Windy Gap Firming Project

401 Water Quality Certification Technical Report

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Municipal Subdistrict
Northern Colorado Water Conservancy District

Prepared for:
Water Quality Control Division
Environmental Data Unit

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Abbreviations

401 Certification	CWA §401 Water Quality Certification
AD	Antidegradation
AI	Assimilative Capacity
AL	Aquatic Life
APFR	Alternative Plan Formulation Report
BAI	Baseline Available Increment
BMPs	Best Management Practices
BWQ	Baseline Water Quality
Ca	Calcium
CBT	Colorado-Big Thompson
CDPW	Colorado Division of Parks & Wildlife
CEQ	Council on Environmental Quality
Chl a	Chlorophyll a
Cl	Chloride
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
CWC	Colorado Wildlife Commission
CWCB	Colorado Water Conservation Board
Dis	Dissolved
DM	Daily Maximum
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EIS	Environmental Impact Statement
FCA	Fish Consumption Advisories
FEIS	Final Environmental Impact Statement
Hg	Mercury
IGA	Intergovernmental Agreement
IPP	Identified Project and Processes
K	Potassium
LBD	Learning By Doing
LEDPA	Least Environmentally Damaging Practicable Alternative
M&I	Municipal and Industrial
Mg	Magnesium
MOU	Memorandum of Understanding
MPWCD	Middle Park Water Conservancy District
MWAT	Maximum Weekly Average Temperature
Na	Sodium
NEPA	National Environmental Policy Act
NH3	Ammonia

NO3+NO2	Nitrate + Nitrite
Northern Water	Northern Colorado Water Conservancy District
OWTS	Onsite Wastewater Treatment System
RFFA	Reasonably Foreseeable Future Action
River District	Colorado River Conservation District
ROD	WGFP FEIS Record of Decision
SCT	Significant Concentration Threshold
Se	Selenium
SiO2	Silicon Dioxide
SMP	Grand County's Stream Management Plan
SO4	Sulfate
SpCond	Specific Conductivity
S&T	Science and Technology
Subdistrict	Windy Gap Firming Project Water Activity Enterprise
SWSI	Statewide Water Supply Initiative
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
Trec	Total Recoverable
TU	Trout Unlimited
UCRA	Upper Colorado River Alliance
USEPA	U.S. Environmental Protection Agency
WAT	Weekly Average Temperature
WGB	Windy Gap Bypass
WGFP	Windy Gap Firming Project
WQCC	Water Quality Control Commission
WQCD	Water Quality Control Division
WS	Water Supply

1 Executive Summary

This technical report was prepared to present the water quality analyses performed in support of Water Quality Certification under Section 401 of the federal Clean Water Act (CWA) for the Windy Gap Firming Project (WGFP). This report was submitted as an attachment to the 401 Certification Application to the Water Quality Control Division (WQCD).

Although the analyses compiled here rely heavily on water quality work done for the WGFP Final Environmental Impact Statement (FEIS), relevant information from the FEIS and associated technical reports were summarized or repeated for an easier read and to minimize the need to refer the reader to other documents.

Section 3 describes in detail the regulatory framework associated with the 401 Certification. Section 4 describes the Proposed Action for the WGFP, which for the purpose of this report, is assumed to be the Least Environmentally Damaging Practicable Alternative (LEDPA), since the antidegradation (AD) review required as part of the 401 certification has to be performed on the LEDPA. This section also describes the alternatives selection process performed for the EIS. Section 5 describes expected water quality impacts associated with the WGFP, and water quality areas of concern based on existing impairment. Section 6 describes data sources used in the water quality analyses. The AD review is presented following a stepwise process. Because the net effect of the activity (including mitigation measures) is to be considered, the analysis is presented in two steps. The first step, presented in Section 7, consists of carrying out the Significant Concentration Threshold (SCT) analysis, which relied on water quality modeling of the Project without mitigation or enhancement measures and qualitative assessments (when modeling was not possible). The second step, presented in section 8, reviews mitigation and enhancement measures under cumulative effects. A summary of the final conclusions of the AD review, presented in section 8.10, reconciles the SCT analysis with mitigation measures into a review of net impacts (Table 47). Section 9 provides information about the purpose and need of the WGFP and examines the necessity of degradation where it cannot be avoided, minimized or mitigated. Section 10 summarizes coordination efforts between the applicant (Municipal Subdistrict, Northern Colorado Water Conservancy District) and the WQCD in the development of this report. Section 11describes best management practices associated with the WGFP. Section 12 summarizes conclusions from the water quality assessment.

Geographic Scope

The analysis performed for the 401 Certification relies on the affected environment as identified in the Final EIS (U.S. Bureau of Reclamation, 2011) (Section 3.8.1). Streams evaluated in the West Slope study area (Figure 8) are the Colorado River downstream of Granby Reservoir to Gore Canyon below the confluence with the Blue River, and Willow Creek below Willow Creek Reservoir. Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir are included in the study area. Windy Gap Reservoir is a small in-channel reservoir and has water quality similar to that of the Colorado and Fraser Rivers; so it was not evaluated separately. As determined in the Final EIS (Section 3.4), below Gore Canyon, the hydrologic effects of the WGFP diminish and potential impacts to aquatics resources are less likely.

The East Slope study area (Figure 9) includes the Big Thompson River below Lake Estes (where additional Windy Gap deliveries would increase flow), and downstream of Participant WWTPs on Big Dry Creek, Coal Creek , St. Vrain Creek, the Big Thompson River and the Cache la Poudre River. East Slope reservoirs in the study area are Carter Lake, Horsetooth Reservoir, along with a potential new reservoir at Chimney Hollow.

Water quality effects to other small reservoirs in the C-BT system were not specifically evaluated because the reservoirs have very short residence times and the water quality would be similar to the major inflows. The other reservoirs in the C-BT system are Mary's Lake, Lake Estes, Pinewood Reservoir, and Flatiron Reservoir. Because water quality effects at Carter Lake would be minor, impacts to Boulder Reservoir,

which receives water from Carter Lake, should be even less as Boulder Reservoir receives water from both Carter Lake and from Lefthand Creek. Green Mountain Reservoir and Willow Creek Reservoir were not included in the study area because they would not be affected by the WGFP.

Windy Gap Firming Project

The Windy Gap Firming Project (WGFP) is a proposed water supply Project that would provide more reliable water deliveries to Colorado's Front Range and West Slope communities and industries.
Due to limitations and constraints with the existing system, the current Windy Gap Project facilities, which were completed in 1985, are unable to deliver the anticipated firm yield of water. Water deliveries from the West Slope currently are limited by storage capacity in Granby Reservoir and by the delivery capacity of the Adams Tunnel, which delivers water from Grand Lake to the East Slope. The WGFP would add water storage and related facilities to the existing Windy Gap operations capable of delivering a firm annual yield of about 30,000 acre-feet (AF) to Project Participants. The intent of the WGFP is to improve the yield from an existing Project and existing Windy Gap water rights.

Project Participants in the WGFP include municipalities, rural domestic water districts, and an industrial water user. Project Participants on the East Slope are the City and County of Broomfield, Central Weld County Water District, Town of Erie, City of Evans, City of Fort Lupton, City of Greeley, City of Lafayette, Little Thompson Water District, City of Longmont, City of Louisville, City of Loveland, Platte River Power Authority, and the Town of Superior. In addition, the Project seeks to firm the water supply for the Middle Park Water Conservancy District (MPWCD), which is a wholesale water supplier that allocates Windy Gap water to about 67 water providers, including towns, water districts, agricultural water suppliers, consumers, and ski areas in Grand and Summit counties on the West Slope. WGFP Participants determined that a cooperative Project was the most efficient means to firm Windy Gap water deliveries rather than each entity developing storage for its own share of Windy Gap water.

Windy Gap Project water is currently diverted from the Colorado River just downstream of the confluence of the Colorado and Fraser rivers into the Windy Gap Reservoir (Figure 3). From the reservoir the water is pumped to Granby Reservoir for storage and conveyance through C-BT Project facilities and ultimate delivery to Windy Gap Project allottees on the East Slope. MPWCD's Windy Gap water is stored in Granby Reservoir and released to replace stream diversions or ground water use by contract holders at various locations in Grand and Summit counties.

Figure 3 - Windy Gap Project Facilities

The purpose of the Windy Gap Firming Project is to deliver a firm annual yield of about 30,000 AF of water from the existing Windy Gap Project to meet a portion of the water deliveries anticipated from the original Windy Gap Project. Firm water deliveries from the Windy Gap Project are needed to meet a portion of the existing and future demands of the Project Participants. The Middle Park Water Conservancy District, an original Participant in the Windy Gap Firming Project, separately negotiated an agreement with the Subdistrict to assure approximately 2,300 acre-feet of the Windy Gap water supplies provided to it by the Subdistrict will be firmed, hence improving the reliability of its Windy Gap water supply for users in Grand and Summit counties, Colorado.

The WGFP consists of a 90,000 AF Chimney Hollow Reservoir, along with the ability to store or preposition C-BT water in the new reservoir.

Water would be conveyed to Chimney Hollow Reservoir via a new pipeline connection to existing East Slope CBT facilities. Connections between Chimney Hollow Reservoir and Carter Lake would allow delivery of water to Participants using existing infrastructure.

The Chimney Hollow Reservoir site is in Larimer County about 8 miles southwest of Loveland, Colorado and ½ mile west of Carter Lake (Figure 2-5). The reservoir would be built in a hogback valley along an intermittent drainage at an elevation of about 5,600 feet.

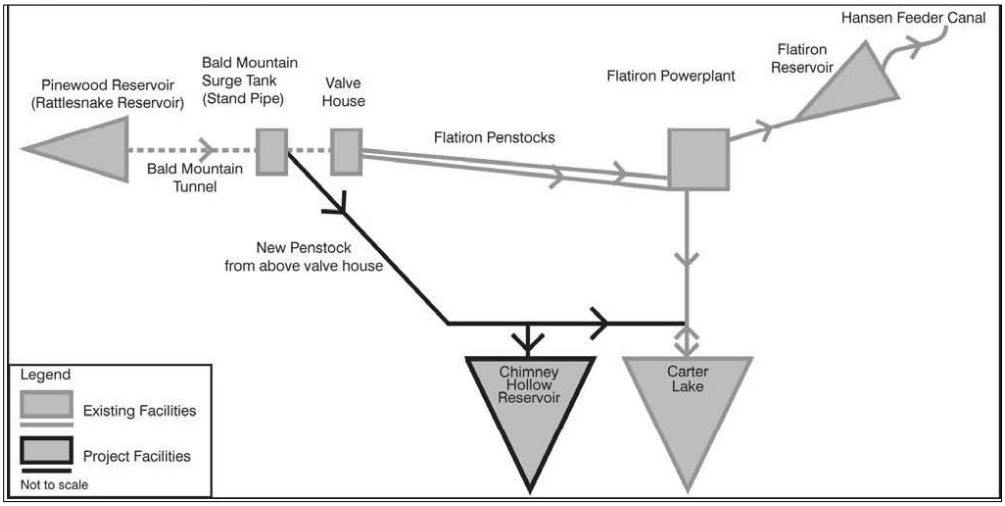

Figure 4 - Chimney Hollow Reservoir Connection Schematic

Antidegradation Review Results

As summarized in section 9, the WGFP will results in significant degradation for dissolved manganese in the Colorado River below Windy Gap Reservoir (water supply standard). It is not anticipated that the increase in manganese concentrations would have any economic impact on downstream users considering the amplitude of the change which is less than 1% of the baseline water quality. The analysis did not show significant degradation for any other parameters.

Because there are instances where the AD review relied on qualitative assessment, there may be some uncertainty or questions regarding the conclusions that are reached. For this reason, a section addressing the necessity of degradation is included in Section 9.

The finding of significant degradation for manganese in the Colorado River is a consequence of the existing impairment and a reflection of the absence of assimilative capacity. As described in section 7.7.2, the projected increase in concentration with the WGFP under cumulative effects is less than 1% of the baseline water quality.

Section 8 provides a detailed discussion of all minimization, avoidance, mitigation, enhancement and other measures that will provide significant net environmental benefits to the Colorado River.

Measures are broken down by type: avoidance, minimization, compensatory mitigation, enhancements and other types of measures. Avoidance, minimization and compensatory measures together are generally referred to as mitigation measures in the FEIS. Avoidance measures are measures that seek to avoid impact before the impact occurs. For water supply projects, they typically include changes in project

operation that remove the impact that would otherwise be associated with the project, before it even takes place. Similarly, minimization measures are changes in project or operation that seek to reduce or minimize the magnitude of the impact without completely eliminating it. Mitigation measures as characterized here are strategies that seek to offset or compensate for impacts associated with the project. Unlike avoidance measures, they do not prevent the impact from occurring but they offset it through some compensatory mechanism. Enhancement measures are not mitigation measures. They are additional measures that have been committed to by the Subdistrict and that address existing issues and by design provide a net benefit unrelated to impacts caused by the project.

Measures associated with the WGFP include:

- enhancements to water temperature in the Colorado River,
- a year-round decrease in TP levels in the Fraser and Colorado rivers as a result of WWTP improvements,
- flushing flows in the Colorado River that will benefit aquatic life,
- coordinated and collaborative efforts to design and implement stream restoration efforts that will restore and enhance the aquatic habitat and aquatic life in the Colorado, Fraser and Williams Fork river basins,
- mitigation of existing dissolved oxygen impairment in Shadow Mountain Reservoir,
- long-term commitments to identify options to improve clarity in Grand Lake,
- a commitment and funding to assess the need for and construct a bypass to Windy Gap Reservoir to allow passage of flows, fish and sediments, or to dedicate funding to restoration efforts if the bypass is deemed unnecessary and
- long-term monitoring commitments including bioavailable mercury, clarity in Grand Lake, nutrients and real-time temperature monitoring in the Colorado River.

Finally, section 9 describes the socio economic importance of the WGFP to meet future water needs of the South Platte basin and the extent of water shortages that are expected in this region and in Colorado as a whole. WGFP is one of the Identified Projects and Processes identified in the Colorado Water Plan to meet Colorado's water gap. Reclamation's ROD confirms that the requirements of the NEPA process have been satisfied and that Alternative 2 of the Windy Gap Firming Project, Chimney Hollow Reservoir, along with implementation of the mitigation measures identified in the Final EIS will provide valuable environmental and socioeconomic benefits.

The Subdistrict will be developing a Stormwater Management Plan that will incorporate BMPs that will provide temporary and permanent erosion and sediment control measures according to 5 CCR 1002-82, §82.6(B)(2). The Stormwater Management Plan will be provided before the start of construction for review and approval by the WQCD.

It is concluded that the identified degradation associated with the WGFP under cumulative effects is largely offset by the identified measures to avoid, minimize, mitigate the project impacts along with measures to enhance the environment, resulting in significant net environmental benefits associated with the Project.

2 Introduction

This technical report was prepared to present the water quality analyses performed in support of Water Quality Certification under Section 401 of the federal Clean Water Act (CWA) for the Windy Gap Firming Project (WGFP). This report was submitted as an attachment to the 401 Certification Application to the Water Quality Control Division (WQCD).

Although the analyses compiled here rely heavily on water quality work done for the WGFP Final Environmental Impact Statement (FEIS), relevant information from the FEIS and associated technical reports were summarized or repeated for an easier read and to minimize the need to refer the reader to other documents.

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3 Relevant Regulatory Framework

The Colorado Water Quality Control Division is responsible for Water Quality Certifications under Section 401 of the federal Clean Water Act for Projects or actions to which the provisions of the Colorado 401 Certification Regulation (WQCC Regulation #82: 5#CCR 1002-82) apply. A CWA §401 Water Quality Certification (401 Certification) is required for any federal license or individual permit that is issued to construct or operate a facility which may result in a regulated fill or discharge into the waters of the United States.

3.1 Authority and Applicability

Pursuant to the federal Clean Water Act,

> *Any applicant for a Federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which may result in any discharge into the navigable waters, shall provide the licensing or permitting agency a Certification from the State . . . that any such discharge will comply with the applicable [water quality standards] . . .*

33 U.S.C. § 1341(1) (2014). The required State Certification is a "statement that there is a reasonable assurance that the activity will be conducted in a manner which will not violate applicable water quality standards." 40 C.F.R.§ 121.2 (a) (3) (July 1, 2013).

The WQCD shall

> *Review and certify, conditionally certify, or deny request for Certification under the provisions of section 401 of the federal [Clean Water] act, and this article, known as "401 certificates". Conditions attached to the Division's Certification shall only implement rules which the commission has made applicable to 401 Certifications.*

C.R.S. § 25-8-302(1)(f) (2014). The Water Quality Control Commission (WQCC) has adopted regulations to implement Colorado's 401 Certification, which apply to 404 permits issued by the U.S. Army Corps of Engineers (Corps), among others. 5 CCR 1002-82, §82.1 (Mar. 30, 2003). 401 Certification applies to "both the construction and operation" of a Project. Id. at §82.3(C). These regulations define what conditions can be required by the WQCD in connection with Certification of federal licenses and individual permits.

> *This regulation applies to Water Quality Control Division Certification of permits issued by the U.S. Army Corps of Engineers pursuant to Section 404 of the Clean Water Act, Federal Energy Regulatory Commission licenses for hydropower Projects, and other federal permits which involve a discharge into waters of the state, including permits issued by the Environmental Protection Agency (EPA) pursuant to section 402 of the Federal Act.*

5 CCR 1002-82 §82.1. For the U.S. Army Corps of Engineers, only individual 404 permits require Certification. Nationwide permits are certified by a provision in the Colorado Water Quality Control Act. C.R.S. §25-8-302(1)(f). Procedural Rules define some of the procedural aspects such as public notice, public comments and appeal procedures. 5 CCR 1002-82 §5.

In Colorado, all potential water quality impacts associated with a Project described in the federal permit application, such as a 404 permit, are considered.

> *The second important issue resolved by this regulation is the Commission's determination that section 401 of the federal act authorizes states to certify (1) that the "discharge" from the section 401 activity will comply with water quality requirements that may be imposed under state law, and (2) that*

> *changes in water quality caused by the activity producing the discharge will also so comply. Consistent with this interpretation of federal law, new condition 21 (of section 2.4.5) permits the Division to impose requirements on section 401 activities (1)* ***to address "direct" water quality impacts resulting from the discharge, and (2) to address "indirect" water quality impacts resulting from the activity itself****. Examples of the latter might include: changes in the character of a body of water caused by an impoundment, reservoir, or water diversion structure requiring a section 404 permit (and consequent state 401 Certification). The Commission believes that section 401 of the federal act and sections 25-8-202 and 25-8-205 of the Colorado Water Quality Control Act authorize the impacts of these activities to be addressed to the extent they alter the biological, chemical, or physical integrity of the waters of the State. These impacts are indirectly caused by the discharge, in that they would not occur unless the discharge is authorized.5 CCR 1002-82 §82.15 (emphasis added)*

Standard conditions apply to all Certifications as described in 5 CCR 1002-82 §6(A) and (B).

In the case of WGFP the only direct impacts are those associated with construction activities and will be addressed in the Stormwater Management Plan (see section 11). Since no discharge is associated with the activity itself, the rest of the impacts are indirect and are the focus of this report.

3.2 Scope

The 401 Certification addresses all water quality impacts from the Project resulting from both construction and operation phases.

> *Any Certification issued by the Division pursuant to these regulations shall apply to both the construction and operation of the Project for which a federal license or permit is required, and shall apply to the water quality impacts associated with the Project*

5 CCR 1002-82 §3(C). This is further discussed in 5 CCR 1002-82 §15.

3.3 Application and Certification

An application for 401 Certification for a 404 individual permit from the Corps shall include:

a. A copy of the federal application for the Corps section 404 permit to discharge dredge and fill material;
b. A map of the Project location;
c. A site plan; and
d. A listing of the selected Best Management Practices ("BMPs") chosen for the Project.

Id. at §82.4(A). Applicants may submit additional water quality related information. The WQCD may request additional water quality related information from the applicant if the information in the federal application or the application is deemed insufficient to reach a Certification decision. *Id*. at §82.4(D).

The WQCD "shall prepare" both a draft Certification for public comment, and a final Certification following the close of public comments. 5 CCR 1002-82, §82.5(B). Once the WQCD has a complete application, it will provide Public Notice the Project. A draft Certification will be prepared and will be noticed in the Water Quality Information Bulletin. Comments can be submitted within 30 days of publication in the bulletin. The draft Certification will include 1) if applicable, a preliminary antidegradation review and 2) a draft Certification determination.

If the Project (constructed, operated and maintained as designed) complies with all applicable requirements, a regular Certification is issued. A conditional Certification can be issued if the Project

complies only under one or more conditions placed on the permit. An emergency Certification can be issued when it is necessary to preserve public health or welfare and some Certification requirements may then be modified or waived. Finally, the WCQD can deny Certification, even with conditions, when it concludes there is no reasonable assurance that the Project will comply with all applicable requirements. *5* CCR 1002-82 §82.5 (A).

The Colorado Water Quality Control Act, C.R.S. 25-8-104 states:

> *Interpretation and construction of water quality provisions. (1) No provision of this article shall be interpreted so as to supersede, abrogate, or impair rights to divert water and apply water to beneficial uses in accordance with the provisions of sections 5 and 6 of article XVI of the constitution of the state of Colorado, compacts entered into by the state of Colorado, or the provisions of articles 80 to 93 of title 37, C.R.S., or Colorado court determinations with respect to the determination and administration of water rights. Nothing in this article shall be construed, enforced, or applied so as to cause or result in material injury to water rights. The general assembly recognizes that this article may lead to dischargers choosing consumptive types of treatment techniques in order to meet water quality requirements. Under such circumstances, the discharger must comply with all of the applicable provisions of articles 80 to 93 of title 37, C.R.S., and shall be obliged to remedy any material injury to water rights to the extent required under the provisions of articles 80 to 93 of title 37, C.R.S. The question of whether such material injury to water rights exists and the remedy therefor shall be determined by the water court. This section shall not be interpreted so as to prevent the issuance of a permit pursuant to sections 25-8-501 to 25-8-503 which is necessary to protect public health. Nothing in this article shall be construed to allow the commission or the division to require minimum stream flows or minimum water levels in any lakes or impoundments.*

The WQCD must protect water quality while complying with section 25-8-104. General and special conditions may be added to the Certification, designed to meet water quality concerns while still allowing the Project to proceed.

The final Certification is prepared following the 30 day public notice. It may include any changes determined appropriate by the WQCD based upon public comments and information raised during the public comment period for the draft Certification. The notice of the final Certification determination is published in the Water Quality Information Bulletin. The final Certification does not require a public comment period.

There may be instances where another regulatory program could address water quality concerns with the federal license or permit, such as a control regulation or a MS4 Stormwater Permit. Ensuring that water quality issues are addressed is the primary concern, regardless of what regulatory program the conditions fall under.

3.4 Antidegradation Review

The WQCD is required to comply with antidegradation review requirements as part of its determination of whether to issue a Section 401 Certification for a Project. *Id.*, § 82.5(A)(1)(a). The first step in the process for activities with new or increased water quality impacts that may degrade the quality of reviewable waters is a preliminary antidegradation determination in the WQCD's draft 401 Certification determination. 5 CCR 1002-21, § 21.16(B)(1)(d). Notice of the preliminary antidegradation determination is given to the applicant, EPA, and any regional council of governments, county, local health departments, and cities and towns that the WQCD believes may be affected by the proposed activity, and any other persons requested by the applicant. *Id.*, § 21.16(B)(1)(d). The WQCD circulates its final determination to the project proponent and all persons requesting notification. *Id.* § 21.16(C)(5).

3.4.1 Water Bodies Subject to Antidegradation Review

Colorado's antidegradation rule provides three levels of protection for water bodies. The highest level of protection is for water bodies that have been designated "Outstanding Waters," which are present almost exclusively within National Park and Wilderness Area boundaries. The lowest level of protection is for water bodies designated "Use-Protected." All other water bodies, referred to as "Reviewable Waters," receive an intermediate level of protection. 5 CCR 1002-31 §31.8. All of the water bodies relevant to the Windy Gap Firming Project (including the mainstem of the Colorado River below Windy Gap Reservoir, Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake and South Platte tributaries) are Reviewable Waters.

Antidegradation review for Reviewable Waters is a two-step process. First, the WQCD determines whether the activity is likely to result in "significant degradation of reviewable waters." 5 CCR 1002-31, § 31.8(3)(c). If the WQCD finds that significant degradation is likely, then it determines whether "the degradation is necessary to accommodate important economic or social development in which the waters are located." *Id.*, § 31.8(3)(d).

3.4.2 Significant Degradation Test

The significant degradation test addresses the net effect of the proposed activity, "taking into account any environmental benefits resulting from the regulated activity and any water quality enhancement or mitigation measures impacting the segment or segments under review, if such measures are incorporated with the proposed regulated activity."*Id.*, § 31.8(3)(c). The determination focuses on the effects of the activity with respect to numeric or narrative standards that have been adopted by the WQCC.

Under the significance test applied to all pollutants, there is no significant degradation of water quality in the segment if:

(i) For bioaccumulative toxic pollutants (i.e., those chemicals for which the bioaccumulation factor (BAF), is equal to or greater than 1000) the new or increased loading from the source under review is less than 10 percent of the existing total load to that portion of the segment impacted by the discharge for critical constituents; provided, that the cumulative impact of increased loadings from all sources shall not exceed 10 percent of the baseline total load established for the portion of the segment impacted by the discharge (the baseline total load shall be determined at the time of the first proposed new or increased water quality impacts to the reviewable waters.); and

(ii) For all pollutants:

(A) The flow rate or volume of a new or increased discharge under review is small enough that it will be diluted by 100 to 1 or more at low flow, as defined in section 31.9, by water in the stream; or
(B) The new activity or increased discharge from the source under review will consume, after mixing, less than 15 percent of the baseline available increment, provided that the cumulative increase in concentration from all sources shall not exceed 15 percent of the baseline available increment. The baseline available increment is the increment between low-flow pollutant concentrations and the relevant standards for critical constituents for that portion of the segment impacted by the discharge. The baseline low-flow pollutant concentration shall represent the water quality as of September 30, 2000, and shall be determined at the time of the first proposed new or increased water quality impacts to the reviewable waters after that date . . .

Id., § 31.8(3)(c). Impacts to water quality will also not be considered significant if the activity will result in only temporary or short term water quality changes. *Id.* at (3)(c)(ii)(C). It is unclear what, if any, criteria are applied to determine if an activity will cause significant degradation with regard to narrative water quality standards, such as silt and sediment, or the Grand Lake narrative clarity standard.

3.4.3 Necessity Test

If the WQCD determines that an activity is likely to result in significant degradation of water quality, then it must determine whether the degradation is "necessary to accommodate important economic or social development in the area in which the waters are located." The "area in which the waters are located" is determined on a case-by-case basis and must include all areas directly impacted by the proposed activity. *Id.* §31.8 (3)(d)(i).

If the activity proponent submits evidence that the activity is necessary to accommodate important development, the WQCD will presume it is important unless there is evidence to the contrary in the public review process. The WQCD must take into account information received during the public comment period and "shall give substantial weight to any applicable determinations by local governments or land use planning authorities." *Id.*, § 31.8(3)(d)(ii).

If the regulated activity is determined to be "important economic or social development," the WQCD must determine whether the degradation that would result from the activity is necessary. *Id.* §31.8 (3)(d)(iii). The WQCD bases this decision on whether there are any "water quality control alternatives available" that would result in less degradation of state waters and are economically, environmentally, and technologically reasonable. The scope of alternatives considered is limited to those that would accomplish the proposed activity's purpose. Also, alternatives considered must be consistent with C.R.S.§ 25-8-104, which provides that the Water Quality Act will not be interpreted to "superseded, abrogate, or impair rights to divert water and apply water to beneficial use . . . [or] to cause or result in material injury to water rights." Finally, the alternatives considered must be technologically and economically reasonable. *5* CCR 1002-31, § 31.8(3)(d)(iii).

3.4.4 Applicable Water Quality Standards

Applicable water quality standards subject to the WQCD consideration in the 401 Certification process consist of the classified uses in addition to the relevant numeric and narrative standards for waters affected by the Project. The segments of interest to the Project are presented in Table 1, with their associated water quality standards:

Table 1- Applicable Water Quality Standards

Segment	Classifications	Physical & Biological	INORGANIC mg/l		METALS ug/l		
Upper Colorado 3. Mainstem of the Colorado River from the outlet of Granby Reservoir to the confluence with Roaring Fork River	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-II) °C 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)=TVS Zn(ch)=TVS(sc)
Upper Colorado 12. Lakes and reservoirs within Araphaoe National Recreation Area, including Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)oC Shadow Mtn Res April-Dec T(WAT)=19.30 °C Granby Res April-Dec T(WAT)=19.42 °C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml * Grand Lake July-Sept 4 meter secchi disk depth, eff. 1/1/2015	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

Segment	Classifications	Physical & Biological	INORGANIC mg/l		METALS ug/l		
Cache La Poudre 14. Horsetooth Reservoir	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CLL) °C Apr-Dec T(WAT)=22.8 °C 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(ac/ch)=TVS Mn(ch)=WS(dis)	Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS
Big Thompson 11. Carter Lake	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CLL) °C April-Dec T(WAT)=22.7 °C 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(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS
Big Thompson 2. Mainstem of the Big Thompson River, including all tributaries and wetlands from the boundary of Rocky Mountain National Park to the Home Supply Canal diversion, except for the specific listing in Segment 7; mainstem of Black Canyon Creek and Glacier Creek below Estes Park water treatment plant.	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-II) °C 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(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS
Big Thompson 9. Mainstem of the Little Thompson River from the Culver Ditch diversion to the confluence with the Big Thompson River.	Aquatic Life Recreation E Agriculture	T=TVS(WS-II) °C D.O.=5.0 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=0.5 NO3=100	As(ac)=340 As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS

Segment	Classifications	Physical & Biological	INORGANIC mg/l		METALS ug/l		
Cache La Poudre 10. Mainstem of the Cache La Poudre River from the Monroe Gravity Canal/North Poudre Supply Canal diversion to Shields Street in Ft. Collins, Colorado.	Aq Life Cold 2 Recreation E Water Supply Agriculture	T=TVS(CS-II) °C 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(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS
Saint Vrain 2b. Mainstem of St. Vrain Creek, including all tributaries and wetlands, from the eastern boundary of Roosevelt National Forest to Hygiene Road.	Aquatic Life Recreation E Water Supply Agriculture	T=TVS(CS-II) °C 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(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS
Saint Vrain 5 - Mainstem of Left Hand Creek, including all tributaries and wetlands from Highway 36 to the confluence with St. Vrain Creek.	Aquatic Life Recreation E Water Supply Agriculture	T=TVS(WS-I) °C D.O.=5.0 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=0.5 NO3=10 SO4=WS	As(ac)=340 As(ch)=0.02-10(Trec) Cd(ac/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(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS
Boulder Creek 9. Mainstem of Boulder Creek from a point immediately above the confluence with South Boulder Creek to the confluence with Coal Creek.	Aq Life Warm 1 Recreation E Water Supply Agriculture	T=TVS(WS-II) °C D.O.=5.0 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=0.5 NO3=10 Cl=250 SO4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac/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(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS

** Narrative standard for Grand Lake: the highest level of clarity attainable, consistent with the exercise of established water rights and the protection of aquatic life (eff., through 12/31/2016).*

Temperature standards are summarized in Table 2. Temperature standards are assessed as the Maximum Weekly Average Temperature (MWAT) for the chronic standard and as the Daily Maximum temperature (DM) for the acute standard.

Table 2 - Temperature Standards

Cold Water	Warm Water
CS-I: June-Sept = 17.0 (ch), 21.7(ac) Oct –May = 9.0 (ch), 13.0 (ac)	**WS-I** Mar-Nov = 24.2(ch), 29.0 (ac) Dec-Feb= 12.1(ch), 14.5(ac)
CSII: Apr-Oct =18.3 (ch), 23.9 (ac) Nov-Mar =9.0 (ch), 13.0 (ac)	**WS-II** Mar-Nov= 27.5(ch), 28.6(ac) Dec-Feb=13.8 (ch), 14.3 (ac)
Lakes & Res: Apr-Dec = 17.0 (ch), 21.2 (ac) Jan-Mar = 9.0 (ch), 13.0 (ac)	**WS-III** Mar-Nov = 28.7 (ch), 31.8 (ac) Dec-Feb = 14.3 (ch), 15.9 (ac)
Large Lakes & Res (<100 acres): Apr-Dec = 18.3(ch), 23.8 (ac) Jan-Mar = 9.0(ch), 13.0 (ac)	**Lakes & Res:** Apr-Dec = 26.3 (ch), 29.5 (ac) Jan-Mar = 13.2 (ch), 14.8 (ac)

Nutrient Criteria were adopted by the WQCC in 2013 and will become adopted in each river basin as the WQCC proceeds with its triennial basin reviews (Upper Colorado River in June 2014 and South Platte Basin in June 2015). These are summarized in Table 3, Table 4 and Table 5. The WQCC adopted a phased approach for implementation of these standards. 5 CCR 1002-31 §31.17 provides:

> *(e) Use of Interim Phosphorus and Chlorophyll a Values for Standards Adoption*
> *Prior to May 31, 2022, the values set forth in the water quality table value standards 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.

Table 3 - Interim Phosphorus Standards

Waterbody Type	Cold	Warm
Lakes and Reservoirs, >25 acres	25 ug/L [1]	83 ug/L [1]
Lakes and Reservoirs, <=25 acres	RESERVED	RESERVED
Rivers and Streams	110 ug/L [2]	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.

Table 4 - Interim Nitrogen Standard

Waterbody Type	Cold	Warm
Lakes and Reservoirs, cold, >25 acres	426 ug/L [1]	910 ug/L [1]
Lakes and Reservoirs, <=25 acres	RESERVED	RESERVED
Rivers and Streams	1,250 ug/L [2]	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.

Table 5 - Interim Chlorophyll a Standards

Waterbody type	Cold	Warm	DUWS
Lakes and Reservoirs, cold, >25 acres	8 ug/L [a]	20 ug/L [a]	5 ug/L [c]
Lakes and Reservoirs, <=25 acres	RESERVED	RESERVED	5 ug/L [c]
Rivers and Streams	150 mg/m2 [b]	150 mg/m2 [b]	

[a] summer (July 1- September 30) average chlorophyll a (ug/L) in the mixed layer of lakes (median of multiple depths), allowable exceedance freq uency 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.

In addition, all waters of the State are subject to certain basic standards. Except where authorized by permits, BMPs, 401 Certifications, or plans of operation approved by the WQCD or other applicable agencies, State surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which:

(a) for all surface waters except wetlands;

(i) can settle to form bottom deposits detrimental to the beneficial uses. Depositions are stream bottom buildup of materials which include but are not limited to anaerobic sludges, mine slurry or tailings, silt, or mud; or

(ii) form floating debris, scum, or other surface materials sufficient to harm existing beneficial uses; or

(iii) produce color, odor, or other conditions in such a degree as to create a nuisance or harm existing beneficial uses or impart any undesirable taste to significant edible aquatic species or to the water; or

(iv) are harmful to the beneficial uses or toxic to humans, animals, plants, or aquatic life; or
(v) produce a predominance of undesirable aquatic life; or
(vi) cause a film on the surface or produce a deposit on shorelines.

3.4.5 Required Best Management Practices

Applicants are required to implement Best Management Practices (BMPs) to obtain a 401Certification. Although the Applicant selects the BMPs to be employed from a list of approved BMPs adopted by the WQCC. 5 CCR 1002-82, at §82.6(B) and App. I. At a minimum, BMPs must provide for:

i. Temporary erosion and sediment control measures to assure economical, effective and continuous control through the construction phase of the Project; and
ii. Permanent erosion and sediment control measures installed at the earliest practicable time consistent with good construction practices, which shall be maintained and replaced as necessary throughout the life of the Project.

5 CCR 1002-82, at §82.6(B)(2).

BMPs involve the proper design and construction of water quality protective features of Projects, and appropriate operation and maintenance of these features to ensure long-term compliance of Projects with erosion and sediment control measures included in the 401 Certification. *Id.* App. I, at A.

4 Project

4.1 Background

The Windy Gap Firming Project (WGFP) is a proposed water supply Project that would provide more reliable water deliveries to Colorado's Front Range and West Slope communities and industries.
Due to limitations and constraints with the existing system, the current Windy Gap Project facilities, which were completed in 1985, are unable to deliver the anticipated firm yield of water. Water deliveries from the West Slope currently are limited by storage capacity in Granby Reservoir and by the delivery capacity of the Adams Tunnel, which delivers water from Grand Lake to the East Slope. The WGFP would add water storage and related facilities to the existing Windy Gap operations capable of delivering a firm annual yield of about 30,000 acre-feet (AF) to Project Participants. The intent of the WGFP is to improve the yield from an existing Project and existing Windy Gap water rights.

Project Participants in the WGFP include municipalities, rural domestic water districts, and an industrial water user. Project Participants on the East Slope are the City and County of Broomfield, Central Weld County Water District, Town of Erie, City of Evans, City of Fort Lupton, City of Greeley, City of Lafayette, Little Thompson Water District, City of Longmont, City of Louisville, City of Loveland, Platte River Power Authority, and the Town of Superior. In addition, the Project seeks to firm the water supply for the Middle Park Water Conservancy District (MPWCD), which is a wholesale water supplier that allocates Windy Gap water to about 67 water providers, including towns, water districts, agricultural water suppliers, consumers, and ski areas in Grand and Summit counties on the West Slope. WGFP Participants determined that a cooperative Project was the most efficient means to firm Windy Gap water deliveries rather than each entity developing storage for its own share of Windy Gap water.

The Municipal Subdistrict, Northern Colorado Water Conservancy District (Northern Water) acting by and through the Windy Gap Firming Project Water Activity Enterprise (Subdistrict), on behalf of WGFP Participants, has received approval from the U.S. Bureau of Reclamation (Reclamation) for additional physical connections to Colorado-Big Thompson (CBT) Project facilities in order to implement the proposed Project. Reclamation's decision on the WGFP is a major federal action requiring preparation of an Environmental Impact Statement (EIS). The EIS summarizes the alternatives analyzed in detail and their anticipated environmental effects. The reader is referred to the entire Final EIS for a more complete description and analysis.

Figure 5 - Windy Gap Project Facilities

Windy Gap Project water is currently diverted from the Colorado River just downstream of the confluence of the Colorado and Fraser rivers into the Windy Gap Reservoir (Figure 5). From the reservoir the water is pumped to Granby Reservoir for storage and conveyance through C-BT Project facilities and ultimate delivery to Windy Gap Project allottees on the East Slope. MPWCD's Windy Gap water is stored in Granby Reservoir and released to replace stream diversions or ground water use by contract holders at various locations in Grand and Summit counties.

The original Windy Gap Project was estimated to deliver about 48,000 acre-feet (AF) of firm annual deliveries to Windy Gap allottees and the MPWCD; however, Project Participants have not been able to rely on Windy Gap water for water deliveries for two primary reasons:

- In dry years, the Windy Gap Project has not been able to divert water because more senior water rights upstream and downstream have a higher priority to divert water and "call out" the more junior Windy Gap Project water right. In addition, the Windy Gap Project is required to bypass water to maintain certain minimum streamflows downstream of the Windy Gap diversion dam.
- Granby Reservoir, a component of the C-BT Project, is currently the only storage available for Windy Gap water prior to delivery to Participants. Water conveyed and stored for the C-BT Project has priority over water conveyed and stored for the Windy Gap Project. Thus in wet years, when the C-BT system is full, there is no conveyance or storage capacity for Windy Gap Project water. This prevents the Windy Gap Project from storing water in some wet years for use in subsequent dry years.

Because the Windy Gap Project is unable to provide reliable yields in both wet and dry years, the current firm yield is zero. Firm yield is typically defined as the amount of water that can be delivered on a reliable basis in all years and is typically determined by yield in dry years. For the Windy Gap Project, lack of available storage space in wet years also affects yield.

The purpose of the Windy Gap Firming Project is to deliver a firm annual yield of about 30,000 AF of water from the existing Windy Gap Project to meet a portion of the water deliveries anticipated from the original Windy Gap Project. Firm water deliveries from the Windy Gap Project are needed to meet a portion of the existing and future demands of the Project Participants. The Middle Park Water Conservancy District, an original Participant in the Windy Gap Firming Project, separately negotiated an agreement with the Subdistrict to assure approximately 2,300 acre-feet of the Windy Gap water supplies provided to it by the Subdistrict will be firmed, hence improving the reliability of its Windy Gap water supply for users in Grand and Summit counties, Colorado.

4.2 Alternatives Selection and Screening

As part of the 401 Certification and the Necessity Test, the WQCD has to make a determination whether there are "water quality control alternatives available"[1] that would result in less degradation of state waters and are economically, environmentally, and technologically reasonable.

A separate alternatives analysis was not performed for the purpose of the 401 Certification, instead a summary of the alternatives selection and screening done for the FEIS is provided here. This approach is consistent with the intent expressed in 5 CCR 1002-31 §31.23 (A)(5)(f) Statement of Basis, Specific Statutory Authority and Purpose (1988 Revisions-Antidegradation).

> *Projects that require 404 section permit are already subject to Corps of Engineers and EPA requirements to consider alternatives (see, e.g. 33 CFR section 320.4 (a)(2)(ii) and 40 CFR section 230.10 (a)). Projects subject to federal NEPA requirements already are faced with an alternatives analysis requirement that goes substantially beyond that required here. The Commission intends that the alternatives analysis for antidegradation review purposes should be coordinated with any such reviews to the extent possible to avoid unnecessary duplication.*

1 It is recognized that even though the scope of 5 CCR 1002-82 includes Federal projects, dischargers are the primary focus of 401 Certification regulations and that the regulatory framework is not always well adapted to projects like the WGFP, nevertheless when such discrepancies were encountered in the process of writing this report, approaches and methodologies were developed to comply with the overall intent of the regulations. In this instance, WQCD staff specifically requested that a summary of the Alternatives Selection and Screening be provided.

The goal of the alternative selection process was to identify a reasonable range of alternatives to meet the purpose and need of the proposed WGFP. National Environmental Policy Act (NEPA) regulations do not specify the number of alternatives that need to be considered in the EIS, but indicate that a reasonable range of alternatives should be evaluated. The Council on Environmental Quality (CEQ) defines reasonable alternatives as "those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant" (CEQ 1986). CEQ regulations also require that all reasonable alternatives, including no action, are rigorously explored and objectively evaluated and that the reasons for eliminating alternatives are discussed (40 CFR 150.14).

In addition to satisfying NEPA requirements, Projects subject to permitting by the U.S. Army Corps of Engineers under the Clean Water Act also must comply with Section 404(b)(1) Guidelines (40 CFR, Part 230) for discharge of dredge and fill material into waters of the U.S. These Guidelines specify "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences" (Section 230.10(a)). An alternative is considered practicable if "it is capable of being done after taking into consideration cost, existing technology, and logistics in the light of overall Project purposes" (Section 230.10(a)(2)). Practicable alternatives under the Guidelines assume that "alternatives that do not involve special aquatic sites are available, unless clearly demonstrated otherwise" (Section 230.3(q)).

Guidelines also assume that "all practicable alternatives to the proposed discharge which do not involve a discharge into a special aquatic site are presumed to have less adverse impact on the aquatic ecosystem, unless clearly demonstrated otherwise" (Section 230.10(a)(3)).

The alternatives analysis required for Section 404(b)(1) can be conducted either as a separate analysis for 404 permitting or incorporated into the NEPA process. Reclamation and the Corps have agreed that an integrated approach for the alternatives analysis is appropriate to satisfy NEPA and 404(b)(1) requirements. Integration of both NEPA and 404(b)(1) Guidelines ensures that the alternatives selected for evaluation in the EIS are both reasonable and practical.

4.2.1 Development of Alternatives

The development of potential alternatives for firming the yield of the Windy Gap Project began with a study conducted by the Subdistrict. The results of this study were documented in an Alternative Plan Formulation Report (APFR) (Boyle Engineering and EDAW, 2003).

The APFR identified several categories of alternatives, including new reservoir sites, enlargement or re-regulation of existing reservoirs and development of ground water storage. In addition, nonstructural measures that did not require new infrastructure were evaluated. Hydrologic modeling results conducted for the APFR and subsequent analyses for the EIS indicate that to meet the Project Participant's goal of a reliable annual firm yield of about 30,000 AF would require around 90,000 AF of new storage.

The APFR began with a broad range of potential Project elements followed by successive phases of screening and evaluation to identify potentially feasible alternatives. A total of 171 different Project elements with individual storage features were evaluated. The analysis resulted in the identification of seven possible alternatives that were presented during the public and agency scoping meetings held in the fall of 2003. The seven identified alternatives were:

- Chimney Hollow Reservoir
- Little Thompson Reservoir
- Cactus Hill Reservoir
- Chimney Hollow Reservoir and Jasper North A Reservoir

- Jasper North Reservoir and Rawhide Reservoir
- Jasper North Reservoir and Chimney Hollow Reservoir
- Chimney Hollow and Rawhide Reservoir

Reclamation and the Corps reviewed the results of the APFR to determine the adequacy of the preliminary identification of potential alternatives and the analyses that were conducted to select alternatives. Both agencies concurred that the APFR provided an excellent compilation of data and alternatives analysis. However, further refinement of the alternative screening and selection process was needed to address the requirements of the 404(b)(1) Guidelines. To comply with 404(b)(1) Guidelines, Reclamation, in concert with the Corps, reevaluated all of the alternatives identified in the APFR, as well as several new alternatives identified following completion of the APFR and scoping.

4.2.2 Alternatives Screening

Three successive levels of screening were applied to the range of potential alternatives to narrow the list of alternatives for consideration in the EIS. Section 404(b)(1) Guidelines were used as the primary screening tool for the evaluation of alternatives. These Guidelines include five categories of screening criteria - purpose and need, logistics, technology, environmental consequences, and the costs to construct the Project (40 CFR 230.10). Cost was not used to screen potential WGFP alternatives because it did not adequately differentiate alternatives. Additional detail on the screening and evaluation of alternatives is found in the Windy Gap Firming Project Alternatives Report (ERO, 2005) and in Section 2.1 of the FEIS. Appendix C of the FEIS provides a Preliminary Draft Section 404(b)(1) Effects Analysis.

Alternatives were screened using Clean Water Act Section 404(b)(1) criteria:

- Purpose and Need
- Logistics
- Technology
- Environmental Consequences

The initial Level 1 screening of alternatives considered four categories of 404(b)(1) criteria: purpose and need, logistics, technical, and environmental. Alternatives that did not meet Level 1 screening criteria were eliminated from further consideration. Alternatives that passed Level 1 screening were further evaluated with Level 2 screening. A total of 124 potential new reservoir sites identified for analysis were eliminated by the Level 1 screening criteria. Thirteen new reservoirs were carried forward for further analysis in level 2, including ten East Slope reservoir sites and three West Slope reservoir sites.

Level 2 screening was based on storage options that would have the least potential effect on wetlands, which are part of the 404(b)(1) evaluation process.

The third level of alternatives analysis evaluated the 11 remaining reservoir alternatives based on their ability to meet the purpose and need of the proposed Project, along with consideration of additional logistical and environmental factors. Based on the screening and evaluation of potential alternatives, four reservoir sites were deemed feasible to meet the purpose and need for the proposed WGFP and were selected for NEPA Analysis.

4.3 Alternatives

The Windy Gap Firming Project Alternatives Report (ERO, 2005) identified four action alternatives in addition to the No Action alternative for detailed evaluation in the EIS. All action alternatives include development of 90,000 AF of new storage in either a single reservoir on the East Slope or a combination of East and West Slope reservoirs.

The Subdistrict's Proposed Action is the construction of a 90,000 AF Chimney Hollow Reservoir with prepositioning.

The alternatives are:

- Alternative 1 (No Action) – Continuation of existing operations and agreements between Reclamation and the Subdistrict for conveyance of Windy Gap water through the Colorado-Big Thompson facilities, including the enlargement of Ralph Price Reservoir by the City of Longmont
- Alternative 2 (Proposed Action) – Chimney Hollow Reservoir (90,000 AF) with Prepositioning
- Alternative 3 – Chimney Hollow Reservoir (70,000 AF) and Jasper East Reservoir (20,000 AF)
- Alternative 4 – Chimney Hollow Reservoir (70,000 AF) and Rockwell/Mueller Creek Reservoir (20,000 AF)
- Alternative 5 – Dry Creek Reservoir (60,000 AF) and Rockwell/Mueller Creek Reservoir (30,000 AF)

Prepositioning, under the Proposed Action, involves the storage of Colorado-Big Thompson (CBT) water in Chimney Hollow Reservoir. Windy Gap water pumped into Granby Reservoir would then be exchanged for C-BT water stored in Chimney Hollow. Windy Gap water stored in Chimney Hollow would be delivered and allocated to the WGFP Participants. This arrangement ensures temporary space in Granby Reservoir to introduce and store Windy Gap water. Total allowable C-BT storage would not change and the existing C-BT water rights and diversions would not be expanded. To prevent the C-BT Project from expanding diversions through prepositioning, total modeled C-BT storage in Granby Reservoir and Chimney Hollow was limited to the capacity of Granby Reservoir, which is 539,758 AF. If this capacity limitation is reached, the model forces the C-BT Project to bypass water at Granby Reservoir. This water is then available for diversion at Windy Gap. Therefore, under prepositioning, C-BT diversions would not be expanded with respect to their current water rights and capacity limitations.

In addition to the action alternatives, a No Action alternative was identified based on what is reasonably likely to occur if Reclamation does not approve the connection of the new WGFP facilities to C-BT facilities. Under this scenario, the existing contractual arrangements between Reclamation and the Subdistrict for storage and transport of Windy Gap water through the C-BT system would remain in place. All Project Participants in the near term would maximize delivery of Windy Gap water according to their demand, Windy Gap water rights, and C-BT facility capacity constraints including availability of storage space in Granby Reservoir, and the Adams Tunnel conveyance constraints. The City of Longmont would develop storage independently for firming Windy Gap water if the WGFP is not implemented. Most Participants indicate that in the long term, they would seek other storage options, individually or jointly, to try to firm Windy Gap water because of the Applicant's need for reliable Windy Gap deliveries and the substantial investment in existing infrastructure.

Those Participants that do not have a currently defined storage option would take delivery of Windy Gap water whenever it is available within the capacity of their existing water systems and delivery points under the terms of the existing Carriage Contract with Reclamation and the Northern Colorado Water Conservancy District (Northern Water). Participants that would operate under this scenario include Broomfield, Central Weld County Water District, Erie, Evans, Fort Lupton, Greeley, Little Thompson Water District, Louisville, Loveland, Platte River Power Authority, and Superior. The City of Lafayette anticipates that it would withdraw from participating in the WGFP and dispose of existing Windy Gap units and not pursue acquisition of future units if the Firming Project is not constructed. Longmont indicates that it would

develop storage facilities for Windy Gap water independently if Reclamation does not approve a connection of WGFP facilities to C-BT facilities. The City would evaluate the enlargement of the existing Ralph Price Reservoir (Button Rock Dam) located on North St. Vrain Creek or Union Reservoir located east of the City. The enlargement of Ralph Price by 13,000 AF would be the City's preferred option because Union Reservoir would not have sufficient capacity for Windy Gap water and conveyance and distribution would be more efficient from a higher elevation reservoir. Middle Park Water Conservancy District, under No Action, would continue to use Windy Gap water to provide augmentation flows for other water diversions in a manner similar to current operations. MPWCD can store up to 3,000 AF of Windy Gap water in Granby Reservoir each year if Windy Gap water can be diverted and storage space is available.

Detailed descriptions of the components and operation of the alternatives is included in the Windy Gap Firming Project FEIS Alternatives Descriptions report.

The Applicant has prepared this application for the 401 Certification based on the Proposed Action (Alternative 2) as the Least Environmentally Damaging Alternative as determined by the Windy Gap Firming Project Record of Decision (ROD). The rest of this document therefore focuses on water quality assessments for the Proposed Action only.

4.4 Proposed Action (Chimney Hollow Reservoir)

The Proposed Action is the construction of a 90,000 AF Chimney Hollow Reservoir, along with the ability to store or preposition C-BT water in the new reservoir.

Water would be conveyed to Chimney Hollow Reservoir via a new pipeline connection to existing East Slope CBT facilities. Connections between Chimney Hollow Reservoir and Carter Lake would allow delivery of water to Participants using existing infrastructure.

The Chimney Hollow Reservoir site is in Larimer County about 8 miles southwest of Loveland, Colorado and ½ mile west of Carter Lake (Figure 2-5). The reservoir would be built in a hogback valley along an intermittent drainage at an elevation of about 5,600 feet.

4.4.1 Infrastructure

4.4.1.1 Dam and Spillway

Chimney Hollow Reservoir would require construction of a 346-foot-high dam to impound about 90,000 AF of water. The maximum normal pool elevation would be 5,866 feet. The reservoir at the maximum water surface elevation would inundate about 742 acres. Preliminary design indicates a rockfill dam type would be appropriate, but the specific type of rockfill dam would not be determined until final design. Appurtenances to the dam would include a spillway to convey a peak discharge of about 2,100 cfs. A 36-foot-high saddle dam would be required at the southern end of the reservoir.

4.4.1.2 Conveyance

Water would be conveyed to the East Slope via existing C-BT facilities as far as the upper end of the Flatiron Penstocks (Figure 7). Water would be conveyed to Chimney Hollow Reservoir using a new buried penstock pipeline to the pressure conduit between the Bald Mountain Tunnel surge tank and the Flatiron Penstock valve house. Other new conveyance facilities would include pipelines and an energy dissipation facility from the Flatiron Penstocks to the Chimney Hollow inlet/outlet along with connections to the existing

Carter Lake pressure conduit. Modifications in the various pipeline connections may be made during final design.

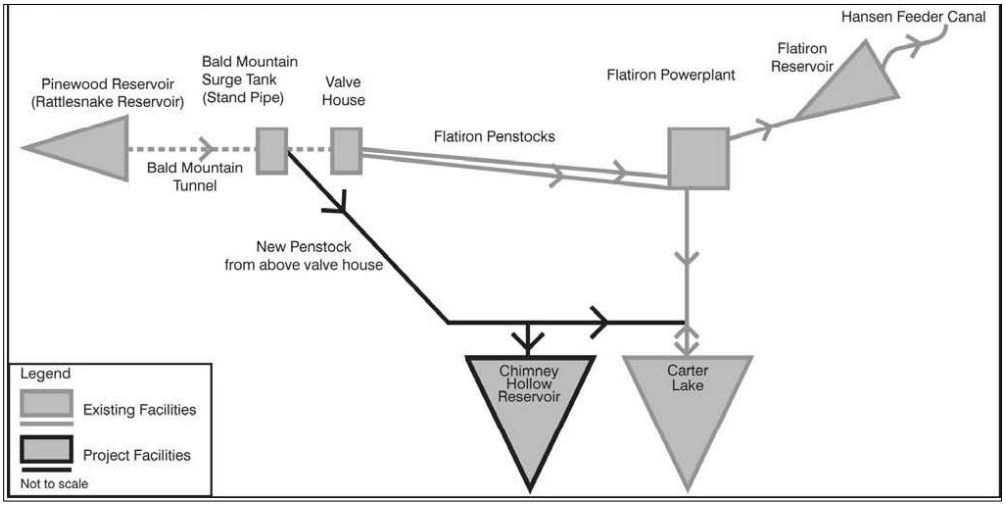
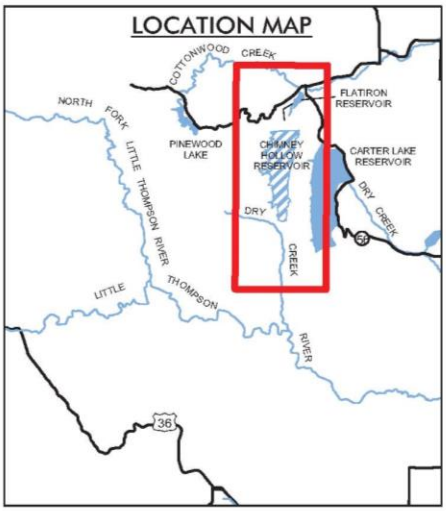


Figure 6 - Chimney Hollow Reservoir Connection Schematic



Inlet - Outlet Tunnel

Spillway and Channel

New Pipeline

Potential Disturbance Area

Transmission Line Corridor

Chimney Hollow Reservoir

Dam

NOTES:

1. FINAL LOCATION OF DAM CREST ACCESS ROAD TO BE DETERMINED THROUGH LARIMER COUNTY PARK PLANNING PROCESS.
2. SOUTH ACCESS ROAD DURING CONSTRUCTION - GATED WITH NO PUBLIC ACCESS FOLLOWING CONSTRUCTION.

0 2,000 4,000 Feet

N

USGS MAP OF THE CARTER LAKE RESERVOIR QUADRANGLE, BOULDER AND LARIMER COUNTIES, COLORADO
SITE SPECIFIC TOPOGRAPHY BASED ON AERIAL SURVEY, APRIL 2003

WINDY GAP FIRMING PROJECT

Alternative 2, Proposed Action Chimney Hollow Reservoir (90,000 AF)

Windy Gap Firming Project

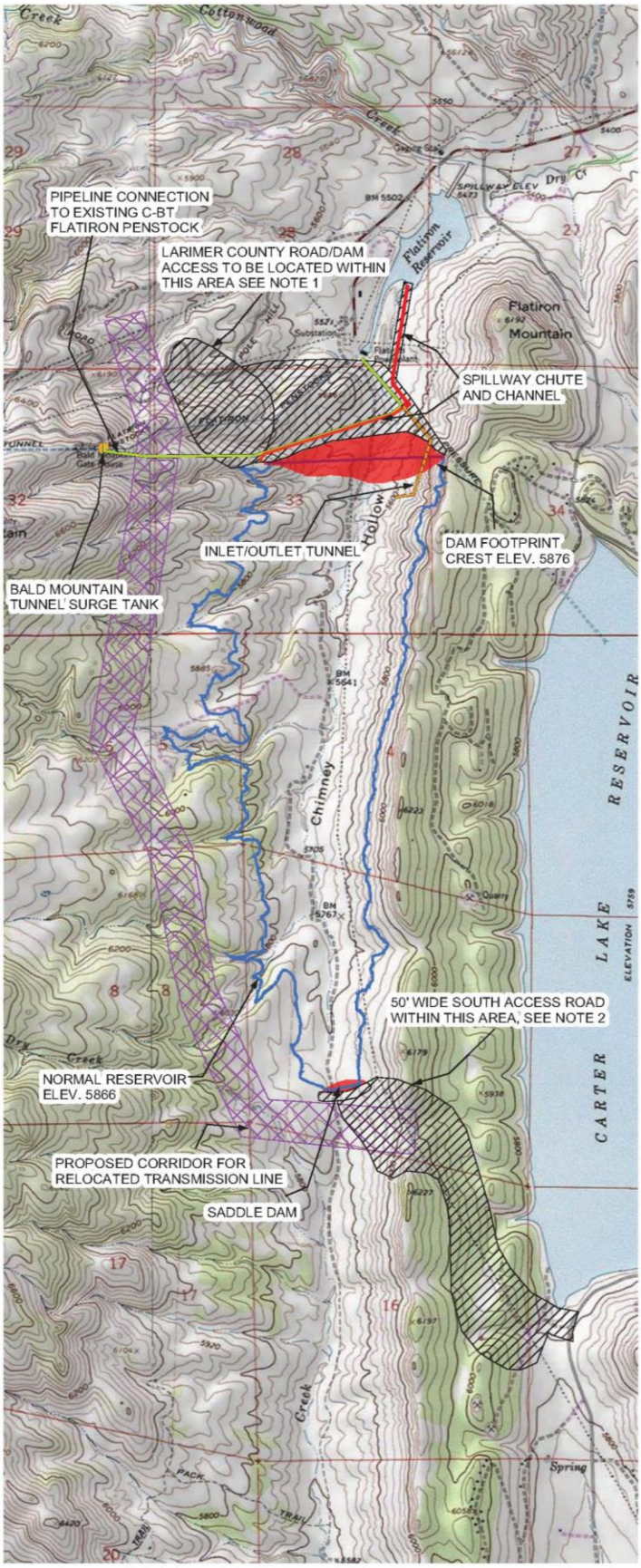


Figure 7 - Proposed Action Map

4.4.1.3 Access, Borrow Areas, and Power

Primary access to Chimney Hollow Reservoir would be from Pole Hill Road below the dam site. A new permanent access road about 1.5 miles long on the northwest side of the reservoir would provide access for construction, maintenance, and public recreation access after the reservoir is completed. The final road layout would be determined in coordination with Larimer County. Construction access to the saddle dam on the southern end of the reservoir would be located along or near an existing transmission line maintenance road. This road would be closed to public access.

Construction materials for the dams would be taken from borrow areas within the reservoir basin. Two primary borrow sources have been identified: 1) granite bedrock along the west rim of the reservoir for use as rockfill in the dam shell; and 2) fine-grained material in the central part of the reservoir for use as low permeability material in the core of the dam. The need for off-site borrow material would depend on the type of dam constructed and quality of the material from within the reservoir site. Off-site borrow material may be needed for concrete production, or bitumen if an asphaltic core rockfill dam is used. Commercial sources for these materials are available in the region if needed.

Power supply to the reservoir and conveyance facilities would come from the existing facilities associated with the Flatiron Power Plant. A substation may be needed to step down voltage.

4.4.2 Operations

Windy Gap water would be diverted from the existing point of diversion at Windy Gap Reservoir and Pump Plant located below the confluence of the Fraser and Colorado Rivers, near the Town of Granby. The existing Windy Gap pipeline would pump water to Granby Reservoir, which would then be delivered to the East Slope using existing C-BT facilities. Water would be routed to Chimney Hollow Reservoir using the new pipeline connections discussed previously in Section 4.4.1. No new West Slope infrastructure is needed to divert or convey water to the East Slope. In addition to storage in Chimney Hollow, Windy Gap water may also be stored in Granby Reservoir when unused capacity is available.

The delivery of Windy Gap water to the East Slope, either for storage or to meet Participant demand depends on several factors including the physical and legal availability of water for diversion, storage space in Granby Reservoir, capacity in the Adams Tunnel, and space in Chimney Hollow Reservoir. Instantaneous delivery of Windy Gap water as allowed by the existing Carriage Contract between Reclamation, Northern Water, and Municipal Subdistrict, Northern Colorado Water Conservancy District allows Windy Gap water in Granby Reservoir to be immediately delivered out of Carter Lake or Horsetooth Reservoir on the East Slope, with the same amount of water being exchanged with C-BT. Instantaneous deliveries reduce conveyance constraints in the Adams Tunnel or if space is not available in Chimney Hollow to take direct deliveries.

Prepositioning would be used to facilitate delivery of Windy Gap water and increase yield. Prepositioning would involve the use of available Adams Tunnel capacity to deliver C-BT water into Chimney Hollow to occupy storage space that is not occupied by Windy Gap water. Delivery of C-BT water to Chimney Hollow in this manner would maintain Chimney Hollow full most of the time. The delivery of C-BT water from Granby Reservoir into Chimney Hollow would create space for Windy Gap water in Granby Reservoir. When Windy Gap water is diverted into Granby Reservoir, the C-BT water in Chimney Hollow would be exchanged for a like amount of Windy Gap water in Granby Reservoir. The amount of C-BT water delivered to Chimney Hollow in any month generally would coincide with the amount of Windy Gap water released to meet Participant demands, which would range from about 1,000 AF to 3,000 AF per month throughout the year. Prepositioning would not require any additional structural facilities to operate and would not change the storage or yield of C-BT Project water. The FEIS includes a mitigation measure to help maintain higher water levels in Granby Reservoir. This mitigation measure, called Modified Prepositioning limits the times that C-BT water will be stored in Chimney Hollow Reservoir to

periods of high water levels in Granby Reservoir when a spill could be reasonably expected. This measure was adopted to minimize the adverse effects of prepositioning on water levels in Granby Reservoir (reduced water levels) that may negatively impact aquatic resources and recreation on Granby Reservoir.

Participants would take delivery of Windy Gap water from Chimney Hollow Reservoir via releases through existing C-BT facilities. Deliveries to Participants to the north would be made via the Flatiron Afterbay to the Charles Hansen Feeder Canal. Deliveries to the south would be released from Chimney Hollow to a tie-in with the Carter Lake Pressure Tunnel and then Carter Lake. Windy Gap water would then be released to the St. Vrain Supply Canal and/or the Southern Water Supply Pipeline.

MPWCD would use its Windy Gap water as a source of augmentation water to replace out-of-priority depletions in Grand or Summit County. MPWCD water would be stored in either Granby Reservoir or Chimney Hollow Reservoir. Middle Park water stored in Chimney Hollow Reservoir would be exchanged back to Granby Reservoir where releases to the Colorado River would be made to offset depletions. Releases would either directly replace depletions for uses on the Colorado River or replace by exchange if depletions occur in the Willow Creek, Fraser River, or Blue River basins.

4.4.3 Construction Program

Construction of Chimney Hollow dam and the associated pipeline, roads, and related facilities would take from 3 to 5 years. Construction sequencing includes construction of a new access road, relocation of the transmission line, development of borrow areas, excavation of the dam foundation, and construction of inlet and outlet facilities, spillway, and delivery pipelines. Construction staging areas would include the permanent reservoir pool, an area below the dam, and possibly Reclamation Flatiron facilities.

The majority of the construction material for the dam would be excavated on-site. Truck deliveries for steel, cement, fuel, and other materials would be needed. Average truck deliveries are estimated at five trucks per day, with peak truck traffic of 10 truck deliveries per day. Pipe delivery would add about three additional trucks per day.

4.4.4 Public Access and Recreation

The proposed Chimney Hollow Reservoir site is currently owned by the Subdistrict and is not open to the public.

Larimer County Parks and Open Lands own about 1,800 acres of land adjacent to the west side of the reservoir site. Larimer County and the Subdistrict entered into an Intergovernmental Agreement that includes a recreational lease of about 1,600 acres of Subdistrict property to the County at no fee (Larimer County - Municipal Subdistrict 2004). The recreational lease is contingent on construction of Chimney Hollow Reservoir. Larimer County recreation plans for this property include non-motorized boating (except for small electric motors on watercraft), hiking, biking, and horseback riding. Anticipated recreation features include a parking area, trails, boat dock and ramp, picnic facilities, and vault toilets. About 10 miles of trail would be constructed on both County and Subdistrict land. No overnight camping would be allowed.

Larimer County would be responsible for all development, building, management, and maintenance of recreation facilities. The County also would provide patrol and law enforcement for Subdistrict property. As part of reservoir construction, the Subdistrict would construct a public access road to recreation facilities on the northwest side of the reservoir.

Larimer County would prepare a recreation management plan for County and Subdistrict property prior to completion of the reservoir. The recreation management plan would be developed with water quality protection as an essential goal. Recreation improvements and general public access would be completed

about the same time as the reservoir. Prior to that, Larimer County may conduct tours or allow limited public access to county property.

5 Water Quality Impacts

5.1 Water Bodies Potentially Affected by the Project

This section describes stream segments and water bodies with potential water quality impacts associated with the Proposed Action. Because the WGFP does not discharge any water, all water quality impacts are an indirect result of the activity itself (see section 3.1).

The analysis performed for the 401 Certification relies on the affected environment as identified in the Final EIS (U.S. Bureau of Reclamation, 2011) (Section 3.8.1).

Streams evaluated in the West Slope study area (Figure 8) are the Colorado River downstream of Granby Reservoir to Gore Canyon below the confluence with the Blue River, and Willow Creek below Willow Creek Reservoir. Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir are included in the study area. Windy Gap Reservoir is a small in-channel reservoir and has water quality similar to that of the Colorado and Fraser Rivers; so it was not evaluated separately. As determined in the Final EIS (Section 3.4), below Gore Canyon, the hydrologic effects of the alternatives (including the Proposed Action) diminish and potential impacts to aquatics resources are less likely.

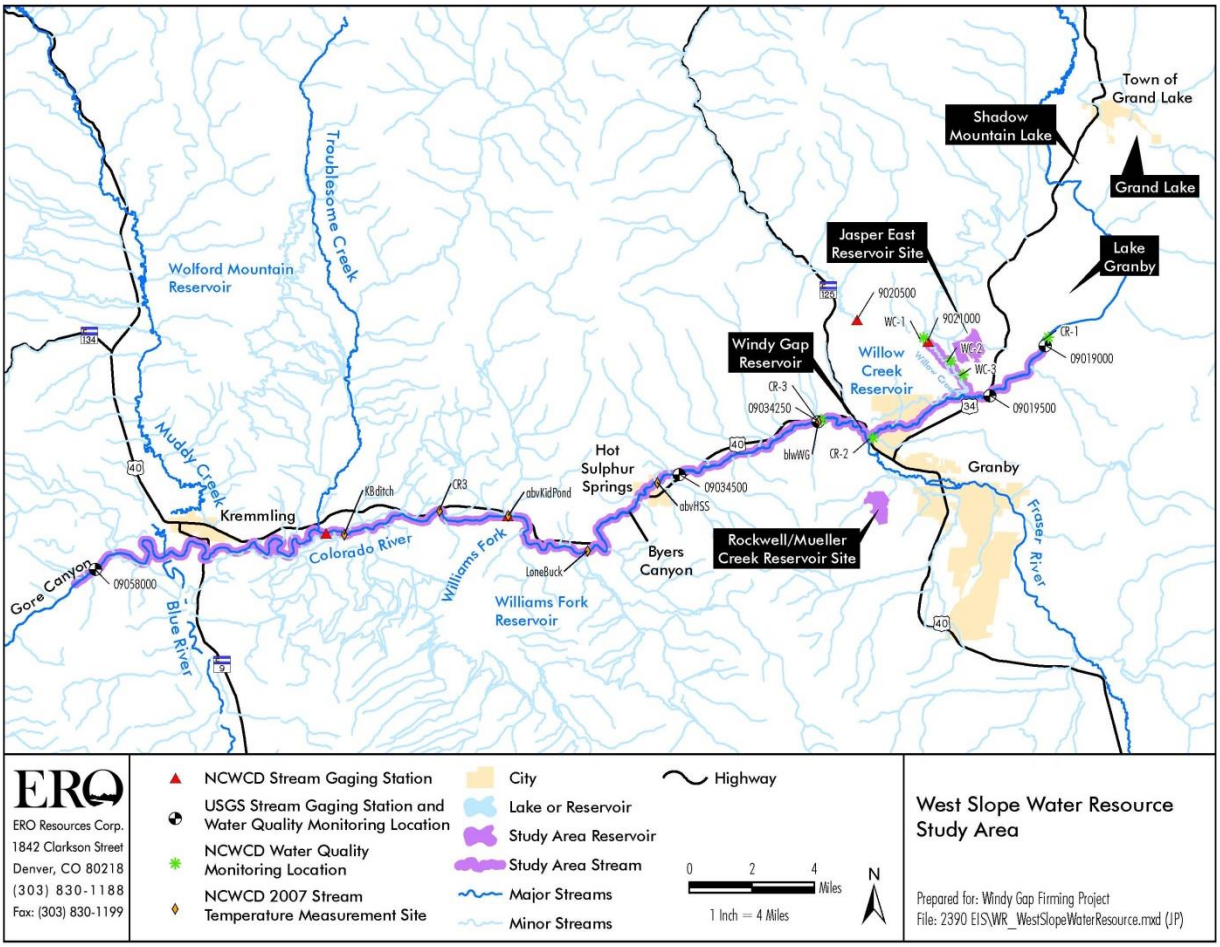


Figure 8 - West Slope Study Area

The East Slope study area (Figure 9) includes the Big Thompson River below Lake Estes (where additional Windy Gap deliveries would increase flow), and downstream of Participant WWTPs on Big Dry Creek, Coal Creek , St. Vrain Creek, the Big Thompson River and the Cache la Poudre River. East Slope reservoirs

in the study area are Carter Lake, Horsetooth Reservoir, along with a potential new reservoir at Chimney Hollow.

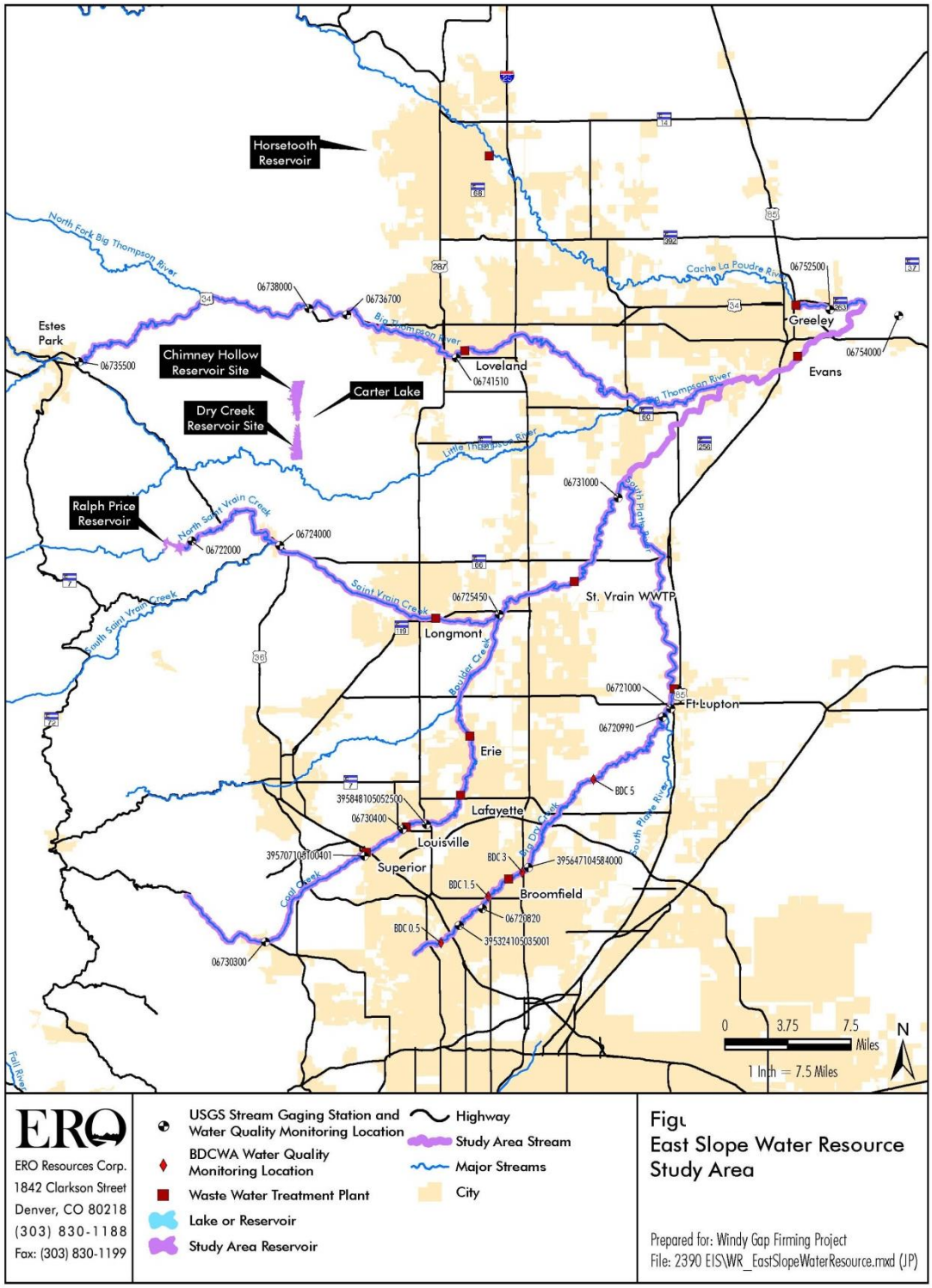


Figure 9 - East Slope Study Area

5.2 Non-impacted Water Bodies

There are eight other reservoirs in the C-BT system that are not described in detail in this report because the effects are expected to be minor or the water quality would remain unchanged from existing conditions. They include:

- Mary's Lake;
- Lake Estes;
- Pinewood Reservoir;
- Flatiron Reservoir;
- Windy Gap Reservoir;
- Willow Creek Reservoir;
- Green Mountain Reservoir; and
- Boulder Reservoir.

Mary's Lake, Pinewood Reservoir, Flatiron Reservoir, and Windy Gap Reservoir are small, shallow reservoirs (mean depths of less than 8 meters) with very short residence times (on the order of 1 to 3 days). Hydraulic water residence times were computed as the average annual contents of the reservoir divided by the average annual water outflow. This is the average time required to refill a lake or reservoir with new water if it were to be emptied (Kalff, 2002). Note that the residence time for Windy Gap Reservoir was also computed on a monthly basis using the average monthly flow through the reservoir for existing conditions and a reservoir volume of 445 AF. This was done to differentiate between periods when Windy Gap is pumping and when it is not. The reservoir residence time in Windy Gap ranges from 0.2 to 3.4 days, when computed on a monthly basis. The minimum value occurs in June while the maximum value is for January. The range for the non-pumping period (August to March) is 1.3 days (August) to 3.4 days (January). In reservoir Water Quality data for Mary's Lake, Pinewood Reservoir, Flatiron Reservoir, and Windy Gap Reservoir could not be located, with the exception of Mary's Lake, which was sampled on two days in July 1987. These reservoirs are assumed to be well-mixed reservoirs and it is anticipated that with short residence times, in-reservoir water quality approximates that of the major inflows.

Lake Estes is also shallow (mean depth of 5 meters) with a short residence time (average of 5 days in July/August). Summer profiles for temperature and specific conductivity for 1998 – 2005 indicate that stratification is weak or absent. In addition, total phosphorus concentrations of the Adams Tunnel (the major source of inflow into Lake Estes), the Olympus Tunnel (the major outflow), and the surface of Lake Estes are similar.

The other three reservoirs are not included because the Proposed Action would not impact in-reservoir water quality. Changes to the operations of Willow Creek Reservoir would not be significant and the inflow into the reservoir would not change. Thus, there would be no change in Willow Creek water quality for the Proposed Action. In addition, Green Mountain Reservoir would not be impacted by the Proposed Action. Boulder Reservoir receives water from Carter Lake. It is assumed that if the effects at Carter Lake are minimal, then the water quality of Boulder Reservoir would be minimally impacted. Because water quality effects at Carter Lake would be minor, impacts to Boulder Reservoir, which receives water from Carter Lake, should be even less as Boulder Reservoir receives water from both Carter Lake and from Lefthand Creek.

5.3 Existing Water Quality Impairments

Table 6 and Table 7 provide a summary of stream segments that are currently listed as impaired (303(d)) or in need of further monitoring and evaluation (M&E) (CDPHE - WQCC, 2012). This information is presented to indicate current areas of concern and highlight water quality issues that may need to receive particular attention in the water quality analysis and to describe how these were handled in this report.

Table 6 - West Slope Water Bodies, 303(d) and M&E List

Segment	Description	Portion	Colorado's Monitoring & Evaluation Parameter(s)	Clean Water Act Section 303(d) Impairment	303(d) Priority	Approach
COUCUCO2	Mainstem of the Colorado River, including all tributaries and wetlands within or flowing into Arapahoe National Recreation Area.	Willow Creek Reservoir		Mn	L	As per Section 5.2, Willow Creek Reservoir is not affected by the WGFP
COUCUC03	Mainstem of the Colorado River from Granby Reservoir to the Roaring Fork River.	From 578 Road Bridge to just above the confluence with the Blue River		Temperature, Mn(WS)	H	Hydrodynamic temperature modeling was included in the water quality analysis. A mass balance was done to evaluate effects on metals, nutrients and general chemistry.
COUCUC03	Mainstem of the Colorado River from Granby Reservoir to the Roaring Fork River.	From the outlet of Windy Gap Reservoir to 578 Road Bridge	Aquatic Life			No AD review (Aq Life is a policy not a water quality standard) but issue addressed in mitigation & enhancements (section 8.7)
COUCUC12	Colorado River and tributaries, wetlands, lakes and reservoirs within Arapahoe National Recreation Area	Shadow Mountain Lake		D.O.	H	Qualitative assessment (section 7.3.4)
COUCUC12	Lakes and Reservoirs within Arapahoe National Recreation Area including Grand Lake, Shadow Mountain Lake and Granby Reservoir	Granby Reservoir		Aquatic Life Use (Hg Fish Tissue)	H	Qualitative assessment (section 7.3.4)

Table 7 - East Slope Water Bodies, 303(d) and M&E List

Segment	Description	Portion	Colorado's Monitoring & Evaluation Parameter(s)	Clean Water Act Section 303(d) Impairment	303(d) Priority	Notes
COSPBO09	Mainstem of Boulder Creek, from South Boulder Creek to Coal Creek	all	Cd, As			Addressed through mass balance below Lake Estes (Section 7.5)
COSPBT02	Big Thompson River and tribs, RMNP to Home Supply Canal diversion	all	Sulfide	Cu, Cd, Zn, temperature	H	Addressed through mass balance below Lake Estes (Section 7.5)
COSPBT09	Little Thompson River, Culver Ditch to Big Thompson River	all	Cu, Se, *E. coli* (May-October), Aquatic Life Use		M/L/H/M	Addressed through mass balance below Lake Estes (Section 7.5)
COSPBT11	Carter Lake	all		Aquatic Life Use (Hg Fish Tissue), As	H	Addressed through mass balance below Lake Estes (Section 7.5)
COSPBT16	Lakes and reservoirs tributary to the Big Thompson from RMNP to Home Supply Canal diversion.	Lake Estes		Cu, Pb	H	Addressed through mass balance below Lake Estes (Section 7.5)
COSPCP10	Cache la Poudre River, Monroe Canal to Shields Street	all		Cu, Temperature	M	Addressed through mass balance below Lake Estes (Section 7.5)
COSPCP14	Horsetooth Reservoir	all		Aquatic Life Use (Hg Fish Tissue), Cu, As	H	Addressed through mass balance below Lake Estes (Section 7.5)
COSPSV02b	St. Vrain Creek, RMNP to Hygiene Road	all		Cu, Temperature	H	Addressed through mass balance below Lake Estes (Section 7.5) – Temperature not addressed – insufficient data to support modeling.
COSPSV05	Mainstem of Left Hand Creek, including all tributaries and wetlands from Highway 36 to the confluence with St. Vrain Creek.	Downstream Lefthand Feeder Canal		Cu	M	Addressed through mass balance below Lake Estes (Section 7.5)

6 Data Sources

In support of the 401 Certification water quality analyses, a water quality database (Database) was developed by Northern Water. The Database includes both discrete water quality data and continuous water temperature data.

For the water quality portion of the Database (as opposed to temperature), sites within the geographic area of interest that were used in modeling efforts (as modeling inputs) associated with the FEIS were included in the Database. Data from existing water quality databases that Northern Water has developed for its own water quality monitoring needs were rolled into the 401 Certification Database. In addition, when available and not already present in existing databases, historical USGS data going back to 1995 were added to supplement the Database for the sites already present in the Northern Water Databases. Additional USGS sites that were used for modeling purposes and that were not part of Northern Water's existing databases were not included in the Database due to formatting complexities. For these sites, data were compiled separately in Excel format.

For temperature, all available continuous temperature data for the geographic area of interest were imported into the Database.

Table 8 lists the sites that are included in the 401 Certification Database and indicates which sites were used in each model developed for the Windy Gap Firming Project FEIS. Figure 10 shows a map of all sites used in modeling, some of which are not included in the Database as explained previously. For these sites, data were provided as Excel files. Detailed maps of sites used in each model can be found in APPENDIX G - MODELING WATER QUALITY SITES MAPS.

Table 8 – Sites included in the 401 Certification Database

Station ID	Station Description	Three Lakes Model	East Slope Model	Colorado River Model	Temperature Model
AC-GRU	Arapahoe Creek at Monarch Lake outlet, upstream of Granby Reservoir (USGS #09016500)	X			
BT-M70	BTWF site M70 (USGS#06736700). Big Thompson River upstream of Dille Tunnel diversion		X		
CL-DAM1	Carter Lake Dam #1 (USGS #06742500)		X		
CR-BLD	Colorado River downstream of the Blue River near Kremmling (USGS #9058000)				X
CR-BLU	Colorado River above Hwy 9 Bridge at Kremmling CO 2.3 mi upstream of the Blue River				X
CR-CON	Colorado River at Public Access East of Con Richard Ranch 3 mi downstream of Parshall				X
CR-GRD	Colorado River downstream of Granby Reservoir (USGS #9019000)	X		X	X
CR-HRU	Colorado River above Hot Sulphur Springs Resort				X

Station ID	Station Description	Three Lakes Model	East Slope Model	Colorado River Model	Temperature Model
CR-HSU	Colorado River above Hot Sulphur Springs Water Treatment Plant				X
CR-KRM	Colorado River near Kremmling (USGS #9058000), upstream of Gore Canyon and downstream of Blue River			X	
CR-LB	Colorado River at Lone Buck below CDOW Office 3 mi downstream of Hot Sulphur				X
CR-PAD	Colorado River above Kid's Pond below Parshall CO				X
CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir (USGS site #09011000)	X			
CR-WFU	Colorado River at South Side of CR3 Bridge near Bar Lazy J Ranch immediately upstream of Williams Fork				X
CR-WGD	Colorado River downstream of Windy Gap (USGS #09034250)	X		X	X
CR-YGAGE	Colorado River downstream of Granby Reservoir at YMCA flow Gage				X
EI-GLU	East Inlet upstream of Grand Lake (USGS #090135000)	X			
FR-WGU	Fraser River upstream of confluence with Colorado River	X		X	X
GL-MID	Grand Lake Mid Section 0-2m composite (USGS #09013900)	X			
GR-DAM	Granby Reservoir Dam (USGS #09018500)	X			
HFC-C50	BTWF site C-50 in Hansen Feeder Canal (USGS #403020105114700) Approximately same location as HFC-HT		X		
HT-SOL	Horsetooth at Soldier Canyon (USGS #06737500)		X		
NI-GLU	North Inlet upstream of Grand Lake	X			
OLY	Olympus Tunnel at Lake Estes (USGS #06734900 or BTWF site C20)		X		
SM-DAM	Shadow Mountain Dam 5m-bottom composite (USGS #09014500)	X			
ST-GRU	Stillwater Creek upstream of Granby Reservoir (USGS #09018000)	X			
WC-3	Willow Creek upstream of confluence with Colorado River	X		X	
WC-Pump	Willow Creek discharge chute to Granby Reservoir	X			

Station ID	Station Description	Three Lakes Model	East Slope Model	Colorado River Model	Temperature Model
WC-WCRD	Willow Creek directly downstream of Willow Creek Reservoir Dam	X		X	X
WC-WCRU	Willow Creek at USGS Gage above C-Lazy-U Ranch			X	
WG-Pump	Windy Gap discharge chute to Granby Reservoir	X			

Windy Gap Firming Project - Water Quality Sites

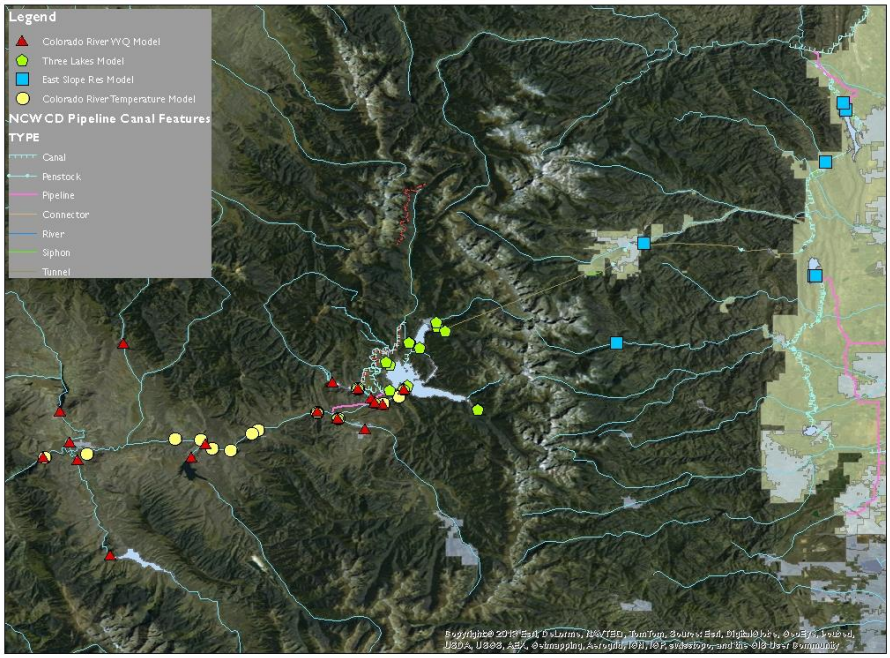


Figure 10 - Water Quality Sites Used in Water Quality Modeling

Constituents included in the Database cover parameters of interest from an antidegradation review standpoint and are listed in Table 9:

Table 9 - Water Quality Constituents Included in 401 Certification Database

General Chemistry	Metals	Nutrients	Physical Parameters
Chloride	Arsenic, Dissolved	Chlorophyll a	Dissolved Oxygen
Calcium	Arsenic, Total	Kjeldhal Nitrogen, Total	Flow
Hardness	Cadmium, Dissolved	Nitrate plus Nitrite	pH
Magnesium	Copper, Dissolved	Nitrogen, Total	Secchi Depth
Sulfate	Iron, Dissolved	Phosphorus, Total	Specific Conductance
Total Suspended Solids	Iron, Total		Water Temperature
	Lead, Dissolved		
	Manganese, Dissolved		
	Mercury, Dissolved		
	Mercury, Total		
	Nickel, Dissolved		
	Selenium, Dissolved		
	Silver, Dissolved		
	Zinc, Dissolved		

A detailed description of the Database, data inventories, data summaries and supporting documentation regarding reporting limits and QA/QC performed on the data are presented in APPENDIX C - DATABASE DOCUMENTATION AND DATA SUMMARIES.

Model outputs were used as needed in support of antidegradation review. They were provided to Northern Water by third-party consultants that performed water quality modeling for the Windy Gap Firming FEIS and are summarized in Table 10.

Table 10 - Water Quality Modeling Outputs

Model	Quantified Outputs	Time Step	Simulation Period
Three Lakes	Ortho P, Organic P, TP, NH3, NO3, Organic N, TN, TOC, chla, Secchi, DO, TSS	Daily	10/01/1974-09/30/1989
Carter Lake (BATHTUB)	chla, Oxygen Demand, Secchi, TN, TP	Annual	1975-1989[2]
Horsetooth Reservoir (BATHTUB)	chla, Oxygen Demand, Secchi, TN, TP	Annual	1975-1989[3]
Chimney Hollow Reservoir (BATHTUB)	chla, Oxygen Demand, Secchi, TN, TP	Annual	1975-1989[4]
Colorado River (RMS)	Temperature	Hourly Jun-Sep	1975, 1979, 1986, 1987, 1988[5]
Colorado River (QUAL2K)	Temperature, SC, DO, Organic N, NH3, NO3, Organic P, Inorganic P, Se Dis, TN, TP	One-day (steady state)	Jul 25th (representative of "typical" conditions on Jul 25th of any given year)[6]
Granby Reservoir (LAKE2K)	Temperature	Daily	10/01/1974-09/30/1989[7]

[2] The modeling approach used for the BATHTUB modeling of east slope reservoirs is detailed in (AMEC, 2008)
[3] The modeling approach used for the BATHTUB modeling of east slope reservoirs is detailed in (AMEC, 2008)
[4] The modeling approach used for the BATHTUB modeling of east slope reservoirs is detailed in (AMEC, 2008)
[5] The modeling approach used for the Temperature modeling of the Colorado river is detailed in (Hydros Consulting Inc., 2011)
[6] The modeling approach used for the Qual2K modeling of the Colorado River is detailed in (ERO and AMEC, 2008)
[7] The modeling approach used for the LAKE2K modeling of Granby Reservoir is detailed in (AMEC, 2008)

7 Significant Concentration Threshold (SCT) Analysis

This section describes the methods that were used to carry out the Significant Concentration Threshold analysis that is part of the antidegradation review required for the 401 Certification for the Windy Gap Firming Project and presents the results of the analysis.

The WQCC AD regulation specifies that:

> *This significance determination shall be made with respect to the* ***net effect of the new or increased water quality impacts of the proposed regulated activity, taking into account any environmental benefits resulting from the regulated activity and any water quality enhancement or mitigation measures*** *impacting the segment or segments under review, if such measures are incorporated with the proposed regulated activity.*

5CCF 1002-13 31.8(3)(c)(emphasis added).

Because the net effect of the activity is to be considered, the analysis is presented in two steps. The first step, presented in this section, consists of carrying out the SCT analysis, which relied on water quality modeling of the Project without mitigation or enhancement measures, and qualitative assessments (when modeling was not possible). The second step, presented in section 8, reviews mitigation and enhancement measures. **A summary of the final conclusions of the AD review, presented in section 8.10, reconciles the SCT analysis with mitigation measures into a review of net impacts (Table 47).**

Since various water quality models were performed as part of the FEIS to assess water quality impacts associated with the WGFP, the information is grouped by geographic area and model.

The antidegradation review requires a quantification of the direct and indirect water quality impacts resulting from the WGFP taking into account cumulative impacts. Because the WGFP does not discharge any water, all water quality impacts are an indirect result of the activity itself (see section 3.1). The determination of the significance of the degradation is done using the Concentration Test. Water quality concentrations reflective of cumulative impacts under operation of the WGFP are deemed significantly degraded if the change of concentration from baseline conditions is greater than 15 percent of the baseline assimilative capacity. Baseline concentrations should be representative of low flow conditions as of September 30, 2000.

The baseline available increment (BAI) is the concentration increment between the baseline water quality and the water quality standard, and represents the assimilative capacity. The baseline water quality (BWQ) represents ambient conditions of the water quality as of September 30, 2000. The significant concentration threshold (SCT) is the baseline water quality concentration plus 15 percent of the baseline available increment. The SCT is the level that differentiates significant from insignificant degradation. A series of tests (Figure 11) determines whether the new or increased water quality impacts will cause significant degradation of a water body. If the impact is deemed to result in significant degradation, the antidegradation review must be completed. (CDPHE, WQCD, 2001).

The regulated activity is considered not to result in significant degradation if:

> *The new activity or increased discharge from the source under review will consume, after mixing, less than 15 percent of the baseline available increment, provided that the* ***cumulative increase in concentration from all sources shall not exceed 15 percent of the baseline available increment.*** *The baseline available increment is the increment between low-flow pollutant concentrations and the relevant standards for critical constituents for that portion of the segment impacted by the discharge.* ***The baseline low-flow pollutant concentration shall represent the water quality as of September 30, 2000****, and shall be determined at the time of the first proposed new or increased water quality*

> *impacts to the reviewable waters after that date, provided, that if water quality subsequently improves as the result of the remediation of impacts from past unpermitted releases of contaminants that affected the water quality as of September 30, 2000, the resulting improved water quality at the time of the proposed new water quality impacts shall be used as the baseline.*

5 CCR 1002-31 §31.8 (3)(c)(ii)(B).

Data analyses presented in this report were prepared to inform the answers to the questions that are part of the process highlighted in Figure 11. This section presents methods to calculate the SCT and summarizes results of the SCT. Section 8 presents the best management practices, minimization, avoidance, mitigation and enhancements associated with WGFP under cumulative effects. Because there are instances where the AD review relied on qualitative assessment, there may be some uncertainty or questions regarding the conclusions that are reached. For this reason, a section addressing the necessity of degradation is included in Section 9.
This section answers the question of whether degradation is necessary to accommodate important social or economic development.

The 401 Certification focuses exclusively on cumulative impacts and AD, which is a narrower scope than that of the NEPA process. Although, the AD analysis heavily relies on the FEIS, at times some additional analyses beyond those performed for the FEIS were needed in order to meet the needs of the AD review. The impact analysis focuses on water quality issues that were directly addressed through the NEPA process. This approach is consistent with the intent expressed in 5 CCR 1002-31 §31.23 (A)(5)(f) Statement of Basis, Specific Statutory Authority and Purpose (1988 Revisions-Antidegradation).

> *Projects that require a 404 section permit are already subject to Corps of Engineers and EPA requirements to consider alternatives (see, e.g. 33 CFR section 320.4 (a)(2)(ii) and 40 CFR section 230.10 (a)). Projects subject to federal NEPA requirements already are faced with an alternatives analysis requirement that goes substantially beyond that required here pertaining to available water quality control options. 5 CCR 1002-31§31.23 (A)(5)(f) (1988). The Commission intends that the alternatives analysis for antidegradation review purposes should be coordinated with any such reviews to the extent possible to avoid unnecessary duplication.*

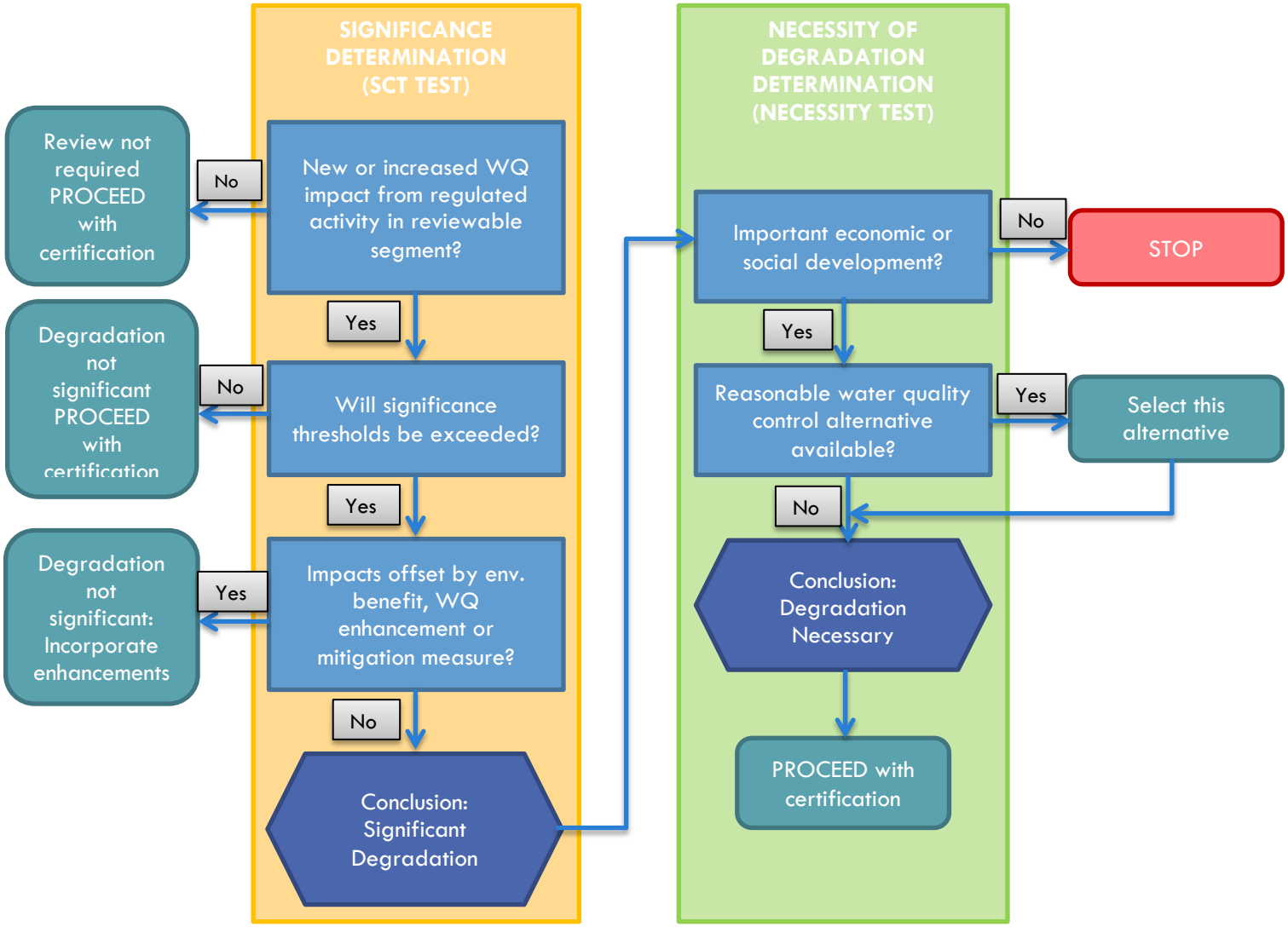


Figure 11 - Antidegradation Review Process Overview

7.1 Scope of the SCT Analysis

The Antidegradation Review should include all reviewable water bodies within the affected geographic area (Section 5.1) and examine all constituents for which there are applicable water quality standards (Section 3.4.4). However, data availability and limitations of the modeling tools to predict Project effects place some constraints on the analysis. When possible, the antidegradation review was carried out to include metals, nutrients and some physical parameters, which are of particular interest to the WQCD. The geographic scope was defined by the affected environment as described in the FEIS and includes the Colorado River from Granby Reservoir to Kremmling, the Three Lakes System (Granby Reservoir, Shadow Mountain Reservoir, Grand Lake), East Slope tributaries to the South Platte that are part of the C-BT System, Horsetooth Reservoir and Carter Lake. Table 11 describes the scope and focus areas of the antidegradation review performed in this report.

Table 11 – SCT Analysis Scope and Rationale

Water Body	Geographic Extent	Constituents	SCT Analysis Performed?	SCT Rationale	Method	Comment
Shadow Mountain Reservoir	Shadow Mountain Reservoir	TN, TP, Chl a	YES	Constituents included in 3-lakes water quality model.	Used 3-Lakes model water quality simulations.	
		Nitrate	NO	Existing concentrations are orders of magnitude below water quality standard.	Assuming all increase would occur in the form of TN, results from the 3-Lakes model were used.	In absence of nitrate data, nitrate+nitrite data were used as surrogate to compute the BWQ.
		DO	NO	Shadow Mountain Reservoir is listed as impaired for DO.	Qualitative assessment provided due to existing 303-d listing.	
		Ammonia	NO	Would require modeling of temperature and pH not available from FEIS and TN standard is more restrictive for this system than the ammonia standard.	Qualitative assessment explaining the use of TN antidegradation results as a surrogate for antidegradation review on ammonia.	TN standards are interim numeric values.
		Temperature	NO	Model does not produce profile data to perform AD. Relied on limited modeling results from FEIS showing no temperature change.	Reviewed LAKE2K modeling results and provided qualitative assessment explaining forcing mechanisms for in reservoir water temperature.	
		Se	NO	No model available to perform the assessment.	Provided a qualitative assessment.	Complexity of Se cycling in aquatic environments does not allow quantitative assessment.
		Hg	NO	No model available to perform the assessment.	Provided a qualitative assessment.	Complexity of Hg cycling in aquatic environments does not allow quantitative assessment.

Water Body	Geographic Extent	Constituents	SCT Analysis Performed?	SCT Rationale	Method	Comment
Grand Lake	Grand Lake	TN, TP, Chl a	YES	Constituents included in 3-lakes water quality model.	Used 3-Lakes model water quality simulations.	
		Secchi	NO	Narrative standard in effect with expected implementation of a numeric standard starting January 1, 2017.	Qualitative assessment.	Addressed through mitigation and enhancements commitments/contractual agreements.
		Nitrate	NO	Concentrations orders of magnitude below water quality standard	Assuming all increase would occur in the form of TN, results from the 3-Lakes model were used.	In absence of nitrate data, nitrate+nitrite data were used as surrogate to compute the BWQ.
		DO	NO	No existing issues in Grand Lake.		
		Ammonia	NO	Would require extensive modeling not available from FEIS and TN standard is more restrictive for this system than the ammonia standard.	Qualitative assessment explaining the use of TN antidegradation results as a surrogate for antidegradation review on ammonia.	TN standards are interim numeric values.
		Temperature	NO	No model available to perform the assessment. Relied on modeling results for Granby showing no temperature change.	Qualitative assessment explaining forcing mechanisms for in reservoir water temperature related to elevation and meteorological factors.	
		Se	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Se cycling in aquatic environments does not allow quantitative assessment.
		Hg	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Hg cycling in aquatic environments does not allow quantitative assessment.

Water Body	Geographic Extent	Constituents	SCT Analysis Performed?	SCT Rationale	Method	Comment
Granby Reservoir	Granby Reservoir	TN, TP, Chl a	YES	Constituents included in 3-lakes water quality model.	Used 3-Lakes model water quality simulations.	
		Nitrate	NO	Concentrations orders of magnitude below water quality standard	Assuming all increase would occur in the form of TN, results from the 3-Lakes model were used.	In absence of nitrate data, nitrate+nitrite data were used as surrogate to compute the BWQ.
		DO	NO	No existing issues in Granby Reservoir.		
		Ammonia	NO	Would require extensive modeling not available from FEIS and TN standard is more restrictive for this system than the ammonia standard.	Qualitative assessment explaining the use of TN antidegradation results as a surrogate for antidegradation review on ammonia.	TN standards are interim numeric values.
		Temperature	NO	Lake2K modeling results show no change in temperature between existing conditions and cumulative effects but no profile data is simulated.	Qualitative assessment.	Relies on the analysis from the FEIS.
		Se	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Se cycling in aquatic environments does not allow quantitative assessment.
		Hg	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Hg cycling in aquatic environments does not allow quantitative assessment.

Water Body	Geographic Extent	Constituents	SCT Analysis Performed?	SCT Rationale	Method	Comment
Colorado River	Below Granby to Williams Fork	Temperature	YES	A portion of this reach of the Colorado River, starting downstream of Windy Gap Reservoir at the 578 Road Bridge, is currently listed as impaired for temperature and it is a parameter of particular concern.	Dynamic temperature model simulations.	
	Immediately Downstream of Windy Gap	Nutrients, metals, general chemistry	YES	Constituents were reviewed based on data availability. Effects are expected to be most significant immediately below the diversion as confounding factors further downstream would obscure interpretation of the results and effects would diminish downstream.	A monthly mass balance of concentrations was performed downstream of the diversion.	
	Immediately Downstream of Windy Gap	Se, Hg	YES	Bioaccumulative pollutants are assessed in terms of change in annual load (less or greater than 10%). Effects are expected to be most significant immediately below the diversion as confounding factors further downstream would obscure interpretation of the results and effects would diminish downstream.	Concentrations were assumed constant and a load (i.e. flow) analysis was performed at the Adams Tunnel comparing flow changes between Existing Conditions and Cumulative Effects.	Increase in flow at the Adams Tunnel are reflective of additional diversions from the Colorado River and flow changes show the decrease in load (the load is removed from the Colorado River).

Water Body	Geographic Extent	Constituents	SCT Analysis Performed?	SCT Rationale	Method	Comment
East Slope Tributaries and Reservoirs	Big Thompson River, South Platte Tributaries, Horsetooth Reservoir and Carter Lake, Chimney Hollow	Temperature	NO	No model/simulated continuous data were available in streams to support such assessment. For reservoirs, relied on modeling results for Granby showing no temperature change.	Qualitative assessment explaining factors influencing water temperature.	
	Immediately below Lake Estes	Nutrients, metals, general chemistry	YES	Constituents were reviewed based on data availability. Effects are expected to be most significant immediately below Lake Estes as confounding factors further downstream would obscure interpretation of the results.	A monthly mass balance of concentrations was performed downstream of Lake Estes.	
	Immediately below Lake Estes	Se, Hg	YES	Bioaccumulative pollutants are assessed in terms of change in annual load (less or greater than 10%). Effects are expected to be most significant immediately below the Adams Tunnel as confounding factors further downstream would obscure interpretation of the results.	Concentrations were assumed constant and a load (i.e. flow) analysis was performed at the Adams Tunnel comparing flow changes between Existing Conditions and Cumulative Effects.	

Water Body	Geographic Extent	Constituents	SCT Analysis Performed?	SCT Rationale	Method	Comment
	Horsetooth Reservoir	Nutrients, metals, general chemistry	NO	Analysis relied on results of the AD performed below Lake Estes, since the reservoir is located downstream of Lake Estes and on limited modeling from the FEIS.	Qualitative assessment using BATHTUB model outputs.	Showing of no degradation below Lake Estes where impacts would be the greatest implies no degradation further downstream. Bathtub model outputs consist of annual averages for TP, TN and Chl a only and are insufficient to perform a quantitative assessment.
		DO	No existing issues in Horsetooth Reservoir.			
		Se	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Se cycling in aquatic environments does not allow quantitative assessment.
		Hg	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Hg cycling in aquatic environments does not allow quantitative assessment.

Water Body	Geographic Extent	Constituents	SCT Analysis Performed?	SCT Rationale	Method	Comment
	Carter Lake	Nutrients, metals, general chemistry	NO	Analysis relied on results of the AD performed below Lake Estes, since the reservoir is located downstream of Lake Estes and on limited modeling from the FEIS.	Qualitative assessment using BATHTUB model outputs.	Showing of no degradation below Lake Estes where impacts would be the greatest implies no degradation further downstream. Bathtub model outputs consist of annual averages for TP, TN and Chl a only and are insufficient to perform a quantitative assessment.
		DO	No existing issues in Carter Lake.			
		Se	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Se cycling in aquatic environments does not allow quantitative assessment.
		Hg	NO	No model available to perform the assessment.	Qualitative assessment.	Complexity of Hg cycling in aquatic environments does not allow quantitative assessment.
	Chimney Hollow Reservoir	TN, TP, Chl a	NO	New reservoir – no existing data	Qualitative assessment using BATHTUB model outputs.	Bathtub model outputs consist of annual averages for TP, TN and Chl a only and are insufficient to perform a quantitative assessment.
		All other water quality constituents	NO	New reservoir – no existing data	Qualitative assessment using Carter Lake data as a surrogate.	

7.2 Representative Baseline Development

One of the first steps in proceeding with the SCT is to characterize the water quality baseline as of September 30, 2000:

> ***The baseline low-flow pollutant concentration shall <u>represent</u> the water quality as of September 30, 2000****, and shall be determined at the time of the first proposed new or increased water quality impacts to the reviewable waters after that date . . .1002-82 5 CCR §31.8 (3)(c)(ii)(B) (emphasis added).*

In the case of the dataset available for the WGFP, water quality data at that particular point in time is limited or non-existent. Therefore, an alternative baseline representative of September 30, 2000 as the low flow nominal water quality baseline had to be developed for use in the antidegradation review. This section describes the methods employed to develop such representative baseline.

7.2.1 Data Sources and Data Compilation

A comprehensive Database of all available water quality at sites sampled since 1995 was compiled in support of the Antidegradation Review. The Database includes USGS data and data collected by Northern Water as part of its Baseline Monitoring Program. Details about the Database can be found in APPENDIX C - DATABASE DOCUMENTATION AND DATA SUMMARIES.

A detailed inventory of available data was compiled and then reviewed with WQCD staff. Summaries of the data inventory are presented in APPENDIX C - DATABASE DOCUMENTATION AND DATA SUMMARIES. Review of the available data revealed a number of limitations for data from the year 2000 (nominal baseline year). Although the nominal baseline year is included in the data record compiled for the FEIS for some sites and for most constituents, most sites do not have sufficient data. Analytical methods for some key constituents, like nutrients and metals, were not adequate during the nominal baseline year for measuring the low concentrations present at most locations.

Improvements in analytical capabilities over time have resulted in fewer non-detects and generally higher data quality for samples collected since 2008. Data was further reviewed to evaluate whether another dataset could be used as baseline for the antidegradation review and still be representative of conditions in 2000.

It was determined in coordination with WQCD staff that defining baseline conditions with high quality data improves confidence in the steps taken to preserve assimilative capacity rather than attempting to use data from the nominal baseline year. As described in more detail below, it is believed that recent data constitute an appropriate "surrogate" for the baseline by being representative of water quality conditions at low flow in 2000.

A two-step approach was taken in establishing the representative baseline (post-2008). A statistical analysis was performed to compare the nominal baseline to the proposed surrogate. A population assessment for the Three Lakes watershed was also carried out in order to assess whether watershed conditions for the representative baseline could be considered representative of conditions for the nominal baseline. The effects of Pine Beetle infestation in Grand County were also considered for potential impact on water quality in the watershed.

Because water quality samples are available from the nominal and proposed representative baseline periods, comparisons can be made for some constituents. Major ions – such as calcium, magnesium, sulfate,

and chloride – are useful because they are usually present in concentrations well above detection limits, and good analytical methods have been available for a long time. A few metals – such as iron and manganese – are similarly attractive for comparisons. Data for nutrients tend to be less useful because non-detects are common in the older data. Although censored (non-detect) data techniques are available for comparing two sets of data, most are precluded in this case by the frequency of non-detects and the presence of multiple (and high) censoring levels (detection and reporting limits).

7.2.2 Population and Watershed Assessment

Population data were compiled by Northern Water. Data were obtained from the 2000 and 2012 Census at the Census Block Group level. Watershed boundaries for the area of interest were delineated using USGS 12-digit HUCs (Figure 12) and intersected with the respective Census Group Blocks (for 2000 and then 2012). The GIS analysis provided a calculation of the acres (as a percentage of the original Census Block Groups) in relation to the acres of the intersected Watershed/Census Block Group. The original Census Block Group population was then multiplied by the percent area to arrive at a corrected population for each polygon in the intersected Watershed/Census Block Group. Results are summarized in Table 12.

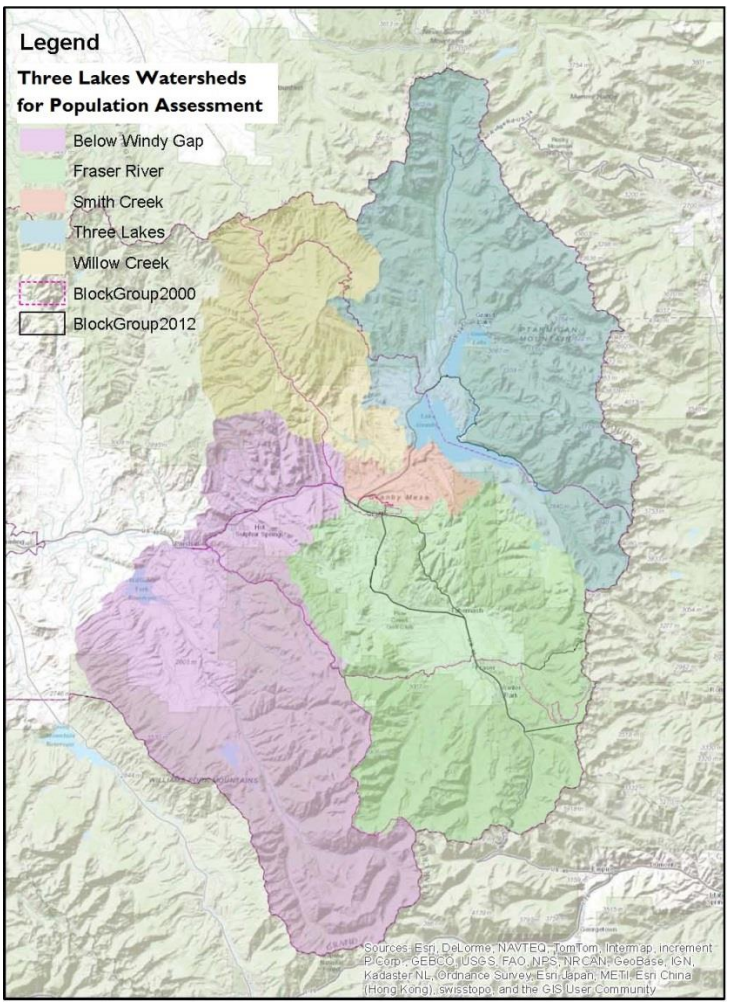


Figure 12 - Three Lakes Watersheds for Population Assessment

Table 12 - Grand County Population Change between 2000 and 2012 (by Watershed)

Watershed	2000 Pop	2012 Pop	% change
Below Windy Gap	673	1,131	68%
Fraser River	5,736	8,447	47%
Three Lakes	2,628	2,506	-5%
Willow Creek	864	652	-25%
Total	9,901	12,735	29%

Population around the Three Lakes appears to have remained stable between 2000 and 2012. This provides support for the assumption that water quality data for the inflows to the Three Lakes and for the lake and reservoirs, is representative of conditions in 2000.

As noted in Table 12, population in the Fraser valley increased significantly between 2000 and 2012. This increase occurred at the same time as treatment plant processes were upgraded in the Fraser valley. Since is it unclear what the net effect of these concurrent changes could be on water quality, data at a representative site (CR-WGD, Colorado River downstream of Windy Gap Reservoir) was compiled for the nominal baseline and the proposed surrogate. This site has a long-term record for specific constituents that are deemed revealing of land use practices or changes. Results are discussed further in this section.

7.2.3 Pine Beetle Impacts

A literature review of the effects of pine beetle infestation on water quality showed that pine beetle infestation has not been established as a direct cause of water quality changes.

It appears that nutrients released by the dead trees and pine needles are taken up by new vegetation and therefore do not translate into increased nutrients in streams (Rhoades C. C., 2012). Studies carried out in Grand County also showed no significant changes in nitrate and dissolved organic carbon. Increases in soil N were not reflected in stream-water chemistry (Clow W. D., 2011). The study did show increases in TN and TP concentrations although this finding is not quite consistent with findings from other studies in the area or from data collected as part of the Northern Water Baseline Monitoring Program, which found no changes in water quality. Another study also carried out in Grand County in the Willow Creek basin (Stednick, 2010) to look at the effects of beetle-killed forested watershed on water quality (nutrients, total organic carbon and potential formation of disinfection byproducts) showed no change in water quality. Northern Water Baseline sampling did not show any water quality impacts related to the pine-beetle infestation.

7.2.4 Representative Baseline Evaluation – Colorado River Sites

After evaluating important land use drivers that can impact water quality, existing water quality data were reviewed to evaluate the validity of a representative baseline.

Five stream sites relevant to the WGFP on the western slope were selected based on period of record and frequency of sampling. These sites (Figure 13) also cover the geographic area of interest and all the major watersheds that could be impacted by the Project:

- CR-GRD – Colorado River downstream of Granby Reservoir
- CR-WGD – Colorado River downstream of Windy Gap Reservoir
- CR-KRM – Colorado River near Kremmling
- FR-WGU – Fraser River upstream of Windy Gap Reservoir
- WC-WCRD – Willow Creek downstream of Willow Creek Reservoir

Figure 13 - Water Quality Sites Used in Representative Baseline Analysis (Colorado River)

Data from these sites were screened to determine which water quality constituents would be most amenable to statistical comparisons. In general, constituents with good temporal coverage and few or no non-detects were most desirable. For reasons discussed further in this section, not all constituents could be tested at every site. A selection of major ions, metals and nutrients was made as any significant changes in the watershed would likely be reflected in concentrations of these constituents.

Data Handling and Statistical Procedures

Water quality conditions are generally characterized in terms of the concentrations of key constituents. The concentrations vary over time, and the variability often displays a pattern that may be determined by physical or biological factors. For example, concentration of a conservative constituent may be inversely related to flow such that it is high during base flow and low during runoff. In addition, concentration of a non-conservative (biologically active) constituent may be influenced by temperature because rates of biological processes are temperature-dependent. The result is that concentrations may show strong seasonality, which influences decisions about comparing data from two time periods.

The regulatory definition of "baseline" states that the data should be representative of low-flow conditions on Sep 30, 2000. For present purposes, the WQCD interprets low flow in September as fall base flow conditions (CDPHE, WQCD, 2001). For the purpose of determining impairment, it is customary to use the

85th percentile of concentrations from a five-year window that included the year 2000 to capture low flow conditions. However, given the high frequency of sampling from the Northern Water's monitoring program, the fall base flow period can be targeted more precisely by restricting attention to a two-month window (September and October) that brackets September 30, instead of using the 85th percentile.

Water quality conditions in the nominal baseline period are characterized with the median concentrations of constituents measured during September and October of the years 1996 through 2004. The reasoning behind the nine-year window is that it spans all consecutive five-year windows that include the year 2000.

Water quality conditions for the representative baseline period are characterized with the median concentrations of constituents measured during September and October of the years 2008-2012. A conventional five-year assessment window is used in the case because it is the maximum window within which high quality data are available.

Nominal and representative baseline concentrations are compared at each site for each constituent for which sufficient data are available. Comparisons are made with the Mann-Whitney test, which is a non-parametric method appropriate for comparing two independent samples. The censored data version of the test is described by (Helsel & Lopaka, Analysis of Environmental Data With Nondetects, 2006). Tests are one-tailed (at 0.05 level) because the concern is about increasing concentrations (and loss of assimilative capacity) over time. Because so many comparisons are being made, there is some risk of false positives.

Constituents are divided into three groups for which patterns and interpretations may be different. Major ions include two cations (calcium and magnesium) and two anions (sulfate and chloride). Metals are restricted mainly to dissolved iron and manganese, although zinc, copper, and total recoverable iron also may be available. Nutrient concentrations are often below detection limits in the older data, but comparisons were possible in some cases for total phosphorus, TKN, and NO3-N+NO2-N.

Statistical Analysis

Only two comparisons (both involving major ions at a site (CR-KRM) downstream of the Project area showed statistically higher concentrations in the representative baseline set. Major ions tended to be slightly higher in the surrogate set, whereas nutrients and metals tended to be lower. Data shows that combined effects of population and changes in treatment process in the Fraser Valley did not result in water quality changes in the stream (CR-WGD).

Table 13 - Summary of Mann-Whitney Test Results for Comparisons of Nominal and Representative Baseline Concentrations at Five Sites.

Constituent	Value	CR-GRD	CR-WGD	CR-KRM	FR-WGU	WC-WCRD
Calcium (mg/L)	Nominal	7.1	17.0	27.7	15.5	13.0
	Representative	7.2	17.0	31.9	19.2	13.6
	Representative/Nominal, %	101%	100%	115%	124%	105%
Magnesium (mg/L)	Nominal	1.3	2.9	5.0	3.0	2.7
	Representative	1.4	3.1	6.2*	3.4	2.9
	Representative/Nominal, %	105%	106%	124%	112%	108%
Sulfate (mg/L)	Nominal		4.5			
	Representative		5.2			
	Representative/Nominal, %		118%			
Chloride (mg/L)	Nominal		2.9	3.3		
	Representative		3.8	4.5*		
	Representative/Nominal, %		132%	136%		
Total Phosphorus (mg/L)	Nominal	0.025	0.044	0.020	0.067	0.020
	Representative	0.014	0.039	0.020	0.044	0.020
	Representative/Nominal, %	56%	89%	100%	66%	100%
Manganese (mg/L)	Nominal		35	22	26	35
	Representative		31	19	25	12
	Representative/Nominal, %		88%	88%	97%	34%
Iron (mg/L)	Nominal	20	212	37	225	84
	Representative	21	191	50	221	64
	Representative/Nominal, %	104%	90%	136%	98%	77%
Iron (Trec) (mg/L)	Nominal	90	490		520	255
	Representative	60	423		469	148
	Representative/Nominal, %	66%	86%		90%	58%
TKN (mg/L)	Nominal		0.280			
	Representative		0.225			
	Representative/Nominal, %		80%			
NO3+NO2 (mg/L)	Nominal	0.060		0.095	0.100	
	Representative	0.036		0.094	0.005	
	Representative/Nominal, %	60%		99%	5%	

Concentrations for the representative baseline set were statistically significantly higher than those for the nominal baseline set only for magnesium and chloride at site CR-KRM; those are marked with "*". The surrogate concentration also is shown as a percent of the nominal concentration.

7.2.5 Representative Baseline – Three Lakes Inlets Sites

A statistical analysis was conducted, similarly to the one just presented, to determine if the water quality of the tributaries to the Three Lakes System measured in 2008-2012 can be used as a surrogate to describe conditions during 1996-2004 (2000 Baseline). The tributaries considered (Figure 14) include Arapaho Creek, the North Fork of the Colorado River, the East Inlet and the North Inlet.

Stillwater Creek, Roaring Fork, and Columbine Creek were not included due to data limitations. Data used for this analysis came from the Three Lakes Database, provided by Northern Water (Stephenson, 2013).

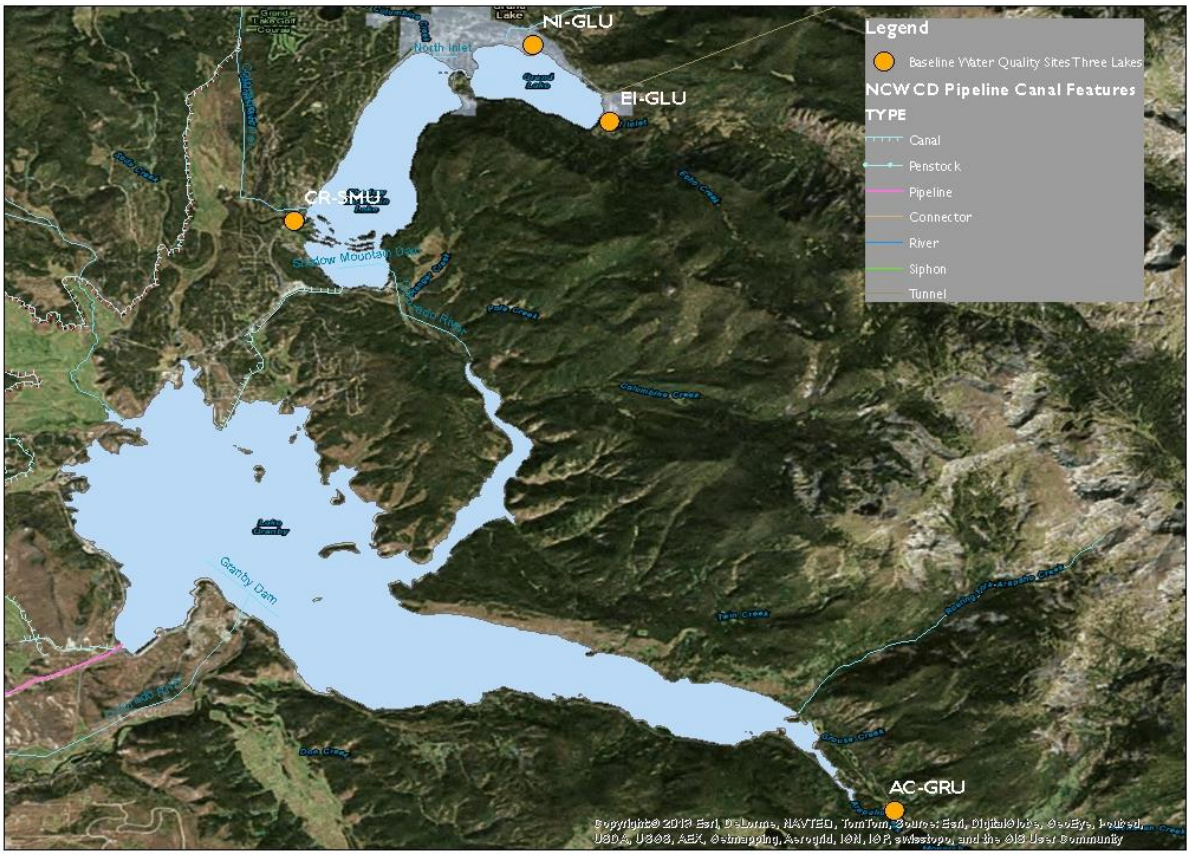


Figure 14 - Water quality sites Used in Representative Baseline Analysis (Three Lakes)

Data Handling and Statistical Procedures

A non-parametric analysis was conducted to compare concentrations from the two periods, as outlined in (CDPHE, WQCD, 2013). Consistent with the analysis presented in section 7.2.4:

- Data that were disqualified in the Database were not included in analysis;
- Only data from September and October were used;
- At least 4 data points for each period were required for inclusion of a constituent;
- For inclusion, more than half of the measurements of a particular constituent were required to be above detection limits;
- Multiple measurements of a parameter taken on the same day at the same location were treated independently.

The Mann-Whitney rank-sum test was chosen for evaluation of differences in location between corresponding datasets. The "rejection level" (alpha) of the test was chosen as: alpha = 0.05. The test was carried out using a one-sided alternative hypothesis to test for possible increases in parameter concentrations in the 2008-2012 period as compared to the 1996-2004 period. If any non-detects were included in the datasets being compared, all observations below the highest detection limit at which a non-detect was recorded were given equal ranks, as recommended by (Helsel, 2012).
The normal approximation to the Mann-Whitney test was used for preliminary comparison: parameters with approximate p-values below or near the rejection level [alpha < 0.1] and small sample sizes [min(N_obs_1, N_obs_2) < 10] were evaluated using the exact version of the Wilcoxon rank-sum test, which produces identical results to the exact version of the Mann-Whitney rank-sum test.

Statistical Analysis

Results from the analysis are summarized in the following tables. A statistical summary by tributary is displayed in APPENDIX E - REPRESENTATIVE BASELINE DEVELOPMENT. Table 14 summarizes the results of the statistical analysis and presents the surrogate concentration (2008-2012) as a percent of the nominal (1996-2004) concentration.

A variety of constituents had adequate data for comparisons, including nutrients, major ions, and metals. Of the comparisons made, only one constituent-tributary pair shows a statistically significant increase in the surrogate period versus the nominal period – specific conductivity for the North Fork. None of the other 44 comparisons show a statistically significant increase. Based on this analysis, we conclude that for the 4 tributaries analyzed, data for the years 2008-2012 can be used to represent conditions in 1996-2004.

Table 14 - Comparison of Median Concentrations for the Two Periods (Nominal: 1996-2004, Representative: 2008-2012)

Constituent	Value	Arapaho	East Inlet	North Inlet	North Fork
Calcium (mg/L)	Nominal	5	2.2	2.085	10
	Representative	4.585	2.065	2.19	9.74
	Representative/Nominal, %	92%	94%	105%	97%
Chloride (mg/L)	Nominal		0.17	0.19	
	Representative		0.135	0.18	
	Representative/Nominal, %		79%	95%	
DOC (mg/L)	Nominal	2.175	1.9	1.8	1.63
	Representative	1.935	1.9	1.9	1.8
	Representative/Nominal, %	89%	100%	106%	110%
Hardness (mg/L)	Nominal		6.795	6.62	
	Representative		6.425	7	
	Representative/Nominal, %		95%	106%	
Potassium (mg/L)	Nominal		0.19	0.23	
	Representative		0.19	0.25	
	Representative/Nominal, %		100%	109%	
Magnesium (mg/L)	Nominal	1.14	0.32	0.3845	2.2
	Representative	1.03	0.3215	0.397	2.245
	Representative/Nominal, %	90%	100%	103%	102%
Sodium (mg/L)	Nominal		0.9	1.18	
	Representative		0.895	1.25	
	Representative/Nominal, %		99%	106%	
Ammonia (mg/L)	Nominal	0.018			
	Representative	0.005			
	Representative/Nominal, %	28%			
NO3+NO2 (mg/L)	Nominal		0.081	0.112	
	Representative		0.042	0.0305	
	Representative/Nominal, %		52%	27%	
Total Phosphorus (mg/L)	Nominal	0.00675	0.0095	0.006	0.01
	Representative	0.00875	0.006	0.006	0.01175
	Representative/Nominal, %	130%	63%	100%	118%
pH	Nominal		7.595	7.21	7.59
	Representative		7.34	7.37	7.94
	Representative/Nominal, %		97%	102%	105%
Silicon Dioxide Dis (mg/L)	Nominal		3.54	5	
	Representative		3.6	4.835	
	Representative/Nominal, %		102%	97%	
Sulfate (mg/L)	Nominal		1.885	1.815	
	Representative		1.42	1.4	
	Representative/Nominal, %		75%	77%	
Specific Conductivity (uS/cm)	Nominal	41.5	18	20	79
	Representative	38	19	22	84*
	Representative/Nominal, %	92%	106%	110%	106%
TKN (mg/L)	Nominal	0.14	0.13	0.1	0.08
	Representative	0.14	0.1045	0.102	0.12
	Representative/Nominal, %	100%	80%	102%	150%
Total Organic Carbon (mg/L)	Nominal		2	2	2
	Representative		1.8	1.935	1.81
	Representative/Nominal, %		90%	97%	91%

Concentrations for the representative baseline set were statistically significantly higher than those for the nominal baseline set only for Specific Conductivity at in the North Fork. It is marked with "*". The surrogate concentration also is shown as a percent of the nominal concentration.

7.2.6 Representative Baseline Summary

The comparative analysis was done using data at sites located downstream of Granby Reservoir, at the Fraser River mouth, downstream of Willow Creek Reservoir and downstream of Windy Gap. All these sites being located downstream of the Three Lakes watershed, it is assumed that any changes in the upper watershed that could impact water quality would be captured by analyzing data at downstream sites which integrate all upstream impacts.

The same Mann-Whitney test was performed on data collected at major inlets to the Three Lakes system and confirms the results from the analysis done on the Colorado River sites downstream of the Three Lakes.

Because the analysis did not reveal statistically significant changes in water quality at the downstream sites and at the inlets to the Three Lakes, it is appropriate that the representative baseline be used for the Three Lakes watershed and the Colorado River downstream of Granby Reservoir, all the way to Kremmling.

Furthermore, the population analysis for this particular part of the basin showed no significant changes between 2000 and 2012.

We conclude that the years 2008-2012 represent baseline conditions for analysis of western slope components of the WGFP and that data from 2008-2012 can be used as a representative baseline for purposes of the antidegradation review.

7.3 Three Lakes Water Quality

The method used for the prediction of Water Quality for Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir is based on the Three Lakes Water Quality Model (Boyer, 2008). The original model was significantly enhanced and updated for the WGFP FEIS effort (documented in a separate report (Boyer, 2008)) and has been further upgraded since then as the model is now also being used to evaluate water quality in the Three Lakes for other purposes. For the FEIS, the model was used to evaluate both direct effects and cumulative effects (U.S. Bureau of Reclamation, 2011).

The Three Lakes Water Quality Model is a dynamic, process-based model. It is dynamic in that it simulates results over time (versus a steady-state condition). It is process-based in that the impacts of inflows, outflows, settling, and constituent transformations are described using differential equations based on an understanding of the physical, chemical and biological processes, which occur in lakes and reservoirs. Since the model is process-based, versus empirically-based, it can be used to predict water quality conditions under a variety of situations that are different from what has happened historically. The Three Lakes Model was developed to simulate flow and water quality of Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir in an integrated fashion. This is important due to the interdependencies between the three water bodies due to C-BT operations.

The Three Lakes Model characterizes Grand Lake and Granby Reservoir as three-layer lakes. Thus, both have an epilimnion, a metalimnion, and a hypolimnion during the stratified period and the water quality of each layer is assumed to be uniform throughout the layer. The model mixes the three layers during other portions of the year. The epilimnion and metalimnion layer thicknesses were determined based on Water Quality data collected by USBR during 2005 and 2006 (NORTHERN WATER, 2007b). The thickness of Granby Reservoir's hypolimnion varies over time as the total content changes. Note that since the surface water elevation of Grand Lake is fixed at 8,366.5 feet, the thickness of the hypolimnion is also unchanging through each simulation. More information is available in (AMEC, 2008).

Outputs from the model include total phosphorus, orthophosphate, organic phosphorus, total nitrogen, ammonia, nitrate/nitrite, organic nitrogen, dissolved oxygen, chlorophyll a, Secchi depth, total suspended solids and total organic carbon. Outputs are produced for each layer and each lake.

The Three Lakes Model is the best tool available to understand and predict water quality changes in the system under various scenarios.

7.3.1 SCT Analysis Methodology

This analysis relies on model outputs produced for the WGFP FEIS (AMEC, 2008) for Existing Conditions and for Cumulative Effects corresponding to Alternative 2 (Proposed Action). The model was used to calculate the incremental change in water quality concentrations between Existing Conditions (EC) and Cumulative Effects (CE). The model was used to examine the change in water quality in a relative fashion rather than in an absolute manner because Existing Conditions may not be representative of Baseline Water Quality. For the purpose of the antidegradation review and to compute the SCT, the incremental water quality change derived from the model runs was then applied to Baseline Water Quality and compared to the SCT. The process is illustrated in Figure 15.

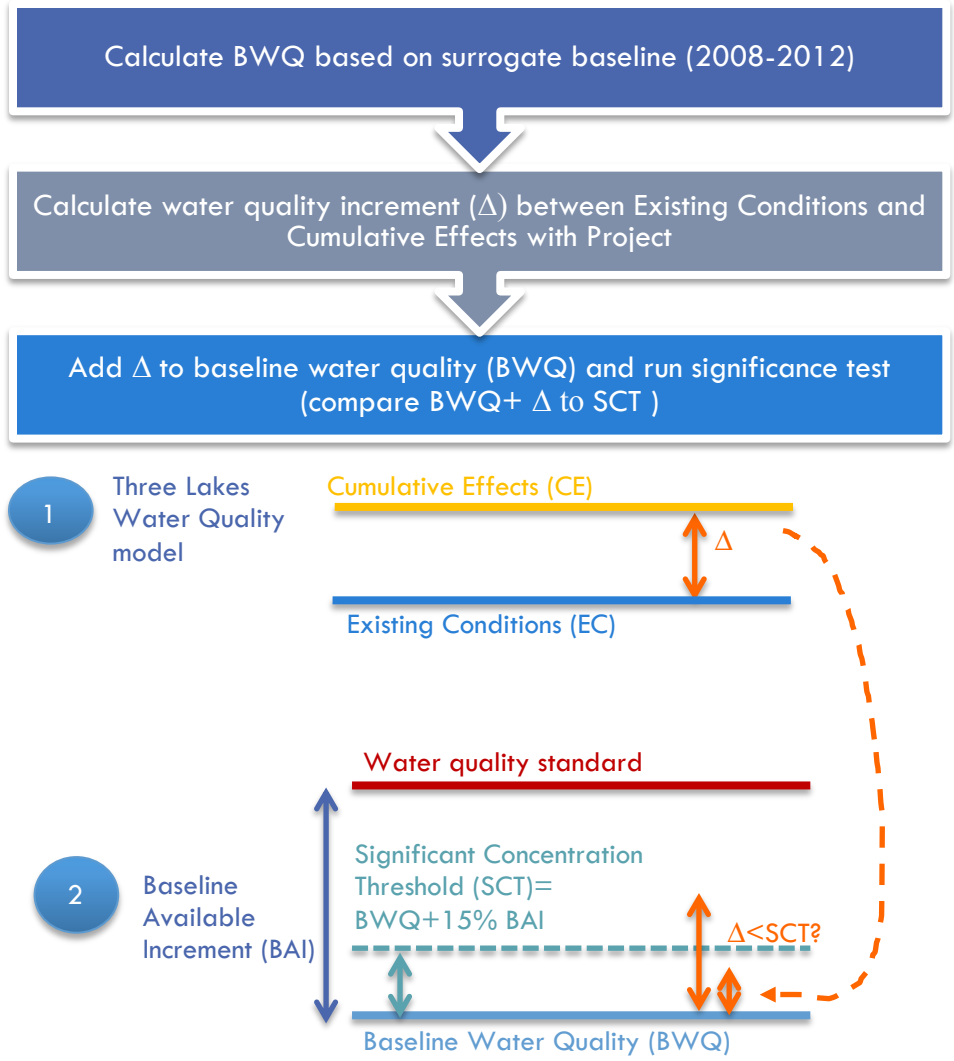


Figure 15 - Three Lakes Model - SCT Methodology Schematic

7.3.2 Representative Baseline Computation for the Three Lakes

As explained in Section 7.1, a representative baseline was developed for the purpose of the antidegradation review for the Windy Gap Firming Project. The representative baseline relies on data from 2008-2012. The following section describes how the representative baseline was developed for the Three Lakes.

Model outputs are produced for TP, Ortho P, Organic P, TN, Ammonia, Nitrate/Nitrite, Organic N Chlorophyll a, DO, Secchi, TSS and TOC. Constituents for which a water quality standard is established include: TP, TN, Nitrate/Nitrite, Chlorophyll a, Ammonia, DO, Secchi (for Grand Lake). For reasons that are further detailed in Section 7.3.4, the BWQ was only computed for TP, TN and Chlorophyll a.

Antidegradation review of lakes and reservoirs had not been the focus of regulatory procedures until recently and is not addressed in the regulations or procedural guidance documents for antidegradation. In recent years, the WQCD has acknowledged the inadequacy of the regulatory framework on this aspect and has fostered discussions about lakes and reservoirs in the development of water quality standards (5 CCR 1002-31 §31) and through the 303(d) listing methodology (CDPHE, WQCD, 2011); however there is

no specific mention of lakes and reservoirs in the Procedural Guidance for Antidegradation Review (CDPHE, WQCD, 2001), with the exception of the following:

> *Q41: How is the BWQ established for Lakes?*
> *A41: The BWQ is established in the same manner for lakes as it is for streams. The BWQ (as defined in Section VI, A on page 10) is the ambient condition of the water quality as of September 30, 2000. It is also the fully mixed condition below a discharge that was in place prior to September 30, 2000. When calculating BWQ with a discharge in place prior to September 30, 2000, a low flow (or dilution) value is needed. The value will be determined based on the results of the required mixing zone analysis (the Basic Standards at Section 31.10(4)(b)(i) and the WQCD's Colorado Mixing Zone Implementation Guidance, April 2002 require mixing zone studies for all discharges to lakes). Necessary adjustments for the baseline dilution condition of September 30, 2000 may be made to the current mixing zone analysis results. See also Q&A number 42 for more information on mixing zones.*

This particular section is of limited help in the case of WGFP as it addresses discharge situations that are not applicable for this Project.

Therefore, general principles laid out in 5 CCR 1002-82 §31, the Procedural Guidance (CDPHE, WQCD, 2001) and the Listing Methodology (CDPHE, WQCD, 2011) were used to develop an acceptable approach for lakes and reservoirs, consistent with the WQCD protocols for rivers and streams and with methodologies established for lakes and reservoirs in the development of water quality standards or for assessing attainment.

As per the Procedural Guidance for Antidegradation Review (CDPHE, WQCD, 2001):

> *The Division consistently characterizes ambient conditions by the 85th percentile of representative data. Since concentrations generally have an inverse relationship to flow (lower flows have higher concentrations), the 85th percentile is more representative of lower flow conditions. Therefore, the 85th percentile concentration is a representation of the baseline low-flow pollutant concentration. If sufficient representative low flow data is available, the 50th percentile of this low flow data may be used to characterize the baseline condition. A judgment as to which method should be used will depend on the stream characteristics and must result in the best characterization of the baseline low-flow concentration.*

For lakes and reservoirs, the concept of low flow needs to be reframed to provide a meaningful antidegradation determination. Low flow conditions are the focus of antidegradation review for rivers and streams because they are representative of critical conditions when impacts from any given discharge into a receiving stream or river are expected to be the worst. For lakes and reservoirs, critical conditions are different and are specific to certain constituents. The following presents the approach that was developed to establish baseline conditions using 2008-2012 data for each relevant constituent in an attempt to capture critical conditions.

For TP, TN and chlorophyll a, the critical timeframe for lakes and reservoirs is typically July through September (the "growing" season in Colorado) as reflected in the recently adopted nutrient criteria. TP, TN and chlorophyll a standards are expressed as July-Sep averages. Considering that abundant data are available in the Three Lakes for the representative baseline period and pursuant to the WQCD procedural guidelines (CDPHE, WQCD, 2001), the median of the Jul-Sep averages for 2008-2012 would constitute adequate representation of baseline conditions for TP, TN and chlorophyll a and captures the critical timeframe for lakes and reservoirs.

The 2008-2012 medians of the Jul-Sep averages are summarized in Table 15, Table 16 and

Table 17 along with the corresponding standards (current or with a delayed implementation date). Data were analyzed at the sites utilized in the model for each water body (Figure 16) and for which water

quality outputs are produced by the model. Tables of the datasets use data included in APPENDIX D - DATASET USED IN SCT COMPUTATIONS.

Baseline water quality was also computed for nitrate (with the assumption that nitrate+nitrite data is a reasonable surrogate for nitrate concentrations since it is the compound predominantly found in surface waters) and is summarized in Table 18. In the case of nitrate the BWQ is based on the 85th percentile of the 2008-2012 data.

Three Lakes Model - Reservoir Sites

Figure 16 - Water Quality Sites Used in the Three Lakes Model

Table 15 - Total Phosphorus (ug/L), Representative Baseline for the Three Lakes (Jul-Sep Average)

Station	2008	2009	2010	2011	2012	BWQ (2008-2012 Median)	Water Quality Standard	Assimilative Capacity	15% of Assimilative Capacity	SCT
GR-DAM	17.3	14.3	11.0	12.4	12.2	12.4	25.0	12.6	1.9	14.3
SM-DAM	19.3	14.7	17.0	14.7	16.8	16.8	25.0	8.2	1.2	18.0
GL-MID	13.6	10.6	11.3	11.0	13.3	11.3	25.0	13.7	2.1	13.4

Table 16 - Total Nitrogen (ug/L), Representative Baseline for the Three Lakes (Jul-Sep Average)

Station	2008	2009	2010	2011	2012	BWQ (2008-2012 Median)	Water Quality Standard	Assimilative Capacity	15% of Assimilative Capacity	SCT
GR-DAM	276	237	214	221	192	221	426	205	31	252
SM-DAM	355	242	388	255	261	261	426	165	25	286
GL-MID	353	216	359	267	265	267	426	159	24	291

Table 17 - Chlorophyll a (ug/L), Representative Baseline for the Three Lakes (Jul-Sep Average)

Station	2008	2009	2010	2011	2012	BWQ (2008-2012 Median)	Water Quality Standard	Assimilative Capacity	15% of Assimilative Capacity	SCT
GR-DAM	2.4	3.6	3.1	2.6	1.1	2.6	8	5.4	0.81	3.4
SM-DAM	3.9	5.6	6.7	5.0	3.7	5.0	8	3.0	0.45	5.5
GL-MID	5.4	5.2	6.4	4.8	8.2	5.4	8	2.6	0.40	5.8

Table 18 - NO3+NO2 (mg/L), Representative Baseline for the Three Lakes (85th percentile)

Station	BWQ (2008-2012 85%ile)	Water Quality Standard	Assimilative Capacity	15% of Assimilative Capacity	SCT
GL-MID	0.075	10	9.925	1.489	1.564
GR-DAM	0.040	10	9.961	1.494	1.534
SM-DAM	0.030	10	9.970	1.496	1.525

7.3.3 Cumulative Effects

As part of the Windy Gap Firming Project EIS, potential cumulative effects to the Three Lakes from the preferred alternative were estimated. These effects are associated with Alternative 2 (the preferred alternative), in addition to identified reasonably future foreseeable actions (RFFAs).

In October 2007, the Three Lakes Water Quality Model (Boyer J. M., Three Lakes Water Quality Model Documentation, 2008) was used to make these estimates and the results were reported. The purpose of this section is to provide an overview of the assumptions behind the cumulative effects model run.

Model input includes daily flows for major tributaries, pumped flows, and releases and daily water quality for inflowing water. Flows for the cumulative effects model run were generated using the WGFP water-resources model (ERO and Boyle, 2007). The cumulative effects run assumed operation of the preferred alternative along with several RFFA's that were anticipated to occur in the future when the modeling effort was conducted. These actions, which affect flows simulated as part of the WGFP water-resources model, included:

- Denver Water's Moffat Collection System Project[8];
- Urban growth in Grand and Summit counties[9];

[8] A scenario of hydrologic modeling was considered that maximizes Denver Water's future diversions from the Fraser Basin, since the proposed action alternative had not been identified at the time.
[9] Based on build-out municipal and industrial demands, as identified in the Upper Colorado River Basin Study (Hydrosphere, 2003)

- Changes in releases from Williams Fork and Wolford Mountain Reservoirs to meet flow recommendations in the 15-Mile Reach;
- Meeting future contract demands for water from Wolford Mountain Reservoir; and
- Expiration of Denver Water's Big Lake Ditch contract.

Since the water resources model used for the hydrologic analysis generated monthly flows, these data needed to be disaggregated to daily flows for the Water Quality model. Because gage data were limited during some portions of the 47-year simulation period used in the water resource model (ERO and Boyle, 2007), because of the significant effort that would have required daily disaggregation for the entire period and to reduce water quality modeling run times, a representative shorter simulation period for the Water Quality model (being statistically consistent with the 47-year period and coinciding with available gage data making the disaggregation process more accurate) was desirable. An analysis was conducted by Boyle Engineering (Thompson, 2005) which concluded that the 15 years from WY75 through WY89 met the criteria listed above. Therefore, Water Quality model runs were based on hydrology from a 15-year period (WY75-WY89) that is representative of the full 47- year period used in the water resource model. The method used for disaggregation to daily flows is described in Boyle, 2005.

Inflow water quality concentrations for Stillwater Creek, North Inlet, East Inlet, the North Fork of the Colorado River, Arapaho Creek, and Willow Creek Pipeline were estimated using historical median concentrations for the month under consideration. Concentrations for the Roaring Fork and Columbine Creek were assumed to be the same as Arapaho Creek because, at the time, there were no data available for these tributaries and the three tributaries each have less-developed watersheds.

Concentrations in the Windy Gap Pipeline, however, were estimated based on assumed future conditions in the Fraser River Basin. A monthly nutrient model of the Fraser River Basin (ERO and AMEC, 2008) was developed, which takes into account nutrient loads from wastewater treatment plants (WWTPs), on-site wastewater treatment systems (OWTSs), and non-point sources related to land use. Flows in the basin were estimated using the WGFP water resources model (ERO and Boyle, 2007) assuming RFFAs and Project operations. For the WWTPs, advanced nutrient removal treatment processes were assumed. Predicted nutrient concentrations at the mouth of the Fraser River were then used in a mass balance to estimate concentrations in Windy Gap Reservoir and thus, Windy Gap Pipeline for use in the Three Lakes Water Quality Model.

The model was run using the daily flows and water quality described above. The results were reported in the Lake and Reservoir Technical Report for the WGFP EIS (AMEC, 2008).

7.3.4 SCT Analysis Results – Three Lakes

The following section presents the results of the SCT analysis and determination of significance of degradation for the Three Lakes. The results are grouped by parameter as differing approaches were used depending on the constituents.

TP, TN and Chlorophyll a

As presented in Section 7.3.1, the incremental change in water quality was calculated using the Three Lakes model runs for Existing Conditions (EC) and Cumulative Effects (CE) from the FEIS. The difference between the two produced the incremental water quality change which was then added to the Baseline Water Quality (BWQ) and compared to the Significant Concentration Threshold as defined in Section 7.3.2.

For each of the 15 years for which the model was run, the Jul-Sep average was calculated for both EC and CE. The incremental water quality change was then computed using the difference between CE and

EC. For each of the 15 years, this incremental change was then added to the BWQ and compared to the SCT producing a determination of exceedance or attainment. The allowable exceedance frequency consistent with 303(d) listing methodology (1 in 5 years for nutrients and chlorophyll a) was then used to make a final determination about significance of the degradation (if any). The results of this analysis are summarized in Table 19, Table 20, Table 21, Table 22 and Table 23. The datasets that support this analysis can found in APPENDIX D - DATASET USED IN SCT COMPUTATIONS.

Table 19 - Computation of Water Quality Impact in the Three Lakes, Total Phosphorus (ug/L)

Station	Year	Modeled TP Change (CE-EC) (ug/L)	TP BWQ (ug/L)	Projected Concentration (ug/L)	SCT Test
GL-MID	1975	0.1	11.3	11.4	PASS
	1976	0.3	11.3	11.6	PASS
	1977	0.6	11.3	11.9	PASS
	1978	5.3	11.3	16.6	EXCEED
	1979	0.3	11.3	11.7	PASS
	1980	0.7	11.3	12.0	PASS
	1981	0.1	11.3	11.5	PASS
	1982	0.3	11.3	11.6	PASS
	1983	0.5	11.3	11.9	PASS
	1984	0.3	11.3	11.6	PASS
	1985	1.5	11.3	12.9	PASS
	1986	0.6	11.3	12.0	PASS
	1987	0.5	11.3	11.8	PASS
	1988	1.2	11.3	12.5	PASS
	1989	0.2	11.3	11.6	PASS
GR-DAM	1975	0.7	12.4	13.1	PASS
	1976	-0.3	12.4	12.1	PASS
	1977	0.3	12.4	12.7	PASS
	1978	-0.6	12.4	11.8	PASS
	1979	0.9	12.4	13.3	PASS
	1980	0.1	12.4	12.5	PASS
	1981	-0.3	12.4	12.1	PASS
	1982	-0.6	12.4	11.8	PASS
	1983	1.7	12.4	14.1	PASS
	1984	1.5	12.4	13.9	PASS
	1985	0.6	12.4	13.0	PASS
	1986	0.4	12.4	12.8	PASS
	1987	-0.1	12.4	12.3	PASS
	1988	1.5	12.4	13.9	PASS
	1989	-0.3	12.4	12.1	PASS

Station	Year	Modeled TP Change (CE-EC) (ug/L)	TP BWQ (ug/L)	Projected Concentration (ug/L)	SCT Test
SM-DAM	1975	0.0	16.8	16.8	PASS
	1976	0.0	16.8	16.8	PASS
	1977	0.5	16.8	17.3	PASS
	1978	4.8	16.8	21.6	EXCEED
	1979	0.5	16.8	17.3	PASS
	1980	0.8	16.8	17.6	PASS
	1981	-0.1	16.8	16.7	PASS
	1982	0.6	16.8	17.4	PASS
	1983	0.7	16.8	17.5	PASS
	1984	0.5	16.8	17.3	PASS
	1985	1.9	16.8	18.7	EXCEED
	1986	0.7	16.8	17.5	PASS
	1987	0.0	16.8	16.8	PASS
	1988	0.9	16.8	17.7	PASS
	1989	0.0	16.8	16.8	PASS

Table 20 - SCT Results in the Three Lakes, Total Phosphorus (ug/L)

Station	# of TP exceedances of the SCT	SCT Exceeded?
GL-MID	1/15	NO
GR-DAM	0/15	NO
SM-DAM	2/15	NO

Table 21 - Computation of Water Quality Impact in the Three Lakes, Total Nitrogen (ug/L)

Station	Year	Modeled TN Change (CE-EC) (ug/L)	TN BWQ (ug/L)	Projected Concentration (ug/L)	SCT Test
GL-MID	1975	0.155	266.9	267.1	PASS
	1976	6.114	266.9	273.0	PASS
	1977	4.538	266.9	271.4	PASS
	1978	45.488	266.9	312.4	EXCEED
	1979	6.929	266.9	273.8	PASS
	1980	14.338	266.9	281.2	PASS
	1981	7.564	266.9	274.5	PASS
	1982	2.759	266.9	269.7	PASS
	1983	12.044	266.9	278.9	PASS
	1984	2.011	266.9	268.9	PASS
	1985	24.473	266.9	291.4	EXCEED
	1986	10.583	266.9	277.5	PASS
	1987	15.330	266.9	282.2	PASS
	1988	21.433	266.9	288.3	PASS
	1989	10.719	266.9	277.6	PASS

Station	Year	Modeled TN Change (CE-EC) (ug/L)	TN BWQ (ug/L)	Projected Concentration (ug/L)	SCT Test
GR-DAM	1975	4.651	220.9	225.6	PASS
	1976	6.774	220.9	227.7	PASS
	1977	4.252	220.9	225.2	PASS
	1978	17.538	220.9	238.4	PASS
	1979	10.781	220.9	231.7	PASS
	1980	12.989	220.9	233.9	PASS
	1981	8.285	220.9	229.2	PASS
	1982	13.545	220.9	234.4	PASS
	1983	8.915	220.9	229.8	PASS
	1984	9.762	220.9	230.7	PASS
	1985	16.892	220.9	237.8	PASS
	1986	14.075	220.9	235.0	PASS
	1987	13.506	220.9	234.4	PASS
	1988	11.641	220.9	232.5	PASS
	1989	12.320	220.9	233.2	PASS
SM-DAM	1975	2.196	260.8	263.0	PASS
	1976	4.713	260.8	265.5	PASS
	1977	3.752	260.8	264.6	PASS
	1978	45.342	260.8	306.1	EXCEED
	1979	8.756	260.8	269.6	PASS
	1980	15.260	260.8	276.1	PASS
	1981	6.686	260.8	267.5	PASS
	1982	6.470	260.8	267.3	PASS
	1983	9.673	260.8	270.5	PASS
	1984	3.794	260.8	264.6	PASS
	1985	27.377	260.8	288.2	EXCEED
	1986	11.141	260.8	271.9	PASS
	1987	12.764	260.8	273.6	PASS
	1988	21.781	260.8	282.6	PASS
	1989	9.898	260.8	270.7	PASS

Table 22 - SCT Results in the Three Lakes, Total Nitrogen (ug/L)

Station	# of TN exceedances	SCT Exceeded?
GL-MID	2/15	NO
GR-DAM	0/15	NO
SM-DAM	2/15	NO

Table 23 - Computation of Water Quality Impact in the Three Lakes, Chlorophyll a (ug/L)

Station	Year	Modeled Chl a Change (CE-EC) (ug/L)	Chl a BWQ (ug/L)	Projected Concentration (ug/L)	SCT Test
GL-MID	1975	0.0	5.4	5.3	PASS
	1976	-0.2	5.4	5.1	PASS
	1977	-0.1	5.4	5.2	PASS
	1978	-0.2	5.4	5.1	EXCEED
	1979	0.1	5.4	5.5	PASS
	1980	0.4	5.4	5.7	PASS
	1981	-0.5	5.4	4.8	PASS
	1982	0.1	5.4	5.5	PASS
	1983	0.2	5.4	5.6	PASS
	1984	0.1	5.4	5.5	PASS
	1985	0.6	5.4	6.0	EXCEED
	1986	0.4	5.4	5.7	PASS
	1987	0.1	5.4	5.4	PASS
	1988	0.3	5.4	5.7	PASS
	1989	-0.4	5.4	5.0	PASS
GR-DAM	1975	0.1	2.6	2.7	PASS
	1976	0.0	2.6	2.6	PASS
	1977	0.0	2.6	2.6	PASS
	1978	0.0	2.6	2.6	PASS
	1979	0.1	2.6	2.7	PASS
	1980	0.0	2.6	2.6	PASS
	1981	0.0	2.6	2.6	PASS
	1982	0.1	2.6	2.6	PASS
	1983	0.1	2.6	2.7	PASS
	1984	-0.1	2.6	2.5	PASS
	1985	-0.1	2.6	2.5	PASS
	1986	0.0	2.6	2.6	PASS
	1987	0.0	2.6	2.6	PASS
	1988	0.2	2.6	2.8	PASS
	1989	0.0	2.6	2.6	PASS
SM-DAM	1975	-0.1	5.0	5.0	PASS
	1976	-0.2	5.0	4.8	PASS
	1977	-0.1	5.0	4.9	PASS
	1978	-0.7	5.0	4.3	EXCEED
	1979	0.0	5.0	5.0	PASS
	1980	0.5	5.0	5.5	PASS
	1981	-0.4	5.0	4.7	PASS
	1982	0.1	5.0	5.1	PASS
	1983	0.0	5.0	5.0	PASS
	1984	0.1	5.0	5.1	PASS
	1985	0.0	5.0	5.0	EXCEED
	1986	0.1	5.0	5.2	PASS

Station	Year	Modeled Chl a Change (CE-EC) (ug/L)	Chl a BWQ (ug/L)	Projected Concentration (ug/L)	SCT Test
	1987	-0.2	5.0	4.8	PASS
	1988	0.1	5.0	5.1	PASS
	1989	0.0	5.4	4.7	PASS

Table 24 - SCT Results in the Three Lakes, Chlorophyll a (ug/L)

Station	# of Chl a exceedances	SCT Exceeded?
GL-MID	2/15	NO
GR-DAM	0/15	NO
SM-DAM	2/15	NO

The SCT analysis described above for TP, TN and chlorophyll a shows that water quality impacts associated with the WGFP do not exceed the SCT. Furthermore, it should be noted that the results are conservative because they do not reflect nutrient mitigation commitments that are discussed in detail in section 8.6 to offset nutrient loading increases associated with the Project.

Therefore it is concluded that there is no significant degradation associated with the WGFP for total nitrogen, total phosphorus and chlorophyll a.

Secchi

The Water Quality Control Commission (WQCC) determined in 2008 that the adoption of a 4 meter numerical standard with a delayed effective date was an appropriate policy choice to encourage cooperative efforts to improve Grand Lake clarity. At the same time, the WQCC adopted the following narrative "The highest level of clarity attainable, consistent with the exercise of established water rights and the protection of aquatic life" as the effective standard. Efforts since 2008 have focused on data collection and understanding the factors controlling clarity.

In 2014, the WQCC adopted a change to the narrative clarity standard that added "protection of water quality throughout the Three Lakes System" as another consideration for attainability in order to recognize the interdependence of water quality in the entire system. The implementation of a numeric standard was further delayed, with the expectation that the issue would be revisited by the WQCC in 2016 after considering attainability constraints including water rights, aquatic life, water quality in the Three Lakes and financial implications related to the implementation of a clarity standard for Grand Lake.

At the time of writing of this report, efforts to examine the attainability of a Grand Lake clarity standard are underway and significant uncertainty remains regarding the outcome of this process, including the USBR-led NEPA process that will accompany the evaluation of possible alternatives to improve clarity in Grand Lake.

In this context, it was not deemed feasible to perform a formal antidegradation review on clarity in Grand Lake. However, a qualitative assessment is provided with respect to the narrative standard. Predicted changes in Secchi depth in Grand Lake under cumulative effects, relative to existing conditions as defined in the FEIS show a decrease in Secchi depth of 3.8% as an annual average (AMEC, 2008). These projections do not reflect mitigation commitments laid out in several agreements involving Northern Water, the U.S. Bureau of Reclamation and Grand County and executed in 2012 (Grand County 1041 Permit for Windy Gap Firming Project (Grand County, 2012) and 2013 (C-BT Repayment Contract Supplement (U.S. Bureau of Reclamation, 2013)) demonstrating long-term commitments from the signatories to continue working on the issue. These agreements are discussed in more detail in (Section 8.8).

Two recent trend analyses ((EMPSi and CP Callahan Inc., 2013), (Helsel, 2014)) have also shown a positive trend in clarity in Grand Lake that can be partly attributed to operational changes with the C-BT in recent years in an attempt to improve clarity in Grand Lake during the summer. It is expected that the trend will continue based on commitments to improve clarity in Grand Lake over the long-term.

Nitrate

Nitrate data are not available in the Three Lakes system. Instead nitrate and nitrite are reported together. However, because nitrite is easily oxidized to nitrate, nitrate is the compound predominantly found in surface waters. Therefore nitrate+nitrite concentrations can be used as a surrogate for nitrate concentrations. A review of observed nitrate+nitrite data in the Three Lakes system shows that levels are orders of magnitude lower than the water quality standard of 10 mg/L (Figure 17). Negative values indicate non-detects reported as equal to the detection limit, with a negative value.

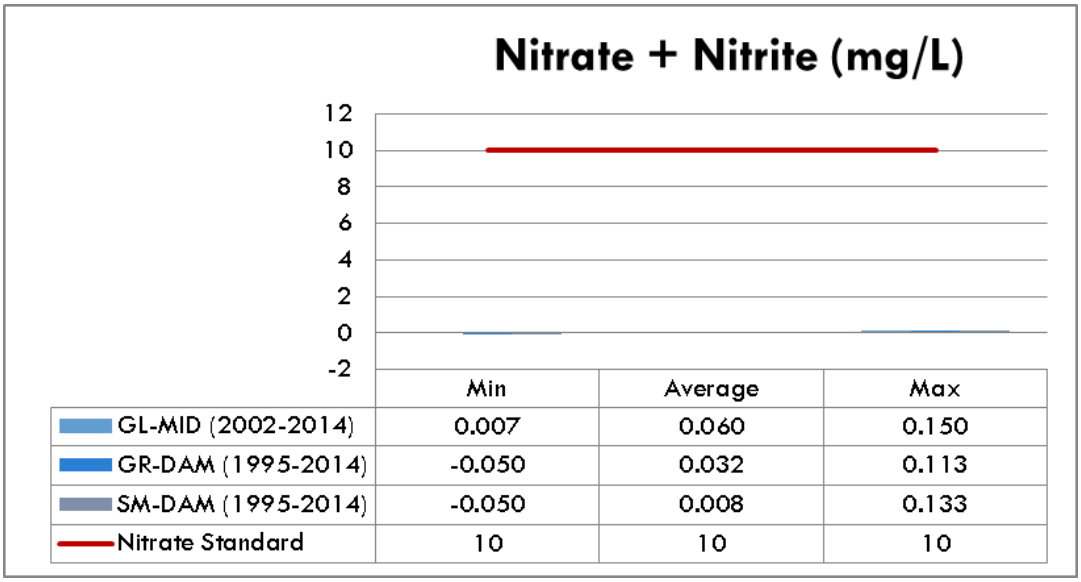


Figure 17 - Nitrate + Nitrite Concentrations in the Three Lakes

Under the most conservative assumption that all increase in TN would be in the form of NO3, based upon results shown in Table 22, the SCT was computed and is presented in Table 25.

Table 25 - Computation of Water Quality Impact in the Three Lakes, Nitrate (mg/L)

Station	Year	Modeled NO3 Change (CE-EC) (mg/L)	NO3 BWQ (mg/L)	Projected increase from BWQ (mg/L)	SCT Test
GL-MID	1975	0.0002	0.075	0.075	PASS
	1976	0.0061	0.075	0.081	PASS
	1977	0.0045	0.075	0.079	PASS
	1978	0.0455	0.075	0.120	PASS
	1979	0.0069	0.075	0.082	PASS
	1980	0.0143	0.075	0.089	PASS
	1981	0.0076	0.075	0.082	PASS
	1982	0.0028	0.075	0.078	PASS
	1983	0.0120	0.075	0.087	PASS
	1984	0.0020	0.075	0.077	PASS
	1985	0.0245	0.075	0.099	PASS
	1986	0.0106	0.075	0.085	PASS
	1987	0.0153	0.075	0.090	PASS
	1988	0.0214	0.075	0.096	PASS
	1989	0.0107	0.075	0.085	PASS

Station	Year	Modeled NO3 Change (CE-EC) (mg/L)	NO3 BWQ (mg/L)	Projected increase from BWQ (mg/L)	SCT Test
GR-DAM	1975	0.0047	0.040	0.044	PASS
	1976	0.0068	0.040	0.046	PASS
	1977	0.0043	0.040	0.044	PASS
	1978	0.0175	0.040	0.057	PASS
	1979	0.0108	0.040	0.050	PASS
	1980	0.0130	0.040	0.052	PASS
	1981	0.0083	0.040	0.048	PASS
	1982	0.0135	0.040	0.053	PASS
	1983	0.0089	0.040	0.048	PASS
	1984	0.0098	0.040	0.049	PASS
	1985	0.0169	0.040	0.056	PASS
	1986	0.0141	0.040	0.054	PASS
	1987	0.0135	0.040	0.053	PASS
	1988	0.0116	0.040	0.051	PASS
	1989	0.0123	0.040	0.052	PASS
SM-DAM	1975	0.0022	0.030	0.032	PASS
	1976	0.0047	0.030	0.035	PASS
	1977	0.0038	0.030	0.034	PASS
	1978	0.0453	0.030	0.075	PASS
	1979	0.0088	0.030	0.039	PASS
	1980	0.0153	0.030	0.045	PASS
	1981	0.0067	0.030	0.036	PASS
	1982	0.0065	0.030	0.036	PASS
	1983	0.0097	0.030	0.039	PASS
	1984	0.0038	0.030	0.034	PASS
	1985	0.0274	0.030	0.057	PASS
	1986	0.0111	0.030	0.041	PASS
	1987	0.0128	0.030	0.043	PASS
	1988	0.0218	0.030	0.052	PASS
	1989	0.0099	0.030	0.040	PASS

Under the most conservative assumptions, the SCT analysis shows no impact associated with the WCGP for nitrate.

It is therefore concluded that that there is no significant degradation associated with the WGFP for nitrate.

Dissolved Oxygen

Considering that Shadow Mountain Reservoir is listed as impaired for dissolved oxygen, a qualitative assessment of the possibility that proposed changes to operations would increase the likelihood of dissolved oxygen problems is provided here.

The 6 mg/L DO standard in Shadow Mountain Reservoir is based on concentrations in the 0.5 to 2 meter strata of the reservoir. Exceedances of the standard have occurred at the southern portion of the reservoir (measured at the SM-DAM site), and are predominantly due to significant flow of low DO water into the reservoir via the Granby Pump Canal when DO concentrations are low in the hypolimnion of Granby Reservoir (Boyer & Hawley, 2013). This phenomenon typically occurs in September. Significant flow from the Granby Pump Canal serves to mix water at the southern end, which affects the entire water column, including the 0.5 to 2 meter strata. Thus, low DO conditions can occur in Shadow Mountain Reservoir when 1) significant Farr pumping occurs in the fall and 2) DO concentrations in the hypolimnion of Granby Reservoir are low in the fall. This last phenomenon is exacerbated when Granby Reservoir contents are low, thus reducing the total volume of the hypolimnion.

The WGFP Three Lakes Water Quality Model characterizes Shadow Mountain Reservoir as a single well-mixed water body and simulates concentrations that are volumetrically averaged. Thus, concentrations at the southern portion of the reservoir in the 0.5 to 2 meter strata are not differentiated. However, the results can provide useful information for a qualitative analysis. Predicted relative changes in DO concentrations in the fall over the period WY1975-WY1989 are very small for 11 of the 15 years. Two years show slightly worse concentrations with the Project (1979 and 1982); while two others (1977 and 1978) show larger changes (but less than 0.5 mg/L). These four years are all expected to pump enough flow from the Farr pumping plant to mix the southern end of Shadow Mountain Reservoir, as are most of the other years. What differentiates these four years, however, is the anticipated difference in Granby Reservoir contents during September. The largest September decreases in Granby Reservoir contents (~52,000, 70,000, 72,000, and 75,000 AF) are anticipated as a result of the Project in these 4 years and are well over the average of the 15-year period (~30,000 AF). We note that 1977 was a particularly dry year and September Granby Reservoir contents under existing conditions are the lowest for 1977 and 1978. When Granby Reservoir levels are low, DO depletions at the bottom of Granby Reservoir are exacerbated due to the lower volume of water available to absorb these depletions. Thus, Shadow Mountain Reservoir is more vulnerable under these hydrologic conditions, regardless of operations due to the WGFP.

Based on this discussion, for most years, the likelihood of additional DO exceedances caused by the Project in Shadow Mountain Reservoir is small under cumulative effect conditions.

Dissolved oxygen concentrations are however, anticipated to be lower in the 0.5-2 meter strata of Shadow Mountain Reservoir with the WGFP when Granby Reservoir contents are significantly reduced due to operations of the Project.

Northern Water in conjunction with the U.S. Bureau of Reclamation is investigating remediation strategies that would improve DO in Shadow Mountain Reservoir. These are discussed in Section 8.3. It should also be noted that mitigation measures aiming at maintaining higher reservoir levels in Granby Reservoir would have a positive impact on DO at the bottom of Granby Reservoir and consequently on Shadow Mountain Reservoir as well. This is further discussed in Section 8.4.

Ammonia

Antidegradation review for ammonia would be challenging because the standard varies as a function of pH and temperature, both of which exhibit diel and seasonal patterns of variation. The standard would change almost continuously, and the response to pH and temperature is non-linear. Consequently, assimilative capacity also would change almost continuously and non-linearly even though the ammonia concentration may remain constant.

Instead, a simpler approach was taken: it is assumed that the interim numeric value for total nitrogen TN of 0.426 mg/L will eventually be adopted as a standard in these lakes and is more restrictive than the ammonia standard for this system. A review of the data shows that this assumption is valid: Three Lakes data shows that temperature never exceeds 20.6 degrees and pH never exceeds 9.2. Under these most restrictive conditions (high pH and high temperature), the computed chronic ammonia standard would be 0.205 mg/L (the acute standard would be 0.7 mg/L for the same pH and temperature values).

Further review of nitrogen data in the Three Lakes also shows that for the representative baseline period (2008-2012), NH3/TN ratios never exceed 19% as shown in Figure 18. Taking a conservative approach and assuming that the portion of TN that is composed of ammonia never exceeds 19%, the ammonia concentration that would correspond to the total nitrogen standard of 0.426 mg/L would be 0.08 mg/L, which, would be considerably more restrictive than the current ammonia standard for these lakes as calculated previously (0.205 mg/L chronic, 0.7 mg/L acute).

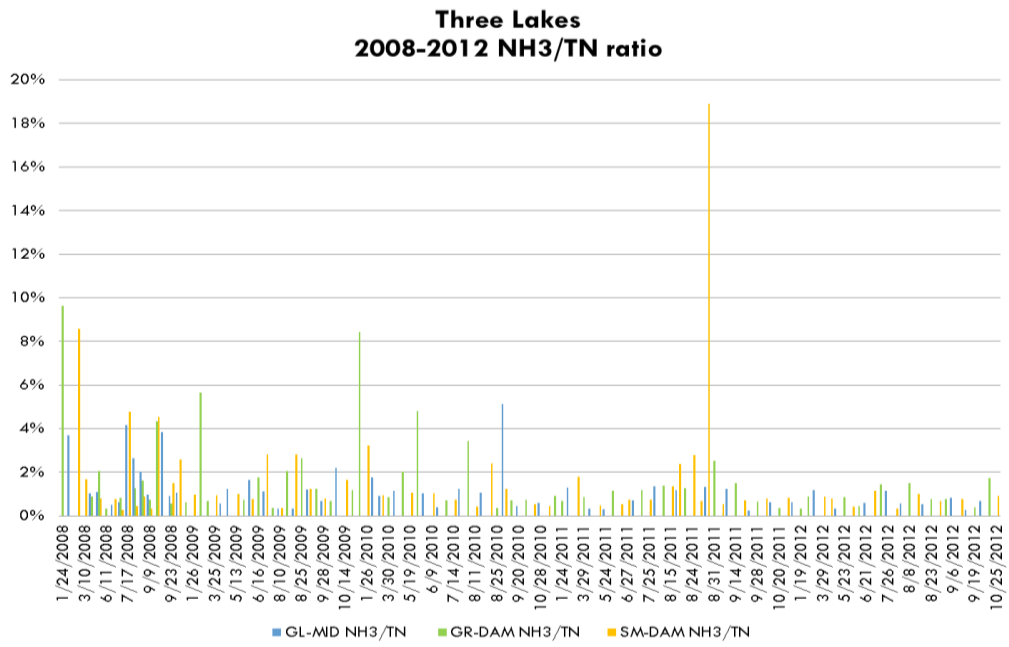


Figure 18 - 2008-2012, NH3/TN Ratios in the Three Lakes

As long as these conditions are maintained in the future, the chance of reaching the ammonia SCT, without also exceeding the TN standard, is therefore very unlikely.

Results from the antidegradation review on TN show no significant degradation and also do not reflect the implementation of mitigation measures described in section 8.6 aiming at offsetting nutrient loading increases associated with the WGFP.

Therefore, it is concluded that there would be no significant degradation for ammonia in the Three Lakes.

Mercury

Granby Reservoir is currently listed as impaired for aquatic life use as a result of the presence of mercury in fish tissue. There are currently no impairments of aquatic life use in Shadow Mountain Reservoir and Grand Lake.

Mercury is usually released into the atmosphere through burning and settles into wetlands or streams, where it can be taken up by aquatic life. One form of mercury (methylmercury) is a neurotoxin that forms under anoxic conditions by sulfate and iron reducing bacteria and that bioaccumulates in the aquatic foodweb. It is often referred to as "bioavailable mercury". Methylmercury molecules are readily absorbed by living tissue and continue to accumulate over time. With the exception of isolated cases of known point sources, the ultimate source of mercury to most aquatic ecosystems is deposition from the atmosphere, primarily associated with rainfall[10,11].

A simplified representation of the mercury cycle is presented in Figure 19. Once in surface water, mercury enters a complex cycle in which one form can be converted to another. It can be brought to the sediments by particle settling and then later released by diffusion or resuspension. It can enter the food chain, or it can be released back to the atmosphere by volatilization. The concentration of dissolved organic carbon (DOC) and pH have a strong effect on the ultimate fate of mercury in an ecosystem.

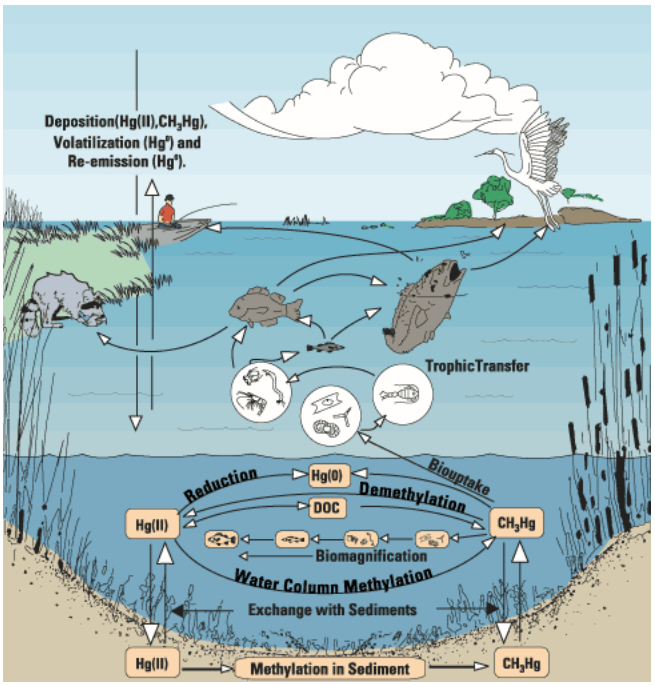


Figure 19 - Mercury Cycling Through the Air, Sediments, Water and Organisms[12]

Because of the inherent link between the mercury/methylmercury and the aquatic foodweb, fishery management also becomes an essential component of the bioaccumulation process (Johnson, Lepak, & Wolff, 2014). The details of mercury cycling and how methylmercury moves through the foodweb are still largely unknown and are likely site-specific[7].

Studies of reservoirs have indicated that methylation of mercury is increased following the initial filling of reservoirs, as nutrient inputs and organic matter decomposition may lead to anaerobic conditions at the

[10] http://wi.water.usgs.gov/mercury/mercury-cycling.html#references
[11] http://water.epa.gov/scitech/swguidance/standards/criteria/health/factsheet.cfm
[12] http://sofia.usgs.gov/projects/index.php?project_url=evergl_merc

water-sediment interface creating conditions favorable to the methylation of mercury (Ullrich, Tanton, & Abdrashitova, 2001) and (TetraTech, 2001).
For the same reasons, reservoir level fluctuations can also enhance the methylation of mercury and subsequent bioaccumulation in the aquatic foodweb. Some reservoir management strategies can be followed in order to minimize mercury methylation and bioaccumulation in fish tissue. Increasing bottom water releases before anoxic conditions develop as well as minimizing water level fluctuations can be beneficial to manage methylmercury in reservoirs[13].

There is no model of mercury methylation for Granby Reservoir, Shadow Mountain Reservoir or Grand Lake; therefore it was not possible to quantify expected changes in mercury and methyl mercury concentrations in the reservoir. A qualitative assessment is presented instead.

The WGFP Three Lakes Water Quality Model characterizes Granby Reservoir and Grand Lake as stratified water bodies and simulates concentrations that are volumetrically averaged in each stratified layer (epilimnion, metalimnion and hypolimnion). Thus, bottom concentrations near the water-sediment interface are not differentiated. Shadow Mountain Reservoir was not represented as a stratified waterbody; therefore concentrations are reported for the entire water column. Nonetheless, the results can provide useful information for a qualitative analysis. Predicted relative changes in DO concentrations over the period WY1975-WY1989 are shown in Figure 20, Figure 21 and Figure 22. Results do not indicate any notable change in hypolimnetic dissolved oxygen levels for the WGFP under Cumulative Effects, as compared to Existing Conditions for Granby Reservoir or Shadow Mountain Reservoir. For Grand Lake, data show an accentuation of low hypolimnetic dissolved oxygen levels in some years.

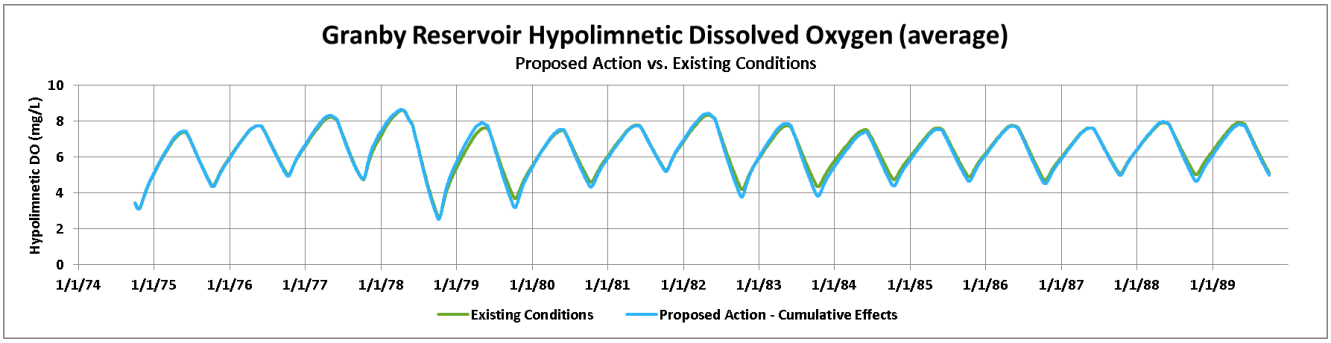


Figure 20 - Granby Reservoir Hypolimnetic Dissolved Oxygen

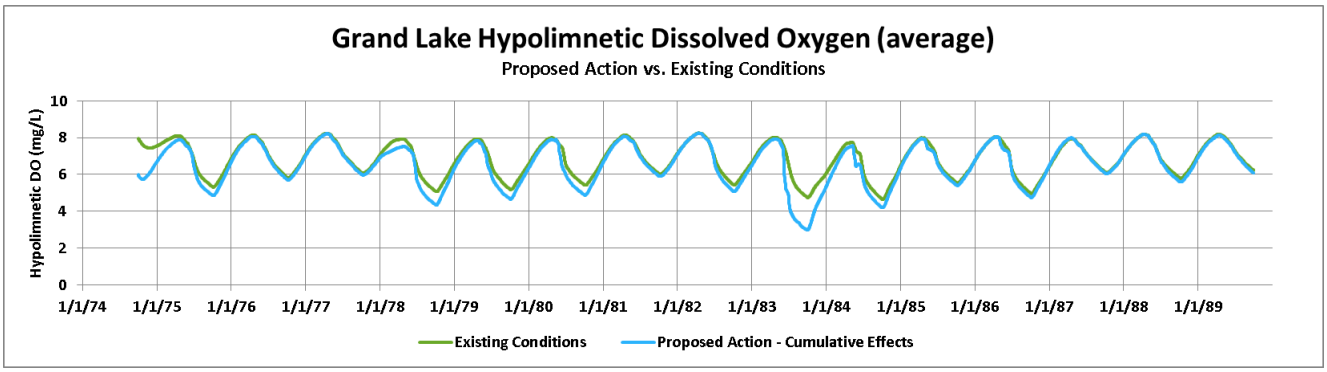


Figure 21 - Grand Lake Reservoir Hypolimnetic Dissolved Oxygen

[13] http://el.erdc.usace.army.mil/workshops/11Sept-EWN/Kubitz_reservoir%20mgmt%20lessons.pdf

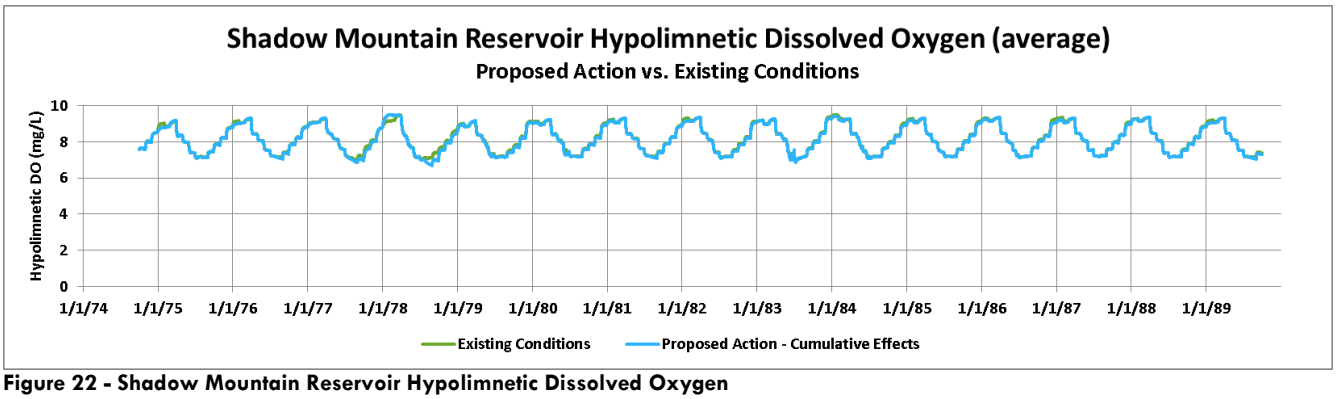


Figure 22 - Shadow Mountain Reservoir Hypolimnetic Dissolved Oxygen

A review of simulated reservoir levels for Granby Reservoir under the WGFP as compared to Existing Conditions shows that Granby may see greater variations in water levels in some years (accentuating the "refill" effect), although water levels are unchanged for most years. It should be noted that these simulations do not reflect mitigation commitments that would offset this effect associated with WGFP. Because water levels in Shadow Mountain Reservoir and Grand Lake cannot vary by more than one foot by contractual obligation, water levels would not be affected by WGFP.

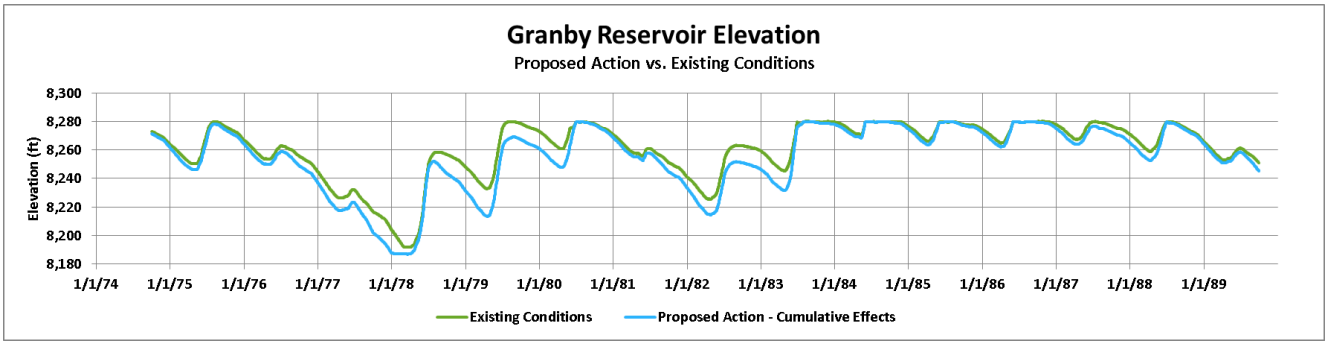


Figure 23 - Granby Reservoir Elevation, WGFP vs. Existing Conditions

However, although dissolved oxygen levels may influence the bioaccumulation of mercury in reservoirs, as explained previously these effects may be impacted by fishery management and additional confounding factors including reservoir operation (such as the amount and timing of deliveries/bottom releases). As a result, it is difficult to predict what trend should be expected.

In summary:

- Increased water levels fluctuations and lower bottom DO can increase the methylation of mercury;
- Hypolimnetic DO levels are not expected to change (except very occasionally in Grand Lake);
- Shadow Mountain Reservoir and Grand Lake water levels will not change under WGFP operation;
- Modeling of Granby water level fluctuations shows greater fluctuations, but these will be offset by mitigation commitments and therefore should not adversely impact mercury methylation;
- Fishery management significantly influence bioaccumulation of mercury in the foodweb but it is uncertain how CPW may manage the fishery in the Three Lakes in the future and costs of fishery management for mercury reduce the likelihood that it would be done;

Based on these confounding factors, **it is not possible to reasonably ascertain a definite direction of change for mercury in Granby Reservoir, Shadow Mountain Reservoir or Grand Lake.**

Selenium

Selenium is a naturally occurring element that is required in the diets of all animals and is toxic at high doses. Toxicity is primarily to the reproductive system, causing organisms to die in the egg or to have weak and deformed offspring. The environmental levels of selenium at which toxicity occurs in fish and birds are highly dependent upon specific chemical and biological attributes of a site and cannot be predicted from water or sediment concentrations alone.

Being a natural element, selenium can be found throughout the environment. Toxic levels of selenium in water bodies have mostly been related to irrigation and/or development of western soils that are naturally high in selenium, ash pond discharges from coal-fired power plants using coal that has selenium in it, petroleum refinery effluents, and runoff or discharges from certain mining activities.

Selenium bioaccumulates in the aquatic food chain by first being converted to a bioavailable form that can be taken up by algae and bacteria in sediments. This conversion occurs most quickly in slow-moving water (such as lakes), which also provides more time for the algae and bacteria to be exposed. Therefore, selenium reaches higher levels in the food chain of lakes, reservoirs, wetlands, or the slow backwaters of rivers and streams, than it does in fast moving rivers. Selenium can increase in the algae and bacteria to levels much higher than in the water. Once the selenium is in these organisms, it is converted to an organic form that is easily taken up by the invertebrates that feed on the algae and bacteria. The amount of selenium continues to increases as it moves through trophic levels from algae and bacteria to invertebrates. Fish that feed on invertebrates ingest selenium as well. Birds also feed on invertebrates and fish. Therefore, birds may be affected, too, if the invertebrates or fish they eat have accumulated high enough levels of selenium. A simplified illustration of selenium cycling is presented in Figure 24.

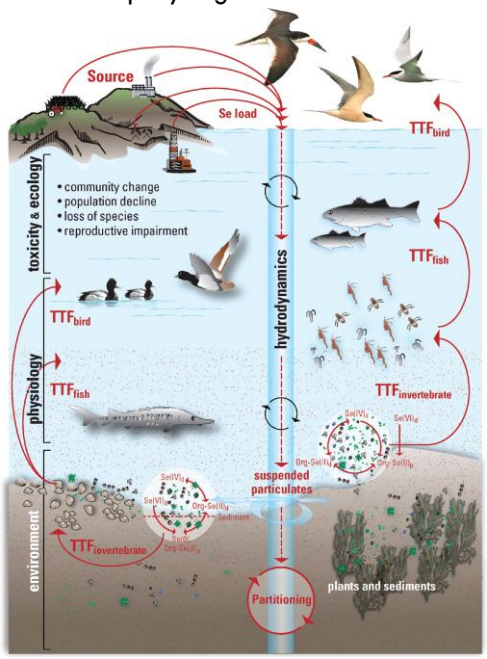


Figure 24 - Selenium Cycling[15]

Although the bioaccumulation of selenium has been studied extensively, there remain significant uncertainties about its transport and environmental partitioning in various ecosystems. The vulnerability of ecosystems to selenium tends to be more site-specific than for most other contaminants[14].

Selenium is not an existing water quality concern in the Three Lakes because no selenium bearing formations are present in the area. As explained previously, selenium is a concern in areas where irrigation and/or development occurs in selenium bearing shale, none of which is a factor in the Three Lakes area.

Due to the complexities and site-specific nature of selenium cycling, it is not possible to predict a direction of change for selenium in Granby Reservoir, Shadow Mountain Reservoir or Grand Lake.

[14] http://wwwrcamnl.wr.usgs.gov/Selenium/Library_articles/pellston_SELSummary.pdf
[15] http://wwwrcamnl.wr.usgs.gov/Selenium/Library_articles/luoma_presser_Nov15_2009_viewpoint_EST_final.pdf

Temperature

Granby Reservoir

As described in WGFP Lake and Reservoir Water Quality Technical Report ((AMEC, 2008)- Appendix C), a temperature model was developed for Granby Reservoir in order to evaluate in-reservoir temperature changes. The LAKE2K model was selected for this purpose and the simulation characterized temperature in each stratified layer (epilimnion, metalimnion and hypolimnion). Because the model does not produce profile data, it is not possible to perform a formal AD assessment using the SCT, which would require the computation of the top 2-meter average temperature (CDPHE, WQCD, 2011).

However, model simulation showed no change in temperature in Granby between existing conditions and the WGFP under cumulative effects.

Based on this assessment, it can be concluded that no significant degradation will occur for temperature in Granby Reservoir with the WGFP under cumulative effects.

Shadow Mountain Reservoir

As described in WGFP Lake and Reservoir Water Quality Technical Report ((AMEC, 2008)- Appendix C), it was assumed that the temperature of water flowing from Shadow Mountain Reservoir to Granby reservoir would not change as a result of the WGFP. This is a conservative assumption in that there is recent evidence that summer water temperatures in Shadow Mountain Reservoir decrease if the flow through the Farr Pumping Plant increases (Hawley, Boyer, & Adams, 2013 Operational and Water Quality Summary Report for the Three Lakes, 2014b). This is due to the introduction of cool water from the hypolimnion of Granby Reservoir to Shadow Mountain Reservoir and the additional flushing that occurs with increased flow through Shadow Mountain Reservoir. An analysis of the anticipated monthly flow changes with the Project as compared to existing conditions, shows increased Farr pumping for both of the critical months from a temperature perspective - July and August (Table 26). No decreases in flow are anticipated during either of these months with the Project.

Table 26 - Difference in Farr Pumping by Month, WGFP versus Existing Conditions

Month	% of Years When Farr Pumping is Greater for the WGFP	Average Increase in Flow (AF/Mo)
July	51%	2,514
August	89%	4,467

Since the Project will result in either no change in Farr pumping or increased Farr pumping during the summer months, Shadow Mountain Reservoir temperatures are anticipated to be the same or cooler with the Project.

Thus, no significant degradation is expected in Shadow Mountain Reservoir from the WGFP under cumulative effects.

Grand Lake

As water from Shadow Mountain Reservoir (Lieberman, 2008) skims the surface of Grand Lake during pumping, it is expected that there would be no increases in surface water temperature for Grand Lake.

Therefore no significant degradation of temperature in Grand Lake is expected from the WGFP under cumulative effects.

7.4 Colorado River Water Temperature

Changes in water resource management, especially on the scale of Projects like the WGFP may result in indirect water quality impacts, including impacts on stream temperatures. New or additional diversions of stream flows have the capacity to increase the daily range of water temperatures, or to change the average temperature. A new reservoir or changes to reservoir operations may increase or decrease water temperatures downstream.

An antidegradation review for temperature needs to rely on modeling to determine the spatial and temporal extent of potential temperature changes. A model makes it possible to evaluate the temperature impacts of structures and a flow regime that do not yet exist.

The antidegradation review for temperature impacts includes consideration of both historical data and model predictions of stream temperatures.

A detailed analysis of the antidegradation review of stream temperature for the Windy Gap Firming Project can be found in APPENDIX F - TEMPERATURE ANTIDEGRADATION TECHNICAL MEMORANDUM. A summary of the approach and the findings is presented below.

7.4.1 Methodology

The approach taken to assess antidegradation of the stream temperature on the upper Colorado River for the WGFP is based on the steps described in a technical memorandum developed by the WQCD (CDPHE, 2014). The approach is quantitative and focused on antidegradation assessment of the numerical chronic (weekly average temperature (WAT)) and acute (daily maximum) standards. The narrative temperature standard is not specifically addressed in this approach.

The general principles of antidegradation review are followed in this approach, applying further guidance that recognizes the challenges specific to the assessment of stream temperature (CDPHE, 2014). The assessment relies on the following information:

- Observed hourly stream temperature data (conditions representative of September 30, 2000 for multiple years through the season(s) of focus at key locations in the assessment reach). These observations do not need to include data from September 30, 2000, but they should exclude any data for which stream geometry, relative heat loading from various sources, and operations (e.g., demands and routing) were significantly different from those in place on September, 30, 2000;
- A conceptual understanding of stream temperature patterns and response drivers in the Project response area to support appropriate selection of spatial and temporal focus for the analysis and for critical review of results;
- A calibrated dynamic temperature model for the reach of focus that generated outputs supporting the computation of DMs and WATs;
- Baseline simulation results from the dynamic temperature model for conditions representative of low-flow, high air-temperature conditions for the system as of September 30, 2000; and
- Simulation results for cumulative effects under the WGFP.

Applying this information, antidegradation can be assessed at each calibration target location where simulated and observed DM and WAT results are available. Calculations follow a four step process:

1. **Determine observed baselines**: First, time-varying temperature baselines for DMs and WATs are developed from observed data for each location.

2. **Compare modeled and observed baselines**: Second, modeled baselines are compared to baselines developed from observed data. The purpose of this comparison is to assess appropriateness of the modeled baseline conditions. To be conservative, modeled baseline stream

temperatures should be comparable to or warmer than the observed baseline at each location. Significantly cooler model baseline temperatures, relative to observed baseline, could indicate that the simulated baseline hydrology and meteorology do not reflect low flow/ high air-temperature conditions targeted for the assessment. There may be reasons for this, but it would require explanation.

3. **Determine the assimilative capacity/ baseline available increment**: Third, each modeled baseline is then compared to the applicable numerical standard for calculation of time-varying assimilative capacity, i.e., the baseline available increment (BAI).

4. **Assess simulated effects**: Fourth, simulated cumulative-effects changes (simulated differences) to DM and WAT values at each location are compared to the respective calculated BAI time-series.

A decision was made to apply modeled baselines to determine assimilative capacity instead of observed baselines based on findings from early attempts to focus on observed baseline. Specifically, it is recognized that assimilative capacity varies from day-to-day as a function of flow rate and meteorological conditions. A single baseline developed from observed data fails to represent baseline conditions for all years, even if both correspond to low-flow, high air temperature seasons. Consequently, early attempts to assess antidegradation with observed baselines compared to modeled effects resulted in cases of both underestimation and overestimation of antidegradation concerns for particular hydrologic years. The existence of a model provides an opportunity to define realistic baseline conditions specific to each simulation year for the given meteorological conditions. As such, it was decided (CDPHE, 2014) to use the modeled baseline conditions, where appropriate, to assess antidegradation for stream temperature. The following subsections describe the basis for defining the spatial and temporal focus of this analysis, the sources of data used, and the calculations performed to assess antidegradation for 401 Certification.

The AD assessment focuses on the upper Colorado River from downstream of Granby Reservoir to just above the confluence with the Williams Fork. This reach corresponds to the segment of the Colorado River for which a dynamic temperature model was developed for the WGFP FEIS (Hawley & Boyer, Review of Cumulative Effects Temperature Results in the Colorado River for Windy Gap Firming Project 401 Certification Process, 2014). This reach will experience changes in flow rates as a result of the WGFP. The downstream limit on the reach for modeling was set based on the cooling effects of inflows from Williams Fork Reservoir that are the primary control on the temperatures downstream, overwhelming any effects associated with the WGFP.

Currently, the reach of the Colorado River from 578 Road Bridge (located ~1 mile downstream of Windy Gap Reservoir) to just above the confluence with the Blue River is on the 303(d) List for temperature (Figure 25). The portion of the modeled reach upstream of the 578 Road Bridge to Granby Reservoir is not on the 303(d) list of impaired waters for temperature. As directed by WQCD, both impaired and non-impaired segments are subject to the antidegradation review for water temperature for 401 Certification. The purpose of inclusion of 303(d)-listed locations in the antidegradation review is to quantify any exacerbation of impairment within a reach (spatially and/or temporally).

Within this area of focus on the Colorado River, the quantitative antidegradation analysis focuses primarily on the temperature observation locations that were calibration targets in the dynamic temperature model.

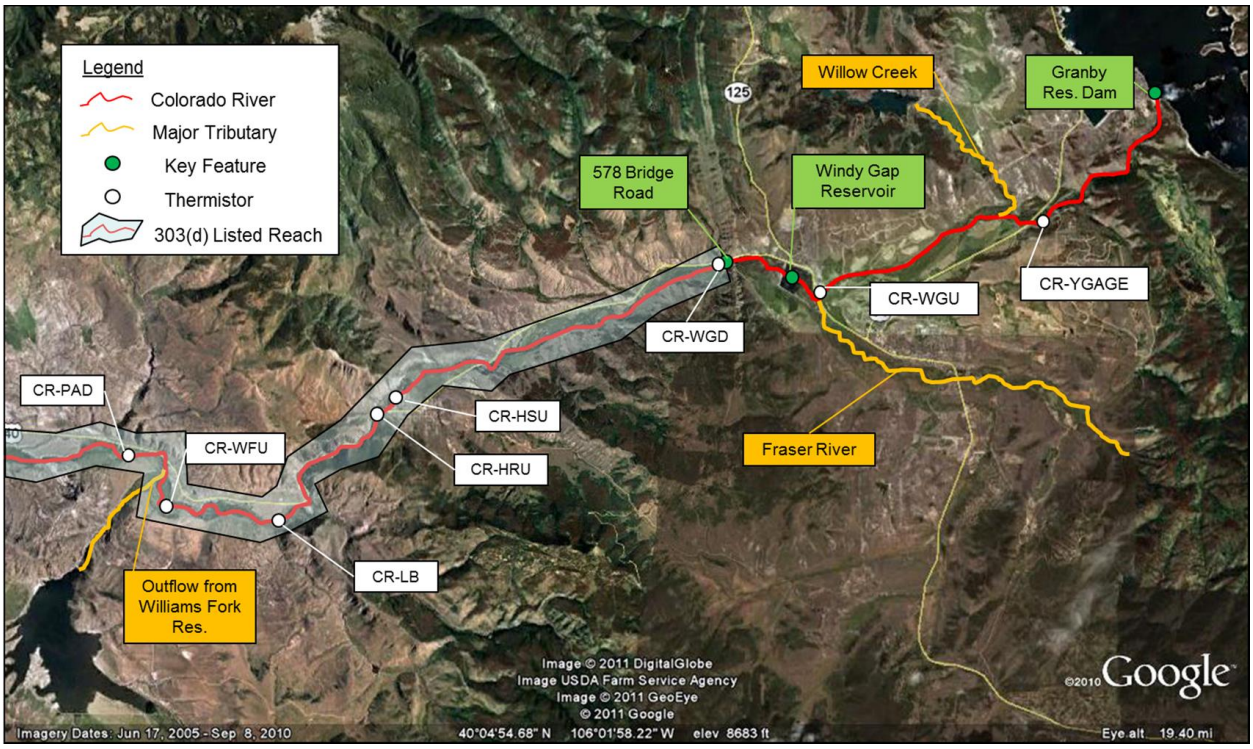


Figure 25 - Upper Colorado River Focus Reach, 303(d) Temperature Listing, Major Tributaries and Target Temperature Gages

7.4.2 Representative Baseline Development

The AD assessment requires simulation results for conditions of stream geometry, relative heat loading from various sources, and operations (e.g., demands and routing) that existed at the time of the target baseline date of September, 30, 2000. This does not mean that specific flows and meteorological conditions from September 30, 2000 need to be simulated. In fact, flow and meteorological conditions should reflect temperature stress conditions of low-flow and high air temperatures to best honor the intent of the antidegradation review principles. This may include multiple simulation years to capture a range of conditions over the season of focus.

The first step in the stream temperature antidegradation analysis for the WGFP was to develop a baseline from observed data at each gage. Because stream temperatures naturally vary temporarily and spatially, a time-varying baseline is needed for each gaging station. Baselines based on observed data are needed to support assessment of the appropriateness of modeled baselines for the antidegradation assessment. For this Project, the baselines based on observed data are not used directly to determine available increment. The approach to development of observed-data baselines followed WQCD guidance. The details of the computation and in depth discussion of the results are presented in APPENDIX F - TEMPERATURE ANTIDEGRADATION TECHNICAL MEMORANDUM.

All resulting June through September observed-data baseline time series for DMs and WATs are presented in Figure 26 and Figure 27 respectively. These figures reflect the conceptual understanding of warming patterns in the upper Colorado River.

A detailed comparison of observed and modeled baseline was performed and showed that they compared well. The one exception occurs at CR-YGAGE, which exhibited consistently lower simulated baseline values than the observed baseline. Differences from June through August are on the order of roughly 2°C, suggesting that modeled baseline conditions at this location may not be representative of

low-flow, high air-temperature conditions in the observed data baseline. This was not considered a major limitation since CR-YGAGE is one of the least sensitive locations in the analysis. Low sensitivity of CR-YGAGE to cumulative effects of the WGFP is attributable to its location upstream of Windy Gap reservoir, low water temperatures reflecting outflows from the bottom of Granby reservoir, and observations consistently well below relevant temperature standards. In spite of the anticipated limited sensitivity at CR-YGAGE, potential underrepresentation of baseline conditions by modeled baselines at CR-YGAGE are addressed in the discussion of the results by consideration of both modeled and observed-data baselines. For all other locations, comparison of observed-data baselines and simulated baselines indicates that the modeled baselines are adequate for direct use in the antidegradation assessment.

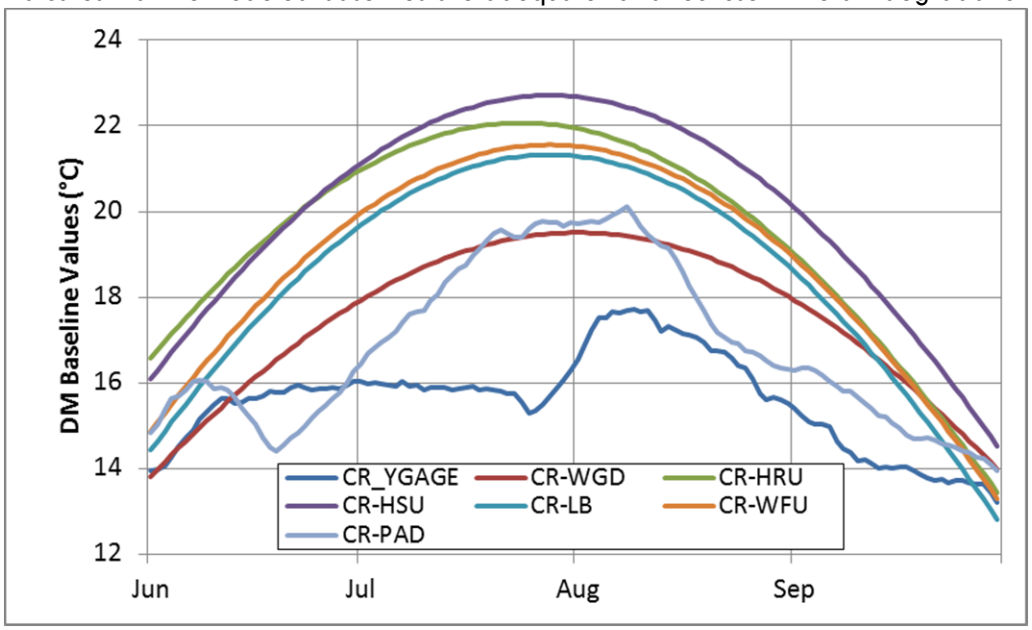


Figure 26 – Observed Data Baseline DM Time Series for Quantitative Analysis of Antidegradation

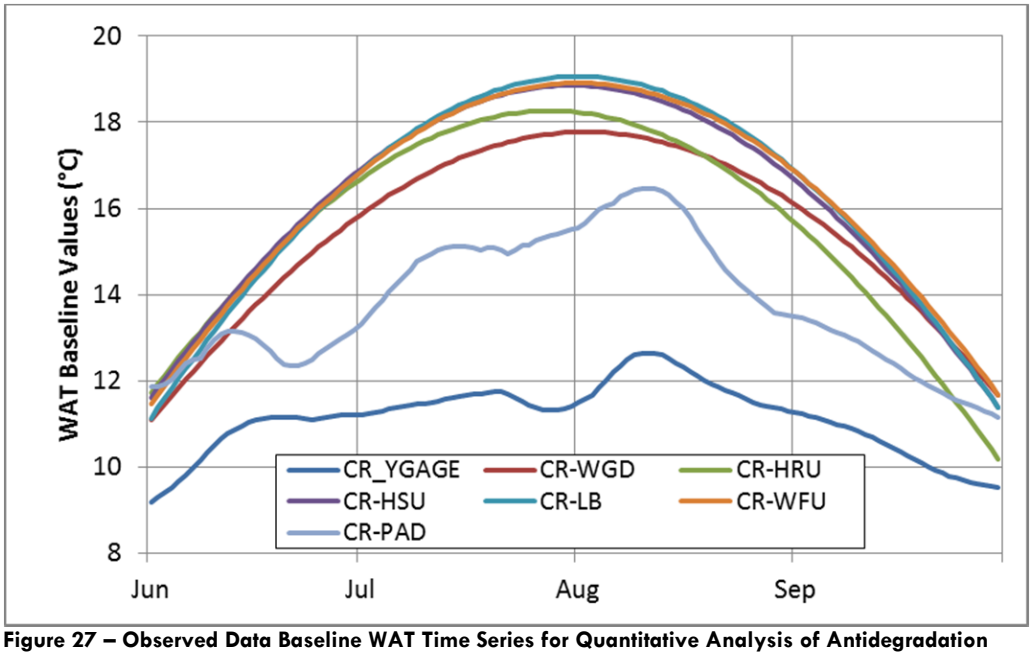


Figure 27 – Observed Data Baseline WAT Time Series for Quantitative Analysis of Antidegradation

7.4.3 Cumulative Effects

The Colorado River Dynamic Temperature Model (Hydros Consulting Inc., 2011) was used to simulate cumulative effects relative to simulated baseline (existing conditions) effects. Cumulative effects are the combined effects of the proposed Project and reasonably foreseeable future actions (RFFAs). The modeling is described in detail in (Hydros Consulting Inc., 2011). This section summarizes key assumptions behind the simulations to determine cumulative effects.

The source of all daily hydrologic inputs for the model application runs was the Windy Gap Firming Project Hydrologic Model (described in (Thompson, 2011). Hydrologic model flow data were used for existing conditions and cumulative effects for June through September for 1975, 1979, 1986, 1987, and 1988. These years were selected among the 15 years of daily hydrologic simulation records (described in Section 7.3.3) to include *all* of the dry-to-average years with increased Windy Gap diversions, as well as one of the wet years (1986). Other wet years with increased Windy Gap diversions were not simulated based on the conceptual understanding that no water temperature issues are anticipated under high flow conditions. This conceptual understanding was further supported by the results of the 1986 simulations.

The existing-conditions simulation results correspond to the antidegradation baseline conditions representative of September 30, 2000, in terms of stream geometry, relative heat loading from various sources, and operations (e.g., demands and routing). The WGFP-modeled hydrology for existing conditions on the upper Colorado River assumed demands based on actual demands for 1998-2003 ((U.S. Bureau of Reclamation, 2011b) and (ERO and Harvey Economics, 2005)).

Cumulative effects simulations include the proposed Project and RFFAs that are anticipated to occur regardless of the implementation of any of the action alternatives or the no action alternative. RFFAs in the cumulative effects simulations which affect the simulated hydrology used in the dynamic temperature model include:

- Denver Water Moffat Collection System Project,
- Increased water use from population growth in Grand and Summit counties,
- Changes in releases from Williams Fork (related to changes to recommended 10825 releases for fish flows in the 15-Mile reach and the expiration of Denver Water's contract with Big Lake Ditch), and
- 5,412 acre-ft (AF) releases from Granby Reservoir, per the release schedule presented in the 10825 Environmental Assessment (USBR, 2011a).

The 5,412 AF releases from Granby Reservoir were assumed to start on August 1. For the 1975 cumulative effects simulation, a second cumulative effects run was completed for an earlier start of 5,412 AF releases (July 15). The actual 5,412 release schedules for average and wet years will be determined by an "Operations Group" composed of representatives from the water users, the U.S. Fish and Wildlife, Reclamation, and the State Division Engineer. The release numbers and schedule applied in the Environmental Assessment were established for modeling and analysis purposes. As such, the schedule of releases could be adjusted for average and wet years if deemed appropriate by the operations group.

For both the existing conditions and cumulative effects simulations, 2007 meteorological conditions were applied to all model runs. This was a hot year, particularly in July and August, selected purposefully to allow a conservatively high estimation of the effect on water temperature of reductions in flow rates. The use of the same meteorological conditions for each run makes flow rate the only variable between the paired existing conditions and cumulative effects runs.

To assess cumulative effects, the following dynamic temperature model runs were conducted:

- 1975 hydrology (2007 meteorology)
    - Existing-Conditions Simulation
    - Proposed Action (Alt2), including Cumulative Effects

    - Proposed Action (Alt2), including Cumulative Effects – with a July 15 start data for 5,412 AF releases from Granby Reservoir
- 1979 hydrology (2007 meteorology)
    - Existing-Conditions Simulation
    - Proposed Action (Alt2), including Cumulative Effects
- 1986 hydrology (2007 meteorology)
    - Existing-Conditions Simulation
    - Proposed Action (Alt2), including Cumulative Effects
- 1987 hydrology (2007 meteorology)
    - Existing-Conditions Simulation
    - Proposed Action (Alt2), including Cumulative Effects
- 1988 hydrology (2007 meteorology)
    - Existing-Conditions Simulation
    - Proposed Action (Alt2), including Cumulative Effects

7.4.4 SCT Analysis Results – Colorado River Temperature

Modeled baseline time series for DMs and WATs (Figure 26 and Figure 27) were used to calculate the baseline available increment (BAI) for each simulated year at each location. This was accomplished by subtracting each value in the baseline time series from the relevant standard to generate a BAI time series. One BAI time series for DMs and one BAI time series for WATs were generated for each simulation year at each location. BAI values were multiplied by 0.15 to obtain the 15% BAI time series for direct comparison with simulated effects in the antidegradation assessment. The full set of resulting 15% BAI time series is presented in APPENDIX F - TEMPERATURE ANTIDEGRADATION TECHNICAL MEMORANDUM (Attachment B, Section II) grouped by location and by simulation year.

As an example, the DM and WAT time series for CR-HSU are presented in Figure 26, Figure 28 and Figure 29. Figure 28 and Figure 29 show that at CR-HSU, 15% of the available increment is very small at times.

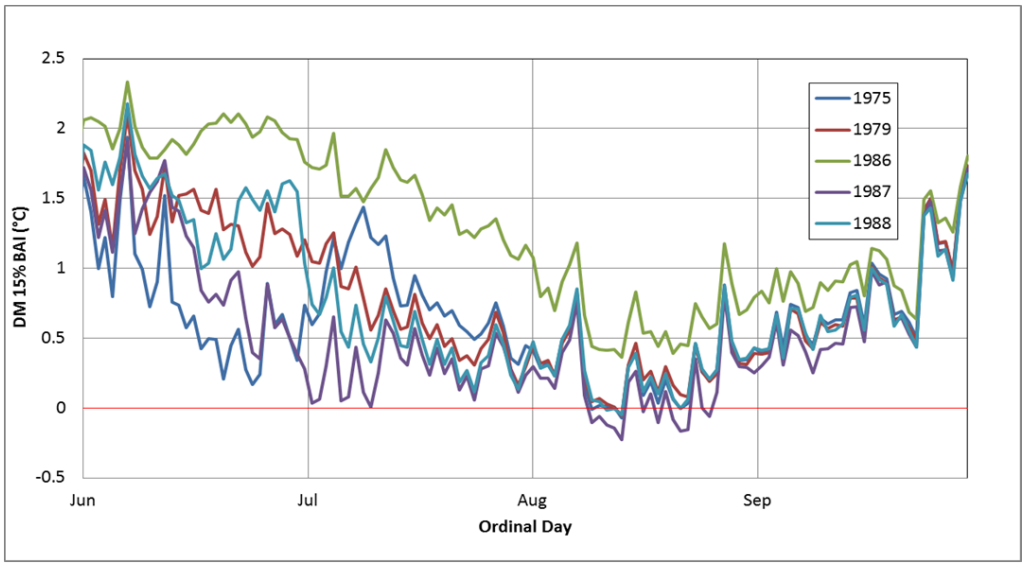


Figure 28 – Simulated CR-HSU DM 15% BAI

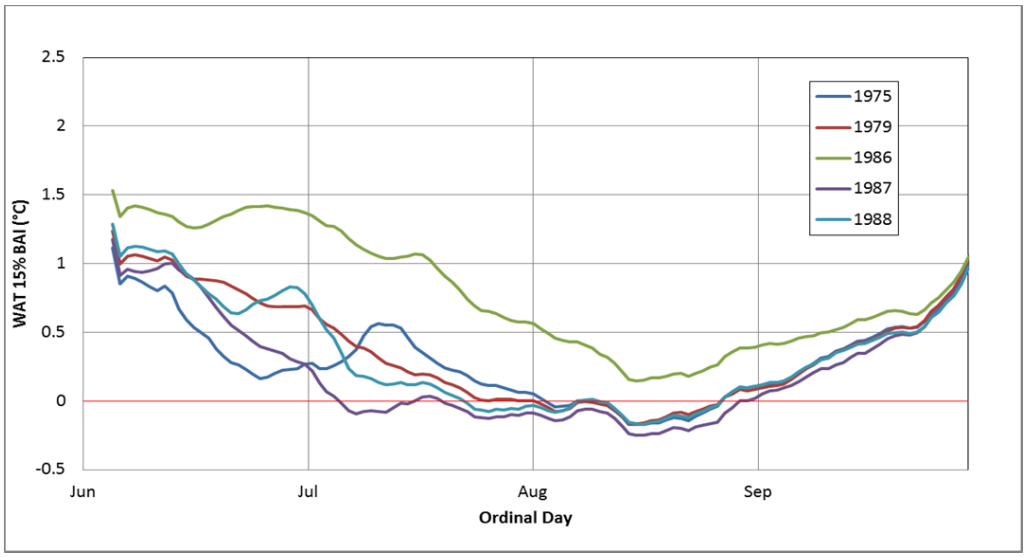


Figure 29 – Simulated CR-HSU WAT 15% BAI

Table 27 and Table 28 summarize the count of days with no available increment at each location for DMs and WATs, respectively. Zero-values are shaded to support visualization of spatial and temporal patterns. Conditions of no available increment were found to occur in the simulation between Hot Sulphur Springs (HSU) and upstream of Williams Fork (WFU). Such conditions were not simulated to occur outside that reach or in the wet year, 1986.

Table 27 - Count of Days with No Simulated Baseline Available Increment for DM (Baseline Condition Excursions)

Simulation year	YGAGE	WGD	HSU	HRU	LB	WFU	PAD
1975	0	0	3	5	0	0	0
1979	0	0	1	2	0	0	0
1986	0	0	0	0	0	0	0
1987	0	0	11	14	5	2	0
1988	0	0	4	4	0	0	0

Table 28 - Count of Days with No Simulated Baseline Available Increment for WAT (Baseline Condition Excursions)

Simulation year	YGAGE	WGD	HSU	HRU	LB	WFU	PAD
1975	0	14	23	24	22	25	0
1979	0	6	25	33	29	34	0
1986	0	0	0	0	0	0	0
1987	0	31	53	53	48	54	0
1988	0	11	33	35	31	36	0

Results of Analysis

- Granby Reservoir to Fraser River – Results of the quantitative assessment at CR-YGAGE and qualitative assessment at CR-WGU do not indicate any river temperature antidegradation concerns in this reach upstream of the Fraser River.
- Fraser River to Williams Fork – Competing effects of warming and cooling need to be assessed.
    - *Warming > 15% BAI* - The analysis indicates that there are days at most locations in most years with simulated cumulative effects water temperature increases in excess of 15% of the BAI in summer months (DMs and WATs). In other words, cumulative effects result in an exacerbation of the adverse temperature conditions across the listed reach at times.
    - *Limited to 4 of 15 Years* - These simulated temperature increases in excess of 15% of the BAI occur in four out of 15 years. This corresponds to the approximate anticipated frequency of additional diversions from Windy Gap in dry and average years for the proposed Windy Gap Firming Project. Other years in the 15-year period exhibited either

no additional diversions for Windy Gap Firming or were wet years like 1986, for which no antidegradation concerns are anticipated.

  - *More Cooling Days than Warming* - The analysis revealed extensive summertime cooling effects across this reach due to the 5,412 Releases from Granby Reservoir included in the cumulative effects simulations. By direct count of days, cooling effects in excess of 15% of BAI outnumber days with warming in excess of 15% of the BAI for both DMs and WATs at all locations.
  - *Reduction in Number of Excursions* - The analysis also revealed a net reduction in the number of summertime exceedances of both DM and WAT standards for the cumulative effects simulation, due to the 5,412 Releases.
  - *Mitigation* – As a reminder, mitigation, in the form of real-time monitoring and operational response are planned for this reach, but mitigation effects are not included in the results assessed here.

- Below Williams Fork
  - *Different Regime* - Temperatures on the Colorado River below Williams Fork are controlled more by releases from Williams Fork than conditions upstream of Williams Fork. This is part of the conceptual understanding upon which the extent of the original modeled reach was based. It is also apparent in the sharp break in the simulated warming and cooling patterns at CR-PAD as compared to upstream gages. Therefore simulated cumulative effects should be evaluated at this location with recognition that the effects are primarily a response to differences in cumulative effects operations at Williams Fork Reservoir, whose operations are unrelated to the Windy Gap Firming Project.
  - *Warming and Cooling at CR-PAD* - Cumulative effects results show that there are summer days of warming in excess of 15% of the BAI for DMs and WATs at this location in all but the simulated wet year, 1986. Also, in total, there were more simulated of days of cooling through the summer months at CR-PAD than warming above 15% of the BAI. This is true on a year-by-year basis for all simulated years except 1988, due to Williams Fork cumulative effects operational changes that year. No temperature excursions are simulated at CR-PAD for any simulations.

In summary, worst-case simulated effects pairing highest historical air temperatures with historical hydrology on water temperatures in the upper Colorado River associated with the WGFP and RFFAs are mixed. Summer days of increased WAT and DM water temperatures in excess of 15% of the BAI are anticipated in four out of 15 years. The extent of the upper Colorado River over which these simulated effects are, at least in part, attributable to the proposed WGFP is from Windy Gap Reservoir to Williams Fork Reservoir. Over this reach, summer days with anticipated cooling, due to 5,412 Releases, exceed anticipated days of warming. Also attributable to 5,412 Releases, the net number of DM and WAT temperature exceedances in this reach is simulated to decrease. Additionally, cooling effects of 5412 releases will occur in all years, not just in years with additional WGFP diversion.

Finally, it should be noted that these results do not consider the effects of proposed mitigation for the Windy Gap Firming Project, which are intended to further minimize temperature impacts via curtailment of pumping at certain times.

Based on these factors it is concluded that **the effects of the Project (without mitigation measures) on water temperature under cumulative effects are mixed.** In some instances water temperature increases in excess of the SCT and in others cooling effects result, with a net effect being a greater number of days with cooling than warming. It should also be noted that this assessment does not reflect avoidance and mitigation measures (section 8.2) which would remove the impacts identified in this section.

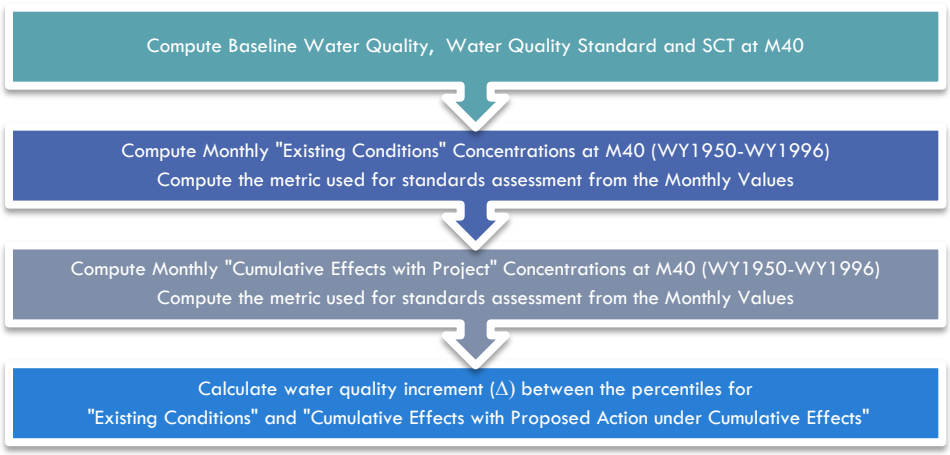
7.5 East Slope Existing Reservoirs and South Platte Tributaries

An SCT analysis was performed for the East Slope reservoir and tributaries, which would be indirectly impacted by operation of the WGFP. The SCT (section 3.4.2 (ii)) was used for all constituents considered with the exception of mercury and selenium. These constituents were analyzed using the Bioaccumulative Toxic Pollutant Test (section 3.4.2 (i)).

Shortly after flows are delivered to the East Slope via the Adams Tunnel, West Slope water enters Lake Estes and is co-mingled with inflows from the Big Thompson River. Lake Estes has a very short residence time and is generally well mixed, therefore it is considered as a "flow through" reservoir where in-reservoir processes are negligible. This mixed water is then delivered to the East Slope reservoirs and tributaries served by C-BT. Although the potential geographic scope of AD review on the East Slope may be large, the outflow from Lake Estes is likely to experience the greatest impact and changes at this location could affect locations downstream. However other confounding factors that occur downstream would make it difficult to perform the AD review. This location was therefore selected as the point where the mass balance should be calculated for this purpose.

7.5.1 Methodology

To perform the SCT test, an analysis was conducted at the Lake Estes outflow site on the Big Thompson River (M40), a location that has been sampled for a number of years. The first step of the process was to determine key constituents and then to determine which of those key constituents had sufficient data to conduct an analysis. Then, for each constituent with sufficient data, the steps shown in Figure 1 were taken. Details for some of the steps are described below, but in a slightly different order than listed.



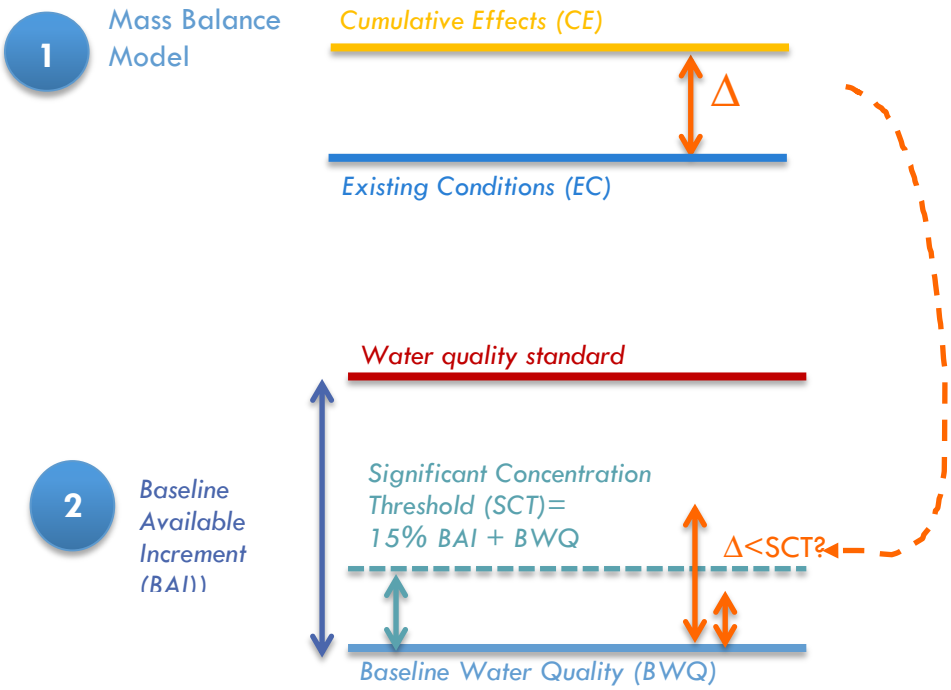


Figure 30 - Schematic Describing the Overall Approach for the East Slope SCT Analysis

Determine Key Constituents

Constituents to consider at M40 were selected following an approach developed by the WQCD (WQCD, 2014) that focused on: the regulatory basis for determining assimilative capacity; whether the constituents were of general concern or used as indicators for a specific aspect of water quality; and/or whether they were present on the 303(d) or M&E list.

The list of key constituents was further limited by data availability and other data limitations (discussed in the following section). In addition, the SCT test is typically assessed only for the chronic standard (Saunders, 2014); thus only chronic standards were considered. Also, constituents exhibiting strong diurnal variation (e.g., pH, temperature and DO) were not included (WQCD, 2014). It should also be noted that the segment where M40 is located is currently listed as impaired for temperature. An AD review of temperature was not performed as no continuous temperature data is available in this reach of the Big Thompson River.

Constituents identified for initial analysis included metals, inorganic parameters, and nutrients and are listed in Table 1. Before describing the methodology for determining whether sufficient data exist, it is useful to describe the overall mass balance approach for which the data will be used. This is discussed in the following section.

Table 29 - List of Constituents Initially Considered for the SCT Analysis at M40

Constituent	Category	Use	Listed Based on Chronic Standard?
Chloride (mg/L)	Inorganic	WS	
Sulfate (mg/L)	Inorganic	WS	
Sulfide (mg/L	Inorganic	AL	M&E
Arsenic (ug/L)	Metal	AL	
Cadmium (ug/L)	Metal	AL	
Chromium (ug/L)	Metal	AL	
Copper (ug/L)	Metal	AL	303(d)
Iron – Diss (ug/L)	Metal	WS	
Iron – Trec (ug/L)	Metal	AL	
Lead (ug/L)	Metal	AL	
Manganese (ug/L)	Metal	WS	
Manganese (ug/L)	Metal	AL	
Nickel (ug/L)	Metal	AL	
Silver (ug/L)	Metal	AL	
Zinc (ug/L)	Metal	AL	
Total Nitrogen (ug/L)	Nutrient	AL (int)	
Total Phosphorus (ug/L)	Nutrient	AL (int)	

NOTES:

All metals in dissolved form, unless otherwise noted
Trec: Total Recoverable
Diss: Dissolved
WS: Domestic Water Supply
AL: Aquatic Life
int: Interim
The segment is on the 303(d) list for cadmium and zinc, based on the acute standard.

Monthly Mass Balance at Lake Estes

As described above, West Slope water enters Lake Estes and is co-mingled with inflows from the Big Thompson River. The lake is generally well mixed. It is assumed that all constituents considered are conservative.

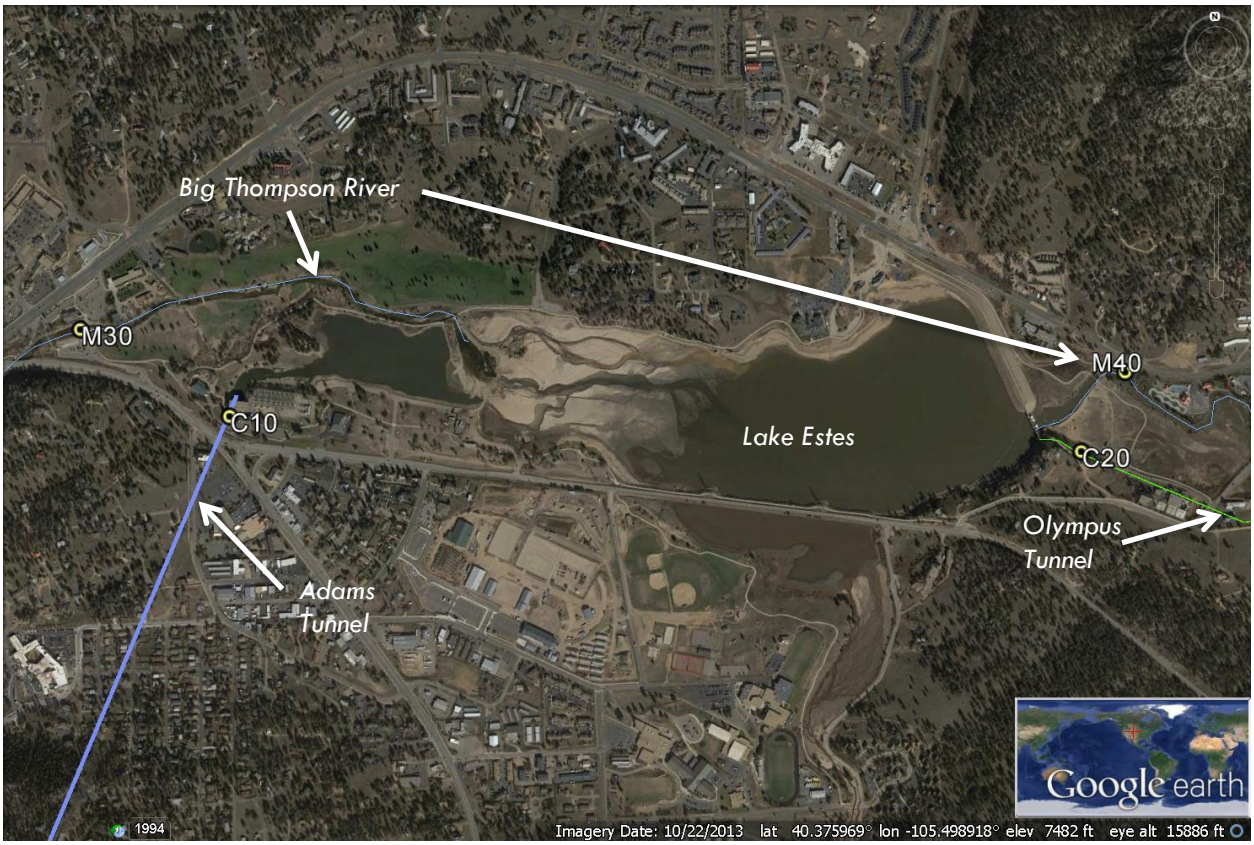


Figure 31 - Sites Used in Mass Balance Analysis for Lake Estes

For the two conditions (existing conditions and WGFP under cumulative effects), monthly flows from the West Slope (site C10) and from the Big Thompson River entering Lake Estes (site M30) were obtained from the WGFP hydrologic model. For all constituents analyzed (except for nutrients), it was assumed that concentrations in the water flowing through the Adams Tunnel with the Project under cumulative effect conditions would not differ from existing conditions and the predicted changes would be due to changes in flow. For nutrients, changes in concentrations predicted by the Three Lakes Water Quality Model were used[16]. For each inflow into Lake Estes, typical monthly concentrations were determined, based on the monthly medians of observed data. The data were reviewed to ensure that general observed intra-annual variations in concentrations were captured (for cases with sufficient data – see next section). These typical monthly concentrations were applied to each year analyzed (WY 1950-WY1996), along with the monthly flows to compute a mixed concentration.

Determine Constituents with Sufficient Data to Conduct the Analysis

Data were obtained from the USGS and from Riverwatch for site M40 and the inflows into Lake Estes. The analyses relied on USGS data with the exception of total recoverable iron, where Riverwatch data were used to supplement USGS data at M40 and at M30. This resulted in sufficient data to conduct an analysis (discussed below). The period considered for inclusion in the analysis was 1998-2013, but the data period was further limited if there was evidence of a data distribution, which differed from what was evident in

[16] The period of analysis for nutrients was WY1975-WY1989, consistent with the Three Lakes Model period.

the year 2000. This was based on visual inspection of time series observation revealing a noticeable change in magnitude and variation. This occurred for the dissolved copper analysis where the period 1998-2004 was used for baseline water quality and the period 2005-2013 was used to determine inflow concentrations into Lake Estes. This also occurred for total nitrogen where the period 2000-2004 was used to establish baseline conditions.
The threshold for determining if sufficient data existed to determine baseline water quality concentrations differed, depending on the standards metric:

- If the metric used for standards assessment of the constituent is a median (e.g. total recoverable metals), there had to be at least four data points (following Saunders 2014). Up to two of those could be below detection limits (BDL) under certain conditions. If there were two censored values, the data could be used if the median value calculated with both BDLs set at their detection limit (DL) was above both DLs. If there was one BDL, the DL had to be below the median calculated setting it to the DL.
- If the metric used for standards assessment of the constituent is an 85th%tile (e.g., dissolved metals and inorganics), there had to be at least eight data points (following Saunders 2014, based on the assertion that at least two data points should be above any percentile calculated from a dataset). The number of acceptable BDLs for an 85th %tile depended on the size of the dataset[17]. A statistical software package was used (NADA for R) to determine if each dataset was sufficient. The methods embedded in the software package are described in Helsel, 2012.

In order to perform the mass balance, sufficient data needed to exist for the flows entering Lake Estes in order to synthesize typical monthly concentrations and annual patterns. Since the metric used for this computation is a median, the rule listed above for when the standards metric was a median, was also used for characterization of the inflow concentrations. If insufficient data exist to establish a monthly time-series, annual medians were used. This occurred for total recoverable copper and dissolved zinc.

The results from investigating if sufficient data exist are summarized in Table 30 by constituent. For constituents with sufficient data, assumed inflow concentrations into Lake Estes (using the median monthly values, in general) can be found in APPENDIX I - ASSUMED CONCENTRATIONS FOR INFLOWS INTO LAKE ESTES.

[17] More BDLs are acceptable with larger datasets, depending on the magnitude of the DLs compared to the 85%tile of the observed data.

Table 30 - Determination of Data Sufficiency for Analysis at M40

Constituent	Category	Use	Sufficient Data?	Comment
Chloride (mg/L)	Inorganic	WS	Yes	
Sulfate (mg/L)	Inorganic	WS	Yes	
Sulfide (mg/L	Inorganic	AL	No	No data available
Arsenic (ug/L)	Metal	AL	Yes	
Cadmium (ug/L)	Metal	AL	No	> 50% BDL at all sites
Chromium (ug/L)	Metal	AL	No	Data only available at C10
Copper (ug/L)	Metal	AL	Yes	
Iron – Diss (ug/L)	Metal	WS	Yes	
Iron – Trec (ug/L)	Metal	AL	Yes	Used ann. median for C10/M30
Lead (ug/L)	Metal	AL	Yes	
Manganese (ug/L)	Metal	WS	Yes	
Manganese (ug/L)	Metal	AL	Yes	
Nickel (ug/L)	Metal	AL	Yes	
Silver (ug/L)	Metal	AL	No	>> 50% BDL at all sites
Zinc (ug/L)	Metal	AL	Yes	Used ann. median for C10/M30
Total Nitrogen (ug/L)	Nutrient	AL (int)	Yes	
Total Phosphorus (ug/L)	Nutrient	AL (int)	Yes	

NOTES:
All metals in dissolved form, unless otherwise noted
Trec: Total Recoverable
Diss: Dissolved
WS: Domestic Water Supply
AL: Aquatic Life
int: Interim

7.5.2 Representative Baseline Development

For each constituent evaluated, baseline Water Quality concentrations and standards were computed for M40. Average hardness, using all available data, was used for the determination of the hardness-based standards. The results are listed in Table 3.

Table 31 - BWQ, WQS, and SCT at M40

Constituent	Water Quality Standard (WQS)	Baseline Water Quality (BWQ)	Significant Concentration Threshold (SCT)
Chloride (mg/L)	250	1.7	39.0
Sulfate (mg/L)	250	3.9	40.8
Arsenic (ug/L)	150	0.21	22.7
Copper (ug/L)	1.9	1.0	1.14
Iron – Diss (ug/L)	300	94.4	125
Iron – Trec (ug/L)	1,000	185	308
Lead (ug/L)	0.387	0.09	0.135
Manganese (ug/L) (WS)	50	7.6	14.0
Manganese (ug/L) (AL)	941	7.6	148
Nickel (ug/L)	12.53	0.49	2.30
Zinc (ug/L)	26.2	1.69	5.37

Constituent	Water Quality Standard (WQS)	Baseline Water Quality (BWQ)	Significant Concentration Threshold (SCT)
Total Nitrogen (ug/L)	1,250	280	426
Total Phosphorus (ug/L)	110	16.0	30

7.5.3 SCT Analysis Results

The difference between existing conditions and the Project was computed and added to the baseline water quality for each constituent. Since concentrations of all of the constituents in water from the Adams Tunnel are lower than those in the Big Thompson River (for most months), the additional flow from the Project serves to dilute the water in Lake Estes and the releases to the Big Thompson River.

Table 32 - Lake Estes SCT Analysis Results (SCT)

Constituent	Significant Concentration Threshold	Projected Concentration With WGFP*	Significant Impact?
Chloride (mg/L)	39.0	1.7	No
Sulfate (mg/L)	40.8	3.9	No
Arsenic (ug/L)	22.7	0.211	No
Copper (ug/L)	1.14	1.002	No
Iron – Diss (ug/L)	125	92.9	No
Iron – Trec (ug/L)	308	184.6	No
Lead (ug/L)	0.135	0.09	No
Manganese (ug/L) (WS)	14.0	7.6	No
Nickel (ug/L)	2.30	0.49	No
Zinc (ug/L)	5.37	1.64	No
Total Nitrogen (ug/L)	426	283	No
Total Phosphorus (ug/L)	30	16.1	No

* Difference between existing conditions and the WGFP under cumulative effects, added to the baseline water quality.

Because the results of this analysis do not show any significant degradation below Lake Estes, and because if there were impacts, they would be greater at this location than at any point further downstream, **it is concluded that there is no significant degradation for any of the constituents assessed in Carter Lake, Horsetooth Reservoir or any of the South Platte tributaries.**

7.5.4 Bioaccumulative Toxic Pollutant Test

The Bioaccumulative Toxic Pollutant Test is based on loads, not concentrations. In order to not have a significant impact, the additional load must be less than 10% of the existing load. The outflow from Adams Tunnel is likely to experience the greatest impact and changes at this location could affect locations downstream. Thus changes in load at the East Portal of the Adams Tunnel were considered for selenium and mercury. Concentrations are assumed to be constant therefore the analysis focused on changes in flow at the Adams Tunnel.

Flow changes were computed for both existing conditions and for the WGFP (cumulative effects) at Adams Tunnel. The results are displayed in
Table 33.

Table 33 - Change in Flow at Adams Tunnel Due to the WGFP under Cumulative Effects

	Existing Conditions	WGFP under Cumulate Effects	Flow Change (Cumulative Effects with WGFP vs. Existing Conditions)
Total Adams Tunnel Flow over 47-Year Period (acre-feet)	11,429,403	12,200,379	6.7%

In this instance, the loading analysis shows that over the 47-year period, the Project would not cause a change in loading greater than 10% and therefore would not cause significant degradation for bioaccumulative pollutants below Adams Tunnel.

It is recognized that in some years, the load increase may be greater than 10%. Because of this, further discussion is presented in section 7.5.5 for Horsetooth Reservoir and Carter Lake about mercury and selenium.

7.5.5 Horsetooth Reservoir and Carter Lake

Mercury

Horsetooth Reservoir and Carter Lake are both currently listed as impaired for aquatic life use as a result of the presence of mercury in fish tissue.

A detailed explanation of the mercury cycle was presented in section 7.3.4 along with a simplified representation of the mercury cycle (Figure 19) and it is not repeated in this section.

No modeling of mercury methylation for Horsetooth Reservoir and Carter Lake was performed as part of the FEIS; therefore it was not possible to quantify expected changes in mercury and methyl mercury concentrations in the reservoir. A qualitative assessment is presented instead.

The BATHTUB models developed for Horsetooth Reservoir and Carter Lake provide some information about oxygen demand that gives an indication of how hypolimnetic dissolved oxygen may change under the WGFP although bottom concentrations near the water-sediment interface are not differentiated. The results can provide useful information for a qualitative analysis. Predicted relative changes in oxygen demand over the period WY1975-WY1989 are shown in Table 34.

Table 34 - Hypolimnetic Oxygen Demand in Horsetooth Reservoir and Carter Lake

Hypolimnetic Oxygen Demand (mg/m^3 day)*	Carter Lake	Horsetooth Reservoir
Existing Conditions	22.2	46.0
WGFP (Cumulative Effects)	24.0	53.1
Change (EC-CE)	1.8	7.1

**Average of 15-year simulations*

These results indicate that hypolimnetic oxygen demand may slightly increase and cause lower dissolved oxygen levels at the bottom of these reservoirs, which may increase mercury mobilization from sediments. However, it should be noted that these simulations do not reflect nutrient mitigation commitments associated with WGFP (discussed in section 8.5), which could at least partially offset the changes predicted with the model.

Furthermore, when reservoir levels are low, DO depletions at the bottom are exacerbated due to the lower volume of water available to absorb these depletions. Thus, the reservoirs are more vulnerable to DO depletions under these hydrologic conditions. This could lead to increases in mercury bioaccumulation in the foodweb. This effect can be counteracted to some degree when bottom releases are made from the reservoir.

A review of simulated reservoir levels for Horsetooth Reservoir and Carter Lake (APPENDIX L - LAKE AND RESERVOIR LEVELS AND HYPOLIMNETIC DISSOLVED OXYGEN LEVELS) under the WGFP as compared to Existing Conditions shows that Horsetooth Reservoir may see slightly greater variations in water levels in some years (accentuating the “refill” effect), although water levels are unchanged for most years. For Carter Lake, water levels are mostly unchanged with the exception of three years out of the 47 years of simulation.

In summary:

- Increased water levels fluctuations and lower bottom DO can increase the methylation of mercury;
- Hypolimnetic DO levels are not expected to change (except very occasionally in Grand Lake);
- Carter Lake water levels are not expected to change significantly under WGFP operation;
- Horsetooth Reservoir water levels may see slightly greater fluctuations under WGFP operation;
- Reservoir operation (such as the amount and timing of deliveries/bottom releases) can influence bioaccumulation of mercury;
- Fishery management has been shown to be an effective tool in the reduction of mercury in the foodweb in Horsetooth Reservoir (Johnson, Lepak, & Wolff, 2014) but it is uncertain how CPW may manage the fishery in the Horsetooth Reservoir and Carter Lake in the future and costs of fishery management for mercury may reduce the likelihood that it would be done;

Based on these confounding factors, **it is not possible to reasonably ascertain a definite direction of change for mercury in Horsetooth Reservoir or Carter Lake.**

Selenium

A detailed explanation of the selenium cycle was presented in section 7.3.4 along with a simplified representation of the selenium cycle (Figure 24) and it is not repeated in this section.

Selenium is not an existing water quality concern in the Carter Lake and Horsetooth because no selenium bearing formations are present upstream of these water bodies and they do not overlay Pierre Shale that is present however further east in the South Platte basin. As explained previously, selenium is only a concern in areas where irrigation occurs in selenium bearing shale, which is not a factor for Carter Lake and Horsetooth Reservoir.

Due to the complexities and site-specific nature of selenium cycling, it is not possible to predict a direction of change for selenium in Horsetooth Reservoir and Carter Lake.

7.6 Chimney Hollow Reservoir

Considering that Chimney Hollow Reservoir would be a new reservoir, it is not possible to perform a formal antidegradation review as no baseline data exist to allow such calculations. However, because the scope of the 401 Certification addresses all water quality impacts from the Project resulting from construction and operation phases (section 3.2), a discussion of water quality impacts and water quality standards associated with Chimney Hollow Reservoir is included.

Water quality in the short reach of Chimney Hollow below the new reservoir and in Dry Creek would be similar to the water quality characteristics of the reservoirs as described later in this section. All water quality parameters are predicted to meet standards below the reservoir.

Because no water quality data are available for Chimney Hollow Reservoir, a comparable reservoir was selected to estimate water quality for Chimney Hollow. Due to its proximity with Carter Lake and because Chimney Hollow will share the same source water (water piped from the Bald Mountain Surge Tank downstream of Pinewood Reservoir) with Carter Lake, Carter Lake provides a reasonable surrogate.

Table 35 compares morphometric and hydrologic characteristics of Carter Lake and Chimney Hollow Reservoir. Although Carter Lake is slightly bigger, the two reservoirs display similar physical characteristics. Similar to Carter Lake, Chimney Hollow is expected to thermally stratify. With a similar temperature regime and water quality characteristics as those of Carter Lake, it would be expected that a similar fishery would develop as well.

Table 35 - Comparison of Morphometric and Hydrologic Characteristics

Characteristics	Carter Lake[18]	Chimney Hollow[19]
County	Larimer	Larimer
Source Water	West Slope + Big Thompson (Mixed at Lake Estes)	West Slope + Big Thompson (Mixed at Lake Estes)
Total Capacity (af)	112,230	92,000 (est)
Active Capacity (af)	108,924	90,000
Max Depth (ft)	180	320
Average Depth (ft)	101	121
Surface Area (acres)	1110	742
Mean Storage (af)	77,271	88,289
Average Mean Depth (ft)	76	121
Average Max Depth (ft)	146	
Maximum Re-Wetted Acres/Mean Storage (acres/AF)	0.004	0.0002
% of Months with No Outflow	0%	85%
Of Months with Outflow, Median Residence Time (years)	1.6	13
% of Years with No Outflow in Either Jul or Aug	0%	96%

Carter Lake is considered to have the highest Water Quality of the seven major reservoirs in the C-BT system (Billica, 2013). Although it is considered a high quality drinking water source, it is listed as impaired for total recoverable arsenic and mercury in fish tissue.

[18] Information for Chimney Hollow based on Model Results 10/49-9/96 (Proposed Action, Cumulative Effects)

[19] Information for Carter Lake based on 1988-2013

It is likely that Chimney Hollow would exhibit similar issues. Mercury in fish tissue may become an issue, particularly during the years following initial filling of the reservoir, as it is known that bioavailable mercury may surge during the first years of a new reservoir ((Ullrich, Tanton, & Abdrashitova, 2001) and (TetraTech, 2001)) . However, water level fluctuations in Chimney Hollow will be less than those observed annually at Carter Lake (as indicated by the Average Re-Wetted Acres/Mean Storage) and may decrease the bioaccumulation processes that lead to mercury contamination in fish.

Total arsenic could be an issue as it is in most reservoirs in Colorado.

Chimney Hollow is a very deep reservoir and is expected to thermally stratify. Residence time in the reservoir will be significantly greater than in Carter Lake, especially during summer months, which makes the reservoir more vulnerable to algae blooms.

Chimney Hollow is significantly deeper than Carter Lake at its deepest point (320 ft vs. 180 ft), which could make it more vulnerable to low dissolved oxygen levels. Deeper reservoirs tend to remain stratified longer as the larger volume of water takes longer (i.e. more energy) to fully mix. As a result, there is a longer period of time during which bottom waters remain disconnected from the surface, which allows the dissolved oxygen depletion at the bottom to be greater until waters are finally mixed during fall turnover. However, since inflows and outflows both come in at the bottom and near the dam (the deepest point), it is expected that dissolved oxygen levels would be similar to those in Carter Lake.

Without mitigation, nutrient concentrations would be expected to increase to some degree in the source water of both reservoirs, however, these increases should be offset by proposed mitigation (section 8.6). Using the BATHTUB model, water quality for Chimney Hollow Reservoir was simulated as part of the FEIS (AMEC, 2008) for nutrients, Secchi and trophic state. The predicted water quality for Chimney Hollow Reservoir for the WGFP is summarized in Table 36. The reservoir is predicted to be oligotrophic with low nutrient and chlorophyll a concentrations. While the predicted water quality outputs are annual averages, which are not directly comparable to the water quality standards, results indicate that there would be no expected compliance issues with nutrient criteria.

Table 36 - Average Predicted Conditions for Chimney Hollow Reservoir (Cumulative Effects)

Parameter	Average Annual Values over the 15-Year Model Period	Water Quality Standard
Total Phosphorus (ug/l)	8.5	25 (Jul-Sep average)
Total Nitrogen (ug/l)	185	426 (Jul-Sep average)
Chlorophyll a (ug/l)	0.7	8 (Jul-Sep average)
Secchi-Disk Depth (m)	3.7	No standard
Trophic State (Index)	Oligotrophic (25)	No standard

7.6.1 Temperature

As described in the WGFP Lake and Reservoir Water Quality Technical Report (AMEC, 2008) and because no change in temperature is predicted in any of the Three Lakes, no change in water temperature is expected in East Slope reservoirs (Carter Lake and Horsetooth Reservoir) or in the Big Thompson River.

Therefore, no significant degradation of temperature is expected from the WGFP under cumulative effects for Carter Lake, Horsetooth Reservoir, the Big Thompson River or any of the South Platte tributaries.

7.7 Colorado River Water Quality

Antidegradation review concerns for the Colorado River are related to the indirect impacts resulting from diversion of flow at Windy Gap Reservoir. These effects are localized to the area immediately downstream of the diversion because confounding factors further downstream, particularly inflows from the Blue River would render the effects de minimis.

Although some water quality modeling was performed as part of the FEIS (Table 10), modeling for the Colorado River did not include a level of detail sufficient for computing the SCT. Water quality was modeled for TP, TN, dissolved selenium and dissolved oxygen, however the simulation was done using QUAL2K (steady state) for one day representative of mid-summer conditions (July 25th). Results involve one longitudinal output file (from immediately downstream of Granby Reservoir to Kremmling) for each water quality output for July 25th. Such output does not support a quantitative antidegradation review. A mass balance approach was therefore developed.

A comparison of modeled flows for Existing Conditions and Cumulative Effects developed for the FEIS for Alternative 2 (Proposed Action), in the Colorado River below Granby Reservoir and in the Fraser upstream of Windy Gap Reservoir, was performed in order to inform the AD review.

7.7.1 Methodology

The approach taken for antidegradation analysis on the Colorado River is similar to the one on the East Slope. Since water is diverted at Windy Gap Reservoir, the analysis focused on the location downstream of the reservoir on the Colorado River (site CR-WGD). This site is likely to experience the greatest impacts from the Project and changes at this location could affect locations downstream. A mass balance was conducted around Windy Gap Reservoir, taking into account Colorado River flows above the confluence with the Fraser River, Fraser River flows, and diversions at Windy Gap. The results were used to determine the predicted change in concentration in the Colorado River (delta), applied to the baseline water quality, and then compared with the SCT.

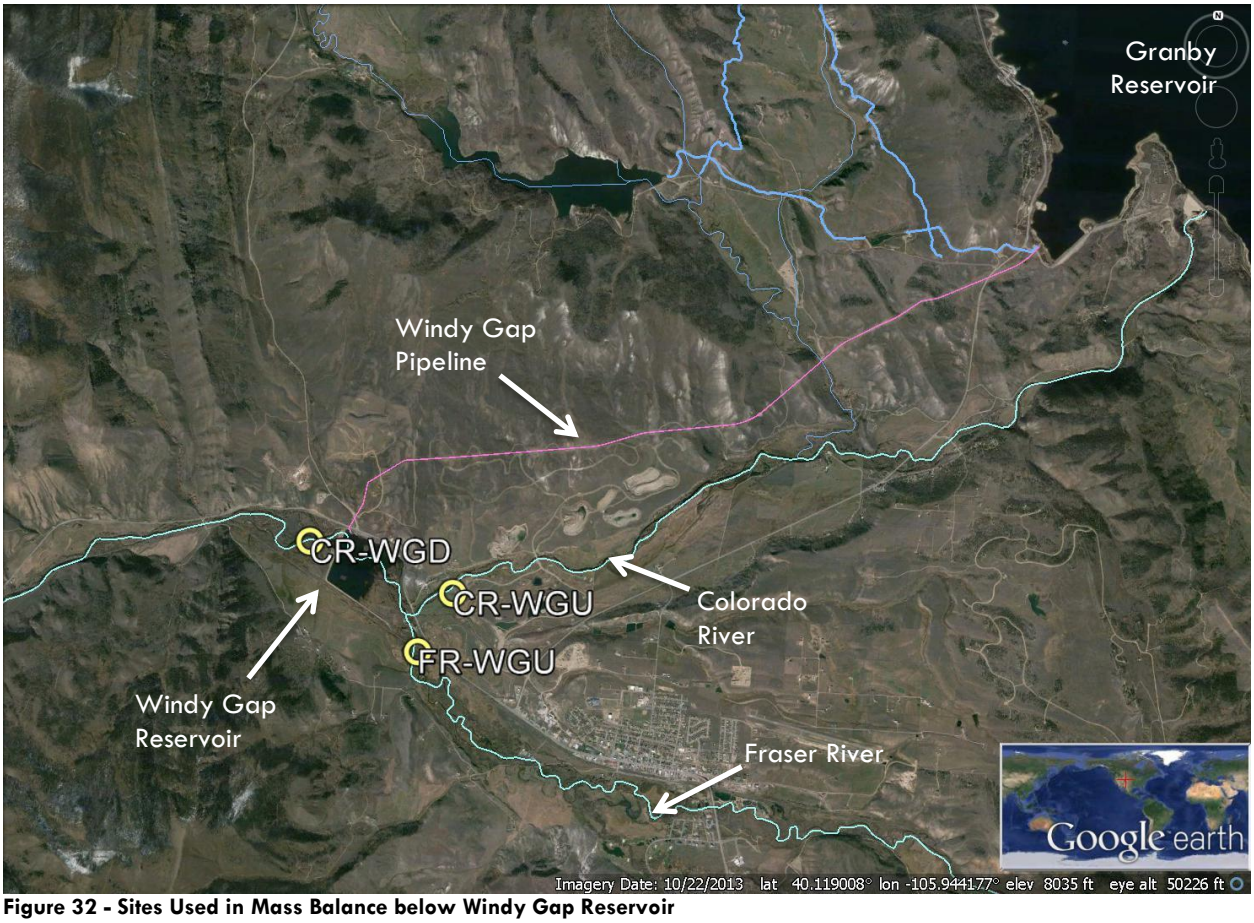


Figure 32 - Sites Used in Mass Balance below Windy Gap Reservoir

7.7.2 SCT Analysis Results

The same list of constituents was initially considered for analysis as for the East Slope Table 37. Note that the reach is also on the 303(d) list for temperature. An analysis for temperature is presented elsewhere.

The results of the analysis to determine if sufficient data exist are shown in Table 38. Four of the constituents (cadmium, chromium, sulfide, and silver) could not be assessed. The standards, baseline water quality, and the SCT are reported in Table 39. Results from the assessment of significant impact are shown in Table 40.

All of the constituents assessed are predicted not to have a significant impact, with the exception of dissolved manganese. The segment does not have any assimilative capacity and the Project is predicted to result in slightly increased concentrations of dissolved manganese.

Table 37 - List of Constituents Initially Considered for Analysis at CR-WGD

Constituent	Category	Use	Listed Based on Chronic Standard?
Chloride (mg/L)	Inorganic	WS	
Sulfate (mg/L)	Inorganic	WS	
Sulfide (mg/L	Inorganic	AL	
Arsenic (ug/L)	Metal	AL	
Cadmium (ug/L)	Metal	AL	
Chromium (ug/L)	Metal	AL	
Copper (ug/L)	Metal	AL	
Iron – Diss (ug/L)	Metal	WS	
Iron – Trec (ug/L)	Metal	AL	
Lead (ug/L)	Metal	AL	
Manganese (ug/L)	Metal	WS	303(d)
Manganese (ug/L)	Metal	AL	
Nickel (ug/L)	Metal	AL	
Silver (ug/L)	Metal	AL	
Zinc (ug/L)	Metal	AL	
Total Nitrogen (ug/L)	Nutrient	AL (int)	
Total Phosphorus (ug/L)	Nutrient	AL (int)	

NOTES:

All metals in dissolved form, unless otherwise noted
Trec: Total Recoverable
Diss: Dissolved
WS: Domestic Water Supply
AL: Aquatic Life
int: Interim

Table 38 - Determination of Data Sufficiency for Analysis at CR-WGD

Constituent	Category	Use	Sufficient Data?	Comment
Chloride (mg/L)	Inorganic	WS	Yes	Trends noted in data but concentrations significantly below reasonable SCT; thus no degradation expected
Sulfate (mg/L)	Inorganic	WS	Yes	Used 1998-2002 for BWQ due to noticeable trend
Sulfide (mg/L	Inorganic	AL	No	No data available
Arsenic (ug/L)	Metal	AL	Yes	Used ann. median for CR-WGU and FR-WGU
Cadmium (ug/L)	Metal	AL	No	>> 50% BDL at all sites
Chromium (ug/L)	Metal	AL	No	Unavailable or > 50% BDL at CR-WGU and FR-WGU
Copper (ug/L)	Metal	AL	Yes	Used 1998-2005 for Baseline due to notable subsequent change
Iron – Diss (ug/L)	Metal	WS	Yes	Used 2007-2013 for CR-WGU and FR-WGU inflow concentrations due to shift in data
Iron – Trec (ug/L)	Metal	AL	Yes	
Lead (ug/L)	Metal	AL	Yes	Used ann. median for CR-WGU and FR-WGU
Manganese (ug/L)	Metal	WS	Yes	Used 2007-2013 for CR-WGU and FR-WGU inflow concentrations due to shift in data
Manganese (ug/L)	Metal	AL	Yes	Used 2007-2013 for CR-WGU and FR-WGU inflow concentrations due to shift in data
Nickel (ug/L)	Metal	AL	Yes	Used ann. median for CR-WGU and FR-WGU
Silver (ug/L)	Metal	AL	No	>> 50% BDL at all sites
Zinc (ug/L)	Metal	AL	Yes	Used ann. median for CR-WGU and FR-WGU
Total Nitrogen (ug/L)	Nutrient	AL (int)	Yes	
Total Phosphorus (ug/L)	Nutrient	AL (int)	Yes	

NOTES:

All metals in dissolved form, unless otherwise noted
Trec: Total Recoverable
Diss: Dissolved
WS: Domestic Water Supply

Table 39 - BWQ, WQS, and SCT at CR-WGD

Constituent	Water Quality Standard (WQS)	Baseline Water Quality (BWQ)	Significant Concentration Threshold (SCT)
Chloride (mg/L)	250	4.5	41.4
Sulfate (mg/L)	250	5.4	42.1
Arsenic (ug/L)	150	0.23	22.7
Copper (ug/L)	4.37	1.0	1.51
Iron – Diss (ug/L)	300	251	258
Iron – Trec (ug/L)	1,000	400	490
Lead (ug/L)	1.19	0.11	0.27
Manganese (ug/L) (WS)	64	64	0*
Manganese (ug/L) (AL)	1,317	64	252
Nickel (ug/L)	29.34	1.0	5.25
Zinc (ug/L)	65.5	5.5	14.5
Total Nitrogen (ug/L)	1,250	357	491
Total Phosphorus (ug/L)	110	51.5	60.3

* No assimilative capacity

Table 40 - Windy Gap Diversion SCT Analysis Results

Constituent	Significant Concentration Threshold (SCT)	Concentration With WGFP*	Significant Impact?
Chloride (mg/L)	41.4	4.4	No
Sulfate (mg/L)	42.1	5.4	No
Arsenic (ug/L)	22.7	0.232	No
Copper (ug/L)	1.51	1.0	No
Iron – Diss (ug/L)	258	248	No
Iron – Trec (ug/L)	490	399	No
Lead (ug/L)	0.27	0.11	No
Manganese (ug/L) (WS)	N/A	64.5	Yes**
Manganese (ug/L) (WS)	252	64.5	No
Nickel (ug/L)	5.25	1.0	No
Zinc (ug/L)	14.5	5.5	No
Total Nitrogen (ug/L)	491	360	No
Total Phosphorus (ug/L)	60.3	51.2	No

** Difference between existing conditions and the Project, added to the baseline water quality*
***Already above the standard. No assimilative capacity. Project results in increased concentrations.*

7.7.3 Bioaccumulative Toxic Pollutant Test

Selenium and mercury were assessed in the same manner as on the East Slope. Because water is transferred from the Colorado River to the East slope via the Adams Tunnel, and concentrations are assumed constant, there is a simple transfer of load (flow) from one point to another. The analysis of flow changes at the Adams Tunnel for the East Slope can also be used to assess the load change in the Colorado River due to the water transfer.

Flow changes were computed for both existing conditions and for the WGFP (cumulative effects) at Adams Tunnel. The results are displayed in Table 41.

Table 41 - Change in Flow at Adams Tunnel Due to the WGFP under Cumulative Effects

	Existing Conditions	WGFP under Cumulate Effects	Flow Change (Cumulative Effects with WGFP vs. Existing Conditions)
Total Adams Tunnel Flow over 47-Year Period (acre-feet)	11,429,403	12,200,379	6.7%

Because the increase in flow through the Adams Tunnel corresponds to an increase in diversions from the Colorado River, the load (i.e. flow) is actually removed from the Colorado River. Therefore, over the 47-year period modeled, there is a 6.7% decrease in selenium and mercury loads in the Colorado River at Windy Gap Reservoir.

In this instance, the analysis shows that over the 47-year period, the Project would not cause a change in loading greater than 10% and therefore would not cause significant degradation for bioaccumulative pollutants in the Colorado River below Windy Gap Reservoir.

7.8 SCT Analysis Summary

Table 42 summarizes the findings from the SCT analysis presented in section 7 and indicates where measures are proposed to avoid, minimize or mitigate the impacts associated with WGFP and where enhancements associated with the WGFP would provide a net environmental benefit (discussed in section 8).

Measures are broken down by type: avoidance, minimization, compensatory mitigation, enhancements and other types of measures. Avoidance, minimization and compensatory measures together are generally referred to as mitigation measures in the FEIS. Avoidance measures are measures that seek to avoid impact before the impact occurs. For water supply projects, they typically include changes in project operation that remove the impact that would otherwise be associated with the project, before it even takes place. Similarly, minimization measures are changes in project or operation that seek to reduce or minimize the magnitude of the impact without completely eliminating it. Mitigation measures as characterized here are strategies that seek to offset or compensate for impacts associated with the project. Unlike avoidance measures, they do not prevent the impact from occurring but they offset it through some compensatory mechanism. Enhancement measures are not mitigation measures. They are additional measures that have been committed to by the Subdistrict and that address existing issues and by design provide a net benefit unrelated to impacts caused by the project.

Other measures (also discussed in section 8), independent of WGFP are also presented as they may be relevant to some the water quality issues of concern. It should be noted that minimization, avoidance, mitigation (defined as compensatory measures), enhancements and other measures were not included in the SCT analysis and that the findings of indirect impacts resulting from this analysis do not reflect any of these measures. A final reconciliation of the results presented here with minimization, avoidance, mitigation, enhancements and other measures described in section 8 is presented later in section 8.10 and shows the net impacts associated with WGFP.

Table 42 – SCT Analysis Summary

Water Body	Constituent	Is there impact based on the SCT?	Are avoidance measures proposed associated with WGFP?	Are minimization measures proposed associated with WGPF?	Are compensatory measures proposed associated with WGFP?	Are enhancements proposed associated with WGPF?	Are other measures, independent from WGFP, proposed?	Comments
Three Lakes (Granby Reservoir, Shadow Mountain Reservoir, Grand Lake)	TN, TP, Chl a	NO	YES (section 8.6)	NO	NO	YES (section 8.6)		Nutrient loading associated with WGPF will be offset in its entirety as the project is intended to be nutrient neutral. Furthermore, some TP reductions measures such as WWTP upgrades and Non-Point Source nutrient reductions will also provide benefits/enhancements in the Fraser River, Willow Creek and the Colorado River compared to Existing Conditions. It is also anticipated that TP reduction commitments will exceed the anticipated loading from WGFP and will provide a net benefit to the Three Lakes compared to Existing Conditions.
	Ammonia	NO (qualitative assessment)	YES (section 8.6)	NO	NO			Mitigation for TN will be protective of Ammonia.
	Temperature	NO (qualitative assessment)	NO	NO	NO	NO		

Water Body	Constituent	Is there impact based on the SCT?	Are avoidance measures proposed associated with WGFP?	Are minimization measures proposed associated with WGPF?	Are compensatory measures proposed associated with WGFP?	Are enhancements proposed associated with WGPF?	Are other measures, independent from WGFP, proposed?	Comments
	Mercury	NA (qualitative assessment)	NO	YES (section 8.5)	NO	NO	YES (section 8.5)	Assessment is inconclusive. Maintenance of higher water levels in Granby Reservoir should minimize mercury issues. WGFP 1041 Permit requires monitoring of bioaccumulative mercury.
	Selenium	NA (qualitative assessment)	NO	NO	NO	NO	NO	Inconclusive assessment.
Grand Lake	Secchi	NA (qualitative assessment)	NO	YES (section 8.6)	NO	NO	YES (section 8.1)	WGPF 1041 Permit references agreements to work on clarity in Grand Lake. Nutrient mitigation should minimize clarity impacts to the extent they are partially dependent on algal productivity.
Shadow Mountain Reservoir	DO	NA (qualitative assessment)	NO	YES (section 8.3)	NO	NO	YES (section 8.3)	Nutrient mitigation and maintenance of higher water levels in Granby Reservoir both will contribute to a minimization of DO impacts. Installation of an aeration system will eventually completely mitigate existing DO issues.

Water Body	Constituent	Is there impact based on the SCT?	Are avoidance measures proposed associated with WGFP?	Are minimization measures proposed associated with WGPF?	Are compensatory measures proposed associated with WGFP?	Are enhancements proposed associated with WGPF?	Are other measures, independent from WGFP, proposed?	Comments
Colorado River	Water Temperature	YES	YES (section 8.2)	NO	NO	YES (section 8.2.3)	NO	Simulated impacts are mixed with some warming and cooling at other times. Pumping curtailment will avoid temperature impacts associated with the WGFP. 10825 releases from Granby Reservoir will provide cooling to Colorado River.
	Nutrients	NO	NO	NO	NO	YES (section 8.6)	NO	WWTP enhancements associated with Nutrient mitigation will provide year round benefits to water quality in the Fraser River and Colorado River beyond the mitigation of impacts associated with the WGFP. TP mitigation commitments exceed the anticipated loading from WGFP and will provide a net benefit to the Three Lakes of TP reduction compared to Existing Conditions.

Water Body	Constituent	Is there impact based on the SCT?	Are avoidance measures proposed associated with WGFP?	Are minimization measures proposed associated with WGPF?	Are compensatory measures proposed associated with WGFP?	Are enhancements proposed associated with WGPF?	Are other measures, independent from WGFP, proposed?	Comments
	Metals	NO Except manganese (Water Supply)	NO	NO	NO	NO	NO	Dissolved manganese (Water Supply) being already listed as impaired there is no remaining assimilative capacity, which is why it appears as an indirect impact, and not so much as a result the WGFP.
	General Chemistry	NO	NO	NO	NO	NO	NO	Mass balance shows no impact.
	Mercury	NO	NO	NO	NO	NO	NO	Flow analysis shows no impact.
	Selenium	NO	NO	NO	NO	NO	NO	Flow analysis shows no impact.
East Slope Tributaries	Nutrients	NO	YES (section 8.6)	NO	NO	YES (section 8.6)	NO	Nutrient loading associated with WGPF will be offset. TP mitigation commitments exceed the anticipated loading from WGFP and will provide a net benefit to the Three Lakes of TP reduction compared to Existing Conditions.
	Metals	NO	NO	NO	NO	NO	NO	Mass balance shows no impact.
	General Chemistry	NO	NO	NO	NO	NO	NO	Mass balance shows no impact.
	Mercury	NO	NO	NO	NO	NO	NO	Some years show increase in flow above 10%
	Selenium	NO	NO	NO	NO	NO	NO	Some years show increase in flow above 10%

Water Body	Constituent	Is there impact based on the SCT?	Are avoidance measures proposed associated with WGFP?	Are minimization measures proposed associated with WGPF?	Are compensatory measures proposed associated with WGFP?	Are enhancements proposed associated with WGPF?	Are other measures, independent from WGFP, proposed?	Comments
East Slope Reservoirs (Carter Lake, Horsetooth Reservoir, Chimney Hollow Reservoir)	Nutrients	NO	YES (section 8.6)	NO	NO	YES (section 8.6)	NO	Nutrient loading associated with WGPF will be offset. TP mitigation commitments exceed the anticipated loading from WGFP and will provide a net benefit to the Three Lakes of TP reduction compared to Existing Conditions.
	Metals	NO	NO	NO	NO	NO	NO	
	General Chemistry	NO	NO	NO	NO	NO	NO	
	Temperature	NO (qualitative assessment)	NO	NO	NO	NO	NO	
	Selenium	NA (qualitative assessment)	NO	NO	NO	NO	NO	Assessment inconclusive.
	Mercury	NA (qualitative assessment)	NO	NO	NO	NO	YES (section 8.5)	Assessment inconclusive.

8 Minimization, Avoidance, Mitigation, Enhancements and Other Measures

Through the federal permitting process (NEPA), a portfolio of mitigation and enhancement measures were developed to address the indirect and cumulative impacts resulting from the WGFP and to offer beneficial enhancements beyond those required to offset impacts. This section describes the minimization, avoidance, mitigation (defined as compensatory measures), enhancement and other measures that will benefit water quality and offer net environmental benefits.

A decade of discussions and negotiations led to numerous agreements detailing voluntary environmental benefits and enhancements that will be provided and that will improve conditions in the Colorado River. State biologists, Grand County officials, Trout Unlimited experts and others have agreed that the WGFP will lead to a healthier river than it is today.

Many of the minimization, avoidance, compensatory mitigation and enhancement measures presented here are part of the existing mitigation (in a broad sense) and enhancement plans for the WGFP. Other measures, that are beyond these commitments, are also presented as they pertain to water quality issues described earlier in this report; these are tied through existing agreements or permits to the WGFP, although they may be targeting existing issues independent of WGFP that would impact water quality under cumulative effects.

Measures are broken down by type: avoidance, minimization, compensatory mitigation, enhancements and other types of measures. Avoidance, minimization and compensatory measures together are generally referred to as mitigation measures in the FEIS. Avoidance measures are measures that seek to avoid impact before the impact occurs. For water supply projects, they typically include changes in project operation that remove the impact that would otherwise be associated with the project, before it even takes place. Similarly, minimization measures are changes in project or operation that seek to reduce or minimize the magnitude of the impact without completely eliminating it. Mitigation measures as characterized here are strategies that seek to offset or compensate for impacts associated with the project. Unlike avoidance measures, they do not prevent the impact from occurring but they offset it through some compensatory mechanism. Enhancement measures are not mitigation measures. They are additional measures that have been committed to by the Subdistrict and that address existing issues and by design provide a net benefit unrelated to impacts caused by the project.

The minimization, avoidance, mitigation and enhancement measures are grouped by water quality topic in the first part of this section. Because of the complexity of the plans and agreements referenced in this section, and because many of these documents are interconnected and cross-referenced, a summary is provided in section 8.8 in order to facilitate the reader's understanding.

8.1 Grand Lake Clarity

8.1.1 Impacts Minimization Measures

As described Section 3.8.3 of the FEIS (U.S. Bureau of Reclamation, 2011), under Cumulative Effects, the annual Secchi depth in Grand Lake is expected to decrease by 3.8% (0.1m) compared to Existing Conditions for the WGFP. As Secchi depth is partially dependent upon algal productivity (Boyer & Hawley, 2010 Operational and Water Quality Summary Report for Grand Lake and Shadow Mountain Reservoir (Revision 1), 2012), nutrient mitigation commitments for WGFP should be considered (Section 8.6.) when evaluating mitigation measures related to clarity in Grand Lake.

Offsetting of the indirect impacts of nutrient loading resulting from the operation of the WGFP should contribute to partially offsetting, and therefore minimizing, the decrease in clarity anticipated with the WGFP. These mitigation commitments are described in the Fish and Wildlife Mitigation plan (FWMP) (section 8.6).

Additionally, several efforts are currently underway to evaluate options to improve Clarity in Grand Lake. Because the focus of these efforts is to improve clarity in Grand Lake independent of any considerations related to WGFP, these are described in section 8.1.2 as other measures that would mitigate existing clarity issues.

8.1.2 Other Measures

Following the adoption of a clarity standard for Grand Lake in 2008 by the WQCC (Section 7.3.4), Northern Water, the U.S. Bureau of Reclamation and Grand County executed in 2010 a Memorandum of Understanding (Appraisal Study MOU) to move forward with an Appraisal Study that would begin the evaluation process of options to improve clarity in Grand Lake.

A report presenting a high level review of possible alternatives was released in 2012 (U.S. Bureau of Reclamation, 2012) and was followed by a more detailed analysis that synthesized existing knowledge about water quality issues in the Three Lakes system and identified informational gaps that needed to be addressed in order to continue to move the process forward. This analysis culminated in 2013 with a 5-year work plan that laid out major tasks to take screened alternatives to a 30% engineering design level (GEI Consultants, 2013).

Concurrently, an amendment to the C-BT Repayment contract (Clarity Supplement) was signed by Northern Water and the U.S. Bureau of Reclamation in 2013. This agreement lays out the terms of a long-term commitment to continue collaborative work on Grand Lake clarity and evaluate possible measures that would improve clarity in Grand Lake to meet the applicable clarity standard.

In 2014, the U.S. Bureau of Reclamation, in conjunction with Northern Water and Grand County, began implementation of the 5-year work plan. Efforts are focused on the development of a solid modeling platform incorporating both water quality and hydrology in order to begin simulation and assessment of alternatives. This work is taking place in parallel to a collaborative effort involving all agencies and stakeholders interested in Grand Lake clarity to lay the ground work in anticipation of a review of the clarity standard, and its attainability, by the WQCC in April 2016.

Northern Water also will continue to fund the Secchi Monitoring Program to document clarity in Grand Lake and Shadow Mountain Reservoir throughout the summer while options to improve clarity are being studied and to evaluate the effectiveness of future management strategies.

Northern Water will continue its collection of baseline water quality data in the Three Lakes in support of all studies and work associated with clarity in Grand Lake and water quality in the Three Lakes.

Northern Water is also in the process of completing a study of particles in Grand Lake and Shadow Mountain Reservoir (McCutchan, Jr., 2014), which is seeking to characterize sources of particulate matter that contribute to decreased clarity in Grand Lake and to understand processes and factors that drive clarity in Grand Lake.

It should be noted also, that Grand County's 1041 WGFP Permit directly references the issue of clarity in Condition 7.

> *While the Subdistrict is not a party to the Grand Lake Clarity Agreement, the Permit Authority has relied on the Clarity Memorandum of Understanding in determining whether the 2012 WGFP complies with its 1041 Regulations; therefore, the 2012 Permit shall not be effective until the Clarity MOU, Clarity Supplement to the 1938 Repayment Contract and Contributed Funds Act Agreement (CFA Agreement) for executing the Colorado-Big Thompson (C-BT) West Slope Collection System Technical Review of Alternatives and Analysis and Plan of Study have been executed. The Subdistrict shall provide County with a status report, every two years, on the progress of meeting the State Water Clarity Standard for Grand Lake.*

8.2 Colorado River Water Temperature

Without impact avoidance and minimization measures, WGFP diversions would result in indirect impacts that would increase stream temperature in the Colorado River below Windy Gap Reservoir and, at times, stream temperature could violate the state DM or MWAT (section 7.4.4). Additionally, decrease in the amount and frequency of available fish habitat in the Colorado River would result from an increase in stream temperature.

Additional stream temperature and climatic data became available following the initial analysis of temperature impacts for the Draft EIS. A dynamic temperature model was used to further evaluate the potential effects of the WGFP on temperature in the Colorado River downstream of the Windy Gap diversion and was subsequently used to perform the antidegradation analysis for temperature (Hawley & Boyer, 2014). Observed data indicated that most exceedances of the chronic MWAT and DM standards tend to occur after July and August. Dynamic modeling indicated that additional MWAT and DM standard exceedances could occur for several consecutive days or weeks depending on the hydrologic year, timing of WGFP diversions, streamflow volume, and climatic conditions. Colorado River temperature between Windy Gap Reservoir and Williams Fork may exceed the 18.3°C chronic MWAT or the 23.9°C DM state standard below WGFP diversions. Project impacts are most likely in the occasional years when WGFP diversions occur in July or August.

The temperature antidegradation review documented in the technical memorandum (Hawley & Boyer, 2014), and summarized in section 7.4.4, indicates that for the reach between Windy Gap Reservoir and Williams Fork water temperature may increase above the allowable SCT at certain times during Project operation. However, it should be noted that cooling effects are also realized under cumulative effects as a result of 5,412 Releases from Granby Reservoir (section 8.8.8), which typically occur later in the year after the Windy Gap pumping period. The combination of these opposite effects amounts to a net reduction in the number of days during summertime with exceedances of both the DM and MWAT standards. In the reach immediately below the Williams fork, both warming and cooling effects are simulated to occur, which are unrelated to the operation of WGFP. Historical data and modeling show that temperatures in this reach are controlled more by releases from Williams Fork Reservoir than by conditions upstream of Williams Fork. There are no simulated exceedances of DM or MWAT standards at this location under any conditions, and there are more days of summertime cumulative effects cooling than warming; however temperature increases in excess of the SCT can occur on the days when warming takes place.

8.2.1 Impacts Avoidance Measures

Effects of the WGFP on temperature in the Colorado River are addressed in the Fish & Wildlife Mitigation Plan (FMWP) developed with the Colorado Division of Parks & Wildlife (CDPW) in accordance with C.R.S. § 37-60-122.2. Temperature mitigation measures include, among other things, installation of real-time temperature monitoring stations at two locations on the Colorado River below Windy Gap and curtailment of diversions in accordance with the requirements of Section 5.3.3 of the FWMP.

In addition, the Subdistrict would use the Windy Gap Project Bypass Valve and Auxiliary Outlet to the maximum extent practicable to release colder water without causing adverse effects to the Windy Gap Project facilities or operations for the bypass of water that is otherwise bypassed from the Windy Gap Project. Other temperature mitigation measures are detailed in Section 5.3.3 of the FWMP.

These requirements are documented in the WGFP FEIS Record of Decision (ROD) (U.S. Bureau of Reclamation, 2014).

The FWMP was adopted by the Colorado Wildlife Commission on June 9, 2011 and by the Colorado Water Conservation Board (CWCB) on July 13, 2011. The FWMP is a component of the mitigation

requirement to address the impacts identified in the FEIS. Mitigation measures from the FWMP to reduce the potential for impacts to stream temperature from the WGFP are described below and are found in the FWMP in Appendix E.

Monitoring Stations. The Subdistrict will work with Denver Water to install, operate, and maintain two continuous real-time temperature monitoring stations on the Colorado River – one at the Windy Gap gage and one upstream of the confluence with the Williams Fork River.

Temperature Thresholds. For the purposes of the FWMP, the threshold temperatures will be the following, as measured at the temperature monitoring stations identified above:
1. MWAT Chronic Threshold: 18.3°C (64.9°F), based on current MWAT Chronic Standard.
2. DM Acute Threshold: 23.9°C (75°F), based on current DM Acute Standard.

MWAT Chronic Threshold Exceedances – Reduction or Curtailment of WGFP Pumping. For the period after July 15 of each year:

1. At such times as the Weekly Average Temperature (WAT) exceeds the MWAT Chronic Threshold, the Subdistrict will reduce or curtail WGFP pumping at the Windy Gap diversion to the extent necessary to maintain temperatures within the MWAT Threshold. Reduced pumping may not be sufficient to maintain temperatures below the threshold.

2. Pumping for the original Windy Gap Project, now and after the WGFP is in operation, may occur at any time that the Windy Gap water rights are in priority and sufficient space is available in Granby Reservoir that such water pumped will not be reasonably expected to spill from the reservoir. Therefore, WGFP pumping will be defined as pumping that occurs at such times as Reclamation and Northern Water jointly determines, based on the most probable forecasts of inflows to Granby Reservoir, that a spill of water from the C-BT system is reasonably foreseeable. All other pumping will be considered to be for the original Windy Gap Project.

DM Acute Threshold Exceedances – Reduction or Curtailment of Pumping for the WGFP and the Original Windy Gap Project:

At such times as the DM temperature is within 1°C of the DM Acute Threshold, the Subdistrict will reduce or curtail pumping for the original Windy Gap Project or the WGFP at the Windy Gap diversion to the extent necessary to maintain temperatures within the DM Threshold although reduced pumping may not be sufficient to maintain temperatures below the threshold. In the future, the 1°C buffer may be altered, based on experience, to maintain compliance with the DM Threshold.

Limitations on Reduction or Curtailment of Windy Gap Pumping. The temperature mitigation measures identified above will be suspended in the event that, and at such times as, there is no material causal relationship between Windy Gap Project or WGFP operations and any exceedance of the MWAT Chronic threshold or DM Acute threshold at the monitoring stations identified above. For the purposes of this paragraph a "material causal relationship" is defined as either an actual measurable impact on temperature using readily available monitoring technology or a modeled impact on temperature that is not de minimis and is based on a computer model or studies accepted by the CDPW. The Subdistrict will cooperate with future studies to determine what factors, other than flow changes, have effects on water temperatures in the Colorado River below Windy Gap.

Use of the Windy Gap Bypass Valve and Auxiliary Outlet. The Subdistrict will use the Windy Gap Project Bypass Valve and Auxiliary Outlet to the maximum extent practicable without causing adverse effects to the Windy Gap Project facilities or operations for the bypass of water that is

otherwise bypassed from the Windy Gap Project. This measure is intended to make releases of water from these outlets deeper in the reservoir that may be colder than water bypassed over the spillway.

These temperature measures were modified in the Grand County 1041 process by Condition 24 of the permit (see section 8.8.3) to simplify the definition of when the original Windy Gap Project or the WGFP are operating and to remove the July 15 time constraint for the MWAT chronic threshold.

Bypass flows required at Granby Reservoir and Windy Gap Reservoir by existing agreements would continue. In addition, the Subdistrict would increase flushing flows as described in the FWMP (see section 8.7.1) and the Grand County 1041 Permit (see section 8.8.3).

8.2.2 Avoidance Measures Implementation Plan

Although temperature impacts avoidance measures are described in detail in the previous section and corresponding agreements, it is helpful to conceptualize certain implementation aspects. The information presented in this section describes how these measures are intended to be implemented and provides additional detail beyond those included in the FWMP (Section 8.8.3) and the WGFP 1041 Permit (Section 8.8.4).

The objective of these impacts avoidance measures is to prevent any exceedances of the applicable temperature standards (both acute and chronic) that could be caused by the operation of the Windy Gap Pump Plant.

In the case of the acute standard (DM), it was agreed that pumping would be curtailed when the daily maximum temperature gets to within 1°C of the applicable standard (currently 23.9 °C). Since the DM can only be calculated when a full 24 hours of data is available, theoretically pumping would not be resumed until at least 24 hours later, and when it was verified that the maximum temperature for that day was greater than 1°C below the DM standard. However, additional information may be taken into account when making these operational decisions. It is possible that with a predictive temperature model, available climate forecasts and an increasing understanding of system dynamics, operational decisions may become more efficient, proactive and effective. The framework described in the Learning By Doing Agreement (Section 8.8.5) allows for an adaptive and iterative approach that is expected to evolve over time as the river and aquatic systems dynamics are better understood. As this process unfolds, the 1°C buffer may be fine-tuned to something more appropriate based on a better understanding of temperature dynamics and system response to operational changes.

Also, because existing temperature data indicates that the critical reach for attainment of the acute temperature standard is just upstream of Hot Sulphur Springs (Figure 33), it is proposed that an additional (third) real-time station would be installed at this location. This would be the site that could trigger operational changes aimed at avoiding exceedances of the acute standard.

In the case of the chronic standard (MWAT), it is tentatively proposed to curtail pumping when the MWAT (calculated as a 7 days running average) gets within 0.3 °C of the applicable chronic standard (currently 18.3 °C). Based on existing temperature data, when MWAT exceedances occur, they are observed from immediately downstream of Windy Gap Reservoir all the way to upstream of the Williams Fork confluence. Typically, these exceedances increase in magnitude and duration from upstream to downstream (Figure 34). Real-time temperature would be monitored at both ends of the segment to inform operational changes, but the 0.3 °C buffer would likely be evaluated at the bottom end of the segment where water temperature is warmer. For the same reasons previously discussed, it is possible that over time operational decisions would become more efficient and proactive and that an iterative approach may lead to fine-tuning a more effective protocol based on a better understanding of temperature dynamics and system response to operational changes.

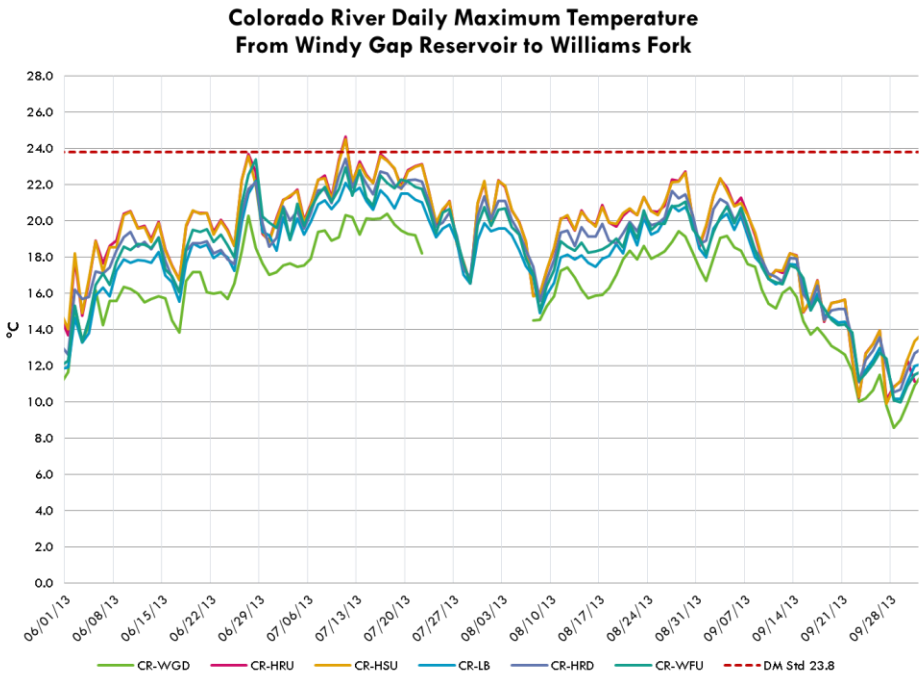


Figure 33 - Colorado River Daily Maximum Spatial Variation[20]

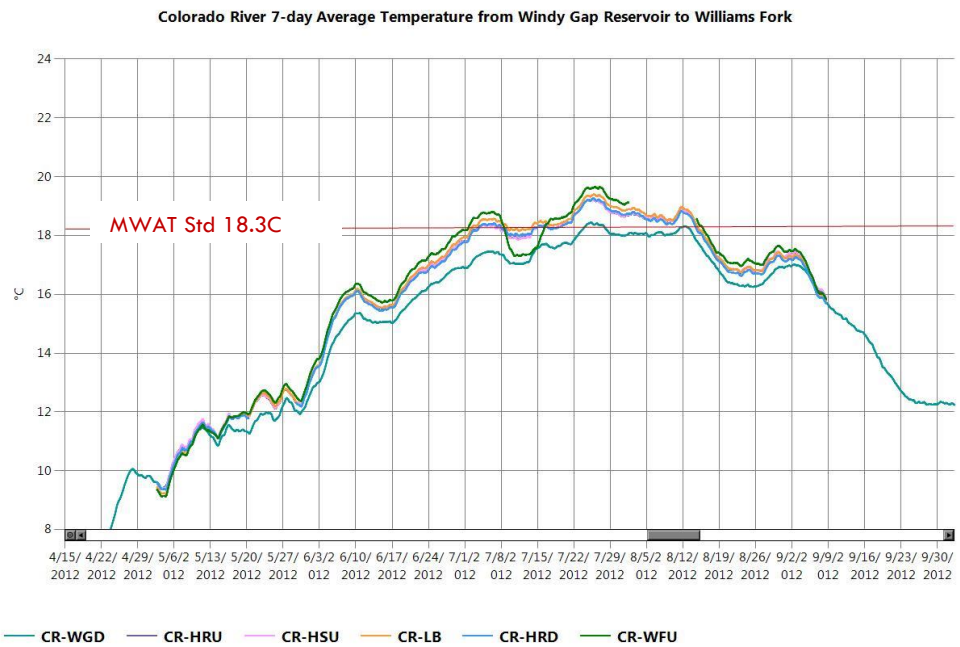


Figure 34 - Colorado River MWAT Spatial Variation[21]

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[20] CR-WGD: downstream of Windy Gap Reservoir, CR-HRU: upstream of Hot Sulphur Resort, CR-HSU: upstream of the town of Hot Sulphur, CR-LB: at Lone Buck, CR-HRD: downstream of Hot Sulphur Resort, CR-WFU: upstream of Williams Fork

[21] CR-WGD: downstream of Windy Gap Reservoir, CR-HRU: upstream of Hot Sulphur Resort, CR-HSU: upstream of the town of Hot Sulphur, CR-LB: at Lone Buck, CR-HRD: downstream of Hot Sulphur Resort, CR-WFU: upstream of Williams Fork

8.2.3 Temperature Enhancement Measures

As described in section 7.4.4, releases from Granby Reservoir associated with the 10,825 Program will have a cooling effect on water temperature in the Colorado River that can be seen downstream of Windy Gap Reservoir and were modeled under cumulative effects. These are discussed in greater detail in section 8.7.3.

8.3 Dissolved Oxygen in Shadow Mountain Reservoir

As discussed in Section 7.3.4, Shadow Mountain Reservoir is currently listed as impaired for DO. Under hydrologic conditions that cause Granby Reservoir levels to be particularly low, WGFP could have a small adverse impact on DO levels in Shadow Mountain Reservoir. Although WGFP is not the cause of the DO depletions and some of the measures discussed here are not pursued for the purpose of mitigating WGFP impacts, it is relevant to review them as they aim at addressing the existing and anticipated continued DO impairment that results from annual cycles in Granby Reservoir.

Some of the measures presented in this section were identified in the FWMP or the FWEP, but not with the initial intent of minimizing DO impacts associated with the Proposed Action (section 7.3.4). Nonetheless, they are relevant as they would provide a minimization of DO impacts related to WGFP.

Additional measures that are not part of the FWMP or the FWEP, and are independent from WGFP, are also discussed in this section as they would address and eventually remedy existing dissolved oxygen issues in Shadow Mountain Reservoir.

As per the FMWP, in any year when Granby Reservoir is Projected to fall below an elevation of 8,250 feet, modified prepositioning, which reduces the delivery of C-BT water from Granby Reservoir to Chimney Hollow Reservoir, will be implemented to maintain higher water levels in Granby Reservoir. Maintenance of higher water levels is also beneficial to minimize DO depletion at the bottom of Granby Reservoir and consequently in Shadow Mountain Reservoir as well (Section 7.3.4).

Furthermore, since the depletion of DO at the bottom of a reservoir is related to the cycling and decomposition of organic matter (part of which is constituted of algal matter) in a reservoir, the nutrient mitigation measures identified in the FMWP and further discussed in section 8.6 would minimize the impact of the WGFP on DO levels in Shadow Mountain Reservoir.

An intensive monitoring program has been tracking dissolved oxygen levels in Shadow Mountain Reservoir and in Granby Reservoir since 2008. Two buoy systems currently monitor dissolved oxygen, temperature, pH, conductivity and turbidity in Shadow Mountain Reservoir on a real-time basis during the open water season (Jun-Oct) throughout the water column. A real-time dissolved oxygen sensor also records dissolved oxygen levels in the Granby Pump Canal year-round. These data are supporting studies aiming at understanding dissolved oxygen dynamics in Shadow Mountain Reservoir.

Independently from any considerations associated with the WGFP, Northern Water, in conjunction with the U.S. Bureau of Reclamation, has started investigating options to increase DO levels in Shadow Mountain Reservoir to meet the aquatic life standard.

Subsequently, the U.S. Bureau of Reclamation was granted $87,000 from the Science & Technology Program (U.S. Bureau of Reclamation, 2014) to design an aeration system that could be operated in the Granby Pump Canal to improve dissolved oxygen levels before they reach Shadow Mountain Reservoir.

Northern Water and the U.S. Bureau of Reclamation are therefore actively pursuing remediation options, as evidenced by the monitoring efforts underway, pilot studies, scoping efforts and the U.S. Bureau of Reclamation's procurement of grant funding to support the evaluation of alternatives that will remedy the existing DO impairment in Shadow Mountain Reservoir. Implementation of measures to improve DO in Shadow Mountain Reservoir will be dependent on the results of these evaluations, available funding, and other factors.

8.4 Water Levels in Granby Reservoir

In any year when Granby Reservoir is Projected to fall below an elevation of 8,250 feet, modified prepositioning, which suspends the delivery of C-BT water from Granby Reservoir to Chimney Hollow Reservoir, will be implemented to maintain higher water levels in Granby Reservoir.

These provisions were incorporated into the WGFP Carriage Contract (APPENDIX B - MITIGATION, ENHANCEMENT PLANS & AGREEMENTS) and will be included in the U.S. Army Corps of Engineers permit, which is currently in progress. The objective is to minimize the adverse effects of prepositioning on water levels in Granby Reservoir. This measure will minimize any potential negative indirect impacts of the WGFP on aquatic resources and recreation in Granby Reservoir that may be caused by reduced water levels from prepositioning.

This measure will also be beneficial in minimizing impacts of the WGFP on DO (section 8.3) as well on the bioaccumulation of mercury in fish in Granby Reservoir (section 8.5).

8.5 Mercury

Granby Reservoir, Horsetooth Reservoir and Carter Lake all are currently listed as impaired for aquatic life use, due to the presence of mercury in fish tissue. Shadow Mountain Reservoir and Grand Lake are not currently listed as impaired for mercury.

As described in section 7.3.4, it is difficult to estimate what changes may take place with the methylation of mercury in these reservoirs due to confounding factors and without being able to predict how the fishery in each reservoir will be managed by CPW in the future.

However, because mercury is an existing concern, Grand County's 1041 permit for WGFP (section 8.8.3) calls for monitoring of bioavailable mercury under Condition 22. The Subdistrict proposes to monitor total mercury in fish tissue in Granby Reservoir, Shadow Mountain Reservoir and Grand Lake, as an indicator of mercury contamination in the Three Lakes. Total mercury in fish tissue is a good surrogate for bioavailable mercury (Bloom, 1992) as over 95% of mercury in fish is typically methylmercury. Total mercury analyses are significantly cheaper and easier to carry out and measuring total mercury also provides a conservative estimate of the bioavailable fraction. Furthermore, total mercury in fish tissue is what is routinely measured to develop fish consumption advisories. A recent study (Johnson, Lepak, & Wolff, 2014) verified this assumption and found that in Horsetooth Reservoir prey fish samples proportions of methylmercury to total mercury were 97.4%.

For the purpose of developing Fish Consumption Advisories (FCA), 10 fish tissue samples are required. For the purpose of 303(d) listing or delisting, 30 fish tissue samples are required (over a 5 year period).

The Subdistrict proposes to contribute funding to CPW and/or CDPHE in order to support their monitoring efforts to sample for mercury in fish tissue in the Three Lakes. It is our understanding that in order to support a sampling program that would be sufficient to evaluate the need for FCAs ever year, the target sample size for each of the species of concern and for each size class would be 10 per year. This would provide an adequate dataset for the purpose of 303(d) listing as well, since the target sample size for each of the species of concern would be a minimum of 30 fish per species and size class over a 5-year period.

As per Grand County's 1041 permit for WGFP, Grand County will need to review and approve a monitoring program for bioavailable mercury. The details of the proposed monitoring plan may evolve as such review takes place and as the implementation details are further explored.

Table 43 - Proposed Bioavailable Mercury (Measured as Total) Sampling Plan

Water Body	Target Species	Samples (1x/year)	Total Number of Samples/year
Grand Lake	Lake Trout	10 large, 10 small	20
Granby Reservoir	Lake Trout	10 large, 10 small	20
Shadow Mountain Reservoir	TBD	10 large, 10 small	20

Northern Water and the Subdistrict will continue to monitor CPW's efforts to develop mitigation strategies to manage mercury in the fisheries in Granby Reservoir, Carter Lake and Horsetooth Reservoir.

Furthermore, it should be noted that mitigation commitments to modify prepositioning to maintain higher water levels in Granby Reservoir should minimize any potential effects on aquatic resources that may be caused by reduced water levels from prepositioning. In this instance, it could be beneficial to offset possible increases in mercury bioaccumulation in Granby Reservoir.

8.6 Nutrients

Increased nutrient (nitrogen and phosphorus) loading in Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake would be an indirect impact resulting from additional WGFP pumping. Nutrient concentrations are of concern in the Three Lakes system because of the role they play in increasing algae growth (measured as chlorophyll *a*), and reducing clarity (Secchi disk depth). Nutrients in the reservoir also affect dissolved oxygen concentrations and the concentrations of metals such as manganese. Water deliveries to the East Slope also convey nutrients to Carter Lake, Horsetooth Reservoir, and other streams and facilities. There could also be higher concentration of nutrients in the Colorado River below Windy Gap Reservoir as a result of WGFP pumping and corresponding decrease in dilution flows.

As part of the WGFP FEIS, additional nutrient loads (over existing conditions) were computed for the WGFP (without RFFAs). Additional average annual nutrient loads were reported to be 778 kg/year for total phosphorus and 6,128 kg/year for total nitrogen on an average annual basis. These numbers were used to determine mitigation efforts.

Subsequent to the submission of the final WGFP EIS, the Three Lakes Model was used for Denver Water's Moffat Collection System EIS (U.S. Army Corps of Engineers, 2014). As part of that process, suggestions were made to modify some of the assumptions in the Fraser Basin Nutrient Model (which had been modified for the Moffat Project) for future conditions. WQCD staff suggested that assumed effluent flows should be reduced to reflect current growth projections, which are lower than those reported in the Upper Colorado River Basin Study (Hydrosphere Resource Consultants, Inc., 2003). In addition, based on Regulation 85 (CDPHE, WQCC, 2012) and other factors, suggestions were made regarding more appropriate wastewater treatment levels for future conditions. These suggestions, along with a few other minor changes regarding Onsite Wastewater Treatment Systems (OWTS) and land use, were used for the Moffat Project to refine predicted water quality conditions at the mouth of the Fraser River.

Since the suggestions described above are based on more likely assumptions than those made in 2007 for the WGFP EIS, it was decided to use the newly predicted concentrations at the mouth of the Fraser River to compute total nutrient loads into the Three Lakes for the WGFP 401 Certification. Using the new predictions for cumulative effects, the additional loads into the Three Lakes system, over existing conditions, is 697 kg/year for total phosphorus and 7,005 kg/year for total nitrogen.

A number of sources affect the nutrient concentrations in the Colorado and Fraser Rivers including WWTP discharges, livestock, agricultural runoff, and other nonpoint sources such as roads and developed areas.

Nutrient loading to the Three Lakes system from additional Windy Gap pumping would be offset by nutrient reductions that could occur in the Willow Creek, Fraser River, and Colorado River watersheds above Windy Gap. Nutrient reductions would result in a year-round improvement to water quality in streams where nutrient reduction measures are implemented.

8.6.1 Impacts Avoidance Measures

To mitigate nutrient loading to the Three Lakes associated with WGFP pumping, the Subdistrict would be required to submit a nutrient reduction plan to Reclamation and the Corps for approval. The plan must be in place prior to the construction and operation of the WGFP. To offset the predicted nutrient loadings into the Three Lakes and reduce the associated water quality effects, the Subdistrict plans to implement both point source and nonpoint source nutrient reduction measures upstream from the Windy Gap Reservoir diversion point. The following sections provide an overview of the currently planned point and nonpoint source nutrient reduction measures the Subdistrict has identified to meet the requirement to provide a documented nutrient reduction credit factor of 1:1 to satisfy Reclamation and Corps mitigation requirements.

Point Source Nutrient Reduction

Improvements to the three largest WWTP operations—Granby Sanitation District, Fraser Sanitation District, and Three Lakes Sanitation District, were evaluated to determine potential treatment process upgrades that would reduce nutrient discharges. Modeling of WWTP operations and upgrades determined that the most cost effective and efficient method for reducing WWTP nutrient discharges would be a series of improvements to the Fraser Sanitation District WWTP located just north of the Town of Fraser (Black & Veatch, 2009).

Proposed Fraser Sanitation District WWTP improvements are estimated to reduce annual total nitrogen discharges to the Fraser River by 5,076 kg/year and total phosphorus loading by 6,566 kg/year. Because the WGFP only pumps a few months out of the year and does not pump all of the water in the river, the reduction in nutrient loading to the Three Lakes was based on Projected WGFP pumping volumes from April to August. Thus, the actual reduction in nutrient loading to the Three Lakes is about 10 to 15 percent of total nutrient reductions from WWTP improvements, or 822 kg/year of total nitrogen and 774 kg/year of total phosphorus (Table 44). The Fraser River below the WWTP and the Colorado River downstream from the Fraser River confluence would benefit from the year-round reduction in nutrient discharges and the Three Lakes would benefit from reduced nutrient delivery when the Windy Gap Project is pumping. Point source nutrient reduction measures would offset about 12 percent of the projected WGFP nitrogen loadings into the Three Lakes and about 111 percent of the phosphorus loadings.

Table 44 - Nutrient Loading Reduction from Mitigation

Nutrient Loading and Reduction Sources	Total Nitrogen (kg/yr)	Total Phosphorus (kg/yr)
Projected nutrient loading to the Three Lakes from the WGFP compared to existing conditions (from FEIS)	6,128	778
Revised nutrient loading to the Three Lakes under Cumulative Effects and updated loading assumptions	***7,025***	***697***
Point source nutrient reduction – Fraser WWTP	822	774
Nonpoint source nutrient reduction – E Diamond H Ranch	684	117
Nonpoint source nutrient reduction – C-Lazy-U Ranch	1,836	237
Total identified nutrient reduction to Three Lakes	3,343	1,128
Additional nutrient reduction needed to offset loading to Three Lakes (based on revised nutrient loading)	**3,682**	**(431)**

To implement WWTP improvements, the Subdistrict and Fraser Sanitation District would enter into an agreement specifying the improvements and Subdistrict funding. Capital costs for improvements are estimated at about $3.3 million and annual operating costs would increase about $120,000 to $230,000. The improvements would be implemented prior to completion of Chimney Hollow Reservoir and operation of the WGFP.

Nonpoint Source Nutrient Reduction. The Subdistrict has identified several nonpoint source nutrient reduction measures to further reduce nutrient loadings from the WGFP. Nonpoint nutrient reduction measures focused on improved agricultural practices and reduced fertilizer application for several parcels of land in the Willow Creek watershed, which is tributary to the Colorado River above Windy Gap Reservoir as described below. Like point source nutrient reduction measures, the watersheds would see a greater reduction in nutrients than the actual nutrient reduction to the Three Lakes. Thus, there are beneficial effects to a broader geographic area than just the nutrient reduction to the Three Lakes.

E-Diamond H Ranch: This 265-acre ranch located on Church Creek, a tributary to Willow Creek, is currently irrigated from the Red Top Ditch and periodically fertilized for hay production. To reduce nutrient discharges from runoff, the land would no longer be irrigated and all fertilizer application would cease. These measures are predicted to reduce total nitrogen loading to the Three Lakes by 685 kg/year and

total phosphorus by 117 kg/year (Table 3-115) (Black and Veatch Oct 9, 2009). The Subdistrict would enter into an agreement with the E-Diamond H Ranch to implement the changes in land management for this property prior to implementation of the WGFP.

C-Lazy-U Ranch: Several ranch management practices and BMPs would be implemented on the 300 acre C-Lazy-U Ranch located immediately upstream of Willow Creek Reservoir to reduce nutrient discharges. Primary improvements include a reduction in chemical fertilizer application, better manure management, use of vegetated buffer strips adjacent to Willow Creek to capture nutrients in surface water runoff, and streambank restoration to reduce erosion. A reduction in nutrient loadings from the C-Lazy-U Ranch would reduce direct nutrient loadings into Granby Reservoir via the Willow Creek Feeder Canal deliveries from Willow Creek Reservoir as well as releases from the reservoir that are pumped to Granby Reservoir from Windy Gap Reservoir. Implementation of these improvements would reduce total nitrogen loading to the Three Lakes by 1,836 kg/year and total phosphorus by 237 kg/year from the C-BT deliveries from Willow Creek Reservoir to Granby Reservoir (Table 44) (Black & Veatch, 2009). The Subdistrict has entered into an agreement with the C-Lazy-U Ranch to implement the changes in land management for this property.

Total Nutrient Reductions. Currently identified nutrient reduction measures would offset about 48 percent of the WGFP total nitrogen loadings to the Three Lakes or 3,343 kg/year. Thus, about 3,682 kg/yr of additional nitrogen reduction measures need to be identified. The Subdistrict will be responsible for developing other nutrient reduction measures or other actions elsewhere in the watersheds upstream of Windy Gap Reservoir to meet the total nitrogen reduction levels needed to provide at least a 1:1 reduction in TN and TP loadings to the Three Lakes. Implementation of point source and nonpoint source nutrient reduction measures would offset WGFP total phosphorus loadings to the Three Lakes by 431 kg/year more than projected WGFP loading (Table 44). While additional phosphorus reduction measures are not needed to offset WGFP loadings, any additional nutrient reduction measures to reduce nitrogen are also likely to further reduce phosphorus loading.

Monitoring. The Subdistrict will submit to Reclamation and the Corps for approval a monitoring program and annual results to ensure that proposed nutrient reduction measures and any additional unidentified point and nonpoint source mitigation measures are effective in offsetting all of the nitrogen and phosphorus loading to the Three Lakes attributable to the WGFP. Nutrient reduction measures would be implemented in an adaptive management approach with the results of monitoring used to demonstrate the effectiveness and need for additional or less mitigation.

The estimates of nutrient reduction from Fraser Sanitation District WWTP improvements are believed to be reasonably accurate because of the controlled environment associated with operation of a closed system. However, the effectiveness of WWTP improvements on nutrient reduction would be monitored at the discharge outlet. The monitoring program would include appropriate sampling parameters and frequency to calculate actual nutrient reduction.

Nonpoint source nutrient reductions are more difficult to predict because of the large geographic area, uncertainties in the interaction of biological, chemical, and physical processes in the watershed, and outside variables. To measure the effectiveness of nonpoint source mitigation measures, a monitoring program would be developed for the E-Diamond H Ranch and C-Lazy-U Ranch. The Subdistrict initiated water quality monitoring on Willow Creek near the C-Lazy-U Ranch and on Church Creek near the E-Diamond H Ranch in 2010 to begin establishing a baseline for water quality prior to implementing nonpoint source mitigation measures. Similar monitoring would be established for other locations where nonpoint source nutrient reduction measures are identified.

In addition, the reduced nutrient loading to the Three Lakes by upgrading the Fraser WWTP and nonpoint source BMPs would likewise reduce the nutrient load delivered to the East Slope in Carter Lake, Horsetooth Reservoir, and the C-BT system. Mitigation measures would offset the incremental total phosphorus loadings from the WGFP under Cumulative Effects. Nutrient mitigation measures would reduce the

potential for reductions in dissolved oxygen in Carter Lake and Horsetooth and the associated concerns with an increase in manganese availability and total organic carbon and geosmin in Horsetooth Reservoir.

8.6.2 Enhancements Measures

The Fraser River below the WWTP and the Colorado River downstream from the Fraser River confluence would benefit from the year-round reduction in nutrient discharges related to the WWTP enhancements in the Fraser River.

Also, because the proposed avoidance measures for nutrients are expected to yield TP reductions in excess of what is needed to offset loading associated with the WGFP, TP levels would be reduced to below what they are under existing conditions and would constitute an enhancement of water quality conditions in the Three Lakes and in the Colorado River below Windy Gap Reservoir. Furthermore, any additional nutrient reduction measures to reduce nitrogen are also likely to further reduce phosphorus loading and further decrease TP levels from existing conditions.

8.7 Streamflow and aquatic habitat in the Colorado River

As part of the FWMP, flushing flows downstream of Windy Gap Reservoir will be enhanced. The Subdistrict's FWEP endorsed by the Colorado Wildlife Commission also includes a component for stream restoration of the Colorado River below Windy Gap. While these measures are independent of impacts identified for the WGFP, they would improve existing aquatic habitat. The measures include funding $4.0 million of stream restoration in the Colorado River from Windy Gap to the Kemp-Breeze State Wildlife Area and engaging in a cooperative, ongoing process to maintain, restore and/or enhance the aquatic environment in areas of the Colorado, Fraser, and Williams Fork river basins through Learning By Doing (LBD). The Subdistrict has also provided funds for a $250,000 third-party study to determine the potential benefits of building a bypass for water around or through Windy Gap Reservoir. The Subdistrict has committed $2 million toward construction of a Windy Gap Reservoir bypass, if the study recommends one or the funds will go toward aquatic habitat restoration efforts in the Colorado River, if a Windy Gap bypass is not built.

Furthermore, up to $250,000 will be provided through Northern Water and its Subdistrict for the Wild and Scenic management plan endowment fund as laid out in the WGFP IGA and the Northern Water IGA (APPENDIX B - MITIGATION, ENHANCEMENT PLANS & AGREEMENTS). The Subdistrict will also support a Colorado Water Conservation Board instream flow on the Colorado River between the Blue and Eagle rivers as described in WGFP IGA (§ IV.I.) and Northern Water IGA (§ 5.)

8.7.1 Flushing Flows

The Windy Gap Project is currently required to bypass 450 cfs for 50 hours once every 3 years, if such flows are naturally available in accordance with the *Memorandum of Understanding Between Municipal Subdistrict, Northern Colorado Water Conservancy District and Division of Wildlife, Colorado Department of Natural Resources, Relating to Minimum Stream Flow in Association with the Windy Gap Diversion Project*, dated June 23, 1980. The Fish and Wildlife Mitigation Plan requires the Subdistrict to modify Project operations as follows:

- The flushing flow provision of the 1980 MOU will be modified to increase the required flushing flow from 450 cfs to 600 cfs.
- In any year when flows below Windy Gap have not exceed 600 cfs for at least 50 consecutive hours in the previous two years, and total Subdistrict water supplies in Chimney Hollow and Granby Reservoirs exceed 60,000 AF on April 1, the Subdistrict will cease all Windy Gap pumping for at least 50 consecutive hours to enhance peak flows below Windy Gap.

This measure was modified in the Grand County 1041 Permit Condition 29 to add the following:

- If, during a five (5) year period, natural conditions meet or exceed flows of 600 c.f.s. required by the Fish and Wildlife Mitigation Plan so that the Subdistrict is not required to make releases or bypass water to achieve the required flow, and a flow of 1200 c.f.s. has not occurred for 72 consecutive hours, then in the sixth year, Subdistrict shall provide a 1200 c.f.s. flow for 72 consecutive hours.

The intent of these measures is to enhance peak flows below Windy Gap. The Subdistrict will coordinate with CPW and other water suppliers, including Denver Water, to maximize benefits of the higher flows and minimize any potential negative impacts to aquatic resources.

8.7.2 Aquatic Habitat Enhancement Measures

Habitat Project

As described in the FWEP, the Subdistrict will provide $3.0 million to implement the Habitat Project that was designed to address concerns raised by CPW and other stakeholders regarding the current conditions of the aquatic ecosystem in the Colorado River downstream of Windy Gap Reservoir. Studies identified a decline in populations of *Pteronarcys californica* (giant stonefly), which, historically, has been a major source of food for trout in the Colorado River as well as other species of stoneflies and mayflies. Populations of the mottled sculpin (*Cottus bairdi*), a native fish that is also an important food source for trout and shares habitat with the *Pteronarcys*, have also declined. CPW believes that riffle areas below the Windy Gap Reservoir have been altered by changes in flow regime, water depletions, sedimentation and armoring of channel bed. Trout populations between Windy Gap and Kremmling have declined. CPW has expressed a desire to return the river to a more functional system considering current and future hydrology. The goal of the Habitat Project is to design and implement a stream restoration program to improve the existing aquatic environment from the Windy Gap diversion to the lower terminus of the Kemp-Breeze State Wildlife Area (Figure 35).

The Subdistrict will also provide $1.0 million to a fund to be used for adaptive management and/or maintenance in the Habitat Project reach to adjust elements of the stream restoration efforts that may not function as designed.

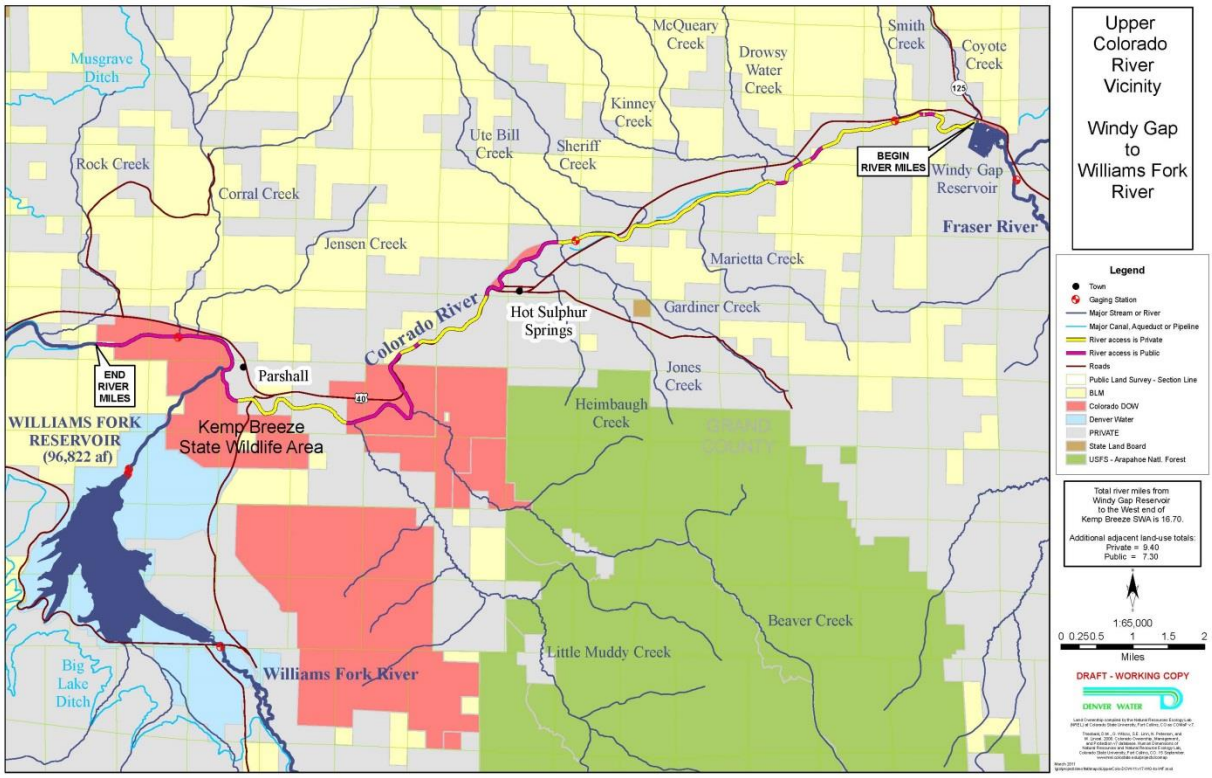

Figure 35 - Habitat Project Stream Restoration Reach

Windy Gap Bypass

As mentioned previously, CPW and other stakeholders expressed concerns regarding the current condition of the aquatic ecosystem in the Colorado River downstream of Windy Gap Reservoir. Observed changes in the aquatic ecosystem are believed to be linked to changes in flow regime and to the impoundment itself. In addition to the stream restoration efforts described in the previous section, stakeholders have expressed a desire for structural modifications that would allow free migration of fish around the Windy Gap dam.

The Subdistrict has funded a $250,000 study (recently completed) (Tetratech, 2015) that evaluate methods for bypassing flows, sediment, and/or fish around Windy Gap Reservoir. CPW directed these studies to identify potential modifications that would provide tangible benefits to aquatic resources below Windy Gap Reservoir. Issues to be studied include sediment transport, water quality (effects on temperature and/or nutrients) and fish passage. The studies have identified potential benefits and if there is stakeholder consensus to pursue the Project, the Subdistrict will provide site access, in-kind service for design and construction of any facilities, and long-term operation and maintenance of the facility in addition to the $2 million committed for construction of the bypass.

8.7.3 10,825 Releases from Granby Reservoir

Northern Water is a participant in the Upper Colorado River Endangered Fish Recovery Program. The program's purpose is to conserve populations of threatened and endangered species in the Upper Colorado River basin. The effort began in 1988 when a coalition of federal, state and regional agencies agreed to recover the endangered fish while simultaneously preserving future water development opportunities. Northern Water chose to voluntarily participate in the recovery program.

The effort focuses on four endangered species in the Upper Colorado River: Colorado pikeminnow, razorback sucker, bonytail chub and the humpback chub. Once abundant in the Colorado River and many of its tributaries, these fish now exist in much smaller numbers in only a few places in the basin. A principal program component includes providing additional water for aquatic life in the 15-Mile Reach of the Colorado River, located immediately above the confluence of the Colorado and Gunnison rivers at Grand Junction.

As a part of the program, Upper Colorado River water users agreed to supply 10,825 acre-feet of water annually to the Colorado River in late summer for the endangered fish. Half of the 10,825 acre feet is released each year from Granby Reservoir and the other half is released from Ruedi Reservoir on the Fryingpan River above Basalt. The Granby Reservoir component was made possible by ceasing irrigation on land upstream of Granby Reservoir, capturing and storing that water in Granby Reservoir, and then releasing it during late summer and early fall for municipal-recreational uses, while also benefitting the endangered fish.

The Granby Reservoir releases in this program (5,412.5 acre-feet annually) began on Aug. 1, 2013 as a result of an agreement between Northern Water and the City of Grand Junction and will occur every year. The timing of the releases from Granby Reservoir, is such that it provides cold water from the bottom of Granby Reservoir at a time when it is common to see water temperature exceed the temperature standards (MWAT and DM) downstream of Windy Gap Reservoir (section 0), although the schedule may vary slightly depending on hydrology and other factors (Table 45 and (U.S. Bureau of Reclamation, 2012a)). As discussed in APPENDIX F - TEMPERATURE ANTIDEGRADATION TECHNICAL MEMORANDUM (section 2.1.3), the cooling simulated for the cumulative effects for the AD review is the result of 5,412 releases from Granby Reservoir, increasing flow rates in the Colorado River beginning on August 1(July 15 in one simulation). The analysis revealed that by counting the number of days when cooling occurred, cooling effects outnumber days with warming in excess of the 15% DAI for DMs and WATs at all stations due to the WGFP. This means that overall, under cumulative effects, the net impact on the Colorado River

below Windy Gap Reservoir to the confluence with Williams Fork, is one of cooling. There are more days of cooling on days of standards excursions than days of warming on days of standard excursions.

Table 45 - Granby Reservoir Releases with 10,825 Project

Month	Granby Reservoir Bypass Requirements (cfs) (without 10,825)	Projected Granby Reservoir releases (cfs) for 10,825[22]		
		Dry	Average	Wet
July 1-14	75	0	0	0
Jul 15-31	75	22	0	0
Aug 1-14	40	47	50	35
Aug 15-31	40	47	50	50
Sep 1	20	55	50	70
Sep 2-9	20	38	50	70
Sep 10-15	20	38	50	50
Sep 16-20	20	21	29	50
Sep 20-30	20	21	29	24

It should also be noted that participation in the 10,825 Project is a permit condition associated with Grand County's WGFP 1041 Permit (Condition 25) that has been statisfied:

> *Because the delivery of the 10825 endangered fish water from Granby Reservoir is an essential consideration for compliance with the Endangered Species Act and compliance with the temperature standard, the Subdistrict must participate in securing approval of the 10825 agreement and must arrange with Northern to do the same.*

[22] From Environmental Assessment Finding of No Significant Impact – Colorado Water Users' Commitment to Provide 10,825 acre-feet to the 15-Mile Reach of the Upper Colorado River Great Plans Region, Eastern Colorado Area Office

8.8 Plans and agreements

This section highlights important clauses of various key agreements relevant to the 401 Certification for WGFP. The agreements are provided in their entirety in APPENDIX B - MITIGATION, ENHANCEMENT PLANS & AGREEMENTS

8.8.1 WGFP Intergovernmental Agreement

The WGFP Intergovernmental Agreement (WGFP IGA) was executed in January 2013 by the Subdistrict, Northern Water, Grand County, Middle Park Water Conservancy District, the Colorado River Water Conservation District and Northwest Colorado Council of Governments.

The WGFP IGA lays out among other things principles of operation for the Project such as carryover, spill, Middle Park and Grand County's water apportionments and additional provisions under which the parties agreed to allow the Project to move forward.

The WGFP IGA also includes a commitment to a cooperative effort for the aquatic environment, participation in the LBD Cooperative Agreement and the commitment to fund 250K towards study of a WG bypass to bypass flows, sediments and fish around the reservoir. These commitments are further detailed in separate agreements described later in the next sections.

The WGFP IGA includes a commitment to provide $50,000 (§ IV.N) to the Upper Colorado Wild and Scenic management plan endowment fund, as well as a commitment to a CWCB instream flow in the Colorado River between the Blue and Eagle Rivers (§ IV.I).

8.8.2 WGFP Carriage Contract

The WGFP Carriage Contract (Carriage Contract) was executed in December 19, 2014 by the Subdistrict, Northern Water and the U.S. Bureau of Reclamation.

The Carriage Contract lays out among other things the terms that allow the use of C-BT facilities for the WGFP such as the use of unused capacity in the C-BT Project, storage conditions of WGFP water, billing and payment, charges payable to the U.S. Bureau of Reclamation and Northern Water, delivery and accounting of WGFP water, reporting requirements, losses and spill conditions and environmental compliance and commitments.

By reference, the Carriage Contract adopts all mitigation and environmental commitments identified in the ROD, as well as funding commitments to the LBD effort of $1,500,000 over the course of ten years.

8.8.3 WGFP 1041 Permit (Grand County Resolution 2012PA-12-1)

The WGFP 1041 Permit issued by Grand County and executed in December 2012 sets forth 31 conditions attached to the authorization of the WGFP. The conditions relevant to water quality issues and net environmental benefits are reproduced below.

> ***Condition 7.*** *While the Subdistrict is not a party to the Grand Lake Clarity Agreement, the Permit Authority has relied on the Clarity Memorandum of Understanding in determining whether the 2012 WGFP complies with its 1041 Regulations; therefore, the 2012 Permit shall not be effective until the Clarity MOU, Clarity Supplement to the 1938 Repayment Contract and Contributed Funds Act Agreement (CFA Agreement) for executing the Colorado-Big Thompson (C-BT) West Slope Collection System Technical Review of Alternatives and Analysis and Plan of Study have been executed. The Subdistrict shall provide County with a status report, every two years, on the progress of meeting the State Water Clarity Standard for Grand Lake. The permit Authority reserves jurisdiction with regard to this condition in the event any signatory to the applicable agreement(s) refuse to sign.*
>
> ***Condition 21.*** *The Subdistrict shall submit the Nutrient Reduction Plan required by Bureau of Reclamation to Grand County for review at the same time it is submitted to Bureau of Reclamation and the Corps of Engineers.*
>
> ***Condition 22.*** *Within six months of issuance of the last Record of Decision for the 2012 WGFP, the Subdistrict shall submit to the County for review and approval of a robust monitoring plan to assure that nutrient loading from the 2012 WGFP for total nitrogen and total phosphorus is reduced to the 1:1 level that the Subdistrict has agreed to achieve.*
>
> *Within six months of issuance of the last Record of Decision for the 2012 WGFP, the Subdistrict shall submit to the County for review and approval a monitoring plan for manganese, bioavailable mercury, dissolved oxygen, and chlorophyll a in the Three Lakes. The plan should also include monitoring for Secchi disc depth July through September of each year in Grand Lake and Shadow Mountain Reservoir. The monitoring plan shall include a schedule for monitoring and reporting and Subdistrict shall provide a publicly accessible data base, and submit to Grand County summary reports on a schedule and in a form approved by Grand County. Following implementation of the WGFP, if monitoring shows increasing trends in manganese, bioavailable mercury, or chlorophyll a, or decreasing trends in dissolved oxygen and Secchi disc depth in Grand Lake, the Subdistrict and Grand County will evaluate and determine the cause for the changes in the trends. If it is determined that these trends are attributable to the WGFP, the Subdistrict will develop and implement a mitigation plan to eliminate the impact of the 2012 WGFP on those constituents.*
>
> *The Permit Authority finds that with regard to Criterion 1(f) there are impacts caused by the 2012 WGFP, which would be mitigated with the following conditions which shall be met by the Subdistrict:*
>
> ***Condition 23.*** *Installation of the real time water temperature gauges required by the Fish and Wildlife Mitigation Plan shall be a condition of this 2012 Permit and the Subdistrict must verify every spring, before the beginning of pumping, that these gauges are in good working order, that they remain so during the time of the year when the standard is in effect, and that they are replaced or repaired when necessary and timely to their need in reporting temperature.*
>
> ***Condition 24.*** *The Subdistrict will address temperature mitigation as follows:*

- *Temperature Thresholds. For the purpose of this Condition, the threshold temperature will be the stream temperature standards adopted by the state Water Quality Control Commission then in effect.*
- *Grand County, Subdistrict, Trout Unlimited, Upper Colorado River Alliance will not, and Subdistrict will assure that Northern Colorado Water Conservancy District will not, independently propose changes to the temperature standards for the reaches affected by the WFP without first working through Learning By Doing.*

Under the currently applicable temperature standards, the following would apply.

- *MWAT Chronic Threshold Exceedances = Reduction or Curtailment of WGFP Pumping. At such times as the Subdistrict is diverting under the 2012 Permit and the Weekly Average Temperature (WAT) exceeds the MWAT Chronic Threshold, the Subdistrict will reduce or curtail WGFP pumping at the Windy Gap diversion to the extent necessary to maintain temperatures with the MWAT Threshold. Reduced pumping may not be sufficient to maintain temperatures below the threshold.*
- *DM Acute Threshold Exceedances – Reduction or Curtailment of Pumping for the WGFP and the original Windy Gap Project (under both the 2012 Permit and original Windy Gap Project Permit). At such times as the Daily Maximum temperature is within 1C of the DM Acute Threshold, the Subdistrict will reduce or curtail pumping for the original Windy Gap Project or the WGFP at the Windy Gap diversion to the extent necessary to maintain temperatures with the DM Threshold. Reduced pumping may not be sufficient to maintain temperatures below the threshold. In the future, the 1 degree buffer may be altered, based on experience, to maintain compliance with the DM Threshold.*
- *Limitations on Reduction or Curtailment of Windy Gap Pumping or WGFP Pumping. The temperature mitigation measures identified above will be suspended in the event that and at such times as WGFP or, in the case of acute standards for both WGFP and the original Windy Gap, stops pumping and the temperature does not improve based on actual measurable effect. In that circumstance, WGFP and/or original Windy Gap may resume pumping. The LBD process will be used to evaluate the effect of the WGFP on temperature exceedances. Whether curtailment of pumping improves stream temperature will be tested on a periodic basis as determined by Learning by Doing.*
- *Use of the Windy Gap Bypass Valve and Auxiliary Outlet. The use of the Windy Gap Project Bypass Valve and Auxiliary Outlet will be considered by Learning by Doing, as appropriate.*

***Condition 25**. Because the delivery of the 10825 endangered fish water from Granby Reservoir is an essential consideration for compliance with the Endangered Species Act and compliance with the temperature standard, the Subdistrict must participate in securing approval of the 10825 agreement and must arrange with Northern to do the same.*

The Permit Authority finds that with regard to Criterion 1(g) there are impacts caused by the 2012 WGFP, which would be mitigated with the following conditions which shall be met by the Subdistrict:

Condition 26*. Within six (6) months of issuance of the Record of Decision by the Corps of Engineers for 2012 WGFP, the Subdistrict shall prepare and submit to Learning by Doing Management Committee, for review, approval and implementation, a fish and aquatics invertebrates monitoring plan. The monitoring data shall be provided to Learning By Doing effort and monitoring shall continue as long as the Learning by Doing effort requires this data. If the bypass/by-through is constructed, the Subdistrict shall adapt and fund the monitoring plan as necessary in consultation with the Management Committee of Learning by Doing.*

Condition 27*. If a bypass/by-through channel is constructed the design shall include a plan for minimizing blowing dust. If such plan is implemented, blowing dust shall not constitute a violation of the 1980 Windy Gap Project 1041 Permit or the 2012 Permit.*

Condition 28. *The bypass/by-through study shall commence on or before issuance of this 2012 Permit. If the results of the study demonstrate that the bypass/by-through will benefit the Colorado River as defined in the Scope of Work/Request for the Qualifications (RFW) Windy Gap Reservoir Modifications Study, November 2012, RFW# PBA-1324, implementation and construction of the bypass/by-through shall proceed in accordance with the Windy Gap Bypass Funding Agreement.*

If the bypass/bythrough is implemented and constructed, the Subdistrict shall contribute no less than $2 million.

Condition 29*. If, during a five (5) year period, natural conditions meet or exceed flows of 600 c.f.s. required by the Fish and Wildlife Mitigation Plan so that the Subdistrict is not required to make releases or bypass water to achieve the required flow, and a flow of 1200 c.f.s. has not occurred for 72 consecutive hours, then in the sixth year, Subdistrict shall provide a 1200 c.f.s. flow for 72 consecutive hours.*

8.8.4 Fish & Wildlife Mitigation Plan

The purpose of the FWMP for the WGFP is to comply with the requirement of Colorado State law (C.R.S. 37-60-122.2), including the Procedural Rules for the Wildlife Commission (Chapter 16). The goal of the Subdistrict and the WGFP participants is to mitigate for environmental impacts of the WGFP through the measures identified in the FMWP and to improve the aquatic and riparian habitat of the Colorado River in Grand County with measures identified in the separate Fish & Wildlife Enhancement Plan (FEWP) discussed in Section 8.8.5. The plans address cumulative impacts from the WGFP and Denver Water's Moffat Project. The Subdistrict and Denver Water agreed to cooperate in a process of simultaneous development of the mitigation and enhancement plans pursuant to C.R.S. 37-60-122.2. Section 122.2 provides, in part:

> *(1)(a) The general assembly hereby recognizes the responsibility of the state for fish and wildlife resources found in and around state waters which are affected by the construction, operation, or maintenance of water diversion, delivery, or storage facilities. The general assembly hereby declares that such fish and wildlife resources are a matter of state-wide concern and that impacts on such resources should be mitigated by the Project applicants in a reasonable manner. It is the intent of the general assembly that fish and wildlife resources that are affected by the construction, operation, or maintenance of water diversion, delivery, or storage facilities should be mitigated to the extent, and in a manner, that is economically reasonable and maintains a balance between the development of the state's water resources and the protection of the state's fish and wildlife resources.*

FWMPs for water Projects considered under C.R.S. 37-60-122.2 are to be developed by the Project applicant, working in cooperation with CPW, and submitted to the Colorado Wildlife Commission (CWC). If the CWC and applicant agree on the mitigation plan, the CWC forwards the mitigation plan to the Colorado Water Conservation Board (CWCB) for adoption as the official state position on the mitigation actions required of the applicant. The FWMP for WGFP was reviewed and approved by the CWC (June 9, 2011) and CWCB (July 13, 2011).

Mitigation measures were developed in the FMWP to address impacts identified in the Draft EIS. The mitigation measures are also intended to address concerns regarding WGFP impacts that were identified by CPW staff in a detailed review of the DEIS impacts. The impacts are based on a comparison of the existing conditions scenario to the WGFP.

The FMWP addresses four main impact areas: water levels in Granby Reservoir (Section 8.4), flushing flows in the Colorado River downstream of Windy Gap Reservoir (Section 8.7), water temperature in the Colorado River downstream of Windy Gap Reservoir (Section 8.2) and nutrient loading to the Three Lakes system (Section). Additional environmental mitigation is included in the FMWP but is not summarized in this section as it falls outside the scope of the 401 Certification. The full FMWP is included in APPENDIX B - MITIGATION, ENHANCEMENT PLANS & AGREEMENTS.

8.8.5 Fish & Wildlife Enhancement Plan

The Fish & Wildlife Enhancement Plan (FWEP) was prepared in addition to the FWMP and lays out enhancement measures pursuant to regulations implementing C.R.S. 37-60-122.2(2) that are intended to enhance fish and wildlife resources over and above the levels existing without the Moffat Project and WGFP. The FWEP for WGFP was reviewed and approved by the CWC (June 9, 2011) and CWCB (July 13, 2011).

Upper Colorado River Habitat Project

The Upper Colorado River Habitat Project (Habitat Project) was designed through collaboration by the Subdistrict, Denver Water and CPW to address concerns raised by CPW and other stakeholders regarding the current conditions of the aquatic ecosystem in the Colorado River downstream of Windy Gap. CPW studies have identified a decline in populations of Pteronarcys californica (giant stonefly) which, historically, has been a major source of food for trout in the Colorado River, as well as other species of stoneflies and mayflies. Populations of the mottled sculpin (Cottus bairdi), a native fish that is also an important food source for trout and shares habitat with the Pteronarcys, have also declined. CPW believes that riffle areas below the Windy Gap Reservoir have been altered by changes in flow regime, water depletions, sedimentation, and armoring of the channel bed. Trout populations between Windy Gap and Kremmling have declined. CPW has expressed a desire to return the river to a more functional system considering current and future hydrology.

The goal of the Habitat Project is to design and implement a stream restoration program to improve the existing aquatic environment from the Windy Gap Diversion to the lower terminus of the Kemp-Breeze State Wildlife Area (Segment). The intent is for Denver Water and the Subdistrict to join with the CPW, along with other stakeholders, in a cooperative effort to identify and address desired improvements to the stream environment.

Learning By Doing (LBD) IGA

This Intergovernmental Agreement (IGA) between Northern Water, the Subdistrict, Grand County, Middle Park, the Colorado River Conservation District (River District) and Denver Water lays out a framework of adaptive management and cooperative efforts to restore and enhance the aquatic environment in the Colorado, Fraser and Williams Fork River Basins. These efforts include coordinated monitoring, mechanisms to identify and prioritize issues of concern and development of resources to address them. These efforts are enhancements beyond mitigation commitments for WGFP.

This collaborative effort is contingent upon the issuance and acceptance of all permits necessary for the WGFP.

The cooperative effort revolves around Grand County's Stream Management Plan (SMP), which is an evolving document that will be refined and revised over time. Management goals will be decided by the Management Committee (representing the signatories to the agreement and other important stakeholders) and will be site-specific. Specifically, appropriate management actions will be developed to address impaired waters within the area subject to this agreement. Management Committee directives will be summarized annually in an operational plan.

Windy Gap Bypass Funding Agreement

The Windy Gap Bypass Funding Agreement executed by Northern Water, the Subdistrict, Grand County, Trout Unlimited (TU) and the Upper Colorado River Alliance (UCRA) lays out the funding commitment from the Subdistrict to support the Windy Gap Bypass (WGB). The WGB Study (funded by the Subdistrict in the amount of $250,000), underway at the time of writing of this 401 technical report, is conducted to evaluate, prioritize and recommend modifications to the existing Windy Gap Dam and related work

necessary in order to bypass flows through and/or around Windy Gap Reservoir. The objective of those modifications is to improve the aquatic biologic health of the Colorado River at and below Windy Gap Reservoir, including reducing sedimentation and stream channel armoring problems; supporting a healthy riparian zone; and accommodating flows anticipated in the future.

The Subdistrict committed to fund up to $500,000 toward engineering and permitting of the WGB (if the WGB Study determines it to be necessary and beneficial to the aquatic environment) and an additional $1,500,000 for construction of the WGB.

This agreement constitutes an enhancement to the Colorado River aquatic system and goes beyond WGFP mitigation commitments. It is also contingent upon the issuance and acceptance of all permits necessary for the WGFP.

In February 2014 a bypass study completed by CPW identified alternatives to improve the aquatic environment. In April 2014, the Subdistrict funded a study to evaluate two alternatives in more detail.

8.8.6 Windy Gap Firming FEIS Record of Decision

After summarizing the major findings from the FEIS, the ROD made a final determination that both the No Action Alternative and Alternative 2 (Proposed Action) are environmentally preferable alternatives but Alternative 2 responds to the Purpose and Need and the No Action Alternative does not.

The ROD also determined that the FEIS for WGFP satisfies the requirements of NEPA and that the Proposed Action should be implemented along with the proposed mitigation and environmental commitments.

After reviewing and considering all of the issues, environmental consequences and mitigation measures, it was determined that the Proposed Action with implementation of the mitigation measures identified in the FEIS will provide valuable environmental and socioeconomic benefits.

> *"Alternative 2 – Chimney Hollow Reservoir represents years of work by the Participants and the Subdistrict to develop a solution to reliably meet their water needs. The Subdistrict worked extensively with communities and entities on the West Slope to reach agreement on responding to concerns with the Project and providing benefits for the West Slope. This is reflected in letters from Grand County, the Colorado River Water Conservation District, and the Middle Park Water Conservancy District to Reclamation (Appendix A). Reclamation's decision to implement Alternative 2 – Chimney Hollow Reservoir with the mitigation identified in Appendix E responds to the Participants' future water needs, implements practicable measures to avoid or minimize environmental impacts from firming the Windy Gap Project yield, and provides benefits that would not be achieved under the No Action Alternative. These factors are the basis for Reclamation's decision to implement Alternative 2- Chimney Hollow Reservoir."*

8.8.7 Grand Lake Clarity Agreements

Appraisal Study MOU

This MOU was signed in October 2010 and laid out the terms under which the U.S. Bureau of Reclamation, Grand County and Northern Water would complete an Appraisal Study and Report. The Appraisal Report was completed and published in August 2012 (U.S. Bureau of Reclamation, 2012).

C-BT Repayment Contract Clarity Supplement

The C-BT Repayment Contract Supplement was executed in October 2013 between Northern Water and the U.S. Bureau of Reclamation and lays out the terms of a long-term commitment to continue to study clarity issues in Grand Lake in an attempt to identify actions to meet any applicable clarity standard.

Clarity MOU

The Clarity MOU is currently still in its draft form and would essentially reassert the commitments laid out in the C-BT Repayment Contract Supplement, except the signatories to this MOU would include the U.S. Bureau of Reclamation, Grand County and Northern Water. This MOU is also specifically referenced in the 1041 WGFP Permit under Condition 7.

8.8.8 10,825 C-BT Contract Supplement and Northern Water IGA

10,825 CBT Contract Supplement

The 10,825 agreement is a supplement to the C-BT Repayment Contract. This contract between Northern Water and the U.S. Bureau of Reclamation was executed in July, 2013. It allows inflow into the C-BT Project resulting from the dry up of irrigated land that had historically received water through the Red Top Ditch to be passed through the C-BT Project for releases to the Colorado River out of Granby Reservoir. Based on engineering study, the amount was set to an annual average of 5,412.5 acre-feet. This water is for the purpose of meeting a portion of the Colorado River water users commitment under the *Final Programmatic Biological Opinion for Bureau of Reclamation's Operations and Depletions; other Depletions, and Funding and Implementation of recovery Program Actions in the Upper Colorado River above the Confluence of the Gunnison River (PBO)*.

Northern Water IGA

The Northern Water IGA is a contract between Northern water, Grand County, Middle Park Water Conservancy District and the Colorado River Water Conservation District. The IGA confirms Northern Water's support for the agreement for the delivery of 5,412 acre-feet of water from Granby Reservoir to the Colorado River for the Recovery Program. The contract echoes commitments laid out in other agreements as well to work through the LBD Cooperative effort, to participate in implementing measures to improve clarity in Grand Lake and not to propose changes to temperature standards in the Colorado River without first working through the LBD Cooperative Effort. In addition, the contract also commits Northern Water to providing $200,000 to the Wild and Scenic endowment fund and supporting a CWCB instream flow in the Colorado River between the Blue and Eagle Rivers.

8.9 Mitigation and Enhancement Commitments Summary

Table 46 provides a summary of water quality issues of concern and proposed mitigation, enhancement and other measures to address them. The table is a synthesis of the information presented in Sections 8 and includes a list of the agreements referencing the commitments to the proposed measures. Many of these agreements have cross-references and commitments are repeated in whole or in parts from other documents, which can make it difficult to get a comprehensive understanding of the complete package of measures associated with the WGFP.

Table 46 - Summary of Mitigation, Enhancements and Other Measures

Issue	Description	Proposed Mitigation/Enhancement/Other Measure	Agreements	Comment
Grand Lake Clarity	Decrease in Grand Lake Clarity	• Monitoring • Reporting • Evaluation of alternatives to improve clarity in Grand Lake • Nutrient reductions	• Clarity Appraisal Study MOU • C-BT Repayment Contract Supplement • 1041 Permit • Clarity MOU (Draft) • FWMP • ROD • Carriage Contract	• These agreements collectively ensure that Northern Water and USBR will continue to work on improving clarity in Grand Lake and evaluate attainable alternatives. • Nutrient reduction commitment also would offset any clarity decrease related to nutrient loading from WGFP
Colorado River Water Temperature	Exceedance of temperature standard	• Real-time monitoring • Pumping reductions/ curtailment • 10,825 releases from Granby	• FWMP • FWEP • 1041 Permit • WGFP IGA • LBD IGA • Northern Water IGA • ROD • Carriage Contract • 10825	• Reduction and curtailment of pumping avoid temperature impacts related to WGFP that would occur otherwise. • Half of the 10,825 releases made from Granby Reservoir late summer/early fall for the benefit of endangered species in the Colorado River provide cooling during that time. This commitment although unrelated to WGFP impacts is part of the enhancements evaluated under cumulative effects.

Issue	Description	Proposed Mitigation/Enhancement/Other Measure	Agreements	Comment
Dissolved Oxygen in Shadow Mountain Reservoir	Existing dissolved oxygen impairment	• USBR S&T Grant • Nutrient Reductions in the Three Lakes • Granby Water Levels	• FWMP • 1041 Permit • Carriage Contract	• There are no formal agreements/commitments related to this particular issue other than the Carriage Contract that addresses water levels in Granby Reservoir. However, the USBR and Northern Water are working on this issue. • It is expected that nutrient reductions associated with WGFP would help improve DO conditions on the Three Lakes. • The maintenance of higher levels in Granby Reservoir will help maintain higher DO levels at the bottom of the Reservoir, which in turns helps DO in Shadow Mountain Reservoir through water pumped from the Granby Pump Canal. This measure was not designed for the purpose of improving DO but provides an ancillary benefit.
Water Levels in Granby Reservoir	Recreation (boat ramp access)	• Modified prepositioning to maintain higher water levels in Granby Reservoir	• FMWP • Carriage Contract	• This measure is focused on alleviating concerns about recreational impacts due to lower levels in Granby Reservoir but provides ancillary benefits in terms of water quality (DO, mercury).

Issue	Description	Proposed Mitigation/Enhancement/Other Measure	Agreements	Comment
Mercury	Mercury in fish tissue	• Monitoring in the Three Lakes • Granby water levels	• 1041 Permit • Carriage Contract	• The maintenance of higher levels in Granby Reservoir will help maintain higher DO levels at the bottom of the Reservoir, which in turns may reduce mercury mobilization from sediments. This measure was not designed for the purpose of improving mercury but may provide an ancillary benefit.
Nutrients in the Three Lakes	Additional nutrient loading from WGFP to the Three Lakes	• Water Treatment Upgrades in the Fraser River • Non-Point Source (NPS) nutrient reductions in the Willow Creek Basin • Monitoring/studies	• FWMP • 1041 Permit • ROD • Carriage Contract	• WWTP upgrades in the Fraser will result in year-round reductions in nutrient in the Fraser and Colorado Rivers (in addition to the decrease in load to the Three Lakes). These reductions are above and beyond the mitigation of impacts from WGFP and provide year-round enhancements to these rivers. • NPS reductions in the Willow Creek watershed will result in nutrient reductions in Willow Creek and further downstream in the Colorado River and provide benefits beyond the mitigation of impacts from WGFP. • Nutrient reductions to the Three Lakes also provide mitigation of impacts on clarity in Grand Lake and dissolved oxygen in the Three Lakes.

Issue	Description	Proposed Mitigation/Enhancement/Other Measure	Agreements	Comment
Streamflow and Aquatic Habitat in the Colorado River below Windy Gap Reservoir	Aquatic life concerns in the Colorado River below Windy Gap Reservoir (not related to water temperature)	• Participate in adaptive management and cooperative efforts • Site-specific stream restoration and enhancement (Colorado River from Windy Gap Reservoir to Williams Fork) • Flushing Flows • Windy Gap Bypass • Funding for Wild & Scenic Fund	• FWMP • FWEP • WGFP IGA • 1041 Permit • LBD IGA • Northern Water IGA • ROD • Carriage Contract • WG Bypass Funding Agreement	• Commitments to restore and enhance the aquatic environment will provide significant environmental benefits. • Although these commitments are attached to the WGFP, they are not related to impacts associated with the WGFP.

8.10 Net Water Quality Impacts Summary

This section reconciles results from the SCT analysis with mitigation and enhancement measures in order to provide an assessment of net indirect impacts resulting from the WGFP. This reconciliation (Table 47) shows only one area where a determination of significant degradation was made after taking into account minimization, avoidance, mitigation and enhancement measures.

Table 47 - WGFP Significant Degradation Summary

Determination of Significant Degradation	Is degradation avoided by mitigation?	Are enhancements provided?	Net effect including mitigation/enhancements
Colorado River downstream of Windy Gap Reservoir - Temperature	YES	YES	No significant degradation, net environmental benefit under cumulative effects
Colorado River downstream of Windy Gap Reservoir – Manganese (Water Supply)	NO	NO	Existing impairment (no available assimilative capacity). Significant (<1%) degradation.

The determination of significant degradation for manganese for the Water Supply standard is caused by existing impairment of the stream. Because no assimilative capacity remains in the stream under baseline conditions, the outcome of the AD review leads to a conclusion of significant degradation even though impacts from the WGFP on manganese are projected to be minimal (less than 1% of the BWQ as shown in Table 39 and Table 40).

As described in detail in section 8, many environmental benefits will come with the implementation of the WGFP under cumulative effects. These include:

- enhancements to water temperature in the Colorado River,
- a year-round decrease in TP levels in the Fraser and Colorado rivers as a result of WWTP improvements,
- flushing flows in the Colorado River that will benefit aquatic life,
- the implementation of coordinated and collaborative efforts to design and implement stream restoration efforts that will restore and enhance the aquatic habitat and aquatic life in the Colorado, Fraser and Williams Fork river basins,
- mitigation of existing dissolved oxygen impairment in Shadow Mountain Reservoir,
- long-term commitments to identify options to improve clarity in Grand Lake,
- a commitment and funding to assess the need for and construct a bypass to Windy Gap Reservoir to allow passage of flows, fish and sediments, or to dedicate funding to restoration efforts if the bypass is deemed unnecessary and
- long-term monitoring commitments including bioavailable mercury (measured as total), clarity in Grand Lake, nutrients and real-time temperature monitoring in the Colorado River.

All these enhancement measures provide a net environmental benefit to the rivers and water bodies affected by the WGFP.

9 Necessity Test

As described in the Purpose and Need of the FEIS ((U.S. Bureau of Reclamation, 2011b), the purpose of the Windy Gap Firming Project is to deliver a firm annual yield of about 30,000 AF of water from the existing Windy Gap Project to meet a portion of the water deliveries anticipated from the original Windy Gap Project and to provide up to 3,000 AF of storage to firm water deliveries for the MPWCD. Firm water deliveries from the Windy Gap Project are needed to meet a portion of the existing and future demands of the Project Participants.

Windy Gap Project water is currently diverted from the Colorado River just downstream of the confluence of the Colorado and Fraser rivers at Windy Gap Reservoir. Once collected, it is pumped to Granby Reservoir for storage and conveyance through C-BT Project facilities and ultimate delivery to Windy Gap Project allottees on the East Slope. Windy Gap water stored in Granby Reservoir is also released as requested to replace stream diversions or ground water use by MPWCD contract holders at various locations in Grand and Summit counties. The MPWCD water users do not take direct delivery of Windy Gap water, but rather use it to augment other water diversions.

In the original Windy Gap EIS, firm annual deliveries to the allottees of the Windy Gap Project were estimated to be about 48,000 AF, following conveyance and evaporation losses and allocations to the MPWCD.

Because each unit of Windy Gap water is entitled to 1/480th of the annual yield of the Windy Gap Project, a unit was expected to produce a yield of 100 AF per year. Actual Windy Gap yield between 1985 and 2004 averaged less than 10,000 AF per year, which is an average annual yield to the Project Participants of about 20 AF/unit, or about 20 percent of the anticipated deliveries (Boyle Engineering 2005a). As discussed in Section 3.5.1.4, Windy Gap pumping from 2005 to 2008 has increased the average annual yield to about 14,700 AF. Windy Gap diversions were less than allowable immediately following construction because demand was less than available supplies. Had Windy Gap unit holders used all available Windy Gap water, the average long-term yield (using hydrology from 1950 to 1996) would have been about 55 to 60 AF per unit (Boyle Engineering 2005a).

No Windy Gap water was diverted in 7 of the 23 years between 1985 and 2008 because of either a lack of available storage space in Granby Reservoir or Windy Gap water rights were not in priority during dry years.

During this period, no Windy Gap pumping occurred in 1986, 1996 through 2000, and in 2002; only 300 AF were pumped in 2004. The lack of pumping, with the exception of 2002 and 2004, was due to a lack of available storage space in Granby Reservoir and/or limited demand for Windy Gap water. No Windy Gap water was diverted in 2002 because the Project's junior water right never came into priority and a dry year in 2004 also limited pumping. Because of the inability of the Windy Gap Project to provide reliable yields in both wet and dry years, the current firm yield is zero. Firm yield is generally defined as the amount of water that can be delivered on a reliable basis in all years and is typically determined by yield in dry years. For the Windy Gap Project, lack of available storage space in wet years also affects yield.

A similar evaluation of the firm annual water storage and yield available for use by the MPWCD indicates its firm yield is essentially zero. Although water may be available for diversion for MPWCD in the early spring, there are a number of years when storage in Granby Reservoir is not available to hold its supplies. Because MPWCD uses its Windy Gap water to augment or replace previous water diversions, releases from Granby Reservoir typically do not occur until September or October. Consequently, Windy Gap water stored for the MPWCD during spring runoff in wet years is often spilled prior to its release for augmentation later in the year.

- Windy Gap allottees and the MPWCD have not been able to rely on Windy Gap water for water deliveries in some dry or wet years. A summary of the reasons why the annual firm yield and deliveries from the Windy Gap Project have been substantially less than 48,000 AF are as follows:
- In dry years, the Windy Gap Project has not been able to divert water because more senior water rights upstream and downstream have a higher priority to divert water and "call out" the more junior Windy Gap Project water right. In addition, the Windy Gap Project is required to bypass water to maintain certain minimum streamflows downstream of the Windy Gap diversion dam. Thus, the Windy Gap Project cannot divert if streamflows immediately below the diversion dam on the Colorado River are less than 90 cfs, if flows at the Williams Fork confluence are less than 135 cfs, or if flows at the Troublesome Creek confluence are less than 150 cfs.
- Under the contract between the Subdistrict, Northern Water, and Reclamation, water conveyed and stored for the C-BT Project has priority over water conveyed and stored for the Windy Gap Project. In wet years when the C-BT system is full, there is no conveyance or storage capacity in the C-BT system for Windy Gap Project water. Windy Gap Project water stored in the C-BT system is sometimes spilled from the system to make room for C-BT Project water. Thus, Windy Gap Project water cannot be stored or carried over in some wet years.
- The Windy Gap Project was built to meet both current and future needs of the Project allottees. During the years immediately after construction, some of the allottees' demands did not require the full use of their Windy Gap Project water, so not all available water was diverted. As demand increased, the need for Windy Gap Project water also increased.

While the inability to divert water in dry years was anticipated when the Windy Gap Project was constructed, the inability to divert and store during an extended set of wet years, such as the late 1990s, was not. Because of the deficiency in deliveries, Project Participants requested that the Subdistrict pursue measures through a joint Project to firm Windy Gap water deliveries. Project Participants determined that a cooperative Project was the most efficient means to firm Windy Gap water deliveries rather than each entity developing separate storage for its own share of Windy Gap water.

The evaluation of the water supplies and demands for each Project Participant indicates that projected water demand would exceed available firm yield in the near future. Project Participants have a firm water supply of about 141,000 AF and a demand of about 120,000 AF in 2005. By 2030, the cumulative water demand for all East Slope Project Participants is projected to reach about 205,000 AF, which would result in a shortage in firm yield of about 64,000 AF. Water demand for East Slope Participants is projected to increase to about 251,000 AF by 2050 and shortages in firm yield at that time would increase to more than 110,000 AF. An additional water demand of up to 17,000 AF by 2030 is projected for West Slope water users partially served by the MPWCD.

The lack of a reliable firm water supply would affect the ability of all of these entities to meet anticipated water needs in dry years. The Projected shortages in firm water supply over the 2005 to 2050 period are shown in Figure 36.

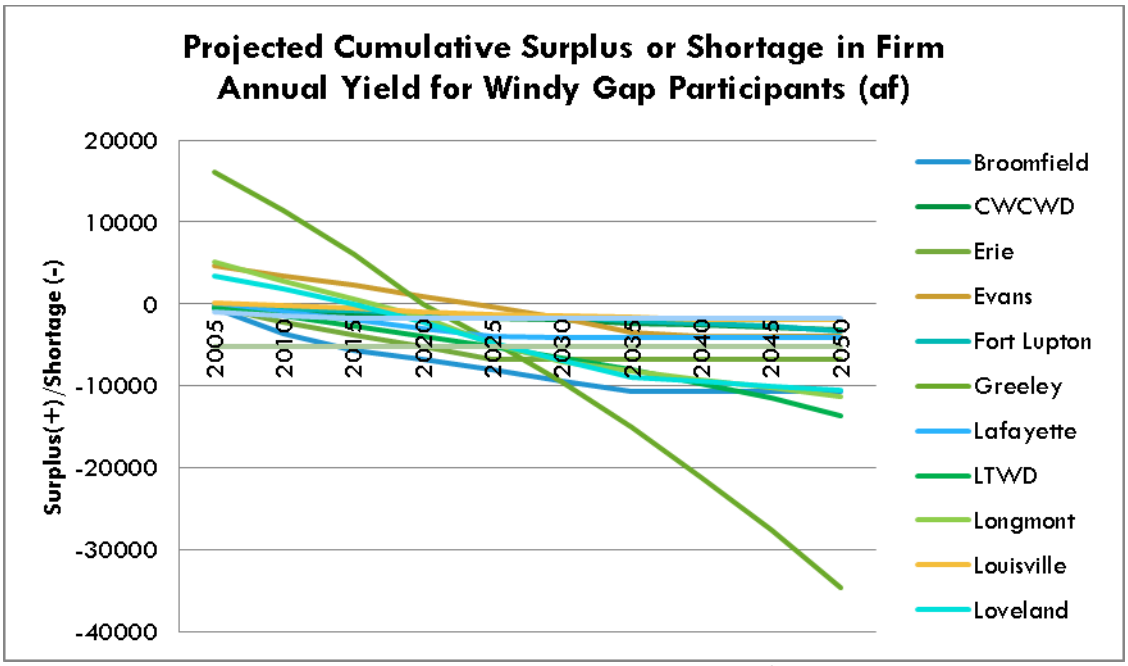

Figure 36 - Projected Cumulative Surplus and Shortage in Firm Annual Yield for Windy Gap Participants

Existing water supplies will meet the current water needs for most Project Participants during average years of precipitation, but supply shortages in dry years are expected to occur within the next 20 years for all of the Project Participants. For many East Slope Participants, a deficit in firm yield could occur soon, depending upon C-BT yields. Other Project Participants have a foreseeable future need for their Windy Gap water supply before 2025.

Project Participants have implemented a variety of effective conservation measures to reduce water demand. Additional improvements in water use efficiency and delivery systems are expected to continue in the future and are an important component in meeting future water supply requirements. While continued conservation is necessary, it would not eliminate the need for the proposed WGFP. Conservation measures may delay the timing for additional water deliveries, but would not change the ultimate need for additional water supplies. Projected future water requirements indicate that even with the WGFP, Participants will need additional conservation savings or for some Participants, additional sources of water to meet from about 10 to 65 percent of 2050 future water needs.

In summary, projected water demands indicate that the Project Participants individually and collectively will have a shortage in annual firm yield in the near future. The projected shortage in firm water supply supports the purpose and need of the proposed WGFP to firm about 30,000 AF of Windy Gap Project water for East Slope Project Participants and provide up to 3,000 AF firming storage of Windy Gap water for the MPWCD. The WGFP would provide about 10 percent of the cumulative water supply needs for the Participants in 2050. Other new sources of water including conservation measures would be needed to meet projected shortfalls.

Furthermore, as identified in the Draft Colorado Water Plan (Chapter 6), The Metro, South Platte and Republican Basins face a municipal gap that could begin as early as 2020 in the Lower South Platte. Future needs in the South Platte Basin as a whole are likely to increase by 340,000 to 505,000 acre-feet. With existing data, currently planned Projects leave a municipal water supply gap within the basin of 203,000 to 312,000. This assumes that identified Projects and processes are implemented at a relatively high success rate.

The Statewide Water Supply Initiative (SWSI), recognized water's critical role in supporting the quality of life and economic prosperity of all Coloradoans (CDM, 2011). The WGFP is one of the Identified Project and Processes (IPP) and it was concluded that implementing the IPPs is critical to minimizing the water supply gap.

Colorado's Draft Water Plan (CWCB, 2014) also recognized that available water, combined with land and labor result in economic prosperity and opportunity. There is statewide consensus that supporting environmental and recreational attributes is vital to local economies and Coloradan's quality of life and there is a clear benefit provided by Colorado's streams and lakes.

WGFP is also one of the 42 Projects and methods identified in the South Platte/Metro Basins to meet future municipal, industrial or agricultural needs (HDR, West Sage Water Consultants, 2014).

A report by Summit Economics and the Adams Group (Summit Economics and the Adams Group, 2009) demonstrates the high value of M&I water use on the Front Range, while acknowledging the trade-offs and value of water for other uses, including agriculture and the environment.

In summary, the WGFP is an essential element of Colorado's plan to meet future water needs. Extensive mitigation and enhancement commitments have focused on developing strategies that, as a whole, provide environmental and socio-economic benefits to the areas affected by the project on both sides of the Continental Divide. The LBD agreements, commitments to reduce water level fluctuations in Granby Reservoir, the 10,825 releases from Granby Reservoir and nutrient mitigation will lead to water quality and aquatic life improvements, over existing conditions, which will in turn support recreation and tourism activities central to the economic health of Grand County. The socio-economic benefits associated with the WGFP are also significant for the East Slope where ensuring the viability of the water supply is essential to maintaining a healthy and resilient economy. The construction of Chimney Hollow Reservoir also creates a new opportunity for recreation and the economy that it supports.

Reclamation issued a Record of Decision in December 2012 that authorizes necessary contracts and permits to implement the Proposed Action (Alternative 2) of the Windy Gap Firming Project, which consists of a 90,000 acre foot Chimney Hollow Reservoir on the East Slope along with the ability to store, or preposition, C-BT water in Chimney Hollow Reservoir. The ROD determined that the Final EIS satisfies the requirements of NEPA, including the necessary evaluation of alternatives. Furthermore, Reclamation determined that Alternative 2, Chimney Hollow Reservoir, along with implementation of the mitigation measures identified in the Final EIS will provide valuable environmental and socioeconomic benefits, and responds well to many of the issues identified by interested parties.

The NEPA process has demonstrated that the Windy Gap Firming Project is an important economic or social development. In addition, the Subdistrict, in conjunction with Reclamation, other state and local agencies and stakeholders, has evaluated alternatives to the project and adopted various measures to avoid, minimize, or mitigate the impacts of the project.

10 Agency Coordination

In preparation of the WGFP 401 Certification Application, Subdistrict staff coordinated with WQCD staff over a period of two years with a series of 10 meetings and conference calls. During these meetings a detailed inventory and review of existing water quality data took place along with discussion of appropriate methods to perform the antidegradation review and a review of the results of the analyses.

In addition, the Subdistrict has engaged with numerous state, federal, and local agencies to identify and address concerns with the project, as evidenced by the Plans and Agreements described in Section 8.8.

11 Construction Work

The Subdistrict will be developing a Stormwater Management Plan that will incorporate BMPs that will provide temporary and permanent erosion and sediment control measures according to 5 CCR 1002-82, §82.6(B)(2).

The Stormwater Management Plan will be provided before the start of construction for review and approval by the WQCD.

12 Conclusions

As summarized in section 9, the WGFP will results in significant degradation for dissolved manganese in the Colorado River below Windy Gap Reservoir (water supply standard). It is not anticipated that the increase in manganese concentrations would have any economic impact on downstream users considering the amplitude of the change which is less than 1% of the baseline water quality. The analysis did not show significant degradation for any other parameters.

Because there are instances where the AD review relied on qualitative assessment, there may be some uncertainty or questions regarding the conclusions that are reached. For this reason, a section addressing the necessity of degradation is included in Section 9.

The finding of significant degradation for manganese in the Colorado River is a consequence of the existing impairment and a reflection of the absence of assimilative capacity. As described in section 7.7.2, the projected increase in concentration with the WGFP under cumulative effects is less than 1% of the baseline water quality.

Section 8 provides a detailed discussion of all minimization, avoidance, mitigation, enhancement and other measures that will provide significant net environmental benefits to the Colorado River. These include:

- enhancements to water temperature in the Colorado River,
- a year-round decrease in TP levels in the Fraser and Colorado rivers as a result of WWTP improvements,
- flushing flows in the Colorado River that will benefit aquatic life,
- coordinated and collaborative efforts to design and implement stream restoration efforts that will restore and enhance the aquatic habitat and aquatic life in the Colorado, Fraser and Williams Fork river basins,
- mitigation of existing dissolved oxygen impairment in Shadow Mountain Reservoir,
- long-term commitments to identify options to improve clarity in Grand Lake,
- a commitment and funding to assess the need for and construct a bypass to Windy Gap Reservoir to allow passage of flows, fish and sediments, or to dedicate funding to restoration efforts if the bypass is deemed unnecessary and
- long-term monitoring commitments including bioavailable mercury, clarity in Grand Lake, nutrients and real-time temperature monitoring in the Colorado River.

Finally, section 9 describes the socio economic importance of the WGFP to meet future water needs of the South Platte basin and the extent of water shortages that are expected in this region and in Colorado as a whole. WGFP is one of the identified Projects and processes identified in the Colorado Water Plan to meet Colorado's water gap. Reclamation's ROD confirms that the requirements of the NEPA process have been satisfied and that Alternative 2 of the Windy Gap Firming Project, Chimney Hollow Reservoir, along with implementation of the mitigation measures identified in the Final EIS will provide valuable environmental and socioeconomic benefits.

The Subdistrict will be developing a Stormwater Management Plan that will incorporate BMPs that will provide temporary and permanent erosion and sediment control measures according to 5 CCR 1002-82, §82.6(B)(2). The Stormwater Management Plan will be provided before the start of construction for review and approval by the WQCD.

It is concluded that the identified degradation associated with the WGFP under cumulative effects is largely offset by the identified measures to avoid, minimize, mitigate the project impacts along with measures to enhance the environment, resulting in significant net environmental benefits associated with the Project.

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