ECT Project No. 14-0500

TECHNICAL MEMORANDUM
Conceptual Site Model and Preliminary Pathway Evaluation

City of Linden
Broad and Bridge Street Benzene Contamination
Linden (Genesee County), Michigan
(MERA ID No. 25000703)

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Prepared for:

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EXECUTIVE SUMMARY

The Michigan Department of Environmental Quality-Remediation and Redevelopment Division (MDEQ-RRD) retained Environmental Consulting & Technology, Inc. (ECT) to assess benzene contamination identified in commercial structures and the sub-grade storm sewer system along a two-block section of Bridge Street (south of the Shiawassee River and north of Hickory Street) in Linden, Michigan. During July and August 2014, ECT sampled indoor air from 109 North Bridge Street and from two storm sewer structures along the east side of North Bridge Street. Soil borings were completed and related soil and groundwater sampling and analysis was conducted with temporary well installation in soil borings for the purpose of groundwater sampling or gauging of light non-aqueous phase liquid (LNAPL). Based on the indoor air results, a vapor mitigation system was installed at 109 North Bridge Street.

Subsurface soil conditions consist of varying thicknesses of sand underlain by gravel and/or natural clay to 20 feet. North of the intersection of Bridge and Broad Streets the natural clay is encountered at shallower depths and the gravel layer pinches out within the clay stratum. A sump in the basement of 109 Bridge Street intercepts the gravel layer. Evidence of hydrocarbon impact, such as, detectable photoionization detector (PID) readings, staining and hydrocarbon odors was observed at 14 of 20 borings completed in the study area.

Groundwater was encountered at depths ranging from 5.5 to 10 feet below grade during drilling at 19 of the 20 soil boring locations. Groundwater flow in the study area is toward the northwest with an estimated hydraulic gradient of 0.007 ft/ft.

Visual and/or analytical evidence of NAPL saturation was observed at 6 of 20 soil boring locations. Five of the 6 locations were south of the intersection of Bridge and Broad Streets. One of the locations, GP-3, was northeast of the intersection of Bridge and Broad Streets. Approximately 0.07 feet of LNAPL was present in GP-15, one of the temporary wells located southeast of the intersection of Bridge and Broad Streets. The temporary well was located in the right-of-way of Bridge Street proximal to existing UST systems.

Volatile organic compounds (VOC) constituents were detected in 12 of 29 soil samples submitted for analyses. In 11 of the 12 samples where VOCs were detected, one or more of the VOCs exceed Part 201 generic residential cleanup criteria. North of the intersection and west of Bridge Street, only benzene, ethylbenzene and n-propylbenzene were detected. A broader spectrum of VOC impacts were identified in soil samples east of Bridge Street, both north and south of Broad Street. The maximum concentrations of VOCs detected in soil were identified southeast of the intersection of Bridge and Broad Streets, proximal to the existing UST systems.

VOCs were detected in 22 of the 25 groundwater samples collected during boring installations and subsequent temporary well sampling. In 15 of the 22 samples where VOCs were detected, one or more VOCs detected exceed Part 201 generic residential cleanup criteria. The maximum concentrations of VOCs detected in groundwater correspond to locations southeast and northeast of the intersection of Bridge and Broad Streets where evidence of NAPL saturation was identified. VOCs were not detected above laboratory reporting limits in the seven groundwater samples collected from the storm water catch basins in the study area on August 28, 2014.
Prior to the installation of the indoor air mitigation system at 109 North Bridge Street, the analytical

results for indoor air samples at that location indicated concentrations of benzene above the 3.3 ug/m^3 *Vapor Intrusion Indoor Air Screening Level*. The analytical results for indoor air samples collected from 109 North Bridge Street after installation of the vapor collection system indicate that the concentrations of VOCs detected in indoor air samples are all below the *Vapor Intrusion Indoor Air Screening Levels*. The composition of the VOCs detected in indoor air samples is indicative of a petroleum hydrocarbon source.

A release of petroleum based LNAPL occurred in the study area. Based on unsaturated soil concentrations and observations of mobile LNAPL, LNAPL saturation appears to be emanating from the property at 110 East Broad Street, the location of several existing USTs. Dissolved phase VOCs are migrating from the area of NAPL saturation to the northwest. The gravel layer, which pinches out within natural clays to the northwest, appears to be a preferential migration pathway for the dissolved phase plume west of Bridge Street. VOC-impacted groundwater has migrated into a basement sump at 109 North Bridge Street.

The backfilled sewer corridor reported to exist in the North Bridge Street east right-of-way may be a preferential migration pathway for soil vapors emanating from the residual source area(s) and might be a cause of the detection of VOCs in air collected from catch basin (CB-2) and a manhole structures proximal to 208 Bridge and indoor air samples collected by the EPA in July 2014 inside the building at 208 Bridge Street.

1.0 INTRODUCTION

The Michigan Department of Environmental Quality-Remediation and Redevelopment Division (MDEQ-RRD) retained Environmental Consulting & Technology, Inc. (ECT) to support the MDEQ-RRD in assessing benzene contamination and other potentially petroleum related volatile organic compounds (VOCs) along a two-block section of Bridge Street (south of the Shiawassee River and north of Hickory St.) in Linden, Michigan (Figure 1), particularly as they relate to vapor and groundwater intrusion into nearby commercial structures and the sub-grade storm sewer system In an effort to further investigate and mitigate relevant exposure risks disclosed during recent response actions undertaken by the MDEQ-RRD and U.S. EPA, ECT completed the evaluations described in this report.

ECT completed evaluation activities in accordance with the approved "Time Critical" Interim Response Work Plan (Work Plan) dated July 24, 2014.

2.0 BACKGROUND INFORMATION

Prior to implementation of the evaluation activities presented in this report, analytical testing had confirmed the presence of benzene in indoor air quality samples collected within occupied buildings along North Bridge Street and concentrations of VOCs in water samples collected from a basement sump (109 North Bridge Street) and a storm water catch basin (208 North Bridge Street). These properties are located along a two-block segment of North Bridge Street in the SW ¼ of Section 20, T.5N, R.6E, in the City of Linden, Genesee County, Michigan. The study area is located in the central business district of the City of Linden. In general the study area encompasses the properties along the east and west sides of North/South Bridge Street (extending north from the intersection of Hickory Street to the Shiawassee River), as well as both sides of East/West Broad Street (specifically, that area between Main Street extending west to Walmer Street); see Figure 2.

Based on a review of documents provided by the MDEQ-RRD (refer to Section 9), ECT has prepared the following brief summary of previous evaluations completed in the study area:

July 2006: Strata Environmental Services, Inc. (Strata) performed subsurface evaluation activities in response to recurring petroleum vapors in utility corridors and basements north of the intersection of Bridge and Broad Streets. The occurrence of vapors reportedly correlated with significant rain events. Vapors were identified in the municipal storm sewer and a sorbent boom was placed along the storm sewer outfall to the Shiawassee River. Strata observed non-aqueous phase liquid (NAPL) in a basement sump and floor drain at 122 Bridge Street. This property is located east of North Bridge Street approximately 150 feet north of the intersection of Bridge and Broad Streets. The NAPL was removed and the basement was ventilated to remove vapors. The building formerly located at 122 Bridge Street has subsequently been demolished.

October 2012: While performing due diligence in advance of a real estate transaction, Atwell, LLC evaluated the environmental condition of the vacant parcel located at 120 North Bridge Street at the northeast corner of the intersection of Bridge and Broad Streets. Atwell, LLC completed six soil borings, AB-1 through AB-6, and submitted four soil and four groundwater samples to an analytical laboratory for analyses. Based on a review of the laboratory testing, Atwell, LLC identified VOCs in soil and groundwater at concentrations above Part 213 risk-based screening levels. The

concentrations of xylenes and/or 1,2,4-trimethylbenzene in two soil samples collected from the southwest corner of the property exceeded the soil saturation screening levels (Csat) which are indicative of residual NAPL saturation. Atwell, LLC assumed the source of the contamination to be south of Broad Street. Atwell, LLC provided notice to the MDEQ regarding the discovery of the contamination.

September 2013: Oneida Total Integrated Enterprises (subcontractor to the U.S. EPA) conducted site assessment activities at 105 North Bridge Street and reportedly observed evidence of petroleum odors and VOCs in sanitary and storm water manholes near the intersection of Bridge and Broad Streets. The source of the VOCs and odors was not determined.

June 2014: In response to reported petroleum odors in occupied structures, the MDEQ-RRD completed preliminary assessment of the properties located at 109 and 208 North Bridge Street. Laboratory analyses of water samples collected from a sump in the basement of 109 North Bridge Street and a storm water catch basin near 208 North Bridge Street identified the presence of trimethylbenzene (TMB) isomers, benzene, toluene, ethylbenzene and xylenes (BTEX), isopropylbenzene and methyl(tert)butylether (MTBE). Benzene was detected at a concentration of 710 micrograms per liter (ug/l) in the basement sump at 109 Bridge Street. As an interim response, the MDEQ-RRD placed two Aller Air carbon filter air purifying units in the partitioned basement of 109 North Bridge Street.

July 2014: The U.S. EPA screened the ambient indoor air conditions at 13 accessible properties along North and South Bridge Street, East and West Broad Street, and North Main Street. The air quality screening results identified the presence of benzene at 4 of the 13 addresses (106 South Bridge Street, 109 North Bridge Street, 211 North Bridge Street, and 132 East Broad Street). The U.S. EPA also collected a total of nine 24-hour duration bottle-vacuum air samples from 109 North Bridge Street (four samples), 208 North Bridge Street (three samples); and 132 East Broad Street (two samples). These samples were analyzed for the full-range of TO-15 VOCs. The concentrations of benzene in each of these samples exceeded the EPA Regional Screening Levels for industrial air (109 North Bridge Street and 132 East Broad Street) and residential air (208 North Bridge Street) of 1.6 $\mu g/m^3$ and 0.36 1.6 $\mu g/m^3$, respectively. Additionally, the concentrations of benzene in the north and south basements of 109 North Bridge Street and the exterior sample location of 132 East Broad Street exceeded the Minimal Risk Level for benzene, as provided in the Agency for Toxic Substances and Disease Registry (ATSDR). These results were made available to the MDEQ-RRD on July 21, 2014.

July 2014: The State of Michigan Licensing and Regulatory Affairs, Bureau of Fire Services-Storage Tank Division (LARA-BFS) inspected the Beacon & Bridge Market located at 110 East Broad Street. Beacon & Bridge Market is an operating retail gasoline station located at the southeast corner of the intersection of Bridge and Broad Streets. LARA-BFS representatives identified the presence of gas and water within a containment sump closest to Pump #1. The Owner/Operator of the facility was notified of the findings and advised of the statutory need to remove, evaluate, and repair the source of the gasoline leakage and subsequently perform an evaluation to assess the potential of a release. Currently, there are no unresolved confirmed release(s) reported for the four existing and nine former USTs associated with the Beacon & Bridge Market; however, a "suspected" release dated July 18, 2014 has been filed by MDEQ-RRD representatives based on the presence of gasoline within the sump of Pump #1.

3.0 WORK PLAN OBJECTIVES

The Work Plan Objectives were as follows:

- Review available documentation and perform municipal interviews (as deemed necessary) related to potential release sources and the conditions/locations/functionality of subsurface utilities in the vicinity of the study area.
- Perform prudent response actions necessary to mitigate indoor ambient vapor conditions within the nearby commercial structures along North Bridge St.
- Perform an evaluation of the storm sewer system to evaluate the potential for preferential migration of petroleum vapors or NAPL within the system.
- Complete a subsurface investigation designed to evaluate the up-gradient source(s) contributing to the petroleum vapor and subsurface conditions discovered within the immediate study area.
- Prepare a Technical Memorandum presenting the results of the evaluation activities and recommendations, if necessary for interim response activities.

4.0 SCOPE OF WORK

ECT completed the following scope of work to address the objectives of the Work Plan:

4.1 Pre-Assessment Activities

- Prepared a Site-Specific Health and Safety Plan (SSHSP) prior to implementation of field activities. The SSHSP was written to meet the requirements of the Occupational Safety and Health Administration Standard for Hazardous Waste and Emergency Response Operations (29 CFR 1910.120).
- Confirmed that the MDEQ-RRD had secured verbal site access agreements from the private property owner at 109 North Bridge Street and the City of Linden for road right-of-ways prior to initiating field activities. ECT also contacted MISS DIG prior to conducting the subsurface activities within the study area. Prior to the soil and groundwater sampling events, ECT personnel coordinated the sample container requisition and pick-up, and sample delivery with MDEQ State Laboratory representatives in accordance with current departmental requirements and procedures.
- Collected 10 indoor air samples at 109 North Bridge Street to assess time specific indoor air conditions and to evaluate the effectiveness of corrective action. At 109 North Bridge Street, samples were collected at three locations on the ground floor of the commercial building to assess the distribution of indoor air concentrations throughout the structure where patrons/occupants are typically present. Two air samples were also collected from the partitioned basement of the building after installation of a vapor mitigation system. Samples were collected from the ground floor locations using vacuum regulated summa canisters set to continuously accumulate indoor air for a predetermined period of 8 or 24 hours. Samples were collected from the basement using Bottle-vac samplers. The samples were submitted to the MDEQ State Laboratory for VOCs analyses.

- Based on the results of the indoor air sampling, which indicated that benzene was present in indoor air at 109 North Bridge Street at concentrations that exceed MDEQ generic cleanup criteria, the former presumptive remedy was replaced. The former remedy at 109 North Bridge Street consisted of two Aller Air Purifier units operating at 360 standard cubic feet per minute (scfm) each. The units were electric powered (110 Volt, 0.8 Amps) and hung from the ceiling in each of the two basements at this location, with the intent of exchanging air and adsorbing vapor phase contamination onto carbon filters housed in the units. The current remedy has been upgraded with a customized air mitigation system which seals the basement sumps and draws vapors directly from those sealed sumps through a network of PVC piping, whereby the vapors are directly vented without vapor treatment to the atmosphere via a vent pipe which terminates above the lowest point of the buildings existing roof line. Floor drains and cracks in the basement floor slab were also sealed to eliminate migration of vapors through these potential conduits.
- Reviewed available municipal construction documents, consulted with the City of Linden DPW Director, and contacted MISS DIG to further identify/locate all non-private subsurface utilities. ECT technical staff visually inspected storm water catch basins, manholes, and other structures (e.g., outfalls) to identify, to the extent feasible, connections between storm water catch basins. Seven aqueous samples were collected from select storm sewer catch basins observed to contain water within the study area. The samples were collected using a peristaltic pump operated from an above-grade position. Elevation data regarding catch basin grade elevations, structural invert elevations, and the depth-to-storm water surfaces were measured by ECT personnel at the time of sample collection. The samples were submitted to the MDEQ State Laboratory for VOCs analyses.
- Evaluated accessible storm water structures for the presence of petroleum vapors and gases using an IonScience 5000+ photoionization detector (PID) instrument and a combustible gas meter (QRAE II four gas detector). At 208 North Bridge Street, air samples were collected from a catch basin and manhole in the east right-of-way using Bottle-vac samplers. The samples were submitted to the MDEQ State Laboratory for VOCs analyses.
- Prepared a detailed site/study area diagram that can be used to import and plot existing site/adjacent property data including existing monitoring/sampling points, property boundaries, legally recorded easements, and physical facility features and elements applicable to this environmental study. ECT contacted the City of Linden DPW to procure elevation control data relevant to the storm sewer structures in the study area.

4.2 Initial Soil and Groundwater Assessment

The objectives of the soil and groundwater assessment were to:

- identify contaminant sources;
- identify and characterize contaminant migration pathways;
- assess the potential presence of NAPL using Sudan IV field screening test kits;
- quantify exposure risks and isolated sample hot spots; and,
- create a Conceptual Site Model (CSM) depicting the apparent study area conditions based on

assimilated data generated during the assessment efforts.

4.2.1 Task 1 - Study Area Soil and Groundwater Assessment

- Collected soil and groundwater samples at 20 soil boring locations, GP-1 through GP-20, using direct-push sampling methods. The borings ranged in depth from 10 to 20 feet below grade. The depth of each boring was contingent upon observed geologic/hydrogeologic conditions and VOC field screening and NAPL observations made at the time of soil boring completions.
- Field screen soil sample cores for ionizable VOCs using an IonScience 5000+ PID . The IonScience 5000+ had a minimum resolution of 0.1 part per billion (ppb) and was calibrated prior to usage.
- Screened the unsaturated or saturated soil sample with the highest PID response at each boring location for NAPL using a Sudan IV field screening test kit.
- Collected groundwater samples at 16 of the 20 soil boring locations using temporary wells constructed with 5-foot long, 1-inch diameter PVC well screens and 1-inch diameter riser pipe.
- Retained a total of 29 soil samples and 18 groundwater samples (including two QA/QC samples) retrieved during boring installation for MDEQ State Laboratory VOCs and (at locations selected by the MDEQ Project Manager) semi-volatile organic compounds (SVOCs) analyses.

4.2.2 Task 2 -Temporary Groundwater Monitoring Wells

Installed and developed six temporary groundwater monitoring wells at the locations of borings GP-1, GP-9, GP-13, GP-15, GP-16 and GP-19 to provide a means for periodic groundwater sampling at these locations.

4.2.3 Task 3 - Site Survey

Surveyed storm water catch basins, ground surface elevations and temporary well casing elevations to the nearest 0.01 foot relative to a bench mark established by the city of Linden. The latitude and longitude of storm water catch basins and soil borings were obtained using a hand held GPS.

4.2.4 Task 4 - Groundwater Quality Sampling

- Collected groundwater elevation and, where present, LNAPL thickness measurements at the six temporary monitoring well locations.
- Collected water level measurements at select storm water catch basin locations.
- Collected groundwater quality samples at five of the temporary well locations and seven storm water catch basin locations. The samples were submitted to the MDEQ State Laboratory for VOCs analyses.

4.2.5 Task 5 - Technical Memorandum

This Technical Memorandum inclusive of a CSM has been prepared to document the work efforts described herein. This document includes the following:

- Text describing the monitoring and sampling activities, field methodologies/procedures employed, and interim response actions undertaken;
- A preliminary exposure pathway evaluation incorporating the objectives of the investigation (see Section 4.2);
- Supporting data including copies of all soil boring/monitoring well logs, IDW profiles/manifests, relevant ECT field data forms completed concurrent with the monitoring/sampling efforts and laboratory analytical results;
- Tabulated versions of the soil, vapor and groundwater data compared to current MDEQ Part 213 Tier 1 Risk-Based Screening Levels;
- A CSM depicting apparent study area conditions;
- A series of scaled diagrams to accurately depict study area features (including USTs, UST system components and subsurface utilities), suspected release location(s), potential receptors, migration pathways identified, sample locations, local geology, contaminant concentrations referenced to sample locations and contaminant iso-concentration contours, if appropriate. Preliminary and estimates of the volume of soil and/or groundwater impact that exhibits a particular risk for all applicable exposure pathways; and,
- Recommendations for the implementation of additional site characterization and interim response activities that would cost effectively mitigate further exposure risks.

5.0 SAMPLING METHODS/PROCEDURES

5.1 Soil Sampling Procedures

From July 30, 2014 through August 1, 2014, ECT and North American Probing Services installed 20 soil borings, GP-1 through GP-20, at the locations shown on Figure 2. With the exception of GP-18, all borings were completed in municipal right-of-ways or on city-owned property. ECT was given verbal permission by the owner to perform GP-18 on privately owned property.

Continuous soil samples were collected at each soil boring location from the ground surface to the boring terminus. Following the retrieval of each soil sample core, soil samples were logged by qualified ECT technical staff in accordance with the Unified Soil Classification System (USCS) and field screened for ionizable VOCs using a IonScience 5000+ PID. The PID had a minimum detection limit of one part per billion (ppb) and was calibrated prior to usage.

The total depth of each boring was determined based upon observed subsurface soil conditions, evidence of impact and the presence of shallow groundwater. The soil borings were advanced to depths ranging from 10 to 20 feet below grade. Discrete soil samples were retained for laboratory analyses. Soil samples were selected from the interval(s) of the core that exhibit the highest PID readings and/or an unsaturated sample obtained from above the apparent vadose zone/saturated interface. At several boring locations samples of unsaturated clay soils encountered at the terminal depth of borings were collected for evaluation of the vertical extent of impact.

Soil samples selected for laboratory analyses were preserved in the field with methanol in accordance with U.S. EPA Method 5035, placed on ice in a cooler for storage and subsequent transportation to the MDEQ State Laboratory. The soil samples were submitted under chain of custody (COC) documentation for VOCs and/or SVOCs analyses using U.S. EPA SW846, Method 8260B and/or 8270.

Upon completion of the soil/groundwater sampling activities at each boring location, down-hole drilling/sampling tools were retracted from the ground, and the open boring was sealed with granular bentonite and finished at grade to match the surrounding materials at each respective soil boring location (e.g., topsoil/seed, bituminous patch, concrete or gravel).

The horizontal location of each boring (to the nearest foot) was determined in reference to the property's existing building and/or other fixed relevant facility features, which provided a means for developing a reliable base map.

To reduce the potential for cross-contamination between drilling locations, drilling and sampling equipment (e.g., core samplers, sampling rods) were properly decontaminated in accordance with standard field procedures. Investigative derived wastes (IDWs) generated during the drilling/assessment activities were placed into 55-gallon steel drums and are temporarily staged on pallets in the City of Linden municipal parking lot located in the northern portion of the study area awaiting waste characterization analyses and coordination of disposal arrangements.

5.2 Groundwater Sampling Procedures

Based upon geologic and hydrogeologic observations, groundwater samples were collected at 19 boring locations during drilling. Groundwater samples were collected concurrent with direct-push soil sampling efforts through a retractable well screen or 1-inch diameter wells which were temporarily installed at, or just below the groundwater/vadose soil interface (no deeper than five feet below the vadose/groundwater interface). Prior to groundwater sample collection, groundwater was purged using a peristaltic pump to develop the screened interval. Following evacuation of the purge water, a groundwater sample was collected in pre-labeled/preserved laboratory provided jars/vials and placed on ice in a cooler for storage and subsequent transportation to the MDEQ State Laboratory. Groundwater samples were submitted to the MDEQ State Laboratory under COC documentation for VOCs and, at some locations, SVOCs analyses using U.S. EPA SW846, Method 8260B and 8270; respectively.

ECT installed temporary groundwater monitoring wells for additional sampling or LNAPL thickness measurements at six boring locations, GP-1, GP-9, GP-13, GP-15, GP-16 and GP19 shown on Figure 2. The temporary monitoring wells were constructed using one-inch diameter, Schedule 40 polyvinyl chloride (PVC) casing and a five-foot long, #10 slotted PVC screen. The annular space between the well screen and borehole was filled with pre-sorted filter sand from the terminus of the borehole to approximately one foot above the top of the well screen. A granular bentonite seal was placed above the filter sand to approximately 1½ feet below surface grade. Each temporary well-head was then completed as a flush-to-surface vault with a threaded PVC cover. Completed temporary monitoring wells were developed by purging while monitoring recovered groundwater clarity.

During the scheduled groundwater monitoring/sampling activities, each monitoring well was accessed and allowed to vent prior to obtaining depth-to-groundwater measurements to avoid the collection of erroneous groundwater data caused by accumulated vapor pressure or a vacuum within a sealed well casing. An electronic dual-phase groundwater level meter was used to measure the depth-to-groundwater and the thickness of any NAPL present.
Low-flow or minimal drawdown techniques were used to sample the temporary wells in which NAPL was not present. At each well location, the intake tubing was placed at a mid-screen elevation during stabilization purging and sample collection. Disposable/dedicated tubing was used at each location to minimize the possibility of cross-contamination between sampling locations.

Peristaltic sampling pumps were used for purging and sampling at temporary monitoring well locations and storm sewer structures. After the pump was in-place and prior to purging, groundwater levels were measured from the top-of-casing using an electric tape and recorded to the nearest 0.01 foot. The water level tape was left in-place during purging and sampling to monitor groundwater level drawdown. The measurement probe was washed with non-phosphate detergent solution and rinsed with fresh water prior to insertion into each sampling location/monitoring well.

Pumping rates were maintained from the lowest sustainable pumping rate to no more than 500 ml/min. Well-specific pumping rates were determined by monitoring groundwater levels during purging and adjusting the pumping rate to stabilize the drawdown at a practical minimum above the top of the well screen at wells with fully submersed screens. At one location, GP-13, drawdown could not be stabilized at the lowest sustainable pumping rate, so purging was discontinued and the well was allowed to recover enough to obtain the required sample volume.

Stabilization parameters (dissolved oxygen [DO], pH, specific conductance, oxidation/reduction potential [ORP], turbidity, and temperature) were measured using a flow-through cell with calibrated sensing probes and real time readouts. The measurements were recorded on field sampling sheets which are included in Appendix A. The stabilization parameters were recorded at intervals of five or greater minutes until the variations in parameters stabilize to:

pH	±0.1 unit
DO	±10% for values greater than 0.5 mg/l, if three Dissolved Oxygen values are less than 0.5 mg/l, consider the values as stabilized
Specific Conductivity	±3%
ORP	±10 mV
Turbidity	10% for values greater than 5 NTU, if three Turbidity values are less than 5 NTU, consider the values as stabilized
Temperature	±3%

After stabilization (or well recovery in the case of low-yield wells), samples were collected upstream of the flow-through cell to eliminate possible residual contamination from the cell vessel. All groundwater samples were placed in laboratory provided/field-preserved (as required) containers, labeled, and put in an iced cooler immediately after collection. Purged water evacuated at each location was handled in accordance with the MDEQ-WMD, May 14, 1999 "Operational Memorandum GEN-10, Revision 1," placed into 55-gallon steel drums and staged in the designated temporary storage area awaiting waste characterization analyses and disposal arrangements.

5.3 Indoor Air Sampling Procedures

On July 27 and 28, 2014, ECT collected the following indoor air samples at 109 North Bridge Street to obtain quantifiable results for comparison to Acceptable Indoor Air Values for Vapor Intrusion:

- One 8-hour summa canister sample and one 24-hour summa canister sample collected from the south counter of the ground floor retail space.
- One 8-hour summa canister sample and one 24-hour summa canister sample collected from the ground floor office.
- One 24-hour summa canister sample from the front desk area of the ground floor retail space.

During this sampling all windows and doors were closed, heating ventilation & air conditioning systems (HVAC) remained off, and the facility was void of all workers and operating equipment, to obtain the best representation of potential off-gassing VOCs. These samples were collected and evaluated for VOCs by U.S. EPA Method TO-15 via summa canister.

On August 20 and 21, 2014, ECT collected the following indoor air samples at 109 North Bridge Street to obtain quantifiable results for comparison to Acceptable Indoor Air Values for Vapor Intrusion:

- One 24-hour summa canister sample collected from the south counter of the ground floor retail space.
- One 24-hour summa canister sample collected from the ground floor office.
- One 24-hour summa canister sample from the front desk area of the ground floor retail space.
- One bottle vac sample collected immediately above the south basement sump, and
- One bottle vac sample collected immediately above the north basement sump.

On August 20, 2014, ECT also collected bottle vac samples from the storm water catch basin (CB-2 in Figure 3) and manhole located in the Bridge Street right-of-way adjoining 208 North Bridge Street.

5.4 Quality Control Samples

Additional samples were collected to ensure the precision and accuracy of the sampling methods, equipment, and laboratory analyses. Quality assurance/quality control samples included duplicate samples, field blanks, and trip blanks.

5.5 Chain of Custody Procedures

Each sample was logged on a COC form that was maintained throughout the sample collection efforts. The COC accompanied each sample following collection, during transportation, storage, and receipt at the MDEQ's State Laboratory. Laboratory personnel recorded the time and signed the form upon sample receipt. The form contains sample identification, analysis assignments, date and time of collection, and names of sampling personnel.

5.6 Elevation Survey

On August 8, 2014, ECT completed an elevation survey for the following locations:

- Ground surface elevations at 20 soil boring locations
- Top of casing elevations at five temporary well locations
- Rim or high point elevations at 19 storm water catch basin locations
- Ground floor, basement floor and sump bottom elevations at 109 North Bridge Street
- Bridge deck and Shiawassee River elevations

Using a City of Linden benchmark at the corner of Bridge and Broad Streets, ECT measured elevations to the nearest 0.01 foot. Each measurement was included in a closed loop that started and ended with the City of Linden benchmark.

5.7 Vapor Mitigation System

On August 8, 2014, Compliance, Inc. (Compliance) of Brighton, Michigan upgraded the air mitigation remedy in the partitioned basement of 109 North Bridge Street. The upgrade consisted of a customized air mitigation system which seals the basement sumps and draws vapors directly from those sealed sumps through a network of PVC piping, whereby the vapors are directly vented without vapor treatment to the atmosphere via a vent pipe which terminates above the lowest point of the buildings existing roof line. Floor drains and cracks in the basement floor slab were also sealed to eliminate migration of vapors through these potential conduits. In August 2014, the MDEQ-RRD removed the previously installed Aller Air carbon filter air purifying units from the partitioned basement.

6.0 FINDINGS

The findings of ECT's evaluation and corrective action activities are summarized in the following sections. Section 6.1 is a description of hydrogeological attributes of the area of study. Section 6.2 is a discussion of the analytical results of soil, groundwater, and air sampling and how the contaminant distribution relates to sources, exposure pathways and environmental risk.

6.1 Hydrogeological Conditions

The study area is located in an area of glacial outwash and post-glacial alluvium south of the Shiawassee River and southwest of the City of Linden Mill Pond. Glacial deposits are underlain by the Mississippian aged Michigan Formation which is comprised of inter-bedded sandstone, limestone and shale. According to available United States Geological Survey (USGS) databases, groundwater flow in the study area is toward the Shiawassee River to the north-northwest. The lithologic profile for the nearest available water well record identified a 15 foot sand layer underlain by 65 feet of clay and gravel and at least 60 feet of sandstone.

6.1.1 Shallow Geology

Boring logs depicting subsurface conditions observed at 20 soil boring locations are attached in Appendix B.

Figure 3 is a cross section location map for cross sections prepared from the boring logs and site survey. Figures 4, 5, 6, and 7 are cross sections constructed parallel and perpendicular to the apparent direction of groundwater flow. As shown on Figure 4, cross section A – A', a west to east cross section through the Property located at 109 North Bridge Street, the soil conditions below surficial paving materials consist of varying thicknesses of sand underlain by natural clay. A continuous 3- to 7-foot thick gravel layer is present within the clay stratum at depths ranging from 5 to 10 feet below grade. The sump in the basement of 109 Bridge Street is interpreted to intercept the gravel layer.

As shown on Figure 5, cross section B-B', a south to north cross section through 109 North Bridge Street, soil conditions south of the intersection of Bridge and Broad Streets consist of approximately 12 to 14 feet of sand generally underlain by a one- to two-feet thick gravel layer which in turn is underlain by natural clay. North of the intersection (at GP-1), the clay stratum is encountered at shallower depths and the gravel layer pinches out within the clay stratum north of 109 North Bridge Street. As shown on Figure 6, cross section C-C', a west to east cross section along Broad Street, approximately 10 to 15 feet of sand is underlain by approximately 1 to 4 feet of gravel which is in turn underlain by clay.

Figure 7 shows a south/north cross-section extending along the east Bridge Street right-of-way and includes the depiction of a 12-inch vitrified pipe storm sewer, reported by the City of Linden DPW director, extending parallel to, and in the Bridge Street right-of-way. The D–D' cross section indicates a fingering and significant thinning of the more permeable sand and gravel layers at the northern extent of the area of study. Based on the available information, the backfilled utility corridor containing the 12-inch sewer may intersect the thinning gravel layer and become a preferred groundwater flow pathway.

Figure 8 depicts the depth to clay observed in the study area. As shown on Figure 8, the glacial clay deposit is shallowest in the area north of Broad Street where a glacial clay mound is interpreted.

Evidence of hydrocarbon impact consisting of detectable PID readings, staining and hydrocarbon odors was observed at 14 of the 20 borings completed in the study area. North of Broad Street, evidence of petroleum impact was greatest in the gravel layer described above. At the intersection of Bridge and Broad Streets, evidence of petroleum impacts was greatest at the water table. Evidence of LNAPL was observed during drilling at borings GP-3, GP-9, GP-10, GP-14, GP-15 and GP-17 (refer to Section 6.1.3). No evidence of NAPL impact was observed during drilling at GP-5, GP-6, GP-8. GP-16, GP-18, GP-19 and GP-20.

6.1.2 Groundwater Occurrence and Movement

Figure 3 is a cross section location map for cross sections prepared from the boring logs and site survey. Figures 11, 12, 13, and 14 are cross sections constructed parallel and perpendicular to the apparent direction of groundwater flow. At 19 of the 20 soil boring locations, groundwater was encountered at depths ranging from 5.5 to 10 feet below grade during drilling. Groundwater was not observed to the explored depth of 20 feet below grade at GP-20, the northernmost boring completed in the municipal parking lot south of the Shiawassee River.

Temporary wells were installed at six locations in the study area, GP-1, GP-9, GP-13, GP-15, and GP-19. Groundwater elevation measurements collected on August 8, 2014 and August 21, 2014 are summarized on Tables 1. Figures 9 and 10 depict groundwater elevation contours prepared using the August 8, 2014 and August 21, 2014 elevation measurements, respectively. As shown on Figures 9 and 10**,** groundwater flow in the study area is toward the northwest. The hydraulic gradient calculated from groundwater elevation measurements collected on August 8, 2014 is 0.007 ft/ft. Using a porosity of 0.25 and a hydraulic conductivity of 10^2 ft/day (coarse sand or fine gravel), a linear velocity of flow in the study area of 2.8 feet per day was calculated. On August 8, 2014, the elevation of the Shiawassee River at Bridge Street was 853.88 and the elevation of the impoundment was 868.79.

As shown on cross section A – A' (Figure11), groundwater flows through an approximately 3-foot thick gravel layer that is present below 109 North Bridge Street. Using Darcy's law and a 230-square foot cross sectional area, the flux of contaminated groundwater flow below 109 North Bridge Street is estimated to be about 1,200 gallons per day.

As shown on the boring logs (Appendix B) and Figure 12 groundwater flow in the southern portion of the study area is unconfined. Groundwater flow in the area where shallow glacial clays are encountered in the northern portion of the study area is confined.

The following factors likely influence groundwater flow in the study area:

- The presence of glacial clay and the apparent absence of a saturated sand or gravel layer to a depth of 20 feet below grade in the area south of the Shiawassee River; and
- The presence of sumps and sewers below the depth of saturated strata.

6.2 Analytical Results and Contaminant Distribution

The results of the analytical testing results for soil, groundwater and ambient air are summarized on Tables 3 through 7 and described in detail in the following sections. Analytical laboratory reports are attached for reference in Appendix C. Appendix D contains tabulated historical sampling results which have been incorporated in Figures 7 and 14.

6.2.1 NAPL Conditions

Visible NAPL was observed in soil cores recovered during drilling at soil borings GP-3 (9 feet below grade) and GP-15 (10 feet below grade). Positive dye testing results confirmed the presence of NAPL at GP-9 (9.5 to 10 feet below grade), GP-10 (10 feet below grade), GP-14 (9.5 feet below grade), GP-15 (10.5 feet below grade) and GP-17 (13 to 14 feet below grade). Soil samples containing one or more constituents at concentrations exceeding soil saturation (Csat) screening levels (refer to Section 6.2.2) were identified at GP-3 (7 – 8'), GP-10 (10'), GP-14 (10') and GP-15. During groundwater elevation measurement on August 8, 2014, 0.07 feet of LNAPL was observed in the temporary well installed at GP-15, adjacent to the existing UST systems at 110 East Broad Street. No exceedances of constituent solubility values were identified by groundwater analyses.

With the exception of LNAPL detected floating on groundwater at GP-15, the NAPL occurrences are related to visual observations during boring, shaker dye tests, and analytical soil concentrations

that appear to be below the water table elevation at the time of investigation as indicated on the cross sections. In light of this, the occurrence of NAPL will only be referred to as LNAPL in association with the floating layer detected at GP-15; otherwise it will be noted simply as NAPL.

As shown on Figure 4 (Cross Section A-A'), NAPL is present within the continuous gravel layer at a location within 65 feet of 109 North Bridge Street. As shown on Figure 5 (Cross Section B-B'), NAPL is interpreted to be present in the vicinity of the existing USTs located at 110 East Broad Street. As shown on Figure 6 (Cross Section C-C'), the NAPL in the vicinity of the USTs at 110 East Broad Street is indicated to extend below Bridge Street to the west.

Review of historical documents indicated the presence of LNAPL in the basement of the former residence located at 122 North Bridge Street, approximately 150 feet north of the intersection of Bridge and Broad Streets. Concentrations of constituents of concern detected in two soil samples collected from borings completed on the vacant lot at the northeast corner of the intersection (Figure 7, Atwell, LLC borings AB-4 and AB-6) are indicative of residual NAPL saturation.

The estimated extent of residual NAPL saturation, including mobile LNAPL is shown on Figure 15. Although not completely delineated, the NAPL is interpreted to cover an area of at least 15,000 square feet and extends from the intersection of Bridge and Broad Streets at least 80 feet to the north to GP-3. Historically, LNAPL has been found at a former residence 150 feet north of the intersection. The estimated thickness of the NAPL saturation is interpreted to range from approximately 1 to 5 feet. These estimates are based on NAPL observations during drilling, soil boring log observations from previous investigations, and the historical account of NAPL at the former 122 North Bridge Street residence. The completion of the extent of contamination delineation may change the estimated extent of residual and mobile NAPL from that represented on Figure 15.

6.2.2 Soil Analytical Results

Soil analytical testing results compared to Part 201 generic residential cleanup criteria are summarized on Table 2. Table 6 is a list of the maximum concentrations detected in soil. Appendix C contains the Atwell, LLC sampling results from October 2012.. In addition, concentrations of BTEX and total VOCs in individual soil samples are depicted on cross sections presented as Figures 4 through 7. Figure 16 is a benzene iso-concentration contour diagram prepared from analytical soil testing results.

<u>VOCs</u>
Excluding dibromodifluoromethane, which was detected in the trip blank, one or more VOC constituents were detected in 12 of the 29 soil samples submitted for analyses. In 11 of the 12 samples where VOCs were detected, one or more of the VOC constituents detected exceed Part 201 generic residential cleanup criteria. North of the intersection and west of Bridge Street, only benzene, ethylbenzene and n-propylbenzene were detected (again, excluding dibromodifluoromethane). A broader spectrum of VOC impacts were identified in soil samples east of Bridge Street, both north and south of Broad Street. As shown on Table 6, the maximum concentrations of detected constituents were identified at either GP-10 or GP-15, both located southeast of the intersection, proximal to the USTs at 110 East Broad Street.

As shown on Figures 4 through 7, significant soil impacts were identified at the water table in the southeast and northeast of the intersection of Bridge and Broad Streets. The soil impacts are generally confined to granular soils above the natural clay stratum which does not appear to be significantly impacted. Figure 16 depicts benzene concentrations in impacted soil samples. As shown on Figure 16, the highest concentrations of benzene were detected southeast of the intersection and are associated with both the occurrence of NAPL and the aforementioned USTs.

The extent of soil impacts above Part 201 generic residential criteria has not been fully delineated.

SVOCs

Eighteen of the 29 soil samples submitted for VOCs analysis were also analyzed for SVOCs. Excluding, nitrobenezene-d5 which was detected in each of the samples, naphthalene and 2-methylnaphthalene were detected at concentrations exceeding one or more Part 201 generic residential cleanup criteria in 5 of the 18 samples submitted for SVOCs analyses. Low concentrations of phenanthrene were detected in two of the 18 soil samples.

6.2.3 Groundwater Analytical Results

Groundwater analytical testing results compared to Part 201 generic residential cleanup criteria are summarized on Table 3. In addition, concentrations of BTEX and total VOCs in individual groundwater samples are depicted on cross sections presented as Figures 11 through 14. Figure 17 is a benzene iso-concentration contour diagram prepared from analytical groundwater testing results. Low flow sampling notes (Appendix A) indicate that outside the area of groundwater impacts (GP-16 and GP-19), groundwater is aerobic with positive ORP values. In the area of groundwater impacts (GP-1, GP-9 and GP-13) groundwater is anaerobic and has negative ORP values.

VOCs

VOCs were not detected at or above laboratory reporting limits in water samples collected from storm water catch basins CBs-2, 7, 16, 18, 23, 26, or 29 in the study area on August 28, 2014. Laboratory report 1408307 in Appendix C shows results and Figure 2.

One or more VOC constituents were detected in 22 of the 25 groundwater samples collected during drilling and subsequent temporary well sampling. In 15 of the 22 samples where VOCs were detected, one or more of the VOC constituents detected exceed Part 201 generic residential cleanup criteria. The maximum concentrations of VOCs detected in groundwater are summarized on Table 7. As shown on Table 7, the maximum concentrations of detected constituents were identified at either GP-3 located north of the intersection of Bridge and Broad Streets or at temporary wells GP-8, GP-9, GP-10 and GP-14 located southeast of the intersection. With the exception of GP-8 (maximum MTBE concentration), these sample locations correspond to borings where evidence of NAPL saturation was identified.

As shown on Figures 11 through 14, significant groundwater impacts are present southeast and northeast of the intersection of Bridge and Broad Street in the proximity of areas of NAPL saturation. The benzene concentrations depicted on Figure 17, indicate the source of the benzene concentrations in groundwater is located southeast of the intersection. The elevated VOC concentrations and NAPL occurrence associated with the property at 110 East Broad are again noted. In addition there appears to be an older residual source area located on the now vacated

parcel northeast of the intersection of Bridge and Broad Streets. Along with the physical separation from the current 110 East Broad Street associated source, the contaminant fingerprint appears more xylene dominant suggesting more mature source.
The extent of groundwater impacts above Part 201 generic residential criteria has not been fully delineated.

SVOCs
Eleven of the 25 groundwater samples submitted for VOCs analysis were also analyzed for SVOCs. Excluding, nitrobenezene-d5 which was detected in each of the samples, one or more SVOCs, predominantly naphthalene and 2-methylnaphthalene, were detected at concentrations exceeding one or more Part 201 generic residential cleanup criteria in 8 of the 11 samples submitted for SVOCs analyses.

6.2.4 Indoor Air Analytical Results

Field screening of ambient air in catch basins in the study did not identify any lower explosive limit (LEL) indicative of an explosion risk.

The analytical testing results for the five 8-hr and 24-hr ambient air samples collected from 109 North Bridge Street during July 2014 and August, before and after installation of the vapor collection system, respectively, are summarized on Table 4. As shown on Table 4 the concentrations of benzene detected before the installation of the vapor collection system in the five samples ranged from 22 to 38 ug/m^3 exceeding the 3.3 ug/m^3 Vapor Intrusion Indoor Air Screening Level but below the draft Immediate Response Acute Vapor Intrusion Screening Levels (IRASLs). After the collection system was installed all of the sample results are below the Vapor Intrusion Indoor Air Screening Levels, indicating the effectiveness of the remedy.

The analytical results for the two bottle vac samples collected from the storm water catch basin, CB-2, and manhole in the Bridge Street right-of-way adjoining 208 North Bridge Street are summarized on Table 5. As shown on Table 6, the concentrations of 1,3-dichlorobenzene, benzene and, at CB-2 hexane, detected exceed the respective Vapor Intrusion Indoor Air Screening Levels. There are no established IRASLs reported for 1,3-dichlorobenzene and hexane. However, the concentrations of benzene in the samples are below the draft IRASL.

Figure 7 shows a south/north cross-section extending along the east Bridge Street right-of-way and includes the depiction of a 12-inch vitrified pipe storm sewer reported by the City of Linden DPW director extending parallel to, and in the Bridge Street right-of-way. An attempt made by the DPW to send a tracked video camera through the 12-inch sewer, both south from a structure near CB-2 s, and north from a structure near CB-13, failed because the pipe was blocked from both directions. While there are no permanent well/piezometers available and the 12-inch sewer invert is assumed, using the observation depths to groundwater during boring GPs-4 the 6 it appears that the water table is below the sewer invert, i.e., impacted groundwater is not likely infiltrating the sewer. However, the backfilled sewer corridor may be a preferential migration pathway for soil vapors emanating from the residual source area(s) and might be the cause of the detection of VOCs in air collected from catch basin (CB-2) and a manhole structures immediate to 208 North Bridge and indoor air samples collected by the EPA in July 2014 inside the building at 208 North Bridge.

6.3 Conceptual Site Model

Field observations during drilling, review of soil boring logs, and analytical testing results indicate that a release of LNAPL occurred in the study area. Based on unsaturated soil concentrations and observations of mobile LNAPL at GP-15, NAPL saturation appears to originate in soils southeast of the intersection of Bridge and Broad Streets (e.g., GP-9, GP-15). Residual NAPL saturation is present at the water table in saturated sand and gravel north of Broad Street and east of Bridge Street. Dissolved phase VOCs are migrating from the area of residual NAPL saturation to the northwest and periodically along the sanitary and storm sewer to the north.. The gravel layer which pinches out within natural clays to the northwest appears to be the preferential migration pathway for the dissolved phase plume west of Bridge Street. VOCs in the groundwater have migrated into the basements of occupied structures west of Bridge Street.

Figure 18 is a pathway and receptor analysis prepared in accordance with ASTM E1739-95 (2010). Tables 6 and 7 summarize, respectively, the maximum concentrations of COCs detected in soil and groundwater. Review of Figure 18 and Table 6 (maximum soil), indicates that relevant and applicable exposure pathways for VOC impacted soil are as follows:

- Soil leaching to groundwater and migration to a drinking water receptor
- Soil leaching to a groundwater and migration to a GSI receptor
- Soil volatilization to an indoor air inhalation receptor
- Soil volatilization to an ambient air inhalation receptor
- Soil direct contact

Review of Figure 18 and Table 7 (maximum groundwater) indicates that relevant and applicable exposure pathways for VOC impacted groundwater are as follows:

- Groundwater migration to a drinking water receptor
- Groundwater migration to a GSI receptor
- Groundwater volatilization to indoor air inhalation receptor

Exposures are presently mitigated by the following factors:

- Impacted soil is indicated to be greater than five feet deep so that surficial pavements and non-impacted soils serve as an exposure barrier.
- The site and surrounding area are served by municipal water supply.
- The dissolve phase plume does not appear to be reaching the Shiawassee River in the study area. We did not find boring data that shows a pathway to the river; however, odor and citizen observations indicate the migration pathway associated with the sewers, appears to impact the river periodically.
- A vapor mitigation system has been successfully installed in a building where potential inhalation exposure was identified.

There are no land or resource use restrictions in-place in the study area which would prevent the installation of a potable water well or identify precautions which should be followed during earthwork activities. In addition, the extent of the release has not been fully delineated such that all

exposures can be assessed and mitigated.

7.0 CONCLUSIONS

ECT has completed a time critical evaluation of soil, groundwater and ambient air in the vicinity of the intersection of Bridge and Broad Streets in downtown Linden, Michigan. Based on the findings presented in Section 6.0 and 7.0, ECT has prepared the following conclusions:

Geological Profile

- Subsurface soil conditions consist of varying thicknesses of sand underlain by gravel and/or natural clay to 20 feet.
- North of the intersection of Bridge and Broad Streets the natural clay is encountered at shallower depths and the gravel layer pinches out within the clay stratum.
- The sump in the basement of 109 Bridge Street intercepts the gravel layer.
- Evidence of hydrocarbon impact consisting of detectable PID readings, staining and hydrocarbon odors was observed at 14 of the 20 borings completed in the study area. North of Broad Street, evidence of petroleum impact was greatest in the gravel layer described above. At the intersection of Broad and Bridge Streets, evidence of petroleum impacts was greatest at the water table.
- Evidence of LNAPL was observed during drilling at six borings locations.

Groundwater Occurrence and Movement

- Groundwater was encountered at depths ranging from 5.5 to 10 feet below grade during drilling at 19 of the 20 soil boring locations. Groundwater was not observed at GP-20, the northernmost boring completed in the municipal parking lot south of the Shiawassee River.
- Groundwater flow in the study area is toward the northwest with an estimated hydraulic gradient of 0.007 ft/ft.
- The estimated linear velocity of groundwater flow through saturated gravel in the study area was estimated at about 3 feet per day.
- An estimated 1,200 gallons per day of contaminated groundwater flows below 109 North Bridge Street.
- Groundwater flow in the southern portion of the study area is unconfined. Groundwater flow in the area where shallow glacial clays are encountered in the northern portion of the study area is confined.
- Low flow sampling notes indicate that outside the area of groundwater impacts, groundwater is aerobic with positive ORP values. In the area of groundwater impacts, groundwater is anaerobic and has negative ORP values.

NAPL Occurrence

- Visual and analytical evidence of NAPL saturation was observed at 6 of the 20 soil boring locations. Five of the 6 locations were south of the intersection of Bridge and Broad Streets. One of the locations, GP-3, was northeast of the intersection of Bridge and Broad Streets.
- Approximately 0.07 feet of mobile LNAPL was present in temporary well GP-15, located

southeast of the intersection of Bridge and Broad Streets. The temporary well was located in the right-of-way of Bridge Street adjacent to existing UST systems at 110 East Broad Street.

- Historical evaluations identified NAPL saturation on properties northeast of the intersection of Bridge and Broad Streets.
- The area of residual NAPL saturation has not been completely delineated.

Vapor Migration

- Storm water conveyances are indicated to be acting as conduits for vapor migration in the vicinity of 208 North Bridge Street.
- Field screening results for LEL did not identify conditions within catch basins that are indicative of an explosion hazard.
- NAPL saturation in the subsurface appears to be the source of VOCs which volatilize from impacted media and migrate to potential receptors.
- Contaminated groundwater that accumulates in the basement sumps is indicated to be the sources of VOCs in the commercial building at 109 North Bridge Street.
- The reported storm sewer utility corridor extending along the east right-of-way of North Bridge Street may be a migration pathway for soil vapors previously detected in the building at 208 North Bridge Street

Soil Sample Laboratory Analyses

- VOC constituents were detected in 12 of the 29 soil samples submitted for analyses.
- In 11 of the 12 samples where VOCs were detected, one or more of the VOC constituents detected exceed Part 201 generic residential cleanup criteria.
- North of the intersection and west of Bridge Street, only benzene, ethylbenzene and n-propylbenzene were detected.
- A broader spectrum of VOC impacts were identified in soil samples east of Bridge Street, both north and south of Broad Street. The maximum concentrations of VOCs detected in soil were identified southeast of the intersection of Bridge and Broad Streets.
- The extent of soil impacts above Part 201 generic residential criteria has not been fully delineated.

Groundwater Sample Laboratory Analyses

- One or more VOC constituents were detected in 22 of the 25 groundwater samples collected during drilling and subsequent temporary well sampling and submitted for analyses. In 15 of the 22 samples where VOCs were detected, one or more of the VOC constituents detected exceed Part 201 generic residential cleanup criteria.
- VOCs were not detected at or above laboratory reporting limits in the seven groundwater samples collected from the storm water catch basins in the study area on August 28, 2014.
- The maximum concentrations of VOCs detected in groundwater were identified at either GP-3 located north of the intersection of Bridge and Broad Streets or at temporary wells GP-8, GP-9, GP-10 and GP-14 located southeast of the intersection. With the exception of GP-8 (maximum MTBE concentration), these sample locations correspond to borings

where evidence of residual NAPL saturation was identified. The contaminant fingerprint is xylene-dominant at GP-3 suggesting an, older source than that currently indicated at 110 East Broad Street.

- The extent of groundwater impacts above Part 201 generic residential criteria has not been fully delineated.

Air Laboratory Analyses

- Prior to corrective action upgrade at 109 North Bridge Street, the analytical testing results for the five 8-hr and 24-hr indoor air samples collected from 109 North Bridge Street on July 27 and 28, 2014, indicate concentrations of benzene above the 3.3 ug/m^3 Vapor Intrusion Indoor Air Screening Level but well below the draft Immediate Response Acute Vapor Intrusion Screening Levels (IRASLs).
- The analytical testing results for the three 24-hr and two bottle vac indoor air samples collected from 109 North Bridge Street during August 2014, after installation of the vapor collection system, indicate that the concentrations of VOCs detected in these indoor air samples are all below Vapor Intrusion Indoor Air Screening Levels.
- The analytical testing results for the two bottle vac samples collected from the storm water catch basin, CB-2, and manhole in the Bridge Street right-of-way adjoining 208 North Bridge Street, indicate that the concentrations of 1,3-dichlorobenzene, benzene and, at CB-2, hexane exceed the respective Vapor Intrusion Indoor Air Screening Levels. There are no established IRASLs reported for 1,3-dichlorobenzene and hexane. However, the concentrations of benzene in the samples are below the draft IRASL.
- The composition of the VOCs detected in ambient air samples is indicative of a petroleum hydrocarbon source.

Conceptual Site Model

- A release of LNAPL occurred in the study area. Based on unsaturated soil concentrations and observations of mobile LNAPL at GP-15, residual NAPL saturation appears to originate in soils southeast of the intersection of Bridge and Broad Streets, proximal to the location of the existing USTs at 110 East Broad Street.
- An area of residual NAPL saturation is present at the water table in saturated sand and gravel north of Broad Street and east of Bridge Street.
- Dissolved phase VOCs are migrating from the area of residual NAPL saturation to the northwest.
- The gravel layer which pinches out within natural clays to the northwest appears to be the preferential migration pathway for the dissolved phase plume west of Bridge Street.
- VOCs in the groundwater have migrated into the basements of occupied structures west of Bridge Street.
- Analyses of soil and groundwater samples indicate the potential for drinking water, GSI, inhalation and direct contact exposures.
- Exposures are presently mitigated by the following factors:
  - Impacted soil is indicated to be greater than five feet deep so that surficial pavements and non-impacted soils serve as an exposure barrier.
  - The site and surrounding area are served by municipal water supply.

- The dissolve phase plume does not appear to be reaching the Shiawassee River in the study area
- A vapor mitigation system has been successfully installed in a building where potential inhalation exposure was identified.

- There are no land or resource use restriction in-place in the study area which would prevent the installation of a potable water well or identify precautions which should be followed during earthwork activities.

8.0 RECOMMENDATIONS

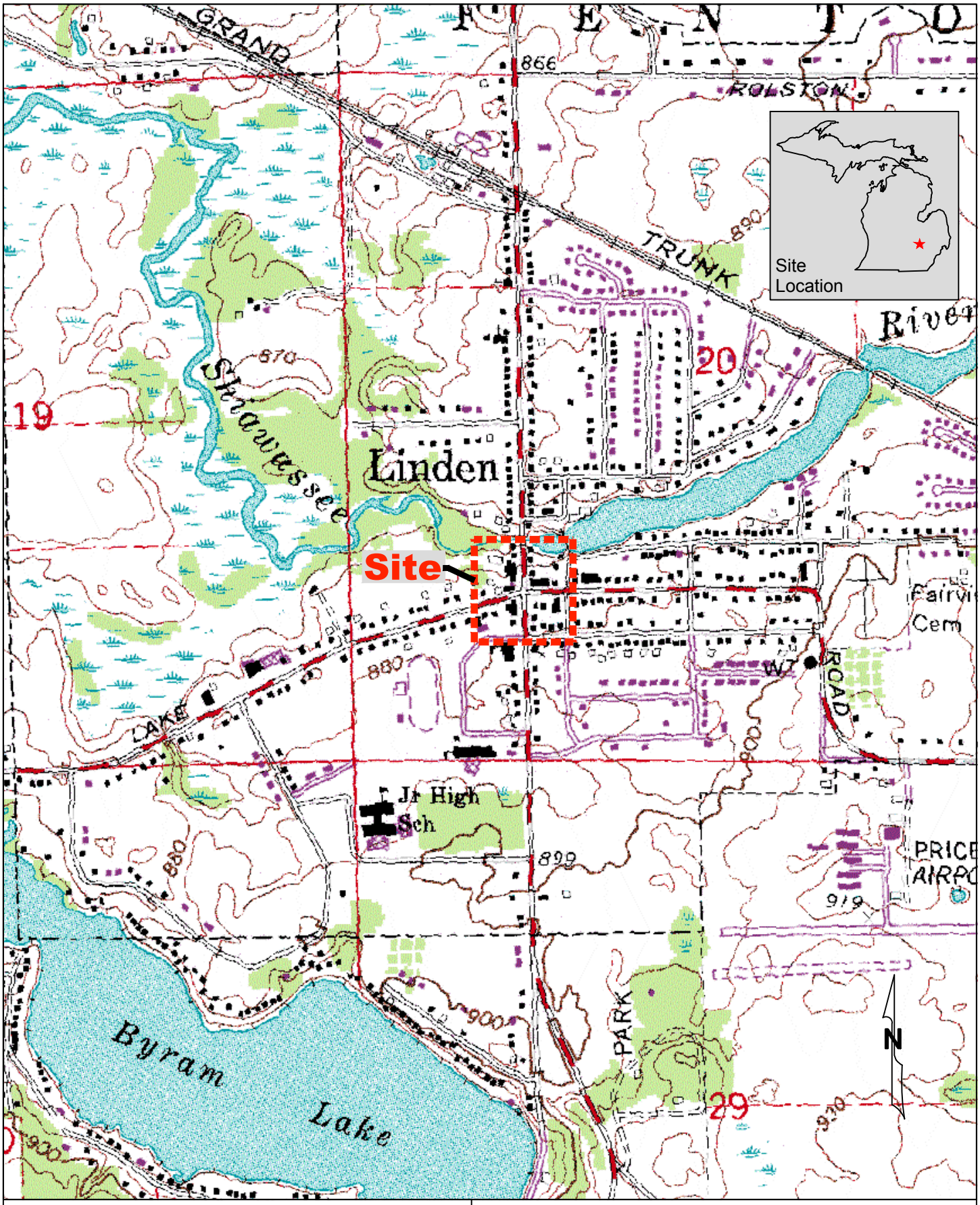
Based on the findings and conclusions presented in this report, ECT recommends completion of the following activities:

- The information in this report should be provided to the City of Linden so that appropriate precautions can be taken during maintenance or repair of subsurface utilities in the study area.
- Develop and distribute indoor air sampling access agreements to owners of commercial properties in the study area. A waiver should be prepared and signed if a property owner denies access for indoor air sampling.
- Perform indoor air sampling in occupied structures in the study area. Sampling should be performed on a 24-hour basis using summa canisters. Samples should be analyzed for VOCs.
- Complete additional soil borings to further delineate the extent of LNAPL and the dissolved phase contaminant plume. Groundwater samples should be collected for VOCs analyses using temporary monitoring wells at each location.
- Install a secure groundwater monitoring network to evaluate the extent of mobile LNAPL and dissolved phase contamination on a seasonal basis. The ground surface and top of casing elevations should be surveyed at each boring and permanent monitoring well location.
- Evaluate any possible entry point of petroleum hydrocarbons into the City of Linden storm water sewer system along North Bridge Street in the study area.

9.0 REFERENCES

- Storm Sewer Investigation - Strata Environmental Services, Inc., August 7, 2006.
- U.S. EPA Site Assessment Report - Oneida Total Integrated Enterprises, November 19, 2013.
- Notice Regarding Discovery of Contamination - Atwell, LLC, December 11, 2013.
- U.S. EPA Indoor Air Monitoring Results Map (Figure 1), June 2014.
- Facility Inspection Report - State of Michigan, Licensing and Regulatory Affairs, Bureau of Fire Services-Storage Tank Division, July 1, 2014.
- U. S. EPA Analytical Data Tables - Bottle-vac Sample Results for July 9 & 16, 2014 and a U.S. EPA Incident Report dated July 10, 2014.

FIGURES



ECT Environmental Consulting & Technology, Inc.

SITELOC2	
Created:	9/3/14 JCF
Revised:	11/19/14 JCF

0 1000
feet

Figure 1
Site Location
City of Linden
Broad and Bridge Street Benzene Contamination

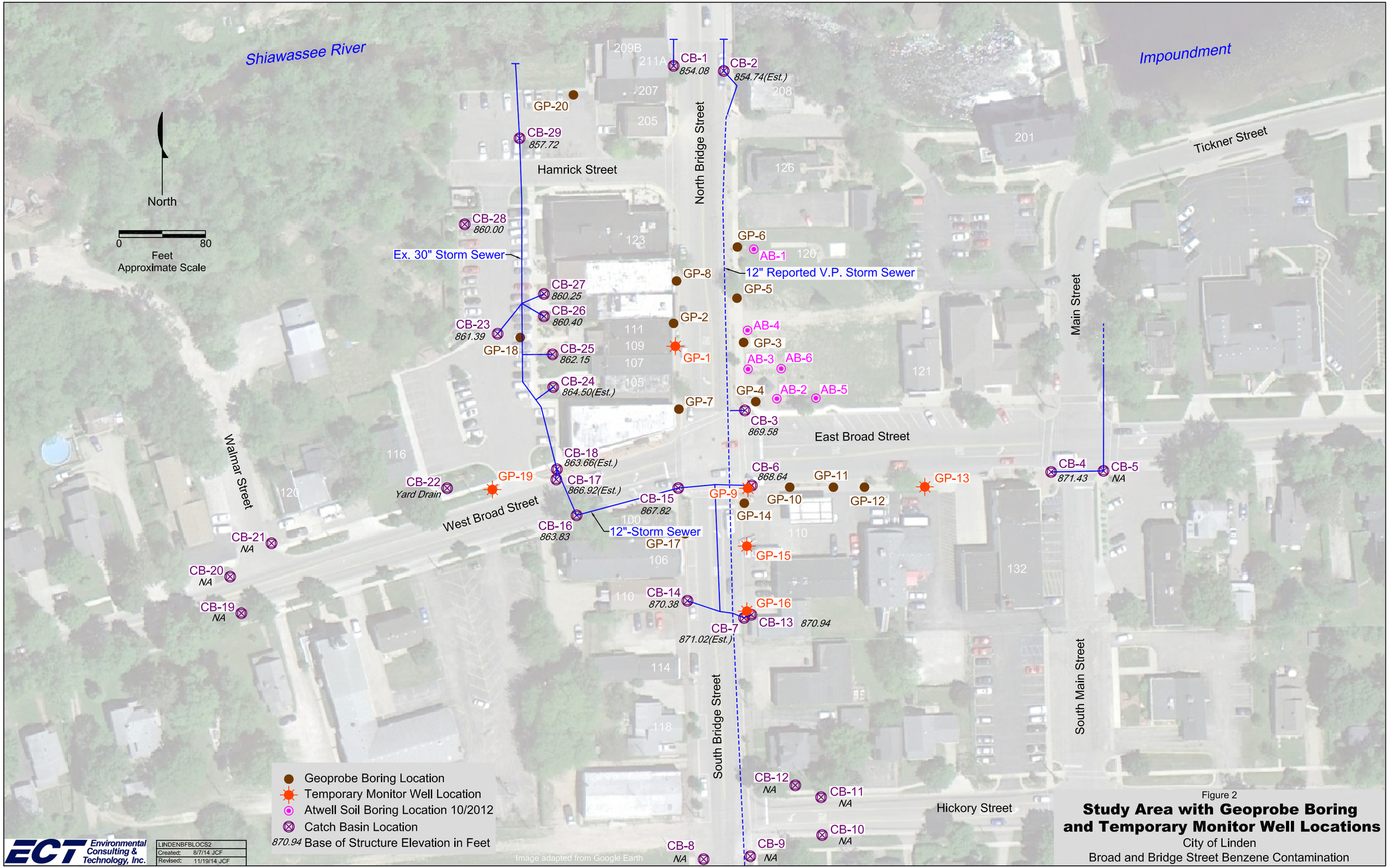


Figure 2

Study Area with Geoprobe Boring and Temporary Monitor Well Locations

City of Linden

Broad and Bridge Street Benzene Contamination

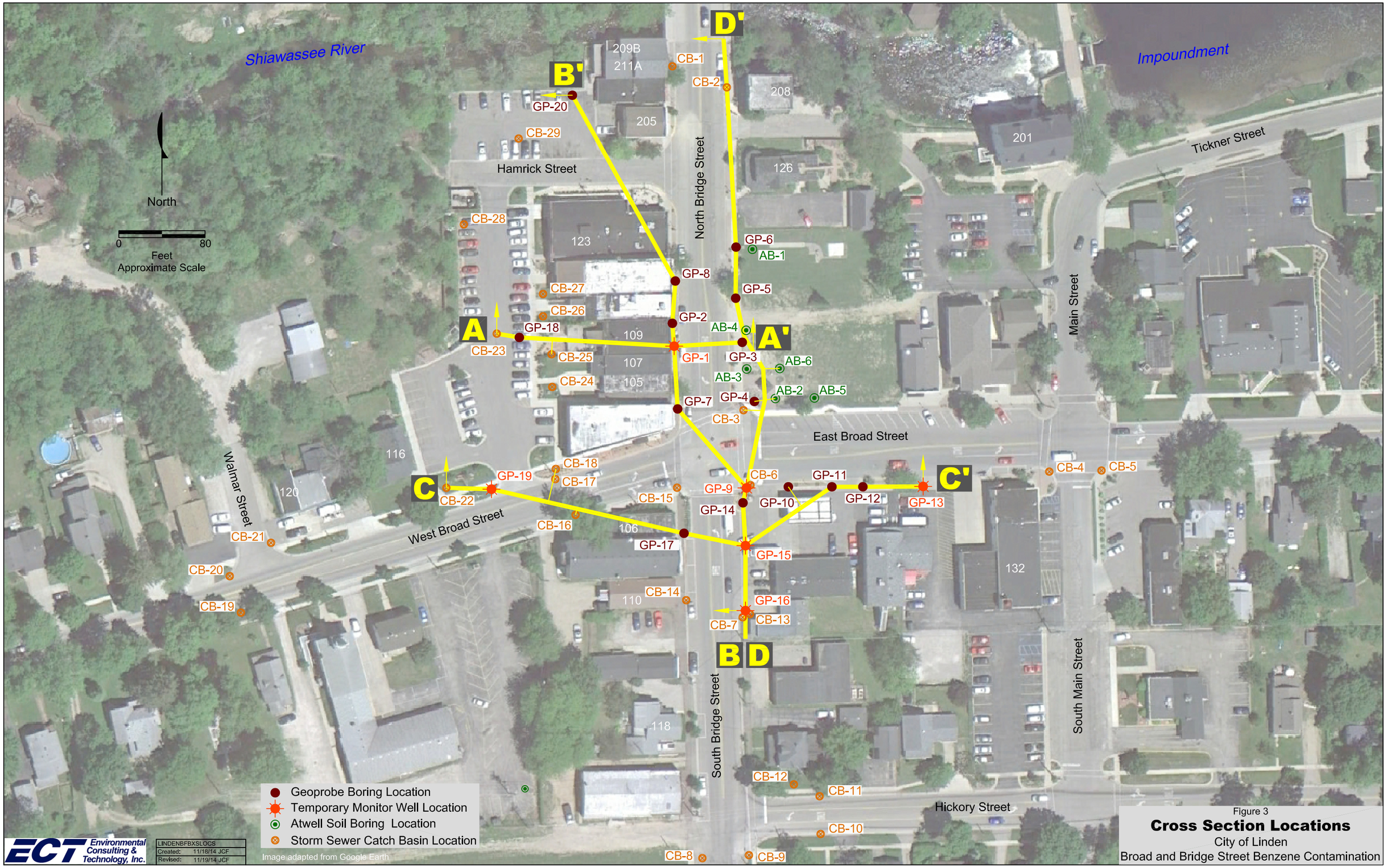
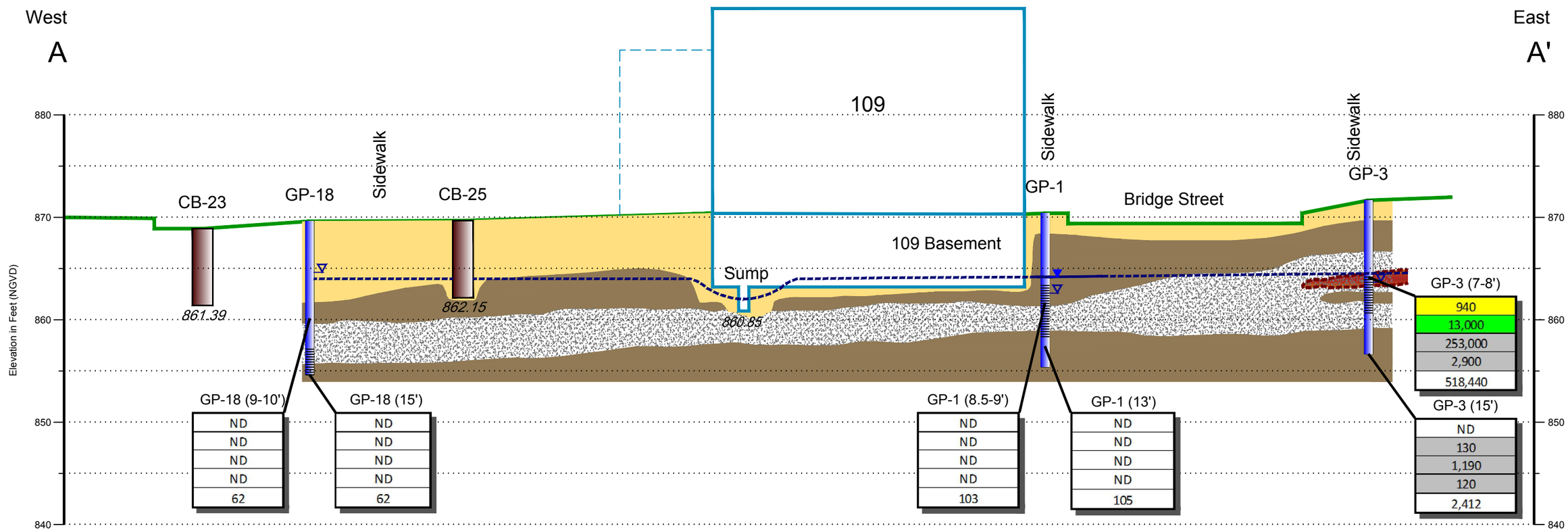


Figure 3

Cross Section Locations

City of Linden

Broad and Bridge Street Benzene Contamination



= Sand

= Clay

= Gravel

= NAPL Observed During Drilling

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.

Benzene	ug/kg dry
Ethylbenzene	ug/kg dry
Total Xylenes	ug/kg dry
Toluene	ug/kg dry
TOTAL VOCS	ug/kg dry

0 feet 10
0 20
Vertical Exaggeration: 2X

862.15 = Base of Structure Elevation in Feet
= Conceptual Water Level Elevation
= Water Level at Drilling
= Static Water Level (8/8/14)

= Screened Interval

ECT Environmental Consulting & Technology, Inc.

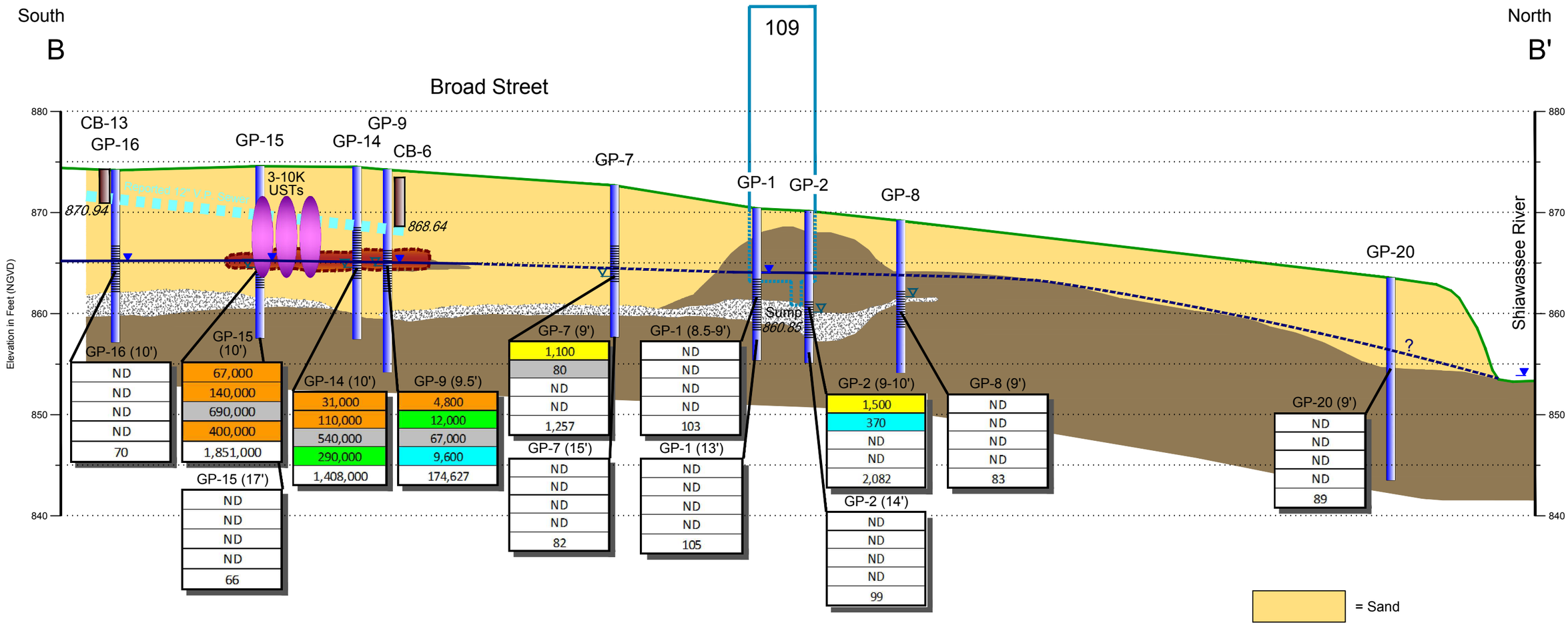
LINDENXSSOILAA
Created: 10/1/14 JCF
Revised: 11/19/14 JCF

Figure 4

Cross Section A-A' with Soil Sample Results

City of Linden

Broad and Bridge Street Benzene Contamination



0 10 feet 0 40
Vertical Exaggeration: 4X

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.

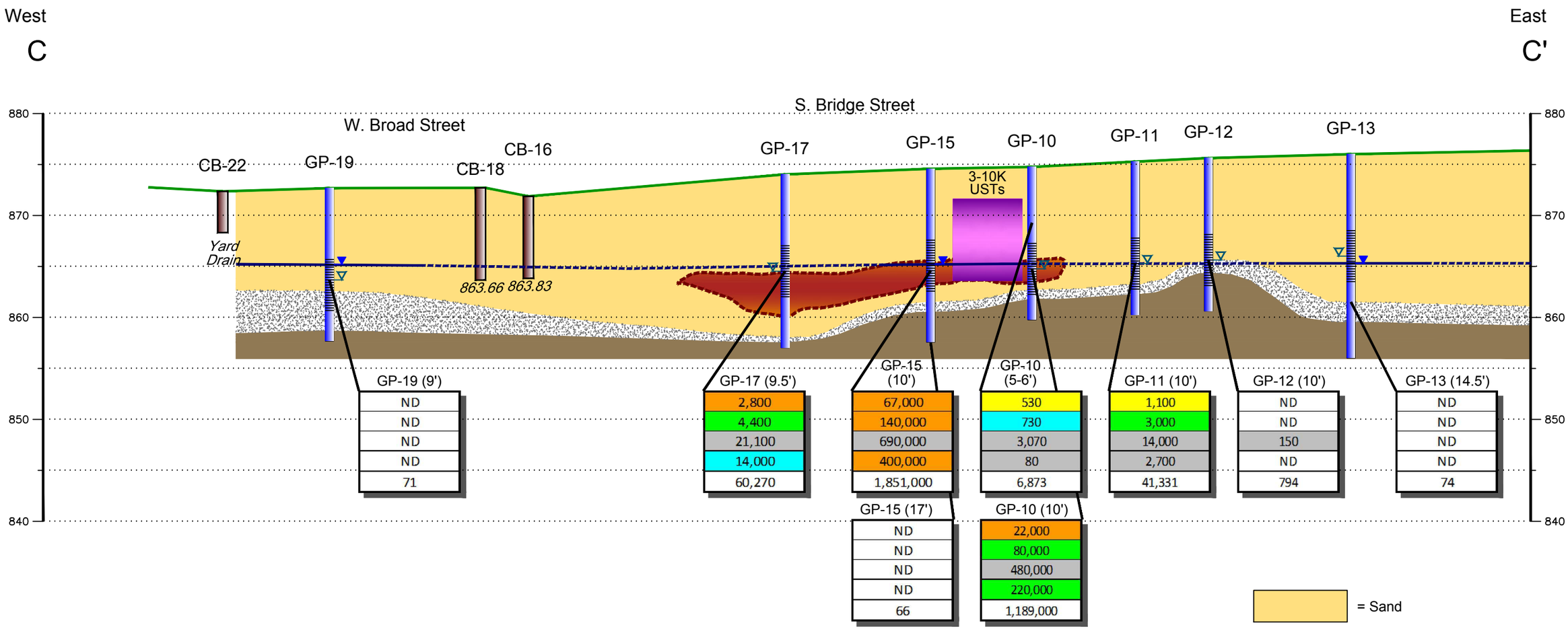
Benzene	ug/kg dry
Ethylbenzene	ug/kg dry
Total Xylenes	ug/kg dry
Toluene	ug/kg dry
TOTAL VOCS	ug/kg dry

870.94 = Base of Structure Elevation in Feet
= Conceptual Water Level Elevation
= Water Level During Drilling
= Static Groundwater Level (8/21/14)
= Screened Interval

ECT Environmental Consulting & Technology, Inc.

LINDENXSSOILBB
Created: 10/2/14 JCF
Revised: 11/19/14 JCF

Figure 5
Cross Section B-B' with Soil Sample Results
City of Linden
Broad and Bridge Street Benzene Contamination



Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.

Benzene	ug/kg dry
Ethylbenzene	ug/kg dry
Total Xylenes	ug/kg dry
Toluene	ug/kg dry
TOTAL VOCS	ug/kg dry

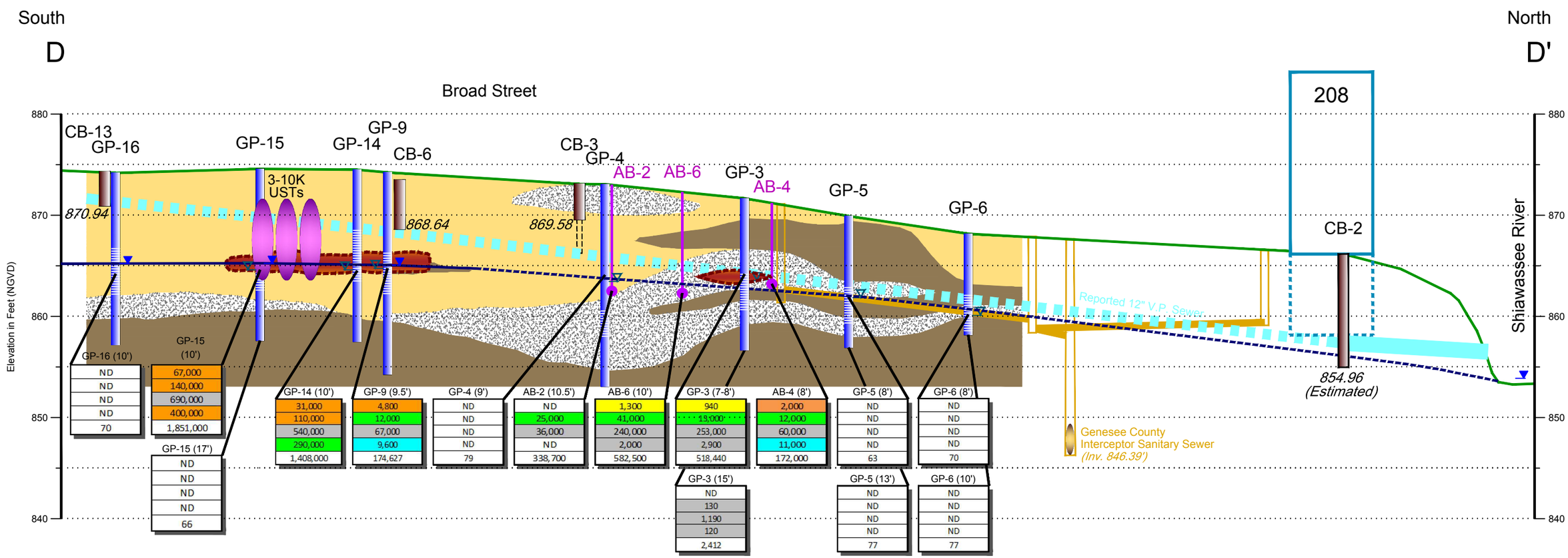
863.66 = Base of Structure Elevation in Feet
= Water Level During Drilling
= Static Water Level (8/8/14)
= Screened Interval

0 feet 10 0 40
Vertical Exaggeration: 4X

Figure 6
Cross Section C-C' with Soil Sample Results
City of Linden
Broad and Bridge Street Benzene Contamination

ECT Environmental Consulting & Technology, Inc.

LINDENXSSOILCC
Created: 10/2/14 JCF
Revised: 11/19/14 JCF



Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.

Benzene	ug/kg dry
Ethylbenzene	ug/kg dry
Total Xylenes	ug/kg dry
Toluene	ug/kg dry
TOTAL VOCS	ug/kg dry

869.58 = Base of Structure Elevation in Feet
= Conceptual Water Level Elevation
= Water Level During Drilling
= Static Water Level (8/21/14)
= Screened Interval
= Atwell Soil Sample (10/17/12)

Figure 7

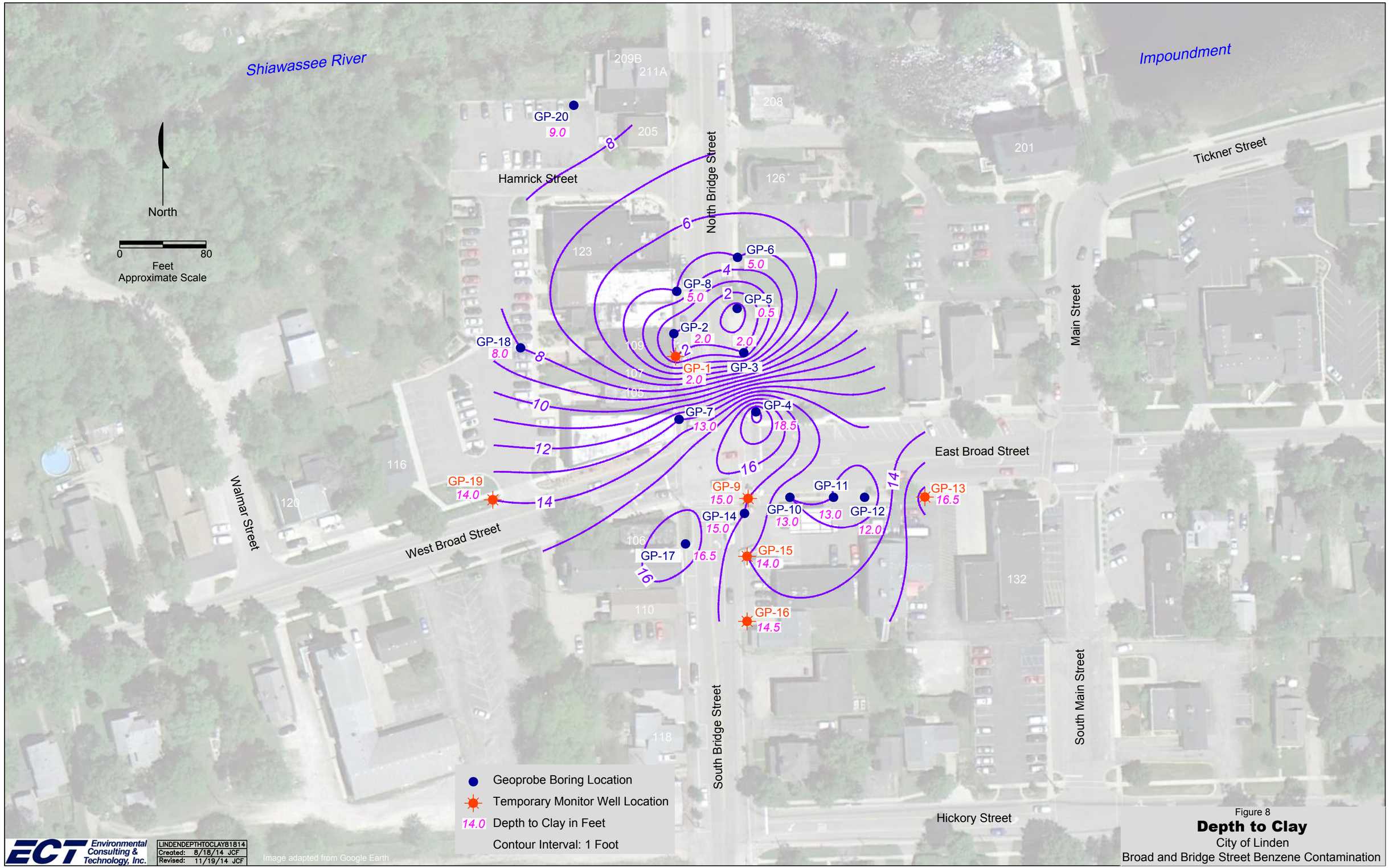
Cross Section D-D' with Soil Sample Results

City of Linden

Broad and Bridge Street Benzene Contamination

ECT Environmental Consulting & Technology, Inc.

LINDENBFBXSSOILDD
Created: 10/2/14 JCF
Revised: 11/19/14 JCF



ECT Environmental Consulting & Technology, Inc.

LINDENDEPTHTOCLAY81814
Created: 8/18/14 JCF
Revised: 11/19/14 JCF

Figure 8

Depth to Clay

City of Linden

Broad and Bridge Street Benzene Contamination

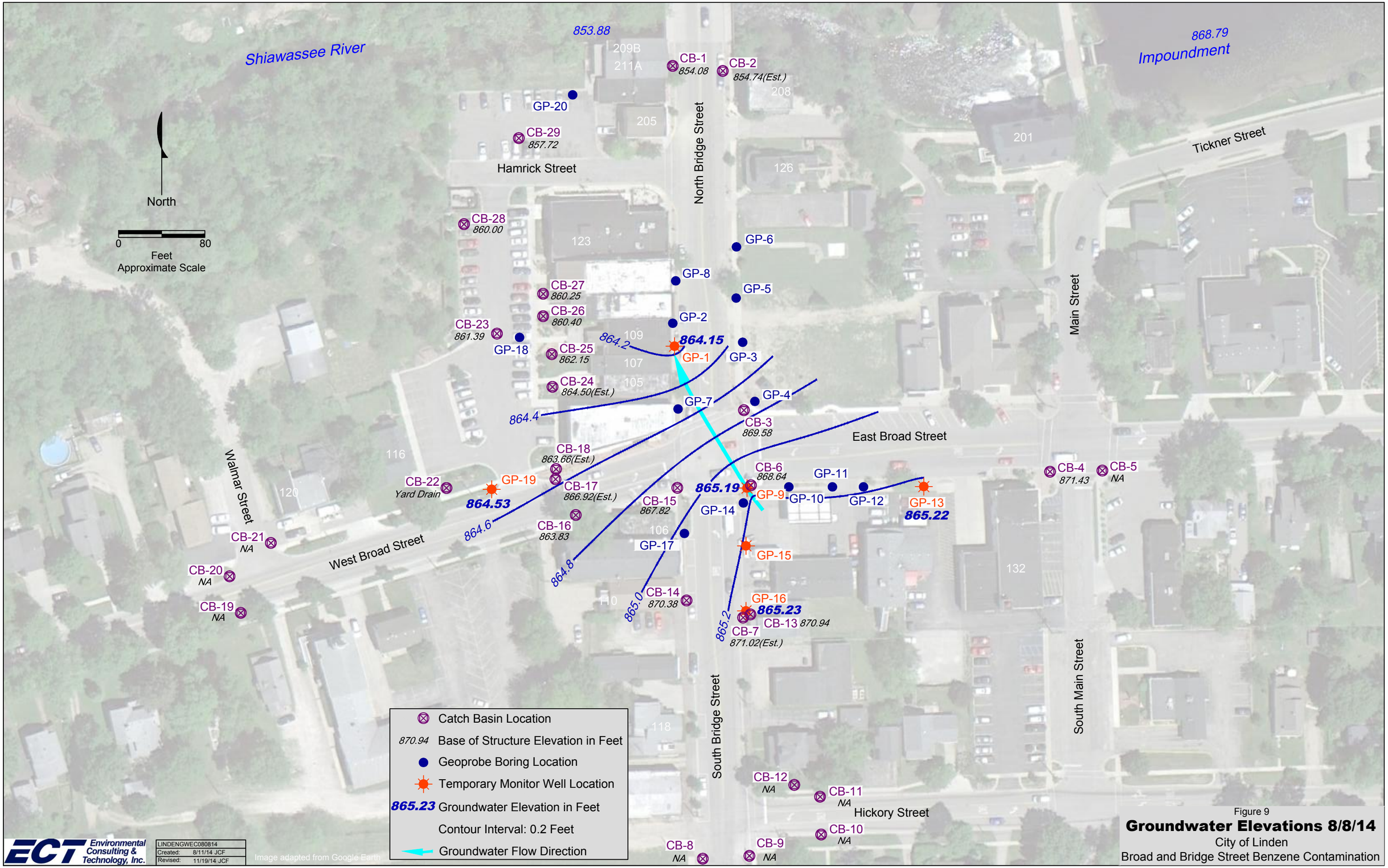


Figure 9

Groundwater Elevations 8/8/14

City of Linden

Broad and Bridge Street Benzene Contamination

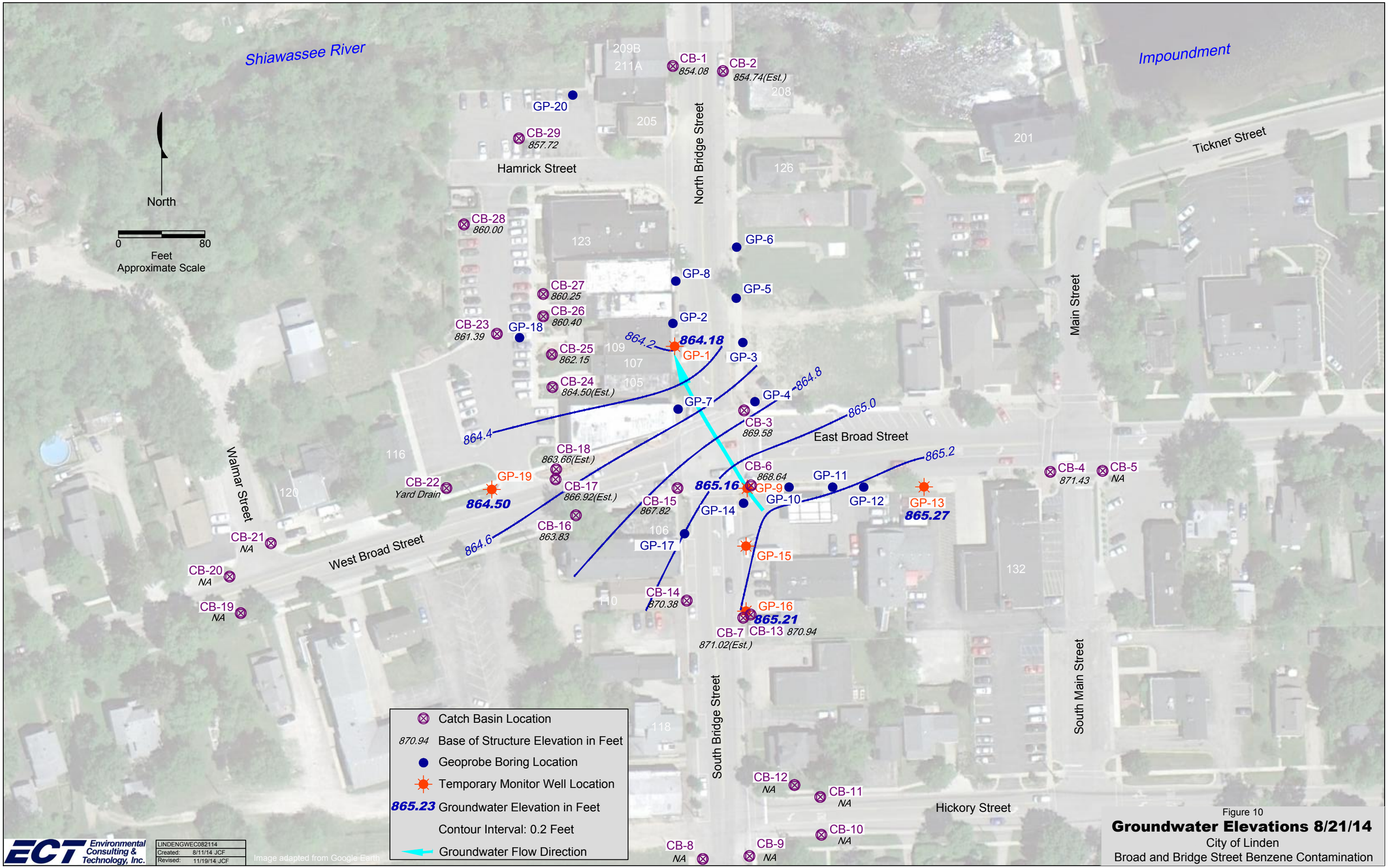
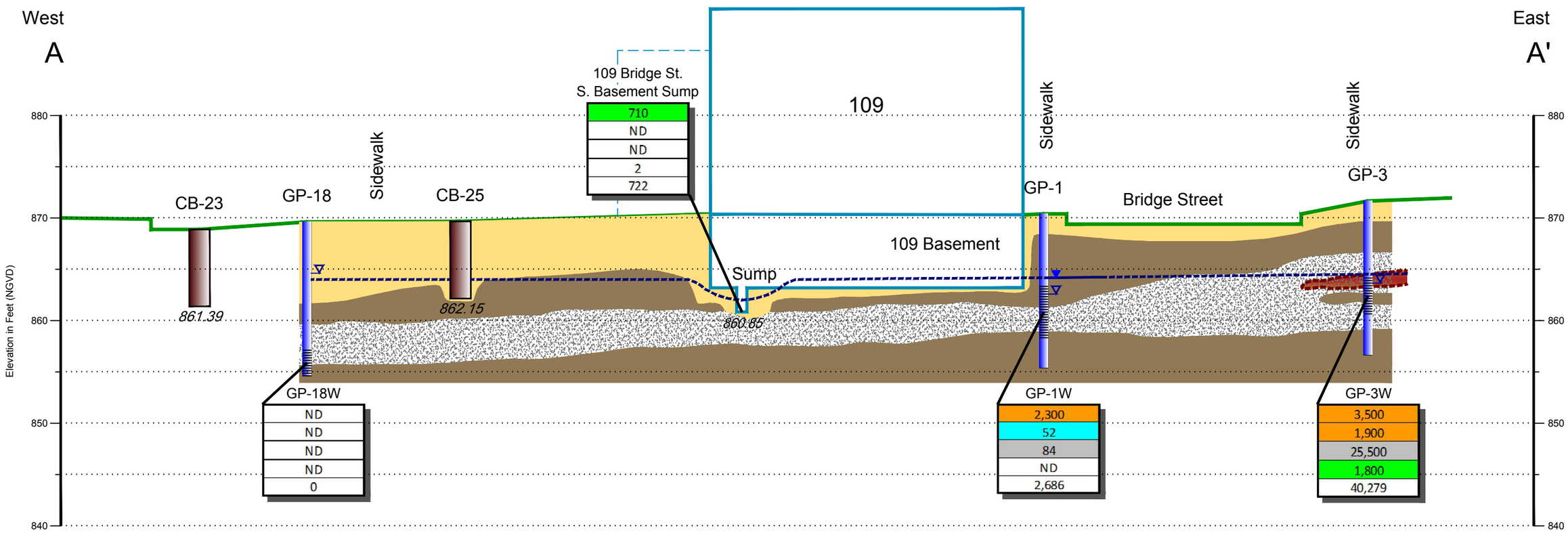


Figure 10

Groundwater Elevations 8/21/14

City of Linden

Broad and Bridge Street Benzene Contamination



= Sand

= Clay

= Gravel

= NAPL Observed During Drilling

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.

Benzene	ug/L
Ethylbenzene	ug/L
Total Xylenes	ug/L
Toluene	ug/L
TOTAL VOCS	ug/L

0
10
feet
0
20
Vertical Exaggeration: 2X

862.15 = Base of Structure Elevation in Feet
= Conceptual Water Level Elevation
= Water Level at Drilling
= Static Water Level (8/8/14)

= Screened Interval

ECT Environmental Consulting & Technology, Inc.

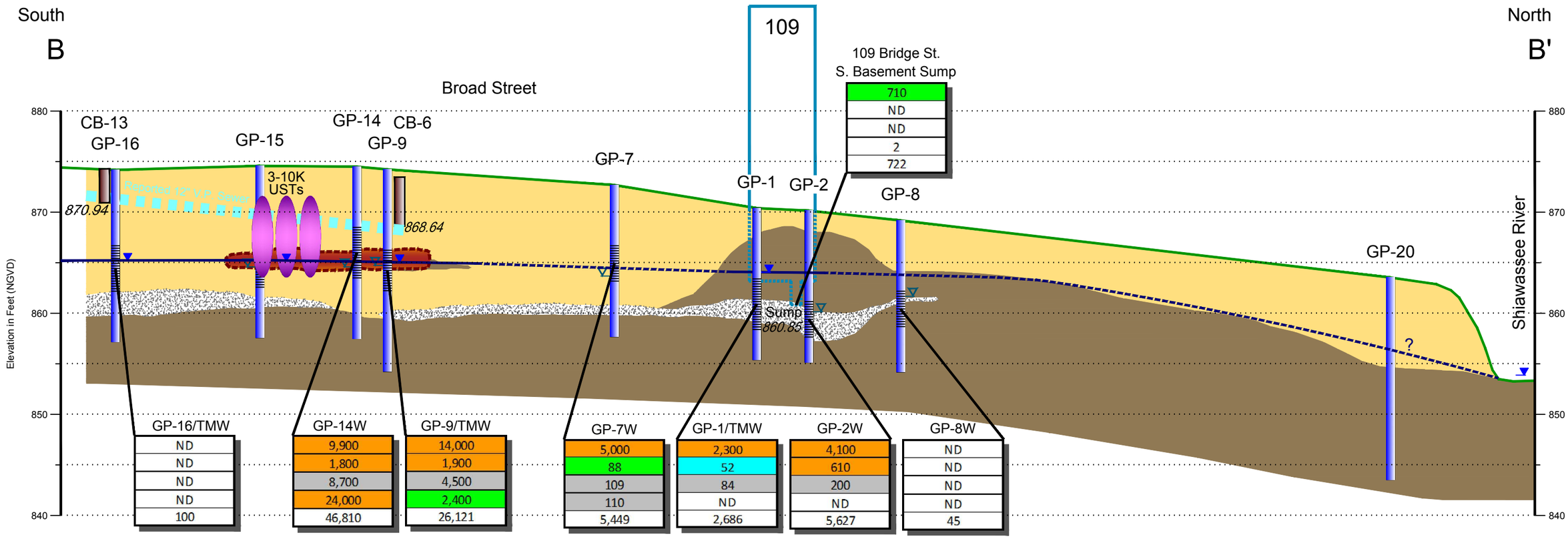
LINDENXSGWAA
Created: 10/2/14 JCF
Revised: 11/19/14 JCF

Figure 11

Cross Section A-A' with Groundwater Sample Results

City of Linden

Broad and Bridge Street Benzene Contamination



= Sand

= Clay

= Gravel

= NAPL Observed During Drilling

0 feet 10

0 40

Vertical Exaggeration: 4X

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.

Benzene	ug/L
Ethylbenzene	ug/L
Total Xylenes	ug/L
Toluene	ug/L
TOTAL VOCS	ug/L

868.64 = Base of Structure Elevation in Feet

= Conceptual Water Level Elevation

= Water Level During Drilling

= Static Groundwater Level (8/21/14)

= Screened Interval

ECT Environmental Consulting & Technology, Inc.

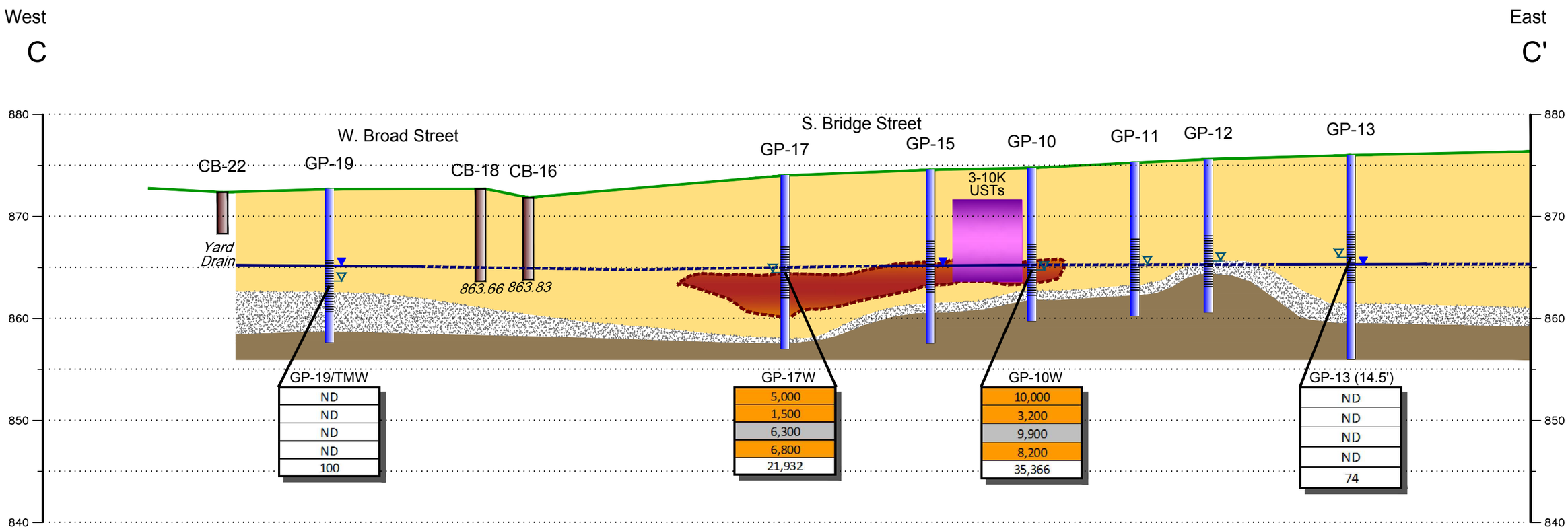
LINDENXSGWBB
Created: 10/2/14 JCF
Revised: 11/19/14 JCF

Figure 12

Cross Section B-B' with Groundwater Sample Results

City of Linden

Broad and Bridge Street Benzene Contamination



Grey indicates contaminant was detected.	
Yellow indicates contaminant exceeds DWPC.	
Blue indicates contaminant exceeds GSIPC.	
Green indicates contaminant exceeds both DWPC and GSIPC.	
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.	

Benzene	ug/L
Ethylbenzene	ug/L
Total Xylenes	ug/L
Toluene	ug/L
TOTAL VOCS	ug/L

= Sand

= Clay

= Gravel

= NAPL Observed During Drilling

863.66 = Base of Structure Elevation in Feet

= Conceptual Water Level Elevation

= Water Level During Drilling

= Static Water Level (8/8/14)

= Screened Interval

0 feet 40
10 0
Vertical Exaggeration: 4X

ECT Environmental Consulting & Technology, Inc.

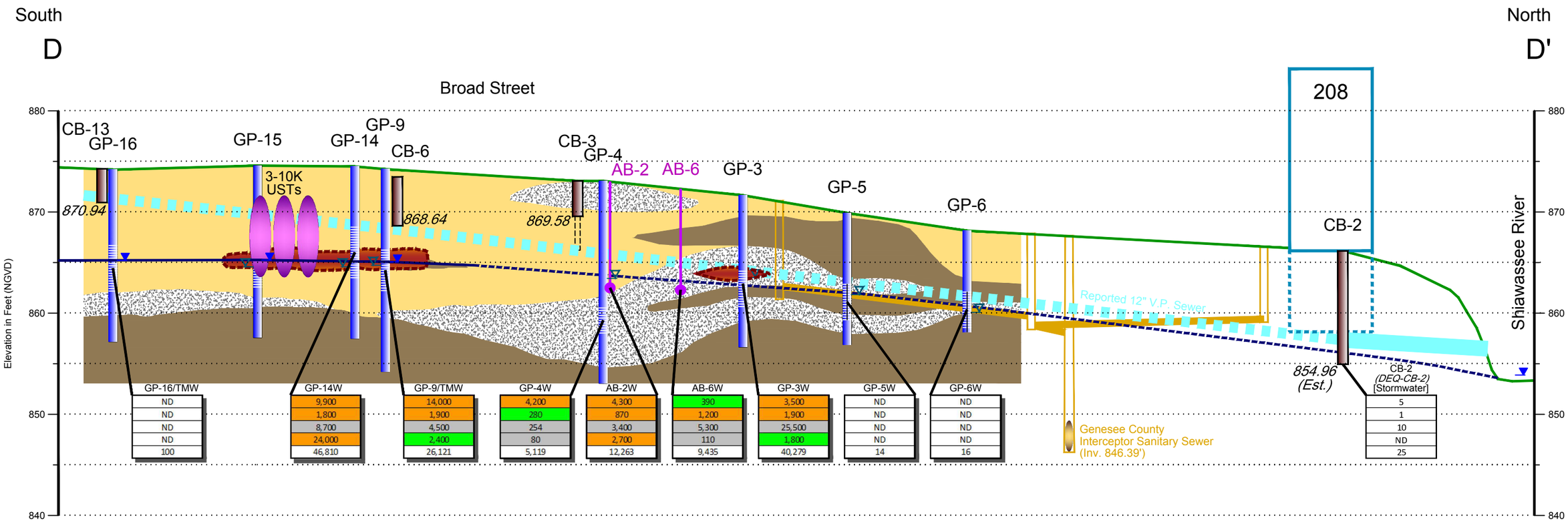
LINDENXSGWCC
Created: 10/3/14 JCF
Revised: 11/19/14 JCF

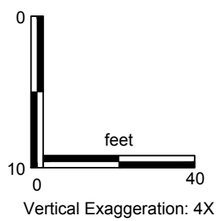
Figure 13

Cross Section C-C' with Groundwater Sample Results

City of Linden

Broad and Bridge Street Benzene Contamination





Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.

Benzene	ug/L
Ethylbenzene	ug/L
Total Xylenes	ug/L
Toluene	ug/L
TOTAL VOCS	ug/L

= Sand
= Clay
= Gravel
= NAPL Observed During Drilling

869.58 = Base of Structure Elevation in Feet
= Conceptual Water Level Elevation
= Water Level During Drilling
= Static Water Level (8/21/14)
= Screened Interval
= Atwell Soil Sample (10/17/12)

Environmental Consulting & Technology, Inc.

LINDENBFBXSGWDD
Created: 10/2/14 JCF
Revised: 11/19/14 JCF

Figure 14
Cross Section D-D' with Groundwater Sample Results
City of Linden
Broad and Bridge Street Benzene Contamination

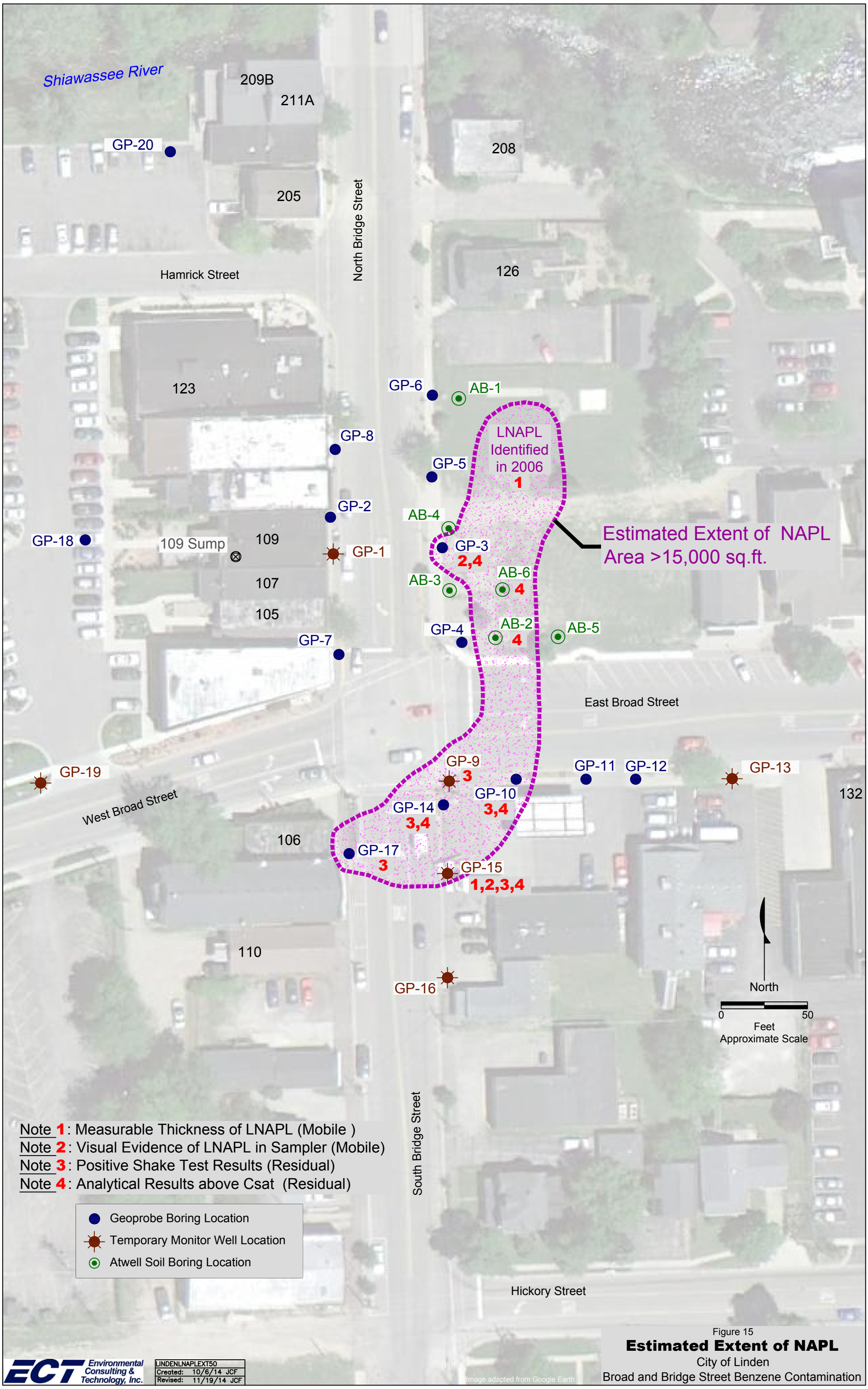


Figure 15

Estimated Extent of NAPL

City of Linden

Broad and Bridge Street Benzene Contamination

ECT Environmental Consulting & Technology, Inc.

LINDENLNAPLEXT50	
Created:	10/6/14 JCF
Revised:	11/19/14 JCF

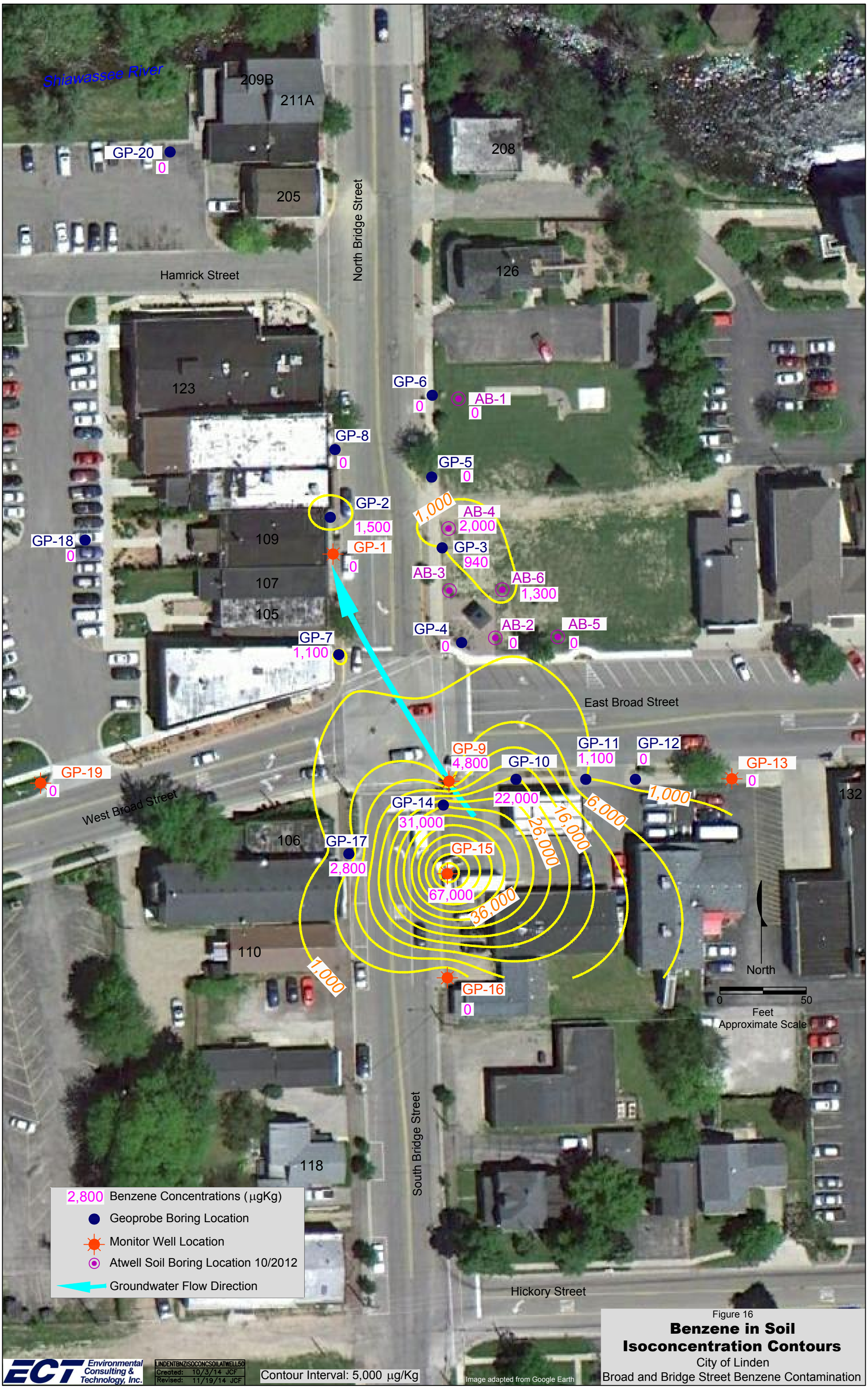


Figure 16

Benzene in Soil Isoconcentration Contours

City of Linden

Broad and Bridge Street Benzene Contamination

ECT Environmental Consulting & Technology, Inc.

LINDENTBNZISOCONCSOILATWELL50
Created: 10/3/14 JCF
Revised: 11/19/14 JCF

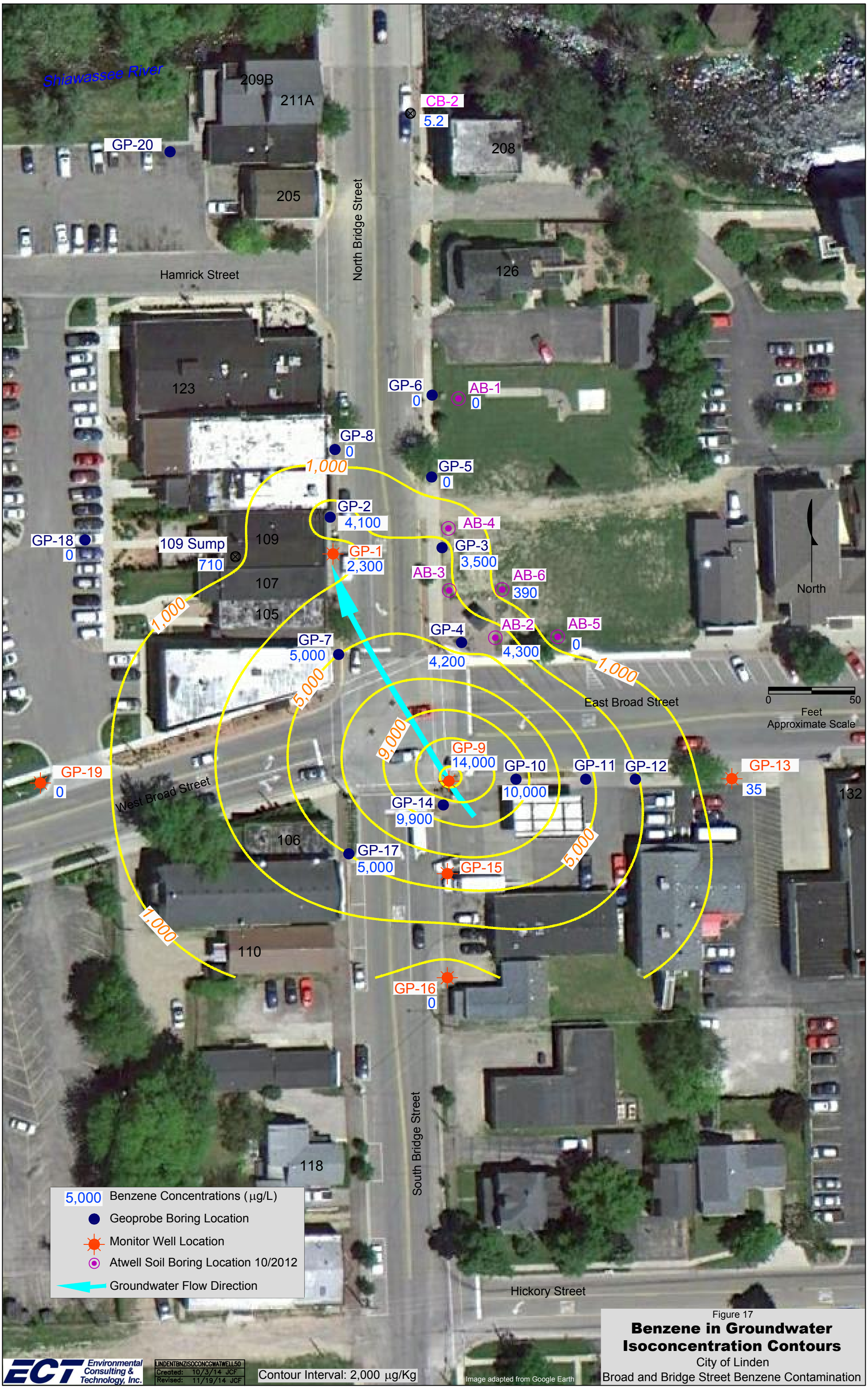


Figure 17

Benzene in Groundwater Isoconcentration Contours

City of Linden

Broad and Bridge Street Benzene Contamination

PATHWAYS AND RECEPTORS ANALYSIS
BROAD AND BRIDGE FIGURE 18

STREET BENZENE CONTAMINATION
LINDEN, MICHIGAN

Exposure Evaluation Flowchart

Primary Sources of Contaminants

- [√] **Product Storage** (USTs/Drums, etc.)
- [ ] **Piping/Distribution** (manifolds, lines, pumps, etc.)
- [ ] **Operations** (waste/blending, etc.)
- [ ] **Waste Management Unit** (sludge disposal, etc.)
- [ ] **Other**

Site Names:
Linden Benzene Contamination Study Area
Site Address:
Broad and Bridge Streets
Facility I.D. No.: not applicable
Release No.: not applicable

Suspected or Known Source Areas:

1 Release from UST system(s)

2

3

4

5

Secondary Sources

- [ ] **Impacted Surficial Soils** (<2 ft. depth)
- [√] **Impacted Subsurface Soils** (>2 ft. depth)
- [√] **Dissolved Groundwater Plume** (>2 ft. depth)
- [√] **NAPL** (Free Phase Liquid or Tar)
- [ ] **Impacted Sediment or Water** (Surface Soils/Sediments/Water)

Transport Mechanisms

- **Wind Erosion and Atmospheric Dispersion**
- **Volatilization and Atmospheric Dispersion**
- [√] **Volatilization & Enclosed-Space Accumulation**
- [√] **Leaching and Groundwater Transport**
- [√] **Mobile Free Phase NAPL**
- **Storm water/Surface Water Transport**

Exposure Pathways

2
- [√] **Soil Ingestion/Absorption**

1
- [√] **Inhalation**

3
- [√] **Potable Groundwater Use**

- **Recreation Use Sensitive Habitat**

Receptor Characterization

- [√] Residential
- [√] Commercial/Industrial
- [√] Construction Worker
- [ ] Sensitive Habitat
- [ ] Other (Specify)

- [√] Residential
- [√] Commercial/Industrial
- [√] Construction Worker
- [ ] Sensitive Habitat
- [ ] Other (Specify)

- [√] Residential
- [√] Commercial/Industrial
- [√] Construction Worker
- [ ] Sensitive Habitat
- [ ] Other (Specify)

- [ ] Residential
- [ ] Sensitive Habitat
- [ ] GSI

Remedial Action Options

List Abbreviations used for Corrective Action Measures Applied at the Valve Symbols

1 Vapor Mitigation System

2 Maintain Exposure Barrier

3 Land and Resource Use Restrictions

4

5

6

Step 1: Characterization Site Sources and Exposure Pathways
a. Complete Tier 1 Work Sheets
b. Check applicable boxes for source, release mechanism, and actual or imminent exposure pathway

Step 2: Identify Receptors, Compare Site Conditions with Tier 1 Criteria Levels
a. Identify Receptors
b. Check applicable boxes for potential receptors and RBSL value(s) exceeded

Step 3: Identify Potential Corrective Measures
a. Complete Tier 1 Summary Report
b. Fill in exposure pathway sheet

Based upon Fig. X5.2 Example 2 - Example Evaluation Flowchart - ASTM E1739-95 (2010)

TABLES

TABLE 1
LINDEN ELEVATION SURVEY MEASUREMENTS
INTERSECTION OF BRIDGE AND BROAD STREETS
LINDEN, MICHIGAN
ECT PROJECT NO. 14-0500

Measuring Point Identification	Elevation (msl)	Depth to Water			Groundwater Elevation			Survey Notes
		8/8/2014	8/21/2014	8/28/2014	8/8/2014	8/21/2014	8/28/2014	
Soil Borings								
GP-1/TMW	870.40	6.25	6.22	6.30	864.15	864.18	864.10	Top of Casing
GP-9/TMW	874.24	9.05	9.08	9.17	865.19	865.16	865.07	Top of Casing
GP-13/TMW	875.91	10.69	10.64	10.68	865.22	865.27	865.23	Top of Casing
GP-15/TMW	874.59	9.34/9.41	NA	NA		NA	NA	Top of Casing - Contained .07' thick LNAPL
GP-16/TMW	874.19	8.96	8.98	9.09	865.23	865.21	865.10	Top of Casing
GP-19/TMW	872.56	8.03	8.06	8.15	864.53	864.5	864.41	Temporary Well Top of Casing

Survey completed August 8, 2014
City of Linden Benchmark #13, northwest corner of concrete base of sign pole at southeast corner of intersection of Bridge and Broad Streets: 874.78
msl: mean sea level
= denotes temporary well contained LNAPL

Table 2
Soil Sampling Results
City of Linden

Sample ID		Drinking Water Protection Criteria (DWPC)	Groundwater Surface Water Protection Criteria (GSIPC)	Soil Volatilization to Indoor Air Inhalation Criteria (SVIIC)	Direct Contact Criteria (DCC)	GP-1 (8.5-9')	GP-1 (13')	GP-2 (9-10')	GP-2 (14')	GP-3 (7-8')	GP-3 (15')	GP-4 (9')	GP-5 (8')	GP-5 (13')
Date Collected						7/30/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014
Organics-Volatiles														
1,2,4-Trimethylbenzene	ug/kg dry	2,100	570	4,300,000	32,000,000	<61	<61	<61	<59	150,000	620	<67	<60	<61
1,3,5-Trimethylbenzene	ug/kg dry	1,800	1,100	2,600,000	32,000,000	<61	<61	<61	<59	45,000	190	<67	<60	<61
2-Methylnaphthalene	ug/kg dry	57,000	4,200	2,700,000	8,100,000	<300	<310	<310	<300	21,000	<300	<330	<300	<310
Benzene	ug/kg dry	100	4,000	1,600	180,000	<61	<61	1,500	<59	940	<60	<67	<60	<61
Ethylbenzene	ug/kg dry	1,500	360	87,000	22,000,000	<61	<61	370	<59	13,000	130	<67	<60	<61
Isopropylbenzene	ug/kg dry	91,000	3,200	400,000	25,000,000	<61	<61	<61	<59	2,600	<60	<67	<60	<61
m & p - Xylene	ug/kg dry	NA	NA	NA	NA	<120	<120	<120	<120	180,000	880	<130	<120	<120
Naphthalene	ug/kg dry	35,000	730	250,000	16,000,000	<300	<310	<310	<300	21,000	<300	<330	<300	<310
n-Propylbenzene	ug/kg dry	1,600	ID	ID	2,500,000	<61	<61	110	<59	9,000	79	<67	<60	<61
o-Xylene	ug/kg dry	NA	NA	NA	NA	<61	<61	<61	<59	73,000	310	<67	<60	<61
sec-Butylbenzene	ug/kg dry	1,600	ID	ID	2,500,000	<61	<61	<61	<59	<110	<60	<67	<60	<61
Toluene	ug/kg dry	16,000	5,400	330,000	50,000,000	<61	<61	<61	<59	2,900	120	<67	<60	<61
Dibromofluoromethane	ug/kg dry	NA	NA	NA	NA	103	<61	102	99	<61	83	79	63	77
Organics-Semivolatiles														
2-Methylnaphthalene	ug/kg dry	57,000	4,200	2,700,000	8,100,000	<550	<550	NA	NA	11,000	<550	NA	NA	NA
Acenaphthene	ug/kg dry	300,000	8,700	190,000,000	41,000,000	<220	<220	NA	NA	<210	<220	NA	NA	NA
Naphthalene	ug/kg dry	35,000	730	250,000	16,000,000	<220	<220	NA	NA	9,200	<220	NA	NA	NA
Nitrobenzene-d5	ug/kg dry	NA	NA	NA	NA	2,690	2,640	NA	NA	2,320	3,030	NA	NA	NA
Phenanthrene	ug/kg dry	56,000	2,100	2,800,000	1,600,000	<220	<220	NA	NA	<210	<220	NA	NA	NA
Inorganics-General Chemistry														
% Total Solids	%	NA	NA	NA	NA	91	90	90	91	95	90	86	90	89

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.
"ID" means insufficient data to develop criterion.
"NA" means a criterion or value is not available or, in the case of background, not applicable.
"NLL" means hazardous substance is not likely to leach under most soil conditions.
"NLV" means hazardous substance is not likely to volatilize under most conditions.
Letters in criteria columns refer to Footnotes of the Criteria/RBSLs tables.

Table 2
Soil Sampling Results
City of Linden

Sample ID		GP-6 (8')	GP-6 (10')	GP-7 (9')	GP-7 (15')	GP-8 (9')	GP-9 (9.5')	GP-10 (5'-6')	GP-10 (10')	GP-11 (10')	GP-12 (10')	GP-13 (14.5')	GP-14 (10')
Date Collected		7/30/2014	7/30/2014	7/31/2014	7/31/2014	7/31/2014	7/31/2014	7/31/2014	7/31/2014	7/31/2014	7/31/2014	8/1/2014	8/1/2014
Organics-Volatiles													
1,2,4-Trimethylbenzene	ug/kg dry	<60	<61	<67	<62	<60	45,000	1,600	230,000	10,000	400	<69	240,000
1,3,5-Trimethylbenzene	ug/kg dry	<60	<61	<67	<62	<60	10,000	440	53,000	3,000	170	<69	71,000
2-Methylnaphthalene	ug/kg dry	<300	<300	<330	<310	<300	8,100	<320	27,000	3,000	<350	<350	33,000
Benzene	ug/kg dry	<60	<61	1,100	<62	<60	4,800	530	22,000	1,100	<71	<69	31,000
Ethylbenzene	ug/kg dry	<60	<61	80	<62	<60	12,000	730	80,000	3,000	<71	<69	110,000
Isopropylbenzene	ug/kg dry	<60	<61	<67	<62	<60	1,600	61	8,100	360	<71	<69	10,000
m & p - Xylene	ug/kg dry	<120	<120	<130	<120	<120	54,000	2,700	370,000	10,000	150	<140	390,000
Naphthalene	ug/kg dry	<300	<300	<330	<310	<300	8,900	<320	30,000	2,400	<350	<350	39,000
n-Propylbenzene	ug/kg dry	<60	<61	<67	<62	<60	6,800	280	35,000	1,700	<71	<69	44,000
o-Xylene	ug/kg dry	<60	<61	<67	<62	<60	13,000	370	110,000	4,000	<71	<69	150,000
sec-Butylbenzene	ug/kg dry	<60	<61	<67	<62	<60	750	<64	3,900	<59	<71	<69	<2600
Toluene	ug/kg dry	<60	<61	<67	<62	<60	9,600	80	220,000	2,700	<71	<69	290,000
Dibromofluoromethane	ug/kg dry	70	77	77	82	83	77	82	<61	71	74	74	<61
Organics-Semivolatiles													
2-Methylnaphthalene	ug/kg dry	<550	NA	<580	<560	NA	1,300	<570	NA	NA	NA	<610	17,000
Acenaphthene	ug/kg dry	<220	NA	<230	<220	NA	<240	<230	NA	NA	NA	<240	<230
Naphthalene	ug/kg dry	<220	NA	<230	<220	NA	1,100	<230	NA	NA	NA	<240	13,000
Nitrobenzene-d5	ug/kg dry	2,610	NA	2,980	2,710	NA	3,250	2,600	NA	NA	NA	3,260	2,930
Phenanthrene	ug/kg dry	<220	NA	<230	<220	NA	<240	<230	NA	NA	NA	<240	<230
Inorganics-General Chemistry													
% Total Solids	%	92	91	87	90	91	84	88	84	91	84	83	87

Table 2
Soil Sampling Results
City of Linden

Sample ID		GP-15 (10')	GP-15 (17')	GP-16 (10')	GP-17 (9.5')	GP-18 (9-10')	GP-18 (15')	GP-19 (9')	GP-20 (9')	TRIP BLANK
Date Collected		8/1/2014	8/1/2014	8/1/2014	8/1/2014	8/1/2014	8/1/2014	8/1/2014	8/1/2014	7/18/2014
Organics-Volatiles										
1,2,4-Trimethylbenzene	ug/kg dry	300,000	<62	<61	9,400	<62	<57	<62	<69	<50
1,3,5-Trimethylbenzene	ug/kg dry	92,000	<62	<61	2,800	<62	<57	<62	<69	<50
2-Methylnaphthalene	ug/kg dry	43,000	<310	<300	1,700	<310	<290	<310	<350	<250
Benzene	ug/kg dry	67,000	<62	<61	2,800	<62	<57	<62	<69	<50
Ethylbenzene	ug/kg dry	140,000	<62	<61	4,400	<62	<57	<62	<69	<50
Isopropylbenzene	ug/kg dry	13,000	<62	<61	400	<62	<57	<62	<69	<50
m & p - Xylene	ug/kg dry	500,000	<120	<120	15,000	<120	<110	<120	<140	<100
Naphthalene	ug/kg dry	50,000	<310	<300	1,900	<310	<290	<310	<350	<250
n-Propylbenzene	ug/kg dry	56,000	<62	<61	1,700	<62	<57	<62	<69	<50
o-Xylene	ug/kg dry	190,000	<62	<61	6,100	<62	<57	<62	<69	<50
sec-Butylbenzene	ug/kg dry	<2500	<62	<61	<66	<62	<57	<62	<69	<50
Toluene	ug/kg dry	400,000	<62	<61	14,000	<62	<57	<62	<69	<50
Dibromofluoromethane	ug/kg dry	<61	66	70	70	62	62	71	89	54
Organics-Semivolatiles										
2-Methylnaphthalene	ug/kg dry	70,000	<550	<550	24,000	<560	<540	<280	NA	NA
Acenaphthene	ug/kg dry	280	<220	<220	<230	<220	<220	<110	NA	NA
Naphthalene	ug/kg dry	66,000	<220	<220	23,000	<220	<220	<110	NA	NA
Nitrobenzene-d5	ug/kg dry	3,290	3,080	2,650	2,490	2,340	2,720	1,210	NA	NA
Phenanthrene	ug/kg dry	510	<220	<220	260	<220	<220	<110	NA	NA
Inorganics-General Chemistry										
% Total Solids	%	88	90	90	87	90	93	89	84	100

Table 3
Groundwater Sampling Results
City of Linden

Sample ID		Drinking Water Criteria (DWC)	Groundwater Surface Water Interface Criteria (GSIC)	Groundwater Volatilization to Indoor Air Inhalation Criteria (GVIIC)	Rule 57 Final Acute Value (FAV)	GP-1W	GP-1/TMW	GP-1W dup	GP-2W	GP-3W	GP-4W	GP-5W	GP-6W
Date Collected						7/30/2014	8/21/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014	7/30/2014
Organics-Volatiles	Units												
1,2,3-Trimethylbenzene	ug/L	NA	NA	NA		<10	19	<10	<20	<50	<1.0	<1.0	<1.0
1,2,4-Trimethylbenzene	ug/L	63	17	56,000	310	110	100	93	410	4,100	130	<1.0	<1.0
1,3,5-Trimethylbenzene	ug/L	72	45	61,000	810	<10	<10	<10	<20	1,100	2	<1.0	<1.0
2-Butanone (MEK)	ug/L	13,000	2,200	240,000,000	40,000	<50	<50	<50	<100	<250	<5.0	<5.0	<5.0
2-Methylnaphthalene	ug/L	260	19	25,000	340	<50	<50	<50	<100	<250	<5.0	<5.0	<5.0
Benzene	ug/L	5	200	5,600	1,900	1,900	2,300	1,900	4,100	3,500	4,200	<1.0	<1.0
Bromofluorobenzene	ug/L	NA	NA	NA	NA	<10	49	<10	<20	<50	<1.0	<1.0	<1.0
Cyclohexane	ug/L	NA	NA	NA	NA	<50	<50	<50	<100	<250	<5.0	<5.0	<5.0
Ethylbenzene	ug/L	74	18	110,000	320	94	52	85	610	1,900	280	<1.0	<1.0
Isopropylbenzene	ug/L	800	28	56,000	500	<10	<10	<10	34	97	17	<1.0	<1.0
m & p - Xylene	ug/L	NA	NA	NA	NA	91	84	84	200	18,000	250	<2.0	<2.0
Methyltertiarybutylether	ug/L	40	7,100	47,000,000	420,000	<10	11	<10	<20	<50	5	1	<1.0
Naphthalene	ug/L	520	11	31,000	200	<50	<50	<50	100	950	77	<5.0	<5.0
n-Propylbenzene	ug/L	80	ID	ID	ID	20	22	19	83	220	27	<1.0	<1.0
o-Xylene	ug/L	NA	NA	NA	NA	<10	<10	<10	<20	7,500	4	<1.0	<1.0
sec-Butylbenzene	ug/L	80	ID	ID	ID	<10	<10	<10	<20	<50	<1.0	<1.0	<1.0
Styrene	ug/L	100	80	170,000	2,900	<10	<10	<10	<20	<50	<1.0	<1.0	<1.0
Toluene	ug/L	790	270	530,000	2,600	<10	<10	<10	<20	1,800	80	<1.0	<1.0
Toluene-d8	ug/L	NA	NA	NA	NA	<10	49	<10	<20	<50	<1.0	<1.0	<1.0
Organics-Semivolatiles													
2-Methylnaphthalene	ug/L	260	19	25,000	340	<5.0	NA	<5.0	<5.0	340	<5.0	<5.0	<5.0
Fluoranthene	ug/L	210	2	210	28	<1.0	NA	<1.0	<1.0	14	<1.0	<1.0	<1.0
Naphthalene	ug/L	520	11	31,000	200	27	NA	28	74	720	33	<1.0	<1.0
Nitrobenzene-d5	ug/L	NA	NA	NA	NA	18	NA	17	16	15	14	12	16
Phenanthrene	ug/L	52	2	1,000	11	<1.0	NA	<1.0	<1.0	10	<1.0	<1.0	<1.0
Pyrene	ug/L	140	ID	140	ID	<1.0	NA	<1.0	<1.0	13	<1.0	<1.0	<1.0

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWC.
Blue indicates contaminant exceeds GSIC.
Green indicates contaminant exceeds both DWC and GSIC.
Orange indicates contaminant exceeds one or more criteria; GVIIC and/or FAV.
"ID" means insufficient data to develop criterion.
"NA" means a criterion or value is not available or, in the case of background, not applicable.
"NLV" means hazardous substance is not likely to volatilize under most conditions.
Letters in criteria columns refer to Footnotes of the Criteria/RBSLs tables.

Table 3
Groundwater Sampling Results
City of Linden

Sample ID		GP-7W	GP-8W	GP-9W	GP-9/TMW	GP-10W	GP-13W	GP-13/TMW	GP-13/TMW dup	GP-14W	GP-16W	GP-16W DUP
Date Collected		7/31/2014	7/31/2014	7/31/2014	8/21/2014	7/31/2014	8/1/2014	8/21/2014	8/21/2014	8/1/2014	8/1/2014	8/1/2014
Organics-Volatiles	Units											
1,2,3-Trimethylbenzene	ug/L	<1.0	<1.0	<20	420	<50	<1.0	11	12	<100	<1.0	<1.0
1,2,4-Trimethylbenzene	ug/L	35	<1.0	2,000	1,200	2,200	18	1.7	2	1,700	<1.0	<1.0
1,3,5-Trimethylbenzene	ug/L	3	<1.0	530	310	350	<1.0	<1.0	<1.0	500	<1.0	<1.0
2-Butanone (MEK)	ug/L	<5.0	<5.0	<100	<100	<250	<5.0	8.4	6.2	<500	<5.0	<5.0
2-Methylnaphthalene	ug/L	<5.0	<5.0	<100	140	<250	<5.0	<5.0	<5.0	<500	<5.0	<5.0
Benzene	ug/L	5,000	<1.0	13,000	14,000	10,000	31	35	35	9,900	2	2
Bromofluorobenzene	ug/L	<1.0	<1.0	<20	49	<50	<1.0	50.3	51	<100	<1.0	<1.0
Cyclohexane	ug/L	<5.0	<5.0		160	<250	<5.0	7.4	7.5	<500	<5.0	<5.0
Ethylbenzene	ug/L	88	<1.0	2,900	1,900	3,200	110	97	98	1,800	<1.0	<1.0
Isopropylbenzene	ug/L	9	<1.0	110	92	100	21	20	22	<100	<1.0	<1.0
m & p - Xylene	ug/L	87	<2.0	7,400	3,400	7,700	<2.0	<2.0	<2.0	5,900	<2.0	<2.0
Methyltertiarybutylether	ug/L	4	28	<20	<20	<50	<1.0	<1.0	<1.0	<100	<1.0	<1.0
Naphthalene	ug/L	38	<5.0	760	600	670	<5.0	<5.0	<5.0	<500	<5.0	<5.0
n-Propylbenzene	ug/L	12	<1.0	290	300	270	40	39	41	210	<1.0	<1.0
o-Xylene	ug/L	22	<1.0	2,900	1,100	2,200	<1.0	<1.0	<1.0	2,800	<1.0	<1.0
sec-Butylbenzene	ug/L	<1.0	<1.0	<20	<20	<50	4	3.5	3.6	<100	<1.0	<1.0
Styrene	ug/L	<1.0	<1.0	110	<20	<50	<1.0	<1.0	<1.0	<100	<1.0	<1.0
Toluene	ug/L	110	<1.0	6,400	2,400	8,200	2	2.2	2.1	24,000	<1.0	<1.0
Toluene-d8	ug/L	<1.0	<1.0	<20	50	<50	<1.0	49.8	49.2	<100	<1.0	<1.0
Organics-Semivolatiles												
2-Methylnaphthalene	ug/L	<5.0	<5.0	110	NA	89	NA	NA	NA	NA	NA	NA
Fluoranthene	ug/L	<1.0	<1.0	<10	NA	<10	NA	NA	NA	NA	NA	NA
Naphthalene	ug/L	24	<1.0	490	NA	370	NA	NA	NA	NA	NA	NA
Nitrobenzene-d5	ug/L	17	17	15	NA	17	NA	NA	NA	NA	NA	NA
Phenanthrene	ug/L	<1.0	<1.0	<10	NA	<10	NA	NA	NA	NA	NA	NA
Pyrene	ug/L	<1.0	<1.0	<10	NA	<10	NA	NA	NA	NA	NA	NA

Table 3
Groundwater Sampling Results
City of Linden

Sample ID		GP-16/TMW	GP-16/TMW dup	GP-17W	GP-18W	GP-19W	GP-19/TMW	TRIP BLANK
Date Collected		8/21/2014	8/21/2014	8/1/2014	8/1/2014	8/1/2014	8/20/2014	7/15/2014
Organics-Volatiles	Units							
1,2,3-Trimethylbenzene	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,4-Trimethylbenzene	ug/L	<1.0	<1.0	1,400	<1.0	<1.0	<1.0	<1.0
1,3,5-Trimethylbenzene	ug/L	<1.0	<1.0	390	<1.0	<1.0	<1.0	<1.0
2-Butanone (MEK)	ug/L	<5.0	<5.0	<250	<5.0	<5.0	<5.0	<5.0
2-Methylnaphthalene	ug/L	<5.0	<5.0	<250	<5.0	<5.0	<5.0	<5.0
Benzene	ug/L	<1.0	<1.0	5,000	<1.0	<1.0	<1.0	<1.0
Bromofluorobenzene	ug/L	50.9	50.5	<50	<1.0	<1.0	51	<1.0
Cyclohexane	ug/L	<5.0	<5.0	<250	<5.0	<5.0	<5.0	<5.0
Ethylbenzene	ug/L	<1.0	<1.0	1,500	<1.0	<1.0	<1.0	<1.0
Isopropylbenzene	ug/L	<1.0	<1.0	82	<1.0	<1.0	<1.0	<1.0
m & p - Xylene	ug/L	<2.0	<2.0	4,600	<2.0	<2.0	<2.0	<2.0
Methyltertiarybutylether	ug/L	<1.0	<1.0	<50	<1.0	<1.0	<1.0	<1.0
Naphthalene	ug/L	<5.0	<5.0	250	<5.0	<5.0	<5.0	<5.0
n-Propylbenzene	ug/L	<1.0	<1.0	210	<1.0	<1.0	<1.0	<1.0
o-Xylene	ug/L	<1.0	<1.0	1,700	<1.0	<1.0	<1.0	<1.0
sec-Butylbenzene	ug/L	<1.0	<1.0	<50	<1.0	<1.0	<1.0	<1.0
Styrene	ug/L	<1.0	<1.0	<50	<1.0	<1.0	<1.0	<1.0
Toluene	ug/L	<1.0	<1.0	6,800	<1.0	<1.0	<1.0	<1.0
Toluene-d8	ug/L	49.5	48.8	<1.0	<1.0	<1.0	49	<1.0
Organics-Semivolatiles								
2-Methylnaphthalene	ug/L	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	ug/L	NA	NA	NA	NA	NA	NA	NA
Naphthalene	ug/L	NA	NA	NA	NA	NA	NA	NA
Nitrobenzene-d5	ug/L	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	ug/L	NA	NA	NA	NA	NA	NA	NA
Pyrene	ug/L	NA	NA	NA	NA	NA	NA	NA

Table 4
Summary of Detected VOCs in Indoor Air
109 North Bridge Street
Linden, Michigan

RESIDENTIAL LAND USE

Hazardous Substance	Chemical Abstract Service Number	*Vapor Intrusion Indoor Air Screening Levels*		*Draft Immediate Response Acute Vapor Intrusion Screening Levels (IRASLs)*	Sample Locations and Dates																
					South Counter 8-hour	South Counter Area 24-hour		Office 8-hour	Office Area Bottlevac	Office Area 24-hour		N. Counter Area/Front Desk 24-hour		Basement N. Sump Bottlevac			N. Basement Old Sump Bottlevac	Basement S. Sump Bottlevac			S. Basement Old Sump Bottlevac
		IAVI-nr		AIAvi	7/27/2014	7/28/2014	8/21/2014	7/27/2014	7/28/2014	7/28/2014	8/21/2014	7/28/2014	8/21/2014	7/27/2014	7/28/2014	8/20/2014	7/27/2014	7/27/2014	7/28/2014	8/20/2014	7/27/2014
		(ug/m3)	(ppbv)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)
1,2,4-Trimethylbenzene	95636	230	44	NA	**2.0**	**1.9**	**4.1**	**2.3**	**5.4**	**2.1**	**3.6**	**1.9**	**3.8**	**1.9**	**1.4**	**4.2**	**7.2**	**5.6**	**2.2**	**4.9**	ND
1,3,5-Trimethylbenzene	108678	230	44	NA	ND	ND	**1.5**	ND	**2.0**	ND	**1.3**	ND	**1.3**	ND	ND	**1.4**	**3.1**	ND	ND	**1.8**	ND
4-Methyl-2-pentanone (MIBK)	108101	3,100	730	NA	ND	ND	ND	ND	ND	**7.9**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	71432	**3.3**	0.97	1,300	**37**	**35**	**1.2**	**38**	**22**	**24**	**1.2**	**22**	**1.0**	**46**	**41**	**1.1**	**29**	**280**	**140**	**1.3**	**44**
Chloromethane	74873	42	20	1,030	**1.2**	**1.2**	**2.1**	**1.2**	**0.9**	**1.2**	**1.5**	**1.1**	**1.7**	**1.0**	**1.0**	**1.2**	**1.0**	**1.0**	**0.9**	**1.2**	**1.0**
Dichlorodifluoromethane	75718	52,000	9,900	NA	**2.2**	**2.1**	**2.3**	**2.2**	**1.9**	**2.0**	**2.4**	**2.1**	**2.1**	**1.9**	**1.9**	**2.2**	**2.0**	**1.8**	**1.9**	**2.2**	**2.0**
Ethylbenzene	100414	87	19	NA	**2.7**	**2.6**	**3.3**	**2.5**	**2.1**	**2.6**	**3.5**	**3.1**	**4.2**	ND	ND	**2.3**	**1.5**	**5.5**	**2.2**	**3.0**	ND
Methylene chloride	75092	58	27	14,000	ND	ND	ND	ND	ND	ND	ND	**1.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes	1330207	100	23	22,000	**4.2**	**4.1**	**6.7**	**4.3**	**7.9**	**4.3**	**6.7**	**4.7**	**6.7**	**2.4**	**1.2**	**5.8**	**12.6**	**8.6**	**3.1**	**7.3**	**1.1**
Styrene	100425	240	53	21,000	ND	ND	**2.1**	ND	ND	**1.6**	**2.3**	**1.1**	**1.9**	ND	ND	**1.1**	ND	ND	ND	**1.7**	ND
Toluene	108883	5,200	1,300	37,000	**4.4**	**4.4**	**13**	**4.8**	**3.6**	**4.4**	**13**	**4.4**	**12**	**1.7**	ND	**5.4**	**4.5**	**2.4**	**1.3**	**7.4**	**1.3**
Remaining VOCs	Varies	Varies	Varies	Varies	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND	All ND

Values obtained from Guidance Document for the Vapor Intrusion Pathway, May 2013

Screening Level Exceeded

ND: Not detected at laboratory reporting limit

NA: Not Available

On August 8, an Indoor Air Mitigation system was installed at 109 N. Bridge Street

Table 5
Summary of Detected VOCs in Ambient Air
208 North Bridge Street
Linden, Michigan

RESIDENTIAL LAND USE

Hazardous Substance	Chemical Abstract Service Number	*Vapor Intrusion Indoor Air Screening Levels*		*Draft Immediate Response Acute Vapor Intrusion Screening Levels (IRASLs)*	CB-2 Bottlevac	Storm Manhole (208 North Bridge) Bottlevac
		IAVI-nr		AIAvi	8/20/2014	8/20/2014
		(ug/m3)	(ppbv)	(ug/m3)	(ug/m3)	(ug/m3)
1,2,4-Trimethylbenzene	95636	230	44	NA	**31**	**28**
1,3,5-Trimethylbenzene	108678	230	44	NA	**11**	**9.9**
1,3-Dichlorobenzene	541731	**3.1**	0.49	NA	**16**	**12**
2,2,4-Trimethylpentane	540841	3,700	740	NA	**940**	**17**
4-Methyl-2-pentanone (MIBK)	108101	3,100	730	NA	ND	ND
Benzene	71432	**3.3**	0.97	1,300	**180**	**6.1**
Chloromethane	74873	42	20	1,030	**1.6**	**1.1**
Dichlorodifluoromethane	75718	52,000	9,900	NA	**2.0**	**2.1**
Ethylbenzene	100414	87	19	NA	**25**	**8.1**
Hexane	110543	**730***	200*	NA	**1,700**	**30**
Methylene chloride	75092	58	27	14,000	ND	ND
Xylenes	1330207	100	23	22,000	**75**	**44**
Styrene	100425	240	53	21,000	ND	ND
Toluene	108883	5,200	1,300	37,000	**50**	**31**
Remaining VOCs	Varies	Varies	Varies	Varies	All ND	All ND

Values obtained from Guidance Document for the Vapor Intrusion Pathway, May 2013

Screening Level Exceeded

ND: Not detected at laboratory reporting limit

NA: Not Available

*Criterion is for n-Hexane

Table 6

Maximum Concentrations in Soil

Broad and Bridge Street Benzene Contamination
Linden, Michigan

Soil Samples			Maximum Concentration	Sample Location	MDEQ Residential Criteria						
Parameter	CAS No.	Units			Drinking Water Protection Criteria & RBSLs	Groundwater Surface Water Interface Protection Criteria & RBSLs	Soil Volatilization to Indoor Air Inhalation Criteria & RBSLs	Infinite Source Volatile Soil Ambient Inhalation Criteria & RBSLs	Particulate Soil Inhalation Criteria & RBSLs	Direct Contact Criteria	Soil Saturation concentration Screening Levels
Volatile Organic Compounds											
Benzene	71432	ug/kg	**67,000**	GP-15, 10'	**100**	**4,000**	**1,600**	**13,000**	380,000,000	180,000	400,000
Ethyl benzene	100414	ug/kg	**140,000**	GP-15, 10'	**1,500**	**360**	**87,000**	720,000	1,000,000,000	140,000	140,000
Isopropylbenzene	98828	ug/kg	**13,000**	GP-15, 10'	91,000	**3,200**	390,000	1,700,000	5,800,000,000	390,000	390,000
2-Methylnaphthalene	91576	ug/kg	**43,000**	GP-15, 10'	57,000	**4,200**	2,700,000	1,500,000	670,000,000	8,100,000	NA
Naphthalene	91203	ug/kg	**50,000**	GP-15, 10'	**35,000**	**730**	250,000	300,000	200,000,000	16,000,000	NA
n-Propylbenzene	103651	ug/kg	**56,000**	GP-15, 10'	**1,600**	ID	ID	ID	1,300,000,000	2,500,000	10,000,000
sec-Butylbenzene	135988	ug/kg	**3,900**	GP-10, 10'	**1,600**	ID	ID	ID	400,000,000	2,500,000	10,000,000
Styrene	100425	ug/kg	**220,000**	GP-10, 10'	**2,700**	**2,100**	250,000	970,000	5,500,000,000	400,000	520,000
Toluene	108883	ug/kg	**400,000**	GP-15, 10'	**16,000**	**5,400**	**330,000**	2,800,000	27,000,000,000	50,000,000	**250,000**
1,2,4-Trimethylbenzene	95636	ug/kg	**300,000**	GP-15, 10'	**2,100**	**570**	**110,000**	21,000,000	82,000,000,000	**110,000**	**110,000**
1,3,5-Trimethylbenzene	108678	ug/kg	**92,000**	GP-15, 10'	**1,800**	**1,100**	94,000	16,000,000	82,000,000,000	94,000	94,000
Xylenes	1330207	ug/kg	**690,000**	GP-15, 10'	**5,600**	**820**	**150,000**	46,000,000	1,000,000,000	**150,000**	**150,000**

Notes:
ug/kg = micrograms per kilogram
< = less than current method detection limit
Bold = Parameter Exceeds Respective Analytical Laboratory Reporting Limit
Shade = Parameter Exceeds Respective Criterion
[1] MDEQ criteria taken from MDEQ Part 201 Generic Cleanup Criteria and Screening Levels - December 30, 2013
Please see MDEQ footnotes for MDEQ Part 201 Generic Cleanup Criteria and Screening Levels - December 30, 3013
ND = Parameter Not Detected at or Above Laboratory Detection Limits
ID = Insufficient Data to Develop Criterion
NA = Criterion of Value is Not Available or Not Applicable
NLV = Hazardous Substance is Not Likely to Volatilize Under Most Conditions
NLL = Hazardous Substance is Not Likely to Leach Under Most Soil Conditions
*Hardness Dependant GSI Criteria Calculated Using an Assumed Hardness of 150 mg CaCO3/L

Table 7

Maximum Concentrations in Groundwater

Broad and Bridge Street Benzene Contamination
Linden, Michigan

Groundwater Samples					MDEQ Residential Criteria			
Parameter	CAS No.	Units	Maximum Concentration	Sample Location	Drinking Water Criteria & RBSLs	Groundwater Surface Water Interface Criteria & RBSLs	Groundwater Volatilization to Indoor Air Inhalation Criteria & RBSLs	Flammability and Explosivity Screening Level
Volatile Organic Compounds								
Benzene	71432	ug/L	**14,000**	GP-9	**5**	**200**	**5,600**	68,000
Cyclohexane	110827	ug/L	**160**	GP-9	NA	NA	NA	NA
Ethyl benzene	100414	ug/L	**3,200**	GP-10	**74**	**18**	110,000	43,000
Isopropylbenzene	98828	ug/L	**110**	GP-9	800	**28**	56,000	29,000
Methyl(tert)butyl ether (MTBE)	1634044	ug/L	**28**	GP-8	40	7,100	47,000,000	ID
2-Methylnaphthalene	91576	ug/L	**340**	GP-3	**260**	**19**	25,000	ID
Naphthalene	91203	ug/L	**950**	GP-3	**520**	**11**	31,000	NA
n-Propylbenzene	103651	ug/L	**290**	GP-9	**80**	ID	ID	ID
Styrene	100425	ug/L	**110**	GP-9	**100**	**80**	170,000	140,000
Toluene	108883	ug/L	**24,000**	GP-14	**790**	**270**	530,000	61,000
1,2,4-Trimethylbenzene	95636	ug/L	**4,100**	GP-3	**63**	**17**	56,000	56,000
1,3,5-Trimethylbenzene	108678	ug/L	**1,100**	GP-3	**72**	**45**	61,000	ID
Xylenes	1330207	ug/L	**26,500**	GP-3	**280**	**41**	190,000	70,000

Notes:
ug/L = micrograms per Liter
< = less than current method detection limit
Bold = Parameter Exceeds Respective Analytical Laboratory Reporting Limit
Shade = Parameter Exceeds Respective Criterion
[1] MDEQ criteria taken from MDEQ Part 201 Generic Cleanup Criteria and Screening Levels - December 30, 2013
Please see MDEQ footnotes for MDEQ Part 201 Generic Cleanup Criteria and Screening Levels - December 30, 2013 criteria
ND = Parameter Not Detected at or Above Laboratory Detection Limits

APPENDICES

APPENDIX A

Field Sampling Sheets

CLIENT: MDEQ-Lansing District
LOCATION: Broad and Bridge Street, Linden, MI

Monitoring Location: _____
Sample ID: GP-19 / TMW
Well Type: 1" PVC - Flush

INSPECTION

Label on well?	YES (NO) REMEDIED	Is cement pad in good repair?	(YES) NO REMEDIED
Is reference mark visible?	(YES) NO REMEDIED	Is protective casing locked and in good repair?	(YES) NO REMEDIED
Standing water present?	YES (NO) REMEDIED	Is inner cap in place and properly sealing well?	(YES) NO REMEDIED
Indication of surface runoff in well?	YES (NO) REMEDIED	Is well casing in visibly good repair?	(YES) NO REMEDIED

Repair Notes:

STATIC WATER LEVEL

Top of Casing Elevation: _____
Depth to Water: ~~12.72~~ 8.05 / 8.06 (8/21)
Elevation of Water: _____

Date: 8/20/14 Time: 1440
Measured with: (ELECTRONIC TAPE) CHALKED TAPE OTHER
Well depth verified? (YES) NO

WELL PURGING

Purge Method: (PERISTALTIC) BLADDER OTHER_____ Date: 8/20/14 Start Time: 1500 (1450 purge)

Measured Well Depth: 12.28 Screen Length: _____ Depth to Screen Midpoint: _____

Time	Water Level (feet)	Drawdown (feet)	Pumping Rate (ml/min)	Temp (°C)	Spec Cond. (umho/cm)	Diss Oxy (mg/l)	pH (S.U.)	ORP (mV)	Turbidity (NTU)
1500	8.11	.06	200	18.06	1531	4.92	6.55	67.0	66.0
1505	8.11	.06	"	17.63	1525	4.57	6.56	64.0	29.2
1510	8.14	.09	250	17.43	1513	4.44	6.63	58.3	15.6
1515	8.16	.11	300	17.19	1516	4.47	6.72	51.8	17.9
1520	8.15	.10	300	17.12	1522	4.44	6.76	45.7	13.7
1525	8.17	.12	400	16.88	1510	4.32	6.76	45.9	17.7
1530	8.17	.12	"	16.86	1510	4.31	6.79	42.9	15.7 / 17.2 (2nd R)
1535	8.17	.12	"	16.94	1508	4.22	6.81	41.3	15.9

Note: Reduce flow rate to 150 ml/min to sample for VOCs

Total Volume Purged (gal): 3.25

Stabilization Criteria:	+/- 3%	+/- 3%	+/- 10% (if > 0.5 mg/l)	+/- 0.1 Units	+/- 10 mV	+/- 10 % (if > 5 NTU)

Stabilization Criteria Reference Doc. USEPA EQASOP-GW 001 Rev #3, January 19, 2010

FIELD ANALYSIS

Time:	1535	
Temperature:	16.94	deg. C
Specific Conductance:	1508	umhos/cm
Dissolved Oxygen:	4.22	mg/L
pH:	6.81	S.U.
ORP:	41.3	mV
Turbidity:	15.9	NTU

CALIBRATION CHECK

	Standard (conc.)	Reading		Mark if Recalibrated
Specific Cond.:			umhos/cm	
Dissolved Oxygen:			mg/L	
pH:			S.U.	
Eh:			mV	
Turbidity:			NTU	

SAMPLE COLLECTION

Time: 1540
Appearance of Sample: clear w/ slight turb
Sample Duplicate ?: no
Sample Method: low flow

NO./BOTTLES:	SIZE:	TYPE:	FILTERED:	PRESERVATIVE:	PARAMETER:
3	40 ml	(glass) plastic	yes (no)	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	VOCs
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	

SAMPLING PERSONNEL

Name (SIGNATURE): [signature] Chain of Custody No._____
Name (SIGNATURE):

CLIENT: MDEQ-Lansing District
LOCATION: Broad and Bridge Street, Linden, MI

Monitoring Location: _____
Sample ID: GP-1/TMW
Well Type: 1" PVC - Flush

INSPECTION

Label on well?	YES (NO)	REMEDIED
Is reference mark visible?	(YES) NO	REMEDIED
Standing water present?	YES (NO)	REMEDIED
Indication of surface runoff in well?	YES (NO)	REMEDIED
Repair Notes:		

Is cement pad in good repair?	(YES) NO	REMEDIED
Is protective casing locked and in good repair?	(YES) NO	REMEDIED
Is inner cap in place and properly sealing well?	(YES) NO	REMEDIED
Is well casing in visibly good repair?	(YES) NO	REMEDIED

STATIC WATER LEVEL

Date: 8/21/14 Time: 0925

Top of Casing Elevation:
Depth to Water: 6.22
Elevation of Water:

Measured with: (ELECTRONIC TAPE) CHALKED TAPE OTHER
Well depth verified? (YES) NO

WELL PURGING

Purge Method: (PERISTALTIC) BLADDER OTHER_____ Date: 8/21/14 Start Time: 0935

Measured Well Depth: 9.29 Screen Length: _____ Depth to Screen Midpoint: _____

Time	Water Level (feet)	Drawdown (feet)	Pumping Rate (ml/min)	Temp (°C)	Spec Cond. (umho/cm)	Diss Oxy (mg/l)	pH (S.U.)	ORP (mV)	Turbidity (NTU)	2nd
0945	6.26	0.04	450	19.01	6867	1.48	7.52	-109.3	78.8	74.
0950	6.26	0.04	"	18.97	6879	0.66	7.42	-110.4	29.1	27.
0955	6.26	0.04	"	18.97	6879	0.30	7.39	-117.2	18.8	16.
1000	6.26	0.04	"	18.95	6881	0.15	7.37	-124.6	15.5	
1005	6.26	0.04	"	18.97	6882	0.11	7.35	-124.1	6.07	5.94
1010	6.27	0.05	"	18.96	6882	0.11	7.34	-127.5	4.77	
1015	6.26	0.04	"	19.01	6883	0.09	7.31	-131.7	4.74	
1020	6.27	0.05	"	18.99	6890	0.11	7.32	-136.3	2.99	

Note: Reduce flow rate to 150 ml/min to sample for VOCs

Stabilization Criteria:	+/- 3%	+/- 3%	+/- 10% (if > 0.5 mg/l)	+/- 0.1 Units	+/- 10 mV	+/- 10 % (if > 5 NTU)

Total Volume Purged (gal): 6

Stabilization Criteria Reference Doc. USEPA EQASOP-GW 001 Rev #3, January 19, 2010

FIELD ANALYSIS

Time:	1020	
Temperature:	18.99	deg. C
Specific Conductance:	6890	umhos/cm
Dissolved Oxygen:	0.11	mg/L
pH:	7.32	S.U.
ORP:	-136.3	mV
Turbidity:	2.99	NTU

CALIBRATION CHECK

	Standard (conc.)	Reading		Mark if Recalibrated
Specific Cond.:			umhos/cm	
Dissolved Oxygen:			mg/L	
pH:			S.U.	
Eh:			mV	
Turbidity:			NTU	

SAMPLE COLLECTION

Time: 1030

Appearance of Sample: Odor (hydrocarbon)

Sample Duplicate ?: no
Sample Method: low flow

NO./BOTTLES:	SIZE:	TYPE:	FILTERED:	PRESERVATIVE:	PARAMETER:
3	40 ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	VOCs
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	

SAMPLING PERSONNEL

Chain of Custody No._____

Name (SIGNATURE): [signature] Name (SIGNATURE):

CLIENT: MDEQ-Lansing District
LOCATION: Broad and Bridge Street, Linden, MI

Monitoring Location: _____
Sample ID: GR-16 /TMW
Well Type: 1" PVC

INSPECTION

Label on well?	YES (NO) REMEDIED	Is cement pad in good repair?	(YES) NO REMEDIED
Is reference mark visible?	(YES) NO REMEDIED	Is protective casing locked and in good repair?	(YES) NO REMEDIED
Standing water present?	YES (NO) REMEDIED	Is inner cap in place and properly sealing well?	(YES) NO REMEDIED
Indication of surface runoff in well?	YES (NO) REMEDIED	Is well casing in visibly good repair?	(YES) NO REMEDIED

Repair Notes:

STATIC WATER LEVEL

Date: 8/21/14 Time: 1300

Top of Casing Elevation:
Depth to Water: 8.98
Elevation of Water:

Measured with: (ELECTRONIC TAPE) CHALKED TAPE OTHER
Well depth verified? (YES) NO

WELL PURGING

Purge Method: (PERISTALTIC) BLADDER OTHER_____ Date: 8/21/14 Start Time: 1317

Measured Well Depth: 12.35 Screen Length: _____ Depth to Screen Midpoint: _____

Time	Water Level (feet)	Drawdown (feet)	Pumping Rate (ml/min)	Temp (°C)	Spec Cond. (umho/cm)	Diss Oxy (mg/l)	pH (S.U.)	ORP (mV)	Turbidity (NTU)	2nd
1330	9.01	.03	400	17.43	1307	5.44	7.42	16.9	31.3	38.6
1335	9.02	.04	450	16.43	1285	3.85	6.77	52.2	16.4	19.2
1340	9.02	.04	450	16.39	1295	3.09	6.80	47.0	15.3	13.6
1345	9.02	.04	"	16.28	1290	2.57	6.87	41.2	12.7	13.4
1350	9.01	.03	"	16.30	1300	2.28	6.91	37.7	7.09	7.09
1355	9.01	.03	"	16.28	1307	2.08	6.96	34.1	4.6	5.08
1400	9.01	.03	"	16.34	1305	2.06	6.97	33.6	4.26	4.46
1405	9.01	.03	"	16.32	1303	2.00	7.01	30.3	4.26	4.25

Reduce flow to 125 ml/min to sample VOCs

Stabilization Criteria:	+/- 3%	+/- 3%	+/- 10% (if > 0.5 mg/l)	+/- 0.1 Units	+/- 10 mV	+/- 10 % (if > 5 NTU)

Total Volume Purged (gal): 5.25

Stabilization Criteria Reference Doc. USEPA EQASOP-GW 001 Rev #3, January 19, 2010

FIELD ANALYSIS

Time:	1405	
Temperature:	16.32	deg. C
Specific Conductance:	1303	umhos/cm
Dissolved Oxygen:	2.00	mg/L
pH:	7.01	S.U.
ORP:	30.3	mV
Turbidity:	4.26	NTU

CALIBRATION CHECK

	Standard (conc.)	Reading		Mark if Recalibrated
Specific Cond.:			umhos/cm	
Dissolved Oxygen:			mg/L	
pH:			S.U.	
Eh:			mV	
Turbidity:			NTU	

SAMPLE COLLECTION

Time: 1410
Appearance of Sample: Clear
Sample Duplicate ?: yes GR-16/TMW dup
Sample Method: low flow

NO./BOTTLES:	SIZE:	TYPE:	FILTERED:	PRESERVATIVE:	PARAMETER:
3	40 ml	(glass) plastic	yes (no)	None, (HCl), HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	VOCs
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	

SAMPLING PERSONNEL

Chain of Custody No._____
Name (SIGNATURE): [signature] Name (SIGNATURE):

CLIENT: MDEQ-Lansing District
LOCATION: Broad and Bridge Street, Linden, MI

Monitoring Location: _____
Sample ID: GP-13 / TMW
Well Type: 1" PVC

INSPECTION

Label on well?	YES (NO) REMEDIED	Is cement pad in good repair?	(YES) NO REMEDIED
Is reference mark visible?	(YES) NO REMEDIED	Is protective casing locked and in good repair?	(YES) NO REMEDIED
Standing water present?	YES (NO) REMEDIED	Is inner cap in place and properly sealing well?	(YES) NO REMEDIED
Indication of surface runoff in well?	YES (NO) REMEDIED	Is well casing in visibly good repair?	(YES) NO REMEDIED

Repair Notes:

STATIC WATER LEVEL

Date: 8/21/14 Time: 1440

Top of Casing Elevation:
Depth to Water: 10.64
Elevation of Water: _____

Measured with: (ELECTRONIC TAPE) CHALKED TAPE OTHER
Well depth verified? YES NO

WELL PURGING

Purge Method: (PERISTALTIC) BLADDER OTHER_____ Date: 8/21/14 Start Time: 1445 purge / 1515 repurge

Measured Well Depth: 12.72 Screen Length: _____ Depth to Screen Midpoint: _____

Time	Water Level (feet)	Drawdown (feet)	Pumping Rate (ml/min) ~450	Temp (°C)	Spec Cond. (umho/cm)	Diss Oxy (mg/l)	pH (S.U.)	ORP (mV)	Turbidity (NTU)
1447	–	well dries - does not support low flow							
		* sample upon recharge							
						peristaltic			
Note: Well does support @			100	lowest rate on pump					
1525	10.78	0.14	100	19.77	14011	1.44	7.91	-161.0	11.8/12.4
1530	10.78	0.14	11	19.49	14061	0.70	7.83	-142.9	7.10/8.32
1535	10.80	0.16	125	19.42	14019	0.36	7.77	-144.3	6.26/6.41
1540	10.78	0.14	100	19.56	13972	0.24	7.73	-143.5	4.58
1545	10.78	0.14	100	20.19	13925	0.22	7.69	-144.4	4.86
1550	10.78	0.14	100	19.87	13945	0.20	7.70	-133.9	4.92
		Stabilization Criteria:		+/- 3%	+/- 3%	+/- 10% (if > 0.5 mg/l)	+/- 0.1 Units	+/- 10 mV	+/- 10 % (if > 5 NTU)

Total Volume Purged (gal): ~~5~~ 1 gal

Stabilization Criteria Reference Doc. USEPA EQASOP-GW 001 Rev #3, January 19, 2010

FIELD ANALYSIS

Time:			1550
Temperature:		deg. C	19.87°C
Specific Conductance:		umhos/cm	13945
Dissolved Oxygen:		mg/L	0.20
pH:		S.U.	7.70
ORP:		mV	-133.9
Turbidity:		NTU	4.92

CALIBRATION CHECK

	Standard (conc.)	Reading		Mark if Recalibrated
Specific Cond.:			umhos/cm	
Dissolved Oxygen:			mg/L	
pH:			S.U.	
Eh:			mV	
Turbidity:			NTU	

SAMPLE COLLECTION

Time: 1555
Appearance of Sample: ~~slight turbid~~ clear, slight hydrocarbon odor
Sample Duplicate ?: yes, dup
Sample Method: grab

NO./BOTTLES:	SIZE:	TYPE:	FILTERED:	PRESERVATIVE:	PARAMETER:
3	40 ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	VOCs
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	

SAMPLING PERSONNEL

Chain of Custody No._____

Name (SIGNATURE): [signature] Name (SIGNATURE):

CLIENT: MDEQ-Lansing District
LOCATION: Broad and Bridge Street, Linden, MI

Monitoring Location:
Sample ID: GP-9/TMW
Well Type: 1" PVC

INSPECTION

Label on well?	YES (NO) REMEDIED	Is cement pad in good repair?	(YES) NO REMEDIED
Is reference mark visible?	(YES) NO REMEDIED	Is protective casing locked and in good repair?	(YES) NO REMEDIED
Standing water present?	YES (NO) REMEDIED	Is inner cap in place and properly sealing well?	(YES) NO REMEDIED
Indication of surface runoff in well?	YES (NO) REMEDIED	Is well casing in visibly good repair?	(YES) NO REMEDIED

Repair Notes:

STATIC WATER LEVEL

Date: 8/21/14 Time: 1618

Top of Casing Elevation:
Depth to Water: 9.08
Elevation of Water:

Measured with: (ELECTRONIC TAPE) CHALKED TAPE OTHER
Well depth verified? YES NO

WELL PURGING

Purge Method: (PERISTALTIC) BLADDER OTHER_____ Date: 8/21/14 Start Time: 1625

Measured Well Depth: 12.36 Screen Length: _____ Depth to Screen Midpoint: _____

Time	Water Level (feet)	Drawdown (feet)	Pumping Rate (ml/min)	Temp (°C)	Spec Cond. (umho/cm)	Diss Oxy (mg/l)	pH (S.U.)	ORP (mV)	Turbidity (NTU)	2nd
1635	9.77		450	~~25.10~~ 18.73	9607	3.07	7.18	-89.4	94.4	93.2
1640	9.65		300	17.83	9320	1.42	6.99	-80.1	52.5	55.9
1645	9.74		300	17.52	9218	0.30	6.93	-82.3	37.4	41.0
1650	9.66		250	17.52	9143	0.14	6.91	-85.2	18.3	18.6
1655	9.66		"	17.49	9093	0.15	6.91	-87.2	19.8	20.0
1700	9.67		"	17.43	9047	0.17	6.91	-88.6	17.9	

Reduce flow rate to 150 ml/min to sample for VOCs

Total Volume Purged (gal): 2.5

Stabilization Criteria:	+/- 3%	+/- 3%	+/- 10% (if > 0.5 mg/l)	+/- 0.1 Units	+/- 10 mV	+/- 10 % (if > 5 NTU)

Stabilization Criteria Reference Doc. USEPA EQASOP-GW 001 Rev #3, January 19, 2010

FIELD ANALYSIS

Time:	1700	
Temperature:	17.43	deg. C
Specific Conductance:	9047	umhos/cm
Dissolved Oxygen:	0.17	mg/L
pH:	6.91	S.U.
ORP:	-88.6	mV
Turbidity:	17.9	NTU

CALIBRATION CHECK

	Standard (conc.)	Reading		Mark if Recalibrated
Specific Cond.:			umhos/cm	
Dissolved Oxygen:			mg/L	
pH:			S.U.	
Eh:			mV	
Turbidity:			NTU	

SAMPLE COLLECTION

Time: 1705
Appearance of Sample: semi-turb/odor (hydrocarbon)
Sample Duplicate ?: no
Sample Method: low flow

NO./BOTTLES:	SIZE:	TYPE:	FILTERED:	PRESERVATIVE:	PARAMETER:
3	40 ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	VOCs
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	
	ml	glass plastic	yes no	None, HCl, HNO_3, NaOH, H_2SO_4, ZnAc, TSP, BAK	

SAMPLING PERSONNEL

Name (SIGNATURE): [signature]
Chain of Custody No._____
Name (SIGNATURE):

APPENDIX B

Boring Logs and Monitoring Well Construction Summaries

Environmental Consulting & Technology, Inc.
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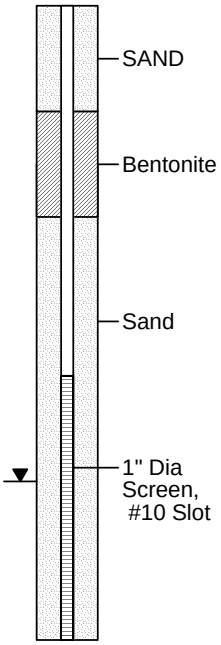
LOG OF BORING GP-1

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 7/30/2014	Boring Location	: 109 N. Bridge Street
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Hand Auger/Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Brick/Paver Stone	
1	SP		0.0	N/A		Light and dark brown, fine to medium grained SAND, some fine to coarse gravel, moist.	
2			0.0				
3	CL		0.0			Brown and gray (mottled), soft to medium-stiff CLAY, some trace gravel.	
4			0.0	24"			
5			0.0				
6			0.0				
7			0.0				
8			0.9	40"			
9			1.2		GP-1 (8.5-9')		Shaker test @ 9' is negative for LNAPL
10	GP		0.0			Gray, fine to medium SAND and fine GRAVEL, hydrocarbon odor, wet	
11			0.0				
12	CL		0.0			Gray, soft CLAY, silty, hydrocarbon odor	
13			.075	60"	GP-1 (13')		
14			0.0				
15			0.0				Screen set from 7 to 12' bgs
16						End of Boring bgs - below ground surface	
17							
18							
19							
20							
21							
22							
23							
24							
25							



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LOG OF BORING GP-2

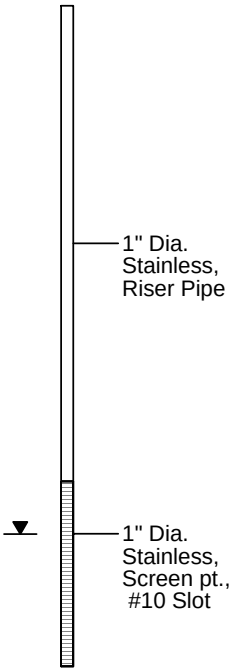
City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed : 7/30/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Hand Auger/Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : 109 N. Bridge Street
Latitude :
Longitude :

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Brick/Paver Stone	
1	SP		0.0	N/A		Brown, medium grained SAND, some fine gravel, moist.	
2			0.0				
3	CL		0.0			Brown, soft to medium-stiff CLAY, some trace gravel.	
4			0.0	24"			
5			0.0				
6	CL		0.0	60"		Gray, soft to medium-stiff CLAY, trace fine gravel	
7			.282				
8			0.0				
9			.460				
10			0.0		GP-2 (9-10')		Shaker test @ 10' is negative for LNAPL
11	GP		0.0	27		Gray, fine to coarse GRAVEL, some fine sand, hydrocarbon odor, wet	
12			16.2				
13			0.0				
14	CL		0.0		GP-2 (14')	Gray, soft to medium-stiff CLAY, no odor, moist	Screen set from 9 to 12.5' bgs
15			0.0				
16						End of Boring bgs - below ground surface	
17							
18							
19							
20							
21							
22							
23							
24							
25							



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LOG OF BORING GP-3

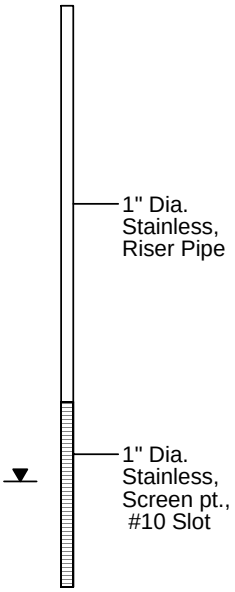
City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed : 7/30/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : Across street from 109 Bridge
Latitude :
Longitude :

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0			0.0			Concrete Sidewalk	
1	SP		0.0			Brown, fine SAND, trace fine gravel, moist.	
2	CL		0.0	42		Gray, medium-stiff CLAY, trace fine gravel.	
3			0.0				
4			5.87				
5	GP		0.0	32		Olive gray, fine to coarse GRAVEL, with some coarse sand, hydrocarbon odor.	
6			2430				
7			0.0		GP-3 (7-8')		
8			141				Shake test @ 9' was negative for LNAPL
9	CL		0.0			Olive gray, medium-stiff CLAY, some coarse gravel, hydrocarbon odor.	
10	GP		0.0	53		Brown, coarse SAND and GRAVEL, hydrocarbon odor, wet.	Visible LNAPL in sampler
11			16.2				
12			0.0				
13	CL		25			Gray, soft to medium CLAY, no odor, moist.	
14			0.0		GP-3 (15')		Screen set from 7.5 - 11' bgs
15						End of Boring bgs - below ground surface	
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							



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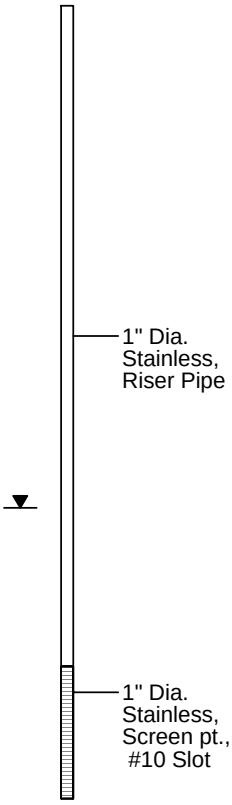
LOG OF BORING GP-4

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 7/30/2014	Boring Location	: NW corner of Bridge & Broad
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Mulch (flower bed)	
1	GP		0.0			Brown, coarse GRAVEL, dry	
2			0.0				
3			0.0	29			
4	SP		0.0			Brown and light brown, fine to coarse SAND, moist	
5			0.0				
6			0.0				
7			2.17				
8			0.0	43			
9			0.150		GP-4 (9')		Shake test @ 9' was negative for LNAPL
10			0.0				
11			0.0				
12			0.0				
13			2.7	60			
14	GP		1.3			Brown and gray, fine to coarse SAND and GRAVEL, hydrocarbon odor, wet	
15			0.0				
16							
17				60			
18							
19	CL					Gray, medium-stiff CLAY, no odor, moist.	Screen set from 12.5 to 15' bgs
20						End of Boring bgs - below ground surface	
21							
22							
23							
24							
25							



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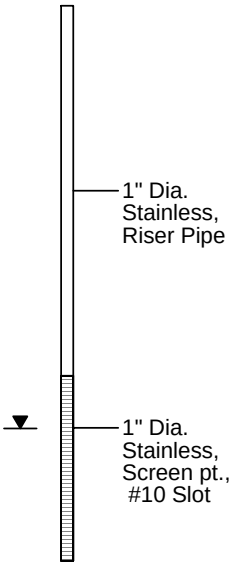
LOG OF BORING GP-5

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 7/30/2014	Boring Location	: Across street from 119 Bridge
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0	SP		0.0			Concrete	
1	CL		0.0			Brown, fine to medium SAND, trace fine gravel, moist	
2			0.0	40		Brown, medium-stiff CLAY, sandy, trace fine gravel	
3			0.0				
4			0.0				
5	CL		0.0			Gray, stiff CLAY	
6			0.0				
7	GP		0.0	39	GP-5 (8')	Gray, coarse SAND & fine to coarse GRAVEL, trace odor, wet	Shake test @ 8' was negative for LNAPL
8	CL		0.0			Gray, medium-stiff CLAY	
9			0.0				
10	GP		0.0	45		fine to coarse GRAVEL, with some medium to coarse sand, wet	
11			0.0				
12	CL		0.0		GP-5 (13')	Gray, medium-stiff CLAY, moist.	Screen set from 7 to 10.5' bgs
13						End of Boring	
14						bgs - below ground surface	
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							



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LOG OF BORING GP-6

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

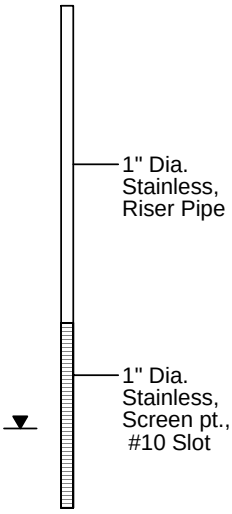
Project #14-0500

Date Completed : 7/30/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : Across street from 123 Bridge
Latitude :
Longitude :

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Concrete	
1	SP		0.0	12		Brown, fine to medium SAND, trace fine gravel, moist.	
2			0.0				
3			0.0				
4			0.0				
5			0.0				Rock at bottom of shoe @ 5'
6	CL		0.0	51		Gray, medium-stiff CLAY, trace coarse gravel	
7			0.0				
8	GP		0.0		GP-6 (8')	Brown, fine to coarse GRAVEL, with coarse sand, wet	Shake test @ 8' was negative for LNAPL
9	CL		0.0			Gray, stiff CLAY, trace fine gravel	
10			0.0		GP-6 (10')		Screen set from 6 to 9.5' bgs

End of Boring
bgs - below ground surface



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LOG OF BORING GP-7

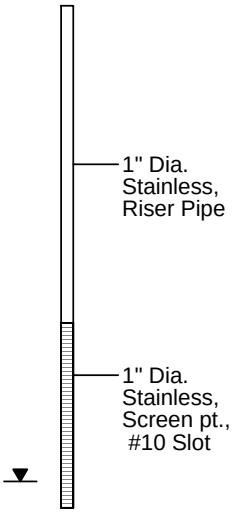
City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed : 7/31/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Hand Auger/Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : NW corner of Bridge & Broad
Latitude :
Longitude :

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Brick/Paver Stone	
1	SP		0.0	N/A		Brown, medium grained SAND, with some fine to coarse gravel, moist	
2			0.0				
3			0.0				
4			0.0				
4			0.0	18			
5	SP		0.0	41		Brown, fine SAND, moist	
6			0.15				
7	SP		4.76			Brown and gray, very fine SAND, silty, hydrocarbon odor	
8	GP		38.3		GP-7 (9')	Gray, coarse GRAVEL, some coarse sand, hydrocarbon odor, wet	Shake test @ 9-10' was negative for LNAPL
9			23				
10	SP		5.8	60		Gray, very fine SAND, some fine to coarse GRAVEL, silty, hydrocarbon odor, wet	
11							
12	GP					Gray, fine to coarse GRAVEL, some coarse sand, hydrocarbon odor, wet	
13	CL		10.8			Gray, medium-stiff CLAY, no odor, moist.	
14					GP-7 (15')		
15						End of Boring bgs - below ground surface	
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							



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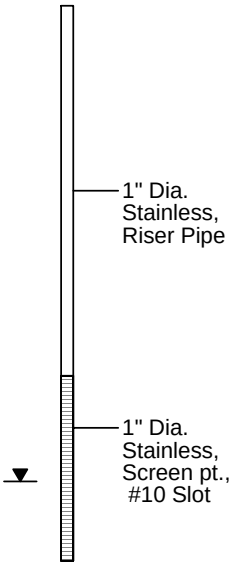
LOG OF BORING GP-8

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 7/31/2014	Boring Location	: In front of Masonic Temple
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Hand Auger/Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0					Concrete	
1	SP	0.0	N/A		Brown, medium SAND, some coarse gravel, moist	
2		0.0				
3		0.0				
4		0.0				
5	SC	0.0	14		Brown, fine to medium SAND, clayey, trace fine gravel, moist	
6	CL	0.0	47		Brown, medium-stiff to stiff CLAY, sandy, moist.	
7		0.0				
8	CL	0.0			Brown, soft CLAY, sandy, moist	
9	GP	0.0		GP-8 (9')	Brown, fine to coarse GRAVEL, with some coarse sand, wet	Shake test @ 9' was negative for LNAPL
10	CL	0.0			Gray, medium-stiff CLAY, moist	
11		0.0				
12		0.0	27			
13		0.0				
14		0.0				
15						Screen set from 7 to 10.5 bgs
16					End of Boring bgs - below ground surface	
17						
18						
19						
20						
21						
22						
23						
24						
25						



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LOG OF BORING GP-9

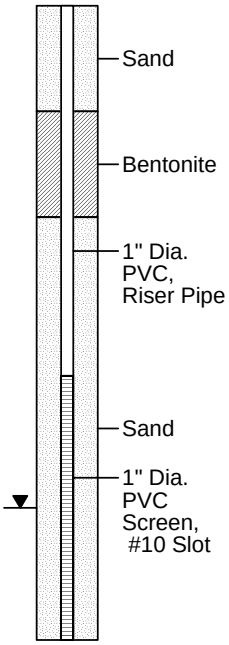
City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed : 7/31/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Hand Auger/Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : SE corner Bridge & Broad
Latitude :
Longitude :

Depth in Feet	USCS	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0	FILL				Brick/Paver Stone	
1	FILL	1.53	23		Brown, medium FILL SAND, some brick and gravel.	
2	FILL				Crushed rock	
3	FILL	2.30			Light gray, fine to medium SAND, hydrocarbon odor, moist	
4	FILL	14.6				
5	FILL	20.8	45			
6	FILL	33.4				
7	SP	101			Gray and black staining, fine SAND, fine to coarse gravel, hydrocarbon odor, moist	
8	SP	340				
9	ML	1880		GP-9 (9.5')	Silt, soft, hydrocarbon odor, moist	Shake test @ 9.5 - 10' was positive for LNAPL
10	SP		40		Brown and black staining, fine grained SAND, hydrocarbon odor, wet	
11	SP	15				
12	SP	332				
13	SP	20.5				
14	GP	0.0			Brown, fine to coarse GRAVEL, wet	
15	CL	.602	30		Gray, soft to medium-stiff CLAY, moist	
16	CL					
17	CL	.355				
18	CL					
19	CL					Screen is set from 7 to 12' bgs
20					End of Boring	
21					bgs - below ground surface	
22						
23						
24						
25						



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LOG OF BORING GP-10

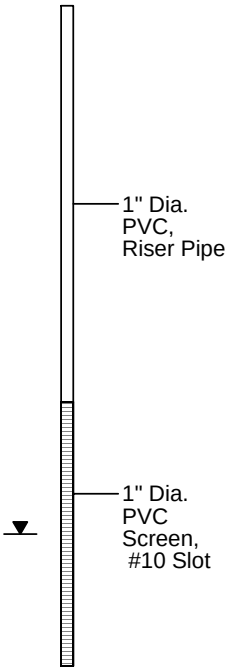
City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed : 7/31/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : East of GP-9
Latitude :
Longitude :

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Concrete	
1	SP		18.7	32		Dark brown and brown, fine to medium SAND, trace fine gravel, hydrocarbon odor.	
2							
3			44.0				
4			25.2				
5			231	45	GP-10 (5-6')		
6			61				
7							
8			144				Gray and black staining @ 8 - 10'
9			2890		GP-10 (10')		
10						Brown and black staining, fine SAND, hydrocarbon odors, wet	Shake test @ 10' was positive for LNAPL
11	SP		1670				
12	GP		526	53		Brown with black staining, fine to coarse GRAVEL, some coarse sand, hydrocarbon odors, wet.	
13	CL		391			Brown and gray, stiff to hard CLAY, slight hydrocarbon odor	
14			12.0				Screen set from 7.25 to 12.5' bgs
15						End of Boring bgs - below ground surface	
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							



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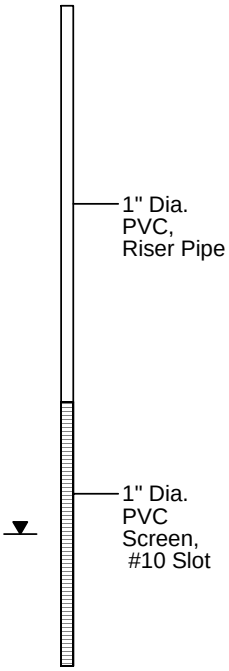
LOG OF BORING GP-11

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 7/31/2014	Boring Location	: East of GP-10
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Concrete	
1	SP		0.0	35		Brown and light brown, fine SAND, trace fine gravel, moist	
2							
3			0.0				
4			0.0				
5				39			
6			8.86				
7							
8							
9			160				
10					GP-11 (10')		Shake test @ 10' was negative for LNAPL
11			660				
12	GP		487	41		Gray, fine to coarse GRAVEL, hydrocarbon odors, wet	
13	CL		105			Gray, stiff CLAY, hydrocarbon odors, moist	
14			0.58				Screen set from 7.5 to 12.5 bgs
15						End of Boring bgs - below ground surface	
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							



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LOG OF BORING GP-12

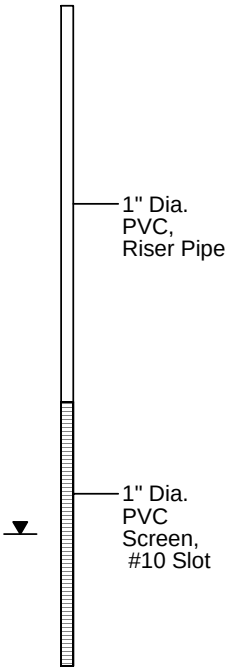
City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed : 7/31/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : East of GP-11
Latitude :
Longitude :

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Concrete	
1	SP		0.0	33		Brown, fine SAND, silty, moist	
2							
3			0.0				
4							
5			0.0				
6			0.0				
7				37			
8			0.0				
9			2.1				
10	ML		10.1		GP-12 (10')	Brown, soft SILT, moist	Shake test @ 10' was negative for LNAPL
11	GP		692			Brown and black staining, fine to coarse GRAVEL, hydrocarbon odors, wet	
12	CL		7.13	40		Gray, stiff CLAY, no odor	
13							
14			3.18				
15			0				Screen set from 7.5 to 12.5' bgs
16						End of Boring bgs - below ground surface	
17							
18							
19							
20							
21							
22							
23							
24							
25							



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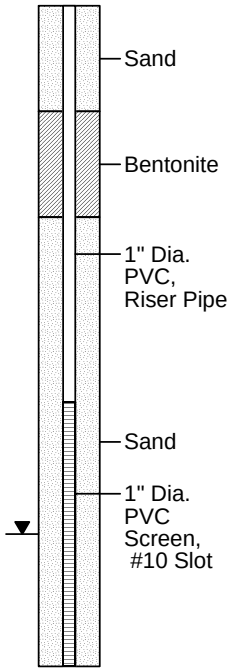
LOG OF BORING GP-13

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 8/1/2014	Boring Location	: East of GP-12
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Concrete	
1	SP		0.0	30		Brown, fine to medium SAND, trace fine gravel, silty, moist.	
2							
3			0.0				
4			0.0				
5				39			
6			0.0				
7			0.0				
8							
9			0.0				
10				26			
11			0.0				
12							
13			0.0				
14					GP-13 (14.5')		Shake test @ 14.5' was negative for LNAPL
15	GP		0.0			Dark gray and brown, fine to coarse GRAVEL, some coarse sand, slight hydrocarbon odor, wet	
16							
17	CL		0.0	60		Gray, medium-stiff CLAY, moist	
18							
19			0.0				Screen set from 7.5 to 12.5' bgs
20						End of Boring bgs - below ground surface	
21							
22							
23							
24							
25							



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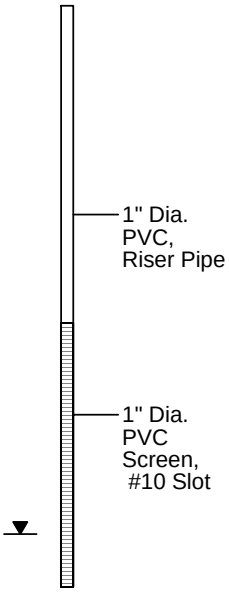
LOG OF BORING GP-14

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 8/1/2014	Boring Location	: South of GP-9
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0	VL					Brick/Paver Stone	
1			0.0			Tan and brown, fine to medium SAND, some gravel, moist	
2				29			
3			1.08				
4			6.7				
5	SP						Black staining and odor starts @ 5.5'
6			53				
7				41			
8			1670				
9			2220				
10	MI				GP-14 (10')	Dark gray with black staining, SILT with some very fine SAND, hydrocarbon odors	Shake test @ 9.5' was positive for LNAPL
11						Dark gray, medium to coarse SAND, trace fine gravel, hyrdocarbon odors, wet	
12	SP		1900	24			
13							
14			5.08				
15			6.79			Gray, medium-stiff to stiff CLAY	
16	CL			33			Screen set from 6 to 11' bgs
			3.76				
17						End of Boring bgs - below ground surface	
18							
19							
20							
21							
22							
23							
24							
25							



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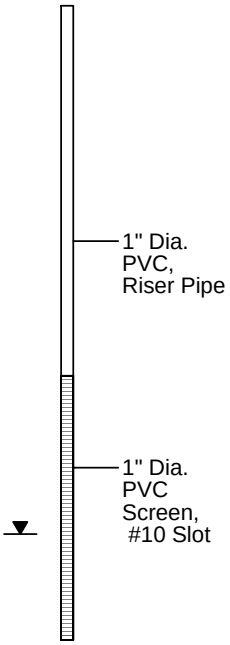
LOG OF BORING GP-15

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 8/1/2014	Boring Location	: South of GP-14, near USTs
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Blacktop	
1	FILL		11.7	30		Brown and gray, fine to medium FILL SAND, gravel, odor	
2							
3			5.06				
4			30.0				
5	SP			40		Gray, fine to medium SAND, hydrocarbon odor, moist	
6			41.6				
7							
8			75.3				
9			2370		GP-15 (10')		
10	SP			60		dark brown and black staining, fine SAND, LNAPL globules, hydrocarbon odor	Shake test @ 10' was positive for LNAPL
11							
12			1830				
13	GP					fine to coarse GRAVEL, hydrocarbon odor, wet	
14			86.8				
15	CL					Gray, medium-stiff CLAY, slight hydrocarbon odor	
16			7.69				Screen placed at 7 to 12' bgs for gauging LNAPL thickness
17			0.0		GP-15 (17')		
18						End of Boring bgs - below ground surface	
19							
20							
21							
22							
23							
24							
25							



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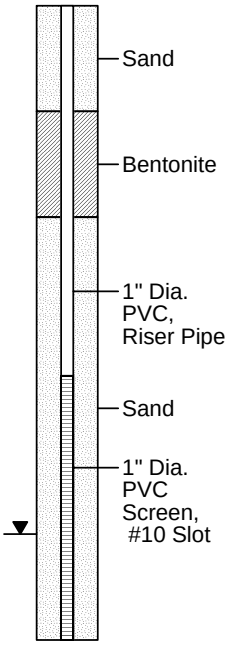
LOG OF BORING GP-16

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 8/1/2014	Boring Location	: South of GP-15
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Topsoil	
1	FILL		0.0	21		Brown, medium FILL SAND, trace coal and brick debris, moist	
2							
3							
4			0.0				
5	SP			38		Brown, fine to coarse SAND, trace fine gravel, moist	
6			0.0				
7							
8							
9			0.0		GP-16 (10')		
10	SP			51		Light brown, fine SAND, trace fine gravel, wet	Shake test @ 10' was negative for LNAPL
11			0.0				
12	GP		0.0			fine to coarse GRAVEL, trace coarse sand, wet	
13							
14			0.0				
15	CL					Gray, medium-stiff CLAY, moist	
16			0.0				Screen set from 7 to 12' bgs
17						End of Boring bgs - below ground surface	
18							
19							
20							
21							
22							
23							
24							
25							



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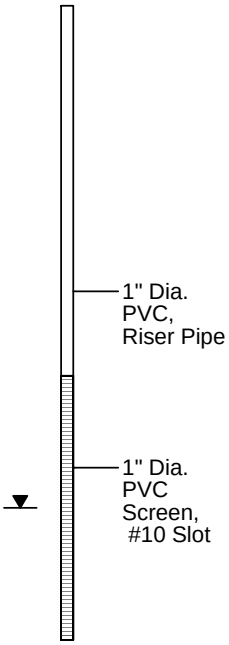
LOG OF BORING GP-17

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 8/1/2014	Boring Location	: Frontage of 106 Bridge St.
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Mulch/Topsoil within edge of flower garden	
1	FILL		0.6			Dark brown, medium FILL SAND, some slag debris, with some topsoil	
2	SP			26		Light brown and gray, fine SAND, moist	
3							
4			0.8				
5							Odor begins
6			65				
7			181	42			
8			2580				
9	SP		2490		GP-17 (9.5')	Dark gray and black staining, medium SAND, hydrocarbon odor	
10	SP					Dark brown and black staining, fine SAND, hydrocarbon odor, wet	
11			572				
12							
13			860	31			Shake test @ 13 - 14' was positive for LNAPL
14			1240				
15							
16	GP		59			Brown, fine to coarse GRAVEL, trace coarse sand, wet, hydrocarbon odor, piece of limestone	Screen set from 7 to 12' bgs
17	CL		0.0			Gray, stiff CLAY, no odor	
18						End of Boring	
19						bgs - below ground surface	
20							
21							
22							
23							
24							
25							



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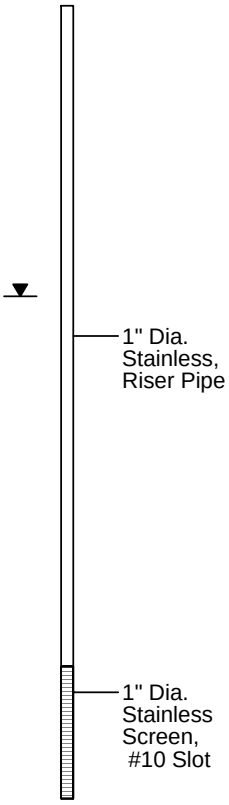
LOG OF BORING GP-18

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 8/1/2014	Boring Location	: Parking lot behind 109 Bridge
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0					Asphalt	
1	SP	0.0	27		Brown, medium SAND, some fine gravel, moist.	
2		0.0				
3		0.0				
4		0.0				
5	GP	0.0	36		Gray, coarse GRAVEL (approx. 1" diam.)	
6	GP	0.0			Brown, coarse SAND and fine to coarse GRAVEL, wet	
7		0.0				
8	CL	0.0			Gray, stiff CLAY	
9		0.0		GP-18 (9-10')		
10	GP	0.0	36		Fine to coarse GRAVEL, wet	
11		0.0				
12		0.0				
13		0.0				Shake test @ 13' was negative for LNAPL
14	CL	0.0		GP-18 (15')	Gray, medium-stiff to stiff CLAY	Screen set from 12.5 to 15' bgs
15					End of Boring bgs - below ground surface	
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						



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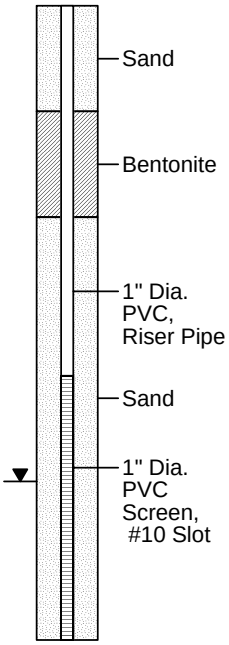
LOG OF BORING GP-19

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed	: 8/1/2014	Boring Location	: SW corner of municipal lot
Hole Diameter	: 2.5"	Latitude	:
Drilling Company	: North American Probing	Longitude	:
Drilling Method	: Geoprobe		
Company Rep.	: Jason Bartholomew		

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Topsoil	
1	FILL		0.17	36		Brown and gray, fine to medium FILL SAND and coarse GRAVEL, trace brick and plastic debris, moist	
2			0.15				
3							
4			0.139				
5				44			
6			0.18				
7							
8							
9	SP		0.139		GP-19 (9.0')	Brown, fine SAND	Shake test @ 9-10' was negative for LNAPL
10	GP			36		Brown, fine to coarse GRAVEL and coarse SAND, wet	
11			0.0				
12							
13							
14	CL		0.0			Gray, stiff CLAY	Screen set from 7 to 12' bgs
15						End of Boring bgs - below ground surface	
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							



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LOG OF BORING GP-20

City of Linden
Broad & Bridge Street Benzene Contamination
Linden (Genesee County), Michigan

Project #14-0500

Date Completed : 8/1/2014
Hole Diameter : 2.5"
Drilling Company : North American Probing
Drilling Method : Geoprobe
Company Rep. : Jason Bartholomew

Boring Location : Parking lot, North of Hamrick
Latitude :
Longitude :

Depth in Feet	USCS	GRAPHIC	PID (ppb)	Recovery (inches)	Sample ID	DESCRIPTION	REMARKS
0						Asphalt	
1	FILL		0.0	43		Dark brown, fine to medium FILL SAND, brick, wood, and metal	
2			0.0				
3							
4			0.0				
5				35			
6			0.0				
7							
8							
9			0.0		GP-20 (9.0')		Shake test @ 9-10' was negative for LNAPL
	CL					Brown, medium-stiff CLAY, trace fine gravel	
10	CL			60		Brown and gray (mottling), stiff to hard CLAY, trace fine gravel	
11			0.0				
12							
13							
14			0.0				
15				60			
16			0.0				
17							
18							
19			0.0				
20						End of Boring	
21						bgs - below ground surface	
22							
23							
24							
25							

APPENDIX D

Historical Sampling Results

Atwell, LLC Soil Sampling Results
City of Linden

Sample ID		Drinking Water Protection Criteria (DWPC)	Groundwater Surface Water Protection Criteria (GSIPC)	Soil Volatilization to Indoor Air Inhalation Criteria (SVIIC)	Direct Contact Criteria (DCC)	**AB-2(10.5')**	**AB-4(8')**	**AB-5(9')**	**AB-6(10')**
Date Collected						10/17/2012	10/17/2012	10/17/2012	10/17/2012
Organics-Volatiles									
1,2,4-Trimethylbenzene	ug/kg dry	2,100	570	4,300,000	32,000,000	180,000	48,000	ND	180,000
1,3,5-Trimethylbenzene	ug/kg dry	1,800	1,100	2,600,000	32,000,000	65,000	15,000	ND	69,000
2-Methylnaphthalene	ug/kg dry	57,000	4,200	2,700,000	8,100,000	ND	ND	ND	ND
Benzene	ug/kg dry	100	4,000	1,600	180,000	ND	2,000	ND	1,300
Ethylbenzene	ug/kg dry	1,500	360	87,000	22,000,000	25,000	12,000	ND	41,000
Isopropylbenzene	ug/kg dry	91,000	3,200	400,000	25,000,000	5,200	15,000	ND	7,600
m & p - Xylene	ug/kg dry	NA	NA	NA	NA	36,000	60,000	ND	240,000
Naphthalene	ug/kg dry	35,000	730	250,000	16,000,000	ND	ND	ND	ND
n-Propylbenzene	ug/kg dry	1,600	ID	ID	2,500,000	24,000	6,800	ND	32,000
o-Xylene	ug/kg dry	NA	NA	NA	NA	ND	ND	ND	ND
sec-Butylbenzene	ug/kg dry	1,600	ID	ID	2,500,000	ND	ND	ND	ND
n-Butylbenzene	ug/kg dry	1,600	ID	ID	2,500,000	3,500	2,200	ND	9,600
Toluene	ug/kg dry	16,000	5,400	330,000	50,000,000	ND	11,000	ND	2,000
Dibromofluoromethane	ug/kg dry	NA	NA	NA	NA	ND	ND	ND	ND
Organics-Semivolatiles									
2-Methylnaphthalene	ug/kg dry	57,000	4,200	2,700,000	8,100,000	ND	ND	ND	ND
Acenaphthene	ug/kg dry	300,000	8,700	190,000,000	41,000,000	ND	ND	ND	ND
Anthracene	ug/kg dry	41,000	ID	1,000,000,000	230,000,000	ND	660	ND	ND
Floranthene	ug/kg dry	730,000	5,500	1,000,000,000	46,000,000	ND	560	ND	ND
2-Methylnaphthalene	ug/kg dry	57,000	4,200	2,700,000	8,100,000	2,800	4,100	ND	3,400
Naphthalene	ug/kg dry	35,000	730	250,000	16,000,000	6,100	8,300	ND	6,900
Nitrobenzene-d5	ug/kg dry	NA	NA	NA	NA	ND	ND	ND	ND
Phenanthrene	ug/kg dry	56,000	2,100	2,800,000	1,600,000	ND	1,100	ND	ND
Pyrene	ug/kg dry	480,000	ID	1,000,000,000	29,000,000	ND	720	ND	ND

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWPC.
Blue indicates contaminant exceeds GSIPC.
Green indicates contaminant exceeds both DWPC and GSIPC.
Orange indicates contaminant exceeds one or more criteria; SVIIC and/or DCC.
"ID" means insufficient data to develop criterion.
"NA" means a criterion or value is not available or, in the case of background, not applicable.
"NLL" means hazardous substance is not likely to leach under most soil conditions.
"NLV" means hazardous substance is not likely to volatilize under most conditions.
Letters in criteria columns refer to Footnotes of the Criteria/RBSLs tables.

Atwell, LLC Groundwater Sampling Results
City of Linden

Sample ID		Drinking Water Criteria (DWC)	Groundwater Surface Water Interface Criteria (GSIC)	Groundwater Volatilization to Indoor Air Inhalation Criteria (GVIIC)	Rule 57 Final Acute Value (FAV)	**AB-1W**	**AB-2W**	**AB-5W**	**AB-6W**
Date Collected						10/17/2012	10/17/2012	10/17/2012	10/17/2012
Organics-Volatiles	Units								
1,2,3-Trimethylbenzene	ug/L	NA	NA	NA	NA	ND	ND	ND	ND
1,2,4-Trimethylbenzene	ug/L	63	17	56,000	310	ND	620	ND	1,500
1,3,5-Trimethylbenzene	ug/L	72	45	61,000	810	ND	240	ND	600
2-Butanone (MEK)	ug/L	13,000	2,200	240,000,000	40,000	ND	ND	ND	ND
2-Methylnaphthalene	ug/L	260	19	25,000	340	ND	ND	ND	ND
Benzene	ug/L	5	200	5,600	1,900	ND	4,300	ND	390
Bromofluorobenzene	ug/L	NA	NA	NA	NA	ND	ND	ND	ND
Cyclohexane	ug/L	NA	NA	NA	NA	ND	ND	ND	ND
Ethylbenzene	ug/L	74	18	110,000	320	ND	870	ND	1,200
Isopropylbenzene	ug/L	800	28	56,000	500	ND	35	ND	85
m & p - Xylene	ug/L	NA	NA	NA	NA	ND	3,400	ND	5,300
Methyltertiarybutylether	ug/L	40	7,100	47,000,000	420,000	ND	ND	ND	ND
Naphthalene	ug/L	520	11	31,000	200	ND	ND	ND	ND
n-Propylbenzene	ug/L	80	ID	ID	ID	ND	98	ND	250
o-Xylene	ug/L	NA	NA	NA	NA	ND	ND	ND	ND
sec-Butylbenzene	ug/L	80	ID	ID	ID	ND	ND	ND	ND
Styrene	ug/L	100	80	170,000	2,900	ND	ND	ND	ND
Toluene	ug/L	790	270	530,000	2,600	ND	2,700	ND	110
Toluene-d8	ug/L	NA	NA	NA	NA	ND	ND	ND	ND
Organics-Semivolatiles									
2-Methylnaphthalene	ug/L	260	19	25,000	340	NA	NA	NA	NA
Fluoranthene	ug/L	210	2	210	28	NA	NA	NA	NA
Naphthalene	ug/L	520	11	31,000	200	NA	NA	NA	NA
Nitrobenzene-d5	ug/L	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	ug/L	52	2	1,000	11	NA	NA	NA	NA
Pyrene	ug/L	140	ID	140	ID	NA	NA	NA	NA

Grey indicates contaminant was detected.
Yellow indicates contaminant exceeds DWC.
Blue indicates contaminant exceeds GSIC.
Green indicates contaminant exceeds both DWC and GSIC.
Orange indicates contaminant exceeds one or more criteria; GVIIC and/or FAV.
"ID" means insufficient data to develop criterion.
"NA" means a criterion or value is not available or, in the case of background, not applicable.
"NLV" means hazardous substance is not likely to volatilize under most conditions.
Letters in criteria columns refer to Footnotes of the Criteria/RBSLs tables.