

WATER & SEWER BOARD AGENDA

Wednesday September 15, 2021

2:00 p.m.

1. Roll Call: _____ Chairman Harold Evans _____ Vice Chairman Mick Todd
 _____ Mr. Fred Otis _____ Mr. Joe Murphy
 _____ Mr. Tony Miller _____ Mr. Manuel Sisneros
 _____ Mrs. Cheri Witt-Brown _____ Mayor John Gates
 _____ Mr. John Karner _____ Mr. Raymond Lee
2. Approval of Minutes
3. Approval of and/or Additions to Agenda

Consent Agenda

The Consent Agenda is a meeting management tool to allow the Board to handle several routine items with one action.

The Board or staff may request an item to be “pulled” off the Consent Agenda and considered separately under the next agenda item in the order they were listed.

4. Approve and Recommend to City Council the Second Amendment to Intergovernmental Agreement for Treated Water Service with the Town of Milliken

End of Consent Agenda

5. Welcome New Employees and Promotions
6. Update on Intergovernmental Agreement for Temporary Infrastructure Use and Cost Sharing with North Weld County Water District
7. Cameron Peak Fire Watershed Recovery and Funding Update
8. Non-Potable Irrigation Water Policy Update
9. Approve and Recommend to City Council the 2021 Non-Potable Water Master Plan
10. Legal Report
 - Recommend filing opposition in Case No. 21CW3108 - Application for change of water rights - Little Thompson Water District
 - Taylor & Gill first right litigation
11. Executive Session (if needed)



If, to effectively and fully participate in this meeting, you require an auxiliary aid or other assistance related to a disability, please contact Shannon Metcalf at 970-350-9818.

12. Director's Report

- Thank you – Board & Council tour
- Chimney Hollow Reservoir Construction
- Larimer County 1041 regulation update
- Report on resolution of litigation against Aggregate Industries

13. Such Other Business That May Be Brought Before the Board and Added to This Agenda by Motion of the Board



If, to effectively and fully participate in this meeting, you require an auxiliary aid or other assistance related to a disability, please contact Shannon Metcalf at 970-350-9818.

**City of Greeley
Water and Sewer Board
Minutes of August 18, 2021
Regular Board Meeting**

Chairman Harold Evans called the Water and Sewer Board meeting to order at 2:02 p.m. on Wednesday, August 18, 2021.

1. Roll Call

The Clerk called the roll and those present included:

Board Members:

Chairman Harold Evans, Vice Chairman Mick Todd, Fred Otis, Joe Murphy, Tony Miller, Manuel Sisneros, Cheri Witt-Brown, Mayor Gates, Roy Otto and Raymond Lee (Interim CM)

Water and Sewer Department staff:

Director Sean Chambers, Deputy Director Water Resources Adam Jokerst, Utility Finance Manager Erik Dial, Chief Engineer Adam Prior, Water Resources Manager Jennifer Petrzalka, Asset Coordinator Cole Gustafson, Water Resources Planning Manager Kelen Dowdy, and Interim Office Manager Ettie Arnold

Legal Counsel:

Counsel to Water & Sewer Board Attorney Carolyn Burr, Senior Environmental and Water Resources Attorney Jerrae Swanson, Environmental and Water Resources Attorney Dan Biwer, Environmental and Water Resources Attorney Aaron Goldman

Guests: CDM Smith Consultant Carl Lundin, Emeritus Board Member Robert Ruyle

2. Approval of Minutes

Mr. Miller made a motion, seconded by Mr. Otis, to approve the July 21, 2021 Water and Sewer Board meeting minutes. The motion carried 7-0.

3. Approval of and/or Additions to Agenda

Item 9, the 2021 Non Potable Master Plan, was removed from the agenda.

Consent Agenda

4. Action: Authorize Closing on the property identified in the Purchase and Sale agreement, dated June 1, 2021 between Longs Peak Dairy and Greeley

On May 19, 2021, the Water and Sewer Board approved the Purchase and Sale Agreement with Longs Peak Dairy for the acquisition of 5.16667 shares of Water Supply and Storage Company (the property). Under Article 6 of the Agreement, Greeley's obligation to close on the property is contingent upon the Boards authorization within 28 days after the expiration of the Inspection Period.

Recommended action: approval of the closing and delegate authority to the Director to make minor amendments to the Purchase and Sale Agreement and execute all other documents necessary to close on the property.

End of Consent Agenda

Mr. Otis recused himself from participating in the discussion and vote on this item due to a possible conflict of interest.

Chairman Evans made a motion, seconded by Vice Chairman Todd, to approve the item on Consent Agenda and the proposed recommended action. The motion carried 6-0.

5. Pulled Consent Agenda Items

There were no items removed from the consent agenda.

6. Welcome New Employees and Promotions

Mr. Chambers provided an introduction of new Water and Sewer Department employees starting this month.

7. Approve Cameron Peak Wildfire Project Management Services Agreement with CPRW

Greeley and the Coalition for the Poudre River Watershed (CPRW) are actively working with other stakeholder partners throughout the affected region to coordinate efforts in response to the Cameron Peak Fire, in part to ensure that available grant funding obtained is used efficiently and effectively to mitigate and rehabilitate the impacts of the Fire. In order to achieve this, Greeley has agreed to partially fund and co-coordinate a post-fire recovery project manager position. This agreement details the management and funding of those services.

Vice Chairman Todd made a motion, seconded by Mrs. Cheri Witt-Brown, to approve Cameron Peak Wildfire Management Professional Service Agreement with CPRW and delegate authority to the Director to make minor amendments before execution. The motion carried 7-0.

8. Approve Reimbursement Agreement for Wildfire Mitigation and Rehabilitation Services with CPRW

Greeley and the Coalition for the Poudre River Watershed (CPRW) have a strong common interest in the protection of the upper Cache la Poudre River watershed, and desire to coordinate on recovery measures and mitigation efforts being employed in response to the Cameron Peak Fire. CPRW has received funding from the Northern Colorado Community Foundation and the Colorado Conservation Board that it wished to provide to Greeley for post-fire recovery and mitigation efforts. This agreement details the process for CPRW to reimburse Greeley for this work.

Mr. Otis recused himself from participating in the discussion and vote on this item due to a possible conflict of interest.

Mr. Miller made a motion, seconded by Mr. Murphy, to approve reimbursement agreement for Wildfire Mitigation and Rehabilitation Services with CPRW and delegate authority to the Director to make minor amendments before execution. The motion carried 6-0.

9. Overview of Proposed Interconnect and transfer of transmission line customers with West Fort Collins Water District

Greeley has a long-term plan to transfer transmission line customers to the water districts in which they are located. Recently, Greeley and WFCWD have reached terms to transfer some of Greeley's transmission line customers to WFCWD. Part of the proposed transaction includes construction of an interconnect between Greeley and WFCWD that will provide redundant supply to each entity. The transaction will also require a transfer of raw water supplies.

10. Approve and Recommend to City Council the Second Amendment to Intergovernmental Agreement for Treated Water Service with the Town of Windsor

The Second Amendment to this IGA will provide Greeley with an annual payment for making up to 350 AF of municipal water available to Windsor in times of shortage. The terms allow Windsor access up to 350 AF of drought protection water supply during times of shortage, which are defined by a CBT quota of < 65% (less than .65 AF/unit). City of Greeley may at its sole discretion curtail lease deliveries if it imposes mandatory city-wide water use restrictions.

Mr. Miller made a motion, seconded by Mr. Murphy, to approve the second agreement to IGA for treated water service with the Town of Windsor and recommend that City Council approve the same. The motion carried 7-0.

11. Legal Report

Mrs. Burr recommended filing a statement of opposition.

- a) **Case number 21CW3093**, Application of Town of Windsor for change of 42.25 shares of New Cache la Poudre Irrigating Company, 27.5 shares of Cache la Poudre Reservoir Company and 1 preferred right of Fossil Creek Reservoir to municipal, commercial and industrial use, as well as change in location of storage to Kyger and Kern Reservoirs. Greeley owns New Cache shares and has other water rights that could be affected without adequate terms and conditions governing the proposed changes.

Vice Chairman Todd made a motion, seconded by Mr. Miller that the Board authorize the filing of a statement of opposition in Case No. 21CW3093 and for staff and legal counsel to seek resolution of issues raised by the cases as consistent with Water and Sewer Board Resolution No. 3 (2015). The motion carried 7-0.

12. Executive Session

At 3:28 p.m. Chairman Evans made a motion to move into Executive Session to address the following matter as provided by C.R.S. §24-6-402(4) (a), (b) and (e) and Greeley Municipal Code 2.04.020 (1), (2) and (5):

1. For the purpose of providing the Board legal advice and determining positions relative to matters that may be subject to negotiations, developing strategy for negotiations, and instructing negotiators on matters related to the water market and the potential, future water right acquisitions.

The motion carried 7-0.

The Board left the public session and moved into a private, executive session. Mr. Otis recused himself from the executive session due to a possible conflict of interest.

Present during the executive session were:

Chairman Harold Evans, Vice Chairman Mick Todd, Fred Otis, Joe Murphy, Tony Miller, Manual Sisneros, Mayor John Gates, City Manager Roy Otto, Interim City Manager Mr. Raymond Lee, Director Sean Chambers, Deputy Director Water Resources Adam Jokerst, Chief Engineer Adam Prior, Utility Finance Manager Erik Dial, Water Resources Manager Jennifer Petrzeka, Senior Environmental and Water Resources Attorney Jerrae Swanson, Environmental and Water Resources

Attorney Dan Biwer, Environmental and Water Resources Attorney Aaron Goldman, Water and Sewer Board Counsel Carolyn Burr, Interim Office Manager Ettie Arnold, Emeritus Board Member Mr. Ruyle

The Executive Session ended at 3:38 p.m. and the regular meeting resumed.

13. Resolution Recognizing Roy Otto as Ex Officio Board Member

Mr. Chambers stated, Mr. Otto's generous contributions of time, judgement, wisdom, and insight, over the last 22 years, have been of incalculable value to the City, and to the Water & Sewer Board and Department.

Mr. Miller made a motion, seconded by Vice Chairman Todd to approve the resolution in recognition of Roy Otto as an ex officio Board Member.

14. Director's Report

- Cameron Peak Fire recovery and mitigation funding update
- City Clerk's analysis of citizen petitions that propose to amend City Charter sections 17-9 and 17-10
- South Platte Roundtable Colorado River Demand Management
- Board and Council Tour

21. Such Other Business That May be Brought before the Board and Added to This Agenda by Motion of the Board

There were no additional items brought before the Board and added to the agenda.

Chairman Evans adjourned the meeting at 4:04 p.m.

Harold Evans, Chairman

Raymond Lee, Interim Board Secretary

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE X NO ENCLOSURE

ITEM NUMBER: 4

TITLE: APPROVE AND RECOMMEND TO CITY COUNCIL THE SECOND AMENDMENT TO INTERGOVERNMENTAL AGREEMENT FOR TREATED WATER SERVICE WITH THE TOWN OF MILLIKEN, COLORADO

RECOMMENDATION &
PROPOSED MOTION: APPROVE THE SECOND AMENDMENT TO INTERGOVERNMENTAL AGREEMENT FOR TREATED WATER SERVICE WITH THE TOWN OF MILLIKEN AND RECOMMEND THAT CITY COUNCIL APPROVE THE SAME

ADDITIONAL INFORMATION:

The City of Greeley entered into an Intergovernmental Agreement (IGA) with the Town of Milliken on July 20, 1999 to set the terms by which Greeley would treat and deliver potable water to Milliken sourced from Milliken owned water resources. That outside city water service IGA was subsequently amended in May of 2017. A copy of the existing First Amendment is enclosed for reference. The IGA continues to obligate Milliken to take or pay for a minimum of 20 million gallons of use and delivery under the terms of the agreement.

The proposed Second Amendment to the IGA will provide for two basic revisions to the 2017 First Amendment. The first area of agreement revision addresses the types of raw water sources allowable for transfer to Greeley to meet supply requirements. The 2017 IGA obligates and limits Milliken to provide Greeley with C-BT exclusively. The Second Amendment would permit Milliken to use GLIC supplies, with appropriate legal rights of use, to be treated at Greeley's Boyd Lake WTP when the seasonal facility is operating. Greeley maintains exclusive control and sole discretion over operations and operating season. The second area of revision to the IGA will provide the parties with greater certainty with respect to peak daily and peak hourly demand factors. This is accomplished by establishing Milliken's peaking factors based upon Greeley's residential peaking, and thereby providing both parties with reliability in the cost of service rate model output.

Second Amendment to IGA for Treated Water Service with the Town of Milliken

**Presented to the Greeley Water & Sewer Board
September 15, 2021**

By: Sean Chambers, Director



Water Service IGA Background

Outside City Water Treatment and Delivery Service IGA

- Milliken does not operate its own water treatment facilities
 - Milliken partners with other providers including Greeley for water treatment service
- 2nd Amendment to the IGA makes limited revisions to the First Amendment to IGA (May of 2017)
- IGA provides ongoing commitment to treat and deliver a portion of Milliken's supply
 - Milliken required to meet Greeley Raw Water Requirements
 - Transferring water to Greeley by April 15 of each year
 - Obligating Milliken to pay all running charges, shrink and system losses



2nd Amendment IGA

Two basic revisions to the First Amendment:

1. Provides that Milliken could transfer to Greeley for treatment appropriately approved for use GLIC supplies for treatment at Boyd WTP, when its in operations.
2. Provides stability in how peak demands are calculated within the Cost of Service Rate Model
 - Change will limit the rate variability that has characterized Milliken's outside city rates and limit impacts to Greeley





Staff Recommendation

- **Staff Recommends Approval of the 2nd Amendment to the IGA for Treated Water Service with the Town of Milliken and Recommend that City Council Approve the Same**



Questions ?



FIRST AMENDMENT TO
INTERGOVERNMENTAL AGREEMENT FOR
TREATED WATER SERVICE

**BETWEEN THE CITY OF GREELEY, COLORADO
AND THE TOWN OF MILLIKEN, COLORADO**

This FIRST AMENDMENT TO INTERGOVERNMENTAL AGREEMENT FOR TREATED WATER SERVICE ("First Amendment") is entered into this 10th day of May, 2017, by and between **THE CITY OF GREELEY**, Colorado, a home rule municipality ("Greeley") and **THE TOWN OF MILLIKEN**, Colorado, a home rule municipality ("Milliken"), to set forth the terms and conditions by which Greeley will use its supply and treatment facilities to provide the treatment and delivery of potable water to Milliken.

WHEREAS, pursuant to C.R.S. §29-1-203, governments may cooperate or contract with one another to provide any function, service or facility lawfully authorized to each of the following cooperating units of government; and

WHEREAS, Greeley and Milliken previously entered into that certain Intergovernmental Agreement for Treated Water Service on July 20, 1999, which was set to expire in July of 2019 ("the 1999 IGA"); and

WHEREAS, authorized representatives of Greeley and Milliken have met on numerous occasions to review the 1999 IGA and discuss the possible renewal and modification of that agreement, in accordance with Section 16 thereof; and

WHEREAS, Greeley and Milliken have a continuing common interest in obtaining high-quality treated water in sufficient quantities to meet the present and future needs of their citizens and service areas; and

WHEREAS, Greeley and Milliken are agreeable to renewing the 1999 IGA under the terms and conditions of this First Amendment; and

WHEREAS, Greeley and Milliken desire to reduce their understandings, and the terms and conditions of this First Amendment to writing;

NOW THEREFORE, for good and valuable consideration, the receipt and adequacy of which is acknowledged, and in further consideration of the mutual covenants, undertakings, terms, and conditions contained herein, Greeley and Milliken agree as follows:

1. **OTHER TERMS IN FULL FORCE AND EFFECT.** Except as explicitly modified in this First Amendment, all of the terms and conditions of the 1999 IGA remain in full force and effect.
2. **AMENDMENTS.** The 1999 IGA is hereby amended as follows.
 - a. Sections 1.7 and 1.8 of the 1999 IGA are stricken in their entirety.

b. Section 2.1 of the 1999 IGA is amended as follows.

2.1 During each full year that this agreement is in effect, Milliken shall take a minimum of 20 million gallons of treated water. If in any year treated water is available to Milliken and Milliken fails to take and use 20 million gallons of treated water, Milliken shall nonetheless pay for this minimum allotment of treated water.

c. Section 2.2 of the 1999 IGA is stricken in its entirety.

d. Section 5 of the 1999 IGA is amended in its entirety as follows.

5. RAW WATER REQUIREMENTS. Milliken shall acquire sufficient water rights which are usable in the Greeley Water System and approved for municipal use in the Milliken Water System under Colorado law in order to satisfy the treated water requirements of Milliken, expressly subject to the following conditions:

5.1 Greeley operates two water treatment plants, the Bellvue Plant and the Boyd Lake Plant, which are both capable of supplying treated water to Milliken. Milliken's raw water requirements under this First Amendment are based on which plant treats the raw water used to supply the treated water to Milliken. At the time this First Amendment is executed, it is anticipated that the Bellvue Plant will treat and supply water to Milliken during the months of January, February, November and December, and that the Boyd Lake Plant will treat and supply water the other months of the year. However, Greeley may in its sole discretion determine which plant will be used to treat any water provided by Milliken under this First Amendment.

5.2 On or before April 15 of each year, Milliken shall transfer to Greeley sufficient Colorado-Big Thompson (CBT) water to satisfy projected Milliken demand for the full year, including a 5% shrink attributable to the Greeley Water System and any shrink due to the Northern Colorado Water Conservancy District. Failure of Milliken water rights to yield sufficient raw water during a drought could result in curtailed delivery of potable water to Milliken.

5.3 Milliken shall pay all assessment costs and running charges on any of the water provided for treatment by Greeley under this First Amendment.

5.4 Water transferred by Milliken to be treated at Greeley's Boyd Lake Plant shall be of a sufficient amount to account for the 5% shrink attributable to the Greeley Water System and any shrink due to the Northern Colorado Water Conservancy District described above, plus the additional Greeley and Loveland Irrigation Company shrink and carryover water, which will vary and be determined on an annual basis. At the time this First Amendment is executed, those losses are 28% (for shrink) and 11% (for carryover).

5.5 Milliken shall be solely responsible for meeting any monthly return flow requirements associated with the raw water it provides to Greeley for treatment, state decree accounting, and other requirements of State or Federal law. While Milliken retains dominion and control over its water, Greeley shall maintain complete and unilateral control over Greeley's system operations. Greeley may use its raw water supply system to move Milliken water rights to the appropriate location for treatment. Any loss in the optimal yield of Milliken water rights due to this necessary flexibility of operations will be in proportion to the effect on Greeley's own operations.

5.6 Greeley shall be obligated to treat for Milliken only that water delivered for treatment under this First Amendment. If actual metered usage by Milliken exceeds the amount delivered by Milliken less losses, Greeley shall notify Milliken of the shortage. Upon such written notification, Milliken will have 20 days to transfer additional raw water to Greeley for treatment. Greeley may, at its sole discretion, agree to lease additional raw water to Milliken at the then current raw water surcharge rate established by the Greeley Water and Sewer Board and adopted in accordance with Section 17-4 of the Greeley City Charter. If Greeley has additional raw water available to lease, Milliken shall be given the priority to lease it on an equal basis with the other municipalities to whom Greeley leases raw water.

e. Section 7 of the 1999 IGA is amended as follows.

7. RATES FOR TREATED WATER SERVICE. The rates for treated water delivered by Greeley to Milliken shall be based upon the City of Greeley water rate cost-of-service model. Milliken agrees to pay the rate of cost-of-service plus ten percent. The cost-of-service rates shall be reviewed annually and adjusted in accordance with Section 17-4 of the Greeley City Charter. Greeley shall give to Milliken an advance notice of 90 days if the then current rate will change. Cost-of-service rates include a cost to provide peak demands, as described below.

f. Section 11 of the 1999 IGA is amended as follows.

11. PEAK DEMAND MEASUREMENTS AND DETERMINATION. Each year either Milliken or Greeley or both may register and record peak daily and peak hourly demands. Milliken's peak daily and peak hourly demand factors will either be flow-weighted averages of the several master meters, or it shall be derived from simultaneous readings from the several master meters, whichever method generates the highest demand factor. Peaking factors will be calculated based upon the average of the previous two years actual recorded peak flows. If the average of the peak hourly or the peak daily demand factors for the immediately two preceding years differs from the factors used in the most current water rate study, then the next rate study will use the highest recorded peak daily or peak hourly factor from those two preceding years. If peak daily or peak hourly demands are not registered in any given year, then the measurements used in the prior year's rate study will be used for the next rate study. In no case will past year's or current year's water bills be adjusted for changes in peak demand factors.

g. Section 12 of the 1999 IGA is amended in its entirety as follows.

12. SYSTEM DEVELOPMENT CHARGES.

12.1 Milliken shall pay to Greeley an annual system development charge ("SDC") when the metered water delivered to Milliken in any year exceeds the acre-feet delivered in the base year. Payment of system development charges will create a new base year delivery. No system development charges will be due in subsequent years for metered delivery equal to or less than the new base year delivery. Payments of the system development charge will occur in twelve monthly increments following the calendar year in which the exceedance occurs. In no case shall system development charges be refunded. Milliken's current base year volume at the time this Agreement is executed is 442.1 acre-feet.

12.2 The SDC due shall be a percentage of the then current Inside the City Greeley ¾-inch tap plant investment fee (expressed in \$/acre-foot), to be multiplied by Milliken's consumption in acre-feet of water metered in excess of the base year delivery. The SDC percentage is calculated as follows: the typical Milliken single-family customer benefits from 75% of Greeley Water System. To express Greeley's plant investment fee in terms of \$/acre-foot, the average annual inside-the-City residential demand, as used in the annual update of the Greeley rate model, is divided into the plant investment fee.

12.3 *THE FOLLOWING CALCULATION UTILIZES 2016 DATA TO DERIVE EXAMPLE FIGURES FOR THE SOLE PURPOSE OF DEMONSTRATING THE SDC METHODOLOGY. ANY ACTUAL SDC BORNE BY MILLIKEN WILL VARY ANNUALLY, IN ACCORDANCE WITH THE METHODOLOGY DESCRIBED IN THIS SECTION 12.*

Example Conversion and Calculation of SDC Rate

Average Annual Demand:	135,000 gallons (0.414 acre-feet per ¾-inch tap)
Current Inside the City Greeley PIF:	\$10,800

Conversion of Greeley PIF: $(\$10,800) / (0.414 \text{ AF/year}) = \$26,087 \text{ per AF/year}$

Milliken SDC: $(75\%) * (\$26,087 \text{ per AF/year}) = \$19,565 \text{ per AF/year}$

Example Base Year and SDC Calculation

Milliken Base Year Volume:	442.1 acre-feet
Milliken Actual Metered Flow:	450 acre-feet (17.9 AF in excess of Base Year Volume)

Calculation of Total SDC Due: $(450 - 442.1) * (\$19,565) = \$154,563.50$

Milliken's Base Year Volume would then increase to become 450 AF

h. Section 15 of the 1999 IGA is amended as follows.

15. INTEGRATION, MERGER, AND SUPERSESSON. This First Amendment incorporates and renews the terms and conditions of the 1999 IGA not explicitly modified herein, and supersedes all terms and conditions of any other agreements regarding water supply previously existing between Greeley and Milliken. This First Amendment contains all agreements and understandings, whether written or oral, between Greeley and Milliken regarding the subject matter herein.

i. Section 16 of the 1999 IGA is amended as follows.

16. TERM OF AGREEMENT. In the interest of reliability and security, this First Amendment shall be for an initial term of twenty years from the date of execution set forth above. This First Amendment expires at the end of such twenty-year term, but may be renewed for subsequent terms of ten years each by a duly authorized and executed mutual written agreement. Greeley and Milliken agree to meet at least two years before the end of the initial twenty-year term, and before the end of any subsequent terms, to review this First Amendment for possible modification.

j. Section 17.3 of the 1999 IGA is amended as follows.

17.3 This First Agreement may be terminated by either party by giving written notice to the other party at least two years before the end of the initial twenty-year term, or at least two years before the end of any subsequent terms. This First Amendment may otherwise be terminated at will by Greeley by giving an advance written notice to Milliken of no less than four years.

IN WITNESS WHEREOF, the City of Greeley and the Town of Milliken have authorized and executed this First Amendment to Intergovernmental Agreement for Treated Water Service on the date first written above.

THE TOWN OF MILLIKEN, COLORADO

ATTEST:

By:

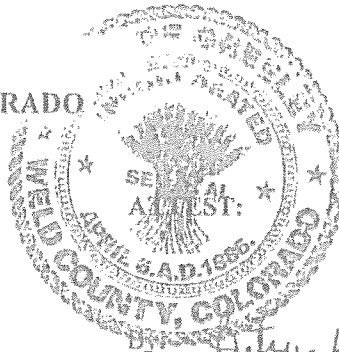
Mayor

By:

Town Clerk

THE CITY OF GREELEY, COLORADO

THE CITY OF GREELEY, COLORADO



By: John A. Sub
Mayor Pro-Tem

By: Patricia A. Felder
City Clerk

WATER AND SEWER BOARD:

AS TO SUBSTANCE:

By: Harold G. Evans
Chairman

By: [Signature]
City Manager

AS TO LEGAL FORM:

AS TO AVAILABILITY OF FUNDS:

By: [Signature]
City Attorney

By: [Signature]
Director of Finance

**INTERGOVERNMENTAL AGREEMENT FOR
TREATED WATER SERVICE**

**BETWEEN THE CITY OF GREELEY, COLORADO
AND THE TOWN OF MILLIKEN, COLORADO**

THIS AGREEMENT is made this 20th day of July, 1999, by and between **THE CITY OF GREELEY**, Colorado, a home rule municipality ("Greeley") and **THE TOWN OF MILLIKEN**, Colorado, a home rule municipality ("Milliken"), for the treatment and delivery of potable water to the Town of Milliken by and through the supply, treatment facilities, and transmission lines of the City of Greeley, Colorado.

WHEREAS, pursuant to § 29-1-203, C.R.S., governments may cooperate or contract with one another to provide any function, service or facility lawfully authorized to each of the cooperating or contracting units of government; and

WHEREAS, the Town of Milliken and the City of Greeley are neighboring municipalities which have a common interest in obtaining high-quality water in sufficient quantity to meet present and future needs; and

WHEREAS, the citizens of Milliken desire long-term reliability in treated water; and

WHEREAS, Milliken and Greeley can cost-effectively combine their demand for treated water through one system of supply, treatment, transmission, and treated water storage thereby achieving economies of scale; and

WHEREAS, in addition to its own needs and demand, Greeley has the capacity and the facilities to meet the needs of Milliken for water treatment and transmission as are more fully set forth herein; and

WHEREAS, Milliken will receive treated water from additional wholesale providers; and

WHEREAS, Greeley intends to develop the Highway 34 corridor and is not willing to provide water to Milliken to support competing growth by Milliken adjacent to Highway 34; and

WHEREAS, Milliken and Greeley shall and will continue to own their water rights individually and separately, each municipality relying upon the yield of its own water rights to provide the raw water necessary for treatment proposed under this agreement; and

WHEREAS, Greeley and Milliken are agreeable to entering into a long-term contract for the treatment and delivery of potable water to Milliken through an intergovernmental agreement; and

WHEREAS, the parties are desirous of reducing the understandings, terms, and conditions of said agreement to writing.

NOW THEREFORE, IN CONSIDERATION of the mutual covenants, undertakings, terms and conditions contained herein, the parties agree as follows:

1. DEFINITIONS. The terms used herein are defined as follows:

1.1 "Greeley" shall refer to the City of Greeley and any authorized representative thereof.

1.2 "Greeley water system" or "Greeley water system enterprise" shall refer to Greeley's water treatment plants, treated water conveyance and storage systems, pump stations and related appurtenances for the collection, distribution, and measurement of water.

1.3 "Peak daily demand" means the greatest rate of treated water delivered by Greeley to Milliken over a twenty-four hour period, beginning at midnight, in a given day.

1.4 "Peak hourly demand" means the greatest rate of treated water delivered by Greeley to Milliken over sixty consecutive minutes for any given day of the calendar year.

1.5 "Milliken" shall refer to the Town of Milliken and any authorized representative thereof.

1.6 "Milliken system" or "Milliken water system enterprise" shall refer to Milliken's treated water conveyance and storage systems, pump stations, and related appurtenances for the distribution of water downstream of master meters gauging Greeley's delivery to Milliken.

1.7 "Year" means a calendar water year beginning on January 1 unless otherwise noted.

1.8 "Milliken Bellvue Demand" is Milliken's total water use in December, January, and February multiplied by four and represents the portion of Milliken's annual demand satisfied by the Bellvue treatment plant.

2. USE. Pursuant to the terms of this intergovernmental agreement, Greeley agrees to treat water, usable in the Greeley water system and approved for municipal use in Milliken system under Colorado law, for Milliken in the manner and in such amounts as are more fully set forth herein.

2.1 It is understood and agreed that in anticipation upon providing water to Milliken, the Town has appropriated certain funds for the construction of a transmission line capable of receiving and transporting such water from Greeley. The parties acknowledge that the construction of this transmission line is a condition precedent to delivery of water to Milliken. Water shall be made available to Milliken upon the completion of the transmission line. Commencing with the first full year that this agreement is in effect and continuing annually for the term of this agreement Greeley shall make available not less than 30 million gallons of treated water. During each full year that this

agreement is in effect Milliken shall take a minimum of 20 million gallons of treated water. If in any year treated water is available to Milliken and Milliken fails to take and use 20 million gallons of treated water, Milliken shall nonetheless pay for this minimum allotment of treated water.

2.2 The parties further acknowledge that the initial year of this agreement will likely not be a full year. In this event, Milliken will be relieved of the 20 million gallons minimum requirement and will be required to pay only for the treated water actually delivered in this first year.

2.3 Nothing herein shall limit Milliken from taking treated water in excess of 20 million gallons subject to the availability thereof. All treated water in excess of 20 million gallons shall be expressly conditioned upon Greeley having the excess capacity to provide such water, and Milliken shall pay for the same.

3. POINT OF DELIVERY.

3.1 Treated water from the Greeley water system shall be delivered to Milliken through multiple master meters, the location of which will be mutually established and agreed upon in writing by both municipalities. Unless specifically authorized by Greeley, no water from Milliken's system shall flow into Greeley's system.

3.2 Unless otherwise agreed upon between the parties, Greeley shall construct, own and maintain treated water meter vaults, meters, back-flow prevention devices and all associated facilities located at the delivery points. All of the costs of the metering facilities attributable to service to Milliken shall be paid by Milliken by and through inclusion in the Milliken rate base charged by Greeley and more fully described in paragraph seven of this agreement. Greeley agrees to design, construct and maintain all metering facilities in a prudent and cost effective manner. Milliken agrees to secure and provide such easements as may be required by Greeley for metering facilities, and to guarantee access to metering facilities for Greeley. Each water meter shall be operated and maintained so as to record both cumulative flow and, as needed, maximum hourly and maximum daily flow within the accuracy prescribed by current American Water Works Standards. Each municipality will give the other seven calendar days notice prior to any routine or independent meter test. Milliken shall have access to all metering facilities herein contemplated to read meters as Milliken may deem necessary. Milliken shall own, operate, maintain, and have the ability to valve the line downstream of the master meter for operation, maintenance, and repair purposes.

3.3 The master meter shall be located at or near the intersection of Weld County Road 54 and State Highway 257. Transmission pipeline north of this point will be constructed by Milliken and dedicated to the City of Greeley. To the extent that Greeley uses the infrastructure installed by Milliken, such usage shall be subject to reimbursement for oversizing in accordance with Greeley's current ordinance.

4. POTABLE WATER PROJECTIONS AND SYSTEM CAPACITY

4.1 No later than April 1 of each year, Milliken shall provide written notice to Greeley of its projected treated water requirements for the current calendar year and the five consecutive years following the year in which such notice is given. The projections in the notice shall include, at a minimum: estimated total annual consumption, estimated maximum day, estimated maximum hourly usage, planned system facility changes, and additional points of delivery to Milliken from Greeley. Any actual usage in excess of projected peak or total demands which has a cost impact, excepting fire flow or other emergencies, shall result in supplemental demand charges as determined by the cost-of-service rate study and approved by the Greeley Water and Sewer Board.

4.2 If Greeley determines the Greeley water system will be unable to meet Milliken's projected demands, Greeley will give Milliken notice two years prior to the projected capacity limitation. Milliken shall have authority to obtain water beyond the capacity limitation from other sources. Greeley will use its best efforts to avoid a capacity limitation.

4.3 It is understood and agreed that as of the date of this agreement Milliken is receiving treated water from Central Weld County Water District. Nothing in this agreement shall be construed as limiting Milliken from continuing to receive treated water from sources other than Greeley during the term of this agreement, in whatever amounts Milliken deems appropriate.

5. RAW WATER REQUIREMENTS. Milliken shall acquire sufficient water rights which shall be usable in the Greeley water system and approved for municipal use in the Milliken system under Colorado law in order to satisfy the treated water requirements of Milliken, expressly subject to the following conditions:

5.1 On or before April 15 of each year, Milliken shall transfer to Greeley sufficient Colorado-Big Thompson (CBT) water to satisfy Milliken demand for the full year including a 5% shrink. Failure of Milliken water rights to yield sufficient raw water during a drought could result in curtailed delivery of potable water to Milliken.

5.2 Milliken shall pay all assessment costs and running charges on any of the water provided for treatment by Greeley under this agreement. Water other than Milliken's Bellvue demand will be treated by the Boyd Lake plant and will be subject to Greeley and Loveland Irrigation Company shrink and carryover water. Presently those losses are 28% and 11% respectively.

5.3 Milliken shall be responsible for meeting any monthly return flow requirements of the raw water provided to Greeley for treatment, state decree accounting, and other requirements of State or Federal law. While Milliken retains dominion and control over its water, Greeley shall maintain complete and unilateral control over Greeley's system operations. Greeley's raw water supply system may be used by Greeley to move Milliken's water rights to the appropriate location for treatment. This necessary flexibility of operations may result in less than optimal yield of Milliken water rights, but will be in proportion to Greeley's own operations..

5.4 Greeley shall be obligated to treat for Milliken only that water delivered for treatment under this Section 5. If metered usage by Milliken exceeds the amount delivered less losses, Greeley shall notify Milliken of the shortage. Upon written notification, Milliken will have 20 days to transfer additional raw water to Greeley for treatment. Greeley may, at its sole discretion, agree to lease additional raw water to Milliken at the then raw water surcharge rate established by the Greeley Water and Sewer Board and adopted in accordance with section 17-4 of the Greeley City Charter. If Greeley has additional raw water available to lease, Milliken shall be given first priority to lease it on an equal basis with the other municipalities to whom Greeley leases raw water.

6. EMERGENCY OPERATIONS. In the event of a shortage of treated water, caused by the inability of a component of the Greeley water system to function, Milliken and Greeley shall share proportionally in water use reductions. Greeley shall develop a schedule and method of reducing water demand, with initial emphasis on reducing all nonessential uses such as lawn and parks irrigation. If a shortage persists, Milliken and Greeley agree to impose emergency rates, developed by Greeley, which may be different for each customer category and which are intended to reduce discretionary consumption of treated water. The impact of the emergency rates shall be fairly and equally distributed among both Milliken and Greeley water customers. In a prolonged shortage, Milliken and Greeley agree to adopt a uniform set of enforcement tools and penalties to curtail usage. In any such event, Greeley will make every effort feasible to continue to meet both Milliken's and Greeley's water demand, including obtaining treated water from other providers. In the event of a shortage, nothing shall prevent Milliken from independently using an alternate source of treated water in whatever amount Milliken deems necessary, until Greeley can again bring its facilities on line.

7. RATES. The rates for treated water delivered to Milliken shall be based upon the water rate cost-of-service model developed by Greeley's water rate consultant, Black and Veatch, and or modified from time to time and accepted by the Greeley Water and Sewer Board. Milliken agrees to pay the rate of cost-of-service plus ten percent. The cost-of-service rates shall be reviewed annually and adjusted in accordance with section 17-4 of the Greeley City Charter. Milliken shall be given 90-days notice of rate changes. Cost-of-service includes a cost to provide peak demands.

8. BILLING. Bills shall be paid within thirty days of the date due, after which time interest penalties shall begin to accrue at the rate of one percent per month, or fraction thereof, during the period in which the bill remains unpaid.

9. NO ACQUIRED RIGHTS OR VESTING IN WATER RIGHTS OR IN WATER SYSTEM.

9.1 As contained in section 17-1 of the Greeley City Charter, the Greeley water system is an Enterprise, as that term is defined pursuant to article X, section 20 of the Colorado Constitution. The Greeley water system Enterprise is owned by the citizens of Greeley. Similarly, the Milliken system is an Enterprise, owned by the citizens of Milliken.

9.2 Milliken specifically acknowledges and agrees that no rights or ownership of the Greeley water system shall become vested as a result of such service. Neither Greeley nor Milliken shall, by reason of any provision of this agreement or the use of water hereunder or otherwise, acquire any vested or adverse right, in law or in equity, in the water rights or water system owned by the other municipality. Neither the assignment, use, rental, or license of water or water rights nor the payment of system development charges shall be deemed to initiate, create, or vest any rights or ownership by either Greeley or Milliken in the other's water rights or water system. Further, Milliken shall not assert or claim any vested rights to continued service, other than as established by the terms and conditions of this agreement.

10. POTABLE WATER. The treated water delivered by Greeley to the Milliken master meters shall be potable water which complies with applicable potable water law.

11. PEAK DEMAND MEASUREMENTS AND DETERMINATION. Each year either Milliken or Greeley or both may register and record peak daily and peak hourly demands. Milliken's peak daily and peak hourly demand factors will either be flow-weighted averages of the several master meters, or it shall be derived from simultaneous readings from the several master meters, whichever method generates the highest demand factor. Peaking factors will be calculated based upon the average of the previous two years actual recorded peak flows. If the average of the peak hourly or the peak daily demand factors for the two immediately preceding years differs from the factors used in the most current water rate study, then the next rate study will use the highest recorded peak daily or peak hourly factor from those two preceding years. If peak daily or peak hourly demands are not registered in any given year, then the measurements used in the prior year's rate study will be used for the next rate study. In no case will past year's or current year's water bills be adjusted for changes in peak demand factors. Until such time as actual peaking factors are determined, Milliken peaking factors shall be assumed to be equal to Greeley's factors which are estimated by Black & Veatch for use in their rate model.

12. SYSTEM DEVELOPMENT CHARGE.

12.1 A system development charge (SDC) shall be due to Greeley when the metered water delivered to Milliken in any year exceeds the acre-feet delivered in the base year. Payment of system development charges will create a new base year delivery. No system development charges will be due in subsequent years for metered delivery equal to or less than the new base year delivery. Payments of the system development charge will occur in twelve monthly increments following the calendar year in which the exceedance occurs. In no case shall system development charges be refunded. The initial base year allowance is zero acre-feet.

12.2 The SDC due is a percentage of the then current inside-Greeley 3/4-inch tap plant investment fee (expressed in \$/acre-foot) and multiplied by Milliken's consumption in acre-feet of water metered in excess of the base year delivery. The SDC percentage is calculated as follows: the typical Milliken single-family customer benefits from 75% of Greeley water system, as determined by the rate model. To express Greeley's plant investment fee in terms of \$/acre-foot, the average

annual residential demand (190,000 gallons or 0.583 AF per 3/4-inch tap) is divided into the plant investment fee; for example:

Greeley's current PIF is $(\$2,920) / (0.583 \text{ AF/year}) = \$5,009 \text{ per AF/year}$
Milliken 1998 SDC is $(75\%)*(\$5,009/\text{AF/yr}) = \$3,756 \text{ per AF/yr}$

Example: if Milliken's year 2001 metered flow were 102 AF, exceeding a base of 92 AF, a SDC of \$37,560 would be due:

$(102 - 92)*(\$3,756) = \$37,560$. The new base year would become 102 AF.

12.3 Milliken's initial SDC for the first full year shall be for a base of 61 acre feet (20 million gallons) at \$3,756/AF equaling \$229,116. The initial SDC shall be paid before service begins.

13. RELEASE, HOLD HARMLESS, INDEMNIFICATION.

13.1 Both Milliken and Greeley are public entities, as that term is defined pursuant to the Colorado Governmental Immunity Act, C.R.S. § 24-10-101, et seq. The parties to this agreement have the benefits and responsibility enumerated in the Colorado Governmental Immunity Act. Each party shall defend any and all claims for injuries or damages pursuant to and in accordance with the requirements and limitations of the Colorado Governmental Immunity Act occurring as a result of negligent or intentional acts or omissions of the parties, their agents, employees and assigns.

13.2 In addition, Greeley shall be responsible for any and all liability for injuries or damages caused by any negligent acts or omissions of Greeley, its officers, employees and agents, performing functions or activities upon the property of Milliken. Greeley shall provide adequate workmen's compensation insurance for all of its employees, agents and assigns engaged in activities and functions upon the property of Milliken.

13.3 Milliken shall be responsible for any and all liability for injuries or damages caused by any negligent acts or omissions of Milliken, its officers, employees and agents, performing functions or activities upon the property of Greeley. Milliken shall provide adequate workmen's compensation insurance for all of its employees, agents and assigns engaged in activities and functions upon the property of Greeley.

13.4 Each party shall furnish the other party current certificates of insurance stating the coverages outlined above are in full force and effect.

14. NO PUBLIC UTILITIES COMMISSION CONTROL. Milliken, its employees and elected or appointed officials, agree neither to assert nor support any statement, policy, petition, rule making, or legislation attempting to place the Greeley water system under the rate making authority or jurisdiction of the Colorado Public Utilities Commission by virtue of this intergovernmental agreement or otherwise.

15. THIS AGREEMENT CONTROLS AND SUPERSEDES PREVIOUS AGREEMENTS. This agreement shall supersede any and all terms and conditions of water supply agreements previously existing between Greeley and Milliken.

16. TERM. In the interest of reliability and security, this agreement shall be for a term of twenty years from the date of its execution, and shall terminate at the end of the term unless renewed by mutual written agreement. Both parties hereby agree to meet at least two years before the end of the term to review their agreement for possible renewal and /or modification.

17. DEFAULT AND TERMINATION.

17.1 In the event either party fails to meet the terms and conditions of this agreement, such failure shall constitute a default of this agreement and the non-defaulting party may give notice of the perceived default. Notice shall be either to the Milliken Town Administrator or the Greeley City Manager. Either party may cure any default during the ninety days following the notice. Upon cure of any default, this agreement shall remain in full force and effect. Upon receipt of notice of perceived default, the defaulting party may invoke dispute resolution as provided in Paragraph 20.

17.2 If after the cure period above or after mutually agreed extensions, the non-defaulting party determines the default has not been cured, they may give two years notice of termination of this agreement. Nothing herein shall limit either party from collecting damages and amounts due from the other party upon termination of this agreement by default.

17.3 The agreement may be terminated by either party by giving written notice to the other party at least two years before the end of the agreement term or renewals thereof.

17.4 Milliken agrees that annexation by Milliken of land north of Weld County Road 54 shall be approved by Greeley in writing prior to the annexation. Violation of this provision shall be grounds for termination of this agreement.

17.5 Milliken agrees not to oppose any annexation by Greeley of property north of Weld County Road 54 and Greeley agrees not to oppose any annexation by Milliken of property south of Weld County Road 54. Both cities acknowledge the value of annexation in conformance with natural, man-made, or political boundaries.

18. JURISDICTION AND VENUE. This agreement shall be interpreted pursuant to the laws of the State of Colorado. Venue to enforce this agreement shall be in Weld County.

19. AMENDMENT. This agreement shall be amended only in writing with the approval of the governing bodies of each municipality. No amendment or modification shall be effective unless in writing signed by the aforesaid persons. This agreement shall be governed by, construed and enforced in accordance with Colorado law.

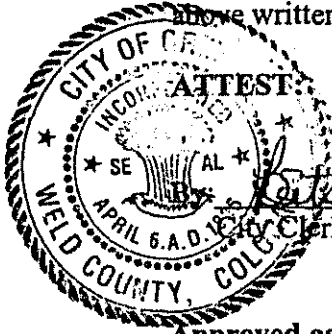
20. DISPUTE RESOLUTION. Should disagreements arise regarding the interpretation of any portion of this agreement the parties agree to make efforts to resolve such disputes through negotiation; first, at the staff level; and second, with the respective Water Boards and/or City Councils. Procedures for such negotiations shall be established by mutual agreement at the time and may, with the concurrence of the parties, involve the use of qualified outside mediators. Any negotiations and resolution agreements reached therefrom must be within the legal authority granted to the parties by appropriate City Charters and/or State statutes, or shall be null and void. Notwithstanding anything to the contrary in this agreement, it is expressly agreed between the parties that this provision for dispute resolution does not apply to the authority granted the Greeley Water and Sewer Board pursuant to § 17-4 of the Greeley City Charter, including but not limited to, the establishment of minimum water rates.

(The remainder of this page is intentionally blank)

Milliken-Greeley Finished Water Agreement

6 July 1999

IN WITNESS WHEREOF, the parties have executed this agreement the day and year first
above written.



THE CITY OF GREELEY, COLORADO

By: [Signature]
Mayor

Approved as to Substance:

By: [Signature]
City Manager

Approved as to Legal Form:

By: [Signature]
City Attorney

As to Availability of Funds:

By: [Signature]
Director of Finance

GREELEY WATER AND SEWER BOARD

By: [Signature]
Vice Chairman

ATTEST:

By: [Signature]
Town City Clerk

THE TOWN OF MILLIKEN, COLORADO

By: [Signature]
Mayor

SECOND AMENDMENT TO
INTERGOVERNMENTAL AGREEMENT FOR
TREATED WATER SERVICE

BETWEEN THE CITY OF GREELEY, COLORADO
AND THE TOWN OF MILLIKEN, COLORADO

This SECOND AMENDMENT TO INTERGOVERNMENTAL AGREEMENT FOR TREATED WATER SERVICE ("Agreement") is entered into this ____ day of _____ 2021, by and between THE CITY OF GREELEY, COLORADO, a home rule municipality acting by and through its Water Enterprise ("Greeley") and THE TOWN OF MILLIKEN, COLORADO, a home rule municipality ("Milliken"), to set forth the terms and conditions by which Greeley will use its supply and treatment facilities to provide the treatment and delivery of potable water to Milliken.

WHEREAS, pursuant to C.R.S. § 29-1-203, governments may cooperate or contract with one another to provide any function, service or facility lawfully authorized to each of the following cooperating units of government; and

WHEREAS, Greeley and Milliken previously entered into that certain Intergovernmental Agreement for Treated Water Service on July 20, 1999 ("1999 IGA"), and into that First Amendment to the Intergovernmental Agreement for Treated Water Service on May 16, 2017 ("First Amendment"); and

WHEREAS, Greeley and Milliken have a continuing common interest in obtaining high-quality treated water in sufficient quantities to meet the present and future needs of their citizens and service areas; and

WHEREAS, Greeley and Milliken desire to further amend the 1999 IGA, as previously amended by the First Amendment, to modify the methodology by which Milliken's peak daily and peak hourly demand factors are to be calculated; and

WHEREAS, Greeley and Milliken desire to reduce their understandings, and the terms and conditions of this Agreement, to writing;

NOW THEREFORE, for good and valuable consideration, the receipt and adequacy of which is acknowledged, and in further consideration of the mutual covenants, undertakings, terms, and conditions contained herein, Greeley and Milliken agree as follows:

1. **DEFINITIONS.** The terms used herein are defined as follows:

1.1 "Greeley" shall refer to the City of Greeley and any authorized representative thereof.

1.2 "Greeley Water System" or "Greeley Water System Enterprise" shall refer to Greeley's water treatment plants, treated water conveyance and storage systems, pump stations and related appurtenances for the collection, distribution, and measurement of water.

1.3 "Milliken" shall refer to the Town of Milliken and any authorized representative thereof.

1.4 “Milliken System” or “Milliken Water System Enterprise” shall refer to Milliken’s treated water conveyance and storage systems, pump stations, and related appurtenances for the distribution of water downstream of master meters gauging Greeley’s delivery to Milliken.

2. USE. Pursuant to the terms of this Agreement, Greeley agrees to treat water, usable in the Greeley Water System and approved for municipal use in the Milliken System under Colorado law, for Milliken in the manner and in such amounts as are more fully set forth herein.

2.1 During each full year that this Agreement is in effect, Milliken shall take a minimum of 20 million gallons of treated water. If in any year treated water is available to Milliken and Milliken fails to take and use 20 million gallons of treated water, Milliken shall nonetheless pay for this minimum allotment of treated water.

2.2 Nothing herein shall limit Milliken from taking treated water in excess of 20 million gallons subject to the availability thereof. All treated water in excess of 20 million gallons shall be expressly conditioned upon Greeley having the excess capacity to provide such water, and Milliken shall pay for the same.

3. POINT OF DELIVERY.

3.1 Treated water from the Greeley Water System shall be delivered to Milliken through multiple master meters, the location of which will be mutually established and agreed upon in writing by both municipalities. Unless specifically authorized by Greeley, no water from the Milliken System shall flow into the Greeley Water System.

3.2 Unless otherwise agreed upon between the parties, Greeley shall construct, own and maintain treated water meter vaults, meters, back-flow prevention devices and all associated facilities located at and upstream of the delivery points. All of the costs of the metering facilities attributable to service to Milliken shall be paid by Milliken by and through inclusion in the Milliken rate base charged by Greeley and more fully described in paragraph 7. Greeley agrees to design, construct and maintain all metering facilities in a prudent and cost effective manner. Milliken agrees to secure and provide such easements as may be required by Greeley for metering facilities, and to guarantee access to metering facilities for Greeley. Each water meter shall be operated and maintained so as to record both cumulative flow and, as needed, maximum hourly and maximum daily flow within the accuracy prescribed by the then-current American Water Works Standards, or such other industry-recognized standard if American Water Works Standards are no longer available. Each party will give the other seven calendar days notice prior to conducting any routine or independent meter test. Milliken shall have access to all metering facilities herein contemplated to read meters as Milliken may deem necessary. Milliken shall own, operate, maintain, and have the ability to valve the line(s) downstream of the master meter(s) for operation, maintenance, and repair purposes.

3.3 The existing master meter is located at or near the intersection of Weld County Road 54 and State Highway 257. The transmission pipeline north (upstream) of this location was constructed by Milliken and dedicated to the City of Greeley. To the extent that Greeley uses any infrastructure installed by Milliken, such usage shall be subject to reimbursement for oversizing in accordance with Greeley’s then-current ordinance.

4. POTABLE WATER PROJECTIONS AND SYSTEM CAPACITY.

4.1 No later than April 1 of each year, Milliken shall provide written notice to Greeley of its projected treated water requirements for the current calendar year and the five consecutive years following the year in which such notice is given. The projections in the notice shall include, at a minimum: estimated total annual consumption, estimated maximum day, and estimated maximum hourly usage. Concurrent with submission of the projections, Milliken shall also provide any planned system facility changes and any additional points of delivery to Milliken from Greeley. Any actual usage in excess of projected peak or total demands which has a cost impact, excepting fire flow or other emergencies, shall result in supplemental demand charges as determined by the cost-of-service rate study and approved by the Greeley Water and Sewer Board.

4.2 If Greeley determines the Greeley Water System will be unable to meet Milliken's projected demands, Greeley will give Milliken notice two years prior to the projected capacity limitation. Milliken has authority to obtain water beyond the capacity limitation from other sources. Greeley will use its best efforts to avoid a capacity limitation.

4.3 It is understood and agreed by Greeley that, as of the date of this Agreement, Milliken is also receiving treated water from Central Weld County Water District. Nothing in this Agreement limits Milliken from continuing to receive treated water from sources other than Greeley during the term of this Agreement, in whatever amounts Milliken deems appropriate.

5. RAW WATER REQUIREMENTS. Milliken shall acquire sufficient water rights which are usable in the Greeley Water System and approved for municipal use in the Milliken System under Colorado law in order to satisfy the treated water requirements of Milliken, expressly subject to the following conditions:

5.1 Greeley currently operates two water treatment plants, the Bellvue Plant and the Boyd Lake Plant, which are both capable of supplying treated water to Milliken. Milliken's raw water requirements under this Agreement are based on which plant treats the raw water used to supply the treated water to Milliken. At the time this Agreement is executed, Greeley anticipates that the Bellvue Plant will treat and supply water to Milliken during the months of January, February, March, April, October, November, and December, and that the Boyd Lake Plant will treat and supply water during the months of May through September. However, Greeley may in its sole discretion determine which plant will be used to treat any water provided by Milliken under this Agreement.

5.2 On or before April 15 of each year, Milliken shall transfer to Greeley sufficient Colorado-Big Thompson ("CBT") water to satisfy the projected Milliken demand for the full year, including a 5% shrink attributable to the Greeley Water System and any shrink due to the Northern Colorado Water Conservancy District ("Northern Water"). Subject to prior written approval from Greeley and the Water Court for Water Division No. 1 by decree or administratively by the State Engineer's Office ("SEO"), Milliken may also transfer to Greeley water rights from the Greeley-Loveland Irrigation Company ("GLIC") to satisfy a portion of the projected Milliken demand. Upon such approval by Greeley and the Water Court or SEO, the transfer of such rights shall be subject to the shrink and carryover described in paragraph 5.4 below. Greeley may immediately curtail deliveries of treated water to Milliken in any event that the transferred Milliken water rights fail to yield sufficient volumes of raw water to meet projected demands or actual metered usage.

5.3 Milliken shall pay all assessment costs from Northern Water for Milliken's CBT water and from GLIC for Milliken's GLIC water, and running charges assessed by Northern Water or GLIC, if applicable, on any of the water provided by Milliken to Greeley for treatment under this Agreement.

5.4 Water transferred by Milliken to be treated at Greeley's Boyd Lake Plant shall be of a sufficient amount to account for the 5% shrink attributable to the Greeley Water System and any shrink applied by Northern Water as described above. Transferred GLIC water shall be of a sufficient amount to additionally account for shrink and carryover factors, which will vary and be determined on an annual basis. At the time this Agreement is executed, those factors are 28% (for shrink) and 11% (for carryover). Greeley shall inform Milliken in writing as soon as Greeley knows that those loss factors have changed.

5.5 Milliken shall be solely responsible for meeting any return flow requirements associated with any GLIC raw water it provides to Greeley for treatment, as well as the submission to the Colorado Department of Water Resources ("DWR") of any decree accounting related thereto, and compliance with any other State or Federal requirements. Milliken shall provide to Greeley a copy of any such accounting submitted to DWR. While Milliken retains dominion and control over its transferred water, Greeley shall maintain complete and unilateral control over Greeley's Water System operations. Greeley may use the Greeley Water System to move Milliken transferred water to the appropriate location for treatment. Any loss in the optimal yield of Milliken water rights due to this necessary flexibility of operations will be assessed in proportion to the loss in yield to Greeley's water.

5.6 Greeley shall be obligated to treat for Milliken only that water delivered for treatment under this Agreement. If actual metered usage by Milliken exceeds the amount delivered by Milliken less losses, Greeley shall immediately notify Milliken of such shortage, and may immediately curtail deliveries of treated water to Milliken. Upon such written notification, Milliken will have twenty (20) days to transfer additional raw water to Greeley for treatment. During this period, Greeley may, at its sole discretion regarding availability, agree to lease additional raw water to Milliken at the then current rate established by the Greeley Water and Sewer Board and adopted in accordance with Section 17-4 of the Greeley City Charter, and also in accordance with the then current City of Greeley Non-Agricultural Water Rental Policy. If Greeley has additional raw water available to lease, Milliken shall be given the priority to lease it on an equal basis with the other municipalities to whom Greeley leases raw water.

5.7 Unless otherwise approved in advance by Greeley in writing, Milliken shall be limited under this Agreement to a maximum volume of treated water from the Boyd Lake Plant of 800,000 gallons per day, and a maximum volume of 70 acre-feet per calendar month. Consistent with the discretion maintained by Greeley and described in paragraph 5.1 above, Greeley may further limit these maximum volumes if it determines that additional capacity at the Boyd Lake Plant is necessary to treat and supply water to its own citizens.

6. EMERGENCY OPERATIONS. In the event of a shortage of treated water, caused by the inability of a component of the Greeley Water System to function, Milliken and Greeley shall share proportionally in water use reductions. Greeley shall develop a schedule and method of reducing water demand, with initial emphasis on reducing all nonessential uses such as lawn and parks irrigation. If a shortage persists, Milliken and Greeley agree to impose emergency rates, developed by Greeley, which may be different for each customer category and which are intended to reduce discretionary consumption of treated water. The impact of the emergency rates shall be fairly and equally distributed among both Milliken and Greeley water customers. In a prolonged shortage, Milliken and Greeley agree to adopt a uniform set of enforcement tools and penalties to curtail usage. In any such event, Greeley will make every effort feasible to continue to meet both Milliken's and Greeley's water demand, including obtaining treated water from other providers. In the event of a shortage, nothing shall prevent Milliken from independently using

an alternate source of treated water in whatever amount Milliken deems necessary, until Greeley can again bring its facilities on line.

7. RATES FOR TREATED WATER SERVICE. The rates for treated water delivered by Greeley to Milliken shall be based upon the City of Greeley water rate cost-of-service model, which includes costs for the use of those Greeley Water System assets involved in the treatment and delivery of water to Milliken under this Agreement. Milliken agrees to pay the rate of cost-of-service plus ten percent. The cost-of-service rates shall be reviewed annually by the City of Greeley and may be adjusted in accordance with Section 17-4 of the Greeley City Charter. Greeley shall give to Milliken an advance notice of ninety (90) days if the then current rate will change. Cost-of-service rates include a cost to provide peak demands, as described below.

8. BILLING. Bills shall be paid within thirty (30) days of the date due, after which time interest penalties shall begin to accrue at the rate of one percent per month, or fraction thereof, during the period in which the bill remains unpaid.

9. NO REQUIRED RIGHTS OR VESTING IN WATER RIGHTS OR IN WATER SYSTEM.

9.1 As contained in section 17-1 of the Greeley City Charter, the Greeley Water System is an Enterprise, as that term is defined pursuant to article X, section 20 of the Colorado Constitution. The Greeley Water System Enterprise is owned by the citizens of Greeley. Similarly, the Milliken System is an Enterprise, owned by the citizens of Milliken.

9.2 Milliken specifically acknowledges and agrees that no rights or ownership of the Greeley Water System shall become vested as a result of such service. Neither Greeley nor Milliken shall, by reason of any provision of this Agreement or use of water hereunder or otherwise, acquire any vested or adverse right, in law or in equity, in the water rights or water system owned by the other municipality. Neither the assignment, use, rental, or license, of water or water rights nor the payment of system development charges shall be deemed to initiate, create, or vest any rights or ownership by either Greeley or Milliken in the other's water rights or water system. Further, Milliken shall not assert or claim any vested rights to continued service, other than as established by the terms of this Agreement, as it may be amended or extended in the future.

10. POTABLE WATER. The treated water delivered by Greeley to the Milliken master meters shall be potable water which complies with applicable Federal and State potable water laws.

11. PEAK DEMAND MEASUREMENTS AND DETERMINATION. The peak daily and peak hourly demand factors to be used in the calculation of Milliken's rate for treated water service shall be equal to the peak daily and peak hourly demand factors assumed for and applicable to Greeley's own inside-the-City residential customers, as calculated in accordance with Greeley's cost-of-service rate model. In no case will past or current water bills be adjusted for changes in the peak demand factor.

12. SYSTEM DEVELOPMENT CHARGES.

12.1 Milliken shall pay to Greeley an annual system development charge ("SDC") when the metered water delivered to Milliken in any year exceeds the acre-feet delivered in the base year. Payment of the SDC will create a new base year delivery volume. No SDCs will be due in subsequent years for metered delivery equal to or less than the new base year delivery volume. Payments of the SDC will occur in twelve monthly increments following the calendar year in which

the exceedance occurs. In no case shall SDCs be refunded. Milliken's current base year volume at the time this Agreement is executed (September 2021) is 442.1 acre-feet.

12.2 The SDC due shall be a percentage of the then-current Inside the City Greeley ¾-inch tap plant investment fee (expressed in \$/acre-feet), to be multiplied by Milliken's consumption in acre-feet of water metered in excess of the base year delivery. The SDC percentage is calculated as follows: the typical Milliken single-family customer benefits from 75% of Greeley Water System. To express Greeley's plant investment fee in terms of \$/acre-feet, the average annual inside-the-City residential demand, as used in the annual update of the Greeley rate model, is divided into the plant investment fee.

12.3 THE FOLLOWING CALCULATION UTILIZES 2016 DATA TO DERIVE EXAMPLE FIGURES FOR THE SOLE PURPOSE OF DEMONSTRATING THE SDC METHODOLOGY. ANY ACTUAL SDC BORNE BY MILLIKEN WILL VARY ANNUALLY, IN ACCORDANCE WITH THE METHODOLOGY DESCRIBED IN THIS PARAGRAPH 12.

Example Conversion and Calculation of SDC Rate

Average Annual Demand:	135,000 gallons (0.414 acre-feet per ¾-inch tap)
Current Inside the City Greeley PIF:	\$10,800

Conversion of Greeley PIF: $(\$10,800) / (0.414 \text{ AF/year}) = \$26,087 \text{ per AF/year}$

Milliken SDC: $(75\%) * (\$26,087 \text{ per AF/year}) = \$19,565 \text{ per AF/year}$

Example Base Year and SDC Calculation

Milliken Base Year Volume:	442.1 acre-feet
Milliken Actual Metered Flow:	450 acre-feet (7.9 AF in excess of Base Year Volume)

Calculation of Total SDC Due: $(450 - 442.1) * (\$19,565) = \$154,563.50$

Milliken's Base Year Volume would then increase to become 450 AF.

13. RELEASE, HOLD HARMLESS, INDEMNIFICATION.

13.1 Both Milliken and Greeley are public entities, as that term is defined pursuant to the Colorado Governmental Immunity Act, C.R.S. § 24-10-101, et seq. The parties to this Agreement have the benefits and responsibility enumerated in the Colorado Governmental Immunity Act. Each party shall defend any and all claims for injuries or damages pursuant to and in accordance with the requirements and limitations of the Colorado Governmental Immunity Act occurring as a result of negligent or intentional acts or omissions of the parties, their agents, employees and assigns.

13.2 In addition, Greeley shall be responsible for any and all liability for injuries or damages caused by negligent acts or omissions of Greeley, its officers, employees, and agents performing functions or activities upon the property of Milliken. Greeley shall provide adequate workmen's compensation insurance for all of its employees, agents, and assigns engaged in activities and functions upon the property of Milliken.

13.3 Milliken shall be responsible for any and all liability for injuries or damages caused by any negligent acts or omissions of Milliken, its officers, employees, and agents, performing functions or activities upon the property of Greeley. Milliken shall provide adequate workmen's compensation insurance for all of its employees, agents, and assigns engaged in activities and functions upon the property of Greeley.

13.4 Each party shall furnish the other party upon request certificates of insurance stating that coverages adequate for the purposes outlined above are in full force and effect.

14. NO PUBLIC UTILITIES COMMISSION CONTROL. Milliken, its employees and elected or appointed officials, agree neither to assert nor support any statement, policy, petition, rule making, or legislation attempting to place the Greeley Water System under the rate-making authority or jurisdiction of the Colorado Public Utilities Commission by virtue of this Agreement or otherwise.

15. INTEGRATION, MERGER, AND SUPERSESSION. This Agreement incorporates and renews the terms and conditions of the 1999 IGA and the First Amendment not explicitly modified herein, and supersedes and replaces the previously existing agreements between Greeley and Milliken in their entirety. This Agreement contains all agreements and understandings, whether written or oral, between Greeley and Milliken regarding the subject matter herein.

16. TERM OF AGREEMENT. In the interest of reliability and security, this Agreement shall be for an initial term of twenty years from the date of execution set forth above. This Agreement expires at the end of such twenty-year term, but may be renewed for subsequent terms of ten years each by a duly authorized and executed mutual written agreement. Greeley and Milliken agree to meet at least two years before the end of the initial twenty-year term, and before the end of any subsequent terms, to review this Agreement for possible modification or renewal.

17. DEFAULT AND TERMINATION.

17.1 In the event either party fails to meet the terms and conditions of this Agreement, such failure shall constitute a default of this Agreement and the non-defaulting party may give notice of the perceived default. Notice shall be either to the Milliken Town Administrator or the Greeley City Manager. Either party may cure any default during the ninety (90) days following the notice. Upon cure of any default, this Agreement shall remain in full force and effect. Upon receipt of notice of perceived default, the defaulting party may invoke dispute resolution as provided in paragraph 20.

17.2 If after the cure period above or after mutually agreed extensions, the non-defaulting party determines the default has not been cured, they may give two years notice of termination of this Agreement. Nothing herein shall limit either party from collecting damages and amounts due from the other party upon termination of this Agreement by default.

17.3 This Agreement may be terminated by either party by giving written notice to the other party at least two years before the end of the initial twenty-year term, or at least two years before the end of any subsequent terms. This Agreement may otherwise be terminated at will by Greeley by giving an advance written notice to Milliken of no less than four years.

17.4 Milliken agrees that annexation by Milliken of land north of Weld County Road 54 shall be approved by Greeley in writing prior to the annexation. Violation of this provision may be grounds for termination of this Agreement.

17.5 Milliken agrees not to oppose any annexation by Greeley of property north of Weld County Road 54 and Greeley agrees not to oppose any annexation by Milliken of property south of Weld County Road 54. Both governmental entities acknowledge the value of annexation in conformance with natural, man-made, or political boundaries.

18. JURISDICTION AND VENUE. This Agreement shall be interpreted pursuant to the laws of the State of Colorado. Venue to enforce this Agreement shall be in Weld County.

19. AMENDMENT. This Agreement shall be amended only in writing with the approval of the governing bodies of each municipality. No amendment or modification shall be effective unless in writing signed by the aforesaid persons. This Agreement shall be governed by, construed and enforced in accordance with Colorado law.

20. DISPUTE RESOLUTION. Should disagreements arise regarding the interpretation of any portion of this Agreement the parties agree to resolve such disputes through negotiation; first, all the staff level; and second, with the respective Water Boards and/or City Councils. Procedures for such negotiations shall be established by mutual agreement at the time and may, with the concurrence of the parties, involve the use of qualified outside mediators. Any negotiations and resolution reached therefrom must be within the legal authority granted to the parties by appropriate City Charters and/or State statutes, or shall be null and void. Notwithstanding anything to the contrary in this Agreement, it is expressly agreed between the parties that this provision for dispute resolution does not apply to the authority granted to the Greeley Water and Sewer pursuant to Section 17-4 of the Greeley City Charter, including but not limited to, the establishment of minimum water rates.

IN WITNESS WHEREOF, the City of Greeley and the Town of Milliken have authorized and executed this Second Amendment to Intergovernmental Agreement for Treated Water Service on the date first written above.

THE TOWN OF MILLIKEN, COLORADO
a Colorado home rule municipality

ATTEST:

By: _____
Mayor

By: _____
Town Clerk

THE CITY OF GREELEY, COLORADO
a Colorado home rule municipality
acting by and through its Water Enterprise

ATTEST:

By: _____
Mayor

By: _____
City Clerk

AS TO SUBSTANCE:

By: _____
City Manager

AS TO AVAILABILITY OF FUNDS:

By: _____
Director of Finance

AS TO LEGAL FORM:

By: _____
City Attorney

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE _____

NO ENCLOSURE X

ITEM NUMBER: 5

TITLE: WELCOME NEW EMPLOYEES AND
 PROMOTIONS

RECOMMENDATION: INFORMATIONAL ONLY

ADDITIONAL INFORMATION:

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE X NO ENCLOSURE

ITEM NUMBER: 6

TITLE: UPDATE ON INTERGOVERNMENTAL
AGREEMENT FOR TEMPORARY
INFRASTRUCTURE USE AND COST SHARING
WITH NORTH WELD COUNTY WATER
DISTRICT

RECOMMENDATION: INFORMATION ONLY

ADDITIONAL INFORMATION:

North Weld County Water District (NWCWD) has historically served customers within the Budweiser Annexation. In a separate, forthcoming agreement in 2022, the City of Greeley will purchase infrastructure from NWCWD and will provide service in this area. In addition, Weld County and City of Greeley Public Works Department are installing roundabouts at 59th Ave. and O St., and 35th Ave. and O St.

Therefore, the Water and Sewer Department will use this opportunity to install infrastructure in anticipation of accepting said customers from North Weld. Said installation will be more cost effective by collaborating Weld County and NWCWD. This IGA will allow NWCWD to use Greeley's new potable water distribution infrastructure located within the new roundabouts and surrounding areas on a temporary basis to serve customers located within the Budweiser Annexation until Greeley assumes responsibility for serving the customers in the separate, forthcoming agreement in 2022. Allowing NWCWD temporary use will limit their installations and reduce Greeley's costs.

The water providers would also like to share the costs associated with the design, acquisition, construction, and installation of master meters, and other associated infrastructure, near the intersection of 35th Avenue and O Street and 59th Avenue and O Street.

Update on IGA for Temporary Infrastructure Use and Cost Sharing with North Weld County Water District

Water and Sewer Board| September 15, 2021



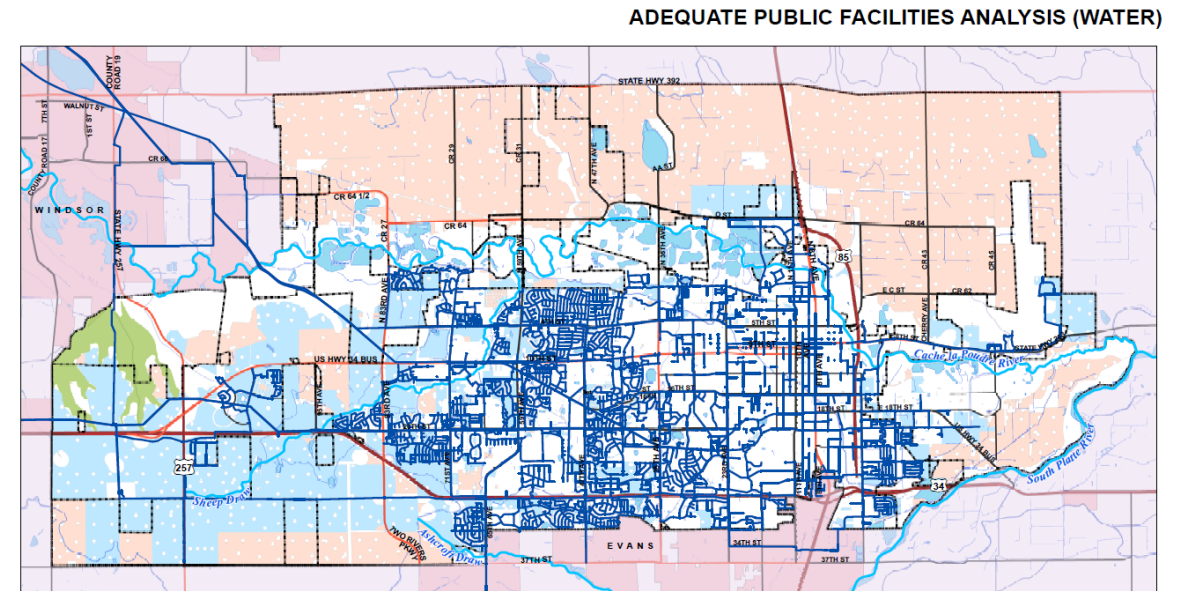
Background and Need for Temp Use IGA

- New Roundabouts at 35th Ave. & 59th Ave. and O Street
 - W&S installing new water lines through the roundabout
 - Cost effective to install with other agencies doing construction
 - Limits future costs
 - Limits impacts to roads when Greeley system is extended

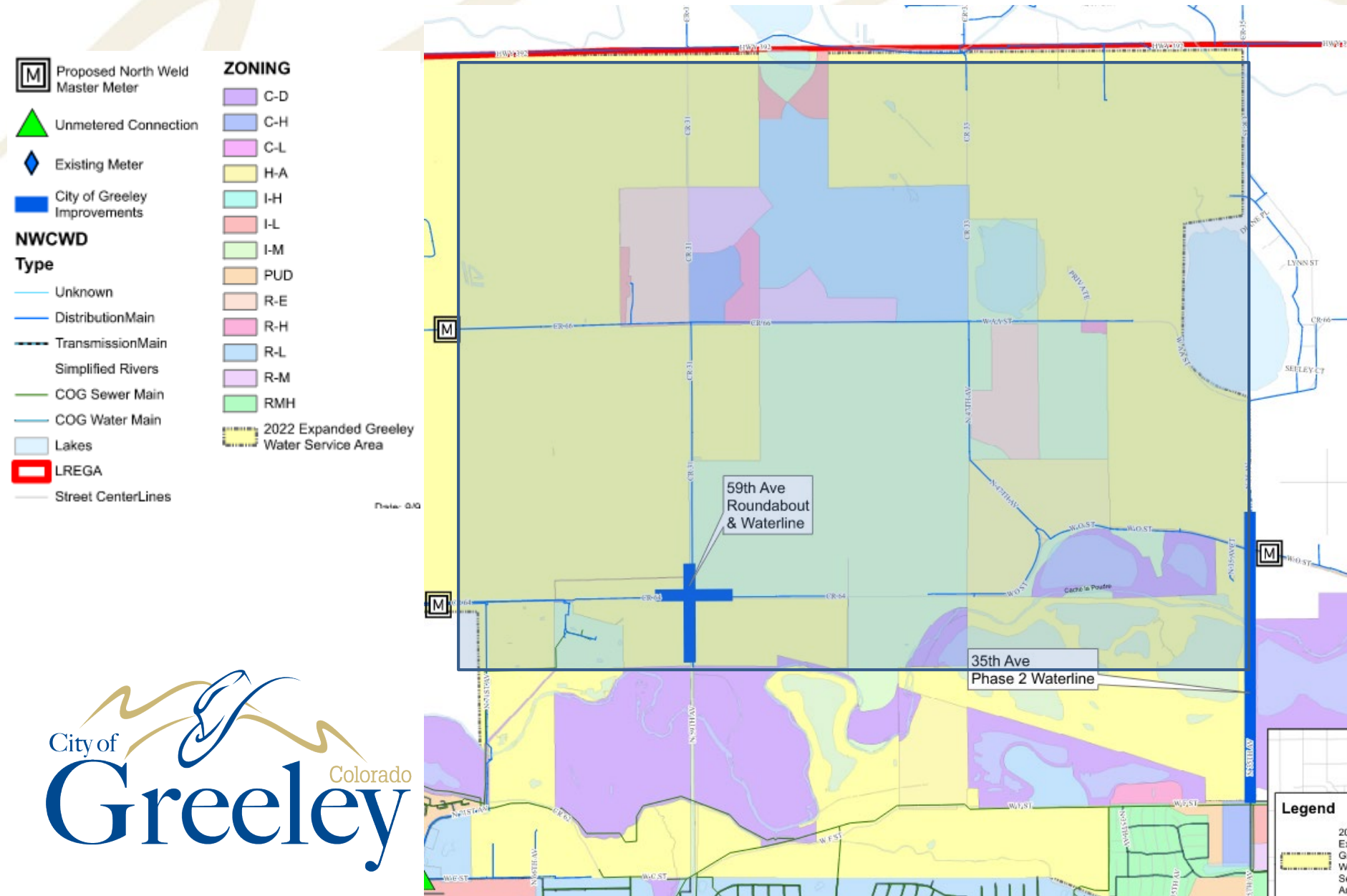


Need for a Temporary Use IGA?

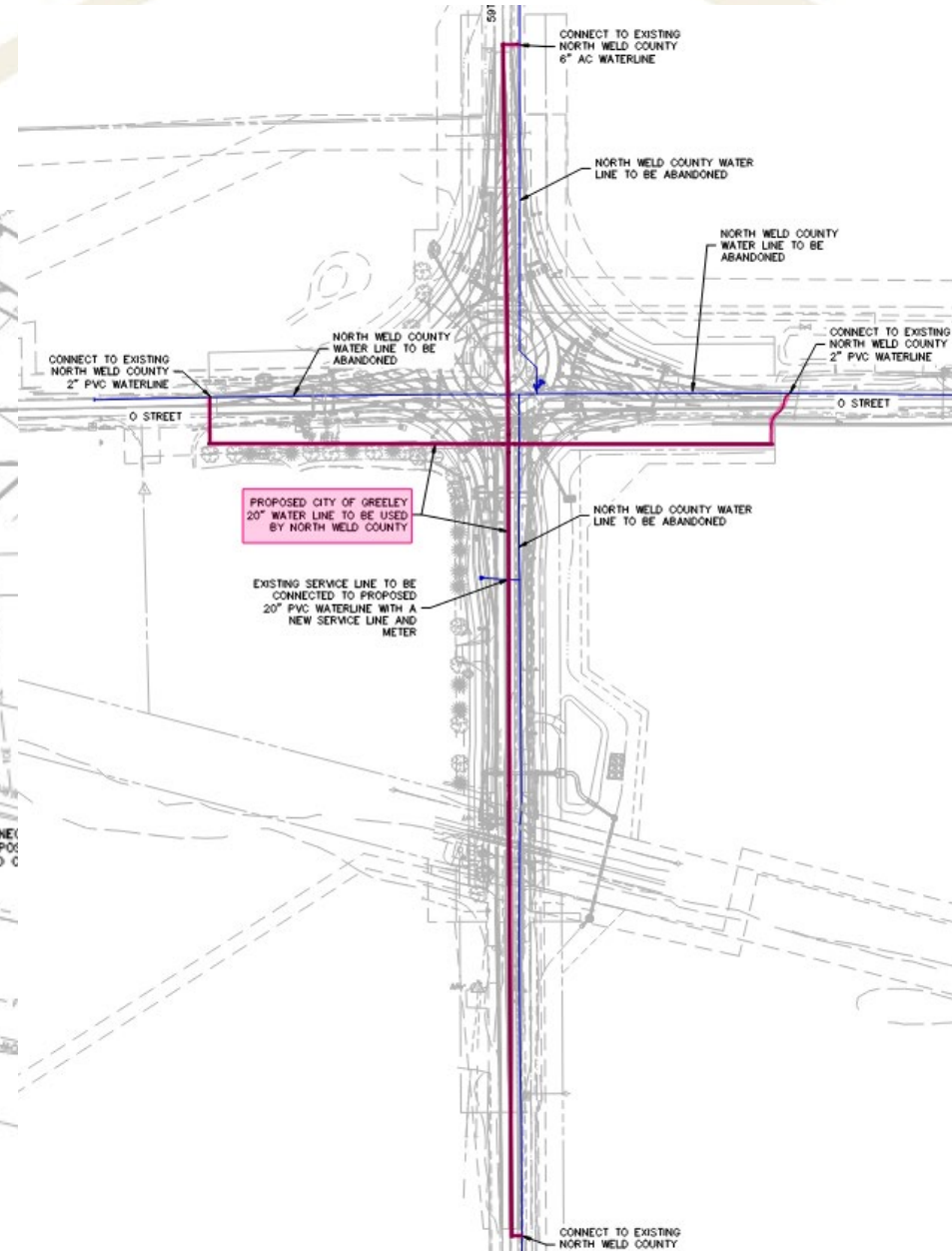
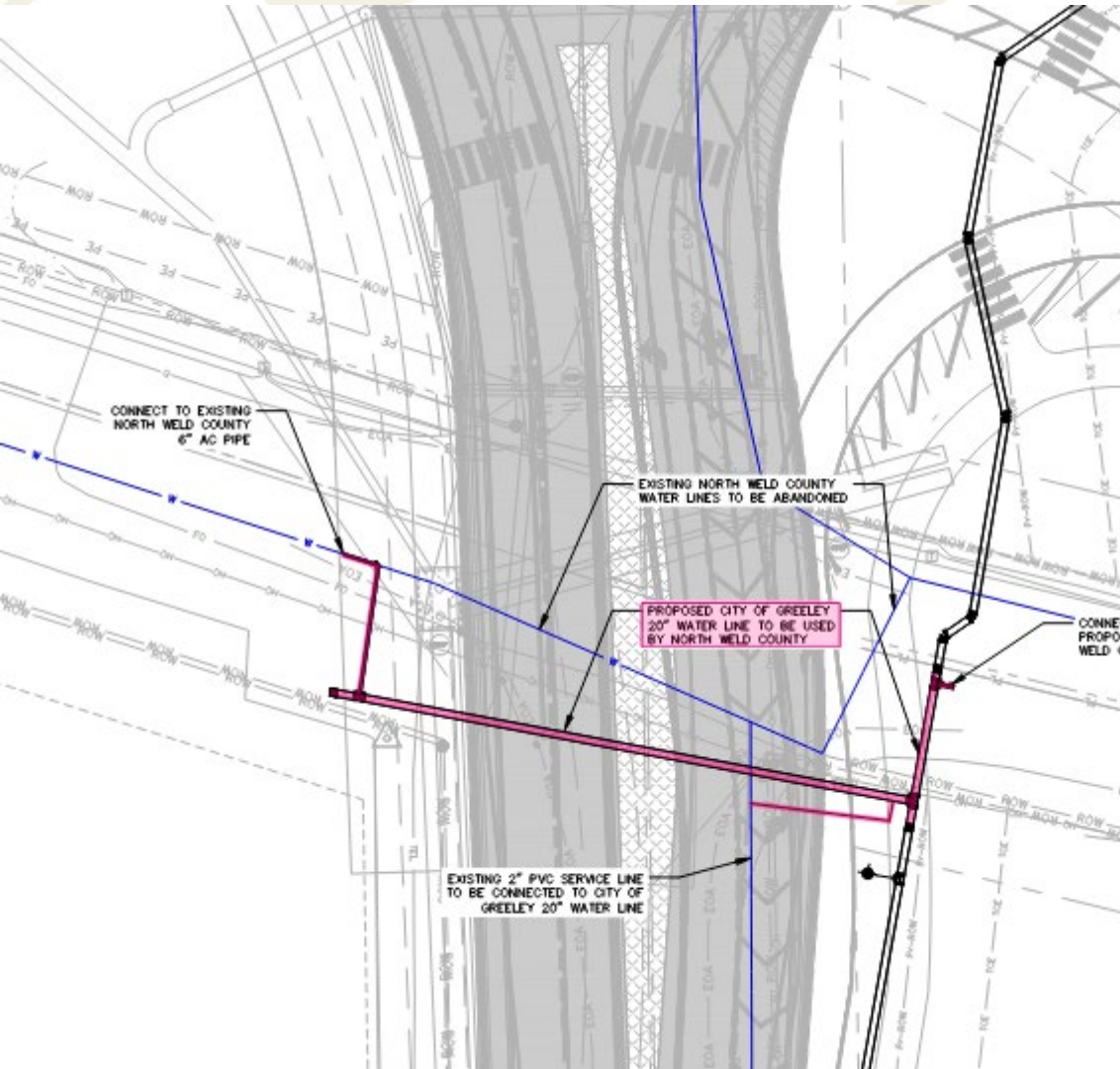
- NWCWD Water Service Area IGA (2013)
 - CoG to purchase North Weld County Water District (NW) service area infrastructure in the Budweiser Annex Area in 2022
 - IGA obligates COG to purchase pipelines from NW when it takes over service area
- Proposed Temp Use IGA minimizes
 - Redundant infrastructure
 - Duplicative costs for COG



Proposed COG Water Service Area



Temporary Shared Infrastructure





Questions?



WATER SERVICE AGREEMENT

THIS AGREEMENT is made and entered into as of the 5th day of February 2013, by and between the North Weld County Water District, acting by and through the North Weld County Water District Enterprise (hereinafter "District"), and the City of Greeley, a home rule municipality, acting by and through its Water Enterprise (hereinafter "Greeley")(collectively "Parties").

RECITALS

WHEREAS, the District is a statutory special district formed under the laws of the State of Colorado and is a quasi municipal corporation; and,

WHEREAS, Greeley is a home-rule municipal corporation; and,

WHEREAS, the North Weld County Water District Enterprise and the Greeley Water Enterprise are established and administered in compliance with the provisions of Section 20, Article X of the Colorado Constitution and Article 45.1 of Title 37 of the Colorado Revised Statutes, and the Greeley City Charter and Municipal Code, as applicable; and,

WHEREAS, the District (on its own or in cooperation with others) owns, maintains and operates a system for the storage and distribution of potable water within Weld County and Larimer County; and,

WHEREAS, Greeley owns, maintains and operates a separate and independent system for the storage and distribution of potable water to its residents and to other customers in Weld County and Larimer County; and,

WHEREAS, the District, as a non-profit quasi municipal statutory special district, must establish and provide water rates to cover the maintenance and operation, depreciation, replacement, and appropriate funding of capital costs of the District; and,

WHEREAS, Greeley's policy is to provide water service to all Greeley citizens; and,

WHEREAS, the District's policy is to provide water service within the boundaries of the District; and,

WHEREAS, the District has a master plan to serve a portion of its service area, lying north of the Poudre River, at densities between one and two dwelling units per five acres; and,

WHEREAS, portions of the District's service area overlap Greeley's Long-Range Expected Growth Boundary, which is outlined in Greeley's 2060 Comprehensive Plan; and,

WHEREAS, Greeley and the District have determined that it is in the best interest of the residents of Greeley and the District for the Parties to cooperate with each other in providing water services; and,

WHEREAS, by enacting Titles 31 and 32 and specifically § 31-35-402(1)(b) and § 32-1-502(2)(c) of the Colorado Revised Statutes and pursuant to Article XIV, Section 18 of the Colorado Constitution, the Legislature of the State of Colorado has: (a) determined that the State of Colorado has a valid interest in providing water for its citizens; (b) clearly articulated and affirmatively expressed the State of Colorado's policy to allow municipalities and special service districts to provide water by utilizing cooperative agreements and to eliminate competition in areas where each Party is capable of providing service; and (c) developed a structure to actively supervise municipalities and special service districts, if the Parties choose to utilize such agreements; and,

WHEREAS, taking into consideration the foregoing factors and the natural drainage basins and topography that affect the quality and cost of utility service in the overlapping service area, Greeley and the District desire to enter into a long-term contract for the treatment and delivery of potable water, to eliminate overlapping facilities, and to coordinate long-range planning prior to initiating costly capital expansion programs; and,

WHEREAS, Greeley and the District desire to craft this Agreement with the following guiding principles: to keep North Weld financially whole; to allow Greeley to maintain land use control of much denser, urban development in the overlapping service area; and to provide for flexible water sharing between the Parties; and,

WHEREAS, Greeley and the District enter into this Agreement pursuant to the provisions of § 29-1-203, C.R.S; and,

WHEREAS, the District and Greeley shall and will continue to own their own water rights individually and separately, with Greeley relying upon the yield of its own water rights to provide the raw water necessary for treatment proposed under this Agreement; and,

NOW, THEREFORE, in consideration of the premises and the covenants and agreements hereinafter set forth, it is agreed by and between the District and Greeley as follows:

ARTICLE 1 DEFINITIONS

1.1 "Delivery Point(s)" shall mean the point(s) at which the Furnishing Party delivers water to the Receiving Party's water system.

1.2 "Furnish" shall mean to treat, to the standards set forth in Section 3.4, and deliver water, which includes all of the intermediate steps necessary to provide water at the Delivery Point(s).

1.3 "Furnishing Party" shall mean the Party who treats, delivers, and performs all of the intermediate steps necessary to provide water at the Delivery Point(s).

1.4 "Master Meter" shall mean a meter at which the Furnishing Party will furnish water to the Receiving Party to enable the Receiving Party to provide water service to its customers.

1.5 "North Greeley Service Area" shall be that area identified within the Long-Range Expected Growth Boundary outlined in Greeley's 2060 Comprehensive Plan.

1.6 "Notice" shall mean the notice described in Section 10.12

1.7 "Raw Water Requirement" shall mean untreated water in an amount equal to 110% of Greeley's net potable water usage at the Master Meter(s) for the previous year plus any anticipated increases or decreases in net usage.

1.8 "Receiving Party" shall mean the Party who takes delivery of water from the Furnishing Party at a Master Meter.

1.9 "Uncontrollable Forces" shall mean any cause beyond the control of the obligated Party, including, but not limited to, failure of facilities, flood, earthquake, storm, lightning, fire, epidemic, riot, civil disturbance, labor disturbance, sabotage, breach of construction contract by a third party or restraint by court or public authority, which through due diligence and foresight, such Party could not have reasonably been expected to avoid.

1.10 Unless described as "raw water", "water" shall mean water treated to the standards set forth in Section 3.4, and shall have the same meaning as "potable" or "treated" water.

1.11 "Water Service" shall mean providing water directly to individual customers.

1.12 "Water Supply" shall include, but is not limited to, existing water supplies, future water supply projects, and development of existing and after-acquired water rights.

1.13 "Water System" shall mean the distribution system whereby a Party provides water service.

ARTICLE 2 GENERAL PROVISIONS

2.1 This Agreement defines the method by which the Parties shall furnish and provide water service to individual customers located within the North Greeley Service Area. It shall also determine the method of transferring the District's customers to Greeley; the transfer of infrastructure upon the exclusion of territory from the District's service area; the provisions for furnishing water to the Parties' respective water systems; and the method by which this Agreement may be amended to account for future growth, expansion, and development within the North Greeley Service Area.

2.2 To account for the transfer of customers to Greeley within the North Greeley Service Area and to track portions of the District's service area that are excluded there from, this Agreement may be amended, from time to time, through the use of exhibits. The exhibits shall contain the information required by Articles 3, 5, and 8 of this Agreement and shall be identified and generally contain the following:

2.2.1 Exhibit A of this Agreement shall contain the name of each Master Meter and its corresponding location; the annual minimum amount of water that Greeley must purchase through Master Meter(s); and the maximum gallons per minute of water that shall be delivered through a Master Meter based on Plant Investment Fees paid and credited. If any of the foregoing information is inapplicable to a Receiving Party, that portion of Exhibit A shall so reflect.

2.2.2 Exhibit B shall contain a complete list of all customers transferred from the District to Greeley.

2.2.3 Exhibit C shall be a map depicting the North Greeley Service Area and any property excluded from the District's service area.

2.3 The exhibits identified in paragraph 2.2 shall be amended prior to any relocation of a Master Meter, increase in peak demand, transfer of customer, or exclusion of territory from the District's service area. The exhibits shall be redefined as agreed to in writing by the Parties, or their respective designee, and made effective in accordance with the Parties' respective rules and procedures. Each amendment shall fully replace the prior exhibit and shall be effective upon the date specified therein.

2.4 The terms of this Agreement shall only apply to the North Greeley Service Area and shall not be extend to, or binding on, the Parties in any other geographical location.

2.5 This Agreement is not intended to provide for emergency water connections and supplies. If, at any time after the effective date of this Agreement, the Parties determine that an emergency interconnection is needed, then the Parties shall negotiate a separate agreement to determine the locations and facilities that will provide for emergency interconnections and the terms and conditions thereof.

ARTICLE 3 WATER SUPPLY

3.1 The District shall furnish potable water via Master Meter(s) for use in Greeley's water system at the locations and in the maximum and minimum annual amounts, peak demands in gallons per minute, and minimum and maximum pressures that shall be specified in Exhibit A.

3.2 Upon the District's written request, Greeley may furnish potable water via Master Meter(s) for use in the District's water system, subject to the terms of this Agreement, at the location(s) that shall be specified in Exhibit A.

3.3 The minimum and maximum pressures shown in Exhibit A shall be met by the Furnishing Party at the Master Meter(s) only. The Receiving Party is responsible for all pressures within its system following delivery from the Furnishing Party at the Master Meter(s). No promise or guarantee of pressure is made by the Furnishing Party or is to be implied from anything contained herein except as established in Exhibit A.

3.4 The furnished water shall be potable water, the quality of which shall be in accordance with the Federal Safe Drinking Water Act and all other applicable drinking water regulations and potable water law. The Parties shall conduct all testing necessary to assure that the water furnished under this Agreement complies with all Federal and State drinking water standards. The Furnishing Party agrees to provide the Receiving Party with the results of its annual testing, on or before April 1 of each year, as required by Colorado Primary Drinking Water Regulations, 5 CCR 1003.

3.5 Neither Party shall, by reason of this Agreement or by use of any water hereunder, acquire vested or adverse right or future right, in law or equity, in the water rights or water system owned by the other Party.

ARTICLE 4 RAW WATER

4.1 On an annual basis, Greeley shall provide raw water to the District, for treatment and delivery by the District through one or more Master Meters, in the amount of one hundred and ten percent (110%) of Greeley's estimated net demand ("Raw Water Requirement"). The Raw Water Requirement shall be calculated based on Greeley's net potable water usage at the Master Meter(s) for the previous year, plus any anticipated increases or decreases in Greeley's net usage. Not later than September 1 of each year, Greeley will supply the District with estimates of its projected Raw Water Requirement for the following year. The Raw Water Requirement made available to the District shall be provided on an actual gallon basis as measured at the intake station at the Soldier Canyon Filter Plant. The stated "one hundred and ten percent (110%)" shall mean one hundred percent (100%) plus an allowance of ten percent (10%) to cover the estimated shrinkage from the Soldier Canyon Filter Plant to the Master Meter(s).

4.2 Greeley's Raw Water Requirement shall be met from the following sources: Colorado-Big Thompson Project ("CBT"), the Windy Gap Project, the Water Supply and Storage Company, the North Poudre Irrigation Company, or from any other source capable of being delivered to and treated by the District's then existing water treatment system to the standards set forth in Section 3.4, and otherwise usable in the District's water system.

4.3 The District shall not be required to acquire, rent or own any additional raw water necessary to meet the Raw Water Requirement. Greeley is solely liable to make arrangements for the raw water necessary to make available the Raw Water Requirement.

4.4 In the event that Greeley does not make sufficient raw water available to the District, based on Greeley's net usage, the District shall notify Greeley as soon as possible but no later than thirty days prior to the time when such additional raw water will be necessary. If, after such notice, Greeley fails or refuses to provide sufficient raw water, the District may, in its sole and reasonable discretion, provide such raw water, at an additional fee to Greeley ("Water Surcharge"). The Water Surcharge shall be determined solely by the District dependant on the availability of raw water and shall be applied per one thousand gallons of water delivered to Greeley of District supplied raw water. The District shall maintain dominion and control over all raw water provided to Greeley under this Paragraph 4.4, and Greeley releases any right to the return flows that result from such water supplied by District, including any reuse rights associated with such water.

4.5 Greeley shall maintain dominion and control over any and all raw water provided to the District for treatment under this Agreement, and the District releases any right to the return flows that result from such water supplied by Greeley, including any reuse rights associated with such water.

ARTICLE 5 FACILITIES

5.1 The Furnishing Party shall take such actions and make such connections between the Receiving Party's system and the Furnishing Party's system necessary to furnish water to the Receiving Party as required by this Agreement at the Furnishing Party's sole cost.

5.2 The Furnishing Party shall install, replace, relocate, or add any necessary metering equipment and Master Meter vault(s) as required by this Agreement. The Furnishing Party shall design the Master Meter vault(s) and flow control device(s) in accordance with the specification of the Furnishing Party. Design shall consider system growth. The Furnishing Party shall submit all designs to the Receiving Party for review and approval prior to construction or installation. Following the Receiving Party's review and approval of such design plans, the Receiving Party shall reimburse the Furnishing Party for all reasonable and customary costs and expenses including design,

construction and installation of all necessary metering equipment and Master Meter vault(s) replaced, relocated, or added after the date of this Agreement.

5.3 The Furnishing Party shall install, own and operate a flow-restricting device(s) at the Master Meter vault(s). Said device(s) shall be capable of controlling the flow rate, if applicable, to the Receiving Party within the rates set forth in Exhibit A. The Receiving Party shall not be responsible for charges based on deliveries at flow rates greater than the flow rates directed by Receiving Party in writing or as stated in this Agreement.

5.4 The Furnishing Party shall own and maintain the Furnishing Party's water system, including but not limited to any interconnection facilities, water lines, pump station and treatment plant facilities necessary to serve the Receiving Party as required by this Agreement up to the Master Meter(s). The Furnishing Party shall own the Master Meter(s), Master Meter Vault(s), Backflow Prevention Assembly, and flow and pressure control facilities, which shall be managed, administered, operated and maintained exclusively by the Furnishing Party. For the purpose of determining operation and maintenance responsibility, the Furnishing Party shall be responsible up to and including the outlet valve(s) on the Receiving Party's side of the Master Meter(s).

5.5 The Receiving Party shall maintain complete and unilateral control over the Receiving Party's system operations. The Receiving Party agrees that it will, at all times, to the extent practicable in the Receiving Party's reasonable discretion operate its water distribution system on the Receiving Party's side of the Master Meter(s) so as not to unreasonably interfere with service to others dependent upon the Furnishing Party for a supply of water. The Receiving Party agrees that it will, to the extent practicable in the Receiving Party's reasonable discretion, operate its facilities, especially any pumping or storage facilities, in correlation with operation of the Furnishing Party's facilities and will install and use such devices, including telemetry, as are necessary to effectuate correlation; provided, however, that Greeley shall not be obligated to pay for the installation of any physical changes to its water distribution system that will benefit only District customers within the District's service area.

5.6 The Parties agrees to maintain all facilities within their respective water systems in good repair and to make such replacements as may be necessary to keep the facilities in proper operating condition at all times.

5.7 The Parties shall cooperate with each other in acquiring any easements and other permits or approvals necessary to accomplish and place into effect this Agreement and for the construction of any necessary facilities.

5.8 Nothing in this Agreement shall be interpreted as creating an "Integrated System" within the meaning of the Colorado Primary Drinking Water Regulations, 5 CCR 1003. Each Party owns its own water system and each is a separate and independent system from the other.

ARTICLE 6 MASTER METERS

6.1 The Furnishing Party shall read the Master Meter(s) at monthly intervals under its own meter reading schedule. If requested by the Receiving Party, the Furnishing Party shall give the Receiving Party notice of any Master Meter reading and allow a Receiving Party representative to be present and observe. For all Master Meter reads performed by Greeley, as the Furnishing Party, it shall deliver the Master Meter reads to the District, on or before a date mutually agreed to by the Parties, in order for the District to calculate the net monthly flow amount as provided in Section 7.1.

6.2 At least once every five years, the Furnishing Party shall test and calibrate the Master Meter(s) at the Furnishing Party's cost. At anytime, upon the Receiving Party's written request, the Furnishing Party shall make or cause to be made a special meter test at the Receiving Party's cost. The Furnishing Party shall notify the Receiving Party in advance of any Master Meter test and allow a Receiving Party representative to be present and observe.

6.3 The readings of any Master Meter, which has been disclosed by tests conducted pursuant to American Water Works Association standards to be inaccurate, shall be corrected from the beginning of the monthly billing period immediately preceding the billing period during which the tests are made in accordance with the percentage of inaccuracy found by such tests.

6.4 If any Master Meter shall fail to register for any period, the Receiving Party and the Furnishing Party shall agree as to the amount of water furnished during such period and the Furnishing Party shall render a bill therefore. If no agreement can be reached, the billing shall be based upon historical usage data.

6.5 If at any time the Receiving Party desires to change the location of any Master Meter vault(s), the Furnishing Party will attempt to accommodate such request if, in the reasonable opinion of the Furnishing Party, such relocation will not detrimentally affect the Furnishing Party's water system in any manner and only upon the condition that Receiving Party shall be responsible for any and all costs and expenses thereof.

ARTICLE 7 RATES AND CHARGES

7.1 The District shall bill Greeley, in monthly intervals, based on Greeley's net monthly water usage. The net monthly usage shall be determined by the difference between Greeley's total monthly water usage and the District's total monthly water usage. If Greeley's total monthly usage is less than the District's, Greeley shall be given a credit that shall be applied to the next monthly billing cycle. In the event that Greeley has a monthly credit on December 31st of any year this Agreement is in effect,

the same amount shall be paid in full by the District to Greeley by January 31st of the following calendar year.

7.2 The District will adopt water service rates sufficient to totally and fully reimburse the District for all costs of furnishing water under this Agreement. Any portion of the rate that is identified as a recovered return on investment shall be limited to 4.5%. The District may adjust the charges to be made for the use of water hereunder. The rates charged to Greeley shall be directly related and limited to the cost incurred by the District in furnishing water to Greeley as fairly determined by the District. The charges provided for in this paragraph shall remain in effect until the District deems it necessary to raise or lower the charges for the water, in accordance with section 7.3. In addition to any other rate or charge herein provided, Greeley shall pay all applicable fees, and such other rates, tolls, charges or combination thereof as the District may, from time to time, in the exercise of its lawful authority impose consistent with this Article and Article 1, Title 32 of the Colorado Revised Statutes.

7.3 The District will, not less than once, but not more than two times in each calendar year, review the Plant Investment Fee and the rates for potable water furnished hereunder. If necessary and consistent with Sections 7.1 and 7.2 hereof, the District shall adjust such rates based upon actual usage and audit figures to produce sufficient revenues to maintain and operate the system necessary to serve Greeley and to establish and maintain reasonable reserves for operation and maintenance.

7.4 The District shall provide Greeley written notice of any expected rate change or any projected operation, maintenance or capital improvement cost that will affect the rates to be paid by Greeley as follows:

7.4.1 The District shall notify Greeley of a proposal for an increase in the rate charged to Greeley at least thirty days prior to the Board Meeting at which formal action on such proposal is scheduled;

7.4.2 The District shall notify Greeley of any new rate within ten days after the District has adopted it; and

7.4.3 The new rate to be charged to Greeley shall not become effective sooner than thirty days after it has been adopted and shall not apply to water delivered by the District on or before the effective date.

7.5 Billing for each month shall be made on or about the last day of the month and payment is due on the tenth day of the following month. Any bill not paid within sixty days of the payment due date shall be delinquent, and Greeley shall pay an additional delinquent fee of one and one-half percent of the unpaid monthly billing per month. If Greeley refuses or fails to pay any bill within sixty days of the payment due date, the District may discontinue delivery of potable water hereunder upon ninety days written notice to Greeley.

7.6 If Greeley's annual water usage does not equal or exceed the total minimum annual amount of water, as stated in Exhibit A, for all Master Meters furnishing water to Greeley, the District shall bill Greeley for the balance due in January of the following year.

7.7 For water service customers within the North Greeley Service Area, Greeley and the District shall establish their own separate rates, fees, and raw water requirements in accordance with the legal procedures and policies applicable to each entity.

ARTICLE 8

INCREASES IN PEAK DEMAND; TRANSFER OF CUSTOMERS; AND EXCLUSION OF TERRITORY FROM THE DISTRICT'S SERVICE AREA

8.1 The Parties have consulted with each other concerning the North Greeley Service Area using the following criteria: natural drainage patterns, topography, existing installations of capital facilities, the probable future needs of customers, the most cost-efficient means for delivering water service, and considerations which reduce the cost of service or result in higher quality of service to the customer. Based on the foregoing, the Parties agree that Greeley shall be responsible for providing water service to new customers within the North Greeley Service Area and, except as provided in this Agreement, the District shall not provide water service to new customers in the North Greeley Service Area.

8.2 The District presently provides water service to a number of customers within the North Greeley Service Area. Existing customers will continue to be served by the Party presently providing water service, except as provided for herein or as otherwise mutually agreed upon in writing by the Parties.

8.3 The District shall refer to Greeley any request it receives for water service within the North Greeley Service Area. Upon receipt of the referral, Greeley will determine whether it intends, or has the infrastructure in place, to provide water service to the applicant. Greeley shall provide written notice of its determination to the applicant and to the District as soon as possible but no later than ninety days after receipt of the application. If Greeley declines to provide water service to the applicant, then the District may provide water service.

8.4 As Greeley extends water service to new development, but prior to annexation by Greeley, Greeley and District may transfer existing District customers to Greeley's water system within the North Greeley Service Area, if Greeley determines that it intends, or shall have infrastructure in place, to provide water service to the existing customer.

8.5 When existing District customers are transferred to Greeley, the District shall permanently transfer to Greeley one unit of CBT per equivalent three-quarter inch tap transferred. In addition, the District shall credit Greeley with one gallon per minute

Plant Investment Fee per equivalent three-quarter inch tap transferred. Greeley shall, in turn, purchase from the District the annual usage of that tap at a Master Meter. The annual usage shall be set at 120,000 gallons per equivalent three-quarter inch tap. Both the annual use and the Plant Investment Fee credit shall be reflected in Exhibit A.

8.6 If Greeley expects additional demand above the peak demand of the transferred customer(s) as established in section 8.5, Greeley shall make written request to the District for the furnishing of additional water to meet such additional expected demand. Upon receipt of such written request, the District shall have thirty days to notify Greeley in writing of its decision and terms to supply such additional water. If the District decides to furnish such additional water, Greeley shall provide the Raw Water Requirements and pay the then existing Plant Investment Fee adopted by the District for each additional one gallon per minute beyond the peak demand amount specified in Exhibit A.

8.7 If the District expects additional master meters, water usage, or demand above the peak demand identified in Exhibit A upon the effective date of this Agreement, the District shall make written request to Greeley for the furnishing of additional water to meet such additional demand. Upon receipt of such written request, Greeley shall have thirty days to notify the District in writing of its decision and terms to supply such additional water. If Greeley decides to furnish such additional water, the District shall provide Greeley a Plant Investment Fee credit for each additional one gallon per minute peak demand requested by the District. Greeley may, in turn, assign or apply such credit at any Master Meter, identified in Exhibit A, that is furnishing water to Greeley as Receiving Party.

8.8 Following annexation of property located within the North Greeley Service Area and upon receipt of notice of intent to exclude territory, the District shall transfer to Greeley, within one year from the date of notice, all of the District's customers and infrastructure within the annexed area. Such transfer shall include all facilities, which are owned or maintained by the District, necessary to provide such service from the Master Meter(s) to the point of connection at the customer's facilities, including but not limited to mains, local distribution lines, meters, meter pits, booster pumps, easements, permits, or rights of way and valves. Such transfer shall not include any transmission lines or associated facilities, distribution lines or associated facilities, easements, permits, or rights of way the District determines are necessary to serve other existing or potential customers of the District. As consideration for such transfer, the following provisions shall apply:

8.8.1 In accordance with the District's Master Plan, the District anticipates serving an average of two three-quarter inch equivalent taps per every five acres of its service area that is located within the North Greeley Service Area. The Parties agree that the District's anticipated annual usage shall equal an annual use of 240,000 gallons of water per five acres. Therefore, as Greeley excludes portions of the District's territory from the North Weld Service Area, Greeley shall compensate the District by purchasing a minimum annual amount of water from

the District at Master Meters. The minimum annual amount of water shall be calculated based on the greater of either (1) the product of 240,000 gallons of water per five acres of all territory excluded in accordance with this section 8.8 or (2) the total annual usage of each equivalent three-quarter inch tap transferred to Greeley in accordance with section 8.5. The minimum annual amount shall be reflected in Exhibit A.

8.8.2 Greeley shall provide the District fair compensation for all facilities transferred from the District to Greeley, taking into account depreciation. The value determination provisions set forth in C.R.S. § 32-1-502, as the same may be amended from time to time, shall govern such compensation.

8.8.3 Greeley shall be responsible for all reasonable costs, excluding attorney fees, associated with the transfer of customers from the District to Greeley within the North Greeley Service Area. However, in the event litigation is pursued against Greeley and/or the District by a transferred customer, the parties shall be responsible for their own costs, expenses, attorney fees and awards, if any.

8.8.4 Exclusion of land from North Weld's territory shall occur before any further subdivision of the property.

8.9. At the time of transfer of customers and facilities to Greeley, North Weld shall provide the best available and known information regarding locations of water lines, meters, appurtenances, and other associated facilities to the best knowledge of the District. Greeley and the District agree to cooperate in preparation and transfer of such information as the Parties deem necessary. North Weld maintains responsibility for locating any of their active or abandoned lines including all asbestos-cement pipe. Any North Weld line transferred to Greeley becomes Greeley's responsibility for One-Call locating. North Weld will for two years assist Greeley in location of any transferred lines, including potholing and establishing position with GPS.

ARTICLE 9 TAXES AND EXCLUSION

9.1 Portions of the North Greeley Service Area are within the District's service area. Pursuant to Colorado Law, the District has authority to assess property taxes by imposition of a mill levy upon property within the District; however, at the time of this Agreement, no such assessment or levy is in place.

9.2 The District agrees that there shall be no property tax assessment or mill levy on any properties within the boundaries of the District that may be located in the North Greeley Service Area and annexed by Greeley. If it is determined to be necessary and/or required by law, the District agrees to exclude from its service area all such property located in the North Greeley Service Area and annexed by Greeley.

ARTICLE 10 GENERAL TERMS AND REMEDIES

10.1 This Agreement shall be effective on the date first above written and remain in effect on a perpetual basis unless terminated as provided in this Article.

10.2 The Parties agree to act in good faith and to the best of their ability in taking all steps necessary to fully implement the terms and conditions of this Agreement, including the execution and delivery of such other documents, certificates, agreements and other writings and the taking of such other actions as may be necessary or desirable to consummate or implement this Agreement. The Parties agree that this Agreement shall be construed and enforced as the fully integrated expression of their contract with respect to the matters addressed herein. No express or implied covenants not specifically set forth shall be deemed to be a part of this Agreement. The Parties expressly aver that no representations other than those specifically set forth in this Agreement have been relied upon by either Party to induce it to enter into this Agreement.

10.3 The Parties shall use reasonable diligence to provide a constant and uninterrupted supply of water, except for interruption or reductions due to: (1) Uncontrollable Forces; (2) operations or devices installed for water system protection; and (3) maintenance, repair, replacement, installation of equipment, or investigation and inspection of the water system, which interruption or reductions are temporary, and in the opinion of the Furnishing Party, necessary. Excepting cases of emergency, the Receiving Party will be given reasonable advance notice of such interruptions. Neither Party shall be considered in default under this Agreement if prevented from fulfilling any obligations by reason of Uncontrollable Forces. A Party rendered unable to fulfill its obligation by reason of Uncontrollable Forces shall exercise due diligence to remove such inability with all reasonable dispatch.

10.4 The Parties have implemented their own respective water conservation plans and shall not be required to adopt the other Party's conservation plan in whole or in part.

10.5 The invalidity or un-enforceability of any provision of this Agreement shall not affect or impair any other provision unless material to the performance of either Party.

10.6 Neither Party may assign or transfer all or any part of this Agreement without the prior written consent of the non-assigning Party which consent will not be unreasonably withheld.

10.7 In the event of a material breach of any provision of this Agreement by any Party, which is not corrected within one year from the date of notice of the breach, the non-defaulting party may either terminate or pursue litigation for specific performance of this Agreement. However, if this Agreement is terminated by the District due to an uncorrected material breach of any provision of this Agreement by Greeley, the District

will not cease water service to Greeley until after two years from the written date of notice of the breach. In the event of an uncorrected material breach of any provision of this agreement by the District, Greeley may terminate this Agreement due to said material breach in which case termination shall be effective two years from the written date of the notice of the breach.

10.8 The Parties agree that, in addition to any other remedies allowed by law consistent with this Agreement, the provisions of this Agreement may be specifically enforced in a Court of competent jurisdiction and, in any judicial action, the unsuccessful party agrees to pay all reasonable costs of such action as actually incurred by the successful party, including attorney fees. Venue for any action shall be the District Court in and for Weld County, Colorado.

10.9 None of the remedies provided for under this Agreement need to be exhausted or exercised as a prerequisite to either party's pursuit of further relief to which it may be entitled. No Party shall waive its rights hereunder by failing to exercise its rights; any such failure shall not affect the right of such Party to exercise at some future time the rights not previously exercised.

10.10 In the event Greeley desires to terminate this Agreement, Greeley shall give written notice to the District of such intent in accordance with the notice provisions of this Agreement. Twenty years after the giving of such notice, District shall no longer furnish water to the North Greeley Service Area through the Master Meters. However, during this twenty year period Greeley shall be obligated to take and pay for, or in the alternative pay for, the minimum annual volume of water defined by Exhibit A. All other provisions and terms of this Agreement, including but not limited to the establishment and descriptions of the North Greeley Service Area, shall remain in effect.

10.11 It is expressly understood and agreed that the terms and the enforcement of the terms and conditions of this Agreement, and all rights of action relating to such enforcement, are strictly reserved to the undersigned Parties and nothing in this Agreement shall give or allow any claim or right or cause of action whatsoever by any other person not included in this Agreement. It is the express intention of the undersigned Parties that no person and/or entity, other than the undersigned Parties, receiving services or benefits under this Agreement shall be deemed any more than an incidental beneficiary only.

10.12 Any notice, demand or request delivered by mail, in accordance with this Agreement shall be deemed given seventy-two hours after the same is deposited certified mail, in any post office or postal box regularly maintained by the United States Postal Service addressed to the District at P.O. Box 56, Lucerne, CO, 80646 and to Greeley, attention to the Director of the Water and Sewer Department, at 1100 10th Street, 3rd Floor, Greeley, CO, 80631. The addresses may be changed at any time by similar notice.

10.13 Nothing herein shall constitute a multiple fiscal year obligation pursuant to

Colorado Constitution Article X, Section 20. Notwithstanding any other provision of this Agreement, Greeley's obligations under this Agreement are subject to annual appropriation by the City Council of the City of Greeley. Any failure by the Greeley City Council to annually appropriate adequate monies to finance Greeley's obligations under this Agreement shall terminate this Agreement in accordance with paragraph 10.10 at such time as such then-existing appropriations are to be depleted. Notice shall be given promptly to the District of any failure to appropriate such adequate monies.

10.14 To the extent legally possible, each Party shall indemnify and hold the other Party harmless from and against any and all liability, loss, damages, costs and expenses, including reasonable attorney fees, arising from the identifying Party's negligence, including but not limited to, negligent delivery of water at rates or pressures which exceed the maximum pressure or do not meet the minimum pressure established on Exhibit A. By such agreement to indemnify and hold each other harmless, neither Party waives any defenses and immunities to third Parties, which it would otherwise be entitled under the Colorado Governmental Immunity Act.

10.15 This Agreement, along with all exhibits and addendums and amendments hereto, encompasses the entire agreement of the parties, and supersedes all previous understandings and agreements between the parties, whether oral or written. The terms of the Water Supply Agreement dated August 26th, 2011 ("August 26th, 2011, Agreement"), shall remain in effect, except that all exhibits attached to the August 26th, 2011, Agreement shall be incorporated and reflected in the corresponding exhibit that are attached hereto and thus superseded hereby. The parties hereby acknowledge and represent, by affixing their hands and seals hereto, that said parties have not relied on any representation, assertion, guarantee, warranty, collateral contract or other assurance, except those set out in this Agreement, made by or on behalf of any other party or any other person or entity whatsoever, prior to the execution of this Agreement. The parties hereby waive all rights and remedies, at law or in equity, arising or which may arise as the result of a party's reliance on such representation, assertion, guarantee, warranty, collateral contract or other assurance, provided that nothing herein contained shall be construed as a restriction or limitation of said party's right to remedies associated with the gross negligence, willful misconduct or fraud of any person or party taking place prior to, or contemporaneously with, the execution of this Agreement.

IN WITNESS WHEREOF, the Parties have executed this Agreement the day and year first above written.

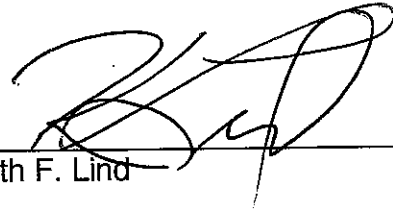
ATTEST:

NORTH WELD COUNTY WATER DISTRICT

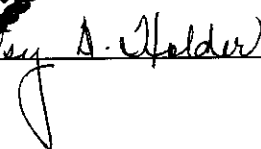
By: Robert Ambrecht
Secretary

By: Charles Achziger
President

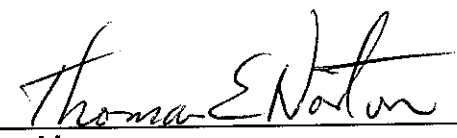
APPROVED AS TO LEGAL FORM:
Lind & Ottenhoff LLP

By: 
Kenneth F. Lind

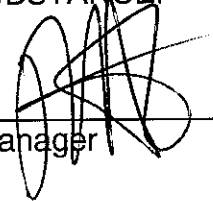



City Clerk

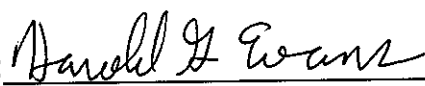
CITY OF GREELEY, COLORADO

By: 
Mayor

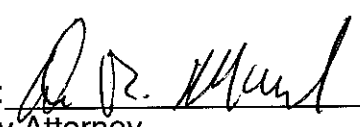
APPROVED AS
TO SUBSTANCE:

By: 
City Manager

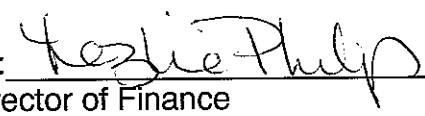
APPROVED:
Greeley Water & Sewer Board

By: 
Chairperson

APPROVED AS TO LEGAL FORM:

By: 
City Attorney

APPROVED AS TO AVAILABILITY OF FUNDS:

By: 
Director of Finance

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE _____

NO ENCLOSURE X

ITEM NUMBER: 7

TITLE: CAMERON PEAK FIRE WATERSHED
RECOVERY & IMPACT MITIGATION &
FUNDING UPDATE

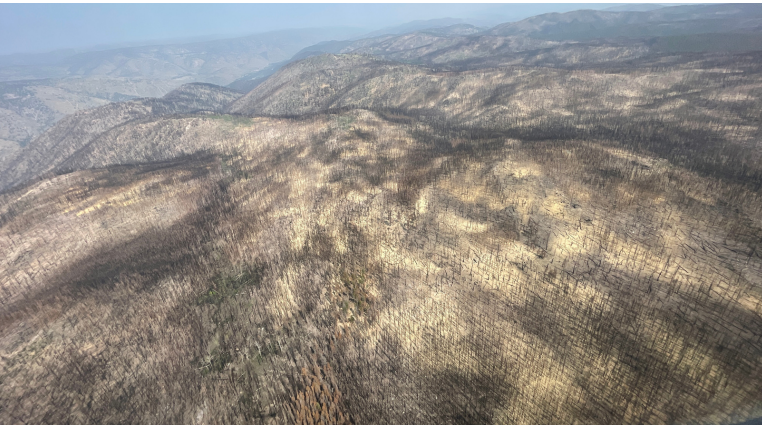
RECOMMENDATION: INFORMATION ONLY

ADDITIONAL INFORMATION: Staff will give an update on Cameron Peak fire mitigation funding and recovery efforts.

Aerial Mulching – Cameron Peak Fire

Summary of Activities – August 9–17, 2021

Cameron Peak Fire Recovery Partners (Coalition for the Poudre Watershed Coalition, City of Greeley, City of Fort Collins, with support from partners USFS and CWCBC) continued aerial mulching operations with Western States and the contractor team. **The team mulched approximately 1,200 acres on priority USFS and private lands locations in the Sheep Creek and Bennett Creek drainages.** The Bennett Creek drainage contains a research location for a CSU and USFS Rocky Mountain Research Station study that will evaluate the long-term impact of aerial mulching on water quality. CPF Recovery Partners will resume aerial mulching later this month or early next month in the Black Hollow drainage, once pending funding has been secured.



Percent of Funds Used
(~\$6.3 million total)



Acres Mulched:
Aug. 9–17, 2021

~1,200

Total Acres Mulched

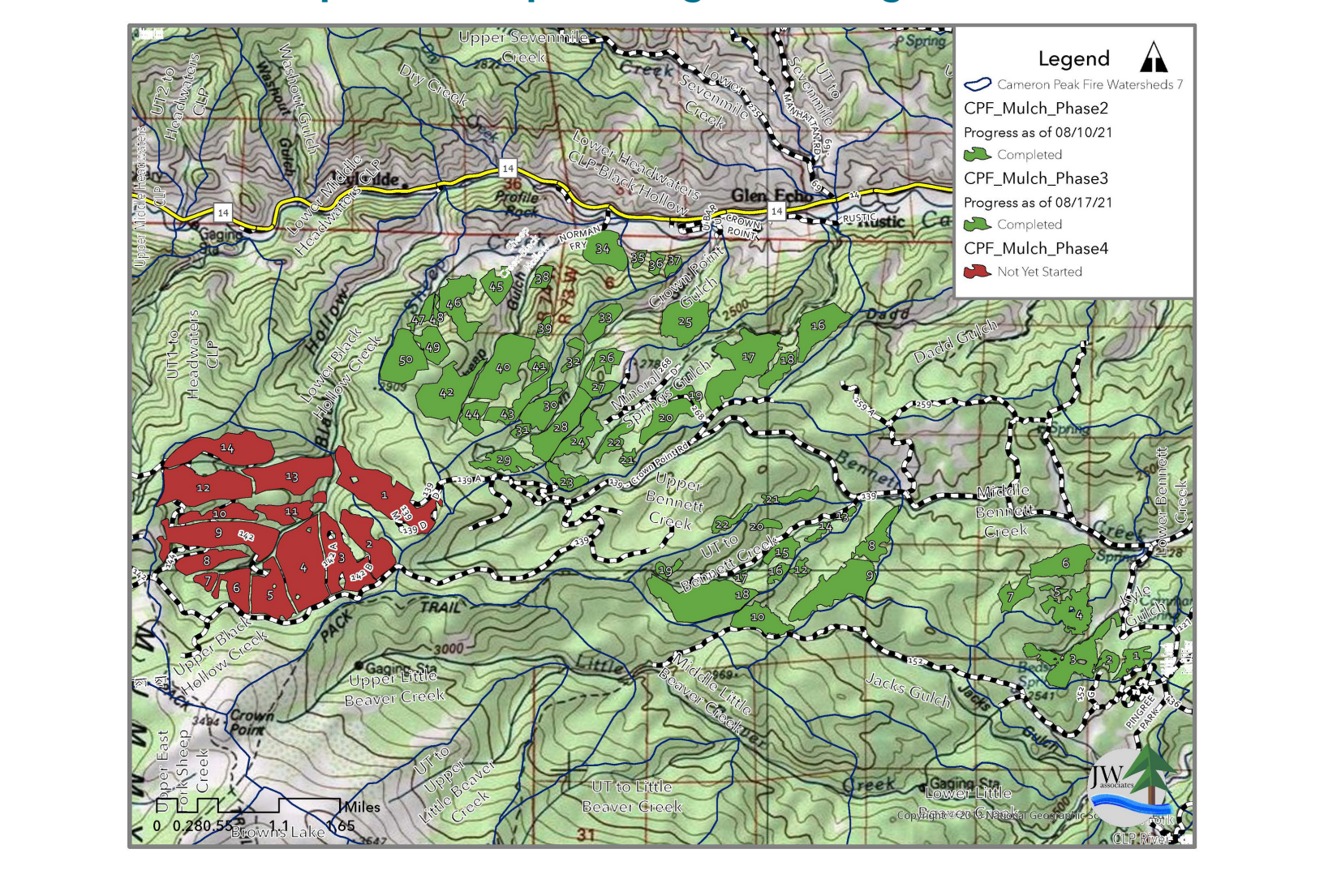
2,590

Acres Inspected:
Aug. 9–17, 2021

~1,200

Total Acres Inspected

2,550



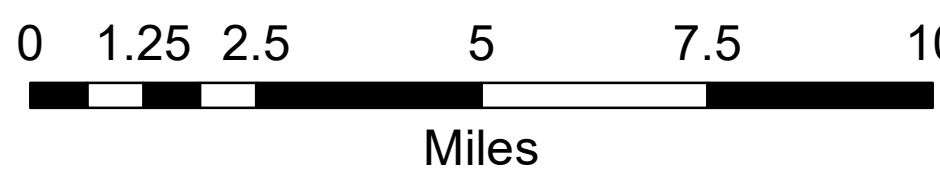
Project Manager:
Shayna Jones
shayna@poudrewatershed.org

**City of Greeley, Colorado
Raw Water and Treatment System**

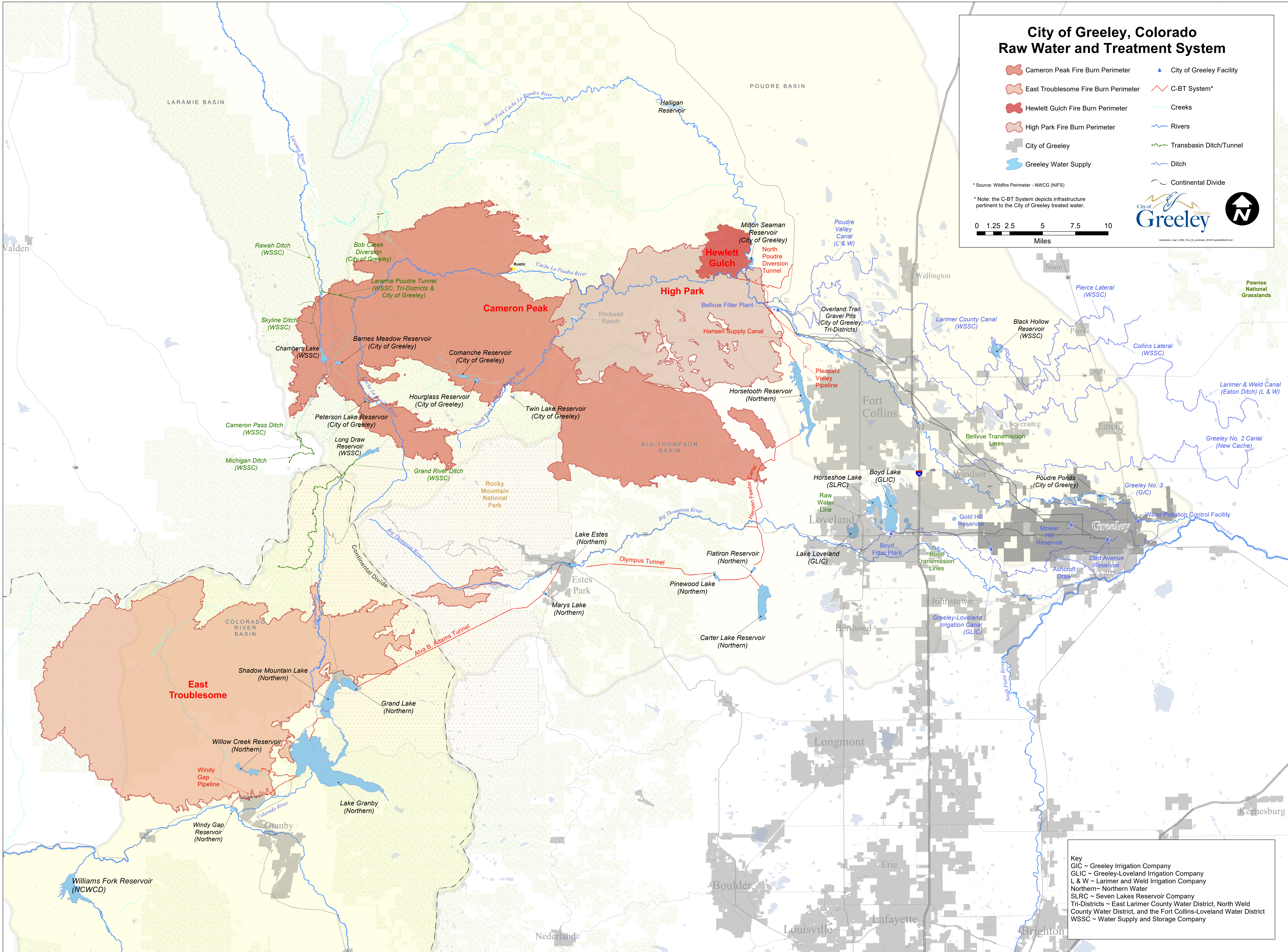
- | | |
|--------------------------------------|--------------------------|
| Cameron Peak Fire Burn Perimeter | City of Greeley Facility |
| East Troublesome Fire Burn Perimeter | C-BT System* |
| Hewlett Gulch Fire Burn Perimeter | Creeks |
| High Park Fire Burn Perimeter | Rivers |
| City of Greeley | Transbasin Ditch/Tunnel |
| Greeley Water Supply | Ditch |
| | Continental Divide |

* Source: Wildfire Perimeter - NWCG (NIFS)

* Note: the C-BT System depicts infrastructure
pertinent to the City of Greeley treated water.



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Key
GIC ~ Greeley Irrigation Company
GLIC ~ Greeley-Loveland Irrigation Company
L & W ~ Larimer and Weld Irrigation Company
Northern ~ Northern Water
SLRC ~ Seven Lakes Reservoir Company
Tri-Districts ~ East Larimer County Water District, North Weld
County Water District, and the Fort Collins-Loveland Water District
WSSC ~ Water Supply and Storage Company

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE X NO ENCLOSURE

ITEM NUMBER: 8

TITLE: REVIEW NON-POTABLE DEVELOPMENT
 WATER POLICY UPDATE

RECOMMENDATION: INFORMATIONAL ONLY

ADDITIONAL INFORMATION:

Greeley has a long history of utilizing non-potable water to irrigate turfed areas using the extensive ditch systems within the City and meeting Greeley's long-term water resource needs will require further expansion of non-potable use. Staff has developed non-potable policy that will require the installation of non-potable infrastructure in new development in most cases. Staff has been communicating the proposed non-potable policy with key stakeholders and has made some revisions to align the policy better with the update to Greeley's Development Code. This presentation will update the Board on the policy changes and the feedback staff has received. Board's approval of the policy will be considered in October with City Council subsequently considering the necessary City Code changes.

Non-Potable Development Policy

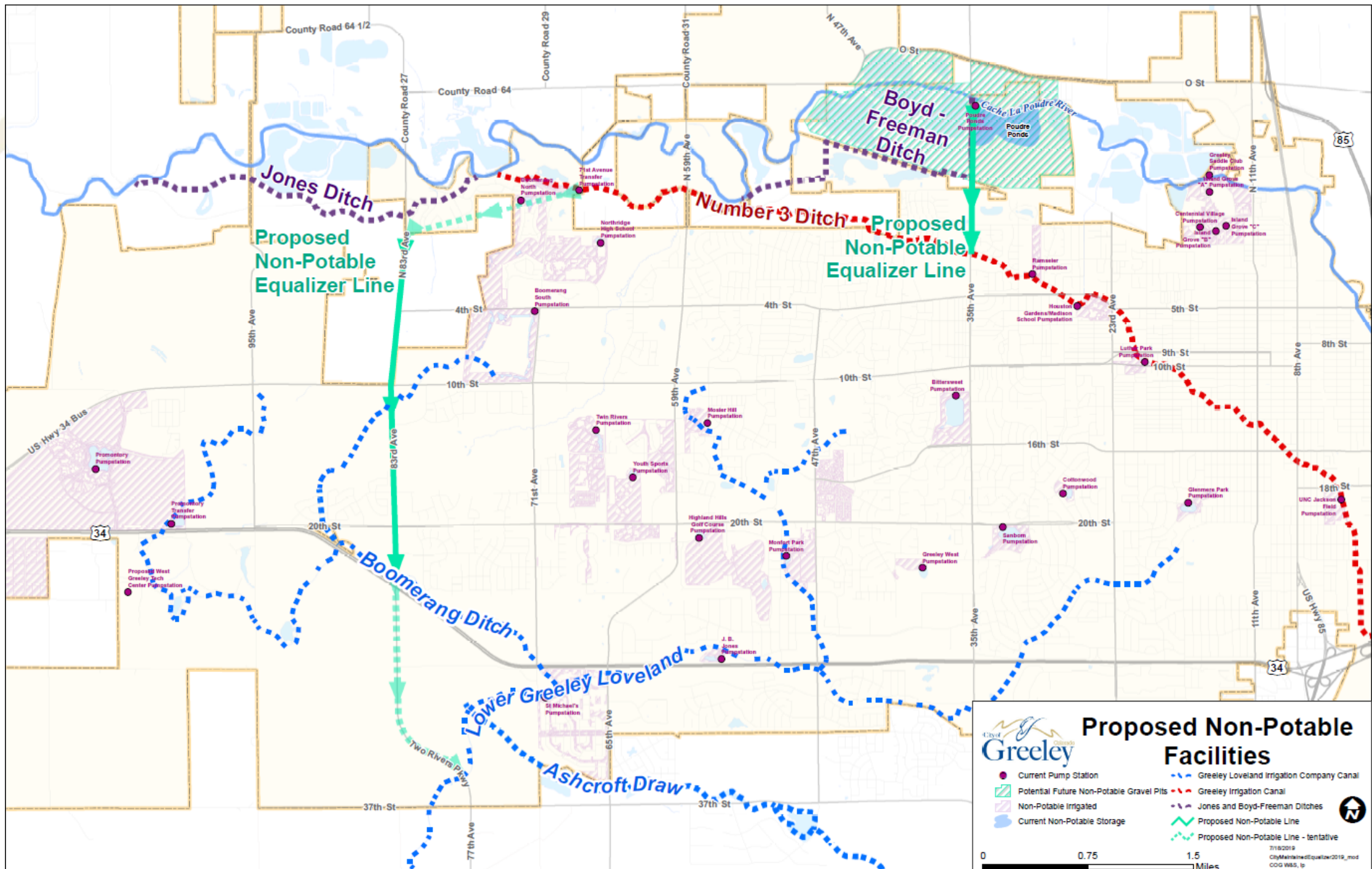
Water and Sewer Board| September 15, 2021



Background and Need

- Current non-potable system
 - 31 pump stations, 10 wells and 90,000 feet of pipe
 - Primarily serves city-owned properties (parks, golf courses, and cemeteries), with some adjacent private customers
 - Constructed by city to reduce peak treatment demands in late 1990s and 2000s
- Sources of supply: GIC, GLIC, exchanged wastewater effluent, Poudre Ponds





Background and Need

- Potable water prices are rapidly escalating. Non-potable water sources are \$25,000 to \$40,000 cheaper per acre-foot
- Non-potable is used (required) elsewhere in Northern Colorado because the economics work
- Need non-potable supply to meet Greeley's long term water demand
 - Current NP demand: 2,500 AF
 - Master Plan volume: 9,000 AF
- **New policy needed to expand non -potable adoption**



City Non-Potable Infrastructure Costs

- 20 year projection ~ \$150 million (net present value)
 - Reflects the backbone infrastructure and projected city contributions to oversizing or new development incentives
 - *The proposed policy would reduce the City's non-potable infrastructure commitments in the CIP*
 - Does **not** reflect the cost for converting developed areas identified in the master plan to non-potable

Policy Details

- Non-Potable is mandatory
 - For all developments with >2 acres of irrigated common area
 - House to house if lot size > 13,000 square feet
- No non-potable plant investment fees
- Increased yield for dedicating certain water shares
- Greeley Irrigation Company shares can only be dedicated for non-potable
- Acceptance of other water sources historically used to irrigate developed area



Proposal Details

- Developer pays for all non-potable infrastructure
- Reduce potable plant investment fees by varying percentages, depending on size of lot and how much non-potable installed
- Most common solution in the region
 - Windsor, ELCO, North Weld, Evans, and Brighton all reduce potable PIFs (varying percentages) if a non-potable system is installed

Revisions to Proposed Policy

- Aligned the proposal details with the Development Code revisions being done by Community Development
 - Residential building types were refined with lot standards that defined lot open space requirements
 - Changes reflect trends toward smaller lots and more variety in housing types

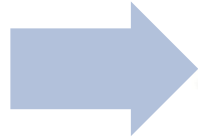
Revisions to Proposed Policy

Residential Building Type	Lot Size	Non-Potable in Common Area	Non-Potable House to House
Row House	>1,000 s.f.	50%	N/A
Detached House - Small Format	1,500-3,000 s.f.	50%	50%
Detached or Multi-Unit House - Small Lot	3,000-4,500 s.f.	40%	50%
Detached or Multi-Unit House - Medium Lot	4,500-6,000 s.f.	30%	50%
Detached or Multi-Unit House - Standard Lot	6,000-13,000 s.f.	25%	50%
Detached House-Estate Lot	>13,000 s.f.	N/A	50%

Process Timeline

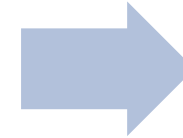
May/June

- Policy Discussion - WS Board
- Community Development Engagement



July-
September

- Developer Workshop
- Planning Commission
- City Council Work Session



October-
November

- WS Board Approval
- City Council Ordinance Change

Non-Potable Conversion Policy

- When the City brings non-potable lines to a developed area
 - The landowner can convert their irrigation system to non-potable realize the full reduction in rates (70% of potable)
 - The landowner can continue to use potable water
 - The landowner can allow the City to hire a contractor to convert their irrigation system to non-potable and they will repay the City the contractor's cost over 3 years
 - A lien is placed on the property until the City is repaid
 - Customer immediately pays non-potable rates

Questions?



DRAFT: Non-Potable Water Supply
Program Policies
September, 2021

Non-Potable Supply Required

For residential developments only, the development shall use non-potable water for irrigation of:

- Common spaces unless the residential development has less than 2 acres of irrigated common space
- Individual lots unless the lot size is less than 13,000 square feet

For commercial or industrial developments only, the development shall use non-potable water for irrigation unless the commercial or industrial development has less than 2 acres of common space irrigation

For developments that are not feasible to immediately connect to the City's non-potable system, but that the City has identified as being feasible for non-potable service, land will be identified and set aside for the installation of non-potable infrastructure when Greeley Water and Sewer deems it feasible.

Special consideration may be made for development projects where engineering limitations make including infrastructure for non-potable water infeasible. The evaluation and all calculations must be provided to the Water & Sewer Director or designee for approval in order to waive the requirement.

Cash-In-Lieu (CIL)

Non-potable CIL is equal to potable CIL.

- New single-family residential non-potable requirements are calculated on the pervious area of the lot and the lot size minus the footprint of the house and other impervious areas. The development HOA or Metro District will be served by master meters as determined by Greeley Water and Sewer.

Credit for Irrigation Company Shares

Non-potable credits for dedicated shares on land that has been historically irrigated are:

- Greeley Loveland Irrigation Company: 12 AF/share
- Loveland and Greeley Reservoir Company: 40 AF/share
- Seven Lakes Reservoir Company: 20 AF/share
- Greeley Irrigation Company: 10.3 AF/share (With Dry up Covenant/Agreement)

Cost of Connection & Cost Sharing

The cost of developing non-potable infrastructure shall be borne by the developer.

- Furthermore, the City, at the discretion of the Water and Sewer Director or designee, shall pay to upsize non-potable facilities in cases when the non-potable system can be used to serve more areas than a single development.
- No non-potable Plant Investment Fees (PIF) will be charged

Potable PIFs will be reduced by the following percentages for Single Family lots where non-potable is installed

Residential Building Type	Lot Size	Non-Potable in Common Area	Non-Potable House to House
Row House	>1,000 s.f.	50%	N/A
Detached House-Small Format	1,500-3,000 s.f.	50%	50%
Detached or Multi-Unit House-Small Lot	3,000-4,500 s.f.	40%	50%
Detached or Multi-Unit House-Medium Lot	4,500-6,000 s.f.	30%	50%
Detached or Multi-Unit House-Standard Lot	6,000-13,000 s.f.	25%	50%
Detached House-Estate Lot	>13,000 s.f.	N/A	50%

Water Budget

All newly installed non-potable accounts shall be assigned a Water Budget.

Drought Restrictions

During times of drought declaration, non-potable developments will be subject to the same watering restrictions and surcharges as potable, Water Budget accounts.

Public Ownership of Non-Potable Systems

No private ownership of non-potable systems in new development is allowed south of the Poudre River.

Private non-potable systems north of the Poudre River will be allowed if Water and Sewer chooses not to be the non-potable provider, however the non-potable system shall be constructed according to City of Greeley construction standards. The City, at the discretion of the Water and Sewer Director, shall become the owner and operator of the non-potable system when financially prudent and desirable to do so.

Shoulder Season Taps

The City shall furnish, without raw water fees or PIFs, potable water taps to supply the non-potable irrigation system during times when the non-potable supply is unavailable (i.e., early spring and late fall shoulder seasons). Shoulder taps will be removed or retired from service if the non-potable system is expanded to serve shoulder seasons. Shoulder season taps are generally provided for parks, large HOAs, and large commercial customers. It is not intended for residential use.

- If potable water is used during periods when non-potable supplies are available, the potable supplies will be subject to the potable raw water surcharge.

Water Rates

Each non-potable system is provided a tiered annual water budget. (Implemented when new utility billing software is live.)

- Water tier volumes for non-potable systems will be the same as the potable water budget program.
 - Water Budget tier = up to 100% of water budget
 - Inefficient Use tier = 101%-130% of water budget
 - Excessive Use tier = 131%-150% of water budget
 - Unsustainable Use tier = >150% of water budget
- Tiered rates for use of non-potable water supplies will be 70% of the residential water budget rates, which are determined annually by the Water & Sewer Board.

Raw Water Dedication

Type of Water Use*	Vegetation Type
High Water Use	Bluegrass, Turf, Annuals, Willow Trees, etc.
Medium Water Use	Drip Irrigation, Fruit Trees, Common Ornamentals, etc.
Low Water Use	Native Plants, Succulents, Drought Tolerant Plants, etc.
*Refer to water use information for plant watering needs from “Greeley WaterWise Landscaping Criteria”	

Type of Water Use	Dedication Requirement
High Water Use	3.0 acre feet/acre
Medium Water Use	2.3 acre feet/acre
Low Water Use	1.6 acre feet/acre

- A service commitment will be recorded with the Weld County Clerk and Recorder that specifies the volume of raw water dedicated (or paid through cash-in-lieu) for the non-potable water use.
 - Because the establishment of landscaping may require extra watering, exceeding the service commitment during the first full calendar year of water service for the new non-potable customer will not be considered as an overage and no raw water surcharge payment will be due.
- If water use for a new non-potable customer exceeds its service commitment in any calendar year, the owner will be required to pay a raw water surcharge for the volume of water exceeding the service commitment.
- If water use in a new non-potable customer exceeds its service commitment in any two consecutive years, the owner will be required to purchase additional water through a Cash-in-Lieu payment.
 - The Cash-in-Lieu payment will be for the two-year average volume of water used above the service commitment.
 - Service commitment pricing is based on the current Cash-in-Lieu of water prices for Greeley.

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE X NO ENCLOSURE

ITEM NUMBER: 9

TITLE: APPROVE AND RECOMMEND THE 2021 NON-
POTABLE WATER MASTER PLAN

RECOMMENDATION &
PROPOSED MOTION: APPROVE AND RECOMMEND TO CITY
COUNCIL ADOPTION OF THE 2021 NON-
POTABLE WATER MASTER PLAN AND
INCORPORATION OF THE SAME BY
REFERENCE AS AN AMENDMENT TO THE
2018 COMPREHENSIVE PLAN AND TO THE
PLANNING COMMISSION
RECOMMENDATION OF THE SAME TO CITY
COUNCIL

ADDITIONAL INFORMATION:

Water and Sewer Department launched the process of completing a Non-Potable Water Master Plan in 2018 with CDM Smith. CDM has extensive master planning experience with Greeley completing work in 2008 and 2014. The two primary goals of the project are to reduce use of potable water for irrigation and increase non-potable use. The development of the master plan started with inventorying all 45 different wells and pump stations within the existing system. This critical step allowed the project team to evaluate the existing system for deficiencies and where the system has capacity for expansion. Next step in the project, development of the existing system model for all sites based on historical usage, piping configurations, and pumping capacity. The project progressed to utilizing the system model to look at existing conditions of the system and planning for the expansion of the system in the 5-year, 20-year, and full system build-out time frames. The expansion of the system was coordinated with the RAS BBC report and matched the middle adoption rates. The adoption scenarios are dependent on final City policy's and should be developed to meet or enhance the adoption rates. The expansion of the system focused on expanding the non-potable system at existing and future parks as the hubs of the systems. The final steps included developing CIP projects throughout the system and making sure it was coordinated with the other two Water & Sewer master plan projects and other City Department CIP projects. The project team conducted work sessions with Westminster, Denver Water, Evans, and Windsor to learn about their systems and examine opportunities for collaboration. The final

aspects of the project included coordinating outreach efforts to discuss the planned master plans with different community members and groups interested in participating in reviewing the City's draft master plan and providing critical input or comments. This different feedback and input has now been incorporated into the master plan final report completed in June 2021.



FINAL

Greeley Non-Potable Water Master Plan

June 2021



**CDM
Smith**

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Acronyms and Abbreviations

\$/LF	dollars per linear foot
AF	acre-feet
AFY	acre-feet per year
BBC report	City of Greeley Population and Water Demand Projections
cfs	cubic feet per second
CMMS	computerized maintenance management system
C-H	commercial high intensity
C-L	commercial low intensity
CIP	capital improvement plan or program
City's Specifications	City of Greeley Design Criteria and Construction Specifications
Dev	development
EDR	engineering development review
EPS	extended period simulation
ENR-CCI	Engineering News Record Cost Construction Index
fps	feet per second
ft	feet
GIS	Geographic Information System
gpm	gallons per minute
gpm/acre	gallons per minute per acre
gpd/acre	gallons per day per acre
GPS	Global Positioning System
GLIC	Greeley-Loveland Irrigation Company
GIC	Greeley Irrigation Company
HOA	homeowners association
HDD	horizontal direct drilling
in	inches
I-L	industrial low intensity
I-M	industrial medium intensity
I-H	industrial high intensity
LREGA	long-range expected growth area
MG	million gallons
MGD	million gallons per day
NPMP	Non-Potable Water System Master Plan
NP	non-potable
OPCC	opinion of probable construction cost
O&M	operations and maintenance
psi	pounds per square inch
Poudre Ponds	Poudre Ponds Complex Project
PLC	Programmable Logic Controller
RTU	Radio Telemetry Unit
R-E	residential estate
R-H	residential high density
R-L	residential low density

R-M	residential medium density
SA	Service Area
SSMP	Sanitary Sewer Master Plan
SCADA	supervisory control and data acquisition
VFD	Variable Frequency Drive
W/S	City of Greeley Water and Sewer Department
WTDMP	Water Transmission and Distribution Master Plan

Definitions

Adoption rate - an estimate of the amount of land that could potentially be irrigated that is expected to use NP irrigation; this value is based on customer type and should only be used for planning level estimates, not design

Buildout - the theoretical point in time where the City has experienced complete development within the LREGA, expected to be sometime after year 2090

Bulk area - the total area of a parcel, including both the irrigated area and the impermeable area (such as buildings and parking lots)

Capital improvement - a recommended construction project to improve or expand the water system, summarized in the capital improvement plan

Conversion area - a previously developed parcel that is currently irrigated by potable water, but may consider switching to NP irrigation in the future; the amount of irrigated area for this type of customer is typically known

Diurnal curve - a pattern of peaking factors applied to a base demand (the typical demand for an area) that shows how demands vary by pattern throughout the day; the diurnal curve typically includes the peak hour

Extended period simulation - a hydraulic modeling methodology that shows how the system performs over a set timescale, during which demands and operating conditions can vary

Flow factor - value used to estimate the water demand that a given amount of land will produce once it's developed, depending on its land use

Hub-and-spoke - methodology for NP infrastructure design where a future pond and pump station (usually located at a park) is not connected to other pump stations and becomes an individual system with distribution piping extending out from it

Irrigated area - the portion of a parcel that requires irrigation (i.e. only permeable area)

Long range expected growth area - the limits of the City's expected growth and where it plans to provide water and wastewater services

Non-potable water - raw (untreated) water from agricultural ditches used to irrigate certain areas within the City

North of the River - the geographic area north of the Poudre River and within the City's LREGA

Opinion of probable construction cost - the costs borne by the contractor to construct a capital project

Peak day demand - the maximum demand anticipated to occur during a one-day period expressed as the daily average

Peak hour demand - the average demand anticipated during a maximum one-hour period for a typical year; this is considered to be a conservative value for infrastructure sizing

Peak month demand - the average demand anticipated during a maximum one-month period for a typical year, typically experienced during July

Planning horizon - a timeframe used to estimate expected demands and infrastructure needs; for this master plan, the three planning horizons are 5-year (2025), 20-year (2040) and buildout

Service area - the general geographic area that is served by or expected to be served by an individual NP system

Shoulder month/season - the periods in early spring and late fall where NP customers begin to require some irrigation water, but the agricultural ditches are not yet operational, occasionally resulting in the NP system being supplied by potable water

Shoulder tap - locations where the NP system can take water from the potable water distribution system during the early spring and late fall shoulder months

Summer water use - the amount of water used in summer months, defined as July and August

Tier 1, 2 or 3 - tier of information used to distribute future flow parameters to currently undeveloped areas or areas of redevelopment

Undeveloped land - land that does not currently have development, but may be eligible for NP irrigation when construction is completed in the future; the amount of irrigated area for this type of customer is unknown and therefore estimated.

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Executive Summary

The City of Greeley, Colorado (the City) is in Weld County approximately 60 miles northeast of Denver, east of Fort Collins and Loveland. The City is the twelfth largest city in Colorado and has developed into a cultural and academic hub, hosting educational institutions such as the University of Northern Colorado and Aims Community College. The City offers an affordable cost of living with many options for housing and economic growth. The City's population grew from 20,354 in 1950 to an estimated population of 108,175 in 2019. The City continues to experience strong growth in population through both infill and also through an expansion of residential, industrial, and commercial development within the City's defined service area.

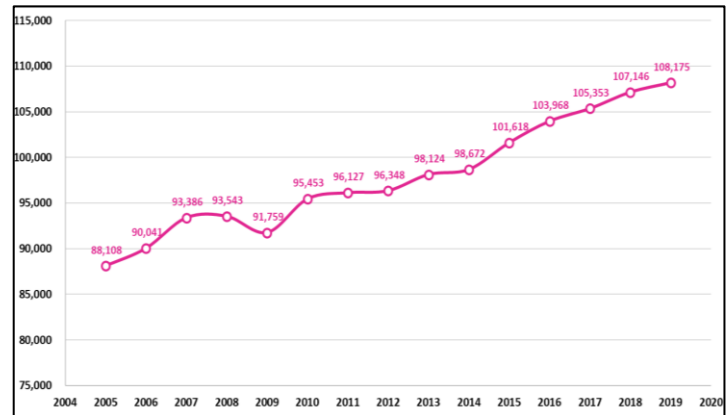


Figure ES-1 Historical Population for the City of Greeley

The 2020 Non-Potable Water System Master Plan (NPMP) is intended to plan for infrastructure growth and develop a capital improvement plan (CIP) for the City's non-potable (NP) irrigation system. The CIP plan will help the City plan for future development and costs both in the short-term and long-term. Continuing to grow and improve the NP system works in tandem with other water conservation efforts to decrease the total potable demand of the City as it experiences ongoing growth through buildout in a semi-arid environment.

ES.1 Greeley Master Plan Integration

To address existing and future system needs, the City developed their 2004 Non-Potable Water Master Plan to forecast water resources and infrastructure needs. The NPMP update occurred concurrently with updates to both the City's Sanitary Sewer Master Plan (SSMP) and the City's Water Transmission and Distribution Master Plan (WTDMP). This provided an ability to use consistent data for population and growth, common planning horizons and an integrated planning approach to CIP development. This approach to integrated master planning provides the City with a defensible and coordinated CIP and allows for the scheduling of CIP projects in ways that minimize the impacts to citizens.

Figure ES-2 illustrates the critical points of coordination between the three master plans.

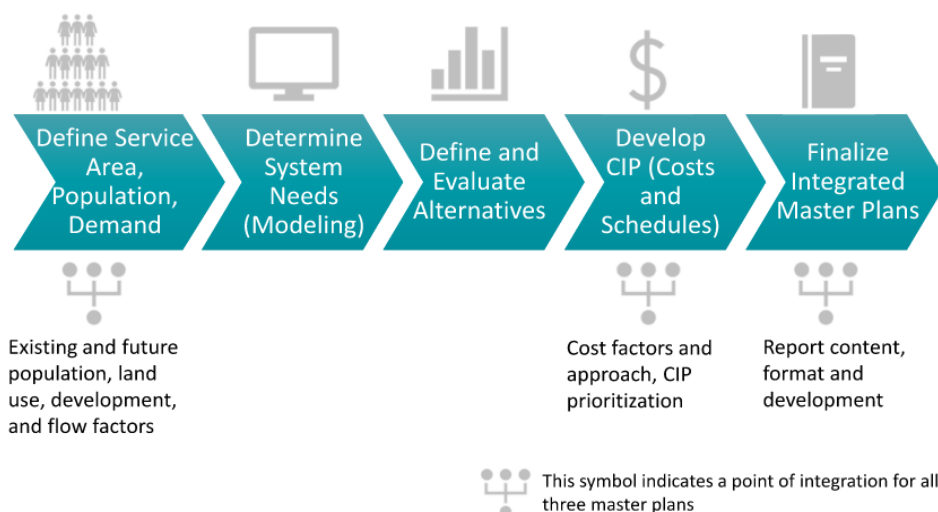


Figure ES-2 Master Plan Approach and Integration with Other Master Plans

ES.2 Existing System Information and Data Collection

The City's NP irrigation system is unique and advanced, particularly for raw water suppliers. In the current system, raw (untreated) water is supplied throughout the City via a system of agricultural ditches and gravity-fed pipes. The water typically flows from these ditches into an intermediate pond before entering a pumped distribution system, which includes 37 disconnected pump stations. This type of system is sometimes referred to as a hub-and-spoke layout. Through this system, the City is able to serve over 100 customers. Growing the NP system and offsetting more potable demands with NP irrigation water is a key goal for the City's water and sewer department.

City-provided data, including mapping, asset information, planning data, development plans, draft policy, and historic records, were used to inform the development of the NPMP. Additionally, a field inventory was conducted to supplement the City's existing geographic information system (GIS) database by geolocating key NP infrastructure, such as pumps, ponds, and valves. All of this information was compiled into a hydraulic model that accurately reflects the existing system. Existing demands were based on billing data and pumping records from July and August in 2018 and 2019 and were calibrated to available supervisory control and data acquisition (SCADA) data.

ES.3 Administrative Considerations

In addition to infrastructure construction and expansion efforts, certain administrative improvements can help the City continue to grow its NP system and act as a leader in potable water conservation and sustainable irrigation practices along the Front Range. The most significant change the City could make to promote NP irrigation would be implement and enforce the revised NP policy, included in **Appendix K**.

Historically, comprehensive data collection has been difficult for NP systems nationwide. Additional studies or data collection, along with more standardized record keeping practices, can

help the City keep track of the overall system. This can include enforcing standards related to construction record drawings, developing and maintaining an internal record-keeping system, creating a plan for regular updates to the GIS database, and/or implementing a computerized maintenance management system (CMMS) for NP infrastructure. Installing SCADA systems at new or rebuilt pump stations can also help with data collection and control.

ES.4 Service Area, Population, and Demand Projections

The City's Long-Range Expected Growth Area (LREGA) is the area where it plans to provide water and sewer services. The future population, and resulting demands, that were distributed over the LREGA for each planning horizon used the "middle" projection from the *City of Greeley Population and Water Demand Projections* (BBC Research & Consulting 2018), referred to as the BBC report, as shown in **Figure ES-3**. Because the 2075 projection does not represent the buildout year for the City within the LREGA boundary, a buildout population was extrapolated using planning data and factors.

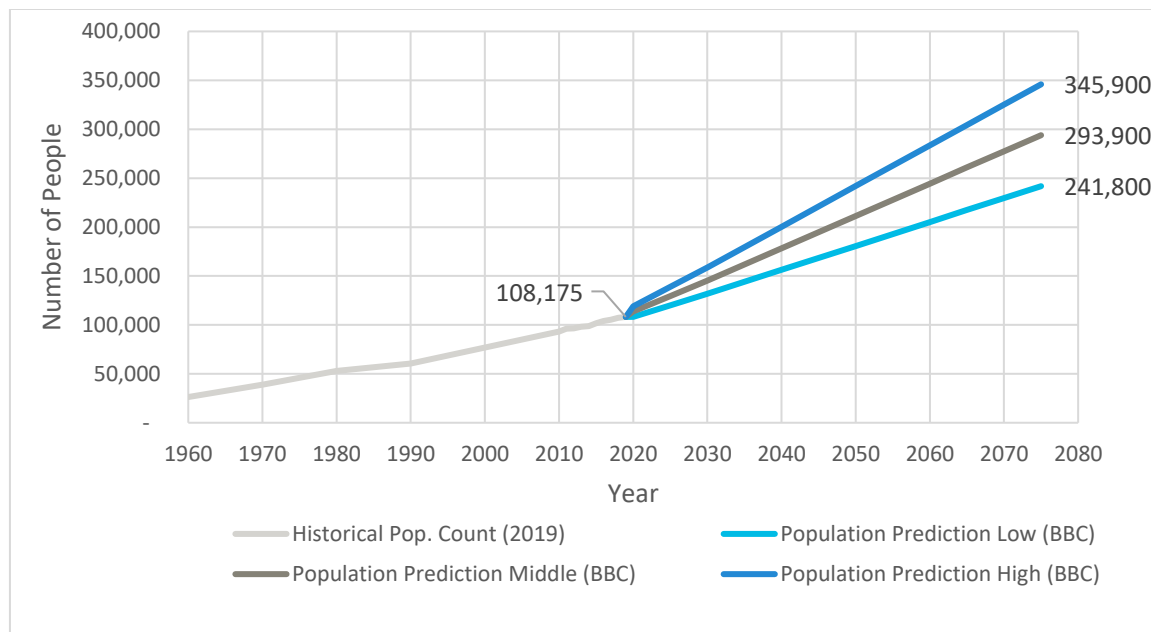


Figure ES-3 Historical and Projected Population

Future NP demand comes from two places: 1) undeveloped land that will use NP irrigation when it develops, and 2) existing areas that may switch from potable to NP irrigation, which are referred to as "conversion areas." Undeveloped land was identified and categorized by land use as part of the WTDMP and SSMP; these land use designations were used to predict NP demand in these areas. Conversion areas were based on the City's knowledge of potential customers; conversion areas are only potential areas that may benefit from NP irrigation but are currently not required to convert.

A set of flow factors were developed that show the expected demand per acre of a certain land use category, or customer type. There are flow factors for irrigated land (defined as the actual acreage of land that is irrigated on a given lot) and bulk land (defined as the total acreage of a

given parcel, including impervious areas). However, just because an area could use NP irrigation, it does not guarantee that it will. To account for this, an adoption rate was applied to each flow factor, which designated the amount of that land that is expected to actually use NP irrigation. The adoption rates were coordinated with the BBC report. It is therefore recommended to use this NPMP for infrastructure planning, and the BBC report for all water resources planning. The total demand projected for both the potable and NP water systems is shown by planning horizon in **Table ES-1**.

Table ES-1 Peak Month Demand by Planning Horizon

Planning Horizon	Total Water Demand (MGD)	Potable Water Demand (MGD)	Non-Potable Water Demand (MGD)
Existing	47.3	46.0	1.3
2025	51.8	49.4	2.4
2040	61.0	56.9	4.1
Buildout	106.3	93.5	12.8

While the NPMP is primarily focused on planning for infrastructure needs based on peak summer demands, it is also important for the City to plan for the total annual water demands through buildout. Water conservation methods, such as improved landscaping practices and the encouragement and adoption of NP water for irrigation, may help reduce the City's annual water demands. The BBC report focused on developing three alternative scenarios for annual water demands. The total annual demands developed for the WTDMP under the NP offsets demand scenario at buildout are captured in **Table ES-2**.

Table ES-2 NPMP Annual Demand Projections at Buildout

Demand	Total Water Demand (AFY) ²	Potable Water Demand (AFY)	NP Water Demand (AFY)
Existing	30,500	28,600	1,900
Future Demands	33,500	28,300	5,200
New I-H Users (6)	10,300	10,300	0
Total	74,300	67,200	7,100

¹ Potable demand shown in this table is for the NP offsets demand scenario.

² AFY = acre-feet per year

ES.5 Model Evaluation and Infrastructure Planning

The existing and future NP system was analyzed using both a hydraulic model (InfoWater) and various desktop analyses that used existing and projected future demands against the system requirements, as outlined in the City's Design Criteria and Construction Specifications, 2008 (City's Specifications). These requirements are summarized in **Table ES-3**.

Table ES-3 System Evaluation Criteria

Metric	Evaluation Criteria	Comments
Piping		
Pressure	70-100 pounds per square inch (psi)	
Velocity	< 5 feet per second (fps)	
Headloss	< 10 ft / 1,000 ft	
Minimum Main Size	8 inches	Not specified in the City's Specifications, City preference for future.
Maximum Inlet Pipe Headloss	6 inches	Not specified in the City's Specifications, but generally considered to be good practice.
Pumping		
Pumping Capacity	120% of peak hour	
Irrigation Window Assumed	10 hours / day	Not specified in the City's Specifications. For irrigation-only pumps, does not apply to transfer pumps.
Pump Station Layout	No standby pump, however low flow pump required	
Ponds		
Storage Volume	4 times peak day + losses	
Demands		
Daily Irrigation Application Rate	24 gallons per minute per acre (gpm/acre)	Peak season metric used in the design of irrigation systems per the City's Specifications. This value is appropriate for areas where the exact irrigated acreage is known but is not appropriate for planning-level estimates of bulk undeveloped land.

Table ES-4 summarizes the existing infrastructure and identified deficiencies by buildout. Typical deficiencies include a pump station being undersized by buildout, undersized inlet or outlet piping, or undersized taps.

Table ES-4 Summary of Existing System Analysis

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Balsam Park	N/A	290	51	51	No deficiencies were identified for this pump station.
Bella Romero Elementary	N/A	330	109	109	No deficiencies were identified for this pump station.
Bittersweet Park	N/A	1,000	854	1,160	Small diameter pipes may be producing high headloss; limited data is available on pipe sizes. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Boomerang	Boomerang North	1,500	769	769	No deficiencies were identified for this pump station.
	Boomerang South	1,500	694	0	This system is being replaced by the Boomerang Regional Pump Station.
	Boomerang Transfer	1,800	951	621	Some of the Boomerang transfer lines are undersized; this issue will be resolved by the construction of the Boomerang Regional Pump Station.
	<i>Boomerang Regional Pump Station</i>	<i>3,260</i>	<i>N/A</i>	<i>2,716</i>	<i>This new pump station is part of a larger redevelopment project and will replace the existing Boomerang South pump station. This pump station is identified as a CIP project.</i>
	North Ridge Transfer	1,800	936	936	No deficiencies were identified for this pump station.
	North Ridge School	2,700	1,205	1,752	No deficiencies were identified for this pump station.
	Poudre River Ranch	175	205	205	The lines to Poudre River Ranch and the pump station do not meet hydraulic design criteria but do not appear to hinder system performance. While there are no recommended changes, additional demand should not be added to this area without upsizing.
Cottonwood Park	N/A	115	69	69	No deficiencies were identified for this pump station.
Delta Park	N/A	95	52	52	No deficiencies were identified for this pump station.
East Memorial	N/A	319	314	440	Bringing on all potential undeveloped and conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
Glenmere Park	N/A	180	135	304	The inlet may be undersized; inlet pipe size data was not available for this system. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Greeley West Park¹	N/A	2,000	72	861	No deficiencies were identified for this pump station.
Highland Hills Golf	N/A	2,001	1,792	1,792	No deficiencies were identified for this pump station.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Island Grove and Saddle Club	Island Grove West	600	605	605	No deficiencies were identified for this pump station.
	Island Grove East	700	401	401	No deficiencies were identified for this pump station.
	Saddle Club	300	72	138	No deficiencies were identified for this pump station.
Jackson Field Sports	N/A	400	258	317	No deficiencies were identified for this pump station.
Josephine Jones Park	N/A	115	106	161	Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Linn Grove Cemetery	N/A	350	95	122	No deficiencies were identified for this pump station.
Luther Park	N/A	530	492	498	The small pipe diameter (4”) at the outlet does not meet hydraulic design criteria; while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Madison Elementary and Houston Gardens	Houston Gardens	125	310	310	While this system appears to be operating over the pump design capacity, it does not hinder system performance, as this system is designed for low pressures.
	Madison Elementary	500	90	93	No deficiencies were identified for this pump station.
Monfort	N/A	2,400	1,423	1,745	The inlet is slightly undersized (10” diameter); while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Peakview Park	Mosier Hill	800	681	681	The pipes at Peakview Park have a small diameter (as low as 4”) and do not meet hydraulic design criteria. Although this does not appear to significantly hinder system performance, the City may consider upsizing if other work is already being done in this area.
Promontory Park	Main	2,100	1,270	1,866	No deficiencies were identified for this pump station.
	Transfer	1,600	1,651	1,651	While this pump station sometimes operates over its design flowrate, it is not significant enough to warrant upsizing. If additional demands in this area increase transfer station operations, expanding the length of time the transfer station operates each day will likely maintain an acceptable flowrate.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Ramseier	N/A	450	734	739	Additional evaluation of this site is needed as outlet pipe size and SCADA data were not available. While current modeling shows that the system is operating over the design head, the peaking factor may be lower than the system-wide diurnal curve, resulting in lower peak demands.
Sanborn Park	N/A	500	268	289	Small diameter lines may be causing high headloss; limited data is available on pipe sizes.
St. Michaels	N/A	1,120	1,121	1,167	This pump station may be undersized. Additional evaluation should be conducted to determine if demand management is effective and whether the pumps can be upsized without replacing the entire station.
Tech Center	N/A	N/A	N/A	N/A	This area is currently only served by a shoulder tap. A pump station is necessary to transition it to NP irrigation (future service area SA-14).
Youth Sports Center	Youth Sports	1,200	941	941	The inlet line does not meet hydraulic design criteria but does not appear to hinder system performance. This line should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
	Twin Rivers Park	4,200	1,314	1,692	No deficiencies were identified for this pump station.

¹ Greeley West Park is planned for replacement before 2025. The values shown in the table represent the design for the new pump station.

Table ES-5 summarizes anticipated future infrastructure through buildout. It is important to note that the majority of future infrastructure will be built by development as the City grows. Future infrastructure is expected to continue using a hub-and-spoke methodology, where future parks are equipped with ponds and pump stations to serve as the hubs of future NP systems.

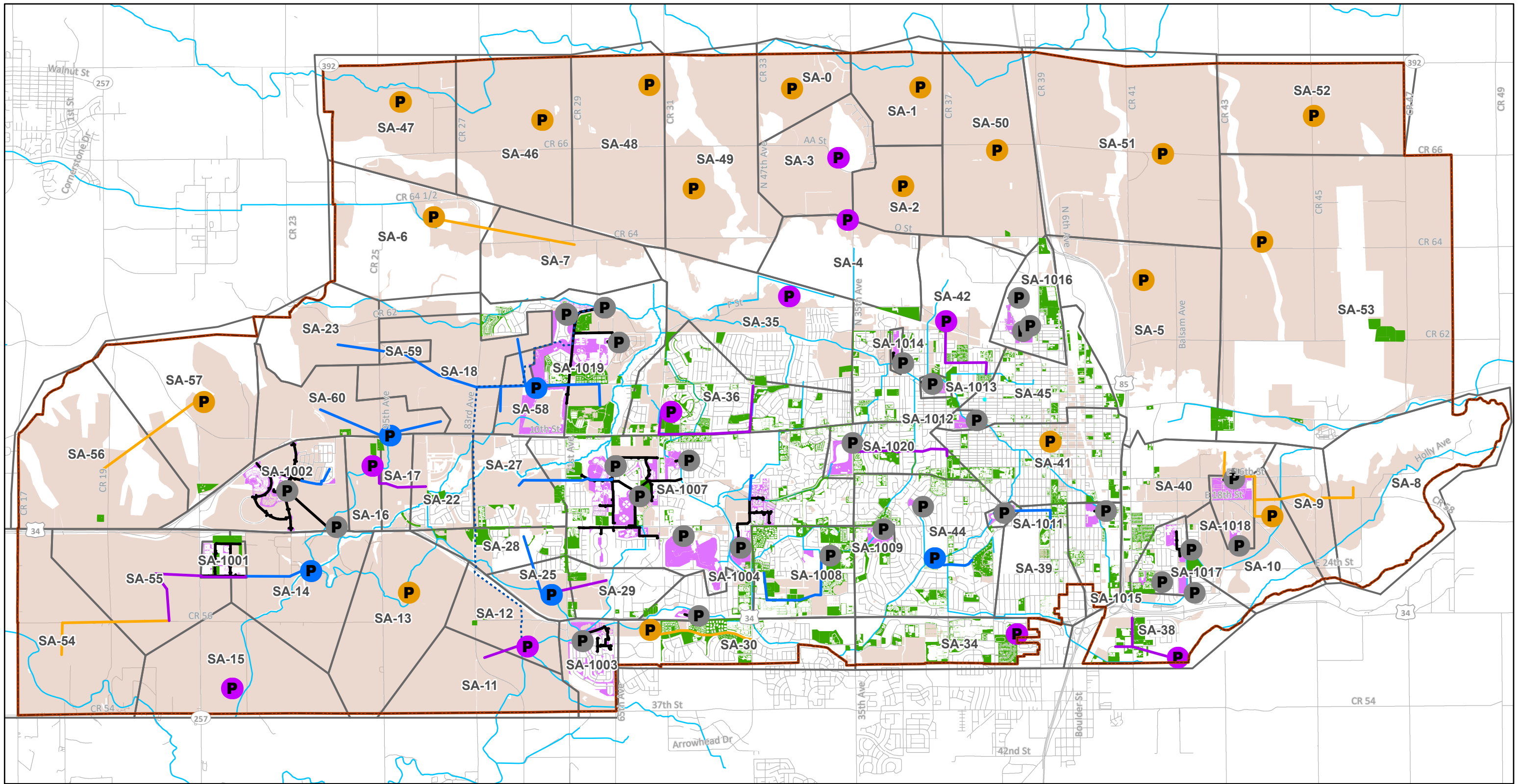
Table ES-5 Proposed Infrastructure by Planning Horizon

Planning Horizon	Pump Stations ¹	Storage in Ponds (AF) ²	New Pipeline (ft) by Diameter					Total
			8-inch	10-inch	12-inch	16-inch	30-inch	
Existing	37	Unknown	23,100	17,600	12,200	3,400 > 12"		90,000
2025	5	35.1	21,800	18,500	0	19,000	26,700	86,000
2040	10	28.1	26,900	11,500	0	8,200	0	46,600
Buildout	18	75.7	28,300	1,000	200	14,800	0	44,300
Total New	33	139.0	77,000	31,000	200	42,000	26,700	150,200

¹ All new pump stations are expected to have a pond.

² AF = acre-feet

Figure ES-4 shows both the existing and future system by planning horizon. Pump station locations and pipeline alignments are approximate and schematic.



Legend

LREGA

Existing NP Irrigated Areas

Future NP Demand Parcels

Greeley Ditch

Existing Pump Station

2025 Pump Station

2040 Pump Station

Buildout Pump Station

Existing NP Pipes

2025 Proposed NP Pipes

2040 Proposed NP Pipes

Buildout Proposed NP Pipes

Upper Equalizer Project

Conversion Areas

Service Areas

NP System by Planning Horizon

Figure ES-4

Greeley Non-Potable Water System Master Plan



May 17, 2021



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ES.6 Capital Improvement Plan Projects and Schedule

The opinion of probable construction cost (OPCC) is the anticipated bid cost of a capital project. The project CIP costs include the OPCC and project implementation costs, such as planning and design, administration, and construction management. Assumptions made during CIP development can add to the variability of final bid project costs when compared to the planning level costs. The assumptions are necessary to capture the costs for project elements that cannot be defined at a planning level. Project costs were developed using modeled pipeline quantity estimates and data, then multiplied by unit cost estimates. During design development, the more specific data will be used to inform the design and the resulting project cost estimate. **Table ES-6** provides a breakdown of the different costing factor assumptions used for project implementation and contingency.

Table ES-6 Costing Factors for Construction Bid and Total CIP Project Costs

Category	Item	Costing Factor
Construction Bid Cost (includes infrastructure and contractor overhead, profit, bonds, and insurance)	Erosion Control/Stormwater Pollution Prevention ¹	2%
	Mobilization and Demobilization ¹	5%
	Contingency ²	35%
Project Implementation ³	Feasibility and Site Studies	9% for OPCC ≤ \$1 million 6% for OPCC of \$1 million to \$10 million 5% for OPCC > \$10 million
	Preliminary and Final Design	9% for OPCC ≤ \$1 million 6% for OPCC of \$1M to \$10 million 5% for OPCC > \$10 million
	Engineering Services During Construction	5%
Additional Project-Related Costs ³	Outside Construction Management - not used if OPCC is < \$1M	5%
	Outside Project Management - not used if OPCC value is < \$1M	3%

¹ Construction costing factors for erosion control/stormwater pollution prevention, mobilization, and demobilization are added to the subtotal of unit cost items.

² Contingency is 35% of the subtotal of the unit cost items and contractor born costs determined by costing factors.

³ Project implementation and additional project-related cost categories are determined as a percentage of the construction cost and part of the total CIP project costs.

ES.6.1 Identified CIP Projects

Table ES-7 summarizes the anticipated capital projects through the 5-year and 20-year planning horizons. Costs for some projects are shared proportionally across the City's water and sewer department, the City's parks department, and with development entities. The split shown in **Table ES-7** has been calculated from the anticipated total demands at buildout that each of these parties is responsible for. For each project these costs and splits will need to be refined during the development plan review process.

Table ES-7 Summary of CIP Projects

Projects	Funding Source ¹	Planning Start Year ²	Design Start Year ²	Construction Start Year ²	Total Cost ³	City of Greeley Water/Sewer	City of Greeley Parks	Development
5-Year Planning Horizon								
SA-44 Centennial Park	Service Expansion	W/S, Parks, Dev	2021	2022	\$5,030,000	\$3,488,100	\$1,379,300	\$162,600
Boomerang Regional Pump Station	Service Expansion	W/S, Parks, Dev	2021	2022	\$6,920,000	\$221,300	\$694,000	\$6,004,700
Boomerang Regional Phase 2	Service Expansion	W/S, Parks, Dev	2021	2022	\$2,390,000	\$76,400	\$239,700	\$2,073,900
Greeley West PS Replace	Service Expansion	W/S, Dev	2022	2023	\$7,470,000	\$6,161,400	-	\$1,308,600
Upper Equalizer Project	Shoulder Season Extension	W/S	2023	2024	\$25,620,000	\$25,620,000	-	-
SA-14 Tech Center Supply	Service Expansion	W/S, Dev	2025	2026	\$5,930,000	\$17,100	-	\$5,912,900
Promontory Park Expansion	Service Expansion	Development	2025	2026	\$720,000	-	-	\$720,000
Monfort Expansion	Service Expansion	W/S, Parks, Dev	2025	2026	\$500,000	\$245,300	\$76,000	\$178,700
Twin Rivers Expansion	Service Expansion	W/S, Parks, Dev	2025	2026	\$2,390,000	\$1,172,400	\$363,300	\$854,300
SA-38 1st Ave Pond	Service Expansion	W/S, Dev	2025	2026	\$3,590,000	\$2,881,600	-	\$708,400
SA-25 Westgate Regional Pump Station	Service Expansion	W/S, Parks	2026	2027	\$2,670,000	\$2,038,415	\$631,585	-
SA-25 Westgate Regional Phase 1	Service Expansion	Dev	2026	2027	\$1,160,000	-	-	\$1,160,000
SA-60 Lake Bluffs	Service Expansion	W/S, Dev	2026	2027	\$6,050,000	\$57,000	-	\$5,993,000
5-Year Subtotal					\$70,440,000	\$41,979,015	\$3,383,885	\$25,077,100
20-Year Planning Horizon								
SA-34 30th St/17th Ave	Service Expansion	W/S, Parks, Dev	2028	2029	\$2,880,000	\$1,932,500	\$281,200	\$666,300
Boomerang Regional Phase 3	Service Expansion	W/S, Parks, Dev	2029	2030	\$8,000,000	\$255,900	\$802,300	\$6,941,800
SA-4 35th Ave/O St	Service Expansion	W/S, Dev	2029	2030	\$1,170,000	\$262,400	-	\$907,600
SA-3 35th Ave/AA St	Service Expansion	Development	2030	2031	\$2,190,000	-	-	\$2,190,000
Bittersweet Park Expansion	Service Expansion	W/S, Parks, Dev	2030	2031	\$3,160,000	\$2,475,181	\$684,819	-
SA-35 44th Ave/F St	Service Expansion	W/S, Parks, Dev	2031	2032	\$2,580,000	\$166,000	\$658,300	\$1,755,700
SA-36 59th Ave/10th St	Service Expansion	W/S, Parks, Dev	2032	2033	\$8,190,000	\$3,810,800	\$2,569,500	\$1,809,700
SA-16 95th Ave/16th St	Service Expansion	W/S, Dev	2035	2036	\$5,260,000	\$205,300	\$610,300	\$4,444,400
SA-14 Tech Center Expansion	Service Expansion	W/S, Parks, Dev	2036	2037	\$3,460,000	\$10,000	-	\$3,450,000

Projects	Funding Source ¹	Planning Start Year ²	Design Start Year ²	Construction Start Year ²	Total Cost ³	City of Greeley Water/Sewer	City of Greeley Parks	Development
SA-15 37th St/SH-257 Pump Station	Service Expansion	W/S, Dev	2037	2038	\$3,880,000	-	-	\$3,880,000
SA-12 Cobblestone Regional	Service Expansion	Development	2038	2039	\$4,260,000	\$48,500	-	\$4,211,500
Glenmere Park Expansion	Service Expansion	W/S, Parks, Dev	2038	2039	\$2,200,000	\$1,427,916	\$603,228	\$168,856
SA-25 Westgate Regional Phase 2	Service Expansion	W/S, Dev	2039	2040	\$1,220,000	\$857,400	-	\$362,600
SA-42 23rd Ave/NW C St	Service Expansion	W/S, Parks, Dev	2040	2041	\$6,030,000	\$2,513,300	\$1,421,100	\$2,095,600
20-Year Subtotal					\$54,480,000	\$13,965,198	\$7,630,746	\$32,884,056
Total					\$124,920,000	\$55,944,212	\$11,014,631	\$57,961,156

August 2020 dollars as adjusted by Engineering News Record Cost Construction Index (ENR-CCI) were used for project OPCCs, total costs, and project fund allocations

¹ W/S: City of Greeley Water and Sewer Department, Parks: City of Greeley Parks Department, Dev: Development

² Project planning, design, and construction years are subject to change pending future project updates, development of projects, and/or schedule changes.

³ OPCC and total costs per project are subject to change pending future project updates, development of projects, and/or schedule changes.

ES.6.2 CIP Implementation Schedule

The CIP schedule implementation process considered several factors that influence a project schedule in addition to the hydraulic evaluation. The City provided the Water and Sewer 10-year CIP, public works CIP, and parks CIP to integrate with projects identified in the WTDMP for developing CIP implementation schedules.

The growth-driven projects will be funded by either the City or developer (or combination), depending on the project driver. Based on the 5- and 20-year CIP schedule, annual funding requirements for City NP projects from 2021 through 2040 are shown in **Figure ES-5**.

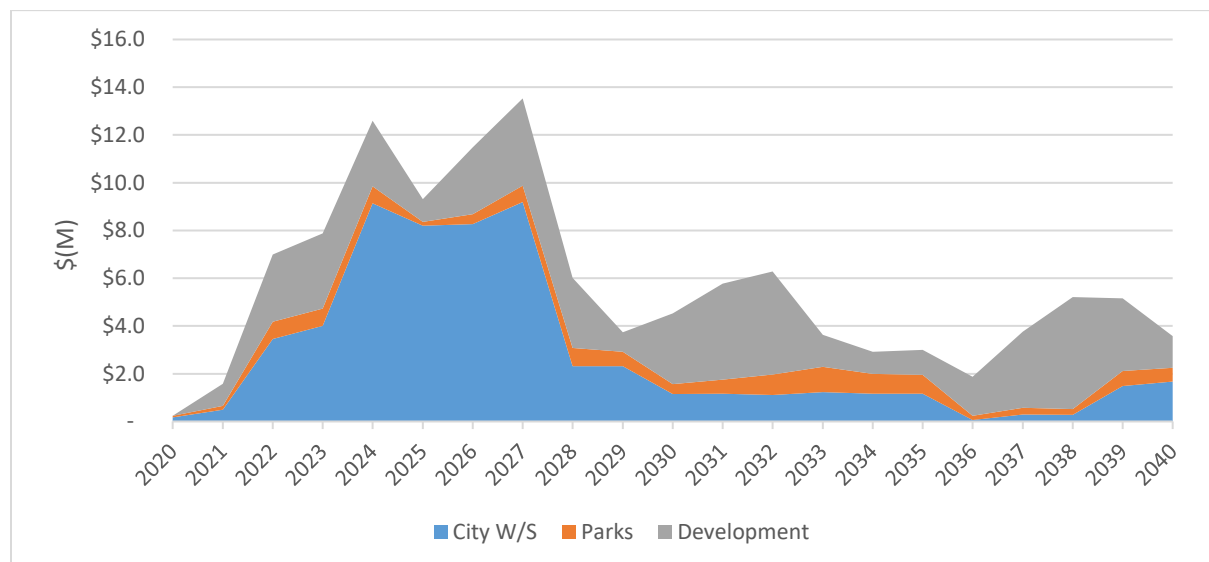


Figure ES-5 Annual NP Funding Projections by Fund

CIP costs are August 2020 dollars from ENR-CCI.

ES.7 Conservatism and Uncertainty in Planning

During master plan development, assumptions were made for existing and future conditions. These included population distribution and flow factors to develop water demand projections for growth and development under future conditions, along with considerations for extreme seasonal conditions that would emphasize higher demands while considering future water conservation planning to help reduce these impacts. The master planning assumptions trended toward conservative values to ensure the potable system was not undersized, which may result in the predicted demands being higher than actual. This NPMP analyzes the existing system and defines future needs, which should be validated by the City as new data becomes available.

The NP water system model, in conjunction with its potable water system companion model, is a tool for analyzing the existing system and defining future capacity needs. Detailed planning and timing of development will inevitably vary from the best planning projections and will result in the need to review areas where the model indicates system deficiencies.

Additional uncertainty can occur during the development of the CIP and, as a result, conservative planning assumptions are used. Planning level cost development considers the major categories

of capital projects but does not include the additional detail available during the preliminary and final design stages of projects. The CIP was developed based on anticipated growth, modeling results, and planning information and is subject to change if the planning information and forecasts shift over time. Prior to COVID-19, a global pandemic, cost inflation tools provided high confidence for predicting unit prices within a given year. However, during and after COVID-19, these cost inflation tools may not be as accurate.

ES.8 Key Findings and Recommendations

The findings and recommendations summarized in this section have been drawn from the planning and evaluation sections of this NPMP. The recommendations identify system needs, actions, and capital improvements through the buildout planning horizon; however, the actual implementation time frame will depend on actual growth rates, order of development, and the level of available capital funding. Additionally, the actual scope and implementation of these recommendations may vary with detailed planning and design.

ES.8.1 Key Findings

Key findings identified as part of the NPMP include the following:

- Discussions with other Front Range stakeholders showed that the City has a unique and advanced NP irrigation system, particularly for raw water suppliers.
- Historically, comprehensive data collection has been difficult for the NP system. Additional studies or data collection, along with more standardized record keeping practices, can help the City keep track of the overall system. Record keeping practices could include recording ditch laterals in GIS, updating and enforcing construction drawing standards, creating a system for regularly updating the NP GIS database, and/or installing SCADA systems.
- Review of historical demands showed that NP usage varied significantly on an annual basis. In particular, demand dropped significantly when parks began the transition process to improved control systems. Future NP demands are expected to come from two sources: 1) undeveloped lands that will use NP irrigation when they develop, and 2) existing areas that will convert to NP irrigation, defined as conversion areas. NP peak season demands are expected to increase by 1.1 million gallons per day (MGD) by 2025, 2.8 MGD by 2040, and 11.5 MGD by buildout. NP adoption is strongly influenced by policy, which is a key step for promoting conservation.
- Some of the existing systems were identified as needing improvement, but no critical deficiencies were identified. These include areas that are expected to have undersized inlet lines, pipes, taps, or pumps by buildout.
- New recommended CIP projects were identified. These primarily consist of new pump stations or expansions of existing pipe systems to serve new areas and customers. New pump stations will be primarily constructed by developers. It is estimated that the system will need 4 new pump stations by 2025, 12 new pump stations between 2025 and 2040, and 19 new pump stations between 2040 and buildout.

ES.8.2 Recommendations

The recommendations for the NPMP include the following:

- Implement and enforce an NP policy to promote and expand NP irrigation practices. It is recommended for this policy to mandate that new developments and redevelopments use NP irrigation and for the policy to generally encourage the growth of the NP system.
- Implement improved operational practices at existing pump stations as it becomes necessary. Also implement improved operational practices during other construction, such as rehabilitating a park irrigation system. Improved operational practices can include items such as increasing the watering window to reduce peak hour demands by decreasing the size of irrigation zones and implementing SCADA where not currently installed. It is recommended for customers to use a watering window of 10 hours a day, where possible, and to use the best landscaping practices included in **Appendix F**.
- Create new standards for data collection and record keeping. This can include enforcing standards related to construction record drawings, developing and maintaining an internal record-keeping system, creating a plan for regularly updating the GIS database, and/or implementing a CMMS for NP infrastructure. It is also recommended that the City conducts a study of ditches and laterals throughout the LREGA and requires developers to include this data in their plans.
- Implement and enforce requirements for the installation of SCADA systems at new or rebuilt pump stations. The City may consider including SCADA requirements in the City's Specifications.
- Continue monitoring and recording demands and pump station flows to identify major changes in operations that may impact system performance.
- Evaluate the St. Michaels pump station to determine whether additional construction is needed at this site to meet higher demands. This evaluation should determine whether demand management could be an effective solution, and whether the pumps can be upsized without replacing the entire pump station.
- Continue maintenance of the InfoWater model. This can include adding new pipes, deleting abandoned pipes, tracking open and closed valves, and reflecting operational changes as the system continues to expand.
- Coordinate this NPMP with other relevant planning documents, such as the WTDMP, SSMP, *Imagine Greeley Comprehensive Plan*, and BBC report. It is recommended to use this NPMP as a guide for infrastructure planning, and to use the BBC report as a guide for water resources planning.
- Continue building the NP system through a hub-and-spoke methodology, as defined earlier. Consider looping or connecting systems where systems are on similar hydraulic grade lines, as looping would improve operational flexibility.

- In areas with limited or interim development, require the construction of NP infrastructure, such as a piped irrigation system, even if a pump station will not be constructed until a later time.
- New pipe and pump station layouts are conceptual in nature and are primarily intended to show hydraulic feasibility for master planning purposes. Conduct a detailed evaluation of pipe alignment and size as well as pump station location and sizing as projects move into design and implementation stages when there is more certainty of development and design criteria. The InfoWater model, if regularly maintained, can be used as a tool to support future planning decisions.
- Complete the capital improvements recommended in **Section 6**, prioritizing the 5-year CIP recommended projects. Coordinate closely with the City's parks department, other utilities, and developers to regularly update the scheduling of these projects. The City should consider using the InfoWater model as a tool to inform developer plans while coordinating with them.
- Update the NPMP every 5 years, including reevaluating demand and population projections every 5 to 10 years. Planning assumptions made for the NP system in the next 20 years and beyond are subject to change with time.

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Section 1

Background Information and Project Purpose

Reliance on NP irrigation and improved irrigation practices is a key part of the City's water conservation plan. The NPMP covered in this report will help the City provide untreated irrigation water to large turf areas, which will help preserve potable water for other uses, reduce treatment costs for the City's water and sewer department, and lower irrigation costs for customers. This master plan update documents the approach and assumptions used to evaluate the system while defining the capital improvements needed for the long-range CIP for the NP system through the year 2040. To plan for the future NP needs of the City, background information was first collected on the historic and current NP water system and is described further below.

1.1 Master Planning Process and Organization

The NPMP was developed in conjunction with the City's SSMP and WTDMP. The City integrated the three master plans, creating a consistent approach to determining existing and future population and water demands and to defining capital projects and costs. A schematic of the City's integrated water system for water, wastewater, and non-potable water is shown in **Figure 1-1**.



Figure 1-1 Greeley's Integrated Water System

The future population projections and associated water demand, planning horizons, and approach to capital and project cost development are consistent between the three master plans, as shown in **Figure 1-2**. This figure also shows the critical points of coordination between the three master plans.

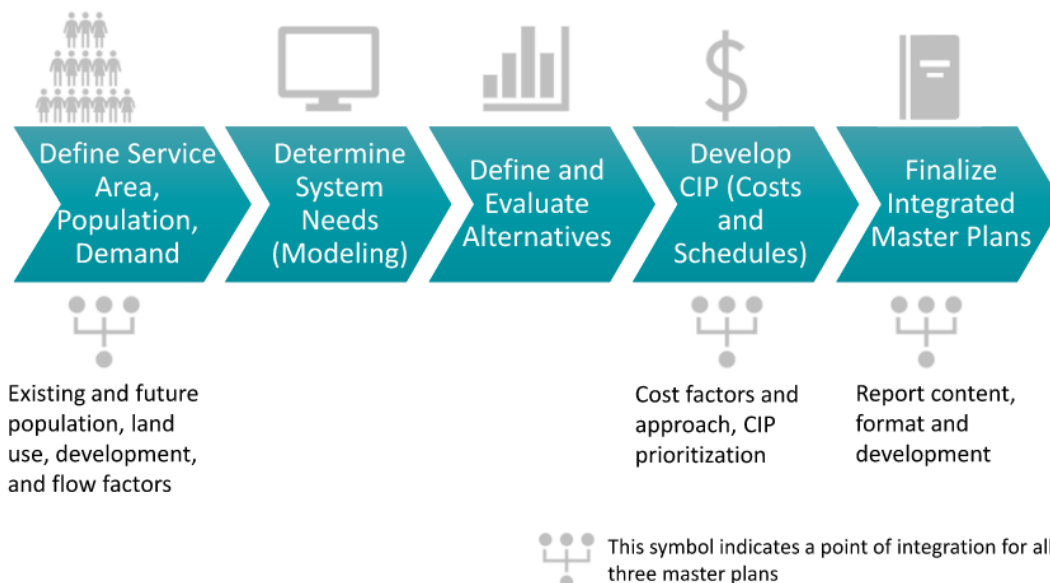


Figure 1-2 Master Plan Approach and Integration with other Master Plans

1.1.1 Report Organization

The NPMP is organized into the following sections:

- Section 1 – Background Information and Project Purpose
- Section 2 – Administrative Considerations
- Section 3 – Demand and Economics
- Section 4 – Development of the Non-Potable System Model
- Section 5 – Existing and Future System Model Evaluation
- Section 6 – Capital Improvement Plan
- Section 7 – Findings and Recommendations

1.2 Review of Existing Data and System

Before any other data gathering was initiated, information on the existing system was collected from the City files. This information primarily came from the two former NPMPs (dated 2002 and 2004), which provided overarching views of the City's goals, strategies, and specific plans for the NP system. These plans analyzed the then current and potential sources of supply and demand, established design and costing criteria for future projects, and examined options for the use of surplus NP water.

Part of the review of the existing system involved examining the records of existing infrastructure and construction projects. This data was checked by field visits and incorporated into the GIS. A new NP tagging and naming convention based on the City's standard naming scheme was established and will be used to describe the existing and future infrastructure. This naming system is included in **Appendix B**.

In general, the City's NP system operates using a "hub-and-spoke" approach, where a pump station (the hub) serves the irrigated areas (the spokes) without any connections to other pump stations or NP systems. Each of the individual systems has a unique setup, as described in **Section 4.1**. A typical NP system is shown in **Figure 1-3**. However, each individual system may differ in whether it pulls from a ditch or well, whether there is an intermediary pond, and how many pumps it has. Detailed descriptions of each system are included in **Table 4-1** and a map of all pump stations is included in **Figure 1-4**.

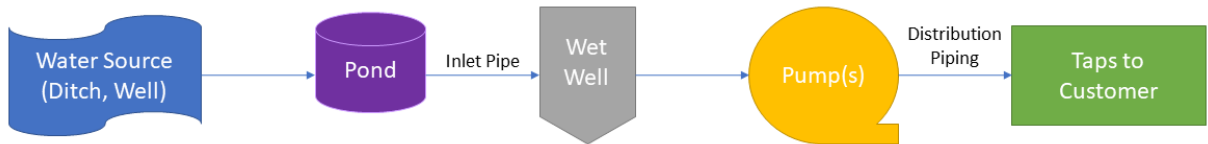
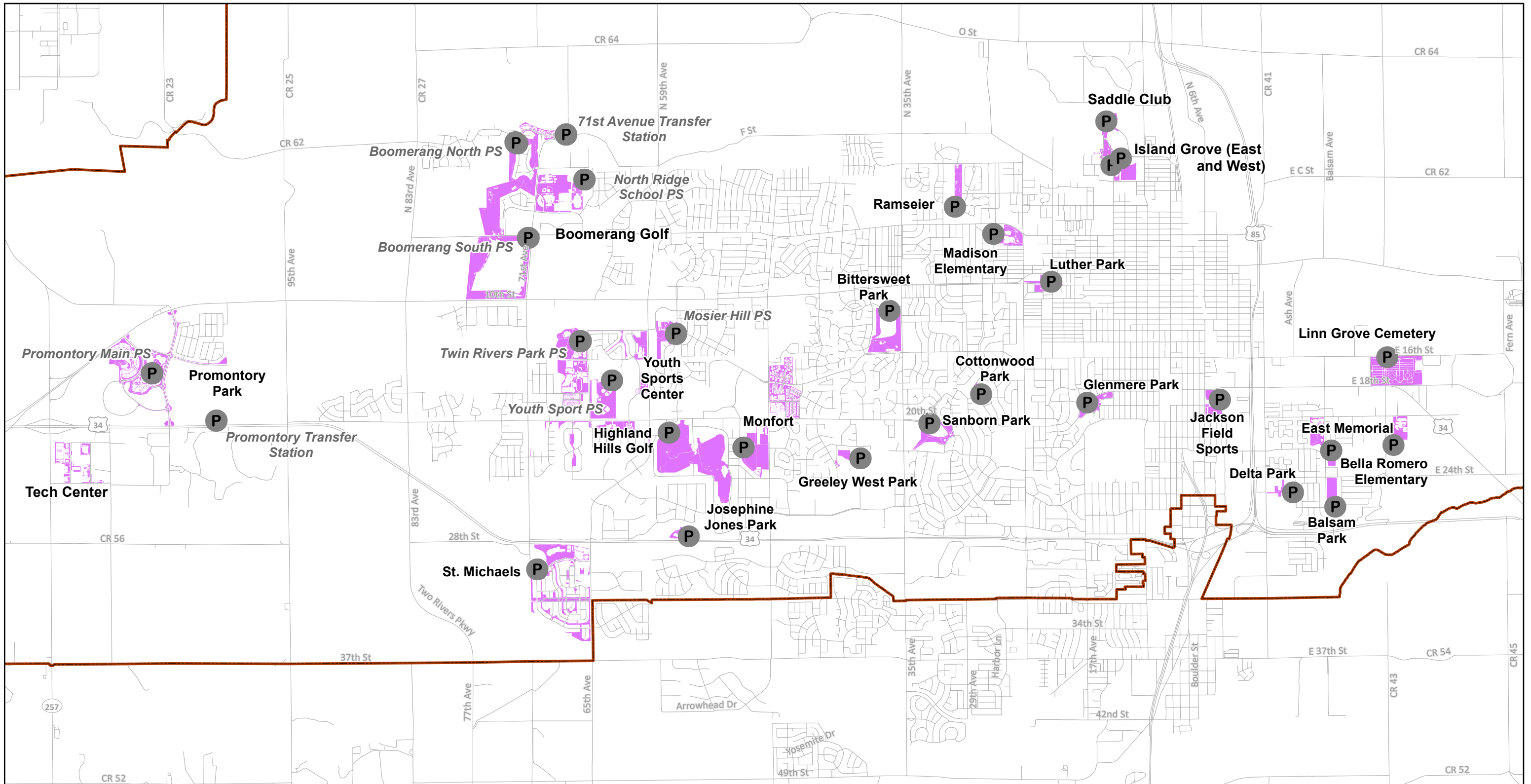


Figure 1-3 Typical NP System Schematic

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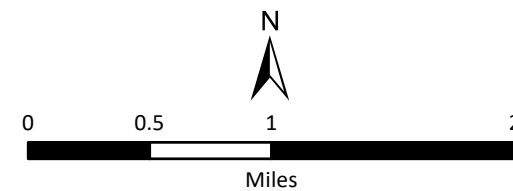


Legend

- LREGA
- P Pump Station
- Existing NP Irrigated Areas



May 17, 2021



Existing Non-Potable Service Areas

Figure 1-4

Greeley Non-Potable Water
System Master Plan

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1.3 Field Visit Data

Field data was collected at each site and locations and elevations of features were recorded using a global positioning system (GPS) unit (Trimble Geo 7x). The GPS unit is accurate within a meter of the exact location. Along with the spatial data, specific operational information for each component was also recorded, as well as any of the operators' background knowledge on the specific item. Major system components visited included pump stations, meters, valves, wells, head gates, and storage ponds. For the pump stations, information that was collected included the number of pumps, the model numbers of the pumps and motors, the operating speed, the visual condition of the equipment, and the condition of the pump house. The unique meter number for each meter was also recorded, along with the transmitter number and diameter of the meter piping. The location and elevation of each valve was taken, and a note was made if the valve was equipped with a powered actuator. Notes were taken detailing the control logic for all actuating valves inventoried. The breakdown of components can be found in **Appendix A**. This information was compiled into a single database spreadsheet and used to update the NP GIS database.

1.4 GIS Mapping and System Inventory

Previously existing GIS data contained spatial locations for both point and linear NP water infrastructure. The point data included wells, pump stations, meters and valves. NP lines, ditches and irrigation areas were all contained in the linear data. Within the attribute table of each shapefile, there is additional information corresponding to each individual component within that infrastructure category. This information is summarized in **Table 1-1**.

Table 1-1 Previously Existing GIS Information

Type of Information	Number of Features	Relevant Attributes
Wells	51	Location, Type of well
NP pump stations	37	Names, Approximate addresses (incomplete)
NP meters	73	Customer number, Transmitter number, Meter number, Approximate addresses (incomplete)
Valves	383	Type of valve, R angle
NP irrigation areas	42	Name of well that supplies the area, Surface area
NP pipes	563	Length, Material, Installation year, Diameter
NP ditches	66	Name, Length, Above or below ground

Review of the GIS data with the operations team revealed that much of this information was either incomplete or out-of-date, especially the wells, ditches, and NP irrigation areas. The data from the field inventory was used for the wells, pump stations, and valves. The GIS data did not include a ponds shapefile; instead, information on ponds was included from the field data or historical documents and drawings. For the pump stations that were not included in the original GIS data, the data from the field inventory or historic documents was used. The NP GIS system should continue to be updated and maintained in the future. The NP pipelines are summarized by diameter in **Table 1-2**.

Table 1-2 Non-Potable Pipe Lengths from City GIS Data

Pipe Diameter (in)	Total Length (ft)
0 (Blank) ¹	4,296
1	17
2	4,022
3	739
4	5,114
6	19,515
8	23,094
10	17,616
12	12,238
14	706
15	370
18	2,106
20	140
24	49
Total	90,022

¹ Pipes with no diameter were reconciled as part of model connectivity updates, described in **Section 4.1.1**.

Review of the NP pipelines shapefile showed that the file was not fully representative of the current system. This shapefile was updated extensively to support model connectivity and an updated shapefile was provided to the City. The following assumptions and key fixes were used to support connectivity:

- Pipes that were within 3 feet of another feature, such as collected field data, were rerouted to connect through that point.
- Pipes without a diameter were assigned a diameter based on design drawings or the diameter of connected features, such as pumps or valves.
- Areas with other NP infrastructure, but no pipes, had pipes added based on design drawings, City operator knowledge, or typical layouts for NP pump stations.
- Two-inch lines were drawn from main lines to meters where relevant.
- Topology checks were used to reconcile pipes that were not connected to each other, identify duplicate features, etc.

Operations and Maintenance (O&M) data for each pump station, as available, was also reviewed. This included original constructions documents, O&M manuals (including pump curves), equipment details, photos of the site, and other historical information. Some of this data was outdated and reflected historic construction, not current conditions. The data provided also contained discrepancies and gaps, due to obsolete data mixed with current data. The data was further reviewed in team meetings to ensure that a comprehensive and accurate understanding of the system was being incorporated into the model.

Additionally, hourly SCADA data was used for the past five years (September 2015 to September 2020) to evaluate the accuracy of the model of the existing NP system and to create diurnal curves that reflect current system usage. SCADA data was not available for all sites. **Table 2-5** includes a list of available SCADA data collected by location.

1.5 Zoning and Land Use Information

Current and planned land use and zoning data in GIS format, along with maps of zoning and land use available through previous master plans, was used to map existing NP customers and irrigation areas, and to identify potential new customers, such as parks, golf courses, and cemeteries.

Additional sources of information included planned unit development reports, a revised version of Greeley's Comprehensive Plan map, as well as other information developed in conjunction with the City's planning department as a part of the water and sewer master plans that contained detailed land use information. This information was used to develop future potable water and sewer demands, which are the basis for the development of future NP demands.

Parks represent a crucial existing and future demand, so the 2016 Parks, Trails, and Open Lands Master Plan was used to address future park demands. This master plan provides information on current parks, as well as park service goals and potential locations for future parks. These details were used to establish park demands for the future planning scenarios.

Current potable water customers were evaluated to determine areas that would be suitable for conversion to NP irrigation. These areas, referred to as conversion areas, were provided on three shapefiles and two PDF maps that showed the names of many of the systems. Conversion areas are discussed in **Section 3** of this report.

The City's NP water system currently serves several areas of varying land use, which includes residential areas, golf courses, parks, and schools with a combined total irrigation area of 890 acres. The current irrigation areas, including areas that are irrigated by private systems, can be seen in **Figure 1-5**. Private systems were not addressed as part of the master plan, as the master plan focused solely on City-owned infrastructure.

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1.6 Review of Supply and Demand

To determine reasonable expectations for supply and demand projections, historic projections were examined. The BBC report was also considered for supply and demand projections. The BBC report projects the NP water demand for an assumed buildout year of 2065 under three scenarios: low, middle, and high. As noted in the report, the middle projection represents the most likely demand scenario. Notably, the middle scenario for total water consumption produces the highest NP consumption. The BBC report included total projected demand at five-year increments, as well as the likely adoption rates per customer type. The results of the NP water demand projections from the BBC report are summarized in **Figure 1-6**.

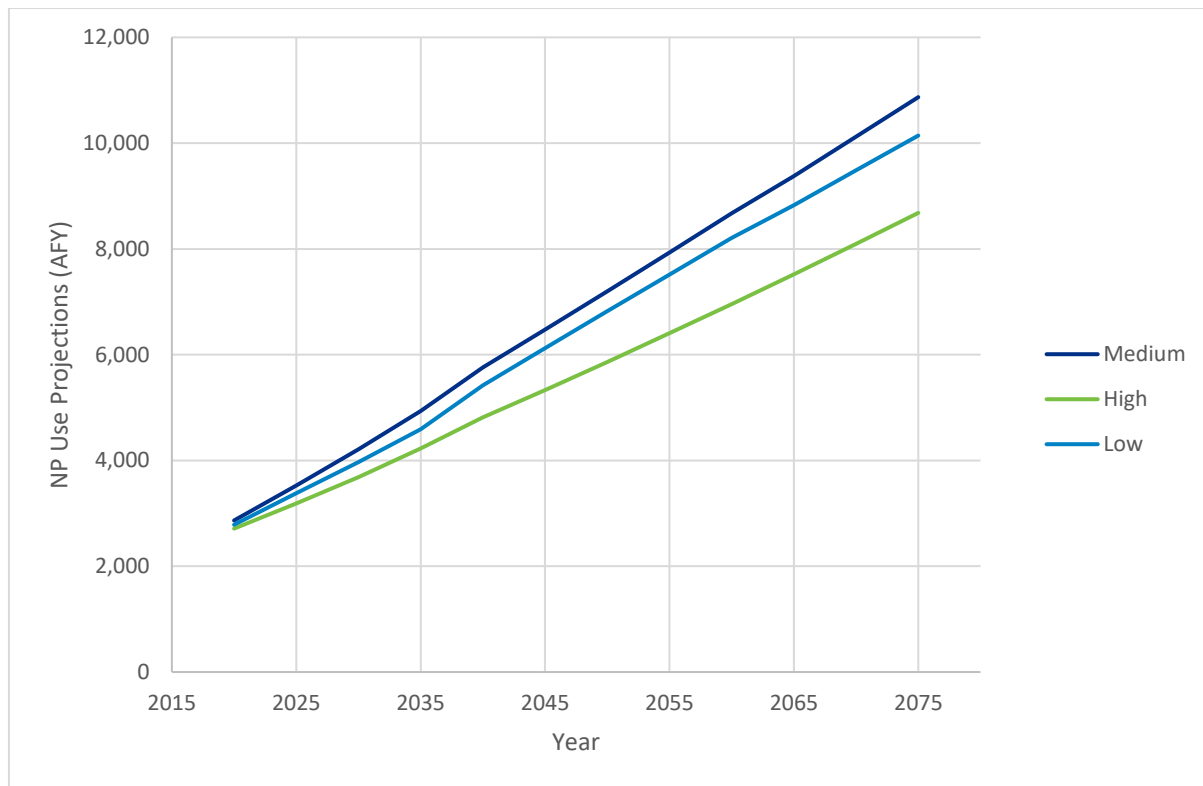


Figure 1-6 Non-Potable Use Projections (BBC Report, 2018)

To determine the actual NP water demand, the most recent water billing data was used. Billing data provided monthly demands from 2014 through 2019. The analysis of the provided data revealed a significant annual variation in demands, as shown in **Figure 1-7**. This annual variation could be due to changes in the City's irrigation control systems which significantly improved irrigation efficiency, especially in parks. As a result, only 2018 and 2019 billing data was used for the development of the models.

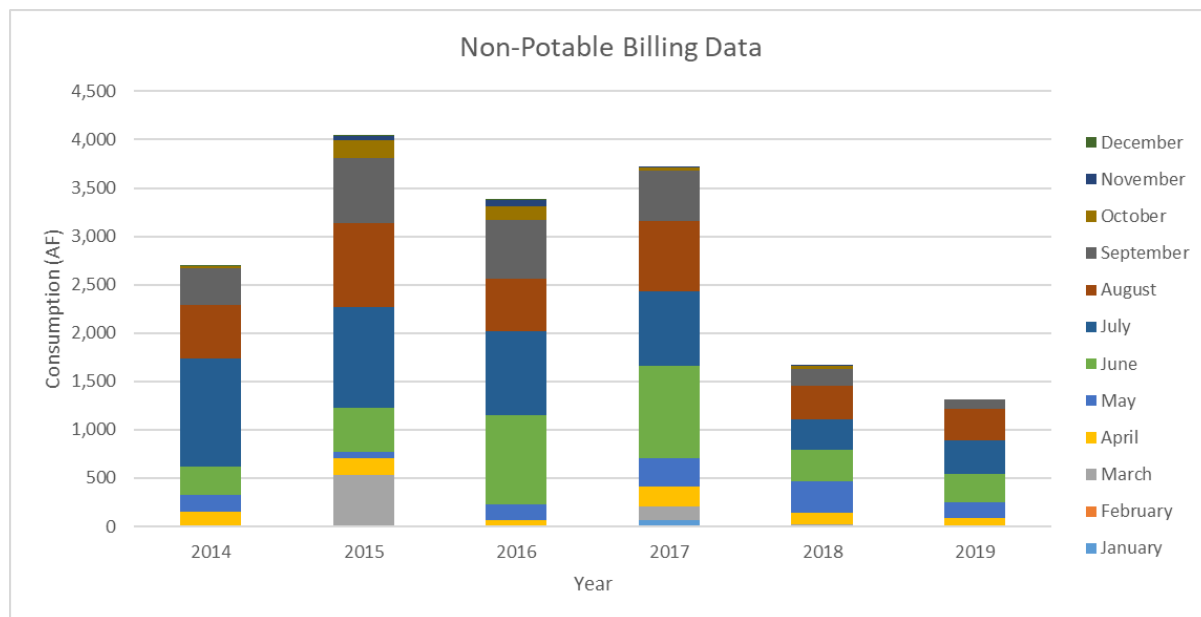


Figure 1-7 Non-Potable Demands (Billing Data)

The billing data was used to project NP demands through buildout. The demand that cannot be supplied by current NP infrastructure helped determine the necessary projects for the CIP. NP water demands were allocated with greater detail and are described further in **Section 3** of this report.

1.7 Costing

Data was collected for the pricing of CIP projects from several sources. This data was consistent across all three master plans. These sources included previous City bid tabs, City CIP databases (such as Greeley's CIP database for water, wastewater, and NP water projects), bid tabs from past CDM Smith projects along the Front Range and in Texas, as well as a consultant project cost estimator. Incorporating multiple data sources makes typical unit costs more robust. Analysis and selection of these line item unit costs are covered in **Section 6** of this report.

In the future, the City may consider mandating NP irrigation for new developments based on economic feasibility, and/or subsidizing NP infrastructure to make it economically feasible. Because of this, City policy could have a large impact on NP adoption. The City provided its draft policy, which was used as a basis for economic considerations. As of writing, the final policy has not been approved by the Water and Sewer Board. As a result, revisions to the draft policy may affect economic feasibility calculations. The final policy is attached in **Appendix K**.

1.8 Ongoing Projects

There are two ongoing projects considered in the NPMP: the Poudre Ponds Complex Project (Poudre Ponds) and the Upper Equalizer project. The information on both these projects is based on the 2016 City of Greeley Non-Potable Water Supply Upper Equalizer Infrastructure Feasibility Study. The Poudre Ponds project is also studied in greater depth in the 2021 Poudre Ponds

Reclamation and Restoration Improvements Project Mini Master Plan, which evaluated plans based on 2030 and 2065 demand scenarios.

The Poudre Ponds project seeks to expand an existing storage site by constructing a gravel pit pond and pump station on a newly acquired parcel. Project goals include improving water supply reliability, NP storage, and community assets via site enhancements for wildlife and recreation. This new pump station will convey 23 cubic feet per second (cfs) to the Greeley No. 3 Ditch or 27 cfs to the Poudre River, returning water back to its source as part of a water rights exchange.

The Upper Equalizer project seeks to expand an existing NP pump station, which currently provides irrigation to a golf course and high school. This project will transfer 31 cfs peak flow from the Greeley No. 3 Ditch to the Greeley-Loveland Irrigation Company (GLIC), which is 4 miles away, with about 200 feet in elevation gain. As 71st Avenue was paved since the writing of the feasibility report, the routing of the pipeline was changed to 83rd Avenue. The NPMP was coordinated with the ongoing design as available and the 31 cfs transfer was incorporated into the plan.

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Section 2

Administrative Considerations

In addition to the infrastructure construction and expansion, certain administrative improvements can help the City continue to grow its NP system and act as a leader in water conservation along the Front Range. This section describes recommendations related to policy, operations, monitoring, and data collection.

2.1 Stakeholder Engagement

Stakeholder engagement efforts were conducted with several local communities and municipalities in the Front Range to identify current system practices, user trends, planning recommendations, and economic considerations surrounding design and expansion of NP systems. These included the City of Westminster, Denver Water, the City of Evans, and the Town of Windsor. Through this process, it was discovered that the City's current NP system is more developed than many other surrounding raw-water suppliers.

Discussion topics during these meetings included factors for site selection, best practices for NP implementation, and potential challenges of NP use. Considerations for site selection include picking high acreage areas with a preference for larger customers, limitations based on pressure zones, economics (cost savings associated with cheaper irrigation water compared to potable), land use/zoning laws, and regulations regarding water reuse. Common best practices include the use of design standards to regulate construction, irrigating at night, use of subsidies to encourage implementation, and NP promotion through sustainability campaigns. Potential challenges with operating an NP system include the variability of supply of reuse water (raw water is less variable), water quality impacts on the distribution system and vegetation, additional education and focus on public perception, more training required for employees, and higher cost of treating NP water for communities that use potable reuse.

2.2 NP Policy Considerations

Modeling considerations and factors used for the hydraulic modeling of existing and future systems were developed with consideration of the City's current NP water supply policies. The City is currently working on drafting a policy related to NP adoption and standards. Policy-related decisions are a large driving force behind NP adoption, conversion, and expansion, and are a key part of the City's water resources conservation strategy. The NPMP is based on a draft version of the policy, and certain assumptions used throughout may be subject to change, depending on the final version. The following are key points to note from the draft policy and recommendations for the final policy:

- The final policy should mandate NP irrigation for new developments and redevelopments where technically and economically feasible. Mandating and enforcing NP irrigation will help promote sustainability for the potable water system and avoid unnecessary upsizing.

- The City should develop NP water rates based on a cost-of-service study to incentivize NP adoption by reducing the price of NP water compared to potable water.
- Growth should pay for growth. The policy should clarify how new developers participate in the construction of new NP infrastructure.
- Large users should be required to plan for at least an 8-hour watering window. The policy should clarify when this is required and should encourage users to use an even larger watering window, to reduce peak hour demands on NP infrastructure.
- The policy should require new developments to construct NP infrastructure, such as separate irrigation pipelines, even if an NP pump station will not be available until after construction is complete. Information should be included on when and how the City's water and sewer department will pay to upsize infrastructure to accommodate future demands.
- The City should develop an impact fee structure that encourages NP adoption and allows for City investment in upsizing the NP system to be repaid in the future.

2.3 Improved Operational Practices

The existing systems are operated efficiently and proactively. The pump stations are rebuilt on a timed cycle and maintenance is performed annually over the winter. The field inspection confirmed that the systems look and are reported to be well maintained and operated.

As the system expands in the future, some operational practices may need to be modified to expand with the system. Some improvements that would help minimize the operational needs of the future system may include:

- Improved SCADA control and monitoring. Generally, sites must be physically visited to monitor pond levels and check for operational issues. Improved SCADA could allow remote monitoring and automatic control of some processes allowing existing staff to operate additional sites. A suggested "default" SCADA system is listed in the next section.
- Implementing a CMMS to improve data and optimize maintenance activities. Adding NP infrastructure to an existing City CMMS will be considered in the future.
- The following systems have high peaking factors, or very high variability, which means the pump stations are limited by maximum flow but only operate for a short irrigation window. These systems could benefit from a longer watering window which would free up capacity for additional demands. Note that lengthening the water window in some cases may only require reprogramming the irrigation controller, but in many cases may require dividing the irrigation system into additional zones. Therefore, these modifications are likely best accomplished during major irrigation system maintenance or replacement. These systems include the following:
 - Mosier Hill (extremely varied)
 - Bittersweet Park

- Madison Elementary
- Saddle Club (extremely varied)
- Luther Park (extremely varied)
- Island Grove West
- Island Grove East
- Twin Rivers Park
- North Ridge School

2.4 Improved Monitoring Systems and Practices

The current NP system includes basic SCADA status communication. Each pump station is controlled by a vendor provided and programmed “island” programmable logic controller (PLC) that monitors pressure and flow. The PLC also monitors station health and protects the pumps from operating outside of safe ranges. Each station has a radio telemetry unit (RTU) that communicates limited status and data. **Table 2-1** summarizes the available data from each of the existing stations. Ultimately, it is recommended for the City to include SCADA for all existing and future pump stations, and eventually add ditch measurements and controls to the SCADA.

Table 2-1 Available SCADA Data from Existing Systems

Service Area	Pump Station	Flow	Pressure	Wet Well Level	Influent Flow
Promontory Park	Main	X	X	X	
	Transfer	X	X	X	
Greeley West Park	N/A				
St. Michaels	N/A	X	X	X	
Boomerang Golf	Boomerang North				
	Boomerang South				
	Boomerang Transfer	X	X		
	North Ridge Transfer	X			
	North Ridge School	X	X	X	
	Poudre River Ranch	X	X		
Youth Sports Center	Youth Sports	X	X	X	
	Twin Rivers Park	X	X	X	
Highland Hills Golf	N/A	X			
Josephine Jones Park	N/A				
Peakview Park	N/A	X	X	X	
Monfort	N/A	X	X	X	
Sanborn Park	N/A				
Cottonwood Park	N/A				
Bittersweet Park	N/A	X	X	X	
Ramseier	N/A	X	X	X	

Service Area	Pump Station	Flow	Pressure	Wet Well Level	Influent Flow
Madison Elementary and Houston Gardens	Madison Elementary	X	X		
	Houston Gardens	X	X		
Luther Park	N/A	X	X		
Glenmere Park	N/A				
Jackson Field Sports	N/A	X	X	X	
Delta Park	N/A	X			
Balsam Park	N/A	X			
East Memorial	N/A	X	X	X	
Bella Romero Elementary	N/A	X	X		
Linn Grove Cemetery	N/A				
Stoney Brook	N/A	X			
Poudre Ponds	N/A	X	X	X	X
Island Grove and Saddle Club	Island Grove West	X	X	X	
	Island Grove East	X	X	X	
	Saddle Club	X	X		

As existing pump stations are replaced and new pump stations are installed, a unified approach to SCADA communication should be followed to allow for future operations flexibility.

Newly installed or replaced stations should be capable of using the City's preferred Modbus TCP/IP communication protocol. It is anticipated that over time the City's fiber network (or at least broadband) will be extended to all pump stations. Broadband network connectivity will allow both data-rich SCADA, as well as the implementation of monitoring and security systems at each site. Alarms should be capable of custom alarm priorities and call-outs. Generally, any status or control available on the local operator interface should be accessible via SCADA. At a minimum, the datapoints for new equipment should include:

- Status to SCADA
 - Mode (local/off/remote)
 - Running (each pump)
 - Motor speed (each pump)
 - Setpoints (pressure, flow)
 - Station flow
 - Station pressure
 - Wet well level
 - Filter flush

- Alarms
 - All alarms available on the vendor package
 - Fault monitoring
 - Power monitoring
 - Communication lost (outside of vendor package, network side)
 - Intrusion (outside of vendor package)
 - Space temperature (may be outside of vendor package)
 - Smoke/fire (outside of vendor package)
- Control from SCADA
 - Mode (in auto)
 - Run
 - Percent speed
 - Setpoints (pressure, flow)
 - Filter flush interval

In some locations, additional information such as ditch level, pond level, headgate position, or other datapoints may be desirable for remote monitoring and operation.

The overall control philosophy will continue to be stations operated in “island” mode, with the local PLC controlling the system to maintain the operational setpoint and protect equipment. In the future, the capability should be retained for SCADA control and orchestration of multiple pump stations, while the local PLC continues to provide equipment protection.

2.5 Data Collection and Record-Keeping

Historically, comprehensive data collection has often been difficult or impossible for distributed NP systems that were built by multiple parties. However, the City’s unique and advanced system calls for improved data collection and record-keeping practices to be implemented. Master planning efforts revealed certain gaps in data that could be remedied with further studies. The following recommendations may help the City to efficiently keep track of its system, pass on important knowledge and history to future employees, and fill in missing datasets:

- Conduct a study of the ditches and laterals throughout the LREGA. This will help identify good locations for future pump stations in undeveloped areas. Additionally, update the current ditches dataset in GIS to capture all stormwater runoff systems that are actually NP ditches, and vice versa. The City may also suggest having developers provide information on existing ditch laterals in a proposed development area as part of the existing conditions report.

- Update and enforce standards related to construction drawings and record keeping after construction or upgrades of an NP pump station, or other infrastructure. Require that developers provide detailed drawings showing the pump station, irrigation pipelines, and pump curves. The City should also develop and maintain its own internal record-keeping system to identify which documents are the most up to date. A CMMS including NP infrastructure could meet this intent.
- Create a system for regularly updating the NP GIS database. While some NP systems have detailed GIS information, other NP systems are not represented in GIS at all. Designating specific staff members with the task of updating the database after a new project and providing them with standard operating procedures may help with this effort.
- Install SCADA systems at new pump stations and pump stations that do not currently have it, to allow for further monitoring of flows and pressures.

Section 3

Demand and Economics

To plan for the future NP needs of the City, existing and future demands were established, and an analysis of economic feasibility of future expansion was completed. The NP water demands established were used in the WTDMP to show how potable water demand can be lowered by meeting demands that do not require the quality of potable water quality with NP water (e.g., irrigation or construction).

3.1 Existing System Demands

The first step in allocating demands in the NP water model is to examine how the City currently uses NP water. NP water is currently used mostly for irrigation, although it may be possible to expand the system so that it can meet some other demands that do not require potable service, such as construction. Information on NP demands was primarily found in the billing data and GIS data, as discussed in **Section 1** of this report.

3.1.1 Review of Billing Data and GIS Data

The existing irrigated areas were examined in GIS and the existing billing data was geolocated and categorized by customer type. Through this process, 99.3% of the total NP demands from the 2019 billing data were allocated to a geolocated meter. Additionally, the City requested that one “customer” be removed from the total, as it is a shoulder tap that feeds other billed customers. Shoulder taps are locations where the NP system can take water from the potable water distribution system during the early spring and late fall shoulder months, when the ditches may not have water but there are still irrigation demands. **Table 3-1** summarizes the billing customers and their associated demands by their City-assigned category. Categories were subsequently adjusted to match water and sewer customer categories.

Table 3-1 Categorized Billing Customers

Customer Category	Number of Billed Meters	Peak Month Consumption ¹ (MG)	Percentage of Total Consumption
Church/Commercial	1	0.8	0.7%
Commercial	36	8.5	7.3%
Golf Course	5	41.4	35.9%
Multifamily Homeowners Association (HOA)	2	0.3	0.3%
Non-Potable	1	0.1	0.1%
Parks	16	34.4	29.9%
Residential	22	13.6	11.9%
School	13	16.0	13.9%
Total	96	115.1	

¹ Average of 2018 and 2019 billing data, in million gallons (MG)

Some NP irrigated sites, such as certain parks, were not included in the billing system. These demands were accounted for with historical pumping data collected weekly through most of August 2019. This data was used for 33 locations (including three wells) across 12 sites, where metered billing data was not available. **Table 3-2** contains the pumping data for these areas.

Table 3-2 Pumping Data

Site Name	Pumped Peak Month Demand ¹ (1,000 gal)
Balsam Park	2,171
Bittersweet Park	4,585
Cottonwood Park	719
Delta Park	712
Glenmere Park	1,401
Greeley West Park	745
Island Grove	3,459
Island Grove Ball Field	3,300
Josephine Jones Park	1,102
Linn Grove	8,328
Saddle Club	69
Sanborn Park	2,783

¹ Average of 2018 and 2019 recorded pumping data

3.1.2 Variability in Demand

NP demands are much more irregular than potable water and wastewater demands. They are largely influenced by seasonal weather patterns, since most NP water is used for irrigation. In general, NP demand is highest in the summer and lowest in the winter. Both potable and NP demands were allocated based on summer usage. However, these seasonal variations do not account for year-to-year variability. This year-to-year variability is shown in **Figure 3-1**, where consumption based on billing data can more than double in certain years. A comparison with annual rainfall did not show a strong correlation to account for the annual variation.

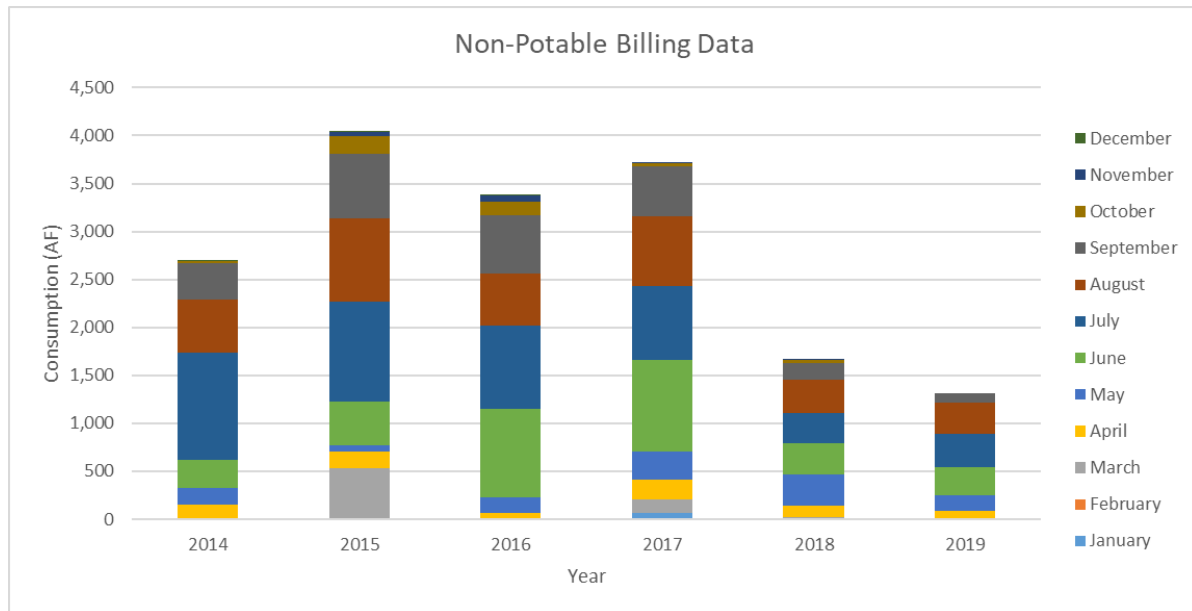


Figure 3-1 Variability in Annual Non-Potable Demand

Based on discussions with the City, it was determined that the reduction in annual demand was due to increased conservation efforts, especially the installation of water-efficient irrigation systems and smart irrigation controllers throughout City parks. To account for these changes, only billing data from 2018 and 2019 was considered for the development of this NPMP.

3.1.3 Flow Factor Development

To calculate future demand projections, it was necessary to establish flow factors. A flow factor is defined as the value used to estimate typical NP demand per acre for a given land use category. The historic billing data and the current NP irrigated areas shapefile were combined to produce flow factors by customer category. These flow factors were then used to estimate future NP demand scenarios through buildout based on land use projections established during the WTDMP.

Flow factors were calculated based on conversations with City staff to determine which areas were irrigated, and by which meters. The meters, and their associated area, had been previously categorized by the City, which was the basis for the flow factor categories. The peak month billed consumption by category was divided by the total irrigated acreage by category. This supplied the Irrigated Land peak month flow factor, as shown in **Table 3-3**. These values represent the amount of consumption for a site where the exact acreage being irrigated is known.

However, in undeveloped areas, the exact irrigated acreage is not known. To account for this, the percent of land that is irrigated out of a total parcel was estimated by category type. The total irrigated land by category was divided by the total (bulk) parcel area by category. These resulted in a Bulk Land peak month flow factor, also shown in **Table 3-3**. The flow factor calculation process is illustrated in **Figure 3-2**.

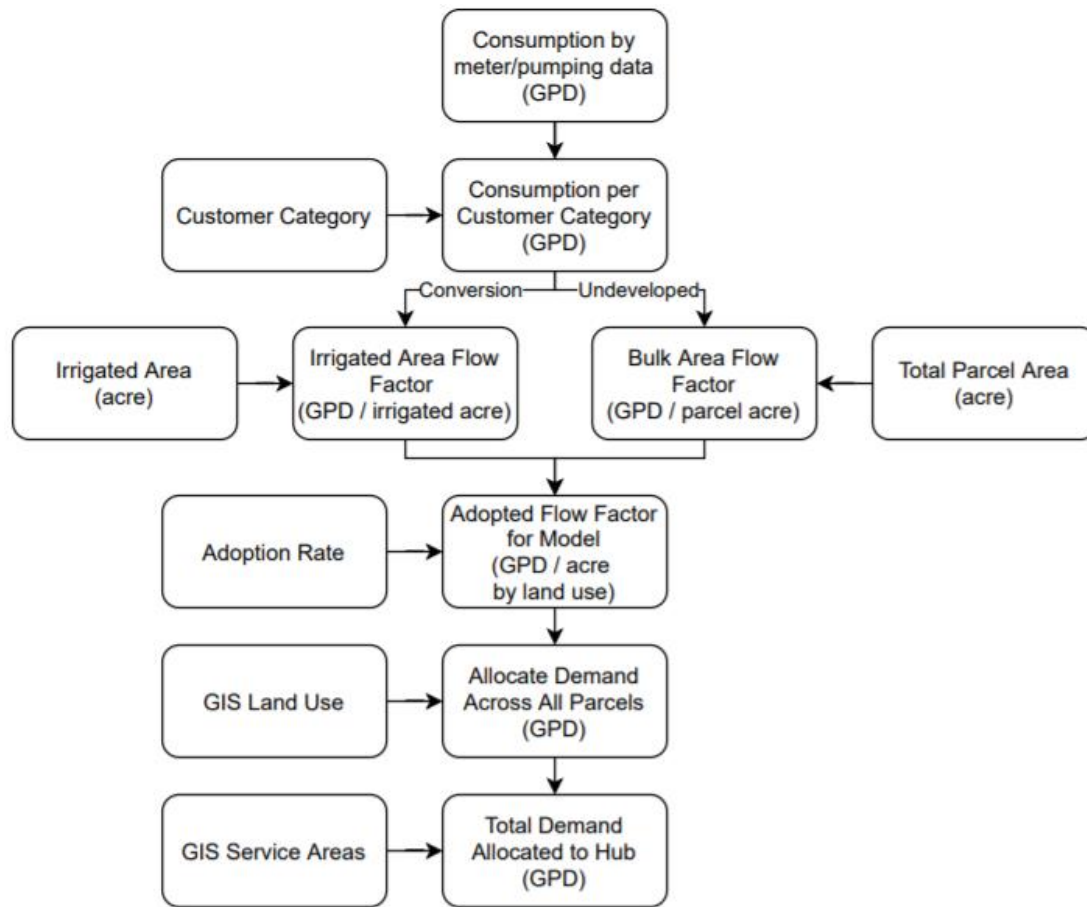


Figure 3-2 Flow Factor Calculation

These customer categories were coordinated with the WTDMP land use projections to examine areas throughout the LREGA. Generally, the Multifamily HOA category was associated with residential high density (R-H) land use category, the Residential customer category was associated with residential medium density (R-M), residential low density (R-L), and residential estate (R-E) land use categories, and the Commercial customer category was associated with commercial high intensity (C-H) and commercial low intensity (C-L) land use categories. However, because the existing NP system serves a limited number of areas, this process did not fully account for all types of land use within the City. The following changes were included in the final flow factors:

- Some land use types in the City do not currently have any examples of NP irrigation. This includes the industrial low intensity (I-L), industrial medium intensity (I-M), and R-E areas. For these areas, a flow factor was based on the difference between the summer and winter flow factors, as developed in the WTDMP and SSMP, respectively.
- Because schools are zoned as R-L, the R-L flow factor was based on a combination of the Residential and School flow factors.

- Because churches are considered commercial, the Commercial flow factor also includes churches. The Church category is used for conversion areas only. There are not many churches currently served by NP irrigation, so the Church flow factor also looks at existing churches that are only served by potable water and compares summer versus winter demand to determine an estimated flow factor.

Losses due to evaporation or seepage were not included in these calculations, as they primarily occur in the ponds and ditches rather than in the distribution system. These losses are estimated at 30%, based on operator knowledge, and are necessary for determining NP supply into ditches.

Table 3-3 Flow Factors

Category	Description	Peak Month Flow Factor for Irrigated Land (gpd/acre) ³	Percent Irrigated	Peak Month Flow Factor for Bulk Land (gpd/acre)	Peak Month Flow Factor for Irrigated Land (in/week)	Annual Flow Factor for Irrigated Land (in/year)	Adoption Rate ²
Church	For conversion areas only	2,000	63%	1,300	0.5	10.9	75%
Commercial	C-H and C-L; includes churches	3,200	42%	1,300	0.8	17.5	20%
Golf Course ¹	Golf course (NP category only)	5,000	87%	4,400	1.3	27.3	N/A
I-L	Industrial Low; Summer vs. winter flow factor	N/A	N/A	500	N/A	N/A	20%
I-M	Industrial Medium; Summer vs. winter flow factor	N/A	N/A	125	N/A	N/A	20%
Multifamily HOA	R-H	4,400	34%	1,500	1.1	24.0	15%
Parks	Parks (NP category only)	3,500	47%	1,600	0.9	19.1	90%
Residential	Single family residential; also used for R-M	5,200	17%	900	1.3	28.4	20%
R-E	Residential Estate; Summer vs. winter flow factor	N/A	N/A	80	N/A	N/A	15%
R-L	Residential Low; Residential and School average flow factor	4,700	26%	1,200	1.2	25.7	20%
School	For conversion areas only	4,300	48%	2,100	1.1	23.5	75%

¹ No additional golf courses are expected in the City through buildout.

² Adoption rates based on the BBC report; see **Section 3.2.1**.

³ gpd/acre = gallons per day per acre

3.2 Future Usage and Demand Projections

Using a combination of the City's planning data, land use projections from the WTDMP, and flow factors developed during the existing demands allocations, future NP demands through the buildout scenario were projected and allocated. This section captures the assumptions and calculations used to arrive at this value.

3.2.1 Adoption Rates

The adoption rates are the estimate of the amount of land that could potentially be irrigated that is expected to use NP irrigation. Future scenarios used the adoption rates, as shown in **Table 3-3**, for undeveloped land and most conversion areas. Undeveloped land had the factors applied per land use category including churches in Commercial and Schools in R-L. Conversion used the same factors, although schools and churches used a 75% adoption rate to account for a push to convert existing large irrigated areas to NP.

3.2.2 Infill and Conversion Areas

As the NP system expands, it may become both feasible and beneficial for some areas that are already developed to convert from potable to NP irrigation. These areas, referred to as conversion areas, were identified by the City based on knowledge of the individual customers, its current usage, and open irrigated acreages. The City identified over 400 individual areas that could be eligible for NP conversion. These areas were then categorized to identify which flow factors best fit them. The total acreage expected to convert to NP by category is summarized in **Figure 3-3** and shown in **Figure 3-4**. Areas that were identified as undeveloped land, roads, or non-irrigated areas were not included in the categorization. This is because undeveloped land is captured in the demand projections for undeveloped land, and roads or medians are too small to be accurately categorized.

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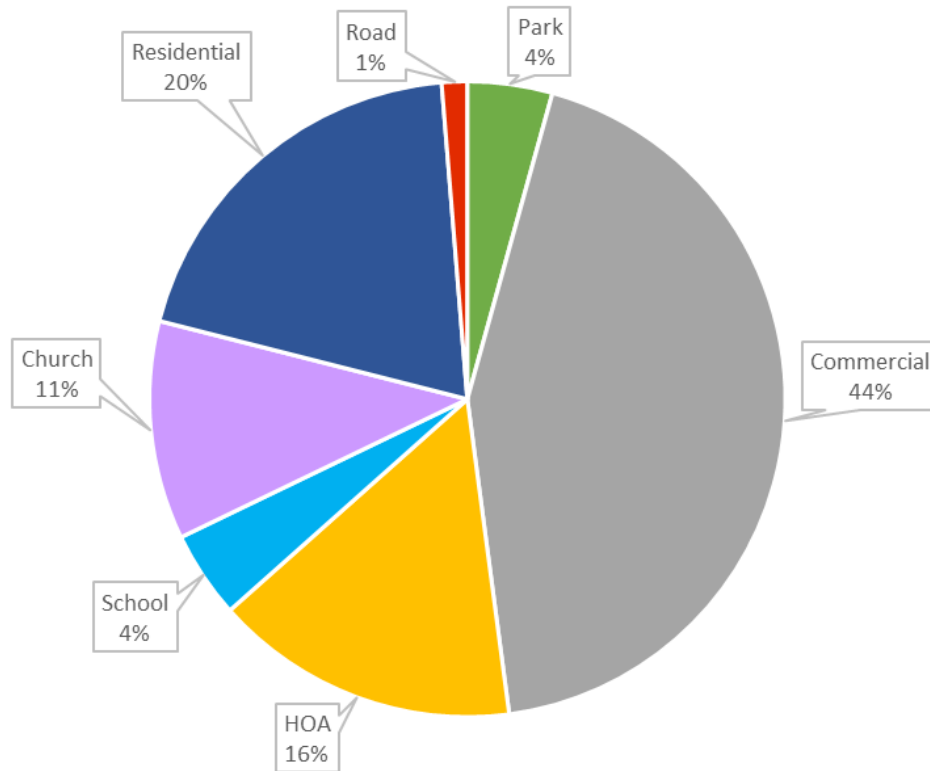
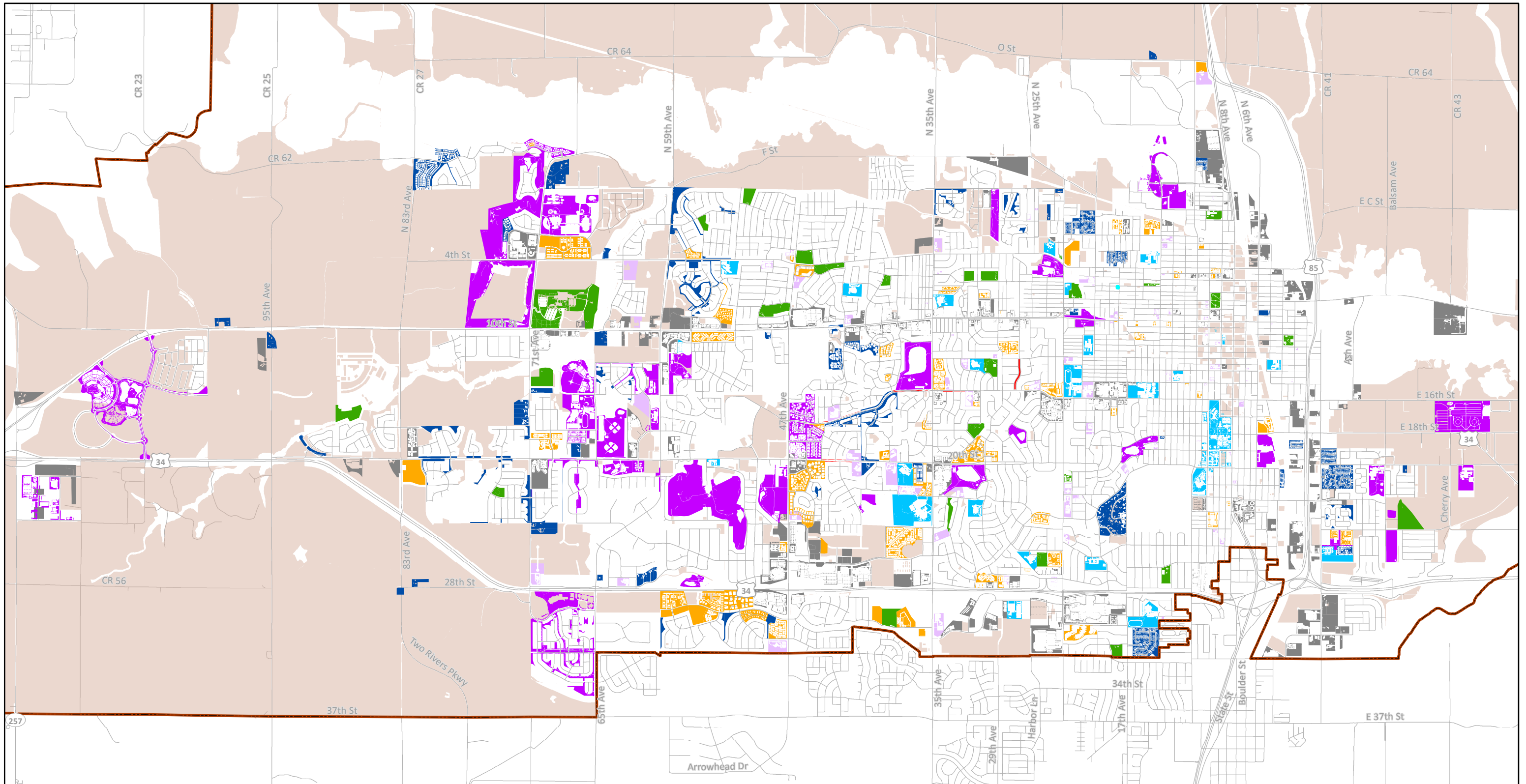


Figure 3-3 Conversion Area Categorization by Acreage

The conversion areas represent irrigable land; therefore the irrigable land flow factor was applied to each area for its category. It is not expected that all of these areas will convert to NP, and inclusion on this list is meant to identify a potential conversion, not set a requirement for conversion. To account for this, the adoption rates were applied to these areas.

Existing customers may be considered good candidates for potential conversion when they have a large irrigated area (greater than 15 acres), higher estimated demands (3,500 gallons per minute [gpm] per irrigated acre or higher), and/or are near existing or planned NP infrastructure. While a customer does not have to meet all these criteria to be eligible for conversion, the City should prioritize these properties. The City may also consider prioritizing customers that are public entities, such as parks and schools. Continued outreach to existing water customers can show them how NP irrigation can benefit them by lowering their water bill. For the purposes of the NPMP, it was assumed that all potential conversion areas will eventually convert to NP irrigation at the adoption rates noted above, regardless of whether they would be considered high priority or not.

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February 23, 2021

Legend

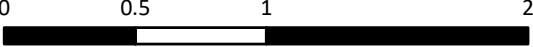
- LREGA
- Existing NP Irrigated Areas
- Future Development

Conversion Areas

- Church
- Commercial
- HOA
- Park
- Residential
- Road
- School



N



0 0.5 1 2
Miles

**Potential Conversion Areas
(Categorized)**

Figure 3-4

**Greeley Non-Potable Water
System Master Plan**

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3.2.3 Parks and Schools

Two land use types required special attention due to their high NP consumption: parks and schools.

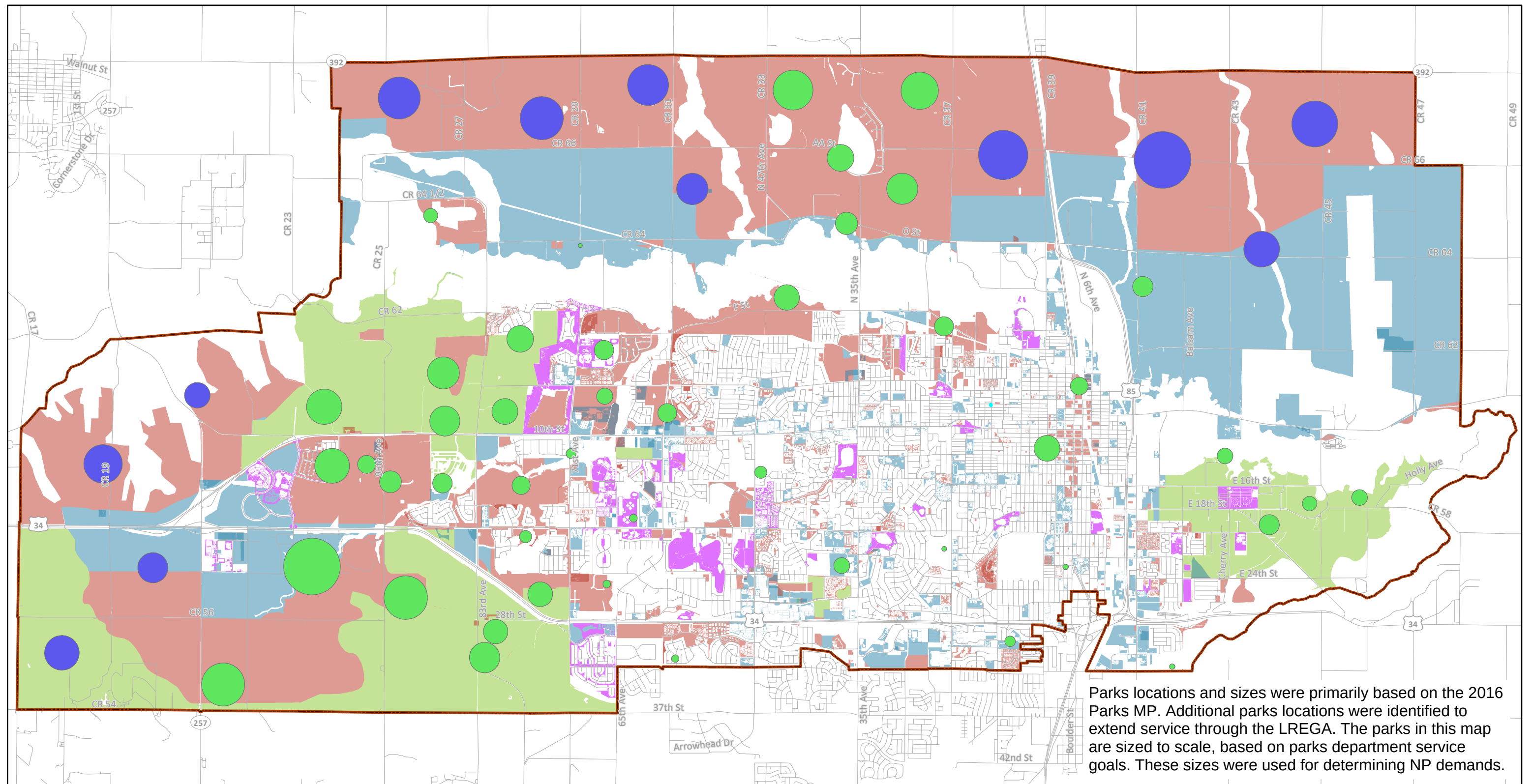
Park locations and sizes were primarily based on the City's Parks, Trails, and Open Lands Master Plan (2016). This document identified potential park locations for the next 20 years. These locations were supplemented by park locations included in this NPMP in order to extend parks service through the LREGA. It should be noted that the location and size of these parks is subject to change in future park master plans. The size of each park was based on population projections from the water and sewer master plans, and the park service goal of 8.25 acres/1,000 people from the 2016 Parks MP. This methodology was approved by the City's parks department.

Figure 3-5 shows all future park locations. Parks will serve as the hubs of the future NP system, and ponds serve both storage and aesthetic purposes.

Because schools represent large irrigable areas, it was desired to incorporate the location of future schools into the future demand projections. However, limited information is available as to the locations, numbers, and size of future schools. Because of this uncertainty, it was considered impractical to select a defensible number, and it was therefore decided to not include schools as a separate source of future demand projections. As schools are generally zoned as R-L, the R-L future flow factor was calculated as a weighted average between Residential and Schools flow factors. In this way, the NP demand from future schools is spread across the future land use areas where schools will eventually be planned.

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3.2.4 Other Land Uses through the LREGA

Outside of conversion areas and parks, NP demand projections for undeveloped land throughout the LREGA were coordinated with the water demand projections. The WTDMP and SSMP used a complex land use categorization methodology to identify around 60 different land uses within the City, which were used to categorize all currently undeveloped areas or areas of redevelopment. Based on discussions with the City and a review of the available information, three tiers were used for the potable water demands, as described below:

1. **Tier 1: Planned Developments.** This data was taken from development reports and planning documents for twelve known developments, which are in various stages of design. These areas represent the most detailed planning information available.
2. **Tier 2: City of Greeley Land Use (Sub-Areas) and Zoning Markup Map (Greeley Markup).** After review of this data, the City marked up 11 areas of growth to apply a specific growth distribution to each area, based on trends developed after the creation of the document. The City's planning department assigned percentages of land use type to each growth area. These areas were then split into sub-areas to better align with the density distribution of the original *Imagine Greeley Comprehensive Plan*.
3. **Tier 3: Zoning and Comprehensive Plan Information.** For all remaining areas, including infill areas, zoning and land use information was used to distribute future populations and water demands. This data was taken from the following sources:
 - a. Zoning from the *Annual Growth & Development Projections Report* (City of Greeley, 2019).
 - b. Land use guidance from the *Imagine Greeley Comprehensive Plan* (City of Greeley Community Development Department, 2018).

Using this data, each parcel in the City was assigned with a residential and nonresidential (i.e. commercial or industrial) future water demand based on its land use category. For detailed information on the potable demand calculations, please see the WTDMP.

The water and sewer land use types were then coordinated with the NP flow factor categorizations to develop separate NP and potable water flow factors for each land use type. These flow factors were applied throughout the LREGA to determine total NP demand.

3.2.5 Buildout Projections Summary

The conversion areas, parks, and undeveloped land were combined to produce a total NP demand set for peak month at buildout. This was incorporated into the future water model to aid in appropriately sizing infrastructure. The peak month buildout demand projections for potable vs. NP are summarized in **Table 3-4**. The NP demand density is shown in **Figure 3-6**. The NP demands comprise 19.5% of all future peak month water demands through buildout. NP demands may decrease if planning shows that it is not hydraulically or economically feasible to serve certain areas or, conversely, NP demands may increase if aggressive NP use policies are adopted.

Table 3-4 Peak Month Buildout Demands Summary

Development Type	Total Future Water Demand (MGD)	Future Potable Water Demand (MGD)	Future Non-Potable Water Demand (MGD)
Existing Demand	47.3	46.0	1.3
Future Development	56.7	47.5	9.2
Conversion Areas	2.3	0	2.3
Total	106.3	93.5	12.8

3.3 Demand Estimates by Planning Horizon

To distribute the future demand parameters in the model at each planning horizon, the percent to which each future development tier is built out at the end of each planning horizon was estimated. The basis for these estimates is the BBC report. At the 2025 and 2040 planning horizons, the calculated population is matched to the BBC report. The overall buildout population is assumed to exceed the 2075 BBC projected population. The total buildout population is projected to be 425,271. For more information on the percentages used, please see the WTDMP. The total phased potable and NP demands are shown in **Table 3-5**.

It is assumed that the Tier 1 projects will be completed first. For this reason, the majority of the Tier 1 projects are assumed to be complete at the 2025 planning horizon, and all of them complete at the 2040 planning horizon.

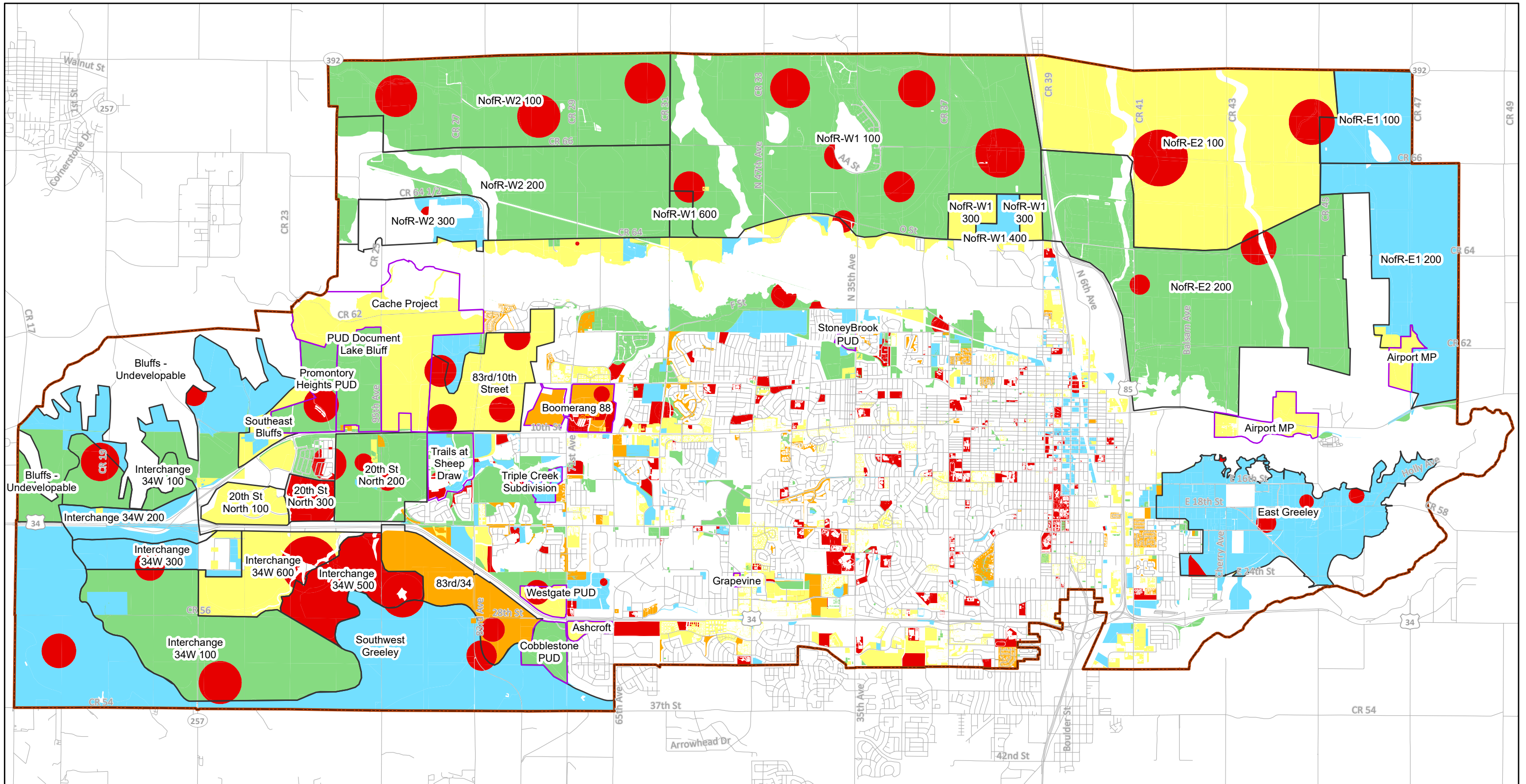
Because of the large areas within the Tier 2 projections category, the Tier 2 percent complete values for the 2025 and 2040 planning horizons have been developed through close discussions with the City. The Tier 2 areas identified for growth at the 2025 and 2040 planning horizons are the areas that the City's planning department have identified as the most likely growth areas.

The Tier 3 growth identified below for the 2025 planning horizon was chosen through discussions with the City. Tier 3 growth included in the 2040 planning horizon was assumed to include all of the infill around the Tier 1 and Tier 2 projected growth areas.

The rate at which existing developments will convert to NP irrigation will vary location-by-location based on economic feasibility, proximity to NP infrastructure, and the willingness of the owner to participate in conservation efforts. To estimate the rate of conversion areas, it was assumed that demand from conversion areas will increase at a similar rate to the total additional water projections. The percentage of water demands increase, as compared to the buildout projections, at each planning horizon was calculated, and this same percentage was applied uniformly to the conversion areas.

Table 3-5 Peak Month Demand by Planning Horizon

Planning Horizon	Total Future Water Demand (MGD)	Future Potable Water Demand (MGD)	Future Non-Potable Water Demand (MGD)
Existing	47.3	46.0	1.3
2025	51.8	49.4	2.4
2040	61.0	56.9	4.1
Buildout	106.3	93.5	12.8

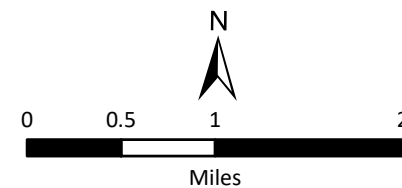


Legend

- LREGA
- Tier 1 (PUDs)
- Tier 2 (Comprehensive Plan)

NP Water Parcels Density

- <250 gpd/ac
- 250 - 500 gpd/ac
- 500 - 750 gpd/ac
- 750 - 1,000 gpd/ac
- >1,000 gpd/ac



Demand Density (Peak Month, Buildout)

Figure 3-6

Greeley Non-Potable Water
System Master Plan

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3.4 Economic Feasibility for Future Projects

In most developments, the decision on whether or not to use NP irrigation is based on economic feasibility, meaning whether the cost savings from using NP over potable outweighs the initial cost of infrastructure construction. This evaluation should consider the current cost of infrastructure against the long-term benefits of reducing potable system expansion, reduced cost of treatment, and freeing up more valuable treatable water rights for potable use. Long-term savings to the eventual owners/occupants of the property should also be considered when evaluating feasibility.

3.5 Water Resources Correlation

It is important for the City to plan for the total annual water demands through buildout. Water conservation methods, such as improved landscaping practices and the encouragement and adoption of NP water for irrigation, may help reduce the City's annual water demands. The City previously conducted a water resources planning study (BBC report), which focused on developing three alternative scenarios for annual water demands. The NPMP primarily focused on planning for future infrastructure needs based on peak summer demands. **Table 3-6** provides a comparison summary between the BBC report and the NPMP.

Table 3-6 NPMP and BBC Report Comparison

NPMP Approach	BBC Approach
Focused on infrastructure sizing, particularly during peak month demands	Focused on supply-side annual demands for water resources planning
Used a peak month: average month ratio of 1.8 for potable demands and 2.5 for NP demands to estimate annual demands from the calculated peak month demands	Only calculated annual demands, and did not calculate demands for peak seasons
Separated residential and nonresidential potable water demands to account for different customer diurnal curves and peak hours	Established a universal gpcd value that included commercial, industrial, and residential demands
Correlated population projections to the BBC report and other City planning department data	Developed three population projections (low, medium, high)
Geolocated demands based on land use to incorporate demand density for infrastructure planning	Used bulk demands for water resources planning, and did not spatially locate demands within the City
Estimated a single most-likely demand scenario for 2025, 2040, and buildout based on historic data and planning data	Provided detailed water resources planning for three scenarios every five years through 2075 and a less detailed buildout scenario

The total annual demands developed for the WTDMP under the NP offsets demand scenario at buildout are captured in **Table 3-7**. These demands are within the range established by the BBC report of 62,000 to 84,000 AFY for total water demands at buildout. Although the six industrial high intensity (I-H) users are included in these totals, these users were not used for modeling purposes, as their location is unknown and could lead to oversizing the system. Each large user's location will require a specific evaluation as to whether each additional user could use NP irrigation, and whether additional infrastructure would be necessary to supply this water.

Table 3-7 NPMP Annual Demand Projections at Buildout

Demand	Total Water Demand (AFY)	Potable Water Demand (AFY)	NP Water Demand (AFY)
Existing	30,500	28,600	1,900
Future Demands	33,500	28,300	5,200
New I-H Users (6)	10,300	10,300	0
Total	74,300	67,200	7,100

¹ Potable demand shown in this table is for NP offset scenario

It is recommended that The City rely on the BBC report for supply-side planning, and the WTDMP and NPMP for infrastructure and distribution system planning.

Section 4

Development of the Non-Potable System Model

Two system models, existing and future, were developed to plan for the future NP needs of the City. These two system models used the same inputs and assumptions as the existing system; projection growth rates and water demands, future service areas, and pipe and infrastructure sizing constraints.

The supply and demand data, asset and infrastructure inventory, and land use analysis were used to develop a model of the existing and future NP system. The future NP system model was created in line with the City's Specifications for NP systems.

4.1 Development of the Existing System Model

A hydraulic model of the existing NP system was developed in InfoWater to simulate current conditions and identify areas that may need short or long-term improvements.

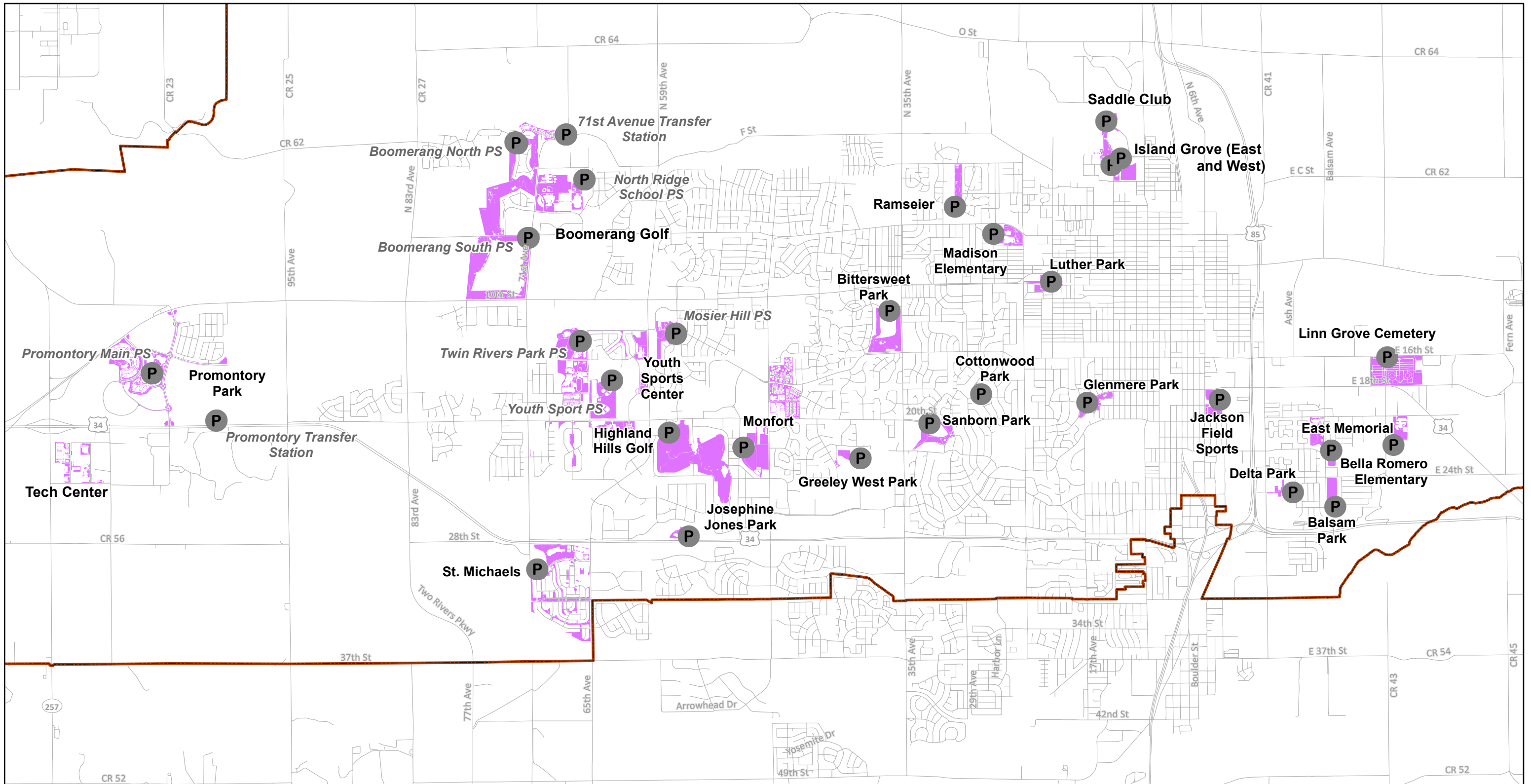
The NP system currently consists of 32 pump stations, including transfer stations, serving over one hundred customers. Most of these pump stations operate independently from other stations, creating 24 individual service areas. The systems at each service area are described in **Table 4-1**, and are shown in **Figure 4-1**. In a typical system, water flows by gravity from an irrigation ditch into a pond. From there, the water enters the wet well of the pump station and is pumped throughout the rest of the pressurized irrigation system.

Table 4-1 NP System by Service Area

Service Area	General Description
Balsam Park	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Bella Romero Elementary	A single pump station irrigates this park. This pump station pulls directly from a well, without a pond.
Bittersweet Park	A single pump station irrigates this park.
Boomerang Golf	The 71 st Avenue Transfer Station provides water to Boomerang Golf Course (north and south), North Ridge High School, and Poudre River Ranch. The Boomerang Transfer pumps provide water specifically to Boomerang North and Boomerang South, while the North Ridge Transfer pumps provide water specifically to North Ridge High School. Boomerang North, Boomerang South, and North Ridge High School receive water from the 71 st Avenue station into ponds, and then pressure pump from there. Poudre River Ranch has a dedicated irrigation pump at the 71 st Avenue station.
Cottonwood Park	A single pump station irrigates this park.
Delta Park	A single pump station irrigates this park.
East Memorial	A single pump station irrigates this park. The pond can be filled by the ditch, a shoulder well, or a shoulder tap.
Glenmere Park	A single pump station irrigates this park.
Greeley West Park	A single pump station irrigates this park.
Highland Hills Golf	A single pump station irrigates this golf course.

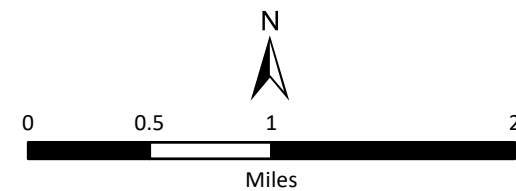
Service Area	General Description
Island Grove and Saddle Club	Island Grove East, Island Grove West, and Saddle Club pump stations all pump from individual wells and irrigate separate areas. Saddle Club also has a truck filling station in addition to general irrigation.
Jackson Field Sports	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Josephine Jones Park	A single pump station irrigates this park.
Linn Grove Cemetery	A series of three wells pump either into the irrigation system directly or fill a pond. A pump station on the pond also serves the cemetery's pressurized irrigation system.
Luther Park	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Madison Elementary and Houston Gardens	A single pump station with two separate pumping systems irrigates this area, splitting into two pipes to serve the school and gardens. This pump station pulls directly from the ditch, without a pond.
Monfort	A single pump station irrigates this area, splitting into three pipes to serve the park, school, and residential/commercial areas.
Peakview Park	A single pump station (Mosier Hill Pump Station) irrigates this park.
Promontory Park	A transfer pump station moves water from the ditch into the main ponds. The main pump station provides irrigation to the park, offices, and residential area. A small water circulation pump at the main station moves water from the lowest pond to the highest pond (not included in the model), creating the water feature.
Ramseier	A single pump station irrigates this park. This pump station pulls directly from the ditch, without a pond.
Sanborn Park	A single pump station irrigates this park.
St. Michaels	A single pump station irrigates this development.
Tech Center	This area is currently fed by potable water at a shoulder tap and does not have an NP pump station. Eventually, it will be transferred to NP water service.
Youth Sports Center	Two pump stations operate independently, but in a similar area: Twin Rivers Park and Youth Sports. Together, they serve two major recreational areas, schools, businesses, and residential areas.

In addition to these areas, Poudre Ponds, Stonney Brook, and the future Upper Equalizer transfer water from one ditch into another. Because these systems do not represent demand, they were not analyzed in depth.



Legend

- LREGA
- P Pump Station
- Existing NP Irrigated Areas



Existing Non-Potable Service Areas

Figure 4-1

Greeley Non-Potable Water
System Master Plan

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4.1.1 Infrastructure Connectivity Updates

Before the existing system could be hydraulically modeled, the City's NP GIS data needed to be updated to reflect current infrastructure. As discussed in **Section 1**, a GIS field survey was conducted to document the existing system. This task identified the location of features such as valves, pumps, and ponds, but did not capture how these features were connected to each other, as most NP piping is underground.

To accurately represent the system, historic operational data was analyzed and translated into GIS updates. As discussed in **Section 1**, the City compiled O&M data for each pump station. The construction documents, photos of the site, and other O&M data was integrated with the GIS field data and the City's original GIS data to fully capture the system. These GIS updates do not represent the full extent of piping through areas such as parks. All GIS updates were verified with City staff. The following overarching assumptions were used to update the system connectivity:

- Where meters appeared to be offset from the main lines, 2-inch laterals were added.
- For areas where the pipe or valve diameter was unknown, the diameter was assigned based on adjacent infrastructure (pipes, pumps, valves, etc.).
- In areas where infrastructure was within a meter of a pipe, it was assumed that this was due to the one-meter accuracy of the GPS unit used to collect the field inventory data. Because the field inventory data is considered to be the most up to date information, the pipes were realigned to connect through the field data.

4.1.2 Modeling Inputs and Assumptions

In general, the NP modeling methodology attempted to follow the same methodology as the potable water system model, to facilitate future integration. However, because the NP system has unique features (such as ditches, shoulder taps, etc.) and because it represents a series of separate systems instead of one larger interconnected distribution system, a unique methodology was needed to accurately depict these features. This section discusses this methodology.

Ditches. When an NP system draws directly from a ditch without an intermediate storage pond, the ditch was modeled as a fixed head reservoir. Because transfer systems are not included in the model, there are no places where water flows into a ditch.

Pipes. All existing and future pipes have of roughness of $C = 130$, to represent PVC.

Ponds. For most systems, the distribution system begins at a pond. For these systems, the pond is modeled as a fixed head reservoir. The fixed head was based on the field inventory, construction drawings, or ground surface elevation, depending on what information was available. For the purposes of modeling, it was assumed that the ponds can supply water to meet the system demands at all times during peak season.

Shoulder Taps. Shoulder taps are locations where the NP system can take water from the potable water distribution system during the early spring and late fall shoulder months, when the ditches may not have water but there are still irrigation demands. These are modeled as a fixed head reservoir with a normally closed valve that prevents it from flowing. The head on the

reservoir is set at peak month operating head in the potable water distribution system model. Notably, the shoulder taps do not typically operate during peak month conditions; therefore, this setting is considered conservative.

Wells. Like ditches, when an NP system draws directly from a well without an intermediate storage pond, the well suction conditions are modeled as a fixed head reservoir. The fixed head is the design pumping depth, as found in the O&M documents. The above ground well pump was modeled using available well pump curves, and submerged well pumps were not included in the model.

Pumps. Where available, the pump curve for each existing pump was used in the model, as provided in the O&M documentation. For pumps without a curve, a design point (defined as design head and flow) was used. Many NP pump stations also include a maintenance pump to maintain pressure during low flow. These are not included in the model.

4.1.3 Existing Demands Allocation

Existing demands were based on historic billing data and pumping data, as discussed in **Section 3**. To establish the peak month base demands used for this model, an average of demands, either billed or pumped, was taken for July and August of 2018 and 2019. The base demand derived from billing data was allocated to the appropriate meter and included in the model. For areas with demand based on pumping data, the demand was allocated to a node directly downstream of the pump station.

4.2 Extended Period Simulation Setup

Both the existing and future models were evaluated under extended period simulation (EPS) to examine how they perform throughout the day, instead of at a single point in time. All model scenarios had a 48-hour time duration. This section describes the methodology used to simulate EPS, including SCADA data calibration, diurnal peaking curves, and the approach to pump controls.

4.2.1 SCADA Data Calibration

As mentioned in **Section 1**, hourly SCADA data from September 1, 2015 to September 5, 2020 was used to calibrate the model. Not all SCADA data was available at all sites, and some sites do not have any SCADA data. For both the overall system and individual systems, a peak week with the highest usage was selected from the July and August 2018 and 2019 dataset. This peak week was selected to align with billing data used for demand projections. The data from the peak week was used for model calibration and diurnal curve development for each system.

Hourly pressure data, where available, was used to set up pump controls. The pump controls were set up to match pressure ranges that are typical to a given system. Diurnal curves were used to derive simple time-based controls to match typical pressure ranges for each system. For areas without available pressure data, pump controls were set so that pressures stayed within the 70 – 100 psi pressure range required by the City's Specifications.

4.2.2 Peaking Factors and Diurnal Curves

Diurnal curves were created from the SCADA data described above to show how the demands change on an hourly basis. These diurnal curves include the peak hour, which is the primary point in time used to evaluate the capacity of pumps and pipes. Ponds are sized on peak day.

The hourly data from the peak week for each system was used to create diurnal curves based on peaking during each day. Individual curves were created for pump stations that had their own SCADA data. These individual curves are included in **Appendix C**. Many of these individual diurnal curves revealed operational inefficiencies, such as watering during the day instead of only at night. Inefficient irrigation practices can increase costs and counteract water conservation goals. For more information on NP best practices, please see the City's WaterWise Landscaping Best Practices Manual Criteria in **Appendix F**.

A system-wide diurnal curve, shown in **Figure 4-2**, was created as a more generalized curve. It was based on SCADA data from the following pump stations: Promontory Main (not transfer), St. Michaels, Youth Sports Center, Monfort, Mosier Hill, Madison Elementary, Ramseier, Island Grove East and West, Luther Park, Jackson Field Sports, Bella Romero Elementary, East Memorial, Balsam Park, Delta Park, Highland Hills Golf, Twin Rivers Park, and North Ridge School (not transfer). The curve average is 1.35, which represents the ratio from peak month to peak week based on SCADA data so that the curve can be applied directly to the peak month demands developed. The individual curves each have different averages based on their own peak week: peak month ratios.

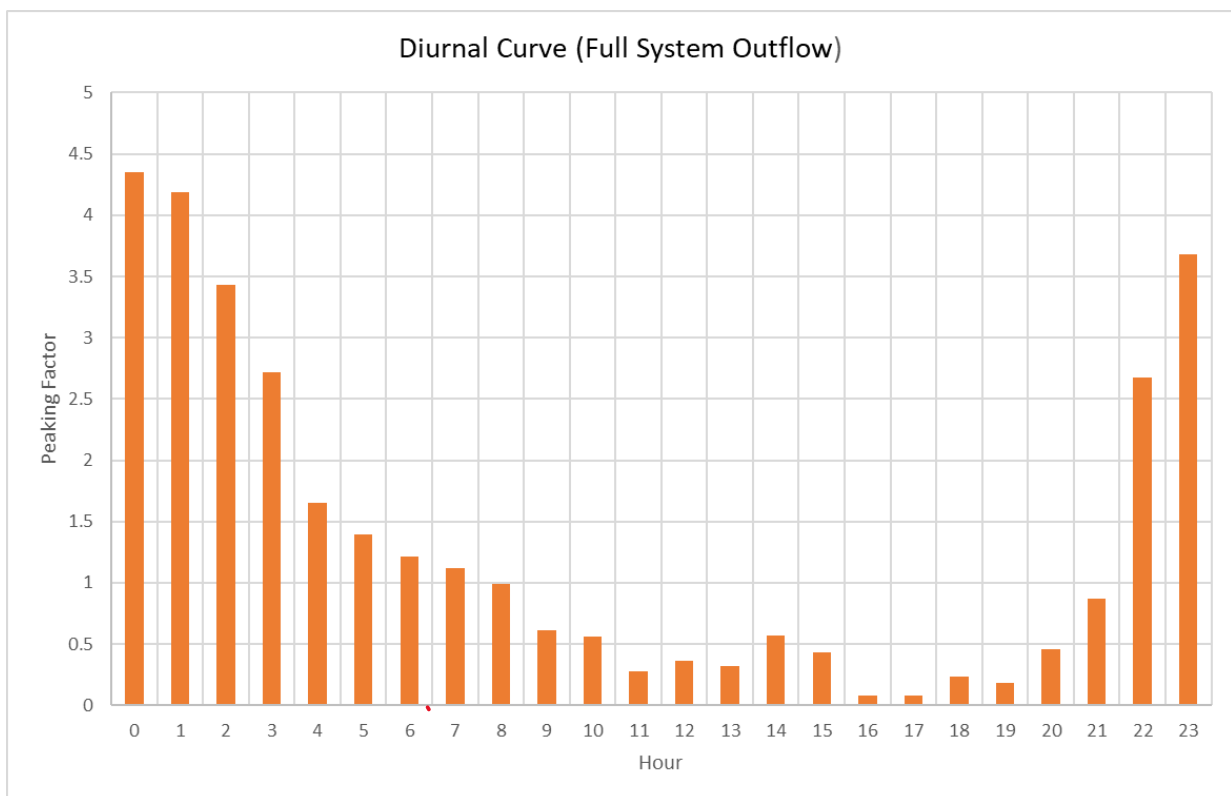


Figure 4-2 System-Wide Diurnal Curve

The peak hour of the system-wide diurnal curve occurs at midnight (hour 0) and has a peaking factor of 4.34. Limited watering appears to occur between 9 am and 8 pm, which aligns with the City's irrigation ordinances and best practices. This curve was applied to existing areas that do not have an individual curve, and to future developments.

For EPS modeling, these diurnal curves are repeated during a 48-hour runtime, in order to align with the potable water system model.

4.2.3 Pump Controls

Because each system is not connected and has unique demands and demand patterns, the modeled pump controls are also unique for each system. In general, pump controls are set by clock time based on the diurnal curve used by the system. For example, if demand drops to zero at hour 4, pumps will turn off or drop to a lower speed at hour 4 to accommodate this change. Because the NP pump stations use variable frequency drives (VFDs), the pumps may vary from 70% to 100% speed. At points where there is no demand in the system, the pumps are modeled as operating at the shutoff point; in real operations, this time period would likely be served by the maintenance pump. This methodology was used for both the existing system and the future system to ensure that appropriate pressures are maintained at all timesteps. This section is specific to modeling methodology; for more information on recommended operation of pump stations, see **Section 2.3** and **Section 2.4**.

4.3 Development of the Future System Model

Future infrastructure was projected throughout the LREGA to show how all areas through the City could be met with NP demand. This section discusses how future infrastructure, including pump stations and piping, was planned and modeled in InfoWater at each planning horizon. All planning horizons (2025, 2040, and buildout) were modeled using the same methodology.

4.3.1 Future Service Areas

In general, it is expected that the NP system will continue to operate as a set of independent systems using a hub-and-spoke methodology. The future parks, as shown in **Figure 4-3**, will serve as the hubs of the future system, as locating the pond and pump station in a park offers both recreational and aesthetic benefits, and provides the open space required for infrastructure.

Because of this, the land through the LREGA was divided into service areas based on the locations of the future parks and the existing NP system. The service areas were initially based on Thiessen polygons around the parks which were then reviewed and customized. The nearest source of NP water was identified, taking topography into account. This informed which areas should have their own pump station (those with a feasible NP source), and which should be served via pressure piping from another NP pump station. Final pump station and pond locations would ultimately be dependent on proximity to a ditch lateral or other water source during the design stage. The following assumptions were used to further refine the future service areas:

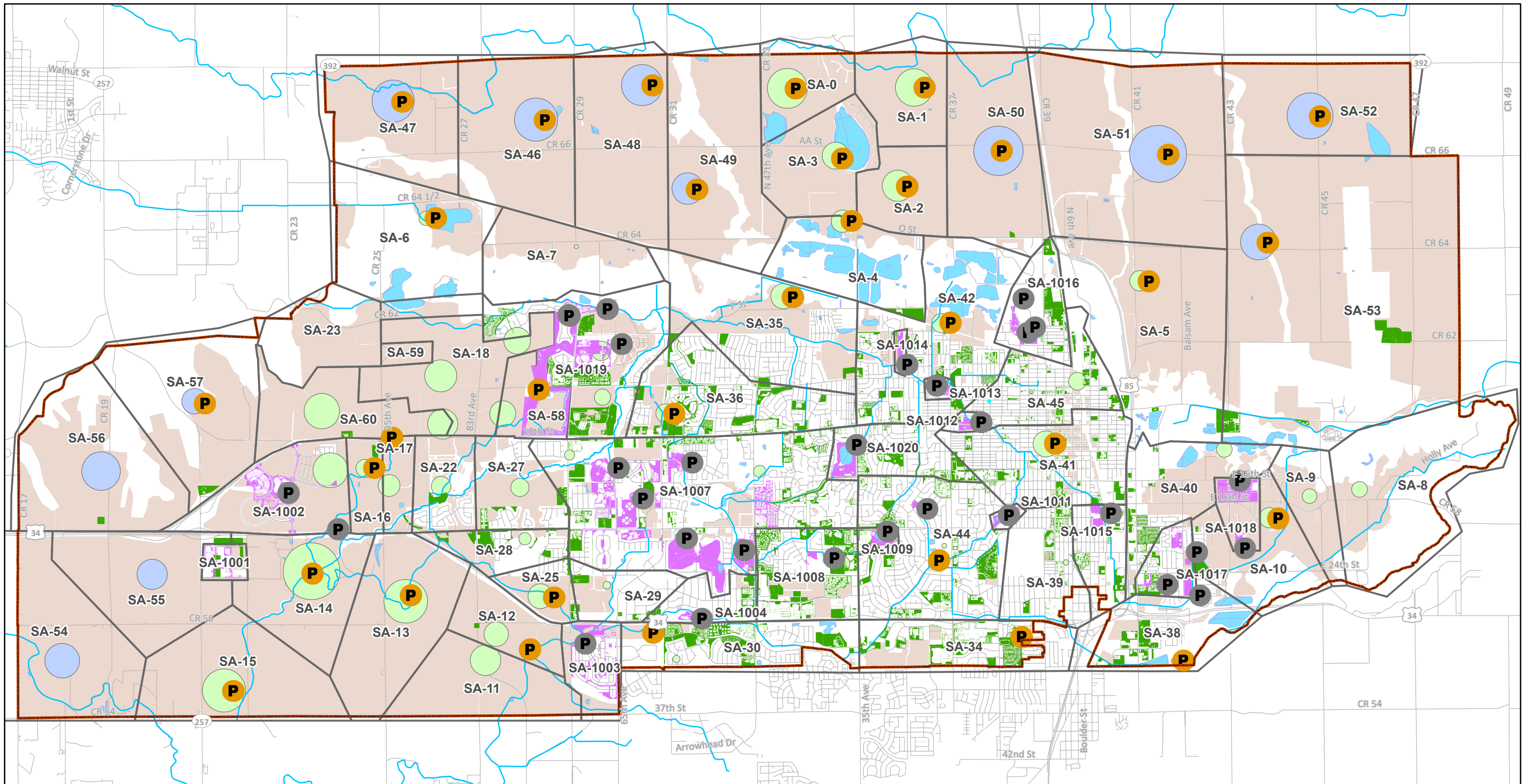
- Looping and connections between existing and future systems were attempted where possible. This can include systems with a similar hydraulic grade line or areas where it is less expensive to construct connecting pipe instead of installing new pumps or a new pump station.

- Railroad, river, and major road crossings were minimized where possible.
- NP water will flow by gravity into the ponds, located within parks, then will flow under pressurized conditions from the pump stations at the ponds.

A map of the future service areas, including future pump stations, is included in **Figure 4-3**.

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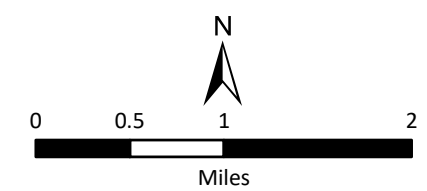
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Legend

- LREGA
- Existing NP Irrigated Areas
- P Future Pump Station
- P Existing Pump Station
- Future NP Demand Parcels
- Greeley Ditch
- Potential Park Location (2016 Parks MP)
- Potential Park Location (Approx. for Planning)

- Service Areas
- Lakes and Ponds
- Conversion Areas



Future Service Areas
 (Buildout)
 Figure 4-3
 Greeley Non-Potable Water
 System Master Plan

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4.3.2 Model Inputs and Assumptions

The preliminary future model was setup for the buildout scenario, which involves setting up infrastructure through the LREGA to account for a more than 800% increase from existing demands. The current City limit is 31,346 acres, while the LREGA is 58,306 acres, representing an 86% increase in land area by buildout, along with those areas that may convert from potable to NP irrigation. While it is impossible to perfectly predict future development needs, the model should provide a roadmap for future pump station locations and sizing, main pipe sizing, and potential interconnections between key areas. Developers should work with the City's engineering development review (EDR) and water and sewer department to discuss how new developments fit into the City's overall plan to provide NP irrigation service at acceptable pressures in both new and existing areas.

In order to establish infrastructure through the LREGA, pump stations were added into the model at each of the locations identified in **Figure 4-3**. Each pump station draws from a pond, modeled as a reservoir, and has two identical pumps in parallel. A typical pump station is shown in **Figure 4-4**. It is expected that each pump station would also have a smaller maintenance pump, not included in the model. Per the City's Specifications, pumps are required to operate with at least 80% efficiency; therefore, the pumps were modeled uniformly as 80% efficient. Pumps are expected to operate using a lead/lag methodology.

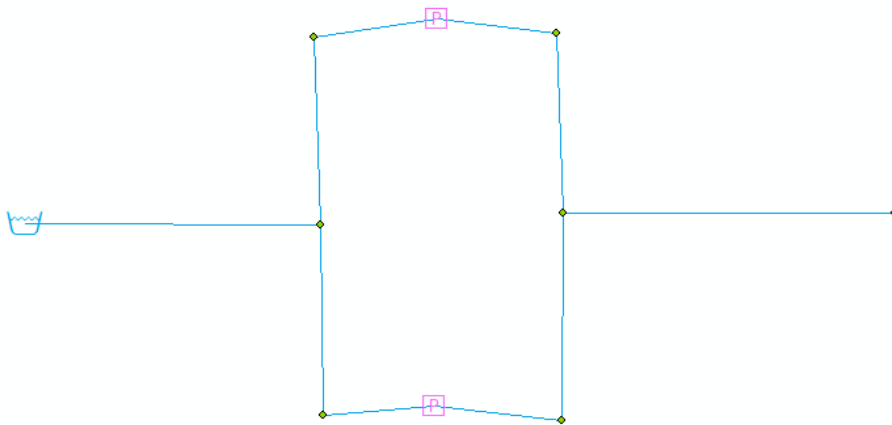


Figure 4-4 Typical Future Pump Station Configuration

In some areas, longer pipelines were drawn from the pump stations to serve undeveloped or conversion areas. These pipelines sometimes end at an anticipated parks location that is not expected to require its own pump station due to distance from a water source or proximity to another pump station. In other cases, the lines are expected to serve higher priority conversion areas, as described in **Section 3.2.2**. As with other infrastructure, these pipes do not represent final layout or sizing and should be reevaluated during the design stage.

The elevation of future nodes, including pumps and ponds, was based on ground surface elevation. Like the existing system, future pipes were modeled with a hydraulic roughness ("C") of 130.

4.3.3 Future Demand Allocation

After the piped network was established, the future demands were set up in the model for the new service areas. Details on demand projections through buildout can be found in **Section 3**.

Future demand datasets were created for each planning horizon, using the existing demand set with future peak month demands for both new developments and conversion areas. Existing and future demands were set as separate demands within the InfoWater demands database to allow for different diurnal curves for existing versus future demands. Each future demand point was tagged with the service area it is in, and all the demand was summed to produce a total demand per service area. This was allocated to the node downstream of the pumps. When there were multiple pump stations within a single service area, the demand was divided evenly between them.

4.3.4 Piping and Infrastructure Sizing Criteria

The hydraulic model is helpful in providing the preliminary sizing of infrastructure such as pump stations, storage ponds, and pipe sizes. These initial models are intended for planning purposes only, and do not constitute a preliminary design plan. Developers should work with the City's EDR and water and sewer department to discuss how new developments fit into the City's overall plan to provide NP irrigation service at acceptable pressures in both new and existing areas. All future infrastructure must comply with the City's Specifications.

As noted previously, each future pump station is modeled with two pumps in parallel. The City's Specifications state that NP pump stations must have a capacity of 120% of peak hour demand. All future pumps are therefore sized where the two pumps are identical, with a combined flow of 120% of the peak hour. An iterative process is used to identify the required design head for these pumps, so that pressure requirements are met downstream.

Per the City's Specifications, NP irrigation mains can be 4-, 6-, or 8-inch, and NP transmission mains can be 10 inch and larger. Per the City's direction, 8-inch will be the smallest pipe size recommended for the City's future NP system. After the meter, developers may use whatever size is required. Additionally, pressures are required to be 70 – 100 psi at each NP irrigation service meter and have a peak flow velocity less than 5 fps and headloss less than 10 ft/1,000 ft. Pipes within the model were sized large enough to meet these pressure and velocity requirements, without incurring extra costs by oversizing. Developers may use any line size that meets the hydraulic requirements described in the City's Specifications.

Ponds are designed to store four days of peak day flow, per the City's Specifications. Storage was calculated using peak day demand to provide preliminary pond sizes for the analysis phase of the project.

Section 5

Existing and Future System Model Evaluation

Existing and future system models were developed to plan for the future NP needs of the City. These models were analyzed for system-wide deficiencies and improvements for the current, the 2025, 2040, and buildout planning horizons. The NP model was incorporated into the potable models for evaluating overall potable and NP water system needs. This Section discusses the way the existing and future systems were analyzed.

5.1 Evaluation Criteria

The existing and future systems were analyzed through a combination of hydraulic modeling in InfoWater and desktop analyses, as discussed on **Section 4**. This section discusses how the various parts of the NP system (such as pipes, pumps, and storage) were evaluated to determine whether existing systems needed improvements and to determine project design points for future systems.

Because the NP system provides primarily irrigation waters, only the peak day was analyzed (which represents peak irrigation season during the summer), using EPS. This is discussed further in **Section 4.2**. Please see **Section 1** for more information on the development of the peak month demands, and **Section 3** for more information on their allocation in the model.

Per the City's Specifications, the NP system must generally provide a pressure between 70 – 100 psi at all meters, and must maintain a velocity of less than 5 fps and headloss of less than 10 ft/1,000 ft in all pipes. While the City's Specifications say that irrigation mains can be as small as 4 inches, it was determined after conversations with the City that all future systems will be designed with a minimum pipe diameter of 8 inches. Additionally, it is considered a best practice to upsize the inlet pipe, from pond to wet well, in order to account for any additional expected demands. A recommended but not required design criteria is to design for less than 6 inches of headloss throughout the length of the pipe. For this NPMP, the inlets were designed for the 10 ft/1,000 ft headloss criteria, which will ensure that the total headloss remains below 6 inches as long as the inlet is less than 50 ft long.

NP pump stations must have a capacity of 120% of the peak hour, per the City's Specifications. The design flow of the future pumps was based on this parameter, and the design head for the future pumps was based on the pressure requirements throughout the modeled system.

Also per the City's Specifications, "ponds shall be sized to accommodate a minimum four (4) days of supply during peak irrigation periods, plus losses." For the NPMP, this means that storage requirements will be 4 times the peak day flow determined, plus 10% for evapotranspiration losses. While 10% losses was used for master planning purposes, developers should ensure that they incorporate calculated losses into their own storage calculations for a design-level report.

Table 5-1 summarizes the evaluation criteria.

Table 5-1 System Evaluation Criteria

Metric	Evaluation Criteria	Comments
Piping		
Pressure	70-100 psi	
Velocity	< 5 fps	
Headloss	< 10 ft / 1,000 ft	
Minimum Main Size	8 inches	Not specified in design criteria, City preference for future
Maximum Inlet Pipe Headloss	6 inches	Not specified in design criteria, good practice
Pumping		
Pumping Capacity	120% of peak hour	
Irrigation Window Assumed	10 hours / day	Not specified in design criteria. For irrigation-only pumps, does not apply to transfer pumps.
Pump Station Layout	No standby pump, however low flow pump required	
Ponds		
Storage Volume	4 times peak day + losses	
Daily Irrigation Application Rate	24 gpm/acre	Peak season metric used in the design of irrigation systems per the City's Specifications. This value is appropriate for areas where the exact irrigated acreage is known but is not appropriate for planning-level estimates of bulk undeveloped land.

5.2 Existing System Evaluation

The existing model was evaluated in both the InfoWater model and through various desktop analyses. The existing model helped identify concerns with pressure and velocity, while desktop analyses helped identify pumps that are at or over capacity and the pond design storage requirements. Existing deficiencies are summarized in **Table 5-2**, and a description of the recommended upgrades and solutions can be found later in this section. For more detailed information on the analysis results for the existing system, including recommended pond sizing, please see **Appendix D**.

The existing system evaluation was limited to the available data on pipe diameters and SCADA data. Refer to **Section 1** for more information about the background data, including the system inventory and SCADA data. Existing pump capacity was based O&M data such as pump curves, along with information from City operators.

The identified deficiencies included possible undersized inlet lines at some areas. However, the inlet pipe size should be confirmed in the field. Another commonly identified deficiency was that in some areas, while the main NP pipelines are sized correctly, the individual taps off to the irrigation systems (which can have diameters as small as 1 inch) are undersized. This produces high velocities and headloss. However, because there is only monthly data available at these taps, rather than hourly data, they may not be experiencing the high peak hours predicted by modeling based on SCADA readings at the pump station and may actually be appropriately sized. (For example, the hourly flows from the pump station have higher peaking factors than the small

diameter tap). If a customer notices low pressure, they may consider upsizing the tap off the mainline to mitigate this issue. Most pump stations (26 out of 34) were found to have sufficient capacity, even through buildout. However, increased NP irrigation adoption may lead to pump stations reaching capacity sooner than expected; flows should be continually monitored to note when pumps are getting close to capacity.

Table 5-2 Summary of Existing System Analysis

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Balsam Park	N/A	290	51	51	No deficiencies were identified for this pump station.
Bella Romero Elementary	N/A	330	109	109	No deficiencies were identified for this pump station.
Bittersweet Park	N/A	1,000	854	1,160	Small diameter pipes may be producing high headloss; limited data is available on pipe sizes. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Boomerang	Boomerang North	1,500	769	769	No deficiencies were identified for this pump station.
	Boomerang South	1,500	694	0	This system is being replaced by the Boomerang Regional Pump Station.
	Boomerang Transfer	1,800	951	621	Some of the Boomerang transfer lines are undersized; this issue will be resolved by the construction of the Boomerang Regional Pump Station.
	Boomerang Regional Pump Station	3,260	N/A	2,716	<i>This new pump station is part of a larger redevelopment project and will replace the existing Boomerang South pump station. This pump station is identified as a CIP project.</i>
	North Ridge Transfer	1,800	936	936	No deficiencies were identified for this pump station.
	North Ridge School	2,700	1,205	1,752	No deficiencies were identified for this pump station.
	Poudre River Ranch	175	205	205	The lines to Poudre River Ranch and the pump station do not meet hydraulic design criteria but do not appear to hinder system performance. While there are no recommended changes, additional demand should not be added to this area without upsizing.
Cottonwood Park	N/A	115	69	69	No deficiencies were identified for this pump station.
Delta Park	N/A	95	52	52	No deficiencies were identified for this pump station.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
East Memorial	N/A	319	314	440	Bringing on all potential undeveloped and conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
Glenmere Park	N/A	180	135	304	The inlet may be undersized; inlet pipe size data was not available for this system. Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Greeley West Park ¹	N/A	2,000	72	861	No deficiencies were identified for this pump station.
Highland Hills Golf	N/A	2,001	1,792	1,792	No deficiencies were identified for this pump station.
Island Grove and Saddle Club	Island Grove West	600	605	605	No deficiencies were identified for this pump station.
	Island Grove East	700	401	401	No deficiencies were identified for this pump station.
	Saddle Club	300	72	138	No deficiencies were identified for this pump station.
Jackson Field Sports	N/A	400	258	317	No deficiencies were identified for this pump station.
Josephine Jones Park	N/A	115	106	161	Bringing on all potential conversion areas may cause this pump station to be undersized after 2040. While no improvements are expected to be necessary before 2040, the system should be evaluated as each conversion area is brought on to ensure there is still sufficient capacity.
Linn Grove Cemetery	N/A	350	95	122	No deficiencies were identified for this pump station.
Luther Park	N/A	530	492	498	The small pipe diameter (4") at the outlet does not meet hydraulic design criteria; while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Madison Elementary and Houston Gardens	Houston Gardens	125	310	310	While this system appears to be operating over the pump design head, it does not hinder system performance, as this system is designed for low pressures.
	Madison Elementary	500	90	93	No deficiencies were identified for this pump station.

Service Area	Pump Station	Existing Capacity (gpm)	Existing Peak Hour Demand (gpm)	Buildout Flow – Peak Hour (gpm)	Comments and Identified Deficiencies
Monfort	N/A	2,400	1,423	1,745	The inlet is slightly undersized (10" diameter); while this does not hinder system performance, it should be monitored as demands on the system increase to ensure the wet well is still able to receive sufficient water.
Peakview Park	Mosier Hill	800	681	681	The pipes at Peakview Park have a small diameter (as low as 4") and do not meet hydraulic design criteria. Although this does not appear to significantly hinder system performance, the City may consider upsizing if other work is already being done in this area.
Promontory Park	Main	2,100	1,270	1,866	No deficiencies were identified for this pump station.
	Transfer	1,600	1,651	1,651	While this pump station sometimes operates slightly over its design flowrate, it is not significant enough to warrant upsizing. If additional demands in this area increase transfer station operations, expanding the length of time the transfer station operates each day will likely maintain an acceptable flowrate.
Ramseier	N/A	450	734	739	Additional evaluation of this site is needed as outlet pipe size and SCADA data were not available. While current modeling shows that the system is operating over the design head, the peaking factor may be lower than the system-wide diurnal curve, resulting in lower peak demands.
Sanborn Park	N/A	500	268	289	Small diameter lines may be causing high headloss; limited data is available on pipe sizes.
St. Michaels	N/A	1,120	1,121	1,167	This pump station may be undersized. Additional evaluation should be conducted to determine if demand management is effective and whether the pumps can be upsized without replacing the entire station.
Tech Center	N/A	N/A	N/A	N/A	This area is currently only served by a shoulder tap. A pump station is necessary to transition it to NP irrigation (future service area SA-14).
Youth Sports Center	Youth Sports	1,200	941	941	The inlet line does not meet hydraulic design criteria but does not appear to hinder system performance. This line should be evaluated as each new area is brought on to ensure there is still sufficient capacity.
	Twin Rivers Park	4,200	1,314	1,692	No deficiencies were identified for this pump station.

¹ Greeley West Park is planned for replacement before 2025. The values shown in the table represent the design for the new pump station.

5.3 Future System Evaluation by Planning Horizon

This section provides an overview of the preliminary results for sizing the pipes, pumps, and ponds to meet the design and evaluation criteria described above. For details on the sizing for each pump station, please see **Appendix E**. A map of all pump stations by planning horizon is shown in **Figure 5-1**. **Table 5-3** summarizes the proposed infrastructure (such as pipes and pump stations) by planning horizon. Only major piping (8 inches and larger) is accounted for in this plan. Detailed distribution piping will be per developer, City water and sewer department, and/or parks department plans. For some systems, it is expected that their pipelines will be expanded after construction as development occurs. For example, the pump station will be constructed to serve a smaller area, then the pipes will be expanded as development continues. It was assumed that pump stations will only be constructed after 20% of the potential buildout demand is met. The City should work with developers to determine best timing for construction of a new pump station as development projects become planned. All proposed projects described below were found feasible using the InfoWater methodology described in **Section 4**, but further design and confirmation is required for each system before construction.

Table 5-3 Proposed Infrastructure by Planning Horizon

Planning Horizon	Pump Stations ¹	Storage in Ponds (AF)	New Pipeline (ft) by Diameter					
			8-inch	10-inch	12-inch	16-inch	30-inch	Total
Existing	37	Unknown	23,100	17,600	12,200	3,400 > 12"		90,000
2025	5	35.1	21,800	18,500	0	19,000	26,700	86,000
2040	10	28.1	26,900	11,500	0	8,200	0	46,600
Buildout	18	75.7	28,300	1,000	200	14,800	0	44,300
Total New	33	139.0	77,000	31,000	200	42,000	26,700	150,200

¹ All new pump stations are expected to have a pond.

All existing and planned future pump stations are shown in **Figure 5-1**. Pump station locations and pipeline alignments are approximate and schematic.

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5.3.1 2025 System Evaluation

The 2025 planning horizon includes improvements to the existing system. The improvements include new pump stations in areas that are already developed (but may experience conversion or infill) and new pump stations in areas that are expected to develop by 2025, especially planned developments. In total, 4 new pump stations are expected by the 2025 planning horizon. Please see **Table 5-4** and **Appendix E** for detailed information on these pump stations. The following are notable projects that are expected to be completed by 2025:

- Upper Equalizer Project¹. This project will expand NP service further into the shoulder seasons by transferring water from the Greeley Irrigation Company (GIC) to the GLIC ditches. The proposed piping will be routed along 83rd Avenue.
- Boomerang Regional Pump Station. This project will be part of a larger project, which involves redevelopment of the southern 9 holes of the Boomerang Golf Course, construction of a new school, and residential development. The piping from the Boomerang Regional Pump Station is expected to serve far to the west, including past 95th Avenue.
- Upsizing of the Greeley West pump station to serve the Centerplace development, as well as other conversion and infill areas.
- Construction of a pump station to serve the Tech Center and adjacent undeveloped areas.
- Expansion of piping (new pipeline) from Glenmere Park along 8th Avenue to serve additional conversion and infill areas.
- Expansion of piping (new pipeline) from Promontory Park along 16th Street to serve newly developing areas.
- Expansion of piping (new pipeline) from Monfort along 47th Avenue to serve additional conversion and infill areas.
- Expansion of piping (new pipeline) from Twin Rivers Park to the west to serve additional conversion and infill areas.

5.3.2 2040 System Evaluation

The 2040 planning horizon includes 12 new pump stations, primarily in areas that are currently undeveloped. In particular, eight new pump stations are expected in the North of the River area due to potential NP demands through that area starting after 2025. However, very limited development is expected in this area until full buildout. The City may consider constructing the NP distribution pipe system but waiting to put in pump stations until there is further development in the area, similar to how the Tech Center was constructed. The following are notable projects that are expected to be completed between 2025 and 2040:

¹ Supply-side projects such as the Upper Equalizer Project were not studied as part of the NPMP, which was focused on the expansion of the distribution system.

- Westward expansion of pipelines from the Tech Center. It is expected that the southernmost 6 inch existing NP lines along the southern edge of the Tech Center are not sized large enough to handle the additional flows and will need to be either upsized or paralleled. The City may decide to complete this project when the new SA-14 pump station is constructed, depending on future development.
- Construction of a regional pump station west of St. Michaels (Cobblestone Regional).

Table 5-4 and **Appendix E** summarize these and other projects.

5.3.3 Buildout System Evaluation

The buildout planning horizon includes 19 new pump stations in areas that are either not expected to have any development, or have less than 20% development, until after the year 2040. The locations of these pump stations were based on even spacing throughout the LREGA, in coordination with the City's parks department. These locations are not final and should be coordinated with the construction of new parks or open spaces, where the ponds can serve as an amenity. **Table 5-4** and **Appendix E** summarize these and other projects.

Table 5-4 Future System Information

Pump Station Name	Planning Horizon	Pump Station Design		PS Outlet Size (in)	Pond Size (AF) ¹
		Flow (gpm)	Head (ft)		
SA-14	2025	3500	230	16	13.4
SA-25	2025	640	160	8	2.4
SA-44	2025	660	160	8	2.5
SA-60	2025	1120	200	10	4.2
Boomerang Regional PS	2025	3260	170	16	12.5
SA-3	2040	620	160	8	2.3
SA-4	2040	240	180	8	0.9
SA-12	2040	1160	210	10	4.4
SA-15	2040	1400	170	10	5.3
SA-16	2040	1040	180	10	4.0
SA-34	2040	560	170	8	2.1
SA-35	2040	620	160	8	2.3
SA-36	2040	900	170	8	3.4
SA-38	2040	160	180	8	0.5
SA-42	2040	720	180	8	2.7
SA-0	2075	780	170	8	3.0
SA-1	2075	780	170	8	3.0
SA-2	2075	660	180	8	2.5
SA-5	2075	620	170	8	2.4
SA-6	2075	360	180	8	1.4
SA-10	2075	1000	170	10	3.8
SA-13	2075	1220	170	10	4.6
SA-30	2075	440	155	8	1.7

Pump Station Name	Planning Horizon	Pump Station Design		PS Outlet Size (in)	Pond Size (AF) ¹
		Flow (gpm)	Head (ft)		
SA-41	2075	1120	160	10	4.3
SA-46	2075	1120	160	10	4.2
SA-47	2075	960	170	10	3.7
SA-48	2075	1040	170	10	4.0
SA-49	2075	1120	170	10	4.2
SA-50	2075	1540	170	12	5.9
SA-51	2075	2500	180	16	9.6
SA-52	2075	1300	170	10	5.0
SA-53	2075	1820	170	12	6.9
SA-57	2075	1480	200	16	5.7

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Section 6

Capital Improvement Plan

6.1 Approach to CIP Development

This Section builds on the capital improvement projects identified in **Section 5** at the 2025 and 2040 planning horizons and defines the approach for development of the 5-year and 20-year CIPs. The identified CIPs were developed with consideration of the City's current and long-range population as well as projected flows, using currently available information. Conditions will change with time and uncertainties will impact the accuracy of each plan in later years. As projects come closer to implementation, it is important that the City reevaluate each CIP to better reflect costs.

This section provides planning level cost estimates for capital improvement project scheduling. Major capital elements are itemized with unit prices. Information from past projects and outside resources, both locally and nationwide, were relied upon to develop unit prices for major capital categories. CIP projects were developed using pipeline quantity estimates and modeling data. GIS mapping was used to identify areas of interest, such as utilities and road crossings. The unit prices were then multiplied by the quantity of each element. Project elements that are difficult to estimate during the planning stage are included in the overall cost as either allowances or as a percentage of the total for the itemized project elements. During design development, the more specific data will be used to inform the design and resulting project cost estimate.

6.2 Cost Development

Unit costs were developed to aid in CIP budgeting, as described below. Cost estimating is considered Association for the Advancement of Cost Engineering (AACE) Class 5 – Conceptual engineering phase.

6.2.1 Project Implementation and Additional Project-Related Costs

Apart from the unit costs used to build-up project material costs (e.g., pipes, pumps, and ponds), several other elements were added as factors. Construction factors include items such as erosion control/stormwater pollution prevention and contractor mobilization and demobilization. These costs are estimated as a percentage of the construction unit costs. Contingency is applied to the subtotal of these construction cost elements to account for variations in unit prices or quantity estimates. Programmatic elements such as engineering, permitting, legal, and administration are estimated as a percentage of the construction cost. **Table 6-1** provides a breakdown of the assumptions used for project implementation and contingency.

Table 6-1 Costing Factors for Construction Bid and Total CIP Project Costs

Category	Item	Costing Factor
Construction Bid Cost (includes infrastructure and contractor overhead, profit, bonds, and insurance)	Erosion Control/Stormwater Pollution Prevention ¹	2%
	Mobilization and Demobilization ¹	5%
	Contingency ²	35%
Project Implementation ³	Feasibility and Site Studies	9% for OPCC ≤ \$1 million 6% for OPCC of \$1 million to \$10 million 5% for OPCC > \$10 million
	Preliminary and Final Design	9% for OPCC ≤ \$1 million 6% for OPCC of \$1 million to \$10 million 5% for OPCC > \$10 million
	Engineering Services During Construction	5%
Additional Project-Related Costs ³	Outside Construction Management - not used if OPCC value is < \$1M	5%
	Outside Project Management - not used if OPCC value is < \$1M	3%

¹ Construction bid cost costing factors erosion control/stormwater pollution prevention and mobilization and demobilization are applied to the subtotal of unit cost items.

² Contingency costing factor is 35% of the subtotal of the unit cost items, erosion control/stormwater pollution prevention, and mobilization and demobilization.

³ Project implementation and additional project-related cost factors are applied to the total construction cost.

6.2.1.1 Erosion Control/Stormwater Pollution Prevention

Project erosion control and stormwater pollution prevention includes the contractor's cost to manage the stormwater during construction through best management practices such as silt fences, rock socks, vehicle tracking, and silt prevention at storm inlets. This category is assumed as 2% of the unit costs and is based on estimator's judgement. This costing factor is added to calculate project OPCC totals.

6.2.1.2 Mobilization and Demobilization

Contractor Mobilization and Demobilization includes the contractor's start-up costs and close-out costs. Start-up costs include items such as moving equipment and personnel to the project location, obtaining permits and bonds, etc. Close-out costs include items such as project cleanup, moving equipment and personnel from the project location, etc. The mobilization and demobilization category is estimated as 5% of the unit costs and is based on estimator's judgement. This costing factor is added to calculate project OPCC totals.

6.2.1.3 Contingency

During the planning phase, the design and field work has not yet been completed for the projects. Therefore, the cost development relies on estimated quantities for each construction element. Project contingency provides for these uncertainties by adding additional costs to the project total. The contingency at the planning level is typically 35% of the OPCC subtotal after the erosion

control/stormwater pollution prevention and mobilization and demobilization costing factors have been included. Project contingency also provides for costs associated with items that are difficult to itemize at a planning level.

6.2.1.4 Feasibility and Site Studies

This cost element includes the planning and field investigations (such as geotechnical, survey, ground sampling, subsurface utility engineering [SUE] and locates, etc.) that are required to implement a project. These are estimated as a percentage of the subtotal of the previous elements and the percentage varies based on the OPCC, plus cost contingency.

6.2.1.5 Preliminary and Final Design

The preliminary and final design cost element includes the cost for engineering services to develop biddable plans and specifications in accordance with applicable standards. This cost is estimated using a percentage of the OPCC, plus cost contingency.

6.2.1.6 Engineering Services During Construction

Engineering services during construction includes the review of contractor submittals, requested changes, and design adjustments that may be required during construction. A percentage of the OPCC is used to estimate this cost element.

6.2.1.7 Additional Project-Related Costs

Outside construction and project management are estimated for projects that are not directly managed by the City. For purposes of this master plan, only projects in excess of \$1 million were assigned these cost elements.

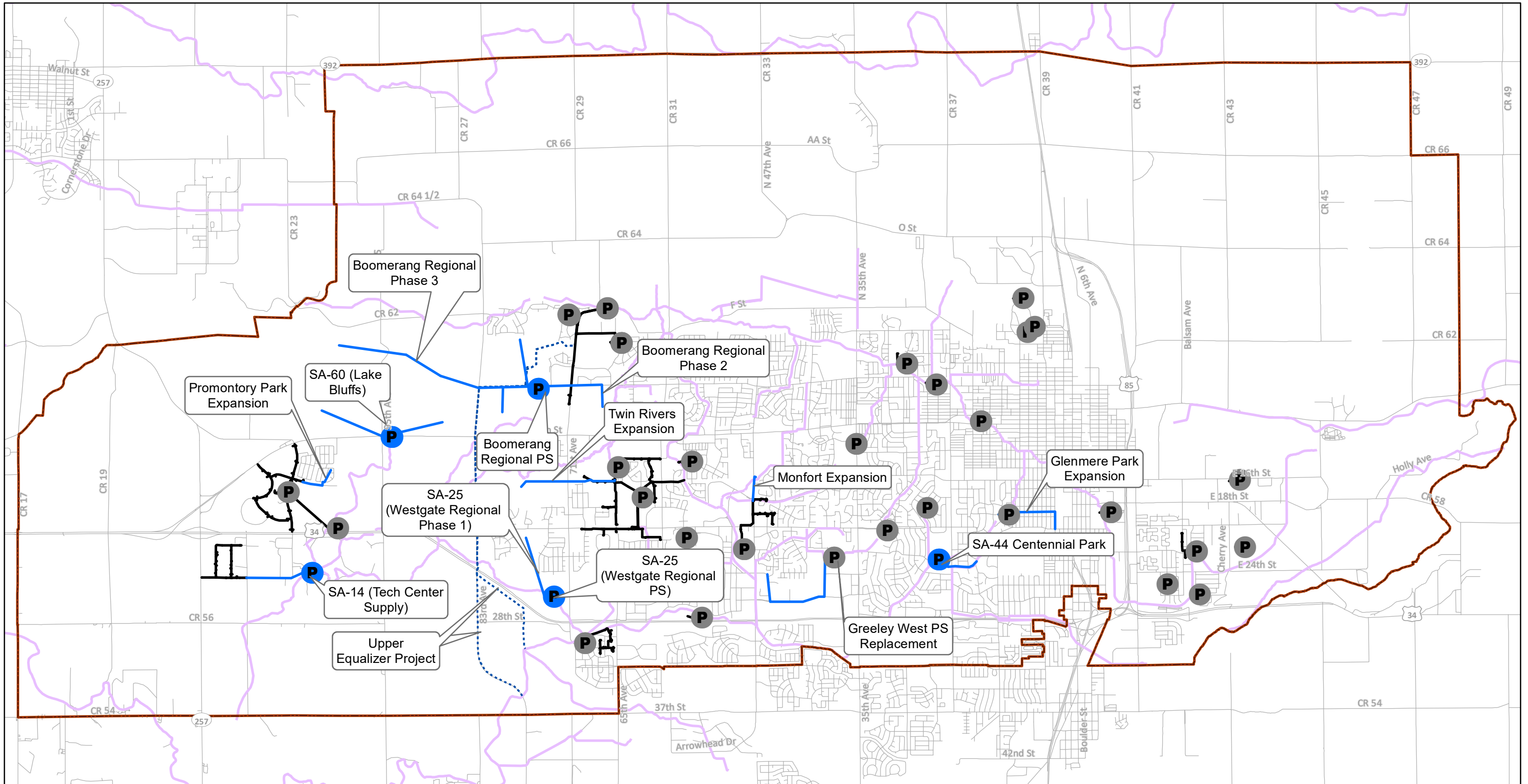
6.3 Identified CIP Projects

Projects are forecast over 5-years (for projects for 2022 through 2025) and 20-years (for projects for 2026 through 2040). Projects were named based on geographic location and service area number. Construction and total project costs were developed for the projects and are described in the following figures and tables.

Figures 6-1 and **6-2** illustrate the locations of the identified projects within the 5-year and 20-year CIPs respectively. For development driven projects, the City will negotiate with developers the cost difference for the installation of a larger pipe diameter or for additional pipe lengths to meet future needs versus the developer's needs.

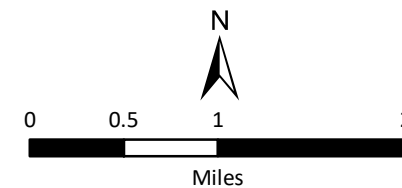
Table 6-2 provides a summary of project drivers. This summary identifies a driver as an existing deficiency or population growth driven, and also whether the project is proposed to be constructed by the City's water and sewer department, the City's parks department, or by developers. In many cases, project costs may be shared between some or all of these three entities. It is assumed that costs will be divided proportionately, based on future demands. Stakeholders for any given NP project should collaborate to develop cost sharing for projects that would mutually benefit all responsible parties.

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Legend

- LREGA
- Existing Pump Station
- 2025 Pump Station
- Existing NP Pipes
- 2025 Proposed NP Pipes
- Greeley Ditch
- Upper Equalizer Project



Recommended 5 Year Improvements

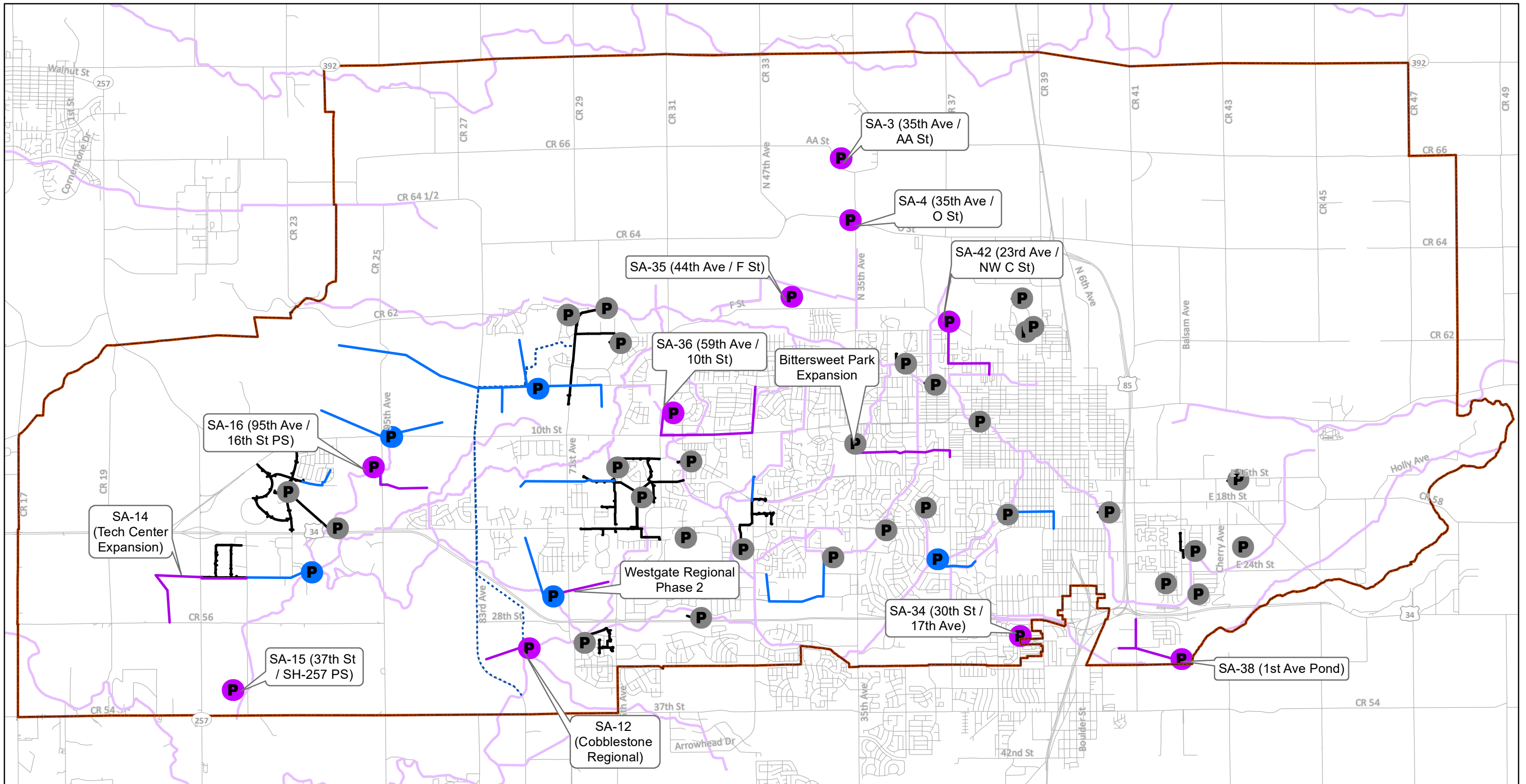
Figure 6-1

Greeley Non-Potable Water
System Master Plan



June 02, 2021

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Legend

LREGA

Existing Pump Station

2025 Pump Station

2040 Pump Station

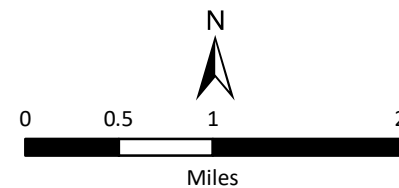
Existing NP Pipes

2025 Proposed NP Pipes

2040 Proposed NP Pipes

Greeley Ditch

Upper Equalizer Project



Recommended 20 Year Improvements

Figure 6-2

Greeley Non-Potable Water
System Master Plan



**CDM
Smith**
June 02, 2021

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Table 6-2 Project Information

Projects	Project Driver	Funding Source ¹	Planning Start Year ²	Design Start Year ²	Construction Start Year ²	OPCC ³	Total Cost ³	City of Greeley Water/Sewer	City of Greeley Parks	Development
5-Year Planning Horizon										
SA-44 Centennial Park	Service Expansion	W/S, Parks, Dev	2020	2021	2022	\$4,020,000	\$5,030,000	\$3,488,100	\$1,379,300	\$162,600
Boomerang Regional Pump Station	Service Expansion	W/S, Parks, Dev	2021	2021	2022	\$5,530,000	\$6,920,000	\$221,300	\$694,000	\$6,004,700
Boomerang Regional Phase 2	Service Expansion	W/S, Parks, Dev	2021	2021	2022	\$1,830,000	\$2,390,000	\$76,400	\$239,700	\$2,073,900
Greeley West Pump Station Replacement	Service Expansion	W/S, Dev	2021	2022	2023	\$5,970,000	\$7,470,000	\$6,161,400	-	\$1,308,600
Upper Equalizer Project	Shoulder Season Extension	W/S	2022	2023	2024	\$20,010,000	\$25,620,000	\$25,620,000	-	-
SA-14 Tech Center Supply	Service Expansion	W/S, Dev	2024	2025	2026	\$4,560,000	\$5,930,000	\$17,100	-	\$5,912,900
Promontory Park Expansion	Service Expansion	Development	2024	2025	2026	\$580,000	\$720,000	-	-	\$720,000
Monfort Expansion	Service Expansion	W/S, Parks, Dev	2024	2025	2026	\$400,000	\$500,000	\$245,300	\$76,000	\$178,700
Twin Rivers Expansion	Service Expansion	W/S, Parks, Dev	2024	2025	2026	\$1,830,000	\$2,390,000	\$1,172,400	\$363,300	\$854,300
SA-38 1st Ave Pond	Service Expansion	W/S, Dev	2024	2025	2026	\$2,760,000	\$3,590,000	\$2,881,600	-	\$708,400
SA-25 Westgate Regional Pump Station	Service Expansion	W/S, Parks	2025	2026	2027	\$2,130,000	\$2,670,000	\$2,038,415	\$631,585	-
SA-25 Westgate Regional Phase 1	Service Expansion	Dev	2025	2026	2027	\$900,000	\$1,160,000	-	-	\$1,160,000
SA-60 Lake Bluffs	Service Expansion	W/S, Dev	2025	2026	2027	\$4,650,000	\$6,050,000	\$57,000	-	\$5,993,000
5-Year Subtotal						\$55,170,000	\$70,440,000	\$41,979,015	\$3,383,885	\$25,077,100
20-Year Planning Horizon										
SA-34 30th St/17th Ave	Service Expansion	W/S, Parks, Dev	2027	2028	2029	\$2,300,000	\$2,880,000	\$1,932,500	\$281,200	\$666,300
Boomerang Regional Phase 3	Service Expansion	W/S, Parks, Dev	2028	2029	2030	\$6,150,000	\$8,000,000	\$255,900	\$802,300	\$6,941,800
SA-4 35th Ave/O St	Service Expansion	W/S, Dev	2028	2029	2030	\$1,000,000	\$1,170,000	\$262,400	-	\$907,600
SA-3 35th Ave/AA St	Service Expansion	Development	2029	2030	2031	\$1,750,000	\$2,190,000	-	-	\$2,190,000
Bittersweet Park Expansion	Service Expansion	W/S, Parks, Dev	2029	2030	2031	\$2,520,000	\$3,160,000	\$2,475,181	\$684,819	-
SA-35 44th Ave/F St	Service Expansion	W/S, Parks, Dev	2030	2031	2032	\$2,060,000	\$2,580,000	\$166,000	\$658,300	\$1,755,700
SA-36 59th Ave/10th St	Service Expansion	W/S, Parks, Dev	2031	2032	2033	\$6,550,000	\$8,190,000	\$3,810,800	\$2,569,500	\$1,809,700
SA-16 95th Ave/16th St	Service Expansion	W/S, Parks, Dev	2034	2035	2036	\$4,040,000	\$5,260,000	\$205,300	\$610,300	\$4,444,400
SA-14 Tech Center Expansion	Service Expansion	W/S, Dev	2035	2036	2037	\$2,660,000	\$3,460,000	\$10,000	-	\$3,450,000
SA-15 37th St/SH-257 Pump Station	Service Expansion	Development	2036	2037	2038	\$3,100,000	\$3,880,000	-	-	\$3,880,000
SA-12 Cobblestone Regional	Service Expansion	W/S, Dev	2037	2038	2039	\$3,270,000	\$4,260,000	\$48,500	-	\$4,211,500
Glenmere Park Expansion	Service Expansion	W/S, Parks, Dev	2037	2038	2039	\$1,690,000	\$2,200,000	\$1,427,916	\$603,228	\$168,856
SA-25 Westgate Regional Phase 2	Service Expansion	W/S, Dev	2038	2039	2040	\$950,000	\$1,220,000	\$857,400	-	\$362,600
SA-42 23rd Ave/NW C St	Service Expansion	W/S, Parks, Dev	2039	2040	2041	\$4,630,000	\$6,030,000	\$2,513,300	\$1,421,100	\$2,095,600
20-Year Subtotal						\$42,670,000	\$54,480,000	\$13,965,198	\$7,630,746	\$32,884,056
Total						\$97,840,000	\$124,920,000	\$55,944,212	\$11,014,631	\$57,961,156

August 2020 dollars as adjusted by ENR-CCI were used for project OPCCs, total costs, and project fund allocations – City of Greeley Water and Sewer Department, City of Greeley Parks Department, and Development.

¹ W/S: City of Greeley water and sewer department, Parks: City of Greeley parks department, Dev: Development

² Project planning, design, and construction years are subject to change pending future project updates, development of projects, and/or schedule changes.

³ OPCC and total costs per project are subject to change pending future project updates, development of projects, and/or schedule changes.

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6.4 CIP Implementation Schedule

Projects identified in the 5-year and 20-year planning horizons were given projected planning, design, and construction start years to help the City schedule project implementation. Annual fiscal requirements from 2021 through 2042 are shown in **Figure 6-3**.

For scheduling purposes, 5-year improvements were identified from 2022 through 2027, based on design start year, while 20-year improvements were identified from 2028 through 2042. NP projects are usually considered lower priority than water, sewer, or transportation projects so they were generally moved in time to match other nearby projects. It was assumed that each stage (planning, design, and construction) will take at least one year with the construction phase taking two, three, or four years if the total CIP cost for a project was greater than \$1 million, \$5 million, or \$10 million, respectively.

Estimated start years for each planning horizon were adjusted based on the following factors:

- Water and Sanitary Sewer Improvements. When applicable, start years of NP projects were adjusted to align with major water and sanitary sewer improvements.
- Transportation Improvements. When applicable, start years were adjusted to coincide with major transportation improvements identified as part of the City's Keep Greeley Moving Phase 2 initiative (City of Greeley, 2021).
- Scheduling. When applicable, start years were adjusted based on needed prioritization of projects.
- Funding. Projects were staggered as needed to balance funding requirements.

If a project start year was shifted, the project is left within its original 2025 or 2040 planning horizon for modeling and analysis purposes but will appear in the correct 5- or 20-year CIP total. Note that the Upper Equalizer Project has major outlays between 2024 and 2028 resulting in higher CIP budgets over that timeframe.

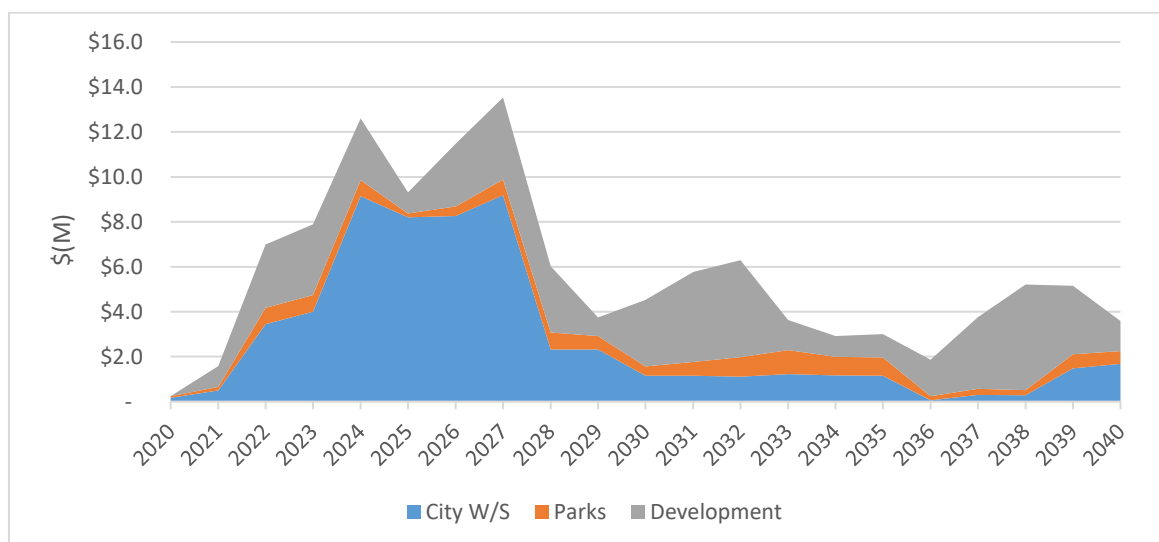


Figure 6-3 Annual NP Funding Projections by Fund

CIP costs are August 2020 dollars from ENR-CCI.

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Section 7

Findings and Recommendations

The findings and recommendations summarized in this section have been drawn from the planning and evaluation sections of this NPMP. The recommendations identify system needs, actions, and capital improvements through the buildout planning horizon. However, the actual implementation time frame will depend on actual growth rates, order of development, and the level of available capital funding. Additionally, the actual scope and implementation of these recommendations may vary with detailed planning and design.

7.1 Key Findings

Key findings identified as part of the NPMP include the following:

- Discussions with other Front Range stakeholders revealed that the City has a unique and advanced NP irrigation system, particularly for raw water suppliers. For more information, see **Section 2.1**.
- Historically, comprehensive data collection has often been difficult for the NP system. Additional studies or data collection, along with more standardized record keeping practices, can help the City keep track of the overall system. Record keeping practices could include recording ditch laterals in GIS, updating and enforcing construction drawing standards, creating a system for regularly updating the NP GIS database, and/or installing SCADA systems. For more information, see **Section 2.4** and **Section 2.5**.
- Review of historical demands showed that NP usage varies annually by significant amounts. In particular, demand dropped significantly as parks transitioned to improved control systems. Future NP demands are expected to come from two sources: 1) undeveloped lands that will use NP irrigation when they develop, and 2) existing areas that will convert to NP irrigation, referred to as conversion areas. NP peak season demands are expected to increase by 1.1 MGD by 2025, 2.8 MGD by 2040, and 11.5 MGD by buildout. NP adoption is strongly influenced by policy, which is a key conservation measure. For more information, see **Section 3**.
- Some of the existing systems were identified as needing improvement, but no critical deficiencies were identified. These include areas that are expected to have undersized inlet lines, pipes, or pumps by buildout. For more information, see **Section 5.2**.
- New recommended CIP projects were identified. These primarily consist of new pump stations or expansions of existing pipe systems to serve new areas and customers. New pump stations will be constructed primarily by development. It is estimated that the system will need 4 new pump stations by 2025, 12 new pump stations between 2025 and 2040, and 19 new pump stations between 2040 and buildout. For more information, see **Section 5.3**.

7.2 Recommendations

The recommendations for the NPMP include the following:

- Implement and enforce an NP policy to promote and expand NP irrigation practices. It is recommended for this policy to mandate that new developments and redevelopments use NP irrigation and for the policy to generally encourage the growth of the NP system.
- Consider implementing improved operational practices at existing pump stations either when it becomes necessary, or during other construction, such as rehabilitating a park irrigation system. This can include increasing the watering window to reduce peak hour demands by decreasing the size of irrigation zones and implementing SCADA where not currently installed. It is recommended for customers to use a watering window of 10 hours a day, where possible, and to use the best landscaping practices included in **Appendix F**.
- Create new standards for data collection and record keeping. This can include enforcing standards related to construction record drawings, developing and maintaining an internal record-keeping system, creating a plan for regularly updating the GIS database, and/or implementing a CMMS for NP infrastructure. It is also recommended for the City to conduct a study of ditches and laterals throughout the LREGA, and/or require developers to include this data in their plans.
- Implement and enforce requirements for the installation of SCADA systems at new or rebuilt pump stations. The City may consider including SCADA requirements in the City's Specifications.
- Continue monitoring and recording demands and pump station flows to identify major changes in operations that may impact system performance.
- Continue maintenance of the InfoWater model. This can include adding new pipes, deleting abandoned pipes, tracking open and closed valves, and reflecting operational changes as the system continues to expand.
- Evaluate the St. Michaels pump station to determine whether additional construction is needed at this site to meet higher demands. This evaluation should determine whether demand management could be an effective solution, and whether the pumps can be upsized without replacing the entire pump station.
- Coordinate this NPMP with other relevant planning documents, such as the WTDMP, SSMP, *Imagine Greeley Comprehensive Plan*, and BBC report. It is recommended to use this NPMP as a guide for infrastructure planning and to use the BBC report as a guide for water resources planning.
- Continue building the NP system through a hub-and-spoke approach. Consider looping or connecting systems where systems are on similar hydraulic grade lines and looping would improve operational flexibility.

- In areas with limited or interim development, require the construction of NP infrastructure, such as piped irrigation system, even if a pump station will not be constructed until later.
- New pipe and pump station layouts are conceptual in nature and are primarily intended to show hydraulic feasibility for master planning purposes. Conduct a detailed evaluation of pipe alignment and size, and pump station location and sizing as projects move into design and implementation stages when there is more certainty of development and design criteria. The InfoWater model can be used as a tool to support future planning decisions, if regularly maintained.
- Complete the capital improvements recommended in **Section 6**, prioritizing the 5-year CIP recommended projects. Coordinate closely with the City's parks department, other utilities, and developers to regularly update the scheduling of these projects. The City should consider using the InfoWater model as a tool to inform developer plans while coordinating with them.
- Update the NPMP every 5 years, including reevaluating demand and population projections every 5 to 10 years. Planning assumptions made for the NP system in the next 20 years and beyond is subject to change with time.

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Section 8

References

- AECOM. 2016. *City of Greeley Non-Potable Water Supply Upper Equalizer Infrastructure Feasibility Study*.
- AECOM. 2021. *Poudre Ponds Reclamation and Restoration Improvements Project Mini Master Plan*.
- Applegate Group, Inc. 2004. *Non-Potable Water Master Plan*.
- Aqua Engineering, Inc. 2002. *Non-Potable Master Plan*.
- BBC Research and Consulting. 2018. *City of Greeley Population and Water Demand Projections*.
- BBC Research and Consulting. 2017. *Technical Memorandum – Updated Water Demand Projections and Future Water Needs*.
- Boyle Engineering Corporation. 1993. *Greeley-Loveland Reservoir Storage and Canal Delivery System Study*.
- City of Greeley. 2019. *Annual Growth & Development Projections Report*.
- CDM Smith. 2021. *CIP Planning Tool: WTDMP, NPMP, and SSMP City of Greeley Excel Spreadsheet*.
- City of Greeley. 2020. *City of Greeley Project Initiation Form Excel Spreadsheet*.
- City of Greeley. 2018. *Comprehensive Plan – Imagine Greeley (including supplemental information)*.
- City of Greeley. 2008. *Design and Criteria and Construction Standards: Potable Water Distribution, Sanitary Sewer Collection, and Non-Potable Irrigation Systems*. Vol. III
- City of Greeley, Intergovernmental Agreements (various dates and sources).
- City of Greeley. 2021. *Keep Greeley Moving Phase 2 by Neighborhood 2023 – 2029*.
- City Greeley. Meetings with Westminster (January 30, 2020), Denver Water (February 25, 2020), Evans (November 4, 2020), Windsor (November 5, 2020).
- City of Greeley. 2021. *Operation Rehab Project 2021 – 2025 Excel Spreadsheet*.
- City of Greeley. 2019. *Pipe Rehabilitation Cost Estimating Template – V4.0 Excel Spreadsheet*.
- City of Greeley. 2021. *Water and Sewer Department 10 Year CIP 2021 – 2030*.
- Design Workshop, Inc. 2016. *Greeley Parks, Trails and Open Lands Master Plan*.
- Design Workshop, Inc. 2016. *Island Grove Regional Park Master Plan*.

ECL. 1999. *Non-Potable Water Program Master Plan*.

EDAW. 2002. *Greeley Parks and Trails Master Plan*.

U.S. Department of Transportation: Federal Highway Administration. 2014. *Mitigation Strategies for Design Exceptions*

Appendix A

Field Inventory Summaries

The following table summarizes the infrastructure identified and recorded as part of the field inventory conducted for the NPMP.

Asset Type	Number of Items Surveyed
Air release valve	19
Augmentation water discharge	1
Backflow preventer	1
Blow off	57
Control panel building	1
Curb stop valve	13
Ditch-point	14
Drain valve	7
Flume level sensor	1
Flush pit	3
Head gate	24
Manhole	4
Meter	131
Pond	20
Pressure release valve	1
Pump	71
Settling vault	1
Tracer wire	38
Truck fill	2
Valve	263
Weir	6
Well	9

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Appendix B

Naming System

The following table captures the naming system used to record infrastructure identified as part of the field inventory for the NPMP.

System	Location	Asset Type
NP-Non-Potable Water	BG-Boomerang Golf	WEL-Well
	BP-Bittersweet Park	MET-Meter
	BS-Balsam Sports	PMP-Pump
	CW-Cottonwood Park	VAL-Valve
	DP-Delta Park	FPT-Flush Pit
	EM- East Memorial	HGT-Head gate
	GM-Glenmere Park	MNH-Man Hole
	GW-Greeley West Park	FLF-Filter Flush
	HH-Highland Hills Golf	PND-Pond
	IG- Island Grove Park	PPL-Pump Panel
	JF-Jackson Field Sports	TKF-Truck Fill
	JJ-Josephine Jones Park	TRW-Tracer Wire
	LG-Linn Grove	SVT-Settling Vault
	LP-Luther Park	ARV-Air Relief Valve
	ME-Madison Elementary	CSV-Curb Stop Valve
	MF-Monfort Elementary	BOF-Blow Off
	NR-North Ridge School	PRV-Pressure reducing valve
	PM-Promontory Park	WER- Weir
	PP-Poudre Ponds	BFP-Backflow Preventor
	PV-Peak View Park	BDT-Boyd Ditch
	RE- Romero Elementary	ADS-Augmentation Discharge
	RP-Ramseier Park	
	SM-Saint Michaels	
	SP-Sanborn Park	
	TC-Tech Center	
	WP-Waggin Tail Dog Park	
	YS-Youth Sports Complex	
	TR-Twin Rivers Park	

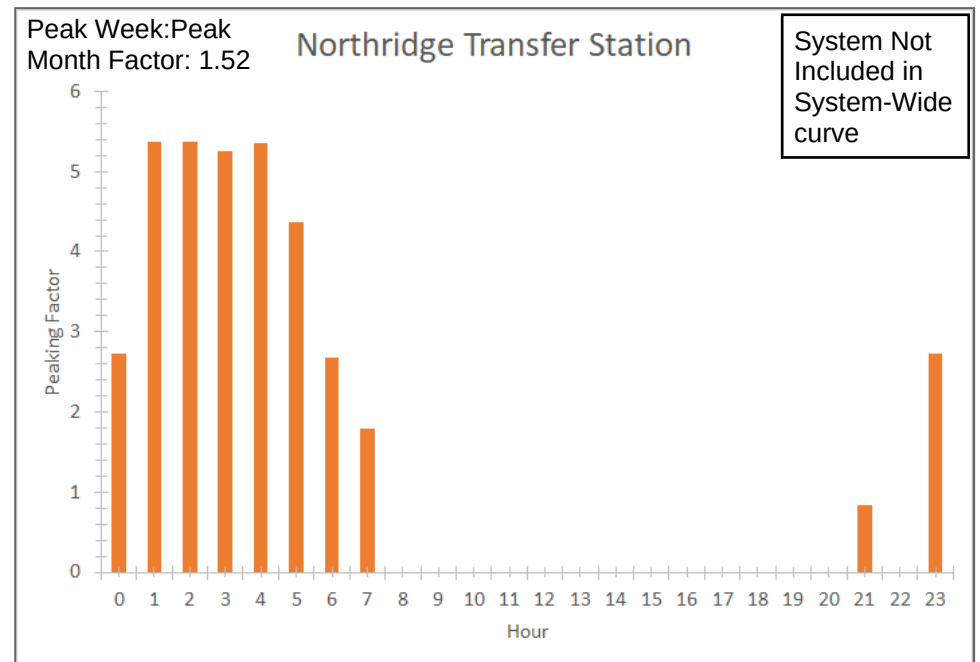
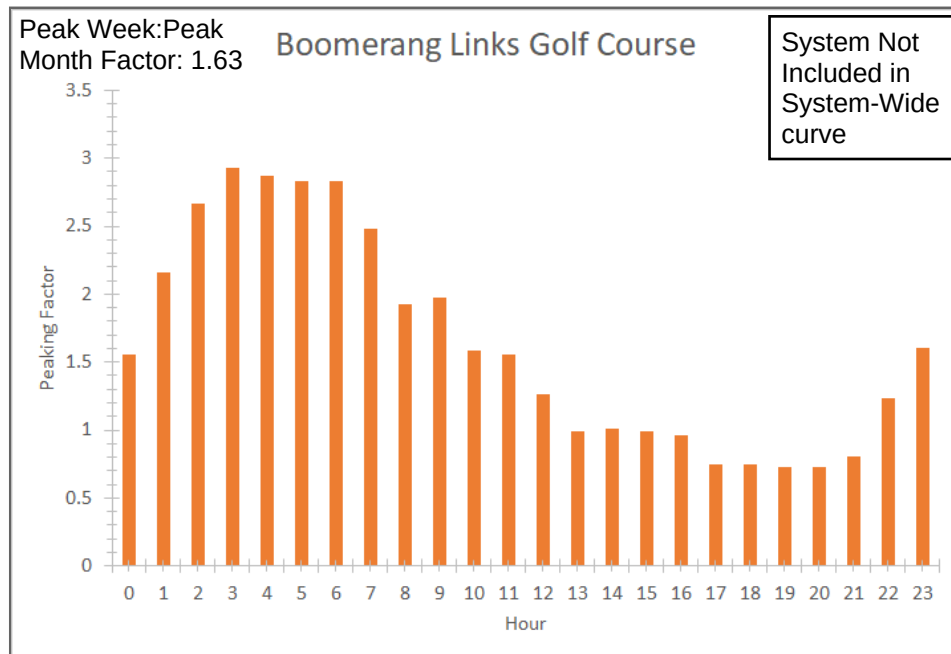
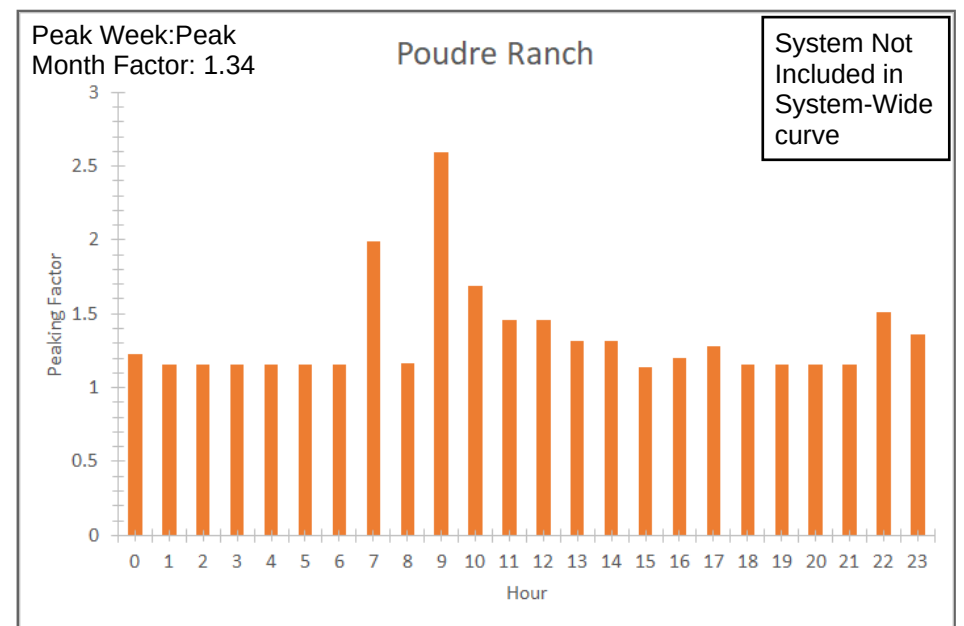
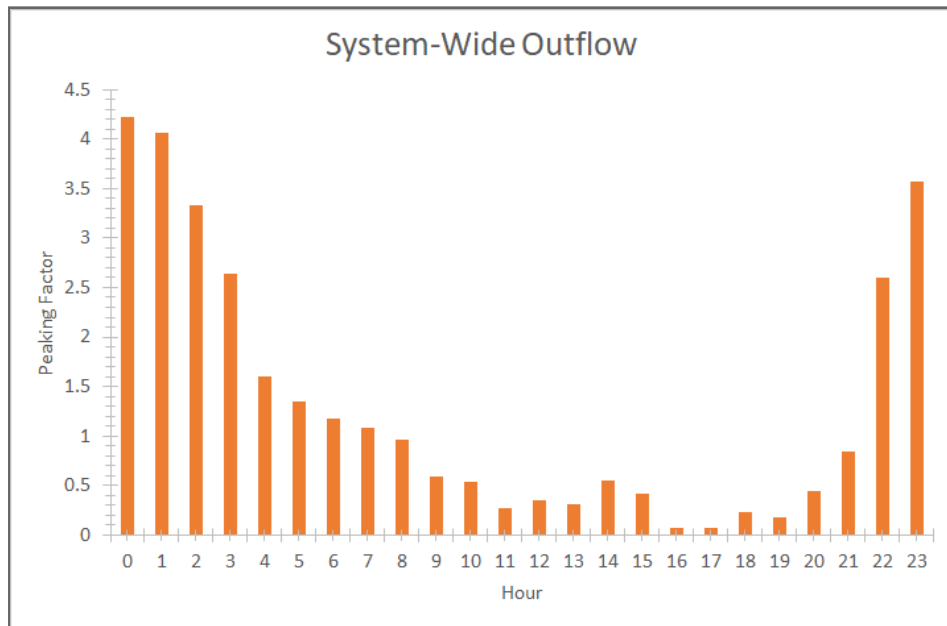
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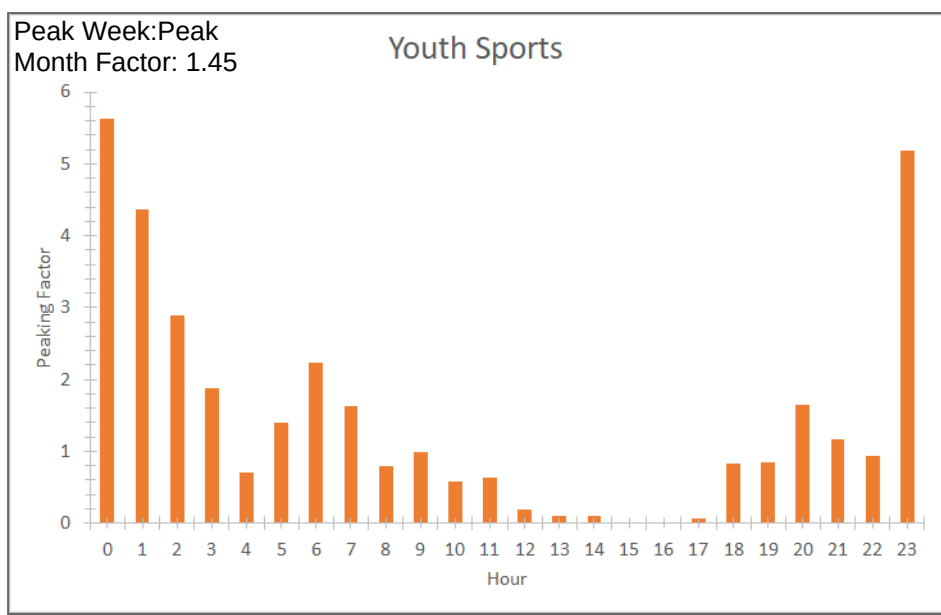
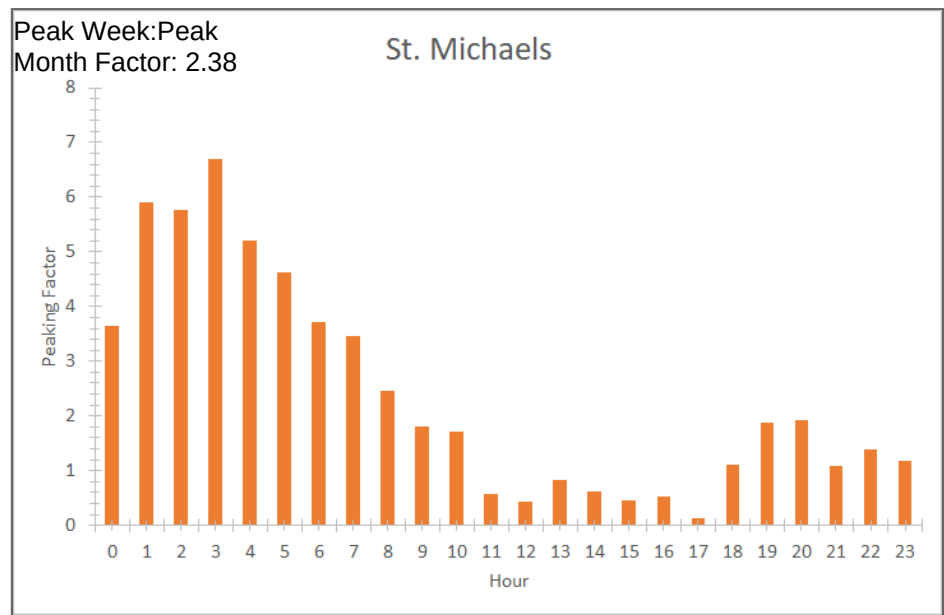
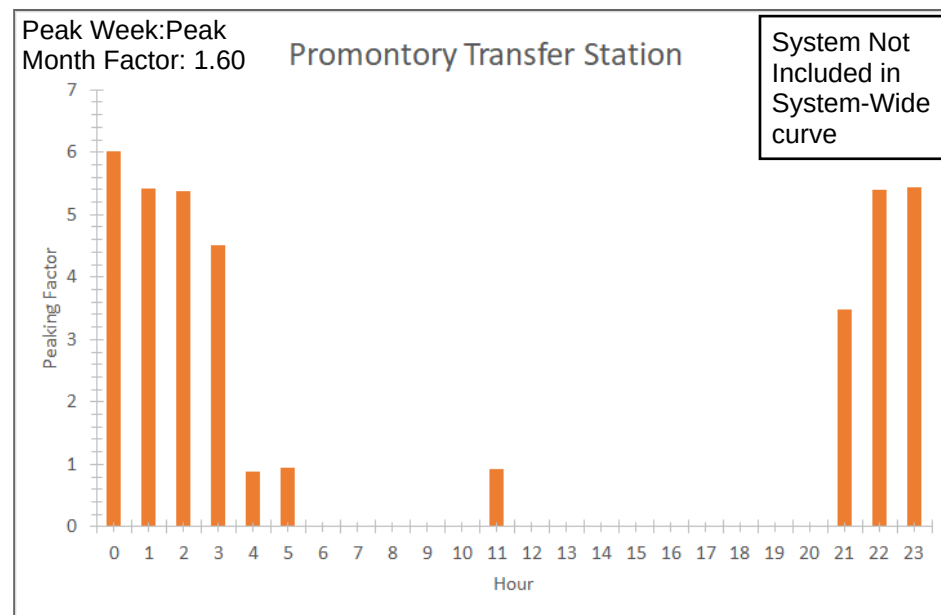
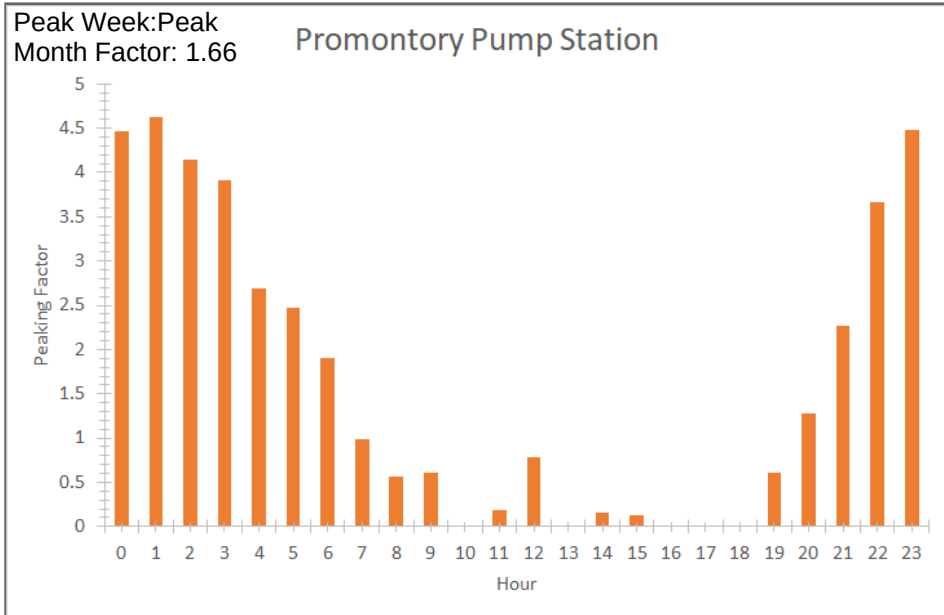
Appendix C

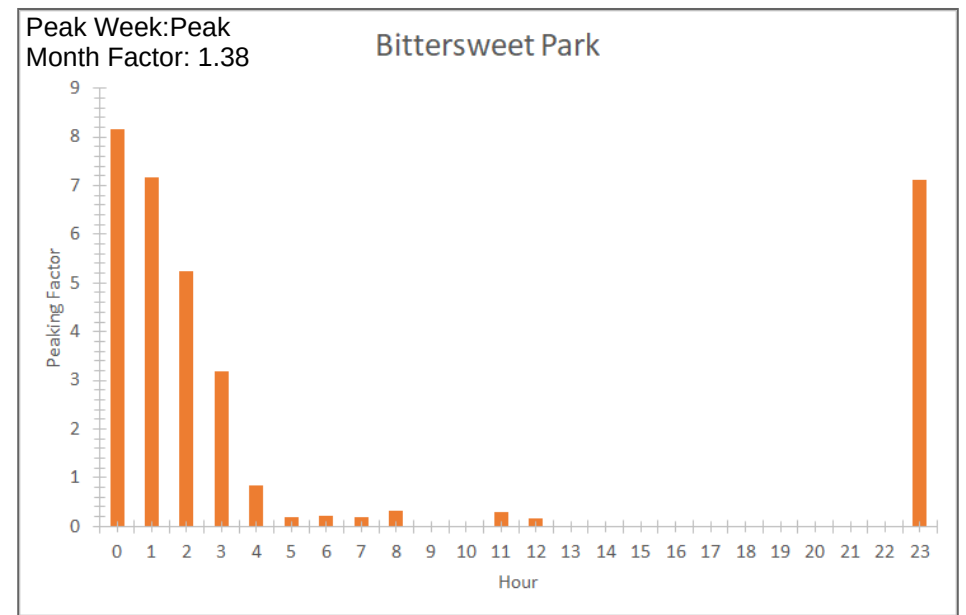
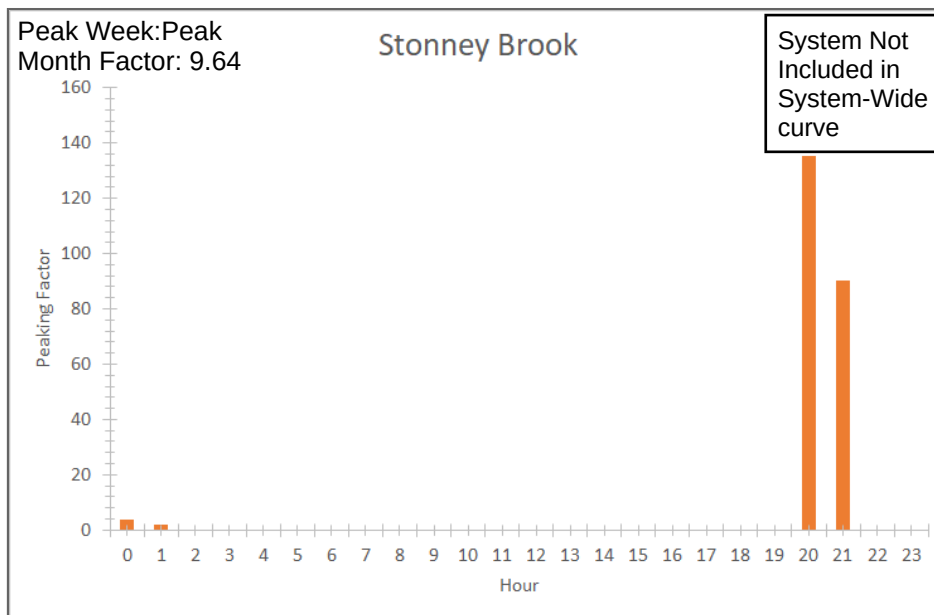
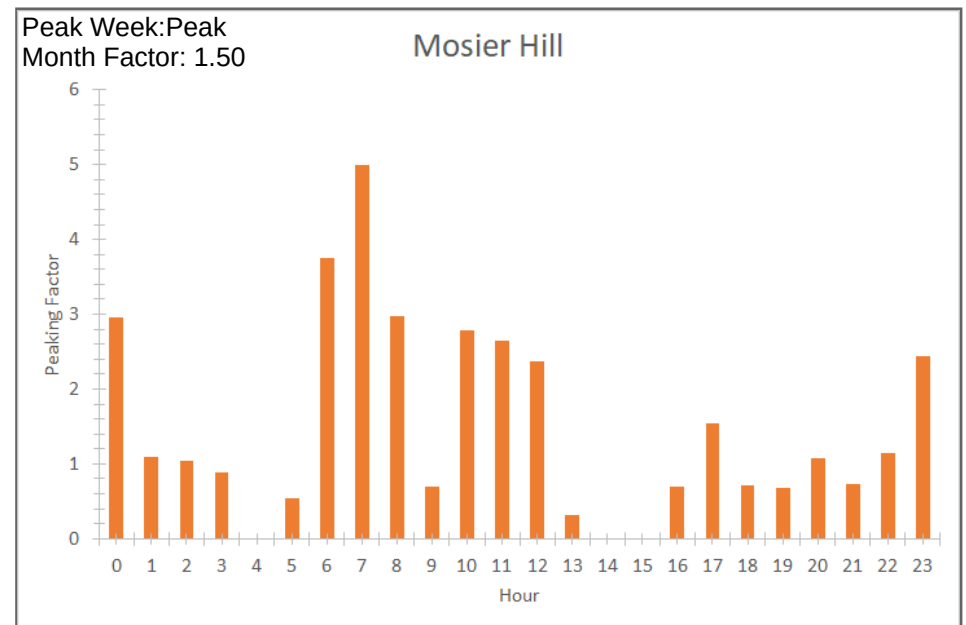
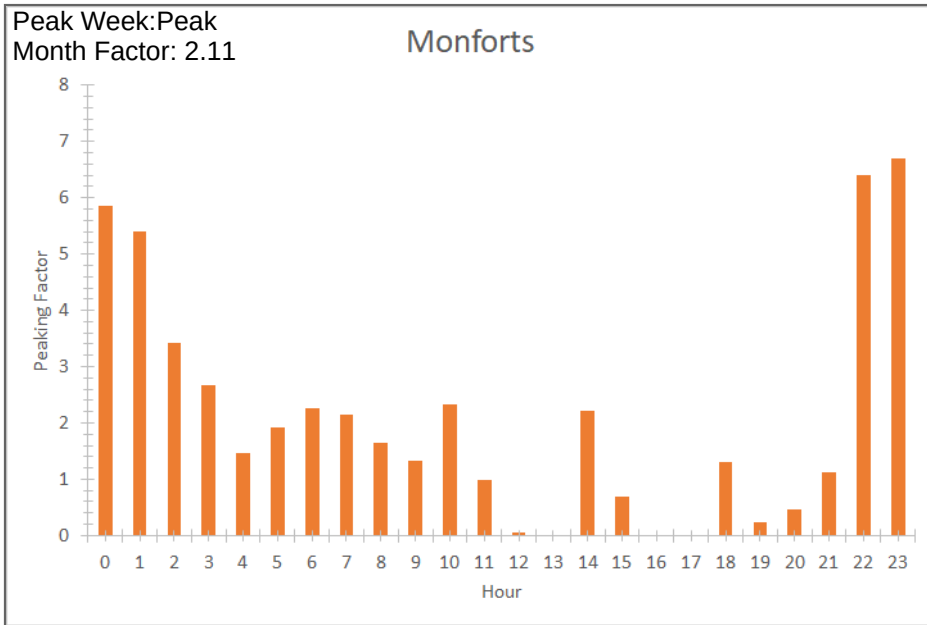
Individual Diurnal Curves

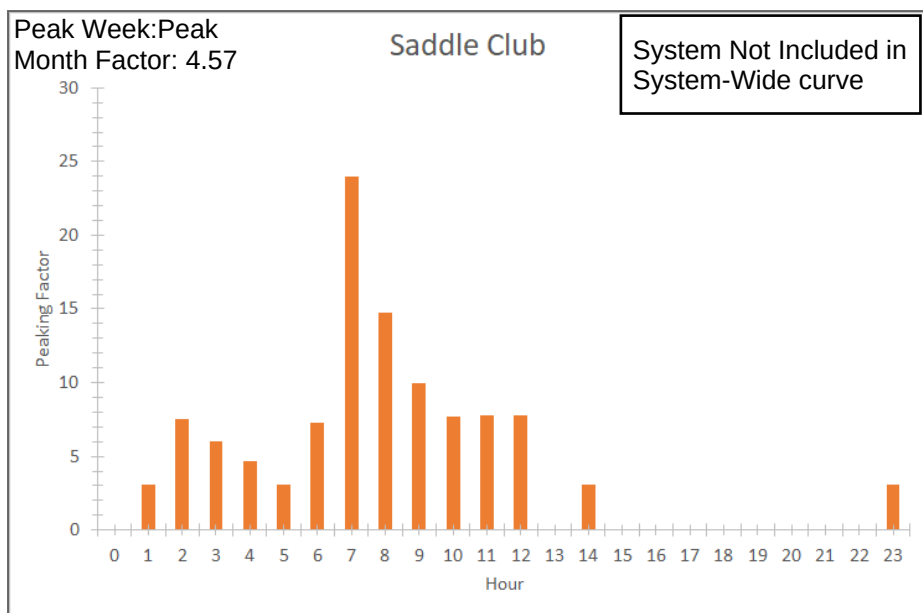
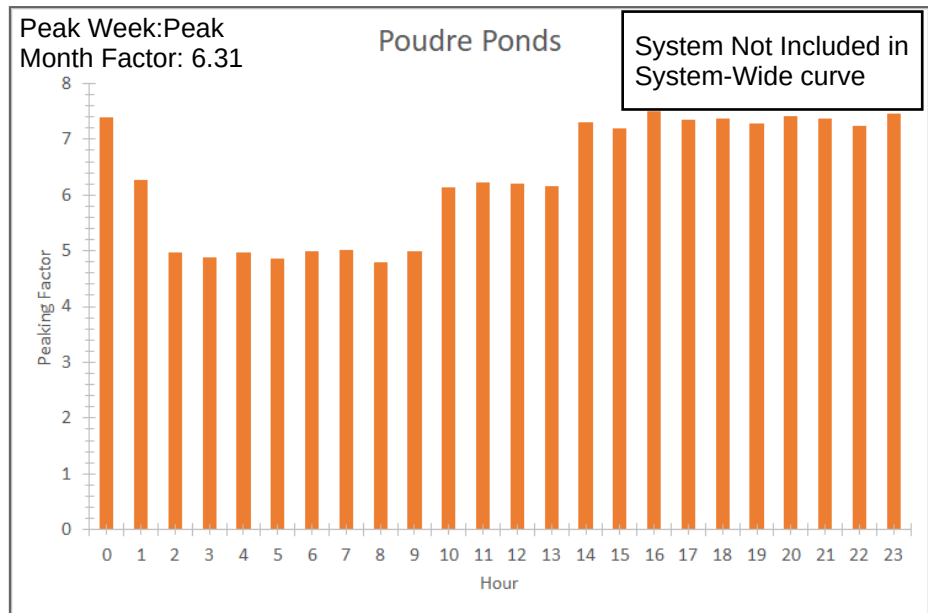
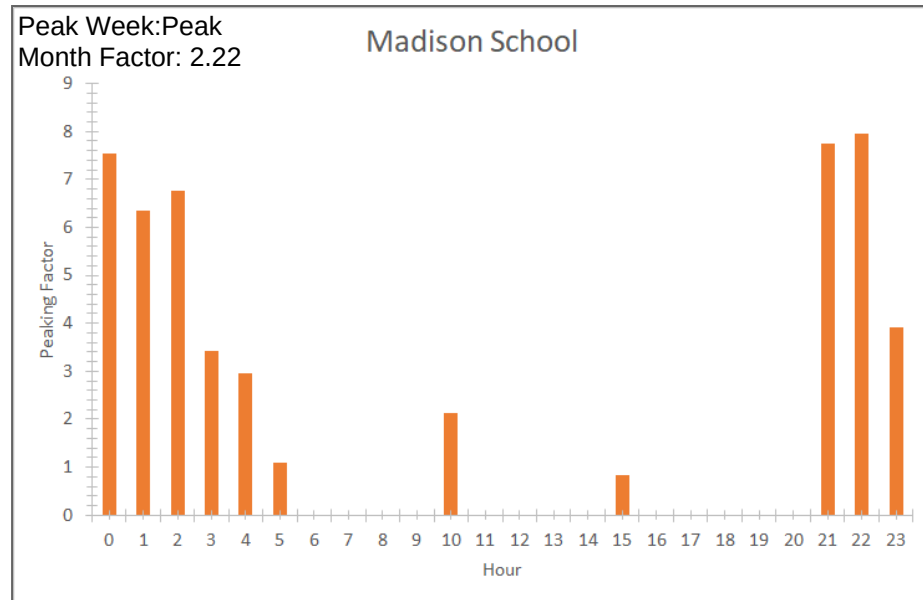
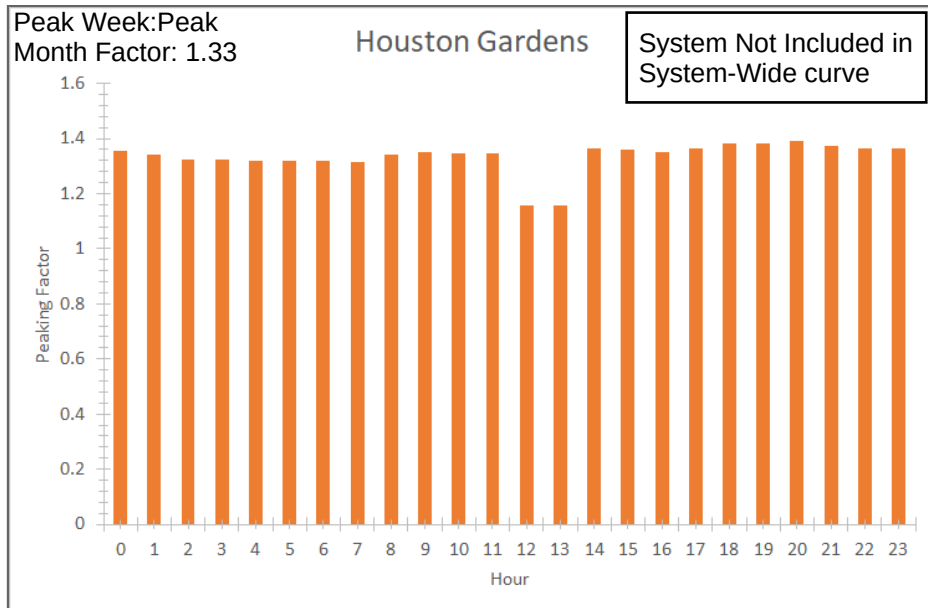
The graphs shown below are diurnal curves for each of the individual existing systems, where SCADA data was available. Each curve has a unique peak week : peak month factor and was based on the system's peak week (during July and August 2018 and 2019). Operational changes may improve individual system performance by flattening demand during periods of use while reducing peak demand factors. Such changes could result in downsizing future pipelines and pumps and potentially reducing future operating costs without changing future maximum month demands. It should be noted that current demand patterns are largely driven by end user choices, such as vegetation, watering schedule and duration, irrigation system configuration, and irrigation controls, as well as future weather conditions. Any or all of these factors could change in the future.

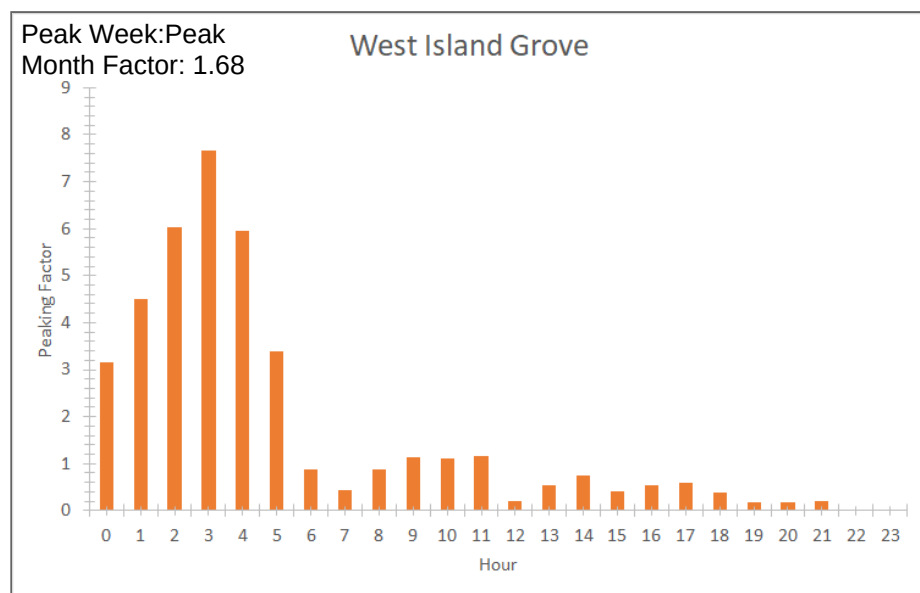
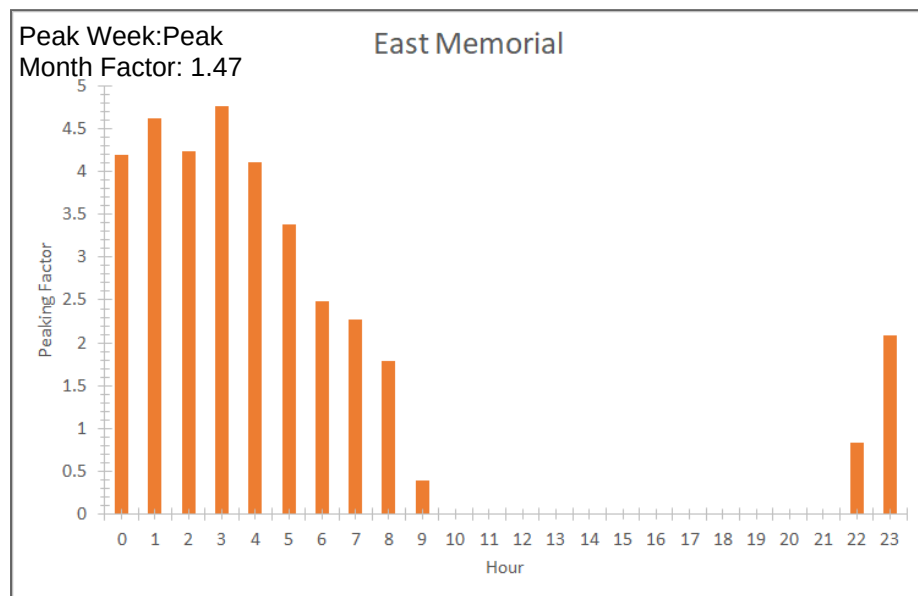
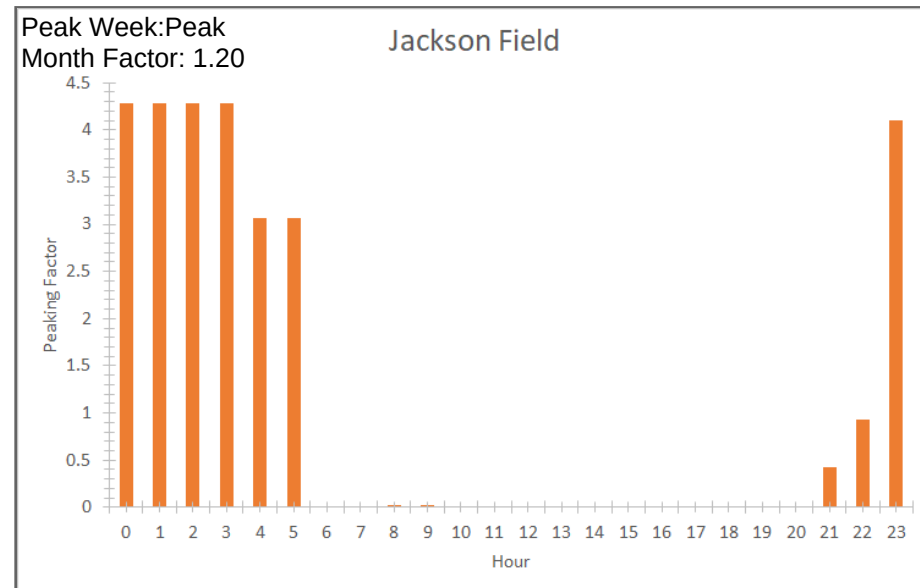
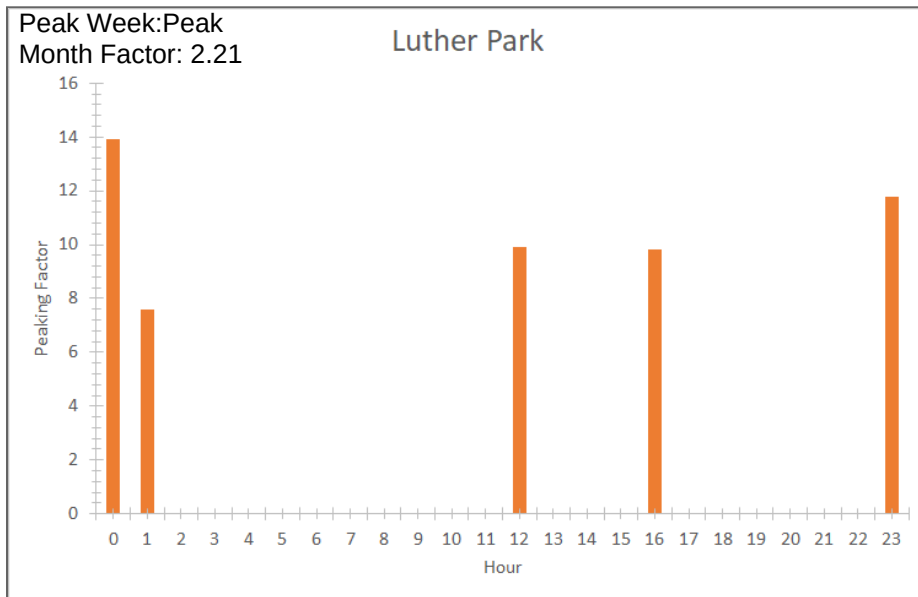
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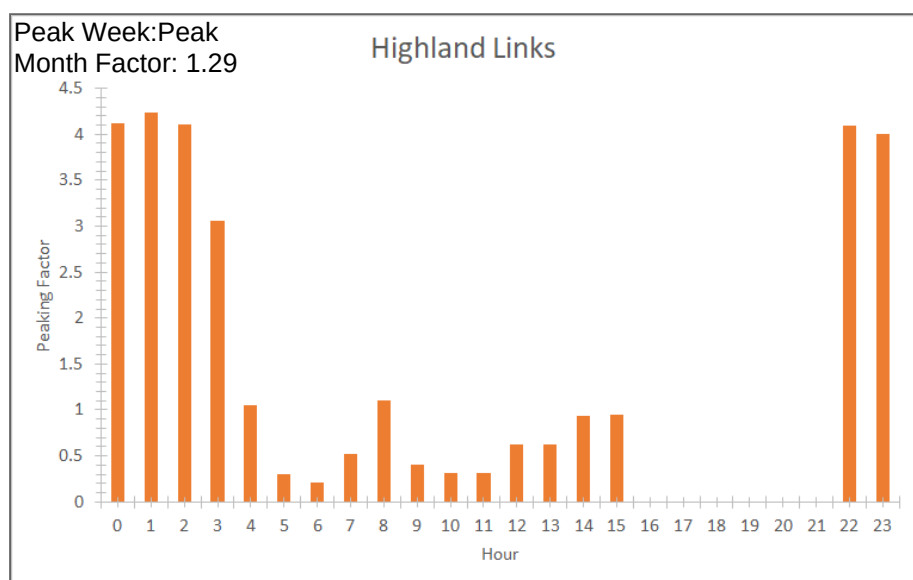
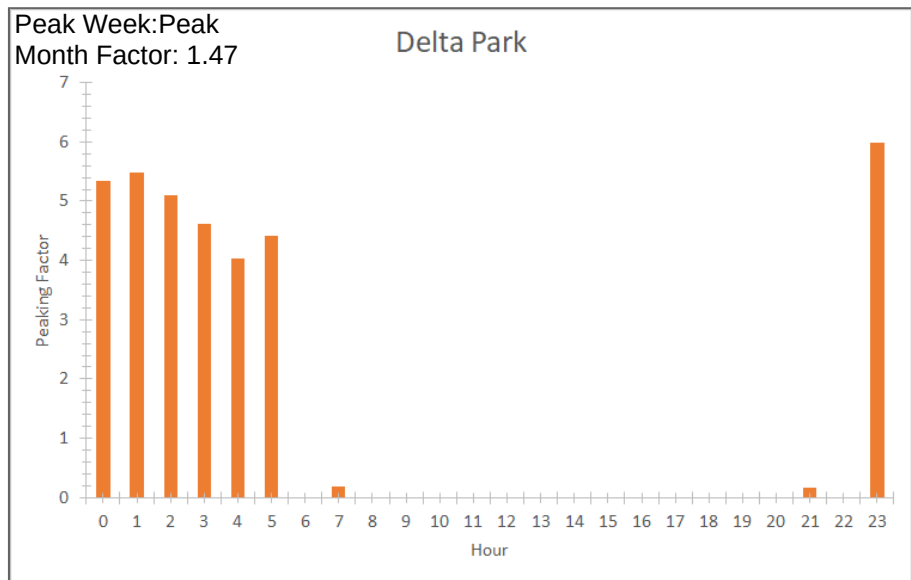
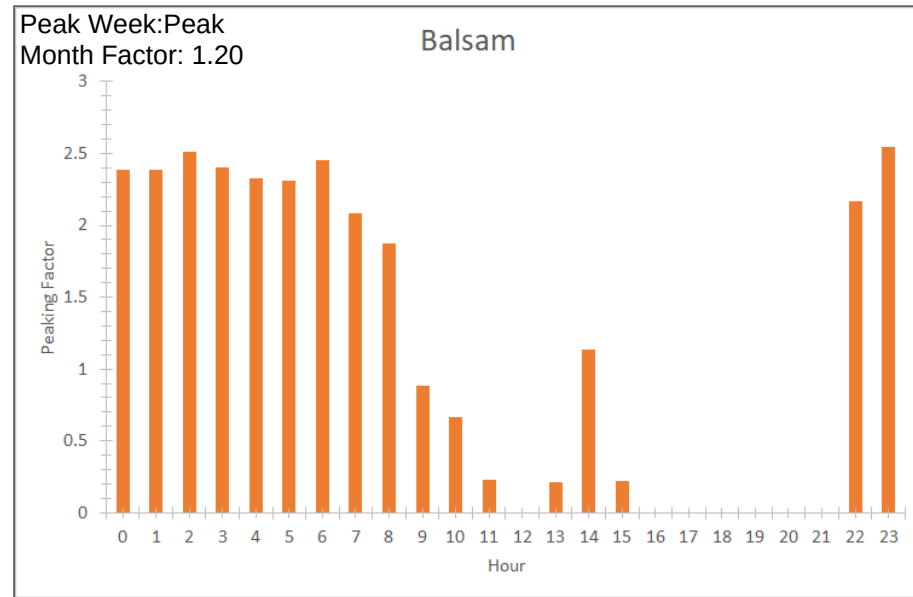
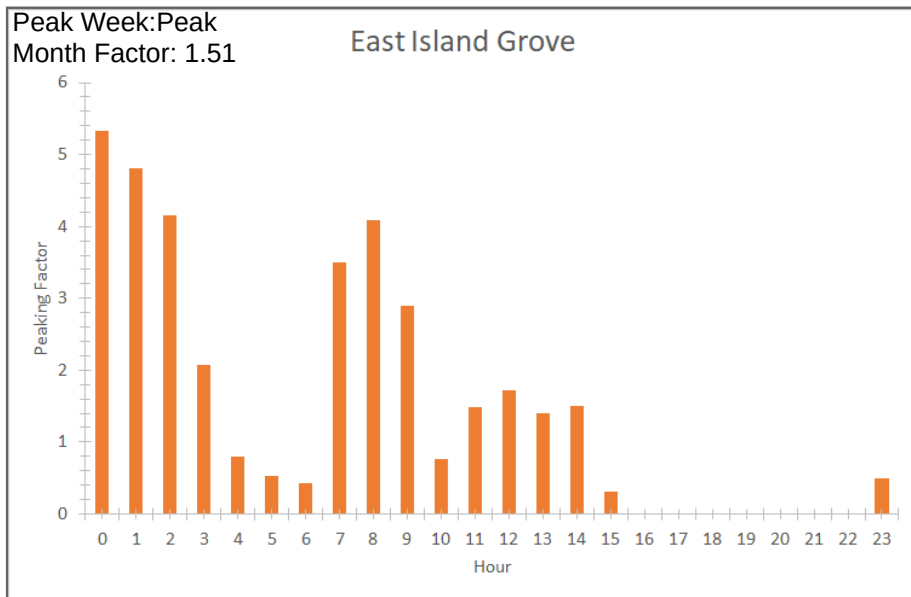


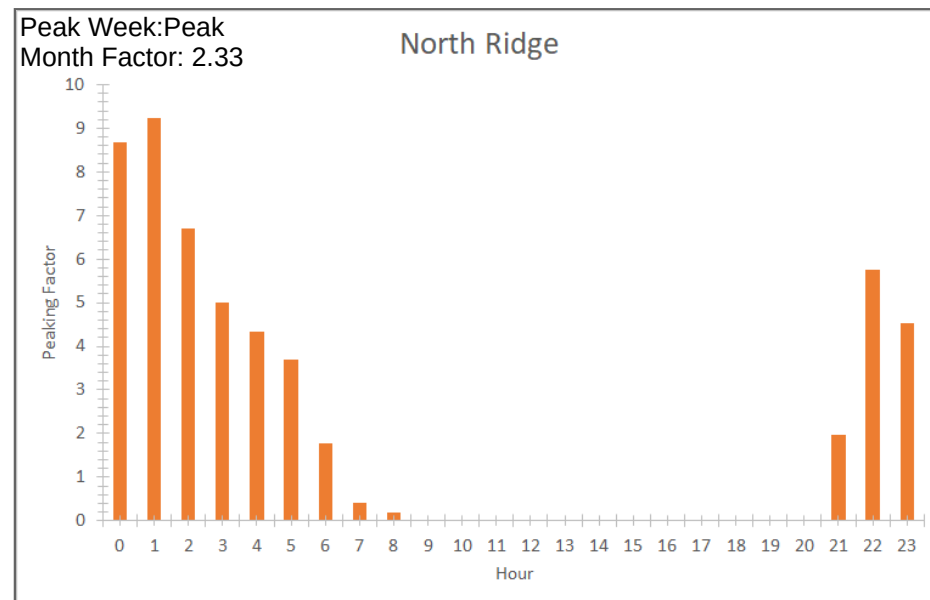
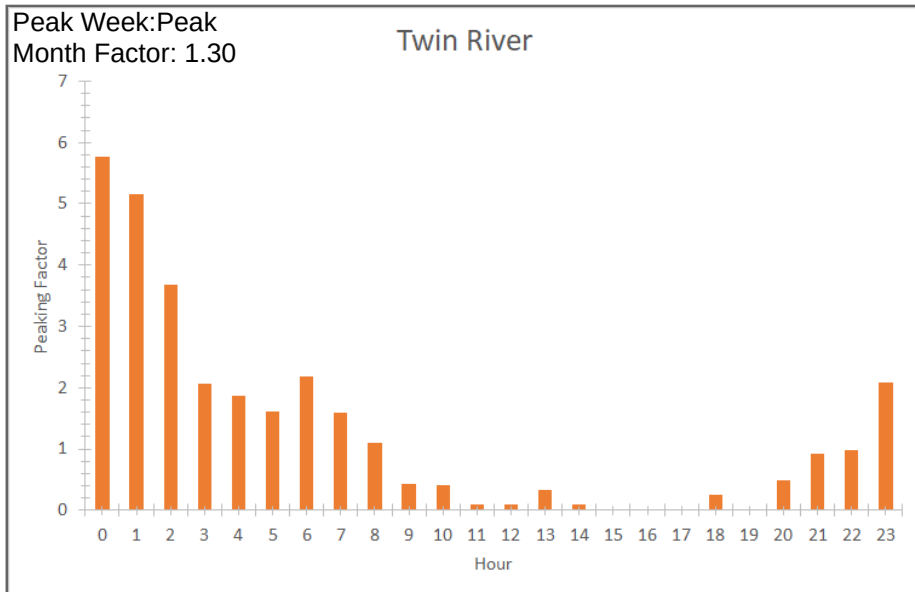












Appendix D

Existing Station Details

The following table contains the results of the modeling and desktop analyses for the existing system. For more information on recommended improvements to the existing system, please see **Section 5.2**.

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Pump Station Name	Pump Name	Pump Design Capacity (gpm) Existing	Station Design Capacity (gpm) Existing	Pumping Head (ft) Existing	Inlet Diameter (Smallest) (in) Existing	Max Hour Demand (gpm) Existing	Max Hour Demand (gpm) Buildout	Max Day Demand (gpm) Buildout	Max Day Demand (gpd) Buildout	Max Hour % of Pumping Capacity Buildout	Max Day % of Pumping Capacity Buildout, 10hrs	Recommended Pond Capacity (AF) Buildout	Inlet Max Headloss at Buildout (ft/1000 ft)	Max Day Demand without Adoption (gpd) Buildout	Notes
Twin Rivers	NP-TR-PMP-01	1,000	4,200	259	10	1,314	2,004	544	782,942	48%	31%	10.6	21	783,205	
	NP-TR-PMP-02	200													
	NP-TR-PMP-03	1,000													
	NP-TR-PMP-04	1,000													
	NP-TR-PMP-05	1,000													
Youth Sports	NP-YS-PMP-06	600	1,200	250	6	941	941	257	370,109	78%	51%	5.0	19	370,109	
	NP-YS-PMP-07	600													
Highland Hills Golf	NP-HH-PMP-01	667	2,001	289	10	1,792	1,792	571	822,053	90%	68%	11.1	18	822,053	
	NP-HH-PMP-02	667													
	NP-HH-PMP-03	667													
Monfort	NP-MF-PMP-01	800	2,400	234	10	1,423	1,745	589	848,074	73%	59%	11.5	21	848,337	
	NP-MF-PMP-02	800													
	NP-MF-PMP-03	800													
Josephine Jones Park	NP-JJ-PMP-01	115	115	223	4	106	161	52	75,413	140%	109%	1.0	30	75,472	
St. Michaels	NP-SM-PMP-01	560	1,120	288	20	1,121	1,167	426	613,800	104%	91%	8.3	0	613,800	
	NP-SM-PMP-02	560													
Peakview Park	NP-PV-PMP-01	400	800	240	8	681	681	148	213,048	85%	44%	2.9	9	213,048	
	NP-PV-PMP-02	400													
Boomerang South	NP-BG-PMP-01	500	1,500	307	N/A	694	0	0	0	0%	0%	0.0	N/A	0	Being replaced by Boomerang Regional Pump Station
	NP-BG-PMP-02	500													
	NP-BG-PMP-03	500													
North Ridge High School	NP-NR-PMP-01	900	2,700	272	18	1,205	1,752	486	699,811	65%	43%	9.4	1	699,811	
	NP-NR-PMP-02	900													
	NP-NR-PMP-03	900													
Boomerang North	NP-BG-PMP-04	500	1,500	307	8	769	769	250	359,309	51%	40%	4.9	11	359,309	
	NP-BG-PMP-05	500													
	NP-BG-PMP-06	500													
Poudre River Ranch	NP-BG-PMP-09	175	175	226	24	205	205	84	120,830	117%	115%	1.6	0	120,830	Single inlet for all 71st Avenue Transfer pumps
Boomerang Transfer	NP-BG-PMP-07	900	1,800	272		951	621	346	498,010	35%	46%	6.7		498,010	
	NP-BG-PMP-08	900				936	936	269	387,346	52%	36%	5.2		387,346	
North Ridge Transfer	NP-BG-PMP-10	900	1,800	272		936	936	269	387,346	52%	36%	5.2		387,346	
	NP-BG-PMP-11	900													
Promontory Park - Transfer	NP-PM-PMP-01	800	1,600	157	12	1,651	1,651	464	668,765	103%	70%	9.0	7	668,765	
	NP-PM-PMP-02	800													
Promontory Park - Main	NP-PM-PMP-03	700	2,100	261	14	1,270	1,866	674	970,200	89%	77%	13.1	3	970,200	
	NP-PM-PMP-04	700													
	NP-PM-PMP-05	700													
Greeley West Park	NP-GW-PMP-01	1,000	2,000	236	4	72	861	280	402,610	43%	34%	5.4	1,150	402,946	Pump station being replaced, proposed inlet size unknown
	NP-GW-PMP-02	1,000													
Sanborn Park	NP-SP-PMP-01	250	500	256	4	268	289	94	135,158	58%	45%	1.8	60	135,168	
	NP-SP-PMP-02	250													
Cottonwood Park	NP-CW-PMP-01	115	115	212	4	69	69	23	32,414	60%	47%	0.4	4	32,414	
Glenmere Park	NP-GM-PMP-01	180	180	226	4	135	304	99	142,214	169%	132%	1.9	127	142,215	
Bittersweet Park	NP-BP-PMP-01	500	1,000	250	6	854	1,160	258	371,563	116%	62%	5.0	150	371,626	
	NP-BP-PMP-02	500													
Luther Park	NP-LP-PMP-01	265	530	224	10	492	498	89	127,469	94%	40%	1.7	2	127,474	
	NP-LP-PMP-02	265													
Madison Elementary and Houston Gardens	NP-ME-PMP-01	125	125	200	8	310	310	298	428,616	248%	571%	5.8	3	428,618	Single inlet for two pumps
	NP-ME-PMP-02	500	500	231		90	93	27	38,203	19%	13%	0.5		38,203	

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Pump Station Name	Pump Name	Pump Design Capacity (gpm) Existing	Station Design Capacity (gpm) Existing	Pumping Head (ft) Existing	Inlet Diameter (Smallest) (in) Existing	Max Hour Demand (gpm) Existing	Max Hour Demand (gpm) Buildout	Max Day Demand (gpm) Buildout	Max Day Demand (gpd) Buildout	Max Hour % of Pumping Capacity Buildout	Max Day % of Pumping Capacity Buildout, 10hrs	Recommended Pond Capacity (AF) Buildout	Inlet Max Headloss at Buildout (ft/1000 ft)	Max Day Demand without Adoption (gpd) Buildout	Notes
Ramseier	NP-RP-PMP-01	225	450	235	8	734	739	240	345,485	164%	128%	4.7	11	345,490	
	NP-RP-PMP-02	225													
Island Grove and Saddle Club	NP-IG-PMP-01	600	600	290	N/A	605	605	135	194,242	101%	54%	2.6	N/A	194,242	
	NP-IG-PMP-02	700	700	300	N/A	401	401	120	172,267	57%	41%	2.3	N/A	172,267	
	NP-IG-PMP-03	300	300	259	N/A	72	138	48	69,595	46%	39%	0.9	N/A	69,677	
Jackson Field Sports	NP-JF-PMP-01	200	400	236	14	258	317	95	137,074	79%	57%	1.9	0	137,132	
	NP-JF-PMP-02	200													
Linn Grove Cemetery	NP-LG-PMP-03	350	350	305	4	95	122	40	57,168	35%	27%	0.8	11	57,168	
Bella Romero Elementary	NP-RE-PMP-01	330	330	263	N/A	109	109	35	50,803	33%	26%	0.7	N/A	50,803	
East Memorial	NP-EM-PMP-01	34	319	189	10	314	440	146	210,600	138%	110%	2.8	2	210,651	
	NP-EM-PMP-02	285		213											
Delta Park	NP-DP-PMP-01	95	95	231	4	52	52	6	8,928	55%	16%	0.1	2	8,928	
Balsam Park	NP-BS-PMP-01	290	290	120	4	51	51	19	27,749	18%	16%	0.4	0	27,749	

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Appendix E

Future Pump Station Details

The following table contains the preliminary design points used to design all future pump stations through buildout. This information is for planning purposes only and does not constitute a full hydraulic design. Additional engineering work, as well as coordination between developers and the City, will be necessary to design all future NP infrastructure.

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Pump Station Name	Planning Horizon	Pump Station Elevation (ft)	HGL (ft) ³	Pump Station Demand (gpm) ²			% of Buildout			Max Day Demand, Unadopted (gpd) Buildout	# Pumps	Pump Design		PS Outlet Size (in)	Pond Size (acre-ft) ¹	Notes
				2025	2040	Buildout	2025	2040	Buildout			Flow (gpm)	Head (ft)			
SA-0	2075	4741	4930	0	0	641	0%	0%	100%		2	390	170	8	3.0	
SA-1	2075	4742	4929	0	0	646	0%	0%	100%		2	390	170	8	3.0	
SA-2	2075	4714	4915	0	0	534	0%	0%	100%		2	330	180	8	2.5	
SA-3	2040	4709	4887	0	118	505	0%	23%	100%		2	310	160	8	2.3	
SA-4	2040	4692	4895	0	110	187	0%	59%	100%		2	120	180	8	0.9	
SA-5	2075	4697	4885	0	0	516	0%	0%	100%		2	310	170	8	2.4	
SA-6	2075	4732	4933	0	0	300	0%	0%	100%		2	180	180	8	1.4	
SA-10	2075	4643	4831	0	0	833	0%	0%	100%		2	500	170	10	3.8	
SA-12	2040	4919	5150	0	284	963	0%	29%	100%		2	580	210	10	4.4	
SA-13	2075	4896	5091	0	0	1006	0%	0%	100%		2	610	170	10	4.6	
SA-14	2025	4898	5150	217	353	2915	7%	12%	100%		2	1750	230	16	13.4	Tech Center
SA-15	2040	4996	5184	0	1	1158	0%	0%	100%		2	700	170	10	5.3	
SA-16	2040	4906	5104	0	265	866	0%	31%	100%		2	520	180	10	4.0	
SA-25	2025	4921	5098	186	374	521	36%	72%	100%		2	320	160	8	2.4	
SA-30	2075	4880	5053	0	0	360	0%	0%	100%		2	220	155	8	1.7	
SA-34	2040	4752	4939	0	190	464	0%	41%	100%		2	280	170	8	2.1	
SA-35	2040	4681	4859	0	381	508	0%	75%	100%		2	310	160	8	2.3	
SA-36	2040	4790	4976	0	284	737	0%	38%	100%		2	450	170	8	3.4	
SA-38	2040	4636	4843	0	46	118	0%	39%	100%		2	80	180	8	0.5	
SA-41	2075	4663	4840	0	0	928	0%	0%	100%		2	560	160	10	4.3	
SA-42	2040	4663	4861	0	278	596	0%	47%	100%		2	360	180	8	2.7	
SA-44	2025	4835	5011	48	147	549	9%	27%	100%		2	330	160	8	2.5	
SA-46	2075	4749	4927	0	0	921	0%	0%	100%		2	560	160	10	4.2	
SA-47	2075	4761	4949	0	0	799	0%	0%	100%		2	480	170	10	3.7	
SA-48	2075	4757	4945	0	0	862	0%	0%	100%		2	520	170	10	4.0	
SA-49	2075	4712	4901	0	0	920	0%	0%	100%		2	560	170	10	4.2	
SA-50	2075	4741	4929	0	0	1275	0%	0%	100%		2	770	170	12	5.9	
SA-51	2075	4730	4928	0	0	2083	0%	0%	100%		2	1250	180	16	9.6	
SA-52	2075	4724	4912	0	0	1078	0%	0%	100%		2	650	170	10	5.0	
SA-53	2075	4686	4874	0	0	1500	0%	0%	100%		2	910	170	12	6.9	
SA-57	2075	4894	5114	0	0	1232	0%	0%	100%		2	740	200	16	5.7	
SA-60	2025	4894	5081	342	733	922	37%	80%	100%		2	560	200	10	4.2	
Boomerang Regional PS	2025	4791	4978	829	1650	2716	31%	61%	100%		2	1630	170	16	12.5	

Notes and Equations:

¹Pond size = ((peak hour demands, gpm) / (4.22 peak hour / peak month) * (1440 min / day) * (1 AF / 325851 gal)) * 1.1 (for ET losses)

²Peak hour demands

³Average head at downstream junction = (Elevation, ft) + (Downstream pressure @ max hour, psi)*(2.31 ft/1 psi)

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Appendix F

WaterWise Landscaping Best Practices Manual Criteria

The following manual was developed by the City of Greeley as a guide for implementing best practices for landscaping and irrigation to promote water conservation.

City of Greeley



WaterWise Landscaping Best Practices Manual Criteria

Draft

November 2019

*Water Conservation
Water Resources*

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WaterWise Landscaping Best Practices Manual

Section 1 – Introduction

Prevalent landscaping practices used in of development today have disregarded the long-term effects on the region's water supply. Nearly 75% of summer water use is consumed by outdoor vegetation. The drought in Colorado has highlighted the necessity of using WaterWise design practices in order to best use our limited water resources. Significant reductions can be gained through minor changes in the arrangement of plantings, alternative plant selection and soil preparation.

The City of Greeley has drafted criteria that includes WaterWise landscape practices that will be can be used to guide development in the design of landscaping. This criteria can also be used as a reference for existing landscapes and irrigation design. The purpose of the project is to:

1. move closer to use of landscaping that matches our semi-arid environment
2. include specific direction in choice of plant material
3. include illustrations
4. to the extent possible, make language easy to understand and apply
5. include both xeriscape requirements and aspirational practices

Besides requirements for new development, the process also includes this “Best Practices Manual” that all citizens can use in making choices about their home landscaping. These Best Practices for landscape design are derived from the seven principles of Xeriscaping, as well as GreenCo's Best Management Practices.

The intention for these Best Practices is to inform home and property owners about landscape and irrigation needs unique to Colorado, and to assist in creating responsible landscape and irrigation design decisions.

WaterWise Landscaping **Best Practices**

Section 2 – WaterWise Principles and Guidelines

DSW, Sources: GreenCo BMPs, Xeriscape Principles

This section focuses on eight “principles” that act as goals for smart planting and irrigating in the Colorado region. Each principle offers a series of design recommendations and techniques in the form of “guidelines”. The guidelines function as steps to achieve the goals. Each guideline is not imperative but still important to ensure healthy plant growth, reduced water waste and increased cost savings over time. The following principles, if used properly, will help to create a useful, efficient and enjoyable WaterWise landscape.

Principle #1 – Plan and design landscaping comprehensively.

Guidelines

- A. Start with an inventory and analysis plan of the site that identifies “existing conditions.” Conditions such as drainage areas, sun exposure, soil types, good views, existing plants, etc. will affect how the site is used (Figure 1). Next develop a list of activities and areas, also called a “program,” expected to occur on the site. For example a backyard program might include a lawn play area, dog run, dining patio, barbecue grill, shade trees and shrub beds. Continue by diagramming possible locations for the program activities, while also providing access and traffic patterns or screening as needed. Finally, use this information to develop a plan that integrates plants into the overall scheme (Figure 2).
- B. Now with your overall plan, consider options on how you would like to conserve water. Several recommendations for water conservation are addressed throughout this document.
- C. Calculate the water requirements for your landscape using the Water Budget Worksheet provided in Section Seven of this manual. Try not to exceed an average total of 15 gallons per square foot annually.
- D. Incorporate trees into the landscape to provide shade, reduce stormwater runoff, stabilize soil and protect against wind. If considering the gross site area, a minimum goal of 20 percent tree canopy coverage (at trees’ maturity) for Front Range communities is recommended.
- E. When designing plant placement on slopes, place lower-water demand plants at the tops of slopes and higher-demand plants at the bottom.
- F. Artificial flowers and grass are discouraged. Exceptions may be granted for special use areas such as synthetic turf athletic fields.

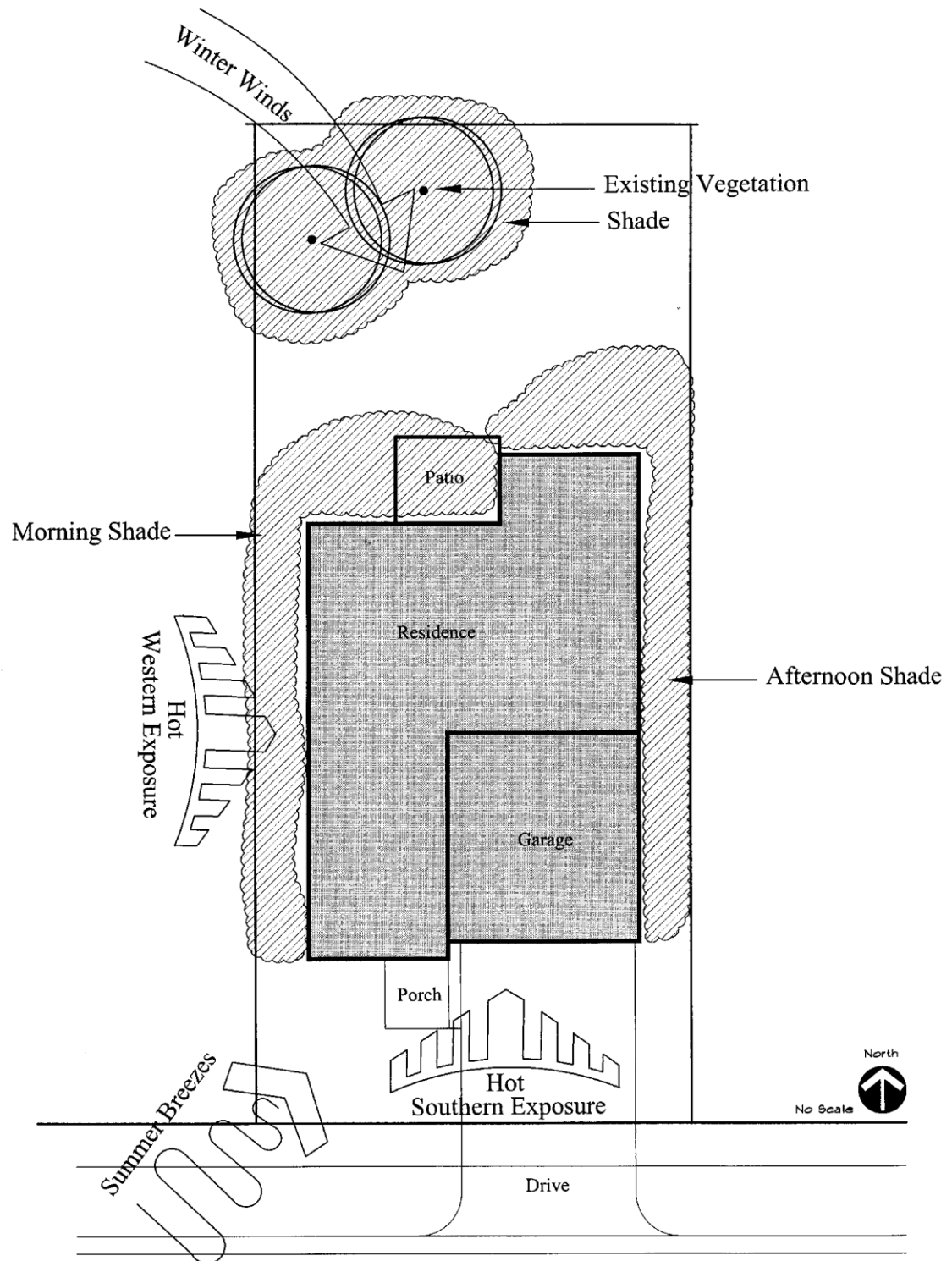


Figure 1. Inventory and Analysis Plan

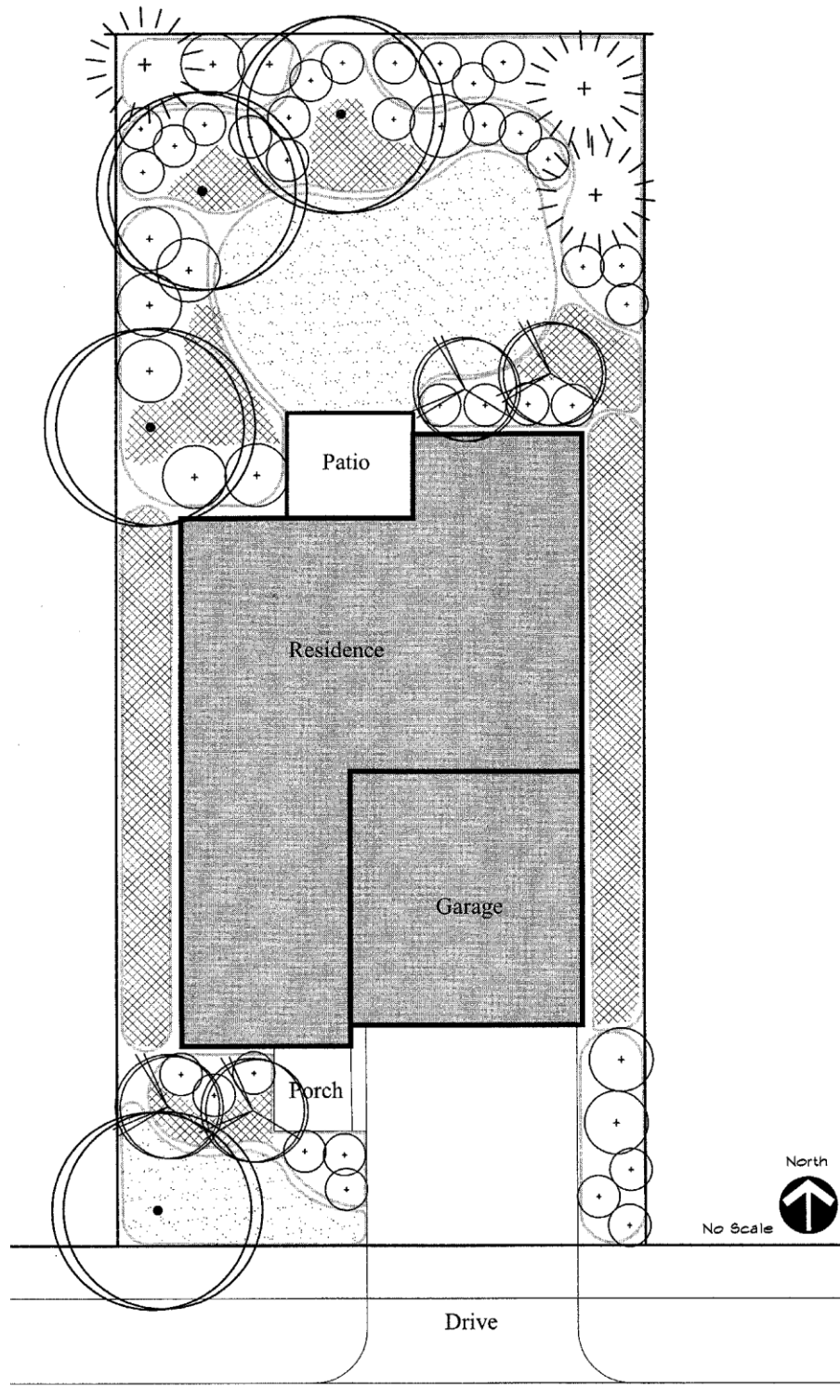


Figure 2. Overall Planting Plan

Principle #2 - Evaluate soil and improve, if necessary.

Guidelines

- A. Soil suitability for planting should be evaluated to identify potential soil amendments that may improve plant health and survival (see Section Five).
- B. Strip and stockpile existing topsoil prior to major site re-grading. Following completion of grading, replace topsoil and improve soil for planting with suitable soil amendments.
- C. Improve soil as suitable (see Section Five) before planting and installing the irrigation system. Soil improvement promotes better absorption of water, improved water-holding capacity and drainage of the soils. It also allows for better oxygen transfer within the root zone.
- D. Add organic material to the plant hydrozones, but only as needed. This typically means adding organic material for High and Moderate water zones, but not for Low and Very Low water zones. pH-balanced examples of organic materials are compost (from plants), sphagnum peat and animal manure (other than cow or horse).
- E. Soil preparation should include the breaking up and loosening, or scarification, of soil to 6 inches, with incorporation of organic amendments, fertilizer, etc. as specified by a landscape designer, landscape architect or soil analysis (Figure 3).

For more information please refer to Section 5, Understanding Soils and Soil Preparation.

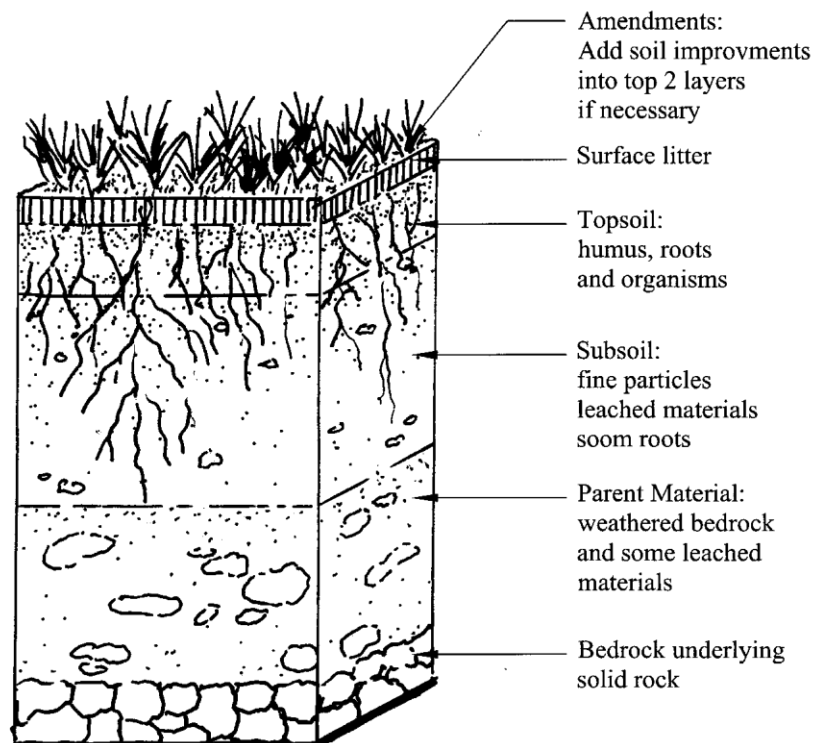


Figure 3. Soil Profile

Principle #3 - Create efficient turf areas.

Guidelines

- A. Include turf areas where they provide defined functions (i.e., recreation, traffic areas, etc.). Plantings of trees, shrubs, ground covers and flowers are best separated from grass so they can be watered separately. Often, portions of turf areas can be replaced with more water-efficient ground covers and mulches (Figure 4).
- B. When selecting turfgrass, consider the use, aesthetic and design goals of the site, estimated water use and maintenance budget. Alternative grass types, such as tall fescue, buffalograss, blue grama and wheat grass, may provide lower water and maintenance needs than bluegrass. In areas where irrigation is not planned for instance, a mix of mainly native bunch and sod-forming grasses might be used. (See Section Four for native seed mix options.)
- C. Avoid using turf in areas less than 8 feet wide and on slopes steeper than 3:1. These areas require inefficient irrigation sprays. Consider using drip-irrigated shrubs or groundcovers with Low or Very Low water requirements as alternatives. A special exception may be streetscape tree lawns, where turfgrass may be most appropriate with careful consideration and monitoring of potential irrigation inefficiencies.
- D. Some sites and turf areas with difficult irrigation or maintenance concerns may perform better with low water grass types or groundcovers. Consider street rights-of-way, industrial sites, drainageways and natural areas for such alternative grasses. (See Principle #8 below.)



Figure 4. Efficient Turf Area in Front Yard

Principle #4 - Use appropriate plants and group according to their water need, i.e. “hydrozoning”.

Guidelines

- A. Plants with lower water requirements, such as native species adapted to Colorado’s climate, should be considered. However, other plants can have a place in xeriscape designs, even if they require larger amounts of water. The key is to use those plants in appropriate locations and not to interplant them with others that have very different, lower water requirements. In effect, the grouping of plants into “hydrozones” based on their water requirements allows them to be irrigated efficiently. A detailed list of Colorado landscape plants and their respective water requirements by “hydrozone category” is included in Section Three.
- B. Group plants with like water needs together (Figure 5). Plants located within the drip line for large, mature trees and shrubs should have similar water requirements as the trees and shrubs. (A drip line is considered the outermost circle on the ground where water drips from the leaves of a tree or shrub canopy above.)
- C. Plants of any water need may be used in the landscape, providing the total annual water use does not exceed Water Allowance for the ET (Evapo-Transpiration) Reference Location. For example, this allowance is 15 gallons/square foot/season in the Denver metro area. (See Section Six below for Water Budget calculations.)
- D. High water zones should be separated from Low and Very Low water zones by Moderate water zones whenever possible.
- E. Select plants that are well adapted to the climate, topographic and geologic conditions of the site.
- F. Select plants with lower water requirements for areas with southern and western exposures.
- G. Strips less than 8 feet wide should be landscaped with Low or Very Low water plants. (See Principle #3 above.)

Principle #5 - Water efficiently with a properly designed irrigation system

Guidelines

- A. Irrigate according to the water need of each hydrozone, not solely on a fixed schedule (Figure 6). Well-planned sprinkler systems can save water when properly installed and operated. Turf areas should be watered separately from beds. Shrubs, flowers and ground covers can be watered more efficiently, by less frequent irrigation that is allowed to penetrate the root zone more deeply. (See Principle #4 above.)
- B. Consider plant water requirements in irrigation design schemes.
- C. Take into account the hydraulic principles when designing the irrigation system. Generally these principles deal with water volume, pressure and patterns of movement.

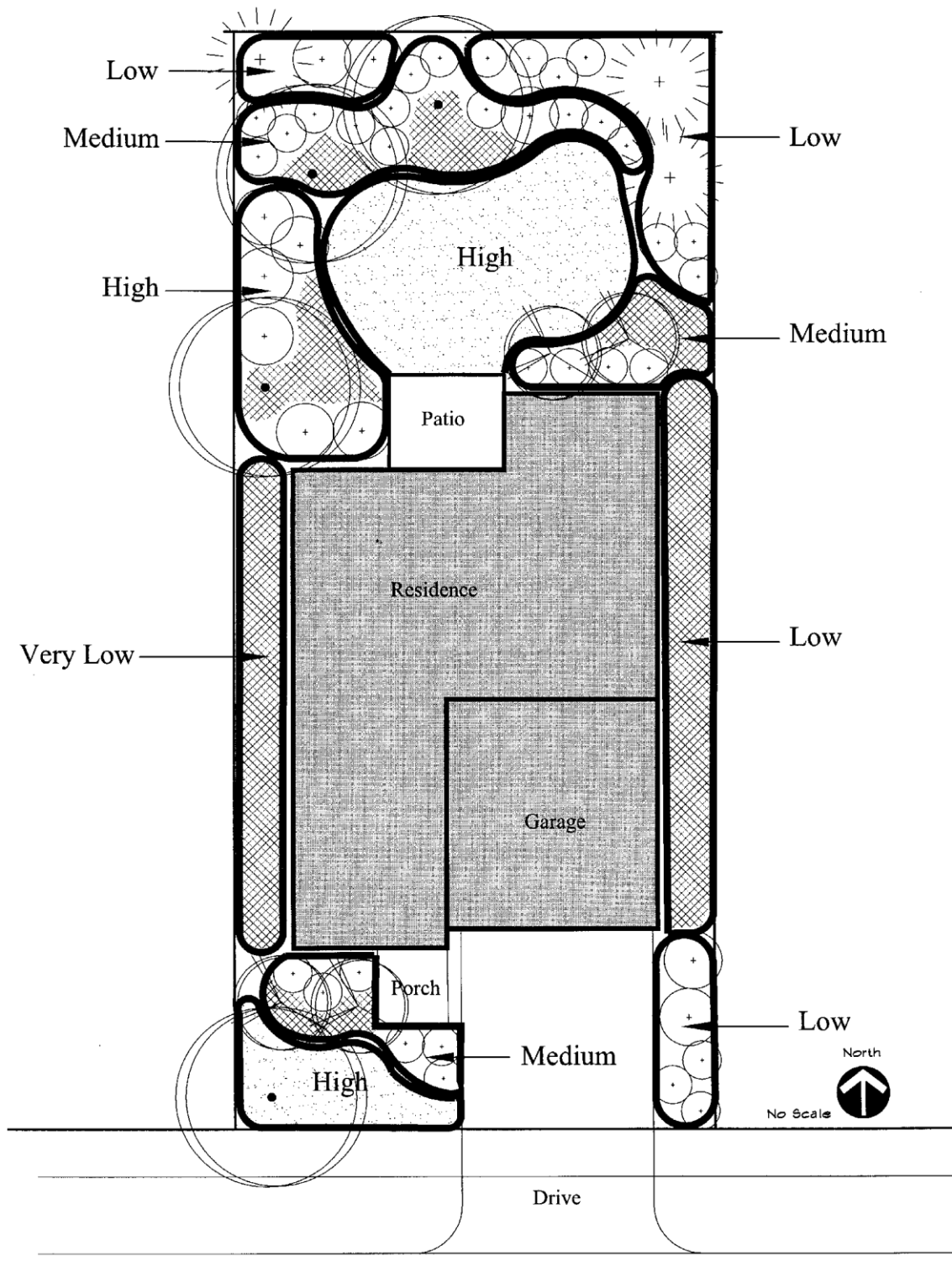


Figure 5. Hydrozone Outline Diagram with 4 water need types

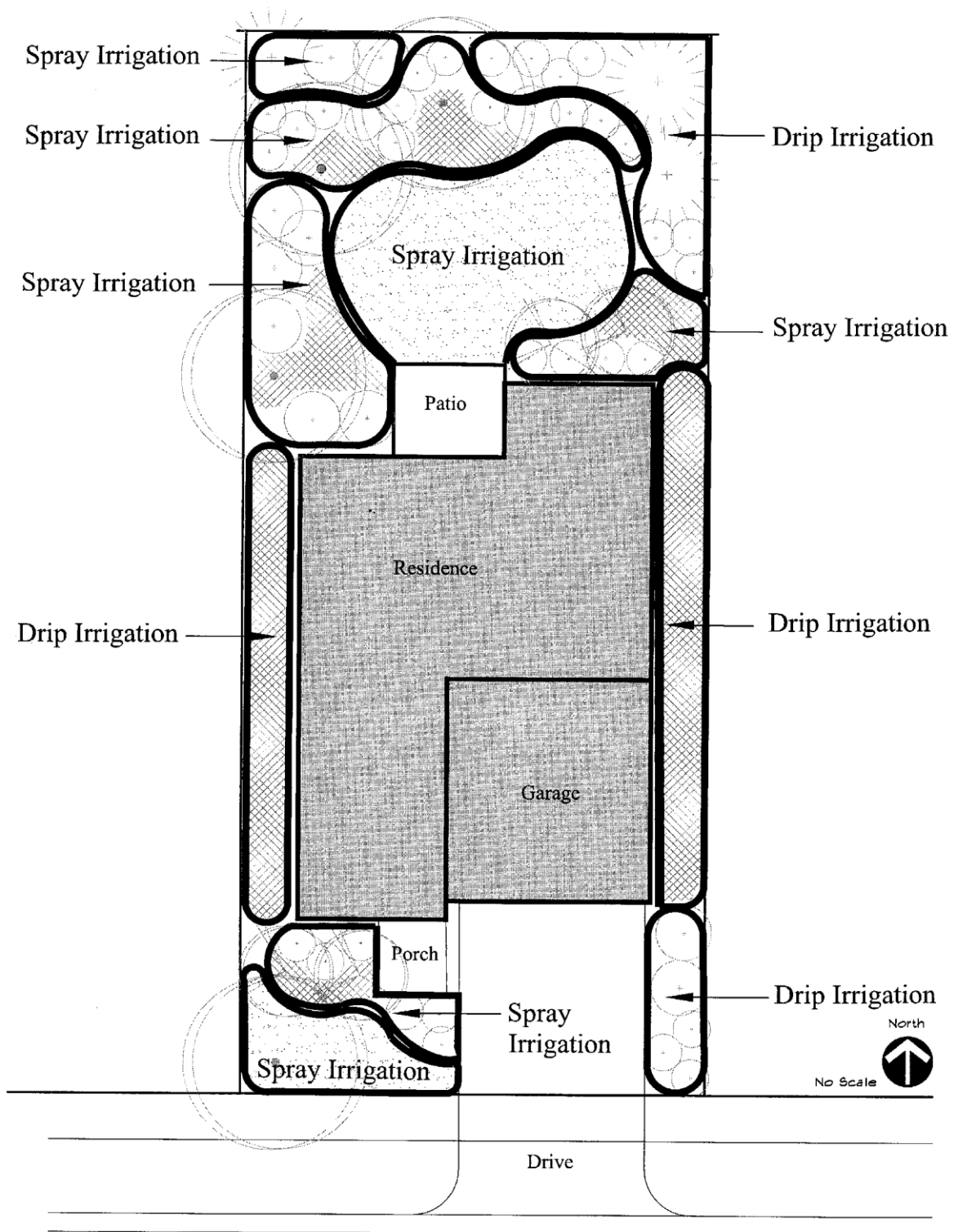


Figure 6. Irrigation Type Diagram

- D. Install an irrigation controller that offers flexible programming. Landscapes should not need as much supplemental watering during a rainy period. Rain or moisture sensors are available to coordinate with controllers, and some controllers are self-adjusting based on weather conditions.
- E. Ensure that the irrigation system is installed per plan and is accurate.
- F. Provide “as-built” drawings of irrigation system after installation with dimensions shown for irrigation components. Such drawings will help to find and correct problems in the future.
- G. Operate irrigation systems to maximize irrigation water efficiency.

For more information please refer to Section 6, Irrigation Design Techniques and Equipment.

Principle #6 - Use mulches to reduce surface evaporation of water and weeds.

Guidelines

- A. Mulched planting beds are an ideal replacement for expansive turf areas. Mulches protect and reduce temperature extremes in the soil, minimize evaporation, reduce weed growth and slow erosion. Mulches also provide landscape interest. Organic mulches are typically bark chips, wood grindings, chopped leaves or pole peelings. Inorganic mulches include rock and various gravel products.
- B. Organic mulches are generally recommended for the most benefit of the plants, but the roots of some plants perform better with inorganic mulch. Landscape professionals can help determine suitable mulches for selected plants. Inorganic mulches may also be preferred as more stable in especially windy locations, areas requiring high maintenance or those apt to erosion.
- C. Place mulch directly on the soil or on breathable fabric (Figure 7). Do not use solid sheet plastic beneath mulched areas, as these keep out water and air – both of which are vital to plant health.
- D. All plantable areas not covered with turf should be covered with a minimum of four inches (4”) of a suitable mulch to retain water, and inhibit weeds.
- E. Mulching exceptions for Low and Very Low hydrozones should be considered.

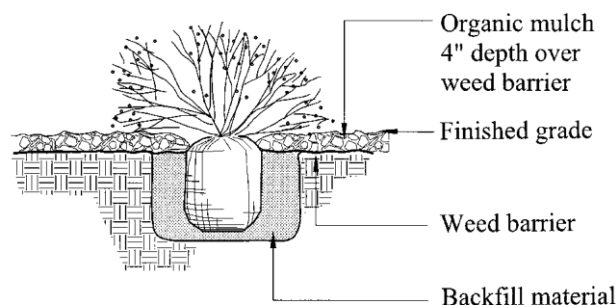


Figure 7. Shrub Planting in Mulch Bed

Principle #7 - Practice appropriate landscape maintenance.

Guidelines

- A. Proper pruning, weeding, mowing and fertilization, plus attention to the irrigation system, are needed to maximize water savings. Regular maintenance of planting and irrigation system preserves the intended beauty of the landscape, and saves water and maintenance costs through efficient operations. Always water according to hydrozone need and current soil moisture conditions, rather than according to a rigid schedule.
- B. Landscapes should be maintained to ensure water efficiency. A regular maintenance schedule should include but not be limited to checking, adjusting, and repairing irrigation equipment; resetting the automatic controller; aerating turf areas; replenishing mulch; fertilizing; pruning, and weeding in all landscaped areas.
- C. Whenever possible, repair of irrigation equipment should be done with the originally specified materials or their equivalents so that original performance and efficiency can be maintained for longer periods. (See Section Six for more Irrigation information.)



Garden Maintenance

Principle #8 – Preserve existing landscape and natural areas.

Guidelines

- A. Where possible preserve existing native remnant plant communities and site conditions that support them.
- B. Where possible preserve healthy trees – established plants have often developed a root system that is adapted to lower water conditions.
- C. Local native plants and plants with documented lower water requirements should be given priority in landscape design. A native plant is a species that “occurs naturally in a particular region, state, ecosystem, and habitat without direct or indirect human action” (Federal Native Plant Conservation Committee, 1994). A local native plant is derived from “a population or ecotype of the native plant species that was grown from genetically local plant materials” (Colorado Native Plant Society).
- D. Use of native plants in the landscape supports local biodiversity, helps sustain local wildlife, enhances recreation experience, supports remnant native plant communities and reduces water consumption.



Natural Area

- E. All landscapes have the potential to impact native communities through transport of and plant propagules by wind and storm drainage.



have
plant
seeds
wind

- Landscapes adjacent to native sites are particularly critical due to the potential of direct spread, but all projects (public or private) should not harbor or install exotic horticultural plant species that are known to be invasive and therefore threaten natural areas. A complete list of threatening plants to avoid is provided by the Colorado Native Plant Society web site: <http://carbon.cudenver.edu/~shill/species_avoid.pdf>.
- F. Landscapes adjacent to native areas should emphasize the use of species with low fuel volume of low flammability. Mowing management can be used to limit build up of flammable plant materials. Information on the fire-resistance of some native plants can be found at <www.ext.colostate.edu/PUBS/NATRES/06307.html>.
 - G. Remove species that are designated state noxious weeds, especially ornamental species such as purple loosestrife, oxeye daisy, tamarisk, myrtle spurge and yellow toadflax. See Section Four below for the 2003 list of noxious weeds for Colorado, or for more information see the “Noxious Weed List (Rules and Regulations)” at <www.ag.state.co.us/DPI/weeds/weed.html>.

For more information please refer to Section 4, Natural Areas and Native Plants.

WaterWise Landscaping Best Practices

Section 3 – WaterWise Plant Lists

A. The Four Hydrozones – WaterWise Plant Groupings

The key to WaterWise landscaping is to arrange plants in appropriate locations and not to interplant them with others that have very different, lower water requirements. This grouping of plants into “hydrozones” is based on their water requirements, and allows them to be irrigated efficiently. The following list shows how to group plants based their water needs.

Due to variability in plant water requirements due to location of the plant on a site, a range of hydrozone categories has been shown for many plants. For purposes of calculating the water budget for each hydrozone, the lowest hydrozone category for each plant shall be used.

High Water need

example: Bluegrass turf – always wet at the surface

uses 18-20 gals./ S.F./season = 3 waterings per week totaling 5 inches (in July)

Moderate Water need

example: turf-type Tall Fescue – ½ the water of Bluegrass turf

uses 10 gals./S.F./ season = ¾ inches of water, once per week

Low Water need

example: Buffalograss turf – needs rain and occasional watering

uses 0-3 gals./S.F./season = ½ inch of water per 2 weeks, optional

Very Low Water need

example: too dry for any turf grass (drier than Denver)

no irrigation required

B. Colorado WaterWise Plant List Summary

1. Shrubs (Deciduous, Rocky Mountain Natives)
2. Shrubs (Deciduous, Introduced to the region)
3. Trees (Deciduous, Rocky Mountain Natives)
4. Trees (Deciduous, Introduced to the region)
5. Evergreens (Coniferous Trees)
6. Evergreens (Coniferous Shrubs)
7. Evergreens (Non-coniferous)
8. Vines
9. Groundcovers (Including turf & meadow grasses)
10. Selected Perennials

The complete Plant Lists are provided on the following pages.

Copying and use of this list is encouraged, only if the following note, & the water needs of plants are included.

For more information see...**WaterWise Landscaping with Trees, Shrubs, and Vines**

Jim Knopf, Chamisa Books

SHRUBS

(Deciduous Rocky Mountain Natives)
[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

* = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Acer•glabrum	Rocky Mountain Maple	(M-H)
Acer•grandidentatum	Bigtooth Maple, Wasatch Maple	(M)
Alnus•tenuifolia	Rocky Mountain Alder	(H)
Amelanchier•alnifolia	Rocky Mtn. Serviceberry	(M+/-)
Amelanchier•utahensis *	Utah Serviceberry	(VL- M)
Amorpha•canescens	Lead Plant	(L- M)
Amorpha•fruticosa	False Indigo	(M +/-)
Amorpha•nana	Dwarf Lead Plant	(L- M)
Atriplex•canescens	Four-wing Saltbush	(VL-L)
Atriplex•confertifolia	Shadscale	(VL-L)
Betula•fontinalis	Rocky Mtn. River Birch	(H)
Betula•glandulosa	Bog Birch	(H)
Ceratoides•lanata *	Winterfat	(L)
Cercocarpus•montanus	Deciduous Mountain Mahogany	(L- M)
Chamaebatiaria•millefolium	Fernbush	(VL-L)
Chrysothamnus•spp.	Rabbitbrush species	(VL-L)
Cornus•sericea (now C. stolonifera)		
Cornus•stolonifera	Redtwig Dogwood	(H)
Corylus•cornuta	Beaked Hazelnut	(H- M)
Crataegus•var.occidentalis *	Native Hawthorn	(M+/-)
Crataegus•erythropoda *	(syn.? C. s. var. occidentalis)	(M+/-)
Crataegus•succulenta•var. macrantha *	Native Hawthorn	(M+/-)
Fallugia•paradoxa	Apache Plume	(VL-L)
Fendlera•rupicola	Cliff Fendlerbush	(L- M)
Forestiera•neomexicana	New Mexico Privet	(M+/-)
Fraxinus•anomala	Singleleaf Ash	(L)
Holodiscus•dumosus	Rock Spray	(L- M)
Jamesia•americana	Jamesia	(M - H)
Lonicera•involucrata	Twinberry	(H)
Lycium•pallidum *	Pale Wolfberry	(L)
Ostrya•knowltonii *	Western Hop Hornbeam	(M+/-)

Parryella•filifolia *	Dunebloom	(M+/-)
Pentaphylloides•floribunda	= Potentilla•fruticosa	
Peraphyllum•ramosissimum *	Squaw Apple	(L - M)
Philadelphus•lewisii	Lewis's Mockorange	(M+/-)
Philadelphus•microphyllus	Littleleaf Mockorange	(M+/-)
Physocarpus•monogynus	Mountain Ninebark	(M+/-)
Poliomintha•incana *	Purple Sage	(VL-L)
Potentilla•fruticosa	Shrubby Potentilla	(M - H)
Prunus•americana	Wild Plum	(M+/-)
Prunus•besseyi	Sand Cherry	(L-M)
Prunus•pensylvanica *	Pin Cherry	(M+/-)
Prunus•pensylvanica•saximontana *	Dwarf Pin Cherry	(M+/-)
Prunus•virginiana	Chokecherry	(M - H)
Ptelea•trifoliata	Hoptree	(M+/-)
Purshia•tridentata	Bitterbrush	(L - H)
Quercus•gambelii	Gambel's Oak	(M+/-)
Quercus•turbinella *	Turbinella Oak	(L - M)
Quercus•undulata *	Wavyleaf Oak	(L - M)
Rhamnus•smithii *	-----	(M+/-)
Rhus•glabra	Smooth Sumac	(L - M)
Rhus•glabra•var. •cismontana	Rocky Mountain Smooth Sumac	(L-M)
Rhus•glabra•'Laciniata'	Cutleaf Smooth Sumac	(L-M)
Rhus•microphylla *	Littleleaf Sumac	(L-M)
Rhus•trilobata	Three-leaf Sumac	(L - M)
Ribes•aureum	Golden Currant	(M+/-)
Ribes•cereum *	Squaw Currant	(M+/-)
Ribes•inerme	Whitestem Gooseberry	(M+/-)
Rosa•woodsii	Wood's Rose	(M+/-)
Rubus•deliciosus	Boulder Raspberry	(M+/-)
Rubus•idaeus•var. •strigosus	Wild Raspberry	(M - H)
Rubus•parviflorus *	Thimbleberry	(M - H)
Salix•irrorata	Bluestem Willow	(H)
Sambucus•caerulea *	Blue Elderberry	(H)
Sambucus•melanocarpa *	Blackbead Elderberry	(H)
Sambucus•racemosa *	Red Elderberry	(H)
Sarcobatus•vermiculatus *	Greasewood	(VL-L)
Shepherdia•argentea	Silver Buffaloberry	(M+/-)
Shepherdia•canadensis *	Buffaloberry	(M+/-)
Sorbus•scopulina *	Rocky Mtn. Mountain Ash	(M - H)
Symphoricarpos•albus	Snowberry	(M+/-)
Symphoricarpos•orbiculatus *	Coralberry	(M+/-)
Tetradymia•canescens *	Gray Horsebrush	(L)

SHRUBS

(Deciduous, Introduced)
[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

* = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./ S.F./season July: 5" -- 3 times per week	10 gals./S.F./ season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation
Abelia•chinensis *	Chinese Abelia (China)	(M-H)	
Abelia•x•grandiflora *	Abelia (origin unknown)	(M-H)	
Abeliophyllum•distichum *	----- (Korea)	(M+/-)	
Acanthopanax•senticosus *	Syn. Elentherococcus s.		
Acanthopanax•sieboldianus *	= Elentherococcus•sieboldianus		
Acer•azimovii * (= A.•ovczimmikovii?)	Azimov Maple	(M+/-)	
Acer•campestre *	Hedge Maple (e. Europe & w. Asia)	(M-H)	
Acer•ginnala	= Acer•tataricum•ssp.•ginnala		
Acer•maximowiczianum *	----- (China-Mongolia-Korea)	(M-H)	
Acer•semenovii *	= Acer•tataricum•ssp.•semenovii		
Acer•tataricum	Tatarian Maple (A. Minor, se. Asia)	(L-M)	
Acer•tataricum•ssp.•ginnala	Ginnala Maple (c. Asia)	(L-M)	
Acer•tataricum•ssp.•semenovii *	Turkestan Maple (c. Asia)	(L-M)	
Aesculus•parviflora *	Bottlebrush Buckeye (Ga., Ala.)	(H)	
Aesculus•sylvatica *	----- (se. USA)	(H)	
Alnus•cordata *	Italian Alder (Corsica, s. Italy)	(H)	
Alnus•glutinosa *	European Alder (Eur., n. Africa, Turkey)	(H)	
Alnus•rubra (was A.•oregona) *	Oregon Alder (w. N. Am.)	(H)	
Amelanchier•stolonifera *	Running Serviceberry (ne. N. Am.)	(H)	
Aralia•elata *	Angelica Tree (Jap., Kor., Manch.)	(M-H)	
Aralia•spinosa *	Devil's Walkingstick (e. USA)	(M-H)	
Aronia•melanocarpa	Chokeberry (e. N. America)	(M+/-)	
Artemisia•abrotanum	Southernwood (s. Europe)	(M+/-)	
Atraphaxis•caucasica *	----- (Transcaucasica)	(M+/-)	
Atraphaxis•pyrifolia *	----- (c. Asia)	(L)	
Berberis•koreana *	Korean Barberry (Korea)	(M+/-)	
Berberis•oblonga *	----- (Turkestan)	(M-L)	
Berberis•thunbergii	Japanese Barberry (Jap.)	(M-H)	
Buddleja•alternifolia *	Butterflybush (nw. China)	(M+/-)	
Buddleja•davidii	Butterflybush (China)	(M+/-)	
Buddleja•globosa *	----- (Chile, Argentina, Peru)	(M+/-)	
Buddleja•x•Lochinch' *	----- (hort. hybrid)	(M+/-)	
Callicarpa•bodineri *	Beauty Berry (c. & w. China)	(M+/-)	
Callicarpa•dichotoma *	Korean Beautyberry (e. USA)	(H)	

<i>Calycanthus occidentalis</i> *	California Allspice (sw. USA)	(H)
<i>Calycanthus chinensis</i> *	----- (e. China)	(H)
<i>Calycanthus floridus</i> *	Carolina Allspice (se. USA)	(H)
<i>Caragana arborescens</i>	Siberian Peashrub (c. Asia - Mongolia)	(L-M)
<i>Caragana aurantiaca</i> *	Dwarf Peashrub (Sib., Afghan., Turkestan)	(L-M)
<i>Caragana frutex</i> *	Russian Peashrub (c. Asia, Siberia)	(L-M)
<i>Caragana maximowicziana</i> *	----- (Tibet, n. China)	(L-M)
<i>Caragana microphylla</i>	----- (nw. China, Sib.)	(L-M)
<i>Caragana pygmaea</i> *	----- (nw. China)	(L-M)
<i>Caragana sinica</i> *	Chinese Peashrub (n. China)	(L-M)
<i>Caryopteris incana</i> *	----- (China, Jap.)	(L-M)
<i>Caryopteris mongolica</i> *	----- (n. China, Mong.)	(L-M)
<i>Caryopteris x clandonensis</i>	Bluemist Spirea (hort. hybrid)	(L-M)
<i>Ceanothus sanguineus</i> *	Oregon Tea (Cal. to BC)	(H)
<i>Cerasus verrucosa</i> *	----- (Tajikistan)	(L-M)
<i>Cercis griffithii</i> *	Griffith's Redbud (c. Asia)	(L-M)
<i>Chaenomeles japonica</i> *	Dwarf Quince (Japan)	(M+/-)
<i>Chaenomeles lagenaria</i>	= <i>C. speciosa</i>	
<i>Chaenomeles speciosa</i> *	Flowering Quince (China, Japan)	(M+/-)
<i>Chamaecytisus hirsutus</i> *	----- (Sib.-n. China)	(M+/-)
<i>Chilopsis linearis</i> *	Desert Willow (desert southwest)	(L-M)
<i>Chimonanthus praecox</i> *	Fragrant Wintersweet (China)	(H)
<i>Chionanthus retusus</i>	Chinese Fringe Tree (China, Kor. Taiwan)	(H)
<i>Chionanthus virginicus</i>	Fringe Tree (e. N. America)	(M-H)
<i>Clematis heracleifolia</i> var. <i> davidiana</i> *	----- (e. China)	(M-H)
<i>Clerodendrum trichotomum</i> *	Glory Bower (Japan)	(H)
<i>Clethra alnifolia</i> *	Summer-sweet (e. N. America)	(H)
<i>Clethra delavayi</i> *	Summer-sweet (w. China)	(M+/-)
<i>Cornus alba</i> 'Elegantissima'	Variegated R'twig Dog'd (Sib., n. Chi., Kor.)	(H)
<i>Cornus alternifolia</i>	Pagoda Dogwood (e. N. America)	(H)
<i>Cornus amomum</i> *	Silky Dogwood (e. N. America)	(M-H)
<i>Cornus controversa</i> *	Giant Dogwood (Japan, China, Him.)	(H)
<i>Cornus kousa</i> *	----- (Japan, Korea, China)	(M-H)
<i>Cornus kousa</i> var. <i> chinensis</i> *	----- (China)	(H)
<i>Cornus mas</i> *	Cornelian Cherry (c. Europe-w. Asia)	(M-H)
<i>Cornus racemosa</i> *	Gray Dogwood (ne. N Am)	(M-H)
<i>Cornus sericea</i> (now <i>C. stolonifera</i>)	(See: Native Rocky Mtn. deciduous shrubs)	
<i>Cornus stolonifera</i> 'Flaviramea'	Yellowtwig Dogwood (N. Am.)	(H)
<i>Coronilla emerus</i> *	Scorpion Senna (s. Norway, Spain, Greece)	(M-H)
<i>Corylopsis pauciflora</i> *	Winter Hazel (Japan, Taiwan)	(H)
<i>Corylopsis sinensis</i> *	Chinese Winter Hazel (c. China)	(M+/-)
<i>Corylopsis spicata</i> *	Japanese Winter Hazel (Japan)	(H)
<i>Corylus avellana</i> *	European Hazel (Europe)	(M-H)
<i>Corylus chinensis</i> *	Chinese Hazel (sw. China)	(H)
<i>Corylus maxima</i> *	Filbert (se. Eur., A. Minor)	(H)
<i>Cotinus coggygria</i>	Smoke Tree (s. Europe-Asia)	(M+/-)
<i>Cotinus obovatus</i> *	American Smoketree (s. USA)	(M-H)
<i>Cotoneaster actinifolius</i>	Peking Cotoneaster (n. China)	(M+/-)
<i>Cotoneaster apiculatus</i>	Cranberry Cotoneaster (China)	(M+/-)
<i>Cotoneaster bullatus</i> *	----- (w. China)	(M+/-)
<i>Cotoneaster divaricatus</i>	Spreading Cotoneaster (China)	(M+/-)
<i>Cotoneaster franchetii</i> *	----- (sw. China, Tibet)	(M-H)
<i>Cotoneaster horizontalis</i>	Rock Cotoneaster (w. China)	(M+/-)
<i>Cotoneaster ignavus</i> *	----- (e. Turkestan)	(M+/-)
<i>Cotoneaster multiflorus</i> *	Many-flowered Cotoneaster (nw. China)	(M+/-)
<i>Cotoneaster racemiflorus</i> * songaricus *	----- (c. Asia)	(M+/-)
<i>Cotoneaster simonsii</i> *	----- (Himal., Sikkim, Nepal)	(M-H)
<i>Crataegus x mordanensis</i> 'Toba'	Toba Hawthorn (hort. hybrid)	(M+/-)
<i>Cudrania tricuspidata</i> *	Chinese Silkworm Thorn (China)	(H)
<i>Cydonia oblonga</i> *	Quince (n. Persia)	(M+/-)
<i>Cydonia sinensis</i> *	= <i>Pseudocydonia sinensis</i>	

Cyrilla•racemiflora *	Leatherwood (e. N. America)	(H)
Cytisus•albus *	= Cytisus•multiflorus	
Cytisus•decumbens *	Prostrate Broom (s. Europe)	(L-M)
Cytisus•hirsutus	= Chamaecytisus•hirsutus	
Cytisus•multiflorus *	Portuguese Broom (se. Europe)	(L-M)
Cytisus•purgans *	----- (s. Eur. - n. Afr.)	(L-M)
Cytisus•scoparius *	Scotch Broom (c. & s. Europe)	(L-M)
Cytisus•x•praecox *	Warminster Broom (hort. hybrid)	(L-M)
Dalea•formosa *	Feather Plume (w. Tex., Okl., Colo.)(L	
Dalea•frutescens *	Black Dalea (w. Tex., Okla.)	(L)
Dalea•scoparia *	Broom Dalea (w. Tex., N. Mex., Az.)	(L)
Daphne•caucasica *	Caucasian Daphne (Caucasus)	(M+/-)
Daphne•genkwa *	----- (China)	(M+/-)
Daphne•giraldii *	Daphne (nw. China)	(M+/-)
Daphne•mezereum *	February Daphne (Europe, w. Asia)	(M+/-)
Decaisnea•fargesii *	----- Bluebean Shrub (w. China)	(M-H)
Deutzia•gracilis *	Slender Deutzia (Japan)	(M-H)
Deutzia•scabra *	Fuzzy Deutzia	(M-H)
Deutzia•x•lemoinei *	Lemoine Deutzia (Hort. hybrid)	(M-H)
Diervilla•lonicera *	----- (e. N. America)	(H)
Diervilla•sessilifolia *	Southern Bush-honeysuckle (se. USA)	(H)
Dipelta•floribunda *	----- (c. & w. China)	(M+/-)
Dipteronia•sinensis *	----- (China)	(M+/-)
Disanthus•cercidifolius *	----- (China, Jap.)	(H)
Elaeagnus•multiflora *	Cherry Elaeagnus (Jap., China)	(M-H)
Elentherococcus•sieboldianus *	----- (Jap., China)	(M+/-)
Eleutherococcus•senticosus *	Siberian Ginseng (ne. Asia)	(M-H)
Elsholtzia•stauntonii *	Mint Shrub (n. China)	(M+/-)
Euonymus•atropurpureus *	Wahoo (NY to Fla, Minn. to Tex.)	(M-H)
Euonymus•alatus	Burning Bush Euonymus (China, Jap., Kor.)	(M+/-)
Euonymus•bungeanus *	Winterberry (China, Korea, Manch., Jap.)	(M+/-)
Euonymus•europaeus *	Spindletree (Europe)	(M-H)
Euonymus•nanus•v. turkestanicus *	Turkestan Euonymus (Caucasus - w. China)	(M+/-)
Euonymus•phellomanus *	----- (n. & w. China)	(M+/-)
Euonymus•sachalinensis *	Sakhalin Euonymus (ne. Asia)	(M+/-)
Exochorda•albertii (now E. korolkowii)		
Exochorda•giraldii *	Pearlbush (c. China)	(M+/-)
Exochorda•korolkowii *	Pearlbush (Uzbekistan, Tajikistan)	(M+/-)
Exochorda•racemosa *	Common Pearlbush (n. China)	(M-H)
Exochorda•serratifolia *	Pearlbush (Korea, Manchuria)	(M+/-)
Exochorda•x•macrantha *	Pearlbush (hort. hybrid)	(M+/-)
Fontanesia•phillyreoides•ssp. fortunei *	----- (China)	(M+/-)
Forsythia•mandschurica *	Manchurian Forsythia (Manch.)	(M+/-)
Forsythia•ovata *	Early Forsythia (Korea)	(M+/-)
Forsythia•suspensa *	Forsythia (China)	(M+/-)
Forsythia•x•intermedia	Forsythia (hort. hybrid)	(M+/-)
Fothergilla•gardenii *	Fothergilla (Va. - Ga.)	(H)
Fothergilla•major *	----- (Allegheny Mts.)	(H)
Genista•tinctoria *	----- (Europe, w. Asia)	(L-M)
Halimodendron•halodendron *	Salt Tree (se. Russia-c. & w. Asia)	(VL-L)
Hamamelis•japonica *	Japanese Witch Hazel (Japan)	(H)

Hamamelis•mollis *	Chinese Witch Hazel (w. China)	(H)
Hamamelis•vernalis *	Witch Hazel (s.e. N. America)	(H)
Hamamelis•virginiana *	Common Witch Hazel (Canada to Georgia)	(H)
Heptacodium•miconioides *	----- (China)	(M+/-)
Hibiscus•syriacus	Rose-of-Sharon Hibiscus (China, India)	(M+/-)
Hippophaë•rhamnoides	Sea Buckthorn (Eurasia)	(M-H)
Holodiscus•discolor *	Rock Spirea (s. Ore.-s. Calif.)	(M+/-)
Hydrangea•arborescens	Hills-of-snow Hydrangea (e. USA)	(H)
Hydrangea•involucrata *	----- (Japan)	(H)
Hydrangea•paniculata	Peegee Hydrangea (China, Japan)	(H)
Hydrangea•quercifolia *	Oakleaf Hydrangea (se. USA)	(H)
Hydrangea•serrata *	----- (Jap., Korea)	(M-H)
Indigofera•amblyantha *	Pink Indigo (China)	(M+/-)
Indigofera•decora *	White Chinese Indigo (China)	(M+/-)
Indigofera•gerardiana *	= Indigofera•heterantha	
Indigofera•heterantha *	----- (Afghan.-w. China)	(M+/-)
Indigofera•incarnata *	= Indigofera•decora	
Indigofera•kirilowii *	----- (n. China, Korea)	(M+/-)
Indigofera•potaninii *	Potanin Indigo (nw. China)	(M+/-)
Itea•virginica *	Sweetspire (e. USA)	(H)
Jasminum•nudiflorum *	Winter Jasmine (China)	(M+/-)
Kerria•japonica	Kerria (Japan)	(M-H)
Kolkwitzia•amabilis	Beautybush (China)	(M+/-)
Leptodermis•oblonga *	----- (n. China)	(M+/-)
Lespedeza•bicolor *	----- (Japan)	(M+/-)
Lespedeza•thunbergii *	----- (Japan, China)	(M+/-)
Ligustrum•vulgare	Common Privet (Medit. region)	(M+/-)
Lindera•benzoin *	Spicebush (e. USA)	(M)
Lindera•obtusiloba *	----- (Kor., Jap., China)	(M-H)
Lonicera•spinosa *	----- (nw Him., Tibet, e. Turkestan)	(M+/-)
Lonicera•alberti *	----- (Turkestan, Tibet)	(M+/-)
Lonicera•caerulea *	----- (Tibet, e. Siberia)	(M+/-)
Lonicera•chrysantha *	----- (ne. Asia, c. Japan)	(M-H)
Lonicera•etrusca *	----- (Medit. to s. Switzerland)	(M+/-)
Lonicera•fragrantissima *	Winter Honeysuckle (China)	(M-H)
Lonicera•hispidula *	----- (Turkestan)	(M+/-)
Lonicera•korolkowii	----- (Mts. c. Asia, Afghan. Pak.)	(M+/-)
Lonicera•maackia *	Amur Honeysuckle (e. Asia)	(M-H)
Lonicera•maximowiczii•v. sachalinensis *	Sakhalin Honeysuckle (Manch, China, Kor.)	(M-H)
Lonicera•microphylla *	----- (nw. Him., Tibet, Sib.)	(M+/-)
Lonicera•morrowii *	Morrow Honeysuckle (Jap.)	(M-H)
Lonicera•pileata *	----- (China)	(M+/-)
Lonicera•quinquelocularis *	----- (Afghan. to Yunnan)	(M+/-)
Lonicera•spinosa•var. alberti *	Fragrant Turkestan Honeysuckle (c. Asia)	(M+/-)
Lonicera•standishii *	Fragrant Winter Honeysuckle (China)	(M+/-)
Lonicera•syringantha	Lilac-scented Honeysuckle (China, Tibet)	(M-H)
Lonicera•tatarica•'Zabelii'	Zabel's Honeysuckle (c. Asia, Afghan.)	(M+/-)
Lonicera•thibetica *	Tibetan Honeysuckle (Tibet., w. China)	(M+/-)
Lonicera•xylostemum *	European Fly Honeysuckle (Eurasia)	(M+/-)
Lonicera•x•Xylostemoides *	----- (garden origin)	(M+/-)
Lycium•chinense *	Chinese Wolfberry (e. Asia)	(M-H)

Magnolia•sieboldii *	Oyama Magnolia (Jap., Korea, w. China)	(H)
Magnolia•stellata	Star Magnolia (c. Japan)	(H)
Myrica•pensylvanica *	Bayberry (e. N. America)	(H)
Neillia•thibetica *	----- (Himalaya Mts.)	(M+/-)
Neviusii•alambamensis *	----- (se. USA)	(H)
Orixa•japonica *	----- (Japan, China, Korea)	(M+/-)
Paeonia•lutea *	Tree Peony (China, Tibet)	(M+/-)
Paeonia•suffruticosa *	Tree Peony (China, Tibet)	(M+/-)
Parrotia•persica *	----- (Persia)	(M+/-)
Parrotiopsis•jacquemontiana *	----- (Himalaya)	(M-H)
Philadelphus•coronarius +	Sweet Mockorange (Europe, sw. Asia)	(M+/-)
Philadelphus•x•virginialis +	----- (Hort. Hybrid)	(M+/-)
Photinia•villosa *	Oriental Photinia (China, Korea, Jap.)	(M-H)
Physocarpus•opulifolius	Dwarf Ninebark (e. N. America)	(M+/-)
Poncirus•trifoliata *	Trifoliate Orange (c. & n. China)	(M-H)
Prinsepia•sinensis *	----- (Manchuria)	(M+/-)
Prinsepia•uniflora *	----- (nw. China)	(M+/-)
Prunus•andersonii *	Desert Peach (sw. U.S.A.)	(L-M)
Prunus•cerasifera	Cherry Plum (A. Minor, Cauc.)	(M+/-)
Prunus•cerasifera•'Newport'	Newport Plum (garden origin)	(M+/-)
Prunus•fruticosa *	European Dwarf Cherry (Eur., Siberia)	(M+/-)
Prunus•nigra *	Canada Plum (ne. N. Am.)	(M-H)
Prunus•padus *	Bird Cherry (Eurasia)	(M+/-)
Prunus•tomentosa	Nanking Cherry (n. w. China, Tib. Kashmir)	(M-H)
Prunus•x•cistena	Cistena Plum (hort. hybrid)	(M+/-)
Pseudocdonia•sinensis *	Quince (China)	(M+/-)
Purnus•fasciculata *	Desert Almond (sw. USA)	(VL-L)
x•Pyracomeles•vilmorinii *	(Pyracanthus•crenatoserrataXOsteomeles•subrotunda)	(M+/-)
Rhamnus•dahuricus *	Common Buckthorn (e. Russia to Japan)	(M+/-)
Rhamnus•frangula	Glossy Buckthorn (Eur., Turk., n. Afr.)	(M+/-)
Rhamnus•frangula•'Asplenifolia' *	----- (Hort. Cultivar)	(M+/-)
Rhodotypos•scandens *	Jetbead (Japan, China)	(H)
Rhus•punjabensis *	----- (c., w. China)	(M+/-)
Rhus•typhina	Staghorn Sumac (e. N. America)	(M+/-)
Rhus•typhina•'Laciniata'	Cutleaf Staghorn Sumac (?)	(M+/-)
Ribes•alpinum	Alpine Currant (w. Europe)	(M-H)
Ribes•nevadense *	Sierra Currant (Ore., Cal., Nev.)	(M+/-)
Rosa•banksiae *	Banksia Rose (w. & c. China)	(M+/-)
Rosa•davidii *	David's Rose (w. & c. China)	(M+/-)
Rosa•ecae *	----- (c. Asia)	(M+/-)
Rosa•filipes *	----- (w. China)	(M+/-)
Rosa•foetida•'Bicolor'	Austrian Copper Rose (c. Asia)	(M-L)
Rosa•foetida•'Persiana'	Persian Yellow Rose (s.w. Asia)	(M-L)
Rosa•glauca	Redleaf Rose (c. & s. Europe)	(M+/-)
Rosa•helenae *	Helen Wilson's Rose (c. China)	(M+/-)
Rosa•hugonis	= R. xanthira•f. hugonis	
Rosa•kokanica *	----- (c. Asia, China)	(M+/-)
Rosa•laxa *	----- (c. Asia, nw. China)	(M+/-)
Rosa•moyesii *	Moyes Rose (w. China)	(M+/-)
Rosa•moyesii *	Moyes Rose (w. China)	(M+/-)
Rosa•persica *	Persian Rose (Persia, Afghan., c. Asia)	(M+/-)
Rosa•pulverulenta *	----- (s. Eur. to Afghanistan)	(M+/-)
Rosa•rubrifolia (now R. glauca)		

Rosa•rugosa	Rugosa Rose (e. Russia)	(M+/-)
Rosa•sericea *	----- (c. Asia, w. China)	(M+/-)
Rosa•setigera *	Prairie Rose (e. & c. USA)	(M+/-)
Rosa•webbiana	----- (c. Asia, Afghan, Kashmir.)	(M+/-)
Rosa•wichuriana *	----- (e. Asia)	(M+/-)
Rosa•xanthina•f. hugonis	Father's Rose (c. China)	(M+/-)
Rosa•x•harisonii *	Harison's Yellow Rose (Hort. hybrid)	(M+/-)
Salix•discolor	Pussy Willow (e. N. America)	(H)
Salix•matsudana•'Tortuosa'	Corkscrew Willow (China, Japan)	(H)
Sambucus•canadensis	Elderberry (e. N. America)	(H)
Sibiraea•altaiensis *	----- (w. China to Balkans)	(L-M)
Sibireae•laevigata	= Siberaea•altaiensis	
Sophora•davidii *	Father David's Sophora (China)	(L-M)
Sorbaria•sorbifolia	Ural False Spirea (Sib., Manch., Korea, Jap.)	(M+/-)
Sorbaria•tomentosa•v. angustifolia *	----- (Afghan., Pak., Kashmir)	(L-M)
Spiraea•betulifolia•var. lucida *	----- (B.C., Ore., Wyo., Mon.)	(M+/-)
Spiraea•cantoniensis *	----- (China)	(M+/-)
Spiraea•douglasii *	----- (B.C. to n. Cal.)	(M+/-)
Spiraea•japonica *	----- (Japan, China)	(M+/-)
Spiraea•japonica•'Albiflora' *	----- (Japan)	(M+/-)
Spiraea•japonica•'Anthony•Waterer'	Anthony Waterer Spirea (garden origin)	(M+/-)
Spiraea•japonica•'Bumalda'	----- (Hort. cultivar)	(M+/-)
Spiraea•japonica•'Froebelii'	Froebel's Spirea (garden origin)	(M+/-)
Spiraea•nipponica *	----- (Japan)	(M+/-)
Spiraea•trilobata	----- (n. Sib., Turkestan, n. China)	(L-M)
Spiraea•wilsonii *	----- (c. & w. China)	(M+/-)
Spiraea•x•vanhouttei	Vanhoutte Spirea (hort. hybrid)	(M+/-)
Spirea•x•arguta*	Garland Spirea (garden origin)	(M+/-)
Staphylea•trifolia*	Bladdernut (e. USA)	(M-H)
Staphylea•holocarpa *	Oriental Bladdernut (China)	(H)
Staphylea•pinnata *	European Bladdernut (c., se. Eur. A. Minor)	(H)
Stephanandra•incisa *	Lace Shrub (Jap., Korea, Taiwan)	(H)
Stephanandra•tanakae *	Lace Shrub (Japan)	(M-H)
Stephylea•bumalda *	Japanese Bladdernut (Japan)	(M-H)
Symphoricarpos•x•chenaultii•'Hancock' +	Hancock Coralberry (garden origin)	(M+/-)
Symplocos•paniculata *	Sapphireberry (Pakistan to Korea)	(M +/-)
Syringa•amurensis *	= Syringa•reticulata•v. mandschurica	
Syringa•joskiaea *	Hungarian Lilac (Hungary)	(M+/-)
Syringa•meyerii *	----- (n. China)	(M+/-)
Syringa•microphylla *	Littleleaf Lilac (n. China)	(M+/-)
Syringa•oblata *	Early Lilac (n. China)	(M+/-)
Syringa•patula *	----- (Korea, China)	(M+/-)
Syringa•persica	Persian Lilac (Persia)	(M+/-)
Syringa•persica•'Laciniata' *	Cutleaf Persian Lilac (Persia ?)	(M+/-)
Syringa•reflexa *	Nodding Lilac (c. China)	(M+/-)
Syringa•reticulata•'Miss•Kim'	Miss Kim Lilac (hort. hybrid)	(M+/-)
Syringa•sweginzowii *	Chengtu Lilac (nw. China)	(M+/-)
Syringa•velutina *	Korean Lilac (Korea)	(M+/-)
Syringa•villosa	----- (China)	(M+/-)
Syringa•vulgaris	Common Lilac (s.e. Europe)	(M+/-)
Syringa•wolfii *	Wolf's Lilac (Korea, Manchuria)	(M+/-)
Syringa•x•chinensis	----- (hort. hybrid)	(M+/-)
Syringa•x•laciniata	Cutleaf Lilac (sw. Asia)	(M+/-)
Syringa•x•prestoniae *	----- (Canadian hort. origin)	(M+/-)
Viburnum•burejaeticum *	----- (n. China, Korea, Russia)	(M-H)
Viburnum•carlesii	Korean Spice Viburnum (Korea, Jap.)	(M-H)
Viburnum•cassinoides *	Witherod Viburnum (e. N. Am.)	(H)

Viburnum•dentatum	Arrowwood Viburnum (e. N. America)	(H-M)
Viburnum•dilatatum *	Linden Viburnum (China, Jap.)	(H)
Viburnum•farreri *	Fragrant Viburnum (n. China)	(H)
Viburnum•lantana	Wayfaring Vib. (Eur., n. Afr., Cauc. A. Minor)	(M+/-)
Viburnum•lentago	Nannyberry (e. N. America)	(M-H)
Viburnum•opulus	European Highbush Cranberry (Eurasia)	(H)
Viburnum•opulus•'Compactum'	----- (cultivar)	(H)
Viburnum•opulus•'Roseum'	European Snowball Viburnum	(H)
Viburnum•plicatum *	----- (Jap., China)	(H-M)
Viburnum•plicatum•'Sterile' *	Japanese Snowball Viburnum (Jap. China)	(H)
Viburnum•plicatum•form•'tomentosum' *	Doublefile Viburnum (Jap., China)	(H)
Viburnum•prunifolium	Black Haw (e. N. Am.)	(M-H)
Viburnum•sargentii *	Sargent's Vib. (e. Sib., n. & w. China, Jap.)	(M-H)
Viburnum•setigerum *	Tea Viburnum (c. & w. China)	(M+/-)
Viburnum•sieboldii *	----- (Japan)	(H)
Viburnum•trilobum	American Highbush Cranberry (N. America)	(H)
Viburnum•trilobum•'Compactum'	----- (cultivar)	(H)
Viburnum•x•bodnantense•'Pink•Dawn' *	----- (hort. hybrid)	(M-H)
Viburnum•x•carlcephalum	----- (hort. hybrid)	(M-H)
Vitex•agnus-castus•f. •latifolia *	Hardy Chaste Tree (s. Europe to c. Asia)	(L-M)
Vitex•negundo•var. •heterophylla *	Cutleaf Chaste Tree(n. China, Mongolia)	(M+/-)
Vitex•rotundifolia *	----- (Asia to Australia)	(M+/-)
Weigela•florida	Weigela (n. China, Korea, Jap.)	(H)
Weigela•middendorffiana *	Middendorff Weigela (n. China, Jap.)	(H)
Xanthocerus•sorbifolium	Yellowhorn (n. China)	(M+/-)
Zanthoxylum•piperitum *	Pepper Tree (China, Korea, Jap.)	(M+/-)
Zanthoxylum•schinifolium *	Pepper Tree (China, Korea, Jap.)	(M+/-)
Zanthoxylum•simulan *	----- (China, Taiwan)	(M-H)
Zenobia•pulverulenta *	Dusty Zenobia (N. Carolina-Florida)	

Trees

(Deciduous Rocky Mountain Natives)
[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

* = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation
Celtis•occidentalis Celtis•reticulata	Hackberry Netleaf Hackberry		(M-H) (M-H)
Fraxinus•cuspidata * Fraxinus•pennsylvanica	Fragrant Ash Green Ash		(M+/-) (M-H)
Populus•angustifolia Populus•deltoides Populus•fremontii Populus•tremuloides Populus•x•acuminata	Narrowleaf Cottonwood Plains Cottonwood Fremont's Cottonwood Aspen Lanceleaf Cottonwood		(H) (H) (H) (H) (H)
Sapindus•drummondii *	Soapberry		(L-M)

Trees

(Deciduous, Introduced)
[Revised April '03]

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Acer•capillipes *	Snake-bark Maple (Japan)	(H)
Acer•cappadocicum *	Caucasian Maple (Cauc., A. Minor, n. India)	(M-H)
Acer•cissifolium *	Ivy-leaved Maple (c. China)	(M-H)
Acer•davidii *	Snake-bark Maple (n. China)	(M-H)
Acer•griseum *	Paperbark Maple (China)	(M-H)
Acer•heldreichii *	Greek Maple (Cauc., Balk., n. Turkey)	(M-H)
Acer•macrophyllum *	Oregon Maple (w. N. Am.)	(H)
Acer•mandschuricum *	Manchurian Maple (Korea, Manch.)	(M-H)
Acer•monspessulanum *	Montpelier Maple (Medit.- c. Asia)	(M+/-)
Acer•palmatum	Japanese Maple (Kor., Jap.)	(H)
Acer•pectinatum	----- (Tibet, w. & c. China)	(M-H)
Acer•platanoides	Norway Maple (Eur. to n. Persia)	(M-H)
Acer•platanoides•ssp. turkestanicum *	Turkestan Maple (c. Asia)	(M+/-)
Acer•pseudoplatanus *	Sycamore Maple (nw. c. Eur. to w. Asia)	(M-H)
Acer•pseudosieboldianum *	Korean Maple (Korea-Manch.)	(H)
Acer•rubrum	Red Maple (e. N. America)	(M-H)
Acer•saccharinum	Silver Maple (e. N. Am.)	(M-H)
Acer•saccharinum•'Laciniatum' +	Cutleaf Silver Maple (Hort. cultivar)	(M-H)
Acer•saccharum	Sugar Maple (e. N. America)	(H)
Acer•triflorum *	Three-flowered Maple (Manch., Korea)	(M+/-)
Acer•truncatum *	Shantung Maple (n. China, Manch., Korea)	(H)
Acer•turkestanicum *	= A. platanoides ssp. turkestanicum	
Aesculus•flava	Sweet Buckeye (e. N. America)	(M-H)
Aesculus•glabra	Ohio Buckeye (e. N. America)	(M-H)
Aesculus•hippocastanum	Horse Chestnut (Eurasia)	(M-H)
Aesculus•octandra	= Aesculus•flava	
Aesculus•pavia *	Red Buckeye (se. USA)	(H)
Aesculus•turninata *	Japanese Horsechestnut (Japan)	(M-H)
Aesculus•x•carnea *	Red-flowered Horsechestnut (hort. hybrid)	(M+/-)
Ailanthus•altissima	Tree of Heaven (n. China)	(L-M-H)
Albizia•julibrissin*	Silk Tree (Iran-Japan)	(M+/-)
Amelanchier•asiatica *	Asiatic Serviceberry (China)	(M+/-)
Asimia•triloba *	Paw Paw (ec. USA)	(H?)
Betula•albosinensis *	Chinese Red Birch (c., w., nw. China)	(M-H)
Betula•ermanii *	Russian Rock Birch (ne. Asia)	(H)
Betula•mandshurica•var. japonica *	Japanese White Birch (Jap., Sakhalin Is.)	(H)
Betula•maximowicziana *	Monarch Birch (Jap.)	(H)
Betula•nigra	River Birch (e. USA)	(H)

Betula•papyrifera	Paper Birch (e. N. America)	(H)
Betula•pendula'•Lacinata'	Cutleaf Weeping Eur.. Birch (hort. hybrid)	(H)
Betula•pendula	European Birch (Eur.-w. Asia)	(H)
Betula•utilis•var. •jacquemantii *	Whitebarked Himal. Birch (Kash., c. Nepal)	(M-H)
Carpinus•betulus *	European Hornbeam (Eur.-w. Asia)	(H)
Carpinus•carolinana *	American Hornbeam (e. N. America)	(H)
Carpinus•cordata *	Heartleaf Hornbeam (China)	(M-H)
Carpinus•henryana *	----- (c. China)	(M-H)
Carpinus•japonica *	Japanese Hornbeam (Japan)	(H)
Carpinus•laxiflora *	----- (Jap., Kor., n. & w. China)	(M-H)
Carpinus•orientalis *	Oriental Hornbeam (se. Eur., A. Minor)	(M-H)
Carpinus•tschonoskii *	Yeddo Hornbeam (ne. & sw. China)	(M-H)
Carpinus•turczaninowii *	----- (w. China)	(M+/-)
Carya•illinoensis *	Pecan (Iowa s. to Mexico)	(M+/-)
Carya•laciniosa *	Shellbark Hickory (e. N. America)	(M-H)
Carya•ovata *	Shagbark Hickory (e. N. America)	(H)
Castanea•crenata *	Japanese Chestnut (Jap.)	(H)
Castanea•dentata	American Chestnut (e. N. America)	(H)
Castanea•mollissima *	Chinese Chestnut (China, Korea)	(M-H)
Catalpa•bignonioides *	Southern Catalpa (se. USA)	(H)
Catalpa•bungei *	----- (n. China)	(M+/-)
Catalpa•fargesii *	----- (w. China)	(M+/-)
Catalpa•ovata *	Chinese Catalpa (China)	(H)
Catalpa•speciosa	Catalpa (e. N. America)	(M-H)
Celtis•australis *	Mediterranean Hackberry (Medit., Mid East)	(M+/-)
Celtis•caucasica *	Caucasian Hackberry (Asia Minor-Afghan.)	(M+/-)
Celtis•laevigata	Sugarberry (se. USA)	(M-H)
Cercidiphyllum•japonicum *	Katsura Tree (Japan, w. China)	(H-M)
Cercis•canadensis	Eastern Redbud (e. N. America)	(M-H)
Cercis•reniformis *	Texas Redbud (N. Mex., Tex., Okla.)	(M+/-)
Chitalpa	= x•Chitalpa•tashkentensis	
Cladrastis•lutea *	Yellowwood (se. USA)	(H)
Cladrastis•platycarpa *	Japanese Yellowwood (Jap., China)(H)	
Cladrastis•sinensis *	Chinese Yellowwood (China)	(H)
Corlyus•columna	Turkish Hazel (se. Europe, w. Asia)	(M+/-)
Cornus•walteri *	Walter Dogwood (c. China)	(M-H)
Corylus•americana *	American Hazel (e. N. America)	(H)
Crataegus•altaica'•Hissarica' *	Hissar Hawthorn (Tajikistan)	(M+/-)
Crataegus•ambigua +	Russian Hawthorn (se. Russia)	(M+/-)
Crataegus•arnoldiana *	----- (New England)	(M+/-)
Crataegus•azarolus *	Red Azarole (s. Eur., n. Afr., w. Asia)	(M+/-)
Crataegus•crus-galli	Cockspur Hawthorn (se. N. America)	(M+/-)
Crataegus•laevigata *	English Hawthorn (Eur., n. Afr., India)	(M-H)
Crataegus•maximowiczii *	----- (ne. Asia)	(M±)
Crataegus•mollis	Downy Hawthorn (e. N. America)	(M+/-)
Crataegus•monogyna *	Singleseed Hawthorn (Eur., n. Afr., w. Asia)	(M+/-)
Crataegus•pedicellata *	----- (ne. USA)	(M+/-)
Crataegus•phaenopyrum	Washington Hawthorn (se. N. America)	(M+/-)
Crataegus•pinnatifida *	Chinese Hawberry (c. Asia, Korea)	(M+/-)
Crataegus•rivularis *	----- (Rocky Mtn. States)	(M+/-)
Crataegus•tianshanica *	Tien Shan Hawthorn (c. Asia)	(M+/-)
Crataegus•turkestanica *	Turkestan Hawthorn (Turkestan)	(M+/-)
Crataegus•viridis•'Winter•King' *	Winter King Hawthorn (e. USA)	(M+/-)
Crataegus•x•nitida *	Shining Hawthorn (s. USA)	(M+/-)
Cyrilla•racemiflora *	Leatherwood (e. N. Am. & e. S. Am.)	(H)
x•Chitalpa•tashkentensis *	Chitalpa (Catalpa•bignonioides X Chilopsis•linearis)	(M+/-)
Diospyros•virginiana *	American Persimmon (e. USA)	(M-H)

Eucommia•ulmoides *	Hardy Rubber Tree (c. China)	(M+/-)
Evodia•daniellii *	= Tetradium•daniellii *	
Evodia•hupehensis *	= Tetradium•hupehensis *	
Fagus•grandifolia *	American Beech (e. N. America)	(H)
Fagus•orientalis *	Oriental Beech (se. Eur.-Iran)	(M+/-)
Fagus•sylvatica	European Beech (Europe)	(H)
Fraxinus•americana	White Ash (e. N. America)	(M-H)
Fraxinus•americana•'Autumn•Purple'	Autumn Purple Ash (hort. cultivar)	(M-H)
Fraxinus•angustifolia•'Raywood' *	Raywood Ash (s. Europe-c. Asia, n. Afr.)	(M+/-)
Fraxinus•angustifolia•ssp.•syriaca *	Turkestan Ash (c. Asia, A. Minor)	(M+/-)
Fraxinus•chinensis *	Chinese Ash (China)	(M+/-)
Fraxinus•cuspidata *	Flowering Ash (N. Mex. to Mex.)	(L-M)
Fraxinus•excelsior *	European Ash (Europe, w. Asia)	(M+/-)
Fraxinus•latifolia *	Oregon Ash (w. US)	(M+/-)
Fraxinus•mandshurica *	Manchurian Ash (n. Asia)	(M+/-)
Fraxinus•nigra *	Black Ash (N. Am.)	(M+/-)
Fraxinus•ornus *	Flowering Ash (s. Europe-w. Asia)	(M+/-)
Fraxinus•oxycarpa•'Raywood' *	= F. angustifolia 'Raywood'	
Fraxinus•quadrangulata *	Blue Ash (Mich., to Ark.)	(M-H)
Fraxinus•sieboldiana *	----- (Japan, China)	(M-H)
Fraxinus•sogdiana *	= Fraxinus•angustifolia•ssp.•syriaca	
Fraxinus•velutina *	Velvet Ash (Ariz., N. Mex.)	(M+/-)
Ginkgo•biloba *	Ginkgo, Maidenhair Tree (se. China)	(M-H)
Gleditsia•caspica *	Caspian Honeylocust (Azerbaijan-n. Iran)	(M+/-)
Gleditsia•triacanthos•var.	Honeylocust varieties (c. & e. N. America)	(M-H)
Gymnocladus•dioica	Kentucky Coffeetree (c. & e. N. America)	(M-H)
Halesia•diptera *	Two-winged Silverbell (s. USA)	(H)
Halesia•tetraptera *	Silverbell Tree (se. USA)	(H)
Hemiptelea•davidii *	David Hemiptelea (n. China to Korea)	(M-H)
Hovenia•dulcis *		
Idesia•polycarpa *	----- (Sichuan)	(M-H)
Juglans•ailanthifolia *	Japanese Walnut (Jap.)	(M+/-)
Juglans•ailantifolia *	Heartnut (Japan)	(H)
Juglans•cinerea *	White Butternut (N. America)	(M+/-)
Juglans•mandshurica *	Manchurian Walnut (Manchuria, ne. China)	(M+/-)
Juglans•microcarpa *	Little Walnut (OK., N. Mex., Tex., Kan., Mex.)	(M+/-)
Juglans•nigra	Black Walnut (e. USA)	(M-H)
Juglans•regia•varieties *	Carpathian Walnut varieties (se. Eur. - China)	(M+/-)
Kalopanax•pictus *	= Kalopanax•septemlobus	
Kalopanax•septemlobus *	Castor-aralia (China, Korea, Japan)	(M-H)
Koelreuteria•paniculata	Golden Raintree (n.China, Korea)	(M+/-)
Laburnum•alpinum *	Alpine Golden Chaintree (sc. Europe)	(M-H)
Laburnum•anagyroides *	Common Laburnum (c. & s. Eur.)	(M+/-)
Laburnum•X•'Waterer' *	Waterer Laburnum (hort. hybrid)	(H)
Larix•decidua	European Larch (Alps, Carpathian Mts.)	(H)
Larix•gmelinii *	Dahurian Larch (e. Asia)	(H)

Larix•kaempferi *	Japanese Larch (Japan)	(H)
Larix•laricina	Tamarack (n. N. America)	(H)
Larix•leptolepis *	= Larix•kaempferi	
Larix•occidentalis *	Rocky Mtn. Larch (B.C. to Montana)	(M-H)
Liquidambar•styraciflua *	Sweetgum (e. N. America to c. America)	(H)
Liriodendron•tulipifera *	Tulip Tree (e. N. America)	(H)
Maackia•amurensis *	Amur Maackia (Manchuria, Korea)	(M+/-)
Maackia•chinensis *	----- (c. China)	(M+/-)
Maclura•pomifera *	Osage Orange (Ark., Tex.)	(M+/-)
Magnolia•acuminata *	Cucumber Tree (e. N. AM)	(H)
Magnolia•kobus *	Tree Star Magnolia (Japan)	(M-H)
Magnolia•x•soulangiana	Saucer Magnolia (hort. hybrid)	(H)
Malus•'Hopa'	Hopa Crabapple (hort. cultivar)	(M+/-)
Malus•'Radiant'	Radiant Crabapple (hort. cultivar)	(M+/-)
Malus•'Snowdrift'	Snowdrift Crabapple (hort. cultivar)	(M+/-)
Malus•baccata	Siberian Crabapple (Manchuria, China)	(M+/-)
Malus•dolgo	Dolgo Crabapple (Siberia ?)	(M+/-)
Malus•ioensis	Prairie Crabapple (c. USA)	(M+/-)
Malus•ioensis•'Plena'	Bechtel Crabapple (hort. cultivar)	(M+/-)
Malus•sp. •'Golden•Delicious'	Golden Delicious Apple (hort. cultivar)	(M+/-)
Malus•sp. •'Red•Delicious'	Red Delicious Apple (hort. cultivar)	(M+/-)
Malus•sp. •'Winesap'	Winesap Apple (hort. cultivar)	(M+/-)
Malus•spp.	Common Apple (se. Europe, c. Asia)	(M+/-)
Mespilus•germanica *	Medlar (Europe-Asia Minor)	(M+/-)
Metasequoia•glyptostroboides *	Dawn Redwood (w. China)	(M-H)
Morus•alba	White Mulberry (Asia)	(M+/-)
Morus•australis *	----- (e. Asia)	(M+/-)
Morus•nigra *	Black Mulberry (sw. Asia)	(M+/-)
Morus•rubra *	Red Mulberry (e. N. America)	(M+/-)
Nothofagus•antarctica *	Southern Beech (Chile, Argentina)	(H)
Nyssa•sylvatica *	Blackgum (Ontario, Texas)	(H)
Ostrya•carpinifolia *	European Hop Hornbeam (s. Eur., se. Asia)	(M)
Ostrya•virginiana *	American Hop Hornbeam (e. N. America)	(H)
Paulownia•fortunei*	----- (China, Japan)	(H)
Paulownia•kawakamii*	----- (s. China, Taiwan)	(H)
Paulownia•tomentosa *	Empress Tree (c. & w. China)	(M-H)
Phellodendron•amurense *	Amur Cork Tree (n. China, Jap., Manch.)	(M-H)
Phellodendron•chinese *	Chinese Cork Tree (c. China)	(M-H)
Phellodendron•Japonicum *	Japanese Cork Tree (c. Japan)	(H)
Phellodendron•sachalinense *	Sakhalin Cork Tree (w. China, n. Jap., Kor.)	(H)
Pistacia•chinensis *	Chinese Pistachio (China, Taiwan)	(L-M)
Pistacia•vera *	Edible Pistachio (Persia, c. Asia)	(L-M)
Platanus•occidentalis *	Eastern Plane Tree (la., to Tex. to Mex.)	(H)
Platanus•orientalis *	Oriental Plane Tree (se. Eur., sw. Asia)	(M+/-)
Platanus•x•acerifolia *	London Plane Tree (hort. hybrid)	(H)
Prunus•armeniaca	Apricot (c. & e. Asia)	(M+/-)
Prunus•armeniaca•var. •mandshurica *	= Prunus•mandshurica	
Prunus•avium *	Bird Cherry (Eur.-A. Minor-e. Sib.)	(H-M)
Prunus•cerasus *	Pie Cherry (se. Eur., Iran, n. India)	(M+/-)
Prunus•cerasus•'Meteor'	Meteor Pie Cherry (hort. cultivar)	(M+/-)
Prunus•cerasus•'Morello'	Morello Pie Cherry (hort. cult.)	(M+/-)
Prunus•cerasus•x•'Montmorency'	Montmorency Pie Cherry (hort. cultivar)	(M+/-)
Prunus•cerasus•x•'North•Star'	North Star Pie Cherry (hort. cultivar)	(M+/-)
Prunus•maackii	Manchurian Cherry (Kor. Manch.)	(M-H)

Prunus•mahleb *	St. Lucie Cherry (Eur.-Asia Minor)	(M+/-)
Prunus•mandshurica *	Manchurian Apricot (Manchuria, Korea)	(M+/-)
Prunus•persica	Peach (c. & e. Asia)	(M+/-)
Prunus•salicina *	Japanese Plum (China, Jap.)	(H-M)
Prunus•sp. •'Green•Gage'	Green Gage Plum (hort. cultivar)	(M+/-)
Prunus•sp. •'Stanely'	Stanley Plum (hort. cultivar)	(M+/-)
Prunus•spp.	Domestic Plums	(M+/-)
Prunus•x•dasycarpa * (P. •armenica x P. •cerasifera)	Black Apricot (c. Asia-Asia Minor)	(M-L)
Pseudolarix•kaempferi *	Golden Larch (e. China)	(H?)
Ptelea•polyadenia*	----- (sw. USA)	(M+/-)
Pterocarya•fraxinifolia *	Caucasian Walnut (Caucasus, Persia)	(M+/-)
Pteroceltis•tartarianovii *	Tartar Wingceltis (n., c. China)	(M+/-)
Pterostyrax•hispidia *	Fragrant Epaulette Tree (Japan, China)	(H?)
Pyrus•bucharica *	= Pyrus•korshinsky	
Pyrus•calleryana•'Bradford'	Bradford Pear (China)	(M+/-)
Pyrus•communis +	Common Garden Pear (Europe, w. Asia)	(M+/-)
Pyrus•communis•'Maxine'	Maxine Pear (hort. cultivar)	(M+/-)
Pyrus•communis•'Moonglow'	Moonglow Pear (hort. cultivar)	(M+/-)
Pyrus•korshinsky *	Buchara Pear (Turkestan)	(L-M)
Pyrus•salicifolia *	Willow-leaved Pear (se. Europe, w. Asia)	(M+/-)

Quercus•acutissima *	Sawtooth Oak (Japan, China, Korea)	(M-H)
Quercus•alba	White Oak (e. USA)	(M+/-)
Quercus•bicolor	Swamp White Oak (ne. N. Am.)	(M+/-)
Quercus•douglasii *	California Blue Oak (w. US)	(M+/-)
Quercus•frainetto *	Hungarian Oak (s. Italy, Balk., Turkey)	(M+/-)
Quercus•glandulifera *	----- (Jap., Korea, China)	(M+/-)
Quercus•imbricaria *	Shingle Oak (e. & c. USA)	(M-H)
Quercus•kelloggii *	California Black Oak (w. US)	(M+/-)
Quercus•macrocarpa	Bur Oak (c., ne. N. America)	(M+/-)
Quercus•mongolica *	Mongolian Oak (ne. Asia)	(M+/-)
Quercus•muehlenbergii *	Chinquapin Oak (e. USA)	(M-H)
Quercus•palustris	Pin Oak (ne. N. America)	(M-H)
Quercus•phellos *	Willow Oak (se. USA)	(M-H)
Quercus•prinus *	Chestnut Oak (e. USA)	(M-H)
Quercus•robur	English Oak (Europe, n. Afr., w. Asia)	(M-H)
Quercus•rubra	Northern Red Oak (ne. USA)	(M-H)
Quercus•sadleriana *	Deer Oak (w. USA)	(M+/-)
Quercus•shumardii *	Shumard's Oak (c. USA)	(M-H)
Quercus•vacciniifolia *	Huckleberry Oak (w. US)	(M+/-)

Salix•pentandra *	Laurel-leaf Willow (Eur.)	(H)
Sassafras•albidum *	Sassafras (e. N. Am.)	(H)
Sophora•davidii *	David's Sophora (China)	(L-M)
Sophora•japonica (aka Styphnolobium•japonicum)	Japanese Pagoda Tree (China, Korea)	(M+/-)
Sorbus•torminalis *	Chequer Tree (A. Minor, n. Africa, Eur. Asia)	(H)
Sorbus•alnifolia *	----- (Jap., Korea)	(H)
Sorbus•americana	American Mtn. Ash (ne. N. America)	(M-H)
Sorbus•aria*	Whitebeam Mtn. Ash (Eur.)	(H)
Sorbus•aucuparia	European Mtn. Ash (Eurasia)	(M-H)
Sorbus•cashmeriana *	Kashmir Mountain Ash (Himalaya)	(H)
Sorbus•commixta *	----- (Korea, Japan)	(M-H)
Sorbus•decora	Showy Mountain Ash (ne. N. America)	(M-H)
Sorbus•forrestii *	Forest's Mountain Ash (China)	(M-H)
Sorbus•hupehensis *	Hupeh Mtn. Ash (c., w. China)	(M-H)
Sorbus•intermedia *	Scandinavian Mtn. Ash (Scand.)	(H)
Sorbus•latifolia *	----- (Europe)	(M-H)
Sorbus•pohuashanensis *	----- (n. China)	(H)
Sorbus•prattii *	Pratt's Mountain Ash (w. China)	(M+/-)
Sorbus•tianschanica *	Tien Shan Mtn. Ash (c. Asian mtns.)	(H)

<i>Sorbus</i> • <i>x</i> • <i>hybrida</i> *	Oakleaf Mtn. Ash (hort. hybrid)	(H)
<i>Stranvaesia</i> • <i>davidiana</i> *	Chinese <i>Stranvaesia</i> (w. China)	(H)
<i>Styphnolobium</i> • <i>japonicum</i>	see <i>Sophora</i> • <i>japonica</i>	
<i>Styrax</i> • <i>japonicum</i> *	Japanese Snowball (Japan, China)	(H)
<i>Styrax</i> • <i>obassia</i> *	Fragrant Snowbell (Japan)	(H)
<i>Syringa</i> • <i>pekinensis</i>	Peking Tree Lilac (n. China)	(M+/-)
<i>Syringa</i> • <i>reticulata</i>	Japanese Tree Lilac (n. Japan)	(M-H)
<i>Syringa</i> • <i>reticulata</i> •var.• <i>mandschurica</i>	Manchurian Tree Lilac (Japan)	(M+/-)
<i>Taxodium</i> • <i>ascendens</i> *	Pond Cypress (se. USA)	(H)
<i>Taxodium</i> • <i>distichum</i>	Bald Cypress (se. N. America)	(H)
<i>Tetradium</i> • <i>danielii</i> *	Korean <i>Evodia</i> (China, Korea)	(H)
<i>Tetradium</i> • <i>hupehensis</i> *	Hupei Bee Bee Tree (sw. China, Korea)	(M+/-)
<i>Tilia</i> • <i>americana</i>	Basswood (c., e. N. America)	(H)
<i>Tilia</i> • <i>amurensis</i> *	Amur Linden (Manch., Korea)	(M-H)
<i>Tilia</i> • <i>cordata</i>	Littleleaf Linden (Eur. to Caucasus)	(H)
<i>Tilia</i> • <i>mongolica</i> *	Mongolian Linden (Mon., e. Russia, n. China)	(M-H)
<i>Tilia</i> • <i>platyphyllos</i> *	Bigleaf Linden (se., Europe)	(M-H)
<i>Tilia</i> • <i>tomentosa</i> *	Silver Linden (se. Europe, w. Asia)	(M+/-)
<i>Tilia</i> • <i>x</i> • <i>euchlora</i> *	Crimean Linden (hort. hybrid)	(M-H)
<i>Toona</i> • <i>sinensis</i>	----- (China)	(M-H)
<i>Ulmus</i> • <i>parvifolia</i> *	Chinese Elm (China, Japan, Korea)	(M-H)
<i>Ulmus</i> • <i>americana</i> •cvs.	American Elm (DED resistant cultivars)	(L-M-H)
<i>Zelkova</i> • <i>carpinifolia</i> *	Caucasian <i>Zelkova</i> (Cauc.)	(M-H)
<i>Zelkova</i> • <i>serrata</i> *	Japanese <i>Zelkova</i> (Jap., Taiwan, e. China)	(H)
<i>Zelkova</i> • <i>sinica</i> *	Chinese <i>Zelkova</i> (e. China)	(H)
<i>Ziziphus</i> • <i>jujuba</i> *	Chinese <i>Jujuba</i> (temp. Asia)	(H-M)

EVERGREENS

(Coniferous Trees)

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

* = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation
Abies•cilicica *		Cilician Fir (s. Turkey, nw. Syria, Lebanon)	(M-H)
Abies•concolor		White Fir (Colo. to Mex.)	(M-H)
Abies•holophylla *		Manchurian Fir (Manch., Korea)	(M-H)
Abies•homolepis *		Nikko Fir (Japan)	(H)
Abies•koreana *		Korean Fir (s. Korea)	(H)
Abies•lasiocarpa		Subalpine Fir (Rocky Mtns.)	(H)
Abies•nordmanniana *		Caucasian Fir (Greece, Cauc., Turkey)	(M)
Calocedrus•decurrens *		Incense Cedar (w. Ore.-Baja Calif.)	(M-H)
Cedrus•atlantica *		= Cedrus•libani•ssp. atlantica	
Cedrus•deodara *		Deodara Cedar (Himalaya Mts. Afghan.-w. Nepal)	(M-H)
Cedrus•libani *		Lebanon Cedar (nw. Syria, se Turkey)	(M-H)
Cedrus•libani•ssp. atlantica *		Atlas Cedar (Atlas Mts.)	(M-H)
Cedrus•libani•ssp. stenocoma *		Hardy Turkish Cedar (s. Turkey)	(M-H)
Cupressus•arizonica *		Arizona cypress (Ariz., N. Mex., Tex., Mex.)	(L-M)
Cupressus•bakeri *		Modoc Cypress (Calif., Oregon)	(M+/-)
Picea•abies		Norway Spruce (n. & c. Europe)	(H)
Picea•engelmannii		Engelmann Spruce (B.C. to N. Mex.)	(H)
Picea•glauca		White Spruce (n. N. Am.)	(M-H)
Picea•glauca•'Black•Hills'		Black Hills Spruce (Black Hills S.Dak.)	(M-/-)
Picea•glauca•'Conica'		Dwarf Alberta Spruce (hort. cultivar)	(H)
Picea•omorika *		Serbian Spruce (Balk.)	(M-H)
Picea•pungens		Colorado Spruce (Wyo., Colo., N. Mex., Utah)	(M-H)
Picea•schrenkiana•ssp. tianshanica *		----- (c. Asia)	(M+/-)
Pinus•heldreichii (was P. leucodermis) *		Bosnian Pine (w. Balkans - se. Italy - Greece)	(M+/-)
Pinus•aristata		Bristlecone Pine (Mts. Cal. to Colo.)	(M, H)
Pinus•bungeana *		Lacebark Pine (nw. China)	(M+/-)
Pinus•cembra *		Swiss Stone Pine (c. Eur. mtns.)	(M-H)
Pinus•contorta•ssp. latifolia		Lodgepole Pine (Alaska, Cal., to Colo.)	(M-H)
Pinus•densiflora *		Japanese Red Pine (Jap., Korea)	(M-H)
Pinus•flexilis		Limber Pine (Albt. to Cal. to Tex.)	(M-H)
Pinus•nigra		Austrian Pine (se. Eur., w. Asia, n. Afr.)	(M-H)
Pinus•peuce *		Macedonian Pine (Balk.)	(M-H)
Pinus•ponderosa		Ponderosa Pine (w. North America)	(M+/-)
Pinus•pumila *		Dwarf Siberian Pine (ne. Asia)	(H)
Pinus•strobiformis		Southwestern White Pine (Colo., Ariz., n. Mex.)	(M-H)

Pinus•strobus	Eastern White Pine (e. N. America)	(H)
Pinus•sylvestris	Scotch Pine (n. Eurasia)	(M-H)
Pinus•wallichiana *	Himalayan White Pine (Himalaya Mtns.)	(M-H)
Pseudotsuga•menziesii	Douglas Fir (B.C. to Mex. to Tex.)	(M-H)
Sequoiadendron•giganteum *	Giant Sequoia (Sierra Nevada Mts.)	(H)
Tsuga•canadensis	Canada Hemlock (ne. N. America)	(H)

EVERGREENS

(Coniferous Shrubs)

[Revised April '03]

WATER NEEDS OF PLANTS

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Reference Location: Denver. Numbers illustrate typical conditions.

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HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Chamaecyparis•pisifera *	----- (Japan)	(H)
Juniperus•chinensis	Chinese Juniper (e. Asia)	(L-M)
Juniperus•chinensis•'Hetzi'•Glaucous	Hetzi Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•'Pfitzeriana'	Pfitzer Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•'Pfitzeriana'•Compacta'	Compact Pfitzer Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•'Tortulosa' *	Hollywood Juniper (hort. cultivar)	(L-M)
Juniperus•chinensis•var. •sargentii	Sargent's Juniper (e. Asia)	(L-M)
Juniperus•communis•saxatilis	Mountain Common Juniper (circumboreal)	(L-M)
Juniperus•horizontalis	Horizontal Juniper (Nov. Sc. to Alaska, N.J., to Mon.)	(L-M)
Juniperus•horizontalis•'Bar'•Harbor'	Bar Harbor Juniper (hort. cultivar)	(L-M)
Juniperus•horizontalis•'Blue'•Chip'	Blue Chip Juniper (e. Asia)	(L-M)
Juniperus•horizontalis•'Plumosa'	Andorra Juniper (hort. cultivar)	(L-M)
Juniperus•horizontalis•'Prince'•of'•Wales'	Prince of Wales Juniper (hort. cultivar)	(L-M)
Juniperus•horizontalis•'Wiltonii'	Wilton Carpet Juniper (hort. cultivar)	(L-M)
Juniperus•monosperma	Oneseed Juniper (Colo., Utah, Tex., Mex.)	(VL-L)
Juniperus•osteosperma	Utah Juniper (sw. USA)	(VL-L)
Juniperus•procumbens var. & cv.	Japargarden Juniper varieties and cultivars	(M-H)
Juniperus•sabina	Savin Juniper (w. Asia)	(L-M)
Juniperus•sabina•'Buffalo'	Buffalo Juniper (hort. cultivar)	(L-M)
Juniperus•sabina•'Skandia'	Skandia Juniper (hort. cultivar)	(L-M)
Juniperus•sabina•var. •tamariscifolia	Tam Juniper (hort. cultivar)	(L-M)
Juniperus•scopulorum	Rocky Mtn. Juniper (B.C. to s. Ariz., to Tex.)	(L)
Juniperus•squamata	----- (India, Tibet, Taiwan)	(M+/-)
Juniperus•squamata•'Meyeri'	----- (hort. cultivar)	(M+/-)
Juniperus•virginiana	Eastern Redcedar (e. N. Am.)	(M-H)
Microbiota•decussata *	Siberian Cypress (Siberia)	(M+/-)
Pinus•edulis	Piñon Pine (Wyo., Cal., Mex.)	(VL-M)
Pinus•mugo	Mugo Pine (c. Eur. Balk.)	(M-H)
Platycladus•orientalis *	Oriental Arborvitae (China, Korea)	(M+/-)
Taxus•baccata *	English Yew (Eur., n. Afr., w. Asia)	(H)

Taxus•brevifolia *	Anticancer Yew (pnw. USA)	(H)
Taxus•cuspidata *	Japanese Yew (Jap., Kor., Manchuria)	(H)
Taxus•x•media *	----- (hort. hybrid)	(H)
Thuja•occidentalis•var.	Western Arborvitae varieties (e. N. Am.)	(H)
Thuja•orientalis (now Platycladus•orientalis)		
Thuyopsis•dolabrata *	False Arborvitae (Japan)	(H)

7. EVERGREENS

(Non-coniferous)

[Revised April '03]

WATER NEEDS OF PLANTS

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HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Agave•parryi *	Parry's Agave (Cal., N.Mex., Mex.)	(VL-L)
Agave•utahensis *	Utah Agave (Cal., Nev. Utah, Ariz.)	(VL-L)
Allenrolfea•occidentalis *	Iodine Bush (sw. USA, deserts)	(L-VL)
Arctostaphylos•patula *	Greenleaf Manzanita (sw. USA)	(M+/-)
Artemisia•cana •(a.k.a. Seriphidium•canum)	Black Sage (w. USA)	(VL-M)
Artemisia•tridentata (a.k.a. S. tridentata)	Big Western Sage (intermtn. w. N. America)	(VL-M)
Aucuba•japonica *	Spotted Laurel (China, Taiwan, s. Japan)	(H)

Berberis•candidula *	Paleleaf Barberry (China)	(M+/-)
Berberis•julianae	Wintergreen Barberry (w. China)	(M+/-)
Berberis•triacanthophora *	= Berberis•X•wisleyensis	
Berberis•verruculosa *	Warty Barberry (w. China)	(M+/-)
Berberis•X•wisleyensis *	Threespike Barberry (hort. hybrid)	(M+/-)
Bruckenthalia•spiculifolia *	Spike Heath (se. Europe, Asia Minor)	(M+/-)
Buxus•microphylla•v.•koreana *	Korean Boxwood (Jap., Korea)	(M-H)
Buxus•sempervirens *	Common Boxwood (s. Eur., w. Asia, n. Afr.)	(M-H)

Ceanothus•fendleri	Fendler Ceanothus (Rocky Mtn. West)	(M+/-)
Ceanothus•integerrimus *	Deerbrush (sw. N. America)	(M+/-)
Ceanothus•sanguineus *	Oregon Tea (B.C. to Mont. to Calif.)	(M+/-)
Ceanothus•velutinus *	Snowbrush Ceanothus (Western Mtns., USA)	(M-H)
Cercocarpus•breviflorus	= Cercocarpus•ledifolius•v.•paucidentatus	
Cercocarpus•intricatus	= Cercocarpus•ledifolius•v.•intracatus	
Cercocarpus•ledifolius	Curlleaf Mtn. Mahogany (Intermtn. USA)	(VL-L)
Cercocarpus•ledifolius•v.•intracatus	Littleleaf Mtn. Mahogany (Intermtn. sw. USA)	(VL-L)
Cercocarpus•ledifolius•v.•paucidentatus	Hairy Mtn. Mahogany (Ariz., N. Mex., Mex.)	(VL-L)
Chamaebatiaria•millefolium	Fernbush (Ore., e. Cal., Wyo., Ariz.)	(VL-L)
Cistus•laurifolius *	Laurel Rock Rose (sw. Europe)	(M+/-)
Coronilla•emerus *	Scorpion senna (c. & s. Europe)	(L-M)
Cotoneaster•congestus *	Pyrenees Cotoneaster (Himalaya Mts.)	(M+/-)
Cotoneaster•conspicuus *	Wintergreen Cotoneaster (c. China, se. Tibet)	(M+/-)
Cotoneaster•dammeri *	Bearberry cotoneaster (c. China)	(M-/-)
Cotoneaster•glaucophyllus *	Brightbead Cotoneaster (w. China)	(L-M)
Cotoneaster•microphyllus *	Littleleaf Cotoneaster (mtns. Afghan. to China)	(L-M)
Cowania•mexicana (syn. Purshia•mexicana)	Cliff Rose (intermtn. sw. USA & Mex.)	(VL-L)
Cytisus•scoparius *	Scotch Broom (Europe)	(M+/-)

Cytisus•x•praecox *	Warminster Broom (hort. hybrid)	(M+/-)
Daphne•cneorum	Daphne (mnts. c. & s. Europe)	(M+/-)
Daphne•retusa *	= Daphne•tangutica	
Daphne•tangutica *	----- (nw. & w. China)	(M+/-)
Daphne•x•burkwoodii	-----	(M+/-)
Daphne•x•burkwoodii•'Carol•Mackie'	Carol Mackie Daphne (hort. cultivar)	(M+/-)
Daphne•pontica *	----- (A. Minor, se. Eur., Cauc.)	(M+/-)
Elaeagnus•pungens *	----- (Jap., China)	(VL, M)
Ephedra•americana•v.•andina *+	----- (Andes, Ecuador. to Patagonia)	(VL-M)
Ephedra•equisetina +	----- (c. Asia, w. china)	(VL)
Ephedra•gerardiana *+	----- (China, Himalaya)	(VL-L)
Ephedra•glauca *	----- (c. Asia-Seravshan Mts.)	(VL-L)
Ephedra•minima *+	----- (China)	(VL-L)
Ephedra•minuta *	----- (c. Asia-Seravshan Mts.)	(VL-L)
Ephedra•nevadensis *+	Nevada Ephedra (Great Basin)	(VL-L)
Ephedra•regaliana *	----- (c. Asia-Pamir Mts.)	(VL-L)
Ephedra•torreyana +	Torrey Ephedra (intermtn. sw. USA)	(VL-L)
Ephedra•viridis +	Green Ephedra, Mormon Tea (Intermtn. sw. USA)	(VL-L)
Euonymus•fortunei•'Vegetus'	Euonymus (c. & w. China)	(M-H)
Euonymus•kiautschovicus•'Manhattan'	Manhattan Euonymus (hort. cultivar)	(M-H)
Fargesia•murielae, A. m., Sinarundinaria m. (see Thamnocalamus•spathaceus) *		
Fargesia•nitida., Arundinaria n., Sinarundinaria n., Thamnocalamus•nitida (see Sinarundinaria•nitida) *		
Fargesia•spathacea, Arundinaria s. (see Thamnocalamus•spathaceus) *		
Fuchsia•magellanica *	Fuchsia (Peru, Chile, Argentina)	(H)
Garrya•flavescens *	Yellow Silktassel (e. Cal., w. Az., s. Utah, s. Nev.)	(L)
Garrya•fremontii *	Fremont's Silktassel (w. Wa., Ore., Cal.)	(M+/-)
Garrya•wrightii *	Wright's Silktassel (sw. AZ., s. N. Mex., w. Tex.)	(L)
Gelsemium•sempervirens *	Carolina Yellow Jasmine (s. USA to c. Am.)	(H)
Hesperaloe•parviflora +	Hesperaloe (sw. Texas)	(VL-M)
Iberis•sempervirens	Evergreen Candytuft (Eurasia)	(M-H)
Ilex•aquifolium *	English Holly (Eur., n. Afr., w. Asia)	(H)
Ilex•cornuta *	Chinese Holly (China, Korea)	(H)
Ilex•crenata *	Japanese Holly (Sakhalin Is., Jap., Korea)	(H)
Ilex•opaca *	American Holly (e. USA)	(H)
Ilex•wilsonii *	Wilson's Holly (c., w., e. China, Taiwan)	(M-H)
Ilex•x•meserveae var.	Blue Prince & Blue Princess Hollies etc. (hort. hybrids)	(H)
Jasminum•fruticans *	----- (Medit. Asia Minor)	(L-M)
Kalmia•angustifolia *	Lambkill Kalmia (Hudson Bay to Georgia)	(H)
Kalmia•latifolia *	Mountain Laurel (e. N. Am.)	(H)
Lavandula•angustifolia var.	English Lavender varieties (Medit.)	(VL-M)
Lavandula•stoechas *	Spanish Lavender (c. Spain, ne. Portugal)	(VL-M)
Leucophyllum•minus *	Cenzia, Texas Ranger (Texas, New Mexico)	(L)
Lonicera•nitida *	Boxleaf Honeysuckle (China)	(H)
Lonicera•pileata *	Privet Honeysuckle (China)	(H)

Mahonia•aquifolium +	Oregon Hollygrape (Cascade mtns.)	(M-H)
Mahonia•fremontii +	Fremont Mahonia (sw. USA)	(VL-L)
Mahonia•haematocarpa +	Redberry Mahonia (sw. USA)	(VL-L)
Mahonia•repens +	Creeping Mahonia (Rocky Mtn. West)	(L-H)
Mahonia•trifoliata *+	Three-leaf Mahonia, Algerita (Ariz., N. Mex., Tex., Mex.)	(L)
x•Mahoberberis•miethkeana *	----- (Berberis•julianae•X•Mahonia•aquifolium)	(M+/-)
Nandina•domestica *	Heavenly Bamboo (India to e. China)	(M-H)
Nolina•microcarpa *	Bear Grass (sw. USA)	(L)
Opuntia•imbricata	Cholla (Colo., Kan., Tex., & Mex., to Ariz.)	(VL-L)
Opuntia•polycantha ,etc.	Prickly Pear Cactus species (w. USA, Can., Mex.)	(VL-L)
Osmanthus•americanus *	Devilwood (se. USA)	(H)
Osmanthus•decorus•Baki•Kasapligil' *	----- (Caucasus)	(H)
Osmanthus•heterophyllus *	Holly Osmanthus (Japan, Taiwan)	(H)
Osmanthus•x•burkwoodii *	----- (garden origin)	(H)
Paxistima•canbyi	Eastern Mtn. Lover (e. N. America)	(M+/-)
Paxistima•myrsinites	= Paxistima•myrtifolia	
Paxistima•myrtifolia *	Western Mtn. Lover (B.C. Cal., Mont., Colo., N. Mex.)	(M-H)
Phillyrea•vilmosiniana *	= Osmanthus•decorus	
Photinia•villosa *	Oriental Photinia (Japan, Korea, China)	(H)
Photinia•serrulata *	Chinese Photinia (China)	(H)
Photinia•x•fraseri *	Photinia (hort. hybrid)	(H)
Phyllostachys•aureosulcata *	Yellow-groove Bamboo (ne. China)	(H)
Phyllostachys•nigra *	Black Bamboo (e., c. China)	(H)
Phyllostachys•nuda *	Bamboo (China)	(H)
Pieris•japonica *	Japanese Pieris (Jap., Taiwan, e. China)	(H)
Prunus•laurocerasus•'Schipkaensis' *	Schipkanensis Cherry Laurel (Bulgaria)	(M-H)
Prunus•laurocerasus•'Zabeliana'*	Zabeliana Cherry Laurel (garden origin)	(M-H)
Purshia•mexicana	= Cowania•mexicana	
Purshia•tridentata	Antelope Bitterbrush (Rocky Mtn. West)	(L-M)
Pyracantha•coccinea	Pyracantha (Eurasia)	(M+/-)
Quercus•grisea *	Gray Oak (Tex., N. Mex., Mex., s. Colo.)	(M+/-)
Quercus•turbinella *	Turban Oak (Cal., & n. Baja. Ca. to w. Tex. & se. Colo.)	(M+/-)
Quercus•vacciniifolia *	Huckleberry Oak (w. US)	(M+/-)
Quercus•virginiana•v. fusiformis *	Texas Shrub Live Oak (Ok., Tex., Mex.)	(L-M)
Rosmarinus•officinalis•'Arp' *	Rosemary 'Arp' (a hardy cultivar from Arp, Texas)	(L-M)
Santolina•chamaecyparissus	Santolina (w. & c. Medit.)	(VL-M)
Santolina•rosmarinifolia	Green Santolina (Portugal to France)	(L-M)
Santolina•viridis	= Santolina•rosmarinifolia	
Sasa•kurilensis *	Kurile Islands Bamboo (Jap. Kor.)	(H)
Sasa•palmata *	Palmate Bamboo (n. Japan)	(H)
Shepherdia•rotundifolia **	Roundleaf Buffaloberry (Az., Utah)	(L-M)
Sinarundinaria•nitida *	Fountain Bamboo (c. China)	(H)
Thamnocalamus•spathaceus *	Umbrella Bamboo (c. China)	(H)
Viburnum•davidii *	David's Viburnum (w. China)	(M-H)

Viburnum•farreri *	Fragrant Viburnum (China)	(M-H)
Viburnum•rhytidophyllum *	Leatherleaf Viburnum (c. & w. China)	(M-H)
Viburnum•x•burkwoodii	Burkwood Viburnum (hort. hybrid)	(M-H)
Viburnum•x•rhytidophylloides•'Mohican'	Mohican Lantanaphyllum Viburnum (garden origin)	(M-H)
Yucca•baccata +	Banana Yucca (Colo. Plateau)	(VL-L)
Yucca•elata +	Soaptree Yucca (Az., N. Mex., Mex.)	(VL-L)
Yucca•glauca +	Front Range Yucca (w. Great Plains)	(VL-L)
Yucca•harrimaniae +	Harriman Yucca (Colo. Plateau)	(VL-L)

VINES

[Revised April '03]

WATER NEEDS OF PLANTS

The following chart shows how to group plants based on their water needs.
Reference Location: Denver. Numbers illustrate typical conditions.

* = Plants with potential, but requiring caution due to limited history in Rocky Mountain landscaping.

HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Akebia•quinata *	Five-leaf Akebia (Japan, Korea, China)	(M-H)
Akebia•trifoliata *	Three-leaf Akebia (c. China, Jap.)	(M-H)
Akebia•x•pentaphylla *	(A. quinata x A. trifoliata) (Japan)	(M-H)
Ampelopsis•aconitifolia *	Monkshood Vine (n. China, Mong.)	(M+/-)
Ampelopsis•brevipedunculata *	Porcelain Vine (China, Jap., Korea)	(M+/-)
Ampelopsis•delavayana *	----- (w. China)	(M+/-)
Ampelopsis•humulifolia *	----- (n. China)	(M+/-)
Ampelopsis•megalophylla *	----- (w. China)	(M+/-)
Aristolochia•durior *	= Aristolochia•macrophylla	
Aristolochia•macrophylla *	Dutchman's Pipe (Appalachian Mts.)	(M-H)
Campsis•grandiflora *	Chinese Trumpet Creeper (Jap., China)	(M-H)
Campsis•radicans +	Trumpet Creeper (e. USA)	(M-H)
Celastrus•loeseneri *	Loesener Bittersweet (c. China)	(M-H)
Celastrus•orbiculatus *	Oriental Bittersweet (ne. Asia)	(M-H)
Celastrus•scandens	Bittersweet (e. N. America)	(M-H)
Clematis (hort. varieties & hybrids)	----- (hort. hybrids & varieties)	(M-H)
Clematis•alpina *	----- (Eurasia)	(M-H)
Clematis•brevicaudata *	----- (Jap., China., w. Mong.)	(M+/-)
Clematis•chrysocoma *	----- (sw. China)	(M+/-)
Clematis•crispa *	Curly Clematis (se. USA)	(H)
Clematis•fargesii *	----- (China)	(M+/-)
Clematis•flammula	----- (s. Eur., to Turkestan)	(M+/-)
Clematis•grata *	----- (China, Himalaya)	(M+/-)
Clematis•ligusticifolia	Western Virgin's Bower (Man. to B.C., Mo., to Calif.)	(M+/-)
Clematis•macropetala *	----- (Siberia, n. China, Mongolia)	(M+/-)
Clematis•maximowicziana	= Clematis•terniflora	
Clematis•montana var. *	----- (Afghanistan. to sw. & c. China, Himalaya)	(M+/-)
Clematis•paniculata *	New Zealand Clematis (New Zealand)	(H)
Clematis•paniculata	= Clematis•terniflora	
Clematis•rehderiana *	Rehder's Clematis (w. China)	(M+/-)
Clematis•tangutica	Golden Lantern Clematis (Mongolia, nw. China)	(M+/-)
Clematis•terniflora	Sweet Autumn Clematis (Korea, China, Japan)	(M+/-)
Clematis•texensis *	Texas Clematis (sw. USA)	(M+/-)
Clematis•tibetana *	----- (Tibet, China, n. India)	(M+/-)
Clematis•vernayi (now C. tibetiana)		
Clematis•viorna *	Leather Flower (s. N. Am.)	(M-H)

Clematis•vitalba *	Traveller's Joy (Eur., Cauc., c. Asia, n. Afr.)	(M+/-)
Clematis•viticella *	----- (s. Europe, w. Asia)	(M+/-)
Dicentra•scandens *	----- (Nepal, to se. China)	(M+/-)
Euonymus•fortunei var.	Wintercreeper varieties (China)	(M-H)
Hedera•colchica *	Persian Ivy (Cauc., Turkey)	(M+/-)
Humulus•americanus	= Humulus•lupulus	
Humulus•lupulus	Hop Vine (n. Temperate regions worldwide)	(M+/-)
Hydrangea•anomala *	Climbing Hydrangea (Himalaya, China)	(H)
Hydrangea•anomala•ssp. •petiolaris*	= Hydrangea•petiolaris	
Hydrangea•petiolaris *	Climbing Hydrangea (Japan, China, Korea, Taiwan)	(H)
Jasminum•beesianum *	----- (China)	(M+/-)
Lathyrus•latifolius	Perennial Sweetpea (c. & e. Europe)	(M+/-)
Lonicera•alesuosmoides *	Evergreen Honeysuckle (w. China)	(M+/-)
Lonicera•caprifolium *	Italian Honeysuckle (Eur., s. Asia)	(M+/-)
Lonicera•flava *	Yellow Honeysuckle (se. USA)	(H)
Lonicera•henryi *	----- (w. China)	(M+/-)
Lonicera•japonica•'Halliana'	Hall's Honeysuckle (e. Asia)	(M-H)
Lonicera•periclymenum	Woodbine Honeysuckle (Eur., w. Asia)	(M+/-)
Lonicera•periclymenum•Graham•Thomas'	Graham Thomas Honeysuckle (hort. cultivar)	(M+/-)
Lonicera•prolifera *	Grape Honeysuckle (c. USA)	(M+/-)
Lonicera•sempervirens	Scarlet Trumpet Honeysuckle (e. & s. USA)	(M-H)
Lonicera•sempervirens•'Alabama•Crimson'	-----	(M-H)
Lonicera•sempervirens•'Sulphurea'	-----	(M-H)
Lonicera•tragophylla *	Chinese Woodbine (w. China)	(M+/-)
Lonicera•x•brownii•'Dropmore•Scarlet' (L.s. x L. brownii)		(M+/-)
Lonicera•x•heckrottii	Heckrottii Honeysuckle (hort. hybrid)	(M-H)
Lycium•halimifolium *	Common Matrimony Vine (se. Europe, w. Asia)	(M+/-)
Mennispermum•canadense *	Moonseed Vine (e. N. America)	(M-H)
Parthenocissus•quinquefolia	Virginia Creeper (e. N. America to Rocky Mtns.)	(M-H)
Parthenocissus•tricuspidata	Boston Ivy (Japan, c. China)	(M-H)
Passiflora•incarnata *	Passion Flower (c. USA)	(H)
Polygonum•aubertii	Silver Lace Vine (w. China, Tibet, Tajikistan)	(M+/-)
Polygonum•baldschuanicum *	Buchara Fleeceflower (c. Asia, Tajikistan)	(M+/-)
Schisandra•chinensis *	Magnolia Vine (China)	(H)
Schizophragma•hydrangeoides *	Hydrangea Vine (Japan, Korea)	(M-H)
Smilax•rotundifolia *	Common Greenbriar (e. USA)	(H)
Tripterygium•regelii *	Regel's Tripterygium (Manchuria, Japan, Korea)	(M-H)
Vitis•amurensis *	Amur Grape (Manchuria)	(M+/-)
Vitis•arizonica	Arizona Grape (w. Tex.- Cal. & Mex.)	(M+/-)
Vitis•coignetiae *	Gloryvine (Japan, Korea)	(M+/-)
Vitis•riparia	Riverbank Grape (Nov. Sc. - Man., Tenn. & Tex. - Rocky Mts.)	(M-H)

Vitis•vinifera•varieties *	Eurasian Grape varieties (Eur., A. Minor, Cauc. Turkestan)	(M+/-)
Wisteria•floribunda *	Japanese Wisteria (Japan)	(M-H)
Wisteria•macrostachys *	Kentucky Wisteria (c. USA)	(H)
Wisteria•sinensis *	Chinese Wisteria (China)	(M-H)

GROUND COVERS (Including turf & meadow grasses)

[Revised April '03]

WATER NEEDS OF PLANTS

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HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
Reference plant: Bluegrass turf (Always wet at surface)	Reference plant: Turf-type Tall Fescue (Half of Bluegrass turf)	Reference plant: Buffalograss turf (Like Denver without irrigation)	Reference plant: Too dry for any turf (drier than Denver)
18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Achillea•ageratifolia	Grecian Yarrow (Greece)	(L-M)
Achillea•serbica	Serbian Yarrow (Balkans)	(L-M)
Aegopodium•podagraria	Bishop's Weed (Europe)	(H)
Ajuga•reptans	Ajuga (Eur., Persia, Transcaucasia.)	(H)
Akebia•quinata *	Five-leaf Akebia (Jap., Korea, China)	(M-H)
Andropogon•scoparius	Little Blue Stem (syn. Schizachyrium•scoparium)	(L-M+/-)
Anemopsis•californica *	Yerba Mansa (sw. USA, Mex.)	(M-H)
Antennaria•parvifolia	Pussytoes (G. Plains, w. to B.C., Wash., Ariz.)	(M+/-)
Antennaria•rosea	Pussytoes (Alaska to Cal. & N. Mex.)	(M+/-)
Arabis•alpina *	Alpine Rock-cress (Europe, Siberia)	(M+/-)
Arctostaphylos•uva-ursi	Kinnikinnick (circumpolar)	(M+/-)
Arenaria•balearica *	Corsican Sandwort (Balearic Is. & Corsica)	(M+/-)
Aronia•melanocarpa	Chokeberry (e. N. Am.)	(M-H)
Asperula•odorata	= Galium•odoratum	
Astroturfoides•ultradeceptiverous	Astro Turf (Houston, Texas)	(L+/-M-)
Aurinaria•saxatilis	Basket-of-gold (c. & se. Europe)	(L-M)
Bouteloua•gracilis	Blue grama (N. America)	(L+/-)
Buchloë•dactyloides	Buffalograss (Great Plains)	(L)
Campanula•poscharskyana	Poscharsky Bellflower (Dalmatia)	(M-H)
Cerastium•tomentosum	Snow-in-summer (Eur. to w. Asia)	(L-M)
Ceratostigma•plumbaginoides	Plumbago (w. China)	(M+/-)
Convallaria•majalis	Lily-of-the-valley (Eurasia, e. N. America)	(M-H)
Cotoneaster•apiculatus *	Cranberry Cotoneaster (China)	(M+/-)
Cotoneaster•dammeri *	Creeping Cotoneaster (China)	(M+/-)
Cotoneaster•microphyllus *	Littleleaf Cotoneaster (Mts. Afghan., China)	(L-M)
Delosperma•cooperi	Hardy Pink Ice Plant (s. Africa)	(M+/-)
Delosperma•nubigenum	Hardy Yellow Ice Plant (s. Africa)	(M+/-)
Duchesnea•indica	Mock Strawberry (Korea, Jap., to India)	(M-H)
Epimedium•alpinum *	Alpine Epimedium (s. & c. Europe)	(M-H)
Epimedium•grandiflorum *	Longspur Epimedium (n. Japan, Korea, s. Manch.)	(M-H)
Euonymus•fortunei•'Coloratus'	Purpleleaf Wintercreeper (hort. cult.)	(M+/-)

Euonymus•obovatus *	Running Euonymus (e. USA)	(H)
Festuca•elatior•cvs.	Turf-type Tall Fescue (Eur., Siberia)	(M+/-)
Galium•odoratum	Sweet Woodruff (Eurasia)	(M-H)
Genista•pilosa *	Dwarf Broom (Europe)	(M+/-)
Geranium•spp.	Hardy Geraniums	(M+/-)
Hosta•spp.	Host species (Jap., China, Korea)	(H)
Juniperus•spp. & cultivars +	Juniper species and cultivars	(L-M)
Lamium•maculatum	Spotted Deadnettle, Lamium (Eur., n. Afr., w. Asia)	(M-H)
Lathyrus•latifolius	Perennial Sweetpea (c. & e. Europe)	(M-H)
Lonicera•japonica•'Halliana'	Hall's Honeysuckle (e. Asia)	(M+/-)
Lonicera•sempervirens	Scarlet Trumpet Honeysuckle (e. & s. N. America)	(M-H)
Lonicera•x•heckrottii	Heckrottii Honeysuckle (hort. hybrid)	(M+/-)
Lysimachia•nummularia	Moneywort (Europe)	(H)
Mahonia•repens	Creeping Mahonia (Rocky Mtn. West)	(L-M-H)
Mazus•reptans *	----- (Himalayas)	(M-H)
Marrubium•rotundifolium	----- (Asia Minor)	(L-M)
Poa•pratensis	Kentucky Bluegrass (Eurasia, n. Africa)	(H)
Osteospermum•berberae	South African Daisy (S. Africa)	(M+/-)
Pachysandra•terminalis	Pachysandra (Japan, nc. China)	(M-H)
Parthenocissus•quinquefolia	Virginia Creeper (e. N. America to Rocky Mts.)	(M-H)
Phlox•stolonifera	Creeping Phlox (se. USA)	(M+/-)
Phlox•subulata	Moss Phlox (Penn. to Ga.)	(M+/-)
Polygonum•affine•'Border•Jewel'	Himalayan Border Jewel (Himalayas)	(M-H)
Polygonum•japonicum•var. •compactum	Fleece Flower (e. Asia)	(M-H)
Polygonum•reynoutria	= Polygonum•japonicum•var. •compactum	
Potentilla•nevadensis	----- (Spain)	(L-M)
Potentilla•verna•'Nana'	Creeping Potentilla (hort. cult.)	(M-H)
Rhus•trilobata	Three-leaf Sumac (w. N. Am.)	(L-M)
Saponaria•ocymoides	Saponaria (mtns. sw. & sc. Europe)	(M+/-)
Schizachyrium•scoparium	= Andropogon•scoparius	
Symphoricarpos•x•chenaultii•'Hancock'	Hancock Coralberry (hort. cult.)	(M+/-)
Teucrium•chamaedrys	Germander (c. & s. Europe, w. Asia)	(M+/-)
Thymus•spp.	Thyme species (Eurasia, N. Africa)	(L-M)
Waldsteinia•fragarioides	Barren Strawberry (e. USA)	(H)

Veronica•liwanensis	Turkish Veronica (ne. Anatolia, Cauc.)	(M-H)
Veronica•pectinata	Woolly Veronica (e. Balkans, A. Minor)	(L-M)
Vinca•major	----- (Italy, Balk.)	(M-H)
Vinca•minor	Vinca (Europe , w. Asia)	(H)

SELECTED PERENNIALS

[Revised April '03]

WATER NEEDS OF PLANTS

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HIGH WATER	MODERATE WATER	LOW WATER	VERY LOW WATER
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18-20 gals./S.F./season July: 5" -- 3 times per week	10 gals./S.F./season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation

Achillea x 'Coronation Gold'	Coronation Gold Yarrow	(VL)
Achillea x 'Moonshine'	Moonshine Yarrow	(VL-L-M)
Aesclepias•tuberosa	Butterfly Weed	M-H
Agastache cana	Double Bubble Mint	(M+/-)
Alchemilla•vulgaris	Lady's Mantle	M-H
Anthemis•tinctoria	Golden Marguerite	M-H
Aquilegia•spp.	Columbines	H
Arum•italicum	Italian Arum	M-H
Aster porteri	Porter's Aster	(VL-L)
Aster•novae-angliae	New England Aster	M-H
Aster•x•frikartii	Frikart's Aster	M-H
Aurinia saxatilis	Basket-of-gold	(L-M)
Baptisia•australis	Baptisia	M-H
Berlandiera lyrata	Chocolate Flower	(VL-L)
Boltonia•asteroides	Boltonia	H
Borago•laxiflora	Borage	M-H
Callirhoe involucrata	Poppy Mallow	(L-M)
Centranthus ruber	Centranthus	(L-M-H)
Cerastium tomentosum	Snow-in-summer	(L-M)
Chrysanthemum•x•morifolium	Chrysanthemums	H
Chrysanthemum•x•superbum	Shasta Daisy	M-H
Convallaria•majalis	Lily-of-the-valley	H
Crocsmia•x•crocsmiiflora	Crocsmia	H
Crocus spp. *	Crocus species	(L-M)
Datura meteloides	Sacred Datura	L-M
Delosperma cooperi	Hardy Pink Ice Plant	(M+/-)
Delphinium•x•elatum	Hybrid Delphiniums	H
Dianthus•spp.	Various Dianthus	L-M
Dicentra•eximia	Bleeding Heart	H
Dictamnus•albus	Gas Plant	L-M
Digitalis•purpurea	Common Foxglove	H
Echinacea•purpurea	Echinacea	M+/-
Echinops•ritro	Globe Thistle	H
Eremurus•spp.	Foxtail Lily	L-M
Eryngium•spp.	Sea Holly	L-M
Gaillardia aristata	Native Gaillardia	(L-M)
Geranium•spp.	Hardy Geraniums	M-H
Helianthemum•spp.	Sun-roses	M+/-
Helianthus maximiliani	Maximilian Sunflower	(M+/-)

Helianthus•spp.	Sunflowers	M+/-
Helleborus•spp.	Hellebores	M-H
Hemerocallis•spp.	Daylilies	M-H
Hosta•spp.	Hostas	H
Iberis•sempervirens	Candytuft	M+/-
Incarvillea•delavayii	Hardy Gloxinia	M+/-
Iris bucharica	Buchara Iris	(M+/-)
Iris germanica cvs..	Bearded Iris varieties	(L-M)
Kniphofia•spp.	Poker Plants	M-H
Lavandula spp.	Various Lavenders	(VL-M)
Liatris punctata	Dotted Gay Feather	(VL-L)
Liatris•punctata	Dryland Gayfeather	VL-L
Liatris•spicata	Wetland Gayfeather	H
Limonium•spp.	Sea Lavenders	L-M
Linum•perenne	Blue Flax	L-H
Lobelia•cardinalis	Cardinal Flower	H
Lobelia•syphilitica	Great Blue Lobelia	H
Lychnis•coronaria	Rose Campion	L-H
Malva•alcea	Hollyhocks	M+/-
Mirabilis multiflora	Native Four O'clock	(VL-L-M)
Monarda•spp.	Monardas	M-H
Narcissus spp.	Daffodils	(L-M)
Nepeta x faassenii	Faassen's Catnip	(L-M)
Paeonia•spp.	Peonies	M+/-
Papaver•orientale	Oriental Poppies	M-H
Penstemon pinifolius	Pineleaf Penstemon	(L-M)
Penstemon strictus	Rocky Mountain Penstemon	(L-M)
Perovskia atriplicifolia	Russian Sage	(VL-L)
Phlomis russeliana	Russel Phlomis	(M+/-)
Phlox subulata	Moss Phlox	(M+/-)
Phlox•paniculata	Garden Phlox	H
Platycodon•grandiflorus	Platycodon	H
Primula•spp.	Primroses	H
Ruta•graveolens	Rue	M+/-
Salvia azurea var. grandiflora	Pitcher Sage	(L-M)
Salvia officinalis	Cooking Sage	(L-M)
Salvia•spp.	Salvias	M+/-
Santolina chamaecyparissus	Santolina	(VL-M)
Saponaria ocymoides	Soapwort	(L-M-H)
Saponaria•ocymoides	Rock Soapwort	M+/-
Scabiosa ochroleuca	Yellow Pincushion Flower	(L-M)
Scabiosa•ochroleuca	Yellow Scabiosa	L-H
Secum•spp.	Sedums	M+/-
Silene laciniata	Mexican Campion	(M+/-)
Tanacetum niveum	Silver Tansy	(L-M)
Verbascum•chaxii	Nettle-leaf Mullein	M+/-
Zauschneria arizonica	Arizona Zauschneria	(L-M)
Zinnia grandiflora	Prairie Zinnia	(VL-L)

WaterWise Landscaping
Best Practices

Section 4 – Natural Areas and Native Plants

A. Proactive Multi-Purpose Drainage Design

1. Introducing the Opportunity

The Front Range prairie is frequently characterized as a rolling grassy landscape folded into meandering wooded drainages. The natural processes that developed this landscape can support the erosion control goals of the drainage design while providing enhanced recreational open space and habitat value. Proactively planned multipurpose drainage design can deliver these goals while saving installation costs and maintenance effort by working with the natural processes.

2. Natural Landscape and Generative Processes

Expanding Front Range developments are covering upland prairies with homes and roads, but the regional landscape can still be seen in the natural drainages. The fundamental character of these drainage areas is defined by the distribution of the thickets of woody species. Wild Plum, Chokecherry, Golden Currant, Snowberry, Sandbar willow and Three-leaf sumac are scattered along the native drainages among occasional towering Plains cottonwoods and the smaller Peach-leaved willows. These species generally occupy the sub-irrigated zones intermediate between the moist central channel areas and the drier upland grasslands.

The natural processes by which woody vegetation expands into upland drainages depend upon a connection to the larger riparian systems below. (Remember: nature abhors a vacuum.) A shallow, young grassy drainage will eventually develop into a deeper, wooded channel. In natural systems normal precipitation cycles coupled with disturbance (grazing, fire, or drought), eventually will lead to erosion and deposition along the grassy channels. In development areas the process is accelerated by the installation of roads or trails, pipelines, and drainage features. Any action that weakens a grassland root system can provide an opening for change.

Seeds of woody species use either wind or wildlife to relocate into disturbed areas in drainages. Native deciduous trees such as the Plain cottonwood and Peach-leaved willow and the smaller Sandbar willows release seeds on the spring winds. When a newly exposed moist soil deposit occurs within a few miles of a well-vegetated river, stream or irrigation ditch, a few seeds from these species will blow into to the site. Once a tree has taken root, it will attract birds as well as raccoons, fox, coyote, and skunks. All these animals follow the drainages in their search for food. They eat the plums, chokecherries, currants, snowberries, hawthorns, sumac or any other wild fruits. As they travel, they rest in and under small trees. Seeds are dropped in these locations as the animals move

on. Droppings from animals are concentrated near existing trees. The shade and leaf litter beneath the trees provide a moist protected site favorable for establishment.

3. Choices

Engineers design channels for expected run off from the new paved surfaces (roofs and pavement) and existing or proposed vegetation. When a natural channel contains a well-developed woody plant community, the plans may accommodate the existing vegetation conditions, allowing the woody vegetation to remain. Woody vegetation supports to goals of the drainage program by decreasing peak flows, slowing flow rates, protecting slopes channel edges from excess erosion.

New developments, lacking historic drainage channels, must make decisions related to the establishment of woody vegetation. In a short time, windblown woody species will find suitable sites in new drainages. Heavier seeded plants will eventually follow. If plans do not create channels with adequate flow capacity for the natural process of woody plant establishment, they will predetermine a maintenance program including expensive woody vegetation control. The erosion control and recreational benefits possible from woody vegetation will be diminished in the battle to prevent the inevitable. Channels can be sized to accommodate woody vegetation to improve slope stabilization. If this is done well, the maintenance program will be able to allow the natural process of woody vegetation development to occur. This requires an approach acknowledging and working with the natural processes typical of these riparian corridors.

4. Cost effectiveness

Proactive, multipurpose drainage design is more cost effective than rigorous maintenance designed to remove all woody vegetation. The woody vegetation serves the underlying purpose of slope stability and erosion control, becoming an ally to the drainage program, instead of a problem. Installation costs of woody vegetation become part of the erosion control program. Costly maintenance aimed at prevention or removal of woody vegetation is no longer necessary. Mowing requirements may mostly be eliminated as perennial vegetation becomes well established. Multipurpose corridors can become more diverse, improving in habitat and passive recreational value, overtime.

5. Lower water usage

In the interest of developing a more water efficient landscape, multipurpose designed drainages within a development can provide a cool, shady wooded retreat area without requiring installation and maintenance of a supporting irrigation system. Properly selected and placed native woody species can be largely selfsufficient once installed.

6. Urban Drainage and Flood Control Support

UDFCD encourages the natural channel concept in drainage design (V. 1, MD-3-9). "Open channel planning and design objectives are often best met by using natural-like vegetated channels". Guidance for planning and execution of this concept is included within the Drainage Criteria manual (V. 2.) revegetation section. Native seed mixtures for a variety of soil types as well as recommended uses and installation methods for trees and shrubs within drainage designs, are included.

7. Success

During the spring of the drought year of 2002, a number of drainage improvement projects were installed. Native woody plantings of trees and shrubs were successfully established in spite of limited or no irrigation. Marcy Gulch at Highlands Ranch, Niver Creek in Thornton, Cottonwood Creek in Greenwood Village, and Lilly Gulch in Littleton were successfully established in spite of many days of unseasonably hot dry conditions.

B. Native Seed Mixes

1. Colorado Native Seed Mix Summary

- a. Short Grass Prairie (grasses & wildflowers)
- b. Mixed Grass Prairie (grasses & wildflowers)
- c. Tall Grass Prairie (grasses & wildflowers)
- d. Moist or Wetland Soils (grasses & wildflowers)
- e. Sandy Loam Soils (grasses & wildflowers)
- f. Clay Loam Soils (grasses & wildflowers)
- g. Select Shrubs and Trees for natural areas

The complete Native Seed lists are provided on the following pages.



Shortgrass prairie species Easter daisy/Townsendia grandiflorus



Heavily grazed native shortgrass prairie

Table 1. Native shortgrass mixture for loam to clay loam dry upland sites. Some taller species included. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Buffalograss	<i>Buchloe dactyloides</i>	Sharp's	4-6"	56000	6.5	
Sideoats grama	<i>Bouteloua curtipendula</i>	Butte	18"	191000	3.0	
Blue grama	<i>Chondrosum gracile</i>	Hachita	6-8"	825000	8.0	
Western wheatgrass	<i>Pascopyrum smithii</i>	Barton	18"	110000	4.0	
Sand dropseed	<i>Sporobolus cryptandrus</i>	Native	18"	5,200,000	2.0	
TOTAL POUNDS/ACRE					23.5	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					OUNCES /ACRE	Double wildflower seeding rate for more color.
Purple prairieclover	<i>Dalea purpurea</i>		12"	210000	3.0	
Blanket flower	<i>Gaillardia aristata</i>		12-18"	132000	4.0	
Golden aster	<i>Heterotheca villosa</i>		6-8"	920000	2.0	
Gayfeather	<i>Liatris punctata</i>		12-18"	138000	4.0	
Flax	<i>Linum lewisii</i>		18"	293000	2.0	
Bluemist penstemon	<i>Penstemon virens</i>		8"	850000	3.0	
Sidebells penstemon	<i>Penstemon secundiflorus</i>		18"	610000	2.0	
Scarlet globemallow	<i>Sphaeralcea coccinea</i>		6-8"	500000	3.0	
Easter daisy	<i>Townsendia grandiflora</i>		6-8"	1200000	0.5	
TOTAL OUNCES/ACRE					23.5	
AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Shortgrass Prairie

This vegetation type is typical of high plains areas with 10- 16 inches on annual precipitation. In native areas shallow soil depth, clay soil, low precipitation, alkaline conditions, heavy grazing or compaction all may contribute to a



Prairie coneflower/*Ratibida columnifera* in restored mixed grass prairie



Restored mixed grass prairie with wildflowers.

Table 2. Native mixed grass for sandy loam, loam, clay loam upland sites. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Sideoats Grama	<i>Bouteloua curtipendula</i>	Butte	18"	191000	4.8	
Buffalograss	<i>Buchloe dactyloides</i>	Texoca	4-6"	56000	5.0	
Blue Grama	<i>Chondrosium gracile</i>	Hachita	6-8"	825000	4.5	
Switchgrass	<i>Panicum virgatum</i>	Blackwell	24-36"	389000	2.0	
Western wheatgrass	<i>Pascopyrum smithii</i>	Ariba	18"	110000	3.0	
Little bluestem	<i>Schyzachrium scoparium</i>	Pastura	18-24"	260000	2.0	
Sand dropseed	<i>Sporobolus cryptandrus</i>	native	18"	5,200,000	0.5	
Green needlegrass	<i>Stipa viridula</i>	native	24"		1.5	
TOTAL POUNDS PLS/ACRE					23.3	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS						
					OUNCES /ACRE	Double wildflower seeding rate for more color.
Smooth aster	<i>Aster laevis</i>				2.0	
Purple prairieclover	<i>Dalea purpurea</i>			210000	3.0	
Blanket flower	<i>Gaillardia aristata</i>			132000	6.0	
Golden aster	<i>Heterotheca villosa</i>				2.0	
Gayfeather	<i>Liatris punctata</i>			138000	4.0	
Flax	<i>Linum lewisii</i>			293000	2.0	
Penstemon	<i>Penstemon angustifolia</i>		24"	590000	2.0	
Prairie coneflower	<i>Ratibida columnifera</i>			1230000	2.0	
TOTAL OUNCES/ACRE					23.0	
*AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Mixed grass midgrass Prairie

Native areas with richer clay-loam to loamy soil, 14-18 inches of precipitation, and less grazing impact may exhibit the taller grasses typical of mixed grass prairie. Restored mixed grass prairie is possible on sites withg



Purple prairie clover/*Dalea purpurea* in restored tallgrass prairie. Grasses will later become 36" or more in height.

Table 3. Native tallgrass mixture for north and east facing sites, low areas. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMONNAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	TOTAL LBS PLS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Big bluestem	<i>Andropogon gerardi</i>	Pawnee	3-4'	130,000	1.5	
Sideoats grama	<i>Bouteloua curtipendula</i>	Butte	18"	191000	2.8	
Blue grama	<i>Chondrosum gracile</i>	Hachita	6-8"	825000	3.5	
Switchgrass	<i>Panicum virgatum</i>	Blackwell	36"	389000	3.0	
Western wheatgrass	<i>Pascopyrum smithii</i>	Ariba	18"	110000	6.0	
Little bluestem	<i>Schizachyrium scoparium</i>	Pastura	24"	26000	3.4	
Yellow Indiangrass	<i>Sorghastrum avenaceum</i>	Holt	3-4'	170000	2.1	
TOTAL POUNDSPLS/ACRE					22.3	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					OUNCES /ACRE	Double wildflower seeding rate for more color.
Showy milkweed	<i>Asclepias speciosa</i>	native				
Blue aster	<i>Aster laevis</i>	native	18"		2.0	
Blanket flower	<i>Gaillardia aristata</i>	native	12-18"	132000	2.0	
Prairie coneflower	<i>Ratibida columnifera</i>	native	18-24"	1230000	4.0	
Purple prairieclover	<i>Dalea (Petalostemum) purpurea</i>	native	12"	210000	4.0	
Flax	<i>Linum lewisii</i>	native	18"	293000	3.0	
Penstemon	<i>Penstemon strictus</i>	native	24"	590000	4.0	
TOTAL OUNCES/ACRE					19.0	

*AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.

Tallgrass seed mixture

The taller grasses are limited to areas of higher precipitation 16-18 inches along the foothills and moist bottomlands near streams. Rocky soils may contribute to greater moisture availability and the presence of remnant tallgrass



Scarlet globemallow/*Sphaeralcea coccinea* and Western wheatgrass/*Agropyron smithii* in mixed grass prairie remnant along Coal Creek in Erie.



Restored shortgrass prairie with Sidebells penstemon/*Penstemon secundiflorus*.

Table 5. Recommended native sand prairie for sandy to sandy loam soil. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	TOTAL PLS /ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Sand bluestem	<i>Andropogon hallii</i>	Garden	36"	113300	2.0	
Sideoats grama	<i>Bouteloua curtipendula</i>	Butte	18"	191000	3.2	
Prairie sandreed	<i>Calamovilfa longifolia</i>	Goshen	24-36"	273000	2.1	
Blue grama	<i>Chondrosium gracile</i>	Hachita	6-8"	825000	2.5	
Switchgrass	<i>Panicum virgatum</i>	Blackwell	36"	389000	2.0	
Western wheatgrass	<i>Pascopyrum smithii</i>	Arriba	18-24"	110000	6.5	
Little bluestem	<i>Schizachyrium scoparium</i>	Pastura	24"	26000	3.0	
Sand dropseed	<i>Sporobolus cryptandrus</i>		18"	1758000	0.5	
TOTAL POUNDS/ACRE					21.8	
						1 acre = 43560 square feet. Divide this per acre seed quantity by 20 to 40 for each 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					TOTAL OZ/ACRE	Double wildflower seeding rate for more color.
Blue aster	<i>Aster laevis</i>		18"		2.0	
Blanket flower	<i>Gaillardia aristata</i>		12-18"	132000	6.0	
Prairie coneflower	<i>Ratibida columnifera</i>		24"	1230000	3.0	
Purple prairieclover	<i>Dalea (Petalostemum) purpurea</i>		12"	210000	3.0	
Flax	<i>Linum lewisii</i>		18"	293000	4.0	
Penstemon	<i>Penstemon strictus</i>		18-24"	592000	4.0	
TOTAL OUNCES/ACRE					22.0	
* AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Sandy loam seed mixture

Isolated areas of sandy soil are better suited to these deep rooted species. Some native shrubs such as Yucca/Yucca glauca, Rabbitbrush/Chrysothamnus nauseosus, and Sand sagebrush/Artemisia filifolia are well suited to these areas



Needle-and-threadgrass/*Stipa comata* with Blanketflower/*Gaillardia aristata* in mixedgrass prairie.

Table 6. Native seed mixture for use on clay loam soils. Application rate on clean seed bed 1/2-1 pound PLS/1000 sq. ft. Fall broadcast seed, rake or harrow to cover 1/10 to 1/3 inch, mulch recommended.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	SUGGESTIONS
GRASSES AND GRASS-LIKE PLANTS						
Buffalograss	<i>Buchloe dactyloides</i>	Sharp's	6"	56000	7.6	
Sideoats grama	<i>Bouteloua curtipendula</i>	Butte	18"	191000	3.5	
Blue grama	<i>Chondrosum gracile</i>	Hachita	6-8"	825000	6.0	
Western wheatgrass	<i>Pascopyrum smithii</i>	Barton	18"	110000	4.8	
TOTAL POUNDS/ACRE					21.9	
						1 acre=43560 square feet. Divide this per acre seed quantity by 20 to 40 for each to 1000 square feet to be seeded.
ADAPTED NATIVE WILDFLOWERS					OZ/ACRE	Double wildflower seeding rate for more color.
Purple prairieclover	<i>Dalea purpurea</i>		12"	210000	3.0	
Blanket flower	<i>Gailardia aristata</i>		12-18"	132000	3.0	
Gayfeather	<i>Liatris punctata</i>		12-18"	138000	3.0	
Flax	<i>Linum lewisii</i>		18"	293000	4.0	
Prairie coneflower	<i>Ratibida columnifera</i>		18-24"		3.0	
Scarlet globemallow	<i>Sphaeralcea coccinea</i>		6"		4.0	
TOTAL OUNCES/ACRE					20.0	
* AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						
Clay loam seed mixture						
The shortgrass prairie species are well adapted to clay loam soils.						



Native woody shrubs and trees stabilize stream channel in Front range open space area. Shade, habitat, and passive recreational value area also enhanced. No irrigation water is required for this amenity.

Table 7. Native shrub and tree species adapted to the Front Range high plains area. Little or no water is required for these species if properly located on landscape. Useful for erosion control, shade, and habitat improvement in drainages.

COMMON NAME	SCIENTIFIC NAME	VARIETY	MATURE HEIGHT	SEEDS/LB	PLS LBS/ACRE	LOCATION
NATIVE WOODY VEGETATION						
Rabbitbrush	<i>Chrysothamnus nauseosus</i>	Native	2-4'			Upland areas, establishment watering. Use smaller plants or seed for best results.
Plains Cottonwood	<i>Populus sargentii</i>	Native	45-60'			Naturally subirrigated lowlands, moist areas, open space drainages. Plant rootball 2-4' into saturated soil, monthly deep watering if planted in upland areas.
Chokecherry	<i>Padus virginiana</i>	Native	10-12'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages. Deep water once a month in upland areas.
Wild plum	<i>Prunus americana</i>	Native	6-8'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages. Deep water once a month in upland areas.
Golden current	<i>Ribes aureum</i>	Native	3-4'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages. Deep water once a month in upland areas.
Three-leaf sumac	<i>Rhus trilobata</i>	Native	4-8'			Upland areas, water monthly 1 year to establish
Peachleaf willow	<i>Salix amygdaloides</i>	Native	15-35'			Naturally subirrigated lowlands, moist areas, open space drainages.
Sandbar willow	<i>Salix exigua</i>	Native	5-6'			Naturally subirrigated lowlands, moist areas, open space drainages.
Snowberry	<i>Symphoricarpos occidentalis</i>	Native	2'			Naturally subirrigated lowlands, shady sites, northfacing slopes, open space drainages.
Yucca	<i>Yucca glauca</i>	Native	2'			Upland areas, water 1 year to establish
TOTAL POUNDS PLS/ACRE					0	
WaterWise Landscaping						
* AV - Arkansas Valley Seed 303-665-6642, WNS - Western Native Seed 719-942-3935. Prepared by The Restoration Group, Inc. 5/03.						

Woody plants

Most native woody vegetation are adapted to drainages and sites with elevated moisture, such as springs or north-facing slopes. These species provide critical habitat for wildlife, shade and diversity, and erosion control in drainage areas.

Best Practices

Section 4 – Natural Areas and Native Plants

C. Plants to Avoid – The 2003 State Noxious Weed List

The following noxious weed listings have been excerpted from the Rules and Regulations Pertaining to the Administration and Enforcement of the Colorado Weed Management Act, as of May 2003. The full text and current listing are available at <www.ag.state.co.us/DPI/weeds/weed.html>.

"Noxious weed" means an alien plant or parts of an alien plant that have been designated by rule as being noxious or has been declared a noxious weed by a local advisory board, and meets one or more of the following criteria:

- (a) Aggressively invades or is detrimental to economic crops or native plant communities;
- (b) Is poisonous to livestock;
- (c) Is a carrier of detrimental insects, diseases, or parasites;
- (d) The direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems.

The following weed species, listed in alphabetical order, are identified as the State Noxious Weeds. They have been identified by individual counties as problem weeds in the county's area or have been recommended for management through public testimony. These weed species should be considered by each local advisory board and local governing body in the development, adoption and enforcement of their noxious weed list and noxious weed management plan. The State Noxious Weeds are:

Absinth wormwood (<i>Artemisia absinthium</i>)	Meadow knapweed (<i>Centaurea pratensis</i>)
African rue (<i>Peganum harmala</i>)	Mediterranean sage (<i>Salvia aethiopis</i>)
Black henbane (<i>Hyoscyamus niger</i>)	Medusahead rye (<i>Taeniatherum caput-medusae</i>)
Black nightshade (<i>Solanum nigrum</i>)	Moth mullein (<i>Verbascum blattaria</i>)
Blue mustard (<i>Chorispora tenella</i>)	Musk thistle (<i>Carduus nutans</i>)
Bouncingbet (<i>Saponaria officinalis</i>)	Myrtle spurge (<i>Euphorbia myrsinites</i>)
Bull thistle (<i>Cirsium vulgare</i>)	Orange hawkweed (<i>Hieracium aurantiacum</i>)
Camelthorn (<i>Alhagi pseudalhagi</i>)	Oxeye daisy (<i>Chrysanthemum leucanthemum</i>)
Canada thistle (<i>Cirsium arvense</i>)	Perennial pepperweed (<i>Lepidium latifolium</i>)
Chicory (<i>Cichorium intybus</i>)	Perennial sowthistle (<i>Sonchus arvensis</i>)
Chinese clematis (<i>Clematis orientalis</i>)	Plumeless thistle (<i>Carduus acanthoides</i>)
Coast tarweed (<i>Madia sativa</i>)	Poison hemlock (<i>Conium maculatum</i>)
Common burdock (<i>Arctium minus</i>)	Puncturevine (<i>Tribulus terrestris</i>)
Common crupina (<i>Crupina vulgaris</i>)	Purple loosestrife (<i>Lythrum salicaria</i>)
Common groundsel (<i>Senecio vulgaris</i>)	Quackgrass (<i>Elytrigia repens</i>)
Common mullein (<i>Verbascum thapsus</i>)	Redstem filaree (<i>Erodium cicutarium</i>)
Common St. Johnswort (<i>Hypericum perforatum</i>)	Rush skeletonweed (<i>Chondrilla juncea</i>)
Common tansy (<i>Tanacetum vulgare</i>)	Russian knapweed (<i>Centaurea repens</i>)
Common teasel (<i>Dipsacus fullonum</i>)	Russian-olive (<i>Elaeagnus angustifolia</i>)
Cypress spurge (<i>Euphorbia cyparissias</i>)	Russian thistle (<i>Salsola collina</i> and <i>S. iberica</i>)
Dalmatian toadflax, broad-leaved (<i>Linaria dalmatica</i>)	Saltcedar (<i>Tamarix parviflora</i> and <i>T. ramosissima</i>)
Dalmation toadflax, narrow-leaved (<i>L. genistifolia</i>)	Scentless chamomile (<i>Anthemis arvensis</i>)
Dame's rocket (<i>Hesperis matronalis</i>)	Scotch thistle (<i>Onopordum acanthium</i> and <i>O. tauricum</i>)
Diffuse knapweed (<i>Centaurea diffusa</i>)	Sericea lespedeza (<i>Lespedeza cuneata</i>)
Downy brome (<i>Bromus tectorum</i>)	Shepherdspurse (<i>Capsella bursa-pastoris</i>)
Dyer's woad (<i>Isatis tinctoria</i>)	Spotted knapweed (<i>Centaurea maculosa</i>)
Eurasian watermilfoil (<i>Myriophyllum spicatum</i>)	Spurred anoda (<i>Anoda cristata</i>)
Field bindweed (<i>Convolvulus arvensis</i>)	Squarrose knapweed (<i>Centaurea virgata</i>)
Flixweed (<i>Descurainia sophia</i>)	Sulfur cinquefoil (<i>Potentilla recta</i>)
Giant salvinia (<i>Salvinia molesta</i>)	Swainsonpea (<i>Sphaerophysa salsula</i>)
Green foxtail (<i>Setaria viridis</i>)	Tansy ragwort (<i>Senecio jacobaea</i>)
Hairy nightshade (<i>Solanum sarrachoides</i>)	Velvetleaf (<i>Abutilon theophrasti</i>)

Halogeton (*Halogeton glomeratus*)
Hoary cress (*Cardaria draba*)
Houndstongue (*Cynoglossum officinale*)
Hydrilla (*Hydrilla hydrilla*)
Johnsongrass (*Sorghum halepense*)
Jointed goatgrass (*Aegilops cylindrica*)
Kochia (*Kochia scoparia*)
Leafy spurge (*Euphorbia esula*)
Mayweed chamomile (*Anthemis cotula*)

Venice mallow (*Hibiscus trionum*)
Wild caraway (*Carum carvi*)
Wild mustard (*Brassica kaber*)
Wild oats (*Avena fatua*)
Wild proso millet (*Panicum miliaceum*)
Yellow foxtail (*Setaria glauca*)
Yellow nutsedge (*Cyperus esculentus*)
Yellow starthistle (*Centaurea solstitialis*)
Yellow toadflax (*Linaria vulgaris*)

The following weed species are recognized as the top ten prioritized weed species for the State of Colorado. After analysis of a statewide survey of counties, these species are acknowledged to be the most widespread and to cause the greatest economic impact in the State of Colorado. These species shall be considered by each local advisory board and local governing body in the development, adoption and enforcement of their noxious weed list and noxious weed management plan. They are listed in alphabetical order:

Canada thistle (*Cirsium arvense*)
Dalmation toadflax (*Linaria dalmatica* and *L. genistifolia*)
Diffuse knapweed (*Centaurea diffusa*)
Field bindweed (*Convolvulus arvensis*)
Hoary cress (*Cardaria draba*)

Houndstongue (*Cynoglossum officinale*)
Leafy spurge (*Euphorbia esula*)
Musk thistle (*Carduus nutans*)
Russian knapweed (*Centaurea repens*)
Yellow toadflax (*Linaria vulgaris*)

The following weed species may not be present or are not yet widespread or causing great economic impact within the State of Colorado. However, counties and local advisory boards are encouraged to contain and eradicate these species before they proliferate and significantly impact the economic and environmental values of the lands of the State. They are listed in alphabetical order:

Absinth wormwood (*Artemisia absinthium*)
African rue (*Peganum harmala*)
Bouncingbet (*Saponaria officinalis*)
Camelthorn (*Alhagi pseudalhagi*)
Coast tarweed (*Madia sativa*)
Common crupina (*Crupina vulgaris*)
Common teasel (*Dipsacus fullonum*)
Cypress spurge (*Euphorbia cyparissias*)
Dyer's woad (*Isatis tinctoria*)
Eurasian watermilfoil (*Myriophyllum spicatum*)
Giant salvinia (*Salvinia molesta*)
Hydrilla (*Hydrilla hydrilla*)

Meadow knapweed (*Centaurea pratensis*)
Moth mullein (*Verbascum blattaria*)
Myrtle spurge (*Euphorbia myrsinites*)
Orange hawkweed (*Hieracium aurantiacum*)
Rush skeletonweed (*Chondrilla juncea*)
Sericea lespedeza (*Lespedeza cuneata*)
Spurred anoda (*Anoda cristata*)
Squarrose knapweed (*Centaurea virgata*)
Sulfur cinquefoil (*Potentilla recta*)
Tansy ragwort (*Senecio jacobaea*)
Venice mallow (*Hibiscus trionum*)
Yellow starthistle (*Centaurea solstitialis*)

WaterWise Landscaping
Best Practices

Section 5 – Understanding Soils and Soil Preparation

A. Introduction to Soils (See Native Plant Revegetation Guide available at:
http://parks.state.co.us/cnap/revegetation-guide/reveg_index.html)

Prairie soils have developed over thousands of years. Native topsoil is a living material containing soil microorganisms, seeds, plant roots, and invertebrate animal in a matrix of minerals (derived from rocks) and dead organic matter (developed from the breakdown of dead plants and animals). Areas with adequate topsoil are better able to develop and support healthy vegetation. Native drought tolerant vegetation may be adapted to a broad or narrow range of soil types. Successful native and drought tolerant landscapes should consider soil properties when designing planting areas. Soil properties include texture, chemistry, and structure. Soil pH, salinity, and percent organic matter may be more critical to the establishment of native and drought tolerant vegetation than soil macronutrient levels (nitrogen, phosphorus, and potassium). In order to better plan for specific soils, consult the reference above.

Topsoil may be recognized in general by its darker color (very dark to deeper brownish earth tones). The distinct transition to brighter earth tones may mark the boundary with subsoil. Recent precipitation may color surface soils darker and should not be mistaken for topsoil. In general topsoil may be 6 to 12 inches deep, deeper in drainages and shallower on slopes and hilltops. Old agricultural fields may have less distinct boundaries due to years of mixing of upper soils and accelerated erosional loss. Pits may be dug to identify topsoil depths prior to removal

B. Salvage of Soils

Topsoil is a living material and must be handled carefully to preserve its quality. Planned developments are frequently re-graded. Topsoil should be salvaged from all areas and stockpiled prior to grading. Topsoil under roads and staging areas should also be removed and stock piled. All salvaged topsoil should be reapplied to the portions of the development site to be revegetated. Salvage topsoil in drainages before erosion of denuded upland areas can contaminate them.

Topsoil is best if it can be removed and hauled directly to the placement site. If storage is necessary it should be for as short a time as possible. The topsoil should be placed in a low mound, in a weed free area, with side slopes of 7:1 or less. A ditch and berm structure around the pile will help reduce loss to erosion. If the pile is to remain for more than four weeks, it should be seeded with a sterile hybrid wheatgrass such as “Regreen”. The depth of the pile should be no greater than 2-3 feet to minimize loss of living microbial components. In general it is best to move topsoil when it is moist. Avoid moving wet soils (may harden to brick-like consistency) or overly dry soils. Dormant hauled soils preserve residual native seed and propagules.

C. Topsoil Sources

If topsoil is to be imported to a site a soil sample or recent soil test should be obtained from the supplier. If possible the source site should be visited to check for weed contamination. Soil sources should be free of noxious weed species. If a prepared soil is to be used, the organic content should only be 2 percent for native seeding areas. (Conventional lawns and higher water usage areas may utilize higher organic matter.)

D. Topsoil Testing

Imported topsoil should be a sandy loam or loam soil as defined by the USDA Soil Conservation Service soil Classification system, as follows:

<u>Textural Class</u>	<u>% Total Weight</u>	<u>Average %</u>
Sand (0.05-2.0 mm dia. Range)	45 to 75	60
Silt (0.002-0.05 mm dia. range)	15 to 35	25
Clay (less than 0.002 mm dia. range)	5 to 25	15

Topsoil should be free of stones over 1" in diameter (lawns and gardens) or over 4" (native seeded areas). Topsoil should be free of debris and excessive plant litter.

Topsoil should have a pH of 6-7.5 and salinity less than 4 mmhos/cm.

Soil Testing is available through the **Colorado State University Extension Service:**

Contact Information:	CSU Soil Testing Lab, Ft. Collins, Colorado
	Phone: 970-491-5061
	Fax: 970-491-2930
	Web: www.colostate.edu/Depts/SoilCrop/soillab.html
Cost:	Routine Analysis = \$18.00 (as of 6/03)
Procedure:	Application & Instruction Forms follow

E. Soil Amendments

It is best to plan native and drought tolerant vegetation around the existing soil conditions. If extreme soil conditions exist, some amendments may improve the soil conditions:

1. pH

If the pH is very high it may be possible to adjust by adding aluminum sulfate. Soil in the Front Range tends to have a high pH and thus, does not generally require the addition of lime, which would further elevate the pH value.

2. Texture

Soil texture effects water availability within soils. Very sandy soils do not retain water well. Very clayey soils do not allow water to penetrate or drain easily. Organic matter may improve both of these extreme soils. Native or to low water usage landscapes generally no more than 2 percent organic matter. Generally, if sandy or

clay soils are amended, 2 cubic yards of composted organic matter/1000 square feet is adequate. To improve deep root penetration in a heavy clay or sandy subsoil (under all water usage levels of landscape) apply 2 cubic yards of compost prior to re-application of topsoil. All compost should be deeply ripped into the soil at least 12 inches. This helps with root penetration into the deeper layers of the soil and makes all landscape types more drought tolerant. Avoid over-working the soil to preserve the soil structure.

3. Organic Amendment

Organic amendments should be composted. Compost may be a mixture of manures (not from stock yards, which may be high in salts), yard wastes (ground grass clippings, leaves and branches), organic byproducts such as brewery wastes, and sewage sludge (should not be used alone due to a high clay content.) Prepared topsoil companies maintain sanitary controlled compost production and are a good source of organic amendments.

4. Nutrient Amendment

Nutrient amendments may not be required for native vegetation. Macro nutrient (N,P,K) levels are low in native prairies. Addition of nutrients to native and drought tolerant planting areas may encourage weeds and damage root systems. If topsoil is very poor or lacking, a slow release organic amendment such as Biosol may be added at a rate of 800 to 1200 pounds per acre to improve plant growth.

SUGGESTED INSTRUCTIONS FOR SUBMITTING SOIL SAMPLES

Use the following steps to submit soil samples:

1. Obtain a spade, trowel, soil tube, or soil auger free of rust and soil.
2. Dig 5-10 samples (depending on the size of the area) from the soil depth where your plants will be rooting. The samples should represent a uniform area consisting of land that is similar in slope, texture, drainage, or other characteristics that make the soil the same. A front and back yard would most likely be very similar to each other, however a garden area may be different from a turf grass area.
3. Place all of the samples into a plastic container and mix well to get your final sample for submittal to the lab. If possible, air dry the sample by spreading it out on paper towels.
4. Remove about 1 1/2 - 2 pints of soil from the container and place it in a plastic bag or soil sample bag.
5. Seal the bag and label the sample with name, address and location of the sample.
6. Complete this soil sample information form as much as possible and include it with the soil sample.
7. Mail the sample to the lab using the following address:

**Soil, Water and Plant Testing Laboratory
Colorado State University
Room A 319 NESB
Fort Collins, CO 80523-1120**

8. Be sure to keep samples cool before mailing. If samples heat up; the nitrogen readings can change dramatically. Keeping the samples in the shade will prevent excessive heating.
9. **DO NOT PREPAY**, you will be billed for the analysis.
10. The lab **DOES NOT** do herbicide or pesticide analysis.
11. If you have additional questions please contact the lab at: (970) 491-5061 or your local county Cooperative Extension agent.

SOIL TESTS AVAILABLE	
TEST	COMMENTS
Routine- pH, soluble salts, organic matter, nitrate-nitrogen, phosphorus, potassium, zinc, iron, lime (estimate), texture, copper and manganese.	Basic evaluation for characterizing the soil fertility status for growing crops. a fertilizer recommendation is given. Normally this test is sufficient unless a special problem is suspected.
Subsoil Nitrate	Evaluation of nitrate supply below soil surface. Fertilizer nitrogen recommendation based on routine soil test of surface soil is adjusted if subsoil nitrate is unusually high.
Subsoil Salinity	It is important to determine the salt content of subsoil for crop management.
Sodium Evaluation - sodium adsorption ratio (ratio of sodium to calcium and magnesium), gypsum, and % lime.	Some Colorado soils contain excess sodium. This test determines whether or not chemical amendments such as gypsum or sulfur will be effective and the amounts of these materials needed.
Routine plus Sodium Evaluation	See above explanations. A recommendation for fertilizer and/or amendments for sodium reclamation is given.
Boron, Sulfate and Molybdenum	Colorado soils usually have sufficient quantities of these nutrients. However, in some soils near mine sites, boron or molybdenum may be found in toxic quantities.

SOIL SAMPLE INFORMATION FOR HORTICULTURAL APPLICATIONS - PLEASE PRINT IN
LANDSCAPE MODE:

See the reverse side for sampling information

DATE: _____
FULL NAME: _____
SSN: _____
ADDRESS: _____
CITY: _____ STATE: _____
ZIP CODE: _____
PHONE: _____ FAX: _____
COUNTY: _____ SAMPLE ID: _____

The following information will help us give you a written explanation of the laboratory results:

PLEASE CIRCLE ALL THAT APPLY.

1. The sample is from:

- A. Lawn E. Golf course
B. Vegetable garden F. Container plantings
C. Flower bed G. Reclamation site
D. Greenhouse H. Other (please specify) _____

2. What do you plan to grow at the site or what is currently growing at the site?

- A. Vegetables B. Flowers C. Turfgrass (How old is the lawn?) _____ D. Trees E. Other _____

If you are growing turf please answer the following :

Is this site to be _____ Seeded _____ Sodded?

Is it an existing lawn? _____

If the lawn is established was it:

Seeded _____ Sodded _____

3. Will this site be

irrigated/watered?

Yes _____ or No _____

4. If yes which method?

- A. Sprinkler C. Drip
B. Flood D. Other please specify _____

5. If sprinkler is used is it:

- A. Automatic C. Hose end
B. In ground D. Other _____

6. About how much water do you apply each time you irrigate/water?

- A. Less than 1 inch. B. 1-3 inches C. 4-6 inches D. More than 6 inches

7. How often do you irrigate/water? Daily _____ Once per week _____ Twice per week _____ Other _____

8. If possible, indicate the types of previous crops or plants that grew at this site. _____

9. What have you added or plan to add to the soil? _____

10. Is there a specific problem with this site? Yes _____ No _____

If yes, please describe the problem, what caused the problem and why you think it was the cause (use a separate sheet if necessary).

11. If you wish to have a fertilizer recommendation based on organic fertilizers please answer the following questions.

What is the type of material that will be used for organic fertilizer?

- A. Composted manure B. Composted sludge C. Other _____

Do you know the nutrient levels in the organic fertilizer? Yes _____ No _____

If so please supply the following information for the organic fertilizer.

% nitrogen	% phosphorus	% potassium	pH	Salts (mmhos/cm)

Additional Comments: _____

By accepting service or goods, I agree to submit payment in full to Colorado State University upon receipt of invoice or University Billing Statement. Late payment charges of 1.5% per month and other penalties specified may be assessed for late payment.

Please call lab for prices.

revised 10-11-2001

SOIL, WATER & PLANT TESTING LABORATORY

CLIENT TYPE (Check One)

- Homeowner Operator
Dealers/Distributor Extension Agent
Lawn Care Company Regulatory Agency
Golf Course Consultant
Nursery /Garden Center Government/School
Other _____

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

PLEASE CIRCLE

ANALYSIS DESIRED

Routine (pH, conductivity, organic matter, NO₃, P, K, Zn, Fe Cu, Mn, lime estimate, texture estimate)

Routine + Sodium Evaluation (SAR)

Routine + Boron, Molybdenum, Cadmium, Lead

Routine + Nitrate OR Salinity on Subsoil

Routine + Salinity + Nitrate on Subsoil

NOTE: A subsoil is a separate sample taken 6" underneath your surface sample.

MINIMUM CHARGE

WaterWise Landscaping *Best Practices*

Section 6 – Irrigation Design Techniques and Equipment

The following information builds upon some of the Guidelines described above in Section 2, Principle #5.

A. Consider plant water requirements in irrigation design schemes

1. Each valve should irrigate a landscape with similar site, slope and soil conditions and plant material with similar watering needs.
2. Soil types, infiltration rate & slopes should be considered in order to avoid runoff, & overspray, where water flows onto adjacent property, non-irrigated areas, walks, roadways, or structures. Proper irrigation equipment, schedules, and repeat cycles should be used to minimizing runoff.
3. Special attention should be given to avoid runoff from slopes, and to avoid overspray in planting areas with a width less than ten feet, like medians.
4. Turf and non-turf areas should be irrigated on separate valves.
5. Drip emitters and sprinklers should be place on separate valves.
6. Bubblers for trees should be placed on a separate valve. Bubbler selected should not exceed 1.5 gallons per minute (gpm) for each device.
7. Hand watering may be considered for Low and Very Low hydrozones.

B. Employ hydraulic principles when designing the irrigation system.

1. The irrigation system should be designed to provide peak season irrigation within a six night, six hour per night watering period.
2. The tap size should be based on the water demand of the site and will take into consideration the areas of each plant type (i.e., turf, native seed, perennials and annuals and shrubs), the evapotranspiration for the site, the water demand of each plant type at peak season, and the water window.
3. The maximum flow rate required for the site should be based on the tap size:

3/4" meter	15 gallons per minute
1" meter	25 gpm
1.5" meter	50 gpm
2" meter	80 gpm
4. The mainline system should be designed such that velocities within the mainline piping do not exceed five feet per second.
5. A reduced pressure backflow preventer should be used on all systems. Where the irrigation point of connection is from the domestic water service, the irrigation tap and backflow preventer shall be installed after the water meter but before any backflow or pressure-reducing valve for the building.
6. A pressure-reducing valve should be used when the static water pressure exceeds the pressure needed by the system by 15 pounds per square inch (psi). Pressure reducing valves can be installed within the project, on the mainline or at the valve, if elevation changes require it.

7. Turf and grass area design principles:
 - a. No single zone should mix head types, such as rotors and pop-up spray heads on the same zone.
 - b. Sprinklers should be spaced for “head-to-head” coverage, where the spray pattern from one head will reach to the next head. (Another way to describe this is that all sprinkler heads should be spaced at a maximum of 50% of design performance diameter of the sprinkler.) Spacing should be reduced below 50% of design performance diameter when conditions demand.
 - c. No overhead sprinkler irrigation systems should be installed in strips less than 8 feet wide.
 - d. Small areas (25 ft wide or less) should be irrigated with fixed nozzle pop-up spray heads with matched precipitation nozzles. Nozzles should be sized to provide head to head coverage. Heads shall pop-up a minimum of 4” in turf areas. Heads can be specified with pressure reducing features, where needed.
 - e. Large areas (wider than 25 ft) should be irrigated with gear driven rotor heads with a minimum precipitation rate of 0.45” per hour for a full circle head. Heads should pop-up a minimum of 4” in turf areas.
 - f. Check valves should be included in heads or valves where low-head drainage will occur due to elevation changes. See irrigation head catalogs for elevation change tolerances.
8. Shrub bed areas with plant material one gallon in size or larger should be irrigated with a drip or subsurface system.
9. Perennial and annual beds should be spray irrigated with 12” pop-up spray heads with a maximum spacing of 10’ on center.
10. Booster pumps should be installed on systems where supply pressure does not meet minimum recommended pressure of the irrigation system, based on hydraulic calculations.
11. Where the water supplied will be from secondary or other non-potable water sources, the use of non-potable color indicators on the equipment is recommended. This includes purple handles on quick coupler valves and gate valve, caps for irrigation heads, valve box lids and marker tape buried above the mainline.
12. All systems should be equipped with an automatic rain shut-off device.
13. All wire connections should be made with watertight connectors and contained in a valve box.

C. Employ irrigation control systems that offer flexibility in programming.

1. All irrigation systems should include an electric automatic controller with multiple programs and multiple repeat and rest cycle capabilities and a flexible calendar program.
2. All controllers should be capable of temporarily shutting down the system by utilizing internal/external options such as rain and wind sensors.
3. The controller should have the ability to adjust run times based on a percentage of maximum ET (evapotranspiration) rate.
4. Each zone/valve should have its own station on the controller. The exception is drip valves, which can be doubled on the controller.

D. Ensure installation of irrigation system is per plan and is accurate.

1. Irrigation system should be installed per plans.

2. The irrigation system should be monitored during installation, especially to verify mainline and lateral line depth, spacing of irrigation heads and construction of valve clusters and quick coupler components.
3. Mainline should be tested to ensure its ability to maintain required pressure for 2 hours.
4. Before acceptance, each zone should be operated and each valve box opened to verify accurate installation.

E. Provide “as-built” drawings of irrigation system after installation with dimensions shown for irrigation components.

1. The “as-built” drawings should show all points of connection, including tap size, line size and static water pressure of service. Dimensions that will be used to locate components shall be shown on plans. Components to be located include meters, backflow preventers, all valves, including quick coupler, control, gate, and manual drain valves, and controller locations.
2. The drawings should also show zone number, valve size and gallons per minute.

F. Operate systems to maximize irrigation waterefficiency.

1. Irrigation should be scheduled to operate between 10 PM and 8 AM to reduce water loss from wind and evaporation and to take advantage of the better water pressure.
2. The target efficiency for rotor heads should be 70%, and 55% for spray heads.
3. Program valves for multiple repeat cycles to reduce runoff, especially on slopes and with soils with slow infiltration rates.
4. All zone run times should be determined based on the precipitation rate of the heads on that zone. The run times should be adjusted seasonally and at least once a month to accommodate the ET rate.
5. System should be winterized in the fall using a compressor to remove water in the lines and components. System should be reopened and adjusted for proper operation in the spring.
6. After each mowing, each zone should be operated for a very short period of time to verify the heads are operating as designed and no damage has occurred.
7. When repairs are made, the new components installed should match exactly those damaged and removed.
8. Run times for zones should be adjusted based on exposure (north and east vs. south and west), slope and soil types to reduce overwatering.

WaterWise Landscaping Best Practices

Section 7 – Water Budgeting

A. Calculating a Water Budget

A Water Budget is the target amount of water a landowner should use in a typical watering season. This target provides simple-to-achieve, realistic goals for landscape irrigation. Water Budgeting focuses less on watering time limits, and is more concerned with a user's water allotment and reducing over-watering. This form can help any user create a target Water Budget from which to work.

The information below will help guide you through the Water Budget Worksheet on the following page.

Step 1. ET Reference Location:

Because climate conditions vary throughout Colorado, the rate at which water evaporates (evaporation) and the rate at which plants use water (transpiration) varies in different areas of the state. Based on those climatic differences, it is important to identify the general Evapo-Transpiration (ET) Reference Locations in which you are located. The four largest regions can be categorized as: Denver, Colorado Springs, Grand Junction and Pueblo.

Step 2. Gallons of Water Needed by Plant Category:

Different plants have different water needs. A plant list that identifies the water needs of landscape plants (High, Moderate, Low, Very Low) is included in Section Three of this Best Practices Manual. The ET Rates are provided on the worksheet, and will need to be applied in the calculations in Step 4 below.

Step 3. Irrigation Areas (zones) based on Plant Water Need Category:

Both automatic irrigation systems and hand-placed yard sprinklers deliver water to plants by watering areas or "zones", and have set watering amounts determined by you, the user. If you have High water need plants within Low or Very Low water plant groupings, the entire area must be considered a High-water area and irrigated as such; however some plants may be over-watered if this occurs. The area of each watering zone can be determined by physically measuring the zone, and multiplying Length (in feet) by Width (in feet). The resulting areas (in square feet, or S.F.) can be entered in Step 4 below.

Step 4. Water-Use Calculations:

Fill in the blanks with area and water need per zone. For example, in the Denver region you might have an area of 300 S.F. in a High Water Zone that would require 20 gallons of water per S.F. After multiplying you would find that area requires 6,000 gallons of water per season.

After calculating the irrigation needs of all areas, determine your average overall water needs per season. To do this, add the total gallons needed for all zones, and divide by the total Square Footage for all zones. The average for the overall site needs to be no more than 15 gallons per S.F. per season. If your average is more than this, you might consider modifying your planting layout to create more Low/Very Low Water Zones that would balance your High/Moderate Water Zones, and reduce over-watering.

WaterWise Landscaping Best Practices

B. Water Budget Worksheet

1. ET Reference Location:

Identify the general Evapo-Transpiration (ET) Reference Location in which you are located. The four largest regions are listed below and include surrounding metropolitan areas:

___Denver ___Colorado Springs ___Grand Junction ___Pueblo

2. Gallons of Water Needed by Plant Category:

Determine the water needs of the various plants in your design. A plant list that identifies water needs (High, Moderate, Low, Very Low) is included in Section Three of this Best Practices Manual.

Plant Water Need Category	Gallons of Water used (ET Rate)*
H = High water plants	(20 gallons/SF/season -- Denver)
M = Moderate water plants	(10 gallons/SF/season -- Denver)
L = Low water plants	(0-3 gallons/SF/season -- Denver)
VL = Very Low water plants	(no irrigation needed; typical rainfall is sufficient)

The ET Rates for regions other than Denver are not yet accurate. One might assume that the ETR for Colorado Springs is 10% less than Denver's, and those for Grand Junction and Pueblo may be as much as 25% higher than Denver's.

3. Irrigation Areas (zones) based on Plant Water Need Category:

Identify each zone requiring irrigation, and calculate the area (in square feet) of each zone. If plants are already installed and/or not grouped together by water need, pick the highest water need category included in each zone.

4. Water-Use Calculations:

HIGH WATER ZONES: _____ S.F. x (_____ gals./S.F.) = _____ gals / season

MODERATE WATER ZONES: _____ S.F. x (_____ gals. /S.F.) = _____ gals / season

LOW WATER ZONES: _____ S.F. x (_____ gals./S.F.) = _____ gals / season

VERY LOW WATER ZONES: _____ S.F. x (_____ gals./S.F.) = _____ gals / season TOTAL

gallons needed by ALL ZONES: _____ = _____ gals / season

TOTAL Square Feet (S.F.) of ALL ZONES: _____ = _____ S.F.

*AVERAGE GALS./S.F./SEASON, ALL ZONES: Total Gals / Total SF = _____ gals / season

**The average needs to be a maximum of 15 gals. / S.F. / season.*

WaterWise Landscaping
Best Practices

Section 8 – Additional Resources

Water Conservation Internet Sources

- Waterwiser, National Water Efficiency Clearinghouse, www.waterwiser.org
- Water Saver Home, www.h2ouse.org
- U.S. Geologic Survey, Water use in the United States, www.water.usgs.gov/watuse
- Western States Water Council, www.westgov.org/wswc
- Colorado Water Conservation Board, www.cwcb.state.co.us
- Colorado Nonpoint Source Program, www.ourwater.com
- Denver Water, www.water.denver.co.gov/indexmain.html
- WaterSaver from Denver Water, www.watersaver.org

WaterWise Landscaping Internet Sources

- GreenCO Best Management Practices, www.grennco.org/bmp_list.html
- National Association of Irrigation Design/ Certification, www.irrigation.org/certification.html
- American Nursery and Landscape Association, www.anla.org
- Associated Landscape Contractors of Colorado, www.alcc.com
- Smart Gardening, www.smartgardening.com
- Xeriscaping, www.xeriscape.org
- Colorado State University Horticulture Department, www.hla.agsci.coloradostate.edu
- CSU Cooperative Extension Service, www.ext.colostate.edu/garden
- Colorado Nurseries, www.colorado-nusery-assn.org

- Gardening Colorado, www.gardeningcolorado.com
- Xeriscape Gardening, www.xratedgardening.com

Seed and Plant Sources

- Garden Centers of Colorado, www.gardencentersofcolorado.org
- Colorado Native Plant Society, www.carbon.cudenver.edu/~shill/conps.html
- High Country Gardens, www.highcountrygardens.com
- Arkansas Valley Seed Solutions, www.seedsolutions.com
- Rocky Mountain Sod Growers Association, www.rockymountainsodgrowers.com

Demonstration Gardens

- Colorado Xeriscape Demonstration Gardens, www.xeriscape.org/demogardens.html

Waterwise Gardening Books

- *The Xeriscape Flower Gardener*, Jim Knopf, Boulder, CO, Johnson Books, 2003
- *Waterwise Landscaping with Trees, Shrubs, and Vines*, Jim Knopf
- *Xeriscape Plant Guide*, Rob Proctor/David Winger, Fulcrum Publishing, 1996
- *Xeriscape Handbook*, Gayle Weinstein/ David Winger, Fulcrum Publishing, 2003
- *Xeriscape Color Guide*, David Winger/Denver Water, Fulcrum Publishing, 1998
- *Western Garden Book*, Kathleen Norris Brenzel, Sunset Publishing, 2001
- *Water-Efficient Landscape Guidelines*, Richard E Bennett/ Michael S. Hazinski, American Water Works Association, 1993
- *The Rocky Mountain Perennial Plant Guide*, Colorado Nursery Association, 1995
- *Rocky Mountain Plant Guide*, Colorado Nursery Association, 1993

Appendix G

5-Year Opinion of Probable Construction and Capital Improvement Plan Costs

OPCCs and CIP total estimates for 5-Year recommended CIP Projects are presented below in **Table G-1** through **Table G-12**. The estimated cost for each line item, also known as the extended cost within a project is determined by multiplying the line item quantity times the unit cost. Each line item extended cost is added to the project total cost column to determine OPCC estimates. All costs are August 2020 dollars from ENR-CCI.

Table G-1 – SA-44 Centennial Park OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,520	\$172/LF	\$605,939	\$605,939
Water Distribution 8" (Trenchless J&B)	200	\$478/LF	\$95,617	\$95,617
Pump Station - 1,300 gpm	1	LS	\$1,734,548	\$1,734,548
New Pond	3	\$60,964/AF	\$154,330	\$154,330
Tier 1 Dewatering	1,800	\$105/LF	\$189,000	\$189,000
Unit Cost Subtotal				\$2,779,435
Erosion Control/Stormwater Pollution Prevention		2%		\$55,589
Mobilization & Demobilization		5%		\$138,972
Subtotal				\$2,973,995
Contingency		35%		\$1,040,900
Opinion of Probable Construction Cost (rounded)				\$4,020,000
Feasibility and Site Studies		6% of OPCC		\$242,000
Preliminary and Final Design		6% of OPCC		\$242,000
Engineering Services During Construction		5% of OPCC		\$201,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$201,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$121,000
Capital Improvement Plan Total				\$5,030,000

Table G-2 – Boomerang PS OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 3,100 gpm	1	LS	\$3,064,486	\$3,064,486
Pond Expansion	12.52	\$60,964/AF	\$763,000	\$763,000
Unit Cost Subtotal				\$3,827,486
Erosion Control/Stormwater Pollution Prevention		2%		\$76,550
Mobilization & Demobilization		5%		\$191,374
Subtotal				\$4,095,410
Contingency		35%		\$1,433,400
Opinion of Probable Construction Cost (rounded)				\$5,530,000
Feasibility and Site Studies		6% of OPCC		\$332,000
Preliminary and Final Design		6% of OPCC		\$332,000
Engineering Services During Construction		5% of OPCC		\$277,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$277,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$166,000
Capital Improvement Plan Total				\$6,920,000

Table G-3 – Boomerang Regional Phase 2 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	5,472	\$178/LF	\$974,896	\$974,896
Tier 2 Dewatering	5,472	\$52.50/LF	\$287,280	\$287,280
Unit Cost Subtotal				\$1,262,176
Erosion Control/Stormwater Pollution Prevention		2%		\$25,244
Mobilization & Demobilization		5%		\$63,109
Subtotal				\$1,350,528
Contingency		35%		\$472,690
Opinion of Probable Construction Cost (rounded)				\$1,830,000
Easement		5% of OPCC		\$92,000
Feasibility and Site Studies		6% of OPCC		\$110,000
Preliminary and Final Design		6% of OPCC		\$110,000
Engineering Services During Construction		5% of OPCC		\$92,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$92,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$55,000
Capital Improvement Plan Total				\$2,390,000

Table G-4 – Greeley West Pump Station Replacement OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	6,993	\$178/LF	\$1,245,879	\$1,245,879
Pump Station - 2,000 gpm	1	LS	\$2,299,902	\$2,299,902
Pond Expansion	9.55	\$60,964/AF	\$582,203	\$582,203
Unit Cost Subtotal				\$4,127,984
Erosion Control/Stormwater Pollution Prevention		2%		\$82,560
Mobilization & Demobilization		5%		\$206,399
Subtotal				\$4,416,943
Contingency		35%		\$1,545,930
Opinion of Probable Construction Cost (rounded)				\$5,970,000
Feasibility and Site Studies		6% of OPCC		\$359,000
Preliminary and Final Design		6% of OPCC		\$359,000
Engineering Services During Construction		5% of OPCC		\$299,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$299,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$180,000
Capital Improvement Plan Total				\$7,470,000

Table G-5 – Upper Equalizer Project OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 36"	25,646	\$421/LF	\$10,805,334	\$10,805,334
Water Distribution 36" (Trenchless J&B)	850	\$1,960/LF	\$1,665,681	\$1,665,681
Water Distribution 36" (Trenchless HDD)	250	\$1,796/LF	\$449,047	\$449,047
Tier 1 Dewatering	350	\$105/LF	\$36,750	\$36,750
Tier 2 Dewatering	17,000	\$52.50/LF	\$892,500	\$892,500
Unit Cost Subtotal				\$13,849,313
Erosion Control/Stormwater Pollution Prevention		2%		\$276,986
Mobilization & Demobilization		5%		\$692,466
Subtotal				\$14,818,764
Contingency		35%		\$5,186,570
Opinion of Probable Construction Cost (rounded)				\$20,010,000
Easement		5% of OPCC		\$1,001,000
Feasibility and Site Studies		5% of OPCC		\$1,001,000
Preliminary and Final Design		5% of OPCC		\$1,001,000
Engineering Services During Construction		5% of OPCC		\$1,001,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$1,001,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$601,000
Capital Improvement Plan Total				\$25,620,000

Table G-6 – SA-14 Tech Center Supply OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 16"	3,286	\$224/LF	\$735,751	\$735,751
Pump Station - 1,120 gpm	1	LS	\$1,573,250	\$1,573,250
New Pond	13	\$60,964/AF	\$818,868	\$818,868
Tier 1 Dewatering	250	\$105/LF	\$26,250	\$26,250
Unit Cost Subtotal				\$3,154,120
Erosion Control/Stormwater Pollution Prevention		2%		\$63,082
Mobilization & Demobilization		5%		\$157,706
Subtotal				\$3,374,908
Contingency		35%		\$1,181,220
Opinion of Probable Construction Cost (rounded)				\$4,560,000
Easement		5% of OPCC		\$228,000
Feasibility and Site Studies		6% of OPCC		\$274,000
Preliminary and Final Design		6% of OPCC		\$274,000
Engineering Services During Construction		5% of OPCC		\$228,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$228,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$137,000
Capital Improvement Plan Total				\$5,930,000

Table G-7 – Promontory Park Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	2,237	\$178/LF	\$398,546	\$398,546
Unit Cost Subtotal				\$398,546
Erosion Control/Stormwater Pollution Prevention		2%		\$7,971
Mobilization & Demobilization		5%		\$19,927
Subtotal				\$426,444
Contingency		35%		\$149,260
Opinion of Probable Construction Cost (rounded)				\$580,000
Feasibility and Site Studies		9% of OPCC		\$53,000
Preliminary and Final Design		9% of OPCC		\$53,000
Engineering Services During Construction		5% of OPCC		\$29,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$0
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$0
Capital Improvement Plan Total				\$720,000

Table G-8 – Monfort Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	1,458	\$172/LF	\$250,983	\$250,983
Tier 1 Dewatering	200	\$105/LF	\$21,000	\$21,000
Unit Cost Subtotal				\$271,983
Erosion Control/Stormwater Pollution Prevention		2%		\$5,440
Mobilization & Demobilization		5%		\$13,599
Subtotal				\$291,022
Contingency		35%		\$101,860
Opinion of Probable Construction Cost (rounded)				\$400,000
Feasibility and Site Studies		9% of OPCC		\$36,000
Preliminary and Final Design		9% of OPCC		\$36,000
Engineering Services During Construction		5% of OPCC		\$20,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$0
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$0
Capital Improvement Plan Total				\$500,000

Table G-9 – Twin Rivers Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	5,574	\$172/LF	\$959,519	\$959,519
Tier 1 Dewatering	256	\$105/LF	\$26,880	\$26,880
Tier 2 Dewatering	5,318	\$52.50/LF	\$279,195	\$279,195
Unit Cost Subtotal				\$1,265,594
Erosion Control/Stormwater Pollution Prevention		2%		\$25,312
Mobilization & Demobilization		5%		\$63,280
Subtotal				\$1,354,185
Contingency		35%		\$473,970
Opinion of Probable Construction Cost (rounded)				\$1,830,000
Easement		5% of OPCC		\$92,000
Feasibility and Site Studies		6% of OPCC		\$110,000
Preliminary and Final Design		6% of OPCC		\$110,000
Engineering Services During Construction		5% of OPCC		\$92,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$92,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$55,000
Capital Improvement Plan Total				\$2,390,000

Table G-10 – SA-38 1st Ave. Pond OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	4,558	\$172/LF	\$784,623	\$784,623
Water Distribution 8" (Trenchless HDD)	350	\$585/LF	\$204,582	\$204,582
Pump Station - 260 gpm	1	LS	\$604,548	\$604,548
New Pond	0.55	\$60,964/AF	\$33,253	\$33,253
Tier 1 Dewatering	807	\$105/LF	\$84,735	\$84,735
Tier 2 Dewatering	3,751	\$52.50/LF	\$196,928	\$196,928
Unit Cost Subtotal				\$1,908,669
Erosion Control/Stormwater Pollution Prevention		2%		\$38,173
Mobilization & Demobilization		5%		\$95,433
Subtotal				\$2,042,276
Contingency		35%		\$714,800
Opinion of Probable Construction Cost (rounded)				\$2,760,000
Easement		5% of OPCC		\$138,000
Feasibility and Site Studies		6% of OPCC		\$166,000
Preliminary and Final Design		6% of OPCC		\$166,000
Engineering Services During Construction		5% of OPCC		\$138,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$138,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$83,000
Capital Improvement Plan Total				\$3,590,000

Table G-11 – SA-25 Westgate Regional PS OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 860 gpm	1	LS	\$1,323,329	\$1,323,329
New Pond	2.40	\$60,964/AF	\$146,386	\$146,386
Unit Cost Subtotal				\$1,469,716
Erosion Control/Stormwater Pollution Prevention		2%		\$29,394
Mobilization & Demobilization		5%		\$73,486
Subtotal				\$1,572,596
Contingency		35%		\$550,410
Opinion of Probable Construction Cost (rounded)				\$2,130,000
Feasibility and Site Studies		6% of OPCC		\$128,000
Preliminary and Final Design		6% of OPCC		\$128,000
Engineering Services During Construction		5% of OPCC		\$107,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$107,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$64,000
Capital Improvement Plan Total				\$2,670,000

Table G-12 – SA-25 Westgate Regional Phase 1 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,527	\$172/LF	\$607,144	\$607,144
Tier 1 Dewatering	100	\$105/LF	\$10,500	\$10,500
Unit Cost Subtotal				\$617,644
Erosion Control/Stormwater Pollution Prevention		2%		\$12,353
Mobilization & Demobilization		5%		\$30,882
Subtotal				\$660,880
Contingency		35%		\$231,310
Opinion of Probable Construction Cost (rounded)				\$900,000
Easement		5% of OPCC		\$45,000
Feasibility and Site Studies		9% of OPCC		\$81,000
Preliminary and Final Design		9% of OPCC		\$81,000
Engineering Services During Construction		5% of OPCC		\$45,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$0
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$0
Capital Improvement Plan Total				\$1,160,000

Table G-13 – SA-60 Lake Bluffs OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,424	\$172/LF	\$589,414	\$589,414
Water Distribution 8" (Trenchless J&B)	250	\$478/LF	\$119,521	\$119,521
Water Distribution 10"	3,786	\$178/LF	\$674,517	\$674,517
Pump Station - 1,120 gpm	1	LS	\$1,573,250	\$1,573,250
New Pond	4.25	\$60,964/AF	\$258,879	\$258,879
Unit Cost Subtotal				\$3,215,581
Erosion Control/Stormwater Pollution Prevention		2%		\$64,312
Mobilization & Demobilization		5%		\$160,779
Subtotal				\$3,440,672
Contingency		35%		\$1,204,240
Opinion of Probable Construction Cost (rounded)				\$4,650,000
Easement		5% of OPCC		\$233,000
Feasibility and Site Studies		6% of OPCC		\$279,000
Preliminary and Final Design		6% of OPCC		\$279,000
Engineering Services During Construction		5% of OPCC		\$233,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$233,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$140,000
Capital Improvement Plan Total				\$6,050,000

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Appendix H

20-Year Opinion of Probable Construction and Capital Improvement Plan Costs

OPCCs and CIP total estimates for 20-Year recommended CIP Projects are presented below in **Table H-1** through **Table H-11**. The estimated cost for each line item, also known as the extended cost within a project is determined by multiplying the line item quantity times the unit cost. Each line item extended cost is added to the project total cost column to determine OPCC estimates. All costs are August 2020 dollars from ENR-CCI.

Table H-1 – SA-34 30th St./17th Ave. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 1,000 gpm	1	LS	\$1,460,713	\$1,460,713
New Pond	2.14	\$60,964/AF	\$130,246	\$130,246
Unit Cost Subtotal				\$1,590,959
Erosion Control/Stormwater Pollution Prevention		2%		\$31,819
Mobilization & Demobilization		5%		\$79,548
Subtotal				\$1,702,326
Contingency		35%		\$595,820
Opinion of Probable Construction Cost (rounded)				\$2,300,000
Feasibility and Site Studies		6% of OPCC		\$138,000
Preliminary and Final Design		6% of OPCC		\$138,000
Engineering Services During Construction		5% of OPCC		\$115,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$115,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$69,000
Capital Improvement Plan Total				\$2,880,000

Table H-2 Boomerang Regional Phase 3 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 16"	15,382	\$224/LF	\$3,444,104	\$3,444,104
Tier 2 Dewatering	15,382	\$52.50/LF	\$807,555	\$807,555
Unit Cost Subtotal				\$4,251,659
Erosion Control/Stormwater Pollution Prevention		2%		\$85,033
Mobilization & Demobilization		5%		\$212,583
Subtotal				\$4,549,275
Contingency		35%		\$1,592,250
Opinion of Probable Construction Cost (rounded)				\$6,150,000
Easement		5% of OPCC		\$308,000
Feasibility and Site Studies		6% of OPCC		\$369,000
Preliminary and Final Design		6% of OPCC		\$369,000
Engineering Services During Construction		5% of OPCC		\$308,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$308,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$185,000
Capital Improvement Plan Total				\$8,000,000

Table H-3 – SA-4 35th Ave./O St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 280 gpm	1	LS	\$634,613	\$634,613
New Pond	0.86	\$60,964/AF	\$52,560	\$52,560
Unit Cost Subtotal				\$687,172
Erosion Control/Stormwater Pollution Prevention		2%		\$13,743
Mobilization & Demobilization		5%		\$34,359
Subtotal				\$735,274
Contingency		35%		\$257,350
Opinion of Probable Construction Cost (rounded)				\$1,000,000
Feasibility and Site Studies		6% of OPCC		\$60,000
Preliminary and Final Design		6% of OPCC		\$60,000
Engineering Services During Construction		5% of OPCC		\$50,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$0
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$0
Capital Improvement Plan Total				\$1,170,000

Table H-4 – SA-3 35th Ave./AA St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 620 gpm	1	LS	\$1,068,076	\$1,068,076
New Pond	2.33	\$60,964/AF	\$141,861	\$141,861
Unit Cost Subtotal				\$1,209,937
Erosion Control/Stormwater Pollution Prevention		2%		\$24,199
Mobilization & Demobilization		5%		\$60,497
Subtotal				\$1,294,633
Contingency		35%		\$453,130
Opinion of Probable Construction Cost (rounded)				\$1,750,000
Feasibility and Site Studies		6% of OPCC		\$105,000
Preliminary and Final Design		6% of OPCC		\$105,000
Engineering Services During Construction		5% of OPCC		\$87,500
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$87,500
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$53,000
Capital Improvement Plan Total				\$2,190,000

Table H-5 – Bittersweet Park Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	6,296	\$172/LF	\$1,083,805	\$1,083,805
Water Distribution 8" (Trenchless J&B)	600	\$478/LF	\$286,851	\$286,851
Tier 1 Dewatering	200	\$105/LF	\$21,000	\$21,000
Tier 2 Dewatering	6,696	\$52.50/LF	\$351,540	\$351,540
Unit Cost Subtotal				\$1,743,196
Erosion Control/Stormwater Pollution Prevention		2%		\$34,864
Mobilization & Demobilization		5%		\$87,160
Subtotal				\$1,865,220
Contingency		35%		\$652,830
Opinion of Probable Construction Cost (rounded)				\$2,520,000
Feasibility and Site Studies		6% of OPCC		\$152,000
Preliminary and Final Design		6% of OPCC		\$152,000
Engineering Services During Construction		5% of OPCC		\$126,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$126,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$75,600
Capital Improvement Plan Total				\$3,160,000

Table H-6 – SA-35 44th Ave./F St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 820 gpm	1	LS	\$1,282,689	\$1,282,689
New Pond	2.34	\$60,964/AF	\$142,566	\$142,566
Unit Cost Subtotal				\$1,425,256
Erosion Control/Stormwater Pollution Prevention		2%		\$28,505
Mobilization & Demobilization		5%		\$71,263
Subtotal				\$1,525,023
Contingency		35%		\$533,760
Opinion of Probable Construction Cost (rounded)				\$2,060,000
Feasibility and Site Studies		6% of OPCC		\$124,000
Preliminary and Final Design		6% of OPCC		\$124,000
Engineering Services During Construction		5% of OPCC		\$103,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$103,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$62,000
Capital Improvement Plan Total				\$2,580,000

Table H-7 – SA-36 59th Ave./10th St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	134	\$172/LF	\$23,067	\$23,067
Water Distribution 10"	8,754	\$178/LF	\$1,559,620	\$1,559,620
Water Distribution 10" (Trenchless J&B)	400	\$581/LF	\$232,590	\$232,590
Pump Station - 1,580 gpm	1	LS	\$1,970,903	\$1,970,903
New Pond	3.40	\$60,964/AF	\$207,115	\$207,115
Tier 1 Dewatering	900	\$105/LF	\$94,500	\$94,500
Tier 2 Dewatering	8,388	\$52.50/LF	\$440,370	\$440,370
Unit Cost Subtotal				\$4,528,165
Erosion Control/Stormwater Pollution Prevention		2%		\$90,563
Mobilization & Demobilization		5%		\$226,408
Subtotal				\$4,845,137
Contingency		35%		\$1,695,800
Opinion of Probable Construction Cost (rounded)				\$6,550,000
Feasibility and Site Studies		6% of OPCC		\$393,000
Preliminary and Final Design		6% of OPCC		\$393,000
Engineering Services During Construction		5% of OPCC		\$327,500
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$327,500
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$197,000
Capital Improvement Plan Total				\$8,190,000

Table H-8 – SA-16 95th Ave./16th St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	4,640	\$178/LF	\$826,666	\$826,666
Pump Station - 1,220 gpm	1	LS	\$1,663,880	\$1,663,880
New Pond	3.99	\$60,964/AF	\$243,309	\$243,309
Tier 1 Dewatering	575	\$105/LF	\$60,375	\$60,375
Unit Cost Subtotal				\$2,794,230
Erosion Control/Stormwater Pollution Prevention		2%		\$55,885
Mobilization & Demobilization		5%		\$139,711
Subtotal				\$2,989,826
Contingency		35%		\$1,046,440
Opinion of Probable Construction Cost (rounded)				\$4,040,000
Easement		5% of OPCC		\$202,000
Feasibility and Site Studies		6% of OPCC		\$243,000
Preliminary and Final Design		6% of OPCC		\$243,000
Engineering Services During Construction		5% of OPCC		\$202,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$202,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$122,000
Capital Improvement Plan Total				\$5,260,000

Table H-9 – SA-14 Tech Center Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 16"	8,221	\$224/LF	\$1,840,722	\$1,840,722
Unit Cost Subtotal				\$1,840,722
Erosion Control/Stormwater Pollution Prevention		2%		\$36,814
Mobilization & Demobilization		5%		\$92,036
Subtotal				\$1,969,572
Contingency		35%		\$689,360
Opinion of Probable Construction Cost (rounded)				\$2,660,000
Easement		5% of OPCC		\$133,000
Feasibility and Site Studies		6% of OPCC		\$160,000
Preliminary and Final Design		6% of OPCC		\$160,000
Engineering Services During Construction		5% of OPCC		\$133,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$133,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$80,000
Capital Improvement Plan Total				\$3,460,000

Table H-10 – SA-15 37th St./SH-257 Pump Station OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Pump Station - 1,400 gpm	1	LS	\$1,820,808	\$1,820,808
New Pond	5.33	\$60,964/AF	\$325,186	\$325,186
Unit Cost Subtotal				\$2,145,994
Erosion Control/Stormwater Pollution Prevention		2%		\$42,920
Mobilization & Demobilization		5%		\$107,300
Subtotal				\$2,296,213
Contingency		35%		\$803,680
Opinion of Probable Construction Cost (rounded)				\$3,100,000
Feasibility and Site Studies		6% of OPCC		\$186,000
Preliminary and Final Design		6% of OPCC		\$186,000
Engineering Services During Construction		5% of OPCC		\$155,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$155,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$93,000
Capital Improvement Plan Total				\$3,880,000

Table H-11 – SA-12 Cobblestone Regional OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 10"	2,023	\$178/LF	\$360,419	\$360,419
Pump Station - 1,180 gpm	1	LS	\$1,627,947	\$1,627,947
New Pond	4.44	\$60,964/AF	\$270,436	\$270,436
Unit Cost Subtotal				\$2,258,802
Erosion Control/Stormwater Pollution Prevention		2%		\$45,176
Mobilization & Demobilization		5%		\$112,940
Subtotal				\$2,416,918
Contingency		35%		\$845,930
Opinion of Probable Construction Cost (rounded)				\$3,270,000
Easement		5% of OPCC		\$164,000
Feasibility and Site Studies		6% of OPCC		\$196,200
Preliminary and Final Design		6% of OPCC		\$196,200
Engineering Services During Construction		5% of OPCC		\$164,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$164,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$99,000
Capital Improvement Plan Total				\$4,260,000

Table H-12 – Glenmere Park Expansion OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	4,136	\$172/LF	\$711,979	\$711,979
Water Distribution 8" (Trenchless J&B)	100	\$478/LF	\$47,808	\$47,808
Pond Expansion	2.91	\$60,964/AF	\$177,404	\$177,404
Tier 1 Dewatering	143	\$105/LF	\$15,015	\$15,015
Tier 2 Dewatering	4,093	\$52.50/LF	\$214,883	\$214,883
Unit Cost Subtotal				\$1,167,089
Erosion Control/Stormwater Pollution Prevention		2%		\$23,342
Mobilization & Demobilization		5%		\$58,354
Subtotal				\$1,248,785
Contingency		35%		\$437,080
Opinion of Probable Construction Cost (rounded)				\$1,690,000
Easement		5% of OPCC		\$85,000
Feasibility and Site Studies		6% of OPCC		\$102,000
Preliminary and Final Design		6% of OPCC		\$102,000
Engineering Services During Construction		5% of OPCC		\$85,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$85,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$51,000
Capital Improvement Plan Total				\$2,200,000

Table H-13 – SA-25 Westgate Regional Phase 2 OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	3,782	\$172/LF	\$651,041	\$651,041
Unit Cost Subtotal				\$651,041
Erosion Control/Stormwater Pollution Prevention		2%		\$13,021
Mobilization & Demobilization		5%		\$32,552
Subtotal				\$696,613
Contingency		35%		\$243,820
Opinion of Probable Construction Cost (rounded)				\$950,000
Easement		5% of OPCC		\$48,000
Feasibility and Site Studies		9% of OPCC		\$86,000
Preliminary and Final Design		9% of OPCC		\$86,000
Engineering Services During Construction		5% of OPCC		\$48,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$0
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$0
Capital Improvement Plan Total				\$1,220,000

Table H-14 – SA-42 23rd Ave./Northwest C St. OPCC and CIP Total

Item	Quantity	Unit Cost	Extended Cost	Total Cost
Water Distribution 8"	5,924	\$172/LF	\$1,019,769	\$1,019,769
Water Distribution 8" (Trenchless J&B)	150	\$478/LF	\$71,713	\$71,713
Pump Station - 1,180 gpm	1	LS	\$1,627,947	\$1,627,947
New Pond	2.75	\$60,964/AF	\$167,555	\$167,555
Tier 1 Dewatering	41	\$105/LF	\$4,305	\$4,305
Tier 2 Dewatering	5,883	\$52.50/LF	\$308,858	\$308,858
Unit Cost Subtotal				\$3,200,146
Erosion Control/Stormwater Pollution Prevention		2%		\$64,003
Mobilization & Demobilization		5%		\$160,007
Subtotal				\$3,424,156
Contingency		35%		\$1,198,460
Opinion of Probable Construction Cost (rounded)				\$4,630,000
Easement		5% of OPCC		\$232,000
Feasibility and Site Studies		6% of OPCC		\$278,000
Preliminary and Final Design		6% of OPCC		\$278,000
Engineering Services During Construction		5% of OPCC		\$232,000
Outside Construction Management - not used if OPCC value is < \$1M		5% of OPCC		\$232,000
Outside Project Management - not used if OPCC value is < \$1M		3% of OPCC		\$139,000
Capital Improvement Plan Total				\$6,030,000

Appendix I

CIP Development

I.1.1 Variability in Data

Data was obtained from past contractor bidding information provided by the City and other Front Range communities, as well as national sources. This data included unit costs for different potential capital expenditures within wastewater, water, and NP projects. The data varied in level of detail and definition of each cost element. For example, pipeline costs may or may not include dewatering, restoration, or paving project sites. Pipe cost data from the different sources also varied by construction depth, ground conditions, and method of installation for pipeline. For example, one data source may have identified unit price for a given pipe diameter size at a given depth, while another data source provided unit costs for given pipe diameter sizes of various depths within developed or undeveloped land areas. Both data sources provide information regarding pipe installation costs but need to be considered based on the level of detail that is desired for project CIP development.

I.1.2 Unknown Elements and Assumptions

Assumptions made during CIP development mean planning level costs will vary from construction bid costs. The assumptions are necessary to capture costs for project elements that cannot be defined at the planning level. Examples of undefinable costs include dewatering areas, utility pipeline crossings, permitting for project implementation, final contractor bid quantities, seasonal soil and ground conditions, and stormwater management of project sites. Assumptions are also made for method of pipe installation, timing of projects, and materials of construction. During design development, additional field information including survey, geotechnical data, groundwater levels, traffic control requirements, and final pipe alignment of project areas should be available to help refine the project elements and construction methods.

Trendlines and linear interpolation were used to develop costs for project elements with insufficient data. For example, cost data was obtained for the trenchless installation of water distribution and transmission lines for 4 inch through 60-inch diameter pipe, however there was limited cost information for 36-inch pipe. Trend line equations for linear, polynomial, and logarithmic and their respective R² values were compared to identify the most probable estimation equation. In this case, the trendline equation with an R² value closest to 1 was selected as the most probable estimation equation. Because the trendline with the most pertinent R² value may not reflect the true cost, CDM Smith recommends the City readjust cost data throughout the planning horizon.

An example of comparing different trend line equations and their respective R² values for approximating missing data is shown in **Figure I-1**. This example highlights the jack and bore (J&B) trenchless installation of water distribution and transmission pipeline items. In this example, the second order polynomial trend line (shown by the purple dotted line below) has the closest R² value to 1 compared to the exponential and logarithmic trend lines (shown by the blue and green dotted lines below, respectively) based on available data. As a result, without

additional industry knowledge and experience, the linear trend line would be assumed to best approximate unit costs for J&B trenchless pipe installation for pipe diameter sizes not available from the given data set. This assumption may conflict with actual J&B trenchless pipe installation data trends known in industry, which may better be approximated by exponential or logarithmic trend lines. This would especially be true when predicting trenchless pipe installation for large pipe diameter sizes (i.e., greater than 24 inch) where predictions of data points of the trend lines begin to greatly diverge. At a planning level, this limitation is acceptable when a cushion of construction cost contingency (i.e., 30%) is added to help absorb this unit cost uncertainty. However, at an engineering design level, where construction cost contingency is lowered, the chosen trend line that best reflects industry data trends should be used to model trenchless pipe installation. This should also be used for all unit cost items where trendlines are used, regardless of if the chosen trend line has an R2 value closest to 1 in order to avoid unnecessary error.

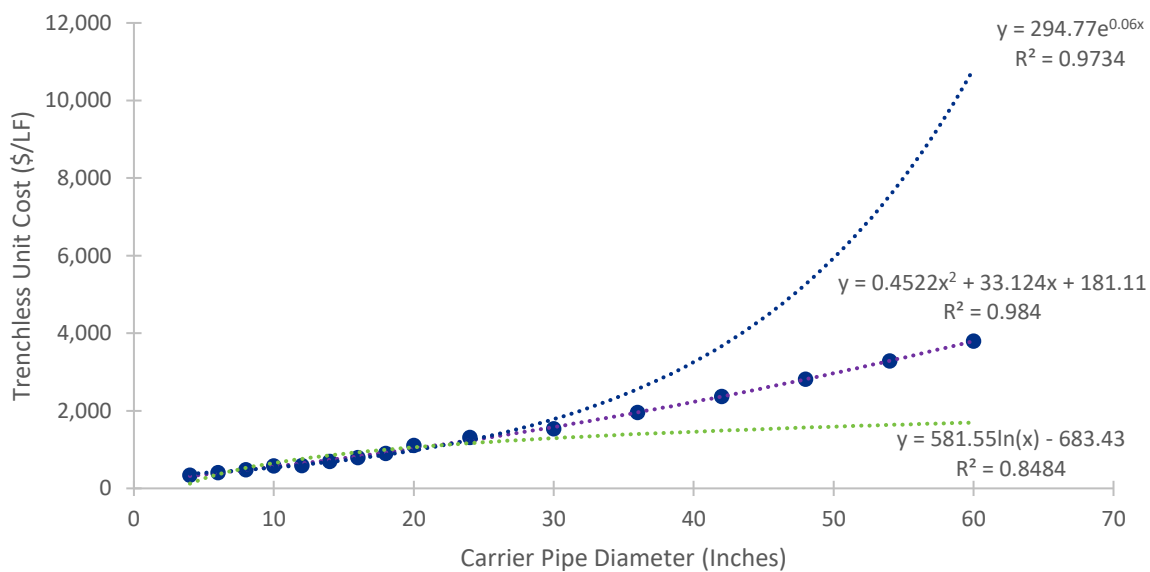


Figure I-1 Example of Different Trendlines for Finding Missing Data of a Line Item

I.1.3 Unpredictability

There is inherent unpredictability to consider during CIP development. This unpredictability is captured in the cost range that is provided for the overall CIP. Examples of unpredictability include future economic trends and inflation rates. Prior to COVID-19, a global pandemic, cost inflation tools provided high confidence for predicting unit prices within a given year. However, after COVID-19, these cost inflation tools may not prove to be as accurate.

I.1.4 Data Sources

Major sources for cost factors included city bid tabs and databases, past project data and contractor construction bid tabs, vendor quotes and cost estimates from CDM Smith's estimating department. A list of external sources that CDM Smith used to develop unit costs for the City's CIP water transmission and distribution cost estimates includes the following:

- City of Greeley Project Initiation Form (City of Greeley, 2021)
- Operation Rehab Project 2021 – 2025 Spreadsheet (City of Greeley, 2021)
- Water and Sewer Department 10 Year CIP 2021 – 2030 Spreadsheet (City of Greeley, 2021)
- Collection, Distributions, Transmission Projects Phase I – (CMAR) (City of Greeley, 2019)
- City of Greeley Pipe Rehabilitation Cost Estimating Template (City of Greeley, 2019)
- Keep Greeley Moving Phase 2 by Neighborhood 2023 – 2029 (City of Greeley, 2021)
- City of Aurora Wastewater Master Plan (AECOM, 2017)

The data was compiled in a single file with line item data reflected as unit costs (dollars per linear foot, dollars per each, etc.). When needed, unit costs for specific line items were calculated using trend line equations. Line items that were not specific or harder to estimate using specific unit cost quantity were reflected as a percentage addition to project costs (mobilization and demobilization, erosion control and stormwater pollution prevention, etc.).

The costs estimated for each project are in August 2020 dollars. Historical data was adjusted to the equivalent August 2020 data by using Engineering News Record's 20-City Construction Cost Index (ENR-CCI). ENR estimates a project each month in 20 different cities around the U.S. and calculates the composite index. Costs are adjusted by multiplying a cost element with the ratio of the current day 20-City ENR-CCI and date of data.

$$\text{Construction Unit Cost (T2)} = \text{Construction Cost (T1)} \times \frac{\text{CCI(T2)}}{\text{CCI(T1)}}$$

T2 and T1 reflect the desired projected year and month desired and the originally year and month of unit costs, respectively.

I.1.5 Major Cost Elements

NP water distribution system CIP costs were developed using five general cost element categories, as shown in **Figure I-2** and described below.



Figure I-2 CIP Categories for Cost Definition

Each of these cost elements is discussed in more detail in the following subsections. Unit priced line items, mobilization and demobilization, and stormwater pollution prevention and erosion control was rounded to the nearest whole dollar. Project contingency was rounded to the nearest \$10 and added to the OPCC subtotals to determine the OPCC project totals which were rounded to the nearest \$10,000. Subsequent costing factors were added to the OPCC project totals to determine CIP estimates used for high-level planning of water transmission and distribution, sewer, and NP master plans.

I.1.6 Pipeline, Pump Stations, & Ponds

Installation of Pipe

NP water lines were generally assumed to be installed using open cut construction. Open cut construction is where contractors remove surface soils to insert pipe, except for arterial roadway and highway, railroad, irrigation ditch, river, and lake crossings. In such instances, trenchless pipe installation was assumed which inserts pipe through tunneling and boring, J&B, or horizontal direct drilling (HDD) methods. Open cut pipeline installation unit costs (in dollars per linear foot of pipe, \$/LF) include the pipe and bedding, excavation, installation including traffic control, tie-ins for service laterals, backfill, restoration, and flow and throttle control valves. Distribution pipelines were classified with pipe diameters up to 20 inch while transmission lines were classified with pipe diameters 24 inch and above.

The open cut installation was divided into developed and undeveloped categories. The developed category includes pipe installed in developed areas such as in neighborhoods, along major City streets, across two lane roads, through developed commercial property and designated agricultural land, and around City boundaries. The undeveloped category was assigned to pipe installed in permanent open space designated as city parks. It was assumed that all NP water lines were installed at less than 10 ft depth unless using trenchless installation for crossings.

Trenchless installation costs (in \$/LF of pipe) include the casing and carrier pipe, supports and grouting of the interstitial space, launching and receiving pits, and ground monitoring using J&B drilling or HDD. Unit prices were developed using bid tabs and CDM Smith's construction cost data base.

Table I-1 gives the unit cost breakdown for installation of NP water lines.

Table I-1 – Unit Costs for NP Lines

Pipe Diameter Size (In.)	Unit Cost (\$/LF of Pipe)			
	Undeveloped Land Designation	Developed Land Designation	Trenchless J&B (Crossings)	Trenchless HDD (River Crossings)
8	119	172	478	585
12	131	184	584	803
16	158	224	791	944
18	171	256	897	1,023
20	184	289	1,105	1,107
24	211	315	1,314	1,272
30	237	368	1,531	1,530
36	264	421	1,960	1,796
42	302	486	2,370	2,054
48	355	566	2,813	2,312
54	395	657	3,288	2,570
60	460	763	3,796	2,827

Pump Stations

Construction costs of new pump stations were developed using Chapter 29 of *Pumping Station Design, Revised 3rd Ed.* (Jones et al. 2006). High and low trend line estimates were averaged based on 2006 cost projections and then projected to the inflated August 2020 equivalents. The cost estimates only include construction of new pump station infrastructure including enclosures, wet wells, instrumentation, electrical, and pumps. The updated August 2020 high, low, and averaged pump station equations are shown below:

$$\text{Low Limit New PS Cost(\$)} = \$2,367 \times \text{PS Flow Rate (gpm)}^{0.77}$$

$$\text{High Limit New PS Cost(\$)} = \$33,648 \times \text{PS Flow Rate (gpm)}^{0.62}$$

$$\text{Averaged Limit New PS Cost(\$)} = \$15,844 \times \text{PS Flow Rate (gpm)}^{0.66}$$

Figure I-3 depicts the comparison of the three equations used for new pump station construction estimates. This master plan assumes all new pump stations costs using the averaged pump station equation.

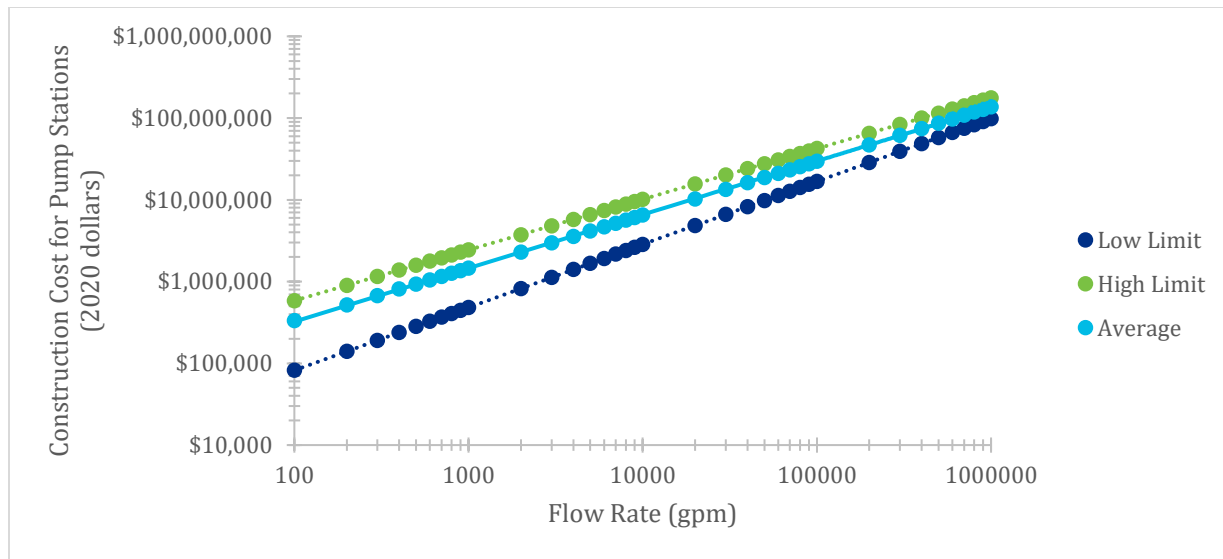


Figure I-3 Pump Station Design High, Low, and Averaged Estimated Construction Costs (Jones et al. 2006)

Ponds

Construction costs for either ponds to accommodate additional storage, or the installation of new ponds, assumed the installation cost of new ponds as a conservative estimate. Pond replacement and new pond installation in \$/AF included costs for pond excavation, subgrade, pond liners and fabric, covering of soil over lake bottom, rip rap, and aeration systems. Pond sizing (in AF) for each project was estimated on future buildout conditions identified in the future system model.

I.1.7 Crossings, Land Considerations, and Dewatering

Irrigation Ditch, River Crossings, and Lake Crossings

ArcMap GIS and City-provided information was used to identify irrigation ditch, river, and lake crossing locations. Irrigation ditch, river, and lake crossings were assumed as 100 ft in length, 250 ft in length, and estimated lake crossing length, respectively. Unit costs for irrigation ditch, river, and lake crossings were approximated by trenchless pipe installation, regardless of pipe depth, using J&B for ditch crossings and HDD drilling for river and lake crossings.

Utility, Roadway, and Railway Crossings

ArcMap GIS, the City's online GIS, and Google Maps were used to identify road, utility, and railroad crossings. Unit prices were developed assuming installation by J&B, where applicable, using the following assumptions:

- Roads were separated into typical (defined as: two to three lane roads located on side streets and in neighborhoods), arterial (defined as: major roadways of four lanes or more assumed at 200 ft wide), and highways (defined as: major roadways with Colorado Department of Transportation Right-of-way requirements at 250 ft wide). Widths were based on the U.S. Department of Transportation Federal Highway Administration (USDOT, 2014). Typical road crossings were included as part of overall open cut installation

described in **Section I.3.3**, while arterial road and highway crossings were accounted as a part of trenchless pipe installation costs described in **Section I.2.2**.

- Railway crossings were estimated as 150 ft in length included in trenchless installation costs, described in **Section I.2.2**.
- Other City and non-City utilities were not included as unit cost estimates but assumed to be covered under project contingency, described in **Section 5.3.5**.

Easements

Easement acquisition was assumed to be required for all new pipeline, not in a City right-of-way or on City-owned property. Easement acquisition was assumed as a costing factor multiplier of the total OPCC at 5%.

Dewatering

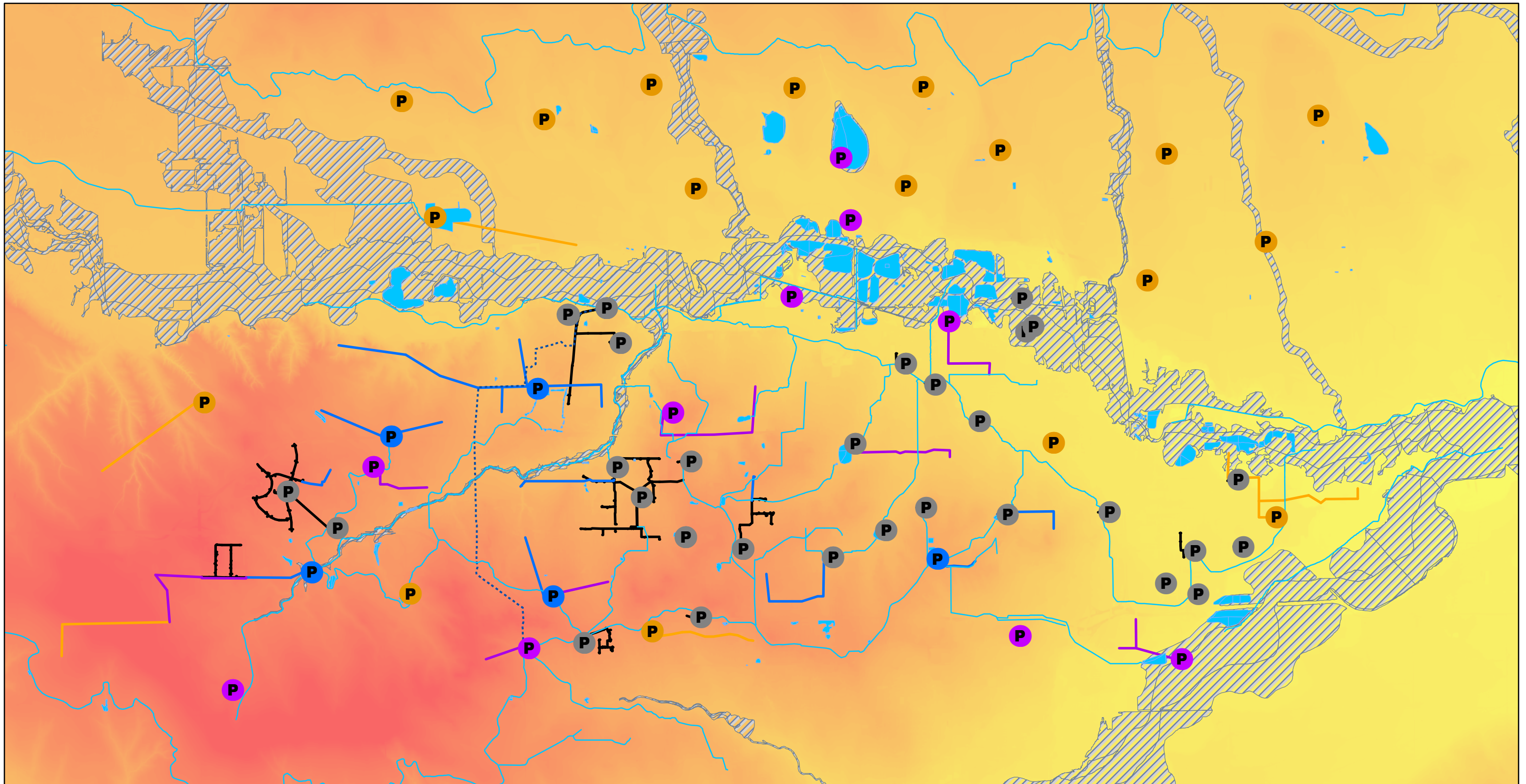
A three-tiered approach was used to determine projected dewatering. The three tiers used for unit cost estimation were developed considering land elevations in and around the City (between approximately 4,600 ft to 5,060 ft), 100-year floodplain maps, and proximity to irrigation ditches and water bodies. Tier 1 includes water distribution and transmission line construction within the 100-year floodplain or within 50 ft of an irrigation ditch, pond, or lake. Tier 2 includes pipe that is not in Tier 1, is below the median elevation of the City (4,828 ft), and is assumed to require 50% of the dewatering needed for Tier 1. Tier 3 includes pipe in areas above the median elevation and assumes no dewatering is required.

Figure I-4 illustrates the three-tiered dewatering profile. **Table I-2** lists the unit costs developed for the three-tiered dewatering categories in \$/LF of pipe.

Table I-2 – Unit Costs for Dewatering by Tier

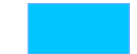
Tier	Unit Cost (\$/LF of Pipe)
1	105
2	52.50
3	0

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Legend

Tier 1

-  100-yr FloodPlain
-  Lake
-  Greeley Ditch

Tier 2

-  4828 ft
-  4596 ft

Tier 3

-  5059 ft
-  4828 ft



Existing Pump Station



2025 Pump Station



2040 Pump Station



Buildout Pump Station

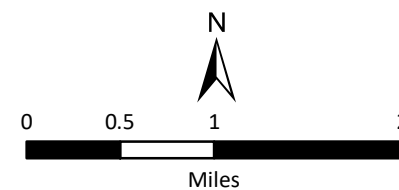
Existing NP Pipes

2025 Proposed NP Pipes

2040 Proposed NP Pipes

Buildout Proposed NP Pipes

Upper Equalizer Project



3-Tiered Dewatering Profile

Figure I-4

Greeley Non-Potable Water
System Master Plan

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1.1.8 Project Implementation and Additional Project-Related Costs

Project elements considered part of project implementation as well as additional project related costs are difficult to quantify at the planning level. Construction elements include items such as erosion control and stormwater pollution prevention and contractor mobilization and demobilization. These costs are estimated as a percentage of the subtotal pipe, pump stations, ponds, and equipment. Contingency is applied to the subtotal of these construction cost elements to account for variations in unit prices or quantity estimates. Programmatic elements include engineering, permitting, legal and administration and are estimated as a percentage of the construction cost.

Table I-3 provides a breakdown of the different assumptions used for project implementation and contingency.

Table I-3 – Costing Factors for Construction Bid and Total CIP Project Costs

Category	Item	Costing Factor
Construction Bid Cost (includes infrastructure and contractor overhead, profit, bonds, and insurance)	Erosion Control/Stormwater Pollution Prevention ¹	2%
	Mobilization and Demobilization ¹	5%
	Contingency ²	35%
Project Implementation ³	Feasibility and Site Studies	9% for OPCC ≤ \$1M 6% for OPCC of \$1M to \$10 Mil. 5% for OPCC > \$10M
	Preliminary and Final Design	9% for OPCC ≤ \$1M 6% for OPCC of \$1M to \$10M 5% for OPCC > \$10M
	Engineering Services During Construction	5%
Additional Project-Related Costs ³	Outside Construction Management - not used if project value is < \$1M	5%
	Outside Project Management - not used if project value is < \$1M	3%

¹ Construction Bid Cost costing factors erosion control/stormwater pollution prevention and mobilization and demobilization are added to the subtotal of unit cost items.

² Contingency costing factor is 35% of the subtotal of the unit cost items and contractor born costs determined by costing factors.

³ Project Implementation and Additional Project-Related Cost categories are determined as a percentage of the construction cost and part of the total CIP project costs.

Project Erosion Control/Stormwater Pollution Prevention

The Project Erosion Control and Stormwater Pollution Prevention cost element includes the contractors cost to manage the stormwater during construction through best management practices. These best management practices include items such as silt fences, rock socks, vehicle tracking, and silt prevention at storm inlets. This category is assumed as 2% of the OPCC subtotal of the items that have unit costs and is based on estimator's judgement and prior reports. This costing factor is added to calculate project OPCC totals.

Mobilization and Demobilization

The Contractor Mobilization and Demobilization cost element includes the contractor's start-up costs and close-out costs. Start-up costs include items such as moving equipment and personnel to the project location, obtaining permits and bonds, etc. Close-out costs include items such as project cleanup, moving equipment and personnel from the project location, etc. The mobilization and demobilization category is assumed as 5% of the OPCC subtotal of the items that have unit costs and is based on estimator's judgement and prior reports. This costing factor is added to calculate project OPCC totals.

Contingency

During the planning phase, the field work and design have not yet been completed for the projects. Therefore, the cost development relies on estimated quantities for each construction element. Project contingency provides for these uncertainties by adding additional costs to the project total. The contingency at the planning level is typically 35% of the OPCC subtotal, after erosion control and stormwater pollution prevention and mobilization and demobilization costing factors have been included. Project contingency also provides for cost associated with items that are difficult to itemize at a planning level.

Feasibility and Site Studies

The Feasibility and Site Studies cost element includes the planning and field investigations (such as geotechnical, survey, ground sampling, utility locates, etc.) required to implement a project and is estimated as a percentage of the subtotal of the previous elements. The percentage varies based on the OPCC, plus cost contingency.

Preliminary and Final Design

The Preliminary and Final Design cost element includes the cost for engineering services to develop biddable plans and specifications in accordance with applicable standards. This cost is estimated using a percentage of the OPCC, plus cost contingency.

Engineering Services During Construction

The Engineering Services During Construction cost element includes a review of contractor submittals, requested changes, and design adjustments that may be required during construction. A flat percentage of the OPCC is used to estimate this cost element.

Additional Project-Related Costs

Outside construction and project management are estimated for projects that are not directly managed by the City. For purposes of this master plan, only projects in excess of \$1M were assigned these cost elements.

Appendix J

Annual Funding Requirements for City NP CIP Projects (2020 – 2043)

Annual funding requirements per identified City NP CIP project and fiscal year totals are shown in the following table. It was assumed that each project stage (planning, design, and construction) will take at least one year with the construction phase taking two, three, or four years if the total CIP cost for a project was greater than \$1 million, \$5 million, or \$10 million, respectively.

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Appendix J – Annual Funding Requirements for City NP CIP Projects (2020-2043)

W/S Expense		Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Project Names		Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
SA44 Centennial Park		2020	2021	2022	\$ 167,819	\$ 167,819	\$ 1,050,140	\$ 1,050,140	\$ 1,050,140	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Boomerang Regional PS		2021	2021	2022	\$ -	\$ 21,239	\$ 66,637	\$ 66,637	\$ 66,637	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Boomerang Regional Phase 2		2021	2021	2022	\$ -	\$ 9,980	\$ 31,089	\$ 31,089	\$ 31,089	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Greeley West PS		2021	2022	2023	\$ -	\$ 296,110	\$ 296,110	\$ 1,855,015	\$ 1,855,015	\$ 1,855,015	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Upper Equalizer		2022	2023	2024	\$ -	\$ -	\$ 2,002,000	\$ 1,001,000	\$ 5,653,000	\$ 5,653,000	\$ 5,653,000	\$ 5,653,000	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Tech Center Supply		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Prom Park Exp		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA38 1st Ave Pond		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ 244,011	\$ 133,243	\$ 1,251,763	\$ 1,251,763	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Twin Rivers Exp		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ 25,607	\$ 25,607	\$ 298,748	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Monfort Exp		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ 246,259	\$ 134,412	\$ 842,610	\$ 842,610	\$ 842,610	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA-25 Westgate Reg. Phase 1		2025	2026	2027	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA60 Lake Bluffs		2025	2026	2027	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,205	\$ 1,205	\$ 11,339	\$ 11,339	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA25 Westgate Reg. PS		2025	2026	2027	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 390,887	\$ 213,003	\$ 1,337,312	\$ 1,337,312	\$ 1,337,312	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA34 30st 17Ave		2027	2028	2029	\$ -	\$ -	\$ -	\$ -	\$ 871,972	\$ -	\$ 92,599	\$ 92,599	\$ 871,972	\$ -	\$ 871,972	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA4 35 Ave Ost		2028	2029	2030	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 13,457	\$ 13,457	\$ 117,747	\$ 117,747	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Boomerang Regional Phase 3		2028	2029	2030	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 21,054	\$ 11,803	\$ 74,100	\$ 74,100	\$ 74,100	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA3 35 Ave AA st		2029	2030	2031	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Bittersweet Park Exp.		2029	2030	2031	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 82,245	\$ 82,245	\$ 774,669	\$ 774,669	\$ 774,669	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA35 44ave Fst		2030	2031	2032	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 7,980	\$ 7,980	\$ 74,909	\$ 74,909	\$ 74,909	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA36 59 ave 10st		2031	2032	2033	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 182,863	\$ 182,863	\$ 1,148,049	\$ 1,148,049	\$ 1,148,049	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA16 95ave 16st		2034	2035	2036	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 17,365	\$ 17,365	\$ 9,482	\$ 9,482	\$ 59,391	\$ 59,391	\$ 59,391	\$ -	\$ -	\$ -	\$ -	
SA14 Tech Cent Exp		2035	2036	2037	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA15 37st SH257		2036	2037	2038	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA12 Cobblestone		2037	2038	2039	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 2,128	\$ 1,161	\$ 10,875	\$ 10,875	\$ -	\$ -	
Glenmere Park Exp		2037	2038	2039	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 234,308	\$ 127,863	\$ 1,199,450	\$ 1,199,450	\$ -	\$ -	
SA25 Westgate Reg. Phase 2		2038	2039	2040	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 94,171	\$ 60,438	\$ 350,683	\$ 350,683	\$ -	
SA42 23ave Cst		2039	2040	2041	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 112,568	\$ 115,870	\$ 727,038	\$ 727,038	\$ 727,038	
Total					\$ 167,819	\$ 495,147	\$ 3,447,976	\$ 4,005,882	\$ 9,140,670	\$ 8,193,370	\$ 8,260,329	\$ 9,188,622	\$ 2,318,971	\$ 2,316,788	\$ 1,154,044	\$ 1,157,360	\$ 1,106,541	\$ 1,222,958	\$ 1,165,414	\$ 1,157,532	\$ 59,391	\$ 295,828	\$ 282,587	\$ 1,483,331	\$ 1,676,878	\$ 1,077,721	\$ 727,038	
Parks		Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
SA44 Centennial Park		2020	2021	2022	\$ 66,361	\$ 66,361	\$ 415,257	\$ 415,257	\$ 415,257	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Boomerang Regional PS		2021	2021	2022	\$ -	\$ 66,595	\$ 208,945	\$ 208,945	\$ 208,945	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Boomerang Regional Phase 2		2021	2021	2022	\$ -	\$ 31,292	\$ 103,754	\$ 103,754	\$ 103,754	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Greeley West PS		2021	2022	2023	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Upper Equalizer		2022	2023	2024	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Tech Center Supply		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Prom Park Exp		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA38 1st Ave Pond		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Twin Rivers Exp		2024	2025	2026	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA-25 Westgate Reg. Phase 1		2025	2026	2027	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA60 Lake Bluffs		2025	2026	2027	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA25 Westgate Reg. PS		2025	2026	2027	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 121,113	\$ 65,997	\$ 414,355	\$ 414,355	\$ 414,355	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA34 30st 17Ave		2027	2028	2029	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 7,934	\$ 7,934	\$ 92,564	\$ 92,564	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA4 35 Ave Ost		2028	2029	2030	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 76,301	\$ 41,646	\$ 261,075	\$ 261,075	\$ 261,075	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Boomerang Regional Phase 3		2028	2029	2030	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA3 35 Ave AA st		2029	2030	2031	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Bittersweet Park Exp.		2029	2030	2031	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA35 44ave Fst		2030	2031	2032	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 22,584	\$ 22,584	\$ 212,722	\$ 212,722	\$ 212,722	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA36 59 ave 10st		2031	2032	2033	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 31,639	\$ 31,639	\$ 296,997	\$ 296,997	\$ 296,997	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA16 95ave 16st		2034	2035	2036	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 123,299	\$ 123,299	\$ 774,098	\$ 774,098	\$ 774,098	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA14 Tech Cent Exp		2035	2036	2037	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA15 37st SH257		2036	2037	2038	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA12 Cobblestone		2037	2038	2039	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Glenmere Park Exp		2037	2038	2039	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
SA25 Westgate Reg. Phase 2		2038	2039	2040	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 98,984	\$ 54,016	\$ 506,711	\$ 506,711	\$ -	\$ -	
SA42 23ave Cst		2039	2040	2041	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 120,194	\$ 65,518	\$ 411,095	\$ 411,095	
Total					\$ 66,361	\$ 164,247	\$ 727,957	\$ 727,957	\$ 708,438	\$ 170,693	\$ 419,637	\$ 688,902	\$ 756,801	\$ 600,812	\$ 413,435	\$ 600,007	\$ 865,365	\$ 1,071,095	\$ 825,728	\$ 802,291	\$ 176,586	\$ 275,570	\$ 230,602	\$ 626,905	\$ 572,229	\$ 411,095	\$ 411,095	
Development		Planning Start Year	Design Start Year	Construction Start Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2								

¹ Refer to 5- and 20-year recommended improvements map in Section 5 for project locations

² Construction span was set based on total CIP cost estimates per project: \$10M – 4 years, \$5M – 3 years, \$1M – 2 years, < \$1M – 1 year

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Appendix K

Comprehensive Plan Action Item List

The City adopted the *Imagine Greeley Comprehensive Plan* in 2018, which is a policy guide that provides framework for public and private growth and development decisions made by the City over the next ten to twenty years. As a part of the Comprehensive Plan, a list of recommended actions was identified in Section 5 to assist in implementation of this plan. A summary of action items addressed with the development of this NPMP to ensure implementation of the Comprehensive Plan is summarized in the following table.



INFRASTRUCTURE (IN)

IMPLEMENTATION ACTION	NON-POTABLE MASTERPLAN ACTION ITEM RESPONSE
Goal IN-1: Ensure developed areas in Greeley are served by adequate public facilities and services.	
IMP IN-1.1 Annually review and update the City's Adequate Public Facilities Area (APFA) concurrent with annual growth and development projections to assist in the planning and funding of municipal infrastructure to accommodate growth. Prepare maps depicting the boundaries of existing and budgeted service areas for infrastructure included in the APFA requirements.	While the NPMP does not review or update the APFA, it identifies the critical infrastructure needed to serve all major developable areas within the LREGA (Section 5) and the anticipated CIP cost (Section 6). This masterplan will assist in planning and funding of municipal infrastructure and determine the anticipated infrastructure to meet the APFA requirements.
IMP IN-1.2 Continue to support timely and effective development in the Long Range Expected Growth Area as it relates to 208 Wastewater planning and treatment. Where possible and practical, look for opportunities to share and/or coordinate such capital improvements with other jurisdictions to efficiently use public resources.	Not Applicable
IMP IN-1.3 Through the annual Population Growth and Projections and Capital Improvements Plan, identify the location for new fire stations, parks and other public facilities commensurate with the City's expected growth.	Not Applicable
IMP IN-1.4 Complete and implement a basin-wide study that addresses drainage improvements through larger, shared, facilities which could also achieve an attractive, functional community or regional park use.	Not Applicable
IMP IN-1.5 Evaluate existing capacity within established areas of the city to understand where investments in expanding infrastructure will be needed in order to support the type and/or intensity of development envisioned in the Land Use Guidance Map	This masterplan has evaluated existing infrastructure to confirm sufficient capacity with the existing conditions, with future development of infill and densification of parcels, and full buildout as envisioned by the Land Use Guidance Map.

IMPLEMENTATION ACTION	NON-POTABLE MASTERPLAN ACTION ITEM RESPONSE
IMP IN-1.6 Update existing functional master plans for infrastructure and services as needed to account for changes in land uses and intensities that result from the adoption of this Comprehensive Plan and completion of implementation actions.	This masterplan incorporates improvements made to the NP water distribution system from the most recent masterplan completed in 2004. This masterplan has incorporated recent land use applications, utilized the Comprehensive Plan to update land uses and anticipated densities, and addressed areas outside of the 20-year plan through guidance and coordination with the Planning department.
IMP IN-1.7 Develop functional master plans detailing the maintenance, operation, and expansion of infrastructure and public facilities where such documents do not currently exist.	Not Applicable
IMP IN-1.8 Consider the extension of water lines to serve larger groups of users and along primary roadways to provide non-potable water to landscaped medians and parkways.	Not Applicable

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Appendix L

Greeley Policy for Non-Potable Irrigation

[Final NP policy will be appended here when approved by the City.]



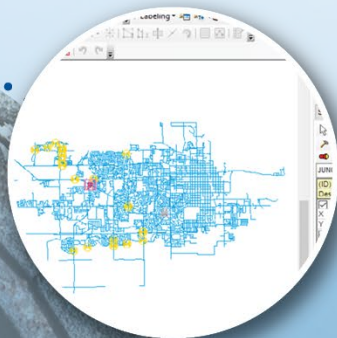
**CDM
Smith**[®]
cdmsmith.com



Non-Potable Water Master Plan

September 15, 2021

Water & Sewer Board Presentation



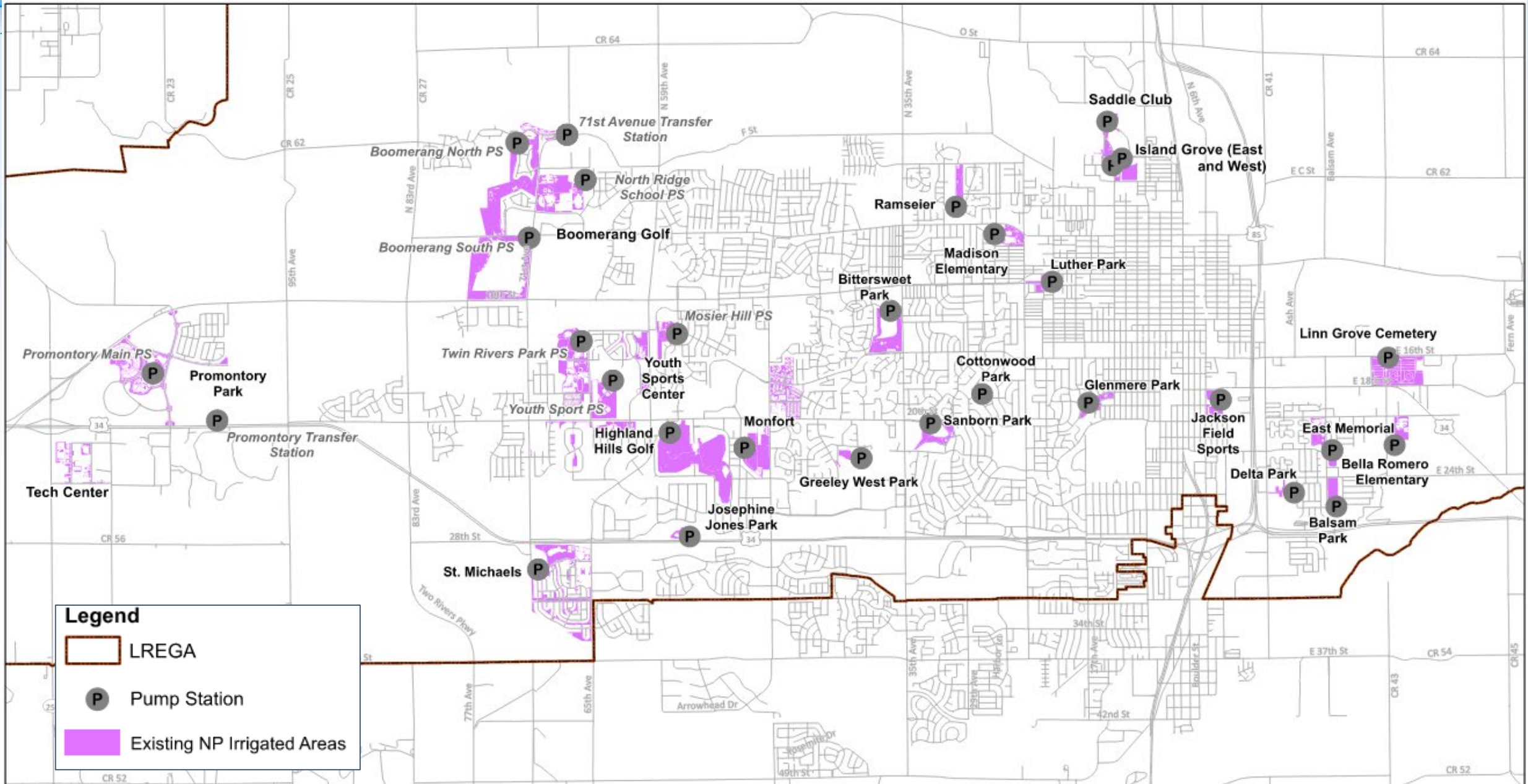
**CDM
Smith**

Existing Water Sources for the Non-Potable Irrigation System

- The Greeley Irrigation Company (GIC) Ditch #3
 - Runs April through October.
- The Greeley Loveland Irrigation Company (GLIC) Ditch runs May through September.
 - Customers on the Greeley Loveland Irrigation Ditch are supplemented with potable water in April and October.
- Exchanged wholly-consumable wastewater effluent
 - Poudre Ponds
 - Augmented wells

Existing Non-Potable System

- Field inventory conducted to identify key infrastructure
- Typically, water goes from a ditch, into a pond, then pumped into the system
- System summary:
 - Over 37 pump stations and 10 wells
 - Maintains 90,000 feet of pipe
 - Over 100 customers
 - 24 unique service areas
- Stakeholder research confirmed that Greeley's system is unique and mature compared to other municipalities



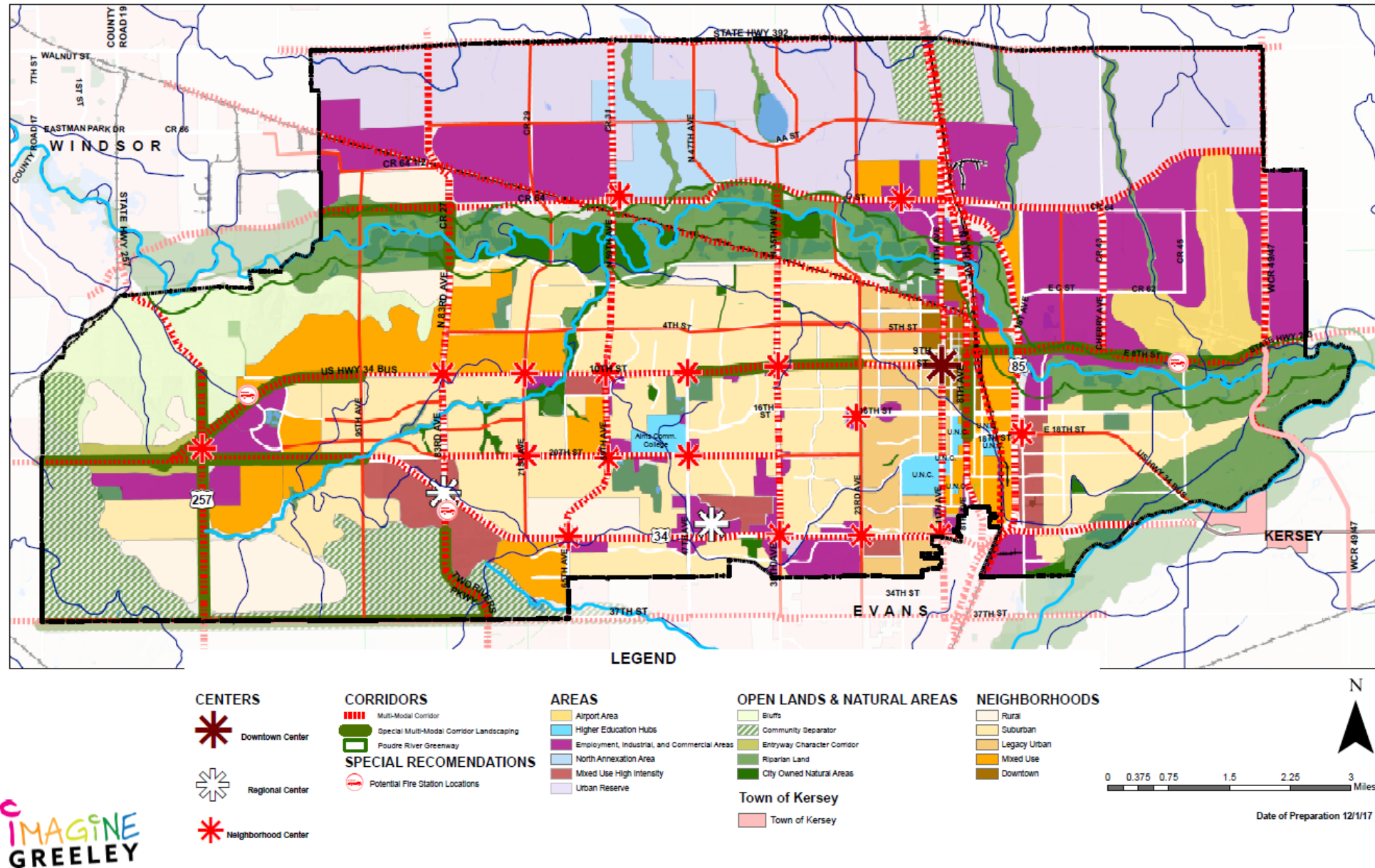


Demands Development

Expanding the Non-Potable System Goals

- Reduce use of potable water for irrigation
 - Allows use of cheaper, untreatable water sources.
 - \$30,000+ for potable sources vs ~\$8,000 for non-potable sources
 - Frees up potable sources for use during droughts
 - Reduces potable water infrastructure expansion
- Increase non-potable use to over 10,000 AF per year
 - Current use: 2,500 AF per year

Comprehensive Plan – Land Use Guidance Map

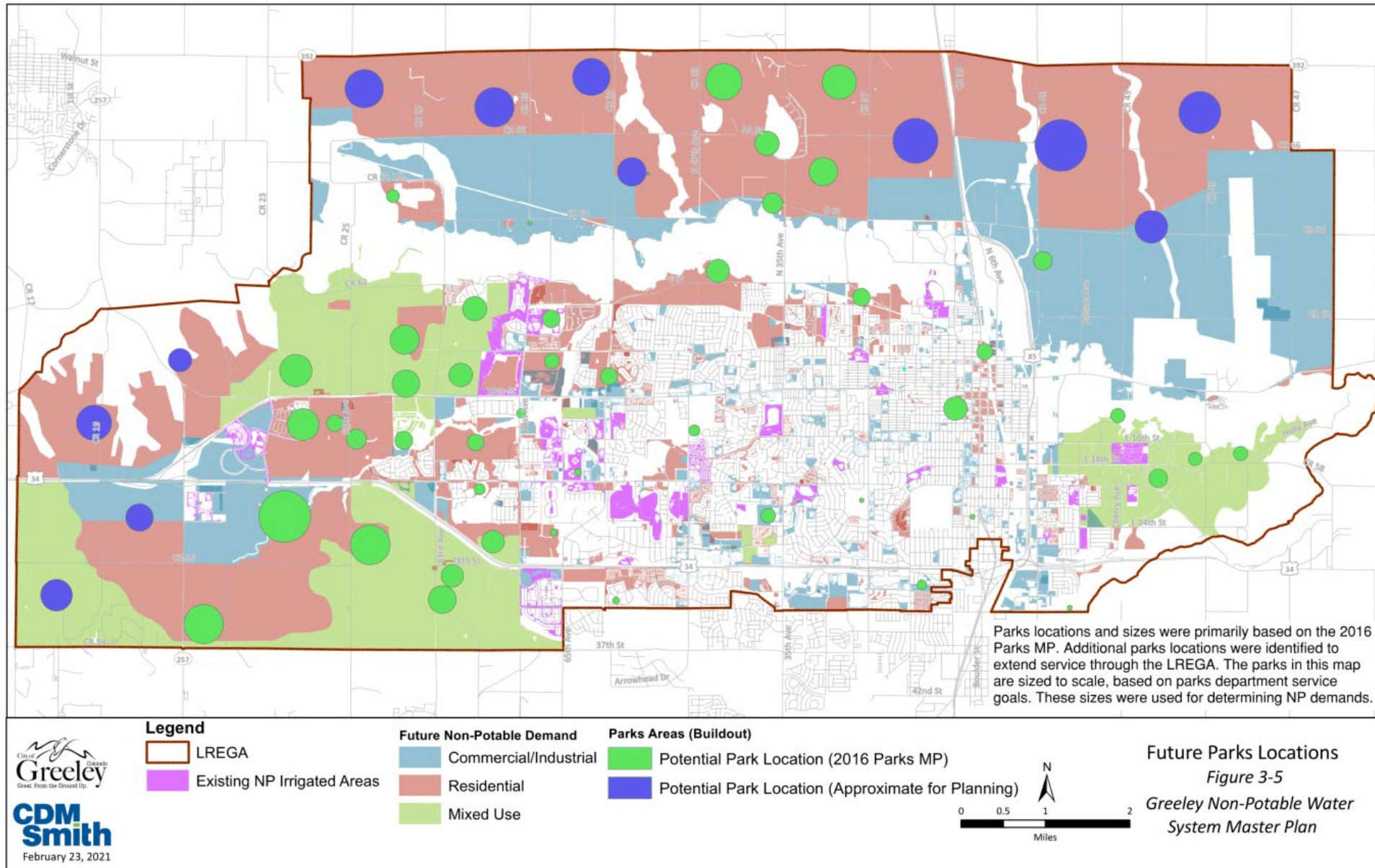


Peak Month Flow Factors and Adoption Rates

Category	Bulk Land Flow Factor gpd/ac	Irrigated Land Flow Factor gpd/ac	Adoption Rate
Park	1,600	3,500	90%
Commercial	1,300	3,200	20%
Multifamily HOA	1,500	4,400	15%
School	2,100	4,300	75%
Church	1,300	2,000	75%
I-L	500	NA	20%
I-M	125	NA	20%
R-L	1,200	4,700	20%
Residential (R-M)	900	5,200	20%
R-E	80	NA	15%

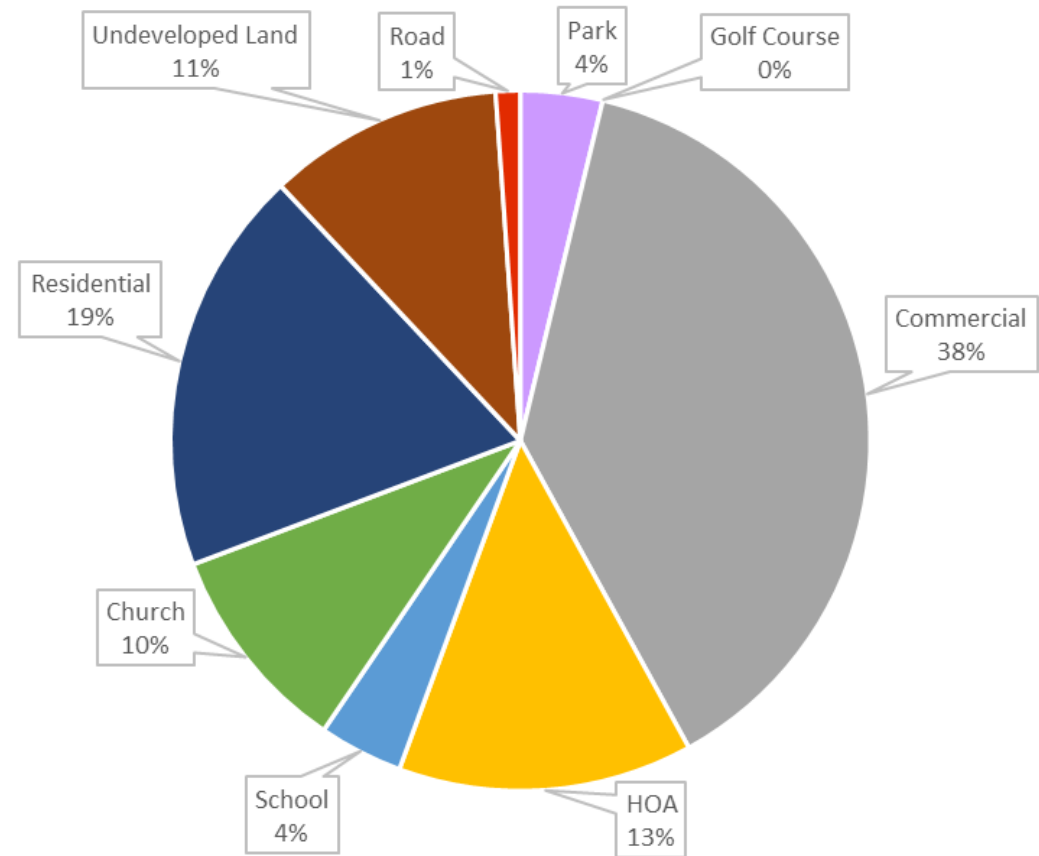
Note: Future adoption rates are highly dependent on policy decisions

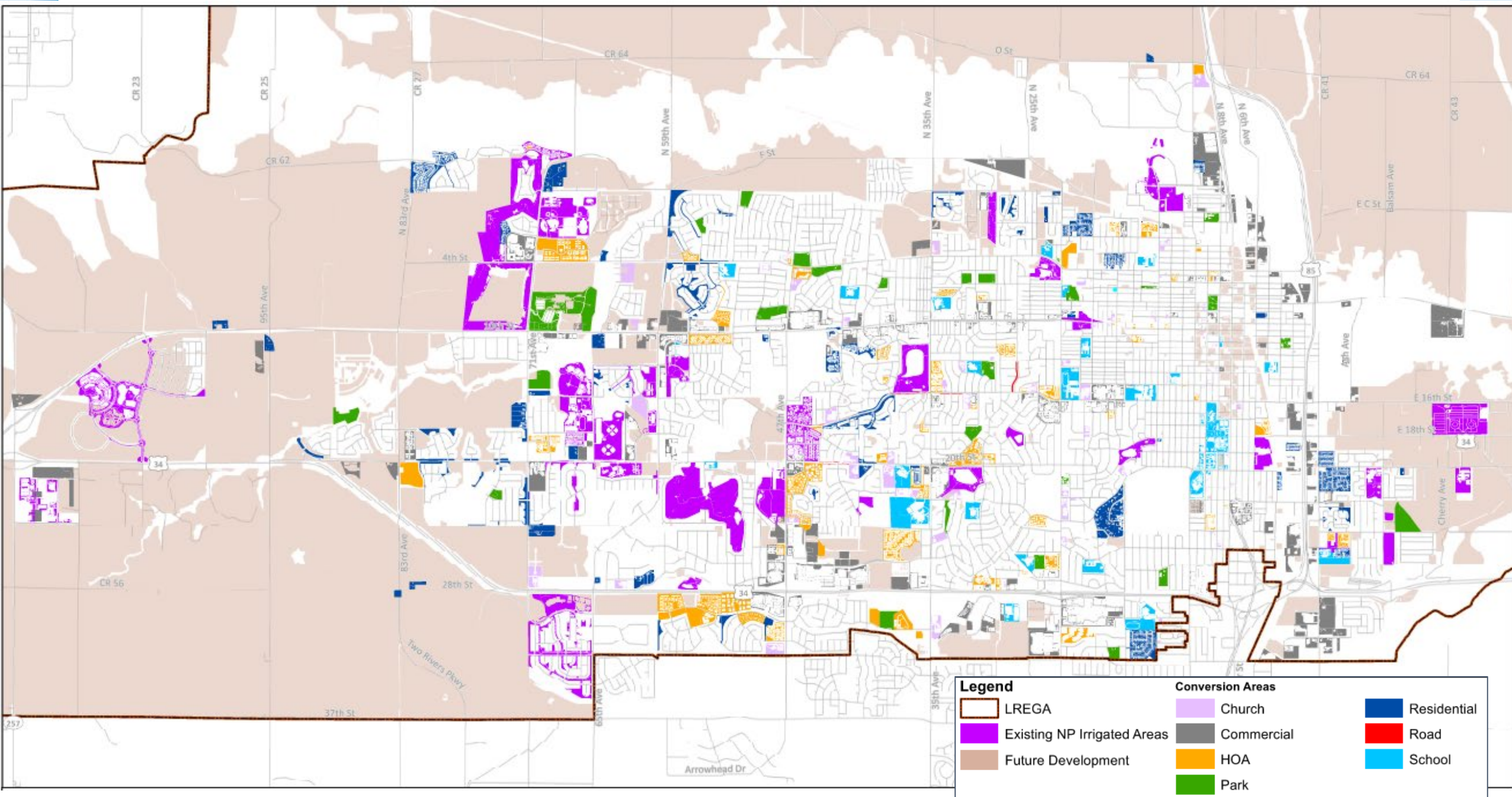
Future Non-Potable Sites



Conversion Areas

- **Potential** areas identified for conversion to non-potable irrigation
 - Over 400 locations at roughly 2,280 acres
- Applied irrigated area flow factors & adoption rates to calculate total demands
- Conversion areas from Potable to non-potable is 2.3 MGD





Demands Summary

- Existing non-potable demand is 6.3% of total water demand (AFY)
- Future development non-potable demand is 15.5% of total
- Projecting that at buildout, non-potable will be 11.1% of total

Development Type	Total Water Demand MGD (AFY)	Potable Water Demand MGD (AFY)	Non-Potable Water Demand, MGD (AFY)
Existing Demand	47.3 (30,500)	46.0 (28,600)	1.3 (1,900)
Future Development (Buildout)	56.4 (33,500)	47.2 (29,300)	9.2 (4,200)
Potable to NP Conversion	2.3 (0)	0 (-1,000)	2.3 (1,000)
Total	106.8 (64,000)	93.2 (56,900)	12.8 (7,100)

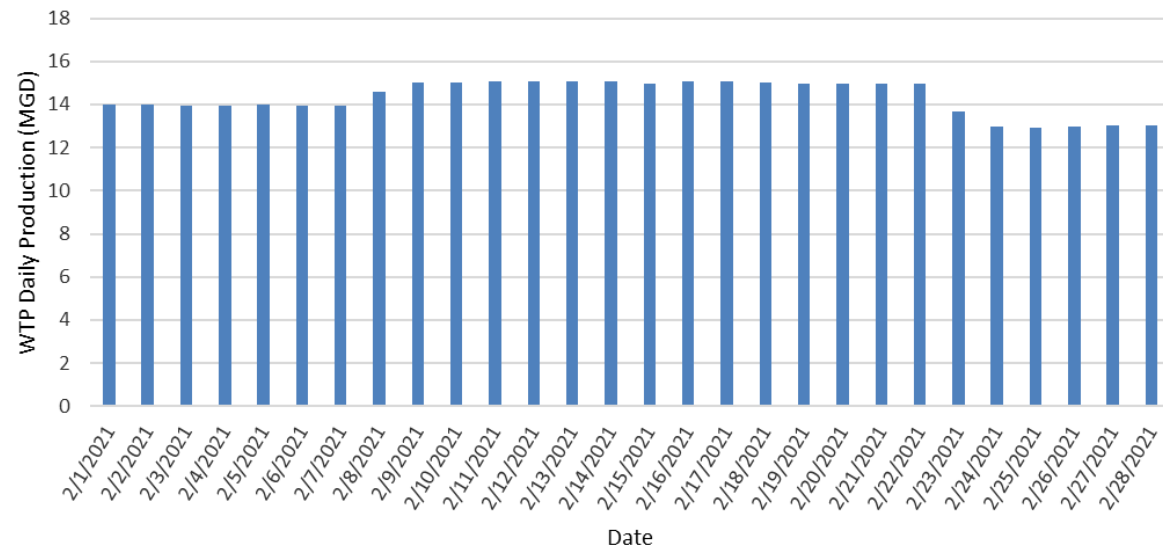
MGD is peak month, AFY is annual total

Note: Future non-potable usage is highly dependent on policy decisions

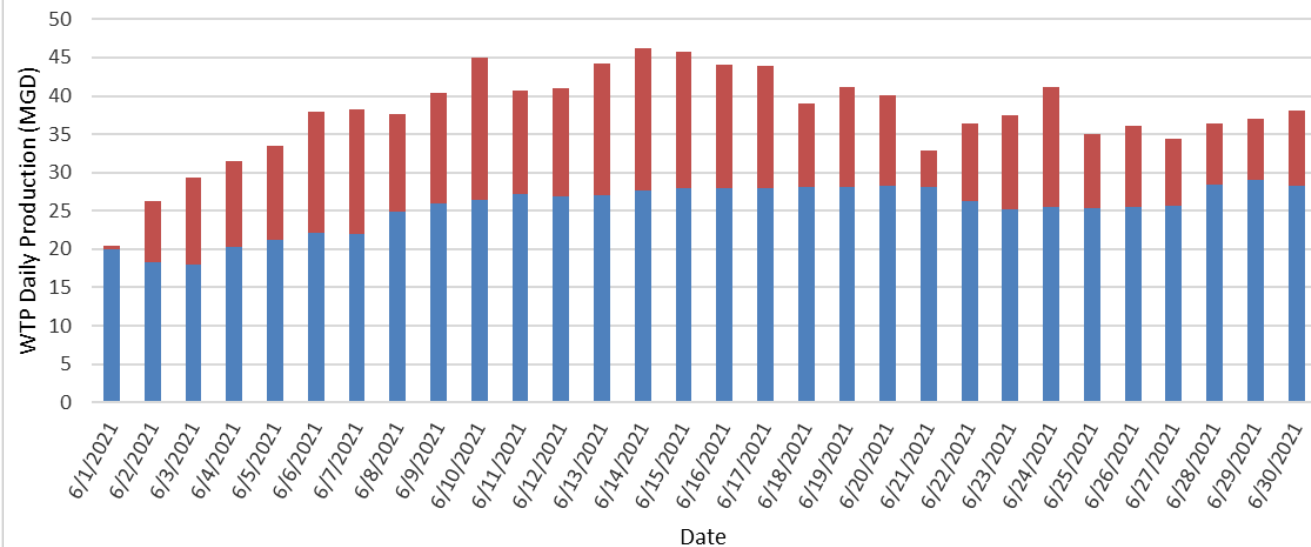
WTP Water Production Comparison

- Base potable demand ≈ 14 MGD
- Summer peak potable demand ≈ 46 MGD
- Irrigation Demand range 0-32 MGD

Feb. 2021 WTP Production (MGD)

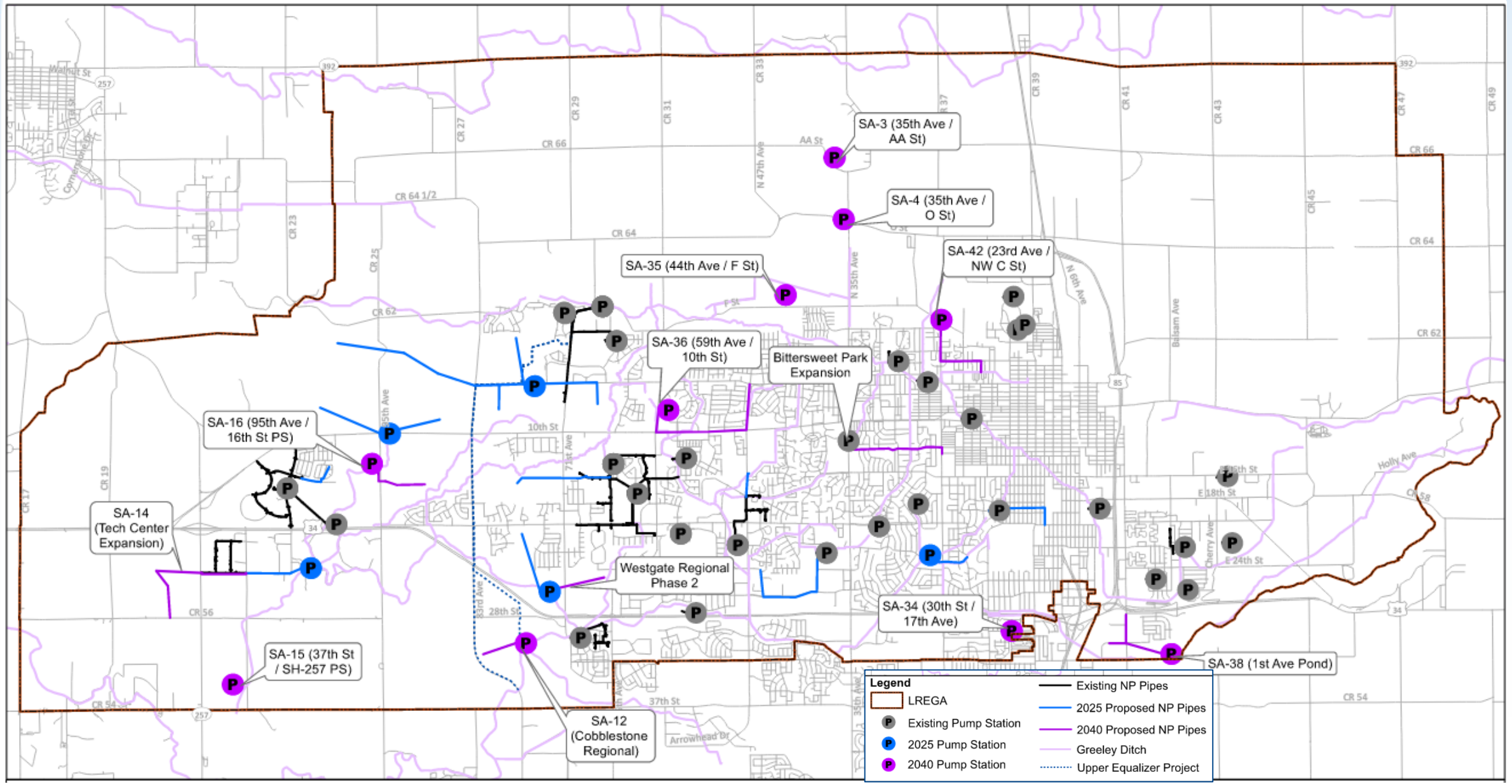


June 2021 WTP Production (MGD)

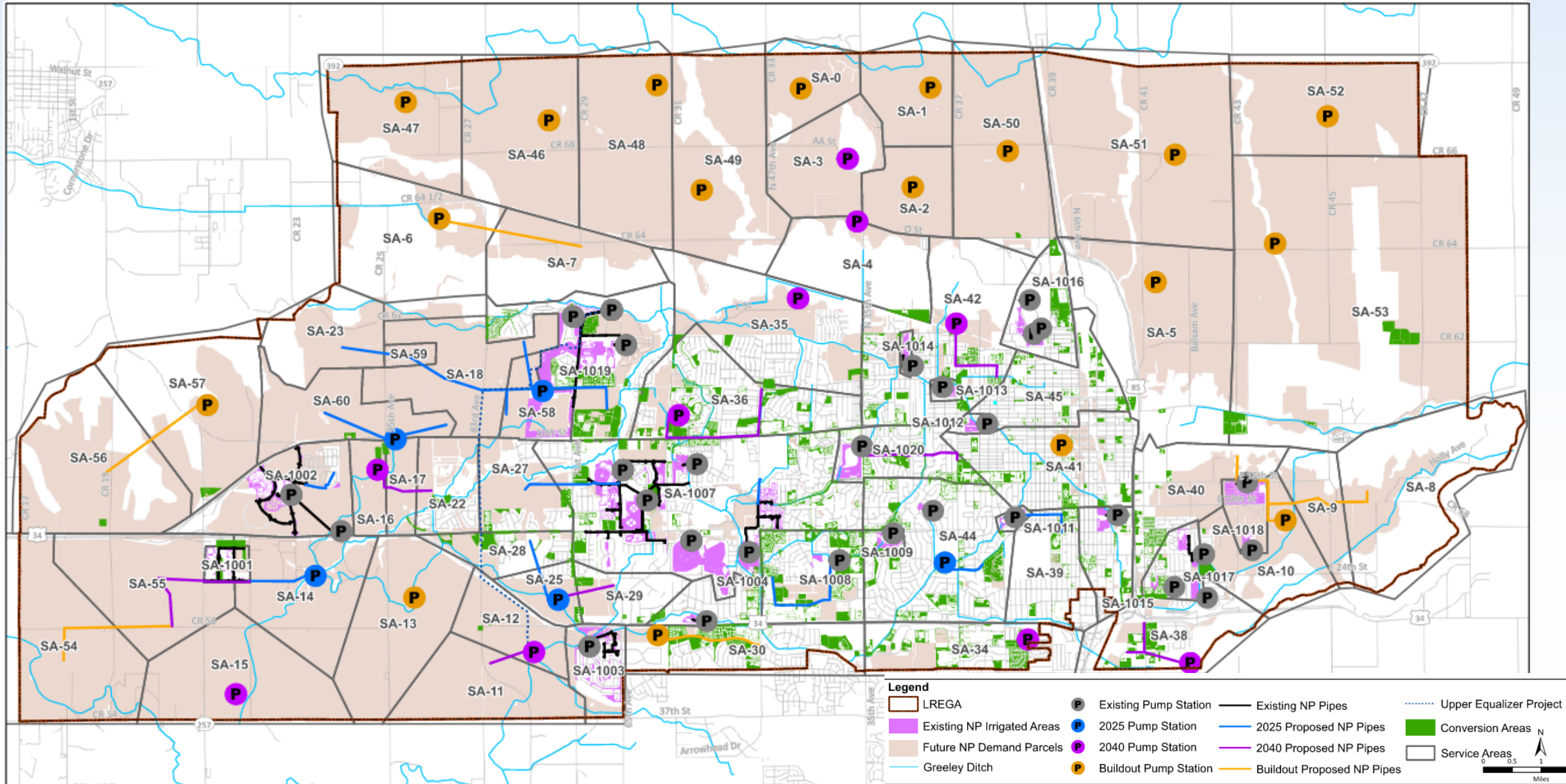




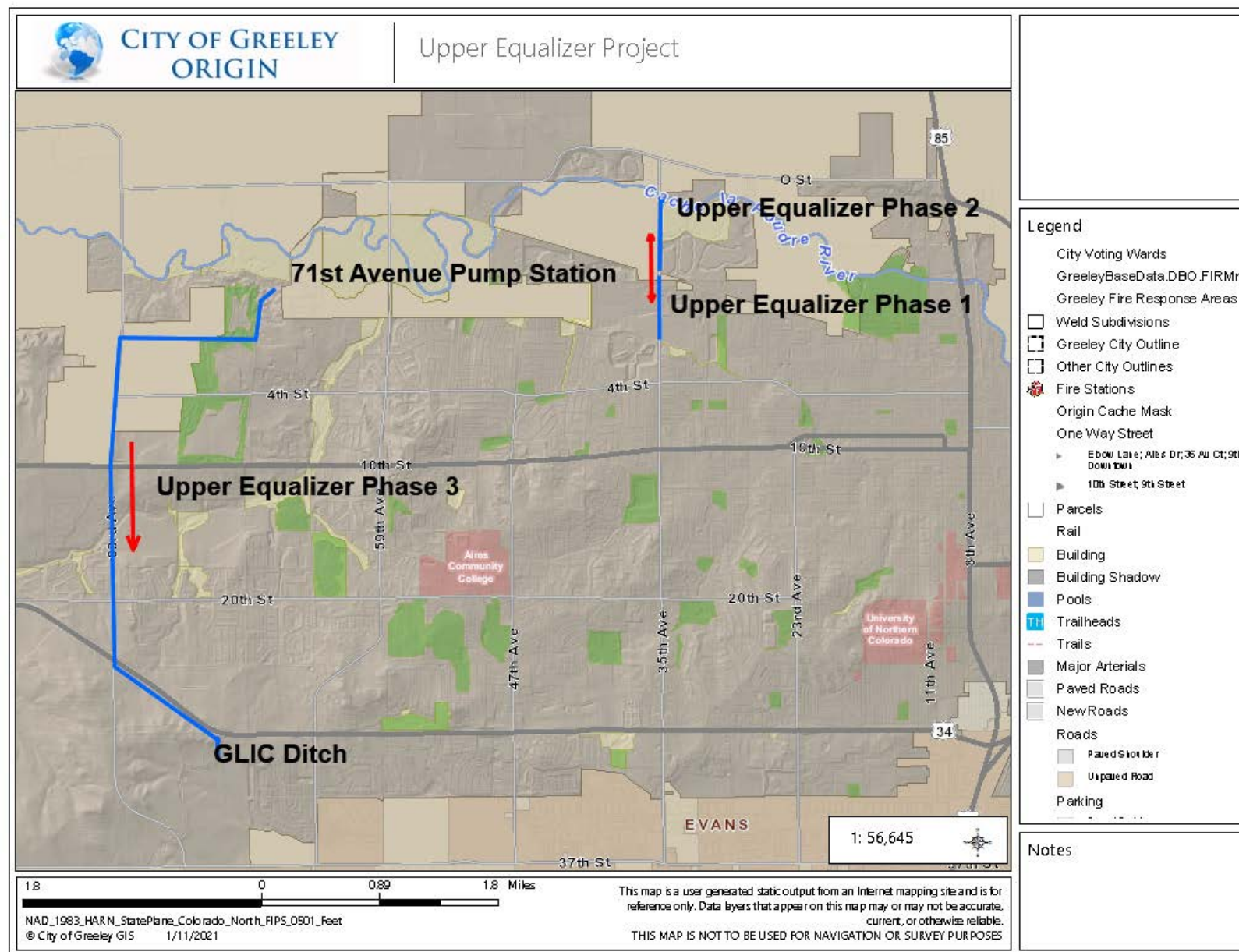
Capital Improvements Plan



Recommended Capital Improvements: Build Out

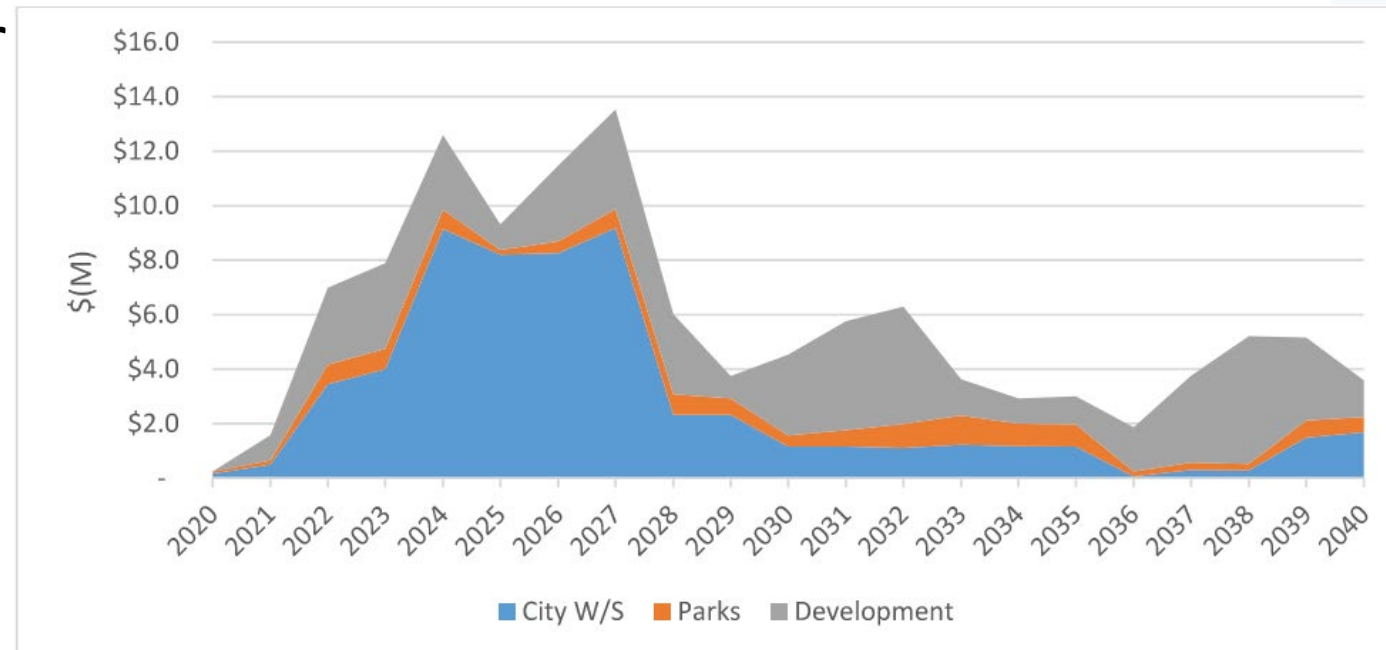
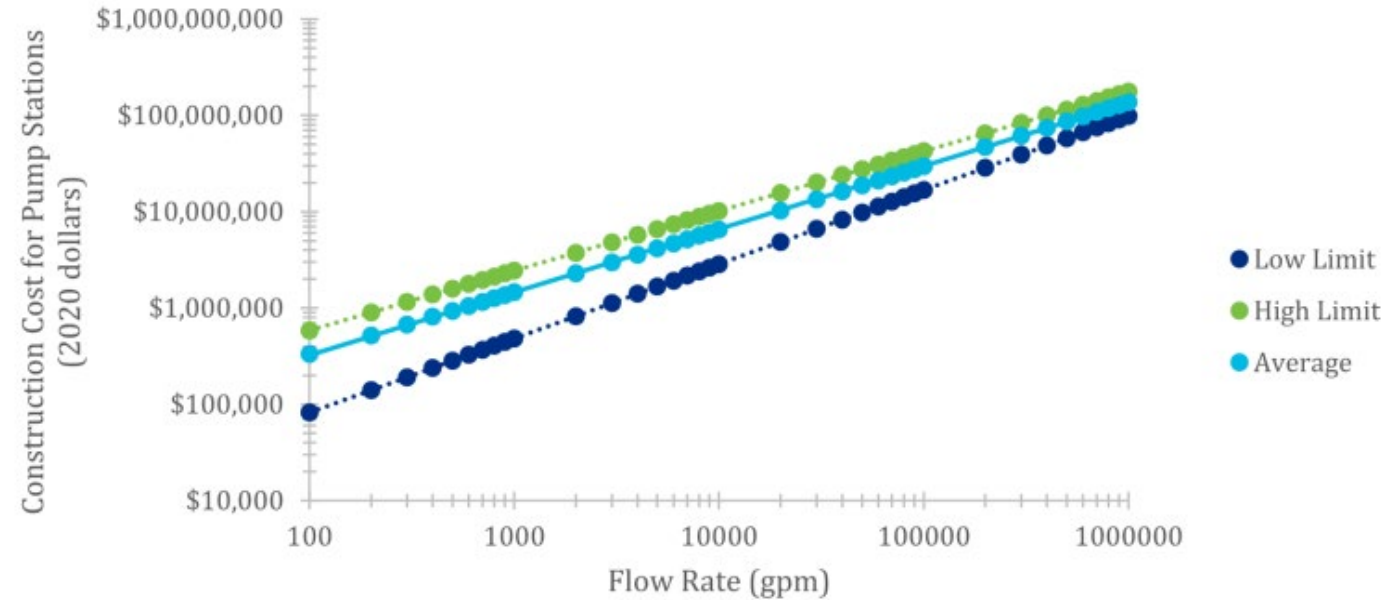


Upper Equalizer Project

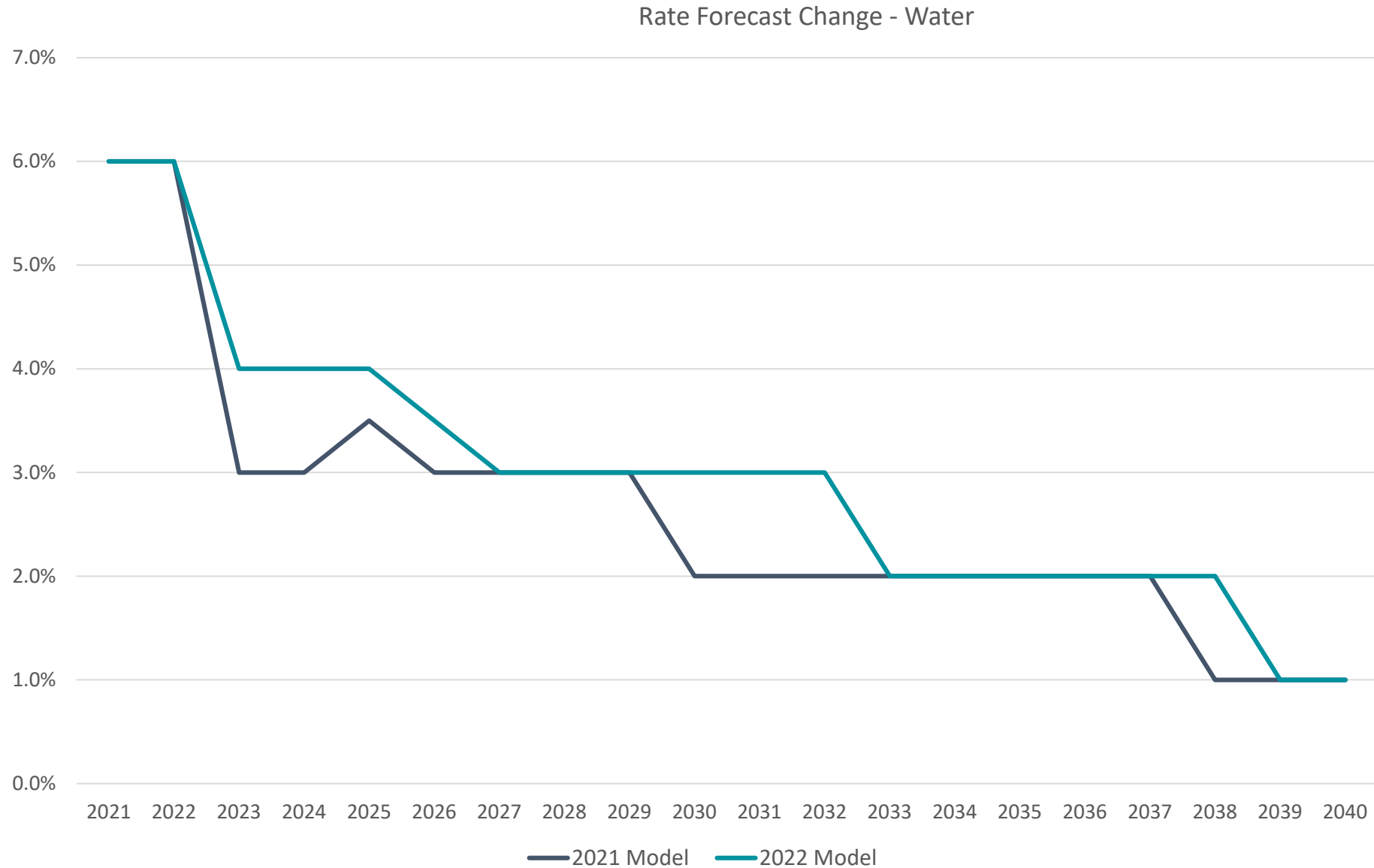


Non-Potable CIP

- 20 year projection - \$150 million
 - Not sustainable
- Backbone infrastructure and projected City contributions
- Proposed \$5 million per year for NP system expansion



Annual Water/NP Funding Projections





Finding and Recommendations

Key Recommendations

- Continue using a hub-and-spoke approach for future NP systems
- Require NP infrastructure even if a PS is not yet constructed
- Conduct detailed evaluations of demands and PS sizing during design
- Improve operational practices, such as lengthening watering windows
 - Allows expansion of system without infrastructure upgrades
- Require SCADA at all new or rebuilt pump stations
- Create plans for data collection and formal record-keeping
- Complete the recommended CIP projects
- Finalize NP policy to encourage adoption



Stakeholder/Community Engagement

Key Takeaways from Stakeholder Meetings

- Meetings held with other stakeholders:
 - Westminster
 - Denver Water
 - Evans
 - Windsor
- Greeley's non-potable system is unique and advanced (especially for raw water)
- Encouraging non-potable adoption is a challenge; most communities focus on larger users only
- Limited opportunities for collaboration with nearby communities
- Regional interest in non-potable is generally growing

Community Engagement

- Community engagement with engineers, planners, developers, and citizens
- Community engagement efforts included:
 - Virtual meeting to introduce MP and development work completed
 - Participants reviewed draft MP and provided comments
 - Follow up virtual meeting was held to discuss comments and responses
- Builders, Realtors, and Developers Roundtable on July 19th, 2021

Next Steps

- Recommendation & approval from Planning Commission – Sept. 14th
- City Council work session non-potable master plan overview – Sept. 28th
- City Council work session non-potable police update – Sept. 28th
- Finalize CIP project budgets
- Master plan acceptance by City Council – Oct. 19



Questions?

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE X NO ENCLOSURE

ITEM NUMBER: 10

TITLE: LEGAL REPORT

RECOMMENDATION: INFORMATIONAL ONLY

ADDITIONAL INFORMATION:

Legal Report
Greeley Water and Sewer Board Meeting
September 15, 2021

- I. **Statement of Opposition:** Based on a review of the July, 2021 Water Court Resume, staff and water counsel recommend that the Board file a statement of opposition in the following case:
 - a. Case Number: **21CW3108:** Application of the Little Thompson Water District for a change of water rights for 94.75 shares (out of 2001) in the Home Supply Ditch Company, and 1/3 share (out of 48) in the Big Thompson Ditch and Manufacturing Company for municipal uses. These are senior water rights on the Big Thompson River. Staff and counsel recommend that Greeley file a statement of opposition to ensure that Applicant's claims do not cause injury to Greeley's Big Thompson River water rights and exchanges.
- II. **Proposed Motion Language:** "I move that the Board authorize the filing of a statement of opposition in Case No. 21CW3108 and for staff and legal counsel to seek resolution of issues raised by this case consistent with Water and Sewer Board Resolution No. 3-15."
- III. **Additional Litigation Item:** The City Attorney is planning to seek authorization from the City Council to institute a legal action against the Taylor & Gill Ditch Company and William Seaworth for a breach of contract. Greeley entered into a Right of First Refusal Agreement with the ditch company in 2014 for carrying capacity in the ditch, for \$119,000. If the ditch company were to receive an offer to acquire excess carrying capacity in the ditch, it was required to give Greeley the opportunity to purchase the capacity on the same terms as the offer. On December 5, 2018, Greeley received notice from the ditch company that it had received an offer that it intended to accept from Mr. Seaworth. Greeley informed the ditch company that it intended to exercise the right of first refusal. After several months of attempted negotiations, the ditch company stopped communications with Greeley. Recently, Greeley was made aware that the ditch company had already entered the contract for the excess ditch capacity with Mr. Seaworth, one day before it provided notice to Greeley of the "offer" it had received. Therefore the ditch company breached the agreement with Greeley. The lawsuit will seek damages because Greeley did not receive the benefit of the Right of First Refusal Agreement.

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE _____

NO ENCLOSURE X

ITEM NUMBER: 11

TITLE: EXECUTIVE SESSION

RECOMMENDATION: INFORMATIONAL ONLY

ADDITIONAL INFORMATION:

WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE X NO ENCLOSURE

ITEM NUMBER: 12

TITLE: DIRECTOR'S REPORT

RECOMMENDATION: INFORMATIONAL ONLY

ADDITIONAL INFORMATION:

- Thank you – Board & Council tour
- Chimney Hollow Reservoir Construction
- Larimer County 1041 regulation update
- Report on resolution of litigation against Aggregate Industries



Chimney Hollow
Reservoir Project

Construction Update

Participants Meeting

August 31, 2021



Preconstruction - Complete



May

- ✓ Obtain Air Permit
- ✓ Authorize Limited Notice to Proceed (~\$6.1)
- ✓ Complete WAPA transmission Line Relocation
- ✓ Provide Balance of SUP Submittals
- ✓ 404 Permit Modification: WOTUS Determination
- ✓ BLM EA: Internal Review Complete
- ✓ Nutrient Reduction: Draft MOU



June

- ✓ Obtain Categorical Exclusion (CE) & Special Use Permit (SUP)
- ✓ Larimer County Permits:
 - Site Plan Waivers
 - Develop. Constr.
 - Septic
 - ROW
 - Access Permit
 - Building Permits
- ✓ Close on CBT unit for NCLWD tap
- Setup Construction Trailers
- Install Temp Utilities
- ✓ BLM EA: FONSI



July

- ✓ Barnard management mobilize to site
- ✓ Limited Site Work:
 - Set pump in Flatiron Reservoir
 - Establish survey controls
- ✓ Nutrient Reduction: approval
- ✓ 404 Modification Complete
- ✓ BLM EA: Free Use Permit



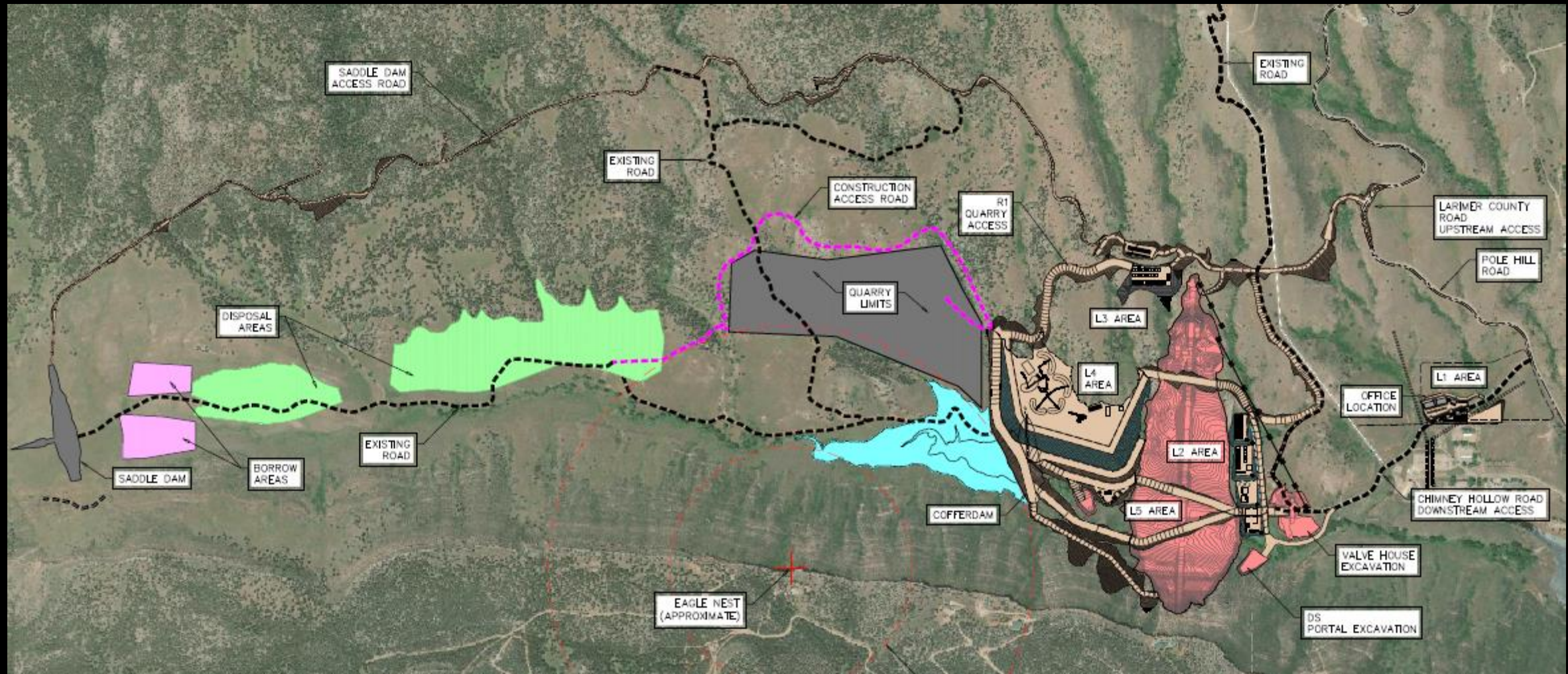
Aug

- ✓ Financing
- ✓ Notice-to-Proceed
- ✓ Begin 48 Month Construction Program

Construction Update

- NTP provided on August 16. Today is day 16 of Construction.
- Work Schedule: Monday-Saturday, 6:30AM to 5:30PM
- Mobilization / Prep Work:
 - Establish Stormwater controls (BMPs)
 - Set pump in Flatiron Afterbay. Install piping, tanks and truck-fill stations.
 - Pressure test HP Water Line
 - Cell Booster Tower Installed
 - Fueling Station Installed
 - Security
 - Equipment Deliveries: ~110 pieces of mobile equipment onsite
 - Staffing: ~70 Barnard Employees onsite
 - Developing access roads and laydown areas

Site Layout



Construction Update (cont.)

- Saddle Dam Access Road
 - Subcontractor H2 mobilized to site.
 - Clearing, stripping and foundation excavation from south to north.
 - Stripping and foundation excavation of Saddle Dam
- Quarry Development
 - Subcontractor Fred Weber mobilized to site.
 - Quarry stripping and access roads initiated
- Main Dam – Self-Performed by Barnard
 - Rock fall protection
 - Access Roads
 - Topsoil stripping
 - Foundation Excavation ~STA 23+00 to 29+00

Quality Control Program

US Army Corps of Engineers three phased quality control for Definable Features of Work (DFOW).

Preparatory Phase:

- Review specs
- Review drawings
- Provisions for testing
- Physical examination of work
- Review hazards
- Procedures for construction
- Review Potential Failure Modes
- Meeting with all Parties

BARNARD Definable Features of Work				
No	Work Area	Definable Feature of Work (DFOW)	Specification Section(s)	Specification Name
1	General	Cofferdam Construction	01 57 23	Diversion, Care of Drainage, and Dewatering
2	Access Roads (Saddle Dam and Larimer County)	Excavation, Backfill and Drainage Features	01 57 23	Diversion, Care of Drainage, and Dewatering
			03 40 00	Precast Concrete
			31 11 00	Clearing and Grubbing
			31 14 14	Topsoil Stripping
			31 23 16	Excavation and Foundation Preparation
			31 23 23	General Earthwork
3	Access Roads (Saddle Dam and Larimer County)	Arch Bridge	TBD	Specs to be developed
4	Access Roads (Saddle Dam and Larimer County) & Main Dam	Finishing Work	31 05 19	Geosynthetics
			31 23 23	General Earthwork
			32 31 13	Fencing and Gates
			32 97 01	Reclamation of Disturbed Areas
5	Main Dam	Foundation Excavation	01 57 23	Diversion, Care of Drainage, and Dewatering
			31 11 00	Clearing and Grubbing
			31 14 14	Topsoil Stripping
			31 23 16	Excavation and Foundation Preparation
			31 71 17	Drilling and Blasting

- Four Preparatory Meetings Completed (Quarry Overburden, Saddle Dam Access Road, Cofferdam, Saddle Dam Common Excavation)

Construction

Temporary Cell Tower and Flatiron Construction Water Supply





Saddle Dam Stripping and Saddle Dam Access Road

Construction Update

Construction – Main Dam (Looking East)



Construction Main Dam (Looking West)



August 30, 2021 12:03 PM

Barnard Construction – Cost Performance



COST PERFORMANCE

Original Contract Amount	\$485,365,000
Change Orders to Date	\$6,179,796
Revised Contract Value	\$491,544,796
Earned to Date (Inc. Retainage)	\$4,496,175
Percent Earned =	0.91%

Per contractor invoice through - July 31, 2021

Change Events

Change Event	Description	Status	Scope	Category	Estimated Cost
7	Barnard Supplied Laboratory Equipment	Waiting Barnard Response	Out of Scope	RFCP	~\$85K
8	Slip Resistant Epoxy Floor Valve House	Waiting Barnard Response	Out of Scope	RFCP	TBD
9	Fiber Optic Conduit to WAPA Structure	Waiting Barnard Response	Out of Scope	RFCP	TBD
13	CP System Refinements	Waiting Barnard Response	Out of Scope	RFCP	TBD
17	Third Delay in NTP	Reviewing Cost	Out of Scope	RFCP	~\$16.9M
18	Bailey Sleeve Vale – Access to Secondary Stage	Waiting Barnard Response	Out of Scope	RFCP	TBD
19	Alternative Details for Shear Keys	Design Development	Out of Scope	VECP	Credit
20	Slip Resistant Epoxy Floor - Lab	Waiting Barnard Response	Out of Scope	RFCP	TBD
21	Potable Water Line to Laydown Area 1	Reviewing Cost	Out of Scope	RFCP	~\$130k
22	Saddle Dam Road Modifications	Waiting Barnard Response	Out of Scope	RFCP	Credit
23	Removal of Trees	Waiting Barnard Response	Out of Scope	RFCP	TBD
24	Left Abutment LC Recreation Area	Waiting Barnard Response	Out of Scope	RFCP	Cost reimbursement by LC

Change Event 17 (Change Order 8)

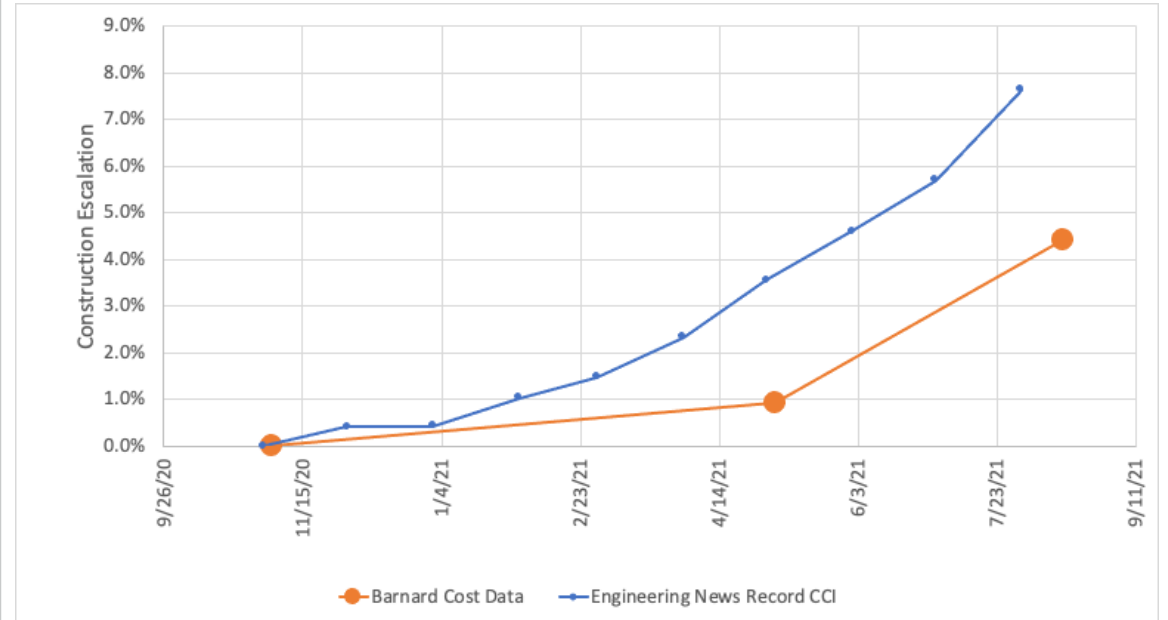
Third Delay in Construction NTP
Total Increase: \$16.9M

- Escalation for all costs in fixed-price contract
- Unprecedented construction escalation this summer
- Compensates Barnard for delays leading to Aug 16 start
- Billed at ~\$354,000 per month over 48 Months

Barnard Construction Company, Inc.
Attachment A - Escalation Cost Summary

8/27/2021

Description	Cost Increase for 3rd Project Delay		
	Total Increase	Escalation % (Annualized)	Cost/Mo
1. Salaried Labor Escalation	\$ 665,138	6.7%	\$ 196,442
2. Craft Labor Escalation	\$ 1,146,290	4.25%	\$ 338,545
3. Insurance Increases	\$ 330,126	6.0%	\$ 97,499
4. Equipment Escalation	\$ 547,982	2.6%	\$ 161,841
5. Diesel/ Gas Escalation	\$ 2,499,605	29.5% \$0.26 / gal	\$ 738,233
6. Bitumen/ Oil/ Grease/ DEF Escalation	\$ 779,515	27.6%	\$ 230,222
7. Other	\$ 663,929	9.5%	\$ 196,085
8. Subcontractor Escalation	\$ 4,129,758	9.8%	\$ 1,219,682
Garney (Conveyance Pipe)	\$ 495,993	8.3%	\$ 146,486
Nicholson (Foundation Grouting)	\$ 383,282	5.4%	\$ 113,198
WALO (Asphalt Core - Excl. Bitumen/Aggs)	\$ 272,212	5.0%	\$ 80,395
Weber (Crushing & Processing)	\$ 988,689	8.9%	\$ 291,999
Sturgeon (Electrical)	\$ 146,685	11.1%	\$ 43,322
McCauley (QA Lab)	\$ 161,453	67.2%	\$ 47,683
TBD (Surveying)	\$ 92,090	5.5%	\$ 27,198
CE Fence (Fencing)	\$ 326,525	106.3%	\$ 96,436
TBD (HVAC)	\$ 29,576	5.5%	\$ 8,735
DCB or Lefever (Valve House Building)	\$ 935,659	104.1%	\$ 276,337
Other	\$ 297,596	3.9%	\$ 87,892
9. Supplier Escalation	\$ 6,229,080	40.5%	\$ 1,839,695
TBD (Cement & Flyash)	\$ 348,441	40.1%	\$ 102,909
TBD (Rebar)	\$ 1,074,937	70.9%	\$ 317,472
Santa Fe Winwater (Valves)	\$ 582,544	17.7%	\$ 172,048
Buckley (Explosive Products)	\$ 224,574	10.0%	\$ 66,326
NWP (Pipe - Both Garney & Barnard)	\$ 3,232,085	60.9%	\$ 954,563
Cody (Misc. Metals)	\$ 117,785	74.9%	\$ 34,786
ATCO (Office Trailer)	\$ 41,360	10.0%	\$ 12,215
Other	\$ 607,355	38.3%	\$ 179,376
Total	\$ 16,991,425	12.3%	\$ 5,018,244





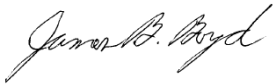
Questions?



DISTRICT COURT, GARFIELD (GLENWOOD SPRINGS) COUNTY, COLORADO	
Court Address: 109 8TH STREET, STE. 104, GLENWOOD SPRINGS, CO, 81601	DATE FILED: September 6, 2021 1:18 PM CASE NUMBER: 2021CW3075
In the Interest of: MUNICIPAL SUBDISTRICT NCWCD	△ COURT USE ONLY △ Case Number: 2021CW3075 Division: E Courtroom:
Decree: Decree of the Water Court	

The motion/proposed order attached hereto: GRANTED.

Issue Date: 9/6/2021



JAMES BERKLEY BOYD
District Court Judge

DISTRICT COURT, WATER DIVISION NO. 5 STATE OF COLORADO 109 Eighth Street, Suite 104 Glenwood Springs, CO 81601 (970) 928-3065	
CONCERNING THE APPLICATION FOR CORRECTION TO ESTABLISHED BUT ERRONEOUSLY DESCRIBED POINTS OF DIVERSION UNDER C.R.S. § 37-92-305(3.6) OF: MUNICIPAL SUBDISTRICT, NORTHERN COLORADO WATER CONSERVANCY DISTRICT In Grand County, Colorado	▲ COURT USE ONLY ▲ Case Number: 21CW3075
FINDINGS OF FACT, CONCLUSIONS OF LAW, RULING OF REFEREE, JUDGMENT, AND DECREE OF THE WATER COURT	

This matter comes before the Water Referee upon the Application of the Municipal Subdistrict, Northern Colorado Water Conservancy District, for correction to established but erroneously described points of diversion pursuant to C.R.S. § 37-92-305(3.6) for four absolute water rights. The Application was filed on April 30, 2021, and referred to the Water Referee by the Water Court in accordance with C.R.S. § 37-92-101 *et seq.* The Referee, having made such investigations as are necessary to determine whether or not the statements in the Application are true, having consulted with the Division Engineer, and having become fully advised with respect to the subject matter in the Application, hereby makes the following Findings of Fact and Conclusions of Law and enters the following Ruling:

FINDINGS OF FACT

1. Applicant: Municipal Subdistrict, Northern Colorado Water Conservancy District (“Municipal Subdistrict”), 220 Water Avenue, Berthoud, Colorado 80513. The Municipal Subdistrict is organized as a subdistrict of the Northern Colorado Water Conservancy District under the Water Conservancy Act, C.R.S. §§ 37-45-101 to -153.

2. Notice and Jurisdiction: Timely and adequate notice of the pendency of these proceedings has been given in the manner required by law pursuant to C.R.S. § 37-92-302(3). The Application was published in the April 2021 Division 5 Resume. The Court has jurisdiction over the subject matter of these proceedings and over all parties affected hereby, whether they have appeared or not. C.R.S. § 37-92-203; *City of Thornton v. Bijou Irrigation Co.*, 926 P.2d 1, 24–25 (Colo. 1996). All new diversion or storage structures or modifications to any existing diversion

or storage structures or existing storage pools are or will be constructed on lands owned by the Municipal Subdistrict. Therefore, the Municipal Subdistrict was not required to provide notice of the Application to any other landowners under C.R.S. § 37-92-302(2)(b)(II).

3. Statements of Opposition: The following parties (“Opposers”) filed timely statements of opposition:

- A. Board of County Commissioners for the County of Grand (“Grand County”).
- B. Colorado River Water Conservation District (“River District”).
- C. Middle Park Water Conservancy District (“Middle Park”).

4. Stipulations: Stipulations were entered into between the Municipal Subdistrict and the Opposers as follows:

- A. Grand County entered into a stipulation on April 27, 2021, which was approved by the Court by an order entered on July 6, 2021.
- B. The River District entered into a stipulation on April 22, 2021, which was approved by the Court by an order entered on July 6, 2021.
- C. Middle Park entered into a stipulation on July 19, 2021, which was approved by the Court by an order entered on the same day.

5. Division Engineer’s Report: The Division Engineer issued a summary of consultation pursuant to C.R.S. §§ 37-92-302(2)(a) & (4) on August 6, 2021. All issues raised in the Summary of Consultation have been addressed by the Municipal Subdistrict.

6. Application: Pursuant to C.R.S. § 37-92-305(3.6), the Application seeks corrections to established but erroneously described points of diversion for four absolute water rights, collectively referred to herein as the “Windy Gap Project Water Rights”: (1) Windy Gap Reservoir; (2) Windy Gap Pump, Pipeline, and Canal; (3) Windy Gap Pump, Pipeline, and Canal, First Enlargement; and (4) Windy Gap Pump, Pipeline, and Canal, Second Enlargement. As described in further detail below, the legal descriptions of the points of diversion for the Windy Gap Project Water Rights contained in the relevant decrees do not coincide with the actual physical locations of those points of diversion as they have existed since completion of construction of the Windy Gap Project in 1985. The Application does not include any action seeking any other type of change of water right or diligence proceeding or application to make absolute with respect to the water rights included in the Application.

7. Decreed Water Rights Subject to Correction:

- A. Name of structure: **Windy Gap Reservoir**, a part of the Windy Gap Water System.
- i. Relevant Decrees (District Court, Water Division No. 5, unless noted otherwise): Civil Action No. 1768, Grand County District Court (Oct. 27, 1980); 84CW112 (Nov. 4, 1985); 85CW135 (Aug. 26, 1985); 88CW169 (Feb. 6, 1989); 95CW33 (Aug. 28, 1995); 01CW203 (Jul. 25, 2002); 08CW92 (Apr. 12, 2012); 17CW3176 (Aug. 16, 2020).
 - ii. Decreed legal description of point of diversion and storage: An onstream reservoir located in Sections 25 and 26, T. 2 N., R. 77 W. of the 6th P.M. The Northwest corner of the proposed dam is located at a point which bears S. 52°00' W. 1,660 feet from the N.E. corner of section 26, T. 2 N., R. 77 W. of the 6th P.M.
 - iii. Source: Colorado River.
 - iv. Amount: 445 acre-feet, absolute.
 - v. Decreed appropriation date and amounts: June 22, 1967.
 - vi. Decreed beneficial uses: municipal, irrigation, industrial, and recreational.
- B. Name of structure: **Windy Gap Pump, Pipeline, and Canal**, a part of the Windy Gap Water System.
- i. Relevant Decrees (District Court, Water Division No. 5, unless noted otherwise): Civil Action No. 1768, Grand County District Court (Oct. 27, 1980); 84CW112 (Nov. 4, 1985); 85CW135 (Aug. 26, 1985); 88CW169 (Feb. 6, 1989); 89CW298 (Jul. 19, 1990); 17CW3176 (Aug. 16, 2020).
 - ii. Decreed legal description of point of diversion: A point on the north bank of the Colorado River whence the northwest corner of Section 25, T. 2 N., R. 77 W. of the 6th P.M. bears north 17°30' west a distance of 2,380 feet.
 - iii. Sources: Colorado River through the Windy Gap Reservoir.
 - iv. Appropriation date: June 22, 1967.
 - v. Amount: 300 cfs, absolute.
 - vi. Decreed beneficial uses: municipal, irrigation, industrial, and recreational.
- C. Name of structure: **Windy Gap Pump, Pipeline, and Canal, First Enlargement.**
- i. Relevant Decrees (all District Court, Water Division No. 5): W-4001 (Oct. 27, 1980); 84CW110 (Nov. 4, 1985); 85CW135 (Aug. 26, 1985); 88CW170 (Feb. 6, 1989); 89CW298 (Jul. 19, 1990); 17CW3176 (Aug. 16, 2020).
 - ii. Decreed legal description of point of diversion: A point on the north bank of the Colorado River whence the northwest corner of Section 25, T. 2 N., R. 77 W. of the 6th P.M. bears north 17°30' west a distance of 2,380 feet.
 - iii. Sources: Colorado River.
 - iv. Appropriation date: July 9, 1976.
 - v. Amount: 100 cfs, absolute.
 - vi. Decreed beneficial uses: municipal, irrigation, industrial, and recreational.

D. Name of structure: **Windy Gap Pump, Pipeline, and Canal, Second Enlargement.**

- i. Relevant Decrees (all District Court, Water Division No. 5): 80CW108 (Oct. 27, 1980); 84CW111 (Nov. 4, 1985); 85CW135 (Aug. 26, 1985); 88CW171 (Feb. 6, 1989); 89CW298 (Jul. 19, 1990); 17CW3176 (Aug. 16, 2020).
- ii. Decreed legal description of point of diversion: A point on the north bank of the Colorado River whence the northwest corner of Section 25, T. 2 N., R. 77 W. of the 6th P.M. bears north 17°30' west a distance of 2,380 feet.
- iii. Sources: Colorado River.
- iv. Appropriation date: April 30, 1980.
- v. Amount: 200 cfs, absolute.
- vi. Decreed beneficial uses: municipal, irrigation, industrial, and recreational.

8. Correction to Established But Erroneously Described Points of Diversion:

A. The corrected points of diversion for the Windy Gap Project Water Rights are legally described as follows:

i. **Windy Gap Reservoir.**

- a. Corrected legal description of point of diversion: A point located in the SW/4 NE/4 of Section 26, T2N, R77W, 6th P.M., Grand County, Colorado, at the following UTM coordinates, NAD83, Zone 13: 4440257.30 Northing, 416217.64 Easting.

ii. **Windy Gap Pump, Pipeline, and Canal;
Windy Gap Pump, Pipeline, and Canal, First Enlargement; and
Windy Gap Pump, Pipeline, and Canal, Second Enlargement.**

- a. Corrected legal description of point of diversion: A point located in the SW/4 NE/4 of Section 26, T2N, R77W, 6th P.M., Grand County, Colorado, at the following UTM coordinates, NAD83, Zone 13: 4440251.92 Northing, 416302.81 Easting.

Figure 1 attached hereto depicts the corrected points of diversion in relation to the erroneously described decreed points of diversion.

B. The points of diversion for the Windy Gap Project Water Rights are established but erroneously described points of diversion as that term is defined in C.R.S. § 37-92-305(3.6)(a)(II). Each Windy Gap Project Water Right has been diverted at the same physical location since each was confirmed absolute in 1989 (Case No. 88CW169, for Windy Gap Reservoir and the Windy Gap Pump, Pipeline, and Canal) and 1990 (Case No. 89CW298, for the Windy Gap Pump, Pipeline, and Canal, First and

Second Enlargements). No modifications have been made to the physical locations of the diversion points of the Windy Gap Project Water Rights since completion of construction of the project structures in 1985. The Municipal Subdistrict has, for the more than thirty-five years since the Windy Gap Project was constructed, diverted water for beneficial use under the Windy Gap Project Water Rights at the actual physical locations of the points of diversion with the intent to divert pursuant to the decrees confirming the water rights. The physical locations of the points of diversion are more than 500 feet from the decreed legal descriptions of the points of diversion. There are no natural surface streams tributary to the diverted stream or other surface water rights between the decreed locations and the corrected legal descriptions for the physical locations.

CONCLUSIONS OF LAW

9. The foregoing findings of fact are incorporated herein to the extent that they constitute conclusions of law.

10. Application Contemplated by Law: The Application in this case is one contemplated by C.R.S. § 37-92-305(3.6)(d)(IV) and C.R.S. § 37-92-302(1)(a). The points of diversion for the rights are already in place, and one or more water rights are diverted at the corrected points of diversion.

11. Notice and Jurisdiction: Timely and adequate notice of the pendency of these proceedings has been given in the manner required by law pursuant to C.R.S. § 37-92-302(3). The Court has jurisdiction over the subject matter of these proceedings and over all parties affected hereby, whether they have appeared or not. C.R.S. § 37-92-203; *Bijou Irrigation Co.*, 926 P.2d at 24-25. The Application and resume publication of the Application placed all potentially interested persons on notice of the claims made by the Municipal Subdistrict in the Application and adjudicated by this Ruling.

12. No Injury or Expansion: Pursuant to C.R.S. § 37-92-305(3.6)(e), correction of the erroneous legal descriptions for the subject water rights described herein will not cause an enlargement of the subject water rights and will not injuriously affect the owner of or persons entitled to use water under a vested water right or a decreed conditional water right. The Windy Gap Project Water Rights will continue to be diverted at the existing points of diversion up to the decreed amounts and flow rates, and subject to decreed volumetric limits and the terms and conditions of the decree entered in Case No. 17CW3176 (“17CW3176 Decree”).

13. No Requantification: In accordance with C.R.S. § 37-92-305(3.6)(g)(I), this decree does not requantify the water rights for which the erroneously described points of diversion are being corrected.

14. All Applicable Standards Met: Applicant has met all applicable standards and burdens of proof, including without limitation those set forth in C.R.S. §§ 37-92-305(3.6). *See also* C.R.S.

§ 37-92-305(3.6)(g)(II) (listing standards not applicable to corrections of established but erroneously described points of diversion).

RULING OF REFEREE

15. The foregoing findings of fact and conclusions of law are incorporated herein.
16. The Referee concludes that all applicable standards and burdens of proof for correction to established but erroneously described points of diversion have been met, that the Application therefore should be granted, and that the points of diversion for the Windy Gap Project Water Rights should be and hereby are corrected as follows:
 - A. **Windy Gap Reservoir:** A point located in the SW/4 NE/4 of Section 26, T2N, R77W, 6th P.M., Grand County, Colorado, at the following UTM coordinates, NAD83, Zone 13: 4440257.30 Northing, 416217.64 Easting.
 - B. **Windy Gap Pump, Pipeline, and Canal; Windy Gap Pump, Pipeline, and Canal, First Enlargement; and Windy Gap Pump, Pipeline, and Canal, Second Enlargement:** A point located in the SW/4 NE/4 of Section 26, T2N, R77W, 6th P.M., Grand County, Colorado, at the following UTM coordinates, NAD83, Zone 13: 4440251.92 Northing, 416302.81 Easting.
17. Other than correction to the legal descriptions of the points of diversion, the Windy Gap Project Water Rights and all of the decrees referenced in Paragraph 7 relating thereto remain unchanged by this Ruling. Specifically, and without limitation, all of the terms and conditions of the 17CW3176 Decree (other than the legal descriptions of the points of diversion) remain unchanged by this Ruling and in full force and effect, including incorporation of the 2012 Windy Gap Firming Project Intergovernmental Agreement dated July 12, 2016, as an integral and non-severable part of the Windy Gap Decrees, 17CW3176 Decree ¶ 44.
18. The Stipulations entered into between the Municipal Subdistrict and Opposers, as described in Paragraph 4 herein, are hereby approved and incorporated into this Ruling.
19. A copy of this Ruling shall be filed with the Division Engineer for Water Division No. 5 and with the State Engineer.

DATED: August 13, 2021.



Susan M. Ryan
Water Referee, Water Division No. 5

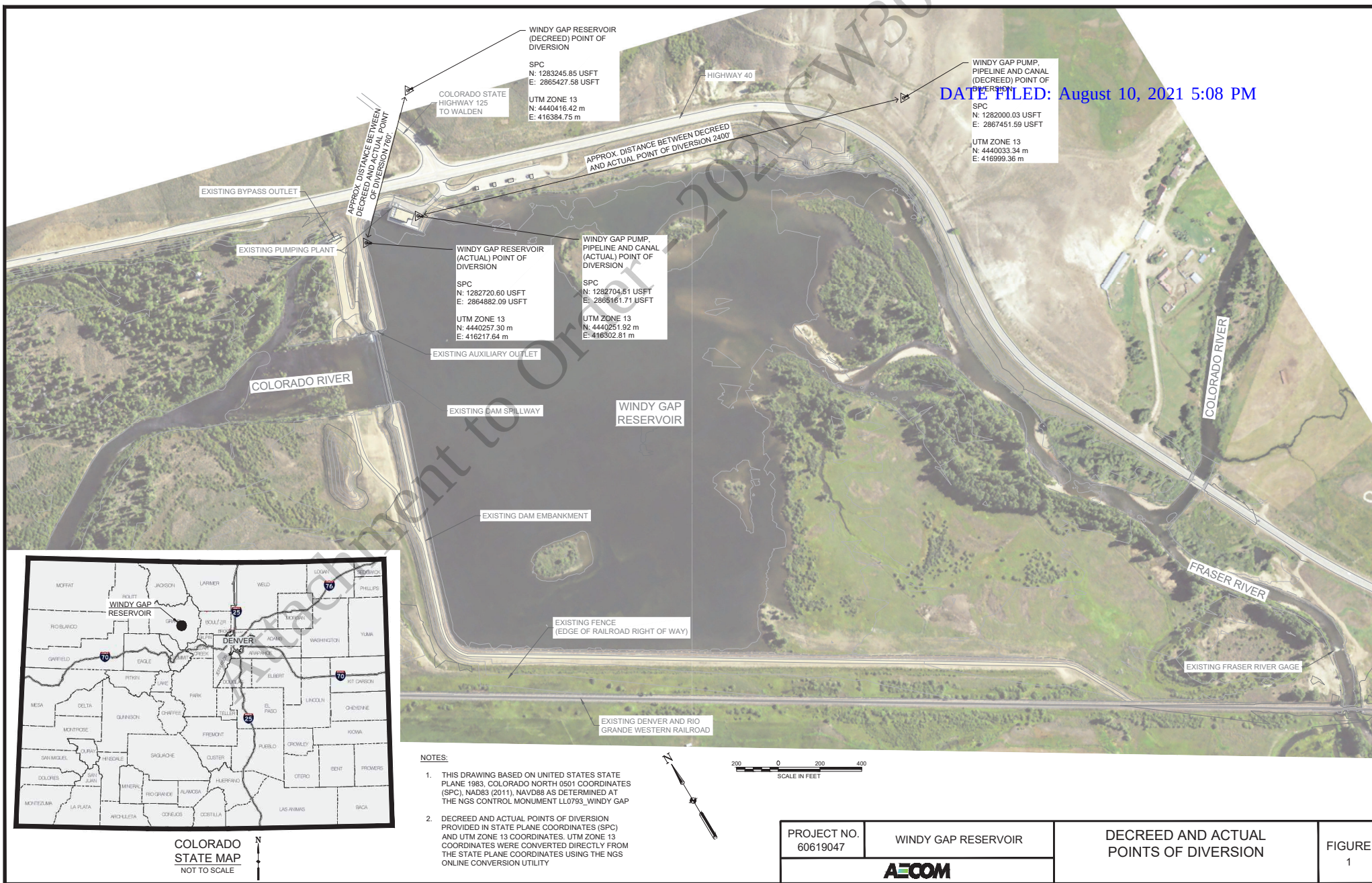
NO PROTEST WAS FILED IN THIS MATTER. THE FOREGOING RULING IS
CONFIRMED AND APPROVED AND IS MADE THE JUDGMENT AND DECREE OF THIS
COURT.

DATED: _____

BY THE COURT:

James B. Boyd
Water Judge, Water Division No. 5

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JUDICIAL ARBITER GROUP, INC.

JAG Case No. 2021-0914

City of Greeley and Boyd Irrigation Company,

Plaintiffs,

v.

Aggregate Industries Wcr, Inc.,

Defendant.

SETTLEMENT AGREEMENT

Pursuant to the statements made at the settlement conference held August 25, 2021, this is to confirm the settlement of the above-captioned case upon the following terms:

Within thirty (30) days of the Plaintiffs' execution and delivery of a waiver and release of liability to be prepared by Defendant, the Defendant and/or its insurer shall pay to Plaintiffs and Plaintiffs' counsel of record, in full satisfaction of their claims, the total sum of \$2,000,000.00, to be allocated as directed by Defendant's counsel after informed by Plaintiffs' counsel.

Such sum shall be allocated to Plaintiffs and Plaintiffs' counsel as they have agreed.

This settlement shall resolve all of Plaintiffs' claims, pled or unpled, against Defendant in Weld County District Court case no. 2018CV30773 captioned as City of Greeley & Boyd Irrigation Company v. Aggregate Industries – WCR, Inc., including but not limited to those arising out of or relating to the alleged failure of Defendant to properly slope or stabilize the western slope of its gravel pit.

Plaintiffs will undertake repairs or restore, re-slope, stabilize, and armor the western slope of the Defendant's property in accordance with the specifications contained in the Wright Water Engineers reports disclosed by Plaintiffs in the above-referenced lawsuit. Additionally, it is understood that Plaintiffs will reinstall the Boyd ditch.

Defendant agrees to cooperate and consent as necessary for Plaintiffs to enter on its property to make the aforementioned repairs.

The parties stipulate that Plaintiffs, by this settlement, are not assuming any liabilities or responsibilities under Defendant's DRMS permit. Plaintiffs will cooperate and inform DRMS that the dispute between Plaintiffs and Defendant is resolved and that Plaintiffs will undertake repairs on Defendant's western slope.

The parties understand and agree that maintenance of Defendant's land remains with Defendant.

Plaintiffs agree to pay all liens and indemnify, defend, and hold Defendant and/or its insurer harmless from any claims, liens and lawsuit by any creditor that may arise out of Plaintiffs' work on Defendant's property in connection with this settlement.

The terms of this settlement shall be confidential and shall not be disclosed to any third party except as may be required by law. The precise form of the confidentiality agreement shall be resolved by counsel for the parties.

The parties intend this Settlement Agreement to be a final written document which qualifies as an exception to the confidentiality provision found at C.R.S. § 13-22-307(2).

The parties understand and agree that this document is binding and enforceable and may be submitted to a court to prove the existence of this Settlement Agreement or for enforcement.

The parties shall cooperate in the execution of any documents necessary to accomplish the terms of this settlement agreement.

Upon execution of this settlement, counsel shall stipulate to dismissal of the pending litigation with prejudice, and each party shall pay said party's own attorney's fees and costs.

Defendant's counsel has authority to sign this Settlement Agreement on behalf of Defendant.

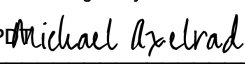
Dated this 25th day of August, 2021.

READ AND AGREED:

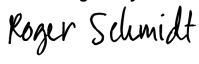
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Sean Chambers
For Plaintiff City of Greeley

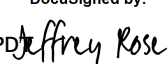
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Michael J. Axelrad, Esq.
Counsel for Plaintiff
Tax ID: _____

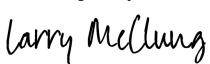
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Roger Schmidt
For Plaintiff Boyd Irrigation Company

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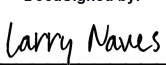
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Jeffrey S. Rose, Esq.
Counsel for Plaintiff Boyd Irrigation Company

8/25/2021 | 4:19 PM PDT

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Larry S. McClung, Esq.
Counsel for Defendant

8/25/2021 | 4:17 PM PDT

WITNESS

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LARRY J. NAVES, Arbiter
JUDICIAL ARBITER GROUP, INC.

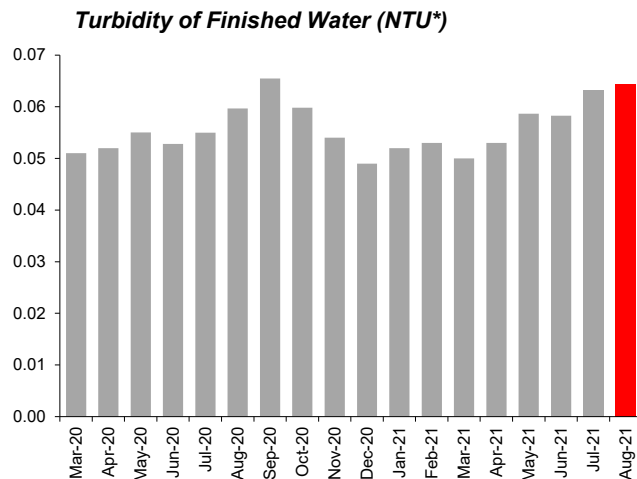
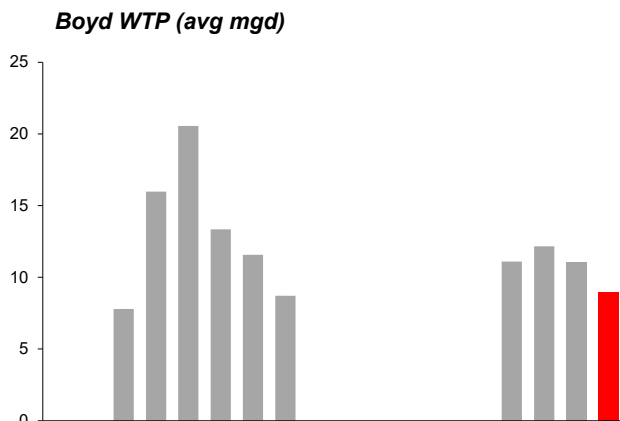
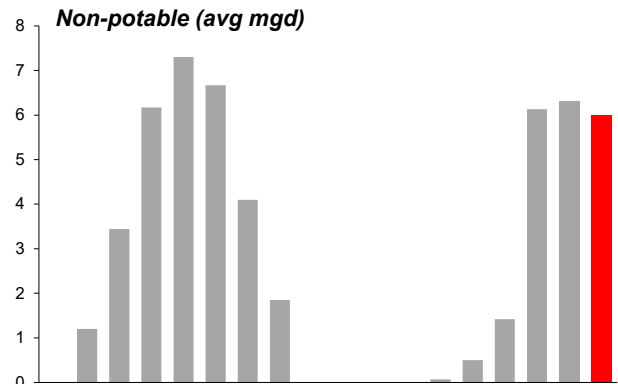
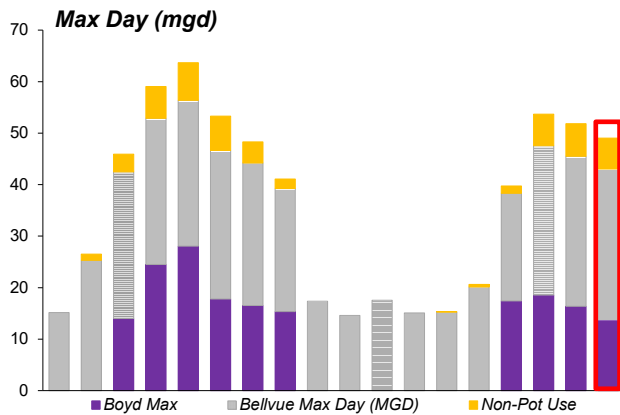
8/26/2021 | 6:43 AM PDT

Water Treatment

Bellvue Water Treatment Plant operates year-round with a transmission capacity of 29.1 million gallons per day (mgd) (plant capacity is 32 to 35 mgd). Water sources include Poudre River direct flows, Colorado-Big Thompson (C-BT), Windy Gap, High Mountain Reservoirs, Laramie-Poudre Tunnel, and Water Supply and Storage. Average volume is 19,000 acre-feet a year (2000-2011). The plant was built in 1907, with its last treatment upgrade in 2009. Solar panels were added in 2014.

Boyd Water Treatment Plant operates normally from April to October with a plant capacity of 38 mgd (transmission capacity is 40 mgd). Water sources include Greeley-Loveland Irrigation Company, C-BT, and Windy Gap. Average Volume is 8,200 acre-feet (2000-2011). The current plant was built in 1974, with its last treatment upgrade in 1999. Solar panels were added at Boyd in 2014. In 2016, tube settlers and platte settlers were replaced in the sedimentation basins. In 2018, all old existing chemical lines were replaced with new lines and the piping was up-sized to carry more chemical. A PLC upgrade was done on the SCADA system. Sludge pumps were replaced and hooked into the Trac Vac system that pulls sludge out of the sedimentation basins.

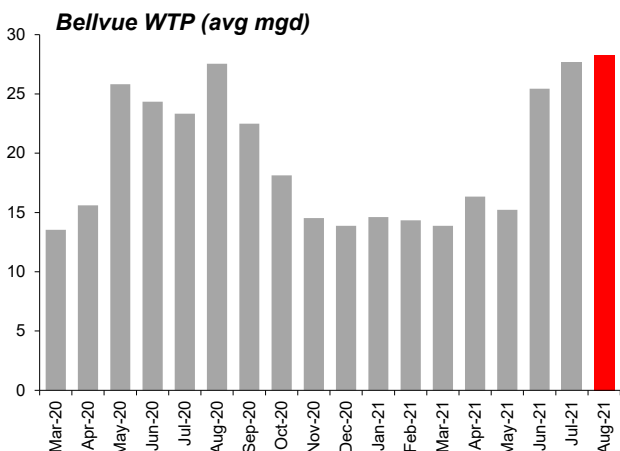
Combined, Bellvue and Boyd can treat a maximum of 70-73 million gallons per day.



Starting May 2016 Bellvue turbidity measurements will use a new method resulting in more accurate readings.

*Turbidity limit: 95% of samples must be below 0.3 NTU.

Turbidity is the measure of relative clarity of a liquid. Clarity is important when producing drinking water for human consumption and in many manufacturing uses. Turbidity is measured in Nephelometric Turbidity Units (NTU).

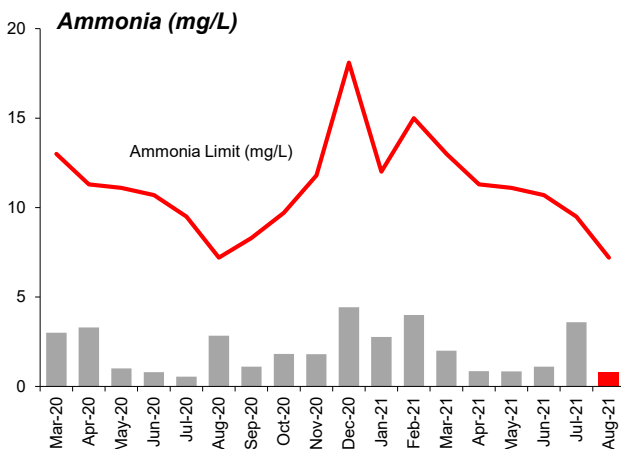
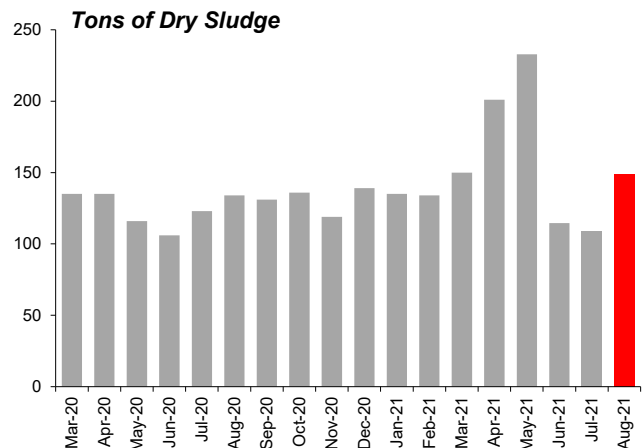
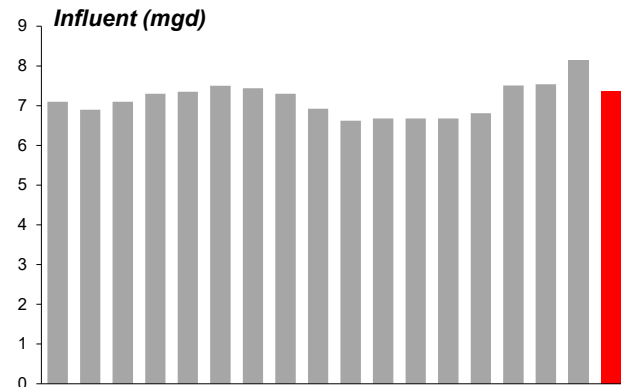
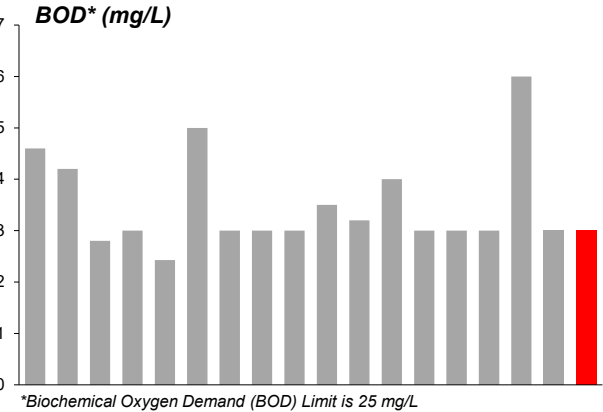
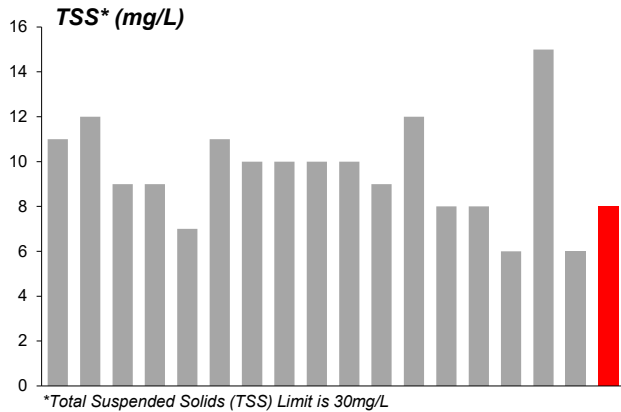


Wastewater Treatment

The Water Pollution Control Facility (WPCF) staff are dedicated environmental professionals who provide quality, safe and cost-effective wastewater treatment services for the citizens of Greeley. The WPCF treats wastewater to meet or exceed Environmental Protection Agency (EPA) and Colorado Department of Public Health & Environment requirements.

In 2011, the WPCF received an Xcel Energy Custom Efficiency Achievement Award for saving 2.78 million kWh and reducing CO2 emissions by 1,584 tons. In 2012, the WPCF received the Rocky Mountain Water Environment Association's (RMWEA) Sustainability Award for Colorado demonstrating excellence in programs that enhanced the principles of sustainability. A Certificate of Achievement from the Colorado Industrial Energy Challenge program managed through the Colorado Energy Office was received in the same year. In 2013, the plant received the City of Greeley's Environmental Stewardship Award for outstanding efforts to reduce energy (watts), conserve energy and water, reduce air and water pollution, and educate and encourage others to be environmental stewards. Also, in 2013, the plant was the recipient of a Bronze Award from the Colorado Environmental Leadership Program. In 2015, after having 5 years without a plant violation, the plant received the 2015 National Association of Clean Water Agencies (NACWA) Platinum Peak Performance award for the City of Greeley Water and Sewer Department.

Note: the red column indicates the current month.



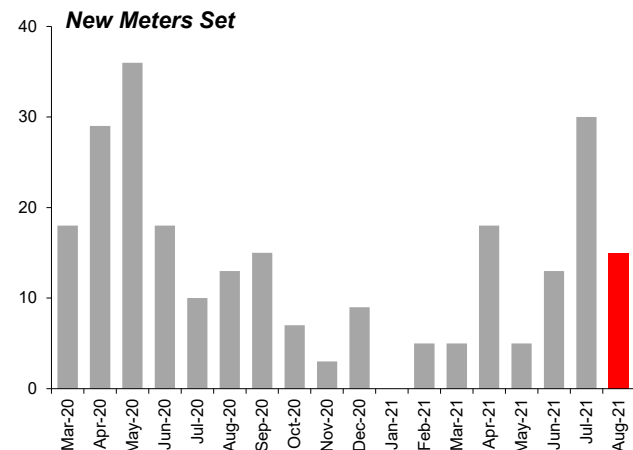
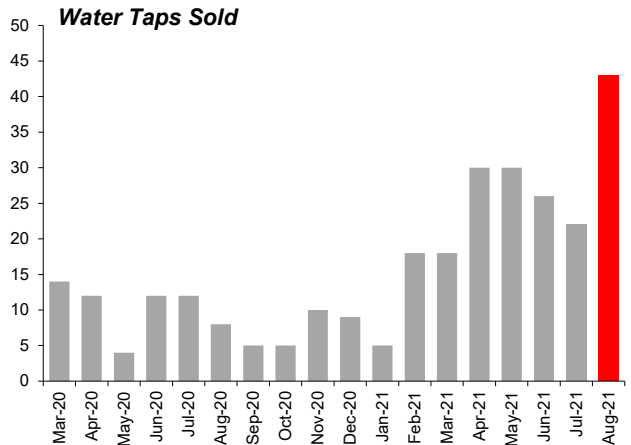
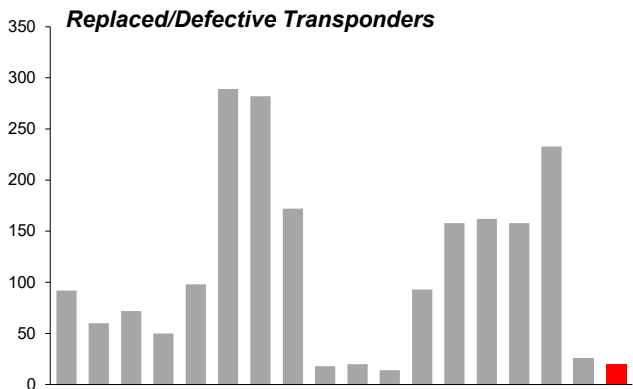
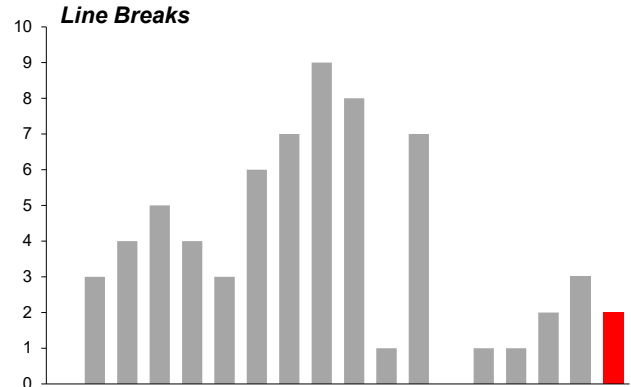
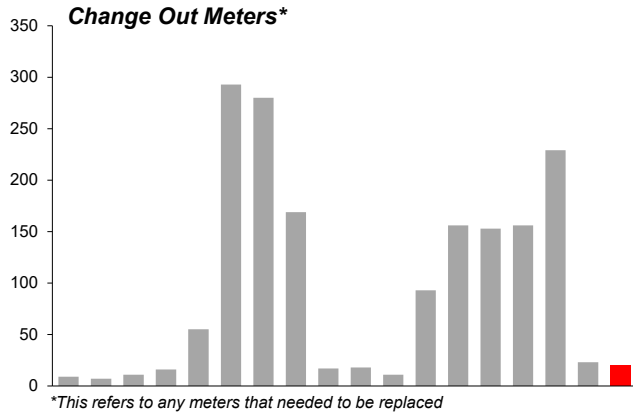
Water Distribution

The Greeley water distribution system consists of various sizes of pipes that generally follow the streets within the City. The distribution system serves residences and businesses in Greeley, Evans and Garden City, and the system is divided into four pressure zones.

There are 69.75 million gallons of potable water storage in Greeley. The water is stored within three covered reservoirs and one elevated tank; 23rd Avenue - 37.5 million gallons, Mosier Hill - 15 million gallons, and Gold Hill - 15 million gallons. The system also has 476 miles of pipeline, 24,233 water meters and 3,378 fire hydrants.

The water pipes in the distribution system vary in size from 4" to 36". Pipe material is steel, ductile iron, cast iron, or polyvinyl chloride. The age of the pipes varies from the 1890's to new installations.

Note: the red column indicates the current month.



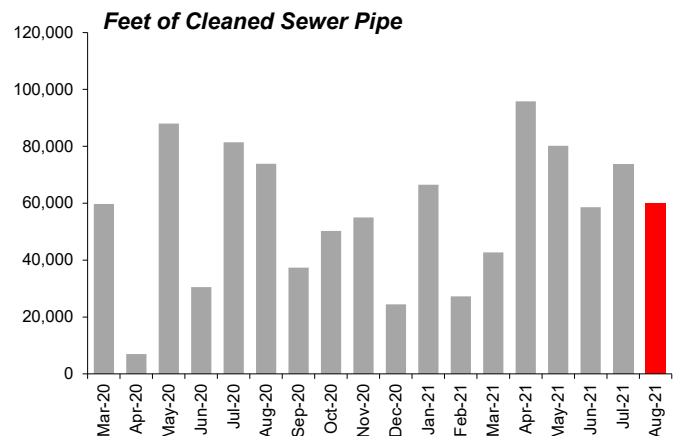
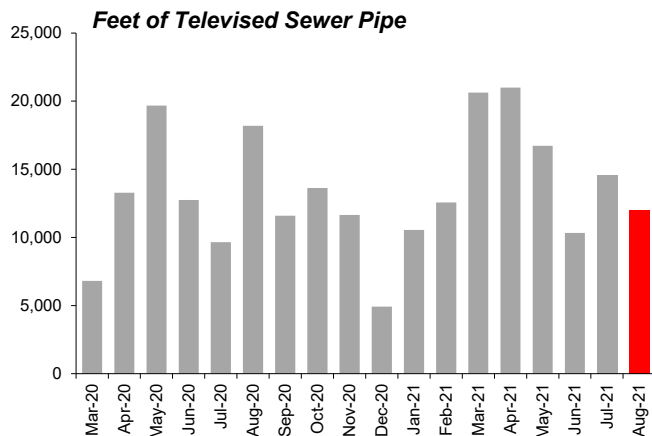
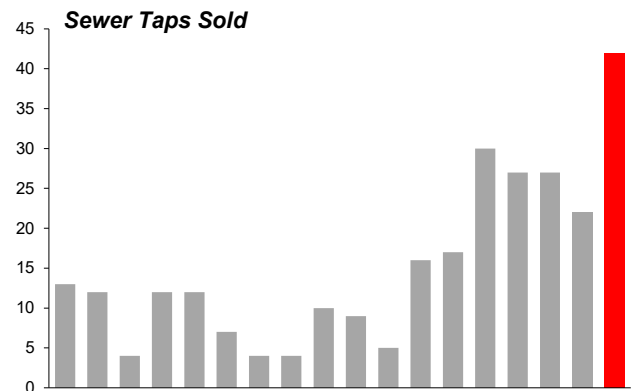
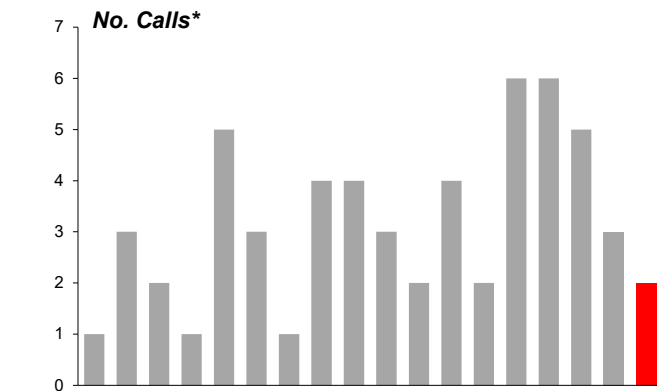
Wastewater Collection

The mission of the Wastewater Collection Division of the Water and Sewer Department is to protect community health by transporting wastewater away from homes and businesses. This includes respecting property values and public safety by reducing the frequency of blockages in the sanitary sewer lines.

A wide variety of work is performed including routine cleaning of sewer lines, inspection of sewer lines, maintenance of the sewage pumping stations, rehabilitation of the system and responding to emergencies.

The wastewater collection system dates back to 1889. At the end of 2017, the system had a total of 364.8 miles of line and 10 sewage pumping stations. The sewer service area is approximately 51 square miles. Over the last 10 years, the system has grown by 17 miles.

Note: the red column indicates the current month.

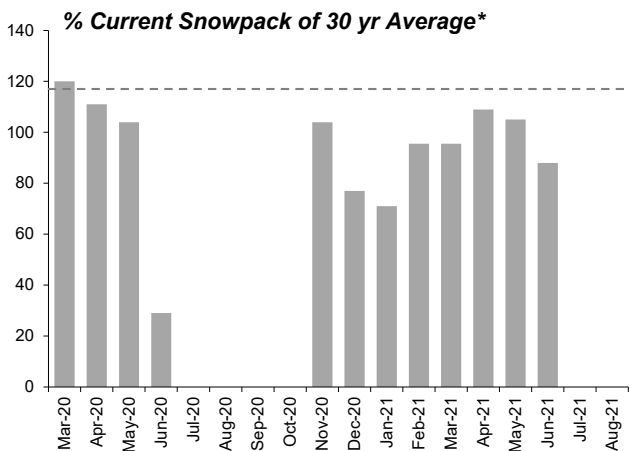
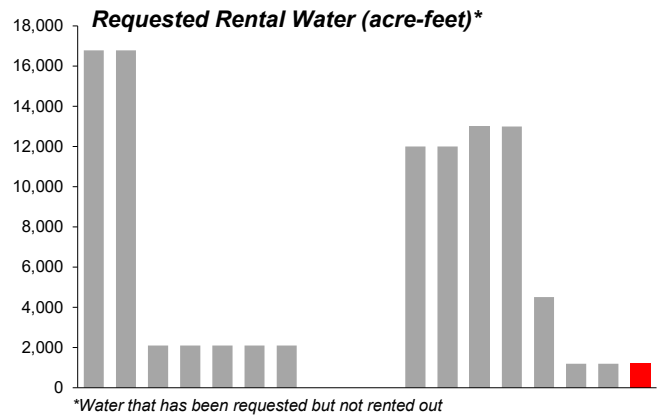
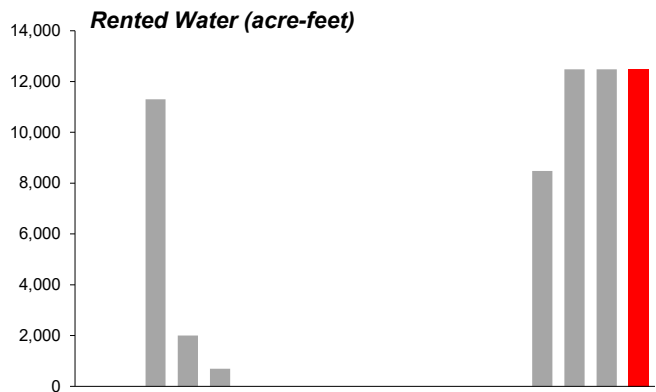
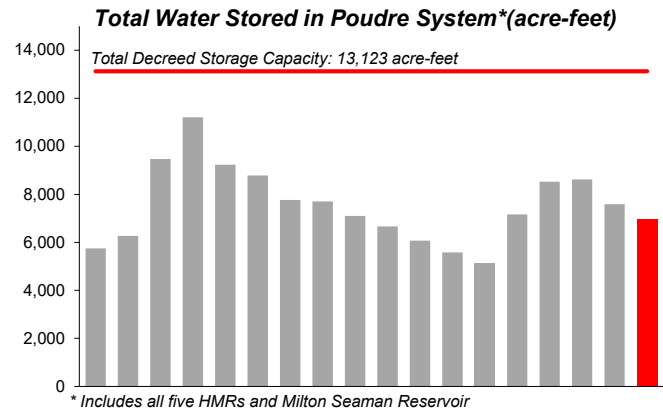
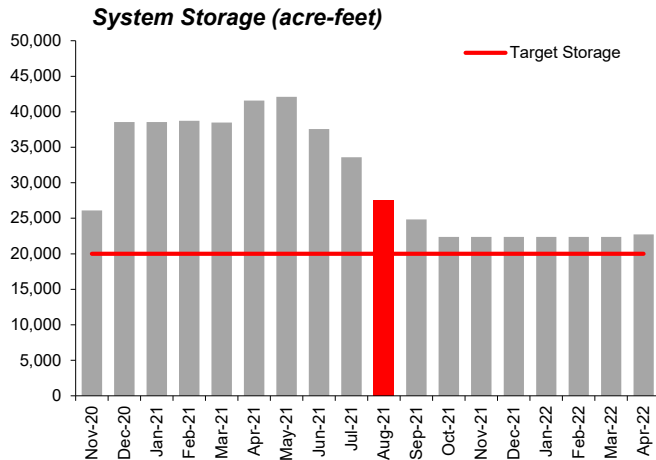


Water Resources

Greeley has numerous water rights in four river basins; the Upper Colorado River, Cache La Poudre, Big Thompson and Laramie River. The Water Resource staff must account for all of this water and comply with the rules of the Colorado Water Court and the State Engineer's Office which is in charge of allocating all of Colorado's water resources. Approximately one-third of the City's water supply comes from agricultural water rights. These water rights must be formally changed to municipal use by a special legal process through the Water Court. In this court, Water Resource staff and attorneys also defend the City's water rights against adverse claims from other parties.

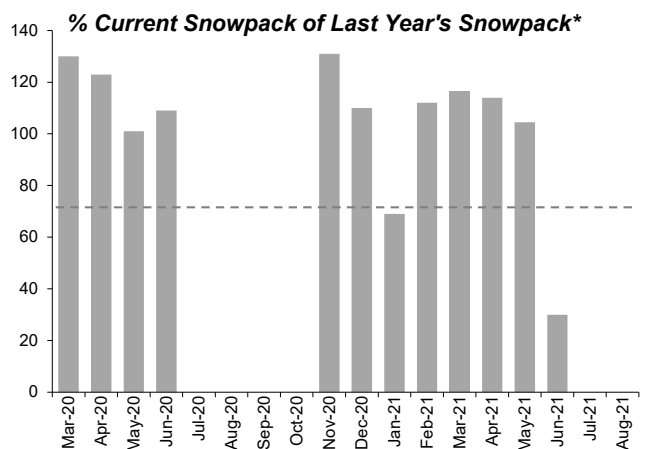
Greeley's goal is to have enough water in carry-over storage to sustain Greeley through a 50-year critical drought. Water in excess of this carry-over drought supply can be leased to agriculture, both for revenue and to support our local agricultural community. Modeling has shown that, given existing population and demand factors, Greeley will have sufficient water for citizens, if at the beginning of the 6-year long, 50-year critical drought, there is 20,000 acre-feet in storage on April 1st of the following year.

Note: the red column indicates the current month.



*Data is from the 1st of the month

**Average of Deadman Hill and Joe Wright



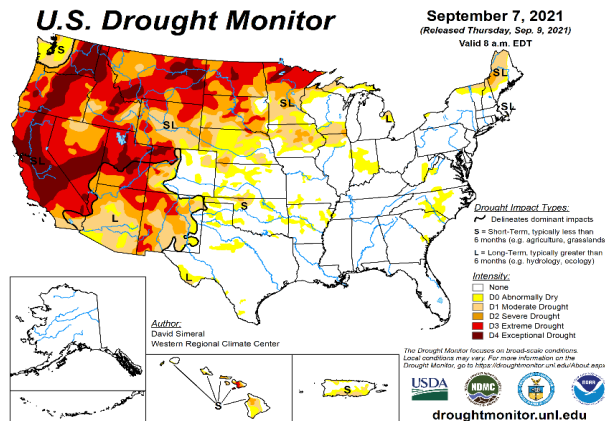
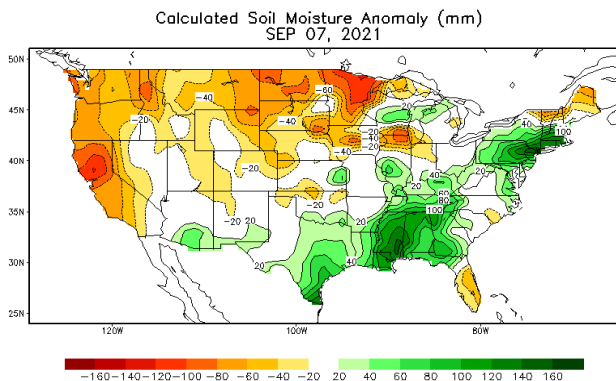
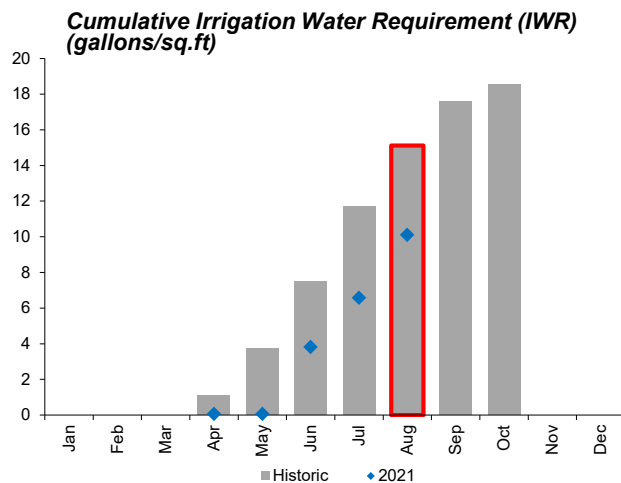
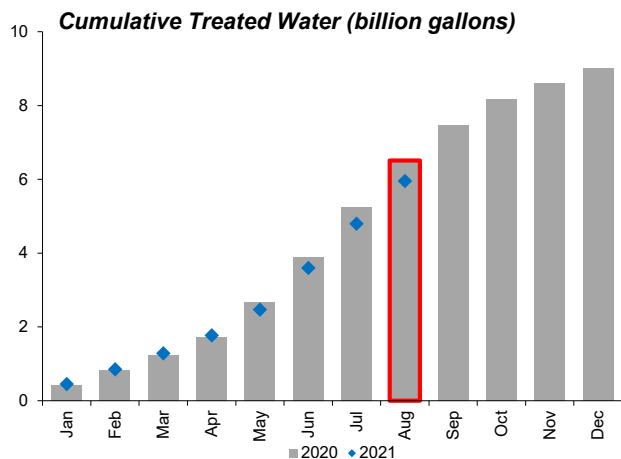
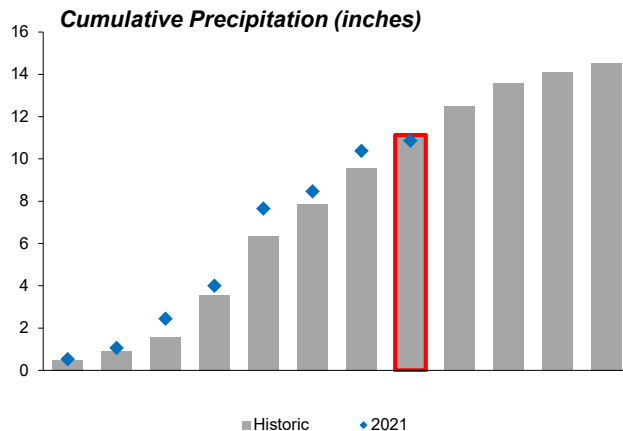
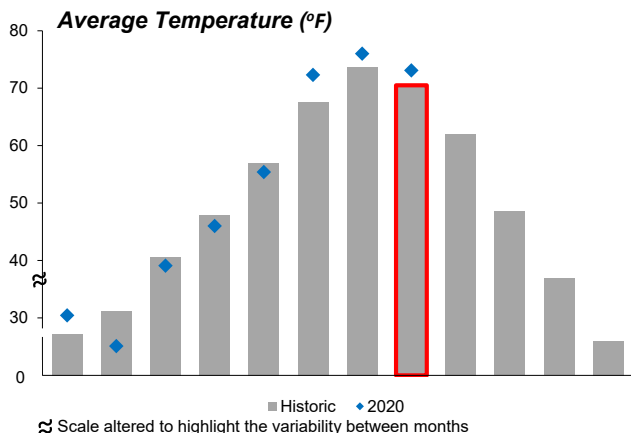
*Data is from the 1st of the month

**Average of Deadman Hill and Joe Wright

Treated Water and Weather Data

January 2021 average temperature was 30.45°F, approximately 3.3°F warmer than average. February average temperature was 25°F which was 6°F colder than average. March and April temperatures were also below average. March 2021 averaged 39.11°F compared to 40.66°F historically and April 2021 averaged 46.03°F compared to 47.86°F. May was also cooler than the historical average, 55.38°F compared to 56.97°F historically. June 2021 temperatures were above average. July temperatures were also above average, 76.01°F compared to 73.67°F. August temperatures were below average.

Greeley precipitation was 0.53 inches in January, which is slightly above average (0.43 inches). February precipitation was also 0.53 inches compared to 0.42 inches, the historical average. March 2021 precipitation was 1.39 inches compared to 0.66 inches historically. April precipitation was 1.56 inches compared to 1.99 inches historically. May precipitation was much above average. Greeley recieved 3.64 inches of rain in May compared to 2.78 inches historically. June precipitation was 0.82 inches which keeps Greeley above average for the year. July precipitation was above average, 1.91 inches compared to 1.52 inches. This was mostly because of the large rain events that dropped 1 inch in one hour. August precipitaion was below average, Greeley only recieved 0.49 inches which puts us just below average to date.



WATER & SEWER BOARD AGENDA SEPTEMBER 15, 2021

ENCLOSURE _____ NO ENCLOSURE X

ITEM NUMBER: 13

TITLE: SUCH OTHER BUSINESS THAT MAY BE
 BROUGHT BEFORE THE BOARD AND
 ADDED TO THIS AGENDA BY MOTION OF
 THE BOARD

RECOMMENDATION: TO BE DETERMINED

ADDITIONAL INFORMATION: