LAREDO SOLID WASTE
MANAGEMENT DEPARTMENT
6912 SH 359
LAREDO, TEXAS 78043

PART III, ATTACHMENT 11

GROUNDWATER SAMPLING AND ANALYSIS PLAN

STATE OF TEXAS
Stephen D. Phillips
Geology
No. 249
LICENSED
PROFESSIONAL GEOSCIENTIST

Except for Appendix 3
Groundwater Model

6/18/15

Original Prepared by City of Laredo – April 1966
Revised by Drukell Trahan, R.P.G., Rust Environment and Infrastructure, December 1998
Revised by SCS Engineers – September 2006
Revised by Stephen Phillips, P.G., PS Phillips Environmental – December 2013
Revised by Stephen Phillips, P.G., PS Phillips Environmental – June 2015

PART III ATTACHMENT 11

GROUNDWATER SAMPLING AND ANALYSIS PLAN
CITY OF LAREDO LANDFILL
WEBB COUNTY, TEXAS
MSW PERMIT 1693A

EXECUTIVE SUMMARY

This Groundwater Sampling and Analysis Plan (GWSAP) is provided to present the groundwater monitoring system, sampling and analysis procedures, the reporting of results, and the assessment monitoring program for the City of Laredo Landfill (CLLF). The monitoring system is currently comprised of 15 point of compliance (POC) wells and 2 upgradient wells screened in the greenish-gray sandstone of the Layer II stratum of the Laredo Formation. These deposits represent the uppermost aquifer at the CLLF. The POC wells are located at the POC along the west, north, and east sides of the landfill. Historically, groundwater in Layer II has flowed in a north and northeasterly direction.

Sampling of groundwater from the POC wells will be conducted using dedicated pneumatic bladder pumps after measuring water levels. Sample progression will be based on the highest water level to lowest unless contamination is suspected to be present. Samples will not be filtered and will be field tested as appropriate, labeled, and preserved for shipment to, and analysis by, a National Environmental Laboratory Accreditation Conference (NELAC) qualified laboratory.

The reporting of groundwater sampling and analyses will be in accordance with §330.407 "Detection Monitoring Program for Type I Landfills." The report will determine whether there has been a statistically significant increase over background of any tested constituent at any compliance well.

As of the time of this application, no plume of contamination has entered the groundwater from a municipal solid waste management area at the CLLC. Section C, Groundwater Sampling and Analysis Procedures, presents the information on a detection monitoring program that meets the requirements of 30 TAC Section §330.407 (relating to Detection Monitoring Program for Type I Landfills).

Based on a review of the groundwater chemistry over the past years the amount of precipitation received at or near the site, and a groundwater model that indicates any release from the landfill would not migrate past the property boundary at concentrations higher than the State groundwater protection levels (PCLs) or the Federal maximum concentration levels (MCLs) and only cis-12-dichloroethene would just cross the southeast boundary after 50 years if the release were continual and no degradation takes place. Therefore, the City is requesting in accordance with 30 TAC 330.407(a)(2) that the groundwater monitoring interval for the CLLF be changed to annual monitoring.

A. GENERAL

The GWSAP for CLLF will be conducted in general accordance with the Municipal Solid Waste Management Regulations as listed in 30 TAC 330, §§330.401-330.421.

The intent of the GWSAP is to provide accurate representation of groundwater quality at the background and downgradient wells located at the facility by including all aspects of groundwater monitoring, purging, and sampling and analysis.

B. GROUNDWATER MONITORING SYSTEM

The Groundwater Monitoring System (GWMS) for the CLLF is designed to comply with the requirements of 30 TAC §330.403 "Groundwater Monitoring System." The CLLF site will use 17 monitoring wells placed at locations shown on **Figure III.11.1** monitoring the Layer II stratum of the Laredo Formation. Monitoring wells MW-4R1 and MW-12 are the upgradient wells. **Figure III.11.2** presents the construction details of the existing wells.

A series of groundwater flow maps prepared by SCS Engineers using groundwater data from June 2004, 2006, and 2007 indicate flow from the southwestern corner (MW-4R1) toward the north, northeast, and east (**Appendix 1**). Groundwater elevations from more recent data (November 2011, November 2012, and December 2014) substantiate the same directions. **Table 1** presents the groundwater elevations for the 2007, 2011, 2012, and 2014 dates.

The point of compliance (POC) for the landfill is a line connecting the downgradient monitoring wells from MW-22 clockwise to MW-5.

If or when any existing wells require abandonment or plugging, the well(s) will be abandoned and plugged in accordance with 16 TAC §76.702 (relating to Responsibilities of the Licensee and Landowner--Well Drilling, Completion, Capping and Plugging) and §76.1004 (relating to Technical Requirements--Standards for Capping and Plugging of Wells and Plugging Wells that Penetrate Undesirable Water or Constituent Zones).

The monitoring frequency for the 17 wells shall be annually, unless otherwise approved, during the active life of the facility and during closure and post-closure periods. Background data sets may be updated once every four years with the annual detection results that are demonstrated to be

TABLE 1
GROUNDWATER ELEVATIONS

Location	June 2007	November 2011	November 2012	December 2014
	Elevations in feet (MSL)			
MW-1	435.64	Plugged		
MW-2	435.96	Plugged		
MW-3R2	435.88	Plugged		
MW-4R1 (U)	479.61	483.00	483.05	488.94
MW-5 (D)	426.51	436.32	437.67	439.72
MW-6 (D)	424.60	429.92	431.04	431.59
MW-7 (D)	425.44	430.69	431.84	432.44
MW-8	427.65	Plugged		
MW-9	428.36	Plugged		
MW-10	429.03	Plugged		
MW-11 (D)	424.52	428.09	429.14	429.90
MW-12 (U)	466.72	471.78	471.58	473.38
MW-13 (D)		436.57	439.07	440.19
MW-14 (D)		438.90	440.10	441.95
MW-15 (D)		440.31	441.94	444.76
MW-16 (D)		436.61	437.41	438.86
MW-17 (D)		433.03	433.74	434.47
MW-18 (D)		432.60	433.35	433.95
MW-19 (D)		431.98	432.58	433.18
MW-20 (D)		432.00	432.66	436.81
MW-21 (D)		431.61	432.33	432.86
MW-22 (D)		436.91	437.31	440.09
MW-23 (D)		437.63	438.23	439.21

representative of background water quality after submitting the proposed data set to TCEQ and receiving permission to make the changes. At least one sample from all wells will be collected and analyzed during each subsequent semiannual sampling event.

The owner or operator shall promptly notify the executive director, and any local pollution agency with jurisdiction that has requested to be notified, in writing of changes in facility construction or operation or changes in adjacent property that affect or are likely to affect the direction and rate of groundwater flow and the potential for detecting groundwater contamination from a solid waste management unit and that may require the installation of additional monitoring wells or sampling points. If such wells or sampling points are required, a modification to the site sampling plan will be requested.

The City's request to change groundwater monitoring to an annual basis is based on a "no migration determination."– This determination is based on a groundwater model developed by Kleinfelder. The groundwater model was developed using the USGS's MODFLOW/MT3DMS programs. The model assumed the source as along the entire perimeter of the landfill waste cells facing the property boundary and the contaminants arsenic, cis-1,2-dichloroethene (DCE) and vinyl chloride identified in the analysis of the landfill leachate. Arsenic and vinyl chloride were selected as the contaminants to model because each has the lowest (Federal and State) maximum concentration level and protective concentration level (MCL and PCL) of 10 and 2 micrograms per liter (ug/l) respectively. DCE was selected because it has the lowest reporting limit (1 ug/L) of the organic compounds identified in the leachate. Arsenic also has the lowest reporting limit (5 ug/L) of the metals identified in the leachate. A copy of the leachate analysis is included as **Appendix 2.** A copy of the groundwater model is included in **Appendix 3**. In addition, a review of the 2011, 2012, and 2014 groundwater monitoring reports indicates that there is currently no groundwater contamination. No volatile organic compounds (VOCs) have been detected in any wells. No metals have been detected in any wells above federally-promulgated maximum concentration levels (MCLs). The only statistically significant change (SSC) seen was for thallium in MW-12 during the May 2011 sampling event. However, confirmation resampling of MW-12 during the November 2011 sampling event indicated a non-detect for thallium. Therefore the SSC for thallium from May 2011 was not confirmed. Thallium was not detected during the November 2012, May 2014, or the December 2014 sampling events.

Data obtained from the National Weather Service, South Texas Climate Normals from 1981 through 2010 indicate a yearly precipitation average of 20.2 inches.

The Texas Climate Extremes indicates that Laredo is the fifth driest city in Texas with an average rainfall amount of 16.22 inches per year. This statement is based on data from the National Climatic Data Center. It is unknown the period of time from which this average was derived.

The Texas Water Atlas indicates the average annual precipitation for the Laredo area ranges from 20.01 to 25.00 inches based on data from the National Oceanographic and Atmospheric Administration from the years 1971 through 2000. Copies of the above data bases are included in **Appendix 4**.

Based on the above climatic data, the amount of leachate created by precipitation should be minimal.

C. GROUNDWATER SAMPLING AND ANALYSIS PROCEDURES

The Groundwater Sampling and Analysis Procedures for the CLLF are prepared in compliance with the requirements of the Municipal Solid Waste Management Regulations as listed in 30 TAC, Chapter 330–Subchapter J, §§330.405, 330.407, 330.409, and 330.419. These procedures are intended to provide an accurate representation of the groundwater quality at the background and downgradient wells located at the facility.

1. Sampling and Analysis Procedures

For each sampling event, the qualified groundwater scientist (QGWS) will use the following procedures:

- Record water levels of all wells prior to sampling. Determine the flow direction and select the order of well sampling in accordance with §330.405(b) (2). Sampling will be conducted from highest water-level elevation to those of successively lower elevations unless contamination is known to be present, in which case wells not likely to be contaminated will be sampled prior to those known to be contaminated.
- Data collected prior to sampling shall be recorded in a field log and shall include the initial depth to groundwater, measured well depth, height of the water column, well volume, purging discharge rate, well purging time, volume of water purged from the well, a record of pH, conductivity, and temperature readings, information from the well inspection, time of day, weather conditions, the names of the sampling personnel and any other pertinent information.
- Using the dedicated pneumatic bladder pumps and laboratory-supplied containers, purge the well of three well volumes. Store the purge water in suitable containers until the results of the groundwater analysis are received. If concentrations are below levels of concern, the purge water may be discharged to the soil surface (but not to any landfill cell). If concentrations indicate the presence of contaminants, discharge the water at an approved facility.
- The groundwater level shall be measured in the well immediately before sampling (after purging) in order to determine the recovery rate and to determine if there is enough water for sampling. The well shall be sampled within 24 hours after purging, and, if feasible, after the groundwater has recharged to at least 90% of the original static water level. Due to slow recharge rates at wells 3R2, MW -2 and MW -5, these wells may be sampled when recovered water levels are less than 90% of their original static levels. Sampling may extend beyond 24 hours with TCEQ approval if adequate volume is not available to collect the full suite of samples.
- **Samples will not be field filtered**. Collect the samples starting with the most volatile constituents to the least volatile constituents. For VOC samples, if air bubbles are seen at any time, the sample will be discarded and the collection process restarted.
- Label each container with the sample number and TCEQ permit number, well number, date and time, sampler name and firm, and analysis requested.
- Properly preserve all samples according to the specifications in the methods, and send to the laboratory in well-sealed, labeled coolers. Add sufficient ice to the coolers to maintain a temperature of 4°C +/- 2°C. Place custody seals on

the outside lids of the coolers.

- Field test for pH, temperature, alkalinity, conductance, and/or other tests as may be appropriate. Inspect and calibrate all field instrumentation prior to and following the sampling event. Each field instrument is standardized in the field prior to use, and the standardization/calibration is recorded in the field log. Battery-operated equipment is checked to ensure full operating capacity.
- Prepare field report of sampling event recording:
  - sampling methodology
  - purpose of event (initial sampling, annual event, etc.)
  - condition of the steel protective and well casings
  - condition of well pad
  - any field equipment malfunction
  - any other conditions affecting sampling protocol or reported results
  - sampling preservation methods
  - sampling sequences
  - number and location of samples taken water levels prior to purging
  - purging date and time, if different from sampling date field conditions (weather, water turbidity, etc.)
  - field measurements
  - sample collector's name
  - chain-of-custody forms and method of transport to laboratory

Analysis for the detection monitoring events shall include the 62 constituents (15 metals and 47 VOCs) listed in 40 CFR 258 Appendix I, July 14, 2005, as referenced by 30 TAC §330.419. The analytical testing shall be conducted by a properly equipped and qualified laboratory using the appropriate testing methods for the specified constituents, as established by *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA SW-846.* The laboratory shall have a documented quality control program, incorporating quality assurance criteria by established review and testing programs.

Laboratory analyses will use as a practical quantitation limit (PQL) the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions available to the facility. The PQL is analogous to the limit of quantitation (LOQ) definition in the most recent NELAC (National Environmental Laboratory Accreditation Conference) Standard. The PQL is method specific, instrument specific, medium specific, and analyte specific, and may be updated as more data becomes available. The PQL must be below the groundwater protection standard established for that analyte as defined by 30 TAC §330.409(h), unless approved otherwise by the TCEQ. The precision and accuracy of the PQL shall be initially determined from the PQLs reported over the course of a minimum of eight groundwater monitoring events. The results obtained from these events shall be used to demonstrate that the PQLs meet the specified precision and accuracy as shown below in **Table 2**. Laboratory standards, which include a laboratory reagent grade sample matrix spiked with the chemicals of concern (COC), will be used to support the PQL. A PQL check will be performed at least quarterly during the calendar year to demonstrate that the PQL continues to meet the specified limits for precision and accuracy as defined in the table below.

Table 2. Quality Control Specification Limits for PQLs.

COC	Precision (% RSD)	Accuracy (% Recovery)
Metals	10	70-130
Volatiles	20	50-150
Semi-volatiles	30	50-150

For analytes that the established PQL cannot meet the precision and accuracy requirements of Table 1, the owner/operator will ensure that the laboratory will submit sufficient documentation and information to the TCEQ for alternate precision and accuracy limits on a case by case basis. Non-detected results will be reported as less than the established PQL limit that meets the precision and accuracy requirements.

2. Statistical Methods for Determination of Statistically Significant Change (SSC)

In accordance with §330.405(e) and (f), statistical analysis of groundwater data at this site will be performed using an intra-well control chart approach that gives control limits for each constituent. Statistical parameters shall be determined after considering the number of samples in the background database, the data distribution, and the range of values for each constituent of concern. Statistical parameters shall be selected to be protective of human health and the environment and to provide a site-wide false negative rate for a five standard deviation release (the chance of failing to report a release from the landfill of five standard deviations above the mean) of less than 5%. Parameters will also be chosen to maintain a false positive rate below 5%.

Existing wells already have a background database used for statistical analyses. Any new wells will collect at least eight statistically independent samples on a quarterly basis as outlined in Section B. Every two years, additional groundwater sampling data may be incorporated into the background dataset (after submitting the proposed data set to TCEQ and receiving permission) for each well so long as the new data is representative of background groundwater quality and does not include a statistically significant change from background due to waste management activities.

Nonparametric limits will be used for constituents which are rarely or never detected and whose data are not normally distributed. For constituents whose background data are all non-detects after 8 samples, the limit will be set at the practical quantification limit for that constituent in that well. Constituents which are detected less than 25% of the time will use a limit equal to the highest of the detected background concentrations or the median quantification limit.

Verification resampling is an integral part of the statistical methodology used for this site. Verification resampling allows the application of a much smaller prediction limit, therefore minimizing both the false positive and false negative rates. Under this procedure, a statistically significant increase is not declared and should not be reported until the results of the verification are known. The probability of an initial exceedance is much higher than 5% for the site as a whole.[2]

D. REPORTING OF SAMPLE ANALYSIS RESULTS

The reporting of groundwater sampling and analyses will be in accordance with §330.407 "Detection Monitoring Program for Type I Landfills." Within 60 days of each sampling event, the City will determine whether there has been a statistically significant increase over background of any tested constituent at any compliance well. Statistically significant increases over background will be reported in writing to the TCEQ and any local pollution agency with jurisdiction requesting to be notified within 14 days of the determination. If there has been an initial exceedance, a verification resampling report will be submitted 60 days of the verification resampling event, and the City will verify whether there has been a statistically significant increase over background. The TCEQ and any local pollution agency with jurisdiction requesting to be notified will be notified in writing of any verified statistically significant increases within 14 days of the determination, and the owner/operator will immediately place a notice describing the increase into the operating record and then establish an assessment monitoring program meeting the requirements of §330.409 within 90 days of the date of the notice to TCEQ.

If a statistically significant increase over background of any tested constituent at any compliance well has occurred and the City has reasonable cause to think that a source other than a monitored landfill unit caused the contamination or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality, then the City will submit a report providing documentation to this effect. In making a demonstration under this paragraph, the City will notify TCEQ, and any local pollution agency with jurisdiction that has requested to be notified, in writing, within 14 days of determining a statistically significant increase over background at the compliance point that the City intends to make this demonstration. Within 90 days of determining a statistically significant increase, the City will submit a report to TCEQ, and any local pollution agency with jurisdiction that has requested to be notified, that demonstrates that a source other than a monitored landfill unit caused the contamination or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Groundwater samples collected for this documentation will not be filtered prior to laboratory analysis and the City will continue to monitor in accordance with the detection monitoring program. The report will be prepared and certified by a QGWS.

If the demonstration is not determined satisfactory by TCEQ, then the City will begin assessment monitoring as described in Section E of this GWSAP.

If an initial exceedance fails to verify, then no statistically significant change has occurred and no reporting is necessary prior to the annual report and the City will continue with detection monitoring.

The City will submit an annual detection monitoring report within 90 days after the second semi-annual groundwater sampling event in a calendar year. The report will include the following information determined since the previously submitted annual report:

- a statement regarding whether a statistically significant increase has occurred over background values in any compliance well during the previous calendar year period and the status of any statistically significant increase events;
- the results of all groundwater monitoring, testing, and analytical work obtained or prepared under the requirements of this permit, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings;
- background groundwater concentration measurements of each constituent of concern listed in Appendix I, for each monitoring well;
- a potentiometric map will be included using the data collected during the preceding calendar year's sampling events from the monitoring wells of the detection monitoring program. The owner or operator shall also include in the report all documentation used to determine the groundwater flow rate and direction of groundwater flow;
- recommendation for any changes., and
- any other items requested by the Executive Director.

The City will submit analytical data from the laboratory, a laboratory case narrative (LCN) identifying any potential bias and/or problems during the analysis, and either a laboratory checklist or a copy of the laboratory QA/QC and analytical data to TCEQ. The analytical report, LCN, and the laboratory QA/QC or checklist shall be included with the TCEQ-0312 forms for all groundwater monitoring events. The checklist may be modified as long as the information that is in the enclosure is included in the facility's checklist. Any information required in the laboratory case narrative that cannot be completed by the laboratory will be completed by the permittee.

If the City determines that the detection monitoring program no longer satisfies the requirements of this section, the City will submit an application for a permit amendment or modification within 90 days of this determination to make any appropriate changes to the program.

E. ASSESSMENT MONITORING PROGRAM

Assessment monitoring is required whenever a statistically significant increase over background for one or more of the constituents listed in §330.419 has been detected and the City does not provide an explanatory report within 90 days of determining a statistically significant increase has occurred and determining a source other than the Municipal Solid Waste Landfill (MSWLF) unit caused the increase. Assessment monitoring, will be conducted in accordance with §330.409 "Assessment Monitoring Program."

Initiation of the assessment monitoring program will be the collection of one set of groundwater samples within 90 days of determining that a statistically significant increase has occurred in accordance with §330.407(b). The samples will be analyzed for the constituents listed in 40 CFR 258, Appendix II (hereafter referred to as the "assessment constituents"). The owner or operator will then, at least semi-annually, sample and analyze the groundwater monitoring system for the full set of assessment constituents. For any new constituent(s) detected in the POC wells as a result of the complete Appendix II analysis, a minimum of four statistically independent samples from each background well will be collected and analyzed to establish background levels for the additional constituent(s).

If the QGWS provides evidence that adequate assessment information would be obtained from a reduced number (subset) of wells, the City will petition TCEQ to approve the subset. Additionally, if there is reasonable evidence that any of the assessment constituents are not expected to be derived from the MSWLF unit waste, the City will petition TCEQ to approve a reduced constituent list.

The owner or operator will submit to TCEQ the results from the initial and subsequent sampling events and place them in the operating record within 60 days of each sampling event. Within 90 days of submittal of the results from a sampling event and on a semi-annual basis thereafter, groundwater samples will be collected and analyzed for all assessment constituents. The results will be submitted to TCEQ within 60 days of the sampling event and will place them in the operating record. At least one sample will be collected and analyzed from each background and POC well.

The groundwater protection standard for assessment monitoring will be established based on historical records (where available) and four statistically independent sampling events. The groundwater protection standard for any monitored assessment constituent at the POC for each MSWLF unit will be as follows: (1) for constituents with a maximum contaminant level (MCL) per Section 1412 of the Safe Drinking Water Act (40 CFR Part 141), the MCL for that constituent; or, (2) for constituents for which MCLs have not been established, the MSWLF unit background concentration for the constituent; or (3) for constituents for which the background level is higher than the MCL, the background concentration or the health-based level identified in accordance with 30 TAC 330.409(i).

If the concentrations of all monitored assessment constituents are at or below background values for two consecutive assessment sampling events, the City will notify TCEQ and resume standard detection upon approval.

If the concentrations of all monitored assessment constituents are shown to be below the maximum allowable concentration values, but above background values, the City will continue assessment monitoring.

If concentrations of any assessment constituents are detected at statistically significant levels above allowable levels, the City will:

- notify TCEQ and appropriate local government officials in writing within seven days, install at least one additional monitoring well between the monitoring well with the statistically significant level and the next adjacent wells along the POC before the next sampling event, and sample these wells;
- characterize the nature and extent of the contamination, installing additional monitoring wells as necessary, and notify affected property owners or occupants in writing if contamination is suspected to have migrated offsite; and
- initiate an assessment of corrective action within 90 days of the notification to the TCEQ.

The City will submit an annual assessment monitoring report to TCEQ within 60 days after the second semi-annual groundwater sampling event in a calendar year. The report will include the following information determined since the previously submitted annual report:

- a statement regarding whether a statistically significant increase has occurred over an established groundwater protection standard in any compliance well during the previous calendar year period and the status of any statistically significant increase events;
- the results of all groundwater monitoring, testing, and analytical work obtained or prepared under the requirements of this permit, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings;

- a potentiometric map (if warranted) will be included using the data collected during the preceding calendar year's sampling events from the monitoring wells of the detection monitoring program. The owner or operator shall also include in the report all documentation used to determine the groundwater flow rate and direction of groundwater flow; and
- recommendation for any changes.

If the City determines that the assessment monitoring program no longer satisfies the requirements of an assessment monitoring program, within 90 days of the determination, the City will submit an application for a permit amendment or modification to make the appropriate changes to the program.

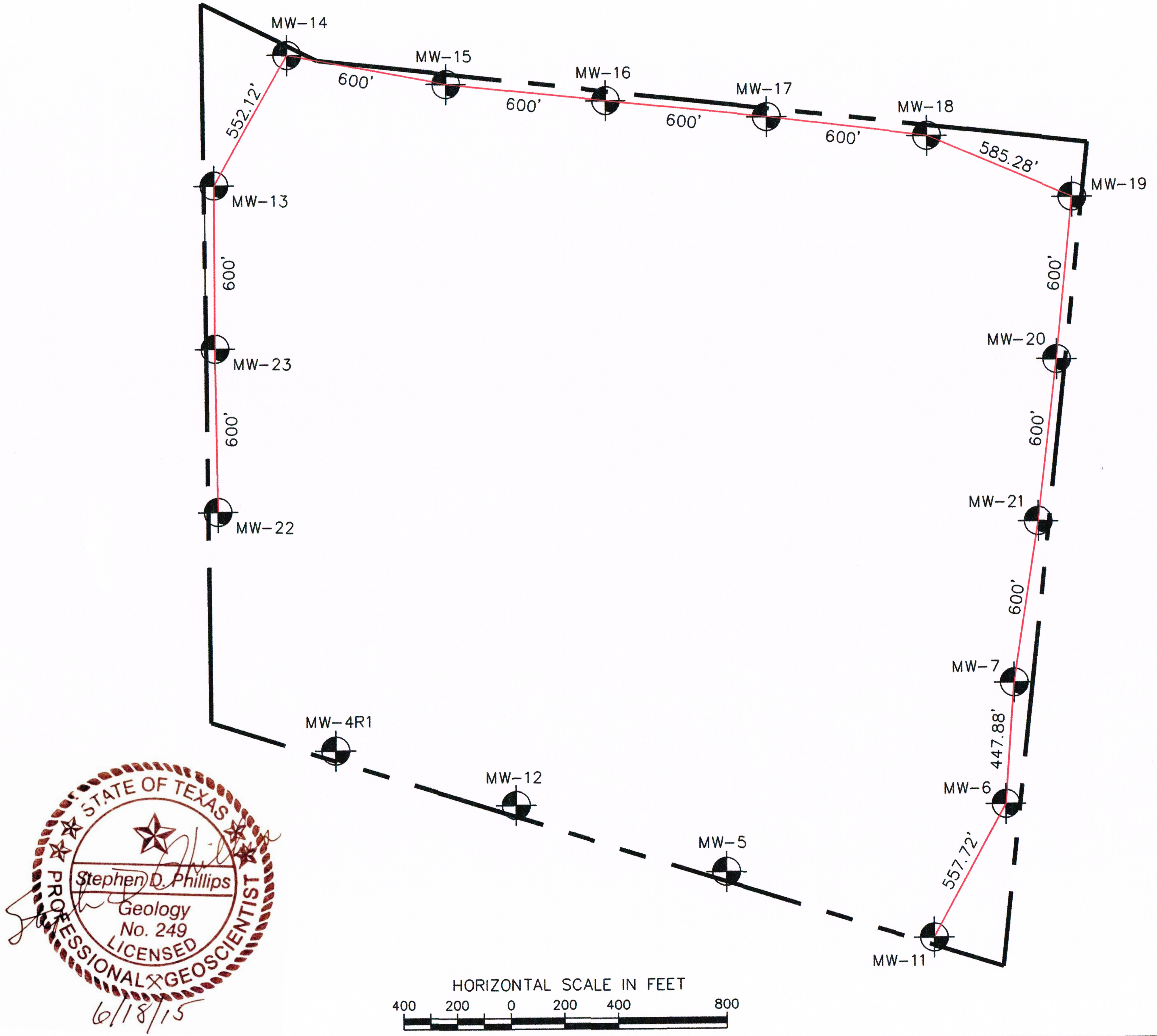
Within 90 days of finding that any of the 40 Code of Federal Regulations Part 258, Appendix II constituents have been detected at a statistically significant level above the groundwater protection standards, the City will initiate an corrective measures assessment. The assessment will meet the requirements of §330.411 and be completed within 180 days of initiating the assessment.

Based on the results of the corrective measures assessment, the City will select a remedy that, at a minimum, meets the standards listed in §330.413(b). Within 30 days of completing the assessment of corrective measures, the City will submit a report to TCEQ for review and approval and place it in the operating record. The report shall describe the remedy or remedies proposed for selection and the way it or they meet the standards.

Based on the schedule established under the corrective measures assessment, the City will establish and implement a corrective action groundwater monitoring program that meets the requirements of an assessment monitoring program, indicates the effectiveness of the corrective action remedy, and demonstrates compliance with groundwater protection standards required by §330.415(f). The City will implement the corrective action remedy selected and take any interim measures necessary to ensure the protection of human health and the environment.

FIGURE III.11.1

GROUNDWATER MONITORING SYSTEM MAP



NOTES

1. Permit Boundary based on AZ&B Drawing No. 1, City of Laredo, Site Layout Plan
2. Point of Compliance and Monitoring Well Locations based on SCS Engineers Drawing No. 1, City of Laredo, Site Map

LEGEND

PERMIT BOUNDARY
POINT OF COMPLIANCE

LAREDO, TEXAS

CITY OF LAREDO LANDFILL
WEBB COUNTY, TEXAS

MSW PERMIT No. 1693A

GROUND WATER MONITORING WELL
LOCATION MAP

PS Phillips Environmental

JOB No.: 12-008	DATE: 09/15/2014	REVISED: 04/03/2015
DRAWN BY: GPP	APPROVED BY: SDP	FIGURE: III-11.1

FIGURE III.11.2
MONITOR WELL CONSTRUCTION DETAILS

838 **Monitor Well Data Sheet**

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
MSWD-SE67

Permittee or Site Name: CITY OF LAREDO

County: WEBB

Date of Monitor Well Installation: 11/26/97

Monitor Well: Latitude: N664146.50 Longitude: E1704060.14

Monitor Well Groundwater

Gradient: Upgradient ___ Downgradient X

MSW PERMIT NO: MSW-1693

Monitor Well I.D. No.: MW-4R

Date of Monitor Well Development: 12/15/97

Monitor Well Driller Name: Jones Environmental Drilling,

License No.: 4931-M

NOTE:

(A) The information shown in the sketch below should be considered the minimum required for an installed ground-water monitor well.
(B) Report All Depths from Surface Elevation and all Elevations relative to Mean Sea Level.
(C) The minimun distance between the inside wall of the Bore Hole and the outside of the Well Casing shall be 2".
(D) Use Flush Screw Joint Casing only, 2" diameter or larger. Recommend 4" diameter minimum & Teflon Taping Casing Joints.
(E) Well development should continue until water is clear, and pH and conductivity are stable.

Geologist, Hydrologist or Engineer Supervising Well Installation: BRENT CHRISTIAN

Static Water Level Elevation (with respect to MSL) after Well Developement: 474.88

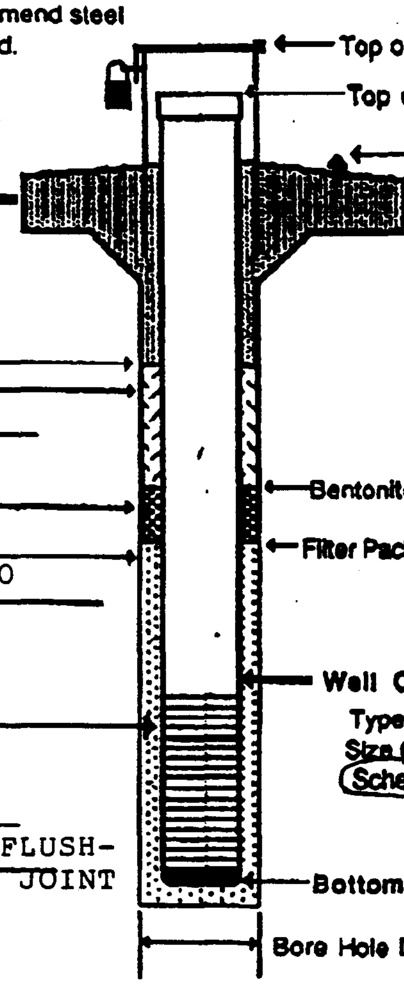
Name of Geologic Formation(s) in which Well is completed: LAREDO FORMATION

Type of Locking Device: MASTER LOCK

Type of Casing Protection: STEEL SLEEVE

Concrete Surface Pad - Recommend steel reinforcement in the Surface Pad.
Surface Pad Dimensions: 6'X 6'

Surface Elevation: ________



Top of Protective Collar Elevation: ________

Top of Casing Elevation: 528.75

Surveyor's Pin Elevation: 526.42

Concrete Seal Depth: 0-50

Casing Seal (Backfill) Material: CONCRETE

Bentonite Seal

Filter Pack

Filter Pack Material: 20/40
Sterilized Sand or Glass Beads

Bentonite Seal Top Depth: 50 Elevation: 476.42

Filter Pack Top Depth: 52 Elevation: 474.42

Well Casing
Type: PVC FLUSH-JOINT
Size (diameter): 4"
Schedule or Thickness: 40

Well Screen
Top Depth: 54
Top Elevation: 472.42
Type of Well Screen: PVC FLUSH-JOINT
Screen Opening Size: 0.010

Bottom Cap (Depth: 64)

Bore Hole Diameter: 10"

839 **Monitor Well Data Sheet**

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Permittee or Site Name: CITY OF LAREDO

County: WEBB

Date of Monitor Well Installation: 08/22/96

Monitor Well: Latitude: N663385.42 Longitude: E1706464.24

Monitor Well Groundwater Gradient: Upgradient ___ Downgradient X

MSW PERMIT NO: MSWD-8867 MSW-1693

Monitor Well I.D. No.: MW-5

Date of Monitor Well Development: 09/28/97

Monitor Well Driller Name: WILLIAM BLUDWORTH

License No.: 4885-M

NOTE:

(A) The information shown in the sketch below should be considered the minimum required for an installed ground-water monitor well.
(B) Report All Depths from Surface Elevation and all Elevations relative to Mean Sea Level.
(C) The minimum distance between the inside wall of the Bore Hole and the outside of the Well Casing shall be 2".
(D) Use Flush Screw Joint Casing only, 2" diameter or larger. Recommend 4" diameter minimum & Teflon Taping Casing Joints.
(E) Well development should continue until water is clear, and pH and conductivity are stable.

Geologist, Hydrologist or Engineer Supervising Well Installation: BRENT CHRISTIAN

Static Water Level Elevation (with respect to MSL) after Well Developement: 424.27

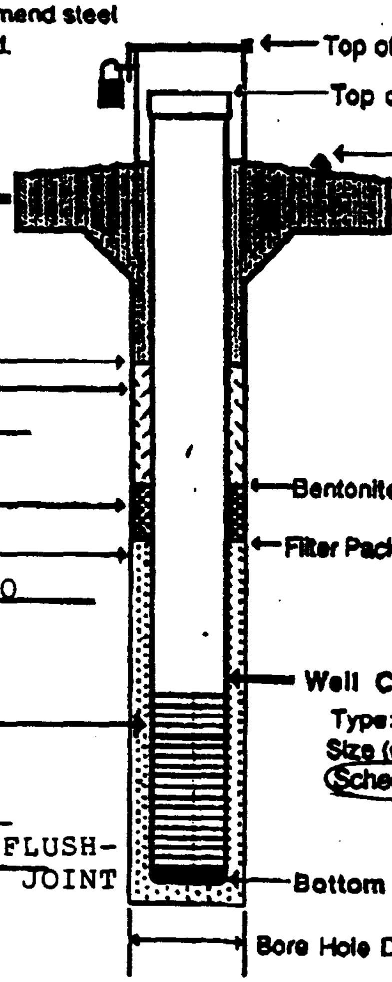
Name of Geologic Formation(s) in which Well is completed: LAREDO FORMATION

Type of Locking Device: MASTER LOCK

Type of Casing Protection: STEEL SLEEVE

Concrete Surface Pad - Recommend steel reinforcement in the Surface Pad.
Surface Pad Dimensions: 6'X 6'

Surface Elevation: ___



Top of Protective Collar Elevation: ___

Top of Casing Elevation: 524.97

Surveyor's Pin Elevation: 523.29

Concrete Seal Depth: 0-92.0

Casing Seal (Backfill) Material: CONCRETE

Bentonite Seal

Filter Pack

Filter Pack Material: 20/40
Sterilized Sand or Glass Beads

Bentonite Seal Top Depth: 92.0 Elevation: 431.29

Filter Pack Top Depth: 95.0 Elevation: 428.29

Well Screen
Top Depth: 103.75
Top Elevation: 419.54
Type of Well Screen: PVC FLUSH-JOINT
Screen Opening Size: 0.010

Well Casing
Type: PVC FLUSH-JOINT
Size (diameter): 4"
Schedule or Thickness: 40

Bottom Cap (Depth: 113.75)

Bore Hole Diameter: 10"

Monitor Well Data Sheet

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
MSWD-SE67

Permittee or Site Name: CITY OF LAREDO
County: WEBB
Date of Monitor Well Installation: 09/09/96
Monitor Well: Latitude: N664301.25 Longitude: E1703530.91
Monitor Well Groundwater
Gradient: Upgradient ___ Downgradient X

MSW PERMIT NO: MSW-1693
Monitor Well I.D. No.: MW-6
Date of Monitor Well
Development: 09/29/96
Monitor Well Driller
Name: WILLIAM BLUDWORTH
License No.: 4885-M

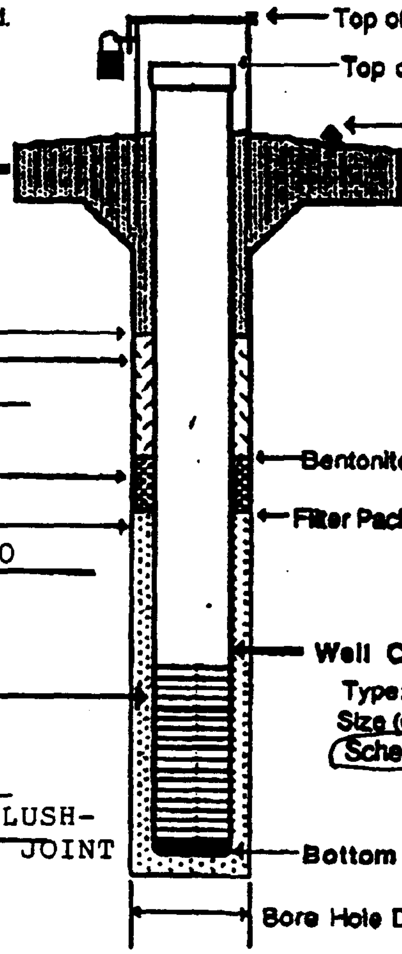
NOTE:

(A) The information shown in the sketch below should be considered the minimum required for an installed ground-water monitor well.
(B) Report All Depths from Surface Elevation and all Elevations relative to Mean Sea Level.
(C) The minimun distance between the inside wall of the Bore Hole and the outside of the Well Casing shall be 2".
(D) Use Flush Screw Joint Casing only, 2" diameter or larger. Recommend 4" diameter minimum & Teflon Taping Casing Joints.
(E) Well development should continue until water is clear, and pH and conductivity are stable.

Geologist, Hydrologist or Engineer Supervising Well Installation: BRENT CHRISTIAN
Static Water Level Elevation (with respect to MSL) after Well Developement: 423.41
Name of Geologic Formation(s) in which Well is completed: LAREDO FORMATION

Type of Locking Device: MASTER LOCK
Type of Casing Protection: STEEL SLEEVE

Concrete Surface Pad - Recommend steel reinforcement in the Surface Pad.
Surface Pad Dimensions: 6'X 6'
Surface Elevation: ______



Top of Protective Collar Elevation: ______
Top of Casing Elevation: 490.74
Surveyor's Pin Elevation: 488.38

Concrete Seal Depth: 0-60.5
Casing Seal (Backfill) Material: CEMENT

Bentonite Seal
Filter Pack
Filter Pack Material: 20/40 Sterilized Sand or Glass Beads

Bentonite Seal Top Depth: 60.5 Elevation: 427.88
Filter Pack Top Depth: 65.0 Elevation: 423.38

Well Screen
Top Depth: 66.71
Top Elevation: 421.67
Type of Well Screen: PVC FLUSH-JOINT
Screen Opening Size: 0.010

Well Casing
Type: PVC FLUSH-JOINT
Size (diameter): 4"
Schedule or Thickness: 40

Bottom Cap (Depth: 76.71)
Bore Hole Diameter: 10"

841

Monitor Well Data Sheet

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
MSWD-SE67

Permittee or Site Name: CITY OF LAREDO

MSW PERMIT NO: MSW-1693

County: WEBB

Monitor Well I.D. No.: MW-7

Date of Monitor Well Installation: 08/18/96

Date of Monitor Well Development: 09/30/96

Monitor Well: Latitude: N665515.15 Longitude: E1703517.71

Monitor Well Groundwater Gradient: Upgradient ___ Downgradient X

Monitor Well Driller Name: WILLIAM BLUDWORTH

License No.: 4885-M

NOTE:

(A) The information shown in the sketch below should be considered the minimum required for an installed ground-water monitor well.
(B) Report All Depths from Surface Elevation and all Elevations relative to Mean Sea Level.
(C) The minimum distance between the inside wall of the Bore Hole and the outside of the Well Casing shall be 2".
(D) Use Flush Screw Joint Casing only, 2" diameter or larger. Recommend 4" diameter minimum & Teflon Taping Casing Joints.
(E) Well development should continue until water is clear, and pH and conductivity are stable.

Geologist, Hydrologist or Engineer Supervising Well Installation: BRENT CHRISTIAN

Static Water Level Elevation (with respect to MSL) after Well Developement: 424.07

Name of Geologic Formation(s) in which Well is completed: LAREDO FORMATION

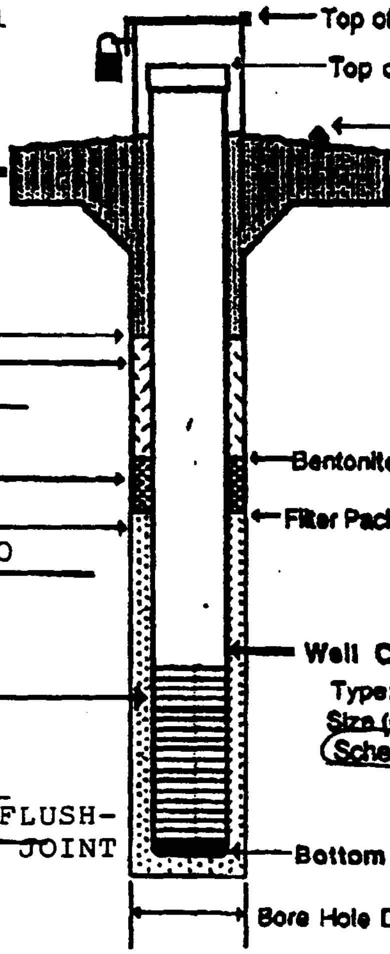
Type of Locking Device: MASTER LOCK

Type of Casing Protection: STEEL SLEEVE

Concrete Surface Pad - Recommend steel reinforcement in the Surface Pad.

Surface Pad Dimensions: 6'X 6'

Surface Elevation: ______



Top of Protective Collar Elevation: ______

Top of Casing Elevation: 487.54

Surveyor's Pin Elevation: 485.42

Concrete Seal Depth: 0-55.5

Casing Seal (Backfill) Material: CEMENT

Bentonite Seal

Bentonite Seal Top Depth: 55.5 Elevation: 429.92

Filter Pack

Filter Pack Top Depth: 58.0 Elevation: 427.42

Filter Pack Material: 20/40 Sterilized Sand or Glass Beads

Well Casing Type: PVC FLUSH-JOINT

Size (diameter): 4"

Schedule or Thickness: 40

Well Screen

Top Depth: 60.83

Top Elevation: 424.59

Type of Well Screen: PVC FLUSH-JOINT

Screen Opening Size: 0.010

Bottom Cap (Depth: 70.83)

Bore Hole Diameter: 10"

845

Monitor Well Data Sheet

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
MSWD-SZ67

Permittee or Site Name: CITY OF LAREDO

MSW PERMIT NO: MSW-1693

County: WEBB

Monitor Well I.D. No.: MW-11

Date of Monitor Well Installation: 11/20/97

Date of Monitor Well Development: 12/15/97

Monitor Well: Latitude: N663444.47 Longitude: E1706272.88

Monitor Well Groundwater Gradient: Upgradient ___ Downgradient X

Monitor Well Driller Name: Jones Environmental Drilling,

License No.: 4931-M

NOTE:

(A) The information shown in the sketch below should be considered the minimum required for an installed ground-water monitor well.
(B) Report All Depths from Surface Elevation and all Elevations relative to Mean Sea Level.
(C) The minimun distance between the inside wall of the Bore Hole and the outside of the Well Casing shall be 2".
(D) Use Flush Screw Joint Casing only, 2" diameter or larger. Recommend 4" diameter minimum & Teflon Taping Casing Joints.
(E) Well development should continue until water is clear, and pH and conductivity are stable.

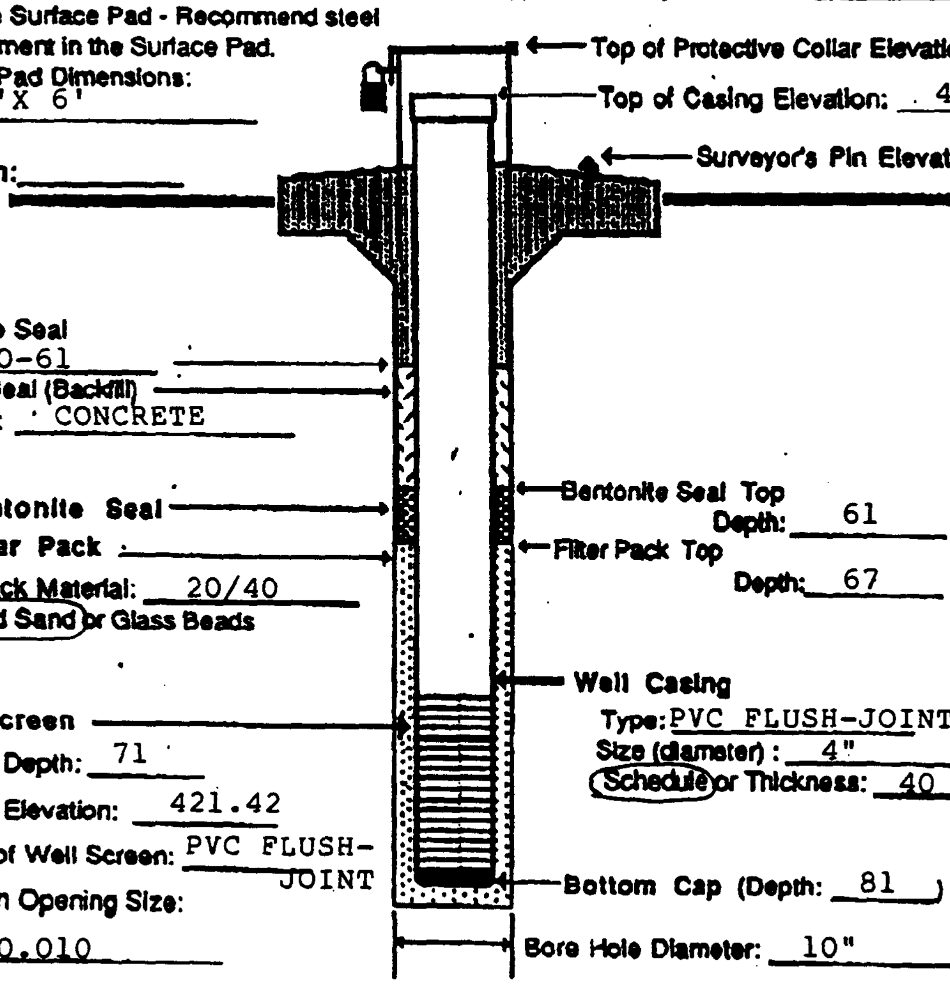
Geologist, Hydrologist or Engineer Supervising Well Installation: BRENT CHRISTIAN

Static Water Level Elevation (with respect to MSL) after Well Developement: 423.38

Name of Geologic Formation(s) in which Well is completed: LAREDO FORMATION

Type of Locking Device: MASTER LOCK

Type of Casing Protection: STEEL SLEEVE



Concrete Surface Pad - Recommend steel reinforcement in the Surface Pad.
Surface Pad Dimensions: 6'X 6'

Surface Elevation: ________

Top of Protective Collar Elevation: ________

Top of Casing Elevation: 494.74

Surveyor's Pin Elevation: 492.42

Concrete Seal Depth: 0-61

Casing Seal (Backfill) Material: CONCRETE

Bentonite Seal

Filter Pack

Filter Pack Material: 20/40
Sterilized Sand or Glass Beads

Bentonite Seal Top Depth: 61 Elevation: 431.42

Filter Pack Top Depth: 67 Elevation: 425.42

Well Screen
Top Depth: 71
Top Elevation: 421.42
Type of Well Screen: PVC FLUSH-JOINT
Screen Opening Size: 0.010

Well Casing
Type: PVC FLUSH-JOINT
Size (diameter): 4"
Schedule or Thickness: 40

Bottom Cap (Depth: 81)

Bore Hole Diameter: 10"

846 **Monitor Well Data Sheet**

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
MSWD-SR67

Permittee or Site Name: CITY OF LAREDO

County: WEBB

Date of Monitor Well Installation: 11/25/97

Monitor Well: Latitude: N663949.54 Longitude: E1704658.46

Monitor Well Groundwater

Gradient: Upgradient ___ Downgradient X

MSW PERMIT NO: MSW-1693

Monitor Well I.D. No.: MW-12

Date of Monitor Well Development: 12/15/97

Monitor Well Driller Name: Jones Environmental Drilling

License No.: 4931-M

NOTE:

(A) The information shown in the sketch below should be considered the minimum required for an installed ground-water monitor well.
(B) Report All Depths from Surface Elevation and all Elevations relative to Mean Sea Level.
(C) The minimum distance between the inside wall of the Bore Hole and the outside of the Well Casing shall be 2".
(D) Use Flush Screw Joint Casing only, 2" diameter or larger. Recommend 4" diameter minimum & Teflon Taping Casing Joints.
(E) Well development should continue until water is clear, and pH and conductivity are stable.

Geologist, Hydrologist or Engineer Supervising Well Installation: BRENT CHRISTIAN

Static Water Level Elevation (with respect to MSL) after Well Developement: 451.11

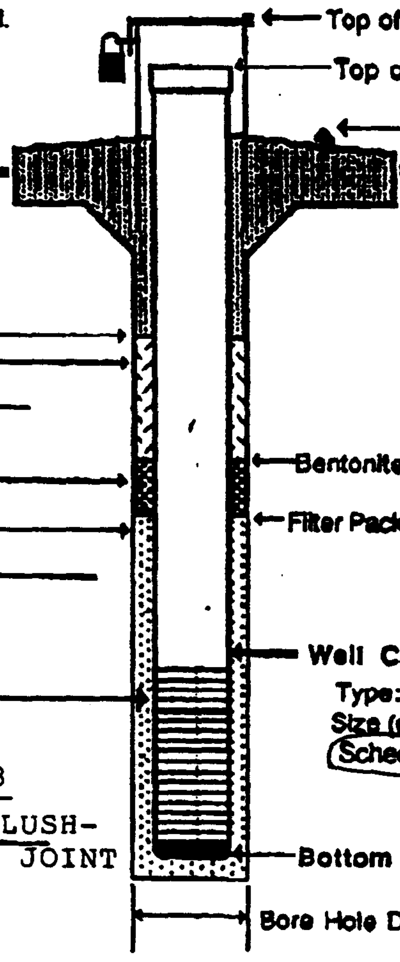
Name of Geologic Formation(s) in which Well is completed: LAREDO FORMATION

Type of Locking Device: MASTER LOCK

Type of Casing Protection: STEEL SLEEVE

Concrete Surface Pad - Recommend steel reinforcement in the Surface Pad.
Surface Pad Dimensions: 6'X 6'

Surface Elevation: ___



Top of Protective Collar Elevation: ___

Top of Casing Elevation: 518.78

Surveyor's Pin Elevation: 516.43

Concrete Seal Depth: 0-58

Casing Seal (Backfill) Material: CONCRETE

Bentonite Seal

Filter Pack

Filter Pack Material: 20/40
Sterilized Sand or Glass Beads

Bentonite Seal Top Depth: 58.0 Elevation: 458.43

Filter Pack Top Depth: 61.25 Elevation: 455.18

Well Screen
Top Depth: 63.5
Top Elevation: 452.93
Type of Well Screen: PVC FLUSH-JOINT
Screen Opening Size: 0.010

Well Casing
Type: PVC FLUSH-JOINT
Size (diameter): 4"
Schedule or Thickness: 40

Bottom Cap (Depth: 73.5)

Bore Hole Diameter: 10"

Monitoring Well Completion Data

Site Name: City of Laredo Landfill

County: Webb — Monitor Well I.D. No.: MW-13

Date of Installation: 06-02-09 — Date of Development: 6-9-09

Northing: 17070555 — Easting: 687677

Well Driller Name and License Number: Brian Kern #54611

Method of well development: Surging and pumping

SCS Field Staff Supervising Installation: Dave Mayes

Static Water Level after Well Development: 74.03'

Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock — Type of Case Protection: Steel

Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'

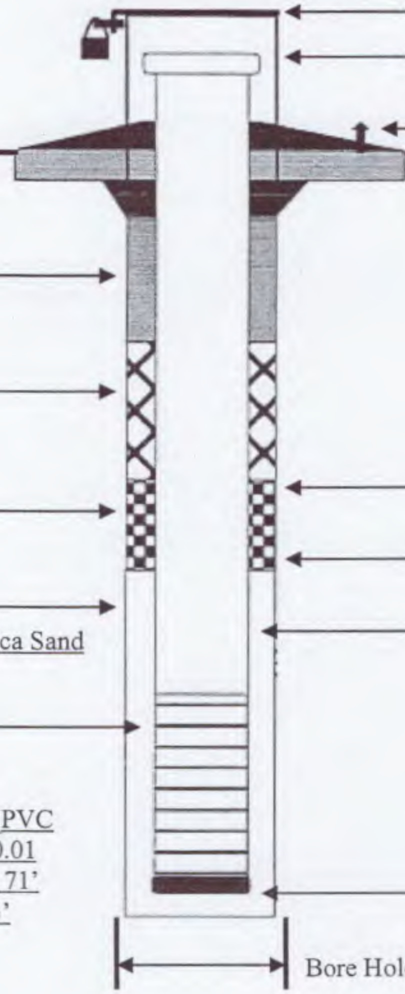
Top of Protective Collar Elevation: 488.19'

Stick-up: 1.87

Top of Casing Elevation: 487.77'

Surface Elevation: 485.30'

Surveyor's Pin Elevation: 485.90



Concrete Seal
Depth: 1'

Casing Seal (backfill)
Material: Bentonite Grout

Bentonite Seal Top
Depth: 53' Elevation: 433'

Bentonite Seal

Filter Pack Top
Depth: 57' Elevation: 429'

Filter Pack
Filter Pack Material: Silica Sand

Well Casing
Type: PVC
Size (diameter): 2"
Schedule or Thickness: 40

Well Screen
Top Depth: 61'
Top Elevation: 425'
Type of Well Screen: PVC
Screen Opening Size: 0.01
Screen Bottom Depth 71'
Bottom Elevation 413'

Bottom Cap Depth: 73'

Bore Hole Diameter 6"

Monitoring Well Completion Data

Site Name: City of Laredo Landfill

County: Webb

Monitor Well I.D. No.: MW-14

Date of Installation: 05-20-09

Date of Development: 6-9-09

Northing: 17071080 Easting: 687973

Well Driller Name and License Number: Brian Kern #54611

Method of well development: Surging and pumping

SCS Field Staff Supervising Installation: Dave Mayes

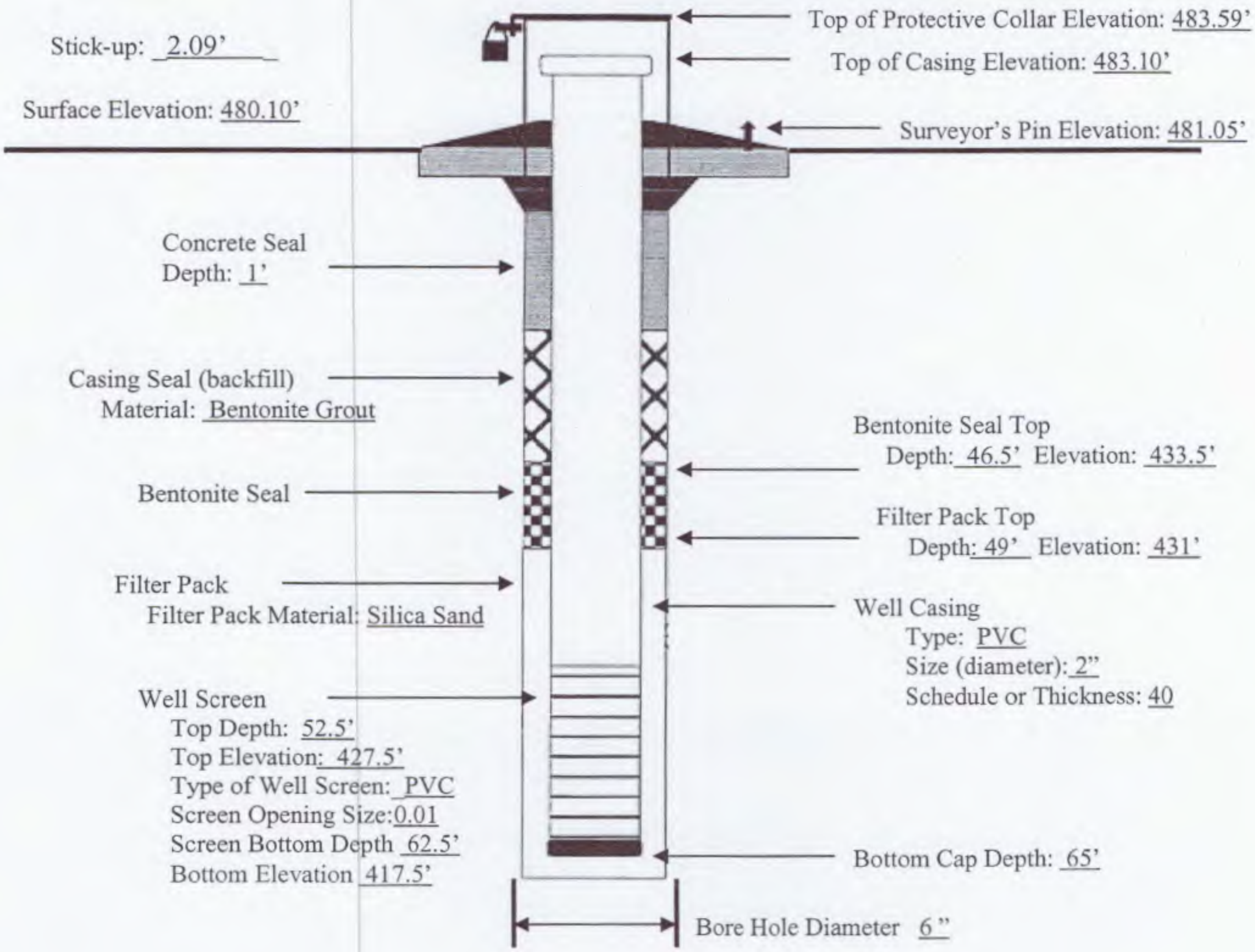
Static Water Level after Well Development: 54.27'

Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock

Type of Case Protection: Steel

Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'

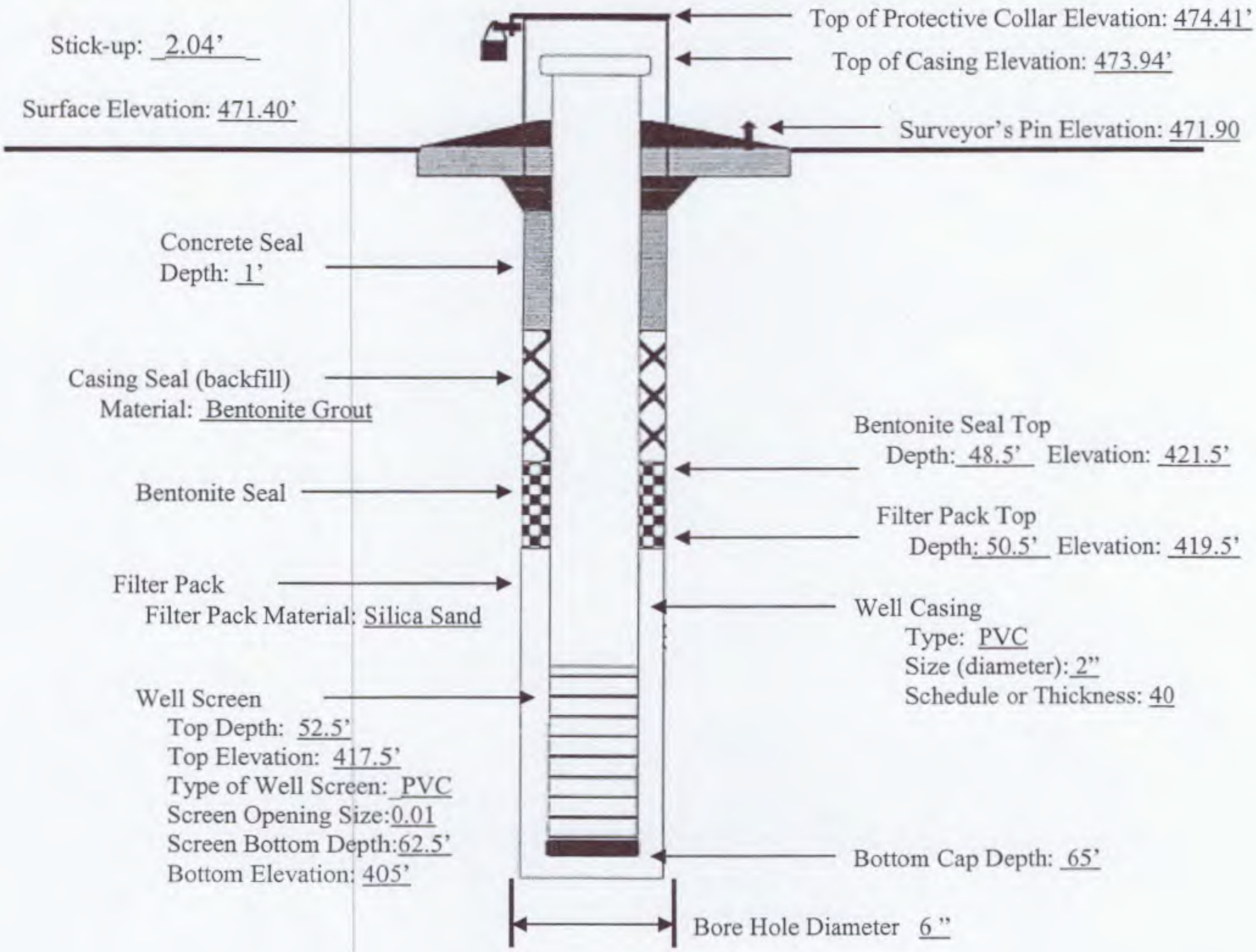


Monitoring Well Completion Data

Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-15
Date of Installation: 05-21-09
Date of Development: 6-9-09
Northing: 17070970
Easting: 688562
Well Driller Name and License Number Brian Kern #54611
Method of well development Surging and pumping

SCS Field Staff Supervising Installation: Dave Mayes
Static Water Level after Well Development: 46.4
Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock
Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'

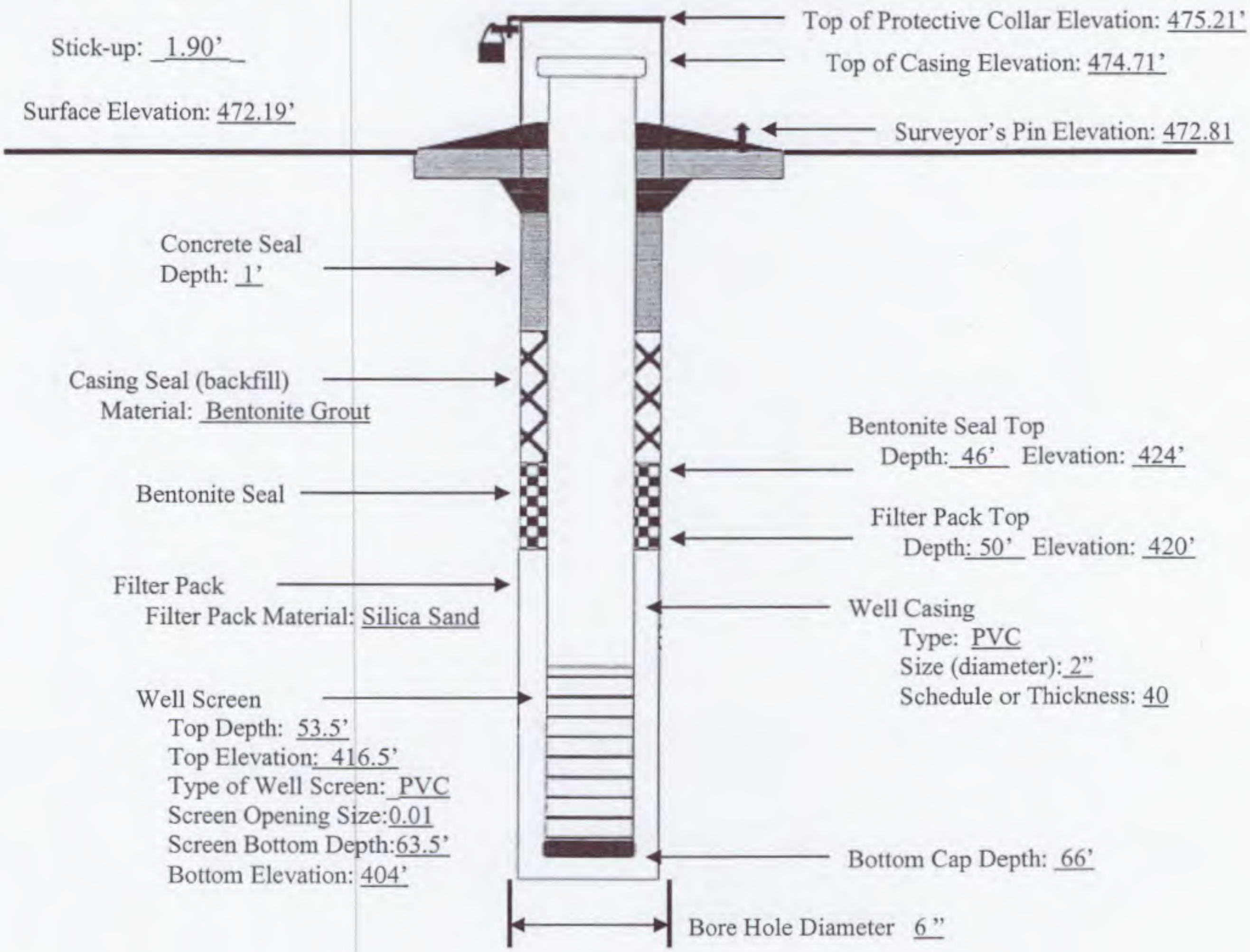


Monitoring Well Completion Data

Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-16
Date of Installation: 05-20-09
Date of Development: 6-9-09
Northing: 17070908
Easting: 689158
Well Driller Name and License Number Brian Kern #54611
Method of well development Surging and pumping

SCS Field Staff Supervising Installation: Dave Mayes
Static Water Level after Well Development: --
Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock
Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'

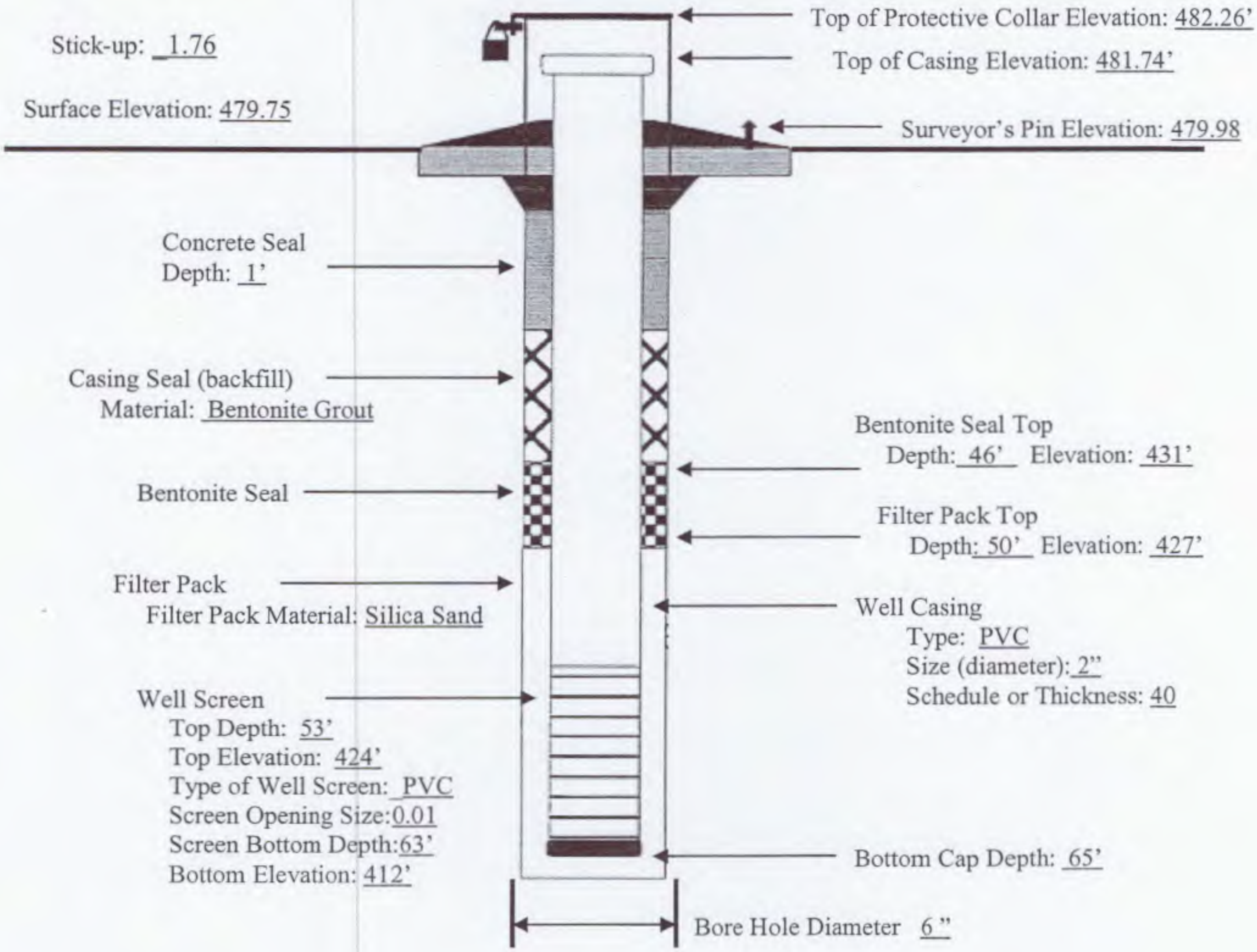


Monitoring Well Completion Data

Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-17
Date of Installation: 05-31-09
Date of Development: 6-9-09
Northing: 17070845
Easting: 689755
Well Driller Name and License Number Brian Kern #54611
Method of well development Surging and pumping

SCS Field Staff Supervising Installation: Gail Davis
Static Water Level after Well Development: 58.12'
Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock
Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'

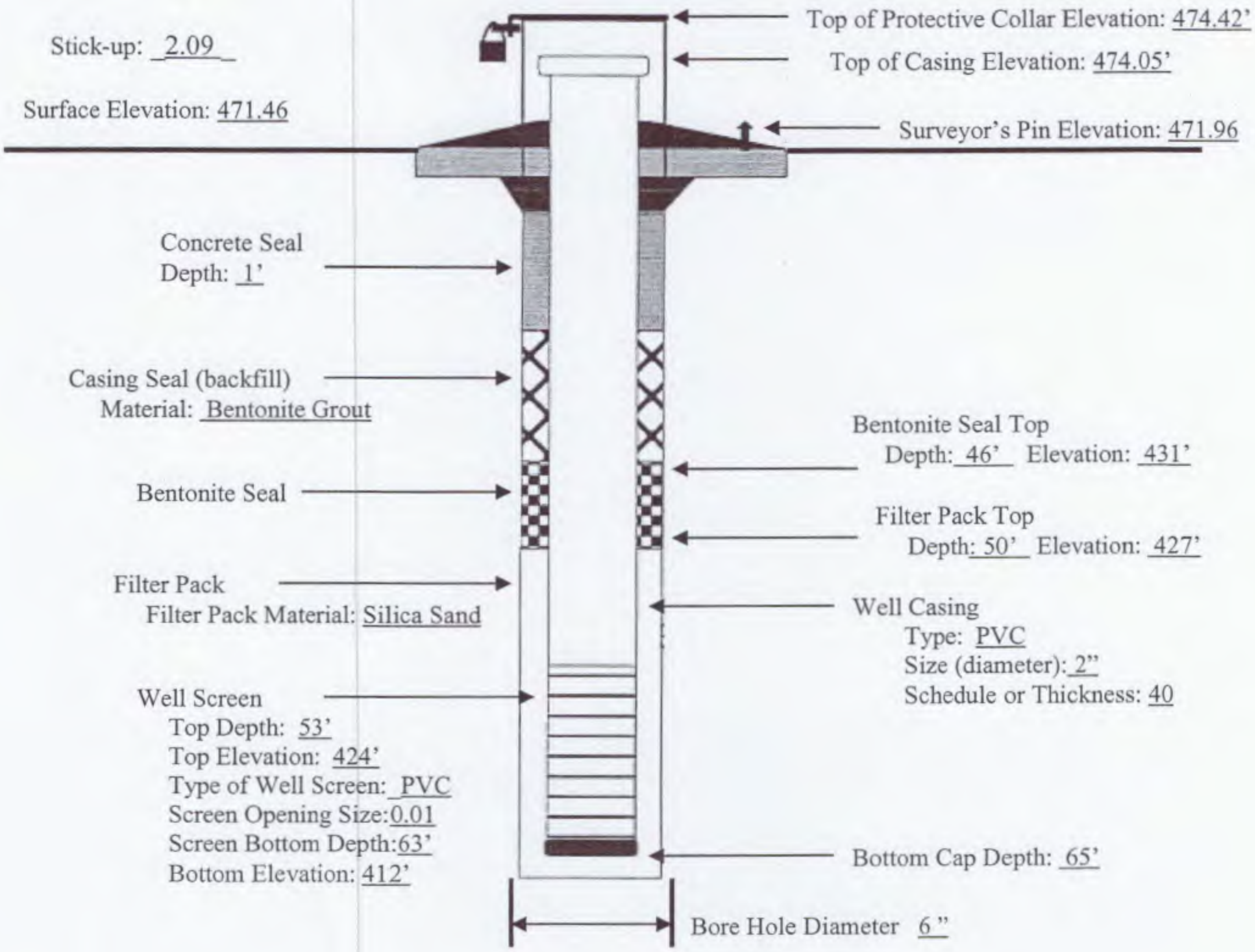


Monitoring Well Completion Data

Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-18
Date of Installation: 06-03-09
Date of Development: 6-10-09
Northing: 17070780
Easting: 690351
Well Driller Name and License Number: Brian Kern #54611
Method of well development: Surging and pumping

SCS Field Staff Supervising Installation: Gail Davis
Static Water Level after Well Development: 53.10'
Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock
Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'



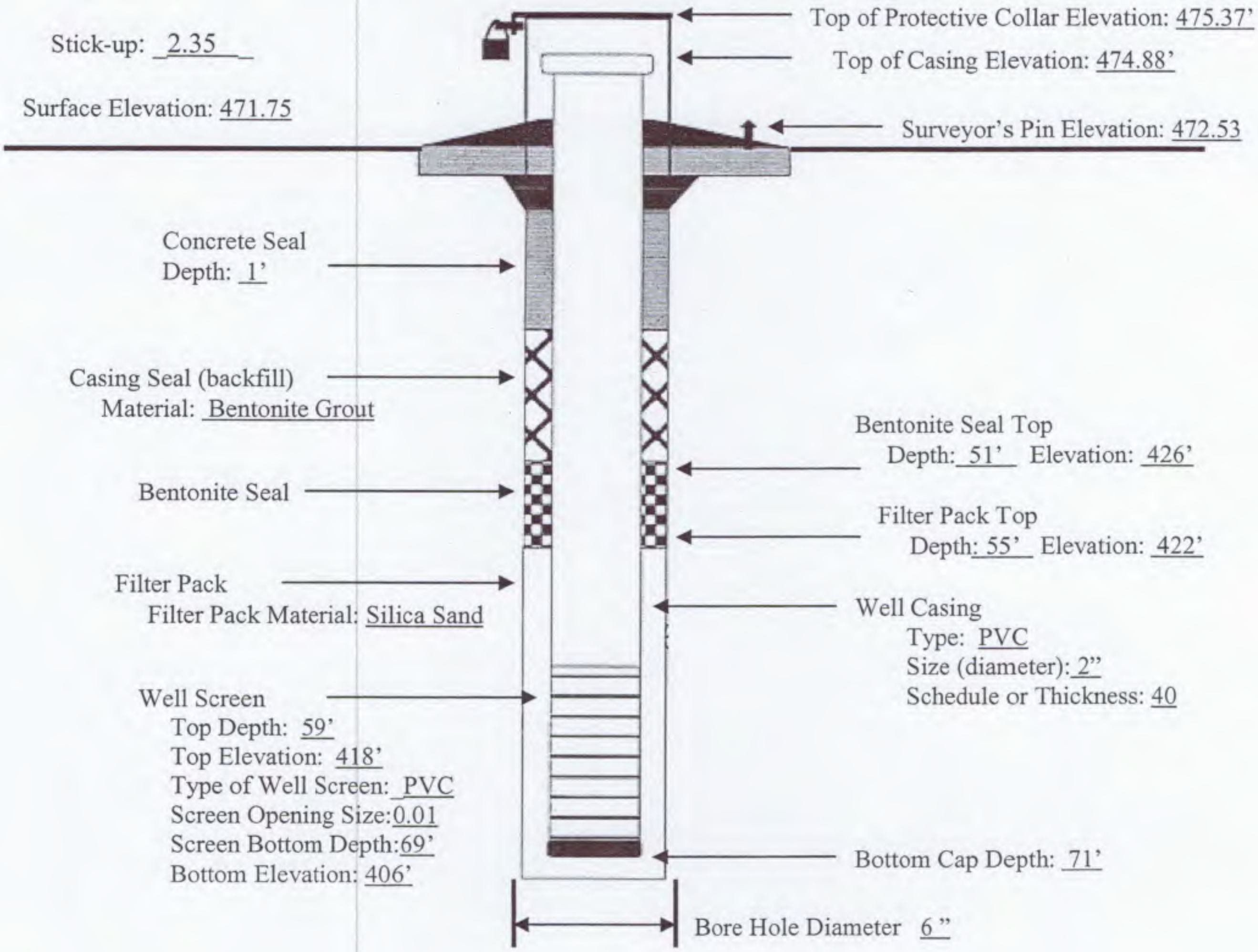
F:\Projects\Laredo\16209005.00 Sub-J Well Install\Report\Well Completion Reports\Well Completion MW-18.doc **SCS ENGINEERS**

Monitoring Well Completion Data

Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-19
Date of Installation: 05-14-09
Date of Development: 6-3-09
Northing: 17070571
Easting: 690931
Well Driller Name and License Number Brian Kern #54611
Method of well development Surging and pumping

SCS Field Staff Supervising Installation: Gail Davis
Static Water Level after Well Development: 43.0'
Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock
Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'



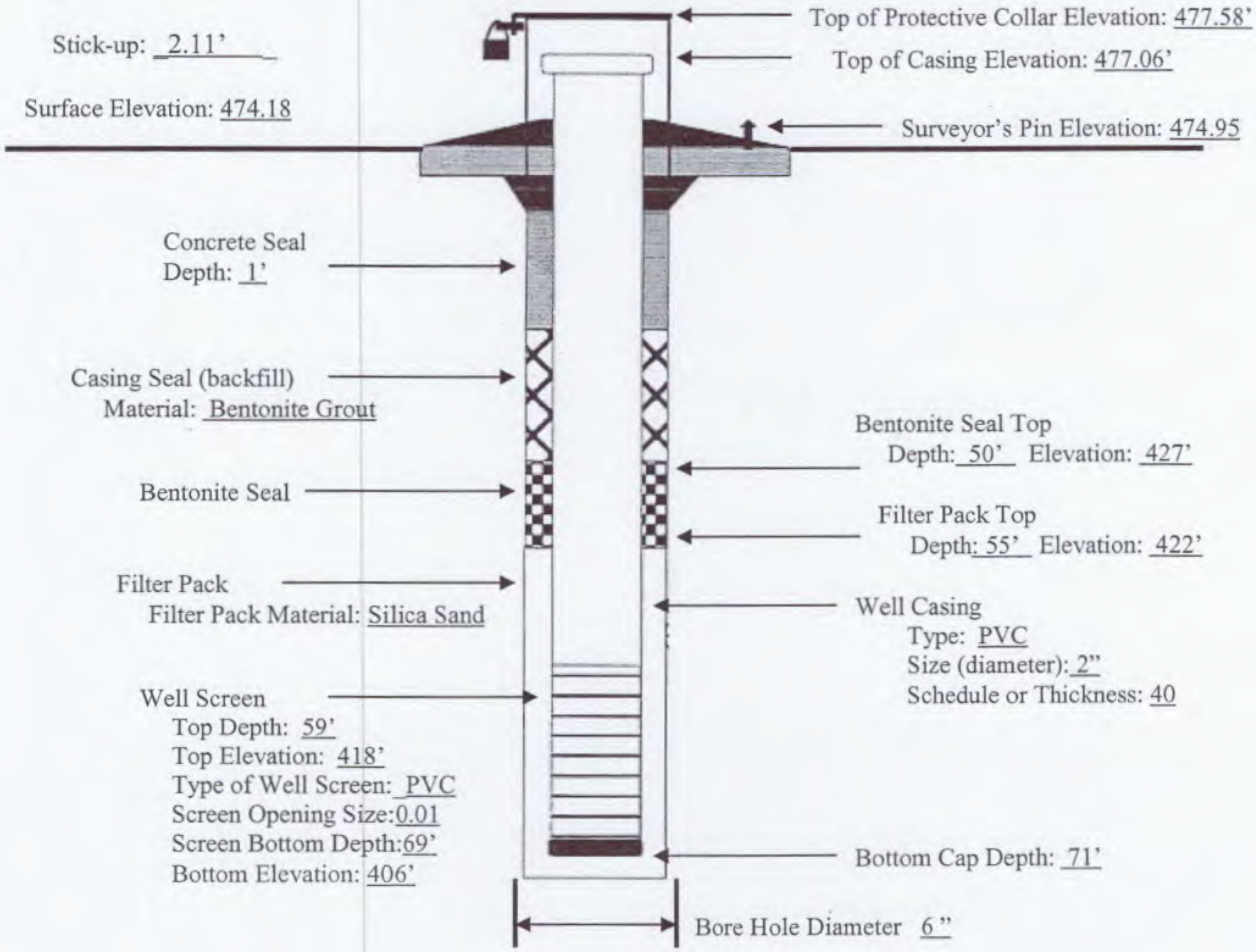
F:\Projects\Laredo\16209005.00 Sub-J Well Install\Report\Well Completion Reports\Well Completion MW-19.doc **SCS ENGINEERS**

Monitoring Well Completion Data

Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-20
Date of Installation: 05-27-09
Date of Development: 6-9-09
Northing: 17069973
Easting: 690866
Well Driller Name and License Number: Brian Kern #54611
Method of well development: Surging and pumping

SCS Field Staff Supervising Installation: Gail Davis
Static Water Level after Well Development: 47.90'
Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock
Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'



Monitoring Well Completion Data

Site Name: City of Laredo Landfill

County: Webb

Monitor Well I.D. No.: MW-21

Date of Installation: 05-28-09

Date of Development: 6-9-09

Northing: 17069377

Easting: 690797

Well Driller Name and License Number: Brian Kern #54611

Method of well development: Surging and pumping

SCS Field Staff Supervising Installation: Gail Davis

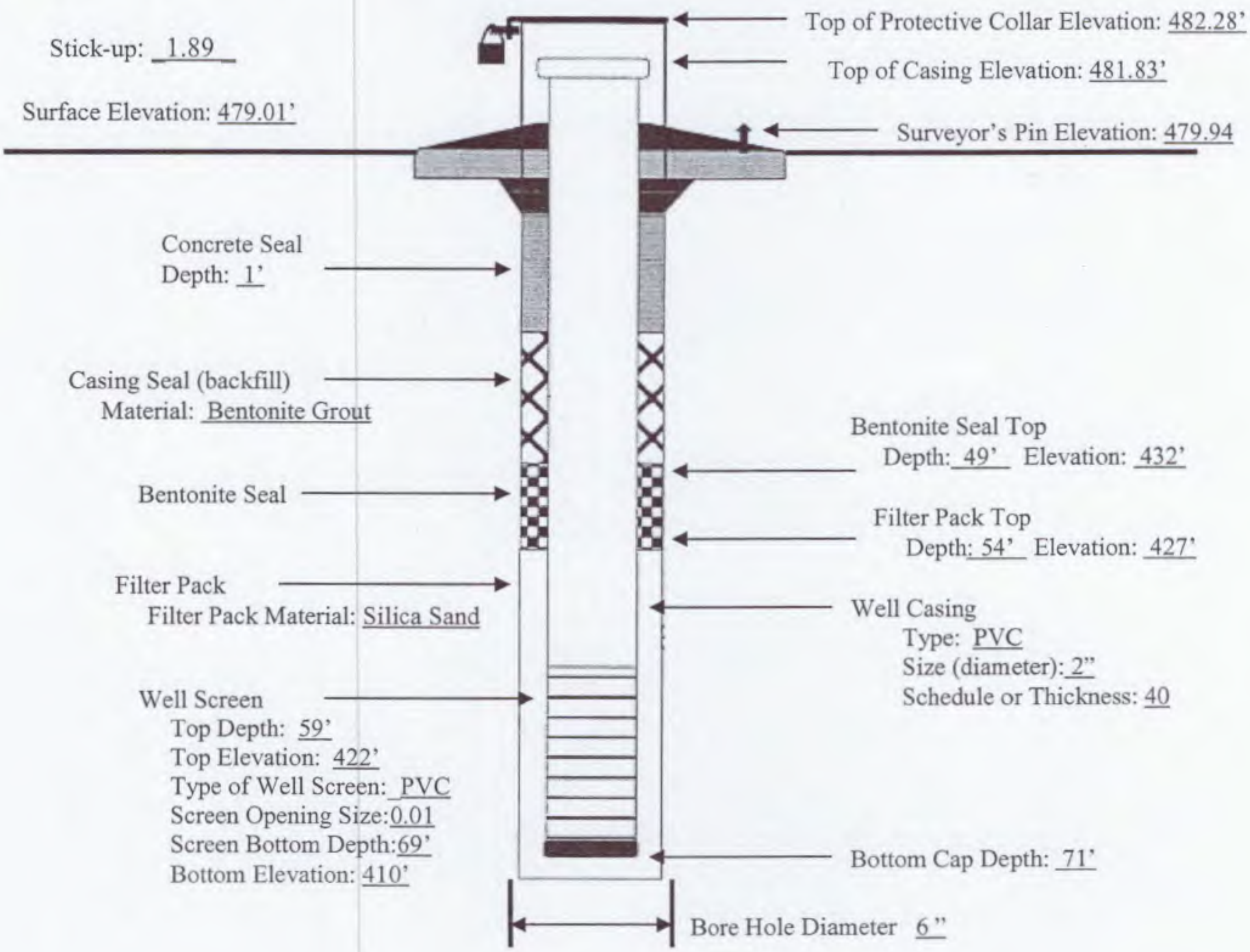
Static Water Level after Well Development: 52.36'

Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock

Type of Case Protection: Steel

Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'

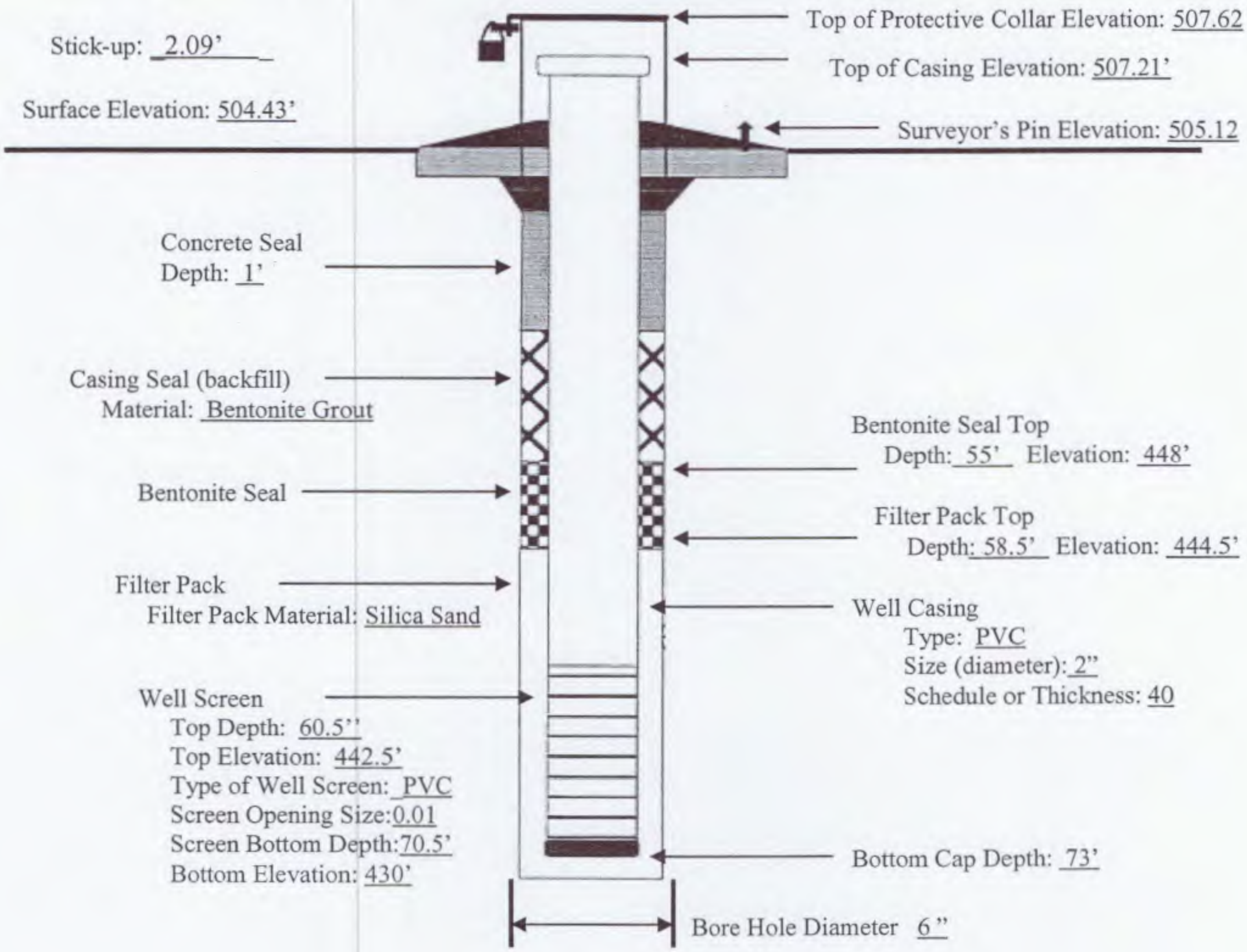


Monitoring Well Completion Data

Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-22
Date of Installation: 05-19-09
Date of Development: 6-9-09
Northing: 17069345
Easting: 687681
Well Driller Name and License Number Brian Kern #54611
Method of well development Surging and pumping

SCS Field Staff Supervising Installation: Dave Mayes
Static Water Level after Well Development: 72.80'
Name of Geologic Formation(s) in which Well is completed: Laredo

Type of Locking Device: Pad Lock
Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'

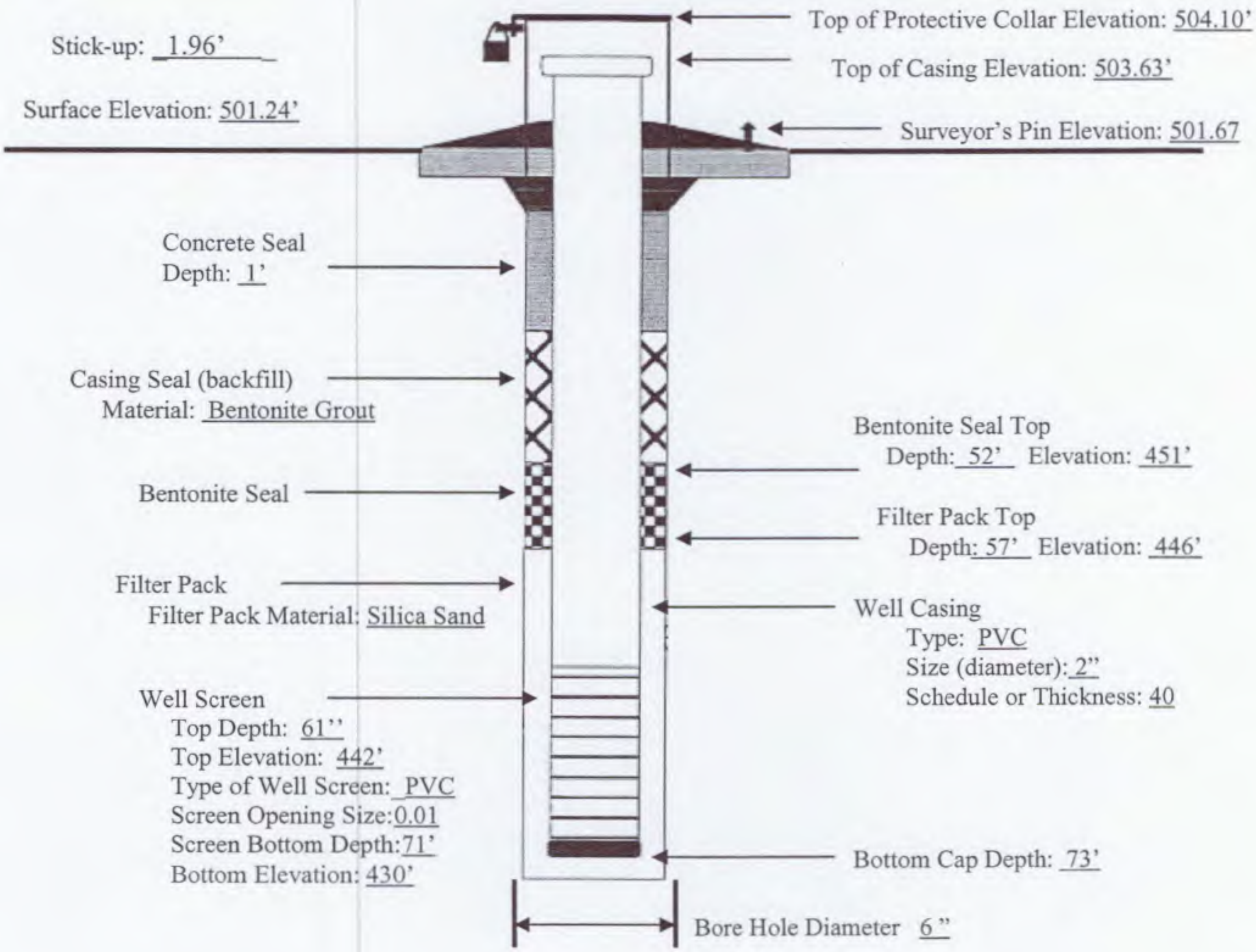


Monitoring Well Completion Data

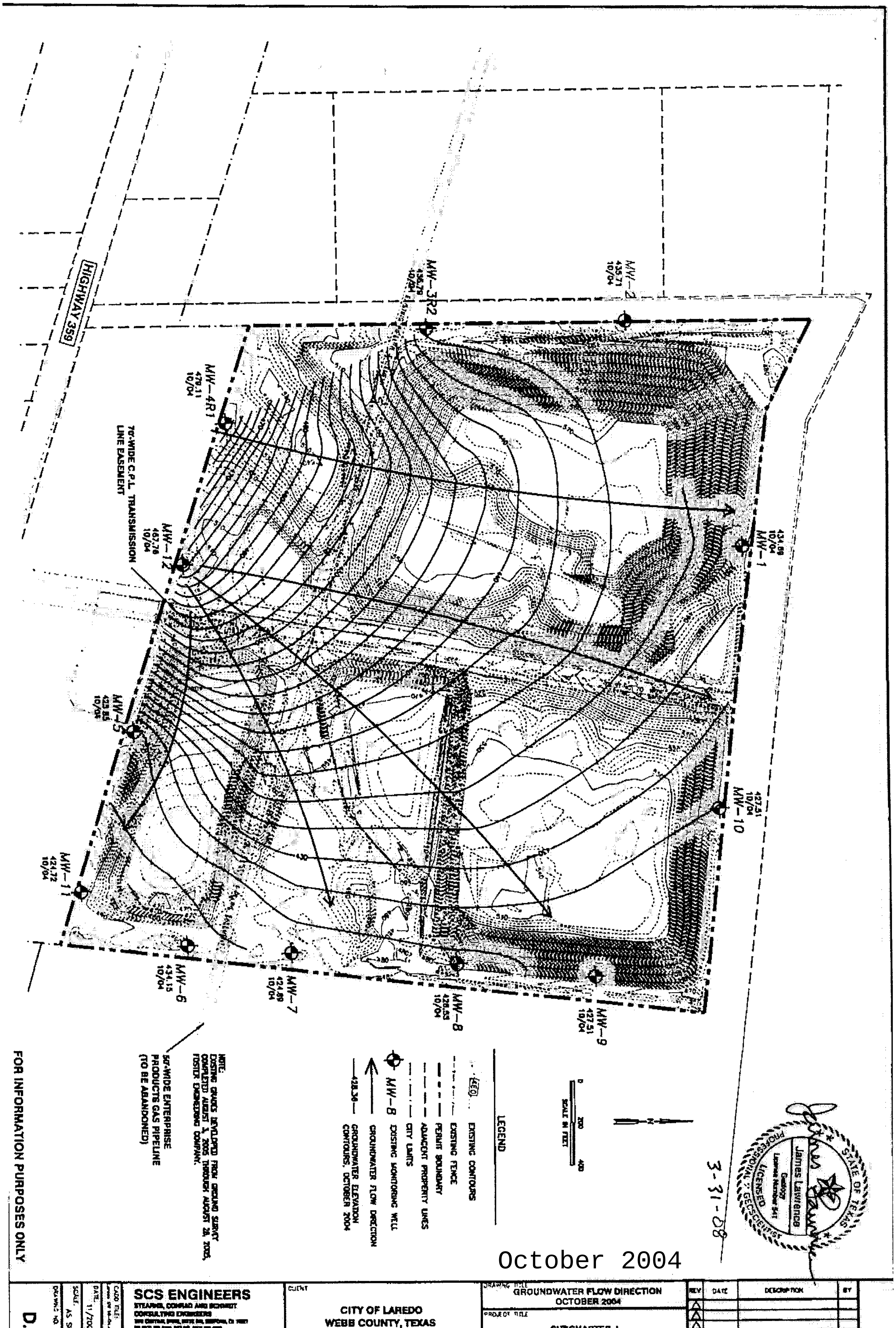
Site Name: City of Laredo Landfill
County: Webb
Monitor Well I.D. No.: MW-23
Date of Installation: 06-1-09
Date of Development: 6-9-09
Northing: 17069956
Easting: 687684
Well Driller Name and License Number Brian Kern #54611
Method of well development Surging and pumping

SCS Field Staff Supervising Installation: Gail Davis
Static Water Level after Well Development: 70.95'
Name of Geologic Formation(s) in which Well is completed: Laredo

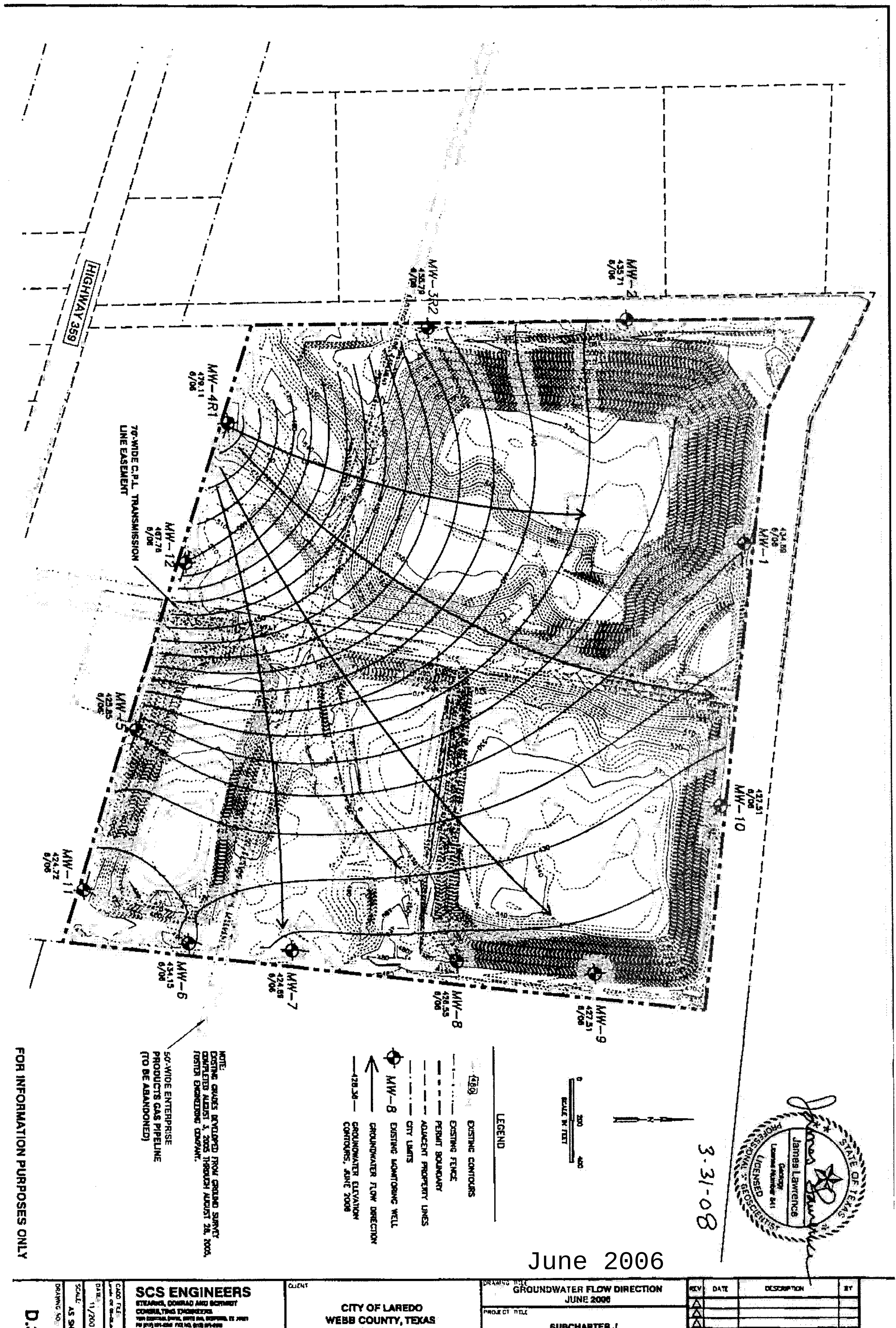
Type of Locking Device: Pad Lock Type of Case Protection: Steel
Concrete Surface Pad (with steel reinforcement) Dimensions: 6'X6'



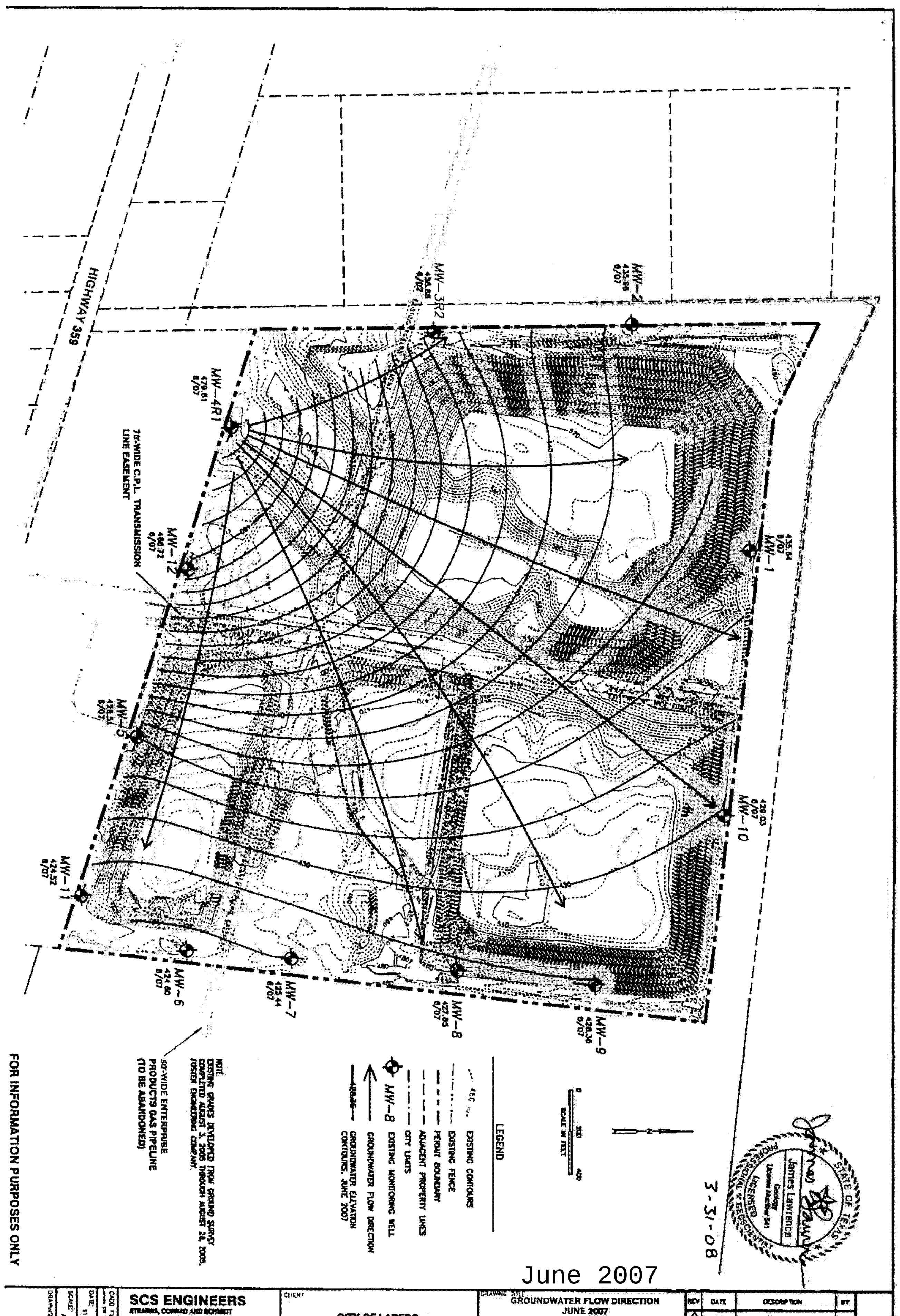
PART III, ATTACHMENT 11, APPENDIX 1
SCS ENGINEERS
GROUNDWATER FLOW DIRECTION MAPS



October 2004



HIGHWAY 359
MW-3R2
MW-2
MW-4R1
MW-12
MW-1
MW-5
MW-10
MW-11
MW-6
MW-7
MW-8
MW-9
70'-WIDE C.P.L. TRANSMISSION LINE EASEMENT
LEGEND
EXISTING CONTOURS
EXISTING FENCE
PERMIT BOUNDARY
ADJACENT PROPERTY LINES
CITY LIMITS
EXISTING MONITORING WELL
GROUNDWATER FLOW DIRECTION
GROUNDWATER ELEVATION CONTOURS, JUNE 2006
SCALE IN FEET
NOTE:
EXISTING GRADES DEVELOPED FROM GROUND SURVEY COMPLETED AUGUST 3, 2005 THROUGH AUGUST 28, 2005. FOSTER ENGINEERING COMPANY.
50'-WIDE ENTERPRISE PRODUCTS GAS PIPELINE (TO BE ABANDONED)
FOR INFORMATION PURPOSES ONLY
STATE OF TEXAS
James Lawrence
LICENSED PROFESSIONAL GEOSCIENTIST
3-31-08
June 2006
SCS ENGINEERS
CITY OF LAREDO
WEBB COUNTY, TEXAS
GROUNDWATER FLOW DIRECTION
JUNE 2006
SUBCHAPTER J
PERMIT RECOMMENDATION
D.3
AS SHOWN
11/2007


HIGHWAY 359
MW-1
MW-2
MW-3R2
MW-4R1
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MW-11
MW-12
70'-WIDE C.P.L. TRANSMISSION LINE EASEMENT
50'-WIDE ENTERPRISE PRODUCTS GAS PIPELINE (TO BE ABANDONED)
LEGEND
EXISTING CONTOURS
EXISTING FENCE
PERMIT BOUNDARY
ADJACENT PROPERTY LINES
CITY LIMITS
EXISTING MONITORING WELL
GROUNDWATER FLOW DIRECTION
GROUNDWATER ELEVATION CONTOURS, JUNE 2007
SCALE IN FEET
FOR INFORMATION PURPOSES ONLY
3-31-08
June 2007
SCS ENGINEERS
CITY OF LAREDO
WEBB COUNTY, TEXAS
GROUNDWATER FLOW DIRECTION
JUNE 2007
SUBCHAPTER J
PERMIT RECOMMENDATION
D.2

PART III, ATTACHMENT 11, APPENDIX 2

LEACHATE ANALYSIS

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Waste Permits Division, Municipal Solid Waste Permits Section

Ground-water Sampling Report (page 1)

Facility name: City of Laredo Landfill
Permittee: City of Laredo
County: Webb

1. MSW permit no.: 1693A
2. Monitor well no.: Leachate
3. Date of sampling: 12/3/2014

Name of sampler: Joe Ortiz
Affiliation of sampler: SCS Engineers
If split sampled, with whom? N/A
Integrity of well: NA
Installation date: NA

Most recent previous sampling: 5/8/2014
Date of water level measuremen NA
Datum reference point: NA
Datum elevation*: NA
Depth to water(below datum)*: NA
4. Water level elevation*: ______

5. Purging/Sampling method: N/A (Enter bailer or pump)
   Were low-flow methods used? ☐ yes ■ no (check one)
   If yes, what volume was purged? ____ gal.
6. Well volumes purged: N/A
7. Was the well dry before purging? ☐yes ■ no (check one)
8. Was the well dry after purging? ☐yes ■ no (check one)
9. How long before sampling? NA
10. Unit of measure? hours (Enter value as days, hours, or mins.)

11. Sample event: Detection
    - Background - Corrective Action
    - Detection - Other
    - Assessment
12. Sample schedule: Semi-Annual
    - Quarterly - Fourth Year
    - Semi-Annual - Other
    - Annual
13. Sample type: Other
    - Regular - Split
    - Duplicate - Other
    - Resample

Field Measurements:

14. pH 6.57
15. Spec. cond. 13,640
17. Temp. 15.0

16. ■ umho/cm, or ☐ mmho/cm (check one)
18. ☐ F, or ■ C (check one)

Laboratory:

19. Name: Columbia Analytical Services, Inc./Jacksonville
    Phone: (904) 739-2277
    Address: 9143 Philips Highway Suite 200, Jacksonville, FL 32256
    Representative's signature: [signature]

Site operator's signature: [signature]
Date: 1/28/15

* Report depth to water and elevations to nearest 0.01 foot relative to mean sea level (msl).

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HEAVY METALS

Sample ID: Leachate
Lab Code: J1409404-001

CONSTITUENT	T/D	CONCENTRATION		REPORTING LIMITS		METHOD
Antimony, Total Recoverable	T	<5	ug/L	5	ug/L	6020
Arsenic, Total Recoverable	**T**	**19.4**	**ug/L**	**5**	**ug/L**	**6020**
Barium, Total Recoverable	**T**	**50.3**	**ug/L**	**10**	**ug/L**	**6020**
Beryllium, Total Recoverable	T	<4	ug/L	4	ug/L	6020
Cadmium, Total Recoverable	T	<2	ug/L	2	ug/L	6020
Chromium, Total Recoverable	T	<20	ug/L	20	ug/L	6020
Cobalt, Total Recoverable	T	<5	ug/L	5	ug/L	6020
Copper, Total Recoverable	**T**	**69.2**	**ug/L**	**10**	**ug/L**	**6020**
Lead, Total Recoverable	T	<15	ug/L	15	ug/L	6020
Nickel, Total Recoverable	**T**	**52.6**	**ug/L**	**20**	**ug/L**	**6020**
Selenium, Total Recoverable	T	<50	ug/L	50	ug/L	6020
Silver, Total Recoverable	T	<10	ug/L	10	ug/L	6020
Thallium, Total Recoverable	T	<1	ug/L	1	ug/L	6020
Vanadium, Total Recoverable	**T**	**12.0**	**ug/L**	**10**	**ug/L**	**6020**
Zinc, Total Recoverable	**T**	**220.2**	**ug/L**	**100**	**ug/L**	**6020**

Reporting Limits are PQLs
(a) Reporting limit is MDL

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Waste Permits Division, Municipal Solid Waste Permits Section

Groundwater Sampling Report, p. 3

VOLATILE ORGANIC COMPOUNDS (VOCs) (1)

Sample ID: Leachate
Lab Code: J1409404-001

CONSTITUENT	CONCENTRATION (ug/L)		REPORTING LIMIT (ug/L)		METHOD	CAS No.
Acetone	<25	ug/L	25	ug/L	8260B	67-64-1
Acrylonitrile	<50	ug/L	50	ug/L	8260B	107-13-1
Benzene	**1.8**	**ug/L**	**1**	**ug/L**	**8260B**	**71-43-2**
Bromochloromethane	<1	ug/L	1	ug/L	8260B	74-97-5
Bromodichloromethane	<1	ug/L	1	ug/L	8260B	75-27-4
Bromoform	<5	ug/L	5	ug/L	8260B	75-25-2
Carbon Disulfide	<5	ug/L	5	ug/L	8260B	75-15-0
Carbon Tetrachloride	<5	ug/L	5	ug/L	8260B	56-23-5
Chlorobenzene	<1	ug/L	1	ug/L	8260B	108-90-7
Chloroethane	<5	ug/L	5	ug/L	8260B	75-00-3
Chloroform	<1	ug/L	1	ug/L	8260B	67-66-3
Dibromochloromethane	<2	ug/L	2	ug/L	8260B	124-48-1
1,2-Dibromo-3-chloropropane	<5	ug/L	5	ug/L	8260B	96-12-8
1,2-Dibromoethane (EDB)	<1	ug/L	1	ug/L	8260B	106-93-4
2-Dichlorobenzene	<2	ug/L	2	ug/L	8260B	95-50-1
1,4-Dichlorobenzene	**6.9**	**ug/L**	**2**	**ug/L**	**8260B**	**106-46-7**
trans-1,4-Dichloro-2-butene	<100	ug/L	100	ug/L	8260B	110-57-6
1,1-Dichloroethane (1,1-DCA)	<1	ug/L	1	ug/L	8260B	75-34-3
1,2-Dichloroethane	**4.7**	**ug/L**	**1**	**ug/L**	**8260B**	**107-06-2**
1,1-Dichloroethene (1,1-DCE)	<1	ug/L	1	ug/L	8260B	75-35-4
cis-1,2-Dichloroethene	**5.3**	**ug/L**	**1**	**ug/L**	**8260B**	**156-59-2**
trans-1,2-Dichloroethene	<1	ug/L	1	ug/L	8260B	156-60-5
1,2-Dichloropropane	<1	ug/L	1	ug/L	8260B	78-87-5
cis-1,3-Dichloropropene	<2	ug/L	2	ug/L	8260B	10061-01-5
trans-1,3-Dichloropropene	<5	ug/L	5	ug/L	8260B	10061-02-6
Ethylbenzene	<2	ug/L	2	ug/L	8260B	100-41-4
2-Hexanone	<5	ug/L	5	ug/L	8260B	591-78-6
Bromomethane	<10	ug/L	10	ug/L	8260B	74-83-9
Chloromethane	<5	ug/L	5	ug/L	8260B	74-87-3
Dibromomethane	<1	ug/L	1	ug/L	8260B	74-95-3
Methylene Chloride	<5	ug/L	5	ug/L	8260B	75-09-2
2-Butanone (MEK)	<5	ug/L	5	ug/L	8260B	78-93-3
Iodomethane	<5	ug/L	5	ug/L	8260B	74-88-4
4-Methyl-2-pentanone (MIBK)	<5	ug/L	5	ug/L	8260B	108-10-1
Styrene	<2	ug/L	2	ug/L	8260B	100-42-5
1,1,1,2-Tetrachloroethane	<2	ug/L	2	ug/L	8260B	630-20-6

Samples for VOCs must not be filtered.
Reporting Limits are PQLs
(a) Reporting limit is MDL

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Waste Permits Division, Municipal Solid Waste Permits Section

Groundwater Sampling Report, p. 3

VOLATILE ORGANIC COMPOUNDS (VOCs) (1)

Sample ID: Leachate

Lab Code: J1409404-001

CONSTITUENT	CONCENTRATION (ug/L)		REPORTING LIMIT (ug/L)		METHOD	CAS No.
1,1,2,2-Tetrachloroethane	<1	ug/L	1	ug/L	8260B	79-34-5
Tetrachloroethene (PCE)	<5	ug/L	5	ug/L	8260B	127-18-4
Toluene	<1	ug/L	1	ug/L	8260B	108-88-3
1,1,1-Trichloroethane (TCA)	<1	ug/L	1	ug/L	8260B	71-55-6
1,1,2-Trichloroethane	<1	ug/L	1	ug/L	8260B	79-00-5
Trichloroethene (TCE)	<5	ug/L	5	ug/L	8260B	79-01-6
Trichlorofluoromethane	<10	ug/L	10	ug/L	8260B	75-69-4
1,2,3-Trichloropropane	<1	ug/L	1	ug/L	8260B	96-18-4
Vinyl Acetate	<100	ug/L	100	ug/L	8260B	108-05-4
Vinyl Chloride	**3.7**	**ug/L**	**2**	**ug/L**	**8260B**	**75-01-4**
Xylenes, Total	<10	ug/L	10	ug/L	8260B	1330-20-7

Samples for VOCs must not be filtered.

Reporting Limits are PQLs

(a) Reporting limit is MDL

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PART III, ATTACHMENT 11, APPENDIX 3

GROUNDWATER MODEL

CITY OF LAREDO LANDFILL
PERMIT AMENDMENT
GROUNDWATER AND TRANSPORT MODELING
TECHNICAL MEMORANDUM
KLEINFELDER PROJECT #20160680.001A

JUNE 15, 2015

A Report Prepared for:

City of Laredo, Texas

CITY OF LAREDO LANDFILL PERMIT AMENDMENT
Groundwater and Transport Modeling Technical Memorandum

Prepared by:

Marcelo Cerucci, PhD
Project Hydrogeologist

Reviewed by:

Jim Finegan, PhD, PG, CHg
Principal Hydrogeologist

Andy Nunnery, PhD, PG
Project Hydrogeologist

STATE OF TEXAS
6/16/15
ANDREW NUNNERY
GEOLOGY
No. 11501
LICENSED
PROFESSIONAL GEOSCIENTIST

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June 15, 2015
Kleinfelder Project No.: 20160680.001A

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PLATES

EXECUTIVE SUMMARY

This *Groundwater and Transport Modeling Technical Memorandum* (Memorandum) presents results of numerical modeling simulations of groundwater flow and contaminant transport within the saturated zone at the City of Laredo Landfill in Laredo, Texas. Modeling was performed to evaluate potential contaminant migration from the landfill to support the permit amendment, which includes a proposal for no further groundwater monitoring at the landfill. The transport modeling simulations indicate that a hypothetical leak of 19.4 µg/L of arsenic, 5.3 µg/L of cis-1, 2-dichloroethene, and 3.7 µg/L of vinyl chloride along the refuse boundary of the landfill would not result in concentrations above the contaminants' Texas or federal regulatory limits or laboratory reporting limits significantly beyond the property boundary over a 50-year simulation period.

1 INTRODUCTION

Kleinfelder, Inc. has prepared this *Groundwater and Transport Modeling Technical Memorandum* (Memorandum) for the City of Laredo Landfill as part of its permit amendment to evaluate potential migration of contaminants from the site. The Landfill is located on 6912 Hwy 359, approximately 2.5 miles east of downtown Laredo, Webb County, Texas (Plate 1). This Memorandum presents the results of a steady-state numerical groundwater flow and fate and transport model of a hypothetical contaminant leak around the Landfill's refuse boundary. No groundwater impacts have been detected to date by the existing monitoring system at the landfill.

1.1 BACKGROUND INFORMATION

The City of Laredo has submitted a permit amendment for its City-owned and operated Landfill. As part of the Landfill permit amendment, the City is requesting that its semi-annual groundwater sampling program be modified to an annual sampling program based on the low level of rainfall in the area and a lack of detected impacts to groundwater by the operation of the Landfill. The Texas Commission on Environmental Quality (TCEQ) rules require a non-migration demonstration (NMD) through fate and transport modeling to fulfill this request. The modeling was performed using existing groundwater monitoring information and data from the City's permit amendment document, which includes geologic, hydrogeologic, and geotechnical information.

1.2 GEOLOGY AND HYDROGEOLOGY

Laredo lies within the Rio Grande embayment of the Gulf Coastal Plain, which is characterized by a relative flat, low-lying surface sloping gradually to the Gulf of Mexico. The elevation ranges from 540 feet above mean sea level (MSL) in the southwest corner of the Landfill to 470 feet MSL near the southeast corner. The closest prominent regional surface water feature in the vicinity of the site is Casa Blanca Lake, which is approximately 2.9 miles from the northwestern corner of the site.

The facility is located on an outcrop of the Laredo Formation. The Laredo Formation is a geologic unit occurring in the Claiborne Group of the Eocene Series within the Tertiary System.

The Geologic Atlas of Texas, Laredo Sheet, 1976, characterizes the Laredo Formation as sandstone and clay with thick sandstone members in the upper and lower part. The formation is described as very fine to fine-grained, in part glauconitic, micaceous, ferruginous, cross-bedded, dominantly red and brown with clay in the middle. It weathers to an orange-yellow color with dark gray limestone layers, and concretions are common. The average thickness beneath the site facility is about 620 feet (Huntingdon, 1994; F.G. Bryant, 1983 and Rust E&I (REI), 1997).

The Laredo Formation beneath the facility is further subdivided into four hydrogeologic units (Huntingdon, 1994):

- Layer I: Surficial unit composed of clay and silty sand ranging from 0 to 36 feet in thickness. This unit does not contain groundwater.
- Layer II: The Upper Shaly Sandstone, characterized by well cemented quartz sandstone with occasional highly cemented calcareous layers. The thickness of this unit ranges from 52 feet to 77 feet. This is the upper-most water-bearing unit at the facility. Groundwater occurs near the base of this unit. Site groundwater monitoring wells are screened within this unit.
- Layer III: A shale unit characterized by very low permeability. This unit provides a barrier to vertical fluid migration and functions as an aquitard. This unit ranges in thickness from 7 feet to 30 feet.
- Layer IV: The Lower Shaly Sandstone is very fine-grained indurated sandstone found to be non-water bearing and composed of low-permeability material. Layer IV is not in communication with the upper-most water-bearing unit (Layer II).

2 NUMERICAL MODEL

This section summarizes the modeling objective and presents the methods and procedures that were followed to produce the numerical groundwater flow and transport model.

2.1 PROBLEM STATEMENT

The model described below seeks to answer the following question:

> *What is the potential migration of a hypothetical contaminant leak from the landfill over a 50-year period?*

The 50-year period includes 20 years of remaining landfill operations plus 30 years of post-closure care.

2.2 NUMERICAL MODEL DEVELOPMENT

The numerical model was constructed using the Visual MODFLOW® (v.4.6.0) modeling platform developed by Schlumberger Water Services, Inc. (2014). The program consists of a series of pre- and post-processors that transfer information to groundwater flow and mass transport computer codes.

Groundwater flow modeling was performed using the United States Geological Survey (USGS) three-dimensional, finite-difference, computer code MODFLOW-2000 (Harbaugh et. al., 2000). MODFLOW-2000 directs the execution of the groundwater flow simulation. It contains a series of user-selectable packages or modules that simulate groundwater flow, control the solution of the finite-difference equations, and simulate boundary conditions. Length and time units of feet and days, respectively, were specified in the model, and the assigned parameter values were in consistent units.

The mass transport model was performed with MT3DMS (Zheng and Wang, 1999). MT3DMS has a comprehensive set of options and capabilities for simulating advection, dispersion/diffusion, and chemical reactions of contaminants in groundwater under general hydrogeological conditions. MT3DMS uses the calculated head elevations from MODFLOW and incorporates attenuation and degradation mechanisms to simulate the transport of solutes in groundwater. Simulations were performed using the implicit Generalized Conjugate Gradient Solver (GCG) with the Upstream Finite Difference method. Internally consistent units of micrograms per liter (µg/L) were used in transport simulations.

The programs used to simulate flow and transport were selected because of their common usage and numerically stable codes having an extensive record of successful use (providing validation of the program).

The numerical modeling process typically first includes developing a conceptual model of the flow system and then includes performing calibration of the computer model. The conceptual model is a simplified representation of the flow system that is based on available field data and information concerning the geology and hydrogeology of the study area. This information is used to discretize and design the model domain and grid, in which a study area is divided into cells defined by a series of rows and columns.

The conceptual hydrogeological model consists of a non-confined layer comprising the surficial unit and Upper Shaly Sandstone unit, which as indicated above, is the water-bearing unit (Huntingdon, 1994). The Upper Shaly Sandstone is characterized by well-cemented quartz sandstone with occasional highly cemented calcareous layers. The aquitard provides a flow barrier to lower units. The conceptual model and hydrogeologic data used to implement the groundwater model were obtained from the *Permit Amendment Application MSW-1693A, Geology Report, Part III, Attachment 4*.

A plan view of the model grid and domain is shown on Plate 2. The grid consists of 250 rows, 250 columns, and one layer. The model includes 62,500 active cells representing an area of approximately 6.4 square miles. Cell size is 53 feet by 54 feet over the entire model domain. The cell size was defined to provide a good resolution within the model domain, with at least five cells between neighboring monitoring wells in any direction. A uniform grid was adopted to provide stable, faster simulations and to optimize the modeling effort. The model was simulated in steady-state mode. The model calibration was performed based on groundwater levels measured in May 2014.

Surface elevations for the simulated layer were obtained from 20-foot-resolution contours for the City of Laredo (City of Laredo GIS Division, 2015). The thickness of the layer was determined according to the *Summary of Boring Information – Laredo Landfill* available in the *Permit Amendment Application MSW-1693A, Geology Report, Part III, Attachment 4*. The borehole logs indicate that the Upper Shaly Sandstone unit dips and thickens to the southeast, and a contour map was created based on the borehole logs. The thickness of the simulated layer varies from approximately 65 feet at the western limit of the landfill to approximately 110 feet near the southeast corner of the landfill.

The WHS solver, which uses a Bi-Conjugate Gradient Stabilized (Bi-CGSTAB) acceleration routine, was used to solve the groundwater flow matrix equations for hydraulic head produced by MODFLOW. The solver calculates the hydraulic head distribution in the model domain by iteratively solving the flow equations. These equations are solved many times until certain criteria are met, indicating that a solution has been obtained. The model's solution has converged when the difference in calculated head values between one iteration and the next is below a set value (the convergence criterion, which in this case was 0.1 foot), indicating that additional iterations will provide only a marginal improvement in the flow field solution.

2.3 GROUNDWATER FLOW MODEL INPUTS AND ASSUMPTIONS

Visual MODFLOW® requires input of aquifer physical/hydrogeological parameters, such as hydraulic conductivity, effective porosity and recharge. The physical and hydrogeological parameters may be property-specific or literature-based values.

The horizontal hydraulic conductivity values selected for the model were based on the results of aquifer tests performed in the project area (*Permit Amendment Application MSW-1693A, Geology Report, Part III, Attachment 4*), and calibration efforts completed during development of the model. Horizontal hydraulic conductivities obtained from aquifer tests vary from 0.0006 feet/day to 1.05 feet/day. Horizontal hydraulic conductivities (K_H) were assigned according to different zones based on the results of the actual site tests and calibration. K_H values varying from 0.0008 feet/day to 0.1 feet/day were assigned to the simulated layer of the model. The ratio of vertical to horizontal hydraulic conductivity (K_H/K_V) was 1:1, although this ratio is not important in a single-layer model. The distribution of hydraulic conductivity zones and their respective values are shown on Plate 3.

An effective porosity of 15 percent was selected for the model based on a midrange of published values of porosity in sandstone (Freeze and Cherry, 1979). The value of effective porosity was assigned uniformly to the model grid.

The boundary conditions selected for the model simulate hydraulic conditions at the limits of the model domain. Constant-head boundary conditions were used at the limits of the model domain. The constant-head boundary conditions are shown on Plate 4. The constant-head boundaries vary according to groundwater elevations measured in site monitoring wells and the elevation of the terrain.

The USGS data for Webb County (USGS, 2004) indicate that recharge to the Laredo aquifer occurs mainly by infiltration of precipitation. The recharge is estimated to be no more than 5 percent of the annual average precipitation of 20.1 inches (approximately 1 inch or less per year of infiltration). The calibrated recharge value used in the model was 0.018 inch per year.

2.4 GROUNDWATER FLOW MODEL CALIBRATION

Calibration of the model involved adjustment of uncertain parameters and boundary conditions, including hydraulic conductivity, constant-heads, and recharge to obtain an acceptable match between observed and simulated hydraulic head values. Model calibration was performed as an iterative process, to evaluate and compare simulated to observed groundwater potentiometric surface elevations measured in May 2014 at 17 monitoring locations (targets) within the model domain. These target wells are shown on Plate 5. Hydraulic head values were used as an initial condition for the simulations.

The quality of the calibration was evaluated first by comparison of observed and modeled heads at the 17 target wells and then by reviewing the incoming and outgoing fluxes (the mass balance) calculated by the model. Residuals were calculated at each target location for the steady-state simulation. Residuals are the difference between observed and simulated head values at calibration targets, with positive values indicating higher simulated heads than observed hydraulic heads and negative values indicating lower simulated heads than observed heads. Calibration was considered complete when a reasonable match between observed and model-calculated head values was obtained. A reasonable match was given by an absolute residual mean of less than 3 feet, and scaled RMS (Root Mean Square) error less than

10 percent. The value of the absolute residual mean was determined as a function of the model objectives and resolution of the available data. The mass balance of a groundwater model is generally considered to be acceptable when the difference between the incoming and outgoing fluxes is less than 1 percent and ideal when the difference is less than 0.1 percent (Anderson and Woessner, 1992).

2.5 TRANSPORT SIMULATION

The MT3DMS transport code (Zheng and Wang, 1999) was used with the calibrated groundwater flow model to evaluate the transport of a hypothetical contaminant leak from the Landfill. The contaminants were conservatively modeled without retardation or biodegradation. Dispersion and advection were considered the dominant factors in the distribution of the contaminants in groundwater. The simulated model layer was assigned with longitudinal and transverse dispersivity values of 37 feet and 3.7 feet respectively. Longitudinal dispersivity was estimated using an equation developed for the United States Environmental Protection Agency (USEPA) BIOSCREEN Natural Attenuation Decision Support System, which is based on empirical relationships of dispersivity and plume length explored by Xu and Eckstein (1995).

Arsenic and vinyl chloride, which presented measured concentrations in leachate above the regulatory limits in December 2014, and cis-1,2-dichloroethene (cis-1,2-DCE), which has a relatively low laboratory reporting limit, were the contaminants simulated with the transport model. The Texas protective concentration levels (PCLs) are 10 µg/L for arsenic, 70 µg/L for cis-1, 2-DCE, and 2 µg/L for vinyl chloride (these are also the federal maximum contaminant levels [MCLs]). The laboratory reporting limits in December 2014 were 5 µg/L for arsenic, 1 µg/L for cis-1, 2-DCE, and 2 µg/L for vinyl chloride. Constant concentrations of 19.4 µg/L for arsenic, 5.3 µg/L for cis-1, 2-DCE, and 3.7 µg/L of vinyl chloride, which correspond to measured leachate values in December 2014, were applied along the refuse boundary of the landfill to simulate a potential leak and to evaluate potential migration of the contaminants. The position of the constant concentrations is shown on Plate 6. The transport simulation period was 50 years. The constant concentration remained active during the entire simulation period. Transport simulations were set up using a Courant number of 0.75, maximum time step size of 100 days, and time step multiplier of 1.01.

3 MODEL RESULTS

A scatter diagram that shows the correlation between observed and computed heads is presented on Plate 7. The calculated absolute residual between observed and computed groundwater surface elevations for the 17 target wells with observed data was 2.72 feet and the normalized RMS was 5.7 percent, both of which are below the criteria listed in Section 2.4. The mass balance of the steady-state groundwater flow model was -0.01 percent (Plate 8), indicating slightly more flux leaving than entering the model. This mass balance value is less than 0.1 percent, so is considered acceptable. The simulated head contours are presented on Plate 9.

The results of transport modeling for arsenic, cis-1, 2-DCE, and vinyl chloride after 50 years of simulation are shown on Plate 10, Plate 11, and Plate 12, respectively. Based on the predictive transport simulations, off-Site concentrations of arsenic and vinyl chloride are expected to be below 5 µg/L and 2 µg/L, respectively, during the entire 50 years. Cis-1, 2-DCE concentrations of approximately 1 µg/L just cross the southeast edge of the Site boundary after 50 years of simulation. However, the transport simulation is very conservative, assuming no degradation or attenuation and a constant concentration for the entire 50 years, although no actual impacts to groundwater have been historically detected at the Site. Thus, the simulation of a potential leak along the refuse boundary indicates no significant contaminant migration above the PCLs or laboratory reporting limits in any direction.

4 CONCLUSIONS

MODFLOW- and MT3DMS-based fate-and-transport modeling of the saturated zone was performed to assess contaminant migration of a potential leak of arsenic, cis-1, 2-DCE, and vinyl chloride from the City of Laredo Landfill. It was predicted that a hypothetical leak of leachate containing a constant concentration of arsenic, cis-1, 2-DCE, and vinyl chloride for 50 years around the refuse boundary would not result in significant off-Site concentrations of the simulated contaminants above their respective PCLs or laboratory reporting limits.

5 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited amount of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee, or warranty, expressed or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

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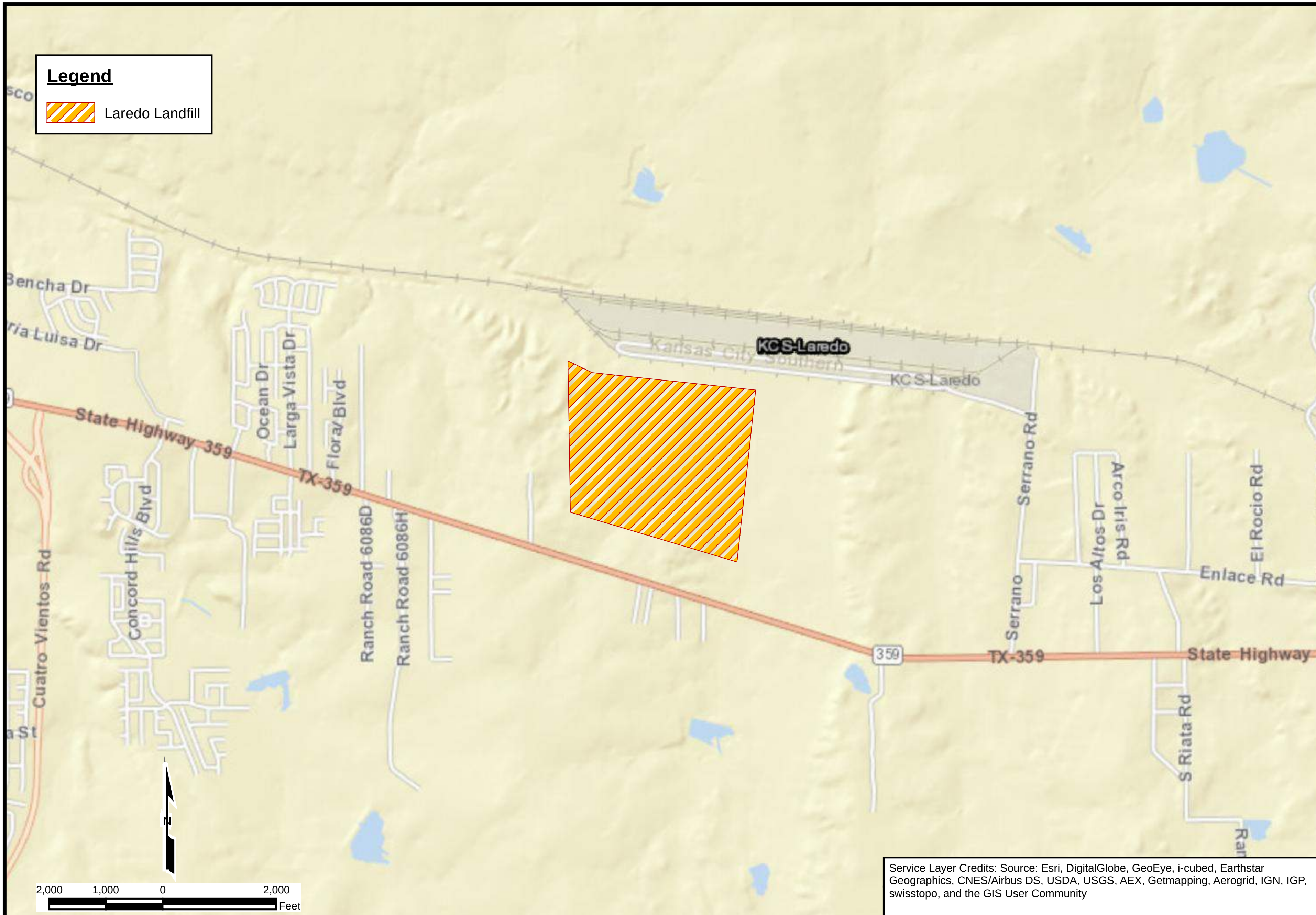
Plates



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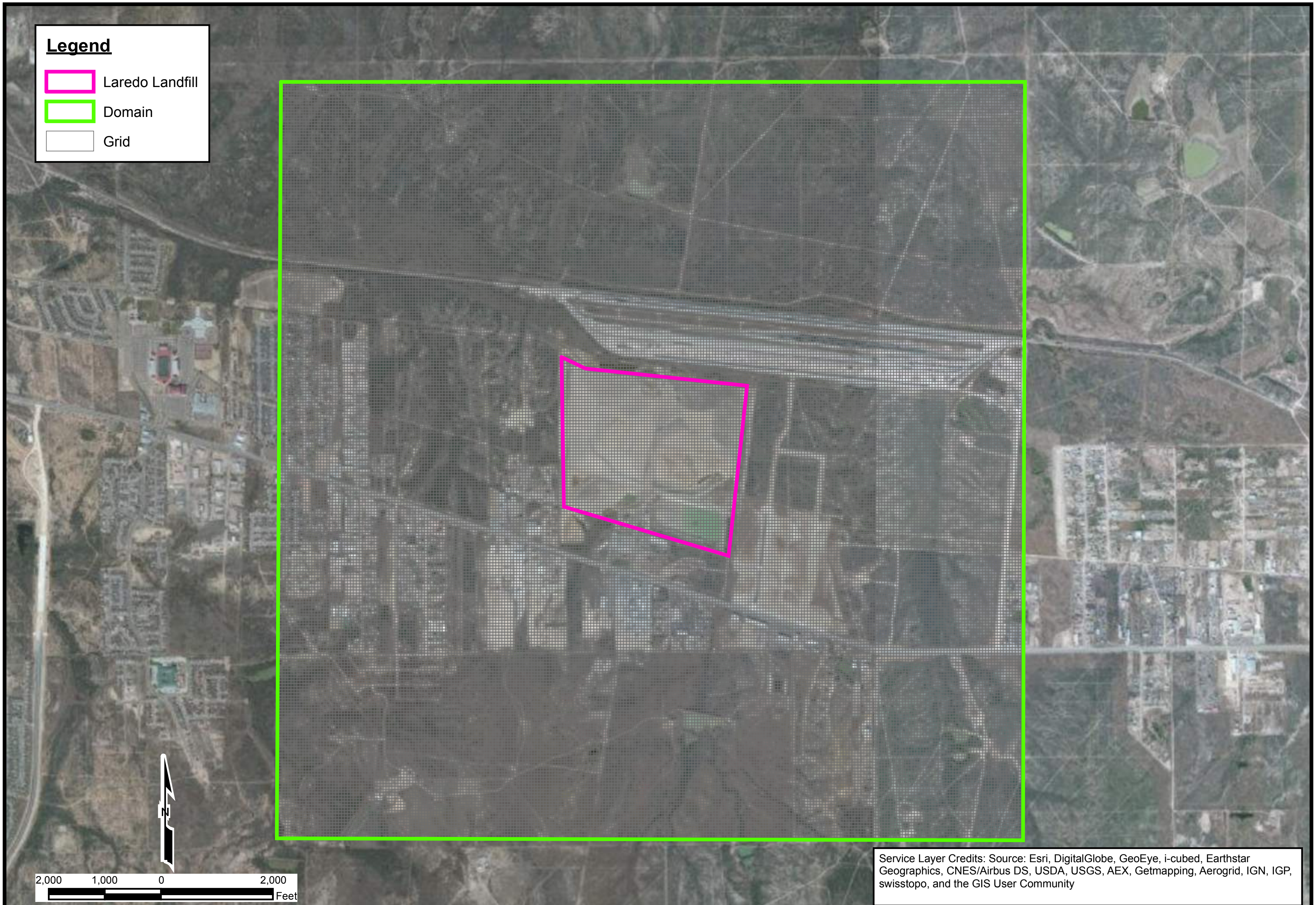
PROJECT NO.	20160680.001A	VICINITY MAP	PLATE
DRAWN:	06/01/2015		1
DRAWN BY:	MC		
CHECKED BY:	JF	CITY OF LAREDO LANDFILL 6912 HYW 359, WEBB COUNTY LAREDO, TEXAS	
FILE NAME:	Laredo fig.mxd		



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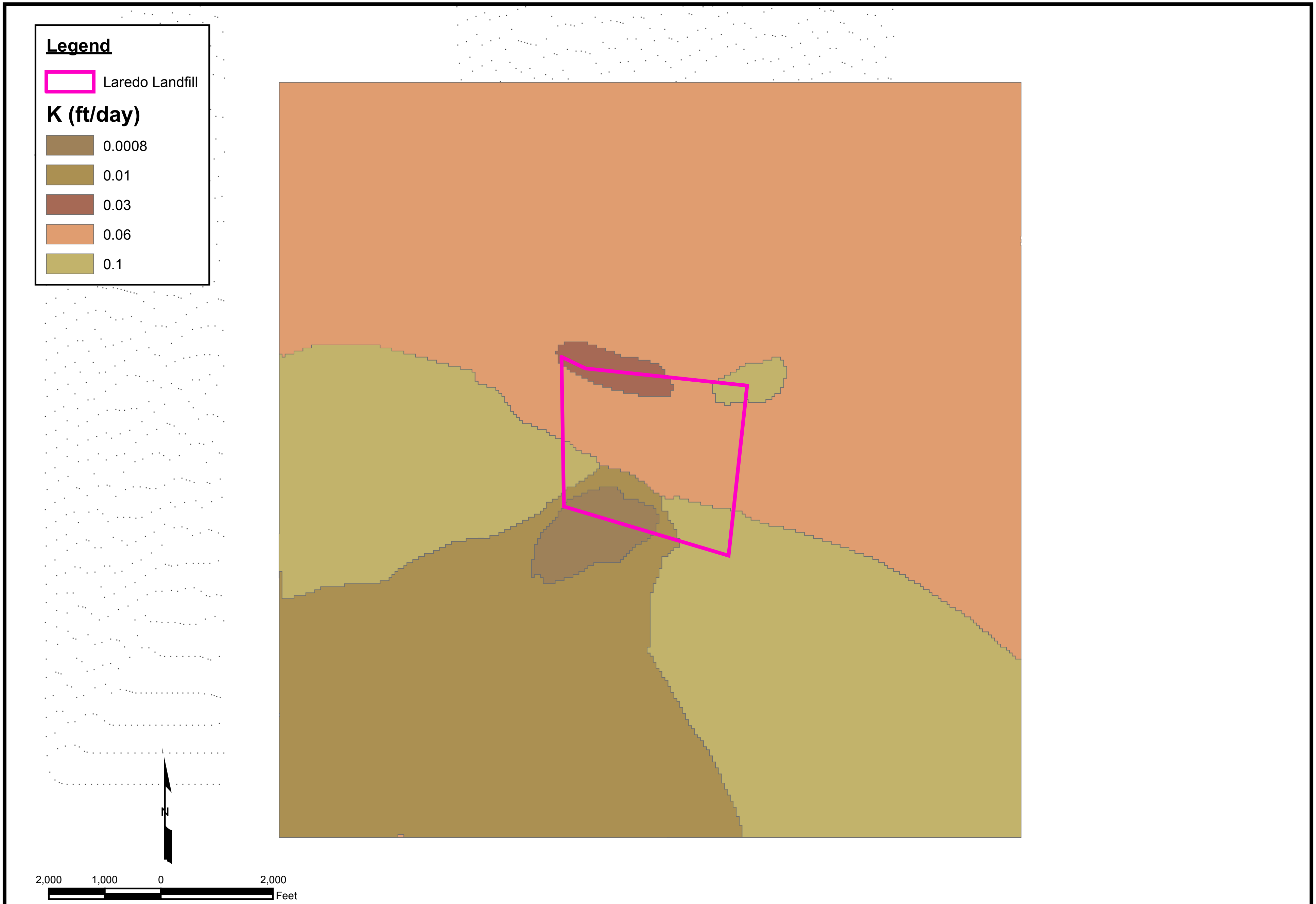
PROJECT NO. 20160680.001A		MODEL DOMAIN AND GRID	PLATE
DRAWN:	06/01/2015		2
DRAWN BY:	MC		
CHECKED BY:	JF	CITY OF LAREDO LANDFILL 6912 HYW 359, WEBB COUNTY LAREDO, TEXAS	
FILE NAME:	Laredo fig.mxd		



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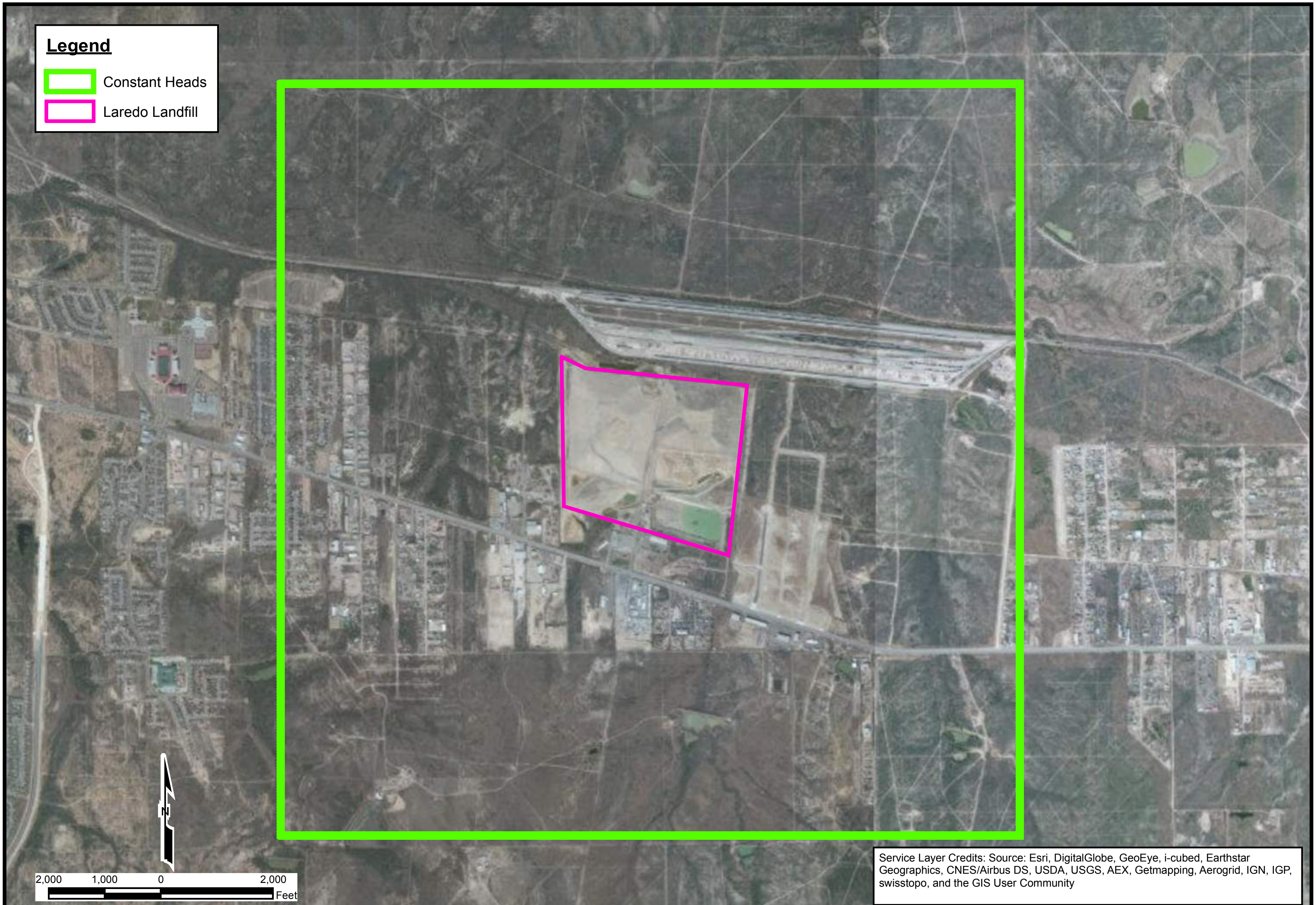
FILE NAME:	Laredo fig.mxd

DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES

CITY OF LAREDO LANDFILL
6912 HYW 359, WEBB COUNTY
LAREDO, TEXAS

PLATE
3



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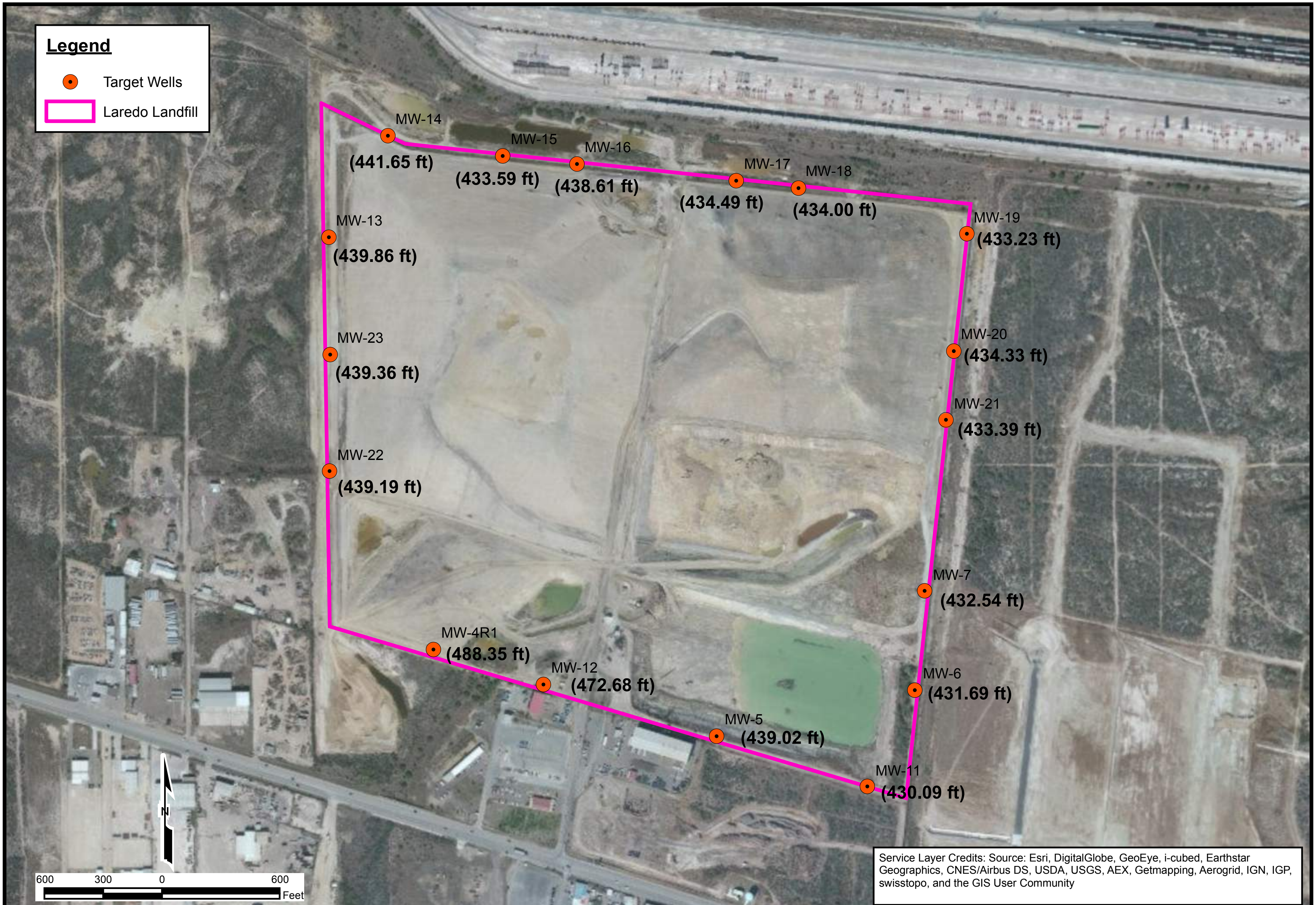
CHECKED BY:	JF
FILE NAME:	Laredo fig.mxd

CONSTANT HEAD BOUNDARY CONDITION

CITY OF LAREDO LANDFILL
6912 HYW 359, WEBB COUNTY
LAREDO, TEXAS

PLATE
4



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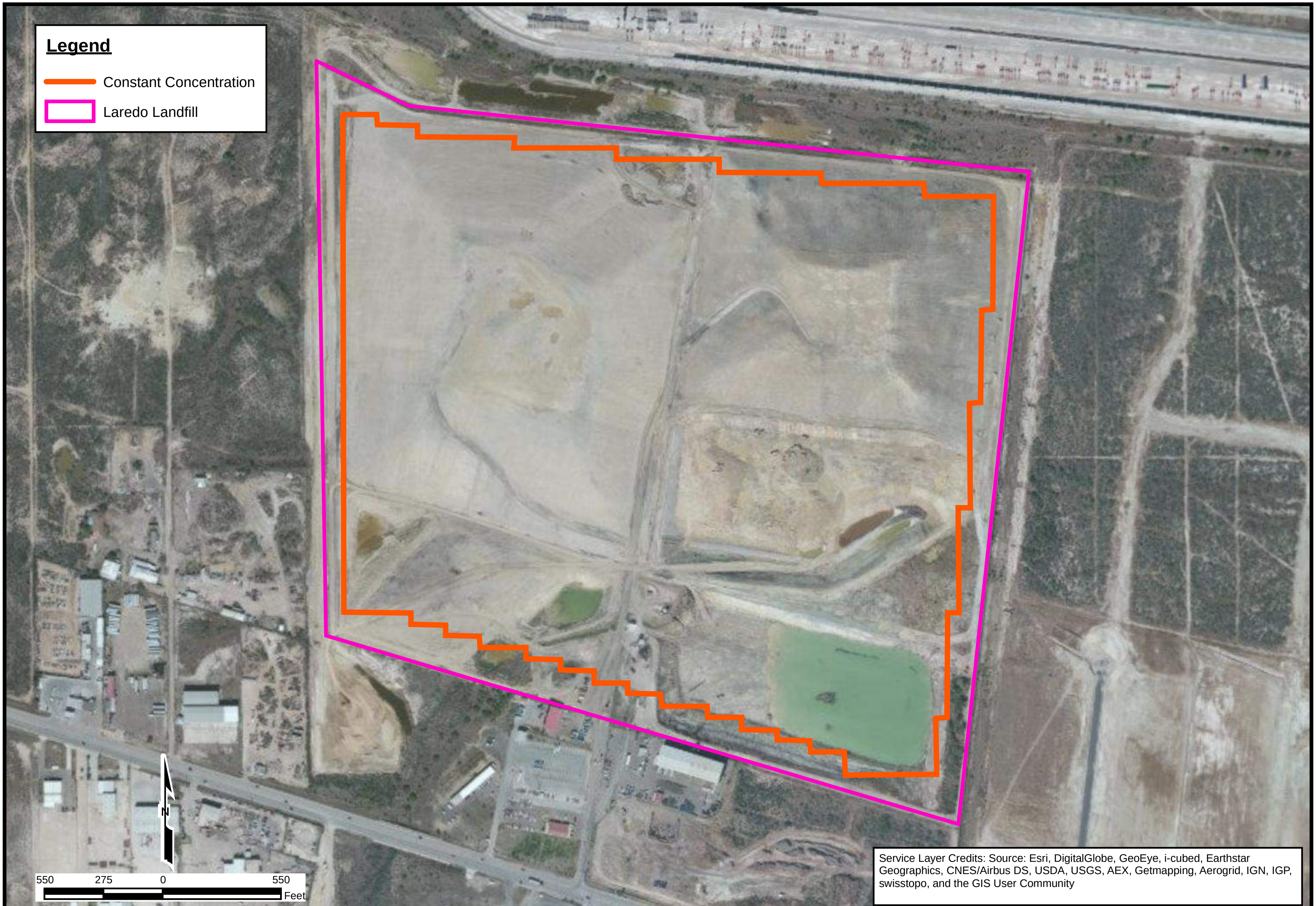
FILE NAME:	Laredo fig.mxd

CALIBRATION TARGETS AND OBSERVED HEADS MAY 2014

CITY OF LAREDO LANDFILL
6912 HYW 359, WEBB COUNTY
LAREDO, TEXAS

PLATE
5



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DRAWN:	06/01/2015
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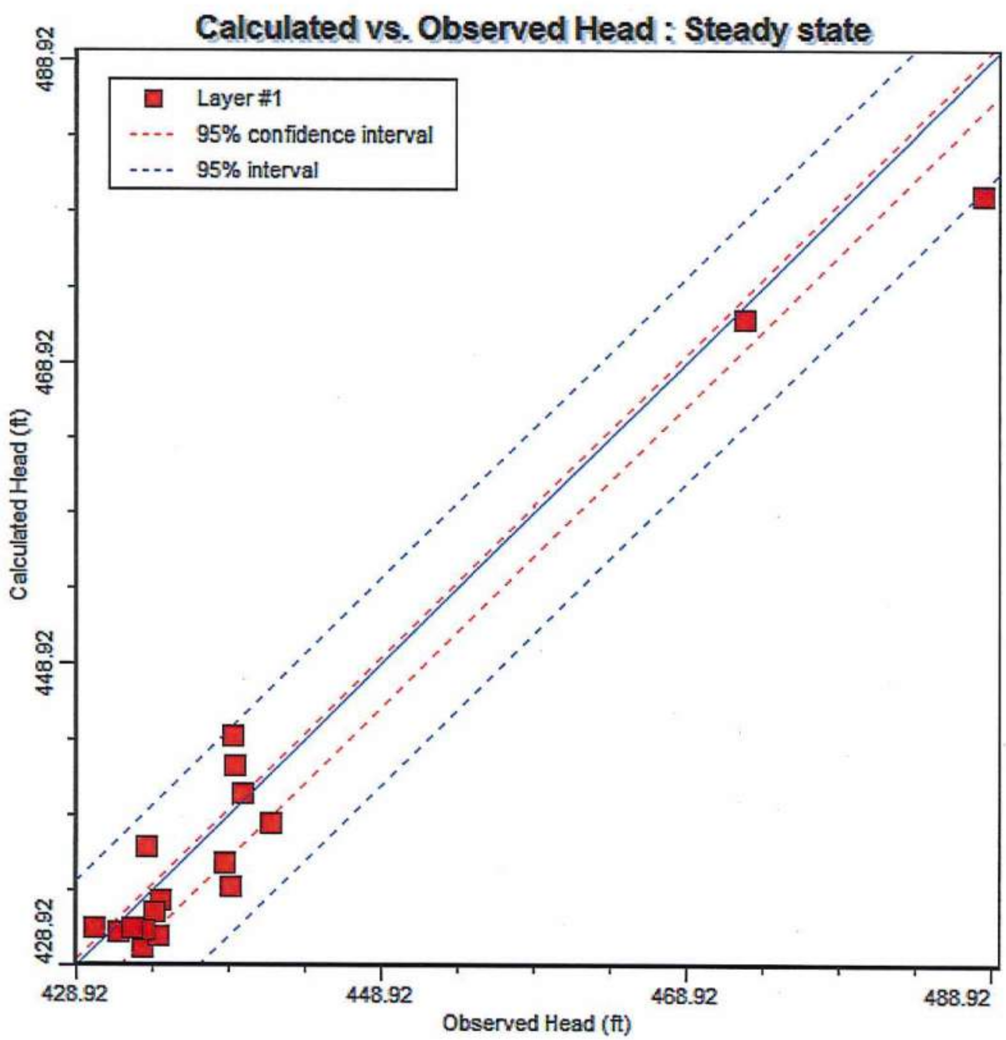
FILE NAME:	Laredo fig.mxd

CONSTANT CONCENTRATION (CONTAMINANT SOURCE LINE)

CITY OF LAREDO LANDFILL
6912 HYW 359, WEBB COUNTY
LAREDO, TEXAS

PLATE
6



Max. Residual: -8.475 (ft) at MW-4R1/1
Min. Residual: 0.499 (ft) at MW-13/1
Residual Mean : -1.196 (ft)
Abs. Residual Mean : 2.72 (ft)

Num. of Data Points : 17
Standard Error of the Estimate : 0.783 (ft)
Root Mean Squared : 3.354 (ft)
Normalized RMS : 5.757 (%)
Correlation Coefficient : 0.98

STATE OF TEXAS
J. ANDREW NUNNERY
GEOLOGY
No. 11501
LICENSED
PROFESSIONAL GEOSCIENTIST
6/1/15

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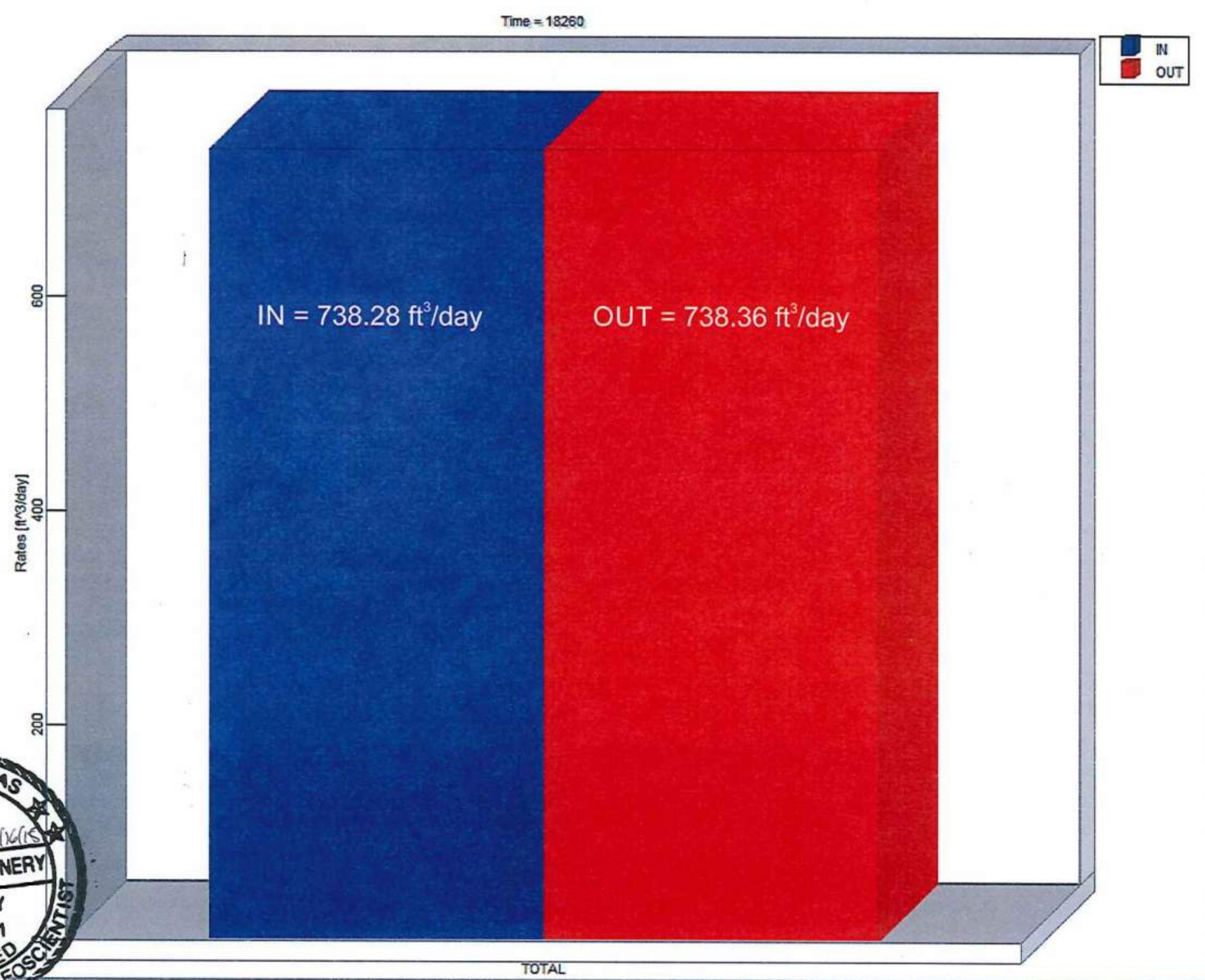
PROJECT NO. 20160680.001A		SCATTER PLOT OF OBSERVED VERSUS COMPUTED GROUNDWATER HEADS	PLATE
DRAWN:	06/01/2015		7
DRAWN BY:	MC		
CHECKED BY:	JF	CITY OF LAREDO LANDFILL 6912 HYW 359, WEBB COUNTY LAREDO, TEXAS	
FILE NAME:	Plate_6.cdr		



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J. ANDREW NUNNERY
GEOLOGY
No. 11501
LICENSED
PROFESSIONAL GEOSCIENTIST

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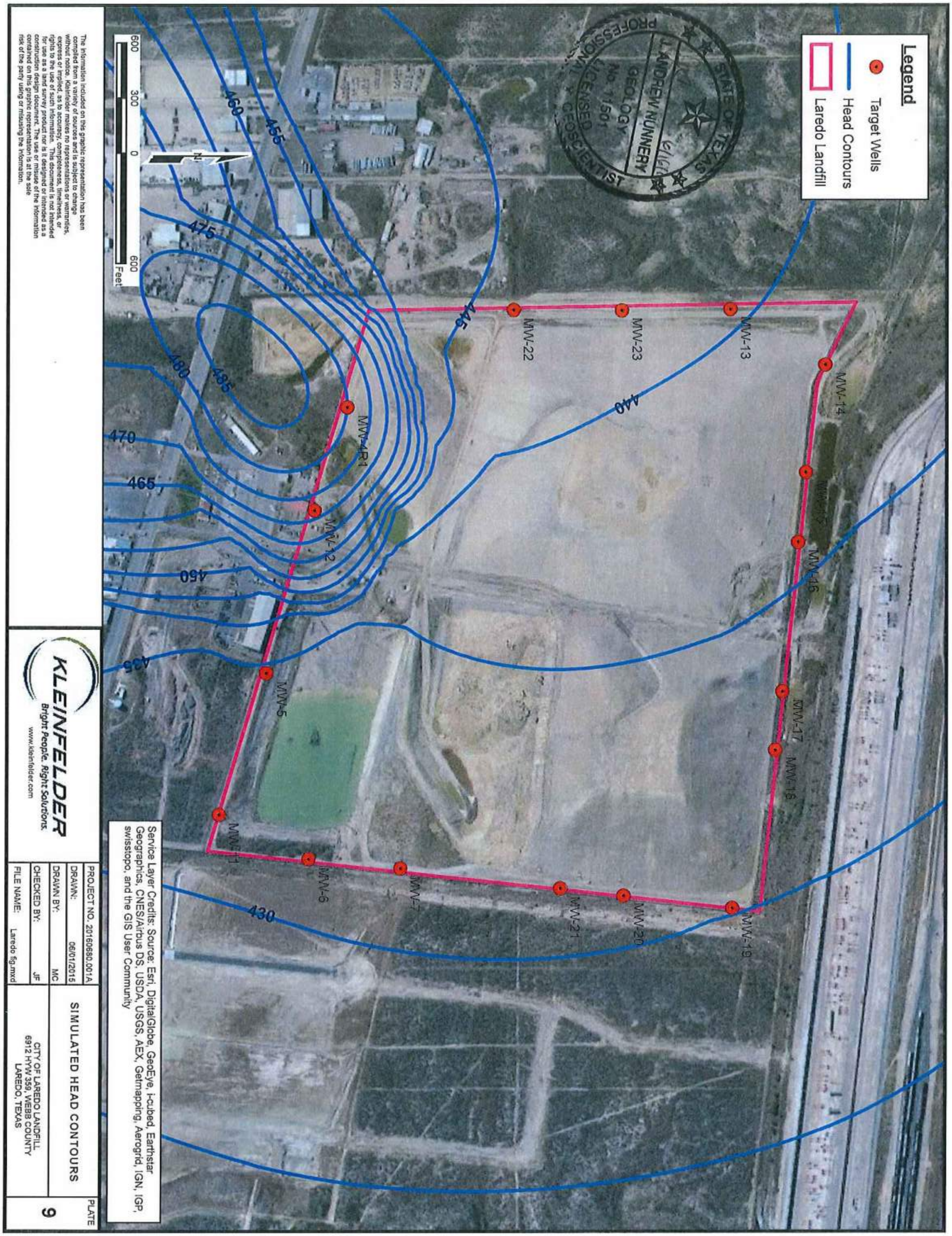
PROJECT NO. 20160680.001A		CALIBRATED MODEL MASS BALANCE	PLATE
DRAWN:	06/01/2015		8
DRAWN BY:	MC		
CHECKED BY:	JF	CITY OF LAREDO LANDFILL 6912 HYW 359, WEBB COUNTY LAREDO, TEXAS	
FILE NAME:	Plate_6.cdr		


Legend
Target Wells
Head Contours
Laredo Landfill
STATE OF TEXAS
J. ANDREW NUNNERY
GEOLOGY
No. 11501
LICENSED
PROFESSIONAL GEOSCIENTIST
600 300 0 600
Feet
N
460
455
475
445
480
485
470
465
450
440
435
430
MW-13
MW-23
MW-22
MW-14
MW-4R1
MW-12
MW-15
MW-5
MW-17
MW-16
MW-11
MW-6
MW-7
MW-21
MW-20
MW-19
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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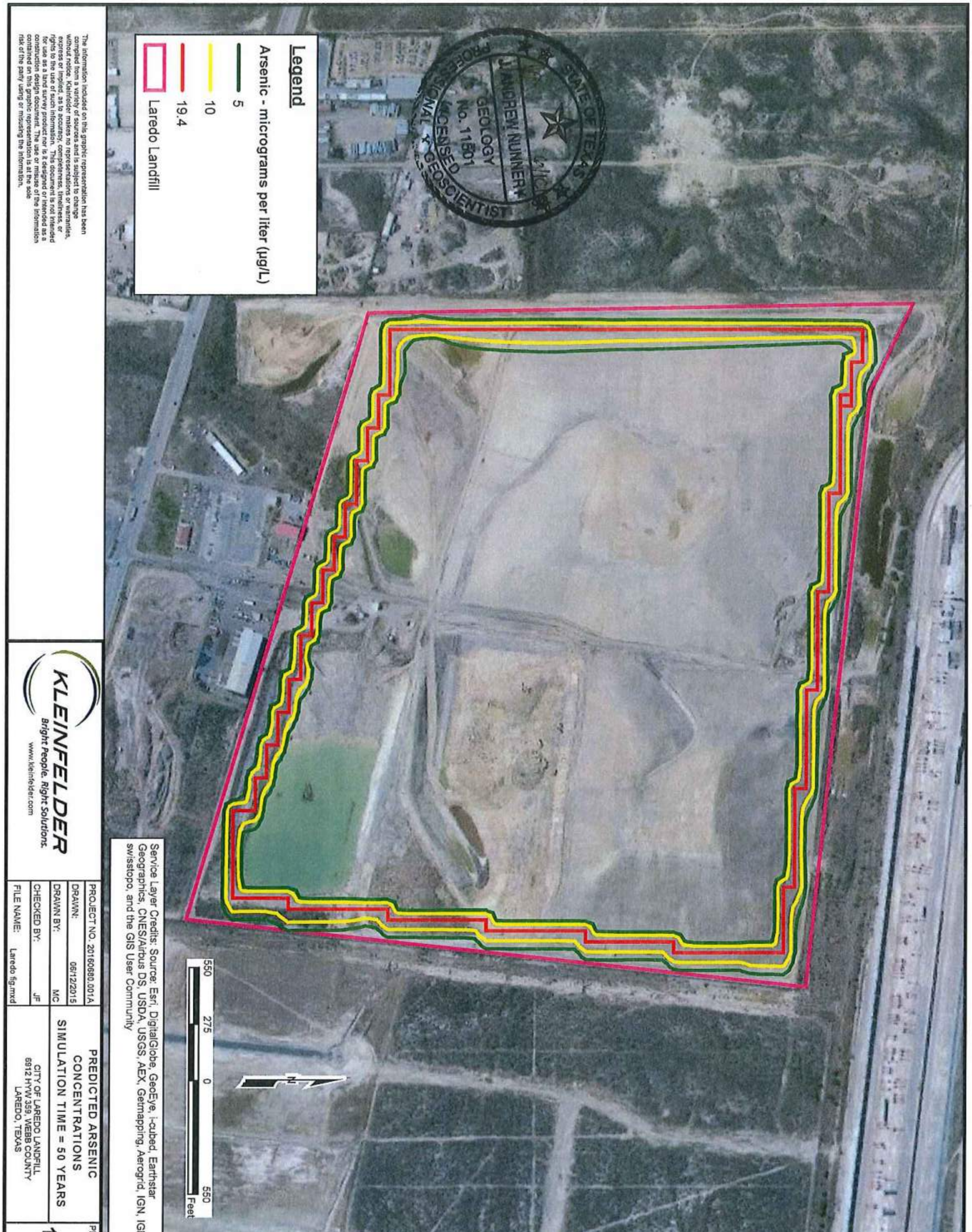
PROJECT NO. 20160680.001A
DRAWN: 06/01/2015
DRAWN BY: MC
CHECKED BY: JF
FILE NAME: Laredo fig.mxd
SIMULATED HEAD CONTOURS
CITY OF LAREDO LANDFILL
6912 HYW 359, WEBB COUNTY
LAREDO, TEXAS
PLATE
9



Legend
Arsenic - micrograms per liter (µg/L)
5
10
19.4
Laredo Landfill
STATE OF TEXAS
J. ANDREW NUNNERY
GEOLOGY
No. 11501
LICENSED
PROFESSIONAL GEOSCIENTIST
550 275 0 550
Feet
N
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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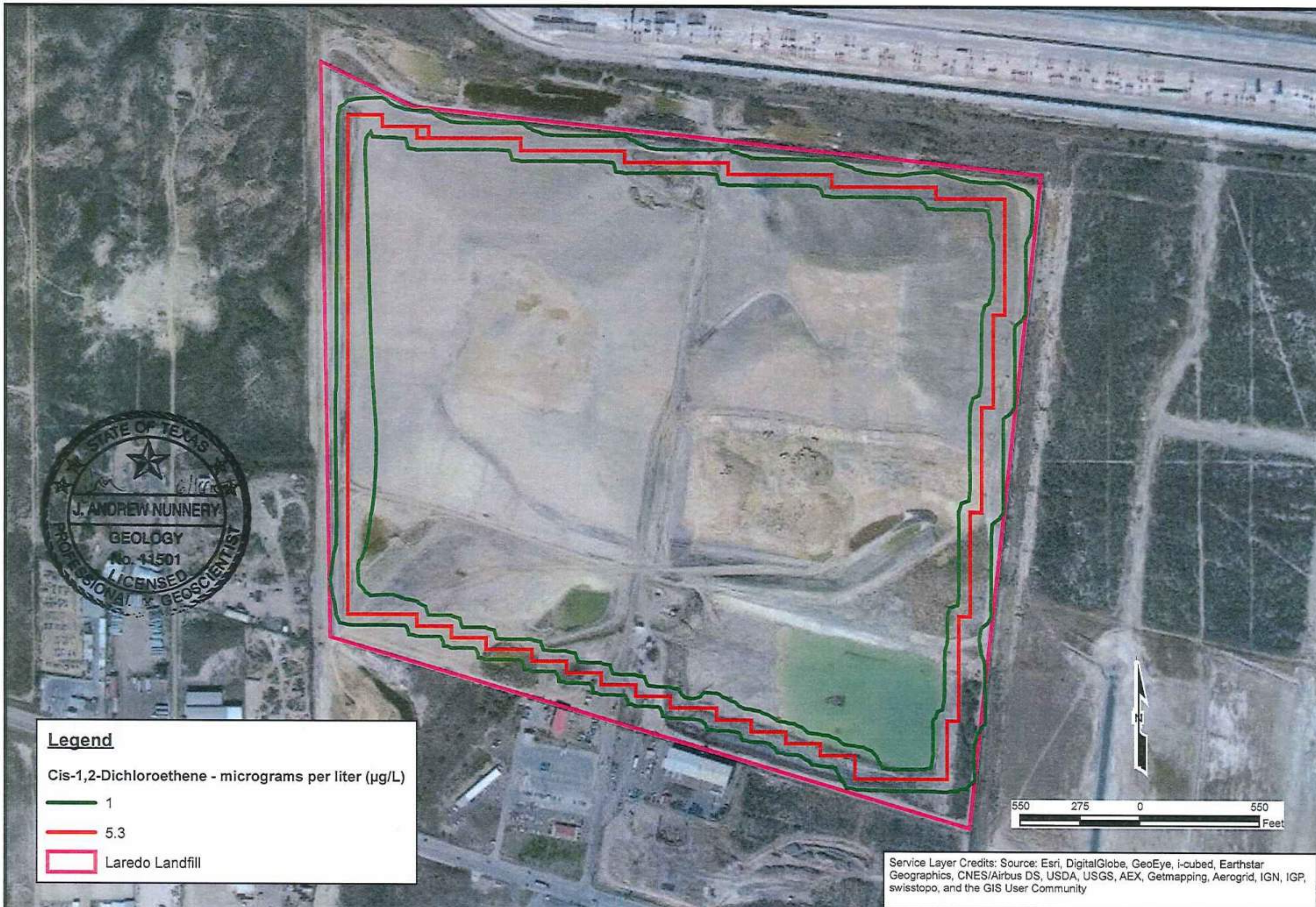
PROJECT NO. 20160680.001A
DRAWN: 06/12/2015
DRAWN BY: MC
CHECKED BY: JF
FILE NAME: Laredo fig.mxd
PREDICTED ARSENIC CONCENTRATIONS
SIMULATION TIME = 50 YEARS
CITY OF LAREDO LANDFILL
6912 HYW 359, WEBB COUNTY
LAREDO, TEXAS
PLATE
10



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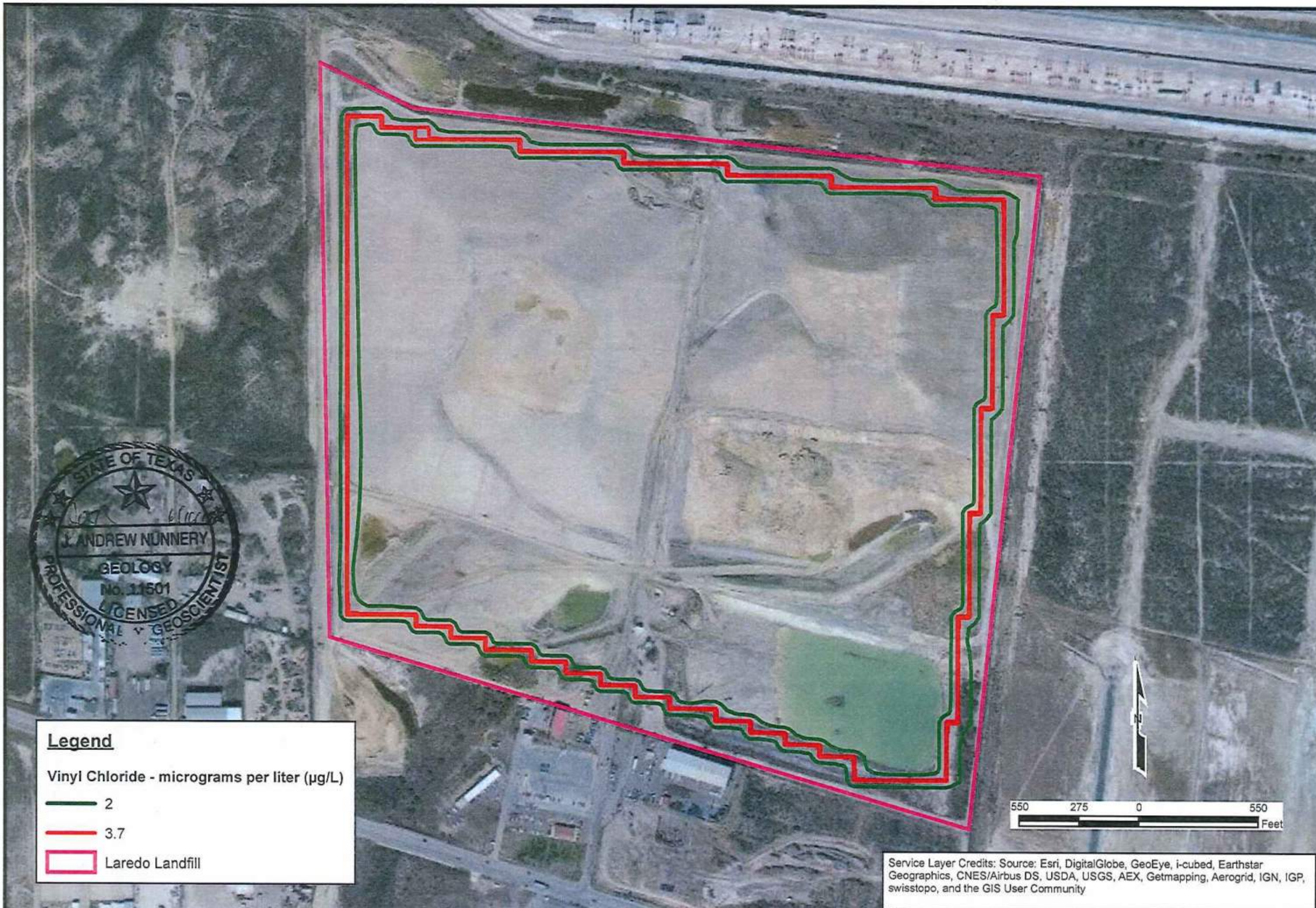
PROJECT NO.	20160680.001A	PREDICTED Cis-1,2-Dichloroethene CONCENTRATIONS SIMULATION TIME = 50 YEARS	PLATE
DRAWN:	06/12/2015		11
DRAWN BY:	MC		
CHECKED BY:	JF	CITY OF LAREDO LANDFILL 6912 HYW 359, WEBB COUNTY LAREDO, TEXAS	
FILE NAME:	Laredo fig.mxd		



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PROJECT NO.	20160680.001A	PREDICTED VINYL CHLORIDE CONCENTRATIONS SIMULATION TIME = 50 YEARS	PLATE
DRAWN:	06/12/2015		12
DRAWN BY:	MC	CITY OF LAREDO LANDFILL 6912 HYW 359, WEBB COUNTY LAREDO, TEXAS	
CHECKED BY:	JF		
FILE NAME:	Laredo fig.mxd		

PART III, ATTACHMENT 11, APPENDIX 4

PRECIPITATION DATA

National Weather Service Weather Forecast Office

Corpus Christi, TX

The New Climatological Normals for the Period 1981-2010

The National Climatic Data Center (NCDC) calculates new climatological normals every 10 years based upon the previous 30-year period. Climatological normals of temperature and precipitation are two of the most common types of normals but many other normals (such as winds, snowfall and heating degree days) are calculated. Prior to July 1, 2011, the 30-year period used in the calculation of climatological normals was from 1971 to 2000. From now through the next decade, the new 30-year period used to calculate climatological normals will be from 1981 through 2010. Officially, these new normals began being used as of August 1, 2011 in our daily climate products:

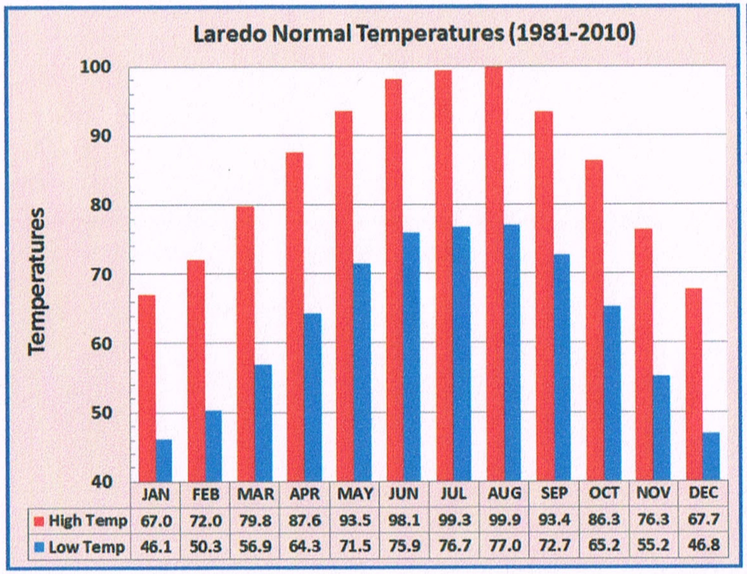
- Daily Climate Report for Corpus Christi
- Daily Climate Report for Victoria
- Daily Climate Report for Laredo

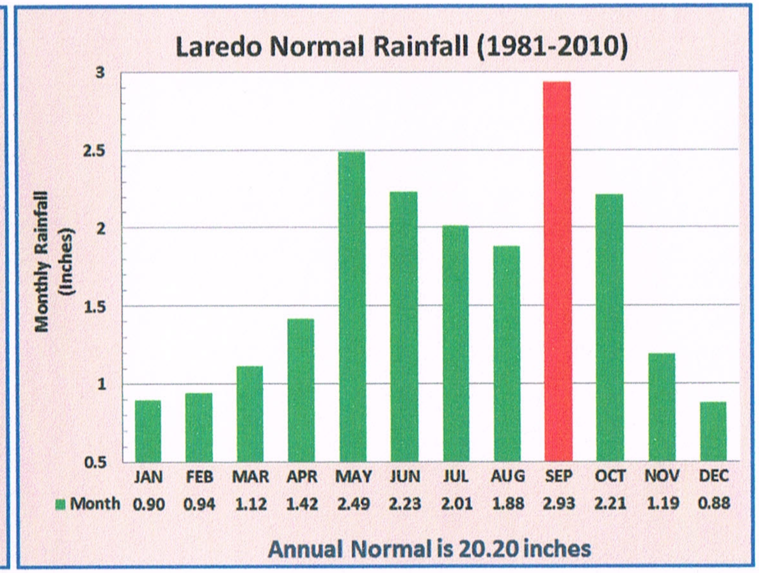
The new normals (1981-2010) will be incorporated into the 2011 August monthly climate information (which will be produced on September 1, 2011). Our monthly climate products are:

- Monthly Climate Report for Corpus Christi
- Monthly Climate Report for Victoria
- Monthly Climate Report for Laredo

For more information on the new climatological normals, please go to the NCDC web page. Monthly data exists below (click images for higher resolution) for Corpus Christi, Victoria and Laredo. Additional data will be forthcoming on the Norms & Records web page.

Laredo Monthly Temperature and Precipitation Normals (1981-2010)





National Weather Service
Corpus Christi, TX Weather Forecast Office
426 Pinson Dr
Corpus Christi, TX 78406
(361) 289-0959
Page Author: CRP Webmaster
Web Master's E-mail: sr-crp.webmaster@noaa.gov
Page last modified: August 5th 2011 8:33 PM

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Texas Climate Extremes

Hottest Texas cities Annual average temperature Cities > 10,000 population	Avg. Temp
1. Mc Allen	74.6
2. Weslaco	74.3
3. Rio Grande City	74.0
4. Mercedes	73.9
5. San Benito	73.9
6. Mission	73.9
7. Brownsville	73.9
8. Harlingen	73.6
9. Alice	72.2
10. Corpus Christi	71.9

Coldest Texas Cities Annual average temperature Cities > 10,000 population	Avg Temp
1. Stratford	55.0
2. Pampa	56.9
3. Amarillo	57.2
4. Plainview	58.4
5. Levelland	59.2
6. Borger	59.2
7. Lubbock	60.2
8. Socorro	60.8
9. Lamesa	61.4
10. Snyder	62.2

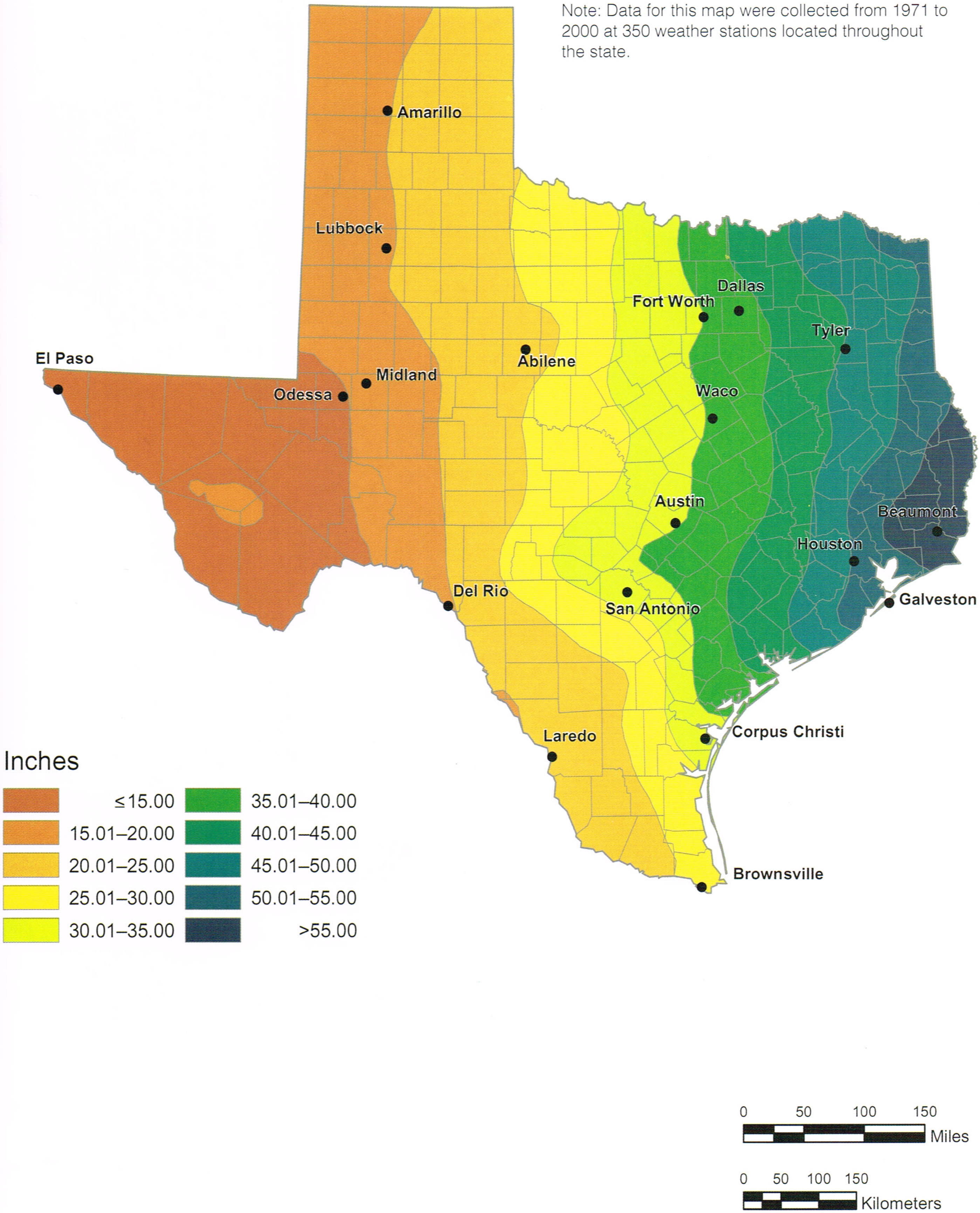
Wettest Texas Cities Annual average precipitation Cities > 10,000 population	Avg Precip
1. Orange	59.76
2. Port Arthur	58.49
3. Houston	56.66
4. Beaumont	55.13
5. Baytown	54.13
6. Angleton	52.84
7. Texarkana	50.54
8. Humble	49.67
9. Nacogdoches	49.53
10. Freeport	49.52

Driest Texas Cities Annual average precipitation Cities > 10,000 population	Avg Precip
1. Socorro	7.68
2. El Paso	8.67
3. Odessa	13.67
4. Midland	14.08
5. Laredo	16.22
6. Lamesa	17.61
7. Del Rio	17.69
8. Dumas	18.20
9. Hereford	18.22
10. Big Spring	18.34

Most # of days with at least .01 precipitation Cities > 10,000 population	Avg # days
1. Port Arthur	105
2. Orange	100
3. Houston	100
4. Beaumont	99
5. Tyler	98

Lowest # days with at least .01 precipitation Cities > 10,000 population	Avg # days
1. Socorro	36
2. Lamesa	46
3. El Paso	48
4. Snyder	49
5. Kingsville	51

Average Annual Precipitation



Source: National Oceanographic and Atmospheric Administration, 2002.