Final Report

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Appendix B: Tables

Project 1007 Feasibility Study
Minnesota Pollution Control Agency

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Tables

Table 1. Groundwater Remedial Technology Screening and Qualitative Scoring.

General Response Action	Potential Remedial Technology	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical & Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) & Screening Comments
No Further Action	Continued operation of POETSs or Municipal Treatment	Impacted communities will receive clean drinking water either through plans detailed in the CDWSP or other treatment approaches if not detailed in the CDWSP or if updates to the CDWSP are required.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Poor. Will not reduce PFAS concentrations in the drinking water aquifers or protect downgradient receptors, though affected residents would receive clean drinking water.	Moderate. Multiple POETs and municipal water treatment plants are required to provide safe drinking water to municipalities.	Good. CDWSP proposes the use of GAC for water treatment which is readily available.	Moderate. Significant costs are required for implementation and annual O&M for the CDWSP.	Yes. No further action provides a baseline against which other technologies can be compared.
Access Restrictions	Institutional Controls/ Engineering Controls	Access restrictions can include groundwater use restriction or management areas, property deed notices, declaration of environmental restrictions, and fencing/signage.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Poor. Groundwater PFAS concentrations would not be reduced and PFAS would continue to migrate downgradient.	Good. Applicable access restrictions could be easily implemented.	Good. No remedial technologies would be required.	Low. Minimal actions would be taken.	Yes. Retained for all groundwater AOCs to aid in the prevention of incidental public exposure to PFAS.
Long-Term Monitoring	Long-Term Monitoring	PFAS concentrations can fluctuate through the natural processes of sorption/retention and dispersion. Additionally, reductions in PFAS in upgradient/upstream AOCs could reduce PFAS concentrations within a specific downgradient/downstream AOC. Long-term monitoring of PFAS concentrations within an AOC would be required to determine if PFAS concentrations are decreasing.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Poor. A large PFAS mass is already present in the groundwater within each of the AOCs. While small reductions may be observed if upgradient PFAS inputs are reduced, this would likely not result in a large decrease in the groundwater concentrations or prevent downgradient migration of PFAS.	Good. This would not require additional remedial action in a specific AOC and a long-term monitoring plan would be developed. This scoring does not take into account efforts to remove the PFAS upstream.	Good. No technology required in the AOC of interest. Does not take into account the technology required for upgradient AOC.	Low. Cost does not account for costs associated with upgradient treatment.	Yes. Long-term monitoring is retained as it may be incorporated into a Site-wide remedial approach for specific AOCs and also provides a comparison for other active remediation alternatives.
Surface Water Hydrology Modifications	Reroute Stream Channel	Rerouting the stream channel would hydrologically modify streams around areas where sediment leaching is a PFAS source to groundwater.	AOC 7	Poor. As a large amount of PFAS mass is already in the aquifer, this will likely not result in large changes in groundwater concentrations.	Poor. Determining and installing a new flow path that also incorporates adequate storm water storage maybe be difficult. Additionally, the hydrology of wetland areas would be disrupted.	Good. No PFAS treatment technology required.	Low to moderate. Implementation costs would be high but ongoing O&M would be similar to that of the current channel.	No. A substantial PFAS mass is already present in the groundwater, and this approach is not expected to greatly decrease groundwater concentrations.
Surface Water Hydrology Modifications	Piping Stream Channel	Piping a segment of the Project 1007 conveyance system would prevent infiltration of PFAS-impacted water or desorption of PFAS within impacted sediment. While this remedial action would be implemented on a surface water AOC, it would impact groundwater AOCs.	AOC 7	Poor. As a large amount of PFAS mass is already in the aquifer, this will likely not result in large changes in groundwater concentrations.	Moderate. The current flow path could be utilized. This could have negative implications on the hydrology of the wetlands within the Raleigh Creek Surface Water AOC. The effect of the reduced water storage capabilities in the watershed would have to be evaluated.	Good. No PFAS treatment technology required.	Low to moderate. Implementation costs would be high but ongoing O&M would be similar to that of the current channel.	No. A substantial PFAS mass is already present in the groundwater, and this approach is not expected to greatly decrease groundwater concentrations. If considerable leaching is expected from sediment to surface water for an extended period of time after concentrations in Raleigh Creek are reduced, then this remedial approach will be reevaluated.
In-Situ Treatment	Permeable Adsorptive Barrier (PAB)	A material capable of adsorbing PFAS would be injected into shallow aquifers perpendicular to the flow of groundwater to absorb PFAS as groundwater moves through the PAB.	AOC 1	Poor to moderate. While PFAS has already spread beyond the WCL, a PAB could prevent additional PFAS mass from migrating downgradient. The PAB would only be implemented in the Quaternary Aquifer and not the bedrock aquifers, reducing the overall effectiveness of stopping the downgradient migration of PFAS. The longevity of PABs and their capacity to reduce vertical aquifer migration are uncertain.	Moderate to Good. A large PAB would be necessary to cover the entire cross sectional area of the plume migrating from WCL. The PAB would not be implemented in bedrock aquifers. Further investigation would be needed to optimize placement.	Good. Has been used at multiple PFAS-impacted sites.	Low to Moderate. No additional costs beyond initial implementation related to O&M are expected.	No, due to uncertainty around long-term performance and limited capacity to reduce vertical aquifer migration.

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General Response Action	Potential Remedial Technology	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical & Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) & Screening Comments
Ex-Situ Treatment (Target-Achieving)	Single-Use Granular Activated Carbon (GAC)	GAC is a highly porous adsorptive media made from color other organic materials like coconut shells. Organic chemicals including PFAS will adsorb into pores in the media and on the surface of the GAC. Once the pores and surface are coated with PFAS or other organic chemicals, breakthrough, or the presence of PFAS in the effluent will occur and GAC must be replaced. Spent media can then be returned to the vendor for reuse as reactivated GAC, incinerated, or disposed of at a landfill. Other technologies are in development to destroy the PFAS-impacted GAC. Single-use GAC is also termed 'virgin' GAC, indicating it has not been used previously for treatment. Drinking water treatment generally requires use of virgin media.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Good. Filtration with GAC has been shown to be highly effective at removing PFAS from water including short-chain PFAS compound such as PFBA to below detection limits, signifying that the treatment targets could be met. Breakthrough will eventually occur, especially with shorter chain PFAS compounds. Other organic chemicals in the water will compete with PFAS for binding spots and will decrease the length of time for break through to occur, decreasing the lifetime of the GAC media.	Moderate. The scoring is dependent on the AOC being targeted as some AOCs would require the filtration of large volumes of water, requiring a large treatment plant. Iron and manganese in groundwater requires pretreatment. The spent GAC would have to be transported off site for disposal or destruction. Future regulations may make this more difficult.	Good. GAC is a widely used technology.	High. While operations costs are generally lower for GAC filtration compared to other media, the costs associated with GAC replacement and disposal are high. Frequent replacement of GAC to remove short chain species would increase costs further.	Yes. However, reactivated or regenerated GAC should be used if possible instead of single-use GAC.
Ex-Situ Treatment (Target-Achieving)	Reactivated GAC	GAC can be reactivated by transporting the spent media offsite to a treatment facility and treating with steam at high temperatures in the absence of oxygen to strip PFAS and other contaminants from the active sites on the GAC. This restores the capacity of the GAC to adsorb more PFAS, and stripped PFAS is destroyed by offgas treatment. The efficiency and mass of PFAS that can be retained on reactivated GAC generally decreases as it is repeatedly reactivated.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Good. Filtration with reactivated GAC, as with virgin GAC, can meet applicable treatment targets. Pretreatment is recommended for groundwater to remove iron and manganese which can precipitate and foul the filters, reducing PFAS adsorption capacity.	Good. Reactivated GAC is widely used for PFAS treatment. If desired for drinking water use, however, implementability would depend on the treatment plant’s ability to manage large amounts of GAC that require reactivation.	Good. This technology is already implemented at the treatment capacities required at all of the AOCs.	Moderate to High. Costs provided by Calgon Carbon indicate reactivation is typically cheaper than virgin GAC by up to 50%. Disposal costs may also be decreased by reactivation, though the degree of cost savings may dependent on the transportation costs and distance to the nearest reactivation facility. Outside of costs associated with the GAC, operation and maintenance costs are generally low. As with single-use GAC and other filtration media, the need for pretreatment would add to material and operation and maintenance costs.	Yes. Reactivated can achieve treatment targets and is implementable.
Ex-Situ Treatment (Target-Achieving)	Regenerated GAC	Regenerated GAC uses the same removal mechanisms as single-use GAC except that instead of reactivation, disposing or destroying the spent GAC, it is treated onsite with a solvent or steam under lower temperature conditions than reactivation to remove contaminants. Thermal regeneration heats GAC to 200°C with steam or nitrogen, as opposed to the higher temperatures required by reactivation. Solvent regeneration of GAC is also in development.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate. Regerated GAC is expected to have PFAS removal performance comparable to virgin GAC and capable of meeting the applicable treatment targets although more frequent GAC changeouts may be required. A site-specific study would be required to evaluate both ability of the GAC to be regenerated and to assess the time to breakthrough and empty bed contact time required with the regenerated GAC.	Moderate. The size and complexity of the treatment plant would depend on the AOC being treated and the required treatment plant capacity. The addition of regeneration does increase the complexity of the system as does pretreatment for iron and manganese.	Poor to Moderate. Not all onsite regeneration technologies may currently be scalable to treat the volume of GAC required depending on the target AOC(s).	High. The capital cost of onsite regeneration equipment is higher than for a single use GAC system, but the cost to regenerate GAC may be lower than the cost of new GAC over the lifespan of the system.	No. Regenerative GAC is not available at the required scale.
Ex-Situ Treatment (Target-Achieving)	Single-Use Ion Exchange	Ion-exchange resin removes PFAS from waste streams via two mechanisms: ion-exchange of a PFAS chain's anionic head with resin anions, and adsorption into the resin itself. Spent single-use resins are currently disposed of at a landfill or incinerated.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Good. Ion exchange can achieved the treatment targets. Pretreatment would be needed to prevent fouling of the ion exchange resin. Once breakthrough occurs, the ion exchange resin would be replaced.	Moderate. Scoring is dependent on the AOC being targeted and the volume of water being treated. IX does require a smaller footprint compared to GAC treatment, but may require more stringent pretreatment. Treatment or disposal options for spent single-use IX are currently limited to landfilling and incineration, although the future of regulations regarding offsite disposal is uncertain, and the availability of facilities accepting PFAS-containing waste may become more limited.	Good. IX resins are widely commercially available.	High. The size and cost of a treatment plant would be dependent on the required treatment volume. Pretreatment may also significantly increase costs. Operations and maintenance costs are also high as resin management, including disposal, can be expensive.	Yes. IX can achieve treatment targets and is readily implementable.

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Ex-Situ Treatment (Target-Achieving)	Regenerable Ion Exchange	Regenerable IX relies on the same mechanisms for PFAS removal described for Single-Use Ion Exchange; however, regeneration extends the lifespan of resins by desorbing PFAS from spent resin to allow the resins to be reused, thereby reducing solid waste from IX resin. The solution required for regeneration is dependent on PFAS composition and concentration in the raw water.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate. PFAS removal performance is often comparable to virgin GAC and capable of meeting the applicable treatment targets although more frequent GAC changeouts may be required. A site-specific study would be required to evaluate both ability of the GAC to be regenerated and to assess the time to breakthrough and empty bed contact time required with the regenerated GAC.	Moderate. Filtration with regenerable ion-exchange resin could be implemented at the Site. The size of the treatment facility would be dependent on the AOC. The spent media could be regenerated and reused, and the PFAS concentrated into "still bottoms" could be disposed of or treated with a destruction technology. The presence of anions, dissolved solids, and organics in surface water could decrease the lifespan of the resin.	Moderate. Regenerable ion exchange resins are commercially available and have been demonstrated in pilot and limited full-scale applications, but they are not as widely used as single-use IX, nor are offsite resin regeneration services widely available.	High. Capital costs for an onsite regeneration system would significantly increase initial cost and would be dependent on the required treatment capacity. Pretreatment would be required.	Yes. Regenerable IX is only retained for the treatment of groundwater if the water will not be used for public distribution.
Ex-Situ Treatment (Target-Achieving)	Nanofiltration (NF)/ Reverse Osmosis (RO)	NF and RO are high-pressure membrane methods used to remove PFAS. NF and RO membranes allow clean water to pass through tiny ports in the membranes, which generates a clean water, or permeate, stream. The retained liquid, which includes PFAS and other contaminants, is called the membrane concentrate or membrane reject. RO removes a broader range of compounds than NF due to the smaller pores of RO membranes, but NF will generate more permeate than RO for the same volume of water treated.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Good. RO treatment of PFAS-containing groundwater is expected to achieve the applicable treatment targets. NF is also expected to achieve applicable targets, although pilot testing would be required to optimize PFBA rejection.	Moderate. The size of the treatment plant is smaller than required for other treatment technologies although the required pretreatment and potential destruction technologies would add to the size and complexity of the treatment plan.	Good. RO and NF are used in large-scale drinking water applications and membranes are commercially available and approved for drinking water treatment.	High. Additional costs for pre-treatment an post-treatment infrastructure.	Yes. NF and RO membranes can achieve treatment targets and are readily implementable.
Ex-Situ Treatment (Non-Target-Achieving Separation)	Novel Adsorbents	Novel adsorbents that are alternatives for GAC and IX, have been developed with potentially improved PFAS adsorption capacity to reduce the rate of media changeouts. Modified clay adsorbents are the most common, but other materials in development include polymer-coated sand, modified cyclodextrin, gel polymers, cellulose, and metal-organic frameworks.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate to good. Have potential to remove up to 99 percent of PFAS and in some cases reach treatment targets. The effectiveness is expected to be variable based on the adsorbent and its ability to remove PFAS from the Site-specific water. A bench-scale study would be required to better evaluate effectiveness and adsorption capacity.	Moderate. Disposal options are likely limited to landfilling or incineration. Novel adsorbents are not approved for drinking water treatment so they would likely not be implementable for groundwater treatment in cases where the groundwater would be distributed as drinking water or injected into groundwater. Required pretreatment to minimize fouling would be significant.	Poor to moderate. Modified clays are commercially available; however, they are not approved for the use of drinking water in the state of Minnesota. Other novel adsorbents are not yet commercially available or are only being implemented at the pilot scale.	High. Pretreatment would likely be required for both the treatment of groundwater to extend media life.	No. Not approved for drinking water treatment and have limited full scale use compared to GAC and IX. Novel adsorbents, however, should be further investigated in the future, particularly if short-chain PFAS removal is demonstrated to be superior to GAC or IX.
Ex-Situ Treatment (Non-Target-Achieving Separation)	Coagulation and Flocculation	The addition of a coagulant followed by flocculation is used in traditional water treatment to remove solids. PFAS has been found to be separated into the flocs and removed during settling or filtration post flocculation. The efficiency is dependent on the type of coagulant and flocculation time and is dependent on the relative starting concentration of PFAS.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Poor. Traditional coagulants are not effective. In areas with higher initial PFAS concentrations, additives designed for PFAS removal (e.g. PerfluorAd®) may perform well as a method to remove the bulk of PFAS in a sample. With the more dilute concentrations that are observed in the AOCs on this Site, however, its effectiveness is unknown, and PerfluorAd® is scored as poor. Bench-scale or pilot studies could change this scoring in the future.	Poor. Treatment of groundwater for the site would require treating millions of gallons per day, making treatment with a polymer addition unlikely to be implementable. It is unknown what could remain in the water after treatment, likely complicating administrative approvals.	Moderate. This is a commonly used process in water treatment; however, coagulation for PFAS removal is typically used on more concentrated sources.	Moderate. The required infrastructure is potentially smaller in comparison to a larger treatment facility.	No. The relative concentration of PFAS is not expected to be high enough to perform well with this technology.
Ex-Situ Treatment (Non-Target-Achieving Separation)	Electrocoagulation and Flocculation	A high-density electrical current is used as a coagulant to form flocs. PFAS may sorb and concentrate on the produced flocs. Flocs must be separate from the bulk water and once separated, may be dissolved in an acid for further treatment.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate to good. Large reductions in PFAS concentrations have been observed with water containing higher PFAS concentrations than is observed in the groundwater at the Site. A pilot study would need to be conducted to evaluate the effectiveness with Site-specific water.	Moderate. Electrocoagulation is commercially available and is most commonly implemented as part of wastewater treatment but could be implemented as part of a surface water treatment train. A smaller volume of flocs is produced with electrocoagulation compared with traditional coagulation/flocculation.	Poor to moderate. Although electrocoagulation units are commercially available, they are not widely used or tested. Current installations have been focused on landfill leachate and may not be as applicable for lower influent concentrations or for drinking water applications.	High. Capital and annual costs are high. Annual electrical requirements are high.	No. Full-scale demonstrations for PFAS are limited and the technology is not ready for full-scale implementation.

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Ex-Situ Treatment (Non-Target-Achieving Separation)	Foam Fractionation	Foam fractionation removes and concentrates PFAS by injecting air into vessels containing impacted water. Foam forms at the top of the vessel and is removed and can be further concentrated by repeating the same process. Foam fractionation can generate highly concentrated PFAS waste.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate to good. Reduces concentrations of long chain PFAS compounds including PFOS and PFOA by over 90% but does not reduce concentrations to below the applicable standards. Can effectively be used as pretreatment to reduce PFAS loading to filtration media.	Moderate to good. The size of the treatment facility will depend on the treatment volumes required. Size of the treatment plant does present challenges, as it would be the largest implementation to date	Moderate to good. Technology is commercially available but not at the scale required for groundwater treatment; however, plans are in place to construct a plant capable of treating the volumes required for the AOCs.	High due to capital costs. Energy and O&M costs are expected to be lower than for other ex-situ technologies.	Yes. Foam fractionation may offer a way to reduce media usage while treating groundwater.
Ex-Situ Treatment (Non-Target-Achieving Separation)	Ozofractionation	Ozofractionation is a foam fractionation process that incorporates the use of ozone along with air to improve PFAS removal efficiency. Foam produced with ozone may be more stable than foam produced by air alone, and ozone may improve the removal of short-chain PFAS.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate. Has been shown to be effective at concentrating PFAS at the pilot scale with wastewater with high organic content. The ability to concentrate lower organic containing water is uncertain.	Poor to moderate. Pilot studies have been completed however the technology is not as advanced as air based foam fractionation systems. The generation and delivery of ozone also a concern.	Poor to moderate. Technology is commercially available but a limited number of pilot studies have been conducted.	High due to capital costs. Energy and O&M costs are expected to be lower than for other ex-situ technologies, though use of ozone increases energy use relative to traditional foam fractionation.	No. The additional safety concerns and energy usage associated with use of ozone are not expected to be worth potential increases in removal efficiency of PFAS.
Ex-Situ Treatment (Disposal)	Landfill	PFAS-containing waste would be disposed of in a lined, PFAS-approved landfill with leachate collection and treatment systems.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Good. All PFAS waste would be removed from the Site and accomplish RAOs; however, it would not be destroyed.	Poor to moderate. There is regulatory uncertainty associated with landfilling PFAS-waste, as more landfills are not accepting PFAS-containing waste. No landfills in Minnesota are currently accepting PFAS-containing waste, so transportation costs would be significant.	Good. PFAS-impacted waste can be sent to landfills out of state currently.	Moderate. Landfilling costs are lower than those of destruction technologies, but costs may increase depending on the proximity of the landfill to the Site.	Yes. Landfilling is only retained in the short term to handle waste as other technologies are being implemented. It is not retained as a long-term remedial solution because of uncertainty around the continuation of landfills accepting PFAS-containing waste.
Ex-Situ Treatment (Destruction)	Incineration	Incineration at temperatures above 1,000°C has been found to destroy PFAS in liquids and solids at an efficiency greater than 99.99%, with shorter chains requiring temperatures as high as 1,400°C for destruction. Thermal oxidizers, operated at similar temperatures to incinerators, have been shown to remove PFAS in contaminated gas streams. Thermal oxidizers can be added to the emissions line of other treatment systems such as GAC reactivation facilities, thermal desorption of soil, or to an incinerator to destroy PFAS transferred to the vapor phase during the process.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Good. Incinerators that maintain temperatures of 1,000 °C or more can achieve 99.99% destruction efficiency. Lower destruction efficiency, especially of shorter chain PFAS compounds, is observed with lower temperatures, which could result in PFAS being released through air emissions.	Good. At this time there are hazardous waste incinerators that the waste could easily be hauled to. If regulations change and these are no longer in operation, the implementability would be poor.	Good. The required incineration facilities are already operational.	Moderate. While disposal costs are high, if the PFAS can be concentrated into a liquid or solid media, the costs are lower relative to the capital and O&M costs associated with other destruction technologies. Transportation costs will be high due to the distance required to move the waste.	Yes. as regulations regarding the incineration of PFAS may change, incineration should only be viewed as a short-term option for destruction while other technologies for the destruction of PFAS are further developed and commercialized.
Ex-Situ Treatment (Destruction)	Supercritical Water Oxidation (SCWO)	Supercritical water is defined as water above 374°C and 218 atmospheres; at this point, chemical reactions that do not occur at standard temperature and pressure begin to occur, including the oxidation of PFAS. SCWO systems operate above these temperatures and pressures to destroy PFAS through oxidation. SCWO produces large amounts of salts and requires an organic co-fuel in waste streams with low organics concentrations.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate to Good. Destruction efficiency is typically greater than 99% for all PFAS and the formation of shorter PFAS chains was not observed. However, effluent concentrations will remain above treatment targets , requiring the effluent to be recycled within the treatment train	Moderate. The commercially available unit can be housed in a shipping container and readily implemented at the Site. A pilot study is required to better evaluate the required O&M associated with low pH, salt precipitation, reagents, and cooling.	Moderate to Good. While this technology is still undergoing pilot studies, it has been implemented with a variety of waste streams and is commercially available through several vendors.	High. In addition to high capital costs, O&M costs are expected to be high because of the electrical requirements and potentially the cleaning requirements to remove precipitates and prevent acid corrosion. The cost of consumables, such as a co-fuel, is dependent upon the starting organics concentrations in the concentrated feedstocks.	Yes. At this stage, all destruction technologies are retained.
Ex-Situ Treatment (Destruction)	Hydrothermal Alkaline Treatment (HALT)	HALT destroys PFAS at sub-supercritical conditions using a highly alkaline pH (which achieved with addition of sodium hydroxide). Under these conditions, water behaves like a nonpolar solvent and allows for catalytic degradation of organics, including PFAS. HALT can produce large amounts of salts from degradation of organic compounds.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate to Good. The destruction efficiency is over 99% for total PFAS; however, the effluent concentrations are still above treatment targets requiring the effluent to be recycled within the treatment train. Site-specific bench scale and pilot studies are also required to determine the effectiveness with Site-specific PFAS concentrate.	Moderate. The commercially available unit can be housed in a trailer and readily implemented at the Site. A pilot study would be required to better evaluate the required O&M.	Moderate. A limited number of field-based pilot studies have been completed to date, but more tests are planned with additional waste streams.	High. Capital costs are expected to be high and the O&M costs are uncertain. Reagents are inexpensive; however, it is unknown if there will be maintenance challenges associated with the Site-specific water chemistry (high hardness) and cleaning requirements are uncertain.	Yes. At this stage, all destruction technologies are retained.

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Ex-Situ Treatment (Destruction)	Electrochemical oxidation	By applying an electrical current through a conductive solution between a cathode and anode, PFAS are oxidized and degraded at the electrode or in the bulk liquid. Electrochemical oxidations often requires addition of salts in low conductivity waste streams and of pH buffers to protect electrodes.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate. Long-chain PFAS compounds are reduced by over 99% but concentrations of short chains did not decrease and, in some instances, increased, during the pilot study as a result of sequential defluorination	Moderate. The systems are housed in a trailer and could easily be implemented at the Site. The DE-FLUORO™ pilot study highlighted areas of increased O&M requirements for operators, but system modifications will continue to address these to decrease O&M frequency. The electrodes are expected to require cleaning and maintenance.	Moderate. Multiple companies have completed pilot testing, and more field trials are planned. Systems utilizing electrochemical oxidation are available through multiple vendors.	High. The capital cost is predicted to be similar to other destruction technologies. Electrical requirements are less than other destruction technologies; however, the costs associated with electrode replacement could be high.	Yes. At this stage, all destruction technologies are retained.
Ex-Situ Treatment (Destruction)	Plasma	Electrical discharge is induced between two electrodes near the PFAS-containing liquid. Plasma, an electrically-charged gas, forms above the liquid and ionizes gas molecules. Once PFAS adsorbs onto water bubble interface with the plasma, the charged section of the PFAS molecule collides with high energy ions in plasma state that cleave carbon-fluorine bonds, destroying PFAS.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate to Good. Over 97% of the total PFAS was destroyed in testing completed with PFAS concentrated waste from other sites.	Moderate. The commercially available unit, currently produced by Onvector, can be housed within a trailer and easily installed at the Site. There is uncertainty associated with the required O&M and a pilot study would be required to better evaluate the required O&M.	Moderate. Systems are commercially available by multiple vendors although full-scale pilot testing is limited. For limited waste volumes (e.g., firefighting foam), a pilot unit could be considered scaled but would not be sufficient for the AOCs.	High. Capital costs are expected to be similar to other destruction technologies. Costs associated with O&M are uncertain and would be better determined during a pilot study.	Yes. At this stage, all destruction technologies are retained.
Ex-Situ Treatment (Destruction)	Photolysis and Photochemical Destruction	Photolysis is the breakdown of chemicals using energy from light, including ultraviolet (UV) light. While the carbon-fluorine bonds in PFAS compounds are not efficiently broken during the direct application of light (or direct photolysis), carbon-fluorine bonds can be broken as a result of indirect photolysis, which occurs when the addition of chemical oxidants or photocatalysts forms reactive species in the presence of light.	AOC 1 AOC 2 AOC 4 AOC 7 AOC 10	Moderate. A large decrease is observed in of TOF concentrations is observed in PFAS concentrate from other sites; however, the PFAS concentrate from the Site is primarily composed of PFOS, which was observed to have a lower degradation rate in the Claros bench-scale study.	Moderate. The commercially available units could easily be installed at the Site. There is uncertainty with the required O&M and a pilot study is required to better evaluate the required O&M.	Poor to moderate. Treatment units are commercially available, but at the time of writing this report, data from additional pilot studies at PFAS-impacted sites are needed to better evaluate the state of development.	High. The capital cost is predicted to be similar to other destruction technologies. Electrical requirements are less than other destruction technologies; however, it is unclear how expensive reagents are or what other O&M costs would be required.	Yes. At this stage, all destruction technologies are retained.

Legend: AOC = area of concern; CDWSP = Conceptual Drinking Water Supply Plan; O&M = operations and maintenance; POETS = point of entry treatment system; TOF = total organic fluoride; WCL = Washington County Landfill.

AOC 1 = Washington County Landfill Surface Water and Shallow Groundwater; AOC 2 = Washington County Landfill Bedrock Aquifers; AOC 4 = Oakdale Disposal Site Groundwater; AOC 7 = Raleigh Creek and Eagle Point Lake Groundwater; AOC 10 = West Lakeland Groundwater.

Table 2. Surface Water Remedial Technology Screening and Qualitative Scoring.

General Response Action	Potential Remedial Technology/Action	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical and Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) and Screening Comments
No Further Action	No Further Action	No further actions or responses including sampling would be implemented with regards to surface water treatment.	AOC 5 AOC 6 AOC 8 AOC 9	Poor. Will not further reduce surface water concentrations.	Good. No action would be taken so this is readily implementable.	Good. No technology is required.	Low. There is no direct cost associated with no further action. However, this does not consider the associated costs with allowing PFAS to continue migration through surface waters.	Yes. No further action provides a baseline against which other technologies can be compared.
Access Restrictions	Institutional Controls/ Engineering Controls	Exposure pathways would be controlled with administrative measures. Institutional controls could include fish consumption advisories and signage. Engineering controls could include fencing and removal of access points.	AOC 5 AOC 6 AOC 8 AOC 9	Poor. Relies on administrative measures to limit exposure to surface water impacts and does not prevent infiltration of surface water to groundwater.	Good. Could be readily implemented.	Good. No technology is required.	Low. Minimal action would be taken.	Yes, retained as possible component of alternatives for all surface water AOCs to aid in the prevention of incidental public exposure to PFAS.
Long-Term Monitoring	Long-Term Monitoring	PFAS concentrations can fluctuate through the natural processes of sorption/retention and dispersion. Additionally, reductions in PFAS in upgradient/upstream AOCs could reduce PFAS concentrations within a specific downgradient/downstream AOC. Long-term monitoring of PFAS concentrations within an AOC would be required to determine if PFAS concentrations are decreasing.	AOC 5 AOC 6 AOC 8 AOC 9	Poor to good. Scoring is dependent on the AOC and where the upstream treatment is ocurring. Scoring ranges from good in the Raleigh Creek AOC if PFAS was prevented from being discharged from ODS to poor in Lake Elmo which is predominantly groundwater fed and upgradient treatment of this groundwater would be more difficult.	Good. This would not require additional remedial action in a specific AOC and a long term monitoring plan would be developed. This scoring does not take into account efforts to remove the PFAS upstream.	Good. No technology required in the AOC of interest. Does not take into account the technology required for upgradient AOC.	Low. Cost does not account for costs associated with upgradient treatment.	Yes. Long-term monitoring is retained as it may be incorporated into a Site-wide remedial approach for specific AOCs and also provides a comparison for other active remediation alternatives.
Infrastructure Modifications	Reroute stream channel	Reroute conveyance system around areas where sediment leaching is a PFAS source to surface water.	AOC 5	Moderate to good. This scoring is valid if the mass of PFAS in the sediments is found to contribute to elevated PFAS surface water concentrations.	Poor. Determining a new flow path and adequate storage to prevent flooding could be difficult especially if the channel were to remain largely unpiped. There would also be regulatory issues with disrupting the hydrology of wetland areas.	Good. No PFAS treatment technology required.	Low to moderate. Initial costs are high to implement but ongoing O&M would be similar to that of the current channel.	No. Minimal impact expected and not retained for further consideration.
Surface Water Hydrology Modifications	Piping stream channel	After surface water has been treated at the outfall from ODS, a segment of the conveyance system could be piped to prevent mobilization of PFAS adsorbed to sediment and subsequent downstream migration of PFAS.	AOC 5	Moderate to good. This scoring is valid if the mass of PFAS in the sediments is found to contribute to elevated PFAS surface water concentrations.	Moderate. The current flow path could be utilized. This could have negative implications on the hydrology of the wetlands within the Raleigh Creek Surface Water AOC. The effect of the reduced water storage capabilities in the watershed would have to be evaluated.	Good. No PFAS treatment technology required.	Low to moderate. Initial costs are high to implement but ongoing O&M would be similar to that of the current channel.	No. Minimal impact expected and not retained for further consideration.
Surface Water Hydrology Modifications	Flow reduction	The control structure at the Eagle Point Lake Dam could be raised to reduce the flow from Eagle Point Lake to Horseshoe Lake.	AOC 9	Moderate. Would decrease the mass of PFAS migrating downstream of the Eagle Point Lake Dam by decreasing the flow rate through the Lake Elmo bypass pipe.	Good. Adding a stop log to the control structures already in place could easily be completed. Modeling would have to be completed to evaluate the risk of upstream flooding.	Good. No PFAS treatment technology required.	Low. Initial costs may be high, but ongoing O&M would be similar to that of the current channel.	Yes. Reduction of flow to Horseshoe Lake could be readily implemented.
In-Situ Treatment	Permeable Adsorptive Barrier (PAB)	A material that adsorbs PFAS can be placed in-stream to passively remove PFAS from surface water. In-situ PABs would likely require modification of the stream to install removable structures that house the adsorbent.	AOC 5 AOC 6 AOC 9	Moderate to Good. The loading capacity and required contact time of the filter material are not yet known and will determine how often the material will need to be changed and how long of a filter would be required to achieve a reduction in PFAS. A bypass would be required to prevent upstream flooding, reducing the effectiveness under these conditions.	Moderate to Good. This could easily by implemented in Raleigh Creek where the stream channel is well defined and smaller. It would be harder to install further downgradient such as in the channels of the West Lakeland Surface Water AOC or in the main lake bodies. Overflow control structures would be installed to prevent upstream flooding.	Moderate to good. Limited use in field studies to confirm effectiveness and longevity but the adsorptive media is readily available.	Low to Moderate. Operations and maintenance are expected to be minimal.	Yes. PABs may offer an interim solution to address PFAS migration and may be lower cost and more quickly implemented than other alternatives.

Table 2. Surface Water Remedial Technology Screening and Qualitative Scoring.

General Response Action	Potential Remedial Technology/Action	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical and Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) and Screening Comments
Ex-Situ Treatment (Target-Achieving)	Single-Use Granular Activated Carbon (GAC)	GAC is a highly porous adsorptive media made from coalor other organic materials like coconut shells. Organic chemicals including PFAS will adsorb into pores in the media and on the surface of the GAC. Once the pores and surface are coated with PFAS or other organic chemicals, breakthrough, or the presence of PFAS in the effluent will occur and GAC must be replaced. Spent media can then be returned to the vendor for reuse as reactivated GAC, incinerated, or disposed of at a landfill. Other technologies are in development to destroy the PFAS-impacted GAC. Single-use GAC is also termed 'virgin' GAC, indicating it has not been used previously for treatment. Drinking water treatment generally requires use of virgin media.	AOC 5 AOC 6 AOC 8 AOC 9	Good. Filtration with GAC has been shown to be highly effective at removing PFAS from water including short chain PFAS compound such as PFBA to below detection limits, signifying that the treatment targets could be met. Breakthrough will eventually occur, especially with shorter chain PFAS compounds. Other organic chemicals in the water will compete with PFAS for binding spots and will decrease the length of time for break through to occur, decreasing the lifetime of the GAC media.	Moderate. The scoring is dependent on the AOC being targeted as some AOCs would require the filtration of large volumes of water, requiring a large treatment plant. Natural organic matter in surface water requires pretreatment. The spent GAC would have to be transported off site for disposal or destruction. Future regulations may make this more difficult.	Good. GAC is a widely used technology.	High. While operations costs are generally lower for GAC filtration compared to other media, the costs associated with GAC replacement and disposal are high. Frequent replacement of GAC to remove short chain species would increase costs further.	Yes. However, reactivated or regnerated GAC should be used if possible instead of single-use GAC due to higher cost of single-use/virgin GAC.
Ex-Situ Treatment (Target-Achieving)	Reactivated GAC	GAC can be reactivated by transporting the spent media offsite to a treatment facility and treating with steam at high temperatures in the absence of oxygen to strip PFAS and other contaminants from the active sites on the GAC. This restores the capacity of the GAC to adsorb more PFAS, and stripped PFAS is destroyed by offgas treatment. The efficiency and mass of PFAS that can be retained on reactivated GAC generally decreases as it is repeatedly reactivated.	AOC 5 AOC 6 AOC 8 AOC 9	Good. Filtration with reactivated GAC, as with virgin GAC, can meet applicable treatment targets. Pretreatment is recommended for surface water to remove organic material which can foul the filters, reducing PFAS adsorption capacity.	Good. Reactivated GAC is widely used for PFAS treatment. If desired for drinking water use, however, implementability would depend on the treatment plant's ability to manage large amounts of GAC that require reactivation.	Good. This technology is already implemented at the treatment capacities required at all of the AOCs.	Moderate to High. Costs provided by Calgon Carbon indicate reactivation is typically cheaper than virgin GAC by up to 50%. Disposal costs may also be decreased by reactivation, though the degree of cost savings may dependent on the transportation costs and distance to the nearest reactivation facility. Outside of costs associated with the GAC, operation and maintenance costs are generally low. As with single-use GAC and other filtration media, the need for pretreatment would add to material and operation and maintenance costs.	Yes. Reactivated GAC can meet treatment targets and may be a lower cost alternative to single-use GAC.
Ex-Situ Treatment (Target-Achieving)	Regenerated GAC	Regenerated GAC uses the same removal mechanisms as single-use GAC except that instead of reactivation, disposing or destroying the spent GAC, it is treated onsite with a solvent or steam under lower temperature conditions than reactivation to remove contaminants. Thermal regeneration heats GAC to 200°C with steam or nitrogen, as opposed to the higher temperatures required by reactivation. Solvent regeneration of GAC is also in development.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate. Regerated GAC is expected to have PFAS removal performance comparable to virgin GAC and capable of meeting the applicable treatment targets although more frequent GAC changeouts may be required. A site-specific study would be required to evaluate both ability of the GAC to be regenerated and to assess the time to breakthrough and empty bed contact time required with the regenerated GAC.	Moderate. The size and complexity of the treatment plant would depend on the AOC being treated and the required treatment plant capacity. The addition of regeneration does increase the complexity of the system as does pretreatment for natural organic matter.	Poor to Moderate. Not all onsite regeneration technologies may currently be scalable to treat the volume of GAC required depending on the target AOC(s).	High. The capital cost of onsite regeneration equipment is higher than for a single use GAC system, but the cost to regenerate GAC may be lower than the cost of new GAC over the lifespan of the system.	Yes. Regenerable GAC could offer a way to reduce adsorptive media usage through GAC reuse.
Ex-Situ Treatment (Target-Achieving)	Single-Use Ion Exchange (IX)	Ion-exchange resin removes PFAS from waste streams via two mechanisms: ion-exchange of a PFAS chain's anionic head with resin anions, and adsorption into the resin itself. Spent single-use resins are currently disposed of at a landfill or incinerated.	AOC 5 AOC 6 AOC 8 AOC 9	Good. Ion exchange can achieved the treatment targets. Pretreatment would be needed to prevent fouling of the ion exhange resin. Once breakthrough occurs, the ion exchange resin would be replaced.	Moderate. Scoring is dependent on the AOC being targeted and the volume of water being treated. IX does require a smaller footprint compared to GAC treatment, but may require more stringent pretreatment. Treatment or disposal options for spent single-use IX are currently limited to landfilling and incineration, although the future of regulations regarding offsite disposal is uncertain, and the availability of facilities accepting PFAS-containing waste may become more limited.	Good. IX resins are widely commercially available.	High. The size and cost of a treatment plant would be dependent on the required treatment volume. Pretreatment may also significantly increase costs. Operations and maintenance costs are also high as resin management, including disposal, can be expensive.	Yes. IX resin may outperform GAC and is retained for further analysis.

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General Response Action	Potential Remedial Technology/Action	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical and Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) and Screening Comments
Ex-Situ Treatment (Target-Achieving)	Regenerable IX	Regenerable IX relies on the same mechanisms for PFAS removal described for Single-Use Ion Exchange; however, regeneration extends the lifespan of resins by desorbing PFAS from spent resin to allow the resins to be reused, thereby reducing solid waste from IX resin. The solution required for regeneration is dependent on PFAS composition and concentration in the raw water.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate. PFAS removal performance is often comparable to virgin GAC and capable of meeting the applicable treatment targets although more frequent GAC changeouts may be required. A site-specific study would be required to evaluate both ability of the GAC to be regenerated and to assess the time to breakthrough and empty bed contact time required with the regenerated GAC.	Moderate. Filtration with regenerable ion-exchange resin could be implemented at the Site. The size of the treatment facility would be dependent on the AOC. The spent media could be regenerated and reused, and the PFAS concentrated into "still bottoms" could be disposed of or treated with a destruction technology. The presence of anions, dissolved solids, and organics in surface water could decrease the lifespan of the resin.	Moderate. Regenerable ion exchange resins are commercially available and have been demonstrated in pilot and limited full-scale applications, but they are not as widely used as single-use IX, nor are offsite resin regeneration services widely available.	High. Capital costs for an onsite regeneration system would significantly increase initial cost and would be dependent on the required treatment capacity. Pretreatment would be required.	Yes. Regenerable IX could offer a way to reduce adsorptive media usage and reduction PFAS concentrations.
Ex-Situ Treatment (Target-Achieving)	Nanofiltration (NF)/ Reverese Osmosis (RO) Membranes	NF and RO are high-pressure membrane methods used to remove PFAS. NF and RO membranes allow clean water to pass through tiny ports in the membranes, which generates a clean water, or permeate, stream. The retained liquid, which includes PFAS and other contaminants, is called the membrane concentrate or membrane reject. RO removes a broader range of compounds than NF due to the smaller pores of RO membranes, but NF will generate more permeate than RO for the same volume of water treated.	AOC 5 AOC 6 AOC 8 AOC 9	Good. RO treatment of PFAS-containing surface water is expected to achieve the applicable treatment targets. NF is also expected to achieve applicable targets, although pilot testing would be required to optimize PFBA rejection.	Moderate. The size of the treatment plant is smaller than required for other treatment technologies although the required pretreatment and potential destruction technologies would add to the size and complexity of the treatment plan.	Good. NF/RO are used in large-scale drinking water applications and membranes are commercially available and approved for drinking water treatment.	High. High O&M costs. Additional costs for pre-treatment an post-treatment infrastructure.	No. High costs and complex treatment plant required for pre-treatment are expected to make NF and RO too expensive for surface water treatment.
Ex-Situ Treatment (Non-Target-Achieving)	Novel Adsorbents	Novel adsorbents that are alternatives for GAC and IX, have been developed with potentially improved PFAS adsorption capacity to reduce the rate of media changeouts. Modified clay adsorbents are the most common, but other materials in development include polymer-coated sand, modified cyclodextrin, gel polymers, cellulose, and metal-organic frameworks.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate to good. Have potential to remove up to 99 percent of PFAS and in some cases reach treatment targets. The effectiveness is expected to be variable based on the adsorbent and its ability to remove PFAS from the Site-specific water. A bench-scale study would be required to better evaluate effectiveness and adsorption capacity.	Moderate. Disposal options are likely limited to landfilling or incineration. Required pretreatment to minimize fouling would be significant.	Poor to moderate. Modified clays are commercially available; however, they are not approved for the use of drinking water in the state of Minnesota. Other novel adsorbents are not yet commercially available or are only being implemented at the pilot scale.	High. Pretreatment would likely be required for both the treatment of surface water to extend media life.	No. Novel adsorbents have limited full-scale use compared to GAC and IX. Novel adsorbents, however, should be further investigated in the future, particularly if short-chain PFAS removal is demonstrated to be superior to GAC or IX.
Ex-Situ Treatment (Non-Target-Achieving)	Coagulation and Flocculation	The addition of a coagulant followed by flocculation is used in traditional water treatment to remove solids. PFAS has been found to be separated into the flocs and removed during settling or filtration post flocculation. The efficiency is dependent on the type of coagulalent and flocculation time and is dependent on the relative starting concentration of PFAS.	AOC 5 AOC 6 AOC 8 AOC 9	Poor. Traditional coagulants are not effective. In areas with higher initial PFAS concentrations, additives such as PerfluorAd® may perform well as a method to remove the bulk of PFAS in a sample. With the more dilute concentrations that are observed in the AOCs on this Site, however, its effectiveness is unknown, and PerfluorAd® is scored as poor. Bench-scale or pilot studies could change this scoring in the future.	Poor. It may not be possible to use coagulants with surface water as the concentration of the polymer remaining in the water after treatment is unknown, as are the potential human and environmental health effects.	Moderate. This is a commonly used process in traditional water treatment; however, coagulants for PFAS removal have not been widely tested or implemented.	Moderate. The required infrastructure is potentially smaller in comparison to a larger treatment facility.	No. The relative concentration of PFAS is not expected to be high enough to perform well with this technology.
Ex-Situ Treatment (Non-Target-Achieving)	Electrocoagulation and Flocculation	A high-density electrical current is used as a coagulant to form flocs. PFAS may sorb and concentrate on the produced flocs. Flocs must be separate from the bulk water and once seprated, may be dissolved in an acid for further treatment.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate to good. Large reductions in PFAS concentrations have been observed with water contianing higher PFAS concentrations than is observed in the surface water at the Site. A pilot study would need to be conducted to evaluate the effectiveness with Site-specific water.	Moderate. Electrocoagulation is commercially available and is most commonly implemented as part of wastewater treatment but could be implemented as part of a surface water treatment train. A smaller volume of flocs is produced with electrocoagulation compared with traditional coagulation/floculation.	Poor to moderate. Alhough electrocoagulation units are commercially available, they are not widely used or tested. Current installations have been focused on landfill leachate and may not be as applicable for lower influent concentrations or for drinking water applications.	High. Capital and annual costs are high. Annual electrical requirements are high.	No. Full-scale demonstrations for PFAS are limited.

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General Response Action	Potential Remedial Technology/Action	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical and Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) and Screening Comments
Ex-Situ Treatment (Non-Target-Achieving)	Foam Fractionation	Foam fractionation removes and concentrates PFAS by injecting air into vessels containing impacted water. Foam forms at the top of the vessel and is removed and can be further concentrated by repeating the same process. Foam fractionation can generate highly concentrated PFAS waste.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate to good. Reduces concentrations of long chain PFAS compounds including PFOS and PFOA by over 90% but does not reduce concentrations to below the applicable standards. Can effectively be used as pretreatment to reduce PFAS loading to filtration media.	Moderate to good. The size of the treatment facility will depend on the treatment volumes required. Size of the treatment plant does present challenges, as it would be the largest implementation to date	Moderate to good. Technology is commercially available but not at the scale required for surface water treatment; however, plans are in place to construct a plant capable of treating the volumes required for the AOCs.	High due to capital costs. Energy and O&M costs are expected to be lower than for other ex-situ technologies.	Yes. Foam fractionation may offer a lower cost method for removing PFAS from surface water than other technologies.
Ex-Situ Treatment (Non-Target-Achieving)	Ozofractionation	Ozofractionation is a foam fractionation process that incorporates the use of ozone along with air to improve PFAS removal efficiency. Foam produced with ozone may be more stable than foam produced by air alone, and ozone may improve the removal of short-chain PFAS.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate. Has been shown to be effective at concentrating PFAS at the pilot scale with wastewater with high organic content. The ability to concentrate lower organic containing water is uncertain. More effective with short chain compounds.	Poor to moderate. Pilot studies have been completed however the technology is not as advanced as air based foam fractionation systems. The generation and delivery of ozone also a concern.	Poor to moderate. Technology is commercially available but a limited number of pilot studies have been conducted.	High due to capital costs. Energy and O&M costs are expected to be lower than for other ex-situ technologies, though use of ozone increases energy use relative to traditional foam fractionation.	No. Higher organic matter in surface water is likely to improve removal of PFAS with traditional foam fractionation; addition of ozone is not expected to be necessary.
Ex-Situ Treatment (Disposal)	Landfill	PFAS-containing waste would be disposed of in a lined, PFAS-approved landfill with leachate collection and treatment systems.	AOC 5 AOC 6 AOC 8 AOC 9	Good. All PFAS waste would be removed from the Site and accomplish RAOs; however, it would not be destroyed.	Poor to moderate. There is regulatory uncertainty associated with landfilling PFAS-waste, as more landfills are not accepting PFAS-containing waste. No landfills in Minnesota are currently accepting PFAS-containing waste, so transportation costs would be significant.	Good. PFAS-impacted waste can be sent to landfills out of state currently.	Moderate. Landfilling costs are lower than those of destruction technologies, but costs may increase depending on the proximity of the landfill to the Site.	Yes. Landfilling is only retained in the short term to handle waste as other technologies are being implemented. It is not retained as a long-term remedial solution because of uncertainty around the continuation of landfills accepting PFAS-containing waste.
Ex-Situ Treatment (Destruction)	Incineration	Incineration at temperatures above 1,000°C has been found to destroy PFAS in liquids and solids at an efficiency greater than 99.99%, with shorter chains requiring temperatures as high as 1,400°C for destruction. Thermal oxidizers, operated at similar temperatures to incinerators, have been shown to remove PFAS in contaminated gas streams. Thermal oxidizers can be added to the emissions line of other treatment systems such as GAC reactivation facilities, thermal desorption of soil, or to an incinerator to destroy PFAS transferred to the vapor phase during the process.	AOC 5 AOC 6 AOC 8 AOC 9	Good. Incinerators that maintain temperatures of 1,000 °C or more can achieve 99.99% destruction efficiency. Lower destruction efficiency, especially of shorter chain PFAS compounds, is observed with lower temperatures, which could result in PFAS being released through air emissions.	Good. At this time there are hazardous waste incinerators that the waste could easily be hauled to. If regulations change and these are no longer in operation, the implementability would be poor.	Good. The required incineration facilities are already operational.	Moderate. While disposal costs are high, if the PFAS can be concentrated into a liquid or solid media, the costs are lower relative to the capital and O&M costs associated with other destruction technologies. Transportation costs will be high due to the distance required to move the waste.	Yes. At this stage, all destruction technologies are retained.
Ex-Situ Treatment (Destruction)	Supercritical Water Oxidation (SCWO)	Supercritical water is defined as water above 374°C and 218 atmospheres; at this point, chemical reactions that do not occur at standard temperature and pressure begin to occur, including the oxidation of PFAS. SCWO systems operate above these temperatures and pressures to destroy PFAS through oxidation. SCWO produces large amounts of salts and requires an organic co-fuel in waste streams with low organics concentrations.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate to Good. Destruction efficiency is typically greater than 99% for all PFAS and the formation of shorter PFAS chains was not observed. However, effluent concentrations will remain above the drinking water HBVs/HRLs and surface water WQC , requiring the effluent to be recycled within the treatment train	Moderate. The commercially available unit can be housed in a shipping container and readily implemented at the Site. A pilot study is required to better evaluate the required O&M associated with low pH, salt precipitation, reagents, and cooling.	Moderate to Good. While this technology is still undergoing pilot studies, it has been implemented with a variety of waste streams and is commercially available through several vendors.	High. In addition to high capital costs, O&M costs are expected to be high because of the electrical requirements and potentially the cleaning requirements to remove precipitates and prevent acid corrosion. The cost of consumables, such as a co-fuel, is dependent upon the starting organics concentrations in the concentrated feedstocks.	Yes. At this stage, all destruction technologies are retained.
Ex-Situ Treatment (Destruction)	Hydrothermal Alkaline Treatment (HALT)	HALT destroys PFAS at sub-supercritical conditions using a highly alkaline pH (which achieved with addition of sodium hydroxide). Under these conditions, water behaves like a nonpolar solvent and allows for catalytic degradation of organics, including PFAS. HALT can produce large amounts of salts from degradation of organic compounds.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate to Good. The destruction efficiency is over 99% for total PFAS; however, the effluent concentrations are still above ttreatment targets requiring the effluent to be recycled within the treatment train. Site-specific bench scale and pilot studies are also required to determine the effectiveness with Site-specific PFAS concentrate.	Moderate. The commercially available unit can be housed in a trailer and readily implemented at the Site. A pilot study would be required to better evaluate the required O&M.	Moderate. A limited number of field-based pilot studies have been completed to date, but more tests are planned with additional waste streams.	High. Capital costs are expected to be high and the O&M costs are uncertain. Reagents are inexpensive; however, it is unknown if there will be maintenance challenges associated with the Site-specific water chemistry (high hardness) and cleaning requirements are uncertain.	Yes. At this stage, all destruction technologies are retained.

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General Response Action	Potential Remedial Technology/Action	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical and Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) and Screening Comments
Ex-Situ Treatment (Destruction)	Electrochemical oxidation	By applying an electrical current through a conductive solution between a cathode and anode, PFAS are oxidized and degraded at the electrode or in the bulk liquid. Electrochemical oxidations often requires addition of salts in low conductivity waste streams and of pH buffers to protect electrodes.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate. Long-chain PFAS compounds are reduced by over 99% but concentrations of short chains did not decrease and, in some instances, increased, during the pilot study as a result of sequential defluorination	Moderate. The systems are housed in a trailer and could easily be implemented at the Site. The DE-FLUORO™ pilot study highlighted areas of increased O&M requirements for operators, but system modifications will continue to address these to decrease O&M frequency. The electrodes are expected to require cleaning and maintenance.	Moderate. Multiple companies have completed pilot testing, and more field trials are planned. Systems utilizing electrochemical oxidation are available through multiple vendors.	High. The capital cost is predicted to be similar to other destruction technologies. Electrical requirements are less than other destruction technologies; however, the costs associated with electrode replacement could be high.	Yes. At this stage, all destruction technologies are retained.
Ex-Situ Treatment (Destruction)	Plasma	Electrical discharge is induced between two electrodes near the PFAS-containing liquid. Plasma, an electrically-charged gas, forms above the liquid and ionizes gas molecules. Once PFAS adsorbs onto water bubble interface with the plasma, the charged section of the PFAS molecule collides with high energy ions in plasma state that cleave carbon-fluorine bonds.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate to Good. Over 97% of the total PFAS was destroyed in testing completed with PFAS concentrated waste from other sites.	Moderate. The commercially available unit, currently produced by Onvector, can be housed within a trailer and easily installed at the Site. There is uncertainty associated with the required O&M and a pilot study would be required to better evaluate the required O&M.	Moderate. Systems are commercially available by multiple vendors although full-scale pilot testing is limited. For limited waste volumes (e.g., firefighting foam), a pilot unit could be considered scaled but would not be sufficient for the AOCs.	High. Capital costs are expected to be similar to other destruction technologies. Costs associated with O&M are uncertain and would be better determined during a pilot study.	Yes. At this stage, all destruction technologies are retained.
Ex-Situ Treatment (Destruction)	Photolysis and Photochemical Destruction	Photolysis is the breakdown of chemicals using energy from light, including ultraviolet (UV) light. While the carbon-fluorine bonds in PFAS compounds are not efficiently broken during the direct application of light (or direct photolysis), carbon-fluorine bonds can be broken as a result of indirect photolysis, which occurs when the addition of chemical oxidants or photocatalysts forms reactive species in the presence of light.	AOC 5 AOC 6 AOC 8 AOC 9	Moderate. A large decrease is observed in of TOF concentrations is observed in PFAS concentrate from other sites; however, the PFAS concentrate from the Site is primarily composed of PFOS, which was observed to have a lower degradation rate in the Claros bench-scale study.	Moderate. The commercially available units could easily be installed at the Site. There is uncertainty with the required O&M and a pilot study is required to better evaluate the required O&M.	Poor to moderate. Treatment units are commercially available, but at the time of writing this report, data from additional pilot studies at PFAS-impacted sites are needed to better evaluate the state of development.	High. The capital cost is predicted to be similar to other destruction technologies. Electrical requirements are less than other destruction technologies; however, it is unclear how expensive reagents are or what other O&M costs would be required.	Yes. At this stage, all destruction technologies are retained.

Legend: AOC = area of concern; O&M = operations and maintenance; ODS = Oakdale Disposal Site; RAO = remedial action objective; TOF = total organic fluoride.

AOC 5 = Raleigh Creek Surface Water; AOC 6 = Eagle Point Lake Surface Water; AOC 8 = Lake Elmo Surface Water; AOC 9 = Horseshoe Lake + West Lakeland Surface Water. Note that remedial alternatives for AOC 3 (Oakdale Disposal Site Surface Water) are not considered as part of this FS as AOC 3 is managed through the MPCA Superfund program.

Table 3. Sediment Remedial Technology Screening and Qualitative Scoring.

General Response Action	Potential Remedial Technology	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical & Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) & Screening Comments
No Further Action	No Further Action	No further actions or responses including sampling would be implemented with regards to sediment treatment.	AOC 11 AOC 12 AOC 13	Poor. No further action will not reduce PFAS concentrations in sediment.	Good. No action would be completed.	Good. No action is required.	Low. No additional work would be completed.	Yes. Retained for all sediment AOCs to provide a baseline against which other technologies can be compared.
Access Restrictions/ Institutional Controls	Institutional Controls/ Engineering Controls	Controls could include access restrictions including signage and fencing to prevent the public from being exposed to sediment exceeding the SDSVs.	AOC 11 AOC 12 AOC 13	Poor. Sediment concentrations would not be reduced and PFAS could continue to leach into groundwater and surface water.	Good. Applicable access restrictions could be easily implemented.	Good. No remedial technologies would be required.	Low. Minimal actions would be taken.	Yes. Retained for consideration as a component of remedial alternatives for all sediment AOCs to aid in the prevention of incidental public exposure to PFAS.
Long-Term Monitoring	Long-Term Monitoring	PFAS concentrations can fluctuate through the natural processes of sorption/retention and dispersion. Additionally, reductions in PFAS in upgradient/upstream AOCs could reduce PFAS concentrations within a specific downgradient/downstream AOC. Long-term monitoring of PFAS concentrations within an AOC would be required to determine if PFAS concentrations are decreasing.	AOC 11 AOC 12 AOC 13	Poor. Will not reduce PFAS mass in the environment. As PFAS does not degrade in the environment, the processes resulting in a decrease in concentration within sediment are only transfer the PFAS to a different media such as groundwater or surface water. This PFAS could adsorb again to sediment.	Good. A monitoring plan would be easily implementable.	Good. No technology is required.	Low. Minimal actions would be taken.	Yes. Long-term monitoring is required to understand changes in PFAS concentrations over time.
In-Situ Treatment	Permeable Adsorptive Barriers (PABs)	PABs in the form of sediment caps can be installed at the bottom of a surface water body to minimize sediment leaching into the surface water body above it. They do not reduce leaching into the groundwater below.	AOC 11 AOC 12 AOC 13	Moderate. A sediment PAB could prevent leaching to surface water but not to groundwater.	Poor to Moderate. It would be difficult to install a sediment PAB without impairing the AOCs' wetland environments.	Moderate. Several soil capping products are available, but their application to PFAS-impacted sites is limited.	Low to Moderate. This treatment option may be less labor intensive than other technologies.	No. This activity may negatively impact wetland environments. May be reconsidered if sediment leaching is found to contribute a large mass of PFAS to surface water in the future.
In-Situ Treatment	Soil Mixing/Stabilization	The leachability of PFAS from contaminated soils and sediment can be reduced by adding and mixing soil stabilizers that immobilize PFAS.	AOC 11 AOC 12 AOC 13	Poor. Although some amendments have demonstrated high soil leachate reduction, longevity is unclear, and effectiveness is heavily impacted by sediment chemistry. Concentrations and public exposure would not be reduced, but migration may be reduced if sediments are not washed downstream.	Poor. The technology would be difficult to implement without impairing the AOC wetland environment. ITRC recommends not employing this in flood-prone areas because of the potential for amendment-stabilized soils with PFAS to erode and be transported downstream/off-site.	Moderate. Several amendments are commercially available and have been applied as soil stabilization agents at the field level.	Moderate to High. The large wetland AOC areas would require extensive mixing.	No. There are concerns around the technology longevity and around transport of PFAS-stabilized sediments downstream from the flood-prone AOCs.
In-Situ Treatment	Thermal Treatment	Thermal treatment heats impacted sediment to temperatures ranging from 350 to 400°C to desorb and volatilize PFAS. The offgas is then captured and treated.	AOC 11 AOC 12 AOC 13	Moderate. Field studies have demonstrated greater than 99.9 percent reduction in PFAS concentrations, but it is unclear if concentrations can be reduced to the extent that leaching/migration would not occur and if full-scale targets could be met.	Poor. The large AOC surface areas would require extensive heating infrastructure and are expected to significantly impair the wetland environments.	Moderate. While in-situ thermal treatment is not widely used for the remediation of PFAS, it is commonly applied for other environmental contaminants.	High. Installation, operation, and energy costs associated with heating infrastructure would be significant.	No. Extensive infrastructure would be required, and environmental impairments to the wetland AOCs are expected to be too extreme.
In-Situ Treatment	Soil Washing	The process of in-situ soil washing saturates an area of contaminated soil or sediment with a wash solution to transfer sorbed PFAS to a liquid stream for recapture and further treatment.	AOC 11 AOC 12	Poor to Moderate. Effectiveness is highly dependent on site conditions and soil/sediment permeability and is anticipated to decrease for soils with high clay and organic content. Treatment may take years, and it is unknown whether washing could achieve concentration reductions to a point at which leaching does not occur.	Moderate. Additional wells would need to be installed, and further characterization of site hydrology and soil characteristics would need to be conducted. A separation technology would need to be paired with this method to treat the wash water.	Poor. Only one field study of in-situ soil washing has been identified, and it was done on sandy soils with low organic content that may not translate well for the wetland AOC's conditions.	Moderate. Cost will be heavily influenced by the paired separation technology.	No. In-situ soil washing has limited field demonstration, and it would be heavily dependent on Site sediment conditions. It is likely less suitable for the clay- and organic-rich sediments characteristic of the sediment AOCs.
In-Situ Treatment	Phytoremediation	Phytoremediation relies on plant species to uptake or stabilize PFAS in sediment/soil. If plant biomass is harvested, the PFAS-containing plant material can be removed from the site and destroyed.	AOC 11 AOC 12 AOC 13	Poor. Phytoremediation has minimal capacity to reduce PFAS concentrations or PFAS migration.	Good. Planting, growing, and harvesting plants for phytoremediation is easily implementable.	Moderate. Several plant species have been demonstrated to remove some PFAS species, but removal is not cost effective or efficient.	Low. The highest cost component would be associated with the disposal or destruction of harvested biomass.	No. This treatment option has very low removal/stabilization efficiencies and a long required time for treatment.

Table 3. Sediment Remedial Technology Screening and Qualitative Scoring.

General Response Action	Potential Remedial Technology	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical & Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) & Screening Comments
Ex-Situ Treatment (Extraction)	Excavation	Excavation involves the removal of contaminated soil and sediment for off-site disposal or further treatment. The excavation can be backfilled with clean soil/sediment or with the excavated material if treated.	AOC 11 AOC 12	Moderate to Good. Effectiveness would be highly dependent on the degree of accuracy achieved by contaminant delineation and the degree of precision of the excavation when removing the contaminated sediment.	Moderate. The sediment AOCs are large and would require an extensive, invasive excavation. They are also typically flooded, and contain valuable wetland habitat. Additional sampling would determine the extent of excavation.	Good. Excavation is widely applied for extraction of contaminants, including PFAS, from the environment.	High. While total cost will depend on the extent of excavation and the secondary treatment option selected for the excavated material, excavation would generate a large volume of material requiring further treatment or disposal and would be expensive.	Yes. Excavation is retained as it could remove a large volume of PFAS-impacted soils, though no excavation should be considered until impacts from ODS are addressed.
Ex-Situ Treatment (Extraction)	Dredging	Dredging is extraction technique which removes submerged sediment from below surface water bodies. Dredging can be performed mechanically or hydraulically. Mechanical dredging uses a mechanical means of removing sediment by grabbing, cutting, or raking the sediment, while hydraulic dredging uses a pump to remove sediment.	AOC 13	Moderate. Reported material on PFAS applications is limited, but the technology is advertised by commercial dredging providers and widely applied for other contaminant extraction. Effectiveness will depend on the necessary extent of sediment removal. The extent to which dredging will prevent leaching is unknown, and dredging can remobilize contaminants and increase suspended solids in downstream waters.	Poor to Moderate. Lakebed sediments could be dredged depending on necessary extent of removal. Restorative substrate would likely need to be placed at the lakebed following removal. Transportation of waste to secondary treatment vessels or facilities may be costly and labor intensive. While technically feasible, the regulatory uncertainty associated with permitting and potential ecosystem damage poses risks.	Good. A large variety of mechanical and hydraulic dredging equipment is widely available for removal of sediments from impacts areas and stormwater ponds. Their application for PFAS dredging is limited but applicable.	High. Dredging labor and equipment, storage and transport of sediment, and the secondary treatment technology selected for the extracted sediment are expected to be costly.	Yes. Although a poor to moderate implementability scoring would eliminate this technology from further consideration within another GRA, the limited availability of commercial technologies targeted for PFAS-impacted sediment treatment results in retention of dredging for treatment of AOC 13. No dredging should be considered, however, until impacts from ODS are addressed. If dredging precedes the conclusion of work at ODS, any treated sediment or clean fill risks becoming contaminated again.
Ex-Situ Treatment (Stabilization)	Ex-Situ Stabilization	Ex-situ stabilization involves first excavating soil prior to treatment. Materials such as activated carbon, modified clays, apatite, other modified sorbents, and biochar that are used for in-situ stabilization can be used for ex-situ stabilization. Soil or sediment is removed for mixing with amendments, for example in a pug mill, before being returned to the same location. Use of stabilization amendments may reduce the leaching of PFAS from impacted soil.	AOC 11 AOC 12 AOC 13	Poor. This technology does not remove PFAS and therefore cannot address concerns around public exposure to impacted sediment, but it can address leaching. While significant reductions in PFAS leachability from sediments have been achieved with a variety of amendments, it is unknown the extent to which the high organic content in the sediment AOCs may impact the PFAS sorption capacity of these amendments. Furthermore, the longevity of this technology is unclear, and the degree to which changing site conditions might impact PFAS leachability is unknown.	Poor. Excavation of soil or sediment prior to mixing with amendments would be highly disruptive to the wetland environments of each sediment AOC.	Moderate. Several amendments are commercially available and have been applied as soil stabilization agents at the field level.	High. The labor required to excavate and mix amendments into the large AOCs areas would be expensive.	No. There is uncertainty around the longevity of this technology. There are also concerns around transport of PFAS-stabilized sediment from flood-prone AOCs.
Ex-Situ Treatment (Separation)	Soil Washing	Soil washing uses a wash solution to desorb contaminants from a solid matrix and transfer it to an aqueous waste stream; this process occurs after soil or sediment has been removed from an impacted area	AOC 11 AOC 12 AOC 13	Moderate. Research has shown significant removals of PFAS from removed soils, though results are mixed. Bench-scale testing would need to be performed to evaluate the Site sediment's capacity for soil washing.	Moderate. Excavation and dredging are invasive and may not be accepted by the community or allowed by regulators. The treatment train is expected to be labor-intensive for extracting, storing, and treating sediment and for handling the impacted wash water and fines following treatment.	Poor to moderate. Soil washing has been used for many years for other contaminants, but its application for PFAS treatment is not widespread. Some soil washing plants may not accept PFAS waste, and the commercial availability of PFAS-targeted soil washing plants is limited in North America.	High. Excavation or dredging would first need to occur, and after soil washing occurs, further treatment of the aqueous PFAS-containing waste would need to be treated. Soil fines may also need to be treated or disposed of.	No. Limited full-scale commercial demonstration at this time.

Table 3. Sediment Remedial Technology Screening and Qualitative Scoring.

General Response Action	Potential Remedial Technology	Technology Description	Potential AOCs	Effectiveness (Achieve/Maintain RAOs and Reliability)	Implementability (Technical & Administrative)	Technology Readiness	Relative Cost	Retained (Yes/No) & Screening Comments
Ex-Situ Treatment (Separation)	Thermal Desorption	Thermal desorption separates PFAS from solid media by heating removed soil high enough temperatures to offgas PFAS. The process generates a volatilized PFAS gas stream that requires further treatment, typically via thermal oxidation, and renders a cleaned soil/sediment that can be recycled.	AOC 11 AOC 12 AOC 13	Moderate. While bench studies at other sites have demonstrated high removal efficiencies, they were performed with higher starting concentrations. The removal efficiency of lower starting concentrations or sediments with high organic content, as seen in the sediment AOCs, is not as well studied.	Poor to moderate. The distance to the nearest thermal desorption facilities is far, and the footprint of mobile units and temporary staging is large.	Moderate. Thermal desorption has been widely applied for other contaminants but is not as widely applied for PFAS treatment.	High. Transportation, storage, and treatment costs are expected to be high.	Yes. Although its poor to moderate implementability scoring would screen the technology out of another GRA category, the commercially available options for sediment treatment are limited at this time.
Ex-Situ Treatment (Disposal)	Landfilling	PFAS-containing waste would be disposed of in a lined, hazardous waste-approved landfill with leachate collection and treatment systems.	AOC 11 AOC 12 AOC 13	Good. All PFAS waste would be removed from the Site and accomplish RAOs; however, it would not be destroyed.	Moderate to good. There is regulatory uncertainty associated with landfilling PFAS-waste, as more landfills are not accepting PFAS-containing waste. No landfills in Minnesota are currently accepting PFAS-containing waste, so transportation costs of large volumes of sediment would be significant. Extracted sediment volume will influence score. If regulatory standards change and incineration is no longer permitted, however, the implementability would be poor.	Good. PFAS-impacted waste can be sent to landfills out of state currently.	High. Transporting large volumes of sediment to landfills accepting PFAS-waste will be expensive.	No. There are not landfills within close proximity to the Site that will accept PFAS-impacted sediment, and transporting large volumes of waste is not feasible.
Ex-Situ Treatment (Destruction)	Incineration	Incineration at temperatures above 1,000°C has been found to destroy PFAS in liquids and solids at an efficiency greater than 99.99%, with shorter chains requiring temperatures as high as 1,400°C for destruction. Thermal oxidizers, operated at similar temperatures to incinerators, have been shown to remove PFAS in contaminated gas streams. Thermal oxidizers can be added to the emissions line of other treatment systems such as GAC reactivation facilities, thermal desorption of soil, or to an incinerator to destroy PFAS transferred to the vapor phase during the process.	AOC 11 AOC 12 AOC 13	Good. Incinerators that maintain temperatures of 1,000 °C or more can achieve 99.99% destruction efficiency. Lower destruction efficiency, especially of shorter chain PFAS compounds, is observed with lower temperatures, which could result in PFAS being released through air emissions.	Moderate to Good. At this time there are hazardous waste incinerators that the waste could be hauled to, although none are in Minnesota. If regulations change and these are no longer in operation, the implementability would be poor.	Good. The required incineration facilities are already operational.	High. Transportation costs will be high due to the distance required to move large volumes of extracted sediment.	Yes. As regulations regarding the incineration of PFAS may change, incineration should only be viewed as a short-term option for destruction while other technologies for the destruction of PFAS are further developed and commercialized.

Legend: AOC = area of concern; ODS = Oakdale Disposal Site; RAO = remedial action objective; SDSV = MPCA Site-Specific Sediment Screening Value.

AOC 11 = Upper Raleigh Creek Wetland Complex; AOC 12 = Anna's Grove Wetland Complex Sediment; AOC 13 = Eagle Point Lake Sediment.

Table 4. Summary of Remedial Action by Area of Concern for Considered Remedial Alternatives.

AOC	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Action	Description	Action	Description	Action	Description	Action	Description
1: WCL – Surface Water and Shallow Groundwater	None	No action will be performed in this AOC for Alternative 1.	Groundwater pump and treat + access restrictions	Localized pump and treat system would be installed to reduce the migration of high concentrations of PFAS horizontally to Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers. Adjustments are expected based on stakeholder input and additional investigation data.	Groundwater pump and treat + access restrictions	Localized pump and treat system would be installed to reduce the migration of high concentrations of PFAS horizontally to Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers. Adjustments are expected based on stakeholder input and additional investigation data.	Groundwater pump and treat + access restrictions	Localized pump and treat system would be installed to reduce the migration of high concentrations of PFAS horizontally to Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers. Adjustments are expected based on stakeholder input and additional investigation data.
2: WCL – Bedrock Aquifers	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Groundwater pump and treat + access restrictions	Localized pump and treat system in Jordan Aquifer to reduce horizontal migration within the Shakopee and Jordan Aquifers. Adjustments are expected based on stakeholder input and additional investigation data.
3: ODS – Surface Water	Raleigh Creek reroute by 3M	No action will be performed in this AOC for Alternative 1 beyond the remedial actions currently being conducted by 3M.	Raleigh Creek reroute by 3M	3M has proposed rerouting Raleigh Creek around ODS to reduce PFAS concentrations in Raleigh Creek. Additional treatment may be required depending on the effectiveness of this action.	Raleigh Creek reroute by 3M	3M has proposed rerouting Raleigh Creek around ODS to reduce PFAS concentrations in Raleigh Creek. Additional treatment may be required depending on the effectiveness of this action.	Raleigh Creek reroute by 3M	3M has proposed rerouting Raleigh Creek around ODS to reduce PFAS concentrations in Raleigh Creek. Additional treatment may be required depending on the effectiveness of this action.
4: Downgradient ODS Groundwater	Continued pumping of Oakdale Municipal Supply Wells; Continued + ODS Pump & Treat	Continued pumping of Oakdale Municipal Supply Wells provides partial plume control. Source zone pump and treat system at ODS provides some source zone control. No additional source zone control will occur at ODS.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions. Pumping of Oakdale Municipal Supply Wells would. Additional remedial efforts may be implemented at ODS which would impact this groundwater. The extent to which 3M treats impacted water offsite from ODS will be determined through Superfund program.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions. Pumping of Oakdale Municipal Supply Wells would. Additional remedial efforts may be implemented at ODS which would impact this groundwater. The extent to which 3M treats impacted water offsite from ODS will be determined through Superfund program.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions. Pumping of Oakdale Municipal Supply Wells would. Additional remedial efforts may be implemented at ODS which would impact this groundwater. The extent to which 3M treats impacted water offsite from ODS will be determined through Superfund program.
5: Raleigh Creek – Surface Water	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring	Monitor impact of upgradient treatment.	Permeable adsorptive barrier	Install a PAB downstream of Anna's Grove Wetland Complex to reduce downgradient migration of leached PFAS currently sorbed to wetland sediment and monitor the impact of the Raleigh Creek reroute in AOC 3.	Permeable adsorptive barrier	Install a PAB downstream of Anna's Grove Wetland Complex to reduce downgradient migration of leached PFAS currently sorbed to wetland sediment and monitor the impact of the Raleigh Creek reroute in AOC 3.
6: Eagle Point Lake – Surface Water	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.
7: Raleigh Creek + Eagle Point Lake - Groundwater	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Groundwater pump and treat + access restrictions	Localized pump and treat with extraction from the Shakopee and Jordan Aquifers to reduce mitigation of PFAS south towards the Tamarack Well Field in Woodbury and reduce PFAS concentration within current plume resulting from infiltration from Raleigh Creek and Eagle Point Lake. Adjustments are expected based on stakeholder input and additional investigation data.
8: Lake Elmo – Surface Water	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.
9: Horseshoe Lake/West Lakeland – Surface Water	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.	Permeable adsorptive barrier	Install a PAB downstream of the Eagle Point Lake and Lake Elmo discharge pipes to reduce downgradient migration of PFAS from Eagle Point Lake and Lake Elmo into Horseshoe Lake and the West Lakeland Storage Ponds.
10: West Lakeland - Groundwater	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment.	Permeable adsorptive barrier	Install a PAB downstream of the Eagle Point Lake and Lake Elmo discharge pipes to reduce downgradient migration of PFAS from Eagle Point Lake and Lake Elmo	Localized pump and treat + access restrictions	A localized pump and treat would be installed in West Lakeland to reduce continued PFAS migration to the east within the Shakopee and Jordan aquifers to unimpacted drinking water aquifers. Treated water would be injected into the Jordan Aquifer. Adjustments are expected based on stakeholder input and additional investigation data.
11: Upper Raleigh Creek Wetland Complexes – Sediment	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.
12: Anna's Grove Wetland Complex - Sediment	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.
13: Eagle Point Lake - Sediment	None	No action will be performed in this AOC for Alternative 1.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.

Table 4. Summary of Remedial Action by Area of Concern for Considered Remedial Alternatives.

AOC	Alternative 5		Alternative 6		Alternative 7		Alternative 8	
	Action	Description	Action	Description	Action	Description	Action	Description
1: WCL – Surface Water and Shallow Groundwater	Groundwater pump and treat + access restrictions	Localized pump and treat system would be installed to reduce the migration of high concentrations of PFAS horizontally to Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers. Adjustments are expected based on stakeholder input and additional investigation data.	Groundwater pump and treat + access restrictions	Localized pump and treat system would be installed to reduce the migration of high concentrations of PFAS horizontally to Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers. Adjustments are expected based on stakeholder input and additional investigation data.	Groundwater pump and treat + access restrictions	Localized pump and treat system would be installed to reduce the migration of high concentrations of PFAS horizontally to Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers. Adjustments are expected based on stakeholder input and additional investigation data.	Groundwater pump and treat + access restrictions	Localized pump and treat system would be installed to reduce the migration of high concentrations of PFAS horizontally to Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers. Adjustments are expected based on stakeholder input and additional investigation data.
2: WCL – Bedrock Aquifers	Localized MBWA + access restrictions	A MBWA installed within AOC 2 and AOC 7 would provide drinking water to the City of Lake Elmo and control horizontal plume migration in both AOCs. Adjustments are expected based on stakeholder input and additional investigation data.	Localized MBWA + access restrictions	A MBWA installed within AOC 2 and AOC 7 would provide drinking water to the City of Lake Elmo and control horizontal plume migration in both AOCs. Adjustments are expected based on stakeholder input and additional investigation data.	Regional MBWA + access restrictions	A MBWA installed within AOCs 2, 4, and 7 would provide drinking water to the Cities of Lake Elmo and Oakdale and control horizontal plume migration in these AOCs. Adjustments are expected based on stakeholder input and additional investigation data.	Regional MBWA + access restrictions	A MBWA installed within AOCs 2, 4, 7 and 10 would provide drinking water to the Cities of Lake Elmo and Oakdale and control horizontal plume migration in these AOCs. Adjustments are expected based on stakeholder input and additional investigation data.
3: ODS – Surface Water	Raleigh Creek reroute by 3M	3M has proposed rerouting Raleigh Creek around ODS to reduce PFAS concentrations in Raleigh Creek. Additional treatment may be required depending on the effectiveness of this action.	Raleigh Creek reroute by 3M	3M has proposed rerouting Raleigh Creek around ODS to reduce PFAS concentrations in Raleigh Creek. Additional treatment may be required depending on the effectiveness of this action.	Raleigh Creek reroute by 3M	3M has proposed rerouting Raleigh Creek around ODS to reduce PFAS concentrations in Raleigh Creek. Additional treatment may be required depending on the effectiveness of this action.	Raleigh Creek reroute by 3M	3M has proposed rerouting Raleigh Creek around ODS to reduce PFAS concentrations in Raleigh Creek. Additional treatment may be required depending on the effectiveness of this action.
4: Downgradient ODS Groundwater	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions. Pumping of Oakdale Municipal Supply Wells would. Additional remedial efforts may be implemented at ODS which would impact this groundwater. The extent to which 3M treats impacted water offsite from ODS will be determined through Superfund program.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions. Pumping of Oakdale Municipal Supply Wells would. Additional remedial efforts may be implemented at ODS which would impact this groundwater.	Regional MBWA + access restrictions	A MBWA installed within AOCs 2, 4, and 7 would provide drinking water to the Cities of Lake Elmo and Oakdale and control horizontal plume migration in these AOCs. Adjustments are expected based on stakeholder input and additional investigation data. Additional control of groundwater at ODS by 3M	Regional MBWA + access restrictions	A MBWA installed within AOCs 2, 4, 7 and 10 would provide drinking water to the Cities of Lake Elmo and Oakdale and control horizontal plume migration in these AOCs. Adjustments are expected based on stakeholder input and additional investigation data.
5: Raleigh Creek – Surface Water	Permeable adsorptive barrier	Install a PAB downstream of Anna's Grove Wetland Complex to reduce downgradient migration of leached PFAS currently sorbed to wetland sediment and monitor the impact of the Raleigh Creek reroute in AOC 3.	Permeable adsorptive barrier	Install a PAB downstream of Anna's Grove Wetland Complex to reduce downgradient migration of leached PFAS currently sorbed to wetland sediment and monitor the impact of the Raleigh Creek reroute in AOC 3.	Permeable adsorptive barrier	Install a PAB downstream of Anna's Grove Wetland Complex to reduce downgradient migration of leached PFAS currently sorbed to wetland sediment and monitor the impact of the Raleigh Creek reroute in AOC 3.	Permeable adsorptive barrier	Install a PAB downstream of Anna's Grove Wetland Complex to reduce downgradient migration of leached PFAS currently sorbed to wetland sediment and monitor the impact of the Raleigh Creek reroute in AOC 3.
6: Eagle Point Lake – Surface Water	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.
7: Raleigh Creek + Eagle Point Lake - Groundwater	Localized MBWA + access restrictions	A MBWA installed within AOC 2 and AOC 7 would provide drinking water to the City of Lake Elmo and control horizontal plume migration in both AOCs. Adjustments are expected based on stakeholder input and additional investigation data.	Localized MBWA + access restrictions	A MBWA installed within AOC 2 and AOC 7 would provide drinking water to the City of Lake Elmo and control horizontal plume migration in both AOCs. Adjustments are expected based on stakeholder input and additional investigation data.	Regional MBWA + access restrictions	A MBWA installed within AOCs 2, 4, and 7 would provide drinking water to the Cities of Lake Elmo and Oakdale and control horizontal plume migration in these AOCs. Adjustments are expected based on stakeholder input and additional investigation data.	Regional MBWA + access restrictions	A MBWA installed within AOCs 2, 4, 7 and 10 would provide drinking water to the Cities of Lake Elmo and Oakdale and control horizontal plume migration in these AOCs. Adjustments are expected based on stakeholder input and additional investigation data.
8: Lake Elmo – Surface Water	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.	Long-term monitoring	Monitor impact of upgradient treatment.
9: Horseshoe Lake/West Lakeland – Surface Water	Permeable adsorptive barrier	Install a PAB downstream of the Eagle Point Lake and Lake Elmo discharge pipes to reduce downgradient migration of PFAS from Eagle Point Lake and Lake Elmo into Horseshoe Lake and the West Lakeland Storage Ponds.	Permeable adsorptive barrier	Install a PAB downstream of the Eagle Point Lake and Lake Elmo discharge pipes to reduce downgradient migration of PFAS from Eagle Point Lake and Lake Elmo into Horseshoe Lake and the West Lakeland Storage Ponds.	Permeable adsorptive barrier	Install a PAB downstream of the Eagle Point Lake and Lake Elmo discharge pipes to reduce downgradient migration of PFAS from Eagle Point Lake and Lake Elmo into Horseshoe Lake and the West Lakeland Storage Ponds.	Permeable adsorptive barrier	Install a PAB downstream of the Eagle Point Lake and Lake Elmo discharge pipes to reduce downgradient migration of PFAS from Eagle Point Lake and Lake Elmo into Horseshoe Lake and the West Lakeland Storage Ponds.
10: West Lakeland - Groundwater	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Localized pump and treat + access restrictions	A localized pump and treat would be installed in West Lakeland to reduce continued PFAS migration to the east within the Shakopee and Jordan aquifers to unimpacted drinking water aquifers. Treated water would be injected into the Jordan Aquifer. Adjustments are expected based on stakeholder input and additional investigation data.	Localized pump and treat + access restrictions	A localized pump and treat would be installed in West Lakeland to reduce continued PFAS migration to the east within the Shakopee and Jordan aquifers to unimpacted drinking water aquifers. Treated water would be injected into the Jordan Aquifer. Adjustments are expected based on stakeholder input and additional investigation data.	Regional MBWA + access restrictions	A MBWA installed within AOCs 2, 4, 7 and 10 would provide drinking water to the Cities of Lake Elmo and Oakdale and control horizontal plume migration in these AOCs. Adjustments are expected based on stakeholder input and additional investigation data.
11: Upper Raleigh Creek Wetland Complexes – Sediment	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.
12: Anna's Grove Wetland Complex - Sediment	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.
13: Eagle Point Lake - Sediment	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.	Long-term monitoring + access restrictions	Monitor impact of upgradient treatment. Limit exposure to public with access restrictions.

Note: Text in black indicates a different treatment proposed for an AOC compared to the previous Alternative; text in gray indicates treatment in the previous alternative is the same for a given AOC.
Legend: AOC = area of concern; MBWA = multi-benefit well array; ODS = Oakdale Disposal Site; PAB = permeable adsorptive barrier; WCL = Washington County Landfill.

Table 5. Analysis of the Ability of Remedial Alternatives to Meet Remedial Action Objectives.

AOC	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO
1: WCL – Surface Water and Shallow Groundwater	None	Low • Impacts from WCL would continue to migrate horizontally, including into Sunfish Lake and Lake Elmo and vertically into the drinking water aquifers.	Groundwater pump and treat + access restrictions	High • WCL pump and treat would result in a reduction in mass flux from the WCL both horizontally towards Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers, decreasing PFAS concentrations in Sunfish Lake.	Groundwater pump and treat + access restrictions	High • WCL pump and treat would result in a reduction in mass flux from the WCL both horizontally towards Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers, decreasing PFAS concentrations in Sunfish Lake.	Groundwater pump and treat + access restrictions	High • WCL pump and treat would result in a reduction in mass flux from the WCL both horizontally towards Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers, decreasing PFAS concentrations in Sunfish Lake.
2: WCL – Bedrock Aquifers	None	Low • Impacts would continue to migrate eastward towards currently unimpacted aquifers and southeast into Lake Elmo.	Long-term monitoring + access restrictions	Moderate • Reductions in concentrations of PFAS may be observed over time with a reduction in mass flux from the WCL; however, migration of PFAS already within the bedrock aquifers would continue.	Long-term monitoring + access restrictions	Moderate • Reductions in concentrations of PFAS may be observed over time with a reduction in mass flux from the WCL; however, migration of PFAS already within the bedrock aquifers would continue.	Groundwater pump and treat + access restrictions	High • The RC+EPL pump and treat system would reduce concentrations within the plume by removing PFAS and reducing downgradient migration. • Reductions in mass flux from the WCL would aid in achieving RAOs.
3: ODS – Surface Water	Raleigh Creek reroute by 3M	Low • No additional changes would occur at ODS, resulting in the continued migration of PFAS from ODS via surface water.	Raleigh Creek reroute by 3M	High • The Raleigh Creek reroute would reduce the mass flux of PFAS leaving ODS via surface water; however, PFAS may still be released from ODS during periods of high flow such as during snow melt and large rain events. • Leaching from impacted sediment downgradient of ODS and the potential discharge of PFAS impacted groundwater to downgradient wetland areas may also result in the continue migration of PFAS downstream.	Raleigh Creek reroute by 3M	High • The Raleigh Creek reroute would reduce the mass flux of PFAS leaving ODS via surface water; however, PFAS may still be released from ODS during periods of high flow such as during snow melt and large rain events. • Leaching from impacted sediment downgradient of ODS and the potential discharge of PFAS impacted groundwater to downgradient wetland areas may also result in the continue migration of PFAS downstream.	Raleigh Creek reroute by 3M	High • The Raleigh Creek reroute would reduce the mass flux of PFAS leaving ODS via surface water; however, PFAS may still be released from ODS during periods of high flow such as during snow melt and large rain events. • Leaching from impacted sediment downgradient of ODS and the potential discharge of PFAS impacted groundwater to downgradient wetland areas may also result in the continue migration of PFAS downstream.
4: Downgradient ODS Groundwater	None; Continued pumping of Oakdale Municipal Supply Wells; Continued pump and treat at ODS	Low to Moderate • Continued pumping of Oakdale supply wells would contain a limited portion of the plume to reduce southerly migration. • Pumping at ODS limits migration of PFAS from the source area but migration via groundwater is likely still ocurring • Would not fully achieve the RAOs as migration into currently unimpacted areas will continue.	Long-term monitoring + access restrictions; Continued pumping of Oakdale Municipal Supply Wells; Continued/ Improved source zone control at ODS	Moderate • Continued pumping of Oakdale supply wells would contain portions of the plume to reduce continued southerly migration. • Additional remedial actions at ODS would further reduce the migration of PFAS impacts to drinking water aquifers which would aid in the reduction of groundwater concentrations and downgradient migration within the bedrock aquifers. • These efforts, however, would not fully achieve the RAOs as migration into currently unimpacted areas would continue.	Long-term monitoring + access restrictions; Continued pumping of Oakdale Municipal Supply Wells; Continued/ Improved source zone control at ODS	Moderate • Continued pumping of Oakdale supply wells would contain portions of the plume to reduce southerly migration. • Additional remedial actions at ODS would further reduce the migration of PFAS impacts to drinking water aquifers which would aid in the reduction of groundwater concentrations and downgradient migration within the bedrock aquifers. • These efforts, however, would not fully achieve the RAOs as migration into currently unimpacted areas will continue.	Long-term monitoring + access restrictions; Continued pumping of Oakdale Municipal Supply Wells; Continued/ Improved source zone control at ODS	Moderate • Continued pumping of Oakdale supply wells would contain portions of the plume to reduce continued southerly migration. • Control of the source zone would reduce mass flux from the source zone which would aid in the reduction of groundwater concentrations and downgradient migration within the bedrock aquifers. • These efforts, however, would not fully achieve the RAOs as migration into currently unimpacted areas would continue.
5: Raleigh Creek – Surface Water	None	Low • PFAS impacted surface water would continue to be discharged from ODS.	Long-term monitoring	Moderate • Reductions in surface water concentrations are expected with the reroute around ODS which would reduce infiltration of PFAS impacted surface water to groundwater. • Sediment leaching from wetland areas is expected to continue, which would result in additional mass loading to surface water.	Permeable adsorptive barrier	Moderate to High • Reductions in surface water concentrations are expected with the reroute around ODS which would reduce infiltration of PFAS impacted surface water to groundwater. • The in-stream PABs would aid in further reducing PFAS concentrations within Raleigh Creek that result from incidental discharges from ODS during large flow events and from leaching of PFAS from sediment.	Permeable adsorptive barrier	Moderate to High • Reductions in surface water concentrations are expected with the reroute around ODS which would reduce infiltration of PFAS impacted surface water to groundwater. • The in-stream PABs would aid in further reducing PFAS concentrations within Raleigh Creek that result from incidental discharges from ODS during large flow events and from leaching of PFAS from sediment.
6: Eagle Point Lake – Surface Water	None	Low • PFAS impacted surface water would continue to be discharged from ODS and flow into Eagle Point Lake via Raleigh Creek.	Long-term monitoring	Moderate • Reductions in surface water concentrations are expected following the reroute of Raleigh Creek; however, sediment leaching and mass discharge from ODS during periods of high flow would extend the time to achieve the RAOs.	Long-term monitoring	Moderate to High • Reductions in surface water concentrations are expected following the reroute of Raleigh Creek • PABs upgradient in Raleigh Creek will aid in the reduction of PFAS entering Eagle Point Lake from sediment leaching, incidental releases of PFAS impacted surface water from ODS, and potentially groundwater discharge of PFAS imapcted groundwater to wetland areas downgradient of ODS. • The length of time for these reductions and the extent of PFAS removal by PABs is uncertain. Leaching of PFAS from sediment in Eagle Point Lake may also impact the ability to meet the RAOs.	Long-term monitoring	Moderate to High • Reductions in surface water concentrations are expected following the reroute of Raleigh Creek • PABs upgradient in Raleigh Creek will aid in the reduction of PFAS entering Eagle Point Lake from sediment leaching, incidental releases of PFAS impacted surface water from ODS, and potentially groundwater discharge of PFAS imapcted groundwater to wetland areas downgradient of ODS. • The length of time for these reductions and the extent of PFAS removal by PABs is uncertain. Leaching of PFAS from sediment in Eagle Point Lake may also impact the ability to meet the RAOs.

Table 5. Analysis of the Ability of Remedial Alternatives to Meet Remedial Action Objectives.

AOC	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO
7: Raleigh Creek + Eagle Point Lake - Groundwater	None	Low • PFAS concentrations would not decrease and PFAS would continue to migrate south towards the Woodbury Tamarack Well field. • Reductions in infiltration are not expected to result in reductions in bedrock aquifer concentrations because of the mass of PFAS already within the aquifers.	Long-term monitoring + access restrictions	Low • PFAS concentrations would not decrease and PFAS would continue to migrate south towards the Woodbury Tamarack Well field. • Reductions in infiltration are not expected to result in reductions in bedrock aquifer concentrations because of the mass of PFAS already within the aquifers.	Long-term monitoring + access restrictions	Low • PFAS concentrations would not decrease and PFAS would continue to migrate south towards the Woodbury Tamarack Well field. • Reductions in infiltration are not expected to result in reductions in bedrock aquifer concentrations because of the mass of PFAS already within the aquifers.	Groundwater pump and treat + access restrictions	High • PFAS within this plume would be captured by the RC+EPL pump and treat system, reducing PFAS concentrations and reducing downgradient migration, especially towards the Woodbury Tamarack Well field. • Reductions in infiltration of PFAS impacted groundwater from Eagle Point Lake and Raleigh Creek would also aid in achieving the RAOs.
8: Lake Elmo – Surface Water	None	Low • PFAS would continue to migrate into Lake Elmo from the WCL and Eagle Point Lake plume.	Long-term monitoring	Moderate • Reductions in PFAS concentrations may be observed over time with the reduction in mass flux from the WCL and reductions in mass flux through the secondary control structure from Eagle Point Lake; however, a large mass of PFAS is already present in the groundwater that discharges into Lake Elmo. • In addition, the long retention time of the lake would likely result in small decreases over many decades.	Long-term monitoring	Moderate • Reductions in PFAS concentrations may be observed over time with the reduction in mass flux from the WCL and reductions in mass flux through the secondary control structure from Eagle Point Lake; however, a large mass of PFAS is already present in the groundwater that discharges into Lake Elmo. • In addition, the long retention time of the lake would likely result in small decreases over many decades.	Long-term monitoring	Moderate • Reductions in PFAS concentrations may be observed over time with the reduction in mass flux from the WCL and reductions in mass flux through the secondary control structure from Eagle Point Lake; however, a large mass of PFAS is already present in the groundwater that discharges into Lake Elmo. • In addition, the long retention time of the lake would likely result in small decreases over many decades.
9: Horseshoe Lake/West Lakeland – Surface Water	None	Low • PFAS would continue to migrated into Horseshoe Lake and the West Lakeland Storage Ponds from Lake Elmo and Eagle Point Lake.	Long-term monitoring	Moderate • Eventual reductions in PFAS in Eagle Point Lake would reduce downstream PFAS concentrations, specifically PFOS; however, PFOA dominated surface water would continue to enter from Lake Elmo until reductions are observed from improved source area control. • The time for reductions to be observed are unknown.	Permeable adsorptive barrier	Moderate to High • The PAB would reduce PFAS mass flux into this AOC from both Eagle Point Lake and Lake Elmo. • This would result in eventual decreases in surface water PFAS concentrations and subsequent mass flux from surface water to groundwater.	Permeable adsorptive barrier	Moderate to High. • The PAB would reduce PFAS mass flux into this AOC from both Eagle Point Lake and Lake Elmo. • This would result in eventual decreases in surface water PFAS concentrations and subsequent mass flux from surface water to groundwater.
10: West Lakeland - Groundwater	None	Low • PFAS concentrations would not be reduced and the plume would continue to migrate eastward towards currently unimpacted drinking water aquifers.	Long-term monitoring + access restrictions	Low • PFAS concentrations would not be reduced and the plume would continue to migrate eastward towards currently unimpacted drinking water aquifers.	Long-term monitoring	Low • While the mass flux of PFAS into the drinking water would be reduced through the PABs, the mass of PFAS already present in the aquifers is large and would continue to migrate downgradient towards unimpacted drinking water aquifers.	Localized pump and treat + access restrictions	High • Groundwater concentrations would be reduced over time with the WLL pump and treat system and with the reduction in mass flux from surface water into groundwater. • Downgradient migration would also be reduced.
11: Upper Raleigh Creek Wetland Complexes – Sediment	None	Low • No changes in surface water concentrations would result in high sediment concentrations. • Human health would not be protected from incidental exposure.	Long-term monitoring + access restrictions	Low to Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed; however, PFAS migration via surface water would continue in the short term.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.

Table 5. Analysis of the Ability of Remedial Alternatives to Meet Remedial Action Objectives.

AOC	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO
12: Anna's Grove Wetland Complex - Sediment	None	Low • No changes in surface water concentrations would result in high sediment concentrations. • Human health would not be protected from incidental exposure.	Long-term monitoring + access restrictions	Low to Mderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations may be observed; however, PFAS migration via surface water would continue in the short term.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.
13: Eagle Point Lake - Sediment	None	Low • No changes in surface water concentrations would result in high sediment concentrations. • Human health would not be protected from incidental exposure.	Long-term monitoring + signage	Low to Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations may be observed; however, PFAS migration via surface water would continue in the short term.	Long-term monitoring + signage	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + signage	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.

Table 5. Analysis of the Ability of Remedial Alternatives to Meet Remedial Action Objectives.

AOC	Alternative 5		Alternative 6		Alternative 7		Alternative 8	
	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO
1: WCL – Surface Water and Shallow Groundwater	Groundwater pump and treat + access restrictions	High • WCL pump and treat would result in a reduction in mass flux from the WCL both horizontally towards Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers, decreasing PFAS concentrations in Sunfish Lake.	Groundwater pump and treat + access restrictions	High • WCL pump and treat would result in a reduction in mass flux from the WCL both horizontally towards Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers, decreasing PFAS concentrations in Sunfish Lake.	Groundwater pump and treat + access restrictions	High • WCL pump and treat would result in a reduction in mass flux from the WCL both horizontally towards Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers, decreasing PFAS concentrations in Sunfish Lake.	Groundwater pump and treat + access restrictions	High • WCL pump and treat would result in a reduction in mass flux from the WCL both horizontally towards Sunfish Lake and Lake Elmo and vertically to the drinking water aquifers, decreasing PFAS concentrations in Sunfish Lake.
2: WCL – Bedrock Aquifers	Localized MBWA + access restrictions	High • The MBWA would reduce concentrations within the plume by removing PFAS and reduce downgradient migration. • Reductions in mass flux from the WCL would aid in achieving RAOs.	Localized MBWA + access restrictions	High • The MBWA would reduce concentrations within the plume by removing PFAS and reduce downgradient migration. • Reductions in mass flux from the WCL would aid in achieving RAOs.	Regional MBWA + access restrictions	High • The MBWA would reduce concentrations within the plume by removing PFAS and reduce downgradient migration. • Reductions in mass flux from the WCL would aid in achieving RAOs.	Regional MBWA + access restrictions	High • The MBWA would reduce concentrations within the plume by removing PFAS and reduce downgradient migration • Reductions in mass flux from the WCL would aid in achieving RAOs.
3: ODS – Surface Water	Raleigh Creek reroute by 3M	High • The Raleigh Creek reroute would reduce the mass flux of PFAS leaving ODS via surface water; however, PFAS may still be released from ODS during periods of high flow such as during snow melt and large rain events. • Leaching from impacted sediment downgradient of ODS and the potential discharge of PFAS impacted groundwater to downgradient wetland areas may also result in the continue migration of PFAS downstream.	Raleigh Creek reroute by 3M	High • The Raleigh Creek reroute would reduce the mass flux of PFAS leaving ODS via surface water; however, PFAS may still be released from ODS during periods of high flow such as during snow melt and large rain events. • Leaching from impacted sediment downgradient of ODS and the potential discharge of PFAS impacted groundwater to downgradient wetland areas may also result in the continue migration of PFAS downstream.	Raleigh Creek reroute by 3M	High • The Raleigh Creek reroute would reduce the mass flux of PFAS leaving ODS via surface water; however, PFAS may still be released from ODS during periods of high flow such as during snow melt and large rain events. • Leaching from impacted sediment downgradient of ODS and the potential discharge of PFAS impacted groundwater to downgradient wetland areas may also result in the continue migration of PFAS downstream.	Raleigh Creek reroute by 3M	High • The Raleigh Creek reroute would reduce the mass flux of PFAS leaving ODS via surface water; however, PFAS may still be released from ODS during periods of high flow such as during snow melt and large rain events. • Leaching from impacted sediment downgradient of ODS and the potential discharge of PFAS impacted groundwater to downgradient wetland areas may also result in the continue migration of PFAS downstream.
4: Downgradient ODS Groundwater	Long-term monitoring + access restrictions; Continued pumping of Oakdale Municipal Supply Wells; Continued/ Improved source zone control at ODS	Moderate • Continued pumping of Oakdale supply wells would contain portions of the plume to reduce continued southerly migration. • Control of the source zone would reduce mass flux from the source zone which would aid in the reduction of groundwater concentrations and downgradient migration within the bedrock aquifers. • These efforts, however, would not fully achieve the RAOs as migration into currently unimpacted areas would continue.	Long-term monitoring + access restrictions; Continued pumping of Oakdale Municipal Supply Wells; Continued/ Improved source zone control at ODS	Moderate • Continued pumping of Oakdale supply wells would contain portions of the plume to reduce continued southerly migration. • Control of the source zone would reduce mass flux from the source zone which would aid in the reduction of groundwater concentrations and downgradient migration within the bedrock aquifers. • These efforts, however, would not fully achieve the RAOs as migration into currently unimpacted areas would continue.	Regional MBWA + Long-term monitoring + access restrictions; Continued pumping of Oakdale Municipal Supply Wells; Continued/ Improved source zone control at ODS	High • Extraction by the MBWA would reduce migration in the groundwater plume resulting from impacts at ODS. • Control of the source zone would reduce mass flux from the source zone which would aid in the reduction of groundwater concentrations and downgradient migration within the bedrock aquifers. • RAOs would be acheived as PFAS mass would be removed at both the source area and from the bedrock plums and migration downgradient into unimpacted aquifers would be reduced.	Regional MBWA + Long-term monitoring + access restrictions; Continued pumping of Oakdale Municipal Supply Wells; Continued/ Improved source zone control at ODS	High • Extraction by the MBWA would reduce migration in the groundwater plume resulting from impacts at ODS. • Control of the source zone would reduce mass flux from the source zone which would aid in the reduction of groundwater concentrations and downgradient migration within the bedrock aquifers. • RAOs would be acheived as PFAS mass would be removed at both the source area and from the bedrock plums and migration downgradient into unimpacted aquifers would be reduced.
5: Raleigh Creek – Surface Water	Permeable adsorptive barrier	Moderate to High • Reductions in surface water concentrations are expected with the reroute around ODS which would reduce infiltration of PFAS impacted surface water to groundwater. • The in-stream PABs would aid in further reducing PFAS concentrations within Raleigh Creek that result from incidental discharges from ODS during large flow events and from leaching of PFAS from sediment.	Permeable adsorptive barrier	Moderate to High • Reductions in surface water concentrations are expected with the reroute around ODS which would reduce infiltration of PFAS impacted surface water to groundwater. • The in-stream PABs would aid in further reducing PFAS concentrations within Raleigh Creek that result from incidental discharges from ODS during large flow events and from leaching of PFAS from sediment.	Permeable adsorptive barrier	Moderate to High • Reductions in surface water concentrations are expected with the reroute around ODS which would reduce infiltration of PFAS impacted surface water to groundwater. • The in-stream PABs would aid in further reducing PFAS concentrations within Raleigh Creek that result from incidental discharges from ODS during large flow events and from leaching of PFAS from sediment.	Permeable adsorptive barrier	Moderate to High • Reductions in surface water concentrations are expected with the reroute around ODS which would reduce infiltration of PFAS impacted surface water to groundwater. • The in-stream PABs would aid in further reducing PFAS concentrations within Raleigh Creek that result from incidental discharges from ODS during large flow events and from leaching of PFAS from sediment.

Table 5. Analysis of the Ability of Remedial Alternatives to Meet Remedial Action Objectives.

AOC	Alternative 5		Alternative 6		Alternative 7		Alternative 8	
	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO
6: Eagle Point Lake – Surface Water	Long-term monitoring	Moderate to High • Reductions in surface water concentrations are expected following the reroute of Raleigh Creek • PABs upgradient in Raleigh Creek will aid in the reduction of PFAS entering Eagle Point Lake from sediment leaching, incidental releases of PFAS impacted surface water from ODS, and potentially groundwater discharge of PFAS imapcted groundwater to wetland areas downgradient of ODS. • The length of time for these reductions and the extent of PFAS removal by PABs is uncertain. Leaching of PFAS from sediment in Eagle Point Lake may also impact the ability to meet the RAOs.	Long-term monitoring	Moderate to High • Reductions in surface water concentrations are expected following the reroute of Raleigh Creek • PABs upgradient in Raleigh Creek will aid in the reduction of PFAS entering Eagle Point Lake from sediment leaching, incidental releases of PFAS impacted surface water from ODS, and potentially groundwater discharge of PFAS imapcted groundwater to wetland areas downgradient of ODS. • The length of time for these reductions and the extent of PFAS removal by PABs is uncertain. Leaching of PFAS from sediment in Eagle Point Lake may also impact the ability to meet the RAOs.	Long-term monitoring	Moderate to High • Reductions in surface water concentrations are expected following the reroute of Raleigh Creek • PABs upgradient in Raleigh Creek will aid in the reduction of PFAS entering Eagle Point Lake from sediment leaching, incidental releases of PFAS impacted surface water from ODS, and potentially groundwater discharge of PFAS imapcted groundwater to wetland areas downgradient of ODS. • The length of time for these reductions and the extent of PFAS removal by PABs is uncertain. Leaching of PFAS from sediment in Eagle Point Lake may also impact the ability to meet the RAOs.	Long-term monitoring	Moderate to High • Reductions in surface water concentrations are expected following the reroute of Raleigh Creek • PABs upgradient in Raleigh Creek will aid in the reduction of PFAS entering Eagle Point Lake from sediment leaching, incidental releases of PFAS impacted surface water from ODS, and potentially groundwater discharge of PFAS imapcted groundwater to wetland areas downgradient of ODS. • The length of time for these reductions and the extent of PFAS removal by PABs is uncertain. Leaching of PFAS from sediment in Eagle Point Lake may also impact the ability to meet the RAOs.
7: Raleigh Creek + Eagle Point Lake - Groundwater	MBWA + access restrictions	High • PFAS within this plume would be captured by the MBWA, reducing PFAS concentrations and reducing downgradient migration, especially that towards the Woodbury Tamarack Well field. • Reductions in infiltration of PFAS impacted groundwater from Eagle Point Lake and Raleigh Creek would also aid in achieving the RAOs.	MBWA + access restrictions	High • PFAS within this plume would be captured by the MBWA, reducing PFAS concentrations and reducing downgradient migration, especially that towards the Woodbury Tamarack Well field. • Reductions in infiltration of PFAS impacted groundwater from Eagle Point Lake and Raleigh Creek would also aid in achieving the RAOs.	Long-term monitoring + access restrictions	High • PFAS within this plume would be captured by the MBWA, reducing PFAS concentrations and reducing downgradient migration, especially that towards the Woodbury Tamarack Well field. • Reductions in infiltration of PFAS impacted groundwater from Eagle Point Lake and Raleigh Creek would also aid in achieving the RAOs.	Regional MBWA + access restrictions	High • PFAS within this plume would be captured by the MBWA, reducing PFAS concentrations and reducing downgradient migration, especially that towards the Woodbury Tamarack Well field. • Reductions in infiltration of PFAS impacted groundwater from Eagle Point Lake and Raleigh Creek would also aid in achieving the RAOs.
8: Lake Elmo – Surface Water	Long-term monitoring	Moderate • Reductions in PFAS concentrations may be observed over time with the reduction in mass flux from the WCL and reductions in mass flux through the secondary control structure from Eagle Point Lake; however, a large mass of PFAS is already present in the groundwater that discharges into Lake Elmo. • In addition, the long retention time of the lake would likely result in small decreases over many decades.	Long-term monitoring	Moderate • Reductions in PFAS concentrations may be observed over time with the reduction in mass flux from the WCL and reductions in mass flux through the secondary control structure from Eagle Point Lake; however, a large mass of PFAS is already present in the groundwater that discharges into Lake Elmo. • In addition, the long retention time of the lake would likely result in small decreases over many decades.	Long-term monitoring	Moderate • Reductions in PFAS concentrations may be observed over time with the reduction in mass flux from the WCL and reductions in mass flux through the secondary control structure from Eagle Point Lake; however, a large mass of PFAS is already present in the groundwater that discharges into Lake Elmo. • In addition, the long retention time of the lake would likely result in small decreases over many decades.	Long-term monitoring	Moderate • Reductions in PFAS concentrations may be observed over time with the reduction in mass flux from the WCL and reductions in mass flux through the secondary control structure from Eagle Point Lake; however, a large mass of PFAS is already present in the groundwater that discharges into Lake Elmo. • In addition, the long retention time of the lake would likely result in small decreases over many decades.
9: Horseshoe Lake/West Lakeland – Surface Water	Permeable adsorptive barrier	Moderate to High. • The PAB would reduce PFAS mass flux into this AOC from both Eagle Point Lake and Lake Elmo. • This would result in eventual decreases in surface water PFAS concentrations and subsequent mass flux from surface water to groundwater.	Permeable adsorptive barrier	Moderate to High • The PAB would reduce PFAS mass flux into this AOC from both Eagle Point Lake and Lake Elmo. • This, in combination to efforts to reduce upstream concentrations would result in eventual decreases in surface water PFAS concentrations and subsequent mass flux from surface water to groundwater. • Installation of the PAB will reduce concentrations faster instead of waiting for Eagle Point Lake and Lake Elmo concentrations to be reduced.	Permeable adsorptive barrier	Moderate to High • The PAB would reduce PFAS mass flux into this AOC from both Eagle Point Lake and Lake Elmo. • This, in combination to efforts to reduce upstream concentrations would result in eventual decreases in surface water PFAS concentrations and subsequent mass flux from surface water to groundwater. • Installation of the PAB will reduce concentrations faster instead of waiting for Eagle Point Lake and Lake Elmo concentrations to be reduced.	Permeable adsorptive barrier	Moderate to High • The PAB would reduce PFAS mass flux into this AOC from both Eagle Point Lake and Lake Elmo. • This, in combination to efforts to reduce upstream concentrations would result in eventual decreases in surface water PFAS concentrations and subsequent mass flux from surface water to groundwater. • Installation of the PAB will reduce concentrations faster instead of waiting for Eagle Point Lake and Lake Elmo concentrations to be reduced.
10: West Lakeland - Groundwater	Long-term monitoring + access restrictions	Low • While the mass flux of PFAS into the drinking water would be reduced, the mass of PFAS already present in the aquifers is large and would continue to migrate downgradient towards unimpacted drinking water aquifers.	Localized pump and treat + access restrictions	High. Reduced surface water concentrations in AOC 9 would reduce the migration of PFAS into the groundwater. The WLL pump and treat system would further reduce PFAS concentrations within the drinking water aquifers and reduce downgradient migration into areas that are less or not impacted.	Localized pump and treat + access restrictions	High. Groundwater concentrations will be reduced over time with the WLL pump and treat system and with the reduction in mass flux from surface water into groundwater. Downgradient migration will also be reduced.	Regional MBWA + access restrictions	High • The MBWA will remove PFAS from the current plume extent, reducing the concentrations over time. • It will also prevent downgradient migration of high PFAS concentrations within the bedrock aquifers, specifically towards private wells and communities located east of the Site. • Reductions in the mass flux of PFAS into the groundwater from Horseshoe Lake and the West Lakeland storage ponds will also aid in achieving these RAOs.

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AOC	Alternative 5		Alternative 6		Alternative 7		Alternative 8	
	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO	Action	Ability to Achieve RAO
11: Upper Raleigh Creek Wetland Complexes – Sediment	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.
12: Anna's Grove Wetland Complex - Sediment	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + access restrictions	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.
13: Eagle Point Lake - Sediment	Long-term monitoring + signage	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + signage	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + signage	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.	Long-term monitoring + signage	Moderate • Access restrictions would help prevent incidental public exposure. • Reductions in the surface water concentrations may result in PFAS leaching from sediment. Long term reductions in PFAS concentrations in sediment may be observed. • The PABs downgradient would reduce downgradient migration of PFAS that results from sediment leaching.

Note: Text in black indicates a different proposed treatment for an AOC and/or a different proposed result compared to the previous Alternative; text in gray indicates treatment in the previous alternative is the same for a given AOC or that the impact of the proposed treatment would be the same on a given AOC.

Legend: AOC = area of concern; MBWA = multi-benefit well array; ODS = Oakdale Disposal Site; PAB = permeable adsorptive barrier; RAO = remedial action objective; RC+EPL = Raleigh Creek and Eagle Point Lake; WCL = Washington County Landfill.

Table 6. Analysis of Long-Term Effectiveness of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Reduction in magnitude of residual risk after completion of remedial activities	Low • This alternative would not implement any remedial activities and thus would not reduce the risks posed by the Site. • Mass flux from the WCL and ODS source zones would continue. • Plume migration through the drinking water aquifers would not be reduced. • Sediment and surface water risk would not be addressed.	Low to Moderate • Mass flux from the WCL source zone would be reduced by pump and treat and 3M would reduce migration of PFAS from ODS thorugh the Superfund program. • Plume migration through the drinking water aquifers would not be reduced. • Access restrictions would reduce risk of resident interaction with contaminated sediment or surface water.	Low to Moderate • Mass flux from the WCL source zone would be reduced by pump and treat and 3M would reduce migration of PFAS from ODS thorugh the Superfund program • Plume migration through the drinking water aquifers would not be reduced. • Access restrictions and PABs would reduce risk of resident interaction with contaminated sediment or surface water.	Moderate to High • Mass flux from the WCL source zone would be reduced by pump and treat and 3M would reduce migration of PFAS from ODS thorugh the Superfund program • Plume migration through the drinking water aquifers would be reduced by pump and treat systems. • Access restrictions and PABs would reduce risk of resident interaction with contaminated sediment or surface water. • Length of time treatment plants must be operated is uncertain; treatment time could exceed 30-50 years.
Long-term potential to reduce remediation efforts	Low • Drinking water treatment will continue indefinitely in currently affected communities. • Additional communities would require treatment in the future as the plume migrates.	Low to Moderate • Source zone treatment will reduce additional PFAS mass loading to the drinking aquifers but does not address PFAS already in the drinking water aquifers. • Drinking water treatment will continue indefinitely in currently affected communities. • Additional communities would require treatment in the future as the plume migrates.	Low to Moderate • Source zone treatment will reduce additional PFAS mass loading to aquifers but does not address PFAS already in the drinking water aquifers. • PABs may help reduce PFAS concentrations in sediment by preventing transfer from surface water to sediment. • Drinking water treatment would continue indefinitely in currently affected communities. • Additional communities would require treatment in the future as the plume migrates.	Moderate to High • Reduction in mass loading to aquifer and plume capture should reduce treatment need in downgradient communities. • Source zone treatment reduces additional PFAS mass loading to the aquifers.
Long-term sustainability	Low to Moderate • GAC is derived from coal and releases carbon emissions during GAC manufacturing, trucking to and from treatment plants, and during reactivation. • Media cannot be reactivated for drinking water treatment, increasing the GAC consumption and waste.	Moderate • GAC is derived from coal and releases carbon emissions during GAC manufacturing, trucking to and from treatment plants, and during reactivation. • Media cannot be reactivated for drinking water treatment, increasing the GAC consumption and waste. • WCL treatment could utilize technology other than GAC to treat source zone, possibly improving the sustainability.	Moderate • GAC is derived from coal and releases carbon emissions during GAC manufacturing, trucking to and from treatment plants, and during reactivation. • Media cannot be reused for drinking water treatment resulting in a high volume of annual media usage. • PAB media would likely require disposal in a landfill, but low relative media usage. • WCL treatment could utilize technology other than GAC to treat source zone, possibly improving the sustainability.	Low • Pump and treat plant effluent would not be used for drinking water, requiring duplicative treatment efforts. • PAB media would likely require disposal in a landfill, but low relative media usage. • WCL and plume treatment could utilize technology other than GAC.
Flexibility in alternative to provide additional protective benefits	Low • No additional protective benefits provided by this alternative.	Low • No additional protective benefits provided by this alternative.	Low • No additional protective benefits provided by this alternative.	Low • No additional protective benefits provided by this alternative.
Degree of certainty that alternative will prove successful	Low • No further action will result in additional communities requiring drinking water treatment.	Low to Moderate • WCL treatment and additional remedial actions at ODS would reduce new PFAS mass loading to drinking water aquifers. • Required treatment time unknown to sufficiently remove mass from WCL. • Long-term effect of reductions in mass flux into drinking water aquifers on plume migration is uncertain but likely limited.	Low to Moderate • WCL treatment and additional remedial actions at ODS would reduce new PFAS mass loading to drinking water aquifers. • Required treatment time unknown to sufficiently remove mass from WCL. • In-stream PABs not widely used; uncertainty over removal efficiency.	Moderate to High • WCL treatment and additional remedial actions at ODS would reduce new PFAS mass loading to drinking water aquifers. • Required treatment time unknown to sufficiently remove mass from WCL. • In-stream PABs not widely used; uncertainty over removal efficiency. • Pump and treat systems should reduce plume spread and protect downgradient communities.
Long-term protection against non-drinking water related risks that would remain	Low • Surface water and sediment AOCs are not addressed by this alternative; therefore, exposure risk to the public would remain.	Low to Moderate • Access restrictions would reduce potential for resident interaction with surface water or sediment but would not reduce concentrations of PFAS in sediment or surface water. • Reroute of Raleigh Creek around ODS may reduce surface water concentrations.	Moderate to High • Access restrictions would reduce potential for resident interaction with surface water or sediment. • Reroute of Raleigh Creek around ODS and PABs may help to reduce surface water and sediment PFAS concentrations	Moderate to High • Access restrictions would reduce potential for resident interaction with surface water or sediment. • Reroute of Raleigh Creek around ODS and PABs may help to reduce surface water and sediment PFAS concentrations.

Table 6. Analysis of Long-Term Effectiveness of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Reduction in magnitude of residual risk after completion of remedial activities	Moderate • Mass flux from the WCL source zone would be reduced by pump and treat and 3M would reduce migration of PFAS from ODS thorugh the Superfund program • Plume migration through the drinking water aquifers would only be partially reduced by Localized MBWA. • Access restrictions and PABs would reduce risk of resident interaction with contaminated sediment or surface water. • Additional downgradient communities likely would still require drinking water treatment in the future.	Moderate to High • Mass flux from the WCL source zone would be reduced by pump and treat and 3M would reduce migration of PFAS from ODS thorugh the Superfund program • Plume migration through the drinking water aquifers would be reduced by Localized MBWA (AOCs 2 and 7) and West Lakeland (AOC 10) pump and treat. • Plume migration south of ODS would continue to partially be reduced through the Oakdale municipal supply wells. • Access restrictions and PABs would reduce risk of resident interaction with contaminated sediment or surface water.	High • Mass flux from the WCL source zone would be reduced by pump and treat and 3M would reduce migration of PFAS from ODS thorugh the Superfund program • Plume migration through the drinking water aquifers would be reduced by Regional MBWA (AOCs 2, 4, and 7) and West Lakeland (AOC 10) pump and treat. • Access restrictions and PABs would reduce risk of resident interaction with contaminated sediment or surface water.	High • Mass flux from the WCL source zone would be reduced by pump and treat and 3M would reduce migration of PFAS from ODS thorugh the Superfund program • Plume migration through the drinking water aquifers would be reduced by the Regional MBWA across the Site. • Access restrictions and PABs would reduce risk of resident interaction with contaminated sediment or surface water.
Long-term potential to reduce remediation efforts	Low to Moderate • Plume capture would not be complete across the Site and would not fully mitigate risk to downgradient communities. • Source zone treatment reduces additional PFAS mass loading to the aquifers.	Moderate to High • Plume capture would mitigate risk to downgradient communities. • Risk to drinking water receptors downgradient of ODS in the areas of the plume not controlled by the Oakdale supply wells is minimal because communities downgradient do not use groundwater for drinking water. • Source zone treatment reduces additional PFAS mass loading to the aquifers.	High • Plume capture would mitigate risk to downgradient communities. • Source zone treatment reduces additional PFAS mass loading to the aquifers.	High • Plume capture would mitigate risk to downgradient communities. • Source zone treatment reduces additional PFAS mass loading to the aquifers.
Long-term sustainability	Moderate • PAB media would likely require disposal in a landfill, but low relative media usage. • WCL and plume treatment could utilize technology other than GAC. • Localized MBWA would provide beneficial use of treated water prior to discharge.	Moderate • PAB media would likely require disposal in a landfill, but low relative media usage. • WCL and plume treatment could utilize technology other than GAC. • Localized MBWA would provide beneficial use of treated water prior to discharge. • AOC 10 pump and treat would discharge treated water without prior beneficial use.	Moderate • PAB media would likely require disposal in a landfill, but low relative media usage. • WCL and plume treatment could utilize technology other than GAC. • Regional MBWA would provide beneficial use of treated water prior to discharge. • AOC 10 pump and treat would discharge treated water without prior beneficial use.	Moderate to High • PAB media would likely require disposal in a landfill, but low relative media usage. • WCL and plume treatment could utilize technology other than GAC. • Regional MBWA would provide beneficial use of treated water prior to discharge. • Reduces the redundancy of treatment.
Flexibility in alternative to provide additional protective benefits	Moderate • Flexibility to adapt to plume migration and to include other communities, such as the Prairie Island Indian Community.	Moderate • Flexibility to adapt to plume migration and to include other communities, such as the Prairie Island Indian Community.	Moderate to High • Potential to provide water to Prairie Island Indian Community or other communities in the future. • Extraction and injection could be modified, giving future operations flexibility.	Moderate to High • Potential to provide water to Prairie Island Indian Community or other communities in the future. • Extraction and injection could be modified, giving future operations flexibility.
Degree of certainty that alternative will prove successful	Low to Moderate • WCL treatment and additional remedial actions at ODS would reduce new PFAS mass loading to drinking water aquifers. • Required treatment time unknown to sufficiently remove mass from WCL. • In-stream PABs not widely used; uncertainty over removal efficiency. • Localized MBWA in this alternative would not complete plume capture.	Moderate to High • WCL treatment and additional remedial actions at ODS would reduce new PFAS mass loading to drinking water aquifers. • Plume control should protect downgradient communities with flexibility in the pump and treat system to change pumping rates and well configuration to provide additional protection is needed. • Required treatment time unknown to remediate WCL and drinking water aquifer. • In-stream PABs not widely used; uncertainty over removal efficiency.	Moderate to High • WCL treatment and additional remedial actions at ODS would reduce new PFAS mass loading to drinking water aquifers. • Plume control should protect downgradient communities with flexibility in the pump and treat system to change pumping rates and well configuration to provide additional protection as needed. • Required treatment time unknown to remediate WCL and drinking water aquifer. • In-stream PABs not widely used; uncertainty over removal efficiency.	Moderate to High • WCL treatment and additional remedial actions at ODS would reduce new PFAS mass loading to drinking water aquifers. • Plume control should protect downgradient communities with flexibility to change pumping rates and well configuration to provide additional protection is needed. • Required treatment time unknown to remediate WCL and drinking water aquifer. • In-stream PABs not widely used; uncertainty over removal efficiency.
Long-term protection against non-drinking water related risks that would remain	Moderate to High • Access restrictions would reduce potential for resident interaction with surface water or sediment. • Reroute of Raleigh Creek around ODS and PABs may help to reduce surface water and sediment PFAS concentrations.	Moderate to High • Access restrictions would reduce potential for resident interaction with surface water or sediment. • Reroute of Raleigh Creek around ODS and PABs may help to reduce surface water and sediment PFAS concentrations.	Moderate to High • Access restrictions would reduce potential for resident interaction with surface water or sediment. • Reroute of Raleigh Creek around ODS and PABs may help to reduce surface water and sediment PFAS concentrations.	Moderate to High • Access restrictions would reduce potential for resident interaction with surface water or sediment. • Reroute of Raleigh Creek around ODS and PABs may help to reduce surface water and sediment PFAS concentrations.

Note: Text in black indicates a different proposed treatment for an AOC and/or a different proposed result compared to the previous Alternative; text in gray indicates treatment in the previous alternative is the same for a given AOC or that the impact of the proposed treatment would be the same on a given AOC.

Legend: AOC = area of concern; GAC = granular activated carbon; MBWA = multi-benefit well array; ODS = Oakdale Disposal Site; PAB = permeable adsorptive barrier; WCL = Washington County Landfill.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Treatment volume of PFAS impacted water	Low • PFAS removal would occur with pumping from existing private wells. • Oakdale municipal supply wells remove PFAS impacted water from the drinking water aquifers south of ODS (AOC 4). • The volume of PFAS impacted water in Lake Elmo and West Lakeland would not be reduced. • All proposed treatment trains would treat long-chain PFAS. • Some of the proposed treatment trains (e.g. GAC) may not effectively treat short-chain PFAS such as PFBA.	Low to Moderate • PFAS removal would occur with pumping from existing private wells. • Oakdale municipal supply wells remove PFAS impacted water from the drinking water aquifers south of ODS (AOC 4). • Source zone treatment at WCL (AOC 1) and ODS would remove the largest mass of PFAS per volume of water treated, reducing the future downgradient volume of PFAS impacted water within the drinking water aquifers. • The volume of PFAS impacted water in Lake Elmo and West Lakeland would not be reduced • All proposed treatment trains would treat long-chain PFAS. • Some of the proposed treatment trains (e.g. GAC) may not effectively treat short-chain PFAS such as PFBA.	Low to Moderate • PFAS removal would occur with pumping from existing private wells. • Oakdale municipal supply wells remove PFAS impacted water from the drinking water aquifers south of ODS (AOC 4). • Source zone treatment at WCL (AOC 1) and ODS would remove the largest mass of PFAS per volume of water treated, reducing the future downgradient volume of PFAS impacted water within the drinking water aquifers. • All proposed treatment trains would treat long-chain PFAS. • Some of the proposed treatment trains (e.g. GAC) may not effectively treat short-chain PFAS such as PFBA. • PABs will remove PFAS from surface water, but removal efficiency is uncertain at high flows, and may not effectively treat short-chain PFAS such as PFBA.	Moderate to High • PFAS removal would occur with pumping from existing private wells. • Oakdale municipal supply wells remove PFAS impacted water from the drinking water aquifers south of ODS (AOC 4). • Source zone treatment at WCL (AOC 1) and ODS would remove the largest mass of PFAS per volume of water treated, reducing the future downgradient volume of PFAS impacted water within the drinking water aquifers. • Pump and treat plants will remove additional PFAS from drinking water aquifers in WCL, Raleigh Creek, and Eagle Point Lake (AOCs 2 and 7) and West Lakeland (AOC 10). • All proposed treatment trains would treat long-chain PFAS. • Some of the proposed treatment trains (e.g. GAC) may not effectively treat short-chain PFAS such as PFBA. • PABs will remove PFAS from surface water, but removal efficiency is uncertain at high flows, and may not effectively treat short-chain PFAS such as PFBA.
Degree of expected reduction in toxicity, mobility, or volume	Low • Lack of source zone treatment at WCL and continued migration of impacts from ODS will allow additional mass flux into the drinking water aquifers. • Lack of groundwater plume control within the drinking water aquifers will result in continued spread of the groundwater plume.	Low to Moderate • Source zone treatment at the WCL and additional remedial actions at ODS will reduce additional mass flux into the drinking water aquifers. Lack of groundwater plume control within the drinking water aquifers will result in continued spread of the groundwater plume.	Low to Moderate • Source zone treatment at the WCL, additional remedial actions at ODS, and PABs would reduce additional mass flux into the drinking water aquifers. • Lack of groundwater plume control would result in continued spread of the groundwater plume.	Moderate to High • Source zone treatment at the WCL, additional remedial actions at ODS, and PABs would reduce additional mass flux into the drinking water aquifers. • Oakdale municipal supply wells decrease the spread of the plume downgradient of Oakdale; however, placement of the supply wells does not fully capture the plume and allows for continued migration. • Pump and treat will decrease spread of the groundwater plume.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Degree to which treatment is irreversible	Moderate to High • PFAS removed by drinking water GAC is destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled.	Moderate to High • PFAS removed by drinking water GAC is destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled. • WCL treatment is expected to utilize destruction technology to destroy removed PFAS.	Moderate to High • PFAS removed by drinking water GAC is destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled. • WCL treatment is expected to utilize destruction technology to destroy removed PFAS. • PABs may desorb PFAS if media not replaced at appropriate frequency but captured PFAS would be destroyed or disposed of to prevent reintroduction into the environment.	Moderate to High • PFAS removed by drinking water GAC is destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled. • WCL treatment and plume pump and treat plants are expected to utilize destruction technology to destroy removed PFAS. • PABs may desorb PFAS if media not replaced at appropriate frequency but captured PFAS would be destroyed or disposed of to prevent reintroduction into the environment.
Reductions in potential toxicity and quantity of residuals that would remain following treatment	Low • Large volumes of spent GAC from drinking water plants would need to be trucked to reactivation facilities. • PFAS destroyed by GAC reactivation, reducing toxicity of GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Large volume of PFAS mass would remain following treatment as targeted treatment is not occurring in the drinking water aquifers.	Low to Moderate • Large volumes of spent GAC from drinking water plants will need to be trucked to reactivation facilities. • PFAS destroyed by GAC reactivation, reducing toxicity of GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Source zone treatment could implement on-site destruction technology to reduce toxicity and quantity of residuals. • Large volume of PFAS mass would remain following treatment as targeted treatment is not occurring in the drinking water aquifers.	Moderate • Large volumes of spent GAC from drinking water plants will need to be trucked to reactivation facilities. • PFAS destroyed by GAC reactivation, reducing toxicity of GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Source zone treatment could implement on-site destruction technology to reduce toxicity and quantity of residuals. • PAB media must be landfilled or utilize destruction technology. • Large volume of PFAS mass would remain following treatment as targeted treatment is not occurring in the drinking water aquifers.	Moderate to High • Large volumes of spent GAC from drinking water plants will need to be trucked to reactivation facilities. • PFAS destroyed by GAC reactivation, reducing toxicity of GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Source zone treatment could implement on-site destruction technology to reduce toxicity and quantity of residuals. • PAB media must be landfilled or utilize destruction technology. • Pump and treat plants will likely utilize media that requires disposal; volume may be large due to treatment plant size.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Degree to which treatment reduces Site risks	Low • Risks to drinking water aquifers southwest of ODS would remain because extraction by the Oakdale municipal wells does not provide full plume control; however, use of the aquifer is limited in this area. • Downgradient drinking water aquifers would not be protected and risk to currently unaffected communities would not be mitigated.	Low • Risks to private and municipal wells east of WCL are reduced through source zone control at WCL. • Risks to drinking water aquifers southwest of ODS would be reduced to a limited extent remain because extraction by the Oakdale municipal wells does not provide full plume control; however, reduction in migration of PFAS impacts from ODS would reduce this migration depending on the extent to which 3M addresses impacts offsite of ODS. The use of the aquifer is limited in this area. • Downgradient drinking water aquifers would not be protected and risk to currently unaffected communities would not be mitigated.	Low • Risks to private and municipal wells east of WCL are reduced through source zone control at WCL. • Risks to drinking water aquifers southwest of ODS would be reduced to a limited extent remain because extraction by the Oakdale municipal wells does not provide full plume control; however, reduction in migration of PFAS impacts from ODS would reduce this migration depending on the extent to which 3M addresses impacts offsite of ODS. The use of the aquifer is limited in this area. • Risks to ecological receptors would be reduced with the implementation of PABs and reduction of PFAS discharge to Lake Elmo via impacted groundwater. • Downgradient drinking water aquifers would not be protected and risk to currently unaffected communities would not be mitigated.	Moderate to High • Risks to private and municipal wells east of WCL are reduced through source zone control at WCL and pump and treat systems in Lake Elmo (AOCs 2 and 7) and West Lakeland (AOC 10). • Risks to private and municipal wells south of Lake Elmo, including the Tamarack Well Field are reduced through pump and treat extraction south of Raleigh Creek and Eagle Point Lake. • Risks to drinking water aquifers southwest of ODS would be reduced to a limited extent remain because extraction by the Oakdale municipal wells does not provide full plume control; however, reduction in migration of PFAS impacts from ODS would reduce this migration depending on the extent to which 3M addresses impacts offsite of ODS. The use of the aquifer is limited in this area. • Risks to ecological receptors would be reduced with the implementation of PABs and reduction of PFAS discharge to Lake Elmo via impacted groundwater.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Treatment volume of PFAS impacted water	Moderate • Source zone treatment at WCL (AOC 1) and ODS would remove the largest mass of PFAS per volume of water treated, reducing the future downgradient volume of PFAS impacted water within the drinking water aquifers. • Oakdale municipal supply wells remove PFAS impacted water from the drinking water aquifers south of ODS (AOC 4). • Localized MBWA will remove PFAS impacted water within the drinking water aquifers downgradient of the WCL, Raleigh Creek, and Eagle Point Lake (AOCs 2 and 7). • The volume of PFAS impacted water in West Lakeland would not be reduced. • All proposed treatment trains would treat long-chain PFAS. • Some of the proposed treatment trains (e.g. GAC) may not effectively treat short-chain PFAS such as PFBA. • PABs will remove PFAS from surface water, but removal efficiency is uncertain at high flows, and may not effectively treat short-chain PFAS such as PFBA.	Moderate to High • Source zone treatment at WCL (AOC 1) and ODS would remove the largest mass of PFAS per volume of water treated, reducing the future downgradient volume of PFAS impacted water within the drinking water aquifers. • Oakdale municipal supply wells remove PFAS impacted water from the drinking water aquifers south of ODS (AOC 4). • Localized MBWA will remove PFAS impacted water within the drinking water aquifers downgradient of the WCL, Raleigh Creek, and Eagle Point Lake (AOCs 2 and 7). • Pump and treat in West Lakeland (AOC 10) would reduce volume of PFAS impacted water that is migrating east towards the St. Croix River. • All proposed treatment trains would treat long-chain PFAS. • Some of the proposed treatment trains (e.g. GAC) may not effectively treat short-chain PFAS such as PFBA. • PABs will remove PFAS from surface water, but removal efficiency is uncertain at high flows, and may not effectively treat short-chain PFAS such as PFBA.	High • Source zone treatment at WCL (AOC 1) and ODS would remove the largest mass of PFAS per volume of water treated, reducing the future downgradient volume of PFAS impacted water within the drinking water aquifers. • Regional MBWA will remove PFAS impacted water within the drinking water aquifers downgradient of the WCL, ODS, Raleigh Creek, and Eagle Point Lake (AOCs 2, 4, and 7). • Pump and treat in West Lakeland (AOC 10) would reduce volume of PFAS impacted water that is migrating east towards the St. Croix River. • PABs will remove PFAS from surface water, but removal efficiency is uncertain at high flows, and may not effectively treat short-chain PFAS such as PFBA. • PFAS removal would occur with pumping from existing drinking water treatment plants downgradient of the Site such as in Woodbury.	High • Source zone treatment at WCL (AOC 1) and ODS would remove the largest mass of PFAS per volume of water treated, reducing the future downgradient volume of PFAS impacted water within the drinking water aquifers. • Regional MBWA will remove PFAS impacted water within the drinking water aquifers downgradient of the WCL, ODS, Raleigh Creek, Eagle Point Lake, and West Lakeland (AOCs 2, 4, 7, and 10). • PABs will remove PFAS from surface water, but removal efficiency is uncertain at high flows, and may not effectively treat short-chain PFAS such as PFBA. • PFAS removal would occur with pumping from existing drinking water treatment plants downgradient of the Site such as in Woodbury.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Degree of expected reduction in toxicity, mobility, or volume	Moderate • Source zone treatment at the WCL, additional remedial actions at ODS, and PABs would reduce additional mass flux into the drinking water aquifers. • Localized MBWA in AOCs 2 and 7 would decrease spread of the groundwater plume downgradient of WCL, Raleigh Creek and Eagle Point Lake. • Oakdale municipal supply wells decrease the spread of the plume downgradient of Oakdale; however, placement of the supply wells does not fully capture the plume and allows for continued migration. • Plume spread in West Lakeland (AOC 10) would continue, increasing the volume of impacted groundwater in this area. • Treatment of surface water with PABs decreases the toxicity of PFAS within surface water, the volume of impacted surface water, and the migration of PFAS leached from sediment or incidentally released from ODS downgradient.	Moderate to High • Source zone treatment at the WCL, additional remedial actions at ODS, and PABs would reduce additional mass flux into the drinking water aquifers. • Localized MBWA in AOC 2 and 7 will decrease spread of the groundwater plume. • Pump and treat in AOC 10 will further decrease groundwater plume spread.	Moderate to High • Source zone treatment at the WCL, additional remedial actions at ODS, and PABs would reduce additional mass flux into the drinking water aquifers. • Oakdale municipal supply wells decrease the spread of the plume downgradient of Oakdale; however, placement of the supply wells does not fully capture the plume and allows for continued migration. • PFAS removed by GAC utilized for drinking water treatment (Regional MBWA) and potentially WCL and West Lakeland treatment would be destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction or disposal technology utilized for PFAS removed through WCL groundwater treatment will be determined based after selection of a treatment train. • Liquid PFAS waste resulting from WCL treatment could be destroyed on site, although this is dependent on the volume resulting from the selected treatment train as it may be more economically feasible to destroy small volumes of PFAS waste elsewhere.	Moderate to High • Source zone treatment at the WCL, additional remedial actions at ODS, and PABs would reduce additional mass flux into the drinking water aquifers. • PFAS removed by GAC utilized for drinking water treatment (Regional MBWA) and potentially WCL treatment would be destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction or disposal technology utilized for PFAS removed through WCL groundwater treatment will be determined based after selection of a treatment train. • Liquid PFAS waste resulting from WCL treatment would likely be destroyed on site, although this is dependent on the volume resulting from the selected treatment train as it may be more economically feasible to destroy small volumes of PFAS waste elsewhere.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Degree to which treatment is irreversible	Moderate to High • PFAS removed by GAC utilized for drinking water treatment (Oakdale municipal supply and Localized MBWA) and potentially WCL treatment would be destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled. • Destruction or disposal technology utilized for PFAS removed through WCL groundwater treatment will be determined after selection of a treatment train, but are expected to prevent reintroduction to the environment. • PABs may desorb PFAS if media not replaced at appropriate frequency but captured PFAS would be destroyed or disposed of to prevent reintroduction into the environment.	Moderate to High • PFAS removed by GAC utilized for drinking water treatment (Oakdale municipal supply and Localized MBWA) and potentially WCL treatment would be destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled. • Destruction or disposal technology utilized for PFAS removed through WCL groundwater treatment will be determined after selection of a treatment train, but are expected to prevent reintroduction to the environment. • Depending on the treatment train utilized in West Lakeland, PFAS destruction may occur on site for liquid waste streams or through GAC reactivation. • PABs may desorb PFAS if media not replaced at right frequency but captured PFAS would be destroyed or disposed of to prevent reintroduction into the environment.	Moderate to High • PFAS removed by GAC utilized for drinking water treatment (Regional MBWA) and potentially WCL treatment would be destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled. • Destruction or disposal technology utilized for PFAS removed through WCL groundwater treatment will be determined after selection of a treatment train, but are expected to prevent reintroduction to the environment. • Depending on the treatment train utilized in West Lakeland, PFAS destruction may occur on site for liquid waste streams or through GAC reactivation. • PABs may desorb PFAS if media not replaced at right frequency but captured PFAS would be destroyed or disposed of to prevent reintroduction into the environment.	Moderate to High • PFAS removed by GAC utilized for drinking water treatment (Regional MBWA including West Lakeland) and potentially WCL treatment would be destroyed during GAC reactivation although the extent to which complete destruction is achieved is not fully understood. • Destruction only occurs if GAC is reactivated or incinerated as opposed to landfilled. • Destruction or disposal technology utilized for PFAS removed through WCL groundwater treatment will be determined after selection of a treatment train, but are expected to prevent reintroduction to the environment. • PABs may desorb PFAS if media not replaced at right frequency but captured PFAS would be destroyed or disposed of to prevent reintroduction into the environment.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Reductions in potential toxicity and quantity of residuals that would remain following treatment	Moderate • Large volumes of spent GAC from drinking water plants would be trucked to reactivation facilities. • PFAS would be destroyed by GAC reactivation, reducing toxicity of GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Localized MBWA is limited in the treatment technologies that could be implemented but single-use IX may be a more sustainable treatment technology than single-use GAC. • IX resin, if selected, could be incinerated (destroys PFAS, but more expensive) or landfilled (no toxicity reduction, but cheaper). • Source zone treatment could implement on-site destruction technology to reduce toxicity and quantity of residuals.	Moderate to High • Large volumes of spent GAC from drinking water plants would need to be trucked to reactivation facilities. • PFAS would be destroyed by GAC reactivation, reducing toxicity of spent GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Source zone treatment could implement on-site destruction technology to reduce toxicity and quantity of residuals. • Localized MBWA is limited in the treatment technologies that could be implemented but single-use IX may be a more sustainable treatment technology than single-use GAC. • IX resin, if selected, could be incinerated (destroys PFAS, but more expensive) or landfilled (no toxicity reduction, but cheaper). • PAB media must be landfilled or utilize destruction technology. • Pump and treat plant will likely utilize media that requires disposal; volume may be large due to treatment plant size.	Moderate to High • PFAS would be destroyed by GAC reactivation, reducing toxicity of GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Regional MBWA is limited in the treatment technologies that could be implemented but single-use IX may be a more sustainable treatment technology than single-use GAC. • IX resin, if selected, could be incinerated (destroys PFAS, but more expensive) or landfilled (no toxicity reduction, but cheaper). • Source zone treatment could implement on-site destruction technology to reduce toxicity and quantity of residuals. • PAB media must be landfilled or utilize destruction technology. • Pump and treat plant will likely utilize media that requires disposal; volume may be large due to treatment plant size.	Moderate to High • PFAS would be destroyed by GAC reactivation, reducing toxicity of GAC. • Reactivation generates a hazardous off-gas waste stream that requires treatment by the vendor. • Regional MBWA is limited in the treatment technologies that could be implemented but single-use IX may be a more sustainable treatment technology than single-use GAC. • IX resin, if selected, could be incinerated (destroys PFAS, but more expensive) or landfilled (no toxicity reduction, but cheaper). • Source zone treatment could implement on-site destruction technology to reduce toxicity and quantity of residuals. • PAB media must be landfilled or utilize destruction technology. • Pump and treat plant will likely utilize media that requires disposal; volume may be large due to treatment plant size.

Table 7. Analysis of Reduction of Toxicity, Mobility, or Volume of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Degree to which treatment reduces Site risks	Moderate • Risks to private and municipal wells east of WCL are reduced through source zone control at WCL and extraction for the Localized MBWA southeast of WCL. • Risks to private and municipal wells south of Lake Elmo, including the Tamarack Well Field are reduced through source zone control at WCL and extraction for the Localized MBWA south of Raleigh Creek and Eagle Point Lake. • Risks to drinking water aquifers southwest of ODS would be reduced to a limited extent remain because extraction by the Oakdale municipal wells does not provide full plume control; however, reduction in migration of PFAS impacts from ODS would reduce this migration depending on the extent to which 3M addresses impacts offsite of ODS. The use of the aquifer is limited in this area. • Risks to private and municipal wells east of West Lakeland would remain as no plume control would be implemented in this area. • Risks to ecological receptors would be reduced with the implementation of PABs and reduction of PFAS discharge to Lake Elmo via impacted groundwater.	Moderate to High • Risks to private and municipal wells east of WCL are reduced through source zone control at WCL and extraction for the Localized MBWA southeast of WCL. • Risks to private and municipal wells south of Lake Elmo, including the Tamarack Well Field are reduced through source zone control at WCL and extraction for the Localized MBWA south of Raleigh Creek and Eagle Point Lake. • Risks to drinking water aquifers southwest of ODS would be reduced to a limited extent remain because extraction by the Oakdale municipal wells does not provide full plume control; however, reduction in migration of PFAS impacts from ODS would reduce this migration depending on the extent to which 3M addresses impacts offsite of ODS. The use of the aquifer is limited in this area. • Risks to private and municipal wells east of West Lakeland would be reduced through the pump and treat system. • Risks to ecological receptors would be reduced with the implementation of PABs and reduction of PFAS discharge to Lake Elmo via impacted groundwater.	High • Risks to private and municipal wells east of WCL are reduced through source zone control at WCL and extraction for the MBWA southeast of WCL. • Risks to private and municipal wells south of Lake Elmo, including the Tamarack Well Field are reduced through source zone control at WCL, ODS, and extraction for the Regional MBWA south of Raleigh Creek and Eagle Point Lake. • Risks to private and municipal wells east of West Lakeland would be mitigated with pump and treat system in AOC 10. • Risks to ecological receptors would be reduced with the implementation of PABs and reduction of PFAS discharge to Lake Elmo via impacted groundwater. • Downgradient communities would be protected through plume control in AOCs 2, 4, 7, and 10.	High • Risks to private and municipal wells east of WCL are reduced through source zone control at WCL and extraction for the MBWA southeast of WCL. • Risks to private and municipal wells south of Lake Elmo, including the Tamarack Well Field are reduced through source zone control at WCL, ODS, and extraction for the Regional MBWA south of Raleigh Creek and Eagle Point Lake. • Risks to private and municipal wells east of West Lakeland would be mitigated with Regional MBWA. • Risks to ecological receptors would be reduced with the implementation of PABs and reduction of PFAS discharge to Lake Elmo via impacted groundwater. • Downgradient communities would be protected through plume control in AOCs 2, 4, 7, and 10.

Note: Text in black indicates a different proposed treatment for an AOC and/or a different proposed result compared to the previous Alternative; text in gray indicates treatment in the previous alternative is the same for a given AOC or that the impact of the proposed treatment would be the same on a given AOC.

Legend: AOC = area of concern; GAC = granular activated carbon; IX = ion exchange; MBWA = multi-benefit well array; ODS = Oakdale Disposal Site; PAB = permeable adsorptive barrier; WCL = Washington County Landfill.

Table 8. Analysis of Short-Term Effectiveness of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Ability to Mitigate Risks to Community During Implementation	Moderate • No remedial alternative would be implemented, thus there would be no construction related risks. • Risks from implementation of plans proposed by the CDWSP are minimal as controls would be in place. • Risks to impacted sediment would not be addressed.	High • Access restrictions implementation should be minimally invasive and short duration with minimal community impact expected. • Minimal short-term impacts expected at WCL treatment as few homes border proposed WCL source zone treatment site and road near WCL provides good construction traffic access.	Moderate to High • Access restrictions implementation should be minimally invasive and short duration with minimal community impact expected. • Minimal short-term impacts expected at WCL treatment as few homes border proposed WCL source zone treatment site and road near WCL provides good construction traffic access. • PAB installation would occur close to some residents’ backyards, but risks would be short in duration and could be mitigated with HASPs.	Moderate to High • Access restrictions implementation should be minimally invasive and short duration with minimal community impacts expected. • Minimal short-term impacts expected at WCL treatment as few homes border proposed WCL source zone treatment site and road near WCL provides good construction traffic access. • PAB installation would occur close to some residents’ backyards, but risks would be short in duration and could be mitigated with HASPs. • Installation of pump and treat systems may be somewhat disruptive to Lake Elmo and West Lakeland community members and may cause nuisance noise, but poses minimal risk to health or safety.
Ability to Mitigate Potential Impacts on Workers	High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Risk can be mitigated with appropriate PPE, HASPs, and training.	Moderate to High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Higher PFAS concentrations at WCL would require stricter engineering and administrative controls. • Risk can be mitigated with appropriate PPE, HASPs, and training.	Moderate to High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Higher PFAS concentrations at WCL would require stricter engineering and administrative controls. • Risk can be mitigated with appropriate PPE, HASPs, and training.	Moderate to High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Higher PFAS concentrations at WCL would require stricter engineering and administrative controls. • Risks at pump and treat plants similar to drinking water plants. • Risk can be mitigated with appropriate PPE, HASPs, and training.

Table 8. Analysis of Short-Term Effectiveness of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Potential Environmental Impacts of Remedial Actions	Moderate • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if offgas is not treated properly. • Larger volumes of GAC may be required than predicted if the higher PFBA concentrations continue to migrate or if the PFBA HBVs/HRLs are further reduced.	Moderate • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if offgas is not treated properly. • Pump and treat at WCL could utilize lower impact technologies besides GAC to treat PFAS, decreasing the environmental impact of remedial action.	Moderate • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if offgas is not treated properly. • Pump and treat at WCL could utilize lower impact technologies besides GAC to treat PFAS, decreasing the environmental impact of remedial action. • PAB media would require disposal or destruction, likely in an out of state landfill or an incineration facility, increasing carbon emissions from disposal of media.	Moderate to High • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if offgas is not treated properly. • Pump and treat systems could utilize other technologies besides GAC to treat PFAS, decreasing the environmental impact of remedial action. • Use of pump and treat systems to remediate aquifers requires duplication of treatment plants, as drinking water treatment plants must still be operated. • PAB media would require disposal or destruction, likely in an out of state landfill or an incineration facility, increasing carbon emissions from disposal of media.
Time Until Protection is Achieved	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and the actions proposed in the CDWSP. • Sediment exposure risk reduction: Low. No further protection from sediment is included in this alternative. • Long-term drinking water risk reduction: Low. Risk would not be mitigated by this alternative and drinking water aquifers would not be protected.	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and the actions proposed in the CDWSP. • Sediment exposure risk reduction: Moderate. Risk is mitigated upon installation of access restrictions and signage. Expected construction time < 1 year. • Long-term drinking water risk reduction: Low. Mass loading to aquifers would be reduced by source zone treatment, but overall risk would not be mitigated due to continued plume migration. Drinking water aquifers would not be protected.	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and the actions proposed in the CDWSP. • Sediment exposure risk reduction: High. Risk is mitigated upon installation of access restrictions and signage. Expected construction time < 1 year. PAB installation could occur within 1-2 years and further mitigate risk and reduce PFAS concentrations. • Long-term drinking water risk reduction: Low to Moderate. Mass loading to aquifers would be reduced by source zone treatment and PABs, with installation of source zone treatment likely within 3 years. Overall risk would not be mitigated due to continued plume migration. Drinking water aquifers would not be protected.	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and the actions proposed in the CDWSP. • Sediment exposure risk reduction: High. Risk is mitigated upon installation of access restrictions and signage. Expected construction time < 1 year. PAB installation could occur within 1-2 years and further mitigate risk and reduce PFAS concentrations. • Long-term drinking water risk reduction: Moderate to High. Mass loading to aquifers would be reduced by source zone treatment and PABs and pump and treat systems will reduce plume migration. Drinking water aquifers would be protected as long as treatment systems stay running. Complete implementation of source zone treatment and pump and treat systems could occur in 3 to 5 years.

Table 8. Analysis of Short-Term Effectiveness of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Ability to Mitigate Risks to Community During Implementation	Moderate to High • Access restrictions implementation should be minimally invasive and short duration with minimal community impacts expected. • Minimal short-term impacts expected for WCL treatment as few homes border proposed WCL source zone treatment site and road near WCL provides good construction traffic access. • PAB installation would occur closer to some residents' backyards, but risks would be short in duration and could be mitigated with HASPs. • Installation of Localized MBWA may be somewhat disruptive to Lake Elmo community members and may cause nuisance noise, but poses minimal risk to health or safety.	Moderate to High • Access restrictions implementation should be minimally invasive and short duration. • Minimal short-term impacts expected at WCL treatment as few homes border proposed WCL source zone treatment site and road near WCL provides good construction traffic access. • PAB installation would occur closer to some residents' backyards, but risks would be short in duration and could be mitigated with HASPs and administrative controls. • Installation of Localized MBWA and AOC 10 pump and treat may be somewhat disruptive to Lake Elmo and West Lakeland community members and may cause nuisance noise, but poses minimal risk to health or safety.	Moderate to High • Access restrictions implementation should be minimally invasive and short duration. • Minimal short-term impacts expected at WCL treatment as few homes border proposed WCL source zone treatment site and road near WCL provides good construction traffic access. • PAB installation would occur closer to some residents' backyards, but risks would be short in duration and could be mitigated with HASPs. • Installation of Regional MBWA and AOC 10 pump and treat may be somewhat disruptive to Lake Elmo, Oakdale, and West Lakeland community members and may cause nuisance noise, but poses minimal risk to health or safety.	Moderate to High • Access restrictions implementation should be minimally invasive and short duration. • Minimal short-term impacts expected at WCL treatment as few homes border proposed WCL source zone treatment site and road near WCL provides good construction traffic access. • PAB installation would occur closer to some residents' backyards, but risks would be short in duration and could be mitigated with HASPs. • Installation of Regional MBWA may be somewhat disruptive to Lake Elmo, Oakdale, and West Lakeland community members and may cause nuisance noise, but poses minimal risk to health or safety.
Ability to Mitigate Potential Impacts on Workers	Moderate to High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Higher PFAS concentrations at WCL would require stricter engineering and administrative controls. • Risk can be mitigated with appropriate PPE, HASPs, and training.	Moderate to High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Higher PFAS concentrations at WCL would require stricter engineering and administrative controls. • Risk can be mitigated with appropriate PPE, HASPs, and training.	Moderate to High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Higher PFAS concentrations at WCL would require stricter engineering and administrative controls. • Risk can be mitigated with appropriate PPE, HASPs, and training.	Moderate to High • Minimal exposure risks are expected for drinking water plant operators. • PFAS impacts are largely dilute in untreated groundwater with regards to dermal or inhalation risk at drinking water plants. • Higher PFAS concentrations at WCL would require stricter engineering and administrative controls. • Risk can be mitigated with appropriate PPE, HASPs, and training.

Table 8. Analysis of Short-Term Effectiveness of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Potential Environmental Impacts of Remedial Actions	Moderate • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if off gas is not treated properly • Pump and treat system at WCL could utilize lower impact technologies besides GAC to treat PFAS, decreasing the environmental impact of remedial action. • Localized MBWA at Lake Elmo could utilize technology other than single-use GAC to decrease environmental impact. • PAB media would require disposal or destruction, likely in an out of state landfill or an incineration facility, increasing carbon emissions from disposal of media.	Moderate to High • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if offgas is not treated properly. • Pump and treat systems at WCL (AOC 1) and West Lakeland (AOC 10) could utilize lower impact technologies besides GAC to treat PFAS, decreasing the environmental impact of remedial action. • Localized MBWA at Lake Elmo could utilize technology other than single-use GAC to decrease environmental impact. • PAB media would require disposal or destruction, likely in an out of state landfill or an incineration facility, increasing carbon emissions from disposal of media.	Moderate to High • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if off gas is not treated properly • Pump and treat systems at WCL (AOC 1) and West Lakeland (AOC 10) could utilize lower impact technologies besides GAC to treat PFAS, decreasing the environmental impact of remedial action. • Regional MBWA at Lake Elmo and Oakdale could utilize technology other than single-use GAC to decrease environmental impact. • PAB media would require disposal or destruction, likely in an out of state landfill or an incineration facility, increasing carbon emissions from disposal of media.	Moderate to High • Current drinking water treatment relies on single-use GAC which generates large volumes of spent GAC. • GAC is derived from coal and releases carbon emissions during manufacturing, trucking to site, and during reactivation of spent GAC. • Reactivation of GAC may create air emissions if off gas is not treated properly. • Pump and treat system at WCL (AOC 1) could utilize lower impact technologies besides GAC to treat PFAS, decreasing the environmental impact of remedial action. • Regional MBWA at Lake Elmo and Oakdale could utilize technology other than single-use GAC to decrease environmental impact. • PAB media would require disposal or destruction, likely in an out of state landfill or an incineration facility, increasing carbon emissions from disposal of media.

Table 8. Analysis of Short-Term Effectiveness of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Time Until Protection is Achieved	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and Localized MBWA would provide drinking water to Lake Elmo once constructed. • Sediment exposure risk reduction: High. Risk is mitigated upon installation of access restrictions and signage. Expected construction time < 1 year. PAB installation could occur within 1-2 years and further mitigate risk and reduce PFAS concentrations. • Long-term drinking water risk reduction: Moderate. Mass loading to aquifers would be reduced by source zone treatment and PABs, and Localized MBWA will partially reduce plume migration. Total plume control would not be achieved. Complete implementation of source zone treatment and MBWA could occur in 5 to 7 years.	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and Localized MBWA would provide drinking water to Lake Elmo once constructed. • Sediment exposure risk reduction: High. Risk is mitigated upon installation of access restrictions and signage. Expected construction time < 1 year. PAB installation could occur within 1-2 years and further mitigate risk and reduce PFAS concentrations. • Long-term drinking water risk reduction: Moderate to High. Mass loading to aquifers would be reduced by source zone treatment and PABs, and the Localized MBWA and West Lakeland pump and treat would reduce plume migration although only limited control would occur in Oakdale south of ODS. Total plume control would not be achieved. Drinking water aquifers would be protected as long as treatment systems stay running. Complete implementation of source zone treatment and MBWA could occur in 5 to 7 years.	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and Regional MBWA would provide drinking water to Lake Elmo and Oakdale once constructed. • Sediment exposure risk reduction: High. Risk is mitigated upon installation of access restrictions and signage. Expected construction time < 1 year. PAB installation could occur within 1-2 years and further mitigate risk and reduce PFAS concentrations. • Long-term drinking water risk reduction: High. Mass loading to aquifers would be reduced by source zone treatment and PABs, and Regional MBWA/AOC 10 pump and treat would reduce plume migration. Total plume control would not be achieved. Drinking water aquifers would be protected as long as treatment systems stay running. Complete implementation of source zone treatment and MBWA could occur in 5 to 7 years.	• Short-term drinking water risk reduction: High. Risk has already been mitigated through temporary measures and Regional MBWA would provide drinking water to Lake Elmo and Oakdale once constructed. • Sediment exposure risk reduction: High. Risk is mitigated upon installation of access restrictions and signage. Expected construction time < 1 year. PAB installation could occur within 1-2 years and further mitigate risk and reduce PFAS concentrations. • Long-term drinking water risk reduction: High. Mass loading to aquifers would be reduced by source zone treatment and PABs, and Regional MBWA would reduce plume migration. Total plume control would not be achieved. Drinking water aquifers would be protected as long as treatment systems stay running. Complete implementation of source zone treatment and MBWA could occur in 5 to 7 years.

Note: Text in black indicates a different proposed treatment for an AOC and/or a different proposed result compared to the previous Alternative; text in gray indicates treatment in the previous alternative is the same for a given AOC or that the impact of the proposed treatment would be the same on a given AOC.

Legend: AOC = area of concern; CDWSP = Conceptual Drinking Water Supply Plan; GAC = granular activated carbon; HASP = health and safety plan; MBWA = multi-benefit well array; ODS = Oakdale Disposal Site; PAB = permeable adsorptive barrier; PPE = personal protective equipment; WCL = Washington County Landfill.

Table 9. Analysis of Implementability of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Technical Feasibility	Moderate • Single-use GAC can reliably treat currently regulated PFAS compounds. • Short-chain PFAS are not effectively treated by GAC, reducing technical feasibility of GAC treatment to meet future PFAS limits, should limits be lowered. • Continued spread of the groundwater plume would require additional treatment systems to treat larger volumes of dilute PFAS concentrations, which is technologically feasible but inefficient.	Moderate to High • Single-use GAC can reliably treat currently regulated PFAS compounds. • Continued spread of the groundwater plume would require additional treatment systems to treat larger volumes of dilute PFAS concentrations, which is technologically feasible but inefficient. • High PFBA at WCL will likely require treatment train approach that utilizes multiple remedial technologies; final technology selection to occur after completion of proposed pilot testing. • WCL pump and treat could utilize technologies not currently permitted for drinking water use, allowing for the use of technologies that are more effective at treating PFBA. • PFAS destruction technologies are available and will be further evaluated to determine technical feasibility of onsite destruction within the treatment train at the WCL.	Moderate to High • Single-use GAC can reliably treat currently regulated PFAS compounds. • High PFBA at WCL will likely require treatment train approach that utilizes multiple remedial technologies; final technology selection to occur after completion of proposed pilot testing. • WCL pump and treat could utilize technologies not currently permitted for drinking water use, allowing for the use of technologies that are more effective at treating PFBA. • Continued spread of the groundwater plume would require additional treatment systems to treat larger volumes of dilute PFAS concentrations, which is technologically feasible but inefficient. • PFAS destruction technologies are available and will be further evaluated to determine technical feasibility of onsite destruction within the treatment train at the WCL. • PABs are relatively new and expected treatment efficiency is unknown for this application. • Short residence time in PABs at high flow may decrease treatment efficiency.	Moderate to High • Single-use GAC can reliably treat currently regulated PFAS compounds. • High PFBA at WCL will likely require treatment train approach that utilizes multiple remedial technologies; final technology selection to occur after completion of proposed pilot testing. • WCL pump and treat could utilize technologies not currently permitted for drinking water use, allowing for the use of technologies that are more effective at treating PFBA. • PFAS destruction technologies are available and will be further evaluated to determine technical feasibility of onsite destruction within the treatment train at the WCL. • PABs are relatively new and expected treatment efficiency is unknown for this application. • Short residence time in PABs at high flow may decrease treatment efficiency. • Injection studies needed to confirm modeled injection capacity of drinking water aquifers is accurate.

Table 9. Analysis of Implementability of Remedial Alternatives.

Consideration	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Administrative Feasibility	Moderate to High • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities.	Moderate • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities. • Minimal hurdles anticipated for sediment access restrictions. • Land is available near WCL that could be used for pump and treat plant. • WCL pump and treat will require groundwater appropriations permitting from the MDNR, which may be complicated by the White Bear Lake Court Order; pumping of shallow groundwater not expected to negatively affect White Bear Lake. • WCL discharge location (injection, surface water, sanitary sewer) undetermined.	Moderate • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities. • Minimal hurdles anticipated for access restrictions. • Land is available near WCL that could be used for pump and treat plant. • WCL pump and treat will require groundwater appropriations permitting from the MDNR, which may be complicated by the White Bear Lake Court Order; pumping of shallow groundwater not expected to negatively affect White Bear Lake. • WCL discharge location (injection, surface water, sanitary sewer) undetermined. • PABs would require permitting and consultation with VBWD, MPCA, MDNR, and local governments.	Moderate • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities. • Minimal hurdles anticipated for access restrictions. • Land is available near WCL that could be used for pump and treat plant. • WCL pump and treat will require groundwater appropriations permitting from the MDNR, which may be complicated by the White Bear Lake Court Order; pumping of shallow groundwater not expected to negatively affect White Bear Lake. • Proposed plume extraction wells outside the 5-mile radius imposed by White Bear Lake Court Order but modeling is required to ensure they will not have an impact. • WCL discharge location (injection, surface water, sanitary sewer) undetermined. • PABs would require permitting and consultation with VBWD, MPCA, MDNR, and local governments. • Land is available for proposed Lake Elmo pump and treat system, but there is uncertainty of land availability in West Lakeland for pump and treat system. • Injection for pump and treat systems would require coordination between MDNR, MPCA, and EPA Region V UIC.
Availability of Services and Materials	Moderate • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Spread of the groundwater plume could drive higher GAC demand, creating competition among communities for media. • Destruction of GAC and other PFAS containing wastes may become more limited in the future.	Moderate • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Spread of the groundwater plume could drive higher GAC demand, creating competition among communities for media. • Destruction of GAC and other PFAS containing wastes may become more limited in the future.	Moderate • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Spread of the groundwater plume could drive higher GAC demand, creating competition among communities for media. • Destruction of GAC and other PFAS containing wastes may become more limited in the future.	Moderate • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Spread of the groundwater plume could drive higher GAC demand, creating competition among communities for media. • Destruction of GAC and other PFAS containing wastes may become more limited in the future.

Table 9. Analysis of Implementability of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Technical Feasibility	Moderate to High • All proposed Localized MBWA treatment trains can reliably treat currently regulated PFAS compounds. • High PFBA at WCL will likely require treatment train approach that utilizes multiple remedial technologies; final technology selection to occur after completion of proposed pilot testing. • WCL pump and treat could utilize technologies not currently permitted for drinking water use, allowing for the use of technologies that are more effective at treating PFBA. • PFAS destruction technologies are available and will be further evaluated to determine technical feasibility of onsite destruction within the treatment train at the WCL. • Continued spread of the groundwater plume would require additional treatment systems to treat larger volumes of dilute PFAS concentrations, which is technologically feasible but inefficient. • PABs are relatively new and expected treatment efficiency is unknown for this application. • Short residence time in PABs at high flow may decrease treatment efficiency. • Injection studies needed to confirm modeled injection capacity of drinking water aquifers is accurate.	Moderate to High • All proposed Localized MBWA treatment trains can reliably treat currently regulated PFAS compounds. • High PFBA at WCL will likely require treatment train approach that utilizes multiple remedial technologies; final technology selection to occur after completion of proposed pilot testing. • WCL pump and treat could utilize technologies not currently permitted for drinking water use, allowing for the use of technologies that are more effective at treating PFBA. • Continued spread of the groundwater plume would require additional treatment systems to treat larger volumes of dilute PFAS concentrations, which is technologically feasible but inefficient. • PFAS destruction technologies are available and will be further evaluated to determine technical feasibility of onsite destruction within the treatment train at the WCL. • PABs are relatively new and expected treatment efficiency is unknown for this application. • Short residence time in PABs at high flow may decrease treatment efficiency. • Injection studies needed to confirm modeled injection capacity of drinking water aquifers is accurate.	Moderate to High • All proposed Regional MBWA treatment trains can reliably treat currently regulated PFAS compounds. • High PFBA at WCL will likely require treatment train approach that utilizes multiple remedial technologies; final technology selection to occur after completion of proposed pilot testing. • WCL pump and treat could utilize technologies not currently permitted for drinking water use, allowing for the use of technologies that are more effective at treating PFBA. • PABs are relatively new and expected treatment efficiency is unknown for this application. • Short residence time in PABs at high flow may decrease treatment efficiency. • Injection studies needed to confirm modeled injection capacity of drinking water aquifers is accurate. • PFAS destruction technologies are available and will be further evaluated to determine technical feasibility of onsite destruction within the treatment train at the WCL.	Moderate to High • All proposed Regional MBWA treatment trains can reliably treat currently regulated PFAS compounds. • High PFBA at WCL will likely require treatment train approach that utilizes multiple remedial technologies; final technology selection to occur after completion of proposed pilot testing. • WCL pump and treat could utilize technologies not currently permitted for drinking water use, allowing for the use of technologies that are more effective at treating PFBA. • PABs are relatively new and expected treatment efficiency is unknown for this application. • Short residence time in PABs at high flow may decrease treatment efficiency. • Injection studies needed to confirm modeled injection capacity of drinking water aquifers is accurate. • PFAS destruction technologies are available and will be further evaluated to determine technical feasibility of onsite destruction within the treatment train at the WCL.

Table 9. Analysis of Implementability of Remedial Alternatives.

Consideration	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Administrative Feasibility	Moderate • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities; other technologies may require additional testing to demonstrate effectiveness. • Minimal hurdles anticipated for access restrictions. • Land is available near WCL that could be used for pump and treat plant. • WCL pump and treat will require groundwater appropriations permitting from the DNR, which may be complicated by the White Bear Lake Court Order; pumping of shallow groundwater not expected to negatively affect White Bear Lake. • Proposed plume extraction wells outside the 5-mile radius imposed by White Bear Lake Court Order. • WCL discharge location (injection, surface water, sanitary sewer) undetermined. • PABs would require permitting and consultation with VBWD, MPCA, MDNR, and local governments. • Land is available for proposed Localized MBWA. • Injection for pump and treat systems would require coordination between MDNR, MPCA, and EPA Region V UIC.	Moderate • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities; other technologies may require additional testing to demonstrate effectiveness. • Minimal hurdles anticipated for access restrictions. • Land is available near WCL that could be used for pump and treat plant. • WCL pump and treat will require groundwater appropriations permitting from the MDNR, which may be complicated by the White Bear Lake Court Order; pumping of shallow groundwater not expected to negatively affect White Bear Lake. • Proposed plume extraction wells outside the 5-mile radius imposed by White Bear Lake Court Order. • WCL discharge location (injection, surface water, sanitary sewer) undetermined. • PABs would require permitting and consultation with VBWD, MPCA, MDNR, and local governments. • Land is available for proposed localized MBWA, land availability uncertain for West Lakeland pump and treat plant. • Injection for pump and treat systems would require coordination between MDNR, MPCA, and EPA Region V UIC.	Moderate • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities; other technologies may require additional testing to demonstrate effectiveness. • Minimal hurdles anticipated for access restrictions. • Land is available near WCL that could be used for pump and treat plant. • WCL pump and treat will require groundwater appropriations permitting from the MDNR, which may be complicated by the White Bear Lake Court Order; pumping of shallow groundwater not expected to negatively affect White Bear Lake. • Proposed plume extraction wells outside the 5-mile radius imposed by White Bear Lake Court Order. • WCL discharge location (injection, surface water, sanitary sewer) undetermined. • PABs would require permitting and consultation with VBWD, MPCA, MDNR, and local governments. • Land is available for proposed Regional MBWA treatment plant, land availability uncertain for West Lakeland pump and treat plant. • Injection for pump and treat systems would require coordination between MDNR, MPCA, and EPA Region V UIC. • Coordination between Lake Elmo and Oakdale would be required, potentially decreasing implementability.	Moderate • Single-use GAC is widely accepted for use in drinking water treatment and is currently in use in many East-Metro communities; other technologies may require additional testing to demonstrate effectiveness. • Minimal hurdles anticipated for access restrictions. • Land is available near WCL that could be used for pump and treat plant. • WCL pump and treat will require groundwater appropriations permitting from the MDNR, which may be complicated by the White Bear Lake Court Order; pumping of shallow groundwater not expected to negatively affect White Bear Lake. • Proposed plume extraction wells outside the 5-mile radius imposed by White Bear Lake Court Order. • WCL discharge location (injection, surface water, sanitary sewer) undetermined. • PABs would require permitting and consultation with VBWD, MPCA, MDNR, and local governments. • Land is available for proposed Regional MBWA treatment plant. • Injection for pump and treat systems would require coordination between MDNR, MPCA, and EPA Region V UIC. • Coordination between Lake Elmo, Oakdale, and West Lakeland would be required, potentially decreasing implementability.
Availability of Services and Materials	Moderate • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Spread of the groundwater plume could drive higher GAC demand, creating competition among communities for media. • Destruction of GAC and other PFAS containing wastes may become more limited in the future.	Moderate to High • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Control of groundwater plume may decrease regional GAC demand long-term. • Destruction of GAC and other PFAS containing wastes may become more limited in the future.	Moderate to High • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Control of groundwater plume may decrease regional GAC demand long-term. • Destruction of GAC and other PFAS containing wastes may become more limited in the future.	Moderate to High • GAC is currently widely available from multiple vendors. • Recent price increases and increasing demand may pose challenges to operations in the future. • Control of groundwater plume may decrease regional GAC demand long-term.

Note: Text in black indicates a different proposed treatment for an AOC and/or a different proposed result compared to the previous Alternative; text in gray indicates treatment in the previous alternative is the same for a given AOC or that the impact of the proposed treatment would be the same on a given AOC.

Legend: AOC = area of concern; MDNR = Minnesota Department of Natural Resources; EPA = United States Environmental Protection Agency; GAC = granular activated carbon; MBWA = multi-benefit well array; MPCA = Minnesota Pollution Control Agency; ODS = Oakdale Disposal Site; PAB = permeable adsorptive barrier; UIC = Underground Injection Control; VBWD = Valleybranch Watershed District; WCL = Washington County Landfill.

Table 10. Summary of Estimated Capital Expenditures by Remedial Alternative.

Remedial Action	Description	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		Alternative 6		Alternative 7		Alternative 8	
		Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost
Drinking Water	Oakdale	$37,950,000	$51,050,000	$37,950,000	$51,050,000	$37,950,000	$51,050,000	$37,950,000	$51,050,000	$37,950,000	$51,050,000	$37,950,000	$51,050,000	-	-	-	-
	Lake Elmo	$105,008,000	$130,270,000	$105,008,000	$130,270,000	$105,008,000	$130,270,000	$105,008,000	$130,270,000	-	-	-	-	-	-	-	-
	West Lakeland	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000	$5,463,000
MBWA	Lake Elmo Treatment Plant	-	-	-	-	-	-	-	-	$52,857,000	$67,056,000	$52,857,000	$67,056,000	$59,657,000	$75,885,000	$58,038,000	$72,238,000
	Oakdale Treatment Plant	-	-	-	-	-	-	-	-	-	-	-	-	$40,859,000	$51,002,000	$52,938,000	$67,137,000
	Pumps and Wells	-	-	-	-	-	-	-	-	$9,530,000	$9,530,000	$9,530,000	$9,530,000	$11,405,000	$11,405,000	$15,060,000	$15,060,000
	Piping - Open Cut & HDD	-	-	-	-	-	-	-	-	$22,862,000	$66,974,000	$22,862,000	$66,974,000	$36,311,000	$110,938,000	$59,141,000	$176,144,000
	Highway Crossings	-	-	-	-	-	-	-	-	$7,721,000	$7,721,000	$7,721,000	$7,721,000	$11,825,000	$11,825,000	$13,193,000	$13,193,000
Pump & Treat (Source Zone)	AOC 1 - Treatment Plant	-	-	$12,395,000	$41,212,000	$12,395,000	$41,212,000	$12,395,000	$41,212,000	$12,395,000	$41,212,000	$12,395,000	$41,212,000	$12,395,000	$41,212,000	$12,395,000	$41,212,000
	AOC 1 - Piping	-	-	$4,463,000	$7,419,000	$4,463,000	$7,419,000	$4,463,000	$7,419,000	$4,463,000	$7,419,000	$4,463,000	$7,419,000	$4,463,000	$7,419,000	$4,463,000	$7,419,000
Pump & Treat (Plume Control)	AOC 2 & 7 - Treatment Plant	-	-	-	-	-	-	$24,084,000	$62,768,000	-	-	-	-	-	-	-	-
	AOC 2 & 7 - Piping	-	-	-	-	-	-	$25,242,000	$49,768,000	-	-	-	-	-	-	-	-
	AOC 10 - Treatment Plant	-	-	-	-	-	-	$24,084,000	$62,768,000	-	-	$24,084,000	$62,768,000	$24,084,000	$62,768,000	-	-
	AOC 10 - Piping	-	-	-	-	-	-	$14,498,000	$30,700,000	-	-	$14,498,000	$30,700,000	$14,498,000	$30,700,000	-	-
PABs	2 Total Installed	-	-	-	-	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000	$3,269,000
Access Restrictions	AGWC Fencing	-	-	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000	$800,000
	Raleigh Creek Fencing	-	-	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000
	Signage/Notifications	-	-	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Long-Term Monitoring	16 Additional Well Nests in Jordan & Shakopee Aquifers	-	-	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000	$1,600,000
WCL Treatment Cost		-	-	*$16,858,000*	*$48,631,000*	*$16,858,000*	*$48,631,000*	*$16,858,000*	*$48,631,000*	*$16,858,000*	*$48,631,000*	*$16,858,000*	*$48,631,000*	*$16,858,000*	*$48,631,000*	*$16,858,000*	*$48,631,000*
All Other Treatment Cost		*$148,421,000*	*$186,783,000*	*$151,471,000*	*$189,833,000*	*$154,740,000*	*$193,102,000*	*$242,648,000*	*$399,106,000*	*$142,702,000*	*$214,113,000*	*$181,284,000*	*$307,581,000*	*$210,421,000*	*$366,305,000*	*$210,152,000*	*$355,554,000*
TOTAL		$148,421,000	$186,783,000	$168,329,000	$238,464,000	$171,598,000	$241,733,000	$259,506,000	$447,737,000	$159,560,000	$262,744,000	$198,142,000	$356,212,000	$227,279,000	$414,936,000	$227,010,000	$404,185,000

Table 11. Summary of Annual Estimated Operating Expenditures by Remedial Alternative.

Remedial Action	Description	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		Alternative 6		Alternative 7		Alternative 8	
		Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost	Lowest Expected Cost	Highest Expected Cost
Drinking Water	Oakdale	$1,744,000	$3,488,000	$1,744,000	$3,488,000	$1,744,000	$3,488,000	$1,744,000	$3,488,000	$1,744,000	$3,488,000	$1,744,000	$3,488,000	-	-	-	-
	Lake Elmo	$964,000	$1,928,000	$964,000	$1,928,000	$964,000	$1,928,000	$964,000	$1,928,000	-	-	-	-	-	-	-	-
	West Lakeland	$1,450,000	$2,900,000	$1,450,000	$2,900,000	$1,450,000	$2,900,000	$1,450,000	$2,900,000	$1,450,000	$2,900,000	$1,450,000	$2,900,000	$1,450,000	$2,900,000	$1,450,000	$1,450,000
MBWA	Lake Elmo Water Treatment	-	-	-	-	-	-	-	-	$3,999,000	$17,052,000	$3,999,000	$17,052,000	$4,594,000	$20,213,000	$4,352,000	$18,654,000
	Oakdale Water Treatment	-	-	-	-	-	-	-	-	-	-	-	-	$3,065,000	$12,469,000	$4,011,000	$17,121,000
Pump & Treat (Source Zone)	AOC 1 Treatment	-	-	$1,465,000	$44,393,000	$1,465,000	$44,393,000	$1,465,000	$44,393,000	$1,465,000	$44,393,000	$1,465,000	$44,393,000	$1,465,000	$44,393,000	$1,465,000	$44,393,000
Pump & Treat (Plume Control)	AOC 2 & 7 Treatment	-	-	-	-	-	-	$1,855,000	$4,617,000	-	-	-	-	-	-	-	-
	AOC 10 Treatment	-	-	-	-	-	-	$1,855,000	$4,617,000	-	-	$1,855,000	$4,617,000	$1,855,000	$4,617,000	-	-
PABs	2 Total Installed	-	-	-	-	$833,000	$833,000	$833,000	$833,000	$833,000	$833,000	$833,000	$833,000	$833,000	$833,000	$833,000	$833,000
Access Restrictions	AGWC Fencing	-	-	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000
	Raleigh Creek Fencing	-	-	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
	Signage/Notifications	-	-	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Long-Term Monitoring	16 Additional Well Nests in Jordan & Shakopee Aquifers	-	-	$142,000	$285,000	$142,000	$285,000	$142,000	$285,000	$142,000	$285,000	$142,000	$285,000	$142,000	$285,000	$142,000	$285,000
WCL Treatment Cost		-	-	*$1,465,000*	*$44,393,000*	*$1,465,000*	*$44,393,000*	*$1,465,000*	*$44,393,000*	*$1,465,000*	*$44,393,000*	*$1,465,000*	*$44,393,000*	*$1,465,000*	*$44,393,000*	*$1,465,000*	*$44,393,000*
All Other Treatment Cost		*$4,158,000*	*$8,316,000*	*$4,324,000*	*$8,625,000*	*$5,157,000*	*$9,458,000*	*$8,867,000*	*$18,692,000*	*$8,192,000*	*$24,582,000*	*$10,047,000*	*$29,199,000*	*$11,963,000*	*$41,341,000*	*$10,812,000*	*$38,367,000*
TOTAL		$4,158,000	$8,316,000	$5,789,000	$53,018,000	$6,622,000	$53,851,000	$10,332,000	$63,085,000	$9,657,000	$68,975,000	$11,512,000	$73,592,000	$13,428,000	$85,734,000	$12,277,000	$82,760,000