COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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TO: Colorado Water Conservation Board Members

FROM: Lauren Ris, CWCB Director
Erik Skeie, Watershed and Flood Protection Section

DATE: November 19-20, 2025

AGENDA ITEM: 17. Bear Creek Lake Reallocation

Staff Recommendation:
This is an informational item only.

Background:

The Bear Creek Dam and Reservoir Project (aka "Bear Creek Lake") was completed in 1977 by the U.S. Army Corps of Engineers (Corps) and is located on Bear Creek at its confluence with Turkey Creek, approximately 10 miles southwest of Denver, Colorado in Jefferson County. The reservoir was authorized for the purposes of flood control, recreation, and fish and wildlife enhancement with a majority of the reservoir being used for flood control. The project's active capacity is 57,678 AF (at the spillway crest) and is currently operated at a maximum priority storage volume of 2,000 AF. The CWCB currently holds existing water rights for Bear Creek Lake decreed for piscatorial, recreational, municipal, domestic, industrial, and irrigation under case Nos. 79CW306 (1989 acre-ft) and 84CW167 (2,000 acre-ft).

In May of 2015, the Corps provided the CWCB with a draft Reconnaissance Study[1] evaluating the potential of reallocating up to 20,000 AF of space from flood control to multi-purpose storage. Based on the initial conclusions of the Reconnaissance Study, the Corps proposed initiating a feasibility study with the CWCB as the local sponsor. Feasibility study costs are split 50/50 between the Corps and the project sponsor.

At its November 2015 meeting, the CWCB Board approved including a request for up to $2,500,000 from the Severance Tax Perpetual Base Fund in the annual Projects Bill for the Bear Creek Reallocation of Storage Study. These funds were officially appropriated in Section 7 of SB16-174.

[1] Also known as a Section 905(b) Analysis, these studies are preliminary assessments of potential reallocation of storage space in Corps dams.

Currently, there are two active aspects of the reallocation process discussed in this memo:

1) Reallocation Feasibility Study with the Army Corps Engineers

2) Potential Water Rights Issues

Reallocation Feasibility Study

On August 30th, 2019 CWCB and the Corps entered into a cost share agreement on a $3 million Reallocation Feasibility Study.

CWCB suspended the work on the study after two issues came to light during that initial scoping meeting. First, the Corps needed to conduct a Risk Assessment before moving forward on a feasibility study. Army Corps staff completed this preliminary Risk Assessment in late September 2020 and concluded that the Reallocation Feasibility Study could proceed. Second, the State Engineer's Office (SEO) advised CWCB staff to work with the Corps on updating hydrology methods for the study. SEO, CWCB, and the Corps came to agreement on the hydrology in June of 2021, and the study resumed.

The Scoping Team Reconvened in August of 2021 and the first Public Scoping Meeting was held virtually on October 14th, 2021. There were over 200 participants, most of whom were local residents in Lakewood. The purpose of the meeting was to gather feedback on the proposed study alternatives.

The Corps proposed five study alternatives:

1. No Change

2. Increase Reservoir Capacity & Normal Operating Pool (up to 20,000 AF)
    a. Structural modifications to dam (e.g. dam raise and spillway raise) to increase reservoir storage for water supply.
    b. Excavate reservoir (remove accumulated sediment or deepen reservoir) to increase in-pool storage for water supply.
    c. Excavate forebays upstream of reservoir to increase storage capacity for water supply.

3. Reallocation of Existing Capacity (up to 20,000 AF)
    a. Reallocation of reservoir storage from flood control and/or flood surcharge zones to conservation zone for water supply.
    b. Reallocation of reservoir storage from multipurpose zone to conservation zone for water supply.

4. Operational Changes (Release More Water/Release Water Sooner)/Increase Normal Operating Pool
    a. Structural modifications to dam (e.g. lower spillway, widen spillway, raise spillway with fuse plug, modify outlet works) to increase dam freeboard.

b. Modify reservoir Water Control Plan and Tri-Lakes System Regulation Plan to release more water sooner to increase dam freeboard.

5. Nonstructural
    a. Nonstructural measures downstream of dam (e.g. floodproofing or relocation of structures) to decrease consequences.

Public comment during the meeting was largely in opposition to the study, citing recreation and environmental mitigation concerns related to any increase in water elevation.

The Corps is currently working on preliminary investigations of these alternatives.

It should be noted that the following points are key to determining whether or not an alternative is feasible:

- The Corps has a policy to evaluate social well being and quality of life in their Reallocation studies.
- Environmental Cost is analyzed for each alternative.
- A full hydrologic analysis is being conducted as part of this study, so while a preliminary look showed that on average 20,000AF of water is available, more detailed analysis is being conducted.
- The primary purpose of the dam is flood control. A feasible alternative can not impede the Corps' ability to mitigate flood risk downstream of the dam.

Recent Progress: The Corps has been conducting a hydrology analysis and storage yield analysis for various Reallocation amounts. The levels currently under investigation are:

1. 300 AF
2. 750 AF
3. 1,865 AF
4. 3,500 AF
5. 6,000 AF

It should be noted that the upper bound of 6,000 AF is where on site mitigation work is still possible. Using the threshold of on site mitigation is based on costs and public feedback.

The Corps presented preliminary cost estimates for the above reallocation amounts to CWCB Staff in September 2025. CWCB Staff met with Stakeholders interested in the project (Table 1) to determine which of these alternatives should be further investigated by the Corps as the study movess forward. Stakeholders are in support of CWCB working with the Corps on further investigation of the 300 AF and 6,000 AF volumes.

CWCB Staff also recently awarded a contract to Brown and Caldwell to support the study moving forward.

Table 1: Bear Creek Lake Reallocation Stakeholder Interest

Partner	Volume (acre-feet)
Brighton	6,200
Evergreen Metro District	200
Hidden Valley Water District	34
Foothills Parks and Recreation	65
Environmental Pool	4,550
TOTAL	11,049

Water Rights

In anticipation that the feasibility study may confirm that an additional 20,000 AF may be stored in Bear Creek Lake, the CWCB Board declared its intent to appropriate 20,000 AF of storage in Bear Creek Lake in March of 2016.

It was determined that partners be identified before an application was filed, and to that end Staff conducted several outreach efforts to build partnerships with local water users and determine interest in the project. Through these efforts the following entities have been identified as potential partners: City of Brighton, Evergreen Metropolitan District, Hidden Valley Water District, and Foothills Parks and Recreation District (Attachment 2). It should be noted that both Berthoud and Dacono are no longer interested in the project.

CWCB hired Brown and Caldwell to conduct the engineering required for a water rights application. Preliminary results are available (Attachment 2). Though the Corps will not include these results in the Feasibility Study, they have received Brown and Caldwell's results and methodology for consideration in their hydrologic analysis.

There are several legal issues to work through regarding water storage rights in Bear Creek Lake. Staff will continue to work with the Attorney General's Office.

Attachments:

1. Army Corps of Engineers September 2025 Presentation to CWCB Staff
2. Preliminary Future Operational Analysis by Brown and Caldwell

Attachment 1

Army Corps of Engineers September 2025 Presentation to CWCB Staff

BEAR CREEK DAM REALLOCATION GI STUDY

CWCB
In-Progress Review

Chris Fassero
Omaha District
25 August 2025

"The views, opinions and findings contained in this report are those of the authors(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation."

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STUDY BACKGROUND

- **Kickoff:** Feasibility Cost Sharing Agreement for study executed between USACE and CWCB on 30 August 2019.
- **Suspension:** 1st Iteration Planning Meeting held with CWCB, Colorado State Engineer, and City of Lakewood on 07 October 2019. Study suspended at CWCB's request from November 2019 to June 2021 to address concerns regarding dam safety considerations related to reallocation and questions regarding estimation of Probable Maximum Precipitation (PMP) and Inflow Design Flood (IDF).
- **Restart:** 2nd Iteration Planning Meeting held with CWCB, Colorado State Engineer, and City of Lakewood on 31 August 2021.
- **3x3 Exemption:** Assistant Secretary of the Army for Civil Works (ASA), approved 3x3x3 Exemption request that HQUSACE submitted for study on 10 November 2022 for an additional 57 months and $3.2M.
- **VTAM Addendum:** VTAM addendum was approved by NWD on 03 July 2024 to move TSP milestone 11 months while keeping overall schedule intact due to delays in completing hydrology analysis.

RISK-INFORMED DECISION OPPORTUNITIES

1. Evaluate Tri-Lakes system risk with reallocation. Is change from existing risk likely to be acceptable or unacceptable?
   a. Complete HEC-WAT model so alternatives can be evaluated.
   b. Evaluate whether with-project system risk would be acceptable or could be mitigated.

2. Evaluate downstream flood risk with reallocation. Will alternatives change flood risk and by how much?
   a. Proceed with hydrology results while advance ATR backchecks are in progress.
   b. Perform hydraulic analysis.
   c. Perform LifeSim/TotalRisk analyses.
   d. Evaluate whether with-project flood risk would be acceptable or could be mitigated.

RISK-INFORMED DECISION OPPORTUNITIES

3. Evaluate whether/how much Town of Morrison's proposed Bear Creek withdrawals for Red Rocks Ranch will change storage-yield analysis (projected future use is ~13x current use).
   a. Need evaluation/feedback from CWCB consultant.
   b. Revisit/revise storage-yield analysis.
   c. Evaluate whether expected future inflows can support reallocation.

4. Screen alternatives based on preliminary total cost.
   a. Develop preliminary estimates of likely capital and environmental/recreational resource mitigation investments associated with each alternative and incorporate into preliminary cost of storage estimates.
   b. For comparison, need input from CWCB regarding cost estimates for most likely non-federal water supply alternatives.

HEC-WAT MODELING RESULTS – ALT 5 (6K AF)

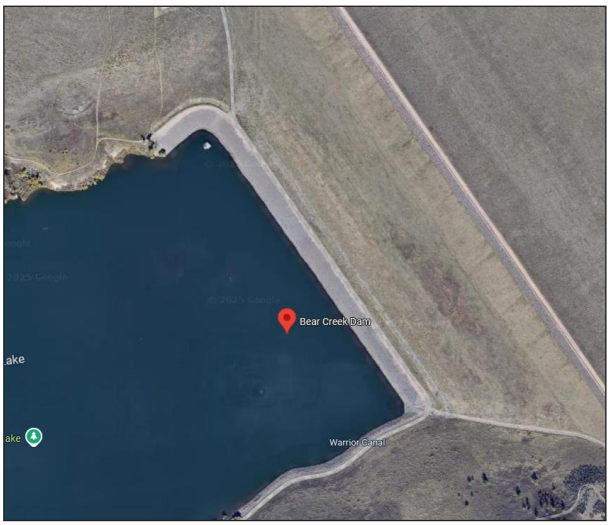
- Outflow- and stage-frequency curves remain unchanged from Baseline for Chatfield, Cherry Creek, and downstream Denver Gage.
- No transfer of risk to Chatfield or Cherry Creek for events up to 0.2% AEP (500-yr).
- No increase in Bear Creek spillway activation for events up to 0.2% AEP (500-yr).
- No increase in non-breach flood risk downstream of Bear Creek seen at Denver Gage for events up to 0.2% AEP (500-yr).
- Bear Creek spillway flows expected to be greater and more frequent for events less frequent than 0.1% AEP (1,000-yr).
- Did not analyze AEPs less frequent than 0.2% (500-yr) in detail; additional WAT runs required for reliable results at less frequent events.

HYDRAULIC MODELING & ECONOMIC ANALYSIS

- Because HEC-WAT model results show no increase in Bear Creek spillway activation for events up to 0.2% AEP (500-yr):
  - Hydraulic modeling of flows downstream of Bear Creek has not been performed.
  - Economic analysis of flood damages downstream of Bear Creek has not been performed.
- Events less frequent than 0.1% AEP (1,000-yr) expected to cause greater and more frequent spillway flows.
  - Less frequent events will need to be analyzed for any alternatives carried forward to quantify changes in non-breach flood risk as well as dam safety risk and incremental flood risk.

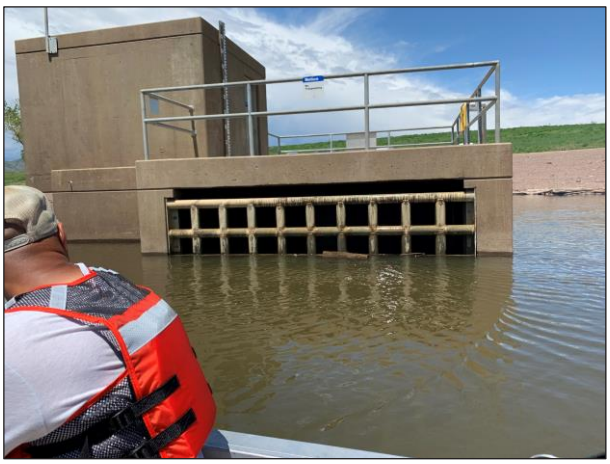
CAPITAL IMPROVEMENTS – TOE ROAD

- Reallocation would raise reservoir normal operating pool, requiring upstream toe road to be raised.
- Preliminary design assumptions for ROM cost estimates.
  - Toe road would need to be raised by same amount as pool raise.
  - Dam face below toe road would be armored with riprap (same as existing).



CAPITAL IMPROVEMENTS – INTAKE TOWER

- Reallocation would raise reservoir normal operating pool, requiring intake tower to be raised.
- Preliminary design assumptions for ROM cost estimates.
  - Alternative 1 (300AF) would not require intake tower raise. It would result in more frequent flooding of intake tower dry well, but impact would be tolerable.
  - For Alternatives 2 – 5, Intake tower would need to be raised by same amount as pool raise.
  - Intake tower would be replaced using same design but with increased wall thickness and reinforcement.



PUBLIC COMMENTS

OCT 2021 – MAR 2025

Current Stats

Total Comments: 528 (very few comments have been received since March)

Opposed: 94% (493) **For: 2%** (13) **Neutral/Unclear: 4%** (22)

Unique Responses: **82%** (434)

Form-Letter Responses: 18% (94)

Majority Contact Method: Email bear-creek-study@usace.army.mil

Summary

Themes in Opposition:
- Potential loss of Bear Creek Lake Park land (up to 615+ acres)
- Irreparable damage to riparian and wildlife habitat
- Negative recreational, educational, and aesthetic impacts
- Flood safety concerns immediately downstream of dam and for Denver metro area

Themes in Support:
- Very few comments support long-term water supply and proactive infrastructure planning

Key Takeaways:
- Public opposition is strong, organized (SaveBearCreekLakePark.org), and has engaged leadership
- Environmental, educational, and recreational concerns dominate
- Community favors less impactful solutions
- Public concerned with water being used to support development of eastward expanding cities

Alternatives Suggested by Public:
- Deepen existing pool
- Construct secondary pool
- Use gravel pits or aquifer storage
- Limit expansion to less impactful options

Path Forward

- Evaluate public input in decision-making
- Hold public meeting(s)
- Communicate results and plans transparently with stakeholders

ENVIRONMENTAL, RECREATION, AND MITIGATION – BLUF

Storage Increase	Wetland/Riparian Impact	Recreation Impact	Mitigation Cost (est.)
300 AF	Negligible – within current lake.	No notable impact – facilities and trails unaffected.	Minimal (<$100K) – lowest mitigation needs.
750 AF	Negligible – less than 0.2 acres lost wetlands and less riparian wetlands lost.	No notable impact – facilities and trails unaffected.	Very Low ($100K's) – 2nd lowest mitigation needs.
1,865 AF	Low – a few acres of riparian area inundated at edges.	Minor trail adjustments in low areas; park usage largely unchanged.	Low (≈ $1-3M) – minor habitat/trail mitigation.
3,500 AF	Moderate – on the order of ~100 acres flooded (valley bottom habitat).	Noticeable – some trails and picnic sites flooded or cut off.	Moderate (≈ $5-15M) – restore some habitat, reroute trails.
6,000 AF	High – significant area inundated (~150+ acres; ~0.5 mi of streams lost).	Major – multiple miles of trails and recreation zones affected.	High (≈ $20M+) – extensive mitigation & relocation required.

Comparative Impacts & Costs by Alternative
(Approximate values: Impact acreage and costs are rough estimates for comparison; actual figures will depend on final design and mitigation requirements.)

Source: The Chatfield Reallocation Project documents and USACE Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS).
Note: **It is likely that we will be able to mitigate on site.** Wetland credits in Jefferson County can range from $60,000 to $160,000 and was used to estimate on-site mitigation. It will likely be on the lower end. Upland impacts range from $10,000 to $60,000 based on numbers taken from Chatfield Project. Both ranges depend on quality of habitat.

ENVIRONMENTAL, RECREATION, AND MITIGATION – DETAILS

Alternative: 300/750 AF Expansion (Smallest)

Environmental: **300 AF** - *Negligible impact.* Water level increase stays within existing reservoir footprint; no meaningful habitat loss. **750 AF** - *Minimal impact*. Slight rise in water level stays largely within existing reservoir footprint. Negligible new inundation of wetlands/riparian areas and most sensitive habitat remains intact.

Recreational: **300 AF** - *No impact.* Trails and facilities remain unaffected. **750 AF** - *No major effects*. Park facilities and trails remain essentially unaffected at this scale. Only minor shoreline adjustments (if any) would be needed for boat ramps or beach areas.

Mitigation: **300 AF** - *Minimal cost.* No significant mitigation or infrastructure changes needed; easiest option to implement. **750 AF** - Low *cost*. Little to no mitigation required aside from minor habitat enhancements. No significant infrastructure moves would be needed. **These alternatives would have minimal mitigation efforts likely under one million dollars.**

Alternative: 1,865 AF Expansion (Minor)

Environmental: *Low impact*. Expands pool marginally into riparian fringes. A few acres of wetland or cottonwood habitat at lake edge would convert to open water, but changes would be mostly confined to existing floodplain.

Recreational: *Minor impacts*. Possible periodic flooding of low-lying trail segments adjacent to current shoreline. Most trails, picnic areas, and park amenities would be mostly unaffected or could be rerouted around any slightly enlarged shoreline.

Mitigation*: Low cost*. Mitigation needs are limited – e.g,. small-scale wetland restoration (to compensate for lost patches) and minor trail re-alignments. **Expected to be on order of 3.5 million dollars or less.**

ENVIRONMENTAL, RECREATION, AND MITIGATION – DETAILS

Alternative: 3,500 AF Expansion (Moderate)

Environmental: *Moderate impact.* Inundates a larger area (~100+ acres of additional footprint), including more riparian habitat along Bear Creek. Some cottonwood stands and wetlands in valley bottom would be lost, though majority of park's habitat would remain above water.

Recreational: *Noticeable impacts.* Higher water could fragment several trails and inundate some picnic areas. Portions of popular paths along Bear Creek and Turkey Creek would need rerouting or boardwalks. Core facilities (e.g., parking, campground) would likely be unaffected, but visitor access around enlarged lake would be disrupted.

Mitigation: *Moderate cost.* Would require habitat mitigation (e.g., restoring wetlands upstream for acres lost) and recreation improvements (building new trail sections, relocating picnic tables). **Rough cost on order of $10 million to offset environmental losses and rebuild park amenities.**

Alternative: 6,000 AF Expansion (Largest under consideration)

Environmental: *Significant impact.* Enlarges lake substantially and approximately 150 to 200 acres of additional land would be inundated. Portions of Bear Creek and Turkey Creek would be submerged (approx. ~0.5 mile of stream corridor combined), eliminating riparian and wetland vegetation in those areas. Wildlife habitat loss would also likely be significant.

Recreational: *High impact.* Floods a broad swath of park's valley floor. Multiple trail miles would be affected, which would likely require closure or rerouting of key trails along creek. Several picnic areas and fishing access points along current shoreline would be underwater. Recreation use would be significantly altered, concentrating activity on higher ground.

Mitigation: *High cost.* Extensive mitigation measures needed. This includes large-scale wetland and riparian habitat restoration to compensate for losses, as well as relocation or replacement of park infrastructure (trails, footbridges, possibly boat ramp). **Costs are expected in tens of millions; by comparison, Chatfield Reservoir reallocation (~20.6K AF) required about $171 million in environmental/recreation mitigation.**

ALTERNATIVES – ROM COST ESTIMATES

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Non-Fed 1	Non-Fed 2	Non-Fed 3	Non-Fed 4
Yield (ac-ft)	300	750	1,865	3,500	6,000	5,390	4,400	3,200	1,770
Capital Costs	$100.0K	$43.2M	$51.8M	$64.4M	$79.7M	$43.4M	$122.5M	$100.0M	$25.0M
Annual Costs									
Storage Reallocation	$132,198	$330,496	$821,834	$1,542,316	$2,643,970				
Toe Road Raise	N/A	N/A	$253,120	$417,613	$608,169				
Intake Tower Raise	N/A	$1,670,881	$1,680,656	$1,696,951	$1,712,923				
Mitigation	$3,887	$7,773	$77,731	$388,655	$777,310				
OMRR&R Allocated to Storage Reallocation	$6,630	$16,575	$41,216	$77,348	$132,597				
Total Reallocation/ Project	$142,715	$2,025,725	$2,874,587	$4,122,883	$5,874,969	$2,549,982	$7,191,361	$5,068,318	$1,467,869
Reallocation/Project per ac-ft	$476	$2,701	$1,541	$1,178	$979	$473	$1,634	$1,584	$829

Non-Fed 1 – Erie Reclaimed Water – increase water reclamation capacity.
Non-Fed 2 – ACWWA Flow Project – renewable water rights, additional storage and water treatment capacity, supply wells, and delivery improvements.
Non-Fed 3 – ECCV Northern Project Phase 3 – renewable water rights, additional reverse osmosis treatment capacity, and delivery improvements.
Non-Fed 4 – Union Reservoir Enlargement – increase reservoir storage from 12K AF to 32K AF.

NOTE: Annual costs are spread over 50 years.

Attachment 2

Preliminary Future Operational Analysis by Brown and Caldwell

Brown AND Caldwell

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Technical Memorandum

Prepared for: Colorado Water Conservation Board

Project Title: Bear Creek Lake Water Rights

Project No.: 154220.002

Technical Memorandum

Subject: PRELIMINARY Future Operations Analysis

Date: September 21, 2021

To: Mr. Erik Skeie, Project Manager, Colorado Water Conservation Board

From: Meg Frantz, Modeling Task Manager
Zach Wengrovius, Project Engineer
Beth Albrecht, Project Engineer
Matt Lindburg, Project Manager

Copy to: Chris Fessaro, Rachel Schulz, Kathryn Seefus, U.S. Army Corps of Engineers (USACE)

Section 1: Introduction

The U.S. Army Corps of Engineers (USACE) is conducting a general investigation into feasibility of reallocating flood control space in Bear Creek Lake to other purposes. The Colorado Water Conservation Board (CWCB) is pursuing a junior water storage right that will utilize this space in Bear Creek Lake. The water right will serve multiple participants. In the analysis of the water right, each participant was assigned a portion of the water right according to their stated needs.

This memo describes a reservoir modeling effort by Brown and Caldwell to understand performance of individual storage pools with respect to participants' objectives, and to predict total reservoir content fluctuations. Brown and Caldwell and CWCB met with interested parties in the fall of 2018 to discuss their needs, the size of pool they were interested in, and to solicit operational information to incorporate into the model. The magnitude and rate of content fluctuation is of interest to the USACE as well as the City of Lakewood and its park managers. In addition, the model demonstrates pool size required to meet a minimum downstream flow requirement that is anticipated as a project mitigation requirement. Note that a specific, minimum downstream flow requirement has not yet been determined, and the required downstream flow rates used for the purposes of this analysis are likely conservative and are subject to future revision.

The purpose of this memo is to summarize and present model results for the total content of Bear Creek Lake. Operation and performance of individual participant pools is considered confidential information, so is not discussed in detail. Furthermore, USACE's interest is in overall operating levels and fluctuation rather than individual pool fluctuations.

Section 2: Description of Model

The model is a daily time step reservoir mass balance model implemented in Excel. The model includes historical inflows, downstream call records, evaporation losses, and lake levels, and it accounts for deliveries to downstream water rights and the current stage-storage-area relationship. The study period for the model is January 1986 through December 2016. The period includes both wet years (1995, 2015) and dry years, including the multi-year dry sequence 2000 through 2003. The period was selected based on availability of gage records used to estimate time series of total reservoir inflow.

Based on interest conveyed by potential partners, Bear Creek Lake was modeled with the operating pools listed in Table 1. The total amount of storage modeled for potential partners (including the Environmental Pool) is 16,965 AF. The model allows the participant pools to be used for storing senior water rights from sources outside of Bear Creek Lake and for storing unappropriated inflows to Bear Creek Lake under a new, junior storage water right.

Table 1. Bear Creek Lake Operating Pools	
Pool	Pool Size (AF)
Berthoud	3,000
Brighton	6,200
Dacono	3,000
Evergreen Metropolitan District	100
Foothills Park and Rec	65
Hidden Valley	50
Environmental Pool	4,550
Total of Participant Pools:	16,965
Historical Pool	varies

The Historical Pool refers to the combined historical contents in Bear Creek Lake, meaning water owned by CWCB, Lakewood, the dead pool, and at times, the flood pool. In the model, the Historical Pool is operated as it did historically, with all new participant operations added "on top" of the existing pool. The inflow that was stored in the reservoir during runoff events (i.e., when historical change in storage was positive) was not available to fill participant accounts. Sections below describe the logic applied by the model to place water in storage, release water from storage, and account for evaporation.

2.1 Storage of Participants' Senior Water

Some participants own senior water rights from other sources that they wish to store and manage using Bear Creek Lake. At least one participant is planning on using reallocated space in Bear Creek Lake without participating in the new water right. Participants with senior water provided year-by-month estimates of yield that they would store in Bear Creek Lake.

Senior water right yield was added to each applicable owner's storage account at the beginning of the time step, before junior water was allocated, subject to capacity of the account at that time. Storing a participant's senior water diminished that participant's remaining capacity in their account, but it did not reduce the total available inflow to be allocated among participants.

2.2 Allocation of Unappropriated Inflow

Unappropriated flow was developed outside the model from inflow time series (partially synthesized, particularly on Turkey Creek), bypass records and requirements, and daily call records. The model distributed the unappropriated inflow to participants with the objective of exercising the CWCB right to the fullest extent within volumetric limits of a fill and refill right and distributing water to participants in proportion to their ownership in the right. These two objectives are at times at odds with one another because the participant pools are depleted under different rates and patterns. If one participant pool has less available capacity than the participant's pro-rata portion of the inflow, that participant's excess portion of the water right should be available to other participants.

The model observed an annual fill limit of 16,900 AF and a refill limit of 16,900 AF for the junior right. November 1 was the beginning of the administrative year at which time available total storage volume was computed as the fill limit volume less the combined contents of participants' accounts. This value was

decremented each day by the available inflow, whether or not it was stored, to simulate paper fill[1] of the decree when water is available but not appropriated.

The modeling logic for the annual fill limit counts all November 1 content as carryover, which is not correct to the extent that the accounts hold senior water on that day. Because Brown and Caldwell did not have enough information to operate (release) senior and junior water differently on behalf of participants, separate senior and junior accounts were not maintained in the model. The simplification may introduce error into a yield analysis, but error may be limited to the moderately wet year following a dry year or years. As participants develop more information about when and how they would use their various sources, the model can be refined.

It should be noted that some existing water rights decrees identify Bear Creek Lake as an alternate location to store senior water rights. However, to Brown and Caldwell's knowledge, only one water user (outside of the CWCB) currently has a contract with USACE for storing senior water in the reservoir. Operations of that water right would be reflected in the historical pool incorporated into the model. Other water rights that could be stored in Bear Creek Lake via their decrees were not represented in the model, because it is unknown whether contracts with USACE to store those rights will ever be sought. In addition, the CWCB has a water right for storage in Bear Creek Lake. This water right was not specifically operated in the model, because its operation is reflected in the historical pool.

2.3 Net Evaporation

Evaporation was computed based on Bear Creek Lake's surface area and daily net loss rates that CWCB currently uses for accounting pursuant to their water right (Colorado water court case no. 14CW3127). The net loss rate is calculated from gross monthly evaporation specified in a document entitled *Memorandum of Understanding Between the United States and the State of Colorado On Regulation of Bear Creek Dam and Reservoir (revised March 1988)* and average monthly precipitation, converted to daily values.

The area-capacity table used to calculate surface area was from the USACE Water Control Manual Bear Creek Dam and Reservoir (February 2018). At each time step, the model assigned a portion of total reservoir evaporation to each pool, in accordance with the pool content's portion of total reservoir storage at the time. Exception to this rule occurs when there is water in the historical flood pool, in which case evaporation is attributed entirely to the flood pool.

2.4 Reservoir Releases

At each time step, each pool released the lesser of available pool content and pre-determined demand, as provided by the participant. Demand at the reservoir for downstream users included the transit losses administered by the Water Commissioner, in addition to the contemplated delivery at the downstream diversion.

The historical pool was assumed to operate as it has in the past. Outflow was computed as the residual term in the mass balance of historical inflow, outflow, change in storage, and evaporation. After participant pool and historical releases and bypasses were determined or estimated, the model checked to see whether a minimum fish flow was met below Bear Creek dam. Colorado Parks and Wildlife (CPW) suggested that for the initial modeling, an instream flow demand of 15 cfs from April 1 through October 15 and 7 cfs from October 16 through March 31 be incorporated. This demand is subject to revision after additional fieldwork. When total outflows for all other purposes were below the minimum, the model allowed additional release from the

[1] When the owner of a storage right foregoes in priority water, the Division of Water Resources administrators typically count foregone water against the fill limit. This is referred to as a "paper fill".

environmental pool. The operation was included in this study to determine the pool size needed to meet the downstream flow rates suggested by CPW throughout the study period. The model was run iteratively to determine that a 4,550 AF pool was needed.

Section 3: Results

3.1 Model Results

Figure 1 shows the time series of inflow stored historically in orange, superimposed on total inflow stored in Bear Creek Lake. Accordingly, the indigo represents inflow stored in the reallocated pool for all participants in aggregate. This stored inflow includes water stored pursuant to the junior right as well as senior rights described in Section 2.1. Storage under senior rights represents a very small portion of the total amount stored. Monthly total inflow to storage is given in Table 2.

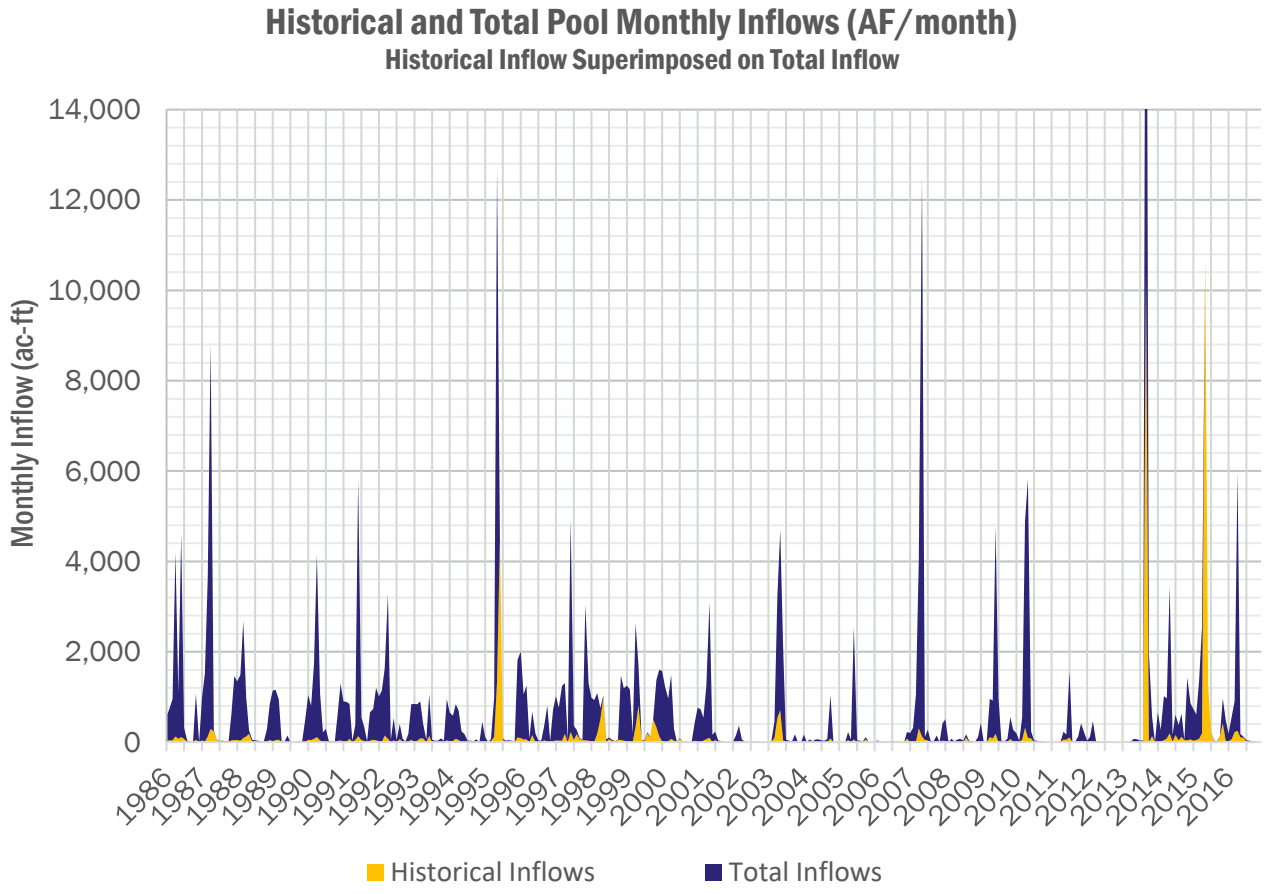

Figure 1. Monthly Inflow to Storage

Table 2. Monthly Total Inflow to Storage (AF)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1986	581	734	955	4,205	1,094	4,620	317	32	19	9	1,071	0	13,638
1987	976	1,523	3,637	8,813	251	64	28	31	18	9	631	1,461	17,443
1988	1,345	1,494	2,671	1,003	262	53	37	32	18	9	288	852	8,063
1989	1,134	1,160	946	19	12	149	3	8	2	18	17	524	3,993
1990	1,043	805	1,733	4,155	1,072	218	293	32	18	9	631	1,295	11,304
1991	903	888	844	30	379	5,819	548	338	18	664	732	1,202	12,365
1992	1,009	1,142	1,635	3,270	48	537	37	403	74	9	187	841	9,191
1993	845	844	905	409	53	1,058	53	31	30	81	31	951	5,291
1994	656	586	843	695	235	185	36	32	18	64	6	449	3,804
1995	110	6	71	980	12,710	4,503	81	36	49	34	15	1,821	20,415
1996	2,012	1,058	1,249	84	678	191	37	31	341	804	35	715	7,236
1997	1,017	764	1,243	1,306	50	4,923	357	276	87	56	3,050	1,305	14,434
1998	982	935	1,088	759	1,029	60	106	56	18	62	1,471	1,191	7,758
1999	1,248	1,165	206	2,630	1,698	57	39	217	127	510	1,378	1,603	10,878
2000	1,571	1,228	965	1,489	295	4	90	1	14	1	0	441	6,100
2001	759	729	544	1,235	3,091	168	230	39	19	9	1	0	6,822
2002	0	163	368	59	13	5	3	15	9	4	0	0	639
2003	0	2	466	3,217	4,692	2,115	56	31	21	171	5	0	10,777
2004	167	0	63	18	59	59	36	33	66	1,042	20	0	1,564
2005	0	0	4	222	58	2,548	38	32	19	112	1	0	3,034
2006	0	39	4	8	14	5	23	14	15	8	1	227	356
2007	203	317	1,053	4,024	12,515	118	274	31	18	143	1	415	19,112
2008	507	0	73	18	57	72	36	177	31	15	0	109	1,096
2009	425	0	4	958	915	4,778	977	31	19	74	554	272	9,008
2010	197	34	551	4,898	5,827	239	37	32	17	8	0	0	11,841
2011	0	0	5	8	229	165	1,563	14	14	127	418	213	2,755
2012	36	119	463	13	20	5	3	2	2	1	0	0	665
2013	0	2	4	23	75	60	36	43	24,319	1,990	567	2	27,121
2014	663	270	1,015	966	3,449	157	605	378	627	54	1,428	864	10,475
2015	731	603	1,362	2,545	10,619	1,292	246	30	18	141	968	494	19,049
2016	185	571	910	5,990	183	118	36	31	17	8	0	10	8,062
Avg	623	554	835	1,744	1,990	1,108	202	80	841	201	436	557	9,171

Figure 2 is a pool hydrograph for the historical pool superimposed on a hydrograph of the entire reservoir content. The reservoir critical period is from May of 1999 to May of 2007, during which content ranges from approximately 19,700 AF to 2,400 AF before returning to over 19,000 AF in storage.

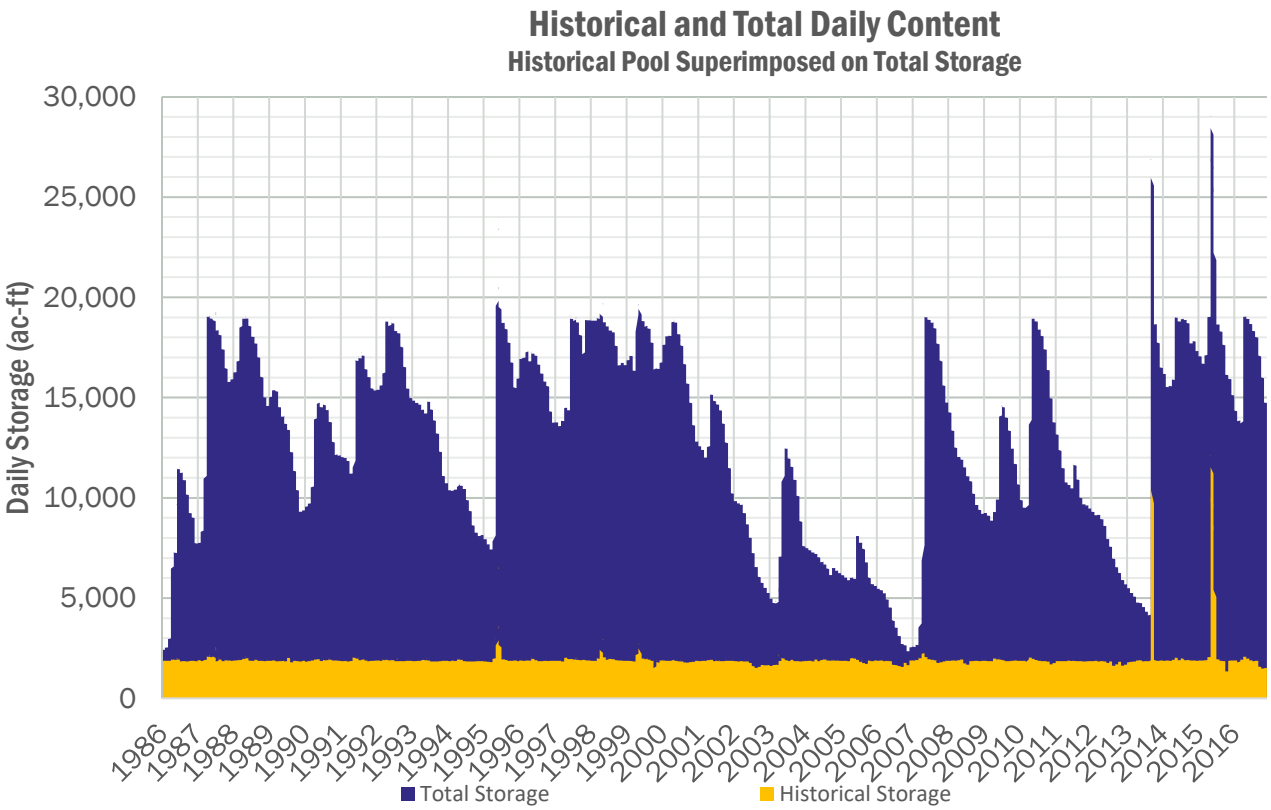

Figure 2. Daily Content

Figure 3 shows daily reservoir elevation:

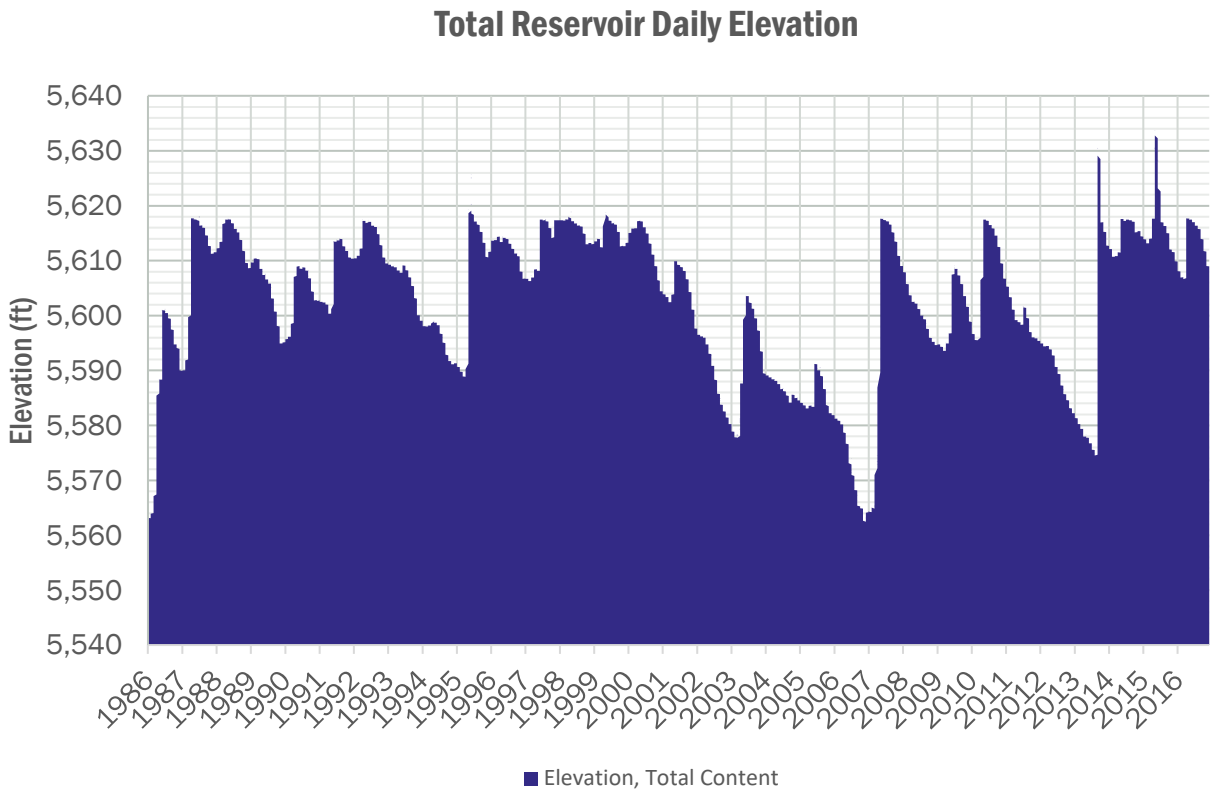

Figure 3. Daily Reservoir Elevation

3.2 Comments

- Water is available and stored generally between November and April or May. Storage is limited in summer months by lack of physical flow and downstream senior water rights.
- The model suggests a storage to yield ratio of 4.9:1 for the reallocated space.
- Storage to yield ratio and firm yield reflect not only variability but also sequential properties of both inflow to and outflow from a reservoir. If the inflow time series in this model was re-ordered, the yield would be affected. Said another way, a different set of inflows with the same mean and standard deviation as the modeled inflows would result in a different yield.
- Minimum total water in storage over the modeling period was approximately 2,340 AF.
- Within-year fluctuations are typically 10 feet or less, but when unappropriated winter and spring inflow is minimal, these 10-foot changes become additive. Water level fluctuations are frequently multi-year rather than seasonal.

References

U.S. Army Corp of Engineers, Omaha, Nebraska. Water Control Manual Bear Creek Dam and Reservoir, South Platte River Basin Colorado. February 2018.

Case No. 14CW3127. Findings of Fact, Conclusions of Law, Judgment and Decree of the Water Court. December 4, 2017.

Memorandum of Understanding Between United States of America and the State of Colorado on Regulation for Bear Creek Dan and Reservoir. March 1988.