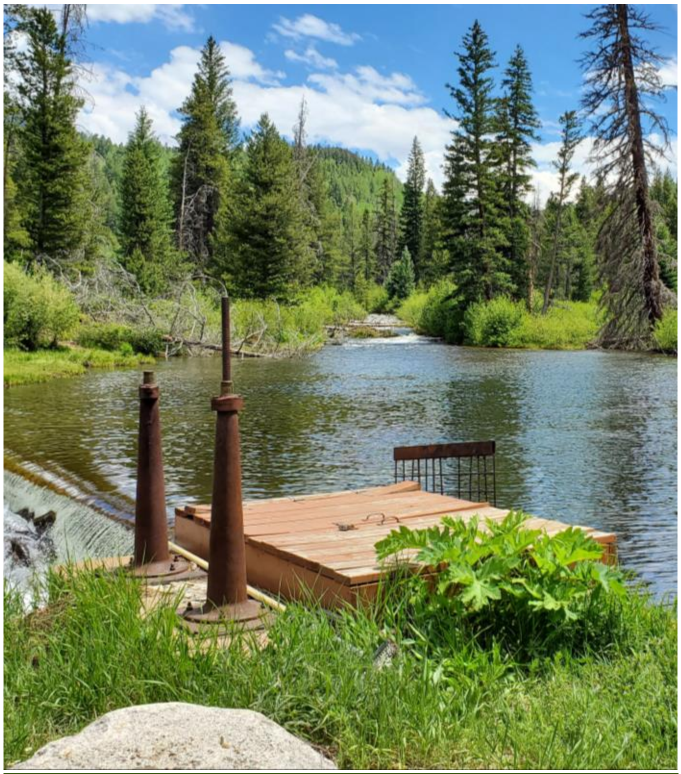

Treatment Process Alternatives Analysis

Minturn Water Treatment Plant

FINAL

Minturn, CO

August 1, 2023

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Executive Summary

The Town of Minturn is evaluating the best path forward for improving the reliability of water production as their existing water treatment plant (WTP) is nearing the end of its serviceable life. A new WTP is proposed to replace the existing one which uses slow sand filtration to treat the surface water. Several alternative treatment process technologies are being considered by Minturn for the new WTP. The treatment technology alternatives under consideration are:

- Alternative A: Rehabilitation of existing slow sand direct filtration WTP
- Alternative B: Construction of new WTP using packaged conventional treatment units with dual-media filters
- Alternative C: Construction of a new WTP with membrane filtration with consideration for expansion and future preliminary treatment

The project team first went through a qualitative exercise to determine the top priorities for Minturn in the selection of the new treatment technology. The following criteria and their relative importance were developed jointly by HDR and the Minturn Water Committee during a workshop on January 12th, 2023. The criteria below are listed in the order of importance to Minturn.

1. Resiliency 35%
2. Operations & Maintenance 26%
3. Long Term Reliability 22%
4. Process Modifiability 13%
5. Capacity Flexibility 3%

Each of the three proposed alternatives were evaluated against the established quantitative criteria, independent of the other alternatives, on a scale of Very Low, Low, Moderate, Strong, and Very Strong. The following table presents how the project team ranked each alternative against each of the criteria . These rankings, in combination with the weighting of each criterion, was used to tabulate a “final score” for each alternative, shown in the last row of the same table. The final score provides a qualitative ranking of the alternatives to showcase which treatment technology best meets the priorities of Minturn.

Criteria	**Alternative A: Slow Sand Filtration**	**Alternative B: Packaged WTP**	**Alternative C: Membrane WTP**
Resiliency (35%)	Moderate	Strong	Very Strong
Operations & Maintenance (26%)	Strong	Moderate	Moderate
Long Term Reliability (23%)	Strong	Strong	Strong
Process Modifiability (13%)	Very Low	Strong	Very Strong
Capacity Flexibility (3%)	Low	Moderate	Very Strong
FINAL SCORE	**56**	**64**	**75**

HDR developed cost estimates for each alternative using parametric estimating tools and vendor proposals for this project. HDR prepared Class 4 Opinions of Probably Construction Costs (OPCCs) as described by the American Association of Cost Estimating (AACE), shown in the table below.

Alternative	Low Capital Cost (-15%)	High Capital Cost (+30%)	Annual O&M
A - Rehabilitation of Existing Slow Sand Filters	$5.8M	$8.9M	$120K
B - Packaged Conventional Water Treatment Plant	$10.5M	$16.7M	$200K
C - Membrane Water Treatment Plant	$9.8M	$14.9M	$150K

Based on the results of this alternative analysis, it is recommended that Minturn move forward with construction of a new membrane filtration plant. Membrae filtration provides the highest qualitative score and is thus recognized to best address the priorities Minturn has for a providing a resilient and reliable treatment system. While rehabilitation of the slow sand filters ultimately had the anticipated lowest cost of the alternatives, the drawbacks of continuing to rely on an aging technology and cutting off the option for the addition of Eagle River water in the future far outweigh the cost savings associated with the option. Membrane filtration allows Minturn to address the needs of its existing customers, while leaving open the option for future water rights.

1 Introduction & Background

The Town of Minturn (Minturn) is evaluating the best path forward for improving the reliability of water production as their existing water treatment plant (WTP) is nearing the end of its serviceable life. A new WTP is proposed to replace the existing one which uses slow sand filtration to treat the surface water. Several alternative treatment process technologies are being considered by Minturn for the new WTP. Three WTP process alternatives are proposed for evaluation against subjective criteria developed by the project team. Life cycle cost estimates for each alternative are provided separate from the qualitative evaluations so that Minturn can make a value-based decision on the best path forward. The alternatives being evaluated are:

- Alternative A: Rehabilitation of existing slow sand direct filtration WTP
- Alternative B: Construction of new WTP using packaged conventional treatment units with dual-media filters
- Alternative C: Construction of a new WTP with membrane filtration with consideration for future preliminary treatment

The evaluation will consider each alternatives' ability to meet or exceed established criteria. The project consists of a new 0.6 mgd capacity water treatment plant using water from Cross Creek, Minturn's only existing surface water source. Minturn also operates two groundwater wells which can provide up to 80 gpm each as supplemental water to the existing WTP's clearwell. The proposed infrastructure is depicted diagrammatically in Figure 1.

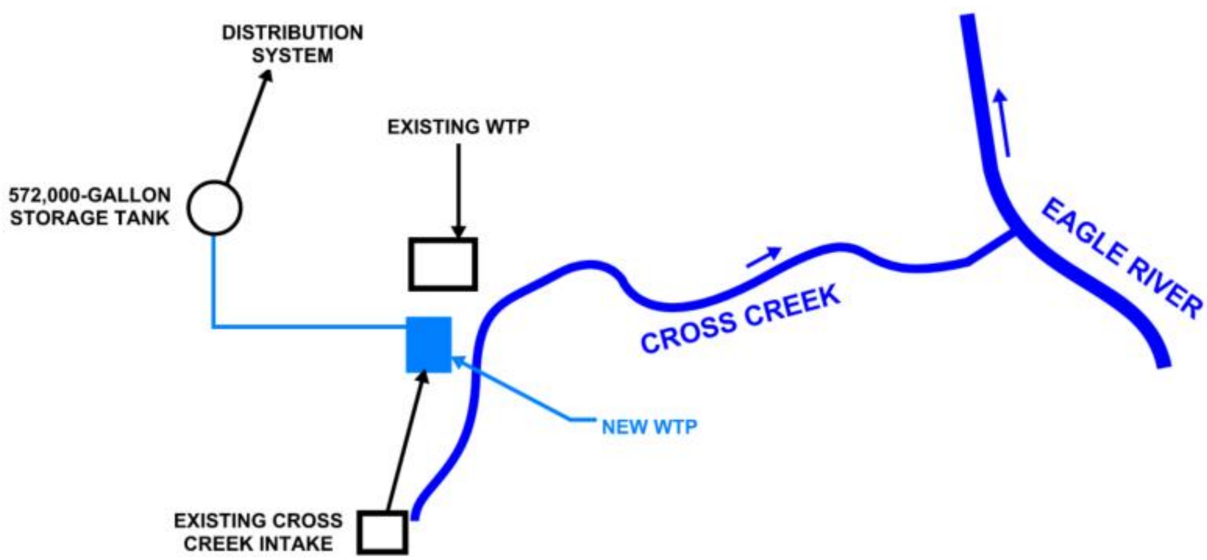

Figure 1. Diagrammatic Overview of Proposed WTP

1.1 Existing Treatment

Minturn presently operates a direct filtration WTP consisting of three slow sand filters. Filter 1 and Filter 2 are earthen pits constructed in 1963. Filter 1 is no longer in service, and Filter 2 feeds a 1.0-micron cartridge filter (Harmsco PPFS-HC-170-1) capable of producing 50 gpm of treated water. Filter 3 is a concrete lined filter constructed in 1991, capable of producing 60 gpm. A process flow diagram of the existing process is presented in Figure 2. Water treated through Filter #3 and the cartridge filter comes from a surface water diversion on Cross Creek. The water is blended together in the WTP clearwell, where chlorine is applied for disinfection, and then pumped to the Minturn distribution system.

During spring runoff, turbidity increases in Cross Creek and Filter 3 struggles to maintain turbidity compliance at the higher solids loading. Filter 3 is subsequently taken offline during spring runoff for filter skimming, where the fouled layer of sand and particles is removed and washed, a process that takes approximately 2-3 months. Filter 3 is brought back online when turbidity has declined, and the filters are clean. While Filter 3 is skimmed, groundwater is used to as the source of supply to Minturn. Groundwater wells #3 and #4 can produce up to 80 gpm each (approx. 0.25 mgd in total) to the existing clearwell where they are combined with the filtrate from the slow sand filters.

Minturn recently completed construction of a new 572,000-gallon unbaffled concrete storage tank. Minturn intends to use the tank to supply water pressure to the distribution system.

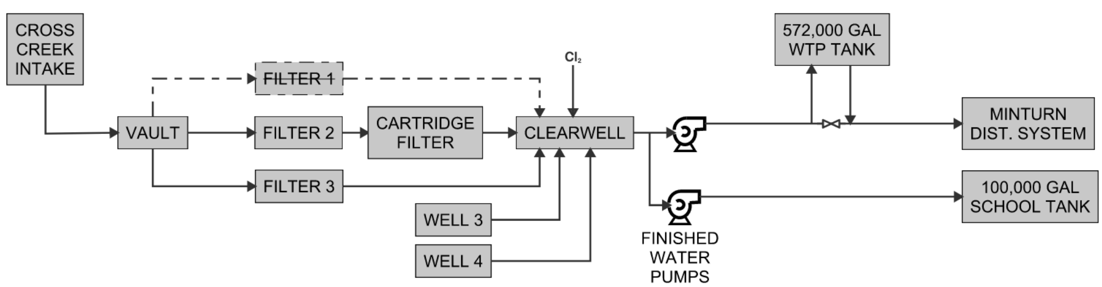

Figure 2. Process Flow Diagram - Existing Treatment Process

The existing infrastructure which may be able to be reused by a new facility would include Filters 1 and/or 2, Filter 3, miscellaneous yard piping, and the 572,000-gallon storage tank.

1.2 Projected Water Demands

Minturn's 2019 Water System Capital Improvement Plan includes a water demand analysis conducted to understand current and projected water demands for Minturn. Table 1 presents a summary of the demand analysis. The results show that the largest demand occurs during the warmer months and is expected to be 0.6 mgd. The demand drops significantly in the wintertime with less outdoor irrigation use. The new WTP flow rate will be 0.6 mgd to meet the existing demands of Minturn. To supplement the WTP, Minturn operates two storage tanks within their distribution system which provide a cumulative approximate 1.2 million gallons (Tank #3 = 572,000 gal, Tank #2 = 588,000 gal).

Table 1. Town of Minturn Existing and Projected Water Demands

Town of Minturn System Demand	Colder Months	Warmer Months
Existing Water Demand (mgd)	**0.1**	**0.4**
Projected Water Demand (mgd)[1]	**0.2**	**0.6**

1.3 Justification for Upgrading Treatment

1.3.1 Sanitary Survey

The Colorado Department of Health and Environment (CDPHE) Water Quality Control Division conducted a sanitary survey of the existing WTP in September of 2018 and observed two significant deficiencies, six violations, and four recommendations/observations. In an October 11, 2018, letter, CDPHE documented several items related to the mechanical process condition of the WTP:

- No liner present in Filters 1 and 2, requiring they be removed from service and significantly decreasing Minturn's production capacity
- Well #3 inadequate source protection; opening on side of casing
- Existing clearwell (bolted steel tank) near end of useful life and experiencing leaks

Minturn is limited in their ability to produce water under their most constrained scenario due to the removal of two slow sand filters from service. Development in Minturn is limited, and existing customers are subject to water restrictions due to the condition of the WTP.

1.3.2 Future Regulations

Minturn is proactive in their endeavors to continue to provide high quality drinking water now and in the future. Although future regulations are difficult to characterize exactly, past trends can be used to estimate what regulations Minturn may be faced with long term.

Near term future regulatory efforts are presently focused on the Lead and Copper Rule Improvements (LCRI) and Per/Polyfluoroalkyl substances (PFAS). The LCRI will address additional key issues and opportunities to reduce risk associated with lead and copper in drinking water. Although lead and copper primarily come from premise plumbing, utilities (i.e. Minturn) will handle addressing corrosion control within their distribution system. PFAS are omnipresent in the environment, and in 2021 the Environmental Protection Agency (USEPA) published their Strategic Roadmap (2021-2024). The roadmap focuses on policy, funding, rules to implement greater investment in PFAS R&D, prevention of PFAS release from point sources, and remediation of contamination. In the near term, monitoring for PFAS may be the impact to Minturn. In addition, the USEPA is evaluating the Stage 2 Disinfection Byproducts Rule to understand the presence of current and unregulated disinfection contaminants. There exists the potential for tightening of current Maximum Contaminant Limits (MCLs) that could impact Minturn's disinfection strategy in the future.

Cross Creek is the only surface water source for the new WTP. There are sufficient water rights on Cross Creek to serve the needs of Minturn and imminent planned infill development. Table 2 presents raw water quality and finished water treatment goals for the Cross Creek source water. The overall raw water quality of Cross Creek is generally good and suitable for all treatment processes being considered. Total Organic Carbon (TOC) has historically trended high in Cross Creek during spring and summer based on available data. TOC causes non-regulated aesthetic issues such as color, taste, and potential odor in water at a minimum. Whereas TOC regulated issues are related to both turbidity and disinfection byproducts. Removal of TOC through flocculation and settled is recommended to prevent formation of disinfection byproducts (regulated through distribution system monitoring).

1.4 Disinfection Considerations for each Alternative

The USEPA's Surface Water Treatment Rule (SWTR) requires surface waters be treated and disinfected to a level which provides 3-log (or 99.9%) removal of giardia and 4-log (or 99.99%) removal of viruses. To reduce dependence on and complications associated with over chlorination, the SWTR allows for well operated treatment processes to provide credit toward the total disinfection requirements. The level of disinfection credit each alternative process (sand filters, packaged conventional treatment, or membranes) provides is presented in the specific sections of this evaluation.

Disinfection credit obtained from the treatment process (e.g. filtration) is not enough to wholly satisfy the required removal of giardia and viruses, so chlorine is typically used to achieve the remaining disinfection requirements. Disinfection with chlorine is validated by the product of chlorine residual concentration and the time which the chlorine was in contact with the water (e.g. contact time). This is referred to as $CT_{required}$. Required CT values are published by USEPA and are a function of water temperature, water pH, chlorine residual concentration, and the level of log-removal required.

Minturn must provide adequate chlorine residual and contact time ($CT_{achieved}$) to validate their disinfection with chlorine (e.g. $CT_{achieved} > CT_{required}$). Each of the proposed process alternatives (sand filters, packaged conventional treatment, or membranes) are being evaluated on the condition that the new 572,000-gallon storage tank will be used as the primary disinfection volume. Modifications to the storage tank are required for the tank to be used for disinfection purposes. Currently, the inlet and outlet of the tank are too close in proximity, which results in a baffling factor of 0 per CDPHE design criteria. The addition of a run of pipe to either the inlet or outlet that extends to the opposite side of the tank would increase the distance between the two and allow the tank to be used for disinfection with a baffling factor of 0.1.

While the value of $CT_{achieved}$ is a factor of both chlorine concentration and contact time, raising the chlorine concentration increases the risk of forming disinfection byproducts (DBPs) which can be harmful to human health with frequent exposure. For this reason, increasing contact time is the preferred method of achieving an adequate CT value.

1.5 Source Water Management

Table 2 shows that Cross Creek experiences levels of total organic carbon (TOC) that are high enough to impact process recommendations. Organic carbon originates from plants, soil, and other organic matter present in the watershed. High TOC occurs in the spring and summer months when water warms, and biological activity is highest. Water quality sampling conducted in 2023 demonstrated the TOC increased to as high as 12 mg/L during the month of April associated with spring runoff conditions. While having no health effects of its own, TOC functions as an indicator for the potential formation of DBPs such as Total Haloacetic Acids (HAA5) and Total Trihalomethanes (TTHM). In the Town of Minturn 2022 Water Quality Report, Minturn reported HAA5 samples as high as 77.1 ppb, above the MCL of 60 ppb. It is assumed these elevated HAA5 results are due to TOC spikes that occur during spring runoff when the turbidity also spikes, and that Minturn supplements with well water during these times to avoid treatment concerns. Further discussion with Minturn around the extent of any DBP exceedances is necessary to understand the nature of the DBP formation, and whether it is a one off or recurring issue.

Because of this, it is pertinent for TOC to be removed from the water, either through treatment or source water management. Different methods of removing TOC through treatment are discussed in subsequent sections. The removal of sediment and debris from the water, prior to filtration and disinfection, may lead to TOC and HAA5 levels dropping into a more manageable range.In terms of source water management, periodic dredging of Cross Creek at the intake is a potential method for improving raw water quality prior to treatment. Permitting from the US Army Corps of Engineers of other entity may be required to perform dredging.

1.6 Residuals Handling

Alternatives B and C will produce process residuals such as settled sludge and waste streams from backwashing and membrane clean-in-place (CIP) processes. The plan for both alternatives would be to convert the existing outdoor filters (Filters 1 and 2) into detention ponds to hold these residuals. The backwash/CIP waste would be neutralized before being recycled back to the front of the process a rate of < 5% to avoid overloading with TOC. Sludge would accumulate in the bottom of the ponds before being dredged and trucked away for disposal on an annual basis. Having two ponds available provides redundancy and would allow for at least one pond to be receiving residuals at all times. The footprint of the existing filters are large enough to provide an adequate amount of storage time for the plant's residuals. Residuals production from Alternative A include waste sand skimmed from the filters and is typically hauled for disposal by Minturn.

Table 2. Raw Water Quality from Cross Creek Water

Parameter	Number of Samples	Concentration (mg/L)	MCL	SMCL	Treatment Required / Treatment Goal	Comments
Arsenic	10	ND	0.01	N/A	No	Non-detect
Barium	8	MIN: 0.0059 AVG: 0.0091 MAX: 0.0112 90th: 0.0111	2	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL
Beryllium	9	ND	0.004	N/A	No	Non-detect
Cadmium	10	ND	0.005	N/A	No	Non-detect
Chromium	8	ND	0.1	N/A	No	Non-detect
Copper	8	MIN: 0.0015 AVG: 0.0030 MAX: 0.0048 90th: 0.0047	1.3	1.0	No	Sample data 90th percentile is <5% of the MCL/SMCL. Minturn will employ Caustic feed as CCT
Fluoride	8	ND	4.0	2.0	No	Minturn does not currently, nor has plans for, fluoridation
Lead	8	MIN: 0.0000 AVG: 0.0000 MAX: 0.0002 90th: 0.0001	0.015	N/A	No	Minturn will employ Caustic feed as CCT
Nitrate	13	MIN: 0.00 AVG: 0.13 MAX: 0.25 90th: 0.24	10	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL
Nitrite	8	ND	1	N/A	No	Non-detect.
Selenium	8	MIN: 0.0000 AVG: 0.0001 MAX: 0.0011 90th: 0.0003	0.05	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL
Aluminum	12	MIN: 0.012 AVG: 0.068 MAX: 0.253 90th: 0.161	N/A	0.05 - 0.2	No	Sample data 90th percentile is within the SMCL range.
Chloride	13	MIN: 0.00 AVG: 0.43 MAX: 1.53 90th: 0.73	N/A	250	No	Sample data 90th percentile is <5% of the MCL/SMCL
Iron	15	MIN: 0.040 AVG: 0.187 MAX: 0.353 90th: 0.302	N/A	0.3	No	While the 90th percentile of the data is at the SMCL, and colored water events can occur even below the SMCL, treatment is not recommended due to the lack of colored water complaints incurred at Minturn
Manganese	15	MIN: 0.0071 AVG: 0.0117 MAX: 0.0182 90th: 0.0160	N/A	0.05	No	Sample data max value is < the MCL/SMCL
pH	21	MIN: 7.2 AVG: 7.4 MAX: 7.7 90th: 7.5	N/A	6.5-8.5	**8.3 ± 0.2 s.u. 95% of the time**	Minturn will control pH >8 as a measure against corrosion control. Caustic is planned for as part of the new WTP.
Silver	8	ND	N/A	0.1	No	Non-detect.
Sulfate	14	MIN: 5.62 AVG: 13.87 MAX: 23.82 90th: 20.32	N/A	250	No	Sample data 90th percentile is <10% of the MCL/SMCL
Total Dissolved Solids	13	MIN: 27 AVG: 47 MAX: 69 90th: 63	N/A	500	No	Sample data average is <10% of the MCL/SMCL
Zinc	10	MIN: 0.001 AVG: 0.002 MAX: 0.005 90th: 0.003	N/A	5	No	Sample data 90th percentile is <5% of the MCL/SMCL
Turbidity (NTU)	26,085	MIN: 0.30 AVG: 0.70 MAX: 17.35 90th: 1.01	N/A	N/A	**≤ 0.1 NTU for 95% of readings**	At no time can turbidity go higher than 1 NTU, and samples must be ≤ 0.3 NTU in 95% of monthly samples
Hardness (mg/L as CaCO3)	12	MIN: 13.0 AVG: 23.0 MAX: 36.1 90th: 29.4	N/A	N/A	No	Water classified as Slightly Hard (17.1 – 60)
Alkalinity (mg/L as CaCO3)	11	MIN: 8.4 AVG: 14.2 MAX: 19.7 90th: 17.2	N/A	N/A	No	Lower alkalinity waters are more susceptible to changes in pH.
Total Organic Carbon	14	MIN: 1.3 AVG: 3.5 MAX: 12.0 90th: 7.2	N/A	N/A	**> 35% Removal**	General goal for limiting DBP formation potential Will require pretreatment to achieve goal
Alpha Particles (pCi/L)	N/A	MIN: AVG: MAX: 90th:	15	N/A	**< 12**	No data available. **Minturn should consider space for advanced processes for radioactive contaminants.**
Beta Particles (mrem/yr)	N/A	MIN: AVG: MAX: 90th:	4	N/A	**< 3.2**	
Radium 226 and Radium 228 (pCi/L)	N/A	MIN: AVG: MAX: 90th:	5	N/A	**< 4**	
Uranium (ug/L)	N/A	ND	30	N/A	**< 24**	

Table 3. Raw Water Quality and Treatment Goals for Eagle River Water

Parameter	Number of Samples	Concentrations (mg/L)	MCL	SMCL	Treatment Required / Treatment Goal	Comments
Arsenic	5	MIN: 0.00000 AVG: 0.00010 MAX: 0.00060 90th: 0.00040	0.01	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL
Barium	5	MIN: 0.0440 AVG: 0.0522 MAX: 0.0585 90th: 0.0573	2	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL
Beryllium	5	ND	0.004	N/A	No	Non-detect.
Cadmium	5	MIN: 0.0000 AVG: 0.0001 MAX: 0.0001 90th: 0.0001	0.005	N/A	No	Sample data 90th percentile is <20% of the MCL/SMCL
Chromium	5	MIN: 0.000 AVG: 0.000 MAX: 0.001 90th: 0.001	0.1	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL
Copper	4	MIN: 0.0013 AVG: 0.0017 MAX: 0.0020 90th: 0.0019	1.3	1.0	No	Sample data 90th percentile is <5% of the MCL/SMCL. Minturn will employ Caustic feed as CCT
Fluoride	5	ND	4.0	2.0	No	Non-detect.
Lead	4	MIN: 0.0005 AVG: 0.0013 MAX: 0.0021 90th: 0.0019	0.015	N/A	No	Sample data 90th percentile is <5% of the Action Level. Minturn will employ Caustic feed as CCT
Nitrate	4	MIN: 0.00 AVG: 0.04 MAX: 0.16 90th: 0.11	10	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL
Nitrite	4	ND	1	N/A	No	Non-detect.
Selenium	5	ND	0.05	N/A	No	Non-detect.
Aluminum	8	MIN: 0.014 AVG: 0.023 MAX: 0.034 90th: 0.031	N/A	0.05 - 0.2	No	Sample data 90th percentile is < the MCL/SMCL
Chloride	8	MIN: 1.10 AVG: 2.16 MAX: 3.30 90th: 2.87	N/A	250	No	Sample data 90th percentile is <5% of the MCL/SMCL
Iron	9	MIN: 0.319 AVG: 0.428 MAX: 0.569 90th: 0.503	N/A	0.3	**< 0.10 mg/L**	**Pre-oxidation and settling**
Manganese	8	MIN: 0.0558 AVG: 0.1343 MAX: 0.2184 90th: 0.1912	N/A	0.05	**< 0.02 mg/L**	**Pre-oxidation, settling, filtration**
pH	14	MIN: 6.2 AVG: 8.0 MAX: 8.5 90th: 8.4	N/A	6.5-8.5	**8.5 ± 0.2 s.u. 95% of the time**	**Minturn will control pH >8 as a measure against corrosion control**
Silver	4	ND	N/A	0.1	No	Non-detect.
Sulfate	9	MIN: 12.59 AVG: 30.08 MAX: 38.22 90th: 37.96	N/A	250	No	Sample data 90th percentile is <10% of the MCL/SMCL
Total Dissolved Solids	9	MIN: 59 AVG: 110 MAX: 131 90th: 127	N/A	500	No	Sample data 90th percentile is <20% of the MCL/SMCL
Zinc	5	MIN: 0.038 AVG: 0.062 MAX: 0.087 90th: 0.083	N/A	5	No	Sample data 90th percentile is <5% of the MCL/SMCL
Turbidity (NTU)	N/A	MIN: AVG: MAX: 90th:	N/A	N/A	**≤ 0.1 NTU for 95% of readings**	**At no time can turbidity go higher than 1 NTU, and samples must be ≤ 0.3 NTU in 95% of monthly samples**
Hardness (mg/L as CaCO3)	6	MIN: 62 AVG: 85 MAX: 118 90th: 107	N/A	N/A	No	Water classified as Moderately Hard (60 -120 mg/L)
Alkalinity (mg/L as CaCO3)	6	MIN: 48 AVG: 61 MAX: 80 90th: 72	N/A	N/A	No	Lower alkalinity waters are more susceptible to changes in pH.
Total Organic Carbon	9	MIN: 1.3 AVG: 2.5 MAX: 6.5 90th: 3.7	N/A	N/A	**> 35% Removal**	**General goal for limiting DBP formation potential**
Alpha Particles (pCi/L)	2	MIN: 1.3 AVG: 2.1 MAX: 2.8 90th: 2.7	15	N/A	No	Sample data 90th percentile is <20% of the MCL/SMCL
Beta Particles (mrem/yr)	1	ND	4	N/A	No	Non-detect.
Radium 226 and Radium 228 (pCi/L)	2	MIN: 0.4 AVG: 2.0 MAX: 3.5 90th: 3.2	5	N/A	**< 4**	**Treatment not required, but Minturn should consider space for advanced processes to remove should Radium 226 increase further.**
Uranium (ug/L)	4	MIN: 0.6 AVG: 0.8 MAX: 1.0 90th: 0.9	30	N/A	No	Sample data 90th percentile is <5% of the MCL/SMCL

2 Decision Tool and Criteria Development

The first step in conducting this alternatives analysis was to determine the tool that would be used to compare each of the three alternatives against each other, and the specific criteria that each alternative would be judged upon.

2.1 Decision Tool Background

Process alternatives were evaluated using a Multi-Criteria Decision Analysis tool called decisionSPACE™, a proprietary program developed by HDR. A series of evaluations were conducted throughout the analysis that ultimately result in a final score of each alternative, described below:

> *Step 1* of the evaluation is to identity a list of qualitative criteria, or goals, specific to Minturn that are the top priorities influencing selection of the new WTP process. The list included the following:
>
> - Capacity flexibility
> - Long-term reliability
> - Operations & maintenance
> - Process modifiability
> - Resiliency
>
> The criteria is further defined in the following sections and in Table 4. The criteria were then evaluated against each other to determine which are more or less important and to develop a criterion specific multiplier, or weight, of each qualitative criterion that reflects the level of relative importance.
>
> *Step 2* involves evaluation of each proposed alternative against the established criteria. The evaluation ranks an alternative based on its ability to meet a specific criterion on a scale of **Very Low (Worst), Low, Moderate, Strong,** and **Very Strong (Best)**, independent of all other proposed alternatives. These ratings, in combination with the weighting of each criterion, are used to tabulate a “final score” for each alternative. The results of the evaluations were analyzed alongside the estimated capital costs and the estimated annual operations & maintenance cost.

Descriptions of the criteria developed for the analysis are presented in this section and the final scores for each alternative are presented in Section 6.

The following criteria and their relative importance were developed jointly by HDR and the Minturn Water Committee during a workshop on January 12th, 2023. The criteria below are listed in the order of importance to Minturn.

2.2 Criterion 1: Resiliency

Minturn's top priority is to select an alternative that provides resiliency to the water supply. Alternatives will be rated based on their ability to meet the following:

- Meet the demand of the existing customers
- Treat Cross Creek water compliant with established finished water quality goals (See Table 2)
- Maintains treatment capacity during high turbidity events, such as spring runoff in Cross Creek

2.3 Criterion 2: Operations & Maintenance

Minturn employs a contract-based operations company to operate and maintain the existing WTP. The existing WTP is not staffed every day, and Minturn desires a similar level of staffing for the future WTP. Alternatives will be rated based on their respective ability to meet the following:

- Ability to remotely monitor and operate the process
- The level of staffing and level of operator certification required
- The expected maintenance frequency
- Locality and availability of replacement parts and service

2.4 Criterion 3: Long-Term Reliability

Minturn requires the selected WTP process alternative to provide long-term reliability for the water system. Alternatives will be rated based on their ability to meet the following:

- The expected equipment lifespan should be close to 30 years

2.5 Criterion 4: Process Modifiability

Looking forward, Minturn expects that the selected alternative can be modified to adapt to more stringent water quality regulations. Additionally, the alternatives will be evaluated for the ability to treat Eagle River source water, as Minturn is actively trying to acquire a water right on that source. Alternatives will be rated based on their ability to meet the following:

- Degree of modification required to treat Eagle River water (See Table 3)
- Degree of modification required to meet more stringent future water quality regulations

2.6 Criterion 5: Capacity Flexibility

The selected alternative must provide some level of flexibility in treatment capacity to Minturn. This criterion considers the proposed WTP process' ability to turn down to meet low demand conditions and the impact that starting and stopping the process has on water quality. Alternatives will be rated based on their ability to meet the following:

- Water production rate turndown
- Ability to start and stop the process without significant impacts to water quality

2.7 Weighting Criteria Results

HDR and Minturn ranked the relative importance of each of the individual criteria to establish a final weighting. Many high-importance rankings, creates a higher weighting value. Similarly, many low-importance rankings create a lower weighted value. The relative importance and resulting weights are presented in Table 4. The arrows indicate the relative importance of each criterion as it compares to the other four. The weighting for each criterion is applied in the tabulation of the final score for each alternative.

Table 4. Decision Making Criteria Rank and Weight

	Criterion	1 Resiliency	2 Operations & Maintenance	3 Long Term Reliability	4 Process Modifiability	5 Capacity Flexibility	Weight
1	Resiliency		→	↗	↗	↑ (much more)	35%
2	Operations & Maintenance			→	↗	↑ (much more)	26%
3	Long Term Reliability				↗	↑ (much more)	22%
4	Process Modifiability					↑ (extremely more)	13%
5	Capacity Flexibility						3%

↑ Is extremely more important than	↑ Is much more important than	↗ Is more important than	→ Is as important as
↓ Is extremely less important than	↓ Is much less important than	↘ Is less important than	

3 Alternative A: Rehabilitation of Existing Slow Sand Filters

Of the three existing slow sand filters, only Filter 3 is in use and in compliance with CDPHE drinking water regulations. A 2018 Sanitary Survey discovered Filters 1 and 2 are unlined, and thus do not comply with CDPHE drinking water regulations. Filter 1 has been completely decommissioned and Filter 2 has been retrofitted into a roughing filter with a 1-micron cartridge filter treating its filtrate prior to disinfection. Filter 3 is housed within a below grade, covered concrete structure with a surface area of 3,000 square feet (75 ft x 40 ft). Filter 3 has a capacity of 60 gpm (based on feedback from operations staff), corresponding to a rate of filtration of 28.8 gpd/sf (0.02 gpm/sf).

Discussions with CDPHE revealed that rehabilitation of Filters 1 and 2 is an acceptable alternative for Minturn but did stipulate certain upgrades that must be met for permitting. These upgrades include lining the filters and providing a structure over the filters to protect them from freezing in the winter and algal growth in the summer. The approach laid out for Alternative A is in accordance with CDPHE direction.

The existing earthen filters (Filters 1 and 2) are trapezoidal with a 3:1 slope and a bottom surface area of 1,300 square feet (approximately 36 ft square). New Filters 1 and 2 would be constructed within the footprint of existing filters and similar in design to the existing Filter 3. The new filters would be constructed of cast in place concrete with vertical sidewalls, allowing the surface area of each filter to be increased to approximately 4,800 square ft, or 60 ft x 80 ft. Rehabilitating Filters 1 and 2 would increase the potential production capacity of the WTP by increasing the available filter footprint. CDPHE regulates the nominal rate of filtration between 45 and 150 gallons per day per square foot (gpd/sf) of sand area.

In colder climates, slow sand filters are typically operated at a lower filtration rate to increase contact time in the filter bed for the biological removals to occur. It is recommended that a rate of filtration less than 72 gpd/sf is used when water temperatures are less than 5 °C. Filter 3’s rate of filtration has been recorded as low as 28 gpd/sf providing evidence that a slower rate of filtration is required to treat Cross Creek raw water. During warmer months, a design filtration rate of 144 gpd/sf was selected as faster throughput is expected in the rehabilitated filters with warmer temperatures. Table 5 presents the recommended design filtration rates and resulting treatment capacity of the rehabilitated filters and shows the rehabilitated slow sand filters can meet the seasonal water demands presented in Table 1.

Table 5. Temperature Based Design Loading Rates for Rehabilitated Slow Sand Filters 1 & 2

Design Parameter	Colder Months	Warmer Months
Water Temperature (°C)	< 5	> 5
Design Rate of Filtration (gpd/sf)	72	144
Individual Filter Capacity (gpd)[1]	345,600	691,200
Firm Treatment Capacity (mgd)[2]	0.45	0.8
Total Treatment Capacity (mgd)[3]	0.90	1.5

[1] Filters 1 & 2 are 60 ft x 80 ft.

[2] Filter 3 is 75 ft x 40 ft and produces a maximum of 60 gpm (0.1 mgd). Filters 1 and 3 are online producing 0.35 mgd and 0.1 mgd respectively. Filter 2 is out of service.

[3] All filters online

The existing slow sand filter 3 struggles to keep up with the solids loading from elevated turbidity experienced during spring runoff, is subsequently taken offline during this time for annual maintenance, and the groundwater wells are utilized as the source of supply. During spring runoff, the TOC is also observed to spike, and switching to the wells allows Minturn to supplement with a lower TOC water and avoid potential DBP issues related to higher TOC. CDPHE recognizes this as an acceptable operational strategy for Minturn and does not have issue as along as it is part of Minturn's operational plan. However, the wells are only capable of producing approximately 0.25 mgd if utilized simultaneously, and cannot meet the existing water demand of Minturn during spring runoff when the slow sand filters are expected to be unusable.

Figure 3 presents the existing WTP process flow diagram with the rehabilitations and modifications thereto being considered by Alternative A. Roughing filters will be installed upstream of the slow sand filters to improve filter performance due to the known elevated turbidity that occurs during spring runoff and are required by CDPHE if the raw water turbidity is known to be greater than 10 NTU. Roughing filters will reduce the solids loading that increases during spring runoff and reduce the frequency of filter skimming that will be inevitable with increased production, particularly in the summer season. It is important to note that roughing filters are only practical at reducing solids loading when the solids are particulate, and not colloidal. Further analysis of the raw water quality would be necessary to determine the type of solids in the water supply.

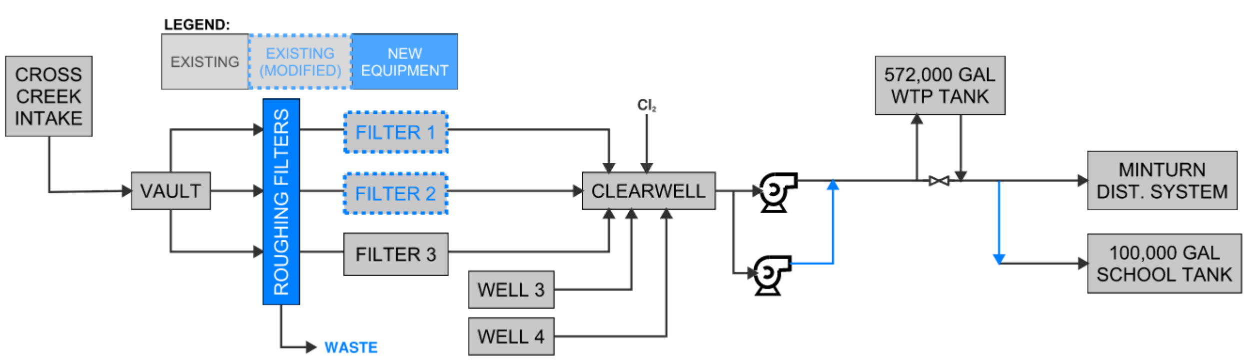

Figure 3. Process Flow Diagram - Alternative A: Rehabilitate Slow Sand Filters

Filter rehabilitation involves complete removal of the existing earthen Filters 1 and 2, excavation, subgrade prep, and construction of the new cast in place filter basins. The basins and surrounding walkways could incorporate some of the foundation which will be needed to support an enclosure required for new slow sand filter installations. An enclosure is required to provide both a cover and freeze protection, both of which are required for plan approval to be issued by CDPHE.

Figure 4. Minturn's Existing Slow Sand Filter (Filter 3)

While rehabilitation of Filters 1 and 2 would increase the current production and address regulatory compliance, it does not resolve issues such as treating high turbidity and high TOC water. Further, future WTP expansions (if necessary) are not possible given the large area required for this technology.

3.1 Resiliency

Rehabilitation of the existing slow sand filters, in addition to the currently operating Filter 3, would provide Minturn with adequate WTP capacity to meet the design flow.

Slow sand filtration is permitted for use by CDPHE on the condition that the raw water turbidity is less than 10 NTU and less than 15 color units. Data available at the time of this evaluation indicates Cross Creek turbidity can exceed these thresholds during spring runoff, but for much of the year, the turbidity is sufficiently low for the filters to perform well. However, a complete set of data during spring runoff has not been collected as the slow sand filters are offline during that time due to high turbidity and strategically scheduled maintenance cleanings. It is typical for raw water turbidity in Colorado mountain streams to exceed 10 NTU during spring runoff and during and during/after wildfire events in the watershed. Minturn's operator for the existing WTP indicates that Filter 3 has struggled to produce turbidity compliant filtrate in the past during spring runoff. With the added concern of elevated TOC contributing to elevated DBPs during spring runoff, the slow sand filters are not expected to perform well during these periods. Therefore, the groundwater wells are brought online as the main source of supply. CDPHE recognizes this as an acceptable operating strategy, so long as Minturn has an operational plan and adequate storage to maintain water production.

Roughing filters are required by CDPHE to ensure compliance with CDPHE design criteria (feed water turbidity to slow sand filters < 10 NTU) and maximize filter performance. An example of roughing filters are fine basket strainers, which would require a building, electricity, controls/communication, and generate a waste stream which would need to be managed. As noted above, it is not a surefire solution for reducing solids loading, as it depends on the type of solids present in the water supply. If the solids are colloidal, roughing filters will not be an effective solution.

The disinfection requirements of a slow sand filtration WTP are presented in Table 6. Slow sand filters can provide up to 2-log of credit for both giardia and viral components.

Table 6. Slow Sand Filtration Disinfection Requirements

	SWTR Disinfection Requirements	Slow Sand Filtration Credit	log-disinfection required by chlorine	$CT_{required}$ (Note 1)
Giardia	3-log	2-log	1-log	87
Viruses	4-log	2-log	2-log	4

Notes 1. $CT_{required}$ based on filtered water quality of:
Temperature = 5 ºC
pH = 8.5
Chlorine residual concentration of 1 mg/L

To achieve adequate disinfection of slow sand filter water with a residual of 1 mg/L chlorine, 870 minutes of disinfection contact time is required. This time is determined by dividing the $CT_{required}$ value (87) by the baffling factor (0.1). Under these conditions, the storage tank provides sufficient disinfection up to a flow of 0.95 mgd, which is higher than the design flow of 0.6 mgd. Because groundwater requires less disinfection contact time, contributions from wells #3 and #4 would need to be managed separately from that of the filtered surface water to accurately track disinfection compliance.

Rehabilitation of the existing slow sand filters does allow for increased treatment capacity within the existing footprint. However, slow sand filters are likely non-viable without pre-treatment in the form of roughing filters installed upstream of them. Sand filters are only permissible when the source water they are treating does not exceed 10 NTU. Given the high variable nature of turbidity in Colorado streams, it is unlikely Cross Creek will always be less than 10 NTU, especially during spring runoff and post wildfire. Furthermore, TOC values have recently been recorded as high as 12 mg/L, and slow sand filters will not be able to remove enough TOC to adequately meet Minturn's DBP reduction goals. During these high turbidity or high TOC events, Minturn can utilize wells #3 and #4 as the main water source albeit at a flow that is less than Minturn's existing and projected water demands. So long as Minturn maintains adequate storage during high demand periods, the reduced flow rate from the wells is likely not an issue. This means that Minturn could successfully provide water throughout the year with the combination of the rehabbed filters and the wells. For these reasons, the slow sand filter alternative was given a rating of **moderate** with respect to resiliency.

3.2 Operations & Maintenance

Minturn has operated the existing slow sand filtration WTP for the past sixty years. The process operates wholly under gravity and little day-to-day operator attention is required beyond observation. There is little instrumentation monitoring the process itself, thus remote operability of slow sand filters is non-applicable.

A slow sand filtration WTP producing up to 0.6 mgd would require a C-level operator (2nd from bottom-most tier); the current and planned operations team for the rehabilitated facility hold A-level treatment licenses which are the highest tier available. The daily operations include monitoring the flow rate, recording the headloss of the filter in operation, and any necessary water quality recording. The proposed modifications for filter rehabilitation would not impact the need for additional licensure nor significantly impact the ability for Minturn to acquire a new operations team should the need arise.

Maintenance of slow sand filters largely requires periodic skimming of the top several inches to remove filtered particles and reduce filtration resistance. The filter to be skimmed must be removed from service, drained, and dried prior to removing the top layer. Minturn has historically conducted this maintenance once per year for skimming during spring runoff as the existing filters have struggled to treat the highly turbid water. As Minturn increases the WTP capacity and operates the filters more consistently throughout the years, the skimming frequency will increase to maintain the filter capacity resulting in an increase in time spent by staff on maintenance. In the past, when Minturn was producing closer to 10 million gallons of water per month (approximately 0.25 mgd), the filters were taken offline every 3-4 months for cleaning. The groundwater wells can be used during these high turbidity periods to reduce the maintenance burden on the filters.

Replacement parts for slow sand filters consist of replacement sand, which can generally be procured from suppliers within the timeframe that coincides with planned skim maintenance. Overall slow sand filters present favorably in the status quo of Minturn’s existing operation strategy and resources and were therefore given a rating of **strong**.

3.3 Long-Term Reliability

Slow sand filters benefit from longevity because of their relative simplicity. If well maintained, their ability to operate, in the capacity of which they were originally designed, is expected to exceed 30 years.

Slow sand filter flow rates are temperature dependent and will be different over the course of a year. However, the slow sand filters can meet the design flow of 0.6 mgd even with lower flowrates in the colder winter months.

Slow sand filters in Minturn possess long term reliability due to their sedentary nature; however, the ability to expand flow capacity is limited. Even still, they can meet the projected demands, giving them a rating of **strong** with respect to long-term reliability.

3.4 Process Modifiability

The slow sand filtration process is suitable only for high quality raw water with turbidity and color less than 10 NTU and 15 units, respectively. Slow sand filters, by themselves, are limited to treating water from Cross Creek, so long as the turbidity can be demonstrated as less than 10 NTU. Eagle River is known to have much higher raw water turbidity, as well as the presence of iron and manganese. The Eagle River water quality is at higher risk for contamination due to the level of adjacent development and mines draining to its watershed and will require more attention to ensure proper operation and maintenance.

To reduce iron and/or manganese (both present in Eagle River), oxidation and settling are common and typical strategies. Doing so converts dissolved inorganics to precipitates, thereby increasing turbidity and solids loading. Oxidation with permanganate will be required to remove the manganese in Eagle River; adding another chemical dose to monitor and adjust as influent levels change. Overdosing of permanganate results in pink water events that may require disposal of the affected water to prevent the occurrence at the taps. Furthermore, the increased solids loading from the oxidized precipitates will increase the filter skimming and maintenance frequency, adding more operational burden to Minturn.

Pilot testing will be required to ensure the slow sand filters could treat Eagle River water prior to developing it as a new source for a slow sand filter WTP. It is unlikely the results of the pilot test would be favorable for slow sand filtration. Without pilot testing, it is hard to predict the slow sand filter design parameters for the Eagle River source. The use of roughing filters will improve the performance on Eagle River; however, the use of filtration to pretreat for slow sand filters is a marginal pursuit. Coupled with pre-treatment for dissolved inorganics, Minturn would effectively be installing a WTP process for the sole purpose of maintaining slow sand filter compliance. At this point, there are better and more typical available technologies to treat water. Furthermore, selection of slow sand filters as the treatment technology does not demonstrate Minturn is actively working towards a successful solution to treat Eagle River raw water and runs the risk of losing access to water rights for Eagle River.

Continuing the operation of the slow sand filters with Eagle River source water adds significant need for additional treatment processes and maintenance for Minturn. Due to their inherit limitations with treating highly turbid waters and the potential risk of losing water rights to Eagle River, slow sand filters exhibit little to no process modifiability and were therefore given a rating of **very low**.

3.5 Capacity Flexibility

Due to the biological process necessary for efficient removal, slow sand filters require a healthy biology within the top layer of the filter called the "schmutzdecke". Therefore, sand filters rely on steady state operations at generally constant flow rates to not disrupt the microorganisms doing all the work. Ideally, the slow sand filters are run at a constant flow rate with minimal "start/stop" operations.

Additionally, the flow rate through the filter bed is critical to maintain that biological removal. Operating at too high of flow, can reduce the efficacy of the biology present in the bed. Conversely, operating at too low of flow can negatively impact the biology by allowing the water too much time in the filter bed. The minimum production rates from the two rehabilitated filters and Filter 3 are 96 gpm and 60 gpm, respectively. Therefore, the minimum production range of a rehabilitated slow sand WTP is 60 gpm or 0.1 mgd.

Slow sand filters maintain the turndown and flexibility to meet low demand conditions that are often present at Minturn, especially in the low demand winter months. The filters do rely on steady state operations for optimal removal, and a "start/stop" operation could result in less efficient removal. Additionally, slow sand filters may suffer from turbidity breakthrough upon startup and lack the ability to waste water until turbidity drops back down into an acceptable range. Due to these drawbacks with starting and stopping, Alternative A was given a rating of **low** with respect to capacity flexibility.

4 Alternative B: Packaged Conventional Treatment Plant

A packaged conventional treatment plant improves upon the existing treatment process by adding pre-treatment consisting of rapid mixing, flocculation, and settling, followed by dual-media filtration within the same container. Each container, or treatment unit, is referred to as a treatment train. Each treatment train mimics the conventional water treatment process, which is commonly employed and widely successful in treating surface water in Colorado. The system would include two 0.3 mgd treatment trains. The proposed process flow diagram for a new packaged treatment plant is presented in Figure 5.

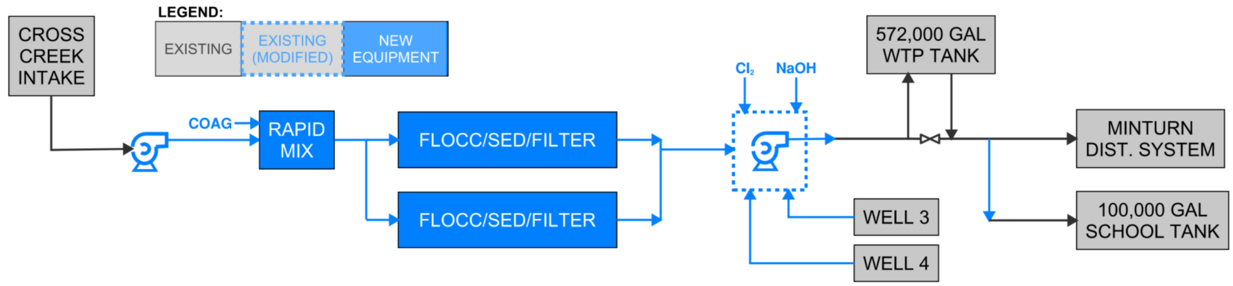

Figure 5. Process Flow Diagram - Alternative B: Packaged Conventional Treatment

When operated properly, the conventional treatment process is capable of treating challenging water with turbidity exceeding 80 NTU. Packaged treatment trains are advantageous to Minturn because of their small footprint and low relative cost compared to a distributed facility with cast-in-place concrete tanks. Their compact nature is a result of steel tank construction and compact arrangement of the process tankage and ancillary supporting equipment such as piping, motors, and valves. An example of a packaged treatment unit is presented in Figure 6.

Figure 6. Example Packaged Treatment Units. Breckenridge, CO.

Settling and filtration both create a waste stream in the form of residuals, or sludge. The sludge produced is typically between 0.1% and 0.5% total solids. The existing outdoor filters (Filters 1 and 2) would be converted into holding ponds for backwash waste and other process residuals. A new building to house the packaged treatment process would be constructed in the unoccupied area owned by Minturn to the south of the existing filters. Filter 3 could ultimately serve as a pumping station where clarified water from the backwash ponds is recycled to the front of the process.

4.1 Resiliency

Packaged conventional treatment units are typical for WTPs of the size and scale being considered by Minturn. The proposed two 0.3 mgd rated trains were selected to provide water at the design WTP capacity of 0.6 mgd. Packaged conventional treatment units can meet the demand of the existing Minturn distribution system.

The disinfection requirements of a conventional filtration WTP are presented in Table 7. A well operated conventional process can provide up to 2.5-log of credit towards disinfection for giardia and 2-log of credit for viral components. These credits reduce the amount of disinfection that must be achieved by chlorine addition, lowering chemical costs, and reducing the potential for DBP formation.

Table 7. Conventional Treatment Process Disinfection Requirements

	SWTR Disinfection Requirements	Conventional Treatment Credit	log-disinfection required by chlorine	$CT_{required}$ (Note 1)
Giardia	3-log	2.5-log	0.5-log	43
Viruses	4-log	2-log	2-log	4

Notes 1. $CT_{required}$ based on filtered water quality of:
Temperature = 5 ºC
pH = 8.5
Chlorine residual concentration of 1 mg/L

To achieve adequate disinfection following conventional filtration with a residual of 1 mg/L chlorine, 430 minutes of disinfection contact time is required. This time is determined by dividing the $CT_{required}$ value (43) by the baffling factor (0.1). Under these conditions, the existing 572,000-gallon unbaffled storage tank provides sufficient disinfection at the 0.6 mgd design flow. The conventional treatment process is highly capable of treating Cross Creek water, is resilient to high turbidity events, and provides for higher disinfection credit allowing Minturn to better manage chlorine and disinfection byproducts. Because groundwater requires less disinfection contact time, contributions from wells #3 and #4 would need to be managed separately from that of the filtered surface water to accurately track disinfection compliance.

Water from Cross Creek is immensely treatable by conventional packaged treatment units, and, if operated properly, is robust against high turbidity water (>100 NTU) such as that found during spring runoff or after the watershed experiences a wildfire event. Additionally, the intrinsically present pretreatment makes Alternative B the best process for removing TOC. Alternative B was given a rating of **strong** with respect to resiliency.

4.2 Operations & Maintenance

There exists a moderate level of motorized equipment, valves, and instrumentation on packaged treatment trains. Each these components can be controlled with a SCADA system that can be operated remotely and automatically. However, it is not recommended to perform a media filter backwash remotely. Backwashing should occur while an operator is in attendance. This requirement may necessitate more frequent visits from operations staff. Additionally, the quantity and complexity of automated equipment is directly proportional to the amount of maintenance required.

The conventional process requires use of a coagulant for flocculation and sedimentation to work effectively; an example chemical storage and feed system of the scale suitable for Minturn is presented in Figure 7. Coagulants consist of a metal salt (e.g. aluminum sulfate) which encourages agglomeration of particles in raw water into larger particles called floc particles. Floc particles are heavier than water and, provided enough time, will settle to the bottom of a tank where they are removed from the process as residuals (or sludge). Application of coagulant introduces a degree of complexity to the operation and would require daily operator involvement to ensure there are no line clogs or leaks in the chemical feed system.

Figure 7. Example Coagulant Feed System

A packaged media filtration WTP producing up to 0.6 mgd would require an A-level operator (highest tier); the current and planned operations team for the new facility hold A-level treatment licenses. The proposed modifications would not impact the need for additional licensure but may impact the ability for Minturn to acquire a new operations team should the need arise.

With the high number of componentry and complexity of the process, maintenance frequency is difficult to predict, but it will be more intensive compared to a slow sand filter process. Most conventional WTPs in Colorado are staffed daily and establish weekly, monthly, quarterly, and annual maintenance schedules for various components.

If selected as an alternative, suppliers of packaged conventional treatment units located in Colorado would be given preference. Additionally, Minturn would be encouraged to stock select spare parts and components in the event of a failure.

Overall, a packaged conventional treatment process has a high degree of required operator involvement due to complexity of operation and chemical feed. Maintenance intervals are increased due to the number of components and steel tank construction. For these reasons, Alternative B was given a rating of **moderate** for operations and maintenance.

4.3 Long-Term Reliability

Steel tanks that hold water experience failures over time due to the corrosive environment in which they reside. Failures are generally minor (e.g. leak at weld seem), but repairs require the unit be completely taken offline and patched. It is not uncommon to have steel tanks be in service for more than 20 years; however, it is likely those tanks will have undergone several in place repairs.

The componentry bolted to the steel tank supporting the process is expected to require replacement on a more regimented schedule. Flocculator chains will likely require maintenance every six months to a year as the chain links stretch and break. Filter media should be replaced in kind every 7 to 10 years. Valves, valve motors, and other miscellaneous equipment should be replaced on an as needed basis and a store of commonly replaced materials should be established by Minturn to minimize downtime.

Overall, the long-term reliability of a packaged conventional treatment process is moderate to high. There are many components that require regimented attention, but a quality manufactured system should last at least 20 years without need for major repairs. For these reasons, Alternative B was rated as **strong** in the realm of long-term reliability.

4.4 Process Modifiability

Packaged conventional treatment units are limited in their ability to treat water they were not originally designed to treat. Additional unit processes may be required to remove dissolved iron and manganese present in the Eagle River. The building and hydraulics of the process should be designed to allow for insertion of polishing processes downstream of the filters, such as pressurized ion exchange or greensand vessels, as presented in Figure 8.

Figure 8. Pressure Filter Tanks for Adsorptive Inorganics Removal

Alternatively, some level of pre-oxidation should be considered. The packaged flocculation and settling basins may not provide enough reaction time for the oxidation-precipitation reaction to reach full yield, so a dedicated reaction basin upstream of the pre-treatment is recommended. This will ensure particulate iron and manganese are introduced to the pre-treatment process where they can coagulate and settle with other particles in the raw water. Without sufficient reaction time, manganese may chemically adsorb onto the filter media and disruptions in water quality could elute the same into the finished water and risk water aesthetics.

The degree of modifiability to a packaged conventional treatment process is limited with respect to the treatment units themselves. Flexibility can be built into the design to accommodate anticipated future process requirements, giving Alternative B a rating of **strong**.

4.5 Capacity Flexibility

Packaged treatment trains can typically be turned down to about 50% of the rated flow. In this instance, each treatment train could be operated as low as 0.15 mgd (50% of 0.3 mgd) providing an estimated treatment range of 0.15 mgd to 0.6 mgd. Starting and stopping a conventional treatment process is challenging. It takes some time for the process to reach steady state and for the coagulant dose to be optimized. Each time a unit starts, it will need to be wasted – meaning filtrate would be routed to the backwash waste ponds until the effluent turbidity is within finished water quality goals. This process typically takes several minutes.

Packaged treatment trains are generally flexible in their ability to turn down but struggle with sporadic start and stoppage. Due to these struggles, Alternative B was given a rating of **moderate** for capacity flexibility.

5 Alternative C: Membrane Water Treatment Plant

Microfiltration (MF) and/or ultrafiltration (UF) membranes represent state-of-the-art filtration technology, do not require pre-treatment to function effectively, and offer an absolute barrier to particles and pathogens common in surface water. They are common and successful in treating Colorado surface waters. Membranes typically benefit from a smaller relative footprint which would fit within the proposed WTP building space.

Membranes typically operate as a direct filtration process, meaning the membranes can effectively operate with little to no pre-treatment depending on the influent water quality parameters. Direct membrane filtration can effectively handle influent turbidity up to 20 NTU without the need for pre-treatment. However, in the presence of elevated total organic carbon (TOC) and other dissolved inorganic contaminants, pre-treatment is recommended to enhance removal efficiencies of those constituents as membrane filtration alone does not meet target removals.

With the Cross Creek TOC spikes discussed in Section 1.4, seasonally operated pretreatment can be implemented should Minturn opt to treat Cross Creek during spring runoff rather than rely on well water to supplement. Coagulant would be added to flocculate suspended and organic materials in the water so that it may be filtered and removed by the membrane system. Downstream of chemical addition, the water would enter the Flocculation Tank, which will consist of a vertical tank and a top mounted mixer. A sweep-flocculation mechanism will occur in this tank, thereby allowing agglomeration of the suspended and organic materials. A vast majority of the coagulated solids will remain in suspension and carry over to the membrane system for removal through filtration. Equipment costs for this type of partial pre-treatment range from $150,000 - $250,000 and are included in the cost estimates developed for Alternative C because while this system would be operated seasonally, the infrastructure would remain in place.

Direct filtration is proposed as Cross Creek water has little dissolved inorganic contaminants throughout much of the year and seasonally operated equipment is planned for periods of high TOC which membranes struggle to remove without pre-treatment. Oxidation would be required to treat Eagle River water for iron and manganese followed by settling to ensure iron and manganese does not carry over to the membranes. The treatment plant would include two 0.3 mgd membrane skids. The proposed process flow diagram for a new membrane treatment plant is presented in Figure 9.

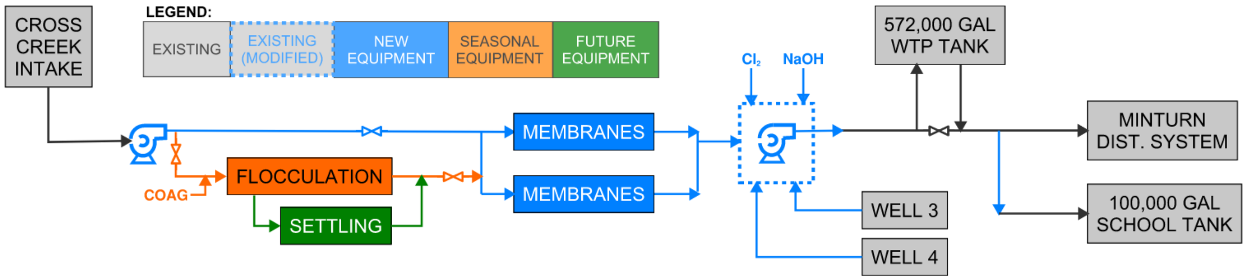

Figure 9. Process Flow Diagram - Alternative C: Membrane Filtration

Figure 10. Typical MF/UF Membrane Skids. Bend, OR.

Membrane skids are made up of many modules, as displayed in Figure 10. Skids are highly automated which simplifies their operation when compared to a conventional filtration treatment plant. The existing outdoor filters (Filters 1 and 2) would be converted into holding ponds for backwash waste. A new building to house the membrane skids and requisite chemical storage systems would be constructed in the unoccupied area owned by Minturn to the south of the existing filters. Filter 3 could ultimately serve as a pumping station where clarified supernatant from the backwash ponds is recycled to the front of the process.

5.1 Resiliency

The proposed two 0.3 mgd rated skids were selected to provide water at the design WTP capacity of 0.6 mgd. The proposed membrane skids can meet the demand of the existing Minturn distribution system with room to spare.

The disinfection requirements of a membrane filtration WTP are presented in Table 8 and consider the use of either MF or UF membranes. When properly operated and validated, membrane filtration can provide 3-log of disinfection credit for giardia, but do not provide any disinfection credit for viral components.

Table 8. Membrane Filtration Disinfection Requirements

	SWTR Disinfection Requirements	Membrane Filtration Credit	log-disinfection required by chlorine	$CT_{required}$ (Note 1)
Giardia	3-log	3-log	None	n/a
Viruses	4-log	None	4-log	8

Notes 1. $CT_{required}$ based on filtered water quality of:
Temperature = 5 ºC
pH = 8.5
Chlorine residual concentration of 1 mg/L

To achieve adequate disinfection of membrane treated water with a residual of 1 mg/L chlorine, 80 minutes of disinfection contact time is required. This time is determined by dividing the $CT_{required}$ value (8) by the baffling factor (0.1). Under these conditions, the existing 572,000-gallon unbaffled storage tank provides ample contact time at the design flow of 0.6 mgd. The use of membranes to treat surface water effectively allows the filtrate, or treated water, to have the same disinfection requirements of ground water, which significantly simplifies the management of chlorine dosing and reporting.

Membrane filtration provides good resiliency and would, with proper operation, produce the highest quality finished water of the three alternatives being evaluated. When considering the relatively high quality of the Cross Creek source, this alternative should have no issues treating the water to finished water quality goals, assuming turbidity and TOC remains low. If the turbidity and TOC spikes during spring runoff increase in frequency or duration, the inclusion of pretreatment would both improve membrane performance and prolong the lifespan of the membrane fibers. Another option would be to run wells #3 and #4 during periods of high TOC. Membranes combined with either wells or pretreatment would result in this alternative providing the most robust resiliency. Therefore, Alternative C was given a rating of **very strong** in this category.

5.2 Operations & Maintenance

Membrane treatment is typical for WTPs of the size and scale being considered by Minturn. Many small neighboring communities have chosen this technology for their system due to its relative simplicity to operate compared to a conventional process (e.g. no coagulation or settling required). Skids can be monitored and controlled remotely, favoring Minturn's contract operations model. There is a high degree of automated valves and monitoring equipment on a membrane skid that will increase the level of operator involvement compared to the existing slow sand filtration process; however, the level of operator involvement is expected to be less compared to a conventional treatment process.

Chemicals consisting of chlorine, an acid (typically citric acid), and a base (typically sodium hydroxide) are used during membrane cleaning cycles. The cleaning cycles are generally automated, and the equipment can be designed and furnished by the membrane supplier.

A membrane WTP producing up to 0.6 mgd would require a B-level operator (2^{nd} from highest tier); the current and planned operations team for the new facility hold A-level treatment licenses (highest tier available). The proposed facility would not impact the need for additional licensure, nor is it expected to impact the ability for Minturn to acquire a new operations team should the need arise. Minturn's existing operations team has experience with membrane WTPs, and it is their preferred process to operate.

With the high number of valves, fittings, and membrane modules on each skid, maintenance frequency is difficult to predict. However, many membrane WTPs in Colorado are not staffed daily. Still, Minturn should establish weekly, monthly, quarterly, and annual maintenance schedules for various components to avoid downtime associated with repair.

If selected as an alternative, membrane skid suppliers located in Colorado would be given preference. Additionally, Minturn would be encouraged to stock select spare parts and components in the event of a failure. Membrane modules are typically not stocked as a spare item, as they need to be kept wet for prolonged storage durations.

Overall, a membrane filtration process poses a reduced level of operator involvement because of its relative simplicity to operate remotely with no coagulation. Maintenance intervals are increased due to the number of components that come with each membrane skid. For these reasons, Alternative C was given a rating of **moderate** in terms of operation and maintenance.

5.3 Long-Term Reliability

The expected lifespan of the membrane modules, which make up the skid, are approximately 7 to 10 years before needing to be replaced. However, the lifespan of membranes is heavily dependent on how they are operated. Methods for extending the lifespan of membranes include pre-treatment, proper cleaning using either clean in place (CIP) procedures, or through chemically enhanced backwashes. It is also recommended to run two skids simultaneously at half capacity to stay below the critical flux; above which fouling is more likely to occur. Flux is the measure of the rate of flow through a single square foot of membrane surface area (e.g. gal/ft^2/day). Higher flux results in more frequent backwashing and cleaning, so lowering loading and fouling potential on the membranes can help to prolong their useful life. The skids include structural framing, supports, and valves which should be able to last up to 30 years with proper maintenance. Overall, Alternative C was given a rating of **strong** with respect to long-term reliability.

5.4 Process Modifiability

To be able to treat water from Eagle River, pretreatment trains would need to be added to the treatment process. A process including both pretreatment and membranes would be the most robust treatment system of the three alternatives, and the lowest risk solution for meeting future water quality standards. As part of the pretreatment, some level of pre-oxidation would need to be added to successfully remove the higher levels of iron and manganese in the Eagle River. Oxidation of dissolved iron by aeration is successfully employed and can be accomplished with fountains (pictured in Figure 11) or aeration towers. The proposed pre-treatment would include flocculation and high rate settling designed around settling oxidized metal compounds.

Figure 11. Example of Fountain Aeration of Iron

The expanded treatment process shown in Figure 9 is the most robust in terms of ability to treat Eagle River water and Cross Creek during spring runoff. Membranes provide a better ability to meet future CDPHE regulations than either slow sand or conventional filtration. For these reasons, Alternative C was given a rating of **very strong** in this category.

5.5 Capacity Flexibility

Membrane skids can be successfully turned down at least 50% of their design flow rate, meaning that each skid could run as low as 0.15 mgd. This flexibility means that periods of low demand would not be a major issue. Further, membrane skids are highly resistant to complications associated with starting and stopping. In fact, a membrane skid may start and stop every 20 minutes as it goes through a short backwash cycle. However, membrane systems are designed for continuous operations, meaning that both skids would need to be run year-round, even during the winter when flows are minimal. In winter months, the two skids would operate in a cycle with one skid operating and one backwashing or primed to come online when the operating skid requires backwashing. This will ensure that both skids remain in continuous operation. Overall, a membrane WTP provides the highest capacity flexibility of the alternatives being considered, resulting in a rating of **very strong**.

6 Cost Analysis of Alternatives

Within the past couple of years, costs for materials, equipment, and freight have been increasing at significant levels. In addition, lead times for equipment and materials have increased. Supply chain issues have created construction market uncertainty on scheduling sub-contractors and overall completion certainty. This combination has produced a potentially volatile situation for utility owners around the country. On one hand, general contractors are drastically holding down fees (and, by default, bid prices) in order to obtain work, but then are exercising force majeure clauses for substantial change orders or adjustment of completion schedules. A project owner would be wise to retain a higher than usual contingency and seek bid and performance bonds on projects that may not normally require them. HDR has prepared opinions of probable construction cost (OPCCs) for the alternatives described in this report. The OPCCs presented in Table 9 are Class 4 as described by the American Association of Cost Estimating (AACE); they are provided with an accuracy range of -15% to +30%.

Since HDR has no control over the costs of labor, materials, equipment, or services or over the selected Contractor's methods of determining prices, HDR does not guarantee that proposals, bids, or actual project construction costs will not vary from the OPCCs prepared. For the OPCCs prepared for the improvements described in this report, HDR has included the following items:

- General contingency for miscellaneous items for estimating at a planning or programming level – 40%.
- Contractor General Conditions, Mobilization, and Demobilization – 8 to 10%.
- Contractor Overhead and Profit – 8 to 10%.
- Contractor Bonds and Insurance – 2%.
- It should be noted that the OPCCs in this report are in 2023 dollars, and escalation costs have not been included.

The capital cost data used as the basis of the estimates for the improvements at the WTP were compiled from a mixture of previous project bid tabs from recent HDR projects and vendor pricing for the specific process equipment associated with each alternative. Detailed cost backup supporting these estimates is available in Appendix A.

Table 9. Opinion of Probable Construction Cost Summary (AACE Class 4)

Alternative	Low Capital Cost (-15%)	High Capital Cost (+30%)	Annual O&M
A - Rehabilitation of Existing Slow Sand Filters	$5.8M	$8.9M	$120K
B - Packaged Conventional Water Treatment Plant	$10.5M	$16.7M	$200K
C - Membrane Water Treatment Plant	$9.8M	$14.9M	$150K

7 Comparison of Alternatives

A qualitative score was tabulated for each alternative after the Alternatives Analysis workshop held on March 20th, 2023. The score for each was determined by the ratings of each of the five criteria and the relative weights of each criteria.

7.1 Alternative Qualitative Scores

Table 10 provides a summary of the ratings for each alternative, culminating in the final qualitative score for each.

Table 10: Alternative Qualitative Scores

Criteria	Alternative A: Slow Sand Filtration	Alternative B: Packaged WTP	Alternative C: Membrane WTP
Resiliency (35%)	Moderate	Strong	Very Strong
Operations & Maintenance (26%)	Strong	Moderate	Moderate
Long Term Reliability (22%)	Strong	Strong	Strong
Process Modifiability (13%)	Very Low	Strong	Very Strong
Capacity Flexibility (3%)	Low	Moderate	Very Strong
FINAL SCORE	**56**	**64**	**75**

From a qualitative perspective, membranes are the most favorable alternative with respect to being able to meet Minturn's goals for a robust, reliable, and flexible water treatment process. Packaged treatment with conventional filtration placed second of the three alternatives. The process was rated as even or just below membranes in all five categories. Slow sand filtration was the lowest scoring alternative due to its lack of flexibility and inability to treat Eagle River water.

8 Expansion of Existing Groundwater Supply

Upon completion of the analysis of the three surface water treatment alternatives presented thus far, a fourth alternative was proposed to address the treatment capacity issues of the existing WTP. Minturn expressed interest in investigating the possibility of increasing the capacity of the existing wells (Wells #3 and #4) such that Minturn could rely solely on the groundwater supply to meet the water demands and eliminate their dependence on challenging treatment of available surface water. Because this potential alternative is reliant on the groundwater supply in Minturn, it was not included in the alternatives analysis that focuses on the three surface water treatment process alternatives. This analysis of the groundwater wells will focus on answering three pertinent questions:

1. Will the Minturn's water rights allow for expanded withdrawals from the wells?
2. Do the existing wells have capacity (or yield) to produce at the required rate (0.6 mgd cumulative)?
3. Will the wells be classified as a ground water source at the increased production rate?

Do Minturn's existing water rights allow for expanded use of the groundwater wells?
In short, yes. The existing water right on Cross Creek could be modified with an "alternative point of diversion" to allow Minturn to exercise its right to that water (with the conditions of consumptive use) from the wells. This process would require going through water court to amend the water right and would be subject to contest.

Do the existing wells have capacity (or yield) to produce at the required rate?
Minturn presently operates two groundwater wells (Wells #3 and #4) at a capacity of 80 gpm each. The wells are used to supplement the surface water treatment plant during the spring runoff when the surface water becomes more difficult to treat. Minturn's well permit allows for up to 225 gpm to be diverted from each well, but pumping limitations result in a maximum flow rate of 80gpm. To increase the yield, larger pumps and casing improvements are necessary to address the pumping limitations.

To determine if the wells are capable of producing at a higher yield, a well test is needed. A well test is performed by a licensed well contractor wherein the well is inspected, cleaned (if necessary), and outfitted with a temporary pump that is designed to pump at the target flow rate. The well is pumped for several days while the water level in the well casing is monitored. Minturn, in cooperation with Martin & Wood Water Consultants is currently reviewing proposals from several well pumpers to perform this testing in the summer of 2024. Both wells need to be yield tested to confirm they are capable of meeting the required 0.6 mgd total demand. Any production capacity less than this negatively impacts the viability of the wells being the only source of water supply in Minturn.

If the wells can produce water at 225 gpm each, will that water still be classified as groundwater (thus not requiring treatment)?

Increasing the well production from 80 gpm to 225 gpm introduces the potential for the water coming from the wells to be influenced by the water in Cross Creek. If that were to occur, this would classify the well water as Ground Water under the Direct Influence (GWUDI) of surface water. shows the location of the wells #3 and #4 which are approximately 160 ft and 80 ft away, respectively, from Cross Creek. Given their proximity to Cross Creek and shallow depth (between 60 and 70 ft to bottom of well), the wells are in a type III aquifer which requires a GWUDI evaluation.

Minturn performed a GWUDI evaluation on the wells in 2017 which resulted in a groundwater classification while the wells were producing at 80 gpm. At the increased flow rate there exists real potential for the groundwater to be influenced by the surface water at the flow rates needed by Minturn prompting a change in classification to GWUDI. Additional data at 225 gpm needs to be collected to evaluate whether the wells are GWUDI at the higher production rate. GWUDI water must be treated the same as surface water; if the wells are found to be GWUDI, this alternative is non-viable.

Figure 12. Proximity of Wells #3 and #4 to Cross Creek

Minturn, HDR, and CDPHE had a conference call in June 2023 to discuss the specific requirements of evaluating a well for GWUDI based on their Policy 003. The testing requirements for a GWUDI evaluation are summarized in Table 11. The results from Well #4 will apply to Well #3, as Well #4 is the more conservative well to analyze given it's closer proximity to Cross Creek. The earliest Minturn can proceed with this GWUDI evaluation is April 1^{st}, 2024. The sampling period runs through October 2024. Therefore, Minturn may not have a decision on the groundwater classification at 225gpm until the end of 2024.

Table 11. CDPHE Groundwater Quality Performance Testing Requirements

Parameter	Location	Frequency	Sampling Dates
Temperature, Turbidity and Conductivity	Well #4 and Cross Creek	2 times per 7-day period	April 1^{st} – October 31^{st}
Total Coliform (with E. Coli)	Well #4	1x month	April 1^{st} – October 31^{st}
Total Aerobic Bacterial Spores	Well #4 and Cross Creek	3 times	April 1^{st} – April 30^{th} July 1^{st} - August 31^{st} September 1^{st} – October 31^{st}
Microscopic Particulate Analysis (MPA)	Well #4	3 times	April 1^{st} – April 30^{th} July 1^{st} - August 31^{st} September 1^{st} – October 31^{st}

9 Recommendations & Conclusions

Based on the results of this alternative analysis, it is recommended that Minturn move forward with construction of a new membrane filtration plant. It resulted in the highest qualitative score and is recognized to best address the priorities Minturn has for a providing a resilient and reliable treatment system. While rehabilitation of the slow sand filters ultimately had the lowest cost of the alternatives, the drawbacks of continuing to rely on an aging technology and cutting off the option for the addition of Eagle River water in the future far outweigh the cost savings associated with the option. Membrane filtration allows Minturn to address the needs of its existing customers, while leaving open the option for future development and water rights.

Appendix A – Detailed Cost Estimates

OPINION OF PROBABLE CONSTRUCTION COST
ALTERNATIVE A - SLOW SAND FILTER RECONSTRUCTION

#	Component		Quantity	Unit	Estimated Cost	Total	*Notes*
	Process Mechanical						
	Sand Filter Underdrains	Qty (2) 60x80 Filters	4800	SF	$ 40	$ 192,000	*Perforated Pipe*
	Sand Filter Media & Support Gravel	Qty (2) 60x80 Filters, 4 ft sand, 1 ft gravel +10%	2078	CY	$ 200	$ 415,556	*Red Flint Sand quote @ $150/CY for sand/gravel.*
	Roughing Filters	Building, Self clenaing Strainers	1	LS	$ 250,000	$ 250,000	
	Structural - Sub and Superstructure						
	Cast-in-place filter basin - Slab	12" thick bottom slab	280	CY	$ 500.00	$ 140,000	
	Cast-in-place filter basin - Walls/Spread Footings	7 ft deep spread footing walls, extedned 8 ft above grade	227	CY	$ 800.00	$ 181,867	
	Cast-in-place building foundation - Spread Footings	7 ft deep spread footing walls	131	CY	$ 800.00	$ 104,948	
	Cast-in-place Walkways around Filters	6 ft wide, perimeter access	47	CY	$ 500.00	$ 23,333	
	Metal Truss Roof System	Enclsure req'd to cover filters	10656	SF	$ 150.00	$ 1,598,400	
	Finished Water Metering Vault	Precast Structure	1	LS	$ 45,000.00	$ 45,000	
A	**Unit Processes + Buildings + Demolition = Subtotal 1**					$ 2,951,103.70	
B	Sitework + Soil Conditions				10%	$ 295,110.37	
C	Piping, Valves, Manholes				5%	$ 147,555.19	
D	Mechanical				2%	$ 59,022.07	
E	Electrical				5%	$ 147,555.19	
F	Instrumentation and Controls				3%	$ 88,533.11	
G	**Construction Subtotal 2 = A+B+C+D+E+F**					**$ 3,688,879.63**	
H	Miscellaneous Elements Not Itemized				40%	$ 1,475,551.85	
I	**Construction Subtotal 3 = G + H**					**$ 5,164,431.48**	
J	General Conditions, Mobilization, Demobilization				8%	$ 413,154.52	
K	**Construction Subtotal 4 = I + J**					**$ 5,577,586.00**	
L	General Contractor Overhead + Profit				8%	$ 446,206.88	
M	**Construction Subtotal 5 = K + L**					**$ 6,023,792.88**	
N	Bonds + Insurance				2%	$ 120,475.86	
O	**Construction Total Today = M + N**					**$ 6,144,268.74**	
P	Projection to Midpoint of Construction = 3.5%/year X 3 years				10%	$ 614,426.87	
Q	**Construction Bid Total = O + P**					**$ 6,758,695.61**	
R	Engineering, Legal, Fiscal, Administration				0%	$ -	*Not included in estimate*
S	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST = Q + R					$ 6,758,695.61	
	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST -15%					**$ 5,744,891.27**	
	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST +30%					**$ 8,786,304.29**	

OPINION OF PROBABLE CONSTRUCTION COST ALTERNATIVE B - PACKAGED MEDIA FILTER WTP							
#	**Component**	**Description & Assumptions**	**Quantity**	**Unit**	**Estimated Unit Cost**	**Total**	***Notes***
	Process Mechanical						
	Cross Creek Pump Station	(3) Pumps/Piping/Valves/Inst inc'l Precast Vault	1	LS	$ 75,000	$ 75,000	
	Rapid Mix Tank	(1) 4,000-gal Steel, 5'D x 12'	1	EA	$ 50,000	$ 50,000	
	Rapid Mixer	(1) Radial Mixer	1	EA	$ 20,000	$ 20,000	
	Packaged Treatment Units	(3) Floc/Sed/Media Filters	1	LS	$ 1,987,500	$ 1,987,500	*Tonka Water Quote*
	Filtered Water Pump Station	(5) Submersible Pumps in Cast Vault	1	LS	$ 60,000	$ 60,000	
	Recycle Pump Station	(2) Pumps/Piping/Valves in Filter 3 Inlet Box	1	LS	$ 50,000	$ 50,000	
	Chemical Systems						
	Coagulant Storage and Dosing	1000 gal tank & feed system, (2) Pumps	1	LS	$ 27,000	$ 27,000	
	Caustic Storage and Dosing	Tote storage & feed system, (2) Pumps	1	LS	$ 15,000	$ 15,000	
	Acid Storage and Dosing	Drum/Tote storage & feed system, (2) Pumps	1	LS	$ 15,000	$ 15,000	
	Hypochlorite Storage and Dosing	500 gal tank & feed system, (2) Pumps	1	LS	$ 20,000	$ 20,000	
	Structural - Sub and Superstructure						
	Building foundation - Spread Footings	7 ft deep spread footing walls	108	CY	$ 800.00	$ 86,696	
	Building Slab	100'x90'	222	CY	$ 500.00	$ 111,111	
	Pre-Engineered Metal Building	Building with provision for expansion	9000	SF	$ 250.00	$ 2,250,000	
	Interoir Rooms	CMU Walls w/CIP deck ceiling	5	LS	$ 25,000.00	$ 125,000	
A	**Unit Processes + Buildings + Demolition = Subtotal 1**					$ 4,892,307.41	
B	Sitework + Soil Conditions				15%	$ 733,846.11	
C	Piping, Valves, Manholes				12%	$ 587,076.89	
D	Mechanical				6%	$ 293,538.44	
E	Electrical Including Generator				20%	$ 978,461.48	
F	Instrumentation and Controls				10%	$ 489,230.74	
G	**Construction Subtotal 2 = A+B+C+D+E+F**					**$ 7,974,461.07**	
H	Miscellaneous Elements Not Itemized				40%	$ 3,189,784.43	
I	**Construction Subtotal 3 = G + H**					**$ 11,164,245.50**	
J	General Conditions, Mobilization, Demobilization				10%	$ 1,116,424.55	
K	**Construction Subtotal 4 = I + J**					**$ 12,280,670.05**	
L	General Contractor Overhead + Profit				10%	$ 1,228,067.01	
M	**Construction Subtotal 5 = K + L**					**$ 13,508,737.06**	
N	Bonds + Insurance				2%	$ 270,174.74	
O	**Construction Total Today = M + N**					**$ 13,778,911.80**	
P	Projection to Midpoint of Construction = 3.5%/year X 3 years				10%	$ 1,377,891.18	
Q	**Construction Bid Total = O + P**					**$ 15,156,802.98**	
R	Engineering, Legal, Fiscal, Administration				0%	$ -	*Not included in estimate*
S	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST = Q + R					$ 15,156,802.98	
	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST -15%					**$ 12,883,282.53**	
	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST +30%					**$ 19,703,843.87**	

#	Component	Description & Assumptions	Quantity	Unit	Estimated Unit Cost	Total	Notes
OPINION OF PROBABLE CONSTRUCTION COST ALTERNATIVE C - MEMBRANE WTP							
	Process Mechanical						
	Cross Creek Pump Station	(3) Pumps/Piping/Valves/Inst inc'l Precast Vault	1	LS	$ 75,000.00	$ 75,000.00	
	Membrane Influent EQ Tank	(1) 4,000-gal PE, 7.5'D x 13.5'	1	EA	$ 20,000.00	$ 20,000.00	
	Membrane System	(3) Membrane Skids @ 0.4 mgd ea	1	LS	$ 1,100,000.00	$ 1,100,000.00	*Price from Memcor and Wigen proposal*
	Feed System w/ Pumps and Strainers						
	Instrumentation						
	Backwash/CIP Skid with Pumps and Tank						
	Filtered Water Pump Station	(3) Pumps/Piping/Valves/Inst in Cast Vault	1	LS	$ 60,000.00	$ 60,000.00	
	Recycle Pump Station	(2) Pumps/Piping/Valves in Filter 3 Inlet Box	1	LS	$ 50,000.00	$ 50,000.00	
	Chemical Systems						
	Caustic Storage and Dosing	Drum/tote storage & feed system, (2) Pumps	1	LS	$ 15,000.00	$ 15,000.00	
	Acid Storage and Dosing	Drum/tote storage & feed system, (2) Pumps	1	LS	$ 15,000.00	$ 15,000.00	
	Hypochlorite Storage and Dosing	500 gal tank & feed system, (2) Pumps	1	LS	$ 20,000	$ 20,000	
	Structural - Sub and Superstructure						
	Building foundation - Spread Footings	7 ft deep spread footing walls	108	CY	$ 800.00	$ 86,696	
	Building Slab	100'x90'	222	CY	$ 500.00	$ 111,111	
	Pre-Engineered Metal Building	Building with provision for expansion	9000	SF	$ 250.00	$ 2,250,000	
	Interoir Rooms	CMU Walls w/CIP deck ceiling	5	EA	$ 25,000.00	$ 125,000	
A	**Unit Processes + Buildings + Demolition = Subtotal 1**					$ 3,927,807.41	
B	Sitework + Soil Conditions				12%	$ 471,336.89	
C	Piping, Valves, Manholes				9%	$ 353,502.67	
D	Mechanical				4%	$ 157,112.30	
E	Electrical Including Generator				20%	$ 785,561.48	
F	Instrumentation and Controls				7%	$ 274,946.52	
G	**Construction Subtotal 2 = A+B+C+D+E+F**					**$ 5,970,267.26**	
H	Miscellaneous Elements Not Itemized				40%	$ 2,388,106.90	
I	**Construction Subtotal 3 = G + H**					**$ 8,358,374.16**	
J	General Conditions, Mobilization, Demobilization				10%	$ 835,837.42	
K	**Construction Subtotal 4 = I + J**					**$ 9,194,211.58**	
L	General Contractor Overhead + Profit				10%	$ 919,421.16	
M	**Construction Subtotal 5 = K + L**					**$ 10,113,632.74**	
N	Bonds + Insurance				2%	$ 202,272.65	
O	**Construction Total Today = M + N**					**$ 10,315,905.39**	
P	Projection to Midpoint of Construction = 3.5%/year X 3 years				10%	$ 1,031,590.54	
Q	**Construction Bid Total = O + P**					**$ 11,347,495.93**	
R	Engineering, Legal, Fiscal, Administration				0%	$ -	*Not included in estimate*
S	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST = Q + R					$ 11,347,495.93	
	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST -15%					**$ 9,645,371.54**	
	TOTAL PROJECT OPINION OF PROBABLE CONSTRUCTION COST +30%					**$ 14,751,744.71**	