# Focused Feasibility Study for Groundwater

## Aramark Uniform
## 400 North West Street
## Sikeston (Scott County), Missouri 63801

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## APPENDICES

# 1.0 Introduction

On behalf Aramark Uniform and Career Apparel, LLC (AUCA), TRC Environmental Corporation (TRC) has prepared this Focused Feasibility Study (FFS) for Groundwater associated with property located in northwest Sikeston (Scott County), Missouri (**Figure 1**). In October 2023, Aramark spun off its uniform division and changed its name to Vestis Services, LLC. For consistency with previous documents, the AUCA name is retained for this FFS report.

For the purposes of this FFS, the "Site" consists of the AUCA Property at 400 North West Street and the Sikeston Board of Municipal Utilities property (BMU Property) at [redacted]. The FFS specifically addresses shallow groundwater within the confines of these properties.

This Site is being managed by AUCA in coordination with the U.S. Environmental Protection Agency (USEPA) Region VII. The Remedial Investigation (RI) is ongoing, and interim remedies are being considered prior to developing the full-Site remedy. The main purpose of this FFS is to determine the most cost-effective approach to address chlorinated volatile organic compounds (CVOCs) in shallow groundwater for evaluation by AUCA, BMU, Chubb insurance, and Chubb's consultant (Rimkus). The groundwater options outlined in this FFS do not constitute a full-Site remedy (see Section 2.3). For example, AUCA is pursuing a soil vapor extraction (SVE) pilot study beneath their building (Section 2.2) and monitored natural attenuation (MNA) will likely also be a component of the full-Site groundwater remedy.

## 1.1 Background

The AUCA Property was previously operated as a commercial laundry by Todd Uniform (Todd) beginning in approximately 1968. In addition to water washing of linens and uniforms, Todd performed limited dry cleaning of leather gloves and jackets. Tetrachloroethene (PCE) was used as a dry-cleaning solvent between approximately 1968 and the early 1970s, before Todd switched to petroleum-based solvents (a.k.a., mineral spirits or Stoddard solvent). AUCA acquired the Todd business in 1995 and continues to operate a commercial water-wash business at this location. There are no longer any dry-cleaning operations at the AUCA Property.

The BMU Property [redacted] includes two high-capacity public water supply wells - Well No. 8 (CW-08) and Well No. 13 (CW-13). [redacted] **Figure 2** provides the main Site features for the AUCA and BMU properties.

Dissolved CVOCs have been historically detected in groundwater monitoring wells on both the AUCA and BMU Properties. Since 2006, low concentrations of CVOCs have been detected in the BMU's water supply well CW-08. In 2013, BMU installed and began operating a second high-capacity well, CW-13, located west of CW-08. Other than two monitoring events in 2009 when tetrachloroethylene (PCE) exceeded the Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L) in the CW-08 samples, there have been no Safe Drinking Water Act (SDWA) exceedances for CVOCs detected in the quarterly VOC samples collected at CW-08, CW-13, or the WTP No. 3 treated water discharge. Samples collected at CW-08, and to a lesser extent at CW-13 and the WTP No. 3 effluent, have shown recent CVOC concentration increases.

## 1.2 Purpose and Scope

The purpose of this FFS is to determine the most cost-effective remedial approach to address CVOCs that exceed MCLs in shallow groundwater, and mitigate their potential for impacting the BMU water supply by:

1. Developing a range of remedial alternatives using approaches and technologies that are practicable and applicable to Site conditions.
2. Performing a detailed analysis of the alternatives to ascertain which alternative most adequately achieves remedial objectives relative to the criteria of being protective of human health and the environment, suitably implementable, and cost-effective.

The scope of this FFS is limited to addressing CVOCs in shallow groundwater media within the boundaries of the Site.

# 2.0 Site Conditions and Remedial Objectives

## 2.1 Summary of Site Conditions

### *2.1.1 Site Geology*

The AUCA and BMU Properties overlie Quaternary-aged Mississippi River Valley alluvium that is predominantly fine- to medium-grained sand. Shallow soil consists primarily of silty sand and silt from the ground surface to between 5 and 15 feet below ground surface (bgs), where it transitions to a poorly graded fine to medium sand. Coarse sand and gravel fractions increase at depths below 100 feet bgs. A stiff silty lean clay was encountered beneath the alluvium at depths ranging from 149 feet bgs (MW-02A) to 202 feet bgs (MW-08A); the clay was not encountered at the MW-06A location to a total drilling depth of 209 feet bgs. The thickness of the underlying clay unit has not been determined but is presumed to be laterally continuous in the vicinity of the AUCA and BMU Properties based on the data collected.

Grain size analyses, geologic logging, and field observations have identified two intermediate silty sand/very fine sand layers. These finer-grained intervals are defined as soil containing more than 80% fine sand size and finer material, e.g., #40 sieve and finer. The uppermost fine sand layer is approximately 10 to 20 feet in thickness and occurs at approximately 70 feet bgs at the west end of the study area (MW-13A and MW-08A), dipping to approximately 90 feet bgs at MW-02A in the eastern portion of the Site. A deeper layer of very fine sand was identified at approximately 150 feet bgs at the MW-06A location. This deeper layer appears to be approximately 15 feet or more in thickness and correlates with fine sand and silty sand layers logged at MW-13A and MW-08A to the west.

### *2.1.2 Groundwater Flow*

Water level measurements have been periodically recorded at the existing groundwater monitoring wells. The water levels were collected as rapidly as possible to represent a “snapshot” of groundwater flow conditions where high-capacity well pumping affects the aquifer.

**Figure 2** depicts the most recent groundwater flow contours from water level measurements taken in May 2023, and are typical for the Site when the BMU supply wells are not actively pumping. Groundwater flow is primarily to the west-southwest beneath the Site, with a horizontal hydraulic gradient ranging from approximately 0.001 to 0.002. There is an apparent northwest to southeast-trending groundwater divide in the vicinity of monitoring wells MW-09 and MW-12, where groundwater at the northeast portion of the AUCA Property flows to the north or northeast. The calculated hydraulic conductivity from slug test data range from $10^{-1}$ to $10^{-2}$ centimeters per second (cm/sec). Using an estimated horizontal hydraulic gradient of 0.0015 and an average hydraulic conductivity (K) of 121 feet/day, the estimated groundwater flow velocity under non-pumping conditions is approximately 220 feet/year.

When CW-08 or CW-13 is pumping, groundwater flow beneath the AUCA Property shifts [redacted]. With well CW-08 pumping, water levels are affected at least 450 feet away. When CW-13 is pumping, the most noticeable effect is a slight increase in the horizontal hydraulic gradient near the pumping well.

Vertical gradients observed at well nests MW-02/MW-02A and MW-03/MW-03A on the AUCA Property are very small (0.0001 to 0.0009 – an order of magnitude less than the horizontal gradients) and are generally downward, whether the BMU supply wells are pumping or not. At the nested monitoring wells on the BMU Property (MW-06/MW-06A, MW-08/MW-08A, and MW-13/MW-13A), the vertical gradients are slightly higher (0.002 to 0.005) and are generally upward during both non-pumping and pumping conditions. The single exception on the BMU property was a stronger downward vertical gradient (0.02) observed at well nest MW-13/MW-13A while well CW-13 was pumping.

In addition to the static/manual water level measurements, continuous water level data were collected using pressure transducers for seven consecutive days in March 2017, and correlated to the BMU pumping data. Using an average aquifer thickness of 120 feet, the calculated transmissivity values translate to an average aquifer hydraulic conductivity (K) of approximately $3 \times 10^{-1}$ cm/s, which is consistent with the slug-test results.

The transmissivity values and well pumping rates were used to calculate the approximate capture zones for each of the municipal supply wells. The maximum width of the estimated capture zones range from approximately 310 to 1,250 feet, with a stagnation point of between 100 and 400 feet downgradient of each well. These data are consistent with the observed groundwater flow conditions observed at the site during pumping.

### *2.1.3 CVOCs in Groundwater*

Site CVOCs consist of dissolved PCE and its natural breakdown compounds – trichloroethene (TCE), and 1,2-dichloroethene (DCE). No dense non-aqueous phase liquid (DNAPL) or dissolved vinyl chloride have ever been detected in Site groundwater samples.

The overall CVOC plume geometry has remained relatively consistent since 2016. The plume configuration from May 2023 groundwater sampling is shown on **Figure 2**. As defined by the MCL 5 µg/L PCE contour, the plume is relatively narrow (maximum 300 ft wide) and mostly limited to 35-60 feet bgs. The plume extends approximately 900 feet downgradient from the historic dry-cleaning area near the northeast corner of the AUCA building.

The CVOC plume follows the predominant horizontal hydraulic gradient [redacted]. PCE and TCE concentrations greater than the MCL have been detected as far downgradient as the MW-08 location and as deep as 105 feet bgs at MW-08ID. Other than MW-08ID, MCLs have not been exceeded in other Site wells screened at the intermediate or deep intervals. Some vertical (downward) migration of CVOCs is occurring in downgradient portions of the plume (e.g., MW-08IS and MW-08ID) and near the supply wells (e.g., MW-18IS).

Prior to the May 2023 sampling event, the maximum CVOC concentrations at the Site were reported either at the western edge of the AUCA Property (MW-03) or beneath the AUCA building (MW-09). In May 2023, however, the maximum concentrations of PCE (459 µg/L), TCE (60.2 µg/L), and cis-1,2-DCE (86.7 µg/L) were all detected in the groundwater sample from well MW-07, which is located on the BMU Property approximately 80 feet southeast (upgradient) of supply well CW-08. CVOC concentrations at MW-07 have steadily increased since December 2020. The increasing CVOC trend at MW-07, recent TCE detections at intermediate depth well MW-18IS (approximately 30 feet from CW-08), and at water supply well CW-08 provide evidence of a shift in CVOC distribution within the plume and an increasing rate of CVOC migration toward well CW-08.

Although no CVOCs have been detected in groundwater at sentinel well nest MW-13/-13IS/-13ID, low concentrations of PCE and TCE (less than the MCL) were reported in samples collected from BMU well CW-13 between April and October 2021, and again in May 2023. These data indicate that while the overall plume geometry near CW-13 has remained relatively stable during the RI, there appears to be some plume migration toward CW-13 in response to pumping at this supply well.

## 2.2 Related Remedial Actions

PCE has been detected in shallow soil beneath the northeast corner of the AUCA building near the historic dry cleaning equipment. Detections were observed in the soil less than 20-ft bgs, at concentrations that exceed the soil screening level (SSL) for migration to groundwater. Sub-slab vapor samples collected below the AUCA building during November 2022 exceeded screening levels and were highest near the northeast building area.

As noted previously, an SVE pilot study and additional soil sampling was conducted in December 2023 to assess the historic drycleaning area near the northeast portion of the AUCA building, and those data will be summarized separately. The initial phase of SVE consisted of conducting design verification testing using a single, nested set of two SVE wells, installed at varying depths, to verify the technology effectiveness and establish design parameters for a full-scale pilot system.

## 2.3 Remedial Action Objectives

The following remedial action objectives (RAOs) for groundwater are as follows:

- In the short-term, prevent exposure to CVOCs at concentrations greater than MCLs from water supplied from BMU wells CW-08 and CW-13;
- In the short-term, mitigate the further migration of CVOCs in groundwater; and
- In the long-term, reduce CVOC concentrations in groundwater to levels sufficient to prevent the future migration of CVOCs (greater than MCLs) from reaching the BMU water supply wells.

## 3.0 Development of Remedial Alternatives

The following list of viable remedial alternatives has been assembled and will be further assessed and reviewed herein:

- Alternative 1 – *In situ* Groundwater Treatment;
- Alternative 2 – Groundwater Treatment at BMU WTP No. 3; and
- Alternative 3 – Relocation of BMU Pumping Wells.

Each of these alternatives for the Site are described in the following subsections and evaluated further in Section 4 and 5 relative to anticipated effectiveness, implementability, and cost.

Alternative 1 was developed based on extensive experience with similar *in situ* treatment applications, with assistance from a qualified remediation vendor (Redox Tech LLC). Alternatives 2 and 3 were developed with the preliminary scoping and costing assistance from Waters Engineering, Inc. (Waters), a BMU engineering consultant, with permission from the BMU Operations Manager.

### 3.1 Alternative 1 – *In situ* Groundwater Treatment

Alternative 1 consists of actively treating groundwater *in situ*, to prevent the continued migration of CVOCs towards the BMU water supply wells. The estimated horizontal extent of the CVOC plume (5+ acres) is such that it is not practical to treat the entire plume area simultaneously. Therefore, under this alternative a series of treatment barrier lines (TBLs) would be installed, oriented roughly perpendicular to the groundwater flow direction, to intercept and treat the CVOCs as they migrate through the treatment zones.

The selected treatment process for Alternative 1 is biochemical reductive dechlorination of the Site CVOCs. Reductive dechlorination of CVOCs via chemical reduction and anaerobic biological processes is an effective, proven technology for the remediation of PCE and its breakdown products. These technologies, which retain a relatively long active period for treatment, are suitably applicable for use in the proposed treatment arrangement (*i.e.,* lines of treatment zones).

Conceptually, four TBLs would be installed across the width of the CVOC plume at variable distances downgradient from the historic drycleaning area on the AUCA Property and upgradient of the BMU wells to address CVOCs within the Site plume. The TBLs would be placed in locations based on plume configuration, but also accounting for accessibility due to existing infrastructure that includes buildings, a public roadway, and buried utilities.

A preliminary layout of the proposed TBLs is presented in **Figure 3** and has been developed based on the current understanding the CVOC plume configuration and likely utility conflicts. The injection components would be designed to sufficiently treat CVOCs to the horizontal extent and depths where they exceed MCLs. The number and location of *in situ* treatment features presented herein are considered preliminary and will be adjusted and modified as additional information is obtained during the remedial design (*i.e*., additional monitoring wells to refine the configuration of the plume).

The first line of *in situ* treatment, TBL-1, would be placed within the parkway along the east side of North West Street and west of the AUCA building. A second line of *in situ* treatment (TBL-2A and TBL-2B) would be established [redacted] on the BMU Property. For the purpose of this FFS, the TBL-2 array has been broken into two separate TBLs to avoid infrastructure conflicts.

- TBL-1 and TBL-2A/2B will provide reductive dechlorination of the CVOCs via the injection of biological substrates including a carbon source such as lactate, along with other amendments such as bioaugmentation, pH buffers, and/or oxygen scavengers to promote the desired biological reductive dechlorination processes. An initial injection as a one-time event of a strong reducing agent, *i.e.,* zero-valent iron (ZVI) using direct push or similar means, may be included as part of the *in situ* treatment approach.
- Continuous treatment across the CVOC plume would be created by the installation of a series of injection points/wells designed to achieve overlapping zones of influence. Permanent injection wells provide the ability to re-introduce biological amendments and thereby continue to treat the groundwater over time, as needed, to achieve remedial objectives.

TBL-3 and TBL-4 would provide *in situ* treatment of the CVOCs directly upgradient of, and proximal to, BMU wells CW-08 and CW-13.

- These treatment lines would provide direct chemical reduction of the CVOCs via the injection of ZVI. ZVI is capable of rapidly reducing CVOCs to inert end products, with little or no creation of intermediate compounds, and is thus an appropriate application nearer to the two water supply wells.
- ZVI particles would be directly injected into the aquifer as a one-time event using direct push or similar means (*i.e.*, temporary points), and therefore no injection well infrastructure would be required.
- Once injected, ZVI can provide a long term treatment mechanism, lasting up to several years. For this Site, the ZVI would only need to remain active for the period of time necessary to remove CVOCs from the shallow aquifer upgradient, via the TBL-1 and TBL-2 treatment lines.

Performance monitoring wells would be placed upgradient and downgradient of each *in situ* treatment line to monitor CVOCs and other key parameters (*e.g.,* pH, select inorganics) necessary to gauge remedial performance.

## 3.2 Alternative 2 – Groundwater Treatment at BMU WTP No. 3

Alternative 2 would consist of upgrading BMU WTP No. 3 to provide the capability to treat CVOCs and remove them from the water supply. Under this alternative, granular activated carbon (GAC) treatment units would be integrated into the existing process treatment at WTP No. 3. The GAC units would be designed to meet the maximum flow capacity [redacted] of the plant and potential future loading of CVOCs. GAC is an effective, proven technology for the removal of PCE and its breakdown products from water.

GAC treatment would likely be inserted to the existing treatment train downstream of the existing sand filters to minimize solids loading onto the GAC units. The existing treatment plant building would be expanded to house the GAC units and associated equipment (pumps, backwash tanks, etc.). The GAC system would include integrated controls and digital telemetry that would be tied into the existing plant's controls systems. The GAC system overall, would conceptually consist of multiple sets of GAC units (4 to 6 units) configured in a parallel (split) flow configuration.

GAC media would be periodically removed and replaced with fresh carbon, as the GAC becomes spent (treatment capacity reached). Backwash liquids would be disposed of at the publicly owned treatment works (POTW) and solids collected from backwashing and filtering would be managed along with existing solids collected by the current WTP No. 3 system.

## 3.3 Alternative 3 – Relocation of BMU Pumping Wells

Alternative 3 would consist of replacing water supply wells CW-08 and CW-13 with new wells located remote from the CVOC plume area and in a different aquifer. Under this alternative, new water supply wells would be installed on available land [redacted] Existing wells CW-08 and CW-13 would be taken out of service and abandoned consistent with state and local requirements.

For the purposes of analysis and cost estimating, Waters identified three locations [redacted] as potential candidates for new pumping wells (see map in **Appendix A**). [redacted]

Other major items and activities associated with this alternative would include the purchase and/or lease of land for the new water wells and pipeline easements, mechanical appurtenances and telemetry, and surface restoration along the pipeline routes.

CVOC plume treatment would be accomplished via MNA that relies on naturally occurring processes such as biodegradation, adsorption, dispersion, and dilution, which have been documented in the previous groundwater investigations. This alternative thus includes 10 years of groundwater monitoring and evaluation to document the MNA processes, track CVOC concentration reductions, and confirm plume stability after the BMU's high-capacity wells [redacted] have stopped pumping.

# 4.0 Remedial Alternatives Analysis

The USEPA has developed evaluation criteria that are employed to evaluate and compare remedial alternatives. These criteria can be segregated into three primary evaluation categories:

- **Effectiveness** – Provides a measure of how well the alternative meets remedial objectives and provides overall protection to human health and the environment. Specific factors considered include the long-term permanence, ability to reduce the toxicity, mobility, or volume of the contaminants, and short-term protection afforded during implementation.
- **Implementability** – Considers the technical and administrative feasibility of each alternative. Factors considered include the availability of materials, suppliers and contractors to execute the alternative; operation and maintenance (O&M) requirements; and required approvals and permits from regulatory agencies.
- **Cost** – Considers the direct capital costs (*e.g.*, materials, equipment, construction, land, buildings) indirect capital costs (engineering services, project administration), and the long-term operation, maintenance, and monitoring (OM&M) costs to implement the alternative. Where remediation timelines are relatively long, *i.e.,* Alternative 2, O&M costs are developed as net present worth (NPW) values.

## 4.1 Alternative 1 – *In situ* Groundwater Treatment

As described in Section 3, Alternative 1 consists of the *in situ* treatment using a series of treatment lines to intercept affected groundwater and conduct biochemical reductive dechlorination to remove CVOCs in groundwater.

| **Effectiveness** |
|---|
| • Reductive dechlorination using biological and chemical means are well proven technologies for effective treatment of Site CVOCs. |
| • Treatment of the CVOCs upgradient of water supply wells CW-08 and CW-13 can meet the remedial objective of preventing exposure, by preventing CVOCs from entering the BMU water supply wells. |
| • The treatment lines configured to intercept the CVOC plume can meet the remedial objective of mitigating the further migration of CVOCs towards water supply wells CW-08 and CW-13. |
| • The time required to achieve target CVOC reductions in the aquifer overall, will depend on the treatment groundwater flow and treatment dynamics associated with the TBLs. Future, spot treatments may be required to meet objectives over the entire plume area. |
| • Biochemical reductive mechanisms will establish aquifer conditions that are amenable to natural attenuation processes, if utilized as a final, future polishing step to achieve target CVOC reductions. |
| • *In situ* treatment will reduce the volume and toxicity of the CVOCs by transforming them to inert end products (ethane, ethene, $CO_2$). |
| • The alternative provides long-term permanence in that the biochemical reactions are non-reversible and in combination with effective source treatment, will permanently remove the CVOCs from the groundwater. |
| • Short-term protectiveness would be addressed with personal protective equipment (PPE), air monitoring, traffic controls, and other standard industry safety measures when conducting response actions. |

| Implementability |
| --- |
| • Materials and contractors for biochemical treatment, injection components, and well construction are readily available.<br>• Pre-design lab or pilot testing will be required to establish design parameters and evaluate water quality conditions downgradient of the treatment lines (*e.g.,* to ensure water quality is acceptable for BMU use).<br>• BMU approval for implementation of remedial components on their property would be required.<br>• Permits and approvals for implementing *in situ* treatment are typically obtainable through existing state permitting programs. These would include:<br>– A Missouri Department of Natural Resources (MDNR)-approved "Underground Injection Well Permit" for the injection of treatment chemicals into the aquifer.<br>– Well construction permits for remedial wells and performance monitoring wells. |
| **Cost** |
| Estimated Cost:<br>• [redacted]<br>• [redacted]<br>• [redacted]<br>**Appendix A** provides a detailed cost estimate for this alternative. |

## 4.2 Alternative 2 – Groundwater Treatment at BMU WTP No. 3

Alternative 2 would modify and upgrade the current treatment process at BMU WPT No. 3 to be able to effectively treat and remove CVOCs from the BMU water supply.

| Effectiveness |
| --- |
| • GAC treatment is a proven technology for the effective removal of Site CVOCs from a pumped water stream.<br>• Removing the CVOCs prior to distribution of the water from WTP No. 3 would meet the remedial objective of preventing exposure to water containing CVOCs.<br>• This alternative would not meet the remedial objective of minimizing the further migration of CVOCs towards the water supply wells; however, the exposure pathway would be effectively removed. Future migration beyond the CW-08 and CW-13 wells would likely be controlled for the duration that these wells remain active.<br>• This alternative will not effectively reduce the mobility or toxicity of the CVOCs in the groundwater, and only gradually reduce CVOC volume over time. A long period of time (*i.e.,* several decades) would be required for the CVOCs to be removed from the groundwater via pumping alone.<br>• The long-term permanence in this alternative would rely on pumping from the [redacted] aquifer for a long period.<br>• There are no major issues regarding short-term protectiveness, as potential exposure to CVOCs by BMU workers would be minimal. |

| Implementability |
|---|
| • Equipment, materials, and contractors for implementing upgrades to WTP No. 3 are readily available.<br>• Pre-design lab and/or pilot testing may be required to establish design parameters for GAC treatment.<br>• BMU approval would need to be obtained to implement a significant change, and associated increased operating cost, for WTP No. 3. No third party approvals for off-Site components would be required.<br>• BMU's National Pollutant Discharge Elimination System (NPDES) Permit would need to be modified and approved by MDNR. |
| **Cost** |
| Estimated Cost:<br>• [redacted]<br>• [redacted]<br>• [redacted]<br><br>**Appendix A** provides a detailed cost estimate for this alternative. |

## 4.3 Alternative 3 – Relocation of BMU Water Supply Wells

Alternative 3 would involve constructing new water supply wells [redacted] Existing supply wells CW-08 and CW-13 would be removed from service and abandoned. Plume treatment would be accomplished via MNA.

| Effectiveness |
|---|
| • Taking water supply wells CW-08 and CW-13 out of service would meet the remedial objective of preventing exposure to groundwater containing CVOCs.<br>• Discontinuing pumping from the BMU wells will significantly reduce the rate of CVOC migration in groundwater.<br>• CVOCs in groundwater would be addressed using MNA processes.<br>• A groundwater use restriction for the BMU property may be implemented to remove this potential exposure pathway during the remediation period.<br>• If there is a hydraulic connection between the [redacted], the new high-capacity water withdrawals [redacted] could potentially alter the CVOC plume direction and geometry over the long term.<br>• Some BMU water treatment activities (e.g., iron and manganese removal) could be reduced by using the [redacted].<br>• This alternative can reduce the volume, toxicity, and mobility of the CVOCs in the groundwater although a long time period would be required.<br>• Long-term permanence for CVOCs in groundwater would rely on the ability of MNA to ultimately achieve cleanup goals.<br>• There are no major issues regarding short-term protectiveness, as potential exposure to CVOCs is eliminated. |

| Implementability |
| --- |
| • Equipment, materials, and contractors for constructing new wells and pipelines are readily available.<br>• The locations of replacement wells would need to be verified, to ensure they would adequately meet BMU's requirements for water quantity and quality. If the preliminary well locations are proven to be unsuitable, alternative locations would need to be developed.<br>• BMU and MDNR approval would need to be obtained to implement a change in the water supply [redacted].<br>• Some third party approvals (land purchase, easement) for implementing off-Site components (wells and piping) would be required but could likely be implemented.<br>• State approval for new water supply wells would be required but should be attainable.<br>• Groundwater monitoring and evaluations for MNA are readily implementable using the existing monitoring well network. |
| **Cost** |
| Estimated Cost:<br>• [redacted]<br>• [redacted]<br>• [redacted]<br><br>**Appendix A** provides a detailed cost estimate for this alternative. |

# 5.0 Comparative and Uncertainty Analyses

## 5.1 Comparative Analysis of Alternatives

A comparative analysis of the three remedial alternatives to each of the evaluation criteria is presented below.

| Alternative/Criteria | Overall Effectiveness | Implementability | Cost |
|---|---|---|---|
| Alternative 1 – In situ Treatment | **Good** – Can reduce or eliminate the potential for CVOCs exposure in the BMU water supply. Capable of significantly reducing CVOC levels and thereby limiting future migration of CVOCs in groundwater. | **Good** – Readily Implementable with BMU and regulatory approvals | Lowest [redacted] |
| Alternative 2 – Treatment at BMU WTP No. 3 | **Good** – meets objective of eliminating exposure, by removing CVOCs prior to distribution in the water system. By continued pumping, would likely control future migration of CVOCs beyond water supply wells CW-08 and CW-13. | **Fair** – Implementable but would require BMU and other regulatory approvals. | Highest [redacted] |
| Alternative 3 – Relocate Water Supply Wells | **Good** – eliminates the potential for CVOC exposure via the BMU water supply and reduces the CVOC migration rate. MNA viability and plume stability will need confirmation after BMU pumping wells are taken out of service. | **Good** – Readily Implementable with BMU and regulatory approvals | Middle [redacted] |

## 5.2 Uncertainty/Sensitivity Analysis

An analysis was conducted to assess the effects of variations in the key assumptions that are included in the scope and costs developed for the remedial alternatives. The purpose of this evaluation is to identify elements that contain the greatest level of uncertainty, that would also have the greatest potential implications regarding the effectiveness, implementability, or cost of that alternative.

### *5.2.1 Alternative 1 – In Situ Groundwater Treatment*

The major uncertainties associated with this alternative are the frequency and number of treatment events and the time required to distribute the treatment chemicals holistically throughout the aquifer sufficiently to achieve remedial objectives. These uncertainties would be managed by increasing the number of treatment cycles, and/or providing some “spot treatment” in sub-areas that are not effectively being treated with the initial *in situ* treatment array. These modifications were addressed in the range of costs included in the cost estimate for this alternative and allow for up to a 23% increase from the baseline alternative cost.

### 5.2.2 Alternative 2 – Groundwater Treatment BMU WTP No. 3

The type of equipment and effectiveness of GAC in removing Site CVOCs is well established. The main technical uncertainty with this alternative relates to the carbon unit sizing (empty-bed contact time) and its usage rate (time to break-through). The carbon unit sizing and the frequency of GAC media changeouts after break-through will be directly dependent on the influent water quality loading rates (CVOCs and other constituents that adsorb to GAC) incurred in the future, which can only be estimated at this time. These uncertainties were addressed in the range of costs included in the cost estimate for this alternative and allow for up to a 50% increase from the baseline alternative cost.

The other main uncertainty is whether the BMU would approve this alternative, as it would present a major upgrade to their current treatment system, require an NPDES permit modification, and require a significant cost investment (capital and long-term O&M) for the new equipment.

### 5.2.3 Alternative 3 – Relocation of Water Supply Wells

For this alternative, the equipment and technology for implementing and connecting new water supply wells are well established. The primary uncertainty relates to the location of the new supply wells. If the preliminary locations developed in this FFS prove unsuitable or the necessary land cannot be secured, alternate locations would need to be developed.

The other major uncertainty is the amount of time required for MNA processes to reduce CVOC concentrations in groundwater over time and achieve plume stability. This uncertainty can be managed by evaluating the plume dynamics and MNA processes once the existing wells [redacted] (CW-08 and CW-13) have stopped pumping. If MNA processes are more gradual than estimated, an additional ten years of MNA monitoring may be required.

These uncertainties were addressed in the range of costs included in the cost estimate for this alternative and allow for up to a 26% increase from the baseline alternative cost.

[redacted]

[redacted]

[redacted]

# Appendix A: Remedial Alternatives Cost Estimates

- A1: Alternative 1- In situ Treatment
- A2: Alternative 2 - Treatment at BMU WPT No. 3
- A3: Alternative 3 - Relocation of BMU Water Supply Wells

# A1
# Alternative 1 – In situ Treatment

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

# A2
# Alternative 2 – Treatment at BMU WPT No. 3

[redacted]

## A3
## Alternative 3 – Relocation of BMU Water Supply Wells

[redacted]

[redacted]

[redacted]