The Colorado Water Conservation Board (CWCB) and Colorado River Water Availability Study (CRWAS or Study) team greatly appreciate the consideration, communication, and comments provided by multiple entities during their review of the March 22, 2010 Draft CRWAS Phase I Report. All written comments received during the Study's public review period (March 22, 2010–July 21, 2010) were reviewed and considered by the CRWAS team to guide model, analysis, and report refinements in order to provide stakeholders with a better understanding of the Study.

Based on public comments, the CWCB has embarked on a series of responsive activities that include public and stakeholder outreach meetings and workshops; generation of a detailed public comment / response matrix documenting formal public comments and responses; refinements in Study computer models and analyses; and report clarifications to Study goals, limitations, approaches, assumptions, results, conclusions, recommendations, and lessons learned.

CRWAS is based on the best available data, science, techniques, and tools that are currently available for this type of study to meet Study objectives. Due to the broad scope and audience of the Study, public comments provided valuable additional input from water stakeholders across the State to assist in refining the Study. This combination of best available data, science, techniques, and tools; public outreach; and responsive steps to refine the Study based on public feedback will provide stakeholders with a valuable body of knowledge for use in further study and application in water planning activities.

Public comment letters associated with the Draft CRWAS Phase I Report are posted at:
http://cwcb.state.co.us/technical-resources/colorado-river-water-availability-study/Pages/CRWASDraftPhase1ReportComments.aspx.
The Draft Public Comment / Response Matrix on the following pages lists those comments and responses according to an index convention that identifies the commenting entity, date of comment, and comment number (e.g., YWBRT.0721.001 represents comment 1 provided on July 21, 2010 by the Yampa/White BRT). Following is an index to comments.

Yampa/White Basin

Comment ID	Comment	Response
YWBRT.0721.001	The Yampa White Green River Basin Roundtable (The Roundtable) appreciates the opportunity to comment on the Draft Phase I Report of the Colorado Water Availability Study. The Roundtable is concerned that there will be a tendency by water project proponents to use Phase I as a means to identify existing levels of water use, and thereby water quantities available for future uses, as a stand-alone document. Yet the reality is that water availabilities will change once Phase II is incorporated. We suggest adding additional text to clarify that Phase I and II should not be utilized independent of each other.	CRWAS Phase I scope was directed to establish technical approaches and evaluate water availability associated with current level of water uses prior to transitioning to a subsequent phase. Subsequent phases of CRWAS will be considered after additional public outreach including BRT meetings, distribution of a refined Draft CRWAS Phase I Report, and further review and deliberation by CWCB staff and Board.
YWBRT.0721.002	Considering the length of time the CRWAS will be active, the Roundtable recommends a detailed description of what mechanism will be used to assure the most current demands and future needs assessments are incorporated into projections. An information feedback loop is necessary to assure that as water demands and future water needs are changed, the study remains current.	The comment refers to ensuring 1) current demands and 2) future needs assessments are incorporated into CRWAS projections. 1. Current demands are included in CRWAS projections and are based on historic diversions, CDSS model assumptions, and discussions with Basin water users. 2. Future needs assessments are currently being determined through CWCB's Statewide Water Supply Initiative (SWSI) and BRT-specific input and basin reports. Should it be determined that there are subsequent CRWAS phase(s), the intent would be to incorporate future needs assessments from SWSI into CRWAS. See response to comment YWBRT.0721.001.
YWBRT.0721.003	Page 3-40 – The Roundtable would like clarification regarding the calculations used to determine annual crop irrigation requirements. We would specifically like to know if the high altitude coefficients modified by CDM Consultants in 2009 in the Yampa/White/Green Roundtable Agricultural Study were incorporated. If these have not been incorporated into Phase I, we request their consideration to assure accurate consumption records. The last bullet point on page VII of the Executive Summary highlights that current water uses were used in Phase I, therefore it is important to the Roundtable to understand the level the revised 2009 modified high altitude crop coefficients and return flow data were incorporated.	We were not provided data by CDM on the 2009 study; however, we will contact CDM to request their basis and assumptions and determine the validity of the approach. For CRWAS, high altitude crop coefficients were used as outlined in SPDSS Task Memorandum 59.1 that looked at lysimeter studies statewide.
YWBRT.0721.004	Page 2-5 and Page 3-12 – The Colorado River Simulation System (CRSS) was used to make quantitative estimates of the amount of consumptive use available. The Roundtable would like clarification if the 2009 adjusted high altitude coefficients, described above, were considered in the CRSS evaluations.	CRSS was not used in CRWAS to make quantitative estimates of the amount of consumptive use available; it was only evaluated for use. CRSS does not model crop consumptive use but instead uses static estimates of future depletions. The estimates of depletions provided by the State of Colorado do incorporate the use of adjusted high-altitude crop coefficients.
YWBRT.0721.005	Page VII Executive Summary – The second bullet point highlights Phase I's reliance on computer models. The Roundtable requests additional wording to	CRWAS is based on the best available data, science, techniques, and tools that are currently available for this type of study to meet CRWAS objectives. This

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	identify the inherent shortfalls of modeling to simulate current water demands, as well as an acknowledgement that the Phase I results do not present a complete picture of water demands without Phase II information.	includes use of proven models developed and regularly used for similar analysis. The next draft of the CRWAS Phase I Report will include additional discussion of Study assumptions, limitations, uncertainty, and use of results. See response to comment YWBRT.0721.001.
YWBRT.0721.006	Page 2-43 and 2-44 – The section on Forest Change Hydrology discounts any effect beetle killed trees will have on basin hydrology by making assumptions that natural reforestation and small wildfire sizes (<30% of a watershed) will offset or negligibly impact runoff. The Roundtable requests an analysis of a scenario where net runoff is increased. The roundtable believes there is a realistic scenario where civiculturists have grown in their understanding of proper functioning forests, and considering the recent history of large catastrophic wildfires and forest devastating beetle-kill, that forestry practices have evolved to the point that society will not see the same vulnerable dense stands of forests that society sees today. Stands could be managed in manner that will not be as susceptible to these catastrophic events, thereby yielding more water than today's forests do. Therefore, the CRWAS makes an assumption that runoff yields will be greater during the immediate future of tree die-off and then be decreased in 40 years when the trees grow back thus rendering a net neutral runoff from forests. The Study assumes that forest managers will allow the forest to return to the existing state, when it is more likely that foresters have learned from their past challenges and future healthy forests could yield more runoff than today's forests. The Roundtable requests an analysis of water runoff assuming proper forest management practices.	CRWAS scope was to evaluate whether current forest change science was sufficient to include in CRWAS analysis. Based on our review of corresponding literature, due to the highly evolving data and understanding associated with forest change and related forest management options, we concluded it is not yet at a stage to warrant inclusion in CRWAS. Please see CRWAS Technical Memorandum 7.3/7.4, available on the CWCB website.

Colorado Basin

Comment ID	Comment	Response
CBRT.0721.001	The Colorado River Water Availability Study intends to answer the following question: *How much water from the Colorado River Basin System is available to meet Colorado's current and future water needs?* Phase 1 considers existing water uses, and Phase 2 intends to include absolute water rights that are not being used and conditional water rights (water rights that have not yet been exercised but which have a senior priority date in the event they are later exercised). Phase 1 concluded that 0 to 1 million acre feet of water in the Colorado River is available for further development in Colorado. To derive this range, the CRWAS considered 112 different climate projections for 2040 and 2070. Five of these projections were chosen because they represent the full range of future water available under the 112 climate scenarios. The Colorado River Basin Roundtable submits the following comments after reviewing a draft of the Phase 1 report. The draft report is available at http://cwcb.state.co.us/NR/rdonlyres/49D5DEE3-C6DF-4D6C-80C9-4F21284ACD9F/0/20100322_CRWAS1_Task10_Phase1Report_Draft.pdf. The 0-1 million acre foot range lends itself to political mischief. The CRWAS Executive Summary concludes that "Phase 1 demonstrates a broad range of water availability;" CRWAS Executive Summary, p. vii. This conclusion leaves the reader with no feel for what scenario is most likely. The five scenarios were apparently chosen because they show the most likely range of possible outcomes, not because they are the most likely scenarios. The result is that the Phase I report can be quoted as authority that there is no water left to develop, or that there is 1 million acre feet left for development. This ultimately means that any decision to develop additional water supplies could be a political one, and not one based on science. It could also justify a decision to not do anything: it could permit Colorado water policy makers to keep avoiding the hard questions that the Colorado River Basin Roundtable believes should be asked regarding (1) land use and xeriscape requirements, (2) agricultural to municipal transfers, (3) oil shale development, or (4) pumpback proposals to pump water in the Gunnison, Colorado, and Yampa River Basins to the Front Range. The CRWAS Phase 1 study is inconclusive, but the data shows a host of possible scenarios and the Colorado River Basin Roundtable is especially concerned that the most likely scenario under existing uses is that shortages and gaps will occur. The Colorado Basin Roundtable recommends that the 0-1 million acre foot range be discussed in terms of risk, as Colorado River District General Manager Eric Kuhn has advocated. If additional water supplies in the Colorado River are developed, what is the risk that these supplies will be called out and curtailed in the future, and what is the risk that prior senior water rights could be called in	CRWAS is based on the best available data, science, techniques, and tools that are currently available to meet CRWAS objectives. CRWAS was scoped to present results for a range of future climate projections. It is recommended that each stakeholder interpret the broad range of future water availability from its own perspective, considering its own assessment of the possible future conditions, its role in water management, the resources it has to adapt to alternative potential futures, and its tolerance for risk. It is CWCB's intention to make the data used in CRWAS analyses and for the Draft CRWAS Phase I Report available to the public such that each stakeholder may use the data for their own purposes. The range of water availability referenced in the comment resulted from the part of the Study involving a preliminary analysis of the potential effects of Colorado River Compact administration under alternate hydrologic scenarios. This preliminary analysis was performed for a wide range of the climate projections currently available. The five climate projections chosen for CWRAS were chosen to represent approximately 80% of the range of conditions reflected across all of the 112 readily available projections. The analysis also involved modeling the hydrologic response of large Colorado River tributary watersheds and operations of federal and non-federal water storage facilities for more widely varying conditions than anticipated under current operating rules and procedures. This preliminary analysis has demonstrated the complexity of these issues, and the range of results is indicative of the current uncertainty associated with climate projections, watershed response, and future reservoir operations. Therefore, the Study is conclusive to the extent possible given current scientific uncertainty of climate change, which does not currently allow application of probability to scenarios. It is recommended that each stakeholder interpret the broad range of future water availability from its own perspective, considering its own assessment of the possible future conditions, its role in water management, the resources it has to adapt to alternative potential futures, and its tolerance for risk. The CWCB Colorado River Compact Compliance Study has recently started to evaluate Compact compliance and curtailment strategies. The on-going seven-state basin study being performed through the Bureau of Reclamation will be tackling related issues of future water supply and demand including simulation of the potential effects on Colorado River basin reservoir operations. CWCB is tracking the Reclamation Basin Study as it progresses. CRWAS analyses and results referenced in the comment will be replaced in the next draft of the CRWAS Phase I Report with a discussion of the challenges and "lessons learned" in doing this type of preliminary assessment and will cite results, if available, from the Reclamation-managed study, of which the State of

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	order to meet Colorado's delivery requirements under the Colorado River Compact?	Colorado is a sponsor and participant. The next draft of the CRWAS Phase I Report will clarify corresponding Study goals, limitations, approaches, assumptions, results, conclusions, recommendations, and lessons learned.
CBRT.0721.002	Reservoir evaporation must be subtracted from available water supplies. The suggestion that one million af is still available for development is misleading since it fails to account for the expected 200,000 af evaporation loss from Lake Powell and Flaming Gorge Reservoirs and the Aspinall Unit. After subtracting these evaporation losses, the projected range is 0 to 800,000 af, and this is the range that should be quoted in future publications and discussions.	The previous CRWAS analysis that will be replaced per the response to comment CBRT.0721.001 includes CRSP evaporation.
CBRT.0721.003	The water demands of an oil shale industry have not been considered in Phase I and must be incorporated into Phase II.	See response to comment YWBRT.0721.001.
CBRT.0721.004	Nonconsumptive uses for environmental and recreational flows have not been considered. Phase 1 has only considered water rights in which the water is consumed; it has not considered nonconsumptive water rights or needs. The final draft of the Water Availability Study should not be released until the Nonconsumptive Needs Analysis has been completed and integrated into the Water Availability Study. The scoping process for Phase 2 of the WAS should include the Nonconsumptive Needs Analysis. Nonconsumptive needs should not be at risk while municipal water rights are considered sacrosanct.	Decreed instream flows and current flow agreements are included in the CDSS model used in CRWAS and therefore have been considered. The next draft of the CRWAS Phase I Report will highlight differences in available flow specifically to instream flows and include refined narrative description. See response to comment YWBRT.0721.001.
CBRT.0721.005	More detail is needed about where the additional supplies will come from. Specific sources for the 0-1 maf range should be indentified so that their impact can be gauged: What rivers are targeted and when will diversions be made?	See responses to comments CBRT.0721.001 and YWBRT.0721.001. CRWAS analyses and results referenced in the comment will be replaced in the next draft of the CRWAS Phase I Report with a discussion of the challenges and "lessons learned" in doing this type of preliminary assessment. Hydrologic and CDSS model data generated for CRWAS will be made accessible to the general public.
CBRT.0721.006	Phase 1 assumes that all future climate projections are equally probable. Phase 1 concludes that 100 randomly generated sequences of annual precipitation based on 56 years of water flow records from 1950-2005 is adequate to provide a full range of potential future water supply scenarios; Executive Summary, page III. This is a statistical technique known as a Monte Carlo analysis. It is used commonly in investment research, especially to estimate the effects that withdrawals will have on investment fund balances and the likelihood of outliving one's money. Many, like Warren Buffet, believe that too much attention is paid to it, and that it is misleading because it treats every scenario as having an equally likely chance of occurring, and because it assumes all distributions are normal. MIT professor Bernard Mandelbrot who researches fractals believe that	The approach used to address variability of hydrologic conditions is a form of Monte Carlo simulation. In Monte Carlo simulation, every iteration is treated as if it is equally probable, but the combinations of variables that can be thought of as making up a "scenario" are sampled out of their individual probability distributions. In the re-sequencing approach used in CRWAS the frequency of spells of wet and dry years are simulated based on the information from the tree ring record and the historical record for the entire period from 762 to 2005 and does not rely solely on the last century. The approach used in CRWAS uses the empirical frequency distribution of flow transitions from the reconstructed paleo record; these distributions are not normally distributed and are not homogeneous over the entire period of the reconstruction. (Monte Carlo simulation is not

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	Monte Carlo simulations and other statistical techniques underemphasize extreme events. Precipitation in the last 56 years is at the upper range of the amount of precipitation that has occurred over the past 1,300 years as illustrated by tree-ring studies. The past century is probably not a reasonable guide for future water management even if the climate wasn't changing; see *Global Climate Change Impacts in the United States*, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.), Cambridge University Press, 2009, p. 49. Mega droughts lasting several decades from 900-1300 AD were substantially worse—over 40% of the West was in drought from 900-1300 AD, while under 30% was in drought from 1900-2000. **Treating every potential future precipitation scenario as equally likely needs to be justified.** Three of the five precipitation scenarios chosen in Phase 1 indicate that no water is available for future consumption. By suggesting that 1 million acre feet may be available can falsely lead policy makers to underemphasize the risk that no additional Colorado River water is available for future consumption.	limited to the use of normal distributions—any probability distribution, including empirical distributions, can be used.) We interpret the term "future precipitation scenario" in the comment to refer to the projected climate scenarios. These are not assigned a probability; each user of the CRWAS Phase I Report can choose to interpret the climate scenarios, either collectively or individually, according to their own preferences. CRWAS was scoped to present results for a range of future climate projections. It is recommended that each stakeholder interpret the broad range of future water availability from its own perspective, considering its own assessment of the possible future conditions, its role in water management, the resources it has to adapt to alternative potential futures, and its tolerance for risk. The methods used in the CRWAS were selected based on their scientific validity and their applicability to the objectives of the CRWAS. In identifying and developing these methods, two principal objectives were to avoid introducing bias and to portray uncertainty realistically, which we believe have been appropriately addressed. In addition, the methods were reviewed by members of the CRWAS technical team, were critically reviewed by the staff of the CWCB and the Colorado Climate Change Technical Advisory Group and were publically documented. See response to comment CBRT.0721.001.
CBRT.0721.007	Global Climate Models (GCMs) specific to the Colorado region are needed. The Executive Summary on page IV suggests that more detailed Global Climate Models are needed. Susan Hassol, a scientist in Basalt and Senior Science Writer of *Global Climate Change in the United States*, states that weather modeling is particularly difficult in mountainous areas. In a talk at the Aspen Center for Environmental Studies on May 1, 2010, she commented that most climate models suggest that the southwest continental US will have less precipitation, while the northwest may have more. Colorado is at the junction of where the lower and higher precipitation model predictions intersect, but only the far northern part of the state is expected to have more precipitation. Scientists whose contributions are reported in *Global Climate Change in the United States* strongly suggest that the entire state of Colorado will have less precipitation except for the Yampa-White river basins: a) Storm tracks will move northward, with the result that dry areas will become dryer and wet areas will become wetter (p. 42); b) Mid continental areas (eastern Colorado) and the Southwest (western Colorado) are particularly threatened by future drought (p. 45); c) Earlier runoff will produce lower late-summer streamflows, which stress human and environmental systems because less water is available and temperatures are higher (p. 46); d) Numerous studies over the past 30 years have indicated that the Colorado River is likely	CRWAS is based on the best available data, science, techniques, and tools that are currently available for this type of study to meet CRWAS objectives. The methods employed in the Study have been widely used in similar impact studies and have been described in numerous peer-reviewed journal articles. The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions. More detailed climate models, referred to as Regional Climate Models (RCMs) may provide better resolution of regional precipitation patterns. Even more finely detailed models may someday be able to resolve orographic effects of Colorado's mountainous terrain. However, these more detailed approaches still rely on GCMs to define boundary conditions and are therefore subject to many of the biases and uncertainties inherent in the GCMs. There are not a sufficient number of runs of RCMs available to characterize the range of projections of future climate in the study area, which was one of the goals of CRWAS. However, it is important to note that many of the GCM projections used in CRWAS exhibit the patterns of climate that are described in the comment.

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	to experience reductions in runoff due to climate change (p. 51); e) Water is being pumped from the Ogallala aquifer faster than it can recharge, suggesting that less water will be available for the Front Range even if agriculture dry ups continue (p. 125); f) Recent warming in the Southwest including Colorado is among the most rapid in the nation, significantly more than the global average in some areas (p. 129); g) Runoff during the early 1900s, upon which the Colorado River Compact calculations are based, turned out to be part of the greatest and longest high-flow period of the last five centuries (p. 130); h) The Southwest remains in a drought that began around 1999. This event is the most severe western drought of the last 110 years, and is being exacerbated by record warming. The most likely future for the Southwest is a substantially drier one (p. 130); i) Temperature increases have made the current drought in the Southwest more severe than the natural droughts of the last several centuries (p. 130); j) Paradoxically, a warmer atmosphere increases the risk of flooding, both because runoff begins sooner and because extreme weather events will be more likely. The greater flooding potential means reservoirs cannot be filled to capacity since reservoir space must be reserved for flood events. This happened in the Roaring Fork Valley in June 2010 when, despite an average snowpack of only 75% on May 17, the Roaring Fork River on June 10 reached its highest levels since 1995, a high snow year (p. 133) These studies, coupled with the fact that it is difficult to model in mountainous areas, makes suspect any prediction of future precipitation in the Upper Colorado River Basin. **The Colorado Water Availability Study must be based on regional studies of future water availability that are specific to Colorado.**	
CBRT.0721.008	Drier 2070 projections should be used. Table 1, the Phase 1 Technical Approach Summary reported on page V of the CRWAS Executive Summary, ignores the drier 2070 projection, since it states: "Subsequent analysis of the selected projections showed that the 2040 projections were representative of streamflow conditions at both time frames, while the 2070 projections were biased toward dry conditions. For this reason the 2040 projections are used." This is an example of irrational bias. The five selected future climate models showed more precipitation in 2040 than in 2070, so Phase I ignores and discounts the drier 2070 projections. Query whether Phase I would have ignored the 2070 projection if it had been wetter than the 2040 projection? Planning and development based on short term precipitation gains while ignoring the longer-term outlook for drier conditions makes no sense. It will only insure that water supply problems will be worse, not better, after 2040.	CRWAS did not reject or discount 2070 model results but they were not used collectively to characterize conditions in 2070. This decision was made due to the evident bias in the selection of projections relative to the entire set of available projections. The next draft of the CRWAS Phase I Report will include additional work and corresponding documentation of approach and results to identify and analyze a set of climate projections for 2070 that better represent the range of projected hydrologic impacts for that time frame. See response to comment YWBRT.0721.001.
CBRT.0721.009	What is the definition of "basin-wide?" Table 2, the Primary Phase 1 Findings Based on 2040 Climate Projections reported on page VI of the CRWAS Executive Summary, describes a variety of changes expected for the Colorado River Basin. These include temperature increases of 3.3 to 3.7 degrees Fahrenheit, increased winter precipitation of 6-13%, decreased summer	For purposes of CRWAS Phase I Report Table 2, basin-wide refers to the Upper Colorado River Basin within Colorado.

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	precipitation of 4-10%, and an increased crop irrigation requirement of 20%. Does basin-wide refer to just the Upper Colorado River Basin within Colorado or the entire Colorado River Basin? If it refers to the entire Colorado River Basin, it could matter significantly if most of the projected 6-13% increase occurs in the Green River Basin. The climate change models suggest this, as stated above, because more precipitation is expected to fall in the northwest and less in the southwest, and Wyoming is north of Colorado. In that case, more water could be diverted from the Upper Colorado River Basin but in fact less water is available, resulting in lower flows for agriculture and nonconsumptive uses. **River health and agricultural production could decrease dramatically under a scenario of more diversions and decreasing native supply.**	
CBRT.0721.010	Increased agricultural consumption could utilize the entire increased winter precipitation. Agricultural consumption is about 70% of Colorado statewide consumption, which means that the 20% projected increase in irrigation will increase agriculture's share of statewide consumption by 14%; see Table 2, p. vi of the CRWAS Executive Summary. This is more than the 6-13% entire Colorado River Basin winter precipitation increase that is projected under the most positive scenarios in 2040.	It is unclear if the comment was intended as a statement or a comment requesting a response. The CDSS models used in CRWAS represent the operation of existing systems and water rights to supply agricultural uses and the results of those model analyses will reflect changes in both stream flows and agricultural water use.
CBRT.0721.011	The CRWAS fails to consider nonconsumptive needs. In general, stream flows decrease statewide; see Table 2, p. VI of the CRWAS Executive Summary. This is at odds with Phase I's general conclusion that up to a million acre feet may be available for future development. The suggestion that stream flows will increase in April and May is likely a transitory phenomenon, reflecting the earlier runoff. Lower flows in the later summer and fall months can cause drastic reductions in river health if minimum flows aren't preserved. **The CRWAS should calculate the stream flows needed to maintain healthy rivers year-round before concluding how much additional Colorado River water is available for development. This includes minimum and optimal flows, flushing flows and occasional high flows for riparian health. These stream flows need to be considered as a legitimate demand on the calculated water available for development.**	See response to comment CBRT.0721.004.
CBRT.0721.012	Dust events. Dust accumulations on snow will exacerbate the earlier runoff, and the snowmelt runoff will largely take place before the summer irrigation season. **Phase I should incorporate the effect that dust accumulations have on runoff which, though recent, are obvious to West Slope residents.**	Recent years have shown that dust accumulations may affect runoff. Future phase(s) of CRWAS, if performed, may explicitly address this topic. The scope of work for CRWAS Phase I was developed in 2007 and did not include this type of analysis. See response to comment YWBRT.0721.001.
CBRT.0721.013	Whether higher elevation streamflows increase or decrease must be clarified. The CRWAS concludes that "Higher elevations generally have less flow available;" see Table 2, p. VI of the CRWAS Executive Summary. This conflicts with the conclusion stated immediately above in Table 2 that "Annual modeled streamflow decreases basin-wide, expect in the Yampa River basin, and higher elevation locations in the Upper Colorado River basin." The latter sentence	There is a difference between modeled streamflow and flow available to meet future demands as defined in the Draft CRWAS Phase I Report. The statement "Annual modeled streamflow decreases basin-wide, except in the Yampa River basin, and higher elevation locations in the Upper Colorado River basin" is specific to those locations. The statement that "Higher elevations generally have less annual flow available to meet future demands, as a percent of modeled

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	suggests that upper elevation streamflows in fact increase.	streamflow" is a general statement of water availability. The next draft of the CRWAS Phase I Report will clarify the difference between modeled streamflow and flow available to meet future demands.
CBRT.0721.014	"Reservoir use" must be clarified. The phrase "Reservoirs show increased use" in Table 2, p. vi of the CRWAS Executive Summary is misleading, since it is not clear whether "increased use" refers to increased use by recreationists or increased fluctuations resulting from increased draw downs in summer months. These uses are generally incompatible as attested by recent draw downs in Dillon and Powell Reservoirs that rendered them unsuitable for boating. If increased use refers to increased fluctuations, then the statement should read, "Reservoirs show increased fluctuation."	The next draft of the CRWAS Phase I Report will clarify that "increased use" means increased fluctuations due to increased reservoir operations (corresponding to the reservoirs' decreed water uses) based on projected climate-adjusted hydrology.
CBRT.0721.015	10825 Water is not absolute. Phase 1 states that the USFWS fish flow recommendations for the 15-mile reach above the confluence of the Colorado and Gunnison Rivers are junior to other basin demands, and that they therefore decrease the reported water available for future diversion from the Colorado River; CRWAS Executive Summary, p. viii. This is a recommendation to eliminate 10,825 Water as an absolute water right, since it is junior and may not run every year. **If 10825 Water is not shown as an absolute water right and it is available for further diversion, CRWAS Phase 1 should state what impact this will have to the four endangered fish that are protected by these flows.**	The 15-mile reach administrative agreement flow recommendations are strictly considered in CRWAS, but the allowable future depletions are not represented. In the current CDSS model used for CRWAS, fish flow recommendations are represented as "senior" to future uses, but junior to all existing water rights and other agreements. The next draft of the CRWAS Phase I Report will include model and result refinements based on a scoped task to work with stakeholders to develop an approach for revising corresponding model representation.
CBRT.0721.016	San Juan fish flows are also junior and not absolute. CRWAS Phase 1 states that flows needed for the San Juan Recovery Program are junior and that by showing them as absolute, reduce the water available for further diversion. **If San Juan Recovery Program flows are not shown as an absolute water right and are therefore available for further diversion, CRWAS Phase 1 should state what impact this will have to the four endangered fish that are protected by this right.**	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to meet with stakeholders to better understand and represent fish flow requirements and allowable depletions in the model. This type of refinement is a key aspect/benefit of CRWAS.
CBRT.0721.017	First of all, I think the engineers did a very good job keeping us awake with the modeling presentation at the last Colorado River Basin Roundtable meeting which is amazing. However, I have some questions that I don't understand based upon my very limited knowledge of the model. Generally, the purpose of the model is to utilize it in studying how much water is still available in the Colorado River Basin. I believe most of us understand that those numbers will be based on a range such as 200,000 acre feet to 500,000 acre feet which will be based upon a certain number of assumptions. In other words it will be based upon the minimum amount available to Colorado in a worst case scenario versus the best case scenario. Unfortunately, in understanding the model, it seems to me we are starting with	CRWAS is based on time series of monthly hydrology. The historical record spans 56 years that reflect observed wet and dry spells. The alternate historical record spans from 762 to 2005 that reflect extended wet and dry spells. The Draft CRWAS Phase I Report showed a range of results for the historical record, paleo-record, and five climate change scenarios as well as graphical representations of low flows for several different durations. The paleo-approach utilized in CRWAS uses information from the paleo and historic records from 762 to 2005 and utilized an approach that has been reported in the refereed scientific literature. We believe that the selected approach provides a sound scientific basis on which to understand and represent the variability of the hydrologic system. The approach, along with alternative approaches, is described in Technical Memorandum 6.4. The results of the development of the alternative historical hydrology are summarized in Technical

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	averages historically which means the lower number, whatever it is, will be wholly inaccurate to begin with. Averages aren't the lowest amount of water available. You have to go to a year like 2002 rather than the historic average to determine the minimum that might be available. Hopefully you will understand this point and if you need clarification give me a call.	Memorandum 6.7. The approach adopted by CRWAS generated and examined 100 56-year traces of alternate historical hydrology. In these traces, for example, the longest drought period for the Colorado River near Cameo was 12 years and the longest surplus period at that location was 11 years. These periods were defined based on annual flows, so a single wet or dry year will interrupt a spell. For example, some 56-year traces showed mean flows below the historical mean, but because there were individual years within that 56-year period that were above the historical mean this would not represent a 56-year drought. The implications of wet and dry spells to Colorado's water availability are best determined by simulation of specific water rights and structures, as is done with the CDSS models. The sequences of alternate historical hydrology have been run through the CDSS models so the output databases from those runs will reflect the impact of variability as captured in the alternate historical hydrology. These output databases will be made available for analysis by water users at the completion of Phase I. Alternate historical hydrology may be used for a subsequent phase of CRWAS to understand how this hydrologic variability may impact project performance. The next draft of the CRWAS Phase I Report will include additional discussion of hydrologic variability and will include additional statistical analysis and results to present return interval and average intensity of historic and climate-adjusted droughts / wet spells.
CBRT.0721.018	The other question is just the accuracy of the entire model to begin with. I know Mike Wageck has pointed out the issue of utilizing instream flows on Jim Creek that aren't in existence. If this is a reference to Fraser River CWCB flows or USFS flows, it isn't accurate. I would point out that the example using Jim Creek has specific problems. You can't model bypass flows or instream flows in the Upper Fraser River as being senior to Denver. The Denver Water Board Bypass Agreement of 1970 provides that Denver can reduce the bypass flows which it has done in times of shortage. Accordingly, bypass flows have to be junior to Denver's decrees. That results in no water being available in a 2002 drought year if it is repeated for three years.	There is a scoped item to work with water users to determine the most appropriate method to represent Moffat bypass flows in the model. Corresponding revisions will be reflected in the next draft of the CRWAS Phase I Report.
CBRT.0721.019	The other inaccuracy might be found with respect to bypass flows in the Colorado River by NCWCD below Granby. They, too, have the ability to reduce their bypass flows based upon how much water is projected to flow into Granby Reservoir. Accordingly, if you are basing the model on their historic bypass flow it may overstate the amount of water that would be available during drought years. Climate change will affect the amount of water available to Denver and Northern on the Front Range and accordingly reduce the amount of water that they would have to bypass on the Fraser and Colorado Rivers which would result in	Granby bypass flows in the model are based on hydrologic year type. The next draft of the CRWAS Phase I Report will include clarifying narrative.

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	considerably less water. I am sure you can do a better job of restating these comments when you do the summary for the Colorado River Roundtable, but hopefully you will understand generally the concerns, or at a minimum, the questions that are out there based upon this letter. Hopefully the River District has taken a close look at the model.	
CRWCD.0719.001	The Colorado River Water Conservation District (River District) is pleased to submit comments on the Colorado River Water Availability Study (CRWAS) Phase I Report. First, the River District would like to commend you and the Colorado Water Conservation Board for undertaking the technically challenging and politically difficult task of trying to answer the fundamental question of "how much water from the Colorado River Basin is available to meet Colorado's future water needs?" The River District understands that this question has been facing Colorado for generations. It is a question for which there will never be an easy answer nor an answer that will necessarily satisfy all of those who are asking the question. The River District has the following general comments concerning the Draft Phase I report: 1. The CRWAS Phase I Report is the first of three basic reports that will be necessary to inform decision makers. The information in the Phase I Report will be of limited value until, and unless, the CRWAS Phase II Report and the related compact compliance and administration studies are completed and made available to decision makers and the public. The River District also recognizes that various legal issues related to interpretation of the 1922 Compact will remain unresolved for the foreseeable future, but this must not hold up these important explorations.	The CRWAS Phase I Study provides value in its: • Progressive approaches that have never been completed before with the adopted combination of data, science, techniques, and tools. • Result trends associated with three different hydrologic bases (historical, paleo, climate change). • Data and approach contribution to other ongoing state studies and processes (IBCC, BRT, SWSI, Drought Plan, and Compact Compliance). • Ability to help CWCB to communicate with other groups performing similar studies (JFRCCVS, Reclamation Study, others). • Outreach activities to share information with stakeholders and BRTs. See response to comment YWBRT.0721.001.
CRWCD.0719.002	2. Recognizing that resources are limited, the River District recommends that the CWCB not allocate time or resources to making cosmetic or editorial changes to the Phase I Report. Instead, we believe that these resources are better spent in preparing an executive summary or synopsis report that succinctly describes the limitations, results, conclusions and lessons from both the phase I and phase II studies.	The Draft CRWAS Phase I Report will be refined based on consideration for comments from all entities that provided comments during the formal public comment period. This will include applicable editorial / graphical changes noted in public comments. The next draft of the CRWAS Phase I Report will include additional discussion of Study assumptions, limitations, lessons-learned, and use of results and will include a refined executive summary based on public comment. See response to comment YWBRT.0721.001.
CRWCD.0719.003	3. The River District believes that the information provided in phase I may more accurately be described as "science" rather than classic "water rights" or water resources "engineering." Climate science is quickly evolving and not static. The information and data obtained from the Global Circulation Models (GCMs), emission scenario assumptions, and downscaling techniques are	The comment highlights the importance of the CRWAS Phase I Study in its ability to place CWCB in a position to intelligently communicate with other groups performing similar studies. The information provided in Draft CRWAS Phase I Report includes science,

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	probably already out-of-date. Better information and more sophisticated models are available today, and will continue to available in the future. However, it does not mean that the information and data contained in phase I are not valuable or relevant. The River District recommends that the Phase II Report include a section describing reports and studies that have been completed and are available to the public since the completion of the draft Phase I Report. For example, the Bureau of Reclamation is currently preparing a Colorado River Basin study. This study will include a detailed analysis of the impacts of climate change on Colorado River Basin hydrology. Hydrology results from Reclamation's study should be available before the completion of the Phase II Report. Rather than utilize resources to re-do the Phase I Report, it may be more informative to analyze the results of the Reclamation study and to describe how these results compare to the results of the Phase I Report. It is essential that this inter-comparative process ensure consistency and improve understanding of the central issue of water availability in the Colorado River system. In addition to the Reclamation study, there will be other relevant studies that can be analyzed and referenced as well. For example, the National Academy of Sciences released a relevant report on Friday July 16, 2010.	computer modeling, and water resources engineering analysis. CRWAS is based on the best available data, science, techniques, and tools that are currently available for this type of study to meet CRWAS objectives. CWCB is sponsoring and tracking the Reclamation Basin Study as it progresses. It should be pointed out that the USBR Basin Study will be looking at general water availability on the mainstem rivers. Water rights and water available to individual tributary demands are not considered in the Reclamation Study. See response to comment YWBRT.0721.001.
CRWCD.0719.004	4. Managing expectations and educating the water community on the value and limitations of CRWAS remains a very difficult objective. While the stated objective of the study is to define "how much water is available?" the true value of the study may be as a tool to better inform water managers and decision makers. Such information is essential to ensure that Colorado can formulate and adopt a successful strategy to meet its long-term future water needs. A section or discussion within the report and executive summary summarizing these limitations is important and recommended.	Since a study of this breadth has not been completed in the past, several lessons have been learned and limitations have been identified. Explanation of the value and limitation of CRWAS is very important to better inform water managers and decision makers. See response to comment CRWCD.0719.001. The next draft of the CRWAS Phase I Report will include additional discussion of Study assumptions, limitations, lessons-learned, and use of results.
CRWCD.0719.005	(4. continued) The River District recommends that the public outreach effort continue during phase II and that the focus shift from the standard AECOM presentation on hydrology to how to incorporate CRWAS and the Reclamation study into water planning and related decision-making processes. It is well understood that due to the divisive nature of both climate science and water politics this task will not be easy.	CWCB has planned two rounds of outreach workshops with seven Basin Roundtables (BRTs) as part of the plan to complete CRWAS Phase I. The first round of BRT workshops will discuss public comments. The second round of BRT workshops will discuss use of Study results, including discussion on how to incorporate CRWAS into water planning and related decision-making processes. Reporting on the Reclamation Study is not currently part of the CRWAS scope. See response to comment YWBRT.0721.001.
CRWCD.0719.006	5. Unfortunately we believe that the Draft Phase I Report does not do a sufficient job of presenting the Colorado River Compact information. Although, the River District is in general agreement with comment #10 of the Front Range Water Council's (FRWC) comments dated June 15, 2010, the Phase II Report should include a much more comprehensive discussion of the compact issues.	See response to comment CBRT.0721.001.

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CRWCD.0719.007	(5. continued) We do not believe that it is productive to discuss how much Colorado River water Colorado has available to meet its future needs without completing Phase II. Phase I looked at existing demand levels, yet we know there are either completed but underutilized and/or projects that are under construction which will be used to meet future demands. For example, Denver Water's Dillon Reservoir/Roberts Tunnel system currently may not be operating at full capacity. The same is probably true for the Windy Gap Project and a number of West Slope projects such as Ruedi Reservoir, the Dallas Creek Projects, and Stagecoach Reservoir. Additionally, the Animas-LaPlata Project (Lake Nighthorse) is now in the process of filling. Future depletions associated with these examples and all reasonably foreseeable projects need to be accounted for in the Phase II analysis of how much water Colorado has available.	CRWAS was originally intended to incorporate both phases; however based on feedback from IBCC and CWCB Board, it was decided that the Study be separated into 2 distinct phases, with the first phase to establish technical approaches and evaluate current levels of water development prior to transitioning to a Phase 2. This is why Phase I must be completed prior to consideration of subsequent phases. See responses to comments CBRT.0721.001 and YWBRT.0721.001.
CRWCD.0719.008	(5. continued) As stated by the FRWC, the bar chart results presented in figure 3-37 is too simplistic. The River District concurs and suggests that the compact water availability presentation cover three broad categories: A. Unresolved legal issues: the major issue is the Upper Basin's obligation to the Mexican Treaty obligation. In simple terms, it appears that this uncertainty is at least 400,000 acre feet to Colorado (0.5175 (or 51.75%) x 750,000 acre-feet). The Phase I report should be revised to clearly flag this uncertainty as one that could significantly impact Colorado's remaining compact entitlement. The Phase II Report needs to describe the Compact delivery uncertainties in more detail and what it means to Colorado's water availability.	See response to comment CBRT.0721.001. The next draft of the CRWAS Phase I Report will include additional discussion of hydrologic uncertainty and the complexities of compact analysis.
CRWCD.0719.009	(5. continued) B. *Hydrologic variability due to multi-decadal changes in climate* (not global warming or climate change). The reconstructed hydrologic record clearly shows that for at least the last 1,000 years or so, there have been periodic prolonged and significant wet and dry cycles throughout the Colorado River Basin. Based on the reconstructed record, how often can these wet and dry periods be expected? And what are the implications to Colorado's water availability based upon these expected events? These natural and dramatic cycles raise a fundamental question of the value of the standard "re-sequencing" methods used to replicate the random character of hydrology. Although, it may be true that resequencing can be done in a way that preserves hydrologic variability, more science on this matter is appropriate to further quantify and understand the inherent hydrological variability in the system.	See responses to comments CBRT.0721.001 and CBRT.0721.017.
CRWCD.0719.010	(5. continued) C. Hydrologic uncertainty due to climate change: the final and perhaps most	See response to comment CBRT.0721.001. The next draft of the CRWAS Phase I Report will include additional discussion

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	difficult challenge is to address the hydrologic consequences to the Colorado River caused by a warming earth. Whether the cause of the warming is manmade (by the emission of greenhouse gases) or natural (as some scientists such as Dr. Bill Gray of CSU suggest), based on the phase I results and a large number of other scientific work, the potential consequences appear to be very significant. The River District believes that the Phase II Report needs to address both the uncertainties and potential risks in a straightforward manner. The Phase I Report provides a good data base, but the presentation is confusing.	of uncertainty and attempt to clarify results to overcome the challenge of presenting new science and methodologies to such a diverse audience. See response to comment YWBRT.0721.001.
CRWCD.0719.011	[5.C. continued] It should also be noted that there is already considerable posturing on how the information should be presented. Examples are; should an "average" of the five projections be included or not in the appendices? Is the blue shading showing the range of the model results too confusing, etc.? Again, the River District suggests the CWCB focus its resources on phase II rather than window dressing existing tables and graphs in the Phase I Report. Instead, we recommend the underlying data in phase I be made available to any entity that desires it.	See response to comment CRWCD.0719.002. Hydrologic and CDSS model data generated for CRWAS will be made available to the general public after Phase I model and analysis refinements are complete.
CRWCD.0719.012	6. How to address the 2070 results in phase I is a major unresolved matter that needs to be addressed as part of the Phase II Report. The basic question to answer is "If temperatures in the Colorado River Basin continue to rise between 2040 and 2070, what are the hydrologic implications?" The original approach to select five basic projections as shown on pages 2-23 and 2-24 appears to be a reasonable approach. To reject or discount the 2070 model results based on how the five were arranged on the cumulative distribution function (data base provided by USBR) at Glenwood Springs only may be a premature conclusion. The Phase II Report should provide more detail on how the five 2070 projections plotted at Lee Ferry and similar Reclamation provided distributions and at locations on the Gunnison River. For example, the hydrologic changes for the small portion of the Colorado River watershed above Glenwood Springs (higher elevation) may not be representative of what is happening at Lee Ferry between 2040 and 2070. To correct or improve the 2070 information, it may be appropriate to consider and reference the results of the Reclamation study, or, if phase II budget resources are available, it may be appropriate to analyze five more projections and increase the sample size to ten. The bottom line is that having more confidence in 2070 hydrology is crucial for the development of an acceptable statewide water strategy.	See response to comment CBRT.0721.008.
CRWCD.0719.013	7. While the information provided in Appendix G for YamColo, Ridgway, Vega and McPhee Reservoirs is helpful and illustrative of the impact of a changing hydrograph and changing demands on reservoir operations, the River District	The reservoirs included in the Draft CRWAS Phase I Report were selected because their demands were refined to reflect the impacts of varying climate projections. They are primarily used as supplemental irrigation supplies. Slightly

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	believes the Phase II Report should include an analysis of other reservoirs such as Green Mountain, Ruedi, Blue Mesa and possibly Navajo. These four reservoirs are more relevant to a larger number of water interests on both sides of the divide.	more than 50 percent of the use from Green Mountain Reservoir is in exchange for CBT diversions through Adams Tunnel, and the contract pool is generally used to meet municipal demands. These demands have not been refined to reflect the effects of the climate projections. However, the Historical Users Pool (HUP) is used to meet western slope demands, mostly irrigation, that have been refined to reflect various climate scenarios. We will present results in the next draft of the CRWAS Phase I Report showing storage and releases from the HUP account under varying hydrology. Contract demands from Ruedi Reservoir meet municipal and industrial demands. These demands have not been refined to reflect the effect of climate projections. Likewise, the transbasin demands that are diverted in exchange for Ruedi Reservoir releases have also not been refined to reflect the effect of climate projections. Blue Mesa Reservoir stores water for Hydropower and other USBR uses, plus water for the Uncompaghre Valley Water Users Association. Demands for Hydropower and releases for other USBR uses have not been refined to reflect the effect of climate projects. However, the UVWUA account demands have been refined to reflect changes in irrigation demands. We will present results in the final report showing storage and releases from the UVWUA account under varying hydrology. Navajo Reservoir demands in New Mexico and for USBR uses are not reflected in the CDSS model. See response to comment YWBRT.0721.001.
CRWCD.0719.014	(7. continued) The River District recommends the Gunnison River Basin Roundtable be carefully consulted on the Blue Mesa operational assumptions and related results. We understand the Aspinall power right was incorrectly modeled. We suggest that this error found by the Upper Gunnison River Water Conservancy District be corrected in the Phase I Report to reflect current operations. Upstream water availability results must be changed to reflect this update.	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to refine representation of Aspinall Unit hydropower operations through discussions and coordination with the UGWCD. We have met with the UGRWCD consultant and, together, we have reviewed and refined the operation. This type of refinement is a key aspect/benefit of CRWAS.
CRWCD.0719.015	8. The River District believes that the handling of the flow recommendations for the 15 Mile Reach described in Section 3.6 is acceptable. We suggest that the Phase II Report look at 2040 and 2070 flow projections in the 15 Mile Reach in conjunction with the modeled operations of Green Mountain and Ruedi Reservoirs. The potential climate change impacts on late summer/early fall irrigation season flows and the potential impact on aquatic species is an absolutely critical issue for all of the tributaries of the Colorado River Basin (e.g., Gunnison, Yampa Rivers the Colorado mainstem and San Juan). The River District would like to thank the CWCB for its management of the important CRWAS studies and to express our appreciation for the opportunity to comment. We now urge you to turn your priorities toward the completion of	See responses to comments YWBRT.0721.001 and CBRT.0721.015.

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	the critically important next step of completing the Phase II Report and related Colorado River Compact compliance studies.	
RWAPA.0719.001	The following is submitted by the Ruedi Water and Power Authority (RWAPA) in response to Phase I of the Colorado River Water Availability Study. The Authority is an intergovernmental consortium made up of the five municipalities and three counties that make up the Roaring Fork Watershed. RWAPA has been involved in water planning and projects centered around Ruedi Reservoir and the Roaring Fork watershed since 1981. One flaw in the study is the absence of any discussion of the "plumbing" in place to move water from one location to another within the current system. The operation of the major reservoirs in the upper Colorado – Green Mountain, Windy Gap, Wolford, Granby, Ruedi – have a significant impact on the availability of water in a given place at a given time. The obligations, operating protocols and maintenance needs of those reservoirs (and other infrastructure elements such as the Shoshone Power Plant) affect the delivery of water and the availability of water on a regular basis. The weekly conference call which determines releases to the 15-mile reach of the Colorado near Grand Junction is one example of an informal infrastructure management tool that can have both short-term and long-term effects on water availability. It is important that both the infrastructure and the management procedures that affect water availability be incorporated into the overall analysis and that recommendations for modifying either infrastructure or management practices be included.	See responses to comments YWBRT.0721.001 and CBRT.0721.015. Operations associated with major reservoirs are explained in detail in the CDSS basin model User Manuals.
RWAPA.0719.002	The study does not make significant mention of the "dust on snow" phenomenon that has had an apparent effect on runoff timing in the last several years. Is this an element of the climate change model or is it a separate phenomenon that can be expected to continue? The timing of runoff in itself deserves more attention. In 2010, a below average snow year nevertheless gave rise to flood hazards in the Roaring Fork valley solely as a result of a sudden and drastic increase in temperature and a dramatic rise in river levels which took management agencies by surprise. This had implications for the flood control capacity and manageability of Ruedi Reservoir, local property safety and late season streamflows. The rate at which winter snow is converted to liquid water, and the various factors that contribute to that rate, should be incorporated into the discussion of climate change.	See response to comment CBRT.0721.012.
RWAPA.0719.003	We agree with other comments made regarding the nonconsumptive needs analysis. To the extent that this study is a "snapshot" of current supply and demand, the current needs of nonconsumptive users, including the flora and fauna that depend on streamflow of a certain amount and timing, must be fully acknowledged and the evident inadequacy of current supplies for nonconsumptive, environmental maintenance purposes must be displayed with the same emphasis as is attached to findings of sufficiency as they relate to	See response to comment CBRT.0721.004.

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	agricultural or municipal needs.	
RWAPA.0719.004	As noted, the flow thresholds in the 15 mile reach are junior and cannot, in and of themselves, put a "call" on the river and they are therefore not seen as critical in determining current needs (at least in comparison to senior rights that can control the flow upstream by way of exercising those rights). However, it should be acknowledged that the Endangered Species Act has the authority to override state law in the interest of endangered species and that, despite the agreements currently in place, releases to the 15-mile reach could be changed in the future. This is a significant unknown that will not be resolved any time soon given the difficulty of determining the long-term viability of endangered species stocks. This unknown, and the potential for water decisions to be dictated by the needs of endangered species, should be given more emphasis in the final study. Thank you for the opportunity to comment. We look forward to the final Phase I report and to follow-up studies.	See responses to comments YWBRT.0721.001 and CBRT.0721.015.
PCo.0721.001	These comments to the Phase I Colorado River Water Availability Study are being sent on behalf of the Pitkin County Board of County Commissioners. The Pitkin County Board of County Commissioners endorses the comments made by our fellow West Slope colleagues and friends as drafts of those comments have been shared with us. Particularly, the Pitkin County Board of County Commissioners endorses those comments of the Colorado River Basin Roundtable.	See responses to all CBRT comments.
PCo.0721.002	Of particular concern to the County is Phase I's apparent understatement of the basin's nonconsumptive flow needs. The nonconsumptive needs component of the study should be enhanced and developed more completely as these needs are every bit as legal and necessary a component to river health, economic vitality and the quality of life for Western slope residents as consumptive water needs. It would appear that because nonconsumptive uses do not permanently deplete stream flows, the Phase I report would conclude that this water is therefore available for other potential future needs. If this is a working assumption, it could not be further from a realistic approach to an accurate water availability study.	The CDSS model used for CRWAS does, in fact, "tie" up water decreed for specific nonconsumptive needs (administered through instream flow decrees and state-recognized operating agreements) and that water is not shown as available to other upstream uses.
PCo.0721.003	All types of nonconsumptive needs should be analyzed within Phase II, not only those necessary for "minimum stream flows" but those necessary for the continued environmental health and a healthy fishery, those flows required and identified for the protection of endangered fish species and those flows necessary for the generation of hydro-electric power.	The nonconsumptive needs listed (instream flows, endangered fish flows, hydroelectric power) are all included in the CDSS model used for CRWAS if they have current water rights, or if they are currently administered under an agreement recognized under Colorado State Engineer rules, policies, and procedures.
PCo.0721.004	The assumption used for minimum stream flows should not merely echo those adjudicated amounts held by CWCB but should consider overall aquatic and riparian health including needed flushing flows and winter sustainability flows.	Non-decreed nonconsumptive demands could be considered for inclusion in a subsequent phase of CRWAS.

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		See response to comment YWBRT.0721.001.
PCo.0721.005	The USFWS Programmatic Biological Opinion requirements for the fifteen mile reach should be reflected as a senior right to future uses as this obligation from the USFWS to water consumers is not somehow made a conditional obligation to those water consumers.	See response to comment CBRT.0721.015.
PCo.0721.006	Additionally, to be accurate, nonconsumptive flow needs should be planned for under more severe climate change models and prolonged below average precipitation cycles. At the very least, the longer period of climatological modeling, that to the year of 2070, should be relied upon and not discounted because its conclusions are not politically palatable.	See responses to comments PCo.0721.004 and CBRT.0721.008.
PCo.0721.007	Finally, the conclusion that available water supplies are within the range from 0 to 1 million acre feet tends to discredit the entire study effort. The range is of course far too broad to be meaningful. Phase II of the Water Availability Study should utilize realistic flow data, with defensible assumptions and modeling, to produce a more useful conclusion that can be supported by water users and the general public. Thank you for the opportunity to comment and we look forward to reviewing Phase II.	See responses to comments CBRT.0721.001 and CRWCD.0719.001.
RFC.0721.001	The following comments are submitted by Roaring Fork Conservancy in response to the "Colorado River Water Availability Study – Phase I Report – Draft" (CRWAS)." Currently, we have two categories of concerns: 1) the inadequate quantification of non-consumptive needs used in the Phase I modeling effort, and 2) the potential risks associated with allowing more water diversions based on the high end of the very wide range of projected available water. We are aware that some of the concerns raised in this letter may be more applicable to Phase II, and that the CWCB plans to address these components in the second phase. The Colorado Water for the 21st Century Act (HB 05-1177) established the Interbasin Compact Committee and nine Basin Roundtables and directed them to "develop a basinwide consumptive and non-consumptive water supply needs assessment, conduct an analysis of available unappropriated waters within the basin, and propose projects or methods, both structural and non-structural, for meeting those needs." The non-consumptive needs assessment consists of two tracks: 1) identifying stream and river segments with important environmental and recreational attributes, and 2) identifying projects and methods to meet the non-consumptive needs of those stream and river segments, including determining the quantity and timing of water necessary to maintain stream and river attributes.	See response to comment CBRT.0721.004.

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	The current study relies solely on decreed CWCB instream flow rights and necessary endangered fish flows to quantify nonconsumptive flow needs. **This has resulted in a gross underrepresentation of actual nonconsumptive flow needs.** CWCB instream flows do not directly consider the importance of other aquatic organisms or in-channel and over-bank indicators. As you are undoubtedly aware, a number of studies have shown that existing instream flow rights are too low.	
RFC.0721.002	Additionally, the CRWAS analysis of climate change only assesses the impact on flows; it does not address the complicated question of how climate change will indirectly affect aquatic species and their flow needs.	See response to comment CBRT.0721.004. The impact of climate change on non-flow-related habitat, e.g. water temperature, is not part of the scope of the CRWAS.
RFC.0721.003	In addition, further clarification on future water supply in headwaters streams due to climate change is necessary. Will high elevation streamflows increase or decrease? The conclusion that "higher elevations generally have less flow available (table 2 executive summary) is not consistent with other citations by saying "annual modeled streamflows decreases basin wide except in the Yampa River Basin, and higher elevations locations in the Upper Colorado River Basin" What will be the impact to the upper Roaring Fork, Frying Pan, and Crystal watersheds be?	Additional higher-altitude locations, which have been generated for CRWAS, will be provided in the next draft of the CRWAS Phase I Report. Hydrologic data generated at over 2000 locations in the state including high-elevation streams will be made available to the general public following Phase I model and analysis refinements.
RFC.0721.004	The quantification of nonconsumptive needs is an extremely difficult task. However, this fact does not negate the need for a much more realistic quantification of flow needs before the results of this study can be considered an accurate portrayal of water availability. **It is imperative that the CRWAS include a robust assessment of the quantity and timing of water necessary to maintain all important stream and river attributes.** [*Commenter included additional discussion of complexities of a more broadly defined nonconsumptive use; examples of nonconsumptive water uses and values; Roaring Fork Watershed Plan's draft recommended actions to help meet environmental, recreational, and hydropower needs.*]	See response to comment CBRT.0721.004.
RFC.0721.005	According to CRWAS, and based purely on historical hydrology, the water available for future consumptive use in the Colorado River is between 0.5 and 0.9 million acre-feet. When alternate climate change scenarios are considered, the range increases from 0 to 1 million acre-feet. CRWAS recommends stakeholders interpret findings: • From their own perspective, • Considering their assessment of possible future conditions, • Considering the resources they have available to adapt, • Considering their role in water management, and • Considering their tolerance for risk. Who are the stakeholders that will interpret these findings, and will they interpret	CRWAS is available for every stakeholder to review, interpret, and utilize. CWCB's role on CRWAS is to evaluate and provide data on ranges of water availability based on best available data, science, techniques, and tools that are currently available for this type of study to meet CRWAS objectives. CWCB's role does not include directing how individual stakeholders will interpret findings or make individual water management decisions.

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	findings with the environmental, recreational, and economic concerns of the Roaring Fork Watershed in mind? For example, developing water at the upper end of the range represents a high risk to the watershed, while development at the lower end of the range represents a lower risk. Will the risk taker pay all of the direct and indirect costs associated with our watershed not having sufficient water in its rivers and streams?	
RFC.0721.006	Finally, as a watershed organization concerned with citizen involvement, Phase 1 should have a citizen education component to educate the general public before Phase 2 is started and completed so that the CWCB proceeds based upon citizen input in the next phase of studies. We appreciate the opportunity to comment on the CRWAS and look forward to working with you on this difficult project in the future.	Public outreach has been scoped to be a significant component of CRWAS since its inception. Since 2008, the CRWAS team has presented and facilitated approximately 40 meetings and workshops around the state. These outreach meetings have included the state legislature, the CWCB Board, the IBCC, BRTs, professional organizations, and water providers. The primary method of public outreach for basin stakeholders is the BRT meetings. We are currently facilitating 14 additional outreach meetings in 2011 at regularly scheduled BRT meetings. The CRWAS team has attempted to accommodate all requested outreach meetings based on time and funding availability. See response to comment YWBRT.0721.001.

Gunnison Basin

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GBRT.0503.001	According to pages 2-20 & 2-21, CWCB directed the CRWAS technical team to coordinate its approach as much as possible with a concurrent Joint Front Range Climate Change Vulnerability Study (FRCCVS), to provide consistency between the two studies. The Front Range utilities had already selected the 2040 and 2070 time frames for the FRCCVS, with each time frame to "be characterized by average conditions over the periods 2025-2054 and 2055-2084 respectively." Why did they want those time frames? SWSI collected information for projections out to 2030, and the state's population projection goes out to 2050; wouldn't it have been more coherent all around to have used 2030 and 2050? Providing a rationale (not available yet at the CRCCVS site) for 2040 and 2070 would be helpful. (FRCCVS website: htt~://cwcb.state.co.us/Home/ClimateChange/JointFRCCVulnerabilitvStudy	Initially, time frames for the FRCCVS study were based on those selected for the Boulder Climate Change Study (Smith, et al., 2009). The Boulder Climate Change Study selected 2030 and 2070 as time frames, but the FRCCVS technical team felt that 2030 was too early to see significant development of climate change impacts, so 2040 was used as the early time frame for the FRCCVS. *Smith, J. B., Strzepek, K., Rozaklis, L. Ellinghouse, C. and K. C. Hallett. 2009. The Potential Consequences of Climate Change for Boulder Colorado's Water Supplies. NOAA Climate Program Office.* Wording will be added to the next draft of the CRWAS Phase I Report to explain rationale used to select the referenced time frames.
GBRT.0503.002	The FRCCVS website says that study will be based on the historical period from 1950-1999. Why is the FRCCVS using 1950-1999 for its historical period while the CRWAS is using 1950-2005? That seems inconsistent with the desire for consistency between the two studies.	The principal areas of consistency between the two studies were the selection of climate projections and the selection of time frames for projected conditions. The longer historical study period (1950-2005) was chosen for CRWAS to include drought years following 1999, including 2002.
GBRT.0503.003	Understanding that it is necessary to distinguish between "climate" (the driver of weather) and "weather" (the local or regional consequences of climate behavior), why does CRWAS not have a section on what is likely to be happening with the climate over the Pacific Ocean, from whence almost all of the Colorado River region weather comes? Is the Southern Oscillation likely to produce more or fewer El Niños? La Niñas? What will warming in oceans and atmosphere do to the jet streams that have powerful impacts on weather in the Southern Rockies? To the atmospheric conditions that create the sub-tropical deserts?	The objective of the Study was to understand and quantify the impacts of projected climate change on Colorado's water resources using the best available data, not to diagnose the processes that will lead to changes in the regional climate.
GBRT.0503.004	Is it accurate to say that the "downscaling" discussed on pages 2-19 and 2-22 is to incorporate weather data rather than climate? How is this downscaling done? CRWAS does not tell about the process. On pg 2-19 the study talks about going from a grid of 40,000 sq. mi. to something in the range of "several hundred to a thousand" sq. mi. To accurately represent the climate weather in just the Upper Gunnison Basin (above Blue Mesa), for example, changes from a high desert climate with less than 11 inches of precipitation to a mountain climate with precipitation water content more than twice that (24-30 inches/year) - all within a 1600 sq-mile area. How does the downscaling take that variety into account?	CRWAS is based on the best available data, science, techniques, and tools that are currently available for this type of study to meet CRWAS objectives. The downscaling method employed by CRWAS includes the effect of topography and the variability of local weather on a monthly time step. The delta approach used in the Study to develop inputs for the hydrology model incorporates variability associated with daily weather. The VIC model used in the Study employs a detailed physical model that simulates snow accumulation and snowmelt. During work on CRWAS, this model was compared to records from SNOTEL stations in the central Rocky Mountains in Colorado. Results of this validation indicate that the snow model performed very well; nevertheless, these elements of climate and hydrology simulation do have inherent uncertainty. The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.

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GBRT.0503.005	A related question: there is occasional mention of "grid cells," but there is no map showing the grid and the cells. How big are the cells? And are they just squares laid over a map, or are they conformed to altitudes demarking different precipitation zones? (E.g., the Upper Gunnison above and below ~8,000 feet)	The best data available at the time of the analysis included a regular orthogonal grid with grid spacing of 1/8th degree. Wording will be added to the next draft of the CRWAS Phase I Report to clarify this.
GBRT.0503.006	In the "Selection of Projections" section, do the five selected projections really cover the desired range of "Qualitative Scenarios" in Table 2-3 on page 2-23? The median is ~10 percentile above the 50 percentile desired. There is nothing below about the 20th percentile, presumably missing the “Hot and Dry” scenario entirely. The "Wet" end of the scenarios, on the other hand, seems to be well represented with two projections at the 80 percentile and above. Could this slant the study toward projections of more water availability than a more accurate set of projections would indicate? Would the final range of estimates of potential water available for the future (0-1 maf) have been less, had the "driest" selected projection been at, say, the 8th percentile instead of the 18th (balancing the "wet" one at the 92nd percentile)? Or if the wettest and driest had both been ~20 points removed from the extremes (rather than 8 from the wettest and 18 from the driest extremes)? Why weren't other projections picked from the scattergram (Figure 2-9) that would have given something closer to the desired "Qualitative Scenarios"?	See response to comment CBRT.0721.008. Considered in the context of the broad range of hydrologic impacts, the selected projections for 2040 adequately meet the selection objective, while those for 2070 do not. Data needed to make this determination for the 2070 planning horizon were not available until the latter portion of the Study. Proposed refinements to the Study include additional work to identify and analyze a set of climate projections for 2070 that better represent the range of projected hydrologic impacts. The CRWAS and the FRCCVS employed a peer-reviewed method to select climate projections based on their simulated change in temperature and precipitation, with the objective of representing approximately 80% of the range of conditions reflected across all of the readily available projections. The position of each projection on the scattergram of Figure 2-9 (which illustrates the selection process) cannot completely represent the impact of the projection on streamflow, so the selected projections will not exactly meet the selection objective. Comprehensive information on the impact of all of the available projections on streamflow, illustrated in Figures 2-10 through 2-13 and which became available to the Study after all of the hydrologic modeling was completed, allowed the Study to evaluate the degree to which selected projections met the a priori selection objective. To our knowledge, no climate change impact study had previously done such an evaluation. The upper bound of the water available for future use was set by the wettest projection and the most optimistic assumption regarding interpretation of the Colorado River Compact. See response to comment and CBRT.0721.001.
GBRT.0503.007	On page 2-22, the selection of "Emissions Scenarios" is very briefly discussed, concluding that "only the B1, A1B (a member of the A1 family) and A2 scenarios" will be used because they "have been used as the basis for projections on many GCMs." Was the CRWAS technical team satisfied that those three scenarios "fit" the Colorado River Basin in Colorado - as satisfied, say, as the FRCCVS techs were that they fit the Front Range? Looking at the SRES Scenarios described in CRWAS as 'low' (B1), 'medium' (A1 B), and 'high' (A2), what rationale was used to decide which ones to pair with the "Qualitative Scenarios" (e.g., "Warm and Wet" paired with the "A2 - High Emissions" scenario)? ("Special Report on Emissions Scenarios": http://www.grida.no/publications/other/ipcc~sr/?src=/climatetipcc/emission)	While different emissions scenarios may impact different regions of the globe to varying degrees, emissions scenarios are global in nature and do not have a specific linkage to a region. The three emissions scenarios were used in the Study because of their widespread use in other impact studies and because model runs based on these scenarios are readily available. The CRWAS and the FRCCVS selected climate projections based on their simulated change in temperature and precipitation, with the objective of representing approximately 80% of the range of conditions reflected across all of the readily available projections. Individual projections were not selected based on other attributes.

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GBRT.0503.008	In the "Findings" section, in Tables 3-2 and 3-3, the "Average Winter and Spring-Summer Precipitation" tables, why are the "Higher" locations so relatively low in their basins? The "Gunnison 3SW" station, for example, is only at 7640 feet, basically still in the Upper Gunnison's high desert sector. The precipitation in the Upper Gunnison mainly falls above 8,000 feet - and there are weather stations at that altitude and higher. Only the "Grand Lake 6SSW" station in the study is above 8,000 feet - and it has the highest average projection of percentage over historical winter precipitation.	Additional higher-altitude locations, which have been generated, will be provided in the next draft of the CRWAS Phase I Report. All hydrologic data generated at over 2000 points will be accessible to the general public.
UGRWCD.0719.001	On behalf of the Board of Directors of the Upper Gunnison River Conservancy District, I am submitting the following comments on the report entitled "Colorado River Water Availability Study – Phase I Report – Draft Findings, March 22, 2010. Our greatest concern is the incorrect values for the water available to meet future demands in the Upper Gunnison Basin reported in the study. The incorrect values are the result of failing to account for the Aspinall Unit direct flow hydropower rights in the water availability analysis. There are numerous tables and figures in the report and appendices that need to be revised to reflect the corrected values. The Aspinall Unit direct flow hydropower water rights are very large, as shown in the following table (See the original letter for table values.) The District's consulting engineer, Jim Slattery, worked with Erin Wilson, consulting engineer for the State of Colorado, to revise the Colorado Decision Support System StateMod model to include the Aspinall Unit direct flow hydropower water rights. Nevertheless, the District's Board of Directors wishes to make a record of this concern to assure that it will be reflected in the final report.	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to refine representation of Aspinall Unit hydropower operations through discussions and coordination with the UGWCD. This type of refinement is a key aspect/benefit of CRWAS.
UGRWCD.0719.002	The estimated water available to meet future demands in the Upper Gunnison River Basin decreased significantly after the Aspinall Unit direct flow water rights were incorporated into the StateMod model. The water available to meet future demands changed from the currently reported annual average value of 330,000 acre-feet per year to less than 7,000 acre-feet per year, with the majority of the years reflecting nothing available. The Aspinall Unit storage rights and direct flow hydropower rights control the entire inflow to the Aspinall Unit except in a few months in extremely high runoff years when the Bureau of Reclamation inadvertently underestimates the forecasted inflow into the Aspinall Unit.	See response to comment UGRWCD.0719.001.
UGRWCD.0719.003	During our review we identified the need to improve the storage targets for Blue Mesa Reservoir. Jim Slattery and Erin Wilson worked with the Bureau of Reclamation to refine the storage targets used in the StateMod model. The	See response to comment UGRWCD.0719.001.

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	change in the storage targets did not have a significant impact on the model results, but are necessary to better represent the operation of Blue Mesa Reservoir.	
UGRWCD.0719.004	Finally, the District Board wishes to express concern, as have other reviewers, that the wide range of values in the conclusion (0-1 million acre-feet) greatly diminishes the value of the study as a planning tool on both State and local levels. At the least, some degree of probability analysis for the various alternatives would be helpful. The District Board appreciates the hard work by Ray Alvarado and his consultant team, both in preparing the report and in making numerous thoughtful presentations to interested parties throughout the state. In the interest of producing the most accurate study possible, the District is prepared to continue to offer the services of its consulting engineer to assist the study team on issues unique to the Gunnison Basin, where his many years' experience can be valuable in evaluating model results. The Board also wishes to thank the Colorado Water Conservation Board for undertaking this daunting task, so necessary for wise planning for Colorado's future Colorado River water development.	See response to comment CBRT.0721.001.
GCo.0720.001	I am authorized by the Board of County Commissioners of Gunnison County, Colorado ("Gunnison County") to submit the following in response to the Colorado River Water Availability Study, Phase 1 ("CRWAS"). Gunnison County affirmatively joins in the written comments, dated July 19, 2010, by the District [the Upper Gunnison River Water Conservancy District]. In particular, Gunnison County notes the findings of the District's consulting engineer, Jim Slattery, which significantly reduce the CRWAS estimate of water availability for development from the Gunnison Basin. Gunnison County fully supports those findings and urges that the findings be reflected in the final Phase 1 report, and carried forward into Phase 2.	We have met with the UGRWCD consultant to review the model assumptions. The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to incorporate revisions. This type of refinement is a key aspect/benefit of CRWAS.
GCo.0720.002	Of additional, and significant, concern to Gunnison County is a "recommendation" at CRWAS, at page VIII and page 4-2, which reads: "Consider revisions to Aspinall Unit Reservoir operations. The Aspinall Unit reservoirs (Blue Mesa, Morrow Point, and Crystal) operate primarily for non-consumptive uses within and outside of Colorado." Gunnison County is concerned that: 1. The "recommendation" is not founded in any substantive data or analysis in CRWAS;	This refers to the current model representation of Hydropower use, and representation of downstream demands. Wording will be added to the next draft of the CRWAS Phase I Report to clarify this.
GCo.0720.003	[Reference GCo.0720.002] 2. The "recommendation" carries an implication that the preferred "revisions" would be from primarily non-consumptive uses to consumptive uses. Such a	This recommendation is not meant to imply revisions from non-consumptive to consumptive uses. Instead it refers to the current model representation that does not represent operations for fish flows as determined by the future EIS. Since

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	revision would invite attempts at transbasin diversion from the Aspinall Unit. Gunnison County would oppose such "revisions". Gunnison County requests that this "recommendation" be removed based on lack of data or analysis.	revised Phase I modeling must be completed in 2011, it will not be possible to incorporate Final EIS/ROD provisions in this current phase of work. Recommendations regarding Phase II modeling may include these refinements. See response to comment YWBRT.0721.001.
GCo.0720.004	In addition, Gunnison County would urge systematic, detailed consideration of the Aspinall Unit as a repository against a down-Colorado river call that could have detrimental consequences within Colorado.	The model representation of the Aspinall Unit is consistent with the comment; it is primarily operated in accordance with its function as a key Colorado River Storage Project reservoir.
GCo.0720.005	Finally, Gunnison County shares the concerns of the Southwest Roundtable and Gunnison Basin Roundtable which "found the range of variability of available water from 0 to 1 million acre feet as contributing to, rather than helping to settle, polarization among the divergent interests who have a stake in the outcome of Phases 1 and 2 of the Study."	See response to comment CBRT.0721.001.

Southwest Basin

Comment ID	Comment	Response
SWBRT.0716.001	On behalf of the Southwest Basins Roundtable, I would like to thank Ray Alvarado for providing a detailed presentation of the Colorado River Water Availability Study at our July 7, 2010 Roundtable meeting. The Roundtable was impressed by the extent and complexity of this effort. After questions and discussion of Ray Alvarado's presentation the Roundtable provided comments as outlined below: The Roundtable found the range of variability of available water from 0 to 1 million acre feet as contributing to, rather than helping to settle, polarization among the divergent interests who have a stake in the outcome of Phases 1 and 2 of the Study. Uncertainty surrounding this wide range is compounded by the fact that all climate change scenarios are considered to be of equal probability.	See response to comment CBRT.0721.001.
SWBRT.0716.002	The Roundtable concluded that Phase 2 should only be undertaken if the result will be a narrowing of this availability gap and provide a most probable scenario for use at the Basin level.	See responses to comments CBRT.0721.001 and YWBRT.0721.001.
SWBRT.0716.003	A necessary step prior to Phase 2 is to correct errors in the Phase 1 analysis. For example, the operation of several Bureau of Reclamation reservoirs should be based on contractual allocations rather that simulated irrigation demand.	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to coordinate with Reclamation reservoir operators in the San Juan basin to better understand and represent reservoir allocations in the model. This type of refinement is a key aspect/benefit of CRWAS.
SWBRT.0716.004	Another step towards a most probable scenario would be to focus on the Historical Average Monthly Modeled Streamflow which falls within the range of the five climate generated stream flows in Appendix E.	CRWAS was scoped to present results for a range of future climate projections. It is recommended that each stakeholder interpret the broad range of future water availability from its own perspective, considering its own assessment of the possible future conditions, its role in water management, the resources it has to adapt to alternative potential futures, and its tolerance for risk. Data used in CRWAS analyses and for the Draft CRWAS Phase I Report also includes historical streamflows. It is CWCB's intention to make this data available to the public such that each stakeholder may use the data for their own purposes.
SWBRT.0716.005	Since the CRWAS is a statewide model intended as a tool for planning, our Roundtable suggests a prominent disclaimer on how information in the report should and should not be used. We are concerned, for example, about the use of this information in water rights applications, compact curtailments, and other State Agency studies and evaluations.	Wording will be added to clarify CRWAS limitations and appropriate uses.
SWBRT.0716.006	Ray Alvarado framed the Study as a tool to help people at the Basin level to make informed decisions about the future. The Roundtable discussed a number of variables that will need to be monitored over time to make decisions going	Monitoring activities noted in the comment are not currently part of CRWAS scope. CRWAS is currently intended to be used as a broad starting point for Basin level planning, and stakeholders are encouraged to utilize CRWAS data for

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	forward. These include crop changes if the growing season expands, the ongoing application of more efficient irrigation technologies and the impact on return flows, changes in the monsoon season as a critical element in water management in our Basin and unfolding efforts to come to grips with non-consumptive uses.	more detailed analysis according to their needs. More detailed analyses can be initiated through the BRT process and projects facilitated through the BRT or potentially through a subsequent phase of CRWAS. See response to comment YWBRT.0721.001.
SWBRT.0716.007	Because the Southwest Basins are in the transitional climate belt between the northern latitudes that are projected to see increased precipitation and the more southern latitudes that are projected to see less precipitation, we need to see how any climate change in our Basin plays out between these poles. Key variables of influence in this regard are our topography including elevation, slope and aspect. To make Phase 2 a useful tool in our Basin, a framework that would help us evaluate and track on these Basin level details would be more useful than climate projections base on global modeling.	See responses to comments SWBRT.0716.006 and YWBRT.0721.001.
SWBRT.0716.008	The Roundtable recommends that before initiating Phase 2 of the CRWAS, a better understanding of assumptions underlying Phase 1 and correction of Phase 1 errors (e.g. reservoir operations) should be facilitated, along with Roundtable level input into shaping Phase 2. We very much appreciate this opportunity to comment on Phase 1 of the CRWAS. We are aware of the challenges, both technical and budgetary in advancing the CRWAS as a useful planning tool. We are interested in continuing to work with you and Ray in shaping our comments and concerns into practical steps forward in this process.	Assumptions will be clarified in the next draft of the CRWAS Phase I Report. The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to refine reservoir operations within the CDSS model. See response to comment YWBRT.0721.001.
DWCD.0716.001	The Dolores Water Conservancy District (DWCD), LaPlata Archuleta Water District (LAPLAWD), Pagosa Area Water and Sanitation District (PAWSD), Pine River Irrigation District (PRID), and San Juan Water Conservancy District (SJWCD) (this "Districts") joined together to have Steve Harris, with Harris Water Engineering, Inc., coordinate the review and development of comments regarding the Colorado River Water Availability Study (CRWAS). The Districts appreciate the opportunity to comment on this important document and are very impressed by the amount of effort and thought represented by the draft report. CRWAS was reviewed from the perspective of the Districts primarily and does not represent comments by other entities in southwest Colorado. These comments are suggestions to improve the CRWAS in order to provide a better basis for evaluation of Colorado River water availability and to provide a source of information for local evaluation of the potential impacts of global warming. The Districts would also like to thank Ray Alvarado and Greg Johnson for the effort they made to attend the Southwest Basins Roundtable on July 7 and several phone calls to assist Mr. Harris in his evaluation. Ray was especially helpful and knowledgeable. The following comments are separated into general comments and comments that the Districts believe are critical and should be addressed	Additional BRT outreach workshops are being implemented prior to refining the Draft CRWAS Phase I Report. We will continue to work with stakeholder representatives to answer questions and address concerns based on their continuing effort to understand CRWAS assumptions and results.

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	before the Phase I CRWAS is finalized. A. General Comments A.1 The CRWAS is a major study with numerous models and assumptions that were developed by numerous CWCB staff and consultants (refer to Figure 1-1). The report is thorough and well organized, but due to its complexity and content it is not possible to understand the content solely by reading the report and reviewing the tables and charts. Mr. Harris spent many hours reading the report; attended several presentations at IBCC, Roundtable, and Colorado Water Congress meetings; attended the July 7 Southwest Roundtable meeting; and talked to CWCB staff on several occasions to attempt to understand some of the details of the study. Even with that effort, it is unlikely that all of the critical assumptions were reviewed to provide comments. Depending upon feedback from other water user entities, CWCB might consider a one or two day technical workshops to provide a full briefing and especially a review of assumptions. If there is a consensus for a workshop, it should be conducted prior to beginning Phase 2.	
DWCD.0716.002	A.2 Figure 3-37 shows five bar graphs reflecting five different estimates of the water available to Colorado under the Colorado River Compact. The "Modeled Study Period", '"Extended Historical Hydrology", and "Alternate Climate Projections" were prepared a part of CRWAS, The bar graphs for "Modeled Study Period" and "Extended Historical Hydrology" provide useful information based on actual hydrology data and tree ring evaluations, but the "Alternate Climate Projection" bar graph is based on significant uncertainty and variability associated with attempting to quantify the potential effects of global warming. The "Alternate Climate Projections" bar graph in Figure 3-37 does not provide a better understanding of the available supply instead increases the misunderstanding and uncertainty. To further confuse the availability, apparently any point between 0 and 1 million acre-feet has the same probability as any other point. This bar graph seems to have politicized the water available because the range is so large that any amount can be selected. The Districts had understood the CRWAS would provide a better understanding of the range of water available to Colorado under the Colorado River Compact. In order to accomplish that goal, the Districts recommend that: (1) the "Modeled Study Period" and "Extended Historical Hydrology" bar graphs are emphasized as study results; and (2) the "Alternate Climate Projections" bar graph be de-emphasized because of the uncertainty and variability inherent in the climate change estimates.	See responses to comments CBRT.0721.001 and SWBRT.0716.004.
DWCD.0716.003	A.3. Nearly all of the figures and hydrographs in the appendices are based on alternative climate analysis. With few exceptions, the historic “2040 (or 2070) Average Monthly Modeled Streamflow" is within the range of the five climate	See response to comments CBRT.0721.001 and SWBRT.0716.004.

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	generated streamflows in Appendix E. Based on this information it appears that the historic streamflow is as good as my modeled estimate. Though the climate change models are interesting, using the historic flow data is the best assumption because it is the most certain, understood, and repeatable of any of the potential hydrographs.	
DWCD.0716.004	A.4. The scope and purpose of Phase 2 of CRWAS should be reviewed to verify that the original intent remains appropriate. Further, if Phase 2 proceeds, the "1950 - 2005 Modeled Study Period' and "Extended Historical Hydrology" should be the primary hydrology and the "alternate climate projections" should not be used or be secondary.	See response to comments CBRT.0721.001 and SWBRT.0716.004.
DWCD.0716.005	A.5. Given that many models were linked to develop the study results and each model has a probability range of providing reliable results, what is the accumulated probability range of the integration of all the models? In other words, does the variability inherent in each model accumulate so there is greater variability and less reliable results in linking the models, or does the variability stay the same or decrease from the linkage?	All measurements contain uncertainty, and estimates of future conditions based on simulations are more uncertain than measurements. Each element of a climate impact analysis contains its own degree of uncertainty. When elements of the analysis are combined, individual uncertainties do not add up in a straightforward way, and overall uncertainty cannot be determined by a simple calculation. However, individual uncertainties do interact and each added element does increase overall uncertainty of the estimate of impact. Wilby and Harris (2006) found that the greatest uncertainty arose in climate impact studies from the climate models themselves, followed, in order, by the downscaling method, the hydrology model structure, hydrology model parameters and finally by the uncertainty in future emissions scenarios. The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions. *Wilby R. L. and I. Harris. (2006). A framework for assessing uncertainties in climate change impacts: Low-flow scenarios for the River Thames, UK, Water Resources Research, Vol. 42, W02419, 2006.*
DWCD.0716.006	A.6. The Districts do not have much knowledge about the global climate models to comment specifically. Theoretically, the downscaling process is logical but whether it is accurate is yet to be seen. If there is sufficient concern about the possibility of climate change, a program to collect climate data to monitor critical information should be designed and implemented by the State. Simply monitoring existing weather stations is not adequate because the stations move and/or instruments change. The program should utilize weather stations that are located exactly the same location and the instruments should be the same type so the measurements are consistent between sites.	See response to comment SWBRT.0716.006. Also, please note that the CWCB can only provide suggestions to other local, state, and federal agencies that own and operate weather stations regarding their locations and instrumentation.
DWCD.0716.007	A.7.a) The "Variable Infiltration Capacity" (VIC) model is critical to the integration of the climate models and StateMod but is not well described. The VIC model is apparently first calibrated to the historic natural flow derived using StateMod. Then a separate VIC model run is made to incorporate the climate adjusted precipitation and temperatures for each of the five climate	The vegetative cover simulated in the VIC model was adopted from the model used by Christensen and Lettenmaier (2007) and these data were in turn derived from data obtained from the Land Data Assimilation System (LDAS). The next draft of the CRWAS Phase I Report will clarify vegetation data used in the VIC

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	scenarios. The assumptions used to estimate the area of various types of natural vegetation and the consumptive use of the natural vegetation is not explained. Each of the five climate scenarios are compared to the historic VIC output and used to determine the "'Average Monthly Modeled Streamflow".	model. The next draft of the CRWAS Phase I Report will clarify the process by which climate-impacted natural flows and modeled flows are determined. *Christensen, N. and D.P. Lettenmaier. 2006. A multimodal ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River basin, Hydrology and Earth System Sciences Discussion, 3:1-44.*
DWCD.0716.008	A.7.b) The VIC model apparently assumes that the natural vegetation of the river basin is the same in 30 years with higher temperatures and the change in the forest cover due to fires and beetle kill. It would seem that the natural vegetation would self-adjust to the new climate conditions and the assumption that the existing vegetation would remain is not appropriate. It would seem the likely adjustment in the types of natural vegetation is a critical component to the VIC model, yet this impact is not included in the modeling for reasons stated in section 2.5. This is a further example of the uncertainty and variability in the alternate climate analysis.	Changes in vegetation were not simulated in developing the CRWAS climate-impacted natural flows, and that this assumption does add uncertainty to the results of the hydrology modeling. This uncertainty is hard to resolve at this time because there is limited scientific analysis available on which to base simulation of the changes of vegetation in response to climate change. However, uncertainty in the types and mix of vegetation may not introduce a corresponding degree of uncertainty to the overall water balance because the amount of evapotranspiration is primarily a function of the energy available to evaporate water, subject to the limited water supply available in the soil from precipitation. As vegetative cover adapts to a new climate, the plants will make full use of the available solar energy and water supply to support plant growth. The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.
DWCD.0716.009	A.8. Table 3-1 shows the projected increased temperature. A column showing the average annual temperature at each weather station would be helpful to understand the increased temperature as a percentage of the average temperature. The precipitation tables (3-2 and 3-3) include this information. As with stream flow gages, the error in measurement can be plus or minus 10%; therefore, if the projected temperature or precipitation change is less than 10% it may be within measurement error. Also a statement of whether, or not, the selected weather stations have been at the same location for the entire 55 year period would be helpful in understanding the reliability of the historical and projected data.	The next draft of the CRWAS Phase I Report will include added corresponding tabular information and discussion on climate station locations.
DWCD.0716.010	A.9. A clear and prominently placed disclaimer statement describing how the information in this report should and should not be used is recommended. For instance: (1) are the hydrographs and data of adequate quality for use in water rights applications, by the proponent and/or opponents? Or (2) the data and hydrographs should not be used in compact curtailment analysis? Or (3) In what manner should the data be used in other State Agency studies and evaluations?	See response to comment SWBRT.0716.005.
DWCD.0716.011	<u>B. Needed Changes to the Report</u> The Districts recommend that the report be modified to address these comments	See response to comment SWBRT.0716.003.

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	because they are critical to the results of the study. Publishing of the data and hydrographs currently in the report will not provide an accurate indication of the basin water supplies and may result in misrepresentations being used in CRWAS Phase 2 and other future reports. B.1.a) The method for operation of McPhee and Vallecito Reservoirs used in the CRWAS is not correct in assuming that irrigated land can "pull" water from the reservoirs based on the crop consumptive use. These reservoirs are Reclamation facilities and as such have contracts and operational criteria that restrict the amount of water that can be provided to each acre of irrigated land served by the reservoirs. For each of these reservoirs, a maximum amount of water is assigned to specific acres of irrigated land according to Reclamation law. For example: Vallecito allocates the non-Indian water by multiplying the maximum reservoir content by 5/6th then dividing by 45,000 PRID Acres. When there is a full reservoir, there is approximately 2.2 AF per PRlD Acre. The CRWAS modeling does not recognize the 2.2 AF per PRID Acre limitation. The model allows lower priority ditches to pull as much water as necessary to fulfill their irrigation crop demand (with global warming the crop demand is much larger as shown on Table 3-4). The result is that Vallecito is shown to fluctuate much more in the future than the past with the implication that the fluctuation is mostly attributable to global warming. In reality the fluctuation has more to do with how the reservoir is operated in the CRWAS modeling. This should be corrected by coordinating with Hal Pierce the PRID manager.	
DWCD.0716.012	B.1.b) The CRWAS modeling also allows irrigators to draw water from McPhee based on irrigation crop demand, instead of the contracts between the project users that establish a maximum annual water supply for each user. With the model, the irrigation water demand for all of the Dove Creek, Montezuma Valley Irrigation Company MVIC), and Tribal acres is drawn from the reservoir until it is empty. In actual operation each of the irrigation entities have a maximum water supply that cannot be exceeded and currently all irrigators are drawing their maximum water supply in most years. The model shows much more water being withdrawn from McPhee than could usually occur which results in the fluctuation of the reservoir content in Figures G-7 and G-8 being too large. Also, the flow downstream of McPhee at Bedrock shown in Figure E-30 and F-30) is less than would actually occur. The flow below McPhee in the Dolores River is a major issue in numerous ongoing studies and the flow under global warming scenarios should be as accurate as possible. The operation of McPhee Reservoir should be corrected by coordinating with the DWCD Manager and Engineer, Mike Preston and Ken Curtis respectively, and the Bureau of Reclamation.	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to coordinate with DWCD to better understand and represent reservoir allocations in the model. This type of refinement is a key aspect/benefit of CRWAS.
DWCD.0716.013	B.1.c) Jackson Gulch and Lemon Reservoirs are also Reclamation reservoirs and are assumed to be operated in a similar manner to Vallecito and McPhee.	See response to comment SWBRT.0716.003.

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	CWCB should contact the entities operating these reservoirs for the appropriate operation criteria.	
DWCD.0716.014	B.2.a) The comparison of the "2040 Average Monthly Modeled Streamflow" and the "2040 Average Monthly Water Available to Meet Future Demands" does not appear to be appropriate for streams in southwest Colorado. The difference in flows between the two scenarios is very large for the gages for Carracas, Los Piños, Florida, Animas, and LaPlata Rivers; minor for Mancos River and McElmo Creek; and are very similar for the Dolores at Bedrock and the San Miguel River at Naturita gages which are not in the San Juan Basin. For example, comparing the flows for the San Juan River at Carracas; Figure E-21 shows an annual flow range of 274,300AF to 484,300AF for the Modeled Streamflow and Figure F-21 shows a flow range of 18,000AF to 271,600AF for the available water to meet future demand. There should be no difference between the two flows because Carracas is immediately upstream from Navajo Reservoir and there are essentially no diversions and no CWCB instream flow water rights downstream to be met. Apparently, the reason for the difference is CRWAS uses the endangered fish flow recommendations in the San Juan River downstream of the City of Farmington and downstream demand (last bullet on page 4-2).	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to coordinate with stakeholders to better understand and represent fish flow requirements and allowable depletions in the model. New Mexico demands will be excluded from the model. Corresponding revisions will be reflected in the next draft of the CRWAS Phase I Report. This type of refinement is a key aspect/benefit of CRWAS.
DWCD.0716.015	B.2.b) Based on the purpose of the San Juan Recovery Program to allow water development simultaneously with recovery of the endangered fish and the fact that the flow recommendations are NOT fixed flow requirements, the use of the flow recommendations as a downstream demand is not appropriate for "2040 (and 2070) Average Monthly Water Available to Meet Future Demands" in the San Juan River basin. The "2040 Average Monthly Modeled Streamflow" and the "2040 Average Monthly Water Available to Meet Future Demands" should essentially be equal for the gages in southwest Colorado in the San Juan River Basin. The Districts believe that using the endangered fish flow recommendations as the downstream demand is a major policy decision that requires active discussion and agreement by the CWCB board and stakeholders. Further, we recommend that the use of the flow recommendations as a downstream demand should be removed from the "2040 (and 2070) Average Monthly Water Available to Meet Future Demands" analysis.	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to meet with stakeholders to better understand and represent the fish flow requirements and allowable depletions in the model. This type of refinement is a key aspect/benefit of CRWAS.
DWCD.0716.016	B.3. The McElmo Creek natural flow estimates for 2040 and 2070 (Figures D-43, D-86, and D-129) are not correct. McElmo Creek is naturally a very small drainage with a small amount of water that runs off early in the spring (e.g. March and April). The flows have been supplemented by water imported from the Dolores River by MVIC since the late 1800's. The analysis in the report appears to include the imported water as if it were natural flow as indicated by the second runoff peak in June/July in Figures D-43 and 86. Though this is not	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to coordinate with basin representatives to better understand McElmo Creek imports and uses, resulting in refined natural flow estimates. This type of refinement is a key aspect/benefit of CRWAS.

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	a critical aspect of the study, it needs to be corrected to accurately reflect the McElmo Creek natural flow.	
SWCD.0716.001	The Southwestern Water Conservation District (SWCD) appreciates the opportunity to comment on the Colorado River Water Availability Study (CRWAS) and is very impressed by the amount of effort and thought presented by the draft report. These comments are suggestions to improve the CRWAS in order to provide a better basis for evaluation of Colorado River water availability and to provide an understanding of the uncertainty and variability associated with potential impacts of climate changes. Steve Harris, with Harris Water Engineering, coordinated the review of CRWAS and the development of these comments. He assisted SWCD and five other water districts within SWCD; a comment letter from the other five districts is similar to this letter. SWCD would like to thank Ray Alvarado and Greg Johnson for the effort made to attend the Southwest Basins Roundtable on July 7 and several phone calls to assist Mr. Harris in his evaluation. Ray was especially helpful and knowledgeable. The following comments are separated into general comments and comments that the SWCD believe are critical and should be addressed before Phase I CRWAS is finalized. <u>A. General Comments</u> A.1. The CRWAS is a major study with numerous models and assumptions that were developed by numerous CWCB staff and consultants (refer to Figure 1-1). The report is thorough and well organized, but due its complexity and content it is not possible to understand the content solely by reading the report and reviewing the tables and charts. Mr. Harris spend many hours reading the report; attended several presentations at IBCC, Roundtable, and Colorado Water Congress meetings; attended the July 7 Southwest Roundtable meeting; and talked to CWCB staff on several occasions to attempt to understand some of the details of the study. Even with this effort, it is unlikely that all of the critical assumptions were reviewed for possible comment. Depending on feedback from other water user entities, the CWCB might consider a one or two day technical workshop to provide a full briefing and especially a review of assumptions. If there is a consensus for a workshop, we suggest this be conducted prior to beginning Phase 2 of CRWAS.	See response to comment DWCD.0716.001.
SWCD.0716.002	A.2. Figure 3-37 shows five bar graphs reflecting five different estimates of the water available to Colorado under the Colorado River Compact. The “Modeled Study Period”, “Extended Historical Hydrology”, “and “Alternate Climate Projections were prepared at part of CRWAS. The bar graphs for “Modeled Study Period” and “Extended Historical Hydrology” provide useful information based on actual hydrology data and tree ring evaluations, but the "Alternate Climate Projections" bar graph is based on significant uncertainty	See responses to comments CBRT.0721.001 and SWBRT.0716.004.

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	and variability associated with attempting to quantify the potential effects of global warming. The "Alternate Climate Projections" bar graph in Figure 3-37 does not provide a better understanding of the available supply but increased the misunderstanding and uncertainty. To further confuse the availability, apparently any point between 0 and 1 million acre-feet has the same probability as any other point. This bar graph seems to have more fully politicized the water available because the range is so large that any amount can be selected based on a political position. SWCD had understood the CRWAS would provide a better understanding of the range of water available to Colorado under the Colorado River Compact. In order to accomplish that goal SWCD recommends that the "Modeled Study Period" and "Extended Historical Hydrology" bar graphs be emphasized as study results; however, the "Alternate Climate Projections" bar graph be de-emphasized because of the uncertainty and variability inherent in the climate change estimates.	
SWCD.0716.003	A.3. Nearly all of the figures, hydrographs in the appendices are based on alternative climate analysis. With few exceptions, the historic "2040 (or 2070) Average Monthly Modeled Streamflow" is within the range of the five climate generated streamflows in Appendix E. Based on this information it appears that the historic streamflow is as good as any modeled estimate. Though the climate change models are interesting, using the historic flow data is the best assumption because it is the most certain, understood, and repeatable of any of the potential hydrographs.	See response to comments CBRT.0721.001 and SWBRT.0716.004.
SWCD.0716.004	A.4. The scope and purpose of Phase 2 of CRWAS should be reviewed to verify that the original intent remains appropriate. Further, if Phase 2 proceeds, the alternate climate information should not be used, or to a lesser extent, but the hydrology reflected by the "Modeled Study Period" and "Extended Historical Hydrology" is the basis of further study.	See response to comments CBRT.0721.001 and SWBRT.0716.004.
SWCD.0716.005	A.5. Given the many models used to develop the results of the study, what is the potential error range of stacking the various models? Does the variability range of each model accumulate as opposed to negating?	See response to comment DWCD.0716.005.
SWCD.0716.006	A.6. SWCD does not have enough knowledge about the global climate models to comment specifically. Theoretically, the downscaling is logical but whether it is accurate is yet to be seen. If there is sufficient concern about the possibility of climate change, a program to collect climate data to monitor critical information should be designed and implemented by the State. Simply monitoring existing weather stations is not adequate because the stations move and/or instruments change. The program should utilize weather stations	See response to comment DWCD.0716.006.

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	that are located at exactly the same location for the study period and the accuracy of the instruments are continually being verified.	
SWCD.0716.007	A.7. The "Variable Infiltration Capacity" (VIC) model is critical to the integration of the climate models and StateMod but is not well described. Then a separate VIC model run is made incorporating the climate adjusted precipitation and temperatures for each of the five climate scenarios. The assumptions used to estimate the area of various types of natural vegetation and the consumptive use of the natural vegetation is not explained. Each of the five climate scenarios are compared to the historic VIC output and used to determine the "Average Monthly Modeled Streamflow". The VIC model apparently assumes that the natural vegetation of the river basin is the same in 30 years with higher temperatures and the change in the forest cover due to fires and beetle kill. It would seem that the natural vegetation would self-adjust to the new climate conditions and the assumption that the existing vegetation would remain is not appropriate. It would seem the likely adjustment in the types of natural vegetation is a critical component to the VIC model, yet this impact is not included in the modeling for reasons stated in section 2.5. This is further example of the uncertainty and variability in the alternate climate analysis.	See responses to comments DWCD.0716.007 and DWCD.0716.008.
SWCD.0716.008	A.8. Table 3-1 shows the projected increased temperature. A column showing the average annual temperature at each weather station would be helpful to understand the increased temperature is as a percentage of the average temperature. The precipitation tables (3-2 and 3-3) include this information. As with stream flow gages, the error in measurement can be plus or minus 10%; therefore, if the projected temperature or precipitation changes is less than 10% it may be within measurement error. Also a statement of whether, or not, the selected weather stations have been at the same location for the entire 55 years period would be helpful in understanding the reliability of the historical and projected data.	See response to comment DWCD.0716.009.
SWCD.0716.009	A.9. A clear and prominently placed disclaimer statement describing how the information in the report should and should not be used is recommended. For instance: (1) are the hydrographs and data of adequate quality for use in water rights applications, by the proponent and/or opponents? Or (2) the data and hydrographs should not be used in compact curtailment analysis? Or (3) in what manner should the data be used in other State Agency studies and evaluations?	See response to comment SWBRT.0716.005.
SWCD.0716.010	A.10. A further concern with the reliability of the alternative climate scenarios is the physical setting of the southwestern Colorado. The San Juan Mountains have the highest average elevation of any mountain range in the Rocky Mountains which greatly impacts the monsoon rains in the late summer and fall. The altitude	Many existing GCMs do not reliably represent the regional scale circulation that drives the North American Monsoon and there is no consensus regarding future changes in monsoonal precipitation in the region (Karl, et al., 2009, Liang, et al., 2008, Lin et al., 2008). The monsoon may intensify or it may weaken, and its

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	will affect how much moisture falls as snow and the melting period (storage) which will affect the stream flow graphs and the ability to utilize the available moisture. If more moisture falls in the winter months, this could have a significant impact on snowpack predictions. This situation is extremely difficult to appropriately incorporate in the general circulation models.	spatial extent may change, but this is difficult to determine from the existing global climate models. This is a recognized uncertainty in the current state of global climate models. As models with finer resolution are developed, more reliable projections of precipitation from the monsoon should become available. The downscaling process, and the approach adopted by CRWAS to adjust historical climate both serve to incorporate the historical extent of the precipitation arising from the monsoon. CRWAS uses downscaled GCM data. Downscaled data use precipitation and temperature observations to adapt the GCM data to the actual topography of the study area. The VIC model employs a detailed physical model that simulates snow accumulation and snowmelt. During work on CRWAS, this model was compared to records from SNOTEL stations in the central Rocky Mountains in Colorado. The results of this limited validation indicated that the snow model performed very well. Nevertheless, these elements of the climate and hydrology simulation do have inherent uncertainty. The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions. *Karl, T. R., Melillo, J. M., and Peterson T. C. (eds) (2009). Global Climate Change Impacts in the United States. Cambridge University Press, 2009.* *Liang, X. Z., Zhu, J., Kunkel, K.E. and Ting, M., (2008). Do CGCMs Simulate the North American Monsoon Precipitation Seasonal–Interannual Variability? Journal of Climate, 21, 4424-4447.* *Lin, J. L., Mapes, B. E., Weickmann, K. M., Kiladis, G. N., Schubert, S. D., Suarez, M. J., Bacmeister, J. T., and Lee, M. I., (2008). North American Monsoon and Convectively Coupled Equatorial Waves Simulated by IPCC AR4 Coupled GCMs. Journal of Climate, 21, 2919-2937.*
SWCD.0716.011	<u>B. Suggested for Changes to the Report:</u> The Districts recommend that the report be modified to address these comments because they are critical to the results of the study. Publishing of the data and hydrographs currently in the report will not provide an accurate indication of the basin water supplies and may result in misrepresentations being used in CRWAS Phase 2 and other future reports. B.1. The method for operation of McPhee and Vallecito Reservoirs used in the CRWAS is not correct in assuming that irrigated land can "pull" water from the reservoirs based on the crop consumptive use. These reservoirs are Reclamation facilities and as such have contracts and operational criteria that restrict the amount of water that can be provided to each acre of irrigated land served by the reservoirs. For each of these reservoirs, a maximum amount of water is assigned to specific acres of irrigated land according to Reclamation For example:	See responses to comments DWCD.0716.011 through DWCD.0716.013.

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	➢ Vallecito allocates the non-Indian water by multiplying the maximum reservoir content by 5/6th then dividing by 45,000 PRID Acres. When there is a full reservoir, there is approximately 2.2 AF per PRID Acre. The CRWAS modeling does not recognize the 2.2 AF per PRID limitation. The model allows lower priority ditches to pull as much water as necessary to fulfill their irrigation crop demand (with global warming the crop demand is much larger as shown on Table 3-4). The result is that Vallecito is shown to fluctuate much more in the future than the past with the implication that it is mostly attributable to global warming. In reality the fluctuation has more to do with how the reservoir is operated in the CRWAS modeling. This should be corrected by coordinating with Hal Pierce the PRID manager. ➢ The CRWAS modeling also allows irrigators to draw water from McPhee based on irrigation crop demand, not the contracts between the project users that establishes a maximum annual water supply for each user. With the model, the irrigation demand for all Dove Creek, MVIC, and Tribal acres is drawn from the reservoir until it is empty. In actual operation each of the irrigation entities have a maximum water supply that cannot be exceeded and currently all irrigators are drawing their maximum water supply in most years. The model shows much more water being withdrawn from McPhee than could actually occur which results in the fluctuation of the reservoir content in Figures G-7 and G-8 being too large. Also, the flow downstream of McPhee at Bedrock shown in Figure E-30 and F-30 is less than would actually occur. The flow below McPhee in the Dolores River is a major issue in numerous ongoing studies and the flow under global warming scenarios should be as accurate as possible. The operation of McPhee Reservoir should be corrected by coordinating with DWCD Manager and Engineer, Mike Preston and Ken Curtis respectively, and the Bureau of Reclamation. ➢ Jackson Gulch and Lemon Reservoirs are also Reclamation reservoirs and are assumed to be operated in a similar manner to Vallecito and McPhee. CWCB should contact the entities operating these reservoirs for the appropriate operation criteria.	
SWCD.0716.012	B.2. The comparison of the "2040 Average Monthly Modeled Streamflow" and the "2040 Average Monthly Water Available to Meet Future Demands" does not appear to be appropriate for streams in southwest Colorado. The difference in flows between the two scenarios are very large for the gages for Carracas, Low Piños, Florida, Animas, and LaPlata Rivers; minor for Mancos River and McElmo Creek; and are very similar for the Dolores at Bedrock and the San Miguel River at Naturita gages which are not in the San Juan Basin. For example, comparing the flows for the San Juan River at Carracas; Figures E-21 shows an annual flow range of 274,300 AF to 484,300 AF for the Modeled Streamflow and Figure F-21 shows a flow range of 18,000 AF to 271,600 AF for the available water to meet future demand. There should be no difference between the two flows because Carracas is	See responses to comments DWCD.0716.014 and DWCD.0716.015.

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	immediately upstream from Navajo Reservoir and there are essentially no diversions and no CWCB instream flow water rights downstream to be met. Apparently, the reason for difference is CRWAS uses the endangered fish flow recommendations in the San Juan River downstream of the City of Farmington as downstream demand (last bullet on page 4-2). Based on the purpose of the San Juan Recovery Program to allow water development simultaneously with recovery of the endangered fish and the fact that the flow recommendations are NOT fixed flow requirements, the use of the flow recommendations as a downstream demand is not appropriate for "2040 (and 2070) Average Monthly Water Available to Meet Future Demands" in the San Juan River basin. The "2040 Average Monthly Modeled Streamflow" and the "2040 Average Monthly Water Available to Meet Future Demands" should essentially be equal for the gages in southwest Colorado in the San Juan River Basin. The Districts believe that using the endangered fish flow recommendations as a downstream demand is a major policy decision that requires active discussion and agreement by the CWCB Board and stakeholders. Further we recommend that the use of the flow recommendations as a downstream demand should be removed from the "2040 (and 2070) Average Monthly Water Available to Meet Future Demands" analysis. In order to address the flow recommendations, a footnote could be added to explain that flow recommendations are not firm downstream demands such as CWCB instream flow water rights but could impact the available developable water for specific projects and should be considered on a case-by-case basis.	
SWCD.0716.013	B.3. The McElmo Creek natural flow estimates for 2040 and 2070 (Figures D-43, D-86, D-129) are not correct. McElmo Creek is naturally a very small drainage with a small amount of water that runs off early in the spring. The flows have been supplemented by water imported from the Dolores River by Montezuma Valley Irrigation Company (MVIC) since the later 1800's. The analysis in the report appears to include the imported water as if it were natural flow as indicated by the second runoff peak in Jun/July in Figures D-43 and 86. Though this is not a critical aspect of the study, it needs to be corrected to accurately reflect the McElmo Creek natural flow.	See response to comment DWCD.0716.016.

Front Range Region

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FRWC.0615.001	Thank you for the extensive collaboration and outreach that has occurred with interested stakeholders regarding the Colorado River Water Availability Study (CRWAS). The Front Range Water Council appreciates the opportunity to provide comments on the draft report for Phase I of the CRWAS. We are hopeful that this study, when properly revised, will provide valuable and important information for long range water resource planning and policy purposes in Colorado. The Front Range Water Council has reviewed the Draft CRWAS Report and identified several concerns with the report. Our general comments are provided in this letter, while more specific comments (edits, questions, etc.) are included in electronic PDF of the Draft CRWAS report that will be transmitted to CWCB. One of our biggest concerns with the draft CRWAS Report is the concluding section that presents a simple bar graph of the annual amount of water estimated to be available for development within the state based on certain Colorado River Compact assumptions. The assumptions made and methods used to estimate the amount of consumptive use that can occur within Colorado are not described or disclosed in sufficient detail in the draft CRWAS report. Absent this information, it is not possible to either understand or complete a meaningful review of the assessment of the amount of water estimated to be available for development within the state under the Compact. We believe that this presentation of study results is too simplistic, and as a result, is misleading.	See response to comment CBRT.0721.001.
FRWC.0615.002	It is our understanding that the Report's summary presents the potential amount of water available for diversion in the most critical 10-yew dry period. The Report fails to present the estimated amount of water available on average and during wetter periods. The 10-year dry period appears to be driven by predictions of climate models. It is not a great surprise that some of the climate models reflect limited water availability during drought cycles, and this condition currently exists even in the absence of Colorado Compact administration. However, the fact that some climate models suggest that additional Colorado River basin water supplies may not be available in critical 10-year dry periods, does not reflect the reality that substantial amounts of water are available at different times for future diversion from the Colorado River basin. Water providers in the State regularly deal with and plan for periods of drought-limited water supply, and one way they do so is to store water available in wetter times. Thus, the availability of water in wetter times should not be ignored or minimized. Equally important is the U.S. Bureau of Reclamation's initiation of a robust assessment of Colorado River water availability (the Colorado River Basin Water Supply and Demand Study), which will provide the most detailed assessment of Colorado River Compact issues available. In addition, future water availability in	CRWAS presented low-flow comparison charts (and not high-flow comparison charts) because focus is purposely placed on water availability during critical time periods associated with drought. This should not be interpreted to mean that the Draft CRWAS Phase I Report's "summary presents the potential amount of water available for diversion in the most critical 10-year dry period". CRWAS results, in fact, present results that consider historical levels of hydrologic periods, not just dry periods. The impact of wet spells on system performance and corresponding alternative operational strategies (e.g., potential additional storage of water during wetter periods) is not within the scope of CRWAS Phase I. The CWCB Board directed the CRWAS Phase I scope to establish technical approaches and evaluate water availability associated with current water supply infrastructure, currently perfected water rights, and current levels of consumptive and nonconsumptive water demands prior to transitioning to a subsequent phase. See response to comment YWBRT.0721.001. See response to comment CBRT.0721.001.

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	Colorado under the Compact will be studied in considerably more detail in the CWCB's upcoming Colorado River Compact Compliance Strategies Study. In light of both the upcoming Reclamation and CWCB studies, and the other issues outlined above, we suggest that the CWCB remove the section of the CRWAS report that deals with Colorado Compact issues, and revisit this aspect of the study as additional information becomes available in Phase 11. Alternatively, the CWCB should remove the quantitative assessment of water available and address this topic only qualitatively with respect to the results derived from the CDSS modeling effort.	
FRWC.0615.003	The intent and limitations of the study should be clearly stated at the beginning of the Report. A more detailed discussion of how the CRWAS study results and data will be used by the state and could properly be used by Stakeholders for long-range planning and policy purposes is needed in the Executive Summary, Introduction and Conclusions and Recommendations. This discussion should highlight and explain the wide range and variability of the climate change projections and emphasize that results are based on climate projections, the probability of which are unknown. This section should also explain how results could properly be used by stakeholders for planning purposes, recognizing that the study does not provide a definitive answer regarding the amount of Colorado River water remaining for development, but rather a range of possibilities that could occur in the future. The study results may be appropriate for evaluating variability and risk in long-term planning but they are not appropriate for short-term operational planning or decision making. The study results should not be used to set State policy on IPP's or be used by opposers in either water rights cases or permit applications for future water supply projects. The Study is not intended to predict or forecast probable climate scenarios, but rather to quantify potential hydrologic effects associated with various climate projections. As such, the results are only useful for relative comparisons and to evaluate system reliability under a variety of climate conditions.	The next draft of the CRWAS Phase I Report will clarify Study goals, limitations, assumptions, and appropriate use of results by the State and stakeholders, including refined descriptions of uncertainty, variability, and probability limitations in CRWAS estimates of future conditions.
FRWC.0615.004	A separate section should be added to the front of the Report that includes a more detailed discussion of the uncertainty inherent in the various climate and hydrology models and associated input data used in the study. Uncertainty is only mentioned briefly in various sections throughout the draft report; however, recognition of the uncertainty is one of the most important points for a proper understanding of the Report. The compounding sources of uncertainty associated with the GCM models, VIC model, CDSS Model and the mass balance analysis (used to evaluate Colorado River Compact requirements) need to be identified and adequately discussed in the context of this study. For example, the GCMs contain a significant amount of uncertainty and routinely fail to represent regional climate phenomena, including the southwestern U.S. monsoon. VIC uses data sets that are interpolated across large spatial and temporal scales, a fact that introduces significant uncertainty in the model results. This section should describe how well the models (VIC and CDSS) are calibrated since that affects	See response to comment FRWC.0615.003. All measurements contain uncertainty, and estimates of future conditions based on simulations are more uncertain than measurements. Each element of a climate impact analysis contains its own degree of uncertainty. When elements of the analysis are combined, individual uncertainties do not add up in a straightforward way, and overall uncertainty cannot be determined by a simple calculation. However, individual uncertainties do interact and each added element does increase overall uncertainty of the estimate of impact. Wilby and Harris (2006) found that the greatest uncertainty arose in climate impact studies from the climate models themselves, followed, in order, by the downscaling method, the hydrology model structure, hydrology model parameters and finally by the uncertainty in future emissions scenarios. *Wilby R. L. and I. Harris. (2006). A framework for assessing uncertainties in*

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	confidence in results and comparisons of the projections.	*climate change impacts: Low-flow scenarios for the River Thames, UK, Water Resources Research, Vol. 42, W02419, 2006.* Many existing GCMs do not reliably represent the regional scale circulation that drives the North American Monsoon and there is no consensus regarding future changes in monsoonal precipitation in the region (Karl, et al., 2009, Liang, et al., 2008, Lin et al., 2008). The monsoon may intensify or it may weaken, and its spatial extent may change, but this is difficult to determine from the existing global climate models. This is a recognized uncertainty in the current state of global climate models. As models with finer resolution are developed, more reliable projections of precipitation from the monsoon should become available. The downscaling process, and the approach adopted by CRWAS to adjust historical climate both serve to incorporate the historical extent of the precipitation arising from the monsoon. CRWAS uses downscaled GCM data. Downscaled data use precipitation and temperature observations to adapt the GCM data to the actual topography of the study area. The VIC model employs a detailed physical model that simulates snow accumulation and snowmelt. During work on CRWAS, this model was compared to records from SNOTEL stations in the central Rocky Mountains in Colorado. The results of this limited validation indicated that the snow model performed very well. Nevertheless, these elements of the climate and hydrology simulation do have inherent uncertainty. *Karl, T. R., Melillo, J. M., and Peterson T. C. (eds) (2009). Global Climate Change Impacts in the United States. Cambridge University Press, 2009.* *Liang, X. Z., Zhu, J., Kunkel, K.E. and Ting, M., (2008). Do CGCMs Simulate the North American Monsoon Precipitation Seasonal–Interannual Variability? Journal of Climate, 21, 4424-4447.* *Lin, J. L., Mapes, B. E., Weickmann, K. M., Kiladis, G. N., Schubert, S. D., Suarez, M. J., Bacmeister, J. T., and Lee, M. I., (2008). North American Monsoon and Convectively Coupled Equatorial Waves Simulated by IPCC AR4 Coupled GCMs. Journal of Climate, 21, 2919-2937.*
FRWC.0615.005	In Chapter 3 a clear explanation is needed regarding how the paleohydrology and resequenced natural flow hydrology were used. The figures and tables presented in the report and the appendices show only the results for historical conditions and climate adjusted hydrology for each climate projection. However, there is no discussion in Chapter 3 under Presentation of Findings that explains that resequenced data is not presented in the figures and tables contained in the body of the report and the appendices. Re-sequenced data is only used to derive the two bottom bars titled Extended Historical Hydrology and Alternative Climate Projections (2040) in Figure 3-37 in the final section of the report.	Information based on re-sequenced flows was not reported in the Draft CRWAS Phase I Report except in Figure 3-37, as the comment notes. The next draft of the CRWAS Phase I Report will clarify the use of re-sequenced flows.
FRWC.0615.006	The Report's use of climate-adjusted irrigation demands and non-adjusted (current) demands for other uses such as transbasin diversions is inconsistent.	It is true that the use of calculated demands does not take into account historical irrigation practices, such as the decision to forego irrigation during the late

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	While agricultural water use under some climate projections may increase significantly due to increased irrigation demands, other factors that influence agricultural use should be addressed. These factors include cropping changes, dry-up of agricultural lands, and increased market pressure for transfers from agricultural to municipal use under drier climate conditions. These factors could reduce the total increase in irrigation demands and thereby lower agricultural water use. More fundamentally, the CDSS model is demand driven, with diversions constrained only by water rights, existing infrastructure capacity limitations and physically available supplies. By using calculated demands, the model does not take into account historical operating conditions that may have limited diversions to something less than what could be physically and legally diverted. As such, the model systematically over-states irrigation diversions under both the historical hydrology and climate projection scenarios. This assumption means that under certain climate projections, the resulting increased irrigation water requirements cause simulated irrigation diversions that are significantly greater than would be expected. This analysis fails to reflect other constraints or institutional arrangements that may limit diversions.	season because there may not be enough growth for an additional cutting. The use of calculated demands for all scenarios (historical, paleo, and climate projections) provides a common basis for analyzing the effects of both increased crop demands and increased length of irrigation season, therefore is appropriate for CRWAS Phase I. The Colorado Decision Support System (CDSS) used for CRWAS is the most comprehensive model of its kind that is based on the best available data and tools that are currently available to meet CRWAS objectives. Since its inception, CDSS has been continually refined and updated to represent statewide operating conditions to the best extent possible. A significant effort has been implemented through CRWAS to continue refinement of CDSS through direct communication with water managers that have input on specific model refinements. The next draft of the CRWAS Phase I Report will include clarifying language on the potential for CDSS accounting for historical operations and why CDSS model assumptions and parameters are appropriate for this Study. The CWCB Board directed the CRWAS Phase I scope to establish technical approaches and evaluate water availability associated with current water supply infrastructure, currently perfected water rights, and current levels of consumptive and nonconsumptive water demands prior to transitioning to a subsequent phase. See response to comment YWBRT.0721.001.
FRWC.0615.007	The presentation of study results needs to be improved. The figures that present results for the climate projections (e.g. hydrographs and low-flow comparison charts) should label the climate projection that applies to each line on the graph so the reader can distinguish how each projection (hot and dry, hot and wet, warm and dry, warm and wet, and median) compares with the historical hydrology. The hydrographs of natural streamflow, modeled streamflow, and water available to meet future demands should show the average annual value for historical hydrology for comparison against the range presented for the climate projections. The blue shaded area that corresponds with the range of model results in the legend could either be removed or the legend changed to range of average model results. In several instances the blue shaded area corresponding with the range extends outside of the climate projection lines and this should be corrected if the range is kept on these graphs (see Figures 3-5,3-11,3-15,3-16 for examples).	The next draft of the CRWAS Phase I Report will include corresponding refined presentation of climate projection results. It is CWCB's intention to make the data used in CRWAS analyses and for the Draft CRWAS Phase I Report available to the public such that each stakeholder may use the data for their own purposes.
FRWC.0615.008	Technical Memorandum 6.7 includes statistical diagnostic analyses of the re-sequenced hydrology including Box and Whiskers plots at key locations. A summary of this information should be included in Section 2.3.2 of the report. Charts for the individual GCM projections are an appropriate place for displaying result ranges (i.e. variability) in the form of Box and Whiskers plots.	CRWAS Phase I Report Section 2 describes approach, while Section 3 presents results. A general summary of the frequency statistics and reference to Technical Memorandum (TM) 6.7 is provided in Sections 2 and 3. Additional Box and Whiskers plots (beyond those included in TM 6.7) will not be included in the CRWAS Phase I Report. See response to comment FRWC.0615.005.

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FRWC.0615.009	The tables included in Appendix A, B, C, E and F combine the results of all five of the GCM projections for comparison against results for historical conditions. This means it is not possible to discern and compare the impacts of each individual climate projection against historical conditions. This difference is very important, so it is important to do a better job of displaying and describing the variability in the results for the GCM projections. The use of average results hides this important variability, and may suggest to the reader that the average is the most likely outcome or prediction, as opposed to one possible outcome out of a number of uncertain possible future conditions. The comparison and analysis of average results in this manner discounts the fact that the models show a large range of possible outcomes. To avoid this problem, the results for each GCM scenario should be presented separately and compared with historical results. It would also be helpful to add the average annual modeled temperature, precipitation, consumptive irrigation requirement and streamflow for historical conditions to these tables. Appendix H should include summary tables similar to the other appendices, which compare the consumptive use broken down by category (e.g. municipal, irrigation, industrial, evaporation and other) for historical conditions and each of the GCM scenarios by basin.	See response to comment FRWC.0615.007. There is no scientific evidence to support the selection of one or more projections that are most likely to occur.
FRWC.0615.010	The water available to meet future demands as calculated by the CDSS model improperly treats the USFWS flow recommendations in the CDSS model as an instream flow right. As a result, when the flow recommendations are not met in the 15-Mile Reach, the CDSS model calculates that there is no flow upstream of that point to meet future demands. This means that the amount of water potentially available to meet future demands upstream of the 15-Mile Reach may be substantially under-estimated because these flow recommendations are not administered as an instream flow right and a call cannot be placed to meet them. This modeling assumption is of great importance to the state of Colorado, and particularly the CWCB, because it has the effect of delivering water out-of-state that might be available for use within the state. This issue was brought to the attention of the CWCB in the Front Range Council letter dated January 21, 2010. The CRWAS study team attempted to address this issue with a qualitative discussion in Section 3.6 of the report. However, that discussion requires further clarification and should be revised to include: (a) more discussion of the flow targets included in the CDSS model and how they can vary from actual operations; (b) a general description of the order of operations to release from various reservoirs to meet those targets; and (c) the potential underestimation of water that may be available to meet future demands at key upstream locations. In addition, a description of the terms and conditions of the Upper Colorado Endangered Fish Recovery Program, which allows for additional new depletions of up to 120,000 AF/yr with the implementation of certain recovery actions, should be included since calculation of water available for future demands currently does not factor in the additional new depletions that could occur pursuant to the Recovery Program. This section should state that revisions to the CDSS model are anticipated in Phase II of the CRWAS, which will consider the	See response to comment CBRT.0721.015.

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	development of new projects and diversions upstream of the 15-Mile Reach that are not subject to the 15-Mile Reach flow targets.	
FRWC.0615.011	The CRWAS Report needs to include a discussion of the differences in water availability as calculated by the CDSS model and presented in Section 3.6, and water available for future consumptive use as calculated by the mass balance analysis and the 2007 Hydrologic Determination as presented in Section 3.9. The CDSS Model does not consider Colorado River Compact requirements, therefore, the water it considers available to meet future demands is considerably higher than the amount calculated by the mass balance analysis, which considers the Compact. These differences need to be fully explained so that the results can be properly understood and correctly interpreted.	See response to comment CBRT.0721.001. The next draft of the CRWAS Phase I Report will be refined to include corresponding clarifying language.
FRWC.0615.012	As discussed in the introduction to this letter, one of the Council's biggest concerns with the draft CRWAS Report is the concluding section, which includes an evaluation of the amount of water available for development within the state based on certain Colorado River Compact assumptions. The assumptions made and methods used to estimate the amount of consumptive use that can occur within Colorado are not described or disclosed in sufficient detail. The summary of results presented in figure 3-37, which is a bar chart that depicts the future consumptive use allowable for Colorado, is too simplistic and misleading. The Report fails to make clear how the values in the bar chart were calculated and whether the results reflect the driest 10-year period or an average of the entire period. Since future water availability in Colorado under the Compact will be studied in considerably more detail in the CWCB's upcoming Colorado River Compact Compliance Strategies Study and the Bureau of Reclamation's on-going Colorado River Basin Water Supply and Demand Study, we recommend that the CWCB remove the section of the CRWAS report that deals with Colorado Compact issues and revisit this aspect of the study as additional information becomes available in Phase II. Alternatively, the CWCB should remove the quantitative assessment of water available and address this topic qualitatively with respect to the results derived from the CDSS modeling effort. Doing so would eliminate the confusion between calculations of water available for future use in Colorado using the CDSS model versus the mass balance approach used for the Compact analysis and avoid possible differences with findings in the other studies. We hope this summary of our comments is helpful. Please refer to the electronic .pdf of the Draft CRWAS Report that will be transmitted to CWCB for more detailed comments. If you have any questions, would like to discuss our concerns at a workshop, or would like any additional information, please do not hesitate to contact us.	See response to comment CBRT.0721.001.
FRWC.0615.013	*FRWC 06/15 Comments below represent comments made within the Draft CRWAS Phase I Report.*	The title will remain “Colorado River Water Availability Study” to be consistent with authorizing legislation and the scope of work. Study goals and objectives

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	Cover Page—"Title--Similar to the Front Range Climate Vulnerability group and characterize this as a sensitivity of streamflow and CU to climate change. The word availability itself lends towards an implied quantification/forecast interpretation. Consider changing the title itself to something that more reflects the comparative nature, rather than predictive nature, of this study. Ex. Colorado River Water Supply, A Climate Sensitivity Assessment."	include evaluations beyond "climate sensitivity assessment".
FRWC.0615.014	*Cover Page*—"General-There are numerous references to water availability throughout the report and I would suggest this theme change to sensitivity throughout the report. For modeling studies of this nature making uncertain estimates is to be expected but that does not necessarily diminish the usefulness in terms of comparative analyses and examining relative differences between scenarios. However, no large fundamental/significant change in assumptions can have occurred from baseline to scenarios. Additionally, model(s) need the ability to skillfully simulate the desired systems given the changes between scenarios. I believe the study team needs to address this issue as I think this question comes to play in several aspects of the study. For example, the poster from Brekke et. al., 2009, discusses relative skill between hydrologic models when calibrated during dry times then examining skill during wet years and vice versa. I believe there is an issue here in terms of hydrologic model skill that is worthy of discussion."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.015	*Page V Table 1*—"Each of the selected climate projections is equally probable; but differs from the others." *Bullet 3 Sub Bullet 3*—Unknown probability	The next draft of the CRWAS Phase I Report will include refinements to state that the projections have an unknown probability, but that they are treated as being equally probable in CRWAS.
FRWC.0615.016	*Page VII Conclusions and Recommendations Bullet 2*—"unknown probability rather than equally-probable."	See response to comment FRWC.0615.015.
FRWC.0615.017	*Page 1-1 Para 1—"*A discussion of the intent and limitations of the study would be appropriate in this section. A more detailed discussion of how the CRWAS study results and data will be used by State and could properly be used by Stakeholders for long-range planning and policy purposes is needed. This discussion should highlight and explain the wide range and variability of the climate change projections and emphasize that results are based on climate projections, the probability of which are unknown. This section should also explain how results could properly be used by stakeholders for planning purposes, recognizing that the study does not provide a definitive answer regarding the amount of Colorado River water remaining for development, but rather a range of possibilities that could occur in the future. The study results may be appropriate for evaluating variability and risk in long-term planning but they are not appropriate for short-term operational planning or decision making. The study results should not be used to set State policy on IPP's or be used by opposers in either water rights cases or permit applications for future water	The next draft of the CRWAS Phase I Report will clarify Study intent, limitations, appropriate use of results, and descriptions of variability, probability, and uncertainty limitations in CRWAS estimates of future conditions.

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	supply projects. The Study is not intended to predict or forecast probable climate scenarios, but rather to quantify potential hydrologic effects associated with various climate projections. As such, the results are useful for relative comparisons and to evaluate system reliability under a variety of climate conditions."	
FRWC.0615.018	*Page 1-1 Bullet 1*—"Change 'is available' to 'may be available'. This wording is used through the report, (e.g., last bullet on next page) please re-word all occurrences as suggested."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.019	*Page 1-1 Bullet 4*—"What is the confidence in extending this far back. Especially going back beyond the living tree record increases the uncertainty.	There is no indication from the paper describing the reconstruction (cited in the Draft CRWAS Phase I Report) that the use of remnant wood increases uncertainty. However, because relatively few chronologies are currently available for those earlier periods, the estimated flows are more uncertain than estimates based on denser networks that become available in later periods. CRWAS used the probability of transition between dry and wet hydrologic states rather than the magnitude of reconstructed flows. This should reduce the sensitivity of CRWAS results to uncertainty in the paleo reconstruction.
FRWC.0615.020	*Page 1-2 Bullet 2*—"Water availability was calculated in two different ways, 1) using the CDSS model, and 2) with a mass balance analysis and the 2007 Hydrologic Determination. It is not clear how should the reader interpret and compare the estimates of water available for future uses in Colorado using the two different modeling approaches. See comment on Page 2-4.	See response to comment CBRT.0721.001.
FRWC.0615.021	*Page 1-4 Section 1.3*—"Uncertainty is described in various sections throughout the report. It would be nice to have a comprehensive discussion, maybe in this section, where the sources of uncertainty are discussed in context. Some examples are provided: 1. GCM's themselves contain a significant amount of uncertainty. The GCMs routinely fail to represent regional climate phenomena in different parts of the globe, included is the southwestern U.S. monsoon. 2. Climate scientists make use of downscaling to get to a finer resolution and bias correction to correct for differing GCM temperature/precipitation results as compared to weather station observations. The downscaling process assumes that the GCM derived boundary conditions are correct, downscaling cannot correct GCM output. 3. VIC uses data sets that are interpolated across large spatial and temporal scales thus likely introducing a significant amount of uncertainty. GCM's provide results at a monthly time step where VIC uses daily time steps requiring many assumptions. 4. There is uncertainty arising from the hydrologic models themselves, specifically how much skill do they have in predicting future runoff? Are the hydrologic processes sufficiently calibrated? See Brekke presentation.	The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.

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	5. Hydrology ratio offsets or adjustments are used to obtain results consistent with historical observations. This is basically a simple adjustment/correction to a highly non-liner transformation of temperature and precipitation into stream flow. Need to explain this and how this will introduce uncertainty into the final results. May want to discuss the option of comparing historical simulation with future condition simulation results without using offsets, i.e., a simple delta comparison. Many comparative analyses are done this way."	
FRWC.0615.022	*Page 1-4 Bullet 2*—"How was it determined that 100 was appropriate? Please describe how this was determined. Bootstrap guidelines are larger than this figure when the selection pool is this large."	100 iterations was a practical limit given the execution time of the water resources models. Using a larger number of iterations would reduce uncertainty, but we believe that the uncertainty in the climate projections is far larger than the incremental uncertainty introduced by the choice of 100 iterations.
FRWC.0615.023	*Page 1-4 Bullet 2*—"An explanation is needed regarding how information from re-sequencing is presented and used. It is not clear that the report does not include the results associated with re-sequencing except in Figure 3-37."	The next draft of the CRWAS Phase I Report will clarify use of re-sequenced flows.
FRWC.0615.024	*Page 1-4 Bullet 3*—"VIC is being run on a daily time step, where GCM's are monthly values. There are spatial and temporal interpolation issues that warrant discussion."	The next draft of the CRWAS Phase I Report will clarify the process by which climate-impacted natural flows and modeled flows are determined.
FRWC.0615.025	*Page 1-5 Para 2*—"GCM downscaling will do nothing to correct for errors in the boundary conditions of the CRWAS model domain."	Wilby and Harris (2006) found that the greatest uncertainty arose in climate impact studies from the climate models themselves (which generate the boundary conditions noted in the comment), followed, in order, by the downscaling method, the hydrology model structure, hydrology model parameters and finally by the uncertainty in future emissions scenarios. By adding information related to the relationship between climate variability and local topography, the downscaling process may remove some bias from GCM outputs. This is uncertain, but the comment is too strong given this possibility. The revised Phase I report will clarify uncertainties in the CRWAS estimates of future conditions. *Wilby R. L. and I. Harris. (2006). A framework for assessing uncertainties in climate change impacts: Low-flow scenarios for the River Thames, UK, Water Resources Research, Vol. 42, W02419, 2006.*
FRWC.0615.026	*Page 1-5 Para 3*—"2040 Planning horizon"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.027	*Page 1-5 Para 3*—"2070 Planning horizon"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.028	*Page 1-5 Para 9*—"Phase I of the CRWAS compares the effects of three alternative water supply scenarios (historic hydrology, paleohydrology and	Corresponding refinements will be considered for the next draft of the CRWAS

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	climate change hydrology)...Need to do a better job of organizing and communicating this in the document. Currently it is difficult to follow what results have the climate effects and which do not."	Phase I Report.
FRWC.0615.029	*Page 1-5 Para 8*—"These future conditions are projections of unknown probability that are equally likely or unlikely to occur."	See response to comment FRWC.0615.015.
FRWC.0615.030	*Page 1-6 Bullet 4*—"Was this analysis only conducted for the mass balance analysis presented in Section 3.9? It is not clear where the results of the extended hydrology are presented."	The next draft of the CRWAS Phase I Report will clarify use of re-sequenced flows.
FRWC.0615.031	*Page 1-6 Bullet 5*—"Need to be clear the assessment of future water availability using the CDSS Model referenced in Bullet No. 3 does not consider potential Compact constraints."	See response to comment CBRT.0721.001.
FRWC.0615.032	*Page 1-7 Figure 1-1*—"An overview and summary of the results of the statistical analysis should be included in either Section 2.3.2 or 2.4.7."	Section 2 describes the approach used and Section 3 reports the results and is the appropriate place for a discussion of results. A general summary of the frequency statistics is provided in Section 3. The next draft of the CRWAS Phase I Report will include additional statistical analysis and corresponding clarifying discussion.
FRWC.0615.033	*Page 2-3 Para 2*—"Change from 'was used to quantify' to – 'was used to test sensitivity to...' Reliability of ET method is touted but the method is omitted. Include it was PM. Just because a model was used previously and was "calibrated" does not in of itself reflect suitability. Good place to discuss the time step and forcing requirements. Additionally, would like to see some discussion regarding Brekke et. al., regarding calibrating hydrologic models in one hydrologic year type (e.g., wet) and skill in other types (e.g., dry)."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.034	*Page 2-3 Section 2.1.3*—"A separate section should be added under Section 2.1.3, which includes a more detailed discussion of the uncertainty inherent in the various climate and hydrology models used in the study and the associated input data."	The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.
FRWC.0615.035	*Page 2-3 Para 3*—"In mountainous terrain such as (something missing here) constitutes much of the significant water producing areas of the Colorado River basin, temperature-based ET models do not perform well without local calibration and physically-based ET models such as is used in VIC, are preferred. I agree so there should be a discussion on the ability of Blaney Criddle (used in State-CU) to respond to changes in the climate forcings."	The next draft of the CRWAS Phase I Report will clarify general limitations to the Blaney-Criddle approach.
FRWC.0615.036	*Page 2-4 Para 3*—"and the current administrative environment as though they were in place throughout the modeled period' 15 mile reach should	The next draft of the CRWAS Phase I Report will reference each basins' model User Manual as a means for the reader to understand administrative agreements.

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	include discussion of the administrative agreements."	
FRWC.0615.037	*Page 2-4 Para 3*—"The CDSS Model does not reflect Colorado River Compact provisions in the estimates of water availability. An explanation should be provided that the CDSS Model provides estimates of water availability within the State of Colorado, whereas, the CRWAS mass balance analysis reflects water availability within the State of Colorado while also considering certain Compact provisions. How should the reader interpret and compare the estimates of water available for future uses in Colorado using the two different modeling approaches? Are the estimates of water availability using the CDSS model too high because Compact provisions are not reflected in those numbers? Is there a location, such as the CO-UT State line, where output from the CDSS model can be compared with results from the CRWAS mass balance analysis presented in Figure 3-37 to assess the impact of the Compact provisions on water availability in Colorado?"	See response to comment CBRT.0721.001. The next draft of the CRWAS Phase I Report will clarify that CDSS models include administrative conditions in Colorado only. Colorado River Compact conditions are not represented.
FRWC.0615.038	*Page 2-4 Para 4-5*—"Please discuss time step of data and models."	The next draft of the CRWAS Phase I Report will discuss the monthly time step.
FRWC.0615.039	*Page 2-5 Para 2*—"Why have a separate section for the CRSS model if it was not used to quantify water available for future consumptive use considering Compact constraints? Section 2.6 explains that CRSS was considered but rejected. Discussion of the CRSS model here makes it appear as if it was used. Technical memorandum 8.6 explains why the CRSS model was not used; therefore, it would be less confusing if the report focused on the CRWAS mass balance analysis that was used to analyze Colorado River Compact provisions as opposed to the CRSS model."	See response to comment CBRT.0721.001. CRSS was originally considered, but ultimately not used, for CRWAS analysis. The next draft of the CRWAS Phase I Report likely will not include corresponding references.
FRWC.0615.040	*Page 2-7 Para 1*—"'use of a standard elevation adjustment to consumptive use results.' What is this?"	Standard elevation adjustments are recommended for estimating evapotranspiration in higher altitudes by ASCE Manuals and Reports of Engineering Practice No. 70, Evapotranspiration and Irrigation Water Requirements and the Colorado State Engineer's Office. Elevation adjustment increases potential crop evapotranspiration by 10 percent per 1000 meters above sea level. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.041	*Page 2-7 Para 4*—"More explanation is needed here regarding how results associated with the re-sequenced data sets were used and presented. The figures and tables in the report do not include any results for re-sequenced data sets except for Figure 3-37 in Section 3.9."	The next draft of the CRWAS Phase I Report will clarify use of re-sequenced flows.
FRWC.0615.042	*Page 2-8 Para 1*—"Change with to within."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.

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FRWC.0615.043	*Page 2-8 Para 1*—"Green Mountain Reservoir would be appropriate to include since it provides supplemental supplies to meet irrigation demands via the Historic User's Pool."	Green Mountain Reservoir operations are included in the CDSS models; however, the graph of its reservoir content was not included because we are representing reservoirs where uses were revised to reflect climate impacts (i.e. irrigation reservoirs only). Green Mountain Reservoir exchanges for out-of-priority diversions for CBT are approximately the same magnitude as HUP releases. Since CBT diversions are not being refined for Phase I, we do not intend to present Green Mountain Reservoir Storage. It is CWCB's intention to make the data used in CRWAS analyses and for the Draft CRWAS Phase I Report available to the public such that each stakeholder may use the data for their own purposes.
FRWC.0615.044	*Page 2-11 Step 3 in Figure*—"Add informed/based on paleo record."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.045	*Page 2-12 Para 2*—"What was the grid spacing? See earlier comment regarding interpolation."	Grid spacing is 1/8th degree. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.046	*Page 2-12*—"Are theses evenly distributed and representative?"	CDSS naturalized flow data are available for 227 headwater nodes and locations with significant inflow, as described in Section 4.7.3 of the basin model's User Manuals. Inflow points are not exactly evenly distributed; however, they are representative of the basins. See response to comment FRWC.0615.039. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.047	*Page 2-12 Para 6*—"First part is confusing, too many pronouns."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.048	*Page 2-13 Para 1*—"A comparison of the extended pre-observation period with the more recent 56-year study period would be helpful. There were longer and more severe droughts in the past, but the recent period may be drier overall than the extended hydrologic record. Why not move the discussion on Page 3-18 to this section?"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.049	*Page 2-14 Para 1*—"What is shown is 1492 to 2005. The executive summary states the record used was from 762. TM uses from 762 but this is not conveyed in the body of this report. See comment regarding extended tree ring chronologies. Discuss appropriateness."	This figure was intended only to be illustrative of the method and covers the common period of the reconstructions shown. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.050	*Page 2-14 Para 3*—"Sequences compared to what mean?"	The existing referenced footnote is intended to clarify.
FRWC.0615.051	*Page 2-15 Para 1*—"Suggest changing the phrase from water use estimates to	Corresponding refinements will be considered for the next draft of the CRWAS

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	tree ring growth estimates."	Phase I Report.
FRWC.0615.052	*Page 2-15 Ref to TM 6.4*—"TM 6.4 describes how the starting state i.e., wet/dry is picked randomly but how about the volume? Additionally, the paleo record length is stated to be 762 - 2005. The Executive summary is the only place that the CRWAS report describing the date range used. All the discussion is around the living tree record, no discussion on the extended paleo. Is the use of extended paleo appropriate given additional uncertainty introduced by extension methods? Using live tree records would presumably be more accurate and provide better correlation. More discussion is in order."	The initial volume is selected after the second state is generated and a transition type is therefore available. The details of the method are described in the paper by Prairie, et al. (2008) referenced in the technical memorandum. The choice of using the Meko et al. (2007) sequences was intended to provide consistency with the work of the Bureau of Reclamation. The next draft of the CRWAS Phase I Report will clarify the use of re-sequenced flows.
FRWC.0615.053	*Page 2-15 Para 4*—"The re-sequencing approach is based on the record of natural flows at Lees Ferry Arizona. How well do key gages upstream compare with the sequences of years (average to wet, wet to dry, etc.) at the Lees Ferry gage? Are they statistically consistent, which would support the re-sequencing of all baseflow points in the same manner as Less Ferry?	The use of flow states at Lees Ferry to represent the hydrologic state of the tributaries may suppress the apparent variability on the tributaries. Because flows are sampled from the historical record as a block representing an entire year, the spatial correlation and seasonal pattern of flows is limited to what is reflected in the historical record. However, because reconstructions have been developed for only a few tributaries, sufficient scientific information is not available to develop a more spatially distributed model of prehistoric flows.
FRWC.0615.054	*Page 2-17 Fig 2-6*—"Putting a mean line on each trace would be helpful. What are the mean, max, min and standard deviation of the traces, how do they compare to historical? Not that they have to be listed but summarize."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.055	*Page 2-17 Para 2*—"A comparison of the paleo-record with the more recent 56-year study period would be helpful. There were longer and more severe droughts in the past, but the recent period may be drier overall than the extended hydrologic record."	The next draft of the CRWAS Phase I Report will include a brief comparison of the statistics of the reconstructed paleo flow record and the observed flow record.
FRWC.0615.056	*Page 2-18 Para 2*—"'Accordingly, we expect that the mean of the alternate historical hydrology will be similar to the mean of the historical hydrology'. Doesn't this contradict statement on previous page 'Why the means differ from trace to trace'? 'The means of the two records (historical and paleo) will differ if the paleo record indicates that the relative frequency of dry versus wet years is different than that experienced in the historical period.' and the results are ...?"	The central tendency (e.g. the grand mean or median) of all constructed traces is expected to be similar to the historical mean. The mean flow of individual traces will vary, which is the objective of using information from the paleo record. The results of the analysis of reconstructed flows are reported in Section 3.4. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.057	*Page 2-18 Para 1*—"A general summary of the information in Technical memorandums 6.7 and 7.12 should be included in the report. The results of the frequency analyses and other statistical analyses could be described in this section or Section 2.4.7."	The next draft of the CRWAS Phase I Report will clarify the process by which the alternate historical hydrology was developed.
FRWC.0615.058	*Page 2-18 Para 3*—"'The objective of CRWAS is to provide quantitative estimates of the impact of projected change in climate on streamflows, water use and water availability to Colorado water rights.' Consider changing 'provide quantitative estimates' to providing comparative analyses between potential	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.

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	scenarios."	
FRWC.0615.059	*Page 2-18 Para 3*—"Replace 'projected change' with 'a range of possible projected changes'.	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.060	*Page 2-19 Fig 2-7*—"Should CRSS be mentioned in this figure since it was not used?"	See response to comment FRWC.0615.039.
FRWC.0615.061	*Page 2-19 Para 1*—"Need to better describe which charts results etc. include resequencing."	The next draft of the CRWAS Phase I Report will clarify the use of re-sequenced flows.
FRWC.0615.062	*Page 2-20 Para 2*—"Recognize that wind is a large driver in evaporation."	The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.
FRWC.0615.063	*Page 2-20 Section 2.4*—"It is important to understand the differences between the GCM simulations e.g., forcings, grid resolution, initial conditions which all play a role in the simulations. Understanding these types of differences will allow a more informed decision as to which GCM's are better suited to a particular study."	The CRWAS and the FRCCVS selected climate projections based only on their simulated change in temperature and precipitation, with the objective of representing approximately 80% of the range of conditions reflected across all of the readily available projections. Individual projections were not selected based on other attributes. There is not sufficient scientific information to evaluate the suitability of individual model codes or individual model runs for projecting conditions in the Colorado River Basin. Identifying the attributes of models and model runs will be misleading because that will imply that a judgment has been made as to which projection is "better".
FRWC.0615.064	*Page 2-22 Para 2*—"Aren't these really of unknown probability?"	See response to comment FRWC.0615.015.
FRWC.0615.065	*Page 2-22 Para 2*—"The SRES scenarios are of unknown probability."	See response to comment FRWC.0615.015.
FRWC.0615.066	*Page 2-22 Para 3*—"Downscaling does not remove boundary condition error!"	See response to comment FRWC.0615.025.
FRWC.0615.067	*Page 2-23 Bullets*—"These definitions could be used in the Figures presented in Chapter 3 so the reader can distinguish how each projection compares with results for historical hydrology."	The definitions used in selecting projections do not correspond to hydrologic impact, as discussed later in this section. See response to comment FRWC.0720.063.
FRWC.0615.068	*Page 2-24 Fig 2-9*—"Is the average annual precipitation shown for 2040 the average for the 30-year period from 2025-2054?"	Yes. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.069	*Page 2-25 Table 2-4*—"Explain the relative output of emission scenarios. High med low."	See response to comment FRWC.0720.063.
FRWC.0615.070	*Page 2-26 Fig 2-10 and others*—"Caption should read natural flow."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.

Comment ID	Comment	Response
FRWC.0615.071	*Page 2-26*—"Include a reference for the source of streamflow data for the Colorado River below Glenwood Springs. Was the VIC model used to estimate streamflows for each projection?"	Yes. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.072	*Page 2-27 Fig 2-11 and others with projection points*—"Label these GCM points."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.073	*Page 2-27 Fig 2-12*—"Reiterate Ben's comments from an April 8th meeting which is 'use with caution'. State there is much less certainty here."	The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.
FRWC.0615.074	*Page 2-28 Para 4*—"If results for the 2070 projections are kept in the Appendices, the report should explain how those results should be interpreted and compared with results for the 2040 projection. The five 2070 projections are not as representative of the distribution of the 112 global climate projections since 4 out of the 5 projections are clustered on the low end of the distribution of the 112 projections. An alternative would be to remove the results associated with the 2070 projections from the Appendices since they do not cover the range from the 10th to the 90th percentile and are not well distributed in terms of affects of streamflows."	See response to comment CBRT.0721.008.
FRWC.0615.075	*Page 2-29 Para 3*—"How were data interpolated?"	We interpret the comment to refer to how the 54 climate stations were used to represent areas of irrigated acreage. Climate stations are "weighted" to areas based on an 8-digit HUC and county combination. These climate station assignments, based on a Theissen Polygon approach, were determined by the U.S. Bureau of Reclamation (USBR) as the basis for determining crop use for the Consumptive Uses and Losses Report requirement of the Upper Colorado River Basin Compact. The CDSS efforts adopted the USBR climate station weights directly.
FRWC.0615.076	*Page 2-30 Para 1*—"In Figure 2-14 is not clear that current conditions is the period 1970 through 1999 and projected conditions for 2040 is the period from 2025 through 2054."	Figure 2-14 is intended to be illustrative of the conceptual approach. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.077	*Page 2-30 Para 2*—"What is the rationale for using a different approach for adjusting temperature versus precipitation? Explain why precipitation change based on a scaling factor but for temperature the change was additive?"	This is a common method, described by Hamlet and Lettenmaier (1999) and Miller, et al. (2003), among others. The rationale for using a shift for temperature and a ratio for precipitation arises from their respective frequency distributions. Temperature is approximately normally distributed and unbounded so a value can be perturbed by a positive or negative shift without producing a physically impossible value. Precipitation is a bounded distribution, so applying a shift could result in a physically impossible value (i.e. negative precipitation). The distribution of precipitation is skewed and approximates a log-normal distribution, so the logs of precipitation are approximately normally distributed and unbounded. Thus, logs of precipitation can be perturbed by a shift representing the projected change in the log of precipitation. This is the same as

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		multiplying the arithmetic value of precipitation by the ratio representing the projected change in precipitation. *Hamlet, A.F., and D.P. Lettenmaier (1999). "Effects of climate change on hydrology and water resources in the Columbia River Basin." Journal of the American Water Resources Association 35(6):1597–1623.* *Miller, N.L., K. Bashford, and E. Strem (2003). "Potential Climate Change Impacts on California Hydrology," Journal of the American Water Resources Association, 39, 771–784.*
FRWC.0615.078	*Page 2-30 last Para*—"VIC uses PM so data availability is not the issue."	The next draft of the CRWAS Phase I Report will clarify: • Why Blaney-Criddle was selected and why it is appropriate. • The difference between estimated and interpolated gridded climate data used in the VIC model's Penman Monteith calculation and the station data used in the Blaney-Criddle calculations. • Why using station data is more appropriate for CDSS and CRWAS.
FRWC.0615.079	*Page 2-31 Para 1*—"Discuss the robustness of BC for determining climate impacts due it formulation as a temperature based method."	Because down-scaled climate data is only available for temperature and precipitation, the temperature-based Blaney-Criddle is well-suited to estimate crop demands based on varying climate projections. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.080	*Page 2-31 Para 3*—"Replace 'allowed' with 'supported'.	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.081	*Page 2-32 Para 4*—"Procedure should be documented somewhere. For baseline simulations was this method also applied or were historical data used?"	This method was applied to the baseline and climate projected scenarios. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.082	*Page 2-33 Para 4*—"This is a linear adjustment to a highly nonlinear transformation of temperature and precipitation into streamflow. In my opinion you are better using simulation results from the historical weather data forcing the hydrology model and comparing those to the simulations results from the climate changed forcings."	The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.
FRWC.0615.083	*Page 2-34 Para 3*—"There are more ways to achieve the goals of this study. For example there are statistical methods that could have been used. For the integration of mechanistic methods this may be true."	The comment is noted. No revision to text is required.
FRWC.0615.084	*Page 2-34 Para 2 last sentence*—"How well are the processes captured for the purpose of this study?"	The next draft of the CRWAS Phase I Report will clarify uncertainties in CRWAS estimates of future conditions.
FRWC.0615.085	*Page 2-34 Para 4*—"ET may be the most significant loss, but not the only loss.	The next draft of the CRWAS Phase I Report will clarify uncertainties in

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	Discuss magnitudes of other losses with respect to calibration of processes."	CRWAS estimates of future conditions.
FRWC.0615.086	*Page 2-34 Para 6 last sentence*—"And the physical basis was what?"	The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.087	*Page 2-35 Para 2*—"Confusing on how MOCOM was used, what were the multiple objective functions? MOSCEM is suggested for future uses. And results from the sensitivity test were what?"	The variables that were used as objective functions were correlation coefficient, Nash-Sutcliff efficiency, the ratio of root mean square error to the observed mean, and the absolute difference between the simulated and observed monthly peak flow. Spot comparisons showed very good agreement between simulated and observed snow accumulation and ablation when using consistent temperature and precipitation values.
FRWC.0615.088	*Page 2-35 Para 2*—"How well does the VIC model estimate natural flows using observed weather conditions at some of the key baseflow nodes in the CDSS model?"	The degree of agreement between simulated and observed flows varies with scale, with smaller basins showing greater disagreement. There is not sufficient information available to establish the degree to which these differences are due to model structure and parameters or to the sparseness of and resulting error in precipitation data.
FRWC.0615.089	*Page 2-36 Para 1*—"How does StateMod disaggregate flows?"	StateMod automates the distribution of the natural flow gains seen at gaged locations to ungaged tributaries and headwater nodes, using the ratio of gaged to ungaged drainage area and annual precipitation. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.090	*Page 2-37 Para 2*—"Not entirely true e.g., 15 mile reach administrative agreements not considered."	See response to comment CBRT.0721.015.
FRWC.0615.091	*Page 2-37 Para 2*—"This statement needs to be highlighted so the reader understands the difference between water availability estimated using the CDSS model versus the CRWAS mass balance approach used to consider Compact provisions. How should the water availability results from these two modeling approaches be compared? See comment on Page 2-4."	See response to comment FRWC.0615.037.
FRWC.0615.092	*Page 2-37 Para 3*—"In some instances historical operating conditions may have limited diversions to something less than what could be physically and legally diverted. Simulated irrigation diversions may be significantly greater than historical diversions under certain climate projections due to higher irrigation water requirements, however, this does not reflect operational constraints that may have limited diversions in the past."	See response to comment FRWC.0615.006. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.093	*Page 2-37 Para 4*—"Other factors that influence agricultural use should be addressed. These factors include the possibility of additional dry-up of agricultural lands, cropping pattern changes, and additional transfers from	Consideration for "other factors that influence agricultural use" is not part of CRWAS Phase I scope. See response to comment FRWC.0615.006.

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	agricultural to municipal use under drier climate conditions."	
FRWC.0615.094	*Page 2-39 Para 2*—"Release requirement below Lake Granby also vary based on hydrologic year type and forecasted inflow."	The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.095	*Page 2-39 Bullet 1*—"Include table of flows and more discussion/background. We can provide details if needed."	We do not intend to add the requested table; instead the next draft of the CRWAS Phase I Report will reference basin model User Manuals for detail on hydrologic-year based flows.
FRWC.0615.096	*Page 2-39 Para 5*—"Additional discussion of the potential effect on results associated with this assumption is needed. How would this assumption affect estimates of water availability? Would municipal diversions likely be over-estimated or under estimated depending on the hydrologic year-type."	Identification of changes to future municipal demands is being investigated for inclusion in a subsequent phase of the Study. See response to comment YWBRT.0721.001.
FRWC.0615.097	*Page 2-39 last Para*—"If you won't revise evaporation at least give a discussion on the magnitude involved."	The next draft of the CRWAS Phase I Report will include refined evaporation rate curves and corresponding refined results.
FRWC.0615.098	*Page 2-40 Para 4*—"Those are variables not parameters."	The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.099	*Page 2-40 Para 6*—"See previous comment on Page 2-37."	See response to comment FRWC.0615.037.
FRWC.0615.100	*Page 2-41 Para 2*—"Will the data DVD be available with documentation? Again, check terminology i.e., parameters vs. variables."	It is CWCB's intention to make the data used in CRWAS analyses and for the Draft CRWAS Phase I Report available to the public such that each stakeholder may use the data for their own purposes. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.101	*Page 2-41 Bullet 3*—"That's great but what were the results, there is no discussion? This is important stuff. As a general comment something that seems lacking is an assessment of current hydrology with respect to historical record and paleo record. For example, compare the probability density function (pdf) of existing stream flow record to that of a resequenced data set. Then compare to pdf of paleo-record conditioned with wet/dry resequencing methods. Comparing these three data sets seems like a logical first step in assessing stream flow variability. Then one could check certain GCM informed hydrologic models against the PDFs to determine if those are within the realm of likely stream flow already realized. If so, then this study's complexity could be reduced. This procedure would use the GCM's in more of a book end type of assessment. TM 6.7 gets to some of this but a complete analysis is missing e.g., similar box-whisker plots are missing for historical data. Side by side these would be useful."	Observed spell statistics are displayed on the charts in Technical Memorandum 6.7. It is CWCB's intention to make the data used in CRWAS analyses and for the Draft CRWAS Phase I Report available to the public such that each stakeholder may use the data for their own purposes. The next draft of the CRWAS Phase I Report will clarify the use of re-sequenced flows and will include a brief comparison of the statistics of the reconstructed paleo flow record and the observed flow record.
FRWC.0615.102	*Page 2-41 Bullet 3*—"See previous comment on Page 2-18. A general summary of the frequency analyses should be included in the report."	The next draft of the CRWAS Phase I Report will include a discussion of spell frequency.

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FRWC.0615.103	*Page 2-42 Para 2*—"Since the results associated with the re-sequenced data are only presented in Figure 3-37, a summary of the evaluation of the frequency of annual flows, drought and wet spells is warranted in the report otherwise the significance of re-sequencing the data is lost."	See responses to comments FRWC.0615.101 and FRWC.0615.102.
FRWC.0615.104	*Page 2-42 Para 3 and 6*—"These comparisons also illustrate the wide range and variability of the projections."	CRWAS interprets the range of results across climate projections to be uncertainty rather than variability.
FRWC.0615.105	*Page 2-44 Para 4*—"Explain why these levels were chosen."	This is explained in CRWAS Technical Memorandum 8.6: *"…the Study incorporates into the modeling bounding values for Lee Ferry flow obligations of 75 MAF (representing the obligation at Lee Ferry with no Mexico treaty deficiency) and 82.5 MAF (representing the obligation at Lee Ferry with a maximum treaty deficiency such that the Upper Division must supply one-half of the entire treaty obligation in every year)."* See response to comment CBRT.0721.001.
FRWC.0615.106	*Page 2-45 Para 1*—"Why wasn't a scenario considered where Upper Basin states use less than their full apportionments? Wyoming especially may not use its full apportionment."	See response to comment CBRT.0721.001.
FRWC.0615.107	*Page 2-47 Para 3*—"The assumptions made and methods used to estimate the amount of consumptive use that can occur within Colorado are not described in sufficient detail to understand the assessment of the amount of water estimated to be available for development within the state under the Compact. The following questions relate to the mass balance analysis described in Technical Memorandum 8.6. 1) How are the power pools used? How much do the power pools represent and in which reservoirs? How does use of the power pools get factored into the mass balance equation? Is a pro-rata amount used each year of the 10-year period depending on the shortage? Is the same amount is available from the power pools each year if needed? 2) What is included in the Spills term of the mass balance equation? Is that just spills from Glen Canyon Dam or all of the 66 Upper Colorado River Basin reservoirs? Why are the spills separated out from the Nominal Lees Ferry flow? Do spills count toward meeting the cumulative flow obligation? 3) How is the consumptive use reduced to prevent the 10-year cumulative flow from falling below the bounding values of 75 MAF and 82.5 MAF? Is it reduced every year in the 10-yr period or in just one year? If consumptive use is reduced in specific years, how do you pick which year(s) to reduce? 4) How are 6% shortages incorporated in the mass balance equation? Is it 6% of the Annual Upper Basin Use? Are shortages only reduced by 6% in the window from 1953 through 1977 or does that assumption apply to the whole 56-year study period?	See response to comment CBRT.0721.001.

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	5) How was re-sequenced data used in the mass balance approach? Is the re-sequenced data only reflected in the Inflow term and Nominal Lee Ferry flow? Is the re-sequenced data from the CRSS model? What values are used in the mass balance equation for carry-over storage, evaporation, spills and year-end storage for the re-sequenced data sets?"	
FRWC.0615.108	*Page 2-48 Para 1*—"If the average annual Upper Basin use is set to 5.98 MAF (scenario 6), is the maximum amount of water available for future consumptive use in any year 0.50 MAF (5.98 MAF * 0.5175 - 2.6 MAF). Similarly, for scenario 8 is the maximum amount of water available for future consumptive use in any year 0.9 MAF (6.76 MAF * 0.5175 - 2.6 MAF). How would it be higher than those amounts as shown in Figure 3-37 where the range extends up to 1.0 MAF for the Alternate Climate Projections? How does water in excess of the cumulative flow obligation at Lee Ferry get factored into water available for future consumptive use? For example, water stored during wetter periods could be used in dry periods. Is that reflected in the mass balance equation?"	See response to comment CBRT.0721.001.
FRWC.0615.109	*Page 2-48 Para 3*—"Should the consumptive use be 2.6 MAF to correspond with Technical Memorandum 8.6? Why was Colorado Consumptive Use set at 2.6 MAF every year of the study period? Wouldn't consumptive use be lower in dry years?"	See response to comment CBRT.0721.001.
FRWC.0615.110	*Page 3-1 Chap 3*—"It is important to remember that while averages are informative water providers are interested in the tails of the flow distribution as well. Dry and wet years, particularly dry, play a large role in water resources planning. Therefore, there needs to be additional discussion and presentation of results with respect to variability. This needs to occur on a monthly basis not annual. Annual volume is one thing, monthly distributions is another. One way to do this is by use of box-whiskers (BW) plots. The band charts do not fill this need."	We do not intend to include box-whisker plots; but do intend to provide time-series information similar to reservoir storage graphs so variation in wet, dry, and average years can be assessed. The next draft of the CRWAS Phase I Report will include additional discussion on variability.
FRWC.0615.111	*Page 3-1 Para 3*—"This section should describe that the re-sequenced hydrology is not reflected in the band charts, the low-flow comparison charts or the Appendices."	The next draft of the CRWAS Phase I Report will clarify the use of re-sequenced flows.
FRWC.0615.112	*Page 3-1 Para 4*—"For all charts and tables -- Do not average 5 projections, rather label them."	See response to comment FRWC.0615.007.
FRWC.0615.113	*Page 3-1 Para 4*—"Where averages of the five projections are used it is not possible to compare the impacts of each projection against historical conditions. The use of a combined average does not display the variability in the results for the climate projections. Present results for each projection separately."	See response to comment FRWC.0615.007.
FRWC.0615.114	*Page 3-2 Charts in general*—"Need more descriptive captions and legends."	Corresponding refinements will be considered for the next draft of the CRWAS

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		Phase I Report.
FRWC.0615.115	*Page 3-2 Para 1*—"These figures should label the climate projection that applies to each line on the graph so the reader can distinguish how each projection (hot and dry, hot and wet, warm and dry, warm and wet, and median) compares with historical hydrology. The blue shaded area that corresponds with the range of model results in the legend should either be removed or the legend changed to range of average model results. In some instances the blue shaded area corresponding with the range extends outside of the climate projection lines and this should be corrected if the range is kept on these graphs."	See responses to comments FRWC.0615.007 and FRWC.0615.063.
FRWC.0615.116	*Page 3-2 Charts in general*—"Clarify in pertinent sections -- Are these historical (actual observations) or simulations using historical forcings? Eliminate range or call it out as a min/max plot composite of all projections. Better choice is to eliminate. Label each trace as to GCM simulation."	See response to comment FRWC.0615.007.
FRWC.0615.117	*Page 3-2 Example Figure*—"The average annual value for historical hydrology should be included in the call-out box for comparison against the range presented for the climate projections."	See response to comment FRWC.0615.007.
FRWC.0615.118	*Page 3-3 Para 1*—"These figures should label the climate projection that applies to each line on the graph so the reader can distinguish how each projection compares to results for historical hydrology. The blue shaded area that corresponds with the range of model results in the legend should either be removed or the legend changed to range of average model results."	See responses to comments FRWC.0615.007 and FRWC.0615.063.
FRWC.0615.119	*Page 3-3 Chart*—"Close but far from informative as B/W plots would be. Other comments on above chart apply. Show historical for comparison then discuss."	See response to comment FRWC.0615.007.
FRWC.0615.120	*Page 3-11 Bullet 2*—"Could this dryness be due to missing the SW monsoon? Monsoon moisture can reduce demands."	See response to comment SWCD.0716.010.
FRWC.0615.121	*Page 3-11 last Para*—"Monsoon comment needs to be incorporated into section regarding overall uncertainty."	See responses to comments YWBRT.0721.005 and SWCD.0716.010.
FRWC.0615.122	*Page 3-12 Para 1*—"This information should be included in a separate section up front that discusses uncertainty in the climate and hydrology models used and the associated input data."	See response to comment YWBRT.0721.005.
FRWC.0615.123	*Page 3-12 Para 1*—"But is BC well suited for this type of study?"	See response to comment FRWC.0615.079.
FRWC.0615.124	*Page 3-12 Para 4*—"Are the ending growing season dates calculated the same way?"	Yes. The next draft of the CRWAS Phase I Report will clarify that ending growing seasons are based on mean monthly temperature values for historical

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		and climate-projected scenarios.
FRWC.0615.125	*Page 3-13 Fig 3-4*—"All the information presented in this table is a combined average of all five climate projections. Ranges should be provided for each column (lowest projection to highest projection) similar to Tables 3-1 through 3-3. Include the word Combined after 2040 in the title of the figure."	See response to comment FRWC.0615.007.
FRWC.0615.126	*Page 3-13 Table 3-4*—"These are from monthly output. See earlier comment regarding killing frost date."	See response to comment FRWC.0615.124. Blaney-Criddle estimates ET for partial months based on this criteria.
FRWC.0615.127	*Page 3-15 Para 1*—"Grass pasture should be changed to pasture grass. See also first paragraph on Page 3-14."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.128	*Page 3-16 Fig 3-8*—"Include the words Combined Average. Why do the low (2.62 inches) and high (6.72 inches) numbers shown in the figure not match the text on Page 3-13, which states the increases in CIR ranges from 2.7 to 6.4 inches per year?"	The cited range is greater than in text because text is describing information shown in the Table for only a subset of climate stations. Figure represents the range for all 58 climate stations used in the analysis. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.129	*Page 3-17 Para 2*—"It should be clear that this figure is a Combined Average for all five projections. The range should also be provided for the five projections in the text and Table 3-5."	See response to comment FRWC.0615.007.
FRWC.0615.130	*Page 3-17 Para 3*—"The statistical analyses are mentioned in Section 2.3.2; however, they are not summarized. A general summary of the statistical analyses presented in Technical memorandums 6.7 and 7.12 should be included in either Section 2.3.2 or Section 2.4.7."	See response to comment FRWC.0615.101.
FRWC.0615.131	*Page 3-18*—"It should be made clear that the results presented in the Figures and Tables in Chapter 3 do not include results associated with the re-sequenced hydrology. By including this paragraph the reader may infer that the ranges shown in the Tables and Figures reflect the re-sequenced hydrology."	The next draft of the CRWAS Phase I Report will clarify the use of re-sequenced flows.
FRWC.0615.132	*Page 3-18 Bullet 5*—"Needs discussion?"	See response to comment FRWC.0615.110.
FRWC.0615.133	*Page 3-20 Fig 3-10*—"The data included in this graph does not correspond with Figure 3-9. If the average annual natural flow ranges from 15,500 to 26,800 AF as shown in Figure 3-10, why does the range in average annual flows in Figure 3-29 extend from about 200,000 AF to 350,000 AF?"	Figure 3-10 in the Draft CRWAS Phase I Report was inadvertently labeled with incorrect data. The next draft of the CRWAS Phase I Report will correct this error.
FRWC.0615.134	*Page 3-24 Para 2*—"Should this figure be included if the operations currently in the model do not make sense for the runoff timing? Refer to the third bullet on Page 4-2 here."	The figure is included to illustrate the limitations associated with using current flood control criteria when runoff characteristics change under climate projections.

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		The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.135	*Page 3-25 Bullet 2*—"Yet this was one of the worst calibrations."	The comment is noted.
FRWC.0615.136	*Page 3-25 Bullet 3*—"Where does this additional water from the higher basins go?"	The greater modeled streamflow in the higher elevations goes to meet the increased consumptive use demands associated with climate change projections.
FRWC.0615.137	*Page 3-26 Bullet 2*—"Can you plot these bars on the same graph to illustrate this?"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.138	*Page 3-26 Bullet 2*—"It would be helpful to refer back to the discussion of uncertainty, which should highlight that monsoon-based conditions prevalent in the southern areas of the State, are not well simulated by climate models."	The next draft of the CRWAS Phase I Report will clarify descriptions of uncertainty limitations in CRWAS estimates of future conditions.
FRWC.0615.139	*Page 3-26 Para 2*—"See comment on Page 2-4 regarding the Compact.	See response to comment FRWC.0615.037.
FRWC.0615.140	*Page 3-28 Bullet 3*—"See comment on Page 2-4 regarding the Compact."	See responses to comments FRWC.0615.037 and FRWC.0615.039.
FRWC.0615.141	*Page 3-28 Para 3*—"Insert the word on."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.142	*Page 3-29 Para 3*—"Is there any indication the Blue Mesa Reservoir operations would change under different climatic conditions? Would the upper limit for storage fill change under drier conditions?"	See responses to comments YWBRT.0721.001 and UGRWCD.0719.001.
FRWC.0615.143	*Page 3-30 Bullets 2 and 3*—"Explain why."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.144	*Page 3-30 Para 3*—"The following section which discusses the modeling of 15-Mile Reach flow recommendations should be revised to include: (a) more discussion of the flow targets included in the CDSS model and how they can vary from actual operations; (b) a general description of the order of operations to release from various reservoirs to meet those targets; and (c) the potential underestimation of water that may be available to meet future demands at key upstream locations such as the Colorado River near Cameo (Figure 3-21). In addition, a description of the terms and conditions of the Upper Colorado Endangered Fish Recovery Program, which allows for additional new depletions of up to 120,000 AF/yr with the implementation of certain recovery actions, should be included since calculation of water available for future demands currently does not factor in the additional new depletions that could occur pursuant to the Recovery Program. This section should state that revisions to the CDSS model are anticipated in Phase II of the CRWAS, which will consider the development of new projects and diversions upstream of the 15-Mile Reach that	See response to comment CBRT.0721.015.

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	are not subject to the 15-Mile Reach flow targets."	
FRWC.0615.145	*Page 3-31*—"Need more discussion of 15 mile reach. 120,000 af in existing PBO for example."	See response to comment CBRT.0721.015.
FRWC.0615.146	*Page 3-32 Fig 3-22*—"The labels in the legend refer to the wrong lines in the figure."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.147	*Page 3-32 Chart 3-22*—"Legend reversed"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.148	*Page 3-33 Para 3*—"The use of climate-adjusted irrigation demands and non-adjusted (current) demands for other uses such as transbasin diversions is inconsistent. This paragraph should state that revisions to transbasin diversions to reflect climate change will be considered in Phase II (see 5th bullet on Page 4-2)."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.149	*Page 3-34 first Sentence*—"Misleading as written. Provide reference if this is official USBR policy statement."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.150	*Page 3-36 Para 2*—"Are there operating conditions at Vega Reservoir that would limit the fill of the reservoir to historical levels? Is the projection, which shows higher levels than historical, realistic?"	The modeled operations are not limiting the Vega fill to historical levels, and we're not aware of any operational reason to limit a full fill if water is physically and legally available. When the projections show greater storage than historical, it is primarily due to increased runoff for those years. Note that new information is available to help refine CDSS natural flow estimates on Plateau Creek and its tributaries, and those refinements will be reflected in the next draft of the CRWAS Phase I Report.
FRWC.0615.151	*Page 3-38 Para 2*—"See comment on Page 3-36 for Vega Reservoir."	The modeled operations are not limiting McPhee fill to historical levels, and we're not aware of any operational reason to limit a full fill if water is physically and legally available. When the projections show greater storage than historical, it is primarily due to increased runoff for those years. Note that we have a scoped item to refine the CDSS representation of the Dolores Project and those refinements will be reflected in the next draft of the CRWAS Phase I Report.
FRWC.0615.152	*Page 3-39 Para 2*—"The use of climate-adjusted irrigation demands and non-adjusted (current) demands for other uses such as transbasin diversions is inconsistent. This paragraph should state that revisions to transbasin diversions to reflect climate change will be considered in Phase II (see 5th bullet on Page 4-2)."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.153	*Page 3-40 Para 1*—"A summary table should be included which provides a break-down of consumptive use by category (e.g. municipal, irrigation, industrial, evaporation and other) for historical conditions and each of the GCM	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.

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	scenarios by basin. The introduction to Section 3.8 should refer to Appendix H for figures of average monthly modeled consumptive use by basin. Do the figures for the 2040 projections need to be repeated in Appendix H?"	
FRWC.0615.154	*Page 3-40 Bullet 4*—"This comment applies to the discussion of crop consumptive use for all five basins. While agricultural water use under some climate projections may increase significantly due to increased irrigation demands, other factors that influence agricultural use should be addressed. These factors include cropping changes, dry-up of agricultural lands, and increased market pressure for transfers from agricultural to municipal use under drier climate conditions. These factors could reduce the total increase in irrigation demands and lower agricultural water use. In addition, under the climate projections, the CDSS model does not take into account historical operating conditions that may have limited diversions to something less than what could be physically and legally diverted. Historical demands reflect constraints or institutional arrangements that may have limited diversions. However, under the climate change projections, State CU model is used to determine diversion demands, in which case historical operating conditions that may have constrained diversions are no longer reflected. As such, the model over-states irrigation diversions under the climate projections."	See response to comment FRWC.0615.006.
FRWC.0615.155	*Page 3-41 Bullet 4*—"Are these low percentage differences distinguishable given the level of resolution in data and models? *Last sentence*—"Are the developable flows based upon this premise?"	Flows available for future development in the Draft CRWAS Phase I Report account for depletive effects of increased crop consumptive use and reflect CU shortages.
FRWC.0615.156	*Page 3-42 Bullet 4*—"Again, aren't these the basis for the developable flow estimates?"	See response to comment FRWC.0615.155.
FRWC.0615.157	*Page 3-42 Bullet 5*—"By basin exports do you mean transbasin diversions to Front Range?"	Yes. The next draft of the CRWAS Phase I Report will be refined to include clarifying language.
FRWC.0615.158	*Page 3-43 Para 1*—"Aspinall evaporation is not counted, presumably due to compact agreements. But for the purposes of this study, as stated, isn't counting evaporation important? Needs more discussion."	The next draft of the CRWAS Phase I Report will show Gunnison basin consumptive use with and without Aspinall unit evaporation. This will provide information regarding what is "charged" to Colorado in Compact reporting, and provide the actual consumptive use in the basin.
FRWC.0615.159	*Page 3-44 Para 1 last Sentence*—"Is this due to not counting the reservoir evaporation?"	No, Navajo Reservoir evaporation is excluded in the historical scenario as well as the climate projected scenarios.
FRWC.0615.160	*Page 3-44 Bullet 3*—"But this is the same value you have stated for the Gunnison."	This occurrence is coincidence only.
FRWC.0615.161	*Page 3-45 Section*—"This section is way too thin and TM 8.6 did little to clarify. All previous comments from multiple presentations still apply. Add calculations	See response to comment CBRT.0721.001.

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	and assumptions. Additionally, a min/max band of values is completely inadequate. We need discussion of variability of the results, one option is B/W plots. We need more discussion on this topic or remove it from the report. As is, even with TM 8.6, this section may be more damaging than helpful to stakeholder processes."	
FRWC.0615.162	*Page 3-45 Para 1*—"Refer to all comments in Section 2.6."	See response to comment CBRT.0721.001.
FRWC.0615.163	*Page 3-45 Fig 3-37*—"For the Alternate Climate Projection (2040), does the bottom end of the range, which shows 0 AF available, reflect that in at least one of the 2040 traces there is one 10-year period there was no water available? What is the frequency that no water is available? Is no water available in just one of the 2040 traces or several of the traces? It would be better to show each projection separately to know if 0 AF is the low end of the range for just one projection or all of the projections."	See response to comment CBRT.0721.001.
FRWC.0615.164	*Page 3-45 Fig 3-37*—"It is not clear how the values in the bar chart were calculated and whether the results reflect the most critical 10-year dry period or an average of the entire period. It is not clear that the two bars at the bottom of the figure reflect the results of the re-sequenced hydrology. How was re-sequenced data used in the mass balance approach? Is the re-sequenced data only reflected in the Inflow term and Nominal Lee Ferry flow? Is the re-sequenced data from the CRSS model? What values are used for carry-over storage, evaporation, spills and year-end storage for the re-sequenced data set? Each of the alternate climate projections should be presented as a separate bar in this figure. This figure does not present the frequency that no water is available under the alternate climate projections. If the upper and lower ends of the range are an average for the entire period from 1950 through 2005 does that mean that no water was available in any running 10-year period in any of the re-sequenced datasets or was no water available in the most critical 10-year year period? How frequently were demands reduced?"	See response to comment CBRT.0721.001.
FRWC.0615.165	*Page 3-46 Bullet 1*—"And the reasonableness was determined how?"	The next draft of the CRWAS Phase I Report will be refined to include a reference.
FRWC.0615.166	*Page 3-46 Bullet 9*—"I don't know if I agree with this as a blanket statement. Presented for Glenwood but not evaluated other places. GCM selection methodology utilized precipitation and temperatures, which is different than streamflow."	The selected projections were also evaluated at Lees Ferry, where there was a more significant dry bias in the selected 2070 projections. The next draft of the CRWAS Phase I Report will include additional work and corresponding documentation of approach and results to identify and analyze a set of climate projections for 2070 that better represent the range of projected hydrologic impacts for that time frame.
FRWC.0615.167	*Page 4-1 Conclusions*—"See previous comments that related to specific	See responses to corresponding comments.

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	conclusions in this section."	
FRWC.0615.168	*Page 4-1 Bullet 3*—"Refer to comments in Section 2.6 and 3.9. This statement is misleading. It is not a great surprise that some of the climate models reflect limited water availability during drought cycles, and this condition currently exists even in the absence of Colorado Compact administration. However, the fact that some climate models suggest that additional Colorado River basin water supplies may not be available in critical 10-year dry periods, does not reflect the reality that substantial amounts of water are available at different times for future diversion from the Colorado River basin. The availability of water in wetter times should not be ignored or minimized."	See responses to comments YWBRT.0721.001 and CBRT.0721.001.
FRWC.0615.169	*Page 4-1 Bullet 2*—"Really unknown probability but treated as equally."	See response to comment FRWC.0615.015.
FRWC.0615.170	*Page 4-2 Bullet 2*—"These are modeled as a right and other agreement portions are not considered. Revise language."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report, including clarification to accurately reflect the revisions to 15-mile reach fish flow representation. See response to comment CBRT.0721.015.
FRWC.0615.171	*Page 4-2 Bullet 5*—"Reference for this broad interpretation."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report, including "official" language referenced from Reclamation.
FRWC.0615.172	*Page 4-2 Bullet 5*—"Eliminate reference to Arkansas basin. There are unique challenges in this basin and this generalization is inappropriate. One size may not fit all that is why there is a feasibility study underway in the Arkansas Basin."	DSS efforts in the Arkansas River basin should consider the development of a model that could link with the current western slope and future South Platte models, providing a platform to investigate how future statewide demands will be met under climate change. The next draft of the CRWAS Phase I Report will clarify accordingly.
FRWC.0615.173	*Page 4-3 Bullet 3*—"A more detailed discussion of how the CRWAS study results and data will be used by State and could properly be used by Stakeholders for long-range planning and policy purposes is needed. This discussion should highlight and explain the wide range and variability of the climate change projections and emphasize that results are based on climate projections, the probability of which are unknown. This section should also explain how results could properly be used by stakeholders for planning purposes, recognizing that the study does not provide a definitive answer regarding the amount of Colorado River water remaining for development, but rather a range of possibilities that could occur in the future. The study results may be appropriate for evaluating variability and risk in long-term planning but they are not appropriate for short-term operational planning or decision making. The study results should not be used to set State policy on IPP's or be used by opposers in either water rights cases or permit applications for future water supply projects. The Study is not intended to predict or forecast probable climate scenarios, but rather to quantify	See response to comment FRWC.0615.003.

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	potential hydrologic effects associated with various climate projections. As such, the results are useful for relative comparisons and to evaluate system reliability under a variety of climate conditions."	
FRWC.0615.174	*Page A-2 Table A-1*—"Separate this table into one table for 2040 and one table for 2070 and include the results of each projection separately as opposed to presenting the combined average delta. It would also be helpful to include the historical average temperature."	See response to comment FRWC.0615.007. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.175	*Page A-5 App A Figures*—"See comments on similar figures in Chapter 3."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.176	*Figure A-5*—"Reported inches should be degrees."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.177	*Page B-2 Table B-1*—"Separate this table into one table for 2040 and one table for 2070 and include the results of each projection separately as opposed to presenting the combined average % Difference. It would also be helpful to include the historical average precipitation."	See response to comment FRWC.0615.007. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.178	*Page B-7 App B Figures*—"See comments on similar figures in Chapter 3."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.179	*Page C-2 Table C-1*—"Include the results of each projection separately as opposed to presenting the combined average results."	See response to comment FRWC.0615.007. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.180	*Page C-3 Table C-2*—"Include the results of each projection separately as opposed to presenting the combined average results."	See response to comment FRWC.0615.007. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.181	*Page C-6 App C Figures*—"See comments on similar figures in Chapter 3."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.182	*Page D-5 App D Figures*—"See comments on similar figures in Chapter 3."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.183	*Page E-6 App E Tables*—"Present the results of each climate projection separately as opposed to a combined average monthly modeled streamflow and combined average reduction in average annual streamflow."	See response to comment FRWC.0615.007. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.184	*Page E-8 Table E6*—"The tables presented for 2070 have the wrong header for average monthly values. The header should read Average Monthly Modeled Streamflow (AF) as opposed to Average Monthly Water Available to Meet Future Demands (AF)."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.

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FRWC.0615.185	*Page E-11 App E Figures*—"See comments on similar figures in Chapter 3. "	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.186	*Page F-6 App F Tables*—"Present the results of each climate projection separately as opposed to a combined average monthly modeled streamflow and combined average reduction in average annual streamflow."	See response to comment FRWC.0615.007. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.187	*Page F-11 App F Figures*—"See comments on similar figures in Chapter 3."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.188	*Page G-2 App G Figures*—"It would be helpful to use different colors for the climate projection results. These figures should label the climate projection that applies to each line on the graph so the reader can distinguish how each projection (hot and dry, hot and wet, warm and dry, warm and wet, and median) compares with historical hydrology."	See response to comment FRWC.0615.007. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0615.189	*Page H-1 App H*—"Include summary tables similar to the other appendices that include consumptive use by category (e.g. municipal, irrigation, evaporation, and other) for historical conditions and each of the climate projections by basin."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
FRWC.0720.001	The discussion regarding the Colorado River compact analysis was particularly helpful. As we explained, we do not think that portion of the study (Sections 2.6 and 3.9 including the bar chart, Figure 3-37) is thorough and rigorous enough to remain in the report. The Phase I work completed to date has been useful in identifying the uncertainties and complications of a Colorado River compact analysis and highlights the need to proceed with caution regarding how results are presented and interpreted. Publishing the compact analysis as it now stands, without the appropriate rigorous analysis and review, could have serious unintended impacts on the ability of the water users in Colorado to develop water available under the compact. Inappropriate conclusions or misuse of the report could occur in Colorado water courts, in negotiations with other basin states, in federal permitting processes and in other arenas. We believe it is critical that the CWCB consider the results of the upcoming, more thorough Bureau of Reclamation study on Colorado River water availability and the Board's upcoming compact compliance study before publishing an analysis of water available under the compact. We do not believe that the authorizing legislation for Water Availability Study requires the compact analysis. Neither SB 07-122 nor HB 08-1346 specifically requires any analysis of or report on the Colorado River Compact. That legislation anticipates the board will evaluate water availability in the Colorado River basin and its tributaries. It required that the board work in full consultation with and be actively involved with the basin roundtables and consider current and potential future in-basin consumptive and nonconsumptive needs. In both SB 07-122 and HB08-1346 the General Assembly expressly stated that it expected	See responses to comments CBRT.0721.001 and FRWC.0615.003.

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	the board will request additional funding in future years for the model implementation phase of the study and to recommend whether additional studies or phases of study should be undertaken. Thus, the scope of the study, which is focused on the physical and legal availability of Colorado River water within the state of Colorado, will satisfy the Phase I requirements of the legislation. A complete and thorough analysis of the compact issues can be made in later phases of the study.	
PWSD.0713.001	Enclosed is a report authorized by Parker Water and Sanitation District (PWSD) regarding the draft Phase I Colorado River Water Availability Study (Study). The report constitutes formal comments to the Study and was prepared by Bruce Lytle of Lytle Water Solutions, LLC (LWS). As you will note upon reviewing the comments, we believe the methodology of the Study is so flawed that the Study should remain in draft form until such time as an independent peer review panel of qualified professionals addresses the flawed data and methodology. Unfortunately, in addition to the Study's flawed methodology, the conclusions and implications of the Study are detrimental to Colorado's position within the Colorado River Compact and among the Upper Basin states, as well as between the Upper Basin states and the Lower Basin. The residents served by PWSD have a significant stake in the outcome of any study that will influence policies related to the availability and distribution of the state's water. Although PWSD has taken vigorous action to conserve and reuse water, and has invested more than $100 million in Rueter-Hess Reservoir to extend the life of the aquifer, we remain short of water. That shortage is a product of the region's growth and dependence on non-renewable groundwater. And we are not alone. According to studies by the Colorado Water Conservation Board, even if all of the projects currently being contemplated are built (which includes projects that will derive water from the Colorado River Basin), the area will still need 90,000 acre-feet of additional water by 2040. That is the key reason PWSD has joined with public water providers from Wyoming and the Colorado Front Range to study the feasibility of transferring available water from Flaming Gorge Reservoir to municipalities and public water providers in Wyoming and Colorado. PWSD's most serious concern with the Study is not that the data is used beyond its level of reliability and the climate models are subject to substantial error, or even that its conclusions have negative implications for the state's residents' water supply, and hence, their quality of life and the economy. Our most serious concern is the lack of leadership in the State of Colorado to defend the state's rightful full compact entitlement. Lytle Water Solutions, LLC (LWS) represents the Parker Water and Sanitation District (PWSD) and is presenting these comments to the draft Phase I Colorado River Water Availability Study (Study) report on PWSD's behalf. PWSD is a quasi-municipal water supplier for a growing community along the Front Range	PWSD.0713.001 comments are introductions and summaries to more specific subsequent PWSD comments. See responses to more specific subsequent PWSD comments below. PWSD.0713.001 questions the usefulness of CRWAS. The next draft of the CRWAS Phase I Report will clarify the value of the Study including: • Refinement of state CDSS modeling tools through close coordination with Colorado water users and operators for the benefit of properly representing water operations for Colorado's water stakeholders. • Updated hydrologic and water operations result trends associated with three different hydrologic bases (historical, paleo, climate change) to help the state and Colorado's water stakeholders in planning activities. • Data and approach contributions to other ongoing state studies, initiatives, and organizations (IBCC and BRT processes and CWCB's Drought Plan, SWSI, and Compact Compliance studies). • Placing CWCB in a position of understanding to intelligently communicate and coordinate with other groups associated with similar initiatives (Upper Colorado River Commission, US Bureau of Reclamation, and Joint Front Range Climate Change Vulnerability Study Group). The methods used in the CRWAS were selected based on their scientific validity and their applicability to the objectives of the CRWAS. In identifying and developing these methods, two principal objectives were to avoid introducing bias and to portray uncertainty realistically, which we believe have been appropriately addressed. In addition, the methods were reviewed by members of the CRWAS technical team, were critically reviewed by the staff of the CWCB and the Colorado Climate Change Technical Advisory Group and were publically documented.

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	in Colorado and is responsible for providing adequate water supplies for its current and future residents. As such, PWSD is concerned that the maximum beneficial use of Colorado's allocation under the Colorado River Compact (Compact) is achieved, since the purpose of Colorado's allocation is to serve all of the people of Colorado. Representatives for PWSD have reviewed this draft Study report, and we are concerned because this draft report does not achieve the objective of protecting and preserving Colorado's rightful water supply for future use because available data are not being fairly and accurately evaluated in a scientifically-defensible manner. The conclusion of the Study that, on the low end, there is zero water availability for current uses, much less future uses, is bad public policy, since it is conceding Colorado's rights based on unrealistic assumptions regarding future use of water and scientifically-unfounded manipulations of available hydrologic and climatic data. A study that produces a margin of error of 1,000,000 acre-feet per year (ac-ft/yr) should be re-evaluated as to whether it has the necessary scientific validity. While it is purported that the Study results will provide important information to Colorado water users with respect to future availability, the fact that there is such a large range of water availability and no recommendations regarding water management options leaves water users, water managers, and policy makers to ponder the usefulness of the Study and what guidance it provides. At the same time, the Study results set a dangerous precedent by concluding that there may be no additional water available for development in Colorado from Colorado River resources. The following sections describe LWS' issues related to the methodologies used to assess future water supply availability based on current uses and the assumptions used to define future demands based on current uses.	
PWSD.0713.002	**Hydrologic Analysis Methods** The draft Study report identifies the following three means of evaluating water availability that were used in the Study: • Historic hydrologic records analyses, • Paleohydrologic analyses, • Climate-adjusted analyses. According to the draft Study report, there are historic hydrologic records dating back to 1909 (although they are incomplete) and a more complete 56-year study period, which was used to represent historical hydrology (1950-2005). In addition to these historic gaged hydrologic data, the draft Study report also used paleohydrology analyses from more than 1,200 years of published tree-ring records. The third hydrologic analysis used in the draft Study report is to assess the magnitude of future water supply availability based on potential effects of climate change. A number of different global climate models were used in the	PWSD.0713.002 comments can be collectively summarized into concern over a perception that more focus is made on CRWAS climate change results than on historical and alternate historical (paleo) results in the Conclusions and Recommendations. The Draft CRWAS Phase I Report shows a range of results for the historical record, paleo-record, and five climate change scenarios as well as graphical representations of low flows for several different durations. The next draft of the CRWAS Phase I Report will include additional language in the Conclusions and Recommendations focused on historical and alternate historical (paleo) results. It is CWCB's intention to make the CRWAS data (historical, alternate historical, and climate change) available to the public such that each stakeholder may use the data for their own purposes. PWSD.0713.002 also raises concern over the use of paleo records. See responses to comments FRWC.0615.005 and FRWC.0615.008. The CRWAS paleo-approach has been reported in refereed scientific literature.

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	Study to complete these analyses. The evaluation and comparison of these alternative hydrologic analysis methods appears to be prudent at face value, only if one assumes that each analysis has received equal scientific rigor in the evaluations. The statement is made in the draft Study report's Executive Summary that "[w]hile the projections of future climate represented by the GCMs [General Circulation Models] are possible representations of future conditions, the Study provides other hydrologic scenarios to allow water managers, policy makers, and stakeholders to base their decisions and actions on a broad range of future possibilities." This would indicate that all of the hydrologic analyses would, and should, be given equal weight by the Study report. However, the historic hydrologic records analyses and paleohydrologic analyses seem only to serve a minor purpose in the Study, with the analyses (and in particular the results) being dominated by climate-adjusted water availability estimates. **Historic Hydrologic Records Analyses** Using historic hydrologic records has typically been the accepted means for projecting future water supply availability when coupled with a representative set of water demands. While this analysis was completed as part of the Study and the results indicate that between 430,000 and 790,000 ac-ft/yr of water is available for future consumptive use by Colorado (Figure 3-37 of the draft Study report), the analysis is given relatively short shrift in the report and is primarily used as a basis for comparison to the climate-adjusted analyses. Rather than drawing conclusions from the generally- accepted methodology for predicting future water availability, the Conclusions and Recommendations section of the draft Study report only describes the results of the climate-adjusted analyses (Page 4-1 of the draft Study report). While the results from the hydrologic records analysis is an equally-likely outcome for future water availability as climate-adjusted values, the range of water availability derived from the historic hydrologic record analyses is not reported in the Conclusions and Recommendations section of the report. In fact, this analysis, as well as the paleohydrologic analyses and some of the climate-adjusted analyses, provide a consistent estimate of water availability in the 450,000 to 900,000 ac-ft/yr range, yet this is not discussed as a conclusion of the study. **Paleohydrologic Analyses** Paleohydrologic analyses necessarily have to provide a link between climate and hydrology, and there are many factors related to climate that cannot be used to draw parallel conclusions to hydrologic conditions. For example, it is well known that two years can have the same climatic conditions related to precipitation, but because the precipitation patterns vary, runoff, and soil infiltration and percolation, can be distinctly different in the two years. For this, and other factors that are not well understood, while paleohydrologic reconstructions can be developed, care needs to be taken before incorporating these analyses into future	We believe that the selected approach provides a sound scientific basis on which to understand and represent the variability of the hydrologic system. The approach, along with alternative approaches, is described in CRWAS Technical Memorandum 6.4. Results of the development of the alternative historical hydrology are summarized in CRWAS Technical Memorandum 6.7. The alternate historical (paleo) approach adopted by CRWAS generated and examined 100 56-year traces of alternate historical hydrology. In these traces, for example, the longest drought period for the Colorado River near Cameo was 12 years and the longest surplus period at that location was 11 years. These periods were defined based on annual flows, so a single wet or dry year will interrupt a spell. For example, some 56-year traces showed mean flows below the historical mean, but because there were individual years within that 56-year period that were above the historical mean this would not represent a 56-year drought. The implications of wet and dry spells to Colorado's water availability are best determined by simulation of specific water rights and structures, as is done with the CDSS models. The sequences of alternate historical hydrology have been run through CDSS models so the output databases from those runs will reflect the impact of variability as captured in the alternate historical hydrology. These output databases will be made available to the public at the completion of the project. Use of the alternate historical hydrology in future model analyses will allow project performance to reflect the impact of variability.

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	predictive analyses. Regardless of the constraints related to paleohydrologic analyses, and even though the draft Study report opines that there are more extended droughts and wet periods from the reconstruction of flow records using paleohydrology, the records for a period of over 500 years (Figure 2-4 of the draft Study report) indicate similar flow conditions to the observed period of record. In fact, in several of the reconstructions, the precipitation patterns are wetter than in the historic recorded period of record. This is also reflected in the estimate of water available for future consumptive use through the extended historical hydrology period, which indicates water availability in the range of 480,000 to 890,000 ac-ft/yr (Figure 3-37 of the draft Study report). Again, even with this extended period of record and similar results to the historic hydrologic record analyses, neither result is reported in the Conclusions and Recommendations section of the draft Study report.	
PWSD.0713.003	**Climate-Adjusted Analyses** LWS has numerous issues with the analyses conducted in the Study related to climate change, starting with the use of global circulation models (GCMs) with an extremely large grid discretization to questionable methodologies of taking limited data from these GCMs and making very site-specific conclusions from theses analyses. In fact, the Study team seems to acknowledge these shortcomings, as it was stated in the Conclusions and Recommendations section of the draft Study report (Page 4- 1) that: "[t]he primary underlying drivers for the broad range of Phase I results are 1) the inherent uncertainties in the available global climate models in projecting the magnitude and nature of future of greenhouse gas emissions; 2) the complexity of modeling atmospheric circulation; and 3) down-scaling the resulting effects of changed temperature and precipitation on natural flows in an area the size of the Colorado River Basin." Regardless of this conclusion and the statement in the draft Study report text on climate change hydrology that states "[t]he problems with this coarse resolution [of the GCMs] are that it does not represent very well the mountainous terrain in Colorado, and the scale of the grid cells is very large compared to the watersheds that supply water within Colorado" (Page 2-19), the draft Study report conclusions still represent that the results from the climate-adjusted analyses are scientifically valid. No justification is provided, which is warranted, particularly in light of the seeming acknowledgment that there are several shortcomings in the methodologies. Initially, we have serious concerns with the scientific validity of GCMs in general. One issue that is not discussed in the draft Study report is whether these GCMs have been calibrated to existing conditions. Typically, future predictive models are calibrated based on historical data to see if the models can replicate the historical data. Without such calibration, these models cannot initially be	PWSD.0713.003 comments can be collectively summarized into concern over the validity and application of GCMs for CRWAS, including: • Variability and uncertainty associated with GCM data • Resolution of GCM data and the adopted downscaling method • Integration of GCMs with hydrologic models and potential "error" See responses to comments FRWC.0615.001 through 004. The methods employed in the Study have been widely used in similar impact studies and have been described in numerous peer-reviewed journal articles. GCM projections exhibit bias when compared to historical climate. A bias-correction step in the downscaling process serves as an ex post calibration process to adjust the projected climate results by the amounts necessary to remove the bias in simulations of historical climate. The CRWAS and the JFRCCVS selected climate projections based only on their simulated change in temperature and precipitation, with the objective of representing approximately 80% of the range of conditions reflected across all of the readily available projections. Individual projections were not selected based on other attributes. There is not sufficient scientific information to evaluate the suitability of individual model codes or individual model runs. Identifying the attributes of models and model runs will be misleading because that will imply that a judgment has been made as to which projection is "better". The next draft of the CRWAS Phase I Report will clarify Study goals, limitations, assumptions, and appropriate use of results, including refined descriptions of uncertainty, variability, and probability limitations in CRWAS estimates of future conditions.

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	used as any reliable predictor of future conditions. Beyond such calibration, with the grid discretization of these GCMs, only one temperature and precipitation value can be obtained for each time step in the model per cell. Therefore, the values obtained from any GCM is averaged over the grid size. As acknowledged in the draft Study report, this coarse resolution means that temperature and precipitation data may be averaged over an area extending from the Continental Divide to Cortez, or from the Continental Divide to the Dinosaur National Monument, both very different climatic regions which would be averaged in one cell of the GCMs. Beyond this averaging effect, based on the grid size of the GCMs, Figure 2-9 in the draft Study report shows how varied the results from the GCMs can be. With GCM data so scattered, how can the Study team have confidence that any prediction is accurate? Obviously, with such scattered results, the accuracy of (a) the input data, (b) the assumptions of the model, and/or (c) the algorithms used to depict air circulation patterns is put into question. Therefore, the use of GCMs as the starting point for the Study related to climate change effects raises serious concerns. In addition to the accuracy of the GCMs to predict the future climatological conditions, our concern with this study is also directly related to the scientifically-unjustified manipulation of the GCM model data. The Executive Summary of the draft Study report states that "[t]his Study is likely the most rigorous and detailed study performed to date that utilizes GCM output and extends the analysis of potential effects to potential impacts of all the water uses (consumptive and non-consumptive) in an entire river basin" (emphasis added). While the Study team recognizes the inadequacy of GCMs to evaluate site-specific flow patterns in the Colorado River Basin by stating in the draft Study report that they can "not represent very well the mountainous terrain in Colorado," the Study team proceeds anyway, using very large extrapolative methods to achieve an end by "extending the analysis." That is, estimating future flow conditions in small sub-basins based on single temperature and precipitation values from the GCMs that cover many multiples of the sub-basin areas. The procedure described in the draft Study report is a consecutive, step-wise process of taking imprecise data from one step to the next, thereby compounding the errors in the analysis as the process continues. According to the draft Study report on page 2-19, this step-wise procedure to "extend the analysis" was a "downscaling" to "translate the outputs from GCMs to a scale that is useful for hydrologic modeling in Colorado." What this means is that single outputs from the GCM over a large area were then modified to be more "representative" of individual sub-basins. However, there is no scientific justification that this manipulation from a large scale to a small scale is representative. Regardless of the resolution of the GCMs, the draft Study report presents estimated flows at gages in drainage basins considerably smaller than 40,000 square miles, as shown in Table 1. The largest drainage area where flows were	

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	simulated is 8,050 square miles (Colorado River near Cameo), which requires the GCM results to be extrapolated and adjusted approximately 5 times from the model resolution, while the smallest drainage area hydrograph is 102 square miles (Colorado River near Grand Lake), which would require an extrapolation in resolution of 392 times from the GCM results. Since the GCM model results cannot provide this resolution, estimates of flow made by the Study team are not based on, nor can be justified by, use of the GCMs. To illustrate, Figure 1 shows the size of the CGM grid and some of the drainage areas where future flow characteristics are estimated in the study report (Table 1). These estimates cannot be made from the GCMs. No explanation, or justification, is provided in the draft Study report as to how this large extrapolation in resolution was based (given that there are no future data projections at this resolution available), or what was the scientific basis for this type of analysis. In addition, there is no mention as to whether this methodology will produce, if applied to historic weather predictions, repeatable results to actual historic flow data. Independent peer review of the validity of this approach is necessary, particularly given the wide range of results that are projected (e.g., see Figure 2-9).	
PWSD.0713.004	Regardless, these down-scaled data were then input to a hydrologic model (a variable infiltration capacity model) to derive flows in sub-basins using extrapolated and interpreted data as input to the model. As previously described, this maneuver only increases the probability of compounding the error in the analysis. For example, a variable infiltration capacity model such as the one used for the Study has to simulate soil types, percolation/infiltration capacities, changes in soil moisture, evapotranspiration, and snow versus rainfall dynamics. However, as a precursor to any infiltration model, there also has to be accurate representation of the precipitation falling within the basin drainage area. The draft Study report indicates that localized thunderstorm activity and monsoon-type precipitation patterns were difficult to account for in the climate models (Page 3- 11). However, there are several portions of the Colorado River Basin in Colorado where these types of precipitation events dominate the summertime precipitation volumes. Therefore, not only is there difficulty in accurately establishing all of the parameters which relate to either runoff or soil infiltration, but there is also difficulty in providing representative precipitation data, which can greatly affect the resultant stream flow estimates. Because of the importance of this step in estimating future water supply availability, LWS would also recommend that an independent peer review of the validity of this approach be conducted.	See response to comment PWSD.0713.003. The next draft of the CRWAS Phase I Report will clarify the process by which climate-impacted natural flows and modeled flows are determined.
PWSD.0713.005	In conclusion, the climate-adjusted analyses in the draft Study report (1) take GCM output from the 40,000 square-mile grid, which admittedly is a problem in Colorado due to the mountainous terrain and the coarse resolution of the model,	PWSD.0713.005 comments are summaries to more specific PWSD comments. See responses to more specific PWSD comments above and below.

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	(2) then take these average precipitation and temperature data to "downscale" output from the GCMs using large extrapolation techniques, (3) then derive site-specific hydrologic factors for individual sub-basins, (4) then run a hydrologic model to estimate runoff under climate-change conditions using factors not found in the GCMs, and (5) use the results as evidence of the future water availability in the Colorado River for Colorado's Compact allocation. This is an unacceptable scientific procedure and, in our opinion, represents bad public policy relative to maximizing beneficial use of the waters of Colorado. Given the questionable techniques that were used in each step of this process renders the final product related to water supply availability highly suspect, as the errors in each step are compounded in reaching the final conclusion on water availability. Furthermore, these steps have ultimately resulted in the sole conclusion that, on the low end, there could be zero water available for Colorado's remaining Compact entitlement (even under current uses), even though the majority of the analyses in the Study reach significantly different conclusions. This means that available data have not been fairly and accurately evaluated in a scientifically-defensible manner and, as a result, puts Colorado's actual remaining Compact entitlement at risk.	
PWSD.0713.006	This draft study report should not be allowed to be finalized until methodologies used to derive future stream flow estimates are fully vetted for their scientific accuracy, defensibility, and applicability to this study. Independent peer review by qualified professionals is required for this process, in addition to the public being allowed to evaluate and comment on these methodologies. Only analyses that can be fully defended on the scientific bases described above should be included in the Study report.	The methods used in the CRWAS were selected based on their scientific validity and their applicability to the objectives of the CRWAS. In identifying and developing these methods, two principal objectives were to avoid introducing bias and to portray uncertainty realistically, which we believe have been appropriately addressed. In addition, the methods were reviewed by members of the CRWAS technical team, were critically reviewed by the staff of the CWCB and the Colorado Climate Change Technical Advisory Group and were publically documented. No additional peer review is scoped at this time. 1. The methods employed in the Study have been widely used in similar impact studies and have been described in numerous peer-reviewed journal articles. Significant effort has been completed on literature review associated with CRWAS methods. Supporting CRWAS technical memoranda, available on the CWCB website, include extensive descriptions of the methodologies and peer-reviewed documents utilized to choose and implement CRWAS approaches. 2. Significant effort has been completed on outreach associated with CRWAS methods. Since the Study began, CRWAS has facilitated over 50 outreach meetings to vet CRWAS approaches including technical groups such as the National Oceanic and Atmospheric Administration (NOAA), the CWCB Climate Change Technical Advisory Group (CCTAG), the Joint Front Range Climate Change Vulnerability Study (JFRCCVS) Group as well as the: • CWCB Board • IBCC and BRTs • Joint Ag Committee • State Engineer's Office

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		• Attorney General's Office • Regional Water Organizations 3. The Study included a formal four-month public review and comment period of the Draft CRWAS Phase I Report resulting in over 400 comments from over 40 commenting entities, including technical working groups such as the Rocky Mountain Climate Organization, Western Resource Advocates, Western Water Assessment, and many others. All written comments received during the Study's formal public review period, which are posted on the CWCB website, were reviewed and considered by the CRWAS team to guide analysis and report refinements to ultimately provide stakeholders with a better understanding of Study objectives, limitations, and value in future State water planning activities. Based on public comments, the CWCB has embarked on a series of responsive activities that range from public and stakeholder outreach meetings and workshops to discuss specific public comments and proposed responses; to generation of a detailed public comment / response matrix to document all formal public comments and corresponding written responses and responsive actions; to refinements in computer models and analyses associated with the Study; to clarification of Study objectives, approaches, results, conclusions, and recommendations. The matrix is being generated for all public comments associated with the Draft CRWAS Phase I Report that will ultimately be posted for public review.
PWSD.0713.007	**Study Assumptions** While LWS has serious concerns related to the water supply estimates presented in the draft Study report, the assumptions used in this Study also exacerbate the estimates of depleted water supply availability. The assumption in the Study that all current operating and management practices are unchanged, even though the Study projects water supply availability and demands to the year 2070, is unrealistic, particularly for the alternative where temperatures are increasing and overall water supply availability is decreasing. For example, the draft Study report assumes no change in irrigation efficiency for the next 60 years, even stating that diversion efficiencies can be as low as 30 percent (Page 2-38). In addition, currently-irrigated acreage and crop types are also carried forward for 60 years, which results in the potential for an increase of approximately 350,000 to 500,000 AF/yr of water for crop irrigation requirements (Table 3-5 of the draft Study report). With continuing growth in Colorado and limited available water supplies (with or without climate change), to produce a report which assumes that irrigated agriculture could increase by 20 percent in the future and that no further water management efficiencies will be implemented in the next 60 years is irresponsible. In fact, one aspect where this Study report would be of benefit would be a	The CWCB Board directed the CRWAS Phase I scope to establish technical approaches and evaluate water availability associated with current water supply infrastructure, currently perfected water rights, and current levels of consumptive and nonconsumptive water demands prior to transitioning to a subsequent phase. See response to comment YWBRT.0721.001.

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	discussion of the potential water management options so that maximum beneficial use can be achieved from the limited water supplies which are available. For example, the results of the Study indicate that more surface water storage is required, better efficiencies in irrigation practices are needed, and water banking concepts should be explored and developed to protect against water supply shortfalls in dry years.	
PWSD.0713.008	**Colorado River Compact** In assessing water availability to Colorado under the 1922 Colorado River Compact (1922 Compact) and the 1948 Upper Colorado River Compact (1948 Compact), future water availability estimates in the draft Study report which impose climate change appear to be based on the equal apportionment of 7,500,000 ac-ft/yr of water for the Upper Basin states and the Lower Basin states, with the allocation of 51.75 percent of this water to Colorado under the Upper Colorado River Compact. However, the draft Study report also says that the modeling in the Study adopts the 2007 United States Bureau of Reclamation Hydrologic Determination (Hydrologic Determination), which found that approximately 6,000,000 ac-ft/yr of water per year is available for the Upper Basin states. It is unclear in the draft Study report whether the Study is basing future water availability on equal apportionment or the reduced volume used in the Hydrologic Determination. If the Hydrologic Determination values are the basis for future water supply availability in the draft Study report, LWS questions why Colorado would be willing (a) to accept anything less than an equal water allocation between the Upper Basin states and the Lower Basin states and (b) to further accept the sole burden of potential reductions in flow due to global climate change as part of Colorado's Compact entitlement, rather than work to protect its rightful Compact entitlement?	See response to comment CBRT.0721.001.
PWSD.0713.009	**Summary** This draft report should not be finalized until all of the methods used have been fully vetted for their scientific accuracy, defensibility, and applicability until the draft Study report has been fully and independently peer-reviewed by qualified professionals. The following issues need to be resolved: 1) GCMs have to be fully calibrated to historic conditions before being used for future predictions. 2) How can any analysis be accurately based on GCMs that have such variable results? 3) How can GCM output data that produces one value for each time step over a 40,000 square-mile area (cell size) be used to predict flows in basins as small as 102 square miles? 4) How can the accuracy of down-scaling be justified when there are no data to support such site-specific extrapolations? 5) When most of the likely outcomes from the various hydrologic analyses are in a common range (approximately 450,000 to 900,000 ac-ft/yr (Figure 3-37)),	PWSD.0713.009 comments are summaries to more specific PWSD comments. See responses to more specific PWSD comments above. The Draft CRWAS Phase I Report will remain in Draft form until such time that we have completed additional scoped public outreach and BRT meetings, distribution of a refined Draft CRWAS Phase I Report, and further review and deliberation by CWCB staff and Board.

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	why is one result (0 to 1,000,000 ac-ft/yr from the climate-adjusted analyses, which appears to be an outlier) emphasized in the Conclusions and Recommendations section, to the exclusion of the more common outcome? 6) Why would the Study assume no changes in water management in the future, even though significant changes in water supply are predicted? 7) Why would Colorado adopt a policy that is anything less than an equal apportionment of Colorado River water between the Upper Basin states and the Lower Basin states? Colorado needs to be diligent in developing its rightful entitlement to Compact water for Colorado. The Colorado River is an important resource for future Colorado water needs and the maximum beneficial utilization of this resource would minimize impacts to agriculture and Colorado's rural communities. Basing study results on questionable science is bad public policy, particularly when it can result in conceding Colorado's rightful entitlement. Because Colorado's entitlement needs to be fully protected, the draft Study report should not be finalized until all of these issues are fully vetted and only scientifically-justifiable results are presented. Steps should also be proposed in the Study report to secure Colorado's full Compact entitlement. If you have any questions regarding our comments on the draft Study report, please feel free to give us a call.	
DWSD.0712.001	The Donala Water & Sanitation District would like to register its concern with the CRWAS Phase I Report as it stands in its draft form. Donala is a small district in northern El Paso County. Although our current source of water is the Denver Basin, we are interested in Colorado River water as a substitute, renewable source. Hopefully, you are aware of the situation that all entities on the Front Range are facing with the depletion of the Denver Basin. Donala is a member of the Colorado Water Authority (CWA), formerly the Colorado Water Resources Project Cooperative Development Authority. As such, we are looking at the Flaming Gorge Reservoir in Wyoming and the use of Colorado's entitlement to that water. For that reason, the accuracy and viability of the CRWAS is very important. It is especially important that a study commissioned by the taxpayers of Colorado does not imply that there is not enough water available for Colorado to realize its rightful share of Colorado River water. As you well know, the lower basin states have long been using more than their Compact share, and for Colorado to state that there may be no more water available - therefore we (Colorado) will not claim any more than we are now using - would be very unfortunate. Any "scientific" engineering report that claims a range of available water from zero to 900,000 acre feet has questionable technical value at best. We urge you to refine the various scenarios and the resulting forecast so that the study can be appropriately used for water manager planning. Already engineering and legal firms in the state with clients on Colorado's West Slope are lining up to cite this	Comments are similar to PWSD comments. See responses to PWSD comments.

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	study to make their clients' case that there is no more water for the citizens of Colorado. As has been documented in court and discussed many times in the past, Colorado's water is there for ALL the citizens of the state. In the past, Colorado water politics has been driven by the West Slope - where 15% of the population controls 85% of the water. This draft appears to us to continue that deference to West Slope interests over Colorado interests in general. Colorado's Executive Director of the Department of Natural Resources, Harris Sherman, gave credence to that policy in 2008 when he issued letters to the two parties interested in Flaming Gorge water. He basically stated that the outcome of CRWAS would answer important questions that would determine, or at least influence, Colorado's support for the project. The study does not appear to answer those important questions. Additionally, the primacy of West Slope interests will result once again in the 85% of the population on the Front Range standing in line behind the lower basin states when it comes to use of Colorado River water which we rightfully own. In summary, we urge you to take a hard look at the study, acknowledge that it falls short of developing policy guidelines for use of the River, initiate a peer review process that includes Front Range interests, and issue a strong statement that reiterates that all the people of Colorado are entitled to the waters under the Compacts, Finally, we urge the state to give up on relying on this study for analysis of the Flaming Gorge project, and move ahead to support the project on that basis of sound science and logic, not internal politics.	
CSL.0713.001	As Colorado State legislators, we are concerned about protecting the State of Colorado's rightful share of water under the Colorado River Compact (Compact). As the Statewide Water Supply Initiative (SWSI) documented, we must address water shortages during eh next several decades. Our share of the Colorado River will be critical in meeting our supply needs. Unfortunately, it appears the Department of Natural Resources has authorized a study that is both flawed in its methodology and has negative implications for Colorado's ability to protect its rightful share of Colorado River water." It appears that the draft Phase I Colorado River Water Availability Study raises serious concerns about the accuracy of data used, the application of climate models and the conclusion the report offers. We note that the report has not had an independent peer review, and the methodology, data, or conclusions reflect sound scientific practices are questionable. We join with Parker Water & Sanitation District's letter to CWCB in offering formal comments relating to the Study. We have attached a letter from Frank Jaeger, District Manager of PWSD and a letter from Bruce Lytle of Lytle Water Solutions, both commenting on the study.	The methods used in the CRWAS were selected based on their scientific validity and their applicability to the objectives of the CRWAS. In identifying and developing these methods, two principal objectives were to avoid introducing bias and to portray uncertainty realistically, which we believe have been appropriately addressed. In addition, the methods were reviewed by members of the CRWAS technical team, were critically reviewed by the staff of the CWCB and the Colorado Climate Change Technical Advisory Group and were publically documented. No additional peer review is scoped at this time. In addition to response bullets listed below, more detail is provided above in responses to comments PWSD.0713.001 through PWSD.0713.009. • The methods employed in the Study have been widely used in similar impact studies and have been described in numerous peer-reviewed journal articles. • Significant effort has been completed on outreach associated with CRWAS methods. Since the Study began, CRWAS has facilitated over 50 outreach meetings to vet CRWAS approaches including technical groups such as the National Oceanic and Atmospheric Administration (NOAA), the CWCB Climate Change Technical Advisory Group (CCTAG), the Joint Front Range Climate Change Vulnerability Study (JFRCCVS) Group, and multiple state agencies. • The Study included a formal four-month public review and comment period

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		of the Draft CRWAS Phase I Report resulting in over 400 comments from over 40 commenting entities, including technical working groups such as the Rocky Mountain Climate Organization, Western Resource Advocates, Western Water Assessment, and many others. • Based on public comments, the CWCB has embarked on a series of responsive activities that range from public and stakeholder outreach meetings and workshops to discuss specific public comments and proposed responses; to generation of a detailed public comment / response matrix to document all formal public comments and corresponding written responses and responsive actions; to refinements in computer models and analyses associated with the Study; to clarification of Study objectives, approaches, results, conclusions, and recommendations. The matrix is being generated for all public comments associated with the Draft CRWAS Phase I Report that will ultimately be posted for public review. • The next draft of the CRWAS Phase I Report will clarify Study goals, limitations, assumptions, and appropriate use of results, including refined descriptions of uncertainty, variability, and probability limitations in CRWAS estimates of future conditions, and including additional language in the Conclusions and Recommendations focused on historical and alternate historical results. • It is CWCB's intention to make the CRWAS data (historical, alternate historical, and climate change) available to the public such that each stakeholder may use the data for their own purposes. • The Draft CRWAS Phase I Report will remain in Draft form until such time that we have completed additional scoped public outreach and BRT meetings, distribution of a refined Draft CRWAS Phase I Report, and further review and deliberation by CWCB staff and Board.
CSL.0713.002	In addition to the technical comments raised in the LWS (Lytle Water Solutions) letter, we believe the intention of the State appropriation related to the Study (SB07-122 and HB 08-1346) has been misspent. Rather, the legislative intent was to support the State of Colorado in its effort to secure its rightful share of the Colorado River water within the Compact rules.	We believe that CRWAS is being implemented according to authorization in SB07-122 Section 15 and HB08-1346 Section 8 and according to direction from the CWCB Board and the IBCC. SB07-122 Section 15 states: "*Colorado water needs and alternatives analysis appropriation. (1) In addition to any other appropriation, there is hereby appropriated out of any moneys in the Colorado water conservation board construction fund not otherwise appropriated, to the department of natural resources, for allocation to the Colorado water conservation board, for the fiscal year beginning July l, 2007, the sum of five hundred thousand dollars ($500,000), or so much thereof as may be necessary, for the board to evaluate water availability in the Colorado river basin and its tributaries. The board shall work in full consultation with, and with the active involvement of, the basin roundtables. The study shall consider current and potential future in-basin consumptive and nonconsumptive needs. The board, in consultation with the basin roundtables, shall recommend whether additional study or phases of study should be undertaken. (2) The moneys appropriated in subsection 1 of this section shall remain available for the designated purposes*

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		until the project is completed." HB08-1346 Section 8 states: "*Colorado river water availability study – continuation – appropriation. (1) In addition to any other appropriation, there is hereby appropriated, out of any moneys in the Colorado water conservation board construction fund not otherwise appropriated, to the department of natural resources, for allocation to the Colorado water conservation board, for the fiscal year beginning July 1, 2008, the sum of five hundred thousand dollars ($500,000), or so much thereof as may be necessary, for the board to continue the model development phase of the Colorado water needs and alternatives analysis, otherwise known as the Colorado river water availability study, authorized in section 15 of Senate Bill 07-122. The board shall continue to work in full consultation with, and the active involvement of, the basin roundtables and shall continue to consider current and potential future in-basin consumptive and nonconsumptive needs. Further, it is expected that the board will request additional funding in future years to undertake the model implementation phase of the study and recommend whether additional studies or phases of study should be undertaken.*" Compact analysis was not included in the referenced legislation. Rather, the referenced legislation directs the CWCB to consult with the BRTs; and the IBCC was therefore involved in the scoping process, resulting in the IBCC recommending that Compact analysis be added to the CRWAS scope to evaluate a corresponding range of water availability.
CSL.0713.003	In addition, Colorado, as an Upper Basin state, for the purpose of the Compact should not be taking action related to water availability without communication and coordination with neighboring states. Colorado should be leading the effort to protect Upper Basin states' water rights, not undermining the effort.	Communication and coordination with Upper Basin states and Federal agencies for the purpose of protecting Colorado's water rights is a significant ongoing effort of CWCB. • The CWCB Director and CWCB Staff work directly with the Upper Colorado River Commission (UCRC) to coordinate on Upper Basin issues. • CWCB has recently started the Colorado River Compact Compliance Study to evaluate Compact compliance and curtailment strategies. • The U.S. Bureau of Reclamation has begun to work on an assessment of Colorado River water availability (Colorado River Basin Water Supply Study). CWCB is actively coordinating with Reclamation to track Study progress and results.
BCo.0720.001	The City and County of Broomfield (the City) has reviewed the draft Colorado River Water Availability Study -- Phase 1 Report dated March 22, 2010 (the Study). It is the City's position that there should be a maximum beneficial use of Colorado's allocation under the Colorado River Compact (the Compact). The City is concerned that this draft of the Study does not achieve the objective of protecting and preserving Colorado's rightful water supply for future use. The City's concerns and comments are as follows:	See response to comment CBRT.0721.001.

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	1.) The Study's concluding section includes an evaluation of the amount of water available for development within the state based on certain Compact assumptions. The assumptions and methods used are not described in sufficient detail to evaluate the Study results. I am sure you can do a better job of restating these comments when you do the summary for the Colorado River Roundtable, but hopefully you will understand generally the concerns, or at a minimum, the questions that are out there based upon this letter. Hopefully the River District has taken a close look at the model.	
BCo.0720.002	2.) Study's summary presents the potential amount of water available for diversion in a critical 10-year dry period. The Report fails to present the estimated amount of water available on average and during wetter periods. Water providers in the state regularly plan for periods of drought. One approach is to store water available in wetter periods. The availability of water in wetter periods should be included in the analyses.	See response to comment FRWC.0615.002.
BCo.0720.003	3.) The model used to calculate demands does not take into account historical operating conditions that may have limited diversions to something less than what could be physically and legally diverted. As such, the model systematically overstates irrigation diversions under both the historical hydrology and climate projection scenarios.	See response to comment FRWC.0615.006.
BCo.0720.004	4.) The U.S. Bureau of Reclamation has begun to work on an assessment of Colorado River water availability (the Colorado River Basin Water Supply and Study), which will provide a detailed assessment of Compact issues. Future water availability in Colorado under the Compact will also be studied in more detail in the upcoming CWCB Colorado River Compact Compliance Strategies Study. In light of both the upcoming Reclamation and CWCB studies, the City suggests that the section of the Study that deals with Compact issues be removed, and be addressed as additional information is available from these two upcoming studies.	See response to comment CBRT.0721.001.
BCo.0720.005	5.) The Study analyses should undergo independent peer review by qualified professionals. Only analyses that can be fully defended for scientific accuracy should be included in the final report.	See response to comment PWSD.0713.006.
BCo.0720.006	6.) The intent and limitations of the Study should be explained more clearly. The Study results may be used for evaluating variability risk in the long-term but are not appropriate for use in operational planning or decision making. The study results should not be used to set state policy or used by opposition to permits for future water supplies or in water cases. The City's position is that these concerns and comments should be fully addressed before the Study is finalized. If you have any questions regarding the City's comments, please contact Alan King, Public Works Director at 303-438-	The next draft of the CRWAS Phase I Report will clarify Study goals, limitations, assumptions, and appropriate use of results, including refined descriptions of uncertainty, variability, and probability limitations in CRWAS estimates of future conditions.

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DCo.0720.001	The Douglas County Board of County Commissioners (BCC) would like to take this opportunity to officially comment on the draft Phase I Colorado River Water Availability Study (Study) released by your office on March 22, 2010. It is our opinion that, while the study may offer a valid scientific analysis of the prehistoric and historic hydrologic conditions of the Colorado River Basin (Basin), these analyses were not given fair and equal treatment with the subsequent climate change analyses addressing potential impacts on future water availability. As such, the overall conclusions of the study which highlight climate change, to the exclusion of the more traditional water supply evaluation techniques using historic recorded data, will not serve water managers well in our existing or future plans to perfect the state's rightful and full compact entitlement. The BCC believes that the methodology used to evaluate the climate-adjusted water availability within the Basin is flawed and needs to be addressed. At numerous places throughout the Study, the limitations of climate change models for use in Colorado's mountainous terrain, and limitations on the subsequent analyses extrapolated from the climate change models, are noted but are then later discounted by the authors when the conclusions to the Study are provided. It is our recommendation that the climate change information be removed completely from the Study, or be reviewed and approved by an independent panel of qualified professionals to direct its methods and conclusions prior to inclusion in the results of the Study. We realize the critical importance of the Study to assist Colorado in perfecting its rightful and full compact entitlement, and applaud you for the effort. It is necessary, however, that the conclusions of the Study be rooted in scientifically defensible and verifiable data. If CWCB approves and finalizes the Phase I report without providing such scientific vetting of the validity of the conclusions of the study, Colorado may appear to have forfeited its remaining Compact entitlement while it should be vigorously defending its rights to this entitlement. This study would benefit from recommendations of means to maximize the beneficial use of Colorado River entitlement water, given the findings of the study, such as additional storage, improved efficiency of irrigation, and water banking.	Comments are similar to PWSD comments. See responses to PWSD comments.
ECo.0720.001	Please consider this letter as formal comments to the Draft Phase I Colorado River Water Availability Study Report ("Study Report") by El Paso County by and through the Board of County Commissioners of El Paso County, Colorado ("Board"), a political subdivision of the State of Colorado. The Board has reviewed the comments prepared by Lytle Water Solutions, LLC ("LWS") by their President, Mr. Bruce Lytle, which were prepared for, and on behalf of, the Parker Water and Sanitation District ("PWSD"). The Board is familiar with Mr. Frank Jaeger's services on behalf of PWSD and on the South Platte Basin Roundtable to vigilantly pursue alternative water resources in this area of Colorado. The Board therefore supports and endorses LWS' analysis and	Comments are similar to PWSD comments. See responses to PWSD comments.

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	PWSD's comments on the Study Report. Through its involvement with the Water Authority and both the Arkansas Basin and South Platte Basin Roundtables, through its involvement with the Upper Black Squirrel Creek Designated Ground Water Basin recharge and water quality studies, and by its continued application its 300 year water supply requirement for subdivision applications in the unincorporated area of El Paso County, the Board is very mindful of the scarce and valuable resource that water is to our high desert region and to the State. El Paso County continues to attract new residents, and has experienced high growth rates over the last several years. Much of that growth is dependent on non-renewable groundwater for its water supply. The board is responsible for approving sufficient water supplies for subdivisions, and realizes that alternative sources of water are required for the future, not only for our County, bur for the entire State. Therefore, we are concerned with the study Report that will limit Colorado's full use of its Colorado River Compact water. The Board believes that the State of Colorado must take every opportunity to protect the public's property rights in the waters of the state. That means that the State of Colorado, through the CWCB must vigorously assert Colorado's rights in, and develop its full and rightful entitlement to Compact water under, both the 1922 Colorado River Compact and the 1948 Upper Colorado River Compact. The Board agrees with LWSs conclusion that the Study Report results are based on questionable scientific analysis and thereby reaches flawed conclusions that will lead to bad public policy positions. The zero availability conclusion means there is no water left to be claimed in the Colorado River, and thus, no rights by the people of Colorado to appropriate any more Colorado River water for beneficial use. If CWCB approves the Study Report, it will have conceded and surrendered any position that Colorado could assert to claims for Colorado's full and rightful Compact entitlements. In other words, in response to any such future assertion by Colorado, California will simply cite to the Study Report and say "case closed" b/c CWCB has asserted there is zero water available so there would be no more water to which Colorado could claim entitlement. The people of El Paso County and Colorado lose. The Board joins Parker Water and Sanitation District and strongly recommends that the CWCB not finalize the Study Report until scientifically sound analysis has been applied; the Study Report has been revised, peer reviewed, and fully vetted; and sound scientific and public policy conclusions have been reached that will not preclude Colorado from asserting its full entitlement to Colorado Compact waters.	
JCo.0721.001	I am submitting my comments in response to the Draft Colorado River Water Availability Study Report. First and foremost, I respectfully request a delay in issuing any further findings or conclusions of the draft study until numerous engineering and technical	Comments are similar to PWSD comments. See responses to PWSD comments.

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	experts have an opportunity to evaluate the draft study in detail. Jefferson County's staff review has raised concerns with the application of the Global Climate Model (GCM), the failure to apply the Colorado River Basin's unique attributes, such as mountain terrain, temperature, and precipitation, and the incorporation of un-vetted assumptions regarding future operating and management practices. In addition, while the estimates of water available for future consumptive use overlap on the upper end of previous studies, the lower end of the range indicates there will be limited water for future development in Colorado. Given such a large range of values, and margin of errors associated with the GCM, this report should have several disclaimers related to the assumptions that lead to the lower end of the range. This report has the potential to provide useful data to be used in the decision process in land use cases throughout Colorado, however, the assumptions used in the GCM should be revisited and the eight refinements in the report (page VIII) should be addressed prior to the next draft. Further, I request independent peer review by professionals knowledgeable of Colorado's environment, as well as incorporation of a public review, be an integral part of the re-evaluation. Whether intended or not, this study has the potential to concede Colorado's water rights based on scientifically unfounded manipulations of available hydrologic and climatic data. Colorado communities must be involved in a fair and accurate study to ensure Colorado's full Compact entitlement.	
PPRWA.0721.001	The Pikes Peak Regional Water Authority is made up of water providers in El Paso County. PPRWA plans to be a member of the Colorado Water Resources Project Cooperative Development Authority, which is currently studying the feasibility of a pipeline from Flaming Gorge Reservoir to the Front Range of Colorado. PPRWA offers the following comments on the draft report of the Colorado River Water Availability Study. We start with a common ground: Colorado has the right under the Colorado River compact and the Upper Colorado River Compact to the beneficial consumptive use of 3.88 million acre feet per year from the Colorado River; Colorado's compact entitlement is for the benefit of the entire state, not just the natural drainage basin of the Colorado River; Colorado is today using less than 3.88 million acre feet per year of its compact entitlement; the state as a whole has a strong interest in maximizing the beneficial consumptive use of water from the Colorado River. We are not qualified to comment on the technical and scientific merits of the study. However, we understand there are serious questions about the scientific merits of using global-scale climate change models to predict runoff in the river's sub-basins in Colorado. The wide range of results strongly suggests the science is difficult, if not entirely inappropriate, to apply to this task. Thorough peer review and vetting of techniques is required at a minimum before the State of	Comments are similar to PWSD comments. See responses to PWSD comments.

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	Colorado can endorse the study. Even with the most rigorous review, the best outcome is a prediction of a range of possibilities. No one should mistake such a prediction for fact. The present range of results provides something for everyone in the argument over who gets to develop Colorado's remaining compact entitlement. For that reason, the study is not helpful. It was intended to answer the question of how much remains to be developed, to assist the state in developing a position on projects such as the Flaming Gorge pipeline proposal. Since it does not answer that question, there may be no good purpose served by continuing the study. The Executive Director of the Department of Natural Resources, in his letters to the Bureau of Reclamation, stated Colorado supports study of the Flaming Gorge pipeline project, subject to the outcome of this study. The wide range of outcomes argues strongly for the state to abandon the idea that the study will dictate policy. There simply is no answer in this draft study that is useful in evaluating this or any other project. Yet, policy decisions must be made. Colorado should unambiguously stand up for Colorado's use of its allocated share for the river for beneficial consumptive use. No matter how the study is improved, the State of Colorado should not endorse in any way a conclusion that there might be no remaining entitlement in the Colorado River. A debate where the State of Colorado has endorsed that possibility cannot be helpful in dealing with the Lower Basin states. That result (no remaining undeveloped water for the State of Colorado) appears to be an outlier that, while it must be acknowledged, should not be treated as equally likely based on this study, and certainly should not be given the credibility added by the State of Colorado's imprimatur. At a minimum, the CWCB should engage a panel of experts to conduct rigorous peer review before the State of Colorado gives its approval to a study that may or may not be cited to undercut Colorado's right to additional beneficial consumptive use of the Colorado River. The State of Colorado should not adapt this study as a basis for policy-making. It is too inconclusive to be relied upon for that purpose. Thank you for the opportunity to express our views.	
SMWSA.0721.001	The South Metro Water Supply Authority whishes to make the following comments on the draft Phase 1 Colorado River Water Availability Study. The study, a political compromise at best, is flawed on several accounts. Many comments by others adequately address these shortcomings. We particularly agree with [comments] of Parker Water & Sanitation District and Douglas County. The Bureau of Reclamation, during the Colorado River shortage negotiations, adequately addressed water availability in the upper basin. This unbiased work, based on historic and prehistoric hydrologic conditions, showed less than 1%	Comments are similar to PWSD and DCo comments. See responses to PWSD and DCo comments.

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	chance of the upper basin failing to comply with the Compact even under the worst of conditions. The study at issue here purports to analyze water availability based on "climate change" to the exclusion of other more traditional analytical methods. Quite frankly, the conclusions are not very useful and present little opportunity for water managers and policymakers to adequately plan for the full development of Colorado's compact allocations. The importance to other States in the upper basin is that this study could be used to allege that New Mexico & Utah have over used their allocations and Wyoming, like Colorado, may have severely diminished water availability in their future. Conclusions such as "zero to 500,000 acre feet available" very well be used to thwart future use of upper basin water allocations. The real fear is that a study of this nature will be used to administer water rights in the Colorado Basin within the State on a 10 year moving average. Such premature administration would neuter the usefulness of the Colorado River Storage Projects (specifically designed to provide insurance for upper basin water use) and cast doubt on the ability of water users to pay for future projects given the allegations of diminished water needed to provide a source of revenue. This study needs to be left in "draft" and the State needs to move on to more pressing issues such as the development of projects necessary to meet our future water needs. The State has an adequate inventory of projects identified through the State Wide Water Supply Initiative. I believe it has always been the intent of the CWCB to move forward on these projects.	
CSU.0806.001	We wanted to make you aware of a situation that has recently come to our attention. Colorado Springs Utilities became aware of data errors in the Colorado River Decision Support System Model, or StateMod, for historical Homestake System diversions, used as demands in StateMod. After assessing the model files posted on the CWCB website, we discovered the demands used for the Homestake diversions totaled 217,000 af/yr, when our historical average has actually been 25,000-30,000 af/yr range. We confirmed the file containing these errors was used for the CRWAS. We have been in contact with your technical staff and consultant team to make them aware of these errors. We are pleased by the quick response of the consultant team in assessing the resulting error. While the impact was negligible in terms of Colorado River water availability, there were substantial changes in the operations of Homestake Reservoir. We will continue to work with your technical staff, as needed, for reanalysis. We also wanted to let you know we identified and corrected these errors in 2008 while using StateMod to model impacts for our Blue River Substitution NEPA process. Our modeling consultant, Heather Thompson, worked closely with your staff in making the changes and corrections, and a memo of all the corrections including copies of the data files were submitted by Heather to your staff by email in February 2009. We are very surprised, and frankly disappointed, to see	The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to work with technical stakeholders to review and refine, as necessary, Homestake Tunnel demands used in the model. This type of refinement is a key aspect/benefit of CRWAS.

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	that these corrections were not made. If you have any questions or would like to discuss our concerns please do not hesitate to contact us.	

Other Commenting Entities

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CDOW.0723.001	1. Five (5) qualitative future climate scenarios (hot and dry, hot and wet, warm and dry, warm and wet, and median) were utilized as the basis for the climate change analysis of future projections of water availability in the Colorado River for 2040 and 2070. It is not entirely clear how these scenarios were derived, what they represent in terms of degree changes in temperature or % changes in precipitation, and how they relate to the specific findings in the 2008 report "Climate Change in Colorado – A Synthesis to Support Water Resources Management and Adaptation". Further, the majority of recent reports on the projected future climate of the West and Rocky Mountain Region seem to indicate hotter and drier conditions. Recent scientific reports also indicate that temperatures for the years of 2000-2009 are some of the hottest temperatures on record. Given these observations, we recommend that some mention and recognition be given to characterizing the observed climate in the Colorado River basin since 1950, and articulating more clearly what each of the 5 scenarios mean in terms of quantified change in temperature and quantified change in amount or form of precipitation.	Diagnosis of historical climate is outside the scope of CRWAS. Table 2-4 identified the ten selected projections (five each for 2040 and 2070). The next draft of the CRWAS Phase I Report will provide additional explanation about the selection of projections and will provide a table summarizing the change in temperature and precipitation for each selected projection.
CDOW.0723.002	2. The Phase 1 report indicates that each of the 5 future climate scenarios has an equal probability or chance of occurrence and covers a significant range of what could potentially happen of the available 112 GCM projections. From our perspective, the report would have greater value and usefulness if the authors will narrow the range of possible outcomes of future water availability by identifying which of the 5 scenarios are most likely to occur and which are not by 2040 and 2070 within the upper Colorado River basin, and highlight the specific water availability findings of each scenario.	There is no scientific evidence to support the selection of one or more projections that are most likely to occur.
CDOW.0723.003	3. It was difficult to differentiate between the "compact effects" and the "non-compact effects" of the study. We recommend that a clarifying statement or description be included in the executive summary and narrative portions of the report to articulate better what is the volume of water available under non-compact vs. compact conditions, or refer to where this specific information can be found if it is not to be included as an integral portion of the Phase I report.	See response to comment CBRT.0721.001.
CDOW.0723.004	4. The Phase I report includes findings for consumptive use and total water demand, yet it does not specifically break out or quantify the difference between consumptive needs, non-consumptive needs, and total water needs. For example, there is no discussion provided on what the projected impacts are to future in-stream flows (non-consumptive use) and how they might be impacted under the various qualitative climate change scenarios mentioned in Item 1 above. We recommend that greater attention be given to clarifying these findings so that future decision and policy makers can better understand the implications to each within the Colorado River basin. Quantification of	See response to comment CBRT.0721.004.

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	projected impacts to in-stream flows will provide valuable information toward the protection of not only species of greatest conservation need, but also important sport fish and game species and the riparian habitats upon which they depend.	
CDOW.0723.005	5. Evaluation of the Phase I report as it relates to how we view the issue of future water availability in the upper Colorado River basin and the various issues we are currently focusing on has prompted the question, "Is there anything the authors need to do differently for the Phase II report of the study?" From a state fish and wildlife perspective, additional information that would really be of value to us is quantifying the magnitude and frequency of drop and/or fluctuation in water levels in the reservoirs, tributaries, and mainstem of the Colorado River throughout a 12-month cycle for the years 2040 and 2070, and a comparison of these results to the conditions that have been experienced for the period 1950-2005.	See response to comment YWBRT.0721.001. It is CWCB's intention to make the data used in CRWAS analyses and for the Draft CRWAS Phase I Report available to the public such that each stakeholder may use the data for their own purposes.
CDOW.0723.006	6. The Phase I study incorporates the use of tree rings and paleo-hydrology to capture the effect of historic wet/dry cycles as the GCM's apparently don't do a good job of this … It is unclear whether the current analysis provides an indication of how the magnitude, extent, and frequency of dry cycles are expected to change by 2040 and 2070 coupled with earlier and faster snowmelt runoff and their resulting impacts on water availability particularly in mid-late summer. If this information is not already captured in the Phase I report, we recommend this information be incorporated into Phase II of the study along with a quantification of how these dry cycles have changed (increased, decreased, remained same in intensity) and the resulting impact on future water availability within the upper Colorado River basin. (It is important to note that we are already experiencing a shift toward earlier (2-4 weeks) and more rapid snowmelt due to higher than normal temperatures and dust on snow … if this trend continues, how much more pronounced will these impacts be to future water availability by the years 2040 and 2070?)	The pattern of wet and dry years and wet and dry spells is generated based on information from the tree ring records. This is combined with estimates of the effect of future climate change on mean flows. The result is that in scenarios where the projected future climate is drier the length and intensity of droughts increase, while the length and intensity of wet spells decreases, relative to the historical mean flow. The opposite is true of scenarios where the projected future climate is wetter. The change in the seasonal pattern of runoff (a tendency for runoff to occur earlier), which is consistent across all climate projections, is represented in the flow scenarios. Warming of the climate will cause additional changes to the frequency of wet and dry spells, but there is scientific evidence to indicate that the current set of GCMs do not have skill in estimating the inter-annual pattern of precipitation. For this reason, CRWAS relied on the use of the paleo record to represent the frequency of wet and dry spells.
CDOW.0723.007	7. Table 2 lists primary Phase I findings for winter and summer precipitation based on 2040 climate projections. If not already specified, we recommend the authors quantify and describe the net outcome of the changes in winter vs summer precipitation, the volume or percentage of water that may no longer be available for future use due to precipitation falling as rain rather than snow, and the management implications for future storage and capture of this water supply during times when the growing season has not yet begun.	The recommended evaluations would be considered for a subsequent phase of the Study. See response to comment YWBRT.0721.001.
CDOW.0723.008	8. Table 2 briefly describes the affect of elevation on modeled streamflow and water available to meet future demands based on 2040 climate projections. If not already provided, we recommend the authors provide a discussion and diagrams to show how the hydrographs for upper, mid, and lower reaches of	Natural flow and projected flow hydrographs for 227 points in the Colorado River Basin are provided in Appendix D. For example, hydrographs are provided for Colorado River near Grand Lake, Colorado River at Dotsero and Colorado River near Cameo. In addition, modeled (depleted) flows are shown in Appendix

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	the upper Colorado River basin are expected to change; and quantify the elevation zones for which significant changes are expected. As an example, the 2008 CWCB report "Climate Change in Colorado – A Synthesis to Support Water Resources Management and Adaptation" indicates significant change in snowfall at elevations below 8200 feet and a minor decrease in snowfall at elevations above 8200 feet. How do this finding correlate with the results in the Phase I report? Based on the expected changes in hydrographs for the upper, mid, and lower reaches of the Upper Colorado River basin, what does this tell us about future water availability within these various portions of the watershed and the implications for future management of rain/snow water supplies?	E for the same points. It is CWCB's intention to make the data used in CRWAS analyses and for the Draft CRWAS Phase I Report available to the public such that each stakeholder may use the data for their own purposes. This will allow site-specific evaluation of the impact of projected climate change on natural and modeled (depleted) flows.
RMCO.0721.001	Thank you for the opportunity to submit comments on the draft of the CWCB's Colorado River Water Availability Study (CRWAS) Phase I Report. The Rocky Mountain Climate Organization (RMCO) also is joining in a group letter reflecting common comments of some members of the Steering Committee of the Water Adaptation Initiative of RMCO's Colorado Climate Project. We submit these additional comments only on our own behalf, and they should not be taken to also reflect the views of any of our partner organizations nor those of either any organizations represented on or individual members of our Water Adaptation Steering Committee. In 2006, before the last gubernatorial election, RMCO convened a blue-ribbon Climate Action Panel to address Colorado's contributions and vulnerabilities to climate change. Of the panel's 70 recommendations, 15 address actions to meet Colorado's water needs in a changed climate. One of those recommendations, adopted unanimously, is: *To ensure that the new Colorado River water supply study is complete, relevant, widely accepted, and useful for future decision making, the state government should ensure that the potential effects of climate change are considered in the study.* Especially because of this recommendation, RMCO has followed with interest the development of the CRWAS. We applaud the CWCB and its contractors for devoting a significant portion of Phase I of CRWAS to considering the potential effects of climate change on the Colorado River. The information that has been gathered and presented in the report is good, useful information that goes beyond previous efforts and will be of significant value in helping people understand how much Colorado River water may be available to our state in the future and what decisions should be made with respect to future water supply and use. The following specific comments about the draft report are intended to suggest changes that may make the final Phase I Report – and the Phase II Report to follow – more "complete, relevant, widely accepted, and useful for decision making," to use the language from the recommendation of RMCO's Climate Action Panel. Our comments should be taken as our thoughts on how to improve	See responses to comments CBRT.0721.001 and CBRT.0721.008.

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	a good effort, not a criticism of the overall effort. **2070 Projections** For the report, projections were made of hydrological conditions for both 2040 and 2070, based in part on climate projections from five different climate models for each of those years. But only the 2040 hydrological projections are discussed in the body of the draft report, and the 2070 projections were included in the appendices only. For the key question to be addressed by the report – how much Colorado River water will be available to the state in the future – an answer was suggested for 2040 on page 3-45: a range of from no additional water to one million acre-feet of additional water. But no comparable answer was even suggested for 2070, although apparently all the underlying projections and calculations made for 2040 were also made for 2070. The grounds stated in the draft report for discounting the analysis done for 2070 are twofold. First, of the five climate models selected for analysis in 2070, four produced results on the drier half of the scale of a larger range of 112 preliminary projections done for a separate effort underway by the U.S. Bureau of Reclamation. Second, the projections done for 2040 are "representative of 2070 conditions except for the driest projections," in support of which comparisons are presented of projections of river flows near Glenwood Springs, for 2040 and 2070, and from the analyses done for this report and the preliminary analyses done for the Bureau. We are not persuaded that these arguments warrant discounting the 2070 projections done for this report, according to a methodology widely agreed to ahead of time – and also paid for by Colorado taxpayers. With respect to the first argument made in the draft report, we do not believe that the preliminary results of other projections being done but not yet even published should be a basis for discounting the work done for this report. Even when finalized and published, this other, fuller range of projections will not be a lasting, definitive standard, as models and modeling will continue to improve. Most importantly, though, the stated argument really applies only to the use of one way of presenting the 2070 results – a combined average of the five projections done for this report. The argument is that this combined average might be skewed toward the drier end of possible projections because four projections are on the dry half of a scale and only one is on the wet half. An easy way to address this is present the 2070 projections by showing the low projection, the high projection, and a simple average of those two projections. Of the five individual 2070 projections, the lowest or driest falls at the 29th percentile of all 112 projections for river flows near Glenwood Springs, and the highest or wettest falls at the 82nd percentile. Those two projections therefore present two representative points out of a full range of possible conditions. Further, the mid-point between those two projections would fall at the 55.5th percentile of the larger range of projections for river flows near Glenwood Springs – perhaps skewed slightly toward wet conditions, but not alarmingly so.	

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	Presenting the 2070 results in these ways (with or without also presenting a combined average of the five 2070 projections) seems to avoid entirely the identified concerns about the 2070 projections, without discounting them unnecessarily. With respect to the second argument, we believe that the information in the appendices of the draft report demonstrates that the 2040 projections are actually not representative of 2070 conditions. The argument that 2040 projections sufficiently represent 2070 conditions is supported by information on river flows near Glenwood Springs – but the river flows at that point are not the most important. For the purposes of determining future water availability, flows at Lee Ferry would be most important, but detailed projections for that point are not presented in the draft report. In the absence of information on Lee Ferry flows, the projected flows of the main stem of the Colorado at near the state line are the most important of those for which information is presented. Tables E-1 and E-6 in the appendices show that a simple average of the low and high projections for river flows there in 2070 is 653,600 acre-feet lower than a simple average of the low and high projections for 2040. (Projections of river flows there for 2040 range from a low of 3,052,100 to a high of 4,986,500 acre-feet. For 2070, they range from a low of 2,823,100 to a high of 3,908,300.) This difference of 653,600 acre-feet between 2040 and 2070 in projected flows as the main stem of the Colorado River leaves our state is very significant. This is not the only factor that would need to be considered to produce an overall estimate of how much water is available to the state in 2070. Also needed to be considered would be changes in the flows of other tributaries and other climate-related changes, such as increased reservoir evaporation from higher temperatures in 2070. But this 653,600 acre-feet of difference clearly means that the projections of 2040 hydrology do not represent likely 2070 conditions. A fuller consideration in the final report of these 2070 projections and their ramifications certainly seems warranted.	
RMCO.0721.002	**Integration of Phase I and Phase II** As was stated in the letter we co-signed with others on our Water Adaptation Steering Committee, we recognize that the CWCB faces choices on how much time and effort should be spent resolving issues in the Phase I report before it is finalized, compared to dealing with those issues in the Phase II report. As said in that other letter, once all comments are submitted to the CWCB on the draft Phase I report, we urge the CWCB to continue to reach out to affected and interested parties around the state to help it decide what to resolve in the Phase I final report and what to leave to Phase II. Again, we complement the CWCB and its contractors for the good work done in Phase I of this study, and for the opportunity to submit these comments.	See response to comment YWBRT.0721.001.
RMCO.0721.003	Thank you for the opportunity to submit comments on the draft of the CWCB's	The next draft of the CRWAS Phase I Report will include additional descriptions

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	Colorado River Water Availability Study (CRWAS) Phase I Report. These comments represent the common views of the signers, who are among the members of the Steering Committee of the Water Adaptation Initiative of the Rocky Mountain Climate Organization (RMCO). In addition to considering the draft report in Steering Committee meetings, many of the signers of this letter also are members of the CWCB's Climate Change Technical Advisory Committee and have had the opportunity to review and discuss the draft report in meetings of that committee. The signatures on this letter should not be taken to mean that this letter represents the overall views on the draft report of any of the organizations represented on RMCO's Water Adaptation Steering Committee. Instead, these comments represent the shared views of the individual signers on the particular points expressed here. Some organizations represented by the signers of this letter may submit separate, more comprehensive comments on the draft report. The purpose of the RMCO Water Adaptation Initiative is to seek adoption and implementation of the water-related elements of Governor Ritter's Colorado Climate Action Agenda and of the recommendations of the blue-ribbon Climate Action Panel convened by RMCO in 2006 to address Colorado's contributions and vulnerabilities to climate change. Of the RMCO panel's 70 recommendations, 15 address actions to meet Colorado's water needs in a changed climate. One of those recommendations, adopted unanimously, is: *To ensure that the new Colorado River water supply study is complete, relevant, widely accepted, and useful for future decision making, the state government should ensure that the potential effects of climate change are considered in the study.* We applaud the CWCB and its contractors for devoting a significant portion of Phase I of CRWAS to considering the potential effects of climate change on the Colorado River. The information that has been gathered and presented in the report is good, useful information that goes beyond previous efforts and will be of significant value in helping people understand how much Colorado River water may be available to our state in the future and what decisions should be made with respect to future water supply and use. The following specific comments about the draft report are intended to suggest changes that may make the final Phase I Report – and the Phase II Report to follow – more "complete, relevant, widely accepted, and useful for decision making," to use the language from the recommendation of RMCO's Climate Action 2 Panel. Our comments should be taken as our thoughts on how to improve a good effort, not a criticism of the overall effort. **Presentation of Information** Most of our comments deal with how information gathered in the phase I report is presented to make the report more useful. To begin with, we suggest that the executive summary should include, at its beginning, a clear explanation of what	and clarifications of Study goals, limitations, approaches, assumptions, results, conclusions, recommendations, and lessons learned.

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	the Phase I Report covers, what it does not cover, and how it fits in the context of other studies and related work on Colorado River water availability. A better summary is also needed of the key information contained in the report. In later comments, we also make some specific suggestions on improving the presentation of some detailed information in the report.	
RMCO.0721.004	**Colorado River Compact** The data, assumptions, and methodology used to produce the projection shown for 2040 in Figure 3-37 on page 3-45 are not described or disclosed in sufficient detail to make it possible to understand or review this projection of the amount of water that may be available within the state under the Colorado River Compact. Since future water availability in Colorado under the Compact will be studied in considerably more detail in the CWCB's upcoming Colorado River Compact Compliance Strategies Study and the Bureau of Reclamation's on-going Colorado River Basin Water Supply and Demand Study, we recommend that the CWCB remove the section of the CRWAS report that deals with Colorado River Compact issues and revisit this aspect of the study as additional information becomes available in Phase II.	See response to comment CBRT.0721.001.
RMCO.0721.005	**2070 Projections** As you are of course aware, the Phase I effort included gathering of information from some projections of climate and hydrological conditions for both 2040 and 2070, but only the 2040 projections were used as a basis for the text and figures of the body of the draft report. The 2070 projections were included in the appendices only, not in the body of the draft report, on the grounds that 4 of the 5 individual projections done for 2070 projected drier conditions at Glenwood Springs than the average of 112 individual projections for those conditions in 2070 that have separately been done for the U.S. Bureau of Reclamation for an ongoing larger study of the Colorado River. Individual members of our Steering Committee have expressed a variety of concerns about how the draft report treats the 2070 projections. The major points on which we are in agreement are: • There should be fuller treatment of the 2070 projections done for the Phase I report, which were selected based on broad review and consideration, along with a fuller explanation of the concerns expressed in the draft report about the 2070 projections and their limitations. • Projected river flows at Lee Ferry are more important than at Glenwood Springs for determining the availability of water from the river; therefore, comparing the results of different projections at Lee Ferry would be more significant than comparing them at Glenwood Springs. Even focusing on the flows of the Colorado River at the state line would be more meaningful than focusing on flows at Glenwood Springs. • We are aware that other studies consistently show an increasing climate	Bullet 1: See response to comment CBRT.0721.008. Bullet 2: The selected projections were also evaluated at Lees Ferry, where there was a more significant dry bias in the selected 2070 projections. Bullet 3 and 4: The next draft of the CRWAS Phase I Report will clarify uncertainty, variability, and probability implications in CRWAS estimates of future conditions.

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	change effect on Colorado River flows later in the century, and we suggest that that point be included in the final report and, to the extent possible, an explanation of any differences shown in the analysis done for this report. • Today's state-of-the-art modeling is not perfected and will continue to improve. Also, the 112 model runs done for the Bureau of Reclamation are preliminary and neither peer-reviewed nor even published. All modeling, whether the 112 preliminary projections done for the Bureau or the projections done for this report, has uncertainties. Clear statements about ranges of projections and the degree of uncertainty associated with them are at least as important as the quantitative results from the projections themselves.	
RMCO.0721.006	**Likelihood of Projected Outcomes** A specific instance of how the degree of uncertainty could be better described occurs in the table on Page V of the Executive Summary, which states, "Each of the selected climate projections is equally probable and differs from the other 99." This is misleading - the report includes neither a probability analysis of future climate scenarios nor an accuracy analysis of climate models. Instead, the report should state that the climate projections were selected to represent some of the range of outcomes resulting from many more projections, with no attempt to identify whether any possible outcomes are more likely than others. Similarly, at Page 2-22, the report states, "IPCC did not assign a likelihood to the SRES scenarios—all are considered equally probable 'alternative images of how the future might unfold' (Nakicenovic et al., 2000, Technical Summary)." A more accurate way to describe the likelihood is as the referenced Technical Study actually states, "IPCC did not assign a likelihood to the SRES scenarios—each is considered 'one alternative image of how the future might unfold.'"	The specific language cited in this comment refers to the 100 simulations of year sequences based on information from tree ring records. It does not refer to climate scenarios. The next draft of the CRWAS Phase I Report will include text to clarify the objectives in selecting the climate projections. See response to comment FRWC.0615.015. The next draft of the CRWAS Phase I Report will be refined to better reflect the language in Nakicenovic et al., (2000).
RMCO.0721.007	**Presentation of Climate Data** As many people will look to the Phase I Report almost as much for what it says about possible climate changes in Colorado as for what it says about future water availability in the state, it is important that care be taken to accurately represent the results of the climate projections made in the Phase I effort. Too often in the draft report, an average of different projections is presented as single projection, when it is more important and accurate to present both the range of the different projections as well as an average. For example, in Table 2 of the Executive Summary of the draft report, there is a statement that temperature by 2040 "increases basin-wide by 3.3 to 3.7 degrees." Instead, an accurate statement would be that projections for future temperature increases at individual sites within the basin by 2040 range from 1.6 to 5.0ºF (with a combined average increase of 3.3ºF) at the low end (at Grand Lake) to 2.0 to 5.4 ºF (with a combined average of 3.7 ºF) at the high end (at Fruita). Similar care in accurately stating both projected ranges and averages of climate values should be exercised throughout the report.	The next draft of the CRWAS Phase I Report will clarify representations of results and implications in CRWAS estimates of future conditions.

Comment ID	Comment	Response
RMCO.0721.008	**Band Charts** We believe the blue shading used in the band charts of hydrographs is inherently misleading, by implying that the shaded areas convey combined results of different projections. It would be more accurate to present the individual lines from different projections without the shading, making it easier for readers to follow how individual projections move up and down over the year.	See response to comment FRWC.0615.007.
RMCO.0721.009	**Integration of Phase I and Phase II** We recognize that the CWCB faces choices on how much time and effort should be spent making changes in the Phase I report before it is finalized, compared to dealing with issues in the Phase II report. Once all comments are submitted to the CWCB on the draft Phase I report, we urge the CWCB to continue to reach out to affected and interested parties around the state to help it decide what to do in the Phase I final report and what to leave to Phase II. Again, we complement the CWCB and its contractors for the good work done in Phase I of this study, and for the opportunity to submit these comments.	See response to comment YWBRT.0721.001.
SJRUCR.0723.001	In Section 4 "Conclusions and Recommendations," Page 4.2, the following statement is made as a bullet point: *"Remove New Mexico structures from the San Juan/Dolores StateMod model. The current StateMod model for the San Juan and Dolores basins includes structures that divert and consume water in New Mexico. These structures, along with Navajo Reservoir, were included in the model to assist the State in identifying options to meet recommended fish flows for the San Juan Recovery Program. New Mexico structures are modeled as junior to Colorado demands, therefore, they cannot "place a call" on the river. <u>However, the current modeling effort allocates water to these demands, thereby decreasing the reported water available for future uses upstream.</u>" (emphasis added)* The statement raises concerns regarding how the endangered fish species flow recommendations are addressed in the Water Availability Study. As part of the Upper Colorado River Endangered Fish Recovery Program and the San Juan River Basin Recovery Implementation Program, U.S. Fish & Wildlife Service is charged with developing flow recommendations to benefit endangered species habitat. To date, flow recommendations have been developed for the following rivers: • San Juan River, • Gunnison River and Colorado River below the Confluence with the Gunnison, • 15-Mile Reach of the Colorado River between Palisade and the Confluence with the Gunnison River, • lower White River, • lower Yampa River, and	See responses to comments CBRT.0721.004, PCo.0721.003, and PCo.0721.004.

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	• Green River in Colorado and Utah. These recommendations were developed over the last 15 years based on available information. Most of the flow recommendations include low flows and peak flows. Peak flows generally vary based on the occurrence of wet, dry, or average hydrologic years, and include a recommended frequency. The flow recommendations are only one component of a broad range of actions to recover the endangered fish species, including non-native fish control, habitat development, stocking, monitoring and research, and, in the case of the San Juan Recovery Program, water quality improvements. The programs – and the Service – recognize that these flow recommendations are, in fact, recommendations at this time. The recommendations do not have legal status. In light of other actions to recover the species, failure to meet the flow recommendations does not mean the fish cannot be recovered. Both programs are evaluating the flow recommendations and their effectiveness in achieving specific habitat goals. This includes ongoing flow, sediment, and habitat monitoring, as well as monitoring of fish populations. The recommendations are subject to adjustment in the future based on scientific research. The recovery programs for both the San Juan and Upper Colorado have the objective of recovering endangered fish while water for human uses is available in accordance with state water law and interstate compacts. As a condition of delisting the species, flows for endangered fish will be legally protected under state law. The operative assumption is that those protected flows will be consistent with both the Upper Basin states' entitlement and delivery requirements under interstate compacts. The flow recommendations should not be considered as demands on Colorado River water supplies that limit or restrict development of water in Colorado, New Mexico, Utah, or Wyoming. To the extent that endangered fish flow recommendations imply limiting development of the Colorado's compact entitlement in the Colorado River Water Availability Study draft, the report should be modified to eliminate such implications. My commendations for an excellent and informative report regarding future use of Colorado River water. If you have any questions regarding the flow recommendations for the endangered species in the Upper Colorado River basin or San Juan River basin, please feel free to contact me at your convenience.	
TU.0720.001	With this letter, we at the Western Water Project of Trout Unlimited would like to provide comments on the Colorado River Water Availability Study (CRWAS) Phase I Final Report (Draft). The Colorado River Water Availability Study (CRWAS) can play an important role in Colorado's water resources management and planning processes. By developing and providing essential information on Colorado's water needs and	This work was originally intended to occur in a subsequent phase of the Study. See response to comment YWBRT.0721.001.

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	supplies, CRWAS can serve as a fundamental element in the decision process for the management of Colorado's water for both consumptive and non-consumptive uses. Although the objective of CRWAS is appropriate and the general approach of the study appears to be reasonably formulated, there are several aspects of Phase I which limit the usefulness of its findings. Most of these concerns can be addressed through the work to be done in the planned Phase II of CRWAS, and it is consequently important to move ahead with Phase II so that the overall objectives of CRWAS may be attained. We suggest that the following issues be addressed in upcoming CRWAS activities: **1. Conditional Water Rights, Full Utilization and Potential Expansion of Trans-basin Diversions** The characterization of Trans-basin exports from the Colorado River Basin to the Front Range does not completely consider issues associated with full utilization of both absolute and conditional water rights held by Front Range water users, and of potential new projects for water exports from the Colorado River Basin. Given the likelihood of changes in Trans-basin exports (some of which are named in the Identified Projects and Processes efforts of the IBCC), and their probable impacts on CRWAS findings and conclusions, further refinement is essential.	
TU.0720.002	**2. Climate Change Impacts on Front Range Water Demands** Front Range climate changes may have significant impacts on Front Range water supplies and demands, with related consequences for Colorado River Basin exports. Such climate change impacts should be considered in a manner consistent with that used to evaluate climate change consequences for water management in the Colorado River Basin. The CRWAS evaluation should take into account the possibility of related increases in Front Range municipal and agricultural/irrigation demands and diminished native Front Range water supplies, and identify probable corresponding changes to demands for water exports from the Colorado River Basin.	This activity would be considered under a subsequent phase of the Study. See response to comment YWBRT.0721.001.
TU.0720.003	**3. Use of the Hydrologic Determination (HD) Procedure** The Hydrologic Determination (HD) model used in the CRWAS analysis depends on assumptions which imply sufficient storage (in appropriate locations) and infrastructure to utilize all water available to Colorado under the compact – a scenario which differs greatly from present conditions. While it may be appropriate to move ahead with the CRWAS analysis on this basis, the assumptions can lead to misleading conclusions regarding the amount of water available under existing and realistic future water infrastructure development scenarios. The limitations and constraints of the HD analysis in this respect	See response to comment CBRT.0721.001.

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	should be clearly identified, and their significance to CRWAS findings should be described.	
TU.0720.004	**4. Consideration of In-Stream Flows** CRWAS Phase I does not give adequate consideration to Colorado's in-stream flow needs for environmental and recreational purposes. In addition to existing flow programs designed to address threatened and endangered fish species, there are many presently decreed water rights for in-stream flows. The probable establishment of future in-stream flow rights and requirements in a wide range of geographic locations, both in the Colorado River Basin, and in Front Range locations which could impact Colorado River exports, should be explicitly addressed in CRWAS.	See response to comment CBRT.0721.004.
TU.0720.005	**5. Presentation of CRWAS Phase I Findings of Colorado River Water Availability** A useful and informative presentation of some CRWAS Phase I findings (and of other studies) is provided in Figure 3-37. On this figure, water available for future consumptive use in Colorado with the "Alternate Climate Projections - 2040" hydrology is shown as ranging from 0 to 1.0 MAF. It would be useful to clarify whether the "dry end" of this range indicates that supplies are already in deficit, or insufficient, under present levels of water development. Such a determination would be of obvious interest to those concerned with Colorado River water management, and the potential significance of such a finding should be discussed to ensure that it is properly understood by the CRWAS audience. We believe that CRWAS can be of great value in Colorado's efforts to move ahead with its water management and planning, and that Phase I is a major step in the right direction, with significant accomplishments. A significant additional degree of effort is, however, necessary to achieve the desired objectives of CRWAS, and to deal with the issues identified in our comments. We therefore encourage the State to move ahead with Phase II of the Colorado River Water Availability Study in order to realize the full benefit of this useful and worthwhile project.	See response to comment CBRT.0721.001.
USFS.0730.001	Thank you for the opportunity to provide comments on the Colorado River Water Availability Study (CRWAS). The Phase I Report is an ambitious undertaking and we appreciate this effort to address the complexity of the issues that are being considered as the water community in Colorado grapples with the likely future scenarios for water in the state. We have comments on two issues for your consideration as you revise Phase I of this study, and prepare for Phase II. **1. Non Consumptive Uses**	See response to comment CBRT.0721.004.

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	As noted on page 1 of the executive summary: "….Phase I (the subject of this report) presenting a water availability assessment based only on existing levels of water use. For Phase I, water uses (also referred to as water demands) were limited to current levels of water demands served by water rights that are currently being used ("perfected" or "absolute" water rights). Phase I is also restricted to interpretations of current operating and management practices for water diversion, storage and conveyance facilities. Assessments of water availability to meet future water needs are reserved for Phase II of the CRWAS." We have a concern that a broad range of environmental, recreational, and other non-consumptive uses on public lands are currently met through natural or regulated flows that are not protected by water rights. The analysis in Phase I might therefore underestimate the water needed for these uses, and overestimate the water available for future consumptive needs. It would be appropriate to acknowledge this in the Phase I Report, as well as provide some discussion of how this issue might be addressed in Phase II of the CRWAS	
USFS.0730.002	**2. Hydrologic Effects of Forest Change.** Given the ongoing interest in the hydrologic effects of forest change, we appreciate that this issue is specifically addressed in this report. We generally support your analysis and findings as summarized in the report and Technical Memo (Forest Change Literature Review and Suggested Methods - CRWAS Task 7.3/7.4). In particular we support your conclusion on page 2-44 that "… an analysis of deforestation is expected to have limited value for the CRWAS planning horizons, the recommended approach is not to conduct a detailed hydrologic analysis and modeling associated with forest change as part of CRWAS." We strongly support the recommendation that future approaches to this issue be informed by current empirical studies of disturbed forests that are underway in Colorado. Executive Summary Page III: "The U.S. Forest Service, in conjunction with the Colorado Water Conservation Board (CWCB) and the North Platte River Basin Roundtable, is completing a multi-year study to collect information regarding forest change processes that most influence the hydrology of disturbed forests within Colorado. Information from the study is expected to better describe corresponding hydrologic processes and to constrain assumptions to be used in future hydrological models. It is therefore appropriate to re-assess the potential for quantifying the impact of forest change on water availability when results of that ongoing work become available and the science of forest change assessment advances.") We note that you have included literature authored by agency researchers and interviews with Forest Service staff in the appendix to your CRWAS task 7.3/7.4 report. We hope that you will continue to rely on expertise in both the management and research branches of the agency as your work on this subject progresses. Please do not hesitate to contact Randy Karstaedt, Director of	No response required.

Comment ID	Comment	Response
	Physical Resources at 303-275-5374, if the agency can be of further assistance to this study.	
WRW.0514.001	*WRW Comments below represent comments made within the Draft CRWAS Phase I Report* *CRWAS Report Page III*—"See comment on page 2-29."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.002	*Page 1-1*—"This may not be 100% true, depending on the model setup for the simulations of this study. From my review of the Upper Colorado River Basin Baseline scenario there are a significant number of "free river" rights that remain on. These were included in the modeling effort because at times these structures historically diverted more than there water rights would allow. Having these "free river" rights on allowed for better historic calibration. However, if these rights are on for this study's simulations the study will be taking into account conditional rights that allow these structures to divert up to their capacity and not strictly being restricted to their absolute water rights. Were these "free river" rights turned for this study's simulations?"	Free-river water rights are assigned to diversions that historically diverted more than their water rights during times of free river in the CDSS models. These rights are required to represent historical conditions for calibration of the CDSS models, but they are not protected from future development. Currently, they are included in the CRWAS analysis. Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.003	*Page 1-4*—"See comment on page 2-29."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.004	*Page 2-24*—"Need to finish the thought."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.005	*Page 2-29*—"This is a clearer description of why the 1950-2005 study period was chosen. When reading the intro it seemed a little ambiguous as to the choice of the study period. Please add this statement to item 1 on page III of the Executive Summary and page 1-4 of the Introduction."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.006	*Page 2-33*—"This statement is confusing. A possible rewording: Second, two hydrologic model (VIC), further described below, simulations are completed first with observed weather and second with climate-adjusted weather. The difference between the resulting modeled flows represent the change in streamflow attributable to the projected change in climate conditions."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.007	*Page 2-36*—"Flip the sentence: StateMod then automates... headwater nodes based on user…"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.008	*Page 2-36*—"I know that this is straight out of the StateMod documentation but where is it being "stored"? Might be more clear to the non-StateMod user to say: Return flows for future time periods are determined and are returned to the stream system during the appropriate future time step(s)."	The next draft of the CRWAS Phase I report will include corresponding clarification.

Comment ID	Comment	Response
WRW.0514.009	*Page 2-36*—"Remove. If water is "stored" in this time step then the entire CIR has been met, therefore water stored in this time step cannot be used to meet CIR in this time step."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.010	*Page 2-37*—"Add "(Baseflows)" as this is how they are referred to in StateMod"	The next draft of the CRWAS Phase I report will clarify that natural flows are referred to as "baseflows" in the StateMod documentation.
WRW.0514.011	*Page 2-37*—"Where precipitation isohyetals redrawn and area-precip ratios recalculated for the ungaged baseflow locations? Or were the baseline ratios used to distribute baseflows to ungaged locations? I'm just curious. Thinking about this it may not make sense to adjust the ratios due to the low resolution from the GCMs, whereas the distributed baseflows are for areas on the order of 10s of square miles."	No, area-precipitation ratios were not refined. They reflect historically calibrated distributions; therefore we do not intend corresponding revisions for climate projections.
WRW.0514.012	*Page 2-40*—"Net upstream depletions lagged return flows and reservoir releases could come into play to affect the modeled stream flow."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.013	*Page 2-40*—"This would work better in the previous sentence as it is an in-basin use and not a transbasin use."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.014	*Page 2-40*—"Excluded in the reporting of Colorado's consumptive use values I think this is what is trying to be conveyed here. Evaporation and later New Mexico's CU are occurring however they do not count against the State of Colorado's entitlement under the Colorado River Compact."	The San Juan/Dolores model is being refined to exclude down-state demands. The next draft of the CRWAS Phase I report will not include the reference to New Mexico uses.
WRW.0514.015	*Page 3-6*—"Should this be Deg F? This also needs to be corrected in the Appendix A Figures."	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.016	*Page 3-7*—"Is this a difference calculation? Or a ratio comparison? Recommend removing "difference" if this is a ratio comparison (simulated/historical)."	This is a ratio comparison. The next draft of the CRWAS Phase I report will include a refined footnote description.
WRW.0514.017	*Page 3-9*—"Footnote from Table 3-2 should be added and modified as noted above."	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.018	*Page 3-10*—"Is there a rendering issue with the above figure on the master file, or is this just in my version that I downloaded? If this also appears in the master I recommend repairing the image used."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.019	*Page 3-12*—"Flip this sentence (The scientific info... until more detailed...), it puts more emphasis on the fact that this study used the best available information and models and that the results are sound until better models are created in the future. The way the sentence is currently written it seems to put the results in	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.

Comment ID	Comment	Response
	question."	
WRW.0514.020	*Page 3-13*—"Would it make sense to present this ratio similar to the precipitation changes? Percent of Historical CIR 121%, 125% etc. Fruita example: With a 3.7 deg F increase from historical average temperature and 91% of historical average irrigation season precipitation the CIR will be 121% of historical average for pasture grass. By presenting it this way I think that it would have more impact to water planners that senior irrigation water rights will be calling more often reducing the flows downstream and calling out the more junior rights upstream. I don't know what the intended message is for this report, so adjust as needed."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.021	*Page 3-16*—"The image rendering is similar to Figure 3-4."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.022	*Page 3-17*—"A few things that came to mind in reading this are: -Historically were there a significant amount of times when the fall frost dates limited the growing season for annual crops? -If yes, then: -Due to increases in temperature for the 2040 scenarios the crop start date should have shifted earlier in the year and the crop end date should have shifted later in the year relative to the historic averages. This potentially could extend the growing season if the fall frost dates were limiting the growing season. How were the fall frost dates adjusted?"	No. Historically the killing frost never limited the growing season for annual crops. The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.023	*Page 3-17*—"Similar to comment above, does it make sense to represent these as % of historical (i.e. Yampa 115%)?"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.024	*Page 3-20*—"Need to revise this figure to match the revised Appendix D figure."	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.025	*Page 3-21*—"Net upstream depletions see note on page 2-40 (p69 of pdf)."	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.026	*Page 3-26*—"I recommend adding a sentence here (see next comment for reasoning): Some of these limitations can be changed/corrected in the future and are not being considered in the StateMod model (i.e. demands could change due to change in crop grown or the number of acres irrigated; diversion capacity limitations could be resolved by enlarging a ditch or resolving current physical limitations)."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.027	*Page 3-26*—"I found this statement slightly confusing because it brings in "existing absolute" rights. The previous sentence makes exceptions for conditional rights and potential compact obligations, which are not being modeled within StateMod. Two sentences previous it is discussing potential limitations to the absolute rights but does not discuss that some of these limitations may be resolved in the future to allow for additional diversions and that these possible resolutions are not being modeled. Absolute rights may not be	The next draft of the CRWAS Phase I report will include corresponding clarification.

Comment ID	Comment	Response
	diverting their full right due to physical constraints on the structure, lack of available flow, and/or demands that are less than the water right. There is also a chance that absolute water rights may not be included within the model due to the lack of historic/future demand associated with the water right's structure and the exclusion of that structure from the StateMod model."	
WRW.0514.028	*Page 3-28*—"Reduced compared to what? Is the "what" shown in the graphs above or presented in some way?"	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.029	*Page 3-28*—"The emphasis of the paragraph is not clear. If it is to show that the modeled flows at a gage are not the available flow at the gage, state that and then state the reasons why this is true. Also, it would be helpful to have a visual of this by adding the modeled stream flows to the figures 3-18 and 3-19. Or reference figure 3-20 in this paragraph."	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.030	*Page 3-29*—"What month through December?"	The next draft of the CRWAS Phase I report will include corresponding clarification.
WRW.0514.031	*Page 3-32*—"Are these labels reversed? To me it doesn't seem logical to have less available water below the 15 mile reach than above the reach when there are no other demands within the reach. The fish flows demand water reducing the available flow above the 15 mile reach but since the fish flows are non-consumptive these flows should then be available below the reach."	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.032	*Page 3-32*—"Is this detailed description necessary at this point in the document (continues to next page)? These types of figures were described above in detail."	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.033	*Page 3-41*—"Something to think about for Phase II (basin wide): Is the data about growing season and water availability (especially late season) currently being presented in a way that water users could analyze and estimate how they might alter their crop irrigation practices (i.e. change crop types, increase efficiencies through the use of drip or sprinkler systems, reduce acreage, or possibly stop irrigating all together)? Are the shortages occurring only on alfalfa and pasture grass or are some of the annual crops and orchards also being shorted? How does this affect the irrigators' decisions? It would be good to get some insight from the irrigators and look at these alternate cropping/irrigation practices."	See response to comment YWBRT.0721.001.
WRW.0514.034	*Page 3-42*—"Phase II Consideration: Interview the ditch companies to see if their ditches could be expanded, if they have conditional right that they would exercise, or if they would file for junior water rights."	See response to comment YWBRT.0721.001.
WRW.0514.035	*Page 3-42*—"How are the East Slope entities going to compensate for this? • More West Slope storage projects (i.e. Wolcott Reservoir, additional storage	This evaluation would be considered in a subsequent phase of the Study. See response to comment YWBRT.0721.001.

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	in the Yampa, White, or Gunnison, etc.) • More East Slope projects • Conservation • Reuse What are the side effects on the East Slope from less water being brought into the basins?"	
WRW.0514.036	*Page 3-43*—"The Aspinall Unit also contains Crystal Reservoir, was there a reason to not exclude its evaporation?"	The CDSS model does include evaporation from all reservoirs (including Crystal); however, its evaporation is not accounted as a Colorado depletion (CRSP reservoir evaporation is a "shared" Upper Basin depletion); and therefore, its evaporation was excluded along with Blue Mesa.
WRW.0514.037	*Page 3-44*—"This statement or a similar statement would be good to include in the first bullet point. This is the only basin that shows a decrease in consumptive uses and it would be good to explain why when the decrees is first introduced."	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.038	*Page 3-45*—"Are these assumptions static for all model runs (same value in AF presumed to be Colorado's CU allotment under the compacts)? Or did they vary based on the CRSS modeled Upper Basin flows adjusted for each climate scenario? -If the assumption are static it may be worth looking into Phase II or the Compact Compliance project how the climate change scenarios affect the Upper Basin's ability to deliver its compact flow obligations to the Lower Basin and how that adjusts the CU allotment to Colorado."	See responses to comments CBRT.0721.001 and YWBRT.0721.001.
WRW.0514.039	*Page 4-2*—"The Homestake Project Baseline demand is a bit ridiculous and should be revised in Phase II. Historically the project has diverted 26,291 af/yr (primarily in March through May) from Homestake Reservoir into the Arkansas basin. In the Baseline dataset the demand is set to 300 cfs year around (legal maximum for the project) which ends up being 217,198 af/yr or about 10 times the historic amount. It would be worthwhile to get a more realistic demand schedule from Aurora and C. Springs. Homestake Reservoir is being modeled as nearly empty most of the time. You can blame me on this one. We didn't revise the demands in 2007."	The next draft of the CRWAS Phase I report will include refined values.
WRW.0514.040	*Page 4-2*—"This isn't 100% true. If the right is shorted, it will place a call on the river. Some water rights folks may take exception to this."	New Mexico structures cannot place a call in Colorado. The next draft of the CRWAS Phase I Report will include refinements based on a scoped task to consider removing New Mexico structures completely from the model. This type of refinement is a key aspect/benefit of CRWAS.
WRW.0514.041	*Page 4-2*—"This can be resolved by turning off the instream flow right at 952002. The demand will remain and will be met by river flow and reservoir releases to the demand and will not tie-up the available flow upstream. However, this instream flow right is set senior to the conditional "free river" rights (see	The proposed approach does not resolve the issues. See response to comment CBRT.0721.015.

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	comment on page 1-1 p.22 of PDF). By turning this right off the "free river" rights divert more and also causes the release from the reservoirs for the fish flow to change. The modeled results will be different due to these changes."	
WRW.0514.042	*Page 4-3*—"Add a similar conclusion but direct it toward State agencies and the legislature: The results from this study do not predict the future but rather offer potential futures. The results from this study should not be used to draft legislation, rules and regulations, or policies that govern the management of water resources within the State of Colorado. Rather, this study and subsequent studies should be used to help understand how the river may operate under these alternate hydrologies. This knowledge will allow water managers and policy makers' options on how to manage water supplies if similar hydrologies do occur in the future."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.043	*Page A-5 through A-18*—"Units on Figures A-3 through A-30, highlight 'inches'"	The next draft of the CRWAS Phase I report will include corresponding revision.
WRW.0514.044	*Page B-5 Fig B-3*—"Poor image quality"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.045	*Page C-5 Fig C-2*—"Poor image quality"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.046	*Page E-11*—"This table is different than the others, bolder lines, rotated 'AF' label."	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.047	*Page E-32*—"This is also different, bolder lines, rotated 'AF' label"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.048	*Page E-54*—"Bolder lines, rotated 'AF/Year' label"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.049	*Page E-75*—"Bolder line and rotated y-axis label"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.050	*Page F-11*—"Bolder lines, rotated label"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.051	*Page F-54*—"Rotated label and bolder lines"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WRW.0514.052	*Page F-75 Fig F-130*—"Bolder lines and rotated label"	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.

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WRW.0514.053	"Overall I thought the report was informative and I believe the project's process is sound based on the available models and data. I have not dug into the models or output data too much but the way it has been presented there should be ample data that water users can delve into to determine how their water projects may be affected under these alternate climate/hydrology simulations."	No response required.
WRA.0715.001	Western Resource Advocates (WRA) would like to offer the following comments on the Colorado Water Conservation Board's (CWCB), "*Colorado River Water Availability Study – Phase I Report – Draft*." The Colorado Water Availability Study (CRWAS) marks an important milestone in the history of water supply planning in Colorado – one for which the CWCB should be commended. The report is a major step forward in assessing climate change impacts on water supply, and makes Colorado a leading thinker on this topic. Furthermore, this is but one of several studies funded by CWCB that aims to quantify this state's future water needs, determine the availability of future supplies, and craft solutions that meet future demands for both consumptive and non-consumptive uses. Together, all of these reports help create a robust decision-making environment for today's and tomorrow's water managers. In general, the draft CRWAS report suggests that climate change will have a far-reaching impact on western slope river flows, and casts serious doubt on past assumptions of the additional availability of Colorado River water to meet Front Range demands. CRWAS describes how increased temperatures and decreased summer precipitation will lead to earlier runoff from watersheds and cause significant reductions in natural river flows. Combined with increased crop irrigation requirements, the take home message is that less water will be available to meet future demands across the state. **CWCB Must Complete Phase II** Notably, CRWAS Phase I does not take into account currently planned projects that would further affect Colorado River flows, such as Denver Water's Moffat Expansion or Northern's Windy Gap Firming Project; nor does it address the impact conditional water rights would have on water availability if they are put to use, like those owned by oil shale companies. These topics are to be addressed in Phase II of the report, along with additional beneficial uses and "non-water right" future consumptive and non-consumptive uses. WRA encourages Phase II to include a robust evaluation of the non-consumptive needs necessary to support healthy fisheries and riparian ecosystems, and consider them as a legitimate demand when assessing future water supplies available for development. One example are the recommended flows established by several federal biological opinions for ESA-listed fish species in the Colorado River basin. Flow analysis should consider both minimum and optimal base flows, as well as flushing flows and the occasional high flows necessary for riparian health. This evaluation should clarify that high flows are not "wasted"	See response to comment YWBRT.0721.001.

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	but rather serve essential ecological functions in our state's rivers. WRA also encourages Phase II to include indirect consequences of climate change, such as increased municipal water demands for landscape irrigation, or increased cooling water demands for electricity production in the face of larger air-conditioning needs. It is imperative for CRWAS Phase II to move forward and capture these additional demands in order for decision-makers to have the most accurate understanding of future Colorado River uses. Clearly, the State needs to act cautiously toward any plans for additional diversions of water out of the Colorado River basin, because additional large-scale development of Colorado River water complicates how we will meet our legal obligations to downstream states under the Colorado River Compact and law of the river.	
WRA.0715.002	**Main Text Must Include 2070 Projections** CRWAS relegates drier 2070 projections to the technical appendices because, "[c]omparison of the distribution of 2040 and 2070 projections show that climate-induced effects on streamflow are very similar for the two time frames", and "2070 projections were biased toward dry conditions". There are several reasons that 2070 projections should be included in the main text and discussed with the same rigor as those for 2040.	See response to comment CBRT.0721.008.
WRA.0715.003	CRWAS shows that streamflows at 2040 and 2070 are similar at Glenwood Springs (Figure 1), but that is not the case at other nodes. Glenwood is at the base of a high-altitude watershed that may not be as greatly impacted by climate change as locations downstream. For example, results in the appendix show that flows at the Colorado state line could be as different as 1 million AF between 2040 and 2070. Data presented in CRWAS conflict with the statement that 2040 provides a "reasonable representation" for potential stream flow reductions at 2070. It would be worthwhile for the study to perform evaluations of the differences between 2040 and 2070 at other locations in Colorado, or further downstream (e.g. Lee Ferry), before fully discounting the results. Furthermore, the suggestion that 2040 stream flows are very similar to 2070 streamflows, despite vast differences in average temperatures at these two time periods, casts doubt on the reliability of the modeling methodology. Work performed by other climate researchers using the same emissions scenarios shows declining flows from 2040 to 2070,1 and preliminary results of the Bureau of Reclamation's Colorado River basin modeling also show declining flows. Its seems highly unlikely that 2040 can be representative of 2070 if the "median" model is 2 degrees (F) warmer in 2070 compared to 2040, and the "hot and dry" model is 3.5 degrees warmer (Figure 2).	The CRWAS report is internally consistent. The distribution of flows (the empirical cumulative distribution function) is similar between 2040 and 2070. It is precisely because of additional bias in the selection of 2070 projections that those distributions collectively (e.g. their mean) should not be used to characterize conditions in 2070 or to compare conditions between 2040 and 2070. See responses to comments CBRT.0721.008 and FRWC.0615.166.
WRA.0715.004	Additionally, one CRWAS objective was to include models that covered a range of future projections covering the 10th percentile to the 90th percentile. This	While the objective of representing 80% of the range of projected impacts was not met for 2040, the bias in that result is small compared to the uncertainty in

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	objective has not been met for the 2040 projections. An evaluation of the cumulative distribution of model projections shows that the 2040 projections cover a range from the 18th to the 92nd percentile; in effect, biasing the results towards a more wet selection of potential futures than what was initially planned (see Figure 1). This shortcoming at 2040 could be mitigated, or at least balanced, by including the drier 2070 projections.	future projected impacts as represented by the range of results. See response to comment CBRT.0721.008.
WRA.0715.005	Finally, discounting the 2070 projections leaves water managers without valuable, long-term information. All of CWCB's other reports are using 2050 as a planning horizon to model future demands and supply opportunities. One could easily argue that the potential impacts of climate change are best evaluated on the longest-term basis possible (i.e. 2070), so that currently planned projects and processes can utilize this information. Planning a project that will be complete in 2050, with climate information only available to 2040 seems counter-productive to the purpose of CRWAS. Furthermore, ignoring potential futures that are a distinct possibility will only make future water supply challenges that much greater.	See response to comment CBRT.0721.008.
WRA.0715.006	**Range of Water Availability is Broad and Misleading** The 0 – 1 million acre foot range of future water availability described by CRWAS is unhelpful for planning purposes and leaves the reader with no feel for what scenario is most likely. Phase I assumes that all future climate projections are equally probable, yet three of the five climate projections used in CRWAS indicate that no water will be available for future consumption at 2040. Other scientific research, mentioned earlier, clearly points to what will be the most probable impacts of climate change in the Colorado River basin – hotter and drier. The CRWAS should report the existing state of science and acknowledge these trends when discussion future water availability. **Concluding Remarks** We recognize the great amount of effort put into this report and commend CWCB for moving forward on such an important topic. We further encourage the State to set aside adequate funding to prepare Phase II of the study. Finally, we hope CWCB finds a way to incorporate 2070 findings into the main text of the report. We would be happy to meet with CWCB staff to provide any clarification of these comments or to provide additional information.	See responses to comments CBRT.0721.001 (range and, interpretation of projections), CDOW.0723.002 (probability), YWBRT.0721.001 (Phase II), and CBRT.0721.008 (2070).
WWA.0721.001	The Colorado River Water Availability Study investigates the impacts of climate variability and change on the availability of water in the state. This is the first study to investigate the impacts of anthropogenic climate change on the Colorado River in our state that includes detailed modeling of water rights. It builds on and integrates with decision support tools including StateMod and StateCU that were developed previously. This study represents an important step forward in supporting the development of climate change adaptation strategies in Colorado,	No response required.

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	and we compliment the CWCB and the consultants on their work. In addition, this work helps develop the modeling framework and tools to enable the State of Colorado to make continuing assessments of impacts on the State's water resources as new scientific information about climate change becomes available. This ability will be particularly relevant as the results from the next internationally coordinated climate modeling program, CMIP5, become available starting in 2011. These results need to be considered in the context of the other studies on the future of the Colorado River. Many of these are summarized in the CWCB "Climate Change in Colorado" Report and references therein. When the average over many models is looked at, the same picture appears – a likely decline in the flow of the Colorado River at Lees Ferry, driven largely by increased temperatures. In this study and in the larger literature, individual model traces ("scenarios") can show increased streamflow, however, reflecting uncertainty in future precipitation trends. One of the more striking results of the study is that the southern parts of the basin show larger impacts than the northern part. It should be noted that this is broadly consistent with the continental-scale picture of climate change – wetter conditions are projected to the north of Colorado and drier to the south.	
WWA.0721.002	Finally, we have some concerns about the way that the results are portrayed and have recommendations for improving the report. Our main recommendations are as follows: • The use of terminology should be made consistent throughout the report and the main terms should be defined in the Executive Summary.	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WWA.0721.003	• The assumptions and methods used in the "compact considerations" part of the study be described in much more detail in the report and related to the "in state" modeling with greater clarity.	See response to comment CBRT.0721.001.
WWA.0721.004	• The scenarios for 2070 should be augmented in a cost-efficient manner to make them more useful for Phase 2, and they should be presented in more detail.	See response to comment CBRT.0721.008.
WWA.0721.005	• The impacts of climate change on reliability should be discussed in addition to the average availability, even if only qualitatively for Phase 1.	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report.
WWA.0721.006	More detailed comments are presented below. **Presentation of assumptions and methods** Our main concern is that the results be presented in a transparent manner – so that the assumptions and limitations are communicated clearly to those may use	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report. See response to comment CBRT.0721.001.

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	this study. • **The point that physical availability ("modeled streamflow") does not necessarily mean legal availability, due to both downstream in-state water rights and to potential compact considerations, should be given greater emphasis in the Executive Summary.** While this point is made in the report, it is a central message that needs clearer communication. • **Throughout the study it is often hard to keep track of terminology, particularly in looking at the figures.** In particular, the definitions of "natural flow", "modeled streamflow" and "water available to meet future needs" (page 2040) should be made more prominent and included in the Executive Summary. • **The terminology is not used consistently throughout the document.** How does "Water Available to Meet Future Needs" differ from "Water Available for Future Consumptive Use"? Are "extended historical" and "paleohydrology" the same? A thorough review of the use of these terms in the figures and text is recommended. • **The similarities and differences between the "in state" and "compact considerations" parts of the study are not clearly stated.** The commonalities and differences should be made clear in the Executive Summary. For example, the same set of climate-altered hydrologic simulations was used in both methods (with the latter covering the whole upper basin), but this is not stated in the text. On the other hand, it is not clear whether the treatment of future consumptive use by existing water rights was consistent in the two parts of the study. A table comparing the two methods is recommended.	
WWA.0721.007	**The "Compact Considerations" section** As noted, the study uses two different modeling frameworks – the modeling of climate change impacts within the state using StateMod and StateCU, and the modeling of "compact considerations" using a simple mass balance model. We found it frustrating that this second part of the study, which has wide ranging implications, was given the less attention. • **The figure "Water Available for Future Consumptive Use by Colorado" (Figure 3-37) is confusing, even though it will likely be the most cited graphic from this study.** This figure combines legal and climate uncertainty in a way that doesn't really give a sense of how each is contributing to the bar graph. • **In addition, it is not stated at what level of reliability this water is projected to be "available".** It is our understanding that this graphic was developed from the average availability rather than the range over individual "re-sequenced" traces. That is, it does not include the risk from climate variability. There should at least be an acknowledgment that reliability is likely to decrease as water use approaches that which is "available". • **The description of the method used to produce the results in the**	See response to comment CBRT.0721.001.

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	"Compacts Considerations" section is inadequate. Technical memo 8.6 does describe the method in more detail, and a more complete description should be included in the report text. A description of the differences in modeling approach between the "in state" and the "compact considerations" should be included, particularly with regard to the issue of future consumptive use.	
WWA.0721.008	**2070 Projections** No substantive discussions of the 2070 projections are given. The CRWAS draws on recent simulations and projections by the Bureau of Reclamation using the same VIC hydrology model to portray the limited set of scenarios modeled in CRWAS in a larger context (figures 2-10 through 2-13). The report draws several conclusions from this comparison. The first is that the 2070 scenarios are not representative of the larger distribution, and the second is that the 2070 streamflow changes are similar to the 2040 changes. Based on this analysis the report only shows results for 2040. The first point can be remedied by performing one or two more model runs to better sample the distribution of 2070 hydrologies for use in Phase 2 of the study. We recommend that this be done as we believe the cost to be minimal. On the second point, we have some trouble reconciling this view with the picture of climate change in the Basin that we get from the scientific literature. In general, the long-term changes in a given model move in tandem with increasing global average temperature: 2070 projections are generally an exaggerated version of 2040. (The latest report from the National Academy of Science, "Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia" documents this principle). **There are several reasons that we feel the 2070 results should be discussed in more detail:** • **2070 streamflow may differ from 2040 streamflow for other basins besides the Colorado above Glenwood Springs.** For example, in the San Juan River basin, models indicate more warming and less precipitation in 2070 than in 2040. Therefore this basin would probably see larger hydrologic impacts in 2070 than in 2040. This comparison should be shown. • **Modeled crop demand is likely to be larger in 2070 than 2040** due to the warmer temperatures and even longer growing season than 2040. This factor warrants more discussion. • **Streamflow timing is likely to be different in 2070 compared to 2040** due to the increased temperatures.	See responses to comments CBRT.0721.008, FRWC.0615.166 and WRA.0715.003.
WWA.0721.009	**Interpretation of the climate change scenarios.** Several points related to the interpretation of the climate change scenarios.	See response to comment FRWC.0615.015.

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	• **These scenarios consist of a range of "plausible futures" that are consistent with the modeling assumptions.** It is not appropriate to assign exact probabilities, or equal probabilities, to these scenarios. The text of Table 1 it states "Each of the selected climate projections is equally probable; but differs from the others." This is incorrect. Each of the selected projection has an unknown probability, but it is a plausible future consistent with the modeling assumptions.	
WWA.0721.010	• **The large range in projected streamflow in the CRWAS scenarios and in the Reclamation runs (Figs 2-10 to 2-13) is not entirely due to climate change, but is partly a result of natural variation in precipitation.** This is true for both the wet and dry extremes. We recommend that this caution be noted in the report and that future work be directed to using or developing methods that can better differentiate between trends and natural variability in precipitation. Note that this is not a significant problem for temperature, where the natural variability is small compared to the projected trends.	The largest part of the range of projected streamflows is due to uncertainty in the projections of future precipitation. Some portion of this uncertainty is due to misinterpretation of the phase error in simulated low-frequency variability of precipitation. Development of fundamental new methods is outside the scope of the CRWAS project, but these recommendations are appropriate for federal agencies and research institutions. The next draft of the CRWAS Phase I Report will clarify variability in CRWAS estimates of future conditions.
WWA.0721.011	• **The cumulative distribution functions (CDFs; Figs 2-10 to 2-13) are hard to read and interpret.** While these provide essential context for the scenarios chosen, more explanation is warranted. In particular, what are the mean and median flow changes for the full distribution? What does this graph look like for the San Juan basin, which is likely to be drier?	The cumulative distribution functions provided in the Draft CRWAS Phase I Report were used only to provide context for diagnosis of the selected projections. The next draft of the CRWAS Phase I Report will provide additional explanation about the selection of projections. Selection will be based on an index flow consisting of the sum of flows from basins representing a large majority of the area of the Colorado River Basin within Colorado. It will be noted that flows arising from that portion of the San Juan River between Archuleta, New Mexico and Bluff, Utah were not included in the index flow because simulated projected flows for the San Juan Basin are available only at those two locations, and the basin above Bluff and below Archuleta includes a large area of very arid lands outside the State of Colorado.
WWA.0721.012	• **The study pools all emissions scenarios when considering climate change.** This will have only a modest effect for the 2040 projections, as the range of temperature and precipitation projections for the three emissions scenarios overlap considerably. However this will have a significant effect for the 2070 projections, where temperature changes are much larger for the A2 scenario than for the B1 scenario. The reason for pooling all the scenarios together should be clearly stated as well as the scientific result that the magnitude of future climate change is contingent on future emissions. This basic fact of climate science should be noted in the report.	See response to comment FRWC.0615.063. The magnitude of future climate change is influenced by emissions, but in the Colorado River Basin, evidence indicates that the influence of emissions is much smaller than the range of disagreement among GCMs. This is consistent with Wilby and Harris (2006). The objective of CRWAS was to represent the overall uncertainty of future climate projections without attributing the sources of that uncertainty. *Wilby R. L. and I. Harris. (2006). A framework for assessing uncertainties in climate change impacts: Low-flow scenarios for the River Thames, UK, Water Resources Research, Vol. 42, W02419, 2006.*
WWA.0721.013	• **Recent research on the effect of dust on the timing of runoff shows that it can lead to air temperature being a less important factor in snowmelt.** Recommendations for future modeling should include incorporating recent dust levels in their calculation. (It is unclear what assumptions were made	See response to comment CBRT.0721.012. The hydrology model was calibrated assuming a constant pattern of albedo which does not reflect the historical influence of dust. This is recognized as a weakness

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	about dust/snow albedo for this study or whether the snow model was calibrated against recent runoff to account for this effect).	of hydrology studies in the Rocky Mountains to date, except for those by Painter et al., (2010) which explicitly addressed dust loadings.
WWA.0721.014	• **The executive summary does not address reliability of supply.** However, the "low flow intensity duration" analysis (for example, page 3–3) addresses this question to some extent, and these results should be mentioned in the executive summary. We encourage the use of the sets of "resequenced" hydrologies developed in this study to help assess the reliability of future supply as a part of Phase II of the study.	See response to comment YWBRT.0721.001.
WWA.0721.015	• **The discussion of sources of uncertainties** (page VII) states "the inherent uncertainties in the available global climate models in projecting the magnitude and nature of greenhouse gas emissions". This should read "the inherent uncertainties in projecting the magnitude and nature of greenhouse gas emissions." as the projections are not done by the climate models. The discussion of uncertainty should also mention "bias correction of climate model output" as well as "uncertainty in hydrologic models processes and parameters" as potentially large factors.	Corresponding refinements will be considered for the next draft of the CRWAS Phase I Report. See response to comment DWCD.0716.005.
WSEO.0719.001	The Wyoming State Engineer's Office provides the following comments on the draft Colorado River Study Phase I Report (hereafter draft CRWAS report). The *Technical Approach and Findings* section includes a description of the methodologies used for this study, which included assessment of historical hydrologic records, paleohydrologic analysis, and the use of climate-adjusted hydrology. Our comments primarily focus on the results of the climate-adjusted hydrologic evaluations. Figure 3-37, entitled "Future Water Available for Future Consumptive Use by Colorado (MAF)" shows a very large range of potential outcomes as to the amount of water available for future use by Colorado. In fact, the climate-adjusted evaluation can be read to indicate that, under certain assumptions, Colorado may have no remaining water to develop. Such a finding becomes headline news even though the analyses are qualified in the *Conclusions and Recommendations* section of the draft CRWAS report (Executive Summary, page VII): "The primary underlying drivers for the broad range of Phase I results are: 1) the inherent uncertainties in the available global climate models in projecting the magnitude and nature of future greenhouse gas emissions; 2) the complexity of modeling atmospheric circulation; and 3) down-scaling the resulting effects of changed temperature and precipitation on natural flows in an area the size of the Colorado River Basin." We note that the report (Executive Summary, page II) states that "Phase I of the CRWAS presents the amount of water that may be available for future consumptive use in Colorado solely for the purposes of this study and is neither	See response to comment CBRT.0721.001.

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	the State of Colorado's nor any party's compact interpretation." We appreciate that statement, and opine that neither must it affect, by association, Wyoming's interpretation of our compact entitlements. Presenting data and stating that the lower range of water availability for future Colorado consumptive use "suggests that Colorado may have not or limited additional water available for development..." (Executive Summary, page VII) can convey a message to other interests in the Colorado River Basin that is problematic when viewed in terms of the mutual interests of the Upper Division States. We will not allow an analysis done in Colorado to, in any way, imply that Wyoming agrees to or is similarly bound by the results. The context of that message is further compounded by this being the Phase I CRWAS study (that purposely has limited water uses to current levels of water demands served by perfected water rights). Some readers may presuppose that the upcoming Phase II study (which will assess water availability to meet future water needs) cannot possibly come up with any other conclusion except that - at the lower range of availability - Colorado has already overdeveloped beyond what its water supply can support. Such a finding would be troubling for both our states. Consider too that article IX(a) of the Upper Colorado River Basin Compact (1948), which allows diversion of water in one signatory state for use in another, requires that such an action involve water "…which is within the apportionment to such State by the Compact." Any finding of no additional developable water for Colorado under the Compact, even as one of several alternative analyses designed for planning purposes, seems to complicate any project conceived along such lines.	