WATER SUPPLY REPORT SERIES III
ENHANCED CONSERVATION AND MANAGEMENT
IN THE MONTANA CLARK FORK RIVER BASIN

PREPARED FOR:

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Chapter 1. Introduction

Drought and water scarcity is a common challenge facing water users in Western Montana. Montana is state which can be both water rich and water limited in any given year. Water is often limited in our streams during summer and fall when rain is sparse and winter snow is depleted in the mountains. Montana's climate also deals reoccurring precipitation and soil moisture droughts ranging in time from a single season to many years in duration. In the past, water users have adapted to the cycles of drought and water availability by building reservoirs, drilling wells to tap groundwater, and organizing locally to find ways to make the limited water supply go further. The prior appropriation water right doctrine, first in right, first in time, has also helped with the orderly allocation of our limited water supply. Recently there is increased interest in finding ways to make our water supply go farther still and meet the new needs of population growth and an increased focus on water needs for fish and aquatic health. There is also a great interest in whether new technologies, efficient irrigation systems, weather and soil monitoring, and other recent advances can help to stretch water supplies further to meet additional needs.

This report looks at opportunities for enhanced water conservation and management with a focus on opportunities for the Clark Fork Basin of Western Montana. These are discussed in the following chapters:

> **Chapter 2.** Looks at methods that have been used for water conservation and drought management planning, including collaborative drought planning, local ordinances, economic incentives, and subsidies to encourage water conservation, and looks at how Montana's water right laws allocate water during water shortages.
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> **Chapter 3.** Describes several water conservation and drought planning success stories in Montana, how they were developed, and lessons learned.
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> **Chapter 4.** Provides summaries of water conservation alternatives for irrigation, municipal, domestic, and stock water uses.
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> **Chapter 5.** Provides information sources, reports, and internet websites for drought management and water conservation planning. This includes guidance for forming a drought committee, developing, and implementing a water conservation plan.
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> **Chapter 6.** Discusses the value of future drought and water management planning in the Clark Fork Basin with the hope that water users in Western Montana will organize to discuss their varying interests and perspectives and work together to form agreements for shared water use and enhanced conservation.

Chapter 2. Methods for establishing water conservation and drought plans

Many different paths have been taken by people to develop water conservation and drought plans. A primary difference being whether it is a voluntary effort or if it is required by law. Voluntary efforts typically are collaborative where diverse stakeholders come together to develop plans that require shared sacrifice but also provide benefits to all involved. Collaborative efforts may also be required where laws require a drought plan or where collaboration is identified as a solution to legal conflict. Local government ordinances which restrict water use or require water efficiency are another form of required water conservation planning. Economic subsidies are yet another method designed to encourage voluntary water conservation. The processes establishing these planning efforts are described further below.

2.1 Collaborative conservation and drought planning

There are many collaborative water conservation / drought management plans in place and working in Montana. The Blackfoot River, for example, has a structured drought management plan that water rights holders voluntarily agreed to implement when the river reaches specific conditions during periods of low flow. A structure plan typical includes a written document which outlines responsibilities and actions which is adopted by participating water users and stakeholders.

Irrigators on smaller creeks and rivers in Montana have a history of getting together and developing informal sharing agreements where diversions are rotated from one user to the next. Water users on the Ruby River an unstructured or “hand-shake” agreement to share water during periods of low flow (Gilman 2014). On rivers such as the Ruby, there is not enough water for all of these users to irrigate simultaneously, but by coordinating their timing everyone can get water. These informal agreements may be effective for many years, but as new people move into a community if they do not know how to or refuse to participate then the agreement has the potential to break down and water right priority date becomes the default way to ration water. Informal agreements like this continue to work in places, especially where neighbors know neighbors and are a relatively easy and inexpensive solution to water planning.

Collaboration typically starts with forming a stakeholder group, often called a watershed group or drought committee. Typically these groups consist of landowners, irrigators, outfitters, business and industry representatives, municipalities or water system operators, government agencies, and conservation organizations. In the early stages of plan development the members will voice their perspectives on the impacts of drought or water scarcity and what outcomes they wish to see; and the group will set objectives for the process. Next the group will assess different strategies and actions which can meet the objectives; typical water conservation alternatives are described in chapter 4 of this report. Conditions which trigger response actions are selected such as a low streamflow or high water temperature measurement. If a formal structured plan is an objective then a written water conservation or drought plan is then drafted detailing responsibilities, action triggers, and response actions. Typically the plan is then adopted and publicized and public education on drought conditions and drought response actions begins. Significantly more detail on the planning process is given in the web links and references identified in chapter 5 of this report

Collaboration brings stakeholders together to explain their interests and develop a cooperative approach to mitigating and responding to water scarcity. Communication among stakeholders allows a group to expand the options available to respond to water scarcity, better understand diverse perspectives, while protecting individuals’ livelihood. One of the most important outcomes of collaborative agreements is the feeling of shared sacrifice that comes with understanding the efforts and sacrifices of other stakeholders, as well as having a shared vision of success to work towards.

Photo: People in the rural watersheds of Montana have a tradition of collaborating on water conservation such as rotating diversions so that more water uses are satisfied.

2.2 Local government ordinance

Municipal water providers that provide public drinking water may be impacted during periods of drought or competing water uses and have a need to reduce water use. Municipalities may also be participants in collaborative efforts to develop water conservation and drought plans and need to adopt ordinances to implement those plans. Typical local ordinances limit when landowners can irrigate lawns, outlaw wasteful use of water, or in more severe drought stop non-essential use of water. Local watering restriction ordinances are currently used in the Clark Fork Basin. The city of Butte, for example, receives some of its drinking water supply from the Big Hole River and has watering restrictions for lawn irrigation when the river is at very low flows or there are significant competing uses for their water supply. In addition to saving water for other uses, including natural resource benefits of instream flow, municipal water conservation can lower costs due to reduced pumping, reduced volume of water treatment, and reduced volume of sewage treatment. Alternatives for municipal water conservation ordinances are described in detail in chapter 4 of this report. Additional sources of information on local water conservation ordinances are provided in section 5 of this report.

2.3 Calling junior water rights (first in time first in right)

In the Montana Water Use Act (Title 85, Chapter 2, MCA), prior appropriation, “first in time, first in right” determines the priority of all water use from stock drinking directly from a stream to municipal and large scale irrigation diversions. A “call” is a request by a senior appropriator for water which the person is entitled to requesting users with junior decrees to cease or diminish their diversions and pass the requested amount of water to the downstream senior water right holder making the call. A call can be made by contacting junior users upstream from the senior's point of diversion to notify them that a call is being made or if a water commissioner has been appointed by contacting the commissioner. The water right priority system is the default method used to allocate water during water shortage and is the enforceable method for managing water.

The Musselshell River in Central Montana is as an example where water calls are a common mechanism senior users must use to control and order use of limited water resources. The Musselshell River Distribution Project, through the Lower Musselshell Conservation District, administers decreed water on over 200 miles of the river and provides an organized framework for water users to make calls for water and understand current river flow. The decree enforcement in the Musselshell began when holders of 15% of the water rights affected by the Montana Water Court Temporary Preliminary Water Decrees petitioned the district court to enforce the decree and hire water commissioners.

Enforcing water right priority can be difficult for water users. When junior water users do not respond to a call it may be economically difficult to impossible for the senior user to pay for legal costs. Individual legal costs may be less when a number of water users join together to petition a district court to enforce water right priority. DNRC can also petition a district court to enforce the distribution of water among appropriators, and may direct the attorney general or a county attorney to bring a suit to enjoin the unlawful use. The State attorney general or a county attorney may bring an action on their own initiative. DNRC has guidance for individuals needing to enforce their water rights in the document Water Right Dispute Options (http://dnrc.mt.gov/divisions/water/water-rights/docs/forms/609-ins.pdf).

Another limitation of the prior appropriation doctrine is it may be ineffective for senior surface water users to make calls against junior users who pump from wells. Given the lag time between pumping a well and the depletions which are caused to surface water, discontinuing use of a well when a water shortage actually happens will not immediately benefit the water source. The proliferation of wells which are exempt from permitting in recent decades has created a formidable challenge for senior surface water right holders to protect their water, and therefore there agriculture operations (Thigpen 2011). For instance in areas of the state where agricultural lands have been converted to residential subdivisions there may be hundreds of exempt wells, placing a significant burden on senior irrigators to enforce water right priority against these junior users who need water for day-to-day use.

In practice, the prior appropriation system is most effective at the orderly distribution of available water, until it is all allocated. A shortcoming of prior appropriation as far as conservation goes is that it does not have to include or incentivize water conservation, or efforts to rotate or schedule water use so as to maximize benefits to as many uses as possible. Collaborative efforts as discussed in chapter 2.1 are likely to be more successful at bringing about benefits to more stakeholders.

2.4 Economic incentives and subsidies

Economic subsidies come in many forms, but in Montana are often related to funding improving irrigation efficiency. Alternatives for irrigation efficiency improvement are described in chapter 4.1 of this report. Irrigation efficiency improvements can in certain locations help with water conservation when the saved water is not used to increase crop production. Subsidies for irrigation efficiency projects are typically paid by U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), Montana Department of Natural Resources and Conservation (DNRC), and in certain instances by conservation organizations who are looking to improve instream flow for fish and aquatic life. Municipalities have had success using rebates, a form of economic subsidy, to encourage the use of water efficient plumbing fixtures and appliances.

Economic incentives have also been used in the U.S. by water providers and ditch companies to reduce use by their customers. Tiered pricing schemes have been successful in incentivizing customers to conserve water and invest in more water efficient technologies. In a tiered pricing structure, users are charged higher rates for larger quantities of water consumed. Tiered pricing has been effectively used by irrigation districts and municipal water providers. In Montana, City of Billings uses a tiered pricing structure to discourage water waste. Tiered pricing has seen more widespread use in California and the Southwest for reducing demand during drought.

Use of a tiered pricing structure by municipal providers allows basic needs, such as in-house use, to be satisfied economically while providing the greatest incentive for conservation for larger users, who can better afford investments in conservation. Water providers may also provide rebates for those customers who upgrade older to newer more efficient technology, such as low-flush toilets and modern washing machines, or conversion to water efficient landscaping. The question of whether or not a water provider will offer incentives for conservation likely comes down to economics. Providers are more likely to pay for conservation incentives if the system is near or over capacity at peak demand; whereas conservation measures at all times may actually lower individual water bills and system revenue.

Chapter 3. Review of active water conservation in Montana

Montana has a history of drought and water conservation planning; there are both municipal ordinances which restrict water use during drought and there are several active collaborative drought plans in the western part of the state. The drought plans are all agreements between irrigators and conservation and angling interests which through cooperation among stakeholders help to limit dewatering and running rivers dry during the irrigation season. The three formal drought management plans are summarized in table 1.

Both these three formal drought management plans as well as active municipal water conservation ordinances are described individually in the sections below. Although they are called drought management plans, many of the following are actually water conservation and allocation plans, meaning the actions included in the plans don’t require a declaration of drought conditions to exist. These plans often deal with water management under climate and streamflow conditions which are typical of a Montana summer outside of drought; although the plans are especially useful in coordinating water use during drought.

Table 1. Montana drought management plans

	Blackfoot	Big Hole	Jefferson
Type	Collaborative, voluntary except for angling closure	Collaborative, voluntary except for angling closure	Collaborative, voluntary except for angling closure
Objective	Protect fisheries and provide equitable distribution of water during critical low flow	Protect fisheries during critical low flow	Protect aquatic resources and provide equitable distribution of water during critical low flow
Drought impacts of concern	Low streamflow or high water temperature effects on fish	Low streamflow or high water temperature effects on fish	Low streamflow or high water temperature effects on fish
Area	Entire watershed to confluence with Clark Fork River	Entire watershed to confluence with Jefferson River	Portion of watershed with most significant flow issues and where agricultural diversions are greatest
Action trigger	Low flow or high temperature thresholds in Blackfoot River	Low flow or high temperature thresholds in Big Hole River	Low flow thresholds in Jefferson River, high temperature for angling restrictions
Actions	Irrigation diversion rotation, reducing overall use, reducing instantaneous use, stopping diversion of surface water. Angling restrictions.	Reduce irrigation, municipal, stock diversions of surface water. Encourage use of wells for stock. Angling restrictions.	Voluntary reduction of irrigation and municipal water use and evaluation by FWP of the need for angling restrictions
Planning committee	Landowners, irrigators, outfitters, government, conservation organizations	Landowners, irrigators, municipalities, outfitters, government, conservation organizations	Agriculture, conservation, business, recreation, community interests, government, and nonprofit organizations.
Coordinating entity	NGO - Blackfoot Challenge	NGO - Big Hole Watershed Committee	NGO - Jefferson River Watershed Council

3.1 Blackfoot Drought Planning

The plan is based on the concept of shared sacrifice of all water users during critical low flow in the river including agricultural, irrigators, outfitters, anglers, recreational users, government agencies, homeowners associations, businesses, conservation groups, and others. The Blackfoot plan offers a collaborative alternative to traditional drought response such as angling restrictions and making calls on irrigators with junior water rights. Activities under the plan are undertaken by the Blackfoot Drought

Committee which includes landowners, irrigators, outfitters, government, and conservation organizations. Coordination is provided by the Blackfoot Challenge a local grassroots non-governmental organization (NGO).

The trigger for actions under the plan include river flow and temperature, as well as considering time of year, water demand, climatic conditions, weather projections and resource conditions. Montana FWP holds a Murphy instream flow water right on the Blackfoot River, with a priority date of January 6, 1971. Irrigators who are junior to the Murphy Right are subject to a call by FWP if they do not participate in the Blackfoot Drought Plan and this is one motivating factor in their participation. A secondary objective under the plan is to organize irrigators who are junior to the FWP Murphy Right and assure that water conservation actions taken by one irrigator do not end up in another's diversion downstream.

The Blackfoot Drought Committee developed individual action plans for each water user who voluntarily participates which identify what water conservation actions the individual will take and how much water will be saved. The amount of water saved is important to know because it can be added up so that the total benefit to the river is known. Actions to reduce water use include irrigation diversion rotation, reducing overall use, reducing instantaneous use, and stopping diversion. Irrigation reductions are not limited to agriculture but include businesses and homeowners with larger irrigation use. Irritation diversion rotation helps to supply each individual's water while avoiding simultaneous diversion which would dewater the river. Water right holders junior and senior to the Murphy Right are asked to voluntarily reduce water consumption when flows reach a low flow threshold in the Blackfoot River; however the biggest incentive is for junior water users who would otherwise be subject to a call by FWP to stop use. Fishing outfitters and anglers are asked to limit fishing hours and/or alter angling techniques when high water temperatures exceed thresholds. Specifics of the plan and lessons learned are described in more detail in a UM Master's Thesis by Molly Smith (2012).

The success of this planning effort owes a large part to its voluntary approach. Irrigators chose to make changes and have the gratification that comes with adding to the collaborative protection of the river.

Photo: Drough planning on the Blackfoot River has been effective in minimizing the impacts to irrigators who are junior to FWP's instream flow water right.

3.2 Big Hole Drought Planning

This is a collaborative water management plan where water users voluntarily coordinate or reduce water use during critical low flow in the river in order to protect fisheries, with focus on the arctic grayling. A primary objective of the effort is to provide local actions which will keep the artic grayling from be listed under the Endangered Species Act and associated implications of such a listing. The agreement includes agricultural irrigators, municipalities, business, anglers, government, and conservation organizations. Collaboration and development of the plan was led by a trained facilitator. Coordination of the plan is undertaken by the Big Hole Watershed Committee a local consensus-driven, multi-stakeholder non-governmental organization (NGO). Actions under the plan are initiated by Big Hole Watershed Committee, FWP, DNRC, and US FWS the federal agency responsible for overseeing endangered species protection.

The trigger for actions under the plan include river flow and temperature. Water users are asked to voluntarily reduce water consumption when flows reach low flow thresholds in the Big Hole River. The action plan is phased according to how low flows are or how high temperature is. Under less severe conditions, actions include contacting water users, outfitting businesses, and issuing news releases to inform the public. If conditions worsen actions include voluntary reduction of irrigation, stock water diversions, municipal water use, angling, and encouraging the use of stock watering wells over surface water diversion for stock. During extreme low flow FWP will close the river according to the FWP statewide Drought Fishing Closure Policy. In addition to the outreach regarding current conditions the Committee is required to provide public education regarding agricultural, municipal, and industrial water conservation measures and the provisions and benefits of a drought management plan. Specifics of the plan and lessons learned are described in more detail in a UM Master's Thesis by Molly Smith (2012).

US Fish & Wildlife Service has made formal decisions not to list the artic grayling as an endangered species in part because they found local conservation efforts are sufficient to protect grayling. The plan has also been noted for its success in bringing together and developing lasting relationships between people with diverse interests who formerly adversaries (Smith 2012).

Photo: Drought planning in the Big Hole has helped to keep the fluvial artic grayling from being listed for Endangered Species Act protection.

3.3 Jefferson Drought Planning

The drought management plan was developed by the Jefferson River Watershed Council and is a voluntary effort involving local interests including agriculture, conservation groups, anglers, municipalities, businesses, and government agencies. The Council developed a draft plan and then solicited comment from others. Coordination of the plan is undertaken by the Jefferson River Watershed Council a cooperative and consensus based stakeholder group and non-governmental organization (NGO).

The trigger for actions under the plan include river flow and temperature. The flow triggers were chosen to prevent complete dewatering of the river and provide enough flow to allow fish passage over shallow riffle areas to reduce fish stranding loss. The action plan is phased according to how low flow is, with a separate water temperature trigger. Under less severe low-flow a press release is made to alert water users and anglers of declining flow conditions and requests voluntary water conservation measures and angler awareness. As flows further drop actions include voluntary reduction of irrigation and municipal water use and evaluation by FWP of the need for angling restrictions.

The Council is also tasked to educate and inform affected parties about the plan, and to identify opportunities and funding sources to resolve resource issues.

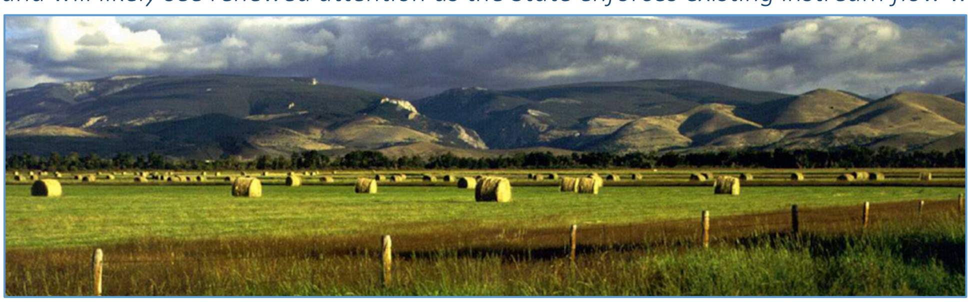
3.4 Upper Clark Fork Drought Planning

A drought management plan has been contemplated for the Upper Clark Fork Basin for many years. The basin is water limited, streamflow is insufficient to support all existing water right claims, and reaches of the Clark Fork River and tributaries are chronically dewatered during summer. The Upper Clark Fork is also legislatively closed to new surface water use and this “basin closure” restricts new uses of water in the basin.

The Upper Clark Fork River Basin Steering Committee was created in 1991 by an act of the Montana State Legislature with the intention of bringing together water users and other stakeholders in the Upper Clark Fork to investigate water resource issues, make changes to the basin closure as needed, identify water management issues and potential solutions, and provide coordination with other basin management and planning efforts. The Steering Committee has indicated the need for a drought plan for the Upper Clark Fork, but so far drought planning efforts have not gained momentum.

The hydropower water right for former the Milltown Dam may provide the necessary motivation for drought planning in the near future. The Milltown water right was transferred to the State of Montana Department of Justice when the former dam owner, NorthWestern Energy, gave up ownership of the facility and agreed to removal of the dam. The water right has a December 11, 1904 priority date and junior surface water appropriators upstream on the Blackfoot and Upper Clark Fork may be called to reduce water use to fulfill this water right. When the Confederated Salish and Kootenai Tribe Compact is ratified by U.S. Congress and the Tribes, the water right will be co-owned by the Tribe and the nature of the Milltown water right will be altered as specified in the Compact. One of these changes is the Compact provides a ten-year delay on enforcing the water right on irrigators with junior water rights (DNRC 2015). This provides an opportunity for irrigators to enter into a collaborative drought plan agreement which would provide incentives for conservation measures and may provide protections for participating irrigators from a call. The specifics of a potential agreement are not known at this time.

Photo: Water conservation and drought planning in the Upper Clark Fork has been discussed for decades and will likely see renewed attention as the State enforces existing instream flow water rights.



3.5 Butte Municipal watering restrictions

Butte-Silver Bow municipal code (13.20.445 - Sprinkling restrictions) allows the Water Department to invoke watering restrictions during summer. Watering restrictions are as-needed with the council of commissioners authorized to choose when watering restrictions begin and end, typically dependent on the weather. During restrictions, properties with odd numbered addresses can water on odd-numbered days of the month, and properties with even numbers should water on even-numbered days of the month. Irrigation is prohibited from 10:00 a.m. to 6:00 p.m. to avoid excessive evaporation during the heat of the day. Municipal code allows for fines of $150 and disconnection of water service.

3.6 Bozeman Municipal Water Conservation Incentive Program

The City of Bozeman offers rebates of up to $250 for installation of WaterSense® labeled high-efficiency toilets, and is offering a short-term $150 rebate on clothes washers which meet Consortium for Energy Efficiency Tier 3, the most water and energy efficient washers made. Bozeman's rebate program is part of a larger water conservation program with the goal of saving water for future needs, saving money, preserving the environment, and delaying or eliminating the need for costly new sources of water and water system infrastructure upgrades.

Chapter 4. Water Conservation Alternatives

Water conservation includes the policies, strategies and actions taken to manage water as a sustainable resource and provide for the current and future human demands and the environment. Water conservation and drought planning in Montana is most often associated with watersheds where water shortages have motivated efforts to balance agricultural water use, instream flow for fisheries, and recreational water use. In this chapter we discuss these and other conservation alternatives which may be useful for future conservation planning, including municipal water conservation measures and emerging technology which further increase agricultural water efficiency.

This discussion does not attempt to dictate specific actions local drought committees should take. Those decisions rest in the hands of the water right holders, agricultural producers, conservation groups, and government agencies which are familiar with a the area and who can find common ground for agreement on proposals for water conservation and drought plans.

The following sections summarize water conservation alternatives potentially useful in the Clark Fork Basin, including a summary of the method, costs, benefits, and potential effectiveness to water conservation.

An abbreviated description of the alternatives is shown in Table 2. The water conservation alternatives are organized by the different sectors: agricultural including stockwater, domestic and municipal water, and alternatives that are applicable to all sectors.

Table 2. Matrix of water conservation alternatives

Sector	Method	Benefits	Drawbacks	Cost	Cost effectiveness	Water right needed?
Agriculture	Ditch and canal lining or piping	Reduced diversions from streams/rivers can increase streamflow below diversion.	Reduced return flow from seepage may reduce summer/fall streamflow and raise water temperatures.	High	Medium	No, unless changing water right purpose to instream flow.
	High efficiency sprinkler irrigation	May reduce peak diversion rate. Increase in crop yield benefits ag producer.	Often increases consumptive water use which can lead to less water availability for other uses. Reduced return flow from field loss may reduce summer/fall streamflow and raise water temperatures.	High	Medium	Not if irrigated area does not increase and not changing water right purpose to instream flow.
	Diversion rotation between users	Can help to ensure junior water right holders get some water. Can decrease risk of stream dewatering to fish and aquatic life.	None	Low	High	No
	Demand based irrigation scheduling	Reduced diversions from streams/rivers can increase streamflow below diversion. Can lower irrigation labor and pumping costs.	To be most effective requires soil moisture or weather monitoring.	Low	High	No

Sector	Method	Benefits	Drawbacks	Cost	Cost effectiveness	Water right needed?
Agriculture	Managed deficit irrigation	Conserves water and reduces irrigation costs associated with pumping and labor	May reduce crop yield and must be carefully done to avoid crop damage.	Low	High	No
	Over-irrigating during high streamflow	Recharges groundwater and can provide return flow to surface water during summer and fall low flows.	Crops which are not tolerant to soil saturation may be negatively affected.	Low	Medium	Not if it is a historical practice.
	Crop selection	Reduces plant water use while protecting ag economics. Can reduce diversions from streams, rivers, and aquifers.	Preference for drought tolerant crop versus high dollar crop may affect economics of farming.	Low	Medium	Not if it does not require increased diversion.
	Stock water wells	Small evaporative water savings from using groundwater vs. surface water	If stock water was formerly diverted by ditch reduced return flow may reduce summer/fall streamflow and raise water temperatures.	Medium	Low	Yes
Domestic and municipal	High efficiency lawn sprinklers	Reduced municipal diversions and private well diversions can conserve water. Reduced evaporative loss.	None	Medium	Medium	No

Sector	Method	Benefits	Drawbacks	Cost	Cost effectiveness	Water right needed?
Domestic and municipal	Drought tolerant landscaping	Significantly reduces lawn and garden irrigation needs, which is the single largest consumptive use of water for residences and municipalities.	Some people may have preference for lush landscaping.	Medium	High	No
	Water metering	Proven effective to encourage water conservation from municipal and public water systems.	Meters need to be purchased, installed, and read.	High	Medium	No
	Watering restrictions	Reduced water use and reduced peak demand.	Requires enforcement to be effective.	Low	High	No
	Water system audit and leak detection	Reduced leakage reduces diversions from streams, rivers and aquifers.	Leaked water typically returns to aquifers and streams, actual water savings depend on circumstances.	High	Low	No
	Municipal water conservation coordinator	Prioritizes resources to maximize conservation benefits.	None	Low	High	No

Sector	Method	Benefits	Drawbacks	Cost	Cost effectiveness	Water right needed?
Domestic and municipal	High efficiency plumbing fixtures and appliances	Reduced diversions from streams, rivers, and aquifers.	None, although water wasted by inefficient plumbing and appliances returns after treatment to streams or aquifers and actual water savings depends on circumstances.	Medium	Low	No
All	Storage in reservoirs and aquifers	Increases water supply when water is needed most.	Reservoirs and dams have environmental consequences, reservoirs greatly increase evaporative loss, and expensive.	High	Medium	Yes
	Incentives for conservation	Can be used to incentivize many different water conservation measures.	Depends on the water conservation measure used.	Varies	Varies	No
	Education to encourage water conservation	Helps the public and stakeholders understand water conservation, drought impacts, and drought planning. Helps foster public support for conservation.	Providing information alone may not be effective at getting people to conserve water. Needs to be combined with other water conservation alternatives.	Varies	Medium	No

4.1 Agriculture

Irrigation efficiency improvements

Ditch and canal lining or piping

Ditch and canal lining or piping is a conservation measure which reduces seepage loss from irrigation conveyance systems and can result in water savings during the irrigation season when streamflow shortage is most acute in Western Montana. Projects which reduce ditch loss can benefit streamflows in creeks and rivers below headgates when the increase in ditch efficiency results in a reduced flow rate diverted. Either installing permanent liners or piping a ditch are expensive alternatives, requiring significant investment in engineering and construction. Temporary spray liners are available for irrigation ditches which may provide short term benefits, and the ability to evaluate potential benefits of permanent lining, at much lower cost than permanent lining.

The key to figuring out how a ditch efficiency project will save water is to understand when ditch loss returns via groundwater to surface water and how much less water will need to be diverted after the lining or piping project is completed. In most of the valleys of Western Montana ditch loss will return to surface water via seepage to groundwater which is hydraulically connected to surface water. The timing of return flows to surface water typically lags behind ditch loss by weeks to months and peak gains in surface water are often during fall or even winter. Stream gains outside of the irrigation season represents lost water availability during the time of year when water shortage is most acute. Methods for determining when ditch efficiency projects will results in increased water availability are described below in the section: *When does improved irrigation efficiency result in increased water availability?*

High efficiency sprinklers

Conversion to more efficient irrigation methods such as upgrading flood or hand line sprinkler to center pivot may lessen peak diversions and benefit stream reaches below a diversion. Upgrading to high efficiency sprinkler systems may result in lower diversion flow rates and shorter irrigation sets than flood irrigation. Upgrading older inefficient center pivot sprinkler heads to new efficient heads can reduce evaporative loss and conserve water. Other modern high efficiency adaptations of the center pivot are available such as Low Energy Precision Application (LEPA), Low Pressure In-Canopy (LPIC), Low Elevation Spray Application (LESA), Mid-Elevation Spray Application (MESA) sprinkler systems. The correct choice of system is dependent on the location, intended crop, and economics of the installation. In addition to reducing peak water demand these sprinkler systems can also increase crop yield owing to their ability to more effectively deliver water and fertilizer to the crop. These high efficient sprinklers often have environmental benefits including reduced leaching and runoff of harmful salts, nutrients, pesticides and herbicides.

A potential drawback to increasing irrigation efficiency with these systems is they can result in increased total water consumption owing to improved crop vigor and irrigation uniformity. Growers may also shift to higher value, higher water-using crops or alfalfa with an efficient sprinkler system. Experience in Kansas with government subsidized upgrades from traditional center pivot to ultra-efficient dropped-nozzle pivot systems showed that diversions actually increased (Pfeiffer and Lin 2014). Montana DNRC has found that irrigation efficiency improvements in recent decades have led to greater water consumption per acre across the state (DNRC 2010). Pivots may also give an irrigator the ability to divert water later in the season when water supplies may not have been sufficient to flood irrigate. While these efficiency improvements provide benefits for agriculture to stretch water supplies and increase yield, the increased efficiency may not achieve goals for other drought impacts such as instream flow needs.

In most of the valleys of Western Montana irrigation field loss typically returns to surface water via seepage to groundwater which is hydraulically connected to surface water; and there is a lag in the timing of return flow. Similar to ditch lining projects, each sprinkler efficiency project proposal needs to evaluate when during the year and where in a stream the project will increase water availability. Methods for determining when improved irrigation efficiency results in increased water availability are described below in the section: *When does improved irrigation efficiency result in increased water availability?*

Photo: Modern high efficiency sprinklers both maximize crop watering and reduce wasteful evaporation.

When does improved irrigation efficiency result in increased water availability?

Calculating when an irrigation efficiency improvement project will make additional water available in a stream or river requires an evaluation of the local hydrogeology. In the valleys of the Clark Fork Basin, ditch and field loss will eventually return to surface water as return flow. Knowing the timing of return flow is critical to knowing whether the project will deplete surface water further during summer periods when water shortage is most severe (Kendy and Bredehoeft 2006). The evaluation also needs to take into account the potential reduction in diverted flow required for the new efficient system. In certain locations the net benefit may not achieve goals of the water conservation effort. For instance in locations where return flows from spring flood irrigation peak during late summer, changing to highly efficient irrigation may actually reduce streamflow and lead to higher water temperature later in the summer if the loss of return flows is greater than the water saved and left instream by the project.

A site-specific analysis is needed to evaluate return flow time lag is, although as a general rule increased distance from surface water increases the lag time. Timing of ditch loss return can be evaluated by a hydrogeologist using modeling tools such as Colorado State University's Alluvial Water Accounting System, "AWAS model" (IDS Group, 2013). Using this or similar tools to evaluate the timing will allow a proposed efficiency project to evaluate when during the year the project will increase water availability and when depletions to flow are likely. In general efficiency improvement projects are likely to result in depletions and lower fall, winter, and early spring streamflow due to the loss of return flow.

Photo: High efficiency irrigation may not always make more water available instream or for other uses due to increases in crop yield and consumptive use. Projects to improve irrigation efficiency should carefully consider whether water conserved will be used to meet project goals.

Changes in irrigation management

Diversion rotation between users

This is an agreement between two or more appropriators to rotate the use of water so that instantaneous demand is reduced from that if everyone were diverting at once. These agreements can be informal, hand-shake agreements between different water users on a creek or they can be formal collaborative agreements among many water users on a larger river, such as accomplished in the Blackfoot Drought Plan (see chapter 3.1). Having a measurement of each participant's diversion capacity and accounting for these will allow quantifying how much water can be saved for other uses. Irrigation rotation is commonly used to stretch limited streamflow to more junior irrigators and to protect streams from dewatering for fish.

Demand-based irrigation scheduling

Irrigation scheduling answers the questions of "When do I irrigate?" and "How much do I apply?" Demand-based irrigation scheduling uses meteorological and soil conditions to optimize irrigation water application timing and location and takes into account evaporation, seepage, and runoff losses, and leaching requirements. This can have environmental benefits including reducing the leaching and runoff of harmful salts, nutrients, pesticides and herbicides. Irrigation scheduling may also help to lower electricity costs for pumping of irrigation water.

Many variations exist on this concept; often recent weather conditions and short term forecasts are used to determine the timing and amount of irrigation water which needs to be applied. Irrigation scheduling often improves crop yield relative to water consumed (Evans and Sadler 2008). US Bureau of

Reclamation (BOR) provides information on the internet useful for irrigation scheduling, called AgriMet, which couples weather stations with crop water use models to assist producers in determining water needs. AgriMet has five weather stations in the Clark Fork Basin providing local irrigation demand estimates including one in the Bitterroot and Upper Clark Fork and three in the Flathead (http://www.usbr.gov/pn/agrimet/agrimetmap/agrimap.html).

Converting from gravity surface irrigation systems to pressurized drip or sprinkler systems can greatly help with irrigation scheduling because these advanced systems can be more closely managed and applications better controlled. More advances irrigation systems which are controlled with soil water moisture sensors in a field can automate this process.

Irrigation field loss in Montana typically returns to surface water via seepage to groundwater which is hydraulically connected to surface water and there is a lag in the timing of return flow. Each project will need to evaluate when during the year the project will increase water availability. As an example, changing to demand-based irrigation scheduling during springtime from a past practice of over-irrigating during springtime high streamflow may actually reduce streamflow and lead to higher water temperature later in the summer because of the loss of groundwater recharge and irrigation return flows.

Photo: Demand based irrigation scheduling can help to maximize crop yield and conserve water.

Managed deficit irrigation

Managed deficit irrigation involves under-irrigation of crops or hay by timing the water deficit to the crop growth stage when water stress has minimal effects on crop yield. This practice is a commonly used drought response in drier regions of the world to maximize yields when water supplies are insufficient for full service irrigation. Deficit irrigation can have the combined benefit of conserving water and reducing irrigation costs associated with pumping and labor during periods when plants can tolerate water stress. Optimal deficit irrigation strategies need to be evaluated for a particular crop in a particular area. Research has shown that managed deficit irrigation is the most effective method to conserve water (Evans and Sadler 2008). Deficit irrigation strategies are described further in Zhang (2003) and English (1996). Implications of deficit irrigation of alfalfa and grass is described in studies by Orloff et al. (2014) and Ottman (2011).

Additional efforts are needed to evaluate if short term non-use in a managed deficit irrigation strategy can have minimal impact on crop yields while creating short term water for instream flow during critical water temperatures or low flow. Additional research and outreach is needed to evaluate potential for cooperative arrangements where irrigators would voluntarily reduce diversions in return for short term payments for yield losses, during the period when instream flow is most limited. This may be a preferred alternative in certain areas to instream flow leases which typically have a duration of a decade or longer. Deficit irrigation strategies will need to consider that without a water right change, protecting unused irrigation water for instream use may not be possible, and arrangements will have to be made with irrigators strategically located above stream or river reaches where flow is most needed or with cooperation of other irrigators to leave conserved water instream.

Over-irrigating during high streamflow

There is a history in Montana of irrigators over-irrigating during spring and early summer high streamflow when excess water is available. Typically producers over-irrigate with the intention of making sure that soil moisture is maximized when streamflow and irrigation water availability inevitably become reduced. This practice also provides valuable groundwater recharge which will help to support streamflows and groundwater pumping during later summer and fall. Water conservation strategies need to consider that actions which increase irrigation efficiency (ditch lining, high efficiency sprinklers, demand based irrigation scheduling, etc.) during times with high streamflow will diminish groundwater recharge. For example demand-based irrigation scheduling may be a valuable method to stretch limited water supplies during later summer, but if implemented during spring would reduce groundwater recharge which supports higher streamflow during late summer. Return flow from irrigation losses are also colder than surface waters are during late summer, owing to groundwater being relatively cold, which helps to mitigate high stream temperatures during late summer low flow. Projects which increase efficiency of water use during spring or early summer could actually lead to greater water scarcity and increased stream temperature later in the summer. Careful evaluation of each projects water savings and return flow hydrogeology is needed to avoid actions which would be detrimental to project goals.

Crop selection

Different crops respond differently to water stress and drought conditions and some plants are more vulnerable to water stress during certain growth stages. Crop selection involves choosing crops which will respond most favorably to anticipated precipitation and irrigation water availability. Crop selection can be used as a drought mitigation strategy when long-term drought is anticipated to limit water availability over a growing season. Crop selection can also be used to choose crops which will respond favorably to short term water stress as part of a managed deficit irrigation water conservation strategy. General categories of crops by vulnerability to water stress include:

Determinate crops

Small grains, cereal crops, peas, beans, and oil seed crops. These crops are most sensitive to water stress during seed formation.

Indeterminate crops

Tubers and root crops such as potatoes, carrots, and sugar beets. These crops are relatively insensitive to moisture stress for intervals or 4-5 days or less. Crop yield is more affected by cumulative water during the growing season than to stress during any particular growth stage and have no specific critical periods for water stress.

Forages

Hay and pasture. Relative to crops, perennial forages are least impacted by moisture stress. Generally as water stress increases forage nutritional value increases, although yield and harvestable protein decreases. Irrigation should be maximized early in the season to maximize yield.

More detailed information on crop selection from the MSU extension service is provided in this publication How and When Does Water Stress Impact Plant Growth and Development? (http://waterquality.montana.edu/docs/irrigation/a9_bauder.shtml) (Bauder 2003) and Irrigating With Limited Water Supplies (http://waterquality.montana.edu/docs/irrigation/limitedwater.shtml) (Bauder 1985).

Photo: Crop selection of drought tolerant varieties can help producers to weather droughts and conserve water.

Stock water

Stock water wells and troughs can save water versus diverting water through leaky ditches for stock watering. This conservation measure is similar to ditch lining and piping; reducing loss can benefit stream reaches immediately below a diversion. Watering stock with wells during critical summer low streamflow, instead of diverting water separately from surface water, can have a positive benefit for streamflow.

Water use by stock is very small compared to irrigation. For instance, assuming cattle drink 15 gallons of water per day (DNRC Planning Guide for Water Use), 1000 head will only consume an average of 0.02 cfs (cubic feet per second) of water. Therefore the impacts of cattle drinking directly from surface water sources is very small and conservation measures should be focused on improving leaky stock water conveyance ditches.

4.2 Domestic and municipal water supply

High efficiency lawn sprinklers

High efficiency residential sprinklers are available which have potential to significantly reduce residential water demand, and consumption by excess evaporation. Sometimes called precision landscape irrigation, these systems rely on better engineering and application which is tied to lawn water needs, not just automatic timing. For instance precision landscape irrigation systems can be combined with weather and/or soil moisture monitoring sensors which automate irrigation application based on lawn water needs.

In order to increase water conservation, automatic sprinkler systems require either weather or soil moisture monitors or education on efficient use. A study in California showed that residential water demand increased with installation of automatic sprinklers over the demand by customers who manually water (Chesnutt and McSpadden 1991). Evidently traditional automatic sprinkling systems make it easier to waste water; this is a concern given the use of automatic sprinklers is increasing.

Photo: A common sight, inefficient lawn sprinklers waste considerable water by evaporation and runoff.

Drought tolerant landscaping

Water used for in-house uses is minor compared to the amount of water needed to irrigate lawns. Americans have grown up and become accustomed to abundant municipal water supplies which allow large areas of lawn to be economically watered. As competition for water increases with greater demand and smaller water supplies available for growth, encouraging landscapes that do not require watering can be promoted or legally adopted through local ordinances.

Xeriscaping with plants which do not need supplemental irrigation or landscaping with native species can conserve significant water. Drought tolerant landscaping may have the added benefit of reducing fertilizer, the need for frequent mowing, and other maintenance needs and costs.

In addition to residential lawns, incentives or local ordinance can be adopted which reduce or eliminate irrigation of road and highway medians and golf course roughs.

The Montana USDA Natural Resources Conservation Service has a Low Impact Development and Urban Conservation website (http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/mt/water/resources/?cid=nrcs144p2_057448) with information related to water-wise landscaping.

The MSU extension service has a brochure Yard and Garden Water Management (http://store.msuextension.org/publications/YardandGarden/MT198915AG.pdf) to help minimize water use while maximizing lawn and garden aesthetics.

Additionally the Montana Drought and Water Supply website (http://drought.mt.gov/Links/Conservation.aspx) contains a number of resources for water wise landscaping.

Photo: Native drought tolerant landscaping is one of the most effective ways to reduce municipal and residential water consumption (photo by Montana Wildlife Gardener).

Water metering

Water metering provides a water bill which increases with the amount of water used. Charging for actual water use both provides an economic incentive for customers to reduce their water consumption and also helps to give consumers an idea of the value of water. Water metering has been shown to reduce reducing water demand by 15 to 45 percent over unmetered service (Gleick et al. 2003). Water metering may be most effective at getting customers to reduce lawn watering, which is the largest demand and consumptive use of water at residential connections (Maddaus, 2001; Linaweaver et al, 1966).

Watering restrictions

Municipalities can adopt ordinances to limit when and how landowners irrigate lawns, wash vehicles, as well as outlawing wasteful use of water. Ordinances can typically allow fines to enforce water conservation. Although voluntary watering restrictions may sound appealing, studies have shown that mandatory restrictions are needed to save more significant water (Kinney et al. 2004). Mandatory watering restrictions have been proven to be effective in reducing water use and peak water demand; the amount of water conserved is dependent on the restrictions chosen.

Example watering restrictions could include the following:

1. Odd numbered houses may irrigate during odd numbered days, even during even days.
2. Don't water during the heat of the day, 10AM-6PM.
3. Don't water during rain.
4. Don't allow your sprinkler system to water driveways, sidewalks and streets.
5. Don't allow irrigation runoff to flow into public right of way or storm water drainage system

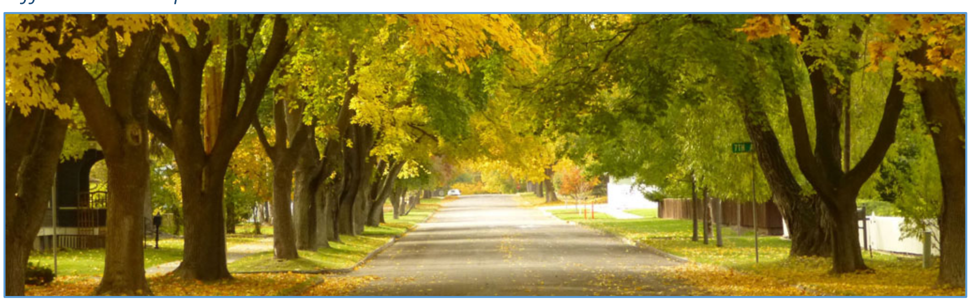
Water system audit and leak detection

Municipal water systems, especially older systems with aging infrastructure leak large quantities of water from underground piping. All water systems, even smaller systems, can implement a basic system of water accounting and strategize repairs. This strategy may include regular testing using computer-assisted leak detection equipment for detecting leaks along water distribution mains, valves, services, and meters. Pipe cleaning, lining leaky pipes, and other maintenance efforts to improve the distribution system will lessen diversion requirements and decrease demand on rivers and aquifers for water. Leaks from water systems typically occur underground and water will return to shallow groundwater and hydraulically connected surface water. Because leaked water will typically return to surface water, repairing leaks may not provide a net benefit for surface waters experiencing shortage leakage increases with system demand during the summer irrigation season.

Municipal water conservation coordinator

Larger municipalities can benefit from a water conservation coordinator who assists with education of the public community and local government on the need for water conservation, related ordinances, and water conservation methods, and technologies. The coordinator can evaluate infrastructure upgrades which will limit water loss, identify and implement incentives to conserve water, and oversee the development of a municipal water conservation plan. Most importantly a water conservation coordinator should help to prioritize resources to maximize conservation benefits.

Photo: Municipalities are under increasing pressure to conserve water as new water rights become more difficult and expensive to obtain.



High efficiency plumbing fixtures and appliances

A wide variety of water efficient household appliances and plumbing fixtures are available on the market. Use of water efficient appliances and fixtures can reduce domestic water demands and diversions from surface water or groundwater. Benefits of water efficient technologies to public water supply systems also include lower costs of both chemicals and energy used for water treatment in the water supply and sewage treatment. Water conservation efforts can also help communities which do not have sufficient water rights or economic resources to upgrade water system infrastructure to meet growing demands on a municipal water system.

Most of the water which goes down the drain from inefficient indoor use is nonconsumptive, meaning it will be treated and discharged back to surface or groundwater where it is available again for reuse. Efforts to improve municipal water efficiency will need to consider where saved water is most needed. If the goal is to improve streamflow in creeks or rivers directly below a water system diversion then efforts to improve the efficiency of nonconsumptive in-house uses may be a viable opportunity to meet that goal. However, if the goal is to increase the availability of water at the watershed scale then these conservation efforts may not benefit water supply because treated water is already available for reuse. Montana is different from much of the country in the way our treated wastewater is reused, whether municipal wastewater or individual septic systems, because we do not discharge treated wastewater to oceans or other waterways where it is not available for reuse. Increased use of land-application disposal, such as irrigation with treated sewage is one exception to this; in that case water conserved indoors is saved.

Any project which seeks to help water shortage by improving municipal or residential water efficiency will need to consider the source of water and where treated wastewater is discharged to know where water conservation efforts are likely to increase water availability. For instance, municipal systems which use groundwater for supply and which discharge treated wastewater to surface water may provide benefits to streamflow and surface water availability during summer periods when surface water supplies are most limited. Given these considerations, indoor water efficiency may not be most effective water conservation alternative for increasing water availability for other uses. Indeed the reduction in water demand from high efficiency fixtures and appliances has proven to be modest (Olmstead and Stavins 2009). Instead the benefits are greater for reducing costs for operating municipal water and wastewater systems.

Photo: Water efficient showerheads, fixtures, and appliances help to decrease water demand and diversions from wells and surface water.

4.3 Conservation methods applicable to all uses

Storage

Storing water in reservoirs is an age old mitigation strategy for drought. The prospect of constructing new large storage projects in Montana is limited by the availability of suitable locations, cost, public support, and the need to mitigate environmental impacts. Smaller storage projects can improve water availability within a given year, but lack significant carry-over storage which would help with water shortages during an extended drought. Another alternative might be to enlarge an existing storage facility to accommodate a greater volume of water. Some existing reservoirs were undersized when constructed and could store additional water if structural capacity was increased. All potential storage projects in the Clark Fork Basin are limited by the fact that much of the water supply is already allocated to existing water right holders. In the Blackfoot, Upper Clark Fork, and Bitterroot Rivers water available for new uses is very limited, in some cases limited to a few weeks or less of the year.

Reservoir storage comes at a cost in evaporation, as it exposes large areas of stored water to evaporative loss. Underground storage, called aquifer storage and recovery, has received a lot of research in recent years and aquifer storage and recovery projects have been built in more arid regions of the world. To our knowledge no large scale aquifer storage and recovery project has been built in Montana. Aquifer storage and recovery is also limited by the availability of water supply which has not been allocated to existing water right holders. Series I of this report, titled *Water Availability and Mitigation Opportunities in the Clark Fork Basin*, provides much more detail on the availability of water for new reservoir and aquifer storage projects.

Incentives for conservation

Municipalities and water companies can provide economic incentives for water conservation at existing residences and new construction which use water efficient plumbing, appliances, and landscaping. Water providers may also provide rebates for those customers who upgrade older to newer more efficient technology, such as low-flush toilets and modern washing machines, or conversion to water efficient landscaping.

Water billing with tiered pricing have been successful in incentivizing customers to conserve water and invest in more water efficient technologies. In a tiered pricing structure, users are charged higher rates for larger quantities of water consumed. Use of a tiered pricing structure by municipal providers allows basic needs, such as in-house use, to be satisfied economically while providing the greatest incentive for conservation for larger users, who can better afford investments in conservation. Tiered pricing has also been effectively used by irrigation districts to encourage irrigators to make more efficient use of water and concentrate irrigation on more economic crops.

Municipalities and local government also have the ability to adopt ordinances to provide landowners financial or other incentives to reduce or eliminate lawns, limit irrigated lawn and garden area, or replace lawn with native dry land landscaping.

One area needing additional research is the potential for municipal water conservation measures to be used to bank water credits for future water uses. In this proposal, reduced water consumption by a community would be banked, then later used to mitigate either future growth by that community or sold to others needing mitigation credits for new water uses permitted by DNRC. The banked credits could be also be used as an economic incentive to bring business into communities which require substantial water for operations. Whether such water banking is possible under current Montana water law needs to be evaluated.

Education to Encourage Water Conservation

Education is one of these education to inform municipal and rural land owners / citizens why water conservation is important and how they can participate

Experience has shown that it is difficult to get people to change behaviors just by providing information alone and incorporating social marketing techniques may help an information campaign achieve goals (McKenzie-Mohr 2011). To get people to change behavior regarding water use, information should be combined with incentives, collaborative agreements, or laws and regulations. Research on municipal water conservation education suggests that a critical level of commitment to education, both duration and the amount of outreach, must be made for education to have a noticeable benefit (Michelsen et al. 1998).

A single or multimedia education approach can be targeted to individuals in a group, watershed, town, or other area. Education topics could potentially include encouraging water conservation planning, understanding consumptive water use vs. nonconsumptive use, and providing a framework and potential resources for locals to organize and develop drought management or water conservation plans.

Education campaigns can include informational materials such as brochures, flyers, videos, reports, internet web sites, and social media sites. Prompts also help people to remember to conserve water. Prompts can be something as simple as a sticker a person places near their hose faucet reminding that lawns should only be watered on odd days. The campaign may also include plans to provide meeting space for drought committees, facilitation, and outreach on committee activities.

4.3 Hydropower generation, reservoir water levels, and infrastructure management

Major hydropower dams in the Clark Fork Basin are managed according to established federal and tribal protocols and Federal Energy Regulatory Commission (FERC) regulations often involving flood and fishery protection. This type of drought management attempts to balance the economic needs of power generation and recreation and the aesthetic and natural resource impacts from low or high water in reservoirs. Typically dam drought plans seek to balance maximizing hydropower generation during times when electricity is needed with the often competing needs of maintaining reservoir levels for recreation, aquatic life, and flood control as well as maintaining instream flow below the dam for recreation and aquatic life. Often the dam management plans use climate indices which measure drought severity or runoff potential to invoke different seasonal management routines.

At Kerr Dam, a drought management plan was mandated by the Secretary of the Interior under authority of the Federal Power Act. The drought management plan uses two climate indices to select seasonal dam management routines. The climate indices are the Multivariate ENSO Index which measures El Niño Southern Oscillation effects on climate and the Flathead Precipitation Runoff Index which uses precipitation measured at weather stations in the basin. If the climate indices from October through December forecast drought conditions the dam drought management plan is implemented. The Kerr Dam drought management plan helps to ensure the lake will refill to normal pool in the event of a drought and that lake refilling is balanced with the need to maintain instream flow below the dam for aquatic life. Flood control operations at Kerr Dam required by Army Corp of Engineers take precedent and cannot be constrained by the drought management plan.

Hungry Horse Dam uses a modern flood control standard called VARQ, which is an acronym meaning "variable flow". VARQ was created by the Army Corp of Engineers with help from State of Montana and the Confederated Salish and Kootenai Tribes and was made permanent at Hungry Horse Dam in 2009. VARQ provides for more flexibility to dam managers and a more natural streamflow hydrograph. In years when water forecasts predict a lower risk of flooding, VARQ allows more water to be stored in the reservoirs during spring. Increased spring storage during dry years reduces deep reservoir drawdown in Hungry Horse Reservoir and helps to provide stabile summer lake levels in Flathead Lake. It also helps to provide a more natural runoff and streamflow, helping native fish in the Flathead including bull trout and westslope cutthroat trout.

Photo: Dam operation plans typically include drought plans which balance hydropower generation and flood control with recreation and fishery needs for water.

Chapter 5. Information sources for drought management and water conservation planning

There is a great deal of information and guidance available on drought management and water conservation planning including information specific to drought planning in the Clark Fork Basin. The following are select information sources for developing drought planning and water conservation efforts.

1) Montana's Drought and Water Information Website: (http://drought.mt.gov/Code/Navigation/GeneralInfo.aspx) this website includes information specific to Montana drought conditions such as current stream and soil drought conditions, information on sources of funding for emergency drought relief and drought management planning, wildfire conditions, water conservation tips, and information on the Governor's Drought Advisory Committee.

2) Detailed drought planning guidance describing a planning process from convening a drought task force through developing, implementing, and updating a drought plan is provided in *Drought Preparedness Planning: Building Institutional Capacity* (Wilhite et al. 2005) which is a chapter of the book *Drought and Water Crises: Science, Technology, and Management Issues*. This chapter as well as other drought planning guidance is available from the National Drought Mitigation Center (http:/drought.unl.edu/planning/planningprocesses.aspx).

3) Chapter 2 of the 2012 UM Master's Thesis by Molly Smith (http://scholarworks.umt.edu/etd/837) provides recommendations for watershed-based collaboration and developing drought plans which she tailored to the Clark Fork Basin. The recommendations were developed by interviews with people in the Clark Fork Basin to identify past and current water planning efforts which have been effective and to discuss what options are available to make collaborative drought planning more effective.

4) Colorado Water Conservation Board: (http://cwcb.state.co.us/water-management/drought/Pages/main.aspx) this website includes information on how Colorado has undertaken local and state-level drought planning and includes the Colorado Drought Mitigation and Response Plan which provides examples for planning efforts in Montana.

5) National Drought Mitigation Center Planning: (http://drought.unl.edu/Planning.aspx) this website includes extensive drought planning information and guidance. The Directory of Drought and Management Plans (http://drought.unl.edu/Planning/PlanningInfobyState/DroughtandManagementPlans.aspx) links to dozens of drought management plans which provide examples for planning efforts in Montana. (Note the plans on this page may be superseded by newer versions; look for updates with the local organizations which maintain the plans.)

6) National Integrated Drought Information System (NIDIS) U.S. Drought Portal: (http://www.drought.gov/drought/) this website includes information on current drought conditions throughout the U.S. as well as extensive drought planning information and guidance. NIDIS has Montana specific information on the Montana Drought Information Page (http://www.drought.gov/drought/area/mt).

7) Water Conservation for Communities (http://pubs.cas.psu.edu/FreePubs/PDFs/AGRS113.pdf) discusses water conservation strategies, identifies water conservation resources, and relates practical advice on beginning a conservation program (Penn State College of Agricultural Sciences Agricultural Research and Cooperative Extension, 2010).

7) Cases in Water Conservation: How Efficiency Programs Help Water Utilities Save Water and Avoid Costs (http://www.epa.gov/WaterSense/docs/utilityconservation_508.pdf). Provides summaries of water conservation plans implemented by 17 communities across America (EPA 2002).

Chapter 6. Future Clark Fork Basin water conservation planning

In the drier regions and headwaters of the Clark Fork River, water is in high demand but is limited in supply. It has been known for years in the Bitterroot, Blackfoot, and Upper Clark Fork that there is less water than needed to meet the needs of existing water right holders. In many of these areas there is too little water left to provide for the needs of fish and the environment. As population grows and we experience inevitable future droughts this water shortage may feel even more severe. Drought and water conservation planning is essential to allow us to make the most of this limited water supply and to prepare for drought and to lessen drought impacts.

The landscape and climate of the Clark Fork Basin is so large and varied, and drought impacts range greatly, such that solutions will need to be local. A Clark Fork Basin-wide drought plan may be possible and beneficial; but must include drought planning for the individual watersheds. A basin plan, if developed will need to provide structure for communication and to coordinate goals between watersheds, and not dictate a one size fits all approach. Future drought planning can build upon and expand to other watersheds the local scale planning that has begun in the basin. But future drought planning will also need to consider the needs and solutions for the more urban and densely populated watersheds.

It is hoped that the information is this report will be used to choose strategies for developing a drought planning process, identify water conservation alternatives, and implement new drought plans. The effort to see this process started must include the people who will be effected by water shortage and who see a collective needs to better manage limited water resources. Experience in the Clark Fork Basin and elsewhere has shown that collaborative planning efforts among people of diverse backgrounds and interests helps to foster effective drought plans. Collaboration brings all parties together is a neutral forum, builds trust, and fosters support for shared sacrifice, something that legal battles and litigation will never accomplish. The future of Western Montana's unique mix of traditional agricultural communities, small cities, and its beautiful environment will depend in part on our ability to carefully manage our use of water, the natural resource that makes it all possible.

Photo: As population grows and water demand increases it will be imperative for Montanans to collaborate on management of this limited resource.

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