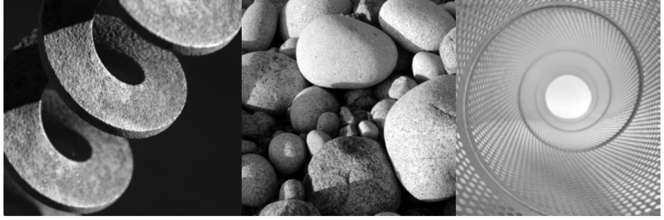

GEI Consultants

Geotechnical
Environmental
Water Resources
Ecological

Final Report – Version 1

Grand Lake Water Clarity Technical Review and Work Plan

U.S. Bureau of Reclamation:

Order No. R12PX60331

Submitted to:
U.S. Bureau of Reclamation
Denver Federal Center
P.O. Box 25007
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GEI Project 128590

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1.0 Introduction

1.1 Purpose and Scope

The purpose of this Technical Review is to provide a roadmap that outlines the steps required to transition numerous proposed alternatives to improve the clarity of Grand Lake into a 30 percent engineering design. The Technical Review considers non-construction operational changes, as well as potential constructed alternatives. The Technical Review addresses the following key questions:

- What data and analyses are required to fill current data gaps in order to better define and evaluate potential alternatives and evaluate their performance in improving the clarity of water in Grand Lake?
- What effects will clarity improvements in Grand Lake have on the water quality in the "Three Lakes System" on the West Slope and Colorado Big-Thompson (C-BT) Reservoirs on the East Slope?
- How should the alternatives be evaluated?
- How long will it take to develop the alternatives, evaluate the alternatives, and prepare 30 percent level designs for the most-promising alternatives and what is the associated cost?

To help answer these questions GEI reviewed 60 project documents and numerous correspondences and conducted five stakeholder meetings. Stakeholder input was solicited on each of three prior versions (April 2013, May 2013, July 2013) of this draft-final Technical Review report that were developed. An interim draft (also dated July 2013) was reviewed by the U.S. Bureau of Reclamation (Reclamation) only. Stakeholder comments and GEI's response to comments are included in Appendices A – D and are included to document the thoughts, concerns and intentions of all stakeholders for future readers.

1.2 Technical Review Organization

The Technical Review is organized into seven sections, including this Introduction. Section 2.0 is intended to provide cursory background information on the project setting for the C-BT project operations and regulations, and overview of the water quality history of the project. It is not intended to provide comprehensive documentation of the history of the C-BT project and Grand Lake clarity concerns, as those are included in many of the referenced documents.

Section 3.0 presents GEI's review of existing project documents and data collection efforts. A summary of three key documents which were integral to this Technical Review is included along with a summary table of the available data for the Three Lakes System.

Section 4.0 presents the identified "Data Gaps"—the additional information that is required prior to the identification of a complete list of alternatives and conducting studies to support the 30 percent design.

Section 5.0 presents a summary of the existing alternatives and a broad methodology for ranking and selecting alternative(s) to take through the NEPA process and ultimately to develop to the 30 percent design level.

Section 6.0 presents the Work Plan that describes the anticipated procedure required to develop the project from its existing status into a 30 percent engineering design.

Section 7.0 contains references for previous work used in the development of this Technical Review.

1.3 Authorization

GEI was retained by Reclamation to perform this work under the terms of Order No. R12PX60331 dated September 11, 2012.

1.4 Project Personnel

The Technical Review, and supporting analyses, was completed by the following personnel from GEI:

Richard Westmore, P.E.	Project Manager
Craig Wolf	Aquatic Ecologist/Limnologist
Kerri Price, P.E.	Project Engineer
Steven Canton	In-house Consultant

Other sources of information, contributions, and comments came from multiple individuals from several stakeholder groups as shown in Table 1:

Table 1: Stakeholders Involved in the Development of the Technical Review

Stakeholder Name	Individuals Involved
Grand County	• Lurline Underbrink-Curran • Katherine Morris
Mid-West Electric Consumer Association	• Thomas Graves
Northern Colorado Water Conservancy District	• Don Carlson • Esther Vincent • Jeff Drager • Peter Nichols • Peggy Montano
U.S. Bureau of Reclamation	• Carlie Ronca • Karl Thiel • Jaci Gould • Laura Harger • Mike Collins • Ron Thomasson • Sara Salber
U.S. Forest Service	• Carl Chambers
U.S. Geological Survey	• Mike Stevens
Western Area Power Administration	• Dave Neumayer • John Gierard
Western States Power Corporation	• Dan Payton

1.5 Limitation of Liability

The professional services for preparing this Technical Review were performed in accordance with generally accepted engineering and ecological practices; no other warranty, expressed or implied, is made.

2.0 Background

2.1 Colorado-Big Thompson Project Background

The C-BT Project had its beginnings in the late 1930s and became fully operational about 20 years later. Its main purpose is to collect water from the upper Colorado River Basin and transport it to the eastern slope of Colorado for use by farmers and residents of northeast Colorado. The C-BT Project was authorized in 1937 by the 75th Congress and constructed by Reclamation between 1938 and 1956. The United States owns the C-BT project and parts of the system are operated by the Reclamation and other parts of the system are operated by Northern Colorado Water Conservancy District (Northern Water), under contract to Reclamation.

Grand Lake, in addition to being the subject waterbody of this report and a unique resource as Colorado's largest natural lake, is used as part of the C-BT Project western slope collection system. To introduce and describe the function of each component, the facilities and operations associated with the C-BT Project are described below (Reclamation, 2013a):

> *The project diverts approximately 260,000 acre-feet of water annually (310,000 acre-feet maximum[1]) from the Colorado River headwaters on the western slope to the Big Thompson River, a South Platte River tributary on the eastern slope, for distribution to project lands and communities. The Northern Colorado Water Conservancy District apportions the water used for irrigation to more than 120 ditches and 60 reservoirs. Eleven communities receive municipal and industrial water from the project. Electric power produced by six powerplants is marketed by the Western Division of the Pick-Sloan Missouri Basin Program.*
>
> *The western slope collection system traps runoff from the high mountains and stores, regulates, and conveys the water to the Alva B. Adams Tunnel for diversion under the Continental Divide.*
>
> *To assure irrigation and power generation under prior rights on the Colorado River, Green Mountain Reservoir was constructed on the Blue River. Spring runoff is stored in this reservoir and later released to meet the requirements of the Colorado River and to allow diversion of water by the project throughout the year.*
>
> *Irrigation systems on the Colorado River, above the Blue River confluence, were improved to enable continued use of existing rights. Releases are made from Lake Granby to maintain the Colorado River as a fine fishing stream.*

[1] *There is no maximum annual diversion volume imposed on the C-BT Project. The original C-BT Project plan contemplated an average annual diversion of 310,000 acre-feet. Footnote is not part of the original text.*

The principal storage features are Lake Granby and Granby Dam, located on the Colorado River near Granby. Willow Creek, a tributary below Lake Granby, is diverted by Willow Creek Dam and Canal. Willow Creek Pumping Plant lifts the water 175 feet; it then flows by gravity to Lake Granby.

Granby Pumping Plant lifts the water 125 feet from Lake Granby to Granby Pump Canal. The canal conveys the water 1.8 miles to Shadow Mountain Lake, which also intercepts North Fork flows of the Colorado River. Shadow Mountain Lake connects with Grand Lake to make a single body of water from which diversions flow to the Alva B. Adams Tunnel to begin the journey to the eastern slope.

Emerging from Alva B. Adams Tunnel into the East Portal Reservoir, the water flows across Aspen Creek Valley in a siphon and then under Rams Horn Mountain through a tunnel. At this point, it enters a steel penstock and falls 205 feet to Marys Lake Powerplant. This powerplant is located on the west shore of Marys Lake, which provides afterbay and forebay capacity for reregulating the flow. Between Marys Lake and Estes Powerplant, on the shore of Lake Estes, the water is conveyed by Prospect Mountain Conduit and Prospect Mountain Tunnel.

Lake Estes, below Estes Powerplant, is formed by Olympus Dam constructed across the Big Thompson River. The afterbay storage in Lake Estes and the forebay storage in Marys Lake enable the Estes Powerplant to meet daily variations in energy demand.

Water from Lake Estes and some Big Thompson River floodwaters are conveyed by Olympus Siphon and Tunnel and Pole Hill Tunnel and Canal to a penstock through which the water drops 815 feet to Pole Hill Powerplant. It is then routed through Pole Hill Powerplant Afterbay, Rattlesnake Tunnel, Pinewood Lake, and Bald Mountain Pressure Tunnel, and dropped 1,055 feet through two penstocks to Flatiron Powerplant. This powerplant discharges into Flatiron Reservoir, which regulates the water for release to the foothills storage and distribution system. The afterbay storage in Flatiron Reservoir and the forebay storage in Pinewood Lake enable Flatiron Powerplant to meet daily power loads.

Southward, the Flatiron reversible pump lifts water from Flatiron Reservoir, a maximum of 297 feet and delivers it through Carter Lake Pressure Conduit and Tunnel to Carter Lake. When the flow is reversed, the unit acts as a turbine-generator and produces electric energy.

The St. Vrain Supply Canal delivers water from Carter Lake to the Little Thompson River, St. Vrain Creek, and the Boulder Creek Supply Canal. The latter delivers water to Boulder Creek and Boulder Reservoir. The South Platte Supply Canal, diverting from Boulder Creek, delivers water to the South Platte River.

Northward, the Charles Hansen Feeder Canal transports water from Flatiron Reservoir to the Big Thompson River and Horsetooth Reservoir. The canal crosses the Big Thompson River in a siphon above the river and highway. Water from the

> *Big Thompson River can be diverted into the canal by Tunnel No.1, Horsetooth Supply Conduit.*
>
> *Project water deliveries and Big Thompson River water to be returned to the river are dropped through a chute from the feeder canal ahead of the siphon crossing, or are passed through the Big Thompson Powerplant to convert the available head to electric energy.*
>
> *Horsetooth Reservoir is west of Fort Collins between two hogback ridges, where Horsetooth Dam closes the gap at one end. Soldier, Dixon, and Spring Canyon Dams and Satanka Dike close the remaining gaps.*
>
> *An outlet at Soldier Canyon Dam supplies water to Fort Collins, rural water districts, Colorado State University, and the Dixon Feeder Canal for the irrigated area cut off from its water supply by the reservoir.*
>
> *The principal outlet from Horsetooth Reservoir is through Horsetooth Dam into the Charles Hansen Canal. This canal delivers water to a chute discharging into the Cache la Poudre River and to a siphon crossing the river to supply the Poudre Valley and Reservoir Company Canal. A turnout supplies the Greeley municipal water works. Water is delivered to the river to replace, by exchange, that water diverted upstream of the North Poudre Supply Canal, which conveys it to the North Poudre Ditch.*

2.2 Three Lakes Background

Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake are collectively referred to as the "Three Lakes" in this report. In this Technical Review, Granby Reservoir, Shadow Mountain Reservoir, Grand Lake, the Farr Pumping Plant, Granby Pump Canal, and Alva B. Adams (Adams) Tunnel are referred to as the "Three Lakes System" which is located in Grand County, Colorado (Figure 1).

Granby Reservoir, the largest of the three lakes, serves as a storage facility for C-BT water and forebay for the Farr Pumping Plant. Water enters Granby Reservoir via tributary flows and pumped water from Willow Creek and Windy Gap Reservoirs. Water can be pumped from Granby Reservoir at the Farr Pumping Plant into the Granby Pump Canal, which connects into Shadow Mountain Reservoir. Alternatively, water can flow via down-gradient from Shadow Mountain Reservoir through the outlet works into the Colorado River that connects to Granby Reservoir.

Shadow Mountain Reservoir is a relatively small and shallow reservoir. The conditions existing prior to the construction Shadow Mountain Reservoir are described as follows by Bunger (Reclamation, 1937):

> *The reservoir site is now mostly in hay meadow lands and swampy areas along the meandering course of Grand Lake outlet, which runs through it. A secondary*

> *highway connecting Grand Lake and Granby, Colorado, runs through a portion of the site and will have to be reconstructed and moved up the mountain above the high water line. All trees, brush, and buildings will be removed from the site, and since the fluctuation of the water surface will be limited to one foot, the 1356 acres of water surface will make attractive addition to Grand Lake with its surface area of 507 acres.*

The key purpose of Shadow Mountain Reservoir for the C-BT system is to aid in the collection and conveyance of water pumped from Granby Reservoir to Grand Lake and the Adams Tunnel supplying the transmountain diversion tunnel with water pumped from Granby Reservoir (Senate Document 80, paragraph 4).

Grand Lake is Colorado's largest natural lake and is adjacent to a small mountain community with the same name. In addition to its use as a recreational amenity for local residents and visitors, it serves as part of the water collection and conveyance system for the Colorado-Big Thompson (C-BT) Project. Water routed into Grand Lake can be diverted into the Adams Tunnel at the northeast shoreline of the lake.

The physical properties of the Three Lakes are documented in Table 2.

Table 2: Physical Properties of the Three Lakes

Waterbody	Storage Capacity (acre-feet)	Surface Area (acres)	Max. Depth (feet)	Shoreline Length (miles)	Average Depth (feet)
Willow Creek Reservoir	10,553	303	124	7	35
Windy Gap Reservoir	445	106	25	1.5	4.2
Granby Reservoir	539,800	7,256	221	40	74
Shadow Mountain Reservoir	17,354	1,852	19.7	8	9.4
Grand Lake	68,621	507	265	4	135

Table data from Lewis (1992) and Reclamation (2007),

2.3 Overview of Water Quality Documentation

There are three primary documents that serve to either influence water quality via water quantity management or regulate water quality conditions in the Three Lakes System:

- Senate Document No. 80, 75th Congress, 1st Session (Senate Document 80);
- Colorado Water Quality Control Commission Regulation No. 31 Basic Standards and Methodologies for Surface Water, 5 CCR 1002-31 (WQCC Reg. 31); and
- Colorado Water Quality Control Commission Regulation No. 33 Upper Colorado River Basin and North Platte River, Classifications and Numeric Standards 5 CCR 1002-33 (WQCC Reg. 33).

Appendices G, H.1 and H.2 contain copies of Senate Document 80 and the portion of WQCC Regs. 31 and 33 that are applicable to the Three Lakes System, respectively.

2.3.1 Senate Document 80

Authorizing legislation for the C-BT Project was described and transmitted by Senate Document No. 80, 75th Congress, 1st Session. Senate Document 80 provides a synopsis of the C-BT Project and outlines the construction and general operating conditions of the Project. Reclamation must operate the C-BT Project in accordance with the Manner of Operations section of Senate Document 80 and uses the remainder of the document as guidance.

Several aspects of Senate Document 80 are relevant to this Technical Review and will influence the alternative selection process. The primary purposes of the C-BT Project are outlined in Senate Document 80 in the section titled "Manner of Operation of Project Facilities and Auxiliary Features" as follows:

> *The construction and operation of [the C-BT Project] will change the regiment of the Colorado River below the Granby Reservoir. The project contemplates the maximum conservation and use of the waters of the Colorado River, and involves all of the construction features heretofore listed[2]. In addition thereto certain supplemental construction will be necessary. This will be for the primary purpose of preserving insofar as possible the rights and interests dependent on this water, which exist on both slopes of the Continental Divide in Colorado. The project, therefore, must be operated in such a manner as to most nearly effect the following primary purposes:*
>
> 1. *To preserve the vested and future rights in irrigation.*
> 2. *To preserve the fishing and recreational facilities and the scenic attractions of Grand Lake, the Colorado River, and the Rocky Mountain National Park.*
> 3. *To preserve the present surface elevations of the water in Grand Lake and to prevent a variation in these elevations greater than their normal fluctuation.*
> 4. *To so conserve and make use of these waters for irrigation, power, industrial development, and other purposes, as to create the greatest benefits.*
> 5. *To maintain conditions of river flow for the benefit of domestic and sanitary uses of this water.*

---

[2] Refers to: 1) Green Mountain Reservoir; 2) hydroelectric plant at Green Mountain Reservoir; 3) Granby Reservoir; 4) Shadow Mountain Reservoir; 5) Farr Pumping Station; 6) Granby Feeder Canal; 7) Adams Tunnel; 8) conduit line through RMNP; 9) waste rock landscaping ; 10) Power Plant No. 1 below Estes Park; 11) Four additional power plants; 12) Carter Lake diversion dam; 13) Carter Lake; 14) siphon to Horsetooth Reservoir; 15) Horsetooth Reservoir; 16) Arkins Reservoir; 17) transmission lines. Footnote is not part of the original text.

In addition to the five primary purposes of the Project, Senate Document 80 lists other operations text in the "Operation of the System" section. These excerpts are lengthy and can be found in Appendix H.

2.3.1.1 Additional Authority or Congressional Approval

It is important to note that some of the proposed alternatives' (pipeline to bypass Grand Lake and/or removing Shadow Mountain Dam, etc.) conditions may be in conflict with Senate Document 80. For example, under natural flow conditions in Grand Lake (e.g., absence of C-BT pumped inflows) there is a potential for fluctuations in lake elevation greater than its normal fluctuation. If an engineered or operational solution can be found that significantly alters the project designs or operational characteristics, it may be necessary to seek additional authority or Congressional approval prior to implementation.

2.3.2 Colorado Water Quality Control Commission Regulation No. 33

Grand County and Northwest Colorado Council of Governments requested that the Colorado Water Quality Control Commission (Commission), and the Colorado Department of Public Health and Environment (CDPHE), adopt a water clarity standard for Grand Lake. The Commission adopted two clarity standards for Grand Lake and these standards are recorded in Colorado Water Quality Control Commission Regulation No. 33 Upper Colorado River Basin and North Platte River, Classifications and Numeric Standards 5 CCR 1002-33 (WQCC Reg. 33). The Grand Lake clarity standards were adopted as a special case where the protection of beneficial uses requires standards not provided by the use classifications identified in Regulations No. 31 and 33 (WQCC Reg. 31). Portions of WQCC Reg. 33 are critical to this Technical Review and the alternative selection process and are excerpted below. The applicable portions of WQCC Reg. 31 and Reg. 33 are provided in Appendix I.

> *The Commission determined that it is appropriate to adopt water quality standards for the protection of Grand Lake's clarity because of Grand Lake's uniqueness as Colorado's largest natural lake. Grand Lake adjoins and complements Rocky Mountain National Park in the headwaters of the Colorado River and its social and economic importance is worthy of protection…*
>
> *The Commission is adopting two clarity standards for Grand Lake. First, the Commission is establishing a narrative clarity standard, to take effect with the other revisions to this regulation. This standard is "the highest level of clarity attainable, consistent with the exercise of established water rights and the protection of aquatic life". This standard is based on the Commission's conclusion that improvement in the clarity of Grand Lake is necessary, while noting that efforts to improve clarity need to be undertaken in a manner consistent with established water rights and need to also consider the protection of the aquatic life use. In basing the standard on "attainability", the Commission intends that attainability is to be judged by whether or not a clarity level can be attained in approximately twenty years by any recognized control techniques that are environmentally, economically, and socially acceptable.*

> *An underlying assumption in setting this narrative standard is that clarity in Grand Lake needs to improve. However, the Commission is not determining in this hearing whether the current evidence of reduced clarity warrants inclusion of Grand Lake on Colorado's Section 303(d) List or the Monitoring and Evaluation List…*

The narrative standard is broad and addresses the need for protection of water rights and aquatic life use concisely. The methodology for protection of water rights is well defined and will not be addressed herein. However, the standard inadequately establishes how aquatic life use is to be protected and how the protection will be measured and enforced. Without attempting to interpret the Commission's intent, all that may be said regarding the protection of aquatic life is that it needs to be "considered" as the design process moves forward. Improvement of clarity within Grand Lake is expected to improve the quality of recreational uses of this unique resource (CDPHE Reg. 33, 2013), although it is uncertain what effects (positive or negative) there will be on aquatic life use, agriculture use, or water supply use.

The numerical clarity standard is defined as follows:

> *Second, the Commission is establishing a numerical clarity standard of 4 meter Secchi depth for the months of July through September, with an effective date of January 1, 2014. The intention is that for the majority of the summertime days, the water of Grand Lake shall be clearer than 4-meter Secchi depth. Attainment of the 4 meter Secchi depth standard will be assessed by comparing the 85th percentile of available Secchi depth data collected during the months July through September to the 4 meter standard. Fifteen percent of the measurements may have Secchi depth shallower than 4 meters. When two samples are collected in different locations, or by different agencies on the same day, the Secchi depth value is the average of those samples.* (WQCC Reg. 33, pg. 107-108).

As stated in WQCC Reg. 33, the numerical clarity standard of 4-m Secchi depth becomes effective January 1, 2014, if a more appropriate standard has not been identified (it should be noted the effective date has changed to January 1, 2015 due to other regulatory timeline changes). However, the Commission does not identify what a more appropriate numerical standard would be or how it would be determined:

> *The Commission has determined that the adoption of the 4 meter numerical standard with a delayed effective date is an appropriate policy choice to encourage cooperative efforts to improve Grand Lake clarity prior to the time that a specific numerical standard goes into effect, while assuring that a protective numerical standard will go into effect in 2014 if monitoring, assessment and water quality improvement efforts between now and then have not resulted in identification of a more appropriate numerical standard…The Commission anticipates that these efforts may result in a proposal for a revised site-specific numerical clarity standard for Grand Lake at a later date.* (WQCC Reg. 33, pg. 108).

The specifics of the collection methodology to be used for assessing the 4-m standard are not outlined within WQCC Reg. 33. In practice, some uncertainties regarding the assessment methodology has arisen and include the number of samples required to adequately measure the clarity, the frequency and location of collection, whether a view scope is to be used, what party/agency is responsible for collecting measurements, and who should pay for the data collection and analysis.

2.3.2.1 Standard Review and Modification Procedure

As with all standards, the clarity standards for Grand Lake are subject to periodic review during the “Basin Hearing” process, and the Commission will open WQCC Reg. 33 to revisit both the narrative and numerical clarity standards in future regulatory review cycles (next review is June 2014). Section 25-8-202(f) of the State Water Quality Control Act requires the Commission to review WQCC Reg. 33 water quality standards at least once every three years (triennial review), although the current practice has such reviews on a 5-year cycle. The Commission's current practice is to conduct triennial reviews by holding an informal Issues Scoping Hearing (ISH) to solicit comments regarding whether particular regulations should be retained, repealed or revised. The ISH is the first step in a three-step process for triennial review of water quality classifications and standards in the Upper Colorado River Basin and North Platte River. The ISH provides an opportunity for early identification of potential issues that may need to be addressed in the next major rulemaking hearing and for identification of any issues that may need to be addressed in rulemaking prior to that time. The ISH typically occurs the first week of October a year and a half before the Basin hearing. The second step in the triennial review process—the Issues Formulation Hearing (IFH)—results in the identification of the specific issues to be addressed in the next major rulemaking hearing. The IFH for regulations typically occurs in November, 6 months before the Basin hearing. The third step is the Rulemaking Hearing (RH), where any revisions to the water quality classifications and standards are presented by parties and formally adopted by the Commission. The RH is typically held in June of the 5-year cycle. Lastly, any revised or newly adopted standards become effective in January following the hearing after U.S. EPA (EPA) review and approval.

Prior to the IFH, the Commission encourages all interested persons or parties to provide their opinions and/or recommendations regarding potential issues in the Upper Colorado River Basin and North Platte River basins and with the rulemaking process. Recommendations should be concise and include a brief explanation of why the issues and processes need to be considered in the IFH. Additional efforts, such as special studies needed to compile additional data to define a more appropriate clarity standard, are identified and planned.

3.0 Review of Existing Project Materials, Data, and Efforts

3.1 Stakeholder Meetings, Existing Reports, and Documentation

The Technical Review consisted of examining numerous documents that have relevance to the issues of water clarity in Grand Lake and generally with water quality in the Three Lakes System. Citations for documents used as part of this work are provided in Section 7.0.

Additionally, GEI and Reclamation conducted several stakeholder meetings throughout the development of this report. The dates of these meetings are listed below:

- February 4, 2013 (in-person meeting);
- February 27, 2013 (phone conference);
- April 3, 2013 (phone conference);
- May 15, 2013 (in-person meeting);
- June 25, 2013 (in-person water quality modeling meeting); and
- August 7, 2013 (in-person meeting).

In addition to the stakeholder meetings conducted as part of this project, GEI also attended several technical meetings and presentations and was provided with meeting minutes and presentations for past events. GEI reviewed these presentations but may not have had a representative in attendance at the presentation. Citations for these presentations are also included in Section 7.0.

3.1.1 Existing Water Quality Reports

The monitoring efforts funded by the U.S. Bureau of Reclamation, Grand County, Northern Water, and other entities have provided much of the water quality data available for the Technical Review, although additional agency and consultant reports have provided technical insight regarding areas of special interests within the Three Lakes System. Many reports and data sources were reviewed and the reports that have provided much of the technical review background included here are listed below:

- 2011 Operational and Water Quality Summary Report for the Three Lakes (Hydros Consulting Inc., 2013a);
- Sources and Characterization of Particles Affecting Transparency in Grand Lake and Shadow Mountain Reservoir (McCutchan, 2013);
- 2010 Operational and Water Quality Summary Report for Grand Lake and Shadow Mountain Reservoir (Hydros Consulting Inc., 2012c);Colorado-Big

Thompson Project West Slope Collection System Grand County, Colorado: Preliminary Alternatives Development Report (Reclamation, 2012);

- Factors Controlling Transparency in Grand Lake, Colorado (McCutchan, 2010);
- Memorandum in response to "Factors Controlling Transparency in Grand Lake, Colorado" (AMEC Earth & Environmental, 2010);
- Physical, Chemical, and Biological Attributes of Western and Eastern Slope Reservoir, Lake, and Flowing Water Sites on the C-BT Project, 2005-2007: Lake Granby, Grand Lake, Shadow Mountain Reservoir, Horsetooth Reservoir, Carter Lake (Lieberman, 2008);
- Windy Gap Firming Project (WGFP): Lake and Reservoir Water Quality Technical Report (Reclamation, 2008b);
- Windy Gap Firming Project: Three Lakes Water-Quality Model Documentation (Reclamation, 2008c);
- Scoping Study – 3-Lakes Water Quality, Grand Lake, Shadow Mountain, Granby Reservoir, Grand County, Colorado (McLaughlin Rincón, 2006);
- Shadow Mountain Lake Restoration Project (HDR Engineering, Inc., 2003); and
- Three Lakes Clean Lakes Watershed Assessment Draft Report (Hydrosphere Resource Consultants, 2003).

Three of these documents were considered key to the development of this Technical Review and a more detailed review of these documents is provided in the following sections. Brief summaries of the other documents follow in the next section. The three documents were:

- 2010 Operational and Water Quality Summary Report for Grand Lake and Shadow Mountain Reservoir (Hydros Consulting Inc., 2012c);
- 2011 Operational and Water Quality Summary Report for the Three Lakes (Hydros Consulting Inc., 2013a);
- Colorado-Big Thompson Project West Slope Collection System Grand County, Colorado: Preliminary Alternatives Development Report (Reclamation, 2012);

3.1.1.1 2010 Operational and Water Quality Summary Report for Grand Lake and Shadow Mountain Reservoir

In 2011, Hydros Consulting Inc. (Hydros) produced a final version of the "2010 Operational and Water Quality Summary Report for Grand Lake and Shadow Mountain Reservoir (2010 OWQ Report), with two figure revisions occurring in 2012 (Hydros Consulting Inc., 2012c). The purpose of this report was to consider the data collected from 2007 to 2010 for Grand Lake and Shadow Mountain Reservoir and present information on the following four objectives:

- *Provide a synopsis of operational changes and their effect on water quality and clarity in Grand Lake and Shadow Mountain Reservoir on an annual basis.*
- *Provide an assessment of the effectiveness of operational modifications under meteorologic, hydrologic and environmental conditions.*
- *Provide recommendations for consideration when examining future operational modifications.*
- *Provide an assessment of non-operational factors that affect water quality and clarity and recommendations on how operational changes might complement and optimize these.*

In 2009, a special study examining the factors that control transparency in Grand Lake was performed by McCutchan (2010). These factors include algae, non-algal organic particles (e.g., detritus, and dead plant matter), inorganic particulates (e.g., silt and clay particles), and dissolved organic matter (e.g., algae and fish excretions), of which McCutchan concluded that 40-60 percent of the total light attenuation in Grand Lake was attributed to non-algal particles (i.e., both detritus and inorganic particulates), and that 50-60 percent was attributed to algae particles from Shadow Mountain Reservoir. The data were also analyzed by Boyer (2011) using a slightly different approach who concluded that 42-52 percent of light attenuation in Grand Lake was attributed to non-algal particles, and 23-39 percent could be attributed to algae. Both evaluations were similar (i.e., less than 10% difference) when the factors that affect water clarity were grouped similarly, including the conclusions for Shadow Mountain Reservoir which are not presented herein, but are contained in McCutchan (2010), Hydros (2012c) and Boyer (2011).

The Hydros report provides a review of operational modifications (i.e., stop-pump periods) conducted in August 2008 and their effect on water clarity in Grand Lake as well as Shadow Mountain Reservoir. The second stop-pump period was conducted in August 2009, which revealed different results when compared to the 2008 stop-pump period. Grand Lake clarity improved during both stop-pump periods, though not to the same degree. Shadow Mountain Reservoir clarity improved in 2008, and declined in 2009. Operational modifications following these two stop-pump periods also provided information regarding the effects of gradually resuming the pumped inflows versus a sudden shift in pumped inflows on factors affecting water clarity. These different approaches indicate that pumping operations may cause the resuspension of settled particulates in Shadow Mountain Reservoir which can affect water clarity in Grand Lake. The stop-pump periods are discussed in greater detail in Section 3.2.2.

The 2010 OWQ Report also summarizes the hydrological water balance, total phosphorus loads, and total nitrogen loads for each tributary, pumped inflow, outflow, precipitation, storm flow, and internal loading sources for Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir. Based on their analysis of 2007 to 2010 water quality and clarity conditions in Grand Lake and Shadow Mountain Reservoir, the 2010 OWQ Report presents numerous conclusions about the behavior of the system relative to water clarity. A partial list of these conclusions is presented below:

- *The variety of operational, hydrologic, and environmental conditions that occurred 2007-2010 did not result in meeting or coming close to the Grand Lake clarity standard, described in Regulation 33.*

- *Weather can play a role in Grand Lake / Shadow Mountain Reservoir water-quality dynamics. High algal concentrations (and poor water clarity) occurred during the hot summer of 2007. Precipitation events increase the amount of stormwater-related nutrients delivered to the water bodies. Wind conditions and air temperatures can impact the amount of stratification in Shadow Mountain Reservoir and associated internal nutrient loading, although the effects have not been quantified.*

- *Because of the complicated and difficult-to-anticipate future conditions (e.g., air temperatures, east slope demands, hydrology, and precipitation events), it is hard to rely on a single operational strategy to achieve water clarity improvements.*

- *Other management decisions (such as the drawdown of Shadow Mountain in late 2006) can also impact subsequent water-quality conditions (as experienced in 2007).*

The 2010 OWQ Report lists the following suggestions to improve water clarity in Grand Lake between July and September:

1. *Minimize the inflow of water with poor water quality into the lake.*
2. *Develop management strategies to improve water quality of inflow such as:*
   a. *Decrease water pumped at the Farr Pumping Plant*
   b. *Improve water quality of Shadow Mountain Reservoir*
   c. *By passing the flow from Shadow Maintain Reservoir around Grand Lake*

It should be noted the 2010 OWQ Report does conclude that it would be "difficult to improve the water quality and clarity characteristics of Shadow Mountain Reservoir due to shallow conditions, sources of nutrients, and weather conditions." However, that report did not make any attempt to weigh the challenge of improving Shadow Mountain Reservoir water quality against the challenges associated with any structural or non-structural alternatives.

Hydros also recommended the following future monitoring and data evaluations:

- *Use the Three Lakes Water-Quality Model to determine the limits or bounds of water-quality conditions for Shadow Mountain Reservoir and Grand Lake, under a variety of operational scenarios.*

- *A systematic analysis of appropriate sampling sites for both Grand Lake and Shadow Mountain Reservoir should be made. It is suggested that additional sites be added for Shadow Mountain Reservoir and that less sites be included for Grand Lake. Currently, there are three sites on Shadow Mountain Reservoir and 14 sites on Grand Lake. Additional Shadow Mountain Reservoir sites should be placed to provide greater resolution of the clarity gradients observed in runoff season and during Farr pumping.*

- *Coordinate water-quality monitoring and water operations efforts to better understand the clarity gradient associated with sudden changes in pumping at the Farr Pumping Plant. It is recommended to collect data immediately before and after significant increases in pumped flows.*

3.1.1.2 2011 Operational and Water Quality Summary Report for the Three Lakes

In 2013, Hydros produced draft and final versions of the "2011 Operational and Water Quality Summary Report for the Three Lakes" (Hydros Consulting Inc., 2013a and Hydros Consulting Inc., 2013b). The 2011 Operational and Water Quality Summary Report of the Three Lakes (2011 OWQ Report) contains an evaluation of 2011 water quality data in the Three Lakes and focuses on the observed patterns in chlorophyll *a*, clarity, and dissolved oxygen. The 2011 OWQ Report includes an assessment of relative annual water quality, comparing 2011 water quality in the Three Lakes to that observed in the previous 4 years with a site-specific Water Quality Index (WQI). The WQI provides a coarse level evaluation tool to compare water quality characteristics relevant to the Three Lakes on an annual basis, as well as a tool to evaluate output from the Three Lakes Water Quality Model. The WQI incorporates three water quality metrics 1) Secchi depth collected from July through September 15; 2) Chlorophyll *a* collected from March through November; and 3) Dissolved oxygen as the minimum average result of concentrations from the 0.5-m to 2-m depths, collected over the calendar year. The WQI methodology normalizes the three metric values to a common scale for comparison within and among the Three Lakes over time. In addition to the WQI value, a supplemental suite of metrics are used to adequately describe the three water quality characteristics (Secchi depth, chlorophyll *a*, dissolved oxygen) in finer resolution.

Hydros found that unique conditions existed during 2011 that affected the Three Lakes water quality. An extensive list of conditions were assessed in the report that included meteorology, runoff patterns, water management operations, inflow water quality, lake and reservoir water quality, external nutrient loading, and physical profiles. Conditions in 2011 differed from previous years as a result of above-normal snowpack and presented an opportunity to assess water quality response to parameters not previously observed. Hydros concluded these conditions include:

- *There was an extended period of no Farr pumping through the summer months. Summer Farr pumping typically begins in July; however, in 2011 no pumping occurred from May 15 through September 6.*

- *Tributary runoff volumes in 2011 into the Three Lakes were twice as high as the average of the preceding four years.*

- *The seasonal runoff peak occurred nearly one month later in 2011.*

- *Among the higher tributary inflows, flows from North Fork were disproportionally higher in 2011, due to reduced upstream diversion operations by Grand Ditch and/or Redtop Ditch. This disproportionate increase in flow is also apparent in a disproportionate increase in nutrient loading from North Fork.*

- *The Three Lakes received no water from Willow Creek or Windy Gap in 2011.*

- *Summer months in 2011 were relatively wet, hot, and calm, with above-average precipitation totals and air temperatures and below-average wind speeds.*

Observations made in the OWQ Summary Report relative to the 2011 conditions, and differences in comparison to observations in 2007-2010, include:

- *High runoff and the extended period of no Farr pumping in 2011 resulted in record post-C-BT maximum clarity observations in Grand Lake and Shadow Mountain Reservoir.*

- *Clarity in Shadow Mountain Reservoir north of the islands (SM-NOR and SM-MID) reached depths that were greater than those observed in 2007-2010. Clarity at the southern end (SM-DAM) did not reach the maximum values seen in 2009 and 2010. Initiation of Farr pumping in September resulted in improved clarity at SM-DAM.*

- *Adverse effects of North Fork water quality on Shadow Mountain Reservoir and Granby Reservoir are more apparent in 2011, due to the disproportionately high inflows from this tributary.*

- *Initiation of Farr pumping in September caused an immediate and sharp deterioration in clarity and an increase in chlorophyll a concentrations in Grand Lake. Continuous data in the Connecting Channel show a sharp increase in turbidity with the initiation of Farr pumping in September.*

- *Dissolved oxygen concentrations near the surface (0.5-2.0 m) were higher than those observed in 2007-2010 for Grand Lake and Shadow Mountain Reservoir. High runoff conditions more than likely contributed to this condition. Surface* *dissolved oxygen concentrations in 2011 in Granby Reservoir were similar to previous years.*

Based on the above observations, the 2011 OWQ Report reaches numerous conclusions about the behavior of the system relative to water clarity. A partial list of these conclusions is found below:

- *Clarity and total suspended solids data indicate that clarity is greater in the winter (including winter months when Farr is pumping) for all three water bodies. In the spring, suspended particulates associated with runoff cause clarity degradation for Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake.*

- *Data point to a source of particulates in the mid-northern portion of Shadow Mountain Reservoir that affects clarity in Shadow Mountain Reservoir and in Grand Lake (when Farr pumping is operational) in summer and fall. Although unclear at this time, this source may be related to macrophytes or resuspension of organic or inorganic particulate matter.*

- *Farr pumping is a key factor influencing stratification, dissolved oxygen, nutrients, temperature, and clarity at SM-DAM. The effects vary by season due to temperatures, dissolved oxygen concentrations, and nutrient concentrations in Granby Reservoir at the elevation of the Farr pump intakes.*

- *Initiation of Farr pumping in summer months causes degradation of clarity in Grand Lake.*

- *There are several factors unique to Shadow Mountain Reservoir that affect stratification. These factors include inflow location, timing, and temperature as well as the existence of prominent islands. The result is stratification patterns that vary more than most lakes or reservoirs, both spatially and temporally.*

- *Internal loading of inorganic phosphorus and nitrogen occurs and is consistent in Granby Reservoir in the summer and in the winter. The impacts of the Granby Reservoir internal loads are then observed in the data at SM-DAM, when the Farr pumps are running.*

3.1.1.3 Preliminary Alternatives Development Report

In August 2012, a “Preliminary Alternatives Development Report” (Alternatives Report) was published by Reclamation (Reclamation, 2012). The goal of this report was to determine whether further development of alternatives were possible to improve water clarity in Grand Lake, Colorado as part of the Colorado Big Thompson Project (C-BT Project) west slope collection system in response to a proposed State water clarity standard to take effect in 2015. The report found that there were water clarity improvement alternatives that could be further developed. The Alternatives Report is the primary source of engineering information for potential structural and non-structural alternatives intended to improve the water clarity in Grand Lake. The Alternative Report presents only preliminary ideas and concepts, as identified in "brainstorming sessions", and estimates of costs were intentionally excluded.

> *This report summarizes water quality issues in the Three Lakes System as follows: Water clarity in Grand Lake and Shadow Mountain Reservoir is predominately a function of non-algal organic particulate matter, algae particles, inorganic suspended solids, and dissolved organic matter. Factors affecting the concentrations of these constituents include hydrology, operations, weather and quality of inflowing water. Water clarity in Grand Lake responds to changes in C-BT Project pumping operations. The conveyance of water from Shadow Mountain Reservoir to Grand Lake appears to be related to detected declines in water clarity.*

The report also provides information on 15 alternative approaches to address the water quality issues. The Alternatives Report provides a qualitative comparison of these alternatives and ranks them. The highest ranking alternatives were assessed based on their merits, risks, and uncertainties and further analyses required for a complete alternatives evaluation were identified. One of the recommendations within the Alternatives Report is to perform a technical review of the alternatives. This Technical Review fulfills this recommendation.

3.2 Existing Water Quality Efforts

3.2.1 Existing Data and On-going Data Collection

Reclamation, Grand County, and Northern Water are cooperatively working together to understand the factors that affect water clarity and develop a methodology to increase clarity in the future. In addition to these three entities, there are also many other agencies, partners, stakeholders groups, and individuals interested and involved in decisions affecting Grand Lake, Shadow Mountain, and Granby Reservoirs.

Currently, due to ongoing focus on Grand Lake clarity and related Three Lakes water quality issues, the agencies and interested stakeholders have been working on what has become known as the Three Lakes Water Quality Study (TLWQS). A technical subgroup called the Three Lakes Technical Committee (TLTC) meets regularly to discuss the varied water quality and clarity related items within the Three Lakes System.

The Three Lakes are monitored mainly as part of Northern Water's Baseline Monitoring Program. The purpose of the Baseline Monitoring Program has been well documented and summarized in various reports that can be found on Northern Water's website (accessed August 2013):

https://www.northernwater.org/docs/WaterQuality/Waterqualityreport.pdf
http://www.northernwater.org/docs/WaterQuality/WQ_Reports/2010WqRepExecSumm.pdf

The objectives of the Baseline Monitoring Program are to:

- Monitor trends and changes in water quality in lakes and reservoirs and flowing sites: streams, rivers and canals;
- Assess potential water quality changes in receiving streams, upstream and downstream of where Colorado-Big Thompson Project and Northern Water Windy Gap Project water is released; and
- Assess compliance with state water quality standards.

Over time, the Baseline Monitoring Program (Appendix G) was modified to accommodate particular water quality concerns in the Three Lakes (e.g., clarity, algae growth, and nutrient cycling). Each year, the monitoring program is reviewed to take into account recommendations and findings from the most recent data summary reports compiled by the Three Lakes Technical Committee and consultants. Sampling is then adjusted to reflect areas needing further investigation and current understanding of the system. Changes to the program are systematically discussed with Hydros and the USGS and then presented to the Three Lakes Technical Committee for final review. Furthermore, over the past eight years, the program was optimized to provide water quality data of interest to study water quality/clarity issues in the Three Lakes and to support modeling efforts.

The existing water quality summaries for Grand Lake and Shadow Mountain Reservoir have documented the patterns of Secchi depth and chlorophyll *a* measurements for the past 5 years, with special efforts given to partition the factors that contribute to decreased water clarity in Grand Lake. Nutrient profiles for the Shadow Mountain Reservoir were collected in 2011 during low dissolved oxygen events. However, it is unclear if there is a sufficient quantity of nutrient profile data available to evaluate potential internal nutrient loading and algae growth in Shadow Mountain Reservoir given bypass alternatives that may reduce or eliminate pumped inflows that influence circulation patterns.

Table 3 shows the existing data collected on the Three Lakes System by the agencies and interested stakeholders. Data collected by Northern Water and measured constituents are summarized in Appendix G.

Table 3: Existing Data Collection Efforts

Type of Data	Period of Data	Data Source
Secchi-Depth	1941-2013	• Grand County Watershed Information Network • Northern Water • Reclamation • USGS • University of Colorado • EPA • Colorado Lake Volunteer Monitoring Program • Grand County Volunteers
Daily Hydrology and Operational Data	2007-2013	• Northern Water • Reclamation • USGS
Inflow Nutrient Data	2007-2013	• Northern Water • Reclamation • USGS
Shadow Mountain Dissolved Oxygen	2008-2013	• Northern Water
Real Time Temperature/Electrical Conductivity for Three Lakes inflows	N/A[2]	• Northern Water
National Acid Precipitation Assessment Program (NADP) in Rocky Mountain National Park	2011-2013	• Grand County Watershed Information Network • Northern Water • Reclamation • USGS
Baseline Monitoring Program (Temp, Cond, DO, pH, TSS, TDS, TOC, Hard, TP, SRP, TKN, NO3+NO2, NH3, As, Se, Fe, Pb, Ag, Cu)	1991-2013	• Northern Water • Reclamation
Cyanobacteria Microcystin Toxin	2007-2013	• Colorado River Water Conservation District • Grand County • Northern Water • Reclamation • Town of Grand Lake
Connection Channel Flow and Water Quality	2010-2013	• USGS
Meteorology	1949-2013	• NOAA • Northern Water • Northern Water, Grand County, Reclamation
Precipitation Water Quality	N/A	• USGS

1. Table modified from Hydros Consulting Inc., 2012a
2. N/A = Not available

3.2.2 Modified-Pumping Periods

From 2008-2011, Reclamation, working cooperatively with Grand County and Northern Water, altered the normal C-BT Project operations to evaluate potential effects on water clarity. In 2008 and 2009, pumping operations were stopped entirely for 2 weeks. In 2010, rate and timing of pumping activity was modified in an attempt to increase the water clarity in Grand Lake.

In 2008, pumping operations were stopped by Reclamation from August 1 – August 14. Although the effort was initially scheduled to last 4 weeks, due to unanticipated east slope C-BT Project reservoir elevation concerns, the stop-pumping period only lasted 2 weeks. Analyses by Hydros documented in the 2010 OWQ Report shows:

> *Prior to August 1st, water clarity was declining in Grand Lake and Shadow Mountain Reservoir. In Grand Lake, the lowest clarity was observed on July 28 (2.0 m average). During the stop-pump period, Grand Lake clarity improved from an average of 2.2 m to 3.5 m. Shadow Mountain Reservoir clarity also improved, although not as much (from an average of 1.8 m to 2.3 m). After the stop-pump period, the amount of pumping was gradually increased…In 2008, clarity continued to improve in Grand Lake after Farr Pumping resumed. Nine days after the pumps were turned on, the average Secchi-depth measurement in Grand Lake had continued to improve, reaching 3.75 m, and then began to decline, reaching 2.6 m on September 11th…For Shadow Mountain Reservoir, clarity also continued to improve after the stop-pump period and reached 3.0 m on August 26th. Clarity then declined to 1.6 m by September 9th. Note that the average clarity values described here were computed using all of the locations sampled on a particular day. This analysis would be improved if the same sites had been consistently sampled on the same days to eliminate any localized impacts on certain dates.*

In 2009, pumping operations were stopped by Reclamation from August 13 – August 26. Analysis by Hydros documented in the 2010 OWQ Report shows:

> *Again, prior to the start of the stop-pump period, water clarity was declining in Grand Lake and Shadow Mountain Reservoir. In Grand Lake, clarity readings declined to an average of 3.2 m on August 13th. During the stop-pump period, Grand Lake clarity improved slightly and reached a value of 3.4 m at the end of the period (although an average of 3.9 m was observed in the middle of the period). As opposed to 2008, Shadow Mountain Reservoir clarity declined from an average of 2.5 m to 1.9 m and the peak chlorophyll a concentration occurred. There was 30% more inflow into Shadow Mountain Reservoir during the stop-pump period in 2008 than there was in 2009. Note that less tributary flow would typically be expected later in the year and the stop-pump period occurred later in 2009 than in 2008. The increased flow in 2008 may have served to dilute and improve clarity conditions. After the 2009 stop-pump period, the amount of pumping was suddenly increased, as opposed to 2008, when operations resumed more gradually. Grand Lake responded (after a short clarity improvement of 3.6 m the day after the stop-pump period) and*

the Secchi-depth readings declined to 2.1 m by September 9th…Clarity in Shadow Mountain Reservoir improved after the stop-pump period from an average of 1.6 m to 4.0 m on September 14th. Again, note that the average values described here were computed using all of the locations sampled on a particular day. This analysis would be improved if the same sites had been consistently sampled on the same days to eliminate any localized impacts on certain dates.

While there were visible benefits to water clarity in Grand Lake during the 2008 and 2009 stop-pumping periods, the effects of the pumping interruptions on water quality in Shadow Mountain Reservoir are mixed and dependent upon confounding factors not fully understood at this time.

In 2010, Reclamation pumped water into Shadow Mountain Reservoir at a constant flowrate to minimize the residence time of water in Shadow Mountain Reservoir and prevent stratification. Pumped flows were held constant, to the extent possible, at 225 cfs until August 27th, 2010. Analysis by Hydros documented in the 2010 OWQ Report shows:

In 2010, high (more clear) Secchi depths were recorded in May and October although the summer months experienced Secchi-depth readings of less than 2 m. In general, clarity tended to degrade in July and August…A degradation and then subsequent improvement in clarity is evident in August 2010. The degradation coincides with the increase in algae concentrations described earlier. Clarity in September was relatively constant and then an improvement was seen in October. Secchi-depth data for Shadow Mountain Reservoir in 2010 indicate very poor clarity in June (<1 m) and several higher (more clear) readings in September. In August, a similar pattern occurs as in Grand Lake, corresponding to the algae bloom.

In 2011, the hydrology and C-BT operations were markedly different from recent years. The substantial snowpack resulted in a delayed peak runoff into the Three Lakes that was two times greater than the preceding 4-year average, and resulted in shorter residence times in all three waterbodies. The Three Lakes did not receive pumped inflows from Willow Creek or Windy Gap, and Farr pumping did not occur until after September 6, 2011. There was a total of 114 days when no pumping occurred during C-BT operations, which provided a unique opportunity to study water clarity in Grand Lake.

In 2011, an unusual combination of extensive snowpack, relatively ample storage in east slope reservoirs, relatively low early spring water demand, and low anticipated power demand combined to produce an opportunity to provide an extended stop-pump period. Pumping usually resumes after spring runoff in mid-July, however, there was no need for pumping during this time, and a downgradient flow from Grand Lake into Shadow Mountain Reservoir was maintained much later into the season than normal. The official 2011 stop-pump period was 7 weeks: when coupled with the customary annual pumping shutdown during spring runoff the result was no pumping for 14 weeks, from late May to early September. During that time, clarity improved to a maximum Secchi depth measurement of 23.8 feet (7.25 m) in late August.

Notably, the proposed numerical water clarity value was not achieved during any of the July through September seasons when the planned stop-pumping or modified-pumping operations were implemented.

3.2.3 Macrophyte Removal in Shadow Mountain Reservoir

The extensive growth of aquatic macrophytes in Shadow Mountain Reservoir has received attention both from a recreational use aspect dating back to 1954 (Nelson, 1982) and more importantly as a primary factor that affects water clarity in Grand Lake (McCutchan, 2010). Annual aquatic macrophytes surveys (combination of acoustic and ground truthing) have been conducted in Shadow Mountain Reservoir since 2004 to document the different types of aquatic macrophytes, percent composition, and spatial coverage. In 2006, Shadow Mountain Reservoir was drawn down during the winter months to expose the plants to desiccation and cold temperatures for 56 days as a strategy to control their growth and development. The 2007 survey showed that the spatial extent of *Elodea* was greatly reduced and other macrophytes such as coontail and curlyleaf pond weed became more dominant due to the lack of competition by *Elodea* for natural resources. Since 2007, annual plant surveys have shown a consistent and relatively stable reduction in the average length of *Elodea* and other common plants when compared to pre-drawdown conditions. However, *Elodea* is still a major nuisance macrophyte for Shadow Mountain Reservoir (Sisneros, 2012). Moreover, the 2007 shallow Secchi depth readings for Grand Lake appear to be related to the 2006 drawdown event (Hydros Consulting Inc., 2012a). Reservoir drawdowns can result in increases in non-algal organic particulate matter which subsequently decomposes into bioavailable forms of phosphorus and nitrogen that benefit algal production. Increases in both non-algal particulate matter and chlorophyll a (due to increases in inorganic nutrients) have a negative effect on water clarity in Grand Lake and Shadow Mountain Reservoir (Hydros Consulting Inc., 2012a). During the 2012 aquatic plant survey numerous floating plant fragments were observed in Shadow Mountain Reservoir which were likely produced from various environmental factors including plant senescing, wind action, recreational activities (Sisneros, 2012). Based on these observations, the control of aquatic macrophytes, from a water clarity perspective, will be impractical to pursue using a drawdown management strategy or an aquatic macrophyte harvest strategy, because the senescence or harvested plants would need to be completely removed from the water body to minimize the effect of non-algal particulate matter on water clarity.

3.2.4 Stormwater Management

Stormwater has been shown to have an effect on inorganic suspended sediment, phosphorus and nitrogen loads to the Three Lakes System when evaluated in the context of the Three Lakes Water Quality Model. Inclusion of stormwater hydrological inputs and the limited nutrient chemistry in the model improved its calibration. The inclusion of stormwater contributions in the model, triggered by quantity and timing of rainfall has indicated that stormwater contributions to the Three Lakes may have an important role in water clarity.

The increased nutrient loads can increase algal growth and chlorophyll *a* content which decreases water clarity, while the increased inorganic suspended sediment can decrease water clarity too. However, the specific effects of stormwater on each water body remain a poorly understood process and current knowledge is based on model assumptions that have not been verified by site-specific stormwater data.

The benefits of stormwater management or best management practices on water clarity in Grand Lake have also not been fully evaluated. Watershed management should be key focus for future studies, because at a minimum these practices should be implemented in conjunction with the selected water clarity alternative. In 2009, the Town of Grand Lake installed an Aqua Filter Stormwater System (AquaShield™) to help manage the stormwater inflows from surrounding impervious land use areas to Grand Lake. Although data evaluating the performance of this system, such as the reduction of suspended sediment and phosphorus in stormwater inflows to Grand Lake, is not available.

Even though stormwater or watershed management control (i.e., erosion control) will likely not improve water clarity in Grand Lake as a stand-alone alternative, these management strategies should be considered as a component to any water clarity implementation alternative. Regardless of alternatives where pumped inflows bypass Grand Lake, stormwater inflows will still continue to provide sediment and nutrient inputs that could diminish water clarity.

3.3 Existing Models

3.3.1 Three Lakes Water Quality Model

The Three Lakes Water Quality Model was developed by Hydros over a number of years, and it has been used for water quality assessments in the WGFP EIS (Reclamation, 2011) and has been periodically updated and refined (Hydrosphere Resource Consultants, 2008). The Three Lakes Water Quality Model is a dynamic, mechanistic water quality model that simulates flow and water quality of Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir. Model development (Excel VBA model) began with the Clean Lakes Study (Hydrosphere Resource Consultants, 2003) and has been periodically updated to meet new objectives, such as the evaluation of the WGFP (Reclamation, 2008c). The model is a nutrient-food chain model that simulates constituents associated with the eutrophication process, with the mathematical equations being similar to those used in the LAKE2K model (Chapra and Martin, 2004). The nutrient-food chain model kinetics includes the transformation of organic nutrients (carbon, nitrogen, phosphorus) to inorganic fractions via hydrolysis, and the uptake by two major algal groups (diatoms and cyanobacteria) via photosynthesis. The model kinetics also includes the first-order rates for respiration/excretion and grazing/death that link primary producers (algae) with primary and secondary consumers (zooplankton). The model theory, assumptions and limitations are discussed in greater detail in the model documentation (Hydrosphere Resource Consultants, 2008). The existing Three Lakes Model provides the only tool currently available to evaluate the achievability rate of the proposed numerical Secchi depth standard given simulated future hydrological scenarios for C-BT operations.

Grand Lake and Granby Reservoir are simulated as three-layer stratified systems (e.g., epilimnion, metalimnion, and hypolimnion) with fixed layer thicknesses except for the hypolimnion thickness that varies over time according to hydrological inputs and outflows (e.g., lake level). As such, thermal stratification and turnover are controlled by a set of operational rules rather than boundary conditions such as climate or thermal mass inputs. The assumption is made that within each layer of the Grand Lake and Granby Reservoir components there is instantaneous dispersion of constituents through-out the entire layer, which may not be the case in the thicker hypolimnion layers. Shadow Mountain Reservoir is modeled as a well-mixed single layer system; hence there is no spatial variability in Shadow Mountain Reservoir. The model requires daily time step of hydrological inflows (e.g., tributary and pumped flows) along with a corresponding daily time step water quality characteristics (e.g., nutrients and suspended solids) to simulate water quality conditions in the outflow water and each of the three water bodies (Table 4). The daily water quality time series for each inflow was developed using the time-interval method described in Scheider et al. (1979).

Table 4: Simulated Water Quality Parameters for the Three Lakes, Outflow from Granby Reservoir, and Adams Tunnel Flows

Constituents
Nutrients
Total Phosphorus
Orthophosphate
Total Nitrogen
Ammonia
Nitrate/Nitrite
Dissolved Oxygen
Chlorophyll *a*
Secchi Disk Depth
Total Suspended Solids
Total Organic Carbon

3.3.2 Water Supply Operations Spreadsheet

The Water Supply Operations Spreadsheet is a simple spreadsheet model that was used for the 2012 Alternatives Study. It assumes the ability to operate the east slope facilities to optimize east slope storage and water delivery (i.e., the ability to properly position water in all east slope reservoirs to meet all delivery requirements). The spreadsheet modeling is performed on a monthly time step. Key features of this model, which also provided monthly flow estimates to assess power generation impacts, include:

1. The model uses the same 47-year analysis period (Water Years 1950-1996) as that used in the WGFP EIS (Reclamation, 2011).

2. The model uses the same C-BT Project demands as those used in the WGFP EIS. Under that model's assumptions, the average annual C-BT Project demand is 234,556 acre-feet/year.

3. The model uses the same Windy Gap Project demands as those used in the Preferred Alternative with Cumulative Effects Analysis in the WGFP EIS. Under those conditions, the average annual east slope Windy Gap Project demands are 25,664 acre-feet/year.

4. On the west slope, the Three Lakes system is considered to be one large reservoir that is not supply limited, meaning that the system has sufficient storage capacity and/or inflow to meet all desired Adams Tunnel diversion requirements; the Farr Plant can be operated in a manner consistent with those diversion requirements; and the combination of Adams Tunnel diversions and Granby Reservoir capacity is sufficient to keep from spilling inflow to the system that would result in a loss of C-BT Project yield.

5. To assure maximum utilization of the east slope C-BT Project water rights, diversion of Big Thompson River water to storage is considered as the first supply for meeting east slope reservoir storage needs.

6. To assure that sufficient water supplies are available on the East Slope, diversions of west slope water through the Adams Tunnel are always maximized to the extent possible.

7. Diversion of Big Thompson River water for power generation is given lowest priority for available Olympus Tunnel capacity. However, the diversion is maximized by using all remaining tunnel capacity after consideration of diversion of Big Thompson River water to C-BT Project storage and Adams Tunnel diversions.

8. Horsetooth Reservoir, Carter Lake, and the proposed WGFP Project east slope storage facility are conceptualized as one large storage reservoir with an active capacity of 326,000 acre-feet.

9. East slope reservoir evaporation is computed from average monthly evaporation rates used in the Bureau of Reclamation's monthly operations planning model.

10. Seepage from the C-BT Project system is estimated to be 200 acre-feet/month.

11. East slope demands, both C-BT Project and Windy Gap, are all considered to be delivered from the conceptualized large east slope reservoir. The monthly C-BT Project and Windy Gap delivery amounts were obtained from the WGFP EIS for the Preferred Alternative in Water Supply Operations Spreadsheet.

12. The end of month content for the one large east slope reservoir is computed based on inflows from the various sources, less evaporation and seepage.

13. If the content for the one large east slope reservoir is insufficient to meet demands, the demands are shorted to the extent necessary.

3.3.3 Power Operations Spreadsheet

The Power Operations Spreadsheet presented in the 2012 Alternatives Report was formulated to provide a simplified model for assessing the power generation impacts that could result from implementing changes in operations of the Three Lakes system to improve water clarity in Grand Lake. The model computations determine the power impacts based on the relationship between monthly flow volume and generation at each C-BT power plant (Marys Lake, Estes, Pole Hill, Flatiron, and Big Thompson). The model uses a dataset from the 47-year period from WY 1950 through WY 1996.

The Power Operations Model was used in the 2012 Alternatives Report to analyze impacts to power generation under the stop-pumping and no-pumping scenarios. The power plant inflow assumptions used in the analysis are identified below:

- Monthly Big Thompson power plant power generation was assumed to be the same for all of the alternatives. Big Thompson power generation was assumed to be identical to that for the WGFP EIS Preferred Alternative.

- The monthly volume of water through each power plant was set at or above the minimum operating flow rate.

- Flows were routed through Marys and Pole Hill power plants in a manner that minimized the need to bypass flows.

- Flows into Marys Lake and Pole Hill power plants are varied for the stop-pump and modify-pump alternatives. For the bypass alternatives, flows to these two power plants are the same as those used in the WGFP EIS for the Preferred Alternative (WGFP EIS Alternative 2, Chimney Hollow with pre-positioning).

- With the multiple generating units at Estes and Flatiron power plants, it was assumed that capacity is always available to generate with the flows routed through those power plants.

- Due to the unknown connection between the C-BT east slope power system and Chimney Hollow reservoir and the simplifying assumptions in the operations analysis, it was assumed that water routed to Chimney Hollow Reservoir would flow through the Flatiron power plant and be pumped up to Chimney Hollow.

- Because the generation flows are monthly, no attempt was made to analyze differences between on-peak versus off-peak generation.

- For the Grand Lake bypass alternatives, the diversion of Big Thompson River water for power generation was adjusted to accommodate differing Big Thompson River hydrology between the WGFP EIS model runs.

The power impacts analysis in the 2012 Alternatives Report uses the Adams Tunnel and Olympus Tunnel flows generated in the C-BT monthly operations calculations to estimate the monthly power generation that would result from implementation of several identified water clarity improvement alternatives. Power generation computations for the 2012 Alternatives Report were performed as follows:

- For each power plant the relationship between monthly flow volume and generation was obtained from the model used by Reclamation for developing its annual operating plans.

- Marys Lake power plant generation was determined on a monthly basis based on the Adams Tunnel flow volume that did not bypass the power plant. Due to maintenance operations it was possible that some of this volume must bypass the power plant. The volume of bypass flow was determined by subtracting the Adams Tunnel flow from the maintenance-adjusted capacity of the power plant. The maintenance-adjusted capacity of the power plant was computed as the percentage of the month that the power plant was operational by the monthly capacity of the power plant.

- Estes power plant generation was estimated on a monthly basis using the Adams Tunnel flow volume. Because the Estes power plant has multiple generating units, no reduction in capacity was applied.

- Pole Hill power plant generation was determined on a monthly basis using the Olympus Tunnel flow volume that did not bypass the power plant. Due to maintenance operations it was possible that some of this volume must bypass the power plant. The volume of bypass flow was determined by subtracting the Olympus Tunnel flow from the maintenance-adjusted capacity of the power plant. The maintenance-adjusted capacity of the power plant was computed as the percentage of the month that the power plant was operational by the monthly capacity of the power plant.

- Flatiron power plant generation was determined on a monthly basis using the Olympus Tunnel flow volume. Because Flatiron power plant has multiple generating units, no reduction in capacity was applied.

- As described in the assumptions above, the Big Thompson power plant generation is assumed to be the same as that for the WGFP EIS Preferred Alternative.

A number of key assumptions were made to develop logic for the spreadsheet analysis of power generation impacts. Under a “no-action” condition, future C-BT Project operations, and therefore the power generation, are anticipated to be similar to that described in the WGFP EIS for the Preferred Alternative. The power impacts associated with the structural alternatives for addressing Grand Lake water clarity were evaluated assuming that C-BT Project operations would be similar to those under the no-action condition. For the non-structural options for clarity improvement, C-BT power plant availability was reduced in the “stop-pump” and “modify-pump” periods.

Results presented in the 2012 Alternatives Report indicate that the stop-pump and modify-pump alternatives do not significantly reduce average annual generation. However, power generation is significantly reduced in the July-September period for the stop-pump alternative and moderately reduced for the modify-pump alternative. Reduction of generation in the peak power demand months could impact the marketability of C-BT power and reduce revenues.

4.0 Identified Data Gaps

Through the process of reviewing the project documents, GEI identified several instances where additional information is required prior to the analysis of alternatives. These items are referred to as "Data Gaps" and differ from studies and investigations that will be required for design of an alternative (further discussed in Section 6.0). Table 5 presents the identified Data Gaps. A detailed explanation of each Data Gap is provided in the text following Table 5.

Table 5: Identified Data Gaps

Data Gap
Identify and involve additional stakeholders
Define "water quality" for the Three Lakes System
Evaluate the effect on aquatic life use
Other Sampling Considerations
Monitor and evaluate the effect of stormwater runoff
Determine the effect of pumping initiation on Grand Lake clarity
Review and update the Three Lakes Water Quality Model
Review the numerical clarity standard value and collection methodology
Review of the water supply operations spreadsheet and development of a water supply operations model for evaluating alternatives and quantity revenue/cost impacts
Review of the power operations spreadsheet and development of the a power operations spreadsheet for evaluating alternatives and quantity revenue/cost impacts

4.1 Identify and Involve Additional Stakeholders

The high visibility and complex nature of this project will complicate the next phase of the work. It is critical the upcoming work be conducted using a transparent process and that all public and private stakeholders be identified and involved throughout the process. Their cooperation and input will be critical to the alternative selection process.

The current stakeholders involved in the development of the Technical Review represent those parties directly involved with the C-BT operations and include:

- Grand County;
- Mid-West Electric Consumers Association (MWECA);
- Northern Colorado Water Conservancy District (Northern Water);
- U.S. Bureau of Reclamation (USBR);
- U.S. Forest Service (USFS);
- U.S. Geological Survey (USGS);
- Western Area Power Administration (WAPA); and
- Western States Power Corporation (WSPC).

4.2 Define “Water Quality” for the Three Lakes System

Owing to the complexity of the C-BT system and the multi-directional flows, each waterbody has developed a key set of data reflecting “water quality” characteristics that affects the adjacent waterbodies in one fashion or another. As a result, the term “water quality” may have different meanings depending on the context in which it is used.

With respect to Grand Lake, “water quality” often refers to water clarity (as measured by Secchi Depth). In Shadow Mountain Reservoir, the term “water quality” may refer to water clarity, but additional characteristics include temperature, chlorophyll *a*, nutrients (total phosphorus and total nitrogen), suspended sediment, or dissolved oxygen. In Granby Reservoir, because the C-BT water is usually pumped from the upper portion of the hypolimnion, “water quality” often refers to the dissolved oxygen content or internal nutrient loading fractions (soluble reactive phosphorus, dissolved inorganic nitrogen). Water delivered from the North or East inlets into the Adams Tunnel has yet another set of “water quality” characteristics. Currently, the water quality characteristics of C-BT water passing through the Adams Tunnel have not been well defined.

4.2.1 Review of Regulatory Water Quality Standards

As part of defining “water quality” it will be important to consider current and future regulatory water quality standards. Future regulatory water quality standards, such as interim nutrient criteria or the new direct use water supply (DUWS) regulations should also be considered and addressed as the project advances.

The interim nutrient criteria will follow a phased implementation approach such that the phosphorus criteria for headwater streams may be adopted prior to May 31, 2022, while nitrogen criteria may be adopted after May 31, 2017 and prior to May 31, 2022. After May 31, 2022 nutrient criteria should be in effect for all water body types (i.e., lakes/reservoirs and rivers/streams). The new DUWS criterion is based on chlorophyll *a* concentrations with discretionary application by the WQCC to lakes and reservoirs that transfer water directly via a pipeline to a water treatment facility. The C-BT system as currently configured appears to be a candidate for the new DUWS chlorophyll *a* criteria, given the YMCA of the Rockies Estes Park Center direct use of C-BT water for a portion of the year; although clarification by the WQCC is needed.

While many of the above mentioned water quality characteristics have statutory limits or concentrations tied to them via WQCC Regulations 31 and 33, as well as Reg. 93 for 303(d) assessment purposes, that does not preclude the possibility of achieving the best possible conditions when water clarity improvement alternatives are considered or implemented. However, from an Alternatives Analysis perspective, achieving the best possible water clarity in Grand Lake should be the primary consideration. The other aspects of “water quality” in Shadow Mountain Reservoir, Granby Reservoir, and C-BT water being delivered to Horsetooth Reservoir, and Carter Reservoir will provide key information regarding secondary goals of each alternative.

4.3 Evaluate Effects on Aquatic Life Use

Colorado water quality standards are developed to protect the most sensitive beneficial use for the waterbody. In the case of the Grand Lake water clarity standards, that use is recreation which encompasses the scenic and uniqueness of Colorado's largest natural lake. Nonetheless, it is important to consider the potential effects to aquatic life use in the Three Lakes regarding the implementation of any water clarity improvement alternative. The bypass alternatives that eliminate pumped inflows to Grand Lake will decrease the nutrient inputs and may likely change the dynamics of the food web that supports the lake trout, kokanee and brown trout fishery. The fisheries in Grand Lake and Granby Reservoir have been managed by the Colorado Parks and Wildlife to optimize the growth of lake trout and kokanee because of the preferential habitat use of each species (Ewert, 2013). The deep water volume of Grand Lake and Granby Reservoir offers a range of thermal habitats that supports different forage bases (zooplankton – Daphnia and Mysis shrimp) for each fish. Kokanee prefer the warmer epilimnion water where their primary forage base (Daphnia) tend to grow better, while lake trout and their forage base (Mysis shrimp) prefer the cooler hypolimnion water. Thus, the success of the forage base and each fish species growth often relies on the thermal regimes as well as the primary producers (algae) that support growth of the zooplankton. Altering this food chain dynamic by potentially changing the nutrient dynamics should be studied more closely for Grand Lake and Granby Reservoir, to better understand the potential responses of aquatic life use.

4.4 Other Sampling Considerations

The sampling plans listed in Appendix F describe proposed collection effort for each component of the C-BT system. The sampling plan lists the constituent or parameter to be measured, the frequency of measurement, and the location(s) of collection. The constituent list was based on the current monitoring efforts and provides a level of frequency that is often desired when evaluating patterns in water quality conditions that exhibit seasonal and annual patterns. It is important to emphasize the routine monitoring of key constituents related to eutrophication process, even though their relative importance may not be considered during periods when water quality impacts are not observed. Maintaining a set of baseline conditions given the unique water movement conditions superimposed upon climate dependent hydrological flows will be important information during the evaluation of secondary water quality effects.

Because the Grand Lake water clarity standard is the first such standard for Colorado, there is little information regarding the July to September pattern in natural lakes and the range observed for Secchi depth during the growing season, especially in a standards assessment context. This information may provide insight into constraints of present day climatic conditions on water clarity (e.g., increased water temperature and algal response), and what might be an appropriate assessment methodology or attainable Secchi depth standard in other natural lakes. Therefore, it may be beneficial to compile a Secchi depth dataset that characterizes water clarity in other natural lake(s) of similar stratification characteristics and runoff that are absent of pumped inflows like the Three Lakes System. Currently, Secchi depth datasets exist for Columbine Lake and Trapper's Lake. These lakes are both natural mountain lakes that might be used to analyze the natural variation in Secchi depth as it relates to seasonal algal growth and storm event conditions.

4.5 Monitor and Evaluate the Effect of Stormwater Runoff

The effect of stormwater runoff from tributary inputs such as the North Fork Colorado River on water clarity in Grand Lake and Shadow Mountain Reservoir are poorly understood. Stormwater or non-point source runoff in urbanized areas has the potential to deliver a substantial amount of suspended sediment to these water bodies and the effect of this sediment and associated nutrient loading on water clarity and/or algal production in the Three Lakes System has not been completely studied. Non-point source runoff generally results from overland runoff created by rainfall or snowmelt conditions that flush atmospheric deposition, urbanized drainage, eroded sediment, or other seepages into nearby waterbodies. Therefore as a first step, characterizing stormwater conditions which represent a composite of multiple non-point source conditions will provide the initial assessment that may be used to formulate conclusions regarding the effectiveness of watershed management in the context of water clarity improvement alternatives. Following the initial assessment of stormwater conditions, it may be determined that key non-point sources may need further evaluation. For example, the effect of non-point sources such as residential septic systems may be an important source of nutrients given proximity to each water body.

The North Fork of the Colorado River can be a large source of phosphorus and nitrogen to Shadow Mountain Reservoir, especially during snow melt runoff or stormflows. The erosive streambank conditions in the upper watershed also provide a substantial influx of suspended sediment to Shadow Mountain Reservoir. When placed in the context of potential resuspension of inorganic particulate matter in Shadow Mountain Reservoir, this may affect water clarity in Grand Lake. A quantitative size-distribution characterization of deposited sediment in the North Fork Colorado River delta along with nutrient analyses could help to define conditions for resuspension of sediment and poorer water clarity related to algal growth in Shadow Mountain Reservoir. Dr. McCutchan's (University of Colorado at Boulder, Center for Limnology) on-going 2013 Particle Study should provide some insight into the sources and size class of suspended sediment in the North Fork of the Colorado River and its effect on water clarity in Shadow Mountain Reservoir and Grand Lake.

Based on the 2007-2009 nutrient loading data to the Three Lakes System, the Windy Gap and Willow Creek reservoirs provide a substantial influx of nutrients to Granby Reservoir that can range on order of magnitude of 3.4 times and 1.6 times greater than the load supplied to the system by the North Fork Colorado River, respectively. These contributions may eventually be part of the Granby Pump Canal inflows to Shadow Mountain Reservoir which can be 7 times the load of the North Fork Colorado River. These other pumped inflows contain stormwater contributions to the Three Lakes that have not been specifically quantified or evaluated for secondary water quality effects on the system.

Date collected from the tributary and pumped inflows should be evaluated in the context of watershed management strategies that may be considered as stand-alone alternatives or paired with other potential alternatives to help achieve the water clarity standard in Grand Lake or secondary water quality considerations for Shadow Mountain and Granby reservoirs. The inclusion of limited stormwater inputs to the Three Lakes Water Quality Model has enhanced the relationship between simulated and observed nutrient concentrations in the Three Lakes. However, the model requires further validation with a more extensive stormwater data set to fully evaluate the accuracy of the model with respect to the influence of stormwater on water clarity in Grand Lake or secondary water quality parameters in the other reservoirs. Then the model may be used to evaluate the effects of stormwater/watershed management in the context of the water clarity improvement alternatives.

4.6 Factors Influencing Water Clarity in Grand Lake

The dynamics of water clarity are being further explored by the TLTC, and key factors of water clarity appear to be strongly linked to the pumping of C-BT water at full capacity especially when the initiation of pumping is performed without ramping up the flow rates. A better understanding of the effects of pumped flows, with and without ramping, is needed to clarify the effects on Grand Lake water clarity. In addition, it is not clearly understood whether Grand Lake or its tributaries provide any dilution potential for water clarity or other water quality parameters during summer-time modified-pumping levels when the clarity standard would be assessed. Currently, the epilimnetic residence time in Grand Lake during pumped inflows is approximately 4-6 days, thus it would appear that there may be little benefit to dilution except for the first week of pumping. Therefore, a spatial and temporal analysis of the hydrodynamics within Grand Lake will help elucidate factors that may affect water clarity and other water quality parameters of water being pumped through the Adams Tunnel. This may also include whether the North and East inlets or the Grand Lake outlet will be able to provide any dilution potential regarding selected water quality parameters that may be important to consider with respect to the water clarity improvement alternatives considered.

While the current monitoring efforts have shown linkages to water clarity patterns, these linkages do not provide sufficient certainty that the water clarity standard will be achieved under conditions that the water clarity improvement alternatives may present. For example, during periods of modified pumping, what is the certainty (uncertainty) associated with attaining the water clarity standard, and does the type of water year (e.g., typical or wet year) have an effect on the attainability of the standard? Furthermore, in the absence of any pumping, what is the certainty associated with attaining the water clarity standard given the effect of algal growth? These types of questions should be addressed through reservoir water quality modeling with an updated version of Three Lakes Water Quality Model or a model that can be used to evaluate future scenarios based on C-BT operation and considering the types of water year if they have a substantial flushing or dilution effect on water clarity. The adequacy of the updated Three Lakes Water Quality Model needs to be evaluated given the context of questions or objectives that need to be answered during the water clarity improvement alternatives analysis process.

Other questions such as the timing of when the bypass alternative may be required to operate should also be considered in the context of Grand Lake water clarity. Currently, winter-time pumping occurs which is outside of the water clarity standard of assessment period, and also during a time when the lake is mostly ice-covered. Therefore, should the bypass alternatives only operate during the July through September water clarity assessment period? Should the effects of the winter-time pumping on the July through September water clarity be considered? Obviously, there are multiple factors to consider during these scenarios. What is the effect of winter-time pumping on water clarity; what is effect of snow-melt runoff (i.e., increased turbidity) on water clarity and will runoff mask any potential effects of winter-time pumping if a summer bypass occurs? These questions should be addressed through reservoir water quality modeling. In 2013, the Three Lakes Model simulates year-round and multi-year conditions, so that “time sensitive” scenarios may be simulated with the current version of the model.

4.7 Review and Update the Three Lakes Water Quality Model

The Three Lakes Water Quality Model was calibrated by adjusting model parameters to obtain the best match between model predictions and measured water quality data (Hydrosphere Resource Consultants, 2008). An iterative process involved attempts to match patterns and the average conditions in water quality data. Goodness-of-fit techniques using graphical time-series and statistical analyses were used to evaluate the model calibration. The 2008 Three Lakes Model simulations captured seasonal patterns in the data (i.e., chlorophyll and Secchi depth) and did a good job of predicting average concentrations, but under-estimated the maximum chlorophyll concentrations and Secchi depth. By 2013, modifications to the model and subsequent refinements improved the simulation of chlorophyll and Secchi depth, although the model does not incorporate information from the concurrent Particle Analysis study by McCutchan (2013).

Because the current assessment methodology for the Secchi depth (e.g., 15th percentile) describes the tails of the data distribution rather than the central tendency, the model output should adequately describe the range of Secchi depth measurements. As noted above the model may adequately predict average Secchi depth over the season, but may need to improve the prediction of shallower Secchi depth conditions to increase the confidence in addressing the attainability of the standard.

The statistical error (absolute mean error, AME) between model predictions and measured Secchi depth in Grand Lake for the July to September 15 time frame ranged from ± 0.52 m in 2008 to ± 0.81 m in 2009, with a 2008-2010 average of ± 0.73 m. When the model was validated using the 2011 data, the AME was ± 0.47 m. This indicates that for each measured Secchi depth value during July 1 to September 15, 2011, the predicted Secchi depth value was within ± 0.47 m of the measured value. When the 90^{th} percentile confidence intervals are applied to the 0.47 m AME for 2011, the model predicts Secchi depth to within ± 0.67 m of the measure value. This model error incorporates the error in measuring Secchi depth (i.e., 10 percent measurement error), which on average by itself would result in ± 0.40 m difference from the true Secchi depth.

The stakeholders will need to determine whether the level of error associated with predicting Secchi depth (primary goal) or other water quality parameters such as dissolved oxygen, nutrients, or chlorophyll *a* (secondary goal) are within their acceptable range. It is uncertain how the different types of error (i.e., model and measurement) will affect the prediction of attaining the 4-m Secchi Depth standard or other water quality end-points. As noted in the Three Lakes Water Quality Model documentation (Hydrosphere Resource Consultants, 2008) there are no widely accepted levels for model error, and that literature indicates a range of 30-45 percent is common in similar eutrophication models.

4.7.1 Possible Updates to the Three Lakes Water Quality Model

In November 2009, the existing Three Lakes Water Quality Model was reviewed by a selected technical expert panel to identify potential issues with the model that may help refine model output and increase the confidence in that model to address questions posed by the Three Lakes Technical Committee. That review resulted in a list of topics that was explored in more detail 1) Nutrient Sources, 2) Grand Lake Clarity, 3) Dissolved Oxygen, 4) Algae Blooms, and 5) Weed Growth. Given the list of issues identified, the modeling team provided a technical consensus memorandum (Bender et al, 2010) outlining steps that could be taken to address each issue, whether it was a model refinement or data collection effort. Subsequent Three Lakes Water Quality Model reviews took place in January 2011 and October 2011.

A key component of the Alternative Analysis process will be to conduct a peer-review of the Three Lakes Water Quality Model, to provide a level of quality assurance with model development and refinement as it has occurred over a number of years. This should include a review of the Excel VBA code as well as the theory and equations used to develop this custom water quality model. In addition, there needs to be a consensus opinion on the acceptable level of model accuracy that is needed to answer the question:

What is the predicted level of confidence that the selected alternative(s) can attain the proposed numerical Secchi depth standard for Grand Lake?

As of January 2011, the model was deemed to be adequate for the "questions posed" by the TLTC, but it is not apparent whether the model can adequately address questions regarding attainability of the water clarity standard or other water quality standards. Furthermore, the "attainability" aspect should be evaluated in the context of the Commission's definition of attainability discussed above. There also needs to be a consensus on how to manage the different expectations for the model.

In January 2011, the modeling team also stated "*that the development of another type of model is not warranted*." While attainment of the proposed numerical Grand Lake Secchi standard is one of the primary foci for alternatives analysis, the general water quality conditions of Shadow Mountain Reservoir and Granby Reservoir appear to be secondary foci as there are concerns for degraded water quality conditions post implementation of various alternatives, as well as concern for providing the best possible water quality for C-BT purposes. It is not clearly evident that a more spatially complex hydrodynamic model would provide a greater comfort level regarding model error and accuracy. However, any concerns given the spatial dynamics in water quality conditions for Shadow Mountain Reservoir may be addressed by modifying the existing Three Lakes Water Quality Model (i.e., longitudinally compartmentalize Shadow Mountain Reservoir) to determine whether spatial water quality conditions should be considered.

Furthermore, the Three Lakes Water Quality Model is constructed such that interflows can be turned off/on and that simulated daily flow conditions (i.e., dry year) can be evaluated in an alternatives scenario context. However, to evaluate alternative hydrological or water quality scenarios, corresponding daily time-series data for flow, nutrients, suspended solids and other water quality data would need to be simulated prior to model input.. In this regard, the Three Lakes Water Quality Model appears to adequately address the questions regarding the effects/benefits of various alternatives, given rerouted flows or modified pumping.

4.8 Review the Numerical Clarity Assessment Methodology

The assessment of the numerical Secchi depth standard will have an important role in the future evaluation of water clarity as well as evaluating output from the Three Lakes Water Quality Model analyses. As discussed above, the model may be used in part to evaluate alternatives in the context of attaining the proposed numerical Secchi depth standard. A consistent and well-defined assessment approach will be important for comparing modeled versus observed compliance of the Secchi depth standard in future analyses.

Site-specific water quality standards are often developed based on an 85^{th} percentile methodology (or 15^{th} percentile depending upon data distribution characteristics) for establishing chronic ambient quality-based standards for normally distributed data. This approach is commonly used for site-specific nutrient and metals standards where ambient quality exceeds table values, but is determined adequate to protect uses. However, in the case of Grand Lake numerical Secchi Depth standard, there appears to be uncertainty regarding the assessment methodology and data required to evaluate the attainment or error associated with the 15th percentile approach. This uncertainty may be related to the frequency of data collection used to develop the ambient based Secchi depth standard or the frequency of data collection associated with the assessment methodology. Ideally, the data conditions should be very similar between site-specific standard development and its assessment methodology. For these reasons, the uncertainty or error associated with the 85th percentile (15th) of Secchi depth data may be evaluated from a standards attainment perspective given sample size and its potential effect on beneficial uses. Since 2008, there has been a considerable effort by the stakeholders to evaluate the factors that control water clarity in Grand Lake, and these data may provide more insight into an appropriate assessment methodology.

While the current focus of the TLTC is to provide a better understanding of the mechanisms responsible for the poor water clarity in Grand Lake, a high level of uncertainly associated with the assessment methodology still exists. The existing assessment methodology implies that multiple measurements collected on the same day be averaged, and that no more than 15 percent of the daily values collected between July 1 and September 30 can be less than the Secchi depth standard. In 2011, 468 Secchi depth measurements were recorded. Based on the data tables and figures provided, it appears that approximately 400 of 468 measurements were made during the assessment period, and that these 400 values were condensed to 37 assessment values. Therefore, only 6 assessment values (i.e., 15th percentile) out of the 37 assessment values could be less than the 4-m assessment value. During the 2011 assessment period, 9 values (25th percentile) were less than 4-m assessment value. There may be better assessment approaches developed for this metric as it becomes better understood in the context of a natural down-gradient flow (bypass) or modified-pumping scenarios.

4.9 Review of Water Supply Operations Spreadsheet and Development of Water Supply Operations Model for Evaluating Alternatives and Quantity Revenue/Cost Impacts

For the “no-action” alternative with respect to implementing measures to improve water quality in Grand Lake, the 2012 Alternatives Study assumed that C-BT Project operations would be similar to those described in the WGFP EIS Alternatives. Under the structural alternatives it was assumed that C-BT Project operations would also be similar to those under the Preferred Alternatives. East Slope deliveries under the non-structural alternatives were assessed using a simple monthly spreadsheet model.

The spreadsheet operational model developed for the 2012 Alternatives Study assumes the ability to operate the east slope facilities to optimize east slope storage and water delivery (i.e. the ability to properly position water in all east slope reservoirs to meet all delivery requirements). The spreadsheet modeling is performed on a monthly time step. This is adequate for preliminary assessment of water supply and power generation impacts of potential non-structural alternatives. However, the simplifying assumptions and monthly timestep used in the Water Supply Operations Spreadsheet render it inadequate for fully analyzing the ability of each alternative to meet the water supply requirements of the Project. Further, the hydrology and operations under each alternative are the basis for analysis of both water quality and power generation. To analyze water quality and power generation under each alternative, the results of an operational model will have to be used as input to both the Three Lakes Water Quality model and a Power Operations/Analysis model. Therefore, a new Water Supply Operations model will have to be developed or Reclamation's existing annual operations model will have to be modified.

4.10 Review of Power Operations Spreadsheet and Development of Power Operations Model for Evaluating Alternatives and Quantity Revenue/Cost Impacts

The assumptions noted in Section 3.3.3 result in changes to the timing and volume of flows to the Adams Tunnel and the East Slope facilities of the C-BT system and to the planned Chimney Hollow Reservoir that will need to be carefully reviewed in future studies. Modeling of flows and power generation for both the non-structural and structural alternatives for Grand Lake water clarity improvements should be performed on a daily time step rather than a monthly time step. This will enable more reliable determination of impacts to power generation. Also, an assessment will need to be made of the impacts associated with reduced power production on the marketing and sales of power and energy from the C-BT system.

The 2012 Alternatives Report does not quantify the revenue impacts associated with reducing generation in the high demand months that would occur with the stop-pump and modify-pump alternatives or the costs of obtaining additional pumping power for the identified bypass alternatives. The differences between the value of on-peak and off-peak hydroelectric generation can be significant depending on the power market conditions. Typically, the value of on-peak power can be a factor of 2 to 3 times higher than the off-peak value. Further, hydroelectric projects like the C-BT plants on the East Slope that provide peaking capacity, black-start and load-following benefits generate ancillary benefits that are valued in the electrical grid. If these benefits are reduced in the peak demand months, additional adverse revenue impacts will occur and must be quantified in future studies.

Hourly operations simulations are likely to be required during critical demand periods to assess these impacts to the C-BT system. The simplifying assumptions and monthly timestep used in the existing Power Operations Spreadsheet render it inadequate for fully analyzing the power generation impacts of each alternative. Therefore, a Power Operations model utilizing a daily or hourly timestep will need to be developed to adequately assess power generation impacts.

5.0 Existing Alternatives and Alternative Selection Process

5.1 Overview of Alternatives Development

The Preliminary Alternatives Development Report (Alternatives Report) evaluated 15 potential alternatives for more detailed review and evaluation:

> *Through stakeholder input and input from the external peer review panel, some of these proposed solutions are not evaluated further in [the Alternatives Report] in order to focus effort on alternatives that appeared to have the highest likelihood of meeting the goal of this report. However, this does not preclude analysis of these as alternatives into the future.* (pg. ES-4, Reclamation, 2012)

During initial discussions, the stakeholders requested that all of the identified alternatives be re-introduced and evaluated as part of the future Work Plan. Additionally, several alternatives not included in the Alternatives Report were identified during discussions with the stakeholders. The now 22 alternatives are organized into five categories:

- Structural Bypass (structural solutions that bypass Grand Lake and/or Shadow Mountain Reservoir);
- Other Structural (structural solutions that reconfigure some portions of the Three Lakes System);
- Operational (modifications to the pumping regime);
- Watershed Management (sediment controls and BMPs located upstream of Grand Lake); and
- No Action.

The 22 alternatives are briefly described in Table 6. The Alternatives Report can be consulted for more complete descriptions of many of these alternatives.

Table 6: Summary of Alternatives

Alternative Type	Alternative Name	Description
Structural Bypass	Alternative A	Intake and pumping station at Shadow Mountain Reservoir and a buried pipeline leading to a discharge structure at the Adams Tunnel portal
Structural Bypass	Alternative B	Intake and pumping station at Shadow Mountain Reservoir and a submerged (marine) pipeline in Grand Lake leading to the Adams Tunnel portal
Structural Bypass	Alternative C	Intake and pumping station at Shadow Mountain Reservoir and a “floating pipeline” in Grand Lake leading to the Adams Tunnel portal
Structural Bypass	Alternative D	Intake and pumping station at Shadow Mountain Reservoir and a water conveyance tunnel to connect with the Adams Tunnel
Structural Bypass	Alternative E	Provision of a removable (seasonal) boating course and submerged funnel-shaped curtain deflectors to reduce mixing in the top 4 feet of Grand Lake
Structural Bypass	Alternative F	Intake and pumping station at the Granby Pump Canal and a buried pipeline leading to a discharge structure at the Adams Tunnel portal (this would bypass both Shadow Mountain and Grand Lake)
Structural Bypass	Alternative G	Intake and pumping station at the Granby Pump Canal and a water conveyance tunnel to connect with the Adams Tunnel (this would bypass both Shadow Mountain and Grand Lake)
Structural Bypass	Alternative H	Diversion of a portion of Granby Water via a bypass pipeline to the upper end of Grand Lake with discharge at depth and release through a conical outlet structure.
Other Structural	Alternative I	Remove Shadow Mountain Dam and provide corresponding changes to the water conveyance system between Granby Reservoir and Grand Lake
Other Structural	Alternative J	Reduce operating pool of Shadow Mountain Reservoir and deepen reservoir near the dam to serve as a forebay for a pumping station and bypass pipeline similar to Alternative C. Restore reaches of the Colorado River and North Fork Colorado River in portion of Shadow Mountain Reservoir absent of storage
Other Structural	Alternative K	Deepen Shadow Mountain Reservoir by dredging or deepen and narrow this reservoir to improve water quality
Other Structural	Alternative L	Provide aeration/oxygenation facilities in Shadow Mountain Reservoir to improve water quality
Other Structural	Alternative M	Drain Shadow Mountain Reservoir and remove debris, algae (i.e. scrap out reservoir bottom)
Other Structural	Alternative N	Induce mixing (by aeration or other methods) in Grand Lake to improve water clarity through mixing of less clear surface zone water with better clarity water in the lower stratified zones
Other Structural	Alternative O	Partial diversion and conveyance of the Grand Lake tributary inflows to mix with water pumped from Granby Reservoir, in order to improve the overall quality of and clarity of water entering Grand Lake from Shadow Mountain Reservoir
Other Structural	Alternative P	Covering the Granby Pump Canal to reduce heating of the water during the summer months and growth of algae in both summer and winter
Other Structural	Alternative Q	Reconfigure the Farr Pump Station intakes to change the withdrawal levels relative to seasonal stratification to improve the quality of water delivered to Shadow Mountain Reservoir

Alternative Type	Alternative Name	Description
Operational	Alternative R	Stop-pumping at Farr Pumping Plant and no diversions through Adams Tunnel in July, August and September
Operational	Alternative S	Modify pumping at Farr Pumping Plant and diversions at Adams Tunnel to operate continuously at low and steady rates
Operational	Alternative T	Operate Farr Pumping Plant and divert at Adams Tunnel continuously at high and steady rates after spring runoff
Watershed Management	Alternative U	Implement sediment controls and best management practices (BMPs) to reduce nutrients and sediment/particulate loadings to the Three Lakes system resulting from land uses, stormwater inflows and overland (diffuse) runoff. Watershed management practices should be considered as a stand-alone alternative and in combination with all other alternatives.
No Action	Alternative V	Do nothing.

Watershed management and implementation of best management practices (BMPs) may, or may not, be a “stand-alone” alternative; however, it appears likely that elements of watershed management and implementation of BMPs will be a part of any structural or non-structural measure that ultimately may be implemented to improve water clarity in Grand Lake.

5.2 Other Water Quality Considerations

While the principal water quality driver in the alternative analysis is the water clarity standard in Grand Lake, secondary water quality considerations, primarily related to algal production (chlorophyll *a*) need to be considered for Shadow Mountain Reservoir. Depending upon the alternatives considered there may be a change in the dominant flow through patterns in Shadow Mountain Reservoir from continued Farr pumping to natural downgradient flow to Granby Reservoir. The change in flow patterns (i.e., natural downgradient flow) may result in increased residence time that may allow for greater algal biomass production which in turn can increase pH and decrease dissolved oxygen due to algae decay. Whether a resulting change in potentially poorer Shadow Mountain Reservoir chlorophyll *a*, pH or dissolved oxygen conditions are substantial enough to outweigh the water clarity benefits in Grand Lake need to be considered and remains undetermined. However, these considerations should also be placed in the context of the interim chlorophyll *a* values or other site-specific values that may become effective in the future.

The islands at the south end of Shadow Mountain Reservoir are known to affect the hydrodynamics of the reservoir and to affect dissolved oxygen concentrations. Recent monitoring efforts have shown that water quality conditions (e.g., clarity, chlorophyll *a*, dissolved oxygen) also vary spatially and temporally in Shadow Mountain Reservoir (i.e., north to south longitudinal direction) that correlate well to pumping activities. Currently, Shadow Mountain Reservoir is a high priority reservoir on the Clean Water Act 303(d) impairment list (Reg. 93) due to poor dissolved oxygen conditions relative to aquatic life. These poor dissolved oxygen conditions are primarily limited to the southern portion of the reservoir near the dam and Granby Pump Canal. The variability in the above mentioned water quality characteristics may be important to consider during placement of the bypass intakes to meet desired water quality conditions in C-BT water or to help better understand the effects of other external or internal loading sources to the reservoir.

5.3 Alternative Ranking Methodology

Because of the complexity of the Three Lakes System and the numerous stakeholders with vested interest in the project, it is unlikely that a simple numerical ranking methodology applied without stakeholder inputs would be sufficient or acceptable for evaluating alternatives to improve the clarity in Grand Lake. Based on interactions with the stakeholders group during the Technical Review, it is considered to be critical that all stakeholders have the opportunity to express their priorities and the tolerable level of risk acceptable to them (likelihood of success in achieving the stakeholders' goals).

The framework and process for evaluation of alternatives for improving the clarity in Grand Lake should allow input from the diverse stakeholders to be accepted, quantified as appropriate, and used in the screening and comparison of project alternatives in a very systematic way. The sensitivity of screening and ranking of alternatives to changes in the importance of various decision-making or weighting factors should be systematically evaluated. While such a process is usually "numerical" in nature, it provides opportunities for discussion among the stakeholders and for consensus-building. The weighting factors can be established in a group setting using a structured voting process and comparison of preferences of individuals and the group for the importance of one criterion over another. This process allows for discussion of important factors and it often elicits valuable insights affecting ultimate design of the project features.

The goals and criteria are established to be independent, and when possible, are based on quantifiable measures (e.g., expected clarity improvement in Grand Lake, impacts on clarity and water quality in Granby Reservoir and Shadow Mountain Reservoir, capital and O&M costs, acres of wetlands impacted, number of cultural sites affected, etc.). Relative weights are assigned to each goal, objective and criterion. Each of the criteria has an associated way to measure its performance. The framework and its application should be transparent and understandable and results from its application must reproducible and defensible. The general logic for such the framework and its application is depicted on Figure 2. Whatever framework is ultimately developed and used for subsequent phases of evaluating alternatives to for improving the water clarity in Grand Lake must be adaptable to the federal process for authority, approval, planning and design of modifications to the C-BT Project.

6.0 Work Plan for 30 Percent Engineering

The purpose of this Work Plan is to describe the tasks that are required to identify alternatives and prepare 30 percent engineering and designs of a selected alternative (or several alternatives) to improve Grand Lake water clarity. If implemented, these alternatives should not cause adverse effects on water quality in the Three Lakes or adversely affect the yield of the C-BT Project. Alternatives should be formulated to be consistent with primary C-BT Project purposes outlined in Senate Document 80. A Memorandum of Understanding 10AG6C0004 between Reclamation, Grand County, and Northern Water, which provides the basis for cooperation in addressing the water clarity issues in Grand Lake, is pending.

The approximate cost and schedule for each element of the Work Plan are provided in Appendix J.

6.1 Main Elements of the Work Plan

The following sections describe a proposed Work Plan for moving forward with studies, analyses, conceptual designs, and supporting activities to develop, screen and systematically evaluate potential alternatives to improve the water clarity in Grand Lake. It is assumed that the technical and engineering studies, alternatives evaluations, and supporting documentation will become part of the record and support for compliance with requirements of the National Environmental Policy Act (NEPA).

TASK 1 - Develop the Statement of Purpose and Need for the Project

Objective: Prepare a statement that demonstrates the purpose and need for implementing a strategy that will help achieve the applicable Grand Lake water clarity standard. The Statement of Purpose and Need should also meet the requirements for the NEPA process and other permitting activities.

Subtasks:

a. Review previous studies, reports, and new data collected as part of ongoing water quality monitoring programs.

b. Prepare summary of water clarity issues and impacts to Grand Lake that are to be addressed by the potential project alternatives.

c. Identify the water quality objectives to be achieved beyond water clarity in Grand Lake, including prevention of water quality degradation in the Three Lakes and in water diverted into the Adams Tunnel.

d. Develop the purpose and need statement. This development will include participation by and inputs from project stakeholders.

Deliverable: Purpose and Need Statement

TASK 2 - Collect and Analyze Additional Data

Objectives: Prior studies of water quality issues in the Three Lakes, which were considered during the Technical Review, have identified the need to obtain additional data and information to support the formulation and evaluation of potential alternatives to improve water clarity in Grand Lake. Findings of GEI's Technical Review support the need to complete the following subtasks:

Subtasks:

The following subtasks will be completed to address the data gaps identified on Table 5.

a. Obtain and evaluate historical information on natural stream flows entering the Three Lakes System, pumped inflows from Windy Gap, and lake levels in Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake. This information will be used in the reservoir water quality modeling using an updated Three Lakes Water Quality Model, as well as in establishing locations and elevations for intake structures associated with potential bypass alternatives and other structural measures.

b. Obtain the following additional data, based on data gaps needs identified in the Technical Review:

    i. Identify additional stakeholders in the issues surrounding clarity in Grand Lake and the alternatives to improve clarity.
    ii. Define "water quality" in the Three Lakes System.
    iii. Monitor and evaluate the effects of stormwater runoff.
    iv. Determine the effect of pumping initiation on Grand Lake clarity.
    v. Evaluate the effects on aquatic life.
    vi. Other sampling considerations.
    vii. Modify and update the Hydros' Three Lakes Water Quality Model for use in evaluating the performance of alternatives to improve Grand Lake water clarity.
    viii. Review the numerical clarity assessment methodology.
    ix. Review the water supply operations spreadsheet and develop a water supply operations model.

x. Review the power generation spreadsheet and develop a power generation model.

c. Assess existing and potential future watershed conditions that may affect water quality in the Three Lakes and particularly clarity in Grand Lake, including:

i. Land uses and agricultural practices.
ii. Forestry practices and wildfire policies and risks.
iii. Residential and commercial development.
iv. Status of septic systems and regional sewage collection and treatment.
v. Recreational land uses and practices.

d. Obtain the other environmental baseline data required to evaluate alternatives and assess environmental impacts of implementing each alternative. Resource areas should include:

i. Wildlife resources.
ii. Vegetation and watershed/forestry management.
iii. Aquatic resources and fisheries.
iv. Threatened and endangered species.
v. Wetlands and riparian/sensitive habitats within "footprint" areas of potential structural alternatives.
vi. Recreation resources.
vii. Cultural resources.
viii. Socioeconomics of the region.
ix. Visual resources and aesthetics.
x. Air quality.
xi. Geology and soils.

e. Obtain GIS and/or LIDAR data sets and maps, aerial photography and topographic mapping required for the formulation, facility sizing, and cost estimating of the structural alternatives. Topographic mapping should be adequate to develop plan and profile drawings of sufficient detail to support conceptual-level designs and cost estimates for the structural alternatives. (Mapping for design can be deferred to the 30 percent design stage in Task 7).

f. Obtain sufficient utility location and easement information from local government agencies to develop conceptual-level designs and cost estimates for the structural alternatives. (Utility locations can be field-verified in the 30 percent design efforts, as required).

g. Obtain and review the water supply operations and power production information required to evaluate the impacts of potential alternatives on C-BT water deliveries and power production. Data should include operations at Farr Pumping Plant and flow and power generation at the East Slope facilities, including dry, average, and wet year diversions and daily/diurnal flow information, as required, to enable assessment of water supply and power generation impacts.

Deliverables: Technical Memoranda on available baseline data grouped by issue category.

TASK 3 - Identify a Full Range of Potential Alternatives to Improve Water Clarity in Grand Lake

Objectives: Building on the work completed for Reclamation's 2012 Preliminary Alternatives Development Report and other studies and reports, formulate a full range of reasonable alternatives for addressing the water clarity issues in Grand Lake, considering both structural and non-structural options and combinations of options. This will include describing the consequences of taking a "no-action" approach on the long-term water clarity in Grand Lake as well as establishing a baseline against which any operational changes will be measured in terms of water supply and power production from C-BT.

Subtasks:

a. Identify and develop details for structural alternatives, including but not limited to those listed below. Development will include conceptual design layouts of key project features and structures, plan and profile drawings, construction quantity and cost estimates (Class 4 estimate per AACE International Classification System), O&M cost estimates including energy costs for pumping, and expected schedules for implementation.

   i. Structural Alternative - Grand Lake Bypass:

      - Intake and pumping station at Shadow Mountain Reservoir and a buried pipeline leading to a discharge structure at the Adams Tunnel portal.
      - Intake and pumping station at Shadow Mountain Reservoir and a submerged (marine) pipeline in Grand Lake leading to the Adams Tunnel portal.

- Intake and pumping station at Shadow Mountain Reservoir and a "floating pipeline" in Grand Lake leading to the Adams Tunnel portal.
- Intake and pumping station at Shadow Mountain Reservoir and a water conveyance tunnel to connect with the Adams Tunnel.
- Provision of a removable (seasonal) boating course and submerged funnel-shaped curtain deflectors to reduce mixing in the top 4 feet of Grand Lake.
- Intake and pumping station at the Granby Pump Canal and a buried pipeline leading to a discharge structure at the Adams Tunnel portal (this would bypass both Shadow Mountain and Grand Lake).
- Intake and pumping station at the Granby Pump Canal and a water conveyance tunnel to connect with the Adams Tunnel (this would bypass both Shadow Mountain and Grand Lake).
- Diversion of a portion of Granby Water via a bypass pipeline to the upper end of Grand Lake with discharge at depth and release through a conical outlet structure.

ii. Other Structural Alternatives:

- Remove Shadow Mountain Dam and provide corresponding changes to the water conveyance system between Granby Reservoir and Grand Lake.
- Deepen Shadow Mountain Reservoir by dredging or deepen and narrow this reservoir to improve water quality.
- Reduce operating pool of Shadow Mountain Reservoir and deepen reservoir near the dam to serve as a forebay for a pumping station and bypass pipeline.
- Drain Shadow Mountain Reservoir and clean out debris and algae.
- Provide aeration/oxygenation facilities in Shadow Mountain Reservoir to improve water quality.
- Induce mixing (by aeration or other methods) in Grand Lake to improve water clarity through mixing of less clear surface zone water with better clarity water in the lower stratified zones.
- Partial diversion and conveyance of the Grand Lake tributary inflows to mix with water pumped from Granby Reservoir, in

order to improve the overall quality of and clarity of water entering Grand Lake from Shadow Mountain Reservoir.

- Covering the Granby Pump Canal to reduce heating of the water during the summer months and growth of algae in both summer and winter.
- Reconfigure the Farr Pump Station intakes to change the withdrawal levels relative to seasonal stratification to improve the quality of water delivered to Shadow Mountain Reservoir.

b. Identify and develop details for non-structural alternatives, including but not limited to those listed below. Development will include conceptual operational descriptions, determination of impacts to water supplies and power production, estimates of potential economic and power market consequences, and expected schedules for implementation.

i. Operational Alternatives:
- Stop-pumping at Farr Pumping Plant and no diversions through Adams Tunnel in July, August and September.
- Modify pumping at Farr Pumping Plant and diversions at Adams Tunnel to operate continuously at low and steady rates.
- Operate Farr Pumping Plant and divert at Adams Tunnel continuously at high and steady rates after spring runoff.

ii. Watershed Management:
- Implement sediment controls and best management practices (BMPs) to reduce nutrients and sediment/particulate loadings to the Three Lakes system resulting from land uses, stormwater inflows and overland (diffuse) runoff.

iii. No Action
- Do nothing.

c. Identify and develop potential combinations of structural and non-structural measures that may be desirable, especially if they could reduce overall cost or improve overall performance in improving water clarity in Grand Lake.

d. Develop a description of the consequences of the "no-action" alternative in terms of the effects on long-term water clarity in Grand Lake. This work will also include establishing a baseline against which any operational changes will be measured in terms of operations and power production from the C-BT Project.

Deliverable: Technical Memorandum on Alternatives

TASK 4 - Perform "Coarse Screening" of Alternatives

Objectives: Alternatives that do not meet the purpose and need for the project, or ones that are not reasonable or practicable to implement based on cost factors or institutional issues, will be screened from further consideration in the 30 percent design efforts that follow. A reproducible and defensible screening framework will be established and used with stakeholder involvement to perform the screening of alternatives, as described in Section 5.3. The screening framework will be structured to comply with NEPA requirements for evaluation of alternatives.

Subtasks:

a. Establish a screening framework for comparison and evaluation of alternatives. The framework should define overarching goals and objectives of the project in the areas of achieving water clarity, minimizing adverse impacts, minimizing adverse effects to C-BT water supplies and power generation, and minimizing costs. Criteria and performance measurements will be identified within each of the objectives. Weighting factors will be established for the objectives and criteria in consultation with stakeholders.

b. Assemble, using the previously developed baseline information, the data needed for the coarse screening of alternatives, including (for each alternative) costs, construction operations and potential effects, environmental impacts, water clarity performance, other water quality impacts, and water supply and energy impacts. This will include development of quantitative and qualitative performance measures for the coarse screening criteria in the screening framework.

c. Perform the coarse screening to evaluate and rank alternatives, test sensitivity to changes in weighting factors for the key objectives, and summarize results.

Deliverable: Technical Memorandum on coarse screening results and the alternatives selected for further development and evaluation in Task 5.

TASK 5 - Develop Additional Details for Alternatives Selected in Task 4

Objectives: Develop additional technical details, cost estimates, and implementation schedules for those alternatives passing the coarse screening in the previous task. Perform additional analyses and technical studies that are required to evaluate and compare the alternatives for improving water clarity in Grand Lake.

Subtasks:

a. Perform additional engineering and supporting technical analyses of the remaining structural alternatives. Prepare updated layout drawings and descriptions of these alternatives.

b. Perform additional engineering and supporting technical analyses of the remaining non-structural alternatives. Prepare updated descriptions of these alternatives.

c. Perform additional engineering and supporting technical analyses of the remaining combination (structural and non-structural) alternatives. Prepare updated descriptions of these alternatives.

d. Develop feasibility-level construction and O&M costs for each of the alternatives (Class 3 estimate per AACE International Classification System). Develop total capital cost opinions and life-cycle cost estimates for each alternative.

e. Assess on a quantitative basis the expected performance of each alternative relative to improving the water clarity in Grand Lake. This should include development and application of appropriate reservoir water quality modeling procedures.

f. Prepare additional, more-detailed analyses of water supply impacts in the C-BT delivery system associated with each remaining alternative. Determine the potential economic and financial impacts associated with any changes in water supplies inherent to each alternative. This should include development of daily flow sequences for a representative period of record that reflects future changes in C-BT operations to reflect changing demand patterns and the WGFP.

g. Prepare additional, more-detailed analyses of energy generation and firm capacity impacts in the C-BT delivery system associated with each remaining alternative. Potential changes in available black-start capability, regional transmission capacity, and voltage/frequency support will be part of this analysis. Determine the potential economic and financial impacts associated with any changes in energy production, firm capacity and marketing of project power inherent to each alternative. For the bypass alternatives involving additional pumping to move water, identify the potential to use off-peak power and the overall impacts on C-BT energy production and firm capacity. This should include application of generated daily flow sequences to the power operations model for a representative period of record that reflects future changes in C-BT operations to reflect changing demand patterns and the WGFP.

h. Identify the legal, institutional, permitting, and administrative issues affecting the implementation of each of the alternatives.

Deliverables: Technical Memorandum on the structural alternatives; Technical Memorandum on the non-structural alternatives; Technical memorandum on operational, watershed management and/or combination alternatives.

TASK 6 - Perform "Fine Screening" of Alternatives Selected in Task 4

Objectives: Evaluate the alternatives using a systematic alternatives evaluation framework and one or several alternatives that are worthy of further development to the 30 percent design level. This is expected to involve refining the framework developed for coarse screening to incorporate additional considerations and details, based on inputs from stakeholders, as described in Section 5.3.

Subtasks:

a. Establish the fine-screening framework for comparison and evaluation of alternatives. This will be a refinement of the framework developed in Task 4, and it will continue to define overarching goals and objectives of the project in the areas of achieving water clarity, minimizing adverse impacts, minimizing adverse effects to C-BT power generation, and minimizing costs. Criteria and performance measurements will be identified within each of the objectives. Weighting factors will be established for the objectives and criteria in consultation with stakeholders.

b. Assemble, using the previously developed baseline information and additional investigations and studies, the data needed for the fine screening of alternatives, including (for each alternative) costs, construction operations and potential effects, environmental impacts, water clarity performance, other water quality impacts, and water supply and energy impacts. This will include development of quantitative and qualitative performance measures for the coarse screening criteria in the screening framework.

c. Perform the fine screening to evaluate and rank alternatives, test sensitivity to changes in weighting factors for the key objectives, and summarize results.

Deliverable: Technical Memorandum on Fine Screening Results and the alternatives that are selected for further development and refinement at the 30 percent design level.

TASK 7 - Develop 30 Percent Designs for the Alternative(s) Identified in Task 6

Objectives: The alternatives (or alternatives) passing the fine screening in Task 6 will be developed to the 30 percent level of design. This design level will be sufficiently detailed for developing implementation plans, schedules and budgets provide the basis for initiating final designs. It is anticipated that a structural alternatives developed further in Task 7 would likely include some watershed management elements and that these may include both structural and non-structural components, as well as BMPs.

Subtasks:

a. Prepare design basis memoranda for the selected alternatives, including both structural and nonstructural alternatives and any operational, watershed management and/or combination alternatives.

b. Obtain additional field surveys, existing utility information, topographic mapping, GIS data, and geologic and geotechnical information needed for the 30 percent design.

c. Perform additional technical analyses to support 30 percent level design of the selected alternatives. These would include: hydraulic, structural, and geotechnical analyses to support preliminary design of structural elements such as intakes, pumping stations, conveyance pipelines, reservoir improvements, etc.

d. Prepare drawings that depict the alignments, profiles, typical sections, and details of the structural components of each alternative, as well as potential areas of conflict with existing utilities and needs for relocations and land acquisition.

e. Prepare detailed descriptions of each alternative, its operations and potential impacts on the existing environment, and requirements for construction and/or modification of current C-BT operations.

f. Prepare opinions of the probable construction costs (Class 2 estimate per AACE International Classification System), O&M costs, total capital costs, and anticipated life-cycle costs of each alternative developed to the 30 percent design level.

Deliverables: A Technical Memorandum for each alternative describing the 30 percent design, operation, impacts, and construction requirements and costs.

TASK 8 - Develop Implementation Plans and Schedules for the Alternative(s) Identified in Task 6

Objectives: To provide detailed plans schedules for implementing the selected alternative(s), considering specific institutional arrangements, authorizations, NEPA compliance, permitting, final engineering, design, and construction, which may be unique to each of the alternatives.

Subtasks:

a. Develop schedules for design, permitting and construction in Microsoft Project or other suitable software to show work task breakdown and interdependencies. This will include consideration of NEPA requirements and other permitting activities based on findings in Task 9.

b. In consultation with Reclamation, prepare write-ups on the institutional and administrative requirements and authorizations needed to implement each alternative.

Deliverables: Implementation plan and schedule for each of the 30 percent design alternatives.

TASK 9 - Identify Required Environmental Compliance

Objective: It is anticipated that many of the alternatives selected for possible implementation will require extensive federal, state, and local permitting efforts to secure approvals for implementation. The objective of this task is to identify the process and likely level of documentation that will be needed for documentation of environmental compliance so that a preferred water clarity improvement alternative can be implemented.

Subtasks:

a. Identify the likely steps in the NEPA process.

b. Identify the applicable agency legal and regulatory permit requirements.

Deliverables: Technical Memorandum on Environmental Compliance.

TASK 10 - Conduct Stakeholder and Public Involvement Programs

Objectives: All of the tasks outlined above will be undertaken in cooperation with a stakeholder Work Group that is already established and has been functioning for several years. Additional representation may be added to this stakeholder group. In addition to stakeholder outreach and coordination this task will also include a program of public involvement and outreach.

Subtasks:

a. Develop and execute a Stakeholder Involvement Program with the existing Grand Lake Work Group, participants in the Three Lakes Water Quality Program, and others, as deemed appropriate to the project planning and evaluation process.

b. Develop and implement a Public Involvement Program.

Deliverables: Descriptions of the two programs and meeting materials and newsletters, as required for communicating effectively with stakeholders and the public.

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Figures

Figure 1: Three Lakes System Map (Hydros Consulting Inc., 2013a)

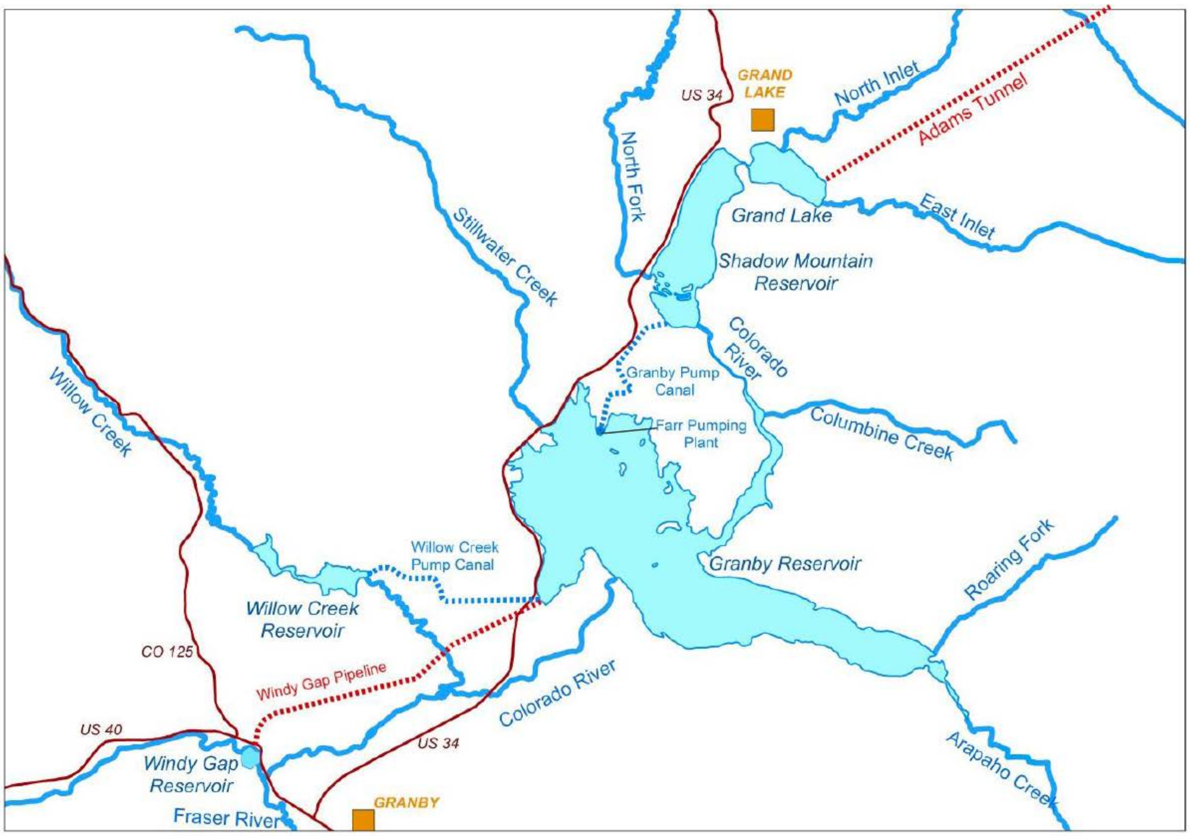
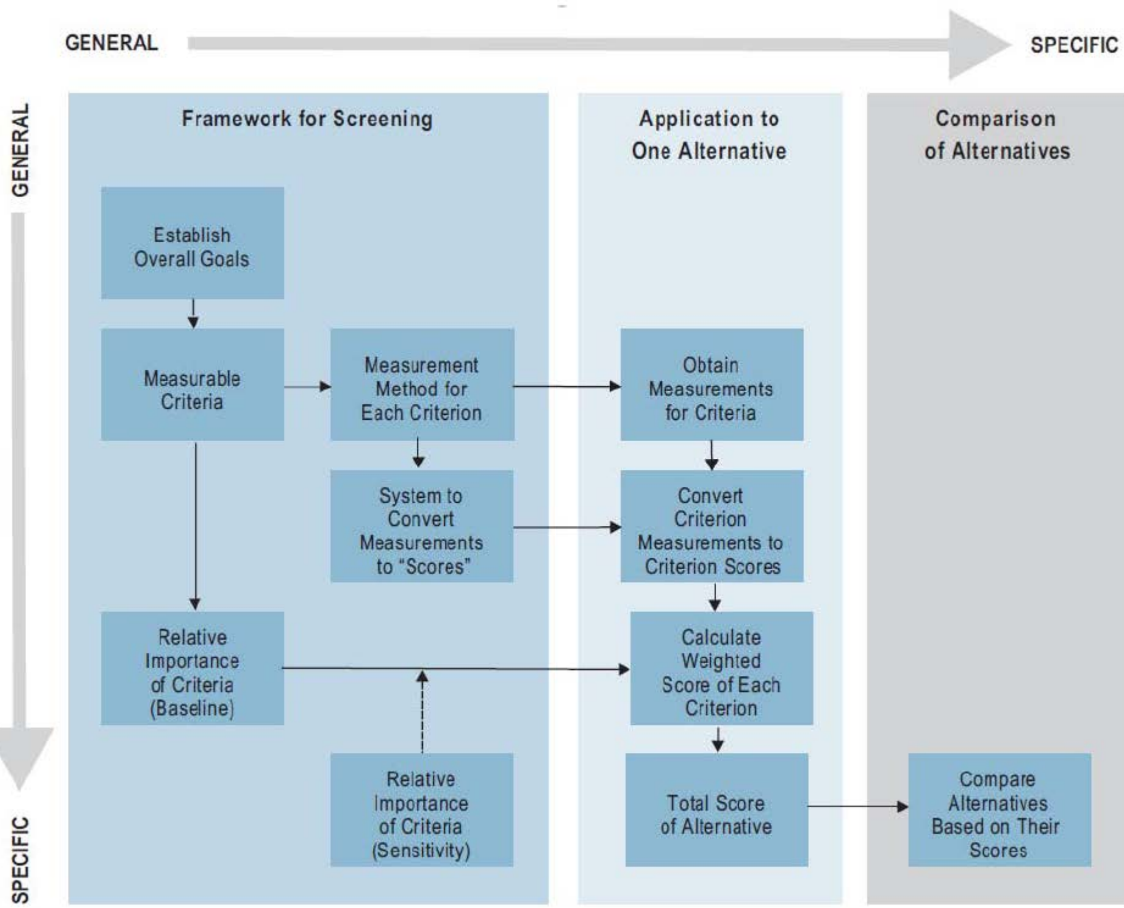


Figure 2: Alternative Screening Process



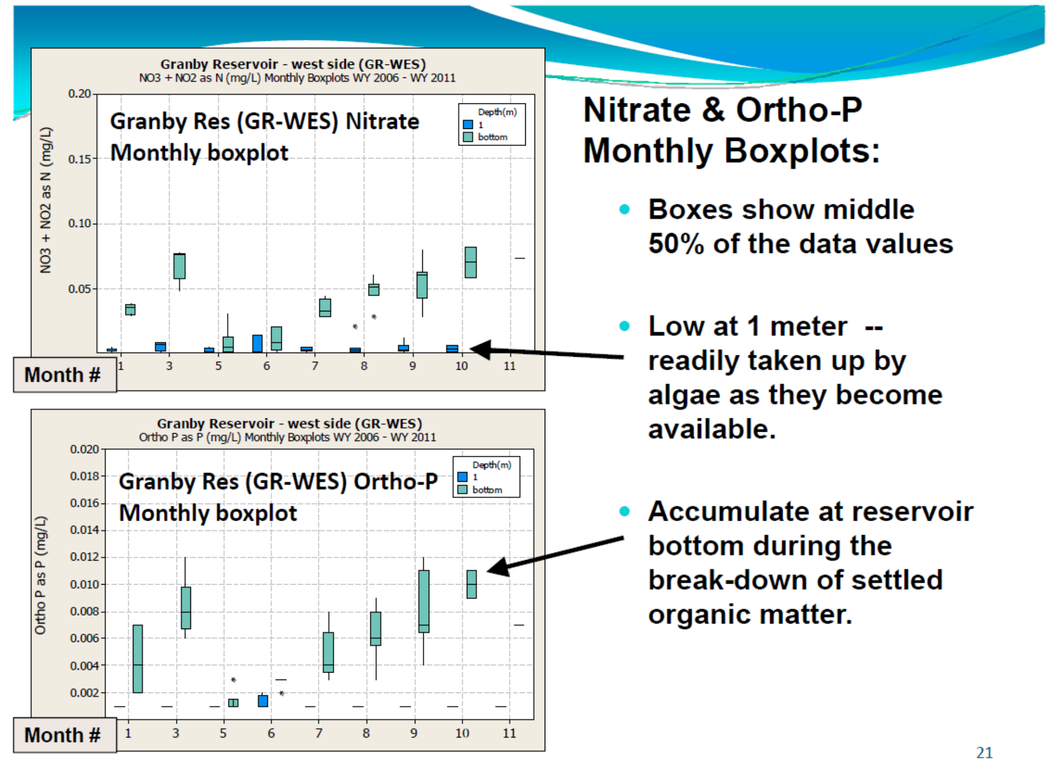
Appendix A

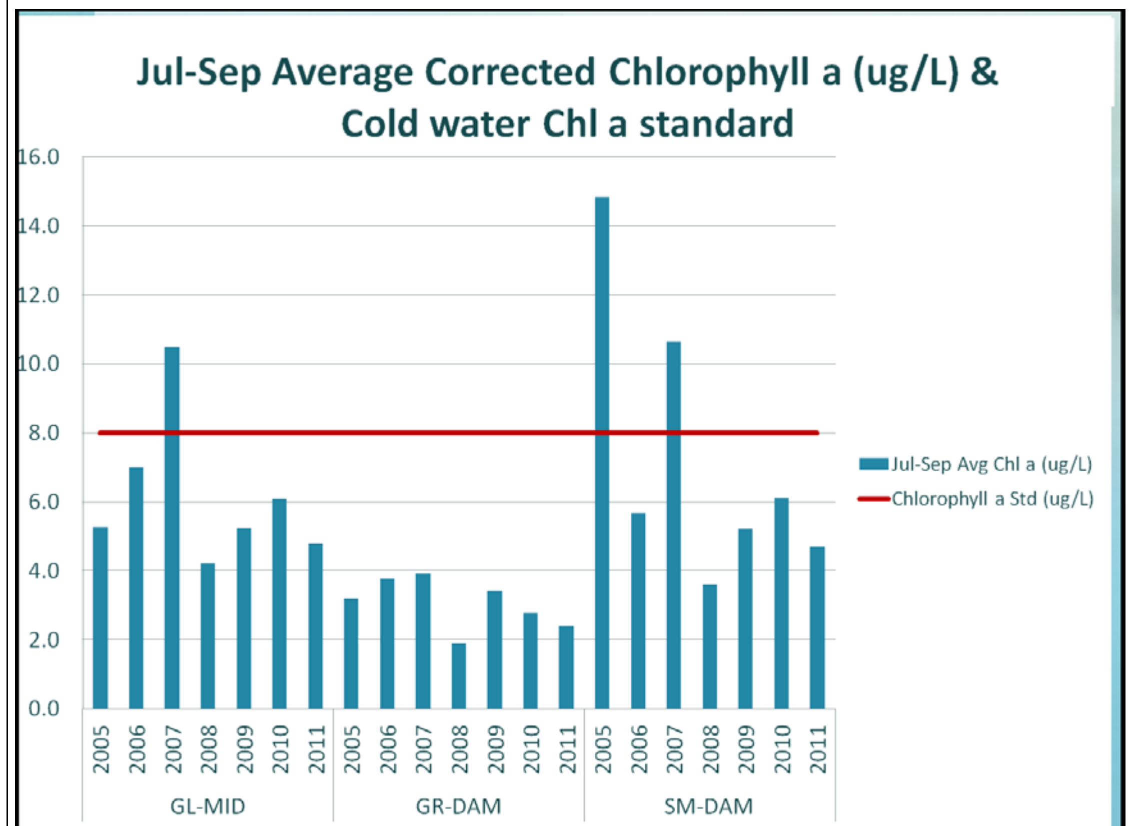
Comments/Response to Comments from April 2013 Draft Technical Report

Comment Number	Agency	Reviewer	Location of Text in April 2013 Draft	Comment	Response to Comment
1	BOR	L. Harger	Page 2	They only mention the numerical clarity standard. There are two clarity standards currently on the books. There was also a narrative clarity standard adopted by the Commission in 2008. It is the " highest level of clarity attainable, consistent with the exercise of established water rights and the 106 protection of aquatic life"	Description of narrative standard was added.
2	BOR	L. Harger	Page 3, 2nd paragraph	I think it is a bit strong to stay that Reclamation has "concluded" that decreased pumping at Farr would mean reductions.....Also same sentence, "decreasing pumping" is an unclear and perhaps inaccurate description. Does this mean the stop-pump operations? and when?	Reworded in response to comment.
3	BOR	L. Harger	Page 6, bottom of page	I would strongly agree that having a defined set of "water quality" characteristics identified is very important. We do want to try to address redirected effects.	Comment noted. 8/28/2013 Revision to RTC– editorial comment. Redirected effects will be addressed in a later draft
4	BOR	L. Harger	Pages 14-17	Screening of Alternatives/Performance Measures. This process needs to be handled carefully. How specifically will stakeholder input in this process? Note: I understand this Technical Review is a big picture type look but, this type of activity will be under the microscope with stakeholders.	Comment noted. 8/28/2013 Revision to RTC– the method for determining stakeholder input will be determined in the next phase(s) of the work
5	BOR	L. Harger	General	In general there is no mention of who or what group would complete tasks? Was this part of GEI's scope of work to provide?	It is not part of GEI's scope of work.
6	BOR	K. Thiel	Pages 8 & 9	It seems to imply that we do not know with certainty that it is possible to meet the 4 m standard even with bypassing Grand Lake. I missed where you may have put in a step for more modeling (or something) to insure that what is done achieves compliance?? Can you go into this a little more? (not enough time for 4/3/13 call, but eventually)	text recommending WQ modeling has been added.
7	NW	EV, PN	General Comment	Should Aquatic life considerations be part of this report? WQCC directed stakehodlers to address potential aquatic life impacts associated with the standard. Recent presentations from CPW to the TLNS have made more apparent the link between WQ and foodweb dynamics. It seems that it is an important aspect that is often ignored and forgotten about.	We agree and expanded discussion of aquatic life considerations will be incorporated into the next draft
8	NW	EV, PN	Page 1, para 3 & 4	Maybe add a little information about Granby. Grand Lake and Shadow Mountain are both mentioned but Granby is left out of these descriptions.	Description of Granby was added.
9	NW	EV, PN	Page 2, para 1	the statement "Reclamation, Grand County and Northern Water are cooperatively working together on a Grand Lake Clarity study to evaluate an appropriate clarity standard" is unfortunately no longer accurate, maybe "…to understand water quality and the factors that affect clarity" would be better.	Reworded in response to comment.
10	NW	EV, PN	Pages 3-4	discussion of 2013 Hydros report relative to 2011 conditions. The points listed are somehwat selective and incomplete. Jean Marie and Christine could provide a more balanced list.	This list is derived from Chapter IV "Watershed Conditions and Operations". The chapter is divided into sub-chapters of "Meteorology", "Hydrology and Operations", and "Inflow Water Quality and Nutrient Loading". This list reflects the categories chosen by Hydros.
11	NW	EV, PN	Page 4	Page 4, discussion of conclusions from Hydros 2013 report. This is also somewhat selective and incomplete. Again, Jean Marie and Christine could provide a more balanced list.	This list of conclusions is derived from the "key general conclusions" list in Chapter VII. Hydros draws 14 key conclusions-some of which don't make sense when taken out of the report or may not have much impact on the Work Plan.
12	NW	EV, PN	Page 6 3rd bullet	I believe the author is Davine Lieberman TSC not TetraTech	Corrected.
13	NW	EV, PN	Page 6, 1st para after bullets	Clarification about the one-foot fluctuation statement in the GEI report: Senate Document 80, Manner of Operations, primary purpose No. 3, states that the elevation of Grand Lake should be preserved and the variations of the elevations should not be greater than their normal fluctuation. The summary sections of SD 80, Continental Divide Tunnel, states that the maximum fluctuation of Grand Lake is four feet. It goes on to say that the elevation would be controlled by the North Fork Diversion Dam (Shadow Mountain Dam) and the tunnel inlet to control the surface elevation such that the fluctuation is less than one foot. The USBR Standard Operating Procedures (SOP) for Shadow Mountain Dam requires the one foot fluctuation limitation during summer months and a 0.3 foot fluctuation during winter months when there is ice cover.	Comment incorporated into the text.

Comment Number	Agency	Reviewer	Location of Text in April 2013 Draft	Comment	Response to Comment
14	NW	EV, PN	Page 7 1st para under Monitoring	There are many monitoring plans. They have never been clearly described in recent reports, although the reports extensively use data generated through these program. Northern Water can provide detailed information about the multiple sampling programs. A lot of the comments and recommendations here are probably not relevant as they are already being addressed with existing programs. Internal loading has been discussed and profiles were taken in SM but not in GL or Granby. There are plans to further investigate internal loading but they were tabled in 2013 to a later date as a result of work priorities. We can certainly provide a matrix of data.	A matrix of data would be great. This section will be further reworded after we receive a comprehensive list of monitoring efforts and additional reports.
15	NW	EV, PN	Page 7 2nd paragraph	The assumption here is that Grand Lake elevation has to be maintained. Under structural alternatives, lengthy permitting and congressional review and authorization would be inevitable, so it could be envision that this particular provision could be revisited.	Comment noted. 8/28/2013 Revision to RTC– while it is not possible to amend SD80, it is possible that under a new alternative the operating criteria could be revisited
16	NW	EV, PN	Page 7 3rd para	This is absolutely true and TLNS has made plans to look into stormwater monitoring. 2013 monitoring in the North Fork should begin this effort but more detailed and focused monitoring will take place in the future. Again, due to work prioritization, stormwater monitoring per se has been tabled until 2014.	Comment noted. 8/28/2013 Revision to RTC– the need for additional study for stormwater monitoring has been incorporated into later drafts
17	NW	EV, PN	Page 8	Page 8, top paragraph. The statement “Based on 2011 data, the 4 m standard may be an appropriate water clarity level for the Grand Lake…” is concerning given that the 4 m standard was not met in 2011 (as explained later in the paragraph), and that 2011 was an incredibly unusual year (which is mentioned later on in the paragraph). This paragraph probably needs to be reframed and rephrased. The attainability of the standard is very questionable and the appropriateness of the 4m has not been demonstrated. It is true that the assessment methodology needs to be revisited but beyond that, no scientific foundation has been developed for the standard to this day. According to statutes it is meant to protect recreation, but the link between the 4m, the assessment methodology and the use protection have never been established. This is problematic. The standard also does not account for the natural seasonal variations in Secchi, which are quite great and may other factors. This is a good discussion to have and it is a complex topic but it may not belong in this document, beyond the more general comment that attainability needs to be addressed. This is more or less laid out in other parts of the document where reference is made to evaluating the certainty of achieving the standard under various alternatives. It is probably as far as you can go within the work plan.	This section has been reworded to better address these issues.
18	NW	EV, PN	Page 9	Second paragraph Please note that clarity is likely greatest in the winter under existing conditions, which is coincidental with high pumping as water moves to the East Slope to fill Horsetooth and Carter before the irrigation season.	Comment noted and will be incorporated into the next draft of the text
19	NW	EV, PN	Page 9	5th paragraph: please mention the islands and the complex hydrodynamics that take place depending on time of year and underflow and surface flows inflows temperature change. Should there be mention of the DO impairment in Shadow Mountain Reservoir?	Comment incorporated into the text
20	NW	EV, PN	Page 11, para 3	Page 11, the third paragraph discusses alternatives to be included that were dismissed from the 2012 Alternatives Report, but does not mention watershed alternatives or removal of Shadow Mountain Dam – although these are mentioned later.	Comment incorporated into the text
21	NW	EV, PN	Page 13 2.1	This subtask seems confusing. How could the analysis of flow data shed some light on clarity drivers? This needs to be clarified.	Reworded for clarity
22	NW	EV, PN	Page 13 2.2	Why is this needed? The 2011 and 2012 Hydros reports have done just that. If other items not addressed in these reports or in the particulate study are envisioned, they need to be clearly stated.	Comment noted. 8/28/2013 Revision to RTC– discussion of Hydros’ reports has been clarified and expanded in later drafts of the text.
23	NW	EV, PN	Page 15	Other structural alternatives: include covering Granby Pump Canal as mentioned earlier in the text	Comment incorporated into the text
24	NW	EV, PN	Page 16, top point above 3.3	While this is general and probably can be interpreted to include land use, stormwater, and watershed runoff, it would be desirable to include those specifically, for example, by adding at the end “… resulting from land use, stormwater inflow, and diffuse surface runoff.”	Comment incorporated into the text
25	NW	EV, PN	Page 19 #9 Objective	“any of the alternatives” will not necessarily require federal, state and local permitting. They may require all three, but they may not. Or they may require some sort of regulation rather than permitting, for example, local land use controls, or a state Water Quality Control Commission control regulation.	Comment noted. 8/28/2013 Revision to RTC– reference to ‘state and local’ permitting was removed as requested by BOR in later drafts of the text
-	GC	KM	Throughout	Grand County redline edits are provided on the attached pages. Comments provided by Grand County, initially provided as comments integral to a draft report, are extracted and shown as comments below.	n/a

Comment Number	Agency	Reviewer	Location of Text in April 2013 Draft	Comment	Response to Comment
26	GC	KM		These sentences are largely redundant.	Reworded in response to comment
27	GC	KM		Please consider using the following language that had already been agreed upon between Reclamation and Grand County: In 2011, an unusual combination of extensive snowpack, relatively ample storage in east slope reservoirs, relatively low early spring water demand, and low anticipated power demand combined to produce an opportunity to provide an extended stop-pump period. Pumping usually resumes in after spring runoff in mid-July, however, there was no need for pumping during this time, and a downgradient flow from Grand Lake into Shadow Mountain Reservoir was maintained much later into the season than normal. The official 2011 stop-pump period was 7 weeks: when coupled with the customary annual pumping shutdown during spring runoff the result was no pumping for 14 weeks, from late May to early September. During that time, clarity improved to a maximum Secchi depth measurement of 23.8 feet (7.25 meters) in late August.	The 2011 conditions are discussed in Section 1.3.2 in broad terms. It is our intent in this chapter to summarize some of the available reports, not to reproduce them.
28	GC	KM		No need to be vague here. Attach photos of 2011 resumption of pumping if necessary—or provide these in section on 2011 stop-pump to support making an honest statement here. Here's a link to the photo http://gcwin.org/picture-gallery/9-8-september-2011/detail/90-9811-a10.html# or for more before and after 2011 pumping photos http://gcwin.org/picture-gallery	Comment noted and will be considered in future revisions of the text.
29	GC	KM		For the record: Grand County was opposed to this ever making it into the report as the 2010 experiment resulted in no noticeable improvement in water quality/clarity with this method.	Comment noted. 8/28/2013 Revision to RTC–comment is noted for the record. Future drafts of the text changed this language to direct quotations
30	GC	KM		There is too much reliance here on this report, which was provided in draft form and over which extensive comments have been made but are not yet incorporated. The 2010 report, however, is a final version and contains many useful insights that are not reflected here. The 2010 report summarizes data from 2007-2010. Both reports should be utilized here for the big picture (as opposed to year to year) insights they provide.	Section 2.2.2 will be added to provide a summary of the 2010 report.
31	GC	KM		The final report will hopefully also include a section (now apparently to be included after finalization as an addendum or other such attachment) on nutrient delivery between water bodies that should be recognized here as well—and that is well explained in the 2010 report.	Added "The 2011 Three Lakes report (Hydros, 2013) is currently in draft form and its conclusions are subject modification" to clarify the 2011 report is still in progress Section 2.2.2 will be added to provide a summary of the 2010 report.
32	GC	KM		It's not proven what amount of clarity degradation is caused by runoff, what amount (if any) is attributable to spring turnover, and what is due to variable pumping conditions, which can generate turbidity as Northern adjusts to spring runoff in April and May. Grand County made extensive comments to this effect on the draft 2011 3 Lakes report. In addition, TSS associated with inflow runoff is vastly different depending upon ownership of the originating basin, with streams draining wilderness (East & North Inlets, Roaring Fork, Arapaho Creek) usually at 1 mg/L, sometimes reaching 3 mg/L TSS, Stillwater and North Fork Colorado reaching as much as 80 mg/L in extremes. Pumped flows at Farr range from 1-6 mg/L, and SM connecting channel TSS ranges from 2-20 mg/L, meaning that pumping and backwards flow introduces more TSS and turbidity to Grand Lake than it would ever receive from its native inflows. These are significant points and they are not captured or summarized in the Hydros report.	Comment noted and will be considered in future revisions of the text.
33	GC	KM		Clarity begins improving ***well before*** runoff even peaks (which can be seen in Hydros' plot), adding to questions about what other factors influence spring clarity.	Comment noted. 8/28/2013 Revision to RTC–we agree there are many questions about what factors influence clarity, in the spring and otherwise. Later drafts of the text identify the largest data gaps relating to this problem.

Comment Number	Agency	Reviewer	Location of Text in April 2013 Draft	Comment	Response to Comment
34	GC	KM		Peaks actually occur twice a year, prior to spring and fall turnover. Northern provided a slide on this during their Water Quality Stakeholder's meeting this spring. (resize this image to be able to see it—we shrunk it to fit in the sidebar) 	Comment noted and incorporated into the text
35	GC	KM		We don't have attachment 1 here, but as stated before, Dr. McCutchan's 2009 study of the stop pump that year should be included here, as should Davine Lieberman's study covering 2005-2007.	These are the key documents we reviewed. McCutchan and Lieberman are listed in Section 2.3.1.
36	GC	KM		Include "Factors Controlling Transparency in Grand Lake, Colorado" James H McCutchan, Jr. April 2, 2010, revised July 2, 2010, March 9, 2012	We have expanded the bullet to specifically list the documents we are referencing
37	GC	KM		Why is this particular condition from SD 80 specified here? The relevant portion of SD80 to primary drivers would be protection of the scenic attraction of GL, the Colorado River, and the RMNP.	Reworded and quotes from SD 80 were added.
38	GC	KM		Watershed management (BMPs) was specifically stated in the report as not being enough on its own to achieve the standard…it was provided for coupling with another alternative. It was not suggested as a means of reliably achieving the proposed standard.	Comment noted. 8/28/2013 Revision to RTC–different stakeholders hold varying opinions regarding the effectiveness of watershed-wide BMPs. We assume BMPs will be implemented in addition to other alternatives but a stand-alone alternative should be considered as well.
39	GC	KM		Farr intake pipe position is 8,170'. This is usually in the hypolimnion (not always the upper portion), but reservoir elevation (especially low elevations) and stratification thickness can change this; the withdrawal location during stratification or low storage may locate withdrawals in the metalimnion or deeper in the hypolimnion, which may be significant.	Added "usually"
40	GC	KM		Clarity as measured by Secchi depth may be what is driving the process, but it is not the ONLY aspect – Senate Doc. 80 provides protection to the aesthetic value of Grand Lake, etc. This is a misleading sentence.	Reworded in response to comment

Comment Number	Agency	Reviewer	Location of Text in April 2013 Draft	Comment	Response to Comment
41	GC	KM		To the use term "best possible water quality" has the effect of diminishing what was given to Grand County in Senate Document 80. The original reports on the CB-T project states that the water quality for irrigation (which is the primary purpose of the project) is more than acceptable. One side of the mountain cannot be more important than the other as this is not the intent of SD 80. Dilution from Grand Lake was not contemplated in the studies SD 80. Grand Lake was to only be a conveyance facility. I think there are studies that show if the water was transferred directly from Granby to the tunnel, water quality would be better than it is today. See Northern's slide from their Water Quality Stakeholders meeting showing the nutrient content of each water body. 	Comment noted. 8/28/2013 Revision to RTC – while Grand Lake water clarity is the primary focus of the project, the secondary water quality goals in the other water bodies are important. Later drafts of the text reword this phrase to emphasize that water quality in the other lakes is a secondary goal.
42	GC	KM		I'd sure like to see a citation on this as I don't know what reports are being talked about; I don't recall seeing this stated in any report. Grand Lake as a whole serves as a huge settling basin for what is pumped into the lake—the tip of which is indicated by the delta formation in Grand Lake near the channel. Then turnover allows for mixing of pumped flows with Grand Lake's comparatively "cleaner" water. Throughout the unstratified portion of the year, and before stratification spans the Tunnel mouth this must improve the quality of diverted water. However the notion that somehow North and East Inlet flows make a beeline for the Adams Tunnel (when Davine Lieberman's reports indicated native inflows plunge at least into the epilimnion) seems ridiculous.	Comment noted. 8/28/2013 Revision to RTC–this text has be reworded in later versions of the draft and appears in Section 4.6 of the final draft, version 1.
43	GC	KM		Good. This is another location where consideration of nutrient concentrations in the three water bodies (per Northern's slide) is relevant.	Comment noted. 8/28/2013 Revision to RTC–editorial comment not incorporated into the text.

Comment Number	Agency	Reviewer	Location of Text in April 2013 Draft	Comment	Response to Comment
44	GC	KM		Is GEI aware that in 2009 the town installed an Aqua Filter Stormwater System from Aquashield?  In addition, I have available the "Grand Lake 104(b)(3) Stormwater Project 1999-2001 Report" from CDPHE if GEI would like a copy.	GEI incorporated this information. We have received this report but have not yet incorporated it into this report.
45	GC	KM		Grand County will have to understand much more about this before we can agree to proposing any change in the standard. 4m is only ½ of what was documented so for us to compromise to that depth was a big step.	Comment noted. 8/28/2013 Revision to RTC – in response to BOR comments, the final draft, version 1, does not include references to reviewing the existing 4m value.
46	GC	KM		No: it's linked to the pumping of C-BT water, period. Hydros suggested there are turbidity impacts seen when pumps go from zero to full without gradual ramping, but I think this area warrants more study. The following url is to a 20 day view of data from the channel sonde. The peak in March 16 shows a turbidity spike following a March 15 total cessation of pumping for 1 day. There's also a recent ramp-down of pumping, and each change of pumping rates seems to be accompanied by a turbidity increase http://waterdata.usgs.gov/nwis/uv?cb_00065=on&cb_00055=on&cb_00010=on&cb_00095=on&cb_63680=on&cb_32283=on&cb_00400=on&cb_62361=on&format=gif_default&period=20&begin_date=2013-03-03&end_date=2013-04-02&site_no=09014050	Comment noted and will be considered in future revisions of the text.
47	GC	KM		Grand County is strongly opposed to any plans to "high grade" water from the North and East Inlets before it ever even reaches Grand Lake. This option has the potential for stagnating Grand Lake. Grand Lake has been loaded for the past 60 years and the full benefits of a bypass option will not be realized unless Grand Lake is permitted to receive its native inflows, and even then the benefits would be anticipated to manifest slowly over time, as successive years of gradual flushing restore as much of Grand Lake's pristine conditions as will be possible. Without pumping, water exiting Grand Lake through the channel is of significantly better quality (lower in nutrients, chl-a, turbidity, conductivity, pH, and cooler) than what enters Grand Lake from Shadow Mountain Reservoir. If a bypass option is selected, the quality of this water would likely improve over time. If water for dilution is needed, it should be taken from this locale instead to prevent the stagnation of Grand Lake. If either option is considered, the reduction in "freshening" flow to the north part of Shadow Mountain Reservoir should be considered.	Comment noted. 8/28/2013 Revision to RTC–water quality of Granby, SMR, and Adams Tunnel water is a secondary goal. Specifics related to dilution and sedimentation of Grand Lake will need to be considered during the alternatives analysis.
48	GC	KM		If a bypass option is operated only temporarily each year, Grand Lake will continue to be "seeded" with non-oligotrophic species of algae and diatoms, will continue to be enriched with nutrients, and will continue to receive particulates from sources that it would not without backwards pumping—potentially maintaining the delta that has formed in Grand Lake. And again, benefits to the north of Shadow Mountain Reservoir from ultra-clean flows from Grand Lake would likely be diminished.	Comment noted and will be considered in future revisions of the text.
49	GC	KM		The potential beneficial effects of allowing flows from Grand Lake to flow through SMR continue to be discounted. If, in addition to low flow periods, spring runoff flows were not diverted directly down the Adams Tunnel, but picked up at the bypass instead (yes, there would be an energy cost, and perhaps this would be prohibitive; on the other hand, perhaps it would be worth the tradeoff), might not there be a benefit to Shadow Mountain water quality? It seems like this should at least be modeled before it is discounted.	Comment noted and will be considered in future revisions of the text.

Comment Number	Agency	Reviewer	Location of Text in April 2013 Draft	Comment	Response to Comment
50	GC	KM		No: Senate Document 80 is clear on this.	Comment noted. 8/28/2013 Revision to RTC–while Grand Lake is the primary focus of this study, SMR is of importance as well, especially because of its 303(d) classification.
51	GC	KM		This is a temporary benefit as the associated nutrient loading quickly turns into increased productivity.	Comment noted.
52	GC	KM		Consider conducting new bathymetric mapping of the lake and 2 reservoirs to compare with original maps. Expected lifetime of Granby Reservoir is clearly going to be surpassed by a long shot. Is this because Grand Lake is collecting much of the sediment that was anticipated to land in Granby? If so, bathymetric mapping of Grand Lake might help to document the purpose and need for a project.	Comment noted. 8/28/2013 Revision to RTC–A Grand Lake bathymetric surveying may be completed in later phases of the engineering design in order to successfully complete the 30% engineering design but is not currently viewed as a data gap.
53	GC	KM		Northern's baseline lake monitoring program needs to increase sample frequency around spring and fall turnover. Inflow monitoring needs to include storm sampling. When GEI meets with Hydros, make sure you obtain copies of the Modeling Team Consensus Document (2010) and the 2011 Three Lakes Model Review Memo. There are many suggestions in the Consensus document and it will be useful to track which of these have been implemented and which would still be beneficial for your "needs" section.	Comment noted. 8/28/2013 Revision to RTC– an ideal sampling plan was added and is provided in the appendix of the final report. We obtained a copy of the referenced document.
54	GC	KM		And growth of algae during both summer and winter, as the sections of the project where water is actively flowing remain open or ice-free, even in winter.	Comment noted. 8/28/2013 Revision to RTC–this is something that will need to be considered during the design phase if this alternative is considered further.
55	GC	KM		This happened in 2010 with no noticeable improvements to clarity.	Comment noted and text reworded
56	GC	KM		This happened in 2012 with very unimpressive clarity results.	Comment noted and text reworded
57	GC	KM		When making this analyses, the 1938 repayment contract as well as Senate Document 80 must be included in the analyses.	Comment noted. 8/28/2013 Revision to RTC– We agree this should be considered during the later analysis
58	GC	KM		This is where the nutrient standards and what was originally considered to be acceptable water quality by SD 80 need to be considered.	Comment noted. 8/28/2013 Revision to RTC–figure does not appear in final report
59	GC	KM		Use of term "sediment" here suggests only inorganic considerations, which have been demonstrated to be comparatively small with organic particulate matter.	Comment noted. 8/28/2013 Revision to RTC–figure does not appear in final report

Appendix B

Comments/Response to Comments from May 2013 Draft Technical Report

Comment Number	Agency	Reviewer	Location of Text in May 2013 Draft	Comment	Response to Comment	Line Number of start of text in July Final Draft (Interim Draft for BOR)
1	BOR	LH	General	**The report has too much text in general and reader gets lost.** Need to convert some of the text sections into tables. There are identified Data Gaps on multiples pages in the report. Same for Data Needs and Alternatives. There are described Data Needs and various Alternatives in several sections and chapters and it is near impossible to remember them from chapter to chapter, flipping back and forth. I would recommend a summary table for "Data Gaps", a summary table for "Data/Future Needs" and a summary table for "Alternatives" somewhere at the beginning of report, maybe beginning of Section 2. This would really help the reader focus on the conclusions rather than having to stumble through pages trying to piece things together. GEI has already done some of this work or plans to do it in Section 3.0 for the Work Plan so, it might be fairly easy to incorporate some of it into Section 2 as needed (i.e. Listing of Alternatives is in Section 3.1 (3) (a)).	Text on data gaps, alternatives, etc. have been consolidated into their own chapters and summarized with tables.	Throughout
2	BOR	LH	Section 2.2	Section 2.2 has no logic to the order the documents are listed and described. The 2011 report I listed first, then back to 2010 report, then jump up to 2012 report. Recommend ordering by date.	Documents ordered by date	S 3.1.1
3	BOR	LH	Section 2.2.3	The report discusses 15 alternatives at the beginning of section and then list 4 at the end. The report should clarify why the 4 are listed and how they are different from the 15. Needs a statement that the 4 alternatives were deemed the most likely to improve water clarity.	Noted. Will address in future draft	
4	BOR	LH	Section 2.3.2	SD80 is “cherry picked” here and needs to be expanded to include the whole document or removed. The report only discusses protecting "scenic attractions" and no mention of all the other elements. The report, as written, could be interpreted that scenic attractions is directly related to clarity (which has not legally been defined) and CBT is operated to protect scenic attractions only. Reclamation would like to keep SD80 whole and in context if referenced.	Discussion of SD80 has been combined to form Section 2.1.1 and we have tried to more clearly define the implications of SD 80 on the future work. SD is contained in entirety an Appendix and referenced in context when used.	S 2.1.1, pg. 2-2
5	BOR	RT	Section 1.1	The C-BT Project is only required to be operated in accordance with the Manner of Operations section of Senated Document 80. The remainder of the document is viewd ae guidance by Reclamation.	Text changed in accordance with comment	S 2.2.1
6	BOR	RT	Section 1.1	Last sentence of third paragraph. Water does not flow from SMR to Granby through the Granby Pump Canal. It is released from SMR dam to the Colorado River and flows by gravity to Granby.	Text changed in accordance with comment	S 3.2.1.1
7	BOR	RT	Section 1.2	Paragrph 5: Reclamation is the entity that alters the project operations. Reword sentence 1 to read: “From 2008-2010, Reclamation, working cooperatively with Grand County and Northern Water, altered the normal C-BT Project operations to evaluate potential effects on water clarity.”	Text changed in accordance with comment	S 3.2.2
8	BOR	RT	Section 2.2.1	Change the year in the fourth bullet from 2001 to 2011.	Text changed in accordance with comment	S 3.2.1.1
9	BOR	RT	Section 2.3.2	It is a reach to call SD80 a regulatory document that influences water quality in the 3-Lakes. That is an unagreed upon interpretation.	Discussion of SD80 has been combined to form Section 2.1.1 and we have tried to more clearly define the propose and reach of SD80	S 2.1.1
10	BOR	RT	Section 2.3.2	Last sentence paragraph 1: The correct term is **Standing** Operating Procedures. Also the SOP’s do not require, but rather provide guidance. Reword the sentence to read “Additionally, the USBR Standing Operating Procedures for Shadow Mountain Dam recommends a one foot fluctuation limitation during summer months and a 0.3 foot fluctuation during winter months when ice cover is present.	Paragraph removed from text	N/A
11	BOR	RT	Section 2.3.3	Paragraph 3 first sentence: The previous use of the term “regulatory documents” to include SD 80 (see comment 9 above) in this sentence implies that SD80 says something about clarity in Grand Lake and the appropriate Secchi depth.	The term “regulatory” has been removed or the “regulatory document” was replaced with the name of the document	S 2.1.1
12	BOR	RT	Section 2.3.5	Paragraph 2 states that 9 values were less than 4 meters in 2011. It would be informative to provide the number of those 9 values that were derived from data taken after pumping resumed on September 7. It could be instructive as to why the standard was not met in 2011.	Noted. Will address in future draft	
13	BOR	RT	Section 2.4	Paragraphs 4 and 5 both state that analysis of daily operations would be required during the “stop-pump” and “modify-pump” periods. Because of system capacity constraints, the daily analysis will be necessary for the entire analysis period (i.e. year ‘round) rather than just during the changed pumping periods.	We agree. The revised report should reflect this approach.	

Comment Number	Agency	Reviewer	Location of Text in May 2013 Draft	Comment	Response to Comment	Line Number of start of text in July Final Draft (Interim Draft for BOR)
14	BOR	RT	Section 3.1 (2.)	Subtask a: The operational data to be used in reservoir water quality modeling should not be historical but rather derived from an operational model. Historical data will not include operations resulting from the Windy Gap Firming Project, Northern Integrated Supply Project, the shift in demand pattern from ag to more M&I, increased maintenance outages, etc.	We agree. The revised report should reflect this approach.	
15	BOR	RT	Section 3.1 (2.)	Subtask g: The operational data to be used to analyze power generation and water deliveries should not be historical but rather derived from an operational model. Historical data will not include operations resulting from the Windy Gap Firming Project, Northern Integrated Supply Project, the shift in demand pattern from ag to more M&I, increased maintenance outages, etc.	We agree. The revised report should reflect this approach.	
16	BOR	RT	Section 3.1 (2.)	Subtask g: This analysis should be based on an analysis period rather than wet, dry, and average year types. Operations are influenced by what happens on both sides of the divide. It can be wet on one side and dry on the other. The analysis should look at the whole range of possibilities through operational modeling for some 30+ year analysis period.	We agree. The revised report should reflect this approach.	
17	BOR	KET	S 1.1, pg 1-1, pp 2	Change "The C-BT Project is required to be operated in accordance with Senate Document No. 80, 75th Congress, 1st Session, which is the authorizing legislation for the Project." to "Senate Document No. 80, 75th Congress, 1st Session is the authorizing legislation for the Project."	Changed in accordance with comment	S 2.1, pg. 2-1, pp 2
18	BOR	KET	S 1.1, pg 1-1, pp 4	Change "The activity storage capacity" to "The active storage capacity"	Changed in accordance with comment	S 2.1, pg. 2-1, pp 4
19	BOR	KET	S 1.1, pg 1-1, pp 4	Change "component" to "purpose"	"Changed to Shadow Mountain's key purpose…"	S 2.1, pg. 2-1, pp 4
20	BOR	KET	S 1.2, pg R-1-2, pp 2	Change "seasonal changes…has" to "seasonal changes…have"	Changed in accordance with comment	S 2.2, pg. 2-2, pp 2
21	BOR	KET	S 1.2, pg R-1-2, pp 3	The statement "The Commission intends that attainability is to be judged by whether or not a clarity level can be attained in approximately twenty years by any recognized control techniques that are environmentally, economically, and socially acceptable." needs to be changed to a quotation with a reference cited.	Changed in accordance with comment	S 2.2, pg. 2-2 and 2-3
22	BOR	KET	S 1.2, pg R-1-2, pp 3	The statement "The underlying assumption is that the clarity in Grand Lake needs to improve." Needs to have a citable based on reason added to it.	Changed in accordance with comment	S 2.2, pg. 2-2 and 2-3
23	BOR	KET	S 1.2, pg R-1-2, pp 3	The phrase "if a more appropriate standard has not been determined." needs to be defined better. As I understand it there is a review process and that a governmental commission will choose to change the standard or not. Also should not a comma be placed after a date?	CWQCC citation added to reflect the specific language. The procedure for changing the standard has been described Comma has been added	S 2.2, pg. 2-3, final paragraph of S 2.2
24	BOR	KET	S 1.2, pg R-1-2, pp 5 & S 1.2, pg R-1-3, pp 2	The discussion of the stop pump periods needs to be divided into separate paragraphs for each stop pump period. Specific information about the length of the periods, the amount of water moved, how the impacts to power were minimized, and what power lost qualitatively, and how the clarity standard was not met should be included. If this information is included later in the report it in not necessary to include it here. Alternatively the information might be arranged in a table.	The text on the modified pumping period has been clarified and expanded to include some of these elements. The impact to power has not yet been added.	S 3.2.2
25	BOR	KET	S 2.2.1, pg R-2-5, pp 2	Change "include" to "included"	Changed in accordance with comment	S 3.1.1.1, pg. 3-2
26	BOR	KET	various	Many places in the document have grammatical errors. Sometimes words appear to be missing, sometimes the tense of the verbs do not match and the plural/singular forms of verbs are not appropriate. I suggest a careful review of these items.	Document reviewed in accordance with comment	
27	BOR	KET	S 2.2.1, pg R-2-7, pp 2	"The internal of loadings" needs to be reworded.	Reworded: "Orthophosphate and inorganic nitrogen accumulate in the hypolimnion of Granby Reservoir just prior to spring and fall turnover due to the breakdown of settled organic matter. Concentrations reach a maximum level just prior to turnover, and impacts of these loadings are then observed in the southern end of Shadow Mountain Reservoir when the Farr Plant is pumping."	S 3.1.1.1, pg. 3-3

Comment Number	Agency	Reviewer	Location of Text in May 2013 Draft	Comment	Response to Comment	Line Number of start of text in July Final Draft (Interim Draft for BOR)
28	BOR	KET	S 2.2.3, pg R-2-7, pp 1	Can the references be numbered and these numbers also placed in the body text? I did not find this particular reference cited on the reference list in the back of the document in Sec 6.0.	The reference section has been updated and numbered and citation throughout the report have been verified for correctness. The numbered citations can be included at a later date when it appears no additional citations will be added to the list.	S 3.1.1.2, pp 1
29	BOR	KET	S 2.2.3, pg R-2-7, pp 2	Are these listed in order of importance? If not should they be in alphabetical order? "non-algal organic particulate matter, algae particles, inorganic suspended solids, and dissolved organic matter."	List has been alphabetized	S 3.1.1.3, pg. 3-4
30	BOR	KET	S 2.2.3, pg R-2-8, pp 4	Is this a GEI assessment or did the Alternatives Report so state? If it is a GEI assessment please provide the reasons it is based on. "Because of C-BT water delivery obligations and the difficulty associated with improving water quality in Shadow Mountain Reservoir (Hydros, 2011) the 2012 Alternatives Report focused on minimizing the inflow of poor quality water into Grand Lake and bypassing flows around Grand Lake and/or Shadow Mountain Reservoir."	deleted paragraph as is adds little to the content of that section.	S 3.1.1.3, pg. 3-6
31	BOR	KET	S 2.3.2, pg R-2-9, pp 1	Referencing the paragraph that starts "The C-BT Project is required to be operated in accordance with Senate Document 80…" does the document address delivery of water or power generation? Since Senate Document 80 is not a water regulation in main purpose, if it mentions other operating criteria they should also be mentioned. Also Senate Document 80 and Colorado Water Quality Control Commission statements should be provided as quotations of whole sentences with an explanation of the context of the sentences.	Discussion of SD80 has been consolidated into Section 2.1.1 and we have tried to more clearly define the implications of SD 80 on the future work Citations have been added	S 2.1.1, pg. 2-2
32	BOR	KET	S 2.3.2, pg R-2-9, pp 2	The phrase "if a more appropriate standard has not been determined." needs to be defined better. As I understand it there is a review process and that a governmental commission will choose to change the standard or not.	The procedure for changing the standard has been described	S 2.2.2
33	BOR	KET	S 2.3.3, pg R-2-9, pp 1 - 3	Would it be appropriate to define "water quality" in terms of applicable regulatory standards or in terms of expected values for typical similar water bodies and then describe how each of the 3 lakes differs from the standard or norm?	I think it would provide little information if "water quality" was defined as the applicable regulatory standards. Most all statewide water quality standards are developed around the protection of aquatic life use, because often that is the most sensitive use to be protected. Plus most standards are derived from a toxicological standpoint because results can be defined by a set endpoint (i.e., death, reproductive, or growth impacts). Given the very site-specific conditions, I believe "water quality" needs to be defined more specifically to address specific characteristics of importance to each water body, and to C-BT water. The water quality characteristics may be placed in the context of statewide standards to show the relative magnitude or importance of each characteristic. However, a goal of the each C-BT alternative should be to attain the best possible water quality condition for each water body, while attaining the ultimate goal of the water clarity standards in Grand Lake. I think the WQI may provide a sufficient metric to characterize the water quality conditions on a level playing field among the three water bodies, but I am not sure how it may apply to characterizing water quality conditions in C-BT water. Unless it can be assumed that the conditions are same as the waterbody that ultimately supplies C-BT water in each alternative scenario considered. This may be a challenge for evaluation of SMR because of the spatially variable water quality characteristics during certain flow conditions.	
34	BOR	KET	S 2.3.4, pg R-2-10 - 11, pp 1 - 3	Please also provide a table or tables that show for each lake or feature what a good baseline monitoring program includes and what each lake now lacks. Make it so that you can look at the table and then easily find in the text explanatory details.	Table occurs in Appendix D. Text referencing the sampling plan is found in Section 4.3.2	Section 4.3.2, Appendix D

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35	BOR	KET	S 2.3.5, pg R-2-11, pp 1	Please add limited summary detail about the water movement conditions, natural inflow volume, and why the standard was not met.	Noted. Will address in future draft	
36	BOR	KET	S 2.3.5, pg R-2-11, pp 1	How the current standard is specifically defined? Is it short enough to be quotable? If not can it be an appendix? Does the standard address where the Secchi measurements are to be made? How many measurements must be taken each day? Do measurements have to be taken each day? Who must take the measurements? Who must pay for them?	This text has been replaced with a summary of the regulation and these questions are addressed there.	S 2.2.2
37	BOR	KET	S 2.3.5, pg R-2-11	The title of the section implies a discussion of what we have and a proposal for what is needed or what might be more easily measurable. I kind of see what we have now from the text. There is no discussion of what the narrative standard means here. I do not see a clear statement that a more measurable standard is needed and why – only hints. Or maybe the current standard is usable?	A discussion of the narrative standard was added in the summary of the regulation along with a discussion of who the standard	S 2.2.2
38	BOR	KET	S 2.3.6 – 2.3.8, pg R-2-12 through R-2-14, pp all	Please make in addition to text, tables that summarize what is lacking, the proposed study or way to get what is lacking, and the reason it is needed or the value added. The text should be arranged so that you can look at the table and easily go to labeled paragraphs for explanatory text.	Tables of proposed sampling plan, existing data, NW sampling plan have been added	Text occurs at S 4.3 and tables appear in the appendices
39	BOR	KET	S 2.4, pg R-2-15, pp 5	The discussion on power impacts existing data and needs should be expanded. Can an analysis of the existing power impact calculation procedures from WAPA and Reclamation be provided? Comparisons to industry or other government power loss costs should be provided. Recommendations about what impact estimating data improvements that should be made to inform the decision should be suggested.	A discussion has been added on the procedures used in the 2012 Alternatives Study and the discussion on expanded procures has been added. Industry/government standards on power loss calculations would in our judgement be based on daily and or hourly simulations, which we have recommended for the next pahse of study.	
40	BOR	KET	S 2.4, pg R-2-14 through R-2-15, pp all	In addition to the text I request a flow chart or similar that shows sequencing of the engineering data collection work relative to the decisions to be made. What, how, and why should be summarized on the chart with easily identifiable supporting text off the chart that provides details.	Figure 1 and Appendix I have been added	Figure 1, Appendix I
41	BOR	KET	S 3.1 2. a - d, pg R-3-17, pp all	It seems that this is addressing data holes? I think we need to keep the phases separate. Start with data holes common to any solution, and a sequence/value to fill the data holes. After data holes are filled you get to at least (2) 30% design work plans – one for operational changes and one for potential construction and maybe something else. Both would have different levels of compliance required with NEPA and Reclamation Directives and Standards. We need sequences and task time periods for at least both of those paths.	We are defining “Data Gaps” as fundamental questions that need to be resolved prior to the selection of a preferred alternative. The effort to get to 30% design will include lots of data gathering and analyses. The items that are not required to make an informed decision of a preferred alternative are shown in the Work Plan.	
42	BOR	KET	S 3.1 2. e - f, pg R-3-18	Do these apply just to a construction alternative, or not?	They would apply to a structural alternative for which drawings are required to depict physical features.	
43	BOR	KET	S 3.1 2. g, pg R-3-18	This seems to be a big data hole that may be prominently discussed earlier? Can specific data items that are now deficient be identified?	Data gaps have been combined and defined into Section 4.0	Section 4.0
44	BOR	KET	S 3.1 3 – 6, pg R-3-18 -24, pp all	In general we need the Statement of Purpose and common data holes first (as you so state). Then the Identification of Alternatives and the coarse and fine screening follow. After that we have work plans to get to 30% for what remains. Specific activities with associated time periods and typical costs should be provided. Refer to work statement 2. Requirements Technical Review paragraphs 3 and 4. Also work statement 2. Requirements Subtask 2 provides an outline that needs to have specific task associated with the bullets. Sequencing, times to accomplish, and typical costs should be provided.	Statement of Purpose occurs in Section 1.0. Data gaps are consolidated and shown in Section 4.0. Conceptual cost estimates are shown in Section 7.0 Schedules are shown in Section 8.0	See comment
45	BOR	KET	S 3.1 8 – 9, pg R-3-24 -2425, pp all	Specific tasks, sequencing, time periods, costs should be provided. Example: “Document the NEPA process” is too vague. We need to go at least one more level down and list specific regulations. It is not necessary to document each step, but enough detail to estimate time periods for accomplishment should be provided.	The task for “documenting the NEPA processs” was intended to be an overview of the process that is expected to occur. The tasks in 9 that follow are specific elements of the process and consultation with the key agencies. We will examine the regulations and provide additional details, as appropriate. However, the intention was to identify that such needed to be done, not to actually do it at this time.	

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46	Grand County	Katherine Morris	P 1-1, pp 2	Willow Creek and Green Mountain Reservoirs should be included here. Three Lakes is generally referred to as a region or just as the Thee Lakes—not as a System.	Facilities operation/description for the C-BT project was quoted from BOR sources to include all facilities. Clarification has been added for the naming of Three Lakes vs. Three Lakes System	77, 155
47	Grand County	Katherine Morris	P 1-1, pp3-5	I believe there are factual errors in these paragraphs but will defer to Reclamation comments to correct them.	Reclamation has reviewed for factual correctness and GEI has made all requested edits.	67-182
48	Grand County	Katherine Morris	P 1-2, pp 2, 1st sentence	This sentence is inaccurate and fails to establish the long history of concern about conditions in Grand Lake since the C-BT project began diversions. Please see Grand County's comments regarding this on draft report version one: "~~During recent years the seasonal changes in~~The effect of the C-BT Project on the decrease in clarity of ~~the~~ water ~~column~~ in ~~certain locations in~~ Grand Lake has been a concern since transfers from Granby Reservoir began, and has grown with the increased demand on the CB-T project over the decades. W~~w~~ith the recently proposed water project pending, clarity -has become an even greater ~~growing~~ concern to Grand County, the Town of Grand Lake, and among a group of residents that live near Grand Lake."	REMOVED FROM TEXT	N/A
49	Grand County	Katherine Morris	P 1-2, pp 3	Sentence beginning "The underlying assumption…" should not be paraphrased. Please quote the language of Section Q narrative explaining why it is appropriate for Grand Lake clarity to improve: "The Commission determined that it is appropriate to adopt water quality standards for the protection of Grand Lake's clarity because of Grand Lake's uniqueness as Colorado's largest natural lake. Grand Lake adjoins and complements Rocky Mountain National Park in the headwaters of the Colorado River and its social and economic importance is worthy of protection. "	The discussion of Reg. 33 has been significantly expanded in Section 2.3.2 and much of the regulation has been quoted. The requested quotation has been added.	249
50	Grand County	Katherine Morris	P1-2, pp5	There are editorial changes that could be made to this paragraph to be cleaner and more succinct.	Section referenced was rewritten and revised text appears in Section 3.2.1, pp1	611
51	Grand County	Katherine Morris	P 1-3, pp2	Please add to the end of the sentence beginning "Notably, the proposed …" the words "with the modified pump operation having no demonstrable benefit to Grand Lake clarity." The distillation of what happened in 2011 to a single, ambiguous sentence "There is an indication that high runoff conditions (i.e. wet year conditions) benefit water clarity when low water and power demands on the eastern slope resulete in an umplanned stop-pumping period" is unacceptable. This year was vastly important for a number of reasons, and Reclamation *did* work to extend the sop-pump period beyond when they could have begun taking water, so the year is appropriately included with the section on stop-pumping experiments. Please return to the language proposed by Grand County (and previously agreed upon with Reclamation for inclusion in another document) in the version 1 report draft: "In 2011, an unusual combination of extensive snowpack, relatively ample storage in east slope reservoirs, relatively low early spring water demand, and low anticipated power demand combined to produce an opportunity to provide an extended stop-pump period. Pumping usually resumes in after spring runoff in mid-July, however, there was no need for pumping during this time, and a downgradient flow from Grand Lake into Shadow Mountain Reservoir was maintained much later into the season than normal. The official 2011 stop-pump period was 7 weeks: when coupled with the customary annual pumping shutdown during spring runoff the result was no pumping for 14 weeks, from late May to early September. During that time, clarity improved to a maximum Secchi depth measurement of 23.8 feet (7.25 meters) in late August."	Added 2011 ¶ to section beginning on pg 3-8 and included text from KM's comment	690, 1067
52	Grand County	Katherine Morris	P 2-5 pp 2	Editorial: Eliminate leading sentence here.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–GEI elected to leave the leading sentence in as it highlights that unique conditions existed in 2011	N/A
53	Grand County	Katherine Morris	P 2-5 pp 2 Bullet point number 3:	Editorial: eliminate the words "late season"	This bullet was modified to reflect the language used in the Final 2011 OWQ Report	516

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54	Grand County	Katherine Morris	P 2-5 pp 2 Bullet point number 4:	Change 2001 to 2011	This bullet was modified to reflect the language used in the Final 2011 OWQ Report	518
55	Grand County	Katherine Morris	P 2-5 pp2 Bullet point number 5	Specify "pumped inflows" rather than just inflows.	This bullet was modified to reflect the language used in the Final 2011 OWQ Report	521
56	Grand County	Katherine Morris	P 2-5, pp 3	Editorial: Bullet point 1 (last on page): Change from "The better water clarity…" to "The exceptional water clarity…"Confine sentence to Grand Lake if necessary.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–GEI opted to retain the existing word choice	N/A
57	Grand County	Katherine Morris	P2-6, bullet point 3	Editorial: The increase in chlorophyll-a was dramatic, and that is not communicated here. Consider "…and correspondingly rapid increase in chlorophyll…"	This bullet was modified to reflect the language used in the Final 2011 OWQ Report	538
58	Grand County	Katherine Morris	P2-6, bullet point 5	DO in surface waters of Grand Lake and SMR are higher not just because of "higher runoff conditions" but specifically because there is higher DO in tributary inflows than in pumped flows.	Fixed per OWQ pg 152, Bullet #2 (no substantive change)	542
59	Grand County	Katherine Morris	P 2-6, pp 1, bullet point 1	This is inaccurate. There is only one secchi measurement from winter in this report, and it comes from SMR. TSS values at AT West actually hit lower levels in late summer than in winter. At SM-Mid, TSS is comparable late summer and winter, which is also grue at GR-Dam and GR-EAS.	Fixed per OWQ pg 152, Bullet #5 (no substantive change)	550
60	Grand County	Katherine Morris	P2-7, bullet point 1	SMR stratification seems less the norm than is implied here, and is also impacted (at least some of us think it is) by wind. Please be clear that stratification is ephemeral.	Listed wind, but this is not consistent with OWQ pg 153, Bullet #5	567
61	Grand County	Katherine Morris	P 2-7, bullet point 2	Same comment as in first draft: Internal loadings of phosphorus and nitrogen occur twice per year, and this makes it seem like it's a once a year event.	Text has been reworded for clarification.	570
62	Grand County	Katherine Morris	2-7, pp2, 1st sentence	Please change the first sentence to read "…is predominantly related to pumping of water containing non-algal organic particulate matter…"	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–this text was quoted from the Alternative Report and was not changed for this reason	N/A
63	Grand County	Katherine Morris	2-7, pp2	The sentence beginning "Factors affecting the concentrations of these constuents include…" should be removed or altered to say "may include". We are currently studying what affects concentrations of these constituents.	Added "may"	590
64	Grand County	Katherine Morris	2-7, pp2	Last sentence, same comment as on 1st draft: there's no reason to be vague here with the word "appears". If water were not pumped backwards though Grand Lake, it would be clear.	This text was changed to a direct citation from the Alternatives Report	596
65	Grand County	Katherine Morris	2-7, bullet point 1	Should read "decrease or *stop water* pumped…"	This text was changed to a direct citation from the Alternatives Report	599
66	Grand County	Katherine Morris	2-7, bullet point 2	This is vague and not included in the alternatives table. Where this comes from and how it would be achieved are not clear.	This text was changed to a direct citation from the Alternatives Report. For reference, this is found on Pg. 2.25 of the Alternatives Report and Pg. 78 of the final 2010 OWQ Report. We have added the conclusion that improving water quality in SMR would be difficult.	602,604
67	Grand County	Katherine Morris	P 2-8, pp 2, bullet point 6	Grand County submitted extensive comments during our review of the Windy Gap Firming Project EIS drafts on the Lake and Reservoir Water Quality Technical Report. We thought this document was flawed at the time, and still do. Our comments are attached the e mail with this document. The analyses run in this document used an old version of the Three Lakes model, and the input data gaps were huge compared to data available now. Any conclusions based on those model runs are stale and need to be re-run. Use of this document is inappropriate for any of the Technical Review or investigations regarding Grand Lake clarity moving forward.	Comment was noted but not incorporated into the text. The salient features of the Technical Review do not depend on this document.	N/A
68	Grand County	Katherine Morris	P 2-9, pp2	There is a particular attachment to the concept of different meanings of water quality that does not seem to benefit this document or the process in any way. It would be easier to understand if GEI simply stated that in Grand Lake, the key concern is clarity, in SMR, DO and chl-a, and in Granby Reservoir, DO and perhaps nutrients.	Reworded some of the paragraph but no substantive changes.	949

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69	Grand County	Katherine Morris	P2-9, last paragraph	Water quality in the North and East Inlets has been defined sufficiently to warrant a cleaner description than is given here. Temperatures are low, conductivity is low, TSS is generally low, nutrients are generally low, etc. This is especially true when compared to pumped inflows from SMR. Use the 2010 report for reference.	Added text re: low nutrients and TSS	956
70	Grand County	Katherine Morris	P 2-10, 1st paragraph	As this is the first place that interim nutrient criteria and drinking water use supply regulations are mentioned, they should be explained more clearly (regulation, agency, limits).	Added text to clarify interim nutrient and DUWS chl	969
71	Grand County	Katherine Morris	P 2-10, pp2	This would be a good place to explain the attempt to quantify “scenic attraction” in SD80 by using secchi depth.	Comment was noted but not incorporated into the text. The relationship between Secchi depth and “scenic attraction” is subjective at this juncture.	N/A
72	Grand County	Katherine Morris	P2-10, pp 4, first sentence	Clarity is not an issue in “the Three Lakes System”, but for Grand Lake.	Changed to Grand Lake	1002
73	Grand County	Katherine Morris	P2-10, pp5	There are no “additional studies” concerning “the Channel’s biological processes”. To what is this referring?	Clarified text. Section 4.3, pp3	1012
74	Grand County	Katherine Morris	P2-11, pp 1	Please specify tht the 7.6 m measurement was achieved with the use of a view scope.	Text was revised in accordance with comment and appears in Section 4.6, pp5see	1216
75	Grand County	Katherine Morris	P2-11, section 2.3.5	This section is presented with an apparent underling assumption that the standard is somehow flawed and that 2011 proves this. The water that was pumped into Grand Lake after September 6 of 2011 was of unacceptable quality. The fact that inclusion of secchi values from post Sep 6 caused Grand Lake not to meet the standard for that year does not mean that the standard is somehow failing or inadequate. On the contrary, the four meter standard, assessed as it currently is written, protects Grand Lake from water of the quality that it received after September 6, which is as it should be. It is unlikely that monitoring would be conducted on a less frequent basis than weekly, but even if it did, a more compelling case needs to be made for what would be wrong with the assessment being determined by 4 failing values in a sample set of 25. Rather than focusing on perceived flaws in the standard, GEI could just as easily focus on how 2011 clarity illustrated how clear the lake can be when supplied exclusively by native inflows, and how a bypass would restore Grand Lake clarity. Grand County does not agree with the concluding paragraph in this section. The 4 meter standard is offering Grand Lake the protection we sought.	Comment was noted but not incorporated into the text. At this point, it is unclear if the 4m standard is or is not appropriate or even attainable. The assessment methodology is not well defined and needs to be clarified. We are not advocating the 4m depth be changed, only evaluated to verify it is a reasonable value for Grand Lake. We want to ensure that if CBT flows are bypassed around Grand Lake (or another alternative) that the 4m standard can be met.	N/A
76	Grand County	Katherine Morris	P 2-12, pp1, first sentence	The concept that pumping performed without ramping flow rates is more detrimental to clarity than ramped pumping has not been proven, but is suspected. Verification of this is necessary.	Clarified text and added data gap.	1069
77	Grand County	Katherine Morris	P 2-13, pp2	What about the 303(d) violation on SMR for DO?	Added 303(d) DO text	1321
78	Grand County	Katherine Morris	P 2-14, pp1	Farr pumping also vastly increases nutrient concentrations into SMR. Look at 2010 Hydros report.	Comment was noted but not incorporated into the text. We do not agree with vastly increases nutrient concentrations. However, it does from a load standpoint just due to the volume of water.	N/A
79	Grand County	Katherine Morris	P 3-17, pp1	See comment 22.	Comment was noted but not incorporated into the text. The salient features of the Technical Review do not depend on this document.	N/A
80	Mid-West Electric	Thomas Graves	General	**Impacts of all inflows must be identified and analyzed before proceeding to development of alternatives.** While some stakeholders have apparently already decided that operations of the Colorado-Big Thompson ("C-BT") are the source of Grand Lake's clarity problems, the initial work that has been conducted on other inflows appears to indicate that there is more than one source contributing to the problem. That being the case, identification and analysis of *all* contributors to Grand Lake clarity need to be identified before consideration of alternatives.	A data gap specific to stormwater was added.	923, 1045

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81	Mid-West Electric	Thomas Graves	General	**A solution to Grand Lake's clarity problems must address the entire problem, not just Colorado-Big Thompson operations.** To focus solely on CBT operations could result in large expenditures by the Bureau of Reclamation expenditures that raise power rates for rural electric cooperatives that serve the area- that would only solve Grand Lake's clarity problems temporarily, since other sources would continue to contribute to clarity problems.	A data gap specific to stormwater was added. Task 5.g in Section 6.0 addresses this comment	1462, 1045
82	Mid-West Electric	Thomas Graves	General	**Draining and cleaning out of Shadow Mountain Reservoi1· should be included as a study alternative.** Colorado-Big Thompson issues seem to revolve around Shadow Mountain Reservoir in large part. The reservoir is shallow, providing a good environment for algae growth. In the past, Reclamation did draw down Shadow Mountain, but did not clean out debris and algae- basically scraping out the reservoir. A complete cleaning of Shadow Mountain could reduce or eliminate C-BT's clarity issues. The solution may be only temporary, so frequency and cost of cleaning operations would have to be assessed in comparison to other potential alternatives.	Added as Alternative L	Table 6
83	Mid-West Electric	Thomas Graves	General	**Any potential solution to clarity issues must be carefully assessed as to "collateral impacts" that may burden Reclamation with additional costs.** Some potential solutions to C-BT operations could result in impacts on Shadow Mountain reservoir and/or Lake Granby- in effect, solving one problem but creating another. If bypassing Shadow Mountain reservoir creates problems at the reservoir, those issues need to be identified and the responsibility for addressing those issues needs to be determined.	Changed in accordance with comment. This text appears as Task 5.f	1617
84	Northern Water	Peggy Montano	General	Please be mindful of the use of the words “water transfer” throughout the document. Instead, change that to “delivered “ or “pumped”.	Text was revised in accordance with comment.	various
85	Northern Water	Esther Vincent	R-1-1 3rd paragraph	“…flow via gravity from Shadow Mountain Reservoir through the Granby Pump Canal to Granby Reservoir”. Change Granby Pump Canal in this sentence to Colorado River Below Shadow Mountain Dam	Wording has been revised “…flow via down-gradient from Shadow Mountain Reservoir through the outlet works into the Colorado River that connects to Granby Reservoir.”	164
86	Northern Water	Esther Vincent	R-1-1 4th paragraph	Last sentence in this paragraph needs to be edited. Perhaps: Shadow Mountain Reservoir’s key role in the C-BT…	Text was revised in accordance with Comment #126 and appears in Section 2.2, pp3	170
87	Northern Water	Esther Vincent	R-1-3 1st paragraph	“the 2008 stop-pumping …for four weekS”	Text was revised in accordance with comment and appears in Section 3.2.2, pp2	633
88	Northern Water	Esther Vincent	R-1-3 1st paragraph	“ The effect of the stop-pumpin period on …uncertain” Replace with “The effects of the pumping interruptions on water quality in Shadow Mountain Reservoir are mixed and dependent upon confounding factors.”	Text was revised in accordance with comment and appears in Section 3.2.2	675
89	Northern Water	Esther Vincent	R-1-3 2nd paragraph	Replace “the detention time pumped water was held in” with “residence time”	Text was revised in accordance with comment and appears in Section 3.2.2	678
90	Northern Water	Esther Vincent	R-1-3 2nd paragraph	“when low water and power demands”: this needs to be verified with USBR but I think it was mostly that there was no place in the system to put the water. I am not sure power had much to do with it.	Text was removed, comment not relevant in final version	N/A
91	Northern Water	Esther Vincent	R-1-3 2nd paragraph	Consider replacing “unplanned” in the second to last sentence with “extended”. Add “in 2011” to the end of the second to last sentence in this paragraph to clarify. Also, consider replacing “during any of the planned or unplanned stop-pump periods” in the last sentence with “for that year”.	Agree to change to extended, However, text was removed, comment not relevant in final version	N/A
92	Northern Water	Esther Vincent	R-1-1 Section 1.0 1st sentence	Delete “a” before “Colorado’s largest natural lake”	Text was revised in accordance with comment and appears in Section 2.1	174
93	Northern Water	Esther Vincent	R-1-1 Section 1.0 4th paragraph	There seems to be an abundance of details about Shadow Mountain Reservoir about capacity, depth, surface area that is not mentioned for the other water bodies. It leaves the reader wondering why the focus on these details. Either provide the same level of detail for all water bodies or remove the details for Shadow Mountain Reservoir.	The verbal description of the physical parameters for SMR have been removed and replaced with Table 1 that lists the physical parameters for all three lakes.	60
94	Northern Water	Esther Vincent	R-1-1 Section 1.0 1st paragraph	“with mixed success”. I am not sure this is totally accurate. The last drawdown was successful in cutting back the weeds. They have now come back to a large extent but it has been 7 years and that was roughly the duration of control anticipated before the drawdown.	Added section on macrophyte management with additional clarity on effectiveness regarding plant control and water clarity	714

Comment Number	Agency	Reviewer	Location of Text in May 2013 Draft	Comment	Response to Comment	Line Number of start of text in July Final Draft (Interim Draft for BOR)
95	Northern Water	Don Carlson	R-1-1 Section 1.1	• The United States owns the C-BT Project and it is jointly operated by Reclamation and Northern Water. • West Slope facilities also include Willow Creek Reservoir and the West Portal. • Water cannot flow via gravity from SMR through the pump canal to Granby Res. • Active storage in SMR is ~1300 af, not 1852.	• Text was revised to reflect the most accurate wording…the US owns the system, BOR operates part and NW operates part under contract to BOR • Refer to comment #1 • Text was revised to reflect the correct system operation • We reviewed Reclamation 1996, Lewis 1992, and Hydros 2013 which all site similar storage values (~1800-1900) for SMR. Only the Hydros report calls this active storage. Table 1 was added and lists total storage for all lakes	• 71 • 155 • 170 • 180
96	Northern Water	Don Carlson	R-1-2 Section 1.2	I think the preliminary study was sometime before 2006.	Text was removed, comment not relevant in final version	N/A
97	Northern Water	Esther Vincent	R-1-2-Section 1.2 3rd paragraph	Perhaps refer to the language in the standard that directs parties to address potential impacts to aquatic life? I would also suggest quoting the standard directly rather than paraphrasing it.	The more complete description of WQCC Reg. 33 can be found in Section 2.3.2 and references to WQCC Reg. 33 (as well as other documents) are now direct quotations. The relevant portion of WQCC Reg. 33 is also provided in its entirety in Appendix G.	240
98	Northern Water	Esther Vincent	R-1-2 Section 1.2 4th paragraph	Last sentence: this is correct but at this point the scope of these multi-year studies has broaden beyond nutrients, so I would replace "nutrient study" with "water quality study".	Changed to water quality study	618
99	Northern Water	Esther Vincent	R-2-6 Section 2.2.1 1st paragraph	"This report is the first report in an annual series": this is incorrect. This is the second annual report but the scope of the 2011 report expanded from the 2010 report. The previous report only cover Grand Lake and Shadow Mountain and was mostly focused on clarity. The 2011 includes all Three Lakes and looks at water quality and operations in a more wholistic manner.	A previous draft contained the "second annual" language but was revised based on a comment stating that the 2011 was the first report to look at all three waterbodies and was therefore the first in the annual series. The sentence has been removed for clarity and brevity.	N/A
100	Northern Water	Esther Vincent	R-2-6 Section 2.2.1 2nd paragraph	"The conditions assessed…nutrient loading". The report looked at water quality in the lake/reservoirs as well including physical profiles, not just inflow water quality. Not all of the graphs are discussed in the body of the report since it was so exhaustive but the analysis was done. Only meaningful findings were reported.	Added lake and reservoir water quality and physical profiles	
101	Northern Water	Esther Vincent	R-2-5 4th bullet	2001 should be 2011	This bullet was modified to reflect the language used in the Final 2011 OWQ Report	518
102	Northern Water	Esther Vincent	R-2-5 4th bullet	Add "at the bottom" to the phrase "…low dissolved oxygen concentrations developed…"	Text was revised in accordance with comment and appears in Section 3.1.2.1 final bullet	540
103	Northern Water	Esther Vincent	R-2-5 5th bullet	DO concentrations were not really higher near the surface in Grand Lake or across all stations in SMR in 2011. Consider adding a bullet stating: "Dissolved oxygen concentration at the bottom of Grand Lake were higher than those observed in 2007-2010, probably because of higher runoff conditions." Then modify the existing 5th bullet to say: "In the southern end of Shadow Mountain Reservoir, dissolved oxygen concentrations were higher than typically observed in the late summer due to the extended period of no Farr pumping. Surface dissolved oxygen concentrations in Grand Lake and Granby Reservoir in 2011 were similar to the previous years of observation."	Text was revised in accordance with comment although specific wording was not used	573
104	Northern Water	Don Carlson	R-2-10 Section 2.3.2	• Documents do not influence water quality • SD 80 is not a regulatory document that influences water quality and specifically does not address water quality. The Manner of Operations require that the project is operated to protect the scenic attractions of Grand Lake, … There is not consensus among those involved with this study what "scenic attractions" means. Some assert clarity and others assert that the one-foot fluctuation limit protects the scenic attraction of Grand Lake.	Clarified text by adding WQCC Regs 31 and 33	240, appendices F, and G

Comment Number	Agency	Reviewer	Location of Text in May 2013 Draft	Comment	Response to Comment	Line Number of start of text in July Final Draft (Interim Draft for BOR)
105	Northern Water	Esther Vincent	R-2-10 Section 2.3.2	Suggest to quote documents directly rather than paraphrasing.	Text revised in accordance with comment	various
106	Northern Water	Esther Vincent	R-2-8 1st paragraph	Reference should be to Hydros, 2012. (Also note 2010 report in reference section should also say 2012, instead of 2013.) One note: The 2010 report does conclude that it would be challenging to improve water quality in SMR due to morphology, loading, etc.; however, that report did not make any attempt to weigh that challenge against those associated with any structural or non-structural alternatives.	Text was modified to reflect comment	604
107	Northern Water	Peggy Montano	R-2-8 Section 2.2.3 1st sentence	"Owing to the complexity of the C-BT system and the multi-directional flow of water between each system, each water body…" the second time using the word system does not seem right - it should be something like each facility or component or waterbody.	Text was revised in accordance with comment and appears in Section 4.2, pp1	950
108	Northern Water	Esther Vincent	R-2-9 ; Section 2.3.3	This section seems to unnecessarily limit definition of water quality concerns (e.g., suggests Grand Lake's only concern is clarity). This assessment seems premature in advance of development of a Statement of Purpose and Need.	Text was revised in accordance with comment and appears in Section 4.2, pp1	954
109	Northern Water	Peggy Montano	R-2-8 Section 2.2.3 3rd bullet	at the bottom Shadow Mountain Reservoir is written as Shadow Maintain Reservoir	Text was revised in accordance with comment	566
110	Northern Water	Esther Vincent	R-2-8 Section 2.2.3 2nd paragraph	"The Alternatives Report indicates that water clarity in Grand Lake and Shadow Mountain Reservoir is predominantly…organic matter." 1) replace "predominately" with "predominantly" 2) This sentence more generally depicts factors that influence clarity but recent studies have shown that particulate matter and algae particles are the two most important drivers. (See 2011 Hydros report page 116 "Inorganic suspended solids and dissolved organic matter were found to be less significant") . "Factors affecting the concentrations…inflowing waters." Autochthonous sources are also important.	This text was changed to a direct citation from the Alternatives Report.	590
111	Northern Water	Esther Vincent	R-2-8 Section 2.2.3 bullets	Add " structural modifications or removal of Shadow Mountain reservoir" and "Watershed Management to improve inflow water quality"	These alternatives are presented in the Table 6	1296
112	Northern Water	Esther Vincent	R-2-10 and R-2-11 Section 2.3.3	The relationship between water quality and scenic attractions has not been defined either.	This relationship is not defined in the text. The relationship between Secchi depth and "scenic attraction" is subjective at this juncture.	N/A
113	Northern Water	Esther Vincent	R-2-10 4th paragraph	Suggest changing "be insightful" to "provide insight".	Text was revised in accordance with comment and appears in Section 4.3, pp2	1008
114	Northern Water	Esther Vincent	R-2-10 5th paragraph	It is unclear what is intended regarding "influence of the channel's biological processes on Grand Lake, in the absence of pumping". Perhaps it would be good to explain further and cite specific studies referenced.	Clarified text	1012
115	Northern Water	Peter Nichols	R-2-12 Section 2.3.4 4th paragraph	this(and any) discussion of stormwatwer needs to mention not only sediment but nutrients as sources of concern. The last sentence added to that paragraph seems out of place – not sure what the point is.	Added Section 4.4 And Section 3.2.4 to clarify text	743, 1045
116	Northern Water	Esther Vincent	R-2-11 1st paragraph	Consider adding the following sentence at the end of the first paragraph: "Any data evaluating performance of this system have not yet been provided for analysis. "	Added text regarding evaluation the performance of the stormwater system and other stormwater data gaps	755
117	Northern Water	Esther Vincent	R-2-11 4th paragraph	Perhaps add this as a second sentence to that paragraph: "No technical basis was presented to the Commission in 2008 to support the 4m value."	The specific language found in the comment was not used. However, the discussion of Reg. 33 has been significantly expanded in Section 2.3.2 and much of the regulation has been quoted.	240
118	Northern Water	Esther Vincent	R-2-11 Section 2.3.4	This section needs to be revised in light of the monitoring program summaries provided. Please note that the baseline monitoring program is just that: baseline. Although it has been modified to account for data needs related to Three Lakes WQ studies, if there are data needs that should be addressed through special studies, that would be separate from baseline monitoring. The CU particulate study is an example of this type of special studies. When making recommendations for additional monitoring it would be helpful to specify if data collection should be on-going or part of a targeted effort, in which case the question to answer should be clearly presented.	The baseline monitoring should include information necessary to evaluate or model the water quality conditions that represent a range of hydrological conditions	1031

Comment Number	Agency	Reviewer	Location of Text in May 2013 Draft	Comment	Response to Comment	Line Number of start of text in July Final Draft (Interim Draft for BOR)
119	Northern Water	Esther Vincent	R-2-12 Section 2.3.5	First Sentence “TLNS Technical Committee”. Let’s refer to it as the Three Lakes Technical Committee more generally speaking since as I commented earlier we are now working on WQ in the Three Lakes in a more general sense. “to provide a better…in Grand Lake”. Our scope is broader, it is to understand water quality in the Three Lakes. Clarity is one focus area among other things.	Changed TLTC to Three Lakes Technical Committee, Other comment noted but text no longer appears in the report.	619
120	Northern Water	Esther Vincent	R-2-14 Section 2.3.6 2nd paragraph	“These types of questions should BE addressed”. Missing “be”. “with an updated version of Three Lakes Water Quality Model”. Maybe, maybe not. The modeling discussion needs to happen and for now it is not a foregone conclusion that the model is inadequate for evaluating alternatives. Maybe this should be rephrased to explain that the question of whether the model can be used to evaluate the alternatives needs to be answered.	Add “be” and added sentence regarding the adequacy of a model to address C-BT alternatives analysis objectives	
121	Northern Water	Esther Vincent	R-2-15 Section 2.3.7 2nd paragraph	“the effect of flow from the North Fork OF THE Colorado River do not appear to be fully accounted by current routine monitoring efforts”. This is not completely accurate. The effects of the North Fork are captured by monitoring but the sources of poorer water quality in the North Fork watershed are poorly understood at this point. McCutchan’s monitoring in 2013 as part of the 2013 Particulate Study should begin to provide an answer.	Added poorly understood, and more info on McCutchan’s 2013 particle study	1109, 1057
122	Northern Water	Esther Vincent	R-2-15 Section 2.3.7 2nd paragraph	“whether a resulting change in potentially …should be considered AND remains undetermined.” Missing “and”	Text was revised in accordance with comment and appears in Section 4.2.2, pp.2	1312
123	Northern Water	Esther Vincent	R-2-15 Section 2.3.7 4th paragraph	“an update and expanded Three Lakes Water Quality Model”. Same comment as for R-2-14 Sectopn 2.2.6. Maybe, maybe not. The modeling discussion needs to happen and for now it is not a foregone conclusion that the model is inadequate for evaluating alternatives. Maybe this should be rephrased to explain that the question of whether the model can be used to evaluate the alternatives needs to be answered.	Did not change text in this section, but the added model section provide more information	
124	Northern Water	Esther Vincent	R-2-13 1st paragraph	“considerable uncertainty associated with the assessment methodology”. I am not clear on what is meant by “considerable uncertainty”.	Clarified text re attainability and error around the 15th percentile	
125	Northern Water	Esther Vincent	R-2-7 bullet point 3	It is important to also note that the decline in clarity started before the onset of pumping, which coincided with increased productivity at the warmest time of the season. The decreased in clarity was then precipitated by the onset of pumping.	Clarified using OWQ 2013 pg 152, last bullet	
126	Northern Water	Esther Vincent	R-2-7 2nd paragraph	“The 2013 report reaches numerous concludsion about the behavior of the system relative to water clarity”. The report is not limited to clarity and includes conclusions for water quality and operations and how the system behaves in a more general fashion. But perhaps you only intended to summarize conclusions related to clarity.	We cannot provide a complete summary of WQ conditions, but rather pulled key summary points	
127	Northern Water	Esther Vincent	R-2-9 1st paragraph	I am not sure this is an accurate characterization. Watershed management is discussed in the report and presented as an integral part of any alternatives that would be envisioned.	Text was revised in accordance with comment and appears in Section 3.1.2.2, pp.4	
128	Northern Water	Esther Vincent	R-2-9 bullets	Add Northern Water’s Flowing Sites Report and Jon Ewert’s presentation to the Three Lakes Technical Committee in March 2013	Comment was noted but not incorporated into the text. The salient features of the Technical Review do not depend on these documents. Both documents are listed as references.	
129	Northern Water	Peter Nichols	R-2-11	Good to see effects on Horsetooth and Carter water quality included on R-2-11.	N/A	
130	Northern Water	Esther Vincent	R-2-12 second paragraph	“Currently, the nutrient monitoring appears…Shadow Mountain Reservoir”. Nutrient profiles were collected during low DO events to characterize nutrient loading in Shadow Mountain Reservoir. The Three Lakes TC has discussed the need for additional internal loading investigations inl Granby and Shadow Mountain. However there have not been discussions of collecting nutrient profiles on an on-going basis as part of baseline monitoring efforts and it is unclear at this point why that would be needed. I realize this is not what is discussed here, but since it came up at the meeting, I thought I would address it here. We will provide a data matrix to show what data is available.	Clarified language about data needs re internal load and algae response for bypass alternatives that reduce or eliminate pumped inflows	

Comment Number	Agency	Reviewer	Location of Text in May 2013 Draft	Comment	Response to Comment	Line Number of start of text in July Final Draft (Interim Draft for BOR)
131	Northern Water	Peter Nichols	R-2-13	In a couple of places the revisions refer to the 4m standard, unless a more appropriate standard is "determined." The better description would be "adopted" (by the WQCC since simply determining a more appropriate standard won't change it unless the Commission adopts it). The last paragraph on page R-2-13 (redline), however, doesn't read consistently with regard to a more appropriate standard. Rather than "better" assessment approaches in that paragraph, "more meaningful" may open for correlating depth to visual perception. As it reads now it seems like the discussion leads to just different math.	The term "determined" has been changed to "identified" which is consistent with the language of WQCC Reg.33. Generally, the discussion of Reg. 33 has been reduced and replaced with quotations.	
132	Northern Water	Esther Vincent	R-2-13 5th paragraph; 1st paragraph of 2.3.8	Need to note concerns about nutrient loading from Granby to Shadow Mountain in this discussion of key concerns for Granby. This loading goes along with the noted DO issue.	Reorganized this section such that the WQ concern is addressed in other section	
133	Northern Water	Esther Vincent	R-2-14 1st paragraph;	Consider adding to sentence that starts: Farr pumping also increases… After "Shadow Mountain Reservoir", add: and served to disrupt stratification near the dam, possibly limiting internal loading.	Added text : "and served to disrupt stratification near the dam, possibly limiting internal loading"	
134	Northern Water	Peggy Montano	R-3-19 Section 3.0	In several places such as 4.a under coarse screening and 6.a fine screening, describe the permissible effects on yield of the CBT Project as "minimizing adverse effects on CBT". There should be no effect on CBT yield, not "minimized" effects.This is of great concern.	This specific language was removed throughout.	various
135	Northern Water	Don Carlson	R-3-19 Section 3.0	I don't believe Reclamation has approved the MOU	The MOU is still pending. The text has been modified and appears in Section 6.0, pp.1	1369
136	Northern Water	Peggy Montano	R-3-23 Task 3.b.ii.1 and General	A substantive discussion about land use controls is missing, beyond the references to the North Fork. Generally, aside from a brief reference in alternative M-4 on page R-6-1, the document seems to be missing this element for a meaningful evaluation. Particularly, in the work plan, Task 3.b.ii.1 on p R-3-23, land use controls should be a separate point #2, and not just mentioned as a reason for BMPs.	Added Stormwater / Watershed Management Section	743, 1045
137	Northern Water	Don Carlson	R -3-19 Section 3.1	"Project" needs defined. Is the "project" defined as improving water clarity in Grand Lake? The purpose and need for improving clarity in Grand Lake should be established.	We named the project Alternative Flow Management Project	various
138	Northern Water	Esther Vincent	R-3-16 Section 3.1	Consider adding subtask to Development of Purpose and Need to also identify any water quality objectives beyond clarity in Grand Lake, including prevention of degradation, if appropriate.	Revised in accordance with text. Appears as 3.c	1394
139	Northern Water	Peter Nichols	R-12-12 to R-12-13 carryover paragraph	It says that the clarity standard was not achieved in 2011. The 4m clarity standard is not effective yet so that's incorrect. It would be accurate to say the 2015 4m standard was not met, however.	Text was revised. In this instance, the word "standard" was changed to "metric". The revised text appears in Section 4.5, pp.3	Various
140	WAPA	John Gierard	general	References to Senate Document 80 (SD80) within the t Report should be by direct quotations from SD80.	The more complete description of Senate Document 80 can be found in Section 2.3.1 and references to Senate Document 80 (as well as other documents) are now direct quotations.	194
141	WAPA	John Gierard	general	Since Senate Document 80 is a relatively short document, it should be included in its entirety as an appendix to the Report so that the Report will be a more useful document upon future reference.	Senate Document 80 is included in its entirety in Appendix F	Appendix F
142	WAPA	John Gierard	Figure 2	Somewhere under Engineering Tasks should be identified Power System Studies to identify impacts of operational alternatives to black start capability, regional transmission capacity, and voltage/frequency support.	Revised in accordance with text. Appears as 5.g	1626
143	WAPA	John Gierard	Figure 2	Somewhere under Engineering Tasks should be identified Modeling Studies to identify impacts of structural and operational alternatives on the timing and amounts of CBT generation.	Revised in accordance with text. Appears as 5.g	1624
144	WAPA	John Gierard	Figure 2	Somewhere under Engineering Tasks should be identified Modeling Studies to identify impacts of structural and operational alternatives on the timing and amounts of available CBT capacity.	Revised in accordance with text. Appears as 5.g	1624

Appendix C

Comments/Response to Comments from July 2013 Interim Draft Technical Report

Comment Number	Agency	Reviewer	Location of Text in July 2013 Interim Draft	Comment	Response to Comment	Line Number of start of text in the July 2013 Final Draft
1	BOR	KET	1.0 1st pp 1, pg 1-1	Add: The Technical Review considers non-construction operational changes as well as potential constructed alternatives. (or similar)	Text was revised in accordance with comment and appears in Section 1.0, pp1	5
2	BOR	KET	1.01 pp 3, pg 1-1	Check the contract. I think you have to identify holes, but not determine what effects will actually be???	N/A	N/A
3	BOR	KET	2.2 pg 2-2	Does Senate Document No. 80 directly address water quality? If not, should it be noted that it addresses operation which indirectly affects quality? Also should the title of this section be quality or clarity???	N/A	N/A
4	BOR	KET	Table 1, column 1, row 14	Help me see where the dates requiring transfer from July to September come from.	Text was revised in accordance with comment	Appendix F
5	BOR	KET	3.1, 2nd pp, pg 3-1	Extra "was"?	Text was revised in accordance with comment and appears in Section 3.1, pp2	N/A
6	BOR	KET	App. H	Can you provide insight into how the costs were estimated? Are the costs and times in 7. And beyond for one alternative or for several?	Based on engineering judgment and experience on other projects	
7	BOR	KET	App H	Please be prepared to show how the information from Directives and Standards was incorporated into the costs and timelines. This is summarized in the flow chart provided.	We agree and flow chart/MS Project figure will be incorporated into the next draft	N/A
8	BOR	KET	Overall	Much better. I still recommend getting a technical writer to scour the document for grammatical and miscellaneous errors. This document will doubtlessly be viewed by many.	We agree and will complete extensive proof reading prior to the final submittal.	N/A
9	BOR	LH	Section 2.1, paragraph 2	Replace "is the authorizing legislation for the Project" with…….***The C-BT Project was authorized in 1937 by the 75th Congress and constructed by Reclamation between 1938 and 1956. Authorizing legislation for the C-BT Project was described and transmitted by Senate Document No. 80, 75th Congress, 1st Session (Senate Document 80).***	Text was revised in accordance with comment and appears in Section 2.1, pp2	70
10	BOR	LH	Section 2.1, paragraphs 3-5	Granby's inflow and outflow/operations are described. The following paragraphs on SMR and Grand Lake need to be consistent and describe water movement into and between reservoirs and lake. A simple map of the Three Lakes should be added.	A complete description of the CBT was added and a map has been added as Figure 1.	77, Figure 1
11	BOR	LH	Section 2.1, paragraph 5	"Water routed into Grand Lake can be diverted into the Adams Tunnel……"	Text was revised in accordance with comment	177
12	BOR	LH	Section 2.2.1, paragraph 1	Remove first sentence. "Senate Document 80 is the authorizing legislation for the C-BT Project". You already described this in previous section.	Duplication was removed.	N/A
13	BOR	LH	Section 3.1.1, bullet # 3	Replace with correct title. "2010 Operational and Water Quality Summary Report for Grand Lake and Shadow Mountain Reservoir (Hydros Consulting , Inc., 2011"	Text was revised in accordance with comment	403
14	BOR	LH	Section 3.1.2.1, paragraph 1	The 2011 report was the second annual report. The 2010 report was the first even though it incorporated a span of 2007-2010 data. Change sentence to "This report is the second report in an annual series……"	A previous draft contained the "second annual" language but was revised based on a comment stating that the 2011 was the first report to look at all three waterbodies and was therefore the first in the annual series. The sentence has been removed for clarity and brevity.	N/A
15	BOR	LH	Section 3.1.2.1, paragraph 2	The 2011 report was final in June 2013. GEI was provided a copy. Change this paragraph to reflect that the report is final.	Text was revised in accordance with comment and appears in Section 3.1.2.1, pp1. Additionally, both versions of the report are referenced.	486, references

Comment Number	Agency	Reviewer	Location of Text in July 2013 Interim Draft	Comment	Response to Comment	Line Number of start of text in the July 2013 Final Draft
16	BOR	LH	Section 3.2.1, paragraph 1	This section needs description of the committees and associated studies. GEI refers to the "TLNS" in section 4.2.1 but, unless I am missing something, never describes it before that. Recommend replacing the first two sentences with the following language and updating the rest of the document as necessary to reflect new acronyms: ***Reclamation, Grand County, and Northern Water are cooperatively working together to understand the factors that affect water clarity and develop a methodology to increase clarity in the future. In addition to these three entities, there are also many other agencies, partners, stakeholders groups, and individuals interested and involved in decisions affecting Grand Lake, Shadow Mountain, and Granby Reservoirs.*** ***Currently, due to ongoing focus on Grand Lake clarity and related Three Lakes water quality issues the agencies and interested stakeholders have been working on what has become known as the Three Lakes Water Quality Study (TLWQS). A technical subgroup called the Three Lakes Technical Committee (TLTC) meets regularly to discuss the varied water quality and clarity related items within the Three Lakes system.***	Text was revised in accordance with comment and appears in Section 3.2.1, pp1	611
17	BOR	LH	Section 3.2.2	Why isn't 2011 "stop-pump" period described here?	Included 2011 stop pump section	690
18	BOR	LH	Section 4.1, bullet #11	In March 2013, Greater Grand Lake Shoreline Association was absorbed by Three Lakes Watershed Association. It would be more accurate to portray it as the following: Three Lakes Watershed Association (joined by Greater Grand Lake Shoreline association, March 2013)	Text was revised in accordance with comment	945
19	BOR	LH	Section 4.2.1, paragraph 1	Have not seen "TLNS" spelled out before this section. Relates to comment #16	References to this group have been changed to TLTC	various
20	BOR	LH	Section 4.2.2, paragraph 1	University of Colorado at Boulder Center for Limnology Study (Particle Study)	Text was revised in accordance with comment	1057
21	BOR	LH	Section 4.3, paragraph 4	Last sentence "In 2009, the Town installed…." is out of place. Recommend removing it. There is no data or monitoring efforts associated with it at this time.	Added Stormwater/watershed management section	743, 1045
22	BOR	LH	Section 4.3.1, paragraph 1	May want to soften last sentence. Currently, Northern manages the water quality program for Reclamation.	Sentence removed from text	N/A
23	BOR	LH	Section 4.2.3, paragraph 1	How does the proposed sampling plan compare to the existing monitoring plans/program? Why is this proposed sampling plan "ideal"? Ideal for what goal(s)?	Text was revised in accordance with comment	1143
24	BOR	LH	Section 4.4.1, paragraph 1	"was reviewed by a selected technical expert panel………………."	Text was revised in accordance with comment	1143
25	BOR	LH	Section 4.4.1, paragraph 1	Last sentence: Subsequent Three Lakes Water Quality Model reviews took place in January 2011 and October 2011. Additional review is currently not deemed necessary.	Text was revised in accordance with comment	1032
26	BOR	LH	Section 5.1, paragraph 5	"19" alternatives does not match text above, where 17 alternatives are mentioned. Confusing. Did GEI develop **4** additional?	There are now 21 alternatives. References the number of alternatives has been corrected	Table 6 and Section 6.0
27	BOR	RT	Section 2.1 paragraph 4	Shadow Mountain key purpose is NOT to help regulate a constant surface elevation of Grand Lake. The purpose is to "aid in supplying the transmountain diversion tunnel with water pumped from Granby Reservoir" [SD 80 para(4)] SD80 para (6) discusses the mechanism for controlling Grand Lake's water elevation.	Text was revised in accordance with comment and appears in Section 2.2, pp3	170
28	BOR	RT	Section 2.2.1 Last paragraph	Only the Manner of Operation section of SD 80 MUST BE followed. This paragraph implies that Reclamation must operate to the criteria shown in table 1. We do not and cannot operate to many of those criteria. For example Grand Lake is not operated between 8268 and 8269, it is operated between 8267 and 8268. Arkins reservoir was never built. We almost never have 256,000 af in storage on the East Slope by July 1. The yield of the Project is 310,000 af not 300,000.	The text was changed to state Reclamation is to operate the CBT in accordance with the Manner of Operations section only and regards the remainder of the document as guidance. The 300,000 af yield refers to the yield of SMR and Granby (Stipulation G) and remains in the table remains and can be found on pg. D-5-16 of SD80. We are unsure why this yield number differs from the Project Yield sited in Stipulation J.	Appendix F

Comment Number	Agency	Reviewer	Location of Text in July 2013 Interim Draft	Comment	Response to Comment	Line Number of start of text in the July 2013 Final Draft
29	BOR	RT	Table 1	Remove table 1. Only the criteria listed in manner of operations are requirements. Most of those listed on the table have to do with Green Mountain reservoir operations, which has nothing to do with Grand Lake clarity.	Text was revised in accordance with comment and follow up email. Table 1 has been moved into Appendix F and GEI interpretations have been removed.	Appendix F
30	BOR	RT	Pg 3-3	4th bullet should read 2011 instead of 2001	This bullet was modified to reflect the language used in the Final 2011 OWQ Report	518
31	BOR	RT	Section 3.3.2 Last paragraph	This paragraph is out of place. The entire section deals with operations that actually occurred. The last paragraph appears to be a statement based on results provided in the Alternatives Development Report.	Added Stormwater/watershed management section	743, 1045
32	BOR	RT	Section 3.3.2 First paragraph	The "Water Supply Operations Model" is a spreadsheet developed solely for use in the Alternatives Development Report. It has never been used for anything else nor is it expected to. It should probably not be given a name, but rather simply be called an "analysis".	The models were relabeled as "spreadsheets" or "spreadsheet models"	various
33	BOR	RT	Section 3.3.3	There is no "Power Operations Model". What is being referred to here is another spreadsheet analysis solely for the Alternatives Development Report. It should also be referred to as an analysis rather than a model. Reclamation uses an entirely different model for developing its annual operating plans.	The models were relabeled as "spreadsheets" or "spreadsheet models"	various
34	BOR	SS	Page 1-1, 3rd paragraph and throughout	Is the 'preferred alternative' discussed in this paragraph referring to the preferred alternative that will be selected through the NEPA process? If not, make sure the difference is clear here and throughout the entire document.	Reviewed throughout and changed accordingly	various
35	BOR	SS	Section 3.1.1	It looks like the 2011 Draft Operational and Water Quality Summary Report by hydros cited twice and given two different references. Also, as indicated in comment 15, this report has since been finalized.	References were verified and corrected throughout	various
36	BOR	SS	Page 3-4, paragraph 1	The 2011 Draft Operational and Water Quality Summary Report is referred to as the "2013 report". Please clarify.	"2013 report" was replaced with "2011 OWQ Report" to clarify which document is being referenced	various
37	BOR	SS	Page 3-5, paragraph 1	The last two sentences of this paragraph are confusing, please clarify.	Text was revised for clarification.	588

Appendix D

Comments/Response to Comments from July 2013 Final Draft Technical Report

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
1	BOR	SS	Throughout	Nowhere in the report or the work plan is it discussed that a Preferred Alternative will be selected through the NEPA process. All references to a "preferred alternative" need to be removed. Additionally, as a suggestion for clarity and consistency throughout the report, certain levels of selected alternatives should be given a title that can be referenced. For example, following the work plan in section 6 you would get… - An all inclusive group of alternative identified in task 3 – this could be referred to as the Alternatives Group A - A selected group of alternatives after performing a coarse screening in task 4 – Alternatives Group B - A selected group of alternatives after performing a fine screening in task 6 – the "Selected Alternatives "or "Proposed Alternative" Throughout the report reference the appropriate group of alternatives to avoid confusion.	Use of the language "Preferred Alternative" has been removed and replaced with appropriate text. The titles of the Tasks were reworded to clarify which Alternatives are to be evaluated during each task.
2	USGS	MS	Line 3	I suggest "purpose" instead of "overall intent"	Text changed in accordance with comment
3	USGS	MS	Line 7	I suggest " addresses" instead of "strives to address"	Text changed in accordance with comment
4	BOR	SS	Pg 1-2, line 25, 40, 41, 44 and throughout	Line 25 says "a preferred alternative" will be selected to develop to 30% design. The work plan provided in Section 6 explains a process where multiple selected alternatives will be developed to 30% design. Please check the entire document to ensure consistency.	Use of the language "Preferred Alternative" has been removed and replaced with appropriate text.
5	USGS	MS	Line 156	I suggest adding "in this report" after "Three Lakes"	Text changed in accordance with comment
6	USGS	MS	Line 162	"Reservoir" should be "Reservoirs"	Text changed in accordance with comment
7	BOR	MC	Pg 2-6, Line 168	Please use the description of the existing condition of Shadow Mtn Res site that is found on page 38 of Vol III, Plans & Cost Estimate, 1937	Text changed in accordance with comment
8	USGS	MS	Line 169	I suggest removing "swampy areas", which is not usually a technical term, because it is redundant with "wetlands". Swampy is kind of a derogatory term that may bias the reader's concept of this ecosystem.	Text changed in accordance with comment #7 and text reflects the language found in Reclamation (1937).
9	USGS	MS	Line 170	I suggest "The key purpose of Shadow Mountain for the C-BT system is ..." for the last line of the paragraph.	Text changed in accordance with comment
10	BOR	MC	Sect 2.3.1, lines 194-225	This section will require Solicitor review before we are ready to finalize.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–you are probably correct.
11	USGS	MS	Line 214-215	Referring to bullet 2 about fishing and recreation: Is this the purpose under which Grand Lake Clarity is protected? If not can that part of the document be pointed out?	The Grand Lake clarity standards were adopted to protect the beneficial uses identified under Colorado statutes rather than SD80, despite the similar language noted in Bullet #2. Bullet #2 is specific to the operations and not water quality standards.
12	BOR	MC	Sect 2.3.1.1, lines 226-239	If an engineered or operational solution can be found that significantly alters the project designs or operational characteristics the agency may have to seek additional authority or Congressional approval prior to implementation. SD80 may not be modified in the process. This section needs to be rewritten to recognize that additional authorities or approvals may be required to implement solutions or dropped in its entirety.	Text changed in accordance with comment
13	BOR	RT	Lines 228-229	The parenthetical implies that modified pumping and stop-pumping may require a change to SD80. That is not the case. In fact, Reclamation has done those operations over the last few years without a change to SD80. Change the parenthetical to read "(pipeline to bypass Grand Lake and/or removing Shadow Mountain Dam)"	Text changed in accordance with comment
14	BOR	RT	Line 232	SD80 Manner of Operations only requires that Grand Lake elevation not fluctuate more than its normal elevation (see para.3 on line 216-217). Replace the phrase "greater than 1 foot during drought conditions." With "greater than its normal fluctuation."	Text changed in accordance with comment
15	USGS	MS	Line 232	If natural hydrology is re-established in Grand Lake, the water level will probably be based on some grade-control structure in the connecting channel. To provide for maximum water level stability, this structure may need to be wider than the current channel.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this section is on SD80 review and modification. We agree that lake level elevation will be a key variable to evaluate and should be a consideration of the Three Lakes Water Quality Model scenario analyses. One example is provided in this section regarding the potential conflict between SD80 language and alternatives to be considered. The mechanism to minimize water level fluctuation should be part of the design criteria

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16	USGS	MS	Line 230-232	Assessing the water balance components will be important for analysis of water-surface fluctuations at periods of low native streamflows if Grand Lake water level is no longer maintained by pumping. Miscellaneous gains/losses, streamflow error, and evaporation uncertainty could make a difference in some scenarios. The hydraulic structure to accomplish this stability also will be critical, especially if a boat lock is also necessary.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this section is on SD80 review and modification. We agree the water balance will an important component of The Three Lakes Water Quality Model evaluation and scenario analyses.
17	BOR	RT	Lines 236-238	This sentence seems to imply that Reclamation could implement a selected alternative prior to obtaining congressional authorization to do so. Reword the sentence to read “However, changing Senate Document 80 to reflect necessary language to implement the selected CBT alternative will take considerable effort.”	Text changed in accordance with comment
18	USGS	MS	Line 238	In reference to the need for updated language for SD80: Your comment seems odd in that congress would probably not be satisfied to implement the alternative and THEN update the language later. Seems like this update will have to be done prior to implementation. Is this what you are saying?	Text changed in accordance with comment #17
19	USGS	MS	Line 272	Protection of aquatic life is achieved to a large degree by the application of existing standards such as water temperature, dissolved oxygen, and un-ionized ammonia. It is important to note that un-ionized ammonia toxicity computations require pH, which is not simulated by the model.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because un-ionized ammonia has not been shown to be a concern in the Three Lakes. Additional complexity of the model is generally not warranted, but may be revisited during model assessment if this becomes important for SMR.
20	USGS	MS	Line 278	The effect on fisheries can be determined in part by modeling water quality, but considerable experience and knowledge from wildlife biologists will be necessary to judge whether one type of fishery or another are more "desirable". For example is a Shadow Mtn (SM) put-and-take fishery better than a trout stream in the former channel of the Colorado River in the restored bed of SM? Perhaps a survey that not only includes residents, but also tourists would be helpful.	Added section regarding the evaluation of effects on aquatic life use (Section 4.3). There will be competing interest regarding recreation use of SMR, and removal of SMR and subsequent stream reclamation has been added as Alt J in Table 6.
21	USGS	MS	Line 319-320	Regarding future standards revisions: A large degree of regulatory certainty will be required before large investments in new structural solutions are made.	Comment was noted but not incorporated into the text in this section. 8/28/2013 Revision to RTC–Section 4.7.1 mentions that there needs to be a consensus opinion on the acceptable level of model accuracy that is needed to evaluate the Secchi depth standard or other standards for that matter.
22	USGS	MS	Line 325	“hearing” instead of “hearting”	Text changed in accordance with comment
23	USGS	MS	Line 531-533	With regard to clarity being improved at north end of Shadow Mtn (SM) and worse at south end for 2011: This pattern is opposite than a typical year primarily because of the direction of flow in 2011 – that flow being in the downstream direction most of the summer. This may suggest that the gradient of worsening water quality as water is transported across SM still operates when the flow is from Grand Lake (GL) to Granby via Shadow Mtn - a possible indication that less pumping in late summer might move the WQ problem to Granby instead of GL.	Comment was noted but not incorporated into the text. 8/28/2013 Revision to RTC–This is a concern that has been noted in other documents and should be evaluated during the scenario analyses of the TLWQ model. It is also discussed in Section 4.7.1
24	USGS	MS	Line 534-536	The higher inflow from NF Colo R might have been a consequence of fewer diversions of water by the Grand Ditch and Red Top Ditch? If so, the additional flushing in the upstream reaches may have cleared out accumulated sediments from low-flow years and debris in upstream channels, or destabilized the sediments from the Grand Ditch failure.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this pertains to summaries from the 2011 OWQ report. Special studies are evaluating the NFCR and its sources of sediments.
25	USGS	MS	Line 539-541	High oxygen demand in Shadow Mtn may not improve with implementation of any of the alternatives. Water from the Granby Pump Canal has decreasing oxygen concentrations in late summer. The pumped water, even at reduced DO concentrations, still adds oxygen to Shadow Mtn but doesn't seem to keep up with the oxygen demands of the Shadow Mtn sediments during the late summer period.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this pertains to summaries from the 2011 OWQ report. The TLWQ model should be able to assess the DO conditions and factors that result in low DO in SMR.

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26	USGS	MS	Line 552	During high snowmelt runoff, water is mostly flowing out of GL. Any decreased clarity in Grand Lake due to runoff from NI and EI will not change as a result of the implementation of any of the alternatives.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this pertains to summaries from the 2011 OWQ report. The TLWQ model should be used to evaluate clarity in the absence of pumped inflows to support this conclusion.
27	USGS	MS	Line 571-572	Suggest: "…due to redox reactions resulting from the breakdown of settled organic matter."Just a clarification: breakdown of organic matter does not directly supply the orthophosphate as seems implied in the statement. Consumption of oxygen during breakdown changes the redox potential at the sediment-water interface which allows bound orthophosphate to be released (often from iron compounds). If sources of organic matter in watersheds or from diversions to Granby can be reduced, the consequences from decomposition of organic matter and subsequent internal loading processes also may be reduced.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this pertains to summaries from the 2011 OWQ report. The mechanism that drives the organic matter breakdown is simplified in the TLWQ model and summaries because the greater complexity of sediment diagenesis is not warranted.
28	USGS	MS	Line 674-676	Regarding effect of stop-pumping periods on clarity in Shadow Mtn: Stormwater from the North Fork Colo R and possible high productivity as a result of increased residence time and internal loading may further degrade Shadow Mtn during stop pump alternatives.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC– although a discussion on secondary WQ impacts is discussed.
29	USGS	MS	Line 708-710	The evidence of non-attainment during stop-pumping trials should be a concern for any alternatives that plan to keep pumping through SM and GL.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because it is discussed in Section 4.7.1 regarding the level of confidence that the alternative can attain the Secchi depth standard.
30	USGS	MS	Line 717	If macrophytes are a primary factor that affects water clarity in Grand Lake, how is that being accounted for in the lake modeling? It is important to understand the life cycle of these aquatic plants to understand how much they contribute to loads of nutrients and particles, and when this contribution occurs so that it can be accounted for in the lake modeling.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–Macrophytes are not modeled in the TLWQ model; however the factors that affect clarity are incorporated. Results from the particle study will be incorporated into the model to enhance the accuracy. The macrophyte surveys continue to provide information regarding life cycles and cover that can be considered.
31	USGS	MS	Line 737	Suggest "senescence" instead of "senescing"	Text changed in accordance with comment
32	USGS	MS	Line 739	"impractical" instead of "impracticable" ?	Impractical is the intended language
33	USGS	MS	Line 739-742	If Shadow Mtn was permanently drawn down, either partially or fully, and a structural alternative that pumps water to the Adams Tunnel were implemented, the lakebed area conducive for macrophyte growth would be greatly reduced.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC– because the relevant text discusses reservoir management strategies to control macrophytes given the current surface area of SMR. Elimination or reduction of SMR to a forebay situation would decrease aquatic macrophyte growth and require extensive stream reclamation.
34	USGS	MS	Line 744-745	It is not clear how the substantial effect from stormwater has been quantified, considering that no systematic stormwater sampling has been done. The occasional routine sample has captured a glimpse of stormwater concentrations, but this hardly supports such a definite conclusion about loads. This statement must be verified by the collection of sufficient water-quality samples in streams/outfalls and appropriate load computations. Otherwise, I think stormwater and also internal loading rates have only been proposed to complete the mass balance for the water-quality model.	Clarified statement regarding effect of stormwater when evaluated in the context of the TLWQ model. The stormwater hydrological input and limited nutrient data increased the accuracy of the water clarity output. This needs to be further evaluated with more stormwater data.
35	USGS	MS	Line 748-750	The stormwater contribution triggers to which you refer are crude at best. They are triggered by bulk precipitation at the lake area and have no reliable connection to the precipitation rate, amount, or footprint in the watersheds. The concentrations and loads from this method of estimation are likely to be highly uncertain. Attributing too much of an effect to stormwater could mask the magnitude of other contributing factors.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this is considered part of the stormwater data gap, peer-review and update of the model given new data.

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36	USGS	MS	Line 764	This description of the Three Lake Water Quality Model is a pretty short. Could use a bit more about the list of processes simulated, the assumptions, and the limitations of the model. References to sources that contain that specific information are necessary at a minimum.	Provided a few sentences to describe the model, including text that references the model documentation
37	USGS	MS	Line 774	A link to Chapra and Martin manual for the LAKE2K model would be greatly appreciated for those who wish to dig deeper. I have not been able to find an accessible copy online.	Provided Dr. Chapra's email for LAKE2K model documentation in the reference section
38	USGS	MS	Line 774	The fixed nature of lake layer thicknesses (except hypolimnion) and the assumption of instantaneous mixing within a layer is a potentially large source of uncertainty during some seasons.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC– although the stakeholder group needs a consensus regarding the acceptable level of uncertainty regarding key modeled parameters. One objective of the model is to make it as simple as possible yet maintain the highest level of accuracy. A more complex model may be needed as discussed in model update section, but the modeling team (and reviewers) indicate a more complex model is not needed (Section 4.7.1).
39	USGS	MS	Line 780	"...hydrological inputs and outflows"	Text changed in accordance with comment
40	USGS	MS	Line 782-785	Perhaps it should be mentioned in this section that water temperature is not simulated, water temperatures for the layers are input. Also stratification and turnover are controlled by a set of operational rules not boundary conditions such as climate or inputs of thermal mass. Having a more flexible inflow placement scheme to the 3-layer system in Granby that is based on daily inflow temperature and layer water temperatures interpreted between field profiles of temperature, could increase the accuracy of simulated nutrients, carbon, chl-a, and oxygen.	Inserted sentence regarding thermal simulation and clarified as data gap analysis for model update
41	USGS	MS	Line 781	The spatial assumptions for Shadow Mtn in the model may impair the chances of identifying the sources of water-quality transformation occurring during water transport through in Shadow Mtn. Perhaps a strategy for dealing with this issue or possible future model enhancements should be considered.	Inserted sentence regarding well mixed nature of each layer and clarified as data gap analysis for model update
42	USGS	MS	Line 782-785	What methods are used to compute the time-series of daily water-quality characteristics for the tributaries? List or describe briefly here. General comment: phosphorus loads, and to a lesser degree, nitrogen loads, from stormwater and internal loading (and gains) make up a large portion of the input mass balances to the water bodies (Preliminary Alternatives Development Report, 2012). None of these load types are particularly well defined by measurements, model processes, or robust estimation techniques at the current (2013) time.	Inserted sentence describing time-series approach and citation.
43	USGS	MS	Line 784	Do you mean "inflows" instead of "three water bodies" in this sentence? Also further in same sentence do you mean "water bodies" instead of system?	Sentence was reworded for clarity.
44	BOR	MC	Sect 4, start line 916	Add discussion regarding potential biological sensitivity of Grand Lake if bypassed.	Added section to evaluate effects on aquatic life use
45	BOR	SS	Pg 4-1, line 919	C-BT Alternative Flow Management Project? Please remove.	Text changed in accordance with comment
46	BOR	SS	Pg 4-1, lines 919-921	States the data gaps "…differ from studies and investigations that will be required to take a preferred alternative to the 30 percent design stage (discussed in Section 6.0)." Task 2.b of the work plan, described in section 6, is collecting and analyzing additional data based on the data gaps. Isn't filling data gaps part of the effort to get to 30%? Please clarify.	Text was reworded for clarification.
47	BOR	MC	Sect 4.1, lines 925-930	This section (lines 925 – 930) needs to be restructured to simply reaffirm the value of a transparent process. Lines 940 thru 948 should be deleted. It creates an exclusive subset of interests and harms the upcoming NEPA administrative record.	Text changed in accordance with comment
48	USGS	MS	Line 940	USFS and NPS should perhaps be stakeholders as well. Their land management decisions will affect WQ in the future. Wildfire policy/mitigation coordination will be essential for future water-quality management.	Comment was noted. Section 4.1 was edited in accordance with Comment #47
49	USGS	MS	Line 949	Defining water quality should address both current and any potential WQ concerns.	Comment was noted but not incorporated into the text
50	USGS	MS	Line 953	Suggest "different" instead of "varying"	Text changed in accordance with comment
51	USGS	MS	Line 956	Water temperature for cold water fisheries would make this list too.	Added temperature to list
52	USGS	MS	Line 962-963	Identification of water-quality characteristics necessary for predicting the effects of CBT west slope water on E Slope interests, is crucial because they may be different than those in the Three Lakes system. Modeling of downstream reservoirs such as Horsetooth, Carter, and Boulder could be done with the predicted changes in water quality due to implementation of the alternatives.	Comment was noted but not incorporated into the text as modeling the water quality in east slope reservoirs will be part of the NEPA process.

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
53	USGS	MS	Line 985-986	The 2013 model results update shows that the model has been well tuned to maximize accuracy of Secchi depth (primary goal). Simulation results for some nutrients (secondary goals) are not quite as accurate in some seasons and some parts of the Three Lakes system.	Added text to model error section regarding Secchi, nutrients, or chl
54	USGS	MS	Line 994	Streamflow computations are just as important as water-quality in the determination of loads. It might be prudent to have the USGS review some portion of the streamflow records each year for quality assurance.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because data obtained from the USGS website should be noted as preliminary or approved. It is assumed that USGS will be part of the model review.
55	USGS	MS	Line 1020	Another suggestion for a short-term special study: More macrophyte study is needed. The life-cycle of these aquatic plants and their contributions to nutrient and particle loads is essential. When do these macrophytes (and any associated epiphytes) shed material? How important is resuspension of dead macrophyte particles? How do we estimate loads from this source?	The relationship between macrophytes and particle resuspension should be addressed by the Particle Analysis study by McCutchan and the Macrophyte studies of Sisneros
56	USGS	MS	Line 995	Additional clarity on data-quality objectives would increase confidence in the model and analysis of the alternatives.	Added sentence to data section
57	USGS	MS	Line 1004-1009	The bottom sample concentrations, which seem to be affected by internal loading during pre-turnover periods in both fall and spring, are being compared to fully-mixed hypolimnetic, volume-weighted concentrations from the model. How should internal loading and the performance of the model with respect to hypolimnetic nutrient concentrations and nutrient storage be evaluated? This is a concern for Granby as well as Shadow Mtn.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this is added complexity should be evaluated in the context of increased model accuracy versus the objectives of the current TLWQ model
58	BOR	MC	Pg 4-4, Line 1019	Reword. Remove reference to SD-80. There will be many requirements for alternative evaluation against a management plan. SD-80 guidance may or may not play a role in establishing those requirements.	Text changed in accordance with comment
59	USGS	MS	Line 1015-1020	Assuming that Grand Lake (GL) and Shadow Mtn (SM) are no longer connected by water surface management, is USBR still responsible for "natural" fluctuations in GL? I would suspect that GL always fluctuated during the water year naturally. Seems a bit odd to make BOR responsible for making GL more hydrologically ideal than the natural hydrologic conditions.	Comment was noted but not incorporated into the text as water level elevation will need to meet SD80 requirements
60	USGS	MS	Line 1022	Replace “is” with “are” in first sentence.	Text changed in accordance with comment
61	USGS	MS	Line 1032	"Ideal" is a description that may not indicate the degree of uncertainty for all potential issues that may come up. The word "preferred” or just "proposed" may work in here. A little bit of information on how and who developed this plan would be nice. Also, what data objectives and cost considerations were used, if appropriate?	Revised section to Other sampling considerations and added text to clarify intent
62	USGS	MS	Line 1036	General comment: An in-lake turbidity sensor combined with a regression analysis of Secchi depth (SD) and turbidity from sampling could provide clues to SD changes that are not evident with the weekly sampling. SD is an integrated measure and turbidity would be point measurements but it could provide a nice continuous time-series for interpreting the weekly secchi data and the influence of weather and water temp variations.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–specific data collection efforts are evaluated on an annual basis relative to the needs of the project.
63	USGS	MS	Line 1047-1051	Stormwater sampling and a strategy for how to interpret the data and turn them into loads should be planned, possibly by adding turbidity probes to any sites to be sampled for stormwater.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–this is data collection details for the stormwater evaluation
64	USGS	MS	Line 1056	General comment: The existence of a large delta means that some portion of the North Fork Colo R sediment load is not being transported thru Shadow Mtn into Grand Lake. Size distribution data and good sample-collection techniques would be crucial for any assessment of suspended and/or bedload sediment transport. A quantitative size-distribution characterization could help to define conditions for resuspension of sediment.	Added sentence regarding quantitative size-distribution characterization of deposited sediment in delta…
65	USGS	MS	Line 1052	General comment: Bioavailability of sediment-related phosphorus and nitrogen from streams can be very different than sources within a lake.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–as this is data collection details
66	USGS	MS	Line 1064	General comment: Mixing assumptions in the model are particularly problematic for the North Fork Colo R and Stillwater Creek. Stormwater effects need to be assessed by sampling, but a good strategy for estimating a load from a storm can be challenging. Just connecting sample concentrations from sample to sample can be very inaccurate. Also keep in mind that it may take a lot of stormwater to make much of a difference in an annual load of a snowmelt dominated stream.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–this is data collection details for stream flow or storm flow evaluation.

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67	USGS	MS	Line 1065	If the land-use condition changes in the watersheds tributary to Grand Lake there may be impacts to turbidity and nutrient fluxes. A number of wildfires over a period of years would likely change the water quality in Grand Lake with or without implementation of alternatives.	Comment was noted but not incorporated into the text. 8/28/2013 Revision to RTC–There is limited WQ data regarding the effects of fire on nutrient fluxes to downstream water bodies, but it is a growing concern and may be considered in the future.
68	USGS	MS	Line 1076	The 4-6 days of residence time is probably a minimum in the "real Grand Lake". There is some evidence in the profile data presented in the particle studies that suggest some mixing is occurring with metalimnion water as well. However, the notion that there is any long-lasting benefit to seasonal clarity due to routing water through GL epilimnion may not be probable. Some particle settling will occur, but is limited by residence times.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this comment is very similar to the current text.
69	BOR	MC	Sect 4.7, start line 1187	Revise per discussion on 8/7	Comment was noted but not incorporated into the text. GEI intends to include the review of 4-m value and methodology as a data gap. 8/28/2013 Revision to RTC–reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)
70	USGS	MS	Line 1090	Nature has a way of taking advantage of new opportunities such as the additional light penetration that would be available with a clearer Grand Lake. More lighted water column would be available to generate phytoplankton and allow nutrients from deeper depths to be utilized for growth.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this this is part of the model scenario analyses required for the alternatives
71	USGS	MS	Line 1127-1128	Is Secchi depth statistical error the only measure of performance for the model to be noted in this section? How about at least mentioning whether other analytes such as nutrients or DO are within the error guidelines. Perhaps a small table would be appropriate?	Added text for other parameters that may be considered for secondary goals
72	USGS	MS	Line 1127	General comment: It would be good in the future to summarize which months or seasons perform the best/worst if there are any generalizations to be made. This is a recommendation but does not need to be accomplished in this report. Also, prediction error analysis for outflows at Colo R blw Shadow and Colo R blw Granby, and the Granby Pump Canal and the Adams Tunnel East Portal would help to understand uncertainties. More information in future supporting documents should place additional emphasis on the analysis of loading. Too much reliance on concentration analysis can obscure the large sources and seasons of transport for nutrients.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because it is relevant to outside documents and not part of this scope.
73	USGS	MS	Line 1129	Overall the model shows skill at prediction of Secchi depths in Grand Lake. Could show a plot here from the latest model calibration. It would support the analysis here.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this information is contained in supporting documentation
74	USGS	MS	Line 1133-1134	It is true that stakeholder acceptance of uncertainty is important. It may be necessary to show perspective from other case studies showing typical errors to help manage expectations for use in making their decisions.	Comment was noted but not incorporated into the text. 8/28/2013 Revision to RTC–This is a detail of the consensus opinion regarding the acceptable level model uncertainty
75	USGS	MS	Line 1139-1140	Is the 20% for Secchi only or for all simulated constituents? Need to specify in this last sentence. Need to give a year in parenthesis when using word "current". Are these error results from the 2013 recalibration release or some other and for which period of years?	Deleted sentence
76	USGS	MS	Line 1174-1175	Currently the model is calibrated to match a top and bottom sample. And the prediction errors are predicated on this comparison. Are the bottom concentrations of ortho-P and ammonia representative of the entire hypolimnion in Granby? Probably not. We can't completely assess whether the model is accurate because the data to assess the mixing assumptions are not collected and evaluated. This is the answer to the question of why we would collect a nutrient profile or two, not at baseline monitoring frequency, but a couple at important seasons some year ---for verification of the model. It might be possible to use the oxygen profiles to check the mixing assumptions in the model. Water temp, pH, and specific conductance are not simulated so those parameters cannot be checked. It might also be good to compute how each assumed layer thickness compares to the actual layer thicknesses each month or how the actual turnover dates compare to the model-assumed schedule. All this being said, because the model seems to stay on track over a number of years, and matches up pretty well with complex processes such as dissolved oxygen concentration simulation and clarity predictions (Secchi depth) that have multiple factors, it is likely that simulation of major nutrient and algal growth processes are reasonably accurate under historical boundary conditions.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this added level of complexity for modeling hypolimnion concentrations may not affect the accuracy of the model as already noted in comment

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
77	USGS	MS	Line 1176	General comment: The statement regarding spatial dynamics could be an issue. The model is not spatial except for the assumptions of basic layer configuration, so how would it evaluate spatial dynamics? Perhaps you mean that this evaluation should come from looking at data observations and special studies that indicate spatially-sensitive processes are occurring and from the apparent ability of the model to match observed data and account for those processes if they are important. If internal loading in Granby, or underflow in Shadow, or localized decomposition of organic matter at various inlets to Granby, or prediction of water temperature, or a precise evaluation of intake level or location is necessary or deemed important, then spatial characterization with a different tool or additional special study might need to be considered at that point. General comment: It may be prudent to model water-release scenarios from Granby to the Colo R blw Granby that could facilitate flushing of hypolimnetic nutrients or hypoxic waters from the reservoir (as long as this does not violate standards or minimum streamflow requirements below the dam.	Comment was noted but not incorporated into the text. 8/28/2013 Revision to RTC–The comment is regarding spatial modeling (multiple compartments) of SMR rather than one dimensional modeling single compartment of SMR
78	USGS	MS	Line 1184-1186	General comment: Regarding water temperatures for the various alternatives: If there is a large change in circulation or residence time, what WTs will be input into the model? Water temperature matters because of DO, and WQ kinetics, algal growth kinetics, and aquatic-life issues. A sensitivity analysis for water temperature might show that there is not much importance to predicting input water temperatures for the water bodies with high accuracy.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because these are details in model evaluation and update and should be evaluated in the context of model complexity versus acceptable model uncertainty
79	USGS	MS	Line 1187	General comment: There should be a clear understanding about the responsibility for clarity issues after any of the alternatives are implemented. What if the clarity is improved but there are still occasional exceedances of standards or new interpretations of SD80?	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because attainability of the standard cannot be assumed to be 100 percent. The water clarity project needs to strive for the best possible water clarity rather than 100% attainment.
80	USGS	MS	Line 1224-1225	General comment: This section is a compelling breakdown of the razor-thin margins for attainability of Secchi-depth given the existing assessment methodology.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because the comment notes the concern with the assessment methodology which is included in text
81	BOR	RT	Line 1228	The existing water supply operations spreadsheet is inadequate (and cannot be adequately modified) for analyzing the alternatives to the level of detail necessary for the 30% design level. So there is no ambiguity on this point, I would suggest retitling the section “Review of Existing Water Supply Operations Spreadsheet and Development of Water Supply Operations Model”	Text changed in accordance with comment
82	BOR	RT	Section 4.8, start 1228	It should be made clear in this section that the hydrology and operational output from the Operations model will be used as input to the Three Lakes Water Quality Model for analysis of alternatives. Similarly the output from the Operational model will be used as input to any Power Operations model. (see suggested language in following comment)	Text changed in accordance with comment
83	BOR	RT	Lines 1240-1242	Suggest replacing the last sentence of the paragraph with: “However, the simplifying assumptions and monthly timestep used in the Water Supply Operations Spreadsheet render it inadequate for fully analyzing the ability of each alternative to meet the water supply requirements of the Project. Further, the hydrology and operations under each alternative are the basis for analysis of both water quality and power generation. To analyze water quality and power generation under each alternative, the results of an operational model will have to be used as input to both the Three Lakes Water Quality model and a Power Operations/Analysis model. Therefore, a new Water Supply Operations model will have to be developed or Reclamation’s existing annual operations model will have to be modified.”	Text changed in accordance with comment
84	BOR	RT	Line 1243	The existing Power Operations spreadsheet is inadequate (and cannot be adequately modified) for analyzing the alternatives to the level of detail necessary for the 30% design level. So there is no ambiguity on this point, I would suggest retitling the section “Development of Power Operations Model”	Text changed in accordance with comment
85	BOR	RT	Lines 1263-1265	Suggest replacing the last sentence of the paragraph with: “The simplifying assumptions and monthly timestep used in the existing Power Operations Spreadsheet render it inadequate for fully analyzing the power generation impacts of each alternative. Therefore, a Power Operations model utilizing a daily or hourly timestep will need to be developed to adequately assess power generation impacts.”	Text changed in accordance with comment
86	BOR	SS	Pg 5-1, lines 1269-1270, 1279, and 1293	Make sure the number of alternatives is correct and consistent each time it is discussed.	Text changed in accordance with comment

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87	USGS	MS	Sec 5.1, p 5-2, table 5, Description column, Alternative I	Suggest the possibility here or maybe in another alternative: "Partial permanent drawdown of Shadow Mtn". Draw SM down to a smaller pool at the deepest end at SM dam. The bypass pump could pump from this remaining "forebay". This would prevent all of the water originating above Granby to have to be pumped back up from Granby via the Farr Pumping Plant. If the deepest parts of the southern end of SM near the dam were excavated and deepened to provide a bit more storage (deepen the shallows at the south end), this forebay could have a fluctuating storage that would allow an off-peak pumping schedule to reduce power consumption, similar to the diurnal operations of the Farr at present. Farr pumping would still have to occur after runoff. This drawdown option could eliminate much of the SM degradation of water quality, save some elevation head for part of the pumping operation, and provide a large new recreation area with restored reaches of the Colo and North Fork Colo River. A sediment catch basin that could be cleaned could be designed for the NF Colo R.	Added alternative J
88	USGS	MS	Sec 5.1, p 5-2, table 5, Description column, Alternative P	As far as I know there is no water-quality profile data to support a detailed modeling analysis a multi-level intake at Farr Pump Plant, but the 3-layer configuration would provide coarse estimates.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this is a special study to evaluate conditions specific to on alternative
89	USGS	MS	Sec 5.1, p 5-3, table 5, Description column, Alternative T	BMPs within the watersheds should be implemented as a supplement to all of the alternatives.	Added text to clarify that watershed management should be considered as a stand-alone alternative and in combination will all other alternatives
90	USGS	MS	Line 1320-1321	This potential increased productivity in Shadow Mtn due to increased residence time may exacerbate oxygen depletion. Water temperatures may increase due to less cool, pumped water coming from Granby. The combination could cause an exceedance of water-quality standards for aquatic life in Shadow Mtn.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this theory will be part of the model scenario analyses to evaluate future conditions in the absence of pumped inflows
91	USGS	MS	Line 1339-1340	Maybe visitors to the area should be polled to see what matters to them. It seems that recreation is one of the most important SD80 issues. The ones who bring the economic benefits to the area and the public who owns and uses the lands (public) could be considered to have a stake in the outcome.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this will be part of the NEPA process for the project
92	USGS	MS	Line 1342	A consensus with stakeholders on the alternative chosen along with an agreement that Reclamation will not be held accountable for further unforeseen clarity issues after implementation might provide the certainty necessary to implement an alternative.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–because this will be part of the alternative analysis and NEPA process
93	BOR	MC	Pg 5-4, Line 1352	This reference, while illustrative for the non-federal new start is informative it is misleading the public. An existing federal project under consideration for modification has its own process for authority, approval, planning, and design. Remove this specific reference and its supporting document appended. Some references to best management practices regarding inclusion, transparency, establishing goals, etc. are of value. The document can be referenced as appropriate but not appended.	Text changed in accordance with comment
94	BOR	MC	Pg 6-1, Line 1386	Remove “4 m Secchi depth” reword with “applicable Grand Lake water clarity standard”	Text changed in accordance with comment
95	USGS	MS	Line 1397	Are stakeholders going to be involved in the development of purpose and need?	Text changed in accordance with comment
96	USGS	MS	Line 1433	Could mention wildfire policies and risks here.	Text changed in accordance with comment
97	USGS	MS	Line 1514	Under “other structural alternatives”: Consider mentioning partial drawdown of Shadow Mountain Reservoir here.	Text changed in accordance with comment
98	BOR	MC	Pg 6-11, Section 6, Task 9 (start line 1715)	Reword this section to focus on NEPA and generically refer to all applicable agency, legal, and regulatory permit requirements. Remove all references to State and County permits.	Text changed in accordance with comment
99	USGS	MS	Section 7.0, p 7-1	The Chapra and Martin (2004) reference exists but is very hard to get a copy of. Perhaps a link to a copy should be included, or a copy placed on Northern Water's website.	Added Chapra’s email address to the reference section and will see about acquiring LAKE2K manual.
100	BOR	MC	Appendix F	Remove the table following SD-80 entitled “Senate Document 80 Operating Stipulations	Text changed in accordance with comment
101	BOR	SS	Appendix H	The tasks listed in the dependency column for tasks 2biii, v, and vi seem to be incorrect. There are no tasks 2ai, 2aii, or 2av.	Dependency column was revised
102	BOR	MC	Appendix H	Add column identifying duration.	Column for duration added
103	BOR	MC	Appendix I	Remove document and add to reference list.	Text changed in accordance with comment

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104	GC	Katherine Morris	General	Grand County is extremely concerned by the extent to which this document appears to criticize the clarity standard on the basis of attainability. We wish to reiterate sentiments expressed at the August 7, 2013 meeting: It is not the intent of this report to evaluate attainability of the clarity standard, except perhaps with respect to recommendations that the ability of each alternative to achieve the standard be evaluated. The root word "attain" shows up in the document twenty times outside of direct standard quotes, most of which appear to be critical of the 4 meter standard (line numbers 292, 293, 294, 296, 1043, 1087, 1089, 1090, 1122, 1135, 1158, 1165, 1166, 1169, 1199, 1206, 1212, and in response to KMorris comment number 30 in appendix C). The Water Quality Control Division (WQCD) and the Water Quality Control Commission (WQCC) accepted Grand County and Northwest Colorado Council of Government's (NWWCOG) logic and data presented for establishing the standard. This report should not second guess the Commission's decisions; rather it should focus on how to meet the standard or show data gaps that are essential to determine how to meet the standard.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)
105	GC	Katherine Morris	General	The stated intent (line 30) of section 2 is "to provide cursory background information on the project setting for the C-BT project operations and regulations, and overview of the water quality history of the project. It is not intended to provide comprehensive documentation of the history of the C-BT project and Grand Lake clarity concerns." That being said, it is Grand County's opinion that the current order of section 2, leading with a relatively comprehensive explanation of power facilities, which are a secondary consideration of the C-BT Project in Senate Document 80, subordinates the purpose for which this process is being undertaken in the first place, which is to restore the scenic attraction of Grand Lake. Grand County would like to see section two reordered, with section 2.2 preceding the current section 2.1, and lines 174 and 175 replaced with language that more accurately captures the importance of Grand Lake such as that used by the WQCC in section Q of the standard (currently line 249) "The Commission determined that it is appropriate to adopt water quality standards for the protection of Grand Lake's clarity because of Grand Lake's uniqueness as Colorado's largest natural lake. Grand Lake adjoins and complements Rocky Mountain National Park in the headwaters of the Colorado River and its social and economic importance is worthy of protection…"	Section 2.1 and 2.2 were not reordered because it wouldn't make logical sense to the reader to introduce elements of a system without first introducing the system as a whole. It is assumed that many will read this report with no background knowledge and therefore continuity of details is important. However, to highlight that Grand Lake is the subject of this report, a sentence (Line 75) to emphasize the Grand Lake within Section 2.1 was added.
106	GC	Katherine Morris	77-153	This section is a subjective description of the C-BT project taken from the Reclamation website. If the intent is to describe the facilities and operation, the "Synopsis of Report, Colorado Big Thompson Project" sections "On Colorado River" and "On Eastern Slope" page D-5-5 & D-5-6 should be used.	Comment was noted but not incorporated into the text. 8/28/2013 Revision to RTC–the referenced documents were considered but are out of date and do not reflect current operations and existing infrastructure (i.e. Arkins Reservoir was never constructed, etc.)
107	GC	Katherine Morris	180	This table should include statistics for Willow Creek and Windy Gap Reservoirs. As water from these water bodies is pumped into Granby Reservoir, their drainage areas significantly increase the effective drainage area for Granby Reservoir, and water quality contributions from these water bodies contributes to water quality in Granby Reservoir and contributes significantly to the complexity of this system, this is material information for this report. The surface area for Grand Lake is incorrectly listed as 265 Acres, and should be changed to 507 acres. Similarly, the average depth should be changed to 135 feet, and that of Shadow Mountain Reservoir changed to 9.4 feet. These values would be attributed to Davine Lieberman's report, and are calculated by dividing the storage capacity by surface area.	Text changed in accordance with comment
108	GC	Katherine Morris	272	A tone of general criticism of the standard is again apparent in the statement "*…the standard inadequately established how aquatic life use is to be protected…"* (emphasis added). The line beginning 274 would be adequate to remark on this issue without the judgment expressed in 272.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC– we feel this is a true statement
109	GC	Katherine Morris	276	"Improvement of clarity within Grand Lake is expected to improve the quality of recreational uses of this unique resource…" unnecessarily and inappropriately limits the potential benefits conveyed with achievement of this standard to recreation, when they could include human health, aquatic life, property values, etc. Suggest removal of this sentence.	Part of this sentence is contained in the Reg 33 standard, rearranged citation, and added clarity to sentence.
110	GC	Katherine Morris	290	It is not relevant that there's no discussion in the standard of how 4 meters was developed. The Division and the Commission accepted Grand County and Northwest Colorado Council of Government's explanation that 4 meters was picked because that's what the lake regularly recovered to within 2 weeks after pumping stopped. This report should not second guess what the Commission decided. Because of this and comments on lines 292-294 Grand County suggests removal of this paragraph in its entirety.	The subject paragraph was removed from the text
111	GC	Katherine Morris	292	Regarding the concept that attainability is vague: The Commission knew that attainability would be different depending upon whether constructed alternatives are available or not available to resolve the issue of the loss of Grand Lake's scenic attraction. As a result, the language they used was deliberately vague so as not to presuppose an outcome. This is not a weakness of the standard but a strength: regardless it is not something that needs to be addressed in this report.	The subject paragraph was removed from the text

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112	GC	Katherine Morris	293	Abstraction of the words “attainability is to be judged by whether or not a clarity level can be attained” from the remainder of the quote “in approximately twenty years by any recognized control techniques that are environmentally, economically, and socially acceptable” renders the language seemingly ridiculous and nonsensical. Taking this particular phrase out of context is inappropriate and misleading.	The subject paragraph was removed from the text
113	GC	Katherine Morris	294	The statement “The Commission does not say that Secchi depth should be the technique that defines clarity…” seems to fly in the face of the fact that the Commission took the evidence presented by Northwest Colorado Council of Governments, Grand County, and Northern Water, and established two clarity standards, the second of which specifically identifies a 4 meter secchi depth. At the time of the hearing Grand County presented an analysis of secchi values and corresponding chlorophyll a in a linear regression, and the Commission specifically did not adopt a chlorophyll a regulation. The Commission established a standard based on secchi depth with a deferred implementation date. Again, this report should not attack that standard or second guess the language, which was deliberately vague so as not to constrain the parties involved as we seek to resolve the issues; rather it is the business of this report to attempt to evaluate methods of achieving compliance.	The subject paragraph was removed from the text
114	GC	Katherine Morris	301	Please strike this sentence and let the language of the standard beginning on line 303 speak for itself. Should GEI wish to emphasize anything from this section perhaps it should be the encouragement of cooperative efforts?	The subject paragraph was reworded and changed in accordance with Comments #115, 116
115	GC	Katherine Morris	312	Again, to shift away from language that is critical of the standard the following language could be substituted: “In practice, some uncertainties regarding assessment methodology have arisen…”	Text changed in accordance with comment
116	GC	Katherine Morris	316	Please don’t forget to include that the regulation does not specify if Secchi measurements are to be made with the naked eye or using a view scope.	Text changed in accordance with comment
117	GC	Katherine Morris	317	This is a lot of detail on a process that is not a part of this technical review and work plan as we are not asking for a reopening of the standard. This material will largely be outdated by June 2014: consider including only the general schedule.	Removed upcoming schedule.
118	GC	Katherine Morris	378	The McLaughlin Rincon report should be included in this list of reports informing the process as it is the only report that contemplates construction of a bypass tunnel, pipe, or treatment facility.	Text changed in accordance with comment
119	GC	Katherine Morris	426	The order of precedence is incorrect in this section. The Hydros report didn’t provide the initial discussion of factors that affect water clarity, the McCutchan report did, as it evaluated the 2009 stop pump and was published in 2010, while the Hydros report evaluated 2010 and prior years and was published in 2011. That same mistake is made in line 437.	Corrected timeline mistakes regarding the order of studies and reports.
120	GC	Katherine Morris	433	The Clarity Workgroup, before it was absorbed into the Three Lakes Technical Committee, addressed the issues brought up by the Hydros Memo. During that meeting we discussed the fact that Jean Marie Boyer, PhD and James McCutchan, PhD grouped the factors that diminish clarity slightly differently and that when grouped similarly, the percent differences between the two methods were between just 1.4% to 9.6% for Grand Lake, which was determined to be well within the standard error of collection methods, etc. I do not understand why this memo keeps being supplied as though there remains a difference of opinion between Northern and Grand County on this subject. Though the meeting minutes were never transcribed, I have the tape from that meeting and can provide a copy to anyone who would like to verify that agreement was reached regarding this issue.	Clarified that different approaches resulted in similar results. It is helpful to understand the nuances of the water clarity issue, especially when management strategies may be considered for different components of water clarity.
121	GC	Katherine Morris	440	Use of the word “inconsistent” seems unnecessary here. Grand Lake clarity improved during both stop-pumps, though not to the same degree. Shadow Mountain Reservoir clarity improved in 2008, and declined in 2009. Why not state the facts?	Added suggested language
122	GC	Katherine Morris	461	Please be clear that “wind conditions and air temperatures [in addition to pumping rates] can impact the amount of stratification…”	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–We opted not to revise quotation from other sources
123	GC	Katherine Morris	624	This table should include monitoring for microcystin toxin, which is supported by Grand County, Northern Water, Reclamation, the Colorado River Water Conservation District, and the Town of Grand Lake, and spans the years 2007 through 2013. The Connecting Channel Flow and Water Quality is supported by Grand County and the River District in cooperation with USGS. Atmospheric deposition should be presented separately from meteorology. That program is supported by the folks in the 3rd met. bullet point, and was just started last year specifically to inform the 3 Lakes Model and achieve certainty where previous reliance was on assumption.	Added suggested data types in Table 3

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124	GC	Katherine Morris	708	With a single sentence the authors could easily explain why the numerical clarity standard would not have been achieved in 2011. This would prevent the reader from being left hanging…	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–Despite the empirical evidence, we cannot definitely conclude that the 2011 season would have met the standard if pumping had not started. We cannot assume clarity would have remained the same during September 2011 because of variations in natural factors. We only have the data available, which includes pumping.
125	GC	Katherine Morris	726	I wouldn't characterize plant surveys as showing a "…consistent and relatively stable reduction…" Weeds grew back a little each year until we are again at a place where folks are clamoring for control. The drawdown was effective over several years, but that benefit was finite.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–the analysis of the Sisneros reports is consistent with the language used
126	GC	Katherine Morris	744	Grand County has disagreed through the comment process on the 2011 3 Lakes report by Hydros with their conclusions about stormwater, which we believe to be based upon several as yet unverified assumptions. At the time, Grand County asked for verification of conclusions with the use of TSS measurements from the tributary inflows and mapping to document which tributaries or interflows contributed the most and if this corresponded to stormwater inflows, but this work was determined to be beyond the scope for that report. Northern and Reclamation are pursuing evaluation of inflow TSS for the next 3 Lakes Report. It is Grand County's opinion that stormwater loading is very dependent upon drainage area, with the North and East Inlets being relatively "clean", oftentimes not even showing significant turbidity after a storm but actually just the reverse, with localized increases in secchi depths. As GEI knows, to date there has not been a targeted stormwater sampling program in any of the tributaries to the 3 Lakes. The long and short of this is that Grand County doesn't agree that "stormwater has been shown to have a substantial effect on inorganic suspended sediment, phosphorus and nitrogen loads to the Three Lakes System." We believe that achieving specificity about where this sentence might be true (which tributary or interflow) should be one of the data gaps identified in this report.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC- Added language to clarify that the inclusion of storm related inflows and the limited nutrient data in to the TLWQ Model has improved model calibration and indicate the importance of these sources. However, the model assumptions need to be verified with site-specific stormwater data.
127	GC	Katherine Morris	763	For both spreadsheet "models", assumptions are detailed with great specificity. Yet for the 3 Lakes model, which is much more complex and involved, assumptions are not indicated. Model assumptions are important to understand and should be enumerated here.	Provided reference for model documentation that presents model theory, assumptions and limitations.
128	GC	Katherine Morris	772	The model is identified as "a nutrient-food chain model". What does this mean and how does this model involve the food-chain?	Added text to clarify nutrient-food chain model
129	GC	Katherine Morris	778	The assumption of instantaneous dispersion throughout model layers is an important one, particularly in the vertically diverse hypolimnion, and deserves mention here.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC - Added text to clarify assumption of GL and GR well-mixed layers, including hypolimnion
130	GC	Katherine Morris	783	What does it mean that the model requires a paired set of water quality characteristics?	Added text to clarify the meaning of daily flow and daily water quality data
131	GC	Katherine Morris	923	Table 5, line 7, should not mention review of the numerical clarity standard value—just review of the collection methodology.	Comment was noted but not incorporated into the text. GEI intends to include the review of 4-m value and methodology as a data gap. 8/28/2013 Revision to RTC–reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)
132	GC	Katherine Morris	964	Grand County doesn't agree with this sentence as written. If there are specific concerns that are known but not indicated here, perhaps it would help to list those?	8/28/2013 Revision to RTC– Removed sentence as it did not add additional information to section

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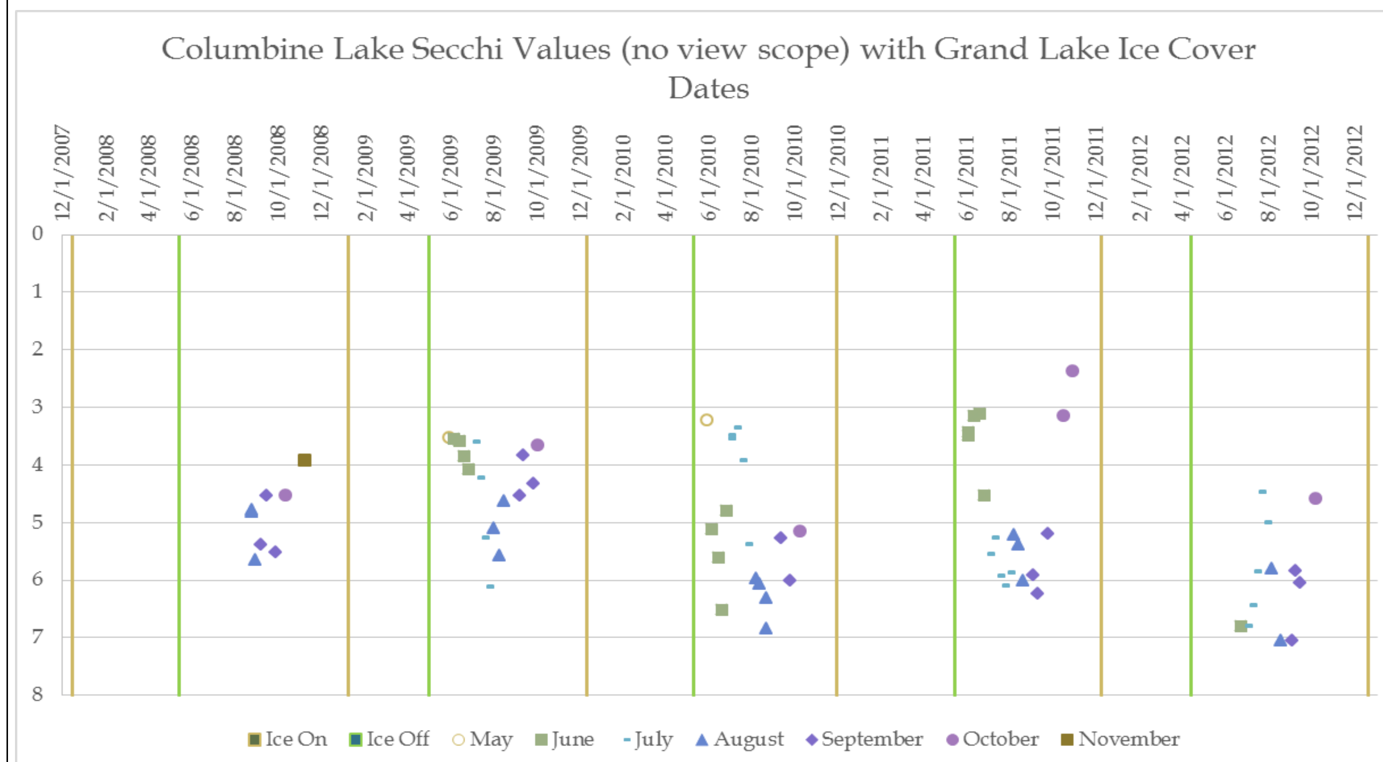
133	GC	Katherine Morris	1035	There is no need to collect a "secchi depth data set …" of the type indicated here. There are already abundant resources that prove 4 meters would be attainable without C-BT influence. We already have data from Columbine Lake, which although tiny in comparison, is located very near to Grand Lake in a similar geological setting. Columbine is not connected to the C-BT system, and Columbine routinely exceeds 4 meter secchi depth (graph below). Dr. McCutchan's study on the 2009 stop pump predicted "Hypothetical Transparency of Grand Lake Prior to the C-BT Project" of between 5 and 7 meters. This was effectively validated during the 2011 stop-pump, which demonstrated that 7.25 m secchi depth (no view scope) could be achieved with abundant native inflow and without pumping from the C-BT Project. And finally, EPA's National Lakes Assessment database has a record of available secchi depths for the western mountains ecoregion. This body of work shows that Colorado Mountain Lakes in 2007 averaged just under 5 meter secchi depth, and Trapper's Lake, which is Colorado's second largest natural lake measured almost 7 meters of secchi depth on July 12, 2007. 	References to the Trapper's Lake and Columbine Lake datasets were inserted.
134	GC	Katherine Morris	1046	Stormwater runoff should not only target the North Fork of the Colorado River, where existing uses may predate installation of the C-BT project.	Revised sentence to encompass other tributary inputs
135	GC	Katherine Morris	1052	Singling out the North Fork of the Colorado River for its contributions to nutrient loading is exactly what Grand County feared with approving use of the Hydros report on 3 Lakes 2011 without inclusion of the promised addendum explaining interflow contributions. This assertion ignores the far more substantive contributions from Windy Gap (3.4 times N. Fork average total P 2007-2009) and Willow Creek (1.6 times) to Granby Reservoir and thence to the system , and from Granby Reservoir to Shadow Mountain Reservoir (7 times N. Fork average total P 2007-2009). And again, stormwater has not been specifically measured.	Added paragraph regarding the importance of Windy Gap and Willow nutrient inputs to the system.
136	GC	Katherine Morris	1063	The Three Lakes Water Quality Model cannot show the importance of stormwater. Output is interpreted to mean this. Grand County has enumerated our opposition to this interpretation until better data is obtained to confirm this assumption.	Revised sentence to more accurately reflect the importance of model validation with a more extensive stormwater data set.
137	GC	Katherine Morris	1074	The epilimnion is present only for a portion of the year. Most pumping takes place in winter, and fall turnover integrates the components of the epilimnion into the mixed water body, providing dilution.	Added text to make is specific to summer when the clarity standard would be assessed.
138	GC	Katherine Morris	1158	Who is being quoted here? This sentence needs to be reorganized so that what's being evaluated is the ability of the alternative to achieve the standard, and not standard attainability.	Text changed in accordance with comment

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139	GC	Katherine Morris	1161	Reclamation is a member of the TLTC. If 'Reclamation's needs' are not being met through the questions posed by the committee, then perhaps Reclamation needs to speak up.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–sentence was reworded
140	GC	Katherine Morris	1165	See comment #1.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)
141	GC	Katherine Morris	1190	See comment #1	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)
142	GC	Katherine Morris	1194	Grand County is opposed to challenging the use of the 85th percentile (15th percentile) metric by which the clarity standard is measured. See comment 30 appendix C.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–GEI feels it is important to review the standard to determine the specifics for measuring, collecting and analyzing the data as well as to determine if the 15th percentile is a reasonable metric.
143	GC	Katherine Morris	1211	See comment #1.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)
144	GC	Katherine Morris	1218	Again, brief explanation of why the clarity standard would not have been met in 2011 would be useful here.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC–refer to comment #124
145	GC	Katherine Morris	1226	We could double the number of sampling days (I think) to twice a week and still arrive at the same result if the extra events were evenly spaced. There is nothing wrong with this. The clarity of the water pumped after September 6 was quite poor, with the highest chlorophyll-a values we've seen yet, and when that happened the standard kicked in and was protective.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC Consistency in collecting data and evaluating the attainment of the ambient-based standard needs to be further clarified, including the error associated with the percentile values and their assessment
146	GC	Katherine Morris	1280/1293	Number of alternatives does not correspond.	Text changed in accordance with comment
147	GC	Katherine Morris	1310	The sentence "Whether a resulting change in potentially poorer Shadow Mountain Reservoir chlorophyll a conditions is substantial enough to outweigh the water clarity benefits in Grand Lake should be considered and remains undetermined." is inappropriate here and does not keep in focus the protections outlined in Senate Document 80.	Comment was noted but not incorporated into the text 8/28/2013 Revision to RTC- Comment was noted but not incorporated into the text because other water quality standards need to be considered in the context of the overall project
148	NW	Vincent	Throughout document	There is no comma between Consulting and Inc. when referencing Hydros. Should read as Hydros Consulting Inc. instead of Hydros Consulting, Inc.	Text changed in accordance with comment

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149	NW	Vincent/ Drager	Page 2-9 Section 2.3.2	This section provides important background information regarding the standard and provides meaningful context for the information gaps that are later on discussed regarding the standard (both the assessment aspect and the standard itself). Whether these information gaps will be addressed as part of the USBR planning process/O&M process or through the WQCC/hearings, the fact remains that these are information gaps that will require analysis and discussion. There are no current plans for these discussions to take place through the hearing process or with the WQCD (discussions are currently in progress about further delaying this dialogue). Therefore it is all the more important to ensure that these data gaps be clearly called out for follow up.	Comment was noted 8/28/2013 Revision to RTC–we agree that these discussions should take place and that sooner is better. However, reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)
150	NW	Vincent	Page 2-9 line 238-239	This sentence is confusing and seems backwards. How could changes to SD80 happen after implementation?	Text changed in accordance with comment #17
151	NW	Vincent	Page 3-6 Line 541	P releases are also accompanied by chlorophyll a increases.	Comment was noted but not incorporated into the text. The referenced line is quoted and not edited.
152	NW	Vincent	Pg 3-2 through 3-7	It appears that text in italics are direct quotes from other documents. It also appears that bulleted non-italicized text is not. There are cases where direct quotes are represented by non-italicized text.	Updated direct quotes from final version and italicized.
153	NW	Vincent	Pg 3-7, line 569	"over time of year" is awkward. "Temporally" or "over time" would be an improvement.	Referenced text is quoted. Comment was noted but not incorporated into the text.
154	NW	Vincent	Pg 3-7, lines 571-572	The accumulation of inorganic nutrients in the hypolimnion of Granby Reservoir is due to more than "the breakdown of settled organic matter". Text should refer to internal loading, which includes other mechanisms as well.	Referenced text is quoted. Comment was noted but not incorporated into the text.
155	NW	Vincent	Page 3-8 Table 3	See comments from Esther Vincent's Memo. Table 3 needs to be updated to reflect all data collection efforts. Some are missing.	Updated table with additional data collection efforts
156	NW	Nichols	Page 3-12, lines 757-762	It would be better not to presuppose that "watershed management control … will likely not improve Grand Lake clarity as a stand along alternative, these management strategies should be considered as a component of any preferred C-BT Alternative Flow Management Project." Perhaps aggressive watershed controls would work alone.	Alternative T reflects a standalone watershed management alternative
157	NW	Vincent	Page 3-13, Table 4	The constituents listed are simulated for the Adams Tunnel, as well as Granby Reservoir outflows	Text changed in accordance with comment
158	NW	Vincent	Pg 4-3, line 991	"historic" should be replaced with "historical"	Text changed in accordance with comment
159	NW	Vincent	Pg 4-6, lines 1098-1108	Since this paragraph is in the section titled "Possible Updates to the Three Lakes Water Quality Model", it may make sense to end this paragraph with a statement acknowledging that the Three Lakes Model simulates year-round and multi-year conditions, so that "time sensitive" scenarios, such as those posed, can be simulated with the current version of the model.	Text changed in accordance with comment
160	NW	Vincent	Pg 4-6, lines 1110-1122	This text is based on the 2008 version of the model, which was calibrated using 2005-2006 data. It needs to be clear that the statements (such as lines 1115-1117) are based on an older version of the model and subsequent refinements and significant improvements have been made.	Identified model versions and subsequent refinements
161	NW	Vincent	Pg 4-8, lines 1182-1184	Sentence is unclear as written	Restructured sentence
162	NW	Vincent	Page 4-1 Table 5	Revise as per Esther Vincent's Memo.	Removed sampling plan and organize data
163	NW	Vincent	Page 4-3 Section 4.3	Revise as per Esther Vincent's Memo.	Removed Section 4.3 Physical Sampling, Data Organization
164	NW	Vincent	Page 4-5 Section 4.5	This section seems much broader than what the title indicates. It would be more appropriate to title it "factors influencing clarity", which seems to be the focus as it discusses particulate matter, pumping regimen, runoff etc… The discussion on attainability although relevant, seems out of place in this section. Perhaps it would be a better fit for 4.7 when discussing information gaps related to the standard.	Changed section heading to factors influencing water clarity
165	NW	Vincent/ Drager	Page 4-8 Section 4.7	The general message contained in the the first sentence (line 1189-1190) is essential and needs to be retained, regardless of wordsmithing and details in the rest of the section. Re-titling the section to focus on assessment only loses sight of a very important information gap as the standard itself has not been examined and was not scientifically established. This motivated the WQCC to give explicit directions to the parties for necessary investigations that have not been addressed and for which there are no current plans for follow up. See comment on section 2.3.2. In order for alternatives to be evaluated in the future, it is critical that the end point be clearly defined and established.	Line 1189-1190 is retained in the text although some of the following language has been changed. 8/28/2013 Revision to RTC–reference to the changing the 4m standard has been removed at Reclamation's request (see Appendix E, Final Report comments #13)

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
166	NW	Vincent	Page 5-3 Section 5.2 Lines 1310-1314	pH may also become of concern for Shadow Mountain Reservoir. 2013 data is currently showing pH consistenly in exceendence of 9.5 (and close to 10) over the past 10 days (since pumping was shut down on Jul 23rd). Strong stratification on DO, pH, Temp and SC that set up immediately following the pumping interruption, shows the kinds of water quality impacts that we have been concerned about on Shadow Mountain. Chlorophyll a data is not available yet but DO and pH data indicate algal productivity is the cause of the high pH and DO levels are dropping quickly at the bottom of the reservoir. See attached data.	Added text regarding relationship between increased algal growth, increased pH and decreased DO
167	NW	Nichols	Page 5-3, line 1298- 1301	same comment as comment 9.	Alternative T reflects a standalone watershed management alternative
168	NW	Nichols	Page 6-1, lines 1384-1388, Task 1	Although GEI discusses that 4 m may not be the appropriate standard and that it could be changed (sec. 2.3.2), Task 1 focuses on achieving 4 meters. It would be better if it said “applicable numeric standard.”	Text changed in accordance with comment

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
169	NW	Nichols	Page 6-3, lines 1429-1436, Task 2	Discuss potential future watershed conditions. “ Forestry practices” are important, but forestry conditions may be more important, such as wildfires.	Text changed in accordance with comment
170	NW	Nichols	page 6-9, Task 7	Development of 30% designs for selected alternative is clearly written for structural alternatives. Watershed management could also include some structural components, such as stream improvements to trap sediment, reduce nutrients, etc. That may be covered implicitly, but may be worth asking about.	Text changed in accordance with comment
171	NW	Vincent/ Drager	Page 6-11 Task 9	We are confused about the purpose of this task. This seems to lay out subtasks that are part of NEPA, yet the allocated budget for this task is not in line with what the NEPA process would cost. Is also seems somewhat redundant with task 8.	Text changed in accordance with comment

Appendix E

Comments/Response to Comments from July 2013 Final Technical Report

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
1	BOR	BOR-LH	Entire document	Replace "C-BT Alternative" with "water clarity improvement alternative" for consistency throughout document.	Text changed in accordance with comment
2	BOR	BOR-RT	Pg 2-1, re 1st paragraph of the quote	Please add the following footnote to page 2-1 to supplement the quote taken from Reclamation's website regarding the C-BT Project. ** There is no maximum annual diversion volume imposed on the C-BT Project. The original C-BT Project plan contemplated an average annual diversion of 310,000 acre-feet.*	Text changed in accordance with comment
3	BOR	BOR-CR	Pg 3-4, section 3.1.1.1	The OWQ Report quote provided in section 3.1.1.3 does not fit well. Quote should be moved to a more appropriate location in 3.1.1.1, see below. Please insert text shown in red. • *Other management decisions (such as the drawdown of Shadow Mountain in late 2006) can also impact subsequent water-quality conditions (as experienced in 2007).* The 2010 OWQ Report lists the following suggestions to improve water clarity in Grand Lake between July and September: 1. *Minimize the inflow of water with poor water quality into the lake.* 2. *Develop management strategies to improve water quality of inflow such as:* *a. Decrease water pumped at the Farr Pumping Plant* *b. Improve water quality of Shadow Mountain Reservoir* *c. By passing the flow from Shadow Maintain Reservoir around Grand Lake* It should be noted the 2010 OWQ Report does conclude that it would be "difficult to improve the water quality and clarity characteristics of Shadow Mountain Reservoir due to shallow conditions, sources of nutrients, and weather conditions." However, that report did not make any attempt to weigh the challenge of improving Shadow Mountain Reservoir water quality against the challenges associated with any structural or non-structural alternatives. Hydros also recommended the following future monitoring and data evaluations: • *Use the Three Lakes Water-Quality Model to determine the limits or bounds of water-quality conditions for Shadow Mountain Reservoir and Grand Lake, under a variety of operational scenarios.*	Moved location of 2010 OWQ quote in 3.1.1.3 to 3.1.1.1

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
4	BOR	BOR-CR	Pg 3-7 to 3-8, section 3.1.1.3	The goal and result of the Alternative Report needs to be included. Additionally, the OWQ Report quote provided in section 3.1.1.3 does not fit well. Quote should be moved to more appropriate location in 3.1.1.1, see comment 3. Section 3.1.1.3 should be revised as shown below. In August 2012, a "Preliminary Alternatives Development Report" (Alternatives Report) was published by Reclamation (Reclamation, 2012). The goal of this report was to determine whether further development of alternatives were possible to improve water clarity in Grand Lake, Colorado as part of the Colorado Big Thompson Project (C-BT Project) west slope collection system in response to a proposed State water clarity standard to take effect in 2015. The report found that there were water clarity improvement alternatives that could be further developed. The Alternatives Report is the primary source of engineering information for potential structural and non-structural alternatives intended to improve the water clarity in Grand Lake. The Alternative Report presents only preliminary ideas and concepts, as identified in "brainstorming sessions", and estimates of costs were intentionally excluded. This report summarizes water quality ~~problems~~ issues in the Three Lakes System as follows: *Water clarity in Grand Lake and Shadow Mountain Reservoir is predominately a function of non-algal organic particulate matter, algae particles, inorganic suspended solids, and dissolved organic matter. Factors affecting the concentrations of these constituents include hydrology, operations, weather and quality of inflowing water. Water clarity in Grand Lake responds to changes in C-BT Project pumping operations. The conveyance of water from Shadow Mountain Reservoir to Grand Lake appears to be related to detected declines in water clarity*. The report also provides information on 15 alternative approaches to address the water quality issues. The Alternatives Report provides a qualitative comparison of these alternatives and ranks them. The highest ranking alternatives were assessed based on their merits, risks, and uncertainties and further analyses required for a complete alternatives evaluation were identified. One of the recommendations within the Alternatives Report is to perform a technical review of the alternatives. This Technical Review fulfills this recommendation. ~~The summary and recommendations found in the Alternatives Report are as follows:~~ ~~*Water clarity in Grand Lake and Shadow Mountain Reservoir is predominately a function of non-algal organic particulate matter, algae particles, inorganic suspended solids, and dissolved organic matter. Factors affecting the concentrations of these constituents include hydrology, operations, weather and quality of inflowing water. Water clarity in Grand Lake responds to changes in C-BT Project pumping operations. The conveyance of water from Shadow Mountain Reservoir to Grand Lake appears to be related to detected declines in water clarity. To improve water clarity in Grand Lake between July and September, [the 2010 OWQ Report] suggests the following:*~~ ~~*1. Minimize the inflow of water with poor water quality into the lake.*~~ ~~*2. Develop management strategies to improve water quality of inflow such as:*~~ ~~*a. Decrease water pumped at the Farr Pumping Plant*~~ ~~*b. Improve water quality of Shadow Mountain Reservoir*~~ ~~*c. By passing the flow from Shadow Maintain Reservoir around Grand Lake*~~ ~~It should be noted the 2010 OWQ Report does conclude that it would be "difficult to improve the water quality and clarity characteristics of Shadow Mountain Reservoir due to shallow conditions, sources of nutrients, and weather conditions." However, that report did not make any attempt to weigh the challenge of improving Shadow Mountain Reservoir water quality against the challenges associated with any structural or non-structural alternatives.~~	Added suggested text and edits to 3.1.1.3 and moved location of 2010 OWQ quote in 3.1.1.3 to 3.1.1.1 (see comment #3)
5	BOR	BOR-CR	Pg 3-8, sect 3.2.1, 2nd bullet	Please revise as shown below. "Assess potential water quality changes in receiving streams, upstream and downstream of where Colorado-Big Thompson Project and Northern Water Windy Gap Project water is released."	Text changed in accordance with comment
6	BOR	BOR-CR	Pg 3-12, last ¶ of section 3.2.2	Remove paragraph. ~~"The Water Supply Operations Model indicates that neither the stop-pump or modify-pump alternatives caused a reduction in yield from the C-BT system, primarily because of the system capacity and its operational flexibility."~~	Text changed in accordance with comment

Comment Number	Agency	Reviewer	Location of Text in July 2013 Final Draft	Comment	Response to Comment
7	BOR	BOR-CR/SKS	Pg 3-14, very top of page	Please revise as shown below. "…considered as a component to any ~~preferred C-BT Alternative Flow Management Project~~ water clarity implementation alternative."	Text changed in accordance with comment
8	BOR	BOR-KT	Pg 4-1, Table 5 and Pg 4-9 Sect 4.9 title	Add text as shown below and revise 4.9 section title accordingly. "Review of the water supply operations spreadsheet and development of a water supply operations model for evaluating alternatives and quantity revenue/cost impacts."	Text changed in accordance with comment
9	BOR	BOR-KT	Pg 4-1, Table 5 and Pg 4-10 Sect 4.10 title	Add text as shown below and revise 4.10 section title accordingly. "Review of the power operations spreadsheet and development of a power operations spreadsheet for evaluating alternatives and quantity revenue/cost impacts."	Text changed in accordance with comment
10	BOR	BOR-CR/SKS	Pg 4-3, section 4.3, 3rd sentence	Please revise as shown below. "…potential effects to aquatic life use in the Three Lakes regarding the implementation of ~~a preferred C-BT Alternative~~ any water clarity improvement alternative."	Text changed in accordance with comment
11	BOR	BOR-MC	Page 4-8 to 4-9, Section 4.8	Section needs to be rewritten such that the standard is not evaluated. Reclamation agrees that clarity is needed on what it means to comply with the standard but it is not in the technical review scope to evaluate the standard. The text of this section and other related document references should assume that whatever standard is put in place will be the goal of compliance efforts. The discussion can then focus on how, where, when and by whom the compliance measurements are made.	Removed portions on revisiting standard and rewrote section in the context of assessment methodology
12	BOR	BOR-CR	Pg 6-2, Task 2 biii	Per conversation between Craig and Laura, please clarify what stormwater management includes? Be more inclusive, i.e. make stronger connection to nonpoint source pollutant language.	Clarified that non-point sources are a component of stormwater, and that initial assessment of stormwater conditions will provide a composite view of all NP sources.
13	BOR	BOR-CR/SKS	Pg 6-11, Task 9, 1st ¶, last sentence	Please revise as shown below. "…documentation of environmental compliance so that a preferred water clarity improvement ~~project~~ alternative can be implemented"	Text changed in accordance with comment
14	BOR	BOR-MC / JG	Comment Appendices	For all comments that were noted, but not incorporated an explanation must be given regarding why the comment was not incorporated.	Explanation for 'noted comments' was added to all sets of comments. Modifications were added with a "8/28/2013 Revision to RTC" header so it was clear that our response to comments had changed.
15	BOR	BOR-KT	Appendix I	Add the work "Potential" to the title of Appendix I.	Text changed in accordance with comment
16	BOR	BOR-SS	Gantt Chart	Please format Gantt chart so nothing is cut off.	Reformatted Gantt Chart

Appendix F

Sampling Plan

Constituent Description	GRAND LAKE		
	Sampling Priority	Sampling Frequency	Location(s) of Data Collection*
Biological			
Algae Toxin	Low		
Chlorophyll, in situ flourometric			
Chlorophyll a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Chlorophyll b	Low		
Chlorophyll c	Low		
Fecal Coliform	Low		
Pheophytin a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Zooplankton concentration, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Phytoplankton concentration, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Nutrient Chemistry			
Ammonia as N, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Kjeldhal Nitrogen as N, Total	Low		
Nitrate as N	Low		
Nitrate plus Nitrite as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Nitrite as N	Low		
Nitrogen Total as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Nitrogen Total as N, Dissolved	Med		
Organic Carbon, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Organic Carbon, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Ortho Phosphate as P	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Phosphorus, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Phosphorus, Total Dissolved	Med		
Ion and Metal Chemistry			
Alkalinity, Bicarbonate	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Alkalinity, Bicarbonate Filtered	Low		
Alkalinity, Carbonate	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Alkalinity, Carbonate Filtered	Low		
Alkalinity, Hydroxide	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Alkalinity, Hydroxide Filtered	Low		
Alkalinity, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Alkalinity, Total Filtered	Low		
Calcium	Low		
Chloride	Low		
Hardness as CaCO3	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Magnesium	Low		
Manganese, Dissolved	Low		
Manganese, Total	Low		
Potassium	Low		
Silica as Silicate, Dissolved	Low		
Silver, Dissolved	Low		
Sodium	Low		
Sulfate	Low		
Arsenic, Dissolved	Low		
Arsenic, Total	Low		
Barium, Dissolved	Low		
Beryllium, Dissolved	Low		

Constituent Description	GRAND LAKE Sampling Priority	Sampling Frequency	Location(s) of Data Collection*
Boron, Dissolved	Low		
Cadmium, Dissolved	Low		
Cadmium, Total	Low		
Chromium, Dissolved	Low		
Chromium, Total	Low		
Cobalt, Dissolved	Low		
Copper, Dissolved	Low		
Copper, Total	Low		
Fluoride	Low		
Iron, Dissolved	Low		
Iron, Total	Low		
Lead, Dissolved	Low		
Lead, Total	Low		
Lithium, Dissolved	Low		
Mercury, Dissolved	Low		
Mercury, Total	Low		
Molybdenum, Dissolved	Low		
Nickel, Dissolved	Low		
Selenium, Dissolved	Low		
Selenium, Total	Low		
Strontium, Dissolved	Low		
Vanadium, Dissolved	Low		
Zinc, Dissolved	Low		
Zinc, Total	Low		
Physicochemical Properties			
Dissolved Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Oxidation Reduction Potential	Low		
Oxygen Concentration, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
pH Field	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
pH Laboratory	Low		
Secchi Depth	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Specific Conductance	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Suspended Solids, Non-Volatile	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Suspended Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Turbidity	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
UV Absorbance at 254 nm	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Water Temperature	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GL-ATW, GL-MID, GL-WES
Meteorological and Hydrological Data			
Air Temperature			
Wind Speed and Direction			
Precipitation			
Solar Radiation			
Tributary Discharge	High	Daily	N & E Inlet

*** Water Column Locations**

Grand Lake Stations	Sample Epilimnion (photic zone) at these stations GL-ATW, GL-MID, GL-WES
Shadow Mountain Reservoir Stations	Sample the water column (top, mid, bottom) at these locations SM-DAM, SM-MID, SM-NOR
Granby Reservoir Stations	Sample the Epilimnion (photic zone) and Hypolimnion at these locations GR-EAS, GR-DAM, GR-WES

Constituent Description	SHADOW MOUNTAIN RESERVOIR		
	Sampling Priority	Sampling Frequency	Location(s) of Data Collection*
Biological			
Algae Toxin	Low		
Chlorophyll, in situ flourometric	High	Continuous	SM-CHL
Chlorophyll a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR, SM-CHL
Chlorophyll b	Low		
Chlorophyll c	Low		
Fecal Coliform	Low		
Pheophytin a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Zooplankton concentration, Total	Med		
Phytoplankton concentration, Total	Med		
Nutrient Chemistry			
Ammonia as N, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Kjeldhal Nitrogen as N, Total	Low		
Nitrate as N	Low		
Nitrate plus Nitrite as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Nitrite as N	Low		
Nitrogen Total as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Nitrogen Total as N, Dissolved	Med		
Organic Carbon, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Organic Carbon, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Ortho Phosphate as P	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Phosphorus, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Phosphorus, Total Dissolved	Med		
Ion and Metal Chemistry			
Alkalinity, Bicarbonate	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Alkalinity, Bicarbonate Filtered	Low		
Alkalinity, Carbonate	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Alkalinity, Carbonate Filtered	Low		
Alkalinity, Hydroxide	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Alkalinity, Hydroxide Filtered	Low		
Alkalinity, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Alkalinity, Total Filtered	Low		
Calcium	Low		
Chloride	Low		
Hardness as CaCO3	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Magnesium	Low		
Manganese, Dissolved	Low		
Manganese, Total	Low		
Potassium	Low		
Silica as Silicate, Dissolved	Low		
Silver, Dissolved	Low		
Sodium	Low		
Sulfate	Low		
Arsenic, Dissolved	Low		
Arsenic, Total	Low		
Barium, Dissolved	Low		
Beryllium, Dissolved	Low		
Boron, Dissolved	Low		
Cadmium, Dissolved	Low		
Cadmium, Total	Low		
Chromium, Dissolved	Low		
Chromium, Total	Low		

Constituent Description	SHADOW MOUNTAIN RESERVOIR		
	Sampling Priority	Sampling Frequency	Location(s) of Data Collection*
Cobalt, Dissolved	Low		
Copper, Dissolved	Low		
Copper, Total	Low		
Fluoride	Low		
Iron, Dissolved	Low		
Iron, Total	Low		
Lead, Dissolved	Low		
Lead, Total	Low		
Lithium, Dissolved	Low		
Mercury, Dissolved	Low		
Mercury, Total	Low		
Molybdenum, Dissolved	Low		
Nickel, Dissolved	Low		
Selenium, Dissolved	Low		
Selenium, Total	Low		
Strontium, Dissolved	Low		
Vanadium, Dissolved	Low		
Zinc, Dissolved	Low		
Zinc, Total	Low		
Physicochemical Properties			
Dissolved Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Oxidation Reduction Potential	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Oxygen Concentration, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
pH Field	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
pH Laboratory	Low		
Secchi Depth	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Specific Conductance	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Suspended Solids, Non-Volatile	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Suspended Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Turbidity	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR,SM-CHL
UV Absorbance at 254 nm	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Water Temperature	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	SM-DAM, SM-MID, SM-NOR
Meteorological and Hydrological Data			
Air Temperature	High	Daily	SM DAM SITE
Wind Speed and Direction	High	Daily	SM DAM SITE
Precipitation	High	Daily	SM DAM SITE
Solar Radiation	High	Daily	SM DAM SITE
Tributary Discharge	High	Daily	NFCR

*** Water Column Locations**

Grand Lake Stations	Sample Epilimnion (photic zone) at these stations GL-ATW, GL-MID, GL-WES
Shadow Mountain Reservoir Stations	Sample the water column (top, mid, bottom) at these locations SM-DAM, SM-MID, SM-NOR
Granby Reservoir Stations	Sample the Epilimnion (photic zone) and Hypolimnion at these locations GR-EAS, GR-DAM, GR-WES

Constituent Description	GRANBY PUMP CANAL		
	Sampling Priority	Sampling Frequency	Location(s) of Data Collection
Biological			
Algae Toxin	Low		
Chlorophyll, in situ flourometric			
Chlorophyll a, Corrected	Low		
Chlorophyll b	Low		
Chlorophyll c	Low		
Fecal Coliform	Low		
Pheophytin a, Corrected	Low		
Zooplankton concentration, Total	Low		
Phytoplankton concentration, Total	Low		
Nutrient Chemistry			
Ammonia as N, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Kjeldhal Nitrogen as N, Total	Low		
Nitrate as N	Low		
Nitrate plus Nitrite as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Nitrite as N	Low		
Nitrogen Total as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Nitrogen Total as N, Dissolved	Low		
Organic Carbon, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Organic Carbon, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Ortho Phosphate as P	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Phosphorus, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Phosphorus, Total Dissolved	Low		
Ion and Metal Chemistry			
Alkalinity, Bicarbonate	Low		
Alkalinity, Bicarbonate Filtered	Low		
Alkalinity, Carbonate	Low		
Alkalinity, Carbonate Filtered	Low		
Alkalinity, Hydroxide	Low		
Alkalinity, Hydroxide Filtered	Low		
Alkalinity, Total	Low		
Alkalinity, Total Filtered	Low		
Calcium	Low		
Chloride	Low		
Hardness as CaCO3	Low		
Magnesium	Low		
Manganese, Dissolved	Low		
Manganese, Total	Low		
Potassium	Low		
Silica as Silicate, Dissolved	Low		
Silver, Dissolved	Low		
Sodium	Low		
Sulfate	Low		
Arsenic, Dissolved	Low		
Arsenic, Total	Low		
Barium, Dissolved	Low		
Beryllium, Dissolved	Low		
Boron, Dissolved	Low		
Cadmium, Dissolved	Low		
Cadmium, Total	Low		
Chromium, Dissolved	Low		
Chromium, Total	Low		

Constituent Description	GRANBY PUMP CANAL		
	Sampling Priority	Sampling Frequency	Location(s) of Data Collection
Cobalt, Dissolved	Low		
Copper, Dissolved	Low		
Copper, Total	Low		
Fluoride	Low		
Iron, Dissolved	Low		
Iron, Total	Low		
Lead, Dissolved	Low		
Lead, Total	Low		
Lithium, Dissolved	Low		
Mercury, Dissolved	Low		
Mercury, Total	Low		
Molybdenum, Dissolved	Low		
Nickel, Dissolved	Low		
Selenium, Dissolved	Low		
Selenium, Total	Low		
Strontium, Dissolved	Low		
Vanadium, Dissolved	Low		
Zinc, Dissolved	Low		
Zinc, Total	Low		
Physicochemical Properties			
Dissolved Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Oxidation Reduction Potential	Low		
Oxygen Concentration, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
pH Field	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
pH Laboratory	Low		
Secchi Depth			
Specific Conductance	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Suspended Solids, Non-Volatile	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Suspended Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Turbidity	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
UV Absorbance at 254 nm	Low		
Water Temperature	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-Pump
Meteorological and Hydrological Data			
Air Temperature			
Wind Speed and Direction			
Precipitation			
Solar Radiation			
Tributary Discharge	High	Daily	Farr Pump Station

Constituent Description	LAKE GRANBY		
	Sampling Priority	Sampling Frequency	Location(s) of Data Collection*
Biological			
Algae Toxin	Low		
Chlorophyll, in situ flourometric			
Chlorophyll a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Chlorophyll b	Low		
Chlorophyll c	Low		
Fecal Coliform	Low		
Pheophytin a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Zooplankton concentration, Total	Low		
Phytoplankton concentration, Total	Low		
Nutrient Chemistry			
Ammonia as N, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Kjeldhal Nitrogen as N, Total	Low		
Nitrate as N	Low		
Nitrate plus Nitrite as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Nitrite as N	Low		
Nitrogen Total as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Nitrogen Total as N, Dissolved	Low		
Organic Carbon, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Organic Carbon, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Ortho Phosphate as P	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Phosphorus, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Phosphorus, Total Dissolved			
Ion and Metal Chemistry			
Alkalinity, Bicarbonate	Low		
Alkalinity, Bicarbonate Filtered	Low		
Alkalinity, Carbonate	Low		
Alkalinity, Carbonate Filtered	Low		
Alkalinity, Hydroxide	Low		
Alkalinity, Hydroxide Filtered	Low		
Alkalinity, Total	Low		
Alkalinity, Total Filtered	Low		
Calcium	Low		
Chloride	Low		
Hardness as CaCO3	Low		
Magnesium	Low		
Manganese, Dissolved	Low		
Manganese, Total	Low		
Potassium	Low		
Silica as Silicate, Dissolved	Low		
Silver, Dissolved	Low		
Sodium	Low		
Sulfate	Low		
Arsenic, Dissolved	Low		
Arsenic, Total	Low		
Barium, Dissolved	Low		
Beryllium, Dissolved	Low		
Boron, Dissolved	Low		
Cadmium, Dissolved	Low		
Cadmium, Total	Low		
Chromium, Dissolved	Low		
Chromium, Total	Low		

Constituent Description	LAKE GRANBY		
	Sampling Priority	Sampling Frequency	Location(s) of Data Collection*
Cobalt, Dissolved	Low		
Copper, Dissolved	Low		
Copper, Total	Low		
Fluoride	Low		
Iron, Dissolved	Low		
Iron, Total	Low		
Lead, Dissolved	Low		
Lead, Total	Low		
Lithium, Dissolved	Low		
Mercury, Dissolved	Low		
Mercury, Total	Low		
Molybdenum, Dissolved	Low		
Nickel, Dissolved	Low		
Selenium, Dissolved	Low		
Selenium, Total	Low		
Strontium, Dissolved	Low		
Vanadium, Dissolved	Low		
Zinc, Dissolved	Low		
Zinc, Total	Low		
Physicochemical Properties			
Dissolved Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Oxidation Reduction Potential	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Oxygen Concentration, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
pH Field	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
pH Laboratory	Low		
Secchi Depth	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Specific Conductance	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Suspended Solids, Non-Volatile	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Suspended Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Turbidity	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
UV Absorbance at 254 nm	Low		
Water Temperature	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	GR-EAS, GR-DAM, GR-WES
Meteorological and Hydrological Data			
Air Temperature	High	Daily	GR-SSW
Wind Speed and Direction	High	Daily	GR-SSW
Precipitation	High	Daily	GR-SSW
Solar Radiation	High	Daily	GR-SSW
Tributary Discharge	low		

*** Water Column Locations**

Grand Lake Stations	Sample Epilimnion (photic zone) at these stations GL-ATW, GL-MID, GL-WES
Shadow Mountain Reservoir Stations	Sample the water column (top, mid, bottom) at these locations SM-DAM, SM-MID, SM-NOR
Granby Reservoir Stations	Sample the Epilimnion (photic zone) and Hypolimnion at these locations GR-EAS, GR-DAM, GR-WES

Constituent Description	TRIBUTARIES TO THREE LAKES SYSTEM		
	Sampling Priority	**Sampling Frequency**	**Location(s) of Data Collection**
Biological			
Algae Toxin			
Chlorophyll, in situ flourometric			
Chlorophyll a, Corrected			
Chlorophyll b			
Chlorophyll c			
Fecal Coliform			
Pheophytin a, Corrected			
Zooplankton concentration, Total			
Phytoplankton concentration, Total			
Nutrient Chemistry			
Ammonia as N, Dissolved	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Kjeldhal Nitrogen as N, Total	Low		
Nitrate as N	Low		
Nitrate plus Nitrite as N	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Nitrite as N	Low		
Nitrogen Total as N	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Nitrogen Total as N, Dissolved	Low		
Organic Carbon, Dissolved	Med		
Organic Carbon, Total	Med		
Ortho Phosphate as P	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Phosphorus, Total	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Phosphorus, Total Dissolved	Med		
Ion and Metal Chemistry			
Alkalinity, Bicarbonate	Low		
Alkalinity, Bicarbonate Filtered	Low		
Alkalinity, Carbonate	Low		
Alkalinity, Carbonate Filtered	Low		
Alkalinity, Hydroxide	Low		
Alkalinity, Hydroxide Filtered	Low		
Alkalinity, Total	Low		
Alkalinity, Total Filtered	Low		
Calcium	Low		
Chloride	Low		
Hardness as CaCO3	Low		
Magnesium	Low		
Manganese, Dissolved	Low		
Manganese, Total	Low		
Potassium	Low		
Silica as Silicate, Dissolved	Low		
Silver, Dissolved	Low		
Sodium	Low		
Sulfate	Low		
Arsenic, Dissolved	Low		
Arsenic, Total	Low		
Barium, Dissolved	Low		
Beryllium, Dissolved	Low		
Boron, Dissolved	Low		
Cadmium, Dissolved	Low		
Cadmium, Total	Low		
Chromium, Dissolved	Low		
Chromium, Total	Low		

Constituent Description	TRIBUTARIES TO THREE LAKES SYSTEM		
	Sampling Priority	**Sampling Frequency**	**Location(s) of Data Collection**
Cobalt, Dissolved	Low		
Copper, Dissolved	Low		
Copper, Total	Low		
Fluoride	Low		
Iron, Dissolved	Low		
Iron, Total	Low		
Lead, Dissolved	Low		
Lead, Total	Low		
Lithium, Dissolved	Low		
Mercury, Dissolved	Low		
Mercury, Total	Low		
Molybdenum, Dissolved	Low		
Nickel, Dissolved	Low		
Selenium, Dissolved	Low		
Selenium, Total	Low		
Strontium, Dissolved	Low		
Vanadium, Dissolved	Low		
Zinc, Dissolved	Low		
Zinc, Total	Low		
Physicochemical Properties			
Dissolved Solids, Total	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Oxidation Reduction Potential			
Oxygen Concentration, Dissolved	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
pH Field	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
pH Laboratory			
Secchi Depth			
Specific Conductance	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Suspended Solids, Non-Volatile	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Suspended Solids, Total	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Turbidity	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
UV Absorbance at 254 nm			
Water Temperature	High	Mo/storm events	NI-GLU, EI-GLU, CR-SMU
Meteorological and Hydrological Data			
Air Temperature			
Wind Speed and Direction			
Precipitation			
Solar Radiation			
Tributary Discharge	High	Daily	NI-GLU, EI-GLU, CR-SMU

Constituent Description	ADAMS TUNNEL WEST PORTAL		
	Sampling Priority	**Sampling Frequency**	**Location(s) of Data Collection**
Biological			
Algae Toxin	Low		
Chlorophyll, in situ flourometric	Low		
Chlorophyll a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Chlorophyll b	Low		
Chlorophyll c	Low		
Fecal Coliform	Low		
Pheophytin a, Corrected	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Zooplankton concentration, Total	Low		
Phytoplankton concentration, Total	Low		
Nutrient Chemistry			
Ammonia as N, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Kjeldhal Nitrogen as N, Total	Low		
Nitrate as N	Low		
Nitrate plus Nitrite as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Nitrite as N	Low		
Nitrogen Total as N	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Nitrogen Total as N, Dissolved	Low		
Organic Carbon, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Organic Carbon, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Ortho Phosphate as P	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Phosphorus, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Phosphorus, Total Dissolved	Med		
Ion and Metal Chemistry			
Alkalinity, Bicarbonate	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Alkalinity, Bicarbonate Filtered	Low		
Alkalinity, Carbonate	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Alkalinity, Carbonate Filtered	Low		
Alkalinity, Hydroxide	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Alkalinity, Hydroxide Filtered	Low		
Alkalinity, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Alkalinity, Total Filtered	Low		
Calcium	Low		
Chloride	Low		
Hardness as CaCO3	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Magnesium	Low		
Manganese, Dissolved	Low		
Manganese, Total	Low		
Potassium	Low		
Silica as Silicate, Dissolved	Low		
Silver, Dissolved	Low		
Sodium	Low		
Sulfate	Low		
Arsenic, Dissolved	Low		
Arsenic, Total	Low		
Barium, Dissolved	Low		
Beryllium, Dissolved	Low		
Boron, Dissolved	Low		
Cadmium, Dissolved	Low		
Cadmium, Total	Low		
Chromium, Dissolved	Low		
Chromium, Total	Low		

Constituent Description	ADAMS TUNNEL WEST PORTAL Sampling Priority	Sampling Frequency	Location(s) of Data Collection
Cobalt, Dissolved	Low		
Copper, Dissolved	Low		
Copper, Total	Low		
Fluoride	Low		
Iron, Dissolved	Low		
Iron, Total	Low		
Lead, Dissolved	Low		
Lead, Total	Low		
Lithium, Dissolved	Low		
Mercury, Dissolved	Low		
Mercury, Total	Low		
Molybdenum, Dissolved	Low		
Nickel, Dissolved	Low		
Selenium, Dissolved	Low		
Selenium, Total	Low		
Strontium, Dissolved	Low		
Vanadium, Dissolved	Low		
Zinc, Dissolved	Low		
Zinc, Total	Low		
Physicochemical Properties			
Dissolved Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Oxidation Reduction Potential	Low		
Oxygen Concentration, Dissolved	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
pH Field	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
pH Laboratory			
Secchi Depth	Low		
Specific Conductance	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Suspended Solids, Non-Volatile	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Suspended Solids, Total	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Turbidity	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
UV Absorbance at 254 nm	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Water Temperature	High	Monthly (Oct-Apr) / 2 weeks (May-Sep)	
Meteorological and Hydrological Data			
Air Temperature			
Wind Speed and Direction			
Precipitation			
Solar Radiation			
Tributary Discharge			

Appendix G

2013 Baseline Monitoring Program and Northern Water Data Collection Matrix

BASELINE MONITORING PROGRAM

Water Year 2013

The following describes Northern Water's Baseline Water Quality Monitoring Program.

The objectives of the Baseline Monitoring Program are to:

1. Monitor current conditions
2. Monitor trends and changes in water quality in lakes and reservoirs and flowing sites: streams, rivers and canals.
3. Assess potential water quality changes in receiving streams, upstream and downstream of where Colorado-Big Thompson Project and Windy Gap Project water is released.
4. Assess compliance with state water quality standards.

Monitoring Locations

The Baseline Monitoring Program covers 56 monitoring sites in eight watersheds on both sides of the Continental Divide in Northern Colorado. There are 42 flowing sites (canals and streams) and 14 lake and reservoir sites. The flowing sites are located downstream of reservoirs, in the canals at points of release to the streams, and upstream and downstream of these release points.

Reservoir Monitoring Locations

Station	Description	Latitude	Longitude	Slope
GL-ATW	Grand Lake West Portal (USGS #401428105481601)	40.2411	-105.8044	West
GL-MID	Grand Lake Mid-Section (USGS #09013900)	40.2433	-105.8136	West
GR-DAM	Lake Granby Dam (USGS #09018500)	40.1497	-105.8614	West
GR-EAS	Lake Granby East Side (USGS #400806105474700)	40.135	-105.797	West
GR-WES	Lake Granby West Side (USGS #401030105521101)	40.175	-105.8697	West
SM-CHL	Shadow Mountain Channel in Grand Lake at mouth of Channel (USGS #09014000)	40.2447	-105.8258	West
SM-DAM	Shadow Mountain Dam (USGS #09014500)	40.2101	-105.8421	West
SM-MID	Shadow Mountain Mid-Section (USGS #401331105501401)	40.2252	-105.8378	West
WC-DAM	Willow Creek at Dam (USGS #400853105563701)	40.1481	-105.9436	West
WG-DAM	Windy Gap Reservoir at Dam (USGS #400631105585501)	40.1084	-105.9824	West
CL-DAM1	Carter Lake Dam #1 (USGS #06742500)	40.3253	-105.2152	East
HT-DIX	Horsetooth at Dixon Canyon (USGS #403317105090000)	40.5543	-105.1506	East
HT-SOL	Horsetooth at Soldier Canyon (USGS #06737500)	40.5888	-105.1649	East
HT-SPR	Horsetooth at Spring Canyon (USGS #403147105083800)	40.5292	-105.1456	East

Flowing Sites Monitoring Locations

Station	Description	Latitude	Longitude	Slope
AC-GRU	Arapahoe Creek at Monarch Lake outlet, upstream of Lake Granby (USGS #09016500)	40.1128	-105.7497	West
CR-GRD	Colorado River downstream of Lake Granby (USGS #9019500)	40.1444	-105.8672	West
CR-SMD	Colorado River downstream of Shadow Mountain Reservoir	40.2059	-105.838	West
CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir	40.219	-105.8577	West
CR-WGD	Colorado River downstream of Windy Gap (USGS #09034250)	40.1082	-106.0037	West
CR-WGU	Colorado River above Windy Gap, upstream of confluence with Fraser River	40.1003	-105.9726	West
EI-GLU	East Inlet upstream of Grand Lake (USGS #090135000)	40.2369	-105.801	West
FR-WGU	Fraser River upstream of confluence with Colorado River	40.0984	-105.9727	West
GR-Pump	Granby Pump Canal at foot bridge on south side of Shadow Mountain (USGS #09018300)	40.2068	-105.8495	West
NI-GLU	North Inlet upstream of Grand Lake	40.2507	-105.8148	West
RF-GRU	Roaring Fork inlet upstream of Lake Granby	40.1308	-105.7671	West
ST-GRU	Stillwater Creek upstream of Lake Granby (USGS #09018000)	40.1829	-105.8892	West
ST-JRD2	Combined sample of mainstem and tributary to Stillwater Creek that merge at CR42	40.1925	-1058973	West
WC-Pump	Willow Creek discharge chute to Lake Granby	40.143	-105.8888	West
WC-WCRD	Willow Creek directly downstream of Willow Creek Reservoir Dam	40.1456	-105.9404	West
WG-Pump	Windy Gap discharge chute to Lake Granby	40.1429	-105.8888	West
AT-EP	Adams Tunnel East Portal near Estes Park (USGS #09013000)	40.3278	-105.5782	East
BFC	Boulder Feeder Canal below cement plant at Hygiene Rd	40.1889	-105.2388	East
BFC-BR	Boulder Feeder Canal to Boulder Reservoir	40.0863	-105.2175	East
BFC-LH	Boulder Feeder Canal at Left Hand Creek	40.104	-105.227	East
BFC-LHD	Left Hand Creek downstream of BFC at golf cart bridge crossing with Left Hand Creek	40.1033	-105.217	East
BFC-LHU	Left Hand Creek diversion into Boulder Feeder Canal	40.1038	-105.2272	East
BSC-BC	Boulder Supply Canal feed to Boulder Creek at Jay Rd	40.053	-105.1877	East
BSC-BCD	Boulder Creek downstream of Boulder Supply Canal	40.0514	-105.179	East
BSC-BCU	Boulder Creek upstream Boulder Supply Canal	40.0507	-105.1874	East
BSC-BR	Boulder Reservoir at outlet to Boulder Supply Canal	40.0775	-105.2071	East
HFC-BT	Hansen Feeder Canal downstream of trifurcation at USGS gage	40.4234	-105.2265	East
HFC-BTD	Big Thompson River downstream of Hansen Feeder Canal and Trifurcation Plant	40.4258	-105.2167	East
HFC-BTU	Big Thompson upstream of Hansen Feeder Canal at canyon mouth by USGS station	40.422	-105.2269	East
HFC-FRD	Hansen Feeder Canal downstream of Flatiron Reservoir	40.3748	-105.2306	East
HFC-HT	Hansen Feeder Canal at Inlet to Horsetooth	40.5056	-105.197	East
HSC-PR	Hansen Supply Canal Release to the Cache La Poudre River	40.659	-105.2098	East
HSC-PRD	Cache La Poudre River downstream of Hansen Feeder Canal	40.6606	-105.2032	East
HSC-PRU	Cache La Poudre River upstream of Hansen Feeder Canal	40.6601	-105.2094	East
OLY	Olympus Tunnel at Lake Estes (USGS #06734900)	40.3764	-105.4858	East
SVSC-CL	Carter Lake outflow to Saint Vrain Supply Canal	40.3173	-105.2068	East
SVSC-LT	Saint Vrain Supply Canal feed to Little Thompson River	40.2615	-105.2083	East
SVSC-LTD	Little Thompson River downstream of St Vrain Supply Canal	40.2584	-105.1977	East
SVSC-LTU	Little Thompson River upstream of Saint Vrain Supply Canal	40.2584	-105.2074	East
SVSC-SV	Saint Vrain Supply Canal at Saint Vrain Creek	40.2182	-105.2582	East
SVSC-SVD	Saint Vrain Creek downstream of Saint Vrain Supply Canal	40.2166	-105.2596	East
SVSC-SVU	Saint Vrain Creek upstream of Saint Vrain Supply Canal	40.2173	-105.2595	East

Monitoring Frequency

Monitoring frequency varies from monthly to weekly depending on the site location. For a weekly breakdown of the anticipated monitoring schedule please see the Excel file entitled 2013 Sampling Schedule.

Parameters

The baseline program includes monitoring of nutrients, metals, general chemistry, physical parameters, zooplankton, phytoplankton and chlorophyll. Different groups of parameters are looked at depending on the location of the site and the timing of the sampling. The groups are defined by codes as shown below. For a breakdown of what code is used when, please see the Excel file entitled 2013 Sampling Schedule.

Parameter	L1	L3	L2	S1	S3	N1	N2	CL	CS	CN	CN	CR	RL	RS
Temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X	X	X	X	X	X
secchi depth												X	X	X
Calcium	X	X	X	X	X			X	X			X	X	X
Magnesium	X	X	X	X	X			X	X			X	X	X
Chloride														
Potassium														
Sodium														
Sulfate														
Dissolved Organic Carbon		X			X			X	X	X	X	X	X	X
Total Organic Carbon	X	X	X	X	X			X	X	X	X	X	X	X
UV254											X	X	X	X
Total Alkalinity	X	X	X	X	X			X	X				X	
Bicarbonate Alkalinity	X	X		X	X			X	X				X	
Carbonate Alkalinity	X	X		X	X			X	X				X	
Hydroxide Alkalinity	X	X		X	X			X	X				X	
Nonvolatile Suspended Solids								X	X	X	X	X		
Total Suspended Solids	X	X	X	X	X	X		X	X	X	X	X	X	X
Total Dissolved Solids	X	X	X	X	X	X		X	X	X	X	X	X	X
Iron, total	X	X	X	X	X			X	X				X	
Arsenic, total	X	X	X					X					X	
Boron, total														
Iron, dissolved	X	X	X	X	X			X	X			X	X	X
Manganese, dissolved	X	X	X	X	X			X	X			X	X	X
Copper, dissolved	X	X	X	X	X			X	X				X	
Silver, dissolved	X	X	X					X					X	
Lead, dissolved	X	X	X					X					X	
Nickel, dissolved	X	X	X					X					X	
Selenium, dissolved	X	X	X					X					X	
Zinc, dissolved	X	X	X					X					X	
Cadmium, dissolved	X	X	X					X					X	
Arsenic, dissolved	X	X	X					X					X	
Mercury			X										X	
TKN	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NH3 as N	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NO3+NO2	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ortho P	X	X	X	X	X	X	X	X	X	X	X	X	X	X
P Total	X	X	X	X	X	X	X	X	X	X	X	X	X	X
chlorophyll a	X	X	X	X	X			X	X	X	X	X	X	X
phytoplankton												X	X	X
zooplankton												X	X	X

In the reservoirs, nutrient, metals and general chemistry samples are collected at a depth 1 meter below the surface and approximately 1 meter above the bottom. Profiles of the physical parameters are taken at one meter increments until a depth of 25 meters, then the increment increases to every 5 meters to the bottom of the water body. Chlorophyll samples are collected by sampling the water column from 0-5 meters, except in Grand Lake where two samples are collected at 0-5 meters and a 0-2 meters depths. Two samples are collected for phytoplankton and zooplankton by sampling the water column from 0-5 meters and 5-10 meters, except in Shadow Mountain where only a 0-5 meter sample is collected due to its shallow depth. Secchi depth is collected at all reservoir sampling events, with a viewscope on the east slope and both with and without a viewscope on the west slope.

Sample Collection and Analysis

Northern Water and the United States Geological Survey (USGS) operate the Baseline Monitoring Program. Most flowing sites are sampled by Northern Water Field Services (NWFS) utilizing protocols guided by the U.S. Geological Survey's "National Field Manual for the Collection of Water-Quality-Data". Lakes and reservoir site sampling is split between NWFS and the USGS.

Samples for nutrients are analyzed at High Sierra Water Lab; a USGS certified private laboratory whose analytical methods have low level detection limits. Samples for metals (except mercury) and general chemistry are analyzed at Huffman Laboratory; a USGS certified private laboratory whose analytical methods for metals have low level detection limits. Samples for mercury are analyzed at Accutest Laboratory; a USGS certified private laboratory whose analytical method for mercury has a low level detection limit. Chlorophyll samples are analyzed at the USRB Laboratory in Denver. Zooplankton and Phytoplankton samples are analyzed at BSA Environmental Services, Inc.

All samples are subject to thorough quality control to validate laboratory procedures and sampling protocols. Between 5% and 10% of the total number of samples are quality control blanks or replicate samples.

Data Processing

All data collected in the field and received from laboratories is subject to thorough QAQC and housed in Northern's SQL Access relational databases. The data are accessible at Northern's website, http://www.northernwater.org/WaterQuality/WaterQualityData.aspx.

Although QAQC protocols are not final at this time, the following steps are taken to ensure the data are accurate and high quality:

- ✓ Sample dates and times are verified.
- ✓ General 'rules' of the results are checked (i.e. the total fraction of a parameter should be greater than the dissolved fraction).

- ✓ Results are compared to typical concentrations specific to the site and time of year.
- ✓ Results are compared to other samples collected at the same time at locations with similar water quality (i.e. if samples are collected in Horsetooth Reservoir, the results are compare for the top depths at all three sites collected for that event in Horsetooth).
- ✓ Results are compared at sites in order from upstream to downstream (i.e. if samples are collected above and below a canal, the results are compared upstream of the canal to downstream of the canal with consideration of canal inputs by looking at the results in the canal).

- ✓ If any outliers are observed, steps are taken to determine why there are differences from the reported results and atypical results:
    - ~ Field notes are looked at to see if anything out of the ordinary was observed during sampling.
    - ~ Results of other parameters that correlate with the parameter in question are looked at to see there is a similar pattern.
    - ~ Operation and maintenance activities of the C-BT system are noted if applicable.
    - ~ The lab is contacted to make sure there was not a reporting error.
- ✓ Re-run analysis by the laboratories or QAQC documentation is requested in order to verify any result that may be suspect. In these cases, the data that is verified is flagged as such in the database.

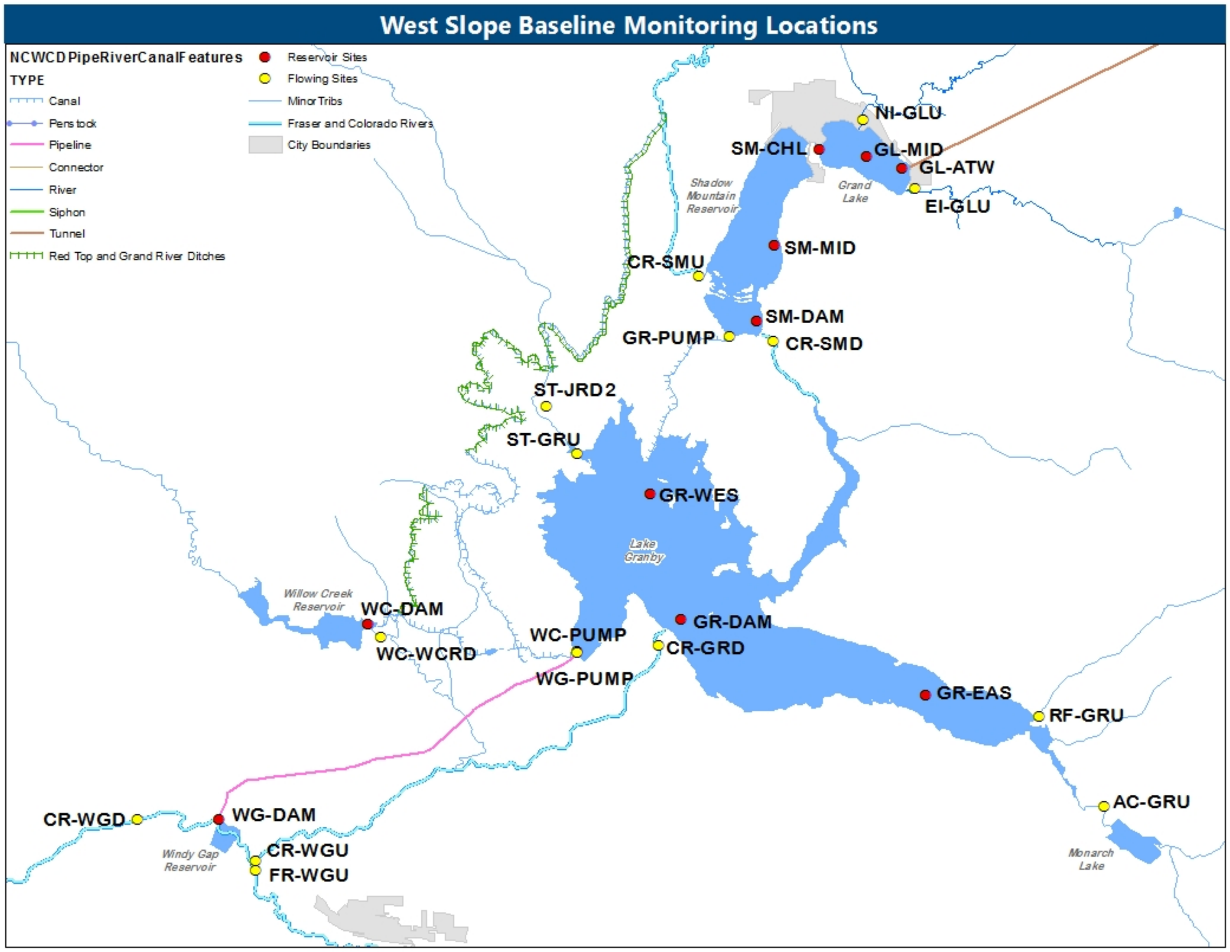
After the QAQC and verification processes, if the data are still found to be suspect due to error in sample collection or error in analysis, the data are marked with a disqualifier in the database. The data that are 'disqualified' are not used internally or available on the database interface on the website.

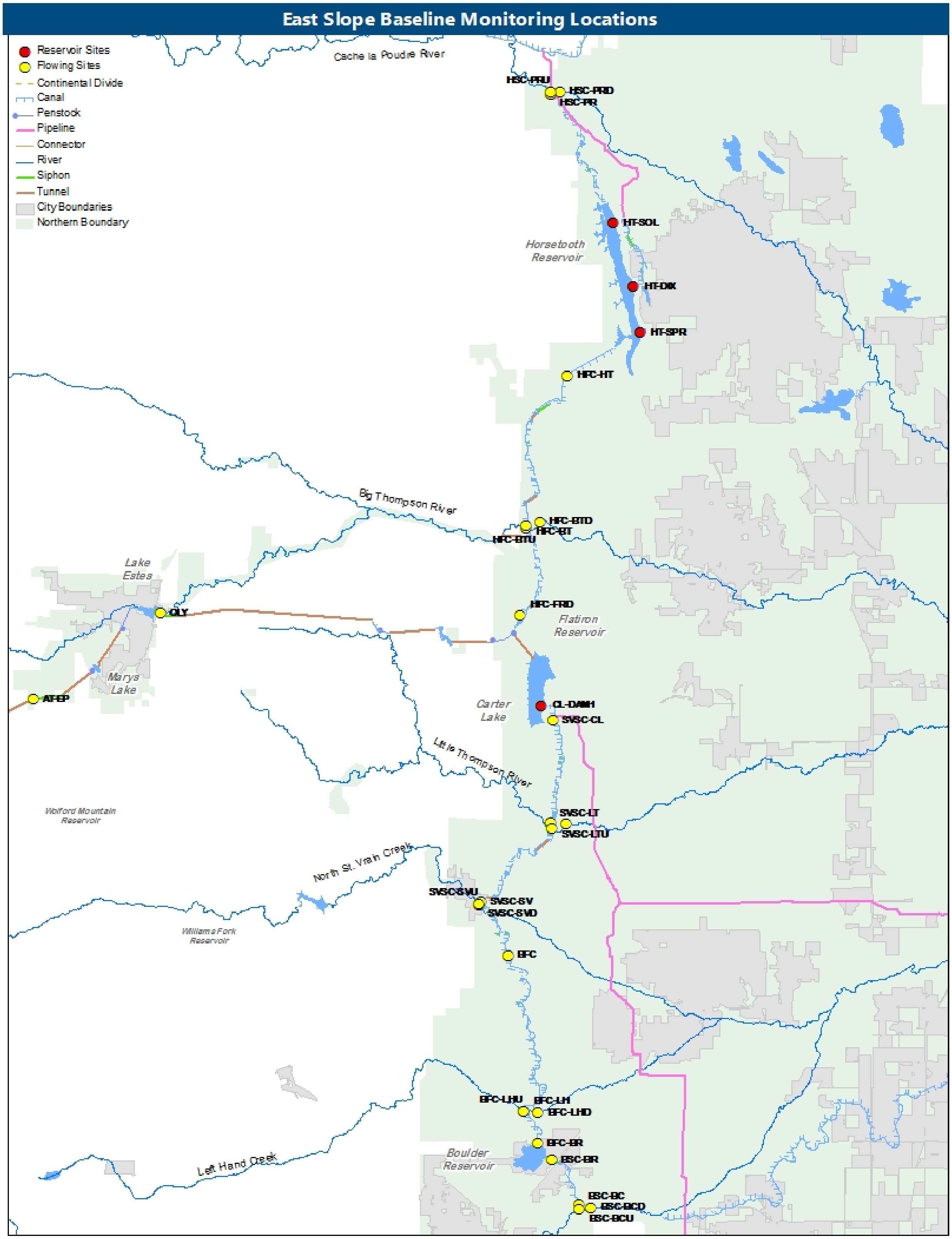
In addition, the QAQC samples that are collected on a regular basis can help determine if there are problems that may not be apparent in the screening of the environmental samples:

- ✓ Field and source water blanks are tracked in order to see if there are any reoccurring patterns of detections that need to be investigated.
- ✓ Replicates are tracked in order to see if there are any reoccurring differences between the environmental and replicate sample that need to be investigated. In general, the following criteria for acceptable replicates are:
    - ~ For concentrations > 10 times the RL the RPD must be <25%
    - ~ For concentrations < 10 times the RL the RPD must be < 50%.

Problems with the QAQC samples may be attributed to several sources and can occur in the field and/or in the laboratory. If reoccurring problems occur with any of the QAQC samples, steps are taken to try to pinpoint the source of the problem.

Maps of Sampling Locations




East Slope Baseline Monitoring Locations
Reservoir Sites
Flowing Sites
Continental Divide
Canal
Penstock
Pipeline
Connector
River
Siphon
Tunnel
City Boundaries
Northern Boundary
Cache la Poudre River
HSC-PRU
HSC-PRD
HSC-PR
HT-SOL
Horsetooth Reservoir
HT-DIX
HT-SPR
HFC-HT
Big Thompson River
HFC-BTD
HFC-BT
HFC-BTU
Lake Estes
OLY
HFC-FRD
Flatiron Reservoir
Marys Lake
AFEP
Carter Lake
CL-DAM1
SVSC-CL
Little Thompson River
Wolford Mountain Reservoir
SVSC-LT
SVSC-LTU
North St. Vrain Creek
SVSC-SVU
SVSC-SV
SVSC-SVD
Williams Fork Reservoir
BFC
BFC-LHU
BFC-LH
BFC-LHD
BFC-BR
Boulder Reservoir
BSC-BR
Left Hand Creek
BSC-BC
BSC-BCD
BSC-BCU

2013 ANALYTICAL COSTS PER CONSTITUENT SUITE

General Field Parameters

	NCWD															USGS/NCWCD
	L1	**L3**	**S1**	**S3**	**N1**	**N2**	**CL**	**CS**	**CN**	**CN***	**CR**	**RL**	**RS**	**AG1**	**AG2**	**L2**
General Field Parameters																
Temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
secchi depth											X	X	X			
Major Ions (plus carbon and mscl)																
Calcium	$10	$10	$10	$10			$10	$10			$10	$20	$20	$10	$10	$10
Magnesium	$10	$10	$10	$10			$10	$10			$10	$20	$20	$10	$10	$10
Chloride														$10	$10	
Potassium														$10	$10	
Sodium														$10	$10	
Sulfate														$38	$38	
Dissolved Organic Carbon		$30		$30			$30	$30	$30	$30	$30	$60	$60			
Total Organic Carbon	$30	$30	$30	$30			$30	$30	$30	$30	$30	$60	$60	$30		$30
UV254										$30	$30	$60	$60			
Total Alkalinity	$25	$25	$25	$25			$25	$25				$50		$25	$25	$25
Bicarbonate Alkalinity	$-	$-	$-	$-			$-	$-				$-		$-	$-	
Carbonate Alkalinity	$-	$-	$-	$-			$-	$-				$-		$-	$-	
Hydroxide Alkalinity	$-	$-	$-	$-			$-	$-				$-		$-	$-	
Non Volatile Suspended Solids							$30	$30	$30	$30	$30					
Total Suspended Solids	$30	$30	$30	$30	$30		$30	$30	$30	$30	$30	$60	$60	$30		$30
Total Dissolved Solids	$30	$30	$30	$30	$30		$30	$30	$30	$30	$30	$60	$60	$30	$30	$30
Metals																
Iron, total	$88	$88	$88	$88			$88	$88				$176		$88		$88
Arsenic, tot	$10	$10					$20					$20				$10
Boron, total														$10	$88	
Iron, dis	$70	$70	$70	$70			$70	$70			$70	$140	$140	$70		$70
Manganese, dis	$10	$10	$10	$10			$10	$10			$10	$20	$20	$10		$10
Copper, dis	$10	$10	$10	$10			$10	$10				$20		$10		$10
Silver, dis	$10	$10					$10					$20		$10		$10
Lead, dis	$10	$10					$10					$20		$10		$10
Nickel, dis	$10	$10					$10					$20		$10		$10
Selenium, dis	$10	$10					$10					$20		$10		$10
Zinc, dis	$10	$10					$10					$20		$10		$10
Cadmium, dis	$10	$10					$10					$20		$10		$10
Arsenic, dis	$10	$10					$10					$20		$10		$10
Mercury (low level; Accutest)												$110				$55
Nutrients																
TKN	$35	$35	$35	$35	$35	$35	$35	$35	$35	$35	$35	$70	$70	$35		$35
NH3 as N	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$50	$50	$25	$25	$25
NO3+NO2	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$50	$50	$25	$25	$25
Ortho P	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$50	$50	$25		$25
P Total	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$25	$50	$50	$25	$25	$25
chlorophyll a	$37	$37	$37	$37			$37	$37	$37	$37	$37	$37	$37			$37
phytoplankton											$120	$240	$240			
zooplankton											$50	$100	$100			
Total	**$565**	**$595**	**$485**	**$515**	**$195**	**$135**	**$635**	**$545**	**$322**	**$352**	**$622**	**$1,663**	**$1,147**	**$596**	**$306**	**$620**

**CN is collected at SM-CHL only. It includes UV254 to determine the source of the algae.*

***CR is only collected at SM-CHL*

*** RL and RS numbers represent the total cost for top and bottom samples and samples collected at various depths; except for Grand Lake 0-2m samples that are accounted for separately*

2013 WATER QUALITY MONITORING SCHEDULE

Updated 12/4/2012

Baseline Water Quality Monitoring – Flowing Sites (NCWCD)

Station	Week of																																																				Comment	Events /Yr
	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31	Jan 07	Jan 14	Jan 21	Jan 28	Feb 04	Feb 11	Feb 18	Feb 25	Mar 04	Mar 11	Mar 18	Mar 25	Apr 01	Apr 08	Apr 15	Apr 22	Apr 29	May 06	May 13	May 20	May 27	Jun 03	Jun 10	Jun 17	Jun 24	Jul 01	Jul 08	Jul 15	Jul 22	Jul 29	Aug 05	Aug 12	Aug 19	Aug 26	Sep 02	Sep 09	Sep 16	Sep 23		
AC-GRU		N1		N1		L3				N1				S3					N1				S3			N1	S3	N1	N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CN		CS		every other week Apr-Nov, Monthly otherwise	22
ST-GRU		N1		N1		L3				N1				S3					N1				S3			N1	S3	N1	N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CN		CS		every other week Apr-Nov, Monthly otherwise	23
ST-JRD2		N1		N1		L3				N1				S3					N1				S3			N1	S3	N1	N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CN		CS		Same as ST-GRU Apr-Sep (back up location for ST-GRU when Granby full)	22
RF-GRU		N1		N1		L3				N1				S3					N1				S3			N1	S3	N1	N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CS		CN		every other week Apr-Nov, Monthly otherwise	22
EI-GLU		N1		N1		L3				N1				S3					N1				S3			N1	S3	N1	N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CS		CN		every other week Apr-Nov, Monthly otherwise	22
NI-GLU		N1		N1		L3				N1				S3					N1				S3			N1	S3	N1	N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CS		CN		every other week Apr-Nov, Monthly otherwise	22
CR-SMU		N1		N1		L3				N1				S3					N1				S3			N1	S3	N1	N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CS		CN		every other week Apr-Nov, Monthly otherwise	22
CR-SMD		N1		N1		L3				N1				S3					N1				S3				S3		N1		N1		L3		N1		S3		N1		CL		CN		CS		CN		CS		CN		every other week Apr-Nov, Monthly otherwise	20
GR-PUMP	S3	N1	N1	N1	N1	L3	N1	N1	N1	N1	N1	N1	N1	S3	N1	N1	N1	N1	N1	N1	N1	N1	S3	N1	N1	N1	S3	N1	N1	N1	N1	N1	L3	N1	N1	N1	S3	N1	N1	CN	CL	CN	CN	CN	CS	CN	CN	CN	CS	CN	CN	CN	weekly when pumping	52
CR-WGU	S1					L1				S1				S1					S1				S1				S1		S1		S1		L1		S1		S1		S1		L1		S1		S1				S1				every other week when pumping	18
FR-WGU	S1					L1				S1				S1					S1				S1				S1		S1		S1		L1		S1		S1		S1		L1		S1		S1				S1				every other week when pumping	17
CR-WGD	S1					L1				S1				S1					S1				S1				S1		S1		S1		L1		S1		S1		S1		L1		S1		S1				S1				every other week when pumping	17
WC-PUMP	S1	S1	S1	S1	S1	L1	S1	S1	S1														S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	L1	S1	S1	S1	S1	S1	S1	S1	L1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1		weekly when pumping	39
WC-WCRD	S1					L1				S1				S1					S1				S1				S1						L1			S1					L1				S1				S1					12
CR-GRD	S1					L1				S1				S1					S1				S1				S1						L1			S1					L1				S1				S1					12
WG-PUMP																													S1	S1	S1	S1	L1	S1	S1	S1	S1	S1	S1	S1	L1	S1	S1	S1									weekly when pumping	16
BFC	S1																															S1				L1				S1					S1				L1					6
BFC-BR	S1																															S1				L1				S1					S1				L1					6
BFC-LH	S1																															S1				L1				S1					S1				L1					6
BFC-LHD	S1																															S1				L1				S1					S1				L1					6
BFC-LHU																																S1				L1													L1					5
BSC-BC	S1																															S1				L1				S1					S1				L1					6
BSC-BCD	S1																															S1				L1				S1					S1				L1					6
BSC-BCU																																S1				L1													L1					5
BSC-BR	S1																															S1				L1				S1					S1				L1					6
HFC-BT	S1					S1								L1									S1				S1					S1				L1				S1					S1				L1					10
HFC-BTD	S1					S1								L1													S1					S1				L1				S1					S1				L1					9
HFC-BTU														L1																		S1				L1													L1					7
HFC-FRD	S1					S1								L1									S1				S1					S1				L1				S1					S1				L1					10
HFC-HT	S1					S1								L1									S1				S1					S1				L1				S1					S1				L1					10
HSC-PR	S1																										S1					S1				L1				S1					S1				L1					7
HSC-PRD	S1																										S1					S1				L1				S1					S1				L1					7
HSC-PRU																																S1				L1													L1					6
SVSC-CL	S1																										S1					S1				L1				S1					S1				L1					7
SVSC-LT	S1																										S1					S1				L1				S1					S1				L1					7
SVSC-LTD	S1																										S1					S1				L1				S1					S1				L1					7
SVSC-LTU																																S1				L1													L1					6
SVSC-SV	S1																										S1					S1				L1				S1					S1				L1					7
SVSC-SVD	S1																										S1					S1				L1				S1					S1				L1					7
SVSC-SVU																																S1				L1													L1					7
																																																						524

Possible sampling events to capture 1st flush event on Mar 25 and Apr 8 at Three Lakes Inflow sites AC-GRU,ST-GRU,ST-JRD2,RF-GRU,EI-GLU,NI-GLU,CR-SMU

2013 WATER QUALITY MONITORING SCHEDULE

Baseline Water Quality Monitoring Lakes and Reservoirs - USGS/NCWCD

Week of

Station	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31	Jan 07	Jan 14	Jan 21	Jan 28	Feb 04	Feb 11	Feb 18	Feb 25	Mar 04	Mar 11	Mar 18	Mar 25	Apr 01	Apr 08	Apr 15	Apr 22	Apr 29	May 06	May 13	May 20	May 27	Jun 03	Jun 10	Jun 17	Jun 24	Jul 01	Jul 08	Jul 15	Jul 22	Jul 29	Aug 05	Aug 12	Aug 19	Aug 26	Sep 02	Sep 09	Sep 16	Sep 23	Comment	Events /Yr
GL-MID	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
GL-ATW	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
SM-MID	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
SM-DAM	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
SM-CHL	RL		N1		N1		N1			N1				RL					N1				RS				N1		N1		N1	RS		N1		RL		N1		CR		CN*		CN*	CR		CR		CR		CR		N1 samples are collected by NCWCD Field Services	22
GR-DAM	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
GR-EAS	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
GR-WES	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
WC-DAM	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS			10
WG-DAM																																RS				RL				RS					RS		RS		RS		RS			7
HT-SPR	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan event: floating event, can be moved based upon ice conditions	9
HT-DIX	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan event: floating event, can be moved based upon ice conditions	9
HT-SOL	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan event: floating event, can be moved based upon ice conditions	9
CL-DAM1	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan event: floating event, can be moved based upon ice conditions	9
																																																						145

West Slope Sites are sampled by USGS except for N1 and CN samples at SM-CHL; East Slope sites are sampled by NCWCD except for winter events (Dec-Mar)

Baseline Water Quality Monitoring (USGS)

Week of

Station	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31	Jan 07	Jan 14	Jan 21	Jan 28	Feb 04	Feb 11	Feb 18	Feb 25	Mar 04	Mar 11	Mar 18	Mar 25	Apr 01	Apr 08	Apr 15	Apr 22	Apr 29	May 06	May 13	May 20	May 27	Jun 03	Jun 10	Jun 17	Jun 24	Jul 01	Jul 08	Jul 15	Jul 22	Jul 29	Aug 05	Aug 12	Aug 19	Aug 26	Sep 02	Sep 09	Sep 16	Sep 23	Comment	Events /Yr
AT-EP**	S1					S1								L2									S1				S1					S1				L2				S1					S1				L2					10
OLY**	S1					S1								L2									S1				S1					S1				L2				S1					S1				L2					10
																																																						20

***All events are paid through NCWCD JFA, all chla and nutrients samples are covered by Northern Water and sent to USBR lab and High Sierra. Chl a is also sent to Fort Collins lab as well as TOC (in-kind through Fort Collins). All metals would be sent to Huffman (NOT NWQL as previously done).*

Willow Creek Non Point Source Monitoring (Pinyon Except for Oct-Mar Field Services)

Week of

Station	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31	Jan 07	Jan 14	Jan 21	Jan 28	Feb 04	Feb 11	Feb 18	Feb 25	Mar 04	Mar 11	Mar 18	Mar 25	Apr 01	Apr 08	Apr 15	Apr 22	Apr 29	May 06	May 13	May 20	May 27	Jun 03	Jun 10	Jun 17	Jun 24	Jul 01	Jul 08	Jul 15	Jul 22	Jul 29	Aug 05	Aug 12	Aug 19	Aug 26	Sep 02	Sep 09	Sep 16	Sep 23	Comment	Events /Yr
WC-WCRU	N2					N2								N2									N2				N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2		N2		N2		N2		N2	weekly for WGFP mitigation - every other month during winter	26
TRB-WCU	N2					N2								N2									N2				N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2		N2		N2		N2		N2		26
WC-IRU	N2					N2								N2									N2				N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2		N2		N2		N2		N2	weekly for WGFP mitigation - every other month during winter	26
CH-WCU	N2					N2								N2									N2				N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2		N2		N2		N2		N2	weekly for WGFP mitigation - every other month during winter	26
WC-WCRD	N2					N2								N2									N2				N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2	N2		N2		N2		N2		N2	weekly for WGFP mitigation - every other month during winter	26
																																																					130

Stillwater Creek Non Point Source Monitoring (Pinyon)

Week of

Station	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31	Jan 07	Jan 14	Jan 21	Jan 28	Feb 04	Feb 11	Feb 18	Feb 25	Mar 04	Mar 11	Mar 18	Mar 25	Apr 01	Apr 08	Apr 15	Apr 22	Apr 29	May 06	May 13	May 20	May 27	Jun 03	Jun 10	Jun 17	Jun 24	Jul 01	Jul 08	Jul 15	Jul 22	Jul 29	Aug 05	Aug 12	Aug 19	Aug 26	Sep 02	Sep 09	Sep 16	Sep 23	Comment	ivents/Y
ST-GRU																																																					every other week Apr-Nov, Monthly otherwise - Coordinated with Baseline Monitoring	0
ST-IRU																																																						0
ST-RDD																																																						0
ST-BAS																																																						0
																																																						0

NISP Monitoring (NCWCD)

Week of

Station	Oct 01	Oct 08	Oct 15	Oct 22	Oct 29	Nov 05	Nov 12	Nov 19	Nov 26	Dec 03	Dec 10	Dec 17	Dec 24	Dec 31	Jan 07	Jan 14	Jan 21	Jan 28	Feb 04	Feb 11	Feb 18	Feb 25	Mar 04	Mar 11	Mar 18	Mar 25	Apr 01	Apr 08	Apr 15	Apr 22	Apr 29	May 06	May 13	May 20	May 27	Jun 03	Jun 10	Jun 17	Jun 24	Jul 01	Jul 08	Jul 15	Jul 22	Jul 29	Aug 05	Aug 12	Aug 19	Aug 26	Sep 02	Sep 09	Sep 16	Sep 23	Comment	Events /Yr
SP-KER																							AG1													AG1																	when call is off and during runoff	2
NCC-EL (NC5)																																				AG2								AG2									during runoff and when reservoirs are releasing in summer	2
NCRW																																												AG2									when reservoirs are releasing in summer	1
LWC-OCE (LW8)																																					AG2							AG2									during runoff and when reservoirs are releasing in summer	2
LWRT																																												AG2									when reservoirs are releasing in summer	1
																																																						8

SECCHI MONITORING PROGRAM
Water Year 2013

The following describes the Grand County Water Information Network's (GCWIN) Secchi Monitoring Program.

The objective of this program is to provide a baseline of data to support review of the Grand Lake Clarity Standard in 2014 by:

1. Monitoring spatial and seasonal variations in clarity in Grand Lake.
2. Monitoring spatial and seasonal variations in clarity in Shadow Mountain Reservoir in relation to clarity in Grand Lake.
3. Monitoring the impacts of C-BT operations on clarity in Grand Lake and Shadow Mountain Reservoir.

Volunteer Secchi monitoring in Grand Lake and Shadow Mountain began in 1990. From 1990 through 2007, there were no standard protocols for taking Secchi measurements. Beginning in 2008, GCWIN implemented a Secchi Monitoring Program which included volunteers and paid field technicians to collect data. A standardized QAQC and sampling protocol was implemented in 2009 and has been refined and updated in each subsequent year.

Monitoring Locations

Northern Station ID	GCWIN Station ID	Water Body	Latitude	Longitude	Paid Program	Volunteer Program
GL-WES	GL-WEST	Grand Lake	40.2419	-105.8215	X	X
GL-KEM	GL-KEMP	Grand Lake	40.2493	-105.8234	X	X
GL-SB	GL-SB	Grand Lake	40.2489	-105.8183	X	X
GL-NI	GL-NI	Grand Lake	40.2473	-105.8159	X	X
GL-MID	GL-MID	Grand Lake	40.2434	-105.8138	X	X
GL-ATW	GL-ATW	Grand Lake	40.2411	-105.8050	X	X
GL-EI	GL-EI	Grand Lake	40.2372	-105.8047	X	X
GL-AR	GL-AR	Grand Lake	40.2381	-105.8090	X	X
GL-NB	GL-NB	Grand Lake	40.2453	-105.8138	X	X
GL-SW	GL-2009-A1	Grand Lake	40.2435	-105.8183	X	X
GL-NE	GL-2009-A2	Grand Lake	40.2434	-105.8099	X	X
GL-SOU	GL-2009-A3	Grand Lake	40.2409	-105.8139	X	X
GL-NE2	GL-2009-A4	Grand Lake	40.2427	-105.8064	X	X
GL-NW	GL-2009-A5	Grand Lake	40.2466	-105.8212	X	X
SMR-NOR	SMR-NOR	Shadow Mountain	40.2467	-105.8383	X	X
SMR-MID	SMR-MID	Shadow Mountain	40.2236	-105.8373	X	X
SMR-DAM	SMR-DAM	Shadow Mountain	40.2086	-105.8431	X	X
SM-NW1	SM-NW1	Shadow Mountain	40.2370	-105.8418	X	X
COL-MID	COL-MID	Columbine Lake	40.2568	-105.8510		X
GR-QUI	GR-QUI	Lake Granby	40.1456	-105.8856		X
GR-RBI	GR-RBI	Lake Granby	40.1556	-105.8781		X

Frequency

Monitoring for the funded Secchi Monitoring Program is from late May through October, a maximum of 24 weeks. Monitoring occurs weekly, unless there are changes in C-BT operations such as a prolonged period of no pumping from the Farr Pump Plant through the Adams Tunnel. In the case of a 'stop-pump' period, two additional weekly monitoring events are scheduled for two weeks before, two weeks after and during the stop-pump period.

The frequency of sampling for the Volunteer Program depends on the availability of the volunteers.

Secchi Monitoring Protocols

Monitoring for the funded Secchi Monitoring Program is done by GCWIN's seasonal/part-time field technician. In the event that the field technician cannot complete the monitoring for a specific event, the monitoring is completed by GCWIN's Executive Director, or other paid and trained GCWIN staff.

Secchi monitoring for both the funded and volunteer programs follows guidelines set forth by the Colorado Lake and Reservoir Management Association (CLRMA), modified for GCWIN. The monitoring protocols have been approved by Steve Lundt (CLRMA) and Katherine Morris (Grand County). QAQC measurements are taken regularly with oversight by GCWIN's Executive Director. There is a standard field sheet which is filled out for each secchi measurement taken for both the funded and volunteer programs.

2011 Lake Field Sheet

(Record original measurements here)

Sampler's Name____________________

Site Name & Number: ____________________

Latitude: ____________ *or* **UTM Northing:** __________

Longitude: ____________ *or* **UTM Easting:** __________

Date/Time: ____________

Surface Water Temperature (deg F): ____________

Secchi Disc Transparency (record to nearest 1/10th of a foot):

(Remember to remove sunglasses and to use only non-tinted prescription glasses)

View Scope (circle one)	**Average Depth**
Yes No	
Yes No	

Lowering Depth	Raising Depth

Did you hit bottom? Yes ____ No____ (check one)

Description (circle one in each column):

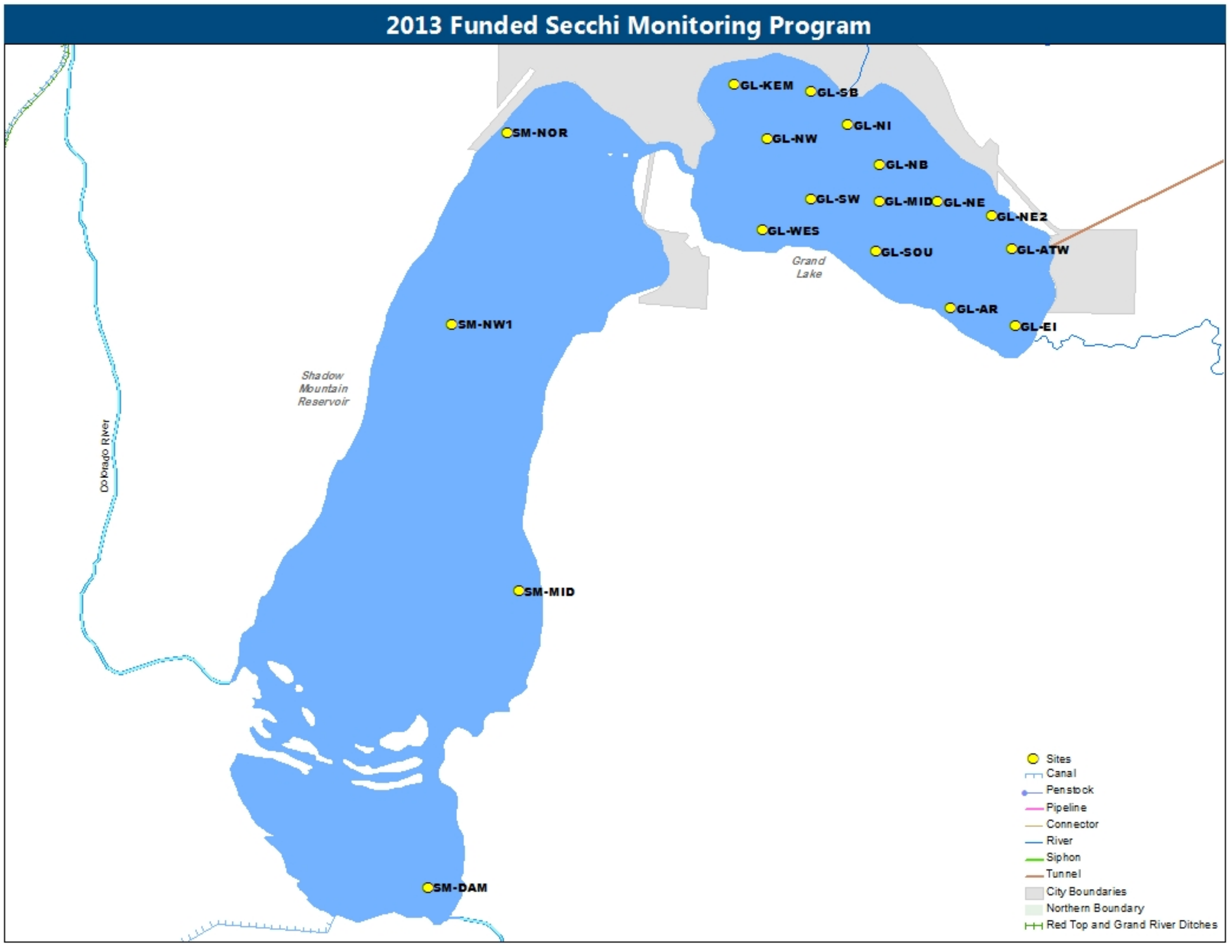
Water Color	**Recreation Potential**	**Physical Appearance**
1 – Brown	1 – Beautiful	1 – Crystal Clear
2 – Blue/Green	2 – Minor Aesthetic Problems	2 – Some Algae
3 - Green	3 – Swimming Impaired	3 – Definite Algae
4 – Yellow/Green	4 – Would not Swim	4 – High Algae (scum)
5 – Light Blue	5 – No Recreation Possible	5 – Severe Algae
6 - Clear		

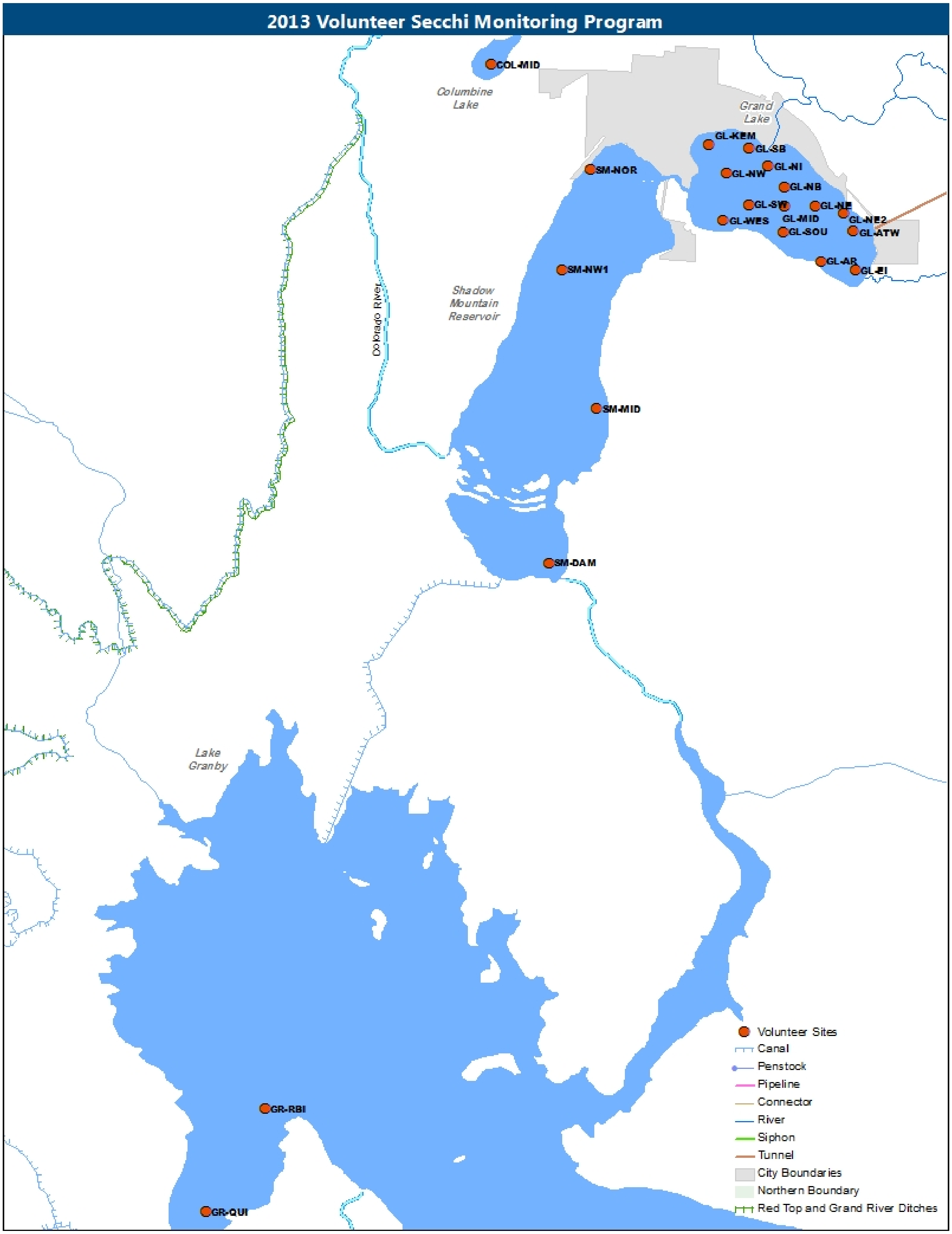
Weather (circle one in each column):

Sky	**Wind**
Sunny (0-25% cloudy)	Calm
Partly Cloudy (25-75% cloudy)	Light Breeze
Overcast (75+% cloudy)	Breezy

Additional Comments: ____________________

Map of Sampling Locations




2013 Volunteer Secchi Monitoring Program
COL-MID
Columbine Lake
Grand Lake
GL-KEM
GL-SB
GL-NI
GL-NW
GL-NB
GL-SW
GL-NE
GL-WES
GL-MID
GL-NE2
GL-SOU
GL-ATW
GL-AR
GL-EI
SM-NOR
SM-NW1
Shadow Mountain Reservoir
Colorado River
SM-MID
SM-DAM
Lake Granby
GR-RBI
GR-QUI
Volunteer Sites
Canal
Penstock
Pipeline
Connector
River
Siphon
Tunnel
City Boundaries
Northern Boundary
Red Top and Grand River Ditches

SHADOW MOUNTAIN CHANNEL MONITORING PROGRAM

Water Year 2013

The following describes the USGS flow and water quality monitoring program in the Shadow Mountain Connecting Channel.

The objectives of this program are:

1. To provide real-time data on directional flow between Grand Lake and Shadow Mountain Reservoir.
2. To provide real-time water quality data in the connecting channel.

This monitoring program began in April 2010.

Monitoring Locations

There are two sites located in within a close proximity in the connecting channel. One site is for the Acoustic Doppler Velocity Meter (ADVM) which measures flow, and the other for the water quality Sonde which measures chlorophyll, pH, specific conductance, temperature and turbidity. Note: the ADVM and the Sonde were located at the same location until WY2013. In WY2013 the ADVM was moved to a site in the channel that is more suitable for accurate discharge measurements.

Station	Description	Latitude	Longitude
ADVM	Discharge site in the Connecting Channel	40.2455	-105.8288
SONDE	Water Quality site in the Connecting Channel	40.2462	-105.8277

Station Equipment

Water-stage and water-velocity are measured with an Acoustic Doppler Velocity Meter (ADVM) and transmitted with satellite telemetry.

A YSI 6920 V2 Sonde is deployed at the water quality monitoring station. It is equipped with the following probes:

- YSI 6136 turbidity probe,
- YSI 6025 chlorophyll probe,
- YSI water temperature/SC probe,
- YSI pH probe.

Station Operation and Maintenance

The station is operated by the U.S. Geological Survey (Lakewood Field Office) in cooperation with Colorado River Water Conservation District, Grand County, Northern Colorado Water Conservancy District, and U.S. Bureau of Reclamation. The USGS site ID is 09014050.

ADVM

The USGS Water Data Report 2012 states:

> "Records good except for Oct. 1 to Feb. 10 and July 5-20 and estimated daily discharges, which are poor. Discharges not published from Feb. 11 to July 4 due to large inaccuracies in the water-velocity data. Flow from Shadow Mountain Reservoir to Grand Lake is shown as positive flow on the daily discharge table and hydrograph. Flow from Grand Lake to Shadow Mountain Reservoir is shown as negative flow."

Twenty-two surface water gage inspections, including discharge measurements, are scheduled for WY2013. The timing of measurements depends on flow conditions and measurements needed to verify the rating.

Water Quality

The USGS inspects the water quality probe at scheduled intervals that vary depending on the time of year (the days are specific to WY2013):

- October – inspection interval is 2 weeks
- November to March 14 – inspection interval is 3 weeks
- March 25 to May 27 – inspection interval is 1 week.
- May 27 to September 30 – inspection interval is 2 weeks.

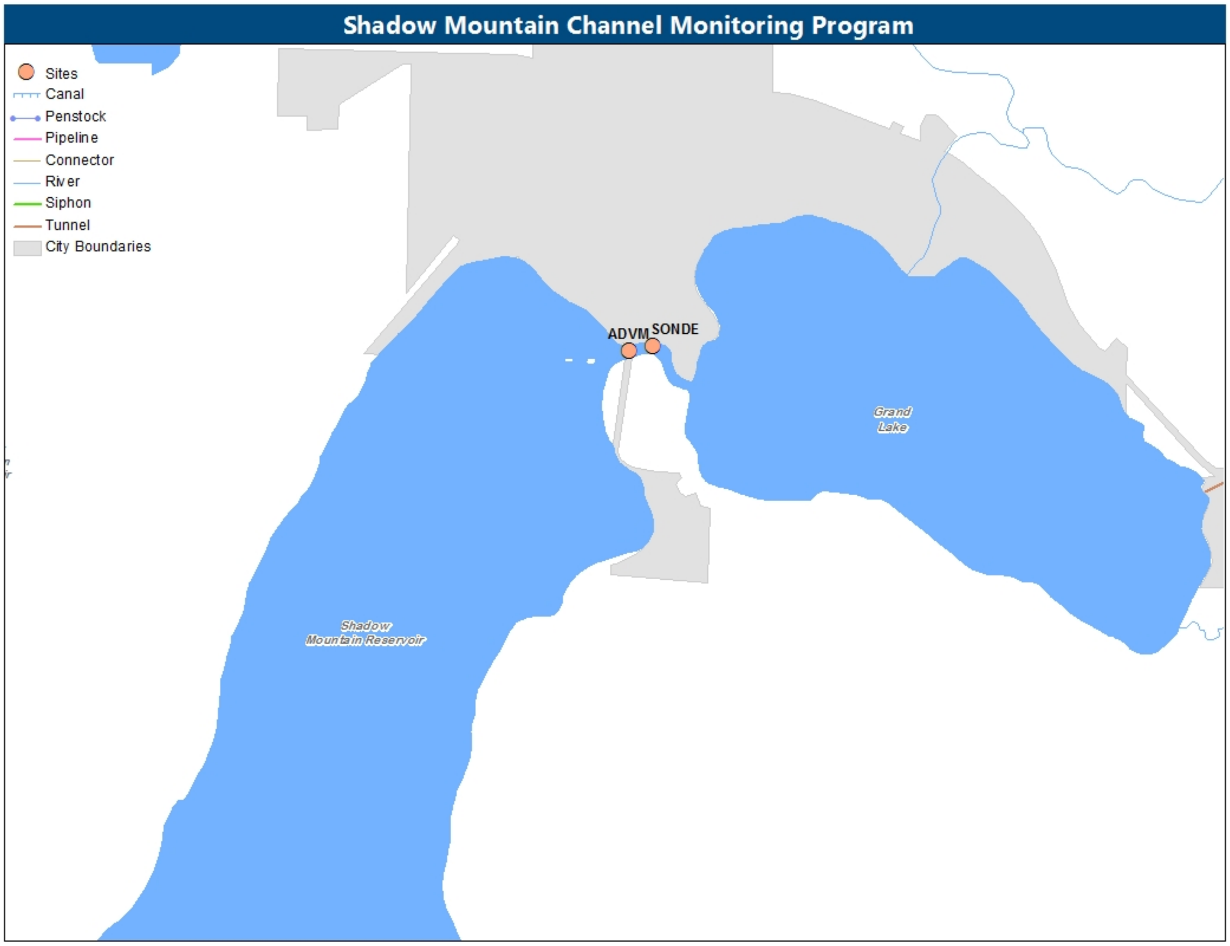
Sue Hartley with the USGS states:

> "Calibration of the turbidity, chlorophyll, specific conductivity, and pH probe is checked at each inspection and calibrations are conducted as needed. A 5-point temperature bath to compare the monitor thermistor with a NIST-certified thermistor is conducted at least 2 times per year to verify/document the accuracy of the monitor thermistor."

Chlorophyll samples are collected at each inspection and submitted to the US Bureau of Reclamation Laboratory in Lakewood, Co for analysis. The analytical values are calibration points for the chlorophyll values reported by the probe.

Real-time discharge and water quality data is available online at:
http://nwis.waterdata.usgs.gov/nwis/dv?site_no=09014050.

Map of Sampling Locations



Three Lakes Data Matrix

Constituent Description	Grand Lake			Lake Granby		Shadow Mountain Reservoir		
	GL-MID	GL-ATW	GR-DAM	GR-WES	GR-EAS	SM-DAM	SM-CHL	SM-MID
Ammonia as N, Dissolved	2000	2006	1995	2008	2008	1995	2004	2006
Arsenic, Dissolved	2006	2007	2006	2008	2008	2007	2007	2007
Barium, Dissolved			1995			1995		
Beryllium, Dissolved			1995			1995		
Boron, Dissolved			1995			1995		
Cadmium, Dissolved	2004	2007	1995	2008	2008	1995	2007	2007
Chloride	2000	2007	1995	2008	2008	1995	2004	2007
Chlorophyll a	2000	2005	1995	2008	2008	1995	2005	2005
Chromium, Dissolved	2006	2007	1995			1995	2007	2007
Copper, Dissolved	2005	2007	1995	2008	2008	1995	2007	2007
Fluoride	2005	2007	1995			1995	2007	2007
Iron, Dissolved	2004	2005	1995	2008	2008	1995	2005	2005
Iron, Total	2007	2007	2007	2008	2008	2007	2007	2007
Lead, Dissolved	2005	2007	1995	2008	2008	1995	2007	2007
Manganese, Dissolved	2004	2005	1995	2008	2008	1995	2005	2005
Mercury, Dissolved	2006	2007	2006			2007	2007	2007
Molybdenum, Dissolved			1995			1995		
Nickel, Dissolved	2005	2008	1995	2008	2008	1995	2007	2008
Nitrate as N	2000		2000			2001		
Nitrate plus Nitrite as N	2002	2006	1995	2008	2008	1995	2004	2006
Nitrite as N			1995			1995		
Oxygen Concentration, Dissolved	2000	2005	1995	2008	2008	1995	2004	2005
pH	2000	2005	1995	2008	2008	1995	2004	2005
Phosphorus, Total	2000	2006	1995	2008	2008	1995	2004	2006
Selenium, Dissolved	2005	2007	2005	2008	2008	2005	2004	2007
Silver, Dissolved	2005	2008	1995	2008	2008	1995	2007	2008
Sulfate	2000	2007	1995	2008	2008	1995	2007	2007
Suspended Solids, Total	2005	2005	2005	2008	2008	2005	2004	2005
Water Temperature	2000	2005	1995	2008	2008	1995	2004	2005
Zinc, Dissolved	2005	2005	1995	2008	2008	1995	2005	2005
Secchi Depth	2000	2005	1995	2008	2008	1995	2005	2005
Specific Conductance	2000	2005	1995	2008	2008	1995	2004	2005
Vanadium, Dissolved			1995			1995		
Silica as Silicate, Dissolved	2000		1995			1995	2007	
Lithium, Dissolved			1995			1995		
Cobalt, Dissolved			1995			1995		
Calcium	2000	2007	1995	2008	2008	1995	2007	2007
Potassium	2000	2007	1995	2008	2008	1995	2007	2007
Magnesium	2000	2007	1995	2008	2008	1995	2007	2007
Phosphorus, Total Dissolved	2004		1995			1995	2007	

Three Lakes Data Matrix

Constituent Description	Grand Lake			Lake Granby		Shadow Mountain Reservoir		
	GL-MID	GL-ATW	GR-DAM	GR-WES	GR-EAS	SM-DAM	SM-CHL	SM-MID
Fecal Coliform			1995			1995		
Sodium	2000	2007	1995	2008	2008	1995	2004	2007
pH Laboratory	2000		1995	2008	2008	1995	2007	2008
Alkalinity, Total	2005	2008	1995	2008	2008	1995		
Chlorophyll b	2003	2005	1995	2008	2008	1995	2005	2005
Hardness as CaCO3	2000	2008	1995	2008	2008	1995	2007	2008
Strontium, Dissolved			1995			1995		
Ortho Phosphate as P	2001	2006	1995	2008	2008	1995	2004	2006
Kjeldhal Nitrogen as N, Total	2000	2006	1995	2008	2008	1995	2004	2006
Dissolved Solids, Total	2012	2012	1995	2012	2012	1995	2004	2012
Organic Carbon, Total	2002	2008	1998	2008	2008	1998	2004	2008
Manganese, Total	2006	2007	2006			2007	2007	2007
Alkalinity, Carbonate	2006	2007	2006	2008	2008	2007	2007	2007
Copper, Total	2006	2007	2006			2007	2007	2007
Zinc, Total	2006	2007	2006			2007	2007	2007
Alkalinity, Bicarbonate	2006	2007	2006	2008	2008	2007	2007	2007
Alkalinity, Hydroxide	2008	2008	2008	2008	2008	2008		
Organic Carbon, Dissolved	2000	2010	2000	2010	2010	2001	2007	2010
Alkalinity, Total Filtered	2000	2008	2000	2008	2008	2001	2007	2008
Pheophytin a, Corrected	2000	2005	2000	2008	2008	2001	2005	2005
Nitrogen Total as N	2004	2008	2004	2008	2008	2004	2007	2008
Nitrogen Total as N, Dissolved	2004	2008	2004	2008	2008	2004	2007	2008
Cadmium, Total	2005	2007	2005			2005	2007	2007
Arsenic, Total	2005	2007	2005	2012	2012	2005	2007	2007
Concentration of organisms	2005	2005	2005	2008	2008	2005	2005	2005
Zooplankton concentration, Total	2005	2005	2005	2008	2008	2005	2005	2005
Chlorophyll c	2005	2005	2005	2008	2008	2005	2005	2005
Chlorophyll a, Corrected	2005	2005	2005	2008	2008	2005	2005	2005
Mercury, Total	2006	2007	2006	2008	2008	2006	2007	2007
Chromium, Total	2006	2007	2006			2007	2007	2007
Lead, Total	2006	2007	2006			2007	2007	2007
Selenium, Total	2006	2007	2006			2007	2007	2007
Air Temperature	2007	2008	2007	2008	2008	2007	2007	2008
Alkalinity, Hydroxide Filtered	2011	2011	2011	2008	2008	2011	2011	2008
Alkalinity, Bicarbonate Filtered	2011	2011	2011	2008	2008	2011	2011	2008
Alkalinity, Carbonate Filtered	2011	2011	2011	2008	2008	2011	2011	2008
Algae Toxin	2008	2008	2008	2008	2008	2008	2008	2008
Turbidity	2011	2011	2011	2011	2011	2009	2009	2009
Suspended Solids, Non-Volatile							2011	
Oxygen (% Saturation), Dissolved	2011	2011	2011	2011	2011	2011	2011	2011
UV Absorbance at 254 nm	2012	2012	2012	2012	2012	2012	2012	2012

StationID1	Station Description	County	Latitude	Longitude	Elevation	Status
GL-AR	Grand Lake 500 feet north of Alligator Rock	Grand	40.2381	-105.8090		Active
GL-ATW	Grand Lake West Portal (USGS #401428105481601)	Grand	40.2411	-105.8044		Active
GL-BEA	Grand Lake Public Beach	Grand	40.2497	-105.8178		Active
GL-DOC	Grand Lake 500 feet off public docks	Grand	40.2498	-105.8206		Inactive
GL-EI	Grand Lake 500 feet northwest of East Inlet	Grand	40.2372	-105.8047		Active
GL-KEM	Grand Lake northwest section of lake, 500 feet off Kemps property	Grand	40.2493	-105.8234		Active
GL-MID	Grand Lake Mid Section (USGS #09013900)	Grand	40.2433	-105.8136		Active
GL-NB	Grand Lake north of the Mid Section (GCWIN site Newby-Boyken)	Grand	40.2453	-105.8138		Active
GL-NE	Grand Lake northeast section of lake, east of Mid Section	Grand	40.2434	-105.8099		Active
GL-NE2	Grand Lake northeast portion of lake, northwest of Adams Tunnel	Grand	40.2428	-105.8064		Active
GL-NI	Grand Lake 500 feet south of North Inlet	Grand	40.2473	-105.8159		Active
GL-NW	Grand Lake west end of lake, north of Shadow Mountain Channel	Grand	40.2466	-105.8212		Active
GL-PIC	Grand Lake by Adams Tunnel Picnic Area	Grand	40.2406	-105.8022		Active
GL-SB	Grand Lake 500 feet off Public Swim Beach	Grand	40.2489	-105.8183		Active
GL-SOU	Grand Lake south section of lake, off shore between Stahls & Zneimers property	Grand	40.2409	-105.8139		Active
GL-STH	Grand Lake South Shore	Grand	40.2378	-105.8108		Active
GL-SW	Grand Lake southwest section of lake, west of Mid Section	Grand	40.2435	-105.8183		Active
GL-WES	Grand Lake west end of lake, south of Shadow Mountain Channel	Grand	40.2419	-105.8215		Active
GR-DAM	Lake Granby Dam (USGS #09018500)	Grand	40.1497	-105.8614		Active
GR-EAS	Lake Granby East Side (USGS #400806105474700)	Grand	40.1350	-105.7970		Active
GR-FAR	Lake Granby near Farr Pumping Plant	Grand	40.1808	-105.8713		Inactive
GR-PUMP	Granby Pump Canal at foot bridge on south side of Shadow Mountain	Grand	40.2068	-105.8495		Active
GR-PUMP2	Granby Pump Canal	Grand	40.2009	-105.8630		Inactive
GR-RBA	Granby at Rainbow Bay	Grand	40.1522	-105.8767		Active
GR-SCG	Granby at Stillwater Campground	Grand	40.1806	-105.8853		Active
GR-WES	Lake Granby West Side (USGS #401030105521101)	Grand	40.1750	-105.8697		Active
SM-CEN	Shadow Mountain Reservoir Center	Grand	40.2248	-105.8439		Inactive
SM-CHL	Shadow Mountain Channel west of footbridge (USGS #09014000)	Grand	40.2447	-105.8261		Active
SM-CHL	Shadow Mountain Channel on Shoreline South East of Rainbow Bridge	Grand	40.2458	-105.8286		Active
SM-CHL	Shadow Mountain Channel by Rainbow Bridge at ADVM (USGS #09014050)	Grand	40.2462	-105.8277		Active
SM-CHL	Shadow Mountain Channel in Grand Lake at mouth of Channel (USGS #09014000)	Grand	40.2447	-105.8258		Active
SM-DAM	Shadow Mountain Dam (USGS #09014500)	Grand	40.2101	-105.8421		Active
SM-GR	Shadow Mountain at Green Ridge Picnic Area	Grand	40.2121	-105.8540		Inactive
SM-ISL	Shadow Mountain by the islands	Grand	40.2159	-105.8487		Inactive
SM-MID	Shadow Mountain Mid Section (USGS #401331105501401)	Grand	40.2252	-105.8378		Active
SM-MID2	Shadow Mountain Mid Section. Historic Secchi site with slightly different coordinates than SM-MID.	Grand	40.2314	-105.8376		Inactive
SM-NE1	Shadow Mountain Reservoir Northeast Bay	Grand	40.2370	-105.8388		Inactive
SM-NE2	Shadow Mountain Reservoir Northeast Bay	Grand	40.2397	-105.8329		Inactive
SM-NEC	Shadow Mountain near North East Condos	Grand	40.2416	-105.8280		Inactive
SM-NOR	Shadow Mountain Reservoir North	Grand	40.2467	-105.8383		Active
SM-NW1	Shadow Mountain Reservoir northwest of the center of the Reservoir	Grand	40.2370	-105.8418		Active
SM-PIC	Shadow Mountain near Shadow Mountain Picnic Area	Grand	40.2129	-105.8533		Inactive
SM-PIN	Shadow Mountain near Pine Beach Picnic Area	Grand	40.2166	-105.8525		Inactive
SM-SIS	Shadow Mountain at South Island/Pine Beach	Grand	40.2172	-105.8533		Active
SM-SOU	Shadow Mountain Reservoir in Southwest area	Grand	40.2100	-105.8479		Inactive
SM-TRM	Shadow Mountain at Trailridge Marina	Grand	40.2246	-105.8501		Inactive

Three Lakes Flowing Sites Data Matrix

Row Labels	AC-GRU	AT-WP	CR-SMU	EI-GLU	NI-GLU	RD-STU	RF-GRU	ST-BAS	ST-GRU	ST-IRU	ST-JRD	ST-JRD2	ST-RDD	GR-Pump	WC-Pump	WG-Pump
(Corrected) Chlorophyll a (mg/m3)	2009		2009	2009	2009		2009		2008	2009		2011		2006	2005	2005
(Corrected) Pheophytin a (mg/m3)	2009		2009	2009	2009		2009		2008	2009		2011		2006	2005	2005
Ag Dis (ug/L)	2009		1996	1997	1996		2007		2007			2011		1991	1991	1991
Ag Tot Rec (ug/L)			1996	1997	1996									1991	1991	1991
Air Temp (Deg C)	2002		2005	2005	2005	2010	2009	2010	2005	2009	2011	2011	2011	1999	2009	2009
Al Dis (ug/L)														1992	1992	1992
Al Tot Rec (ug/L)														1992	1992	1992
Alk Total (mg/L)	2004	2006	1996	1997	1996		2007		2004					1991	1991	1991
Alk Total Dis (mg/L)	2000		2006	2006	2006		2009		2007			2011		2000	2009	2009
Alk-Bicarb (mg/L)		2006	1996	1997	1996		2007							1992	1992	1992
Alk-Bicarb Dis (mg/L)	2010		2010	2010	2010		2009		2010			2011		2009	2009	2009
Alk-Carb (mg/L)		2006	1996	1997	1996		2007							1992	1992	1992
Alk-Carb Dis (mg/L)	2010		2010	2010	2010		2009		2010			2011		2009	2009	2009
Alk-OH (mg/L)		2006	1996	1997	1996		2007							1992	1992	1992
Alk-OH Dis (mg/L)	2010		2010	2010	2010		2009		2010			2011		2009	2009	2009
As Dis (ug/L)	2010		2010	2010	2010		2007		2010			2011		1992	1992	1992
As Tot Rec (ug/L)	2012		2012	2012	2012		2012		2007					1992	1992	1992
B Tot Rec (ug/L)														1992	1992	1992
Ba Dis (ug/L)														1992	1992	1992
Ba Tot Rec (ug/L)														1992	1992	1992
Be Dis (ug/L)														1992	1992	1992
Be Tot Rec (ug/L)														1992	1992	1992
Ca (mg/L)	2000	2006	1996	1997	1996		2007		2004			2011		1991	1991	1991
Cd Dis (ug/L)	2009		2009	2009	2009		2007		2007			2011		1991	1991	1991
Cd Tot Rec (ug/L)									2007					1991	1991	1991
Chlorophyll a (mg/m3)	2009	2005	2009	2009	2009		2009		2008	2009		2011		2005	2005	2005
Chlorophyll b (mg/m3)	2009	2005	2009	2009	2009		2009		2008	2009		2011		2005	2005	2005
Chlorophyll c (mg/m3)	2009	2005	2009	2009	2009		2009		2008	2009		2011		2005	2005	2005
Cl (mg/L)	2000	2006	1996	1997	1996		2007		2004			2011		1991	1991	1991
Cl Residual (mg/L)														1992	1992	1992
Co Dis (ug/L)														1995		
COD (mg/L)														1991	1991	1991
Cr 3+ Dis (ug/L)														1992	1992	1992
Cr 3+ Tot Rec (ug/L)														1992	1992	1992
Cr 6+ Dis (ug/L)														1992	1992	1992
Cr 6+ Tot Rec (ug/L)														1992	1992	1992
Cr Dis (ug/L)														1995		
Cu Dis (ug/L)	2009	2006	1996	1997	1996		2007		2007			2011		1992	1992	1992
Cu Tot Rec (ug/L)			1996	1997	1996									1992	1992	1992
Cyanide (free) (mg/L)														1992	1992	1992
DO %	2001															
DO (mg/L)	2000		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
DOC (mg/L)	2000		2004	2004	2004		2010		2004			2011		2000		
E Coli (C/100mL)														2004		
F (mg/L)	2004		2004	2004	2004				2004					1991	1991	1991
Fe Dis (ug/L)	2009	2006	1996	1997	1996		2007		2007			2011		1991	1991	1991
Fe Tot Rec (ug/L)	2010	2006	1996	1997	1996		2007		2010			2011		1992	1992	1992
Fecal Coliform (C/100mL)			1996	1997	1996									1991	1991	1991
Flow (cfs)	2000		1996	1997	2004	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
Gage Height (ft)	2001		2005	2005	2005				2008							
Hardness (CaCO3) (mg/L)	2000		1996	1997	1996				2004					1991	1991	1991
Hg Dis (ug/L)														1992	1992	1992

Three Lakes Flowing Sites Data Matrix

Row Labels	AC-GRU	AT-WP	CR-SMU	EI-GLU	NI-GLU	RD-STU	RF-GRU	ST-BAS	ST-GRU	ST-IRU	ST-JRD	ST-JRD2	ST-RDD	GR-Pump	WC-Pump	WG-Pump
Hg Tot Rec (ng/L)														2006		
Hg Tot Rec (ug/L)														1992	1992	1992
K (mg/L)	2000	2006	1996	1997	1996		2007		2004			2011		1991	1991	1991
Li Dis (ug/L)														1995		
Mg (mg/L)	2000	2006	1996	1997	1996		2007		2004			2011		1991	1991	1991
Mn Dis (ug/L)	2009	2006	1996	1997	1996		2007		2007			2011		1992	1992	1992
Mn Tot Rec (ug/L)			1996	1997	1996									1992	1992	1992
Mo Dis (ug/L)														1995		
N Total as N (mg/L)	2003		2004	2004	2004				2004					2003		
N Total as N Dis (mg/L)	2004		2004	2004	2004				2004					2004		
Na (mg/L)	2000	2006	1996	1997	1996		2007		2004			2011		1991	1991	1991
NH3 as N (mg/L)	2000		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
Ni Dis (ug/L)	2009		2009	2009	2009		2007		2007			2011		1992	1992	1992
Ni Tot Rec (ug/L)														1992	1992	1992
NO2 as N (mg/L)			1996	1997	1996									1992	1992	1992
NO3 + NO2 as N (mg/L)	2001		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
NO3 as N (mg/L)	2000		1996	1997	1996									1992	1992	1992
NVSS (mg/L)	2011		2011	2011	2011		2011		2012			2011		2011		
Ortho P as P (mg/L)	2001		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1992	1992	1992
P Total (mg/L)	2000		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
P Total Dis (mg/L)	2006		2006	2006	2006				2006					1995		
Pb Dis (ug/L)	2009		2009	2009	2009		2007		2007			2011		1991	1991	1991
Pb Tot Rec (ug/L)														1991	1991	1991
pH	2002		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
pH Lab	2000	2006	1996	1997	1996		2007		2007					1991	1991	1991
Sb Dis (ug/L)														1992	1992	1992
Sb Tot Rec (ug/L)														1992	1992	1992
Se Dis (ug/L)	2004		2004	2004	2004		2007		2004			2011		1992	1992	1992
Se Tot Rec (ug/L)														1992	1992	1992
SiO2 Dis (mg/L)	2000		2004	2004	2004				2004					1995		
SO4 (mg/L)	2000	2006	1996	1997	1996		2007		2004			2011		1991	1991	1991
SpCond (uS/cm)	2000		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
SpCond Lab (uS/cm)	2000	2006	1996	1997	1996		2007		2006					1991	1991	1991
Sr Dis (ug/L)														1995		
Stream Width (ft)	2002		2004	2004	2004			2011	2004	2011			2011	2002		
Sulfide Total (mg/L)			1996	1997	1996									1992	1992	1992
TDS (mg/L)	2004	2006	1996	1997	1996		2007		2004			2012		1991	1991	1991
Temp (Deg C)	2000		1996	1997	1996	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
TI Dis (ug/L)														1992	1992	1992
TI Tot Rec (ug/L)														1992	1992	1992
TKN as N (mg/L)	2000		2004	2004	2004	2010	2007	2010	2004	2009	2011	2011	2011	1991	1991	1991
TOC (mg/L)	2004		1996	1997	1996		2009		2004			2011		1996	1999	2001
TSS (mg/L)	2004	2006	1996	1997	1996		2007		2004		2011	2011		1991	1991	1991
Turbidity (NTU)	2010		2010	2010	2010	2010	2009	2010	2010	2009	2011	2011	2011	2010	2009	2009
U Tot Rec (ug/L)			1996	1997	1996									1992	1992	1992
V Dis (ug/L)														1995		
Zn Dis (ug/L)	2009		2000	2000	2000		2008		2007			2011		1995	2000	2001
Zn Tot Rec (ug/L)			1996	1997	1996									1992	1992	1992

StationID	Station Description	County	HUC	Latitude	Longitude	Elevation	Slope	Status
AT-WP	Adams Tunnel West Portal	Grand	14010001	40.2416	-105.8001	8380	W	Inactive
GR-Pump	Granby Pump Canal at foot bridge on south side of Shadow Mountain (USGS #09018300)	Grand	14010001	40.2068	-105.8495	8366	W	Active
WC-Pump	Willow Creek discharge chute to Lake Granby	Grand	14010001	40.1430	-105.8888	8297	W	Active
WG-Pump	Windy Gap discharge chute to Lake Granby	Grand	14010001	40.1429	-105.8888	8295	W	Active
AC-GRU	Arapahoe Creek at Monarch Lake outlet, upstream of Lake Granby (USGS #09016500)	Grand	14010001	40.1128	-105.7497	8306	W	Active
EI-GLU	East Inlet upstream of Grand Lake (USGS #090135000)	Grand	14010001	40.2369	-105.8010	8380	W	Active
NI-GLU	North Inlet upstream of Grand Lake	Grand	14010001	40.2507	-105.8148	8389	W	Active
RF-GRU	Roaring Fork inlet upstream of Lake Granby	Grand	14010001	40.1308	-105.7671	8285	W	Active
ST-GRU	Stillwater Creek upstream of Lake Granby (USGS #09018000)	Grand	14010001	40.1829	-105.8892	8254	W	Active
CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir (USGS site #09011000)	Grand	14010001	40.2190	-105.8577	8405	W	Active
ST-IRU	Stillwater Creek upstream of Irrigated Areas at the Crossing of Red Top Ditch	Grand	14010001	40.2094	-105.8967		W	Inactive
ST-BAS	Stillwater Creek upstream of irrigated areas (baseline)	Grand	14010001	40.2264	-105.9130	8673	W	Inactive
RD-STU	Red Top Ditch upstream of the confluence with Stillwater Creek	Grand	14010001	40.2085	-105.8966		W	Inactive
ST-JRD	Mainstem of Stillwater Creek downstream of J Ranch at CR42 bridge crossing	Grand	14010001	40.1925	-1058973	8346	W	Inactive
ST-RDD	Stillwater Creek downstream of Red Top Ditch	Grand	14010001	40.2071	-105.8964		W	Inactive
ST-JRD2	Combined Sample of mainstem and tributary to Stillwater Creek that merge downstream of J Ranch at CR42 bridge crossing	Grand	14010001	40.1925	-1058973	8346	W	Active

Appendix H

Senate Document 80

75TH CONGRESS } 1st Session } SENATE { DOCUMENT No. 80

COLORADO-BIG THOMPSON PROJECT

SYNOPSIS OF REPORT

ON

COLORADO-BIG THOMPSON PROJECT, PLAN OF DEVELOPMENT AND COST ESTIMATE PREPARED BY THE BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR

PRESENTED BY MR. ADAMS

JUNE 15, 1937—Ordered to be printed without illustrations

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1937

CONTENTS

LETTER OF TRANSMITTAL

FEBRUARY 3, 1937.

From Senior Engineer Porter J. Preston.
To Chief Engineer.
Subject: Colorado-Big Thompson project.

1. Transmitted herewith is a synopsis of the report of plan of development and cost estimate of the Colorado-Big Thompson project.

2. The plans and designs upon which the estimates are based are shown in the full report to follow this synopsis.

3. The detail estimates have been worked out in the Denver office under the following divisions:

Canals: H. R. McBirney.
Reservoirs: K. B. Keener.
Power: L. N. McClellan.
Hydraulics: E. B. Debler.

4. The field work was done under the supervision of M. E. Bunger.

5. The economic study was carried on by R. L. Parshall, senior irrigation engineer, Bureau of Agricultural Engineering, United States Department of Agriculture. This study is later proposed to be issued as a separate document.

PORTER J. PRESTON.

Revised synopsis of report submitted June 11, 1937.

LETTERS OF SUBMITTAL

June 11, 1937.

Hon. Harold L. Ickes,
Secretary of the Interior.

My Dear Mr. Secretary: There is attached hereto the portion of the report on the Colorado-Big Thompson project in Colorado covering the principles and stipulations governing the construction and operation of said project for the protection of the rights and interests dependent on the Colorado River in Colorado.

The provisions contained therein have been considered by the Northern Colorado Water Users' Association, representing the irrigation and other interests on the eastern slope in Colorado, and we respectfully submit that they are satisfactory and meet the approval of said association.

We ask that acknowledgment be made of this communication.

Respectfully yours,

Northern Colorado Water Users' Association,
Chas. Hansen, *President.*
Moses E. Smith, *Vice President.*
Thomas A. Nixon, *Attorney.*

June 11, 1937.

Hon. Harold L. Ickes,
Secretary of the Interior.

My Dear Mr. Secretary: There is attached hereto the portion of the report on the Colorado-Big Thompson project in Colorado covering the principles and stipulations governing the construction and operation of said project for the protection of the rights and interests dependent on the Colorado River in Colorado.

The provisions contained therein have been considered by the Western Slope Protective Association, representing the irrigation and other interests on the western slope in Colorado, and we respectfully submit that they are satisfactory and meet the approval of said association.

We ask that acknowledgment be made of this communication.

Respectfully yours,

The Western Slope Protective Association,
Silmon Smith, *Secretary.*
Clifford H. Stone, *Director.*
A. C. Sudan,
Special Representative of Grand County.

SYNOPSIS OF REPORT, COLORADO-BIG THOMPSON PROJECT

OUTLINE OF CONSTRUCTION AND OPERATING CONDITIONS

The Colorado-Big Thompson project in Colorado contemplates the diversion of surplus waters from the headwaters of the Colorado River on the Pacific or western slope to lands in northeastern Colorado on the Atlantic or eastern slope greatly in need of supplemental irrigation water.

To accomplish this diversion, the following features are required:

ON COLORADO RIVER

(1) Storage on the Blue River in what is called Green Mountain Reservoir located about 16 miles southeast of Kremmling, Colo., where the Blue enters the Colorado River. This reservoir is to be used to replace water diverted to the eastern slope that would be required by prior rights along the Colorado River.

(2) A hydroelectric plant below the Green Mountain Dam to utilize the flow of the Blue River and water stored in the reservoir for the generation of electrical energy.

(3) A storage reservoir located on the Colorado River about 6 miles northeast of Granby, Colo., to be known as Granby Reservoir. This reservoir will store the flow of the Colorado at this point as well as water diverted from Willow Creek, a tributary of the Colorado and Strawberry and Meadow Creeks, tributaries of the Fraser River.

(4) A diversion dam located about one-half mile below the junction of the North Fork and Grand Lake outlet and about 3 miles south of the village of Grand Lake. This dam will create a lake known as Shadow Mountain Lake which will have the same elevation as Grand Lake and will aid in supplying the transmountain diversion tunnel with water pumped from Granby Reservoir. This lake together with Grand Lake is to be kept at nearly constant level.

(5) An electrically driven pumping plant on the shore of Granby Reservoir, where water will be pumped into a canal feeding Shadow Mountain and Grand Lakes. The length of the canal is 4½ miles.

(6) An outlet channel at the east end of Grand Lake connecting the lake with the portal of a transmountain diversion tunnel and provided with control features that will regulate the level of Grand Lake within a fluctuating range of 1 foot.

(7) A transmountain diversion tunnel under the Continental Divide 13.1 miles in length extending from Grand Lake to a point in Wind River about 5 miles southwest of Estes Park village.

ON EASTERN SLOPE

(8) A conduit 5.3 miles in length extending from diversion tunnel outlet to penstock of a power plant on the Big Thompson River just below Estes Park village. This conduit will be made up of buried

pipe, siphons, tunnels, and open canal. It will be entirely concealed through the area authorized to be taken into Rocky Mountain National Park.

(9) The waste rock from the tunnel is to be terraced and landscaped and all structures connected with the tunnel will be constructed to blend into their natural surroundings.

(10) A power plant known as power plant no. 1 constructed along the Big Thompson River just below the village of Estes Park utilizing the western slope water.

(11) Four additional power plants down the Big Thompson Canyon to utilize all available fall and also all water available for power in the Big Thompson River in addition to the western slope water diverted.

(12) A diversion dam on Big Thompson River about 12 miles west of Loveland to divert the water by means of a canal 9 miles in length to a storage reservoir known as Carter Lake.

(13) Carter Lake Reservoir located 8 miles northwest of Berthoud, Colo., to store water brought over during winter months. Water is released from this reservoir through a 4-mile canal into the Big Thompson River and through a 9-mile canal into the St. Vrain River for irrigation purposes.

(14) A siphon across the Big Thompson River, 9 miles west of Loveland, Colo., and a canal 10 miles in length to convey water from the fourth power plant to a storage reservoir, located about 5 miles west of Fort Collins, known as Horsetooth Reservoir.

(15) A canal from Horsetooth Reservoir to the Cache La Poudre River and extended north to a pumping plant which lifts water high enough to serve the North Poudre Canal.

(16) A storage reservoir near the mouth of Buckhorn Creek to be known as Arkins Reservoir, supplied from a canal diverting from the Big Thompson River just below the last power plant. It is to be used to aid in balancing the demands for power and irrigation, also storing excess water available in the Big Thompson River. Water will be released from the reservoir for supplemental irrigation in the South Platte area.

(17) Transmission lines connecting the Valmont steam plant of the Public Service Co. with all the hydroelectric plants contemplated, also connecting with the transmountain tunnel portals and the Granby and North Poudre pumping plants. The line connecting power plant no. 1 and Granby pumping plant will run east, and south of the outside boundaries of the Rocky Mountain National Park, crossing the Continental Divide at Buchanan Pass.

In order to carry out the construction, operation, and maintenance of the project as outlined above, it will be necessary to comply with the following requirements as agreed to by representatives of the eastern and western slopes in Colorado and here made as a part of this report.

MANNER OF OPERATION OF PROJECT FACILITIES AND AUXILIARY FEATURES

The construction and operation of this project will change the regimen of the Colorado River below the Granby Reservoir. The project contemplates the maximum conservation and use of the waters of the Colorado River, and involves all of the construction features heretofore listed. In addition thereto certain supplemental construction will be necessary. This will be for the primary purpose of preserving insofar as possible the rights and interests dependent on this water, which exist on both slopes of the Continental Divide in Colorado. The project, therefore, must be operated in such a manner as to most nearly effect the following primary purposes:

1. To preserve the vested and future rights in irrigation.
2. To preserve the fishing and recreational facilities and the scenic attractions of Grand Lake, the Colorado River, and the Rocky Mountain National Park.
3. To preserve the present surface elevations of the water in Grand Lake and to prevent a variation in these elevations greater than their normal fluctuation.
4. To so conserve and make use of these waters for irrigation, power, industrial development, and other purposes, as to create the greatest benefits.
5. To maintain conditions of river flow for the benefit of domestic and sanitary uses of this water.

In order to accomplish these purposes the project should be operated by an unprejudiced agency in a fair and efficient manner, equitable to all parties having interests therein, and in conformity with the following particular stipulations:

(*a*) The Green Mountain Reservoir, or similar facilities, shall be constructed and maintained on the Colorado River above the present site of the diversion dam of the Shoshone power plant, above Glenwood Springs, Colo., with a capacity of 152,000 acre-feet of water, with a reasonable expectancy that it will fill annually. Of said capacity, 52,000 acre-feet of water stored therein shall be available as replacement in western Colorado, of the water which would be usable there if not withheld or diverted by said project; 100,000 acre-feet shall be used for power purposes; and all of said stored waters shall be released under the conditions and limitations hereinafter set forth.

(*b*) Whenever the flow in the Colorado River at the present site of said Shoshone diversion dam is less than 1,250 cubic feet per second, there shall, upon demand of the authorized irrigation division engineer or other State authority having charge of the distribution of the waters of this stream, be released from said reservoir as a part of said 52,000 acre-feet, the amount necessary with other waters available, to fill the vested appropriations of water up to the amount concurrently being diverted or withheld from such vested appropriations by the project for diversion to the eastern slope.

(*c*) Said 100,000 acre-feet shall be stored primarily for power purposes, and the water released shall be available, without charge, to supply existing irrigation and domestic appropriations of water, including the Grand Valley reclamation project, to supply all losses chargeable in the delivery of said 52,000 acre-feet of water, and for future use for domestic purposes and in the irrigation of lands thereafter to be brought under cultivation in western Colorado. It shall be released within the period from April 15 to October 15 of each year as required to supply a sufficient quantity to maintain the specified flow of 1,250 cubic feet per second of water at the present site of said Shoshone diversion dam, provided this amount is not supplied from the 52,000 acre-feet heretofore specified. Water not required for the above purposes shall also be available for disposal to agencies for the development of the shale oil or other industries.

(*d*) The cost of construction and perpetual operation and maintenance of said reservoir or reservoirs shall be a charge against the project and shall be paid from revenues collected from this project as may be provided in contracts between the Secretary of the Interior and the beneficiaries of the project in eastern Colorado, and any other contracting parties.

(*e*) In the event said reservoir or reservoirs are not maintained with a capacity of 52,000 acre-feet, the Secretary of the Interior should withhold the diversion of water from the western to the eastern slope of Colorado until such storage capacity is made available.

(*f*) The Secretary of the Interior shall have the option to require the transfer to the United States of any and all rights initiated or acquired by the appropriation or use of water through the works of the project in eastern Colorado, at any time: *Provided, however*, That the title so taken shall be subject to a beneficial use of such water as may be provided in the repayment contract or contracts; and the rights to store water to the extent of said 152,000 acre-feet shall be initiated, acquired, and held by the appropriate authorities for use in western Colorado, for replacement of water diverted to the eastern slope, and for other purposes contemplated for this project.

(*g*) The Secretary of the Interior shall operate this project in accordance with the following stipulations as to priorities of water use as between the parties claiming or using project water and within the limits of his legal authority. Said 52,000 acre-feet of replacement storage in Green Mountain or other reservoirs shall be considered to have a date of priority for the storage and use of replacement water earlier than that of the priorities for the water diverted or stored for delivery to the eastern slope. The 100,000 acre-feet of storage in said reservoir shall be considered to have the same date of priority of appropriation as that for water diverted or stored for transmountain diversion.

(*h*) Said Green Mountain Reservoir, or such other replacement reservoirs as provided in paragraph (*a*) herein, as are planned as a part of the project, shall be constructed at the same time as the other parts of the project and shall be completed before any water is diverted to the eastern slope of the Continental Divide by means of said project.

(*i*) Inasmuch as the State of Colorado has ratified the Colorado River Compact, and inasmuch as the construction of this project is to be undertaken by the United States, the project, its operation, maintenance, and use must be subject to the provisions of said Colorado River Compact of November 24, 1922 (42 Stat. 171), and of section 13 of the Boulder Canyon Project Act, dated December 21, 1928 (45 Stat. 1057–1064). Notwithstanding the relative priorities specified in paragraph (*g*) herein, if an obligation is created under said compact to augment the supply of water from the State of Colorado to satisfy the provisions of said compact, the diversion for the benefit of the eastern slope shall be discontinued in advance of any western slope appropriations.

(*j*) An adequate system, as determined by the Secretary of the Interior, shall be provided for the irrigation of the lands in the vicinity of Kremmling, now irrigated by either natural or artificial means, and the installation made therefor shall be a part of this project. The rights to the use of water for the irrigation of these lands shall be considered to have a date of priority earlier than that of the rights to the use of water to be diverted through the works of this project to the eastern slope. This system shall be designed and built in a manner requiring the least possible continuing annual expense for operation and maintenance but the cost thereof shall not exceed $300,000; and said system shall be provided and in operation before any water is stored for transmountain diversion. In addition, the Secretary shall protect, add to, or improve the source of supply of domestic waters for the municipalities of Kremmling and Hot Sulphur Springs in the manner and to the extent which he may determine to be necessary to provide a source of supply not less than that now available for these municipalities. The cost of these features shall be included in the total project cost.

(*k*) To compensate Grand County for the loss of taxes through the transfer of property to the United States for the construction of this project, $100,000 shall be paid to said Grand County. This payment shall be made in 10 annual installments of $10,000 each, commencing upon the date when 10 percent of the total property in Grand County required for said project has been removed from taxation.

(*l*) The project and all of its features shall be operated in a manner determined by the Secretary of the Interior as necessary to provide the water to preserve at all times that section of the Colorado River between the reservoir to be constructed near Granby and the mouth of the Fraser River as a live stream, and also to insure an adequate supply for irrigation, for sanitary purposes, for the preservation of scenic attractions, and for the preservation of fish life. The determination of the need for and the amount and times of release of water from Granby Reservoir to accomplish these purposes shall be made by the Secretary of the Interior, whose findings shall be final.

In order to facilitate compliance with the stipulation in paragraphs (*j*), (*k*), and (*l*) hereof a representative may be selected and designated by the interests dependent thereon in Grand County, Colo., and when so designated he will be recognized as the official spokesman of said interests in all matters dealing with project operations affecting Grand County.

The principles and provisions expressed in these stipulations have been approved by the Western Colorado Protective Association, representing interests in western Colorado, and the Northern Colorado Water Users Association as evidenced by the letters hereto attached.

SUMMARY

The Colorado-Big Thompson project comprises 615,000 acres of irrigated lands, out of approximately 800,000 acres lying under the canal systems in the northern and northeastern portions of Colorado.

The water supply for the area is to be derived from a portion of 782 square miles of drainage area above Hot Sulphur Springs lying west of the Continental Divide in Grand County, Colorado, and varying in elevation from 8,050 to 14,000 feet.

HISTORY

The first irrigation in northeastern Colorado occurred about 1860 where the early settlers plowed out small ditches with sufficient grade and length to irrigate a few acres of land in the first bottom—i. e lands not far above the high-water line of the streams and adjacent to them.

The first irrigation of the higher or second bench lands along the Cache La Poudre River was by the Old Union Colony, of Greeley, in

1870. This colony was organized by Horace Greeley, then editor of the New York Tribune, who will be remembered here especially for his advice to eastern young men to "Go west and grow up with the country."

This colony irrigated about 12,000 acres under their first project and it was a success from the start, due in a large measure to the fact that they were people of considerable means and were then able to finance themselves over the period required to bring raw prairie land into profitable cultivation.

This colony was soon followed by others along the Poudre at Fort Collins, on the Big Thompson, at Loveland and the St. Vrain near Longmont.

The difficulties experienced by these colonists in distributing the water between them led to the creation of Colorado's irrigation laws which have been copied by most of the irrigation States of the West.

This irrigated area of six hundred to eight hundred thousand acres was developed by means of individual initiative and by small scale cooperative enterprises. Today there are 6,400 irrigated farms, served by 124 canals and ditches and 60 storage reservoirs.

IRRIGATION USE

In the early days irrigation in this area was confined to growing crops to supply local needs, the lack of transportation contributing to high prices for the home-grown production and prohibiting shipping to distant points. The crops grown were mainly the grains and hay for local consumption, with some vegetables. Such irrigation corresponded with the run-off of the streams.

As mining developed in the State, Denver and other towns grew into cities, and after these cities were connected to the East by railroads the markets demanded a more diversified agriculture to supply their needs. Thus a gradual demand developed for late water which the streams could not supply.

This change created a need for storing the flood waters for late irrigation. From 1890 to 1910 was a period of reservoir construction, during which storage was provided for all the available water supply of the streams over and above the direct irrigation requirements for the area here under discussion. Much of this development took place during a decade of more than normal run-off on the eastern slope and also during a period expanding the agricultural area throughout the West.

Attempts to maintain the area under cultivation with the depleted run-offs during the past 10 years have spread the water supply to such an extent that much acreage has had an insufficient water supply to produce full crops or crops producing the higher values. Attempts have been made to supplement the individual farm water supply by the development of the underground sources by pumping from numerous wells throughout the region. This is lowering the water table and already is affecting the water supply of the lower South Platte Valley which receives its irrigation supply largely from return waters.

NEED OF SUPPLEMENTAL WATER

Under such conditions only the older water rights have any assurance of an adequate water supply, and in the dryer years the owners of junior rights are forced to confine their farming to crops that can be matured by the early flood flow or that require a minimum amount of water. In years when the supply is not correctly estimated considerable loss results. Ordinarily the crops raised in this and other irrigated areas do not compete with those grown under rainfall conditions, but a shortage of water always leads to the raising of more of the competing crops. Such crops also cut the income of the irrigation farmer below what he can earn with the higher type, noncompetitive crops.

On fully three-fourths of the 615,000 acres in this area the water supply is inadequate, in spite of every effort to conserve, store flood water, or otherwise add to the water supply that has been within the financial ability of the farmer. This inadequacy is due not only to a development probably too large for the period when run-off of the streams was much higher than at present, but to the fact that the last 10 years have seen a very marked decrease in the stream flow. It must be emphasized that the additional water supply here contemplated is to be used for a supplemental supply and not to create a large new additional irrigated acreage.

There has been expended in this area to date for various types of irrigation works, including nearly $750,000 for pumping plants, most of which have been installed in the last 10 years, about $35,000,000 against which there is an outstanding indebtedness of only $1,510,650. These people, however, have about reached their limit as individuals and mutual irrigation companies to provide for themselves a supplemental water supply so badly needed to make their present water supply secure and are obliged to seek Government aid to bring this about.

It has been conceded by a majority of the irrigation interests in this section of the State that the water supply in 1926 was ample for all their present acreage now irrigated. In order, therefore, to determine the normal shortage in acre-feet over a period of years a comparison of the supply in these years with that of 1926 was made and the difference obtained. These differences are set up in the following table:

TABLE 1.—*Showing water districts, acreage irrigated, deficiencies 1925 to 1935 with tentative allocation of total supplemental supply*

Water district no.	Area irrigated	1926 diversion, acre-feet	Average diversion, 1925–35	Difference, 1926, 11-year average required supplementary water in acre-feet	Tentative allocation of supplemental supply			
					Colorado-Big Thompson project water	Moffat and Jones Pass tunnel water return	Present seepage return, acre-feet	Total supplemental supply, acre-feet
(1)	(2)	(3)	(7)	(15)	(16)	(17)	(18)	(19)
3	213, 640	530, 000	398, 000	132, 000	104, 000	----------	49, 500	153, 500
4	68, 408	235, 000	163, 000	72, 000	44, 100	----------	21, 000	65, 100
5	81, 806	113, 000	94, 000	19, 000	38, 800	----------	18, 500	57, 300
1	92, 394	663, 000	457, 000	206, 000	81, 400	11, 000	83, 000	175, 400
2	37, 899	170, 000	154, 000	16, 000	5, 000	4, 500	5, 100	14, 600
64	121, 289	513, 000	383, 000	130, 000	36, 700	14, 500	37, 400	88, 600
Total	615, 436	2, 224, 000	1, 649, 000	575, 000	310, 000	30, 000	214, 500	554, 500

It will be noted from column no. 15 that the total average shortage in this project area which comprises water districts 3, 4, 5, 1, 2, and 64 is 575,000 acre-feet. Column no. 16 is a tentative allocation of the proposed supplemental supply to the various districts. Column no. 18 is the estimated usable return flow that would arise from the addition of 310,000 acre-feet of new water to this area. Column no. 19 is the total usable supplemental supply amounting to 554,520 acre-feet, an amount within 5 percent of the 10-year average shortage. The sale or rental of supplemental water, when available, in the Poudre Valley has averaged $4.50 per acre-foot over a period of years. In extreme cases it has sold as high as $9 per acre-foot.

The deficiency in water supply for the period 1925 to 1934, inclusive, reflected a direct economic loss in crop production of approximately $42,355,000.

The following shows the approximate annual loss in value of crops because of inadequate water supply:

Sugar beets	$1, 900, 000
Alfalfa	948, 000
Small grain	470, 000
Beans	302, 000
Corn	228, 000
Potatoes	425, 000
All other crops	444, 000
Total	4, 700, 000

This average annual direct crop loss is about 19 percent of the $24,800,000 estimated cost of the Colorado-Big Thompson irrigation project.

The crop loss in 1934, due to shortage of water, as compared to 1926, after variation in price and acreage factors had been accounted for, amounted to $12,400,000, or just one-half the cost of the project.

The losses here given are the farm losses and do not include the losses that are due to processing, transporting, or handling of that quantity of production, which would add several million dollars to the loss of the community as a whole.

The effect of such inadequate water supply for the period 1925–35 is shown graphically on drawing no. 1 following.

SUPPLEMENTAL WATER SUPPLY

In 1929 the State engineers of Colorado, in cooperation with the Platte Valley Water Conservation League, and the United States Army engineers, made a comprehensive study of the water resources of the South Platte Basin in northeastern Colorado. This study included the Cache La Poudre River in water district no. 3, the Big Thompson River in water district no. 4, and the St. Vrain River in district no 5. The investigators determined the excess water available on these streams above present normal demands and also above the normal demands on the South Platte River proper below where these streams enter.

The investigators also determined the location, capacity, and cost of the most feasible reservoir sites for the storage of this excess water.

The results are shown in the following table and have been brought up to date by using the same demands for irrigation as set up in the report and using the water-supply records furnished by the State engineer's office.

Stream	Excess supply available for storage, average, 1918-35	Capacity proposed reservoir by Army engineers	Average annual yields at reservoirs	Total reservoir costs	Cost per acre-foot capacity	Cost per acre-foot yield
	Acre-feet	*Acre-feet*				
Cache La Poudre	30,000	52,000	25,500	$2,747,000	$72	$147
Big Thompson	16,000	32,700	11,300	2,006,000	61	178
St. Vrain	16,000	30,000	14,000	2,136,000	73	156

From the foregoing table it is evident that there is not sufficient excess water available that originates in this area to supply the demands for supplemental water, and the cost of making use of what is available is prohibitive. It will be shown, however, that 16,000 acre-feet of this surplus is available for storage in the Colorado-Big Thompson project reservoirs on the eastern slope with no additional cost.

The water users in northeastern Colorado have now exhausted every possible source of obtaining supplemental water or augmenting their present supply either by storage, transmountain diversion within their individual cooperative means, and by pumping. Fortunately, however, there exists a surplus of water on the headwaters of the Colorado River west of this area and separated from it by the Continental Divide.

In the spring of 1935, $150,000 was allocated to the Bureau of Reclamation to make surveys and prepare plans and cost estimates for bringing water from the headwaters of the Colorado River into the area in northeastern Colorado in need of supplemental water.

In August 1935 the Bureau of Reclamation started surveys for the project and previously there had been started a land classification to determine the irrigated and arable land in the Colorado River Basin in Colorado in order to arrive at the approximate amount of water now used in the area and how much might be used when full development has been made. Both surveys have been completed, insofar as this project is involved, and the following is the result of the land classification.

LAND CLASSIFICATION—COLORADO RIVER AREA

Since the quantity of water available for diversion from the headwaters of Colorado River might be limited now by the water rights of lands already irrigated, or might in the future limit in turn the development of lands in the Colorado Basin within the State, all the land on Colorado River and its tributaries above the Colorado-Utah line, except the Gunnison River area, has been classified to show the location and extent of irrigated lands and of lands capable of irrigation.

This classification was undertaken in all areas covered by former reports, supplemented by local information as to possible projects and by reconnaissance. For localities with no records of water supply it was assumed to exist unless the contrary was obvious, and doubtful areas were included rather than excluded from the classification. The land was measured by plane-table survey except some small isolated areas which were estimated.

Land that had customarily been irrigated was so classed, no matter how inadequate the supply. Land capable of irrigation was tested according to a set of standards which fairly represent the experience on this area and others as to what constitutes arable land. Where pumping for irrigation was involved land was classified up to 200 feet above the source of supply.

The result of the survey of the irrigated and arable land appears in the following table.

It should be stated, that, as will be shown under the discussion of water supply which follows, the present irrigated area above the Utah State line does not limit the diversion possible at the location chosen. It is also true that the diversion when in operation, and replacing the summer flow of Colorado River in the manner contemplated by the project plan, will not limit the future development of all the arable land on Colorado River and its tributaries above Gunnison River.

Colorado River drainage—Gunnison excepted—Colorado (land classification according to streams)

Stream name	Irrigated	Arable	Total
	Acres	*Acres*	*Acres*
Colorado River:			
1. To Granby Dam	2,600	1,100	3,700
2. Granby Dam to Hot Sulphur Springs	1,300	350	1,650
3. Hot Sulphur Springs to Kremmling	3,200	1,200	4,400
4. Kremmling to Glenwood Springs	1,100	260	1,360
5. Glenwood Springs to Palisade	7,000	2,500	9,500
6. Palisade to State line	70,600	32,800	103,400
Total	85,800	38,210	124,010
Tributaries:			
Willow Creek	860	120	980
Fraser River	7,100	650	7,750
South Fork Colorado River	610	30	640
Small streams [1]	2,300	4,000	6,300
Williams Fork River	3,600	10,900	14,500
Troublesome Creek	4,200	7,200	11,400
Muddy Creek	4,900	5,100	10,000
Blue River	8,400	3,100	11,500
Small streams [2]	610	570	1,180
Sheephorn Creek	1,200	50	1,250
Piney Creek	790	50	840
Egeria Creek	5,700	9,300	15,000
Cabin Creek area	5,700	2,600	8,300
Catamount Creek	1,000	10	1,010
Sweetwater Creek area	1,100	380	1,480
Eagle River	16,400	5,000	21,400
Small streams [3]	930	60	990
Roaring Fork River	33,100	9,400	42,500
Garfield Creek	2,100	------------	2,100
Elk Creek	3,000	130	3,130
Divide and Mam Creeks	13,700	9,100	22,000
Rifle Creek	11,100	3,200	14,300
Parachute Creek	1,700	370	2,070
Roan Creek	5,600	3,300	8,900
Plateau Creek	24,000	7,000	31,600
Small streams [4]	10,200	3,000	13,200
Grand total	256,300	122,830	379,130

[1] Above Hot Sulphur Springs.
[2] Between Hot Sulphur Springs and Kremmling.
[3] Between Kremmling and Glenwood Springs.
[4] Between Glenwood Springs and Palisade.

WATER SUPPLY

The stream flow records at the different stations in the Colorado River Basin show the amount of water passing the stations after all present irrigation has taken place above, so there is no need for any further adjustment of stream flow to take care of water consumed in this irrigation.

It is assumed that all arable lands as shown will be irrigated some time in the future, notwithstanding the fact that quite a percentage is so located that it would never be feasible to irrigate. It is also further assumed that reservoirs would be built on the tributaries to conserve a portion of the flood flows to make the irrigation of these arable lands possible.

With the above assumptions it has been found that in a year like 1931, with the run-off only 40 percent of the average for a 31-year period, and the lowest year of record, the Colorado-Big Thompson project would only have to supply approximately 53,000 acre-feet to replace water diverted by the proposed project that could have been used by the Colorado River water users for power and irrigation, provided the project was in operation at that time.

The average run-off of the Colorado for the years of record are: Hot Sulphur, 31 years, 523,000 acre-feet; Glenwood Springs, including Roaring Fork, 3,413,000 acre-feet, Fruita, 6,300,000 acre-feet. These amounts are exclusive of supply consumed in present irrigation of Colorado River Basin lands.

The following is the estimated amount of water available for diversion from the drainage area above the Colorado-Big Thompson collection system at 8,260 feet elevation.

YIELD OF GRANBY RESERVOIR

Stream-flow records available on the Colorado River near the Granby Dam site for the years 1908–11 and 1935–36, and on Willow Creek for the years of 1935 and 1936, were supplemented by estimates based on available stream-flow records on the Colorado River at Hot Sulphur Springs and Glenwood Springs to cover the 37-year period, 1900 to 1936, inclusive.

A capacity of 482,000 acre-feet was selected as the best capacity for the Granby Reservoir, considering cost and use. Of this capacity, 20,000 acre-feet were set aside for dead storage to reduce pumping lifts for waters delivered to Shadow Mountain Reservoir. A further objective is to keep to the lowest practicable area the exposure of reservoir bed when storage is exhausted. This leaves an active capacity of 462,000 acre-feet.

Reservoir operating studies are based on the following conditions:

(*a*) Recorded (or estimated) past flows of Colorado River at Shadow Mountain and Granby Dams reduced by 27 percent prior to 1906, and 13 percent thereafter, of the flow of the North Fork at Grand Lake to allow for increasing diversions by the Grand River ditch.

(*b*) Willow Creek diverted to reservoir to the extent of 90 percent of the flow of Willow Creek and other streams intercepted by the diversion canal from May to October, inclusive, of each year.

(*c*) Strawberry, Meadow, and Walden Hollow Creeks also diverted whenever practicable. The flow of these streams, together with some additional waters capturable from Willow Creek at times, are expected to offset evaporation and seepage losses in excess of present losses from the Granby and Shadow Mountain Reservoir sites.

(*d*) No releases from Granby Dam for any reason.

(*c*) Transmountain tunnel to be operated at full capacity from October 1 until March 31 following, with operations thereafter gaged to fit run-off conditions so as to avoid spills and yet concentrate flows in the period of July 15 to September 15, for the purposes of best distribution in power production and to minimize reregulating storage requirements on the eastern slope. The computations assumed infallible forecasts of run-off.

(*f*) A minimum storage hold-over of 100,000 acre-feet on September 30 of each year to assure dependable power production in winter.

Under these conditions, a yield of 320,000 acre-feet of primary water is secured as follows:

Unit 1,000 acre-feet

Run-off year (October to September)	Inflow to Granby Reservoir		Tunnel diversion	Spills	Shortages
	Colorado River	Willow Creek			
1899-1900	242.8	52.4	320.0		
1900-1901	246.9	53.4	320.0		
1901-2	164.9	34.7	255.1		64.9
1902-3	222.0	48.8	270.8		49.2
1903-4	253.5	51.2	304.7		15.3
1904-5	287.9	64.9	310.2		9.8
1905-6	292.4	58.7	320.0		
1906-7	381.0	78.3	320.0		
1907-8	190.6	25.6	320.0		
1908-9	323.8	91.5	320.0		
1909-10	200.1	32.5	320.0		
1910-11	268.5	53.6	320.0		
1911-12	350.4	79.3	320.0		
1912-13	215.4	40.3	320.0		
1913-14	371.0	85.1	320.0		
1914-15	223.2	43.8	320.0		
1915-16	249.5	47.8	320.0		
1916-17	348.3	79.7	320.0		
1917-18	322.9	81.2	356.4	18.7	
1918-19	189.6	36.4	320.0		
1919-20	361.2	78.4	345.6		
1920-21	347.9	90.7	368.6	70.0	
1921-22	196.8	39.5	320.0		
1922-23	280.3	60.2	320.0		
1923-24	262.2	54.4	320.0		
1924-25	202.6	36.7	320.0		
1925-26	346.4	70.0	320.0		
1926-27	275.0	54.8	320.0		
1927-28	317.5	61.9	338.3		
1928-29	297.1	61.2	358.3		
1929-30	247.4	42.9	320.0		
1930-31	171.5	36.6	320.0		
1931-32	243.9	48.0	320.0		
1932-33	239.6	54.5	320.0		
1933-34	128.9	26.2	320.0		
1934-35	209.2	41.8	252.5		67.5
1935-36	279.7	53.8	310.0		10.0
Average	263.6	55.4	318.7	2.5	5.5

Operating results cannot be expected to result so favorably. The operating conditions enumerated imply superhuman ability to forecast stream flow. Occasional releases will be required from Granby Reservoir although small in amount. Interruptions in tunnel operation cannot always be arranged so as to lose no water.

In view of these conditions, it is concluded that the firm yield of tunnel water from the Granby and Shadow Mountain Reservoirs should be taken as 300,000 acre-feet annually. Shortages of 5 percent may be expected on an average of once every 5 years and shortages of 25 percent may be expected on an average of once every 20 years. Secondary water may be expected to be available in some years in amounts up to 50,000 acre-feet.

EFFECT OF THE PROPOSED TRANSMOUNTAIN DIVERSION ON FUTURE WESTERN SLOPE DEVELOPMENT

Most of the diverted water is derived from the spring floods, when there is an excess of water over all present and future requirements along the Colorado River in the State. To permit full use of the inflow to the Granby Reservoir, Ranch Creek Reservoir may be constructed near Tabernash to store water locally surplus. The waters there conserved would in part be utilized to replace the waters withheld at Granby Dam, but the greater part of the conserved water would be used to augment irrigation supplies down to Hot Sulphur Springs and to maintain a satisfactory stream flow in this locality for recreational purposes.

With the region above Hot Sulphur Springs taken care of by the Ranch Creek Reservoir, the critical points along the Colorado River, from the standpoint of present and future use of water, are at Glenwood Springs, where the Shoshone power plant of the Public Service Co. uses present stream-flows up to 1,250 second-feet, and near Palisades at the head of the Grand Valley, where the Government high-line canal diverts water for irrigation and power purposes. The present irrigated area along the Colorado River between Palisades and the Colorado-Utah State line is 70,600 acres.

The additional arable area in this region, not now irrigated, is as follows:

	Acres
Under constructed canals	13, 800
Pumping unit of Grand Valley project, for which canal capacity has been provided	10, 000
Lands on Mack Flat, no present provision for water service	9, 000
Total	32, 800

Maximum irrigation demand at the head of the Grand Valley for the present irrigated area and for the additional area of 23,800 acres for which provision has been made in the constructed canals, is estimated as 1,700 second-feet, and this amount is being demanded in the pending adjudication proceeding.

With maximum irrigation demands there is a full water supply for the Orchard Mesa pumping plant and for the Grand Valley power plant. In the nonirrigation season the controlling requirement is for power with a total demand of 800 second-feet for power and for domestic needs under the higher canals. With the new area of 9,000 acres developed, the future demands are then estimated as 1,800 second-feet in the months of May to August, inclusive, tapering off uniformly to 800 second-feet on April 1 and on November 30.

In determination of the effect of the Colorado-Big Thompson transmountain diversion on the western slope, the past stream flows at Glenwood Springs and at the head of the Grand Valley were first depleted to show the resulting stream flows with the following developments:

(*a*) Full irrigation development of 276,000 acres of irrigated and arable lands along the Colorado River and tributaries above Palisades (the present irrigated area is 186,000 acres).

(*b*) Full development of Moffat Tunnel diversion from Fraser River and tributaries, Jones Pass diversion from Williams River, and Independence Pass diversion from the Roaring Fork, including replacement storage so that these projects may divert all flows interceptible.

From the reconstructed flows, thus computed, there was subtracted the water estimated to be withheld at the Granby Reservoir site. The reductions in stream flow at Glenwood Springs and at the head of the Grand Valley, during those periods of each year when the resulting stream flows would be less than the future demands above described, then represents the effect of the project on the western slope if no replacement storage were provided. These computations were made for the years 1926 to 1936, inclusive, at Glenwood Springs, and for the entire period of record, 1902 to 1936, inclusive, at the head of the Grand Valley, with the following results:

Year	Shortages at Glenwood Springs (acre-feet)			Shortages at head of Grand Valley (acre-feet)		
	End of flood season, Oct. 31 [1]	Nov. 1 to flood season of following year [2]	Total	Before flood season in spring [3]	After flood season to Oct. 31	Total
1902	(4)	(4)	----------	6,000	39,000	45,000
1903	(4)	(4)	----------	3,000	12,000	15,000
1904	(4)	(4)	----------	None	2,000	2,000
1905	(4)	(4)	----------	None	14,000	14,000
1906	(4)	(4)	----------	None	None	None
1907	(4)	(4)	----------	None	None	None
1908	(4)	(4)	----------	None	6,000	6,000
1909	(4)	(4)	----------	None	None	None
1910	(4)	(4)	----------	None	12,000	12,000
1911	(4)	(4)	----------	None	1,000	1,000
1912	(4)	(4)	----------	None	None	None
1913	(4)	(4)	----------	None	7,000	7,000
1914	(4)	(4)	----------	None	None	None
1915	(4)	(4)	----------	None	9,000	9,000
1916	(4)	(4)	----------	None	None	None
1917	(4)	(4)	----------	None	None	None
1918	(4)	(4)	----------	None	1,000	1,000
1919	(4)	(4)	----------	None	7,000	7,000
1920	(4)	(4)	----------	2,000	None	2,000
1921	(4)	(4)	----------	None	None	None
1922	(4)	(4)	----------	None	None	None
1923	(4)	(4)	----------	None	None	None
1924	(4)	(4)	----------	None	4,000	4,000
1925	(4)	(4)	----------	None	None	None
1926	18,000	19,000	37,000	None	2,000	2,000
1927	7,000	32,000	39,000	None	None	None
1928	10,000	18,000	28,000	None	None	None
1929	None	20,000	20,000	None	None	None
1930	12,000	14,000	26,000	None	None	None
1931	37,000	16,000	53,000	1,000	27,000	28,000
1932	14,000	24,000	38,000	None	3,000	3,000
1933	23,000	21,000	44,000	5,000	15,000	20,000
1934	31,000	17,000	48,000	None	28,000	28,000
1935	20,000	15,000	35,000	2,000	11,000	13,000

[1] Encroachment on irrigation supplies.
[2] Encroachment on winter power waters.
[3] These shortages occur in years of late run-off when irrigation requirements rise faster than stream flow. Winter flows are always adequate Nov. 1 to Apr. 1.
[4] Not computed.

DIVERSION PLAN AND STRUCTURES

REPLACEMENT

In order to protect the water users in the Colorado River Basin against any depletion of their water supply by diversions through the Continental Divide tunnel to northeastern Colorado, a storage reservoir is planned on the Blue River about 16 miles southeast of Kremmling, Colo. This reservoir is to be known as the Green Mountain.

The dam site is located in the E ½ of sec. 15, T. 2 S., R. 80 W., sixth principal meridian, near the head of a box canyon, between Green and Little Green Mountains, caused by the river cutting through a porphyry sill. The foundation bedrock consists of sedimentary rocks, either Dakota sandstone or Morrison shales, and the intrusive porphyry.

The irrigation outlet capacity is 1,000 cubic feet per second, and the power outlet capacity is 1,500 cubic feet per second. The spillway capacity is 25,000 cubic feet per second.

The reservoir will flood 2,100 acres of land and will have a capacity of 152,000 acre-feet.

From the water-supply studies it was found, assuming that full development had taken place in the Colorado River Basin and that the Big Thompson project had been in operation the last 35 years, that in the year 1931, the lowest year of dependable run-off record, the Colorado Basin users above Glenwood Springs would have been shorted 37,000 acre-feet for irrigation use and the Public Service Co. would have been shorted 16,000 acre-feet at their power plant at Shoshone during the nonirrigation season, or a total shortage of 53,000 acre-feet. Accordingly, 50,000 acre-feet of Green Mountain storage have been allocated to replacement purposes for which the water users in northeastern Colorado will pay $1,500,000. The remaining 100,000 acre-feet are allocated to power and will be paid for out of power revenues.

Since the average shortage for both power and irrigation for the last 10 years, the lowest 10 years of run-off record is 36,000 acre-feet. There would be the 16,000 acre-feet difference, and a portion of the 100,000 acre-feet let out for power that could be used by the Colorado Basin users to supply shortages that might occur in their irrigation use in years of extreme low run-off, these shortages not being caused by the transmountain diversion.

The total estimated cost of the dam and reservoir is $3,776,032, $2,276,032 of which will be paid for from power revenues.

GRANBY RESERVOIR AND STORAGE

The storage of Colorado River waters for the project is to be made in what is known as Granby Reservoir which is located in Tps. 2 and 3 N., Rs. 75 and 76 W., sixth principal meridian, in Grand County, Colorado. The reservoir basin occupies the valleys of Stillwater Creek, the south fork or Arapaho Creek, and the main Colorado River.

The damsite is located about 4 miles northeast of the town of Granby, Colo., in the NE¼ of sec. 11, T. 2 N., R. 76 W., in Grand County, Colo. It is located at the head of a short canyon which the river has cut through pre-Cambrian rocks forming a spur of the main Rocky Mountain mass. At the damsite the canyon at river-bottom level is 200 feet wide, while at elevation 8,275 it is 720 feet in width.

The dam is to be a combination earth and rockfill structure with a maximum height of 223 feet. The outlet capacity is 300 cubic feet per second and the spillway capacity is 12,000 cubic feet per second.

With the high-water line at elevation 8,275 feet the reservoir has a capacity of 482,860 acre-feet, and will flood an area of 6,943 acres.

This reservoir will not only intercept the flow of the Colorado at that point, but the flow of Willow Creek will be intercepted near Dexter, Colo., and brought into the reservoir through a canal of 1,000 cubic feet per second capacity. Willow Creek enters the Colorado about 2 miles below Granby Dam.

It is estimated that Willow Creek will supply an average of about 60,000 acre-feet per year, and that the total estimated cost of this diversion is $733,203.

The storage in Granby Reservoir will also be augmented by the flow of Meadow and Strawberry Creeks, tributaries of Fraser River which enters the Colorado about 5 miles below the dam. The canal intercepting these two creeks will have a capacity of 500 cubic feet per second, and it is estimated they will produce an average of 12,000 acre-feet a year. The total estimated cost of this diversion is $133,600.

If water supply records kept in the future show there is sufficient water supply left in the Fraser River below the City of Denver's diversion, a canal could be taken out of it just below the mouth of St. Louis Creek near the town of Fraser, Colo., and extend from there to Granby Reservoir, intercepting Ranch, Meadow, and Strawberry Creeks on the way. A small regulating reservoir should be built on Ranch Creek above where the Canal intercepts it.

NORTH FORK DIVERSION DAM AND SHADOW MOUNTAIN LAKE

In order to divert the water of the North Fork of the Colorado into Grand Lake and thence to the channel extending from it to the west portal of the Continental Divide tunnel, it is planned to construct a concrete overflow dam 35 feet in height, above streamed, across the North Fork about one-half mile below its junction with the Grand Lake outlet.

The dam site proper is located in the NW¼ of sec. 19, T. 3 N., R. 75 W., and is a glacial morain cut through by the river.

The water backed up by this dam will form a lake called Shadow Mountain, the name of a nearby mountain, which will have a surface area of 1,356 acres. The elevation of this lake will be the same as Grand Lake and connected with it by means of the present outlet.

NORTH FORK DIVERSION DAM

The dam proper is a concrete gravity overflow spillway section, 90 feet long, with crest elevation at 8,370. This spillway is designed for maximum discharge of 1,800 cubic feet per second. On each side of the overflow section is a concrete gravity section containing three automatic siphon spillways on each side. The total spillway capacity is 9,400 cubic feet per second.

The total estimated cost is $483,928.

GRANBY PUMPING PLANT

As stated before, the water surface elevation of Granby Reservoir is 8,275 and the water surface of Shadow Mountain and Grand Lakes is 8,369. In order to get the water stored in Granby Reservoir into Shadow Mountain Lake and available for delivery through the Continental Divide tunnel, a pumping plant is located on the north shore of Granby Reservoir about one-half mile above the junction of the South Fork with the Colorado. A granite spur juts out into the reservoir site at that point making it ideal for the intake tunnels and a shaft for the pump.

The proposed pumping plant will contain three motor-driven vertical-shaft pumping units having a total capacity of 900 cubic feet per second with full reservoir and 550 cubic second-feet at low water. At normal water surface the capacity will be 870 cubic feet per second.

Each pump will be driven by a 6,500-horsepower synchronous motor.

Power will be delivered to the plant from a 69,000-volt transmission line extending from power plant no. 1 just below Estes Park, around the Rocky Mountain National Park, and crossing the Continental Divide at Buchanan Pass about 5 miles south of the park boundary.

The water from the pumps empties into a canal of 900 cubic second-feet capacity and runs by gravity into Shadow Mountain Lake. It is planned to operate this canal all winter when temperatures get as low as 40° below zero. The latent heat in the water and the friction heat absorbed from the pumps will prevent this water from freezing and will keep quite an area open after the water reaches Shadow Mountain Lake.

The total estimated cost of the pumping plant is $1,250,000.

The total estimated cost of the pump canal is $417,553.

CONTINENTAL DIVIDE TUNNEL

The west tunnel portal is connected with Grand Lake by means of a channel constructed 67.5 feet in width and 15 feet in depth. At the lake end of this channel a permanent concrete barrier or weir will be placed with a crest elevation at 8,368 which would be the minimum elevation to which the water in Grand Lake could be drawn. Since the barrier is so constructed that it requires the water to be 1 foot in depth over it to supply the normal capacity of the tunnel, the normal elevation of Grand and Shadow Mountain Lakes would be 8,369 feet.

The present maximum fluctuation of Grand Lake is about 4 feet, or from an elevation of 8,368 in winter to 8,372 feet during the peak run-off from melting snow. The automatic control gates at the North Fork Diversion Dam and at tunnel inlet will so control the elevation of the water surface in Grand Lake that it would never fluctuate more than 1 foot.

The Continental Divide tunnel extends from the easterly end of Grand Lake to Wind River, southwest of Estes Park, with an azimuth of 242° 20′ 30″, and length of 69,023 feet. It is to be horseshoe shape 9.5 feet in diameter and lined throughout with a 9-inch concrete lining.

It will be located entirely in pre-Cambrian rock consisting of the Longs Peak and related granites and the gneisses and schists of the Idaho Springs formation. The granites are strong massive rocks. Gneisses predominate over schists and only a small proportion have prominent and continuous cleavage planes. The proportion of granite to gneiss and schist is approximately 4 to 1.

From a detailed geological survey of the tunnel and comparing it with conditions actually encountered in the Moffat Railroad tunnel, which was built under the Continental Divide for the Denver & Salt Lake Railroad, and about 25 miles due south of this one, it was estimated there would be only 400 feet of bad ground and 5,200 feet of ground needing support. However, for purposes of estimate, it was figured there would be 6,900 feet of bad ground and 17,500 feet of ground needing support.

The total estimated cost is $7,271,371.

POWER CONDUIT NO. 1

Power conduit no. 1 extends from the east portal of the Continental Divide tunnel in Wind River to the penstock of power plant no. 1 on the northeast slope of Prospect Mountain.

Both ends of the Continental Divide tunnel are without the national-park boundaries but the area east of the east portal is authorized by Congress to be taken in, through that area. The water will be taken through a closed conduit consisting of a 10-foot reinforced concrete pipe completely buried. The total length of power conduit is 5.36 miles, of which 1.86 miles is closed conduit, 1.19 miles is concrete lined tunnel, 0.98 mile is siphon, and the remainder is open canal.

The total estimated cost of power condı it no. 1 is $1,101,000.

POWER PLANT NO. 1

Power plant no. 1 will be located on the south bank of the Big Thompson River about one-half mile east of Estes Park. It will contain two 15,000 kilovolt-ampere generating units with auxiliaries. Each unit will consist of a vertical-shaft, single-runner, spiral-casing type hydraulic turbine operating under an effective head of 705 feet direct connected to a 15,000 kilovolt-ampere water-wheel type generator. A complete description with cost estimate will be found in Power and Pumping Summary.

Until there has developed a sufficient market for power to justify the construction of power plants nos. 2 and 3, the water will be turned into the Big Thompson at power plant no. 1 and carried by that stream to a diversion dam located in SE¼ sec. 1, T. 5 N., R. 71 W., about midway between the present diversion dam and power plant for the town of Loveland, Colo.

POWER CANAL NO. 4

From this diversion dam the water will be carried in a canal of 750 cubic second-feet capacity on the south side of the stream a distance of 4.93 miles to a point just above the mouth of the Big Thompson Canyon. At this point a portion of the water will drop direct into the Big Thompson River to supply the supplemental water demands of that stream and a portion will be siphoned across to elevation 5,450 to supply the canal going to the Poudre River, which will be described later. Power plants nos. 4 and 4–A will be constructed at this point to take advantage of a fall of 550 feet into the Thompson and 358 feet to the Poudre Canal when the power market justifies.

CARTER LAKE SUPPLY CANAL

About 3.07 miles below the diversion dam mentioned above, a canal of 300 cubic feet per second takes off toward the south and supplies Carter Lake.

This canal is 8.78 miles in length, of which 7,040 feet is tunnel 1,878 feet siphon, and the remainder is open canal.

The estimated cost of this supply canal is $710,629.

CARTER LAKE RESERVOIR

This site is located in Ts. 4 and 5 N., R. 70 W., of sixth principal meridian, about 1 mile north and 7 miles west of Berthoud, Colo.

The reservoir will occupy a valley about 2¾ miles long and from one-half to 1 mile wide. The northern portion of the area is a natural basin called Carter Lake. This lake dried up during the last 5 drought years, for the first time within the memory of the white settlers.

The proposed maximum water surface in the reservoir is at elevation 5,760 with a capacity of 111,963 acre-feet. The area of high water line is 1,150 acres. For this water surface three dams will be required. Dam no. 1 is located at the natural outlet of the valley and will contain the outlet works for the reservoir; the other two dams will occupy saddles. These dams are earth and rock fill; the main dam is 243 feet high, and the saddles 43 and 48, respectively.

The capacity of the outlet to St. Vrain supply canal is 300 cubic feet per second, the outlet to the Big Thompson has a capacity of 1,000 cubic feet per second.

The total estimated cost of the reservoir is $1,822,202.

ST. VRAIN FEEDER CANAL

A canal of 300 cubic feet per second capacity will extend from the small outlet of Carter Lake to the St. Vrain, reaching the St. Vrain high enough to supply all ditches.

The length of this canal is 9.76 miles with 3,445 feet in tunnel, 1,575 feet of siphons, and the remainder open canal.

The estimated cost of the St. Vrain feeder is $368,951.

BIG THOMPSON FEEDER

About one-half mile below Carter Lal e Dam a canal will be taken out of the draw leading from the dam, and will run into Cottonwood Creek, a tributary of the Big Thompson. This canal will have a capacity of 1,000 cubic feet per second and be 5.37 miles in length.

The cost is estimated at $155,246.

HORSETOOTH SUPPLY CANAL

This canal starts at the end of a siphon across the Big Thompson from power conduit no. 4. This water will pass through power plant no. 4–A when constructed. The canal starts at elevation 5,450 with a capacity of 250 cubic feet per second. The structures, however, are designed for a capacity of 400 cubic feet per second on the theory that some time in the future it might be necessary to increase the capacity of the canal to that amount. The length of this canal is 9.88 miles, of which 12,863 feet is tunnel, 3,296 feet is siphons, and the remainder open canal.

The elevation of 5,450 was chosen because it not only puts the water above all present diversions on the Poudre River, but it afforded the most direct and economical route.

The estimated cost of this feeder is $1,208,391.

HORSETOOTH RESERVOIR

The proposed Horsetooth Reservoir will occupy a valley 6 miles long and from one-quarter to three-quarters miles wide, extending in a north-south direction, formed by the erosion of soft red beds of Lykens formation between harder ridges of Lyons on the west and Dakota sandstone on the east. There are three natural outlets to the east through the Dakota hogback, namely, Soldier, Dixon, and

Spring Canyons, which are the sites of three proposed dams of the same names. The fourth proposed dam, Horsetooth, will cross the valley at the north end on a low saddle separating the valley from drainage to the north into the Poudre River. The outlet will be through the Horsetooth Dam saddle. There are no outlets through the other dams. The proposed water surface is at 5,400 feet in elevation which gives a capacity of 96,756 acre-feet. The area flooded will be 1,513 acres. The outlet capacity was designed for 1,200 cubic feet per second with reservoir full. This large capacity is necessary as the irrigation use requires that the entire amount of supplemental water be delivered at a rate that would supply it in 60 days.

The advantages of a reservoir at this point are: It is high enough to supply all users from the main Cache La Poudre River and is located close to it. It takes the place of 6 miles of canal through rough country and allows a canal of 250 cubic second-feet to be constructed from the Big Thompson instead of one for 1,000 cubic feet per second.

The estimated cost of the reservoir is $3,625,021.

POUDRE FEEDER CANAL

From the outlet of Horsetooth Reservoir a canal of 1,000 cubic second-feet capacity will extend north to Lewstone Creek, a tributary of the Poudre. The water will run down this creek to the Poudre above all the diversions except the Poudre Valley.

POUDRE VALLEY FEEDER CANAL

A canal will extend from Lewstone Creek to the Poudre Valley Canal about 1 mile below its headgate, crossing the Poudre River in a siphon. This canal will have a capacity of 400 cubic feet per second to take care of the supplemental demands of the Poudre Valley Canal and also the demands of the North Poudre irrigation district. The total length of the two canals is 5.48 miles.

The cost of the Poudre Feeder and Poudre Valley Canals is estimated at $632,843.46.

NORTH POUDRE FEEDER CANAL

It is planned to enlarge the Poudre Valley Canal for a distance of 3.58 miles from the point the supply canal enters to the location of the pumping plant for the North Poudre district. This will enlarge the canal from a capacity of 500 to 750 cubic feet per second and the estimated cost is $11,436.

NORTH POUDRE PUMPING PLANT

This pumping plant, constructed on the banks of the Poudre Valley Canal, will consist of two 75 cubic second-feet capacity vertical synchronous motor driven single stage pumps, operating against an effective head of 187 feet.

The estimated cost is $200,000.

NORTH POUDRE FEEDER CANAL

This canal of 150 cubic second-feet capacity extends from the pressure outlets of the pumping plant to the North Poudre Canal, a distance of 9.98 miles.

The estimated cost is $128,889.

ARKINS RESERVOIR

This reservoir is located on Buckhorn Creek, a tributary of the Big Thompson, in Tps. 5 and 6 N. R. 70 W., sixth principal meridian, and about 8 miles northwest of Loveland, Colo. The object of this reservoir is to provide storage for Colorado River waters brought over in the wintertime and to be used to supply supplemental water on the lower South Platte in water districts 1, 2, and 64. It will also serve in connection with the use of the 16,000 acre-feet of floodwater now available on the Big Thompson.

The bringing of more of the supplemental water over in the wintertime aids materially in the production of a maximum amount of power out of the waters of the Big Thompson River. For that reason the entire cost of the inlet to Arkins Reservoir and one-half the cost of the reservoir itself is assessed against power and paid for out of power revenues from plant no. 1.

The capacity of Arkins Reservoir is 50,000 acre-feet with a high water line at 5,275 feet elevation and floods 929 acres of land.

The dam site occupies a notch cut through the Dakota sandstone ridge by Buckhorn Creek.

The main dam is an earth- and rock-fill structure 155 feet in height with an outlet capacity of 650 cubic feet per second and a spillway of 10,000 cubic second feet capacity.

There is a saddle dam, in addition to the main dam of earth- and rock-fill construction, 50 feet maximum height, built across a saddle at the southern extremity of the reservoir.

The total estimated cost of the reservoir and dam is $1,740,737.

The estimated cost of the Arkins Reservoir inlet is $351,488.

This inlet diverts from the Big Thompson River just below the dam of the Handy Canal and follows around the north side of the river a distance of 2.33 miles to Arkins Reservoir.

ROCKY MOUNTAIN NATIONAL PARK

Every effort has been made in the survey and design of this project to not disturb the natural beauties of the Rocky Mountain National Park and its surrounding areas. The Continental Divide tunnel was lengthened 1.6 miles in order that its extremities should fall outside the boundaries of the park. The conduit leading from the east portal of the tunnel to power plant no. 1 is to be buried and the surface landscaped through the area authorized by Congress to be added to the park. The waste from the east portal of the tunnel placed in this area is to be terraced and planted with evergreen trees. The waste from the west portal is to be used to fill up some low areas and render the area suitable for the building of summer homes.

The approach to the Western Gateway of the Rocky Mountain National Park will be along the shores of Shadow Mountain Lake with its fluctuation of only 1 foot instead of the swampy area that now breeds mosquitoes and exposes mud flats in low water.

The bill authorizing the creation of the Rocky Mountain National Park reserved the right for the Bureau of Reclamation to survey and construct an irrigation project within the boundaries of the park.

OPERATION OF THE SYSTEM

IRRIGATION PROJECT OPERATIONS

The system is planned and it is anticipated that it will be operated in a manner to have the water available in Carter Lake, Horsetooth and Arkins Reservoirs available by July 1, to the full capacity of those reservoirs, 256,000 acre-feet. The usual demand for supplemental water begins July 1 to 15 and extends to September 15 to 30. The outlets of the reservoirs are planned to deliver the water from the reservoirs in 60 to 75 days, including the water that must pass through them for direct delivery that may be in the way of being transferred from the Colorado River Basin to the eastern slope during the period of irrigation application. The balance of the 310,000 acre-feet, or 54-000 acre-feet, will be available for direct irrigation use as brought over during the above period or to some extent may be required prior to July 1.

The run-off of the waters of the Colorado River here contemplated to be used will largely be secured from the melting snows during May, June, and early July and stored in the Granby Reservoir. During the fall of that year, winter and spring of the following year, the water will be transferred from the Granby Reservoir through the Continental Divide tunnel at a uniform rate and restored in the Carter Lake, Horsetooth, and Arkins Reservoirs. This will permit a flow that is well suited to the development of firm power through the five power plants that will eventually be constructed along the Big Thompson as shown on the map of the general layout.

Granby Reservoir will act as a hold-over reservoir to carry the water from years of excessive run-off to years of subnormal flow.

POWER PROJECT OPERATION

Water will be carried through the Continental Divide tunnel at a uniform flow for the generation of power at the several power plants, except that the quantity will be reduced during the summer season when some water from the Big Thompson is available for power purposes in power plants nos. 2, 3, 4, and 4–A. At this period there will be little or no demand for power for pumping at the Granby pumping plant, which will permit the cutting down of the quantity of water to take care of the commercial power load.

It is planned to construct the Granby pumping plant and the Granby pump canal 150 percent of the capacity of the Continental Divide tunnel. This will permit the operation of the pumping plant at full capacity with off-peak power, and reduce the amount of pumping with firm power. The varying discharge of the pump ditch during the 24-hour period will be equalized by the Shadow Mountain and Grand Lakes, so that a uniform discharge will be maintained through the Continental Divide tunnel. The range in height of water surface in Shadow Mountain and Grand Lake to equalize this flow will not exceed two-tenths of a foot, and will be greatest in the winter and early spring months.

There is an average of 16,000 acre-feet of surplus water on the Big Thompson available for storage in the system mainly in May and June. In order to take this water into the reservoirs it will be necessary to reserve capacity in the three reservoirs on the eastern slope until toward the latter part of June. The snowfall, the main source of this water supply, will be known well in advance so that operations of the several parts of the system, including the production of power at the several power plants, can be adjusted to take care of this water and hold back an equal amount in Granby Reservoir.

TENTATIVE PROJECT FINANCIAL SET-UPS

This proposed development consists of two projects: first, the irrigation project, and second, the power project.

It is planned that those features of the development that are used mainly for irrigation are grouped under the irrigation project set-up, while those used entirely, or are made of a greater capacity because of power development, are grouped in whole or in part in the power project set-up.

IRRIGATION PROJECT

The following major features with their appurtenant structures are given with the estimated field costs including 10 percent for engineering and 15 percent for contingencies. The full capacity of Arkins Reservoir is necessary to develop a larger portion of firm power than would otherwise be possible without it. At the same time, a reservoir of half its capacity or additional capacity in Horsetooth or Carter Lake Reservoirs would be necessary to provide capacity to deliver the irrigation water as needed. It is, therefore, deemed equitable to divide the cost of this reservoir equally between the irrigation and power projects.

The Green Mountain Reservoir, with a capacity of 152,000 acre-feet, is larger than is necessary to furnish replacement for a like amount of water diverted by the project above Granby Dam at a time when it would be required for irrigation, present and future, and to furnish the Shoshone power plant 1,250 second-feet or such lesser amount that they would be entitled to receive if the proposed project was not operating. From studies made, it appears that 50,000 acre-feet will be sufficient to replace all the water that the proposed project will take at a time when required for use lower down in the stream within the State. Therefore 52,000 acre-feet of the Green Mountain Reservoir capacity is allocated for replacement (including evaporation losses) and charged to the irrigation project. The balance of the capacity or 100,000 acre-feet is allocated to the power project and is to be paid for out of power revenues.

The following is a summary of the irrigation project costs:

Estimated cost chargeable to irrigation feature

Willow Creek feeder canal	$733, 203
Granby Reservoir	2, 813, 703
Granby pumping plant	1, 250, 000
Granby pump canal	417, 553
North Fork diversion dam	483, 928
Continental Divide tunnel	7, 271, 371

Estimated cost chargeable to irrigation feature—Continued

Carter Lake supply canal		$710, 629
Horsetooth supply canal		1, 208, 391
St. Vrain feeder canal		368, 951
Big Thompson feeder canal		155, 246
Poudre feeder canal		632, 843
Poudre Valley feeder canal		11, 436
North Poudre feeder canal		128, 889
North Poudre pumping plant		200, 000
Horsetooth Reservoir		3, 625, 021
Arkins Reservoir		1, 859, 323
Carter Lake Reservoir		1, 925, 253
Green Mountain Reservoir (52,000 acre-feet replacement) (100,000 acre-feet for power)		3, 776, 032
Improvement of Colorado River above Kremmling to maintain fishing and to adjust the present irrigation system to the altered conditions		300, 000
		27, 871, 772
Less the following items tentatively chargeable to power:		
One-half cost of Arkins Reservoir	$929, 661	
Portion of cost of Green Mountain Reservoir for 100,000 acre-feet	2, 276, 032	
		3, 205, 693
Cost of irrigation features		24, 666, 079
Say		24, 800, 000

REPAYMENT

Twenty-four million eight hundred thousand dollars upon 310,000 acre-feet at $80 per acre-foot.

Two dollars per acre-foot on 40-year repayment basis.

In the above repayment is predicated upon the contracts to be made upon a basis of 310,000 acre-feet. Beside the 320,000 acre-feet available from the Colorado River drainage there is an average of 16,000 acre-feet available for storage on the Big Thompson, making 336,000 acre-feet in all, leaving 26,000 acre-feet for losses on the eastern slope and for the uncertain, heretofore mentioned in operations on the western slope.

The power costs are shown under the heading "Power and pumping system."

The construction of power plant no. 1 as shown in the power set-up is a necessary development in order to secure power for pumping purposes at the Granby pumping plant.

POWER AND PUMPING SYSTEMS

The ultimate power and pumping system is proposed to consist of the major pumping plant at Granby, power plant no. 1 near the town of Estes Park, power plant no. 2 near Drake post office, power plant no. 3 at Cedar Cove, power plants nos. 4 and 4–A near the mouth of the Big Thompson Canyon, and power plant no. 5 at the Green Mountain Reservoir. If conditions justify, there may also be a pumping plant on the Poudre River near the point where the proposed Poudre supply canal crosses the river. Power plant no. 5, Granby pumping plant, and power plant no. 1, would be interconnected by a single circuit 69,000-volt transmission line. Power plants nos. 1 to 4–A, inclusive, would be interconnected by two 115,000-volt transmission lines and these same lines would extend to one or more load centers where the power could be disposed of commercially.

The buildings for the power and pumping plants would be of reinforced concrete construction of suitable size to house the machinery and provide space for such facilities as would be required for efficient and economical operation. For scenic reasons, special care would be taken in the architectural design of the buildings to make them blend in with the beauties of the surrounding territory so as to be both as inconspicuous as possible and also as artistic as feasible without undue expenditure. An artist's sketch of one of these buildings is included with the report.

Following is a tabulation covering the essential data for each of the power and pumping plants:

Power plants

Plant designation	Effective head in feet	Turbine capacity in cubic feet per second	Power available in horsepower	Number of units	Size of each unit in horsepower	Installed power in kilowatts
No. 1	704	550	38,800	2	20,000	30,000
No. 2	1,195	550	65,800	2	34,000	50,000
No. 3	328	550	18,000	2	9,000	13,500
No. 4	550	400	22,000	1	22,000	16,000
No. 4-A	381	250	9,500	1	9,500	7,000
No. 5	225	1,500	33,800	2	17,000	26,000
Total installed power in kilowatts						142,500

Pumping plants

Plant designation	Head in feet	Pump capacity in cubic feet per second	Capacity of each pump in cubic feet per second	Number of pumps	Rating of each motor in horsepower	Power required in kilowatts
Granby	130	870	290	3	6,500	15,000
Poudre	187	150	75	2	2,000	3,000
Total installed pumping, kilowatts						18,000

POWER PLANT NO. 1

Power plant no. 1 will be located on the south bank of the Big Thompson River about one-half mile east of the village of Estes Park and will contain two 15,000 kilovolt-ampere generating units with auxiliaries. Each unit will consist of a vertical-shaft, single-runner, spiral casing type hydraulic turbine operating under an effective head of approximately 705 feet and direct connected to a 15,000 kilovolt-ampere water-wheel type generator with direct connected exciter and pilot exciter. Water would be supplied to each turbine through a steel penstock approximately 5,000 feet long, with synchronous bypasses provided so that the flow through the penstock can be discharged either through the turbines or the bypasses into the Big Thompson River. The bypasses will be mechanically connected to the turbine gate operating mechanism so that rapid governing of the units under varying load conditions can be effected without creating excessive water hammer. Trashracks with shut-off gates for each penstock will be provided in the forebay structure. The headgates will be controlled from the power plant. A spillway will be provided to care for the flow when the headgates are closed and the penstocks inoperative. The plant will be equipped with all necessary auxiliaries, including a traveling crane for handling the large pieces of equipment. A small machine shop will be provided for making minor repairs. An outdoor type substation with self-cooled transformers will be provided for stepping the voltage up to 69,000 for transmission to the Granby pumping plant, and to 115,000 volts for transmission to commercial markets. The substation structure will be of the conventional structural steel type with high voltage oil circuit breakers, lightning arresters and necessary auxiliaries. The control of the oil circuit breakers will be from the main power plant switchboard. Operators' quarters, a warehouse, and a large machine shop for general project repairs will be provided in the vicinity of the power plant.

POWER PLANT NO. 2

Power plant no. 2 will be located about one-half mile northwest of Drake, on the south bank of the north fork of the Thompson River just above its junction with the Big Thompson. The plant will contain two 25,000-kilovolt-ampere generating units of the horizontal shaft type. The net head will be approximately 1,195 feet. Each unit will consist of a double overhung impulse wheel hydraulic turbine with the generator mounted in the center, between the two runners. A direct connected exciter and pilot exciter will be mounted at one end. Water will be delivered to the turbines through two steel penstocks about 4,150 feet long. Each penstock will be provided with two branches to the turbine nozzles and each branch will be provided with a synchronous bypass arranged so that the flow through the penstock can be discharged through either the nozzles of the bypasses to the river. The bypasses will be mechanically connected to the turbine nozzle operating mechanism so that rapid governing can be effected under varying load conditions without excessive water hammer. The head-gate structure will be provided with trash racks and sliding gates at the end of the penstocks and a spillway to care for the flow when the gates are closed. The plant will be complete with all necessary auxiliaries for station service requirements and with a crane for handling the machinery. A structural steel outdoor type substation will be provided with self-cooled transformers for stepping the voltage to 115,000 volts, and with outdoor type oil circuit breakers, lightning arresters, and other necessary auxiliaries. The operation of the substation will be handled from the main switchboard of the power plant. Quarters for the operators will be provided adjacent to the power plant.

POWER PLANT NO. 3

Power plant no. 3 will be located about one-half mile east of the Loveland power-diversion dam on the north bank of the Big Thompson River. The plant will contain two 6,500 kilovolt-ampere generating units, each consisting of a vertical hydraulic turbine direct connected to a generator with main exciter and pilot exciter. The effective head will be approximately 328 feet. Water from the head-gate structure will be delivered to the turbines through steel pen stocks about 650 feet long. Each pen stock will be provided with a synchronous bypass arranged so that the flow through the pen stock can be discharged either through the turbines or the bypasses to the Big Thompson River, and to allow rapid governing of the units without excessive water-hammer. The head-gate structure will be provided with trash racks and sliding gates at the head of the pen stocks and a spillway to care for the flow when the gates are closed. The plant will be complete with all necessary auxiliaries for station-service operation, and with a crane for handling equipment. The plant will be provided with a structural-steel outdoor-type substation similar to that proposed for plant no. 2.

POWER PLANTS NOS. 4 AND 4–A

Power plant no. 4 will be located about 2 miles east of Cedar Cove on the south bank of the Big Thompson River, while power plant no. 4–A will be located a short distance upstream from plant no. 4, and at an elevation about 175 feet above the river. The capacity of plant no. 4 will be 16,000 kilovolt-amperes and of plant no 4–A, 7,000 kilovolt-amperes. One unit only will be provided at each plant and will consist of a vertical-shaft, single-runner, spiral-casing type turbine direct connected to a vertical water wheel generator with direct connected main and pilot exciters. Plant no. 4 will have an effective head of about 550 feet, and plant no. 4–A, 380 feet. Plant no. 4 will receive its water through a single steel penstock about 1,960 feet long, and plant no. 4–A, through a similar pipe about 1,400 feet long. Each plant will be provided with synchronous bypasses similar to those in plants nos. 1 and 3. Plant no. 4 will discharge directly into the Big Thompson River. Plant no. 4–A will be siphoned under the river through a pressure tunnel to the proposed Poudre supply canal, but will have provisions so that if so desired, the water may be discharged directly into the Big Thompson River. The headgate structure will be provided with trashracks, sliding gates, and spillways similar to those in plants nos. 1, 2, and 3. A single outdoor structural steel type switchyard will be provided for the two plants. The equipment in this substation will be similar to that for plants nos. 1, 2, and 3. Plant no. 4–A will be remotely controlled from plant no. 4, so that the two plants can be operated with one set of operators. The plant will be complete with auxiliaries and cranes similar to that in other plants. Quarters for the operators will be provided in the vicinity of the plants.

POWER PLANT NO. 5

Power plant no. 5 will be located about 12½ miles southeast of Kremmling, on the east bank of the Blue River, immediately downstream from the dam forming the proposed Green Mountain Reservoir. The plant will contain two 13,000 kilovolt-ampere generating units of the vertical hydraulic-turbine driven type, with direct connected generator with main and pilot exciters. The plant will have a varying head depending upon reservoir water surface, but it is expected that the average head will be about 225 feet. The trashrack and intake structure will be located immediately upstream from the dam and a single steel penstock installed in the tunnel will conduct the water to the power plant. Each turbine will be provided with a pressure regulator or relief valve to limit the water hammer under sudden change of load conditions. The plant will be complete with necessary auxiliaries for station service, a small machine shop for minor repairs, and a crane for handling equipment. An outdoor structural steel substation will be provided complete with equipment for stepping the voltage up to 69,000 volts for transmission and with oil circuit breakers and other necessary auxiliaries for the control and protection of the lines and equipment. The oil circuit breakers will be controlled from the main switchboard of the power plant. Quarters for operators will be constructed in the vicinity of the power plant.

GRANBY PUMPING PLANT

The Granby pumping plant will be located approximately 6 miles south of the village of Grand Lake on the north shore of the proposed Granby Reservoir. The plant will contain three motor-driven vertical-shaft pumping units having a total capacity of 900 second-feet at full reservoir, and 550 second-feet at low water. The total capacity at the normal water surface will be approximately 870 second-feet. The motors will be of the synchronous type and arranged for semimagnetic operation. That is, the operator will be required only to close the main switch to the unit in order to place it in operation, and to open the same switch to discontinue operation. The motors will be equipped with direct connected exciters. The water from the Granby Reservoir will be delivered to the pumps through tunnels about 155 feet long. A channel in the reservoir will convey the water to the mouth of the intake tunnels in extreme low water. Water from each pump will be discharged through about 175 feet of tunnel, and 165 feet of steel pipe to the canal at elevation approximately 8,381. This canal, which will be approximately 4 miles in length, will discharge into the proposed Shadow Mountain Lake. The center line of each pump and propeller will be at approximately elevation 8,145, with the base of the motor driving the pump 135 feet above, or at elevation 8,280. Vertical shafts in the rock between the underground pump room and the motor room on the surface will accommodate the shafts connecting the pumps to the motors. Each pump will have a capacity of 290 second-feet when operating under a total dynamic head of 130 feet and will be driven by a 6,500-horsepower synchronous motor.

The entrances to the intake tunnels will be provided with trashrack and stop-log structures, and sliding gates will be installed at the intake and discharge of each pump. The intake gates will be located in the gallery adjoining the pump room and will be hydraulically operated. The discharge gates will be located at the head of the canal and will be of a type which will close automatically in the event power service is interrupted, so as to prevent water in the canal from running back down through the pump.

The pumping plant will be complete with auxiliary pumping units for unwatering the intake and discharge tunnels and the drainage sump. It will also be complete with all other necessary station auxiliaries, including a crane for handling the equipment. A small machine shop will be provided for making minor repairs. Quarters for the operators will be provided in the vicinity of the plant.

Power will be delivered to the plant from a 69,000-volt transmission line, through an outdoor structural steel type substation containing self-cooled transformers, together with all necessary protective apparatus and auxiliaries. The operation of the substation will be handled from the main switchboard of the pumping plant.

POUDRE PUMPING PLANT

The Poudre pumping plant will be located on the Poudre Valley Canal at a point about 3 miles below the crossing of the proposed Poudre supply canal. It is proposed to have a capacity of 150 second-feet, composed of two 75-second-foot vertical synchronous-motor-driven single-stage pumps, operating against an effective head of 187 feet. The plant will be complete with all necessary auxiliaries, including a crane for handling the equipment. An outdoor substation will be provided for stepping the voltage down from transmission voltage to motor voltage. Due to the relatively short periods of operation, it is not probable that it will be necessary to construct operator's quarters at this plant.

TRANSMISSION SYSTEM

The transmission system will consist of a single 69,000-volt circuit connecting power plant no. 5 with the Granby pumping plant and power plant no. 1. Power plants nos. 1 to 4–A, inclusive, will be connected by two 115,000-volt lines and two 115,000-volt lines will continue to market. For the purpose of this report only, and to include a sufficient amount in the cost estimates for any probable transmission set-up, this market has been assumed as the valmont steam plant of the Public Service Co. of Colorado. Power plant no. 4 will be connected with the Poudre pumping plant by one 34,500-volt transmission line. The number of lines and mileage involved in each are as shown in the following tabulation:

From—	To—	Number of lines	Number of miles	Voltage
Power plant no. 5	Ka Rose	1	36	69,000
Granby pumping plant	Grand Lake	1	10	69,000
Do	Power plant no. 1	1	36	69,000
Power plant no. 1	Power plant no. 2	2	12	115,000
Power plant no. 2	Power plant no. 3	2	3	115,000
Power plant no. 3	Power plant no. 4	2	4	115,000
Power plant no. 4	Valmont	2	27	115,000
Do	Poudre pumping plant	1	18	34,500

The line to the Poudre pumping plant would be a wood-pole line with pin-type insulators. All other lines would be of the wood-pole, H-frame type, with suspension insulators, and combining all of the most modern features for continuity of service, ease of maintenance, and long life. The line from power plant no. 1 to the Granby pumping plant will probably require special construction to give added strength in the mountainous region near the Continental Divide.

In order to provide power for construction, it is proposed that one of the first features of the project would be to build one of the permanent 115,000-volt circuits from the Valmont plant to plant no. 1, the permanent 69,000-volt lines from plant no. 1 to Granby pumping plant and from Ka Rose to the Green Mountain dam site, and an extension from the Granby Pumping Plant to the west portal of the proposed tunnel. Initially this entire line would be operated at 69,000 volts, and under such operation would be adequate for all contemplated construction activities. In connection with supplying construction power it would also be necessary to install a substation at the Valmont steam plant to step voltage up to 69,000 volts for transmission. Preliminary studies indicate that it would be advisable to make this substation of approximately 5,000 kilovolt-ampere capacity.

The estimated cost of installing the facilities to provide construction power are as indicated in the following tabulation:

From—	To—	Miles	Cost	
			Per mile	Total
Valmont	Power plant no. 2	34	$6,750	$229,500
Power plant no. 2	Power plant no. 1	12	4,100	49,200
Power plant no. 1	Granby pumping plant	36	3,600	129,600
Granby pumping plant	Grand Lake	10	3,200	32,000
Ka Rose	Power plant no. 5	36	3,600	129,600
Total transmission lines		128		569,900

Substation at Valmont	$61,300
Total to supply power for construction	631,200

The transmission system as provided to furnish construction power would be adequate for transmission of power to markets from power plant no. 1 or power plant no. 5 if either were built individually, but the additional complete system would probably be constructed when two or more plants are constructed. The additional costs of the lines involved in this construction are shown in the following tabulation:

From—	To—	Miles	Cost	
			Per mile	Total
Power plant no. 1	Power plant no. 2	12	$4,100	$49,200
Power plant no. 2	Valmont	34	6,750	229,500
Power plant no. 4	Poudre pumping plant	18	1,800	32,400
Total additional cost of permanent transmission system		64		311,100

In addition to the transmission lines required for the disposal of power, it may be necessary that the Government also construct a substation at the point of power disposal. As a market survey has not been conducted to establish the points at which this power can be disposed of, or the quantities involved at each point of disposal, it is assumed for the purpose of this report that the substations will average in cost $10 per kilowatt of capacity. Assuming that provision is made to dispose of a peak capacity of 140,000 kilowatts, this will involve an additional expenditure of $1,400,000.

POWER OUTPUT

Water supply studies indicate that with power plant no. 1 only constructed, there is available, above all requirements for pumping purposes, a constant power output at 100 percent load factor of 120,000,000 kilowatt-hours per year. Since the pumping plant capacity proposed is sufficient to allow pumping to be done in 16 hours of each day it will be possible to handle peak commercial power requirements without undue interference. With this in mind, it has been assumed for the purpose of this report that a market can be found which has a load factor such that 60 percent of this power or 72,000,000 kilowatt-hours per year can be absorbed as firm energy. The balance of this energy, or 48,000,000 kilowatt-hours per year, plus about 40,000,000 kilowatt-hours additional, which is available during various parts of the year, is classed as secondary energy.

Since the Valmont steam plant of the Public Service Co. of Colorado has an installed capacity of 75,000 kilowatts, it appears that the 88,000,000 kilowatt-hours of secondary energy could be absorbed as a fuel saving measure if the price does not exceed fuel costs. Allowing 10 percent for line losses, this is equivalent to an average load of about 9,000 kilowatts.

FINANCIAL OPERATION OF POWER SYSTEM

It is contemplated that the initial power development would consist of the construction of power plant no. 1 only, together with such transmission lines and substations as are required to supply power to the Granby pumping plant and to commercial markets. The estimated construction cost of the strictly power features, as well as items which it is expected that power revenues will repay, is given below.

It is assumed that 5 mills per kilowatt-hour can be secured for firm energy and 1.8 mills per kilowatt-hour for secondary energy with delivery at the market. In each case 10 percent loss is allowed for transmission. The following gives the financial set-up for power plant no. 1, operation costs and returns.

While for the purpose of this report the allocation of construction cost to irrigation and power has been made on the basis set out below, it is understood that this allocation is not thereby fixed, and the same may be changed as further information may warrant until such time as the contract for repayment of the cost of the irrigation features has taken final form.

Power plant no. 1 construction costs

Power plant no. 1 near Estes Park	$1, 778, 000
Conduit from east portal continental divide tunnel to power plant no. 1	1, 101, 000
Transmission lines connecting power plant no. 1 with Granby pumping plant—with Valmont and line to North Poudre pumping plant	440, 000
Commercial substation (30,000 kilowatts)	300, 000
Headquarters at power plant no. 1 for operation of power system	100, 000
Subtotal	3, 719, 000
Interest during construction, 3 percent	112, 000
Total repayable in 50 years with interest	3, 831, 000
One-half cost of Arkins Reservoir	929, 661
Portion of cost Green Mountain Reservoir, for 100,000 acre-feet allocated to power	2, 276, 032
Payable on 40-year basis without interest	3, 205, 693
Total cost power plant no. 1 including other items that are required to be accomplished with the initial development	7, 036, 693

Annual revenues from power plant no. 1

From sale of 65,000,000 kilowatt-hours firm power, at $0.005	$325, 000
From sale of 79,000,000 kilowatt-hours secondary power, at $0.0018	142, 000
From rental of water for power development to privately owned plants	20, 000
Gross annual income	487, 000

Annual operation and maintenance plus retirement of principal

Brought forward	$487, 000
3.887 percent, on $3,831,000, interest and retirement of investment on basis of 50 years	148, 000
Repayment of $3,205,693 on basis of 40 years without interest	80, 000
Operation and maintenance of power plant	36, 000
Operation and maintenance Granby pumping plant	27, 000
Operation and maintenance of transmission lines	13, 800
Operation and maintenance conduit, tunnel, and canals	15, 000
Depreciation, 1.5 percent, on $3,831,000	57, 000
General expense	18, 200
Total annual costs	395, 000
Annual surplus during 40 years repayment period of the non-interest-bearing obligation	92, 000

FULL POWER DEVELOPMENT

The results of this study indicate that the initial installation proposed is sufficient from a financial standpoint to return all necessary costs of operation and repayments.

There are five additional plants that can be developed in the future in a manner that will keep pace with the power requirements of the section that may be served and not have a large unearning investment tied up for some years.

The following is an estimate of the cost of the additional power plants that may be constructed in the future, but are not a part of the initial development.

Power plant no. 5	$1, 190, 000
Green Mountain-Ka Rose transmission line	130, 000
Operators' quarters	60, 000
Substation (20,000 kilowatts)	200, 000
Subtotal	1, 580, 000
Interest during construction, 3 percent	47, 400
	1, 627, 400

The above plant, together with plant no. 1, will produce: 113,000,000 kilowatt-hours firm power annually; 92,000,000 kilowatt-hours secondary power annually.

The following are the construction costs of developing power plants nos. 2, 3, 4, and 4–A with appurtenant structures:

Power plant no. 2	$2, 325, 000
Power plant no. 3	665, 000
Power plant no. 4	760, 000
Power plant no. 4–A	420, 000
Power canal no. 2	2, 444, 000
Power canal no. 3	493, 000
Power canal no. 3–A	113, 000
Power canal no. 4	1, 194, 000
Operators' quarters	150, 000

Substations (90,000 kilowatt hours)	$900, 000
Additional transmission lines	311, 000
Subtotal	9, 775, 000
Interest during construction, 3 percent	293, 250
Total repayable in 50 years with interest	10, 068, 250
Arkins Canal feeder, payable in 40 years without interest	351, 000
Total power plants nos. 2, 3, 4, and 4-A	10, 419, 250
Total power plant no. 5	1, 627, 400
Total second-stage development	12, 046, 650
Primary development plant no. 1	7, 036, 693
Cost of full power development	19, 083, 243

The total salable output of the full development is estimated as follows, exclusive of that used for pumping:

	Kilowatt-hours
Firm power, annually	360, 000, 000
Secondary power, annually	[1] 200, 000, 000

[1] Out of an available production of 387,000,000 kilowatt-hours secondary power.

CONCLUSIONS

(1) There is a large area (615,000 acres) of irrigated land in northeastern Colorado, the major portion of which has an inadequate water supply.

(2) The feasible storage possibilities with the available water supply in the drainage area has been exhausted.

(3) There is at least an available water supply of 310,000 acre-feet on the upper drainage area of the Colorado River that can be diverted to supplement the present water supply on the eastern slope.

(4) That the diversion of this quantity of water from the Colorado River watershed will not interfere with or encroach upon the present or future irrigation along the Colorado River and tributaries within the State, with the protection provided in the Green Mountain Reservoir.

(5) That the plan for the project here laid out appears entirely feasible from a construction point of view.

(6) That the cost of construction estimated at $2 per acre-foot per annum over the repayment period of 40 years is less than storage water is now commanding and that it will increase the crop values five or more times this annual cost, showing its economic worth.

(7) That the power developments that may be made in the six power plants will produce a large quantity of cheap hydroelectric power that will materially benefit Colorado.

(8) That the revenues from the commercial power generated at power plant no. 1 will pay for the power features as set up under the initial power development, in addition to the power required for pumping at Granby pumping plant, and in lieu of the irrigation features used in power development, the operation of the system to a point where the water leaves the tailrace of the lower power plants can be taken care of by the power development.

(9) That the cost of the irrigation feature of the project is within the ability of the water users to pay.

Appendix I

Excerpts from Colorado Water Quality Control Commission Regulations No. 33 and No. 31

Appendix I.2 – Excerpts from Colorado Water Quality Control Commission Regulation No. 31

Appendix I.1 – Excerpts from Colorado Water Quality Control Commission Regulation No. 33

31.17 NUTRIENTS

(a) Overview

This section establishes interim numeric values for phosphorus, nitrogen and chlorophyll a and also sets forth provisions regarding the use of these numeric values for the adoption of water quality standards.

(b) Interim Phosphorus Values

Table 1 Interim Total Phosphorus Values

Lakes and Reservoirs, cold, >25 acres	25 ug/L [1]
Lakes and Reservoirs, warm > 25 acres	83 ug/L [1]
Lakes and Reservoirs, <=25 acres	RESERVED
Rivers and Streams – cold	110 ug/L [2]
Rivers and Streams - warm	170 ug/L [2]

[1] summer (July 1-September 30) average Total Phosphorus (ug/L) in the mixed layer of lakes (median of multiple depths), allowable exceedance frequency 1-in-5 years.
[2] annual median Total Phosphorus (ug/L), allowable exceedance frequency 1-in-5 years.

(c) Interim Nitrogen Values (Effective May 31, 2017)

Table 2 Interim Total Nitrogen Values

Lakes and Reservoirs, cold, >25 acres	426 ug/L [1]
Lakes and Reservoirs, warm, > 25 acres	910 ug/L [1]
Lakes and Reservoirs, <=25 acres	RESERVED
Rivers and Streams – cold	1,250 ug/L [2]
Rivers and Streams - warm	2,010 ug/L [2]

[1] summer (July 1–September 30) average Total Nitrogen (ug/L) in the mixed layer of lakes (median of multiple depths), allowable exceedance frequency 1-in-5 years.
[2] annual median Total Nitrogen (ug/L), allowable exceedance frequency 1-in-5 years.

(d) Interim Chlorophyll a Values

Table 3 Interim Chlorophyll *a* Values

Waterbody type		**DUWS**
Lakes and Reservoirs, cold, >25 acres	8 ug/L [a]	
Lakes and Reservoirs, warm, > 25 acres	20 ug/L [a]	5 ug/L [c]
Lakes and Reservoirs, <=25 acres	RESERVED	
Rivers and Streams – cold	150 mg/m^2 [b]	
Rivers and Streams - warm	150 mg/m^2 [b]	

[a] summer (July 1- September 30) average chlorophyll *a* (ug/L) in the mixed layer of lakes (median of multiple depths), allowable exceedance frequency 1-in-5 years.
[b] summer (July 1-September 30) maximum attached algae, not to exceed.
[c] March 1-November 30 average chlorophyll *a* (ug/L) in the mixed layer of lakes (median of multiple depths), allowable exceedance frequency 1-in-5 years.

(e) Use of Interim Phosphorus and Chlorophyll a Values for Standards Adoption

Prior to May 31, 2022, the values set forth in subsection (b) and (d) above will be considered for the adoption of water quality standards for specific water bodies in Colorado in the following circumstances.

(i) Headwaters located upstream of

(A) all permitted domestic wastewater treatment facilities discharging prior to May 31, 2012, or with preliminary effluent limits requested prior to May 31, 2012, and

(B) any non-domestic facility subject to Regulation #85 effluent limits and discharging prior to May 31, 2012.

(ii) Discretionary Application of the Values for Direct Use Water Supply (DUWS) Lakes and Reservoirs. The Commission may determine that a numerical chlorophyll standard is appropriate for specific water bodies with this sub-classification after consideration of the following factors:

(A) Whether the public water system using the lake or reservoir as a raw water supply experiences impacts attributed to algae on an intermittent or continual basis;

(B) Whether there are lake or reservoir use restrictions in place that recognize the importance of the reservoir as a water supply;

(C) Whether application of this value appropriately balances protection of all classified uses of the lake or reservoir;

(D) Other site specific considerations which affect the need for a more protective value.

(iii) Circumstances where the Commission has determined that adoption of numerical standards is necessary to address existing or potential nutrient pollution because the provisions of Regulation #85 will not result in adequate control of such pollution.

(f) Use of Interim Nitrogen Values for Standards Adoption

After May 31, 2017 and prior to May 31, 2022, the values set forth in subsection (c) above will be considered for the adoption of water quality standards for specific water bodies in Colorado in the circumstances identified in subsection (e)(i) and (iii) above.

(g) Phase 2 Application of Numeric Standards

After May 31, 2022, the values set forth in Section (b), (c), and (d) will be considered by the Commission when applying numeric standards to individual segments. For each individual segment where numeric standards for total phosphorus, total nitrogen, and chlorophyll a have not yet been adopted, numeric standards will be adopted by the Commission where necessary to:

(i) protect the assigned use classifications, and

(ii) comply with the Colorado Water Quality Control Act and the Federal Act.

(h) Site-Specific Flexibility to Consider Alternatives to the Interim Values

In accordance with the preceding subsection, both before and after May 31, 2022, in considering adoption of numeric standards for specific water bodies in Colorado, the Commission may review relevant site-specific factors and conditions in determining what numeric standards are most appropriate, and may adopt standards, either more or less stringent than the 31.17(b)(c) and (d) interim values.

(i) Where evidence demonstrates that an alternative numeric standard would be more appropriate for the protection of use classifications, the Commission may consider assigning ambient quality-based standards or site-specific criteria based standards as outlined in 31.7(1)(b)(ii-iii).

(ii) Where it has been demonstrated that interim values are not feasible to achieve, the Commission may consider modifying the use classification as outlined in Section 31.6(2).

(iii) Where the conditions established in Section 31.7(3)(a) are met, the Commission may consider granting a temporary modification.

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

WATER QUALITY CONTROL COMMISSION

5 CCR 1002-33

CLASSIFICATIONS AND NUMERIC STANDARDS FOR UPPER COLORADO RIVER BASIN AND NORTH PLATTE RIVER (PLANNING REGION 12)

ADOPTED: APRIL 7, 1980
EFFECTIVE: JUNE 9, 1980
AMENDED: DECEMBER 6, 1982
EFFECTIVE: JANUARY 30, 1983
AMENDED: JUNE 12, 1984
EFFECTIVE: JULY 30, 1984
AMENDED: AUGUST 13, 1984
EFFECTIVE: SEPTEMBER 30, 1984
AMENDED: FEBRUARY 4, 1985
EFFECTIVE: MARCH 30, 1985
AMENDED: APRIL 7, 1986
EFFECTIVE: MAY 30, 1986
TRIENNIAL REVIEW: SEPTEMBER 12, 1986
AMENDED: JUNE 2, 1987
EFFECTIVE: JULY 30, 1987
AMENDED: JULY 6, 1988
EFFECTIVE: AUGUST 30, 1988
TRIENNIAL REVIEW: SEPTEMBER 5, 1989
AMENDED: MAY 8, 1991
EFFECTIVE: JUNE 30, 1991 EMERGENCY AMENDED: SEPTEMBER 9, 1991
EFFECTIVE SEPTEMBER 9, 1991
AMENDED: JANUARY 6, 1992
EFFECTIVE: MARCH 1, 1992
AMENDED: MARCH 1, 1993
EFFECTIVE: APRIL 30, 1993
AMENDED: SEPTEMBER 7, 1993
EFFECTIVE: OCTOBER 30, 1993
AMENDED: OCTOBER 11, 1994
EFFECTIVE: NOVEMBER 30, 1994
AMENDED: JULY 10, 1995
EFFECTIVE: AUGUST 30, 1995
AMENDED: DECEMBER 11, 1995
EFFECTIVE: JANUARY 30, 1996
AMENDED: DECEMBER 9, 1996
EFFECTIVE: JANUARY 30, 1997
AMENDED: JULY 14, 1997
EFFECTIVE: AUGUST 30, 1997
AMENDED: NOVEMBER 3, 1997
EFFECTIVE: DECEMBER 30, 1997
AMENDED: NOVEMBER 9, 1998
EFFECTIVE: DECEMBER 30, 1998
AMENDED: OCTOBER 13, 1999
EFFECTIVE: NOVEMBER 30, 1999
AMENDED: MAY 14, 2001
EFFECTIVE: JUNE 30, 2001
AMENDED: DECEMBER 10, 2001
EFFECTIVE: JANUARY 30, 2002
AMENDED: MARCH 11, 2002
EFFECTIVE: APRIL 30, 2002
AMENDED: SEPTEMBER 8, 2003
EFFECTIVE: JANUARY 20, 2004
AMENDED: JUNE 13, 2005
EFFECTIVE: JULY 31, 2005
AMENDED: DECEMBER 12, 2005
EFFECTIVE: MARCH 2, 2006
AMENDED: JANUARY 9, 2006
EFFECTIVE: MARCH 2, 2006
AMENDED: JANUARY 8, 2007
EFFECTIVE: MARCH 4, 2007
AMENDED: FEBRUARY 12, 2007
EFFECTIVE: JULY 1, 2007
AMENDED: APRIL 9, 2007
EFFECTIVE: SEPTEMBER 1, 2007
AMENDED: JANUARY 14, 2008
EFFECTIVE: MARCH 1, 2008
AMENDED: AUGUST 11, 2008
EFFECTIVE: JANUARY 1, 2009
AMENDED: FEBRUARY 8, 2010
EFFECTIVE: JUNE 30, 2010
AMENDED: JULY 12, 2010
EFFECTIVE: NOVEMBER 30, 2010
AMENDED: JANUARY 10, 2011
EFFECTIVE: JUNE 30, 2012

Q. Grand Lake. Upper Colorado Basin-Clarity Standard

The Northwest Colorado Council of Governments, supported by Grand County and the Greater Grand Lake Shoreline Association, proposed a clarity standard for Grand Lake of 4 meter Secchi disk depth, effective July through September.

The Commission determined that it is appropriate to adopt water quality standards for the protection of Grand Lake's clarity because of Grand Lake's uniqueness as Colorado's largest natural lake. Grand Lake adjoins and complements Rocky Mountain National Park in the headwaters of the Colorado River and its social and economic importance is worthy of protection. Senate Document 80 (which recorded the legislative intent of the federal Congress in February 1937) provided in part that the Colorado BigThompson Project must be operated in a manner to preserve the scenic attraction of Grand Lake. Concern about the visible loss of transparency of Grand Lake has resulted in local, state and federal initiatives to address the changes in water quality. The earliest measurement of Grand Lake clarity is 9.2 meters (September 6, 1941). The 851h percentile of clarity measurements from 2006 is 2. 7 meters.

The Commission recognizes that this is the first time that a clarity standard has been adopted in the Colorado. Clarity standards are being adopted pursuant to the Basic Standards at section 31.13(3), which states "In special cases where protection of beneficial uses requires standards not provided by the classification above, special standards may be assigned after full public notice and hearings." Improvement of clarity within Grand Lake is expected to improve the quality of recreational uses of this unique resource.

The Commission is adopting two clarity standards for Grand Lake. First, the Commission is establishing a narrative clarity standard, to take effect with the other revisions to this regulation. This standard is "the highest level of clarity attainable, consistent with the exercise of established water rights and the protection of aquatic life". This standard is based on the Commission's conclusion that improvement in the clarity of Grand Lake is necessary, while noting that efforts to improve clarity need to be undertaken in a manner consistent with established water rights and need to also consider the protection of the aquatic life use. In basing the standard on "attainability", the Commission intends that attainability is to be judged by whether or not a clarity level can be attained in approximately twenty years by any recognized control techniques that are environmentally, economically, and socially acceptable.

An underlying assumption in setting this narrative standard is that clarity in Grand Lake needs to improve. However, the Commission is not determining in this hearing whether the current evidence of reduced clarity warrants inclusion of Grand Lake on Colorado's Section 303(d) List or the Monitoring and Evaluation List. That issue can be addressed as appropriate in the 2010 hearing on Regulations #93 and #94, based on additional evidence and analysis developed prior to that time.

Second, the Commission is establishing a numerical clarity standard of 4 meter Secchi depth for the months of July through September, with an effective date of January 1, 2014. The intention is that for the majority of the summertime days, the water of Grand Lake shall be clearer than 4 meter Secchi depth. Attainment of the 4 meter Secchi depth standard will be assessed by comparing the 85th percentile of available Secchi depth data collected during the months July through September to the 4 meter standard. Fifteen percent of the measurements may have Secchi depth shallower than 4 meters. When two samples are collected in different locations, or by different agencies on the same day, the Secchi depth value is the average of those samples.

The Commission has determined that the adoption of the 4 meter numerical standard with a delayed effective date is an appropriate policy choice to encourage cooperative efforts to improve Grand Lake clarity prior to the time that a specific numerical standard goes into effect, while assuring that a protective numerical standard will go into effect in 2014 if monitoring, assessment and water quality improvement efforts between now and then have not resulted in identification of a more appropriate numerical standard.

All parties agreed that improvement in Grand Lake water clarity is desirable. The Commission strongly encourages all interested stakeholders to work together to further identify the causes of reduced clarity and to explore options for identifying and implementing reasonable and effective measures to improve clarity, consistent with the other factors noted in the narrative standard. The Commission anticipates that these efforts may result in a proposal for a revised site-specific numerical clarity standard for Grand Lake at a later date.

Concerns have been raised regarding the potential impact of the proposed clarity standard on the exercise of water rights. The Commission recognizes that Section 25-8-104, C.R.S. states in part that "Nothing in this article [the Colorado Water Quality Control Act] shall be construed, enforced or applied so as to cause or result in material injury to water rights." If non-attainment of the numerical clarity standard is determined to be caused by the valid exercise of those water rights and the exceedance cannot be eliminated in a manner consistent with C.R.S. 25-8-104, the Commission would consider adoption of a revised site-specific standard as provided in section 31.7(1)(b)(ii). The Commission is hopeful that options can be identified to improve Grand Lake clarity in a manner consistent with section 25-8-104.

The Commission is not determining in this hearing precisely what types of options and alternatives are or are not consistent with section 25-8-104. The Commission believes that that issue is better addressed in the course of a process that more fully examines the causes of current clarity limitations on Grand Lake and the options for mitigating identified impacts.

While stating that it did not oppose a 4 meter clarity standard for Grand Lake, the Colorado Division of Wildlife noted that it is important that efforts to improve clarity in Grand Lake consider potential effects on recreational fisheries. The Commission intends that potential positive or negative impacts on aquatic life in Grand Lake be taken into account in implementing the narrative standard now being adopted, and in any efforts to consider potential refinement of the numerical standard now being adopted with a delayed effective date.

The Commission believes that this is an appropriate first step toward protecting Colorado's high quality water resources in a manner consistent with law and regulation. As with all standards, the clarity standards for Grand Lake are subject to periodic review, and the Commission expects to revisit this issue in future review cycles.

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 12 BASIN: **Upper Colorado River**	Desig	Classifications				NUMERIC STANDARDS			TEMPORARY MODIFICATIONS AND QUALIFIERS
Stream Segment Description			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			
10c. Mainstem of the Fraser River from a point immediately below the Hammond Ditch to the confluence with the Colorado River.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-II)oC D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH3(ac/ch)=TVS Cl2(ac)=0.019 Cl2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO2=0.05 NO3=10 Cl=250 SO4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=WS Mn(ac/ch)=TVS Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS Zn(ch)=TVS(sc)	
11. All lakes and reservoirs within Rocky Mountain National Park and within the Never Summer, Indian Peaks, Byers, Vasquez, Eagles Nest and Flat Tops Wilderness Areas.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CL,CLL)oC D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH3(ac/ch)=TVS Cl2(ac)=0.019 Cl2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO2=0.05 NO3=10 Cl=250 SO4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=WS Mn(ac/ch)=TVS Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
12. Lakes and reservoirs within Arapahoe National Recreation Area, including Grand Lake, Shadow Mountain Lake and Lake Granby.		Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CL,CLL)oC Shadow Mtn Res April-Dec T(WAT)=19.30oC Granby Res April-Dec T(WAT)=19.42oC D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH3(ac/ch)=TVS Cl2(ac)=0.019 Cl2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO2=0.05 NO3=10 Cl=250 SO4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=WS Mn(ac/ch)=TVS Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	See * for narrative clarity standard. July through September Grand Lake Clarity =4 meter secchi disk depth, effective January1, 2015.

*Narrative standard for Segment 12, Grand Lake: The highest level of clarity attainable, consistent with the exercise of established water rights and the protection of aquatic life.

Appendix J

Potential Cost, Schedule and Dependency of Work Plan Elements

Grand Lake Water Clarity Improvements
Work Plan for 30 Percent Engineering

Tasks and Subtasks	Approximate Budget	Estimated Duration (Months)	Dependency (See Following Schedule)
1. Develop the Statement of Purpose and Need for the Project			
Objective: Prepare a statement that demonstrates the purpose and need for implementing the project that eventually can be tailored to meet the requirements for the NEPA process and other permitting activities.			
Subtasks:			
a. Review previous studies, reports, and new data collected as part of ongoing water quality monitoring programs.	$50,000	1	NTP
b. Prepare summary of water clarity issues and impacts to Grand Lake that are to be addressed by the potential project alternatives.	$25,000	1	1a
c. Identify the water quality objectives to be achieved beyond water clarity in Grand Lake, including prevention of water quality degradation in the Three Lakes and in water diverted into the Adams Tunnel.	$25,000	1	1a
Deliverable: Purpose and Need Statement	$15,000	1	1b,1c
	$115,000		
2. Collect and Analyze Additional Data			
Objectives: Prior studies of water quality issues in the Three Lakes, which were considered during the Technical Review, have identified the need to obtain additional data and information to support the formulation and evaluation of potential alternatives to improve water clarity in Grand Lake. Findings of GEI's Technical Review support the need to complete the following subtasks:			
Subtasks:			
a. Obtain and evaluate historical information on natural stream flows entering the Three Lakes System, pumped inflows from Windy Gap, and lake levels in Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake. This information will be used in reservoir water quality monitoring, as well as in establishing locations and elevations for intake structures associated with potential bypass alternatives and other structural measures.	$30,000	2	P&N
b. Obtain the following additional data to Fill Data Gaps:		6	P&N
Identify and involve additional stakeholders	$15,000		
Define "water quality" for the Three Lakes System	$25,000		
Evaluate the effect on aquatic life use	$30,000		
Other Sampling Considerations	$30,000		
Monitor and evaluate the effect of stormwater runoff	$60,000		
Determine the effect of pumping initiation on Grand Lake clarity	$20,000		
Review and update the Three Lakes Water Quality Model	$80,000		
Review the numerical clarity standard value and collection methodology	$30,000		
Review of the water supply operations spreadsheet and development of a water supply operations model for evaluating alternatives	$150,000		

Tasks and Subtasks	Approximate Budget	Estimated Duration (Months)	Dependency (See Following Schedule)
Review of the power operations spreadsheet and development of the a power operations spreadsheet for evaluating alternatives	$150,000		
c. Assess existing and potential future watershed conditions that may affect water quality in the Three Lakes and particularly clarity in Grand Lake, including:		6	P&N
Land uses and agricultural practices	$20,000		
Forestry and wildfire policies and risks	$15,000		
Residential and commercial development	$15,000		
Status of septic systems and regional sewage collection and treatment	$20,000		
Recreational land uses and practices	$20,000		
d. Obtain the other environmental baseline data required to evaluate alternatives and assess environmental impacts of implementing each alternative. Resource areas should include:		6	P&N
Wildlife resources	$15,000		
Vegetation and watershed/forestry management	$15,000		
Aquatic resources and fisheries	$35,000		
Threatened and endangered species	$20,000		
Wetlands and riparian/sensitive habitats within “footprint” areas of potential structural alternatives	$25,000		
Recreation resources	$25,000		
Cultural resources	$20,000		
Socioeconomics of the region	$15,000		
Visual resources and aesthetics	$15,000		
Air quality	$10,000		
Geology and soils	$15,000		
e. Obtain GIS and/or Lidar data sets and maps, aerial photography and topographic mapping required for the formulation, facility sizing, and cost estimating of the structural alternatives. Topographic mapping should be adequate to develop plan and profile drawings of sufficient detail to support conceptual-level designs and cost estimates for the structural alternatives. (Mapping for design can be deferred to the 30 percent design stage in Task 7).	$200,000	3	P&N
f. Obtain sufficient utility location and easement information from local government agencies to develop conceptual-level designs and cost estimates for the structural alternatives. (Utility locations can be field-verified in the 30% design efforts, as required).	$35,000	2	2e
g. Use the models developed in Task 2 to evaluate the water supply operations and power generation impacts of potential alternatives.Data should include operations at Farr Pumping Plant and flow and power generation at the East Slope facilities, including dry, average, and wet year diversions and daily/diurnal flow information, as required, to enable assessment of water supply and power generation impacts.	$50,000	2	2a
Deliverables: Technical Memoranda on available baseline data grouped by issue category.	$25,000	2	2b,2g
	$1,230,000		

Tasks and Subtasks	Approximate Budget	Estimated Duration (Months)	Dependency (See Following Schedule)
3. <u>Identify a Full Range of Potential Alternatives to Improve Water Clarity in Grand Lake</u>			
Objectives: Building on the work completed for Reclamation's 2012 Preliminary Alternatives Development Report and other studies and reports, formulate a full range of reasonable alternatives for addressing the water clarity issues in Grand Lake, considering both structural and non-structural options and combinations of options. This will include describing the consequences of taking a "no-action" approach on the long-term water clarity in Grand Lake as well as establishing a baseline against which any operational changes will be measured in terms of water supply and power production from C-BT.			
Subtasks:			
a. Identify and develop details for structural alternatives, including but not limited to those listed below. Development will include conceptual design layouts of key project features and structures, plan and profile drawings, construction quantity and cost estimates (Class 4 estimate per AACE International Classification System), O&M cost estimates including energy costs for pumping, and expected schedules for implementation.		4	Task 2 TM
Grand Lake Bypass Alternatives:			
Intake and pumping station at Shadow Mountain Reservoir and a buried pipeline leading to a discharge structure at the Adams Tunnel portal;	$50,000		
Intake and pumping station at Shadow Mountain Reservoir and a submerged (marine) pipeline in Grand Lake leading to the Adams Tunnel portal;	$20,000		
Intake and pumping station at Shadow Mountain Reservoir and a "floating pipeline" in Grand Lake leading to the Adams Tunnel portal;	$20,000		
Intake and pumping station at Shadow Mountain Reservoir and a water conveyance tunnel to connect with the Adams Tunnel;	$30,000		
Provision of a removable (seasonal) boating course and submerged funnel-shaped curtain deflectors to reduce mixing in the top four feet of Grand Lake;	$25,000		
Intake and pumping station at the Granby Pump Canal and a buried pipeline leading to a discharge structure at the Adams Tunnel portal (this would bypass both Shadow Mountain and Grand Lake);	$30,000		
Intake and pumping station at the Granby Pump Canal and a water conveyance tunnel to connect with the Adams Tunnel (this would bypass both Shadow Mountain and Grand Lake);	$15,000		
Diversion of a portion of Granby Water via a bypass pipeline to the upper end of Grand Lake with discharge at depth and release through a conical outlet structure; and	$30,000		
Reasonable combinations of selected alternatives from the above listing.	$15,000		

Tasks and Subtasks	Approximate Budget	Estimated Duration (Months)	Dependency (See Following Schedule)
Other Structural Alternatives:			
Remove Shadow Mountain Dam and provide corresponding changes to the water conveyance system between Granby Reservoir and Grand Lake;	$25,000		
Deepen Shadow Mountain Reservoir by dredging or deepen and narrow this reservoir to improve water quality;	$25,000		
Reduce the operating pool in Shadow Mountain Reservoir to provide a forebay for for a pumping station and bypass pipeline	$50,000		
Provide aeration/oxygenation facilities in Shadow Mountain Reservoir to improve water quality;	$15,000		
Induce mixing (by aeration or other methods) in Grand Lake to improve water clarity through mixing of less clear surface zone water with better clarity water in the lower stratified zones;	$15,000		
Partial diversion and conveyance of the Grand Lake tributary inflows to mix with water pumped from Granby Reservoir, in order to improve the overall quality of and clarity of water entering Grand Lake from Shadow Mountain Reservoir;	$10,000		
Covering the Granby Pump Canal to reduce heating of the water during the summer months and growth of algae in both summer and winter;	$10,000		
Reconfigure the Farr Pump Station intakes to change the withdrawal levels relative to seasonal stratification to improve the quality of water delivered to Shadow Mountain Reservoir; and	$20,000		
Reasonable combinations of selected alternatives from the above listing.	$15,000		
b. Identify and develop details for non-structural alternatives, including but not limited to those listed below. Development will include conceptual operational descriptions, determination of impacts to water supplies and power production, estimates of potential economic and power market consequences, and expected schedules for implementation.		4	Task 2 TM
Operational Alternatives:			
Stop pumping at Farr Pumping Plant and no diversions through Adams Tunnel in July, August and September;	$15,000		
Modify pumping at Farr Pumping Plant and diversions at Adams Tunnel to operate continuously at low and steady rates; and	$15,000		
Operate Farr Pumping Plant and divert at Adams Tunnel continuously at high and steady rates after spring runoff.	$10,000		
Watershed Management:			
Implement sediment controls and best management practices (BMPs) to reduce nutrients and sediment/particulate loadings to the Three Lakes system resulting from land uses, stormwater inflows and overland (diffuse) runoff;	$15,000		
c. Identify and develop potential combinations of structural and non-structural measures that may be desirable, especially if they could reduce overall cost or improve overall performance in improving water clarity in Grand Lake.	$20,000	2	3a

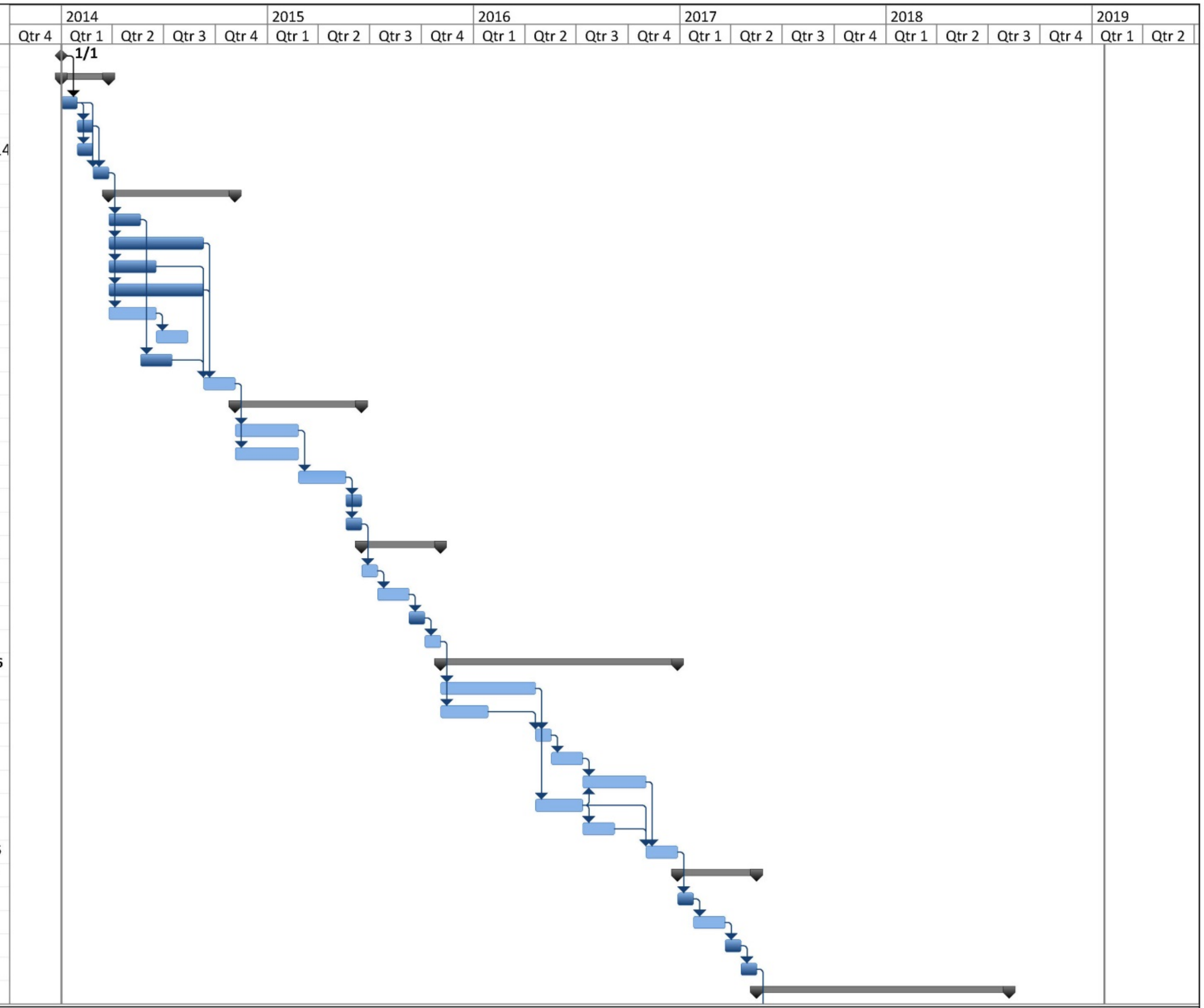
Tasks and Subtasks	**Approximate Budget**	**Estimated Duration (Months)**	**Dependency (See Following Schedule)**
d. Develop a description of the consequences of the “no-action” alternative in terms of the effects on long-term water clarity in Grand Lake.	$15,000	1	3c
Deliverable: Technical Memorandum on Alternatives	$40,000	1	3d
	$550,000		
4. <u>Perform “Coarse Screening” of Alternatives</u>			
Objectives: Alternatives that do not meet the purpose and need for the project, or ones that are not reasonable or practicable to implement based on cost factors or institutional issues, will be screened from further consideration in the 30% design efforts that follow. A reproducible and defensible screening framework will be established and used with stakeholder involvement to perform the screening of alternatives. The screening framework will be structured to comply with NEPA requirements for evaluation of alternatives.			
Subtasks:			
a. Establish a screening framework for comparison and evaluation of alternatives. The framework should define overarching goals and objectives of the project in the areas of achieving water clarity, minimizing adverse impacts, minimizing adverse effects to C-BT water supplies and power generation, and minimizing costs. Criteria and performance measurements will be identified within each of the objectives. Weighting factors will be established for the objectives and criteria in consultation with stakeholders.	$20,000	1	Task 3 TM
b. Assemble, using the previously developed baseline information, the data needed for the coarse screening of alternatives, including (for each alternative) costs, construction operations and potential effects, environmental impacts, water clarity performance, other water quality impacts, and water supply and energy impacts. This will include development of quantitative and qualitative performance measures for the coarse screening criteria in the screening framework.	$30,000	2	4a
c. Perform the coarse screening to evaluate and rank alternatives, test sensitivity to changes in weighting factors for the key objectives, and summarize results.	$15,000	1	4b
Deliverable: Technical Memorandum on Coarse Screening Results and the alternatives selected for further development and evaluation.	$25,000	1	4c
	$90,000		
5. <u>Develop Additional Details for Selected Alternatives</u>			
Objectives: Develop additional technical details, cost estimates, and implementation schedules for those alternatives passing the coarse screening in the previous task. Perform additional analyses and technical studies that are required to evaluate and compare the alternatives for improving water clarity in Grand Lake.			
Subtasks:			
a. Perform additional engineering and supporting technical analyses of the remaining structural alternatives. Prepare updated layout drawings and descriptions of these alternatives.	$120,000	6	Task 4 TM
b. Perform additional engineering and supporting technical analyses of the remaining non-structural alternatives. Prepare updated descriptions of these alternatives.	$60,000	3	Task 4 TM

Tasks and Subtasks	Approximate Budget	Estimated Duration (Months)	Dependency (See Following Schedule)
c. Perform additional engineering and supporting technical analyses of the remaining combination (structural and non-structural) alternatives. Prepare updated descriptions of these alternatives.	$25,000	1	5b
d. Develop feasibility-level construction and O&M costs for each of the alternatives (Class 3 estimate per AACE International Classification System). Develop total capital cost opinions and life-cycle cost estimates for each alternative.	$50,000	2	5c
e. Assess on a quantitative basis the expected performance of each alternative relative to improving the water clarity in Grand Lake. This should include development and application of appropriate reservoir water quality modeling procedures.	$150,000	4	5d
f. Prepare additional, more-detailed analyses of water supply impacts in the C-BT delivery system associated with each remaining alternative. Determine the potential economic and financial impacts associated with any changes in water supplies inherent to each alternative.	$50,000	3	5e
g. Prepare additional, more-detailed analyses of energy generation and firm capacity impacts in the C-BT delivery system associated with each remaining alternative. Determine the potential economic and financial impacts associated with any changes in energy production, firm capacity and marketing of project power inherent to each alternative. For the bypass alternatives involving additional pumping to move water, identify the potential to use off-peak power and the overall impacts on C-BT energy production and firm capacity.	$50,000	3	5e
h. Identify the legal, institutional, permitting, and administrative issues affecting the implementation of each of the alternatives.	$25,000	2	5g
Deliverables: Technical Memorandum on the structural alternatives; Technical Memorandum on the non-structural alternatives; Technical memorandum on combination alternatives.	$30,000	2	5g
	$560,000		
6. <u>Perform "Fine Screening" of Alternatives</u>			
Objectives: Evaluate the alternatives using a systemic framework and one or several alternatives that are worthy of further development to the 30 percent design level. This is expected to involve refining the framework developed for coarse screening to incorporate additional considerations and details, based on inputs from stakeholders.			
Subtasks:			
a. Establish the fine-screening framework for comparison and evaluation of alternatives. This will be a refinement of the framework developed in Task 4 and it will continue to define overarching goals and objectives of the project in the areas of achieving water clarity, minimizing adverse impacts, minimizing adverse effects to C-BT water supplies and power generation, and minimizing costs. Criteria and performance measurements will be identified within each of the objectives. Weighting factors will be established for the objectives and criteria in consultation with stakeholders.	$15,000	1	Task 5 TM

Tasks and Subtasks	Approximate Budget	Estimated Duration (Months)	Dependency (See Following Schedule)
b. Assemble, using the previously developed baseline information and additional investigations and studies, the data needed for the fine screening of alternatives, including (for each alternative) costs, construction operations and potential effects, environmental impacts, water clarity performance, other water quality impacts, and water supply and energy impacts. This will include development of quantitative and qualitative performance measures for the coarse screening criteria in the screening framework.	$40,000	2	6a
c. Perform the fine screening to evaluate and rank alternatives, test sensitivity to changes in weighting factors for the key objectives, and summarize results.	$15,000	1	6b
Deliverable: Technical Memorandum on Fine Screening Results and the alternatives that are selected for further development and refinement at the 30 percent design level.	$25,000	1	6c
	$95,000		
7. <u>Develop 30 Percent Designs for the Selected Alternatives</u>			
Objectives: The alternative or alternative(s) passing the fine screening in Task 6 will be developed to the 30 percent level of design. This design level will be sufficiently detailed for developing implementation plans, schedules and budgets provide the basis for initiating final designs.			
Subtasks:			
a. Prepare design basis memoranda for the selected alternatives, including both structural and nonstructural alternatives and any operational, watershed management and/or combination alternatives.	$50,000	2	Task 6 TM
b. Obtain additional field surveys, existing utility information, topographic mapping, GIS data, and geologic and geotechnical information needed for the 30 percent design.	$100,000	3	7a
c. Perform additional technical analyses to support 30 percent level design of the selected alternatives. These would include: hydraulic, structural, and geotechnical analyses to support preliminary design of structural elements such as intakes, pumping stations, conveyance pipelines, reservoir improvements, etc.	$360,000	4	7b
d. Prepare drawings that depict the alignments, profiles, typical sections, and details of the structural components of each alternative, as well as potential areas of conflict with existing utilities and needs for relocations and land acquisition.	$90,000	3	7c
e. Prepare detailed descriptions of each alternative, its operations and potential impacts on the existing environment, and requirements for construction and/or modification of current C-BT operations.	$90,000	3	7c
f. Prepare opinions of the probable construction costs (Class 2 estimate per AACE International Classification System), O&M costs, total capital costs, and anticipated life-cycle costs of each alternative developed to the 30 percent design level.	$60,000	3	7d
Deliverables: A Technical Memorandum for each alternative describing the 30 percent design, operation, impacts, and construction requirements and costs.	$40,000	2	7e
	$790,000		

Tasks and Subtasks	Approximate Budget	Estimated Duration (Months)	Dependency (See Following Schedule)
8. <u>Develop Implementation Plans and Schedules for the Alternative(s) Identified in Task 6</u>			
Objectives: To provide detailed plans schedules for implementing the selected alternative(s), considering specific institutional arrangements, authorizations, NEPA compliance, permitting, final engineering, design, and construction, which may be unique to each of the alternatives.			
Subtasks:			
a. Develop schedules for design, permitting and construction in Microsoft Project or other suitable software to show work task breakdown and interdependencies. This will include consideration of NEPA requirements and other permitting activities based on findings in Task 9.	$15,000	1	Task 7 TM
b. In consultation with Reclamation, prepare write-ups on the institutional and administrative requirements and authorizations needed to implement each alternative.	$15,000	1	8a
Deliverables: Implementation plan and schedule for each of the 30 percent design alternatives.	$15,000	1	8c
	$45,000		
9. <u>Prepare Required Environmental Compliance Documentation</u>			
Objective: It is anticipated that many of the alternatives selected for possible implementation will require extensive federal, state, and local permitting efforts to secure approvals for implementation. The objective of this task is to identify the process and likely level of documentation that will be needed for documentation of environmental compliance so that a preferred water clarity improvement project can be implemented.			
Subtasks:			
a. Identify the likely steps in the NEPA compliance process.	$15,000	1	Task 8 TM
b. Identify the applicable agency legal and regulatory permit requirements.	$15,000	1	9a
Deliverables: Technical Memorandum on Environmental Compliance	$15,000	1	9b
	$45,000		
10. <u>Conduct Stakeholder and Public Involvement Programs</u>			
Objectives: All of the tasks outlined above will be undertaken in cooperation with a stakeholder Work Group that is already established and has been functioning for several years. Additional representation may be added to this stakeholder group. In addition to stakeholder outreach and coordination this task will also include a public involvement and outreach program that meets guidelines under NEPA.			
Subtasks:			
a. Develop and execute a Stakeholder Involvement Program with the existing Grand Lake Work Group, participants in the Three Lakes Water Quality Program, and others, as deemed appropriate to the project planning and evaluation process.	$50,000	3	Task 9 TM
b. Develop a Public Involvement Program.	$50,000		10a
Deliverables: Descriptions of the two programs and meeting materials and newsletters, as required for communicating effectively with stakeholders and the public.	$30,000	3	10a
	$130,000		
Total Cost	**$3,650,000**		

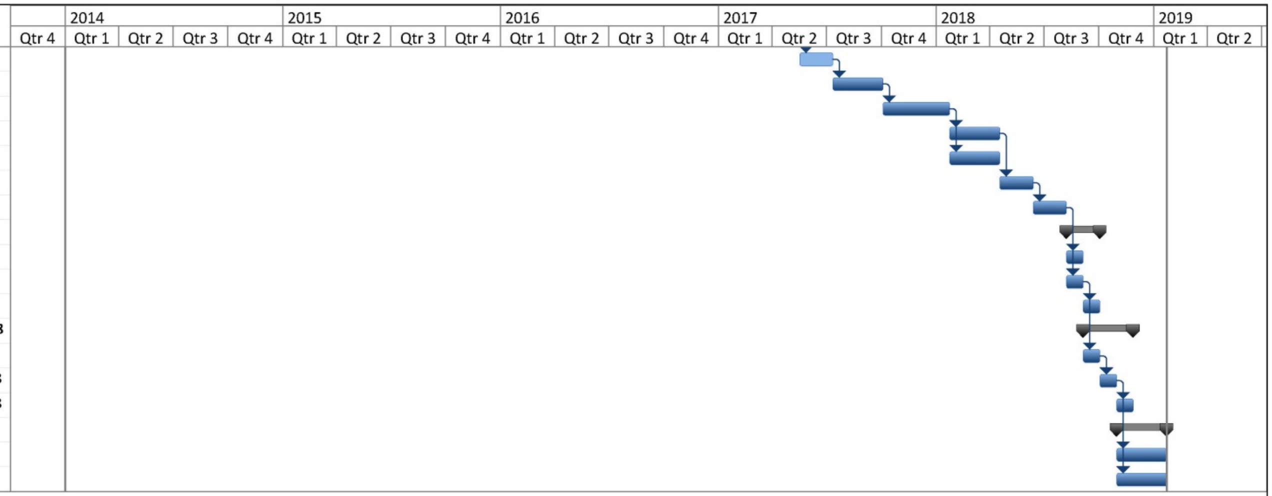
ID	Task Name	Duratio	Start	Finish
1	Notice to Proceed	0 days	Wed 1/1/14	Wed 1/1/14
2	**1. Statement of Purpose and Need**	**3 mo**	**Wed 1/1/14**	**Tue 3/25/14**
3	a. Review prior studies	1 mo	Wed 1/1/14	Tue 1/28/14
4	b. Clarity Issues	1 mo	Wed 1/29/14	Tue 2/25/14
5	c. WQ Issues	1 mo	Wed 1/29/	Tue 2/25/14
6	P&N Statement	1 mo	Wed 2/26/14	Tue 3/25/14
7	**2. Collect and Analyze Additional Data**	**8 mo**	**Wed 3/26/14**	**Tue 11/4/14**
8	a. Historical Flow data	2 mo	Wed 3/26/14	Tue 5/20/14
9	b. Fill Data Gaps	6 mo	Wed 3/26/14	Tue 9/9/14
10	c. Assess Watershed Conditions	3 mo	Wed 3/26/14	Tue 6/17/14
11	d. Environmental Baseline Data	6 mo	Wed 3/26/14	Tue 9/9/14
12	e. GIS Data Base	3 mo	Wed 3/26/14	Tue 6/17/14
13	f. Utility Locations	2 mo	Wed 6/18/14	Tue 8/12/14
14	g. Water Supply and Power Operations	2 mo	Wed 5/21/14	Tue 7/15/14
15	Technical Memorandum	2 mo	Wed 9/10/14	Tue 11/4/14
16	**3. Identify Alternatives**	**8 mo**	**Wed 11/5/14**	**Tue 6/16/15**
17	a. Structural Alternatives	4 mo	Wed 11/5/14	Tue 2/24/15
18	b. Non-Structural Alternatives	4 mo	Wed 11/5/14	Tue 2/24/15
19	c. Combination Alternatives	3 mo	Wed 2/25/15	Tue 5/19/15
20	d. No-Action Alternative	1 mo	Wed 5/20/15	Tue 6/16/15
21	Technical Memorandum	1 mo	Wed 5/20/15	Tue 6/16/15
22	**4. Coarse Screening of Alternatives**	**5 mo**	**Wed 6/17/15**	**Tue 11/3/15**
23	a. Framework	1 mo	Wed 6/17/15	Tue 7/14/15
24	b. Assemble Data for Evaluation	2 mo	Wed 7/15/15	Tue 9/8/15
25	c. Perform Screening	1 mo	Wed 9/9/15	Tue 10/6/15
26	Technical Memorandum	1 mo	Wed 10/7/15	Tue 11/3/15
27	**5. Develop Selected Alternatives**	**15 mo**	**Wed 11/4/15**	**Tue 12/27/16**
28	a. Structural Alternatives	6 mo	Wed 11/4/15	Tue 4/19/16
29	b. Non-Structural Alternatives	3 mo	Wed 11/4/15	Tue 1/26/16
30	c. Combination Alternatives	1 mo	Wed 4/20/16	Tue 5/17/16
31	d. Cost Estimating	2 mo	Wed 5/18/16	Tue 7/12/16
32	e. Assess Performance of Alternatives	4 mo	Wed 7/13/16	Tue 11/1/16
33	f./g.Water Supply and Power Operations	3 mo	Wed 4/20/16	Tue 7/12/16
34	h. Implementation Issues	2 mo	Wed 7/13/16	Tue 9/6/16
35	Technical Memorandum	2 mo	Wed 11/2/16	Tue 12/27/16
36	**6. Fine Screening of Alternatives**	**5 mo**	**Wed 12/28/1**	**Tue 5/16/17**
37	a. Framework	1 mo	Wed 12/28/1	Tue 1/24/17
38	b. Assemble Data for Evaluation	2 mo	Wed 1/25/17	Tue 3/21/17
39	c. Perform Screening	1 mo	Wed 3/22/17	Tue 4/18/17
40	Technical Memorandum	1 mo	Wed 4/19/17	Tue 5/16/17
41	**7. 30% Design of Selected Alternatives**	**16 mo**	**Wed 5/17/17**	**Tue 8/7/18**



Project: GLC Work Plan Schedule
Date: Wed 8/14/13

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline	
Split	External Tasks	Inactive Summary	Manual Summary	Progress	
Milestone	External Milestone	Manual Task	Start-only		
Summary	Inactive Task	Duration-only	Finish-only		

ID	Task Name	Duratio	Start	Finish
42	a. Design Basis Memorandum	2 mo	Wed 5/17/17	Tue 7/11/17
43	b. Field Surveys	3 mo	Wed 7/12/17	Tue 10/3/17
44	c. Additional Technical Analyses	4 mo	Wed 10/4/17	Tue 1/23/18
45	d. Drawings of Alternatives	3 mo	Wed 1/24/18	Tue 4/17/18
46	e. Descriptions of Alternatives	3 mo	Wed 1/24/18	Tue 4/17/18
47	f. Cost Estimating	2 mo	Wed 4/18/18	Tue 6/12/18
48	Technical Memorandum	2 mo	Wed 6/13/18	Tue 8/7/18
49	**8. Implementation Plan**	**2 mo**	**Wed 8/8/18**	**Tue 10/2/18**
50	a. Schedules	1 mo	Wed 8/8/18	Tue 9/4/18
51	b. Institutional Requirements	1 mo	Wed 8/8/18	Tue 9/4/18
52	Technical Memorandum	1 mo	Wed 9/5/18	Tue 10/2/18
53	**9 . Identify Required Environmental Cplinace**	**3 mo**	**Wed 9/5/18**	**Tue 11/27/18**
54	a. NEPA Process Plan	1 mo	Wed 9/5/18	Tue 10/2/18
55	b. Application Agency Requirements	1 mo	Wed 10/3/18	Tue 10/30/18
56	Technical Memorandum	1 mo	Wed 10/31/1	Tue 11/27/18
57	**10. Public Involvement Plans**	**3 mo**	**Wed 10/31/1**	**Tue 1/22/19**
58	a. Stakeholder Plan	3 mo	Wed 10/31/1	Tue 1/22/19
59	b. Public Plan	3 mo	Wed 10/31/1	Tue 1/22/19



Project: GLC Work Plan Schedule
Date: Wed 8/14/13

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress