Analysis and Technical Update to the Colorado Water Plan

Technical Memorandum

Prepared for:

Colorado Water Conservation Board

Subject:

Opportunities and Perspectives on Water Reuse

Date: May 15, 2019

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Table of Contents

Section 1 : Water Reuse Overview 1
Section 2 : Hypothetical Examples of Different Types of Water Reuse 3
Reuse via Exchange 7
Non-Potable Reuse 9
Indirect Potable Reuse 11
Direct Potable Reuse 13
Graywater Reuse 15
Section 3 : Considerations for Future Evaluations & Implementation of Water Reuse Projects 17
Appendix A: Example Mass Balances of Hypothetical Water Reuse Projects 21

List of Figures

Figure 1: Hypothetical Current Conditions System 4
Figure 2: Hypothetical Increased Demands System 5
Figure 3: Qualitative Comparison of Reuse Options 19

List of Tables

Table 1: Recently Implemented Reuse Examples in Colorado 2

As part of the analysis and technical update to the Colorado Water Plan (Technical Update), this technical memorandum (TM) provides an overview of different types of water reuse mechanisms and key considerations for evaluation and potential implementation of future reuse projects in Colorado. The concepts outlined in this TM build upon the ideas and recommendations from Colorado's Water Plan. Key objectives of this TM include:

- Provide guidance on how to define potential municipal reuse projects in future Basin Implementation Plan (BIP) efforts.
- Provide conceptual examples that demonstrate how to perform evaluations that quantify water supply benefits to the implementing entity and both quantify or qualify the impact of a local reuse project on the greater basin and watershed system.

Section 1: Water Reuse Overview

Colorado's Water Plan notes that various forms of water reuse will be an important component of closing future supply-demand gaps for municipalities, and the plan encourages water providers to build on the successes of the many types of reuse projects already implemented in Colorado. The following sections presents an overview of key types of municipal water reuse that may be encountered in Colorado, and further expands on descriptions of reuse provided in Section 6.3.2 of Colorado's Water Plan. Reuse mechanisms summarized in the following sections of this TM include:

- **Reuse via exchange**: Reuse via exchange can be described as when water right decrees stipulate if a water right holder can reuse water after the initial first use or if they are required to return unconsumed water (assumed to be treated wastewater from municipal users) to the watershed. Under the reuse via water exchange method, return flow water that can be legally reused is returned to the river or watershed and a like amount of water can be diverted from the river at a different point upstream (resulting in no water particles physically being reused) as long as the exchange does not adversely impact other water right holders. Reuse via exchange may fall outside the typical definition of "reuse" for water treatment professionals; however, it is appropriate and relevant when considered in the context of meeting a municipal supply and demand imbalance, or "gap".
- **Non-potable reuse:** Under the non-potable reuse method (also termed "reclaimed water"), water that can be legally reused receives additional treatment at the wastewater treatment plant and is then conveyed through a non-potable water distribution system (sometimes referred to as a "purple pipe system") to approved non-potable demands (e.g. commercial landscape areas, parks, golf courses, commercial cooling towers).
- **Indirect potable reuse:** Under the indirect potable reuse method, water leaving a wastewater treatment plant is further treated to potable water standards by an advanced treatment plant before or after being introduced into an environmental buffer water source and prior to delivery for potable consumption. This buffer can be a reservoir, natural stream, or aquifer storage facility to allow blending of the advanced treated water with water in the buffer. The water is either further treated via advanced water treatment, or blended with the other raw water sources and treated at the existing Water Treatment Plant before entering the potable drinking water distribution system.
- **Direct potable reuse:** Under the direct potable reuse method, water leaving a wastewater treatment plant is further treated to potable water standards by an advanced water treatment plant before being introduced directly into a potable water distribution system, where it is blended with other treated drinking water supplies.

- **Graywater reuse:** Graywater reuse has been implemented in other regions but is not currently fully approved in Colorado. Graywater reuse is typically implemented at an individual building or small community level. This type of reuse involves capturing drainage flows from showers, sinks (not including kitchen sinks), and clothes washers, and then sending that water through a localized water treatment and storage system to satisfy a portion of indoor flushing and outdoor irrigation demands. Like reuse via exchange, graywater reuse may not be considered a formal reuse mechanism by some, but it is appropriate to consider in the context of addressing supply/demand gaps.

Legal Eligibility of Reuse Water

In Colorado, water that is reused must first meet certain legal eligibility requirements. Water sources that can be reused typically include:

- **Water That is Not Native to the Basin**: These types of sources, such as some transbasin water and non-tributary groundwater, can be reused because downstream water right holders cannot develop a dependence on return flows or make a legal claim to water that is not native to the basin unless they are the owner of that water.
- **Historically Consumptive Water Which is Changed to Non-Consumptive Use**: Water that was historically consumptively used but has since been transferred to a non-consumptive use can be reused because downstream water right holders have not historically been dependent on any return flows for this water right.
- **Other Legally Decreed Water Sources**: Select other sources of water that have been legally decreed as reusable in Colorado water court.

Municipal Drivers for Exploring Reuse

Municipal water reuse can generally be divided into two typical situations: 1) a municipality begins to reuse water that they have historically had the legal right to reuse but have not historically reused or 2) a municipality acquires new water supplies that are legally reusable and immediately begins to reuse return flows from those supplies. A few recently implemented examples of these two situations in Colorado include:

Table 1: Recently Implemented Reuse Examples in Colorado

Examples of Reuse of Previously Unused Existing Supplies:	Example of Reuse of New Supplies:
• Aurora Water: Prairie Waters Project • Colorado Springs Utilities: Southern Delivery System • Denver Water: Non-Potable Recycled Water System	• Aurora Water: Reuse of the historically consumed portion of acquired agricultural water rights

Thus far in Colorado, implemented large-scale reuse projects have taken the form of non-potable reuse, indirect reuse, or reuse via exchange. No direct potable reuse (DPR) projects have been implemented for municipal use in Colorado to date, although several pilot-scale research installations of DPR have been developed (such as Denver Water’s 1 million-gallon per day DPR demonstration project in the 1980s, and their 2018 PureWater Colorado Demonstration Project). However, the Colorado Department of Health and Environment (CDPHE)—along with support from the Colorado Water Conservation Board (CWCB) and key water providers—has been working to clarify the regulatory environment and enable future DPR projects. Therefore, DPR projects should be considered a viable option when a water provider is contemplating future water reuse alternatives.

Regulatory Considerations

Key regulatory considerations for reuse in Colorado include the following:

- Non-Potable Reuse: CDPHE Regulation 84 currently governs the uses and treatment standards for non-potable reuse water in Colorado
- Indirect-Potable Reuse: Existing Colorado Primary Drinking Water Regulations apply to the Water Treatment Plant prior to reuse water entering the potable water system. It is worth noting that reuse source water is, however, not explicitly regulated.
- Direct Potable Reuse: There are no current federal or state regulations in Colorado that specifically control implementation of direct potable reuse. However, CDPHE—along with support from the CWCB and key water providers—has been working towards developing a framework for regulating direct potable reuse in Colorado, similar to many other states.
- Graywater Reuse: CDPHE Regulation 86 currently governs the uses and treatment standards for graywater reuse water in Colorado.

Section 2: Hypothetical Examples of Different Types of Water Reuse

Different types of water reuse projects have unique effects on the overall water balance within a watershed. This section describes how some reuse projects (mostly non-potable) result in one-time water reuse and others (reuse via exchange or indirect and direct potable reuse) result in opportunities for multiple reuse cycles. Per Action Item #2 in Section 6.3.2 of Colorado's Water Plan, this section also describes how some reuse mechanisms can result in minimal future reductions in flow in the watershed downstream of the reuse project, while others can have a one-to-one reduction in downstream flow. When reductions in downstream flow occur, basin scale water planning should consider that the water supply-demand gap for one region may be reduced while the gap for a downstream region can be increased. The purpose of providing these hypothetical examples is to help illustrate the trade-offs of different reuse strategies and provide guidance on how to quantify the future benefits and potential impacts of different reuse projects.

Note that the hypothetical examples, evaluations, and concepts presented herein are generic examples that are not based on any actual implemented or planned reuse projects in Colorado.

The following sections examine a hypothetical municipality that has a current municipal and industrial (M&I) demand of 100 units of water and a future demand of 150 units of water[1]. The community is located near a river that has 900 existing units of water flowing from upstream.

In this example, the following assumptions are made:

- The municipality is assumed to fill an existing storage facility with existing water rights and release 100 units of water from storage as needed to satisfy current demands.

[1] Hypothetical flow, demand, or supply units of water presented in this TM are assumed to be annual units of water unless otherwise noted

- It is also assumed that 50% of the current M&I demands are attributed to non-consumptive uses (such as toilet, shower, and sink uses) and, therefore, 50 units of water are returned to the river as return flows from the municipality's wastewater treatment plant. This results in a river flow of 900 units of water in the river upstream of the community and 950 units of water downstream of the wastewater treatment plant return flow location. This current conditions system is shown in Figure 1, with conceptual units of flow through the system shown in red text for each major system component.

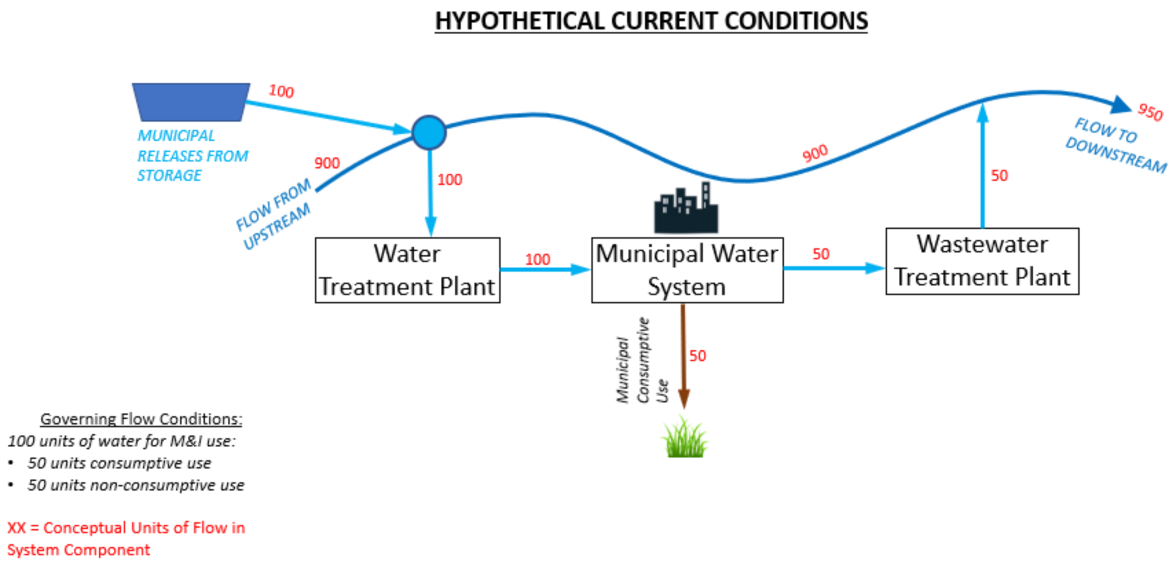

Figure 1: Hypothetical Current Conditions System

Next, it is assumed that the municipality experiences growth and M&I demands increase by 50 units of water. Under a default operational scenario with no reuse implemented, the municipality would be required to obtain 50 additional units of new water supplies to satisfy the increased demands. This scenario is shown below in Figure 2, with 50 additional units of newly acquired water supplies being released from upstream storage to satisfy the increased demands. Note that the upstream flow in the river is assumed to be unchanged from the current condition and, therefore, the new units of water are assumed to be from a transferred water right or non-tributary water right. This assumption is typical in Colorado due to the state's prior appropriation water right system.

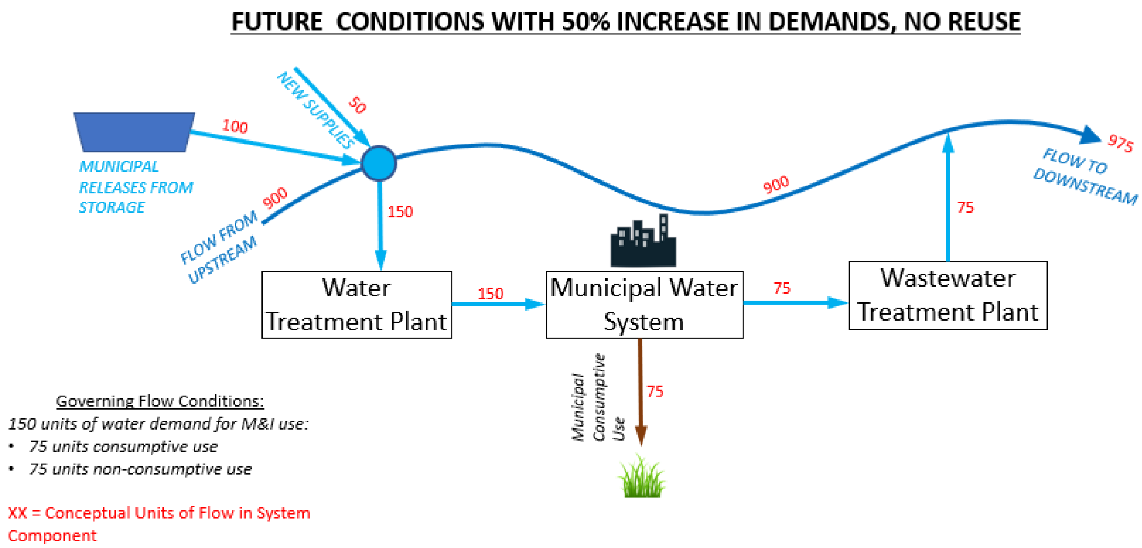

Figure 2: Hypothetical Increased Demands System

Alternatively, instead of acquiring a full 50 units of new water supplies to satisfy increased demands (which may be increasingly difficult or prohibitively expensive for some municipalities in the future), the municipality could implement a form of water reuse to meet all or part of the increased demands and potentially reduce the amount of new supplies that need to be acquired.

Following are several examples of types of reuse projects that could be used to meet the hypothetical increase in demands described above. Evaluation of each type of reuse is presented in fact-sheet style format. These fact-sheets are designed to convey the following major points for each type of reuse:

- A definition and description of how the particular type of reuse functions
- A mass-balance schematic showing how the type of reuse accommodates the hypothetical increased-demands scenario. Schematics are included for two situations:
    - where demands are met by reuse of return flows that have historically not been reused
    - where demands are met via reuse of new supplies
- A brief discussion of potential benefits, tradeoffs, and unintended consequences of the type of reuse
- Key water quality, treatment and regulatory considerations

In each of the below hypothetical mass-balances presented in the fact-sheets, annual conditions are assumed. Appendix A (at the end of this TM) provides a more extensive quantification comparison of each of the reuse mechanisms during annual conditions.

Additionally, a generic qualitative example of how graywater reuse could be considered is provided in fact-sheet format.

It is worth noting that multiple forms of reuse (such as indirect potable, direct potable, and non-potable) can potentially be combined, further altering the overall water balance considerations presented in this TM.

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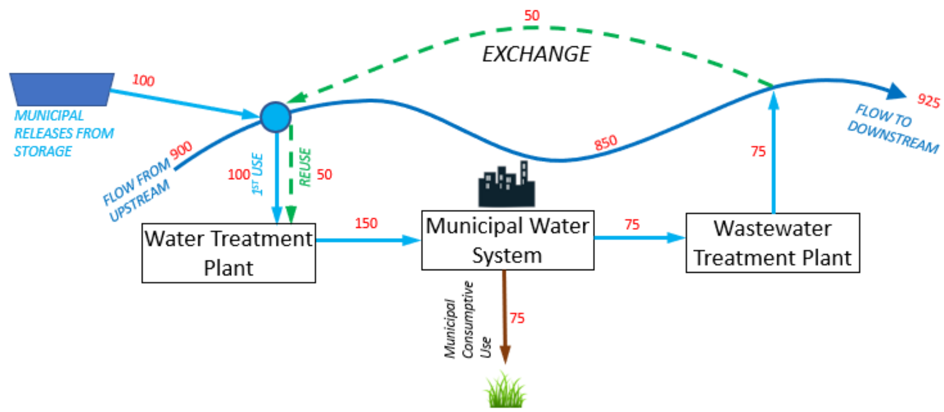
Reuse via Exchange

Reuse via Exchange can be described as when water right decrees stipulate if a water right holder can reuse water after the initial first use or if they are required to return unconsumed water (assumed to be treated wastewater from municipal users) to the watershed. Under the reuse via water exchange method, return flow water that can be legally reused is returned to the river or watershed and a like amount of water can be diverted from the river at a different point upstream (resulting in no water particles physically being reused) as long as the exchange does not adversely impact other water right holders. Reuse via exchange may fall outside the typical definition of “reuse” for water treatment professionals; however, it is appropriate and relevant when considered in the context of meeting a municipal supply and demand imbalance, or “gap”.

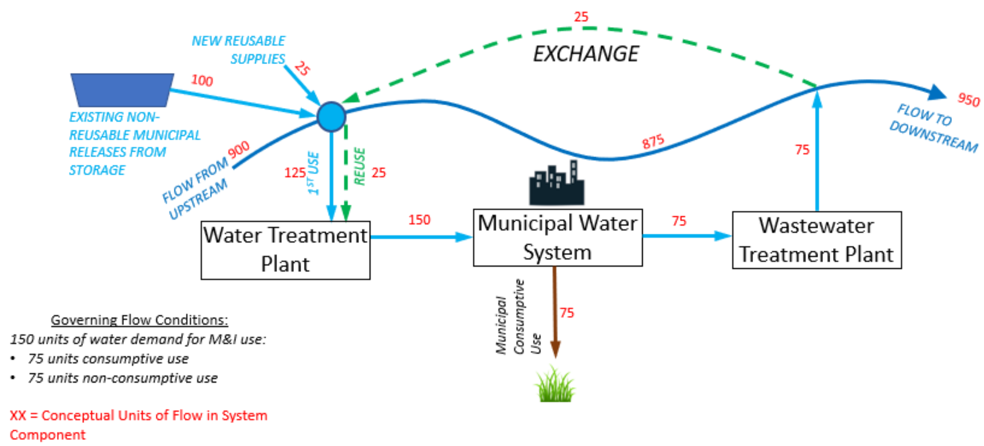
The below example examines a hypothetical municipality that has a current daily municipal and industrial (M&I) demand of 100 units of water and a future demand of 150 units of water. The community is located near a river that has 900 existing units of water flowing from upstream. The green path of water highlights the reuse cycle and the light blue path of water highlights traditional supplies, including new supplies. The brown path of water represents where water leaves the watershed entirely (i.e. consumptive use).

Reuse via Exchange

Reuse of Water Not Historically Reused



Reuse of New Supplies



Note that the hypothetical examples, evaluations, and concepts presented herein are generic examples that are not based on any actual implemented or planned reuse projects in Colorado.

Benefits:

- **Reduced Salt Build-up:** Water particles are not directly and physically reused, creating an open system which avoids a closed loop that can result in elevated salt/Total Dissolved Solids (TDS) concentrations over time.
- **Uses Conventional Treatment**: Requires conventional water and wastewater treatment only.
- **Not Infrastructure Intensive:** Typically does not require conveyance infrastructure.
- **Less Water Diverted:** Although the total amount of consumptive demands are the same in all of the hypothetical water supply scenarios (assuming all demands are met), the amount of new water supplies required to satisfy increased demands for this reuse via exchange example is lower when compared to not implementing any form of reuse.

Tradeoffs:

- **Exchange Potential Needed:** Requires sufficient water in river for exchange to occur without adversely impacting other water right holders.
- **Increased Water Accounting**: Can require more complex water accounting and water rights administration than other reuse alternatives.

Reuse via Exchange

- **Reduced Instream & Downstream Flow**: Results in less river flow through both the instream exchange reach and downstream reach when compared to current conditions.
- **Increased WTP Capacity**: The capacity of the Water Treatment Plant needs to be increased by 50 units of water in order to accommodate exchanged reuse flow.

Unintended Consequences:

- Reuse via exchange methods encourage all return flow to be returned to the watershed. Return flows are often of lower quality and higher salinity than existing flow in the river, resulting in stream water quality degradation. Other reuse methods divert the return flow water and apply it to other water demands that do not require as high of quality water, reducing undesirable constituents returned to the river.

Typical Treatment Required/Water Quality Considerations:

- Conventional wastewater treatment at return flow location.
- Conventional water treatment at diversion location.

Regulatory Considerations:

- Under this reuse scenario, water is not directly reused, and there are no current applicable reuse regulations.

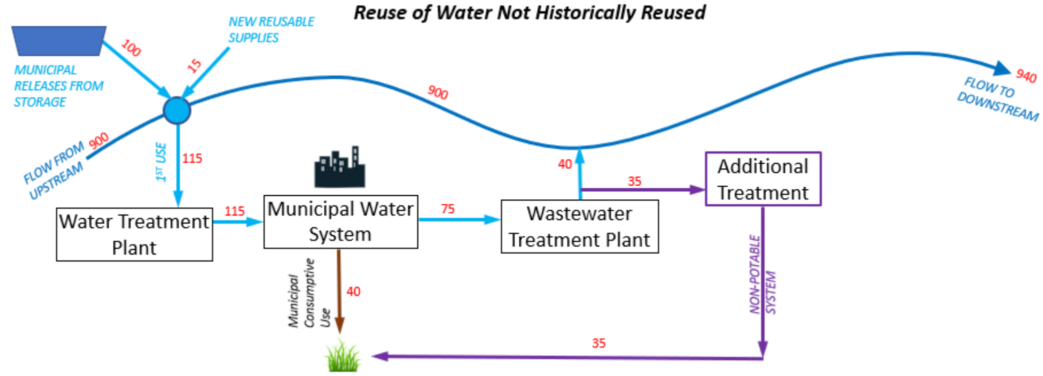
Non-Potable Reuse

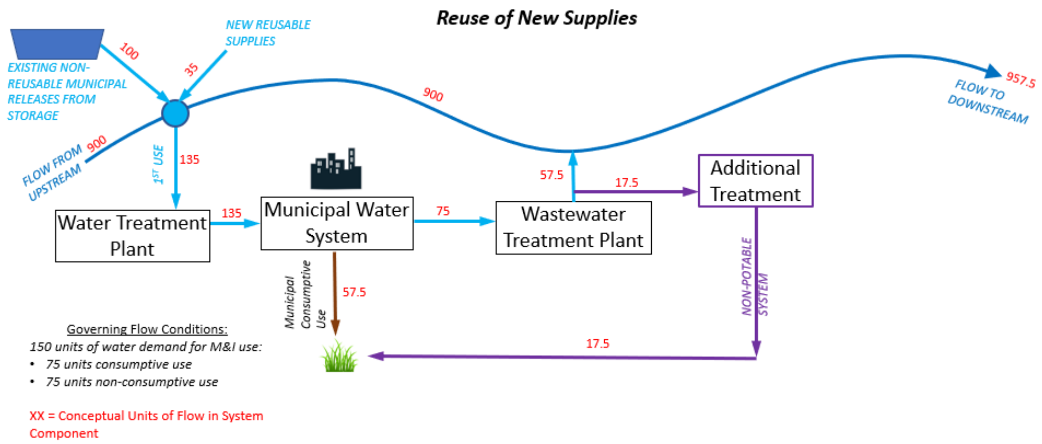
Under Non-Potable Reuse, water right decrees stipulate if a water right holder can reuse water after the initial first use or if they are required to return unconsumed water (assumed to be treated wastewater from municipal users) to the watershed. Under the non-potable reuse method (also termed “reclaimed water”), water that can be legally reused receives additional treatment at the wastewater treatment plant (to CDPHE Water Quality Control Commission Regulation 84 standards) and is then conveyed through a non-potable water distribution system (sometimes referred to as a “purple pipe system”) to approved non-potable demands (e.g. commercial landscape areas, parks, golf courses, commercial cooling towers). Recently passed legislation in 2018 and 2019 allows for non-potable water to be used on edible crops, marijuana cultivation and industrial hemp use, and indoor toilet flushing if the reclaimed water meets specified water quality standards.

The below example examines a hypothetical municipality that has a current daily municipal and industrial (M&I) demand of 100 units of water and a future demand of 150 units of water. The community is located near a river that has 900 existing units of water flowing from upstream. The

Non-Potable Reuse

purple path of water highlights the reuse cycle and the light blue path of water highlights traditional supplies, including new supplies. The brown path of water represents where water leaves the watershed entirely (i.e. consumptive use).





The above schematics show just one potential configuration where non-potable reuse water serves only consumptive uses. Non-potable reuse water could also be used to serve other non-consumptive demands such as industrial or power generation activities.

Note that the hypothetical examples, evaluations, and concepts presented herein are generic examples that are not based on any actual implemented or planned reuse projects in Colorado.

Benefits:

- Less Water Diverted: Although the total amount of consumptive demands (75 units of water) are the same in all of the hypothetical water supply scenarios (assuming all demands are met), the amount of new water supplies required to satisfy increased demands for this non-potable reuse example is lower when compared to not implementing any form of reuse.
- Lower Impacts to Instream Water Quality: In this example, lower quality and higher salinity water is not returned to the watershed because it is consumed by end uses that do not require as high of quality water (such as irrigation and some industrial uses), reducing undesirable constituents returned to the river relative to the existing condition.

Tradeoffs:

- Separate Distribution System: Requires costly parallel pipe distribution system to be operated and maintained by the water provider.

Non-Potable Reuse

- **Seasonal Operation**: Non-potable systems are built to meet demands that typically only exist during the warmest months of the year (~4 months per year), resulting in potentially limited amounts of reused water on an annual basis as compared to other water reuse mechanisms.
- **Reduced Downstream Flow**: Because the total amount of water diverted is reduced, non-potable reuse results in a flow reduction in the downstream river reach when compared to not implementing reuse.

Unintended Consequences:

- Some end users may justify high water use landscaping in lieu of xeric landscaping methods because the landscaping is irrigated with reuse water. This logic can create a false public perception that reuse water is less usable and valuable than other water supplies, which can potentially cause inefficient uses of reuse water and result in unnecessary reductions in downstream river flows.
- End use of water that is often largely consumptive, therefore limiting reuse to one use cycle.

Typical Treatment Required/Water Quality Considerations:

- Reuse water destined for non-potable demands typically requires tertiary wastewater treatment (filtration and disinfection) which is not as expensive as potable reuse options. However, the potable water treatment plant size can be reduced as reuse is meeting a portion of summer/peak season demands.

Regulatory Considerations:

- Regulation 84 governs the uses and treatment standards for non-potable reused water in Colorado.

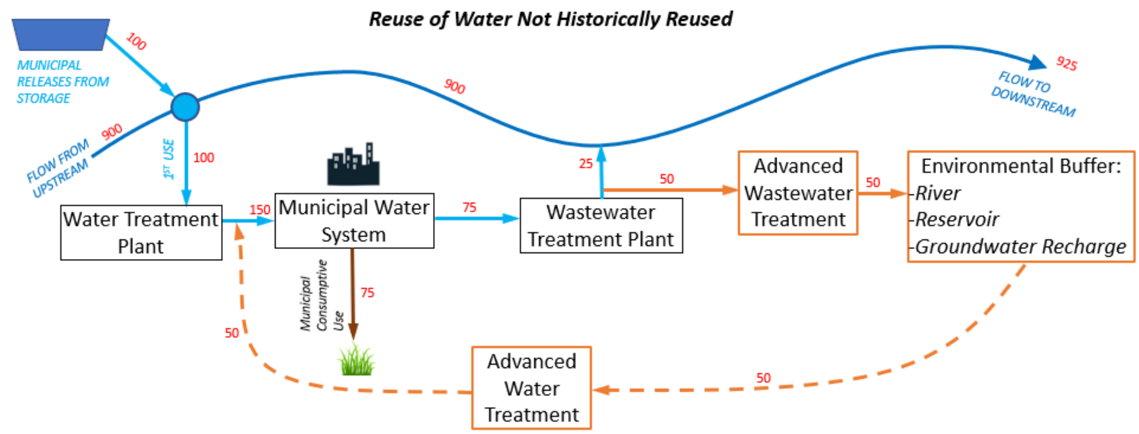
Indirect Potable Reuse

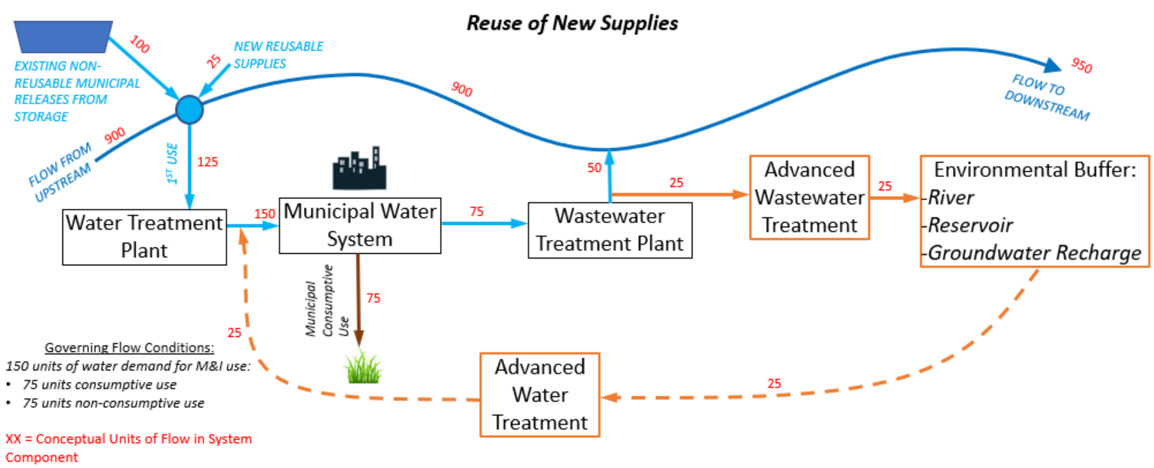
Under Indirect Potable Reuse, water right decrees detail whether a water right holder can reuse water after the initial first use or if they are required to return unconsumed water (assumed to be treated wastewater from municipal users) to the watershed. Under the indirect potable reuse method, water leaving a wastewater treatment plant is further treated to potable water standards by an advanced wastewater treatment plant before or after being introduced into an environmental buffer water source. This buffer can be a reservoir, natural stream, or aquifer storage facility to allow blending. The water can then be further treated via advanced water treatment after leaving the buffer and before entering the potable drinking water distribution system.

The below example examines a hypothetical municipality that has a current daily municipal and industrial (M&I) demand of 100 units of water and a future demand of 150 units of water. The community is located near a river that has 900 existing units of water flowing from upstream. The orange path of water highlights the reuse cycle and the light blue path of water highlights traditional

Indirect Potable Reuse

supplies, including new supplies. The brown path of water represents where water leaves the watershed entirely (i.e. consumptive use).





The above schematics represent just one example configuration of Indirect Potable Reuse. Water leaving the environmental buffer could also be blended with other raw water upstream of the water treatment plant before water treatment and introduction into the potable distribution system.

Note that the hypothetical examples, evaluations, and concepts presented herein are generic examples that are not based on any actual implemented or planned reuse projects in Colorado.

Benefits:

- No Separate Distribution System: When compared with non-potable reuse, indirect potable reuse does not require construction of two separate water distribution systems to enable use of reused water.
- Year-Round Use by All Demands: Unlike non-potable reuse, indirectly reused water can be reused by all demands, which allows year-round operation of the reuse system and multiple reuse cycles.
- Less Water Diverted: Although the total amount of consumptive demands are the same in all of the hypothetical water supply scenarios (assuming all demands are met), the amount of new water supplies required to satisfy increased demands for this indirect-potable reuse example is lower when compared to not implementing any form of reuse.

Indirect Potable Reuse

Tradeoffs:

- **Treatment & Conveyance Systems:** Expensive advanced treatment systems are required to treat reuse water to required water quality standards, and extensive conveyance systems may be required to convey the water to a location where it can be reintroduced to the distribution system.
- **Salt Buildup Over Time:** Because water particles are being directly and physically reused, multiple reuse cycles of water can cause salt/TDS buildup in the reuse system over time.
- **Reduced Downstream Flow**: Indirect potable reuse also results in a flow reduction in the downstream river reach by the amount of reuse water used when compared to the no-reuse conditions.

Unintended Consequences:

- Water stored in a reservoir environmental buffer may require chemical or other treatment to prevent algae growth that negatively impacts water quality. This may become less of a concern as future regulations reduce allowable nutrient levels in wastewater effluent.

Typical Treatment Required/Water Quality Considerations:

- Advanced wastewater treatment processes may be required, and advanced water treatment processes are required for indirect potable reuse.

Regulatory Considerations:

- There is no explicit regulation of indirect potable reuse in Colorado. Discharge to an environmental buffer is regulated by water quality requirements of the receiving water body.
- Existing Colorado Primary Drinking Water Regulations apply to the final delivered potable water from the Water Treatment Plant.

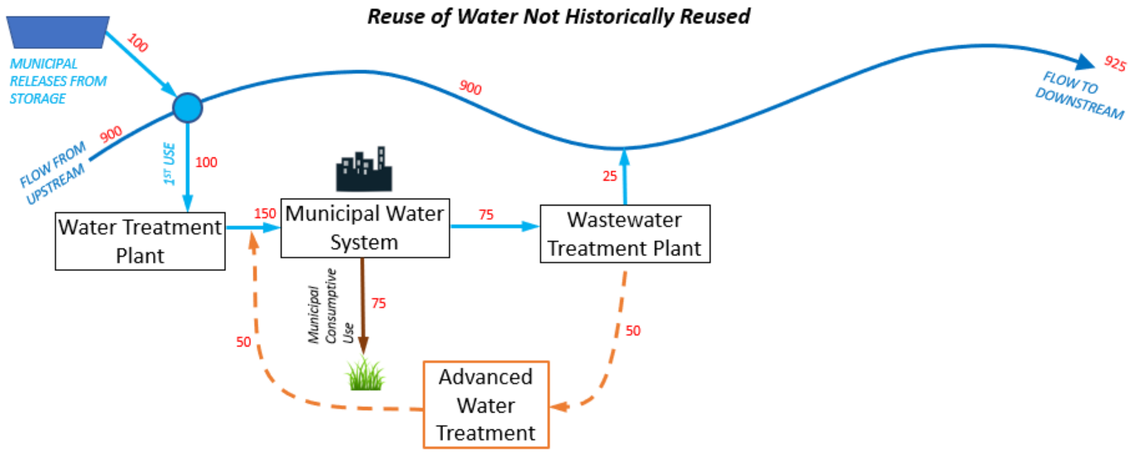
Direct Potable Reuse

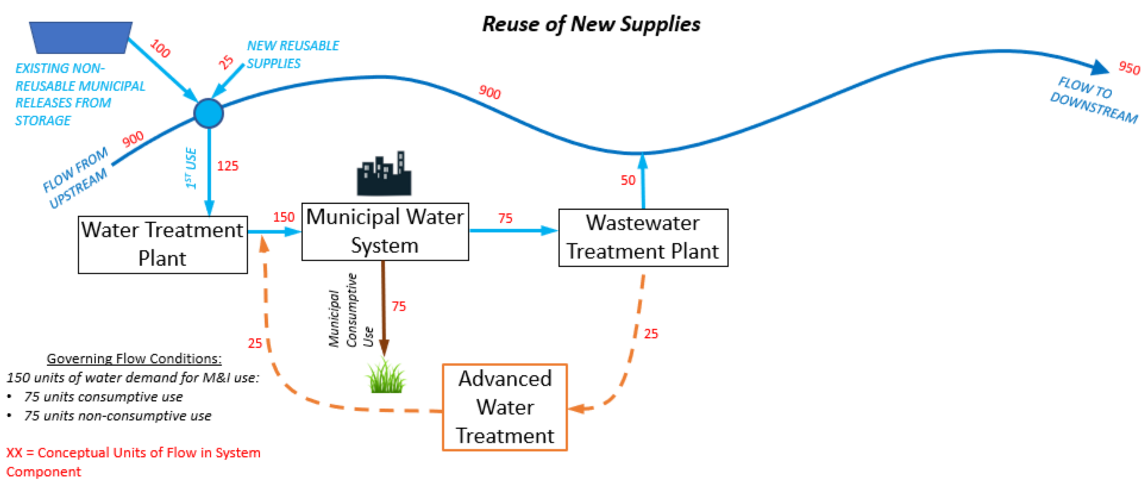
Under Direct Potable Reuse, water right decrees stipulate if a water right holder can reuse water after the initial first use or if they are required to return unconsumed water (assumed to be treated wastewater from municipal users) to the watershed. Under the direct potable reuse method, water leaving a wastewater treatment plant is further treated to potable water standards by an advanced water treatment plant before being introduced directly into a potable water distribution system, where it is blended with other treated drinking water supplies.

The below example examines a hypothetical municipality that has a current daily municipal and industrial (M&I) demand of 100 units of water and a future demand of 150 units of water. The community is located near a river that has 900 existing units of water flowing from upstream. The

Direct Potable Reuse

orange path of water highlights the reuse cycle and the light blue path of water highlights traditional supplies, including new supplies. The brown path of water represents where water leaves the watershed entirely (i.e. consumptive use).





Note: The above schematic represents just one example configuration of direct potable reuse. DPR can discharge water either upstream of the water treatment plant or directly into the distribution system.

Note that the hypothetical examples, evaluations, and concepts presented herein are generic examples that are not based on any actual implemented or planned reuse projects in Colorado.

Benefits:

- No Separate Distribution System: When compared with non-potable reuse, direct potable reuse does not require construction of two separate water distribution systems to enable use of reused water.
- Year-Round Use by All Demands: Unlike non-potable reuse, directly reused water can be reused by all demands, which allows year-round operation of the reuse system and multiple use cycles.
- Less Water Diverted: Although the total amount of consumptive demands are the same in all of the hypothetical water supply scenarios (assuming all demands are met), the amount of new

Direct Potable Reuse

water supplies required to satisfy increased demands for this direct potable reuse example is lower when compared to not implementing any form of reuse.

Tradeoffs:

- **Treatment Systems**: Expensive advanced treatment systems are required to treat reuse water to required water quality standards.
- **Additional Water Quality Monitoring**: Extensive monitoring of water quality is required since there is not a significant buffer between the treatment of wastewater and introduction of the treated water to the potable water system.
- **Public Acceptance**: Public perception issues must be overcome to enable successful long-term implementation.
- **Reduced Downstream Flow**: Direct potable reuse results in a flow reduction in the downstream river reach by the amount of reuse water used, when compared to current conditions.
- **Salt Buildup Over Time**: Because water particles are being directly and physically reused, multiple reuse cycles of water can cause salt/TDS buildup in the reuse system over time.

Unintended Consequences:

- Reverse-osmosis (RO) treatment is not required for direct potable reuse unless salinity buildup becomes a challenge, in which case it may be required to meet water quality objectives. If required, disposal of brine concentrate resulting from RO treatment may be difficult from both a technical and permitting standpoint.

Typical Treatment Required/Water Quality Considerations:

- Advanced treatment for direct potable reuse requires a multi-barrier approach to pathogens and organics. The treatment processes included in direct potable reuse schemes are typically more expensive (both capital and operating) relative to conventional drinking water treatment.
- Some states (such as California) have historically required RO to be one of the treatment processes used in potable reuse applications. Other states (such as Texas) have not mandated the use of RO for potable reuse applications. Initial discussions with CDPHE have indicated Colorado is not likely to require RO as part of Direct Potable Reuse implementation.

Regulatory Considerations:

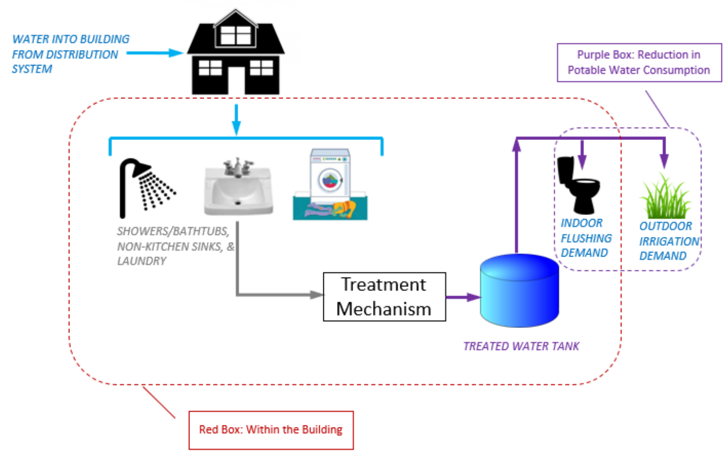
- There are no current federal or state regulations in the United States that specifically control implementation of direct potable reuse. However, CDPHE—along with support from the CWCB and key water providers—has been working towards developing a framework for regulating direct potable reuse in Colorado, similar to many other states. This will address technical and public acceptance barriers and aim towards approval and development of a direct potable reuse project in Colorado.

Graywater Reuse

Graywater Reuse has been implemented in other regions but is not currently fully approved in Colorado. Graywater reuse is typically implemented at an individual building or small community level. This type of reuse involves capturing drainage flows from showers, sinks (not including kitchen sinks), and clothes washers, and then sending that water through a localized water treatment and storage system to satisfy a portion of indoor flushing and outdoor irrigation demands.

Graywater Reuse

GRAYWATER REUSE



Benefits:

- Reduces potable water consumption by meeting some indoor flushing and outdoor irrigation demands.

Tradeoffs:

- High installation, operation, and maintenance costs for end-users.
- Customer perception of water quality.
- Compliance with future regulations.
- Cross connection of non-potable pipes and potable water pipes within the building is an increased risk.
- Requires building/home owners to maintain their own relatively sophisticated water treatment system.

Unintended Consequences:

- Potable backup supply still required if full water service is desired in times when graywater reuse system is not operational.

Typical Treatment Required/Water Quality Considerations:

- Graywater treatment systems typically include tanks that allow solids to settle to the bottom and fats and greases to float to the top. The remaining water then passes through a cartridge type filter. Chemicals that improve the treatment process may or may not be used.

Regulatory Considerations:

- Graywater reuse is not fully approved for use in Colorado as of the date of this TM.
- Regulation 86 (adopted by the Water Quality Control Commission) was developed by CDPHE in 2015 and governs the uses and treatment standards of graywater in Colorado. The regulation requires that counties and cities adopt their own ordinances for local graywater regulation.
- Additionally, a plumbing code governing graywater piping will need to be developed and adopted by the Colorado Plumping Board, although advancement of this action has not yet occurred.

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Section 3: Considerations for Future Evaluations & Implementation of Water Reuse Projects

The mass balance exercises described in the previous section highlight four key metrics that should be considered when evaluating future water reuse projects:

- Annual volume of water reused under the particular reuse mechanism
- Annual volume of new supplies required (water that is not reused and must be sourced from elsewhere to satisfy increased demands, and must be of a suitable reliability to fit within a water provider’s overall water supply portfolio)
- Flow in the river between the diversion location and return flow location
- Flow in the river downstream of the return flow location

Figure 3 provides a qualitative comparison of different reuse options against each of the above four metrics for the reuse mass balances presented previously. A full numerical summary of the mass balance for each compared option can be found in Appendix A.

			Annual Volume of New Supplies [annual units of water]	Flow Between Diversion & Return Points [annual units of water]	Annual Volume of Water Reused [annual units of water]	Downstream Flow [annual units of water]
		Current Conditions	0	900	0	950
Future Conditions	**No reuse**	Meet New Demands With New Supplies and **Without Reuse**	--	=	=	++
	Assumes Existing Supplies are Reused	Meet New Demands With Reuse of **Historically Unused Return Flows via. Exchange**	=	--	++	--
		Meet New Demands With **Non-Potable Reuse of Historically Unused Return Flows**	-	=	+	-
		Meet New Demands With **Indirect-Potable Reuse of Historically Unused Return Flows**	=	=	++	--
		Meet New Demands With **Direct-Potable Reuse of Historically Unused Return Flows**	=	=	++	--
	Assumes New Supplies are Reused	Meet New Demands With New Supplies and **Exchange Reuse of New Supplies**	-	-	+	=
		Meet New Demands With New Supplies and **Non-Potable Reuse of New Supplies**	-	=	+	+
		Meet New Demands With New Supplies and **Indirect Potable Reuse of New Supplies**	-	=	+	=
		Meet New Demands With New Supplies and **Direct Potable Reuse of New Supplies**	-	=	+	=

indicates most favorable when compared to current conditions
indicates more favorable when compared to current conditions
indicates no change from current conditions
indicates less favorable when compared to current conditions
indicates least favorable when compared to current conditions

Figure 3: Qualitative Comparison of Reuse Options

Key Takeaways

Figure 3 confirms many commonly known benefits and considerations of water reuse projects, including the following:

Reuse of Existing Reusable Return Flows: If a municipality can reuse existing return flows, the amount of new supplies needed to meet future demands can be reduced. Implementing indirect, direct, or reuse via exchange methods have the largest opportunity to reduce the need for new supplies due to the ability to reuse water year-round. It is important to note that when a municipality begins to reuse return flows that have not historically been reused, this can result in a flow reduction to downstream users. Coordination between the water provider and downstream water users could help those users plan for this reduction in downstream water availability.

Reuse of New Supplies: If a municipality cannot reuse existing return flows, reuse of future, new legally reusable supplies will reduce the amount of future new supplies needed. If a municipality reuses the new supplies using indirect, direct, or reuse by exchange methods, these types of reuse can be used year-round, maximizing the benefit of reuse to the municipality and minimizing the amount of new supplies needed.

Appendix A: Example Mass Balances of Hypothetical Water Reuse Projects

		Example System, Annual Conditions							
		M&I Demands [annual units of water]	**Release from Existing Storage** [annual units of water]	**New Supplies Required** [annual units of water]	**Annual Volume Reused** [annual units of water]	**Upstream River Flow** [annual units of water]	**Flow Between Diversion & Return Points** [annual units of water]	**Downstream River Flow** [annual units of water]	**Comment**
	Current Conditions	100	100		-	900	900	950	-
	Meet New Demands With New Supplies and Without Reuse	150	100	50	-	900	900	975	-
Future Conditions, Assuming Existing Supplies are Reusable	**Meet New Demands With Reuse of Historically Unused Return Flows via. Exchange**	150	100	0	50	900	850	925	Reuse via exchange meets year-round demands without the need for new water supplies, but results in less river flow through both the instream exchange reach and downstream reach when compared to current conditions
Future Conditions, Assuming Existing Supplies are Reusable	**Meet New Demands With Non-Potable Reuse of Historically Unused Return Flows**	150	115	15	35	900	900	940	Non-potable reuse largley meets summer consumptive use demands, resulting in lower new supplies needed when compared to meeting new demands solely with new supplies. The amount of demand met by reuse water on an annual basis is lower than other options due to the seasonality of non-potable demands.
Future Conditions, Assuming Existing Supplies are Reusable	**Meet New Demands With Indirect-Potable Reuse of Historically Unused Return Flows**	150	100	0	50	900	900	925	Indirect potable reuse reduces the need for new supplies needed when compared to meeting new demands solely with new supplies, is not dependent on an exchange river reach, and indirect potable reuse water can be used to meet year-round demands. Indirect potable reuse also results in a flow reduction in downstream reach by the amount of reuse water used, when compared to current conditions.
Future Conditions, Assuming Existing Supplies are Reusable	**Meet New Demands With Direct-Potable Reuse of Historically Unused Return Flows**	150	100	0	50	900	900	925	Same impacts to hydrologic system as indirect potable reuse, minus the use of an environmental buffer. This option could require treatment processes that produce waste streams that require extra consideration.
Future Conditions, Assuming Existing Supplies are not Reusable	Meet New Demands With **New Supplies** and **Exchange** Reuse of New Supplies	150	100	25	25	900	875	950	This option assumes that historical return flows are not reusable, but new supplies obtained to meet increased demands are fully reusable
Future Conditions, Assuming Existing Supplies are not Reusable	Meet New Demands With **New Supplies** and **Non-Potable Reuse** of New Supplies	150	100	35	17.5	900	900	957.5	This option assumes that historical return flows are not reusable, but new supplies obtained to meet increased demands are fully reusable. New suppies are required to meet summmer consumptive demands
Future Conditions, Assuming Existing Supplies are not Reusable	Meet New Demands With **New Supplie**s and **Indirect Potable Reuse** of New Supplies	150	100	25	25	900	900	950	This option assumes that historical return flows are not reusable, but new supplies obtained to meet increased demands are fully reusable
Future Conditions, Assuming Existing Supplies are not Reusable	Meet New Demands With **New Supplies** and **Direct Potable Reuse** of New Supplies	150	100	25	25	900	900	950	This option assumes that historical return flows are not reusable, but new supplies obtained to meet increased demands are fully reusable

Notes:

- When M&I demands are held constant, various types of reuse can result in varying reductions in reservoir releases to meet the M&I demand. The water left in storage can be used to meet demands during drought conditions, or future demands.

- Under all scenarios, the amount of water not released from storage due to reuse results in a like amount of downstream flow reductions.