The Pathfinder Project: A Collaborative Effort to Provide for Instream Flow Management

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The Pathfinder Project was a pilot effort initiated by the USDA Forest Service Washington Office and hosted by the Grand Mesa, Uncompahgre and Gunnison National Forest (GMUG) from 2000 thru 2004. Water users, state water officials, local watershed coalitions and conservation organizations met and worked together with the forest to determine how best to provide for instream flow needs in the Forest Plan, while recognizing historic needs and existing laws. Technical work and field investigations involving examination of water rights, diversion points, basin hydrology and comparison of instream flow quantification models were key components and are addressed in this paper. The results of this collaborative effort produced a product different than that envisioned by the Forest Service, but provided a useful critical public perspective on instream flows early in the planning process. The Pathfinder Project has been used as an example of cooperation between the state of Colorado and the Forest Service, in an effort to find common ground on an issue of long standing conflict.

Keywords: *water rights, instream flow, stream diversions, R2Cross method, collaboration, GMUG*

Introduction

Conflicts over water, particularly in the arid western United States, have been and will continue to be a key resource allocation issue facing both elected officials and policy makers. There are many facets to this subject, with instream flows being just one. In states where water is controlled by the doctrine of prior appropriation, water use is considered to be a property right and falls primarily under the jurisdiction of the states. This situation presents huge challenges for federal land management agencies.

In Colorado, instream flow uses are generally looked upon as secondary to consumptive uses, or those uses which capture and control the stream in order to put it to beneficial use. Additionally, instream flows are often very junior to long established agricultural, industrial and municipal uses. The Forest Service must comply with a host of federal laws that direct it to protect the environment and sustain ecosystems. Therein lays the conflict, because without water in stream channels it is impossible to sustain ecosystems.

Colorado has been a real battleground over federal vs. state interests in water. In order to provide water for national forest purposes, the Washington Office was interested in exploring alternatives to litigation, which has historically been costly and less than fully successful. The Pathfinder Project was a Washington Office initiative intended to learn if collaboration could be used as a way to share ownership in water issues and perhaps cut through the contentious and entrenched positions that surround water issues in Colorado. Because the Grand Mesa, Uncompahgre and Gunnison National Forests (GMUG) were initiating a Forest Plan revision, which provides the framework for determining resource management objectives and authorized uses of the national forest, the GMUG was selected as an excellent candidate to test a collaborative process. Water users, state water officials, local watershed coalitions and conservation organizations were brought together for the purpose of assisting the forest in determining how best to provide for instream flow needs in the Forest Plan, while recognizing historic needs and existing laws.

The GMUG is located in western Colorado (Figure 1). These national forest lands are the headwaters for and control about 60% of the Gunnison River basin, which is the largest tributary to the Colorado River within the state. Annual water production is on the order of 2.9 million acre-feet (3,576 million cubic meters), which flows down 3500 miles (5,600 km) of streams. There are 162 reservoirs and 212 ditches authorized by special-use permits or easements on the forests. The Grand Mesa National Forest

M Furniss, C Clifton, and K Ronnenberg, eds., 2007. *Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, CA, 18-22 October 2004*, PNW-GTR-689, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

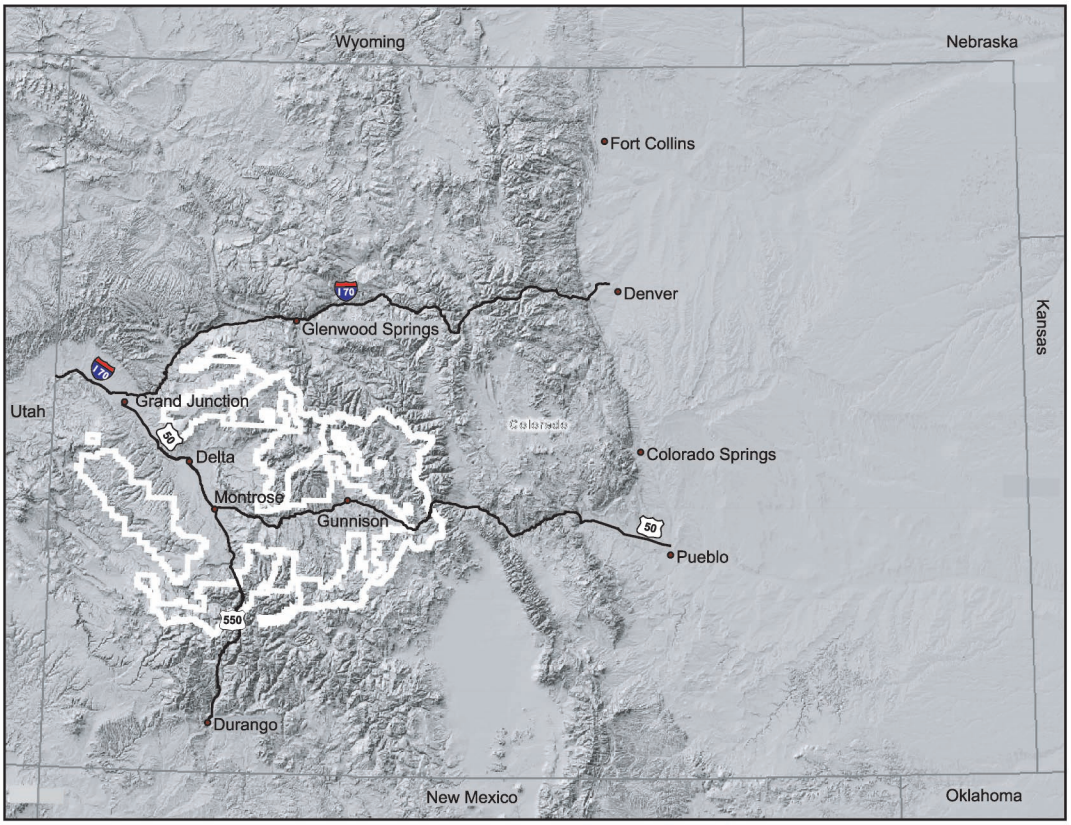


Figure 1. Location of the Grand Mesa, Uncompahgre, and Gunnison National Forests in Colorado.

has more water related facilities authorized than any other national forest in the nation.

Over an approximately three-year period the forest used the extra funding provided by the Pathfinder initiative to undertake a considerable effort to gather and analyze hydrologic data, conduct field investigations and develop both tabular and spatial databases needed to support the project. The efforts can be categorized into four groups. Components of these efforts occurred simultaneously and were often inter-connected. These were:

1) Characterization of flows and basin water yields for the forest;
2) Site investigations of diversion points on the forest;
3) Acquisition of private water right records for locations on the forest; and
4) Comparison of instream flow quantification methodologies and application to a study site on the forest.

A key component of our dialog centered on Colorado's existing instream flow program, which was first adopted by the state legislature in 1974. An issue, which surfaced repeatedly in our citizens work group, questioned whether the state's program, which is based upon protection of "minimum flows necessary to preserve the natural environment to a reasonable degree" (CWCB 1993), can or should be relied upon to meet the more stringent federal environmental legislative mandates of the national forest. The highlighted streams on the map indicate instream flow rights held by the state for streams on the GMUG (Figure 2). Instream flow rights established and held by the state are often very junior, and in some circumstances do not provide any water to the stream, particularly during periods of critical water shortage.

Characterization of Flows and Basin Water Yields for the Forest

In conjunction with the United States Geological Survey (USGS) Water Resources Division, we analyzed existing flow records so that we could better understand the hydrology of our streams. All USGS gage site records, both active and abandoned, were reviewed. Sites were selected that were located on the National Forest or within a few miles of the boundary. Sites with fewer than three years of record were discarded as were those where stream flows were regulated. A total of 60 stations were selected. For all stations with ten or more years of record, an instantaneous peak-flow frequency analysis was performed using the log-Pearson type-III distribution. To the standard set of return intervals, we added the 1.5-year flood, often used to approximate bankfull discharge. The daily mean low-flow and high-flow frequency analysis for 1, 3, 7, 15, 30, 60, 120 and 183 consecutive days was calculated. For all stations with three or more years of record, flow

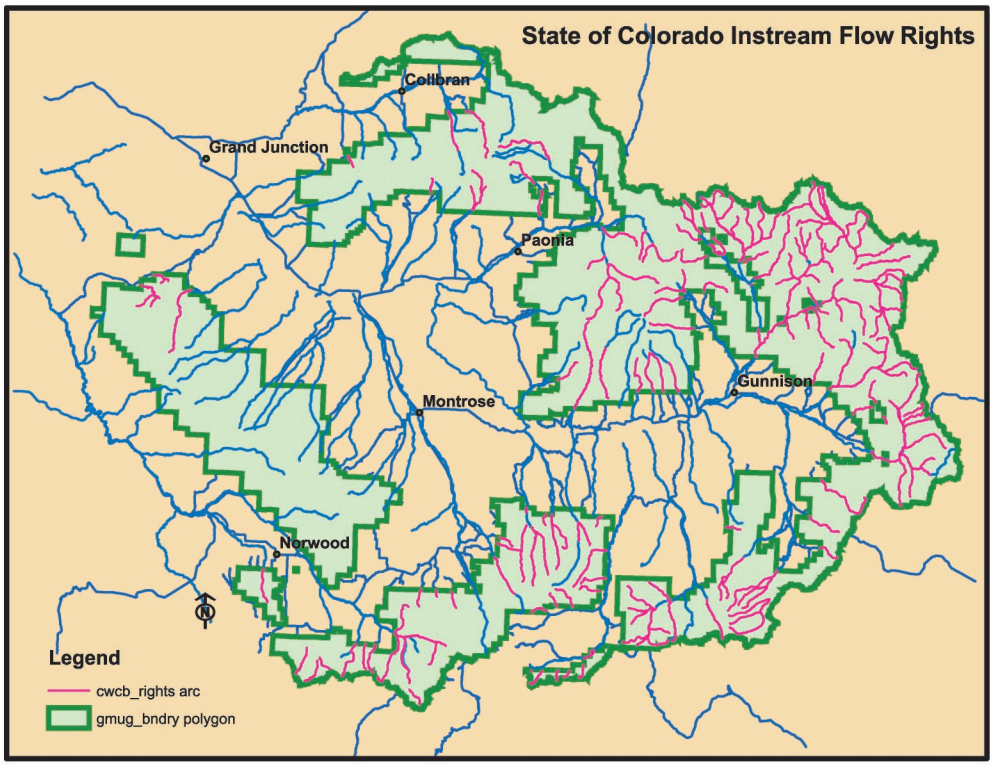


Figure 2. Colorado Water Conservation Board existing instream flow rights on the GMUG.

duration curves using daily means were generated for both an annual and monthly basis (Kuhn 2003).

It was recognized that a lack of long term flow data for headwater streams in the study area would be problematic. In an effort to address this information gap, we selected five sites distributed across the forest for pairing with one or more long-term USGS sites that share hydrologic similarities. Simultaneous discharge measurements taken at the paired sites over a minimum of one full hydrologic cycle were used to estimate monthly streamflow characteristics. In order to get a good representation for the range in flows, sampling was done more frequently during the rising and falling limbs of the hydrograph and less frequently during baseflow periods. At two of the sites, we established continuous water level recorders that allowed us to estimate mean daily flows. The alteration of flow pattern and inundation of the water level recorder due to repeated invasion by persistent beavers (*Castor canadensis*) resulted in the abandonment of one site.

For those basins with no gaging data, we estimated natural streamflow characteristics using published regression equations for western Colorado (Kircher et al. 1985)

Figure 3 is an example of one of the products that was developed from the analysis of flow data. Relative water yield was calculated using mean daily flows projected at the mouth of each watershed. While mean annual flow values are related to basin size, they are primarily influenced by annual precipitation, geology and basin morphology. This information was useful in helping to focus our efforts on watersheds where conflicts may occur with existing diversions or where future water development projects might be expected. In other words, where diversions exist in drier basins, the potential for diminished flow issues is more likely, and similarly, those basins that have greater water production are potentially better suited for future water development demands.

Site Investigations of Diversion Points on the Forest

The field inventory of physical diversions was an interesting and revealing exercise. Our diversion inventory sites were identified by compiling location and attribute information from both Forest Service permits and state water right records. Even though all the structures we visited were under some type of federal authorization, there was often only limited information in our files. We found that in some cases it had been 20 or more years since there was a documented site visit. Our inventory was not sophisticated and did not attempt to quantify flow impacts directly. We employed a two-person crew for three summers, and they inventoried 246 different diversions. The primary attributes recorded were: structure type; evidence of use; maintenance issues; appearance of fish in the stream at the point of diversion; notation of flow measurement devices and channel morphology characteristics, both above and below the diversion point. During the site visit, an estimate was made of the percentage of the stream that was diverted. The estimate of

Figure 3. Relative water yield of watersheds on the GMUG National Forest.

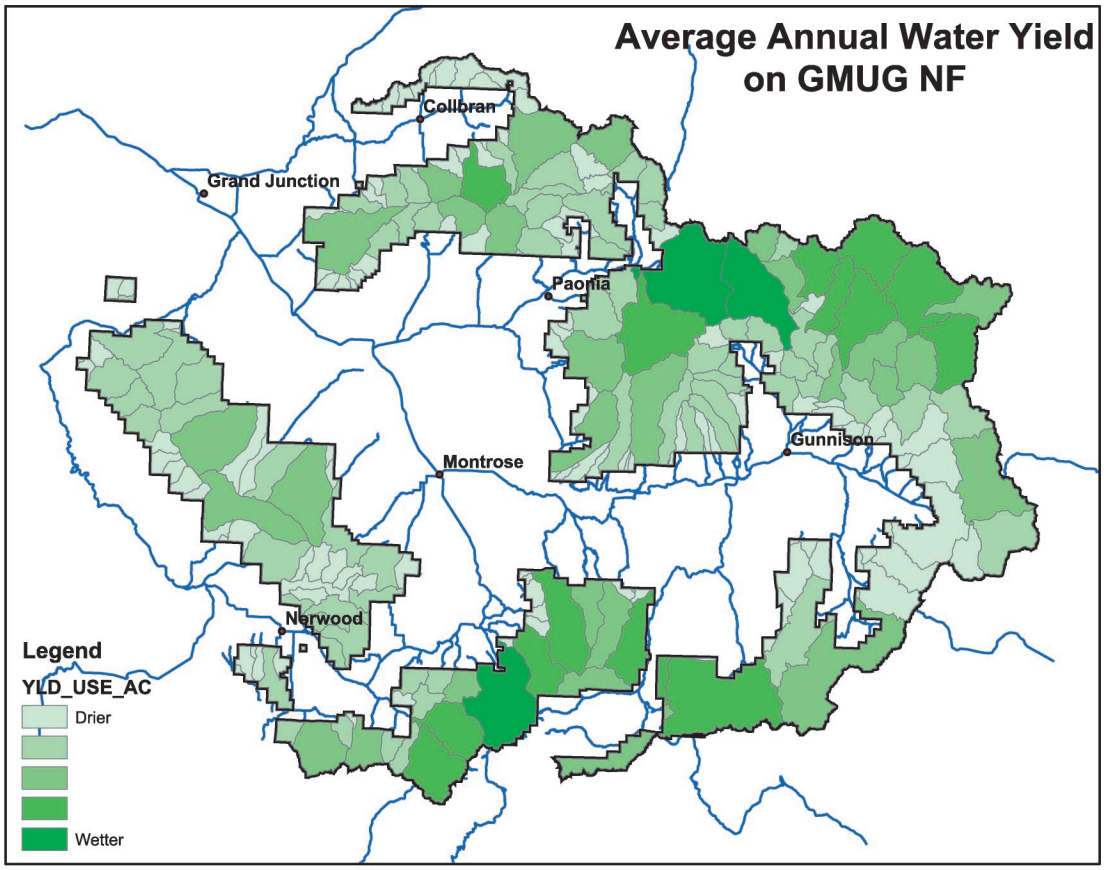
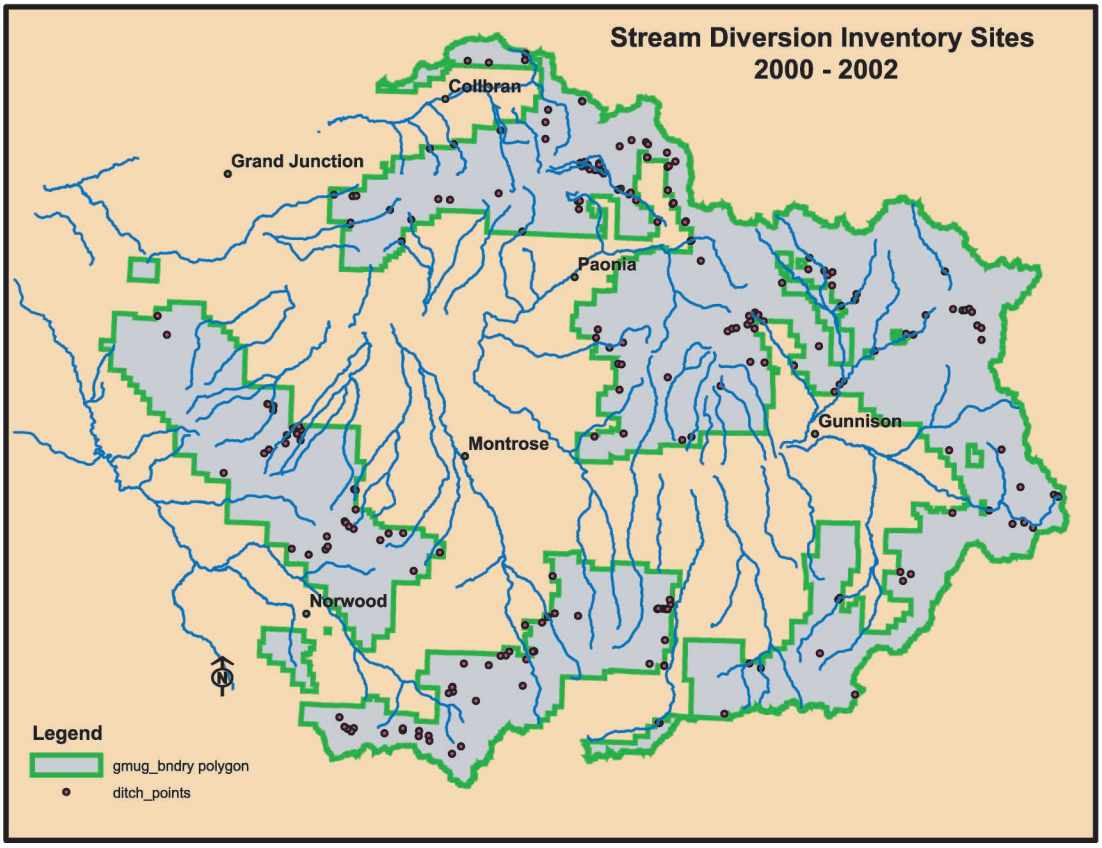


Figure 4. Stream diversion inventory sites on the GMUG NF, 2000-2002.



stream diversion was a key piece of data and was used later to prioritize diversions of concern. However, since our inventory was a one-time visit the estimate on diversion percentage and how it could be used was limited. Digital images were taken and Global Positioning System (GPS) coordinates obtained. This information was used to create a GIS point coverage of diversion sites on the forest with active hotlinks to the digital images (Figure 4). The data from field sheets was used to create a Microsoft Access™[1] data table, which enabled us to sort and query the data. We had enthusiastic support from our lands staff, who recognized that this inventory was going to be very beneficial in evaluating "Ditch Bill" easements and development of operation and maintenance plans. This work proved to be very useful in defining thresholds of concern when used in combination with assigned flow-dependent values and streamflow data for specific basins.

A number of the diversions were well-designed, permanent concrete structures, but most were primitive and made of wood, rock and plastic. Many structures were probably reconstructed, if not every year then every few years, either by hand or with equipment in the channel. Many were barriers to fish passage and virtually none prevented movement of fish into the ditch. While most would be considered small diversions, taking less than 25% of the flow, a few virtually dried up the stream. Most diversions were located within a mile of the forest boundary, but a few were located in the headwaters and were usually associated with a trans-basin diversions or private land inholdings. The farther up in the watershed the original point of diversion was located, the more likely the water transport facility consisted of a series of diversions, ditches and natural channels used to move water to the desired place of use.

ACQUISITION OF PRIVATE WATER RIGHT RECORDS FOR LOCATIONS ON THE FOREST

The GMUG National Forest has been the source of water for use in surrounding communities and agricultural/industrial uses for more than 100 years. A significant number of water rights were established prior to the creation of the Forest Reserves. There are in excess of five hundred private water rights associated with diversion structures on the GMUG. Each point in Figure 5 represents the location of a private decreed water right.

Electronic water rights records where obtained from the state of Colorado Engineer's Office and used to extract information such as location, type of right (conditional or absolute), quantity and priority. In addition, we obtained records of actual diversions. This was extremely useful in separating a decreed water right flow amount, which is often inflated, from what has been historically diverted. Early in the process we experimented with an examination

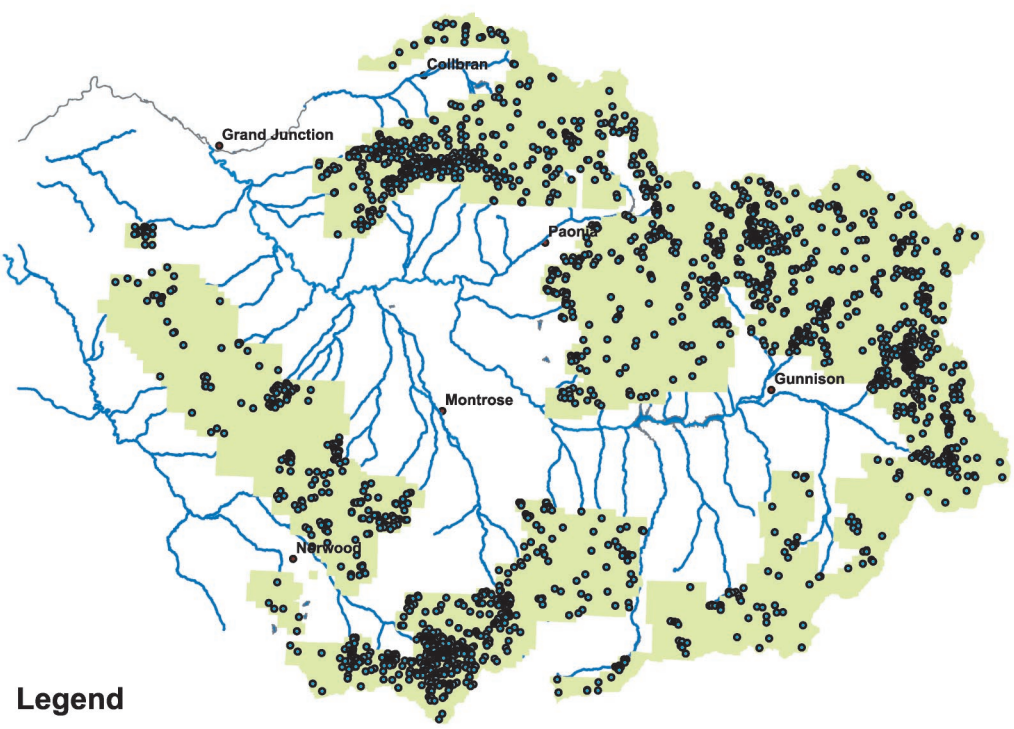


Figure 5. Existing private water rights on the GMUG NF.

[1]The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

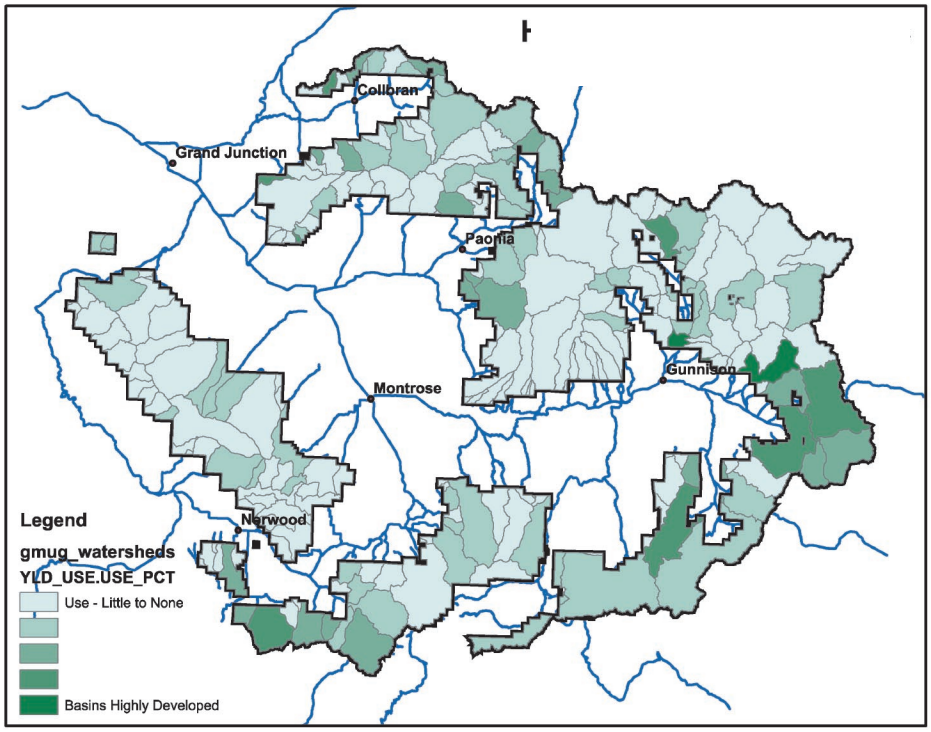


Figure 6. Historic water withdrawals on the GMUG NF.

of water storage and release records, but quickly learned that correlating reservoir operations with stream flows was a very a complicated accounting problem. As a result, we abandoned the idea of addressing the effects of storage facilities and focused primarily on historic stream diversions.

Given our ability to predict native stream flows and with some indication of how much water is being diverted off for human uses, we were able to estimate how much water is being left in the streams. A determination on whether or not that is enough water to fulfill national forest purposes and public expectations really depends upon the site-specific situation and was not something we could answer in the context of a forest-wide assessment.

Using the information gained from our evaluation of basin hydrology and gaging records, we were able to make projections of basin water yields. When combined with water diversion records associated with identified diversion points, we were able to portray the scale of water withdrawals on the forest as a percentage of yield. (Figure 6) This served as a good communication tool with our working group and the public, and indicated which of our basins are heavily impacted by water diversions. The effects of storage are not considered. The percent of basin yield that was captured and diverted was calculated, whether there were one or many points of diversion. Several basins on the forest have more than 50% of their annual yield captured and removed from the stream, with the largest proportion being 70% of annual yield.

Comparison of Instream Flow Quantification Methods

The West Willow Creek study was intended to look in detail at a representative forest stream and compare several popular instream flow estimation methods. West Willow Creek (Figure 7) is a stream with high flow dependent values, typical in size and morphology of many headwater streams and one with no existing diversions above the study site. The West Willow Creek Study was a joint effort between the Forest Service, Colorado Water Conservation Board and Colorado Division of Wildlife. The field work was done by our integrated team, the hydrology work was done by the Forest Service, and Miller Ecological Consultants did the PHABSIM modeling.

Five methods were examined in detail. The Colorado R2Cross Method (Nehring 1979; Espegren 1996) used by the Colorado Water Conservation Board is based on one or more cross sections and the hydraulic modeling and selection of established width, depth, and velocity criteria intended to provide for "reasonable" protection of aquatic resources. The modified Tennant Method (Tennant 1976), which is based on a percentage of mean monthly flows, is intended to mimic the form of a natural hydrograph. The Wetted Perimeter Method (Nelson 1980; Stalnaker et al. 1995) is obtained by graphing discharge versus wetted perimeter and selecting the inflection point. The Physical Habitat Simulation Method (PHABSIM) requires establishment of multiple cross sections and is resurveyed at different discharges. It results in a determination of the

Figure 7. Field work on the West Willow Creek study.

weighted usable area according to fish species and life stage (Milhous et al. 1989). These four methods are designed to estimate the flows necessary to sustain fish populations. The fifth method used was developed by the U.S. Forest Service with the objective of estimating flows necessary to move sediment and maintain channel morphology (Schmidt and Potyondy 2004). This method requires a determination of bankful discharge and the 25-year return interval flow. Table 1 (see next page) summarizes the characteristics of each method and their strengths and weaknesses.

Using our water level recorder and the 20 discharge measurements we made over a two-year period, a correlation was established between the West Willow site and a nearby USGS gage, and estimates of mean daily flow values were derived. The mean annual peak is approximately 22 cubic feet per second (cfs) (0.62 cubic meters per second [cms]) and the mean base flows are 3 to 4 cfs (0.085 to 1.13 cms). Bankful discharge is estimated at 17.5 cfs (0.5 cms).

Upon completion of fieldwork and analysis of the data, we compared the resulting protection flows that were determined from either application of standards or interpretation by staff. These results were overlaid on the mean annual hydrograph, which was synthesized by correlating short term mean daily flow records at our study site with long term records at a nearby USGS gaging site (Figure 8).

The Tennant method tracks the hydrograph well, as expected. Applying the standards used for R2Cross resulted in a 1.6 cfs (0.045 cms) winter flow and 2.6 cfs (0.074 cms) summer flow protection recommendation. Interestingly in this case, the Wetted Perimeter (5.7 cfs [0.16 cms]) and PHABSIM (5.0 cfs [0.14 cms]) flows were very similar. PHABSIM could be interpreted for seasonal variability but to date this has not been done for this study. In order to provide for sediment transport and periodic disturbance of sufficient magnitude to maintain fluvial processes, flows would need to be protected once they exceed 80% of

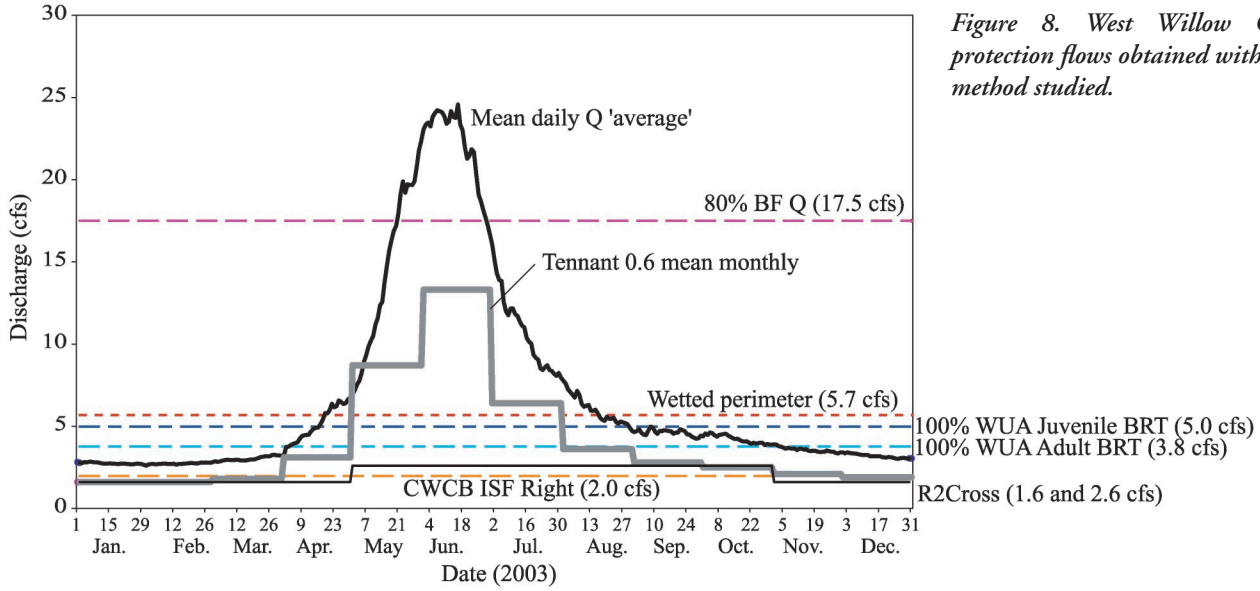


Figure 8. West Willow Creek protection flows obtained with each method studied.

Table 1 - Comparison of instream flow quantification methods.

A. General Characteristics of ISF Methods

	Hydrology Based	Field Based	Existing Standards	Time/Cost Efficiency
R2X	No	Yes	Yes	Moderate
PHABSIM	No	Yes	No	High
Tennant	Yes	No	Yes	Low
Wetted Perimeter	No	Yes	No	Moderate
Channel Maintenance	Yes	No	Yes	Moderate

B. Pros and Cons of Each Methodology

R2Cross

Pros	Cons
Data gathering in short period of time	Modeling limitations - Current version of R2X doesn't allow Manning "N" to vary with changes in modeled flows (modeling accuracy constrained to 0.4 to 2.5 times measured flow)
Inexpensive	Only addresses in-channel fishery needs, mostly used for trout
There are accepted standards	No flexibility of standards
Data and results are reproducible	Doesn't address out-of-channel needs or invertebrates
Looks at "reasonable protection" of trout	Doesn't' address pools w/in Manning's equation (assumes that maintaining riffle habitats will also maintain pool habitats)
Institutionally accepted by the State of Colorado	TU says amounts are too low
R2Cross-based ISF recommendations have been used by the state to "preserve the natural environment to a reasonable degree" since 1973.	Doesn't deal with flushing flow or channel maintenance
	Doesn't deal with impacts of changes of velocity on fish (is not an issue on Willow Creek, is an issue on the GMUG)
	Have we been able to calculate if R2X provides a "reasonable level of protection" since the 1979 standards setting?

PHABSIM

Pros	Cons
Very adaptable/more variables	Labor intensive/ expensive
Deals with habitat types other than riffles	"Illusion of technique"
Deals with life history of fish species	No relationship between WUA and fish
Facilitates looking at tradeoffs of different flows	Takes 1 year to develop data
Learn more about the stream	No standards - difficult to defend in legal arena
Useful where we need more detailed analysis (in a high conflict area, may be a useful tool)	Difficult to interpret results
	Difficult to apply across all of the GMUG
	Consistency of analytical technique--the different variables can lead to subjectivity

Tennant (Montana Model)

Pro	Con
Inexpensive	No clear standards
Don't have to go to field	Relies on professional judgement
Ball park answer	May not have records, rely on empirically derived estimates which may be inaccurate
Accounts for full range of flows	
Based on actual records, where they exist	
Commonly used/easily applied	

Table 1 continues on next page.

Table 1. (continued)

Wetted Perimeter

Pro	Con
Can be evaluated with data using several hydrologic models	Inflection pt. can be subjective based on channel type
	Requires fieldwork
	Is a single flow recommendation rather than a two stage one
	No biological component

USFS Channel Maintenance Method

Pro	Con
Looks at channels maintaining the system, moving the sediment, plus benefits to habitat	This process may not necessarily create a "healthy" stream
Has side benefits related to over bank flows and recharging banks/ground water	Difficult to administer
Simple model	If you have in system storage there is more difficulty in meeting flow requirements
Easy to calculate discharge requirments until bank full level level is exceeded	Not as applicable below dams for determining flow releases
Greater applicability to some stream types	Above bank full flows discharge levels difficult to determine
Has very specific standards	Some stream types not applicable
	Works best where sufficient flow data exists to conduct frequency analysis

QBF (bankfull discharge), which is 14 cfs (0.40 cms), and protection would continue until flows exceeded the 25-year flood event (61 cfs [1.7 cms]).

The consequences of instream flow protection on limitations to potential channel storage projects are presented in Table 2. This table displays West Willow Creek's total average basin water yield of 4,986 acre-feet (6,147,738 m^3) and the amounts and percentage of yield that would still be available above protection levels and therefore available for storage. The values range from a low of 21% of annual yield when the objective is to provide for both channel maintenance and adult brown trout (*Salmo trutta*) habitat needs, to a high of 69% of the annual yield when protection is based upon standards used in R2Cross.

Collaborative Process

The Pathfinder project involved a lengthy collaborative process. True collaboration involves meaningful dialogue between stakeholders and differing points of view provide for a broader approach to management options. While total agreement is rare, the outcome of collaboration is a function of many minds rather than a few. The "front loading" of stakeholder involvement is a departure from the traditional federal agency process where agency scientists and specialists work out a plan or system of strategies then release the results to the public for review. Collaboration early on, brings issues to the forefront sooner rather than later. It attempts to address a full array of concerns, build consensus, and have participants attain a level of ownership in the outcome. Key to any collaborative approach is a group of stakeholders committed to the process, the outcome, and representative of a large array of public perspectives.

The Pathfinder Steering Committee began meeting in May 2000. The Steering Committee was a diverse group of individuals representing the perspectives of organizations or entities concerned with water-resource use and management on national forest lands, private water users, local water purveyors and managers, state regulatory and management interests, and conservation and environmental perspectives. Individual participants and their organizations included: Reeves Brown (Club 20), Charlie Stockton (Ute Water), Peter Kasper (Overland Ditch and Reservoir Company), Steve Glazer (High Country Citizens Alliance), Stan Irby (rancher), John Trammell (Trout Unlimited), Nathan Fey (San Miguel Watershed Coalition), Dan Merriman (Colorado Water Conservation Board), Wayne Schieldt (Colorado Division of Water Resources), Ron Valvarde (Colorado Division of Wildlife), Bob Storch and Carmine Lockwood (U.S. Forest Service). This group held 45 meetings and conducted several public outreach efforts to address instream flow issues and management for the GMUG.

Over time, the interest of the Steering Committee became clear and they focused much of their work addressing two major perspectives on providing for instream flows: (1) Bypass flows, meaning a federal action that imposed regulatory control by administratively requiring a

Table 2. Water available for withdrawal in West Willow Creek.

	Flow Protection		Necessary for Instream Flows (AF and % of total)	Available for Development (AF and % of total)
Average Basin Yield = 4986 AF				
Existing CWCB ISF Claim	2.0 cfs Jan - December		1450 (29%)	3536 (71%)
R2X Method	1.6 cfs Nov - April 2.6 cfs May - Oct		1526 (31%)	3460 (69%)
Tennant Method	Jan. - 1.6 cfs	July - 6.4 cfs	2977 (60%)	2009 (40%)
	Feb. - 1.6 cfs	Aug. - 3.6 cfs		
	March 1.8 cfs	Sept. - 2.8 cfs		
	Apr. - 3.1 cfs	Oct. - 2.5 cfs		
	May - 8.7 cfs	Nov. - 2.1 cfs		
	June - 13.3 cfs	Dec. - 1.9 cfs		
Wetted Perimeter	5.7 cfs, Jan - Dec		3118 (63%)	1868 (37%)
PhabSim (Juvenile) Method	5.0 cfs, Jan - Dec		2941 (59%)	2045 (41%)
PhabSim (Adult) Method	3.8 cfs, Jan - Dec		2526 (51%)	2460 (49%)
Channel Maintenance*	14 cfs, 21 May - 21 June		1687 (34%)	3299 (66%)
R2X + BF Method			3009 (60%)	1977 (40%)
PhabSim (Juvenile) + BF Method			4239 (85%)	747 (15%)
PhabSim (Adult) + BF Method			3917 (79%)	1069 (21%)

Time of flow protection varies in accordance with availability of flows exceeding 80% bankfull Q. During low flow years, no water would be allocated for channel maintenance.
Calculations are based upon a synthesized mean annual hydrograph correlated between the study site and adjacent long-term USGS gaging sites.

needed volume of water to by-pass the diversion structure or that require specific releases from storage facilities to provide downstream flows; and (2) Colorado instream flow rights that reserve a baseline flow rate to protect the environment to a "reasonable degree". The Steering Committee determined that an array of existing "tools" or mechanisms could be used to provide some level of instream flow protection or enhance stream flows in Colorado. (Table 3) They further found that in order to achieve cooperation and coordination between the various stakeholders involved in water use and water management, it was critical to implement these tools in a tiered approach, meaning that some tools are more acceptable and easier to implement if they follow an order of implementation.

Within the Steering Committee, the perspectives on these two procedures to provide for instream flow had varied acceptance. For example, the state of Colorado asserted that the Forest Service does not have the legal authority to impose bypass flows on a decreed water right. In contrast, some stakeholders held that bypass flows are the "price" of doing business on national forest land, or that imposing bypass flow requirements was the most effective means to protect instream flows on public lands.

The consensus of the Steering Committee was to use an array of options or strategies rather than focusing on one solution. First was to focus on cooperative efforts - voluntary actions that provide for better operations and management of water and then, if resource protection needs are not met, to move to more coordinated efforts - actions that involve multiple participants, call on differing authorities and institutional programs. A last resort would be to take unilateral federal action and impose bypass flow requirements or acquire water through condemnation. This process of tiered implementation is important, and if done in a progressive manner, a full array of opportunities to provide for instream flows would have been considered by the Forest Service before there was a need to move into the more regulatory actions where bypass flow requirements are imposed on water users.

MANAGEMENT STRATEGIES

The tiered implementation of tools was captured in a management strategy matrix (Table 4, p. 524). This

Table 3. Tools for instream flow protection.

Forest Service Management Options	Cooperative or Partnership Approach Options	CWCB's Instream Flow Program Options
1. Inventory and consult with permittee on water rights, water uses, and permits.	11. Assist Colorado Water Conservation Board (CWCB) and State Engineer in monitoring and protecting existing ISF rights on GMUG National Forests (NF)	21. Pursue opportunities offered by CWCB ISF Program
2. Negotiate permit conditions for instream flow purposes on new water development.	12. Work with CWCB to recognize the NF land and resource management objectives and quantification methods for streams on the Forest may differ from the objectives and methods CWCB currently provides.	22. Seek CWCB agreement to appropriate or acquire needed flows on NF lands.
3. As a permit condition, limit diversions to decreed amounts when needed, seasonally.	13. Investigate voluntary re-operation alternatives with existing diversion permit holders to meet FS and permittee objectives.	23. Encourage CWCB to file on USFS flow recommendations the year they are made.
4. Implement channel and fish habitat improvements to compensate for lower flows when a determination has been made that such improvements have biologic merit.	14. Seek voluntary agreement with new applicants to develop operational plans to meet FS and applicant's objectives.	24. Establish legal, shared property ownership with the CWCB for acquired ISF rights on NFS lands.
5. Consider other forest practices that influence stream flows, such as vegetation management.	15. Consider new and expanded storage with participation by the USFS for instream flow purposes (which include the Forest Service appropriating or acquiring an interest in the water rights).	25. Encourage CWCB to file on peak spring flows and shoulder flows under ISF Program to allow for recharge of groundwater and to maintain riparian and off-channel habitat.
6. Use land and water acquisition programs and water right purchases to obtain water rights that could be converted to instream flow (ISF) rights.	16. Consider off-channel storage for later release.	26. Encourage the State Legislature to expand the CWCB ISF program to include recreational, scenic, and aesthetic uses.
7. Ensure that water rights acquired as part of an USFS acquisition or exchange are incorporated into the Forest water right inventory.	17. Provide State Engineer with documentation on water rights not being used.	27. Identify stream segments currently limited by availability of water for ISF protection and improvement.
8. Protect water rights held by USFS.	18. Initiate educational program for water conservation and promote/facilitate delivery and application efficiencies.	
9. Expand USFS efforts to inventory and assess the aquatic and riparian resources on GMUG NF.	19. Establish ISF management objectives for watersheds on the GMUG NF.	
10. Practice good watershed and streamside management to deliver sufficient quantity and quality of water to meet downstream and forest uses.	20. Work cooperatively with local governments to establish Recreational Instream Channel Diversion (RICD) on stream segment(s) located on NFS lands.	

matrix of strategies looks at implementation by working in two directions. First, streams were categorized into four diversion classes. These four categories are: no diversions; zero to 25% diverted; 25 to 50% diverted; and over 50% diverted. The tools or strategies were identified for implementation moving from top to bottom of the matrix in a tiered approach based on the resource or water use objectives. Those objectives and values included water rights (recognizing existing rights), flow regimes, future water development, recreation, restoration, and water quality.

Implementation strategies are progressive in their approach. As water use increases, the protection objectives become more intensive. The implementation strategies also vary depending upon the instream flow objectives or values being managed for.

To evaluate the effectiveness of the strategies outlined in the matrix, the Steering Committee conducted a paper exercise where we tested the process using some real-world hydrologic conditions and water use situations. Each time the test showed that there were at least one or two points along the implementation process where instream flow needs could be met provided there was some level of agreement between the entities involved to use the tools. If not, then the tool of last resort was the final tier of action and the Forest Service would have to take unilateral action (requiring bypass flows) to provide the necessary resource protection.

With the tests completed and input from the public and those agencies, entities, and organizations represented by the Steering Committee, a Steering Committee Report, Strategies for Instream Flow Management, was finalized in May 2004. This report is available at the Grande Mesa, Uncompahgre and Gunnison National Forests Website, *http://www.fs.fed.us/r2/gmug/policy*.

The Steering Committee Report is written from the stakeholders' perspective to detail strategies and processes that could be used by the Forest Service to protect or provide for instream flows on national forest lands. It relies on existing procedures, programs, regulations and laws to manage for instream flows. It focuses on cooperation and coordination before unilateral action by the Forest Service is suggested. It is intended to provide the Forest Service with a possible strategy or template to address instream flows in the Forest Plan revision.

This Steering Committee Report is not a Forest Service document, nor does it represent a final decision by the GMUG National Forests on instream flow management, but it is a workable strategic plan for instream flow management in Colorado.

The Pathfinder Project will provide forest planners with possible instream flow objectives, desired conditions for water development, and tools that may work as standards and guidelines for instream flow management.

Conclusions

The technical aspects of this project have afforded us an opportunity (funding and priority) to gather related hydrologic data and do a kind of analysis that is not typically done. This has proven to be beneficial for uses beyond our instream flow needs deliberations. It has allowed us to improve our understanding of the water resources that shape the local environment. That understanding may prove to be most the lasting benefit of what this project set out to accomplish. The analysis process was a challenging blend of field hydrology, statistical analysis and GIS work.

Did collaboration accomplish our goals? Yes and no. The key benefits of the process have proven to be the relationships we have developed with the stakeholders, and in particular with their representatives on the Steering Committee. The Pathfinder Project has developed a level of trust among the parties involved that has already carried over into other projects, and that can with trust, cooperation and coordination, continue into the future.

The Forest Service now has an approach and strategy that can be incorporated into the Forest Plan Revision process for instream flow management and water management that comes to the agency with a level of support from our stakeholders and the public that we could not have developed in the more traditional plan review process.

The Pathfinder Project was a major time commitment for the forest involving almost four years of effort. The results of the collaborative effort produced a product that wasn't exactly what was envisioned by the Forest Service when it embarked on this project. That is the nature of a collaborative efforts, and they frequently take on the focus and concerns of the stakeholders and participants rather than agency expectations. Collaboration however provides a critical public perspective early in the process rather than at the end of the planning cycle, which is most useful to any public agency.

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Table 4. Instream flow management matrix for Grand Mesa, Uncompahgre and Gunnison National Forest watersheds.

	No Recorded Diversions		0 to 20% Diverted of Annual Yield	
	Species of Concern	No Species of Concern	Species of Concern	No Species of Concern
	GOAL I: Preserve existing natural flows for the benefit of species of concern, ecosystem integrity and reference conditions.	GOAL II: Protect hydrologic flow regimes needed to maintain baseline values.	GOAL III: Maintain existing flow conditions for the benefit of species of concern and ecosystem integrity.	GOAL IV: Establish and/or maintain a reasonable balance between consumptive and non-consumptive uses of water resources on the forest.
Water Rights	OBJECTIVE I. A: Preservation of these watersheds will be the Forest Service's top priority for the conservation of species of concern TOOLS: Tier I: 9, 10, 19, 21, 22, 23, 25 Tier II: 12 Tier III: none	OBJECTIVE II. A: Instream flow volumes, including peak flows and timing regimes shall not be reduced to the extent that existing baseline flow-related values are unacceptably impacted or degraded within a sixth level watershed (HUC) TOOLS: Tier I: 10, 19, 21, 22, 23, 25 Tier II: 6 Tier III: none	OBJECTIVE III. A: Recognize existing legal water uses TOOLS: Tier I: 1 Tier II: 7, 8, 17 Tier III: none	OBJECTIVE IV. A: Recognize existing legal water uses TOOLS: Tier I: 1 Tier II: 7, 8, 17 Tier III: none
	OBJECTIVE I. B: Recognize conditional water right TOOLS: Tier I: 1, 17 Tier II: none Tier III: none	OBJECTIVE II. B: Recognize conditional water rights TOOLS: Tier I: 1, 17 Tier II: none Tier III: none	OBJECTIVE III. B: Recognize conditional water rights TOOLS: Tier I: 1 Tier II: 7, 17 Tier III: none	OBJECTIVE IV. B: Recognize conditional water rights TOOLS: Tier I: 1 Tier II: 7, 17 Tier III: none
Stream Flows	OBJECTIVE I. C: Achieve flow regimes that maintain self-sustaining populations of species of concern TOOLS: Tier I: 9, 10, 21, 22, 23, 25 Tier II: 4, 6 Tier III: none	OBJECTIVE II. C: For those segments identified in cooperation with the DOW as potentially providing high value habitat for reintroduction of species of concern, pursue protection efforts TOOLS: Tier I: 10, 19, 21, 22, 23, 24, 25 Tier II: 4, 18 Tier III: none	OBJECTIVE III. C: Achieve flow regimes that maintain self-sustaining populations of species of concern TOOLS: Tier I: 9, 10, 21, 22, 23, 25 Tier II: 4, 5, 6, 13 Tier III: Unilateral federal actions	OBJECTIVE IV. C: Ensure instream flows necessary to sustain baseline ecological values TOOLS: Tier I: 9, 10, 21, 22, 23, 25 Tier II: 4, 5, 6 Tier III: Unilateral federal actions
Water Development	OBJECTIVE I. D: Entertain future water development only when the action can be determined to have an insignificant impact on flow regimes necessary for the conservation of species of concern TOOLS: Tier I: 2, 3, 10, 11, 19 Tier II: 18 Tier III: none	OBJECTIVE II. D: Accommodate future water development requests when a high level of ecosystem protection can be ensured TOOLS: Tier I: 3, 11, 21 Tier II: 2, 18 Tier III: none	OBJECTIVE III. D: Entertain future water development requests when a high level of population protection and habitat protection can be ensured TOOLS: Tier I: 2, 3, 4, 19 Tier II: 14, 15 Tier III: none	OBJECTIVE IV. D: Accommodate future water development so long as baseline recreational and ecological values are not precluded TOOLS: Tier I: 3, 15 Tier II: 2, 4 Tier III: none
Recreational	OBJECTIVE I. E: Protect appropriate instream flows so that recreational uses (high use areas/unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 10, 11, 15, 20 Tier II: 12, 18, 25, 26 Tier III: none	OBJECTIVE II. E: Protect appropriate instream flows so that recreational uses (high use areas/ unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 4, 10, 15, 20 Tier II: 12, 24, 25, 26 Tier III: none	OBJECTIVE III. E: Protect appropriate instream flows so that recreational uses (high use areas/ unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 1, 4, 10, 15, 20, 26 Tier II: 12, 24, 25 Tier III: none	OBJECTIVE IV. E: Protect appropriate instream flows so that recreational uses (high use areas/ unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 1, 4, 10, 15, 20, 26 Tier II: 12, 24, 25 Tier III: none
Restoration				
Water Quality	OBJECTIVE I. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2 Tier III: none	OBJECTIVE II. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2 Tier III: none	OBJECTIVE III. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2, 3 Tier III: none	OBJECTIVE IV. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2, 3 Tier III: none

Table 4. (continued)

20 to 50% Diverted of Annual Yield		Greater Than 50% Diverted of Annual Yield	
Species of Concern	No Species of Concern	Species of Concern	No Species of Concern
GOAL V: Maintain existing flow conditions for the benefit of species of concern and ecosystem integrity.	GOAL VI: Establish and/or maintain a reasonable balance between consumptive and non-consumptive uses of water resources on the forest.	GOAL VII: Maintain existing flow conditions for the benefit of species of concern and ecosystem integrity.	GOAL VIII: Establish and/or maintain a reasonable balance between consumptive and non-consumptive uses of water resources on the forest.
OBJECTIVE V. A: Recognize existing legal water uses TOOLS: Tier I: 1 Tier II: 7, 8, 17 Tier III: none	OBJECTIVE VI. A: Recognize existing legal water uses TOOLS: Tier I: 1 Tier II: 7, 8, 17 Tier III: none	OBJECTIVE VII. A: Recognize existing legal water uses TOOLS: Tier I: 1 Tier II: 7, 8, 17 Tier III: none	OBJECTIVE VIII. A: Recognize existing legal water uses TOOLS: Tier I: 1 Tier II: 7, 8, 17 Tier III: none
OBJECTIVE V. B: Recognize conditional water rights TOOLS: Tier I: 1 Tier II: 7, 17 Tier III: none	OBJECTIVE VI. B: Recognize conditional water rights TOOLS: Tier I: 1 Tier II: 7, 17 Tier III: none	OBJECTIVE VII. B: Recognize conditional water rights TOOLS: Tier I: 1 Tier II: 7, 17 Tier III: none	OBJECTIVE VIII. B: Recognize conditional water rights TOOLS: Tier I: 1 Tier II: 7, 17 Tier III: none
OBJECTIVE V. C: Achieve flow regimes that maintain self-sustaining populations of species of concern TOOLS: Tier I: 9, 10, 21, 22, 23, 25 Tier II: 4, 5, 13, 15, 17 Tier III: Unilateral federal actions	OBJECTIVE VI. C: Ensure instream flows necessary to sustain baseline ecological values TOOLS: Tier I: 9, 10, 21, 22, 23, 25 Tier II: 4, 5, 6, 13 Tier III: Unilateral federal actions	OBJECTIVE VII. C: Achieve flow regimes that maintain self-sustaining populations of species of concern TOOLS: Tier I: 9, 10, 21, 22, 23, 25 Tier II: 4, 5, 6, 13, 16 Tier III: Unilateral federal actions	OBJECTIVE VIII. C: Pursue instream flows necessary to sustain baseline ecological values TOOLS: Tier I: 9, 10, 21, 22, 23, 25 Tier II: 4, 5, 6, 13 Tier III: Unilateral federal actions
OBJECTIVE V. D: Entertain future water development requests when a high level of population protection and habitat protection can be ensured TOOLS: Tier I: 2, 3, 4, 19 Tier II: 14, 15 Tier III: none	OBJECTIVE VI. D: Accommodate future water development so long as baseline recreational and ecological values are not precluded TOOLS: Tier I: 3, 15 Tier II: 2, 4 Tier III: none	OBJECTIVE VII. D: Do not entertain future water development requests if it would contribute to degradation that causes loss of species viability TOOLS: Tier I: 2, 3,14 Tier II: 15, 16 Tier III: none	OBJECTIVE VIII. D: Scrutinize future water development to avoid unacceptable impairment of baseline recreational and ecological values TOOLS: Tier I: 3, 4, 15 Tier II: 2 Tier III: none
OBJECTIVE V. E: Protect and/or enhance appropriate instream flows so that recreational uses (high use areas/ unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 1, 4, 10, 15, 20, 26 Tier II: 3, 6, 12, 16, 18, 24, 25 Tier III: none	OBJECTIVE VI. E: Protect and/or enhance appropriate instream flows so that recreational uses (high use areas/ unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 1, 4, 10, 15, 20, 26 Tier II: 3, 6, 12, 16, 18, 24, 25 Tier III: none	OBJECTIVE VII. E: Protect and/or enhance appropriate instream flows so that recreational uses (high use areas/ unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 1, 4, 10, 15, 20, 26 Tier II: 6, 12, 16, 18, 24, 25 Tier III: none	OBJECTIVE VIII. E: Protect and/or enhance appropriate instream flows so that recreational uses (high use areas/ unique recreation attractions) are not precluded by future water development TOOLS: Tier I: 1, 4, 10, 15, 20, 26 Tier II: 6, 12, 16, 18, 24, 25 Tier III: none
OBJECTIVE V. F: For those segments identified in cooperation with the DOW as potentially providing high value habitat and/or recovery sites pursue restoration efforts to improve flow and habitat conditions TOOLS: Tier I: 2, 3, 11, 13, 15, 21, 22, 23, 24, 25 Tier II: 4, 5, 6, 7, 12, 16, 18 Tier III: Unilateral federal actions	OBJECTIVE VI. F: Consider restoration of baseline values where evaluation has concluded that restoration is needed. TOOLS: Tier I: 1, 3, 5, 6, 10, 11, 13, 19, 21, 22, 23, 24, 25 Tier II: 4, 7, 18, 27 Tier III: Unilateral federal actions	OBJECTIVE VII. F: For those segments identified in cooperation with the DOW as potentially providing high value habitat and or recovery sites pursue restoration efforts to improve flow and habitat conditions TOOLS: Tier I: 2, 3, 6, 13, 15, 21, 22, 23, 24, 25 Tier II: 4, 5, 7, 12, 16, 18 Tier III: Unilateral federal actions	OBJECTIVE VIII. F: Seek restoration of baseline values where evaluation has concluded that restoration is needed. TOOLS: Tier I: 1, 3, 5, 6, 10, 11, 13, 19, 21, 22, 23, 24, 25 Tier II: 4, 7, 18, 27 Tier III: Unilateral federal actions
OBJECTIVE V. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2, 3, 5 Tier III: none	OBJECTIVE VI. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2, 3, 5 Tier III: none	OBJECTIVE VII. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2, 3, 5 Tier III: none	OBJECTIVE VIII. G: Recognize Forest Service obligation to comply with provisions of the Clean Water Act (303(d)) as it relates to instream flow TOOLS: Tier I: 10 Tier II: 2, 3, 5 Tier III: none

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