Windsor Sewer Plume Focused Feasibility Study Report

October 12, 2020

Former Hoffmann-La Roche Inc. Facility

Prepared For:

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Nutley, New Jersey

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ACRONYM LIST

ARARs	Applicable or Relevant and Appropriate Requirements
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	contaminants of concern
CVOCs	chlorinated volatile organic compounds
DNAPL	dense non-aqueous phase liquid
DO	Dissolved oxygen
EISB	Enhanced *In-Situ* Bioremediation
FFS	Focused Feasibility Study
ft bgs	feet below ground surface
ft/d	feet per day
ft/ft	foot/foot
GWQS	Ground Water Quality Standards
IA	Investigative Area
IRMs	interim remedial measures
ISCO	*In-Situ* Chemical Oxidation
MCLs	Maximum Contaminant Levels
mg/L	milligrams per liter
MNA	Monitored Natural Attenuation
mV	millivolts
NCP	National Contingency Plan
NJDEP	New Jersey Department of Environmental Protection
ORP	Oxidation-Reduction Potential
PBR	Permit-by-Rule
RAO	remedial action objective
RAP	Remedial Action Permit
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
Roche	Hoffmann-La Roche Inc.
SVE	Soil Vapor Extraction

TBC	to-be-considered
TCE	Trichloroethene
TRC	TRC Environmental Corporation
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
µg/L	micrograms per liter

1.0 Introduction

On behalf of Hoffmann-La Roche Inc. (Roche), TRC Environmental Corporation (TRC) has prepared this Focused Feasibility Study (FFS) to document the development and evaluation of response alternatives to address groundwater contamination within the Windsor Sewer Plume located in and near the western portion of the former Roche facility (Site) located at 340 Kingsland Street in Nutley, New Jersey (Figure 1).

1.1 Background

Extensive subsurface characterization activities have been conducted at the Site, including work performed on the Site and Windsor Place in 2015 through 2017 (TRC, 2016; TRC, 2017). The data generated by these activities identified evidence of an historical release of trichloroethene (TCE) from a segment of the Nutley municipal sewer along Windsor Place (Figure 2), which is not on, but abuts the former Roche facility. This sewer drains northward prior to joining the Nutley municipal trunk sewer that runs through the western portion of the Site. This historical release from the sewer resulted in a TCE plume in groundwater, which is referred to as the Windsor Sewer Plume (TRC, 2019a).

As discussed in the NJDEP-approved *December 2019 Groundwater Remedial Action Work Plan* (RAWP) (TRC, 2019a), Roche proposes to conduct final groundwater remedial action for seven “Remedial Action Plumes” at the Site (Investigative Area [IA]-9 Pipe Trench Area Plumes, IA-6 Chlorobenzene Plume, IA-10 Building 104 Plume, IA-10 Building 70 Area Plume, IA-1/4 Dioxane Plume, IA-2 Tank Farm Area Plume, and the Windsor Sewer Plume). To select the most appropriate remedial technology for each Remedial Action Plume, multiple technologies were evaluated in the RAWP based on their performance during Roche’s implementation of interim remedial measures (IRMs) for ten plumes under the Site. This FFS documents the evaluation process, as described in the United States Environmental Protection Agency’s (USEPA’s) *Guidance for Conducting Remedial Actions and Feasibility Studies Under CERCLA,* EPA/540/G-89/004, OSWER Directive 9355.3-01, followed by Roche for one of those seven plumes -- the Windsor Sewer Plume -- that led to Roche’s proposed final remedy for that plume in the RAWP. The location of the former Roche Site, and the area of the Windsor Sewer Plume, are shown on Figure 1. Roche’s proposed remedy for the Windsor Sewer Plume in this FFS will be issued for public comment pursuant to the National Contingency Plan (NCP), 40 C.F.R. Part 300. Roche’s proposed remedy for all of the Remedial Action Plumes in the RAWP (including the Windsor Sewer Plume) will be subject to public notice in accordance with the New Jersey Department of Environmental Protection’s (NJDEP’s) *Technical Requirements for Site Remediation*, N.J.A.C. 7:26E and Roche’s NJDEP-approved April 9, 2013 Enhanced Notification and Public Outreach Plan.

1.2 Focused Feasibility Study Purpose and Scope

The purpose of this FFS is to document the process used to evaluate a wide range of potential remedial alternatives for the Windsor Sewer Plume, conduct a detailed evaluation of a limited number of viable remedial alternatives, and select the preferred proposed remedy to achieve the remedial action objectives (RAOs) defined in Section 2.5.

2.0 Site Conditions and Remedial Action Objectives

2.1 Summary of Remedial Investigation

The Windsor Sewer Plume originates along a segment of the 340-foot long portion of the Nutley municipal sewer in Windsor Place (Figures 1 and 2). The plume migrates southeast away from the sewer. It is characterized by a high proportion of TCE relative to other chlorinated volatile organic compounds (CVOCs). At the suspected release area, the top of bedrock is close to land surface, and there is little to no saturated overburden. As such, the plume is present primarily in shallow bedrock.

The investigation conducted by Roche in this area reported the following conditions:

- Groundwater investigations completed in January 2016 determined that the highest TCE concentrations in the shallow groundwater are present in the immediate vicinity of a segment of the sanitary sewer that runs beneath the center of Windsor Place (TRC, 2016).

- The highest TCE concentration (9,000 micrograms per liter [µg/L]; TRC, 2019b) in shallow groundwater was detected in monitoring well MW-488A, which is screened in the shallow bedrock located immediately adjacent to the sewer line.

- The portion of the plume with TCE concentrations greater than 1,000 µg/L is restricted to an area of approximately 60 by 60 feet and to a depth of 10 to 30 feet below ground surface (ft bgs). The maximum TCE concentrations in shallow groundwater during the last 4 years of sampling have ranged from about 4,000 to 9,000 µg/L[1].

- Persistent TCE concentrations in shallow bedrock beneath and near the sewer in Windsor Place act as a source for the TCE plume that migrates southeastward under the Site.

- Monitoring wells installed immediately west (hydraulically upgradient) of the Windsor Place sewer showed low (< 10 µg/L) or non-detectable TCE concentrations, indicating the absence of a TCE source upgradient of the sewer.

- The geochemical conditions are characterized by a neutral pH (between 7.0 and 7.6), a positive Oxidation-Reduction Potential (ORP) (100 to 299 millivolts [mV]), and dissolved oxygen (DO) concentrations ranging from 0 to 7.8 milligrams per liter (mg/L). These conditions are slightly oxidizing to oxidizing.

[1] The highest TCE concentration in the Windsor Sewer Plume area (approximately 13,000 µg/L) was detected in late 2016 in monitoring well MW-479B, which is downgradient of and screened in a slightly deeper zone than the shallow bedrock immediately adjacent to the suspected release area. The TCE concentration in this well has been steadily declining since mid-2017, and is currently less than 10 µg/L.

2.2 Summary of Geology and Hydrogeology

The geologic materials in the Windsor Sewer Plume source area consist of about 10 feet of overburden (*i.e.*, historic fill and glacial deposits) over weathered sedimentary bedrock of the Passaic Formation. The weathered bedrock transitions downward to competent rock; the weathered zone is from 5 to 10 feet thick (see Figure 3).

The average depth to groundwater in this area is about 8 ft bgs, so the uppermost saturated zone (referred to in this FSS as “shallow groundwater”) occurs primarily in the shallow weathered bedrock and the upper part of the competent bedrock. Shallow groundwater in this area flows to the southeast, under a hydraulic gradient of approximately 0.03 foot/foot (ft/ft). The Windsor Sewer Plume migrates from the source area to the southeast in the weathered and upper part of the competent bedrock. The hydraulic conductivity of this shallow groundwater zone ranges from around 0.5 to 3 feet per day (ft/d).

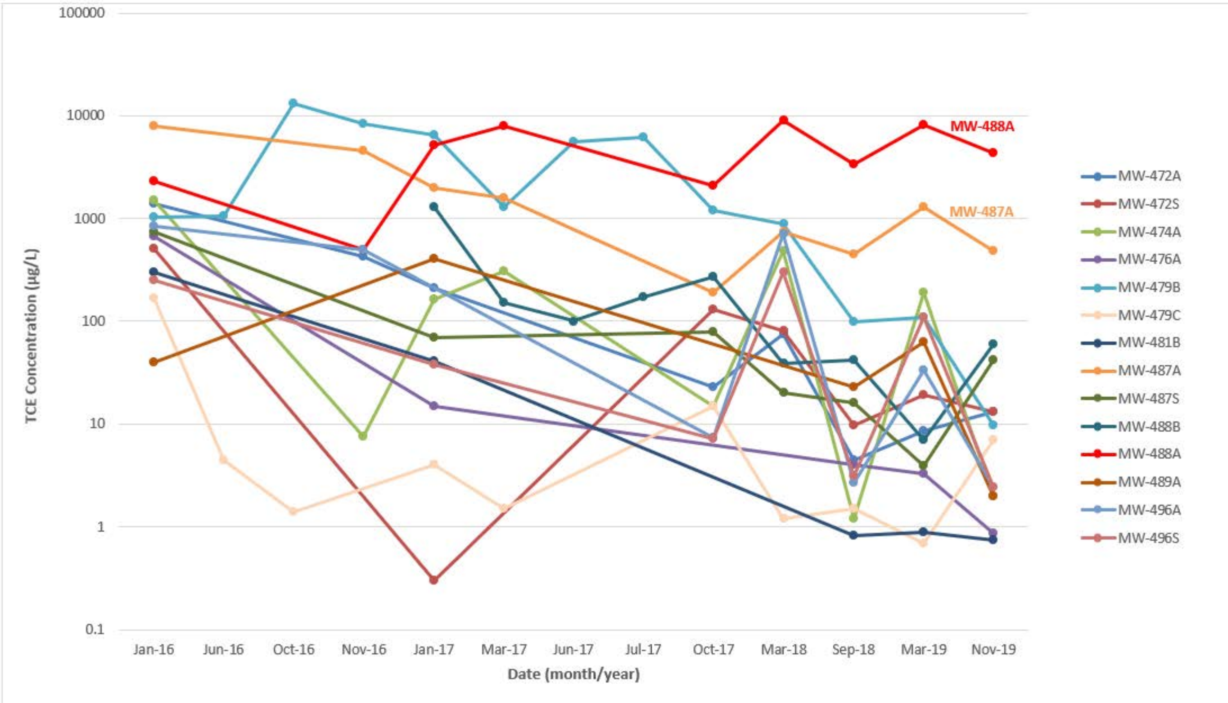
The bottom of the sewer that runs south to north along the east side of Windsor Place is about 10 ft bgs; the sewer sits close to or on top of the weathered bedrock surface. Therefore, the releases from the sewer that caused the Windsor Sewer Plume discharged TCE directly to the shallow weathered bedrock, below the overburden. The hydrogeology of the Windsor Sewer Plume area and the depth of the sewer are shown on the cross-section depicted on Figure 3.

2.3 Groundwater Quality

TCE was detected at concentrations greater than 100 µg/L at least once between 2016 and 2019 in each of 14 monitoring wells characterizing the Windsor Sewer Plume (Figure 2). Recent monitoring data (from a sampling event carried out in November 2019) indicate that only two wells continue to exhibit TCE concentrations of this magnitude: MW-487A and MW-488A[2]. These wells are located adjacent to the Windsor sewer, within the current TCE source area. The most recent TCE concentration for each well that had exhibited a TCE concentration above 100 µg/L from 2016 to the present is shown on Figure 2; in addition, a time-series plot of TCE concentrations for these wells are shown on Figure 2-1 (below). None of these wells have recently exhibited TCE concentrations greater than one percent of the aqueous solubility of this compound[3], indicating that there is no evidence that dense non-aqueous phase liquid (DNAPL) remains in the Windsor Sewer Plume.

[2] Both wells are screened from 10 to 20 feet below ground surface (ft bgs), immediately adjacent to the sewer.
[3] The aqueous solubility of TCE is reported to be 1,100 milligrams per liter (mg/L) or 1,100,000 µg/L (Pankow and Cherry, 1996).

Figure 2-1. TCE concentrations versus time for all wells located within the Windsor Sewer Plume that have exhibited at least one TCE concentration greater than 100 µg/L since January 2016



The uppermost saturated zone, within the weathered and transition zone bedrock, functions as a dual porosity system, in that, while groundwater flow and contaminant transport occur primarily in the interconnected fractures that transect the bedrock (secondary porosity), there is also primary porosity in the void spaces within the bedrock. Therefore, some contaminant mass has diffused into the matrix, where it is generally inaccessible to treatment, but can act as a source of back diffusion of contaminants for the foreseeable future.

2.4 Summary of Applicable or Relevant and Appropriate Requirements

The NCP requires the identification of Applicable or Relevant and Appropriate Requirements (ARARs) that may apply to a site-specific release(s) or proposed remedial action (40 CFR 300.400[g]). The NCP also requires that any advisories, criteria, or guidance that may apply should be identified as to-be-considered (TBC) items.

ARARs are identified as part of remediation conducted consistent with the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. Sections 9601 *et seq.,* to evaluate clean-up goals and potential remedies that are protective of the environment and public health. Definitions of these requirements and TBC guidance include the following:

1. Applicable Requirements: These requirements are, "...those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, constituent, remedial action, location or other circumstances…." at the Site (USEPA, 1988). Therefore, in order for a requirement to be applicable, the requirement

must satisfy all of the legal prerequisites for application of the requirement standing on its own. In other words, a requirement will be applicable if, and only if, it would legally apply to the response action notwithstanding the fact that the cleanup is proceeding under CERCLA.

2. Relevant and Appropriate Requirements: These requirements are those standards that "...address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site." (40 C.F.R. § 300.5). The term "relevant and appropriate" therefore requires that the requirement: (1) be a promulgated law or regulation; and (2) be particularly well suited to address the cleanup issue at the Site. In addition, the nature of the constituents prevalent at the Site, the characteristics of the Site, the circumstances of the release, the ability of the action to address the release, the purpose of the requirement versus the goals of remediation, the similarity of the action regulated by the requirement to the action in the remediation, and waivers from the requirement and their applicability to Site conditions are considered in the analysis.

3. TBC Criteria: These criteria include non-promulgated advisories or guidance documents issued by the federal or state government that are not legally binding and do not have the status of potential ARARs. In determining the necessary level of cleanup for protection of human health or the environment, TBC criteria may be used where no specific ARARs exist for a chemical or situation, or where such ARARs are not sufficient to afford protection.

4. Since the Site is subject to the Corrective Action program under the federal Resource Conservation and Recovery Act (RCRA), 42 U.S.C. Sections 6901 et seq., various USEPA technical and procedural guidance documents are TBC criteria.

Each remedial alternative and treatment process option must be assessed to ensure compliance with ARARs. This section presents a summary of potential ARARs that have been identified for evaluating remedial alternatives to be employed to treat the Windsor Sewer Plume.

There are three general categories of ARARs:

- Chemical-specific ARARs define acceptable exposure levels and can be used in establishing cleanup goals. Examples that are applicable to the Site are federal Maximum Contaminant Levels (MCLs) and New Jersey Ground Water Quality Standards (GWQS).

- Action-specific ARARs can set controls for particular hazardous waste treatment and disposal activities.

- Location-specific ARARs can set restrictions on activities in certain areas.

If no ARARs address a particular situation, other federal and state criteria, advisories, guidance, or proposed standards that are not legally enforceable may be considered for developing remediation goals and cleanup alternatives. These TBC criteria may provide useful information or recommended procedures that supplement, explain, or amplify the content of ARARs.

The following ARARs and TBC criteria were used to initially screen potential technologies for the treatment of TCE in groundwater in the Windsor Sewer Plume source area:

- The chemical-specific ARARs are attainment of the final remediation standards in N.J.A.C. 7:26D and 7:9C.

- Action-specific ARARs which specify well construction and permitting requirements at N.J.A.C. 7:9D are applicable.

- Action-specific ARARs applicable to *in-situ* treatment remedial alternatives include the requirement to obtain NJDEP underground injection permits (NJDEP, 2019) for *in-situ* placement of treatment chemicals and substrates.

2.5 Remedial Action Objectives for Groundwater

The RAO for the Windsor Sewer Plume is to attain the applicable final remediation standards in N.J.A.C. 7:26D and 7:9C; specifically, reduction of TCE and associated degradation product concentrations in groundwater to below the NJDEP GWQS.

While the RAO is to attain NJDEP GWQS, it is important to note the results of the receptor evaluations performed by Roche. On behalf of Roche, TRC submitted an initial receptor evaluation in 2011 (TRC, 2011), and has submitted two Site-wide receptor evaluation updates, the first in 2014 (TRC, 2014), which was approved by the NJDEP in 2014, and one in 2018 (TRC, 2018), which is still under NJDEP review. Both of these updates concluded there are no human or ecological receptors being impacted by groundwater contamination at the Site.

3.0 Identification and Screening of Remedial Technologies

3.1 Technology Screening Rationale

TRC has identified several technologies that are applicable to address TCE in groundwater. The viability of each technology/approach was evaluated relative to conditions in the Windsor Sewer Plume source area using the following criteria:

- Effectiveness (short-term and long-term): Each technology is evaluated with respect to the capability of the technology to provide protection and to reduce or remove TCE mass/volume, toxicity, and mobility and meet response objectives for groundwater. Short-term effectiveness relates to the construction phase and long-term effectiveness refers to the period after the remedial action is complete. TRC has considered technologies with demonstrated success in reducing CVOC concentrations, based on TRC's direct experience at the Site and relevant case histories of technology applications at sites with similar conditions.

- Implementability (technical and administrative feasibility): Each technology is evaluated based on the ability to effectively apply, construct and operate the technology in a public street adjacent to the Site, based on physical conditions, chemical make-up, and phase of the contamination, and hydrogeological conditions present. Other factors include operational and monitoring considerations and the ability to obtain regulatory approvals and permits.

- Cost: Technologies that are cost prohibitive to apply, or that have a large degree of cost uncertainty (*e.g.*, new and emerging technologies) may be screened out from further consideration based on this criterion.

The screening of remedial technologies/approaches in this FFS is based primarily on TRC's prior experience implementing a variety of technologies at this Site and at other sites with similar conditions, and review of the scientific and regulatory literature.

3.2 Potential Remedial Technologies

3.2.1 No Action

For FFSs conducted consistent with the NCP, the no-action alternative must be evaluated to establish a baseline for comparison. Under this alternative, no remedial action of any kind would be employed. The no-action alternative will not reduce any potential risk associated with direct contact, ingestion, or inhalation of impacted materials or releases to the environment; therefore, this alternative is not more protective of human health and the environment than the current condition.

Even though the no-action alternative does not meet the RAOs, it is retained as an alternative to serve as a basis for the comparison of performance of other alternatives.

3.2.2 Monitored Natural Attenuation

NJDEP (2012) states that Monitored Natural Attenuation (MNA) "refers to the reliance on natural attenuation processes to achieve the applicable groundwater remediation standard. Natural attenuation processes include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants. At sites with organic compound contamination, MNA is most effective where the natural processes permanently degrade or destroy contamination."

MNA is being implemented for several plumes at the Site and can be implemented as either a standalone remedy or as a supplemental component after an active technology. MNA is effective in the long-term, feasible and cost effective, and will be further evaluated in the comparative analysis.

3.2.3 Air Sparge/Soil Vapor Extraction

Air sparging involves the injection of atmospheric air into groundwater to enhance the transfer of volatile organic compounds (VOCs) from groundwater to soil vapor. Air sparging systems rely on mass transfer of VOCs from soil and groundwater to a mobile vapor phase. The volatilized compounds are collected by a soil vapor extraction (SVE) system and treated above grade, as necessary, to satisfy air discharge limits. Activated carbon is commonly used to treat the extracted gases.

The compound of concern (TCE) is amenable to air sparging because of its volatility. If effective, this technology would be protective of human health and the environment as it would remove TCE mass from the source area. Calculations of volatilized VOC mass would be necessary to determine the appropriate above-grade treatment as well as determine if any air permitting is necessary to meet federal, state, and local guidelines.

However, this technology is not effective in either the short-term or the long-term given the Site geology. The low-permeability nature of the weathered bedrock and overlying unconsolidated deposits would cause short-circuiting of the injected air, which would limit treatment efficacy. Further, the presence of the sewer and its relatively permeable sand or gravel bedding material could also serve as a short-circuiting mechanism, which could transport resulting VOC vapors away from the treatment area toward potential receptors before they are captured by SVE systems. VOC vapors in the sewer could impact other structures downstream of the treatment area, and at high concentrations, could represent other hazards. Thus, this technology has been removed from further analysis.

3.2.4 Thermal Remediation

Thermal treatment increases soil temperatures to increase the volatility of the constituents of concern, increasing their transfer to the vapor phase, where SVE operations can recover the vapors. Thermal treatments can involve various heating enhancements including steam, electrical resistance, and thermal conduction.

Thermal remediation has proven effective in both short-term and long-term remediation of TCE and it is feasible to implement in low permeability soils and weathered bedrock. However, the presence of the active sewer pipe and the significant infrastructure associated with this technology would pose substantial challenges, and potential safety and infrastructure risks, for implementation in a public roadway. The safety risks include the potential dangers associated with contact with active high voltage equipment and a ground surface heated to high temperatures, in an area accessible to the public. Another negative aspect of this technology is the time required for implementation; raising the temperature of the groundwater in the weathered bedrock to the required temperatures would take many months to as long as a year, and that temperature would need to be maintained for a similarly long period. Furthermore, this technology is relatively costly to implement. Given the Site constraints, this technology has been removed from further analysis.

3.2.5 Enhanced In-Situ (Anaerobic) Bioremediation

Enhanced *In-Situ* Bioremediation (EISB) involves the introduction of electron donors with micronutrients, pH buffer, and specialized bioaugmentation cultures to bolster the microbial population capable of degrading TCE. The electron donor material would be introduced through permanent injection points. If geochemical conditions are amenable or can easily be manipulated to establish favorable conditions, and if a suitable microbial population exists (or can be established), EISB is effective in degrading TCE mass. The conditions observed in the Windsor Plume area are similar to other areas of the Site where EISB was successfully implemented.

The degradation process involves biochemical reactions that substitute hydrogen for chlorine from a chlorinated organic compound (*e.g.*, TCE) in a stepwise fashion, a process known as biological reductive dechlorination.

As anaerobic bioremediation is an effective treatment for TCE and other CVOCs, the technology is protective of human health and the environment. Intermediary breakdown products (*e.g.*, *cis*-1,2-dichloroethene and vinyl chloride) typically form as part of the reductive dechlorination process but are eventually reduced to innocuous end products and byproducts (*e.g.,* ethene, carbon dioxide, methane, chloride ions) which do not require any further remediation or treatment. Therefore, compliance with regulations is limited to injection permitting. When completed appropriately, EISB is a very effective long-term solution as the source area can be largely removed. Though challenging to inject into low-permeability weathered and fractured bedrock, these obstacles are mitigated by the small size of the source area and can be overcome through effective design.

This technology has been implemented successfully to treat TCE and other CVOCs in several different areas at the Site. In IA-3/7 North, EISB reduced CVOC concentrations from around 600 µg/L to around 40 µg/L. In the overburden in IA-11, EISB reduced CVOC concentrations in excess of 20,000 µg/L to less than 20 µg/L (TRC, 2019a). However, the technology has proven to have limitations at this Site, due to the dual porosity nature of the fractured bedrock, and the diffusion of some CVOC mass into the bedrock matrix, where it will be inaccessible to injected amendments. Based on Site experience, it is anticipated that this technology will reduce TCE concentrations below 100 µg/L. It would likely need to be combined with other remedial approaches to achieve the RAOs.

A potential concern associated with EISB is that development of reducing conditions in the subsurface can result in mobilization of metals present in soil. However, previous EISB applications at this Site did not result in the observation of metals mobilization. EISB is considered both feasible and cost effective and will be further evaluated in the comparative analysis. It may need to be combined with other technologies to achieve the RAOs.

3.2.6 In-Situ Chemical Oxidation

In-Situ Chemical Oxidation (ISCO) involves the injection of an oxidizing agent (*e.g.*, permanganate, base-activated persulfate, ozone, etc.) to chemically degrade contaminants *in-situ* into non-toxic substances. A variety of commercially available oxidants can be injected into wells or a trenched infiltration gallery to deliver the oxidant to promote contact with TCE. The process involves a contact reaction, whereby oxidants typically break molecular bonds in CVOCs, in this case, the double bond within chlorinated ethenes like TCE. Implementation of ISCO requires an understanding of the oxidant demand from the CVOCs and the oxidant demand associated with naturally occurring minerals in the treatment zone. Using Site-specific data, calculations are performed to determine the total oxidant demand; these calculations are used to design an oxidant injection program to satisfy that demand.

Two oxidants have been used at the Site: base-activated persulfate and ozone. Base-activated persulfate was used in IA-12 and IA-6 for treating CVOCs, and also used for treating the IA-1/4 dioxane plume. In all cases, the persulfate failed to accomplish the treatment most likely because the iron-rich bedrock consumed the available oxidant before contaminant reduction could be achieved. These applications also resulted in transient mobilization of metals from the bedrock. In addition, the technology has limitations at this Site, due to the dual porosity nature of the fractured bedrock, and the diffusion of some CVOC mass into the bedrock matrix noted in other plumes at the Site where it will be inaccessible to injected oxidants. In contrast, ozone was used successfully to treat CVOCs and dioxane at IA-12 and IA-1/4, respectively, and did not mobilize metals (TRC, 2019a). For these reasons, ozone is the retained ISCO reagent for detailed evaluation.

One concern with ISCO using ozone is the risk of an inadvertent release of oxidant into the sewer pipe. During previous ISCO injections at the Site, also near an active sewer pipe, potential short-circuiting (*i.e.*, release) of ozone into a sewer pipe was noted, resulting in the need for implementation of response actions. Since ozone is a hazardous material, the implementation of this remediation must be completed carefully to be protective of human health and the environment. Given the shallow depth of the ozone injections, it is also possible that ozone could short circuit to the ground surface, resulting in potential inadvertent releases to the atmosphere, which could pose a risk to human health and the environment.

Though challenging to inject oxidants into weathered bedrock, these obstacles may be overcome through effective design. Based on Site-specific experience, ozone ISCO can be expected to reduce TCE concentrations to 100 µg/L or less. Therefore, it is considered both feasible and cost effective and will be further evaluated in the comparative analysis. It may need to be combined with other technologies to achieve the RAOs.

3.2.7 Excavation of Weathered Bedrock

Since the Windsor Sewer Plume originates from a zone of TCE diffused into and sorbed to the shallow weathered bedrock, excavation of the TCE-containing weathered bedrock is a viable technology. Excavation would require the removal of impacted weathered bedrock contributing to the plume. This option provides both short- and long-term effectiveness as the source area is removed completely. Although effective and theoretically feasible under applicable regulations, the implementation of this technology is not possible due to the excavation depth and presence of an active sewer pipe transecting the potential excavation area. These challenges would have significant cost implications. Furthermore, the weathered bedrock transitions to competent bedrock with depth, and excavation of competent bedrock is not implementable. Therefore, excavation may not remove all the TCE-impacted bedrock in the source area. Therefore, this technology has not been retained for further analysis.

3.3 Summary

Based on the results of the technology screening process, four treatment technologies were retained for further evaluation: no action, MNA, EISB, and ISCO. Because the considerable Site remedial experience demonstrated that EISB and ISCO cannot alone achieve GWQS, Roche evaluated EISB combined with MNA, and ISCO combined with MNA.

4.0 Detailed Analysis of Remedial Alternatives

4.1 Description of Remedial Alternatives for Further Evaluation

Each of the retained technologies is described below.

4.1.1 No Action

Evaluation of the No Action Alternative is a required element in Feasibility Studies (USEPA, 1988). Under the No Action Alternative, no action is assumed.

4.1.2 MNA

Under the MNA technology alternative, a network of ten monitoring wells would be sampled for TCE and other VOCs for the foreseeable future. An initial sampling event would include analysis for a broader range of biogeochemical conditions to document the conduciveness of Site conditions for TCE degradation. The MNA well network would be sampled quarterly for 2 years, to demonstrate that the conditions are amenable for attenuation, and that concentrations are declining over time. Following the quarterly sampling program, the well network would be sampled annually for 4 years, every 2 years for the next 4 years, and every 8 years after that, as specified in the NJDEP's MNA guidance (NJDEP, 2012). Under the NJDEP's Remedial Action Permit (RAP) program, the MNA sampling will be documented in biennial certifications. In addition to monitoring, an Institutional Control in the form of a Classification Exception Area (CEA) would be required by NJDEP regulations (NJDEP, 2020), to prevent the use of groundwater until GWQS are achieved.

Based on a time period of 30 years, the cost for implementing this remedy is estimated to be approximately $400,000. A preliminary cost estimate for implementing this remedial technology is provided in Appendix A.

4.1.3 EISB with MNA

The conceptual remedial design for the EISB with MNA alternative would include the following:

- Bioremediation-enhancing amendments (*e.g.*, electron donor, pH buffer, micronutrients, and bioaugmentation culture) would be injected into approximately six new injection wells screened from approximately 10 to 30 ft bgs, three of which would be installed upgradient of the source, and three downgradient.

- Initially, amendments would be injected into the upgradient wells, and the downgradient wells would be used to extract and recirculate groundwater, thereby enhancing the distribution of amendments through the area of high TCE concentrations.

- After a period of time, injection would cease at the upgradient wells and injection only operations would be conducted at the downgradient wells to target the downgradient edges of the treatment zone.

- It is anticipated that one round of injections will suffice to reduce TCE concentrations to below 100 µg/L.

A Permit-by-Rule (PBR) authorization from the NJDEP would be required for injection of the amendments along with a performance monitoring program and reporting. The entire active remedial program can be completed in approximately 1 to 2 years.

Under this alternative, it is anticipated that TCE and/or its degradation products would persist at low concentrations (below 100 µg/L) after the active injection and performance monitoring phase. It is further anticipated that eight consecutive quarterly post-injection groundwater monitoring events will demonstrate stable or decreasing concentration trends for contaminants of concern (COCs). Assuming that occurs, the remedy will then transition to MNA. It is assumed that, because the EISB remedy will lower TCE to concentrations below 100 µg/L, MNA is anticipated to meet the GWQS in a period of approximately 10 years after the active remedial phase.

MNA will consist of quarterly sampling for 2 years, annual sampling for the following 4 years, and sampling every 2 years after that. Under the NJDEP's RAP program, the MNA sampling will be documented in biennial certifications. In addition to monitoring, an Institutional Control in the form of a CEA would be required by NJDEP regulations, to prevent the use of groundwater until GWQS are achieved.

The cost for implementing this remedy is estimated to be approximately $1,000,000. A preliminary cost estimate for implementing this remedial technology is provided in Appendix A.

4.1.4 ISCO with MNA

The conceptual remedial design for the ISCO alternative would include the following:

- Ozone would be injected into four new ozone sparging wells screened from approximately 28 to 30 ft bgs. The ozone sparging wells would be installed in a grid-like pattern across the targeted treatment area. The ozone will rise through the formation to treat the targeted vertical intervals.

- The ISCO system will require above grade equipment to supply ozone to the wells and to extract and treat the recovered vapors, which would require a power drop.

- Ozone will be generated on-site by a mobile trailer-based system that would be positioned on the Prism property adjacent to the work area in the roadway.

- A robust SVE system, using closely spaced SVE wells and/or trenches, will be required to effectively capture sparged vapors in the unsaturated zone.

- To effectively treat the target plume area, remediation wells and trench runs will be required within the roadway. All wells and trenched pipe runs within the road would be completed flush with the road surface and include vaults and covers that are rated for heavy traffic loads. Surface paving would be replaced in-kind. Outside of the roadway area, piping runs and equipment may be a combination of above grade and below grade installations.

- Multiple or cyclic injections of ozone can be delivered to the treatment zone without re-mobilizing equipment to the site (as would be required with a liquid-based oxidant such as sodium persulfate). This will allow flexibility to quickly respond to rebound of TCE concentrations, if necessary.

- It is anticipated that ozone injections will reduce TCE concentrations to 100 µg/L or less.

A PBR authorization from the NJDEP would be required for ozone injection, along with a performance monitoring program and reporting. An Air Pollution Control Preconstruction Permit and Certificate to Operate would also be required to treat vapors collected by the SVE system. The entire active remedial program can be completed in approximately 1 to 2 years.

Under the ISCO alternative, it is anticipated that TCE will persist at low concentrations after the active injection and performance monitoring phase. It is further anticipated that eight consecutive post-injection quarterly groundwater monitoring events will demonstrate stable or decreasing concentration trends for COCs. Assuming that occurs, the remedy will then transition to MNA. It is assumed that, because the ISCO remedy will lower TCE concentrations to 100 µg/L or less, MNA is anticipated to meet the GWQS in a period of approximately 10 years after the active phase.

MNA will consist of quarterly sampling for 2 years, annual sampling for the following 4 years, and sampling every 2 years after that. Under the NJDEP's RAP program, the MNA sampling program will be documented in biennial certifications. In addition to monitoring, an Institutional Control in the form of a CEA would be required by NJDEP regulations, to prevent the use of groundwater until GWQS are achieved.

The cost for implementing this remedy is estimated to be approximately $1,400,000. A preliminary cost estimate for implementing this remedial technology is provided in Appendix A.

4.2 NCP Evaluation Criteria

This analysis compares the strengths and weaknesses of the short-listed source area treatment technologies/approaches (MNA alone, ISCO with MNA, and EISB with MNA) to one another with respect to the following nine criteria in the federal NCP (40CFR Part 300):

1. **Overall Protection of Human Health and the Environment:** This criterion evaluates whether the alternative is protective of human health and the environment.

2. **Compliance with ARARs:** This criterion reviews any chemical-specific, action-specific, or location-specific ARARs that may need to be accounted for if the technology is selected.

3. **Long-term Effectiveness and Permanence**: This criterion evaluates the ability of the treatment technology to reduce TCE concentrations within the target treatment area to achieve the target cleanup goal and sustain those reductions over time.

4. **Reduction in Toxicity, Mobility, and Volume:** This criterion evaluates the treatment process used and materials treated, the volume of materials destroyed/treated, and the degree of expected reductions. This should also take into consideration the type and quantity of any residuals remaining after remediation.

5. **Short-term Effectiveness**: This criterion evaluates the protection of the community, workers, and the environment during implementation.

6. **Implementability:** This criterion evaluates the ability to successfully implement the treatment technology under Site-specific conditions. The primary drivers for successful implementation are the ability to effectively access the contaminant mass without adversely impacting the active sewer pipe or interfering with Site redevelopment or operations.

7. **Cost:** This criterion provides an estimate of the overall expenditure required to implement each technology. Preliminary cost estimates were developed for each of the remedial alternatives. The costs for the MNA alternative assume monitoring and reporting costs for 30 years. The costs for the active remedial alternatives (ISCO and EISB) each include the costs associated with the active portion of the remedy, supplemented by the monitoring and reporting costs associated with10 years of MNA before achieving compliance with the RAO.

8. **State Acceptance:** This criterion evaluates the likelihood of agency acceptance of the proposed technology.

9. **Community Acceptance:** This criterion evaluates the likelihood of community acceptance of the proposed technology.

4.3 NCP Analysis of Individual Remedial Alternatives

No Action: This alternative is implementable and cost effective; however, the No Action alternative will not comply with ARARs (*e.g.*, fails to establish a required CEA; will not meet GWQS) or reduce the toxicity, mobility, or volume of the contaminants. No Action will not provide for continued monitoring of the groundwater in the Windsor Sewer Plume source area and will not restrict potential future groundwater use, and therefore will not be protective of human health and the environment or be effective in the long or short term. This alternative is unlikely to be acceptable to the state or the community.

MNA: MNA used as the sole remedial technology will eventually attain and sustain GWQS (*i.e.*, long-term effectiveness and compliance with ARARs), but not within a reasonable period of time. Although this technology on its own is not effective in the short term, the CEA will prevent the use of groundwater until GWQS are achieved. Because there are no human or ecological receptors, it does provide overall protection of human health and the environment with continued monitoring of the plume. It is highly implementable. It would achieve reduction in toxicity, volume and mobility, but very slowly. However, given the longtime frames, it is also unlikely to be acceptable to the state or community.

ISCO with MNA: ISCO followed by MNA will achieve and sustain GWQS (*i.e.*, long-term effectiveness and compliance with ARARs) in a reasonable time frame. It is somewhat effective in the short term, assuming the health and safety risks associated with injecting ozone in an off-Site, public road can be mitigated. It provides overall protection of human health and the environment with continued monitoring of the plume. It is highly implementable. It would achieve reduction in toxicity, volume, and mobility.

EISB with MNA: EISB followed by MNA will achieve and sustain GWQS (*i.e.*, long-term effectiveness and compliance with ARARs) in a reasonable time frame. It is effective in the short term. It provides overall protection of human health and the environment with continued monitoring of the plume. It is highly implementable. It would achieve reduction in toxicity, volume, and mobility, and may do so to a greater extent than ISCO with MNA because the stimulated biodegradation may generate biomass that will enhance MNA.

4.4 Comparative Analysis of Alternatives

Each technology is ranked relative to each of these criteria using a scale of one to three (*i.e.*, from worst to best). The comparative analysis ranking is provided in Table 1.

Table 1 – Comparative Analysis Ranking of Alternatives

Characteristic	No Action	MNA	ISCO/MNA	EISB/MNA
Overall Protection of Human Health and the Environment	1	2	3	3
Compliance with ARARs	1	2	3	3
Long-Term Effectiveness and Permanence	1	2	2	3
Reduction in Toxicity, Mobility, Volume	1	1	3	3
Short-Term Effectiveness	1	2	2	3
Implementability	3	3	2	3
Cost	3	2	1	1
State Acceptance	1	2	3	3
Community Acceptance	1	2	2	3
Total	**13**	**18**	**21**	**25**

5.0 Recommended Alternative

Based on the technology screening and comparative analysis above, EISB with MNA is selected as the best overall groundwater remedy for the Windsor Sewer Plume. The rationale for this selection is as follows:

- The No Action alternative scored poorly on all criteria except for cost and implementability. It is not an appropriate alternative to address the Windsor Sewer Plume.

- The MNA (alone) remedy is viable but would not achieve the RAOs in a reasonable time frame and scores poorly under state and community acceptance.

- ISCO/MNA and EISB/MNA are similar remedies in that they both involve injection of remedial additives to treat TCE in place, followed by MNA. As a result, many of the rankings were the same for each of these technologies. There were four categories where the rankings for these technologies differed: long-term effectiveness and permanence, short-term effectiveness, implementability, and community acceptance.

- ISCO/MNA involves injection of a hazardous material into the subsurface in close proximity to an active sewer pipe. During previous ISCO injections at the Site, also near an active sewer pipe, evidence of short-circuiting of injectate to the pipe was noted, resulting in the need for implementation of response actions. Though a similar situation could occur during injection of remedial additives during EISB, those additives are typically food-grade substances that would not pose the same concern if they were to enter the sewer pipe. Because of the absence of risk for potentially discharging hazardous materials into an active sewer, EISB/MNA was given a score of three for implementability versus a score of two for ISCO.

- Injection of ozone as part of ISCO/MNA, while feasible, presents health and safety risks to onsite workers and occupants, and considerably more infrastructure than EISB. Because EISB has been successfully demonstrated at the Site without such risks, it was given a score of three for short-term effectiveness, versus a score of two for ISCO.

- EISB has been successfully implemented in several source areas at the Site to treat CVOCs, including TCE. The effects of EISB in those areas have been sustained over time. Because of its proven track record at the Site, EISB/MNA was given a score of three for long-term effectiveness and permanence, versus a score of two for ISCO/MNA, which does not have a proven track record at the Site.

For the reasons explained above, EISB with MNA is selected as the best overall groundwater remedy for the Windsor Sewer Plume. It is the most effective and implementable remedial technology for this plume, while reducing contaminant mass and concentrations, being protective of human health and the environment, and fully complying with all legal requirements.

6.0 References

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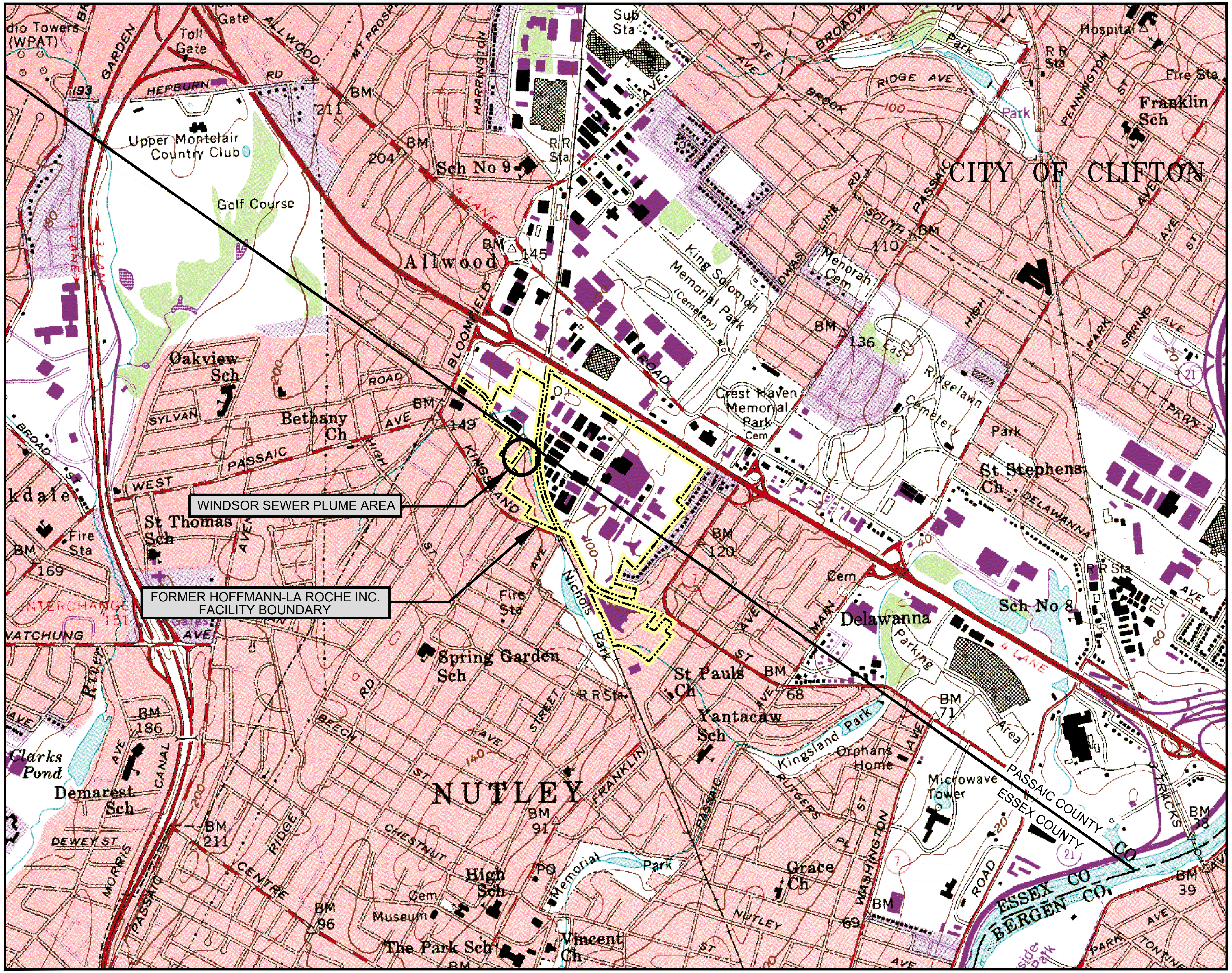
TRC, 2019a. Hoffmann-La Roche Inc., Nutley Facility, December 2019 Groundwater Remedial Action Work Plan for the Hoffmann-La Roche Inc. Site Nutley, New Jersey.

TRC, 2019b. Hoffmann-La Roche Inc., Nutley Facility, Site-Wide Groundwater Progress Report. February 22, 2019.

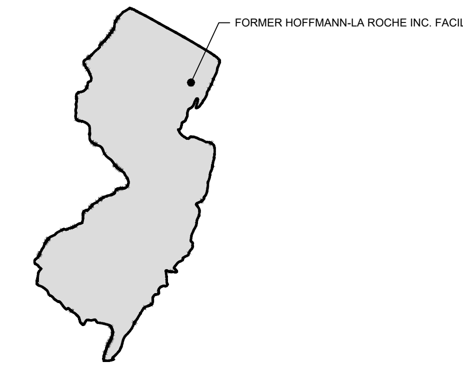
USEPA, 1988. Guidance for Conducting Remedial Actions and Feasibility Studies Under CERCLA, EPA/540/G-89/004, OSWER Directive 9355.3-01.

FIGURES



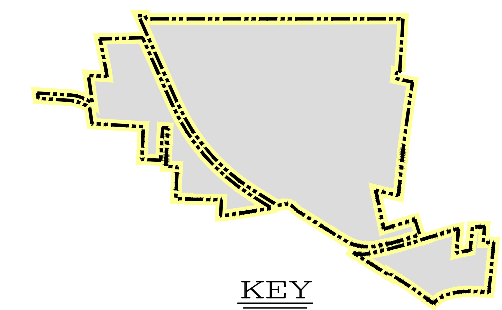
BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES
ORANGE, N.J. 1955, PHOTOREVISED 1981

N



KEY MAP

CENTER OF FACILITY
(0,0 PLANT GRID SYSTEM)
LAT.: 40° 50' 03.7"
LONG.: 74° 09' 21.9"



KEY

FORMER HOFFMANN–LA ROCHE INC. FACILITY BOUNDARY LIMITS

GEODETIC DATA

(FOR THE PLANT CENTROID)

N.A.D. 1927 ADJUSTMENT	N.A.D. 1983 ADJUSTMENT
LATITUDE/LONGITUDE	LATITUDE/LONGITUDE
LAT.: 40° 50' 03.7"	LAT.: 40° 50' 04.08"
LONG.: 74° 09' 21.9"	LONG.: 74° 09' 20.45"
N.J. STATE PLANE COORDINATES	N.J. STATE PLANE COORDINATES
NORTH: 729,307.93	NORTH: 729,078.36
EAST: 2,141,288.07	EAST: 587,396.30

SCALE

0 750 1500

1 INCH = 1500 FEET

PROJECT:
FORMER HOFFMANN-LA ROCHE INC. FACILITY
NUTLEY, NEW JERSEY

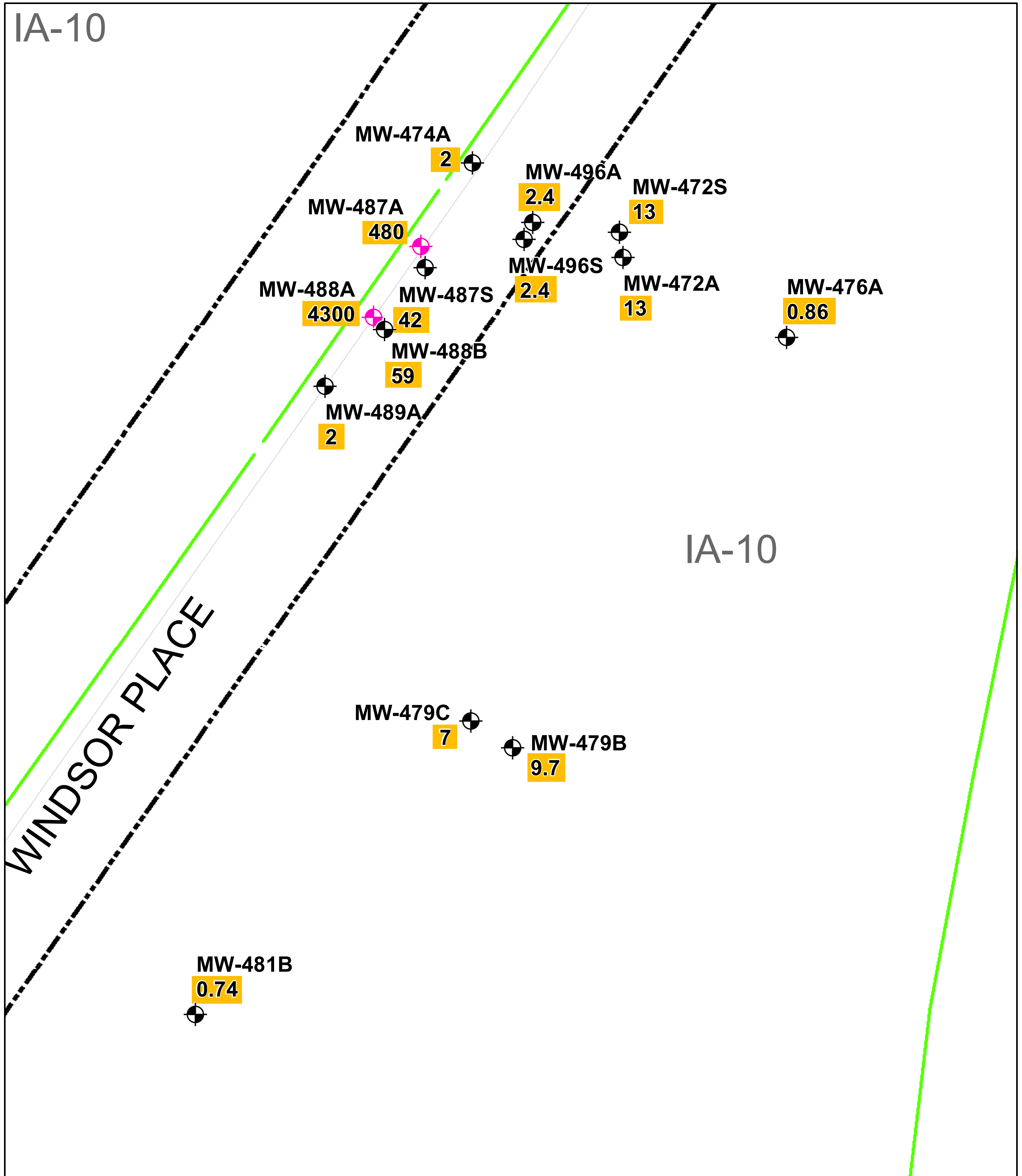
TITLE:
SITE LOCATION MAP

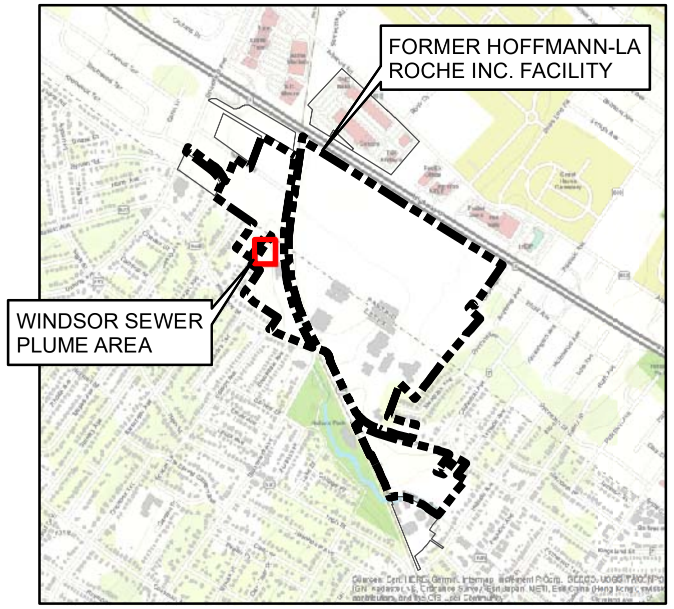
DATE: JUNE 2020 | PROJ NO.: 224283

FIGURE 1

TRC ENVIRONMENTAL CORP.
41 Spring Street, Suite 102
New Providence, New Jersey, 07974
908-988-1700

FILE NO.: FIGURE 1 - Site Location Map with WSPA.dwg





KEY MAP
SCALE: 1" = 2,000'

LEGEND

FORMER HOFFMANN-LA ROCHE INC. FACILITY PROPERTY BOUNDARY

ROADWAY

NUTLEY MUNICIPAL SEWER

WELL LOCATIONS

MW-487A **480** WELLS CURRENTLY WITH TCE > 100 µg/L

MW-479C **7** WELLS CURRENTLY WITH TCE < 100 µg/L; PREVIOUSLY > 100 µg/L

NOTES

1. TRICHLOROETHENE (TCE) DATA SHOWN ON THIS FIGURE ARE FROM SAMPLES COLLECTED IN NOVEMBER 2019.
2. THIS MAP DOES NOT DEPICT WELLS WHERE TCE CONCENTRATIONS HAVE NOT EXCEEDED 100 µg/L IN THE WINDSOR SEWER PLUME.CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µg/L).
3. THE NJDEP GROUND WATER QUALITY STANDARD (GWQS) FOR TCE IS 1 µg/L.

PROJECT:
FORMER HOFFMANN-LA ROCHE INC. FACILITY
NUTLEY, NEW JERSEY

TITLE:
WELLS WITH TCE HISTORICALLY > 100 µg/L
IN WINDSOR SEWER PLUME

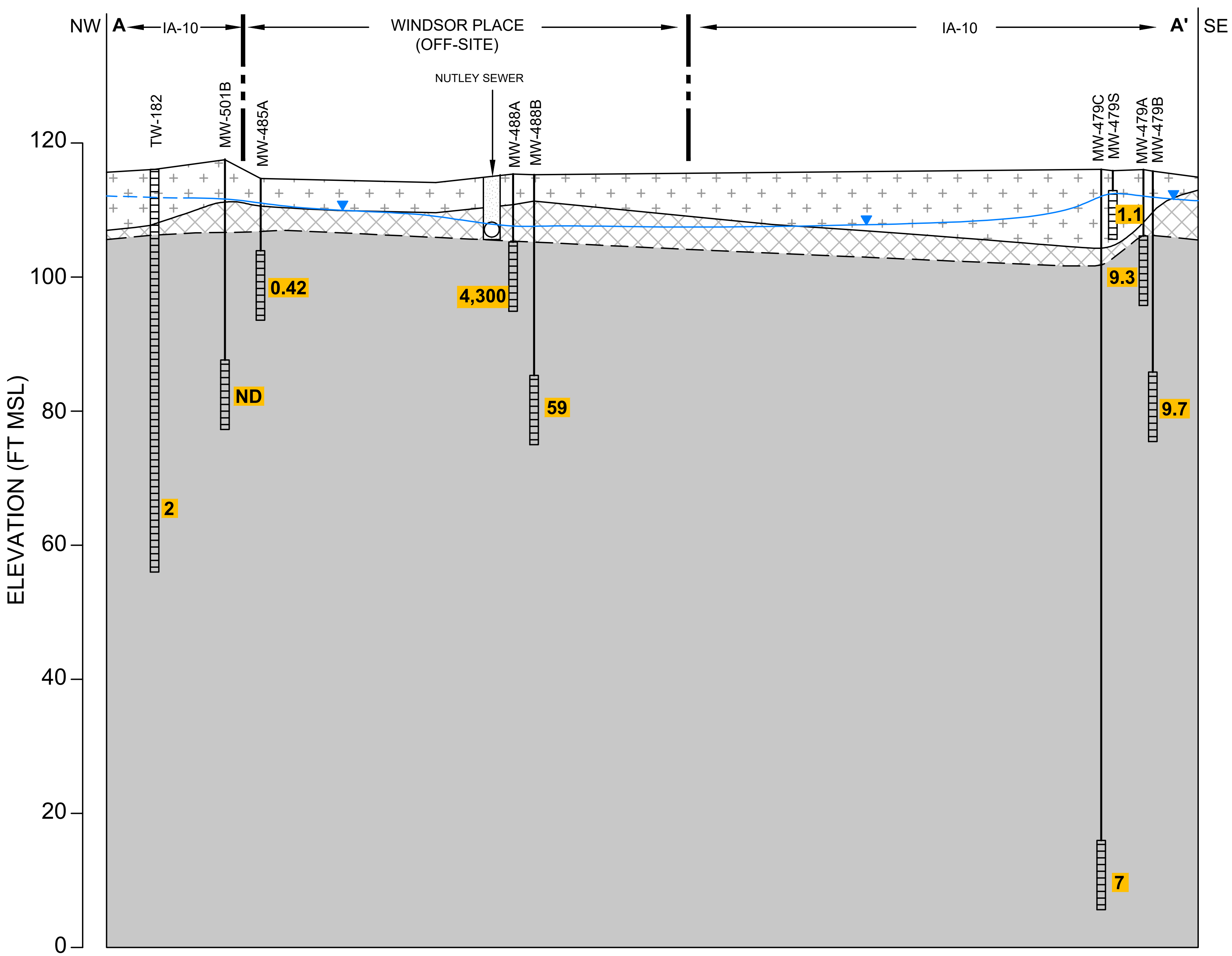
DATE: OCTOBER 2020 | PROJ. NO.: 224283

FIGURE 2

TRC

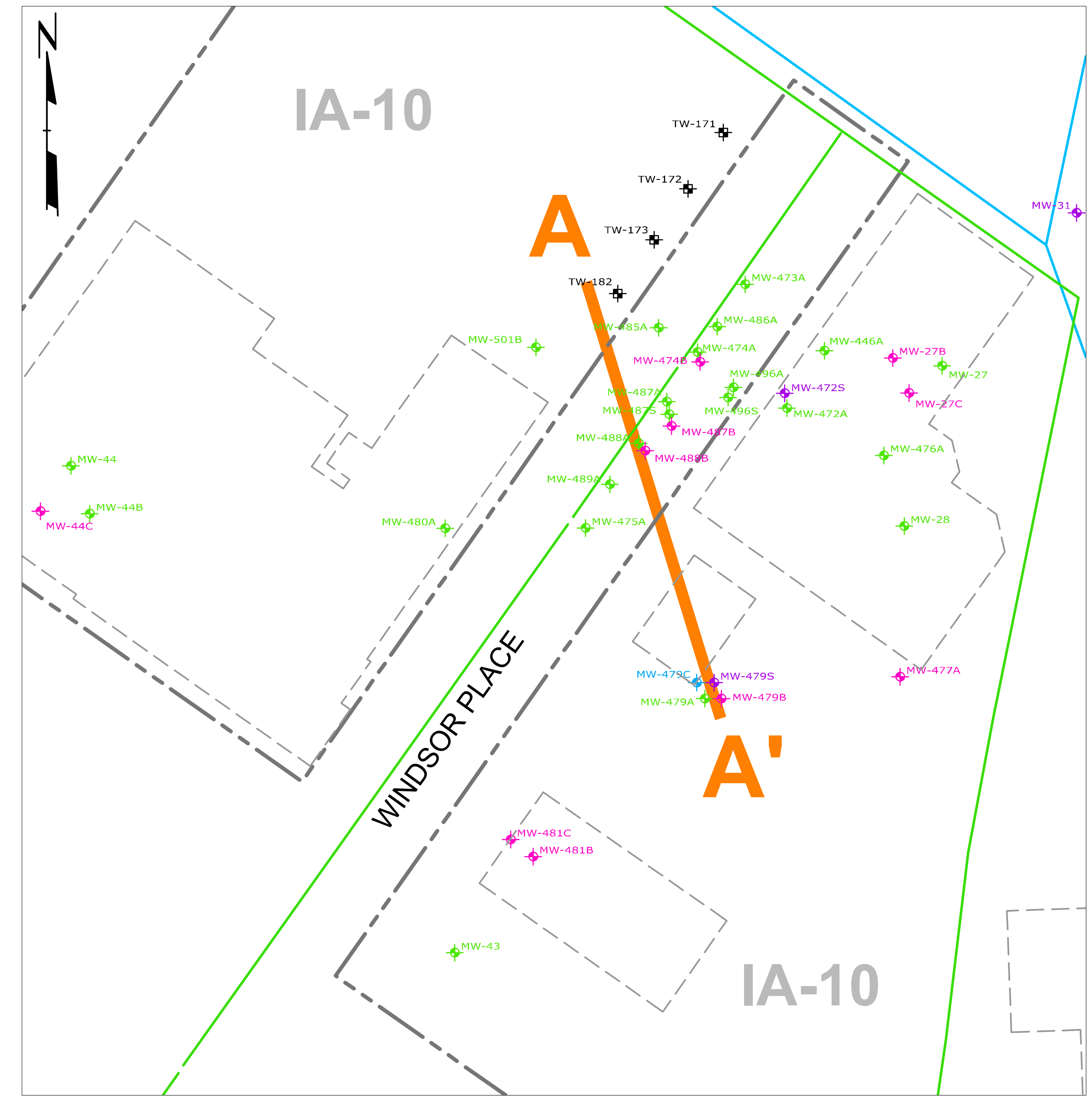
41 Spring Street, Suite 102
New Providence, NJ 07974
Phone: 908.988.1700
www.TRCcompanies.com

FILE NO.: fIGURE 2 - Recent TCE Concentrations in Windsor Sewer Plume.mxd



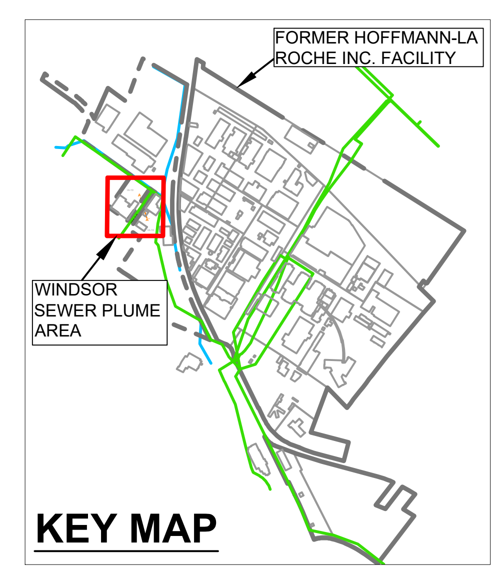
CROSS-SECTION A - A'

HORIZONTAL SCALE: 1"=20'
VERTICAL SCALE: 1" =20'



AREA IN DETAIL

SCALE: 1"=60'



KEY MAP

SCALE: 1"=1500'

LEGEND

- NUTLEY MUNICIPAL SEWER
- FORMER HOFFMANN-LA ROCHE INC. FACILITY PROPERTY BOUNDARY
- DEMOLISHED BUILDING
- OVERBURDEN WELL LOCATION
- HGU 1 WELL LOCATION
- HGU 2 WELL LOCATION
- HGU 3 WELL LOCATION
- TEMPORARY WELL
- OVERBURDEN
- WEATHERED BEDROCK
- COMPETENT BEDROCK
- BACKFILLED TRENCH MATERIAL ASSOCIATED WITH THE NUTLEY MUNICIPAL SEWER INSTALLATION. APPROXIMATE SEWER LINE ELEVATION IS 107 FEET MSL.
- MW-501B — WELL ID
- WELL SEAL/CASING
- WATER TABLE ELEVATION
- WELL SCREEN INTERVAL
- ND — TCE IN µg/L

NOTES:

1. TRICHLOROETHENE (TCE) DATA SHOWN ON THIS FIGURE ARE FROM SAMPLES COLLECTED IN NOVEMBER 2019 (EXCEPT FOR TEMPORARY WELL TW-182).
2. TW-182 WAS SAMPLED IN AUGUST 2015.
3. CONCENTRATIONS ARE IN MICROGRAMS PER LITER (µg/L).
4. THE NJDEP GROUND WATER QUALITY STANDARD (GWQS) FOR TCE IS 1 µg/L.
5. ND = NOT DETECTED
6. FT MSL = FEET MEAN SEA LEVEL
7. GROUNDWATER ELEVATION DATA FROM NOVEMBER 4, 2019 WERE USED TO APPROXIMATE WATER TABLE DEPTH (DASHED WHERE INFERRED).

PROJECT:	FORMER HOFFMANN-LA ROCHE INC. FACILITY NUTLEY, NEW JERSEY
TITLE:	HYDROGEOLOGIC CROSS SECTION THROUGH WINDSOR SEWER PLUME
DATE: JUNE 2020	PROJ NO.: 224283
FIGURE 3	
TRC	TRC ENVIRONMENTAL CORP. 41 Spring Street, Suite 102 New Providence, New Jersey, 07974 908-988-1700
FILE NO.:	FIGURE 3 - Cross Section WP.dwg

APPENDIX A

APPENDIX A-1
PRESENT VALUE CALCULATION - MONITORED NATURAL ATTENUATION
Nutley, New Jersey

YEAR	OM&M COSTS						Total Annual Cost (Not Adjusted for Inflation)	PRESENT VALUE (AT 3.00% DISCOUNT RATE)
	Annual OM&M				Periodic OM&M			
	MNA/LTM Monitoring	Permit Fee	Reporting	PM and Contingency	Well repair and abandonment	Monitoring Well Abandonment		
0	$ 27,520.00	$ -	$ -	$ 15,000	$ -	$ -	$ 42,520	$42,520
1	$ 27,520.00	$ -	$ -	$ 15,000	$ -	$ -	$ 42,520	$41,686
2	$ 6,880.00	$ -	$ 75,000	$ 5,000	$ -	$ -	$ 86,880	$83,506
3	$ 6,880.00	$ 165	$ -	$ 5,000	$ -	$ -	$ 12,045	$11,350
4	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 17,045	$15,747
5	$ 6,880.00	$ 165	$ -	$ 5,000	$ 2,500	$ -	$ 14,545	$13,174
6	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$9,026
7	$ 6,880.00	$ 165	$ -	$ 5,000	$ -	$ -	$ 12,045	$10,486
8	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$8,676
9	$ 6,880.00	$ 165	$ -	$ 5,000	$ -	$ -	$ 12,045	$10,079
10	$ -	$ 165	$ 5,000	$ 5,000	$ 2,500	$ -	$ 12,665	$10,390
11	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$4,154
12	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$8,015
13	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$3,993
14	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$7,704
15	$ -	$ 165	$ -	$ 5,000	$ 2,500	$ -	$ 7,665	$5,695
16	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$7,405
17	$ 6,880.00	$ 165	$ -	$ 5,000	$ -	$ -	$ 12,045	$8,602
18	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$7,117
19	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$3,545
20	$ -	$ 165	$ 5,000	$ 5,000	$ 2,500	$ -	$ 12,665	$8,523
21	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$3,408
22	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$6,575
23	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$3,275
24	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$6,320
25	$ 6,880.00	$ 165	$ -	$ 5,000	$ 2,500	$ -	$ 14,545	$8,866
26	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$6,074
27	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$3,026
28	$ -	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 10,165	$5,839
29	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$2,908
30	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ 5,000	$ 22,045	$12,170
						Total Cost	**$ 459,100**	
						Total Discounted OM&M Costs:		**$380,000**
			2.00%			Discount Factor		

APPENDIX A-2
PRESENT VALUE CALCULATION - ENHANCED IN-SITU BIOREMEDIATION WITH MONITORED NATURAL ATTENUATION
Nutley, New Jersey

YEAR	EISB Injection Program*	OM&M COSTS: Annual OM&M: MNA/LTM Monitoring	OM&M COSTS: Annual OM&M: Permit Fee	OM&M COSTS: Annual OM&M: Reporting	OM&M COSTS: Annual OM&M: PM and Contingency	OM&M COSTS: Periodic OM&M: Well repair and abandonment	OM&M COSTS: Periodic OM&M: Monitoring Well Abandonment	Total Annual Cost (Not Adjusted for Inflation)	PRESENT VALUE (AT 3.00% DISCOUNT RATE)
0	$ 750,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 750,000	$750,000
1	$ -	$ 27,520.00	$ -	$ -	$ 15,000	$ -	$ -	$ 42,520	$41,686
2	$ -	$ 27,520.00	$ -	$ 75,000	$ 15,000	$ -	$ -	$ 117,520	$112,957
3	$ -	$ 6,880.00	$ 165	$ -	$ 5,000	$ -	$ -	$ 12,045	$11,350
4	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 17,045	$15,747
5	$ -	$ 6,880.00	$ 165	$ -	$ 5,000	$ 2,500	$ -	$ 14,545	$13,174
6	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 17,045	$15,135
7	$ -	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$4,496
8	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 17,045	$14,548
9	$ -	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$4,322
10	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ 5,000	$ 22,045	$18,085
11	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
12	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
13	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
14	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
16	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
17	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
18	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
19	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
20	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
21	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
22	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
23	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
24	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
26	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
27	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
28	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
29	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
30	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
							Total Cost	**$ 1,020,100**	
							Total Discounted OM&M Costs:		**$1,010,000**
				2.00%			Discount Factor		

Notes:

* EISB Injection Program costs (including Permit-by-rule monitoring costs, Project Management and Contingency are presented in Appendix A-3).

APPENDIX A-3

Feasibility Study Cost Estimate
Windsor Place EISB
Roche Facility - Nutley/Clifton, NJ

BY: K. Robbins	Date:	6/22/2020	Checked by: B. Lazar	Date:	6/23/2020

EISB Injections

Activities

Install Wells	Install six EISB injection and six performance monitoring wells to a depth of 30 ft. bgs.	
EISB Duration	6-12	months
Operation and Sampling	One round of injections with subsequent monitoring.	
Well Abandonment	Abandon six EISB injection wells and ten monitoring wells	

Design Components

WELLS

# of EISB Well Locations	6	Depth EISB Injection Wells	30	Ft
# New Monitoring Wells:	2	Depth:	30	Ft
	3	Depth:	30	Ft
	1	Depth:	20	Ft
Drilling Production Rate:	2	wells per day per crew		
Total Number of wells	12			
Days to complete Drilling	6			

Task 1: Pre-design Investigation

Description	QTY	Unit	Rate	Cost	Notes
Utility Clearance	1	LS	$ 2,500	$ 2,500	
Survey and Mark Locations	1	LS	$ 2,000	$ 2,000	
Driller Mob/Demob	1	LS	$ 3,500	$ 3,500	
Install EISB Injection Well	30	Ft	$ 280	$ 8,400	
Install Monitoring Wells	120	Ft	$ 280	$ 33,600	
Soil disposal	7	Tons	$ 100	$ 700	
CCTV Sewer Inspection	1	LS	$ 6,500	$ 6,500	
Field Equipment/Vehicles	1	LS	$ 6,820	$ 6,800	
Sampling and Analysis	1	LS	$ 32,000.00	$ 32,000	
Contractor Admin and Proj Mgmt (4%)				$ 3,800	
			Sub Total:	**$ 99,800**	

Task 2: Installation of Wells

Description	QTY	Unit	Rate	Cost	Notes
Utility Clearance	1	LS	$ 2,500	$ 2,500	
Survey and Mark Locations	1	LS	$ 2,000	$ 2,000	
Driller Mob/Demob	1	LS	$ 3,500	$ 3,500	
Install EISB Injection Wells	150	Ft	$ 280	$ 42,000	
Install Monitoring Wells	50	Ft	$ 280	$ 14,000	
Soil disposal	9	Tons	$ 100	$ 900	
Field Equipment/Vehicles	6	Days	$ 250	$ 1,500	
Contractor Admin and Proj Mgmt (4%)				$ 2,700	
			Sub Total:	**$ 69,100**	

APPENDIX A-3

Feasibility Study Cost Estimate
Windsor Place EISB
Roche Facility - Nutley/Clifton, NJ

Task 3: EISB Injections

Description	QTY	Unit	Rate		Cost		Notes
EISB Injection Substrate	1	LS	$	10,500.00	$	10,500	
Injection Contractor	1	LS	$	147,000	$	147,000	
Frac Tank Rental / Cleaning	1	LS	$	7,400.00	$	7,400	
Field Equipment/Vehicles	1	LS	$	9,520	$	9,520	
Admin and Management (4%)					$	7,000	
				Sub-total:	**$**	**181,420**	

Task 4: Performance PBR Monitoring

Description	QTY	Unit	Rate		Cost		Notes
Field Equipment/Vehicles	4	Event	$	4,000	$	16,000	Baseline, 1-month, 3-month, 6-month
Field Sampling Crew	4	Event	$	7,500	$	30,000	
Sampling and Analysis	4	Event	$	10,000.00	$	40,000	
				Sub Total (O&M):	**$**	**86,000**	

EISB Subtotal:	**$**	**436,000**

System Decommissioning & Well Abandonment

Description	QTY	Unit	Rate		Cost		Notes
Well Abandonment	6	EA	$	750	$	4,500	Remediation and perf monitoring wells
Surface Restoration	1	LS	$	5,000	$	5,000	
				Total	**$**	**9,500**	

SUBTOTAL - CAPITAL AND TREATMENT COST		**$**	**445,500**
Engineering and Consulting			
Project Management	6%	$	27,000
Remedial Design	12%	$	53,000
Construction Management	10%	$	45,000
Reporting	12%	$	53,000
Subtotal Project Cost Without Contingency		$	624,000
Contingency	20%	$	125,000
ESTIMATED TOTAL PROJECT COST		**$**	**750,000**

APPENDIX A-4

PRESENT VALUE CALCULATION - IN-SITU CHEMICAL OXIDATION WITH MONITORED NATURAL ATTENUATION

Nutley, New Jersey

		OM&M COSTS							
		Annual OM&M				Periodic OM&M			
YEAR	**ISCO Ozone Injection Program***	**MNA/LTM Monitoring**	**Permit Fee**	**Reporting**	**PM and Contingency**	**Well repair and abandonment**	**Monitoring Well Abandonment**	**Total Annual Cost (Not Adjusted for Inflation)**	**PRESENT VALUE (AT 3.00% DISCOUNT RATE)**
0	$ 1,130,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,130,000	$1,130,000
1	$ -	$ 27,520.00	$ -	$ -	$ 15,000	$ -	$ -	$ 42,520	$41,686
2	$ -	$ 27,520.00	$ -	$ 75,000	$ 15,000	$ -	$ -	$ 117,520	$112,957
3	$ -	$ 6,880.00	$ 165	$ -	$ 5,000	$ -	$ -	$ 12,045	$11,350
4	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 17,045	$15,747
5	$ -	$ 6,880.00	$ 165	$ -	$ 5,000	$ 2,500	$ -	$ 14,545	$13,174
6	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 17,045	$15,135
7	$ -	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$4,496
8	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ -	$ 17,045	$14,548
9	$ -	$ -	$ 165	$ -	$ 5,000	$ -	$ -	$ 5,165	$4,322
10	$ -	$ 6,880.00	$ 165	$ 5,000	$ 5,000	$ -	$ 5,000	$ 22,045	$18,085
11	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
12	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
13	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
14	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
16	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
17	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
18	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
19	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
20	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
21	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
22	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
23	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
24	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
26	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
27	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
28	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
29	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
30	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0
						Total Cost		**$ 1,400,100**	
						Total Discounted OM&M Costs:			**$1,390,000**
				2.00%			Discount Factor		

Notes:

* ISCO Ozone Injection Program costs (including Permit-by-rule monitoring costs, Project Management and Contingency) are presented in Appendix A-5.

APPENDIX A-5

Feasibility Study Cost Estimate
Windsor Place ISCO
Roche Facility - Nutley/Clifton, NJ

BY: K. Robbins	Date:	6/22/2020	Checked by: B. Lazar	Date:	6/23/2020

Ozone Sparging and SVE

Activities

Install Wells	Install 4 ozone sparge wells to a depth of 30 ft. bgs (6" diameter)
Install Performance Monitoring Wells	Install 6 performance monitoring wells (2" diameter)
Install System Piping	Install ~150 linear ft of trench and piping
Install SVE Trailer	Mobilization of a rental trailer Ozone/SVE system
Electrical Connection	Electrical drop for Ozone/SVE system power
System Startup	Two weeks of daily operation to assess and tune the system
ISCO Duration	12 months
Operation and Sampling	Operation for 12 months for the ISCO system
Well Abandonment	Abandon 4 ozone sparge wells and 10 monitoring wells
Abandon Piping	Grouting of approximately 150 ft of pipe
System Shut-down/de-mob	Remove electrical connection and system, system piping

Design Components

WELLS

# of Ozone Sparge Locations	4	Depth Ozone Wells		30	Ft
# New Monitoring Wells:	**2**		Depth:	30	Ft
	3		Depth:	30	Ft
	1		Depth:	20	Ft
Drilling Production Rate:	2	wells per day per crew			
Total Number of wells	10				
Days to complete Drilling	5				

TRENCHING AND PIPING

SVE Trenches	120	Ft		
Length of Supply Lines	Above Grnd		Below Grnd	
	50	Ft	100	Ft

GAC:	12	2	C	Site Visit Frequency:	2	per month	
				Number of site visits:	29	visits	A few extra site visits for maintenance

Task 1: Pre-design Investigation

Description	QTY	Unit	Rate	Cost	Notes
Utility Clearance	1	LS	$ 2,500	$ 2,500	
Survey and Mark Locations	1	LS	$ 2,000	$ 2,000	
Driller Mob/Demob	1	LS	$ 3,500	$ 3,500	
Install Performance Monitoring Wells	120	Ft	$ 280	$ 33,600	
Soil disposal	5	Tons	$ 100	$ 500	
CCTV Sewer Inspection	1	LS	$ 6,500	$ 6,500	
Field Equipment/Vehicles	6	Days	$ 250	$ 1,500	
Sampling and Analysis	1	LS	$ 37,000.00	$ 37,000	
Contractor Admin and Proj Mgmt (4%)				$ 3,500	
			Sub Total:	**$ 90,600**	

APPENDIX A-5

Feasibility Study Cost Estimate
Windsor Place ISCO
Roche Facility - Nutley/Clifton, NJ

Task 2: Installation of Wells

Description	QTY	Unit		Rate		Cost	Notes
Utility Clearance	1	LS	$	2,500	$	2,500	
Survey and Mark Locations	1	LS	$	2,000	$	2,000	
Driller Mob/Demob	1	LS	$	3,500	$	3,500	
Install Ozone Sparge Wells	120	Ft	$	280	$	33,600	
Install Performance Monitoring Wells	50	Ft	$	280	$	14,000	
Soil disposal	7	Tons	$	100	$	700	
Field Equipment/Vehicles	5	Days	$	250	$	1,300	
Contractor Admin and Proj Mgmt (4%)					$	2,100	
				Sub Total:	**$**	**59,700**	

Task 3 Installation of SVE lines and System Piping

Description	QTY	Unit		Rate		Cost	Notes
Utility Clearance	1	LS	$	2,500	$	2,500	
Contractor Mob/Demob	1	LS	$	5,000.00	$	5,000	
Saw cut asphalt	440	ft	$	10	$	4,400	
Trench Excavation (SVE and Piping)	30	CY	$	25.00	$	750	
SVE Trench Backfill - Material and Loading	107	Tons	$	18	$	1,920	Gravel
Install below ground piping - SVE	120	ft	$	10	$	1,200	2" Sch 80 PVC
Below grade piping backfill	0	CY	$	10	$	-	Replace with existing removed
Install below ground piping - Supply Lines and Electrical Power	100	ft	$	20	$	2,000	Multiple lines, tubing strung in PVC for ozone
Install above ground piping - Supply Lines and Electrical Power	50	ft	$	18	$	900	Multiple lines, tubing strung in PVC for ozone, pipe support
Well Vaults	8	Ea	$	2,000	$	16,000	4 Ozone, 4 SVE
Soil Disposal	80	Tons	$	100	$	8,000	SVE trenches only
Surface Repair	200	SY	$	40	$	8,000	4-ft wide asphalt cut, assume all SVE trenching is paved
Survey	1	LS	$	5,000	$	5,000	
Piping Integrity testing	1	EA	$	2,500.00	$	2,500.00	
Field Equipment/Vehicles	15	Days	$	250	$	4,000	
Admin and Management (4%)					$	2,400	
				Sub-total:	**$**	**64,570**	

Task 4: Procurement and Setup of Ozone Supply & SVE Equipment Systems

Description	QTY	Unit		Rate		Cost	Notes
Manufactured Equipment Systems	1	Ea	$	150,000	$	150,000	
Shipping	1	Ea	$	10,000	$	10,000	
Startup Assistance - Equip Mfr	1	Ea	$	3,000	$	3,000	
Piping Hookups	1	Ea	$	5,000	$	5,000	
Electrical Power and Controls	1	Ea	$	10,000	$	10,000	
				Sub Total:	**$**	**178,000**	

Task 5: Ozone and SVE Systems OM&M (12 months)

Description	QTY	Unit		Rate		Cost	Notes
Power (Annual)	12	months	$	3,467	$	41,600	Based on 50 Hp per system
GAC Replacement	2,000	lbs	$	4	$	8,000	Assume replace 1-2,000 lb GAC per quarter
Air Samples - Lab	36	Ea	$	100.00	$	3,600	Assume avg 1/Month for each system (inlet, mid, outlet of GAC)
System Repairs and Maintenance	1	Ea	$	20,000	$	20,000	$20,000/yr Annual Allowance per system
System Startup	1	Ea	$	20,000	$	20,000	
Operations Labor	29	Visits	$	1,440	$	41,760	29 visits total, $120/hr avg rate (technician and support)
Field Equipment	29	Days	$	150	$	4,350	29 days on site
Field Vehicles	29	Days	$	100	$	2,900	29 days, on site
				Sub Total (O&M):	**$**	**142,210**	

APPENDIX A-5

Feasibility Study Cost Estimate
Windsor Place ISCO
Roche Facility - Nutley/Clifton, NJ

Task 6: Performance PBR Monitoring

Description	QTY	Unit	Rate	Cost	Notes
Field Equipment/Vehicles	5	Event	$ 5,000	$ 25,000	Remediation and perf monitoring wells
Field Sampling Crew	4	Event	$ 7,500	$ 30,000	
Sampling and Analysis	5	Event	$ 10,000.00	$ 50,000	Baseline, 3-month, 6-month, 9-month, 12-month
			Total	**$ 105,000**	

Ozone Subtotal:	**$**	**640,000**

System Decommissioning & Well Abandonment

Description	QTY	Unit	Rate	Cost	Notes
Well Abandonment	4	EA	$ 750	$ 3,000	Remediation and perf monitoring wells
Piping Plugging/Grouting	220	LF	$ 5	$ 1,100	
System De-Mob and De-con	1	Ea	$ 5,000	$ 5,000	
Well Vaults	8	LS	$ 500	$ 4,000	Paving
Surface Restoration	1	LS	$ 20,000	$ 20,000	
			Total	**$ 33,100**	

SUBTOTAL - CAPITAL AND TREATMENT COST		**$**	**673,100**
Engineering and Consulting			
Project Management	6%	$	40,000
Remedial Design & Engineering	12%	$	81,000
Construction Management	10%	$	67,000
Reporting	12%	$	81,000
Subtotal Project Cost Without Contingency		$	943,000
Contingency	20%	$	190,000
ESTIMATED TOTAL PROJECT COST		**$**	**1,130,000**