Appendix F3
Options Characterization Criteria and Rating Descriptions

Appendix F3 — Options Characterization Criteria and Rating Descriptions

1.0 Introduction

The *Plan of Study* (see *Study Report*, *Appendix 1 – Plan of Study*), laid out specific objectives related to the development and evaluation of options evaluated in Phase 4 of the Colorado River Basin Study (Study). Options proposed by the Project Team and the general public were characterized by the Study Team to describe each of the submitted options, provide a relative comparison of the option attributes, and support the eventual development of option portfolios. Characterization of the proposed options was based primarily on information provided by the option proponents; however, existing literature and/or relevant studies were reviewed to support the characterization process.

Characterization of the options was based on 17 evaluation criteria that are consistent with the criteria outlined in the *Plan of Study*. The approach to characterization included the following steps for each of the proposed options:

1) ***Review the submission of the option for relevance and completeness of data***. In some cases, clarification or additional information was requested from the proponent if it was believed that it was required for appropriate characterization of the option. Options that had limited definition or were not directly amenable to characterization through the 17 evaluation criteria were identified and cataloged for future consideration but are not characterized here.
2) ***Validate and refine information submitted by the option proponent.*** Criteria information submitted by the option proponent was compared with similar information in relevant case studies or readily available databases to confirm accuracy. If quantitative information was not readily available for a criterion, the Study Team used its collective expertise and experience to qualitatively evaluate information provided by the option proponent.
3) ***Characterize each option using a bin classification system.*** Qualitative or quantitative values were generated for each evaluation criterion using information provided by the option proponent or through refinements. A characterization summary table was developed for each option by assigning each criterion in the option to one of its five classification categories, or bins, "A" through "E". In general, the "A" category is most favorable, whereas the "E" category is least favorable. If insufficient information was available to assign a criterion to one of its classification bins, the associated entry in the option characterization summary table was left blank.

2.0 Characterization Criteria

Characterization of options by the public and Project Team was based on 17 criteria that captured important attributes for the Study. The criteria are listed below and are described more fully in this appendix and in attachment A.

1) Quantity of yield
2) Timing
3) Cost

4) Technical feasibility
5) Implementation risks
6) Long-term viability
7) Operational flexibility
8) Permitting
9) Energy needs
10) Energy source
11) Other environmental factors
12) Recreation
13) Socioeconomics
14) Policy Considerations
15) Legal
16) Hydropower
17) Water quality

Details about information requested from option proponents, the information confirmation approach, and bin classifications for each criterion are given in the following sections. In general, each option was provided with a five-point rating ("A" through "E") for each of the criteria. As previously stated, "A" generally represented the most favorable rating and "E" represented the least favorable rating for the specific criterion.

2.1 Quantity of Yield

The quantity of water associated with each option was a key characterization criterion. The quantity of yield criterion was not limited to new water supplies, but also included the quantity of water saved via demand reduction measures or the quantity of water that could be used in a different manner after a modification in system operations.

The option submittal form requested that the submitter roughly quantify the range of the potential amount of water that the option could provide annually over the next 50 years. If known, the submitter was also asked to specify any important seasonal (e.g., more water could be available in winter) and/or frequency (e.g., more water could likely be available during above-average hydrologic years) considerations.

Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. The yield of the proposed option was compared with yields estimated in relevant case studies that were readily available. Basic checks of fundamental hydrology were performed for some options to assist in refining or validating the quantity of yield estimates provided in the submission.

The classification of each option for this criterion was based on the range of quantity of water available. After refining the quantity estimates, each option was assigned to one of five bins shown in the characterization matrix in attachment A. It is important to note that some options (such as desalination plants) may produce the same amount of water in almost every year; however, other options may be dependent on hydrologic conditions and may have varying annual quantities. The characterization included documentation of the assumptions behind estimating the "average yield" based on research of relevant case studies or as supported by available hydrology information.

2.2 Timing

For this criterion, the essential element was the estimated first year the option could begin operation. In order to arrive at the first year of operation, the timing to conduct feasibility studies, permitting and environmental documentation, and to implement the option were assessed.

The cumulative duration of (1) feasibility, (2) permitting and environmental documentation, and (3) implementation phases constitutes the earliest year of operation. In addition, if the option could be implemented in phases, a description of the phasing potential was developed. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. The timing of the proposed option was compared with those in relevant case studies that were readily available. Options that included new large-scale infrastructure or significant revisions in operations could take many years for planning, permitting, and implementation. When reviewing relevant case studies, the time to complete these phases on similar projects was noted.

In addition, the following general assumptions were used in evaluating the timing criteria:

- There is a level of urgency that results in persistent and consistent pursuit of the option.
- There is generally positive political alignment and political desire to pursue the project.
- When possible, timing required for feasibility, permitting, and implementation were based on similar reference projects.
- When the scale of a project was larger than "reference" projects, additional time was typically allotted but generally not more than 5 additional years (for some projects, this could be viewed as optimistic).
- When legal or policy challenges were identified, additional time was typically allotted, but generally not more than 5 additional years (for some projects, this could be viewed as optimistic).

The classification of each option for this criterion was based on an estimate of the total number of years for the feasibility, permitting and environmental documentation, and implementation phases. In addition to preparing a best estimate of the first year of potential operation, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

2.3 Cost

The cost criterion included capital and annual costs expressed in terms of unit costs in dollars per acre-foot (af). The cost evaluation used consistent methods and assumptions to better allow for comparisons of option costs.

The option submittal form asked for cost information including capital, operations, maintenance, repair, replacement, and any other costs. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. The cost estimates provided by the option proponent were reviewed and refined, as necessary, to ensure consistency on cost estimating procedures and assumptions. The review confirmed that capital expenditures included all costs associated with obtaining land, easements, rights-of-way, and permits for

construction and operation. Annual costs include those necessary for the continued operation and maintenance (O&M) of the option. Details of the cost evaluation methods and assumption are provided in attachment B.

In addition to the assessment of the annualized cost expressed in dollars per af, each option was assigned to one of five bins shown in the characterization matrix in attachment A.

2.4 Technical Feasibility

For this criterion, the essential element was the overall technical feasibility of the option based on the extent to which the underlying technologies or practices have been widely and reliably used.

The option submittal form asked for a description of the technical maturity of the option and what research and/or new technologies might be required for implementation. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. The proposed option was compared with those in relevant case studies, focusing on confirming the degree to which option technologies and practices have been previously used and proven. If an option was based on technologies and practices that are widely available and previously proven, it was considered to be more technically feasible than options based on relatively new and unproven technologies or practices.

The classification of each option for this criterion was based on an assessment of whether the type of option has been: a) regularly implemented in the United States at the proposed scale, b) occasionally or regularly implemented somewhere in the world at similar scale, c) regularly implemented at smaller scales, d) has not been implemented, but peer review articles indicate promise, or e) has not been implemented and no peer review articles exist or they indicate challenges. The bins shown in attachment A match these categories.

2.5 Implementation Risks

For this criterion, risks separate and distinct from risks associated with technical feasibility, life-cycle cost, permitting, legal and policy considerations, and ongoing system reliability were of particular interest. Implementation risks identified for each proposed option were used in a qualitative fashion in the characterization of proposed options; however, the actual magnitude of individual risks was not quantified.

The option submittal form asked for an identification and description of risk or uncertainty related to implementation of the proposed option. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. Implementation risks associated with the proposed option were compared with similar risks in relevant case studies that were readily available. Implementation risks of particular interest included the viability of funding mechanisms for infrastructure and facilities construction, competing demands for option-specific critical resources, and potential for mitigation requirements that may be impractical to achieve.

For each option, the following checklist was used to assess implementation considerations. Based on this assessment, each proposed option will be assigned to one of five bins shown in the characterization matrix in attachment A.

Implementation Risks Checklist	
Evaluation of implementation risks is necessarily qualitative because the entities responsible for funding, operations, and mitigation cannot be determined at this time. As such, the criterion will consist of a general assessment. For each checklist item the following options are available for selection: • Does not have this risk. • Has this risk.	
Checklist Item	**Description**
Risk of Raising Capital	Either large amount of capital required or funding required from entity without reliable access to sufficient funds.
Challenging Operations	Integrating new supply into existing facilities is feasible, but requires possibly an unrealistic degree of operating flexibility or precision. Example: Delivering large amounts of ocean desalination water to a potable water system in a location that requires extreme precision in operating the potable water system or flexibility in terms of coordinating the use of the desalted water with use of other supplies.
Challenging Mitigation Requirements	Mitigation requirements anticipated to be required under the permitted phase results in mitigation operations that are impractical to achieve. Example: New water supply concept results in in-stream flow changes in a certain river reach and the operations require extreme precision in exchanging the water into a reservoir and staying within the in-stream flow requirements. Another example would be that changes in the flow regime to an environmentally sensitive area, such as the Salton Sea or the Cienega de Santa Clara, require extensive mitigation.

2.6 Long-term Viability

For this criterion, the anticipated reliability of the option considering its capability to meet proposed objectives over the long-term was of particular interest. The option submittal form asked for the identification and description of any known risks to supply or demand, such as drought risk, water contamination risk, or risk of infrastructure failure. The long-term viability rating was essentially a qualitative evaluation of the risk of the option to provide the expected quantity of yield benefits in the long term.

Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. When considering long-term viability, the options were compared with similar projects to identify viability risks. Of particular interest were risks related to ongoing operations and sustainability of a proposed option that were separate and distinct from risks associated with technical feasibility, construction cost, permitting, legal and policy considerations, and implementation. When considering operational flexibility, the degree to which the option could be operated (or implemented) across a wide range of hydrologic conditions, by having the ability to adjust the magnitude of operations each year to meet the required conditions was also considered.

Each option was assessed using the following checklist. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Long-term Viability Checklist	
For each checklist item the following options are available for selection: • Does not have this risk. • Has this risk.	
Checklist Item	**Description**
Intermittent or Uncertain Supply	Supply is susceptible to factors that could make it intermittent or uncertain. Example: Supplies susceptible to intermittent yield are those that are susceptible to drought, climate change, etc. Supplies with limited susceptibility are those such as conservation, reuse, ocean supplies, Mississippi River supplies, etc. Uncertain supplies are those for which the magnitude of available supply is difficult to measure or predict. Examples include options related to land management, weather modification, or vegetation management.
Contamination	Supply could be lost or cost could significantly increase if water quality changes due to "reasonable risk" of contamination. Example: Groundwater storage project mobilizes arsenic or other mineral that is regulated.
Infrastructure Failure	Supply depends on infrastructure that is vulnerable to natural disaster or non-natural disaster. Example: Offshore ocean desalter that is destroyed by an earthquake and resultant tsunami.
O&M Cost Escalation	Supply depends on operations that are at some risk to cost inflation. Example: Options that are power-dependent are at risk of power cost inflation. Other O&M risks could be labor-intensive, etc.
Unintended Consequences or Behaviors	Supply increase or demand reduction depends on predictability of community behavior or acceptance. Example: Imposition of odd/even day watering restrictions may lead to increased water use because "scarcity" perceptions drive greater water use on prescribed days.

2.7 Operational Flexibility

The operational flexibility of each option was also characterized based on the ability of the option to be idled from year to year. This criterion hints at the flexibility for an option to be used in short-term deficit conditions, but scaled back during subsequent wetter conditions with limited financial impacts. The specific characterization bins are shown in the matrix in attachment A.

2.8 Permitting

This criterion provides information related to the permits (number and type) that may be required to implement the particular option. The overall list of potentially required permits was the important item of information. In particular, a requirement to complete an Environmental Impact Statement (EIS) prior to implementation was important. Permitting considerations were used in a qualitative manner to characterize an option.

The option submittal form asked for a list of the permits required for implementation of the option and status of the permitting process if implementation has been initiated. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. In particular, review of similar case studies demonstrated a comprehensive list of permitting requirements for a given option.

For each option, the following checklist was used to assess permitting challenges. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Permitting Items Checklist	
For each checklist item, the following assessment will be performed: • Not required or not applicable. • Required, but precedent shows similar options have received permit. • Required, but no precedent exists and permit likelihood is unknown. • Required and precedent shows significant permit challenges.	
Check List Item	**Description**
NPDES	National Pollution Discharge Elimination System
CWA 404	Clean Water Act, Section 404 Wetlands Permits
CWA 401	Clean Water Act, Section 401 Water Quality Permits
Coastal Commission	California Coastal Commission Permits
Land Use Permits	For facilities located in or passing through federal, county, state, local jurisdictions.
Special Use Permits	In public lands or using public facilities (Bureau of Land Management, U.S. National Forest Service, etc.)
Fish & Wildlife	Federal or state permits
FERC	Federal Energy Regulatory Commission
IBWC	1944 Treaty with United Mexican States (Mexico) and subsequent minutes
Other Permits	Required international, federal, state, or local permits

2.9 Energy Needs

For this criterion, the required additional energy to convey, treat, and deliver new supplies was of particular interest. These additional energy requirements were separate and distinct from energy generated at hydroelectric facilities that might exist at other locations.

The option submittal form asked for the estimated amount of energy (kilowatt hours [kWh]/af) required to convey, treat, and deliver the additional yield provided by the proposed option to the proposed locations at a specified water quality. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. The energy required (kWh/af) to operate the option was estimated using data provided by the option proponent or other readily available information from relevant case studies. Raw water quality and target finished water quality, as well as distance and elevation difference between supply origination and delivery location(s), were used to estimate the required energy (kWh/af) for pumping and treatment. Other basic engineering estimates were made for non-traditional water supply options.

For each proposed option, the required energy needs were estimated. Each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A based on this assessment.

2.10 Energy Source

For this criterion, the source of any new required energy was of particular interest. Energy sources ranging from renewable sources (wind, solar, geothermal, hydropower) to nuclear, natural gas, diesel, and coal were assessed.

The option submittal form requested that the anticipated source(s) of any new required energy be identified, when applicable. Information, analyses, and references provided by the option proponent were reviewed based on known potential for energy sources available to the option. In some cases, the energy targeted for the option was reflective of a mix of sources (i.e., Western Area Power Administration grid). In those circumstances, the dominant energy source was identified or simply indicated as "grid" energy sources.

For each option, an assessment was made regarding whether the option: a) requires no new energy, b) uses renewable energy as the primary source of energy, c) uses natural gas or a mix of sources from the "grid" as the primary source of energy, d) uses diesel fuel as the primary source of energy, or e) uses coal as the primary source of energy. The bins shown in the characterization matrix in attachment A match these categories.

2.11 Other Environmental Considerations

For this criterion, ecosystems that might be affected by the proposed option such as aquatic, wetland, and riparian habitats were of particular interest. The assessment was qualitative and did not replace the detailed Colorado River Simulation System (CRSS) modeling of Colorado River ecological resources metrics.

The option submittal form requested a description of any potential positive or negative impacts on ecosystems within or outside the Basin associated with the proposed option. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. Relevant environmental assessment/EIS reports also were reviewed and past findings of ecosystem impacts associated with concepts similar to those described in the proposed option were noted.

For each option, the following checklist was used to guide the assessment of potential environmental impacts. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Environmental Items Checklist	
For each checklist item, the following options are available for selection: • Significantly positive. • Moderately positive. • No significant change. • Moderately negative. • Significantly negative.	
Check List Item	**Description**
Air Quality	Positive or negative impacts to dust or any other applicable air quality standard. An example would be the extent to which energy needs for an option are being met by renewable energy sources such as wind or solar compared to coal-fired power plants that produce emissions.
Listed Species	Positive or negative impacts, either directly or through habitat modification, on species listed as threatened or endangered.
Non-listed Species	Positive or negative impacts, either directly or through habitat modification, on non-listed species.
Riparian Habitat	Positive or negative impacts on riparian habitat or other sensitive natural community.
Wetlands	Positive or negative impacts on federally protected wetlands (including but not limited to marsh, vernal pool, coastal, etc.)
Cultural	Positive or negative impacts on historical resources, archaeological sites, paleontological sites, or unique geologic features.
Noise	Positive or negative impacts on ambient noise levels.

2.12 Recreation

For this criterion, potential impacts to recreational activities throughout the Basin were of interest. The assessment was qualitative and did not replace the detailed CRSS modeling of Colorado River recreation metrics.

The option submittal form asked for the identification of any positive or negative effects on recreation. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. Impacts of estimated changes in flow of the proposed option on recreational activities were compared with those estimated in relevant case studies that were readily available.

For each option, the following checklist was used to assess potential recreation impacts. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Recreation Items Checklist	
For each checklist item, the following options are available for selection: • Significantly positive. • Moderately positive. • No significant change. • Moderately negative. • Significantly negative.	
Check List Item	**Description**
Upper Basin Recreation Access	Adverse effects to any designated or proposed wild or scenic rivers, trails, wilderness areas, or other recreational areas.
Upper Basin Lake Levels	Consider the extent to which lake levels decline to levels that adversely affect recreation by reducing usability of boat ramps or impairing access to desirable boating or fishing areas.
Upper Basin Boating Flows	Consider extent to which flows in streams used for boating are reduced and the magnitude of impact of the reduced flow on the value of boating in affected reaches.
Upper Basin Visual Impacts	Alteration of any scenic vista or creation of an aesthetically offensive site or effect that is open to public view.
Lower Basin Recreation Access	Adverse effects to any designated or proposed wild or scenic rivers, trails, wilderness areas, or other recreational areas.
Lower Basin Lake Levels	Consider the extent to which lake levels decline to levels that adversely affect recreation by reducing usability of boat ramps or impairing access to desirable boating or fishing areas.
Lower Basin Boating Flows	Consider extent to which flows in streams used for boating are reduced and the magnitude of impact of the reduced flow on the value of boating in affected reaches.
Lower Basin Visual Impacts	Alteration of any scenic vista or creation of an aesthetically offensive site or effect that is open to public view

2.13 Socioeconomics

For this criterion, consideration of potential impacts to the socioeconomic conditions of regions within or outside the Basin due to implementation of the option was of particular interest.

The option submittal form asked for a description of any anticipated positive or negative socioeconomic effects. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. Changes in demographic use of water and location of water use associated with the proposed option were qualitatively estimated. Specific public, private, commercial, industrial, and agricultural sectors affected by demographic changes in water use were of particular interest.

For each option, the following checklist was used to assess potential socioeconomic impacts. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Socioeconomic Items Checklist	
For each checklist item, the following options are available for selection: • Significantly positive. • Moderately positive. • No significant change. • Moderately negative. • Significantly negative.	
Check List Item	**Description**
Employment	Positive or negative impacts on construction-related employment, locational shift of businesses, employment for O&M, or other employment impacts.
Public Fiscal Cost	Positive or negative impacts on capital costs, O&M costs, revenue from charges and fees, or regulatory costs.
Private Cost	Positive or negative impacts on homeowner user charges, property taxes, special assessments, real estate values, or costs to businesses or industries.

2.14 Policy Considerations

For this criterion, potential changes to existing federal, state, or local policies that concern water resources management or water use in order to implement the option were of interest. These policies might be promulgated by individual government agencies, inter-governmental groups, non-governmental organizations, or utility boards. Policies related to water resource management and water use promulgated by government agencies are often codified in laws, statutes, or ordinances. As considered here, water policies are separate and distinct from legal issues related to water rights, inter-Basin transfers, and international treaties. Policy considerations identified for each proposed option were used in a qualitative fashion in characterization of proposed options.

The option submittal form asked for the identification and description of changes in federal, state, or local policies that may be required for implementation of the proposed option. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. The Study Team also referred to information from readily available and relevant case studies to evaluate the policy implications of a proposed option. Water policies related to water conservation, land development, or energy exploration were of particular interest.

For each option, the following checklist was used to assess policy considerations. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Policy Items Checklist	
The following checklist is a means to explore whether the affected jurisdictions have the policies enumerated in the list in place. The list is both prospective, such that enumerated policies may need to be enacted, and reactive, leading to a search as to whether such policies are in place. The policies are to be explored at all levels (federal, state, and local). For each checklist item, the following options are available for selection: • Consistent with current policy or not applicable. • Requires changes, but precedent shows proposed changes can be publically acceptable. • Requires changes, but no precedent exists and acceptability is unknown. • Required changes and precedent shows significant public acceptance challenges.	
Checklist Item	**Description**
Growth management policies	Policies are implemented that limit residential, commercial, industrial, or infrastructure growth due to limited water availability or other constraints.
Urban land use policies	Land use policies are implemented that mandate higher-density lots or limit less water-intensive land uses such as golf courses.
Urban water use policies	Policies are implemented that mandate water efficiencies possibly with maximum gallons per capita mandates.
Public lands policies	Policies are adopted that change land use (and water use) on public lands as implemented by entities such as the Bureau of Land Management, U.S. National Park Service, or U.S. Forest Service.
Forest management policies	Policies are adopted that allow the thinning of natural vegetation to reduce evapotranspiration.
Energy resources development policies	Policies are implemented that favor domestic development of energy sources and consequently favor water use required to develop those energies, but mandates are also passed that make sure water is used as efficiently as possible.
Agricultural policies	Policies are adopted that change the amount of water allowed to be used for agriculture in arid regions or limit the type of crops that can be grown in arid regions.
Reservoir operation policies	Policies are adopted that change the current operating standards for reservoirs in the Basin, possibly changing how releases are made to favor environmental or recreational flows and with a possible impact to desired hydropower operations or divertible water quantities.
Recreation policies	Policies are adopted that set target recreational flows or force minimum water levels in reservoirs that change the current operating band or release schedules from reservoirs.
Transportation policies	Policies are adopted that change the location and types of transportation infrastructure. An example would be a denser road network in forested areas to allow more harvesting, thereby reducing forest density.
Fish and wildlife policies	Policies are adopted that change the current operating standards for the rivers or reservoirs in the Basin, possibly changing how releases are made to favor environmental flows, with a possible impact to desired hydropower operations or divertible water quantities.

2.15 Legal

For this criterion, the various legal constraints and associated legal instruments and measures required for implementation of an option were of particular interest. The legal criterion focused on potential legal hurdles that would need to be addressed to implement each option.

The option submittal form asked for the identification and description of all required legal considerations or agreements or other legal processes required for implementation of the option. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. Particular emphasis was placed on review of legal requirements for implementation of similar options and review of the requirements of the Law of the River. Options that would involve interstate or international implementation of options, transfers of the rights to use water, or any other inter-jurisdictional cooperation would have documented special legal needs.

For each option, the following checklist was used to assess legal challenges. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Legal Risks Checklist

For each checklist item, the following options are available for selection:

- Consistent with current legal framework or item not applicable.
- Local or federal laws may require changes, but precedent shows that item can be addressed
- Legal action is required, no precedent exists, and timeframe or likelihood of success is unknown.
- Legal action is required and precedent shows that the legal challenges may not be overcome.

Checklist Item	Description
Law of the River[1]	Requires potential change in laws, policies, or regulations associated with the Law of the River. This particularly applies when variation in state water allocations are needed or when existing provisions of the Law of the River will not be met.
Water Rights Changes	Requires transfers or leasing of water rights or changes in the conditions associated with water rights. Examples of the conditions associated with the water rights include consumptive use limitations or constraints on place of use, point of diversion, or type of use.
Inter-Jurisdictional Agreements	Requires agreements among two or more jurisdictions. These jurisdictions may be federal agencies, state agencies, counties, municipalities, local water agencies, irrigation districts, industries, energy utilities, special interest groups, or federally recognized tribes.
New or Revised Legislation	Requires new legislation or revisions to existing legislation at either the state or federal level. This applies to legislation that is not already commonly considered to be part of the Law of the River. Examples would be legislation related to land use, forest management, farm programs, and water quality permitting.
International Agreements	New agreements are required between the United States and Mexico or between agencies or utilities in both countries. An example would be the various agreements required to implement ocean desalting in Mexico and allow credits for Colorado River system water to be shared upstream. By implication, new minutes to the present international treaty may be required.

[1] Law of the River includes but is not limited to the following:

- Colorado River Compact, 1922
- Boulder Canyon Project Act, 1928
- California Seven Party Agreement, 1931
- Water Treaty With Mexico, 1944
- Upper Colorado River Basin Compact, 1948
- Colorado River Storage Project Act, 1956
- Arizona v. California Supreme Court Decree, 1964
- Colorado River Basin Project Act of 1968
- Criteria for the Coordinated Long Range Operation of Colorado River Reservoirs, 1970
- Minute 242 of Water Treaty With Mexico, 1973

- Colorado River Basin Salinity Control Act, 1974
- Grand Canyon Protection Act, 1992
- Colorado River Interim Surplus Guidelines, 2001
- Colorado River Water Delivery Agreement, Federal Quantification Settlement Agreement, 2003
- Arizona v. California Supreme Court Consolidated Decree, 2006
- Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead, 2007
- 43 Code of Federal Regulations 414 Offstream Storage of Colorado River Water in the Lower Division States
- 43 Code of Federal Regulations 417 Lower Basin Water Conservation Measures

2.16 Hydropower

For the hydropower criterion, identifying potential increases or decreases in hydroelectric energy generation was of particular interest. The assessment was qualitative and does not replace the detailed CRSS modeling of Colorado River hydropower effects.

The option submittal form asked for estimates of anticipated increases or decreases in hydroelectric energy generation. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. The potential impact on hydroelectric power generation was considered, using the submitted quantity, location, and timing information. The qualitative assessment considered whether new hydropower resources were included in the option and whether, and to what extent, implementation of the option may affect existing hydropower resources.

For each proposed option, it was estimated whether the option may have: a) significantly positive impacts, b) moderately positive impacts, c) no impacts or impacts expected to be "neutral", d) moderately negative impacts, or e) significantly negative impacts. The bins shown on the characterization matrix in attachment A match these categories.

2.17 Water Quality

For this criterion, changes in water quality brought about by implementation of the option were of particular interest. The assessment was qualitative and did not replace the detailed CRSS modeling of Colorado River water quality metrics.

The option submittal form asked for identification of key water quality implications (salinity and other constituents) associated with implementation of the option in all of the locations that the option might affect. Information, analyses, and references provided by the option proponent were reviewed for accuracy and completeness. Depending on the option and data availability, the water quality data provided by the option proponent were compared to data readily available from U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency databases.

For each option, the following checklist was used to assess potential water quality impacts. Based on this assessment, each proposed option was assigned to one of five bins shown in the characterization matrix in attachment A.

Water Quality Impact Items Checklist

This checklist relates only to whether the option relates to improvement or decline for the listed items. The extent to which specified water quality standards are being met or violated is covered separately as part of the evaluation of metrics.

For each checklist item, the following options are available for selection:

- Significantly positive.
- Moderately positive.
- No significant change.
- Moderately negative.
- Significantly negative.

Checklist Item	Description
Salinity	The salinity of water added to the system or returned to the system should be compared to present levels to determine whether the option improves or degrades salinity concentrations. Present system criteria will be based on the closest USGS monitoring station with total dissolved solids salinity data.
Sediment	Consider the potential impact the option would have on sediment transport through the system. Options that maintain "flushing flows" are the ones that will best maintain sediment transport. Also consider how conversion of land uses can affect sediment loadings.
Temperature	Consider whether option may increase or reduce temperature of receiving waters. An example would be conversion of electrical energy-generating facilities from either once-through or recycled evaporative cooling to non-evaporative cooling with no thermal discharges to receiving waters. Another example is changes in reservoir release policies.
Dissolved Oxygen	Consider if option increases or decreases the amount of oxygen-depleting substances (biochemical oxygen demand and chemical oxygen demand) discharged to Basin receiving waters.
Nutrients	Consider if the option would change the overall nutrient balances being discharged to Basin receiving waters. Primary nutrients of concern are nitrogen and phosphorus.
Algae	Consider whether the changes in nutrient discharges are likely to increase or decrease algal production in areas of concern. For example, any increase of nutrient levels in Lake Mead increases the likelihood of production of algal blooms that may adversely affect drinking water in Las Vegas and the ecosystem.
Metals	Consider if the option changes the total loadings of metals discharged to the system.
Perchlorate	Consider if the option introduces perchlorate to the system.
Emerging Contaminants	Consider if the option will change the concentration or presence of potential emerging contaminants, such as endocrine-disrupting compounds. An example would be increased recycling of conventionally treated municipal wastewater effluent to groundwater or reservoirs that serve as sources of potable water supply.

Appendix F3

Attachment A
Detailed Options Characterization Criteria and Ratings

Attachment A — Detailed Options Characterization Criteria and Ratings

ATTACHMENT A
Detailed Option Characterization Criteria and Ratings

No.	Criteria	Criteria Measurement	Option Characterization Rating Criteria				
			A	B	C	D	E
1	Quantity of Yield	Average af per year	> 500	> 350	> 250	> 100	< 100
2	Timing	Years before option could begin operation	< 5	< 10	< 20	< 30	> 30
3	Cost	Annual dollars per af, Present Worth	< 500	< 1000	< 2000	< 3000	> 3000
4	Technical Feasibility	5-pt qualitative scale	Regularly implemented in U.S. at scale proposed	Occasionally implemented somewhere in the world at similar scale	Regularly implemented but at smaller scales	Occasionally implemented somewhere in the world or has not been done, but peer review articles indicate promise	Has not been done and no peer review articles exist or they indicate challenges
5	Implementation Risks	5-pt qualitative scale	No major implementation risks	Some implementation risks, but risks can be managed	Multiple implementation risks, but may be managed	Multiple implementation risks, ability to manage risks is unknown	Multiple implementation risks and ability to manage risks is low
6	Long-term Viability	5-pt qualitative scale	No major risks	Some viability risks	Multiple, but limited risks	Multiple, moderate risks	Multiple, significant risks
7	Operational Flexibility	5-pt qualitative scale	Option can be operated/idled in any year with no financial implications	Option can be operated/idled in any year with limited financial implications	Option can be operated/idled in any year with moderate financial implications	Option can be operated/idled in any year with significant financial implications	Option does not have the flexibility to be operated or idled from year to year

ATTACHMENT A
Detailed Option Characterization Criteria and Ratings

No.	Criteria	Criteria Measurement	Option Characterization Rating Criteria				
			A	B	C	D	E
8	Permitting	5-pt qualitative scale	Does not require an EIS or other major permits	Requires an EIS or other major permits, but similar projects of this scale have been approved in the past 20 years	Requires an EIS or other major permits, but similar projects of smaller scale have been approved in the past 20 years	Requires an EIS and no precedent exists for the option.	Requires an EIS and similar options have been declined during the permit process
9	Energy Needs	kWh/af	Requires no energy, or results in net positive generation	< 1000	< 3000	< 5000	> 5000
10	Energy Source	5-pt qualitative scale	No new energy required	Renewable energy sources are primarily used	Natural gas or "grid" is primary source of energy	Diesel fuel is primary source of energy	Coal is primary source of energy
11	Other Environmental Factors	5-pt qualitative scale	Significantly positive impacts are likely to exist, and negative impacts are not readily apparent	Moderately positive impacts are anticipated at some locations while other locations may or may not have negative impacts of a lesser degree	Option does not have an impact or impacts are expected to be neutral	Moderately negative impacts are anticipated at some locations while other locations may or may not have positive impacts of a lesser degree	Significant negative impacts are likely to exist, and positive impacts are not readily apparent
12	Recreation	5-pt qualitative scale	Significantly positive impacts are likely to exist, and negative impacts are not readily apparent	Moderately positive impacts are anticipated at some locations while other locations may or may not have negative impacts of a lesser degree	Option does not have an impact or impacts are expected to be neutral	Moderately negative impacts are anticipated at some locations while other locations may or may not have positive impacts of a lesser degree	Significant negative impacts are likely to exist, and positive impacts are not readily apparent
13	Socioeconomics	5-pt qualitative scale	Significantly positive impacts are likely to exist, and negative impacts are not readily apparent	Moderately positive impacts are anticipated at some locations while other locations may or may not have negative impacts of a lesser degree	Option does not have an impact or impacts are expected to be neutral	Moderately negative impacts are anticipated at some locations while other locations may or may not have positive impacts of a lesser degree	Significant negative impacts are likely to exist, and positive impacts are not readily apparent

ATTACHMENT A
Detailed Option Characterization Criteria and Ratings

No.	Criteria	Criteria Measurement	Option Characterization Rating Criteria				
			A	B	C	D	E
14	Policy Considerations	5-pt qualitative scale	Consistent with current local and federal policies	Local policies may require changes, but precedent shows can be publicly acceptable	Changes to federal or interstate policy is required but precedent shows public acceptance is likely	Changes to local or federal policy is required, and public acceptance is unknown	Changes to local or federal policy is required, and public acceptance is unlikely
15	Legal	5-pt qualitative scale	Consistent with current legal framework	Local laws may require changes, but consistent with current federal legal framework	Federal or interstate legal action is required but precedent shows item can be addressed	Federal legal action is required, no precedent exists, and timeframe or likelihood of success is unknown	Federal legal action is required and precedent shows that the legal challenges may not be overcome
16	Hydropower	5-pt qualitative scale	Significantly positive impacts are likely to exist, and negative impacts are not readily apparent	Moderately positive impacts are anticipated at some locations while other locations may or may not have negative impacts of a lesser degree	Option does not have an impact or impacts are expected to be neutral	Moderately negative impacts are anticipated at some locations while other locations may or may not have positive impacts of a lesser degree	Significant negative impacts are likely to exist, and positive impacts are not readily apparent
17	Water Quality	5-pt qualitative scale	Significantly positive impacts are likely to exist, and negative impacts are not readily apparent	Moderately positive impacts are anticipated at some locations while other locations may or may not have negative impacts of a lesser degree	Option does not have an impact or impacts are expected to be neutral	Moderately negative impacts are anticipated at some locations while other locations may or may not have positive impacts of a lesser degree	Significant negative impacts are likely to exist, and positive impacts are not readily apparent.

Appendix F3

Attachment B
Methods Used for Performing Unit Cost Calculations

Attachment B — Methods Used for Performing Unit Cost Calculations

As part of the option characterization process, all submitted options were characterized using 17 evaluation criteria that were developed by the Options and Strategies work group. The relative cost of an option (expressed in unit annual cost of dollars per acre-feet) was one of the characterization items. This unit cost was calculated by taking the present worth of all option costs over the study period and dividing by the annual yield of the option. More details on the methods used for this calculation are described below.

Guidelines for evaluating the feasibility of water resources projects are provided in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (U.S. Water Resources Council, 1983). The following points summarize the key guidelines applicable to cost analyses:

1. Monetary values are to be expressed in average annual equivalents by appropriate discounting and annualizing techniques using the applicable discount rates. (section 1.7.1)
2. Monetary analyses shall consider the following (section 2.1.2):
    a) Installation period – the number of years required for installation of the option.
    b) Installation expenditures – the dollar expenses expected to be incurred during installation.
    c) Period of analysis – Use the same period of analysis for all alternative plans. The period of analysis is the lesser of the period of time over which any alternative plan would have significant beneficial effects or 100 years.
    d) Benefit stream – the pattern of expected benefits (in this case focusing on water yield) over the period of analysis.
    e) Operation, maintenance, and replacement (OM&R) costs – the expected costs over the period of analysis for OM&R activities.
    f) Discount rate – the rate established annually for use in evaluating federal water projects.
3. Discount any deferred installation costs and OM&R costs to the beginning of the period of analysis using the applicable project discount rate.
4. Guidance on the "appropriate discounting and annualizing techniques" is provided in Circular No. A-94 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (Office of Management and Budget, 1992).
5. The prescribed discount rate to be used on federal water projects is provided via the Treasury Annual Interest Rate Certification, table 5 – Bureau of Reclamation. For 2011, the prescribed discount rate for federal water projects stood at 4.125 percent.

Period of Analysis and Useful Life Duration

The Study period is from 2012 through 2060, and all the financial analyses will also be performed over that period. However, some options may require significant time to implement, and the useful life of some facilities may not be over by 2060. Therefore, the estimated

remaining depreciated value of the facilities will be included in the present-worth cost calculations when appropriate. For the Study, straight-line depreciation will be assumed and the useful life of key facilities will be assumed as follows:

Useful Life of Installed Facilities[1]	
Facility	**Useful Life (years)**
Plant Facilities	45
Evaporation Ponds	45
Pump Stations/Hydropower	45
Pipelines and Tunnels	60
Diversion Structures	60
Dams	75
Land	100
All other facilities / investments	45

[1] Major overhaul and replacement costs for certain facility components such as pumps, valves, and electrical switchgear, are included in annual OM&R costs.

References

Office of Management and Budget. 1992. *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.* Memorandum for Heads of Executive Departments and Establishments, Circular No. A-94 Revised, October 29

U.S. Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies,* March 10.

Appendix F3

Attachment C
Characterization Results

Attachment C — Characterization Results

Detailed characterization results for the representative options are presented in a Tableau workbook. Tableau is MicroSoft® Windows® software that facilitates data exploration and visualization. A free "reader" program is required in order to view the information. The reader program is available at http://www.tableausoftware.com/products/reader.

The workbook with the characterization results is available on the compact disc that accompanies this report and on the Study website at http://www.usbr.gov/lc/region/programs/crbstudy.html.

The workbook consists of two sheets, 1) showing numeric results, where applicable (yield, timing, and annualized unit cost) and 2) showing the ratings ("A" through "E") for each of the option characterization criteria. For the numeric results tab, option categories can be selected or removed by clicking their check box. For the letter ratings, option categories and criteria can be selected or removed by clicking their check box. The technical report and appendices include information on the rating criteria and rating process. Assumptions associated with individual ratings can be seen by either placing the mouse over that rating and hovering or by clicking on the individual rating.