fine-grained, fairly hard, nodular, fossiliferous, marly, extensively burrowed limestone.	Yields little or no water in Bell County. K = 0.01 – 30,000 ft/day (mean of 9 ft/day) (Jones 2003).	Variety of carbonate marine environments (reef, lagoonal, shoal, basinal, and supratidal.
			Walnut Formation		100	Hard and soft limestones, marls, clays, and shell beds.	Yields little or no water in Bell County.	Lagoonal or subtidal.
		Trinity	Paluxy Formation	Upper Trinity	10	Fine-grained quartz sand, in part indurated by calcium carbonate cement. Locally contains thin beds of limestone and marl.	Yields very small to moderate quantities of fresh and occasionally slightly saline water. K= 1-31 ft/day for	Sand bar deposited in shallow marine environment.

System	Series	Group	Stratigraphic Unit		Hydrologic Unit	Approximate Maximum Thickness (feet)	Lithology	Water Bearing Properties/ Hydraulic Conductivities	Depositional Environment
								overall Trinity aquifer (Ryder 1996).	
			Glen Rose	Upper Member		600	Alternating beds of limestone, dolomite, shale, and marl with some anhydrite and gypsum.	Yields very small to moderate quantities of fresh and occasionally slightly saline water. K= 1-31 ft/day for overall Trinity aquifer (Ryder 1996).	Marine.
			Glen Rose	Lower Member	Middle Trinity	330	Massive, fossiliferous limestone and dolomite in the basal part grading upward into thin beds of limestone, shale, marl, and gypsum.	Yields very small to moderate quantities of fresh to moderately saline water. K= 1-31 ft/day for overall Trinity aquifer (Ryder 1996).	Marine.
			Travis Peak	Hensell Sand Member		75	Sand gravel, conglomerate, sandstone, siltstone, and shale.		Fluvial.
			Travis Peak	Cow Creek Limestone Member		80	Massive, often sandy, dolomitic limestone, frequently forming cliffs and water falls. Contains gypsum and anhydrite beds.		Marine.
			Travis Peak	Hammett Shale Member	Confining Unit	30	Shale and clay with some sand, dolomite, and limestone.	Not known to yield water in Bell County.	Marine.

System	Series	Group	Stratigraphic Unit	Hydrologic Unit	Approximate Maximum Thickness (feet)	Lithology	Water Bearing Properties/ Hydraulic Conductivities	Depositional Environment
			Sligo Member	Lower Trinity	300	Limestone, dolomite, occasionally sandy, and shale. Thins to the west.	Yields small to moderate, and with acidizing, large quantities of fresh to moderately saline water. K= 1-31 ft/day for overall Trinity aquifer (Ryder 1996).	Subtidal to supratidal.
			Hosston Member		800	Basal conglomerate grading upward into a mixture of sand, siltstone, and shale, with some limestone beds.		Fluvial.
Pennsylvanian	Lower Pennsylvanian	Strawn			800	Alternating beds of sandstone and shale, with some conglomerates.	Not known to yield water in Bell County.	Subtidal.
		Bend	Smithwick Shale		500	Shale with sandstone and siltstone in the upper portion. Metamorphosed to phyllites and quartzites in the Quachita Fold Belt.	Not known to yield water Bell County.	Open marine.
			Marble Falls Limestone		400	Cavernous, massive, siliceous, fossiliferous limestone	Not known to yield water in Bell County, but may yield small to moderate quantities of slightly to moderately saline water.	Open marine and shoals.

Notes:

Modified from Duffin, G. and S.P. Musick. 1991. TWDB Report 326

3.3 Fault Areas

Compliance with 30 TAC §330.555 related to the location restriction criterion of fault areas begins with determining whether or not the disposal facility is located within 200 feet of a fault that has experienced displacement during the Holocene Epoch, extending from the end of the Pleistocene Epoch to the present (representing the most recent 10,000 years), referred to herein as an active fault.

A fault evaluation was previously prepared for the Temple Recycling and Disposal Facility (which included the area under assessment for the expansion) in 1994 by Rust Environment & Infrastructure ("Rust"), as documented in the previous permit application Part III, Attachment 4, Appendix D. That evaluation included a review of the following existing documentation:

- Published information on the structural and seismic history of the Temple area
- Documented locations of seismic epicenters recorded in recent times
- Evidence of displacement in surficial deposits
- Evaluation of lineaments in aerial photographs

It was concluded that the nearest known fault to the site is located approximately 2 miles to the northwest of the facility, in the BFZ. There are no known faults or surface expression of faults within a 3,000 foot radius of the facility.

The site, including the expansion area, was re-examined for the presence of faulting for this permit amendment. Available geologic literature and geologic maps were reviewed (BEG 1979, 1992; Duffin and Musick 1991; Jones et al 2003; and Kelly et al 2014).

The results of the faulting studies indicated that the site is not located within 200 feet of a fault that has experienced displacement during the Holocene Epoch.

As depicted on Figure III-4-6, the nearest mapped inactive fault is located approximately 2 miles northwest of the site.

3.4 Seismic Impact Zones

The location restriction criterion in 30 TAC §330.557 requires that new disposal units and lateral expansions not be located in seismic impact zones unless the owner or operator can demonstrate that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the facility. A seismic impact zone is defined as an area with a 10 percent or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10 g in 250 years. If the maximum horizontal acceleration is less than or equal to 0.10 g, then the design of the unit will not need to incorporate an evaluation of seismic effects.

Areas within the United States where seismic effects need to be evaluated, as determined by USGS, are shown on Figure III-4-7. As indicated on this figure, the Temple Recycling and Disposal Facility is not located within a seismic impact zone.

3.5 Unstable Areas

The location restriction criteria in 30 TAC §330.559 require engineering measures to be incorporated into the design of a disposal unit located in an unstable area to ensure that the integrity of the structural components of the disposal unit will not be disrupted. Unstable areas, by definition, are areas susceptible to natural or human-induced events or forces that are capable of impairing the integrity of some or all structural components (i.e., liners, leachate collection systems, final covers, etc.) of a disposal unit. Unstable areas can include poor foundation conditions, areas susceptible to mass movement, salt domes, or karst terrain.

The determination of potential unstable areas at the landfill site is based on site observation and a review of existing site documentation by a licensed professional engineer. Site observations included:

- Observation of the sides and bottom of the excavations and liner subgrade during construction of Cells 2A, 2B, and 3A in Tract 4
- Observations of the excavation of ponds
- Observations of the existing structures
- Observations of the samples from the recent subsurface investigation

Review of documentation included:

- Temple Recycling and Disposal Facility Permit Amendment Application MSW No. 692A
- Boring logs from past and current subsurface investigations
- Aerial surveys and photographs of the property

Based on this review, the foundation conditions and the local geologic and geomorphologic formations are stable. In addition, there is no evidence to suspect mass movement of natural formations of earthen material on or in the vicinity of this site. No foundation problems exist at the site. The proposed landfill components were evaluated with respect to differential settlement, heave and slope stability. The detailed analysis is included in Part III, Attachment 3. Based on the results of these analyses, the existing and proposed human-made features have been predicted to have adequate factors of safety with respect to stability.

Based on site observations, a review of existing geological data, and geotechnical analysis of the structural components of the landfill development, the site is not located in an unstable area and the integrity of the landfill is not expected to become impaired by natural, surface, or subsurface human-made features or events.

3.6 Erosion Potential

30 TAC §330.63(e)(2) requires a discussion of active geologic processes in the vicinity of the facility, including the potential for erosion. The potential for erosion due to surface water processes such as overland flow, channeling, gullying, and fluvial processes exemplified by meandering streams and undercut banks, has been evaluated. Based on that evaluation, the most likely processes that are applicable to the development of this site are overland flow, channeling, and rill to gully erosion. As part of the surface water management design for this facility, an erosion and sedimentation control plan was developed to control erosion along landfill embankments and sedimentation of stormwater collection and storage facilities. These controls include stabilization measures for disturbed areas and structural controls to divert runoff and remove sediment. Erosion and sediment controls will be implemented during the construction and operation periods of the landfill to prevent and control the potential loss of soil from the site into receiving waters. The erosion and sedimentation control plan is included in Part III, Attachment 2.

4.0 HYDROGEOLOGY

The most significant regional aquifers in the vicinity of the site are, in the order of their importance, the Cretaceous Edwards Limestone, the Cretaceous Trinity Group, and Quaternary alluvial deposits (Brune and Duffin 1983). In accordance with 30 TAC 330.63(e)(3), the following discussion provides a description of these aforementioned regional aquifers based upon available published and open-file sources. The stratigraphy of the Temple area and water-bearing characteristics are summarized on Table III-4-1. Chemical characteristics of the aquifer units are summarized in Table III-4-2.

4.1 Regional Hydrogeology

The regional subsurface aquifers have been disrupted by faulting within the BFZ, which is located 2 miles northwest of the Site. Flow rates vary laterally within each aquifer, especially in areas where the aquifer is displaced by faults. This displacement has resulted in restriction of groundwater flow, particularly in the Edwards and Trinity aquifers, which has resulted in high concentrations of dissolved solids (Brune and Duffin 1983). Although the displacement has restricted groundwater flow in the individual aquifers, this may allow interconnection between aquifers regionally. The faults from the BFZ affect the groundwater movement, particularly in the Edwards and associated limestones in which the faults have formed natural paths for solution channels and also have formed underground barriers (Brune and Duffin 1983). The three units of the middle Trinity aquifer are hydraulically connected to some extent due to the fault system (Brune and Duffin 1983). Regionally aquifers may be interconnected to some extent, but shown on Figure III-4-6 there are no faults within two miles of the Site.

The following is a discussion of the significant regional aquifers.

4.1.1 Edwards and Associated Limestones

The Edwards aquifer pinches out southwest of the site and extends to the Lampasas River in Southern Bell County, but is included here as part of the regional aquifer discussion. The Edwards aquifer is located within the BFZ in the south-central portion of Bell County, southwest of Temple. Figure III-4-9.3 present the water level elevations of the northern segment of the Edwards aquifer. The water levels in this segment of the Edwards aquifer range from 550 to 750 feet-mean sea level. The potentiometric surface slopes east-northeast in this region. The source of recharge for the Edwards aquifer is from precipitation in the drainage areas west of the BFZ. Precipitation infiltrates the subsurface through numerous scattered dissolution features and faults, which act as conduits for recharging the limestone aquifers. In the BFZ, the entire aquifer is usually saturated and water may occur under artesian conditions (Duffin and Musick 1991). The groundwater in the Edwards aquifer is not recommended for drinking near its downdip limit of fresh to slightly saline water, where higher concentrations of dissolved minerals occur (Duffin and Musick 1991). As shown in Figure III-4-5, the Edwards Formation is overlain by Navarro and Taylor Group, Austin Chalk, Eagle Ford Group, and Woodbine Group, all of which yield very small quantities of water (see Table III-4-1). The thickness and low permeability characteristics of this aquifer's overlying strata indicate that it is highly unlikely that groundwater could infiltrate through the site and into any aquifers underlying the site that may be used for human consumption.

Due to its karst and faulted nature, hydraulic properties of the Edwards aquifer vary both laterally and vertically. Permeability in the Edwards is high and water moves rapidly through the aquifer. Because the porosity within the Edwards is not evenly distributed, permeabilities and transmissivities vary significantly. Permeabilities vary from 8.7 to 877 gallons/day/square foot, or 350 to 34,700 liters/day/square meter (Brune and Duffin 1983). Because of the large range in permeability and variability in thickness, transmissivity values range from 0.5 to 4 x 10^6 ft^2/day (calculated from specific capacity data) (Jones 2003). Hydraulic conductivity values range from 0.01 to 30,000 ft/day (mean of 9 ft/day) (Jones 2003). In the subsurface, the Edwards consists of 200 to 360 feet (61 to 107 meters) of brittle, thick-bedded to massive limestone, commonly dolomitic, containing minor beds of shale, clay, and siliceous limestone. The total thickness of the Edwards and associated limestone aquifers, where fresh to slightly saline, ranges from 250 to 450 feet (76 to 137 meters). Since groundwater in the Edwards and associated limestone moves in underground channels, it moves relatively fast. The direction of movement is generally to the east-southeast in Bell County. In some areas of north-central Texas, faulting has placed the relatively impervious Del Rio Clay, Buda Limestone, and Eagle Ford Group opposite the aquifer. This faulting has resulted in a series of underground barriers that restrict the lateral movement of the groundwater in the confined portion of the aquifer (Brune and Duffin 1983).

4.1.2 Trinity Group Aquifers

The Trinity Group aquifer is the next significant aquifer in the area at a depth of approximately 1,500 feet below the site. The source of recharge for Trinity is from precipitation in the drainage areas west of the BFZ. The Trinity outcrops extensively west of the site and thus receives most of its recharge through precipitation on outcrops and seepage, underflow, and leakage from lakes and streams. Areas of recharge are illustrated in Figure III-4-8, which shows where the Edwards and Trinity aquifers outcrop.

The Trinity Group is subdivided into upper, middle, and lower units. Figures III-4-9.1 and III-4-9.2 present the elevations of the Trinity subdivisions. As shown in Table III-4-1 and on Figure III-4-5, the lower Trinity aquifer consists of the Hosston and Sligo members of the Travis Peak Formation. These units are generally of low permeability and groundwater pumpage has caused declines in this aquifer. The hydraulic conductivity for the entire Trinity aquifer ranges from about 1 to 31 feet per day according to the USGS (Ryder 1996). According to Brune and Duffin (1983), water from this unit is usually slightly to moderately saline (Total Dissolved Solids [TDS] = 549 to 1,042 mg/l). The total thickness of the lower Trinity aquifer increases towards the eastern portion of Bell County up to nearly 1,000 feet in the downdip area to the east (Duffin and Musick 1991). Regionally, beds of the lower Trinity aquifer dip east-southeast at a rate ranging from 15 to 320 feet/mile (Brune and Duffin 1983). In the subsurface, the lower Trinity aquifer is overlain by the impervious Hammett Shale and, as a result, is under confined conditions. The aquifer is hydraulically connected through the joints and cavities in the limestone of the Sligo member as well as the pore spaces in the Hosston member. Aquifer tests indicate that the lower Trinity has permeabilities ranging from approximately 84 to 97 gallons/day/square foot and transmissivity values of 8,300 to 9,600 gallons/day/foot in Bell County (Duffin and Musick 1991).

The middle Trinity aquifer is comprised by the Hensell Sand and Cow Creek Limestone members of the Travis Peak Formation, and the lower member of the Glen Rose Formations. Permeabilities and transmissivities are low, and well yields are usually small. Groundwater derived from the middle Trinity aquifer is slightly more saline than the lower Trinity. The total thickness of the middle Trinity aquifer varies from 0 feet in west Bell County to more than 150 feet in the eastern portions of the county. Groundwater in the middle Trinity aquifer occurs under water-table conditions in the outcrop area in western Bell County. Confined conditions exist in downdip areas because the Hensell Sand is overlain by the relatively impervious shale and limestone of the lower portion of the Glenn Rose. Test data for the middle Trinity aquifer in Bell County is limited in the reports consulted, but for adjacent counties, permeabilities ranging from approximately 47 to 115 gallons/day/square foot and transmissivities ranging from 0 to 4,000 gallons/day/foot or 0 to 49,700 liters/day/meter are observed (Brune and Duffin 1983).

Within the confined area in Bell County, water from the upper Trinity exhibits fresh to saline quality and small yields. The permeability of the aquifer is very low, and resultant well yields are generally very small. The thickness of the upper Trinity aquifer increases in an eastwardly trend and ranges from 0 feet (in western portions of Burnett and Lampasas Counties) up to approximately 900 feet in Milam County. Groundwater in the upper Trinity aquifer occurs primarily under water-table conditions in the outcrop area in western Bell County. Confined conditions exist in the subsurface. Limited test data was available for the upper Trinity aquifer in Bell County and the results indicate a coefficient of permeability of 1 gallons/day/square, and a transmissivity of 40 gallons/day/foot (Duffin and Musick 1991).

4.1.3 Quaternary Alluvium Deposits

The Quaternary age alluvium consists of gravel, clay, silt, and sand deposited in channels and terraces. These deposits are the thickest on ridges in eastern Bell County and are not present at the site. Small to very large quantities of fresh to slightly saline groundwater are produced from the Quaternary age alluvial and terrace deposits in Bell County. The terrace deposits consist of gravel, sand, silt, and clay, and occur at higher elevations than more recent floodplain deposits. Terrace deposits range in thickness up to 60 feet, with the thickest sediments in eastern Bell County. These deposits produce very small to moderate amounts of fresh to moderately saline groundwater under water-table conditions (Brune and Duffin 1983). Stream or river alluvium of recent or Holocene age is composed of up to 60 feet of unconsolidated material, chiefly gravel, sand, and silt. Recharge to the alluvium and terrace deposits is mainly from rainfall. Areas of aquifer recharge are illustrated in Figure III-4-8, in which recharge takes place in areas where quaternary alluvium deposits are located. Alluvium deposits are located just east of the Site along Elm Creek. Aquifer test data for these deposits in Bell County was not available. Water in the quaternary alluvium is likely under water table conditions.

Other minor aquifers that yield groundwater in Bell County include the Austin Chalk, Navarro, and Taylor Groups of the Gulf series, and the Midway Group of the Eocene series. Well yields in these aquifers are very small and the water quality ranges from fresh to moderately saline (Duffin and Musick 1991).

Table III-4-2: Source, Significance, and Concentration of Dissolved Mineral Constituents and Properties of Water

Constituent or Property	Source or Cause	Significance	Hensell	Hosston	Lower Glen Rose	Upper Glen Rose	Edwards	Austin Chalk	Taylor
Silica (SiO_2) (mg/L)	Dissolved from rocks and soils, commonly less than 30 mg/L. High concentrations, as much as 100 mg/L, generally occur in highly alkaline water.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.	1 – 40	2.9 – 60	8 – 13	6.59 – 11	8.2 – 42.3	8 – 20	NA
Calcium (Ca) and Magnesium (Mg) (mg/L)	Dissolved from soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water: soap consuming (use hardness). Waters low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.	1 – 113	4 – 144	12 – 82	34 – 184	16 – 150	72 – 132	205 – 205
			1 – 84	1 – 61.1	10 – 84	27 – 733	5.2 – 66	1.2 – 5.5	7 – 7
Sodium (Na) and Potassium (K) (mg/L)	Dissolved from rocks and soils. Found also in oil-field brines, sea water, industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium content may limit the use of water for irrigation.	13 – 1,352	253 – 1,580	295 – 1,206	33.4 – 1,600	3.89 – 1,319	5 – 67	50 – 50
			2.29 – 15	0.4 – 25.2	7 – 9.19	1.1 – 21.1	0.47 – 19	2.8 – 2.8	NA
Bicarbonate (HCO_3) and Carbonate	Action of carbon dioxide in water on carbonate rocks such as limestone	Bicarbonate and carbonate reduce alkalinity. Bicarbonates of calcium and magnesium decompose in	234.31 – 841	127.89 – 519.87	353.9 – 621.15	307.09 – 676.07	200.14 – 640.68	205.02 – 377.11	354.1

Constituent or Property	Source or Cause	Significance	Hensell	Hosston	Lower Glen Rose	Upper Glen Rose	Edwards	Austin Chalk	Taylor
(CO_3) (mg/L)	and dolomite.	steam boilers and hot water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.	0 – 124.8	0 – 73.2	NA	0 – 2.4	0 – 18	0	NA
Sulfate (SO_4) (mg/L)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate, in combination with other ions, gives bitter taste to water. Texas Department of Health (1977) drinking water standards recommend that the sulfate content should not exceed 300 mg/L.	12 – 2,162	142 – 2,390	153 – 1,530	42 – 2,367	7 – 1,863	16 – 51	102
Chloride (Cl) (mg/L)	Dissolved from rocks and soils. Present in sewage and found in large amounts in oil-field brines, sea water, and industrial brines.	In large amounts, in combination with sodium, gives salty taste to drinking water. In large quantities, increases the corrosiveness of water. Texas Department of Health (1977) drinking water standards recommend that the chloride content should not exceed 300 mg/L.	23 – 1,040	68 – 1,003	96 – 1,040	132 – 1,177	2 – 743	4 – 115	181
Fluoride (F) (mg/L)	Dissolved in small to minute quantities from most rocks and soils. Added to many waters by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual (Maier 1950).	0.3 – 6.8	0.1 – 5.5	3.2 – 5.4	2.23 – 5.5	0.12 – 8.5	0 – 0.4	NA

Constituent or Property	Source or Cause	Significance	Hensell	Hosston	Lower Glen Rose	Upper Glen Rose	Edwards	Austin Chalk	Taylor
Nitrate (NO_3) (mg/L)	Decaying organic matter, sewage, fertilizers, and nitrates in soil.	Concentration much greater than the local average, may suggest pollution. Texas Department of Health (1977) drinking water standards suggest a limit of 45 mg/L (as NO_3) or 10 mg/L (as N). Waters of high nitrate content have been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding (Maxey 1950). Nitrate is shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms that produce undesirable tastes and odors.	0 – 15	0 – 5.62	0 – 10	0 – 8	0.09 – 41	3.98 – 68	NA

Constituent or Property	Source or Cause	Significance	Hensell	Hosston	Lower Glen Rose	Upper Glen Rose	Edwards	Austin Chalk	Taylor
Total Dissolved Solids (TDS) (mg/L)	Chiefly mineral constituents dissolved from rocks and soil s.	Texas Department of Health (1977) drinking water standards recommended that waters containing more than 1,000 mg/L dissolved solids not be used if other less mineralized supplies are available. For many purposes, the dissolved-solids content is a major limitation on the use of water. A general classification of water based on dissolved-solids content, in mg/L, is as follows (Winslow and Kister, 1956: Waters containing less than 1,000 mg/L of dissolved solids are considered fresh; 1,000 to 3,000 mg/L, slightly saline; 3,000 to 10,000 mg/L, moderately saline; 10,000 to 35,000 mg/L, very saline, and more than 35,000 mg/L, brine.	335 – 4,274	696 – 5,267	898 – 3,967	358 – 5,431	277 – 3,582	213 – 498	719 – 719
Hardness as $CaCO_3$ (mg/L as $CaCO_3$)	In most waters, nearly all the hardness is due to calcium and magnesium. The metallic cations other than the alkaline metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness up to 60 mg/L are considered soft; 61 to 120 mg/L, moderately hard; 121 to 180 mg/L, hard; more than 180 mg/L, very hard.	9 – 602	16 – 578	105 – 550	275 – 3,185	100 – 498	184 – 337	540 – 540

Constituent or Property	Source or Cause	Significance	Hensell	Hosston	Lower Glen Rose	Upper Glen Rose	Edwards	Austin Chalk	Taylor
Percent Sodium (% Na)	Sodium in water.	A ratio (using milliequivalents per liter) of the sodium ions to the total sodium, calcium, and magnesium ions. A sodium percentage exceeding 50% is a warning of a sodium hazard. Continued irrigation with this type of water will impair the tilth and permeability of the soil.	8 – 99	77 – 97	75 – 92	20 – 88	2 – 93	5 – 34	16 – 16
Specific conductance (micromhos at 25°C)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.	635 – 7,752	1224 – 3,480	1823 – 7,446	653 – 7,840	465 – 6,670	375 – 750	NA
Hydrogen ion concentration (pH) (standard units)	Acids, acid generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals. The Texas Department of Health (1977) recommends a pH greater than 7.0.	7.4 – 9.8	7.28 – 9.6	7.5 – 8.2	7.14 – 8.4	7 – 8.7	7.3 – 7.9	NA
Sodium adsorption ratio (SAR)	Sodium in water.	A ratio for sol extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil (US Salinity Laboratory 1954.	0.33 – 58.38	11.12 – 42.61	10.36 – 36.34	0.88 – 30.19	0.1 – 29.96	0.16 – 1.74	0.94 – 0.94

4.2 Local Groundwater Use

Surface water is used for domestic purposes more frequently than groundwater in the greater Temple area. When groundwater is used, it generally comes from an aquifer of Cretaceous age discussed above. Some groundwater is also obtained from the Quaternary age alluvium in localized areas. The locations of groundwater wells within 1 mile of the property boundary were determined based on a water well database search performed by Banks Information Solutions, Inc. ("Banks") of Austin, Texas, and on information supplied by the Clearwater Underground Water Conservation District (CUWCD). Figure III-4-10 shows the approximate locations of these wells.

The Banks study identified one water well record within 1 mile of the site. The water well is reportedly screened in the Taylor formation at a depth of 57 ft-bgs. Approximately 26 additional water well records listed with an active status were identified from CUWCD within approximately 1 mile of the site. Total depths of these water wells are listed between 15–57 feet, are reportedly screened in Alluvium, the Ozan formation (upper portion of Taylor), or Austin Chalk, and are used as domestic or livestock wells. Two of these well records were plotted within the permitted expansion boundary of the landfill. These wells were field located by CUWCD and Golder Associates Inc. (Golder) on July 9, 2015. The CUWCD did not have drilling report records pertaining to these two wells, but based on recollection of the previous owner, both wells are believed to have been hand dug around the mid-1960s. Based on other well information in the area, these two wells are likely between 20 and 50 feet deep, unused, and will be proposed for plugging and abandonment prior to excavation for borrow or cell construction in the area. Based on the distance of remaining active wells from the site and the relatively low permeability of the lithology, these receptors are unlikely to be impacted by a release from the site. Furthermore, according to CUWCD, East Bell Water Supply Corporation provides water for the area in the vicinity of the site. Public water supply lines are located along Little Flock Road, Bob White Road, and Highway 53.

The engineered and natural controls on the mobility of potential impacts from the site protect the above mentioned wells for several reasons. First, the engineered low-permeability clay and geosynthetic liner systems installed within the disposal cells provide a barrier to prevent the release of potential contaminants. Secondly, in the unlikely event a release was to occur and penetrate through the engineered liner system, the low-permeability of both the weathered and unweathered natural soils will hinder migration. Furthermore, there are several hundred feet of vertical separation between landfill cells and the deeper aquifers (Trinity), and there is currently over 2,600 feet of horizontal separation in very low permeable material between existing landfill cells and the closest active shallow water well, which is 240 feet from the proposed eastern permit boundary and over 380 feet from the limit of waste. The groundwater monitoring wells installed on the perimeter will detect any release, which will prompt measures to mitigate the release well in advance of any off-site impacts.

5.0 SUBSURFACE INVESTIGATION REPORT

The current and previous investigations of the geology, geotechnical properties, and hydrogeology of the facility have resulted in more than 160 borings, piezometers, and wells. A sufficient number of borings were drilled to establish subsurface site stratigraphy and to determine the geotechnical properties of the soils beneath the site. Geologic strata have been characterized to depths of up to 145 feet. A summary of the requirements to include supplements of previously prepared documents as sources of references are provided and discussed in the following sections, as required by 30 TAC §330.63.(e)(4).

5.1 Previous Investigations

The following previous investigations were prepared for the site in support of previous permitting activities:

- 1979 – Twenty-eight soil borings drilled to characterize the original site. Borings were generally advanced to a depth of 40 ft.-bgs and covered the entire western portion of the site (Trinity Engineering).
- 1992/1993 – Twenty-six borings and piezometers were drilled to augment the Trinity Engineering characterization of the original site (Jones & Neuse).
- 1993 – Twelve soil borings were advanced to confirm previous investigations (Rust).
- 1994 – Twenty-two soil borings and piezometers were installed to investigate the site hydrogeology in order to develop the site groundwater monitoring system. Several borings were shallow twins of adjacent deeper borings in which no boring log was prepared (Rust).
- 1996 – Ten gas monitoring probes were installed around the site perimeter to implement the gas management plan (Rust).
- 1996 – Fifteen new monitoring wells (including replacement well MW-5R) and one new piezometer were added to the monitoring well network. Only 13 borings are new as two of the new monitoring wells are converted piezometers (Rust).
- 1998 – One soil boring was drilled to confirm site stratigraphy (EarthTech [Rust]).
- 2010 – Installed eight new monitoring wells to expand the previous groundwater monitoring network (Tetra Tech).

The investigations performed by Trinity Engineering Inc. ("Trinity"), Jones & Neuse ("J & N"), Rust, EarthTech, and Tetra Tech characterized the western portion of the site where the currently permitted disposal cells are located. The Tetra Tech investigation installed additional monitoring wells to augment the existing groundwater monitoring system, in compliance with 30 TAC §330 subchapter T. Figure III-4-11 shows the locations of the previous borings and monitoring wells and Table III-4-3 presents the coordinates and elevations of the previously completed borings at the site. A total of 122 borings have previously been advanced at the site. The borehole location coordinates and surface elevations for borings installed by Trinity Engineers (1979), Jones & Neuse (1993), Rust (1993), Rust (1994), and Rust

(1996) were retrieved from the table found on Figure 4-7 of the Geology Report in the Rust E&I (1999) previous Permit Amendment Application No. MSW-692A. The borehole location coordinates and surface elevations for borings installed by Tetra Tech in 2010 were derived from Figure 1 of the Installation Report for Groundwater Monitoring Wells by Tetra Tech dated January 28, 2011. The locations of the monitoring wells on this Figure were surveyed by Surveying and Mapping, Inc. (SAM, Inc.).

Table III-4-3: Coordinates and Elevations of Previously Advanced Borings

BORING NO	LOCATION		GROUND ELEVATION (FT-MSL)	BORING DEPTH (FT)	BOTTOM ELEVATION (FT-MSL)
	NORTHING	EASTING			
Trinity Engineering, 1979 (Soil Borings: Boring No. 1-28 as noted on boring logs) (1)					
TE-1	525875	2946625	621.0	40.0	581.0
TE-2	525330	2947820	609.5	40.0	569.5
TE-3	525165	2947450	603.0	40.0	563.0
TE-4	524890	2947740	593.0	40.0	553.0
TE-5	525145	2946550	618.0	40.0	578.0
TE-6	524585	2946900	601.0	40.0	561.0
TE-7	524280	2947575	590.5	40.0	550.5
TE-8	524450	2946340	604.0	40.0	564.0
TE-9	523850	2947070	602.0	40.0	562.0
TE-10	523250	2947215	577.0	40.0	537.0
TE-11	523550	2946550	577.0	40.0	537.0
TE-12	524190	2945950	582.5	40.0	542.5
TE-13***	Unknown	Unknown	594.0	40.0	554.0
TE-14	526640	2948620	572.0	40.0	532.0
TE-15	526470	2949300	574.0	40.0	534.0
TE-16	526155	2949910	563.5	40.0	523.5
TE-17	526001	2948070	618.0	40.0	578.0
TE-18	525805	2948535	604.0	40.0	564.0
TE-19	525615	2949070	605.0	40.0	565.0
TE-20	525535	2949720	581.0	40.0	541.0
TE-21	525250	2948115	597.0	40.0	557.0
TE-22	524440	2948690	600.0	40.0	560.0
TE-23	524290	2949300	592.0	40.0	552.0
TE-24	524125	2948490	590.0	40.0	550.0
TE-25	523915	2947635	594.5	40.0	554.5

BORING NO	LOCATION		GROUND ELEVATION (FT-MSL)	BORING DEPTH (FT)	BOTTOM ELEVATION (FT-MSL)
	NORTHING	EASTING			
TE-26	523585	2948760	563.5	37.0	526.5
TE-27	522480	2947230	566.5	40.0	526.5
TE-28	522200	2948385	559.5	40.0	519.5
Jones & Neuse, 1993 (Soil Borings & Piezometers: B-1 to B-22 and P-1 to P-4 as noted on boring logs) (1)					
JN-1	523029.42	2947455.77	573.4	70.0	503.4
JN-2	522850.00	2948120.00	566.9	50.0	516.9
JN-3	522929.96	2948460.98	565.3	67.0	498.3
JN-4	523542.18	2947596.73	590.0	55.0	535.0
JN-5	523375.00	2948155.00	573.8	55.0	518.8
JN-6	523200.00	2948725.00	568.3	45.0	523.3
JN-7	524054.31	2947749.20	586.0	55.0	531.0
JN-8	523895.00	2948295.00	582.7	45.0	537.7
JN-9	523705.00	2948885.00	578.7	60.0	518.7
JN-10	524717.70	2947748.07	591.0	40.0	551.0
JN-11	524515.00	2948475.00	595.0	55.0	540.0
JN-12	524255.67	2948715.12	595.0	90.0	505.0
JN-13	525235.92	2947401.16	599.7	100.0	499.7
JN-14	525351.41	2947957.21	602.3	60.0	542.3
JN-15	525200.00	2948530.00	596.6	40.0	556.6
JN-16	525014.79	2948949.08	595.8	55.0	540.8
JN-17	525965.00	2948320.00	604.9	60.0	544.9
JN-18	525806.15	2948738.46	608.7	65.0	543.7
JN-19	525775.00	2949001.00	600.3	55.0	545.3
JN-20	526609.33	2948532.07	582.1	80.0	502.1
JN-21	526500.00	2948940.00	581.3	40.0	541.3
JN-22	526373.83	2949348.20	574.5	80.0	494.5
JN-P1	525925.98	2946607.90	639.5	33.0	606.5
JN-P2	524643.25	2946094.45	600.0	28.0	572.0
JN-P3	523584.11	2946361.48	576.7	25.0	551.7
JN-P4	523120.11	2947058.68	573.7	30.0	543.7
Rust, 1993 (Soil Borings & Piezometers: CT1-1 to 3; TW-1A to 4; TB-5 to 7; CB-14 and CB-16 as noted on boring logs.) (1)					
CT1-1*	--	--	NA	5.0	NA

BORING NO	LOCATION		GROUND ELEVATION (FT-MSL)	BORING DEPTH (FT)	BOTTOM ELEVATION (FT-MSL)
	NORTHING	EASTING			
CT1-2*	--	--	NA	3.0	NA
CT1-3*	--	--	NA	4.0	NA
RST-1A	523160.00	2946490.00	570.0	40.0	530.0
RST-2	522610.00	2947070.00	563.0	40.0	523.0
RST-3	524615.00	2945430.00	580.0	36.0	544.0
RST-4	523995.00	2945700.00	580.0	40.0	540.0
RST-5	523960.00	2948390.00	590.0	50.0	540.0
RST-6	524705.00	2948630.00	600.0	50.0	550.0
RST-7	525865.00	2948835.00	610.0	50.0	560.0
RST-14	525300.00	2947957.00	600.0	61.0	539.0
RST-16	524940.00	2948949.00	592.0	55.2	536.8
Rust, 1994 (Soil Borings & Piezometers: Boring No. same as on boring log) (1)					
RST-102	525917.99	2946609.31	639.5	82.0	557.5
RST-104	523578.22	2946355.59	576.5	78.0	498.5
RST-105 (3)	523032.91	2947466.89	573.5	22.0	551.5
RST-106	523040.19	2947460.02	573.8	80.0	493.8
RST-107 (3)	522179.30	2948337.45	559.1	24.0	535.1
RST-108	522182.90	2948320.79	559.5	78.0	481.5
RST-109 (3)	523437.89	2948814.73	572.5	37.0	535.5
RST-110	523448.29	2948817.63	572.5	77.0	495.5
RST-111 (3)	524147.93	2949348.32	589.5	40.0	549.5
RST-112	524148.32	2949359.75	589.4	77.0	512.4
RST-113 (3)	524271.97	2948713.49	595.6	22.0	573.6
RST-114	524263.65	2948708.12	595.3	80.5	514.8
RST-116	524742.60	2947743.60	591.3	80.0	511.3
RST-117 (3)	525037.75	2949652.66	582.5	29.0	553.5
RST-118	525027.90	2949649.31	582.5	73.0	509.5
RST-119 (3)	526329.60	2949982.23	553.8	22.0	531.8
RST-120	526334.15	2949984.44	553.7	72.0	481.7
RST-121 (3)	525763.44	2948927.43	612.9	27.0	585.9
RST-122	525771.73	2948929.47	612.8	81.0	531.8
RST-123	526600.00	2948525.00	583.0	61.5	521.5
RST-124	526600.28	2948531.67	582.6	86.0	496.6

BORING NO	LOCATION		GROUND ELEVATION (FT-MSL)	BORING DEPTH (FT)	BOTTOM ELEVATION (FT-MSL)
	NORTHING	EASTING			
RST-125	524235.00	2948770.00	595.0	71.0	524.0
Rust, 1996 (Gas Monitoring Probes: Boring No. same as on boring log) (1)(4)					
GMP-1	526093.75	2946701.30	633.0	28.0	605.0
GMP-2	525978.23	2947205.78	616.9	35.0	581.9
GMP-3	525715.33	2948109.89	609.2	30.0	579.2
GMP-4	526637.86	2948398.35	585.9	22.5	563.4
GMP-5	526654.59	2949382.46	559.3	25.0	534.3
GMP-6	525919.52	2949918.61	567.6	32.5	535.1
GMP-7	525048.97	2949653.22	582.7	35.0	547.7
GMP-8	524154.45	2949365.45	589.3	40.0	549.3
GMP-9	523612.14	2948879.94	576.2	42.5	533.7
GMP-10	522760.26	2948617.12	563.1	32.5	530.6
Rust, 1996 (Monitoring Wells: Boring No. same as on boring log) (1)					
MW-1	525541.48	2946455.93	631.2	26.0	605.2
MW-2	524268.37	2946085.09	592.5	26.0	566.5
MW-3	523556.99	2946339.15	575.9	26.0	549.9
MW-4	523212.29	2946810.46	571.4	26.0	545.4
MW-5**	523032.91	2947466.89	573.5	22.0	551.5
MW-5R	522887.45	2947423.35	570.6	23.5	547.1
MW-6	522944.89	2948020.33	568.3	36.0	532.3
MW-7**	523438.52	2948815.15	572.4	37.0	535.4
MW-8**	524148.50	2949348.22	589.7	40.0	549.7
MW-9	524723.53	2949559.73	585.7	31.0	554.7
MW-10	525310.06	2949734.40	578.3	30.0	548.3
MW-11	526263.38	2950027.17	555.2	25.0	630.2
MW-12	526659.39	2949344.99	559.5	21.0	538.5
MW-13	526676.48	2948737.91	571.6	29.0	542.6
MW-14	525735.70	2948131.64	609.0	31.0	578.0
T-1	526659.94	2949367.58	559.6	40.0	519.6
Earth Tech, 1998 (Boring: Boring No. same as on boring log)					
B 98-01	525362.20	2948978.70	602.40	83.5	518.80
Tetra Tech, 2010 (Monitoring Wells: Boring No. same as on boring log) (2)					
MW-15	523080.62	2948482.24	568.4	34.00	533.9

BORING NO	LOCATION		GROUND ELEVATION (FT-MSL)	BORING DEPTH (FT)	BOTTOM ELEVATION (FT-MSL)
	NORTHING	EASTING			
MW-16	524003.95	2948989.50	587.4	36.00	552.4
MW-17	525901.88	2949877.27	571.2	37.00	534.1
MW-18	526377.79	2949582.43	570.2	29.00	542.0
MW-19	523042.05	2947199.15	573.5	32.00	541.3
MW-20	525818.50	2947750.00	622.1	39.00	581.3
MW-21	525971.25	2947213.46	616.6	38.00	578.2
MW-22	524040.29	2946044.59	593.0	39.50	552.3

* Shallow auger borings to verify soil cover thickness.

NA – Not Available

** MW-5 - Converted piezometer RST-105; no boring log provided and not displayed on Figure III-4-11.

MW-7 - Converted piezometer RST-109; no boring log provided and not displayed on Figure III-4-11.

MW-8 - Converted piezometer RST-111; no boring log provided and not displayed on Figure III-4-11.

*** Boring log is included, but coordinates unknown and not placed on Figure III-4-11.

(1) Borehole location coordinates and surface elevations were retrieved from the table found on Figure 4-7 of the Geology Report in the Rust E&I (1999) previous Permit Amendment Application No. MSW-692A.

(2) Borehole location coordinates and surface elevations were surveyed by SAM, Inc.

(3) Boring logs were not provided; possibly shallow twin of adjacent deeper borings in which no boring log was prepared and therefore not displayed on Figure III-4-11.

(4) Gas monitoring probe locations are displayed on Figure III-6-2.

The previously completed investigations were supplemented by additional borings in the area of the proposed expansion area. The number and depth of additional borings were determined to meet the requirements of 30 TAC §330.63(e)(4)(A) and (B) as described in the soil boring plan that was approved by the Texas Commission on Environmental Quality (TCEQ). The soil boring plan and the TCEQ approval letter are presented in Appendix III-4A.

As proposed in the approved boring plan, a total of 26 additional borings (labeled GA-01 through GA-26) were advanced in the area of the proposed expansion area. Additionally, a secondary set of 16 borings (labeled GA-27 through GA-42) were advanced to further characterize the interface of the weathered and unweathered zones within the Taylor Marl beneath the site. This investigation was performed to better delineate the upper water bearing unit. Table III-4-4 provides the coordinates and elevations of the borings. As listed, 42 total additional borings were advanced, of which 15 reached a depth 30 ft below the elevation of the deepest excavation (approximately 503 ft-msl). The other borings were advanced to at least 5 ft below the deepest excavation. The locations of all the site borings are shown on Figure III-4-11 and the surface of the weathered-unweathered interface in the expansion area as determined from the Golder 2015 geotechnical investigation is shown on Figure III-4-12.

The borings were advanced through the clay materials with either hollow-stem augers or rotary drilling with HQ coring equipment in rock that yielded 2.25-inch diameter core samples. All borings were plugged in accordance with 16 TAC §76.702 and §76.1004 and seven were completed as piezometers to provide groundwater elevation data (GA-4, GA-14, GA-22, GA-23, GA-24, GA-25, and GA-26).

The boring logs from the site investigations are attached as Appendix III-4B. Laboratory data on soil samples obtained during the recent investigation are summarized in Appendix III-4C. Data from the above-referenced previous studies by EarthTech, J & N, Rust, Tetra Tech, and Trinity are attached as Appendix III-4D.

Table III-4-4: Coordinates and Elevations of Borings Advanced at the Proposed Expansion

Boring	Northing	Easting	Ground Elevation (ft-msl)	Depth (ft)	Bottom Elevation (ft-msl)
GA-1	526015.8	2947432	614.9	145.0	469.9
GA-2	523899.9	2950212	601.0	130.0	471.0
GA-3	526292.8	2947891	614.0	120.0	494.0
GA-4	526612	2947503	596.9	105.0	491.9
GA-5	525983.9	2950251	555.7	85.0	470.7
GA-6	525163.7	2951860	550.5	80.0	470.5
GA-7	525063.7	2950834	593.1	125.0	468.1
GA-8	524671.4	2950828	594.4	125.0	469.4
GA-9	524430.8	2949593	585.2	115.0	470.2
GA-10	523539.9	2949986	593.3	125.0	468.3
GA-11	523370.2	2951392	580.0	110.0	470.0
GA-12	522816.5	2950289	570.1	100.0	470.1
GA-13	523569	2949270	575.2	105.0	470.2
GA-14	521850.4	2950642	553.5	60.0	493.5
GA-15	522256.5	2951080	562.4	93.0	469.4
GA-16	522662.5	2948776	560.3	90.0	470.3

Boring	Northing	Easting	Ground Elevation (ft-msl)	Depth (ft)	Bottom Elevation (ft-msl)
GA-17	525247.6	2950132	578.2	110.0	468.2
GA-18	524465.1	2950260	597.3	103.0	494.3
GA-19	523996.2	2951615	579.1	110.0	469.1
GA-20	523359.8	2950551	588.2	95.0	493.2
GA-21	523002.7	2949612	566.5	70.0	496.5
GA-22	525705.8	2950797	557.1	73.0	484.1
GA-23	524605.2	2951837	564.6	68.0	496.6
GA-24	523949.4	2950751	599.7	105.0	494.7
GA-25	522924.2	2951295	575.4	80.0	495.4
GA-26	522517.5	2949749	560.0	65.0	495.0
GA-27	525404.7	2949722	571.3	41.0	530.3
GA-28	524772.4	2951431	571.8	38.0	533.8
GA-29	525162.2	2950476	589.8	46.0	543.8
GA-30	524829.3	2951052	588.4	44.0	544.4
GA-31	524816.3	2950518	600.6	56.0	544.6
GA-32	524786.5	2949727	583.3	39.0	544.3
GA-33	524513.8	2950596	601.0	52.0	549.0
GA-34	524326.8	2951031	594.8	47.0	547.8
GA-35	524259.1	2950567	601.9	59.0	542.9
GA-36	524326.1	2949895	587.2	46.0	541.2
GA-37	524090.5	2950151	595.3	49.0	546.3
GA-38	524062.8	2949852	586.7	41.0	545.7
GA-39	523566.6	2950476	595.2	61.0	534.2
GA-40	523767.4	2949707	581.8	39.0	542.8
GA-41	523352.8	2948905	570.0	40.0	530.0
GA-42	524062.6	2951236	590.3	60.0	530.3

5.2 Site Stratigraphy

The site stratigraphy has been illustrated through a series of seven cross-sections, as shown on Figures III-4-13.1 through III-4-13.7. These cross-sections utilize previous borings at the site in conjunction with new borings installed in 2014 and 2015 by Golder. No water was observed by Golder during drilling of the new borings installed in 2014 and 2015. Initial water levels were not recorded from borings where wet rotary techniques were used as they were not representative measurements. The results of the subsurface investigations show that the site is underlain by three distinct strata, which is consistent with previous studies and permitting at the site, namely (in order from ground surface down):

- Stratum I – Residual clay in the lower Taylor Marl - Ozan Formation: Stiff to hard, dark brown to tan, low plasticity clay, with high plasticity clay with organic content comprising the top of the stratum in some areas.
- Stratum II – Weathered claystone in the Ozan Formation: Weathered, extremely weak to weak, tan and light gray, with orange mottling, claystone.
- Stratum III – Unweathered claystone in the Taylor Group: Slightly weathered to fresh (unweathered), massive, weak to strong, light gray claystone.

All three stratums belong to the Cretaceous Gulf Series of the Navarro-Taylor Groups. Stratum I, a low-plasticity clay with pockets of high plasticity clay and organic content, is the product of Stratum II clay weathering. The interface between Stratum I and II was not always easily defined because of the gradual transition from residual soil to rock. Also, multiple criteria were considered in determining the top of Stratum III, which included the change of rock type, change in color, SPT N-values, and change from completely/highly weathered, fissile claystone to slightly weathered/unweathered, massive claystone.

5.3 Soil Properties

In accordance with 30 TAC §330.63(e)(5), the geotechnical properties of the predominant strata at the site are summarized in the following sections.

5.3.1 Stratum I

This stratum is described as hard, dark brown, tan or gray (with frequent orange mottling), high plasticity clay. The thickness of Stratum I ranges from 0 to 28 ft. Table III-4-5 summarizes the properties of Stratum I. This Stratum roughly corresponds to the uppermost soil type or topsoil described in Permit MSW-692A.

Table III-4-5: Properties of Stratum I

	Minimum Value	Maximum Value	Average	Number of Tests	Test Method
Water Content (%)	12.8	30.2	19.4	12	ASTM D2216
Liquid Limit	49	73	58	13	ASTM D4318
Plastic Limit	15	22	18	13	ASTM D4318
Plasticity Index	34	51	40	13	ASTM D4318
Liquidity Index	-0.117	0.185	0.029	13	ASTM D4318
Undrained Triaxial Compression Test (tsf)	0.9	3.9	2.4	2	ASTM D2850
Vertical Permeability (cm/s)	4.80E-08	1.63E-07	1.1E-07	3	ASTM D5084
Horizontal Permeability (cm/s)	3.91E-08	—	—	1	ASTM D5084

5.3.2 Stratum II

Stratum II consists of completely weathered to moderately weathered, fissile and friable, gray to light gray, extremely weak to weak claystone. Fossilized shells and pyrite nodules were identified in some samples. The Rock Quality Designation (RQD) was generally greater than 50%, as shown on the borehole logs in Appendix III-4B. The top of Stratum II was found between approximately elevation 517 and 601 ft-msl, with a thickness up to 49 ft. The average top of the layer is approximately at elevation 563 ft-msl and corresponds to the weathered claystone described in Permit MSW-692A. Table III-4-6 summarizes the properties of Stratum II.

Table III-4-6: Properties of Stratum II

	Minimum Value	Maximum Value	Average	Number of Tests	Test Method
Water Content (%)	9.7	16.8	13.8	4	ASTM D2216
Liquid Limit	44	76	58	4	ASTM D4318
Plastic Limit	16	27	19	4	ASTM D4318
Plasticity Index	28	49	39	4	ASTM D4318
Liquidity Index	-0.208	-0.043	-0.128	4	ASTM D4318
Vertical Permeability (cm/s)	1.57 E-8	—	—	1	ASTM D5084
Horizontal Permeability (cm/s)	8.30 E-8	6.40 E-6	9.08 E-7	12	ASTM D4044

5.3.3 Stratum III

Stratum III is slightly weathered to fresh, massive, light gray, weak to strong claystone. Rock cores were generally free of joints and discontinuities, excepting few locations. The RQD was generally greater than 80% and often 100%, as shown on the borehole logs in Appendix III-4B. The top of Stratum III was found between approximately elevation 506 and 565 ft-msl. The average top of the stratum is approximately 533 ft-msl. The bottom of this stratum was not identified. Stratum III corresponds to the unweathered claystone described in Permit MSW-692A. Table III-4-7 summarizes the results of properties from the tested samples in this stratum.

Table III-4-7: Properties of Stratum III

	Minimum Value	Maximum Value	Average	Number of Tests	Test Method
Unconfined Compressive Strength (tsf)	81.1	92.5	88.2	2	ASTM D2938
Vertical Permeability (cm/s)	2.0E-09	3.3E-08	1.69E-08	3	ASTM D5084
Horizontal Permeability (cm/s)	2.29E-09	—	—	1	ASTM D5084

The geotechnical evaluation of site materials and slope/waste stability is included in Attachment III-3, the Waste Management Unit Design Report. This design report presents the geotechnical summary and engineering evaluations and analyses. These analyses indicate that the soils at the proposed facility are suitable for the intended purpose. The underdrain analyses are included in Appendix III-3F, the Liner Quality Control Plan. Each phase of the soil and liner evaluation is to be conducted by or under the supervision of the Quality Assurance/Quality Control (QA/QC) independent third-party professional engineer (PE) licensed in the State of Texas. In addition to full-time monitoring, a qualified engineering technician will perform daily QA/QC observations and testing.

5.4 Material Requirements

On-site soils will be required for construction of the soil liner and protective cover components of the liner system, and the cohesive soil cover layer and protective/erosion layer components of the final cover system. On-site soils will also be required for daily and intermediate cover and general earthfill.

The soil liner and cohesive soil cover layers must be constructed from soils that can be compacted to form a low hydraulic conductivity barrier. The classification and hydraulic conductivity test results indicate that the material excavated from the site should be satisfactory for use as compacted soil liner and cohesive soil cover layer material.

The test results and boring logs indicate that any of the soil material excavated from the site should be suitable for use as operational and protective cover, and that the surface soils should be suitable for use as the final cover system protection/erosion layer.

6.0 GROUNDWATER INVESTIGATION REPORT

6.1 Local Hydrogeology

The Taylor Group, which directly underlies the site, produces only a small amount of the total groundwater used in Bell County. In the site area, the Taylor Group is mainly a clay, calcareous claystone and marl unit, which crops out east of the BFZ. The site itself is located on an outcrop of the Taylor Marl. Groundwater occurs primarily within the weathered portions of the clay unit, sometimes perched on top of the unweathered claystone. The clays are montmorillonitic and have high shrink/swell potential. Recharge to the shallow groundwater unit in the saturated zone above the Stratum II/Stratum III interface occurs when rainwater falls on the hills and then flows downslope into the valleys and streams, and from infiltration from farm ponds, lakes, and streams. Recharge may also occur through desiccation cracks when precipitation follows a dry period. A detailed discussion of the groundwater conditions in the site area is presented in the following section.

6.2 Groundwater Investigation

Historically, numerous subsurface soil borings have been drilled at the Temple Recycling and Disposal Facility for purposes related to geological and hydrogeological characterization, groundwater monitoring, and gas monitoring. These borings have been compiled with the initial and static water level data and are included on Table III-4-8.

Table III-4-8: Summary of Initial and Static Water Level Data

Boring No.	Initial Ground-water Elevation ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)
TE-1	NR	NR	JN-15	NR	NR	RST-122	NR	NR	GA-4	NR	NR
TE-2	NR	NR	JN-16	NR	578.2	RST-123	NR	NR	GA-5	NR	NR
TE-3	NR	NR	JN-17	NR	NR	RST-124	NR	NR	GA-6	NR	NR
TE-4	NR	NR	JN-18	NR	555.1	RST-125	NR	NR	GA-7	NR	NR
TE-5	NR	NR	JN-19	NR	NR	GMP-1	DRY	NR	GA-8	NR	NR
TE-6	NR	NR	JN-20	DRY	DRY	GMP-2	DRY	NR	GA-9	NR	NR
TE-7	NR	NR	JN-21	NR	NR	GMP-3	DRY	NR	GA-10	NR	NR
TE-8	NR	NR	JN-22	NR	553.3	GMP-4	DRY	NR	GA-11	NR	NR
TE-9	NR	NR	JN-P1	NR	615.2	GMP-5	DRY	NR	GA-12	NR	NR
TE-10	NR	NR	JN-P2	NR	591.4	GMP-6	DRY	NR	GA-13	NR	NR
TE-11	NR	NR	JN-P3	NR	572.1	GMP-7	DRY	NR	GA-14	NR	NR
TE-12	564.5	NR	JN-P4	NR	566.3	GMP-8	DRY	NR	GA-15	NR	NR
TE-13	NR	NR	CT1-1	NR	NR	GMP-9	DRY	NR	GA-16	NR	NR
TE-14	NR	NR	CT1-2	NR	NR	GMP-10	DRY	NR	GA-17	NR	NR
TE-15	NR	NR	CT1-3	NR	NR	B 98-01	DRY	DRY	GA-18	NR	NR
TE-16	NR	NR	RST-1A	539.4	553.4	MW-1	DRY	NR	GA-19	NR	NR
TE-17	NR	NR	RST-2	DRY	523	MW-2	DRY	DRY	GA-20	NR	NR
TE-18	NR	NR	RST-3	555.8	NR	MW-3	NR	552.9	GA-21	NR	NR
TE-19	NR	NR	RST-4	560.8	NR	MW-4	DRY	DRY	GA-22	NR	NR
TE-20	NR	NR	RST-5	NR	NR	MW-5	NR	NR	GA-23	NR	NR
TE-21	NR	NR	RST-6	NR	NR	MW-5R	DRY	NR	GA-24	NR	NR

Boring No.	Initial Ground-water Elevation ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)
TE-22	NR	NR	RST-7	NR	NR	MW-6	DRY	NR	GA-25	NR	NR
TE-23	NR	NR	RST-14	NR	NR	MW-7	NR	NR	GA-26	NR	NR
TE-24	NR	NR	RST-16	NR	NR	MW-8	NR	NR	GA-27	NR	NR
TE-25	NR	NR	RST-102	NR	NR	MW-9	DRY	NR	GA-28	NR	NR
TE-26	NR	NR	RST-104	NR	NR	MW-10	DRY	DRY	GA-29	NR	NR
TE-27	556	NR	RST-105	NR	NR	MW-11	532.3	543.3	GA-30	NR	NR
TE-28	556.5	NR	RST-106	NR	559.1	MW-12	DRY	NR	GA-31	NR	NR
JN-1	NR	562.8	RST-107	NR	NR	MW-13	DRY	543.4	GA-32	NR	NR
JN-2	NR	NR	RST-108	NR	NR	MW-14	DRY	NR	GA-33	NR	NR
JN-3	NR	563.2	RST-109	NR	NR	T-1	NR	544.8	GA-34	NR	NR
JN-4	NR	584.4	RST-110	NR	NR	MW-15	DRY	NR	GA-35	NR	NR
JN-5	NR	NR	RST-111	NR	NR	MW-16	DRY	NR	GA-36	NR	NR
JN-6	NR	NR	RST-112	NR	NR	MW-17	DRY	NR	GA-37	NR	NR
JN-7	NR	584	RST-113	NR	NR	MW-18	DRY	NR	GA-38	NR	NR
JN-8	NR	591.2	RST-114	NR	NR	MW-19	DRY	NR	GA-39	NR	NR
JN-9	NR	NR	RST-116	571.3	NR	MW-20	DRY	NR	GA-40	NR	NR
JN-10	NR	589.8	RST-117	NR	NR	MW-21	DRY	NR	GA-41	NR	NR

Boring No.	Initial Ground-water Elevation ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)	Boring No.	Initial Ground-water Elevation (ft-msl)	Static Ground-water Elevation (ft-msl)
JN-11	NR	NR	RST-118	NR	NR	MW-22	DRY	NR	GA-42	NR	NR
JN-12	NR	591.8	RST-119	NR	NR	GA-1	NR	NR	-	-	-
JN-13	NR	594.8	RST-120	NR	542.2	GA-2	NR	NR	-	-	-
JN-14	NR	590.8	RST-121	NR	NR	GA-3	NR	NR	-	-	-

Note: NR = Not Recorded

Water level data, collected from August 1994 to June 2015 from 37 previous piezometers, 23 current wells, and 7 newly installed piezometers, are summarized in Tables III-4-8, III-4-9A, and III-4-9B. Tabulated historical groundwater quality results from the ongoing monitoring program(s) are shown in Appendix III-4E, which presents the results of all semiannual and applicable quarterly groundwater monitoring events since 1996. Verification resamples, if collected as part of the statistical analysis, are also included in the appendix. Using data from December 2014, March 2015, June 2015, October 2015, December 2015, and May 2016, potentiometric maps of the groundwater flow system present on-site were prepared and are included as Figures III-4-14.1, III-4-14.2, III-4-14.3, III-4-14.4, III-4-14.5, and III-4-14.6, respectively. A seasonal high potentiometric surface is presented in Figure III-4-14.7. In the areas where conclusive groundwater level data are absent, the potentiometric surface has been inferred based on the Stratum II/III interface contour and topography, as shown by the dashed contours on the figures.

It should be noted that one of the newly installed piezometers, GA-24, has been omitted from groundwater elevation contours. This piezometer has exhibited anomalous behavior: for instance, the water level within GA-24 rose 46 feet between December 2014 and April 2015. The piezometer was investigated using a camera, but no damage was observed. This anomaly is attributed to preferential flow within desiccation cracks that the piezometer encounters.

Shallow, unconfined groundwater, like that observed at the Temple Landfill is influenced by surface topography, whereby groundwater flows in subdued conformity to the land surface (i.e. from topographically high areas to areas with lower elevation). In addition, the groundwater at the Temple Landfill is influenced by the presence of relatively impermeable unweathered material (aquiclude) underlying the weathered materials that comprise the uppermost aquifer. For these reasons, the potentiometric maps developed for the Temple Landfill (Figures III-4-14.1, III-4-14.2, III-4-14.3, III-4-14.4, III-4-14.5, III-4-14.6, III-4-14.7, and III-5-5.1 through III-5-5.6) considered the surface topography, weathered/unweathered structure and measured groundwater elevations from monitoring wells and piezometers. The structure map was developed from previously installed borings which were sufficiently deep to identify the weathered/unweathered interface.

Table III-4-9A: Summary of Groundwater Elevations – Piezometers

Piezometer	Installation Date	08/01/1994	08/11/1994	08/18/1994	09/08/1994	10/20/1994	12/01/1994	01/12/1995	02/22/1995	04/11/1995	05/31/1995	04/09/1996	09/13/1996	12/05/1996	03/25/1997	06/03/1997	09/18/1997	12/18/1997	06/03/1998
JN-1	11/03/1992	563.26	563.34	563.31	563.32	563.29	563.03	564.16	564.37	566.06	566.42	NA	560.36	564.91	571.39	571.11	568.53	563.25	NA
JN-3	11/04/1992	557.34	557.17	556.96	556.19	555.61	555.87	557.26	558.43	560.01	560.90	NA	552.89	554.60	557.55	560.31	554.65	552.96	NA
JN-4	11/04/1992	574.68	574.63	574.63	574.51	574.53	575.16	580.29	575.91	582.99	576.31	NA	572.95	581.35	583.43	581.18	574.40	575.75	NA
JN-7	11/02/1992	574.80	574.15	573.74	572.36	571.22	574.43	578.01	577.56	579.85	578.80	NA	569.47	574.97	584.12	583.45	NA	NA	NA
JN-10	10/26/1992	585.54	584.99	584.58	583.41	582.62	585.21	588.57	588.40	589.97	589.38	NA	580.28	582.12	590.29	590.92	NA	584.87	NA
JN-12	11/05/1992	579.92	579.55	579.35	579.05	579.27	584.20	589.78	584.05	589.85	592.18	NA	583.30	587.59	590.12	589.26	580.20	583.02	NA
JN-13	11/02/1992	593.46	593.25	593.08	592.52	591.85	593.31	595.41	596.38	596.59	596.04	NA	587.79	581.65	594.50	595.89	594.26	594.47	595.69
JN-14	11/09/1992	592.26	592.10	592.08	591.90	591.49	591.17	592.39	593.54	594.12	594.27	NA	589.20	590.06	592.97	594.24	593.20	NA	NA
JN-16	11/09/1992	579.80	579.74	579.67	578.15	578.39	579.64	580.54	581.34	581.89	582.34	NA	579.08	588.75	592.05	597.11	588.95	585.34	588.71
JN-18	10/27/1992	588.73	589.13	589.54	590.19	591.19	592.00	592.82	593.40	607.95	605.97	NA	NA	NA	NA	NA	NA	NA	NA
JN-20	10/30/1992	560.37	560.39	560.44	560.52	560.63	560.82	560.96	561.24	561.45	561.84	NA	NA	NA	NA	NA	NA	NA	NA
JN-22	10/30/1992	553.52	553.57	553.36	553.46	553.36	553.19	554.82	558.19	564.18	NA	NA	562.63	563.91	565.09	NA	562.88	NA	NA
JN-P1	11/06/1992	617.82	618.25	618.45	619.09	619.69	620.76	627.83	630.93	630.83	627.27	NA	620.20	632.47	637.34	634.83	626.64	625.15	NA
JN-P2	11/06/1992	589.01	588.72	588.50	588.02	587.31	591.33	592.80	592.02	592.05	591.49	NA	590.91	594.40	595.75	594.32	590.19	591.43	591.38
JN-P3	11/06/1992	566.30	566.09	565.91	565.39	565.36	566.86	568.10	567.58	571.78	576.07	NA	NA	NA	NA	NA	NA	NA	NA
JN-P4	11/06/1992	561.91	561.61	561.42	561.08	560.85	562.08	563.06	563.45	564.41	564.67	NA	548.41	562.24	570.36	570.50	563.35	562.89	565.60
RST-102	03/25/1994	575.32	575.67	576.11	577.10	579.75	588.87	595.95	601.62	606.61	610.86	NA	619.3	620.95	630.95	631.85	627.91	625.99	630.7
RST-104	03/26/1994	509.24	509.60	509.83	510.72	511.61	567.04	568.10	567.52	567.96	567.75	NA	566.42	568.14	571.23	570.52	566.93	567.99	568.15
RST-105	04/09/1994	560.13	559.81	559.62	559.08	558.70	560.43	565.79	564.18	568.36	567.06	NA	560.11	**	**	**	**	**	**
RST-106	03/26/1994	563.35	563.43	563.38	563.35	563.37	562.96	564.23	564.35	566.15	566.48	NA	558.73	NA	571.44	571.08	568.62	563.03	NA
RST-107	04/09/1994	547.29	547.05	546.95	546.51	545.93	548.30	550.05	548.61	549.56	548.56	NA	543.82	547.38	551.84	552.45	548.87	546.67	549.24
RST-108	03/29/1994	490.87	491.10	491.25	491.75	492.52	493.42	494.24	494.92	495.62	496.24	NA	548.57	550.49	551.69	552.04	551.01	548.34	549.23
RST-109	04/09/1994	559.37	558.74	558.38	557.42	556.77	562.56	567.22	566.98	565.57	567.26	NA	558.29	**	**	**	**	**	**
RST-110	03/29/1994	502.99	503.24	503.36	503.81	504.36	522.13	549.42	552.98	555.06	556.68	NA	557.90	566.05	570.51	571.11	563.11	563.19	562.22
RST-111	04/08/1994	570.03	571.02	571.36	571.75	571.84	572.27	575.76	575.13	575.53	575.81	NA	568.55	**	**	**	**	**	**
RST-112	04/06/1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	568.67	581.92	583.82	583.16	578.85	581.94	NA
RST-113	04/14/1994	575.39	575.46	575.74	576.13	576.78	578.00	580.99	581.90	584.17	583.84	NA	587.04	592.10	592.17	591.41	584.31	587.80	NA
RST-114	04/08/1994	526.78	527.02	527.21	527.78	528.60	530.36	589.39	584.48	584.07	583.80	NA	584.18	590.18	591.98	587.46	581.65	587.85	NA
RST-116	03/25/1994	585.49	585.74	585.79	584.81	584.59	585.35	586.57	587.06	587.52	587.38	NA	580.96	583.28	590.37	590.49	NA	586.20	NA
RST-117	04/14/1994	553.76	553.95	554.18	554.73	554.36	571.93	575.56	570.51	576.79	574.75	NA	563.99	576.15	576.25	576.65	571.62	568.53	572.97
RST-118	04/13/1994	518.93	519.72	520.05	521.42	525.48	567.67	568.46	567.12	567.37	570.23	NA	562.57	576.15	576.18	575.68	571.65	568.88	572.97
RST-119	04/13/1994	Dry	Dry	Dry	Dry	Dry	Dry	546.77	543.83	550.15	544.98	NA	540.60	542.05	551.14	551.55	542.49	541.61	544.14
RST-120	04/11/1994	543.09	542.99	543.78	543.71	543.59	545.09	546.31	545.82	546.20	545.47	NA	543.66	544.50	548.24	549.10	543.31	544.34	544.32
RST-121	04/13/1994	Dry	Dry	Dry	586.18	586.69	588.82	605.20	600.60	604.42	601.97	NA	NA	NA	NA	NA	NA	NA	NA
RST-122	04/09/1994	540.05	539.52	539.73	539.86	540.63	541.57	603.32	599.68	606.22	599.96	NA	NA	NA	NA	NA	NA	NA	NA
RST-124	03/22/1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
T-1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	544.79	NA	NA	NA	NA	NA	NA	NA

Note: NA = Data Not Available; ** = Converted to Monitoring Well

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Table III-4-9B: Summary of Groundwater Elevations – Monitoring Wells

Monitoring Well	Installation Date	06/26/1996	09/13/1996	12/05/1996	03/25/1997	06/03/1997	09/18/1997	12/18/1997	03/25/1998	06/03/1998	10/09/1998	4/1/1999	10/1/1999	4/18/2000	12/1/2000	6/1/2001	12/1/2001	1/1/2002	2/1/2002	3/1/2002	5/1/2002
MW-1	3/29/1996	617.70	621.44	625.88	628.01	627.79	621.52	624.26	628.24	625.59	625.37	625.67	617.07	623.57	627.05	626.87	627.82	NA	NA	NA	626.33
MW-2	4/1/1996	568.98	569.25	574.29	583.52	582.46	577.24	574.59	582.14	578.67	575.13	578.35	574.22	573.43	579.73	580.10	579.13	NA	NA	NA	579.46
MW-3	4/1/1996	566.51	567.32	569.18	571.09	570.34	567.81	569.35	570.88	568.37	569.34	568.92	567.49	567.98	570.50	568.94	570.83	NA	NA	NA	568.75
MW-4	4/1/1996	555.19	558.37	561.20	566.33	566.96	563.81	562.53	567.15	565.30	562.40	566.79	562.09	562.42	562.96	566.69	564.20	NA	NA	NA	566.84
MW-5	4/9/1996	556.36	558.66	566.01	571.42	570.93	NA	NA	566.84	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-5R	3/25/1998	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	562.36	559.11	563.29	557.24	558.03	561.72	565.55	564.27	NA	NA	566.74	566.80
MW-6	4/2/1996	538.03	541.92	555.85	567.23	556.42	558.04	558.82	564.67	560.61	555.75	562.35	555.12	557.84	559.39	564.42	563.00	NA	NA	NA	565.01
MW-7	4/9/1994	553.97	558.28	565.47	570.05	570.68	561.57	563.10	564.24	559.97	563.17	560.36	555.06	555.17	561.16	564.13	564.00	NA	NA	NA	567.09
MW-8	4/8/1994	569.06	568.69	582.10	583.96	583.31	578.92	582.06	583.91	580.76	583.44	580.91	577.62	574.81	586.54	582.22	584.21	585.01	NA	NA	582.81
MW-9	4/3/1996	557.97	559.00	564.01	572.99	575.08	574.29	573.78	577.70	575.25	573.56	576.37	572.83	573.63	574.78	579.91	577.53	NA	NA	NA	579.67
MW-10	4/3/1996	557.58	558.49	563.67	570.28	570.53	564.60	564.83	571.62	567.83	563.85	569.04	561.88	563.61	562.06	568.99	567.86	NA	NA	NA	570.15
MW-11	4/4/1996	545.55	547.30	554.62	555.09	555.17	548.94	555.28	555.70	553.19	555.41	555.65	552.98	555.02	555.37	553.78	555.62	NA	NA	NA	553.20
MW-12	4/4/1996	546.40	551.91	556.91	558.54	558.99	554.98	557.34	559.19	556.69	551.32	558.33	551.22	558.41	559.72	559.01	559.92	NA	NA	NA	558.31
MW-13	4/9/1996	557.26	559.75	562.42	565.70	565.64	556.43	559.15	565.59	559.41	561.09	560.81	555.83	559.13	561.94	560.84	563.31	NA	NA	NA	561.41
MW-14	4/8/1996	NA	581.78	587.17	601.14	600.56	594.56	594.22	600.61	596.19	593.79	595.76	591.83	591.21	593.54	598.33	599.24	NA	601.61	599.47	599.14
MW-15	12/6/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
MW-16	12/7/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
MW-17	12/7/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
MW-18	12/7/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
MW-19	12/6/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
MW-20	12/8/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
MW-21	12/8/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
MW-22	12/8/2010	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-4	7/24/2014	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-14	7/24/2014	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-22	7/24/2014	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-23	7/24/2014	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-24	7/24/2014	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-25	7/24/2014	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-26	7/24/2014	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI

Monitoring Well	12/1/2002	5/1/2003	12/1/2003	7/13/2004	10/1/2004	4/5/2005	10/18/2005	4/4/2006	10/3/2006	4/19/2007	10/9/2007	4/24/2008	10/16/2008	4/15/2009	11/11/2009	5/3/2010	5/3/2010	6/23/2011	12/13/2011	5/24/2012
MW-1	627.62	627.74	625.51	628.49	626.13	627.49	624.90	626.43	619.63	627.48	626.18	625.95	617.39	622.56	627.58	626.92	619.13	620.02	621.57	625.37
MW-2	585.04	580.41	575.26	581.97	576.37	582.17	574.81	574.12	572.75	579.06	579.86	577.32	574.65	572.57	580.27	583.12	P&A	P&A	P&A	P&A
MW-3	572.03	569.06	568.88	570.65	568.90	571.16	567.98	568.04	567.19	570.30	569.44	575.39	567.8	567.35	570.22	572.12	568.13	566.58	566.01	568.02
MW-4	565.83	564.54	563.97	568.5	564.73	569.80	563.65	563.58	562.11	566.11	567.24	569.03	564.61	564.62	566.05	568.02	565.9	563.95	563.77	564.48
MW-5	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-5R	567.44	567.55	562.09	568.92	564.06	569.99	563.79	566.20	567.92	571.32	570.66	571.04	565.08	565.87	570.74	570.47	565.12	565.8	562.07	567.09
MW-6	564.82	565.26	560.08	564.97	561.42	567.09	561.82	566.04	561.38	568.17	566.22	567.21	562.68	560.99	567.35	567.16	563.02	562.99	558.73	563.61
MW-7	568.26	NA	561.23	567.99	561.97	567.89	562.08	560.89	558.60	568.02	564.58	565.02	558.7	557.83	564.56	568.73	560.1	559.89	556.14	560.34
MW-8	586.55	586.84	575.81	583.98	577.51	584.28	576.49	573.69	574.19	583.90	581.33	578.33	575.38	574.08	583.48	583.52	577.89	574.23	574.9	576.11
MW-9	578.07	578.33	574.71	581.33	577.05	582.36	575.33	576.30	572.70	577.57	579.22	578.48	573.76	573.66	579.81	581.01	575.21	573.3	571.12	574.59
MW-10	566.93	567.25	566.66	570.52	566.54	571.97	565.70	565.94	563.64	567.74	567.14	567.28	563.21	562.06	562.43	568.83	564.26	562.68	560.11	563.23
MW-11	554.88	555.31	554.28	554.14	553.72	554.14	550.88	552.70	548.54	554.40	552.65	552.69	548.16	546.85	555.72	555.1	P&A	P&A	P&A	P&A
MW-12	559.70	559.66	555.41	560.49	556.97	559.74	553.91	557.37	551.50	560.00	558.13	557.93	551.7	550.39	560.99	560.57	555.55	554.59	550.26	554.88
MW-13	563.61	564.13	559.33	565.47	561.09	566.01	558.50	561.30	560.56	565.46	561.46	563.15	556.86	558.37	562.69	564.72	557.77	558.48	557.44	559.27
MW-14	598.78	598.89	592.46	599.19	593.54	599.96	592.18	592.48	590.99	600.31	596.06	595.70	590.12	591.27	599.42	598.86	P&A	P&A	P&A	P&A
MW-15	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	561.62	558.28	562.62
MW-16	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	573.33	571.95	573.63
MW-17	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	561.58	557.5	562.27
MW-18	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	554.06	549.45	554.63
MW-19	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	565.78	561.86	567.39
MW-20	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	590.48	598.97	603.82
MW-21	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	607.4	604.7	609.14
MW-22	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	569.35	568.14	572.08
GA-4	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-14	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-22	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-23	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-24	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-25	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI
GA-26	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI	NYI

Monitoring Well	12/4/2012	5/28/2013	12/11/2013	5/1/2014	8/1/2014	9/1/2014	10/1/2014	11/13/2014	12/1/2014	1/1/2015	2/1/2015	3/1/2015	4/1/2015	5/1/2015	6/1/2015	7/1/2015	8/1/2015	9/1/2015	10/1/2015	11/1/2015	12/23/2015
MW-1	616.27	626.66	626.19	622.42	623.45	619.15	623.52	625.74	626.17	626.88	626.43	627.35	626.99	627.66	627.99	627.27	625.37	623.53	617.66	628.74	627.79
MW-2	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-3	566.61	566.63	567.78	565.43	565.79	565.63	566.52	567.04	567.04	567.98	568.9	569.75	570.04	568.6	570.04	565.88	567.41	567.01	566.72	568.8	570.23
MW-4	562.95	562.9	563.97	561.67	561.74	561.4	561.95	562.89	562.27	563.9	564.75	565.65	566.16	565.55	566.02	565.47	563.85	562.55	562.03	561.93	564.35
MW-5	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-5R	561.34	565.9	564.87	562.02	563.02	561.89	563.53	564.74	564.92	565.54	563.42	564.38	563.59	563.88	563.7	563.03	560.16	559.29	558.07	565.74	566.28
MW-6	561.2	561.69	565.32	563.97	561.2	561.1	561.02	561.96	555.17	568.01	566.07	567.39	566.55	565.73	565.37	564.97	563.15	561.79	558.37	549.35	567.57
MW-7	556.43	559.4	560.56	560.64	559.26	557.81	557.87	559.34	560.25	561.74	563.46	564.79	566.64	567.74	565.26	566.89	563.89	561.22	557.94	559.54	564.27
MW-8	573.7	572.79	579.46	572.01	572.61	572.19	572.5	573.35	579	582.79	581.73	573.76	582.89	583.5	583.9	582.82	580.06	577.84	575.33	586.81	585.02
MW-9	572.61	573.31	577.58	574.11	575.62	574.86	575.15	575.93	565.58	576.12	577.83	577.63	577.53	576.88	573.93	576.33	577.31	576.01	575.55	569.43	576.18
MW-10	560.79	561.09	560.69	561.03	558.42	557.75	558.35	559.19	556.49	559.63	560.89	561.88	562.41	563.19	564.41	564.44	560.87	559.18	557.49	556.97	557.67
MW-11	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	560.05	556.18	554.85	P&A	P&A	P&A
MW-12	549.65	559.38	559.78	556.59	554.39	551.98	552.3	555.22	558.23	560.17	559.8	560.74	560.49	560.81	560.72	565.82	560.49	559.65	549.96	557.89	561.58
MW-13	556.99	562.34	562.89	560.85	560.88	560.29	561.59	561.71	562.26	564.19	563.89	566.71	565.73	567.59	566.27	563.03	560.16	559.29	560.66	564.72	567.48
MW-14	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-15	559.26	561.44	563.3	563.3	561.72	554.38	560.29	562.03	559.15	564.25	565.4	566.07	566.49	566.58	567.07	566.63	563.7	561.98	559.83	562.99	565.82
MW-16	572.6	573.54	577.5	575.69	574.92	574.66	574.1	574.22	572.36	575.44	578.4	583.03	582.28	580.57	579.42	578.94	578.15	577.48	576.07	573.25	577.87
MW-17	560.68	563.39	563.53	561.13	561.43	560.63	562	562.96	563.36	564.58	564.12	565.6	565.11	565.36	565.86	564.35	561.78	560.84	559.58	564.93	566.44
MW-18	550.73	555.83	558.52	555.61	554.51	552.55	554.57	556.48	557.37	559.14	558.91	560.11	559.42	559.95	560.06	558.99	555.35	553.78	551.59	557.83	560.5
MW-19	563.81	563.49	566.41	566.13	565.66	565.2	564.63	565.52	555.24	565.86	567.35	567.35	567.84	567.14	565.81	567.32	566.21	563.91	562.52	550.99	562.73
MW-20	601.42	602.8	603.83	603.12	598.26	603.84	604.6	605.79	594.4	602.88	608.52	611.04	612.57	613.11	604.21	605.75	609.3	609.8	608.64	607.84	606.32
MW-21	605.85	608.5	608.8	609.16	608.09	607.75	607.77	607.82	608.1	610.45	612.86	614.78	614.46	614.96	615.1	613.7	610.9	609.38	608.20	610.67	615.27
MW-22	568.23	570.27	572.55	571.54	574.51	568.44	569.31	570.49	571.47	573.96	575.36	576.04	575.91	575.69	575.69	575.79	573.06	571.47	569.50	574.53	577.53
GA-4	NYI	NYI	NYI	NYI	574.36	577.61	579.61	580.92	581.86	584.54	588.5	590.41	590.54	588.49	590.41	590.12	588.53	586.5	584.61	593.61	593.76
GA-14	NYI	NYI	NYI	NYI	546.73	546.53	547.59	548.71	547.19	547.74	548.27	548.64	548.85	565.09	565.12	549.71	547.61	546.16	544.30	546.16	549.29
GA-22	NYI	NYI	NYI	NYI	538.54	540.65	543.39	548.48	553.77	561.02	564.27	565.44	565.46	554.31	554.6	565.03	562.83	559.18	556.38	557.87	566.5
GA-23	NYI	NYI	NYI	NYI	545.16	548.02	549.37	550.18	550.71	552.47	553.94	554.71	555.05	546.93	558.04	554.06	553.38	553.15	553.26	554.04	556.8
GA-24	NYI	NYI	NYI	NYI	540.39	541.37	542.63	544.05	545.28	550.4	569.94	582.1	591.28	569.36	568.81	561.39	568.55	568.1	571.22	572.44	577.75
GA-25	NYI	NYI	NYI	NYI	544.58	552.14	555.58	558.63	558.28	565.62	561.28	564.72	567.33	555.2	555.47	567.43	564.83	562.87	559.84	568.12	566.68
GA-26	NYI	NYI	NYI	NYI	546.48	550.83	550.82	551.47	552.1	553.37	554.23	555.09	555.43	549.02	548.83	555.68	555.23	554.05	551.71	551.17	552.88

Monitoring Well	1/12/2016	2/3/2016	3/1/2016	4/1/2016	5/10/2016	6/21/2016	7/8/2016	8/23/2016	9/1/2016	10/4/2016	11/15/2016
MW-1	627.57	626.95	626.88	626.81	627.47	627.1	626.08	627.08	626.15	624.68	626.1
MW-2	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-3	570.27	570	569.8	570.16	570.16	570.32	568.89	568.13	568.03	567.01	567.8
MW-4	565.03	563.89	565.47	565.87	565.84	565.95	564.59	563.8	563.55	562.84	563.57
MW-5	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-5R	565.87	564.45	564.65	563.7	564.72	565.03	563.21	562.16	561.86	561.22	561.64
MW-6	567.45	565.87	566.23	565.17	565.92	563.67	562.35	561.52	561.47	561.1	553.27
MW-7	566.55	563	566.57	566.71	567.96	567.4	566.11	565.56	560.58	559.56	559.65
MW-8	584.65	583.45	582.77	583.39	584.36	583.34	583.76	583.19	581.99	577.66	577.41
MW-9	577.72	578.26	578.02	578.63	578.6	576.95	578.48	577.83	577.74	577.21	573.63
MW-10	560.62	564.96	565.76	566.35	567.08	565.93	554.68	566.13	563.39	561.92	562.72
MW-11	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-12	561.4	560.68	561.11	561.08	561.61	561.38	558.69	558.47	558.51	555.59	556
MW-13	567.39	565.99	566.7	566.61	567.64	567.96	566.77	564.91	563.99	562.73	563.21
MW-14	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A	P&A
MW-15	566.2	566.08	566.19	566.08	566.92	566	564.62	562.45	562.67	561.39	561.85
MW-16	578.81	579.03	578.92	579.63	580.38	579.11	578.53	577.57	577.48	576.95	575.09
MW-17	566.16	564.98	564.85	565.05	565.85	564.45	562.85	563.2	563.2	563.1	555.73
MW-18	560.22	559.08	559	559.22	559.91	558.61	556.72	556.35	556.91	555.22	555.89
MW-19	566.04	561.57	568.34	568.25	568.47	568.18	566.44	565.47	565.32	564.87	560.54
MW-20	610.94	613.14	613.97	614.92	615.52	607.72	606.54	611.62	612.03	612.2	597.32
MW-21	615.08	613.59	614.09	613.08	614.4	612.73	611.46	610.59	610.91	609.8	609.68
MW-22	576.56	575.81	575.49	575.89	575.91	575.74	574.57	573.93	572.73	571.599	NA
GA-4	593.81	593.17	592.22	591.83	592.91	592.41	591.7	587.2	587.09	586.43	585.61
GA-14	549.65	549.07	548.95	548.55	549.71	548.74	547.46	545.43	545.28	543.99	544.06
GA-22	566.79	566.12	565.83	564.85	565.46	564.41	563.14	557.13	557.54	557.57	555.93
GA-23	557.64	558.1	558.18	558.15	557.9	556.97	556.41	555.71	555.37	555.1	555.5
GA-24	579.48	579.14	582.08	583.72	585.3	584.45	587.4	587.3	587.32	587.28	587.04
GA-25	567.21	567.1	566.45	567.47	567.99	567.8	566.56	563.51	563.47	562.48	561.2
GA-26	555.63	555.28	555.51	555.14	555.83	555.35	554.07	554.25	553.95	552.7	551.25

Notes:
** – Converted to Monitoring Well
NA – Data Not Available
NYI – Not Yet Installed
P&A – Well is Plugged and Abandoned

Contours of the Stratum II/III interface were developed based on information obtained from soil borings and from pre-development site topography and are presented as the Weathered-Unweathered interface in Figure III-4-12.

Based upon an evaluation of the soil boring and groundwater data from site investigations, there is a preferential flow pathway for groundwater at and above the Stratum II/III interface. During rainfall events, surface water enters desiccation cracks and other macroporosity features within the overall low-permeability claystone matrix. Groundwater flows vertically through these desiccation cracks in the Stratum II clay until it reaches the interface with Stratum III where these cracks are absent. These cracks, observed in the samples collected from geotechnical borings, are sometimes infilled with gypsum and exhibit mineralization, as indicated by the brown coloration on either side of the crack. These cracks occur irregularly, and are oriented vertically, horizontally, and diagonally with respect to ground surface. The groundwater in these cracks, where present, flows in various directions depending on the part of the site under consideration, but normally flows in subdued conformity to topography. Vertical flow is restricted by Stratum III materials.

Investigations of the groundwater flow conditions in the Stratum III claystone have indicated that Stratum III is not hydraulically connected to Stratum II and acts as the local aquaclude dividing the upper water bearing unit from lower aquifers.

The excavation of the proposed expansion area is designed to be within the weathered claystone. However, due to the variable elevation in the Stratum II/III interface and the extrapolation method used to estimate the elevation between borings, some limited portions of the expansion may extend into the Stratum III material.

6.2.1 Groundwater Flow and Direction

The predominant groundwater flow direction in the uppermost water bearing unit (unweathered claystone) is generally controlled by the natural surface topography as well as the topography of the weathered/unweathered interface, which generally mimics the pre-construction land surface. Pursuant to these controls, groundwater at the site generally flows towards the east from MW-1; however, the flow direction begins to deviate in the eastern portion of the site as a result of the influence of the weathered/unweathered interface. As presented on Figures III-4-14.1 through III-4-14.6, the groundwater flow direction begins to flow radially outward from the center of the expansion area, resulting from the topographic high in both the ground surface and the weathered/unweathered interface surface.

Historically, wells at the site have a slow (several months) lag time to reaching an equilibrium static water level. This lag is observed in the newly installed piezometers; the potentiometric surface (as indicated by the piezometers) on the eastern portion of the site is observed to slowly rise.

The hydraulic gradient for the western portion of the site was previously estimated at 0.02 ft/ft by Rust, during their 1994 investigation. The 2014–2015 Golder investigation determined a hydraulic gradient of 0.005 ft/ft for the eastern portion of the site based on potentiometric surfaces for the December 2014, March 2015, and June 2015 gauging events. The difference in hydraulic gradients between the western and eastern portions of the site are attributed to the western portion of the site occupying a more hydraulically upgradient position as observed in Figure III-4-13.1 where it can be seen that there is a downward trend in elevation from west to east across the site.

6.2.2 Hydraulic Properties and Groundwater Velocity

Table III-4-10 summarizes the hydraulic properties for the site. The overall hydraulic conductivity of Stratum II is low due to the fine-grained nature of the materials and the irregularity of the thin cracks at the interface. Consequently, groundwater flow, where present, is relatively slow, as shown on Table III-4-11. The thickness of the uppermost aquifer depends on the seasonal groundwater levels and is defined from the unweathered/weathered interface to the top of the saturated zone. The uppermost aquifer thickness was calculated by subtracting the unweathered/weathered interface elevation (found from the cross-sections) _from the groundwater elevation average for 2015 at each borehole. The average aquifer thickness determined from borings in the eastern expansion area was approximately 31.45 feet. Aquifer thicknesses ranged, for example borehole GA-22 on the northern point of cross-section D determined a thickness of approximately 38.35 feet, borehole GA-24 in the middle of cross-section E determined a thickness of 30.12 feet, and borehole GA-14 at the southern point of cross-section E determined a thickness of approximately 28.65 feet.

The top of Stratum II was found between approximately elevation 517 and 601 ft-msl, with a thickness up to 49 ft. The average top of the layer is approximately at elevation 563 ft-msl and corresponds to the weathered claystone described in Permit MSW-692A. The top of Stratum III (unweathered claystone) was found between approximately elevation 506 and 565 ft-msl. The average top of the stratum is approximately 533 ft-msl.

During the investigation described in the Rust (1994) report, slug tests were performed in piezometers located on the portion of the facility west of the proposed expansion area to determine the hydraulic properties of the Stratum II/III interface. Golder slug tested four additional wells during the 2015 investigation to measure the hydraulic properties of the Stratum II/III interface in the area of the proposed expansion. These tests were conducted using the falling and rising head methods, whereby the water levels were displaced by introducing a "slug" into the water column. The drop and subsequent rise (following removal of the slug) in water level was then monitored with respect to time to determine the horizontal hydraulic conductivity. Hydraulic conductivity values for each test were determined using AqteSolv Pro® software. The output from each AqteSolv Pro® analysis may be found in Appendix III-4F. From the results of the slug testing, Golder calculated the geometric mean hydraulic conductivity to be as follows:

Table III-4-10: Summary of Aquifer (Slug) Tests

Consultant	Stratum	Geometric Mean Hydraulic Conductivity (cm/sec)
Rust (1994) (West)	II	2.2×10^{-7}
Rust (1994) (West)	III	5×10^{-10}
Golder (2015) (East)	II	9.1×10^{-7}

Horizontal travel velocities were estimated for the saturated zone above the Stratum II/III interface from the hydraulic gradient calculated for the December 2014, March 2015, and June 2015 potentiometric surfaces using the formula:

$$V = (ki)/n_e$$

Where:

V= travel velocity

k= hydraulic conductivity of the aquifer

i= hydraulic gradient (West = 0.02; East = 0.005)

n_e = effective porosity (0.06)

Resulting values indicate an average velocity of approximately 0.08 ft/year for both western and eastern portions of the site. Values used for calculations are as shown in Table III-4-11 and calculation steps are shown below.

Table III-4-11: Estimated Groundwater Velocities

Consultant	Area of Site	Hydraulic Conductivity (k) (cm/sec)	Approximate Hydraulic Gradient (i)* (ft/ft)	Effective Porosity (n_e)**	Linear Velocity (v) (ft/yr)
Rust (1994)	West	2.2 x 10^{-7}	0.02	0.06	<0.1
Golder (2015)	East	9.1 x 10^{-7}	0.005	0.06	0.08
			Golder Mean		0.08

* Gradient estimated from December 2014, March 2015, and June 2015 potentiometric maps.
** Effective porosity for clay from McWorter and Sunada (1977).

Hydraulic properties of the uppermost aquifer on the western portion of the site are as follows:

- Average Linear Velocity: 0.08 ft/yr (7.33 x 10^{-8} cm/s)
  - Calculated from: (2.20 x 10^{-7} * 0.02) / 0.06

Hydraulic properties of the uppermost aquifer on the eastern portion of the site are as follows:

- Average Linear Velocity: 0.08 ft/yr (7.57 x 10^{-8} cm/s)
  - Calculated from (9.08 x 10^{-7} * 0.005) / 0.06

7.0 SUMMARY

This report, prepared in accordance with 30 TAC §330.63(e), summarizes available data from reports related to regional and local geology and aquifers in the area.

The project site is underlain by the Cretaceous age Taylor Group. The weathering of the Taylor Group has resulted in the formation of low-permeability clay. Stratum I, a high-plasticity clay, is the uppermost clay and underlies the facility. Underlying this clay is a weathered to highly-weathered fissile calcareous claystone (Stratum II), which is underlain by an unweathered massive claystone (Stratum III), both of which have low permeabilities. Below the claystone is a competent marl layer. The planned landfill expansion cells are to be founded in the clay with portions potentially extending into the weathered claystone as discussed above, each of which provide a stable foundation for the cells. The low permeability of these units provides additional containment beyond that provided by engineered liner systems, resulting in low groundwater velocities (where groundwater is present) and restricts potential pollutant migration rates in the event of a release from the landfill.

Based upon an evaluation of the soil boring and groundwater data from site investigations, there is a preferential flow pathway for groundwater in the saturated zone above the interface of the weathered claystone (Stratum II) and the unweathered claystone (Stratum III), referred to as the Stratum II/III interface. Groundwater flows through cracks, some of which are infilled with crystallized minerals that were observed during site investigations. Groundwater, where present, generally flows in subdued conformity to topography, which varies across the site.

Based on a review of this data, and on the results of geotechnical investigations conducted at the site, the proposed site is suitable for its continued use as a municipal solid waste disposal facility.

8.0 REFERENCES

Abbott, Patrick L. and C.M. Woodruff. 1986. The Balcones Escarpment: Geology, Hydrology, Ecology and Social Development in Central Texas. Geological Society of America Annual Meeting, San Antonio, Texas, pp. 204.

Brune, Gunnar and Gail L. Duffin. 1983. Occurrence, Availability, and Quality of Ground Water in Travis County, Texas. Texas Department of Water Resources Numbered Report 276, pp. 20, 46 and 76.

Bureau of Economic Geology (BEG). 1979. Geologic Atlas of Texas – Waco Sheet. University of Texas at Austin, Austin, Texas.

Bureau of Economic Geology (BEG). 1992. Geologic Atlas of Texas. University of Texas at Austin, Austin, Texas.

EarthTech Inc. (Formerly Rust). 1999. Temple Recycling and Disposal Facility Permit Application No MSW-692A, Part III, Attachment 4 - Geology Report.

Duffin, Gail and Steven P. Musick. 1991. Evaluation of Water Resources in Bell, Burnet, Travis, Williamson and Parts of Adjacent Counties, Texas. Texas Water Development Board Numbered Report 326, pp. 74.

Jones & Neuse. 1993. Geotechnical Investigation

Jones, Ian C. 2003. Groundwater Availability Modeling: Northern Segment of the Edwards Aquifer, Texas. Texas Water Development Board Numbered Report 358, pp. 22 and 30.

Kelly, Van A., John Ewing, Toya L. Jones, Steven C. Jones, Neil Deeds, and Scott Hamlin. 2014. Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers. INTERA Inc., Austin, Texas & Bureau of Economic Geology, University of Texas at Austin, Austin, Texas, pp. 990.

Maier, F.J. 1950. Fluoridation of public water supplies. American Water Works Association Journal. Volume 42, pt. 1, p. 1120-1132.

Maxey, K.F. 1950. Report on the relation of nitrate concentrations in well waters to the occurrence of methemoglobinemia. National Research Council Bulletin – Sanitary Engineering. p. 265-271.

McWhorter, D.B. and D.K. Sunada. 1977. Ground-Water Hydrology and Hydraulics. Water Resources Publications, Colorado.

Rust Environment & Infrastructure. 1994. Hydrogeology/Geotechnical Site Investigation, Temple Landfill, Temple, Texas.

Ryder, Paul D. 1996. Ground Water Atlas of the United States Oklahoma, Texas. U.S. Geological Survey Contents of HA 730-E, Alluvial Aquifers Along Major Streams. http://pubs.usgs.gov/ha/ha730/ch_e/E-text1.html. Accessed October 31, 2016.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed April, 13 2015.

Tetra Tech Inc. 2010. Temple Recycling and Disposal Facility Permit Application No MSW-692A, Part III, Attachment 5 – Water Characterization Report Revision 4

Tetra Tech Inc. 2011. Temple Recycling and Disposal Facility – MSW Permit No. 692A, Installation Report of Groundwater Monitoring Wells.

Thorkildsen, David and Robert D. Price. 1991. Ground-Water Resources of the Carrizo-Wilcox Aquifer in the Central Texas Region. Texas Water Development Board Numbered Report 332, pp. 16.

Trinity Engineering. 1979. Geotechnical Investigation

U.S. Salinity Laboratory Staff. 1945. Diagnosis and improvement of saline and alkali soils: U.S. Department of Agriculture Handbook. 60, pp. 160.

Winslow, A.G. and L.R. Kister. 1956. Saline-water resources of Texas. U.S.G.S professional paper 1365, pp. 105.