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Letter of Transmittal

Attention:	Mr. Tauren Beggs Hydrogeologist, WDNR 2984 Shawano Ave Green Bay, WI 54313	Date:	8/18/16
Project reference:	Former Newton Pit BRRTS No. 02-36-000268	Project number:	60135471

We are sending you the following:

Number of originals:	Number of copies:	Description:
One	Zero	Remedial Action Options Report & Conceptual Design Report

Mr. Beggs,

Attached is the Remedial Action Options Report & Conceptual Design Report for the Former Town of Newton Gravel Pit, Manitowoc Wisconsin.

Enclosed with the hard copy of the report is a Check ($1,050.00) for the WDNR Remedial Action Options Report review fee.

We look forward to your review and approval of the reports.

Please let me know if you have any questions.

Thank you.

D. S. Henderson

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Cc: Kathleen M. McDaniel, City Attorney, City of Manitowoc
Dan Koski, Director of Public Infrastructure, City of Manitowoc
Elizabeth Heinen, Drinking Water Specialist, WDNR

AECOM Environment

Prepared for:
City of Manitowoc
Manitowoc, Wisconsin

Prepared by:
AECOM
Milwaukee, WI
August 18, 2016

Remedial Action Options Report & Conceptual Design Report

Former Town of Newton Gravel Pit
3130 Hecker Road, Manitowoc, Wisconsin

WDNR FID 436104020, BRRTS #02-36-000268

AECOM Environment

Prepared for:
City of Manitowoc
Manitowoc, Wisconsin

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Milwaukee, WI
August 2016

Remedial Action Options Report & Conceptual Design Report

Former Town of Newton Gravel Pit

3130 Hecker Road, Manitowoc, Wisconsin

In conformance with NR 712.09 submittal certification requirements:

"I, Jeffrey D. Maletzke, hereby certify that I am a hydrogeologist as that term is defined in s. NR 712.03 (1), Wis. Adm. Code, am registered in accordance with the requirements of ch. GHSS 2, Wis. Adm. Code, or licensed in accordance with the requirements of ch. GHSS 3, Wis. Adm. Code, and that, to the best of my knowledge, the information contained in this document is correct and the document was prepared in compliance with applicable requirements in chs. NR 700 to 726, Wis. Adm. Code."

WISCONSIN PROFESSIONAL GEOLOGIST
JEFFREY D. MALETZKE
G-13
SHEBOYGAN, WIS.

Prepared By: Jeffrey D. Maletzke, P.G.
Senior Hydrogeologist

"I, David Henderson, hereby certify that I am a registered professional engineer in the State of Wisconsin, registered in accordance with the requirements of ch. A-E4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch.A-E8, Wis. Adm. Code, and that, to the best of my knowledge, the information contained in this document is correct and the document was prepared in compliance with applicable requirements in chs. NR 700 to 726, Wis. Adm. Code."

WISCONSIN PROFESSIONAL ENGINEER
DAVID S. HENDERSON
E-32524
CEDARBURG
WIS.

Reviewed By: David S. Henderson, P.E.
Senior Project Manager

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Executive Summary

AECOM Technical Services, Inc. (AECOM) has prepared this Remedial Action Options Report (RAOR) and Conceptual Design Report for the City of Manitowoc (City) to address impacts to soil and groundwater at the Former Town of Newton Gravel Pit (Former Newton Pit) site.

The Former Newton Pit site is currently regulated by the Wisconsin Department of Natural Resources (WDNR). Therefore, the RAOR and CDR were prepared to meet Wisconsin Administrative Code (WAC) NR 722 and NR 724 requirements respectively. AECOM has incorporated, where appropriate, components of the U.S. Environmental Protection Agency (EPA) Toxic Substances Control Act (TSCA) regulations as they apply to polychlorinated biphenyl's (PCBs) under the 40 CFR Part 761 rules.

The Former Newton Pit was the location of disposal practices that included discharge of liquid industrial wastes during the 1960s and early 1970s. Site investigation activities have delineated soil impacts in the Western Source Area, defined as a light non-aqueous phased liquid (LNAPL) free product within the source area, and identified both a shallow groundwater contaminant plume that extends east-southeast to Silver Creek (Groundwater Treatment Area) and deeper (bedrock) groundwater impacts continuing to the southeast (Potable Well Target Zone).

Soil sampling has identified volatile organic compound (VOC) levels that exceed WAC Chapter NR 720.09 generic soil residual contaminant levels (RCLs) and NR 720.19 EPA soil screening levels. Polycyclic Aromatic Hydrocarbon compounds also exceed the WDNR Interim PAH Generic RCLs.

Measureable levels of light non-aqueous phase liquid (LNAPL) free product continue to exist in source area monitoring wells. The LNAPL is a mixture of petroleum compounds, chlorinated volatile organic compounds (CVOCs), and PCBs.

The vertical and horizontal extent of the groundwater contaminant plume has been defined. Analytical results indicate WAC Chapter NR 140 Enforcement and Preventative Action Limit standard exceedances for petroleum and CVOC compounds.

Silver Creek, flows through the property from the north/northwest to the south/southeast. Surface water monitoring in the reach adjacent to the site has identified three CVOC compounds including a limited WAC Chapter NR 105 standard exceedance for one compound, vinyl chloride.

The RAOR reviews an appropriate range of alternatives for remediating impacted soil and groundwater based on the chemicals present, the nature and extent of the contaminated media, and site characteristics. It focuses on identifying a selected remedial technology that is deemed technically and economically feasible while considering value engineering, sustainability and optimization; with the ultimate goal of site closure.

The selected remedial alternative includes an engineered cap, soil vapor extraction, and LNAPL recovery in the Western Source Area along with an engineered groundwater treatment pond and phytoremediation in the Groundwater Treatment Area. This combination addresses the remediation goals while providing protection to human health and the environment.

The Conceptual Design Report provides the initial design details for the selected remedial alternative. Within the Western Source Area that includes:

- An engineered cover system (i.e. cap) designed in accordance with WAC Chapter NR 500 requirements to address direct contact and groundwater infiltration exposure pathways and also meet EPA TSCA regulatory requirements. The cap will cover an approximately 63,000 square foot area and be constructed with geo-synthetic clay liner.

- An integrated SVE and LNAPL recovery system that share, where appropriate, eight extraction wells, piping and trenching runs, and a remediation building to provide operational flexibility for SVE only, LNAPL removal only, or combined SVE and LNAPL removal as conditions warrant.

  The SVE system will include 5 extraction wells operating with a radius of influence of between 40 and 60 feet, a wellhead vacuum level of 24 inches water column, an air flow rate of 50 standard cubic feet per minute per extraction well, and an initial single well average contaminant emission rate of 2.35 lbs/hr of VOCs.

  The LNAPL recovery system will operate with a total of six recovery wells with pneumatic down-well skimmer pumps to provide active, long term, low effort, free product recovery.

Remediation within the Groundwater Treatment Area includes an engineered groundwater treatment pond in conjunction with phytoremediation.

- The engineered groundwater treatment pond is approximately 500 feet long, 160 feet wide, and 20 feet deep designed to intercept and treat the groundwater contaminant plume in the mined area immediately down gradient of the Western Source Area. The treatment process anticipated to occur within the pond includes volatilization, phytoremediation, aerobic-bioremediation, and solar oxidation. The pond will be equipped with a floating solar-powered circulator designed to improve evaporation and stripping of VOCs, as well as to keep the pond operational during the winter months. Treated groundwater will be discharged through a channel and pipe via gravity to Silver Creek.

- Phytoremediation activities are anticipated to be in partnership with the US Department of Agriculture (USDA), Forest Service, under an EPA Great Lakes Restoration Initiative Action Plan II grant. The grant is funding a Forest Service, Landfill Leakage Remediation study. The outcome of the study for the City and the project site will be a professionally designed and managed phytoremediation study that will leave a legacy of approximately 2.4 acres of trees that will continue to remediate the site.

AECOM, on behalf of the City of Manitowoc, requests that the WDNR review and approve the Remedial Action Options and Conceptual Design reports as presented. The approval request includes several specific proposed actions and a proposed schedule for implementation that incorporates a five year groundwater monitoring period prior to deciding whether the SVE and LNAPL recovery system installation is necessary.

1.0 Introduction

AECOM Technical Services, Inc. (AECOM), on behalf of the City of Manitowoc (City), has prepared a Remedial Action Options Report (RAOR) and Conceptual Design Report (CDR) to address impacts to soil and groundwater from past industrial waste disposal practices at the Former Town of Newton Gravel Pit (Former Newton Pit) site.

1.1 Regulatory Status

The Former Newton Pit site is currently regulated by the Wisconsin Department of Natural Resources (WDNR). Based on the *One Cleanup Program Memorandum of Agreement Between the United States Environmental Protection Agency Region 5 and the Wisconsin Department of Natural Resources*[1] (MOA) AECOM anticipates that remedial actions conducted at the Former Newton Pit will continue to be overseen by the WDNR. This is based on the classification of the site under Attachment A of the MOA.

Attachment A of the MOA identifies the process under which WDNR and U.S. Environmental Protection Agency (EPA) Region 5 will recognize WDNR's leadership role for the remediation of certain sites with polychlorinated biphenyl's (PCBs) contamination. AECOM believes that the Former Newton Pit site is a "Type B" site, which includes PCB sites that are generally not subject to Toxic Substances Control Act (TSCA) requirements and only subject to WDNR review and approval. By definition this includes sites where PCB remediation waste resulted from spills or other releases into the environment prior to April 18, 1978, regardless of the concentration of the spill or release.

AECOM and the City have received confirmation from the EPA and WDNR[2] of the Type B status for the Former Newton Pit site.

Therefore, the RAOR presented below is based on WDNR regulations as presented in the WAC Chapter NR 700 series of rules. With the understanding that State regulations cannot be less strict than Federal regulations, AECOM has incorporated, where appropriate, components of the EPA TSCA regulations as they apply to PCB remediation under the 40 CFR Part 761 rules.

1.2 Project Participants

<u>Owner</u>

City of Manitowoc
900 Quay Street
Manitowoc, WI 54220
Contact: Mr. Dan Koski, PE
Director of Public Infrastructure
920-686-6910

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[1] *One Cleanup Program Memorandum of Agreement Between the United States Environmental Protection Agency Region 5 and the Wisconsin Department of Natural Resources,* WDNR, November 2006.

[2] *PCBs @ Former Town of Newton Gravel Pit*, email from Alan T Nass, DNR, dated Wednesday, May 16, 2012, 9:19 AM.

Consultant

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Oversight Agency

Wisconsin Department of Natural Resources
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Northeast Region
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Hydrogeologist
920-662-5178

1.3 Site Location and Description

The Former Newton Pit property is owned by the City of Manitowoc, is approximately 58 acres in size, and is located at 3130 Hecker Road in the Town of Newton, Manitowoc County Wisconsin (Figure 1). The property's legal description is the southwest ¼ of the northwest ¼ of Section 2, Township 18 north, Range 23 east.

Within the 58 acres, approximately one acre along the western property boundary was the location of a disposal pit that received industrial wastes (the Western Source Area) during the 1960's and early 1970's. The Western Source Area is located on an elevated area of the property. Former gravel pit operations have lowered the ground surface elevation to the west from 15 to 20 feet and to the east approximately 30 feet.

The land use in the vicinity of the property is rural. Bordering the property to the west is an active gravel pit, to the north is farmland and forest, to the east is farmland and rural residences, and to the south is farmland and an active gravel pit. A small creek, Silver Creek, flows through the property from the north/northwest to the south/southeast. Site features are shown on Figure 2.

1.4 Report Objectives

This report was prepared in general accordance with the Wisconsin Administrative Code (WAC) Chapter NR 722 RAOR requirements and to present a conceptual design of the selected remedial action consistent with the requirements of WAC Chapter NR 724. Where applicable, the report also fulfills the requirements of the EPA TSCA requirements for PCBs as presented in the Code of Federal Regulations (CFR) Title 40, Part 761.61.

The purpose of the RAOR is to identify and evaluate the remedial options that will meet the following objectives:

- Be regulatory compliant.
- Result in a reasonable cost and timeframe for remediation.
- Reduce mass of volatile organic compounds (VOCs) in soil at the Western Source Area.

- Remove light non-aqueous phase liquid (LNAPL) from the Western Source Area.
- Reduce mass of VOCs in the shallow groundwater contaminant plume.

The CDR provides a description of the chosen remedial option with supporting documentation including, but not limited to;

- Engineering design criteria, concepts, assumptions, and calculations,
- treatability study and pilot test results,
- applicable permits, and
- preliminary discussions of monitoring along with the operations and maintenance for the chosen remedial action

The CDR also incorporates elements that may require review and approval by the WDNR in general accordance with 40 CFR, Part 761.61 regulations.

2.0 Investigation Summary and Conceptual Site Model

2.1 Background

The Former Newton Pit was the location of disposal practices that included discharge of liquid industrial wastes such as petroleum products and chlorinated solvents. The identified past waste disposal activities encompassed an approximate 100 x 100-foot area along the westernmost boundary of the former gravel pit (Figure 2). This area is referred to as the Western Source Area.

The disposal practices spanned an approximate 10-year time period between the early 1960s and early 1970s. Environmental investigation activities began with the Wisconsin Department of Natural Resources (WDNR) notification of the site to the City of Manitowoc in 1991. A detailed historical perspective of site activities has been previously presented in a June 1996 site investigation report[3]. A detailed list of project specific regulatory submittals, including reports and technical memos, is available on the WDNR Bureau for Remediation and Redevelopment Tracking System (BRRTS) web site data base for BRRTS No. 02-36-000268 (http://dnr.wi.gov/botw/GetActivityDetail.do?detailSeqNo=33760).

2.2 Geology

Manitowoc County lies within the Eastern Ridges and Lowland Physiographic Region[4]. Geologic strata present in Manitowoc County consist of variable thicknesses of Quaternary-age glacial drift and lake deposits overlying dolomite bedrock of Silurian age (Niagara Dolomite). Well construction reports obtained from the Wisconsin Geological and Natural History Survey for residential drinking water wells in the vicinity of the site indicate that bedrock is approximately 100 to 120 below ground surface (bgs). The overall dip of the bedrock surface is to east. The glacial drift deposits in the vicinity of the site consist largely of till and stratified gravel and sand.

The geologic characterization of the site is based on soil boring logs. The stratigraphy beneath the site is predominantly outwash sands and gravels with fill material and occasional lenses of lacustrine sediments and till. The outwash deposits were encountered in every boring completed at the site. Generally, these deposits can be described as dominantly pale brown to yellowish brown, with gray brown to dark gray, well to poorly graded, subangular, fine to medium sand (USCS SW and SP). Gravel layers and cobbles are present in the sand but tend to decrease with depth. The finer grained lacustrine deposits are discontinuous and typically consist of very thinly layered clays, silts, silty sands, and fine sand.

The occurrence of local gravel pits in the area coincides with the glacial outwash deposits. These outwash deposits transition to predominantly clayey basal till deposits east of the site in the approximate area of County Road CR[5].

Cross-sections A-A' through E-E' previously submitted as part of the *2014 Expanded Down-Gradient Investigation and Groundwater Monitoring Letter Report*[6] provide views of site and regional geology.

[3] *Site Investigation and Remedial Action Options Report*, Former Gravel Pit, Town of Newton, Wisconsin. Rust Environmental & Infrastructure, Inc. dated June 1996.

[4] Finley, Robert W., 1976, Geography of Wisconsin, University of Wisconsin Press, Madison, Wisconsin, 558 p.

[5] *Preliminary Quaternary Geologic Map of Calumet and Manitowoc Counties, Wisconsin*. Wisconsin Geologic & Natural History Survey, dated 2004.

2.3 Hydrogeology

The most recent groundwater monitoring data is presented in the *2015 Groundwater Monitoring Letter Report*[7]. These data provide interpreted groundwater flow direction based on measurements in wells grouped according to their screened elevation.

Water elevations measured in water table wells ranged between approximately 688 and 680 feet mean sea level (MSL). These data indicate a general groundwater flow direction to the east-southeast within the shallow local groundwater flow system (sand and gravel outwash) that is consistent with previous data. The exception to this generalized flow direction is an area adjacent to a Silver Creek meander, where an apparent groundwater divide creates a shallow groundwater flow system towards the creek (See Figure 3 in the *2015 Groundwater Monitoring Letter Report*). Silver Creek serves as a discharge point for the shallow local groundwater flow system.

Groundwater measured in mid-level (A-series) piezometers (screened approximately 630 feet MSL within sand and gravel outwash) ranged between approximately 685 and 678 feet MSL. These data indicate groundwater flow within the mid-level unconsolidated aquifer to be east-southeast (See Figure 4 in the *2015 Groundwater Monitoring Letter Report*).

Groundwater measured in deeper (B-series) piezometers (screened approximately 600 MSL primarily within clay till immediately above the top of bedrock) ranged between approximately 685 and 677 feet MSL. These data indicate groundwater flow within the deep unconsolidated aquifer to be east-southeast (See Figure 5 in the *2015 Groundwater Monitoring Letter Report*).

Groundwater measured in bedrock (C-series) piezometers ranged between approximately 681 and 670 feet MSL. These data indicate bedrock groundwater flow to the east (See Figure 6 in the *2015 Groundwater Monitoring Letter Report*). This is consistent with regional flow toward Lake Michigan.

A summary of groundwater elevations is presented in Table 1 of the *2015 Groundwater Monitoring Letter Report*.

2.3.1 Hydraulic Gradients

Horizontal and vertical hydraulic gradients were calculated based on groundwater elevation data collected October 19, 2015, as previously provided in Table 1 of the *2015 Groundwater Monitoring Letter Report*.

The vertical hydraulic gradients as measured at monitoring well/piezometer well nests were variably low downward or upward. Downward vertical gradients range between 0.003 and 0.097 feet/foot. Upward vertical gradients range between 0.025 and 0.002 feet/foot. Average calculated horizontal gradients for the outwash sands and gravel range between 0.003 and 0.006 feet/foot. Within the bedrock the average horizontal gradient is 0.012 feet/foot.

2.3.2 Hydraulic Conductivity

The hydraulic conductivity of the outwash sands and gravel is based on recent (August 2015) test results from monitoring well P-1[8] as averaged with the hydraulic conductivity results for water table wells previously presented in the June 1996 *Site Investigation Report*.

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[6] *2014 Expanded Down-Gradient Investigation and Groundwater Monitoring Letter Report*, AECOM Technical Services, Inc., dated June 12, 2015.

[7] *2015 Groundwater Monitoring Letter Report*, AECOM Technical Services, Inc., dated March 26, 2016.

The geometric mean hydraulic conductivity for the outwash sand and gravel aquifer is 3.9 x 10^{-3} cm/sec, which compares favorably with generally accepted ranges for these types of deposits.

2.3.3 Groundwater Flow Velocity

As previously reported in the *2015 Groundwater Monitoring Letter Report*, the average linear groundwater flow velocities for the sand and gravel outwash, glacial till, and bedrock were calculated using a modification of Darcy's Law:

$$V = \frac{KI_h}{n_e}$$

Where: V = average linear velocity
K = horizontal hydraulic conductivity
I_h = horizontal hydraulic gradient
n_e = effective porosity

Average linear flow velocities were calculated as follows:

- Water Table Wells: An average linear flow velocity of 0.20 ft/day (73 ft/yr) was calculated for the sand and gravel outwash using the mean hydraulic conductivity of water table wells (3.9x10^{-3} cm/sec), an average horizontal gradient (0.004 feet/foot), and an estimated effective porosity of 0.25.

- A-series Piezometers: An average linear flow velocity of 0.13 ft/day (47 ft/yr) was calculated for the sand and gravel outwash using the mean hydraulic conductivity of 3.9x10^{-3} cm/sec, an average horizontal gradient for the mid-level A-series piezometers (630 feet MSL) of 0.003 feet/foot, and an estimated effective porosity of 0.25.

- B-series Piezometers: An average linear flow velocity of 0.0005 ft/day (0.17 ft/yr) was calculated for the glacial till using a horizontal hydraulic gradient data for the B-series piezometers (600 feet MSL) of 0.006 feet/foot, an estimated hydraulic conductivity of 1x10^{-5} cm/sec, and an estimated effective porosity of 0.40.

- C-series Piezometers: An average linear flow velocity of 0.18 ft/day (6.6 ft/yr) was calculated for the bedrock using a horizontal hydraulic gradient for the C-series piezometers of 0.012 feet/foot, an estimated hydraulic conductivity of 1x10^{-4} cm/sec, and an estimated effective porosity of 0.20. This calculated flow velocity for the bedrock does not account for fracture flow or potential preferential flow along bedding planes.

2.4 Summary of Identified Impacts

As previously mentioned, site investigation activities have been ongoing since 1991. The activities have delineated soil impacts along with an LNAPL free product plume within the in the Western Source Area, identified both a shallow groundwater contaminant plume that extends east-southeast towards Silver Creek (including a Groundwater Treatment Area), and deeper (bedrock) groundwater impacts continuing to the southeast (Potable Well Target Zone). Each of these impact areas are described further in the following subsections.

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[8] *2015 Task 31; Groundwater Treatment Area Feasibility Study Technical Memo*, AECOM Technical Services, Inc., dated April 4, 2016.

2.4.1 Contaminants of Concern

As identified during site investigation activities, the following are the principal contaminants of concern (COCs):

- Petroleum VOCs: Benzene (ethyl, n-propyl, tri-methyl), heptanes, hexanes, naphthalene, toluene, xylenes, and polycyclic aromatic hydrocarbons (PAHs).

- Chlorinated VOCs (CVOCs): Tetrachloroethylene (PCE), trichloroethylene (TCE), 111-trichloroethane (111-TCA), and their dechlorinated breakdown compounds of cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), and vinyl chloride.

- Polychlorinated biphenyls.

- An LNAPL plume containing a mixture of the above constituents.

2.4.2 Extent of Soil Impacts

The known soil impacts are limited to the Western Source Area.

2.4.2.1 Western Source Area

The Western Source Area was the location of a former waste disposal pit. Liquid industrial waste was reportedly disposed of in this pit and allowed to infiltrate the ground surface.

Identified impacts include the following:

<u>Soil/Vadose Zone Impacts</u>
- Chlorinated compounds including PCE, TCE, 111-TCA, and daughter compounds cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride.
- Petroleum compounds including benzenes, heptanes, hexanes, naphthalene, toluene, xylenes, and PAHs.
- VOC contaminant levels indicative of source area soil contamination concentrations exceeded NR 720.09 generic soil residual contaminant levels (RCLs) and NR 720.19 EPA soil screening levels (SSLs). PAH compounds also exceed the WDNR Interim PAH Generic RCLs.
- These impacts are restricted to the Western Source Area as bounded to the north and south by analytical results from WT-17 and B-8 & B-20, respectively. Soil impacts extend to the east as far as B-02 (WT-02) and to the west to the property line and WT-14.

<u>LNAPL Impacts</u>
- An LNAPL free product plume with petroleum and chlorinated compounds consistent with soil impacts.
- Measureable levels of LNAPL free product exist in monitoring wells WT-02, WT-09, and WT-14.
- The LNAPL plume includes PCB compounds with Total PCBs greater than (>)50 milligrams per kilogram (mg/kg).

<u>Groundwater Impacts</u>
- Petroleum and chlorinated compounds consistent with soil impacts.
- Groundwater analytical results indicate NR 140 enforcement standard (ES) and preventive action levels (PAL) exceedances.

Remediation/Redevelopment Considerations

- It is anticipated that the surficial soil and LNAPL impacts will require remediation or a cap and maintenance plan for case closure under WAC NR726 and 40CFR, Part 761.61 regulations.
- Contaminant mass removal may be required under WAC NR722.
- Investigation derived waste (IDW) (drummed soil) from previous activities will be disposed of under the proposed cap.

2.4.3 Extent of Groundwater Impacts

Impacted groundwater extends from the Western Source Area to the mined area immediately down gradient (i.e. east) in the vicinity of monitoring wells WT-13, P-1, and P-10. This area is identified as the Groundwater Treatment Area. The width of the plume in the Groundwater Treatment Area is approximately 500 feet.

The plume continues southeastward toward Hecker Road (well nest WT-25). Chlorinated compounds in this area appear to be infiltrating the bedrock between well nests WT-24 and WT-25. From the area of WT-24 and WT-25, impacts extend further down gradient within bedrock to the area identified as the Potable Well Target Zone.

In total, groundwater detections of COCs extend approximately 1.5 miles from the Western Source Area.

2.4.3.1 Groundwater Treatment Area

The Groundwater Treatment Area is identified as the mined area immediately down gradient (southeastward) of the Western Source Area. In general, the area is delineated by monitoring wells WT-13, P-1 and P-10 (See Figure 2).

Groundwater Impacts

- Exceedances of compounds above PAL and ES standards within the groundwater treatment area include PCE, TCE, and 111-TCA; and daughter compounds cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, and benzene.
- The vertical extent of the contaminant plume is defined by TCE and vinyl chloride concentrations above NR140 ES standards at temporary monitoring well P-3 (screened approximately 30 feet bgs) and a lack of VOC detections at monitoring wells P-12 and P-13, screened approximately 40 and 50 feet bgs, respectively.
- A summary of the groundwater impacts as VOC isoconcentration lines is shown on Figure 3 and on site Cross-Section Y-Y' (Figure 4).

Surface Water Impacts

- Groundwater discharges appear to impact Silver Creek, which is at the down gradient edge of the Groundwater Treatment Area. The creek flows through the property from the north/northwest to the south/southeast. Surface water monitoring in the reach adjacent to the site has identified three CVOC compounds including a limited WAC Chapter NR 105 standard exceedance for one compound, vinyl chloride.

Remediation/Redevelopment Considerations

- Within the Groundwater Treatment Area, depth to groundwater on the southern edge of the area is 6 to 9 feet bgs; depth to water in the center and north end of the area is approximately 3 to 4.5 feet bgs.
- COCs found within the Groundwater Treatment Area are characterized as having high vapor pressures, which may allow for effective in-situ treatment by volitization.

2.4.3.2 Potable Well Target Zone

The Potable Well Target Zone includes groundwater impacts to potable wells down gradient from the Western Source and the Groundwater Treatment Areas. The zone typically includes deeper (bedrock) groundwater impacts and it extends approximately 1.5 miles from the Western Source Area (See Figure 5).

Groundwater Impacts

- Impacts are typically limited to cis-1,2- DCE and vinyl chloride compounds.
- Cis-1,2-DCE detects are uniformly below the NR140 PAL. Vinyl chloride detects, when they are observed, are typically above the NR140 ES.
- A summary of sampling results is presented in the *March 2016 Semi-Annual Potable Well Monitoring Letter Report*[9].

Remediation/Redevelopment Considerations

- The City of Manitowoc has provided clean/safe drinking water for all residents where NR140 ES exceedances have been observed. Nine properties have been provided with new replacement potable wells (including one pending replacement well). Nine properties have been provided City water via an extension of a City of Manitowoc, Public Utility District, water main along Viebahn Street and CTH CR.
- The WDNR has established a Special Well Casing Pipe Depth Area within the Target Zone area.
- Other than providing clean/safe drinking water at locations with NR140 ES exceedances, no additional remediation activities are proposed for the Potable Well Target Zone.

2.5 Potential Receptors

The site is located on a secure property with access limited by a locked gate and its remote location. The property is essentially unoccupied with the exception of an adjacent police department firearms training facility that is occasionally occupied during typical business hours.

With the exception of a single underground electric utility to the police facility, there are no utilities on the property.

Potential exposures to receptors include VOC migration pathways for vapor intrusion and direct contact to contaminated soils within the Western Source Area, and direct contact to surface water (via groundwater discharge to Silver Creek).

Direct contact and vapor intrusion is not currently an exposure pathway of concern because of the site's security, its remote location, and the rural nature of the surrounding land use.

The direct contact issue associated with the contaminant groundwater discharge to Silver Creek is of limited concern due to the minimal standard exceedances, the limited down-stream extent of impacts[10] and the fact that Silver Creek is not used as a public drinking water supply.

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[9] *March 2016 Semi-Annual Potable Well Monitoring Letter Report*, AECOM Technical Services, Inc., dated July 14, 2016.

[10] *2014 Silver Creek Sampling Letter Report*, AECOM Technical Services, Inc., dated December 2, 2014.

3.0 Remediation Goals and Objectives

The goals and objectives are for site-wide management of residual soil and groundwater impacts, focusing on protection of human health and the environment while considering value engineering, sustainability and optimization for implemented remedial actions.

The envisioned project end-point includes regulatory closure of the site, reduced groundwater monitoring within the Groundwater Treatment Area and Potable Well Target Zone, and safe/clean down gradient potable water supplies within the Potable Well Target Zone.

3.1 Soil Remedial Action Goals

The soil remedial action will address the following Western Source Area impacts:

- Vadose zone VOC impacts.
- LNAPL plume impacts.
- PCB constituents within the LNAPL plume.

The goals of a soil remedial action include:

- Reducing or eliminating the soil direct contact and groundwater exposure pathways.
- Reduce the source area contaminant mass.
- Obtain regulatory site closure with limited continuing obligations.

These goals have been selected to effectively address the direct contact exposure pathway while also reducing source area contaminant mass that could continue to serve as a source for ongoing groundwater impacts.

3.2 Groundwater Remediation Goals

Groundwater remediation will address VOC impacts within the Groundwater Treatment Area, immediately down gradient of the Western Source Area.

The remediation goal is to reduce the groundwater contaminant mass migrating down gradient towards the Potable Well Target Zone and to promote natural attenuation as a viable final groundwater remedial alternative allowing regulatory site closure with limited continuing obligations.

3.3 Anticipated Post-Remedial Site Conditions

The site is currently zoned Industrial (I2). There are no plans for redevelopment of the property after remediation. It is anticipated that the site will continue to be zoned industrial and used by the City for storage and training for local law enforcement.

4.0 Development and Evaluation of Remedial Action Options

The purpose of this section is to present an appropriate range of remedial technology alternatives that could be reasonably implemented and are capable of meeting the remedial goals and objectives.

The remedial alternatives are then evaluated in accordance with the requirements presented in WAC Ch. NR 722 *Standards for Selecting Remedial Actions*. This includes a comparison of the advantages and limitations of the alternatives relative to each other.

Typically a No Further Action alternative serves as a baseline against which other alternatives can be compared. However, due to the soil and groundwater impacts identified at the site, the No Further Action alternative would not achieve the remedial action goals and objectives. Therefore, it is not presented as an acceptable alternative.

The evaluation criteria of each remedial alternative is presented below followed by a discussion of how the alternatives are intended to address impacts identified at each of the site areas (the Western Source Area, Groundwater Treatment Area, and Potable Well Target Zone).

4.1 Evaluation Criteria

The remedial alternatives were evaluated using the criteria specified in WAC Ch. NR 722.07 as summarized below:

4.1.1 Technical Feasibility

The technical feasibility of potential remedial action options were evaluated using the following criteria:

1. Long-term effectiveness. Taking into account the following factors;
   - The degree to which the toxicity, mobility and volume of the contamination is expected to be reduced; and
   - The degree to which a remedial action option, if implemented, will protect public health, safety and welfare and the environment over time.
2. Short-term effectiveness. Taking into account any adverse impacts on public health, safety and welfare and the environment that may be posed during the construction and implementation period until case closure.
3. Implementability. The technical and administrative feasibility of construction and implementation of the remedial action options.
4. Restoration timeframe. The expected timeframe needed to achieve the necessary restoration.

4.1.2 Economic Feasibility

The economic feasibility of each potential remedial alternative was evaluated considering the following criteria: capital costs, annual operation and maintenance costs, and total present worth of the costs. Costs associated with potential future liabilities were not incorporated as a quantitative measure, but were evaluated qualitatively.

4.1.3 Sustainability

The overall sustainably of each option was considered during the evaluation process in accordance with NR722.09 (2m). The criteria used included energy use, generation of air pollutants, water use, enhancements to ecosystems, waste minimization, and optimizing sustainable practices.

4.2 Western Source Area

Three different remedial options or alternatives are being considered to meet the remediation goals and objectives within the Western Source Area. They are Monitored Natural Attenuation, an Engineered Treatment System, and Excavation.

4.2.1 Monitored Natural Attenuation

The monitored natural attenuation (MNA) alternative involves no active treatment of contaminated soil and groundwater. In engineering terms is viewed as the “do nothing alternative.”

MNA takes advantage of natural physical, chemical, and/or biological processes to reduce and attenuate contaminant mass, toxicity, mobility, volume, or concentration to acceptable levels. Natural attenuation processes and rates of contaminant degradation are monitored by changes in contaminant concentrations and contaminant - daughter product ratios over time.

MNA may eventually reduce and attenuate contaminant mass, but the time frame for the realization of this alternative is extremely long and during that time extent of the impacts would likely expand.

In order for the plume to stabilize or recede at an acceptable rate over time, the source(s) of continuing groundwater contamination should also be stabilized. Once the source area is addressed, additional groundwater sampling would be required to determine if the contaminant concentrations have stabilized or are receding over time.

The implementability is high for this alternative because it represents a continuation of long term monitoring and reporting consistent with the past several years. MNA is a sustainable remedial option as minimal energy and water resources are utilized during implementation. This alternative would result in the least amount of disruption to the site. Assuming that no additional monitoring wells need to be installed, it has no associated capital costs. However, long term monitoring, maintenance, analytical, and reporting costs are estimated to range from $40,000 to $100,000 per year.

However, from an administrative feasibility point of view, this alternative will likely not be accepted by the WDNR because of the extremely long time frame to implement this alternative, the possibility for expanded impacts during implementation, and it does not adequately address soil and vadose zone impacts that may continue to be a source of groundwater impacts that could migrate off-site.

Therefore, MNA as a remedial alternative for the Western Source Area is not retained for further evaluation.

4.2.2 Engineered Treatment System

An engineered treatment system applicable to the Western Source Area will incorporate the following remedial technologies to address vadose zone, LNAPL, and PCB impacts:

- Surface Cap
- Soil Vapor Extraction (SVE)
- LNAPL recovery

An engineered cap system meeting the requirements of WAC NR 500 will limit exposure to soils in excess of the VOC and PAH direct contact RCLs. Because of the concentration of PCBs in the LNAPL emplacement of a surface cap is also a TSCA regulatory requirement (40CFR 761.61). The cap will also mitigate infiltration and percolation of surface water through the soil and prevent the continued transport of contaminants into the groundwater.

The SVE system will apply a vacuum to the subsurface to induce a controlled flow of air to volatize and remove VOCs from the soil. The system will consist of several extraction wells, trenching and piping, and associated vacuum pump equipment. The surface cap described above will help prevent surface short circuiting and increase the radius of influence of the extraction wells.

An LNAPL recovery system will provide active, long term, low effort, free product recovery. The system will include extraction wells, pneumatic down well skimmer pumps, trenching and piping, and associated recovery equipment.

The SVE system will be integrated with the LNAPL extraction system such that a total of eight wells will provide for combined SVE and LNAPL removal. The conceptual layout for the engineered system alternative is shown on Figure 6.

The installation of a cap, and integrated SVE and LNAPL recovery systems can be implemented and is considered technically feasible. Together, the system components provide an effective long-term remedy by eliminating the direct contact pathway for VOC impacts and reducing contaminant mass and loading to groundwater. From an administrative/regulatory feasibility point of view, this alternative is acceptable as the remedy is anticipated to meet the remedial objectives for the Western Source Area.

The time required for installation of the cap and SVE/LNAPL removal system is relatively short; however, the SVE/LNAPL system would need to operate for an extended period of time (estimated at five years) before regulatory closure could be considered.

Conceptual costs for the cap and SVE/LNAPL removal system are estimated between approximately $330,000 and $350,000.

The grading and capping portion of this alternative will have a moderate carbon footprint during implementation. Fossil fuel consumption would occur due to trucking associated with transporting cap material to the site. The potential for the use of clean on-site soils as backfill material could help to reduce this impact. Long-term energy inputs are required due to continued operation of this SVE/LNAPL removal system. Waste generation will be moderate during implementation, with only limited options for reduction.

4.2.3 Excavation

Excavation and off-site disposal of contaminated soils would include the area were LNAPL is present or soil sample analytical data indicate significant concentrations within the unsaturated zone. PCB impacted soil would also be excavated (PCBs present in the LNAPL).

Under this alternative, an extensive volume, approximately 24,000 cubic yards (cu yds) of source soil extending to approximately 30 feet bgs, would be excavated. It is assumed that approximately 10,000 of the 24,000 cu yds would be impacted by PCBs above TSCA limits and require off-site disposal at a Subtitle C landfill. Approximately 11,000 cubic yards of excavated soil would be transported off-site for treatment/disposal at a Subtitle D landfill. The remaining approximately 3,000 cubic yards is expected to be non-impacted soil removed during over-excavation. This soil would remain on site and could be used for re-grading.

Because the Western Source Area is located adjacent to a mined area, the excavation could be accomplished by excavating into the scarp that separates the Western Source Area from the floor of the former gravel pit. The resulting excavation would not require backfilling to match the current topography, but rather re-grading to extend the floor of the former gravel pit and provide for a stable transition to the higher surrounding topography to the north.

Soil excavation can be implemented and is considered technically feasible. From an administrative/regulatory feasibility point of view, this alternative is acceptable as the remedy is anticipated to meet the remedial objectives by removing the contaminant source and eliminating further leaching to groundwater.

This alternative will have some short-term impact on the surrounding area during implementation due to the use of heavy equipment (excavators, loaders), increased truck traffic, and potential for dust generation. The short-term potential direct contact exposure to contaminants could be high during performance of the LNAPL excavation activities.

The time required for implementation of this alternative is relatively short. Post remediation monitoring would be required to demonstrate effective completion of the remedial objectives. It is anticipated that the source removal would greatly reduce the time required to achieve regulatory closure.

Costs associated with excavation and soil disposal can be significant. Conceptual costs for this alternative are estimated between approximately $3,800,000 and $5,100,000.

This alternative will have a large carbon footprint during implementation; however there are no long-term energy inputs required as part of this remedial option. Fossil fuel consumption would be high due to the off-site transportation of excavated materials to Subtitle C and Subtitle D facilities.

The costs associated with this option do not make this alternative an attractive option.

4.3 Groundwater Treatment Area

4.3.1 Monitored Natural Attenuation

The MNA alternative for the Groundwater Treatment would involve no additional treatment of contaminated groundwater at the site. At a minimum, it is anticipated that MNA could only be considered for the Groundwater Treatment Area in conjunction with removal or stabilization of the contaminant source in the Western Source Area.

Additional groundwater sampling would be required to determine if the contaminant concentrations have stabilized or are receding over time. Additional controls may also be necessary to address residual groundwater impacts above the ES not addressed by MNA. Residual groundwater impacts in the Groundwater Treatment Area could continue to impact bedrock in the Potable Well Target Zone.

The implementability is high for this alternative because it represents a continuation of long term monitoring and reporting consistent with the past several years - no additional action is proposed. MNA is also a sustainable remedial option as minimal energy and water resources are utilized during implementation. However, from an administrative feasibility point of view, this alternative will likely not be accepted by the WDNR as the remedy for the Groundwater Treatment Area because it does not actively address residual groundwater impacts throughout the plume that may continue to be a source of off-site groundwater impacts within the Potable Well Target Zone.

This alternative would result in the least amount of disruption to the site. Assuming that no additional monitoring wells need to be installed, it has no associated capital costs. However, long term monitoring, maintenance, analytical, and reporting costs are estimated to range from $40,000 to $100,000 per year.

As indicated above, this alternative will likely not be accepted by the WDNR and is not retained for further evaluation.

4.3.2 Permeable Reactive Barrier

Permeable reactive barriers (PRBs) are in-situ remedial systems designed to treat groundwater contaminants and limit plume migration. A PRB system could be installed within the Groundwater Treatment Area down gradient of the Western Source Area. They are constructed so that impacted groundwater flows through the PRB, usually under natural gradients.

Shallow PRBs are usually installed as a trench within the aquifer, perpendicular to groundwater flow, and filled with media, typically a mixture of zero valent iron and sand, to create an environment in which contaminants are degraded and/or destroyed. Construction of a PRB at deeper depths is typically achieved by injection of the treatment media through a series of boreholes or some type of pneumatic or hydraulic fracturing and injection.

It is estimated that a 500-foot long and 40-foot deep PRB would be needed to intercept the down gradient contaminant plume. However, in the absence of a lower confining unit for the barrier to be keyed into, the PRB would be a “hanging wall” under which impacted groundwater could still move.

Treatability testing would need to be performed as part of the remedial design activities. This testing would involve laboratory column tests using groundwater from the site and commercial granular iron material. The results of these tests would provide data to predict PRB performance and to assist in the design of the system. Additional post installation groundwater monitoring wells would be required to demonstrate the effectiveness of the PRB.

This alternative may not be technically feasible due to the absence of a lower confining unit for the barrier to be keyed into. In addition, the installation of an injected PRB lacks control over the thickness and uniformity of the treatment zone which may reduce the remedial performance. There are also some questions regarding the long-term effectiveness of this alternative as inorganic constituents in the groundwater may form mineral precipitates on the iron surface and clog the PRB.

The actual installation of the PRB is the largest energy expenditure and will have a large carbon footprint. After construction this alternative fits the concept of green and sustainable technology.

Costs associated with the design, treatability testing, PRB installation, and groundwater monitoring can be significant. Conceptual costs for this alternative are estimated between approximately $1,100,000 and $2,300,000.

These costs coupled with questions regarding the technical feasibility and long-term effectiveness do not make this alternative an attractive option.

4.3.3 Engineered Pond

An engineered pond would serve as an in-situ remedial alternative designed to intercept and treat the groundwater plume directly down gradient of the Western Source Area. The width of the plume in this area is approximately 500 feet and the depth of the plume extends to approximately 30 feet bgs. Therefore to intercept the vertical and horizontal extent of the plume, a pond will need to be sized to provide hydraulic control of the groundwater plume.

An oblong-shaped pond, approximately 500 feet long and 160 feet wide would be constructed to intercept the groundwater plume as shown conceptually in Figure 7. The maximum depth of the pond would be approximately 20 feet deep to directly intercept approximately two-thirds of the vertical extent of the plume as shown conceptually in Figure 8.

Although the designed depth of the pond does not directly intersect the full vertical extent of the groundwater plume, and it is expected that engineering controls could improve the hydraulic gradient control (i.e. capture zone) of the pond. It is anticipated that the pond will include a discharge to Silver Creek and a phytoremediation component, both of which will create a groundwater capture zone around and underneath the pond, effectively increasing the size of the pond.

In addition to the pond's size, the ability of a pond to effectively reduce the mass of VOCs in the groundwater is largely dependent upon volatilization of the COCs from the pond. To facilitate volatilization under this alternative, circulation equipment would be used to provide physical mixing and aeration of the water. This would improve evaporation and stripping of COCs, as well as keep the pond open and operational during the winter months.

From an administrative/regulatory point of view, this alternative is acceptable as it meets the objectives of reducing the toxicity and volume of impacted groundwater down gradient of the source and in limiting off-site migration of residual groundwater impacts. The time required for construction of the pond is short; however the pond would need to be functional for an extended period of time before regulatory closure could be considered.

This alternative will have limited short-term impacts on the surrounding area, because heavy equipment operation will be confined to on-site use, without the need for off-site disposal of soil and the corresponding impact of increased truck traffic on public roads.

Conceptual costs for this alternative are estimated between approximately $488,000 and $564,000. This estimate incorporates assistance from the US Department of Agriculture, Forest Service. The forest service would supply the phytoremediation component of this remedy as part of their Great Lakes Watershed emphasis.

This alternative will have a moderate carbon footprint during excavation of the pond. The use of the excavated soil on-site helps to reduce this impact. Long-term energy inputs are low due to the use "green tools" such as the solar-powered mixing equipment and phyto buffers to treat the COCs and improve hydraulic control.

4.4 Potable Well Target Zone

Due to the intricacies of characterizing and remediating impacted groundwater in a fractured bedrock setting no remediation treatment is planned for the Potable Well Target Zone. Rather remedial actions will focus on the Western Source Area and Groundwater Treatment Area to manage the source area and on-site groundwater plume. In this manor, a reduction in contaminant mass can be accomplished to ultimately prevent further down gradient contaminant migration to the Potable Well Target Zone.

Therefore, the Potable Well Target Zone is not retained for further evaluation of remedial alternatives.

4.5 Recommended Remedial Alternative

The combination of an engineered treatment system in the Western Source Area and an engineering pond augmented with phytoremediation in the Groundwater Treatment Area is recommended as the most technically and economically feasible alternative for implementation at the site.

This alternative provides for soil and groundwater source control and is considered protective of human health and the environment. The engineered treatment system in the Western Source Area includes a combination of capping, SVE, and LNAPL recovery. The engineered pond with phytoremediation intercepts and treats down gradient groundwater impacts. The total estimated cost for installation of the treatment system and construction of the pond is approximately $914,000.

Although no active remediation activities will occur within the Potable Well Target Zone (bedrock), long-term monitoring of down gradient potable wells will continue as part of the recommended approach for the Western Source Area and Groundwater Treatment Area.

The selected approach addresses the remediation goals and objectives for site-wide management of soil and groundwater impacts, focusing on the protection of human health and the environment while considering potential available funding for remediation.

5.0 Remedial Action Conceptual Design

This section provides engineering criteria, concepts, assumptions, and calculations in support of the conceptual design for the recommended remedial action at the Western Source Area and Groundwater Treatment Area. A drawing presenting the comprehensive treatment system conceptual design (cap, SVE, and LNAPL removal) and engineered treatment pond with phytoremediation is provided on Figure 9.

This information is provided consistent with the requirements of WAC NR 724 *Remedial and Interim Action Design, Implementation, Operation, Maintenance and Monitoring Requirements*.

5.1 Western Source Area – Engineered Treatment System

The engineered treatment system incorporates a surface cap and combined SVE/LNAPL active remediation system to address soil and vadose zone impacts at the Western Source Area. Each of these components is detailed in the following sections in support of the conceptual design.

5.1.1 Surface Cap

The engineered cover system (i.e. cap) is to address both direct contact and groundwater infiltration exposure pathways in accordance with the WDNR's *Guidance for Cover Systems as Soil Performance Standard Remedies*[11] document. Due to the presence of PCB compounds at concentrations >50 mg/kg, the surface cap should also meet the EPA TSCA regulatory requirements as presented in 40CFR 761.61(a)(7) *Cap Requirements*. Both of these standards are met by designing the cap in compliance with the requirements of WAC Chapter NR 504.07 *Minimum Design and Construction Criteria for Final Cover Systems*.

Prior to the construction of the cap, existing monitoring wells WT-02, PZ-02, WT-09, WT-10, WT-14, WT-17, and WT-18 will be properly abandoned. AECOM anticipates that a limited number of these monitoring wells will be replaced, after cap construction, to facilitate future groundwater, LNAPL, and SVE system monitoring. The exact number of replacement wells will be determined during the drafting of the system operation and maintenance plan.

Additionally, AECOM proposes to incorporate the disposal of investigation derived waste (IDW) (i.e. soil cuttings from historical soil borings currently stored on-site in drums) into the source area below the engineered cap. This disposal option is in consistent with the final remedy and in general agreement with WDNR guidance[12].

The Western Source Area will be re-graded prior to the installation of the cap. The re-grading is anticipated to include filling with soils obtained from the groundwater treatment area – engineered pond excavation and from re-grading the topographic high areas around the cap. The cap contours shown on the conceptual design grading plan (Figure 9) are preliminary. The final grading plan to be presented in the plans & specs documents will meet the WAC Chapter NR 500 grading/slope requirements.

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[11] *Guidance for Cover Systems as Soil Performance Standard Remedies*, WDNR R&R Publication Number RR-709, dated October 2013.

[12] *Guidance for the Management of Investigative Waste*, WDNR R&R Publication Number RR-556, dated April 2015.

AECOM anticipates that the cap will cover an approximately 63,000 square foot area and, in general, be constructed (from bottom up) as follows:

- A minimum 2-foot thick soil barrier layer (e.g. the existing re-graded site soils). The soil barrier layer will consist of fine-grained soil or well graded sandy soil with fines, meeting Unified Soil Classification (USCS) soil types ML, CL, CH, SM, or SC. The upper one foot with a maximum particle size of 2 inches or less and the lower one foot with a maximum particle size of 4 inches or less.

- A geocomposite liner (GCL) with an integral geomembrane. The GCL will consist of sodium bentonite clay encapsulated between two geotextiles and placed in direct contact with the soil barrier layer. An integral 40-mil geomembrane will be installed directly over the GCL.

- A minimum 2.5-foot thick drainage and rooting zone layer installed above the geomembrane. The drainage layer above the geomembrane should consist of sand with a minimum hydraulic conductivity of $1x10^{-3}$ cm/sec. It is anticipated that soils available on-site may be utilized for this drainage and rooting zone layer.

- Where necessary (e.g. if drainage from the drainage zone is confined by topographic conditions), a perimeter drain pipe will be placed at the low end of the final cover side slopes.

In accordance with WAC Chapter NR 700 requirements, the engineered cap will require the establishment of a Cap Maintenance Plan as a condition for future site closure.

AECOM has incorporated, where appropriate, components of the EPA regulations as they apply to PCB remediation under the 40 CFR Part 761 rules. In general, AECOM proposes implementing the following 40 CFR 761.61(a), self-implementing rules into the remedial design:

- 40 CFR 761.61(a)(4)(B) – Low Occupancy Areas. AECOM considers the Western Source Area a low occupancy site (occupied less than 335 hours annually).

- 40 CFR 761.61(a)(7) – Cap Requirements. As noted above, the engineered cap is designed to meet this requirement.

- 40 CFR 761.61(a)(8) – Deed Restrictions for Caps, Fences, and Low Occupancy Areas. Typically, the use of the low occupancy classification incorporates the use of an engineered cap, a deed restriction, possible fencing, and signage including the M_L mark (i.e. a PCB notification sign).

  Engineered Cap
  As noted above, the engineered cap has been is designed to meet TSCA requirements.

  Deed Restriction
  40 CFR 761.61(a)(8)(i)(A) notes that a deed restriction on the property, "… or on some other instrument which is normally examined during a title search, …" can be used. AECOM proposes that, instead of a deed restriction/notification on the property, the registration of the site on the WDNR's Geographic Information System (GIS) and on the Bureau for Remediation and Redevelopment Tracking System (BRRTS) database will fulfill the TSCA deed restriction requirement.

Fencing

AECOM proposes that no fencing be placed around the engineered cap. The use of the engineered cap will limit direct contact with the PCB-containing materials. Additionally, the site is a secure property with access limited by a locked gate. The property is essentially unoccupied with the exception of an adjacent police department firearms training facility that is occasionally occupied during typical business hours.

Signage

AECOM proposes installing signage that includes the M_L mark on the perimeter of the engineered cap. The signage can include owner information, information on the engineered cap, and notification of PCB impacts including the M_L mark.

5.1.2 SVE and LNAPL Recovery Systems

The SVE system will be integrated with an LNAPL recovery system. The two systems will share, where appropriate, extraction wells, piping and trenching runs, and a remediation building to provide operational flexibility for SVE only, LNAPL removal only, or combined SVE and LNAPL removal as conditions warrant.

5.1.2.1 Extraction Wells

The SVE system wells will be integrated with the LNAPL recovery system wells so that a total of eight wells will provide for the combined SVE and LNAPL removal as follows:

- Two wells will operate as SVE only wells.
- Three wells will operate as only LNAPL recovery wells.
- Three wells will combine SVE and LNAPL recovery.

The five SVE extraction wells will be installed centered on the Western Source Area hot spot. The ROI between wells will include a 50 percent (%) overlap to insure coverage of the contaminated vadose zone soils. The overall area of influence can be varied by turning one or two wells off, thus increasing the SVE airflow/radius of influence on the remaining operating well(s), and by pulsing the operation of the wells. It is anticipated that by operating the system in this manner the entire area of impacts can be remediated.

The LNAPL system will include six recovery wells located within the central area of the estimated LNAPL plume. For three of the six recovery wells, recovery will be enhanced by operating under a vacuum (i.e. the wells will also operate as SVE wells).

AECOM anticipates that the SVE and LNAPL recovery wells will consist of 4-inch diameter stainless steel riser pipe with 20-foot stainless steel high flow screens installed to a total depth of approximately 10 feet below the top of the water table; a bottom of well elevation of approximately 675 feet MSL. Installing the wells to a depth of 10 feet below the water table will facilitate the installation of the LNAPL recovery pumps and provide adequate depth for possible future remedial options.

Well installations will include filter packs, annular space seals, and surface seals consistent with the well installation requirements of WAC Chapter NR 141. The extraction wells will be installed through the engineered cap and sealed in accordance with WAC Chapter NR 500 design requirements; typically by sealing the well penetration with bentonite.

5.1.2.2 SVE System

The technical basis for the SVE system design is presented in the *Soil Vapor Extraction Pilot Study Technical Memorandum*[13]. The tech memo presents the results of the SVE pilot test conducted in September 2015 along with a discussion of the system design parameters. The recommended SVE system operational parameters are as follows:

- A minimum radius of influence (ROI) of 40 feet.
- A maximum ROI of 60 feet.
- A wellhead vacuum level of 24 inches water column (WC).
- An air flow rate of 50 standard cubic feet per minute (SCFM) per extraction well.
- An initial single well average contaminant emission rate of 2.35 pounds per hour (lbs/hr) of VOCs.

The SVE system equipment, specifically the regenerative vacuum blower, will be sized to facilitate a lower-effort, longer-term operational period. This is a sustainable approach to SVE system operation, where the extraction blower is not oversized to meet initial/maximum operational conditions, but rather, the blower size is optimized to facilitate the entire SVE operational period. AECOM requested and received agreement from the WDNR to use this sustainable approach to the SVE system operation[14].

The SVE system will operate with a total of five extraction wells with wellheads, trenching, piping, and associated extraction equipment.

Sub-surface SVE monitoring will be conducted using the non-operational SVE extraction wells and the limited number of replacement groundwater monitoring wells.

5.1.2.3 LNAPL Recovery System

LNAPL recovery bail-down testing and a short-term free product recovery field test were conducted during the investigation phase of the project. Indications from the field testing, along with the aquifer characteristics (e.g. sandy soils) suggest that LNAPL recovery is a feasible remedial method to reduce LNAPL mass.

The LNAPL free product has been characterized twice during the investigation. LNAPL data along with mass calculations are presented in the *LNAPL Characterization and Contaminant Mass Analysis Technical Memorandum*[15]*.* The tech memo presents the LNAPL laboratory results along with a discussion of the results. The LNAPL recovery system has been designed to provide active, long-term, low-effort, free product recovery based on the field testing and the LNAPL characterization data.

Since the LNAPL product has a specific gravity and viscosity similar to an SAE 40 weight motor oil, AECOM is considering providing down-well, low voltage, intrinsically safe, 100 watt “finger” heaters. The

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[13] 2015 Task 32; Soil Vapor Extraction Pilot Study Technical memorandum, AECOM Technical Services, Inc., dated August 1, 2016.

[14] *Response to SVE Remedial Option Planning and Report Submittal Modification*, email from Tauren R Beggs, DNR, dated Thursday February 2, 2016, 9:09 AM.

[15] *2015 Task 32; LNAPL Characterization and Contaminant Mass Analysis Technical Memorandum*, AECOM Technical Services, Inc., dated August 1, 2016.

heaters will warm the LNAPL within the well, which will facilitate pumping of the product. The product heaters along with the vacuum enhanced recovery should increase the efficiency of the LNAPL recovery system.

The LNAPL recovery system will operate with a total of six recovery wells with pneumatic down-well skimmer pumps, trenching and piping, and associated recovery equipment.

Sub-surface LNAPL level monitoring will be conducted using the non-operational SVE extraction wells and the limited number of replacement groundwater monitoring wells.

5.1.2.4 Remediation Systems Infrastructure

Infrastructure for the SVE and LNAPL recovery systems includes both below grade and above grade structures. The below grade infrastructure includes the extraction/recovery wells as described above, LNAPL pneumatic down-well skimmer pumps, wellheads, wellhead manholes, and piping. The above grade infrastructure includes a remediation building that houses; HVAC equipment, extraction equipment (SVE blower, moisture separator, LNAPL air compressor, etc.), piping manifolds, pressure and flow measurement, LNAPL storage (with secondary containment), and a combined system control panel. It is anticipated that the building will be located adjacent to the Western Source Area. Additional infrastructure details are as follows:

<u>System Piping</u>
The system piping will be 4-inch Schedule 40 PVC piping installed below ground (within the rooting zone layer of the engineered cap) between the extraction wells and the remediation building. The individual wellheads will be constructed with a “Tee” fitting, to allow access to the wells while the system is installed, and a vapor sample port. SVE piping between the wellheads and the remediation building will be plumbed in parallel, with each well receiving its own end-run pipe. The SVE piping will be manifolded within the remediation building with individual valves to control which wells are operational.

Due to the low level of vacuum required by the SVE system (e.g. 24 inches WC at the wellhead) it is not anticipated that large volumes of groundwater will be extracted by the system. The air velocity within the SVE piping will be less than 1,000 feet per minute (fpm), which will limit the amount of groundwater and liquid condensate that is transported to the treatment equipment in the remediation building. Additionally, the pipe will be sloped slightly back towards the extraction wells to allow the liquids to drain back to the wells.

AECOM anticipates providing secondary containment for the LNAPL recovery piping (i.e. tubing) by installing the LNAPL tubing within the SVE manifold piping. For the three wells initially operated for LNAPL recovery only, the wellhead and piping will be installed identical to an SVE well, which will facilitate the secondary containment of the LNAPL tubing and allow for possible future SVE operation, if necessary. In this way, possible leaks will be contained and directed back to the extraction wells.

<u>SVE System Components</u>
The two main components of the SVE system include a vapor/water separator vessel (i.e. knock-out tank) and the vacuum blower.

The knock-out tank will remove condensation from the extracted vapor prior to the vacuum blower. The tank will be fitted with a high/high level alarm that will shut the system down when the tank fills with water. When necessary, water will be manually pumped from the knock-out tank to drums for proper disposal.

The preliminary design for the vacuum blower includes sizing to accommodate three wells operating at full capacity, accounting for the additive nature of sub-surface vacuum drawdown (ROI), and for friction head loss in the manifold piping and the knock-out tank. The proposed blower specifications are as follows:

- Blower – regenerative type.
- Motor – 3 Hp, 240 volt, single phase, 60 hertz.
- Operating point; 160 cfm at 24 inches of water column vacuum.

It is anticipated that the knock-out tank and vacuum blower will be provided as an integrated unit on a blower skid. The blower will exhaust through a 10 foot tall stack directly to the atmosphere.

<u>LNAPL System Components</u>
The main LNAPL system components include the use of 4-inch down-well pneumatic LNAPL skimmer pumps designed for heavy oil applications, an air compressor with a membrane air dryer, a pumping cycle controller, and high-level shutoff switches for product storage vessel.

<u>Control Instrumentation and Sampling</u>
The SVE and LNAPL recovery systems will be operated through an integrated control panel. The panel will incorporate alarm functions and provide recording of system operational time. The SVE blower skid will include vacuum gauges, a flow gauge (typically an averaging pitot tube), a bleed valve to adjust vacuum levels, and vapor sampling ports.

<u>Electrical System</u>
The SVE and LNAPL equipment operation will require a 120/240 volt, single phase power service from the electrical utility (Wisconsin Public Service). Since the contaminants of concern include petroleum products, portions of the electrical system within the remediation building will have to be National Fire Protection Association (NFPA) Publication 70 – National Electric Code (NEC) rated for hazardous locations (i.e. rated for explosive atmospheres).

<u>Remediation Building</u>
AECOM proposes a two room insulated remediation building approximately 10x15 foot in size located on a concrete slab foundation. One room, the smaller room, would contain the SVE and LNAPL systems manifold piping and LNAPL free product storage vessels with secondary containment. The larger room would hold the SVE and LNAPL remediation equipment. It is anticipated that a NEC Class I, Division 2 rating will apply to the interior rooms of the remediation building.

5.1.3 Operation & Maintenance

Once the engineered treatment system equipment designs are finalized, AECOM will provide the WDNR with a compliant WAC Chapter NR 724.13(2) *Operation and Maintenance Plan* (O&M Plan). The plan will outline the operation, monitoring, and maintenance activities to ensure compliance with regulatory permits and the effective operation of the remedial systems. Additionally, where applicable, the number and location of the replacement groundwater monitoring wells will be defined in the O&M Plan.

5.1.4 Permits

There are several permits required for the operation of the engineered treatment system (i.e. the engineered cap, SVE, and LNAPL recovery systems). These include:

- construction and zoning permits,
- a possible air discharge permit, and
- a WDNR GIS registry and an approved cap maintenance plan.

Construction and Zoning Permits
All required construction and zoning permits will be obtained through the City of Manitowoc.

Air Discharge Permit
Air emissions from the SVE system are regulated and permitted as both total VOC emissions (e.g. Chapter NR 419.07 4 (b) limits) and as individual compounds (WAC Chapter NR 445.07 Table A values).

WAC Chapter NR 419, *Control of Organic Compound Emissions*, specifically addresses total VOC emission limits from remediation of contaminated soil or water. WAC Chapter NR 419.07 4 (b) states that emissions from the remediation or disposal of contaminated soil or water may not exceed: 137 pounds of VOC compounds per day (an average of 5.7 lbs/hr) in Manitowoc county or the maximum emission limit for any hazardous air contaminant listed in Table A of WAC Chapter NR 445.07.

As noted throughout the site investigation data, the COCs disposed of at the site includes a broad range of VOC compounds. A comparison of the principal COCs identified within the Western Source Area (as presented in the *LNAPL Characterization and Contaminant Mass Analysis Technical Memorandum,* Table 1, Attachment C) to the WAC Chapter NR 445.07 Table A values for those VOC compounds is provided in Table 1 below:

Table 1: Comparison of Principal COCs to WAC Chapter NR 445.07 Table A Values.

Principal COCs Listed as NR 445.07 Hazardous Air Contaminants	NR 445.07 Threshold for Emission from Stack <25 ft. (lbs/hr or lbs/yr)	NR 445.07 Time Period for Standard and Threshold
Benzene	228	Annual
1,2-Dichloroethylene	42.6	24 Hr Avg
Ethyl benzene	23.3 177,688	24 Hr Avg Annual
Isopropyl benzene	13.2	24 Hr Avg
Naphthalene	2.82	24 Hr Avg
Tetrachloroethylene	9.11 301	24 Hr Avg Annual
Trichloroethylene	14.4 888	24 Hr Avg Annual
Xylene (total)	23.3	24 Hr Avg

If the SVE system emissions exceed either the WAC Chapter NR 419.07 4 (b) limits (137 pounds of VOC compounds per day or an average of 5.7 lbs/hr) or the WAC Chapter NR 445.07 Table A values (See Table 1 above), then emission controls will be required for the system. AECOM anticipates that the most limiting of these two regulatory requirements will be the total VOC emission limit of 137 lbs/day (avg. 5.7 lbs/hr).

In order to stay below regulatory discharge limits, AECOM proposes that VOC emissions from the SVE system be managed through system operation procedures including:

- Start-up and initial operation with a limited number of extraction wells.
- Control of vacuum levels and flow rates to limit the extraction rate.

By keeping emissions below regulatory limits additional emission controls and air permits will not be required. Therefore, AECOM proposes that a WAC Chapter NR 419 air permit exemption be issued for the operation of the SVE system.

If during SVE system operation, the actual emission data indicate a possibility to exceed either the WAC Chapter NR 419.07 4 (b) limits or the WAC Chapter NR 445.07 Table A values, AECOM will propose an emission control plan to the WDNR to mitigate the possible exceedances.

<u>GIS Registry and an Approved Cap Maintenance Plan</u>
The use of an engineered cap as a final remedial alternative will require land use limitations and a cap maintenance plan as conditions for closure of the site. A future property owner is typically notified of these conditions through the WDNR's GIS and BRRTS database.

AECOM anticipates that at some future date, when closure of the site is under consideration, a case closure request submittal (Case Closure – GIS Registry (Form 4400-202)) will be submitted to the WDNR along with a cap maintenance plan for the engineered cap.

5.2 Groundwater Treatment Area – Engineered Pond and Phytoremediation

Groundwater treatment includes an engineered groundwater treatment pond with phytoremediation to address impacts within the Groundwater Treatment Area. The components of the treatment system are designed to reduce contaminant levels in groundwater as it flows downgradient to the Potable Well Target Zone. Each of these system components are detailed in the following sections in support of the conceptual design. A drawing presenting the comprehensive treatment system conceptual design (cap, SVE, and LNAPL removal) and engineered treatment pond with phytoremediation is provided on Figure 9.

5.2.1 Engineered Treatment Pond

<u>Background and Physical Parameters</u>
During a project specific Technical Information meeting[16] between the City, WDNR and AECOM; Dave Johnson, Hydrogeologist with the WDNR Division of Environmental Management, Drinking and Groundwater Section, suggested that the Former Newton Pit site presents a unique combination of contaminant compounds, subsurface conditions, and a topographic profile that might make it a good candidate for the installation of a groundwater treatment pond.

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[16] *Manitowoc City/Former Newton TN Gravel Pit Technical Information Meeting Minutes*, April 1, 2015, Oshkosh DNR Service Center.

As a result of further discussions, research, and data from additional field investigation activities; an engineered groundwater treatment pond is presented as a recommended remedial alternative. A summary of the specific research and the additional field investigation activities has been previously submitted to the WDNR in a *Groundwater Treatment Area Feasibility Study Technical Memorandum*[17]. The tech memo summarizes that, to the extent that a pond can be engineered to capture the vertical and horizontal extent of the plume, a pond would be a viable in-situ remedial option to treat the contamination plume prior to it traveling off site.

One concept integral to the proposed use of a constructed treatment pond is that the pond itself is not considered by the WDNR as a “water of the state”. Rather, it is accepted as a remedial action treatment system that is exempt from the applicable WDNR surface water standards. AECOM requested and received confirmation of this interpretation from the WDNR[18].

Prior to pond construction, existing monitoring wells P-1 through P-13, WT-04, and WT-13 will be properly abandoned. It is anticipated that a limited number of these monitoring wells will be replaced, after pond construction, to facilitate future groundwater monitoring. The exact number of replacement wells will be determined during the drafting of the system operation and maintenance plan.

The pond, as designed, is roughly ‘kidney beaned’ shaped, approximately 500 feet long, 160 feet wide, with a maximum depth of approximately 20 feet below groundwater elevation (e.g. an approximate bottom of pond elevation of 665 feet MSL). Along the northeastern portion of the pond a discharge channel will terminate at a weir flow control structure that will control the gravity discharge of treated pond water, via a pipe, to Silver Creek. The sidewalls of the pond will be constructed to intersect the water table at an approximate elevation of 685 MSL and the pond will include a 10-foot wide safety shelf.

It is estimated that a total of approximately 82,000 cubic yards (CY) of soil will be excavated to create the pond and channel. Of this volume, approximately 49,000 CYs will be excavated from above the water table elevation (685 MSL) and approximately 33,000 CYs will be excavated from below the water table. AECOM proposes that the excavated material be managed as follows:

- Material excavated from above the water table will be considered clean material not impacted with VOC compounds. AECOM proposes that these clean materials can be used without limitation. They can be relocated on the property for use as fill or they can be transported off-site for use as fill on any commercial project.

- Material excavated from below the water table will be considered impacted by VOC compounds. AECOM proposes that these VOC-impacted materials can be used on-site as fill within the formally delineated VOC groundwater plume area. If these materials are tested and found to have no-detectable levels of VOCs (as defined by the laboratory method detection limit for VOCs) – these materials may be used without limitation.

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[17] *2015 Task 31; Groundwater Treatment Area Feasibility Study Technical Memorandum*, AECOM Technical Services, Inc., dated April 4, 2016.

[18] *Surface Water Standards Question for a Pond acting as a Remedial Action*, email from Tauren R Beggs, DNR, dated Friday May 29, 2015, 2:44 PM.

Hydraulic Control

Although the designed depth of the pond (approximately 665 MSL) does not directly intersect the full vertical extent of the groundwater plume (the bottom of the plume is at approximately 655 MSL) it is anticipated that engineering controls will improve the hydraulic gradient control (i.e. the capture zone) of the pond. Additional hydraulic control is also anticipated through phytoremediation as discussed in Section 5.2.2.

The pond design includes a drainage channel to the east with a discharge pipe extending to Silver Creek. The channel and pipe will use gravity flow to discharge water from the pond. The discharge of water will create a predominately horizontal hydraulic gradient within the underlying sand and gravel towards the pond to enhance groundwater capture.

This imposed hydraulic gradient will create a capture zone that will primarily extend up-gradient from the pond and neutralize the downward gradient currently associated with the Western Source Area. The new hydraulic gradient will not re-capture contaminated water that is currently beneath the pond; however, future groundwater flow will be directed horizontally toward the pond bringing with it the newly captured up-gradient groundwater plume.

A preliminary analysis was completed to model the various flow conditions that occur as the pond is “pumped”. For the purpose of this evaluation, evaporation of water from the pond surface was considered to have a minimal influence on the “pumping” of the pond.

The analyses began by reviewing approximately 22 years (1993 through 2015) of groundwater elevation data for the monitoring wells located in the vicinity of the proposed pond (WT-02A, WT-03, WT-13 and WP-04). During that period the maximum average groundwater elevation was 686.11 MSL, the average groundwater elevation was 685.14 MSL, and the minimum average groundwater elevation was 684.01 MSL.

Next a range of flow rates for the pond (i.e. of the aquifer draining into the pond) were modeled based on Darcy’s Law:

$$Q = KiA$$

Where: Q = flow rate
K = hydraulic conductivity
i = horizontal hydraulic gradient
A = cross sectional area of the pond

A range of flow rates were calculated using the following values:

- The measured hydraulic conductivity (K) for the aquifer is 3.90E-3 cm/sec (11.06 ft/d).
- A range of assumed horizontal hydraulic gradients (i) as follows:
    - A maximum hydraulic gradient of 1.0 ft/ft, with no correction in the aquifer due to drawdown in the pond.
    - An engineer’s estimated hydraulic gradient of a 0.10 ft/ft. This is 10% of the maximum gradient and assumes the aquifer will correct itself for pond drawdown within a distance of only 10 feet away from the pond. This may be an unrealistically high gradient given that the measured natural gradient corrects 1 foot over 227 feet (a gradient of 0.004 ft/ft).

   - A minimum hydraulic gradient of 0.004 ft/ft. This is the naturally occurring hydraulic gradient in the aquifer assuming no drawdown in the pond.

- A perimeter cross-sectional area of the pond (A) equal to approximately 30,820 square feet. This assumes horizontal flow predominates in the sand and gravel aquifer.

The calculated flow rates for the pond based on Darcy's Law using the site hydraulic conductivity, the pond cross-sectional area, and pond drawdown conditions equal to the range of assumed hydraulic gradients were as follows:

- Q_{max} was 3.93 cubic feet per second (cfs) at a hydraulic gradient/pond drawdown of 1.0 ft/ft.

- Q_{est} was 0.39 cfs at a hydraulic gradient/pond drawdown of 0.10 ft/ft.

- Q_{min} was 0.02 cfs at the natural hydraulic gradient of 0.004 ft/ft.

These flow rates along with the anticipated groundwater elevation conditions were then used to design operational conditions for the pond, as follows:

- The anticipated pond operating water levels are based on the historical groundwater data as follows:
   - a maximum pond elevation of approximately 686.11 MSL,
   - a minimum pond elevation of approximately 684.01 MSL, and
   - an average pond elevation of approximately 685.14 MSL.

  The current (October 2015 data) groundwater elevation is approximately 685 MSL.

  Based on the historical and current water elevation data, the proposed design normal water level (NWL) elevation for the pond is 685 MSL.

- The maximum drawdown of the pond is anticipated to be 1-foot (an elevation of approximately 684 MSL based on the proposed NWL of 685 MSL), equivalent to the maximum horizontal hydraulic gradient and the historical average minimum groundwater elevation. Calculating the pond flow rate under this condition gives a maximum flow of approximately 4 cfs.

  The impact of storm water flows into the pond and the impact of high groundwater elevations will also impact the maximum flow conditions.

  Storm water flows were reviewed. Based on the limited size of the drainage basin and the sand and gravel nature of the gravel pit surface (e.g. minimal runoff) the impact of storm water flows into the pond was determined to be minimal.

  The future possibility of high groundwater elevations will have an impact on the maximum flow rate from the pond. To account for this variability in high groundwater elevations, the weir structure controlling the flow of water from the pond will be designed to be adjustable, so that pond drawdowns can be managed for differing groundwater elevations.

  Taking into account possible elevated pond surface water elevations created by both storm water flows and elevated groundwater conditions, the top of the pond bank elevation was designed at 688 MSL, approximately two feet above the historic maximum average groundwater elevation.

- The average operating drawdown of the pond is anticipated to be 0.10-foot (an elevation of approximately 684.9 MSL based on the proposed NWL of 685 MSL), equivalent to the engineer's estimated hydraulic gradient of a 0.10 ft/ft. Calculation of the pond flow rate under this condition gives a flow of approximately 0.39 cfs.

- The pond flow rate based on the minimum hydraulic gradient was not calculated because it assumes no drawdown in the pond.

These pond water level elevations and flow conditions were then used to conduct a hydraulic analysis of the gravity pipe flow from the pond.

Hydraulic Analysis

The intent of the hydraulic analysis was to size the outlet and outlet pipe that would run from the pond's drainage channel to Silver Creek. The criteria for sizing the pipe were to maintain a positive hydraulic gradient from groundwater elevation to the pond surface water elevation, to the discharge point at Silver Creek. To determine this, an XP-SWMM (Storm Water Management Model) model was developed. The hydraulic module of the program, XTRAN, was used to analyze the pond. This model was selected because it is effective in modeling pipe flow that transitions from open to pressure flow conditions, which will likely be the case with the pond outlet pipe.

Based on groundwater monitoring information and topographic survey elevations provided by the City, it is anticipated that pond outlet pipe will have an upstream invert elevation of 684.0 MSL. As a result, if there was no flow input into the pond, the pond water surface elevation would equalize to that elevation. The downstream invert elevation of the pipe is based on elevation of the channel bed of Silver Creek. The creek bed elevation at the proposed outfall location is approximately 682.5 MSL. It is estimated that the downstream end of the outlet pipe will have an invert elevation of 683.0 MSL (0.5 feet above the creek bed). Under high creek flows (subsequent to spring thaw and large rain events), it is likely that water from the creek would backup into the pond. Based on the design intent of the pond for treating groundwater, where water movement is measured in months and years, the short-term creek backflow condition, occurring typically less than a few weeks per year, is acceptable. Creek base flow conditions will likely yield creek water elevations at or below 683.0 MSL adjacent to the pipe outlet.

The results of the hydraulic analysis are presented in Table 2 below. Flows analyzed ranged from 0.25 to 4 cfs, and are based on anticipated groundwater flow into the pond. The results indicate that an outlet pipe at least 15-inches in diameter is required. This size pipe would provide acceptable performance for most anticipated flows, however at higher inflows (e.g. 4 cfs), the resultant water surface elevation (WSE) is higher than desirable (685.6 MSL). The use of an 18-inch diameter pipe would have a higher likelihood of performing in the full range of flows and provide a more favorable hydraulic gradient. Relative to the overall construction costs and efforts, the use of an 18- versus a 15-inch diameter pipe is relatively negligible. A 24-inch diameter pipe was also modeled, and results indicate only a marginal performance improvement over the 18-inch diameter pipe. It is therefore recommended to use an 18-inch diameter outlet pipe from the pond to Silver Creek. During the design process, an outlet structure with stop-logs (or similar) would be designed at the upstream end of the pipe to allow control of discharge during pond "start-up" conditions, to adjust the pond discharge elevation during times of high groundwater levels, and to minimize future maintenance.

Table 2 – Hydraulic Analysis Summary

Pond Outlet Pipe Diameter (in)	Base Flow (cfs)	WSE	Base Flow (cfs)	WSE	Base Flow (cfs)	WSE	Base Flow (cfs)	WSE	Base Flow (cfs)	WSE	Base Flow (cfs)	WSE
6		684.4		686.2		691.5		697.6		700+		700+
8		684.4		684.4		686.0		688.7		692.0		700+
10		684.3		684.4		684.6		685.5		686.7		694.6
12	0.25	684.3	0.5	684.4	1	684.6	1.5	684.7	2	685.1	4	688.5
15		684.2		684.3		684.5		684.6		684.8		685.6
18		684.2		684.3		684.5		684.6		684.7		685.0
24		684.2		684.3		684.4		684.5		684.6		684.9

Treatment

The treatment process of VOCs anticipated to occur within the pond include volatilization, phytoremediation, aerobic-bioremediation, and solar (i.e. UV radiation) oxidation. Volatilization is anticipated to be the main remedial process with phytoremediation, aerobic-bioremediation, and solar oxidation providing minimal benefits that will vary according to the season.

Volatilization is dependent on the physical properties of the aquifer, the pond, and of the VOCs.

The physical hydrologic properties of the aquifer include:

- A hydraulic conductivity (K) of 3.90E-3 cm/sec (11.06 ft/d).
- An average linear flow velocity (V) of 0.20 ft/day (73 ft/yr).

The physical properties of the pond include:

- Dimensions of approximately 500x160x20 (LxWxD) feet.
- A surface area of approximately 86,000 square feet.
- A volume of approximately 6.7 million gallons of water.
- A range of anticipated discharge flow rates from 0.25 to 4 cfs (153 thousand gallons per day (gpd) to 2.6 million gpd) with an estimated discharge rate of 0.39 cfs (255 thousand gpd).

These properties were then used to evaluate the groundwater retention time in the pond.

- Retention time as a function of average pond width (70 feet at elevation 675 MLS) and groundwater velocity (73 ft/yr) indicates that the pond’s average physical width is equivalent to one year's (365 days or 8,760 hours) travel time of the groundwater under the influence of the natural groundwater gradient (i.e. no discharge from the pond).

- Retention time as a function of pond volume (6.7 million gallons) and a range of discharge rates provides:

    - A minimum discharge flow rate of 0.25 cfs (153 thousand gpd) provides a groundwater retention time of approximately 44 days or 1,056 hrs.

    - The estimated discharge flow rate of 0.39 cfs (255 thousand gpd) provides a groundwater retention time of approximately 26 days or 624 hours.

    - A maximum discharge flow rate of 4 cfs (2.6 million gpd) provides a groundwater retention time of approximately 2.6 days or 62 hours.

The physical properties of the VOCs, as discussed in the *Groundwater Treatment Area Feasibility Study Technical Memorandum*, include the Henry's Law constants, vapor pressures, and half-life for the VOCs. The Henry's Law constants and vapor pressures all indicate a strong physical ability for the compounds to volatilize. The half-life data, the amount of time in hours required for a compound to be half of its original concentration during volatilization from a typical surface water body, indicates that for most VOCs present the half-life ranged from 2.5 to 3.4 hours. Only cis-1,2-dichloroethene was significantly different with a half-life of 96 hours.

Comparing the pond groundwater retention times to the VOC half-life data indicates:

- For most VOC compounds to be treated by the pond, with half-lives between 2.5 to 3.4 hours, the pond provides a retention/treatment time ranging from:

    - approximately 20 half-lives under the maximum discharge flow rate of 4 cfs, to

    - approximately 200 half-lives under the estimated discharge flow rate of 0.39 cfs, to

    - greater than 2,000 half-lives when the pond is not discharging water and water flows through the pond driven by the natural hydraulic gradient.

- For cis-1,2-dichloroethene with a half-life of 96 hours, the pond provides a retention/treatment time ranging from:

    - approximately 0.6 half-lives under the maximum discharge flow rate of 4 cfs, to

    - approximately 6.5 half-lives under the estimated discharge flow rate of 0.39 cfs, to

    - greater than 91 half-lives when the pond is not discharging water and groundwater flows through the pond driven by the natural hydraulic gradient.

To improve the treatment efficiency of the pond, AECOM proposes the use of floating solar-powered circulation equipment. The mixer is designed to provide physical mixing and aeration, which will improve evaporation, volatilization of COCs, promote aerobic bio-remediation and solar oxidation, as well as to keep the pond open and operational during the winter months.

In summary, the physical properties of the VOCs found within the pond are characterized by having a strong potential to volatilize. A review of retention times as compared to VOC half-lives indicates that, for most VOCs present, the pond will provide significant treatment time for volatilization to occur. All of these properties will be improved with the incorporation of a floating solar-powered pond mixer.

5.2.2 Phytoremediation

Phytoremediation within the Groundwater Treatment Area is anticipated to be implemented within three ecological zones; the pond littoral zone, the pond's riparian zone, and the upland zone around the pond.

The shoreline and shallow water littoral zone will be allowed to naturally vegetate with locally occurring plants. The zone should be managed to promote species such as cattails (Typha sp.), a known and hearty phytoremediation species, and to limit invasive species such as common reed grass (Phragmites sp.).

It is anticipated that the pond riparian zone and the surrounding upland zone will be actively managed for phytoremediation in cooperation with the US Department of Agriculture (USDA), Forest Service, under an EPA Great Lakes Restoration Initiative Action Plan II grant. The grant is funding a Forest Service, Landfill Leakage Remediation study. The study is being directed by Ronald S. Zalesny Jr., Team Leader and Research Plant Geneticist at the Northern Research Station in Rhinelander Wisconsin.

The Landfill Leakage Remediation study is a phytoremediation system project using a tree buffer system to control and remediate contaminated runoff to help prevent/decrease contamination to watersheds of the Great Lakes. The specific objectives of the study are to:

1. Project the volume of runoff captured and treated by integrating water quality, hydrogeologic, and soil health metrics (i.e., WATER BALANCE),

2. Delineate potential leakage plumes using *phytoforensic* methods (i.e., PHYTOFORENSICS),

3. Assess the health of existing trees by measuring uptake of inorganic and organic contaminants along with monitoring of physiological parameters (i.e., TREE HEALTH ASSESSMENTS),

4. Install phyto buffers of selected species and varieties for surface and subsurface pollution mitigation (i.e., PHYTO-RECURRENT SELECTION), and

5. Synthesize steps 1-4 to assess the overall reduction of nonpoint source pollution impacts on nearshore health (i.e., SYNTHESIS).

The outcome of the study for the Forest Service will be data for use in presentations and publications.

The outcome of the study for the City and the project site will be a professionally designed and managed phytoremediation study that will leave a legacy of approximately 2.4 acres of trees that will continue to remediate the site.

At this point in the phytoremediation project planning, the conceptual design provides for:

- A ring of willows that will provide an approximately 6-foot wide phyto buffer around the entire pond.

- On the up- and side-gradient (northwest and west) sides of the pond, approximately three rows of hybrid poplar trees planted at approximately 8-foot spacing. A total of approximately 0.4 acres of trees.

- On the down gradient side of the pond (east and southeast), approximately two acres of hybrid poplar trees will be planted at approximately 8-foot spacing.

It is anticipated that 3 to 4 years will be required for the trees to establish their root systems and provide significant water uptake. This uptake will provide additional hydraulic groundwater gradient control within the vicinity of the pond, providing treatment to the impacted groundwater.

At this time the City and the Forest Service have a verbal understanding that the Forest Service is interested in starting the study in 2017, after the pond is constructed. A final contract, in the form of a memorandum of understanding, must be authorized to formalize the project.

5.2.3 Operation & Maintenance

Once the engineered pond and phytoremediation designs are finalized, AECOM will provide the WDNR with a compliant WAC Chapter NR 724.13(2) O&M Plan. The plan will outline the operation, monitoring, and maintenance activities to ensure compliance with regulatory permits and the effective operation of the pond as a remedial system. A long term operation, maintenance, and monitoring plan will likely be required to achieve regulatory closure.

Where applicable, the number and location of the replacement groundwater monitoring wells and piezometers will be defined in the O&M Plan. The need for additional monitoring wells and piezometers is anticipated to aid in evaluating the pond's effectiveness in capturing impacted groundwater.

5.2.4 Permits

There are several permits required for the operation of the engineered treatment pond system. These include:

- possible construction and zoning permits,
- a WDNR Wisconsin Pollutant Discharge Elimination System (WPDES) permit,
- a WDNR Chapter 30 Permit, and
- a possible air discharge permit.

Construction and Zoning Permits
All required construction and zoning permits will be obtained through the City of Manitowoc.

WPDES Permit
AECOM anticipates that a WDNR WPDES general permit *Contaminated Groundwater from Remedial Action Operations (Permit No. WI-0046566)* will be required for the discharge of treated groundwater from the pond to Silver Creek. During the permit application process, AECOM expects to discuss the operation and management of the pond discharge, especially the requirements for treatment verification prior to beginning discharge.

Chapter 30 Permit
The construction of the treated pond water discharge outfall structure within the riparian zone of Silver Creek may require a WDNR Chapter 30 permit. Due to the type of outfall structure and the limited disturbance required to install the structure, AECOM anticipates that a WDNR *Intake or Outfall Structure (Exemption Checklist #11)* Chapter 30 exemption may apply. To apply for the exemption the submittal of a *Chapter 30 Exemption Determination Request (Form 3500-107, R5/11)* will be required.

Air Discharge Permit
Air emissions created by volatilization of VOCs from the pond are regulated and permitted as both total VOC emissions (e.g. Chapter NR 419.07 4 (b) limits) and as individual compounds (WAC Chapter NR 445.07 Table A values).

WAC Chapter NR 419, *Control of Organic Compound Emissions*, specifically addresses emissions from remediation of contaminated soil or water. Due to the parts-per-billion levels of COCs in the groundwater the emissions created by volatilization of VOCs from the groundwater are considered negligible. Therefore, AECOM anticipates that emission controls and air permits will not be required for the pond operation and that a WAC Chapter NR 419 air permit exemption be issued for the operation of the pond as a treatment system.

5.3 Proposed Schedule for Implementation

The proposed schedule for the implementation of the Former Newton Pit remedial actions is as follows:

- Fall and winter 2016 – Engineered Treatment Pond construction. Prepare plans & specs bid documents, conduct bidding, award, and begin construction.
- Spring and summer 2017 –
    - Begin Groundwater Treatment Area phytoremediation study activities.
    - Engineered Cap construction. Prepare plans & specs bid documents, conduct bidding, award, and begin construction.
- 2017 through 2022 – Conduct five years of groundwater monitoring to determine the aquifer response to Engineered Treatment Pond, Phytoremediation, and the Engineered Cap remedial actions.
- 2023 – Review past five years of groundwater monitoring data to determine if the Engineered Treatment Pond, Phytoremediation, and the Engineered Cap are effective in reducing COCs in groundwater. If groundwater data indicates steady state or declining contaminant levels, AECOM proposes that the SVE and LNAPL recovery system installation may not be necessary. If the initial remedial options are determined not to be effective in reducing groundwater contaminants, begin the process to install the SVE and LNAPL recovery remediation system.

This schedule is dependent on multiple factors (i.e. regulatory approval, permit approval time frames, available budgets, bidding processes, winter working conditions, etc.). Project schedule updates will be provided to the WDNR during our regularly schedule project team meetings.

5.4 Request for Approval

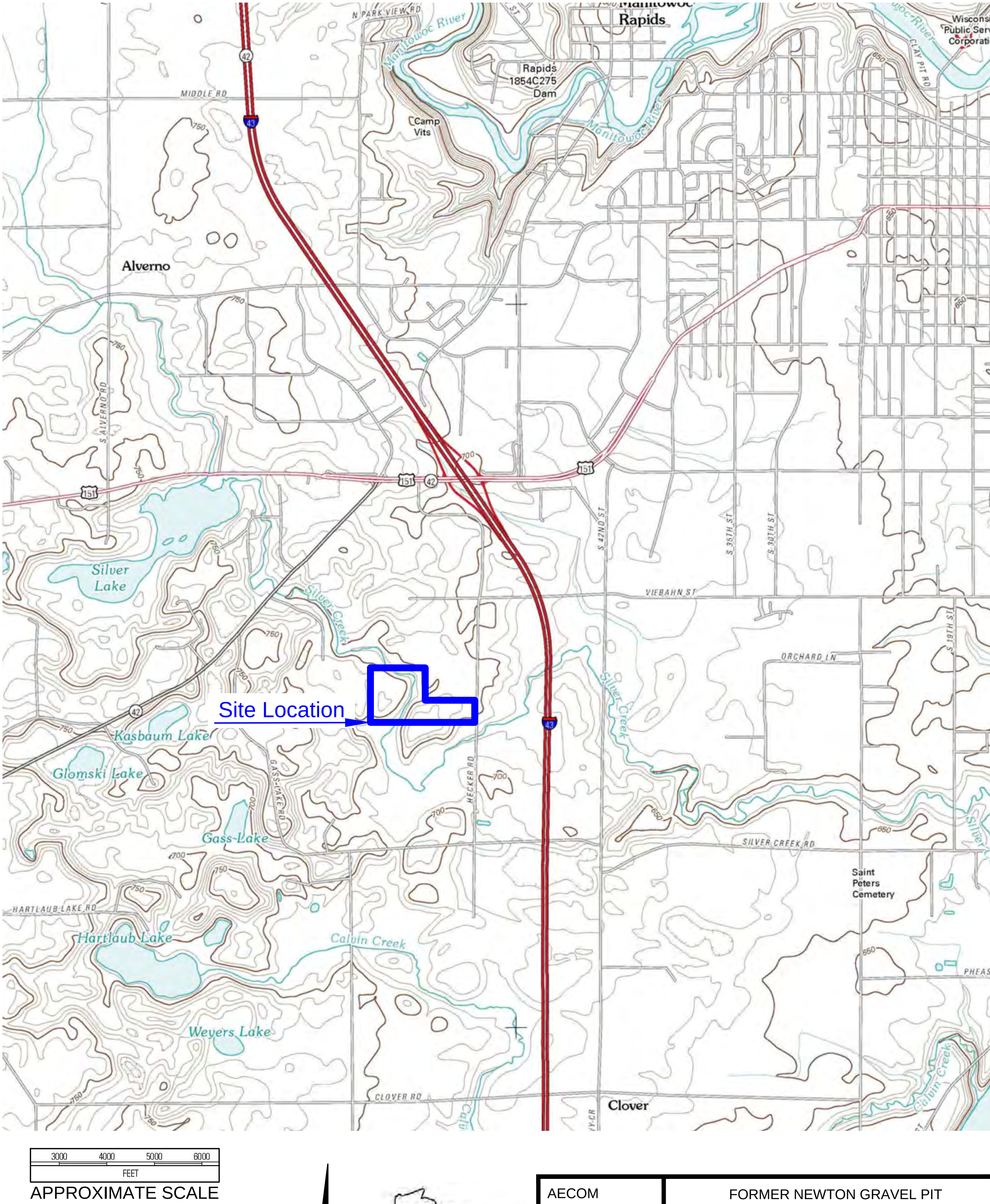
AECOM, on behalf of the City of Manitowoc, requests WDNR review and approval of the Remedial Action Options and Conceptual Design reports as presented. The approval is for the recommended remedial option including:

- An engineered treatment system incorporating a surface cap and a combined SVE/LNAPL active remediation system to address soil and vadose zone impacts at the Western Source Area.
- An engineered groundwater treatment pond with phytoremediation to address groundwater impacts within the Groundwater Treatment Area.

Included in the approval request are several specific proposed actions including:

- For the engineered treatment system:
  - Disposal of IDW, soil cuttings from historical soil borings, into the source area below the engineered cap.
  - Registration of the site with the WDNR's GIS and BRRTS database to fulfill the TSCA deed restriction requirement.
  - No fencing around the engineered cap.
  - The use of signage that includes the PCB M_L mark on the perimeter of the engineered cap.
  - An air permit exemption for the operation of the SVE system.
- For the engineered pond and phytoremediation systems:
  - Clean materials excavated from above the water table may be used as fill without limitation.
  - VOC impacted materials excavated from below the water table may be used as fill within the formally designated on-site groundwater plume area.
  - An air permit exemption for the operation of the pond.
- Approval of the proposed schedule for implementation, including the five year groundwater monitoring period prior to deciding whether the SVE and LNAPL recovery system installation is necessary.

Figures



NOTES:

Topographic Map courtesy of the United States Geological Survey
http://store.usgs.gov
Map Date: 2010

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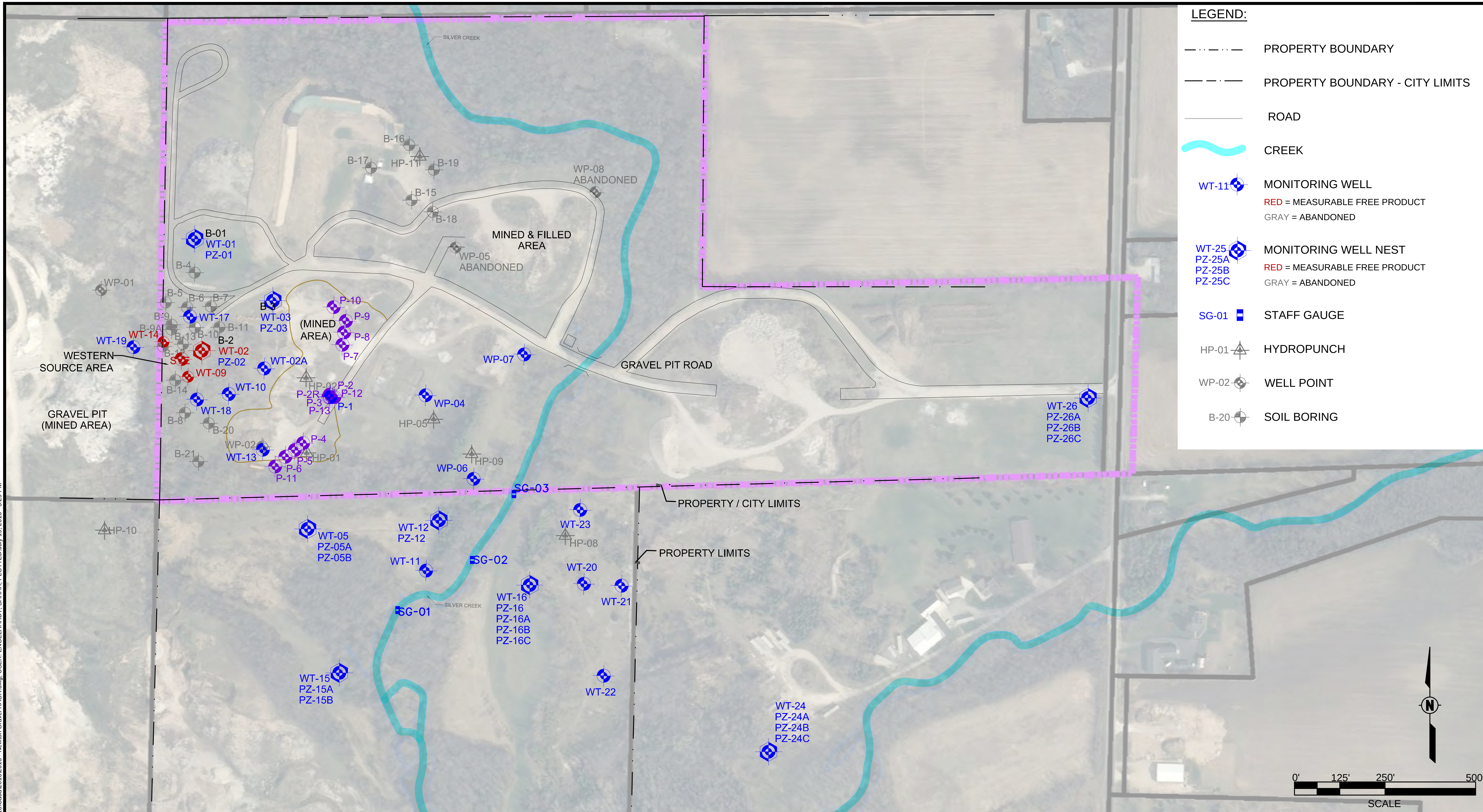
FORMER NEWTON GRAVEL PIT
2016 RAOR AND CONCEPTUAL DESIGN REPORT

SITE LOCATION

Project Number:	Drawn By:	Date:	
60311767	SAE	7/14/2016	Figure No. 1

File: \\USMWK1FS001\prod\Data\Library\work\82518\Cadd\2016\2016 - Newton Gravel RAOR.dwg; USER: ENGELHARDT, SARAH; PLOTTED:July 14, 2016 - 2:08 PM



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AECOM

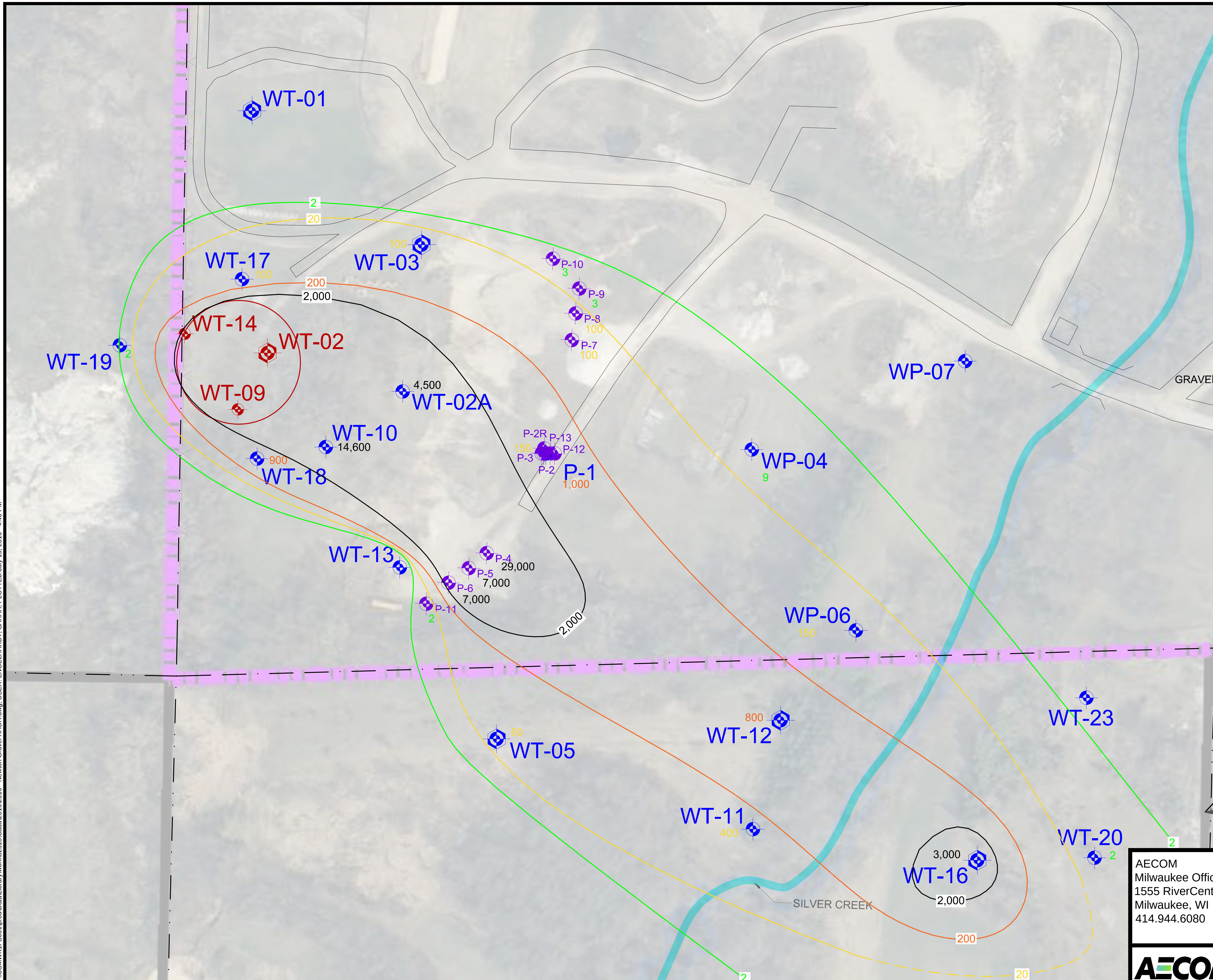
FORMER NEWTON GRAVEL PIT
2016 RAOR AND CONCEPTUAL DESIGN REPORT

SITE FEATURES

Project Number:	Drawn By:	Date:
60311767	SAE	7/19/2016

Figure No. 2

File: \\USMWK1FS001\prod\Data\Library\work\82518\Cadd\2016\2016 - Newton Gravel RAOR.dwg; USER: ENGELHARDT, SARAH; PLOTTED:July 19, 2016 - 5:29 PM



LEGEND:

- PROPERTY BOUNDARY
- PROPERTY BOUNDARY - CITY LIMITS
- ROAD
- CREEK
- WT-11 MONITORING WELL
  RED = MEASURABLE FREE PRODUCT
- WT-03 MONITORING WELL NEST
  RED = MEASURABLE FREE PRODUCT
- P-11 MONITORING WELL - POND
- APPROXIMATE AREA OF MEASURABLE FREE PRODUCT

VOC ISOCONCENTRATION LINES
- 2 ug/L
- 20 ug/L
- 200 ug/L
- 2,000 ug/L

NOTES:

1. GROUNDWATER MONITORING WELLS WT-02, WT-09 AND WT-14 WERE NOT SAMPLED DUE TO THE PRESENCE OF MEASURABLE PRODUCT.

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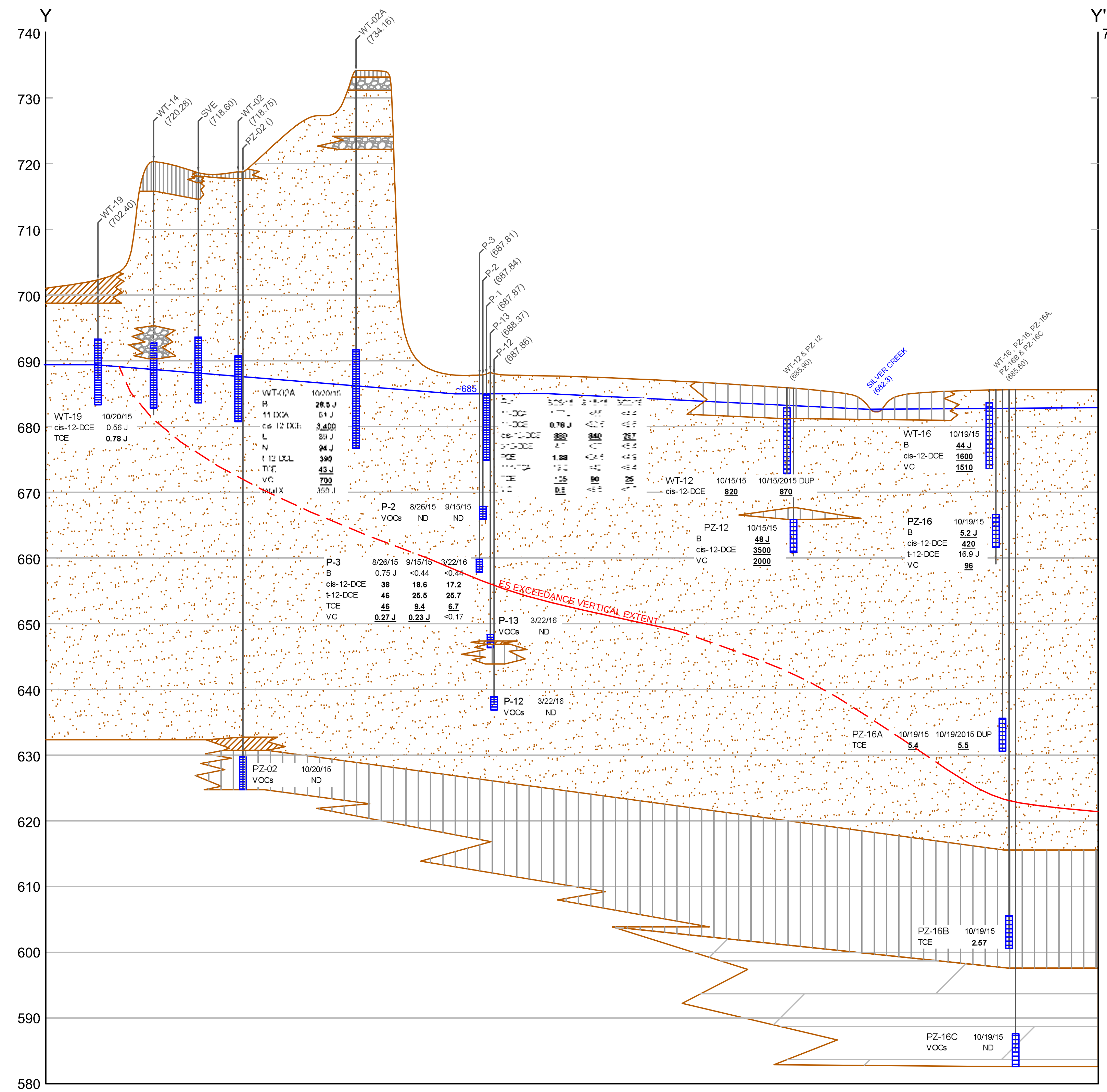
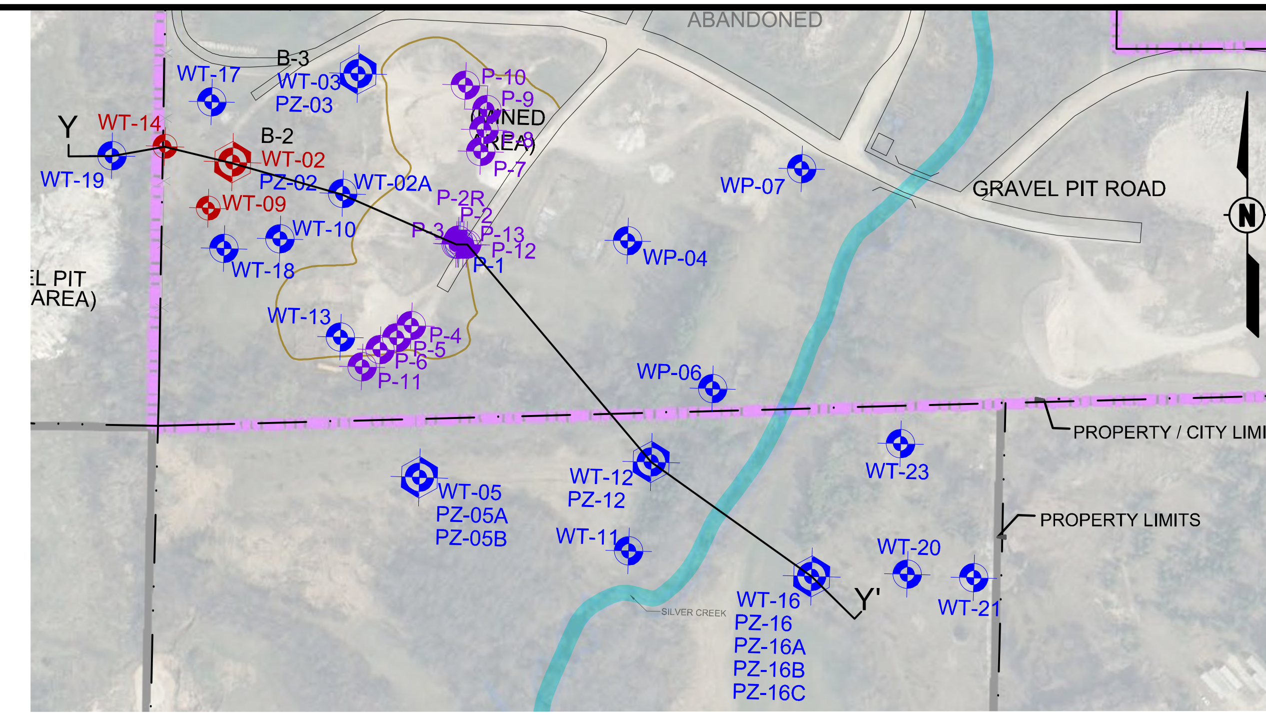
FORMER NEWTON GRAVEL PIT
2016 RAOR AND CONCEPTUAL DESIGN REPORT

SITE LAYOUT AND
INTERPRETED VOC ISCONCENTRATION LINES
(October 2015 through March 2016)

Project Number: 60311767 | Drawn By: SAE | Date: 7/15/2016 | Figure No. 3

File: \\USMWK1FS001\prod\Data\Library\work\82518\Cadd\2016\2016 - Newton Gravel RAOR.dwg; USER: ENGELHARDT, SARAH; PLOTTED: July 15, 2016 - 4:40 PM





LEGEND:

- GRAVEL
- SAND
- SILT
- CLAY
- BEDROCK (SILURIAN DOLOMITE)
- MONITORING WELL - SCREEN INTERVAL
- POTABLE WELL - CASING
- CASING DEPTH
- OPEN BOREHOLE DEPTH

SCALE: 0' 100' 200' 400' (horizontal); 0' 10' 20' 40' (vertical)

NOTES:

VOCs = VOLATILE ORGANIC COMPOUNDS MEASURED IN MICROGRAMS PER LITER (UG/L)
B = BENZENE
C = CHLOROMETHANE
11-DCA = 1,1-DICHLOROETHANE
11-DCE = 1,1-DICHLOROETHENE
cis-12-DCE = CIS-1,2-DICHLOROETHENE
t-12-DCE = TRANS-1,2-DICHLOROETHENE
E = ETHYLBENZENE
N = NAPHTHALENE
n-P = N-PROPYLBENZENE
PCE = TETRACHLOROETHENE
T = TOLUENE
111-TCA = 1,1,1-TRICHLOROETHANE
TCE = TRICHLOROETHENE
VC = VINYL CHLORIDE
total X = TOTAL XYLENES
J = COMPOUND WAS DETECTED AT A CONCENTRATION BETWEEN THE LIMIT OF DETECTION AND THE LIMIT OF QUANTITATION
BOLD INDICATES A PREVENTIVE ACTION LIMIT (PAL) EXCEEDANCE
BOLD AND UNDERLINED INDICATES AN ENFORCEMENT STANDARD (ES) EXCEEDANCE

APPROXIMATE VERTICAL EXTENT OF ES IMPACTS IN GROUNDWATER

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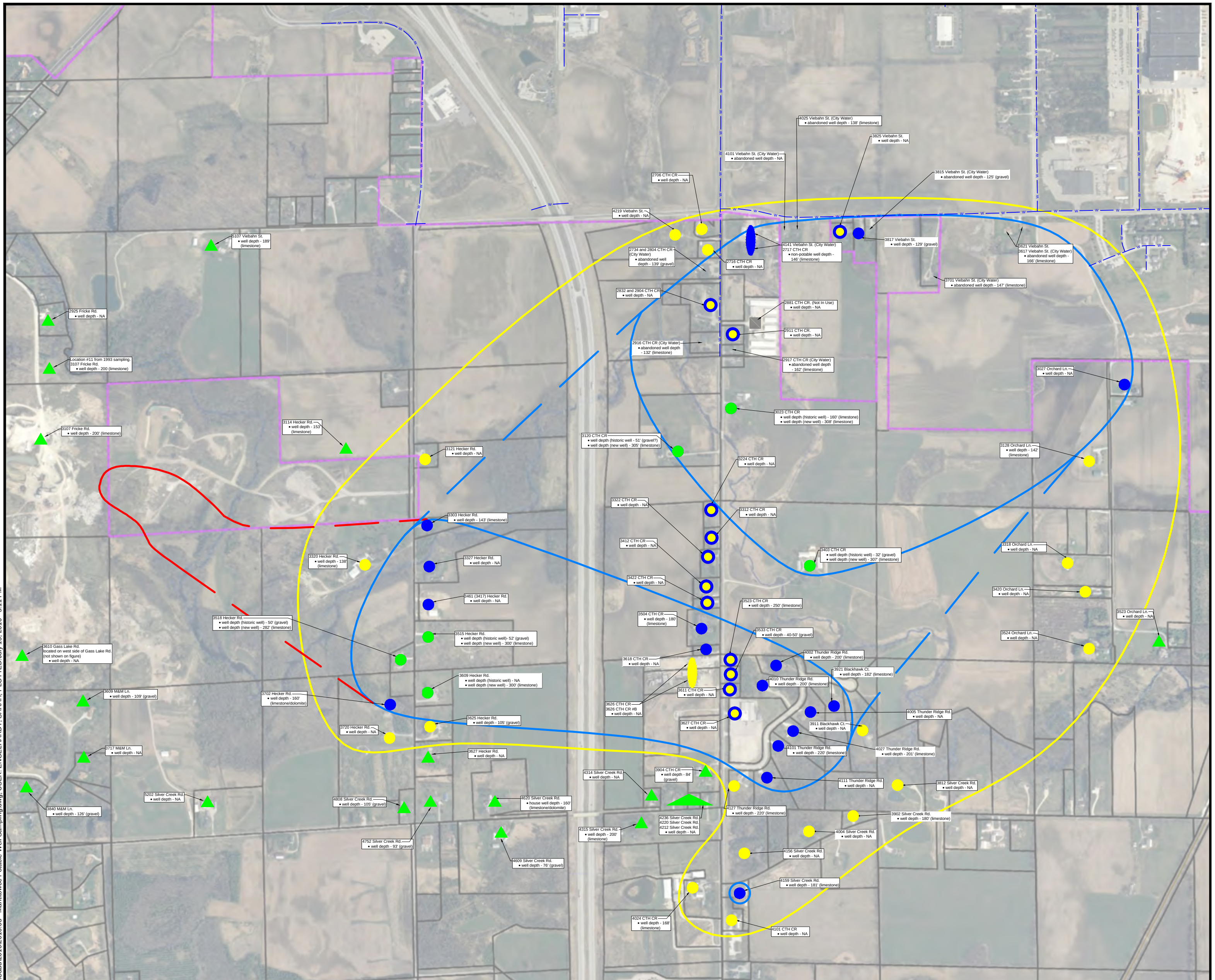
CROSS SECTION
Y - Y'

Project Number: 60311767 | Drawn By: SAE | Date: 7/14/2016

Figure No. 4

File: \\USMWK1FS001\prod\Data\Library\work\82518\Cadd\2016\2016 - Newton Gravel RAOR.dwg; USER: ENGELHARDT, SARAH; PLOTTED:July 14, 2016 - 3:20 PM



LEGEND:

PROPERTY BOUNDARY
PROPERTY BOUNDARY - CITY LIMITS
UTILITIES:
-POTABLE WATER SUPPLY (from City of Manitowoc)

POTABLE WELL SAMPLE LOCATIONS
-WITHIN TARGET ZONE
-WITHIN TARGET ZONE WITH NO DETECTS
-WITHIN SENTINEL ZONE

-REPLACEMENT WELL WITHIN TARGET ZONE
-UPGRADIENT AND HISTORICALLY SAMPLED WELLS
TARGET ZONE
SENTINEL ZONE
FORMER GRAVEL PIT ZONE

WELL OUT OF SERVICE

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2016 RAOR AND CONCEPTUAL DESIGN REPORT

POTABLE WELL SAMPLING LOCATIONS

Project Number:	Drawn By:	Date:	Figure No. 5
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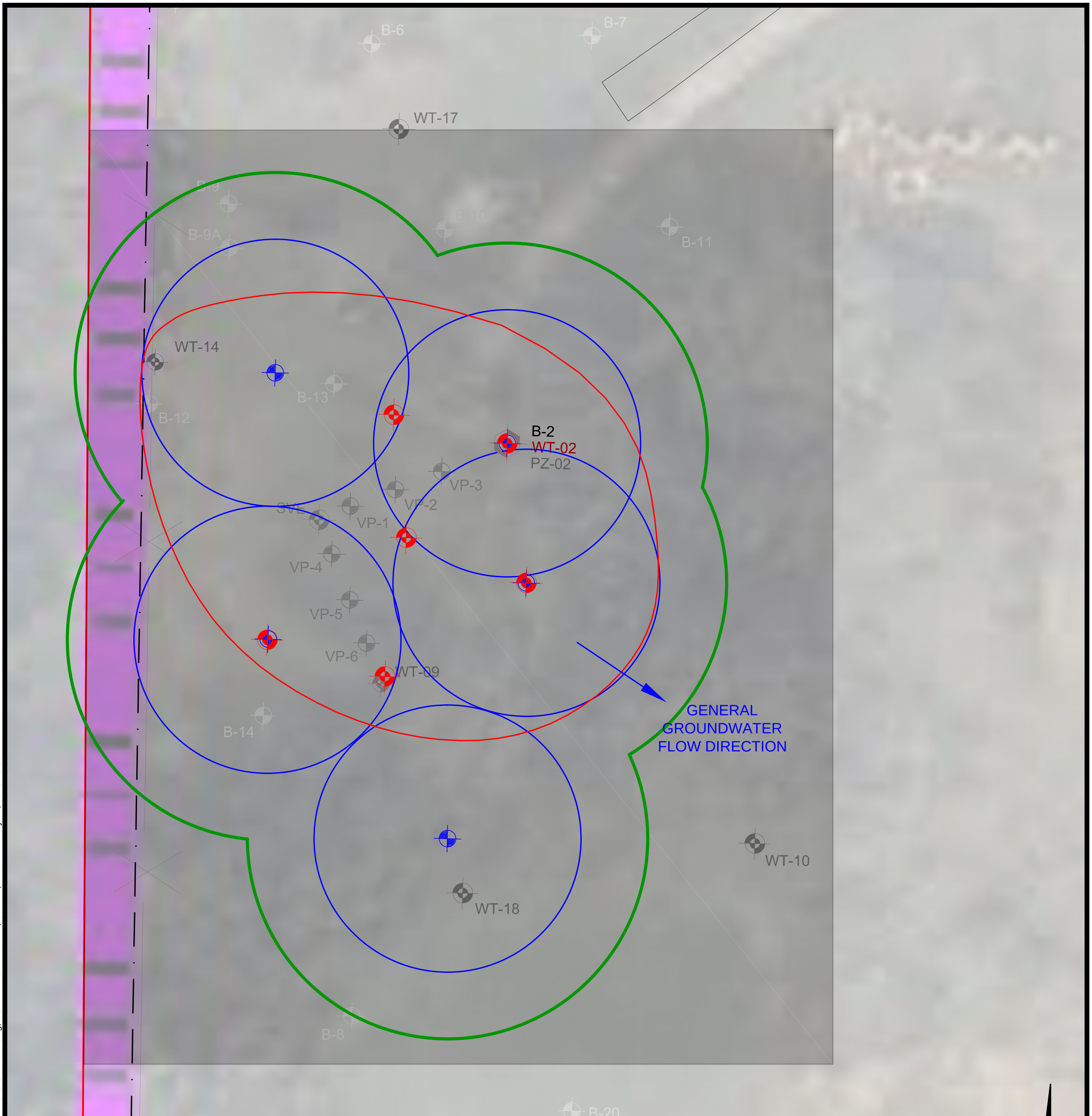
File: \\USMWK1FS001\projectData\Library\work\82518\Cadd\2016\2016.03 - Manitowoc Potable Well Sampling.dwg; USER: ENGELHARDT, SARAH; PLOTTED July 15, 2016 - 5:11 PM



LEGEND:

- PROPERTY BOUNDARY
- PROPERTY BOUNDARY - CITY LIMITS
- ROAD
- WT-11 — MONITORING WELL
  RED = MEASURABLE FREE PRODUCT
- WT-25 PZ-25A PZ-25B PZ-25C — MONITORING WELL NEST
  RED = MEASURABLE FREE PRODUCT
- P-1 — SVE SAMPLE LOCATIONS (2015)
- PROPOSED FREE PRODUCT RECOVERY WELL
- APPROXIMATE AREA OF FREE PRODUCT
- PROPOSED SVE EXTRACTION WELL
- SVE 40' RADIUS OF INFLUENCE
- SVE 60' RADIUS OF INFLUENCE
- PROPOSED CAP AREA

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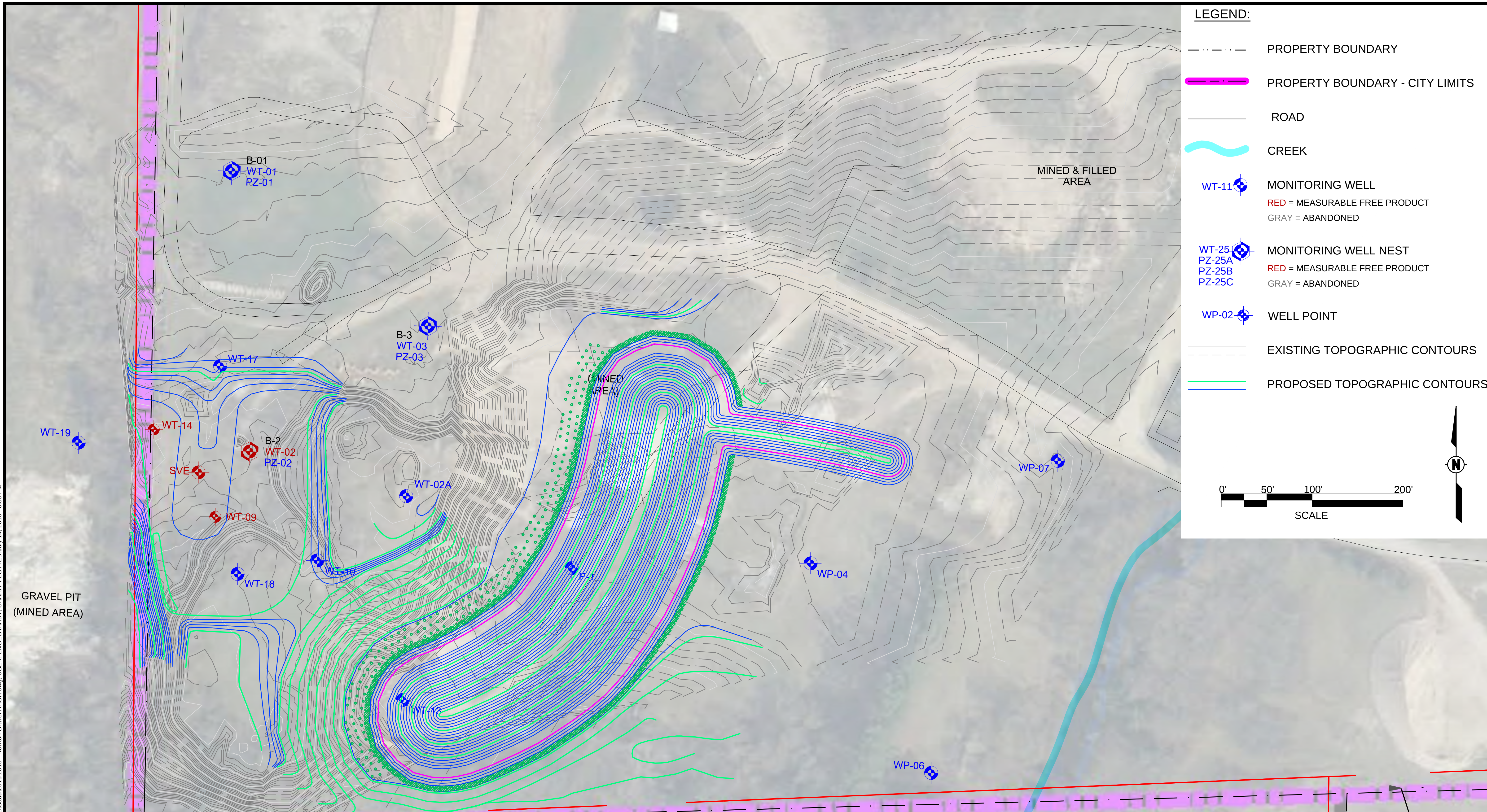
2016 RAOR AND CONCEPTUAL DESIGN REPORT

PROPOSED FREE PRODUCT RECOVERY WELL LOCATIONS / SVE WELL LOCATIONS / CAP AREA

Project Number:	Drawn By:	Date:	Figure No. 6
60311767	SAE	7/15/2016	

File: \\USMWK1FS001\prod\Data\Library\work\82518\Cadd\2016\2016 - Newton Gravel RAOR.dwg; USER: ENGELHARDT, SARAH; PLOTTED:July 15, 2016 - 5:00 PM



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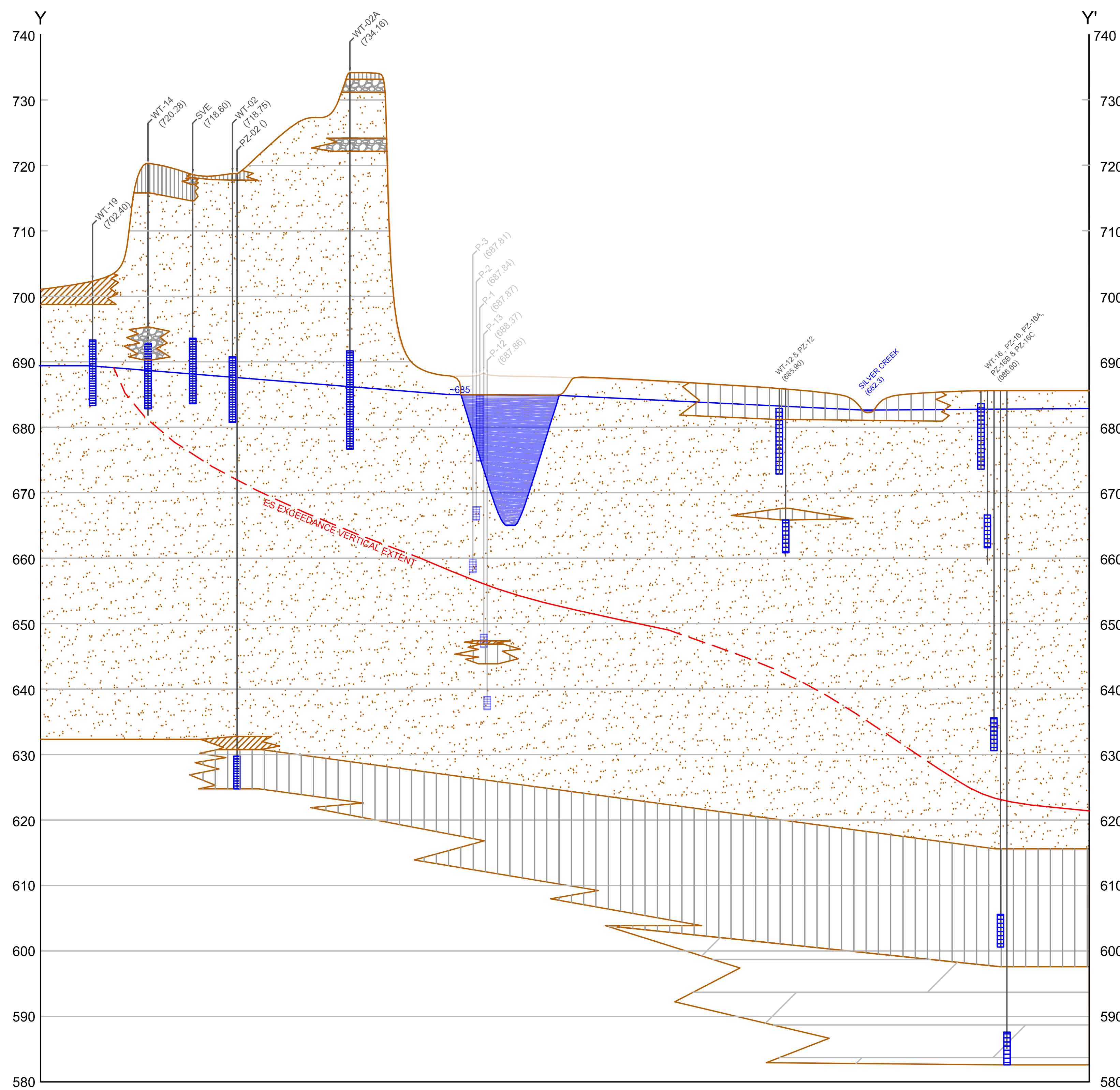
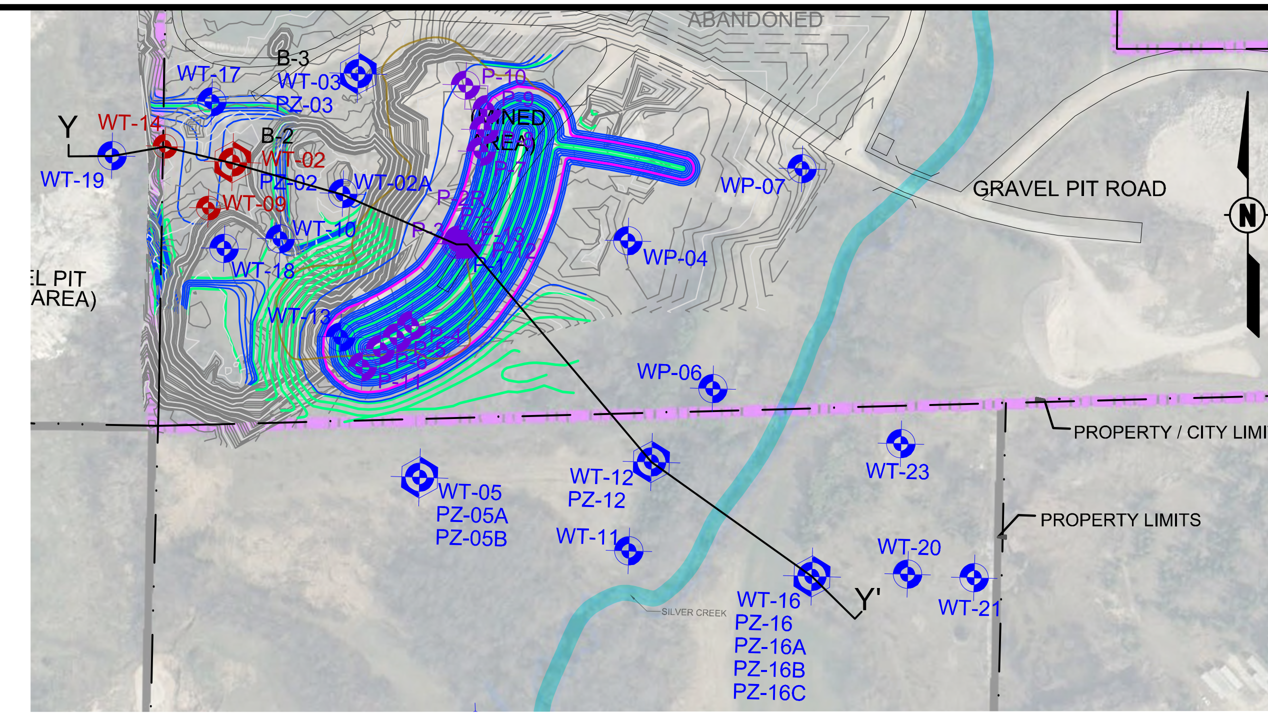
2016 RAOR AND CONCEPTUAL DESIGN REPORT

PROPOSED TOPOGRAPHIC MAP
AND POND LOCATION

Project Number:	Drawn By:	Date:	
60311767	SAE	7/14/2016	Figure No. 7

File: \\USMWK1FS001\prod\DataLibrary\work\82518\Cadd\2016\2016 - Newton Gravel RAOR.dwg; USER: ENGELHARDT, SARAH; PLOTTED:July 14, 2016 - 3:59 PM





LEGEND:

GRAVEL

SAND

SILT

CLAY

BEDROCK (SILURIAN DOLOMITE)

MONITORING WELL
- SCREEN INTERVAL

POTABLE WELL
- CASING

- CASING DEPTH

- OPEN BOREHOLE DEPTH

APPROXIMATE VERTICAL EXTENT OF ES IMPACTS IN GROUNDWATER

0' 100' 200' 400'
SCALE

40'
20'
10'
0'

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2016 RAOR AND CONCEPTUAL DESIGN REPORT

CROSS SECTION Y - Y'
WITH PROPOSED POND LOCATION

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Figure No. 8

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Proposed Earthwork Volumes			
	Cut (Cu Yds)	Fill (Cu Yds)	Net (Cu Yds)
Below WT	31,410	-	31,410 [CUT]
Above WT	48,792	1,650	47,142 [CUT]
Channel	1,785	-	1,785 [CUT]
Cap	2,535	7,175	4,640 [FILL]
		Net Total	75,697 [CUT]

Note: WT=Proposed water table of pond at El. 685'

NOTES:
1. CONTOURS GENERATED FORM SURVEY PERFORMED BY CITY OF MANITOWOC ON
2. VERTICAL DATUM: NAD 88
3. HORIZONTAL DATUM: MANTIOWOC COUNTY COORDINATES

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PROJECT

FORMER NEWTON GRAVEL PIT - CAP & POND DESIGN

MANITOWOC, WISCONSIN

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SUB CONSULTANT

REGISTRATION

ISSUE/REVISION

I/R	DATE	DESCRIPTION

KEY PLAN

PROJECT NUMBER

60311767

FIGURE TITLE

CONCEPTUAL SITE PLAN

FIGURE NUMBER

FIGURE 9

Plotted By: engelhardts 5:02 PM
Plot File Date Created: Jul/15/2016
Filename: \\USMWK1FS001\PROD_DATA\LIBRARY\WORK\82518\CADD\2016\2016 – NEWTON GRAVEL CONCEPTUAL SITE PLAN.DWG
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