Raw Water Supply Yield Analysis Update
City of Loveland

Prepared for:

City of Loveland, Colorado

DRAFT
August, 2011

Prepared by:

Spronk Water Engineers, Inc.
1000 Logan Street
Denver, Colorado 80203

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Raw Water Supply Yield Analysis
City of Loveland

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. The City provides potable water supply and wastewater treatment to a population of approximately 67,500 (awaiting confirmation) through the Loveland Department of Water & Power. 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.

Concerns regarding the adequacy of the City's water supply were heightened as a result of the recent multi-year drought that began in 2000 and intensified in 2002. These concerns related both to the adequacy of the City's existing supply and to the Water Bank[1] development credit given by the City. As a result of these concerns, and the City's desire for sound water resources planning and management, the City contracted with Spronk Water Engineers, Inc. ("SWE") in 2003 to analyze and model the City's raw water supply system. The analysis was performed in accordance with the City's 100- year drought planning policy and a report was prepared in 2004 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 of that system, and presented the results of various analyses performed with the 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

1 The City operates a Water Bank whereby it receives deposits of water rights in the form of ditch shares, CBT units, etc., and in exchange provides the depositor credit against the water dedication requirement for new developments. See Section 2.4 for additional discussion of the Loveland Water Bank.

(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. City contracted with SWE in 2010 to update the 2004 Raw Water Yield Study 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.

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 2004 report. It describes the City's water supply system and changes that have occurred since 2004, summarizes the updating of the simulation model of the water supply system, and presents results of the analyses performed with the model. The City requested several analyses including (a) estimate the firm yield of the City's current (2010) supplies, including use of ditch shares under the terms and conditions decreed in 2010 in Case No. 02CW392, (b) estimate potential uses and benefits of exchange of reusable wastewater treatment plant (WWTP) effluent, (c) estimate potential volumes and uses of reusable lawn irrigation return flows, and (d) estimate 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.

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 1930's and 1950's, the shorter but severe drought of the late-1970's and the most recent 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; i.e., 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. The City of 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 has 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 citizens. 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 system yield.

The two most recent analyses of the Loveland water supply system are a 1988 study by Camp, Dresser & McKee, Inc. ("CDM") and the 2004 Raw Water Yield Study prepared by SWE.

2.2 1988 Water Supply Analysis

A comprehensive analysis of the Loveland water supply was performed in 1988 by CDM.[2] CDM analyzed the City's water supply using a model that simulated the yield of the City's water rights based on one thousand year 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 was capable of supplying an annual demand of 11,700 acre-feet per year ("af/y") with an average one-in-100 year failure rate[3]. 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 analysis of yield considered the City's water rights and facilities as they existed in 2003. Changed conditions between the 1988 report and the 2004 analysis included expansion of Green Ridge Glade Reservoir to 6,785 acre feet and acquisition of additional ditch shares, CBT units and Windy Gap units. Using a study period of 1951 through 2003 and a daily time step, the

---

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

3 Sum of the 1985 demand from Table 7-3 (7,575 af/y) plus the annual surplus for 1985 demand at 100-year recurrence interval (4,139 af/y)

firm yield was determined as the total demand in acre-feet the City could have supplied each year without any shortage. The firm yield was estimated to be 22,400 acre-feet per year and conformed to the 1 in 100 year drought policy

In addition to estimating the firm yield of existing supplies, the 2004 Yield Study also evaluated various alternatives for additional water supply. Among the alternates 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 LUC. The RWMP was the basis for several revisions to the City's water rights dedication policy in 2005.

2.4 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 1 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.

As a result of the 2004 Yield Study and the subsequent RWMP developed by City staff and the LUC, on November 15, 2005, the City Council adopted Ordinance No. 5039, which modified the City's water right dedication policies. A copy of the ordinance can be found in Appendix A.

2.5 Loveland Water Bank

The City has operated the Loveland Water Bank ("Water Bank") since the mid-1980's, and deposits to the bank have been the source of most of Loveland's water acquisitions during recent years. Operation of the Water Bank is described in the "Water Bank Information Sheet," a copy of which is attached as Appendix B. 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, etc.) and pay a native raw water storage fee for ditch company shares deposited in the water bank. For water rights requirements of up to four acre-feet, cash-in-lieu of additional water may be paid. Since April 1, 2006, forty percent of every raw water payment must be CBT units or existing fully-paid cash credits in the City's Water Bank. In exchange for depositing water or cash-in-lieu 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.

The development 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 1995 that is used to meet the water requirements for a development initiated in 2011 would be converted to water supply credit based on the conversion rate in effect in 2011. The conversion rate in 2011 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. 5039 in 2005. 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. This fee is in recognition that raw water storage is necessary to firm up native water sources[4]. 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."

4 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 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[5]. 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 study 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 study, the Water Bank conversion rates were revised effective January 1, 2006. A summary of the current (2011) Water Bank Credits allowed for various irrigation company shares and transmountain sources is shown in Appendix C. One of the purposes of the current yield study is to review the current credits in the context of the City's current water portfolio and facilities.

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

5 See Ordinance No. 1053, Section 6, City of Loveland, October 21, 1969.

west of Loveland and just upstream from Handy Ditch and the Hansen Feeder Canal, as shown in the schematic diagram in Figure 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 ("NCWCD"). 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 - 2009.

The City relies on the CBT and Windy Gap Projects to supplement its primary native water supplies. The sources of water to these transmountain water projects include the Colorado River, Fraser River and Willow Creek in the upper Colorado River watershed. The NCWCD prepares undepleted flow estimates for several upper Colorado River tributaries and these data are available from 1950 - 2009.

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 2. During the period of concurrent record (1950 - 2009), the undepleted flow of the Big Thompson River averaged approximately 123,000 af/y while the Colorado River averaged 266,000 af/y. During this 60-year period the driest year at 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, acre-feet
Big Thompson River and Colorado River

	Big Thompson River at Canyon Mouth		Colorado River above Lake Granby	
Year	**Undepleted Flow, af**	**% of Average Flow**	**Undepleted Flow, af**	**% of Average Flow**
1950-2009 Average	123,000		266,000	
1954	54,000	44%	155,000	58%
1977	72,000	58%	156,000	59%
2002	48,000	39%	120,000	45%

The NCWCD 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 60 years. However, given the entire population 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 60 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.

3.3 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 435 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 29 years. For the Colorado River above Granby, 2002 was the 5th driest year during the 621-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 120 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 60 percent of Loveland's firm water supply yield is derived from native Big Thompson River sources and the remainder is from transmountain Colorado River sources. 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 - 2009 period of record were normalized by computing the annual flow for each year as a percentage of average. Figure 4 shows the normalized flows for the two gages over the 441-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 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 weighted combined normalized flow of the two gages over the 1569 - 2009 period is shown in Figure 5. The combined normalized 2002 flow is approximately 42 percent of average. Compared to the 441-year record, 2002 is the 6th driest year in the period. This corresponds to an average frequency of occurrence of approximately one in 70 years.

A frequency distribution of all of the combined normalized gage flows was prepared and is shown in the solid line in Figure 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 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 well 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 would appear to conform with the City's 100-year drought supply policy.

4.0 LOVELAND WATER USE

Note: this section is being updated by City staff, August 2011

A summary of Loveland's historical annual potable water use since 1987 and the projected future potable water use is provided in Figure 7. 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 untransferred 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 study, except for about 90 af/y of park irrigation demand that for modeling purposes was assumed to be supplied from the potable water system.

The City also leases reusable water to other parties for augmentation use. As of 2011, 18 parties lease a total amount of up to 500 af/y, with actual deliveries averaging about 300 af/y. The leases are supplied by various sources including 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 study as an additional demand of 590 af/y. The augmentation demand was not included in the 2004 analysis.

In 2003, the Loveland city staff estimated the City's ultimate water demand based on alternative methodologies. The first method involved determining typical annual water use figures for nonresidential water use (1.26 af/acre), residential water use (0.42 af/dwelling unit) and park irrigation (3.0 af/acre) and applying these figures to the areas slated for development in the City's current Land Use Plan. This procedure yielded a projected annual ultimate water demand of 28,900 acre-feet.

The second method involved determining the City's per capita water use and applying this figure to future population estimates. The City's per capita water use was computed at 0.2117 af/person based on the 2001 water use and the current population of 63,583. The population projection for the City's Water Utility Service Area was estimated at 127,000 based on adjusted population estimates from the City's Long Range Planning Department. The resulting projected ultimate annual water demand by the population method is 26,900 acre-feet.

The two alternative water demand estimates were presented to the Loveland Utilities Commission ("LUC") for consideration. Based on these estimates, the LUC has adopted a conservative build-out water demand figure of 30,000 af/y to use for water supply planning purposes.

Based on information provided by the City staff, future increases in water demand were assumed to match the City's future population growth as estimated by the City Planning Department. Future population growth through 2030 is assumed to mirror the projected growth for Larimer County developed by the Colorado State Demographer. After 2030, the population is projected to grow at a rate of 1.7 percent per year until build-out of the Loveland service area in approximately 2042. (2056 if we use 67,500 as the current population and same rate of growth)

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 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 590 acre-feet of usable capacity in the reservoir provided minimal conservation storage to enhance the City's supply during a severe drought, and the reservoir was routinely operated only in the top two to three feet. The reservoir was enlarged in 2004 and now has a usable capacity of 6,785 acre-feet.

Treated water is delivered to Loveland's customers through a looped distribution system that includes approximately 19.5 million gallons of treated water storage in tanks. Wastewater is collected and treated at the Loveland Wastewater Treatment Plant ("WWTP") which discharges to the Big Thompson River just upstream of the Hillsborough Ditch.

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 demands 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. For purposes of the yield study, the City's current non-potable water uses were not explicitly analyzed except for 90 af/y estimated by the Parks Department. 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 excess yield from the City's transferred irrigation water rights. The 90 af demand would be met through the potable water system.

In 2004, the City investigated the feasibility of developing a large-scale non-potable irrigation system that would be located in the eastern portions of the City's service area. This project was identified as the "Second Use Water System" and is described in an August 2004 report[6]. This system, if constructed, would be supplied by treated reusable effluent and untreated diversions from the Big Thompson River. Based on economic considerations, the Loveland City Council elected not to pursue development of the project at that time. However, the City requested that potential demands for the Second Use Water System be evaluated as a part of the2004 yield analysis, and the analysis was updated for this report. Unlike the other existing non-potable irrigation uses, it was assumed that the Second Use Water System would compete with the supplies used to meet the City's potable water demands.

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

6.0 LOVELAND WATER SOURCES

Loveland's water sources are derived from a combination of irrigation water rights from the Big Thompson River that have been 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 early in its history: 0.5 cfs in 1887 and 2.5 cfs in 1901. These water rights were assigned domestic priorities No. 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 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

6 Richard P. Arber and Associates, Final Report of the Second Use Water Program Development Study (August 2004)

of simulation used in the model does not imply that the City is waiving its rights to divert year-round under the domestic priorities.

6.2 Transferred Irrigation Water Rights

In the course of its development, Loveland has 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 uses. Loveland's early transfers of irrigation water rights included 3.44 cfs of the No. 1 Big Thompson River priority in the 1880's and two shares (6.0 cfs) of the Big Thompson Ditch and Manufacturing Company ("BTD&MC") in the 1920's. 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. Portions of these shares were used informally for a number of years until an application was filed in Case No. 82CW202 (A) ("202A") in 1982 to transfer a large block of shares in several different companies to municipal use by the City. The 202A decree was entered by the Water Court in 1986. Since that time the City has made several additional irrigation water rights transfers under the terms and conditions of the 202A decree. The final 202A transfer is currently pending in Case No. 2000CW108.

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 rights that is left in the original ditches for ditch losses. The City's diversions are limited by certain monthly, annual and long-term volumetric limitations. The City's use of its shares is restricted to certain starting and ending dates that vary by 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 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 of its ditch shares, as specified in the 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. Loveland's future transfers will follow a modern format that involve 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 transfer of this type was decreed on May 14, 2010 in Case No. 02CW392 (“392”), involving shares of several different 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 rights 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 diversions, both for direct flow use and storage, through monthly return flow percentages specified in the 392 decree. All water that remains after the return flow requirements are met may be reused. Future transfers of shares in the same ditches that were included in the 392 decree will likely use the same per-share volumetric limits and similar terms and conditions. New transfers of ditch company shares for ditches that were not included in the 392 decree will use a similar format.

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.

A summary of the City's transferred irrigation water rights is provided in Table 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. Project water is delivered to Lake Estes in the upper Big Thompson River basin through the Alva B. Adams Tunnel. From there, the water is distributed through a series of tunnels, reservoirs and canals to water users in the Northern Colorado Water Conservancy District (NCWCD), which comprises approximately 1.5 million acres in the South Platte River basin of northeastern Colorado. 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 the NCWCD.

There are 310,000 outstanding units in the CBT Project of which Loveland currently owns 11, 786 units, or about 3.8 percent. The Project was created to provide a supplemental irrigation supply to water users in the NCWCD service area. Each year in April, the NCWCD sets a quota that establishes the amount of delivery entitlement for each project 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, the NCWCD began formally setting a winter quota for municipal and industrial water users. With the increasing municipal ownership of CBT units, the trend may be toward setting the annual quota in November so that the CBT supply is fully available year-around.

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 NCWCD.

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 the unused capacity of the CBT Project. 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 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.

Yield from the Windy Gap Project is quite variable as a result of 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 as a result of storage of CBT Project water.

As a result of the unreliability of the Windy Gap Project supply, efforts were undertaken by the Subdistrict several years ago to study potential ways to enhance the yield of this supply. The Windy Gap Firming Project ("WGFP") is being proposed as a means to enhance the project yield, particularly during dry years. The WGFP, if approved and funded, will involve an East Slope storage reservoir (e.g., Chimney Hollow Reservoir[7]) and revised operation and coordination with the CBT Project. Loveland is participating in the development of the WGFP, presently at the level of 7,000 acre-feet of storage. Studies of the benefits of the WGFP have been performed for the Subdistrict and are documented in a 2003 report.[8] Additional technical reports were prepared between 2005 and 2008. A draft environmental impact statement ("EIS")

7 The proposed alternative identified by the Subdistrict for an East Slope storage reservoir developed as part of the Windy Gap Firming Project is at Chimney Hollow located immediately west of Carter Lake. The actual site selection is subject to further analysis and federal permitting requirements. For purposes of discussion, the East Slope storage reservoir will be referred to as Chimney Hollow Reservoir in this report.

8 Windy Gap Firming Project, Alternative Plan Formulation Report, Boyle Engineering, February 2003.

was released for public comment in 2008[9]. A final EIS is expected to be published in 2011. If the project is approved by the U.S. Bureau of Reclamation, a permit is required from the U.S. Army Corps of Engineers, followed by five to six years of design and construction.

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 the NCWCD whereby the City agreed to abandon the Eureka Ditch in exchange for 180 af/y of firm CBT yield.

6.4 Other Water Sources

In addition to its native Big Thompson River water rights and transmountain supplies, Loveland can divert additional water by exchange or during free river conditions.

6.4.1 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 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, free river, water diverted under Loveland's junior storage decree filed in 1984, and Windy Gap water, and will include yield derived from future water rights transfers. The City is seeking to adjudicate its exchange appropriations in Case Nos. 02CW393 and 02CW394.

---

9 Windy Gap Firming Project, Draft Environmental Impact Statement (DES 08-30), U.S. Bureau of Reclamation, Great Plains Region, August 2008.

6.4.2 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 as much water as it can without regard to the limits of its direct flow and storage water rights. These conditions occur infrequently, typically during the spring runoff of wetter than average years or following high rainfall events.

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 ("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 - 2006 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 of 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 - 2006. 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 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. Potable leases were not simulated in the 2004 analysis. In the current model, 90af/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 the period 2000-2010. These records include the severe drought of 2002 in which the City's water use declined as a result of voluntary water use restrictions and water conservation publicity. The demand distribution used in the 2004 analysis were based on water use records from 1997-2001, a period that predates the severe drought. The 1997-2001 distribution shows a bimodal pattern, with peaks in July and again at the end of August. The 2001-2010 distribution does not exhibit this bimodal pattern. A comparison of the two demand distributions is shown in Figure 8. Based on discussions with the City staff a decision was made to use the "normal" seasonal water use pattern reflected in the 2000-2010 records for planning purposes. 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 represents potential future irrigation water uses located downstream of the City's WWTP. This demand may be satisfied in the 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 model from reusable WWTP effluent, the reusable portion of water discharged to the river from processes at 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 downstream gravel pit storage. The 2004 analysis did not simulate an augmentation demand. In the current model, an augmentation demand of 500 af/y is simulated. Based on the relative locations of the current leases, 50 af/y higher in the basin is met only by WTP decant 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 2010, 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 flowrate in priority during a diversion season specified by the user. Under current administration, the season is April 1 – October 31.

City also has a water right decreed to the Loveland Pipeline for domestic and municipal purposes in CA4862. This water right, generally referred to as the “domestic right”, has two separate priorities: 0.5 cfs and 2.5 cfs. There are unresolved issues regarding the priority and diversion season of these rights. The yield of this water right 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 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 model does not imply that the City is waiving its rights 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 and (b) to include the City's historical diversions of its transferred irrigation water rights. The diversions by private or contract rights were modified from the 2004 analysis to reflect the updated analyses that were done for the 392 transfer. The simulated divertable 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 decreed volumetric limits and it was determined that the volumetric limits only rarely would have been violated[10].

During periods when there is 202A yield that is in excess of the City's demands, the excess supply is stored in the simulated upstream storage (i.e., Green Ridge Glade Reservoir) and/or in any simulated downstream storage. 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[11]. 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 first transfer decree.

7.3.4 392 Transfers

Loveland's 392 case water rights transfer follows a format that 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

---

10 This is expected as the volumetric limits were derived from the historical diversions during the 1951 - 1979 period.

11 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 is to be used for replacement of evaporation associated with a gravel pit on a portion of the lands historically irrigated by the ditch. The remaining diversion entitlement of 407.5 af/y comprises 84 percent of the transferred annual diversion entitlement.

contract water rights that are carried in certain ditches and (b) to include the City's historical diversions of its transferred irrigation water rights. The simulated divertable 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 simulated diversions, including the amount left in the stream, were compared to the decreed volumetric limits and it was determined that the volumetric limits only rarely would have been violated[12].

During periods when there is 392 yield that is in excess of the City's demands, the excess supply is stored in the simulated Green Ridge Glade Reservoir and/or in any simulated downstream storage. 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 Post-392 Transfers

Loveland's future water rights transfer will likely follow a format similar to the 392 transfer. 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. For future transfers of shares in ditches that were not included in the 392 decree (Handy, Home Supply, Hillsborough and GLIC), the precise terms are unknown. The yield of these 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.

12 This is expected as the volumetric limits were derived from the historical diversions during the 1951 - 1979 period.

7.3.6 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 limited by the free river criteria remaining satisfied. In the 2004 report, free river diversions were treated as not reusable. Loveland's water counsel has recently advised that such diversions for municipal use should be considered reusable.

7.3.7 Exchanges

Exchanges are simulated in the model on days when exchange potential exists and there is reusable WWTP effluent in excess of augmentation and return flow demands, from the WWTP outfall to the Loveland Pipeline and Green Ridge Glade reservoir. If downstream gravel pit storage is simulated, an exchange may also be operated from the gravel pit to Green Ridge Glade Reservoir. Modeled sources of reusable water include 392 water, stored 202A water, free river diversions, Windy Gap water, and WWTP effluent from these sources.

7.3.8 Decant from Water Treatment Plant

The treatment train at the Chasteen Water Treatment Plant 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 be stored in the downstream gravel pit storage if it is simulated. Although the amount of decant varies somewhat seasonally and with the processes at the WTP, it is simulated in the model as 2.5% of diversions to the plant. This percentage may be changed by the user.

7.3.9 CBT Units

Loveland's CBT Project yield is simulated based on the historical annual quota set each year during the study period between 1953 and 2006. The quota for 1951 and 1952 is based on estimated CBT yields determined as part of the WGFP modeling (see Section 7.3.10). 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 NCWCD policy, one half of the annual quota is assumed to be available for use during the period November 1 - March 31. The other half of the annual quota is assumed to be available for use beginning on April 1. Carryover of CBT supply to the next year is limited to the lesser of 0.20 acre-feet 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.

7.3.10 Windy Gap

Windy Gap water is the last source to be used in the Yield Model. The yield of Loveland's Windy Gap units is simulated differently in the 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"), now AECOM, 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 NCWCD 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 because Granby Reservoir spilled in those years. In 2000 - 2006, the Windy Gap yields were generally limited by the available supply on the West Slope.

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 7,000 acre-feet 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, during 1997 - 2000, there was no yield from the Windy Gap Project 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 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[13]. During 2001 - 2006, the actual Windy Gap yields were assumed to represent the amount that could have been pumped to Chimney Hollow Reservoir.

---

13 In years when Granby doesn't spill, the capacity of the Adams and Olympus Tunnels is not a constraint to the Windy Gap Project yield due to the NCWCD's instantaneous delivery and accounting policy. Under this policy, a water user may take delivery of Windy Gap Project water from any of the NCWCD'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 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.

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.

7.3.11 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 to meet return flow obligations. A release from storage is the next-to-last source of water used to meet Loveland's water demand. The simulated capacity in the Yield Model is the 6,785 acre-feet capacity determined in 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 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[14], 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.

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.

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.

---

14 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.

7.4.2 Consolidated Home Supply Irrigating and Reservoir Company ("Home Supply")

The Home Supply Ditch diverts from the south bank of the Big Thompson River. The City uses Home Supply’s diversion dam used 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 acre-feet. Mariano Reservoir is the No. 3 priority storage water right with a decreed capacity of approximately 4,130 acre-feet. 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 fill 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 divertable 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 recently transferred Home Supply shares to municipal use in Case No. 98CW410. The change decree 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 ("GLIC")

The 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 also 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 acre-feet. 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 per share yields before the 22 percent delivery shrink that is charged by the company. The storage dividend is the yield from Boyd Lake storage and the river dividend is the yield of 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[15] for the Greeley transfer of GLIC shares in Case No. 87CW329.

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 22 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.

15 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).

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 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 ("RGRC")

The 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 acre-feet and the decreed source of water to the reservoir is Ryan Gulch. The largest shareholders in the RGRC are the Handy Ditch Company (37%) and Bill Bierwaltes (31%). The City of Loveland currently owns 13.75 shares (13.75%) in the RGRC, and these shares are used for non-potable irrigation uses. Most or all of 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 (e.g., Bill Bierwaltes) 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 carryover in storage for use in the subsequent year.

7.4.5 Lawn Irrigation Return Flows

In the 202A and 392 cases, Loveland applied for the right to reuse and successively use to extinction its return flows resulting from irrigation of lawns, parks, golf courses, and other areas ("LIRFs") derived from fully consumable sources. Loveland did not perform an engineering analysis regarding the amount and timing of its LIRFs at the time of those decrees, but reserved the right to file an application at a later date to quantify its LIRF credits from the Subject Water Rights, and to fully use, reuse, and successively use such LIRF credits in the future. 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.

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 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[16].
- 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 Potential Future Downstream Reservoir

- Available storage space.
- 100 cfs assumed maximum inflow rate.
- 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:

16 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.

Order of Simulated Water Use (First to Last)

Direct Flow Use	Pipeline Rightss[1]	202A Transfers[2]	392 Transfers[3]	Future Sources[4]	Exchange[5]	Free River	CBT	From Storage	WG
To GRG Storage	202A Transfers2	392 Transfers[3]	Future Sources[4]	Exchange[5]	Free River	CBT	WG		
To D/S Storage	202A Transfers[2]	392 Transfers[3]	Future Sources[4]	Reusable Effluent	Reusable WTP Decant	Reusable LIRF	Free River		
To Aug Leases	Reusable Effluent	Reusable LIRF	From D/S Storage	Reusable WTP Decant	From GRG Storage				
To NP Irrigation	202A Transfers2	392 Transfers[3]	Future Sources[4]	Reusable Effluent	From D/S Storage	From GRG Storage			

<u>Notes</u>

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 and 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 Model diverts 202A water first, followed by 392 water. This may not be the way the water rights are operated in the future, and the 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 relative to one another may be specified by the model user. In some cases, free river water would actually be used before the transferred irrigation water rights. 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 loosely follows a junior to senior order. This ditch order was reversed in the 2004 analyses.

7.7 Exchanges

The model simulates exchanges of reusable effluent discharged to the river at Loveland's WWTP. In addition, when downstream storage capacity is simulated (e.g., terminal storage) the model simulates exchanges of reusable water released from 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 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*
- Measured outflows or diversions*
+/- Unmeasured reach gains or losses*

<u>Note:</u>
* between the upstream gage and the point of interest.

A schematic diagram illustrating the operation of the Point Flow Model is shown in Figure 9.

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 of 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 10. 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).

7.8 Differences with 2004 Analysis

A number of changes in the City‘s water supply portfolio and facilities between 2004 and 2011 necessitated revision to some of the assumptions and operations in the Yield Model. Some of the important model changes are listed below:

- Extension of the study period through 2006 (it formerly ended in October 2003).
- Revision of river call information based on revisions made to the records by the State Engineer.

- Revision of the municipal water demand distribution based on 2000-2010 data.
- Revision of the number of ditch shares in the 392 transfer to those actually transferred.
- Revision of the diversions allotted to private or contract rights in several ditches per the analysis in the 392 transfer.
- Application of the return flow provisions decreed in the 392 transfer (instead of using 202A).
- Increase of the capacity of the WTP and Loveland Pipeline to 90 cfs.
- Incorporation of the WGFP at the 7,000 af level (WGFP was not included in 2004).
- Use of Green Ridge Glade Reservoir releases to meet demands before using Windy Gap supply.
- Allowing Windy Gap water to be stored in Green Ridge Glade Reservoir any time it is less than half full (formerly was limited to late summer).
- Revision of simulated inflows to the WGFP per revisions made by Boyle in 2008
- Increase in CBT units from 10,538 to 11,786.
- Change free river diversions from "not reusable" in 2004 to "reusable" in the current model.
- Reversed the order of use of the ditch shares from senior-to-junior to approximately junior-to-senior.
- Added decant water from the WTP as a supply for meeting augmentation demand and return flow obligations.

- Addition of an augmentation demand of 590 af/y to the modeled demands.

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

7.9 Yield Model Operation and Use

The Loveland Yield Model is a multi-page Microsoft Excel spreadsheet that simulates the daily raw water supply yield for the City of Loveland over the period from 1951 through 2006. The 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, and
- 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 model is shown in Figures 11A and 11B.

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 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 model is rerun. If there is no shortage, then the demand may be 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 particular set of input parameters.

If 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, for example, the irrigation demand, while still meeting the municipal demand with no shortage. For this analysis, all demands were assumed 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 therefore comprised of the sum of the municipal demand at which the firm yield is calculated plus the 590 af. If the augmentation demand is not simulated or is allowed to have a shortage, the municipal portion of the firm yield would be increased.

The Model spreadsheet is linked to a Summary spreadsheet containing various graphs and tables that allow automatic summarizing, visualization and comparison of model runs. Additional tables and graphs can be generated from manual user 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 existing sources in different ways. All model runs included 590 af/y of augmentation demand, assumed to be fully met each year, in addition to the municipal demand. The results are reported as the total firm yield, as well as the municipal and augmentation portions of the total firm yield. 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 amount available in the dry year of 2002 are shown in Table 3. The average annual available supply totals approximately 35,870 acre-feet, while the availability of these sources in the 2002 dry year totals only 16,060 acre-feet. 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 annual water supply yield, assuming current water sources and facilities without the WGFP in place, was determined from the Yield Model to be approximately 24,280 af/y (23,690 af municipal and 590 af augmentation). However, when the WGFP is constructed, Loveland’s current participation level of 7,000 af of storage ("Base Run") will increase the firm annual yield to 27,390 af (26,800 af/y municipal and 590 af/y augmentation). This is the simulated annual demand that can be reliably delivered in each year of the 1951 - 2006 study period. The firm yield is greater than the 2002 dry-year yield of Loveland's direct flow sources as a result of carryover storage in Green Ridge Glade Reservoir and Chimney Hollow Reservoir, and exchanges of reusable effluent. A comparison of the firm annual yield to the past and projected future water demands is provided in Figure 7. This figure shows that the current water supply would be adequate to meet the drought year water demands without water use restrictions through approximately 2027 assuming future drought yields are no worse than during the 1951 - 2006 period, and growth is no greater than projected by the City. Table 4 summarizes the relative contributions of the City's water sources to the modeled total Base Run firm yield on an average basis.

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 12. This chart shows that the amount of transferred irrigation water rights used to meet the City's demand varies from year to year depending on whether the native water supply is relatively good or poor. In drought years, when the native supply is low, there are greater uses of transmountain supplies and releases from Green Ridge Glade Reservoir to meet the City's demand. Green Ridge Glade Reservoir remains at least half full during much of the 56-year study period as shown in the line graph of the reservoir contents provided in Figure 13. This is the result of allowing Windy Gap water to maintain Green Ridge Glade Reservoir storage levels in the model. The contents of Loveland's account in Chimney Hollow Reservoir are also shown on Figure 13. Both reservoirs are drawn down to empty in the simulated spring of 2005, thus providing the limit on the annual demand that can be satisfied during the study period. The drought of the late 1970's was another period in which there was a substantial draw on the reservoir contents in the Base Run.

Charts illustrating the daily simulated water supply during the drought years of the mid-1950's, late-1970's and early 2000's are included in Appendix D. 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 20 cfs during the winter to more than 70 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 and Loveland's account in Chimney Hollow Reservoir (read on the right chart axis).

The daily supply charts show that the Loveland Pipeline Rights (a.k.a. Early Transfers and domestic rights) provide relatively continuous base supply year-around. 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, the reservoir releases typically occur in the latter portions of the irrigation season after the City has exhausted its CBT quota for the year. In the Base Run, Windy Gap deliveries to the WTP would be used after releases from Green Ridge Glade Reservoir, but these deliveries are not needed in most years, and in the critical year of 2004, Windy Gap water is not available because the City's account in Chimney Hollow Reservoir is empty.

8.1.2 Base Run Generation of Reusable Return Flows

In the Yield Model, reusable return flows are generated at the WWTP and in the form of LIRFs due to the use of reusable water supplies to meet the water demands. Reusable return flows at the WWTP are used in the Base Run of the model to exchange for diversions at the Loveland Pipeline and Green Ridge Glade Reservoir, and to meet return flow obligations and augmentation demands. An average of 2060 af/y of reusable WWTP effluent is generated in the Base Run, mostly in the spring and fall months when free river diversions, and releases of stored water are available. Generation of reusable effluent is low in July when a large portion of the supply is from 202A transfers. The average annual modeled use of the return flows is for exchange to Loveland Pipeline (700 af), exchange to Green Ridge Glade Reservoir (30 af), winter return flow obligations (11 af), and augmentation leases (174 af). The Base Run indicates the excess unused reusable return flows average 1,144 af. Figure 14 is a chart summarizing the generation and use of the reusable WWTP effluent in the Base Run.

The reusable portion of LIRFs is not used as a source in the Base Run, but an option to use the LIRFs for augmentation and return flow demands and storage in a potential downstream gravel pit may be selected by the user for other model runs. The reusable LIRFs in the Base Run average 465 af/y.

8.2 Increased Yield from Green Ridge Glade Reservoir Enlargement

The enlargement of Green Ridge Glade Reservoir in 2004 substantially increased Loveland's firm water supply yield. A model run was made to estimate the City's firm yield with Green Ridge Glade Reservoir at its 600 acre-feet capacity prior to enlargement. Comparison of this run to the Base Run resulted in an increase in firm yield of about 2,700 acre-feet with the enlarged reservoir. The increase in firm yield from the enlarged reservoir is illustrated in Figure 7.

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 would increase the City's firm yield. The increased firm yield would vary with the level of project participation, currently at a level of 7,000 af of storage space. The WGFP increases the firm yield of Loveland's water supply by maintaining storage levels in Green Ridge Glade Reservoir and by providing a drought year 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 would 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.

The City's current level of participation in the WGFP in the Base Run is 7,000 af. Because the WGFP has not yet been approved, permitted and constructed, it is conceivable that the City's participation level could change. 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 7,000 acre-feet. The results of these model runs are shown in the following table and in the chart in Figure 15.

Increased Firm Yield
from Loveland Participation
in the Windy Gap Firming Project
(af/y)

WGFP Participation* (af)	Total Firm Yield** (af/y)	Increased Firm Yield*** (af/y)
0	24,280	-3,110
2,000	25,070	-2,320
5,000	26,580	-810
7,000	27,390	0
9,000	27,890	500
10,000	28,130	740
12,000	28,650	1,260
20,000	30,520	3,130

*Storage capacity in Chimney Hollow Reservoir
**Total Firm Yield includes 590 af of augmentation demand
*** Compared to Base Run

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 7,000 acre-feet participation level run provided in Figure 13 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. (need reference)

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 storage 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 acre-feet 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 1,400 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 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
af/y

Description	Incremental Firm Yield (af/y)
Firm Yield to Loveland without Chimney Hollow Reservoir	1,400
Additional Firm Yield with WGFP (7,000 af) participation)	3,100
Total Firm Yield to Loveland from Windy Gap	4,500

8.4 Shortages at Greater Demands

Alternative 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 26,800 af/y Base Run level, shortages in the augmentation demands begin to occur, first in 2005 and then in other years. The following is a summary of magnitude of the shortages and the number of years of shortages in the 56-year study period at increased demand levels.

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

Annual Municipal Demand (af/y)	Maximum Annual Municipal Shortage (af)	Number Years of Muni Shortage	Maximum Annual Augmentation Shortage (af)	Number Years Of Aug Shortage
26,800	0	0	0	0
27,000	200	1	110	2
28,000	1,830	3	130	4
29,000	3,400	3	210	5
30,000	6,080	8	280	13
31,000	7,500	15	280	16
32,000	10,230	21	280	21

A chart illustrating the results of the increased demand runs is shown in Figure 16. These results show the amount and frequency of municipal demand shortages that occurred at greater demand levels during the simulated 1951 - 2006 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 30,000 af/y in 48 years of the 56-year study period. Demand reduction would be required in the other eight years, with a maximum required annual reduction of approximately 6,080 acre-feet (20%). Although it can be effective, relying on water conservation as a way to meet future water demands can reduce the City's ability to withstand future droughts that are more severe than a 100-year drought. The City has chosen to plan for meeting all demands in the 100-year drought rather than impose water restrictions.

8.5 Effect of 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 competing exchanges have operated for long periods of time, and their operation is 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 Ditch 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 and Evans, that are senior to all or portions of Loveland's exchanges. As the uses of any senior exchanges are increased in frequency and amount, they may reduce Loveland's exchanges to amounts less than what were simulated in the historical 1951 - 2006 period.

The potential effect on Loveland's firm yield resulting from increased operation of senior Big Thompson River exchanges was analyzed using the Yield Model. Model runs were made to assess the impact of exchanges over two different reaches of the Big Thompson River. The first category of runs assessed the potential impact of senior 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 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 entire reach of Loveland's exchange from the Loveland WWTP outfall to the Loveland Pipeline ("middle river exchanges"). The modeled increased exchanges were assumed to operate continuously during the irrigation season limited only by the river exchange potential. If the senior exchanges are actually operated for only part of the irrigation season in the future rather than continuously, the effect on the City's exchanges could be less than estimated by the Model.

The results of the impact of increased operation of senior exchanges on Loveland's firm yield are shown in Figure 17 for exchange rates up to 100 cfs. The results show that the lower river exchanges would have less impact on Loveland's firm yield than would the middle river exchanges. For example, at an assumed additional senior exchange rate of 50 cfs, the lower river exchanges would reduce Loveland's firm yield by approximately 2,300 af/y while middle river exchanges at the same rate would reduce the firm yield by approximately 4,400 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. Exchanges on the lower river reaches often may be limited by canals that are drying up the river while exchanges on the middle river can operate unimpeded. 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 Colorado Big Thompson Project. CBT 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 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 18. The chart shows there has been a decline in CBT Project deliveries since the mid-1980's.

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 CBT deliveries are shown in Figure 19. Because the critical period in the analysis is the recent drought, reductions in historical CBT deliveries to current levels did not affect the firm yield estimated in the Base Run. However, further reduction of CBT deliveries to one-half the current level would result in an estimated loss of 110 af/y of firm yield while curtailment of all CBT deliveries down the Big Thompson River would reduce the firm yield by approximately 450 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 Increased Firm Yield from Additional Sources

One of the purposes of the Loveland Yield Study was to estimate the increase in the City's firm water supply 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 by development of downstream storage (e.g., gravel pit reservoirs). Selected amounts of each of these water sources or storage capacity 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 3 and in Figures 19 - 21. Descriptions of the model results for the various categories of water sources potentially available to the City follow.

8.7.1 Direct Flow Irrigation Sources

Acquisition of additional shares in the various Big Thompson River irrigation companies would have varying benefit to Loveland's firm annual yield. In the 02CW392 case, Loveland agreed not to transfer any more Barnes or Chubbuck inches except in certain limited circumstances; therefore no acquisitions from these ditches were simulated in the model. The increase in firm yield resulting from adding 500 af/y of average annual yield in each irrigation company is shown in Table 5 and Figure 20, and ranges from less than 50 af/y Buckingham shares to over 300 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 2004 (“critical year”). In order to assess the sensitivity of the analyses to the particular 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 (2003). 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 2003).

A second set of alternative runs was made by further increasing the annual demand to establish another baseline condition that includes failures in both 2003 and 2004, with 2002 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 21. The results show that the incremental firm yield added in the original and alternative runs for most sources are similar for most sources (e.g., the yields for Buckingham shares are less than 50 af/y in each of the three critical periods, while the yields of the BTD&MC shares are between 180 and 210 af/y).

8.7.2 CBT Units

The addition of 500 af/y of average CBT Project yield (approximately 671 units) would result in an estimated increase in Loveland's firm yield of approximately 590 af/y, as shown in Figure 22. Adding CBT units generally has more benefit to Loveland's firm yield than does adding shares in the various irrigation companies due to (a) the somewhat more dependable yield of the CBT Project, (b) the flexible timing of Project deliveries, (c) the ability to carryover excess yield to the next year and (d) the upstream location that avoids having to exchange water upstream for delivery to Loveland. This incremental yield is somewhat less than was found in the 2004 analysis due to different baseline conditions of the Base Run.

8.7.3 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

7,000 acre-feet 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 7,000 acre-feet 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 7,000 acre-feet), 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 22 without the WGFP, and with the WGFP at assumed participation levels of 7,000, 9,000 and 12,000 acre-feet.

8.7.4 Upstream Storage

The benefit of increasing Loveland's upstream storage was simulated using the Yield Model by increasing the capacity of Green Ridge Glade Reservoir from its current 6,785 acre-feet capacity. Storage capacity was added in varying amounts up to an additional 30,000 acre-feet. 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 study.

The estimated benefits of additional upstream storage capacity to Loveland's firm yield are shown in Figures 23 and 25. By adding 10,000 acre-feet of storage capacity, Loveland's estimated firm yield would increase by approximately 2,600 af/y. As storage capacity is added, the incremental benefit to Loveland's film yield declines. Above 25,000 acre-feet of additional upstream storage capacity the incremental benefit of more storage is minimal. It should be noted that results shown in Figures 23 and 25 are relevant for the City's current water supply sources. As the City acquires additional sources, the marginal benefit of increased storage may change.

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 8.7.1 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 19 (read on the right chart 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 20 (1,940 acre-feet). For sources that add little firm yield by themselves to Loveland's water supply (e.g., 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.

It should be noted 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.

8.7.5 Downstream Storage

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 for later exchange when the river conditions improve. Terminal storage could be potentially developed through acquisition and lining of existing or proposed gravel pits located adjacent to the Big Thompson River.

The increases in Loveland's firm yield resulting from various amounts of terminal storage are shown in Figure 24 and Figure 25. The results indicate that the City's firm yield could be increased by adding up to approximately 1,000 acre-feet of terminal storage if there is no additional downstream demand. Beyond this amount, the exchange potential during the critical period becomes the limitation on how much additional firm yield can be added to the Loveland supply.

Figure 24 also shows the increase in firm yield that could be realized if Loveland also had a downstream demand that it could supply from the terminal reservoir without having to operate an exchange (e.g., the proposed Second Use Water System). Results are shown for assumed downstream demands of 1,500 af/y and 3,000 af/y. (Note- the 3,000 af demand level has not been completed). The results indicate that terminal storage of up to approximately 4,000 acre-feet would increase the City's firm yield in combination with a downstream demand of 1,500 af/y.

8.7.6 Operational Changes

During the performance of all 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 29,200 af (28,610 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 6,200 af. Table 6 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.

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 City's projected growth estimates. Additional water supplies will be necessary to meet projected water demands at full build-out of the City's water service area. However, the gap between the firm yield of the City's water supplies and the projected demand is less than was found in the 2004 analysis, due to the changes discussed in Section 7. These and other conclusions from the updated yield study are summarized as follows

1. Drought Frequency - Analysis of 435 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. 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 is capable of withstanding the 2002 drought conform reasonably well with 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 - 2006 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 relevant 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 - 2006 simulated study period without shortage. The estimated firm yield of Loveland's current water supply is approximately 24,280 af/y (23,690 af

municipal and 590 af augmentation). The City's firm yield was increased about 1,140 af/y through the acquisition of 1,238 CBT units since 2004.

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 Windy Gap Firming Project will be construction of an East Slope reservoir in which 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 7,000 af, which would increase the total firm yield to 27,390 af (26,800 af municipal and 590 af 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 acre-feet to 20,000 acre-feet of Chimney Hollow Reservoir space. The results of the model runs are shown in Figure 15 and indicate that participation at a 12,000 acre-feet storage level would increase Loveland's firm yield by approximately 1,260 af/y. Greater participation would increase Loveland's firm yield, especially if it acquired more Windy Gap units.

5. Reduction in Firm Yield from Increased 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. Greeley and Evans both claim exchanges that are mostly senior to Loveland's exchanges. The potential impact of increased senior exchanges was evaluated with the Yield Model and the results are shown in Figure 17. The results indicate that exchanges on the lower reach of the Big Thompson River, such as those by Greeley and Evans, could reduce Loveland's firm yield by 2,300 af/y 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 exchanges on the middle reach of the river could have even greater impacts on Loveland's firm yield, but operation of the senior exchanges for fewer days could moderate the impact on the City’s exchanges..

6. <u>Reduction in Firm Yield from Decreased Agricultural CBT Project Deliveries</u> - 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 was evaluated with the Yield Model. The results showed that cessation of agricultural use of CBT water on the Big Thompson River would reduce Loveland's firm yield by at least 450 af/y. 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.

7. <u>Increased Firm Yield from Acquisition of Irrigation Company Shares</u> - 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 5 and Figure 20, 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. 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.

8. 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 5 and Figure 22 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.

9. Increased Yield from Windy Gap Units - The benefit to Loveland of additional Windy Gap units depends on the extent of participation in the Windy Gap Firming Project. 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 add firm yield to Loveland's water supply depending on the level of participation. For example, at a participation level of 7,000 acre-feet, the increase in firm yield would be approximately 44 af/y per additional Windy Gap unit, while participation at 12,000 acre-feet of storage capacity would result in an increase in firm yield of 81af/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.

10. 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 Figures 23 and 25. 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 24, the City would also benefit by limited amounts of downstream terminal storage (up to approximately 1,000 acre-feet). Additional amounts of downstream storage would be helpful if the City develops downstream water demands, such as non-potable irrigation or augmentation, that would allow use of the stored water directly without exchange.

11. 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 6. Maximizing the yield of existing supplies may be an alternative to developing new supplies.

12. 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 is capable of withstanding a 100-year drought. Given that the 1951 - 2006 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 1970's and early 2000's. 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 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.

S:\Projects\74.15.LOV\Report\Raw Water Supply Yield Analysis_7415LOV-draft.docx

TABLES

Table 1

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

Ditch	202A Transfers	392 Transfers	Loveland Total	Ditch Company Total	Loveland % Total
Big Thompson Ditch & Manuf. Co.	2.6	3.8	6.4	20.8	30.8%
Barnes Ditch	1306.8	24.5	1331.3	1944.2	68.5%
Chubbuck Ditch	596.6	815.0	1411.6	1590.4	88.8%
George Rist (Buckingham) Ditch	6.1	89.3	95.4	200.0	47.7%
Louden Ditch	191.5	61.5	253.0	600.0	42.2%
South Side Ditch	57.5	23.0	80.5	265.0	30.4%
Farmers Ditch[2]	0.0	0.0	0.0	30.0	0.0%
Greeley Loveland Irrigation Company	0.0	0.0	0.0	1636.0	0.0%
Home Supply Ditch	0.0	0.0	0.0	2001.0	0.0%

Notes:

(1) Share figures rounded to nearest tenth.

(2) Leased Shares

Table 2
Loveland Raw Water Yield Study
Summary of Differences in Base Run Conditions, 2004 and 2011 Analyses

	2004	2011*
Municipal Firm Yield, AF	**22,440**	**26,800**
Augmentation Demand, AF	**0**	**590**
TOTAL DEMAND, AF	**22,440**	**27,390**
Municipal Demand Distribution Basis	1997-2001	2000-2010
Last Year of Study Period	2003	2006
Call Revisions	No	Yes
LPL Capacity, cfs	71.3	90
WGFP Participation, AF	OFF	7,000
Updated WG Inflows	No	Yes
WG Order	Before GRG	Last (after GRG)
CBT Units	10,538	11,786
Municipal 6 cfs (BTDM)	When BTDM diverting	In Priority,Apr 24-Oct 30
Domestic 6 cfs	Off	In Irrigation Priority, Apr-Oct
Ditch Source Order	Sr to Jr	Jr to Sr
Rist & Goss Order	After	Before
392 Conditions Modeled	No	Yes
Free River Diversions	Not Reusable	Reusable
WWTP Exchange	To GRG	Also to LPL
WTP Decant	NA	WTP Decant used as source

* Preliminary

Table 3

Simulated Average and Dry Year Water Supply[1]
City of Loveland
(acre-feet per year)

Source	1951 - 2006 Average	Dry Year (2002)
LPL (3.44 cfs)	2,490	2,490
Early BTDM (6cfs)	2,180	1,240
Domestic (6 cfs)[2]	670	120
202A Transfers[3,4]	9,510	2,710
392 Transfers[4]	4,610	1,250
CBT	8,790	8,250
Windy Gap	7,620	0
Total	35,870	16,060

Notes:

(1) Doesn't include yield from Green Ridge Glade Reservoir, free river diversions and exchanges of reusable effluent.

(2) Diverted Apr-Oct 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 the questions are resolved, the rights are 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 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.

Table 4

Simulated Average and Dry Year Base Run Yields[1]
City of Loveland
(acre-feet per year)

Source	Municipal + Park Irrigation 1951 - 2006 Average	Municipal + Park Irrigation Dry Year (2002)	Augmentation 1951 - 2006 Average	Augmentation Dry Year (2002)
Loveland Pipeline Rights[2]	5,340	3,849		
202A Transfers	7,300	2,215		
Rist&Goss Transfer	250	122		
392 Transfers	880	432		
Free River	1,180	31		
WWTP Effluent[3]	700	2,430	170	240
CBT	8,840	8,430		
GRG Release	2,400	9,381	310	230
Windy Gap (Direct)[4]	0	0		
WTP Decant			20	30
Total	26,890	26,890	500	500

(1) Modeled 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 Loveland Pipeline in the Base Run results, but it is diverted into Green Ridge Glade Reservoir and is part of the total reservoir releases

Table 5

Summary of Incremental Firm Yield Analysis
City of Loveland

Water Source	Added Supply	Total Yield of Additional Supply		Unit Yield (e.g., yield per share)		Add'l Storage to Firm 500 af/y	
		Avg Historical Yield (af/y)	Firm Yield (af/y)	Unit Avg Historical Yield (af/y)	Unit Firm Yield (af/y)	Storage Capacity (acre-feet)	Firming Ratio (3)
(1) Additional Ditch Supply (shares or inches)							
Louden	41.090	500	100	12.17	2.43	1,550	3.1
Big T Ditch & Mfg.	2.680	500	190	186.57	70.90	1,200	2.4
South Side	109.840	500	160	4.55	1.46	1,310	2.6
Barnes	0.000						
Chubbuck	0.000						
George Rist	78.660	500	30	6.36	0.38	1,840	3.7
Handy	53.000	500	100	9.43	1.89	1,520	3.0
Home Supply	49.808	500	300	10.04	6.02	620	1.2
GLIC	56.670	500	310	8.82	5.47	350	0.7
Hillsborough	4.490	500	190	111.36	42.32	1,180	2.4
Ryan Gulch Res	100%	320	220	320.00	220.00	310	1.0
(1) Additional Transmountain Supply (units)							
CBT	671.1	500	590	0.75	0.88		
WG Unfirmed	6.98	500	0	71.63	0.00		
WGFP (7,000) (4)	5.67	500	250	88.18	44.09		
WGFP (9,000) (4)	5.67	500	430	88.18	75.84		
WGFP (12,000) (4)	5.67	500	460	88.18	81.13		

(2) Additional Storage Capacity (af)

					Firming Ratio(3)
Upstream	1,000	--	250	--	4.0
Downstream	500	--	1490	--	0.3

Notes:

(1) Increase in Loveland's current firm yield resulting from addition of 500 af/y of average annual yield.

(2) Increase in Loveland's current firm yield resulting from addition of upstream or downstream storage.

(3) Firming ratio computed as the increased storage capacity divided by the firm yield.

(4) Based on Loveland participation in the Windy Gap Firming Project (WGFP) at 7,000, 9,000 and 12,000 af of East Slope storage.

Table 6

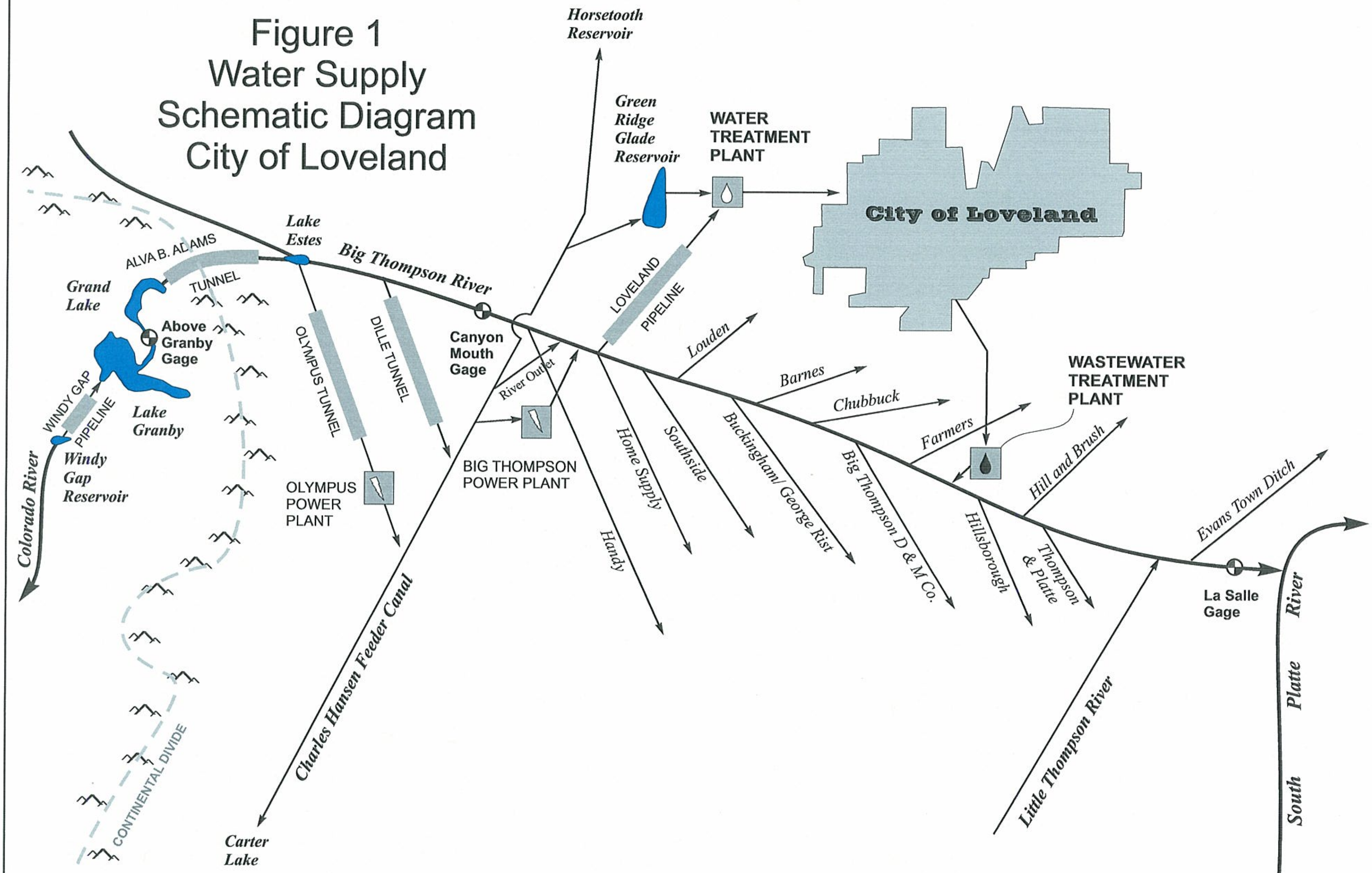
Loveland Raw Water Yield Analysis
Incremental Firm Yield[1] of Alternate Water Supply Operations

Run Name	Description	Municipal Firm Yield AF	Incremental Yield AF
BASE RUN	Base Run	**26,800**	
Domestic 2	Diverted year-round with irrigation priority	27,610	810
Domestic 3	DivertedyYear-round with domestic priority	28,610	1,810
CBT2	CBT used after GRG	20,640	-6,160
CBT3	CBT and GRG are used 50/50 in Winter	26,360	-440
CBT4	CBT and GRG are used 50/50 year-round	26,360	-440
Exch All Year	Allow exchanges all year, not just April-Oct	26,830	30
LIRF ON	LIRFs used for augmentation and return flow obligations	27,210	410
Rist&Goss Order	Used Last afrter other Transferred Rights	26,880	80
Windy Gap 2	Windy Gap (direct) is used before GRG releases	26,360	-440
All Max conditions		29,120	2,320

(1) Municipal Firm Yield is used in the table. Total Firm Yield for these model runs includes an additional 590 af of augemntation demand met.

FIGURES

Figure 1
Water Supply
Schematic Diagram
City of Loveland

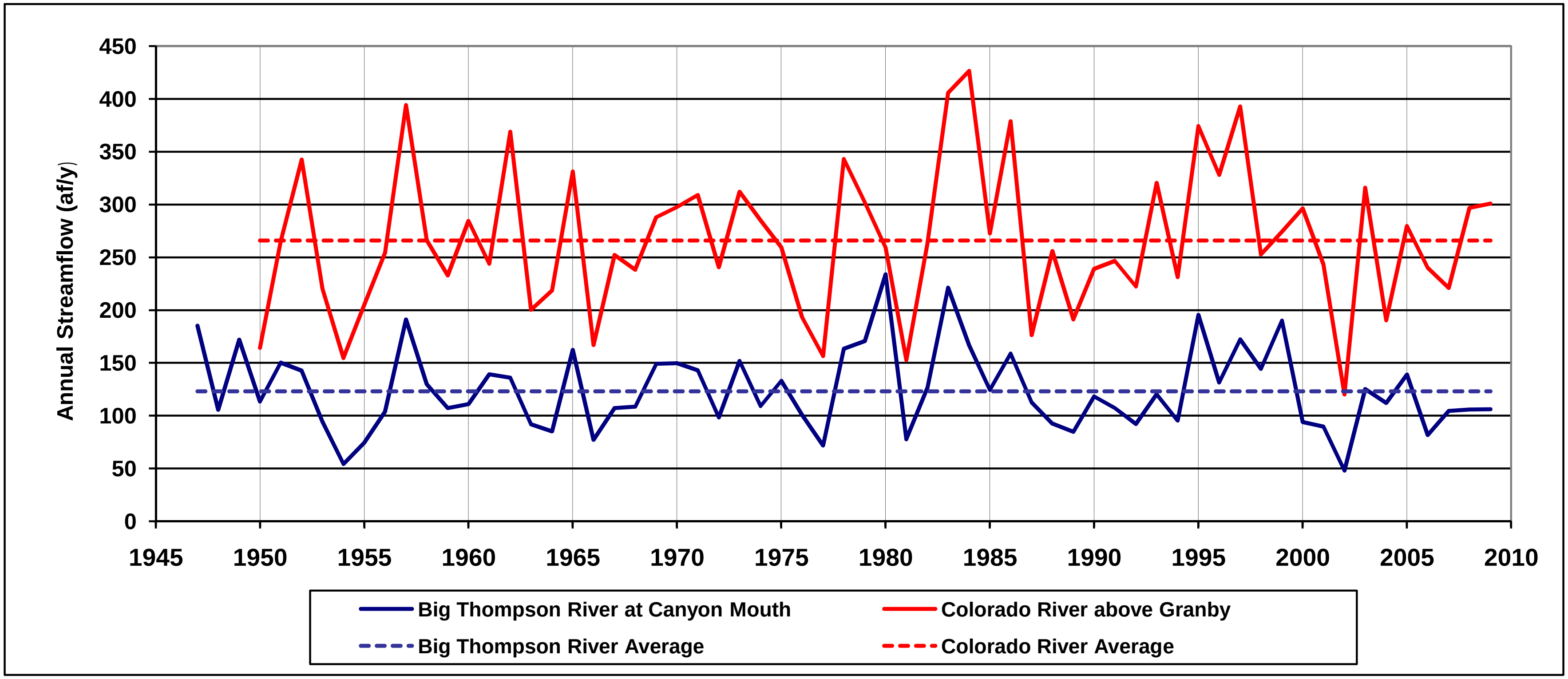


Schem.cdr
Sspronk Water Engineers, Inc.

10/28/2004

Figure 2

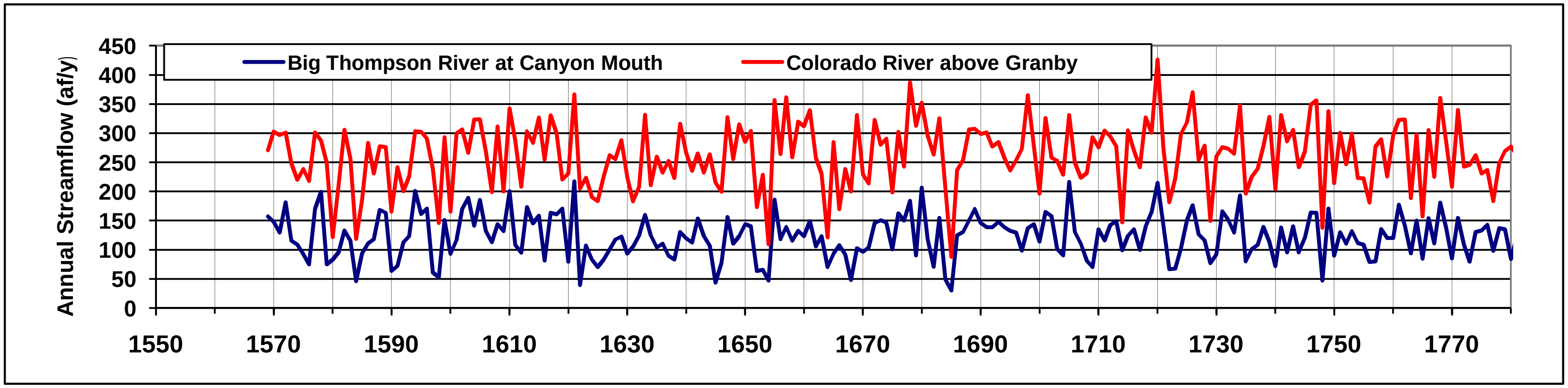
Historical Annual Virgin Streamflow
Big Thompson River at Canyon Mouth and
Colorado River above Granby
1947 - 2009
(acre-feet per year)

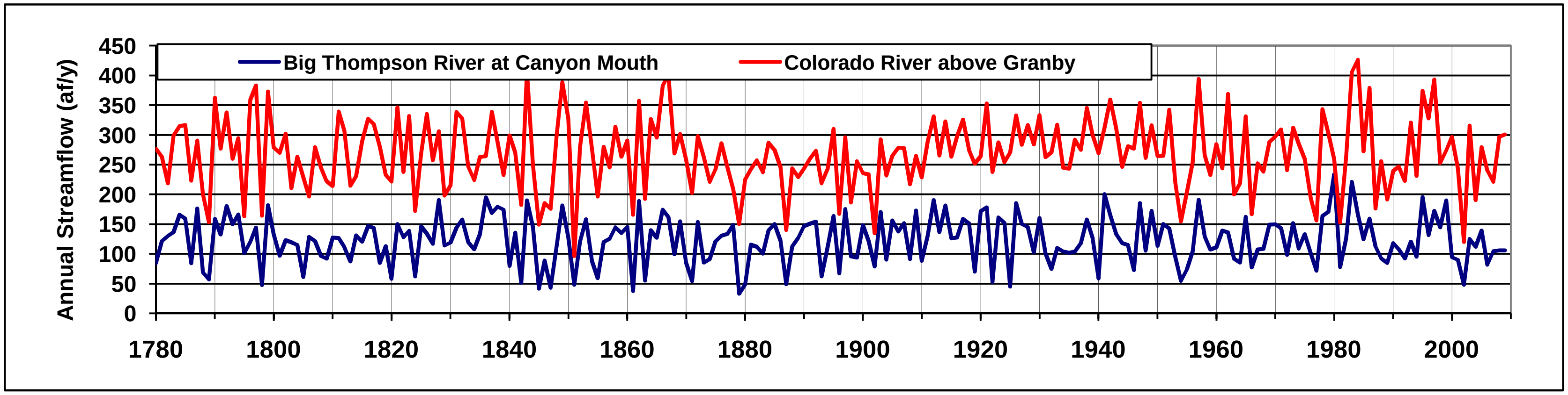


Note:
Historical "virgin"(undepleted) flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2009) and the Colorado River above Granby Reservoir (1950-2009).

Figure 3

Historical and Reconstructed Annual Virgin Streamflow
Big Thompson River at Canyon Mouth and
Colorado River above Granby
1569 - 2009
(acre-feet per year)





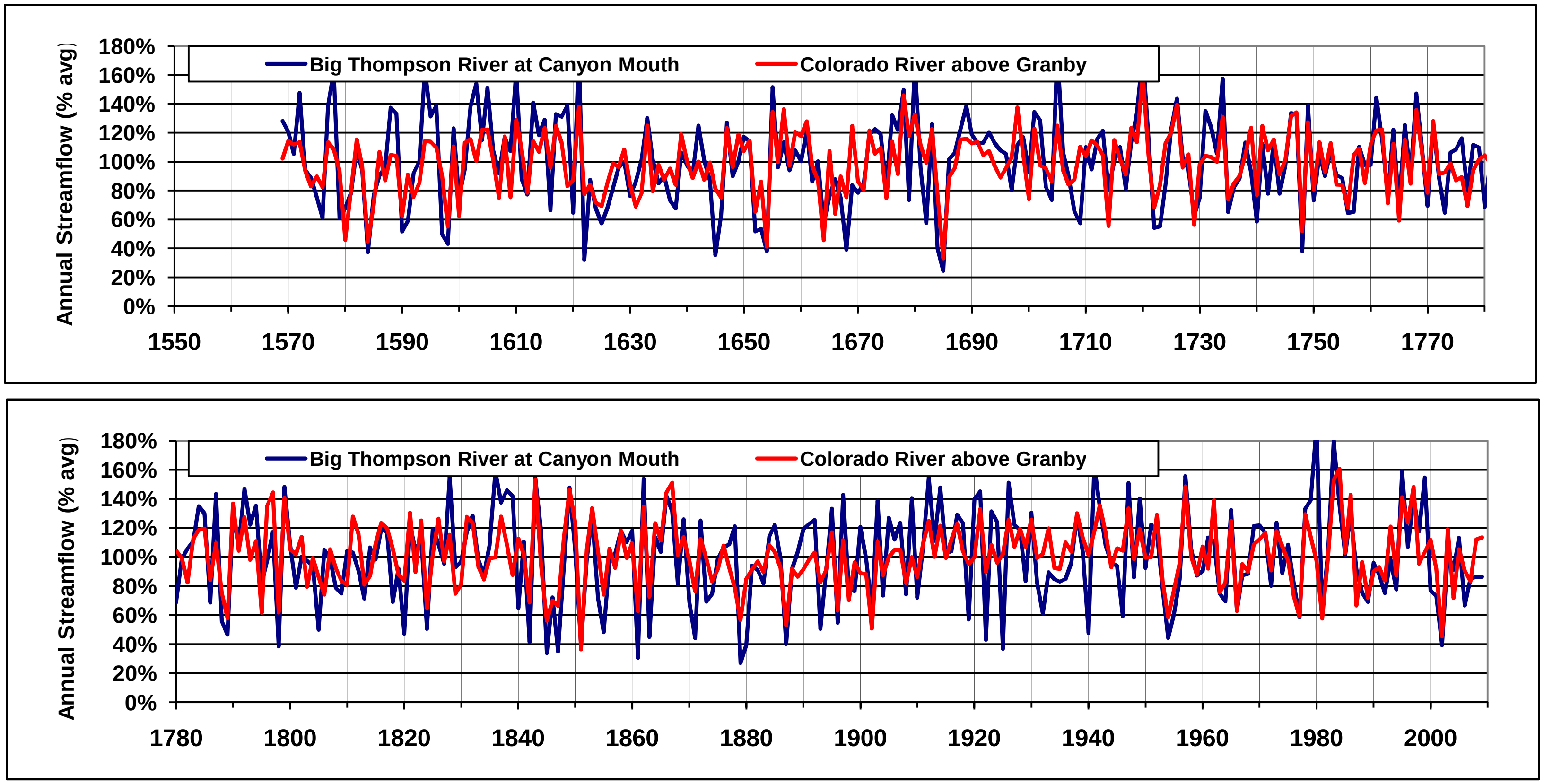
Notes:

Historical "virgin" flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2003) and the Colorado River above Granby Reservoir (1950-2003).

Reconstructed "virgin" flows provided by Connie Woodhouse of NOAA for the period prior to the historical data.

Figure 4

Normalized Historical and Reconstructed Annual Virgin Streamflow
Big Thompson River at Canyon Mouth and
Colorado River above Granby
1569 - 2009
(% annual average flow)



Notes:

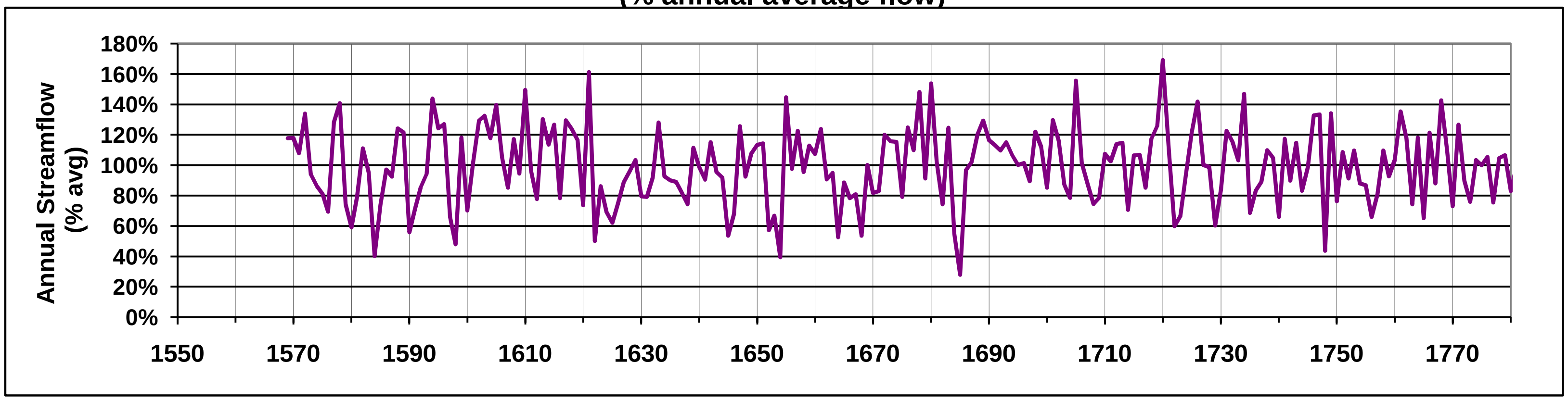
Historical "virgin" flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2003) and the Colorado River above Granby Reservoir (1950-2003).

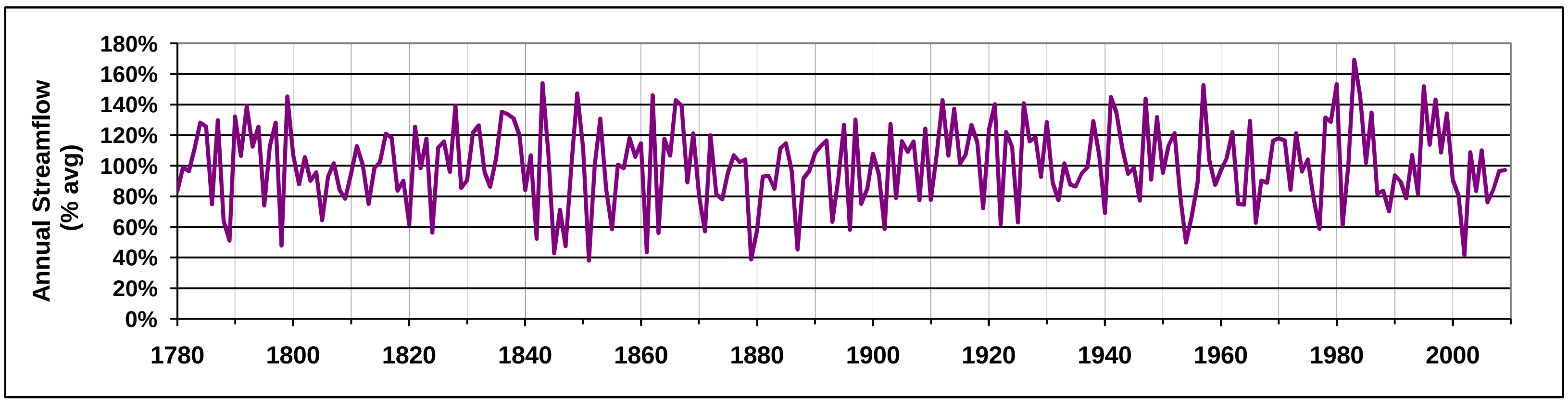
Reconstructed "virgin" flows provided by Connie Woodhouse of NOAA for the period prior to the historical data.

Normalized flows computed as annual flows divided by 1569 - 2003 average flow.

Figure 5

Normalized Historical and Reconstructed Annual Virgin Streamflow
Composite of Big Thompson River and Colorado River
1569 - 2009
(% annual average flow)





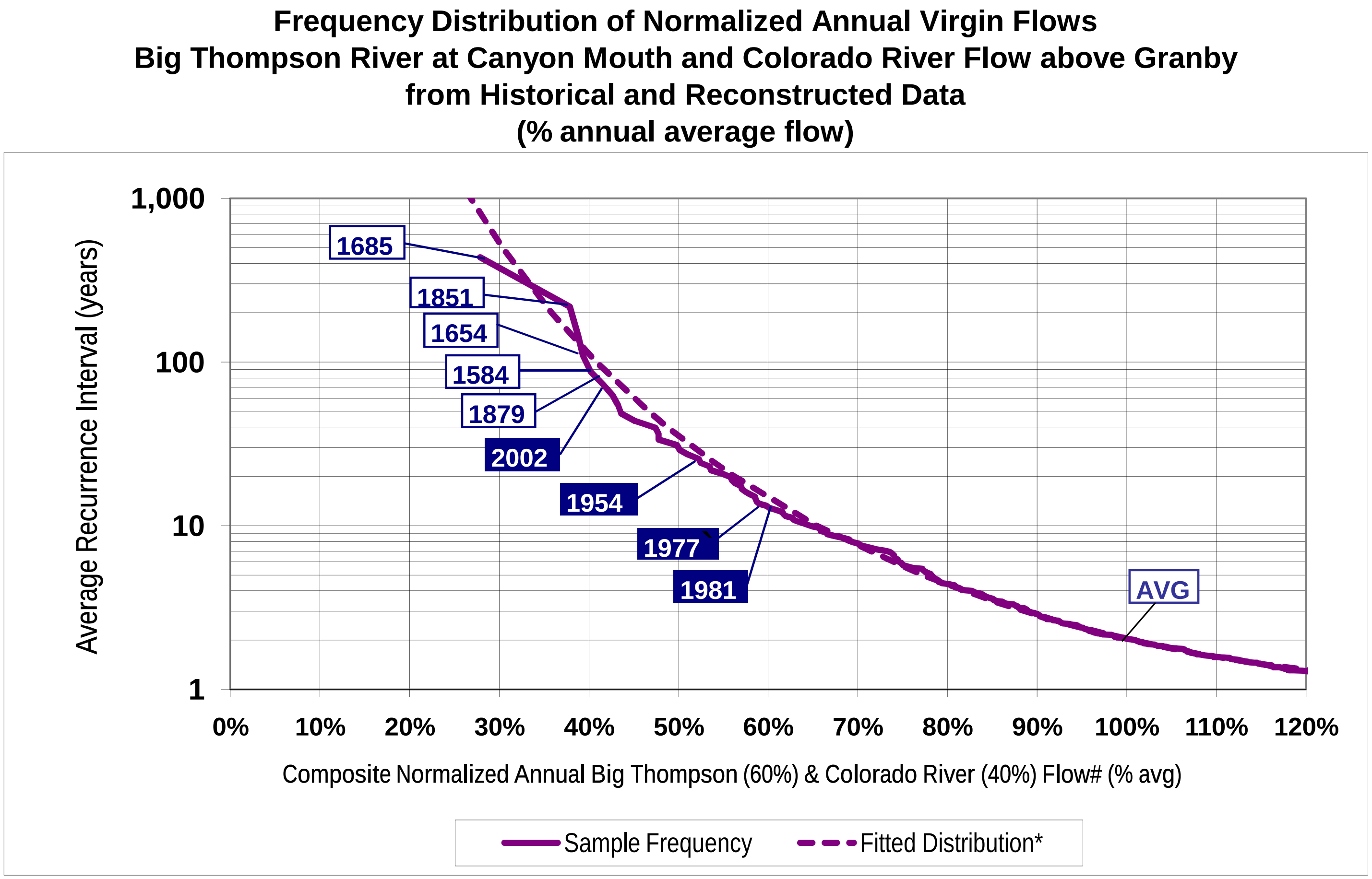
Notes:

Historical "virgin" flow data provided by the NCWCD for the Big Thompson River at the Canyon Mouth (1947-2003) and the Colorado River above Granby Reservoir (1950-2003).

Reconstructed "virgin" flows provided by Connie Woodhouse of NOAA for the period prior to the historical data.

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).

Figure 6



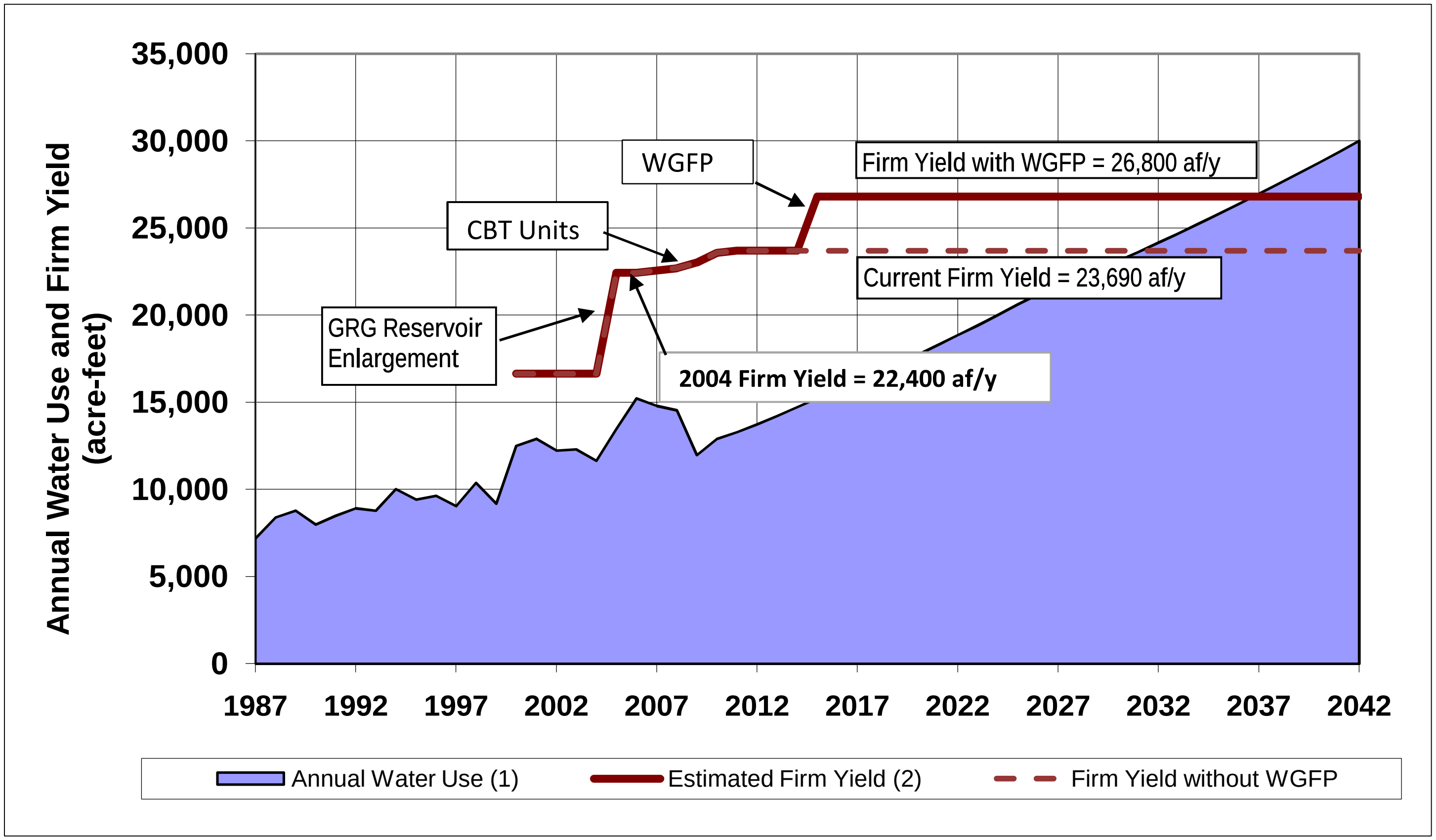
Notes:

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.

* Log Pearson Type III Distribution fit to data.

Figure 7

Historical and Projected Water Demand
vs. Estimated Firm Water Supply Yield
City of Loveland
1987 - 2042
(acre-feet per year)



<u>Notes:</u>

(1) Actual water use through 2010, and projected by City staff thereafter

(2) Firm yield does not include additional supply from additional future water supply .

Figure 8

City of Loveland
Simulated Daily Water Demand Distribution 2000-2010

With Comparison to 1997-2001 Distribution

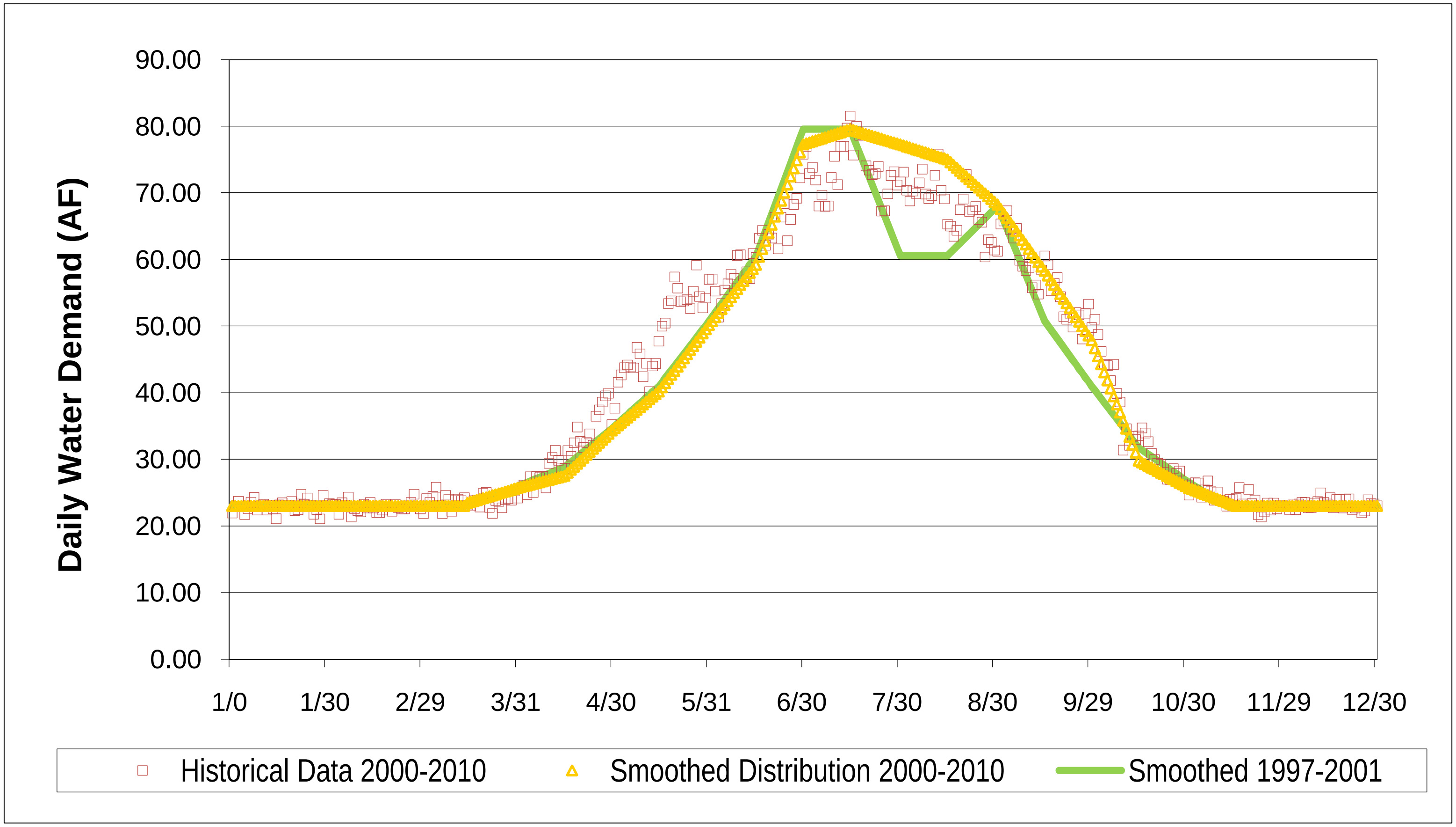
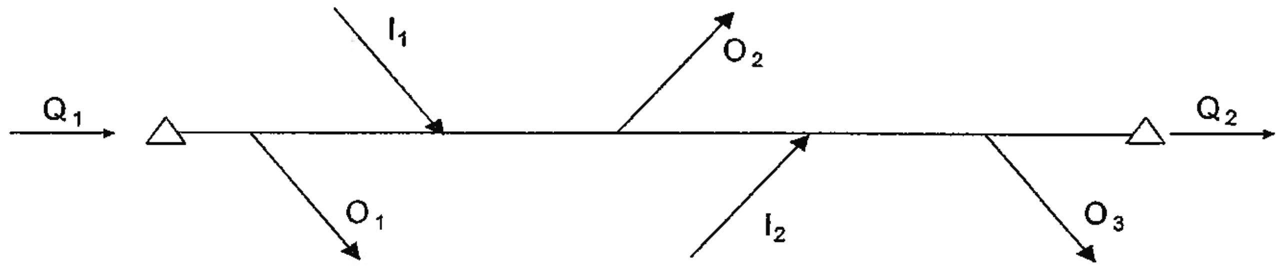


Figure 9

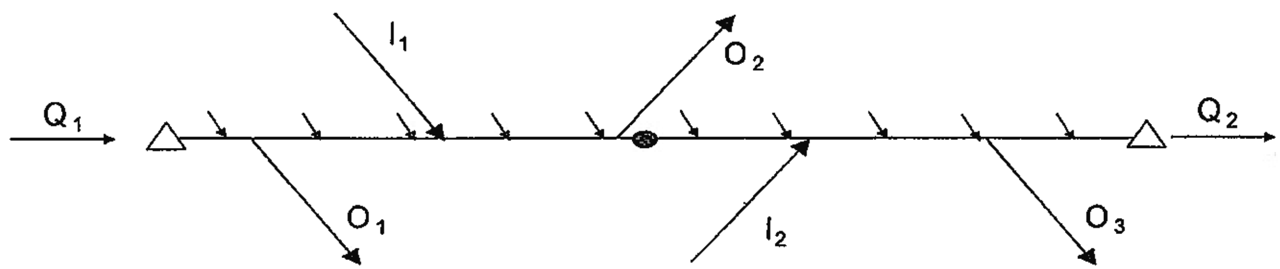
Point Flow Model Illustration

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

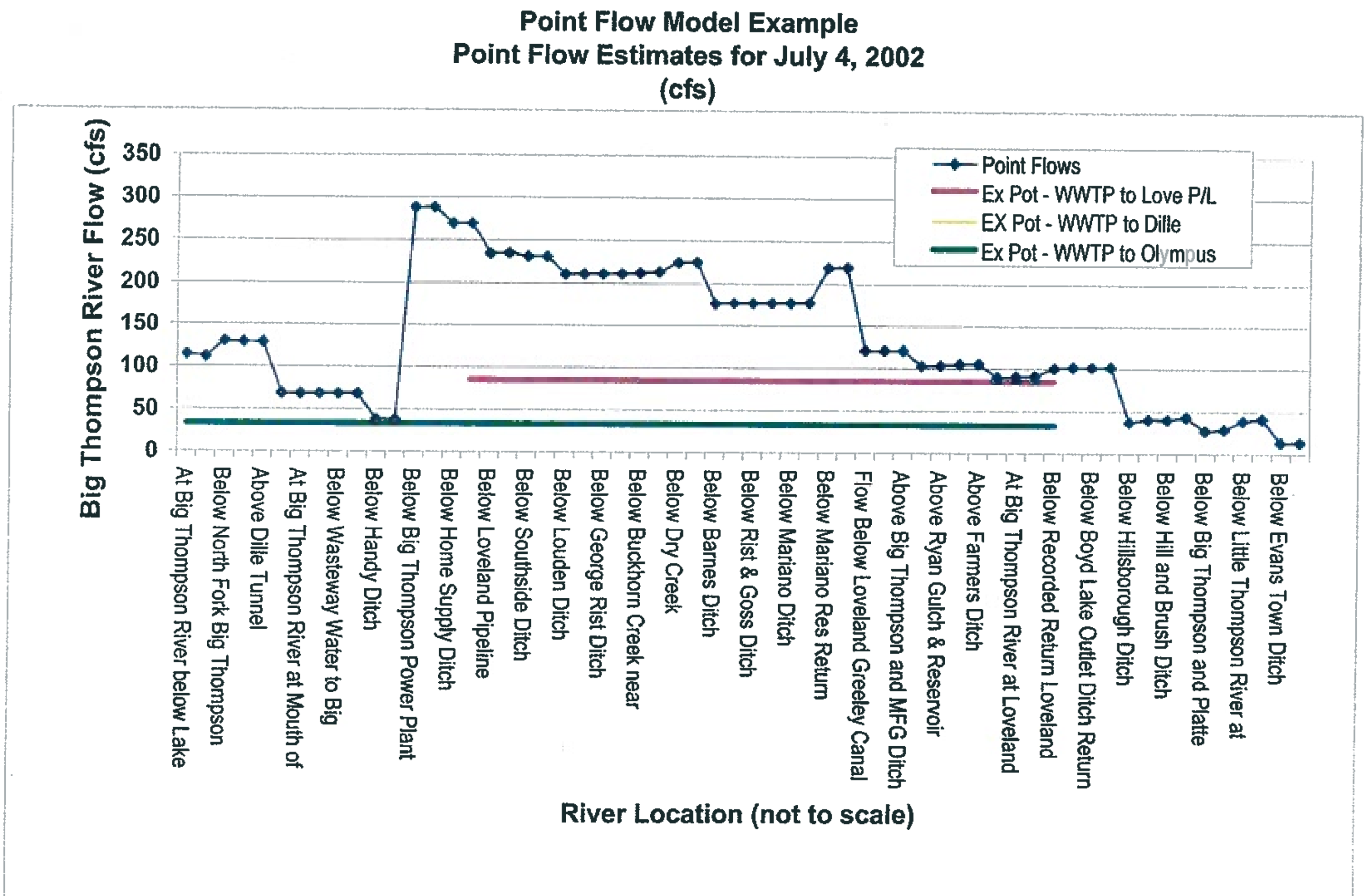


3. Compute Flow at Any Point Along the River

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

Figure 10



Point Flow Example.xls
Spronk Water Engineers, Inc.

10/27/2004

Figure 11 A

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 Shrt	Critical Yr	Shortage	Aug Shrt	Critical Yr	Shortage	Aug Shrt
51-06	0.0	24.6	1954	0	0	1982	0	0	1993	0	0
51-65	0.0	3324.1	1972	0	0	1987	0	0	1994	0	0
66-75	0.0	3321.5	1973	0	0	1988	0	0	2002	0.0	0.0
76-85	0.0	3313.8	1977	0	0	1989	0	0	2003	0.0	0.0
86-95	0.0	3323.9	1978	0	0	1990	0	0	2004	0.0	0.0
96-06	0.0	24.6	1979	0	0	1991	0	0	2005	0.0	0.0
All Demands Met?	OK		1981	0	0	1992	0	0	2006	0.0	0.0

	Muni	Aug	NP Irr	Ret Flow
Average Annual Shortage (af)	0.0	0.0	0.0	0.0
Maximum Annual Shortage (af)	0.0	0.0	0.0	0.0
No. of Years of Shortage	0	0	0	0

Titles For Summary Workbook

Run Description: **Aug 2011 BASE RUN , All Aug 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

26800

-

TOTAL DEMAND

Annual Municipal Demand, AF	**26,800**	71.6
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**	
Sum of Demands, AF	**27,390**	

Change Lease Distribution on Sheet D

IRRIGATION USE

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

RETURN FLOWS

WWTP Returns,% of Indoor Use	**95%**
Lawn Irrigation Returns, % of Irrigation Use	**20%**

Notes:

Flow Condition: NORMAL- Input July 2011

Shares per 02CW392 2/2010

Date Modified: **8/9/11**

WATER SUPPLY

CBT Supply

Number of Units 6/2011: 11,786 — **New Acquisitions**

Windy Gap Supply

Number of Units (2003)	40			**New Acquisitions**
WGFP Condition	2	**Firmed**	**7,000**	**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 Future	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%		0.0%	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%		0.0%	1
Louden	600.000	191.537	31.9%	61.547	10.3%	0.00	0.0%	6
South Side	265.000	57.500	21.7%	23.000	8.7%		0.0%	4
Rist & Goss	300.000	300.000	100.0%					12
Farmers	30.000			0.000	0.0%		0.0%	11
GLIC	1636.000	-		-	0.0%		0.0%	7
Handy	900.000	-		-	0.0%		0.0%	9
Hillsborough	118.000	-		-	0.0%		0.0%	8
Home Supply	2001.000	-		-	0.0%		0.0%	10

RESERVOIR SOURCES

	Boyd L	Lake Loveland	Horseshoe	Rist Benson	Ryan Gulch	agler/Lone
	GLIC		7 Lakes	Louden?	Independent	Home Supply
Ownership% from Ditch Shares	0%				100%	0.0%
Include in analysis? 1=yes						

CAPACITIES, ETC.

TOTAL UPSTREAM STORAGE

(New Storage simulated with additional GRG capacity)

Green Ridge Glade Reservoir

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

New Storage, Upstream Location

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

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

DOWNSTREAM TERMINAL STORAGE

Capacity, AF	
Initial Contents, AF	
Fill Rate Limit, cfs	**100**

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

Figure 11 B

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	Base Run Selected	Max Run Selected
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		1	3
6cfs early BTDM transfer	2		0=OFF	1=In Priority only on days when BTDM Diverts	2=Specified Irr Season in Priority			2	2
6 cfs BTDM Start Date	4/24	Date						4/24	4/24
6 cfs BTDM End Date	10/30	Date						10/30	10/30

CBT	Selected	Other	0	1	2	3	4	Selected	Selected
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	1	1

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

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

Other Sources	Selected	Other	0	1	2	3	4	Selected	Selected
WTP Decant Water, % of WTP	2.5%	% of WTP						2.5%	2.5%
Rist&Goss Order of Use	1			1=Before Other Ditches	2=After Other Ditches			1	2
Exchange Potential Season (FLOWS page)	1			1=Irr Season Only	2=All Year			1	2

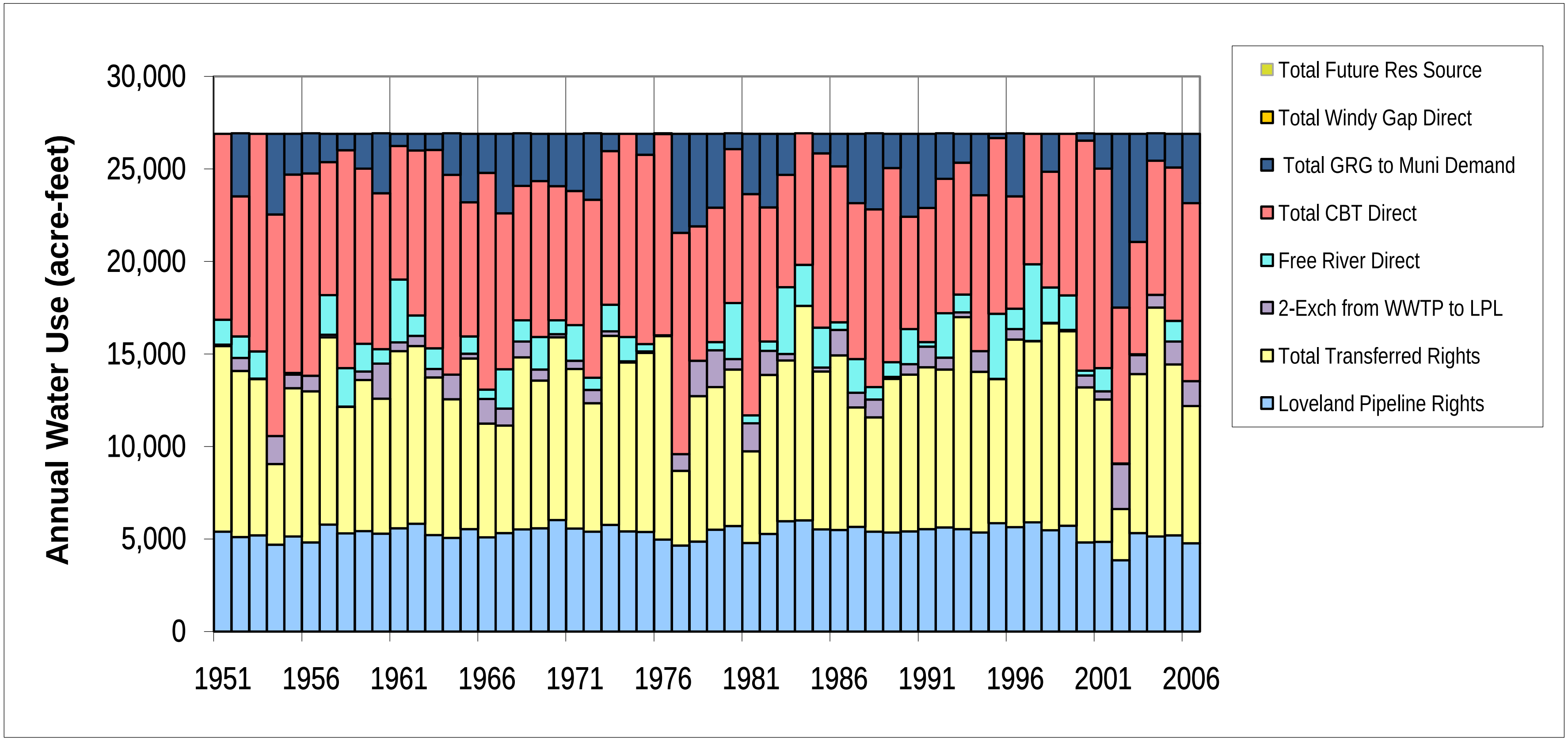
LIRF Uses (See lagging Factors on Sheet C)	Selected	Other	0	1	2	3	4	Selected	Selected
Reusable LIRF used for Augmentation	0		0=NO	1=YES				0	1
Reusable LIRF used for Return Obligations	0		0=NO	1=YES				0	1
Reusable LIRF stored in Gravel Pit?	0		0=NO	1=YES				0	0

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

Augmenatation Leases	Selected
Meet Every Day (0), Not during Free Rivre (1)	-

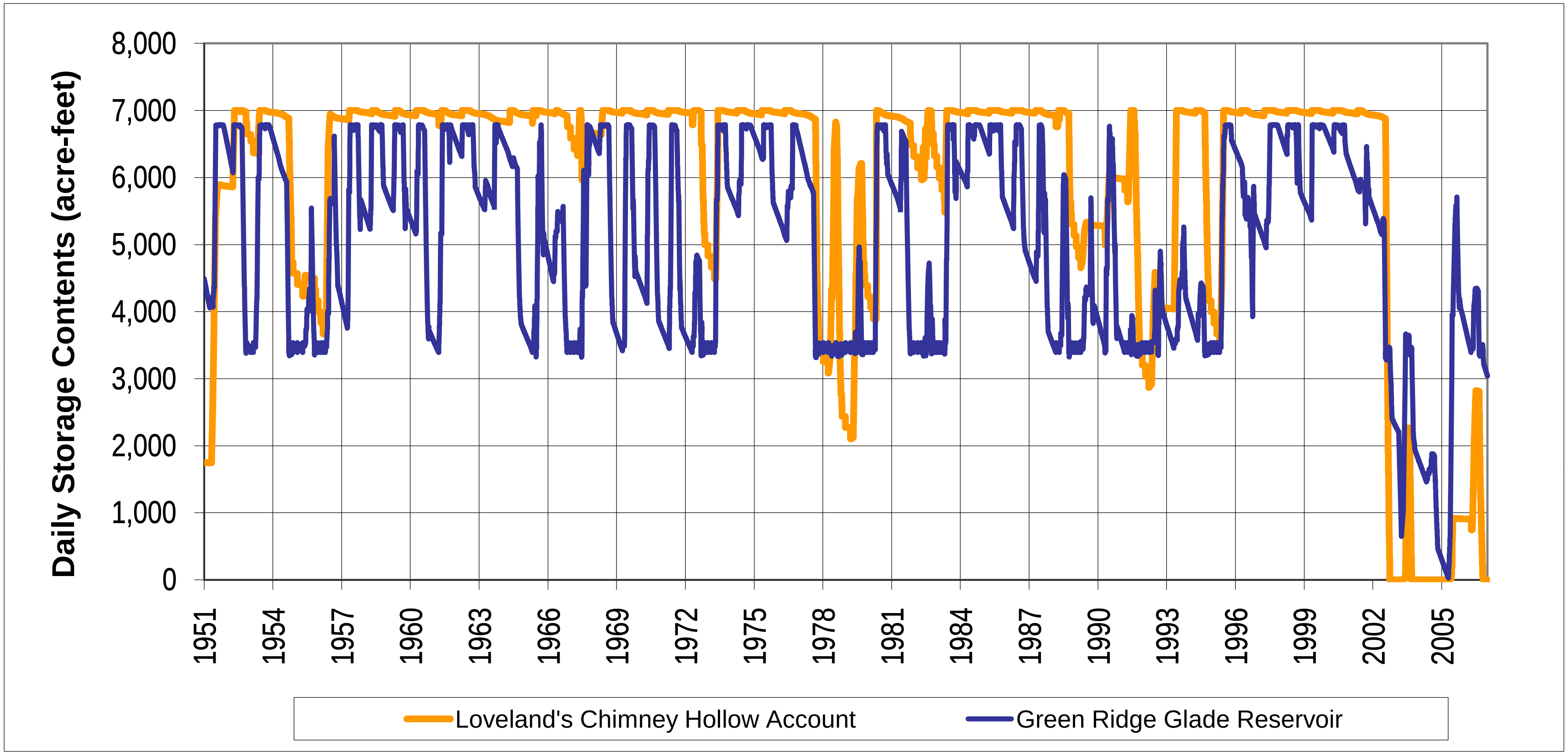
Figure 12

Annual Firm Yield Summary
City of Loveland
Firm Annual Yield = 26,800 + 590 = 27,390 AF



Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Figure 13
Daily Simulated Reservoir Contents
Windy Gap Firming Project and Green Ridge Glade Reservoir
City of Loveland



Aug 2011 BASE RUN , All Aug Demands Met

Figure 14
Loveland Raw Water Yield Model

Average Monthly Generation and Reuse of Reusable WWTP Effluent in the Base Run

Firm Annual Yield = 26,800 + 590 = 27,390 AF

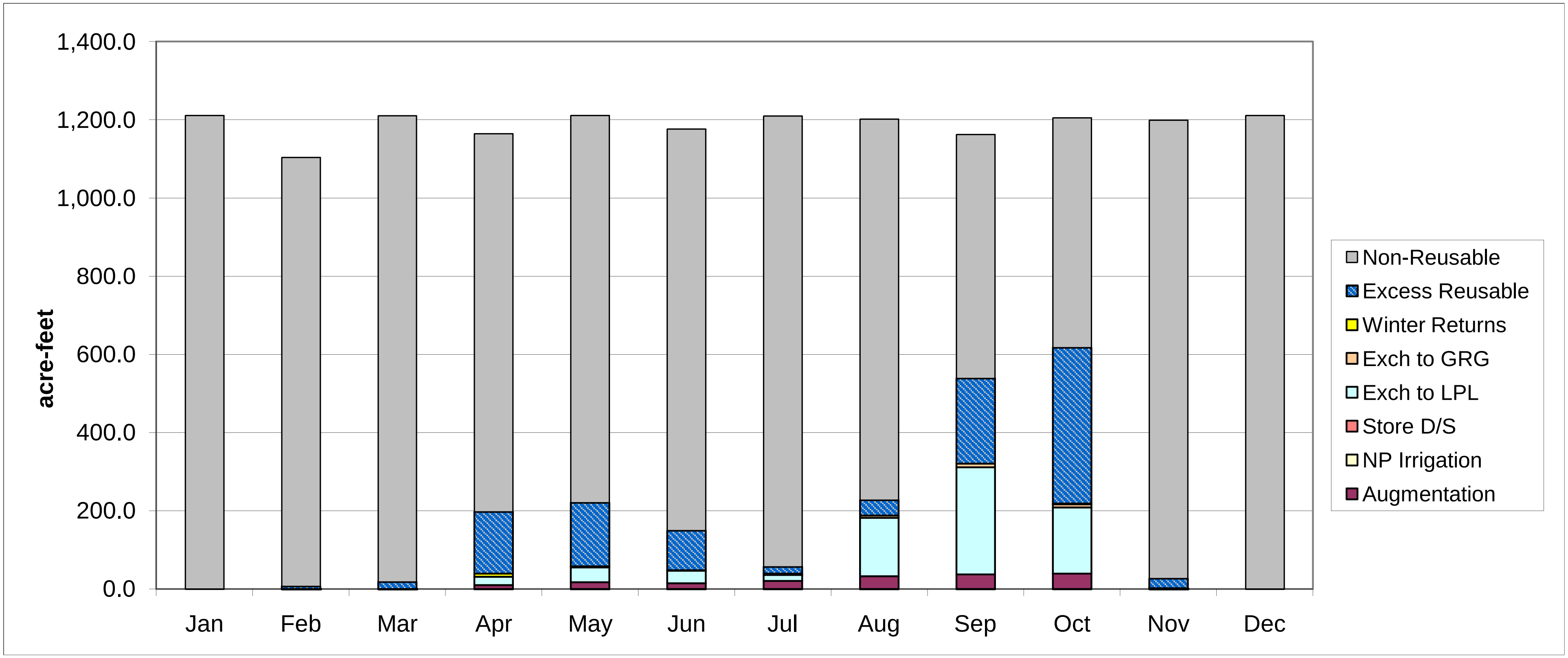


Figure 15

Increased Firm Yield from
Participation in the Windy Gap Firming Project
City of Loveland

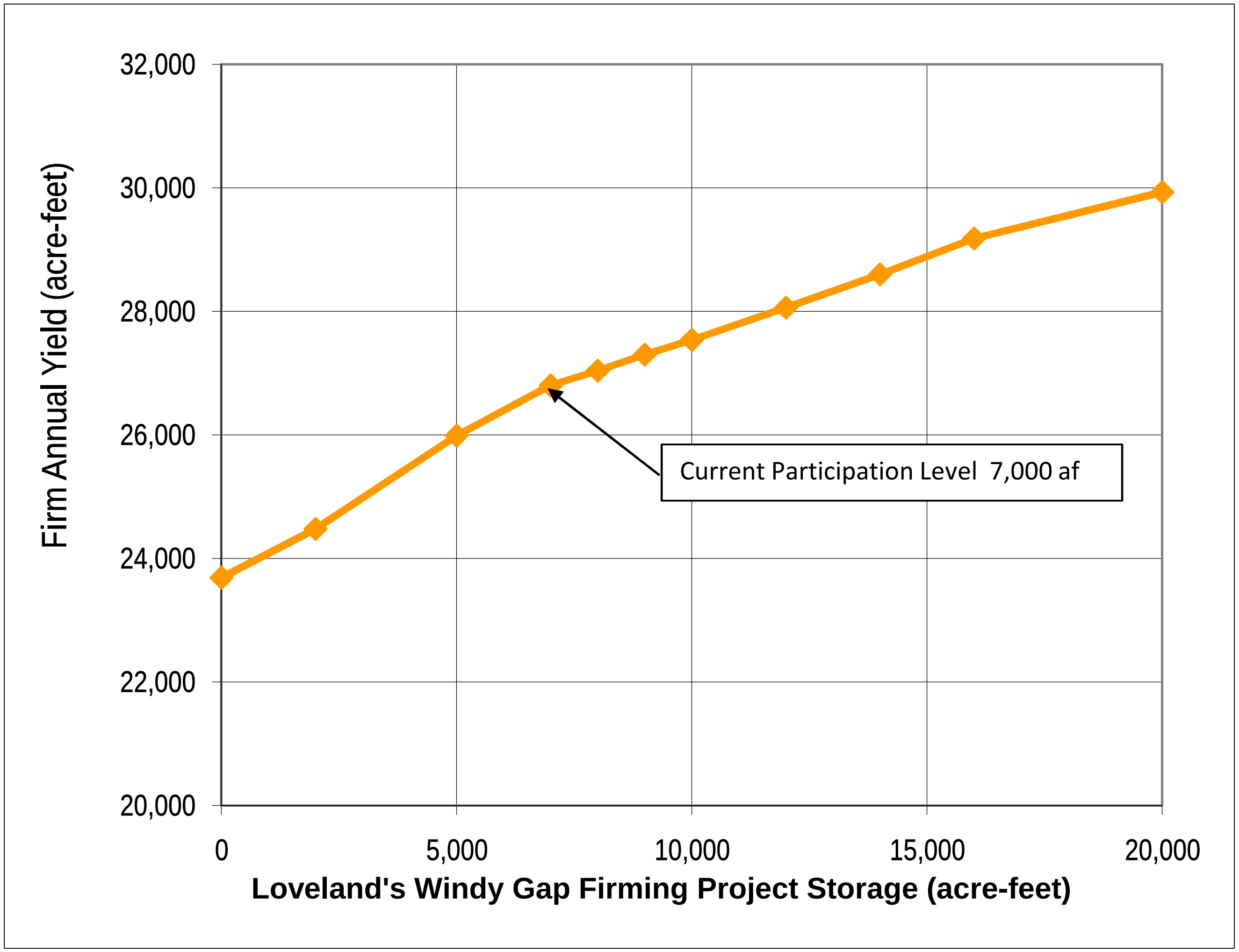


Figure 16

Simulated Annual Water Demand vs. Water Shortage
City of Loveland
Firm Annual Yield =26,800 acre-feet plus 590 acre-feet Augmentation Demand

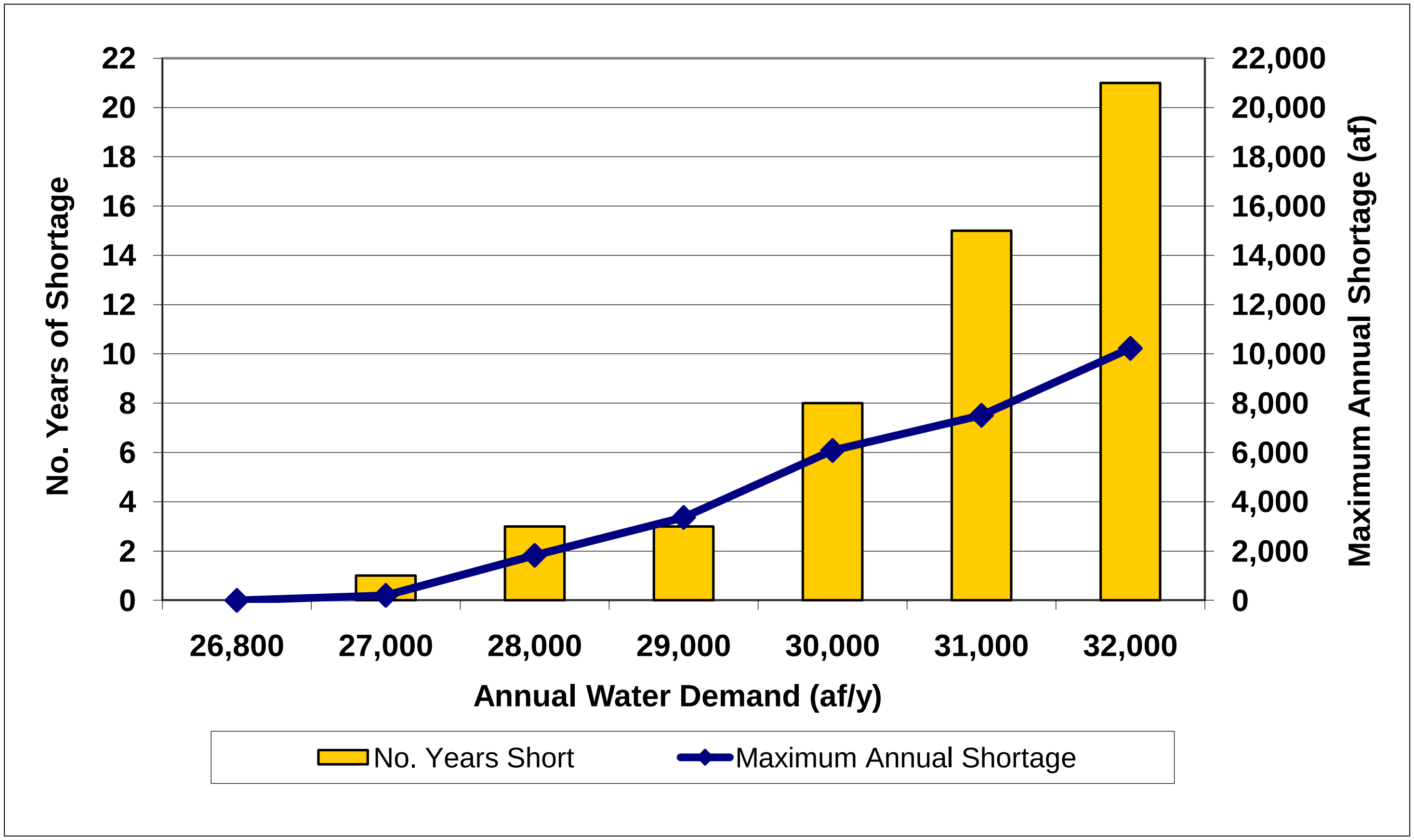
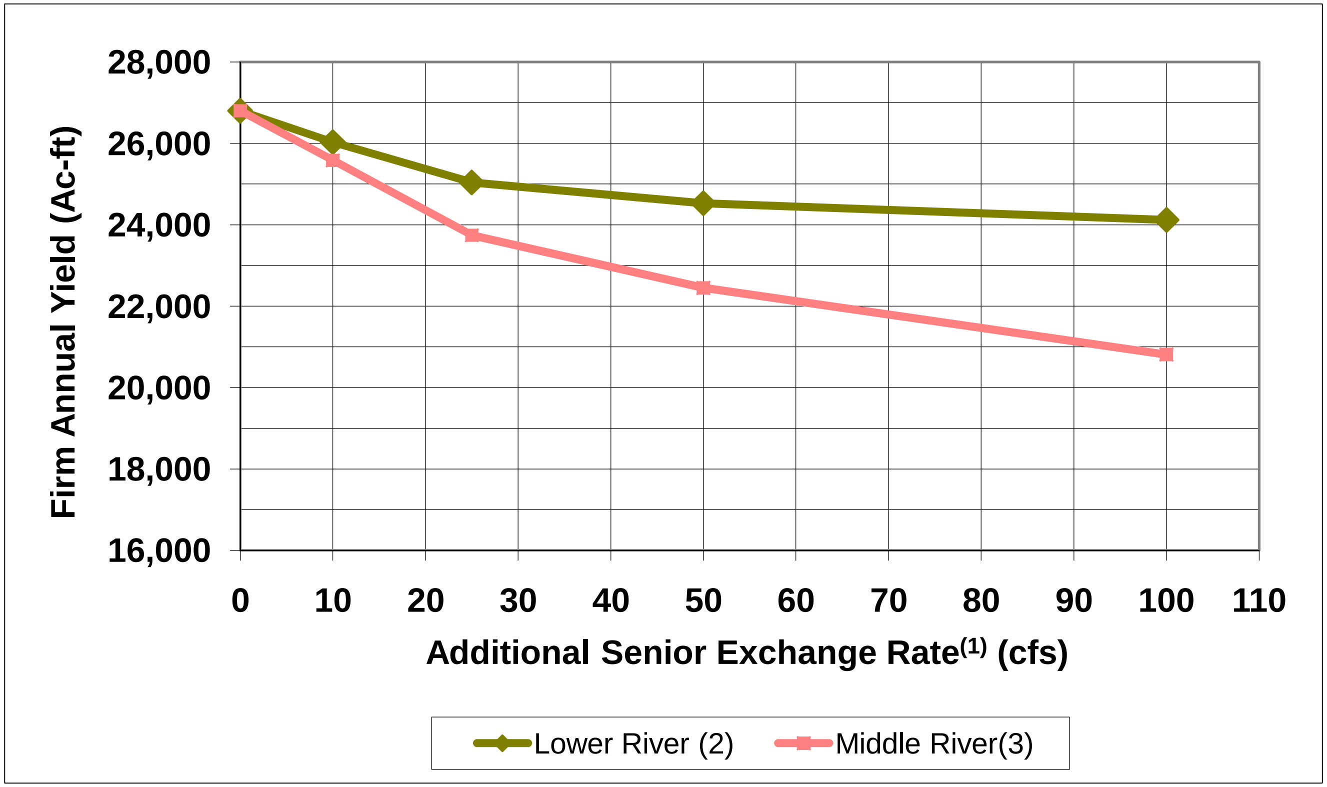


Figure 17

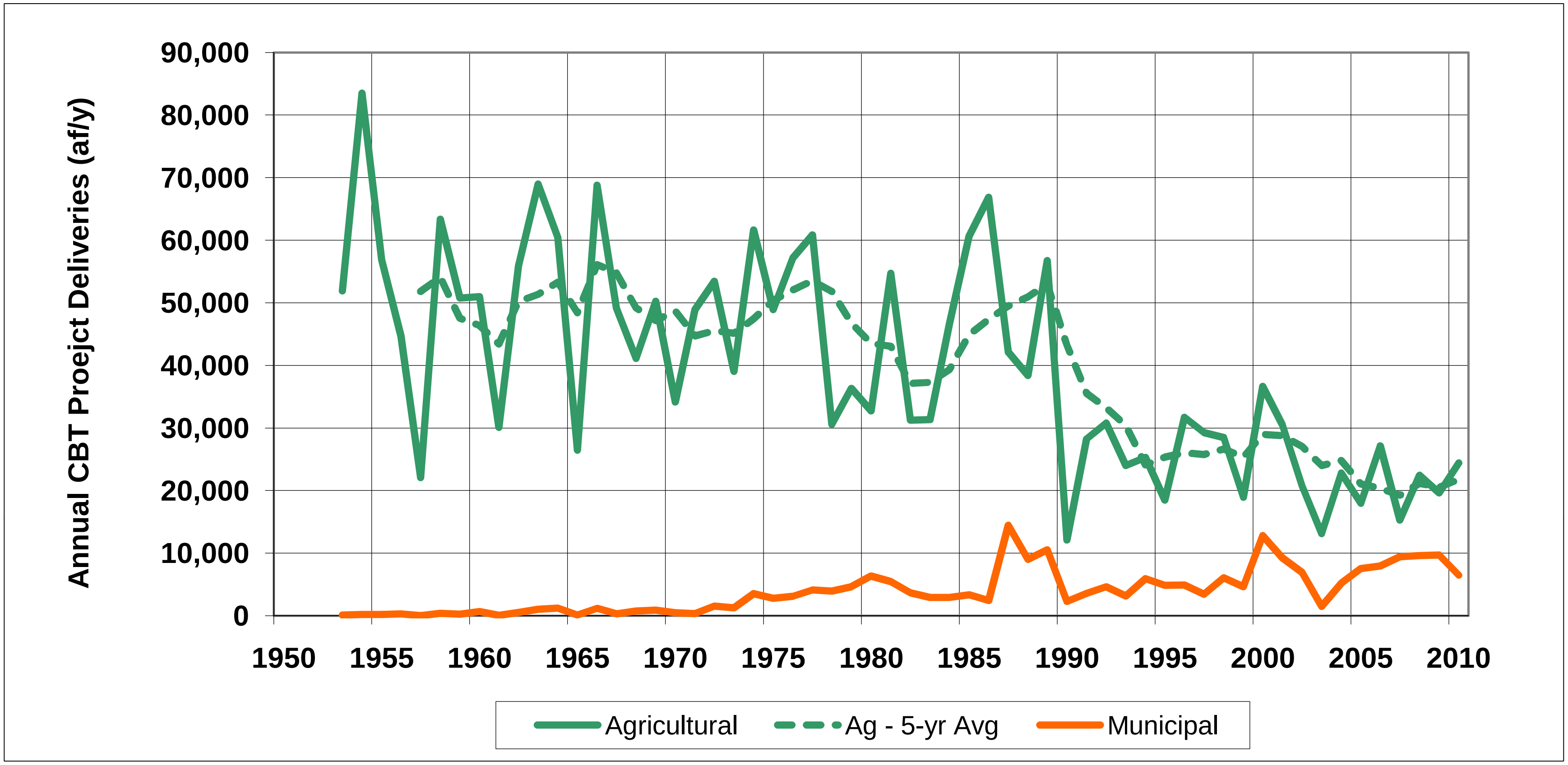
Effect of Increased Senior Big Thompson River Exchanges
On Firm Annual Yield
City Of Loveland



(1) Effect of historically operated exchanges (largely agricultural) are included in the baseline firm yield estimate (i.e., with additional senior exchanges = 0).
(2) Exchange from confluence with the South Platte River to Barnes Ditch headgate.
(3) Exchange from above the Hillsborough Ditch to the Loveland Pipeline.

Figure 18

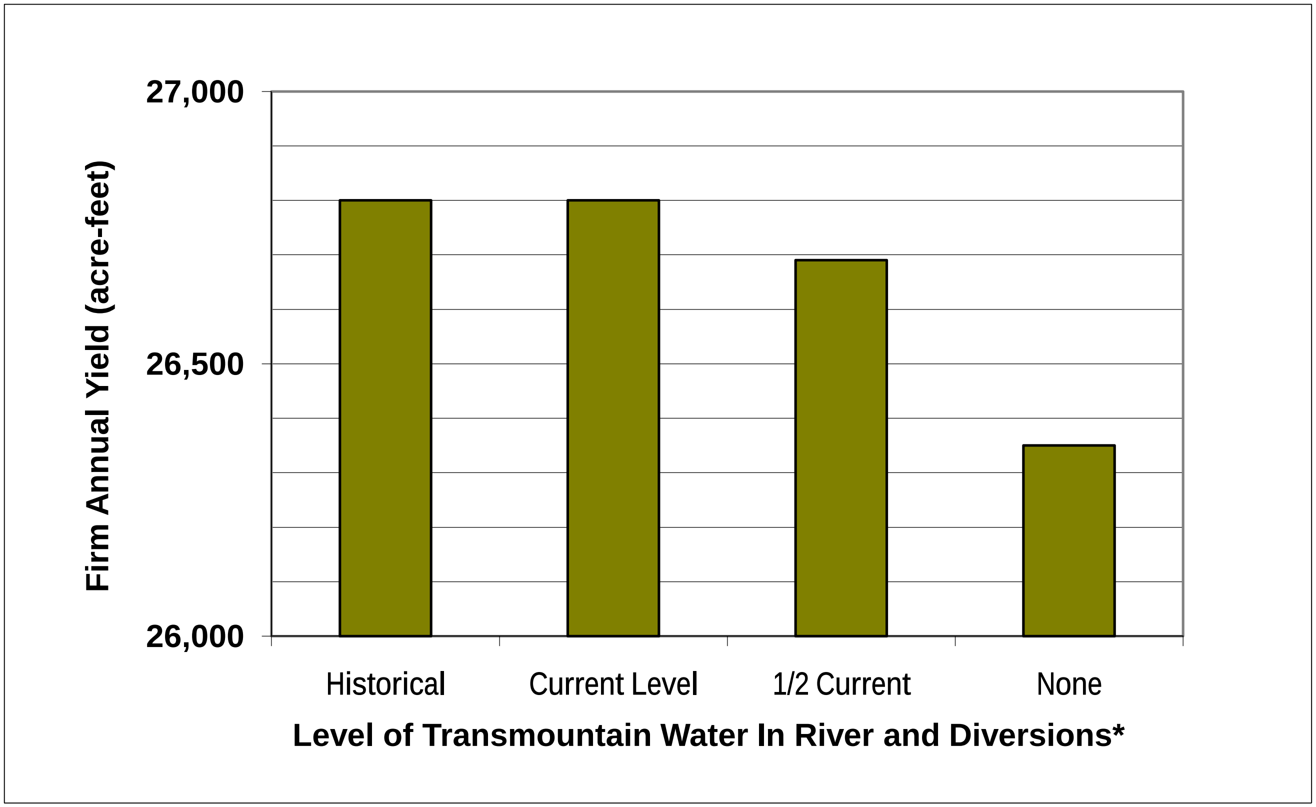
Historical Annual Agricultural and Municipal Deliveries of CBT Project Water to Big Thompson River



<u>Note:</u>
Data from the Northern Colorado Water Conservancy District.

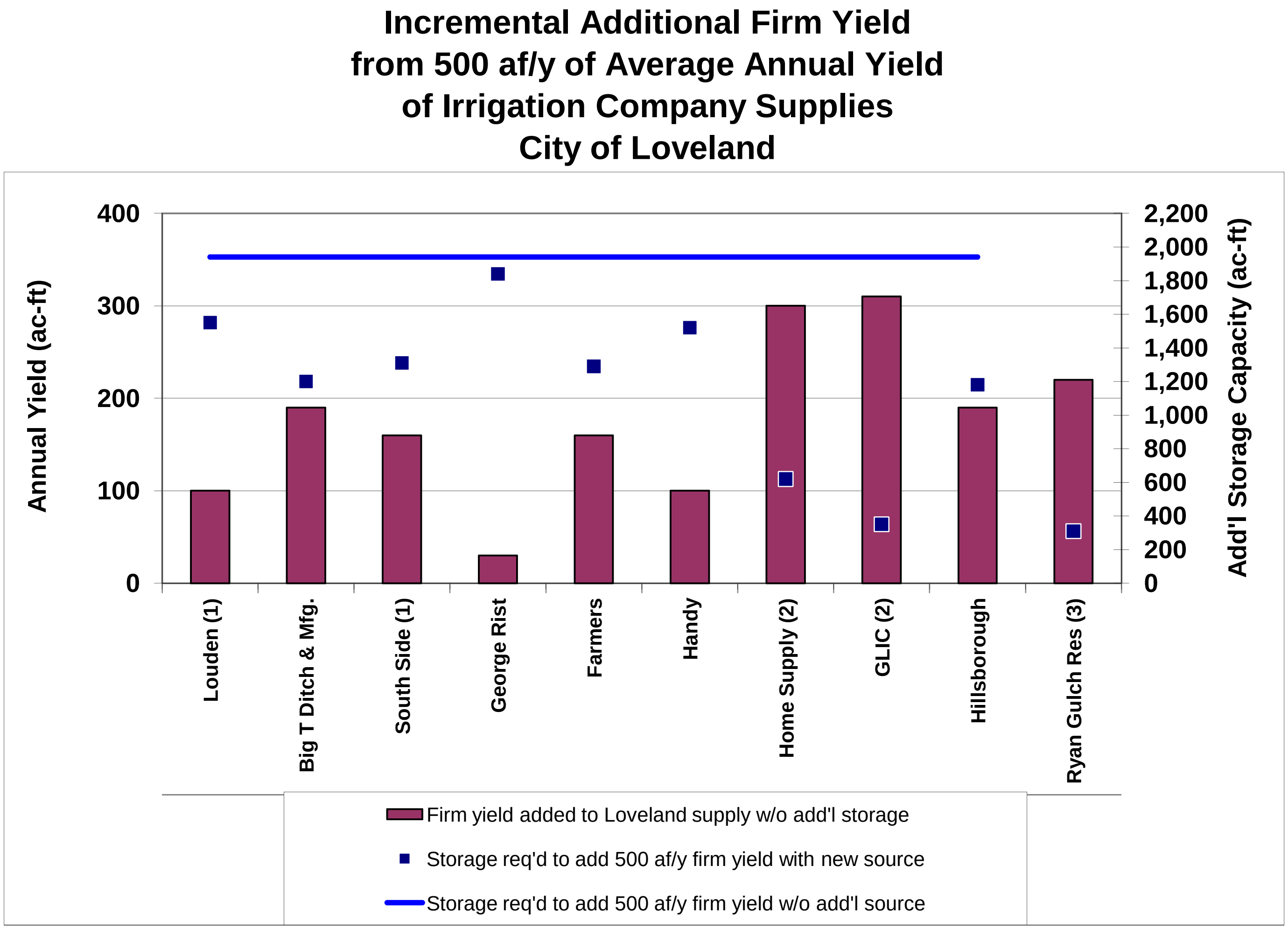
Figure 19

Effect of Reduced CBT Project Deliveries On Annual Firm Yield City Of Loveland



* Exchange potential adjusted to remove all or portions of the reported historical transmountain water deliveries from the streamflow and diversion records.

Figure 20



Notes

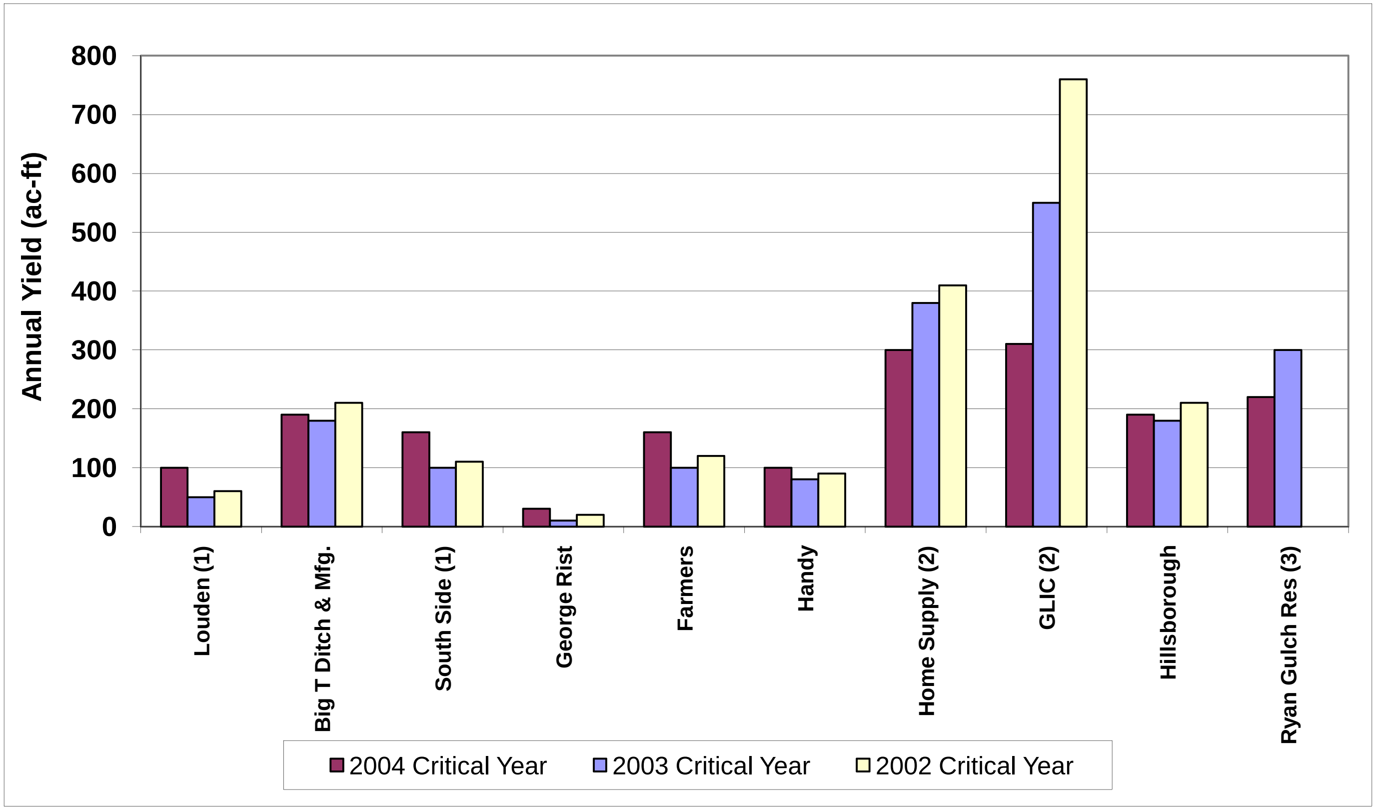
(1) Louden and South Side results do not include yield from storage in those systems.

(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 21

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

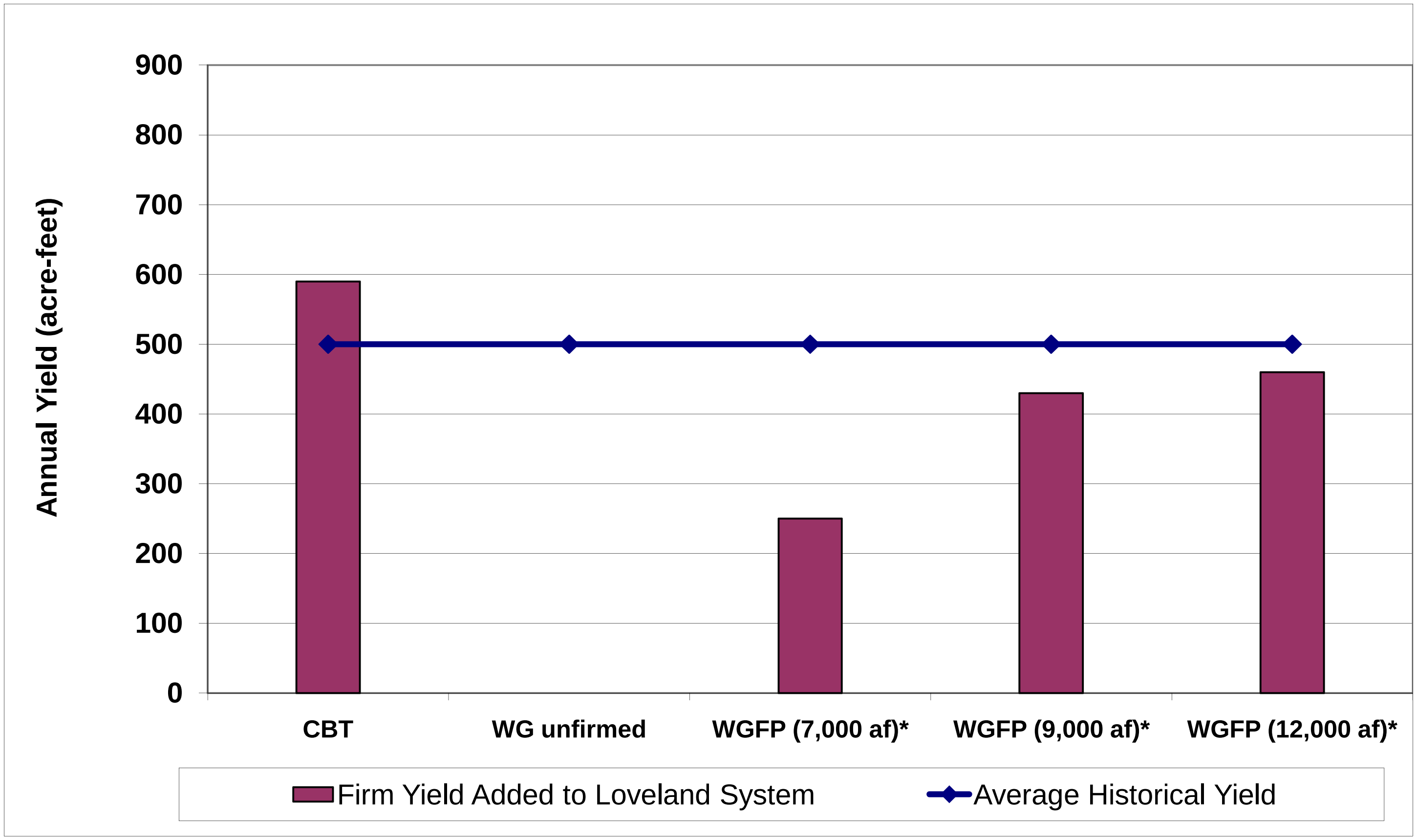
(1) Louden and South Side results do not include yield from storage in those systems.

(2) 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.

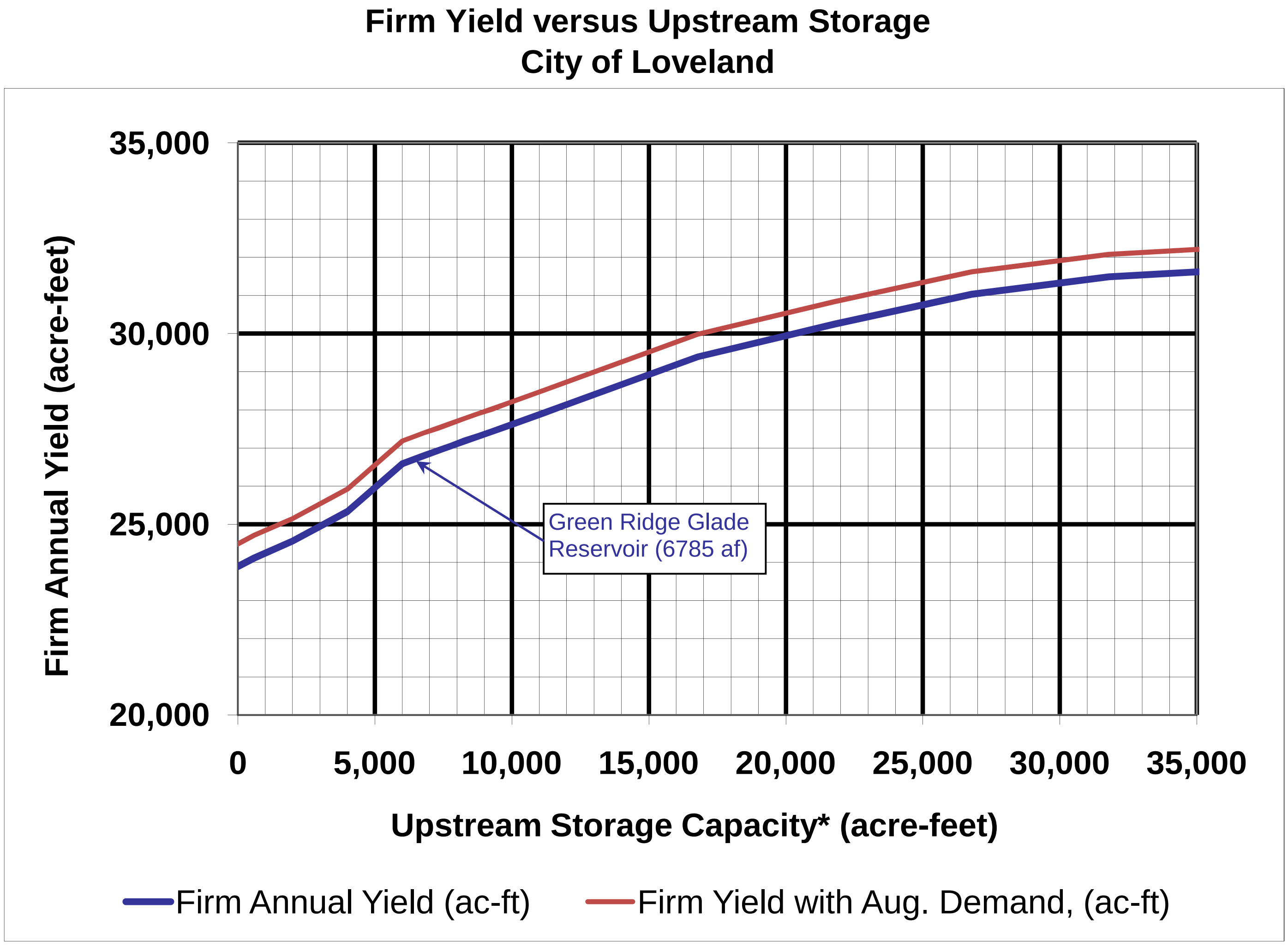
Figure 22

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



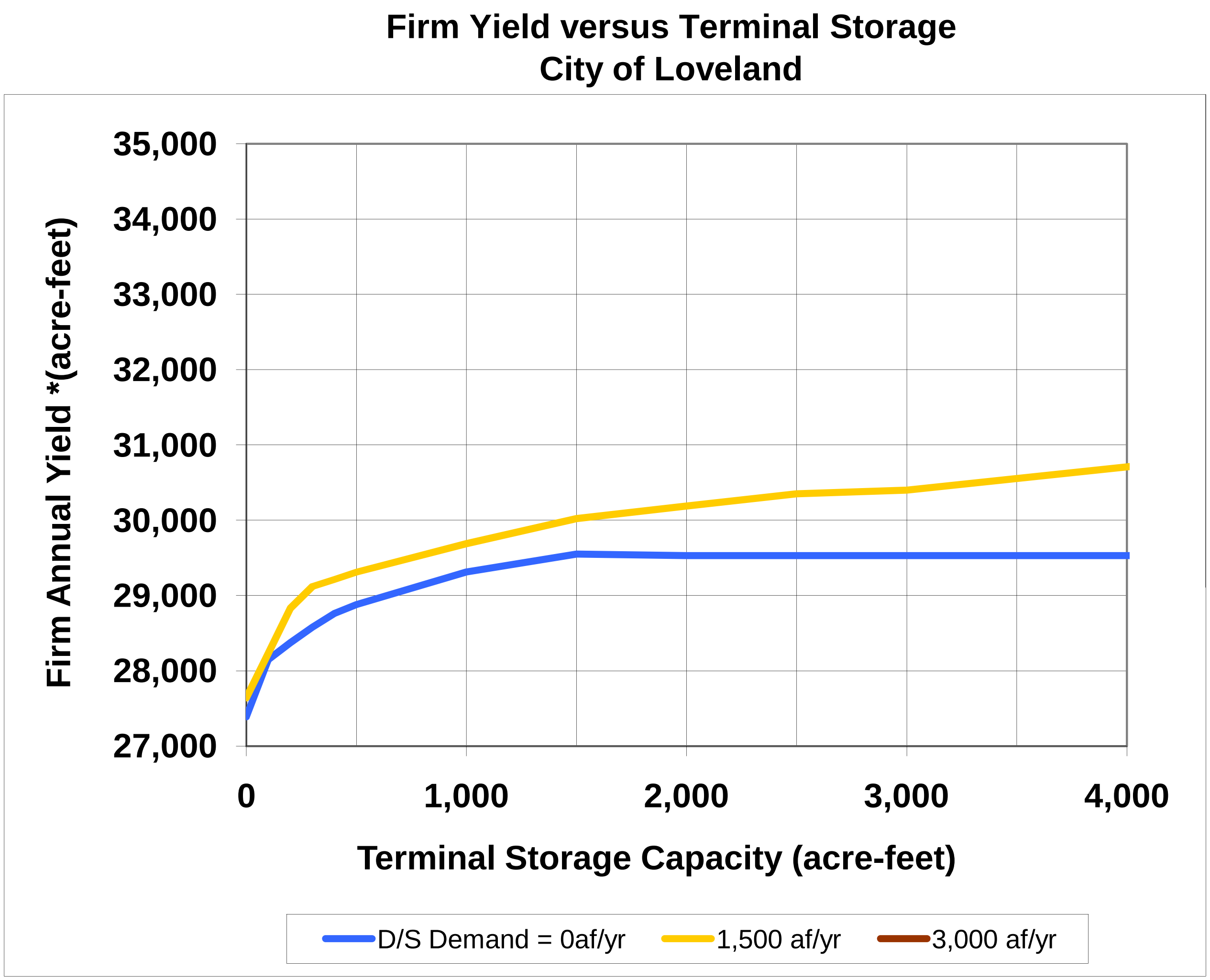
*** Based on Loveland participation in the Windy Gap Firming Project (WGFP) at 7,000 acre-feet, 9,000 acre-feet and 12,000 acre-feet of East Slope storage capacity.**

Figure 23



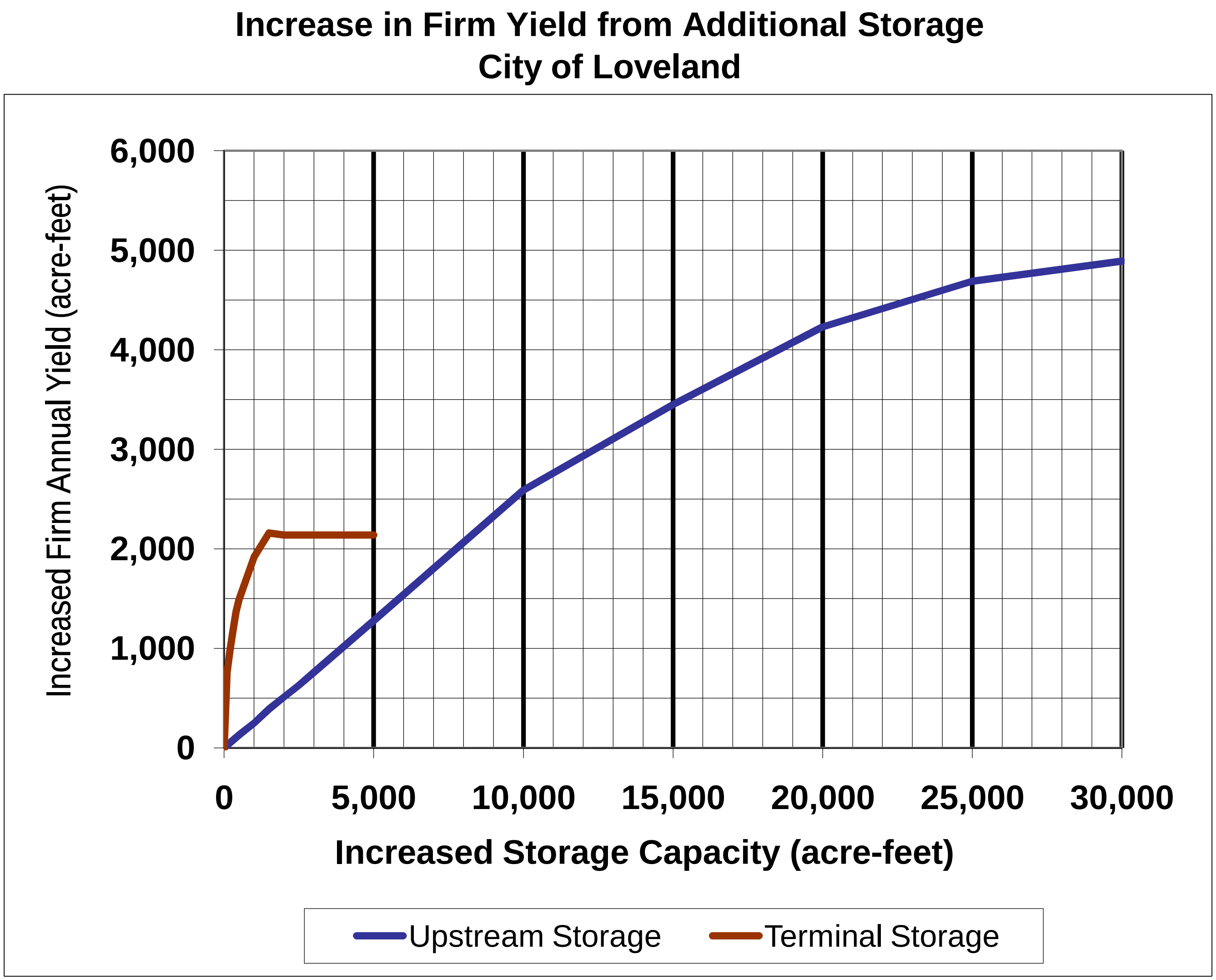
*** Including Green Ridge Glade Reservoir.**

Figure 24



*** Firm Yield includes the downstream and augmentation demands**

Figure 25


Increase in Firm Yield from Additional Storage
City of Loveland
6,000
5,000
4,000
3,000
2,000
1,000
0
Increased Firm Annual Yield (acre-feet)
0
5,000
10,000
15,000
20,000
25,000
30,000
Increased Storage Capacity (acre-feet)
Upstream Storage
Terminal Storage

APPENDIX A

City Ordinance No. 5039

First Reading: November 3, 2005

Second Reading: November 15, 2005

ORDINANCE NO 5039

AN ORDINANCE AMENDING CHAPTER 19.04 OF THE LOVELAND MUNICIPAL CODE

WHEREAS, in 2002, City staff formally addressed the Loveland Utilities Commission ("LUC") and City Council on two separate occasions regarding the City's acquisitions of raw water for development, which are not keeping pace with actual demands; and

WHEREAS, City Council instructed staff and the LUC to study this issue and bring suggestions back to City Council for modifying the City's raw water policies; and

WHEREAS, as part of that study, Spronk Water Engineers ("SWE") was selected to perform an analysis of the City's raw water system to estimate the firm raw water yields the City can expect to meet future water demands; and

WHEREAS, on March 1, 2005, City Council adopted Resolution #R-25-2005 accepting SWE's "Raw Water Supply Yield Analysis" ("Spronk Report") and directing staff to use the Spronk Report as a tool in developing a raw water master plan for the City; and

WHEREAS, using the Raw Water Supply Yield Analysis as a tool, staff and the LUC explored a number of water supply alternatives, including structural and non-structural elements, which were incorporated into a draft Raw Water Master Plan for City Council's consideration; and

WHEREAS, on July 12, 2005, staff and the LUC presented the draft Raw Water Master Plan to City Council at a study session, and City Council directed staff to return with an ordinance revising Chapter 19.04 of the Loveland Municipal Code incorporating the recommendations set forth in the draft Raw Water Master Plan; and

WHEREAS, City Council finds that said revisions to Chapter 19.04 are in the best interests of the citizens and rate payers of the City of Loveland.

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF LOVELAND, COLORADO:

Section 1. That Section 19.04.010 of the Loveland Municipal Code is hereby amended to read as follows:

Section 19.04.010 - Definitions

A. As used in this Chapter 19.04, all words and phrases shall be interpreted and defined in accordance with the provisions set forth in this Section 19.04.010 and in Section 16.08.010.

B. As used in this Chapter 19.04, unless the context requires otherwise, the term "water right" shall include, without limitation, units in the Colorado-Big Thompson Project, notwithstanding the fact that each unit does not represent an ownership in the Colorado-Big Thompson Project, but rather represents a contractual right to use a proportionate share of the water allocated to the Northern Colorado Water Conservancy District under the 1938 Repayment Contract between the United States Bureau of Reclamation and the Northern Colorado Water Conservancy District.

Section 2. That Chapter 19.04 of the Loveland Municipal Code is hereby amended by the addition of a new Section 19.04.015 to read as follows:

Section 19.04.015 - Water bank

The city has established a water bank for the purpose of facilitating transfers of water rights to the city in satisfaction of the city's water rights requirements. In exchange for the transfer of water rights to the city in accordance with Section 19.04.017A.1., the city shall issue water bank credit in the city's water bank in the form of a holding receipt for use in accordance with the terms and conditions set forth in the water bank agreement, the holding receipt, and this Chapter 19.04. Water bank credit, as represented by the holding receipt, may be transferred, in whole or part, to a third party upon the third party's execution of an assumption of obligations agreement in a form acceptable to the city attorney. Any water bank credit transferred on or after April 1, 2002 in violation of this Section 19.04.015 shall be deemed void.

Section 3. That Chapter 19.04 of the Loveland Municipal Code is hereby amended by the addition of a new Section 19.04.016 to read as follows:

Section 19.04.016 – Water bank agreement

The Loveland utilities commission, in consultation with the city attorney, shall approve the form of the water bank agreement.

Section 4. That Chapter 19.04 of the Loveland Municipal Code is hereby amended by the addition of a new Section 19.04.017 to read as follows:

Section 19.04.017 – Acquiring water bank credit

A. Credit in the city's water bank may be acquired by either of the following methods:

   1. By transferring to the city, by good and sufficient conveyance, grant, assignment, or decree, ownership of water rights acceptable to the city. Applications to transfer water rights to the city shall be filed with the Department of Water and Power. The applicant shall pay all expenses incurred in order to transfer ownership of the water rights to the city, unless otherwise agreed between the city and the applicant. In exchange for such transfer, the applicant shall receive credit in the city's water bank. Ownership of the water rights must be fully vested in the city, and all other applicable requirements set forth in this Chapter 19.04 must be satisfied, before water bank credit will be issued.

   2. By acquiring credit in the city's water bank from a water bank account holder. Upon an applicant's request, the city shall make available a list of water bank account holders who have informed the city that they are willing to sell water bank credit. The purchase price of such water bank credit shall be determined by the parties without further involvement of the city.

B. Credit in the city's water bank may not be acquired from the city by cash purchase on or after January 1, 2006.

Section 5. That Chapter 19.04 of the Loveland Municipal Code is hereby amended by the addition of a new Section 19.04.018 to read as follows:

Section 19.04.018 – Value of water bank credit

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. The current value shall be as follows:

A. Ditch water rights:

Ditch / Ditch Company	Value
Barnes Ditch	3.24 acre-feet of water per inch
Big Thompson Ditch & Manufacturing Company	189.11 acre-feet of water per share
Chubbuck Ditch	2.97 acre-feet of water per inch
Reorganized Farmers Ditch Company	98.43 acre-feet of water per share
Buckingham Irrigation Company (George Rist Ditch)	6.07 acre-feet of water per share
Louden Irrigating Canal and Reservoir Company	11.05 acre-feet of water per share
South Side Ditch Company	4.22 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 dated December 15, 2004. 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.

B. Colorado-Big Thompson Project units shall be valued at 0.82 acre-foot per unit beginning on January 1, 2006; valued at 0.91 acre-foot per unit beginning on January 1, 2007; and valued at one (1) acre-foot per unit beginning on January 1, 2008.

Section 6. That Section 19.04.020 of the Loveland Municipal Code is hereby amended to read as follows:

Section 19.04.020 - Water rights required for development

A. Water Rights Due on Zoning.

1. No land shall be initially zoned for any use within the city until the city has received by a good and sufficient conveyance, grant, assignment, or decree the perpetual right to use one (1) acre foot of water per acre of such zoned land, except that no water rights shall be due upon zoning in the event such land is initially zoned PUD, DR, Be, B or I or was initially zoned DR and is subsequently re-zoned PUD, Be, B or I.

2. No land which was initially zoned PUD, DR, Be, B or I or which was subsequently rezoned PUD, Be, B, or I from DR shall be re-zoned for another use until the city has received by a good and sufficient conveyance, grant, assignment, or decree the perpetual right to use one (1) acre foot of water per acre of such rezoned land.

3. Additional water rights for all land shall be transferred to the city as provided in subsections B. and C.

B. Residential Development.

1. Land zoned R1e, R1, R2, R3e, or R3 after June 4, 1985 and developed for residential uses and land zoned PUD and developed for residential uses shall not receive final approval for development, nor shall construction or development be allowed on any such land, nor shall water service be furnished to any such land, until the city has received by grant or transfer the perpetual right to use the total amount of divertible water rights, in acre feet of water, as determined by the following formula:

Total water rights due (in acre-feet) = (1.6 x net lot acreage) + (1.4 x acreage of that portion of each 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)

Notwithstanding anything herein to the contrary, water rights required under this subsection B. may not be paid prior to the current planning manager's acceptance of a complete application for final plat or final development plan, as applicable.

2. The applicant shall have a credit toward the requirements set forth in this subsection B. for water rights previously furnished in conjunction with annexation or zoning.

C. Nonresidential Development.

1. Any lot or tract zoned PUD, if the developed use will be non-residential, and any lot or tract zoned Be, B, or I shall not be entitled to receive a building permit or a type 1 zoning permit for any construction on the lot or tract until the city has received by a good and sufficient conveyance, grant, assignment, or decree the perpetual right to use the acre feet of water required by the following schedule:

Water Tap Size	Acre-feet Required
¾"	1
1"	4
1½"	8
2"	13
3"	26
4"	40
6"	80
8"	128
10"	184
12"	273

Notwithstanding anything herein to the contrary, water rights required under this subsection C. may not be paid prior to the building official's acceptance of a complete application for building permit or type 1 zoning permit, as applicable.

2. The applicant shall have a credit toward the requirements set forth in the schedule for water rights previously furnished in conjunction with annexation or zoning.

3. Where property has been subdivided at or after the time of the furnishing of water rights, the water rights furnished shall be prorated among the

parcels of the subdivision based upon the respective land areas. Water rights furnished to fulfill the requirements of this subsection C. in connection with other water taps previously granted on the same tract or larger tract, as the case may be, shall not be prorated.

4. Whenever a water tap is abandoned or reduced in size, a credit shall be established in the city's water bank for the difference between the required water rights for the existing water tap and the required water rights for the new water tap, if any. Said credit shall be eligible for use only to fulfill water rights requirements arising on the property served by the original water tap, unless otherwise approved by the city council. Any unused credit remaining after ten years from the date the credit is created shall be canceled, and the owner thereof shall have no further claim to said credit. Upon application to the city council made prior to the expiration date, the city council may, for good cause shown, extend the expiration date as it sees fit.

5. Common areas in non-residential developments to be irrigated with treated city water shall be required to provide three (3) acre feet of water for each acre of irrigated common area in accordance with the following formula:

$$3.0 \times \text{net irrigated common area acreage}$$

D. Transfers required by this Section 19.04.020 are summarized in the following table:

	Conventional Zoning	Final Plat or Final Development Plan	Building Permit or Type II Zoning Permit
R1e, R1, R2, R3e, R3	1 acre-foot/acre	Total water as determined by 19.04.020.B. Credit given for water rights paid at annexation or zoning.	None
Residential PUD	None	Total water as determined by 19.04.020.B. Credit given for water rights paid at annexation or zoning.	None
Nonresidential PUD	None	None	Total water as determined by 19.04.020.C. Credit given for water rights paid at annexation or zoning.
Be, B, I	None	None	Total water as determined by 19.04.020.C. Credit given for water rights paid at annexation or zoning.

E. All city water rights requirements for zoning or final plat shall be satisfied a sufficient number of days prior to final city council consideration of such action to be included in the regular council agenda.

<u>Section 7</u>. That Section 19.04.030 of the Loveland Municipal Code is hereby repealed in its entirety.

<u>Section 8</u>. That Section 19.04.040 of the Loveland Municipal Code is hereby amended to read as follows but superseded as of April 1, 2006 as provided in Section 9 below:

Section 19.04.040 - Methods of satisfying water rights requirements

A. The city's water rights requirements as provided in Sections 13.04.245.C and 19.04.020 may be met by any one or combination of the following methods:

   1. The applicant may apply water bank credit in an amount sufficient to satisfy the city's water rights requirements.

   2. The applicant may pay the cash-in-lieu fee to satisfy the city's water rights requirements for up to a maximum of four (4) acre-feet of water. The cash-in-lieu fee shall be 1.03 times the market price of one (1) Colorado-Big Thompson Project unit as recognized by resolution of the Loveland utilities commission. Said fee shall be calculated in accordance with the resolution in effect at the time such payment is due.

Section 9. That effective April 1, 2006, Section 19.04.040 of the Loveland Municipal Code is hereby amended to read as follows and shall supersede in all respects Section 8 of this Ordinance:

Section 19.04.040 - Methods of satisfying water rights requirements; restrictions

A. The city's water rights requirements as provided in Sections 13.04.245.C and 19.04.020 may be met by any one or combination of the following methods:

   1. The applicant may apply water bank credit in an amount sufficient to satisfy the city's water rights requirements; provided, however, that a minimum of forty percent (40%) 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 ("40% Rule"). If the acre-feet requirement resulting from the 40% Rule results in a fractional requirement of less than 0.50 acre-feet, it may be rounded down to the nearest acre-foot.

   2. The applicant may pay the cash-in-lieu fee to satisfy the city's water rights requirements for up to a maximum of four (4) acre-feet of water.

      a. For water rights requirements of four (4) acre-feet or less, the applicant may pay the cash-in-lieu fee to satisfy all or part of the total water rights requirements. If cash-in-lieu payment is made to satisfy only part of the total water rights requirements, said payment may be used to satisfy all or part of the acre-feet requirement resulting from the 40% Rule set forth in subsection A. above.

      b. For water rights requirements of more than four (4) acre-feet, the applicant may only pay the cash-in-lieu fee where such payment would not result in a reduction of the 40% Rule set forth in subsection A. In other words, said payment may not be used to satisfy the acre-feet requirement resulting from the 40% Rule set forth in subsection A. above.

c. The cash-in-lieu fee shall be 1.03 times the market price of one (1) Colorado-Big Thompson Project unit as recognized by resolution of the Loveland utilities commission. Said fee shall be calculated in accordance with the resolution in effect at the time such payment is due.

B. The following illustrate by way of example, and not limitation, how water rights must be satisfied under the methods authorized in this Section:

1. If thirty-eight (38) acre-feet of water are needed in any single transaction to satisfy the city's water rights requirements, the applicant must use a combination of water bank credit issued for cash and/or Colorado-Big Thompson units to satisfy forty percent (40%) of the total requirement, or fifteen and two-tenths (15.2) acre-feet. However, the applicant may round the fifteen and two-tenths (15.2) acre-feet requirement resulting from the forty percent (40%) rule down to fifteen (15) acre-feet.

2. If one hundred (100) acre-feet of water are needed in any single transaction to satisfy the city's water rights requirements, the applicant could use any combination of water bank credit issued for cash and/or Colorado-Big Thompson units to satisfy forty (40) acre-feet, pay the cash-in-lieu fee for four (4) acre-feet, and use any combination of water bank credit issued for cash, Colorado-Big Thompson units, or ditch water rights to satisfy the remaining fifty-six (56) acre-feet.

3. If five (5) acre-feet of water are needed in any single transaction to satisfy the city's water rights requirements, the applicant could use any combination of water bank credit issued for cash and/or Colorado-Big Thompson units to satisfy two (2) acre-feet and pay the cash-in-lieu fee or use any combination of water bank credit issued for cash, Colorado-Big Thompson units, or ditch water rights to satisfy the remaining three (3) acre-feet.

4. If four (4) acre-feet of water are needed in any single transaction to satisfy the city's water rights requirements, the applicant may pay the cash-in-lieu fee to satisfy all four (4) acre-feet. Alternatively, the applicant may pay the cash-in-lieu fee to satisfy something less than all four acre-feet. For example, the applicant may pay the cash-in-lieu fee to satisfy two (2) acre-feet and use any combination of water bank credit issued for cash, Colorado-Big Thompson units, or ditch water rights to satisfy the remaining two (2) acre-feet.

Section 10. That Chapter 19.04 of the Loveland Municipal Code is hereby amended by the addition of a new Section 19.04.045 to read as follows:

Section 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. 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 native raw water storage fees shall be as follows:

Ditch / Ditch Company	Native Raw Water Storage Fee Per Acre-Foot By Effective Date		
	Jan. 1, 2006	Jan. 1, 2007	Jan. 1, 2008
Barnes Ditch	$1,920	$3,840	$5,750
Big Thompson Ditch & Manufacturing Company	$1,180	$2,360	$3,530
Buckingham Irrigation Company (George Rist Ditch)	$2,470	$4,940	$7,400
Chubbuck Ditch	$2,470	$4,940	$7,400
Louden Irrigating Canal and Reservoir Company	$2,280	$4,560	$6,850
Reorganized Farmers Ditch Company	$1,460	$2,920	$4,380
South Side Ditch Company	$2,260	$4,520	$6,770
Average of All Ditches	$2,006	$4,011	$6,011

The native raw water storage fees set forth in the table above are taken from the city's Raw Water Master Plan, adopted by city council by resolution on November 15, 2005. 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 fee.

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.

Section 11. That Section 19.04.060 of the Loveland Municipal Code is hereby repealed in its entirety.

Section 12. That Section 19.04.080 of the Loveland Municipal Code is hereby amended to read as follows:

Section 19.04.080 - Requirements for acceptance of ditch water rights

A. Applications to transfer ditch water rights to the city shall be filed with the Department of Water and Power. No ditch water rights shall be accepted by the city unless first approved by the Loveland utilities commission. Said approval shall not be given without satisfaction of each of the following requirements:

1. Evidence of the applicant's ownership of the ditch water rights in a form satisfactory to the city attorney;

2. A water bank agreement executed by the applicant and, if applicable, other documentation, such as a statement of historical use and dry-up covenant, in a form approved by the city attorney; and

3. A finding by the Loveland utilities commission that it is in the city's best interests to accept the ditch water rights.

B. The Loveland utilities commission may place conditions or restrictions on the city's acceptance of the ditch water rights or the applicant's use of the corresponding water bank credit as necessary to protect the city's interests. Applicants who do not wish to transfer their ditch water rights to the city subject to such conditions or restrictions may withdraw their application prior to execution of the water bank agreement by the city.

Section 13. That Chapter 19.04 of the Loveland Municipal Code is hereby amended by the addition of a new Section 19.04.085 to read as follows:

Section 19.04.085 – Other water rights

The city may accept water rights other than ditch water rights and Colorado-Big Thompson Project units upon such terms and conditions as are approved by city council by resolution.

Section 14. That the current and previous versions of the Water Bank Information Sheet, on file with the Department of Water and Power, are hereby declared null and void. Department of Water and Power staff, in consultation with the City Attorney, is hereafter authorized to draft any future documentation, consistent with the requirements of the Loveland Municipal Code, describing the city's water bank and explaining how water rights transfers to the city are made and how water bank credits are acquired, transferred, and applied.

Section 15. That this Ordinance shall be effective ten days after its publication after adoption on second reading as provided in Loveland Charter section 4-8(b), but the provisions of this Ordinance shall not go into effect until January 1, 2006, with the exception of the provisions of Section 9, which provisions shall not go into effect until April 1, 2006.

Signed this 15th day of November, 2005.

SEAL
CITY OF LOVELAND
COLORADO

~~Larry D. Walsh, Mayor~~
Gene Pielen
Mayor Pro tem

ATTEST:

Donna Visconti
City Clerk

I, Donna Visconti, 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 Nov 3 2005 and was initially published in the Loveland Daily Reporter Herald, a newspaper published within the city limits in full on Nov 5 2005, and by title except for parts thereof which were amended after such initial publication which parts were published in full in said newspaper on Nov. 19 2005.

Donna Visconti
CITY CLERK

EFFECTIVE
DATE Nov 29 2005

APPENDIX B

City of Loveland Water Bank Information Sheet

SATISFYING THE CITY OF LOVELAND'S WATER RIGHTS REQUIREMENT

(Effective April 1, 2006)

The following is a summary of the methods of satisfying the City of Loveland's water rights requirement. 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.ci.loveland.co.us/finance/municipalcode/Title_19/Chap%2019.04.htm

METHODS

Apply Water Bank credit in an amount sufficient to satisfy the City's water rights requirement applicable to your development:

- C-BT credits can be used to satisfy up to 100% of the water rights requirement.
- Cash credits* can be used to satisfy up to 100% of the water rights requirement.
- Ditch water credits can be used to satisfy up to 60% of the water rights requirement.

AND / OR

Pay the cash-in-lieu fee to satisfy the City's water rights requirement applicable to your development:

- Up to 100% if the water rights requirement is less than or equal to 4 acre-feet.
- Up to 60% or 4 acre-feet (which ever is less) of the water rights requirement if the requirement is over 4 acre-feet ("40% Rule").

WHAT THIS MEANS FOR YOUR DEVELOPMENT

If your development requires **4 acre-feet or less** of water, you may apply:

- C-BT credits for up to 100% of the water rights requirement.
- Cash credits* for up to 100% of the water rights requirement.
- Ditch water credits for up to 60% of the water rights requirement. The remaining 40% can be C-BT credits, Cash credits, or cash-in-lieu.
- Pay the cash-in-lieu fee for up to 100% of the water rights requirement.

If your development requires **more than 4 acre-feet** of water, you must apply C-BT credits or cash credits to satisfy at least 40% of the water rights requirement ("40% Rule"). The remaining 60% may be satisfied by:

- Applying C-BT credits;
- Applying cash credits*;
- Applying ditch water credits; and/or
- Paying the cash-in-lieu fee up to a maximum of 4 acre-feet.

Please see Section 19.04.040 for further explanation and examples.

* Cash credits are no longer available for purchase from the City. Where referenced, cash credits refer to those credits purchased from the City before January 1, 2006.

APPENDIX C

Ditch Credit Share Value, City of Loveland Water Bank

SUMMARY OF WATER RIGHTS REQUIREMENTS

The following water rights requirements are set forth in Ordinance #5039, which was adopted on November 15, 2005. The provisions of Ordinance #5039 went into effect January 1, 2006 except where noted. 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.ci.loveland.co.us/finance/municipalcode/Title_19/Chap%2019.04.htm

Colorado-Big Thompson Units (C-BT):

- Effective April 1, 2006, the City will require that at least 40% of every raw water payment be made with C-BT or existing cash credits in the Water Bank (see "40% Rule" set forth in Section 19.04.040).
- C-BT value: 1 C-BT unit = 1.0 acre-foot

Native Water:

- No ditch water rights shall be accepted by the city unless first approved by the LUC.
- Native water value:

Ditch / Ditch Company	Value
Barnes Ditch	3.24 acre-feet of water per inch
Big Thompson Ditch & Manufacturing Company	189.11 acre-feet of water per share
Chubbuck Ditch	2.97 acre-feet of water per inch
Buckingham Irrigation Company (George Rist Ditch)	6.07 acre-feet of water per share
Louden Irrigating Canal and Reservoir Company	11.05 acre-feet of water per share
South Side Ditch Company	4.22 acre-feet of water per share

(Average yield for ditch credit as determined by the Spronk Report.)

- Native Raw Water Storage Fee (applicable to all native water deposited in the Water Bank on or after July 21, 1995):

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

Cash-in-Lieu Fee:

- C-I-L Fee = market price of one C-BT unit (LUC to set market price by resolution), divided by the yield of one C-BT unit as set forth in Section 19.04.018.B (see "C-BT Value," above), with the resulting quotient multiplied by 1.03.
- C-I-L Fee may be paid in satisfaction of up to 4 acre-feet of any water rights requirements.
- Effective April 1, 2006, the C-I-L Fee may be paid in satisfaction of up to 100% of water rights requirements of 4 acre-feet or less (see "40% Rule" set forth in Section 19.04.040).
- Can no longer pay the C-I-L Fee to obtain "cash credits" in the Water Bank.
- Call Sarah Smith at (970) 962-3718 for the current Cash-in-Lieu fee. This fee is subject to change.

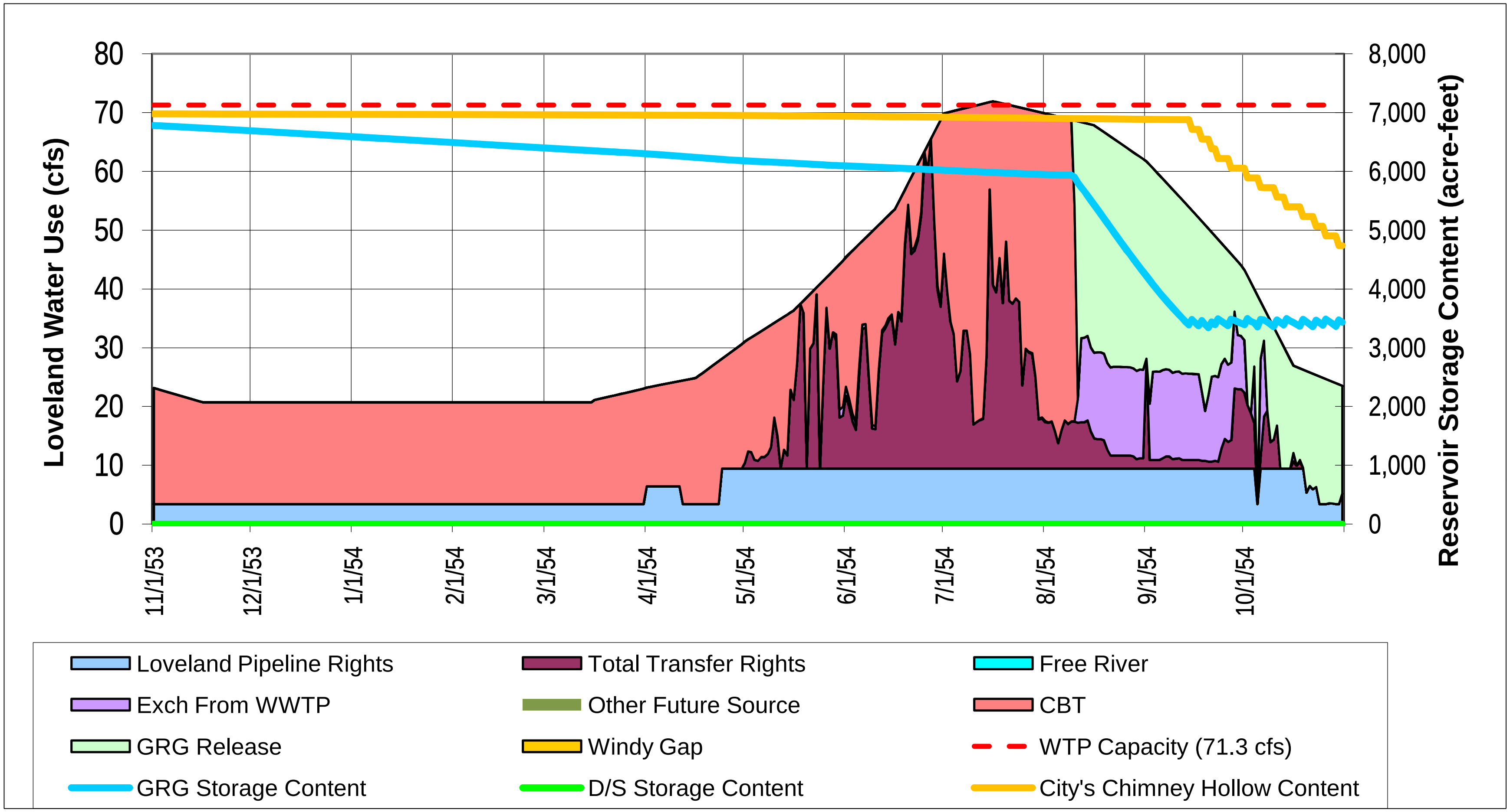
APPENDIX D

Simulated Daily Loveland Municipal Water Supply During Selected Drought Periods, Loveland Water Supply Yield Model

Simulated Daily Loveland Municipal Water Supply

Water Year 1954

Firm Annual Yield = 26,800 + 590 = 27,390 AF

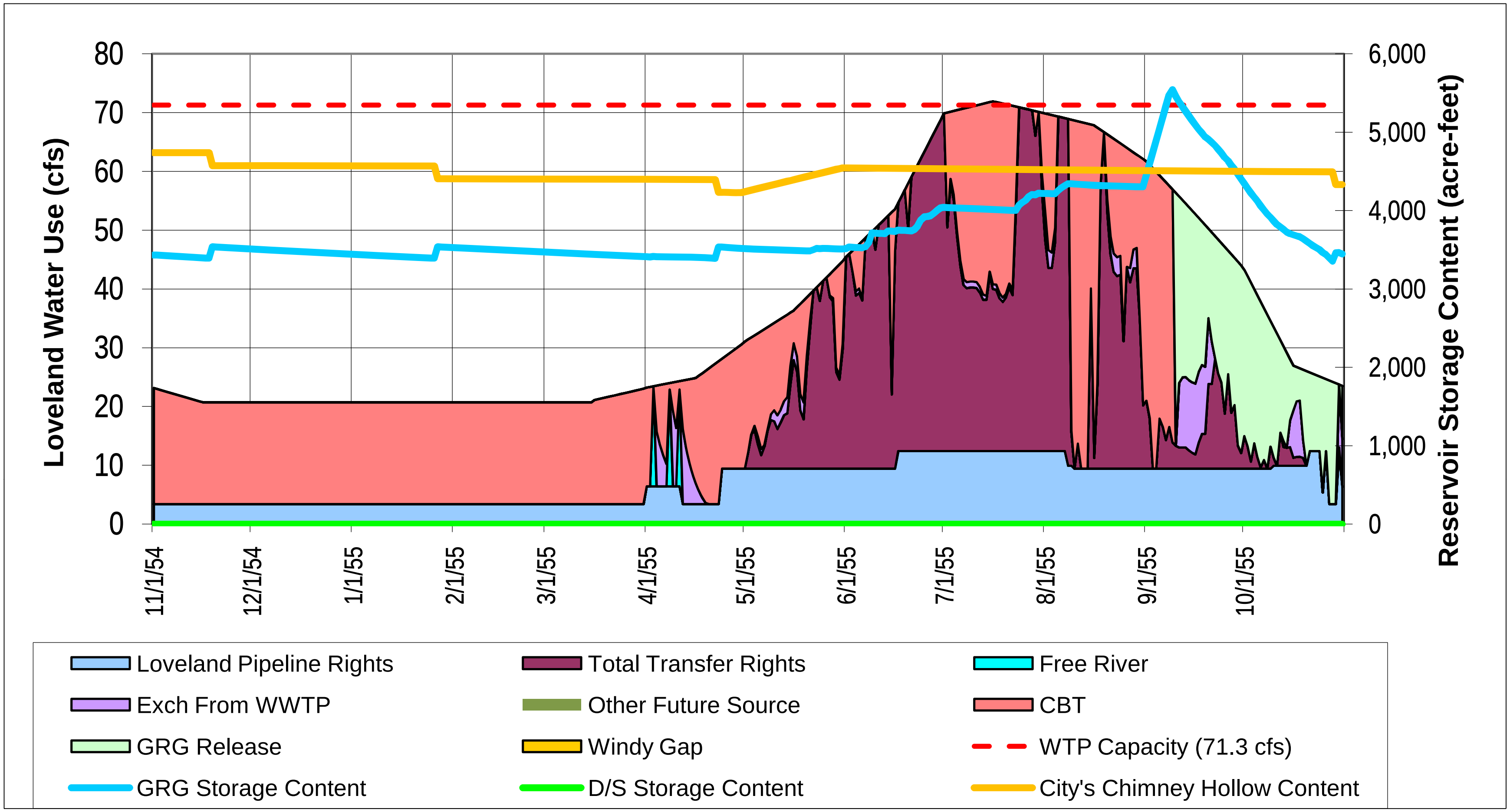


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 1955

Firm Annual Yield = 26,800 + 590 = 27,390 AF

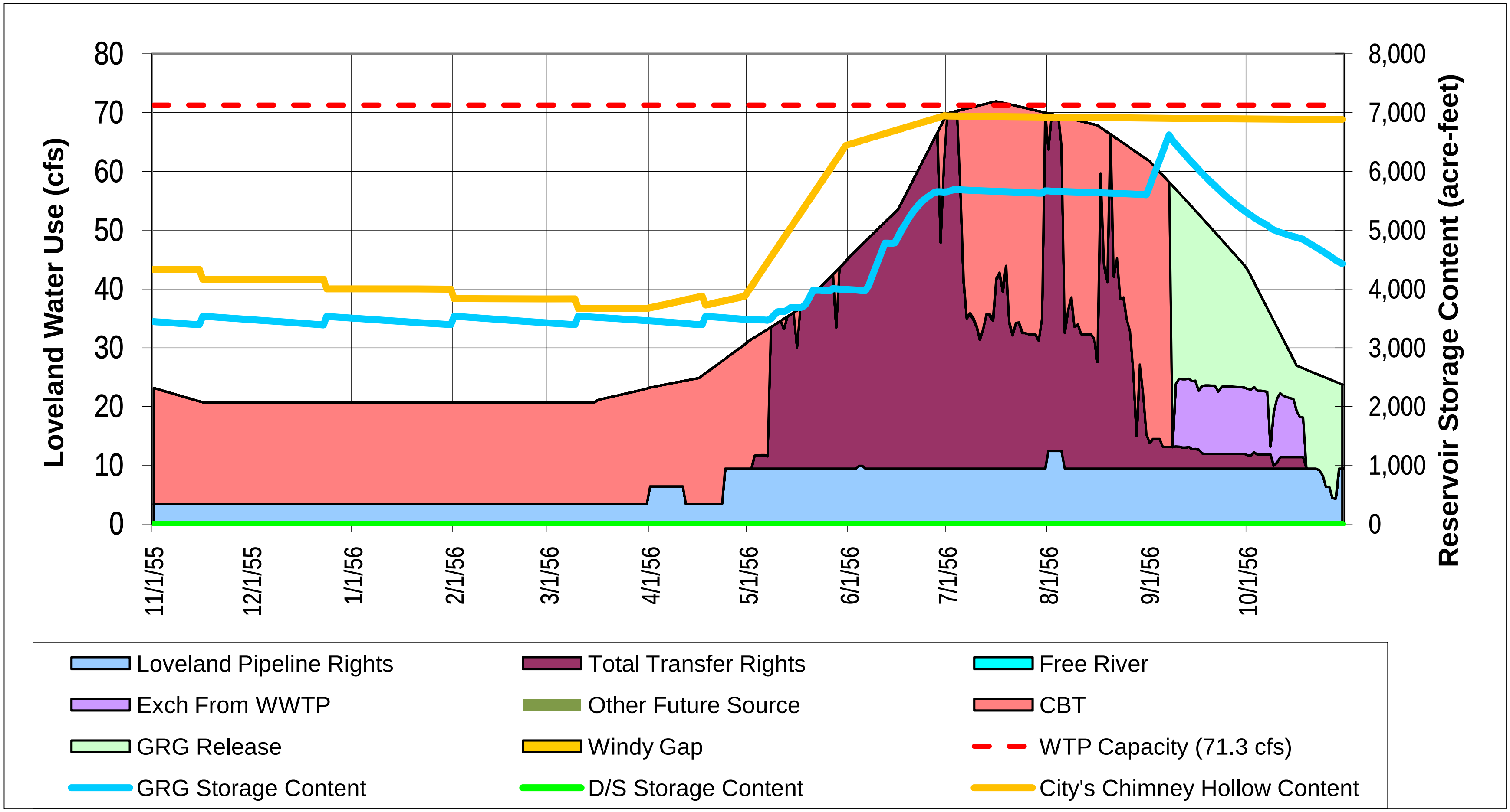


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 1956

Firm Annual Yield = 26,800 + 590 = 27,390 AF

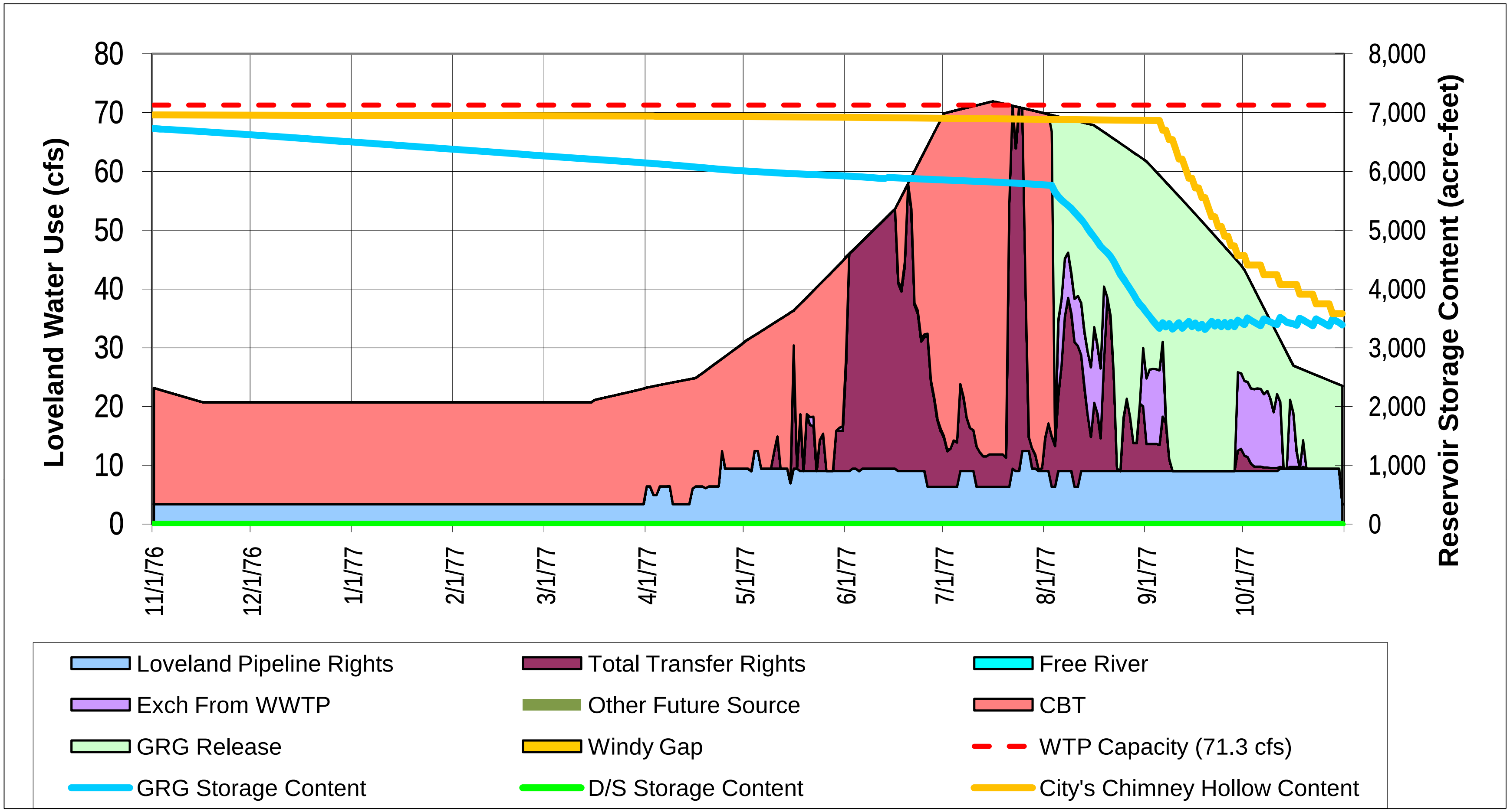


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 1977

Firm Annual Yield = 26,800 + 590 = 27,390 AF

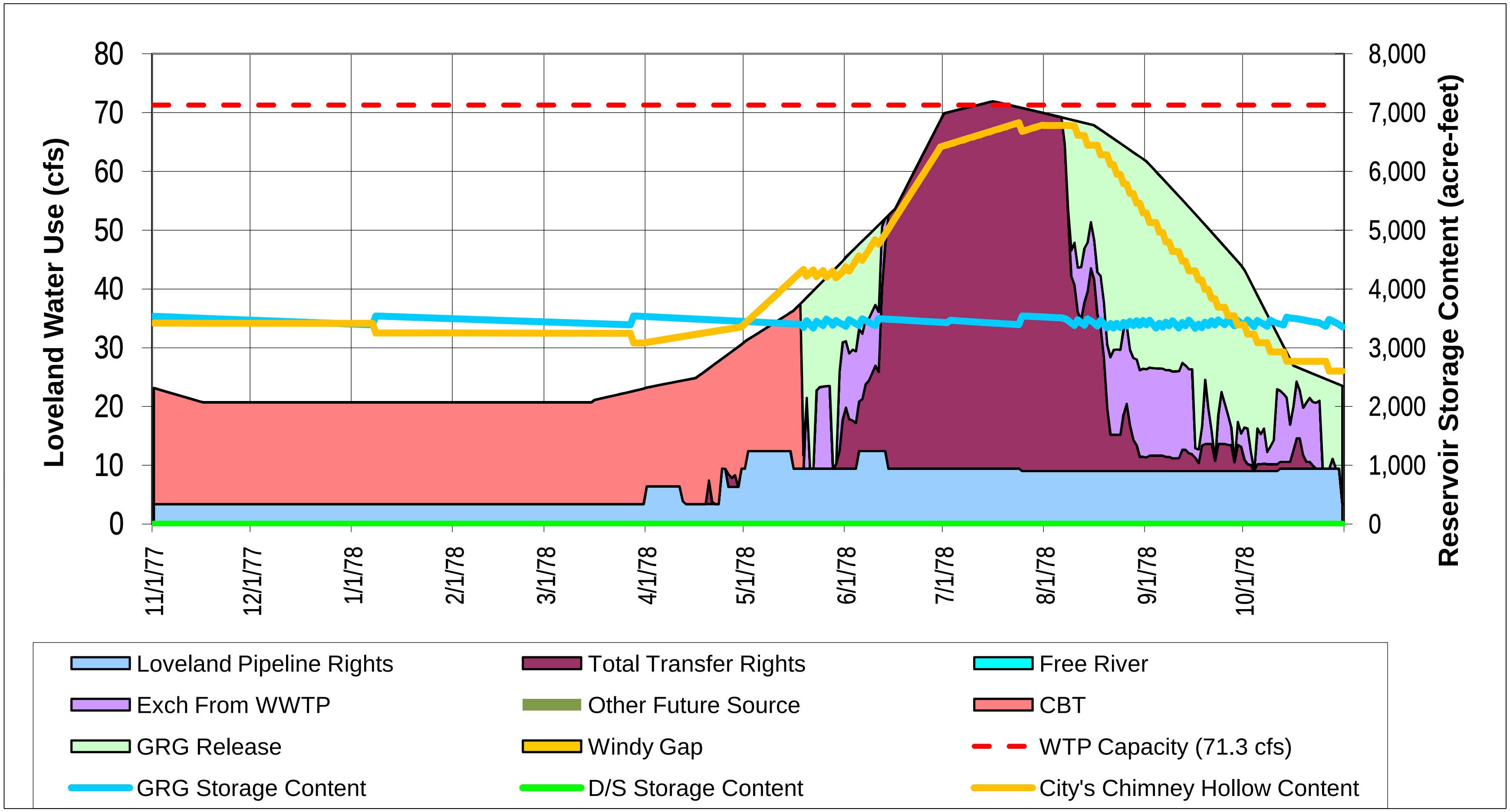


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 1978

Firm Annual Yield = 26,800 + 590 = 27,390 AF

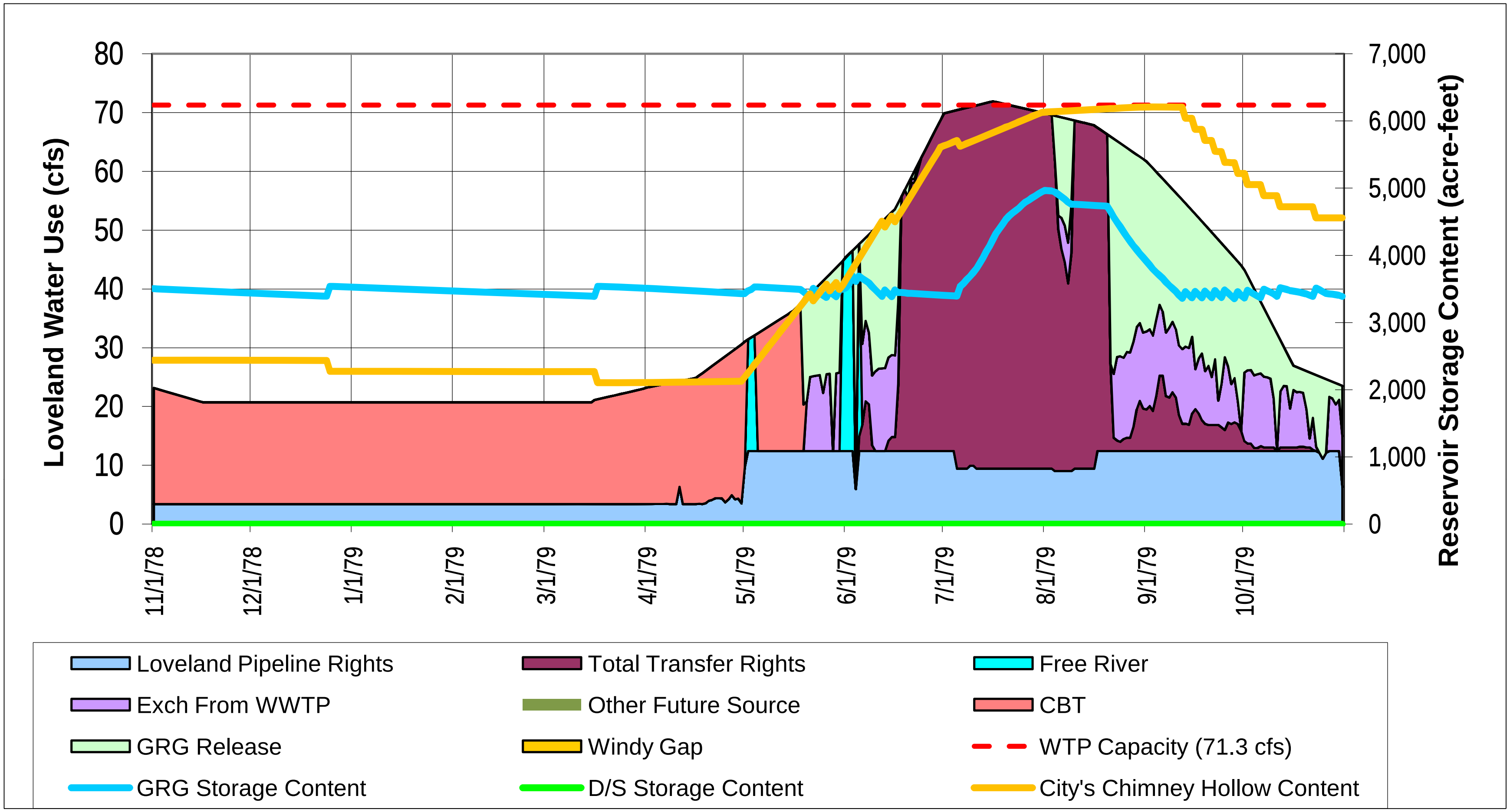


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 1979

Firm Annual Yield = 26,800 + 590 = 27,390 AF

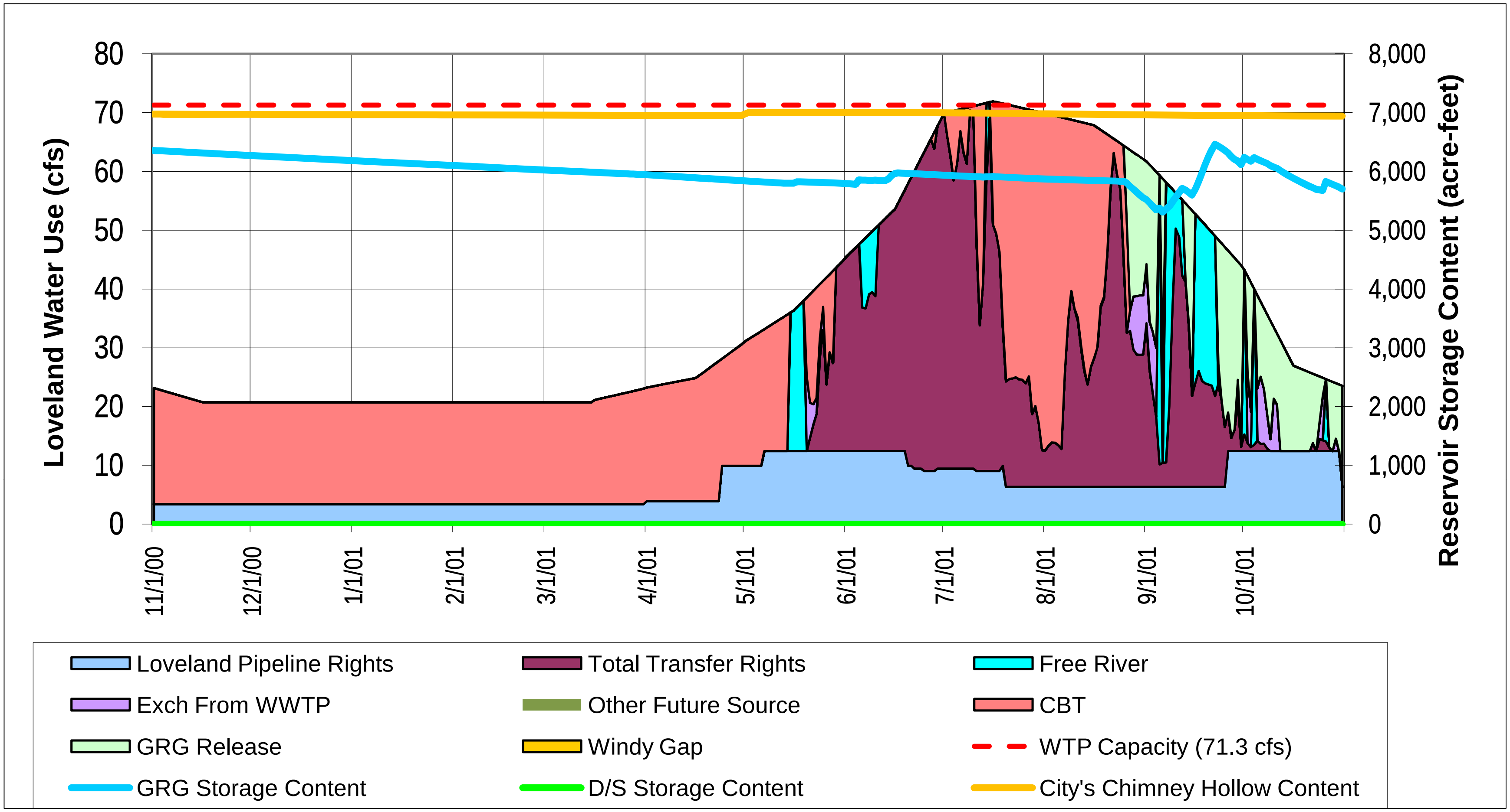


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 2001

Firm Annual Yield = 26,800 + 590 = 27,390 AF

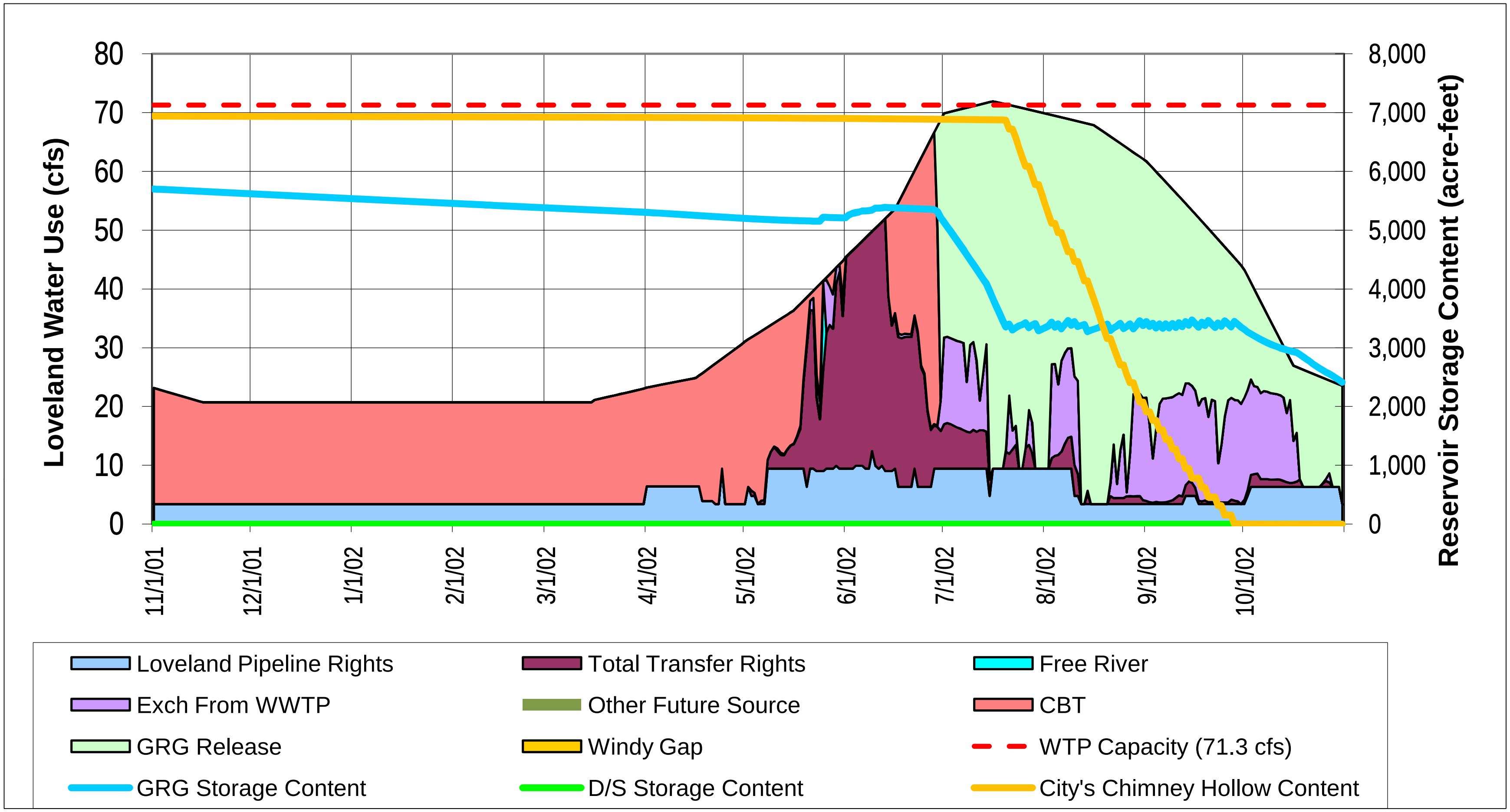


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 2002

Firm Annual Yield = 26,800 + 590 = 27,390 AF



Current Run = Aug 2011 BASE RUN , All Aug Demands Met

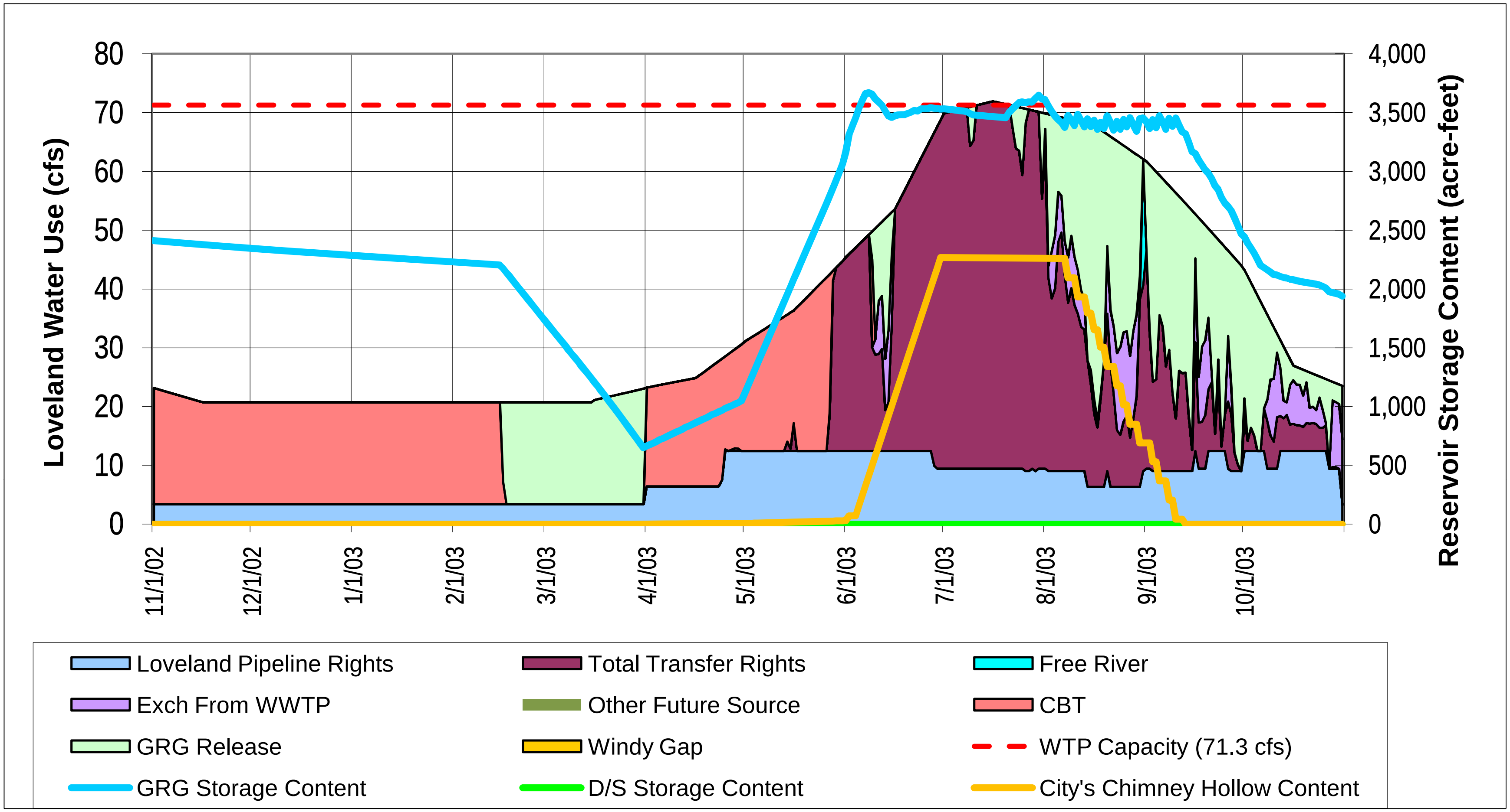
LoveYieldSummary 2011-WTP Limit.xlsx
Spronk Water Engineers, Inc.

8/11/2011

Simulated Daily Loveland Municipal Water Supply

Water Year 2003

Firm Annual Yield = 26,800 + 590 = 27,390 AF

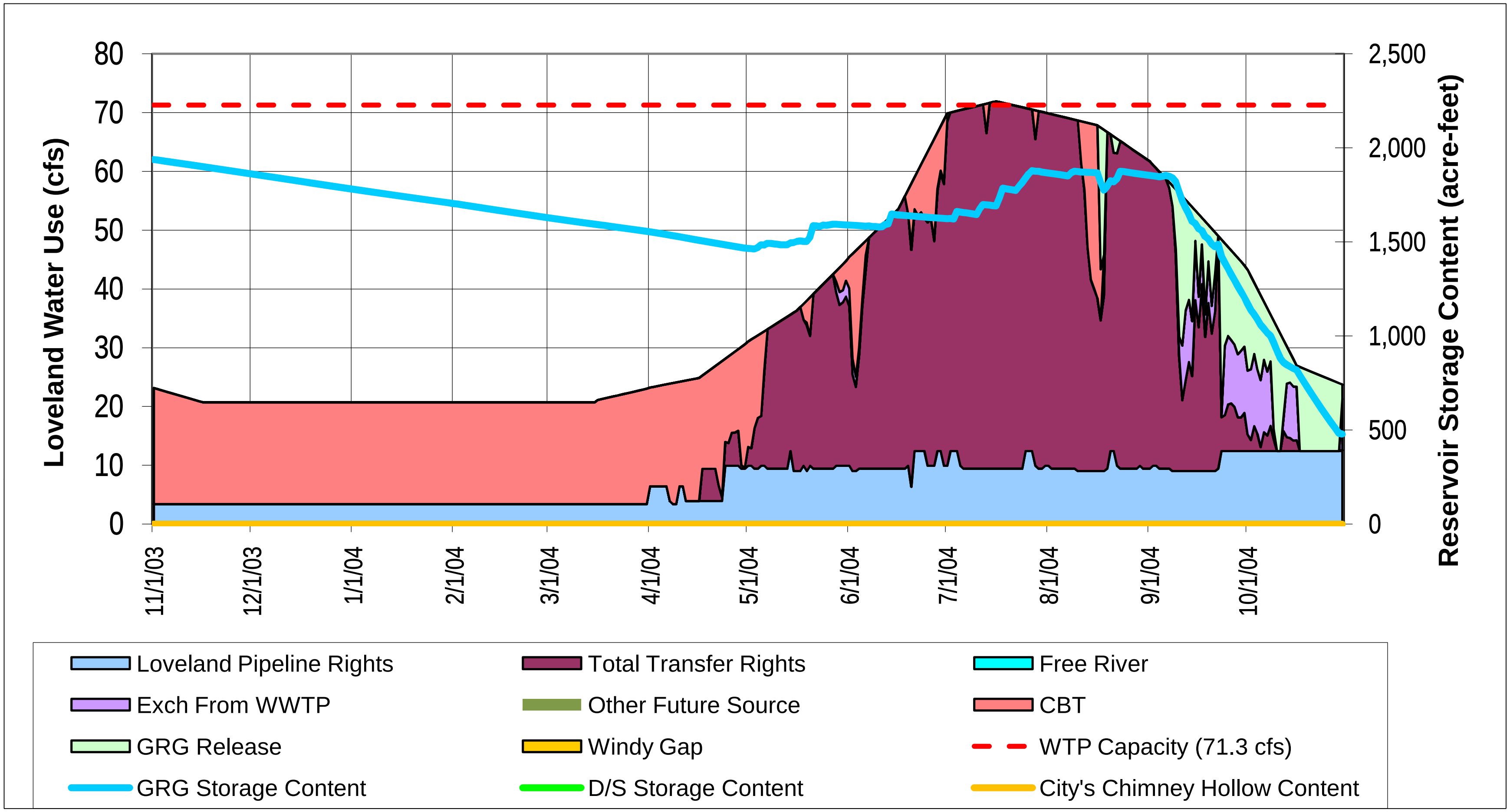


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 2004

Firm Annual Yield = 26,800 + 590 = 27,390 AF

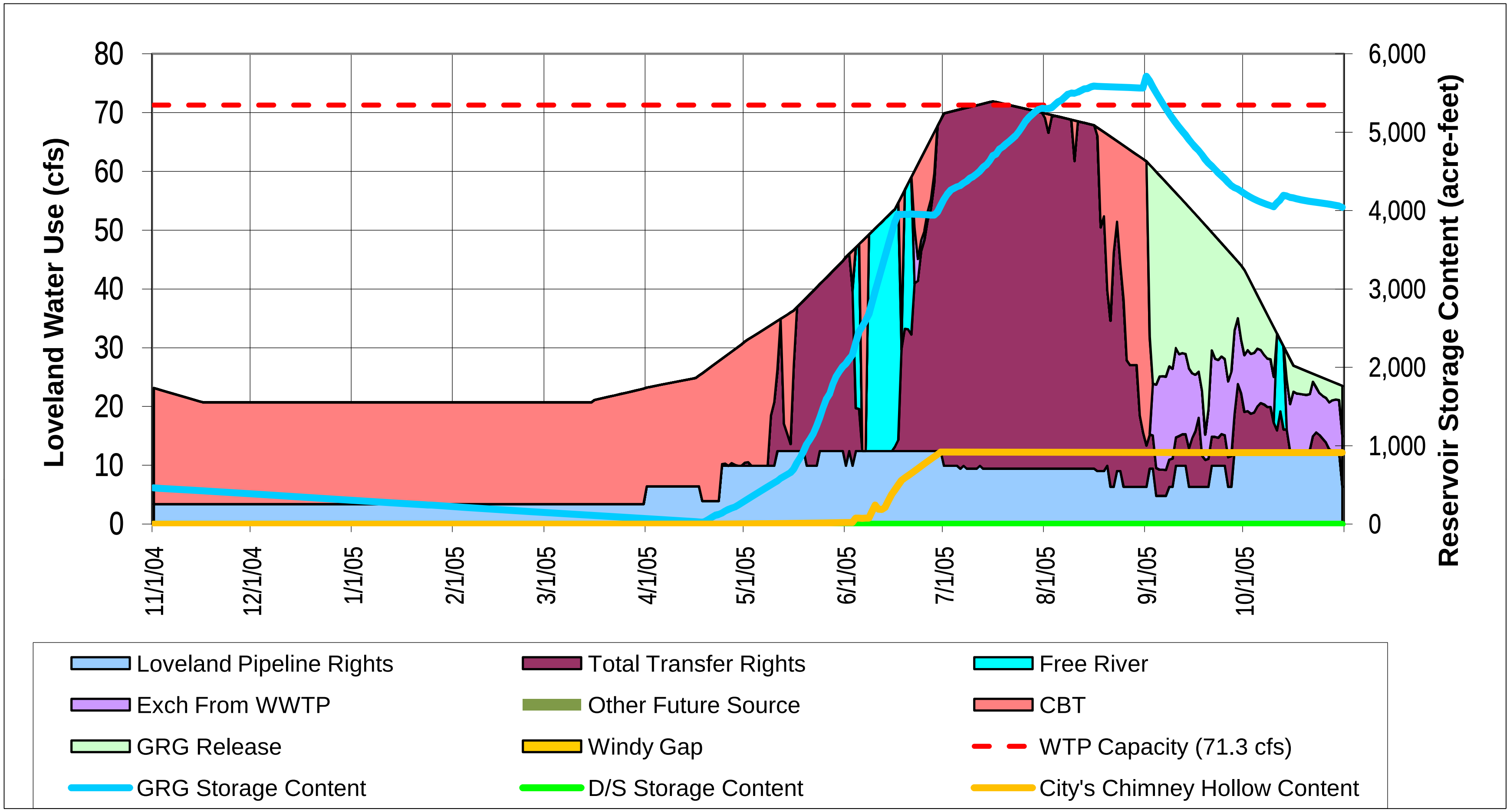


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 2005

Firm Annual Yield = 26,800 + 590 = 27,390 AF

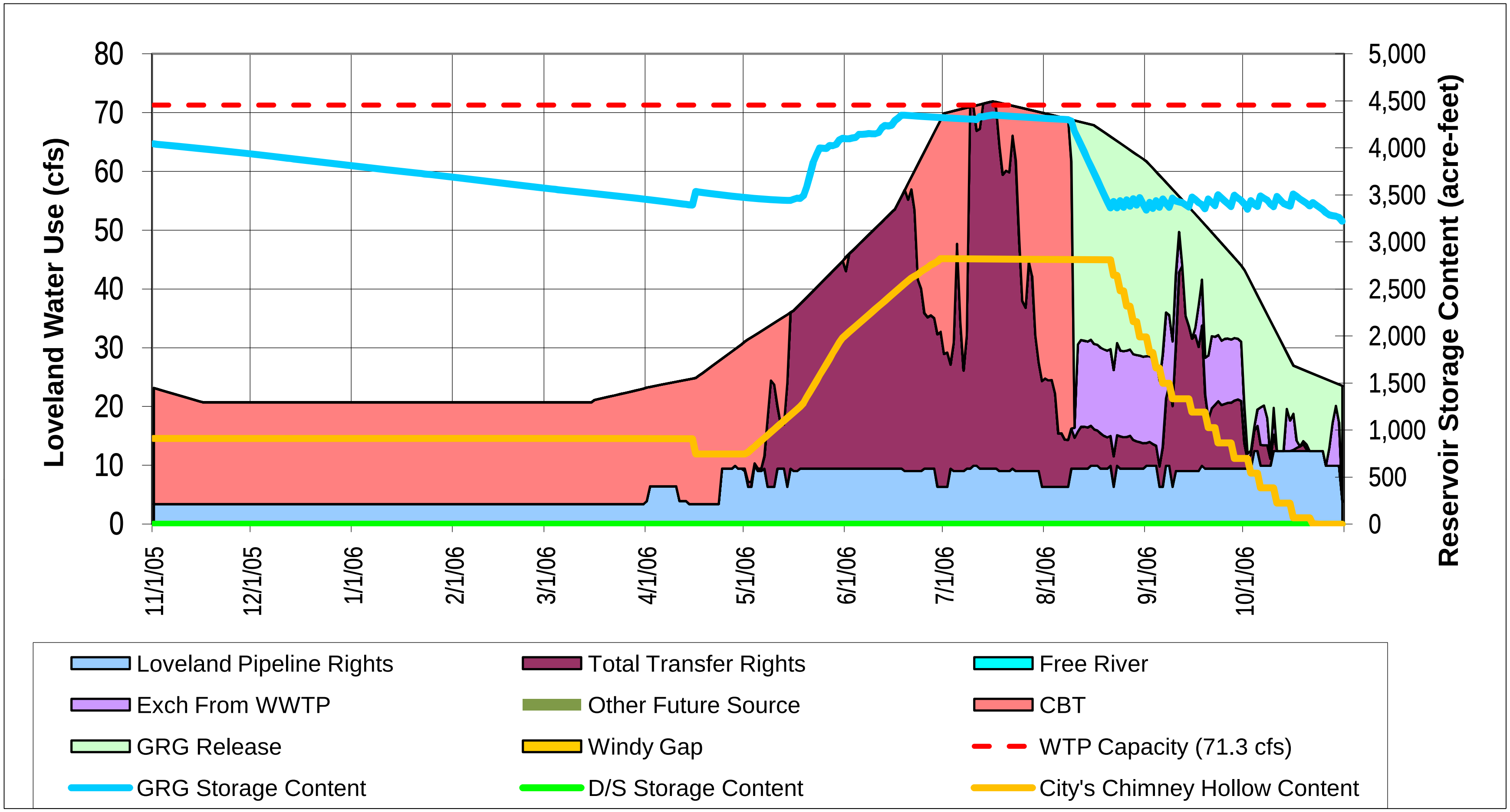


Current Run = Aug 2011 BASE RUN , All Aug Demands Met

Simulated Daily Loveland Municipal Water Supply

Water Year 2006

Firm Annual Yield = 26,800 + 590 = 27,390 AF



Current Run = Aug 2011 BASE RUN , All Aug Demands Met