City of Loveland 2020 Raw Water Master Plan

Loveland
Water and Power

November 2020

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UNIT ABBREVIATIONS:

AF	Acre-feet or acre-foot
cfs	Cubic feet per second
gpcd	Gallons per capita per day
l	Liters
mg	Milligrams
MGD	Million Gallons per Day
sf	Square feet
yr	Year

Acronyms and Abbreviations:

1.	108/354 decrees	2000CW108/2003CW354 decrees
2.	202A decree	82CW202A decree, replaced by 2000CW108/2003CW354 decrees, but still used as a collective name by the City for that set of decrees
3.	392 decree	2002CW392 decree
4.	Ag	Agriculture
5.	Barnes	Barnes Ditch, part of the Greeley Loveland Irrigation Company
6.	BTDM	Big Thompson Ditch and Manufacturing (Company)
7.	BTR	Big Thompson River
8.	Buckingham	George Rist Ditch (aka Buckingham Ditch)
9.	CBT	Colorado Big Thompson (Project)
10.	CC	Cash Credits
11.	CHFC	Charles Hansen Feeder Canal
12.	Chimney Hollow	Chimney Hollow Reservoir (aka Windy Gap Firming Project)
13.	Chubbuck	Chubbuck Ditch, part of the Greeley Loveland Irrigation Company
14.	CIL	Cash-in-Lieu
15.	Council	City Council
16.	Farmers	Reorganized Farmers Ditch Company
17.	George Rist	Buckingham Ditch (aka George Rist Ditch)
18.	GLIC	Greeley/Loveland Irrigation Company
19.	GMA	Growth Management Area
20.	GRGR	Green Ridge Glade Reservoir
21.	Home Supply	Consolidated Home Supply Irrigating and Reservoir Company
22.	LGWR	Loveland Great Western Reservoir
23.	LIRF	Lawn Irrigation Return Flows
24.	Louden	Louden Irrigation Canal and Reservoir Company
25.	LWP	Loveland Water and Power Department
26.	LUC	Loveland Utilities Commission
27.	M&I	Municipal and Industrial
28.	Municipal Subdistrict	Northern Colorado Water Conservancy District Municipal Subdistrict
29.	NEPA	National Environmental Policy Act
30.	Northern Water	Northern Colorado Water Conservancy District
31.	NWSF	Native Water Storage Fee
32.	R&G	Rist and Goss
33.	RWMP	Raw Water Master Plan
34.	RWSYA	Raw Water Supply Yield Analysis
35.	South Side	South Side Irrigation Company
36.	Strategic Planning	City of Loveland Development Services Department, Division of Community and Strategic Planning
37.	SWE	Spronk Water Engineers
38.	USBR	United States Bureau of Reclamation
39.	Water Bank	Loveland Water Bank
40.	WG	Windy Gap
41.	WGFP	Windy Gap Firming Project (aka Chimney Hollow Reservoir)
42.	WRF	Water Reclamation Facility
43.	WTP	Water Treatment Plant

1. INTRODUCTION

The Loveland Utilities Commission (LUC) and City staff have been involved since 1981 in planning activities directed toward meeting the City's future raw water needs and to identify means to effectively manage the City's existing and future sources of raw water. This report builds on work performed by the former Loveland Water Board, City staff, and the engineering consultant, Camp, Dresser & McKee in the *Drought Study* report accepted and approved by City Council in 1988. One recommendation of that study, which is now accomplished, was to provide increased raw water storage for the City. Following years of planning, design and construction, the City enlarged its storage in Green Ridge Glade Reservoir (GRGR) from its original 600 acre-feet (AF) capacity to its current storage capacity of approximately 6,835 AF at the normal high-water line with completion of construction and commencement of first fill occurring in 2004. GRGR is located about seven miles west of the City, in the valley above Chasteen's Grove Water Treatment Plant (WTP).

FIGURE 1-A: Expanded Green Ridge Glade Reservoir with 6,835 AF Storage Capacity

The original City of Loveland *Raw Water Master Plan (RWMP)* was designed as a tool to help the City Council determine that the steps necessary to assure the City's estimated future demands for raw water are met. The *RWMP* presented and analyzed alternative projects and provided guidelines for ongoing evaluation of those alternatives regarding which ones best meet those future demands. The City anticipated revisiting the *RWMP* periodically and updating it based on the City's future water supplies and demands. Part of this process was to look at the future availability of various sources of raw water and the most feasible way of utilizing those sources as modelled by Spronk Water Engineers in the Raw Water Yield Model and reported in the *Raw Water Supply Yield Analysis*. This report reflects the second update to the *2005 RWMP*.

This update to the *RWMP* follows some significant or anticipated events and actions since the 2012 update:

- **Economic Downturn Followed by Economic Recovery**
  Following the economic downturn that started in 2008, development slowed significantly. Between 2008 and 2012 only two significant water dedications occurred. Beginning in 2013 through 2019, Loveland experienced an average annual growth rate of approximately 2.1%.
- **New Water Court Filing under Conditions of the Decree in Case No. 2002CW392**
  The City anticipates filing an application with the Water Court to add recently acquired water rights in a new decree under the conditions of the 2002CW392 decree completed in 2010.
- **Drought & Flood Events**
  Although not as severe as the historic drought of 2002, a significant drought occurred in 2012 and lasted until the historic flood of September 2013. A minor drought event occurred in 2018 resulting in a hot and relatively dry summer.
- **Windy Gap Firming Project Permitted**
  The Windy Gap Firming Project (WGFP) is fully permitted and final design is essentially complete. Construction is anticipated to begin upon resolution of a pending lawsuit in federal district court.
- **Downstream Storage Reservoir**
  In February 2019, the City purchased approximately 120 acres that includes a lined gravel pit, estimated to hold approximately 1,600 AF of storage. Previously, on December 21, 2018, the City had filed an application for a conditional water storage right at this site (Case No. 2018CW3215). This is now referred to as the Loveland Great Western Reservoir (LGWR).
- **Lawn Irrigation Return Flows**
  In April 2019, the City filed an application for a Lawn Irrigation Return Flows (LIRFs) decree (Case No. 2018CW3193) for the quantification and use of return flows from Loveland's fully-consumable sources. This case is still pending in the Water Court.
- **Loveland Gard Right**
  Case No. 07CW325 was decreed on September 15, 2015, transferring 1.0 cfs of a No. 1 right owned by the City from the Home Supply Ditch. This right will net approximately 80 AF of consumptive use annually for the City.
- **Rebuilt Diversion Dam with Home Supply Ditch Company**
  The Home Supply diversion dam in the Big Thompson River, from which Loveland diverts water directly into the Water Treatment Plant, was heavily damaged in the September 2013 flood. The City partnered with Home Supply Ditch Company to design and rebuild the damaged sections and to add a controlled spillway structure. In addition, non-flood related maintenance was performed to ensure the continued structural integrity of the dam.

1.1 Guiding Principles

Certain principles as expressed to Staff by Council beginning with the *Phase I – Drought Study* by Camp Dresser & McKee in 1986, and as modified or expanded during discussions on the *2005 RWMP*, and the *2012 RWMP* update have guided the participants in this work. It is the City's purpose to continue to:

- Acquire and maintain a raw water supply sufficient to meet the demands of the City at a level of a 100-year drought without curtailment as the City expands into the Growth Management Area.

- Develop a diversified water supply portfolio consisting of water rights from both the South Platte River Basin (specifically from the Big Thompson River) and from the Colorado River basin.
- Develop flexible raw water strategies that enable the City to respond to changes in supply and demand conditions.
- Formulate and apply City policies, taking into consideration the overall impacts on all parties.

1.2 Background

The City refers to its raw water resources as its water rights portfolio. The City has required water rights as a condition of annexation since 1960. Depending on their yields in acre-feet of raw water per share/right/unit/inch for the various water sources, different credit values are applied. Changes to the raw water requirements, ditch share credits, and the Cash-In-Lieu (CIL) of raw water fees have occurred in the past and will continue to change as the City grows.

> The City's water supply is designed to adequately meet a 1-in-100-year drought event without curtailment.

Over the years, these changes have generally allowed greater flexibility in the timing of water rights payments by developers and provided greater equity in quantifying the requirements. A brief summary of the requirements, credits and CIL fees as they have changed over time are presented in **Appendix I**.

Key assumptions made in the *2020 RMWP* are included below:

- **Future Demands:** Future water demands will be adequately met by the firm yield of the City's water supplies up to a drought event with an average recurrence interval of 1-in-100 years.
- **Existing Growth Management Area Basis:** The current Growth Management Area (GMA), as last updated by the City Council in 2017 and officially revised on October 24, 2017, is used as the limit of future development. See **Figure 1** in **Appendix V** for the Water Service Area and Growth Management Area. However, it is recognized that future redevelopment could increase demands within that area if densities increase. The City's water utility serves a portion of the area within the GMA and limited areas outside the GMA. Service will primarily occur within the boundaries of the GMA. Loveland will continue to apply its water dedication policies to all new annexations and developments in the City's water utility service area.
- **Development Rate:** Development through build out of the GMA is assumed to occur as presented in the City's current *Comprehensive Master Plan*.
- **Transbasin Water:** No significant administrative changes, yields or allocations of water will occur in Colorado-Big Thompson (CBT) or Windy Gap (WG) Project operations. Northern Water's CBT Project Water Tracking Rule effective July 12, 2018, requires more accounting and effectively limits some uses of CBT, but does not negatively affect the City's direct use of this water. Consideration of climate variability factors indicate a potential reduction could occur in the quantity of available water in the Colorado River Basin if warming trends continue. The completion and build out of the WGFP will significantly increase the firm yield of Loveland's Windy Gap units.

- **In-fill (Including Enclaves):** In-fill of undeveloped lands will be similar to surrounding development.
- **Water Consumption Rate:** Future customers will use water at a rate similar to existing customers. Projected water conservation through increased irrigation efficiency and more water efficient appliances and fixtures is not expected to last indefinitely. We anticipate the rate of reduction in gallons per capita per day (GPCD) to slow after approximately 10 years.
- **Commercial & Industrial Users:** Industrial and commercial users will develop at approximately the same ratio as they currently exist in the City. No new significant industrial users will locate within the City's water utility service area. If any do, the *RWMP* should be adjusted to account for any significant demand changes this will cause.
- **Regulatory Climate and Laws:** No significant changes will occur in the regulatory climate that might affect the yield of the water rights in Loveland's portfolio, or might affect operation of new or existing raw water storage facilitates. No significant changes in federal or state laws, administration of current laws, or federal requirements for environmental releases of water will occur.
- **Climate Variability:** The variability of climate conditions has been analyzed with the potential impacts on the City's water portfolio yield from both native water and transbasin water sources. Spronk Water Engineers studied several climate-forecasting models, and there is not a clear correlation between the various models as to the degree of climate variability impacts. Climate variability may impact the availability of water sources as well as the form and timing of those sources with the possibility of any of the following occurring:
    - Future streamflow may increase as a result of increased precipitation offsetting the impact of increased temperatures.
    - Future streamflow may decrease as a result of increased evapotranspiration due to increased temperatures and decreases in precipitation.
    - Declines in snowpack may occur.
    - Runoff may occur earlier during the season.

  Water providers should monitor climate change indicators, encourage climate science research to aid in hydrologic assessments, and incorporate updated climate models in their planning processes. This process will be followed on future updates to the City's *RWMP*.
- **Operational Criteria:** The analysis of Loveland's water supply system and its ability to meet future demands was completed using a typical operation of the water rights portfolio and raw water facilities. We assume these patterns will continue in the future.
- **Water Rights Administration:** No significant revisions to water rights administration policy under State law will occur.
- **Non-potable Water:** Existing commitments of water for non-potable purposes such as irrigation or augmentation totaling 590 AF were included as a demand that must be met. This is in addition to the municipal or potable demand.

1.3 System Description

The City of Loveland derives its raw water supplies from a complex river, tunnel and canal system involving several different water supply sources. Some of the water comes from native Big Thompson River flow rights as well as shares in local ditch companies diverting off the Big Thompson River. To utilize these water rights, Loveland has developed a system of diversions, conveyances, raw water storage sites, and treatment facilities. Under the terms of the City's Water Court decrees, water from any of the sources may be diverted from the Big Thompson River directly into the City's WTP at Chasteen's Grove through the Loveland pipeline by diverting water at the diversion dam owned by the Consolidated Home Supply Irrigating and Reservoir Company (Home Supply). The City can also use an existing contract with the United States Bureau of Reclamation (USBR) and the Northern Colorado Water Conservancy District (Northern Water) to convey native water rights through the CBT system into GRGR when system capacity is available. See **Figure 2** in **Appendix V** showing a map of Loveland Irrigation Features.

Loveland's other major source of water is from transbasin diversions, which bring water to Loveland from the Colorado River Basin on the other side of the continental divide through the City's participation in the Colorado-Big Thompson and the Windy Gap Projects. **Figure 3** in **Appendix V** shows the CBT and Windy Gap systems. The City receives CBT and Windy Gap water through the facilities of the USBR and Northern Water. This transbasin diversion water may be delivered directly into the Loveland Pipeline from the Big Thompson River or into GRGR through the Charles Hansen Feeder Canal (CHFC), which is part of the CBT distribution system.

1.4 Current Raw Water Dedication Policies

Appendix I shows a history of raw water requirements, credits for ditch shares, and cash-in-lieu of raw water fees. The City's raw water requirements, in acre-foot credits per share for ditch shares, and cash-in-lieu fees have changed a great deal over the years in response to changing conditions.

The City currently grants credit for native raw water based upon average yields, as determined in the *2011 Raw Water Supply Yield Analysis* (RWSYA) model developed by Spronk Water Engineers (SWE). An updated study by SWE was completed in 2020, and these updated credit values will likely be applied in the near future pending City Council action. These credits are adjusted to account for private water rights carried in the ditches and for water that must be left in the ditches for shrinkage as a condition of moving the point of diversion to the WTP.

The current credit the City gives for CBT units is based on the firm yield, as determined in the *2011 RWSYA*. The Cash-in-Lieu fee (CIL) is based upon the current market price of CBT units. CBT units have recently been available at prices around $55,000/unit and are edging upwards toward $60,000/unit. The CIL fee was last increased on December 18, 2019 to $47,640/AF. The *2020 RWSYA* results indicate the credit for CBT units should be decreased from 1.0 AF/unit to 0.9 AF/unit to match the actual impact on the City's firm yield. If this CBT credit reduction were applied, the current CIL fee would increase to $52,930/AF.

The raw water acre-foot requirements for commercial and industrial taps are based on the diameters of the taps needed and are due at the time of application for a building permit. The requirements for residential taps are calculated using a formula taking into account the density of the proposed development, and are currently due at the time of the final plat approval. Pending City Council action in December 2020, additional flexibility in payment of residential water rights may be offered; the water rights for residential taps could be paid at the time of final plat approval, by phases or individually at building permit. Irrigation taps, regardless of their location, require 3 AF of raw water per irrigated acre, based on the actual amount of water required for bluegrass and accounting for losses in treatment and conveyance. Hydrozone taps are available for designated irrigated landscaping with low water requirements that meet the City's criteria for the program. Additional information on the Hydrozone program is provided in **Section 6.6**.

1.5 Drought Planning

The City's first effort at long-range resource planning was a drought study performed by Camp, Dresser & McKee, Inc., with final report dated August 28, 1986. On October 7, 1986 Council accepted the report and gave direction to staff to prepare the City to meet its full demands during a drought event with a recurrence of 1-in-100 years without curtailment. A 1-in-100-year drought is a drought having a one percent chance of occurring in any given year. This level of drought protection has remained the consistent goal for the City since approval of the recommendations in Phase I of the August 28, 1986 *Drought Study* prepared for the City by Camp, Dresser & McKee, having been reaffirmed by Council in the *2005 RWMP* and the *2012 RWMP Updates*.

This *RWMP* update is predicated upon updating the *2011 RWSYA* model, which the City contracted with SWE in 2018 to update. The update includes modeling the effects of changes in the City's raw water supply system and water supply portfolio that have occurred since that time. The results of the model and analysis are summarized in **Appendix II**. Using the model, the City's firm yield supply of raw water is determined based upon the historic flow conditions during the 1951 through 2015 study period. This period covers several wet and dry years and includes both the recent droughts of 2002 to 2003 and 2012. Other dry years included 1954 and 1977. Recent wet years include 2009 and 2015. The analysis determined that the extreme conditions experienced in 2002 reasonably represent 1-in-100-year drought conditions.

As part of the *2020 RWSYA*, SWE prepared a computer model to simulate conditions in the Big Thompson River Basin throughout the study period. This *2020 RWSYA* report is included in the presentation of the RWMP to City Council in 2020. Using the model, the City's firm yield supply of raw water was determined based upon the historic flow conditions over that period. SWE recommends that the City should continue its policy of maintaining a water supply capable of withstanding a 100-year drought.

1.6 Key Conclusions and Recommendations from the 2020 Raw Water Supply Yield Analysis

Below are some of the key conclusions and recommendations from the *2020 RWSYA,* which were used in the formation of the current *RWMP* update.

2020 RWSYA CONCLUSIONS

1. **Drought Frequency:** The 2002 drought reasonably represents the conditions of Council's direction to develop the City's water supply to withstand a 1-in-100-year drought without curtailment.
2. **Yield Model:** The model simulates daily water supply and demand from 1951 through 2015 using historical records. The model and historical data can be used to assist the City in its current and future water supply planning efforts.
3. **Firm Yield of Current Loveland Supply without the Windy Gap Firming Project:** The firm yield is defined as the maximum annual demand that can be dependably supplied through the

1951 through 2015 simulated study period without shortage. The estimated firm yield without the Windy Gap Firming Project is approximately 25,210 AF/yr.

4. **Increase Yield with the Windy Gap Firming Project:** Loveland recently increased its participation level in the project to 10,000 AF of storage capacity, which increases the City's total firm yield to 29,080 AF/yr.

   Note: In August of 2020, the City initiated the process of acquiring an additional 413 AF of storage which became available. This was done according to the direction provided by Council to staff in Resolution R-72-2016 on August 2, 2016 to increase participation up to 10,000 AF of storage.

5. **Increased Yield with the Windy Gap Firming Project and Loveland Great Western Reservoir:** Once LGWR becomes operational, it will increase the City's total firm yield to 30,890 AF/yr.
6. **Reduced Firm Yield from Increased Competing Senior Exchanges:** Competing exchanges on the lower reach of the Big Thompson River, such as those by the Cities of Greeley and Evans, could reduce Loveland's firm yield by 3,760 AF/yr in the unlikely worst-case scenario in which exchanges were operated continuously. The impact could be as high as 6,000 AF/yr if such exchanges were also operated on a continuous basis in the middle reaches of the Big Thompson River.
7. **Reduced Firm Yield from Decreased Agricultural Deliveries of Colorado Big Thompson Project Water:** The results indicate that complete cessation of agricultural use of Colorado Big Thompson (CBT) water on the Big Thompson River and the resulting decreased exchange potential in the river would reduce Loveland's firm yield by 2,480 AF/yr.
8. **Increased Firm Yield from Acquisition of Irrigation Company Shares:** Analysis of projected future acquisitions of additional irrigation company shares provided updated credit values in acre-feet per share.
9. **Increased Firm Yield from Acquisition of CBT Units:** Loveland's level of ownership of CBT units was capped in July 2019 by Northern Water, eliminating the City's option to purchase additional CBT water directly. However, the acquisition of additional CBT units from developers as growth occurs is permitted, benefitting Loveland's firm yield and helping maintain the diversity of its raw water supply, providing additional drought reliability. According to the modeling, one unit provides 0.9 AF of firm yield.
10. **Increased Yield from Windy Gap Units:** Without the WGFP, additional Windy Gap units will add no firm yield to Loveland's water supply due to the absence of dry year yield from the project. At the City's current WGFP participation of 10,000 AF, acquisition of one unit (nominally 100 AF) of Windy Gap water would result in an incremental benefit of 56.4 AF.
11. **Increased Firm Yield from Additional (Non-Windy Gap) Storage Capacity:** If the City acquires more direct flow water sources, additional upstream storage would be needed to realize the firm yield from those supplies.
12. **Effect of Alternative Water Supply Operations:** The firm yield of the City's water supplies can change with different modes of operation of its existing supplies and facilities. Maximizing the yield of existing supplies may be an alternative to developing new supplies.

2020 RWSYA RECOMMENDATIONS

1. **1-in-100 Year Drought Planning:** The City should continue its policy of maintaining a water supply that can withstand a 100-year drought.
2. **Water Use Restrictions:** The reliability of the City's water supply is enhanced by not depending on reduced water use as a planning strategy to withstand severe droughts. This allows the City to keep the benefits of water use restrictions as a hedge against potential future droughts that are worse than a 100-year drought.
3. **Water Acquisition Strategies:** The City should use the results described in the *2020 RWSYA* and the Yield Model to develop and refine water acquisition strategies to meet its future water demands. These strategies may include alternative water supply operations, acquiring irrigation company shares, acquiring transmountain water supplies, development of storage, greater participation in the WGFP, development of non-potable water supply systems and other measures.
4. **Changes in Firm Yield:** As the City acquires more water, the incremental firm yield from various water sources and the benefits of additional storage may vary as a result of the dynamic interrelationships among the City's water supply components. However, the Yield Model will continue to provide a basis to evaluate potential changes to the City's water supply and operations.

For a more thorough explanation of these recommendations and conclusions and associated tables and figures, please see **Appendix II**.

2. RAW WATER DEMAND

2.1 Summary

As a target to aid in the development of this update to the City's *RWMP*, staff employed two projections to estimate the future water demand for the portion of the GMA served by the City's water utility. Demands were projected out to 2060, approximately 40 years into the future. From these analyses and discussions with the LUC, a resulting estimate of Loveland's raw water demand target of 30,000 AF is considered to be reasonable based on available information. Factors which cannot be reasonably predicted at this time may cause impacts to the future water supply needs of Loveland and should be monitored for their possible effects.

Examples of such factors are:

- Changes in the City's GMA boundary
- Changes in the water utility's service area
- Changes in water use or development patterns
- Changes in densities resulting from redevelopment
- Long-term climate variability patterns
- Significant new industrial users
- Changes in landscaping requirements

City of Loveland is planning for 30,000 AF of total future annual demand.

The targeted demand value of 30,000 AF is used to facilitate effective analyses of structural and non-structural alternatives to increase the firm yield of Loveland's raw water supply. This demand is the same as the previous estimate used in the *2012 RWMP*, and may change in the future in response to observed conditions. It will be important to re-evaluate this *RWMP* periodically as the City develops to assure that the conclusions drawn remain valid or are adjusted as needed.

An important factor added to this update is the demand for sources of augmentation water needed to meet decreed obligations owed to the river. The City of Loveland provides reusable water developed from its own sources to meet its required augmentation payments. These requirements typically relate to evaporation from exposed groundwater and pumping of ground water for parks and open spaces. The City also has entered into agreements to provide reusable supplies for similar uses by other entities in the Big Thompson River Basin needing similar water supplies. In recent years, the State's administration of augmentation supplies has been significantly formalized, requiring the use of water sources that have been decreed as fully reusable and limiting more informal options and methods used in the past. These augmentation requirements will sometimes compete for the supplies used to meet the City's potable municipal demands, and this is considered when determining the City's firm yield.

The *2020 RWSYA* includes 590 AF needed to meet annual augmentation demands. The City's population projections are used to project future municipal demand requirements. This 590 AF demand is then added in each scenario considered to arrive at the total projected demands the City must meet.

The current draft Intergovernmental Agreement between the City of Loveland and Little Thompson Water District indicates that the City will provide water service along the Colorado Highway 402 corridor as it develops as far east as Interstate 25. The City is already committed to providing sewer service in this area as well. The City will need to monitor and address the rate of development along this corridor to ensure adequate infrastructure and supplies are in place as necessary. The water demand for this area is included in the water service area projection in the *2020 RWSYA*. Home Supply Ditch waters currently serve agricultural needs in this area. The City must consider how shares in that company may be used as the area develops. These shares may become the subject of a new Water Court application by the City, be sold or traded for other raw water supplies, or could be used for raw water irrigation in the historic area.

2.2 Population Projections

Staff relied on the Planners in the City's Development Services Department, Division of Community and Strategic Planning (Strategic Planning) and also on data from the Colorado State Demographer's Office to provide the population projections on which the demand targets are based. The population estimates through 2045 were taken from data provided by the City of Loveland Development Services, Strategic Planning Division in August 2020. By the year 2045, the City's population is projected to be 133,006 with a water service population estimated by staff to be 116,663. The projected service population is based on the number of residential and multi-family taps served by Loveland, adjusted annually by the associated percent change projections from the population projections from the above referenced report, and multiplied by an estimated 2.32 people per household. Population projections for the service area were carried out to 2060.

2.3 Raw Water Supply Demand Estimates

Staff employed two methodologies similar to methods used in the *2012 RWMP*. They are referred to as *Scenarios A* and *B*. Please reference **Table 2-A** below with the City's recent raw water demands, when considering the raw water supply demand scenarios:

TABLE 2-A: Historic Raw Water Demand

Year	Loveland Population	WTP Production Demand (AF)	Per capita Water Demand (AF per person)
2001	52,233	12,903	0.237
2002	53,858	12,221	0.218
2003	55,483	11,156	0.195
2004	57,108	10,364	0.176
2005	58,733	12,040	0.200
2006	60,358	14,309	0.234
2007	61,983	13,636	0.216
2008	63,608	13,652	0.211
2009	66,132	11,794	0.178
2010	67,742	12,754	0.188
2011	68,761	13,250	0.193
2012	69,341	14,969	0.216
2013	70,370	12,958	0.184
2014	71,370	12,858	0.181
2015	73,420	13,340	0.182
2016	74,385	14,143	0.190
2017	75,840	14,448	0.191
2018	77,231	14,312	0.185
2019	79,150	13,129	0.166
5-Year Average (2015-2019)		**13,875**	**0.183**

Based on the results of the *2020 RWSYA*, the firm yield of the City's water rights portfolio is estimated to provide 30,890 AF of annual firm yield by 2031, not including future possible acquisitions of shares in local ditch companies. This firm yield considered all of the City's water rights that have been changed in Water Court and those that are currently owned and anticipated to be changed for municipal use in the future. It also assumes that the Chimney Hollow Reservoir and the City's downstream storage project, Loveland Great Western Reservoir, will be completed and operational by 2031.

The City ran two scenarios as a cross-check to determine if approximately 40 years into the future, a firm yield of 30,890 AF would still meet the projected water demand. Based on these scenarios, the City's demands are met out to 2056. The projected population in 2060 is 173,100 with an average projected water demand of 32,736 AF. A basic summary of the two cross-check scenarios is presented below.

TABLE 2-B: Projected Water Demand Scenarios

	Scenario A	Scenario B
Start Demand of Scenario Projections	Largest historical annual treated water produced from the Loveland WTP plus 590 AF for augmentation and irrigation demands *(15,559 AF from 2012)*	5-year average *(2015 to 2019)* treated water produced from the Loveland WTP plus 590 AF for augmentation and irrigation demands *(13,875 AF)*
Beginning Year of Scenarios	Last year of verified data *(2019)*	
Beginning Population	2019 population estimate for Loveland* *(79,150)*	
Demand Growth Rate	Through the year 2045, increased demands were based on estimated population growth rates*. For projections beyond 2045, the average of the last 15 years *(2031-2045)* of estimated growth rates* was applied.	
End Year of Projections	Approximately 40 years into the future *(2060)*	
*Notes: Based on the population estimates and estimated growth rates through the year 2045 from data provided by the City of Loveland Development Services, Strategic Planning Division in August 2020.		

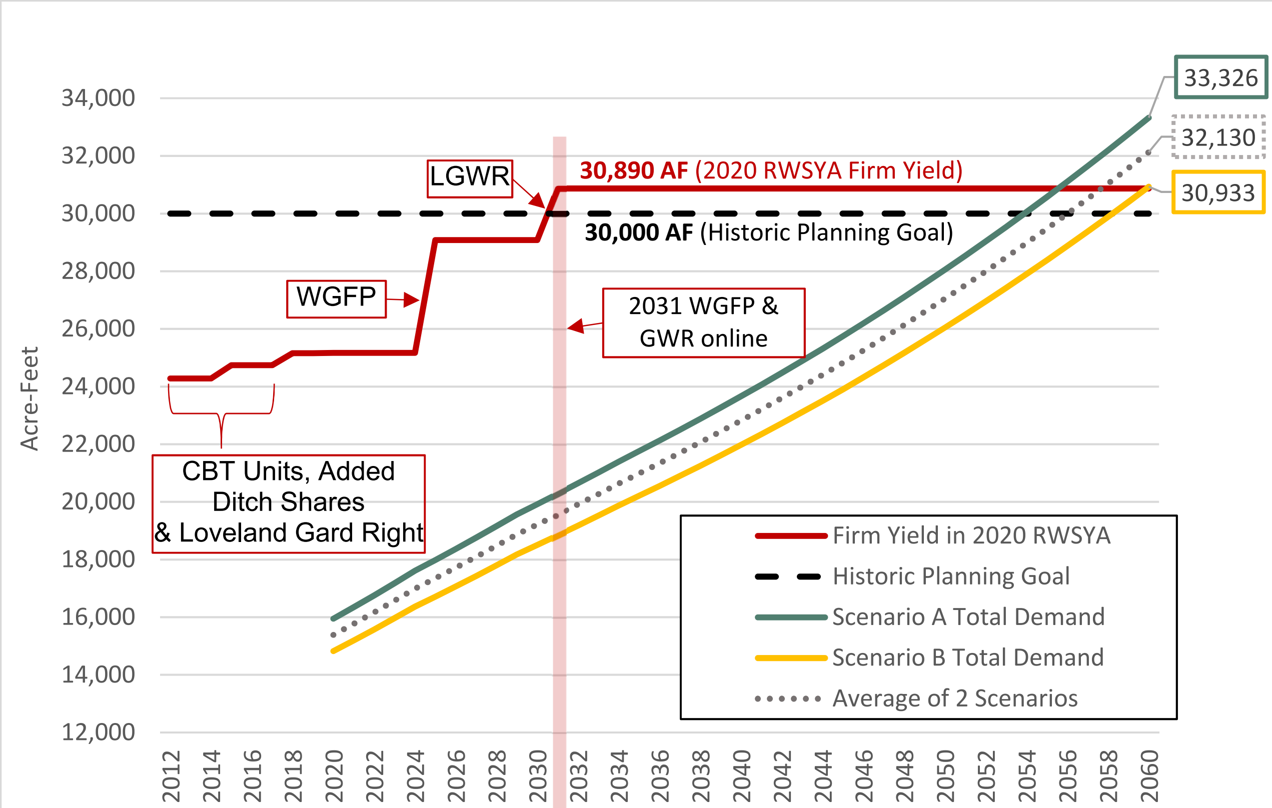
2.4 Comparison of the Scenarios and 2012 Results

Loveland's projected demands in 2060, using the two scenarios, are shown in **Table 2-C** and **Figure 2-A**. The average of the scenarios, including 590 AF of augmentation demand, is 32,130 AF. This is approximately 1,240 AF more than the SWE projected firm yield of the City's water rights portfolio by the year 2031, which was 30,890 AF.

TABLE 2-C: 2020 Estimate of Target Water Supply for City Water Utility Service Area

	Scenario A	Scenario B	Scenario Averages	Historic Planning Goal	2031 Firm Yield from 2020 RWSYA
Municipal Demand	32,736 AF	30,343 AF	**31,540 AF**		
Augmentation Demand	590 AF	590 AF	**590 AF**		
Total City Demand	**33,326 AF**	**30,933 AF**	**32,130 AF**	**30,000 AF**	**30,890 AF**

FIGURE 2-A: City's Total Water Demand Projections vs. Firm Yield Projections



For comparison purposes, the scenario results from the *2012 RWMP* are shown in **Table 2-D**. The 2012 report used three cross-check methods. Two of those methods were used for the updated 2020 report. The most conservative scenario was excluded as the conditions it portrayed were considered unlikely to occur. Note that all scenarios in both 2012 and 2020 are reasonably near the historic planning goal of 30,000 AF and the projected firm yield of 30,890 AF. These scenarios demonstrate that the City's water portfolio is resilient and capable of providing water to meet demands even if senior exchanges on the river are operated more extensively in the future or if deliveries of agricultural deliveries of CBT water in the Big Thompson River Basin continue to decline.

TABLE 2-D: 2012 Estimate of Target Water Supply for City Water Utility Service Area

	Scenario A	Scenario B	Scenario Averages	Historic Planning Goal
Municipal Demand	28,422 AF	26,164 AF	**27,293 AF**	
Augmentation Demand	590 AF	590 AF	**590 AF**	
Total City Demand	**29,012 AF**	**26,754 AF**	**27,883 AF**	**30,000 AF**

Note that new technologies (i.e. leak detection, more water efficient appliances and fixtures, better water meters, more efficient irrigation systems, etc.) may cause per capita water use to go down. New large industrial customers could increase the future overall demand. The estimates of future land use, irrigation/landscaping requirements, and dwelling unit densities can all change with sociological, economic trends or mandates yet to be identified. The estimates of the utility's target demands made using these approaches may change based on future conditions, but are considered the best available at this time. As was the case with the original master plan, inherent is an understanding that 30,000 AF is actually a target, and the eventual demand realized may be different.

2.5 Recommendation for Target Demand

It is recommended that the City continue using a raw water demand target of 30,000 AF.

3. WATER RIGHTS INVENTORY

3.1 Current Water Supply Portfolio

The City's current water supply is a resilient combination of supplies from the Big Thompson and Colorado River Basins. Roughly one-half of the water supply comes from each basin. Having water sources from two basins adds drought protection to the City's portfolio. When one basin has a lesser water supply, it is likely the deficit can be made up from the other basin. **Table 3-A** shows the City's current ownership of various raw water sources. **Table 3-B** shows the City's current ownership of shares in various irrigation companies.

Specifically, the City's portfolio includes water rights for the "native" supply from the Big Thompson River and contracts for transmountain (or transbasin) water delivered to the Big Thompson River from the Colorado River Basin through the facilities of the Colorado Big Thompson Project and the Windy Gap Project. Collectively, these rights and contracts make up the water supply portfolio. The portfolio is described generally in this report. For more detailed information please refer to the *2020 RWSYA*.

In 1887, the City filed for its first water right to use water from the Big Thompson River. Its second right was filed in 1901. Some early annexation plats submitted to the City show dedication of water rights that were appurtenant to the land being annexed. Over time, other rights were purchased outright. These early domestic rights and transfers on the river form the foundational portion of the City's water rights. In 1960, the City began formally requiring dedication of water rights as a condition of annexation. The City has historically accepted native ditch shares/inches, CBT Project water and CIL of water rights to satisfy raw water requirements for development. Since the *2012 RWMP*, the City has acquired an additional 424 CBT units. Currently, the City owns 12,210 CBT units.

The City was also one of the original "Six Cities" that initiated work on the Windy Gap Project (WG) in the 1960s, resulting in a water right filed on the Fraser River in 1967. Construction on the project was completed by 1986. The City is also currently involved in the planning, permitting, and financing processes of the Windy Gap Firming Project (WGFP), which will provide storage for the Windy Gap Project waters. The WGFP involves 12 participants, and upon completion of construction will provide the City of Loveland with 10,000 AF of storage for its 40 units of Windy Gap water.

Unique benefits and limitations are associated with each type of water right the City owns. With most native water offered to the City for development, availability is limited to the historic irrigation season, generally April through October, depending on stream flows in the Big Thompson River. Although some native rights have storage associated with them, this storage historically enhanced the yield for the users on the ditch, but has not generally benefitted the City's diversions at the WTP. The seasonal availability of these rights represents a challenge to the City because when it accepts the water and applies it for development, it also accepts the responsibility to meet a demand occurring on a year-round basis. Water must be provided to meet demands throughout the year. Conversely, the CBT and WG Project waters are stored and can be delivered at any time throughout the year. However, the pumped WG Project water can be lost during wet years from Lake Granby when the reservoir spills into the Colorado River, necessitating the storage anticipated at Chimney Hollow in the WGFP.

Native ditch rights are diverted directly from the Big Thompson River and consist of the City's early transfers and domestic filings, the 1982CW202A ("202A") decree and inclusory decrees now combined into the consolidated cases 00CW108/03CW354, the Rist & Goss transfers and the 2002CW392 ("392") decree. Some of the water attributable to Loveland's CBT units, 202A transfers, and 392 decree may be used for non-potable irrigation of many City-owned parks and golf courses or for agricultural purposes when not needed for diversion at Loveland's WTP.

TABLE 3-A: Loveland's Water Supply Sources

Water Source	No. of Shares or Units Owned	
Transbasin Supplies		
Colorado-Big Thompson (CBT)	12,210	units
Windy Gap Project	40	units
Eureka Ditch	180	AF
Early Transfers		
Portion of No. 1 Priority on Big Thompson River	3.44	cfs
#2 Domestic	0.5	cfs
#3 Domestic	2.5	cfs
Big Thompson Ditch and Manufacturing Co.	2	shares
Reservoir Storage[1]		
Green Ridge Glade Reservoir	6,835	AF of storage
Windy Gap Firming Project (Chimney Hollow Res.)	10,000	AF of storage
Great Western Reservoir (downstream storage)	1,600	AF of storage
202A Transfers and Subsequent Transfers, and Rist and Goss Transfer[1]		
Big Thompson Ditch and Manufacturing Co.	2.6	shares
Barnes Ditch	1,284.6	inches
Chubbuck Ditch	458.0	inches
Buckingham Ditch	6.1	shares
Louden Ditch	191.5	shares
South Side Ditch	57.5	shares
Rist and Goss (1974 and 1986 Decrees)	487.5	AF
392 Transfer[2]		
Big Thompson Ditch and Manufacturing Co.	3.8	shares
Barnes Ditch	24.5	inches
Chubbuck Ditch	815.0	inches
Buckingham Ditch	89.3	shares
Louden Ditch	61.5	shares
South Side Ditch	23.0	shares
108 Case Water Court Decree[2,3]		
Barnes Ditch	22.1	inches
Chubbuck Ditch	138.6	inches
Pending Water Court Application[2,4]		
Big Thompson Ditch and Manufacturing Co.	5.3	shares
Buckingham Ditch	24.7	shares
Louden Ditch	22.0	shares
South Side Ditch	34.8	shares
Home Supply Ditch	30.0	shares

Notes:

(1) Reservoir storage in the Windy Gap Firming Project is still unrealized since project is not built yet. The value reported is Loveland's purchased allocation in the project.
(2) Share figures rounded to nearest tenth.
(3) These inches are included in 00CW108. The case become part of a consolidated case along with Case No. 03CW354 that was decreed on February 23, 2012.
(4) Shares owned by Loveland, but not part of a Water Court application as of October 2020. Some of these shares were acquired recently and are not included in the 2020 Raw Water Supply Yield Analysis.

TABLE 3-B: Loveland's Ownership in Ditch Companies

Irrigation Company[1]	W&P Units Owned	Other Depts. Units	Loveland Total Units Owned[2]	Ditch Company Outstanding	Loveland % of Total
Big Thompson D&M	11.7	0.0	11.7	20.8	56.1%
Barnes Ditch[3]	1,331.3	0.0	1,331.3	1,944.2	68.5%
Chubbuck Ditch[3]	1,411.6	0.0	1,411.6	1,590.4	88.8%
Buckingham Ditch	120.1	0.0	120.1	200.0	60.0%
Louden Ditch	271.5	18.2	289.7	600.0	48.3%
South Side Ditch	113.25	12.0	125.3	265.0	47.3%
Home Supply Ditch	30.0	14.5	44.5	2,001.0	2.2%

Notes:

(1) Share figures rounded to nearest tenth
(2) This data includes all City owned shares, changed and unchanged, Water & Power owned shares, and Parks & Recreation owned shares.
(3) Historic diversions adjusted for contract/private right.

3.1.1 Transbasin Water

Transbasin water is introduced into a stream system from a hydrologically separate drainage system. In Loveland's case, water from the CBT and WG projects is conveyed through Adams Tunnel, flowing underneath the Continental Divide from the Colorado and Fraser River Basins and introduced into the Big Thompson River Basin.

Colorado Big Thompson Project

Loveland's 12,210 units of CBT water account for the largest portion of the City's transbasin water supply. Yields from the CBT Project vary from year to year depending on available water supplies and the quota established annually by the Northern Water Board. The CBT yields are typically set to be inversely proportional to the available supplies along Colorado's Northern Front Range. Historically, the Spring CBT quotas have ranged between 50 percent (0.5 AF/unit) and 100 percent (1.0 AF/unit). However, in November 2003, during the 2002-2003 drought, the CBT quota was set at 30 percent based upon the limited availability of water and then was increased in April 2003 to 50 percent.

Windy Gap Project

Loveland owns 40 units of WG water, collected from the Fraser River, which is tributary to the Colorado River on the West Slope. WG water does not currently provide a fully firmed water supply to the City. Loveland has only taken delivery of limited supplies of WG water in 1988, 2003, and 2010. In the future, Loveland will need WG water for drought supply and to meet increased water demand and to develop reusable effluent at the water reclamation facility (WRF).

Eureka Ditch
In 1941, the City acquired ownership of Eureka Ditch, a high mountain collection ditch that had been used since its construction in 1902 to deliver water across the Continental Divide from the West Slope through the Bighorn Flats area north of Flattop Mountain in Rocky Mountain National Park. This ditch eventually emptied into the Forest Canyon drainage of the Big Thompson River. The City, National Park Service, USBR, and Northern Water negotiated an agreement in 1995 under which the City abandoned the ditch, and Northern Water agreed to annually provide the City with 180 AF of firm yield from the CBT Project pre-quota supplies. This water was made available to Loveland starting in November 1996 and is the first 180 AF of water the City takes from the CBT Project each year. This water is separate and distinct from the City's CBT ownership.

3.1.2 Native Rights (Big Thompson River Basin)

Early Rights
Loveland's earliest water was derived from domestic rights filed on the Big Thompson River to provide water directly to the WTP at Chasteen's Grove. The first 0.5 cfs was filed by the City in 1887, and an additional 2.5 cfs was filed in 1901. In the course of its development, Loveland has also acquired shares in various irrigation companies that supply water in and around the City. These shares typically were historically associated with land parcels that were developed for residential, commercial or other uses. Loveland's early transfers of irrigation water rights includes 3.44 cfs of the No. 1 Big Thompson River irrigation priority acquired in 1907 and two shares of the BTDM acquired in the mid-1920s (totaling up to 6.0 cfs when the ditch's four decrees are all in priority and available from the river). Loveland uses its early rights first to meet its potable demands. These early decrees do not provide for storage of the diverted waters and are considered to be direct diversion rights only.

202A Transfer, Inclusory, and Rist & Goss Transfer Decrees (00CW108/03CW354)
Following the early filings and transfers, the City continued to acquire ditch shares as it grew. Because these shares could not be diverted at the WTP and used by the City for treated water supplies until allowed by a decree from the courts, portions of these shares were initially used for raw water irrigation on municipal lands that could be irrigated under the ditches. An application was filed in Case No. 1982CW202(A) (a.k.a. "202A") in 1982 to transfer a large block of these shares from several different companies to municipal use by the City. The 202A Decree was signed by the Water Court Judge on June 18, 1985. Subsequently, the City made several additional transfers of water right shares it had acquired through development. These involved several different ditch companies and the transfers were done in separate court filings, but under the terms and conditions of the 202A Decree. These are known as the "Inclusory Decrees", and together with the original 202A Decree, are referred to as the 202A Transfers. At the time the decrees were filed, the 202A Transfers included Loveland's full ownership of shares in the Barnes Ditch, BTDM, Buckingham (George Rist) Ditch, Chubbuck Ditch, Louden Ditch, and South Side Ditch.

Loveland had also transferred all of the water rights associated with the Rist and Goss Ditch in two separate proceedings, two-thirds of the rights in 1974, and one-third in 1986. These were also included in the 202A Transfers to increase their flexibility. All of this water is available for delivery to the City's WTP for processing and distribution to meet potable water demands.

All these decrees were consolidated into a pair of final cases filed as 2000CW108 and 2003CW354 and eventually combined by the court into the Consolidated Case Nos. 00CW108 and 03CW354. This combined case modified and replaced the terms and conditions of the original 202A case and subsequent inclusory decrees and added additional shares.

392 Transfer Decree

The City has continued through the years to accept shares in the various ditches for development. Due to concerns from other users on the river, the City agreed in 2000 not to use the 202A decree as a template for future transfer decrees. As an alternative, the City implemented ditch-wide studies of consumptive use in the individual ditches. These studies were used as the basis for an application filed in 2002, known as Case No. 2002CW392 (a.k.a. "392"), which sought to transfer a large block of shares in several of the same ditch companies subject to the 202A transfers. New terms and conditions were implemented for all but the Barnes and Chubbuck Ditches, which because of earlier agreements remained essentially the same. Transfers include Loveland's share ownership in Barnes Ditch, BTDM, Buckingham Ditch, Chubbuck Ditch, Louden Ditch, and South Side Ditch. In addition, following negotiations with the Greeley/Loveland Irrigation Company (GLIC), which carries the Barnes and Chubbuck waters, the City entered into a Settlement Agreement with GLIC on January 25, 2010 to not transfer any additional Barnes or Chubbuck inches. The 392 Decree was signed by the Water Court on May 14, 2010. Loveland may reuse return flows resulting from any use of the 392 transfer water once the return flow obligations are met. Starting in 2011, water rights under the 392 Decree were diverted for municipal use. As additional shares are acquired, the City will apply to transfer them to municipal use under similar terms and conditions.

Reservoir Storage

A major expansion of Loveland's Green Ridge Glade Reservoir, from approximately 600 AF to 6,835 AF, was completed in 2004. This storage primarily enhances the availability of water from native ditches, making it possible to provide water on a year-round basis. The reservoir expansion also gave the City a greater buffer and layer of protection against drought or emergency conditions that may occur on the river. Of the total storage, 50 AF is below the level of the reservoir outlet and is considered dead storage space. This water could only be used by pumping it into the outlet. The remaining 6,785 AF is active storage capacity. The SWE modeling also shows that the reservoir has value for storing Windy Gap and CBT waters.

Post-392 Transfers

Loveland owns additional native ditch shares that are not yet legally transferred in Water Court for municipal use. The firm annual yield of these shares has not been realized since they are not yet transferred to meet potable demands. In the yield analysis model ran by SWE, these shares were assumed to be transferred in the near future and would be available to contribute to the City's firm yield. This water currently meets non-potable demands where feasible, including irrigation of City parks and golf courses.

Other Water Sources

In addition to its native Big Thompson River water rights, transmountain supplies, exchanges, and reusable sources of water, Loveland can divert additional undecreed water during free river conditions. This source sometimes delivers substantial quantities of water, but is marginally reliable on a firm yield basis. The City also acquired and changed part of the Gard water contract right, which was historically carried through the Home Supply Ditch. This water was decreed under Case No. 07CW325 to allow for municipal use. In addition, the City has two pending Water Court applications, which will yield additional water. The new applications are Case No. 2018CW3193 for Lawn Irrigation Return Flows (LIRFs) and 2018CW3215 for Loveland Great Western Reservoir. The City also plans a new inclusory decree adding water using the terms and conditions of the 2002CW392 decree.

3.2 Future Water Rights Portfolio

Loveland's future water supplies will likely come from transfer or purchase of native ditch shares, CBT Project units, Windy Gap Project units, storage projects, and/or future regional projects yet unnamed.

3.2.1 Transfer of Native Ditch Shares

The City will likely continue to accept additional shares in select local irrigation companies over time as development continues within the GMA. These estimates are shown in **Table 3-C**. It is not expected the City will obtain 100 percent of any of the irrigation systems in the foreseeable future, as many shares permanently serve small acreages and 'hobby farms' that have developed around the City. The City may reasonably expect about 540 AF of firm yield or 1,700 AF of average yield. Average yields (column 7) and firm yields (column 8) were calculated using values from **Table 8-5** of the *2020 RWSYA* found in **Appendix II**. Firm yield is the maximum annual water demand that could be dependably supplied by the City for each water source as all of the City's sources are integrated. The yield using the City's current credit value is based on the average historical yield from the *2020 RWSYA*.

TABLE 3-C: Estimate of Native Irrigation Company Water Available for Transfer

Irrigation Company[1]	Estimated Water Still Available for Transfer	Current Credit in Municipal Code[2]	Unit Yield Using 2020 RWSYA		Total Yield Using Current Credit[2]	Total Yield Using 2020 RWSYA	
			Avg. Historical Yield	Firm Yield w/o Storage		Avg. Historical Yield	Firm Yield w/o Storage
	Share or Inch	AF/sh	AF/sh	AF/sh	AF	AF	AF
Barnes[3]	0.0	3.32	3.31	0.66	0	0	0
BTDM	6.7	186.57	189.11	68.08	1,258	1,275	459
Buckingham	10.0	6.36	5.76	0.38	64	58	4
Chubbuck[3]	0.0	2.94	2.9	0.29	0	0	0
Louden	27.8	12.17	11.92	2.14	338	331	59
South Side	10.0	4.55	4.97	1.49	46	50	15
				Totals	**1,706**	**1,714**	**537**

Notes:

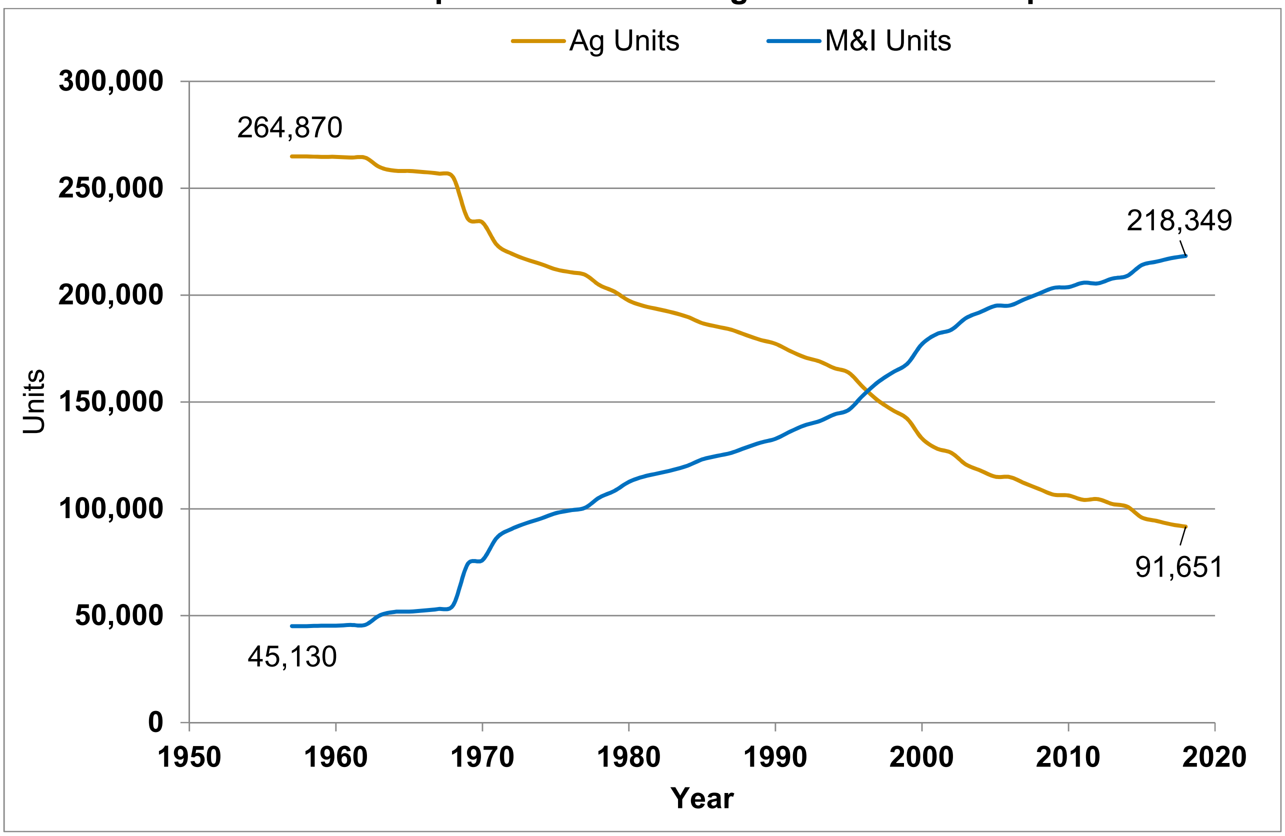
(1) The City no longer accepts shares from the Farmers Ditch and it is not included in the City's decrees.
(2) Per the values in the *2011 RWSYA*
(3) Under a settlement agreement entered in 2010 with the GLIC, the City may not include any additional Barnes or Chubbuck Inches in future Water Court applications.

Yields from shares not already in the Water Bank were not included in the base run modeled by SWE in the *2020 RWSYA*. To fully realize the 1,714 AF of additional average yield in **Table 3-C** would require construction of approximately 4,456 AF of new storage, using a weighted storage ratio of approximately 2.6 AF of storage to firm each acre-foot of yield. Without additional storage, these native water rights would only provide approximately 537 AF of firm yield if acquired by the City. This information is based on data from **Table 8-5** of the *2020 RWSYA* in **Appendix II** and **Table 3-C** of this *RWMP* Report.

3.2.2 Colorado Big Thompson Project

The City's ownership of CBT units was capped in the Fall of 2019 by Northern Water based on the balance of the City's raw water portfolio. This means the City may not purchase additional CBT units, but may still accept them from developers for specific projects. Units in the CBT Project currently remain available on the market, but these units are becoming less obtainable. **Figure 3-A** illustrates the transition of CBT units from Agriculture (Ag) to Municipal and Industrial (M&I). It is estimated by Northern Water staff that out of 310,000 total CBT units in the CBT Project, approximately 34,000 units remain from Class D Allotment Contracts (agricultural) that may still be available for transfer or purchase by a municipality or industry.

FIGURE 3-A: CBT Ownership Transition from Agriculture to Municipal & Industrial



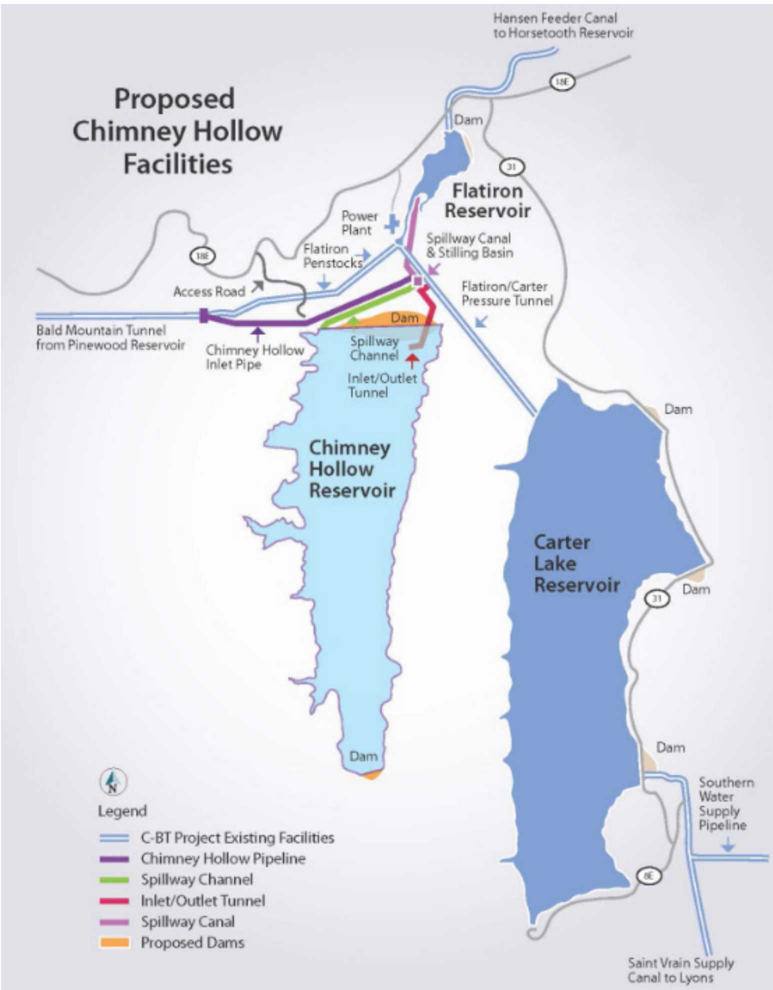
3.2.3 Windy Gap Firming Project

The City has been a participant of the WGFP since its inception. This project will create storage in Chimney Hollow Reservoir (located immediately west of Carter Lake) to make firm the waters from the WG Project. Chimney Hollow Reservoir site is the most viable and cost-effective alternative for firming WG water.

Loveland owns 40 units of the WG Project, all of which are available for firming in the WGFP. These units are projected to yield approximately 100 AF/unit when firmed. Northern Water lists the following major steps on its WGFP Milestones from 2011 until the current year:

- 2011: **State Officials** approve the Fish and Wildlife Mitigation Plan and Voluntary Enhancement Plan
- 2011: **USBR** publishes the Final Environmental Impact Statement

- 2012: **Grand County** and the **Municipal Subdistrict Board** approve agreements to create improvements to the Colorado River
- 2014: **USBR** issues its Record of Decision and signs a carriage contract to transport water to Chimney Hollow Reservoir
- 2016: **State of Colorado** issues a 401 Water Quality Certification
- 2017: **U.S. Army Corps of Engineers** issues its final Record of Decision2019: Barnard Construction Inc. selected as the construction contractor to build a 355' tall asphalt-core dam



The staff of the Northern Colorado Water Conservancy District Municipal Subdistrict (Municipal Subdistrict) anticipate the WGFP construction may begin in 2021, depending upon the resolution of a pending lawsuit filed by a consortium of environmental interests against the federal agencies permitting the project, and any subsequent appeals. Construction is expected to take three to four years depending on conditions.

The City is subscribed to 10,000 AF of storage in the Chimney Hollow Reservoir Project. Following City Council direction, the staff successfully identified and Council acquired the City's final 413 AF of additional storage in the WGFP to bring its total participation to 10,000 AF of storage.

FIGURE 3-B: Proposed Chimney Hollow Facilities

3.2.4 Feasibility Study on Possible Expansion of GRGR

The dam at GRGR was constructed approximately 3 feet higher than necessary to accommodate a possible future increase in spillway height. This would create approximately 450 AF of additional storage, increasing the overall reservoir capacity to 7,285 AF and increasing the City's firm yield by approximately 150 AF. The feasibility of making this change is currently under study by staff and consultant AECOM.

3.2.5 GRGR Raw Water Bypass

As GRGR was expanded from 2000 to 2004, three 18" HDPE pipelines were installed around the site to carry water directly from the CHFC to the WTP. Upon completion of the project, one of the pipelines was removed for salvage and two pipelines remain. Staff and consultants have completed a feasibility study considering the reattachment of these pipelines at the CHFC and at the WTP. The City is currently in the permitting process to move this project forward. Having this option in place will provide greater flexibility in the management of the reservoir and raw water supplies delivered into the WTP.

3.3 Water Bank

The City has operated the Loveland Water Bank (Water Bank) since the mid-1980s as a subset of its overall raw water portfolio. Deposits to the Water Bank have been the source of most of Loveland's water acquisitions during recent years. Water rights held in the Water Bank represent deposits that have been made with ownership conveyed to the City in exchange for Water Bank credit, generally expressed by numbers of ditch shares or by acre-feet. Credits in the Water Bank are a subset of the City's raw water portfolio that have not yet been applied for zoning or development within the City's service area. For the City, these deposits represent future commitments to provide water service when requested.

Basic details about the Water Bank are described in the *Summary of Water Rights Dedication and Requirements* sheet in **Appendix III**. Developers or entities seeking water supply service from the City are required to provide water rights including the storage fee where appropriate. Suitable water rights currently are derived from local ditch company shares approved as acceptable by the LUC, or from Water Bank credits, CBT units, or CIL.

The Water Bank provides depositors the convenience of conveying ownership of native waters or CBT units before they are needed for development. (With the current cap on the City's ownership of CBT units, only those units committed to a specific development may be placed into the Water Bank.) Credit issued by the City may be exchanged on the free market between owners of the credit and developers and is then readily available to meet development requirements as they occur. Ownership of the water allows the City to proceed with the steps needed to make it useful for potable diversions at the City's WTP, such as the legal transfer or exchange in Water Court or to make contractual arrangements for carriage of water for delivery to City facilities.

The water rights credit given for Water Bank deposits is determined at the time the credit is applied to meet zoning or development requirements based on the conversion rate in effect at that time. For example, a deposit to the Water Bank in 2005 that is used to meet the water requirements for a development initiated in 2012 would be converted to water credit based on the conversion rate in effect when the water was applied. The conversion rate at that time may be higher or lower than the rate that was in effect when the water was deposited in 2005.

3.3.1 Credit for Native Ditch Shares

Credit for native ditch shares refers to the number of acre-feet recognized by the City for specific shares based on the yield in acre-feet per share. Historically, this yield has been calculated using a number of methods.

- Originally, a dry-year scenario was used in which the three years of lowest diversions from the most recent twenty-year period were selected. The lowest year was eliminated, and the second and third lowest were averaged with adjustments made for shrinkage and for any private rights carried through the ditch by contract.
- From 1969 through 2005, the City gave credit for average annual yield based on a 20-year average.
- Starting in 2006, the City used credit values that were developed through the original *2005 RWSYA*. These were updated again in the *2011 RWSYA* and were adopted by City of Loveland Ordinance #5691 on July 17, 2012.

A summary of the 2012 Water Bank credit allowed for various irrigation company shares and transmountain sources is shown in the *Summary of Water Rights Dedication and Requirements* sheet in **Appendix III**. This summary sheet will be updated with new conversion rates based upon City Council adoption of the *2020 RWMP*.

3.3.2 Native Water Storage Fee

Ditch company shares typically yield water only during portions of the irrigation season. This season is defined by the State as April 1st through October 31st and often is a much shorter period of time depending on the seniority of the ditch rights involved, the crops being raised, and the annual weather conditions. Storage is necessary to convert these seasonal water sources to year-round supplies as well as to increase dry-year deliveries.

From 1969 through 1995, the City gave credit for average annual yield while providing water throughout even the dry years. In 1995, Council acknowledged that the policy was eroding the City's ability to provide a reliable water supply. This led to the establishment of the Native Water Storage Fee (NWSF) on July 20, 1995. Depositors of native water shares from ditch companies deposited after July 20, 1995 are required to pay the NWSF when the water is applied to development for water rights credit. This fee recognizes that raw water storage is necessary to firm up native water sources. If the depositor opts out of paying the NWSF, then the water rights credit is a lower value, which reflects the firm yield under drought conditions. The current rates are in **Table 3-D** below. This table is also included within the *Summary of Water Rights Dedication and Requirements* sheet in **Appendix III**. The proposed updated conversion values and fees are in **Table 3-E**.

The NWSF was established at $400/AF by City Council on June 20, 1995 (Ordinance No. 4096). On March 4, 1997, in Resolution #R-12-97 City Council set the fee at $475/AF. On November 15, 2005, in Ordinance #5039 City Council set the fee at different amounts for the various ditches to reflect the differing seniorities of their decrees. The average fee was targeted to be $6,000/AF, which reflected the approximate market difference between the value of CBT, which is stored, and native rights from the ditches, which require storage. The fee amount is the NWSF that is in effect at the time the credit is used to meet a development requirement. The increased fee from $475/AF to $6,000/AF was phased in as follows:

1) One third of the amount was due for transactions beginning January 1, 2006.
2) Two thirds were due for transactions beginning January 1, 2007.
3) The full fee, averaging $6,000/AF, went into effect beginning January 1, 2008.

The NWSF has remained in place since that time, but is subject to periodic review and adjustment by City Council. Market conditions have changed, and Storage Fee adjustments to reflect actual cost of building storage may be considered, which would increase the Storage Fee. One adjustment option to consider would be to base the fee on the estimated cost of the City's next water storage project at Chimney Hollow Reservoir. Northern Water's project cost estimate as of September 8, 2020 for Chimney Hollow was approximately $676 million with a storage capacity of 90,000 AF. This translates to $7,511/AF. The firming ratios for each ditch listed in Table 8-5 of the RWSYA which is required to provide firm yield in a 100-year drought would be multiplied by the $7,511/AF to calculate this portion of the NWSF per acre foot.

In addition, engineering and legal costs are incurred when the native water is changed for municipal use in the Water Court. The City's last action changing this water was for case number 02CW392. In this case, 3,500 AF of water was changed at a cost of $1.4 Million which results in a cost of $400/AF. Using this value and adjusting for inflation using the Handy Whitman Index for Source of Supply Plant from 2009 to 2020 results in a value of $482/AF. This is the value recommended for this portion of the NWSF per acre foot (See **Appendix VI**).

The combined storage cost and court cost fees result in the final NWSF values listed in the column labeled "Native Water Storage Fee per AF" in **Table 3-E**.

TABLE 3-D: 2012 Native Ditch Values & Fees

Native Ditch Right	AF Value WITH Payment of Native Raw Water Storage Fee[1]	Native Water Storage Fee per AF	AF Value WITHOUT Payment of Native Water Storage Fee[2]
Barnes Ditch[3]	3.32 per inch	$5,750	0.86 per inch
BTDM	186.57 per share	$3,530	70.90 per share
Buckingham Irrigation Company	6.36 per share	$7,400	0.38 per share
Chubbuck Ditch[3]	2.94 per inch	$7,400	0.41 per inch
Louden Irrigating Canal and Reservoir Company	12.17 per share	$6,850	2.43 per share
South Side Ditch Company	4.55 per share	$6,770	1.46 per share

Notes:

(1)(2) Average yield[(1)] and firm yield[(2)] for ditch credits as determined by the 2011 RWSYA

(3) The City no longer accepts deposits of Barnes or Chubbuck Ditches. These values only apply to ditch rights previously dedicated to the City's water bank and not yet dedicated to meet a City development requirement.

TABLE 3-E: 2020 Proposed Native Ditch Values & Fees

Native Ditch Right	AF Value WITH Payment of Native Raw Water Storage Fee[1]	Native Water Storage Fee per AF (Includes $482/AF Water Court Costs)	AF Value WITHOUT Payment of Native Water Storage Fee[2]
Barnes Ditch[3]	3.31 per inch	$27,522	0.66 per inch
BTDM	189.11 per share	$18,662	68.08 per share
Buckingham Irrigation Company	5.76 per share	$26,022	0.35 per share
Chubbuck Ditch(3)	2.90 per inch	$26,322	0.29 per inch
Louden Irrigating Canal and Reservoir Company	11.92 per share	$23,012	2.14 per share
South Side Ditch Company	4.97 per share	$21,962	1.49 per share

Notes:

(1)(2) Average yield (1) and firm yield (2) for ditch credits as determined by the 2020 RWSYA

(3) The City no longer accepts deposits of Barnes or Chubbuck Ditches. These values only apply to ditch rights previously dedicated to the Loveland Water Bank.

3.3.3 Credit for CBT

The City has accepted CBT units since the early 1960s to meet its raw water requirements. The City's credit for CBT units, the number of acre-feet per CBT unit available for development, was initially set as an average of the annual quotas set by the Northern Water Board. The quotas are set at different values each year, ranging from 0.5 AF/unit to 1.0 AF/unit and provide a "supplemental supply" to the native rights in the area. As such, their yields are intentionally set as the inverse of the quantities available from the annual native raw water supplies. A quota below 0.5 AF/unit would only occur if there was physically an insufficient water supply.

The first City CBT credit on record was established by City Ordinance No. 1053 passed in 1969. It was calculated as the average annual CBT quota, beginning with the first annual quota, issued in 1957. The average used the most recent years' quotas and, as data became available, extended to a period not to exceed the most recent 20 years. Since then in response to fluctuating conditions, the City's CBT credits have also been set at different times to be 0.6 AF/unit, 0.75 AF/unit, and 1.0 AF/unit. A history of the credits granted for CBT units for development by the City are included in **Appendix I**. The current CBT credit of 1.0 AF/unit was derived from the *2011 RWSYA* and reflected the results of the modeling showing that this source yielded more water during dry times and thereby helped mitigate drought conditions. However, the most recent *2020 RWSYA* indicates that the yield has reduced during the drought scenario to a value of 0.9 AF/unit based on the modeled conditions. One adjustment option to consider would be to adjust the credit based on the 2020 modeled results.

3.3.4 Credit for Cash-in-Lieu

The City of Loveland currently accepts Cash-in-Lieu (CIL) payments from developers as a way to meet the raw water requirements for development. Throughout its history, the CIL fee has been linked to the market price of an acre-foot of CBT water. A history of the City's CIL fees is included in **Appendix I**. Ordinance 5039, adopted by Council on November 15, 2005, prohibited the practice of purchasing Cash Credits in the Water Bank. Previously, unlimited purchases of Cash Credits had been accepted using the CIL fee per acre-foot in effect when the cash payment was made for the purchase of the credit. Although the City's ownership of CBT units was recently capped as discussed in Section 3.2.2, CBT prices set the market rates for raw water in Northern Colorado. Staff recommends that the CBT market price remain the basis for the City's CIL fee.

CIL fees have produced yield for the City through purchases of water or by funding projects that produce yield. Examples of such projects are as follows:

- Purchasing units of CBT water
- Paying for a portion of the GRGR expansion
- Meeting the City's repayment obligation in the original WG Project
- Saving funds for the eventual construction of the WGFP (Chimney Hollow Reservoir)
- Building, acquiring or expanding upstream native raw water storage
- Building the infrastructure for the downstream storage at Loveland Great Western Reservoir acquired in 2019
- Feasibility study on possible expansion of GRGR
- Design and construction of GRGR raw water bypass to allow additional flexibility for delivery of water into the WTP

3.3.5 Summary of Existing Water Bank Balances

Table 3-F shows the existing balances in the Water Bank for the various sources of raw water available to the City as of October 2020. These values represent credits that have not yet been applied to meet development requirements. As such, these Water Bank balances represent a commitment by the City to provide service in the future. See **Appendix I** for additional details on the Water Bank balances and credit values.

- ***Current Balance*** describes the water in terms of shares or inches of Native Ditches, acre-feet of Cash Credits, CBT Units, and acre-feet of Rist and Goss Ditch.
- ***Current Credit Values*** show the City's current credit per share/inch/unit.

The current Water Bank commitments are listed below using the conversion rates in effect since July 31, 2012, as well as firm yield values from the *2020 RWSYA* from SWE.

TABLE 3-F: Water Bank Values with Storage Option as of October 2020

Type of Water Bank Credit[1]	Native Ditch Credit	Cash Credits	CBT	Other[3]	Grand Total
Units[2]	AF	AF	AF	AF	AF
Current Credit[4]	1,988	1,218	290	322	**3,818**
Recommended Credit[5]	1,995	1,218	261	322	**3,795**
Recommended Credit w/o Storage[6]	506	2,218	261	322	**2,307**

Notes:

*(1) **Balances:** Current balances represent credit in the Water Bank which have not yet been applied to meet development requirements as of October 2020.*

*(2) **Rounding:** AF values are rounded to whole numbers.*

*(3) **Other** represents any water credit in the Water Bank not associated with the typical unit of shares, inches, or units of a particular type of water. It may also be for a specific type of water that is not listed in the table.*

*(4) **Current Credit** is the total credit in the Water Bank using current acre-foot credit values*

*(5) **Recommended Credit** is the total credit in the Water Bank using average historical yields per acre-foot from the 2020 RWSYA*

*(6) **Recommended Credit w/o Storage** is the total credit in the Water Bank using firm yields per acre-foot without storage from the 2020 RWSYA*

4. EXISTING SUPPLY ANALYSIS

4.1 Modeling Process

In January 2003, the City Manager directed Staff and the LUC to participate in the process of developing a study and computer model to evaluate the City's water supply. A subcommittee was formed with members of the LUC, Staff, and City Council. Spronk Water Engineers (SWE) was chosen to develop the study and construct the model due to their expertise and comprehensive knowledge of the City's water supplies.

The LUC was updated regularly on the progress of the study and model. The results of the study were presented to the LUC on November 17, 2004. On March 1, 2005, the City Council approved the use of the study and model as a tool to be used in the development of the *Raw Water Master Plan*. The City Council Resolution #R-25-2005 approving the use of the report is included in **Appendix II**.

It was anticipated the *RWMP* would need to be revisited and updated on a periodic basis of approximately five years or as circumstances would indicate. Following issuance in mid-2010 of the Court's final findings in the City's application in Case No. 2002CW392, which added about 6,051 AF of municipal supply at average yields, the City contracted with SWE to update the *2004 RWSYA* to include consideration of the effects of changes in the City's raw water supply system and water supply portfolio that had occurred since 2004. Results from the updated analysis were presented to the LUC in August 2011.

Since the *2011 RWSYA* and the *2012 RWMP*, additional shares and inches of ditches, units of CBT Project water, and downstream storage at LGWR have been acquired or purchased by the City. The City has also increased its subscription in the WGFP at Chimney Hollow to 10,000 AF. In preparation for this *2020 RWMP*, SWE again updated the model to include additional years of data and changes in the City's raw water portfolio. SWE was also instructed to include the potential yields from LIRFs, the Gard water, and the storage at LGWR.

This *2020 RWMP* update relies on this analysis and recommendations provided by the *2020 RWSYA* and considers the results of adding various sources to the City's water supply portfolio. It considers options for meeting the City's future raw water needs. Below is more discussion about the *2020 RWSYA*.

4.2 Raw Water Supply Yield Analysis

A computer model of the Loveland water supply system known as the Water Supply Yield Model was constructed in 2004 in an Excel-based workbook to simulate the integrated yield of the City's various water sources. The initial model and related report entitled, *Raw Water Supply Yield Analysis,* considered the yields of the City's current water sources during a 53-year study period from 1951 through 2003. This included 6,835 AF in GRGR, transferred water rights, pending transfers of water rights, current ownership of CBT and current ownership of WG. It did not include the WGFP. The historical conditions of the Big Thompson River Basin were represented by streamflow and diversion records from the Office of the State Engineer. The City's portfolio of raw water sources as it existed in 2003 was modeled with data from the study period to determine the water demand that it would support in a 100-year drought scenario.

The City's resulting raw water supply firm yield was defined as the number of acre-feet the City could have supplied each year to meet demands during the study period. This figure was derived by increasing the demand incrementally in the model until the City could no longer meet that increased demand. The 2005 firm yield of the City's then current raw water supplies was estimated to be 22,400 AF/year. When updated in 2011, the baseline firm yield increased to an estimated 27,390 AF.

The Loveland Water Supply Yield Model was updated in 2020 using the most current version of Excel and is now being used to estimate the impact of various alternative actions. The October 2020 update adds additional years of data through 2015 and considers the yields of the City's current water sources. The total firm yield estimate was 30,890 AF from the baseline run of the *2020 RWSYA*. The municipal water demand distribution was based on 2005 to 2015 data. See **Table 7-2** of the *2020 RWSYA* included in **Appendix II** for the various updates and differences.

The baseline model conditions used the historical stream flow and diversion records of the Big Thompson River. The City's 2020 water portfolio was modeled using data from the study period. This included the following sources, storage components, and exchanges:

- Transferred water rights in the City's Water Court decrees
- Pending transfers of water rights
- Current ownership of CBT units
- Current ownership of WG units
- Storage in GRGR
- Current participation in WGFP
- Anticipated downstream storage capacity in LGWR
- Pending LIRF decree

The conditions included the following adjusted and new factors, which were not modeled in the 2012 report:

1. **Additional Units in the Colorado Big Thompson Project:** The City purchased and/or acquired 424 additional CBT units beyond the 11,786 units modeled in 2011, making 12,210 units.
2. **Additional Storage in the Windy Gap Firming Project:** The City acquired 3,000 AF of additional storage in the WGFP beyond the 7,000 AF modeled in 2011. The project awaits resolution of a legal challenge to the federal agencies permitting the project, before construction may begin. Once construction begins, it is expected to extend for three to four years depending on weather conditions.
3. **Downstream Storage in Loveland Great Western Reservoir:** The City purchased the LGWR in January 2019. A capacity of 1,300 AF was modeled as the preliminary operational storage capacity. The actual storage may be as high as 1,600 AF. This reservoir provides storage of reusable return flows that can be exchanged upstream or released to meet return flow requirements or augmentation demands.
4. **Added the Loveland Gard Right:** The City is in the process of implementing the Loveland Gard Water Right into its water rights portfolio. The Loveland Gard Water Right, decreed in Case No. 07CW325, comes from a contract right of priority number one irrigation water historically carried in the Home Supply Ditch.
5. **Added Unchanged Ditch Shares:** Added unchanged ditch shares acquired since 2012.

Based on the modeling the firm yield is estimated to be 30,890 AF from the City's current supplies. This amount will meet 30,300 AF of municipal demand and 590 AF of augmentation/irrigation demand. This firm yield will be available to the City in a 1-in-100-year drought scenario without requiring any mandated watering restrictions. The 30,890 AF also assumes that the WGFP is constructed as planned. Issues discussed in the *2020 RWSYA* may increase or decrease the estimated firm yield value. This firm yield should continue to be re-evaluated periodically.

5. FUTURE SUPPLY REQUIREMENTS

5.1 Reserve Analysis

As discussed in the previous chapter, Loveland's current annual water supply firm yield, assuming the use of all available sources and that the WGFP is in place, was determined by SWE's modeling to total approximately 30,890 AF. This is the sum of 30,300 AF per year for municipal demands and 590 AF per year to meet augmentation and irrigation demands. With 30,000 AF as the current demand target and 30,890 AF as the projected water supply firm yield, it was determined that the City will have sufficient water supply to meet the anticipated needs of the City of Loveland's service area for a population of approximately 160,000 people. This depends upon completion of future native ditch share change cases, construction of WGFP, and development of LGWR, as modeled. As densities increase, it is difficult to identify a firm buildout population for Loveland. It is recognized that 30,000 AF is a target for planning purposes and that more or less water may be needed if development densities, redevelopment, or water use patterns change.

It is anticipated the City will continue to develop supplies in advance of its demands as has historically been done, thus maintaining a margin of new water supplies as the population continues to grow. This process is necessary as the lead-time for water infrastructure projects or Water Court cases often requires many years. Until it is needed for domestic purposes by the City, water in this margin can be used to:

- Serve customers within the service area with an even greater level of security.
- Serve adjacent water providers (districts or cities) as they make their own system improvements.
- Provide water for development of parks or open spaces while permanent water sources are being developed for those purposes.

LUC and Staff identified the following characteristics that are believed to be important considerations in developing additional supplies:

- **Quality:** Raw water supplies should be of high-quality and easily treated, with taste and odor characteristics acceptable to customers.
- **Cost:** Development of the supply through inclusion in decrees, building storage, etc., should be reasonable relative to alternative sources.
- **Drought Availability:** Sources should meet Council direction that the sources provide adequate resources for up to a 1-in-100-year drought without curtailing use.
- **Diversity:** Sources should maintain diversity in the City's portfolio regarding seasons of use, stored versus direct flow, reusable versus non-reusable, and native versus transbasin.

The margin of firm yield the City can supply at a given time above the amount needed for the current demand may be affected by the following factors:

- **Redevelopment** within the existing service area that may change densities
- **Expansion** of the existing service area or GMA
- **Changes in City policies** regarding raw water requirements
- **Changes in water use patterns** as water is used more efficiently
- **Increased demand** from new large water user(s)

It is prudent to keep in mind that the cost to permit and construct future water supply projects may be higher than for existing projects and the regulatory environment within which they occur will vary.

6. WATER EFFICIENCY

The City of Loveland's water utility was formed in 1887. The efficient use of water as well as providing high-quality water at a fair price have consistently been important to the City. The water utility uses a number of tools to promote the wise use of water, as described below.

6.1 Watering Restrictions

Lawn watering regulations appeared on the books only six years after the Water Utility was established. In 1893, the town fathers passed an ordinance dividing the town into two sections; one area watering from 5 am to 1 pm and the other area watering from 1 pm to 9 pm. This schedule was in effect from April to September each year. The City imposed more formal watering restrictions on its customers during the summer of 1970. Those restrictions were implemented to efficiently use the available WTP capacity and were not caused by inadequate raw water supplies. Until 1981, water restrictions allowed customers to irrigate lawns only two or three days per week. The installation of water meters and the expansion of the WTP allowed the restrictions to be lifted.

In the Spring of 2002, water restrictions were implemented in response to a limited water supply and uncertainty concerning the duration of the drought. The watering restrictions were lifted later that summer when water supply conditions improved. Since that time, watering restrictions have not been needed, but they remain a tool that can be employed should the need arise.

6.2 Water Meters

In July 1979, the Loveland City Council approved an ordinance requiring water meters for all new construction and for existing homes when ownership changed hands. Before that time, the City required meters only for commercial accounts within the City and for all accounts served outside the City limits. Less than a year later, in June of 1980, the Council passed another ordinance requiring meters for all water customers.

By 1981, the City was completely metered at a cost of over $3 million. The average annual water usage declined by 20 percent. Before metering, the WTP's maximum day demand was 22 million gallons per day. After metering, the maximum day demand was 16.7 million gallons per day. On a per capita basis, these reductions remain reflective of today's uses along with additional decreases per capita attributed to the City's customer based using more water-efficient fixtures and practices.

6.3 Water Rates

In 1887, the Water Utility established a flat rate, based on the type of dwelling and number of fixtures. Customers paid the yearly fee in advance. Until 1968, water rates were based on a flat fee determined by fixture count. Keeping track of the number of bathrooms and toilet fixtures in homes was difficult, so in July 1968, the City developed a flat rate charge per family based upon average water usage. Lot size determined the rate for lawn sprinkling. Since 1981, the monthly billing has reflected actual water use with the installation of meters.

In 1989, the City Council approved a series of rate increases that specified water rates from 1990 to 1997. A portion of the revenues from these rate increases allowed Loveland to purchase additional CBT units, cash fund the recent GRGR expansion and set aside money to pay off the City's obligation in the original WG Project. In 2001, the City lowered rates by 33 percent as a good-faith gesture to the customers once the specified needs for the rate increases were met.

Rates are and have been set for a number of years using a cost-of-service methodology, which means that rates reflect the real cost of providing water service to each customer class. For instance, because the irrigation customer class uses water during the peak water production times of the year, they pay a higher usage fee, because their water usage contributes more toward costly plant expansion projects required to meet peak demands.

Beginning in 2014, City Council began approving 10-year utility rate tracks with yearly water rate increases. In November of 2018, City Council approved the following 10-year water utility rate track with a 7% rate increase for 2020, followed by three consecutive years with rate increases of 7% per year, capped off by six consecutive years with rate increases of 3.5% per year.

The City can expect some decrease in demand due to these scheduled rate increases. Based on various studies, the price elasticity of annual residential water use is likely between 0.35 to 0.45, which means that a 10% rate increase would produce between a 3.5% to 4.5% reduction in demand over time with the outdoor demand being more elastic than indoor demand[1].

6.4 City Raw Water Planning Policy

On March 1, 1988, the City Council adopted the recommendations contained in a 1988 study that the City's water supply be capable of meeting design demands during a 1-in-100-year drought. This planning policy requires developing sufficient supplies to meet the City's full water demand during the 1-in-100-year drought without water use restrictions.

The LUC and City Council reaffirmed this policy as part of the approval process for the original Raw Water Master Plan in 2005 and then again with the 2012 update.

6.5 Water Efficiency Plan Update

Loveland's citizens can be proud they have historically been good stewards of the community's water resources. Continuing in that tradition, Staff is studying steps to enhance its current programs by encouraging wise uses of water. Using less water while also maintaining the desirable community attributes enjoyed in Loveland is an important issue. A consultant assisted with the 2012 update of the *1996 Water Conservation Plan*, which focused on education, maintaining already low gallons per capita per day water use, and identifying specific ways to further reduce the quantity of water used on an annual basis.

Beginning in July 2012, the Colorado Water Conservation Board expanded the focus of these plans to emphasize water efficiency, which includes practices, techniques, and technologies to extend water supplies, in addition to conserving water, with the objective to improve the efficiency of municipal demand and water supply systems. **Section 6.6** contains examples of water efficiency improvements that have been made throughout the City's water system. Because of the change in focus, Loveland's updated plan will be called the Water Efficiency Plan instead of Water Conservation Plan. The Water Efficiency Plan was presented to City Council and unanimously approved on June 2, 2020.

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[1] Griffin, Ronald C. Water Resource Economics: The Analysis of Scarcity, Policies, and Projects. The MIT Press, Cambridge, MA. 2006. http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/rates/White-Paper-Rate-Structures-and-Conservation-March-13-2009.pdf

6.6 Annual Water Audits

The City supports the accountable and efficient management of its water supplies by making efforts to understand its system inefficiencies and focusing efforts on continual improvement in tracking and billing the water that goes through the water distribution system. To support these efforts, the City has conducted annual audits of the water distribution system since 2000.

Between 2000 and 2014, the City performed an "Unaccounted for Water Loss Report" – a high-level audit with a basic calculation to deduct known water uses from the total water produced in a given year to determine the remaining "unaccounted for water" portion.

Beginning with the 2015 calendar year audit, the City began using AWWA's M36 water loss audit methodology in the *Water Audits and Loss Control Programs, Manual of Water Supply Practices*. These M36 water loss audits provide a much more thorough and in-depth approach. It requires gathering information from existing records, procedures, and databases and estimating other uses to categorize and quantify where water enters and exits the City's distribution system each calendar year. These audits focus not only on reducing water loss and non-revenue water, but also on improving the validity of each number entered into the audit.

During the course of compiling these M36 audits, several problem areas and inefficiencies were identified and corrected. Following are some of the key improvements made to increase revenue water, improve water efficiency, and better account for the water:

6.6.1 Volume from Own Sources

Through draw down tests, City staff discovered the master source meter was over registering the amount of water entering Loveland's water distribution system by approximately 3.85%. This difference had previously been attributed to water loss.

6.6.2 Billed Metered

When determining the boundaries of what to include and exclude from the audit, staff identified customer overlaps with neighboring water providers in which one water provider supplied the water to customers, but the customers were billed by another water provider. For the annual M36 audit, staff excluded water provided by other water providers billed to the City's customers, and included water the City provides to customers that are billed by other water providers.

During the 2018 and 2019 audits, some data entry errors in the consumption records when meters were replaced or customers changed were found and staff is working with Utility Billing to prevent these errors from occurring in the future.

From 2015 to 2018, the City metered and billed an additional 32 MG more from the following corrections and improvements:

- **Wastewater Utility** now pays for all water used at the WRF
- **Storm Water Utility** pays for the irrigation of two drainage ponds and at one ditch siphon
- **Local HOA** now pays for the irrigation water of the grounds around a neighborhood sewer lift station
- **Parks Department** pays for all downtown watering and for water used at the train depot at North Lake Park
- **Public Works Department** installed two more meters on their vehicles with water storage tanks rather than estimating usage by load counts.

Starting with the 2018 audit, the City began including construction water in the audit, which had inadvertently been excluded from prior years due to not being included on the consumption reports from the Utility Billing Department. Construction water is the initial water furnished to a premise during construction of improvements when no water meter had previously been installed. The Building Department charges a flat fee based on the tap size for an allotted number of gallons. The City had 530,815 gallons in 2018 and 682,779 gallons in 2019 of construction water.

6.6.3 Billed Unmetered

From 2015 to 2018, the billed unmetered usage dropped from 193 thousand gallons per year to less than 30 thousand gallons per year. Beginning in 2019, the Wastewater Utility began reimbursing the Water Utility for the water used for sanitary sewer jetting on a quarterly basis. Between 2015 and 2019, the estimated amount of water used for sanitary sewer jetting ranged from 3 MG up to 12 MG per year. The only other use remaining in the billed unmetered category is for the remaining Public Works vehicles with unmetered water storage tanks, for which the usage is estimated and billed based on the volume of tank capacity per vehicle and load counts.

6.6.4 Unbilled Metered

Since 2015, the unbilled metered usage has dropped from over 12 million gallons per year to less than 16 thousand gallons per year. The Water Utility now bills other departments, other City utilities, and a neighborhood HOA for water usage that previously had not been billed. See Billed Metered section above for more details.

6.6.5 Unbilled Unmetered

The City has dramatically improved the way that it tracks and estimates unbilled unmetered water usage. Logs with estimated water usage are submitted annually for the following unbilled unmetered activities:

- Fire hydrant flushing
- Transmission line flushing
- Water storage tank cleaning and draining
- Disinfection and construction projects
- Fire training grounds fire hydrant usage
- Off-site fire training
- Firefighting
- Fire hydrant flow tests
- New fire sprinkler systems
- Annual fire pump tests

6.6.6 Water Losses

The City's water engineering staff have focused efforts on rehabbing and replacing the worst performing waterlines in the water distribution system. Between 2015 and 2019, the total annual estimated water loss from the water distribution system (real losses and apparent losses) dropped by 440 million gallons.

6.6.7 Water Metering Inaccuracies

Water meters act as the cash registers for water utilities and it is important that they accurately record water usage so that each customer pays their fair share of the cost of the utility. Meters that test outside of the acceptable specifications are either replaced or rebuilt. The City currently employs the following meter testing procedures in addition to testing any meter flagged for a problem:

Small Meters (0.75” and 1.0”): Starting in 2017, the City began testing a yearly sampling of these meters.

Medium Meters (1.5" and 2.0"): Tested at intervals based on the rate of consumption verses the cost of testing and meter replacement, where not impeded due to issues in access, area disturbance or other difficulties.

Large Meters (3.0", 4.0" and 6.0"): Tested at intervals based on the rate of consumption verses the cost of testing and meter replacement, where not impeded due to issues in access, area disturbance or other difficulties.

6.7 Promoting Water Efficiency and Water Conservation

In May 1996, the City of Loveland prepared a Water Conservation Plan outlining sixteen conservation measures it wanted to initiate by 2001. Loveland implemented a host of water conservation programs, and in 2010 LUC and City Council approved the implementation of additional programs.

Loveland currently encourages water efficiency and water conservation through the following programs:

- Promotes the importance of water conservation and efficiency to its customers via social media posts, web content, videos, flyers, and events.
- Distributes publications through the Loveland Public Library, the Utility Billing Office, and the Utility Service Center.
- Provides dye tablets to test for toilet leaks.
- Partners with Resource Central to offer water efficient landscaping through the Garden-In-A-Box program.
- Maintains xeriscape demonstration gardens at the Service Center and at the Jeff Peterson Gardens.
- Informs customers of the water supply management program through the monthly City Update newsletter.
- Advertises water efficiency programs in print sources, including the newspaper and direct mailers.
- Offers an option for low water use irrigation meters using a water budget and conserving water through its Hydrozone Program. This option also lowers water rights requirements and potentially lowers system impact fees if tap sizes can be reduced.
- Requires soil amendments in the City's Unified Development Code in Section 18.08.06.03 for new construction as appropriate for the landscaping.
- Refines its leak detection program and repairs and replaces aging infrastructure to reduce system loss.
- Ensures meter accuracy through a proactive meter-testing program.
- Participates in the Children's Water Festival for 900 fifth graders where City staff lead activities that help teach kids about the importance of conserving water.
- Works with Larimer County Youth Conservation Corps to offer energy and water audits for residential customers.
- Partners with Resource Central to offer irrigation audits.

- Offers rebates to commercial and residential customers on certain water efficient fixtures through the Efficiency Works program.
- Maintains membership in Colorado WaterWise and promotes its *Live Like You Love It* water efficiency campaign to customers.

6.8 2003 Drought Response Plan

After living through one of the driest years on record (2002) in Loveland, the City Water and Power Department set out to develop a drought management plan for 2003 to prepare the City in case hydrologic and water supply conditions in 2003 were similar to those in 2002.

Specific actions taken included:

- Developed a program to rent CBT water on the rental market
- Implemented a staged lawn-watering schedule and excessive water use fee ordinance
- Established a Water Conservation and Drought Education Team
- Stored available water supply

A *2003 Drought Management Plan Summary Report* was prepared to document the actions taken in 2003 in response to the potential drought situation and, where applicable, to report on the effectiveness of the actions implemented. The report served as a tool for planning a response to future water supply shortages. The report included details about all projects and contained an extensive appendix to provide examples of the materials prepared and used.

The *2003 Drought Management Plan* was created specifically for that calendar year. Aspects of that plan were taken and expanded upon to create a broader *Drought Management Plan* published in 2013 applicable to all drought years. The revised plan added four increasingly restrictive drought response levels linked to the severity of the projected water supply shortage to reduce customer water usage and lower the overall demand on Loveland's water system. The degree of restriction in each level is meant to coincide with the drought severity and decrease the demand on the system by an estimated ten percent per level.

6.9 "Shave the Peak" Campaign

The "Shave the Peak" Campaign was the moniker given in 2010 to the operational practices designed to temporarily reduce the maximum day water production at the WTP. Instead of putting an $8.1 million-dollar project into the proposed 2011 budget. City Council approved the campaign with alternatives to reduce peak water demand and still meet the customers' water needs. The program started in 2011 and successfully delayed the costly water treatment capacity expansion project until 2014.

Staff reviewed data and trends in the City's water use, particularly WTP production. Building treatment facilities is expensive and much of the capacity is needed only during a relatively short period of time in the summer, remaining idle the remainder of the year. Water used for irrigation of urban landscapes was the primary driver to do costly WTP capacity improvement projects. Delaying the need to build additional water treatment capacity can save millions of dollars. Staff developed strategies designed to reduce the peak water demand on Loveland's WTP and delay the need for spending construction money, while having minimal impact on customers.

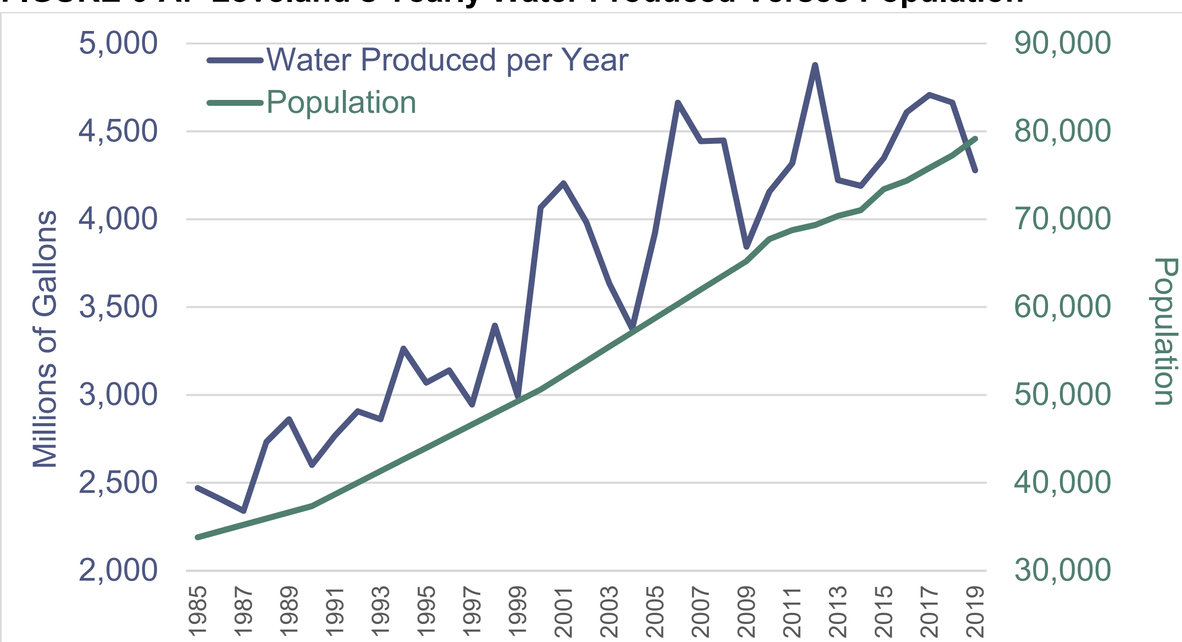
The City has several emergency interconnects with other water providers; however, this program focused on one particular interconnect. The program proposed activation of an interconnect from the Little Thompson Water District to the City's distribution system, and promoted enhanced community involvement through implementation of a voluntary every-other-day outdoor watering schedule. This interconnect would add treated water to the City's supplies when necessary, and the watering schedule balanced the community's water demand.

The plant expansion referenced above concluded in 2016 and increased the capacity from 30 MGD to 38 MGD. Over the last five years, the City's peak day flows per year have ranged from 24.8 MGD on the low end in 2019 to 27.7 MGD on the high end in 2018. We expect to employ a similar strategy when future peak day flows begin to approach the current 38 MGD capacity to delay the next expansion project to a time when the customer base has the need to use the additional capacity that the improvements would provide.

6.10 Current Status

Initial per capita consumption rates began decreasing once customers' water use became metered. Treated water production has varied despite annual increases in the customer base. Generally, the water demand is affected by the seasonal weather. During hot dry years, water production spikes to keep up with the higher irrigation demands, and during cold wet years, water production decreased to be in line with the lower irrigation demands. **Figure 6-A** illustrates the annual variability in water production with an increasing trend that follows Loveland's population growth.

FIGURE 6-A: Loveland's Yearly Water Produced Verses Population



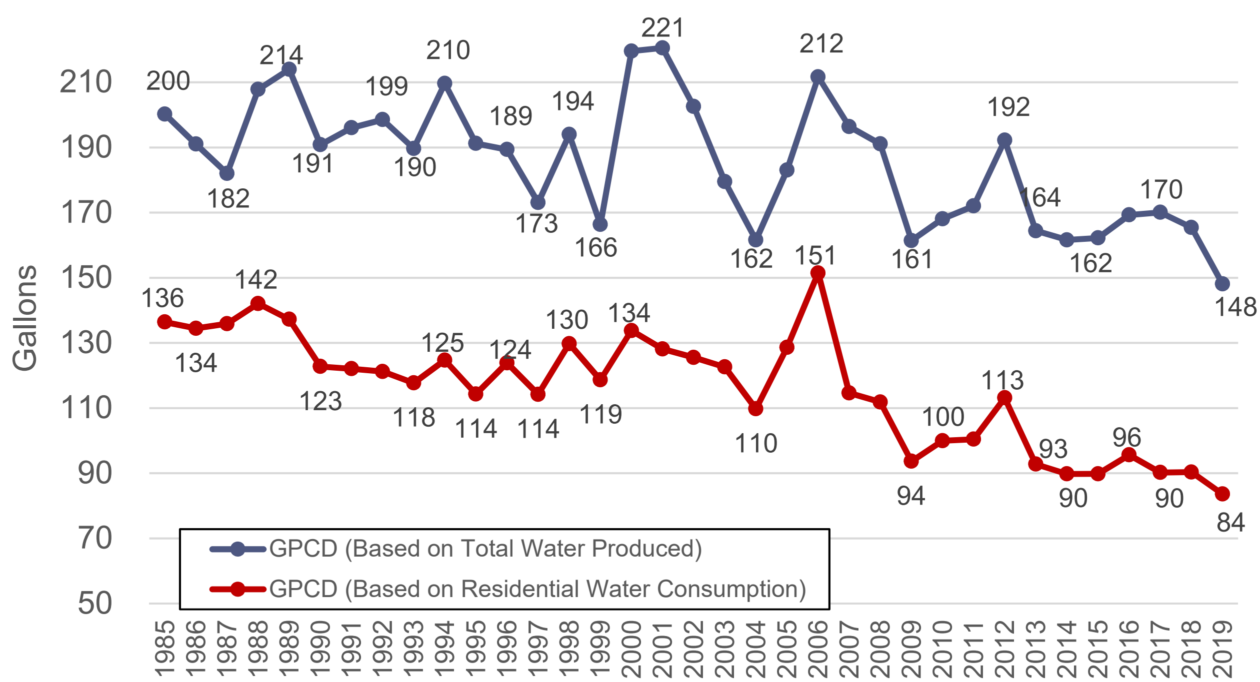
Water conservation is encouraged for our customers; however, Council has directed the staff to not include demand reduction goals or watering restrictions to meet future demands up to a 1-in-100-year drought event. More restrictive water conservation measures are considered to be a tool to manage drought events worse than a 1-in-100-year drought.

The 1992 Energy Policy Act[2] mandated the following low-flow fixtures be installed in all new single-family residential dwellings beginning in 1994 and in all new multi-family dwellings beginning in 1997:

- 1.6 gallon per flush toilets
- 2.2 gallon per minute at 60 psi bathroom faucets
- 2.5 gallon per minute shower heads

Loveland's average GPCD for residential water use has seen an overall decline after these plumbing code changes were implemented (See **Figure 6-B**); however, this decline has begun to level off with four of the last six years coming in at 90 gallons per capita per day.

FIGURE 6-B: Loveland Gallons per Capita per Day



Note: Prior to 2007, some irrigation tap water usage was included in the yearly residential water consumption numbers. There was not a separate irrigation customer class prior to 2008 and until that time irrigation tap water usage was partially accounted for in residential consumption and partially in commercial consumption.

Yearly gallons
÷ Population
÷ Number of days per year
Gallons per Capita per Day (GPCD)

The City's gallons per capita per day is in line with the national average, estimated to be between 80 to 100 GPCD[3]. The City projects 0.5% decrease in GPCD per year for the next 10 years as customers continue to replace older less efficient plumbing fixtures with more efficient models. To create an additional decrease in GPCD, the City would need to pursue additional conservation measures or expand its current conservation measures such as increasing xeriscaping, decreasing turf grass, and accelerating the replacement of older less efficient plumbing fixtures with more efficient models through rebates or other programs.

[2] U.S. Government Publishing Office https://www.govinfo.gov/content/pkg/BILLS-109hr6enr/pdf/BILLS-109hr6enr.pdf
[3] United States Geological Survey, https://water.usgs.gov/edu/qa-home-percapita.html

7. ALTERNATIVE SUPPLIES – OPTIONS AND ANALYSES

Both structural and non-structural options are possible for adding to the City's firm yield raw water supply. Only 4,790 AF more is required between the current firm yield and the demand target of 30,000 AF at build-out (30,000 AF demand target – 25,210 AF current firm yield = 4,790 AF). This is a useful number to consider when analyzing alternatives and their relative contributions to the City's raw water supply. The WGFP and LGWR are estimated to be online by 2031. Each will add firm yield to the City's portfolio.

7.1 Structural Plan Elements

Structural plan elements include physical facilities built to improve water supply. The structural plan elements examined in this RWMP include individual components and combinations of various reservoirs, conveyance facilities, diversion structures, and wells.

7.1.1 Upstream Storage

This discussion on Upstream Storage assumes the construction of the Chimney Hollow Reservoir Project will proceed to completion and considers the construction of other municipal storage capable of providing water to the City's WTP at Chasteen's Grove.

Such storage can provide significant benefits including protection from drought and opportunities for better management of the City's raw water supply. Additional firmed water supply would result from storing either existing or additional native water rights, WG waters or CBT Project waters. However, significant pros and cons involved with building additional municipal storage are important to consider:

Pros:

- **Provides Annual Storage** – Water from native ditch irrigation rights effectively become available on a year-round basis, not just during the irrigation season when the water is directly available from the river.
- **Provides Firming Storage** – The ability to keep additional water in storage during wetter years, above immediate demands, makes water available during periods of drought.
- **Provides Reuse Storage** – Reusable water exchanged from downstream can be stored upstream until needed.
- **Allows Gravity Conveyance** of water to the WTP, if located properly.
- **Provides Versatility** – Additional firm yield can be provided by storing native water rights the City currently owns or may acquire in the future, or excess WG or CBT Project waters.

Cons:

- **Relatively High Estimated Cost for New Construction**, from a low of $9,750/AF to a high of $47,910/AF of storage[4]. See discussion below for updated cost information.
- **More than 1 AF of Storage is Required to Obtain 1 AF of Firm Yield.** Information contained in **Figure 8-10** and **Table 8-5** in **Appendix II** of the *2020 RWSYA* may be used to calculate that a weighted average of 2.6 AF of storage is required for water from the local ditches, which Loveland currently accepts, to create 1 AF of firm yield, a 2.6 to 1 storage ratio.
- **Permitting:** Requires expensive federal environmental compliance permitting.
- **Conveyance:** Requires either a contract with USBR and Northern Water to use excess capacity in the CBT system for filling, or a separate conveyance system. Limited excess conveyance capacity may be available.
- **Infrastructure Modifications:** May require physical modification to existing CBT infrastructure.
- **Terrain:** Most prospective sites are in mountainous terrain, which will affect the cost by requiring tunnels, pipelines, or canals for filling and/or releasing water.
- **Project/Site Identification:** A specific site and project has not yet been identified.

Timing:

- Storage requires a single large capital expenditure. Payment can be distributed over time only by borrowing or by saving collected fees.

Between 2005 and early 2008, a series of studies conducted by BasePoint Design, Corporation, culminated in the June 19, 2009 *Comprehensive Study Report, Loveland Reservoir Storage Project*. This study is discussed in further detail in the *2012 RWMP*. The study analyzed potential reservoir sites in the Big Thompson River Basin and its tributaries, lying below Rocky Mountain National Park and west of Interstate Highway 25 and included sites in both the mountains and the plains. Utilizing a tabletop map study and using site selection criteria for screening 67 potential sites with staff. The work focused on specific site reconnaissance and feasibility level studies for seven sites, one with two possible configurations, making eight options identified. No plains reservoir sites were deemed acceptable for feasibility level study, for both cost and water quality reasons. See **Appendix IV** for a summary of the upstream storage site location options.

The most feasible option was for storage of 9,000 AF below the Hansen Feeder Canal at a site referred to as Maitland Canyon, at an estimated cost in 2008 of $67.5 Million. This resulted in an estimated constructed storage cost of $7,500/AF. Using the *Handy-Whitman Index for Collecting and Impounding Reservoirs*, the December 2019 estimated cost has increased to $89.093 Million, making the current estimated cost of constructed storage to be $9,900/AF. Using Storage to firm 500 AF values for the Louden, BTDM, South Side and Buckingham ditches from **Table 8-5** from the *2020 RWSYA* in **Appendix II** indicates a combined firming ratio of approximately 2.6:1.0 would be required to make the yield firm from newly acquired shares in those ditches (1,300 AF average storage/500 AF firm yield). This makes the estimated storage cost of firm yield for newly acquired raw waters about $25,740/AF.

[4] Updated from 4th quarter, 2008 dollars in the June 19, 2009 *Comprehensive Study Report* by BasePoint Design for storage in the mountains west of the City.

7.1.2 Plains Irrigation Reservoirs, Reuse, River Exchanges, & Downstream Storage

Generally, existing plains irrigation reservoirs, new downstream storage, reuse, and river exchanges are interrelated and are not necessarily stand-alone options for increasing Loveland's water supply. It is likely two or more of these options, sometimes involving both structural and non-structural components, would need to be implemented simultaneously to be effective. To avoid duplication, logical combinations are addressed here in the structural section, and the information is not repeated in the non-structural portion of this discussion.

1. **Plains Irrigation Reservoirs**

   A significant number of reservoirs belonging to local irrigation companies are filled using water diverted from the Big Thompson River. Most are located on the plains east of the foothills in and around the City. These historically provided water for irrigation in the basin and continue that function today. Several are near the same size or larger than GRGR that has 6,835 AF of storage capacity. The City owns shares in a number of these companies. As part of the *Comprehensive Study Report* discussed previously, BasePoint Design and CH2MHill investigated the possibility of using municipal storage in these reservoirs.

   Significant administrative, technical and financial challenges must be addressed before extensive use of irrigation storage for City purposes would be feasible. Water stored in plains reservoirs would need to be delivered to the WTP or GRGR, both of which are located at higher elevations on the river. From the plains reservoirs, physical infrastructure, such as pumps and pipes, or administrative delivery methods, such as exchanges or alternate points of diversion, would be required to deliver water into the City's facilities.

   Moving water from these reservoirs to the City's own downstream storage would also trigger physical or administrative challenges, but would allow holding it as the source for a raw water irrigation system, for exchange upstream, or for sale or trade to others.

   Changes in points of diversion or types of use must also be considered. These may involve negotiating agreements with irrigation companies and pursuing decrees in Water Court. Since none of these irrigation reservoirs are at elevations above the City's river headgate at the WTP, their use for municipal purposes can only be assured by exchanging water in the river, pumping, or finding a downstream municipal use or non-municipal user.

   The City's*1980 Water and Wastewater Master Plan* developed by Black and Veatch previously investigated the use of plains reservoirs to meet municipal demands. At that time, the City's 600 AF original GRGR had been in service for approximately a year. As a first approach to acquiring more raw water storage, the report recommended that the City endeavor to work out an exchange arrangement with an irrigation company, which was considered more cost-effective than construction of a large new reservoir (Black and Veatch, 1980). It has not been possible to arrange significant storage capacity because of limitations on exchange capacities and concerns of the irrigation companies on the effects to their yields. Results from the *2005, 2011*, and *2020 RWSYA* reports illustrate the limitations on upstream exchanges which are necessary for increasing firm yield.

   Another scenario that the *1980 Water and Wastewater Master Plan* explored was the possible future location of a WTP near an existing plains reservoir. As part of the *2009 Comprehensive Study* Report, BasePoint Design and CH2MHill further investigated this possibility. Two major concerns with this scenario are the proximity to urbanization and the relatively degraded water quality. Locating a WTP near urbanized areas may be opposed by nearby residents due to its visual impact (including but not limited to lagoons) together with probable increases in noise and traffic flow. The use of plains reservoirs also lends themselves to other issues not usually experienced by a reservoir located at a higher elevation. Shallower, warmer raw water storage reservoirs such as those existing on the plains present increased taste and odor problems and subsequent treatment related to increased algal growth and other issues. Also, the conveyance into such a reservoir would most likely utilize existing canals which flow through developed urbanized areas. Contamination due to surface runoff, spills, and pipeline breaks are real threats to the potable water supply. Surface runoff from urbanized areas is of special concern since it may possibly contain organics, bacteria, heavy metals, suspended solids and residues from fertilizers, pesticides, herbicides, fuels, oils and greases. Should even small quantities of these undesirable constituents find their way into conveyance ditches, structures, or the lakes themselves, they would almost surely lead to increased treatment costs.

2. Reuse

Loveland has water sources, which when used, create flows returning to the river that may be claimed and reused. These sources include WG Project water, waters stored under the combined terms and conditions of the 2000CW108/2003CW354 decrees (originally the 82CW202A, aka 202A decree) and waters diverted under the terms and conditions of the 2002CW392 decree. Portions of this reusable water, when used for lawn irrigation, results in return flows to the groundwater that eventually makes its way into the Big Thompson River. These flows are known as lawn irrigation return flows (LIRFs). The City is currently working on an application to the Water Court, Case No. 2018CW3193, intended to demonstrate its dominion and control over this water and making it available for meeting required return flows to the river and for augmentation. The decree is targeted for completion in 2021 or 2022, and may create several hundred acre-feet of additional firm yield for the City.

Reuse already contributes to the City's firm yield of 30,890 AF (upon completion of the Chimney Hollow Reservoir upstream and the LGWR downstream) to the extent exchanges are administratively possible in the Big Thompson River when capacity is available. **Section 8** of the *2020 RWSYA* in **Appendix II** provides details on how the City's firm yield may be negatively affected if other conditional exchanges, senior to Loveland's, are exercised more than expected in the future, or if less CBT water is delivered through the Big Thompson River.

A study conducted on behalf of the City by Richard P. Arber Associates evaluated the feasibility of developing a second use water system where reuse would supply raw water irrigation. The study culminated in a July 2004 report, *City of Loveland Second Use Water Program Development Final Report*, showed that raw water irrigation from downstream storage through a parallel 'purple pipe' system is relatively expensive and is not considered feasible. At the time of the report, the eastern portion of Loveland was considered the most feasible area for installation. This report was brought to the City Council for consideration in October 2004. The City Council accepted the recommendation of Staff and LUC to not pursue construction of such a system in the near future, but to monitor whether this may become a more attractive option at a later time due to changing economic conditions. Since that time, significant development has occurred in the eastern portion of Loveland, including streets, utilities, businesses and homes, significantly increasing the costs of constructing a purple pipe system in this area.

The City claims some of the reusable waters to meet its own augmentation and return flow replacement requirements. It has also investigated marketing the reuse to a downstream user other than the City. No significant downstream users willing to purchase or lease the water on a long-term or permanent basis have been identified. As markets develop, the City's downstream storage at LGWR will help ensure that a reliable supply of reuse water will be available on demand to satisfy the City's existing augmentation and return flow obligations under agreements and Water Court decrees and to maximize the beneficial use of the City's reusable water supplies.

3. **River Exchanges**

   A river exchange of water allows an upstream diverter to take water from the river that would otherwise flow to a downstream senior diverter with a substitute supply made available to that downstream diverter. River exchanges are a desirable alternative to pumping when they can be operated on a reliable and rigorously managed basis. The upstream diverter must ensure that the downstream diverter has sufficient water to meet their demand from the river, and if necessary, must provide a suitable replacement supply of water, coincident in amount, timing and quality with the water they would otherwise be receiving. This process precludes the need for expensive direct pumping of water from a down-gradient reservoir to meet an up-gradient demand. The City's *1980 Water and Wastewater Master Plan* by Black and Veatch determined that pumping water was economically infeasible (Black and Veatch, 1980). Increased costs of energy and infrastructure for pumping ensure that this situation has not changed. Staff will continue to monitor this situation as the value of water continues to increase.

   Using an exchange, Loveland can release legally reusable treated effluent to the Big Thompson River and divert a like amount of water upstream. The City has adjudicated its conditional exchange appropriations in Water Court Case No's. 02CW393 and 02CW394. An exchange can only operate through an active or live stream to the extent that it does not interfere with the operation of senior water rights diverting within the exchange reach. This means that if a senior user within the exchange reach is diverting and drying up the stream, then Loveland cannot operate the exchange. Loveland's sources of reusable water include stored 202A water, 392 water, WG water, and will include yield derived from future water rights transfers. Return flows from the use of these sources not required for return obligations are reusable by the City. Such reuse may occur directly (as discussed in the **7.1.2.2 Reuse Section** above) or by exchange, such as diversions at the Loveland Pipeline in exchange for discharges of reusable effluent at the WRF. The rate of exchange is limited by the available capacity of the diversion facilities and by the river exchange potential between the WRF outfall or reservoir outlet and the upstream diversion point. The relatively small flows in the Big Thompson River limit the reliability of newer exchanges in this basin.

   From **Section 8.1.2** of the *2020 RWSYA* in **Appendix II**, the average simulated annual use of reusable return flows derived from using the City's conditional river exchange applications is 1,965 AF. This component is a contributing factor in the City's firm yield of 30,890 AF.

   The *2020 RWSYA* shows that the City's firm yield may be negatively affected if other conditional exchanges, senior to Loveland's, are exercised to a greater degree than expected, or if less CBT Project water is delivered down the Big Thompson River reducing opportunities for exchanges, due to the changing character of ownership of CBT water from agricultural to municipal and industrial users.

   1. **Exchanges by Others:** The effects of exchanges operated by other parties is discussed in **Section 8.5** of the *2020 RWSYA* in **Appendix II**. Variability exists, depending on which section of the river is involved and when and how the exchanges are operated, as shown graphically in **Figure 8.6** of the *2020 RWSYA* in **Appendix II**. The lower river exchanges have less impact on Loveland's firm yield than the middle river exchanges because there is less conflicting demand. For an assumed exchange rate by other parties on the river of

50 cfs being operated whenever possible, the lower river exchanges would reduce Loveland's firm yield by about 3,760 AF/yr while middle river exchanges at the same rate would reduce the firm yield by approximately 6,330 AF/yr. These are worst case values, and future operation of those exchanges will likely be significantly less than the rates assumed for modeling purposes.

2. **CBT Ownership Changes:** The effects of reduced deliveries of CBT to agricultural users along the river are discussed **Section 8.6** of the *2020 RWSYA* in **Appendix II**. In the unlikely event CBT agricultural deliveries ceased entirely on the Big Thompson River, Loveland's firm yield would drop about 2,480 AF/yr because of reduced opportunity for exchange. For comparison, if they dropped by half Loveland's firm yield would drop by about 1,500 AF/yr, shown graphically in **Figure 8-7** and **Figure 8-8** of the *2020 RWSYA* in **Appendix II**.

Operating a river exchange requires City Staff to be vigilant in planning and operating, as well as staying in regular communication with the River Commissioner who provides oversight on river administration. City staff is proactive in protecting its firm yield position wherever possible from changes on the river as they occur.

4. **Downstream Storage**

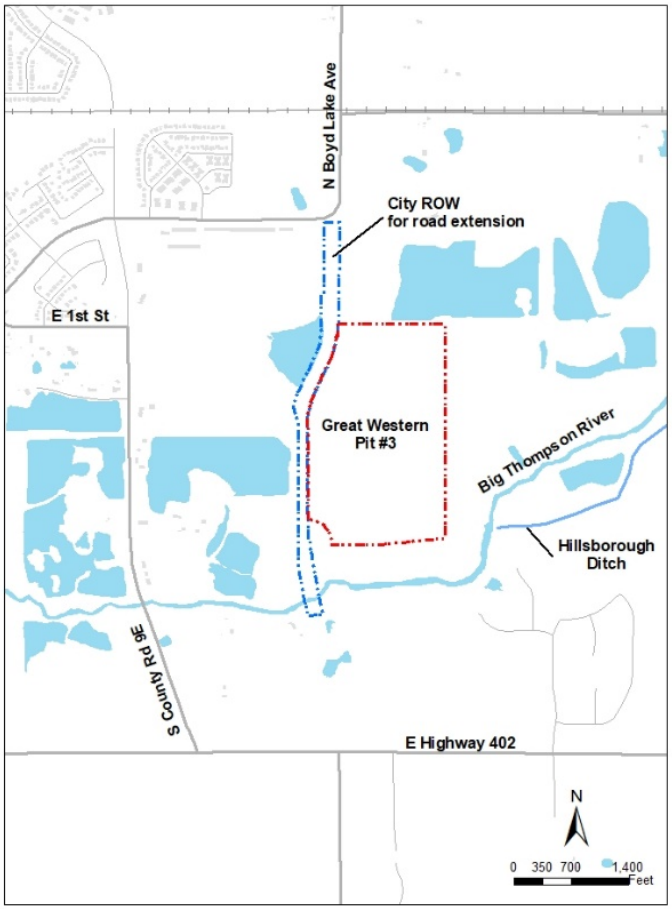
Downstream storage involves using existing plains reservoirs, lined gravel pits or constructing new storage reservoirs. These vessels would capture reusable effluent from Loveland's WRF or could store water using the City's 202A, 392, or future storage decrees. In 2019, the City completed the purchase of Loveland Great Western Reservoir (a.k.a. Great Western Pit No. 1, or Kaufman Pit) at a price of approximately $2,690/AF of storage volume. Additional infrastructure is necessary to make diversions into and out of the reservoir. The project to install that infrastructure is expected to occur approximately eight to ten years in the future. When completed, this will provide the City with an estimated 1,300 AF of active storage space resulting in 1,810 AF of additional firm yield (**Section 8.1.1** from the *2020 RWSYA* in **Appendix II**: 30,890 AF firm yield with LGWR and – 29,080 AF firm yield with only WGFP = 1,810 AF firm yield of LGWR).

Reusable effluent in excess of that needed by the City to meet its own augmentation requirements may then be used in a number of ways:

1. Used for raw water irrigation
2. Moved upstream to the WTP physically by pumping or through an exchange
3. Marketed to a downstream user other than the City, preferably for water the City can use directly such as CBT.

The benefit of downstream storage is the ability provided to store reusable sources of raw water until downstream demands arise or until exchange potential is available in the river and the water may be exchanged upstream. According to the *2020 RWSYA*, adding downstream or terminal storage to Loveland's water system would increase the City's firm yield by providing a place to store reusable effluent and other reusable water sources when the exchange potential is limited.

FIGURE 7-A: Loveland Great Western Reservoir Site Location



The increases in Loveland's firm yield resulting from various amounts of additional terminal storage above the 1,300 AF modeled in LGWR are shown in **Figure 8-17** of the *2020 RWSYA* in **Appendix II**. The City's firm yield would be enhanced by about 460 AF, using reservoir fill and release rates of 10 cfs, by exchanging reusable water upstream from an additional 200 AF of downstream storage near the WRF where reusable effluents could be captured and temporarily stored. Results from the *2020 RWSYA* indicate that terminal storage up to approximately 1,500 AF would provide appreciable increases in the City's firm yield, so the acquisition of LGWR with estimated 1,300 AF of active storage capacity fits well under the curve shown in **Figure 8-17** in **Appendix II**. There was minimal additional benefit from a greater volume of downstream storage.

Current cost estimates for downstream storage along the river, including land purchase and construction of infrastructure, are about $6,500/AF of storage. The LGWR purchase price was $3.5M, and the necessary infrastructure is estimated to be about $5M, for the estimated 1,300 AF of active storage space. Downstream storage presents many of the same quality and administrative challenges as discussed in the "Plains Reservoirs" section. Downstream storage in about a decade will become a useful tool in the City's water supply toolbox. To obtain the projected increases in firm yield will require proactive operation of that tool by City staff and open communications with the River Commissioner, who provides administrative oversight.

7.1.3 Wells

In general, water pumped from wells originates from two sources, non-tributary and alluvial.

1. **Non-tributary Ground Water** refers to aquifers geologically confined such that they have no measurable connection to surface waters, generally referred to as "designated ground water basins." Because this water is unconnected to the surface stream its use is not regulated by the prior appropriation system. In fact, deep ground water requires completely different management from surface streams and tributary ground water. However, there are no "designated ground water basins" in Larimer County, according to the State Engineers Office and the Colorado Ground Water Commission. No deposits of deep ground water are available to develop to meet the City's demands.

   Before this was generally understood, in 1885 and 1886 the City drilled what was anticipated to be an artesian well on the southwest corner of the 4th Street and Cleveland Avenue intersection, at a cost of $14,000. Drilling stopped far below any alluvial sources at a depth of 2,742 feet, when a small flow of water came to the surface. After cleaning out the well and installing a two-inch pipe, the flow of water increased to 40 barrels a day. The supply was obviously inadequate in quantity, and the water produced was not satisfactory for domestic use as it contained high concentrations of mineral salts, including hydrogen sulfide.

2. **Alluvial or Tributary Ground Water** hydrologically connects to the river. The primary source of water for the wells that are located near Loveland is the Big Thompson alluvial aquifer, which is tributary to the South Platte River. Prior to the development of the extensive irrigation network in the river flood plain and terraces, there was little groundwater available. As irrigation occurred, the water table raised to the point that some wells along the Big Thompson River were developed. However, the production rates of these wells are only suitable to support relatively small domestic uses, such as indoor household use and limited stock watering or garden irrigation. These wells do not produce enough yields on a consistent basis to consider them a reliable source for the City's domestic water supply.

   An interesting example of the limitations of local alluvial groundwater sources occurred in nearby Union Colony (Greeley), which originally used shallow alluvial wells to meet potable demand. In 1886, the early settlers constructed the City's first water system, consisting of a series of infiltration wells drilled into the gravel bed of the Poudre River a short distance from the center of town. The quality of the well water degraded as nutrients from the surrounding agriculture flowed into the wells. The water was described as being of "exceptionally poor quality," and the available volume was very limited during dry seasons. The water quality continued to degrade until 1900, when the residents decided they must look for a source with better water quality[5].

   Groundwater in the alluvial aquifer is for the most part, harder and more mineralized than the overlying surface waters. Total dissolved solids concentrations ranged between 450 to 4,060 mg/l during 1965 (U.S. Geological Survey, 1965). Values for hardness ranged up to 1,950 mg/l of total hardness. Major constituents in the ground water include calcium, magnesium, sodium, bicarbonate, and sulfate, the latter of which ranged in concentration up to 2,210 mg/l (U.S. Bureau of Reclamation, 1979). These concentrations are high and would likely be prohibitively costly to treat, requiring ion exchange, and/or reverse osmosis technologies. For example, the secondary drinking water standard for dissolved solids cannot exceed 500 mg/l. Alluvial ground water in this basin is generally of lower quality than surface water and is not considered suitable for treatment and drinking. Loveland operates several alluvial wells for park irrigation, but yields are limited. Since they are tributary to the river, their use requires augmentation of the river using other water sources, and none, singly or collectively, are capable of meeting a significant portion of the City's potable demand. Limited flows, significant initial capital costs, water quality concerns, ongoing operation and maintenance costs, costs to provide augmentation water, and the costs for legal and engineering efforts associated with obtaining the necessary permits and augmentation plans all contribute toward making the small alluvial wells possible in the area of the City ineffective in significantly contributing additional amounts to the City's firm yield.

[5] City of Greeley. *Water History of Greeley.* 2005. http://greeleygov.com/services/ws/system/water-history

7.2 Non-Structural Plan Elements

Non-structural plan elements include means of improving water supply without constructing significant physical facilities. Non-structural plan elements examined in this *RWMP* include combinations of operational changes, modifying the City's water rights dedication policy, and reuse or exchanges of the City's water rights. Reuse or exchange of the City's available water is discussed in the Structural Element section in conjunction with the discussion on downstream storage (See **Section 7.1.2**).

7.2.1 Operational Changes

During the performance of yield model runs, SWE observed that the firm yield results can change substantially depending on how various existing water sources are used, even without acquisition of additional ditch shares or storage. The operational changes could include varying the order of use of the various supplies. **Section 8.9** of the *2020 RWSYA* in **Appendix II** briefly discusses the possible effects on the model results.

Table 8-9 of the *2020 RWSYA* in **Appendix II** summarizes the results of various model runs simulating changes in the City's operations or the assumptions about the water sources. The "All Max" run incorporates all of the operational changes that increase the firm yield, into a single model run. The All Max run increased the firm yield over the base run by 2,020 AF, but making some of the changes will require additional work to memorialize them for future certainty.

7.2.2 Acquire CBT Units

The CBT Project provides a supplemental water supply to East Slope entities within the boundaries of Northern Water (See **Figure 2** in **Appendix V**). The Project has 310,000 AF units, of which Loveland currently owns 12,210. Each unit represents a maximum potential delivery of 1.0 AF of water per year. Since 1957, an annual quota has been issued by Northern Water's Board to set the percentage of an acre-foot that would be allocated per unit during that specific water year. Under the Northern Water's current ownership policies, the City is "capped," meaning the City cannot purchase additional units. This is memorialized in a letter from Northern Water dated September 24, 2019. The City may, however, accept CBT units for development when offered.

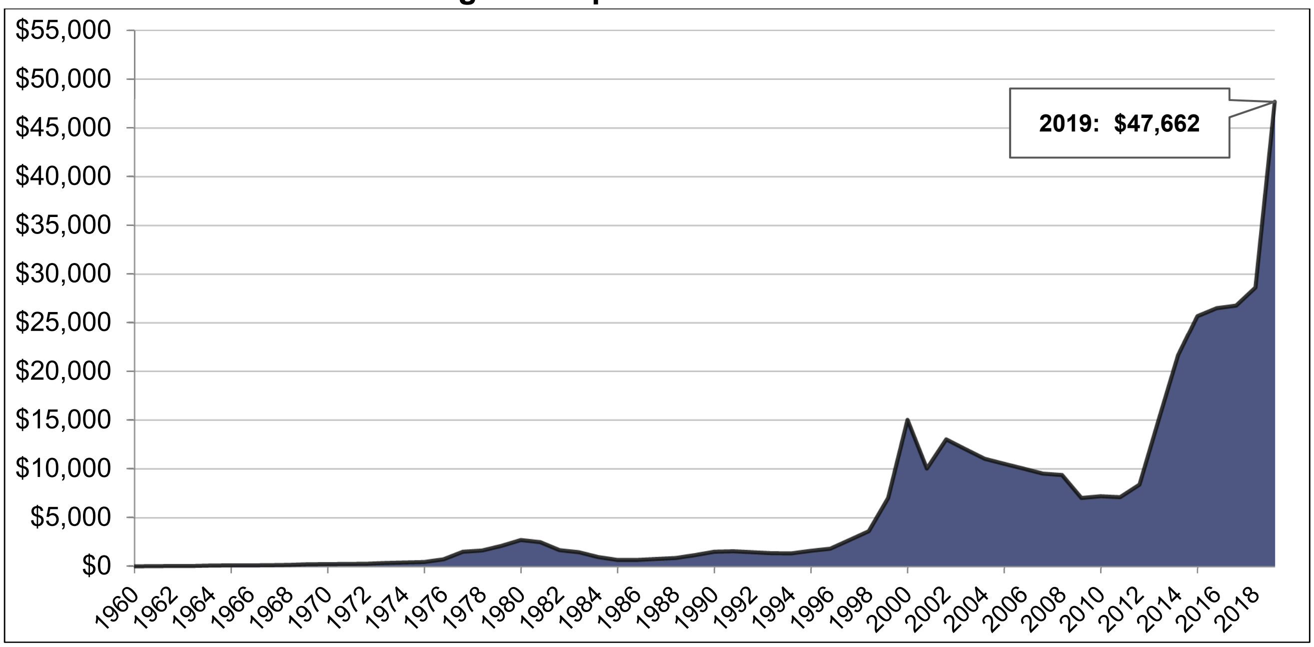
Since 2011, and particularly in the last few months, CBT market prices have climbed rapidly to over $50,000/unit, with March and April 2020 sales having exceeded $60,000/unit. **Figure 7-B** shows historical average CBT prices over time and illustrates the steep increase in market price that has occurred since 2011. Please reference **Figure 3-A** that shows the trend in ownership of the CBT units as transfers from agricultural to municipal and industrial ownership have occurred. Demand for CBT units for domestic purposes has reached a point where few are available and few are offered to the City for development. This remains a raw water source the City should accept when available. General pros and cons to the City of owning and/or acquiring CBT units are as follows:

Pros:

- Historic operation as a supplemental supply allows for increased yield when projections for native Big Thompson basin water supplies show decreased yield.
- It is available incrementally and may be purchased in large or small blocks at any time contingent on market conditions (when the City is not capped).
- Additional storage is not required as it is already stored.
- It is available at any of the City's delivery points and at any flow rate, by order on the previous day. It is essentially available on demand.
- No Water Court actions are required to make it available for use.

- The source is located in the Colorado River Basin. Hydrologic and climatic conditions are usually not the same or of the same degree in the Colorado River Basin and the Big Thompson River Basin simultaneously. Having water from both basins provides the City with an additional increment of drought protection. If conditions are dry in the Colorado River Basin and supplies are limited, less severe conditions may exist in the Big Thompson River Basin, or vice versa.
- Quantities not needed by the City on an annual basis are readily available for agricultural use through water rentals.

FIGURE 7-B: Historical Average Price per CBT Unit



Cons:

- Prices have climbed steeply in recent years, and developers are less likely to offer CBT units for development. See **Figure 8-A**.
- Return flows resulting from first use are not reusable.
- CBT is a limited, finite supply. The available supply is diminishing, which may cause continuing upward price pressure. See **Figure 3-A**.
- Decisions by Northern Water's Board regarding future carry-over policies, Rule 11 charges, assessment charges, winter deliveries, or annual quota setting may constrain future uses and/or affect operational costs.
- Use is subject to terms and conditions of Colorado River Compact, Drought Contingency Plans and possible litigation concerning West Slope interests.
- Use is subject to the impacts of Federal oversight of Endangered Species Act protections and any changes on the Colorado River that may arise.
- In the future, a limited supply may be available. The number of CBT units held by entities (primarily farms), which may still be available in the future, is currently estimated by Northern Water staff at about 34,000 units and continues to decline. The decline indicates that more of these units are being acquired by municipal, industrial, and rural domestic water purveyors.

<u>Timing</u>:

- The City's ownership is "capped," and the City may only accept CBT units when they are conveyed for specific development projects.

To determine the firm yield value of CBT water to the City, SWE analyzed the potential benefit of adding another 500 AF per year of average annual CBT yield. Using the long-term historical average of CBT, this required adding another 668.1 CBT units to the City's current ownership. The increase in firm yield of adding the 668.1 CBT units was an additional 610 AF/yr. This is equivalent to a yield of about 0.88 AF/unit. The City's credit of 1.0 AF per unit for CBT water may require adjustment to more closely match this yield value. These results are pertinent for the addition of the 668.1 CBT units and may vary at higher levels of CBT acquisition.

7.2.3 Increase Participation in Windy Gap and/or Windy Gap Firming Project

Increased participation in the WG Project could occur in any of the follow three ways, each discussed below:

1. Acquire additional WG Units without the WGFP in place
2. Increase storage capacity in the WGFP
3. Acquire additional WG Units with the WGFP in place

The City owns 40 units (at an anticipated yield of 100 AF/unit) of the WG Project, or nominally 4,000 AF. The repayment contract for the WG Project matured in 2017. Payments over the life of the 30-year loan totaled approximately $718,000/unit. For comparison, recent sales of WG units have been above $2M/unit.

The City's subscription in the WGFP is 10,000 AF of storage. Participation in the project increases the City's firm yield, but the benefit diminishes with incremental increases in the City's participation. A combination of more storage and additional units provides the greatest increase in firm yield, but the cost per acre-foot rises. See **Figure 8-4** in the *2020 RWSYA* in **Appendix II** for an analysis of benefits to the City from acquiring additional WG units and/or additional acre-feet of storage in the WGFP.

1. **Acquire Additional Windy Gap Units without the Windy Gap Firming Project in Place**
   The *2020 RWSYA* found that without the proposed WGFP, additional unfirmed WG units add no firm yield to Loveland's water supply on their own. Loveland's currently unfirmed 40 WG units do add a marginal amount of increased firm yield to Loveland's system in the *2020 RWSYA* modeling by bolstering Loveland's carryover supply in GRGR going into the critical drought period, but more WG units would not increase the carryover supply.

2. **Increase Storage Capacity in the Windy Gap Firming Project**
   The City's current level of participation in the WGFP is 10,000 AF of storage at a projected Project cost of $7,511/AF. As the Project is not yet under construction, it is theoretically possible the City could acquire additional storage space without acquiring additional WG units. The *2020 RWSYA* estimates the increase in Loveland's firm water supply yield, using various assumed levels of storage up to a maximum of 20,000 AF of storage. The results are displayed graphically in **Appendix II** in **Figure 8-4** of the *2020 RWSYA* and in the table in **Section 8.3** of that report, *Increased Firm Yield from Loveland Participation in the Windy Gap Firming Project*. For example, increasing the storage volume by 500 AF up to 10,500 AF results in an increased firm yield of 130 AF, giving a storage ratio of 3.8 to 1, and an estimated cost of $28,500/AF.

With an additional 6,000 AF of storage, totaling 16,000 AF, Loveland would increase its firm yield by 1,360 AF/yr, giving a storage ratio of 4.4 to 1, meaning approximately 4.4 AF of additional storage will provide 1.0 AF of additional firm yield at an estimated cost exceeding $33,000. As discussed in point 1 above, adding storage space and WG units results in greater increases in firm yield, but results in greater cost per acre-foot of firm yield. See **Table 7-A** for more details.

TABLE 7-A: Increased Firm Yield vs. Windy Gap Firming Project Participation and Windy Gap Units

Windy Gap Firming Project Storage (AF)	Windy Gap Units		
	40	45	50
0	26,130	26,130	26,130
2,000	26,820	26,820	26,820
5,000	28,580	28,580	28,580
7,000	29,900	29,900	29,900
9,000	30,610	30,780	30,780
10,000	**30,890**	31,210	31,210
11,000	31,160	31,580	31,640
12,000	31,440	31,840	32,050
14,000	31,960	32,320	32,720
16,000	32,250	32,610	32,970
20,000	32,610	32,960	33,340

Note:
Loveland owns 40 Windy Gap Units and is currently participating in the Windy Gap Firming Project in the amount of 10,000 acre-feet of storage.

3. **Acquire Additional Windy Gap Units with the Windy Gap Firming Project in Place**
Purchasing additional firmed WG units with the WGFP in place would increase Loveland's firm yield, depending on the level of WGFP participation. By adding more firmed WG units, the carryover storage in Chimney Hollow Reservoir leading into a drought can be enhanced, which in turn increases the potential firm yield available to Loveland. A summary of the incremental firm yield from 500 AF/yr of average annual WG yield is shown in **Figure 8-12** of the *2020 RWSYA* in **Appendix II**. When Chimney Hollow Reservoir is in place with the City's 10,000 AF of storage and its 40 units of WG water, acquiring an additional WG unit at an estimated cost of $2,500,000 would result in a 56.44 AF increase in the City's firm yield, as shown in **Table 8-5** of the *2020 RWSYA* in **Appendix** II, at an estimated cost of over $44,000/AF.

7.2.4 Acquire Native Rights

The City currently accepts shares from a number of local ditch rights for development credit if certain conditions are met. Native water rights from these ditches have historically been acquired by the City through the development process, as their ownership is conveyed to the City in exchange for acre-foot credit that can be used to meet raw water requirements for new development. These rights may be bought and sold, and the City could focus on purchasing some of the more senior rights as opportunities arise, including associated dry-up covenants and adequate historic use.

As addressed earlier, staff estimates there remain available within the City's Growth Management Area native ditch rights totaling about 1,714 AF of average yield, if approximately 4,456 AF of new storage were constructed, using a projected storage ratio of 2.6 AF of storage necessary to make firm each acre-foot of yield. Without additional storage, these rights would provide approximately 537 AF of firm yield if acquired by the City. This information comes from **Table 3-C** of this RWMP report.

General pros and cons for purchasing native ditch shares are as follows:

Pros:

- Generally, minimal annual operational costs (assessments).
- Timing: availability coincident with City's highest demand (irrigation season).

Cons:

- Conveyance costs associated with using the CBT Project facilities to place the water in storage at GRGR (approximately $35/AF currently, and may significantly increase when the current carriage contract, which expires in 2026, is renegotiated).
- Storage is required to make these direct flow waters available to meet year-round municipal demands.
- Storage is required to firm the yields for 1-in-100-year drought conditions.
- Requires significant investment of time and money to transfer rights in Water Court for municipal use.

The *2020 RWSYA* analyzed the potential increase in Loveland's firm yield by the addition of shares of various Big Thompson River Basin irrigation companies, including shares of selected irrigation companies in which Loveland has not previously transferred shares to municipal use. In order to facilitate comparison of the yields from shares in various irrigation companies, the report evaluated the increase in firm yield resulting from a Water Court transfer of 500 AF of average annual historical yield for each irrigation company. The results of the analysis are shown in **Table 8-5** and **Figure 8-10** of the *2020 RWSYA* in **Appendix II**.

Without added storage, the estimated increase in Loveland's firm yield for newly acquired shares is typically much less than the average annual historical yield of these shares. The principal reason is that the City's demand pattern occurs throughout the entire calendar year, but the historic deliveries for these shares occurred during the irrigation season only. Storage is required to allow continued diversions of the water under historic patterns and then make it available to meet year-round municipal demands.

The City's demand pattern differs significantly from the historic runoff patterns and the firm yield values are significantly diminished if storage is not added. Storage to firm the water is required to assure adequate yields, and its cost is in addition to acquisition of the water and its transfer in Water Court for municipal use. The combined cost of purchasing native water rights and building the storage necessary to make them firm must be compared with the cost of purchasing CBT water, additional WG units, or WGFP storage capacity.

The City will likely continue to acquire native rights through its operation of the Water Bank. However, because of the costs to transfer water for municipal use in Water Court and of building the necessary storage, purchases of native ditch shares to meet firm yield goals could result in increased costs relative to other options.

7.2.5 Modify Water Rights Dedication Policies

In 2006, the City made significant changes to its water rights dedication policies. These policies were extended in 2012 with only minor modifications. The changes were sought as an alternative to pursuing capital projects or purchasing water rights, both of which require cash outlays, and they were intended to guide acquisitions so they would maintain a good balance in the City's water rights portfolio.

The following is a summary list of the major components of the current policies:

- At least 50% of every raw water payment must be CBT, CIL, or Water Bank cash credits.
- CBT credit is 1.0 AF/unit.
- Average yields used for ditch credits are as determined by the *2011 RWSYA*.
- Only native water shares in the City's GMA that can reasonably be expected to transfer successfully in Water Court for municipal use are accepted for development. (i.e. shares from mutual ditch companies that the City has already transferred to municipal use in a previous decree and which are not limited by policies or agreements).
- CIL fee is set at 1.05 times the market price of CBT water as recognized by the LUC.
- Purchase of cash credits in the Water Bank is not allowed.
- NWSF is set at an average of about $6,000/AF, as found from the *2020 RWSYA* (See ***Appendix II***), although it varies according to the relative seniority of the ditches. It is recognized that this price is unlikely to cover the actual cost of providing storage.

Changes in the current policy can be made to influence the type of water that the City deems necessary to receive.

1. **Require a Portion of Each Payment to be CBT**
   The City currently requires for water rights dedication for developments that at least 50 percent be made using CBT, CIL, or Water Bank Cash Credits, when using native ditch shares to meet the remainder of the requirement. To encourage the acquisition of CBT units, the City could modify its current raw water dedication policy to require more CBT in each water rights dedication.

2. **Change Credits for Ditch Shares**
   The current credits and the corresponding updated values from the *2011 RWSYA* are shown in **Table 7-B** below.

TABLE 7-B: Current Water Bank Credits Calculated by the City of Loveland and per Share Ditch Yields Calculated by Spronk Water Engineers

Irrigation Company	Current Water Bank Credit (2011 RWSYA)	2020 RWSYA Firm Yield (AF/sh)	2020 RWSYA Average Yield (AF/sh)
South Side	4.55	1.49	4.97
Louden	12.17	2.14	11.92
Buckingham	6.36	0.35	5.76
Barnes	3.32	0.66	3.31
Chubbuck	2.94	0.29	2.90
BTDM	186.57	68.08	189.11

3. **Change Cash-In-Lieu Policy**
   There is no question that water demands must ultimately be met with water, not money. But money can be turned into water. The issue for the City staff is how to make the biggest impact using the City's available cash.

   For example, the City has used, or plans to use, its CIL reserves to do the following:

   - Paid one-half of GRGR
   - Paid a portion of the WG bond payments
   - Paid the permitting and design costs for 10,000 AF of storage in the WGFP
   - Purchased close to 1,000 units of CBT in 2010 and 2011
   - Will use cash reserves to cover a portion of the WGFP construction costs

   Assuming the Chimney Hollow Reservoir Project moves to construction, the City will have a well-defined, feasible water supply project. In the absence of that project, the time necessary to develop an alternative storage project and bring it online would likely be ten to thirty years into the future. This creates uncertainty in projecting costs and makes it important to ensure that current supplies will meet future demands until the new project is developed and becomes available. If the market value of water is high and CIL is generating funds, the City can take advantage of market fluctuations and delay purchasing or developing water until the market has come down, to buy as much as possible. This worked to the City's advantage in 2010 and 2011, when the City purchased close to 1,000 CBT units when the market conditions were low. With the cap on CBT ownership in place, the concept may still be applied to the development of storage projects such as the LGWR, the purchase of native waters or studying the expansion of GRGR.

   It is important to recognize that new demands must be met immediately, and most projects take time to develop and bring online. However, the City's firm yield projections as calculated by the *2020 RWSYA* provide a margin sufficient to meet the City's demands years into the future, if monitored carefully, allowing time to turn the CIL into water through raw water projects.

   The City has identified opportunities to increase its water supply, all of which require cash. If a decision is made to proceed with a specific project, it may be appropriate to lift or relax the limits on CIL transactions.

4. **Change Credit for CBT Units**
   In the *2011 RWSYA*, the firm yield of CBT was 0.88 AF/unit, and in the *2012 RWMP,* Staff and LUC recommended waiting until the next RWMP update before adjusting the City's credit for

CBT water, to see where the projected yield fell rather than changing the CBT credit at that time.

The *2020 RWSYA*, on **Table 8-5** in **Appendix II**, shows that adding an average yield of 500 AF from CBT requires the conveyance of 668.1 units, which results in a firm yield of 600 AF, or 0.90 AF/unit. The City's current credit, considered to be a firm yield value, is 1.0 AF/unit. This value was adopted because of the inverse nature of the CBT yields to native yields, making them more reliable in a drought situation. This 1.0 AF/unit credit for CBT water may require adjustment to more closely match the 0.90 AF/unit yield value.

5. **Change Native Water Storage Fee**
The NWSF is a one-time charge per acre-foot of native water rights credits, payable when the credits are applied towards a development. This fee applies only to native water rights deposited into the Water Bank after July 20, 1995. Its purpose is to address the fact that most native water rights are not available twelve months out of the year, and a solution is necessary to make the source available to meet the City's demands on its regular annual pattern. As most of these rights deposited into the Water Bank are from irrigation ditches, Loveland's transfer decrees only allow diversions of these rights during the irrigation season. The fee can be used to provide storage to provide a source for meeting demands during the months the native ditch rights are not available.

It was determined in 1995 that native ditch rights generally could provide approximately half of the annual demand without storage. At the time, CBT units could be purchased for $800/unit, so the NWSF was initially set at $400/AF to purchase half a unit of CBT with each acre-foot of native water, to meet the other half of the annual demand. The fee was subsequently increased to $475/AF but at that point was no longer linked to the market price of CBT units.

In 2005, the approximate market differences between the value of CBT at $11,000/unit, which is stored and native rights from the ditches at $5,000/AF, which require storage, was $6,000/AF. This $6,000 value was targeted as the average NWSF. The fee was adjusted for the relative seniorities of the various ditches so that it was lower for more senior ditches, and higher for the junior ditches, using actual storage ratios developed in the *2011 RWSYA*. The increased fee from $475/AF to $6,000/AF was phased in between January 1, 2006 and January 1, 2008.

It was recognized at the time the NWSF were reset in 2005 that they were lower than the cost of developing the necessary storage. The current estimated price of storage in the Chimney Hollow Project is approximately $7,511/AF. This value if multiplied by the firming ratio of each ditch yields an average cost of $23,434/AF, considerably higher than the current average $6,000/AF NWSF.

In the *2020 RWSYA*, these values were re-evaluated, and the estimated cost of $7,511/AF of storage in the Chimney Hollow Reservoir project multiplied by the storage ratio for each ditch plus court cost fees was targeted as the NWSF for water for each ditch. The results are shown in **Table 7-C** below.

TABLE 7-C: Native Water Storage Fee

Irrigation Company[1]	Current NWSF[2] ($/AF)	2020 RWSYA ($/AF)	Difference Current vs. 2020 RWSYA
Barnes[3]	$5,750	$27,522	$21,772
BTDM	$3,530	$18,662	$15,132
Buckingham	$7,400	$26,022	$18,622
Chubbuck[3]	$7,400	$26,322	$18,922
Louden	$6,850	$23,012	$16,162
South Side	$6,770	$21,962	$15,192

Notes:

(1) The City no longer accepts shares from the Farmers Ditch and they are not included in the City's decrees.

(2) Per section 19.04.045 of the Loveland Municipal Code, adopted July 17, 2012.

(3) In a settlement agreement, dated July 25, 2010, with Greeley Loveland Irrigation Company, which carries the Barnes and Chubbuck waters, the City agreed not to include additional Barnes or Chubbuck Inches in future Water Court applications.

8. Recommendations

The most important objectives of the *RWMP* are to ensure the reliability of raw water rights the City accepts into the City's water bank and to define the basic principles that guide staff's management of the City's raw water resources, thereby adhering to the charge of City Council to provide the City's customers with a full water supply without curtailment up to a 1-in-100-year drought event. The impact of any policy changes affecting the cost of development within Loveland will inevitably affect community members in different ways. Any changes recommended must be fair and reflect the true cost of acquiring, maintaining, and ensuring legal use of raw water supplies. Policy changes also must meet Loveland Water and Power's Mission to:

- Provide quality customer service
- Provide reliable service
- Plan for the future
- Be environmentally sensitive
- Offer safe and secure utilities at competitive rates
- Be fiscally responsible

8.1 1-in-100 Year Drought Planning

- Continue to plan for the City's long-term policy of preparing for a 1-in-100-year drought event, with no curtailment. The conditions encountered during the 2002 drought were very similar to the expected conditions of a 1-in-100-year drought event. Therefore, the 2002 drought data was used for the modeled drought conditions in the Raw Water Supply Yield Analysis.
- Continue to use the City's water resources wisely. Use conservation as a buffer against drought and to help meet demands during drought events that are more severe than a 1-in-100-year event. Conservation should not be used as a tool to directly reduce future demands in long-term planning.

8.2 2020 Raw Water Supply Yield Analysis Update - Raw Water Supply Model

- Use the 2020 *Raw Water Supply Yield Analysis Update* and the Raw Water Supply Model as tools to evaluate proposed policy changes related to acquisition and planning for raw water supplies.

8.3 Adopt a Raw Water Demand Target

- Continue using the raw water demand target of 30,000 acre-feet (AF), as was adopted in the 2012 Raw Water Master Plan.
    A. The results of the *2020 Raw Water Supply Yield Analysis* model by Spronk Water Engineers determined the firm yield of the City's water rights portfolio was projected to be approximately 30,890 AF per year by approximately 2031 when both the Chimney Hollow Project and the Loveland Great Western Reservoir projects are completed and online. This firm yield considered all of the City's water rights that have been changed in Water Court and are anticipated to be changed in the near future for municipal use. The current firm yield, without these projects, is 25,210 AF.

B. The City ran two scenarios as a cross check to determine how far into the future a firm yield of 30,890 AF would meet the projected water demand of the City based on projected growth rates. The scenario results indicate the City's demands will be met out to 2056, approximately 36 years into the future. The projected population for the year 2060 is 173,100. A basic summary of the two scenarios is presented in **Table 8-A**.

TABLE 8-A: Projected Water Demand Scenarios

	Scenario A	Scenario B
Start Demand of Scenario Projections	Largest historical annual treated water produced from the Loveland WTP plus 590 AF for augmentation and irrigation demands *(15,559 AF from 2012)*	5-year average *(2015 to 2019)* treated water produced from the Loveland WTP plus 590 AF for augmentation and irrigation demands *(13,875 AF)*
Beginning Year of Scenarios	Last year of verified data *(2019)*	
Beginning Population	2019 population estimate for Loveland* *(79,150)*	
Demand Growth Rate	Through the year 2045, increased demands were based on estimated population growth rates*. For projections beyond 2045, the average of the last 15 years *(2031-2045)* of estimated growth rates* was applied.	
End Year of Projections	Approximately 40 years into the future *(2060)*	
*Notes: Based on the population estimates and estimated growth rates through the year 2045 from data provided by the City of Loveland Development Services, Strategic Planning Division in August 2020.		

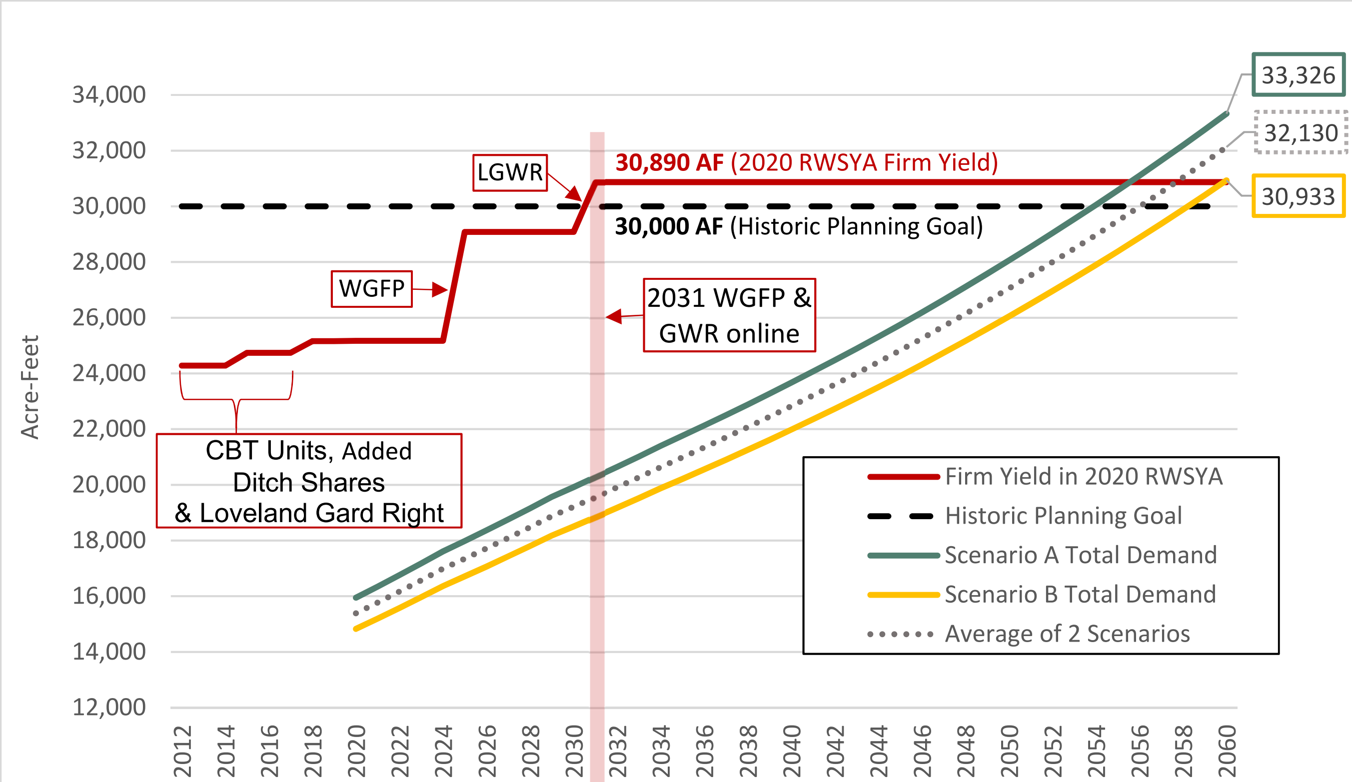
C. **Summary of** the **Two Scenarios:** A summary of the two scenarios is included in **Table 8-B** and **Figure 8-A** below.

- **High and Low:** The results of the projected total City demands yield values of 30,933 AF and 33,326 AF. Both values are higher than the 30,890 AF of firm yield supply projected in the *2020 RWSYA*.
- **Average:** The average of these projected demand values is 32,130 AF. This is approximately 1,240 AF or 3.9% above the *2020 RWSYA* 30,890 AF projection of firm yield supply in 2031.

TABLE 8-B: 2020 Estimate of Target Water Supply for City Water Utility Service Area

	Scenario A	Scenario B	Scenario Averages	Historic Planning Goal	2031 Firm Yield from 2020 RWSYA
Municipal Demand	32,736 AF	30,343 AF	**31,540 AF**		
Augmentation Demand	590 AF	590 AF	**590 AF**		
Total City Demand	**33,326 AF**	**30,933 AF**	**32,130 AF**	**30,000 AF**	**30,890 AF**

FIGURE 8-A: Total Water Demand Projections vs. Firm Yield Projections



8.4 Retain or Modify the City's Current Policy for Accepting Raw Water

The basic components of any policy revisions should consider, without limitation, the following:

A. CBT Recommendation: Require that a minimum amount of every raw water payment be made using CBT, existing Cash Credits in the Water Bank, or Cash-in-Lieu (CIL), with exceptions for transactions equal to or less than 1.0 AF, using the follow guidelines:

a. **Payment Types Allowed:** Allow payment of CBT, Cash Credit, or CIL for full payment of any raw water requirement.

Note on Cash Credits: Ordinance 5039, adopted by Council on November 15, 2005, prohibited the practice of purchasing Cash Credits in the Water Bank. Therefore, credit in the City's water bank may not be acquired from the City by cash purchase on or after January 1, 2006 (Section 19.04.017). Previously, unlimited purchases of Cash Credits had been accepted using the CIL fee per acre-foot in effect when the cash payment was made for the purchase of the credit. Storage fees do not apply to Cash Credits.

b. **50% Rule:** Maintain the City's current 50% Rule, where at least 50% of every raw water payment is made with CBT, existing Cash Credits in the Water Bank, or CIL, as set forth in the Municipal Code, Section 19.04.040. Modify existing code to allow exceptions to this requirement for transactions of 1.0 acre-foot or less.

c. **CBT Credit:** Decrease CBT credit from 1.0 AF/unit to 0.9 AF/unit beginning January 1, 2021 to reflect the yield value calculated in the *2020 RWSYA.*

Note: The City's current credit for CBT water is 1.0 AF/unit. The CIL fee is currently calculated as the LUC's recognized market value of CBT water, divided by the City's CBT credit, plus 5%. Decreasing the CBT credit would increase the CIL fee as currently calculated. Decreasing the CBT credit would also impact credit within the Water Bank that is associated with units of CBT.

B. Ditch Share Recommendation: Adjust the credits for ditch shares to the values as determined by the *2020 RWSYA* report using the following guidelines (See **Table 8-C** for the current and recommend credit values.):

a. **Credits with Storage Fee Payment:** Payment of the Native Water Storage Fee (NWSF) is required to receive the average ditch yield credit.

b. **Credits without Storage Fee Payment:** If no payment of the NWSF is made, the lower firm yield credit applies.

c. **Native Waters Accepted:** The City will only accept native water rights that can, in the City's opinion and based on a review of the historical use of the specific native water rights proposed for acceptance, be successfully transferred in Water Court, and which are not limited by policies or agreements.

TABLE 8-C: Summary of Incremental Firm Yield of Native Ditch Rights

Native Ditch Right[1]	Current AF Credit in Municipal Code WITH Payment of Storage Fee[2]	AF Value WITH Payment of Native Water Storage Fee (Average Yield)[4]	AF Value WITHOUT Payment of Native Water Storage Fee (Firm Yield)[4]
Barnes[3]	3.32 per inch	3.31 per inch	0.66 per inch
BTDM	186.57 per share	189.11 per share	68.08 per share
Buckingham	6.36 per share	5.76 per share	0.35 per share
Chubbuck[3]	2.94 per inch	2.90 per inch	0.29 per inch
Louden	12.17 per share	11.92 per share	2.14 per share
South Side	4.55 per share	4.97 per share	1.49 per share

Notes:
[1] The City no longer accepts shares from the Farmers Ditch and it is not included in the City's decrees.
[2] Per the values in the 2011 RWSYA
[3] Under a settlement agreement entered in 2010 with the GLIC, the City is prohibited from including any additional Barnes or Chubbuck Inches in future Water Court applications.
[4] Per Table 8-5 in the 2020 RWSYA

C. Cash-In-Lieu Recommendation

a. **Transaction Limits:** Do not set a limit on CIL transactions, as long as there is a specific project for which the funds will be used.

Note: CIL payments at this time may be applied toward construction or loan payments of the Chimney Hollow Project, the development of the Loveland Great Western Reservoir, and studying the expansion of Green Ridge Glade Reservoir.

b. **Tie to Price of CBT:** Continue to tie the City's CIL fee to the market price of CBT water as published annually by Northern Water and recognized by LUC resolution.

c. **Eliminate the 5% Administrative Cost on the CIL Fee**.

Note: The CIL fee is currently calculated as the LUC's recognized market value of CBT water, divided by the City's CBT credit, plus 5%.

D. Native Water Storage Fee Recommendation

a. **Tie Costs to Storage in Chimney Hollow Reservoir:** Tie the storage fee to the estimated cost per acre-foot of storage in Chimney Hollow Reservoir.

Note: Costs for storage have increased. Currently, the reservoir is designed for 90,000 AF of storage at a projected cost of $676 M. This comes to an estimated cost of approximately $7,511/AF of storage. Currently, rounding the estimated costs to the nearest thousand dollars would result in a $7,000/AF storage fee.

b. **Adjust Fee by Ditch Firm Ratio:** Adjust the fee based on the firm ratios determined in the *Incremental Firm Yield Analysis* in **Table 8-5** of the *2020 RWSYA* in **Appendix II** for the individual ditches, applied to the rounded estimated cost per acre-foot of storage in Chimney Hollow Reservoir. (See **Table 8-D** below for the current firming ratios and fees, the recommended fees and the calculated difference.)

*Note: To use the average ditch yield credit values, the NWSF would apply to each acre-foot of ditch water dedicated. If the firm yield values are used, no NWSF would apply. Ditch shares dedicated to the City prior to July 21, 1995, would be excluded from the NWSF. The firming ratios for each ditch listed in **Table 8-D** which is required to provide firm yield in a 100-year drought would be multiplied by the cost per acre foot of storage in Chimney Hollow Reservoir to calculate this portion of the NWSF per acre foot (estimated costs as of October 2020 were $7,511/AF).*

c. **Add Water Court Costs:** In order to store or otherwise use the water, engineering and legal costs are incurred when the native water is changed for municipal use in the Water Court. The City's most recent action changing this water was for case number 02CW392, completed in February 2010. In this case, 3,500 AF of water was changed at a cost of $1.4 Million resulting in a cost of $400/AF. Using this value and adjusting for inflation as shown results in a value of $482/AF. This is the value recommended to be included as part of the NWSF.

d. **Phased Approach:** Staff recommends phasing in the cost-based fees over ten years. The actual fee amount may be adjusted each year based on the current projected or actual costs of Chimney Hollow Reservoir and the results of future analyses of the firm yield for the various ditches.

e. **Simplify Name:** Staff recommends simplifying the name from the "Native Water Storage Fee" to "Storage Fee."

f. **Set in Utility Rates, Charges, and Fees:** Staff recommends removing the actual amounts from Municipal Code and listing these in the Utility Rates, Charges, and Fees, which are updated annually.

The combined storage cost and court cost fees result in the final NWSF values listed in the column labeled "Native Water Storage Fee per AF" in **Table 3-E**.

TABLE 8-D: Firm Ratios and Native Water Storage Fees by Ditch

Irrigation Company	Firm Ratio (AF Storage/ AF Firm Yield)[1]	Recommended NWSF	Current NWSF	Difference (Recommended less Current)
Barnes[2]	3.60	$27,522	$5,750	$21,772
BTDM	2.42	$18,662	$3,530	$15,132
Buckingham	3.40	$26,022	$7,400	$18,622
Chubbuck[2]	3.44	$26,322	$7,400	$18,922
Louden	3.00	$23,012	$6,850	$16,162
South Side	2.86	$21,962	$6,770	$15,192

Notes:
[1] Firm ratio as determined by the *2020 RWSYA*
[2] The City no longer accepts deposits of Barnes and Chubbuck Ditch. Those values only apply to ditch rights already dedicated to the City's water bank.

8.5 Maximize the Benefits of Storage

A. **Storage Recommendation:** Maximize the benefits of the City's water storage by pursuing current projects at Chimney Hollow Reservoir and Loveland Great Western Reservoir to completion. Explore and evaluate other storage opportunities as they arise.

a. **Upstream Storage:** Provides annual and firming storage.

- Complete Windy Gap Firming Project with the other participants
- Expand Green Ridge Glade Reservoir if feasible
- Store native waters in Chimney Hollow if feasible
- Consider other upstream storage options

b. **Downstream Storage:** Provides staging for upstream exchanges or meeting required downstream releases.

- Complete the infrastructure required at Loveland Great Western Reservoir.

  Note: In January 2019, the City purchased Loveland Great Western Reservoir, a downstream storage reservoir, with an estimated storage capacity between 1,300 AF and 1,600 AF. It is estimated the infrastructure for this storage will be completed in eight to ten years at an estimated cost of approximately $4.8M in 2017 dollars[6].

8.6 Maximize Raw Water Operations

A. Maximize Raw Water Operations Recommendation: Explore additional firm yield scenarios using alternative water supply operations by considering the maximum run conditions identified in the 2020 RWSYA. Associated costs of the various alternatives should be considered to determine feasible options for increasing the City's firm yield.

*Note: See **Table 8-9** of the 2020 RWSYA in **Appendix II** for possible options to increase firm yield from alternate water supply operations.*

8.7 Evaluate the Most Effective Ways to Make Use of Reusable Supplies

A. **Reusable Supplies Recommendation:** Apply any or all of the following measures as opportunities arise:

a. Exchange Upstream for Municipal Use. Pursue exchange decrees as needed to make upstream municipal uses possible.

b. Sell or Lease to Downstream Users: Implement and utilize the augmentation water policy approved by resolution #R-2-2019U at the May 15, 2019 LUC meeting, concerning requests for long-term leases of augmentation water to others.

c. Purple Pipe System: Continue to monitor the feasibility and applicability of a purple-pipe raw water irrigation system. Consider the concerns of cross contamination and the relatively high expense of building a new utility in already developed parts of the community. Increases in the costs of developing water may make this option feasible in the future.

[6] Anderson Consulting Engineers, Inc., *Kauffman Reservoir Water Storage Facility Feasibility Report.* June 26, 2017.

8.8 Conclusions

Results from the *2020 RWSYA* indicate that with the development of planned projects at Chimney Hollow Reservoir and Loveland Great Western Reservoir, the City's supplies will meet projected demands until 2056, depending on the rate of growth. Depending on market and supply conditions and the timing of projects, ongoing re-evaluation of the alternatives considered in this *RWMP* should occur. As the City acquires additional native ditch water, CBT, or CIL, its overall water supply portfolio will change. Factors such as growth, climate variability, or the addition of major commercial or industrial water customers may cause the ultimate demand to vary from current projections.

Cover photo was taken by Dick Knapp from Dick's Photography.

APPENDIX I

Table 1 - City of Loveland Credits, Requirements and Cash-in-Lieu Timeline (A historical summary of water dedication policy changes.)

Table 2 - Water Bank Values as of October 2020 for Ditches with Storage Option

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	ORDINANCE/ RESOLUTION #		CREDITS & REQUIREMENTS ACTIONS	CASH-IN-LIEU ACTIONS
8-16-1960	City Council Motion	a.	Two AF/acre required prior to first reading for annexation	
11-15-1960	City Council Motion	a.	Two AF/acre required at the time the plat of property to be annexed is filed	Cash-in-lieu of water rights
6-2-1964	City Council Motion	a.		City engineer determines amount of cash-in-lieu and policy set
10-26-1969	1053	a.	Two AF/acre required for annexation, regardless of zoning	
		b.	Ditch shares or CBT units accepted	
		c.	Ditch shares credited based on a 20-year running average	
		d.	CBT units credited based on average availability for a period not longer than 20 years	
		e.		Allowed if water not available
		f.	City paid the cost of transfer of all water rights	
		g.	City reserved the right to purchase additional water rights associated with annexed property at the market price	
6-22-1975	1437	a.	Annexation water not required for land zoned DR, Developing Resource	
		b.	Two AF/acre required for all zonings other than DR	
		c.	Landowner required to pay all expenses involved with transferring water rights to the City	
2-7-1978	R37-78	a.		Requirements set at $3,000 per acre of annexed land or $1,500/AF

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
12-5-1978	1734	a.	Three AF/acre required for all zonings other than DR	
		b.	Land filed for zoning other than DR before January 1, 1979, required to pay only 2 AF/acre	
		c.	Land zoned DR after January 1, 1979, required to pay 3 AF/acre for any U graded zoning classification	
		d.	CBT units credited at 1.0 AF/unit	
12-19-1978	R315-78	a.		For land with 2 AF/acre requirement, cash-in-lieu = $2,135 ac/ft
		b.		For land with 3 AF/acre requirement, cash-in-lieu = $1,600 ac/ft
12-19-1978	R316-78	a.	For land zoned DR being rezoned prior to January 1, 1979, CBT credit set to 0.75 AF/unit	
1-2-1979	1743	a.	For land with 2 AF/acre requirement, CBT credit = 0.75 AF/unit	
		b.	For land with 3 AF/acre requirement, CBT credit = 1.0 AF/unit	
3-20-1979	R76-79	a.		Increase to $1,750/AF
4-17-1979	R105-79	a.		Increase to $2,000/AF
1-15-1980	R12-80	a.		Increase to $2,250/AF
1-19-1982	R20-82	a.		Decrease to $2,000/AF
5-4-1982	R58-82	a.		Decrease to $1,750/AF
11-16-1982	2064	a.	Raw Water Fund created	
		b.	Excess water use surcharge established	

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
		c.	1 AF/acre required for all C & I zonings	
		d.	For commercial and industrial, raw water final requirement changed to correspond to the tap diameter. A minimum of 1 AF/acre required for zoning. This counted as a credit against the final requirement. ¾” – 1 3” – 26 1” – 4 4” – 40 1 ½” – 8 6” – 90 2” – 13 8” – 190 All larger than 8" set by City Council mandate	
		e.	3 AF/acre still required for all residential zonings	
		f.	For land with Residential zonings, CBT credit = 1.0 AF/unit For commercial and industrial, raw water final requirement changed to correspond to the tap diameter. A minimum of 1 AF/acre required for zoning. This counted as a credit against the final requirement. ¾” – 1 2” – 13 6” – 90 1” – 4 3” – 26 8” – 190 1 ½” – 8 4” – 40 All larger than 8” set by City Council mandate	
		g.	For land with C & I zonings, CBT credit = 0.6 AF/unit	
12-21-1982	R135-82	a.		Decrease to $1,500/AF
4-5-1983	R28-83	a.		Decrease to $1,300/AF
11-15-1983	3021	a.		CBT credit = 0.75 AF/unit for all

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
				applications
1-1-1984	R74-83	a.		Increase to $1,700/AF
3-20-1984	R11-84	a.		Decrease to $1,300/AF
6-5-1984	3082	a.	1 AF/acre required for all residential zonings	
		b.	Residential total development requirements calculated with formula: Total = (0.154 x #units) + (1.54 x net acres)	
		c.	Total development requirements for C & I zoned areas remained tied to tap sizes	
6-18-1985		a.	Transfer Decree 82CW202A signed by judge in Division I Water Court	
12-3-1985	R84-85	a.		Decrease to $1,000/AF
4-1-1986	R18-86	a.		Decrease to $875/AF
11-4-1986	R59-86	a.		Increase to $950/AF
12-9-1986	3361	a.	Revision of water rights requirement for the acceptance of water rights	
7-21-1987	R38-07	a.		Increase to $1,000/AF
9-5-1989		a.		Increase to $1,250/AF
2-20-1990	RII-90	a.		Increase to $1,500/AF
7-17-1990	R24-90	a.		Increase to $1,800/AF
10-6-1992	R47-92	a.		Decrease to $1,200/AF
12-1-1992		a.	CBT 1.0 AF/unit all applications	
6-7-1993		a.	New PUD ordinance	
7-20-1995	4096	a.	Created Native Raw Water (NRW) storage fee	
		b.	Set NRW storage fee at $400/AF	
6-6-1995	R31-95	a.		Increase to $1,600/AF
6-17-1996	R61-96	a.		Increase to $1,800/AF

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
1-7-1997	R2-97	a.		Increase to $2,200/AF
3-4-1997	RI2-97	a.	Set NRW storage fee at $475/AF	
9-2-1997	R49-97	a.		Increase to $2,750/AF
5-5-1998	R46-98	a.		Increase to $3,000/AF
5-5-1998	4338	a.	Raw water irrigation	
		b.	Escrow option for certain circumstances	
		c.	Timing of water rights conveyance	
2-2-1999	RI5-99	a.		Increase to $3,500/AF
8-4-1999	R69-99	a.		Increase to $4,800/AF
8-20-1999	4459	a.		Allow Loveland Utilities Commission (LUC) to set cash-in- lieu prices
9-15-1999	LUC	a.		Increase to $5,400/AF
11-2-1999	4488	a.	Revising residential formula to Total Water Rights Due (in acre-feet) = (1.6 x net lot acreage) + (1.4 x acreage of that portion of residential lot which is greater than 15,000 square feet) + (0.23 x number of dwelling units) + (3.0 x net common area acreage irrigated with treated water)	
1-19-2000	R-1-2000U	a.		Increase to $6,500/AF
3-15-2000	R-2-2000U	a.		Increase to $15,000/AF
6-21-2000	R-3-2000U	a.		Decrease to $13,000/AF
9-20-2000	R-4-2000U	a.		Decrease to $11,500/AF

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
2-19-2002	4702	a.	Allowing *all* water rights for non-residential development to be paid at building permit. Removed 1 AF/ac requirement for non-residential zoning.	
2-20-2002	R-2-2002U	a.		Decrease to $10,500/AF
9-18-2002	R-4-2002U	a.		Increase to $15,000/AF
10-1-2002	4843	a.	CBT credit changed to 0.7359 AF/unit	
9-16-2003	4840	a.	Added reference to Type 1 Zoning Permit in the Loveland Municipal Code	
11-15-2005	5039	a.	CBT credit changed to: 0.82 AF/unit on Jan 1, 2006 0.91 AF/unit on Jan 1, 2007 1.00 AF/unit on Jan 1, 2008	
		b.	Native credit changed to: Barnes 3.24 AF/Inch BTD&M 189.11 AF/Share Chubbuck 2.97 AF/Inch Buckingham 6.07 AF/Share Louden 11.5 AF/Share South Side 4.22 AF/Share	
		c.	NWSF changed from $475/AF to: **2006 2007 2008** Barnes $1920 $3840 $5750 BTD&M $1180 $2360 $3530 Chubbuck $2470 $4940 $7400 Buckingham $2470 $4940 $7400 Louden $2280 $4560 $6850 South Side $2260 $4520 $6770	
		d.	Not allowed to purchase cash credits in the water bank	
		e.	Cash-in-lieu for satisfying the water requirement is capped at 4 AF	
		f.	40% of all requirements must be CBT or cash credits	
1-1-2006	5039	a.		CBT Credit changed per Resolution 5039, decreasing CIL to $13,817/AF
8-1-2006	5120	a.	Irrigation meters required to pay 3 AF/ac	

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
1-1-2007		a.		CBT Credit changed per resolution 5039, decreasing CIL to $12,451/AF
3-6-2007	5172	a.	Removed 1 AF/ac requirement for residential zoning	
4-19-2007	R-1-2007U	a.		Decrease to $11,885/AF
8-21-2007	5229	a.	Created Hydrozone program Changed residential calculation to Water Rights Due (in acre-feet) = (1.6x net lot acreage) + (1.4 x acreage of that portion of residential lot which is greater than 15,000 square feet) + (0.23 x number of dwelling units) Water rights for irrigation due prior to activating the meter.	
10-17-2007	R-2-2007U	a.		Decrease to $11,319/AF
1-1-2008		a.		CBT Credit changed per resolution 5039, decreasing CIL $10,300/AF
2-3-2009	5385	a.	Conversion of 166 CBT units from Temporary Use Permit to Section 131 Contract	
3-19-2009	R-1-2009U	a.		Decrease to $9,579/AF
10-22-2009	R-2-2009U	a.		Decrease to $7,900/AF
12-1-2009	5475	a.	NWSF changed to: Barnes $5750 AF BTD&M $3530 AF Chubbuck $7400 AF Buckingham $7400 AF Louden $6850 AF South Side $6770 AF	
		b.	Amended to reflect that the City no longer accept shares of Reorganized Farmers Ditch Company	
		c.	Establish irrigation base rate	

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
2-3-2010	5483	a.	Conversion of 8 acre-ft units of CBT project water	
10-20-2010	LUC	a.	Elimination of Type 1 zoning permit in Title 19	
11-17-2010	LUC	a.	Closed 2 water contracts for purchase of CBT. (62 units at $6800/unit and 65 units at $6800/unit)	
1-19-2011	LUC	a.	Conversion of 132 CBT Units from Temporary Use Permit to Permanent Section 131 Contract	
3-3-2012	5672	a.	Supplemental Appropriation for CBT water purchase in the amount of $2.5M	
4-18-2012	R-1-2012U	a.		Increase to $8436
7-17-2012	5691	a.	With Payment of NWSF: Barnes 3.32 AF/Inch BTD&M 186.57 AF/Share Chubbuck 2.94 AF/Inch Buckingham 6.36 AF/Share Louden 12.17 AF/Share South Side 4.55 AF/Share	
		b.	Amendment to water rights requirements, applicant may choose not to pay NWSF at a value of: Barnes 0.86 AF/Inch BTD&M 70.90 AF/Share Chubbuck 0.41 AF/Inch Buckingham 0.38 AF/Share Louden 2.43 AF/Share South Side 1.46 AF/Share	
		c.	Cash-in-lieu multiplier changed from 1.03 to 1.05 x CBT Market price	
12-12-2012	5725	a.	Municipal Code Amendment – Water Rights for Service Outside City Limits 19.04.023	
1-16-2013	LUC	a.	Conversion of 282 CBT units from Temporary Use Permit to Section 131 Contract	
2-20-2013	R-1-2013U	a.		Increase to $11,200/AF
6-19-2013	R-2-2013U	a.		Increase to $13,650/AF
7-17-2013	R-3-2013U	a.		Increase to $15,750/AF

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
8-14-2013	R-4-2013U	a.		Increase to $18,375/AF
1-15-2014	R-1-2014U	a.		Increase to $19,425/AF
3-18-2014	5856	a.	Code Amendment 19.04.080 to remove Barnes and Chubbuck ditches under the definition of ditch water rights	
4-16-2014	R-2-2014U	a.		Increase to $23,100/AF
10-15-2014	R-3-2014U	a.		Increase to $26,250/AF
2-3-2015	R-12-2015	a.	Conversion of 10 CBT units from Temporary Use Permit to Section 131 Contract	
2-16-2016	R-18-2016	a.	Conversion of 50 CBT units from Temporary Use Permit to Section 131 Contract	
1-18-2017	R-1-2017U	a.	Average CBT price recognized as $26,553	Increase to $27,880/AF
6-20-2018	R-01-2018U	a.	Average CBT price recognized as $28,292	Increase to $29,710/AF
2-5-2019	R-16-2019	a.	Conversion of 12 CBT units from Temporary Use Permit to Section 131 Contract	
2-20-2019	R-01-2019U	a.	Average CBT price recognized as $35,444	Increase to $37,220/AF
5-15-2019	R-2-2019U	a.	Long-term Augmentation Supply Agreements Criteria	
7-17-2019	R-03-2019U	a.	Average CBT price recognized as $37,453	Increase to $39,330

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
9-17-2019	6324	a.	Revising residential formula to Total Water Rights Due (in acre-feet): **Single Family Detached** Indoor: 0.22 AF/unit Outdoor: 1.4 AF/acre x net lot acreage + 1.6 AF/acre x net lot acreage >15,000 sf **All Other Residential Types Recognized by UDC** *(Cottage, Micro, SF Attached, Multi- family)* Indoor: 0.16 AF/unit Outdoor: 1.3 AF/acre x net lot acreage + 1.7 AF/acre x net lot acreage >15,000 sf Outdoor with dedicated irrigation tap: 3.0 AF/acre x irrigated acre	
12-18-2019	R-04-2019U	a.	Average CBT price recognized as $45,368	Increase to $47,640
10-20-2020	6429		Residential Water Rights Payment Choices 1. Prior to recording plat 2. Groups ≥ 4 AF 3. Individual building (CIL Only)	
Pending Dec 2020	Ordinance TBD	a.	With Payment of NWSF: Barnes 3.31 AF/Inch BTD&M 189.11 AF/Share Buckingham 5.76 AF/Share Chubbuck 2.90 AF/Inch Louden 11.92 AF/Share South Side 4.97 AF/Share	
		b.	Amendment to water rights requirements, applicant may choose not to pay NWSF at a value of: Barnes 0.66 AF/Inch BTD&M 68.08 AF/Share Buckingham 0.35 AF/Share Chubbuck 0.29 AF/Inch Louden 2.14 AF/Share South Side 1.49 AF/Share	

TABLE 1 - CITY OF LOVELAND CREDITS, REQUIREMENTS, & CASH-IN-LIEU TIMELINE				
DATE	**ORDINANCE/ RESOLUTION #**		**CREDITS & REQUIREMENTS ACTIONS**	**CASH-IN-LIEU ACTIONS**
Pending Dec 2020	Ordinance TBD	a.	NWSF changed to: Barnes $ AF BTDM $ AF Buckingham $ AF Chubbuck $ AF Louden $ AF South Side $ AF	

APPENDIX I – TABLE 2

**Water Bank Values as of October 2020
for Ditches with Storage Option**

	IRRIGATION COMPANY						Cash Credits	CBT	Rist and Goss	Other[4]
	Barnes	BTDM	Buckingham	Chubbuck	Louden	South Side				
UNITS	Inches	Shares	Shares	Inches	Shares	Shares	AF	Units	AF	AF
Current Balance[1,2]	100.74	4.53	16.08	97.90	21.85	34.42	1,217.61	289.89	227.90	94.45
Current Credit Values (AF/sh)[3]	3.32	186.57	6.36	2.94	12.17	4.55	1.00	1.00	1.00	1.00
2020 RWSYA Avg Yield (AF/sh)[3]	3.31	189.11	5.76	2.90	11.92	4.97	1.00	0.90	1.00	1.00
2020 RWSYA Firm Yield (AF/sh)[3]	0.66	68.08	0.35	0.29	2.14	1.49	1.00	0.90	1.00	1.00

TOTAL CREDIT IN WATER BANK USING	IRRIGATION COMPANY						Cash Credits	CBT	Rist and Goss	Other[4]	GRAND TOTAL IN WATER BANK
	Barnes	BTDM	Buckingham	Chubbuck	Louden	South Side					
UNITS	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF
Current Credit	334	841	102	288	266	157	1,218	290	228	94	**3,818**
2020 RWSYA Avg Yield	333	853	93	284	260	171	1,218	261	228	94	**3,795**
2020 RWSYA Firm Yield[5]	67	307	6	28	47	51	1,218	261	228	94	**2,307**

Notes:

[1] *Current Balance represent credits in the Water Bank which have not yet been applied to meet development requirements as of October 2020.*

[2] *Inches, Shares, AF, and Units are rounded to two decimal places.*

[3] *"sh" represents shares, inches, or units accordingly*

[4] *Other represents any water credit in the Water Bank not associated with the typical unit of shares, inches, or units for that type of water. It may be also be for a specific type of water that is not listed in the table.*

[5] *2020 RWSYA Firm Yield is calculated without storage.*

APPENDIX II

Spronk Water Engineers:
Raw Water Supply Yield Analysis Update
City of Loveland (2020)

City Council Resolution #R-46-2012:
Resolution directing staff to use
the 2012 Raw Water Master Plan to develop and compare
policy options to meet the future water needs
of the City of Loveland

Raw Water Supply Yield Analysis
2020 Update
Final Draft

Prepared For:

City of Loveland

Prepared By:

_____________________ _____________________

Gregory K. Sullivan, P.E. Katryn S. Leone, P.E.

October 2020

Spronk Water Engineers, Inc.

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APPENDICES

1.0 INTRODUCTION

The City of Loveland ("City" or "Loveland") is located along the Big Thompson River, a tributary of the South Platte River, in northern Colorado. Through its Department of Water and Power, the City provides treated water service to approximately 79,000[1] people located in a 35 square mile service area as shown in **Figure 1-1**. The City's water supply is derived from the Big Thompson River pursuant to water rights for the native supply, and contracts for transmountain water delivered to the Big Thompson River from the Colorado River basin through the facilities of the Colorado-Big Thompson ("CBT") Project and the Windy Gap Project.

Beginning in 2003, Loveland contracted with Spronk Water Engineers, Inc. ("SWE") to analyze and model the City's raw water supply system in response to concerns related both to the adequacy of the City's existing supply and to development credit given by the City for water that is put in the Loveland Water Bank ("Water Bank")[2]. The 2004 Raw Water Yield Analysis was performed in accordance with the City's 100-year drought planning policy and a report was prepared to summarize the results of SWE's analysis of the yield of Loveland's raw water supply. The report described the City's water supply system, the development and operation of a simulation model ("Yield Model") of that system, and presented the results of various analyses ("Yield Analysis") performed with the Yield Model, including (a) estimation of the reliable or firm yield of the City's current water supply and (b) estimation of the increase in the City's firm yield that would result from possible acquisition of various Big Thompson River and transmountain water sources, or development of additional raw water storage. The City used the results of these analyses to develop a Raw Water Master Plan ("RWMP") in 2005, and to modify its water rights dedication policies. The RWMP was adopted with the intention to reevaluate the plan at regular intervals of approximately five years to adjust the conclusions and recommendations for changes in population growth, the City's water portfolio, or other factors.

In 2011, SWE updated the 2004 Raw Water Yield Analysis to include analysis of the effects of changes in the City's raw water supply system and water supply portfolio that have occurred since the RWMP was developed. In 2016, the City again contracted with SWE to update the Raw Water Yield Analysis to include analysis of the effects of changes in the

[1] 2019 population estimate from draft Annual Data and Assumptions Report. City of Loveland Community and Strategic Planning. August 2020.
[2] See Section 2.6 for additional discussion of the Loveland Water Bank.

City's raw water supply system and water supply portfolio that have occurred since the 2011 Raw Water Yield Analysis Update.

This report was prepared to summarize SWE's updated analysis of the yield of Loveland's water supply. In order to serve as a stand-alone document, the report repeats some of the descriptive and explanatory material contained in the prior reports. It describes the City's water supply system and changes that have occurred since 2011, summarizes the updating of the Yield Model of the water supply system, and presents results of the analyses performed with the Yield Model. The City requested several analyses including (a) an estimate the firm yield of the City's current supplies, including use of the Loveland Gard Right under the terms and conditions decreed in 2015 in Case No. 07CW325, (b) estimates of potential uses and benefits of exchange of reusable wastewater treatment plant ("WWTP") effluent, (c) estimates of potential volumes and uses of reusable lawn irrigation return flows, (d) estimates of the increase in the City's firm yield that would result from possible acquisition of various Big Thompson River and transmountain water sources, or development of additional raw water storage, and (e) estimates of the potential impacts of future water supply reductions.

2.0 BACKGROUND

2.1 Municipal Water Supply and Drought

Drought is a normal and recurrent feature of the Colorado climate with which municipal water suppliers must contend. Climate records kept during the past century show that Colorado has been affected by numerous short-term and long-term droughts. The most well-known historical droughts in Colorado are the multi-year droughts of the 1930s and 1950s, the shorter but severe drought of the late-1970s and the drought of the 2000s that began in 1999 and included the driest year of record in 2002 in the Big Thompson River and upper Colorado River basins.

The effect of drought on a municipal water supply depends on (a) the characteristics of the drought, including the time of onset, duration and severity (departure from average) of the drought, and (b) the adequacy of the municipal water supply system to withstand the effects of drought. Short duration droughts (e.g., 6-months or less) occur more frequently than multi-year droughts. Municipal water suppliers with little or no raw water storage tend to be most affected by severe short-term droughts. Systems with significant raw water storage can withstand the effects of short-term droughts, and the yield of these systems is defined by the supply that can be provided through a prolonged drought period.

The yields of municipal water suppliers are often characterized by their firm yield. Firm yield is the maximum annual water demand that can be dependably supplied each year during a representative historical study period. Firm yield is distinguished from the drought yields of the individual sources available to a water provider by certain water supply enhancing features that allow a municipality to improve its supply during drought periods. For example, a municipal water supplier can increase its yield in drought years by storing excess water in average and wet years for use in the drought years or by exchanging legally reusable supplies for additional diversions.

Most large municipal water suppliers along the Front Range of Colorado have a variety of water sources and/or water rights from which their water supplies are derived. Loveland is typical in this respect as its water supply is derived from senior and junior water rights that are native to the Big Thompson River, and transmountain water from the Colorado River basin delivered pursuant to CBT and Windy Gap units owned by the City. Each of these sources have drought yields that can be characterized individually based on historical flow records or other procedures. However, the yield of the Loveland water supply is defined by how its various sources are integrated and delivered to meet the demands of the Loveland customers. While the yields of individual sources in isolation are important (e.g., the yield of a ditch system as evidenced by historical diversion records), the City's yield is also affected by the capacity of its diversion facilities, the available physical supply at its points of diversion, the capacity of its water storage facilities, the timing of its water demand, the legal reusability of its water sources and other factors.

As the City contemplates acquisition of new water sources, it needs to consider what the new sources will contribute to enhancing its overall system yield. For example, if a new water source adds water only at times when the City already has excess supplies then the new source may not increase the overall firm yield.

Three prior analyses of the Loveland water supply system have been conducted. They include the 1988 study by Camp, Dresser & McKee, Inc. ("CDM"), the 2004 Raw Water Supply Yield Analysis prepared by SWE, and the 2011 Raw Water Supply Yield Analysis Update prepared by SWE.

2.2 1988 Water Supply Analysis

A comprehensive analysis of the Loveland water supply was performed in 1988 by CDM.[3] CDM analyzed the City's water supply using a model that simulated the yield of the City's water rights based on one thousand years of synthetic streamflow records for the Big Thompson River and for streams in the Colorado River basin that supply the CBT and Windy Gap Projects. The results of the CDM analysis indicated that the City's water supply in 1985 could supply an annual demand of 11,700 acre-feet per year ("AF/y") with an average one-in-100 year failure rate[4]. The City has acquired additional water sources and constructed additional water storage capacity since the CDM study was performed.

2.3 2004 Raw Water Yield Analysis

The 2004 Yield Analysis considered the City's water rights and facilities as they existed in 2003. Between the 1988 report and the 2004 analysis, Loveland expanded Green Ridge Glade Reservoir ("GRG") to 6,785 acre-feet ("AF") and acquired additional ditch shares and CBT units. Using a study period of 1951 through 2003, the firm yield was estimated to be 22,400 AF/y and conformed to the City's 1-in-100 year drought policy.

[3] Camp, Dresser & McKee, Inc., Phase I - Drought Study, City of Loveland Raw Water Supply System (August 28, 1986).

[4] Sum of the 1985 demand from Table 7-3 in the CDM report (7,575 AF/yr) plus the annual surplus for 1985 demand at 100-year recurrence interval (4,139 AF/yr)

In addition to estimating the firm yield of existing supplies, the 2004 Yield Analysis also evaluated various alternatives for additional water supply. Among the alternatives investigated were additional storage facilities without acquisition of additional ditch shares, storage needed to firm the yield of ditch shares acquired in the future, exchange and reuse of reusable WWTP effluent, participation in the Windy Gap Firming Project, and acquisition of additional CBT units and ditch shares.

The 2004 report was used as one of the bases for the RWMP that was developed by City staff and the Loveland Utilities Commission ("LUC"). The RWMP was the basis for several revisions to the City's water rights dedication policy in 2005.

2.3 2011 Raw Water Yield Analysis

The 2011 Yield Analysis considered the City's water rights and facilities as they existed in 2011. Between the 2004 and the 2011 analyses, the City acquired additional ditch shares, CBT units, and committed to participation in the Windy Gap Firming Project ("WGFP"). The 2011 Yield Analysis also included simulation of return flow obligations decreed in Case No. 02CW392 ("392"), increased the modeled capacity of the Loveland Water Treatment Plant ("WTP") and Loveland Pipeline, modification of the order of water supply use, modification of free river diversions to be reusable, and addition of an augmentation demand of 590 AF/y to the modeled demands.

Using a study period of 1951 through 2006, the firm yield was estimated to be 27,390 AF/y and conformed to the City's 1-in-100 year drought policy.

The 2011 Yield Analysis also evaluated various alternatives for additional water supply. Among the alternatives investigated were additional storage facilities without acquisition of additional ditch shares, storage needed to firm the yield of ditch shares acquired in the future, exchange and reuse of reusable WWTP effluent, participation in the Windy Gap Firming Project, and acquisition of additional CBT units and ditch shares.

The 2011 Yield Analysis report was used as one of the bases for the RWMP that was updated by City staff and the LUC. The RWMP was the basis for several revisions to the City's water rights dedication policy in 2012.

2.4 2020 Raw Water Yield Analysis

The 2020 Yield Analysis considered the City's water rights and facilities as they existed in 2020. The 2020 analysis included the following:

- Extension of the study period through 2015.
- Revision of the municipal water demand distribution based on 2005-2015 data.
- Increased WGFP participation to 10,000 AF.
- Increased CBT units from 11,786 to 12,210.
- Adjustment to South Side Ditch diversions related to conveyance of a portion (0.75 cfs) of the O'Hara private contract right back to the ditch company.
- Addition of the Loveland Gard Right[5].
- Addition of a 1,300 AF downstream gravel pit, Great Western Reservoir[6].
- Addition of unchanged ditch shares acquired since 2012.

Using a study period of 1951 through 2015 and a daily time step, the firm yield was determined as the total demand in acre-feet the City could have supplied each year without shortage. The firm annual yield was estimated to be 30,890 AF and conformed to the City's 1-in-100 year drought policy.

In addition to estimating the firm yield of existing supplies, the 2020 Yield Analysis also evaluated various alternatives for additional water supply. These include reevaluation of the alternatives evaluated in the 2011 Yield Analysis, evaluation of the impact of potential future reductions in surface water supplies, and changes in the calculation of Loveland's reusable irrigation return flows.

2.5 City Raw Water Planning Policy

On March 1, 1988, the Loveland City Council adopted the recommendations contained in the 1988 CDM study that the City's water supply be capable of meeting design demands during a one-in-100 year drought ("100-year drought"). A 100-year drought has a one percent chance of occurring in any one year and would be expected to recur on average once every 100 years. The 100-year drought might occur more or less than one time in any particular 100-year period. According to the City staff, this planning policy requires developing sufficient supplies to meet the City's full water demand during the 100-year drought without water use restrictions. This planning policy remains in effect today.

[5] The Loveland Gard Water Right was decreed in Case No. 07CW325 and equates to 1.0 cfs from the beginning of the irrigation season until noon on July 14th each year and 0.5 cfs from noon on July 14th through August 31st each year. The City is in the process of implementing the Loveland Gard Water Right into its water rights portfolio.
[6] 1,300 AF was modeled as the preliminary operational storage capacity of Great Western Reservoir.

As a result of the 2011 Yield Analysis and the subsequent RWMP developed by City staff and the LUC, on July 17, 2012, the City Council adopted Ordinance No. 5691, which modified the City's water right dedication policies. A copy of the ordinance can be found in **Appendix A**.

2.6 Loveland Water Bank

The City has operated the Water Bank since the mid-1980s, and deposits to the bank have been the source of most of Loveland's water acquisitions during recent years. Developers or other entities, who seek water supply service from the City, are required to provide additional water (e.g., ditch company shares, CBT units, or cash-in-lieu) and pay a Native Water Storage Fee if and when the ditch company shares are dedicated to a developing property. In exchange for depositing water in the Water Bank, the developer receives a credit that can be applied toward the water requirements for zoning or development anywhere the City serves treated water. Since April 1, 2006, a minimum of fifty percent of every raw water transaction to satisfy the requirements must include water bank credits received in exchange for CBT units transferred to the City, or water bank credits previously acquired from the City by cash purchase[7], or by paying the cash-in-lieu price ("50% Rule"). If the acre-feet requirement resulting from the 50% Rule results in a fractional requirement of less than one-half an acre-foot, it may be rounded down to the nearest acre-foot. The full amount is still required, but the percentages are allowed to be adjusted.

The development credit given for Water Bank deposits is determined when the credit is applied to meet zoning or development requirements based on the current conversion rate in effect. For example, a deposit to the Water Bank in 2005 that is used to meet the water requirements for a development initiated in 2020 would be converted to water supply credit based on the conversion rate in effect in 2020. The conversion rate in 2020 may be higher or lower than the rate that was in effect when the water was deposited. The conversion rates currently in effect were adopted with Ordinance No. 5691 in 2012. Depositors of native water (i.e., ditch company shares) are also required to pay a "Storage Fee" when the water is converted for water supply credit or accept a lower conversion rate. This fee is in recognition that raw water storage is necessary to firm up native water sources[8]. In addition to the water dedication/cash-in-lieu requirement, entities seeking treated water service must also pay "System Impact Fees", a "Raw Water Development Fee" and "Tap & Meter Fees."

[7] Since January 1, 2006, credit in the City's Water Bank acquired from the City by cash purchase has not been allowed.

[8] Ditch company shares yield water only during a typical May through October irrigation season. Storage is necessary to convert these sources to year-around supplies, as well as to increase dry year deliveries.

The City has required water rights as a condition of development since 1960. The first such requirement is recorded in the form of an approved motion from a City Council meeting on August 16, 1960. Through 2005, credit for dedication of irrigation company shares was based on average annual diversions by each irrigation company over the past 20 years[9]. As a result of giving credit for average annual yield while needing to provide water supply during dry years, the Water Bank conversion policy resulted in erosion of the City's water supply drought cushion during this period. One of the purposes of the 2004 Yield Analysis was to estimate the actual increase in firm yield associated with addition of various water sources to the City's water portfolio for comparison with the then-current Water Bank conversion rates. As a result of the 2004 Yield Analysis, the Water Bank conversion rates were revised effective January 1, 2006. The Water Bank conversion rates were revised again after the 2011 Yield Analysis. A summary of the current water rights dedication and requirements for various irrigation company shares and transmountain sources is shown in **Appendix B**. One of the purposes of the current yield analysis is to review the current credits in the context of the City's current water portfolio and facilities.

[9] See Ordinance No. 1053, Section 6, City of Loveland, October 21, 1969.

3.0 DROUGHT FREQUENCY

The City's policy of requiring that its water supply be capable of withstanding a 100-year drought is reasonable, but it raises a question about how to define the 100-year drought. Drought may generally be defined as a water supply deficiency relative to a long-term average condition. It may be determined based on precipitation records, streamflow records, soil moisture supply or other measures. Because the City's water supply is derived from both the Big Thompson River and the upper Colorado River, it is reasonable to assess the drought frequency of Loveland's water supply based on the combined flows of these sources.

3.1 Historical River Flows

The Big Thompson River is the source for Loveland's primary raw water supply derived from municipal transfers of native irrigation water rights. The flow of the Big Thompson River is measured at several locations including the Big Thompson River at Canyon Mouth gage, located west of Loveland and just upstream from Handy Ditch and the Hansen Feeder Canal, as shown in the schematic diagram in **Figure 3-1.** The Canyon Mouth gage provides a reasonable indication of the water supply available to water users in the basin as it is located downstream of the higher elevations that provide substantial snowmelt runoff and upstream of most of the significant diversions in the basin. However, the historical records of the Canyon Mouth gage are affected by the operation of the CBT Project facilities. A better indication of the available native water supply is provided by estimates of the undepleted flow (also known as "virgin" flow) at the Canyon Mouth developed by the Northern Colorado Water Conservancy District ("Northern Water"). This is the flow that would have existed but for the operation of the CBT and Windy Gap Projects. Monthly undepleted flow estimates are available from 1947 - 2015.

The City relies on the CBT and Windy Gap Projects to supplement its primary native water supplies. The sources of water for these transmountain water projects include the Colorado River, Fraser River and Willow Creek in the upper Colorado River watershed. Northern Water prepares undepleted flow estimates for several upper Colorado River tributaries, and these data are available from 1950 - 2015.

The annual undepleted flows of the Big Thompson River at the Canyon Mouth gage and the Colorado River above Granby gage were analyzed to assess the frequency and magnitude of droughts affecting Loveland's raw water supply. The annual historical undepleted flows for these two gages are shown in **Figure 3-2**. During the period of concurrent record (1950 - 2015), the undepleted flow of the Big Thompson River averaged approximately 124,000 AF/y while the Colorado River averaged 270,000 AF/y. During this 66-year period the lowest undepleted flow for both locations occurred in 2002. Other dry years included 1954 and 1977. Flows at the two locations for these dry years are shown in the table below.

Annual Historical Undepleted Flows
Big Thompson River and Colorado River
(acre-feet)

	Big Thompson River at Canyon Mouth		Colorado River above Lake Granby	
Year	Undepleted Flow	% of Average Flow	Undepleted Flow	% of Average Flow
1950-2015 Average	124,000	---	270,000	---
1954	54,000	44%	154,000	57%
1977	71,000	58%	156,000	58%
2002	48,000	39%	120,000	44%

The Northern Water undepleted flow estimates provide information on the historical flows of the Big Thompson and upper Colorado Rivers. However, this data is not conclusive on the frequency of occurrence of very low flow events. For example, the most that can be said about the 2002 flow of the Big Thompson River from the virgin flow record is that it had a sample recurrence interval of one in 67 years. However, given the entire data set of Big Thompson River flows (including flows prior to the undepleted flow record), the 2002 flow could have an actual average recurrence interval of more or less than one in 67 years. Fortunately, there are methods that can be used to estimate the long-term frequency of low-flow events. One of these methods, involving the use of reconstructed flow through paleohydrologic analysis, is described in the following section.

3.2 Reconstructed Flows from NOAA Tree-Ring Study

The National Oceanic and Atmospheric Administration ("NOAA") has performed analyses of streamflows along the Front Range and in the Colorado River basin to extend the historical streamflow record using tree-ring data. These analyses involve developing a relationship between the thickness of annual tree rings in a watershed and the corresponding annual virgin streamflow during the period of the historical streamflow records. This relationship is then applied to earlier tree-ring data to estimate annual virgin streamflows prior to the period of record.

Reconstructed annual flows for the Big Thompson River at the Canyon Mouth gage are available for the period 1569 - 1999 and for the Colorado River above Granby from 1383 - 1999. A chart showing the historical and reconstructed annual Big Thompson River and Colorado River flows is shown in **Figure 3-3**. Historical undepleted flows are shown for the period 1947 through 2015 for the Big Thompson River at Canyon Mouth, and for the period 1950 through 2015 for the Colorado River above Granby. The reconstructed flows are used for the period 1569 through the start of the historical data.

3.3 Frequency of Big Thompson River and Colorado River Droughts

The combined historical and reconstructed undepleted flow record for the Big Thompson River indicates that 2002 was the 15th driest year in comparison to the 447 years of annual flows included in the record. An annual flow equal to or less than the 2002 flow occurred in 3.4 percent of the years. This corresponds to an average sample recurrence interval for the 2002 flow of one in 30 years. For the Colorado River above Granby, 2002 was the 5th driest year during the 633-year combined historical and reconstructed undepleted flow record. This indicates the sample recurrence interval for 2002 in the upper Colorado River basin was approximately one in 127 years.

In addition to the individual recurrence intervals for the Big Thompson River and upper Colorado River flows, the recurrence interval for both sources considered together is of interest to Loveland. The results of the yield analysis described in Section 8.1 indicate that approximately 55 percent of Loveland's water supply availability is from native Big Thompson River sources and 45 percent is from transmountain Colorado River sources, but approximately 69 percent of Loveland’s water supply firm yield is derived from the native Big Thompson River sources as illustrated on **Tables 8-1 and 8-2**. Based on this relative mix, the average recurrence interval for a composite supply comprised 60 percent from the Big Thompson River and 40 percent from the Colorado River was estimated as follows.

First, the composite reconstructed and historical undepleted flow records for each gage during the overlapping 1569 - 2015 period of record were normalized by computing the annual flow for each year as a percentage of average. **Figure 3-4** shows the normalized flows for the two gages over the 447-year period. Comparison of the normalized flows provides an indication of the degree to which droughts in the upper Colorado River basin have coincided with those in the Big Thompson River basin.

The next step was to compute a weighted composite annual normalized flow as 60 percent of normalized Big Thompson River flow plus 40 percent of the normalized Colorado River flow. A line chart illustrating the normalized historical and reconstructed annual virgin streamflow of the composite Big Thompson River and Colorado River over the 1569 - 2015 period is shown in **Figure 3-5**. The composite normalized 2002 flow is approximately 42 percent of average. Compared to the 447-year record, 2002 is the 6th driest year in the period. This corresponds to an average frequency of occurrence of approximately one in 75 years.

A frequency distribution of all the composite normalized gage flows was prepared and is shown in the solid line in **Figure 3-6**. The actual average recurrence interval of very low frequency events is difficult to assess from historical data because of the small number of these events in the sample. In consideration of this, a mathematical distribution can be fit to the sample data, and the fitted distribution may be used to characterize the low frequency events for the entire population of flows (i.e., the frequency of flows that would occur over a very long time period). One distribution that is commonly fit to streamflow data is the Log-Pearson Type III distribution ("LP-III"). The LP-III distribution was fit to the weighted combined normalized Big Thompson River and Colorado River annual flow data, and the result is shown in the dashed line in the **Figure 3-6**. Based on this fitted distribution, the 2002 weighted combined normalized flow has an average recurrence interval of approximately one in 90 years.

3.4 Historical Droughts and City Planning Policy

The one-in-90-year average frequency of occurrence of the combined normalized Big Thompson River and Colorado River flow in 2002 is close to the one-in-100-year frequency associated with the City's water supply planning policy. The 2002 combined normalized annual flow of 0.42 (42% of average) is only slightly greater than the normalized flow of 0.41 (41% of average) that corresponds to the one-in-100-year frequency of occurrence. This difference in flow is within the measurement accuracy of the Big Thompson River and Colorado River stream gages as well as the accuracy of the procedures used in the tree-ring streamflow reconstructions. As a result, water supply planning analyses based on the City's water supply being able to withstand the 2002 drought are consistent with the City's 1-in-100 year drought supply policy.

4.0 LOVELAND WATER USE

A summary of Loveland's historical annual potable water use since 1987 and the projected future potable water use is provided in **Figure 4-1**. The historical water use figures are based on the measured flow through the Chasteen Water Treatment Plant and do not include the non-potable water uses on certain of the City parks and other open space areas, which typically average approximately 800 AF/y. The non-potable irrigation uses are generally supplied by unchanged irrigation water rights and other sources not used to meet the City's potable water demands. The City's existing non-potable irrigation uses were not included in this yield analysis, except for about 90 AF/y of park irrigation demand that was assumed to be supplied from the potable water system for modeling purposes, as explained in more detail in Section 5.0.

The City also leases reusable water to other parties for augmentation use. As of 2020, the City provides reusable water for 19 leases totaling 390 AF/y. An extra 110 AF/y was incorporated into the future lease demand to allow for growth within the City's lease program. The leases are supplied by various sources including reusable water discharged to the river from the decant pond at the WTP and reusable treated wastewater effluent, and at times will compete with the supplies used to meet the City's potable water demands. The augmentation leases and park irrigation may be supplied by some of the sources used to meet potable demands, and have been included in this update of the yield analysis as an additional demand of 590 AF/y.

In 2020, the Loveland staff estimated the City's water demand through 2045 based on per capita water use and the population growth rates. The City's future water demand was projected from the 2019 population of 79,150 using annual growth rates of 1.5% and 2.0%. A per capita water use of 165 gal/person/day was applied to the future population for each of the years[10]. A conservation factor of 0.5% was applied to each of the first 10 projected years (2020 to 2028)[11] reducing the per capita water use to 158 gal/person/day by 2028. The water demand estimates were then extended out to 2060 for the purposes of this analysis. The anticipated municipal water demands at the various growth rates are presented below. The augmentation demand will increase the total demand by 590 AF.

[10] The per capita water use, 165 gal/person/day, was derived from the past 5 years of Loveland's water treatment plant production and population data.
[11] The conservation factor represents a reduction in the projected water demand associated with increased efficiency in water fixtures. The impact to the City's water supplies from the increased efficiency is anticipated to level out in the future.

Anticipated City's Water Service Area Population
At Various Growth Rates

Annual Growth Rate	1.5 %	2.0%
2040 Population	108,203	119,965
2040 Municipal Demand (AF)	19,150	21,232
2060 Population	145,733	178,262
2060 Municipal Demand (AF)	25,792	31,549

5.0 LOVELAND WATER SUPPLY FACILITIES

Loveland's water supply is diverted from the Big Thompson River at several locations. The City's direct flow diversions are made primarily at the Loveland Pipeline which is located immediately east of the canyon mouth at a diversion dam owned by the Consolidated Home Supply Irrigation and Reservoir Company (“Home Supply”) that the City shares with Home Supply. The Loveland Pipeline has a capacity of 71.3 cubic feet per second ("cfs") and delivers water to the City's Chasteen Grove Water Treatment Plant (“WTP”). Loveland also diverts water from the Big Thompson River at the United States Bureau of Reclamation's ("USBR") CBT Project diversion facilities at Olympus Dam (on Lake Estes near Estes Park) and at the Dille Tunnel (approximately 2.5 miles west of the Loveland Pipeline). These facilities deliver CBT Project water through conveyance tunnels to the Charles Hansen Feeder Canal ("CHFC"). Loveland has a turnout from the CHFC that delivers water to its Green Ridge Glade Reservoir which is another source of raw water to the City's water treatment plant. Use of the USBR’s facilities for delivery of the City’s Big Thompson water supplies into Green Ridge Glade Reservoir is controlled by a long-term agreement that allows Loveland to divert water, using the excess capacity of the USBR facilities, up to a maximum rate of 75 cfs.

Green Ridge Glade Reservoir was constructed in 1977 and 1978 as a short-term regulation facility for the City's CBT supply and to provide a source of emergency water supply. The original usable capacity of approximately 600 AF provided minimal conservation storage to enhance the City's supply during a severe drought. The reservoir was enlarged in 2004 and now has a usable capacity of 6,785 AF.

Treated water is delivered to Loveland's customers through a looped distribution system that includes approximately 20.3 million gallons (62.3 AF) of treated water storage in tanks. Wastewater is collected and treated at the Loveland Wastewater Treatment Plant ("WWTP") and discharged to the Big Thompson River just upstream of the Hillsborough Ditch headgate.

In 2019, Loveland purchased Great Western Reservoir (“GWR”), a lined gravel pit that is also known as Great Western Pit No. 1 and Kauffman Reservoir. GWR is located downstream of the Loveland WWTP near the Hillsborough Ditch headgate and will be filled by water gravity fed or pumped from the Big Thompson River will be gravity-fed or pumped into the storage facility. Loveland filed a water court application in Case No.

18CW3215 to adjudicate a conditional storage water right for 1,600 AF[12] in Great Western Reservoir with the right to fill and refill by diversions from the Big Thompson River, local tributary inflows, and direct precipitation on the reservoir. In addition to water stored under the conditional water right, Great Western Reservoir will also be used to store fully consumable water derived from Loveland's other water rights.

The Loveland Parks Department irrigates several parks within the City with raw water delivered from irrigation ditches and reservoirs located throughout the City. The sources of supply for these non-potable irrigation uses are private irrigation rights owned by the City that are delivered in area irrigation ditches, excess irrigation company shares that are not needed for potable water uses (e.g., in non-drought years) and spot rentals of CBT Project units. It was assumed these demands would continue to be met by either supplies not included in the yield analysis (e.g., private rights or rented CBT units) or by excess yield from the City's changed irrigation water rights. For purposes of the yield analysis, the City's current non-potable water uses were not explicitly modeled except for 90 AF/y associated with irrigation from the Barnes Park pond that the Parks Department estimated would not be available from non-potable sources in a dry year. The 90 AF demand in the analysis was treated as a lease that would be met through the potable water system.

The reusable water that the City leases to other parties for augmentation use is currently delivered as WTP decant water, WWTP effluent, and releases from Green Ridge Glade Reservoir.

[12] Though 1,600 AF of storage was claimed in Case No. 18CW3215, 1,300 AF was modeled as the preliminary operational storage capacity of Great Western Reservoir.

6.0 LOVELAND WATER SOURCES

Loveland's water sources include water rights appropriated for municipal use, irrigation water rights transferred to municipal use, and from deliveries of transmountain water from the Colorado River basin based on ownership of contracts for CBT and Windy Gap Project supplies. Summaries of these water sources follow.

6.1 Domestic Water Rights

The City appropriated two water rights for domestic and municipal uses from the Big Thompson River - 0.5 cfs in 1887 and 2.5 cfs in 1901. These water rights were assigned domestic priority Nos. 2 and 3, respectively, in Case No. CA4862. There are unresolved issues regarding the priority and diversion season of these rights. Although it appears from the decree in CA4862 that the rights could be diverted year-round under the domestic priorities, until the questions are resolved, the water rights are conservatively simulated in the Yield Model using irrigation priorities 51 and 81 with a diversion season of April 1 through October 31. The manner of simulation used in the Yield Model is conservative and does not imply that the City is waiving its right to divert year-round under the domestic priorities.

6.2 Transferred Irrigation Water Rights

As Loveland grew, it acquired shares in various irrigation companies that supply irrigation water in and around the Loveland area. These shares typically were associated with land parcels that were developed for residential, commercial or other purposes. Loveland's early transfers of irrigation water rights included 3.44 cfs of the No. 1 Big Thompson River priority in 1907 and two shares (6.0 cfs when all the rights are in priority) of the Big Thompson Ditch and Manufacturing Company ("BTD&MC") in 1925. Together, these two early transfers and the domestic rights are generally referred to as the City's municipal rights, or the Loveland Pipeline rights. The 3.44 cfs right is diverted year-round, but the two shares of BTD&MC are diverted only during the irrigation season. Under current administration, the irrigation season is April 1 through October 31.

Following the early transfers, the City continued to acquire ditch shares as it grew. The first formal requirement for raw water as a condition of development was expressed as a motion by City Council in august 16, 1960. Portions of these acquired shares were used for municipal use informally for several years until an application was filed in Case No. 82CW202(A) ("202A") in 1982 to transfer a large block of shares in several ditch companies to municipal use by the City. The 202A decree was entered by the Water Court in 1986. Since that time, the City transferred additional shares to municipal use under the terms and conditions of the 202A decree. The final 202A transfer was approved by the water court in Consolidated Case Nos. 00CW108 and 03CW354.

The 202A decree allows Loveland to divert its transferred irrigation water rights at the Loveland Pipeline, Dille Tunnel, and Olympus Tunnel for direct flow uses when the rights are in priority, less 15 percent of the City's pro-rata share of the diversion rate entitlement that is left in the original ditches for ditch losses. The City's diversions are limited by certain monthly, annual and long-term volumetric limits. Use of the transferred irrigation water rights is limited to diversion seasons defined by decreed starting and ending dates that vary by ditch company, but generally correspond to a May - October season. Direct flow uses of the 202A water rights are limited to a one-time use meaning that the return flows (WWTP return flows and lawn irrigation return flows) cannot be reused.

The 202A water rights may be stored provided that Loveland replicates the historical return flows associated with the prior irrigation use as specified in the 202A decree. During the irrigation season, the return flow requirements for stored water are met by the City leaving a portion of its diversion entitlement in the stream. The decree contains monthly percentages that specify the amount of the City's pro-rata diversion entitlement that may be stored. During the non-irrigation season, the City is required to return to the stream 13 percent of the volume stored under the 202A water rights during the prior irrigation season. The winter return flow requirement may be met by WWTP discharges following municipal use of the stored water. Return flows from use of stored 202A water that are not required for the winter return obligation may be reused by the City. Such reuse may occur directly or by exchange (e.g., diversions at the Loveland Pipeline in exchange for release of reusable WWTP discharges).

Based on negotiations with other Big Thompson water users and a desire for increased flexibility in its water use, Loveland agreed to not make further transfers of ditch company shares under the terms and conditions of the 202A decree. Instead, Loveland agreed that transfers would follow a modern format with Loveland diverting its pro-rata share of the water rights in priority and replicating historical return flows with wastewater discharges, irrigation return flows, reservoir releases, and other sources. The water that remains after meeting the return flow requirements may be reused directly or indirectly to extinction. The City’s first modern transfer was decreed on May 14, 2010 in Case No. 02CW392 (“392”) and involved shares in several ditch companies.

Except for Loveland’s ownership in the Barnes and Chubbuck Ditches, which were transferred under terms similar to the 202A decree, the 392 decree allows Loveland to divert its transferred irrigation water rights at the headgates of the irrigation ditches and at the Loveland Pipeline, Dille Tunnel and Olympus Tunnel, for direct flow or storage uses when the rights are in priority, less 15 percent of the City's pro-rata share of the diversion rate entitlement that is left in the original ditches for ditch losses. The monthly, annual and long-term volumetric limitations, as well as the diversion starting and ending dates, differ somewhat from those in 202A but are similar. Historical return flows are replicated for all direct flow and storage diversions through monthly return flow percentages that are specified in the 392 decree. All water that remains after the return flow requirements are met may be reused to extinction. Future transfers of shares in the ditches that were included in the 392 decree may use the same per-share volumetric limits and similar terms and conditions.

Loveland also transferred the water rights associated with the Rist & Goss Ditch to the Loveland Pipeline in two separate proceedings in Case Nos. W-7412 and 86CW050. These transfer decrees include rate of flow and annual volumetric limits.

In Case No. 07CW325 Loveland transferred a portion of the Big Thompson Ditch[13] that had been carried in the Home Supply Ditch since 1903. This transfer decree included a rate of flow of 1.0 cfs through noon on July 14th and 0.5 cfs thereafter. Additionally, this decree includes monthly, annual, and long-term volumetric limitations and requirements to make return flow replacements to the Big Thompson River, the Little Thompson River, and two other locations.

A summary of the City's transferred irrigation water rights is provided in **Table 6-1**.

6.3 Transmountain Water Sources

Loveland's other major sources of water are derived from transmountain diversions from the Colorado River basin through the City's interest in the CBT Project and the Windy Gap Project. The following is a summary of these sources and the City's interest in each.

6.3.1 Colorado-Big Thompson Project

Water for the CBT Project is diverted from the headwaters of the Colorado River basin and stored in several reservoirs. CBT Project water is delivered to Lake Estes in the upper Big Thompson River basin through the Alva B. Adams Tunnel which conveys water beneath the Continental Divide in Rocky Mountain National Park. From there, the water is distributed through a series of tunnels, reservoirs and canals to water users in the Northern Water service area which comprises approximately 1.5 million acres in the

[13] The Big Thompson Ditch was the original No. 1 ditch in the basin. The Big Thompson Ditch no longer exists and was replaced by the Hillsborough Ditch. The Big Thompson Ditch is not the same as the Big Thompson Ditch & Manufacturing Company.

South Platte River basin. The CBT Project was constructed by the USBR and began delivering water in the late 1940's. The project is jointly operated by the USBR and Northern Water.

There are 310,000 outstanding units in the CBT Project, of which Loveland currently owns 12,210 units, or about 3.9 percent. The CBT Project was created to provide a supplemental irrigation supply to water users in the Northern Water service area. Each year in April, Northern Water sets a quota that establishes the amount of delivery entitlement for each CBT unit. The quota typically averages approximately 0.7 AF/unit. During years of low snowpack in the South Platte River basin, the quota may be increased depending on project water availability. Conversely, the quota may be set lower than 0.7 AF/unit during wet years when the demand for supplemental water is less, or during dry years when the project supply is limited. Municipal and industrial water users, who take delivery of project water during the non-irrigation season, generally have been permitted to receive up to approximately 50 percent of the annual quota during the November - March period before the annual quota was set. Beginning in November 2001, Northern Water began formally setting a winter quota for municipal and industrial water users.

Owners of CBT units may carry over a portion of their unused allocation for use during the subsequent year. The carryover is limited to the lesser of 0.2 AF/unit or 90 percent of the unused allocation remaining in the user's account on October 31. Return flows from initial use of CBT Project water may not be reused. Instead, these return flows accrue to the South Platte River and its tributaries to the general benefit of water users throughout the Northern Water service area.

6.3.2 Windy Gap Project

The Windy Gap Project was developed to provide additional water supply for municipal and industrial water users on the East Slope using unused capacity in the CBT Project facilities. Water for the project is diverted from the Colorado River immediately downstream of the confluence with the Fraser River and is pumped into the unused space in Granby Reservoir. The water is then delivered as needed through the Adams Tunnel for the use of the members of the Municipal Subdistrict of the Northern Colorado Water Conservancy District ("Subdistrict"). Loveland owns one-twelfth of the supply, or 40 units out of the 480 units in the project. Each unit was originally projected to yield an average of 100 AF/y, although actual yields have been less since the project began delivering water in 1985 because full demands have not yet been placed on the system by most of the users. Unlike the CBT Project, return flows resulting from initial use of Windy Gap Project water may be reused to extinction.

Yield from the Windy Gap Project is variable due to the relatively junior water rights that supply the project and the reliance on the excess storage and conveyance capacity of the CBT Project facilities. During dry years, the project yields little or no water because of upstream diversions by senior water rights, and by calls against the project water rights from senior downstream water users. During wet years, there may be insufficient capacity in Granby Reservoir to store water pumped from the project diversion facilities on the Colorado River. In addition, Windy Gap Project water stored in Granby Reservoir is subject to spill in wet years due to storage of CBT Project water.

As a result of the unreliability of the Windy Gap Project supply, efforts were undertaken by the Municipal Subdistrict several years ago to study potential ways to enhance the yield of this supply. The Windy Gap Firming Project ("WGFP") is being developed to enhance the project yield, particularly during dry years. The WGFP involves construction of an East Slope storage reservoir ("Chimney Hollow Reservoir") and revised operation and coordination with the CBT Project. Loveland is participating in the development of the WGFP, presently at the level of 10,000 AF of storage capacity. Studies of the benefits of the WGFP have been performed for the Subdistrict and are documented in a 2003 report[14]. Additional technical reports were prepared between 2005 and 2008. A Record of Decision on the final WGFP Environmental Impact Statement ("EIS") was published on December 19, 2014[15] and the Record of Decision on the Section 404 Permit was finalized May 16, 2017[16]. Project construction is anticipated to begin in 2021.

6.3.3 Eureka Ditch

The Eureka Ditch was a hand-dug ditch that diverted water across the Continental Divide at Sprague Pass to the Big Thompson River basin. Loveland acquired the ditch in 1941 as a source of municipal supply and operated and maintained the ditch for many years. In 1995, the City entered an agreement with the National Park Service, the USBR and Northern Water whereby the City agreed to abandon the Eureka Ditch in exchange for 180 AF/y of firm CBT yield.

6.4 Exchanges

Loveland operates exchanges from its WWTP outfall to its various points of diversion on the Big Thompson River. By these exchanges, Loveland can deliver legally reusable

[14] Windy Gap Firming Project, Alternative Plan Formulation Report. Boyle Engineering, February 2003.
[15] Record of Decision Windy Gap Firming Project, Final Environmental Impact Statement, U.S. Bureau of Reclamation, Great Plains Region, December 2014.
[16] Record of Decision Windy Gap Firming Project, Section 404, U.S. Bureau of Reclamation, Great Plains Region, May 2017.

treated effluent to the Big Thompson River and divert a like amount of water upstream. The exchanges can only operate to the extent that they do not interfere with the operation of senior water rights that divert within the exchange reach. This means that if a senior user within an exchange reach is diverting and drying up the stream, then Loveland cannot operate the exchange. Loveland's sources of reusable water include 392 water, stored 202A water, the Loveland Gard Right water, free river diversions, water diverted under Loveland’s 1984 Green Ridge Glade Reservoir storage water right, Windy Gap yield, and will include yield derived from future water rights transfers. The City adjudicated its exchange appropriations in Case Nos. 02CW393 and 02CW394.

6.5 Free River

During high flow periods when the demands of all downstream users on the Big Thompson River and the South Platte River are satisfied, Loveland may divert water without restriction (“Free River”). In November 2015, the State Engineer issued Written Instruction 2015-02 - Instruction Concerning the Administration of Diversions of Water during Free River (“Free River Instructions”). During Free River conditions, if water is diverted for uses allowed under Loveland’s existing water rights those diversions will be counted against the decreed volume limits and must be consistent with all relevant decree terms and conditions. Additional diversions in excess of the volume limits during Free River are not subject to the decree conditions. Diversions for undecreed uses are not subject to terms and conditions of Loveland’s decreed water rights and are considered reusable. Free river conditions occur infrequently, typically during times when Loveland has excess yield from its other water rights, and therefore diversions during these conditions generally do not add to Loveland’s firm yield.

7.0 YIELD MODEL DESCRIPTION

A computer model of the Loveland water supply system was constructed to simulate the integrated yield of the City's various water sources. The Loveland Water Supply Yield Model is based on the historical records for the various Big Thompson River irrigation systems and the CBT Project over a study period from 1951 – 2015 using a daily time-step. Simulated yields for the Windy Gap Project developed as part of the planning for the WGFP are used in the Yield Model. Loveland's pro-rata share of the historical diversion records and simulated Windy Gap Project yields are computed based on ownership information input by the model user. Other user inputs include Loveland's annual potable water demand, leases of augmentation water to other entities, downstream non-potable water demand, and upstream and downstream raw water storage capacity. Descriptions of the model input data, assumptions and operation follow.

7.1 Historical Records

Daily diversion and monthly storage records for all the major irrigation companies on the Big Thompson River mainstem were downloaded from the Colorado Decision Support System database maintained by the Colorado Division of Water Resources. The daily diversion records generally include the total amount diverted as well as the disaggregated amounts associated with native water rights, transmountain sources, exchanges, and other categories. The monthly storage records generally consist of end-of-month reservoir storage content. The diversion and storage records were spot checked against paper copies of the historical water commissioner records.

Daily records of the operation of the CBT Project were obtained from the USBR. These records include a wide variety of information including streamflows, diversions, power production, reservoir stage, water orders, etc. Daily records were available in digital form from 1976 - 2015. Prior to 1976, the records are available only in paper form. Daily information was extracted from the digital data and input from the paper records for the Olympus Tunnel, Dille Tunnel, Charles Hansen Feeder Canal, Big Thompson Power Plant and Hansen Feeder Wasteway.

7.2 Municipal Water Demand

Loveland's annual potable and non-potable water demands are input by the model user. The potable water demand is the principal simulated water use in the Yield Model and is met by diversions at the Loveland Pipeline or from Green Ridge Glade Reservoir releases. Leases of potable water to other parties can also be included as part of the potable water demand. In the current Yield Model, 90 AF/y for parks irrigation is simulated as a potable lease, with a monthly distribution provided by the City. The annual potable demands specified by the model user are distributed to daily amounts based on the historical pattern reflected in the City's daily water use records for 2005 – 2015 as shown in **Figure 7-1.** A smoothed line was fit to the historical data to develop the daily water demand distribution used in the Yield Model. If desired, the model user may alter the daily water use distribution.

The non-potable irrigation demand of 90 AF/y represents potential future irrigation water uses located downstream of the City's WWTP. This demand may be satisfied in the Yield Model from the same sources used to supply the potable demand, as well as direct use (i.e., not by exchange) of reusable effluent and releases from downstream reservoir storage. The annual non-potable irrigation demand may be distributed to monthly and daily amounts in a pattern specified by the user. The current default distribution is based on the City's current irrigation demand pattern.

The augmentation demand is also a non-potable demand and represents leases of reusable water to other parties for augmentation purposes. This demand may be satisfied in the Yield Model from reusable WWTP effluent, the reusable portion of the WTP decant water, the reusable portion of 392 transfer water that is not diverted at the Loveland Pipeline or Green Ridge Glade Reservoir, and releases from Green Ridge Glade Reservoir or Great Western Reservoir. In the current Yield Model, an augmentation demand of 500 AF/y is simulated in addition to the 90 AF/y of park irrigation described above. Based on the relative locations of the current augmentation leases, 50 AF/y of the current lease demand is located higher in the basin can only by WTP decant water and releases from Green Ridge Glade Reservoir, and the remaining 450 AF/y is met by any of the available sources. The annual augmentation demand is currently distributed based on records of augmentation deliveries for 2005-2015, but the distribution may be changed by the user.

7.3 Simulated Water Supplies Currently Used by Loveland

All of Loveland's primary water sources described in Section 6 are simulated in the Yield Model. In addition, there are other irrigation companies that may be simulated for which Loveland currently has no shares transferred to municipal use. Loveland's yield of the irrigation company sources is determined as a pro-rata share of the historical diversions of the subject source limited by the estimated flow that is physically available at Loveland's point of diversion. Additional information regarding the simulation of each of Loveland's water sources follows.

7.3.1 Early City Transfers and Domestic Water Rights

Loveland's early water rights transfers included 3.44 cfs of the Big Thompson Ditch and two shares (6.0 cfs) of the BTD&MC which has four priorities. Loveland's 3.44 cfs of the Big Thompson Ditch may be diverted year around and, because this is the No. 1 priority on the Big Thompson River, it was assumed to always be available. The yield of Loveland's early transfer of the BTD&MC is determined based on the flow rate in priority during a diversion season specified by the user. Under current administration, the season is April 1 – October 31.

City also has water rights decreed to the Loveland Pipeline for domestic and municipal purposes in CA4862. These water rights, generally referred to as the "domestic rights", have two separate priorities for 0.5 cfs and 2.5 cfs. There are unresolved issues regarding the priority and diversion season of these rights. The yield of these water rights can be modeled based on days in priority during the year, or during a diversion season specified by the user. The priority can be based on the rights' relative priority with respect to irrigation ditches ("irrigation priority") or with "domestic priority" that is senior to irrigation rights and therefore assumed to be available every day. The user can also select the option to not use this water right in the Yield Model. Although it appears from the decree in CA4862 that the rights could be diverted year-round under domestic priorities 2 and 3, until the questions are resolved, the rights are conservatively simulated in the Yield Model using irrigation priorities 51 and 81 with a diversion season of April 1 through October 31. The manner of simulation used in the Yield Model does not imply that the City is waiving its right to divert year-round under the domestic priorities.

7.3.2 202A Transfers

The yield of Loveland's 202A water rights is determined as 85 percent of the City's pro-rata portion of the adjusted historical direct flow irrigation diversions associated with each ditch company. The historical diversions were adjusted to (a) exclude assumed diversions of private or contract water rights that are carried in certain ditches[17] and (b) to include the City's historical diversions of its transferred irrigation water rights. The diversions by private or contract rights were modified in the 2011 analysis to reflect the updated analyses that were performed for the 392 transfer. The simulated divertible yield to Loveland is limited to days between the starting and ending dates specified in the 202A decree. The volumetric limits from the 202A decree were not directly imposed on the simulated diversions. However, the simulated diversions were compared to the

[17] The 2020 Yield Model includes an adjustment to the South Side Ditch diversions related to conveyance of a portion (0.75 cfs) of the O'Hara private contract right back to the ditch company.

decreed volumetric limits and it was determined that the volumetric limits would have been reached only rarely[18].

During periods when there is 202A yield that exceeds of the City's demands, the excess supply is stored in the simulated upstream storage (i.e., Green Ridge Glade Reservoir) and/or downstream at Great Western Reservoir. The amount stored is limited to the direct flow yield multiplied by the monthly storage percentages in the 202A decree. Any simulated storage of 202A water also creates a winter return flow obligation of 13 percent of the amount stored. This obligation can be met by using the stored water through the City's water system during the winter and dedicating the return flows to the river.

7.3.3 Rist & Goss Transfers

Loveland's yield of its transferred Rist & Goss Ditch water rights is computed similarly to the yield of the 202A water rights. Loveland was assumed entitled to use approximately 84 percent of the Rist & Goss Ditch historical yield[19]. Diversions were limited to a daily total of 5.48 cfs and a total annual volume during the period April 1 – October 31 and were further limited by the monthly volumetric limits in the second transfer decree.

7.3.4 392 Transfers

Loveland's 392 water rights transfer allows Loveland to reuse return flows resulting from any use of the transferred water once the return flow obligations are met. The yield of Loveland's 392 water rights is determined as 85 percent of the City's pro-rata portion of the adjusted historical direct flow irrigation diversions associated with each ditch company. The historical diversions were adjusted to (a) exclude assumed diversions of private or contract water rights that are carried in certain ditches[20] and (b) to include the City's historical diversions of its transferred irrigation water rights. The simulated divertible yield to Loveland is limited to days between the starting and ending dates specified in the 392 decree. For modeling purposes, the irrigation season return flows are assumed to be left in the stream, and only the reusable portion is diverted for use. In actual operations, the City could divert its entire pro-rata entitlement if the irrigation return flow requirements are met by other sources. The non-irrigation season return flow obligations are met by various reusable water sources. The volumetric limits from the 392 decree were not directly imposed on the simulated diversions. However, the

[18] This is expected as the volumetric limits were derived from the historical diversions during the 1920 - 1979 period.

[19] The combined annual diversion entitlement from the City's two Rist & Goss Ditch transfer decrees is 487.5 AF/y, of which 80 AF/y may be used for replacement of evaporation associated with a gravel pit on a portion of the lands historically irrigated by the ditch.

[20] The 2020 Yield Model includes an adjustment to the South Side Ditch diversions related to conveyance of a portion (0.75 cfs) of the O'Hara private contract right back to the ditch company.

simulated diversions, including the amount left in the stream, were compared to the decreed volumetric limits and it was determined that the volumetric limits would have been reached only rarely[21].

During periods when there is 392 yield that exceeds of the City's demands, the excess supply is stored in the simulated Green Ridge Glade Reservoir and/or downstream in Great Western Reservoir. The amount stored is limited to the reusable portion of the available amount. Any simulated storage of 392 water also creates a winter return flow obligation as specified in the 392 decree.

7.3.5 Loveland Gard Right Transfer

The yield of the transferred Loveland Gard Right[22] is simulated similarly to the yield of the 392 water rights with simulated reuse of any remaining return flows resulting after return flow obligations are met. The Loveland Gard Right transfer in Case No. 07CW325 required return flows to be replaced at five different return flow sectors. For modeling purposes, all the return flow obligations were aggregated into Big Thompson River sectors upstream and downstream of the Loveland WWTP. The City's ability to replace return flow obligations in the smaller return flow sectors could affect the City's yield from the Loveland Gard Right. The volumetric limits from the Loveland Gard Right decree were not directly imposed on the simulated diversions. However, the simulated diversions were compared to the decreed volumetric limits and it was determined that the volumetric limits would have been reached only rarely[23].

During periods when there is Loveland Gard Right yield that exceeds the City's demands, the excess supply can be stored in Green Ridge Glade Reservoir. The amount stored is limited to the reusable portion of the available amount.

7.3.6 Post-392 Transfers

Pursuant to the terms of the 392 decree, Loveland may transfer additional ditch company shares in accordance with the terms and conditions of the 392 decree. For future transfers of additional shares in irrigation ditches that were included in 02CW392, the decreed per-share volumetric limits and monthly return flow obligations will be used. The precise terms of future transfers of shares in ditches, that were not included in the 392 decree (Handy, Home Supply, Hillsborough and GLIC), are unknown. The yield of these

[21] This is expected as the volumetric limits were derived from the historical diversions during the 1951 - 1979 period.
[22] Diversions of the Loveland Gard Water Right are limited to 1.0 cfs from April 17 through noon on July 14. From noon on July 14 through August 31, the diversion of the Loveland Gard Water Right is limited to 0.5 cfs.
[23] This is expected as the volumetric limits were derived from the historical diversions during the 1950 - 1998 period.

transfers is computed based on a similar procedure used for the 392 transfers, using the average of return flow percentage values from the 392 decree. These values may be modified by the user.

7.3.7 Free River Diversions

There are no long-term records of historical priority calls on the Big Thompson River, and therefore the periods of free river (no priority call) were estimated based on the following criteria: (a) no call exists on the South Platte River downstream of the Big Thompson River confluence, (b) the flow in the Big Thompson River at La Salle is greater than 20 cfs and (c) exchange potential exists between the La Salle gage and the Canyon Mouth gage. It is assumed that Loveland could divert up to its daily water demand under the free river criteria and the Office of the State Engineer's Free River Instructions.

7.3.8 Exchanges

Exchanges are simulated in the Yield Model on days when exchange potential exists and there is reusable WWTP effluent and/or reusable water stored downstream in Great Western Reservoir in excess of augmentation and return flow demands. The exchanges are simulated to release reusable water from a downstream location such as the WWTP and/or Great Western Reservoir and to divert reusable water at an upstream location either at the Loveland Pipeline or the Olympus and Dille Tunnels to Green Ridge Glade Reservoir. Modeled sources of reusable water include 392 water, stored 202A water, Loveland Gard Right water, free river diversions, Windy Gap water, and WWTP effluent from these sources.

7.3.9 Decant Water from Water Treatment Plant

The treatment process at the Chasteen WTP generates a stream of water, known as decant water, that is returned to the Big Thompson River near the point of diversion. The reusable portion of the decant water may be used for augmentation and return flow demands and may also be stored downstream in Great Western Reservoir. Currently, Loveland uses the decant water under administrative approval from the State Engineers Office. The City has a pending water court application, Case No. 18CW3193, to quantify and use the return flows associated with the decant water. Although the amount of decant varies somewhat seasonally with the processes at the WTP and is expected to decrease over time, it is simulated in the Yield Model as 2.5% of diversions to the plant. This percentage may be changed by the user.

7.3.10 CBT Units

Loveland's CBT Project yield is simulated based on the historical annual quota set each year during the study period between 1953 - 2015. The quota for 1951 and 1952 is based on estimated CBT yields determined as part of the WGFP modeling (see Section 7.3.11). The quota is generally treated as a supply of water that Loveland could draw on at any time to meet its demands, similar to a reservoir. In accordance with Northern Water policy, one-half of the annual quota is assumed to be available for use beginning November 1. The remaining portion of the annual quota is assumed to be available for use beginning when the annual quota is set by Northern Water's Board at its April meeting each year. Carryover of CBT supply to the next year is limited to the lesser of 0.20 AF per simulated CBT unit or 90 percent of the amount of unused quota remaining on October 31. In addition to yield from its CBT units, 180 AF/y of firm CBT yield is simulated based on the City's Eureka Ditch agreement.

7.3.11 Windy Gap

The yield of Loveland's Windy Gap units is simulated differently in the Yield Model depending on whether the firmed or unfirmed yield is being analyzed. As described above, the yield of the current Windy Gap Project (i.e., unfirmed) is variable from year to year due to the relatively junior priority of the Windy Gap water rights and the availability of excess capacity in the CBT Project facilities. The West Slope yield of the Windy Gap Project was simulated by Boyle Engineering ("Boyle") in 2003 and updated in 2008 as part of their modeling for the WGFP. This provided estimates of the project yield for the period from 1951 - 1996, when the Boyle study period ends. After 1996, a combination of the actual yields from Northern Water and the procedures used in the Boyle analysis was used to develop Windy Gap yield estimates for the Yield Model.

When simulating yields from the unfirmed Windy Gap Project, the Boyle yield estimates were totaled annually, and Loveland's pro-rata portion was assumed available for delivery any time after March. The exception to this was during years of Granby Reservoir spills when the Windy Gap yield was set to zero. After 1996, the actual Windy Gap yields were used for the simulated unfirmed Windy Gap yields. This was deemed reasonable as there was no Windy Gap yield from 1997 – 2000, 2011, and 2014 – 2015 because Granby Reservoir spilled in those years. In 2001 – 2008, 2010, and 2012 – 2013, the Windy Gap yields were generally limited by the available supply on the West Slope. In 2009, Windy Gap yields were limited to prevent Granby Reservoir from spilling.

The WGFP modeling was intended to estimate the increased yield reliability that could be available to the Subdistrict members who participate in the WGFP. The approach taken in the WGFP modeling was to estimate the firm annual yield that could be delivered from the Windy Gap Project to each participant. This implied a constant annual demand for water from the Windy Gap Project. However, Loveland will not likely use its Windy Gap supply in this manner. Instead, it will more likely use its Windy Gap supply as a supplemental water source to be drawn upon in dry years when its other native and transmountain water sources are in shorter supply. As a result, SWE discussed with Boyle Engineering an alternative modeling approach whereby Loveland's yield from the WGFP could be treated as a supplemental dry year supply.

As part of the WGFP, Loveland will be entitled to use a portion of the proposed Chimney Hollow Reservoir to regulate its Windy Gap Project yield. Loveland is currently proposing to participate in the WGFP to the extent of 10,000 AF of East Slope reservoir storage space. Loveland's pro-rata share of the Boyle estimates of the West Slope yields for the period 1951 - 1996 were assumed available for storage in Loveland's portion of the proposed Chimney Hollow Reservoir.

As described above, there was no yield from the Windy Gap Project in several years because Granby Reservoir spilled during those years. However, if there had been storage space available on the East Slope for project water, then water could have been pumped through Granby Reservoir directly to Chimney Hollow Reservoir. The potential Windy Gap yield during 1997 – 2000, 2011, and 2014 – 2015 was estimated based on the daily flow at the Colorado River at Windy Gap gage during the months of April - August, less 90 cfs for a downstream minimum flow water right. The resulting daily values were further limited by the daily unused capacity in the Adams and Olympus Tunnels[24]. During 2001 – 2009, 2010, and 2012 – 2013, the actual Windy Gap yields were assumed to represent the amount that could have been pumped to Chimney Hollow Reservoir.

The yield of the WGFP to Loveland was estimated in the Loveland Yield Model based on simulation of a separate reservoir of variable capacity intended to represent Loveland's pro-rata share of the proposed Chimney Hollow Reservoir space. Inflows to this separate reservoir were computed based on Loveland's pro-rata share (40 Loveland units / 480 Total units) of the total Windy Gap Project yield described above. The regulated Windy Gap yield is utilized in the Yield Model as necessary to supplement the other simulated water sources.

[24] In years when Granby does not spill, the capacity of the Adams and Olympus Tunnels is not a constraint to the Windy Gap Project yield due to Northern Water's instantaneous delivery and accounting policy. Under this policy, a water user may take delivery of Windy Gap Project water from any of the Northern Water's CBT supplies available on the Eastern Slope. Such deliveries are accounted for by a paper transfer of Granby Reservoir storage from Windy Gap to CBT.

The results of the Yield Model simulation of the WGFP supply were provided to Boyle who input the simulated variable Windy Gap Project water use as a demand schedule to their yield model. Boyle verified that the WGFP water use simulated in the Loveland Yield Model could be delivered in their simulation model.

7.3.12 Green Ridge Glade Reservoir

Loveland's Green Ridge Glade Reservoir is simulated to regulate all of Loveland's water sources for all municipal uses including potable uses and releases, when necessary, to meet return flow obligations. The simulated capacity in the Yield Model is the 6,785 AF based on the as-built survey of the reservoir. Simulated reservoir inflows are limited to the 75 cfs capacity of the turnout from the Hansen Feeder Canal and by the historical excess capacity in the CBT Project facilities. Evaporation losses are computed based on average unit evaporation losses determined in accordance with the State Engineer's procedures related to gravel pit reservoirs. These unit evaporation losses are multiplied by the surface area of the reservoir determined from the simulated reservoir content and the area-capacity table for the reservoir. There are no seepage losses from the reservoir simulated in the Yield Model.

The simulated reservoir storage contents are divided into reusable and non-reusable pools, with individual reservoir accounts for each water source. All sources stored in the reservoir are assumed to be reusable except for CBT Project deliveries. Releases from storage are assumed to be colored based on the concurrent mix of reusable and non-reusable in storage, except for releases to demands that require only reusable water. Simulated evaporation losses are applied pro-rata to the relative contents of the reusable and non-reusable pools [25].

7.4 Simulated Water Supplies Not Currently Used by Loveland

Loveland may acquire and transfer shares in other irrigation companies for which the City has not previously changed shares to municipal use. At the request of the LUC in 2004, the potential benefit to the City's water supply of shares for selected Big Thompson River irrigation companies was evaluated. The analysis was updated for this report. A description of these companies and the procedures used to evaluate the potential yield to the City's water supply follows.

[25] Loveland may operate to release water from the individual reusable and non-reusable accounts; however, this method of operation is not currently simulated except in the case of releases for return flow obligations and augmentation leases.

7.4.1 Handy Ditch Company

The Handy Ditch is the only irrigation ditch on the Big Thompson River that diverts upstream of the Loveland Pipeline. The ditch irrigates land on the south side of the Big Thompson River and in the Little Thompson River drainage. The City of Berthoud historically has taken delivery of its Priority No. 1 water through the Handy Ditch. Berthoud's diversions are accounted for separately from the agricultural diversions in the historical records for the Handy Ditch.

The potential yield of Handy Ditch Company shares to Loveland is estimated in the Yield Model assuming that Loveland would be entitled to a pro-rata share of the historical agricultural diversions by the Handy Ditch. It is assumed that Loveland would be required to leave 15 percent of its diversion entitlement in the Handy Ditch to replicate historical ditch losses and an average of 40 percent in the river to replicate historical return flows. The water remaining after paying the assumed return flow obligation is assumed to be fully reusable.

7.4.2 Consolidated Home Supply Irrigating and Reservoir Company

The Consolidated Home Supply Irrigating and Reservoir Company (“Home Supply”) Ditch diverts from the south bank of the Big Thompson River. The City uses Home Supply’s diversion dam for its Loveland Pipeline on the north bank of the river. Home Supply is primarily a storage-based irrigation company. The company owns and operates three water storage reservoirs that fill from the Big Thompson River. Lone Tree Reservoir is the No. 1 priority storage water right on the Big Thompson River and has a decreed capacity of approximately 9,180 AF. Mariano Reservoir is the No. 3 priority storage water right with a decreed capacity of approximately 4,130 AF. The storage water right for Home Supply's third reservoir, Lon Hagler Reservoir, is one of the most junior storage water rights in the basin. The Home Supply reservoirs are generally filled during the non-irrigation season from November - April. Lone Tree and Mariano Reservoirs fill almost every year while Lon Hagler Reservoir rarely fills under its own priority. Lon Hagler Reservoir is used by the shareholders primarily to store excess CBT water or leased water sources.

The company also has 56 cfs of direct flow water rights by virtue of acquisition and transfer of portions of the Big Thompson Ditch and Manufacturing Company in the early twentieth century. Most of this water may only be diverted by Home Supply during the irrigation season until July 14 of each year in accordance with the terms of the transfer decree. Home Supply also owns a relatively junior (1881 priority) direct flow water right for 279 cfs that is divertible only during periods of high streamflow.

During the early portions of the irrigation season when runoff is relatively high, Home Supply tends to rely more on its direct flow water rights. When the runoff ebbs, and after July 14 when its senior transferred water rights must be curtailed, Home Supply transitions to use of its storage water rights. Shareholders in some portions of the Home Supply service area cannot receive water directly from storage. These users are supplied water by exchange. Water is released from Home Supply's storage reservoirs to the Big Thompson River and a comparable amount of water is diverted upstream at the Home Supply Ditch headgate. The Home Supply exchange is decreed for 76 cfs and is the No. 2 exchange right on the river.

The annual "issue" (yield) to shareholders in the Home Supply Ditch Company is determined each year by the board of directors based on review of expected runoff, amount of water in storage and other factors. The annual issue is net of conveyance and evaporation losses and may be delivered by a combination of direct flow diversions and releases from storage. The potential yield of Home Supply shares to Loveland is computed based on historical records of the annual issue. It is assumed that the City could take delivery of the annual issue at any time during the irrigation season up to the historical annual amounts for each year. It was also assumed that the City could receive its deliveries as necessary under the Home Supply exchange right.

The Town of Johnstown has transferred Home Supply shares to municipal use in Case Nos. 98CW410 and 06CW224. The change decrees provided that an average of 60 percent of the direct flow deliveries and 65 percent of the storage yield was consumed, and the remainder returned to the stream. Based on these findings it was assumed that Loveland would have an average return flow obligation for any transfer of Home Supply shares equal to 40 percent of the annual issue.

7.4.3 Greeley - Loveland Irrigation Company

The Greeley – Loveland Irrigation Company ("GLIC") operates the Barnes Ditch and the Loveland and Greeley Canal (a.k.a. "Chubbuck Ditch"). Predecessors of the GLIC acquired the water rights of the Barnes Ditch and the Chubbuck Ditch pursuant to a series of contracts entered in the late-nineteenth century with the original water right holders. In exchange for the water rights, the GLIC agreed to deliver certain amounts of water expressed as "inches" to each of the contract holders. These contract rights are the source of the Barnes and Chubbuck inches that have been acquired by the City and transferred to municipal use over the years. To the extent that there is yield from the Barnes Ditch and Chubbuck Ditch water rights that is excess to the delivery requirements of the inch-holders, the excess yield accrues to the GLIC shareholders. In addition to the excess yield from the Barnes Ditch and Chubbuck Ditch water rights, the GLIC owns another large (297 cfs), but relatively junior (1881 priority), direct flow water right. The GLIC also owns and operates Boyd Lake which has a decreed capacity of 48,564 AF. Most of the yield to the GLIC shareholders is derived from the Boyd Lake storage water right. The largest GLIC shareholder is the City of Greeley. Loveland owns three GLIC shares that are used for non-potable irrigation use.

Each year, the GLIC sets a "storage dividend" and a "river dividend." These figures establish the annual water available per share before the delivery shrink that is charged by the company. The storage dividend is derived from Boyd Lake storage and the river dividend is derived from the company's direct flow water rights. Historical records of the GLIC dividends for the period 1968 - 1985 are contained in the 1987 engineering report for the Greeley transfer of GLIC shares in Case No. 87CW329[26].

The GLIC is unique in the Big Thompson River basin, in that it allows shareholders to carry over to the next year any unused portion of their pro-rata share of the annual dividend in Boyd Lake. Any water that is carried over from December 31 to January 1 is subject to an 11 percent storage charge. Carryover of unused dividend water is termed "protected" carryover storage. Shareholders may also store other water in Boyd Lake on a space available basis. All foreign water and "protected" carryover storage is subject to spill as a result of diversions under the Boyd Lake storage water right. The foreign water is the first to spill followed by the "protected" carryover storage. However, due to its relatively junior storage priority, Boyd Lake rarely fills.

For purposes of estimating the potential benefit of GLIC shares to Loveland, the direct flow yield of the GLIC shares was simulated in the Yield Model based on a pro-rata share of the computed historical annual direct flow diversions that were excess to the delivery entitlements of the Barnes and Chubbuck inches less an assumed 11 percent shrink. The storage yield of the GLIC shares was determined from the 1968 - 1985 storage dividends contained in the 1987 Greeley engineering report. For the period prior to 1968 and after 1985, estimates of the GLIC storage dividends were made based on a relationship developed between the 1968 - 1985 storage dividends and the reported March 31 storage contents of Boyd Lake.

The annual storage dividend less a 22 percent shrink charge was assumed available for use at any time during the irrigation season. The GLIC carryover policy was also simulated by assuming that Loveland could carry over its unused storage dividend in its pro-rata share of the Boyd Lake storage space. Simulated carryover storage was assessed an 11 percent shrink charge in accordance with company policy. An average return flow

[26] W.W. Wheeler & Associates, Inc., City of Greeley and Public Service Company of Colorado. Water Use Study - Task B, Greeley and Loveland Irrigation and Associated Companies (September 1987).

obligation of 40 percent was estimated to apply to Loveland's computed diversion entitlement in addition to the shrink charge described above. Water remaining after the return flow requirement was assumed to be fully reusable.

7.4.4 Ryan Gulch Reservoir Company

The Ryan Gulch Reservoir Company ("RGRC") owns and operates a storage reservoir on Ryan Gulch, a tributary that joins the Big Thompson River approximately one-quarter mile upstream from the Farmers Ditch headgate. The reservoir has a decreed capacity of approximately 730 AF, and the decreed source of water to the reservoir is Ryan Gulch. The largest shareholders in the RGRC are the Town of Berthoud (34%) and private homeowners (30.5%). The City of Loveland currently owns 15.75 shares (15.75%) in the RGRC, and these shares are used for non-potable irrigation uses. Most or all the uses of water from Ryan Gulch Reservoir are diversions made from the Big Thompson River in exchange for releases from the reservoir to the river. In recent years, certain of the RGRC shares have been acquired by property owners near the reservoir who prefer to leave their share of the reservoir yield in storage for aesthetic purposes. The storage water right for Ryan Gulch Reservoir has a relatively junior 1904 priority date. Because the reservoir fills from Ryan Gulch, it does not compete with the other Big Thompson River reservoirs for supply. However, it is subject to priority calls from downstream storage water rights on the South Platte River.

The potential yield of RGRC shares to Loveland was estimated using the historical reservoir storage records. The historical annual yield was estimated as the historical increase in storage during the storage season less an assumed 15 percent evaporation and conveyance loss. Any of the annual yield not used was allowed to be carried over in storage for use in the subsequent year.

7.4.5 Lawn Irrigation Return Flows

Loveland's lawn irrigation return flows ("LIRFs") originate from the irrigation of lawns, parks, golf courses, and other areas with fully consumable sources. Loveland has a pending application in Case No. 18CW3193 to quantify and use its reusable return flows to the Big Thompson River, including LIRFs, to the Big Thompson River for payment of return flow obligations associated with the prior change cases, as a substitute supply, and as replacement sources in decreed augmentation plans. Loveland seeks approval to use its reusable return flows for all municipal purposes, including reuse, and successive use to extinction and disposition to others by sale, lease, trade, or other arrangement.

The LIRFs from the use of the various water sources can be tracked in the Yield Model, and the user may choose to use the reusable portion to meet augmentation and return flow demands. Because the LIRFs have not yet been quantified in a decree, the Base Run does not include simulation of this source. The LIRFs procedures from the preliminary engineering report prepared by SWE in support of Case No. 18CW3193 are included as a model run under an alternative water supply operation.

7.5 Diversion Constraints

The Loveland Yield Model includes several limitations on direct flow and storage diversions that are intended to mimic actual constraints on Loveland's water use. In addition to the water rights constraints described above, the following is a summary of the Yield Model limitations on direct flow and storage diversions:

Loveland Pipeline Diversions

- Actual diversion capacity of 71.3 cfs but increased to 90 cfs to simulate additional capacity that will be needed at higher demand levels.
- Historical available river flow at the point of diversion.
- Diversions of transferred irrigation water rights are limited to the exchange potential between the Loveland WWTP and the Loveland Pipeline.

Diversions to Green Ridge Glade Reservoir

- Available storage space.
- 75 cfs limit of USBR contract.
- Historical excess capacity in the Olympus Tunnel, Dille Tunnel and Charles Hansen Feeder Canal plus historical skim[27].
- Diversions of transferred irrigation water rights are limited to the historical available physical flow and the available river exchange potential.
- CBT water remaining unused in September and October.
- Windy Gap water, at times when Green Ridge Glade is less than half full.

Diversions to Great Western Reservoir

- Available storage space.

[27] The USBR has historically diverted native water at the Olympus and Dille Tunnels for power generation and returned this water to the river upstream of the Loveland Pipeline so as not to affect diversions by senior water rights. This is termed the USBR's "skim" operation. In accordance with Loveland's contract with the USBR, Loveland may divert against the skim provided that it pays the USBR a power interference charge.

- 20 cfs assumed maximum inflow and outflow rates[28].
- Diversions of reusable treated effluent are limited to the amount remaining after paying winter return flow obligations and augmentation leases, direct non-potable uses and upstream exchanges.

7.6 Order of Simulated Water Use

The simulated order of use of Loveland's various raw water supplies to meet the City's daily water demands is patterned after the order in which the sources are actually used. Based on discussions with the City staff, the following is a summary of the simulated order of use of the City's raw water supplies to meet direct flow water demands and for diversions to storage:

Order of Simulated Water Use (First to Last)

Direct Flow Use	Pipeline Rights[1]	202A Transfers[2]	392 Transfers[3]	Loveland Gard Right	Future Sources[4]	Exchange[5]	Free River	CBT	From Storage	WG
To GRG Storage	202A Transfers[2]	392 Transfers[3]	Loveland Gard Right	Future Sources[4]	Exchange[5]	Free River	CBT	WG		
To GWR Storage	202A Transfers[2]	392 Transfers[3]	Future Sources[4]	Reusable Effluent	Reusable WTP Decant	Free River				
To Aug Leases	Reusable Effluent	Reusable LIRF	From D/S Storage	Reusable WTP Decant	From GRG Storage					
To NP Irrigation	202A Transfers[2]	392 Transfers[3]	Future Sources[4]	Reusable Effluent	From D/S Storage	From GRG Storage				

Notes:
1. Early transfers to municipal use and the City's domestic use right (when simulated).
2. Past transfers of irrigation water rights in Case No. 82CW202A, related cases, and Rist & Goss Transfers.
3. Transfer in Case No. 02CW392 and future related cases.
4. Transfers of Ditch and reservoir rights not included in 82CW202A and 02CW392.
5. Exchange of reusable effluent and water from terminal storage (when simulated).

Currently, the Yield Model diverts 202A water before 392 water. This may not be the way the water rights are operated in the future, and the Yield Model may need to be modified to divert in ditch order rather than decree order to better simulate actual operations. The order of use of the various transferred irrigation company shares

[28] Inflow and outflow rates to Great Western Reservoir are still under design and could be up to 40 cfs. For the 2020 Yield Analysis, the rates were conservatively modeled at 20 cfs.

relative to one another may be specified by the model user. However, the order of use in the above table maximizes use of the transferred irrigation water rights and provides a better basis for comparison of the yields from shares in the various irrigation companies. For the Base Run scenario (the model run used for comparison of other alternatives), the order of use of ditch company shares generally follows a junior to senior order.

7.7 Exchanges

The Yield Model simulates exchanges of reusable effluent discharged to the river at Loveland's WWTP and of reusable water release from downstream storage. In exchange for the reusable effluent or storage releases, water may be diverted at the Loveland Pipeline for direct flow uses or to storage in Green Ridge Glade Reservoir through the Dille Tunnel or Olympus Tunnel. The rate of exchange is limited by the available capacity of the diversion facilities and by the river exchange potential between the WWTP outfall or reservoir outlet and the upstream point of diversion.

The river exchange potential between the downstream point of discharge and the upstream point of diversion limits the amount of water that may be exchanged upstream. The exchange potential is defined by the minimum flow that exists in the river along the exchange reach. Exchange potential for the Loveland Yield Model was determined using a point flow model of the Big Thompson River. The Big Thompson River Point Flow Model ("Point Flow Model") was constructed using historical daily streamflow and diversion data. The Point Flow Model is simply an arithmetic determination of the flow that exists at various points along the river between known flows measured at streamflow gages. The flow at any point along the river is computed in the Point Flow Model as follows:

Flow at any point = Measured flow at the nearest upstream gage

+ Measured inflows or returns [(1)]

- Measured outflows or diversions [(1)]

+/- Unmeasured reach gains or losses [(1)]

<u>Notes:</u>

[(1)] between the upstream gage and the point of interest.

A schematic diagram illustrating the operation of the Point Flow Model is shown in **Figure 7-2**.

The unmeasured gains or losses between two streamflow gages are determined daily based on the difference between the flow at the downstream gage and the flow at the upstream gage plus and minus all the measured inflows and outflows between the two gages. Upstream of the Canyon Mouth gage, the unmeasured gains or losses were distributed proportionately based on the distance between various points. Downstream of the Canyon Mouth gage, the unmeasured gains or losses are primarily the result of irrigation return flows along the river, and therefore they were distributed along the river based on the relative width of the irrigated area lateral to the river. This procedure caused more of the unmeasured gains and losses to be shifted downstream.

The daily exchange potential along key reaches of the Big Thompson River was conservatively computed as the minimum flow from the Point Flow Model less 5 cfs. The resulting historical daily exchange potential estimates were input to the Loveland Yield Model and used as constraints on the simulated exchanges. A chart illustrating the operation of the Point Flow Model is provided in **Figure 7-3**. The chart shows the flows computed at various points along the Big Thompson River on July 4, 2002. The exchange potential (minimum flow minus 5 cfs) between the WWTP outfall and the Loveland Pipeline is shown by the pink line in the graph (84 cfs). The line extends from the WWTP outfall on the right to the Loveland Pipeline on the left. The exchange potential between the WWTP outfall and the Dille Tunnel is shown by the green line (33 cfs).

For illustration of the exchange conditions over the 1951 - 2015 study period, **Figure 7-4** shows average daily flows and exchange potential in a similar manner for the months of January and August. These months show some of the range in daily river flows and exchange potential that can exist over the year. Note that this summary of exchange potential is based on estimated flows from the Point Flow Model and does not consider the timing and location of local calls on the Big Thompson River. The existence of these calls, particularly reservoir calls in the non-irrigation season, may limit the number of days and river reaches for exchanges.

Table 7-1 summarizes the average simulated exchange potential in river reaches over which Loveland is likely to operate an exchange. The upper portion of the table shows the average daily cfs of exchange potential in each month. The lower portion of the table shows the average number of days that exchange potential existed during the 1951 - 2015 study period. Although the actual existence and amount of exchange potential will vary daily and may be limited by the existence of local calls, **Table 7-1** provides information on when the Point Flow Model indicates that exchanges could be performed. The months of May through July have the highest average exchange potential as well as the highest number of days.

7.8 Revisions to the Yield Model

A number of changes in the City's water supply portfolio and facilities between 2011 and 2020 necessitated revision to some of the assumptions and operations in the Yield Model. Some of the important Yield Model changes are listed below:

- Extension of the study period through 2015. The extended study period encompasses the September 2013 flood on the Big Thompson River which directly impacted the City of Loveland by limiting diversions at Loveland facilities due to infrastructure damage. The two years following the September 2013 flood where characterized by multiple extended periods of Free River which facilitated municipal diversions.
- Revision of the municipal water demand distribution based on 2005-2015 data.
- Incorporation of the WGFP at the 10,000 AF level.
- Increase in CBT units from 11,786 to 12,210.
- Addition of Loveland Gard Right to the water right portfolio and associated return flow obligations.
- Addition of future ditch shares currently deposited in Loveland's water bank.
- Adjustment to South Side Ditch diversions related to conveyance of a portion (0.75 cfs) of the O'Hara private contract right back to the ditch company.
- Addition of the ability to switch the order of use for CBT and Windy Gap water supplies.

Changes in the Base Run conditions are summarized on **Table 7-2** for several important parameters.

7.9 Yield Model Operation and Use

The Loveland Yield Model is a multi-tabbed Microsoft Excel spreadsheet that simulates the daily raw water supply yield for the City over the period from 1951 - 2015. The Yield Model is operated by the user specifying various input parameters on two input data sheets and then recalculating the spreadsheet to compute the model results. The user-defined inputs include the following:

- Annual water demand: municipal, potable leases, augmentation, non-potable irrigation.
- WWTP return flow percent.

- Transferred irrigation company shares.
- Priority of irrigation company share use.
- CBT units.
- Windy Gap Project units.
- Upstream and downstream raw water storage capacity and starting contents.
- Loveland's WGFP storage capacity.
- Diversion facility capacities.

The user may also select from several alternate operational options on the second data sheet. A copy of the input data sheets from the Yield Model is shown in **Figures 7-5 and 7-6.**

The process of computing the firm yield of Loveland's raw water supply requires iterative runs of the Yield Model. After setting the various input parameters on the input data sheets, including the annual water demand, the spreadsheet is recalculated. Among the Yield Model outputs are summaries of the volume of any simulated water shortages. If a shortage occurs, then the annual municipal demand is reduced, and the Yield Model is rerun. If there is no shortage, then the demand is increased. The process of increasing or decreasing the annual water demand is repeated until the maximum annual demand that can be satisfied in every year of the study period is determined. This maximum annual demand defines the firm yield for the selected input parameters.

When non-potable irrigation or augmentation lease demands are simulated, the annual shortage is calculated separately for each of these demands in order to allow shortage in the irrigation demand for example, while still meeting the municipal demand with no shortage. For this analysis, all demands were required to be met in order to determine the firm yield. A total of 590 AF/y of augmentation and potable park irrigation demand was kept constant and only the municipal demand was increased or decreased. The total firm yield is computed as the maximum municipal demand that can be satisfied each year plus the 590 AF of augmentation demand. If the augmentation demand is not simulated or is allowed to be shorted, the municipal portion of the firm yield would be increased.

The Yield Model spreadsheet is linked to summary spreadsheets containing various graphs and tables that allow automatic summarizing, visualization, and comparison of model runs. Additional tables and graphs can be generated from manual entry of firm yield results into a results spreadsheet.

8.0 YIELD MODEL RESULTS

Numerous runs of the Loveland Water Supply Yield Model were made to evaluate the yield of Loveland's current water supply and the increase in yield that would result from adding various additional water sources or from operating the water supply system in different ways. All Yield Model runs included 590 AF/y of augmentation demand, assumed to be fully met each year, in addition to the municipal demand. Firm yield is defined as the maximum annual water demand that can be dependably supplied each year of the 1951 - 2015 study period. The results are reported as the total firm yield, including both the municipal and augmentation portions of the total simulated demand.

The analysis of the increase in firm annual yield that would result from acquisition of various water sources was performed by comparing the results of a “Base Run” of the Yield Model that simulates Loveland’s current water supplies against a “Test Run” that simulates Loveland’s current supplies plus an additional increment of a particular water source or a change in operation. Subtracting the Base Run firm yield from the Test Run firm yield provides an estimate of the change in firm yield resulting from the water source or operational scheme being evaluated. The following is a description of these model runs and results.

8.1 Base Run Results

8.1.1 Yield of Current Water Supplies

Loveland's current average annual simulated water supplies and the amounts available in the dry year of 2002 are shown in **Table 8-1**. The average annual available supply totals approximately 37,005 AF, while the availability of these sources in the 2002 dry year totals only 17,315 AF. These figures do not include diversions during free river periods, exchanges of reusable effluent or the regulating benefits of Green Ridge Glade Reservoir.

Loveland's firm yield, assuming current water sources and facilities without the WGFP in place, was determined from the Yield Model to be approximately 25,210 AF/y (24,620 AF municipal and 590 AF augmentation). When the WGFP is constructed[29], Loveland’s current participation level of 10,000 AF of storage will increase the firm yield to 29,080 AF (28,490 AF municipal and 590 AF augmentation). When both the WGFP and Great Western Reservoir[30] storage are operational ("Base Run") the firm yield to 30,890 AF

[29] The WGFP is assumed to be online in 2025 based on information from Loveland staff.
[30] Great Western Reservoir is assumed to be online in 2031 based on information from Loveland staff.

(30,300 AF municipal and 590 AF augmentation). This is the simulated annual demand that can be reliably delivered in each year of the 1951 - 2015 study period. The firm yield is greater than the 2002 dry-year yield of Loveland's direct flow sources shown in **Table 8-1** as a result of carryover storage in Green Ridge Glade Reservoir and Chimney Hollow Reservoir, and exchanges of reusable effluent and downstream storage at Great Western Reservoir. A comparison of the firm yield to the past and projected future water demands is provided in **Figure 4-1**. This figure shows that the current water supply would be adequate to meet City's water demands during the drought year, at the 1.5% growth rate, without water use restrictions through 2056. If the WGFP and Great Western Reservoir are constructed, assuming future drought yields are no worse than during the 1951 - 2015 period, the City could meet the water demand at the 2.0% growth rate until 2057. **Table 8-2** summarizes the relative contributions of the City's water sources to the modeled total Base Run firm yield on an average basis and during the dry year of 2002.

A chart illustrating the annual amounts of Loveland's various water sources simulated to meet the Base Run firm yield demand is provided in **Figure 8-1**. This chart shows that the amount of transferred irrigation water rights used to meet the City's demand varies from year to year depending largely on the yield of the in-basin water supplies. In drought years, when the in-basin yields are low, there are greater uses of transmountain supplies and releases from Green Ridge Glade Reservoir to meet the City's demand.

The simulated contents of Green Ridge Glade Reservoir, Loveland's Chimney Hollow Reservoir account, and Great Western Reservoir are shown in **Figure 8-2**. Releases from the Chimney Hollow Reservoir account to Green Ridge Glade Reservoir are simulated as needed to try and maintain the latter reservoir at least half full. Both reservoirs are simulated to empty in the spring of 2005, and this is the constraint that establishes the firm yield of Loveland's water supply system. The drought of the late 1970s was another period in which there was a substantial draw on the reservoir contents in the Base Run. The drawdown seen in early 2014 is the result of Post-2013 Big Thompson flood operations.

The study period contains several droughts. Charts illustrating the daily simulated water supply during the drought years of the mid-1950s, late-1970s and early 2000s are included in **Appendix C**. These charts show how the daily municipal water demands at the Base Run firm yield level are met with Loveland's various water supply sources. The top of the colored area in the charts corresponds to the daily simulated municipal water demands that vary from about 25 cfs during the winter to more than 80 cfs during the peak summer demand period. The different colors correspond to the various water sources simulated to meet the daily water demands. Superimposed on each chart are lines showing the current capacity of the WTP (read on the left axis), and the contents of

Green Ridge Glade Reservoir, the contents of Great Western Reservoir, and Loveland's account in Chimney Hollow Reservoir (read on the right axis).

The daily supply charts show that the Loveland Pipeline Rights (a.k.a. Early Transfers and domestic rights) provide relatively continuous year-round base supply. During the winter season of most years, CBT Project yield provides the balance of the winter supply. During the irrigation season, the transferred irrigation water rights typically provide the majority of the water supply. In low water supply years, the irrigation supply is supplemented by CBT Project deliveries and releases from Green Ridge Glade Reservoir. When necessary, reservoir releases are simulated to meet any remaining unmet demand, typically in the latter portions of the irrigation season after the City has exhausted its annual CBT quota.

8.1.2 Base Run Generation of Reusable Return Flows

Reusable return flows from use of legally reusable water supplies reusable are simulated as releases from the WTP decant ponds, discharges of treated effluent at the WWTP, and as LIRFs (when simulated). Reusable decant pond releases and treated effluent discharges are simulated to meet return flow obligations, augmentation demands, and exchanged for diversions at the Loveland Pipeline and Green Ridge Glade Reservoir. An average of 175 AF/y of reusable decant pond releases and 3,065 AF/y of reusable treated effluent discharges are produced in the Base Run, mostly in the spring and fall months when free river diversions and releases of stored water are available. Reusable effluent is low in July when a large portion of the supply is from non-reusable 202A sources. On average, the simulated annual use of reusable return flows is comprised of 1,120 AF exchanged to the Loveland Pipeline, 50 AF exchanged to Green Ridge Glade Reservoir, 20 AF to pay winter return flow obligations, 235 AF to satisfy augmentation leases, and 540 AF stored in Great Western Reservoir. Excess unused reusable return flows average 1,275 AF/y in the Base Run. Excess unused reusable return flows occur during periods of free river call conditions, when reservoir storage is full, and/or there is no exchange potential on the Big Thompson River. **Figure 8-3** is a chart summarizing the simulated production and use of the reusable WWTP effluent discharges and decant pond releases in the Base Run.

Loveland is seeking to quantify its reusable LIRFs in a pending Water Court application. Because this quantification is uncertain, the reusable LIRFs were not simulated as a source in the Base Run. However, the reusable LIRFs may be simulated in alternative model runs to pay return flow obligations and to meet augmentation demands.

8.2 Changes in Firm Yield Due to Differences Between 2011 and 2020 Models

There were several modifications made to the Yield Model between 2011 and 2020 to reflect changes in Loveland's water supply portfolio and operating procedures, as described in Section 7.8. Some of the changes produced relatively small changes in firm yield, but others were more substantial and had a larger effect on use of the City's water supplies and the incremental firm yields of additional sources that were modeled in 2011. The table below summarizes the effect on the firm yield due to some of the major Yield Model changes. The table does not include the effect of every model change.

Yield Model Change	Effect on Firm Yield, AF
Add CBT Units (from 11,786 to 12,210)	290
WG Firming Project Participation (from 7,000 AF to 10,000 AF)	990
Add Great Western Reservoir (1,300 AF[31])	1,810

The additional simulated water supplies from municipal rights, ditch shares, CBT units, participation in the Windy Gap Firming Project, and Great Western Reservoir in the 2020 Yield Model Base Run resulted in a significant increase in Loveland's firm yield (30,890 AF/y in 2020 compared to 27,390 AF/y in 2011). The major change to the Yield Model was the addition of the 1,300 AF Great Western Reservoir to the Base Run. The downstream reservoir allows Loveland to store reusable return flows and exchange that water upstream when exchange potential exists, which increases the simulated firm yield.

Table 8-3 shows the differences in the use of the City's water supplies in the 2011 and 2020 Base Runs.

8.3 Increased Yield from Windy Gap Firming Project

Participation by Loveland in the WGFP by funding a portion of the construction and operation of the proposed Chimney Hollow Reservoir will increase the City's firm yield. The increased firm yield will vary with the level of Loveland's participation in the project, which is currently at a level of 10,000 AF of storage space. The WGFP increases the firm yield of Loveland's water supply by helping to maintain storage levels in Green Ridge Glade Reservoir and by providing a drought water supply to supplement the limited yield from the City's other water sources. Use of the WGFP as a drought supply in this manner

[31] 1,300 AF was modeled as the preliminary operational storage capacity of Great Western Reservoir.

will require filling Loveland's account in the proposed Chimney Hollow Reservoir through the irregular yield available from the Windy Gap facilities on the West Slope and then drawing on the water stored in Chimney Hollow Reservoir in dry years.

Because the WGFP has not yet been constructed, it is conceivable that the City could change its participation from the current 10,000 AF level. The increase in Loveland's firm water supply yield was estimated at various assumed levels of project participation ranging from 0 AF to 20,000 AF of Chimney Hollow Reservoir capacity. In general, there is some benefit from additional project participation above the current level of 10,000 AF. The results of these model runs are shown in **Table 8-4** and in the chart in **Figure 8-4**.

The simulated Windy Gap supply available in the years subsequent to the drought year 2002 becomes the limiting factor in the firm yield provided by the WGFP. This is illustrated in the reservoir storage hydrograph for the 10,000 AF participation level run provided in **Figure 8-2**. In the years leading up to 2002 the reservoir fills to capacity. The limitation on the Windy Gap supply during the dry years immediately following 2002 is the lack of flows in priority on the West Slope.

Without Chimney Hollow Reservoir or other East Slope storage, the Windy Gap Project is generally considered to have no firm yield. This is due to the absence of yield from the project in very dry years when the Windy Gap water rights have no yield, and the lack of yield in very wet years when there is no excess capacity in Granby Reservoir to store pumped Windy Gap water. However, the Windy Gap Project does add firm yield to the Loveland water supply as a result of the City's other water resources. First, Green Ridge Glade Reservoir provides a place to store excess Windy Gap yield in average water supply years for carryover and use in subsequent dry years. In addition, the availability of Windy Gap supply in average years can also allow Loveland to save some of its CBT Project yield for carryover to subsequent dry years (up to the 0.2 AF per unit carryover limit).

Two runs of the Yield Model were made to estimate the amount of Loveland's current firm yield that is derived from the City's current Windy Gap supply without the proposed Chimney Hollow Reservoir. This was accomplished by first recomputing the City's firm yield without the WGFP, and then by another run setting Loveland's Windy Gap supply to zero and then recomputing the City's firm yield. The difference in firm yield with and without the City's Windy Gap supply is estimated at approximately 870 AF, and this is the estimated amount of firm yield provided by the City's current Windy Gap supply without the WGFP in place. The following table is a summary of current and potential firm yield provided by Loveland's Windy Gap supply.

Summary of Firm Yield
from Loveland's Windy Gap Supply

Description	Incremental Additional Firm Yield (AF/y)
Without WGFP	870
With WGFP (10,000 AF participation)	3,890
Total Firm Yield to Loveland from Windy Gap	4,760

8.4 Shortages at Greater Demands

Alternative Yield Model runs were made to estimate the amount and frequency of water shortages that would exist at simulated annual water demands in excess of the estimated firm yield of the City's current supplies. As the municipal demand is increased above the 30,300 AF/y Base Run level, shortages in the augmentation demands begin to occur, first in 2004 and then in other years. The following is a summary of magnitude of the shortages and the number of years of shortages in the 65-year study period at increased demand levels.

Volume and Frequency of Water Shortages
at Increased Annual Municipal Water Demand
In Excess of the Firm Yield of Loveland's Current Water Supply

Annual Municipal Demand (AF/y) [1]	Maximum Annual Municipal Shortage (AF)	Number Years of Municipal Shortage	Maximum Annual Augmentation Shortage (AF)	Number Years of Augmentation Shortage
30,300	0	0	0	0
30,500	47	1	5	2
31,000	782	2	8	3
32,000	2,902	6	14	6
33,000	6,211	14	17	14
34,000	7,065	22	17	20
35,000	9,168	26	10	25

Notes:
1 The annual total demand is equal to the sum of the municipal demand and the augmentation demand of 590 AF/y. The Base Run annual total demand shown on the first line of the table is 30,890 AF/y which is the municipal demand (30,300 AF/y) + augmentation demand (590 AF/y).

A chart illustrating the results of the increased demand runs is shown in **Figure 8-5**. These results show the amount and frequency of municipal demand shortages that occurred at greater demand levels during the simulated 1951 - 2015 period. The results can be used to assess the approximate increase in water supply that could be delivered in most years, provided that the City could reduce its demand in dry years (e.g., through water use restrictions). For example, the results show that Loveland could satisfy an annual demand of 32,000 AF/y in 59 years of the 65-year study period. Demand reduction would be required in the other 6 years, with a maximum required annual reduction of approximately 2,900 AF (9%). Although it can be effective, relying on water conservation to meet future water demands can reduce the City's ability to withstand droughts that are more severe than a 100-year drought. The City has chosen to plan to meet all demands during the 100-year drought without watering restrictions.

8.5 Effect of Competing Senior Conditional Exchanges

Loveland's exchanges from its WWTP outfall to various upstream points of diversion compete for the available exchange potential with exchanges by other Big Thompson water users. Many of the exchanges exercised by other Big Thompson River water users have operated for long periods, and their operation is already reflected in the historical streamflow and diversion records utilized in the Point Flow Model and the Yield Model. These are largely agricultural exchanges involving releases from storage in exchange for upstream diversions. Among the Big Thompson River water users with decreed agricultural exchanges are the Handy Ditch, Home Supply, South Side and the GLIC.

In addition to the exchanges that have operated historically there are several conditional exchanges for municipal purposes, including exchanges claimed by the Cities of Greeley[32] and Evans[33], that are senior to all or portions of Loveland's exchanges ("Competing Exchanges"). As the use of any Competing Exchanges are increased in frequency and amount, they may reduce Loveland's exchanges to amounts less than what are simulated in the historical 1951 - 2015 period.

The potential effect on Loveland's firm yield resulting from increased operation of Competing Exchanges was analyzed using the Yield Model. Model runs were made to assess the impact of Competing Exchanges over two different reaches of the Big Thompson River. The first category of runs assessed the potential impact of Competing Exchanges operated on the lower reach of the Big Thompson River from at or near the confluence with the South Platte River upstream to the Barnes Ditch and Loveland and

[32] In Case No. 99CW325, the City of Greeley agreed to limit the operation of their exchanges decreed in Case Nos. 87CW329, 95CW042, and 99CW325 to 30 cfs.
[33] In Case No. 98CW958, the City of Evans agreed to limit the operation of their exchange to 16 cfs.

Greeley Canal. This is the reach over which the Cities of Greeley and Evans operate their exchanges ("Lower River Exchanges"). The second category runs were made to estimate the impact of Competing Exchanges over the reach from the Loveland WWTP outfall to the Loveland Pipeline ("Middle River Exchanges"). The modeled increased Competing Exchanges were assumed to operate continuously during the irrigation season limited only by the river exchange potential. If the Competing Exchanges are operated for only part of the irrigation season in the future rather than continuously, the effect on the City's exchanges would be less than simulated.

The results of the impact of increased operation of Competing Exchanges on Loveland's firm yield are shown in **Figure 8-6** for exchange rates up to 50 cfs. The results show that the competing Lower River Exchanges would have less impact on Loveland's firm yield than would the competing Middle River Exchanges. For example, at an assumed additional Competing Exchange rate of 50 cfs, the Lower River Exchanges would reduce Loveland's firm yield by approximately 3,760 AF/y while Middle River Exchanges at the same rate would reduce the firm yield by approximately 6,330 AF/y. The reason for the difference in impact is that the exchange potential on the lower reaches of the Big Thompson River is typically less than on the middle reaches and the City has fewer existing facilities located in this reach. Exchanges in the lower reach do not contribute as much to the firm yield as exchanges in the middle river, where more of the City facilities are located. Competing Exchanges in the middle reach can affect more of the City's opportunities for exchange. While there are no known significant conditional exchanges on the middle river reach, the sensitivity of the results to increased middle river exchanges suggests that Loveland should be vigilant in protecting flow conditions upstream of the WWTP (e.g., through opposition to change water right applications, etc.).

8.6 Effect of CBT Project Supply on Exchange Yields

The exchange potential on the Big Thompson River has been enhanced by the operation of the CBT Project. Project deliveries to downstream users have increased the flow of the Big Thompson River, thus providing more opportunities for river exchanges. However, the historical operation of the CBT Project may not be representative of future conditions due to the changing character of ownership of the CBT Project from agricultural to municipal and industrial. As the CBT Project ownership changes there will likely be less transmountain water delivered down the Big Thompson River, and this will reduce the available exchange potential. A chart showing the historical deliveries of CBT Project water to Big Thompson River water users is shown in **Figure 8-7**. The chart shows there has been a general decline in CBT Project deliveries since the mid-1980s.

The Yield Model was used to estimate the potential effect of reduced agricultural CBT deliveries on Loveland's firm yield. Alternative runs were made for various levels of reduced deliveries of CBT Project. These runs included (a) reducing historical deliveries over the entire study period to approximate current levels, (b) further reductions to approximately one-half the current level and (c) no deliveries of CBT Project water. Reduced deliveries were subtracted from the historical diversions of the Big Thompson River ditches and the records of the Big Thompson River flow gages in the Point Flow Model resulting in lower simulated Big Thompson River exchange potential.

The results of the Yield Model runs for reduced agricultural CBT deliveries are shown in **Figure 8-8**. Reductions in historical CBT deliveries to current 5-year average levels have resulted in an estimated loss of 590 AF/y in the Base Run. However, further reduction of CBT deliveries to one-half the current 5-year average level would result in an estimated loss of 1,500 AF/y of firm yield while curtailment of all CBT deliveries down the Big Thompson River would reduce the firm yield by approximately 2,480 AF/y. These results may understate the actual impacts to Loveland's firm yield as the reductions in irrigation return flows that would result from reduced CBT Project deliveries were not evaluated.

8.7 Future Water Supply Variability

New to the Loveland Yield Analysis in 2020 is an analysis of the impact of future supply reductions to the City's firm yield. Several entities have undertaken examinations of future water supply impacts in northern Colorado due to climate variability. Those entities are the United States Bureau of Reclamation ("USBR"), the Water Research Foundation, and Western Water Assessment.

8.7.1 Climate Change and Future Water Supply Research

8.7.1.1 Western Water Assessment Report

In 2008, The Western Water Assessment ("WWA") prepared a report titled <u>Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation</u> for the Colorado Water Conservation Board. This report included several projections on future water supplies in Colorado including:

- Declines in snowpack with more declines at lower elevations
- Runoff shifting earlier in the season
- Reduction in Colorado River basin runoff ranging from 6% to 20%

- Increase in temperature leading to increased evapotranspiration ("ET") and higher water demands
- Increase in drought severity

The WWA report also identified key unresolved issues associated with climate implications on Colorado's water resources as follows:

> *"The current state of the science is unable to provide sufficient information to decision makers and stakeholders on a number of crucial scientific issues regarding Colorado's water resources. Often, there are insufficient data, in time or space, to assess long-term observational trends. In other cases, research is in progress, but the results may not be as robust as needed. Four overlapping areas with unresolved issues are climate models, research specific to Colorado, drought, and reconciling hydrologic projections."*

8.7.2 United States Bureau of Reclamation Report

In 2012, the USBR prepared the Colorado River Basin Water Supply and Demand Study Technical Report B – Water Supply Assessment. In this report, the USBR evaluated four climate scenarios:

- Observed Record Trends and Variability (Observed Resampled): Future hydrologic trends and variability are similar to the past approximately 100 years.
- Paleo Record Trends and Variability (Paleo Resampled): Future hydrologic trends and variability are represented by reconstructions of streamflow for a much longer period in the past (nearly 1,250 years) that show expanded variability.
- Observed Record Trends and Increased Variability (Paleo Conditioned): Future hydrologic trends and variability are represented by a blend of the wet-dry conditions of the longer paleo reconstructed period (nearly 1,250 years), but magnitudes are more similar to the observed period (about 100 years).
- Downscaled General Circulation Model ("GCM") Projected Trends and Variability (Downscaled GCM Projected): Future climate will continue to warm with regional precipitation and temperature trends represented through an ensemble of future Downscaled GCM Projections and simulated hydrology. The downscaled GCM model is a basin-wide model which incorporates 112 climate predictions and runs using a 30-year timestep.

The USBR report projects Upper Colorado River basin precipitation will increase during November-March and decrease during April-June, with an overall increase. Increased temperatures are projected to increase ET during April-June, and runoff and cause snowmelt runoff to occur earlier.

Collectively, the four climate scenarios in the USBR report show a projected reduction of 2.0% to 8.7% in the mean flow of the Colorado River at Lee's Ferry by 2060. The GCM scenario projects the average reduction in streamflow will reach 12.4% by 2095.

The USBR cautions that *"…climate projections are used to generate projections of future streamflow, contains a number of areas of uncertainty."* In particular, *"The GCMs were applied at relatively coarse scales (~150- to 200-km resolution) in relation to what is required for watershed assessments, and therefore are not likely to capture important regional phenomena."*

Future refinement of the USBR analyses was presented in two reports published in 2016: Technical Memorandum No. 86-68210-2016-01 West-Wide Climate Risk Assessments: Hydroclimate Projections and the SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2016. These reports echo the findings of the 2012 USBR report.

8.7.3 Water Research Foundation Report

Also, in 2012 the Water Research Foundation ("WRF") published a Joint Front Range Climate Change Vulnerability Study in collaboration with the following entities:

- City of Aurora
- City of Boulder
- City of Cheyenne
- City of Colorado Springs
- City of Fort Collins
- City of Longmont
- City of Westminster
- Colorado Water Conservation Board
- Denver Water
- National Center for Atmospheric Research
- Northern Colorado Water Conservancy District
- Principal Investigators
- Riverside Technology Inc
- Western Water Assessment

The objective of the WRF study was to analyze the sensitivity of streamflow to climate change for the headwaters of the Arkansas, Colorado, and South Platte Rivers and to develop projected streamflow scenarios that represent the effects of climate change.

Of the 112 climate projections available, the WRF analysis used five projections (hot and dry, hot and wet, warm and dry, warm and wet, and median) which were selected to represent the range of climate models. The five projections were repeated to evaluate 30-year periods surrounding 2040 and 2070. The WRF study also incorporated undepleted stream flows at 18 gage locations distributed within the three watersheds. The undepleted streamflows are the historical streamflow records adjusted to remove diversions, reservoir storage releases, and return flows.

The WRF study used two climate models, the Water Evaluation and Planning ("WEAP") model from Stockholm Environmental Institute and the Sacramento model from the National Weather Service River Forecast System, to simulate the impact of climate change on streamflow. They also used a two-stage approach to test the sensitivity of each model and gauge locations: a simple sensitivity analysis and a GCM-based sensitivity analysis.

- Simple Sensitivity Analysis – Tested the effect of uniform temperature increases (excluding precipitation changes) and uniform precipitation adjustment (excluding temperature changes) on each of the models and streamflow gauge locations.
- GCM-base Sensitivity Analysis – Test the effect of the five climate projections (which had temperatures and precipitation amounts that varied spatially over the study area and temporally over the study period) each of the models and streamflow gauge locations.

The following table presents the range of projected annual percent change in streamflow volumes for the Big Thompson River and the upper Colorado River across the two climate models and the five climate projections.

Projected Annual Percent Change in Streamflow Volumes
(% Change from Model Baseline)

Sacramento Model	*Big Thompson River at Canyon Mouth near Drake, CO*	*Colorado River near Granby, CO*
Simple Analysis	-21% to +17%	-24% to +16%
2040	-21% to +16%	-24% to +16%
2070	-17% to +17%	-19% to +11%
WEAP Model	*Big Thompson River at Canyon Mouth near Drake, CO*	*Colorado River near Granby, CO*
Simple Analysis	-16% to +18%	-22% to +8%
2040	-18% to +25%	-10% to +13%
2070	-20% to +19%	-15% to +10%

The key takeaways from this study for water providers include:

- Future streamflow may decrease as a result of increased ET due to increased temperatures and decreases in precipitation.
- Future streamflow may increase as a result of increased precipitation offsetting the impact of increased temperatures.
- Runoff is expected to occur earlier during the season.
- *"There is substantial variability in projected future streamflow based on the range of climate model projections that were used for streamflow simulation."*
- *"Spatial and temporal distribution of temperature and precipitation changes across multiple sub-basins and over the twelve-month period has considerable influence on hydrologic model results."*
- *"While increased temperatures are shown to reduce simulated average annual streamflow, the reductions are not uniform across the study area, with the driest basins, such as those in the South Platte, experiencing the greatest percent reduction in streamflow due to warmer conditions, while the wetter basins, including the upper areas of the Colorado, show a smaller percent reduction."*

- Water providers should monitor climate change indicators, encourage climate science research to aid in hydrologic assessments, and incorporate updated climate models in their planning processes.

8.7.4 Potential Colorado River Compact Call

The State of Colorado is a party to the Colorado River Compact, signed in 1922, which apportions the Colorado River streamflow between the Upper Basin and Lower Basin states. The Upper States (Colorado, New Mexico, Utah, and Wyoming) are obligated to provide 7.5 million AF of water, on a 10-year rolling average, to the Lower Basin states. Since 2000, an extended drought within the Colorado River basin and low storage in Lake Mead and Lake Powell have led to concerns that the Lower Basin states will place the first ever call for their portion of the compact streamflow. A Colorado River Compact call could result in curtailment of upstream water diversions in order to deliver water downstream. Curtailment would likely occur by priority, with post-compact water users curtailed first, unless the upstream water users develop a different curtailment scheme. The parties to the Colorado River Compact recently undertook collaborative efforts to manage water supplies through drought contingency plans with the hope of heading off a compact call. The drought contingency plans are still in the planning stages.

In March 2019, the Colorado Water Conservation Board voted to explore the feasibility of a demand management program to help assure compliance with the Colorado River Compact and to avoid a priority-based compact call. The CWCB and State of Colorado seek to avoid the implementation of additional water right priority administration to in order to fulfill the Upper Basin's compact obligation. As a step in that direction, CWCB has adopted a policy stating that a demand-management program would be a voluntary, temporary and compensated. Key components of this strategy are to share the water shortages among water users and to pay water users who volunteer to not divert their water.

The potential impacts of a Colorado River Compact call on Colorado water users are uncertain and the effects of a call on Loveland's CBT and Windy Gap water supplies cannot be presently quantified. Loveland should continue to monitor the developments on the Colorado River Compact compliance negotiations and drought contingency plans.

8.7.5 Reduced Water Supplies in Loveland Yield Analysis

Given the information presented in the foregoing studies and recognizing the current uncertainties in climate modeling, Loveland has chosen to take a conservative approach in the 2020 Yield Model update by focusing on potential reductions to the water supply.

Several alternative model runs were made with reductions in the yields of Loveland's water sources and Big Thompson River flows for exchange ranging from 5% to 20%, with the results shown in **Figure 8-9**. A 5% reduction in supply results in a projected decrease in firm yield of 1,160 AF while a 20% reduction in supply would cause a 3,760 AF reduction in firm yield. Additional analysis of future reductions in the CBT water supply can be found in Section 8.6. These results should be considered approximate as the potential future reductions in streamflow would not likely uniformly reduce the yield of Loveland's water sources. Assuming that water will continue to be administered in Colorado based on the prior appropriation doctrine, flow reductions will likely have a disproportionately greater impact on the yields of junior water rights rather than senior water rights.

8.8 Increased Firm Yield from Additional Sources

One of the purposes of the Loveland Yield Analysis was to estimate the increase in the City's firm yield resulting from the addition of various water supply sources, namely irrigation company shares, CBT Project units and Windy Gap Project units. In addition, estimates were made of the increase in firm yield resulting from increased upstream storage capacity (e.g., increased capacity in Green Ridge Glade Reservoir or construction of other upstream storage) and increased downstream storage (e.g., increased capacity in Great Western Reservoir or construction of other gravel pit reservoirs). Selected amounts of each of these water sources or storage capacities were added individually to the simulated Loveland water supply and the resulting increase in firm yield was estimated using the Yield Model. In order to make the results comparable among the various water sources, 500 AF/y of average annual yield of each source was added in each of the alternative model runs. A summary of the results of the incremental firm yield analysis is provided in **Table 8-5** and in **Figures 8-10, 8-11, and 8-12**. Descriptions of the model results for the various categories of water sources potentially available to the City follow.

8.8.1 Additional Direct Flow Irrigation Sources

Acquisition of additional shares in the various Big Thompson River irrigation companies would have varying benefit to Loveland's firm yield. In the 392 case, Loveland agreed to not transfer any more Barnes or Chubbuck inches except in certain limited circumstances; therefore, no acquisitions from these ditches were simulated. The increase in firm yield resulting from adding 500 AF/y of average annual yield in each irrigation company[34] is shown in **Table 8-5** and **Figure 8-10**, and ranges from 30 AF/y for George Rist (Buckingham) shares to 330 AF/y for GLIC shares with storage.

The increased firm yield tends to be greater for irrigation companies with more senior water rights and companies that have storage. The greater yield for the GLIC shares is due in large part to the company's carryover policy that allows excess storage yield to be carried over from one year to the next in a pro-rata share of the available storage capacity of Boyd Lake. The GLIC yield depends on the continued availability of sufficient exchange potential to exchange releases from Boyd Lake upstream to the Loveland points of diversion. Note that the results for Ryan Gulch Reservoir are for acquisition of the entire reservoir for municipal uses (the average annual yield of Ryan Gulch Reservoir is less than 500 AF/y).

The results of the incremental firm yield analyses depend on the particular hydrologic conditions and irrigation company operations during the recent drought. In the Base Run, the first year a shortage appears as demands are increased is 2005 ("critical year"). In order to assess the sensitivity of the analyses to the drought conditions, alternative model runs were made to estimate the incremental benefit to Loveland's water supply during other drought periods. One set of these alternative runs was made by increasing the simulated annual water demand until just before a shortage occurs in a second year (2004). This established an alternative baseline condition. Then, incremental yield runs were made for each source against the new baseline condition (i.e., adding 500 AF/y of average annual yield and then increasing the demand until just before a shortage occurs in 2004).

A second set of alternative runs was made by further increasing the annual demand to establish another baseline condition that includes failures in both 2004 and 2005, with 2003 becoming the critical year. Then, the incremental runs for each source were made as described above. The results of the original and alternative incremental yield runs are shown in **Figure 8-11**. The results show that the incremental firm yield added in the original and alternative runs is similar for most sources (e.g., the yields for George Rist (Buckingham) shares are less than 30 AF/y in each of the three critical periods, while the yields of the BTD&MC shares range from 170 - 180 AF/y).

In addition to the incremental yields from addition of direct flow irrigation sources, the City also requested a tabulation of the "portfolio yield" of ditch shares it currently owns. The portfolio yield is defined as the contribution of a particular ditch to the total firm

[34] For the George Rist (Buckingham) Ditch, it is not possible to achieve the full 500 AF/yr of incremental firm yield. The City currently owns 120.05 shares of the total 200 shares leaving 79.95 shares available for future acquisition by the City; the 79.95 shares are equivalent to approximately 461 AF/yr of average annual yield.

yield, divided by the total number of shares in the City's portfolio. **Table 8-6** summarizes the incremental yield of the ditch shares in the 2011 and 2020 Yield Models.

Differences in the incremental firm yield between the 2011 and 2020 Yield Models resulting from adding 500 AF/y of average annual yield in each irrigation company are due to many of the same factors that affect the overall yield described in Section 8.2. For example, the ditch shares have a variable yield based on historical diversions that may not be as well-matched to the revised demand pattern.

8.8.2 Additional CBT Units

Adding additional CBT units generally has more benefit to Loveland's firm yield than does adding shares in the various irrigation companies due to (a) the more dependable yield of the CBT Project, (b) the flexible timing of CBT deliveries, (c) the ability to carryover excess yield to the next year and (d) the upstream location that avoids having to exchange water for delivery to Loveland. When an additional 668 units (500 AF/y average yield) are added to Loveland's water supply, the simulated annual water demand throughout the study period can be increased by 590 AF/y above the demand in the Base Run before a shortage occurs as shown in **Figure 8-12**. Therefore, an incremental firm yield of 590 AF/y is attributed to the additional 668 units, or 0.88 AF/y per unit.

Table 8-7 shows the contribution of Loveland's water supplies to the increased firm yield from addition of CBT units from 2000 through 2006. The values in the table illustrate the effect of the reduced availability of excess supply at the overall higher firm yield level in the 2020 Yield Model.

The results of the CBT firm yield analysis have prompted questions about how the incremental firm yield can exceed the average annual yield (0.75 AF/unit) and maximum annual yield (1.00 AF/unit) available from the CBT Project. These questions can be answered by examination of (a) how yield from the additional CBT units is enhanced by the carryover storage available in the CBT facilities, (b) how the 2020 Yield Model differs from the 2011 version and (c) how use of the CBT units interacts with the City's other water supplies. These factors are explained below:

- Carryover Storage in CBT Project - CBT Project owners may carry over yield from one year to the next if there is space available in the project facilities. CBT carryover is limited to the lesser of 0.2 AF per unit owned or 90 percent of the amount of allocated supply remaining at the end of the year (October 31)[35]. Based on the City's ownership of 12,210 CBT units, Loveland's maximum CBT carryover

[35] CBT owners are assessed a 10% storage charge to carry over water to the next year.

is 2,442 AF. With the simulated addition of 668 CBT units, the maximum CBT carryover would increase to 2,576 AF.

- As noted above, in most years, Loveland has water supplies that are available in amounts greater than the City can use. As a result of these excess supplies available from Loveland's other water sources in most years, portions of the simulated additional CBT supply can increase Loveland's carryover in the CBT facilities, subject to the limitations described above. **Figures 8-13 and 8-14** contain bar graphs that illustrate the simulated available CBT supply that results from adding CBT units to provide 500 AF/y on average to Loveland's current water supplies for the 2011 and 2020 CBT Test Runs[36]. The information shown in **Figures 8-13 and 8-14** is expressed on a per-CBT-unit basis. The two bar graphs summarize the annual supply from the declared quota and from the simulated carryover of water in Loveland's CBT account. **Figure 8-13** shows that the annual available CBT supply, including simulated carryover, exceeds 1.0 AF/unit in three years of the study period for the 2020 Yield Model runs. **Figure 8-14** shows that in the 2011 Yield Model runs, the CBT quota plus simulated carryover exceeded 1.0 AF/unit in five years of the study period.

- <u>Differences Between 2011 and 2020 Models</u> - Because of the dynamic interaction of the water supplies in the model, changes in model assumptions and operations can affect the yield estimated for the various water supplies. As discussed in Section 8.2, the model changes and additional simulated water supplies in the City's current portfolio allow a higher level of demand to be met than in 2004 and 2011. The higher 2020 demand reduces the excess supply that can contribute to increased firm yield from incremental additions of other supplies. Additionally, the reusable water exchanged from Great Western Reservoir up to Green Ridge Glade reduces the available local storage space for CBT supplies. Another factor in the reduced CBT yield from the addition of CBT units compared to 2011 is that part of the total demand in the 2011 and 2020 Yield Models is the augmentation demand that must be met with reusable water supplies. CBT units are not reusable and are therefore not used for this purpose.

- <u>Interaction of CBT Units and Other Loveland Water Supplies</u> - Loveland utilizes its CBT supply to supplement the yield from its native Big Thompson direct flow water rights. In the Yield Model, the supplemental nature of the CBT supply is simulated by diverting it after all the native ditch and exchange supplies. Other supplemental supplies include Windy Gap Project deliveries and water stored in Green Ridge Glade Reservoir. The Windy Gap Project deliveries include the

[36] The study period in the 2011 Yield Model ended in October 2006 while the study period for the 2020 Yield Model ended in October 2015.

simulation of Loveland's current participation level of 10,000 AF in the planned WGFP. At the simulated firm yield demand of 30,890 AF/y in the 2020 Base Run, the Yield Model simulates use by the City of nearly all available yield from its native and transmountain water sources, use of all the water in Loveland's account in the WGFP reservoir (Chimney Hollow Reservoir, simulated as full entering 2001 and empty at the end of 2002), and use of all water stored in Green Ridge Glade Reservoir (the reservoir is simulated as full entering 2000 and is drawn down to empty in April 2005). **Figure 8-2** shows the daily contents of both Green Ridge Glade Reservoir and Chimney Hollow Reservoir in the 2020 Base Run. However, even in the critical period, there are some days when excess supply exists because the transferred ditch shares yield amounts greater than the simulated daily municipal demand and the available exchange potential.

When 668 CBT units are added to Loveland's water system, this allows the simulated annual water demand to be increased to a greater firm yield amount. In most years, this increased demand can be met in part by the excess supplies that the City has available during certain times of the year. As described above, the excess supplies are primarily transferred ditch shares and reusable exchanges that are simulated to be used before the CBT units in the Yield Model. **Figure 8-15** shows the simulated annual use of water from each source. The sum of all increased or decreased use of supplies in each year equals 590 AF of increased firm yield attributed to the simulated CBT units. Note that due to the interaction of the various water sources in the Yield Model, use of some sources declines in certain years as a result of simulating the additional CBT units. For example, in several years, releases from Green Ridge Glade Reservoir decline as a result of the additional CBT supply, and this is indicated by the yellow areas shown as negative on the chart. In other years, the increased use of CBT due to the addition of the 668 units reduces the amount of reusable water exchanged from the Loveland WWTP to the Loveland Pipeline, because the CBT units are not reusable. These types of supply interactions are typical of dynamic simulation models.

Table 8-8 shows the contribution of Loveland's water sources to the additional yield of 590 AF/y from the 668 CBT units during 2000-2006. In the modeled critical year of 2005, there is no CBT carryover available, and the CBT yield from the 668 additional simulated units is limited to the annual quota of 468 AF which are used on a direct flow basis. An additional 122 AF are able to be delivered from other direct flow and exchange sources resulting in the 590 AF/y of firm yield attributed to the 668 CBT units. Any further increases in demand result in Green Ridge Glade Reservoir emptying earlier in 2005, thereby causing a water shortage. The reservoir remains above empty during other years of the study period, and there is excess direct flow yield that cannot be exchanged to storage. This means that more than 590 AF of additional supply could be delivered in most other years.

8.8.3 Additional Windy Gap Units

The benefit to Loveland's firm annual yield from additional Windy Gap units varies depending on whether the WGFP is in place. Without the proposed Chimney Hollow Reservoir of the WGFP, additional Windy Gap units would not add any firm yield to Loveland's water supply. While Loveland's current Windy Gap units add some firm yield to Loveland's system as a result of enhancing Loveland's carryover supply going into the critical drought period, the addition of more Windy Gap units would not increase the carryover supply as it is already maximized by Loveland's current supplies.

On the other hand, additional Windy Gap units with the WGFP in place would increase Loveland's firm yield depending on the level of WGFP participation. At the current proposed 10,000 AF level of participation, the benefit of the WGFP to Loveland's firm yield is limited by the amount of storage space (recall that at the 10,000 AF participation level, Loveland's Chimney Hollow Reservoir storage space fully refills prior to entering the critical drought and additional units could not be stored). At lower WGFP participation levels (e.g., less than 10,000 AF), the benefit of additional Windy Gap units to Loveland's firm yield is less. At a higher participation level, Loveland's Chimney Hollow Reservoir storage space does not fully refill prior to entering the critical drought. Therefore, by adding more Windy Gap units, the carryover storage in Chimney Hollow Reservoir leading into the drought can be enhanced which in turn increases the potential firm yield to Loveland. A summary of the incremental firm yield from 500 AF/y of average annual Windy Gap yield is shown in **Figure 8-12** without the WGFP, and with the WGFP at assumed participation levels of 10,000 and 12,000 AF.

8.8.4 Additional Upstream Storage

The benefit of increasing Loveland's upstream storage capacity was simulated using the Yield Model by increasing the capacity of Green Ridge Glade Reservoir from its current 6,785 AF capacity. Storage capacity was added in varying amounts up to an additional 30,000 AF. The additional storage could be at Green Ridge Glade Reservoir or at other potential sites in the general vicinity. The availability of potential storage sites was not evaluated as part of the yield analysis.

The estimated benefits of additional upstream storage capacity to Loveland's firm yield are shown in **Figure 8-16**. By adding 10,000 AF of storage capacity, Loveland's estimated firm yield would increase by approximately 1,840 AF/y. As storage capacity is added, the incremental benefit to Loveland's firm yield declines. It should be noted that results shown in **Figure 8-16** are relevant for the City's current water supply sources. As the City acquires additional sources, the benefit of increased storage may increase.

In addition to analyzing the effects of increased storage by itself, the benefit of adding storage in combination with the various irrigation company water sources was also evaluated. This analysis supplements the analysis of the irrigation company shares that is described in Section 8.8.1 above. In this supplemental analysis, estimates were made of how much additional storage, in combination with the 500 AF/y of average annual yield from the ditch company shares, would be necessary to produce 500 AF/y of additional firm yield to Loveland. The amount of required additional storage is shown by the dots above the bars in **Figure 8-10** (read on the right axis).

For comparison purposes, the amount of additional storage alone that would provide 500 AF/y of additional firm yield is shown by the blue line near the top of **Figure 8-10** (1,750 AF). For sources that add little firm yield by themselves to Loveland's water supply (e.g., George Rist (Buckingham) shares), it is necessary to add almost the full amount of storage that it would take when adding storage alone to increase the firm yield by 500 AF/y. For other sources with better dry year yields, the required amount of additional storage is less. Note that when adding storage in combination with the irrigation company shares, the additional storage helps not only to firm the particular additional shares that are being simulated, but also helps to firm all of Loveland's existing unfirmed supply.

8.8.5 Additional Downstream Storage

Adding additional downstream gravel pit storage to Loveland's water system would increase the City's firm yield by providing a place to store more reusable effluent and other reusable water sources when the exchange potential is limited for later exchange when the river conditions improve.

The benefit of increasing Loveland's downstream storage capacity was simulated using the Yield Model by increasing the capacity of the Great Western Reservoir from its current 1,300 AF capacity. Storage capacity was added in varying amounts up to an additional 1,000 AF and increasing the fill and release rates. The additional storage could be at the Great Western Reservoir or at other potential sites in the general vicinity. The availability of potential storage sites was not evaluated as part of the yield analysis.

The increases in Loveland's firm yield resulting from various amounts of additional downstream storage are shown in **Figure 8-17**. The results indicate that the City's firm yield could be increased by adding additional downstream storage and that the increase is dependent on the fill / release rates selected. The exchange potential during the critical period becomes the limitation on how much additional firm yield can be added to the Loveland supply.

8.9 Operational Changes

When making the model runs described in the preceding sections, it was observed that the firm yield results could change substantially depending on how the various existing water sources were used, even without additional amounts of ditch shares or storage. For example, if the City's domestic rights could be operated year-round with a domestic priority that is senior to irrigation priorities, the firm yield would increase to 32,470 AF (31,880 AF municipal plus 590 AF augmentation). In contrast, operating the CBT water supply in a different order relative to Green Ridge Glade Reservoir could reduce the firm yield by up to 8,200 AF. **Table 8-9** summarizes the results of various Yield Model runs simulating changes in the City's operations or the assumptions about the water sources. The "All Max" run incorporates all the operational changes that increase the firm yield into a single model run.

9.0 Conclusions and Recommendations

The analysis of Loveland's raw water supply system described in this report indicates that the City's water supply should be adequate to withstand a 100-year drought during approximately the next two decades based on the two growth projections described in Section 4. Additional water supplies will be necessary to meet projected water demands in 2060 under both growth scenarios. However, the gap between the firm yield of the City's water supplies and the projected demand varies depending on the growth rate considered. The conclusions from the updated yield analysis are summarized as follows:

1. Drought Frequency - Analysis of 447 years of historical streamflow records and reconstructed streamflows from NOAA tree-ring analyses indicates that the 2002 drought in the Big Thompson and upper Colorado River basins has an estimated average composite recurrence interval of approximately 90 years. The one-in-90-year average frequency of occurrence of the combined normalized Big Thompson River and Colorado River flow in 2002 is close to the one-in-100-year frequency associated with the City's water supply planning policy. The 2002 combined normalized annual flow of 0.42 (42% of average) is only slightly greater than the normalized flow of 0.41 (41% of average) that corresponds to the one-in-100-year frequency of occurrence. Given the accuracy of streamflow measurements and the drought analysis methodology, this average frequency of occurrence generally corresponds with the City's planning policy that requires the City's water supply be able to withstand a 100-year drought. Therefore, it is concluded that analyses showing that the City's water supply can withstand the 2002 drought conform reasonably well to the City's planning policy.
2. Yield Model - The Loveland Water Supply Yield Model was developed to assess the adequacy of the City's raw water supply and to assess the potential benefits to the City from acquisition of additional water sources and development of additional storage. The Yield Model simulates daily water supply and demand over a study period from 1951 - 2015 using historical records of streamflows, diversions and transmountain water supplies. Modeled water supply yields to the City are generally determined based on a pro-rata share of historical yields for the simulated ownership of irrigation company shares, CBT Project units, etc. The simulated municipal water use is limited by available physical flow, capacities of diversion facilities, available raw water storage capacity, estimated river exchange potential and other factors. The Yield Model is intended to be a tool that can be used to assist the City in its current and future water supply planning efforts.

3. Firm Yield of Current Loveland Supply Without the WGFP - The Yield Model was used to estimate the firm yield of Loveland's current water supply without the WGFP in place. The firm yield is defined as the maximum annual demand that can be dependably supplied through the 1951 - 2015 simulated study period without shortage. The estimated firm yield of Loveland's current water supply is approximately 25,210 AF/y (24,620 AF municipal and 590 AF augmentation). The City's firm yield was increased by about 930 AF/y through the acquisition of 424 CBT units, the Loveland Gard Right, and additional ditch shares since the 2011 Yield Analysis update.
4. Increased Yield with the Windy Gap Firming Project - Loveland is one of several area municipalities participating in a project to increase the reliability of the Windy Gap Project supply. The cornerstone of the WGFP will be construction of an East Slope reservoir known as Chimney Hollow Reservoir to store the variable Windy Gap yield so that it can be delivered more reliably when needed. Loveland is currently participating at a level of 10,000 AF of storage capacity, which would increase the total firm yield to 29,080 AF/y (28,490 AF/y municipal and 590 AF/y augmentation). Since the project has not been constructed, model runs were made to evaluate the increase in firm yield that will result from different levels of participation ranging from 6,000 AF to 20,000 AF of Chimney Hollow Reservoir space. The results of the model runs are shown in **Figure 8-4** and indicate that participation at a 12,000 AF storage level would increase Loveland's firm yield by approximately 550 AF/y over the firm yield at the current participation level. Loveland's firm yield could be increased further under the WGFP through acquisition of more Windy Gap units.
5. Increased Yield with the Windy Gap Firming Project and Great Western Reservoir - The Yield Model was used to estimate the firm yield of Loveland's current water supply with the WGFP and 1,300 AF of raw water storage in the Great Western Reservoir that was recently acquired by Loveland downstream of the Loveland WWTP near the Hillsborough Ditch headgate. Loveland plans to use the Great Western Reservoir to store fully consumable water not needed to meet return obligations as well a water diverted under a new conditional storage right. Great Western Reservoir, after completion of improvements to the inlet and outlet facilities, will increase Loveland's total firm yield to 30,890 AF/y (30,300 AF/y municipal and 590 AF/y augmentation).
6. Reduction in Firm Yield from Increased Competing Senior Exchanges - The Yield Model is generally based on historical water supply operations on the Big Thompson River. It is likely that the historical river conditions will change with increased operation of municipal water exchanges, and this change may affect

the operation of Loveland's exchanges. The Cities of Greeley and Evans both operate exchanges that are mostly senior to Loveland's exchanges. The potential impact of increased Competing Exchanges was evaluated with the Yield Model and the results are shown in **Figure 8-6**. The results indicate that Competing Exchanges on the lower reach of the Big Thompson River, such as those by the Cities of Greeley and Evans, could reduce Loveland's firm yield by 3,760 AF/y from the Base Run based on an assumed exchange rate of 50 cfs and continuous operation of the exchange over the irrigation season. Exchanges at greater rates on the lower river, or more moderate Competing Exchanges on the middle reach of the river could have even greater impacts on Loveland's firm yield. The impact of increased Competing Exchanges would be less than shown on **Figure 8-6** if the exchanges were not operated continuously, leaving more opportunity for Loveland to operate its own exchange.

7. Reduction in Firm Yield from Decreased Agricultural CBT Project Deliveries - Another change in historical practices that may affect Loveland's exchanges is the ongoing reduction in the use of CBT Project water by agricultural users as the ownership of the CBT Project becomes increasingly municipal and industrial. Historical deliveries of CBT water to agricultural users have augmented the natural flow of the Big Thompson River and have enhanced the river exchange potential. The potential impact of further reductions in agricultural CBT Project deliveries and corresponding reductions to exchange potential was evaluated with the Yield Model. The results shown in **Figure 8-8** indicate that complete cessation of agricultural use of CBT water on the Big Thompson River and the resulting decreased exchange potential would reduce Loveland's firm yield by at least 2,480 AF/y from the Base Run. The actual impact from such a change is likely to be greater due to the coincident loss of irrigation return flows from use of CBT Project water. The effect of the reduced return flows was not evaluated.

8. Increased Firm Yield from Acquisition of Irrigation Company Shares - The Yield Model was used to evaluate the potential increase in Loveland's firm yield by the addition of shares of various Big Thompson River irrigation companies, including shares of selected companies in which Loveland has not previously transferred shares to municipal use. In order to facilitate comparison of the yields from shares in various companies, the increase in firm yield resulting from transfer of 500 AF/y of average annual historical yield in each company was evaluated. The results of the analysis, shown in **Table 8-5** and **Figure 8-10**, indicate that the estimated increase in Loveland's firm yield is typically much less than the average annual historical yield of these shares. The principal reasons for the low firm yield to average yield ratios are (a) the lower than average yields from most sources in dry years and (b) the necessity of the City providing year-around municipal water

deliveries with sources that only yield water during the irrigation season. In general, irrigation companies with senior water rights or significant storage provide more potential firm yield than those companies with more junior water rights and minimal storage. However, because Loveland could generally use storage releases only by exchange, the yield of ditch shares from companies that include storage could be affected by conditions that reduce exchange potential. The estimated yields for additional irrigation company shares acquired by the City are based solely on the modeling described herein and do not consider the uncertainty in the transferrable yield that is inherent in the process of changing irrigation water rights to municipal use.

9. Increased Firm Yield from Acquisition of CBT Units - Analyses of the potential benefit of additional transmountain water sources were made with the Yield Model. The results provided in **Table 8-5** and **Figure 8-12** show that acquisition of additional CBT units will substantially benefit Loveland's firm yield. The principal reasons for this are (a) CBT deliveries are generally available on demand, (b) additional yield comes essentially firmed with additional storage and (c) no exchange is necessary to utilize the supply. In addition, the source of CBT supply is from a different watershed that may not be affected by drought in the same degree or timing as the Big Thompson River basin supplies. This helps to diversify Loveland's water supply and provides additional drought reliability.

10. Increased Yield from Windy Gap Units - The benefit to Loveland of additional Windy Gap units depends on the extent of participation in the WGFP as shown in **Table 8-5** and **Figure 8-12**. Without the WGFP, additional Windy Gap units will add no firm yield to Loveland's water supply due to the absence of dry year yield from the project. However, additional Windy Gap units, in conjunction with participation in the WGFP, adds firm yield to Loveland's water supply depending on the level of participation. For example, at the current participation level of 10,000 AF, the increase in firm yield would be approximately 56 AF/y per additional Windy Gap unit, while participation at 12,000 AF of WGFP storage capacity would result in an increase in firm yield of 83 AF/y per unit. These results are pertinent to the next 500 AF/y of average annual Windy Gap yield added to the City's current number of Windy Gap units.

11. Increased Firm Yield from Additional Storage Capacity - The addition of more upstream water storage capacity would increase the City's firm yield based on results of the Yield Model runs shown in **Figure 8-16**. Additional storage capacity would allow the City to store more of its excess supplies during average and wet periods for use in dry years. If the City acquires more direct flow water sources, additional upstream storage could be more beneficial. As shown in **Figure 8-17**,

the City would also benefit from downstream storage in addition to the 1,300 AF in Great Western Reservoir, although the extent of this benefit depends on increasing the fill and release rates to take advantage of the exchange potential during critical periods.

12. Effect of Alternative Water Supply Operations - Even without acquisition of new water supplies or additional storage capacity, the firm yield of the City's water supplies can change with different modes of operation of its existing supplies and facilities. Some alternative operations are summarized in **Table 8-9**. Maximizing the yield of existing supplies may be an alternative to developing new supplies.

13. Water Supply Planning Recommendations - Based on the analyses of Loveland's raw water supply described herein, the following recommendations are offered regarding the City's water supply planning.

    a. The City should continue its policy of maintaining a water supply that can withstand a 100-year drought. Given that the 1951 - 2015 study period was found to generally comply with this policy, the City might consider refining the policy to specifically require planning to be based on a study period that includes the droughts of the 1970s and early 2000s. This would avoid the uncertainty that exists about how to define the 100-year drought.

    b. The reliability of the City's water supply will be enhanced by not depending on reduced water use as a planning strategy to withstand severe droughts. This would allow the City to keep the benefits of water use restrictions as a hedge against potential future droughts that are worse than the 100-year drought.

    c. The City should use the results described in this report and the Yield Model to develop and refine water acquisition strategies to meet its future water demands. These strategies may include alternative water supply operations, acquiring irrigation company shares, acquiring transmountain water supplies, development of additional storage, greater participation in the WGFP, development of non-potable water supply systems, and other measures.

    d. As the City acquires more water, the incremental firm yield from various water sources and the benefits of additional storage may change from the figures presented in this report as a result of the dynamic interrelationships among the City's water supply components. However, the Yield Model will continue to provide a basis to evaluate potential additions or changes to the City's water supply.

Figures

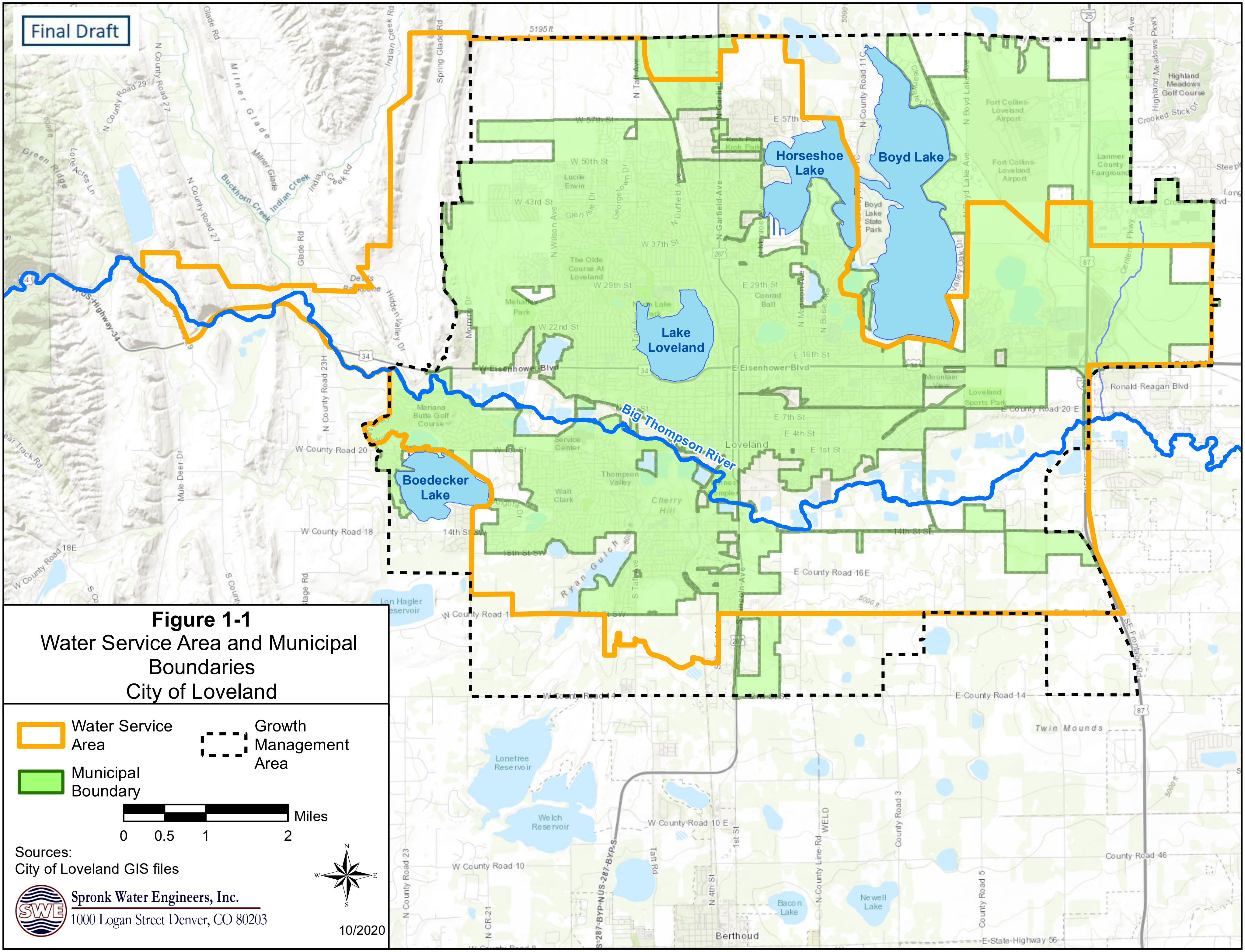


Figure 1-1
Water Service Area and Municipal Boundaries
City of Loveland

Final Draft

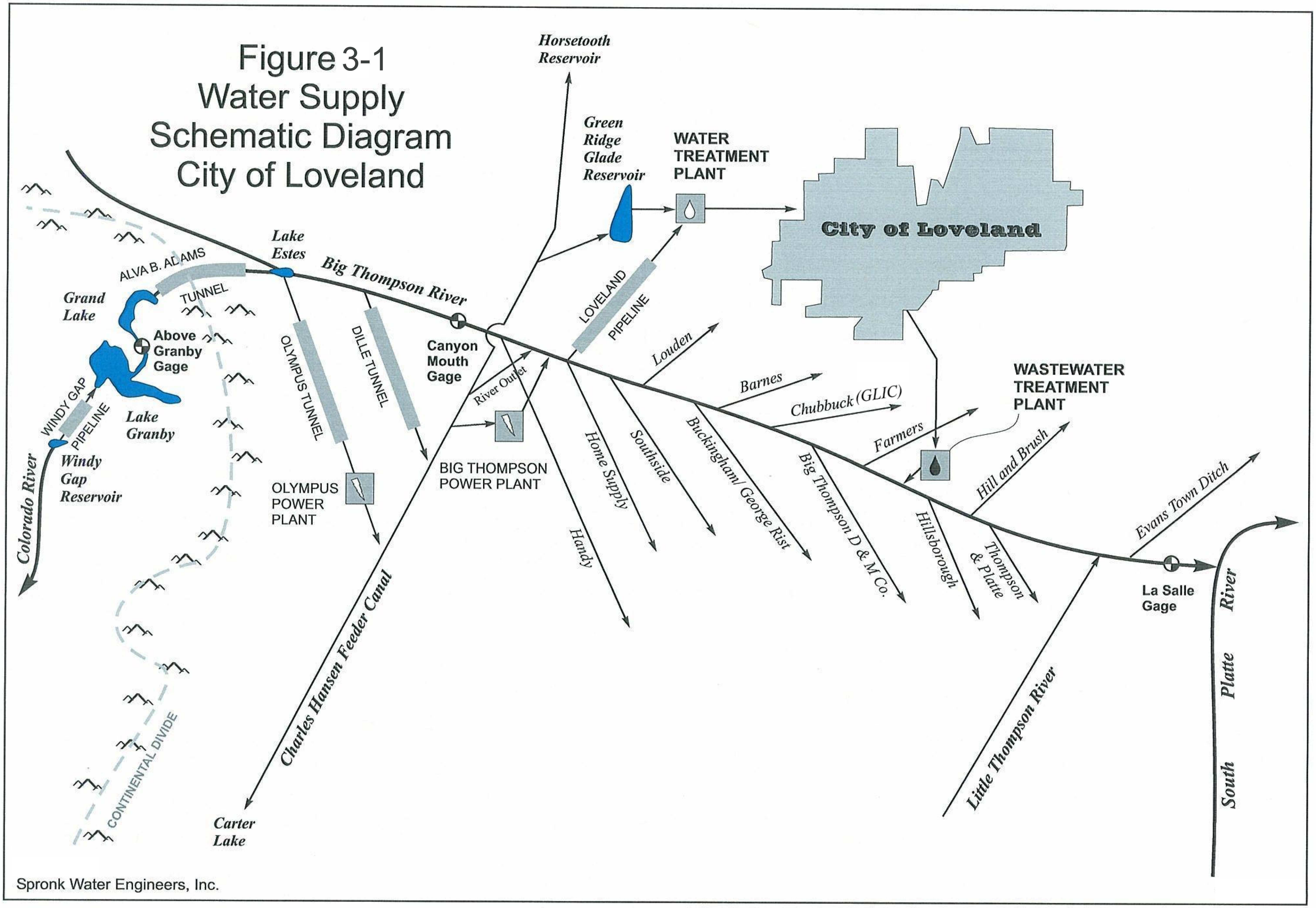
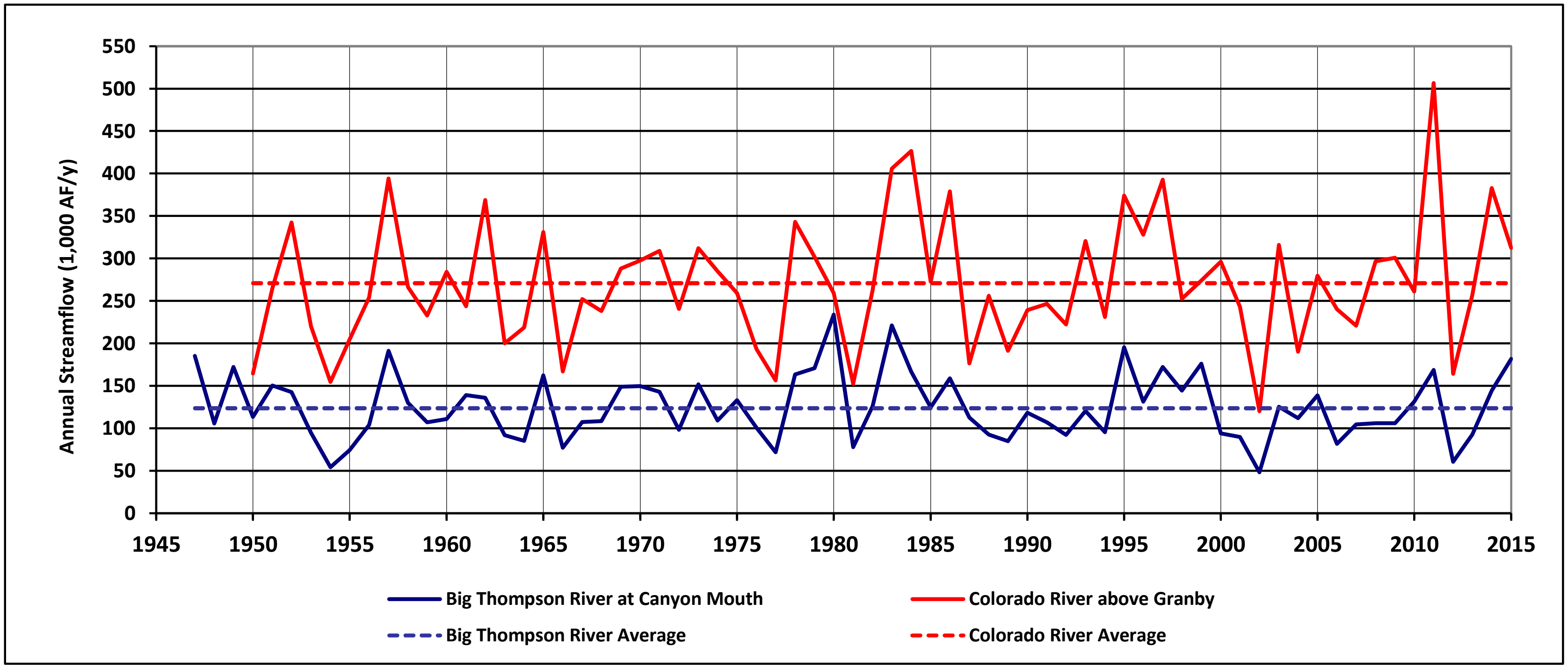


Figure 3-1
Water Supply
Schematic Diagram
City of Loveland
Horsetooth Reservoir
Green Ridge Glade Reservoir
WATER TREATMENT PLANT
City of Loveland
Lake Estes
Big Thompson River
ALVA B. ADAMS TUNNEL
Grand Lake
Above Granby Gage
Lake Granby
WINDY GAP PIPELINE
Windy Gap Reservoir
Colorado River
OLYMPUS TUNNEL
DILLE TUNNEL
Canyon Mouth Gage
LOVELAND PIPELINE
River Outlet
BIG THOMPSON POWER PLANT
OLYMPUS POWER PLANT
Louden
Barnes
Chubbuck (GLIC)
Farmers
WASTEWATER TREATMENT PLANT
Hill and Brush
Evans Town Ditch
Home Supply
Southside
Buckingham/ George Rist
Big Thompson D & M Co.
Hillsborough
Thompson & Platte
Handy
La Salle Gage
Charles Hansen Feeder Canal
Little Thompson River
South Platte River
CONTINENTAL DIVIDE
Carter Lake
Spronk Water Engineers, Inc.

Final Draft

Figure 3-2

Historical Annual Virgin Streamflow [1]
Big Thompson River at Canyon Mouth and
Colorado River above Granby
1947 - 2015
(1,000 acre-feet per year)



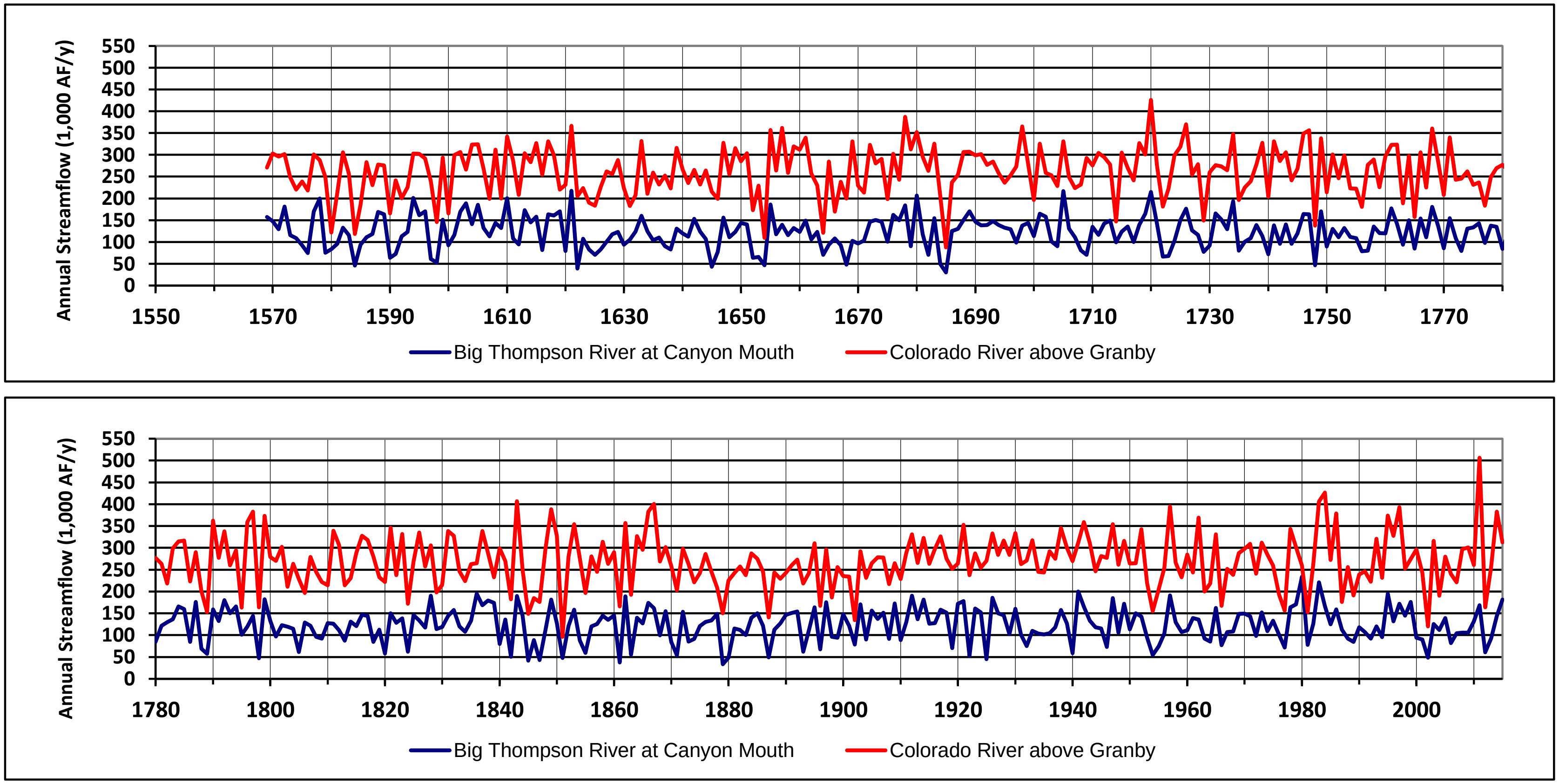
Note:

[1] Historical "virgin"(undepleted) flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2015) and the Colorado River above Granby (1950-2015).

Final Draft

Figure 3-3

Historical and Reconstructed Annual Virgin Streamflow [1]
Big Thompson River at Canyon Mouth and
Colorado River above Granby
1569 - 2015
(1,000 acre-feet per year)

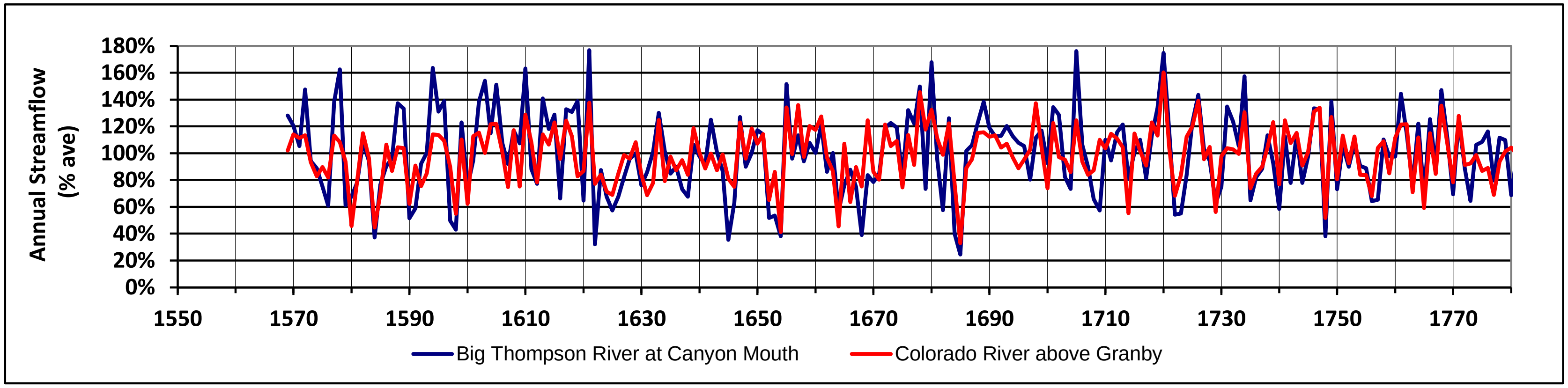


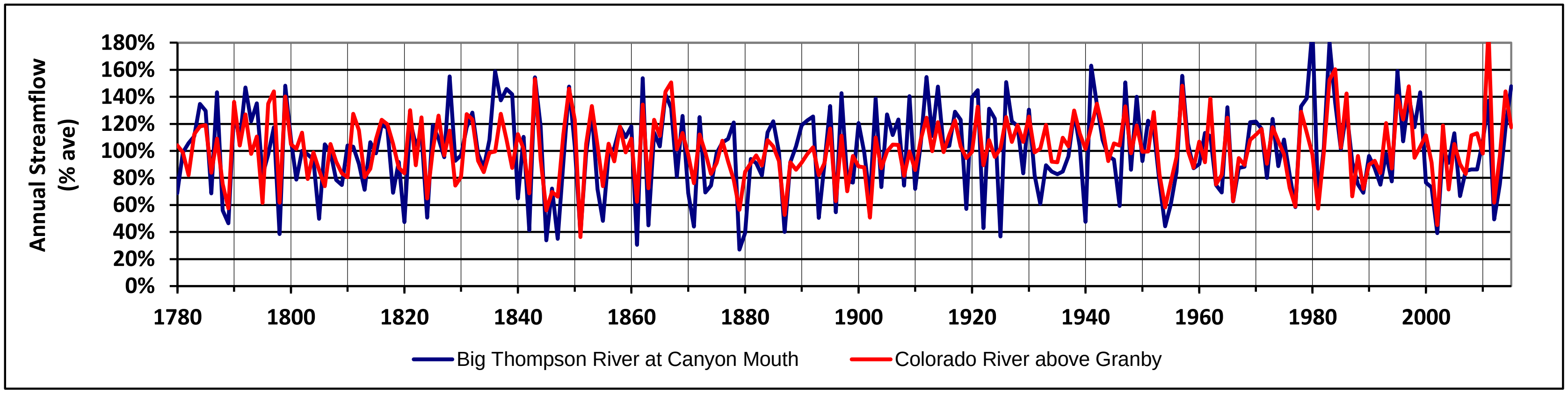
Notes:

[1] Historical "virgin" flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2015) and the Colorado River above Granby (1950-2015). Reconstructed "virgin" flows obtained from the World Data Center for Paleoclimatology, Boulder and the NOAA Paleoclimatology Program for the period prior to the historical data.

Figure 3-4

Normalized Historical and Reconstructed Annual Virgin Streamflow [(1)]
Big Thompson River at Canyon Mouth and
Colorado River above Granby
1569 - 2015
(% annual average flow)



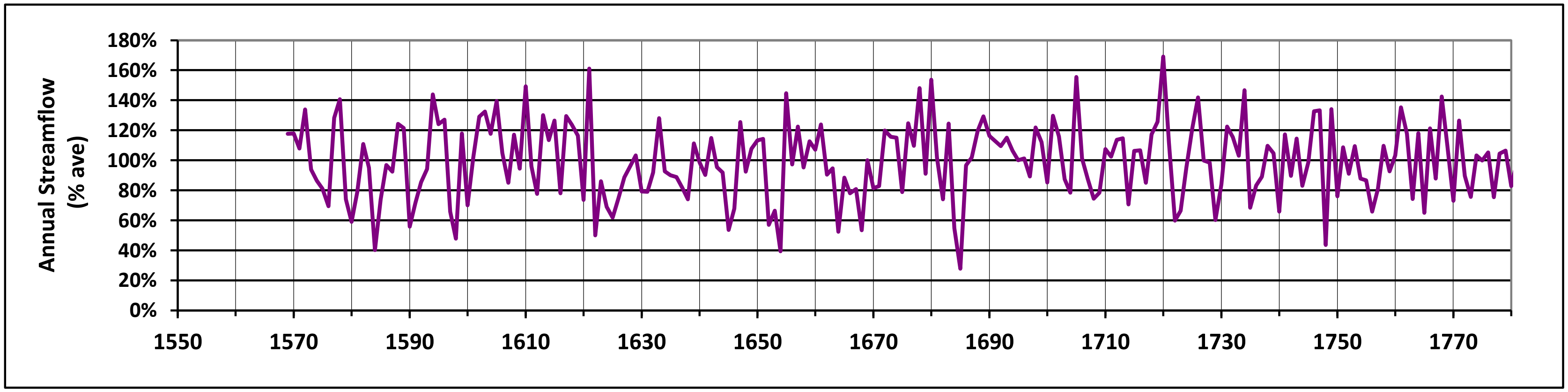


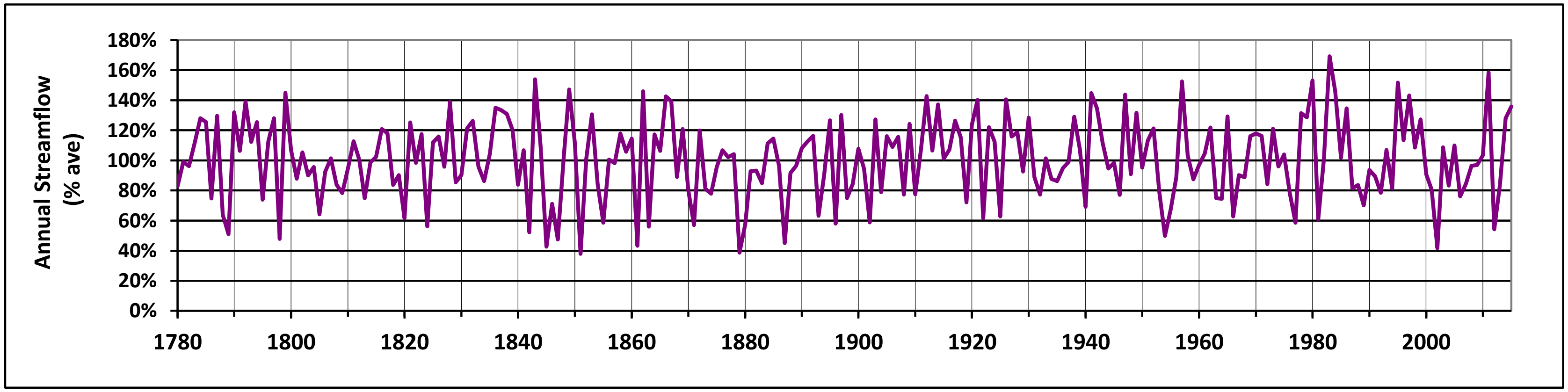
Notes:

(1) Normalized flows computed as annual flows divided by 1569 - 2015 average flow. Historical "virgin" flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2015) and the Colorado River above Granby (1950-2015). Reconstructed "virgin" flows obtained from the World Data Center for Paleoclimatology, Boulder and the NOAA Paleoclimatology Program for the period prior to the historical data.

Figure 3-5

Normalized Historical and Reconstructed Annual Virgin Streamflow [1]
Composite of Big Thompson River and Colorado River [2]
1569 - 2015
(% annual average flow)





Notes:

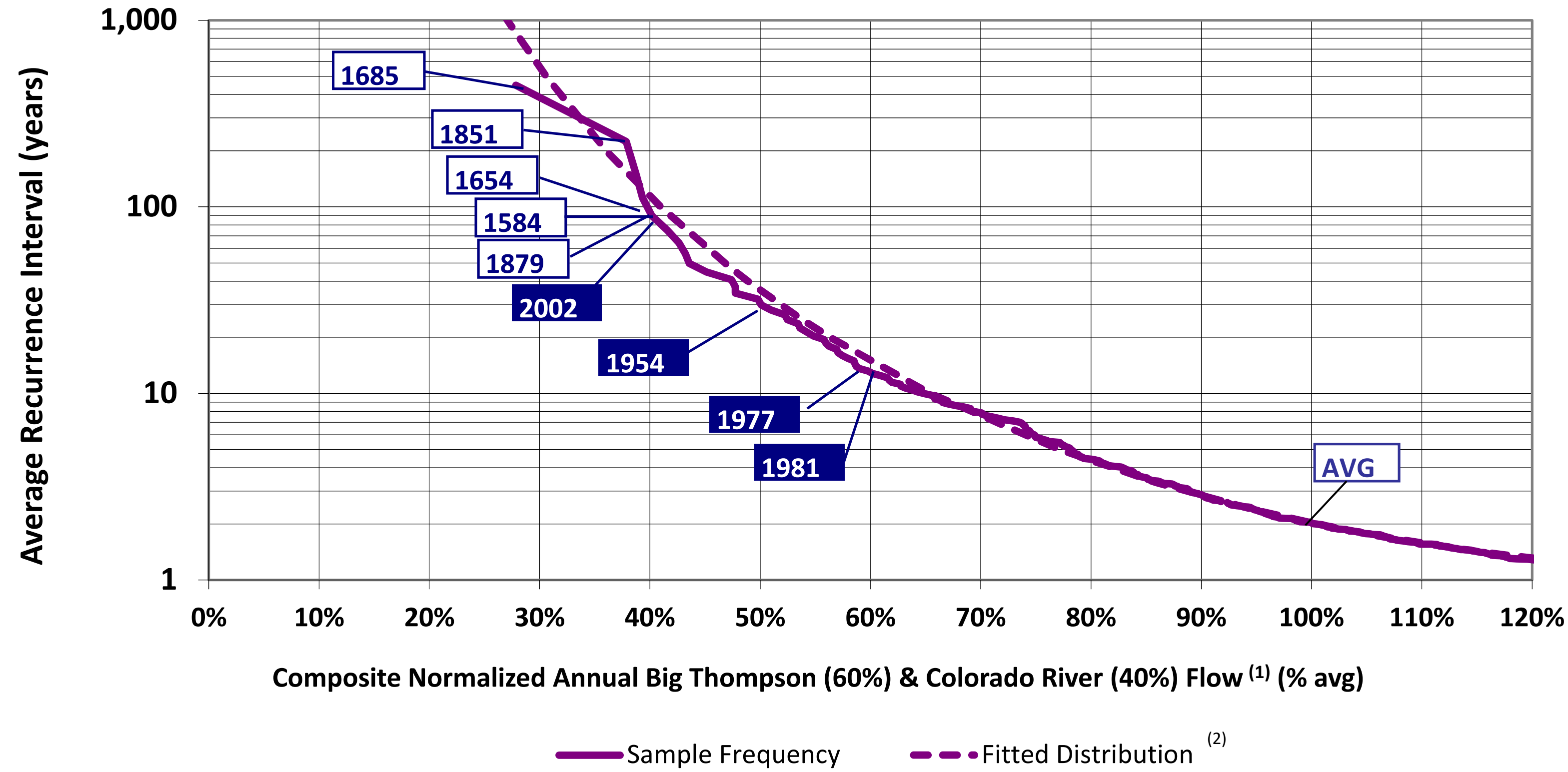
(1) Normalized flows computed as annual flows divided by 1569 - 2015 average flow. Historical "virgin" flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2015) and the Colorado River above Granby (1950-2015). Reconstructed "virgin" flows obtained from the World Data Center for Paleoclimatology, Boulder and the NOAA Paleoclimatology Program for the period prior to the historical data.

(2) Composite flows computed as 60% of the normalized Big Thompson River flow plus 40% of the Colorado River flow (approximate split of current Loveland water supply).

Final Draft

Figure 3-6

Frequency Distribution of Normalized Annual Virgin Flows
Composite of Big Thompson River at Canyon Mouth and Colorado River Flow above Granby [(1)]
from Historical and Reconstructed Data
(% annual average flow)



Notes:

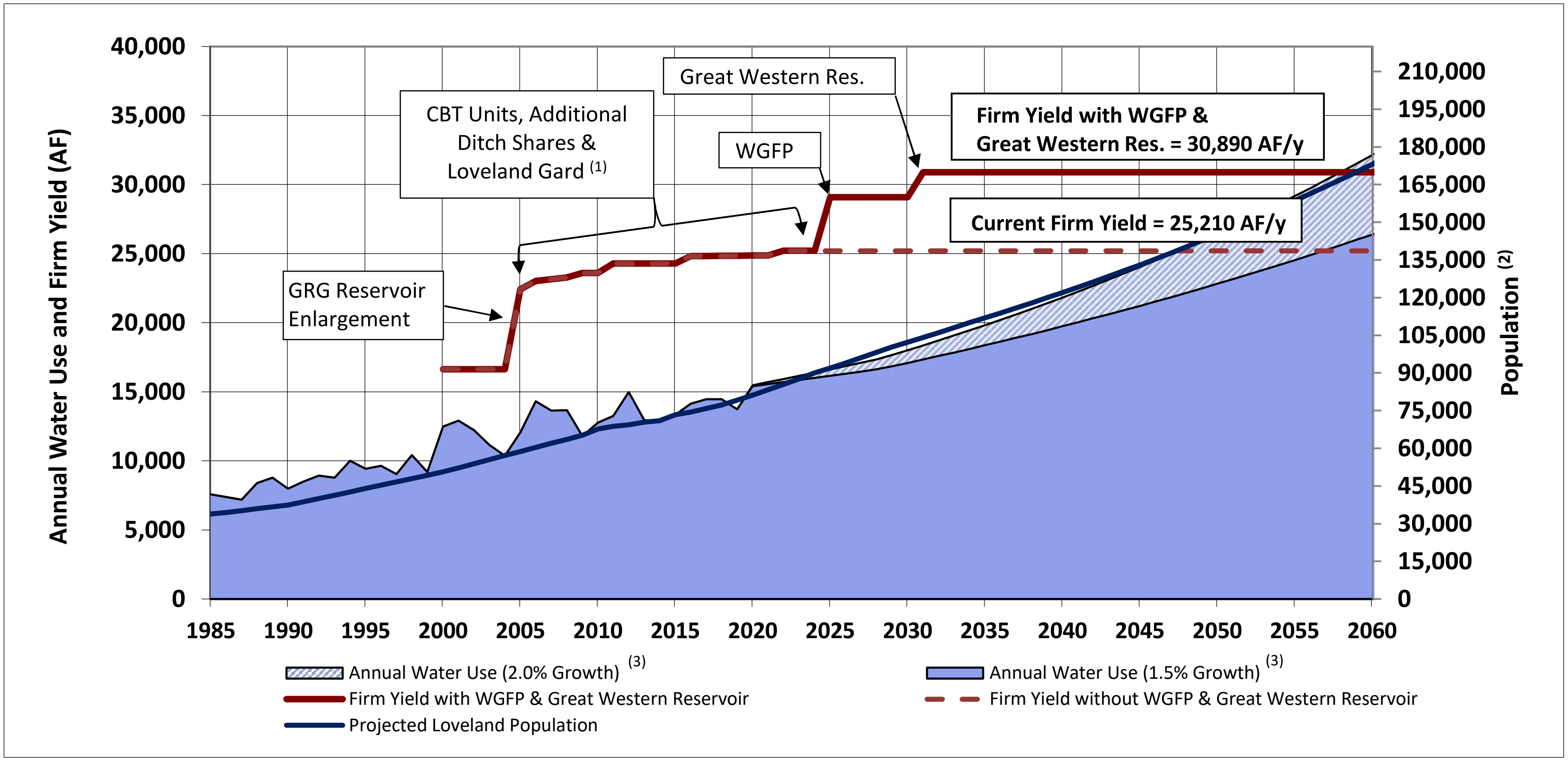
[(1)] Annual streamflows were normalized by computing the annual flow as a percentage of average. The composite annual flow was computed as 60% of the Big Thompson normalized flow plus 40% of the Colorado River normalized flow based on the approximate long-term split of Loveland's current water supply.

[(2)] Log Pearson Type III Distribution fit to data.

Final Draft

Figure 4-1

Historical and Projected Water Demand vs. Estimated Firm Water Supply Yield City of Loveland 1987 - 2060 (acre-feet per year)



Notes:

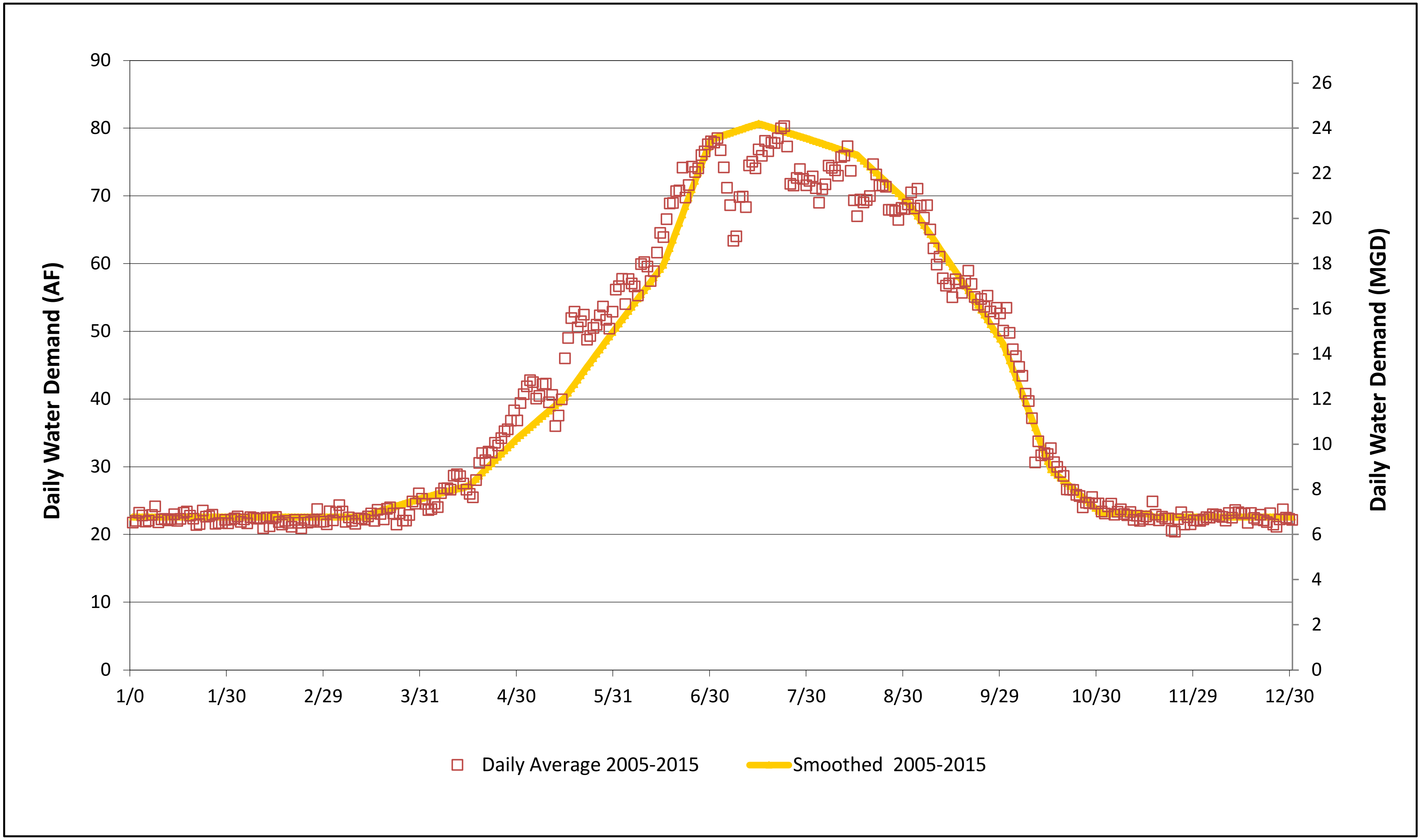
(1) The Loveland Gard Right has not been implemented yet.

(2) Population values through 2045 from the 2020 Data and Assumptions Report data.
Population values from 2046 - 2060 were estimated using the average % increase (1.77%) from the prior 15 years of data.

(3) Actual water use through 2019 and projected by City staff using a two growth rates through 2060 with conservative conservation rate (0.5%) for 10 years and then a conservation rate of (0%). Projected use includes augmentation demand of 590 AF/y.

Figure 7-1

City of Loveland
Simulated Daily Water Demand Distribution 2005-2015

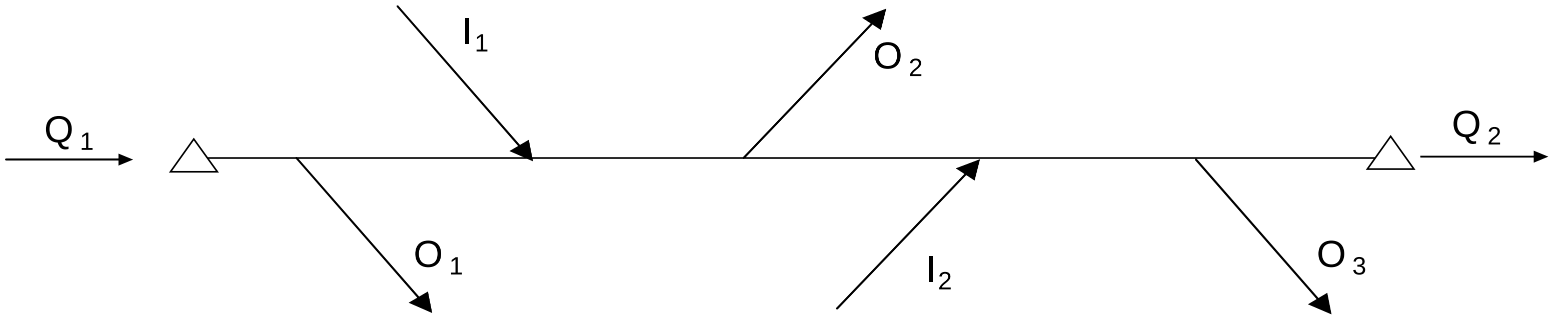


Final Draft

Figure 7-2

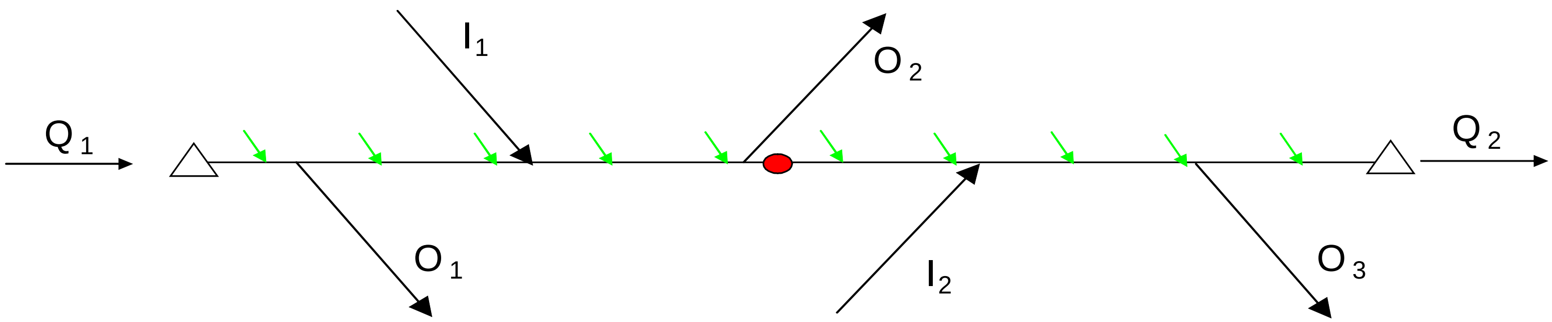
Point Flow Model Illustration

1. Compute Unmeasured Gain/Loss



Unmeasured Gain/Loss = $[Q_1 + I_1 + I_2 - O_1 - O_2 - O_3] - Q_2$

2. Distribute Unmeasured Gain/Loss Along River Reach



3. Compute Flow at Any Point Along the River

Point Flow = Q_1 + Measured Inflows (I) - Measured Outflows (O) +/- Unmeasured Gains/Losses

e.g., Point Flow Below $O_2 = Q_1 - O_1 + I_1 - O_2$ + Unmeasured Gains between Q_1 and O_2

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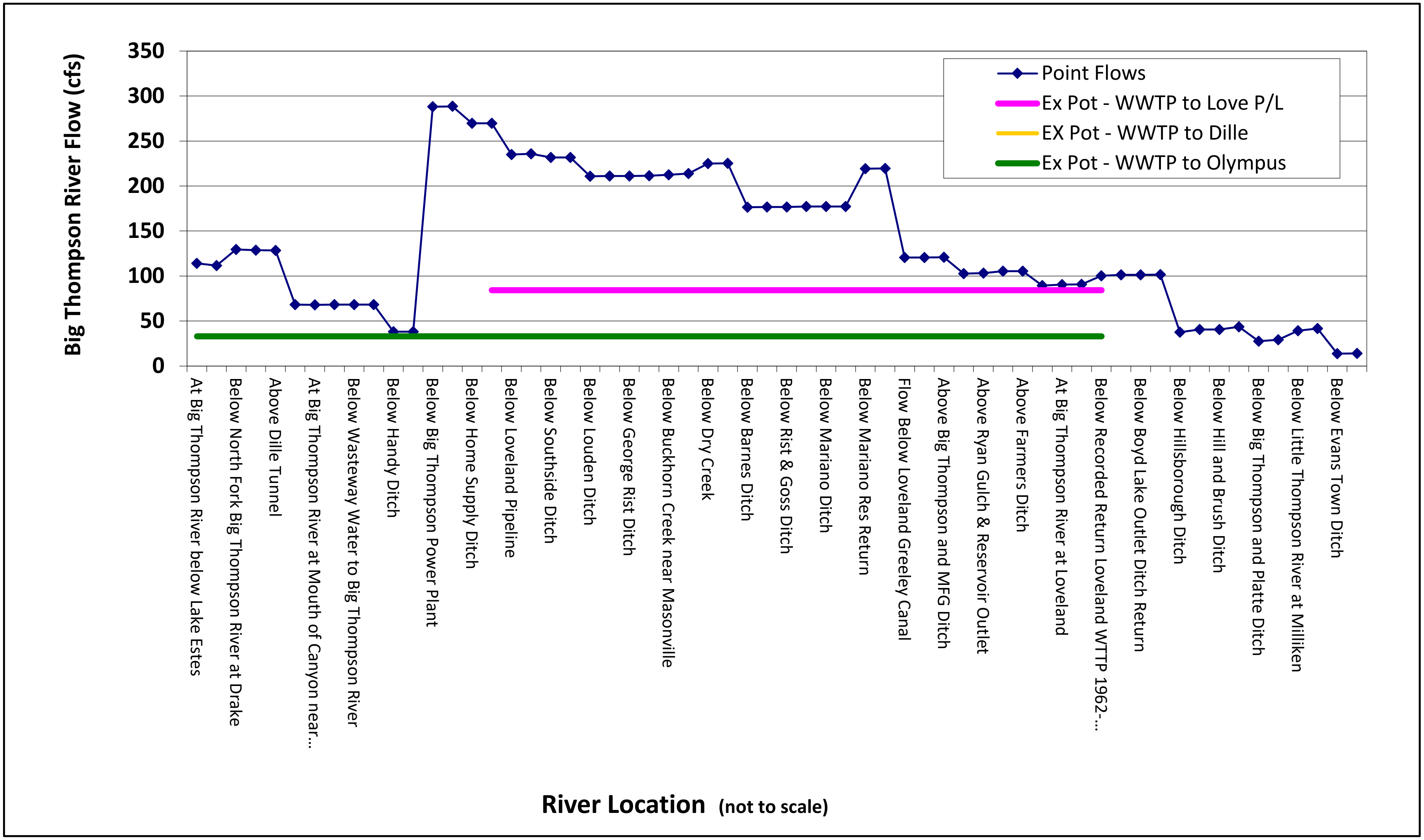
Figure 7-3

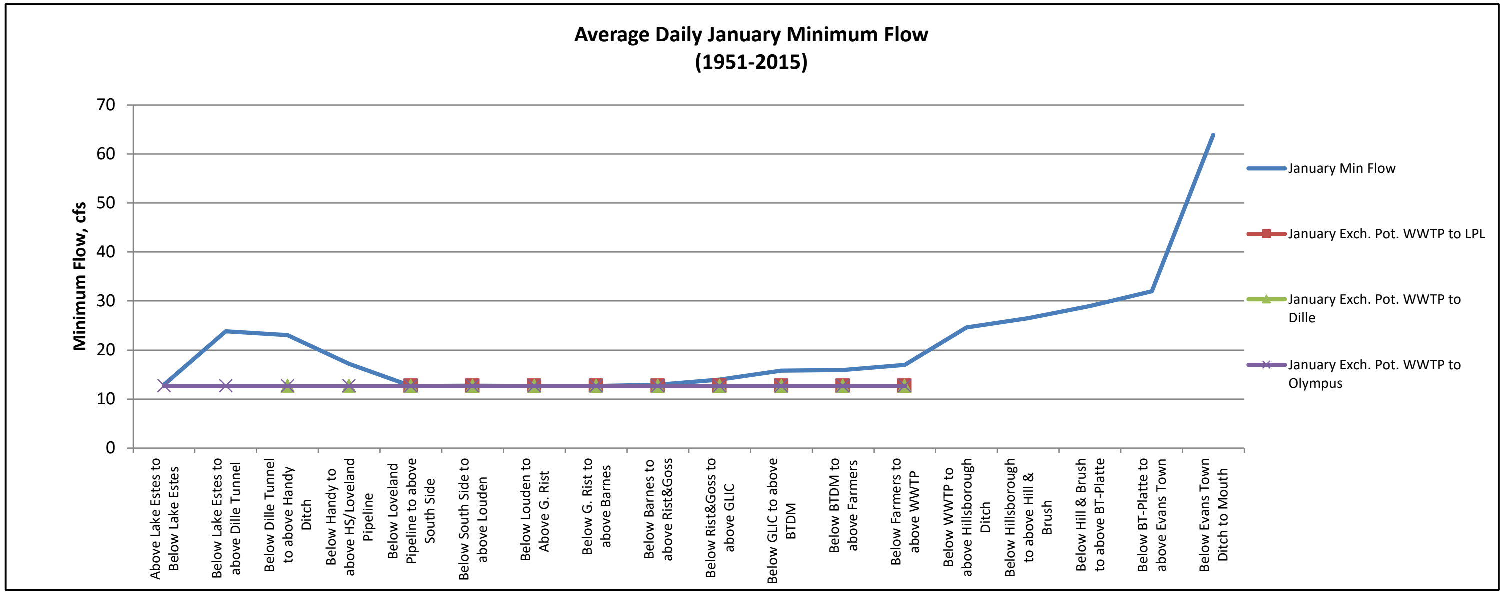
Point Flow Model Example
Point Flow Estimates for July 4, 2002
(cfs)

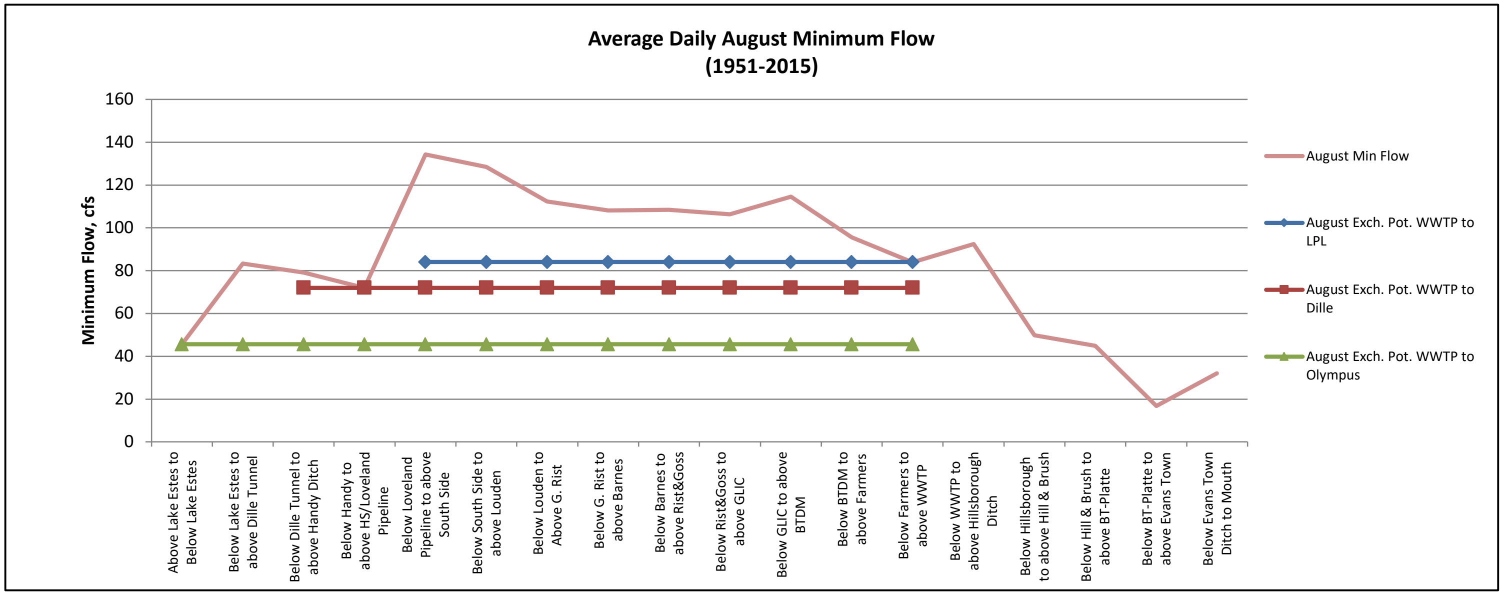


Final Draft

Figure 7-4

Average Daily Flows and Exchange Potential in Loveland Exchange Reaches - Big Thompson River





Final Draft

Figure 7-5

Loveland Water Supply Yield Model
Example Input Data Sheet 1

Sheet A1 - Main Input Page

Increase annual water demand (C16-C20) until a shortage occurs. The demand at which a shortage is impending is the firm yield

WATER SHORTAGE SUMMARY

	Shortage	GRG Min	Critical Yr	Shortage	Aug Short	Critical Yr	Shortage	Aug Short	Critical Yr	Shortage	Aug Short
51-15	0.0	4.8	1954	0	0	1987	0	0	2002	0	0
51-65	0.0	3304.2	1972	0	0	1988	0	0	2003	0	0
66-75	0.0	3292.7	1973	0	0	1989	0	0	2004	0	0
76-85	0.0	3286.9	1977	0	0	1990	0	0	2005	0	0
86-95	0.0	3316.0	1978	0	0	1991	0	0	2006	0	0
96-05	0.0	4.8	1979	0	0	1992	0	0	2012	0	0
06-15	0.0	1361.8	1981	0	0	1993	0	0	2013	0	0
All Demands Met?	**OK**		1982	0	0	1994	0	0	2014	0	0

	Muni	Aug	NP Irr	Ret Flow	
Average Annual Shortage (af)	0.0	0.0	0.0	0.0	OK
Maximum Annual Shortage (af)	0.0	0.0	0.0	0.0	OK
No. of Years of Shortage	0.0	0.0	0.0	0.0	OK

Titles For Summary Workbook

Run Description: **2020 BASE RUN, All Municipal and Augmentation Demands Met**

Summary Title: 0.00 shares added

User-Defined Inputs (Yellow Shading)

Gray-shaded boxes are not required inputs, but may be changed if necessary.

DEMANDS

OK

TOTAL DEMAND

Annual Municipal Demand, AF	**30,300**	
Annual Potable Leases to Others, AF	**90**	
Annual Non-Potable Irr Demand, AF		OK
Aug. Leases above WWTP, AF	**50**	OK
Aug. Leases below WWTP, AF	**450**	
Windy Gap Lease, AF	300	
Sum of Demands, AF	**30,890**	

Change Lease Distribution on Sheet D

IRRIGATION USE

Municipal Irrigation Demand, % of Total Municipal Use	**44%**

RETURN FLOWS

WWTP Returns,% of Indoor Use	**95%**

Notes:

Flow Condition: Normal - Input 2020

Date Modified: **9/16/20**

WATER SUPPLY

CBT Supply

Number of Units 12,210 — **New Acquisitions**

Windy Gap Supply

Number of Units 40 — **New Acquisitions**

WGFP Condition 2 **Firmed** — **10,000** **WGFP Res. Participation, AF**

(set on Sheet A2) — 1 Apply Re-introduction charge ? 1=yes

Ditch Shares

Ditch Name	Total Company Shares	202A Shares Owned	Calculated % Ownership	392 Case Shares Owned	Calculated % Ownership	No. of Shares Unchanged	Calculated % Ownership	Priority of Use	
Barnes	1944.230	1306.750	67.2%	24.500	1.3%		0.0%	3	
Big T Ditch & Mfg.	20.792	2.583	12.4%	3.811	18.3%	5.26	25.3%	5	
Chubbuck	1590.400	596.579	37.5%	815.001	51.2%		0.0%	2	
Buckingham-George Rist	200.000	6.050	3.0%	89.250	44.6%	24.70	12.4%	1	
Louden	600.000	191.537	31.9%	61.547	10.3%	21.95	3.7%	6	
South Side	265.000	57.500	21.7%	23.000	8.7%	32.75	12.4%	4	
Rist & Goss	N/A	N/A	100.0%					12	
Loveland Gard Right						N/A	100.0%	13	
Farmers	30.000			-	0.0%		0.0%	11	0
GLIC	1636.000	-		-	0.0%		0.0%	7	0
Handy	900.000	-		-	0.0%		0.0%	9	0
Hillsborough	118.000	-		-	0.0%		0.0%	8	0
Home Supply	2001.000	-		-	0.0%	30.00	1.5%	10	0

* Loveland Gard Right is a portion of the Gard private right in the Home Supply Ditch. **Include in analysis ? (1=Yes, 0 = No)**

RESERVOIR SOURCES

	Boyd L	Lake Loveland	Horseshoe	Rist Benson	Ryan Gulch	Mariana/Lon Hagler/ Lone Tree
	GLIC		7 Lakes	Louden?	Independent	Home Supply
Ownership% from Ditch Shares	0%				100%	1.5%
Include in analysis? 1=yes						0

CAPACITIES, ETC.

TOTAL UPSTREAM STORAGE

Green Ridge Glade Reservoir

Capacity, AF	**6,785**
Initial Contents, AF	**4,500**

New Storage, Upstream Location

(New Storage simulated with additional GRG capacity)

Capacity, AF	
Initial Contents, AF	
Total U/S Capacity, AF	**6,785**
Total Initial Contents, AF	4,500

DOWNSTREAM GRAVEL PIT STORAGE

Capacity, AF	**1,300**
Initial Contents, AF	
Fill Rate Limit, cfs	**20**
Release Rate Limit, cfs	**20**

New Storage, Downstream Location

(New Storage simulated with additional D/S Gravel Pit capacity)

Capacity, AF	
Initial Contents, AF	
Fill Rate Limit, cfs	
Release Rate Limit, cfs	
Total D/S Capacity, AF	**1,300**
Total Initial Contents, AF	-
Fill Rate Limit, cfs	**20**
Release Rate Limit, cfs	**20**

Evap and Area-Capacity, see Sheet C
Other Options, see Sheet A2

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Figure 7-6

Loveland Water Supply Yield Model
Analysis Options Input Flags

Sheet A2 - User-Defined Input Options for Sources

Input Flag Options

Domestic and Municipal Rights	Selected	Other	0	1	2	3	4
Domestic Rights 1887 and 1901	1		0=OFF	1=Apr 1-Oct 31 in irrigation priority	2=All Year in irrigation priority	3=All Year, Domestic Priority Superior to Irrigation Rts	
6cfs early BTDM transfer	2		0=OFF	1=In Priority only on days when BTDM Diverts	2=Specified Irr Season in Priority		
6 cfs BTDM Start Date	4/24	Date					
6 cfs BTDM End Date	10/30	Date					

CBT	Selected	Other	0	1	2	3	4
CBT (Direct) Order of Use	1			1=Before GRG All Yr	2=After GRG All Yr	3=50/50 Winter with GRG	4=All Yr 50/50 with GRG
CBT Used after Windy Gap	0			0=NO	1=YES		

Windy Gap	Selected	Other	0	1	2	3	4
Windy Gap Simulated Yields Condition:	2			1=Unfirmed	2=Firmed	3=Test Data	
Windy Gap (Direct) Order of Use	1			1=Last after GRG	2=At LPL after CBT		
Windy Gap to GRG storage, when GRG <	50%	% full threshold to store WG in GRG					
Only after Month # (0= all year)	0	Month #					
Chimney Hollow contents below which no WG is sent to GRG storage	-	AF					

Free River	Selected	Other	0	1	2	3	4
Free River diverted into GRG?	1		0=NO	1=YES			
Only after Month # (0= all year)	0	Month #					
Free River diverted into Gravel Pit?	1		0=NO	1=YES			
Only after Month # (0= all year)	0	Month #					

Other Sources	Selected	Other	0	1	2	3	4
WTP Decant Water, % of WTP	2.5%	% of WTP					
Rist & Goss Order of Use	1			1=Before Other Ditches	2=After Other Ditches		
Loveland Gard Right Order of Use	2		0=Ignore, Not Diverted	1=Before Other Ditches, After Rist & Goss (direct)	2=After Other Ditches, After 392		
Exchange Potential Season (FLOWS page)	1			1=Irr Season Only	2=All Year		

LIRF Uses (See lagging Factors on Sheet C)	Selected	Other	0	1	2	3	4
Reusable LIRF used for Augmentation	0		0=NO	1=YES			
Reusable LIRF used for Return Obligations	0		0=NO	1=YES			
Reusable LIRF stored in Gravel Pit?	0		0=NO	1=YES			

Reservoirs-Other Inputs	Selected	Other	0	1	2	3	4
Replace Non-reusable in GRG when possible?	1		0=NO	1=YES			
Use Gravel Pit for non-potable irrigation in addition to other uses?	1		0=NO	1=YES			

Augmentation Leases	Selected
Meet Every Day (0), Not during Free River (1)	0

Exchange Potential Lagging	Selected	Other	0	1	2	3	4
Lag Exchange Potential Due to Potential Administrative Approval Delay?	0		0=Same Day	1=Delay 1 Day	2=Delay 2 Days	3=Delay 3 Days	

Supply Reductions	Selected	Other	0	1	2	3	4
Reduce East Slope Supplies	15%	% Reduction					
	0		0 = no reduction	1 = East Slope Reduction		Note: Reduced East Slope Supplies does not include a reduction to Non-Base Run reservoir sources.	
Reduce West Slope Supplies	15%	% Reduction					
	0		0 = no reduction	1 = Windy Gap Reduction Only	2 = Both Windy Gap & CBT Reductions		

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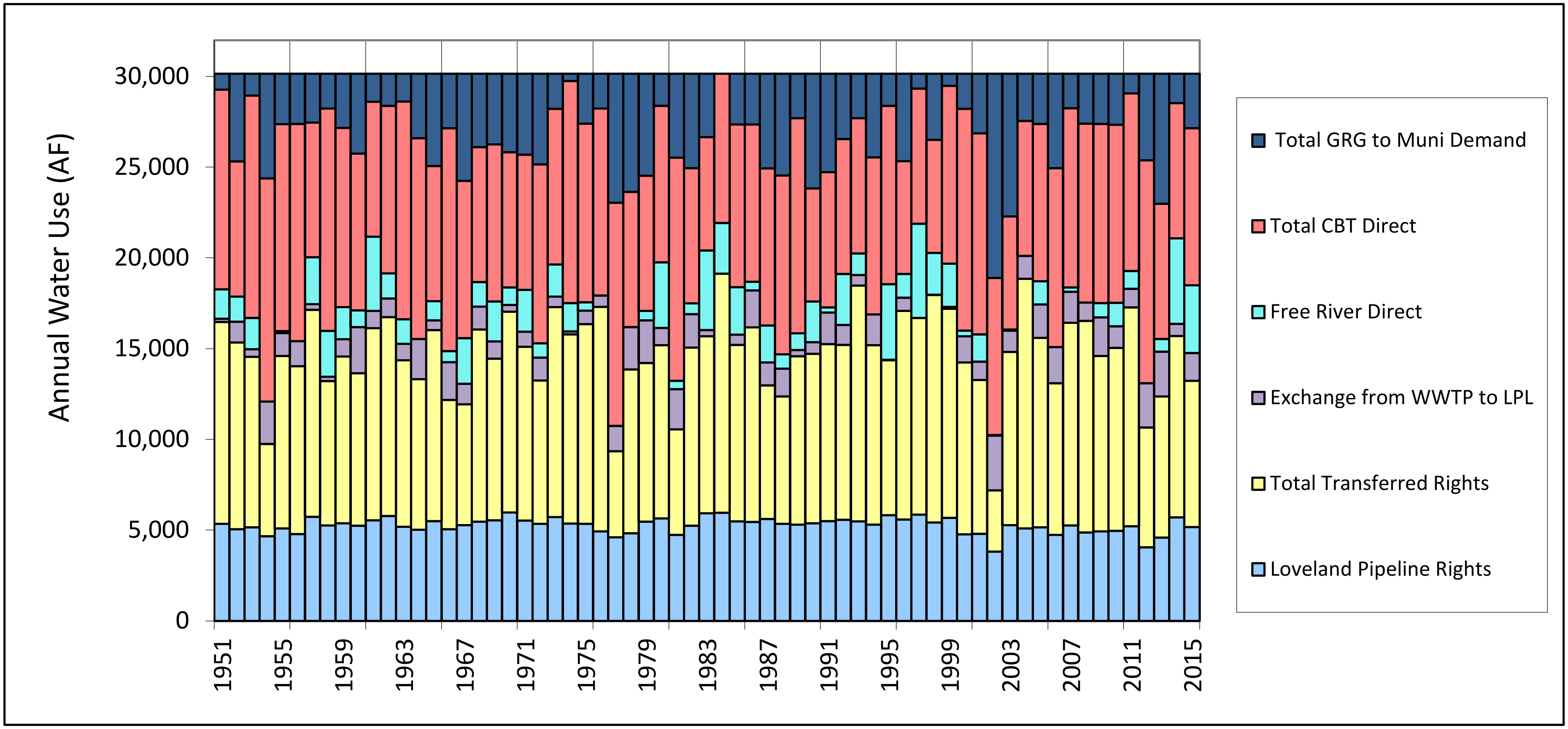
Figure 8-1

Annual Municipal Firm Yield Summary
City of Loveland
Municipal Firm Yield = 30,300 AF (Base Run)



2020 BASE RUN, All Municipal and Augmentation Demands Met

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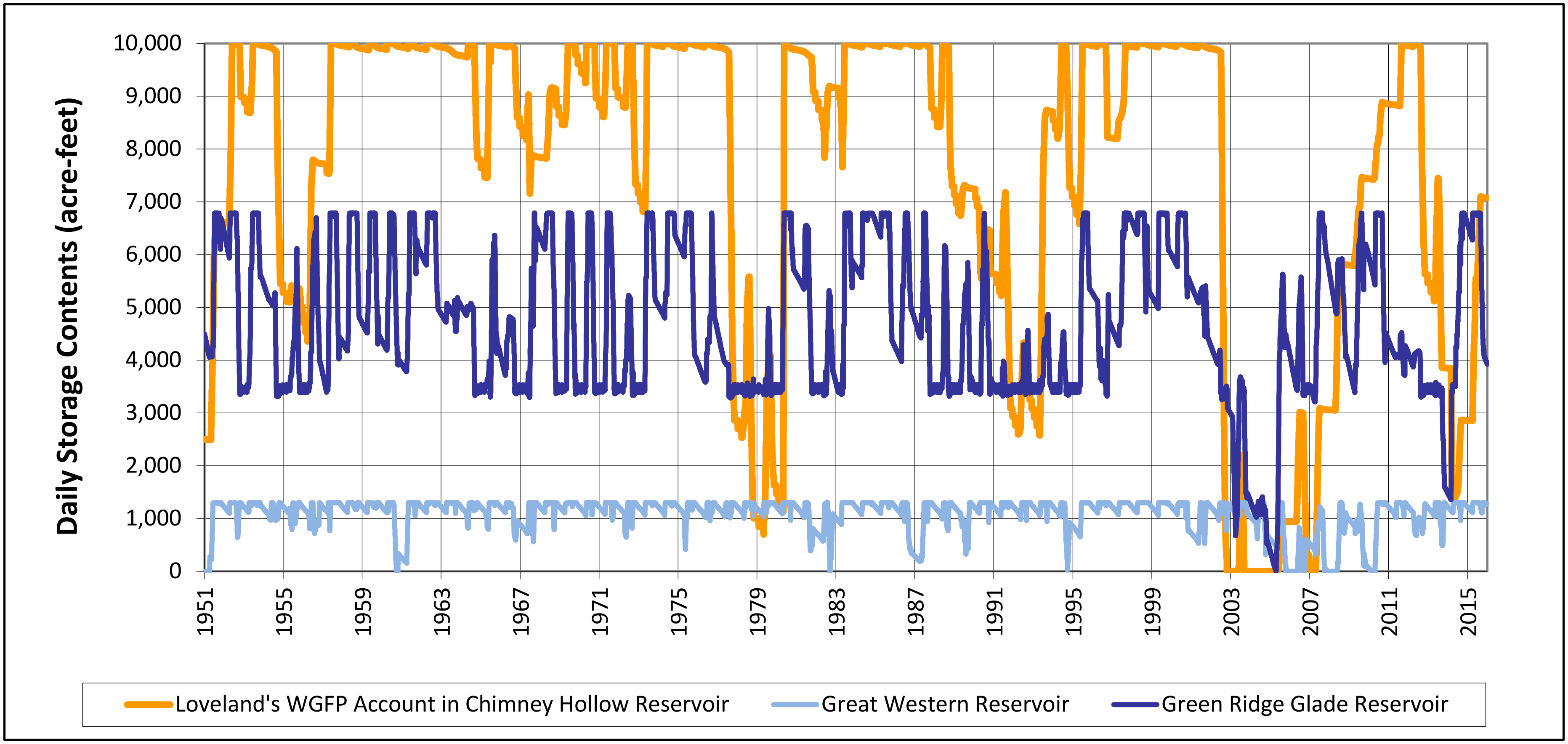
Figure 8-2

Daily Simulated Reservoir Contents
Green Ridge Glade Reservoir, Chimney Hollow Reservoir, and Great Western Reservoir
City of Loveland



2020 BASE RUN, All Municipal and Augmentation Demands Met

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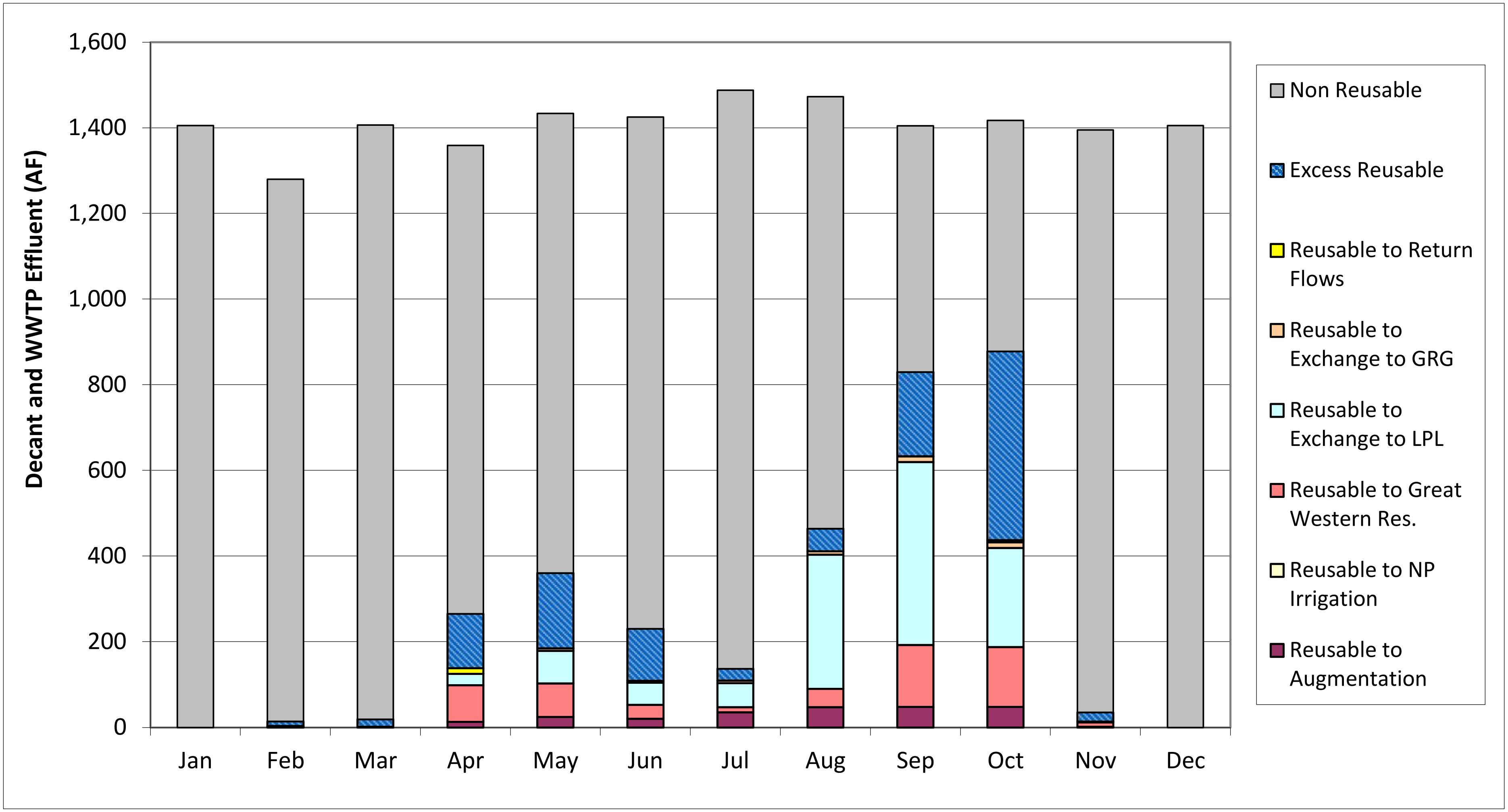
Figure 8-3

Simulated Average Monthly Production and Use of WWTP Effluent and Decant Pond Discharge

Firm Annual Yield = 30,300 + 590 = 30,890 AF (Base Run)



2020 BASE RUN, All Municipal and Augmentation Demands Met

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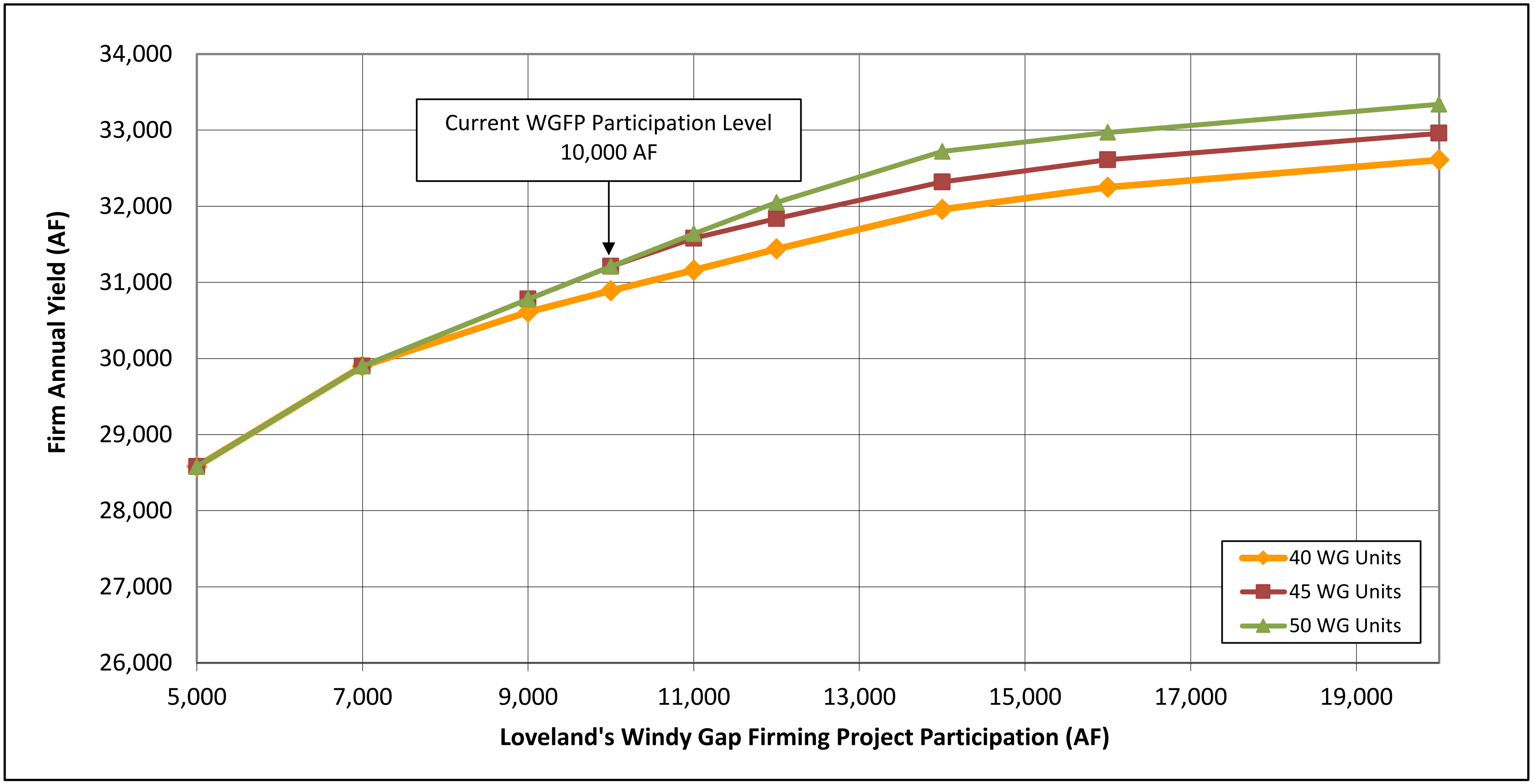
Figure 8-4

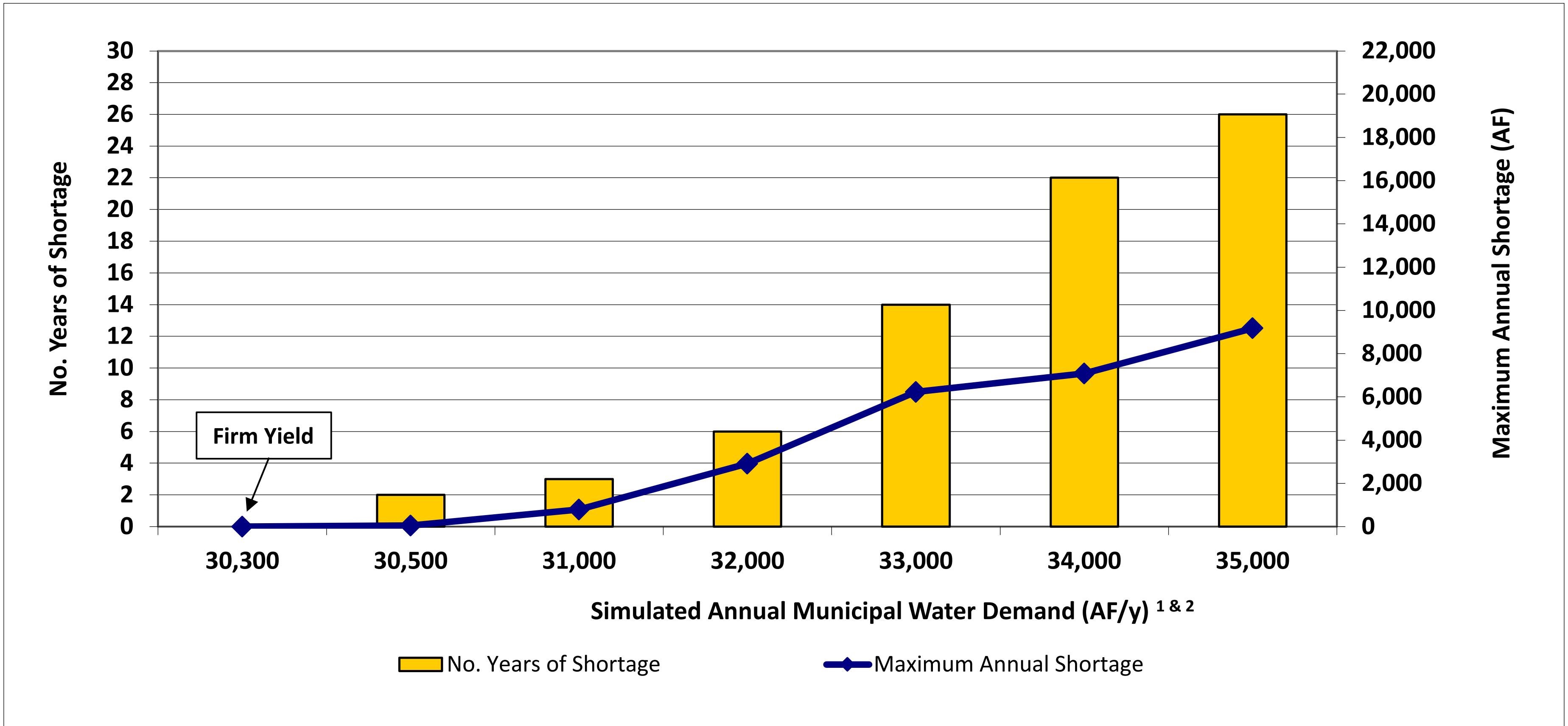
Firm Yield vs. Windy Gap Firming Project Participation and Windy Gap Units
City of Loveland



Note:
Loveland owns 40 Windy Gap Units and is currently participating in the Windy Gap Firming Project in the amount of 10,000 acre-feet of storage.

Figure 8-5

Simulated Water Shortages at Demands Greater than Firm Yield
City of Loveland



Notes:

(1) Bars read on left axis and line read on right axis.

(2) The simulated municipal firm yield is based on the 1951- 2015 study period. The total firm yield includes 590 AF of augmentation demand in addition to the municipal demand.

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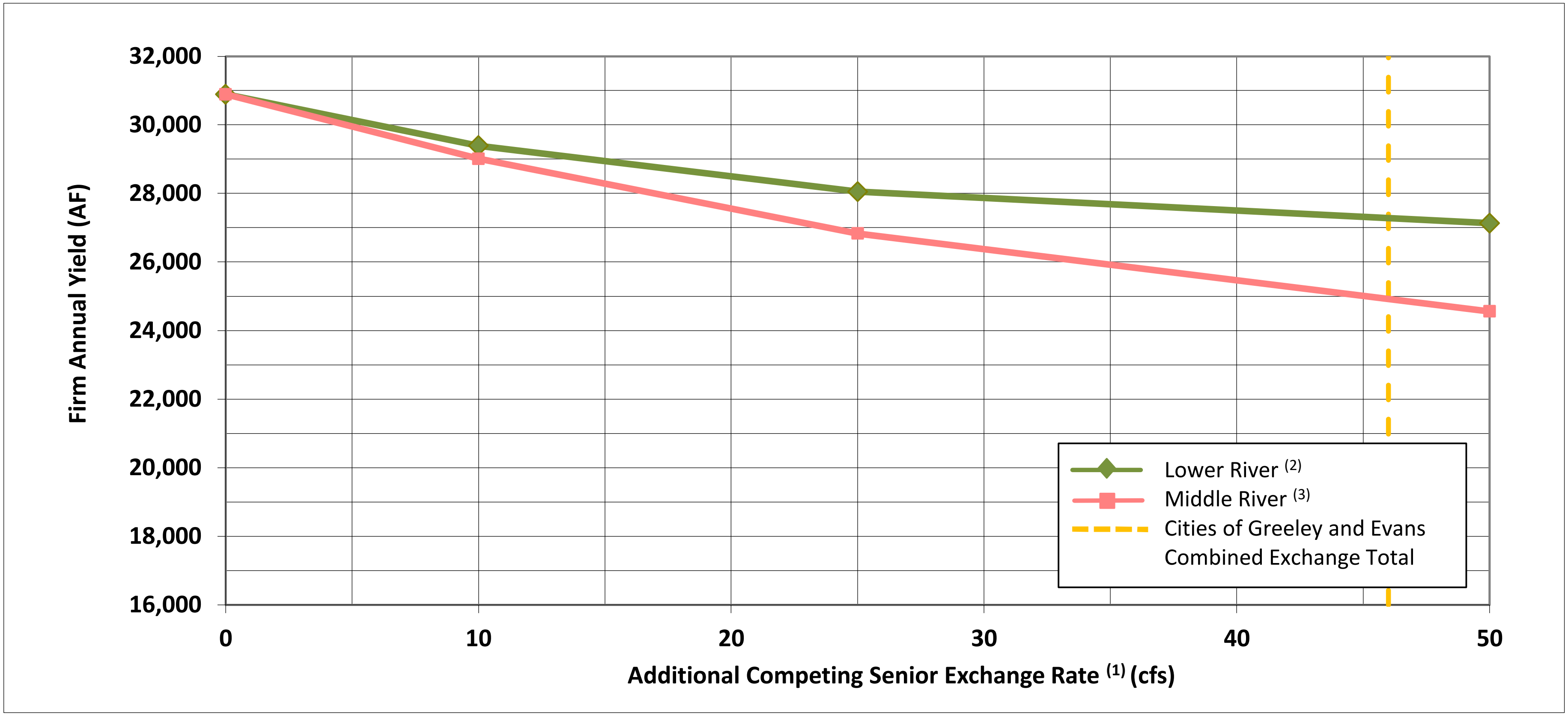
Figure 8-6

Effect of Increased Competing Senior Big Thompson River Exchanges on Firm Annual Yield City of Loveland



Notes:

[1] Effect of historically operated exchanges (largely agricultural) are included in the baseline firm yield estimate (i.e., with additional senior exchanges = 0).

[2] Competing exchanges from other entities in the reach from the confluence with the South Platte River to Barnes Ditch headgate. The Cities of Greeley and Evans have decreed exchanges in the Lower River reach at the rates of 30 cfs and 16 cfs, respectively.

[3] Competing exchanges from other entities in the reach from above the Hillsborough Ditch to the Loveland Pipeline.

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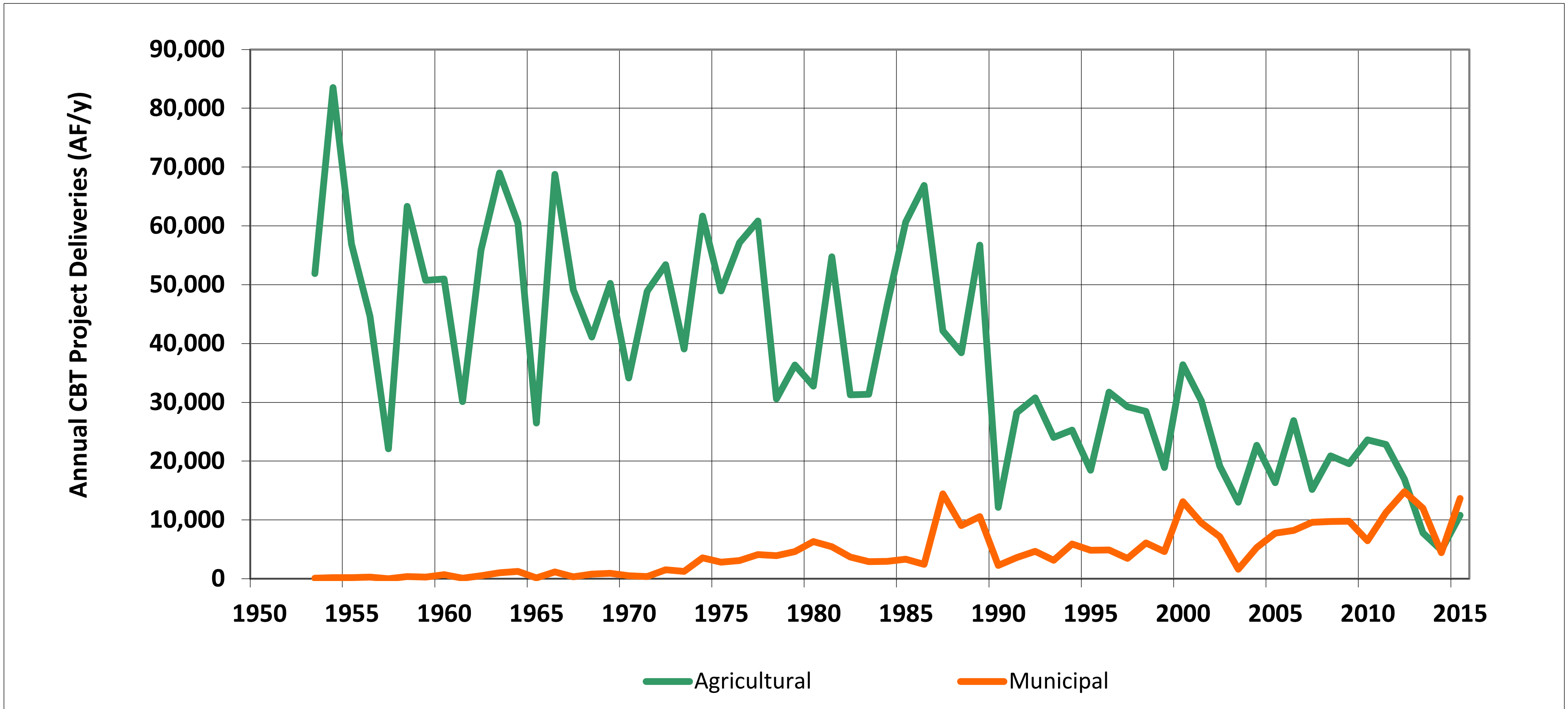
Figure 8-7

Historical Annual Agricultural and Municipal Deliveries of CBT Project Water to Big Thompson River



Note:

Data from the Northern Colorado Water Conservancy District.

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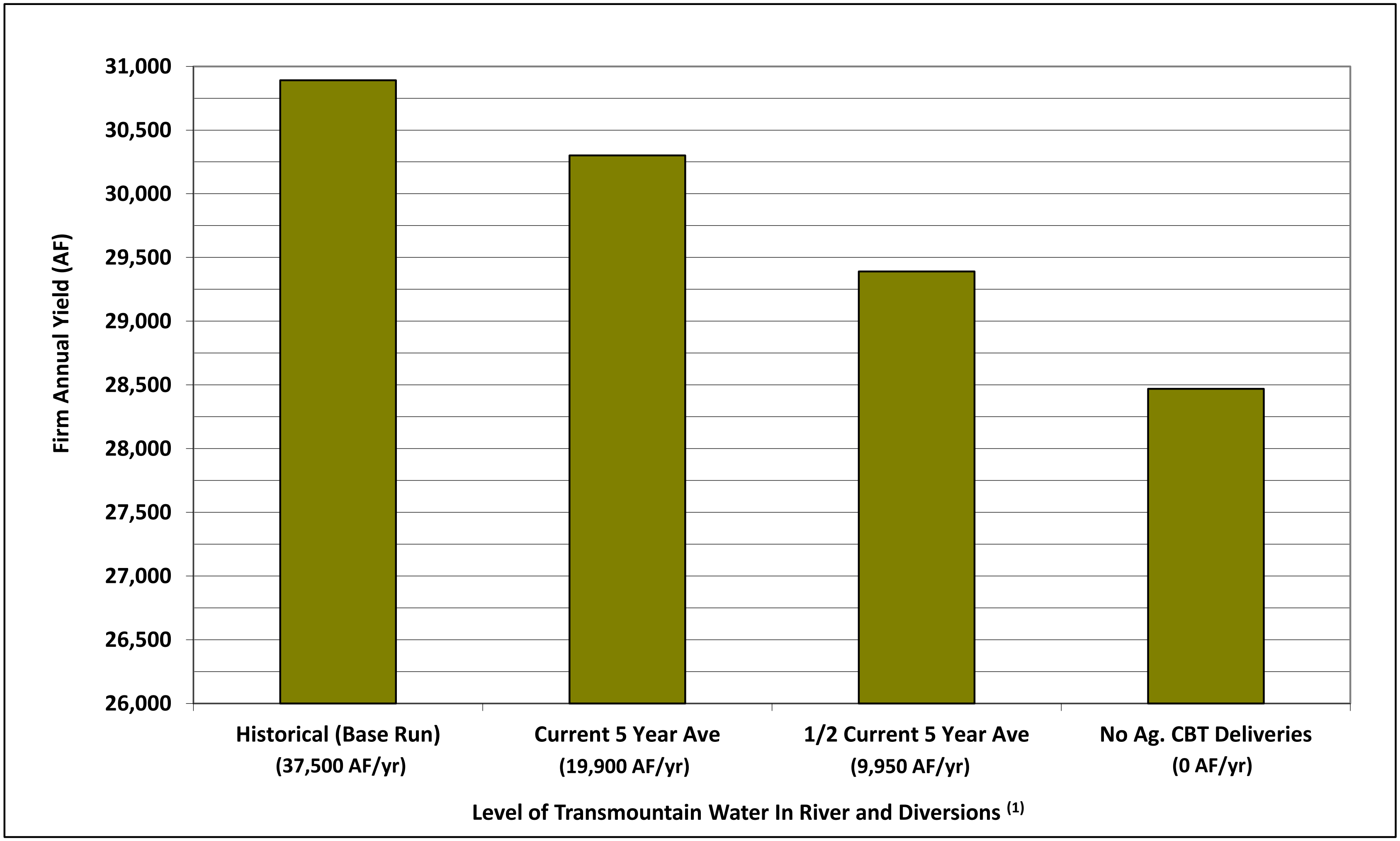
Figure 8-8

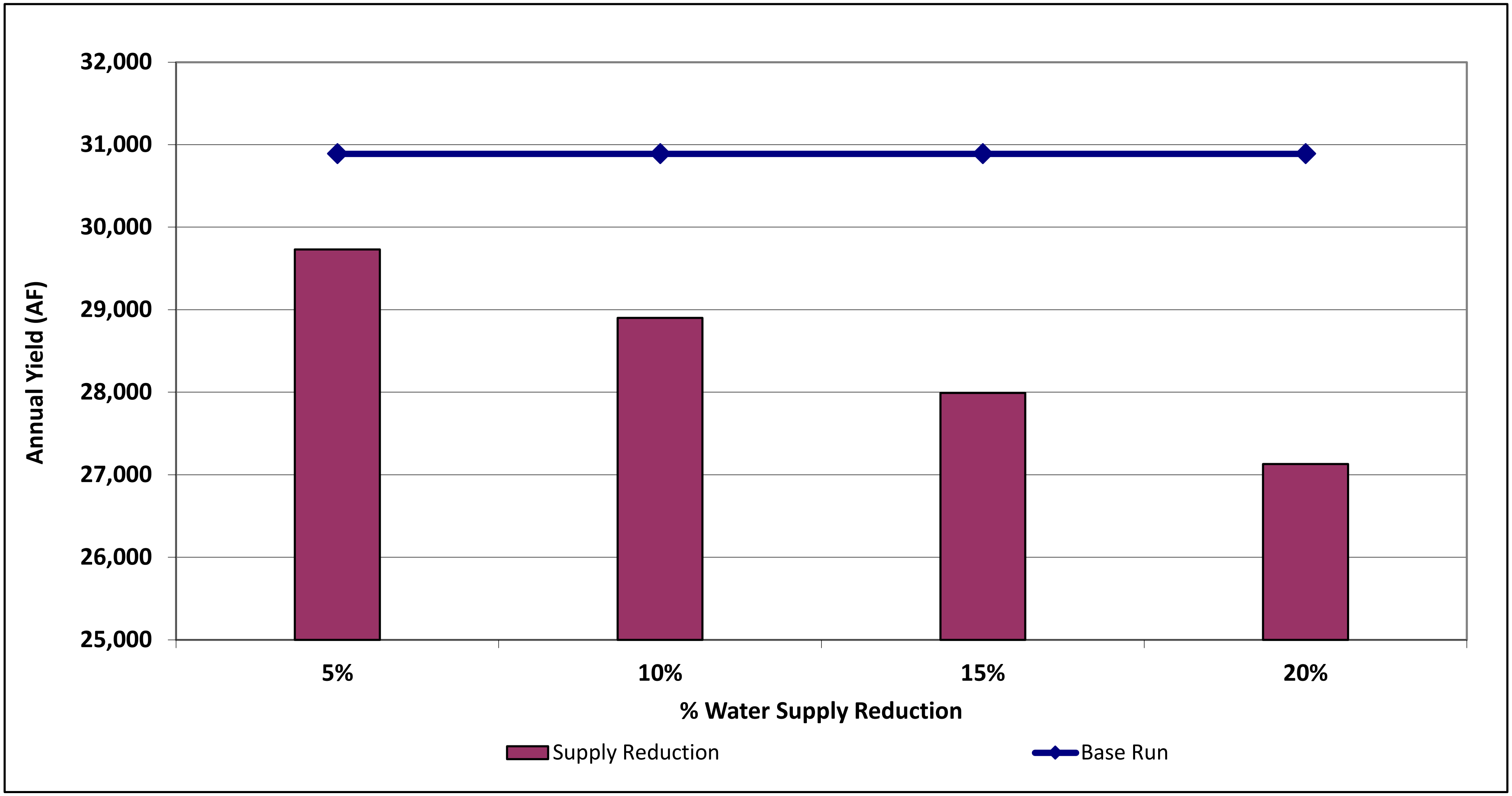
Effect of Reduced Agricultural CBT Project Deliveries and Decreased Exchange Potential on Annual Firm Yield City of Loveland



Note:
(1) Exchange potential adjusted to remove all or portions of the reported historical transmountain water deliveries from the streamflow and diversion records.

Figure 8-9

Effect of Future Reduced Water Supplies on Annual Firm Yield City of Loveland



Note:
The % water supply reduction applies to all East and West slope water supplies.

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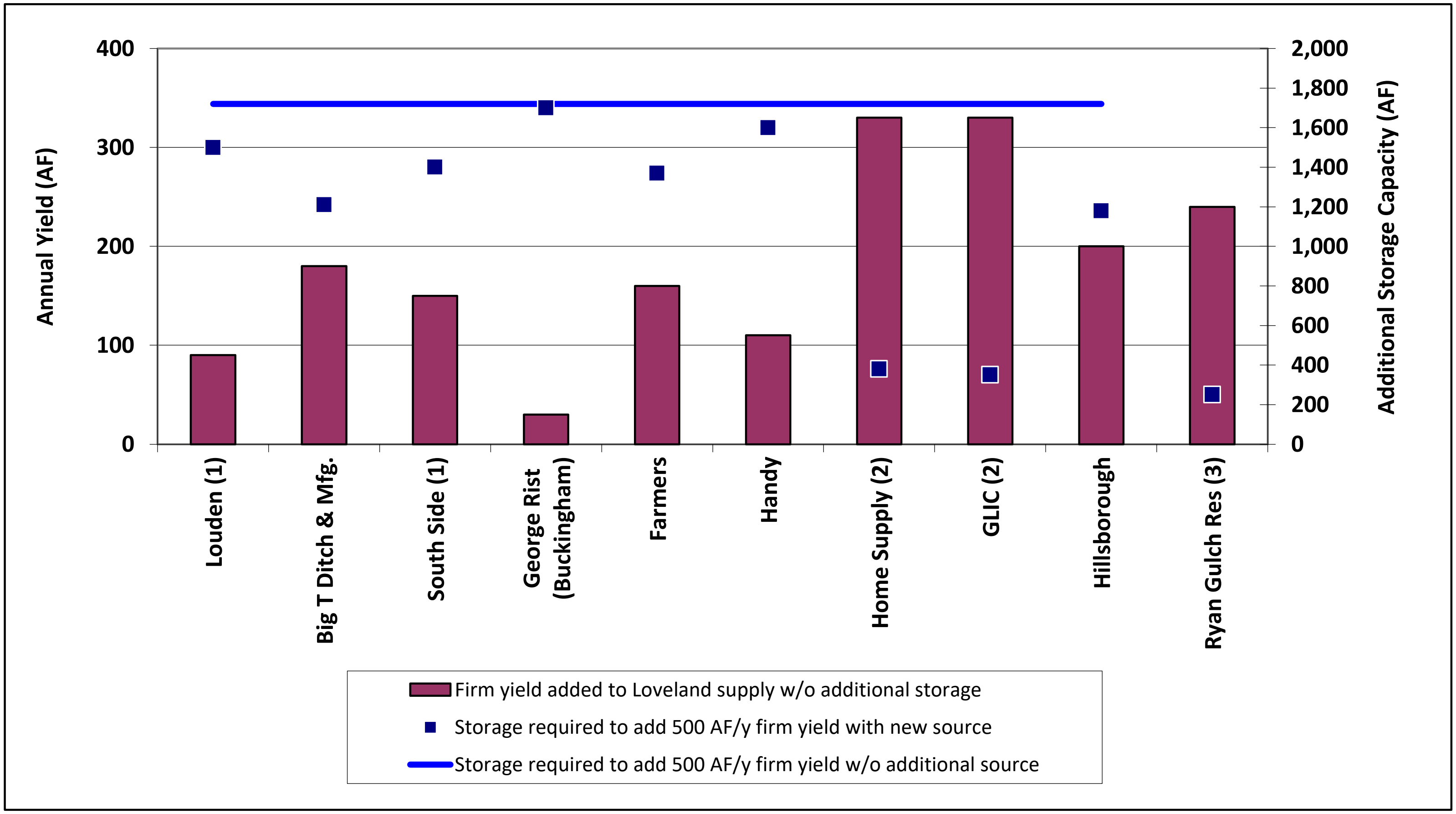
Figure 8-10

Incremental Additional Firm Yield
from 500 AF/y of Average Annual Yield of Irrigation Company Supplies
City of Loveland



Notes:

(1) Louden and South Side results do not include yield from storage in those systems.

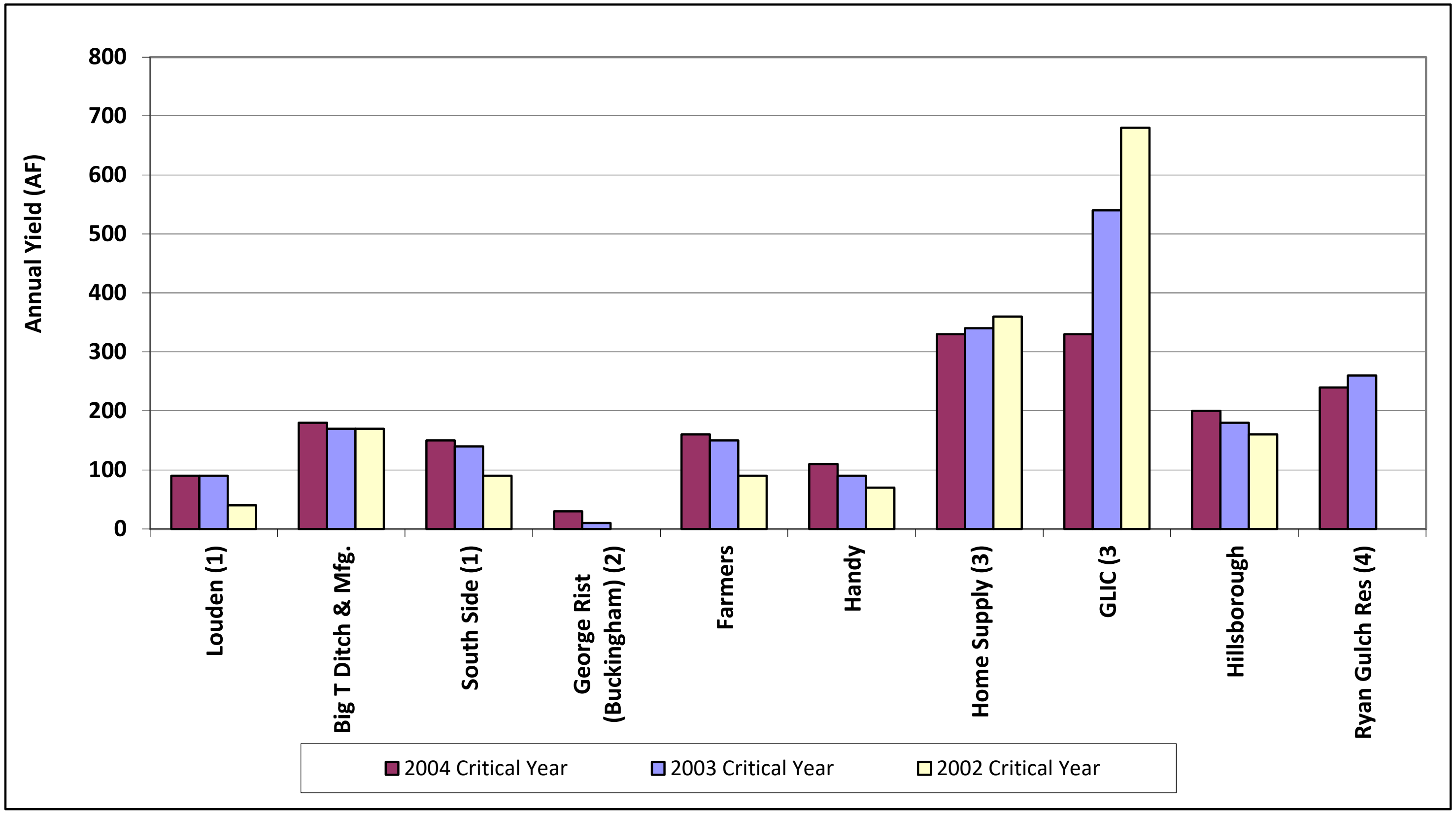
(2) Home Supply and GLIC results include yield from storage.

(3) Ryan Gulch Reservoir yield is based on use of the reservoir for municipal supply during drought periods.

The average annual total yield of Ryan Gulch Reservoir is estimated at 320 AF/y, which is less than the 500 AF/y of additional average annual yield simulated for the other companies.

Figure 8-11

Incremental Additional Firm Yield
from 500 AF/y of Average Annual Yield of Irrigation Company Supplies
for Various Critical Drought Years
City of Loveland



Notes

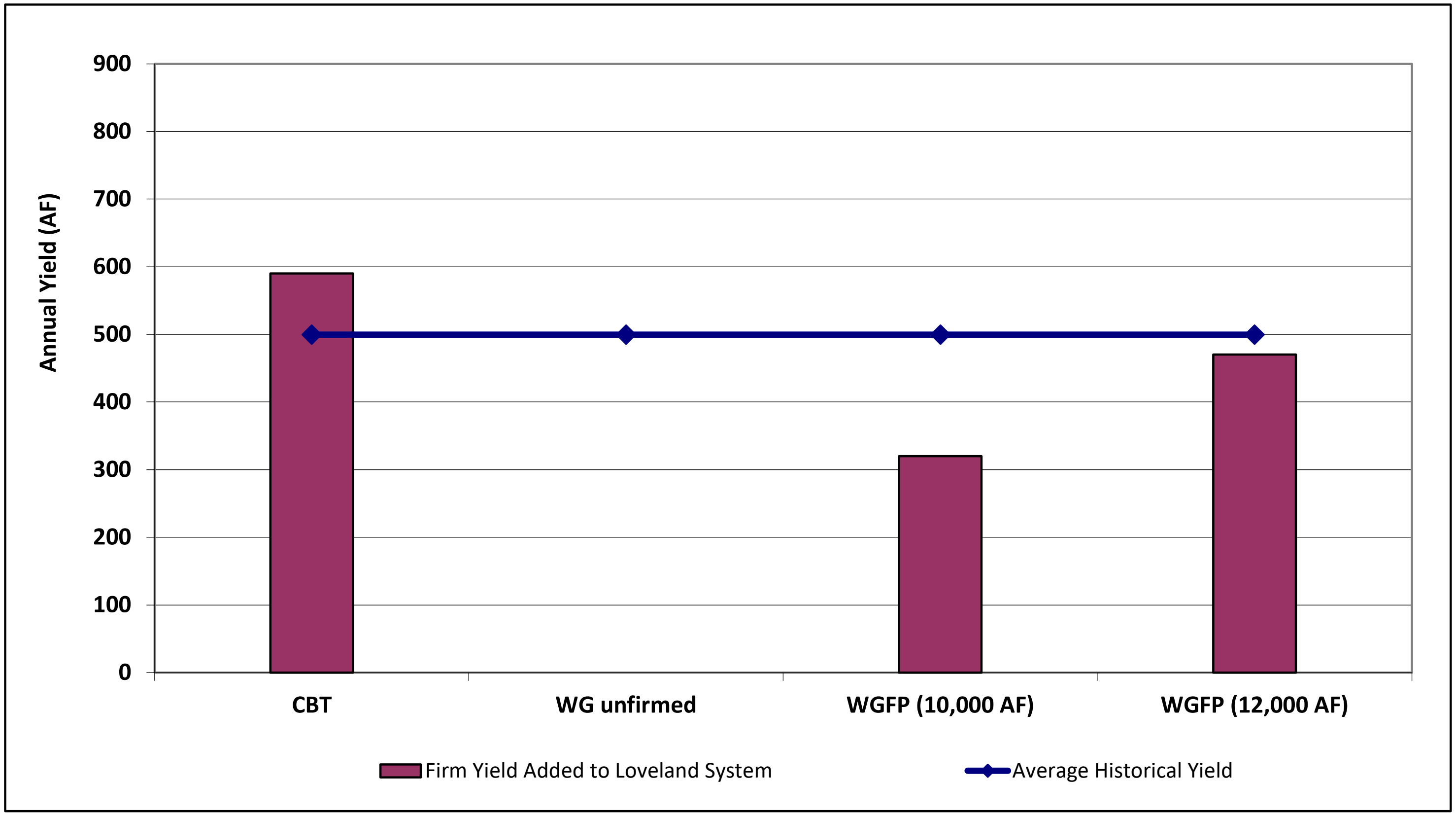
(1) Louden and South Side results do not include yield from storage in those systems.

(2) For the George Rist (Buckingham) Ditch, it is not possible to add the full 500 AF/yr of incremental firm yield. The City currently owns 120.05 shares of the total 200 shares leaving 79.95 shares available for future acquisition by the City; the 79.95 shares are equivalent to approximately 461 AF/yr of average annual yield.

(3) Home Supply and GLIC results include yield from storage.

Figure 8-12

Incremental Additional Firm Yield from 500 af/y of Average Annual Yield of Transmountain Sources City of Loveland



Note:

Based on Loveland participation in the Windy Gap Firming Project (WGFP) at 10,000 AF and 12,000 AF of East Slope storage capacity.

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Figure 8-13

Simulated CBT Supply - 2020 Yield Analysis
For Additional CBT Units (500 AF/y average annual yield)
City of Loveland (1952-2015)

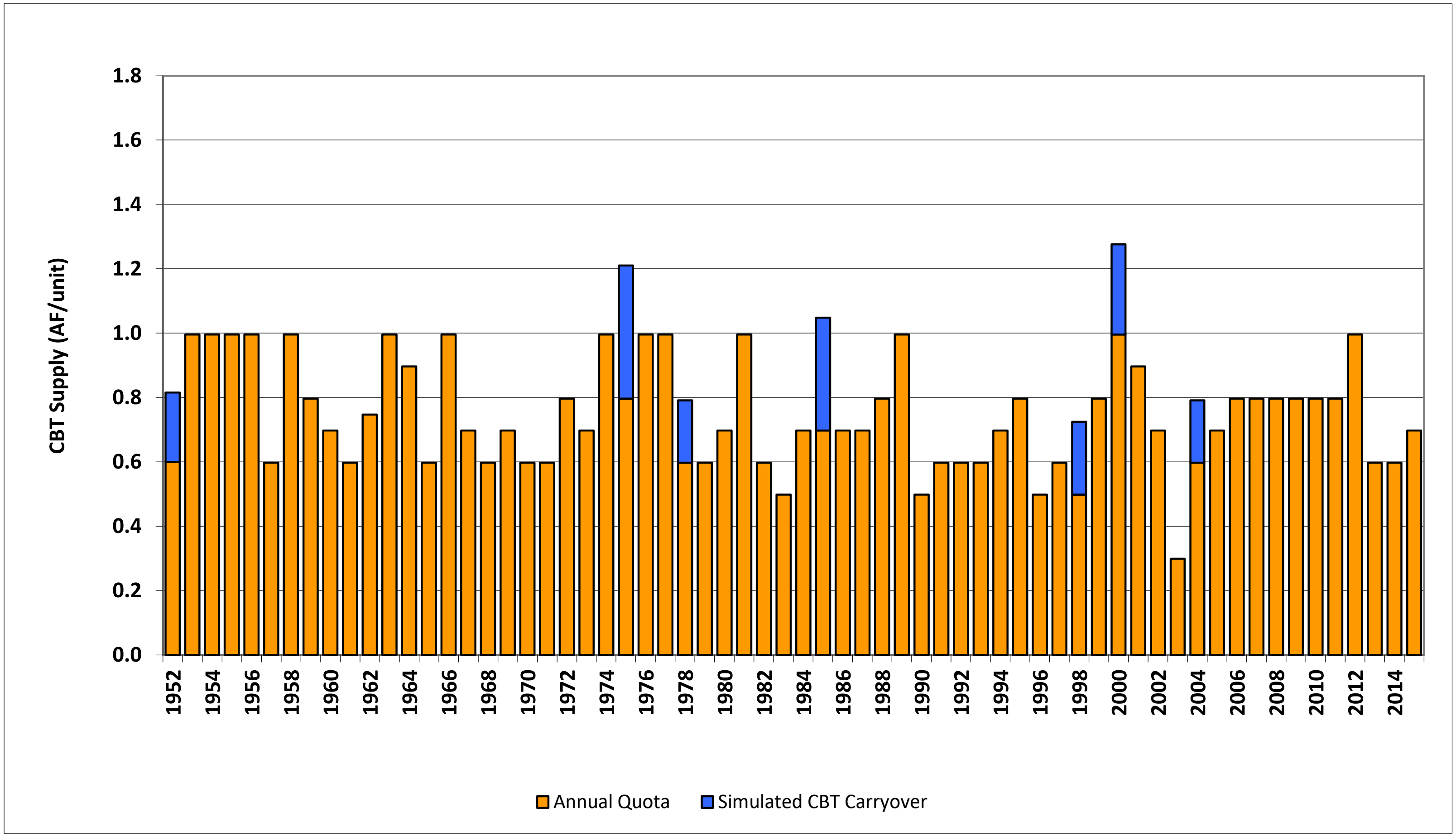

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Figure 8-14

Simulated CBT Supply - 2011 Yield Analysis
For Additional CBT Units (500 AF/y average annual yield)
City of Loveland (1952-2006)

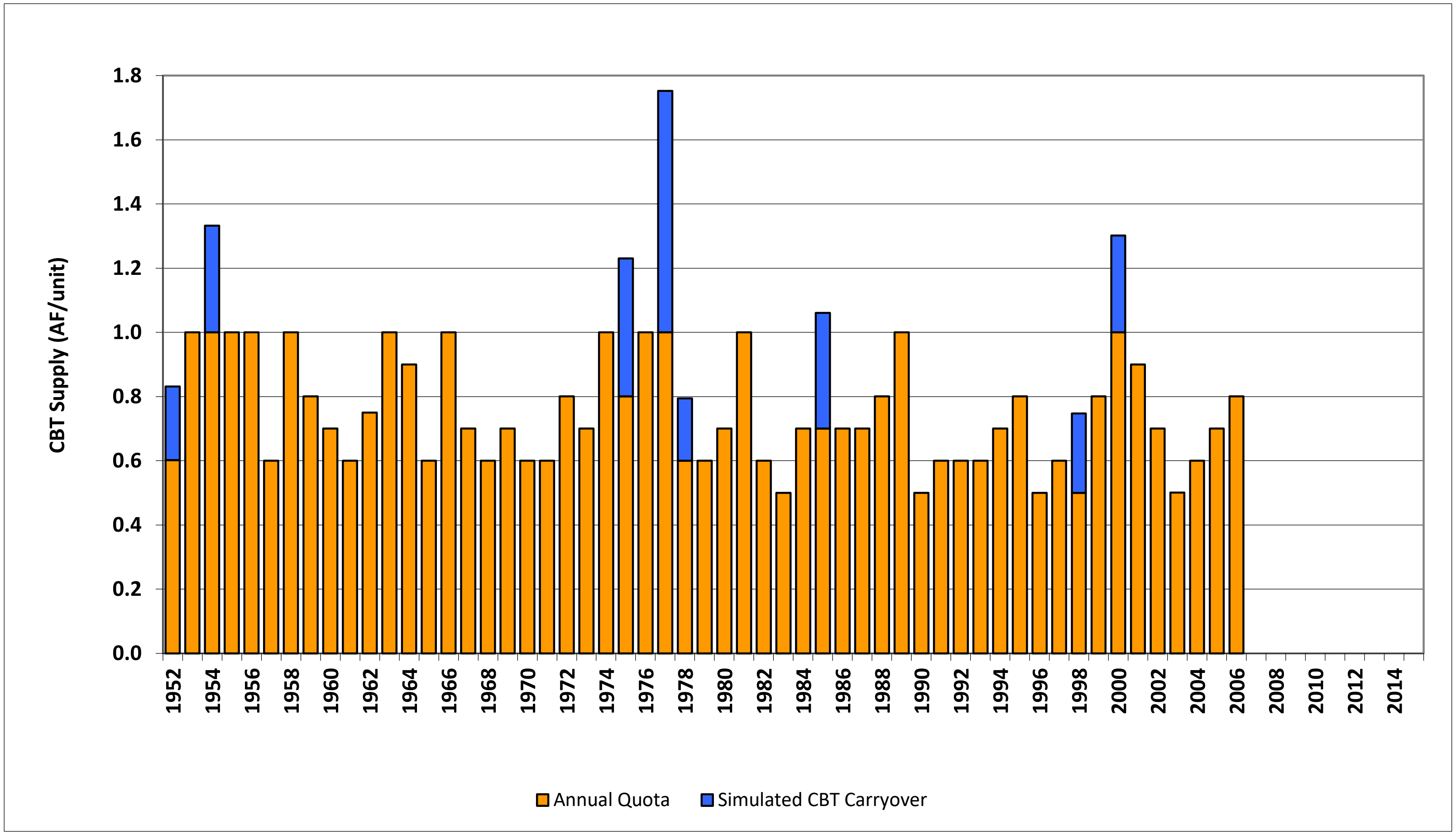

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Figure 8-15

Change in Annual Simulated Water Supply
with 668 Additional CBT Units (500 AF/y average annual yield)
City of Loveland (1952-2015)

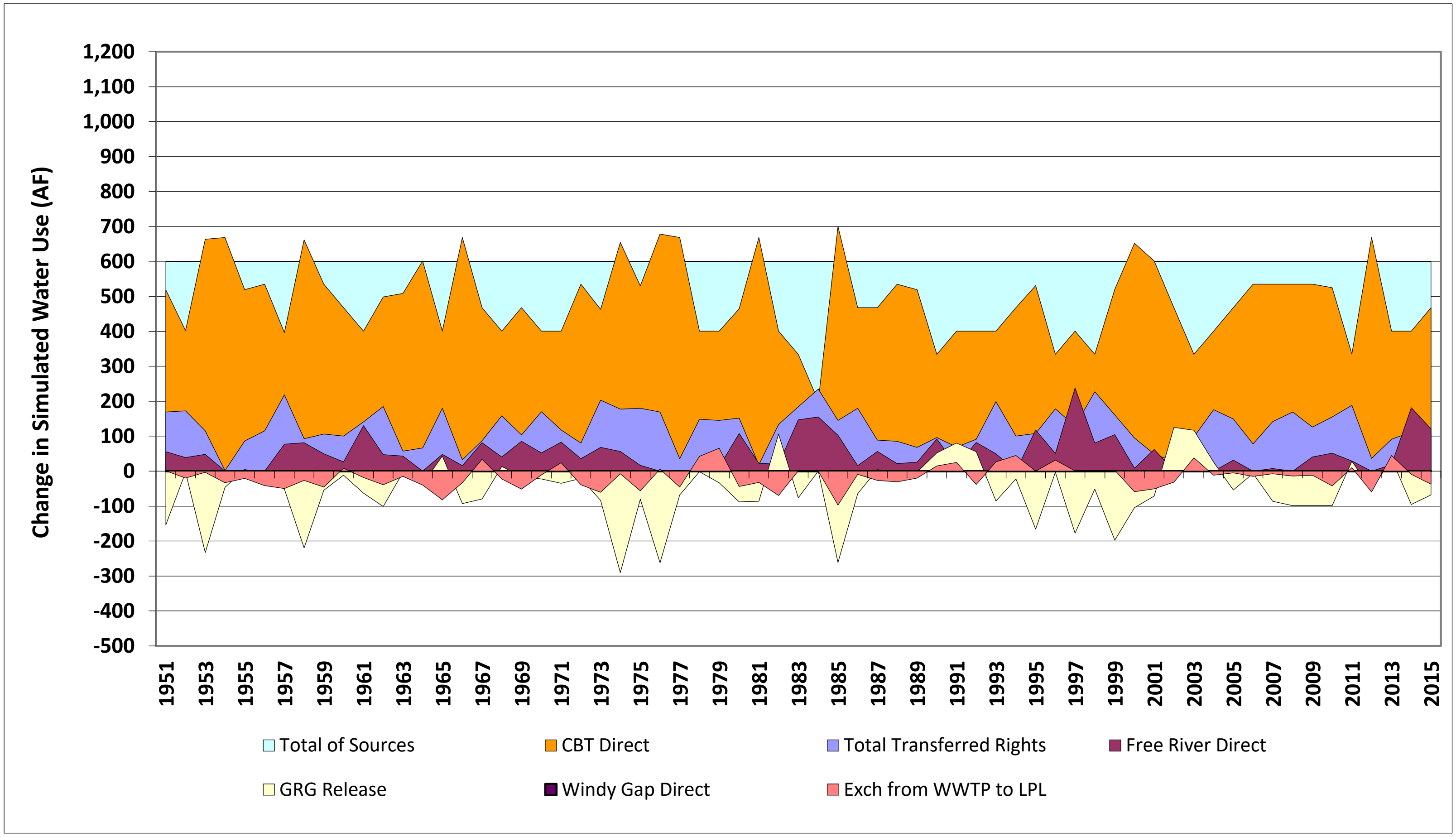

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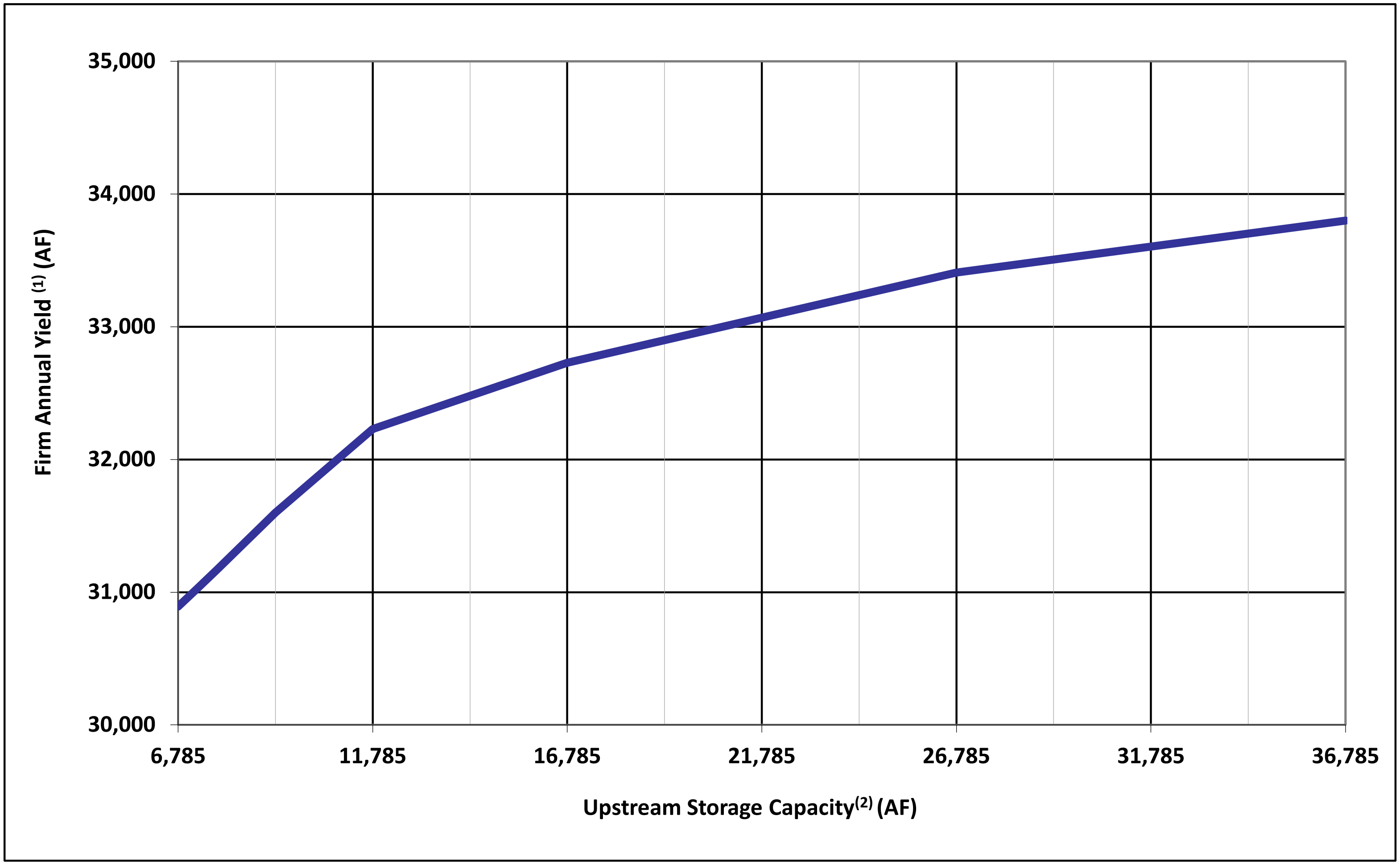
Figure 8-16

Firm Yield vs. Additional Upstream Storage
City of Loveland



Notes:

(1) Firm Yield includes municipal and augmentation demands.

(2) Includes the existing 6,785 AF of storage in Green Ridge Glade Reservoir.

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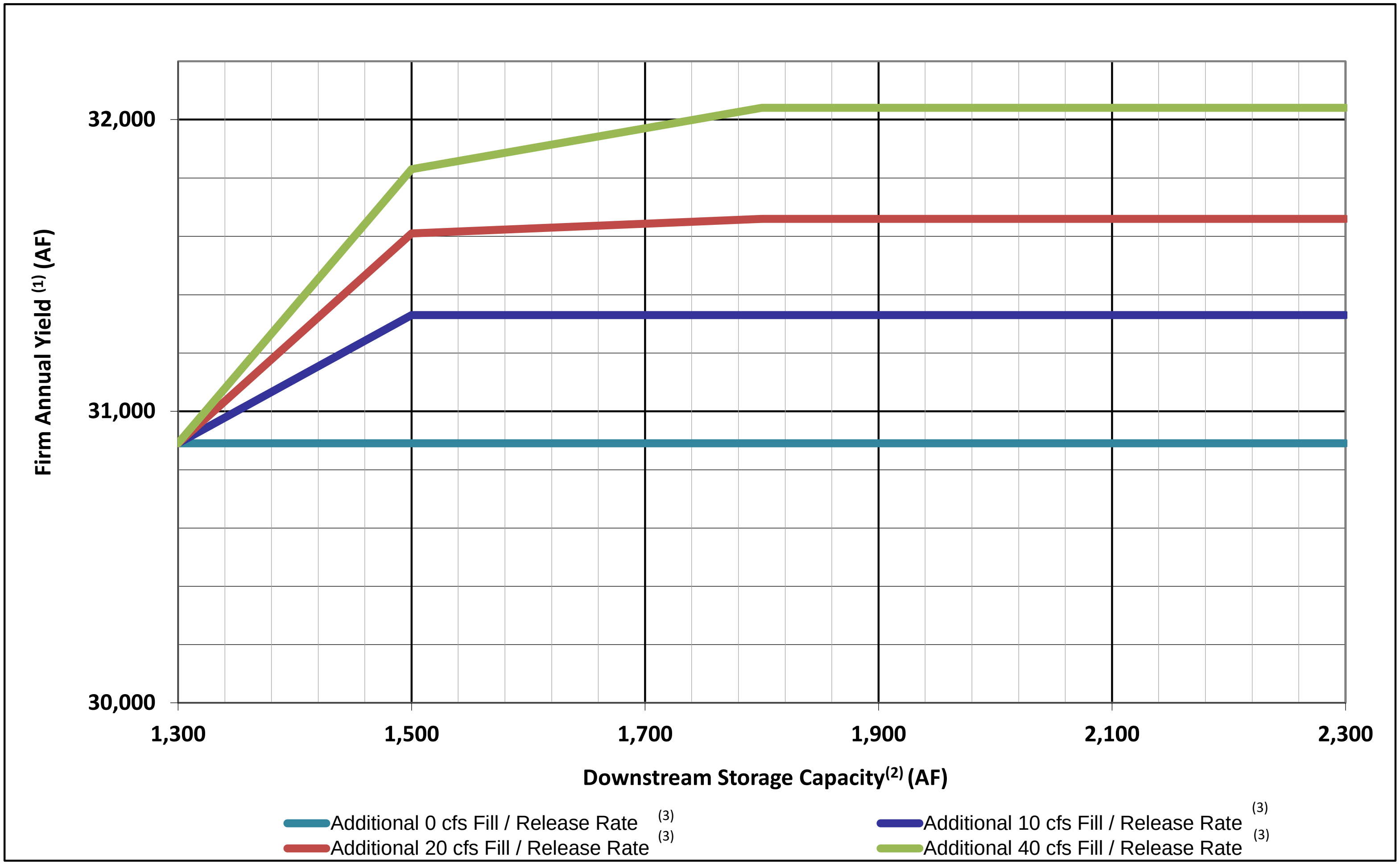
Figure 8-17

Firm Yield vs. Additional Downstream Storage
City of Loveland



Notes:

[1] Firm Yield includes municipal and augmentation demands.

[2] Includes the conservatively estimated 1,300 AF of storage in Great Western Reservoir. The inflow and outflow rates to Great Western Reservoir are still under design and could be up to 40 cfs. For the 2019 Yield Analysis, the rates were conservatively modeled at 20 cfs.

[3] The fill / release rates shown are in addition to the 20 cfs fill / release rates modeled in the Base Run (e.g. an additional 40 cfs fill/ release rate would total a 60 cfs fill / release rate).

Tables

Table 6-1

Summary of Irrigation Company Shares/Inches/Rights[1]
City of Loveland

Ditch	202A Transfers	392 Transfers	Other Transfers	Untransfered	Loveland Total	Ditch Company Total	Loveland % Total
Big Thompson Ditch & Mfg Co.	2.583	3.811	0.0	5.258	11.65	20.8	56.0%
Barnes Ditch	1306.750	24.500	0.0	0.000	1331.25	1944.2	68.5%
Chubbuck Ditch	596.600	815.001	0.0	0.000	1411.60	1590.4	88.8%
George Rist (Buckingham) Ditch	6.100	89.250	0.0	24.700	120.05	200.0	60.0%
Louden Ditch	191.500	61.547	0.0	21.955	275.00	600.0	45.8%
Rist & Goss	0.000	0.000	W-7412 & 86CW50 [2]	0.000	N/A	N/A	N/A
South Side Ditch	57.500	23.000	0.0	32.750	113.25	265.0	42.7%
Home Supply Ditch	0.000	0.000	Loveland Gard Right [3]	30.000	30.00	2001.0	1.5%

Notes:

(1) Shares changed to municipal use (rounded to nearest tenth).

(2) The W-7412 decree (adjusted to account for Loveland Ready Mix's use) equates to 3.74 cfs and 323.8 AF annually. The 86CW50 decree equates to 2.136 cfs and 117.5 AF annually, which is further limited by monthly volumetric limits.

(3) Loveland is the successor in interest to a one-fifth interest in the Gard Water Right ("Loveland Gard Right") that was historically carried in the Home Supply Ditch. The Loveland Gard Right may be diverted at 1.0 cfs from the beginning of the irrigation season until noon on July 14 and 0.5 cfs from noon on July 14 through August 31. Loveland has not yet begun using the Loveland Gard right.

Table 7-1

Summary of Exchange Potential
Big Thompson River
1951 - 2015

Average Exchange Potential (cfs)

	Between WWTP and:			**Between LaSalle Gage and:**		
Month	Olympus Tunnel	Dille Tunnel	Loveland Pipeline	Olympus Tunnel	Dille Tunnel	Loveland Pipeline
January	7.3	10.0	13.8	7.2	9.4	13.0
February	6.9	9.0	13.8	6.8	8.7	13.1
March	8.3	10.6	15.6	7.8	9.4	13.3
April	24.5	27.0	43.1	18.5	20.4	32.3
May	64.2	64.5	120.4	55.8	58.0	131.0
June	137.3	136.5	194.4	121.4	121.5	188.4
July	82.3	77.7	91.7	57.1	57.1	64.0
August	45.1	38.0	50.0	33.2	35.1	40.8
September	23.9	19.0	22.8	19.0	18.9	19.7
October	22.1	24.1	30.6	20.7	24.2	31.1
November	17.0	19.8	26.5	16.8	19.4	25.4
December	9.4	12.7	18.7	9.4	11.8	16.6

Average No. Days of Exchange Potential

	Between WWTP and:			**Between LaSalle Gage and:**		
Month	Olympus Tunnel	Dille Tunnel	Loveland Pipeline	Olympus Tunnel	Dille Tunnel	Loveland Pipeline
January	16	16	17	16	16	17
February	14	14	15	14	14	15
March	15	15	15	15	15	15
April	16	17	17	14	14	14
May	25	26	27	18	18	18
June	28	28	28	21	21	21
July	25	30	30	13	14	14
August	15	27	29	9	10	11
September	8	18	21	6	6	7
October	10	12	13	9	10	10
November	16	16	17	16	16	16
December	16	16	16	16	16	16
Annual (1951-2015)	204	235	245	166	169	173

Table 7-2

Summary of Differences in Base Run Conditions
Between 2004, 2011, and 2020 Yield Analyses

Simulated Firm Yield (AF/yr)	**2004**	**2011**	**2020**
Municipal Demand	22,440	26,800	30,300
Augmentation Demand	0	590	590
Total Supply	22,440	27,390	30,890

Yield Model Assumptions	**2004**	**2011**	**2020**
Municipal Demand Distribution Basis	1997-2001 average	2000-2010 average	2005-2015 average
Last Year of Study Period	2003	2006	2015
Call Revisions	No	Yes	Yes
LPL Capacity (cfs)	71.3	90	90
WGFP Participation (AF)	Off	7,000	10,000
Updated WG Inflows	No	Yes	Yes
WG Order	Before GRG	Last (after GRG)	Last (after GRG)
CBT Units	10,538	11,786	12,210
Municipal 6 cfs (BTDM)	When BTDM diverting	In Priority; Apr 24-Oct 30	In Priority; Apr 24-Oct 30
Domestic 3 cfs	Off	In Irrigation Priority; Apr-Oct	In Irrigation Priority; Apr-Oct
Ditch Source Order	Senior to Junior	Junior to Senior	Junior to Senior
Rist & Goss Order	After other ditches	Before other ditches	Before other ditches
392 Conditions Modeled	No	Yes	Yes
Free River Diversions	Not Reusable	Reusable	Reusable
WWTP Exchange	To GRG	Also to LPL	Also to LPL
WTP Decant	n/a	Used as source	Used as source
Loveland Gard Right Included	No	No	Yes (1)
Great Western Reservoir (AF)	0	0	1300 (2)

Notes:
(1) The Loveland Gard Right has not been implemented yet.
(2) 1,300 AF was modeled as the preliminary operational storage capacity of Great Western Reservoir.

Table 8-1

Simulated Average and Dry Year Yield[1]
City of Loveland Water Sources
(AF/yr)

	Source	1951 - 2015 Average	Dry Year (2002)
	LPL (3.44 cfs)	2,490	2,490
	Early BTDM (6cfs)	2,180	1,242
(2)	Domestic (3 cfs)	679	117
(3,4)	202A Transfers	9,458	2,720
(4)	392 Transfers	6,051	2,050
	Loveland Gard Right Transfer	156	149
	CBT	9,100	8,547
(5)	Windy Gap	6,891	0
	Total	37,005	17,315

Notes:

(1) Values reflect the simulated available yield from Loveland's water sources prior to regulation in Green Ridge Glade Reservoir, and does not include free river diversions and exchanged of reusable effluent.

(2) Diverted April - October with irrigation priority. There are unresolved issues regarding the priority and diversion season of these rights. Although it appears from the decree in CA-4862 that the rights could be diverted year-round under domestic priorities 2 and 3, until these questions are resolved, the domestic water rights are simulated using irrigation priorities 51 and 81 with a diversion season of April 1 - October 31.
The manner of simulation used in the model does not imply that the City is waiving its rights to divert year round under the domestic priorities.

(3) Includes Rist & Goss Ditch transfer yield.

(4) Loveland's pro-rata portion of historical diversions, less 15% left in ditch.

(5) Average of Loveland's portion of the simulated Windy Gap Project yield prior to regulation in Chimney Hollow Reservoir through the Windy Gap Firming Project as set forth in a 2003 Boyle Engineering report (updated in 2008) and in the NCWCD records.

Table 8-2

Simulated Average and Dry Year Base Run Yields(1)
City of Loveland
(AF/yr)

Source	Municipal Use		Augmentation and Potable Leases	
	1951 - 2015 Average	Dry Year (2002)	1951 - 2015 Average	Dry Year (2002)
Loveland Pipeline Rights[2]	5,286	3,838	16	11
202A Transfers	7,739	2,350	23	7
Rist & Goss Transfer	273	126	1	0
392 Transfers	1,528	816	5	2
Loveland Gard Right Transfer	48	98	0	0
Free River	1,420	34	4	0
WWTP Effluent[3]	1,179	3,024	213	254
CBT	9,246	8,701	27	26
GRG Release	3,581	11,313	43	51
Windy Gap (Direct)[4]	0	0	-	-
WTP Decant	-	-	26	33
Downstream Gravel Pit Release	-	-	232	205
Total	30,300	30,300	590	590

Notes:

(1) Simulated yield of Loveland's water supplies under Base Run conditions.

(2) Includes municipal and domestic rights.

(3) WWTP effluent used by exchange for municipal uses and directly for augmentation uses.

(4) No Windy Gap water is diverted directly at the Loveland Pipeline in the Base Run, but it is diverted into Green Ridge Glade Reservoir and is part of the total reservoir releases.

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Table 8-3

Difference in Simulated Annual Yields
of Loveland Water Sources
During the 2000 - 2006 Drought Period
Between the 2011 and 2020 Yield Analyses
(acre-feet)

Source	2000	2001	2002	2003	2004	2005	2006	Avg
Loveland Pipeline	0	0	0	0	0	0	0	0
Transferred Rights	1,188	833	631	1,019	1,520	1,280	1,011	1,069
Free River	51	269	4	11	0	180	0	73
WWTP Exchange	801	572	603	167	586	620	654	572
CBT Direct	-84	382	297	212	254	446	339	264
Windy Gap Direct	0	0	0	0	0	0	0	0
GRG Release	1,549	1,445	1,965	2,092	1,146	975	1,496	1,524
Total	3,505	3,500	3,500	3,500	3,505	3,500	3,500	3,502

Note:
(1) Differences computed as 2020 Model results minus 2011 Model results.

Table 8-4
Increased Firm Yield vs.
Windy Gap Firming Project Participation
and Windy Gap Units
City of Loveland

Windy Gap Firming Project Storage (af)	Windy Gap Units		
	40	45	50
0	26,130	26,130	26,130
2,000	26,820	26,820	26,820
5,000	28,580	28,580	28,580
7,000	29,900	29,900	29,900
9,000	30,610	30,780	30,780
10,000	**30,890**	31,210	31,210
11,000	31,160	31,580	31,640
12,000	31,440	31,840	32,050
14,000	31,960	32,320	32,720
16,000	32,250	32,610	32,970
20,000	32,610	32,960	33,340

Note:
Loveland owns 40 Windy Gap Units and is currently participating in the Windy Gap Firming Project in the amount of 10,000 acre-feet of storage.

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Table 8-5

Summary of Incremental Firm Yield Analysis
City of Loveland

Water Source	Added Supply	Total Yield of Additional Supply: Average Historical Yield (1) (AF/yr)	Total Yield of Additional Supply: Firm Yield (AF/yr)	Unit Yield (e.g., yield per share): Unit Average Historical Yield (AF/yr)	Unit Yield: Unit Firm Yield (AF/yr)	Unit Yield: Storage to Firm 500 AF	Unit Yield: Firming Ratio
(2) & (3) Additional Ditch Supply (shares or inches)							
Louden	41.962	500	90	11.92	2.14	1,500	3.0
Big T Ditch & Mfg.	2.644	500	180	189.11	68.08	1,210	2.4
South Side	100.520	500	150	4.97	1.49	1,430	2.9
Barnes	151.040	500	100	3.31	0.66	1,800	3.6
Chubbuck	172.337	500	50	2.90	0.29	1,720	3.4
(4) George Rist (Buckingham)	79.950	461	28	5.76	0.35	1,570	3.4
Farmers	7.817	500	160	63.97	20.47	1,370	2.7
Handy	55.202	500	110	9.06	1.99	1,600	3.2
Home Supply	50.310	500	330	9.94	6.56	680	1.4
GLIC	58.423	500	370	8.56	6.33	350	0.7
Hillsborough	4.594	500	200	108.84	43.53	1,260	2.5
Ryan Gulch Res	100%	320	240	320.00	240.00	310	1.0
(2) Additional Transmountain Supply (units)							
CBT	668.1	500	590	0.75	0.88		
WG Unfirmed	6.98	500	0	71.63	0.00		
WGFP (10,000) (5)	5.67	500	320	88.18	56.44		
WGFP (12,000) (5)	5.67	500	470	88.18	82.89		
(6) Additional Transmountain Supply (storage, AF)					Firming Ratio (7)		
WGFP	500		130		3.8		
WGFP	1000		270		3.7		
(7) Additional Storage Capacity (af)					Firming Ratio (8)		
Upstream	1,000	--	290	--	3.4		

Notes:
(1) Historical average based on 1951 - 2015 average.
(2) Increase in Loveland's current firm yield resulting from addition of 500 AF/yr of average annual yield.
(3) Ditches currently accepted into the Water Bank with proper analysis and documentation include: Louden, Big Thompson Ditch & Mfg, South Side, and George Rist (Buckingham). The City no longer accepts inches from the Barnes or Chubbuck.
(4) For the George Rist (Buckingham) Ditch, it is not possible to add the full 500 AF/yr of incremental firm yield. The City currently owns 120.05 shares of the total 200 shares leaving 79.95 shares available for future acquisition by the City; approximately 86.8 shares would be required to obtain the full 500 AF/yr of incremental firm yield. In order to model the remaining 79.95 ditch shares, the yield values were allowed to be deviate from the 10 af increment rule-of-thumb used in the yield model.
(5) Based on Loveland participation in the Windy Gap Firming Project (WGFP) at 10,000 and 12,000 AF of East Slope storage.
(6) Increase in Loveland's current firm yield resulting from additional WGFP storage participation above the current 10,000 AF level (at 40 WG units).
(7) Increase in Loveland's current firm yield resulting from addition of upstream storage.
(8) Firming ratio computed as the increased storage capacity divided by the firm yield.

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Table 8-6

Historical Simulated Available Supply and Firm Yield
Comparison of 2011 and 2020 Yield Analysis Results (1)

Simulated Ditch Company Shares			Simulated Average Available Supply				Water Bank Credit (AF/share)	Simulated Firm Yield			
			Total Supply (AF)		Unit Supply (AF/share)			Total Yield (AF)		Unit Yield (AF/share)	
Simulated Incremental Yield of 500 af of Additional Supply											
392 Transfer Conditions	2011	2020	2011	2020	2011	2020	Current	2011	2020	2011	2020
George Rist (Buckingham)	78.66	86.79	500	500	6.36	5.76	6.36	30	30	0.38	0.35
Chubbuck (2)	170.10	172.34	500	500	2.94	2.90	2.94	70	---	0.41	---
Barnes (2)	150.68	151.00	500	500	3.32	3.31	3.32	130	---	0.86	---
South Side	109.84	100.52	500	500	4.55	4.97	4.55	160	150	1.46	1.49
Big T Ditch & Mfg.	2.68	2.64	500	500	186.57	189.11	186.57	190	180	70.90	68.08
Louden	41.09	41.96	500	500	12.17	11.92	12.17	100	90	2.43	2.14

Note:
(1) The study period for the 2011 Yield Model ended in 2006 while the 2020 Yield Model study period ended in 2015.
(2) Ditches currently accepted into the Water Bank with proper analysis and documentation include: Louden, Big Thompson Ditch & Mfg, South Side, and George Rist (Buckingham).
The City no longer accepts shares from the Barnes or Chubbuck.

Table 8-7

Comparison of Simulated Annual Water Supplies
Municipal and Potable Lease Demand
Base Run and CBT Test Run
(acre-feet)

Base Run	2000	2001	2002	2003	2004	2005	2006	Avg
Loveland Pipeline	4,816	4,840	3,849	5,314	5,141	5,199	4,773	4,847
Transferred Rights	9,564	8,535	3,400	9,620	13,881	10,509	8,417	9,132
Free River	313	1,513	35	54	0	1,298	0	459
WWTP Exch / Release	1,451	1,018	3,033	1,191	1,282	1,862	2,008	1,692
CBT Direct	12,339	11,169	8,727	6,285	7,506	8,727	9,948	9,243
Windy Gap Direct	0	0	0	0	0	0	0	0
GRG Release	1,955	3,315	11,347	7,927	2,627	2,795	5,244	5,030
All Sources	30,437	30,390	30,390	30,390	30,437	30,390	30,390	30,404

CBT Test Run	2000	2001	2002	2003	2004	2005	2006	Avg
Loveland Pipeline	4,816	4,840	3,849	5,314	5,141	5,199	4,773	4,847
Transferred Rights	9,658	8,584	3,427	9,718	14,057	10,659	8,495	9,228
Free River	321	1,575	37	57	0	1,330	0	474
WWTP Exch	1,392	967	3,001	1,229	1,270	1,857	1,992	1,673
CBT Direct	12,991	11,770	9,195	6,619	7,907	9,195	10,482	9,737
Windy Gap Direct	0	0	0	0	0	0	0	0
GRG Release	1849.9	3243.2	11471.7	8044.1	2652.9	2741.0	5237.4	5,034
All Sources	31,028	30,980	30,980	30,980	31,028	30,980	30,980	30,994

Difference	2000	2001	2002	2003	2004	2005	2006	Avg
Loveland Pipeline	0	0	0	0	0	0	0	0
Transferred Rights	95	49	27	98	176	150	77	96
Free River	8	62	2	3	0	31	0	15
WWTP Exch	-59	-51	-32	38	-12	-5	-15	-19
CBT Direct	652	601	468	334	401	468	534	494
Windy Gap Direct	0	0	0	0	0	0	0	0
GRG Release	-105	-72	125	117	26	-54	-7	4
All Sources	591	590	590	590	591	590	590	590
Sources other than CBT	-61	-11	122	256	190	122	56	96

Note: The 2002 total of all sources in the Base Run (30,390 AF) is comprised of 30,300 AF for municipal use and 90 AF for potable lease use.

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Table 8-8

Simulated Additional Annual Water Supply
During 2000 - 2006 Drought Period
from Addition of 668 CBT Units
Resulting in 590 Acre-Feet of Firm Yield
(acre-feet)

Water Source	2000	2001	2002	2003	2004	2005	2006	Avg
Loveland Pipeline	0	0	0	0	0	0	0	0
Transferred Rights	95	49	27	98	176	150	77	96
Free River	8	62	2	3	0	31	0	15
WWTP Exch	-59	-51	-32	38	-12	-5	-15	-19
CBT Direct	652	601	468	334	401	468	534	494
Windy Gap Direct	0	0	0	0	0	0	0	0
GRG Release	-105	-72	125	117	26	-54	-7	4
All Sources	591	590	590	590	591	590	590	590
Sources other than CBT	-61	-11	122	256	190	122	56	96

Table 8-9

Additional Firm Yield from Alternate Water Supply Operations
Loveland Water Supply Yield Model

Run Type	Run Description	Firm Yield (AF/y)	Incremental Firm Yield (AF/y)
Base Run	Base Run with current water supply operations	**30,890**	----
Test Runs with Alternate Water Supply Operations			
Domestic	Diverted year-round with irrigation priority	31,590	700
Domestic	Diverted year-round with domestic priority	32,470	1,580
CBT	CBT used after GRG	22,690	-8,200
CBT	CBT and GRG used 50/50 in winter	29,660	-1,230
CBT	CBT & GRG used 50/50 year-round	30,850	-40
Exchange All Year	Allow exchanges all year, not just April - October	30,970	80
Windy Gap	Windy Gap used before CBT	26,910	-3,980
LIRFs	LIRFs included (1)	31,110	220
Ditch Lease	Long Term Lease of ditch shares to other entities (2)	30,810	-80
CBT Lease	Long Term Lease of CBT units to other entities (2)	30,410	-480
WG Lease	Long Term Lease of WG Units to other entities (2)	30,470	-420
Ditch Lease	Short Term Lease of ditch shares to other entities (3)	30,820	-70
CBT Lease	Short Term Lease of CBT units to other entities (3)	30,760	-130
WG Lease	Short Term Lease of WG Units to other entities (3)	30,480	-410
Alt CBT Lease	Long Term Lease of CBT units to other entities with Loveland receiving the water in 3/10 years (4)	30,760	-130
All Max Conditions	Simulated conditions that maximize the firm yield	32,910	2,020

Note:
(1) Due to the Yield Model limitations, the LIRFs are not represented at their full beneficial use.
(2) Ditch share / CBT Unit/ WG Unit lease of 500 af of average annual yield for entire study period.
(3) Ditch share / CBT Unit/ WG Unit lease of 500 af of average annual yield for 5 years during the critical 2000-2006 period.
(4) CBT Unit lease of 500 af of average annual yield for randomly selected 3 years out of every 10 years during the entire study period.

Appendix A

Final Draft

FIRST READING July 3, 2012

SECOND READING July 17, 2012

ORDINANCE #5691

AN ORDINANCE AMENDING THE LOVELAND MUNICIPAL CODE AT CHAPTER 19.04 CONCERNING WATER RIGHTS IN ACCORDANCE WITH THE 2012 RAW WATER MASTER PLAN

WHEREAS, on June 5, 2012, the City Council adopted Resolution #R-46-2012 adopting the 2012 Raw Water Master Plan of the City of Loveland; and

WHEREAS, the City Council desires to amend the Loveland Municipal Code at Chapter 19.04 in accordance with 2012 Raw Water Master Plan.

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF LOVELAND, COLORADO:

Section 1. That Section 19.04.018 of the Loveland Municipal Code is hereby amended to read as follows:

19.04.018 Value of water bank credit.

A. The value of water bank credit received in exchange for water rights transferred to the city shall be determined at the time such water bank credit is applied to satisfy the city's water rights requirements.
B. The current value of ditch water rights shall be as follows:

Ditch/Ditch Company	**Value**	
	With Payment of the Native Raw Water Storage Fee	**Without Payment of the Native Raw Water Storage Fee**
Barnes	3.32 acre-feet of water per inch	0.86 acre-feet of water per inch
Big Thompson Ditch & Manufacturing Company	186.57 acre-feet of water per share	70.90 acre-feet of water per share
Buckingham Irrigation Company (George Rist Ditch)	6.36 acre-feet of water per share	0.38 acre-feet of water per share
Chubbuck Ditch	2.94 acre-feet of water per inch	0.41 acre-feet of water per inch
Louden Irrigating Canal and Reservoir Company	12.17 acre-feet of water per share	2.43 acre-feet of water per share
South Side Ditch Company	4.55 acre-feet of water per share	1.46 acre-feet of water per share

The values set forth in the table above represent the historical average yield of each ditch as stated in Spronk Water Engineers' Raw Water Supply Yield Analysis Update dated January 2012. These values are subject to change at any time by ordinance of city council. The value of water bank credit received in exchange for transferring to the city ditch water rights not set forth in the table above shall be determined by city council by resolution on a case-by-case basis at the time such water bank credit is applied to satisfy the city's water rights requirements. The native raw water storage fee applicable to each ditch or ditch company is set forth in Section 19.04.045.

C. The current value of Colorado-Big Thompson Project units shall be one (1) acre-foot per unit.

Section 2. That Section 19.04.040 of the Loveland Municipal Code is hereby amended to read as follows:

19.04.040 Satisfying water rights requirements.

To satisfy the city's water rights requirements, the applicant must apply water bank credit in an amount sufficient to satisfy the city's water rights requirements. A minimum of fifty percent (50%) of every transaction to satisfy such requirement must include water bank credits received in exchange for Colorado-Big Thompson Project units transferred to the city or water bank credits acquired from the City by cash purchase, or by paying the cash-in-lieu price ("50% Rule"). If the acre-feet requirement resulting from the 50% Rule results in a fractional requirement of less than 0.50 acre-feet, it may be rounded down to the nearest acre-foot.

Section 3. That Chapter 19.04 of the Loveland Municipal Code is hereby amended by addition of a new Section 19.04.041 to read as follows:

19.04.041 Cash-in-lieu price.

The cash-in-lieu price shall be equal to the market price of one (1) Colorado-Big Thompson Project unit as recognized by resolution of the Loveland utilities commission, divided by the yield (in acre-feet) of one (1) Colorado-Big Thompson Unit as set forth in Section 19.04.018.B, with the resulting quotient multiplied by 1.05. Said fee shall be calculated in accordance with the resolution in effect at the time such payment is due.

Section 4. That Section 19.04.045 of the Loveland Municipal Code is hereby amended to read as follows:

19.04.045 Native raw water storage fee.

A. When credit in the city's water bank received in exchange for the transfer of ditch water rights to the city is applied to satisfy the city's water rights requirements, it shall be subject to the native raw water storage fee unless exempted under subsection B. or C. below. Said fee shall be calculated and due at the time such water bank credit is applied to satisfy the city's water rights requirements as provided in Sections 13.04.245.C and 19.04.020. The current native raw water storage fee applicable to each ditch or ditch company shall be as follows:

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Ditch / Ditch Company	Native Raw Water Storage Fee Per Acre-Foot
Barnes Ditch	$5,750
Big Thompson Ditch & Manufacturing Company	$3,530
Buckingham Irrigation Company (George Rist Ditch)	$7,400
Chubbuck Ditch	$7,400
Louden Irrigating Canal and Reservoir Company	$6,850
South Side Ditch Company	$6,770

The native raw water storage fees set forth in the table above are taken from the city's 2012 Raw Water Master Plan, adopted by city council by resolution on June 5, 2012. These values are subject to change at any time by ordinance of city council. The native raw water storage fee applicable to water bank credit received in exchange for transferring to the city ditch water rights not set forth in the table above shall be determined by city council by resolution on a case-by-case basis at the time such water bank credit is applied to satisfy the city's water rights requirements. The native raw water storage fee shall not apply to water bank credits received in exchange for the transfer of Colorado-Big Thompson Project units to the city or water bank credits acquired from the city by cash payment or to payments of the cash-in-lieu price.

B. When credit in the city's water bank received in exchange for the transfer of ditch water rights to the city on or before July 20, 1995 is applied to satisfy the city's water rights requirements, it shall not be subject to the native raw water storage fee, notwithstanding the provisions of subsection A. above.

C. When water bank credit is applied to satisfy the city's water rights requirements, the person applying the credit may choose not to pay the native raw water storage fee set forth above, in which case the value of the credit shall be decreased in accordance with the table set forth in subsection B. of Section 19.04.018.

Section 5. That as provided in City Charter Section 4-9(a)(7), this Ordinance shall be published by title only by the City Clerk after adoption on second reading unless the Ordinance has been amended since first reading in which case the Ordinance shall be published in full or the amendments shall be published in full. This Ordinance shall be in full force and effect ten days after its final publication, as provided in City Charter Section 4-8(b).

ADOPTED this 17th day of July, 2012.

Cecil A. Gutierrez, Mayor

ATTEST:

City Clerk Deputy

CITY OF LOVELAND SEAL COLORADO

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APPROVED AS TO FORM:

[signature]
Assistant City Attorney

I, Teresa G. Andrews, City Clerk of the City of Loveland, Colorado, hereby certify that the above and foregoing Ordinance was introduced at a regular (or special) meeting of the City Council, held on July 3, 2012 and was initially published in the Loveland Daily Reporter-Herald, a newspaper published within the city limits in full on July 7, 2012 and by title except for parts thereof which were amended after such initial publication which parts were published in full in said newspaper on July 21, 2012.

[signature]
City Clerk

Effective Date: July 31, 2012

Appendix B

Final Draft

SUMMARY OF WATER RIGHTS DEDICATION AND REQUIREMENTS

The following water rights requirements are set forth in Ordinance #5691, which was adopted on July 17, 2012. The provisions of Ordinance #5691 went into effect July 31, 2012. This document summarizes the City's water rights requirements; it is not intended to replace Chapter 19.04 of the Loveland Municipal Code. Any conflicts should be resolved in favor of Chapter 19.04, available at the City's website at: http://www.cityofloveland.org/government/municipal-code or http://online.encodeplus.com/regs/loveland-co/doc-viewer.aspx#secid-3743

Satisfying the Water Rights Requirement

- The City requires that at least 50% of every raw water payment be made with Colorado-Big Thompson units (CBT), existing Cash Credits in the Water Bank, or Cash-In-Lieu (CIL). See "50% Rule" set forth in Municipal Code Section 19.04.040 for more details.
- Current CBT value: 1 CBT unit = 1.00 acre-foot (may be subject to change)

Native Water:

- No native ditch water rights shall be accepted by the City without approval by the Loveland Utility Commission (LUC).
- These values may be subject to change at any time at the City's sole discretion.

Native Ditch Right	Value WITH Payment of Native Raw Water Storage Fee(1)	Native Raw Water Storage Fee per Acre-foot	Value WITHOUT Payment of Native Raw Water Storage Fee(2)
Barnes Ditch(3)	3.32 acre-feet per inch	$5,750	0.86 acre-feet per inch
Big Thompson Ditch & Manufacturing Company	186.57 acre-feet per share	$3,530	70.90 acre-feet per share
Buckingham Irrigation Company (George Rist Ditch)	6.36 acre-feet per share	$7,400	0.38 acre-feet per share
Chubbuck Ditch(3)	2.94 acre-feet per inch	$7,400	0.41 acre-feet per inch
Louden Irrigating Canal and Reservoir Company	12.17 acre-feet per share	$6,850	2.43 acre-feet per share
South Side Ditch Company	4.55 acre-feet per share	$6,770	1.46 acre-feet per share

(1)(2) Average yield(1) and firm yield(2) for ditch credits as determined by the 2011 Spronk Report
(3) The City no longer accepts deposits of Barnes and Chubbuck Ditch. Those values only apply to ditch rights already dedicated to the City's water bank.

- The Native Raw Water Storage Fee is applicable to all native water deposited in the Water Bank on or after July 21, 1995.
- The above table (column 3) indicates the storage fees associated with each ditch. Those fees are due when the water bank credit is applied to development, not when the shares are put into the Water Bank.

Cash-in-Lieu (CIL) Price:

- CIL Price = Market Price of one CBT unit, as set by the LUC, divided by the yield of one CBT unit as set forth in Section 19.04.018.C (see "Current CBT Value," above).
- Credit in the City's water bank may not be acquired from the City by cash purchase on or after January 1, 2006.
- Call Nathan Alburn at (970) 962-3718 for the current CIL Price. This Price may be subject to change at any time.

Appendix C

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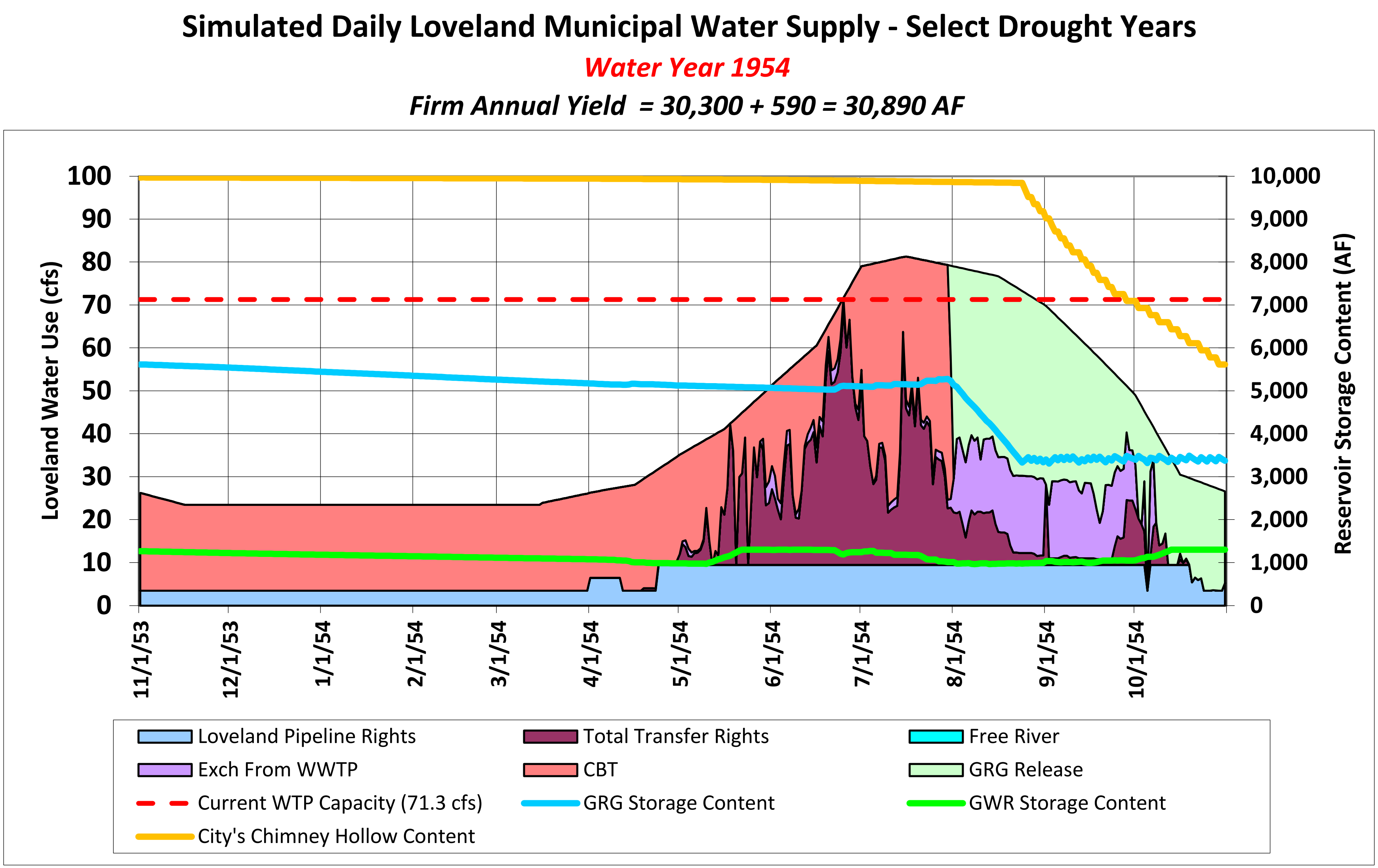

Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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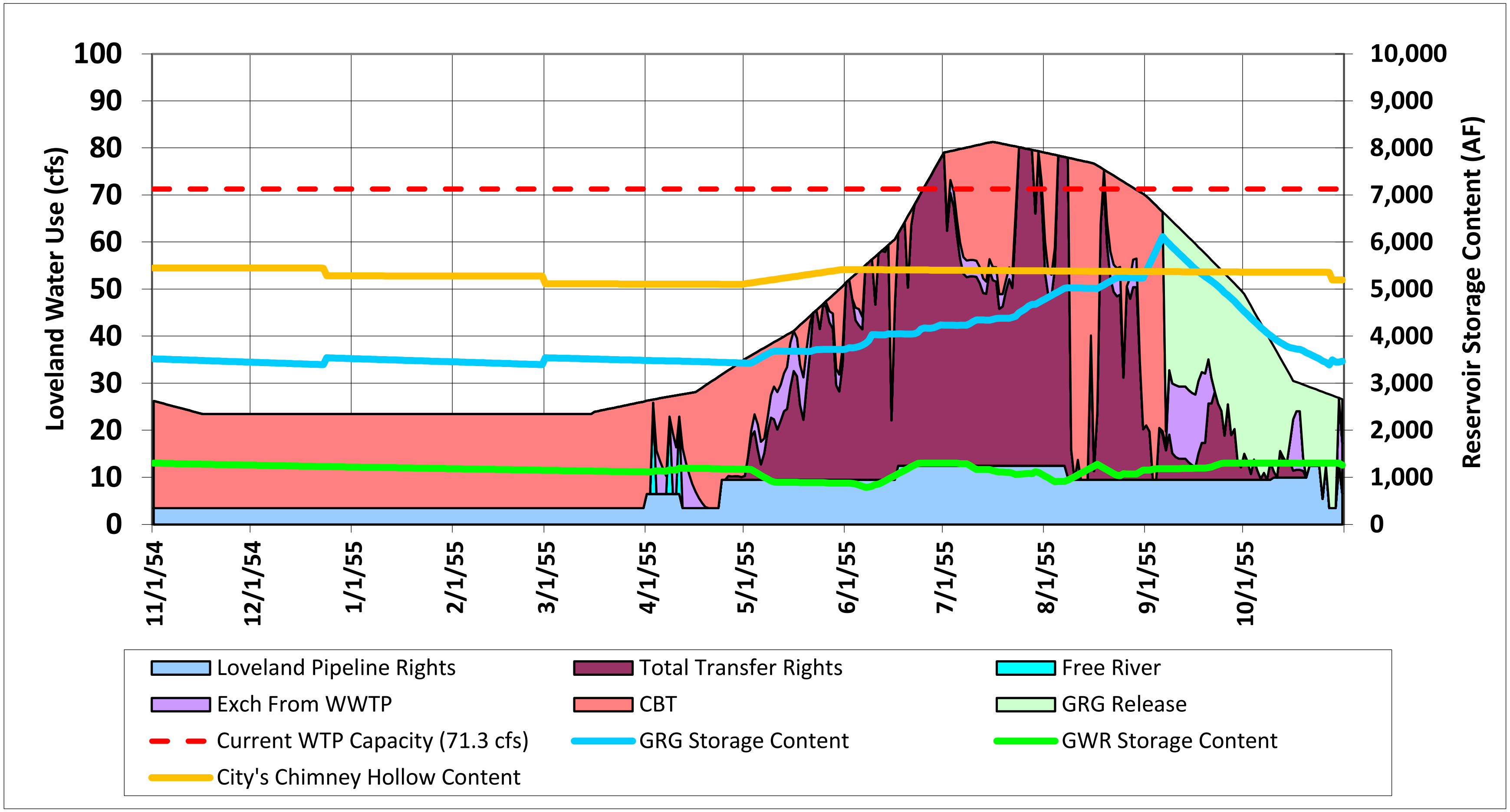
Simulated Daily Loveland Municipal Water Supply - Select Drought Years

Water Year 1955

Firm Annual Yield = 30,300 + 590 = 30,890 AF



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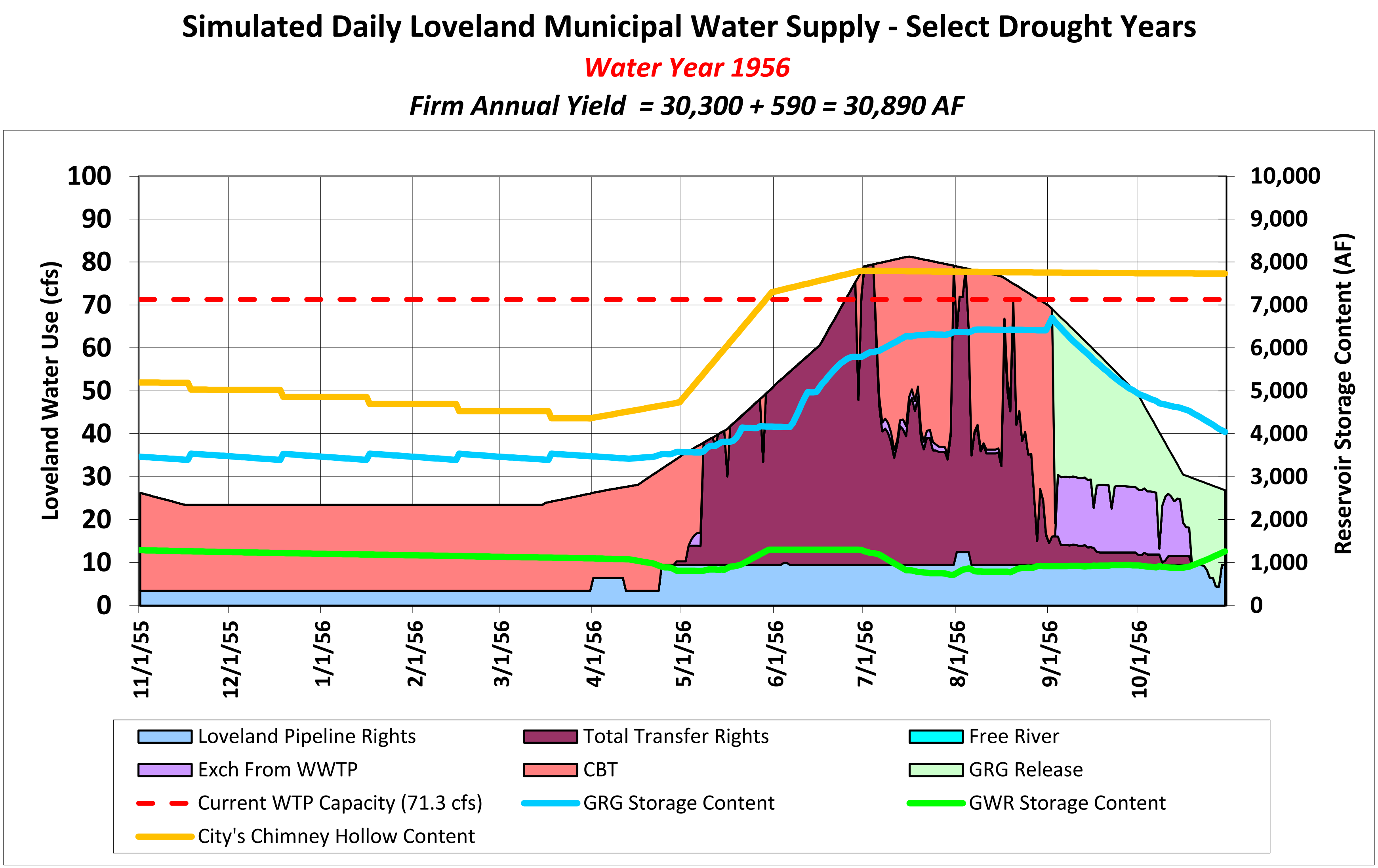

Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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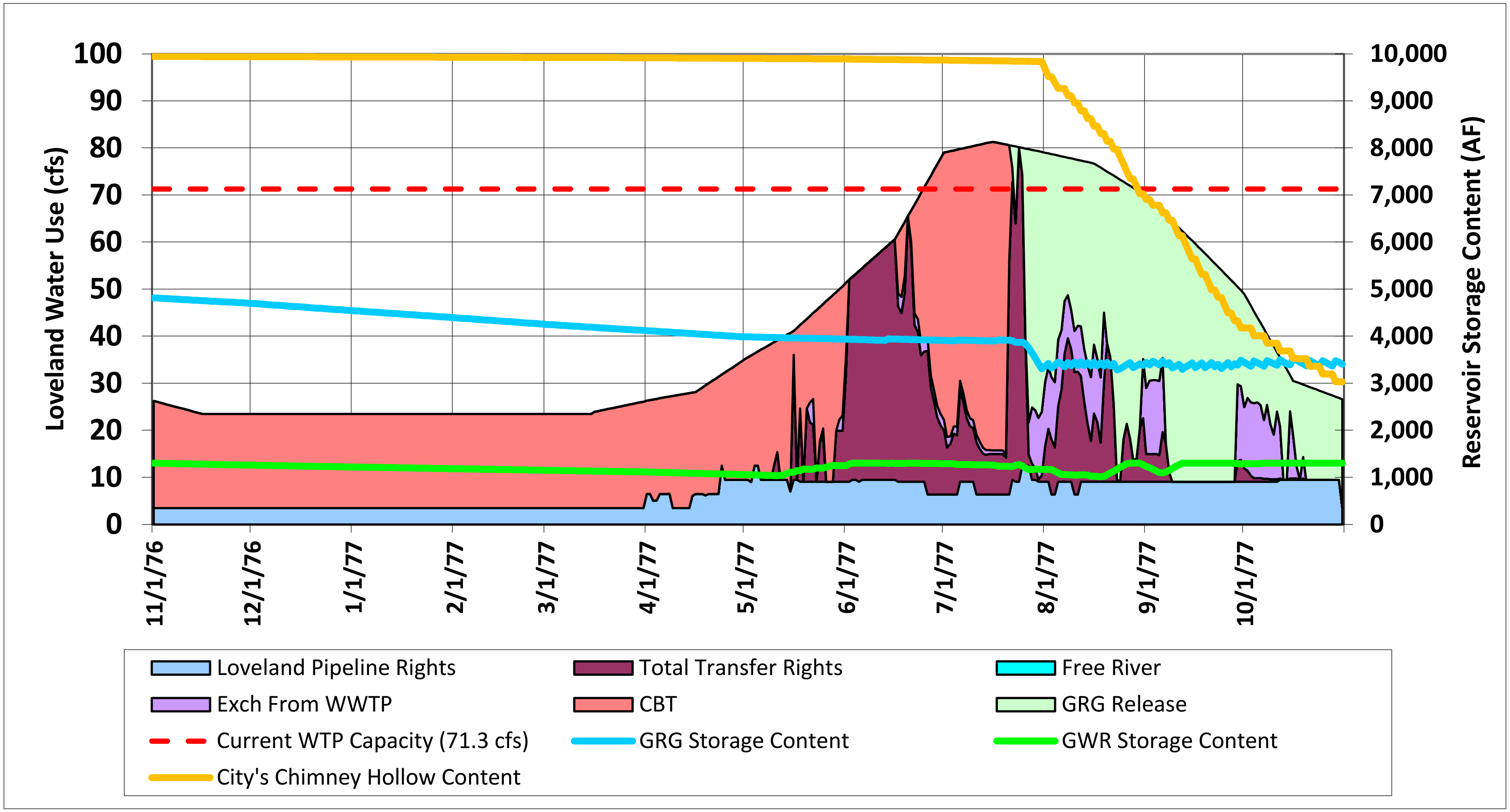
Simulated Daily Loveland Municipal Water Supply - Select Drought Years

Water Year 1977

Firm Annual Yield = 30,300 + 590 = 30,890 AF



Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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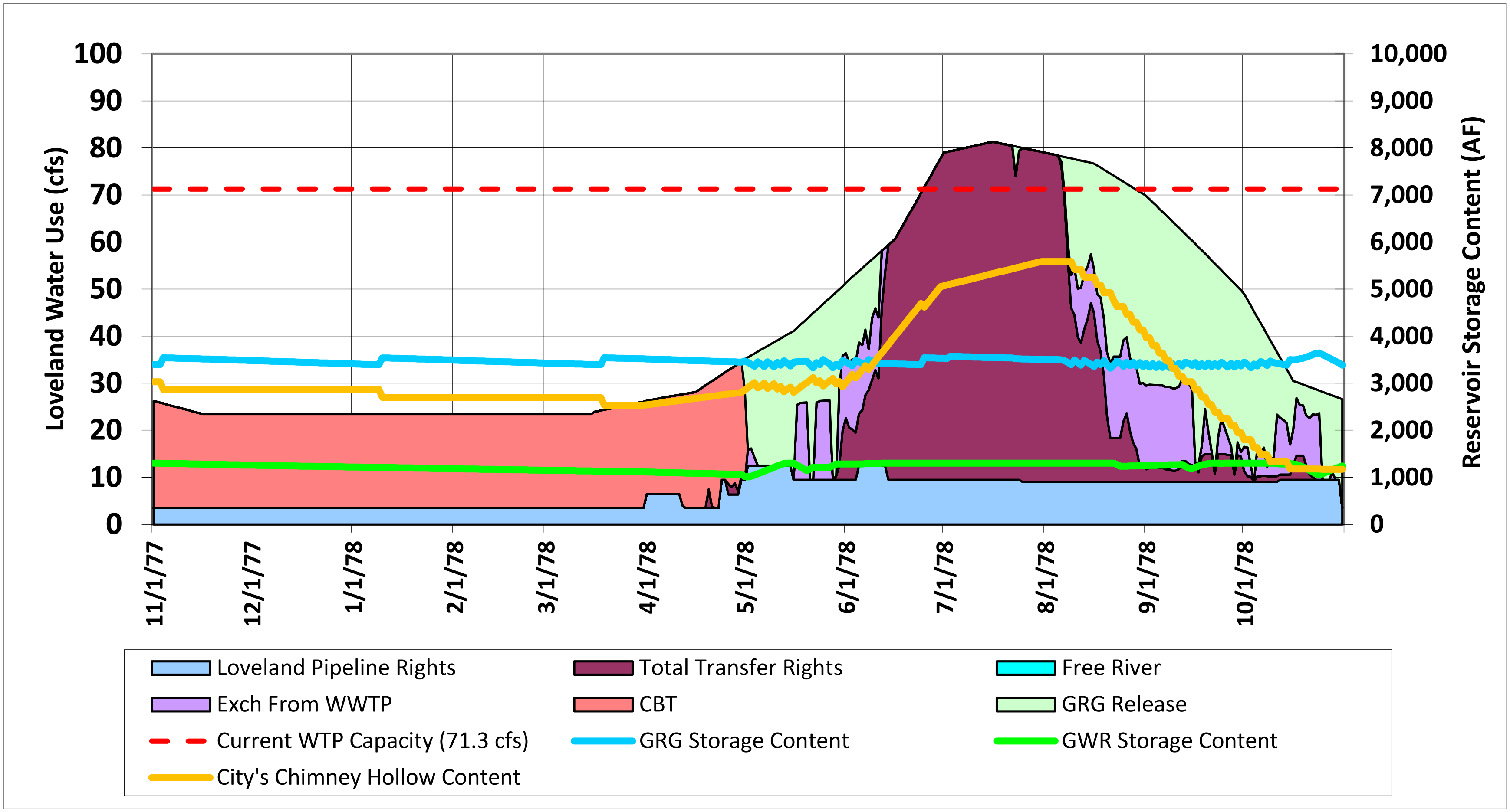
Simulated Daily Loveland Municipal Water Supply - Select Drought Years

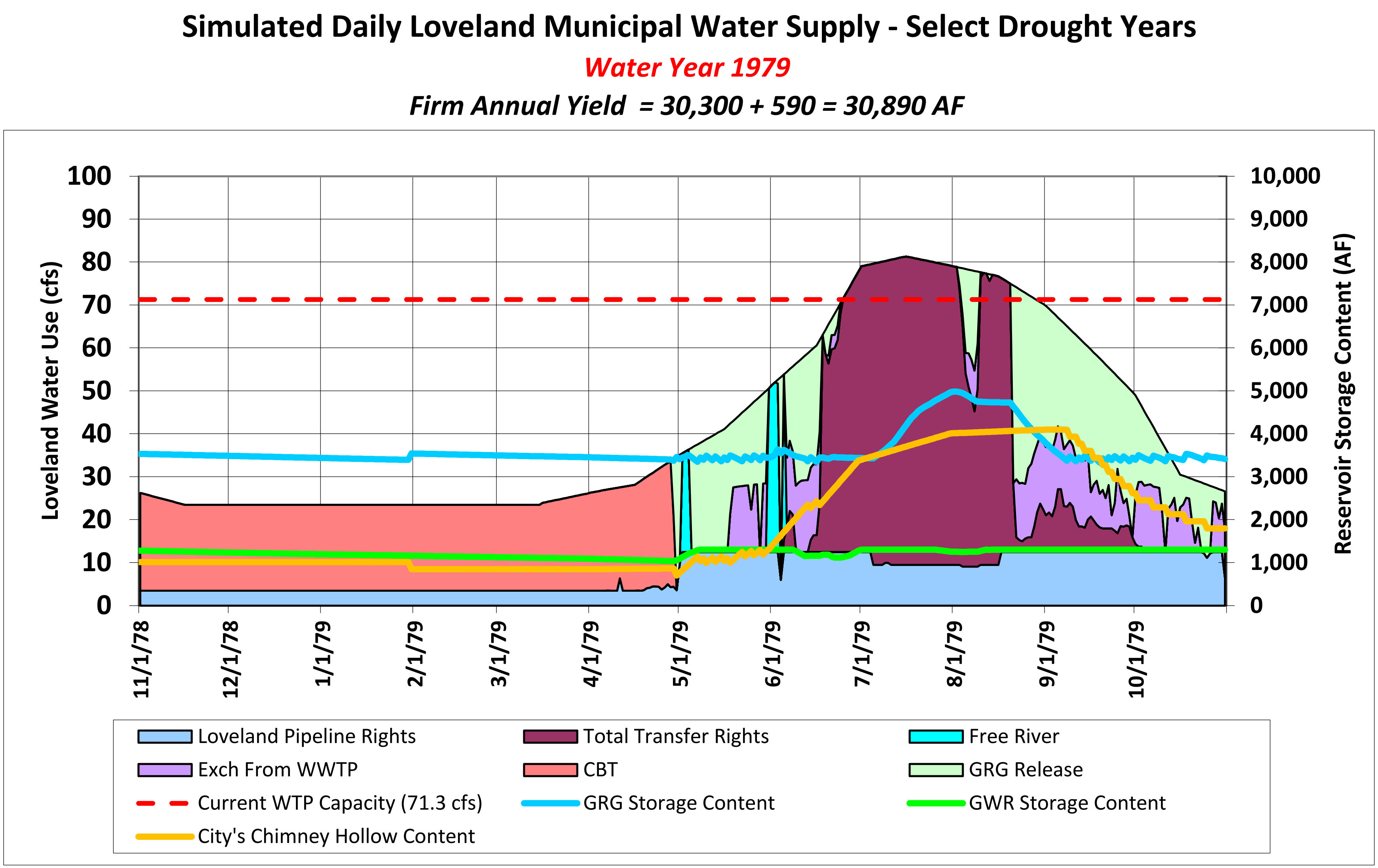
Water Year 1978

Firm Annual Yield = 30,300 + 590 = 30,890 AF



Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

Final Draft



Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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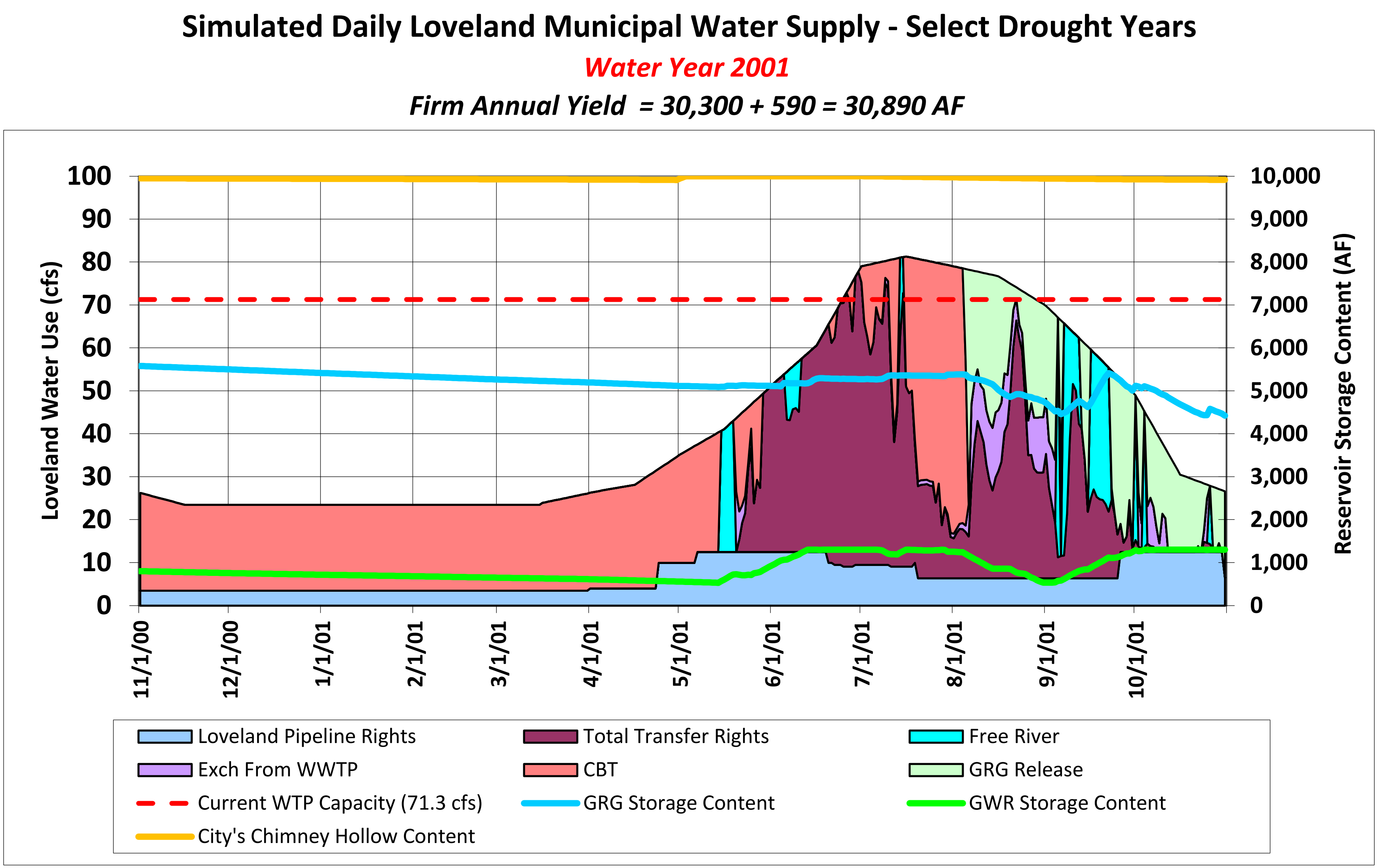

Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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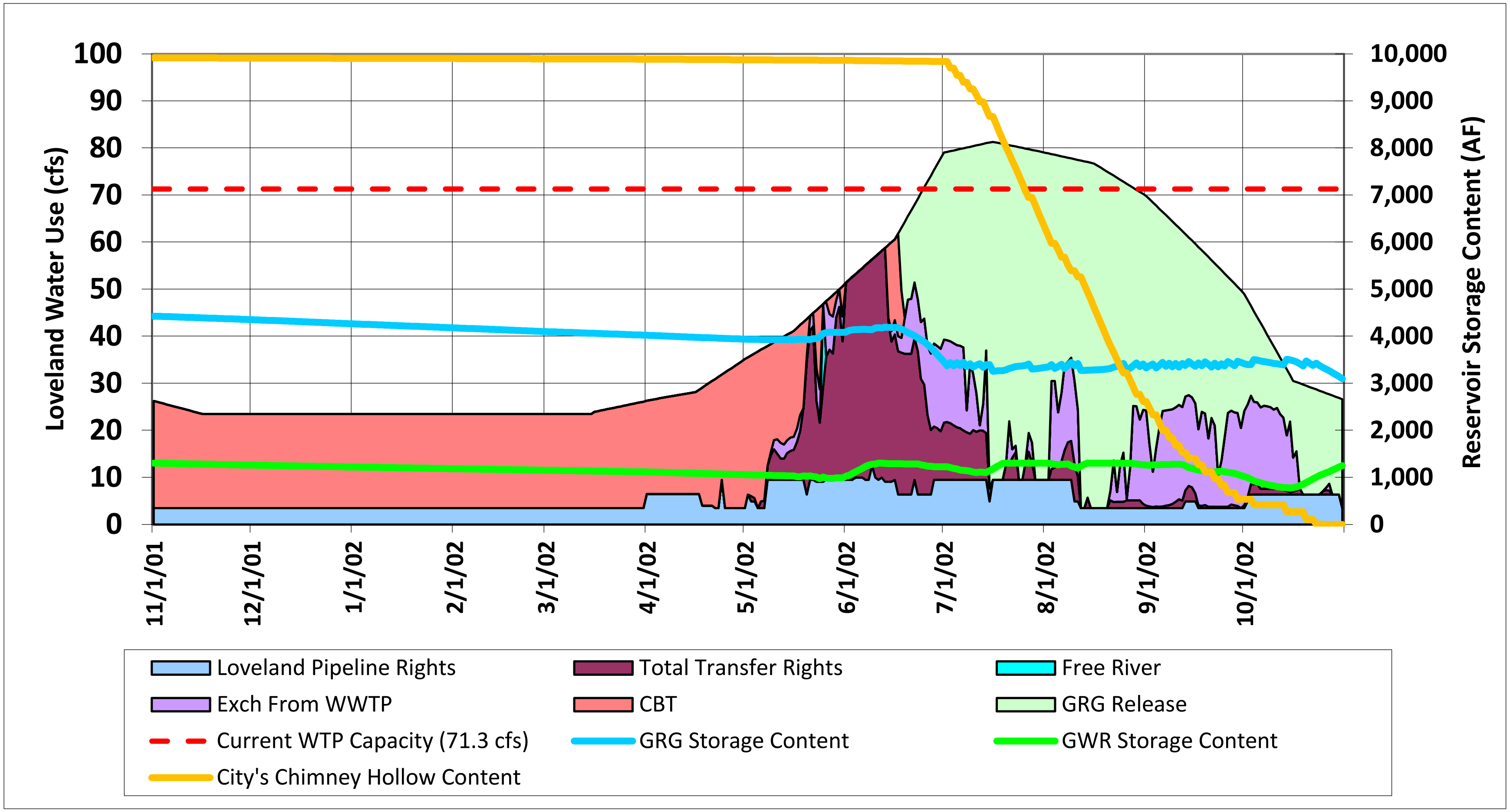
Simulated Daily Loveland Municipal Water Supply - Select Drought Years

Water Year 2002

Firm Annual Yield = 30,300 + 590 = 30,890 AF



Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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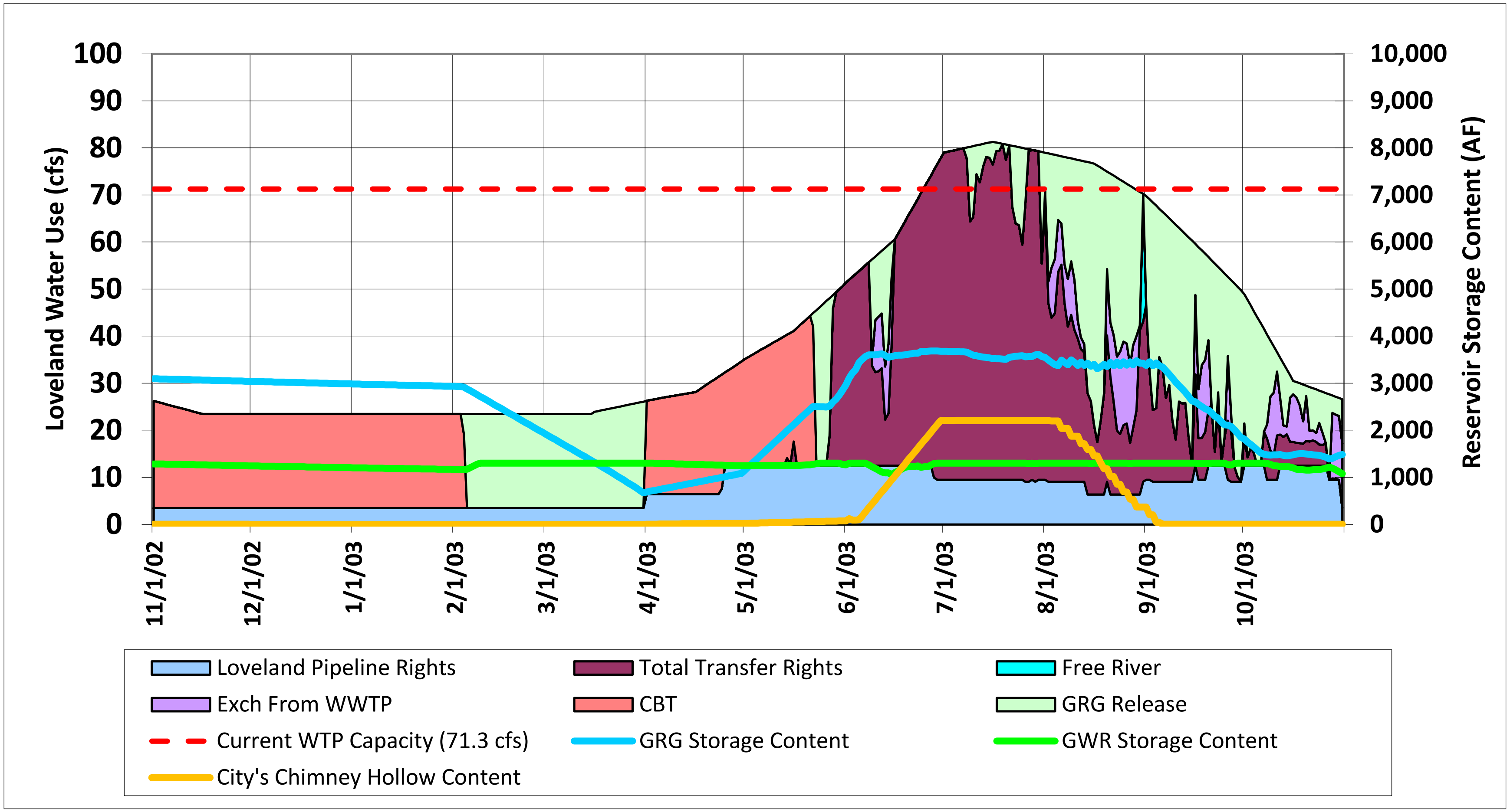
Simulated Daily Loveland Municipal Water Supply - Select Drought Years

Water Year 2003

Firm Annual Yield = 30,300 + 590 = 30,890 AF



Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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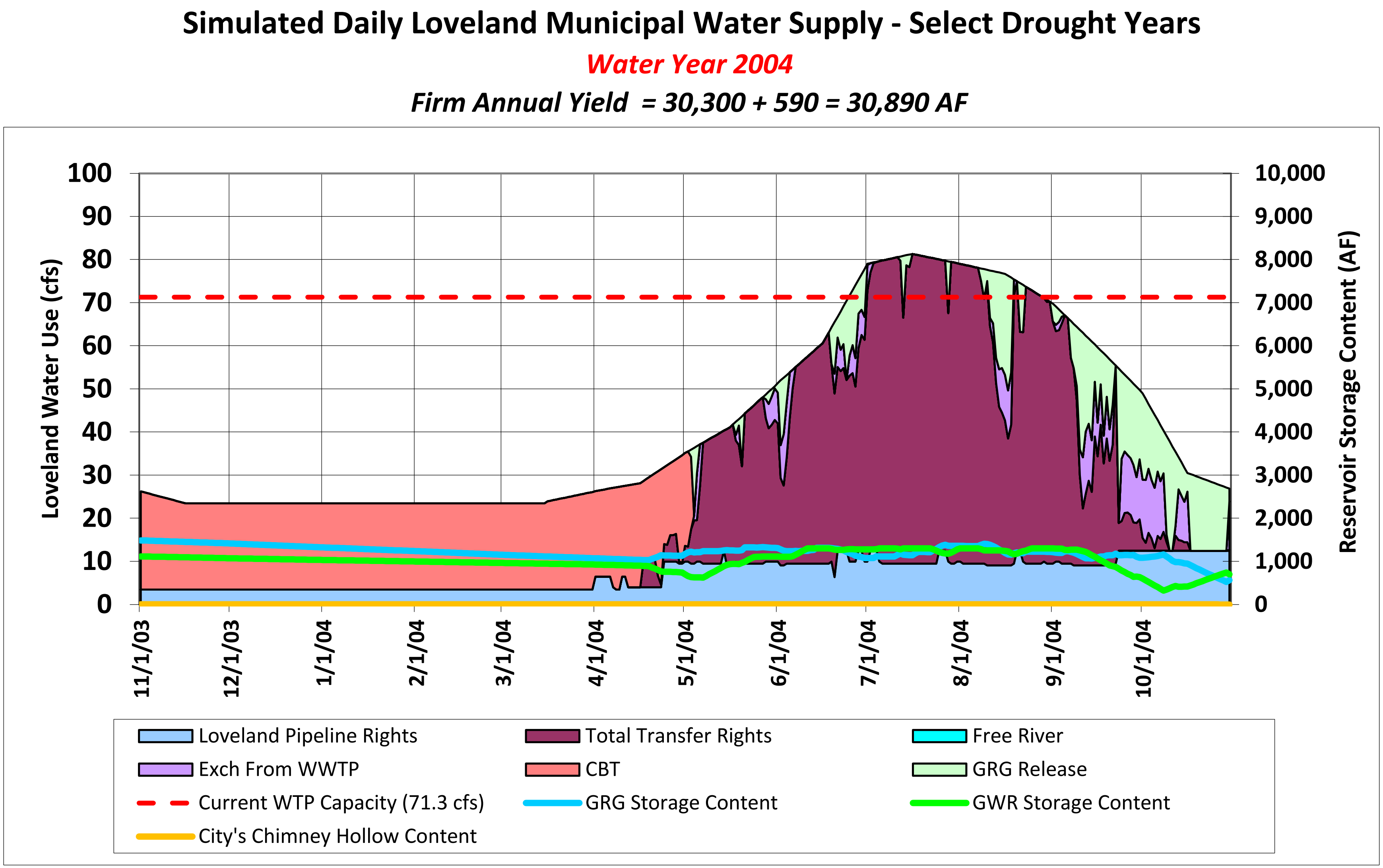

Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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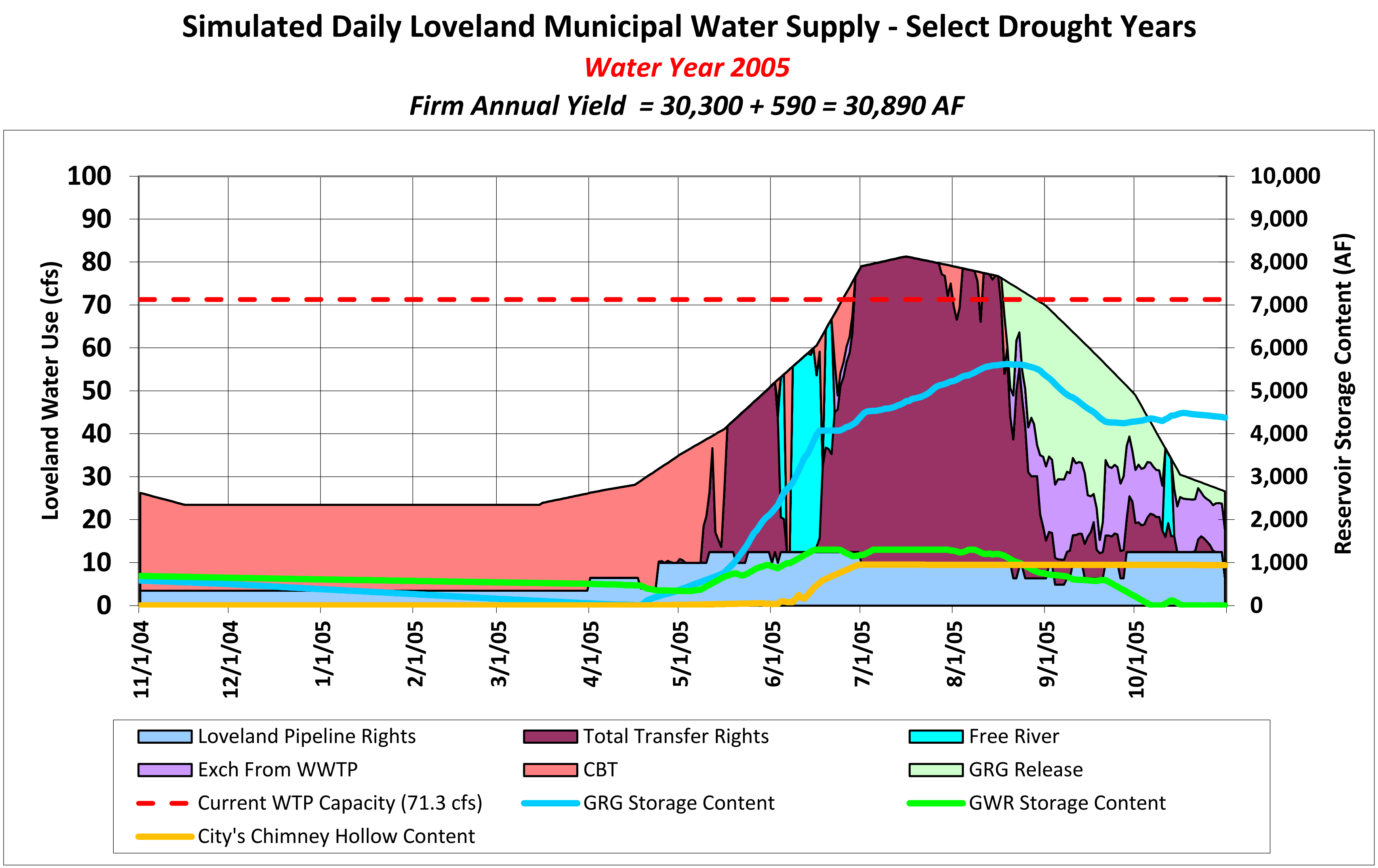

Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

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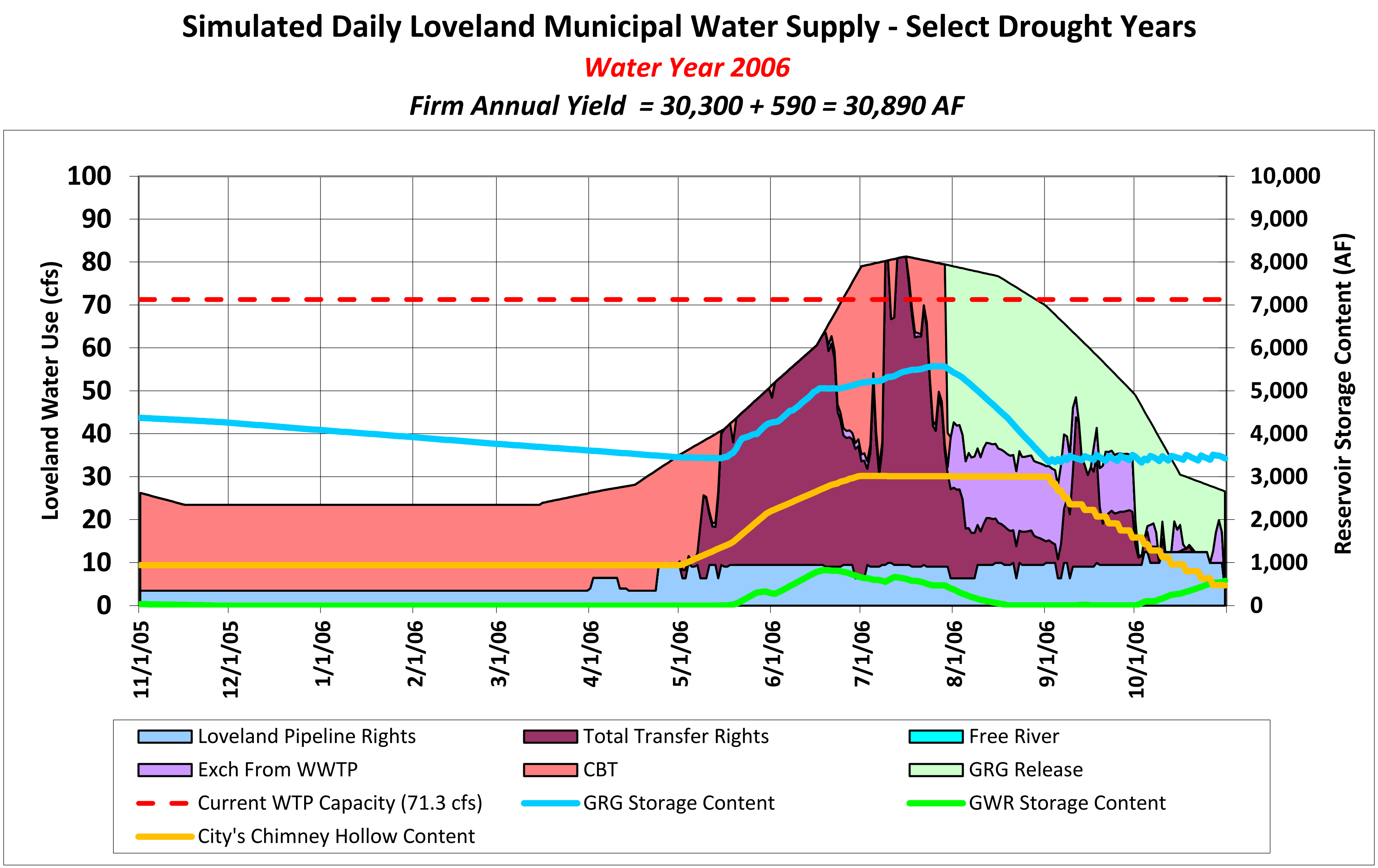
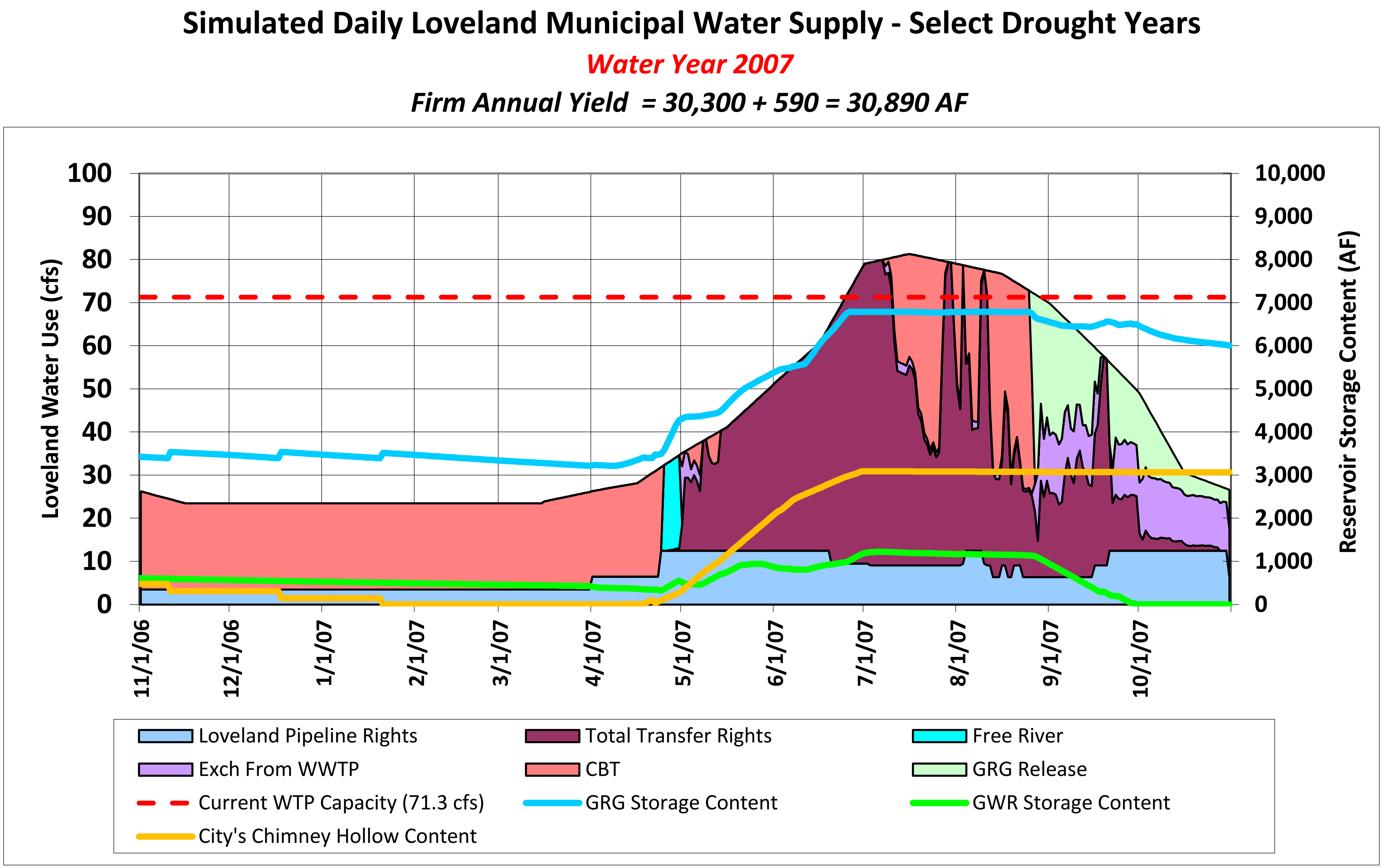


Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

Final Draft



Current Run = 2020 BASE RUN, All Municipal and Augmentation Demands Met

RESOLUTION #R-46-2012

A RESOLUTION ADOPTING THE 2012 RAW WATER MASTER PLAN OF THE CITY OF LOVELAND AND AMENDING THE 2005 COMPREHENSIVE MASTER PLAN BY ADDITION OF THE 2012 RAW WATER MASTER PLAN AS A FUNCTIONAL (COMPONENT) PLAN ELEMENT

WHEREAS, on November 15, 2005 by Resolution #R-95-2005, the City Council of the City of Loveland adopted the City's first Raw Water Master Plan ("2005 Raw Water Master Plan") to be used by the City to develop and compare policy options to meet the future raw water needs of the City; and

WHEREAS, Water and Power Department staff prepared an update to the 2005 Raw Water Master Plan, the draft of which was referred to throughout 2011 as the 2011 Raw Water Master Plan ("2011 Raw Water Master Plan"); and

WHEREAS, on October 19, 2011, the Loveland Utilities Commission adopted a motion recommending that the City Council adopt the 2011 Raw Water Master Plan; and

WHEREAS, on October 27, 2011, the Construction Advisory Board adopted a motion recommending that the City Council adopt the 2011 Raw Water Master Plan; and

WHEREAS, on November 14, 2011, the Planning Commission adopted a resolution recommending that the City Council amend the 2005 Comprehensive Master Plan by addition of the 2011 Raw Water Master Plan as a functional (component) plan element, and making certain findings in support of that recommendation as required by Section 6.0 of the 2005 Comprehensive Master Plan; and

WHEREAS, the 2011 Raw Water Master Plan was subsequently modified to reflect several substantive changes recommended by the City Council at a study session held on December 13, 2011, and was retitled the "2012 Raw Water Master Plan"; and

WHEREAS, on January 17, 2012, the City Council considered the 2012 Raw Water Master Plan and directed staff to address certain questions and an alternative proposal, and take the 2012 Raw Water Master Plan and the alterative proposal back through the advisory boards and public process for further consideration and comment; and

WHEREAS, on April 4, 2012, the Loveland Utilities Commission held a special meeting to receive public comment on the 2012 Raw Water Master Plan and the alternative proposal; and

WHEREAS, on April 25, 2012, the Construction Advisory Board adopted a second motion recommending that the City Council adopt the 2012 Raw Water Master Plan; and

WHEREAS, on May 16, 2012, the Loveland Utilities Commission adopted a second motion recommending that the City Council adopt the 2012 Raw Water Master Plan; and

WHEREAS, the City Council desires to adopt the 2012 Raw Water Master Plan and amend the 2005 Comprehensive Master Plan by addition of the 2012 Raw Water Master Plan as in the best interest of the citizens and rate payers of the City of Loveland.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF LOVELAND, COLORADO:

Section 1. That the 2012 Raw Water Master Plan, a copy of which is on file with the Loveland City Clerk, is hereby adopted and shall be used by the City to develop and compare policy options to meet the future raw water needs of the City.

Section 2. That the City Council hereby adopts and incorporates by reference the findings set forth in Resolution #11-02 adopted by the Planning Commission on November 14, 2011.

Section 3. That the 2005 Comprehensive Master Plan is hereby amended by the addition of the 2012 Raw Water Master Plan as a functional (component) plan element.

Section 4. That this Resolution shall take effect as of the date of its adoption.

ADOPTED this 5th day of June, 2012.

Cecil A. Gutierrez, Mayor

ATTEST:

City Clerk

CITY OF LOVELAND SEAL COLORADO

APPROVED AS TO FORM:

Assistant City Attorney

APPENDIX III

Summary of
Water Rights Requirements
for Development

SUMMARY OF WATER RIGHTS REQUIREMENTS FOR DEVELOPMENT

The following water rights requirements are set forth in Ordinance #5691, which was adopted on July 17, 2012. The provisions of Ordinance #5691 went into effect July 31, 2012. This document summarizes the City's water rights requirements; it is not intended to replace Chapter 19.04 of the Loveland Municipal Code. Any conflicts should be resolved in favor of Chapter 19.04, available at the City's website at:

http://www.cityofloveland.org/government/municipal-code or

http://online.encodeplus.com/regs/loveland-co/doc-viewer.aspx#secid-3743

Satisfying the Water Rights Requirement

- The City requires that at least 50% of every raw water payment be made with Colorado Big Thompson units (CBT), existing Cash Credits in the Water Bank, or Cash-In-Lieu (CIL). See "50% Rule" set forth in Municipal Code Section 19.04.040 for more details.
- Current CBT value: 1 CBT unit = 1.00 acre-foot (may be subject to change)

Native Water:

- No native ditch water rights shall be accepted by the City without approval by the Loveland Utility Commission (LUC).
- These values may be subject to change at any time at the City's sole discretion.

Native Ditch Right	Value WITH Payment of Native Raw Water Storage Fee (1)	Native Raw Water Storage Fee per Acre-foot	Value WITHOUT Payment of Native Raw Water Storage Fee (2)
Barnes Ditch (3)	3.32 acre-feet per inch	$5,750	0.86 acre-feet per inch
Big Thompson Ditch & Manufacturing Company	186.57 acre-feet per share	$3,530	70.90 acre-feet per share
Buckingham Irrigation Company (George Rist Ditch)	6.36 acre-feet per share	$7,400	0.38 acre-feet per share
Chubbuck Ditch (3)	2.94 acre-feet per inch	$7,400	0.41 acre-feet per inch
Louden Irrigating Canal and Reservoir Company	12.17 acre-feet per share	$6,850	2.43 acre-feet per share
South Side Ditch Company	4.55 acre-feet per share	$6,770	1.46 acre-feet per share

(1)(2) Average yield (1) and firm yield (2) for ditch credits as determined by the 2011 Spronk Report

(3) The City no longer accepts deposits of Barnes and Chubbuck Ditch. Those values only apply to ditch rights already dedicated to the City's water bank.

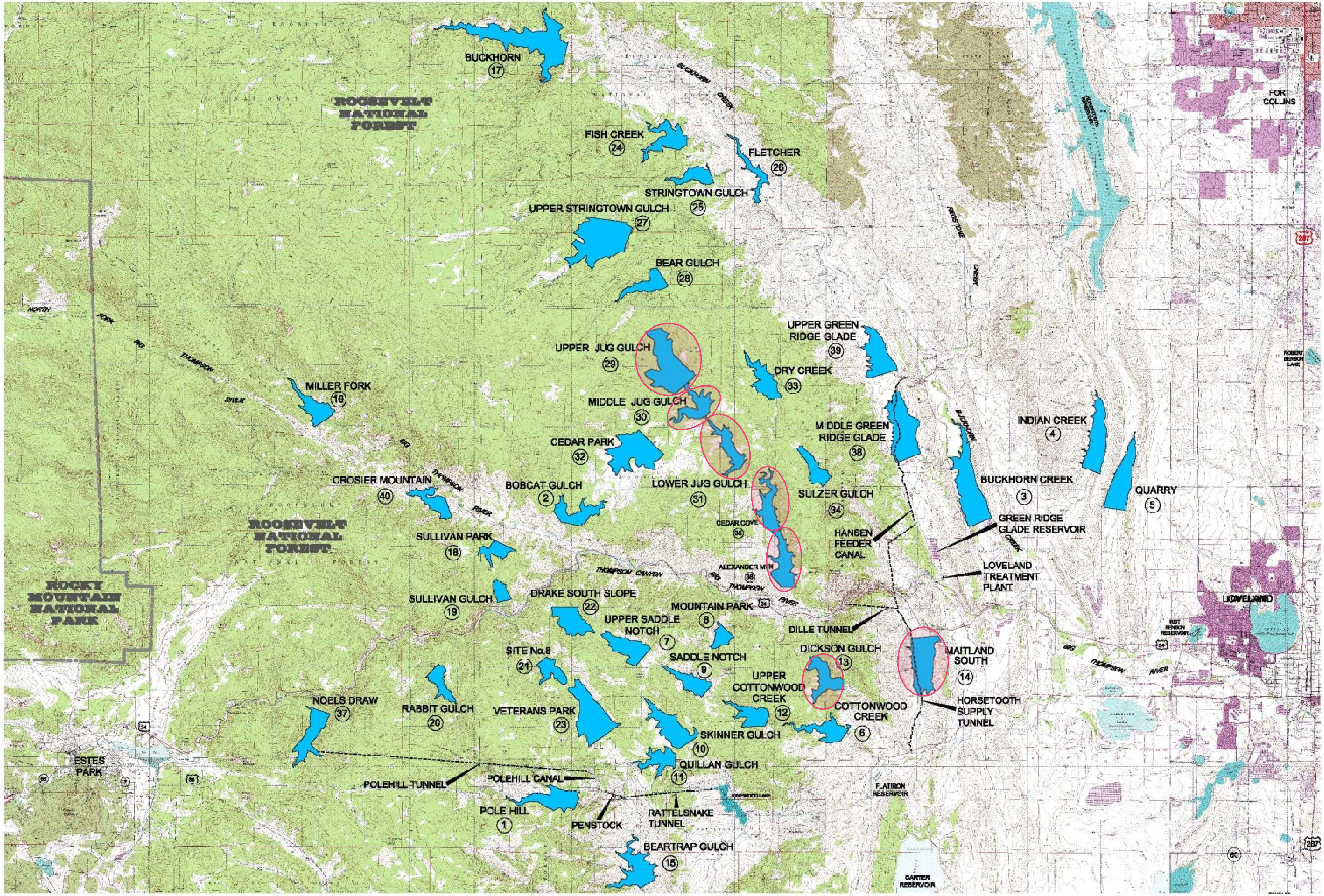
- The Native Water Storage Fee is applicable to all native water deposited in the Water Bank on or after July 21, 1995.
- The above table (column 3) indicates the storage fees associated with each ditch. Those fees are due when the water bank credit is applied to development, not when the shares are put into the Water Bank.

Cash-in-Lieu (CIL) Price:

- CIL Price = Market Price of one CBT unit, as set by the LUC, divided by the yield of one CBT unit as set forth in Section 19.04.018.C (see "Current CBT Value," above).
- Credit in the City's water bank may not be acquired from the City by cash purchase on or after January 1, 2006.
- Call Nathan Alburn at (970) 962-3718 for the current CIL Price. This Price may be subject to change at any time.

APPENDIX IV

Summary of Acceptable and Feasible Upstream Storage Sites



N

0 2500 5000 10000
Approximate Scale in Feet

LOVELAND RESERVOIR STORAGE PROJECT

GENERAL PLAN OF CANYON RESERVOIR SITES

BasePoint Design Corporation
Civil / Geotechnical Design Services

Excerpts of pages 48-49

Comprehensive Study Report, Loveland Reservoir Project
by BasePoint Design, Corporation
Published June 19, 2009
Study Period 2005-2008

8.4 Project Cost Summaries

The total project costs (construction plus City program costs) and the unit cost per acre-foot of storage for the seven potential sites are summarized below:

Comparison of Project Costs
Loveland Reservoir Storage Project

Site No.	Name	Storage Capacity (AF)	Per Acre-Foot Cost *(Costs from late 2008)*
13	Dickson Gulch (target storage)	10,000	$ 23,600
13	Dickson Gulch (smaller storage)	8,300	$ 20,800
14	Maitland South	9,000	$ 7,500
29	Upper Jug Gulch	10,000	$ 36,860
30	Middle Jug Gulch	10,000	$ 21,790
31	Lower Jug Gulch	10,000	$ 21,830
35	Cedar Cove	10,000	$ 16,670
36	Alexander Mountain	10,000	$ 24,460

Excerpts of pages 50-51

Comprehensive Study Report, Loveland Reservoir Project
by BasePoint Design, Corporation
Published June 19, 2009
Study Period 2005-2008

SUMMARY AND RECOMMENDATIONS

9.1 Study Summary

1. Forty (40) potential new canyon reservoir sites were identified in the map study within the Big Thompson canyon and mouth of the canyon study area. After further evaluations and screening, there are seven (7) potential reservoir sites remained for the final phase of the study (feasibility design). Six of seven remaining sites are each capable of providing at least 10,000 acre-feet of target storage.

2. Fourteen (14) existing reservoir sites and 13 potential new reservoir sites were identified in the map study within the "plains" study area east of 1he Big Thompson canyon. After further evaluations and screening, all of the existing reservoir sites are no longer being considered for further study because of limitations on enlargements, and all of the new plains reservoir sites are also no longer being considered because of current land usage, development, and ownership issues.

3. A feasibility design was performed for each of the seven potential reservoir sites. The design consisted of a site reconnaissance, flood hydrology analysis and reservoir routings, preliminary environmental review, geologic review, design of the dam and conveyances, and construction cost estimate. All of the dams were designed to meet the dam safety rules and regulations of the Colorado State Engineer's Office for high-hazard potential structures.

4. None of the seven potential reservoir sites that remained have environmental "fatal flaws" or technical "fatal flaws" to be developed as permanent storage reservoirs. Several of the potential reservoir sites, however, have environmental issues that will complicate permitting from federal agencies such as the U.S. Forest Service, U.S. Army Corps of Engineers, and the U.S. Bureau of Reclamation.

5. The estimated project costs of the seven potential reservoir sites ranged from $7,500 per acre-foot of storage for Site #14 (Maitland South) to $36,860 per acre-foot of storage for Site #29 (Upper Jug Gulch). The project cost included the construction cost of the new facilities and the City's program costs.

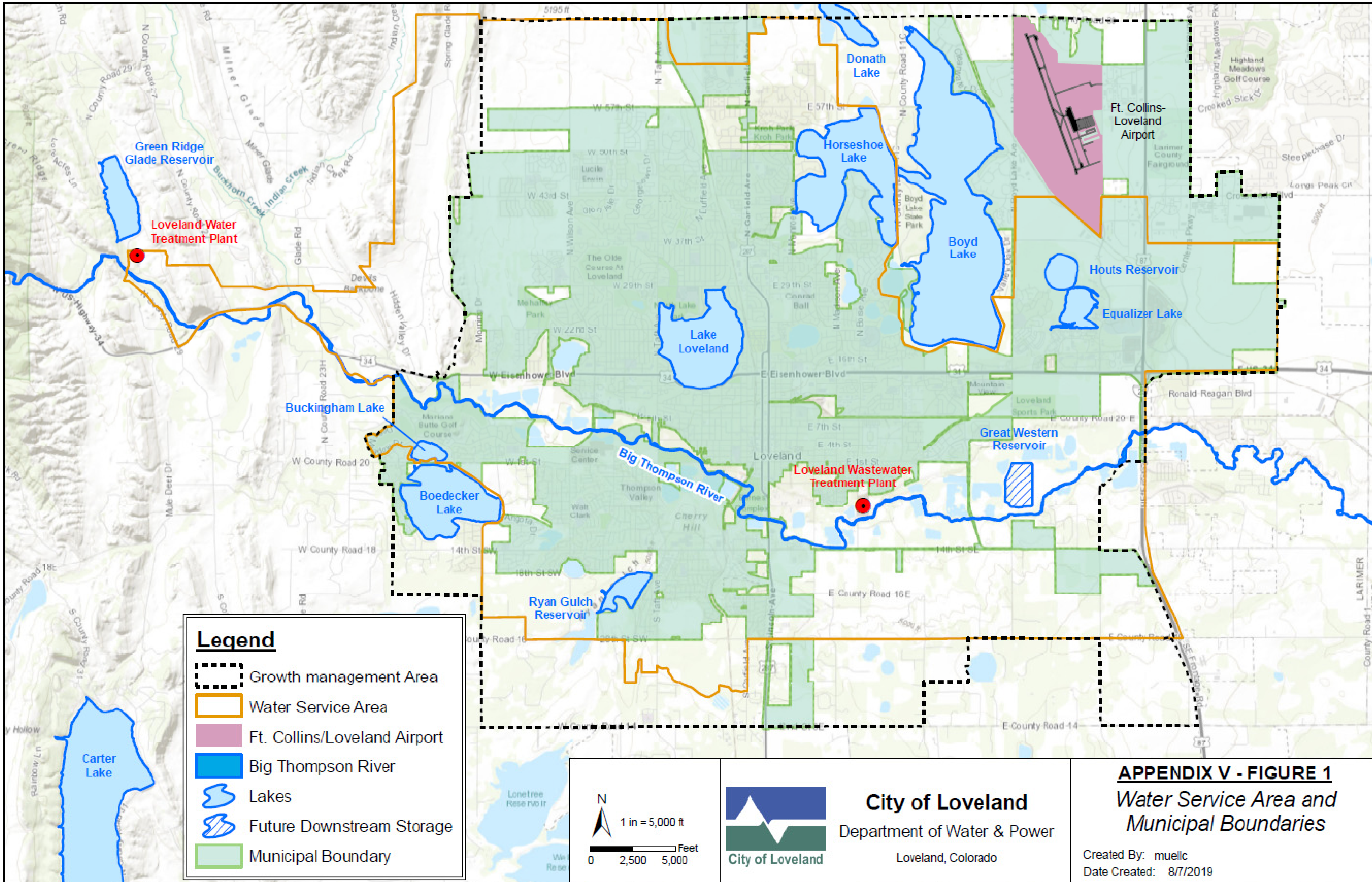
9.2 Recommendations

We offer the following recommendations for future evaluations of the seven potential reservoir sites:

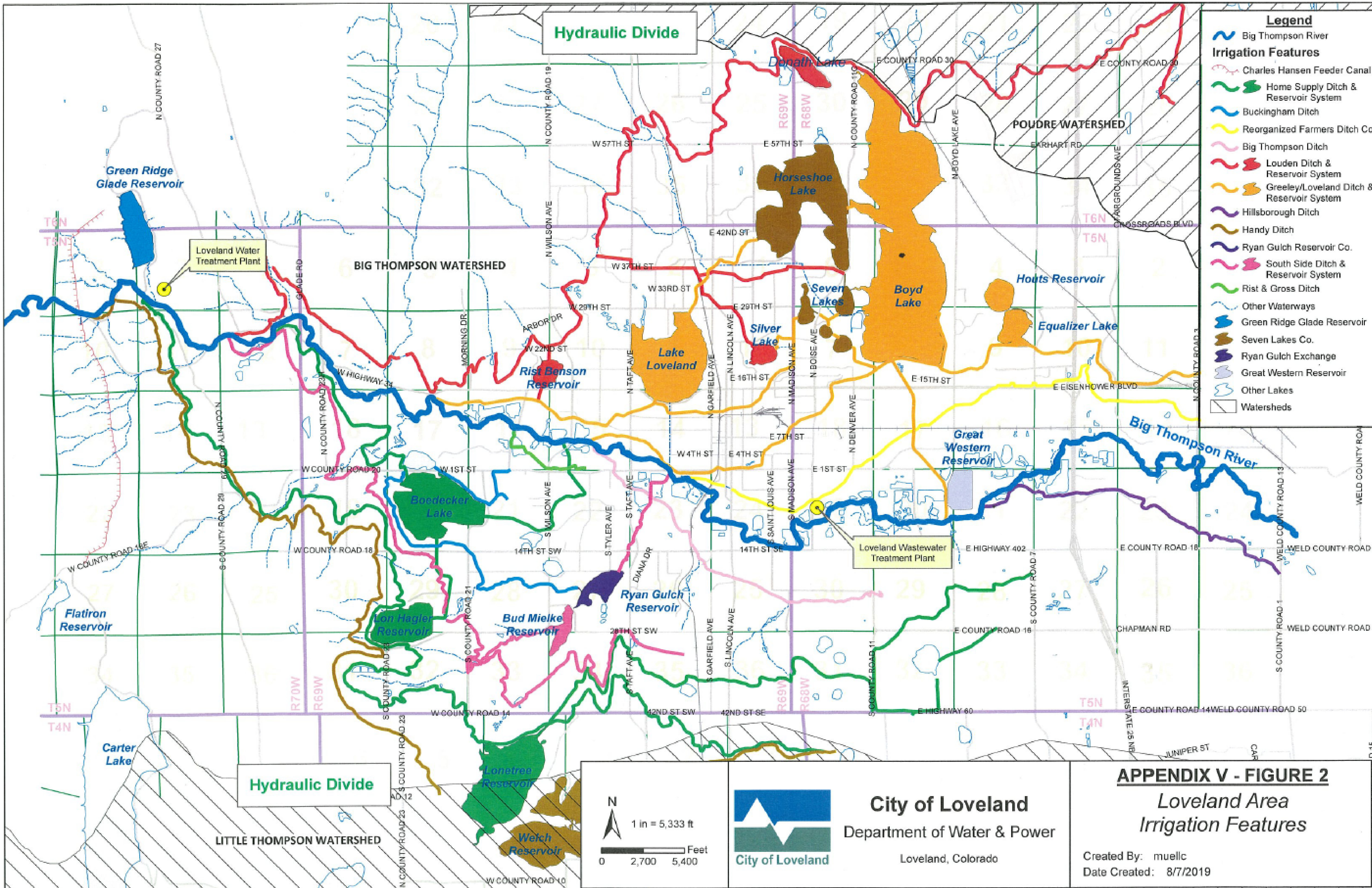
1. Conduct additional environmental field studies to determine the likelihood that the drainages on Site #13 (Dickson Gulch) and Site #14 (Maitland South) are not subject to Section 404 of the Clean Water Act. The results of the additional studies should then be confirmed with the U.S. Army Corps of Engineers.
2. For Site #13 (Dickson Gulch), discuss with the U.S. Forest Service regarding the stream flow issues associated with using Cottonwood Creek for inlet conveyance, and with using Dickson Gulch for outlet conveyance.
3. For Site#13 (Dickson Gulch), discuss with the U.S. Bureau of Reclamation and the Northern Colorado Water Conservancy District regarding the usage of Pinewood Lake water for diversion to this new storage facility.
4. For Site #14 (Maitland South), discuss with the U.S. Bureau of Reclamation and the Northern Colorado Water Conservancy District regarding the usage of Charles Hansen Feeder Canal for diversion to and release from this new storage facility.
5. For the sites with the two lowest project costs (Sites #14 and #35), evaluate the feasibility of filling the reservoirs by pumping instead of a gravity-fed tunnel so as to minimize the involvement and use of federal facilities.

APPENDIX V

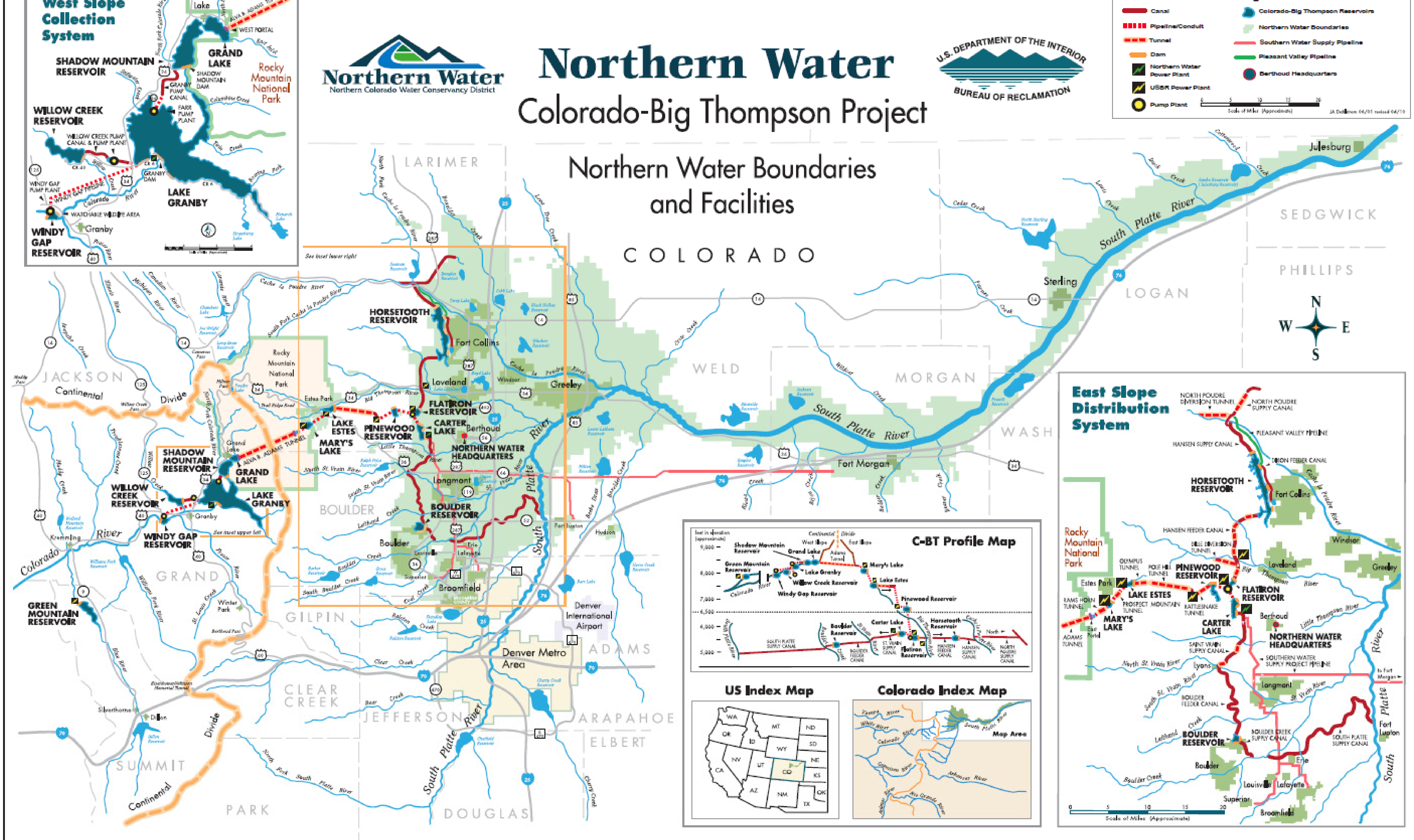
Additional
Figures and Tables

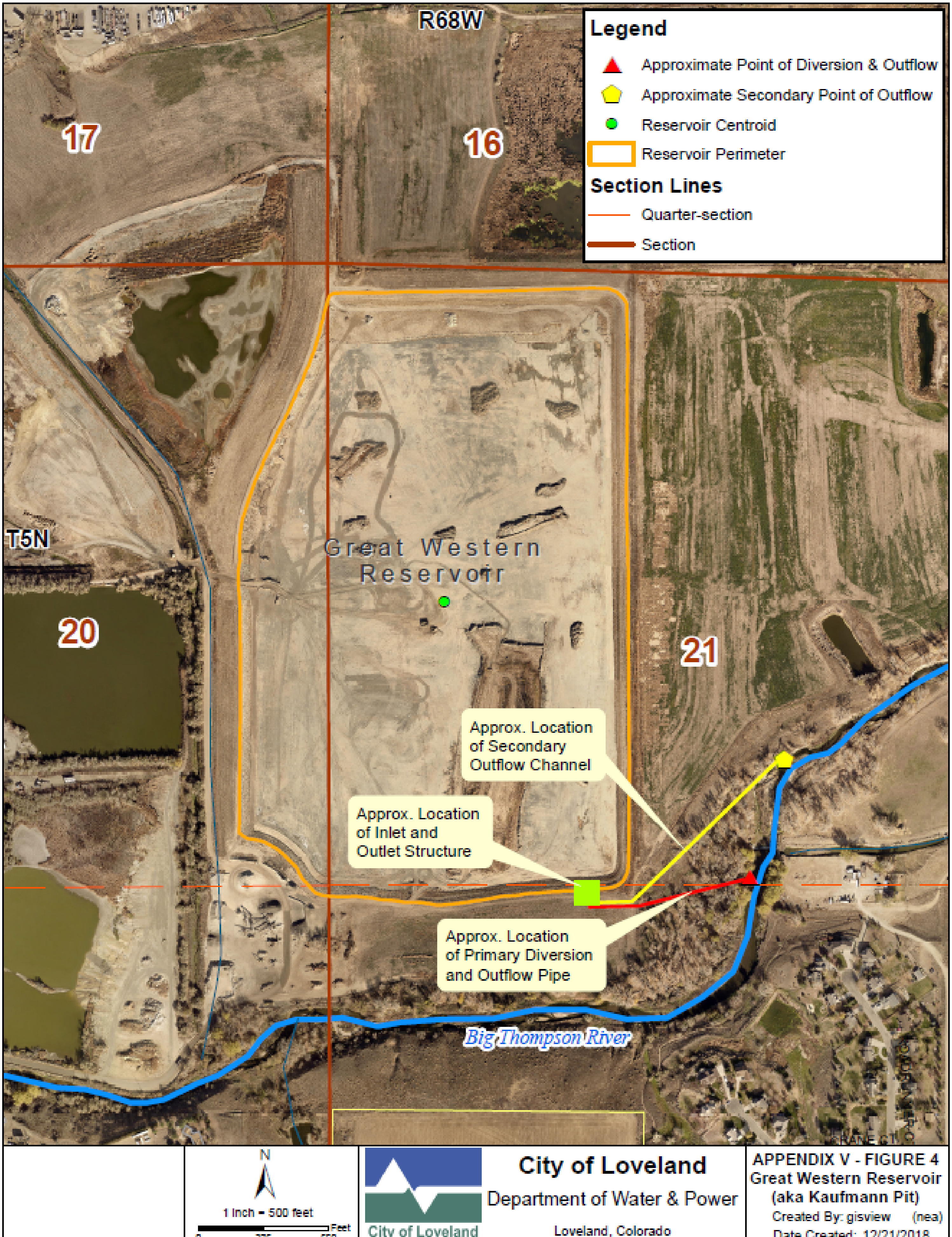


APPENDIX V - FIGURE 1
Water Service Area and Municipal Boundaries
City of Loveland
Department of Water & Power
Loveland, Colorado
City of Loveland
Created By: muellc
Date Created: 8/7/2019
N
1 in = 5,000 ft
0 2,500 5,000 Feet
Legend
Growth management Area
Water Service Area
Ft. Collins/Loveland Airport
Big Thompson River
Lakes
Future Downstream Storage
Municipal Boundary
Green Ridge Glade Reservoir
Loveland Water Treatment Plant
Donath Lake
Horseshoe Lake
Boyd Lake
Ft. Collins-Loveland Airport
Houts Reservoir
Equalizer Lake
Lake Loveland
Buckingham Lake
Boedecker Lake
Big Thompson River
Loveland Wastewater Treatment Plant
Great Western Reservoir
Ryan Gulch Reservoir
Carter Lake
Loveland
W Eisenhower Blvd
E Eisenhower Blvd
Ronald Reagan Blvd
W County Road 20
W County Road 18
E County Road 16E
W 57th St
E 57th St
W 50th St
W 43rd St
W 37th St
W 29th St
E 29th St
W 22nd St
E 16th St
E 7th St
E 4th St
E 1st St
14th St SE
16th St SW
W County Road 14
E County Road 14
Highland Meadows Golf Course
Larimer County Fairgrounds
Boyd Lake State Park
Loveland Sports Park
Mariana Butte Golf Course
Cherry Hill
Crooked Stick Dr
Steeplechase Dr
Longs Peak Cir
LARIMER
WELD


Hydraulic Divide
Legend
Big Thompson River
Irrigation Features
Charles Hansen Feeder Canal
Home Supply Ditch & Reservoir System
Buckingham Ditch
Reorganized Farmers Ditch Co.
Big Thompson Ditch
Louden Ditch & Reservoir System
Greeley/Loveland Ditch & Reservoir System
Hillsborough Ditch
Handy Ditch
Ryan Gulch Reservoir Co.
South Side Ditch & Reservoir System
Rist & Gross Ditch
Other Waterways
Green Ridge Glade Reservoir
Seven Lakes Co.
Ryan Gulch Exchange
Great Western Reservoir
Other Lakes
Watersheds
Green Ridge Glade Reservoir
Loveland Water Treatment Plant
BIG THOMPSON WATERSHED
POUDRE WATERSHED
LITTLE THOMPSON WATERSHED
Donath Lake
Horseshoe Lake
Boyd Lake
Seven Lakes
Silver Lake
Lake Loveland
Houts Reservoir
Equalizer Lake
Rist Benson Reservoir
Great Western Reservoir
Big Thompson River
Loveland Wastewater Treatment Plant
Boedecker Lake
Ryan Gulch Reservoir
Bud Mielke Reservoir
Lon Hagler Reservoir
Flatiron Reservoir
Carter Lake
Lonetree Reservoir
Welch Reservoir
Hydraulic Divide
N
1 in = 5,333 ft
0 2,700 5,400 Feet
City of Loveland
City of Loveland
Department of Water & Power
Loveland, Colorado
APPENDIX V - FIGURE 2
Loveland Area Irrigation Features
Created By: muellc
Date Created: 8/7/2019

APPENDIX V – FIGURE 3





City of Loveland
Department of Water & Power
Loveland, Colorado

APPENDIX V - FIGURE 4
Great Western Reservoir
(aka Kaufmann Pit)
Created By: gisview (nea)
Date Created: 12/21/2018

Report from Jason Mumm to be added after joint LUC, CAB, and Planning Commission meeting on October 21, 2020