

EXECUTIVE SUMMARY

The purpose of this report is to summarize the results of a reconnaissance level investigation of 19 alternatives to supply 20,000 acre-feet of water to the head of the 15-Mile Reach to help recover four species of endangered fish in the Colorado River in Colorado pursuant to the Programmatic Biological Opinion (PBO) for the 15-Mile Reach. This investigation is in response to the findings, conclusions and recommendations of the Phase 1 report for this project, *Phase 1 Coordinated Facilities Water Availability Study for the Endangered Fishes of the Upper Colorado River* (Colorado Water Conservation Board, September 2000). These 19 alternatives include:

1. Expanded Coordinated Reservoir Operations

- Alternative 1a: Green Mountain Reservoir reduced winter power operations
- Alternative 1a: Green Mountain Reservoir conjunctive pool operations
- Alternative 1a: Preemptive release and water carried over in Green Mountain Reservoir
- Alternative 1b: Ruedi Reservoir modified operations
- Alternative 1d: Modify Colorado-Big Thompson (CBT) west slope facilities operations
- Alternative 1e: Denver Water system modified operations
- Alternative 1f: Bypass diversions to storage
- Alternative 1g: Reduce constraints on Coordinated Reservoir Operations Program (CROP)

2. Efficiencies of Conveyance And Distribution Facilities

- Alternatives 3d and 3e investigated as components of 1a: Re-analysis of Grand Valley Project (GVP) and analysis of Grand Valley Irrigation Company (GVIC) water management for additional efficiency as a component of Alternative 1a, Green Mountain Reservoir operations.

3. New Storage Projects

- Alternatives 4f, 4g, 4k, 4n, and 4o: New tributary storage facilities below Shoshone Power Plant
- Alternative 4m: New mainstem storage facility

4. Power Plant Operations and Scheduling

- Alternative 5a: East slope power operations and scheduling, investigated as a component of Alternative 1d: CBT west slope facilities operations.

- Alternative 5b: Shoshone Power Plant

5. Other Alternatives

- Alternative 6a: Insurance Pool

The methodology used in the analyses, together with the results and conclusions from this investigation are summarized in this report. Detailed analysis methodology, results and conclusions are presented in a series of eleven Technical Memoranda that are included in the Appendices.

GENERAL RESULTS, CONCLUSIONS AND RECOMMENDATIONS

The findings, conclusions and recommendations listed below concerning feasibility of the alternatives are the result of using a monthly hydrology model called StateMod and the C1 data set as agreed by the Executive Committee at the start of the study process. It was realized that perspectives and model analysis might differ from the perspectives and model analysis of some Executive Committee members and the water conservation districts, water suppliers and water users who may be affected by these alternatives.

In reality, reservoir operators will not preemptively release water from their reservoir(s) unless one of two conditions exists: 1) the operator, based upon real time snow pack and runoff knowledge, determines that it is highly likely the reservoir will fill and spill or 2) the operator has access to an “insurance pool” of water in case a preemptive release results in the loss of water to the reservoir. The first condition is basically what occurs in the CROPS and cannot be counted as a new alternative. The second condition is the most promising alternative for meeting the 20,000 acre-foot goal through use of existing reservoirs. While these conclusions are somewhat different than a reader might deduct by solely reading the study, the study participants agreed that it was important, in furtherance of the commitments in the Programmatic Biological Opinion, to list the following study results for documentation purposes:

1. Supplying 20,000 acre-feet to the 15-Mile Reach was not required every year. It was necessary to supply the 20,000 acre-feet in only six years (1975, 1978, 1979, 1980, 1985 and 1986) and possibly 1982 and 1991 for a total of eight years out of the 17 years during the 1975-91 study period.
2. Supplying the 20,000 acre-feet was not required during the very dry years of the study period. For example, releases were not required in 1977 or 1981. Further analysis indicates that supplying the 20,000 acre-feet would not have been required in 2001 and 2002. It is also important to recognize that there is a fundamental difference between what a monthly hydrology model calculates is possible and what reservoir operators will actually agree to do after dry years. For example, no reservoir operator would allow non-required reservoir releases in years following dry years—like 1978 or 1982—until it was demonstrated that the reservoir would fill, regardless of the fact that the model indicates this type of release could be accomplished. The difference in the projected availability of releases and the reality of available releases is because the model has “perfect

knowledge” on when the reservoir would refill—reservoir operators do not. Because the model indicates that supplying the 20,000 acre-feet in dry years is not required, it provides reservoir operators some comfort that firm yield would not be impacted.

3. Based on the results of sensitivity analysis, it appears that it should be possible to make the CROP bypasses and the 20,000 acre-feet release and have only limited effects (on junior water rights).
4. Results of sensitivity analysis indicate that if an alternative is feasible under the current conditions of the C1 Data Set, it is likely to remain feasible under future flow conditions in which there would be up to approximately 120,000 acre-feet of additional depletions.
5. Sensitivity analysis on estimated CROPS bypasses, reduced Grand Valley Project demands, Palisade Pipeline bypasses and the Shoshone Power Plant maintenance schedule indicates continued feasibility of the alternatives investigated in the Technical Memoranda. Sensitivity analyses involving these parameters indicate there would be little effect on availability of Green Mountain Reservoir storage for making the 20,000 acre-feet release from CROPS bypasses, reduced Grand Valley Project demands, Palisade Pipeline bypass flows and the Shoshone Power Plant maintenance schedule. Including CROPS bypasses, however, would not always leave sufficient release capacity through the Green Mountain Reservoir turbines to make the 1,000 cfs CFOPS release during the 10-day peak flow. This lack of sufficient release capacity at Green Mountain Reservoir would necessitate allocating responsibility for making a portion of the 20,000 acre-feet CFOPS release to other reservoirs. The opportunity for Green Mountain Reservoir to function as an insurance pool in these situations and payback the other reservoirs could also be considered.
6. An analysis was made of the effect on Colorado River flows at the head of the 15-Mile Reach to determine if making the 20,000 acre-feet release generally during June would reduce flows during other months. Results of this analysis indicate that the maximum average monthly reduction occurred during July and reduced flows in that month by 1,048 acre-feet (295,601 acre-feet to 294,553 acre-feet).

Throughout the investigation, it was noticed that the exchanges and substitutions among Dillon, Granby and Williams Fork reservoirs using the C1 data set in StateMod differed from the simulations by Denver Water using their daily PACSM model. In order to address this issue, the CWCB modified StateMod and a fifth revision was made to the C1 Data Set. A comparison of the base runs with the C1 Data Set (Fourth Revision) and the Modified StateMod and C1 Data Set (Fifth Revision) was made to determine if these changes were sufficient to necessitate redoing the previous work with the Modified StateMod and C1 Data Set (Fifth Revision). A comparison of these two base runs indicated that a difference remained, which was increased storage in Dillon Reservoir and decreased storage in Williams Fork Reservoir. In order to further check the need for rerunning previous simulation runs with the Modified StateMod and C1 Data Set (Fifth Revision), simulation runs for two alternatives were made: (1) Green Mountain Reservoir making the 20,000 acre-feet release and replacing this release using its refill priority and (2) the “Coordinated Reservoir Augmentation Project” with responsibility for

making the 20,000 acre-feet release divided equally among Granby, Green Mountain and Williams Fork Reservoirs. Results of these additional simulation runs did not differ significantly enough to change original conclusions presented in the Technical Memoranda concerning these alternatives. However, comparing simulations by Denver Water using its daily PACSIM model with StateMod showed differences in accounting for exchanges and substitutions into and out of Dillon, Williams Fork and Wolford Mountain reservoirs. These differences would overstate the availability of water for release from these reservoirs for meeting the 20,000 acre-foot goal. Rather than continue to investigate and debate the need for further refinements to the models, it was determined that time would be better spent working on what could be done to meet the 20,000 acre-foot goal.

FEASIBILITY OF EXPANDED CROPS ALTERNATIVES

From an engineering and economic perspective, the following alternatives probably could supply the 20,000 acre-feet to the 15-Mile Reach when required during the study period, at reasonable costs:

- Alternative 1a: Green Mountain Reservoir reduced winter power operations
- Alternative 1a: Green Mountain Reservoir conjunctive pool operations
- Alternative 1a: Preemptive release and water carried over in Green Mountain Reservoir
- Alternative 1d: Modify CBT West Slope Facilities Operations
- Alternative 1e: Denver Water system modified operations
- Alternative 1f: Bypass diversions to storage
- Alternative 1g: Reduce constraints on CROPS

The StateMod model calculated that the effects of supplying the 20,000 acre-feet on reservoir storage, reservoir yield, reservoir operations, hydropower generation, water deliveries, channel constraints, and the Check Case Settlement would vary among these alternatives. These effects are briefly summarized in this report and presented in detail in the Technical Memoranda. The results discussed below and in the Technical Memoranda assume that the StateMod model accurately simulated reservoir operations in this study. Some study participants have questioned that assumption. However, the study participants agreed the studies were sufficient for their purpose and to document the results of the study in order to move on to discussing what can realistically be accomplished to meet the 20,000 acre-foot goal.

The study showed that the above alternatives were generally able to replace the 20,000 acre-feet release/bypass by diverting to storage under the reservoirs' refill rights. This replacement was generally done within a period of several months. In some cases (e.g. Granby Reservoir) the replacement was not completed for several years. In the case of Granby Reservoir, replacement of the 20,000 acre-feet release/bypass to the 15-Mile Reach was probably delayed because Granby Reservoir does not have a decreed refill priority. In general, however, replacement of the 20,000 acre-feet by diverting to storage under the reservoirs' refill rights proved to be more

efficient, effective, and less costly, than some of the measures incorporated into the above alternatives for providing sources of replacement water for the 20,000 acre-feet release/bypass.

Because of this, replacement of the 20,000 acre-feet should be done by diverting to storage under the reservoirs' refill rights rather than utilizing some of the specific strategies included in the above alternatives for replacement. One issue that will have to be addressed is that most existing refill rights are not decreed for this new use. Therefore, most of the reservoirs would require new junior refill rights for this new use.

The only Expanded CROPS alternative that the study showed was not feasible in its proposed form was Alternative 1b, Ruedi Reservoir Operations, which was not able to make the full 20,000 acre-feet release/bypass because of: (1) downstream channel constraints and (2) limited physical water availability which prevented the replacement of the 20,000 acre-feet in Ruedi Reservoir under the Reservoir's refill right. For these reasons, the consultant team recommends that Ruedi Reservoir's contribution to the 20,000 acre-feet release/bypass be limited to 7,000 acre-feet or less.

The "Coordinated Reservoir Augmentation Project" consists of Alternatives 1f and 1g. The "Coordinated Reservoir Augmentation Project" attempts to minimize the risk to individual facilities by placing responsibility on as many facilities as possible for supplying some portion of the 20,000 acre-feet to the 15-Mile Reach. Analysis of this alternative indicates that the 20,000 acre-feet can generally be replaced in the various facilities by diverting to storage under the reservoirs' refill rights or a new refill right. The "Coordinated Reservoir Augmentation Project" may also be necessary because of the limited release capacity at some of the reservoirs. For example, Green Mountain Reservoir was restricted from making both the estimated CROPS bypasses and the 20,000 acre-feet release in one of the eight years of the study period in which the 20,000 acre-feet release would be required.

Technical Memorandum No. 7 (Appendix H) utilized both a proportionate release among nine reservoirs, and an equal release among three reservoirs to model the "Coordinated Reservoir Augmentation Project." A Modified "Coordinated Reservoir Augmentation Project" was developed in which responsibility for supplying the 20,000 acre-feet release was shared among Green Mountain, Granby, Ruedi, Williams Fork and Wolford Mountain Reservoirs. Under this Modified "Coordinated Reservoir Augmentation Project," as much of the 20,000 acre-feet was released from Green Mountain Reservoir as possible without releasing flows through the turbine bypass and releasing the remainder of the 20,000 acre-feet from other reservoirs. The study showed this alternative had the least impact on reservoir storage of all the alternatives investigated.

FEASIBILITY OF EFFICIENCIES OF CONVEYANCE AND DISTRIBUTION FACILITIES ALTERNATIVES

Alternatives 3d, Re-analysis of Grand Valley Water Management Alternatives, and 3e, Analysis of GVIC Water Management, were analyzed as components of Alternative 1a, Green Mountain Reservoir Operations. This analysis focused on: (1) making the 20,000 acre-feet release to the 15-Mile Reach from Green Mountain Reservoir and (2) the potential for replacing this 20,000 acre-feet in Green Mountain Reservoir by accruing “savings” to the Historic Users Pool (HUP) through increased GVP and GVIC efficiency.

Analysis of this alternative indicated that diverting to storage under the Green Mountain refill priority was a more efficient way to replace the 20,000 acre-feet supplied to the 15-Mile Reach than attempting to make this replacement with reduced demand for releases from the Green Mountain HUP. Furthermore, based on the analysis using StateMod and the C1 data set, there was limited reduced demand on the HUP as a result of increased GVP efficiency. Therefore, it appears that this alternative would be a more efficient and effective source of supply for making releases to the 15-Mile Reach during the late summer and early fall than for releases during the spring peak flows.

FEASIBILITY OF NEW TRIBUTARY STORAGE PROJECTS BELOW SHOSHONE

The alternatives for building new tributary storage (Alternatives 4f, 4g, 4k, 4n and 4o) are all costly, due primarily to the limited physical supplies of water available from the tributaries and the need to depend on pumping from the mainstem Colorado River to supply water to most of these proposed reservoirs. However, since cost was the limiting factor, these new reservoir sites should be considered further if the reliability and frequency to provide the 20,000 acre-feet of water from existing reservoirs is not sufficient to meet the Programs needs. This alternative should also considered in coordination with other possible reservoir storage projects that water users need to provide the 10,825 acre-feet of late summer and fall base flow releases for the Program. The economy of scale of building a new reservoir to provide both the 10,825 acre-feet and the 20,000 acre-feet could make a new tributary reservoir more attractive.

FEASIBILITY OF NEW MAINSTEM STORAGE PROJECT

An additional engineering and economic feasibility investigation of the mainstem Webster Hill site was completed in Technical Memorandum No. 4a (See Appendix E). The cost of reservoir storage at this site for making the 20,000 acre-feet release to the 15-Mile Reach would be partially offset by the generation of hydropower. Net capital costs per acre-foot of yield from the Webster Hill Reservoir would range from \$29 to \$134/acre-foot of yield per year depending on the assumed value of hydropower produced at the site. Results from this additional investigation further indicate that this site would likely be feasible if: (1) the necessary right-of-way can be obtained at reasonable cost and (2) the U.S. Fish and Wildlife Service (Service) would approve construction of a reservoir at the Webster Hill site, which would be located in the upper end of the currently designated critical habitat.

The Webster Hill Reservoir would produce a firm yield of 20,000 to 40,000 acre-feet per year. It is important to emphasize that the 20,000 acre-feet release would be available from Webster Hill Reservoir even in dry years when this release would not be required. Therefore, the Webster Hill Reservoir alternative would produce yield with a greater reliability than is required. It makes sense as a next step to analyze the economy of scale of building Webster Hill Reservoir to provide both the 10,825 acre-feet committed by the water users and the 20,000 acre-feet that is the subject of this study.

FEASIBILITY OF POWER PLANT OPERATIONS AND SCHEDULING ALTERNATIVES

Alternative 5a, East Slope Power Operations and Scheduling, was investigated as one component of Alternative 1d, CBT West Slope Facilities Operations. This alternative primarily consisted of: (1) delaying winter deliveries through the Adams Tunnel, (2) using these delayed winter deliveries to replace the release/bypass of the 20,000 acre-feet from Granby Reservoir to the 15-Mile Reach and (3) replacing the delayed deliveries to east slope reservoirs by diversions to storage in these reservoirs under the east slope priorities.

Alternative 5a was not modeled because:

- This alternative cannot be fully investigated using StateMod and the C1 data set. StateMod and the C1 data set only cover the Colorado River basin in Colorado and do not presently extend to east slope facilities and systems. Specifically, StateMod and the C1 data set cannot be used to determine the quantity of deliveries through the Adams Tunnel that could be replaced through use of NCWCD's east slope water rights.
- The Bureau of Reclamation in its October 12, 2001 letter to the Colorado River Water Conservation District concludes that it is not feasible for a number of reasons to delay winter and early spring deliveries of west slope water to the east slope via the Adams Tunnel in order to keep east slope reservoir storage relatively low.

Alternative 1d was found to be an apparently feasible alternative for supplying the 20,000 acre-feet from Granby Reservoir without the possible source of replacement water resulting from Alternative 5a.

Alternative 5b, Shoshone Power Plant, focused on general, not selective, removal of the Shoshone Power Plant priority call. Analysis of this alternative indicated that general removal of this priority call would result in an increase in stored water in those reservoirs, which could supply the 20,000 acre-feet to the 15-Mile Reach; thereby reducing the risk of lower storage and/or lower reservoir yields accruing to those reservoirs. Elimination of the Shoshone priority call decreased the value of Shoshone power production by an average of approximately \$116,000 per year. Therefore, it appears that Alternative 5b could be an efficient and effective component of Alternative 6a, Insurance Pool, discussed below. Further sensitivity analysis of this alternative was completed to determine the effects of removing the Shoshone priority call on November through April Colorado River flows at the head of the 15-Mile Reach. Results of this

analysis indicate that the average monthly reduction in flows at the head of the 15-Mile Reach was approximately 6 cfs.

FEASIBILITY OF OTHER ALTERNATIVES

Alternative 6a, Insurance Pool, would establish an insurance pool to reduce the risk of lower storage and yields to individual facilities providing all or a portion of the 20,000 acre-feet to the 15-Mile Reach. Two possibilities for establishing an insurance pool were considered and investigated:

- Increasing the number of facilities providing a portion of the 20,000 acre-feet to the 15-Mile reach spreads the risk among a larger number of facilities. Allocating responsibility for the 20,000 acre-feet release among several reservoirs is necessary because of limited release capacity in Green Mountain Reservoir, which prohibits Green Mountain Reservoir from making both the CROPS bypass and the 20,000 acre-feet release in six of the eight years of the study period in which the 20,000 acre-feet release would be required.
- Removing the Shoshone priority call in those years in which the 20,000 acre-feet would be supplied to the 15-Mile Reach provides replacement water to storage in those facilities supplying the 20,000 acre-feet release.

Either of these possibilities, or a combination of the two, might provide the basis for an effective insurance pool.

A third, and perhaps the most promising insurance pool concept, was identified late in the comment process for the study. The insurance pool could be provided by the Service's Environmental Pools: first from Ruedi Reservoir and second from Wolford Mountain Reservoir. Each year, the Service would determine whether peak flow augmentation in the spring or low flow augmentation in the fall was the best use of water from the Environmental Pools. If the USFWS decided on or about May 1st of the year that peak flow augmentation was the best use of a portion or all of water from the Environmental Pools, the Service would designate up to 20,000 acre-feet of the water as the insurance pool for preemptive releases from existing reservoirs to augment peak flows in the spring. That way, operators of existing reservoirs would have virtually no risk to yield from their reservoirs if they preemptively released water from those reservoirs. By way of example, if Denver Water released 10,000 acre-feet from Williams Fork Reservoir for peak flow augmentation and the runoff was not sufficient to refill Williams Fork Reservoir, a 10,000 acre-foot exchange or substitution would occur from Ruedi or Wolford Mountain reservoirs to make up for the lost water to Williams Fork Reservoir. However, if Williams Fork Reservoir did fill after a preemptive release, the Service could use that 10,000 acre-foot insurance pool for low flow augmentation later in the fall.

EXECUTIVE COMMITTEE RECOMMENDATION

The Executive Committee of the Coordinated Facilities Operation Study (CFOPS) recommends the following two alternatives for spring peak-flow augmentation to benefit endangered fishes in the 15-mile reach of the Colorado River.

Recommendation 1: Maximize Coordinated Reservoir Operations (CROPS) - As documented in the 1997 CFOPS report, the CROPS process was developed by a group of cooperating agencies over a number of years. Its purpose is to bypass storable inflows at participating reservoirs, in a way that does not impact a reservoirs' yield, to increase the magnitude of the peak flow through the 15-mile reach in years when the predicted peak flow at the Cameo gauge is greater than 12,900 cfs, but not likely to exceed 26,600 cfs or otherwise cause flooding concerns. CROPS were first implemented in 1997, and the process has demonstrated success in 1997, 1998, and 1999. This process should be continued as the primary means of augmenting the spring peak in the 15-mile reach, and efforts should be made to encourage increased participation in the process.

Recommendation 2: Augment the spring peak by using up to 20,000 acre-feet of stored water in addition to CROPS - The Service and Recovery Program may determine that in certain years additional peak-flow augmentation would be desirable above and beyond what can be accomplished through CROPS. Under this scenario, up to 20,000 acre-feet of stored water would be released from existing reservoirs for that purpose in addition to CROPS. The amount of water released from storage in those years would depend on the size of an insurance pool of water that would be designated by the Service on or about May 5, from existing Environmental Pools in Ruedi, Green Mountain, Wolford Mountain, and Williams Fork reservoirs (which are now used solely for summer/fall base-flow augmentation). In any given year, the insurance pool would ensure that releases of stored water from the specified reservoir(s) for peak-flow augmentation would not jeopardize that (or those) reservoir's water supply yield. If the specified reservoir(s) re-fills and the insurance pool water is not used to offset reservoir shortages, then all Environmental Pool water would be available for base-flow augmentation. The Environmental Pool will only be reduced to the extent of a shortage in the filling of the specified reservoir(s) caused by the peak flow release. The ability to implement this recommendation depends on successfully addressing the institutional issues and uncertainties discussed in the report. The effectiveness of CFOPS for peak flow enhancement and its impact on the Service's Environmental Pool, its operation in coordination with CROPS, and all institutional issues will be assessed and reported annually.

Reservoir Storage: In addition to the two recommendations above, the CFOPS study identified a mainstem reservoir alternative just downstream from the City of Rifle that could have multiple benefits and provide greater certainty of instream flow augmentation to benefit the endangered fishes. Although new storage to provide water for only the 20,000 acre-feet peak-flow augmentation was found to be expensive in the CFOPS study, a multi-purpose storage project, possibly including run-of-the-river hydropower and other water supply and recreation functions, may be much more cost effective and provide added benefits for endangered fish and their habitat as well. At some point in the future the water users may conduct an independent feasibility study of options for a multi-purpose reservoir to provide water for both 20,000 acre-

feet of peak-flow augmentation and 10,825 acre-feet for base-flow augmentation. The feasibility study would be funded outside the Recovery Program and address a set of environmental questions and criteria provided by the Service, which would include among other things measures of direct adverse impacts to endangered fish and their habitat. Upon completion of the feasibility study, the Recovery Program would consider whether or not to participate in the proposed multi-purpose project. If the Program wished to participate in the proposed multi-purpose reservoir project, further negotiations would be required to determine the level and means of Program participation.

POLITICAL AND INSTITUTIONAL ISSUES ASSOCIATED WITH IMPLEMENTATION OF THE EXECUTIVE COMMITTEE RECOMMENDATIONS

Executive Committee Recommendation No. 1, Maximize Coordinated Reservoir Operations (CROPS), is an expansion of the existing CROPS program, no new issues associated with this alternative were identified that would hinder the expansion of this program.

There are, however, several potential issues associated with implementation of Executive Committee Recommendation No. 2. Some of the reservoirs, e.g. Ruedi and Green Mountain, operate under federal authorizing legislation and operating criteria. Other reservoirs, e.g. Wolford Mountain and Williams Fork, operate pursuant to federal and local permits or licenses, such as federal rights of way or local 1041 permits. These authorities define purposes and prescribe limitations on the use and operation of these facilities. Additionally, all of the reservoirs operate under state water right decrees that define the purposes for which water may be stored and released. Before further considering implementation of the Executive Committee recommendation, the implementing agencies should undertake a joint analysis of the legal issues associated with this recommendation. For example, implementing the recommendation may require amending authorizing legislation, operating criteria, permits, or licenses, or may require changes of water rights or new water rights decrees, or may require new or amended contracts. Additionally, implementation of the recommendation may entail compliance processes with NEPA and the ESA. These issues may apply both for using each of the reservoirs that would make releases for augmenting the spring peak by using up to 20,000 acre-feet of stored water in addition to CROPS, and for providing an insurance pool to release stored water for replacement purposes to other reservoirs.