2020 Water Resources Master Plan

Prepared for:
Town of Berthoud

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SECTION 1: EXECUTIVE SUMMARY AND RECOMMENDATIONS

For this project LRE Water (LRE) updated and enhanced Berthoud’s existing Raw Water Model to include: the most recent years of historical data, including Berthoud’s demand data; the addition of shares in the Ryan Gulch Reservoir Company (RGRC), the Handy Ditch Company, the Loveland Lake and Ditch Company (LLDC), and Windy Gap Units; and consideration of climate change on Berthoud’s long-term operations.

In summary, Berthoud should be able to meet its build-out demands (2,860 AF potable and 1,950 AF non-potable, under projected climate change conditions) by: closing on its 5 additional Windy Gap Units for a total of 8 Windy Gap Units; acquiring and/or developing new storage or the right to store water in existing reservoirs to regulate and increase the yield of the Town water supplies; maximizing its reuse capabilities by using fully consumable effluent to augment a new junior water right; acquiring a controlling number of shares in the Loveland Lake and Ditch Company (LLDC) to allow Berthoud to store alternate supplies there; and by acquiring and changing Handy Ditch (46.83 total shares [452 AF/yr]) and LLDC (150 total shares [446 AF/yr]) shares in Water Court.

LRE’s recommendations, upon running nine Model scenarios, are:

- Berthoud should develop the ability to reuse its fully consumable water supplies to extinction, by diverting water from the Little Thompson River with a junior water right, and augmenting those diversions with the fully consumable portion of Berthoud’s wastewater treatment plant (WWTP) effluent. Currently, Berthoud may only reuse changed Handy Ditch Company shares and Windy Gap supplies, but the ability to reuse those supplies provides the most impact on the number of potable taps that Berthoud can serve. Storing Windy Gap reuse is the only way for Berthoud to firm its Windy Gap Units, and any remaining reuse is available for augmentation and replacement.

- Berthoud’s existing Windy Gap Units provide a significant amount of potable water supplies once reuse is possible. To the extent that Berthoud wishes to expand the maximum number of potable taps that could be served, the acquisition of additional Windy Gap Units, especially if firmed, would be the most effective way to do that when compared to the acquisition and change of Handy Ditch Company or LLDC shares.

- Berthoud would gain an extraordinary amount of flexibility for serving non-potable irrigation demands by acquiring additional LLDC shares for storage and control of the company to ensure the ability to operate its capacity in Loveland Lake independently to allow the storage of C-BT Units and other supplies in the reservoir. In that event, Loveland Lake could also be used to firm a portion of Berthoud’s Windy Gap Units. This would free up space in Berthoud Reservoir for potable supplies such as changed water rights and diversions from the Little Thompson River. The benefit of changing LLDC shares to municipal uses is more limited than Windy Gap Units due to return flow obligations, which require additional storage to cover periods when Berthoud cannot claim WWTP effluent because C-BT Units were delivered through Berthoud’s municipal system.

- Non-potable irrigation systems are likely viable in both the Handy Ditch and Loveland Lake and Ditch Company systems, which run through Berthoud’s service area. Based on the available data, water available under the Welch system could not reliably serve non-
potable irrigation systems without a substantial amount of potable water also being required, due to estimated releases falling far short of estimated irrigation demands. Due to the reliability of data, only non-potable taps under the Handy Ditch system could be projected. For all non-potable irrigation systems, LRE recommends that they be evaluated on a case-by-case basis, with operating systems recording delivery and demand data so that the Model can be calibrated to actual conditions and deliveries. LRE’s Model scenarios projected that the number of non-potable taps that can be served are cut in half once climate change factors are considered. This is a significant difference, and further reinforces that systems should be evaluated case-by-case to ensure that they can be adequately supplied long-term.

- The difference in potable taps, with and without climate change factors, is 1,368 taps at Berthoud’s current water supplies, and increases as supply and demand increases. This gap can be treated as a “buffer” on potable taps. If Berthoud limits the number of potable taps, for planning purposes, to the values calculated with climate change consideration, this buffer gives some room for restriction on Berthoud’s supplies without compromising the ability to serve its customers.

- LRE recommends Berthoud consider appropriating a junior direct flow and storage water right on the Little Thompson River to complement the reuse water source. The junior water right would divert in an augmentation plan and any out-of-priority stream depletions would be replaced with fully reusable Windy Gap and in-priority junior water right return flows. To maximize the yield of the augmentation plan, storage is required to regulate the release timing of reusable return flow sources. The same storage space could also be used to store in-priority diversions of the junior water right for subsequent direct or augmentation use.

SECTION 2: INTRODUCTION AND BACKGROUND

The Town of Berthoud (Berthoud or Town) contracted LRE Water (LRE) to update and expand the 2013 Water Resources Master Plan (WRMP). Berthoud has an extensive water supply portfolio that has historically provided sufficient water supplies, even during drought years. The purpose of this report is to characterize the reliability of Berthoud’s existing supplies under various climate change scenarios, examine yield of future water supply alternatives to determine potential future water demands that could be met without shortages for various climate change scenarios, and provide guidance on the expansion of its water resources portfolio.

A Water Resources Planning Model (Model) was developed in Microsoft Excel to assist Berthoud in balancing its current water supplies and demands, while identifying the future supplies and water resources projects needed to continue to provide a reliable water supply even amidst uncertain climatic conditions.

As described throughout this report, LRE made several assumptions and relied upon limited data for some of Berthoud’s current and future water rights. As such, there is an uncertainty built into the Model that can be calibrated and corrected as more data becomes available in future years. LRE recommends that the Model scenarios be revisited every five years so that new data can be incorporated.
2.1 BACKGROUND
Berthoud is located in Larimer and Weld Counties, Colorado, and is in a position for significant near-term growth within Colorado’s dynamic Front Range corridor (Figure 1). Berthoud was established in 1888, and today, provides drinking water to more than 9,000 residents, as well as commercial, industrial, and municipal customers located within and adjacent to Berthoud’s boundary. Berthoud owns senior water rights within the Big Thompson River basin and obtains its raw water from Carter Lake through the Colorado-Big Thompson (C-BT) and Windy Gap Southern Water Supply Project Pipeline or through the Handy Ditch system. Berthoud also owns water rights in the Handy Ditch Company (“Handy”), Loveland Lake and Ditch Company (LLDC), the Welch Lateral Ditch, the Ryan Gulch Reservoir Company (RGRC) and the McIntyre Lateral Ditch. Berthoud currently shares a non-potable water system with Thompson School District for irrigation of the Bein/Waggener Farm Parks. Berthoud’s municipal return flows and most of its non-potable irrigation return flows accrue to the Little Thompson River.

Figure 2 shows the planning area for the Town, which is known as the Berthoud Growth Management Area (GMA). Berthoud is obligated through an Intergovernmental Agreement (IGA) with the Little Thompson Water District (LTWD) to provide water service within the IGA Service Area.
Figure 1 – Town of Berthoud Location Map
Figure 2 – Town of Berthoud Planning Area and Key Ditch Locations
2.2 MUNICIPAL WATER SUPPLY AND DROUGHT MANAGEMENT

The Town’s water rights portfolio consists of very senior direct flow water rights decreed for municipal and irrigation uses, supplemented with storage rights and NCWCD transmountain water supplies as shown below in Table 1.

Table 1 – Berthoud’s 2020 Water Right Portfolio

<table>
<thead>
<tr>
<th>Water Right</th>
<th>Berthoud Case Nos.</th>
<th>Decreed Uses</th>
<th>Average Yield (AF/yr)a/</th>
<th>Firm Yield (AF/yr)a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Thompson River Priority No. 1</td>
<td>CA4862 CA8426</td>
<td>Municipal</td>
<td>2,191</td>
<td>2,191</td>
</tr>
<tr>
<td>Handy Ditch Companyb/</td>
<td>00CW110</td>
<td>Municipal/Irrigation</td>
<td>260</td>
<td>93</td>
</tr>
<tr>
<td>Ryan Gulch Reservoir Companyc/</td>
<td>-</td>
<td>Irrigation</td>
<td>144</td>
<td>Unknown</td>
</tr>
<tr>
<td>Windy Gap Projectd/</td>
<td>-</td>
<td>Municipal/Irrigation</td>
<td>421</td>
<td>0</td>
</tr>
<tr>
<td>Colorado-Big Thompson Projecte/</td>
<td>-</td>
<td>Municipal/Irrigation</td>
<td>692</td>
<td>494</td>
</tr>
<tr>
<td>Loveland Lake and Ditch Companyf/</td>
<td>-</td>
<td>Irrigation</td>
<td>227</td>
<td>5</td>
</tr>
<tr>
<td>Berthoud Reservoir</td>
<td>CA4862</td>
<td>Municipal/Irrigation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Welch Contract Rightsg/</td>
<td>-</td>
<td>Irrigation</td>
<td>489</td>
<td>131</td>
</tr>
<tr>
<td>McIntyre Lateral Ditch Companyh/</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Consolidated Home Supply Ditch and Reservoir Companyi/</td>
<td>-</td>
<td>Irrigation</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

a/ The average and firm yield values provided in Table 1 are based on the Model results presented in this report over the 2000-2018 Model period using no climate change factors.

b/ Berthoud owns 37.83 out of 900 outstanding shares in the Handy Ditch Company. In Case No. 00CW110, Berthoud changed 7.5 shares to allow for municipal use.

c/ Berthoud owns 34 out of 100 outstanding shares in the RGRC. Berthoud is in the process of changing the place of use of its RGRC shares to allow for their irrigation under the Handy Ditch.

d/ Berthoud owns 8 out of 480 Units in the Windy Gap Project.

e/ Berthoud owns 988 out of 310,000 Units in the Colorado-Big Thompson Project.

f/ Berthoud owns 76.16 out of 150 shares in the Loveland Lake and Ditch Company.

g/ Berthoud owns 86 out of 450 inches in Welch Contract Rights.

h/ Berthoud owns 2 shares in the McIntyre Lateral Ditch Company, which is a carriage ditch used for Handy Ditch supplies. There are no additional water rights conveyed with the McIntyre Lateral Ditch Company shares.

i/ Berthoud owns 2 shares in the Consolidated Home Supply Ditch and Reservoir Company, which were not modeled for irrigation purposes in the 2020 WRMP due to the ditch system being outside of Berthoud’s GMA.

These water rights provide very reliable yields, even under drought conditions such as 2002, 2003, and 2012. Because of this reliability, Berthoud has not historically experienced water shortages. Berthoud’s water rights, which are discussed in more detail in Section 3, will continue to provide reliable water supplies for the Town at its existing level of service and some degree of growth. The volume and reliability of Berthoud’s existing senior water rights exceed the current
demands, which allows for drought protections. However, as Berthoud’s population increases, its water supply will be more fully utilized, and the Town will require additional water supplies to meet projected future municipal demands.

Depending upon which future water supplies Berthoud acquires, yields may not be as reliable during a drought as the Town’s senior water rights have been. In order to prepare for future droughts, Berthoud needs to assess the vulnerability of its future supplies to droughts in meeting projected demands. Options to increase and firm the yield of acquired supplies include development of storage reservoirs and raw water supply diversification. A goal of this report is to estimate the amount of additional water supplies Berthoud will need to meet its projected water demands, which are summarized in Section 4. The various raw water supply and storage alternatives are discussed in Section 5.

To help address potential gaps in water supply during drought conditions, future water supplies will need to include a safety factor in yield or additional storage to ensure that water is available during periods of drought, which is also discussed in Section 5.

Finally, Berthoud has an operational Water Conservation Plan detailing a number of water conservation programs and measures to reduce the per-capita water demand over time, thus helping the Town retain some water supplies for use during drier years. New growth will continue to include water saving measures, which will help to reduce Berthoud’s overall demand. Conservation plays an integral part in drought management; however, physical supplies in storage will still be required to meet the future demands and protect against droughts, especially with changing climate.

2.3 MUNICIPAL POTABLE WATER SYSTEM

Berthoud is currently responsible for supplying potable water to areas located within its IGA service area as shown in Figure 2. Berthoud’s raw water supplies have historically come from the Big Thompson River. Berthoud has diverted its Big Thompson River water rights through the Handy Ditch since the early 1900’s. Beginning in the 1980’s, Berthoud started taking transbasin water through the C-BT Project (Berthoud currently owns 988 C-BT Units). In 1993, Berthoud received a decree in Case No. 84CW421 from the District Court in Water Division 1, which allows the Town to divert its Big Thompson direct flow water rights through either the Handy Ditch system or the C-BT Project. In 2018, Berthoud acquired 3 Windy Gap Units, and has just purchased an additional 5 Windy Gap Units. Berthoud completed the necessary facilities and entered into a temporary water conveyance contract with the United States Bureau of Reclamation (Bureau) in 2003. A long-term Water Conveyance Contract with the Bureau was finalized in 2007.

Raw water for potable use has historically been delivered to Berthoud Reservoir and distributed to the Town through the facilities shown in the attached Figure 3. Berthoud’s raw water supply also includes transmountain water through ownership of C-BT Project Units (C-BT Units). Berthoud has completed a raw water bypass pipeline, which can bypass Berthoud Reservoir and deliver its Big Thompson River and C-BT supplies directly to the Town’s water treatment plant (WTP).
Figure 3 – Town of Berthoud Potable System
At the time that the 2013 WRMP was being prepared, Berthoud was in the process of completing necessary upgrades to its water treatment plant and water transmission facilities. These upgrades were completed in 2019. Berthoud has also upgraded Berthoud Reservoir to add storage capacity and to store water for potable purposes. Figure 3 shows Berthoud’s potable raw water delivery system, WTP, and major treated water transmission lines.

2.4 MUNICIPAL NON-POTABLE WATER SYSTEM

Municipalities such as Berthoud can have two different types of water systems; one for potable demands and one for non-potable demands. Potable demands require water treatment to a safe level to meet the Environmental Protection Agency (EPA) Drinking Water Standards, which is considered safe for all indoor uses. Non-potable demands are typically for irrigation, and raw water is used to meet these demands and usually does not require additional treatment. Non-potable water systems take untreated water through specially designated and separate non-potable infrastructure for irrigation use.

When municipalities provide non-potable supplies for outdoor irrigation, it reduces the total volume of potable water required, which results in lower water treatment costs. Additionally, outdoor irrigation can require a large volume of water in a short amount of time, which increases the treatment and transmission capacity required to meet irrigation demands. By providing non-potable supplies for outdoor irrigation, municipalities can reduce the peak treatment and transmission capacity required to meet only indoor uses. For Berthoud’s parks and open spaces, non-potable irrigation would involve delivering irrigation water to on-site temporary storage that can be used to regulate the supply to match irrigation practices. For individual households, separating potable and non-potable supplies would require two different sets of transmission systems to homes, and generally requires developers to plan for these systems prior to breaking ground. Potable transmission lines would go into homes while non-potable transmission lines would be used for irrigation of residential lots and open space areas within the development.

The Town is generally within the historical irrigation service area of the Handy Ditch, Loveland Lake and Ditch Company, and Welch Reservoir systems. Irrigation water rights that Berthoud owns can be delivered through these systems for irrigation use to meet non-potable demands without further water court action in the areas that have been historically irrigated. Berthoud is in the process of going to Water Court to obtain Decrees to use Handy Ditch and RGRC water at Heron Lakes, which was not historically irrigated by those rights. Historically Berthoud has delivered raw irrigation water to parks and golf courses, but could serve residential developments in the future.

Berthoud currently shares a portion of its non-potable water system with the Thompson School District for a portion of the Town’s parks. The Thompson School District irrigates Berthoud High School with raw water supplies transported through the Welch Lateral. In December 2007, a report was developed for Thompson School District titled, “Raw Water Delivery System for Turner Middle School with Possible Expansion to Additional Sites.” This report describes detailed plans to provide raw water to Turner Middle School with raw water supplies conveyed through the LLDC and potential expansions of the non-potable system to additional schools and parks within Berthoud. According to discussions with the Thompson School District Resource Conservation Manager, the non-potable system expansions to other schools were put on hold due to budget constraints. Berthoud irrigates the Ellen B. Bein Park, which is adjacent to the high school, with non-potable irrigation supplies through the system and the Town plans to irrigate Waggener Farm Park with non-potable supplies through the adjacent Middle School non-potable system.
Berthoud historically attempted to provide non-potable irrigation supplies to Greenlawn Cemetery, one mile east of Town, through the McIntyre Lateral. Due to a lack of on-site storage and the ability to regulate flows, irrigation proved difficult and is currently served with potable water supplies. Berthoud would like to improve its non-potable facilities, and again provide non-potable water to Greenlawn Cemetery in the future.

**Figure 4** shows existing ditch laterals, reservoirs and non-potable infrastructure that Berthoud owns as well as the existing and planned parks.
SECTION 3: 2020 WRMP MODEL UPDATES AND ENHANCEMENTS

For the 2020 WRMP LRE is providing the following updates and enhancements to the Model that are explained further in subsequent sections:

- Extension of the study period by six additional years (2012-2018);
- Inclusion of Berthoud’s water demand data from 2017-2019 for establishing unit demand averages and trends;
- Inclusion of the RGRC and additional Handy Ditch shares, for raw irrigation and/or changed for municipal uses;
- Inclusion of Berthoud’s Windy Gap Units, with the option to be firmed at a future storage location and available for municipal potable and non-potable uses;
- Inclusion of proposed changed LLDC shares in Loveland Lake or Berthoud Reservoir for municipal uses;
- Inclusion of a new junior water right on the Little Thompson River;
- Inclusion of indirect diversion of fully consumable effluent from the Little Thompson River and an on-site storage facility or Loveland Lake to re-time the yield of that water prior to delivery to Berthoud’s WTP.
- Separation of non-potable demands by ditch system for each of Berthoud’s parks and open space properties, as well as non-potable residential taps; and
- Inclusion of climate change parameters, such as reduced ditch flows, increased irrigation demands, and earlier runoff seasons.

3.1 EXTENSION OF MODEL PERIOD

In the 2013 WRMP, the Model period consisted of the years 2000 through 2012. Actual historical data was obtained for these years for Berthoud’s water rights, when available, to reflect the variance in those supplies over average, wet, and dry years. In particular, 2002 and 2012 were very dry, resulting in less direct flow deliveries.

As part of the 2020 WRMP, LRE extended the Model period to include the years 2013 through 2018, and also used historical climate data over the Model period to estimate the irrigation demand for bluegrass for use in the non-potable demand analysis. More detail about the estimated non-potable demands is provided later in this report.

3.2 BERTHOUD’S WATER DEMANDS

For potable water demands, the Model relied upon actual metered data provided by Berthoud for residential, commercial, multi-family, and education taps. Every few years, Berthoud provides the most recent meter data to LRE so that the Model’s demands can be calibrated. The last such calibration was conducted in 2017, so LRE included metered data for the years 2018 and 2019 in the Model update.
In the 2013 WRMP, the Model averaged per-tap unit demands for use throughout the entire Model period. In this update LRE also added the functionality to follow the demand trend over time, or to rely upon the more recent 2015-2019 demand average rather than the long-term average. The 2015-2019 average was used for modeling because residential unit demands were relatively constant for the most recent three years of complete data (0.266 AF/unit in 2016, 0.260 AF/unit in 2017, and 0.265 AF/unit in 2018), suggesting that unit demands have equalized after conservation efforts have taken effect. It should be noted that these numbers do not include any system losses, and that Berthoud requires 0.4 AF/unit for dedication to account for all transmission, storage and delivery losses. Berthoud’s cash-in-lieu structure is graduated, dependent upon the size of the tap.

### 3.3 ADDITIONAL POTABLE AND NON-POTABLE WATER SUPPLIES

In the 2020 WRMP, LRE has added Berthoud’s RGRC shares, additional Handy Ditch shares and Windy Gap Units to the Model, and included modeling of storage in Loveland Lake to better estimate when supplies would be available and to simulate the ability to store other irrigation water rights in the reservoir. LRE also included a new junior water right on the Little Thompson River, although the in-priority yield from this junior priority water right has not been included in any of the Model scenarios due to the uncertainty of physically available supply of native flows from the Little Thompson River.

### 3.4 REUSE OF BERTHOUD’S FULLY CONSUMABLE WATER SUPPLIES

Portions of Berthoud’s water portfolio, most notably its Windy Gap Units, are able to be used and reused successively to extinction. This is in contrast to C-BT Units, which can only be used once. Reusing Berthoud’s water supplies would involve claiming credit for a portion of Berthoud’s WWTP effluent returning to the Little Thompson River, and using that water as an augmentation supply for the out-of-priority diversions of the junior water right described in the previous section. This practice would allow Berthoud the ability to increase Berthoud’s overall yield with reuse of its Windy Gap and any other reusable water supplies. Berthoud’s Windy Gap return flows can also be used with regulatory storage to firm the overall yield of the Windy Gap Units.

### 3.5 NON-POTABLE DEMANDS UNDER THE HANDY, LOVELAND, AND WELCH SYSTEMS

The 2013 WRMP valued Berthoud’s non-potable demands by breaking them out into types of parks, to which any of Berthoud’s non-potable water supplies could be used. In a 2018 update, LRE added the ability to include non-potable residential taps, where it was assumed, based on Berthoud’s Municipal Code which provides that 0.2 AF/yr of irrigation water would be required for each residence connected to a non-potable delivery system on lots between 3,500 ft² and 12,500 ft².

For the 2020 WRMP, LRE expanded upon the non-potable portion of the Model to examine the actual demand under each of the three main ditch systems running through Berthoud’s service area: the Handy Ditch, LLDC, and Welch systems. LRE relied upon Berthoud’s Parks Master Plan, prepared in 2016, to obtain a list of Town parks and open space properties that would require irrigation.

LRE categorized each property into one of three groups: existing parks, undeveloped parks, and conservation easements. Existing parks were included in the non-potable demand calculations as a baseline, while undeveloped parks, and conservation easements can be included with a
toggle. Each park was inspected and assigned to either be planted in bluegrass, requiring irrigation, or natural vegetation, requiring no irrigation. LRE used the DWR’s StateCU software and weather data for the Model period to estimate the irrigation water requirement (IWR), in AF/acre, for each crop, and multiplied those monthly values by the irrigated acreage of the park to estimate the monthly non-potable demand in AF for each property. A map showing each of the ditch systems and the properties that could be irrigated by them is included as Figure 5.
Figure 5 – Town of Berthoud Non-Potable Irrigation Systems

Note: The Town owns shares in the Ryan Gulch Reservoir Company, and these water rights can be exchanged to the headgate of the Handy Ditch for diversion and irrigation use.
Additionally, non-potable taps have been included for the Handy Ditch system. No non-potable taps were modeled for the Welch system because the Welch Contract Rights owned by Berthoud, typically delivered via the Welch Lateral, have limited delivery data and are restricted to a specific area of irrigation.

We believe a similar problem exists with available LLDC data based on discussions with Berthoud staff, Handy Ditch staff, and the District 4 Water Commissioner, that available records dramatically underestimate the amount of water available to LLDC shareholders. Because of this, the provided Model scenarios do not consider non-potable taps served by the LLDC system because the Model cannot accurately estimate how many taps can be served (until better data are obtained). Berthoud’s first non-potable system served by the LLDC system, Farmstead, is currently being constructed and delivery data should be available in 2021. In the future, Berthoud should approve individual developments for use of a non-potable system that could easily be satisfied with the Town’s existing LLDC water rights, and then measure and record delivery and demand data for that development, which could be used to further refine the Model.

3.6 IMPACT OF CLIMATE CHANGE ON BERTHOUD’S WATER DEMANDS

In the 2013 WRMP, LRE modeled the variability of outdoor non-potable demands by evaluating climate data in historical wet, dry, and average years, and using those data to inform Model scenarios that could include more dry years than historically occurred. For the 2020 WRMP Update, Berthoud requested a high-level evaluation of, the long-term impacts of climate change on its raw water supplies. It is generally accepted that climate change will affect Colorado’s water providers in the following distinct ways, which have been included in the Model:

- Tightened river administration will result in reduced ditch flows, especially for junior water rights, which may not be able to divert at all;
- Hotter and drier summers will result in increased irrigation demands, and potentially lengthen the growing season for most crops; and
- Hotter and drier winters will result in an earlier runoff season that peaks earlier, shifting the season of available diversions to earlier months.

3.6.1 Reduced Ditch Flows

In order to estimate the potential reduction in ditch flows, LRE reviewed an analysis of Handy Ditch diversions prepared by Lamp Rynearson on behalf of Berthoud (direct flow and storage rights) for the Model period. We relied upon Table B17 of that report (Total Farm Headgate Deliveries) to model Berthoud’s Handy Ditch yield. For the years 2016-2018, which were not included in the Lamp Rynearson analysis, the Model includes the average monthly yield over the 2000-2015 period. Over the 2000-2018 Model period, the Handy Ditch averaged 10,319AF/yr of direct flow diversions for irrigation. In its worst year (2003), only 7,296.0 AF was diverted, 29.3 percent less than average. The bottom quartile of average annual diversions corresponds to approximately 8,759.3 AF/yr, 15.1 percent less than average. The Model now includes the option to reduce ditch flows by anywhere from 0 to 50 percent to reflect the higher occurrence of dry years. Because this reduction applies to every year of the Model, rather than just historical dry years, LRE felt it would be too extreme to use the worst-year reduction (29.3 percent) for the entire analysis. A 15 percent reduction, corresponding to the bottom quartile of Handy Ditch diversions, was chosen for the Model scenarios that include climate change consideration.
In addition, LRE included in the Model an option to change C-BT quota allocations from the historical pattern of quotas to an average, dry, or very dry schedule of quotas that include more years like 2003 and 2013, where the initial quota was quite low and there was little to no supplemental April quota to increase supplies. Low C-BT quotas typically lag Colorado’s hydrology by 1 year, meaning that particularly dry years don’t immediately affect C-BT quotas.

### 3.6.2 Increased Irrigation Demands

For increased irrigation demands, LRE reviewed the irrigation water requirement (IWR) for bluegrass, the most common crop within Berthoud’s non-potable system. The average IWR for bluegrass over the Model period was 2.27 AF/acre per year, with a maximum year of 2.65 AF/acre, corresponding to a 15.7 percent increase. In Model scenarios that include climate change consideration, a 10 percent increase in non-potable demands was included, corresponding to the average of the highest quartile of IWR years.

There is a significant likelihood that, as irrigation demands increase due to increased temperatures and drier summers, the growing season for vegetation will be extended further into October or into November. LRE did not update the Model to consider this possibility, primarily because it is unclear what extended growing season would look like with respect to demand in those months. Additionally, so few of Berthoud’s non-potable water supplies are available for use in October and November. In the event that this extension of the growing season does occur, Berthoud would need to further supplement irrigation with potable water supplies in the months of October and November.

### 3.6.3 Earlier Runoff Season

The *Colorado River Availability Study Phase II – Task 7: Climate Change Approach and Results*, prepared for the Colorado Water Conservation Board in June 2019, evaluated the impacts of climate change on the runoff season in Colorado. The results of the report estimate that there will be a shift of about 1 month for most stations in the upper Colorado River. Based on this analysis, LRE updated the Model to allow for a 1-month shift in water supplies in each year. For example, if a given water supply was historically available in April through October, the Model can now be set up so that this supply is available in March through September, instead. The shift in timing can make it more difficult to optimize water supplies when they are available, but has an attenuated effect on Berthoud because so much of the Town’s water supplies can be regulated with storage.

### SECTION 4: CURRENT AND FUTURE RAW WATER DEMANDS

Berthoud meters its customers’ treated water deliveries, which represent the potable water demands. However, larger volumes of raw water supplies are needed at the diversion locations due to system losses. The total raw water demand (diversion demand) is the volume of water required to meet delivered potable supplies plus raw water transmission losses, water treatment losses, and treated water distribution losses.

Based on communications with Berthoud, it was estimated that 2 percent of the river diversions are lost between Carter Lake and the Berthoud WTP in addition to the 3 percent losses assessed by the Bureau of Reclamation. There are even greater losses when Berthoud takes delivery of its water through the Handy Ditch, and Berthoud also measures the water incoming to its WTP and its treated water delivery (coming out of the WTP). Losses within the treatment process...
include sludge removal, backwashing and evaporation. Additionally, treated water losses occur within Berthoud’s treated water distribution system. The treatment and distribution losses were estimated based on data contained in a report prepared by JVA Consulting Engineers (JVA) in 2011 (Water System Master Plan or WSMP). The approximate system loss was calculated to be 8.8 percent using the JVA period of record August 2009 through July 2010 during months in which no billing error occurred.

For the purposes of the WRMP, all treated water demands were increased to estimate river diversion or contract delivery demands to account for the actual amount of water required at the beginning of Berthoud’s water supply system. The aggregate 10.8 percent loss was applied by dividing treated water demands by 0.892 to estimate the river diversion or contract delivery demand. As stated above, Berthoud also needs to plan for significantly greater losses when it takes delivery of its water through the Handy Ditch at times that water can’t be diverted through the C-BT system.

Water delivered by Berthoud for non-potable uses will be metered at the points of delivery from ditches and laterals to the Town’s parks. Non-potable ditch demand is estimated as the non-potable demand plus the non-potable system transmission losses (Including ditch rider reported ditch and lateral losses, and evaporative losses when stored).

4.1 EXISTING WATER DEMANDS

Available water billing data were provided by Berthoud to determine the current usage and unit demands by customer type at the final tap locations. These demands represent the end use and do not include the system losses previously described. The billing data include monthly records for 2011 through August 2019 for residential, multiple, commercial, and education customers, and include the water use and number of units for each type. The most recent (2018-2019) monthly metered water use data and number of customers/taps for each metered customer class are shown below in Table 2, which excludes diversion, treatment, transmission and other system losses. The number of customers and billed demand for October, November, and December are based on 2018 data because LRE had the most recent data through September 2019.
### Table 2 – Berthoud’s Monthly Water Demands and Number of Customers for 2019

<table>
<thead>
<tr>
<th>Month</th>
<th>Year</th>
<th>Number of Customers</th>
<th>Billed Demand (AF)</th>
<th>Number of Customers</th>
<th>Billed Demand (AF)</th>
<th>Number of Customers</th>
<th>Billed Demand (AF)</th>
<th>Number of Customers</th>
<th>Billed Demand (AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct</td>
<td>2018</td>
<td>212</td>
<td>10.65</td>
<td>3,077</td>
<td>54.35</td>
<td>109</td>
<td>7.47</td>
<td>5</td>
<td>3.82</td>
</tr>
<tr>
<td>Nov</td>
<td>2018</td>
<td>213</td>
<td>4.95</td>
<td>3,094</td>
<td>34.96</td>
<td>111</td>
<td>4.59</td>
<td>5</td>
<td>0.52</td>
</tr>
<tr>
<td>Dec</td>
<td>2018</td>
<td>213</td>
<td>7.64</td>
<td>3,138</td>
<td>32.26</td>
<td>109</td>
<td>3.84</td>
<td>5</td>
<td>0.59</td>
</tr>
<tr>
<td>Jan</td>
<td>2019</td>
<td>222</td>
<td>4.14</td>
<td>3,138</td>
<td>36.27</td>
<td>111</td>
<td>4.37</td>
<td>5</td>
<td>0.44</td>
</tr>
<tr>
<td>Feb</td>
<td>2019</td>
<td>221</td>
<td>3.58</td>
<td>3,182</td>
<td>30.88</td>
<td>111</td>
<td>3.73</td>
<td>5</td>
<td>0.57</td>
</tr>
<tr>
<td>Mar</td>
<td>2019</td>
<td>221</td>
<td>3.61</td>
<td>3,259</td>
<td>31.70</td>
<td>115</td>
<td>3.92</td>
<td>5</td>
<td>0.41</td>
</tr>
<tr>
<td>Apr</td>
<td>2019</td>
<td>221</td>
<td>5.99</td>
<td>3,303</td>
<td>41.00</td>
<td>114</td>
<td>4.43</td>
<td>5</td>
<td>0.79</td>
</tr>
<tr>
<td>May</td>
<td>2019</td>
<td>222</td>
<td>7.87</td>
<td>3,346</td>
<td>53.79</td>
<td>116</td>
<td>6.67</td>
<td>5</td>
<td>0.60</td>
</tr>
<tr>
<td>Jun</td>
<td>2019</td>
<td>222</td>
<td>17.00</td>
<td>3,359</td>
<td>108.69</td>
<td>115</td>
<td>14.14</td>
<td>5</td>
<td>4.03</td>
</tr>
<tr>
<td>Jul</td>
<td>2019</td>
<td>223</td>
<td>28.68</td>
<td>3,368</td>
<td>130.16</td>
<td>117</td>
<td>17.46</td>
<td>5</td>
<td>6.27</td>
</tr>
<tr>
<td>Aug</td>
<td>2019</td>
<td>224</td>
<td>28.52</td>
<td>3,410</td>
<td>157.41</td>
<td>117</td>
<td>18.46</td>
<td>5</td>
<td>7.96</td>
</tr>
<tr>
<td>Sep</td>
<td>2019</td>
<td>227</td>
<td>27.13</td>
<td>3,394</td>
<td>131.17</td>
<td>118</td>
<td>16.63</td>
<td>5</td>
<td>8.48</td>
</tr>
<tr>
<td><strong>Total Annual</strong></td>
<td></td>
<td><strong>149.75</strong></td>
<td></td>
<td><strong>842.64</strong></td>
<td></td>
<td><strong>105.72</strong></td>
<td></td>
<td><strong>34.48</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Total Annual Demand for All Customer Types**  **1,132.6**

Annual demands (in AF per tap by customer type) were tabulated for the years 2011 through 2019, but only the metered data from 2015 through 2019 were used as those data are most representative of future growth. Demands were calculated separately for commercial, single-family residential, multi-family residential and education customers. In the future, Berthoud will continue to monitor and archive its billing data to allow comparison of future water use to historical use. These comparisons are helpful when planning for future water supply needs.

**Table 3**, shown below, provides the monthly distribution of use by customer type for Berthoud in 2018-2019.
Table 3 – Monthly Treated Water Demand Distribution by Customer Type

<table>
<thead>
<tr>
<th>Month</th>
<th>Commercial</th>
<th>Residential</th>
<th>Multi-family</th>
<th>Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>2.8%</td>
<td>4.3%</td>
<td>4.1%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Feb</td>
<td>2.4%</td>
<td>3.7%</td>
<td>3.5%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Mar</td>
<td>2.4%</td>
<td>3.8%</td>
<td>3.7%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Apr</td>
<td>4.0%</td>
<td>4.9%</td>
<td>4.2%</td>
<td>2.3%</td>
</tr>
<tr>
<td>May</td>
<td>5.3%</td>
<td>6.4%</td>
<td>6.3%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Jun</td>
<td>11.4%</td>
<td>12.9%</td>
<td>13.4%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Jul</td>
<td>19.2%</td>
<td>15.4%</td>
<td>16.5%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Aug</td>
<td>19.0%</td>
<td>18.7%</td>
<td>17.5%</td>
<td>23.1%</td>
</tr>
<tr>
<td>Sep</td>
<td>18.1%</td>
<td>15.6%</td>
<td>15.8%</td>
<td>24.6%</td>
</tr>
<tr>
<td>Oct</td>
<td>7.1%</td>
<td>6.4%</td>
<td>7.1%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Nov</td>
<td>3.3%</td>
<td>4.1%</td>
<td>4.3%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Dec</td>
<td>5.1%</td>
<td>3.8%</td>
<td>3.6%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

4.2 PROJECTED GROWTH
Historically, Berthoud experienced slower population growth than neighboring communities due to a number of factors. Berthoud is now preparing for significant near-term growth. Berthoud’s 2011 WSMP indicated that the Town’s known annexed or approved developments will increase Berthoud’s population by more than 7,000 residents. The WSMP identified a population increase of 35,000 people within its IGA Service Area by 2030. Berthoud is preparing for the anticipated growth; however, it does not want to tie the growth to a specific future date. Therefore, for the purpose of this report, growth is tied to an increase in the number of residential taps and is time independent. For this report and analysis, future demands are tied directly to the number of total residential taps that can be served a dependable potable water supply.

4.3 FUTURE POTABLE DEMANDS
Berthoud is anticipating more rapid growth in coming years than the Town has historically experienced, but recognizes that the rate of growth in terms of population is difficult to estimate. As an alternative, projections for future water demands were estimated based on the number of new taps by customer type (residential, commercial, etc.) built within the service area.

The projected number of taps for residential and commercial development at build-out were determined based on projections in the WSMP. The projected number of schools at build-out is an approximation based on conversations with school district staff. It is our understanding that Berthoud does not plan to add additional schools at specific population levels, favoring to build them as they are needed. For the purpose of our analyses it was estimated that two additional schools would be required by build-out. To develop Berthoud’s future diversion demands to incorporate into the Model we utilized the number of build-out taps times the current unit demands for each customer type. It was estimated that the non-residential water uses would increase
proportionally to the increase in residential taps. **Table 4**, shown below, provides the demand by customer type, current number of units, build-out units, and projected annual demand at build-out for each use type.

**Table 4 – Berthoud’s Current and Projected Number of Taps and Demand**

<table>
<thead>
<tr>
<th>Use Type</th>
<th>Unit Demand (AF/unit/yr)</th>
<th>Current Taps</th>
<th>Build-Out Taps</th>
<th>Projected Build-out Demand (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family Residential</td>
<td>0.259</td>
<td>3,394</td>
<td>12,489</td>
<td>3,234</td>
</tr>
<tr>
<td>Multi-Family Residential</td>
<td>0.807</td>
<td>118</td>
<td>417</td>
<td>337</td>
</tr>
<tr>
<td><strong>Total Residential</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>0.510</td>
<td>227</td>
<td>184</td>
<td>94</td>
</tr>
<tr>
<td>Education</td>
<td>6.258</td>
<td>5</td>
<td>7</td>
<td>44</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>3,744</td>
<td>13,097</td>
<td>3,709</td>
</tr>
</tbody>
</table>

a/ Build-out Taps were first used in the 2013 WRMP and were originally obtained from the 2011 JVA Consulting Engineers Water System Master Plan.

The previously described system losses of 10.8 percent were accounted for to determine the required river diversion demand prior to treatment.

### 4.4 FUTURE NON-POTABLE DEMANDS

The updated version of the Model estimates the monthly irrigation demand for Berthoud’s parks, open spaces, and conservation easements as defined in Berthoud’s Parks, Recreation, Open Space, and Trails Plan (2016). As part of the 2020 Update, LRE separated non-potable demands out by ditch system: Handy Ditch, LLDC, or Welch Lateral. Figure 4 shows each property and which ditch system it could be physically served by.

In order to estimate the demand on each of these properties, LRE used the software StateCU to estimate the monthly per-acre irrigation water requirement for bluegrass. The table included on Figure 5 shows the estimated crop and irrigated area for each of the modeled properties. For planning purposes, the irrigation demand for open space was estimated to be negligible as Berthoud has indicated these areas will likely only have natural vegetation. During extreme droughts or vegetation establishment, water may be required to keep vegetation alive on open space. The average annual irrigation water requirement for bluegrass was estimated to be 2.29 AF/acre per year.

The majority of Berthoud’s parks and open space areas are currently being irrigated with treated water. Berthoud has indicated a desire to transfer as many of these properties as possible to non-potable water supplies, in order to alleviate demand for treated water in summer months. A significant portion of the 2020 WRMP update involved separating out Berthoud’s non-potable demands by the various ditch systems that could supply them, and evaluating where shortfalls currently occur and could occur in the future.

The Model distinguishes between potable and non-potable demands. This allows projections of these demands to be calculated separately to allow for increased non-potable supplies to meet these future non-potable demands. In the Model, when non-potable supplies are insufficient to meet non-potable demands, potable water is supplied to the deficit.
SECTION 5: BERTHOUD’S CURRENT AND FUTURE RAW WATER SUPPLIES

Berthoud currently owns raw water supplies derived from senior water rights on the Big Thompson River, C-BT Units, Windy Gap Units, Handy Ditch Shares, Welch Contract Rights, McIntyre Lateral Ditch Company shares, LLDC shares, RGRC shares, Berthoud Reservoir, and Consolidated Home Supply Ditch shares (as shown in Table 1). Historical deliveries over the period of 2000 through 2018 were incorporated into the Model as a representative range of future raw water supplies. A brief description of the water rights and estimated deliveries for each are included in the following sections.

5.1 BERTHOUD’S CURRENT AND FUTURE WATER RIGHTS AND CONTRACT SUPPLIES

Berthoud treats raw water at its WTP for distribution to its customers. Water can be delivered either directly to Berthoud’s WTP or following storage in Berthoud Reservoir. Although the current amount of non-potable irrigation is limited, Berthoud could deliver its water supplies through the Handy Ditch, LLDC, and Welch Lateral systems to irrigate parks and open space areas. The following sections describe Berthoud’s water rights that can be used for potable and non-potable demands.

5.1.1 Big Thompson River Water Rights

Berthoud’s water portfolio includes the most senior water rights on the Big Thompson River (3 cfs for domestic uses and 4.14 cfs for municipal uses). Berthoud is able to deliver this water through both the Handy Ditch and the C-BT system between April 27 and October 31, up to 159 days per year. This amount is subject to a 22.5 percent loss to the Handy Ditch Company pursuant to its carriage agreement, and deliveries through Carter Lake are subject to an additional 3 percent carriage loss. This results in 1,664 AF of water available per year. It should be noted that the 22.5 percent loss will be reduced as additional Handy Ditch shares are changed in Water Court to non-irrigation uses.

5.1.2 Colorado-Big Thompson Project

Berthoud currently owns 988 C-BT Units. The yield from C-BT Units has historically ranged from 0.5 to 1.0 AF/Unit per year. C-BT is available year-round and is delivered through Berthoud’s Carter Lake pipeline. Typically, an initial quota of 50 percent is set in November, which is available to shareholders. The Town recognizes a firm yield of 0.6 AF/Unit, which results in 593 AF per year.

The Northern Colorado Water Conservancy District (NCWCD) operates the C-BT system and considers supplemental quotas each spring ranging from zero to 50 percent. Any unused C-BT supplies revert back to NCWCD’s ownership on November 1, with the exception of a maximum carryover of 20 percent of an owner’s total number of C-BT units, subject to a 10 percent shrink.

Berthoud’s C-BT Units can be used for both municipal and irrigation uses, but only for a single use. Berthoud cannot reuse C-BT Units that return to the river via irrigation or municipal return flows.

5.1.3 Windy Gap Project

Berthoud owns 8 units in the Windy Gap Project, which includes 5 units that were recently purchased. NCWCD diverts water from the Colorado River for storage in Lake Granby, Shadow
Mountain Reservoir, and Grand Lake. Water is then delivered through the Alva B. Adams tunnel across the continental divide for distribution to east-slope communities via NCWCD’s C-BT Project infrastructure. Berthoud takes delivery of its Windy Gap water from Carter Lake. However, Windy Gap Project water is not as reliable as C-BT Project water because of its junior priority and because it is subject to being spilled from Lake Granby in wet years. The 2013 WRMP did not include Windy Gap Project supplies.

For the 2020 WRMP, LRE included Berthoud’s Windy Gap Units in the Model. Projected unit yields of Windy Gap deliveries for the Model period were not readily available. A simplified assumption was made that in years where there is pumping under the Windy Gap Project, Berthoud would have received its full 100 AF/Unit of supplies from the Windy Gap project. LRE also included the ability to capture and store Windy Gap indoor use return flows for indirect reuse to increase the yield of the Windy Gap Units.

Berthoud’s Windy Gap Units are a particularly important piece of its water rights portfolio because that water can be reused to extinction, whereas Berthoud’s C-BT Units may only be used once. This would allow Berthoud to divert the fully consumable portion of its WWTP effluent directly or by exchange to storage, or use as an augmentation supply for a junior water right on the Little Thompson River. The augmented junior water right supply could subsequently be stored, delivered for treatment at Berthoud’s WTP, and subsequently effluent returns could be reused. This practice of use and reuse dramatically increases the efficient use of Berthoud’s Windy Gap water supply. To maximize the reuse capabilities, it is recommended that Berthoud pursue additional water storage capacity to firm the reusable yield of its Windy Gap Units.

5.1.4 Handy Ditch Shares
Berthoud currently owns 37.83 shares in the Handy Ditch, of which, 7.5 shares were changed in Case No. 00CW110. Handy Ditch shares have a dry-year yield of 4.4 AF/share. Unchanged Handy Ditch shares may be utilized in the future as a supply to meet Berthoud’s non-potable irrigation demands within the Handy Ditch system. If Handy Ditch shares are used for municipal purposes, a portion of the yield from the shares must be used to replace historical return flows throughout the year. This may require releases from storage during the non-irrigation season.

5.1.5 Welch Contract Shares
Berthoud currently owns 86 inches of Welch Contract Rights and 32 shares in the Welch Lateral Ditch Company. Welch contract water is available on a limited basis (based upon its priority) because the Welch Reservoir water right is often only in priority when the Handy Ditch is carrying its direct flow water. It is a contract water right and currently can only be used on the Bein Park due to its location within the designated contract area.

5.1.6 Loveland Lake and Ditch Company
Berthoud currently owns 76.16 shares in the LLDC, whereby water is diverted via the Handy Ditch and delivered to Loveland Lake for later irrigation use, primarily within Berthoud’s service area. The 2013 WRMP included 7.84 LLDC shares as a non-potable irrigation supply, but did not model storage in Loveland Lake and was grouped with all other non-potable supplies to meet all non-potable demands, with no consideration for what lands could be irrigated and the specific irrigation demands of those properties.
In a small update to the Model in 2018, after Berthoud acquired an additional 68.32 LLDC shares, modeling of storage in Loveland Lake was included in the Model. For the 2020 WRMP, LRE additionally added the flexibility to deliver other, non-LLDC supplies to Loveland Lake, under the assumption that, if Berthoud were to continue acquiring LLDC shares, that operational flexibility could be obtained. The current version of the Model has the option to allow Loveland Lake to operate as a storage vessel for C-BT and Windy Gap Units for either irrigation use under the LLDC system or delivery to Berthoud Reservoir and Berthoud’s WTP.

5.1.7 Ryan Gulch Reservoir Company
Berthoud owns 34 shares in the RGRC, which it has acquired since the 2013 WRMP. The Ryan Gulch Reservoir fills via seepage and runoff from irrigation tributary to the Big Thompson River. Water is released from Ryan Gulch Reservoir for direct irrigation or for delivery to the Big Thompson River, where it is taken in several locations by exchange. One such location is the headgate of the Handy Ditch, where it could be diverted and made available for Berthoud’s irrigation use as long as those shares were historically used under the Handy Ditch system. If Berthoud were to change its RGRC shares in Division 1 Water Court, those supplies could also be delivered to other locations for irrigation use, such as Heron Lakes, or to Berthoud Reservoir for direct municipal use.

For the 2020 WRMP, LRE included the RGRC supplies in the Model, with an option to use unchanged shares for irrigation and changed shares for irrigation or municipal uses. The DWR maintains diversion and reservoir release records for most structures, but there are very few records for Ryan Gulch Reservoir. As a result, LRE relied upon calculated unit values from the Case No. 06CW89 decree, wherein the City of Loveland changed RGRC shares. The Case No. 06CW89 decree includes an average monthly supply, return flow factors, and resultant consumptive use available to Loveland’s changed shares.

While Berthoud’s current and future RGRC shares would have had a different historical use, resulting in different return flows and consumptive use, the Case No. 06CW89 values were relied upon as being reasonable, absent specific data and analyses.

5.1.8 Consolidated Home Supply Ditch and Reservoir Company
Berthoud currently owns 2 shares in the Consolidated Home Supply Ditch and Reservoir Company. These shares are dedicated for use on open space located on a property within Berthoud’s IGA Service Area. The water rights and physical supplies are tied to the land, which Berthoud plans to develop into an open space area. This water supply and the associated open space property were therefore not included in the Model.

5.1.9 Berthoud Reservoir
Berthoud Reservoir has a current capacity of approximately 513 AF and has historically been used as a potable storage facility during winter months when the Handy Ditch was not diverting. In more recent years, Berthoud Reservoir has not been needed for winter supplies because the pipeline from Carter Lake can deliver to the Town year-round, but has still been useful in regulating flows into Berthoud’s WTP. It has recently been rehabilitated and will play a critical role in supplying water to the WTP.
5.1.10 Reuse of Fully Consumable Water Supplies

One of the primary purposes of the 2020 WRMP was to evaluate the benefit of Berthoud reusing the portion of its potable water supplies that are legally available for use to extinction. The primary mechanism by which this could be accomplished is by diversion of water from the Little Thompson River under a new water right that can be used to extinction, where out-of-priority stream depletions are augmented by the reusable portion of Berthoud’s WWTP effluent. The primary water rights that are available for reuse and successive use to extinction are Berthoud’s Windy Gap Units.

LRE estimated the amount of wastewater as 90 percent of the monthly indoor use. Indoor use was estimated as the average monthly demand for the preceding November through February period. Without WWTP discharge data, a consumption factor of 10 percent between meter measurements and the WWTP is generally accepted as a conservatively low estimate for reuse as a supply.

The amount of reusable effluent was based on sum of Windy Gap and new water right deliveries as a percent of total potable demand. The ability for Berthoud to reuse its other water supplies is particularly crucial for future development because this supply will scale with Berthoud’s water demand: as Berthoud increases its Windy Gap, Handy Ditch, and any other fully consumable water supplies to meet rising demands, the reusable supply will increase as well.

To simulate the augmentation plan, the Model includes an on-site storage vessel for water diverted by the new water right, with diversions equal to the reusable effluent return flows on the Little Thompson River. The on-site storage vessel is used to regulate river diversions to match delivery demands at Berthoud’s WTP for treatment. It is important, when evaluating the potential yield of reuse supplies, to estimate the optimum size of this storage vessel, and the Model scenarios that include reuse have a storage amount that is optimized for that scenario.

5.1.11 Little Thompson River New Water Right

As part of adopting a reuse practice, Berthoud could appropriate a new junior water right on the Little Thompson River, which would allow for diversions when there is available flow and no downstream calling water right on the Little Thompson or South Platte Rivers. When the junior water right is not in priority, diversions can be augmented with the consumable portion of Berthoud’s effluent, primarily from Windy Gap return flows. Water could be diverted via a surface diversion or pump station, or a series of vertical and/or horizontal wells. LRE has found that horizontal wells are ideal for achieving desired yields with improved water quality from these types of diversions. In order to estimate the amount of water that could be available, LRE reviewed call and streamflow records for the Little Thompson and South Platte Rivers, and also inquired with the District 4 Water Commissioner about the viability of appropriating a new water right.

In general, downstream irrigation water rights control the flow of the Little Thompson River between the months of May and November, making the likelihood of diverting a junior priority extremely low. In the winter, the controlling call at the location of Berthoud’s WWTP on the Little Thompson river is generally one of the large reservoirs far downstream on the South Platte River in District 1 or District 64. Depending on antecedent river conditions, however, the reservoirs may not call or may call for a shorter period, which potentially results in many days where water would be legally available for diversion on the Little Thompson River.
It is less clear how much physical supply would be available for diversion, however. Streamflow measurements have historically been recorded up near the canyon mouth of the Little Thompson River and downstream near its confluence with the Big Thompson River, however those records are sporadic and are a considerable distance from Berthoud’s expected point of diversion. We recommend that, if Berthoud plans to appropriate a direct flow junior water right on the Little Thompson River above the water reclamation discharge point, that streamflow measurements be taken at various times during the winter months in order to estimate the amount of water that could be physically available for appropriation and diversion. Traditional alluvial wells or horizontal directional drilled HDD wells are also an option for a physical water supply. A hydrogeologic investigation is also recommended to determine the viability of riverbank filtration to improve water quality above and below the reclamation discharge point.

The scenarios provided with this report that consider climate change effects do not include any in-priority water attributable to a junior water right on the Little Thompson River. This is because, as the climate gets drier and hotter, it is likely that river administration will tighten and junior priorities will be first to divert less, and then not at all. We still recommend filing for such a water right, because it is compatible with the same diversion infrastructure and storage as the reuse water supplies and, when available, can be used and reused and may increase the whole system’s dependable yield. The scenarios do include water attributable to diversions under a junior water right, augmented with Windy Gap return flows, as set forth below. The following subsection provides an example, with a high-level estimate of cost, of what infrastructure would be required to operate the junior water right and reuse operations.

5.2 NEW INFRASTRUCTURE FOR LITTLE THOMPSON RIVER WATER

As described in the previous section, Berthoud would benefit from being able to divert water from the Little Thompson River while augmenting those diversions with the reusable portion of its WWTP effluent. Water could be taken either by a surface diversion or by wells drilled into the Little Thompson River’s alluvial aquifer. All else being equal, a wellfield is generally the preferred option when the water is put to municipal use, due to natural filtration that occurs in the alluvium. The opinions of cost in this section consider that such a wellfield would be hydrogeologically viable; Berthoud should consider conducting an investigation of the geology in this area to verify that this is true.

In the 2013 WRMP, Berthoud’s potable taps at build-out numbered 12,489 (3,234 AF/yr). At that demand, the Model estimates that an alluvial wellfield will need to produce up to 1,500 gpm of water to reliably capture the associated reusable supplies. Based on the Model scenarios, a 500 AF on-site storage vessel was included to regulate flow to Berthoud’s WTP. Finally, a 12-inch pipeline from the wellfield to the storage vessel and from the storage vessel to Berthoud’s WTP would also need 1,500 gpm of capacity. The pipeline alignment was estimated to run 0.7 miles north to Highway 56, 1.36 miles west to County Road 15, 1.92 miles north and then 0.2 miles west to Berthoud’s WTP, for a total length of 4.18 miles.

In order to estimate the high-level cost of this infrastructure, LRE relied upon a waster costing tool built by the Colorado Water Conservation Board to help estimate the capital and labor cost of large water projects. Table 5, below, provides a summary of the estimated costs for two versions of this project: one where a new reservoir must be constructed; and one where Berthoud is able to store supplies in Loveland Reservoir.
Table 5 – High-Level Opinion of Cost for Infrastructure for Berthoud’s Reuse of Water Supplies

<table>
<thead>
<tr>
<th>Aspect of Project</th>
<th>Cost w/ Reservoir</th>
<th>Cost w/out Reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Field Development</td>
<td>$1,176,000</td>
<td>$1,176,000</td>
</tr>
<tr>
<td>Pipeline Construction</td>
<td>$4,400,000</td>
<td>$4,400,000</td>
</tr>
<tr>
<td>Reservoir Construction</td>
<td>$6,000,000</td>
<td>$0</td>
</tr>
<tr>
<td>Engineering Services</td>
<td>$1,400,000</td>
<td>$1,115,000</td>
</tr>
<tr>
<td>Surveying</td>
<td>$72,000</td>
<td>$56,000</td>
</tr>
<tr>
<td>Legal Services</td>
<td>$720,000</td>
<td>$558,000</td>
</tr>
<tr>
<td>Financing and Bond Assistance</td>
<td>$72,000</td>
<td>$56,000</td>
</tr>
<tr>
<td>Environmental and Cultural Studies</td>
<td>$72,000</td>
<td>$56,000</td>
</tr>
<tr>
<td>Permitting</td>
<td>$72,000</td>
<td>$56,000</td>
</tr>
<tr>
<td>Interest during Construction</td>
<td>$290,000</td>
<td>$223,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$14,274,000</strong></td>
<td><strong>$7,696,000</strong></td>
</tr>
<tr>
<td><strong>Unit Cost ($/AF Yield)</strong></td>
<td><strong>$10,200</strong></td>
<td><strong>$5,500</strong></td>
</tr>
</tbody>
</table>

While the reservoir is crucial for Berthoud’s long-term reuse supplies, Berthoud could operate without storage, delivering water directly to Berthoud Reservoir or Berthoud’s WTP for treatment. This practice is not as efficient, because there may not be a demand for water when it is available, but would allow reuse of some supplies until a reservoir can be constructed.

The preferred alternative is to acquire the ability to deliver non-LLDC water supplies to Loveland Lake, that reservoir could be used to store Little Thompson Water prior to its delivery to Berthoud’s WTP. This may be the most attractive option because it would avoid the construction cost of a new storage facility, but would compete with Berthoud’s other non-potable and potable water supplies in Loveland Lake.

5.3 NON-POTABLE PLAN

Berthoud has identified its interests in furthering its development of a non-potable irrigation system. Berthoud’s existing parks are all within the historical irrigation areas of the major irrigation ditches in the area. Berthoud’s Bein Park can have non-potable supplies delivered through the Welch Lateral by its Welch Contract Rights or Handy Ditch shares. The rest of Berthoud’s existing parks (as well as the planned Wagner and Pioneer Parks) could have non-potable supplies delivered through the LLDC system. Based on the proximity of Berthoud’s existing parks to the irrigation ditches within the area, a conceptual pipeline route as developed for each park, as shown on Figure 4.

Berthoud will likely seek approval from the LLDC to carry the Town’s supplies and construct new headgates or turnouts, if necessary. It is anticipated that each park would need access to operational storage to regulate supplies with irrigation demands. The DWR currently allows for direct flow water rights to be stored up to 72 hours (3 days) for operational storage and control within Division 1. Raw water storage could be completed through an underground tank, sump, or...
pond. Additionally, raw water storage could be combined for multiple facilities to create a larger water feature at a Town park. However, the estimated construction costs would likely be comparable, since the same total storage volume would be required.

The implementation of the non-potable systems could be completed over time, as Berthoud is able to secure funding. Berthoud should focus on the areas with the largest overall demand. Figure 4 shows the conceptual proposed pipelines to Berthoud’s parks.

As Berthoud continues to develop its future parks system within its GMA, it will need to determine if those parks can be met with non-potable supplies from irrigation rights, and if the proximity of the future parks to the existing irrigation ditches is sufficiently close. Berthoud should continue to coordinate its infrastructure planning with the Town’s Parks Department and should leverage its unchanged irrigation water rights with potential opportunities to further develop a functional non-potable system.

Berthoud’s existing parks should maintain their potable irrigation systems as a back-up supply during times of drought or periods when irrigation supplies are unavailable. As Berthoud develops its non-potable system, it will determine the reliability of its irrigation supplies and can assess ways to improve any future concerns with reliability or yield through possible long-term storage opportunities or the acquisition of additional supplies. The ability to use existing storage reservoirs for regulating flows to the non-potable systems will result in less on-site storage being required, which would reduce the construction costs of non-potable irrigation systems.

SECTION 6: WATER RESOURCES ALTERNATIVES

Based on Berthoud’s location, existing water rights, and infrastructure, it has a number of alternatives that should be considered by the Town to optimize its current water rights and infrastructure as well as meet its future demands.

6.1 WATER RIGHTS CONSIDERATIONS

Berthoud has historically relied upon its Big Thompson River water rights, Handy Ditch shares, and C-BT Units. All of these water supplies will continue to be important resources for Berthoud. As Berthoud expands, it will develop lands historically irrigated by the Handy Ditch system and can use the Handy Ditch shares supplemented with other supplies to meet future irrigation demands.

Berthoud’s C-BT Units are another important water resource. While the annual C-BT quota varies and can be as low as 50 percent (0.5 AF/Unit), which Berthoud needs to plan for, the average historical quota is 70 percent. C-BT supplies are reliable and provide a consistent back-up water supply for Berthoud, especially in the winter when its Big Thompson River water rights are unavailable.

Due to an increased demand for water supplies along Colorado’s Front Range, the cost for Handy Ditch shares and C-BT Units continues to increase. Berthoud should not plan on acquiring additional CBT Units at this time due to the current prices. Rather, as explained below, water dedication fees should be utilized to firm the Town’s 8 Windy Gap Units and to pursue the system to reuse its Windy Gap water. Berthoud should also seek other local irrigation supplies, such as
LLDC water rights, and storage capacity in local reservoirs, such as Welch Reservoir or Loveland Reservoir. When future growth occurs on lands historically irrigated by local ditch supplies, the benefit of those supplies, without having to go to water court, should be considered for any non-potable demands within the historical irrigation service areas.

Berthoud has acquired (or is in the final stages of acquiring) additional transmountain water supplies for a total of 8 Windy Gap Units since the 2013 WRMP. Berthoud’s Windy Gap Units will be a critical raw water supply for future growth because Windy Gap water can be used and reused to extinction. This practice allows Berthoud to claim credit for a portion of its WWTP effluent as Windy Gap return flows. These return flows can be utilized to augment stream depletions of a new fully consumptive water right (direct flow or alluvial wells). Return flows of the new water right can then be utilized in the same manner to augment additional diversions of the new water right. This type of reuse augmentation plan can increase the initial yield of Windy Gap Units many times over depending on the percent of return flows that occur from each use.

The Northern Integrated Supply Project (NISP) is another potential water supply source. This project, proposed by NCWCD, will involve storing water supplies from the Cache la Poudre River and South Platte River in two off-channel reservoirs, primarily during wet years. NCWCD would use a new pipeline to convey the water, where it could be distributed to NISP participants. With Berthoud’s acquisition of 8 Windy Gap Units, Berthoud’s participation in NISP may not be necessary.

6.2 WATER STORAGE CONSIDERATIONS

The conducted modeling of Berthoud’s water supplies shows the importance of storage to increase Berthoud’s ability to provide a firm or dependable water supply to meet projected demands. In addition, storage is vital to meet delayed return flow obligations in winter months from changed irrigation rights.

To meet projected build-out demands Berthoud would require additional storage, included in the Model as Loveland Lake and a new storage site near the Little Thompson River. Additionally, Berthoud’s irrigation water rights could be firmed with additional raw water irrigation storage within the Town’s service area. Berthoud has indicated an interest in acquiring additional LLDC shares so that Berthoud might gain the flexibility to store other water rights in Loveland Lake. If Berthoud were to gain the flexibility to deliver C-BT Units and other irrigation water rights to Loveland Lake, this would free up space in Berthoud Reservoir for additional potable supplies. Finally, additional storage will be important to firm the yield of Berthoud’s Windy Gap Units.

6.3 OPERATION CONSIDERATIONS

Berthoud should consider construction of non-potable irrigation systems for its parks, open space areas, and even future residential development. The use of irrigation water rights and C-BT Units for irrigation would allow fully consumable water supplies, such as Windy Gap Units and changed water rights, to be used only for treatment and distribution. These fully consumable supplies then become an augmentation supply in the river that can be used to augment alluvial wells or a surface diversion, allowing the water rights to be reused in Berthoud’s system.

Berthoud should continue to implement its Water Conservation Plan with respect to future growth. Berthoud should also refine and improve its Water Conservation Plan as technology improves water efficiencies, which will reduce overall demands.
Berthoud could also look for opportunities with other nearby municipalities or special districts to partner in future water supply or water storage projects, to reduce the overall cost of projects.

6.4 WATER QUALITY CONSIDERATIONS

At the time of the 2013 WRMP, Berthoud was nearing the completion of its water treatment plant upgrades. Those upgrades provided a better treatment process for Berthoud, which provided a more consistent finished water quality to the Town’s residents. The construction of Berthoud’s bypass pipeline also improved the water quality coming to the plant.

Berthoud’s existing raw water supplies should maintain their current water quality characteristics. Therefore, if Berthoud adds a new source of water to its portfolio, it will need to assure its water quality is sufficient for its water treatment process. Additionally, if Berthoud finds that a future dredging of Berthoud Reservoir is not successful in improving water quality, or isn’t able to dredge the sediment out of the reservoir, its future water treatment process could be modified to meet the additional water treatment needs.

6.5 WATER RATES CONSIDERATIONS

Berthoud has developed a water rate structure and billing system that is designed to encourage efficient and fiscally responsible water use. Berthoud utilizes a two-tiered increasing block rate structure based on water use (as water use reaches a defined amount, the rate increases per thousand gallons) and is varied based on type of use and meter size. Rates are also based on whether the user is an inside or outside Town customer.

We recommend that Berthoud continue to utilize the increasing block rate structure as this is a commonly used and effective water conservation practice. It is recommended that Berthoud research and consider other block rate structures in neighboring communities, comparing per-capita usage to determine if it would be valuable to develop a multi-tiered or steeper rate structure in the future.

Berthoud will likely need to revise its rates in the future to account for increased costs associated with future water treatment, raw water delivery costs, and future storage operation costs. Additionally, Berthoud may decide in the future to increase its rates to account for future capital costs associated with future water supplies, storage facilities, transmission infrastructure, or water treatment upgrades.

As long as Berthoud is providing non-potable supplies to its own parks and irrigable lands, it will not need to develop a non-potable rate structure. For residential non-potable irrigation, Berthoud has expressed an interest in structuring those systems so that Berthoud is obligated to provide a certain amount of water to a master meter, at which point a special water district created by the developer or homeowners’ association would be responsible for regulating and distributing irrigation supplies. This practice frees Berthoud from having to operate and administer development-specific irrigation systems.
SECTION 7: MODEL ASSUMPTIONS AND SCENARIOS

The results of all Model scenarios run by LRE and described in the following sections are summarized on Figure 6, attached with this report. The highlighted columns show the number of potable and non-potable taps (under the Handy Ditch system) that can be supported under each scenario. Each scenario, other than the baseline, had the goal of maximizing the number of potable taps. If non-potable taps were also included, the goal was to maximize those as well by limiting the amount of potable water that would be required to supplement irrigation, and assuming that non-potable taps would only be associated with the construction of new potable taps.

The following sections provide summaries of the assumptions that were made for all Model scenarios, and then a description of each Model scenario, its results, and what conclusions LRE has drawn from those results.

7.1 MODEL ASSUMPTIONS

The Model contains many settings and toggles, but many of these values were kept consistent throughout all Model scenarios. This section describes these settings, and explains why they were kept constant.

7.1.1 Reservoir Volume

It is common, when executing a water supply model to determine the dependable yield of a system with storage to have modeled reservoirs be at least as full at the end of the Model period as they are at the beginning. If the reservoir loses water over the Model period, it suggests that if Berthoud operated two or more Model cycles, they would be running out of water. Ensuring the modeled reservoirs maintain their storage over the Model period makes the modeled operations sustainable under the modeled conditions.

The starting volume of Berthoud Reservoir, Loveland Lake, and the on-site storage for Little Thompson River diversions are all set to begin at 75 percent of capacity. If 100 percent were chosen, it becomes very difficult to make sure all reservoirs are full at the end of the Model period. If a lower percentage were chosen, it can create shortages early in the Model (where there are drier years) that are perhaps not realistic except when modeling worst-case scenarios.

The volume of Berthoud Reservoir was set at 389.3 AF. The volume of Loveland Lake was estimated to be 2,165 AF. The volume of the on-site storage for Little Thompson River water was variable and fluctuated throughout the Model scenarios, however the initial volume was set at 75% of the selected capacity.

7.1.2 Berthoud’s Potable Demands

Part of the Model update included evaluating and simulating Berthoud’s potable demands in different ways. In the 2013 WRMP, the average monthly unit demand for each tap type was used throughout the Model period. In this Model update, LRE also summarized the data by trends and by a 2015-2019 average rather than a long-term average. For all Model scenarios, LRE used the 2015-2019 average instead of the long-term average. The more recent years include more current water conservation practices, which will be more representative of future potable demands.
7.1.3 Berthoud’s Non-potable Taps
Most of the Model scenarios presented in Section 7.2 include a number of non-potable irrigation taps to be served under the Handy Ditch system. While non-potable irrigation demands typically exist in the months of April through October, the vast majority of Berthoud’s non-potable supplies are reliable between the months of May through September. This means non-potable irrigation demands will incur shortages with non-potable irrigation supplies alone, and will require supplemental potable supplies in some years. In order to avoid committing too large a portion of potable supplies to non-potable demands, each scenario limits the number of non-potable taps so that no more than 10 percent of the total non-potable demand is met by potable supplies.

7.2 MODEL SCENARIOS
The following subsections describe each of the scenarios run by LRE and results for possible potable taps by use type, and non-potable use (residential taps and park irrigation) are summarized in Figure 5. The scenarios begin by evaluating Berthoud’s current water supplies with varying demand and climate change scenarios (Scenarios 0 through 2). The next group of scenarios evaluate acquiring additional ditch and contract water rights and changing them for municipal use (Scenarios 3 through 6). The final group of scenarios evaluate Berthoud obtaining the ability to reuse its current and future water supplies under varying demand scenarios (Scenarios 7 through 9). Throughout the scenarios, the number of supported potable taps shown correspond to the number of single-family residential taps, because other potable taps were estimated to scale proportionately with single family residential taps as they increase and decrease in the Model.

7.2.1 Scenario 0 – Current Supplies/Maximum Demand/No Climate Change
This scenario consists of Berthoud’s current potable and non-potable supplies, to determine the maximum potable taps, with no non-potable irrigation of residences or parks that have yet to be developed. The current number of residential potable taps (3,394) is based on the September 2019 data provided by Berthoud (2019 Baseline). It should be noted that, even though no non-potable taps are included in Scenario 0, there is a baseline non-potable demand associated with Berthoud’s developed parks under the Handy Ditch system. All scenarios include Berthoud’s 8 Windy Gap Units, as it is our understanding that the Town closed on the additional 5 Units in November 2020.

<table>
<thead>
<tr>
<th>Total Residential Potable Taps</th>
<th>Number of Residential Potable Taps over Baseline</th>
<th>Average Potable Demand (AF/yr)</th>
<th>Non-potable Taps</th>
<th>Non-potable Demand (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,087</td>
<td>+2,693</td>
<td>2,015</td>
<td>0</td>
<td>360</td>
</tr>
</tbody>
</table>

7.2.2 Scenario 1 – Current Supplies/Maximum Demand with NP Taps/No Climate Change
This first scenario estimates the maximum number of potable and non-potable taps that Berthoud could support with the Town’s current water supplies, including the addition of non-potable taps under the Handy Ditch system. This demonstrates that Berthoud will be able to serve more taps by including non-potable irrigation systems and offloading a significant portion of the summer potable demand to non-potable sources. For this, and all future scenarios with non-potable taps, some supplementation with potable water was necessary.
Table 7 – Scenario 1 Results

<table>
<thead>
<tr>
<th>Total Residential Potable Taps</th>
<th>Number of Residential Potable Taps over Baseline</th>
<th>Average Potable Demand (AF/yr)</th>
<th>Non-potable Taps</th>
<th>Non-potable Demand (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,717</td>
<td>+4,323</td>
<td>1,821</td>
<td>4,323</td>
<td>1,232</td>
</tr>
</tbody>
</table>

The addition of non-potable taps results in the ability to increase potable taps by 1,630 when compared to Berthoud’s current water supplies with no non-potable system, by moving the majority of the potable tap irrigation demands to non-potable supplies. In fact, the total potable demand is 194 AF/yr less even though more taps are served. This effect is increased as both supplies and demands are increased in future scenarios.

7.2.3 Scenario 2 – Current Supplies/Maximum Demand/Climate Change

This scenario is identical to Scenario 1, but with the inclusion of lower-quota C-BT years, a 15 percent reduction in ditch flows, a 10 percent increase in irrigation demands, and a shift in the delivery season to be 1 month earlier for the yield of Berthoud’s water rights.

Table 8 – Scenario 2 Results

<table>
<thead>
<tr>
<th>Total Residential Potable Taps</th>
<th>Number of Residential Potable Taps over Baseline</th>
<th>Average Potable Demand (AF/yr)</th>
<th>Non-potable Taps</th>
<th>Non-potable Demand (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,349</td>
<td>+2,955</td>
<td>1,653</td>
<td>2,630</td>
<td>1,097</td>
</tr>
</tbody>
</table>

As expected, introducing the climate change factors drastically reduces the maximum number of both potable and non-potable taps compared to Scenario 1. However, the maximum number of potable taps is still greater than in Scenario 0, the current maximum with no non-potable irrigation systems. This suggests that including non-potable irrigation systems in future developments can allow Berthoud to mitigate the effects of climate change.

7.2.4 Scenario 3 – Add Handy Ditch/Maximum Demand/Climate Change

Scenario 3 builds on Scenario 2 by including the change of Berthoud’s 29.33 Handy Ditch shares to include municipal uses, and the acquisition and change of an additional 10 Handy Ditch shares for that purpose, for a total of 46.83 changed Handy Ditch shares. It should be noted that, in the time since these Model Scenarios were performed, Berthoud has acquired 1 additional Handy Ditch share (30.33 unchanged Handy Ditch shares total). This share was not included in any of the Model Scenarios.

Table 9 – Scenario 3 Results

<table>
<thead>
<tr>
<th>Total Residential Potable Taps</th>
<th>Number of Residential Potable Taps over Baseline</th>
<th>Average Potable Demand (AF/yr)</th>
<th>Non-potable Taps</th>
<th>Non-potable Demand (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,203</td>
<td>+3,809</td>
<td>1,701</td>
<td>3,809</td>
<td>1,338</td>
</tr>
</tbody>
</table>
Under this scenario, Berthoud’s Handy Ditch shares would be prioritized for municipal uses, although a much larger amount of water would be owed to the Little Thompson River in order to maintain historical return flows, averaging 158 AF/yr. Until Berthoud claims the reusable portion of its effluent as a replacement supply, it will be difficult to maintain historical return flow obligations to the Little Thompson River. Even then, the replacement of return flows may require significant storage supplies so that enough water can be released during periods when Berthoud cannot claim any of its WWTP effluent, such as when C-BT water is the only source being taken through the potable system.

7.2.5 Scenario 4 – Change LLDC/Maximum Demand/Climate Change

Scenario 4 builds on Scenario 2 by including the change of Berthoud’s 76.16 LLDC shares to allow for municipal use. In order to evaluate each supply independently, no additional change or acquisition of Handy Ditch shares was included in this scenario.

<table>
<thead>
<tr>
<th>Table 10 – Scenario 4 Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Residential Potable Taps</td>
</tr>
<tr>
<td>7,970</td>
</tr>
</tbody>
</table>

Under this scenario, Berthoud’s LLDC supplies would be prioritized for municipal uses, reducing the amount available for non-potable demands under the LLDC and Handy systems. Similar to changed Handy Ditch shares, changing LLDC shares would involve maintaining historical return flows to the Little Thompson River, which will be difficult until Berthoud claims reuse of its WWTP effluent, and even then, may require storage.

7.2.6 Scenario 5 – Acquire & Change LLDC/Maximum Demand/Climate Change

Scenario 5 builds upon Scenario 4 by including the acquisition and change of the remaining 73.84 outstanding LLDC shares. This number was chosen because Berthoud has previously expressed interest in acquiring most, if not all, of the LLDC water rights so that Loveland Lake could be operated exclusively by Berthoud, and could be used to store C-BT or other water supplies for irrigation or municipal use. For this scenario and others which model Berthoud’s ownership of all 150 LLDC shares, the Model allows for changed LLDC shares and C-BT Units to be stored in Loveland Lake.

<table>
<thead>
<tr>
<th>Table 11 – Scenario 5 Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Residential Potable Taps</td>
</tr>
<tr>
<td>9,844</td>
</tr>
</tbody>
</table>

This scenario results in a dramatic increase in the number of residential taps that can be served by Berthoud. This results from a combination of the additional changed LLDC shares and the ability to store C-BT Units in Loveland Lake, which frees up space in Berthoud Reservoir for other water supplies.
7.2.7 Scenario 6 – Add Windy Gap/Maximum Demand/Climate Change
Scenario 6 builds upon Scenario 2 by including Berthoud’s acquisition of an additional 5 Windy Gap Units, for a total of 13 Windy Gap Units. This scenario does not include firming of Windy Gap supplies or the ability to use Windy Gap return flows. In order to evaluate each supply independently, no additional change or acquisition of Handy Ditch or LLDC shares was included in this scenario.

Table 12 – Scenario 6 Results

<table>
<thead>
<tr>
<th>Total Residential Potable Taps</th>
<th>Number of Residential Potable Taps over Baseline</th>
<th>Average Potable Demand (AF/yr)</th>
<th>Non-potable Taps</th>
<th>Non-potable Demand (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,072</td>
<td>+3,678</td>
<td>1,862</td>
<td>2,800</td>
<td>1,132</td>
</tr>
</tbody>
</table>

This scenario demonstrates that, without firming and reuse, acquiring additional Windy Gap Units does not increase the maximum number of residential taps as much as acquiring other water supplies does. Subsequent scenarios examine how this result changes when firming of Windy Gap supplies and reuse of Windy Gap return flows are included in the Model.

7.2.8 Scenario 7 – Firm & Reuse Windy Gap/Maximum Demand/Climate Change
As a comparison to Scenario 6, Scenario 7 instead allows the existing 8 Windy Gap Units to be “firmed,” providing 800 AF/yr in all years, as well as allowing Berthoud to use the consumable portion of its return flows as an augmentation supply. This scenario also includes the construction of 500 AF of storage or the right to use Loveland lake for those purposes to regulate and re-time reuse water and provide for replacement of winter return flows.

Table 13 – Scenario 7 Results

<table>
<thead>
<tr>
<th>Total Residential Potable Taps</th>
<th>Number of Residential Potable Taps over Baseline</th>
<th>Average Potable Demand (AF/yr)</th>
<th>Non-potable Taps</th>
<th>Non-potable Demand (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,500</td>
<td>+7,106</td>
<td>2,327</td>
<td>6,200</td>
<td>1,826</td>
</tr>
</tbody>
</table>

Scenario 7 provides a significant increase in maximum residential taps by firming Berthoud’s Windy Gap supply and by obtaining the ability to reuse the consumable portion of Berthoud’s WWTP effluent in the Little Thompson River. Because Windy Gap Units can be reused until extinction, and 10 percent of the indoor use returns to the creek, 1 AF of Windy Gap water can be used in a municipal system many times before it is lost to outdoor irrigation.

7.2.9 Scenario 8 – Combination of Acquired Supplies/Maximum Demand/Climate Change
Scenario 8 considers if Berthoud were to acquire the Handy Ditch, LLDC, and Windy Gap Units considered in Scenarios 3, 5, and 7, with Handy Ditch and LLDC supplies also being available for reuse after discharged from Berthoud’s WWTP.
The results of Scenario 8 show that Berthoud’s other water rights (Handy Ditch and LLDC) would also benefit from the ability to reuse Berthoud’s WWTP effluent in the Little Thompson River. The estimated 14,880 total residential taps are in excess of the estimated 12,489 residential taps at build-out identified in the 2011 JVA Report.

SECTION 8: CONCLUSIONS AND RECOMMENDATIONS

Based on the reviewed documents, discussions with Berthoud and completed modeling, LRE’s conclusions and recommendations are included in this section, and recommendations are split into those that are continued from the 2013 WRMP and those that are new based on the Model results in the 2020 WRMP.

8.1 CONCLUSIONS

After conducting the Model Scenarios and completing the 2020 WRMP, LRE reached the following conclusions:

- When compared to the full 2011-2019 period for which billing data exists, the 2015-2019 average unit demands are 6 percent higher. This suggests increasing potable water demands within Berthoud's service area.

- Modeling indicates that developing a non-potable irrigation system for Berthoud’s existing and proposed parks will slightly increase the current firm supply, and will significantly reduce Berthoud’s annual water treatment costs, as well as reducing the maximum WTP capacity needs.

- Berthoud has sufficient non-potable supplies in the Handy Ditch, LLDC, and Welch systems to irrigate some parks, open space areas, and residential developments, although a lack of delivery data prevents more certainty about how much irrigation could be supported long-term.

- The data that does exist suggests that Berthoud’s non-potable water supplies are reliable in the months of May through September. Non-potable irrigation systems will likely require supplemental potable water supplies in the shoulder months of April and October.

- If Berthoud were to obtain the ability to store non-LLDC water supplies in Loveland Lake, it would dramatically increase Berthoud’s ability to serve non-potable irrigation systems under the Handy Ditch and LLDC service areas.

- The effects of climate change more heavily impact Berthoud’s non-potable water supplies due to increased irrigation demands and lower ditch flows, when compared to Berthoud’s potable water supplies, which are mostly derived from storage.
• Berthoud has sufficient potable water supplies to serve up to 2,433 additional residential potable taps.

• Once non-potable irrigation systems are in place, Berthoud would be able to serve up to 3,680 additional residential potable taps due to decreased treatment demand in summer months. That number decreases to 1,984 additional residential potable taps once the effects of climate change are considered.

• Changing additional Handy Ditch shares would result in approximately 24.8 additional residential potable taps per share.

• Changing LLDC shares would result in 13.7 to 18.9 additional residential potable taps per share, with the higher end of the range representing Berthoud’s ability to store non-LLDC supplies in Loveland Lake.

• Acquisition of additional Windy Gap Units, without firming them or obtaining the ability to reuse that water to extinction, would only result in approximately 1.4 additional residential potable taps per Unit.

• If instead of acquiring additional Windy Gap Units, Berthoud firmed its 8 Windy Gap units and developed the ability to reuse that water to extinction, it could result in up to 4,209 additional residential potable taps (526 taps per Unit) with a winter-time delivery schedule.

• If Berthoud were to acquire 10 additional Handy Ditch shares, the remaining outstanding LLDC shares, and its 5 Windy Gap Units under contract, firm all 8 Windy Gap Units, and allow for reuse of all of its changed water rights, Berthoud could support approximately 11,486 additional residential potable taps for a total of 14,880, which is in excess of the 12,489 total residential taps identified as build-out conditions.

8.2 RECOMMENDATIONS
The following recommendations included in the 2013 WRMP are still valid in the 2020 WRMP:

• Berthoud should reevaluate its current potable water rate structure as it experiences significant increases in its capital and annual costs.

• Berthoud should continue to archive all billing data, so that historical use can be evaluated and the Model inputs could be revised, if desired.

• Berthoud should monitor plant inflows to the WTP, as well as metered use, so that treatment and distribution losses can be reevaluated.

• Berthoud should examine Carter Lake pipeline inflows and metered volumes into the WTP to evaluate the transmission losses for that system.

• Berthoud should periodically update the Model with revised annual and monthly use data by customer for future evaluations.
• Berthoud should monitor its raw water quality for both potable and non-potable demands as well as monitor future water quality regulations to ensure its current treatment facilities are sufficient for Berthoud’s future needs.

• Berthoud should monitor its ability to meet return flow obligations associated with changed ditch shares, specifically the delayed groundwater returns, so that it can use its changed shares for municipal uses.

• Once Berthoud begins to use its changed Handy Ditch shares or any future changed shares, it should look for ways to reuse the legally available fully consumable effluent, such as non-potable irrigation or as an augmentation supply for a new water right.

• Berthoud should look for opportunities to participate in regional water supply projects with other municipalities and special districts, to help diversify its water rights portfolio and minimize the costs of developing new supplies.

• Berthoud should evaluate the location of future parks for the ability and feasibility to use its existing irrigation water rights on those properties.

• In the future, individual parks’ usage (potable or non-potable) should be metered and evaluated annually. If significant changes in the demands are observed, then the Model should be updated as appropriate.

• Berthoud should focus on combining operational storage needs for several of its parks and determine if a water feature, such as a pond, is feasible.

• Berthoud should phase the development of a non-potable irrigation system over time and should prioritize the completion of individual projects by the largest annual demands.

The following recommendations are new in the 2020 WRMP, based on the results of the Model scenarios:

• Berthoud should obtain the ability to firm its existing Windy Gap Units and/or reuse that water to extinction prior to actively seeking additional Windy Gap Units since Model results indicate there may be sufficient supply when reuse facilities are developed to meet projected build-out taps.

• Berthoud should evaluate non-potable irrigation systems, particularly for residential developments on a case-by-case basis. Once these systems are installed, Berthoud should measure deliveries and irrigation demand so that LRE can better estimate how much irrigation these water rights can support.

• Berthoud should periodically evaluate the climate change factors included in the 2020 WRMP, and whether or not they are still reasonable assumptions about the effects of climate change.
• Berthoud should construct a diversion (surface or well field) and pipeline from the Little Thompson River to its WTP, to facilitate reuse of fully consumable water rights such as Windy Gap Units.

• Berthoud should conduct a hydrogeological investigation along the Little Thompson River to determine if an alluvial well field (vertical or horizontal) would be viable for the diversion.

• Berthoud should construct lined storage near the point of diversion on the Little Thompson River, to store return flows for changed water rights and to better regulate diversions from the junior priority for when supplies are needed for treatment or augmentation.

• Berthoud should acquire additional LLDC shares, and obtain the ability to operate its pro-rata share of storage so that some or all of Loveland Lake can be used to store Berthoud's other water supplies, freeing up space in Berthoud Reservoir as demands continue to grow.

• Berthoud should not change additional Handy Ditch shares to municipal uses until the Town develops a reliable way to make return flow replacements to the Little Thompson River, such as the lined storage discussed previously. It would be beneficial for Berthoud to change the place of use for enough Handy Ditch shares so that the golf course can have a dependable irrigation supply.
### Figure 6 - Summary of 2020 WRMP Scenarios

<table>
<thead>
<tr>
<th>#</th>
<th>Description</th>
<th>Ditch &amp; Contract Water Rights</th>
<th>Ditch Flow Reduction</th>
<th>Earlier Runoff</th>
<th>Increased Crop Demand</th>
<th>Reuse of Effluent</th>
<th>Commercial</th>
<th>Single Family</th>
<th>Single-Family (Over Current)**</th>
<th>Multi Family</th>
<th>Education</th>
<th>Total Potable Demand (AF/yr)</th>
<th>Non-potable Taps</th>
<th>Non-potable Demand (AF/yr)</th>
<th>Total Demand Met (AF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Current Supplies Max Demands No Climate Change</td>
<td>Water Rights Decreed for Municipal Use</td>
<td>0%</td>
<td>No Shift</td>
<td>0%</td>
<td></td>
<td>407</td>
<td>6,087</td>
<td>2,693</td>
<td>212</td>
<td>7</td>
<td>2,015</td>
<td>0</td>
<td>360</td>
<td>2,375</td>
</tr>
<tr>
<td>1</td>
<td>Current Supplies Max Demands w/ NP Taps No Climate Change</td>
<td>Unchanged Water Rights, 29.33 Handy Ditch Shares, 76.16 Loveland Lake Shares, 86 Welch Contract Right Inches, 34.0 Ryan Gulch Reservoir Shares</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>516</td>
<td>7,717</td>
<td>4,323</td>
<td>268</td>
<td>7</td>
<td>1,821</td>
<td>4,323</td>
<td>1232</td>
<td>3,053</td>
</tr>
<tr>
<td>2</td>
<td>Current Supplies Max Demands w/ NP Taps Climate Change</td>
<td>NCWCD Contract Rights, 8 Windy Gap Units, 988 Colorado-Big Thompson Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>425</td>
<td>6,349</td>
<td>2,955</td>
<td>221</td>
<td>7</td>
<td>1653</td>
<td>2630</td>
<td>1097</td>
<td>2,750</td>
</tr>
<tr>
<td>3</td>
<td>Additional Handy Ditch Max Demands w/ NP Taps Climate Change</td>
<td>Scenario 0/1/2 + Acquire 10 Handy Ditch shares and change all 39.33 shares for a total of 46.83 Handy Ditch shares.</td>
<td>15%</td>
<td>1 Month Earlier</td>
<td>10%</td>
<td></td>
<td>482</td>
<td>7,203</td>
<td>3,309</td>
<td>250</td>
<td>7</td>
<td>1701</td>
<td>3,809</td>
<td>1338</td>
<td>3,039</td>
</tr>
<tr>
<td>4</td>
<td>Change Existing LLDC Max Demands Climate Change</td>
<td>Scenario 0/1/2 + Change Berthoud’s existing 76-16 LLDC shares to allow municipal use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>533</td>
<td>7,970</td>
<td>4,576</td>
<td>277</td>
<td>7</td>
<td>2029</td>
<td>3960</td>
<td>1369</td>
<td>3,298</td>
</tr>
<tr>
<td>5</td>
<td>Additional LLDC Max Demands Climate Change</td>
<td>Scenario 0/1/2 + Acquire remaining 73.84 LLDC shares and change all 150 LLDC shares. Add ability to store 6-8 and changed LLDC water in Loveland Lake.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>658</td>
<td>9,844</td>
<td>6,450</td>
<td>342</td>
<td>7</td>
<td>2371</td>
<td>4,900</td>
<td>1561</td>
<td>3,932</td>
</tr>
<tr>
<td>6</td>
<td>Additional Windy Gap Max Demands Climate Change</td>
<td>Scenario 0/1/2 + Acquire 5 additional Windy Gap units.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>473</td>
<td>7,072</td>
<td>3,678</td>
<td>246</td>
<td>7</td>
<td>1862</td>
<td>2800</td>
<td>1132</td>
<td>2,994</td>
</tr>
<tr>
<td>7</td>
<td>Firm &amp; Reuse Windy Gap Max Demands Climate Change</td>
<td>Scenario 0/1/2 + Adds firming of Windy Gap Units and ability to reuse return flows, with 500 AF of storage for LT diversions/releases.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>702</td>
<td>10,500</td>
<td>7,106</td>
<td>365</td>
<td>7</td>
<td>2327</td>
<td>6,200</td>
<td>1826</td>
<td>4,153</td>
</tr>
<tr>
<td>8</td>
<td>Combined Supplies + Reuse Max Demands Climate Change</td>
<td>Scenarios 3, 5, and 7, with 500 AF of storage for LT diversions/releases.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>995</td>
<td>14,880</td>
<td>11,486</td>
<td>417</td>
<td>7</td>
<td>2640</td>
<td>11,486</td>
<td>2060</td>
<td>5,546</td>
</tr>
</tbody>
</table>

**a/ The current number of residential taps, as of September 2019, is 3,394**

**Water Rights Decreed for Municipal Use**
- 7.14 cfs of Big Thompson River Priority No. 1
- 7.50 Handy Ditch Shares

**Unchanged Water Rights**
- 76.16 Loveland Lake Shares
- 86 Welch Contract Right Inches
- 34.0 Ryan Gulch Reservoir Shares

**NCWCD Contract Rights**
- 8 Windy Gap Units
- 988 Colorado-Big Thompson Units

**Ditch Flow Reduction**
- 0%
- 15%
- 10%

**Earlier Runoff Season**
- No Shift
- 1 Month Earlier

**Increased Crop Demand**
- 0%
- 10%