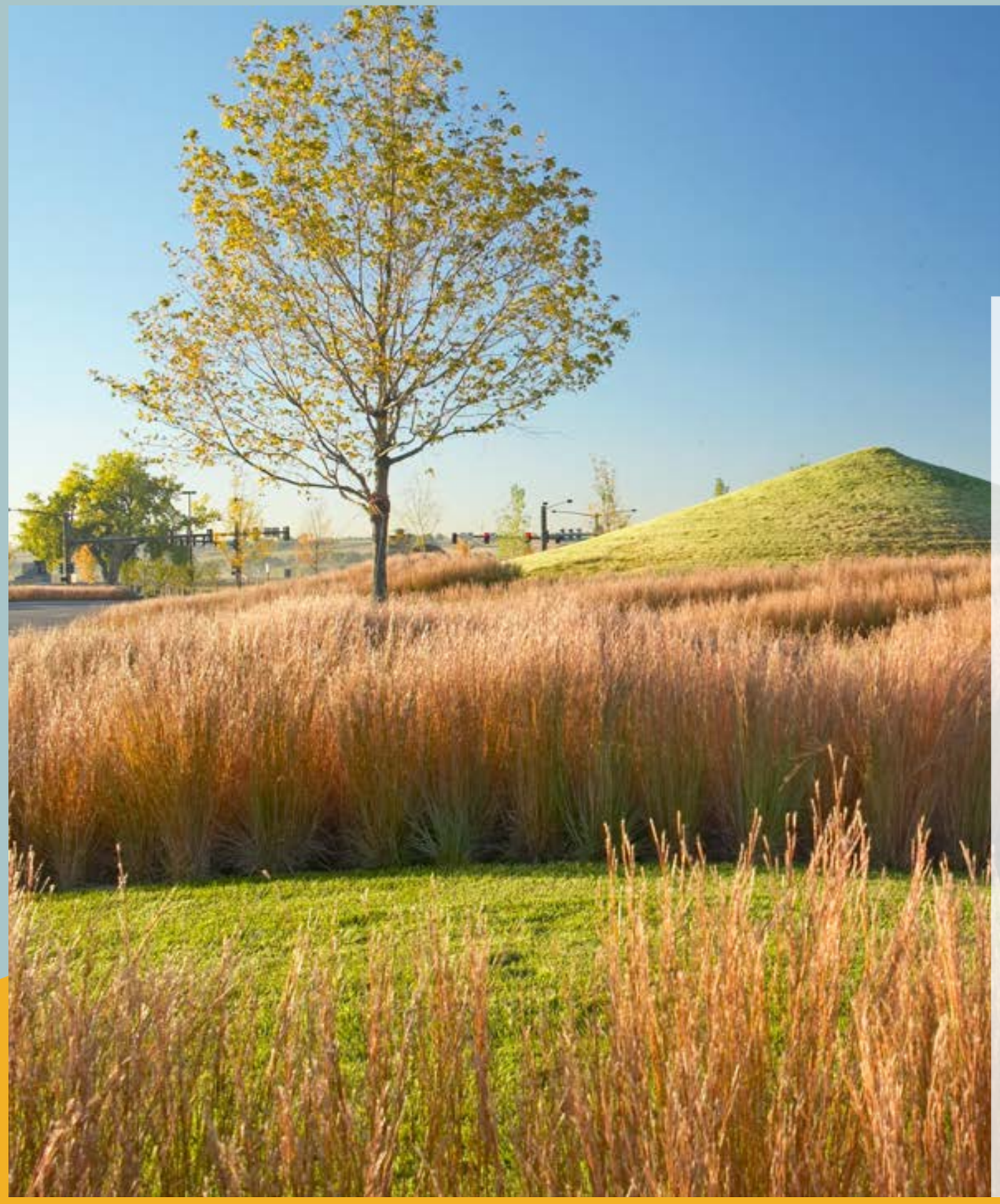

GENERAL DESIGN GUIDELINES

IRRIGATION

Irrigation Design and Construction Criteria

IRR-2 · Irrigation Design Criteria for Water Supply and Distribution
IRR-2 · Irrigation Water Use
IRR-3 · Irrigation Design Criteria for Control System
IRR-4 · Irrigation Design Criteria for Planting Areas
IRR-4 · Irrigation Design Criteria for Turfgrass Areas
IRR-4 · System Management Guidelines
IRR-5 · Operation Manual
IRR-6 · General Operation
IRR-6 · Routine General Monitoring
IRR-7 · Adjustment, Maintenance and Troubleshooting of Equipment

July 2026

General Irrigation Design and Construction Criteria

Centerra is intended to be developed in a manner which is responsive to many environmental considerations, one of the most important being water conservation. This concern for water conservation must be reflected in efficient application and effective management of landscape irrigation.

Efficient irrigation is first made possible through proper evaluation of project requirements and appropriate irrigation design, utilizing current technology and methods for determining the most effective irrigation approach. It is also vital for water conservation to incorporate proper management tools within the irrigation system design, to maximize the ability to fine tune water applications specific for individual landscape water requirements.

All projects shall obtain the recommendation of a Geotechnical engineer to provide recommendations regarding interface of irrigation systems and building foundation systems.

1.0 Irrigation Design Criteria For Water Supply And Distribution

1.1 Policy

Irrigation Design shall be submitted with Landscape Plans to DRC for approval. Zone precipitation rates and irrigation zone run times must be included on the Irrigation Plans. Irrigation run times shall be based upon providing 1-1/2 inches of water per week. All irrigation improvements shall allow for the option of utilizing non-potable water as provided by a separate entity of Centerra. All systems shall be capable of applying peak water requirements during optimum night time period with no daytime watering allowed, except during establishment or as approved by the DRC. As-Builts Irrigation Plans shall be submitted upon completion of construction.

1.2 Criteria

1.2.1 Water Demand Analysis – Complete the worksheet for each designed landscape and submit with landscape and irrigation plans to the DRC for review.

1.2.2 Irrigation Water Supply/Point of Connection

a) Provide tapped connection to the City of Loveland potable water system and extend service line to road right-of-way.

b) Provide either a turbine type or compound water meter downstream of tapped connection for total volume water use readings.

c) Provide FEBCO 825 YA reduced pressure assembly with a downstream blowout. See City of Loveland Guidelines for Point of Connection and Backflow Installation: https://www.lovelandwaterandpower.org/business/development-and-building/cross-connection-and-backflow

d) A solenoid operated master valve is required equipment for tenant sites as added protection against continuous water discharge in the event of a mainline break. Master valve is to be connected immediately downstream of water meter, or backflow preventer for potable water systems, and make control wire connection to tenant control system.

e) A Data Industrial Flow Meter, or approved equal, is to be installed after the master valve per manufacturer's recommended volumetric flow for various pipe sizes. Two additional blue control wires, 14 gauge or larger, shall be run to the irrigation controller.

f) Provide curb ball stop valve and a 3/4-inch brass blow out assembly for winterization purposes (not inverted).

g) A tee off of main building supply is acceptable with back flow preventer identified above.

1.2.3 Distribution Piping System (Mainline Pipe)

a) Determine routing of distribution piping system so as to not conflict with common area irrigation, tree locations, and paved surfaces. Maintain a minimum distance from any structures of ten (10) feet, or greater if required by soil engineer recommendations.

b) Size distribution piping system to allow peak demand flows as determined by the Water Demand Analysis worksheet. Do not exceed velocities of 5 F.P.S. Allow for simultaneous controller or remote control valve operation as necessary.

c) Provide quick coupling valves at point of connection and dead ends of piping runs (minimum) to facilitate expelling water from distribution piping system for winterization of system. In addition, quick coupling valves shall be located at every 300 feet of continuos mainline runs.

2.0 Irrigation Water Use

2.1.1 Irrigated turf shall not exceed 20% of the total landscaped area for new developments, renovations, or projects requiring DRC review. Turf shall only be allowed in areas where it provides functional recreational value, such as parks, playgrounds, and active use areas. Non-functional turf, such as narrow strips, medians, or parking islands, is prohibited unless specific functional or environmental justifications are approved by the DRC.

2.1.2 All landscaped areas must utilize efficient irrigation technologies, such as drip irrigation, smart controllers, and moisture sensors. Overhead spray systems are only permitted in functional turf areas.

2.1.3 Public areas and private parcels shall have a specified maximum amount of water that is available for irrigation, based upon the landscape prototype for the type of use and size of parcel.

2.1.4 The following table lists the maximum irrigation water use per square foot, per year, based upon gross lot size for each type of land use. Landscape and irrigation system designs shall demonstrate that they will not exceed the water allotment assigned to the specific parcel by submitting a water budget with the landscape plan.

Land Use	Allowable Metered Gallons Per Square Foot of Gross Lot Area Per Year
Business Park	4.5
Commercial	3.5
Residential	5.5
Parks/Irrigated Open Space	12.0
Naturalized Open Space	3.0*

* Use based on drip irrigation to trees and shrubs. Temporary irrigation for the purposes of seed establishment is allowed for up to three years.

2.1.5 All irrigation improvements shall allow for the option of using non-potable water if it becomes available.

2.1.6 Separate zones for turf, shrubs, perennials, annuals, etc. are required.

2.1.7 Separate zones for landscape in easement areas to be maintained by the Centerra Master Association or Metropolitan District are required.

2.1.8 The amount of irrigation water actually applied shall be the minimum amount necessary to result in plant life of acceptable health and vigor.

2.1.9 The irrigation application shall be in accordance with the local historical evapotranspiration (ET) rate curve and modified in response to recent ET rates. Although during periods of extreme ET, the amount of water applied will need to be greater than the historical ET value, at no time shall it exceed the historical ET by more than 30%. ET data is available from an on-site weather station, which will download weather data to the irrigation central control system.

2.1.10 Irrigation systems shall be designed to prevent run-off, over-spray, or ponding on sidewalks, streets, paved areas, fences, walls, buildings, or structures.

2.1.11 Sidewalks shall not be "overthrown" or receive direct over spray.

2.1.12 All Public area irrigation shall be connected to the Centerra central control system, which is capable of communicating with all field satellite units as well as assessing and downloading environmental data from on-site weather stations. Communication method shall be in compliance with control system manufacturer's instructions and the current Centerra irrigation master plan.

2.1.13 All irrigation control systems on individual building sites shall utilize technology compatible with Centerra's central control system and shall connect to it. The site system shall be capable of addressing individual landscape water requirements and appropriate scheduling needs to maximize water conservation potential.

2.1.14 Use drip irrigation for plant material whenever possible. Plant material irrigated with overhead spray shall be minimized.

2.1.15 Tree and shrub planting in low water or non-irrigated grass areas shall be supplemented with a permanent drip irrigation system or other low water alternative.

2.1.16 Design all overhead irrigation to create a uniform water distribution pattern, taking into account wind velocity, slopes, berms, landforms, and tree obstructions.

2.1.17 Design laterals to allow for plant zoning according to varying plant water needs, exposure and slopes, mowing heights, turf maintenance practices, topography, building shade, and paving reflection.

2.1.18 Avoid any direct or wind blown spray onto any roadways, parking lots, hardscape surfaces, or structures. Wind sensor technology shall be used with the central control system to adjust watering schedules during periods of high winds. Low trajectory nozzles and subsurface irrigation shall be used as necessary.

2.1.19 All head spacing shall be adjusted for constant ten MPH wind conditions.

2.1.20 Border roadways with pop-up spray heads or low trajectory pop-up rotors to better control potential over spray.

2.1.21 Provide pressure regulating control valves on all zones that should be reduced by 20 PSI or more to allow heads/emitters on that zone to operate at the manufacturer's recommended operation pressure. For spray sprinkler laterals, a pressure-compensating device integral to the sprinkler head is acceptable.

2.1.22 Laterals shall be designed so that all heads on that zone shall operate within a ten percent pressure differential.

2.1.23 Provide sprinkler head check valves where required to prevent low head drainage.

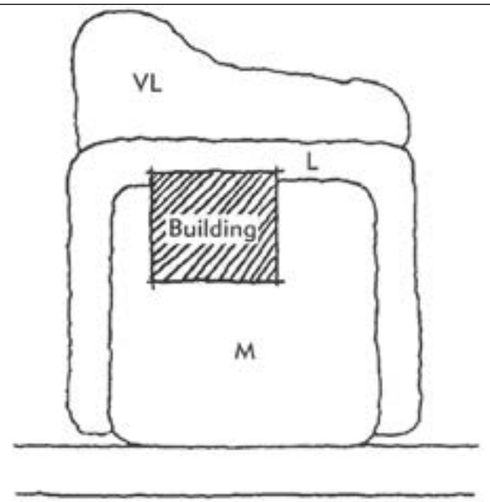

fig. 2a Water Use Zones

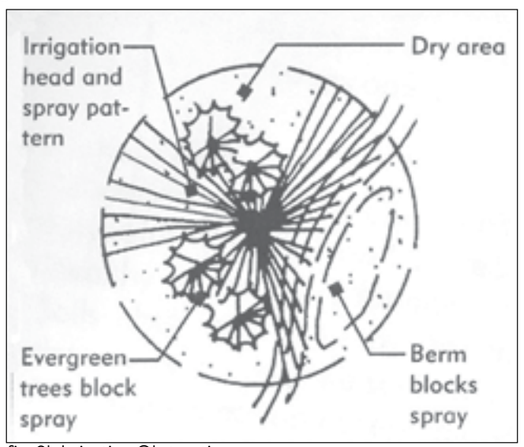

fig. 2b Irrigation Obstructions

3.0 Irrigation Design Criteria for Control System

3.1 Policy

3.1.1 All common area irrigation systems shall be designed for compatibility with the Centerra irrigation management infrastructure and the applicable irrigation control system serving the project area. Controller type, communication method, and system architecture shall be selected based on compatibility with the existing irrigation network within the specific service area.

Centerra currently operates a combination of irrigation control systems, including ET Water smart controllers that communicate via cellular internet, Rain Bird smart controllers that communicate via the internet, and select Hunter controllers that operate as standalone, manually programmed units. New irrigation systems shall be compatible with the existing controller platform serving the project area unless otherwise approved by Centerra.

Designs shall account for existing field conditions, including both conventional and two-wire irrigation systems. Where proposed improvements interface with existing two-wire systems or other legacy infrastructure, the design shall identify compatibility requirements and any necessary system modifications or conversions. Any proposed controller replacements, communication upgrades, or system conversions shall be reviewed and approved by Centerra prior to implementation.

The irrigation designer shall coordinate with Centerra during design to confirm the appropriate controller platform, communication method, and integration requirements for the specific project location.

3.2 Criteria

3.2.1 Common Area Control Systems

a) Irrigation controllers for common areas shall be compatible with the existing irrigation control system serving the project area, as approved by Centerra. Current controller platforms include ET Water smart controllers, Rain Bird smart controllers, and, in select locations, Hunter standalone controllers. Controller selection shall be based on compatibility with the existing irrigation infrastructure and any project-specific requirements.

b) Field controllers shall be installed in locking, weather-resistant enclosures and located in discreet positions within the right-of-way or other approved locations. Controllers shall be screened from roadway view whenever practical while remaining readily accessible to maintenance personnel. Locate controllers behind signage, berming, or landscape screening where feasible.

c) Controllers shall be installed in accordance with the manufacturer's recommendations, including grounding, surge protection, and electrical protection requirements. Grounding systems shall meet or exceed manufacturer recommendations, and all controller installations shall include appropriate surge protection devices.

3.2.2 Individual Building Site Control Systems

a)Individual building site irrigation controllers shall be compatible with the irrigation control system serving the project area and shall be approved by the Centerra DRC. Smart controllers shall be utilized where compatible with the existing irrigation infrastructure. Controller locations shall be outdoors in an accessible location approved by the Centerra DRC.

b)Controllers shall be sized and configured so that the maximum instantaneous flow does not exceed the value calculated on the Water Demand Analysis Worksheet and the required irrigation schedule can be completed within a maximum watering window of nine (9) hours. Construction drawings shall include a note stating that controllers shall operate valves sequentially and/or simultaneously, as necessary, to achieve the required water application within the designated watering window while not exceeding the maximum service tap or irrigation system flow rates.

c) Where projects connect to or modify existing irrigation systems, the irrigation designer shall verify controller compatibility with the existing infrastructure, including two-wire and conventional systems. Any required controller upgrades, communication modifications, or system conversions shall be identified during design and approved by Centerra prior to installation.

4.0 Irrigation Design Criteria For Planting Areas

4.1 Policy

The Centerra site's exposure to wind and interest in water conservation necessitate the use of drip irrigation for plant material whenever possible. Plant material irrigated with overhead spray should be minimized. Tree and shrub planting in low water or non-irrigated grass areas are to be supplemented with a permanent drip irrigation system.

4.2 Tree Planting

a) Provide drip emitters equally spaced around root ball edge, a maximum of 18 inches on center.

b) Use 1.0 GPH emitters on 2-inch caliper and smaller deciduous trees, and 8 feet and smaller evergreen trees. Use 2.0 GPH emitters on deciduous trees greater than 2-inch caliper size and evergreen trees over 8 feet.

c) Zone trees separately based on exposure to wind, building shade, and paving reflection.

d) Trees located within regularly irrigated turf areas shall be provided with supplemental deep-root irrigation as necessary to ensure adequate establishment and long-term health. Designers shall not assume that overhead turf irrigation alone will provide sufficient water to meet tree irrigation requirements, particularly during periods of peak summer demand.

Trees located in low-water (warm-season turf) or no-water (native grass) landscape areas shall be provided with dedicated drip irrigation or other approved deep-root watering methods. Supplemental irrigation systems shall be designed to promote deep root development, reduce the risk of drought stress, and improve tree stability while allowing irrigation schedules for turf and trees to be managed independently where appropriate.

e) All drip and emitter tubing to be buried a minimum of 8 inches below finish grade in grass areas, and under landscape fabric and mulch in planting beds.

f) Provide quick coupling valves as necessary to reach all drip irrigated plant material with maximum 300-foot hose.

4.3 Shrub Planting

a) Provide drip irrigation to all plant material one (1) gallon and larger in size, or plant material spaced 18 inches on center or greater.

b) Use one (1) GPH emitters on all shrub material, 2 per plant unless one (1) gallon or smaller spaced less than 24 inches on center.

c) Zone shrubs separately based on hydrozone (low, medium, high water req.), exposure to wind, building shade, and paving reflection.

d) All drip and emitter tubing to be buried below landscape mulch.

4.4 Groundcover, Annual, Perennial Planting

a) All groundcover spaced 18 inches or greater to be drip irrigated. Perennial plantings to be reviewed by species for capability of being drip irrigated.

b) All annuals as well as appropriate perennials and groundcover are to be spray irrigated with 6-inch or 12-inch pop-up spray heads. Low precipitation rate spray nozzles and rotary nozzles are permitted for planting beds of any size when their application is appropriate for the landscape design and irrigation requirements. Nozzle selection shall be based on achieving uniform water distribution, minimizing overspray and runoff, and maximizing irrigation efficiency. Street medians shall be designed with irrigation equipment appropriate for the planting area and site conditions.

c) Zone annual areas separate from groundcover and perennials.

d) Zone separately based on hydrozone, building shade, and paving reflection.

e) No direct spray on signage, structures, or paved surfaces is allowable.

5.0 Irrigation Design Criteria for Turfgrass Areas

5.1 Policy

Turf grass irrigation is the largest consumptive water use element of landscape irrigation at Centerra. As such, it is essential to utilize the most sophisticated design techniques and methods practical to maximize application efficiency. The design goal for all overhead turf grass irrigation is to create a uniform water distribution pattern, taking into account wind velocity, landforms, and tree obstructions.

5.2 Criteria

5.2.1 Turfgrass Species

a) Areas of turf grass species mix must be irrigated separately through valve zoning from pure species or species blends, e.g.: blue rye fescue mix to be separate from a bluegrass blend.

b) Areas of turf grass, which are intended to receive differing maintenance and/or varying mowing heights, are to be separated through valve zoning, to allow for different water applications and scheduling even though turf grass type is identical.

5.2.2 Design Approach

a) Roadways are to be bordered with pop-up spray heads or low trajectory pop-up rotors equipped with built in check valves to prevent low head drain down along roadways.

b) No public sidewalk is to be overthrown or receive direct overspray. Only walkways less than 5' wide, which meander through open space areas, may be overthrown.

c) Care is to be taken to avoid any direct or wind blown spray onto any roadways, parking lots, hardscape surfaces, or structures. Wind sensor technology will be utilized with the central control system to adjust watering schedules during periods of high wind. Additionally, low trajectory nozzles and subsurface irrigation shall be used as necessary.

d) Large turf areas may be irrigated with rotors.

e) Design irrigation to adequately address landforms through zoning and head placement, to allow tops of berming and areas of slope to receive individualized water applications and scheduling.

f) Illustrate location of evergreen and large deciduous trees on irrigation design drawings. Select irrigation equipment, space heads, and zone accordingly to allow uniform water distribution in and around obstructive plant material.

g) Design laterals to allow for zoning according to varying exposure, topography, building shade, and paving reflection.

h) All head spacing to be adjusted for constant 10 MPH wind condition.

i) Provide adjustable pressure regulating control valves or individual pressure regulation valve downstream of control valve, on all zones that should be reduced by 20 PSI or more to allow heads on that zone to operate at the manufacturer's recommended operating pressure. For spray sprinkler laterals, a pressure compensating device integral to the sprinkler head is acceptable.

j) Laterals shall be designed so that all heads on that zone shall operate within a 10% pressure differential. Provide sprinkler head check valves with pressure reducing capability on all sprinklers to reduce low head drainage.

k) All piping is to be PVC.

l) Drip zones serving multiple beds shall be zone controlled using ball valves to isolate individual planting beds.

6.0 System Management Guidelines

6.1 It is the Owner's responsibility to supply all construction documents in their entirety, including the plans, specifications, details, these notes, and the Contractor-drawn "as-built" plans, to any future Owner, maintenance company, or Homeowner's Association.

6.2 The purpose of the irrigation system is to supplement natural precipitation to maintain healthy, vigorous plant material while maximizing water conservation and irrigation efficiency. The amount of water applied shall be the minimum necessary to sustain plant health and meet the water requirements of the landscape.

Irrigation scheduling shall be based on local

evapotranspiration (ET) data and adjusted in response to current weather conditions using the smart irrigation controller platform serving the project area. ET data shall be obtained through the controller manufacturer's weather-based services (e.g., AccuWeather or equivalent approved weather data source) or other approved ET data source compatible with the existing irrigation management system.

During periods of unusually high evapotranspiration, irrigation runtimes may be adjusted to address increased plant water demand. However, irrigation scheduling shall continue to emphasize water efficiency and shall not exceed 130 percent of the historical ET rate unless otherwise approved by Centerra based on site-specific conditions.

6.3 Soil moisture conditions shall be routinely monitored by a qualified individual with a suitable soil sampling tube and auger. This shall be performed in order to determine if acceptable moisture conditions, as defined above, are being maintained. The irrigation schedule shall be adjusted accordingly, depending upon the results of this monitoring.

6.4 Short, multiple irrigation cycles shall be utilized as necessary to minimize ponding and runoff.

6.5 At no time shall water be applied to cause soil saturation. Over-watering can result in death of plants and soil expansion, causing possible damage to pavement and foundations. A qualified structural engineer shall be retained by the owner of the system on at least an annual basis to inspect roadway pavement and building structures for damage due to excessive soil moisture.

6.6 Inspections of the irrigation system shall be made on a daily basis to observe and provide repairs or remedies to the following unacceptable problems:

6.6.1 Over-spray on sidewalks, streets, paved areas, fences, walls, buildings, or other structures.

6.6.2 Drainage or run-off across sidewalks, streets, or paved areas.

6.6.3 Irrigation ponding on any landscape surface, sidewalk, street, or paved area.

6.6.4 Damaged, leaking, or improperly operating sprinklers, pipe, valves, controllers, or other irrigation equipment.

6.7 Only qualified Landscape Contractors and Landscape Maintenance individual shall provide or make repairs to the irrigation system.

6.8 At all times, the Landscape Contractor or Maintenance Contractor shall assign a qualified individual or individuals to inspect and monitor the irrigation system. Owner's Representatives shall be supplied with 24 hour emergency phone numbers for use in reporting broken or damaged irrigation equipment.

6.9 All irrigation equipment requires routine and methodical maintenance, cleaning, adjustment, parts inspection and replacement. It is the responsibility of the Landscape Contractor or landscape maintenance company to provide these services on a regular and continual basis.

6.10 The responsibility of ensuring that the above system management guidelines are properly observed is that of the Owner. The Irrigation Consultant has been retained to prepare construction documents only and does not provide post-construction reviews nor review of on-site maintenance. The Irrigation Consultant does not assume responsibility nor liability for ongoing maintenance of the irrigation system.

7.0 Operational Manual

7.1 Description of Equipment

7.1.1 Impact Rotor Sprinklers

Impact rotors shall not be used.

7.1.2 Closed Case Rotor Sprinklers

A distinguishing mark of a closed case rotor is that it's housing (case) is closed to the elements of dirt, sand, grass and other debris. Another distinction is it's small exposed top diameter. These design features make it the rotor of choice in turf areas used for recreational purposes, and eliminates maintenance required due to entrapped debris in the case.

7.1.3 Pop-up Spray Sprinklers

These sprinklers include a range in pop-up heights, with the 4-inch and 12-inch being utilized on this project. The 4-inch pop-ups are utilized in turf areas with widths generally less than 25 feet. They are also useful in irrigating slightly larger turf areas that are not conducive to rotor sprinklers due to being more oddly-shaped, such as with curved boundaries. The 12-inch pop-ups are used in the same sort of geometries but in planting beds rather than turf areas, where the additional height is necessary for the spray to clear plant material. The matched precipitation spray nozzles are available in set arcs of between 60 degrees and 360 degrees and with radii of throw of 10, 12, and 15 feet (at a pressure of 30 psi). The radius of throw is adjustable down to approximately 75% of the full radius.

7.1.4 Pressure Compensating Drip Emitters

These emitters are used to irrigate shrubs and trees in planting beds, and have the advantage of delivering a fairly uniform flow rate over a large operating pressure range.

7.1.5 Remote Control Valves

Remote control valves (RCV's) are installed on the mainline as a means of controlling the distribution and timing of irrigation to individual laterals. The valves covered in this section will be electrically operated. All remote control valves can be separated into two different types. The difference between the two is how the water enters the upper chamber. This chamber is the area between the cover and the top side of the diaphragm. Once the water has entered the upper chamber there are only two paths for it to escape, the manual bleed, or the solenoid exhaust port.

In a reverse flow valve the water can enter the upper chamber in several ways. Through an external tube that runs from the pressure side to the upper chamber, or through holes in the outer edge of the diaphragm, or through ports machined in the valve body. In a forward flow valve the water enters the upper chamber through a port in the center of the diaphragm. This port will normally be filtered. It is important that the filter is kept clean.

In normal operation, water enters the valve on the pressure side (usually the side opposite the solenoid). The water will then enter and fill the upper chamber through the path provided in the valve. When operating properly, this water is trapped in the upper chamber. The valve will only open once the force above the diaphragm has been relieved. This can happen in either of two ways, the solenoid has been energized by the controller, or the manual bleed has been activated.

7.1.6 Quick Coupling Valves

Quick coupling valves are installed on the irrigation mainline for incidental watering purposes. The quick coupling valves are activated by inserting a special lug key into the valve. The key can be equipped with a hose swivel ell for manual watering or for use with a sprinkler. Quick coupling valves equipped with a hose swivel ell are very useful in the establishment of plant materials. This particular quick coupling valve is one piece, bronze construction, with a yellow rubber cover.

7.1.7 Gate Valves

Gate valves are installed on the irrigation system mainline, and are used to isolate certain sections of a mainline for ease of repair and maintenance. The isolation gate valves are sized to match the

mainline pipe. Gate valves are bronze, with threaded connections on 2-inch and smaller valves. The 3-inch and larger valves have a resilient seat and cast iron body with flanged or mechanical joints.

7.1.8 Pressure Reducing Valves

Pressure reducing valves (PRV's) are used to reduce irrigation system pressure downstream of the installed location in order to minimize equipment wear and malfunction, and pipe fitting failure. The use of pressure reducing valves on this project will be limited to area which would have City water pressures exceeding 80 PSI at the meter. Regularly scheduled maintenance and freeze protection is required for these valves to insure reliable operation and system protection.

7.1.9 Irrigation Control System

The irrigation controller is the time clock for the irrigation system. The controller actuates the solenoid valves for the specific time and duration a sprinkler or drip lateral operates. All scheduling of valves and setting of the time clock may be accomplished at the field controller. The water budgeting feature on these controllers may be used to reduce or increase by a percentage factor the irrigation times for all stations for seasonal controller adjustment. The overall effect of using the water budgeting feature is to reduce water waste, and still provide adequate irrigation water to properly maintain the landscape.

7.1.10 Central Control System

The irrigation controller is the time clock for the irrigation system. The controller actuates the solenoid valves for the specific time and duration a sprinkler or drip lateral operates. With the addition of a centralized control system the irrigation supervisor has the ability to reduce irrigation times on cool days, increase the time on warm days, and delete irrigations on rain or high wind days, all from a central location. The overall effect of using the central irrigation controller is to reduce water waste, and still provide adequate irrigation water to properly maintain the landscape. Refer to the manufacturer's maintenance manual for further information on this equipment.

7.1.11 Mainline and Lateral Pipe

All of the mainline pipe is solvent weld or gasketed Class 200 PVC. The lateral pipe is solvent weld Class 200 PVC. Concrete thrust blocks have been poured at all fittings, sizes 3-inch and larger and at all gasketed fittings.

8.0 General Operation

8.1 System Start-up and Shut-down

Considering the fact that the climate in Loveland is cold enough to necessitate winterization of the irrigation system, there will be an annual spring start-up and autumn shut-down requirement This will consist of expelling water from the entire system, including the inlet and outlet riser to the backflow prevention assembly, as well as insuring that the mainline piping and any other components between the City water meter and the backflow preventer are protected.

Additionally, in the event of mainline pipe or component repair, the following general information is provided.

For the repair of any one section of mainline or a mainline component, the irrigation system should be shut down at the first available upstream valve. This would be either at an isolation gate valve or at the point-of-connection for that mainline. After the repair is completed, the valve should be opened gradually, in order to minimize the possibility of water hammer. Furthermore, in order to bleed air from the system, a nearby downstream quick coupling valve or a sprinkler lateral should be opened/activated while the valve is gradually opened. After a sufficient amount of water has passed through the system to purge entrapped air, the quick coupling valve or sprinkler lateral may be closed.

8.2 Scheduling

Irrigation scheduling is defined as the management process of determining and implementing the timing and duration of irrigation applications. The key information required for scheduling irrigations is evapotranspiration rates through the growing season. Evapotranspiration (ET) is the amount of water transpired from plant material and evaporated from the plant and soil surfaces.

An ET rate curve is a graphical representation of the ET as it varies throughout the "average" growing season. An on-site weather station will download ET data on a daily basis to the central software.

In addition to monitoring the health of plant material and relating the depth of irrigations to the evapotranspiration, a valuable irrigation scheduling tool is a soil probe. A soil probe is a metal tube of approximately one inch in diameter and varying length that is pushed or driven into the soil in order to extract a soil core sample. It is a simple, quick, and inexpensive means of determining the soil moisture content at various depths within the soil. Used in this way it is a helpful, supplemental method of monitoring irrigation applications and effectiveness.

Soil moisture sensors can be an effective adjunct for a centrally-controlled irrigation system. These sensors are installed in representative locations in the landscape and are useful in terminating an irrigation cycle when a pre-set moisture level is reached. In this way, if previous irrigation or rainfall has been sufficient to meet the landscape's water requirements, the moisture sensor will shut down irrigation until such a time that the soil has dried out sufficiently to drop below the pre-set level.

9.0 Routine General Monitoring

9.1 Need for General Monitoring

The visual appearance and the very life of the landscape plant material is dependent upon the proper functioning of the irrigation system. For that reason it is imperative that the irrigation system be routinely monitored. The visual appearance of the landscape plant material can provide valuable feedback about the functioning of the irrigation system. There are three general factors that contribute to the need for this monitoring:

9.1.1 The ever-changing water needs of the plant material, dependent upon seasonal variations and life cycle variations.

9.1.2 Variable weather conditions, and its effect upon the water needs of the landscape.

9.1.3 The condition of the irrigation system itself.

9.2 What to Look for in General Monitoring

There are several key areas to look for when engaging in general monitoring of the landscape and irrigation system. Some of these necessitate watching the irrigation system operate, while others can be observed without the system operating. The key areas are:

9.2.1 Adequate and uniform coverage for all areas. This involves watching for dry spots, stressed plant material, and over or under-adjusted radii and arcs of throw for sprinklers.

9.2.2 Excessively wet areas, possibly indicating pipe breakage.

9.2.3 Broken or stuck sprinkler heads.

9.2.4 Overspray onto walkways, roads, buildings, parked cars, or other hardscapes.

9.3 Scheduled Routine Inspections

On a pre-established and routine basis, the irrigation system should be inspected in a more thorough manner than that possible with the general monitoring described above. This inspection process involves sequencing through all of the controller stations to verify proper operation of the controller, valves, sprinklers and drip emitters.

With the size of this system, it would probably be desirable, to break this inspection process up into more numerous inspections of portions of the system spread out during the year. As a suggestion, these portions of the system could be defined by the point-of-connection.

When a problem is observed it should be corrected as soon as possible. The Adjustment, Maintenance and Troubleshooting of Equipment section that follows is intended to aid in the correction of problems observed through general monitoring.

10.0 Adjustment, Maintenance And Troubleshooting Of Equipment

10.1 Pop-up Spray Sprinklers

10.1.1 General

Pop-up spray sprinklers are used throughout the District for irrigating turf and landscape areas. Several nozzle technologies are currently in use, each with different operating characteristics, precipitation rates, and maintenance requirements. Designers and maintenance personnel shall select and maintain nozzle types appropriate for the application while maximizing irrigation efficiency and distribution uniformity.

10.1.2 Nozzle Types

a) Standard Fixed-Arc Spray Nozzles

Standard fixed-arc spray nozzles provide a predetermined arc and radius of coverage and are best suited for regularly shaped planting areas. Radius may be adjusted within the manufacturer's recommended range. If significant radius reduction is required, the nozzle should be replaced with the appropriate size rather than excessively restricting the spray.

b) Variable Arc Nozzles (VAN)

Variable Arc Nozzles allow adjustment of the irrigation arc in the field to accommodate irregular landscape shapes. While providing installation flexibility, these nozzles typically have lower distribution uniformity than fixed-arc nozzles and should be used only where necessary. Excessive adjustment can result in uneven precipitation and water waste.

c) High-Efficiency Spray Nozzles

High-efficiency spray nozzles, including Toro Precision™ or approved equivalents, provide lower precipitation rates and improved distribution uniformity compared to conventional spray nozzles. These nozzles are encouraged where appropriate to reduce runoff, improve infiltration, and increase irrigation efficiency.

d) Rotary Spray Nozzles

Rotary spray nozzles (such as MP Rotator®, Rain Bird R-VAN®, or approved equivalents) apply water at significantly lower precipitation rates through multiple rotating streams. Rotary nozzles are well suited for larger turf areas, slopes, and soils with low infiltration rates where runoff is a concern. Because precipitation rates differ substantially from conventional spray nozzles, rotary nozzles shall not be mixed with conventional spray nozzles on the same irrigation zone.

10.1.3 Adjustment

The necessary adjustments for pop-up spray sprinklers are minimal. Occasionally an adjustment of the radius of throw is required. That is accomplished by turning the screw in the top of the nozzle in a clockwise or counter-clockwise direction as necessary to increase or decrease the throw. Care should be taken not to adjust the throw downward by more than 25% (For example, the lower limit of a 15-foot radius nozzle is approximately 11 feet). If further reduction of the radius is necessary, another size in the nozzle series should be considered.

The arc of throw may also occasionally need adjustment. The arcs for each of the nozzles is fixed, but the positioning of that arc can be adjusted. That is accomplished by either rotating the sprinkler body or by rotating the pop-up stem (when it has a ratchet mechanism). If the range of arc needs to be adjusted (as opposed to the positioning of that arc), a different nozzle should be considered.

If varible arc nozzles (VAN) are used, first set the left stop. Then turn the knurled band on the nozzle to increase or decrease the angle of coverage.

10.1.4 Maintenance

The pop-up spray sprinklers have a screen that may occasionally require cleaning. This screen is accessed by simply unscrewing the nozzle from the top of the stem.

10.1.5 Troubleshooting

a) Misting: This is a result of excessive water pressure. Reducing the pressure may be done in one of two ways. Either by using the flow control on the remote control valve, or by installing a pressure regulator before or on the valve.

b) Inaccurate pattern: This is usually caused by some type of blockage, either in the nozzle itself or in the screen. Only water, air or a soft bristled object should be used to clean the nozzle. Use water to clean the screen.

c) Leaking around the stem: This is usually caused by debris between the wiper seal and stem. A quick way to solve this problem is to step down lightly on the stem while the sprinkler is in operation. This causes water to flush quickly between the stem and cap, taking the debris with it. If this does not work, the cap is probably damaged and needs to be replaced.

10.2 Remote Control Valves

10.2.1 Adjustment

Typically the only adjustment required on a remote control valve is related to pressure regulation. On valves that have external pressure regulators, connect a pressure gauge to the schrader valve connection on the regulator. Adjust the regulator knob until the desired downstream pressure required for proper system operation is attained. This device will maintain the desired downstream pressure regardless of variations in supply pressure. Valves without pressure regulators can be adjusted to reduce the flow and downstream system pressure by turning down the flow control stem. However, it is not recommended to exceed a 25% reduction in pressure using this method.

10.2.2 Maintenance

Valves can be cleaned by removing the bonnet and accessing the diaphragm assembly. Remove debris that has collected in the upper chamber or below the diaphragm. Clean the solenoid screen of grit and organic material. Some solenoids can be disassembled and cleaned internally. Clean diaphragm screen or ports, external flow tube or other filters in the valve.

10.2.3 Troubleshooting

Before assuming that there is a valve problem, check the obvious. Is the water turned on, is the controller plugged in and programmed correctly, are there isolation valves that might be turned off? Verify valve operation by using the manual bleed, this might indicate a controller or wiring problem if the valve works properly when using the manual bleed. Typical problems include:

a) Valve will not close: There are two things that will cause this. The first cause is a physical obstruction (rocks or other debris) preventing the diaphragm from seating. When removing a physical obstruction, be sure to thoroughly inspect the diaphragm assembly and valve seat area for damage. The second reason is insufficient force being applied above the diaphragm. Probable causes:

- The solenoid plunger is missing, or stuck in the up position. Remove and inspect the solenoid.
- Diaphragm filter plugged. This will prevent water from entering the upper chamber.
- Flow control turned up too high. The

diaphragm can stick in the up position under low flow/low pressure conditions.

- Constant voltage from the controller. The solenoid will usually be warm to the touch and a slight vibration can be felt if this is happening.
- Leak between the bonnet and body. Water will be visibly leaking where the body and bonnet are connected. This will again prevent sufficient force from developing in the upper chamber.
- An open manual bleed. An open external manual bleed will be very obvious. An internal manual bleed system can be unknowingly activated if the valve is unfamiliar to the customer.
- A large hole in the diaphragm. (Forward flow valve only). Sufficient force will not build in the upper chamber. Remove the diaphragm assembly and inspect it very carefully, replace it if there are any bubbles or other signs of wear.
- The valve is installed backwards. The arrows on the valve body indicate the direction of water flow through the valve.

b) Valve seeping: This is usually indicated by a puddle at the lowest sprinkler head. Using an automotive stethoscope may aid in determining which valve is leaking in a manifold. There are two main causes for this to happen.

- Solenoid, or solenoid seat is damaged. Water will constantly leak past the plunger. Replace the solenoid plunger or the seat if possible.
- Valve seat is damaged. Check the valve seat and the diaphragm seating area for pitting and small debris. Replace the diaphragm if damaged, it may be necessary to replace the valve body if the seat area is damaged.

c) Valve will not open: There are again two main causes of this problem. The first cause is an adjustment problem, the flow control stem is tightened all the way down. The second, is that the force is not being released from the upper chamber. Probable causes:

- Solenoid burned out. A resistance test will verify if the coil is bad (Refer to the volt ohm-meter section to learn how to perform this test). Replace if necessary.
- A torn diaphragm (Reverse flow valve only). The hole in the diaphragm will allow more water into the upper chamber than can be bled off through the solenoid port. Inspect the diaphragm, and replace it if necessary.
- Plugged ports. The port below the solenoid, and/or the port leading to the solenoid chamber is plugged. This would again prevent the water in the upper chamber from being relieved. Clean the ports with a paper clip, never drill out the ports.
- Solenoid not receiving voltage. The controller is not sending the necessary voltage, or there are wiring problems, or the wire connections are faulty (Refer to the volt ohm-meter section to learn how to inspect the field wiring).

10.2.4 Pressure Reducing Valves

For information on the operation, maintenance, and troubleshooting of the pressure reducing valves, refer to the manufacturer's manual.

10.2.5 Irrigation Control System

This section will describe some troubleshooting procedures that will determine if the controller is indeed the bad component in the irrigation system. The controller is usually the first component blamed from an irrigation system failure. Typically, once the controller has been removed and taken to a repair facility, more than 25% are returned without a defect being found in the controller.

Controller Check: Before removing the controller it is recommended that the following are checked:

a) Programming - A program consists of three steps:

- Start time - The time of day that the irrigation should begin.
- Run time - The irrigation duration for each station.
- Days on - The day that the irrigation will operate.

If any of these steps are missing, the controller will not activate the valves.

b) Auto/Off switch - This switch must be in the AUTOMATIC or ON position in order for the controller to operate.

c) Sensors - If the controller is equipped with a rain sensor or moisture sensor, the program will not run if they have been activated.

10.2.6 Hybrid/Solid State Troubleshooting

Hybrid and solid state controllers are designed to provide the programming versatility that is needed to better protect our water resources. The technology that is necessary to accomplish this makes repairs by untrained persons nearly impossible. The following items should be checked before assuming that the controller is the problem:

a) Visible damage - Inspect the controller for any visible signs of damage. Check the keyboard for collapsed buttons, run your finger lightly over each of the buttons, a slight "hill" should be felt at each location. If a "valley" is felt then the keyboard must be replaced. Inspect the printed circuit board for burned components, this is normally caused by lightning or, other power surges.

b) Primary power - Verify that the primary power is within acceptable limits. Contact an electrician if incorrect.

c) Transformer - Verify that the transformer output voltage is between 24 and 28 VAC, if the output voltage is zero, and the primary power is correct, then replace the transformer.

d) Circuit breaker/Fuse - Check the condition of the circuit breaker or fuse. If it has blown, the most likely reason is a field wiring short. When this happens, it only interrupts the 24 volt section of the transformer. The 12 volt section will remain active, therefore the display will show that the station is on. Press the appropriate button(s) on the keypad to turn the active station(s) off. Reset the circuit breaker, or replace the fuse with the value specified by the manufacturer. Manually advance the controller to station #1 and allow it to run for one minute. If station #1 operates correctly then advance to station #2 and repeat this procedure until the fuse blows. This will determine the problem station. Once the defective station has been located, disconnect the wire that operates that valve. Continue the above procedure to test the rest of the stations, as there could be more than one problem. Once this has been completed the controller will operate all of the stations that are still connected. The faulty field wiring will have to be repaired before it can be reconnected to the controller.

e) Microprocessor lockup problems - The microprocessor is the "brains" of the controller. Occasionally due to electrical problems the microprocessor will freeze all of its functions. The symptoms of this are:

- Display blank; the display does not show any information, or
- Frozen display with the display showing erratic information that cannot be cleared or changed from the keypad and the controller will not perform any of its programmed functions.

If the following steps are taken, the microprocessor will usually resume its normal functions. It will be necessary to completely power down the controller. Note: This process will delete your existing program.

- Primary power - It is necessary to disconnect the controller from its primary electrical source either by unplugging it from the outlet or by turning off the appropriate circuit breaker in the electrical panel.
- Battery backup - Remove the battery from the controller. The purpose of the battery is to maintain the information inside of the microprocessor in the event of a primary power failure. By removing the battery the microprocessor is allowed to reset itself to its normal condition.
- Wait - Maintain this power down condition

for 5 minutes to be certain the microprocessor will reset itself.

- Primary power - Reconnect the primary power to the controller.
- Function check - The display should now show 12:00 A.M. Set the time and day to the current setting. Using the manual controller function, turn on several stations and observe that they operate properly.

If the controller now operates properly re-enter your original program and continue to step f.

If controller still will not perform correctly it will need to be repaired by a qualified repair facility.

- Battery replacement - If the controller uses an alkaline battery, it is recommended that it be replaced with a new one at this time. Reinstall the correct battery in the controller and perform a final resistance test to ensure proper operation. This procedure will normally resolve approximately 30% of the solid state "failures".

10.2.7 Central Control System

For information on the operation, maintenance, and troubleshooting of the central control system, refer to the manufacturer's manual.