Sterling Ranch Precipitation Harvesting Pilot Study Application

Prepared for
Colorado Water Conservation Board
March 2010

STERLING RANCH

Leonard Rice Engineers, Inc.

STERLING RANCH PRECIPITATION HARVEST PILOT STUDY APPLICATION

PREPARED FOR
COLORADO WATER CONSERVATION BOARD

MARCH 2010

PROJECT NO.: 1197HSJ01

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March 1, 2010

Via Email and U.S. Mail

Colorado Water Conservation Board
Office of Water Conservation & Drought Planning Section
1313 Sherman St., Room 721
Denver, CO 80203

Attention: Veva Deheza, Section Chief of Office of Water Conservation & Drought Planning

Re: Sterling Ranch Precipitation Harvesting Pilot Study Application

Dear Ms. Deheza:

We are very pleased for the opportunity to provide you with our proposed Sterling Ranch Precipitation Harvesting Pilot Study Application (Pilot Project) for your review.

Over the last decade, Sterling Ranch has been planning a development focused on a sustainable community that blended with the local character, geography, natural beauty, and other communities in the area. Each component of the development has centered on improving the natural and sustainable benefits to new members, as well as preserving the heart of the area for those who have long made it their home. As such, Sterling Ranch has been pursuing new philosophies, methodologies, and technologies that will allow us to leverage the limited resources available. Precipitation harvesting is an exciting and natural opportunity that would fit well with the Sterling Ranch vision, and the communities' way of life.

As a new development exemplifying a water-challenged area with a wide range of geography and development types, and as a community of adequate size to represent diversity and the potential for real impact as a result of this study, we believe that Sterling Ranch is an excellent candidate for piloting precipitation harvesting. And since Sterling Ranch is at the opportune development stage of planning

and permitting, but not yet having broken ground, this site also offers the opportunity to monitor the precipitation harvesting from natural conditions to implementation and to optimally implement precipitation harvesting without retrofitting over the largest area that may benefit.

Already moving forward with the County zoning process, including proposing sweeping changes in key conservation practices as contemplated in the County's Master Plan, Sterling Ranch submitting the Land Use application on February 12, 2009, and an appeal to the County's water regulations that will foster and provide incentives for water conservation on December 03, 2009. Sterling Ranch is currently working with the County and responding to public comments to prepare for public hearings later this year. Sterling Ranch's water plan, which will move water conservation dramatically forward, does not rely on precipitation harvesting however the plan is designed such that a test site for precipitation harvesting can be added.

As part of the County Master Plan, the County has mandated that new development have conjunctive water supplies that are based upon renewable water supplies. Sterling Ranch is well on their way to providing a water supply to the prospective home buyers. Though Sterling Ranch has already secured part of their conjunctive water supplies, Sterling Ranch has requested that the final sources and plans for these water supplies be provided to the County at each platting stage of development to address the expense and timing of securing renewable water supplies over the long and variable development period.

In addition, Sterling Ranch has recommended a self-correcting mechanism with a 5-year time period for determining adequate water supply that introduces the opportunity to use metered water use data to determine the sufficient amount of supply required for the development. By introducing a mechanism that uses actual water use as part of determining the development's water supply requirements, conservation measures have the potential for true impact on the water supply planned for, built for, and used within the development.

This provides a unique opportunity to evolve the Pilot Project partnership with the actual savings in water over an entire development. The Pilot Project data collected directly from the outdoor water demand management and precipitation capture practices described herein, will be directly correlated to the water use and conservation data that will be collected for the purposes of meeting Sterling Ranch's overall water supply needs, a synergy of water use and water supply data that will be very useful in application of a potential precipitation harvesting water supply.

The Sterling Ranch Pilot Project described herein shows a process and a schedule of monitoring and data collection, including natural conditions, early monitoring, new home monitoring, and the connection of precipitation harvesting with outdoor water demand management. By selecting Sterling Ranch as a candidate in this first selection process, we will be able to adequately monitor the natural conditions of Sterling Ranch as well as utilize early Sterling Ranch development in the data collection. This may include the potential of measuring and testing monitoring techniques on new irrigation demand directly tied with precipitation harvesting through experimental sites on locations within the Sterling Ranch

development. This then allows us the best opportunity for implementing what is learned from the pilot study throughout the Sterling Ranch community, thus providing the most beneficial water conservation and financial savings potential throughout the development.

This application describes how Sterling Ranch meets the application requirements as provided in the Colorado Water Conservation Board (CWCB) Criteria and Guidelines for the Pilot Project and provides concepts for the implementation of the Pilot Project. We are excited at the prospect of combining the forward thinking of precipitation harvesting with our vision for conservation and a sustainable community. To follow through with such a project we believe that this project will require a full commitment of adequate time, the right resources, and the continued cooperation amongst the many who understand the complexity and importance of water conservation and supply, and we would very much like to be a part of your team.

Thank you, again, for your continued efforts and for your consideration.

Best regards,

Harold R. Smethills, Jr.
Managing Director
Sterling Ranch, LLC

cc: Jack N. Hoagland
Diane Smethills
Beorn Courtney
Greg Roush
Mary Kay Provaznik
Gordon Meurer

Encl: Sterling Ranch Precipitation Harvesting Pilot Study Application, March 1, 2010

Sterling Ranch Precipitation Harvesting Pilot Study Application

EXECUTIVE SUMMARY

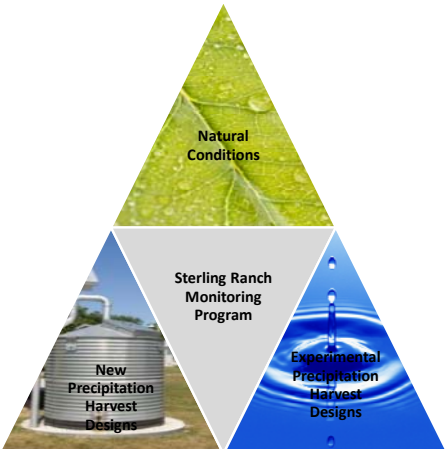
The Sterling Ranch Project, consisting of over 3,000 acres in northwest Douglas County (which includes one section of land being developed with the State Land Board), is an area where readily available renewable water supplies are limited for new development. During the conceptualization of this new community, precipitation harvesting became a personal topic of interest to the family that is developing this property, who saw the opportunity to incorporate this key renewable water supply into their planned conservation practices. In 2007, Sterling Ranch began working both independently and with Douglas County on water conservation, including completing the study entitled "Holistic Approach to Sustainable Water Management in Northwest Douglas County, "(Holistic Report) which challenged all of Colorado to progress its attitude toward water conservation and sustainable water management. Following up on the study recommendations, Sterling Ranch was a key supporter of House Bill 09-1129 that was signed on June 2, 2009 by Governor Ritter as an act concerning the authorization of Pilot Projects for the beneficial use of captured precipitation in new real estate developments. Sterling Ranch has a vision to establish Precipitation Harvesting as a sustainable, defensible, component of its non-potable water supply in combination with its advanced outdoor water demand management to set an example for future developments in the state of Colorado.

Sterling Ranch is seeking to be selected, and would be an excellent candidate, for a precipitation harvesting pilot project for the following reasons:

1) Sterling Ranch is located in a water supply challenged area where ground water supplies are declining and alternative renewable water supplies are expensive, making the development of precipitation harvesting more financially viable and acceptable to the community as part of an overall conservation and resource management way of life.
2) Sterling Ranch is a community of similar geography and climate, and of adequate size and diversity, to be able to learn and benefit from the initial phases of a Pilot Project for its own full implementation, as well as provide significant transferrable and scalable data for the Front Range and potentially for all of Colorado.
3) Sterling Ranch is at the final stages of planning and permitting, and hasn't yet broken ground. This offers Sterling Ranch the opportunity to monitor the precipitation harvesting from natural conditions to implementation and to optimally implement harvesting without retrofitting over the largest area that may benefit.

4) Sterling Ranch is committed to setting a new standard for water use and attractive landscaping, to making education of water conservation and water-wise management an integral part of their community, and to sharing its results with other communities in Colorado.

Because Sterling Ranch is a large development with diverse planning areas, the final precipitation collection design is currently envisioned to potentially consist of a combination of; 1) regional collection systems of various sizes based on storm water collection system modifications, and 2) individual home or commercial site collection systems. To optimally use the regionally collected water, a distribution system to non-potable uses would also be needed, offering the added benefit of tying to another source of water to supplement the collected precipitation when captured precipitation is not available to meet all potential non-potable demands. For Sterling Ranch, the non-potable system may be tied to the raw water system as that supplemental water source.



Sterling Ranch Precipitation Harvest Pilot Project

There are four objectives to the Sterling Ranch Precipitation Harvest Pilot Project designed to meet the guidelines and criteria provided by the Colorado Water Conservation Board (CWCB) that are being accomplished in three Phases.

Objective 1 – Evaluate natural conditions (climate, hydrology, and plant use) to quantify the amount of precipitation physically available as a water supply and characterize the destination of precipitation that is; surface runoff, stored in soil moisture, deep percolation to ground water, and consumed by plants.

The **Natural Conditions, or Phase 1**, sets the baseline data for evaluating the natural variation in climate and hydrology for the supporting information necessary to determine the volume of water that is physically available from precipitation harvesting and resulting augmentation requirements to prevent injury to vested water rights and decreed conditional water rights if captured and put to use. Information will include measurements and monitoring such as local weather and precipitation patterns, precipitation event intensity, frequency, and duration, precipitation ground and surface water return flows, and preexisting natural vegetation consumption of precipitation. Efforts on the natural conditions phase will start immediately upon acceptance of the Pilot Project, and will continue throughout the study. Specifically:

- Sterling Ranch proposes to evaluate natural conditions in two drainage basins on the property with a climate station, additional precipitation gages, stream gages, ground water monitoring holes, and lysimeters to measure plant water use.
- There will be annual reporting of data collected and preliminary results as the study proceeds. The data will be evaluated to; 1) estimate potential yield of precipitation, and 2) develop a relationship between precipitation event types and stream contribution as surface runoff and delayed ground water returns as support for a future precipitation harvesting substitute water supply plan (SWSP) and application for a decreed augmentation plan.

Objective 2 – Evaluate a variety of precipitation collection designs (size, type, materials etc.) so that a single or combination of types can be implemented in the development of the Sterling Ranch Pilot

Project to then be used to target the best collection system for each type of development that may be constructed in all of Sterling Ranch. New technologies are being tested and implemented in other states that Sterling Ranch has been monitoring and evaluating. This process and technical progress will continue throughout the life of the Sterling Ranch Project.

Taking advantage of the Sterling Ranch's early development stage, the **Experimental Designs, or Phase 2**, leverages the time during natural conditions data collection and prior to new development to explore and optimize the landscaping, irrigation, and capture designs and design elements for the New Designs, or Phase 3. Phase 2 will also start as soon as possible, and will continue as the sites provide valuable information to the Pilot Project and to the potential designs for Sterling Ranch. Specifically;

- For initial data collection, Sterling Ranch proposes to setup and collect data on; 1) capture and use of precipitation on existing residential site with landscaping similar to a future Sterling Ranch planned community (using Senate Bill 09-80 which allows users on individual wells to file a permit to capture precipitation), 2) measurement of runoff on an individual commercial site (no capture or use thus no need for an SWSP), and 3) measurement of existing regional development of potential precipitation harvesting (no capture or use thus no need for an SWSP), such as drainage from the Roxborough development.
- Results of Phase 2 will be used to assist in the design of appropriate precipitation capture facilities for proposed development types on Sterling Ranch that maximize the use of collected precipitation for various development amenities requiring irrigation.
- The goal will be evaluate capture efficiencies and system losses, storage requirements, and operational issues. The annual report will include a summary of data collected and preliminary results as the study proceeds.

Objective 3 – Evaluate precipitation harvesting paired with advanced outdoor water demand management as a water conservation practice.

The **New Designs, or Phase 3**, will include newly constructed development sites within Sterling Ranch that represent the mixed land use and precipitation harvesting systems at a scale that the pairing of precipitation harvesting with outdoor water demand management can be monitored and measured to better understand the actual water saved. The New Designs phase is not expected to start for a couple of years, with the information from Phases 1 and 2 used to help in the design and implementation of the new development designs. The minimum two year data collection period required under an approved SWSP in new residential or mixed-use developments will begin in Phase 3. The New Designs phase is expected to extend approximately four years.

- Sterling Ranch proposes to have developers construct and Sterling Ranch will evaluate: 1) capture and use of precipitation from residential sites, 2) measurement of runoff on an individual commercial sites, and 3) regional development utilizing the modification of existing stormwater collection facilities.
- The goal will be to evaluate the dependability of precipitation, storage requirements for regulating the supply to match demands, evaluate supplemental water supplies required to maintain the water-wise landscape that is aesthetically appealing, and evaluate operational issues.

- There will be annual reporting of data collected and preliminary results as the study proceeds.

Objective 4 - Create a baseline set of data to support (Sterling Ranch Monitoring Program);

a) An engineering report for a water court application for a Precipitation Harvesting augmentation plan to capture and use harvested precipitation without having to replace 100% of the captured water with a replacement water supply. Full replacement is the current law and the requirement under an approved SWSP.
b) A report on the feasibility of the sound, transferable, and scalable methodologies developed in this Pilot Project for use at other locations in the state of Colorado.

Analyses described in the Holistic Report showed that pairing precipitation harvesting with outdoor water demand management results in water savings above what water conservation alone can provide. The water-wise landscaping plans of Sterling Ranch, combined with the actual application of precipitation harvesting, either by regional or individual collection and distribution, is the ultimate question to be answered by the Pilot Project data collection. The goal for the precipitation collection system will be to evaluate the economic and water savings potential of pairing precipitation harvesting with outdoor water demand management techniques. Initial estimates of individual systems, regional systems, and mixed systems show that by configuring the various collection systems based on drainage basin characteristics and types of proposed development there is potential to provide water supply yields of similar costs to those associated with potable water tap fees.

The Pilot Project recognizes the need for, and welcomes coordination with CWCB, the State Engineer's Office, and other stakeholders for the Project's successful implementation and completion, and also recognizes the flexibility required for a project that is addressing such unique, new ground. With each phase, and each annual report, the project is expected to unfold, with better understanding, more detail, and more information for the next steps to come. The goal of the efforts described in this Pilot Project is to provide at its conclusion the data of appropriate quality and quantity to allow participating parties to better understand the actual water conserved, to secure a precipitation harvesting water supply for Sterling Ranch if it is shown feasible, and to make decisions regarding implementation of precipitation harvesting across Sterling Ranch and for other new developments in Colorado.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS/ACRONYMS

Abbreviation	Definitions
AF	Acre-Feet
AF/YR	Acre-Feet per Year
AWAS	Alluvial Water Accounting System
CIT	Center for Irrigation Technology
CU	Consumptive Use
CUHP	Colorado Urban Hydrograph Procedure
CWCB	Colorado Water Conservation Board
DCSD	Douglas County School District
DRCOG	Denver Regional Council of Governments
DCWRA	Douglas County Water Resource Authority
EPA	Environmental Protection Agency
ET	Evapotranspiration
ICI	Industrial, Commercial, Institutional
NRCS	Natural Resources Conservation Services
sf	square feet
SFE	single family equivalent
SEO	State Engineer's Office
SWMM	Storm Water Management Model
SWSI	Statewide Water Supply Initiative
SWSP	Substitute Water Supply Plan
WTP	Water Treatment Plant

1.0 INTRODUCTION

On June 2, 2009 Governor Ritter signed the act concerning an authorization of Pilot Projects for the beneficial use of captured precipitation in new real estate developments (House Bill 09-1129). Sterling Ranch is pleased to provide an application for the "Sterling Ranch Precipitation Harvesting Pilot Study Application" (Pilot Project) based on the criteria and guidelines outlined by the Colorado Water Conservation Board (CWCB).

With limited resources, a set timeline, and high expectations for the Pilot Project, the State has the challenge of reviewing and selecting applications based on the characteristics of the sponsor site as it represents other potential beneficial users across the State, and based on the sponsors ability and propensity to implement the Pilot Project's objectives.

The aim of the Pilot Project is to use field verification at specific sites to better understand, for all of Colorado, the feasibility of precipitation harvesting as a water conservation enhancement through pairing with advanced outdoor water demand management, and the feasibility of precipitation harvesting as a legally obtainable water supply.

Sterling Ranch's participation in the Pilot Project is a reflection of their own goals for establishing sustainable, defensible, non-potable water supplies for their development, as well as to be a positive example of conservation and efficient resource management. The Pilot Project presented here offers the flexibility to include nearby land owners and other potential partners that have already expressed interest in potentially participating in and/or supporting Sterling Ranch's precipitation harvesting efforts.

Sterling Ranch is to be developed in a number of platted filings, reaching build out in an estimated 20 years. The concepts of the Sterling Ranch Pilot Project presented herein are aimed to help determine the most feasible implementation of precipitation harvesting, tied with the Sterling Ranch conservation plan, for the largest beneficial impact over the development. The Sterling Ranch Pilot Project concepts are designed to build on data and information as it is collected and analyzed, providing a phased approach that integrates the information from each stage and offers the opportunity to evaluate the feasibility as the project progresses.

At this early stage, it is estimated that the Sterling Ranch Pilot Project will last approximately five to seven years.

Successful implementation of precipitation harvesting for all of Sterling Ranch will depend as much on the education and acceptance of the homeowners, builders, and other interested parties in the community, as on the valuable data collected during the Pilot Project. The Pilot Project education component will need to include adequate information for these parties to understand the benefits of precipitation harvesting as well as the proper equipment, installation and the best practices associated with it, and will need to include opportunities to ask questions and provide input for consideration in the Pilot Project process.

This application describes the conceptual Sterling Ranch planning policies and requirements, including their current water conservation plan and the Sterling Ranch Pilot Project strategy to be implemented in assisting in the overall precipitation harvesting design.

To assist in providing the necessary information required to meet the CWCB criteria objectives, this application has been primarily divided into three parts:

1) a quick reference to how the applicant meets the criteria, (see Appendix A);
2) a detailed description of the criteria requirements and how the Sterling Ranch Planned Development meets them, including Sterling Ranch's development description and its commitment, characteristics of precipitation harvesting and outdoor water demand management, and administration of precipitation harvesting; and
3) a detailed description of the Sterling Ranch Precipitation Harvesting Pilot Program development and implementation.

The success of the Pilot Project also depends on the partnership between the applicant and the CWCB. Sterling Ranch is excited about this opportunity to work with CWCB to help them meet their objectives in this Pilot Project, as well as to meet the needs of the Sterling Ranch community. Just a few of the ways that we believe our project may provide benefit to CWCB and SEO include:

- Sterling Ranch is committed to setting a new standard for water use and attractive landscaping by maintaining a water-wise approach to our Colorado lifestyle.
- With ground water as its primary source in rural areas, Douglas County is facing significant water supply challenges and shortages in the future and is committed to meeting those challenges and helping its neighbors.
- Sterling Ranch intends to evaluate a variety of precipitation harvest collection systems.
- Sterling Ranch is a diverse planned community that will be able to provide a wide variety of data on precipitation harvesting and outdoor water demand management in Colorado.
- The Sterling Ranch Pilot Project approach and methodologies will be transferrable throughout Colorado.
- Sterling Ranch is committed to making education of water conservation and water-wise management an integral part of their community and sharing its results with other communities in Colorado.

Sterling Ranch is looking forward to this opportunity to work with CWCB and the State Engineer's Office (SEO) to better understand the true benefits of precipitation harvesting while protecting existing senior water rights. We believe that you will find Sterling Ranch to be **a key Pilot Project** for your state-wide study, and appreciate the opportunity to describe our project's potential in this application.

2.0 STERLING RANCH – THE SPONSOR DEVELOPMENT

BACKGROUND

The proponents of the Sterling Ranch development have been passionately working for over eight years to prepare a vision for the land that is in harmony with the area, the community, and the State, and that meets a significant need for housing and infrastructure in the area. During the conceptualization of this new community, precipitation harvesting became a personal topic of interest to the family proponents, who saw the opportunity to incorporate this key renewable water supply into the planned water conservation practices. As such, Sterling Ranch was a key supporter in passing the bill to pilot precipitation harvesting studies.

Dominion Water and Sanitation District (Dominion), the wholesale water provider for Sterling Ranch, has a mission to provide a new conjunctive use water supply to the area in accordance with the goals set in Douglas County's 2030 Comprehensive Master Plan. Upon approval of Sterling Ranch's zoning application, Dominion will designate a Sterling Ranch District(s) that will be responsible for enforcing the water conservation plan and program set forth in the Sterling Ranch Water Plan, submitted to Douglas County on May 8th, 2009. The water conservation plan will guide the Sterling Ranch development team and District in planning, building, tracking, and monitoring water consumption and to meet the targeted water use described in the Sterling Ranch Water Plan.

In 2007, Sterling Ranch began working both independently and with Douglas County on water conservation, including completing the study entitled "Holistic Approach to Sustainable Water Management in Northwest Douglas County," which challenged all of Colorado to progress its attitude toward water conservation and sustainable water management. Sterling Ranch continues to further advance the outdoor water conservation concepts from that study in the development of a water conservation ethic for the Sterling Ranch community.

To adequately understand precipitation harvesting on a large scale as a viable water supply and incorporate water conservation practices into the planned development is not a small undertaking and must be followed through, from planning to completion. Some of the efforts Sterling Ranch has made to progress its vision of a water-wise community are:

- Sterling Ranch has taken an active role in the advisory and peer review committee of the original document "Holistic Approach to Sustainable Water Management in Northwest Douglas County".
- Applicant was instrumental in the House Bill 09-1129 process.
- Sterling Ranch is installing a real-time climate station on the site to meet current water conservation goals and help achieve a data-based approach to water management in Douglas County.
- Other examples of commitment can be found in the Planned Development Application (zoning permit) and the Sterling Ranch Water Plan that is included in the Application.

DEVELOPMENT DESCRIPTION

Sterling Ranch is approximately 3,000 acres of contiguous land located in northwest Douglas County. The development is bounded on the north by the South Platte River and Chatfield Reservoir, Plum Creek on the east, the town of Sedalia on the south, and the foothills on the west. The parcel is located in Sections 6, 19, 25, 29, 30, 31, and 36 in Townships 6 and 7 South, Ranges 68 and 69 West of the 6th Principal Meridian. The development falls within Water District 8 of Division 1. Figure 2-1 shows the location of the Sterling Ranch development site.

Sterling Ranch is located along the western edge of the Denver Basin regional bedrock aquifer system at a point where the geologic formations comprising the aquifer are exposed at or near the ground surface. The Denver Basin aquifer formations that underlie the property (from east to west) are the Denver formation, the Arapahoe formation, and the Laramie-Fox Hills formation. Based on the Natural Resources Conservation Service (NRCS) soil survey of the area, Sterling Ranch is 40% Sandy Loam, 19% Loam, and 41% Clay Loam.

Willow Creek and East Willow Creek watersheds are tributary to the South Platte River and Sterling Gulch is tributary to Plum Creek. Chatfield Reservoir is approximately 2 miles north of Sterling Ranch and is the confluence of Plum Creek with South Platte River. Willow Creek and Sterling Gulch are intermittent streams.

The diverse community planned for Sterling Ranch ranges from a high density mixed-use town center and surrounding villages on the north end near Titan Road to lower density residential villages to the south. Estate and equestrian lots will be located in the outlying areas of the site. In total, 37% of the planned development will be set aside for parks and open space. Figure 2-2 shows the planned development of Sterling Ranch in more detail. The planning areas are further described in Appendix C.

Current Conditions of Sterling Ranch

Sterling Ranch has been a working ranch for well over 100 years, keeping the natural conditions much the same as they have historically been; a high desert rangeland situated at the base of the foothills with rolling hills and rocky outcrop ridges, and predominantly mid-grass prairie with a variation of vegetation dependent on the topography. The site contains approximately 475 acres (less than 15% of the property) that have been previously disturbed. The Roxborough Filtration Plant is located on 10 acres near the middle of the Sterling Ranch Parcel. The site ranges in elevation from approximately 5,600 feet on the north to 6,000 feet on the south with slopes ranging from 2 to 25%.

Located near the foothills on the front range of Colorado, Sterling Ranch has a wide range of climatic conditions throughout the year. The temperature at Sterling Ranch on average ranges from 73.3 °F during the summer months to 31.5 °F during winter months. The average growing season is 164 days beginning in late April and ending in late September. The average annual gross evaporation from a free water surface for Water District 8 is 41.52 inches with an average of 6.0 inches during the summer months (CDSS, 2006). Like most other areas in Colorado, Sterling Ranch receives the majority of its precipitation in April and May usually in the form of snow. With an average annual precipitation of 17.5 inches, spring and summer convective storms provide 67% of precipitation for the area, with 12% of precipitation received during the winter months and 21% received during the fall months.

Figure 2-1 Project Location Map

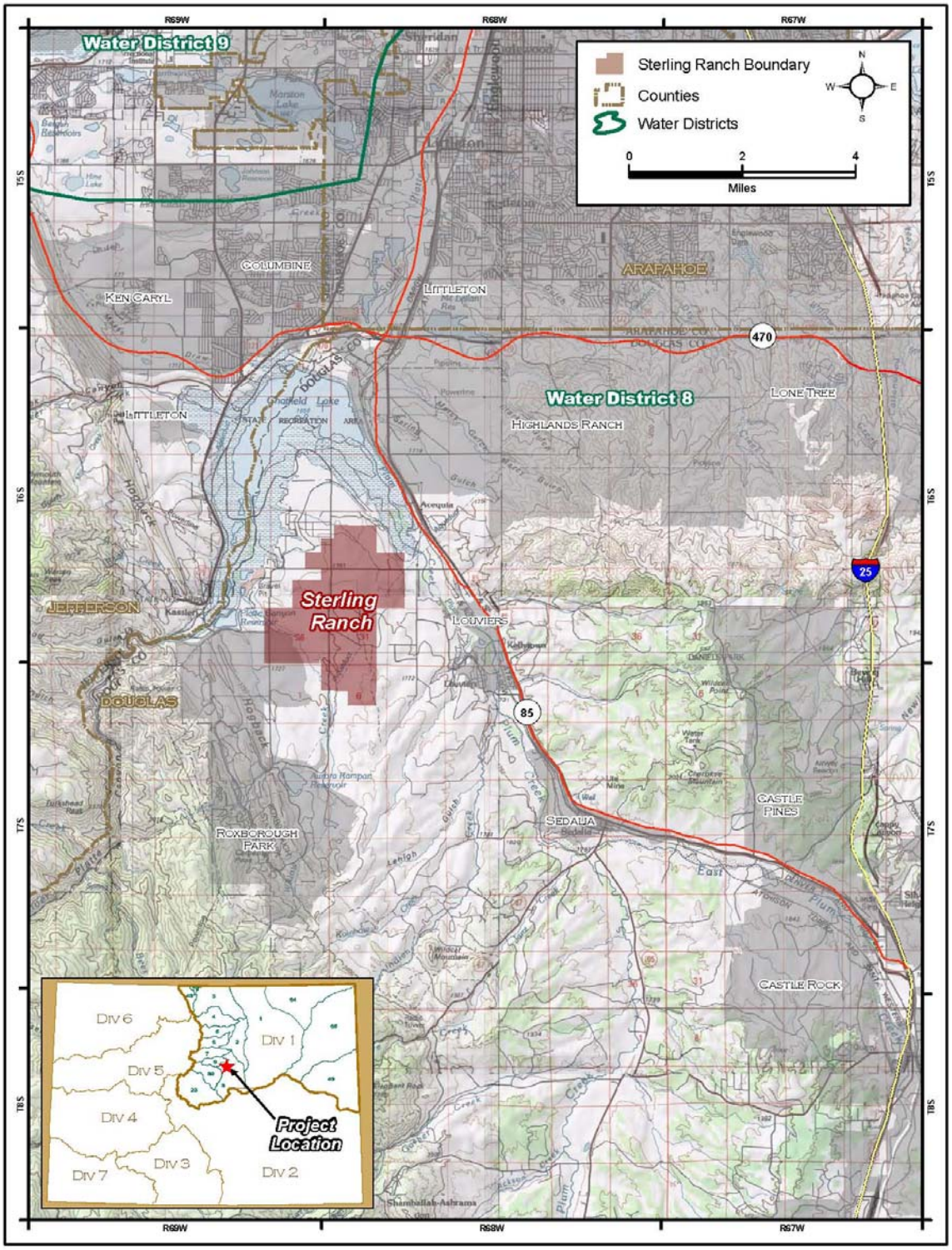
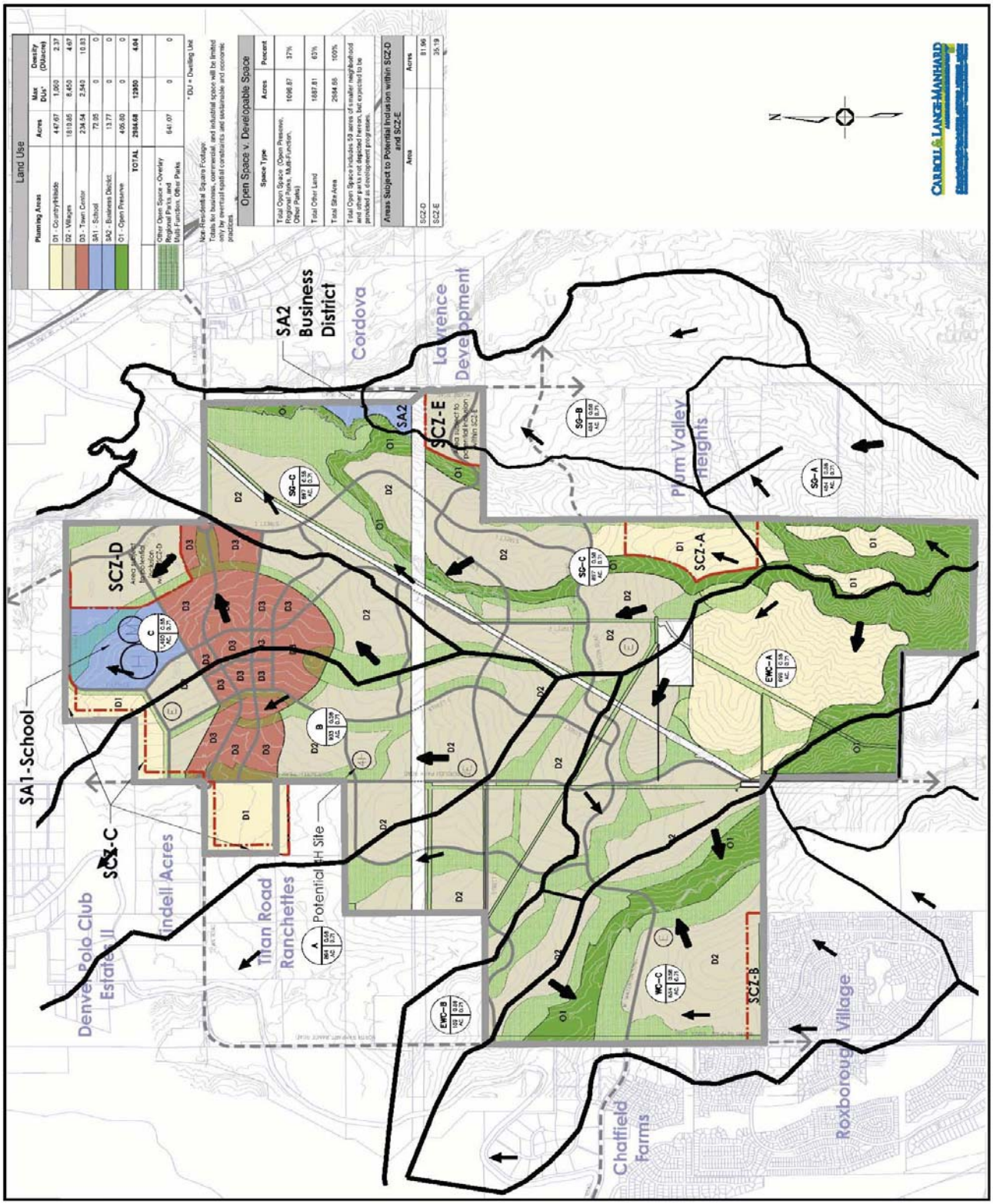


Figure 2-2 Sterling Ranch Planned



AREA WATER SUPPLY CHALLENGES AND REQUIREMENTS

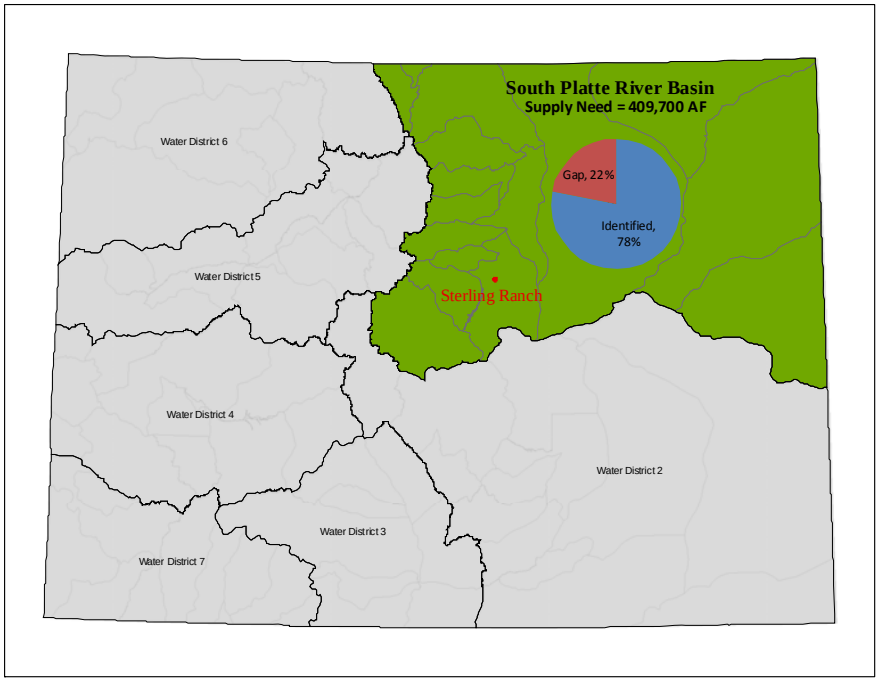
Renewable Water Supply Challenges

As requested in **Criteria Objective #6,** this section provides a description of the renewable water supply challenges in the area and how the Sterling Ranch Pilot Project addresses these. The Statewide Water Supply Initiative (SWSI) is a comprehensive report that identifies water supply challenges and projected water shortages throughout the State and is the basis for the discussion herein of how the Sterling Ranch Pilot Project addresses the identified challenges and needs.

SWSI refers to a renewable resource as a natural resource that can replenish itself naturally over time. Water can qualify as a renewable resource when treatment and release occur after usage at a rate that will sustain supply when combined with natural inflows. In the state of Colorado, especially along the Front Range, renewable water resource supplies are becoming more limited and difficult to secure and develop. Because of this, new projects, ideas, and processes are needed to satisfy the increasing demand, including exploring less traditional opportunities.

Sterling Ranch is located within the South Platte Basin, where SWSI predicts 50% of the irrigated agricultural land will be dried up by 2030 for use by M&I[1]. By 2030, SWSI predicts that the South Platte Basin will need an additional 409,700 AF of water. A gap of 22%, or 90,600 AF per year, exists for the basin after identified water processes and projects have been fully implemented[2]. The map below shows the South Platte River Basin and the location of the Sterling Ranch development.

Figure 2-3 South Platte River Basin Water Supply Need



1 (Colorado Water Conservation Board, 2004), Section 5, page 11
2 (Colorado Water Conservation Board, 2004), Section 6, page 10

As a development in Douglas County, where water providers and residents have historically relied primarily, if not completely, on non-renewable ground water, Sterling Ranch is in one of the most water scarce areas of Colorado. With population projections in Douglas County increasing from 315,297 in (2010) to 444,784 (2030)[3], Douglas County residents and water providers will no longer be able to afford to secure and manage their water supplies in the traditional ways. As well yields decline, additional wells and infrastructure will be needed to continue the use of Denver Basin aquifer, causing costs to dramatically increase to maintain the required level of pumping. SWSI anticipates that by 2050, aquifer production will decline by 40 to 85 percent of the current production if the number of wells is not increased[4].

According to SWSI, the South Metro Sub-basin (Arapahoe, Elbert, and Douglas Counties) has a projected future increased water demand of 88,000 AF per year[5]. Of that, there is an estimated 38,300 AF of demand that will be met by identified projects, processes, and additional conservation[6]. The water shortage for the South Metro Sub-basin will be 50,300 AF per year by 2030, or 57%; all potentially dependent upon non-renewable water sources[7].

The future of water resources will need to focus on expansion of current projects and processes as well as increased coordination and cooperation among providers. It is already understood that traditional methods will not be able to provide the sustainability that is needed given the future demand. A new trend in water resources is needed, and already underway, focusing on additional conservation, reuse, exchanges, and other creative projects including the potential of beneficially using precipitation harvesting.

Meeting Local Water Supply Requirements, Other than Utilizing Precipitation Harvesting

The Sterling Ranch vision for a sustainable community includes the use of renewable water in a conjunctive use system, partnered with the implementation of water conservation measures and infrastructure. Including precipitation harvesting as an important part of their conjunctive water supply would fit directly into Sterling Ranch's current conservation planning efforts. However, since precipitation harvesting is only in the developmental stage, the Sterling Ranch's current Water Supply Plan, as presented to the local governmental agencies, shows how Sterling Ranch will be able to operate without precipitation harvesting.

This section generally describes the applicable local water supply requirements, the water supply outlined in the Sterling Ranch Water Plan and how the planned water supply will meet the water supply requirements per **Criteria Objective #5** as referenced to in Section 37-60-115(6)(b)(IV), C.R.S.:

> *… The board shall establish criteria and guidelines for applications and the selection of pilot projects, including … (IV) The requirement that the proposed development meet any applicable local government water supply requirement through sources other than precipitation harvesting;*

3 (Douglas County Community Development Planning and Zoning Services Division, 2008), Section 1, page 4
4 (Colorado Water Conservation Board, 2004), Section 7, page 5
5 (Colorado Water Conservation Board, 2004), Section 6, page 72
6 (Colorado Water Conservation Board, 2004), Section 6, page 70
7 (Colorado Water Conservation Board, 2004), Section 6, page 76

Douglas County Water Supply Requirements

Applicants for land use approvals in Douglas County are required to provide Douglas County with proof of adequate water supply. The recently updated Water Supply Section 8 of the Douglas County 2030 County Master Plan reflects the County's recognition of the dire need for integrated, more sustainable water resource planning. To meet these needs, and to address the requested information by Douglas County, Sterling Ranch has provided Douglas County with the Sterling Ranch Water Plan, April 23, 2009.

Dominion will be the entity providing a water supply for the Sterling Ranch Development, which will be consistent with the conjunctive use water system as defined in the Douglas County 2030 Comprehensive Master Plan, stating that the water supply should include a **"combined use of surface and ground water systems to optimize resource use and minimize adverse effects of using a single source."**

Douglas County zoning regulations require applicants to provide evidence of sufficient water supply in terms of quantity, quality, and dependability (sections 1506.09 and 1801A, Douglas County Zoning Section 18 A Water Supply – Overlay District). As the water provider of Sterling Ranch, Dominion will provide a water supply that meets Douglas County requirements.

Colorado Water Supply Requirements

In addition to Douglas County water supply requirements, the Colorado Revised Statutes (C.R.S.) describes water supply requirements for land use control and conservation in C.R.S. Section 29-20-304. Developments that will be served by a water supply entity are required to have the following list prepared by a registered professional engineer or water supply expert. Such information was prepared by one or more registered professional engineers and/or water supply experts, and is described in the Sterling Ranch Water Plan in the noted sections.

- An estimate of the water supply requirements for the proposed development through build-out conditions; (Section 3)
- A description of the physical source of water supply that will be used to serve the proposed development; (Section 5)
- An estimate of the amount of water yield projected from the proposed water supply under various hydrologic conditions; (Section 5)
- Water conservation measures, if any, that will be implemented within the development; (Section 2)
- Water demand management measures, if any, that will be implemented within the development to account for hydrologic variability; (Section 2)
- Such other information as may be required by the local government (see Douglas County requirements above).

Sterling Ranch Planned Water Supply

Through its Water Plan, Sterling Ranch (Dominion) intends to prolong the life of non-tributary ground water resources through: 1) maximizing the use of available renewable water supplies, and 2) implementation of conservation measures to reduce demands.

The current water supply plan utilizes tributary water as the renewable surface water supply in average or better rainfall years, supplemented with storage and Denver Basin non-tributary ground water in drought years. This is a reliable and less expensive alternative for the homeowners than large storage reservoirs capturing excess flows in wet years (where much of the water is lost to evaporation).

Dominion will be relying on the South Platte River as the principal water source (~70% of supply), replacing stream depletions (diversions less return flows) with fully consumptive renewable tributary water and using non-tributary ground water as the back up to the tributary supplies. As a result, Dominion's non-tributary ground water supply is reduced from being the sole supply to less than 30% of the total supply. To replace South Platte River Stream depletions, consumptive use (CU) water will be acquired at a ratio of 60% tributary water and 40% non-tributary ground water. An illustrative depiction of this water supply framework is shown as Figure 2-4.

Dominion's conjunctive water supply system is currently being developed for eventual approval in water court using the following concepts:

- South Platte River will be the primary water supply diverted with a junior water right as part of an augmentation plan.
- Augmentation sources, or replacement supplies, on average will consist of 60% tributary sources and 40% non-tributary sources.
- Non-tributary ground water imported from the Central Basin and/or Margin B in the Denver Basin Aquifer will serve as back-up in times of drought, or after limiting times of available surface supplies.
- Both tributary and non-tributary water supplies will be regulated in one or more reservoirs before delivery to demands.

Dominion plans to divert tributary water from diversion structures or wells along the South Platte River upstream of Chatfield Dam where there is a dependable physical water supply. The plan is to have the return flows made in the same vicinity to minimize stream depletion impacts to this reach of the South Platte River, which has minimum stream flow standards.[8] The total planned water supply is shown in Table 2-1.

Dominion's water-wise residential water demand is based on 0.22 AF/YR/unit plus a 10% system loss and 20% additional security factor for a total planning demand of 0.286 AF/YR/unit[9]. In addition to the additional 30% described above, due to the new levels of conservation that Sterling Ranch proposes to implement , although well proven in other parts of the United States , in studies and in a test home in

8 Denver Water has a minimum streamflow requirement in this reach of the South Platte River. Dominion would not divert Denver's storage water or operate exchanges on natural flow that would negatively impact the minimum flow.

9 (Sterling Ranch, December 3, 2009)

Douglas County, the engineers representing the Douglas County Community Planning and Sustainable Development Department (Planning Department) have discussed that a water surcharge of some amount, for example 0.10 AF/YR/residential unit, be available until Sterling Ranch has provided metered water use data from Sterling Ranch residential development.[10] Such surcharge, if any, would be determined by the Douglas County Board of County Commissioners. Dominion has also agreed to offer water to roughly 700 existing nearby Chatfield Valley neighbors whose wells are not sustainable.

Table 2-1 Total Planned Water Supply

Water Supply Source	Supply* (af/yr)	Surcharge** (af/yr)
2010 Junior Right - New Augmented S. Platte River Right	2,080	640
Tributary Consumptive Use Water**	1,600	370
Total Tributary Diversion - South Platte	**3,680**	**1010**
Central Basin Non-Tributary Pumping	**1,500**	**300**
Losses (Evaporation and Non-Tributary ground water Transit from Central Basin and/or Margin B)	-633	-105
Total Annual Supply to Demands	**4,547**	**1,205**

* Supply considers the total residential planning demand of 0.286 AF/YR/unit. County-mandated Surcharge is an additional amount of 0.10 AF/YR/unit.

**To be acquired plus additional supply to cover conveyance losses for Tributary CU Water Supply TBD after acquisition.

The water system will include adequate storage to optimize and regulate the yield of water supplies for: 1) raw water deliveries to the water treatment plant (WTP), 2) releases to meet stream depletions, and 3) releases to meet delayed historical return flow obligations resulting from changes of irrigation water rights.

On-site storage is incorporated as part of the aesthetic amenities of the development and may include storage for a Douglas County requirement of 1-year minimum carryover storage of replacement water. The 1-year minimum carryover storage may also consist of non-tributary ground water currently stored within the aquifer.

Water conservation, a main part of Sterling Ranch's Water Plan, can be considered part of the water supply in that it reduces the amount of supply needed from outside sources. After extensive study, Sterling Ranch has established that water use can be kept to an average of 0.22 AF/YR/unit or less for a single-family residence, which is the main basis of the water conservation plan.[11] This residential water use is significantly lower than the current Douglas County water supply planning number of 0.75 AF/yr/unit and will be achieved through Sterling Ranch's water management and conservation standards. Water conservation information from seven other communities with a similar conservation ethic were used in the Plan to illustrate that even with varying assumptions, this water use target is achievable. More information about the water conservation plan and estimated water use can be found

10 (Sterling Ranch, December 3, 2009)
11 (Sterling Ranch, December 3, 2009)

in the summary in Appendix B and in Chapter 2 of the Sterling Ranch Water Plan. Conservation and how it will be partnered with precipitation harvesting is also further discussed in section 4 of this report. As the water supply for Sterling Ranch is currently described in their Water Plan to the County, it assumes no precipitation harvesting. However, all aspects of the Plan will be enhanced by harvesting precipitation and as it proves to be a reliable source, this new water supply will reduce the amount required from the other planned water sources and enhance the water conservation success. Using results gained from the initial phases of the Pilot Project, the storage, storm water systems, and any intended precipitation harvesting systems will be modified as necessary to accommodate collected precipitation, and the water conservation plan will be updated to reflect the new information.

The Water Demand Standard Self Correcting Mechanism

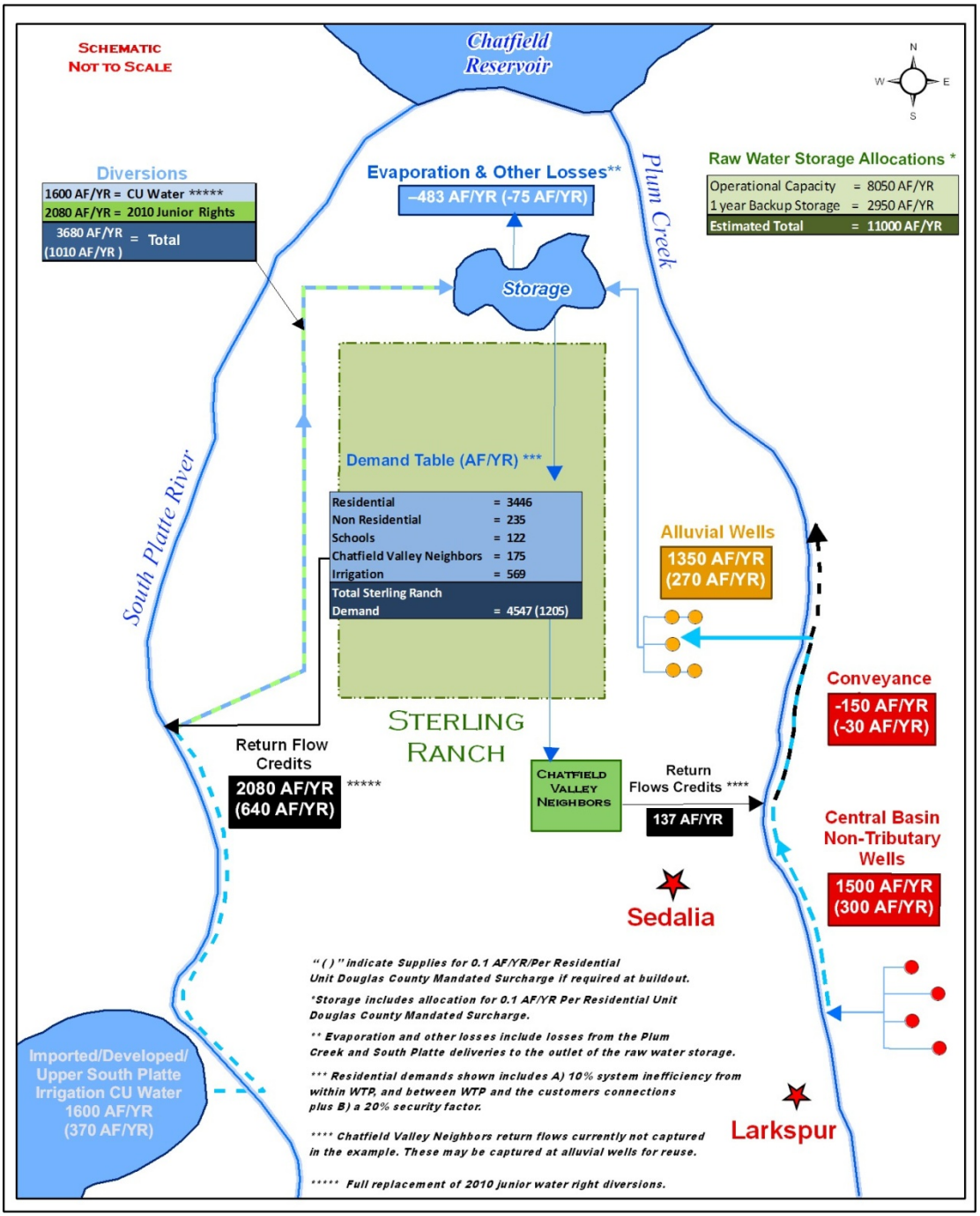
As part of adjusting to a conservation conscious development, dependent on a conjunctive water supply, Douglas County is currently asked to consider an innovative aspect to the Sterling Ranch water supply planning that allows the water supply requirements of the community to be based on the actual water use data (this concept has also been used effectively in at least one other state when it transitioned to water wise projects). This self-correcting mechanism assists Douglas County in assuring that the community has adequate drought protection, while providing opportunity for innovative conservation practices such as those in the Sterling Ranch Water Plan and those that may be validated through the Pilot Project to have a positive influence on the entire region. The self-correcting mechanism calls for:

1) the Water Demand Standard for each project sector be subject to modification after five years of metered water use data is available from a sufficient amount of development within that Sector;
2) once an Adjusted Water Demand Standard is established for a Project Sector, the County-mandated Surcharge for such Project Sector, if any, would no longer be required (because such Adjusted Water Demand Standard will be based on metered water use data from then-existing development within Sterling Ranch; and
3) that such Adjusted Water Demand Standard be subject to modification every five years thereafter and water dedication requirements for new building permits be adjusted accordingly.

Engaging this self-correcting mechanism at five-year intervals incorporates demand variability and provides fiscal and water supply protection for those being served. This also allows the Water Demand standards to be adjusted to reflect future development characteristics, changing water technologies, and other changing conditions. Under this self-correcting mechanism, Water Demand standards may be increased or decreased over time based on actual water use and system performance data.

Specific to this project, by instituting such a self-correcting mechanism, the information collected in this Pilot Project, such as from water conservation practices and the partnering of precipitation harvesting, have the real opportunity to impact the water savings of this community and the region. As designs are modified based on the information collected in the Pilot Project, the positive impacts of those designs are not only experienced by those users, but by the development as a whole, and by the region as the water use data is collected, organized, and analyzed in a method that is representative of an arid region of the State and is transferable to other communities.

Figure 2-4 Sterling Ranch Water Supply Framework



STERLING RANCH WATER SUPPLY FRAMEWORK BUILDOUT EXAMPLE YEAR
12,050 UNITS, RESIDENTIAL DEMANDS @ 0.286 AF/YR/UNIT*** PLUS
0.1 AF/YR/UNIT DOUGLAS COUNTY MANDATED SURCHARGE,
IF REQUIRED AT BUILDOUT, SHOWN IN "( )"

3.0 PRECIPITATION HARVESTING SYSTEM DESIGNS

INTRODUCTION

Criteria Objective #4 as referenced to in Section 37-60-115(6)(b)(II), C.R.S. states that:

> *… The board shall establish criteria and guidelines for applications and the selection of pilot projects, including … (II) a description of the proposed development and the proposed precipitation harvesting system;*

As required in the Criteria, this section provides a description of precipitation harvesting collection systems as they may be designed for Sterling Ranch including:

a. Description of the collection system sizing, design, and maintenance plan.
b. Estimated average volume of water to be captured each month based on historical precipitation data.
c. Method for metering inflow and measuring capture efficiencies.

The precipitation harvesting collection systems described herein provide a range of options for implementation to the Sterling Ranch development as a whole. These descriptions are preliminary and are provided for the purposes of overall understanding of the potential ranges of benefit to Sterling Ranch as a full development.

The Pilot Project, described in detail in Section 6 of this report, will provide the means to validate or refine the assumptions used to estimate the capture efficiencies, potential yield, and construction costs presented in this section. Because of the scale of Sterling Ranch, the Pilot Project will be developed in stages, with initial stages involving collecting information on the natural conditions of the site and the development of experimental sites to collect information to better understand collection efficiencies, storage options and optimization, water quality, maintenance requirements and system construction costs. Updates to this information will be provided with the annual reports of the Pilot Project as more refined information is gathered and the final designs for each plat are planned and implemented.

DESCRIPTION OF POTENTIAL PRECIPITATION COLLECTION SYSTEM DESIGNS

Because Sterling Ranch is a large development with diverse planning areas, the final precipitation collection design is currently envisioned to potentially consist of a combination of regional collection using a modified storm water system with individual collection on outlying sites. The goal for the precipitation collection systems will be to maximize the economic and water saving potential of pairing precipitation harvesting with outdoor water demand management techniques.

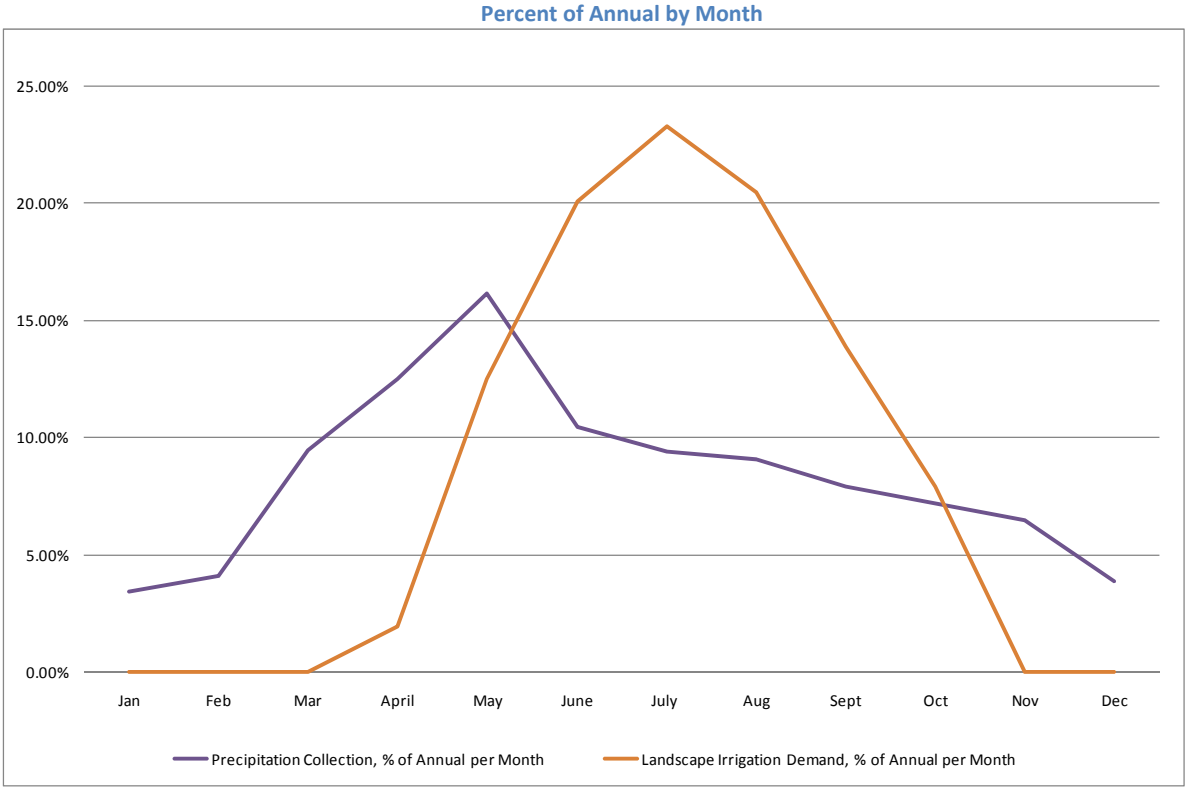
In this section two different precipitation collection approaches are presented and compared. The first is a regional precipitation collection system where precipitation will be collected through the developments' storm water drainage system and stored in detention/retention ponds modified to provide storage of water for non-potable use. The collected precipitation could then be delivered to individual residences, commercial properties, parks, and schools through a non-potable distribution system. The second precipitation collection approach presented is a site-specific collection system that would direct precipitation collected from roofs for residential lots, and possibly parking lots and roofs

for commercial and school properties, to underground cisterns or small storage reservoirs constructed as part of the storm drainage system. When these regional cisterns or storage reservoirs are for a set community, water use from the community cistern could be metered to the home to equitably share costs of supplemental water when needed. Water would be pumped from the cisterns and applied to the site's landscape through the irrigation system. A settling basin, pump and filtration system would be required for each capture system to utilize the harvested precipitation through the site's irrigation system.

A back-up water supply will be required for any precipitation harvesting design described in this application. The back-up water supply is required to augment irrigation demand when captured precipitation is not sufficient to provide all or part of the irrigation needs. For a regional precipitation capture system, the backup water supply will be provided by one or a combination of sources, including potable water, raw water, or recycled water, since the water may be distributed thru a non-potable system. For individual collection systems, the backup water supply is assumed to be potable water. Currently, it is assumed that the systems will be designed such that the back-up water supply will supply water to the system when the captured precipitation water storage level falls below a preset minimum.

One of the keys to a successful precipitation harvesting system is storage. Based on historical precipitation for Sterling Ranch, the months with the highest precipitation are March, April, May, and June while the peak irrigation demands occur in June, July, and August. The following graph illustrates the potential precipitation capture versus irrigation demand.

Figure 3-1 Rainfall Collection & Landscape Irrigation Demand Patterns by Month
Percent of Annual by Month



Regional Precipitation Collection Systems

In general, the regional precipitation collection system concept described herein would be built as part of the required storm drainage system for a development. For a pilot study of the regional precipitation collection system, the normal infrastructure required to safely direct storm water runoff away from buildings, roads, and other developed features will be used as the primary precipitation collection system. Enhancements to a typical storm water drainage system would be required to fully develop the runoff as a water source, including modifications to typical detention or retention basins required to control runoff. Typical modifications include additional long term storage capacity to allow for storage of historically high precipitation months in the spring to be used later in the summer when landscape consumptive use demands are high. Other modifications to the ponds could include the construction or installation of clay or membrane liners to reduce seepage loss.

To beneficially use the regionally collected water, a distribution system to non-potable uses will be required. A non-potable distribution system would include pump stations, pipelines, meters, and valves to deliver the precipitation to all of the potential users. Since captured precipitation would not always be available to meet all of the potential non-potable demands, another source of water would be required to augment the collected precipitation. For Sterling Ranch, the non-potable system may be tied to the raw water system as that augmentation source. This would potentially provide a core distribution system that is partially pressurized for the use of non-potable water distribution. The scale to which the system could be utilized would be evaluated as part of the Pilot Project.

Figure 3-2 illustrates the regional precipitation collection system concept.

Individual Precipitation Collection Systems

Individual precipitation collections systems could be installed on each residential lot, commercial parcel, or school site and would have its own collection and distribution system. Precipitation would be collected from the rooftop and other impervious areas on the site, and stored in a cistern or reservoir on the site. The water would then be pumped into the irrigation system from an on-site pumping and filtration system. The system would also include piping to direct runoff from impervious areas to the cistern or reservoir. For costing purposes, the assumption for this scenario is that each individual property would have its own discrete precipitation harvesting system and all properties would be equipped with a system.

Figure 3-3 illustrates a typical residential and commercial precipitation capture system. In all cases, a potable backup water supply would be required to meet irrigation water demands when collected rainfall is inadequate.

Figure 3-2 Regional Precipitation Collection System Schematic

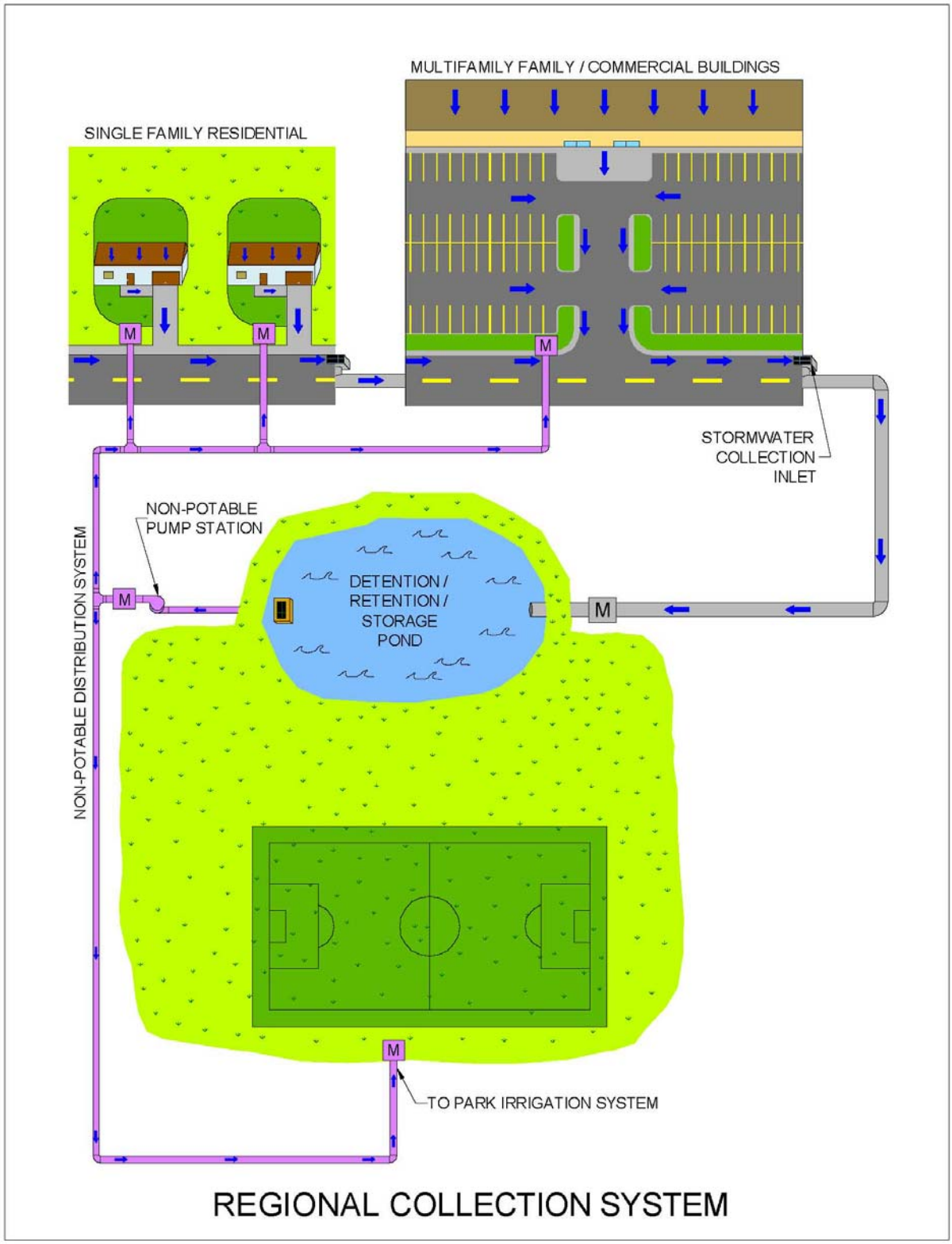
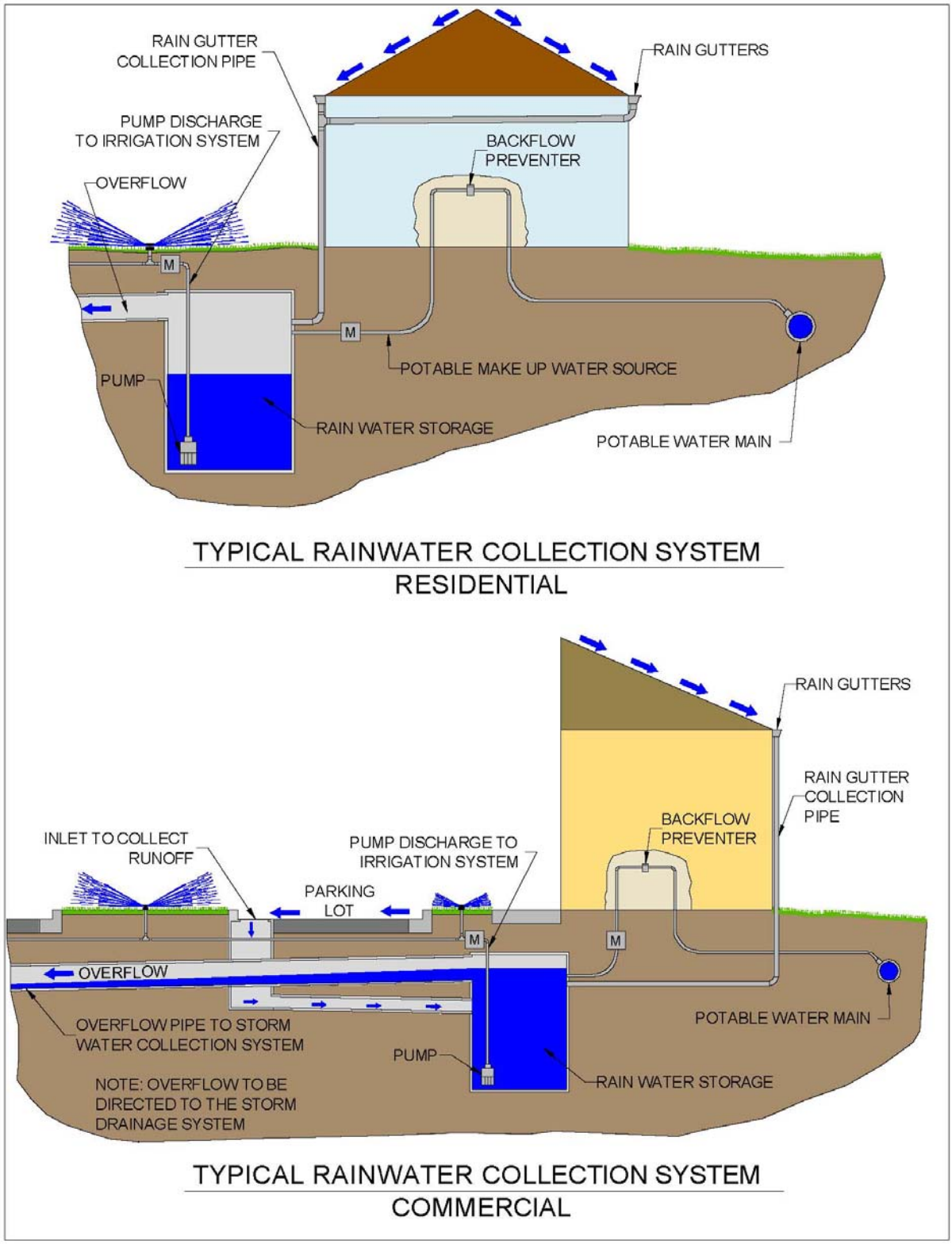


Figure 3-3 Individual Precipitation Collection System Schematic



ESTIMATED PRECIPITATION COLLECTION SYSTEM VOLUMES AND COSTS

This section describes the opportunity and potential volumes and costs of the precipitation harvesting systems as applied to all of Sterling Ranch. Costs for precipitation collection systems were evaluated for three different concepts:

1) A regional precipitation collection system over the whole development where precipitation run-off is collected from all impervious areas on the site and distributed to all park, school, commercial, multi-family, and single-family residential lots through a non-potable system.
2) A targeted regional precipitation collection system where precipitation is collected from the most cost effective impervious areas on the site and distributed through a non-potable system to the highest water use customers within the development including park, school, commercial, and multifamily developments. A non-potable system would not be provided to single-family residential lots under this scenario.
3) The provision of Individual precipitation harvesting systems for each commercial or multi-family parcel, and for each residential lot.

The preliminary opinion of probable costs and potential precipitation harvest potential developed for each concept are provided for comparison purposes and to help determine what data is critical from the Pilot Project. It is likely that no one single concept will be ultimately used to collect precipitation from the site, but that a combination of the approaches presented will be pursued.

ESTIMATED VOLUME OF WATER TO BE CAPTURED ON AN AVERAGE MONTHLY BASIS

The amount of precipitation that can be captured and used for irrigation on the site depends on the following:

- Impervious area where runoff can be collected
- Amount of storage available to collect precipitation
- Conveyance loss
- Storage losses, including seepage and evaporation

The potential precipitation that could be collected by month for regional, targeted regional or individual site collection systems is presented in Table 3-1. The average precipitation data used to calculate potential precipitation capture is from the Kassler Weather Station located approximately 1 mile from Sterling Ranch. The potential precipitation capture efficiency used is 80% for the individual site collection systems, and 56% for regional capture systems. The regional capture system efficiency is lower because of anticipated conveyance and storage losses assumed to be 20% of captured precipitation.

Table 3-1 Estimated Potential Precipitation Collection for the Sterling Ranch Development (Based on 1950-2004 precipitation data from the Kassler Weather Station) AF

Collection System	Summary - Rainfall Collection by Month												
	Annual	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Full Regional Collection System	990	33.9	40.4	93.4	123.6	159.6	103.2	92.9	89.6	78.1	71.2	64.1	38.5
Targeted Regional Collection System	630	21.7	25.9	59.8	79.1	102.2	66.1	59.5	57.4	50.0	45.6	41.1	24.6
Individual Collection System	420	14.4	17.1	39.5	52.3	67.6	43.7	39.3	37.9	33.1	30.1	27.1	16.3

The above table assumes the following:

1. *Potential Precipitation Collection based on preliminary planning impervious area percentages provided by Carroll & Lange-Manhard Engineering.*
2. *Rainfall data presented is average for the period of 1950 thru 2004 at the Kassler Weather Station.*
3. *Capture efficiencies are 80% for Individual Systems, and 56% for Regional Systems*

METHOD FOR MEASURING CAPTURE EFFICIENCIES AND IRRIGATION DEMAND

Capture efficiencies will be calculated by dividing the quantity of collected precipitation to be used for irrigation by the potential precipitation that could be collected based on actual precipitation and impervious area within the collection area or basin. This analysis will be completed for regional collection systems, as well as individual collection systems. In general, the following simple equation applies:

$$Capture\ Efficiency = \frac{\text{Precipitation Captured}}{\text{Precipitation Available}}$$

For a given capture system the precipitation captured can be further defined as:

$$Precipitation\ Captured = \text{Total Irrigation Demand} - \text{Makeup Irrigation Water Required}$$

And precipitation available is defined as:

$$Precipitation\ Available = \text{Total Precipitation x Impervious Area of Collection Basin or Roof}$$

For regional precipitation collection systems, the volume of precipitation used for irrigation will be determined by measuring the volume of water pumped out of the precipitation storage ponds for irrigation use less the volume of supplemental water from other sources required to meet the irrigation demand. The volume of potential precipitation that could be collected would be measured by multiplying the annual rainfall by the impervious area within the collection basin. The impervious area could include roofs, driveways, roads, parking lots, and other hardscape areas.

For individual site precipitation collection systems, the volume of precipitation used for irrigation will be calculated by subtracting the volume of potable water used for irrigation from the total volume of water used for irrigation. Water meters will be required to measure water pumped from storage, and to measure potable water added to storage to make up irrigation demand not supplied by precipitation. The potential precipitation that could be captured will be calculated by multiplying the annual rainfall by the capture area, typically the roof footprint, parking lots, and hardscape areas that are directed to the on-site storage vessel.

Whole Development Regional Precipitation Collection System

Based on very preliminary data, the following estimated costs were developed for the construction of a full regional precipitation collection and distribution system for the entire development at build out. The costs include a non-potable distribution system to all residences, commercial and multi-family areas, schools, and parks as well as additional reservoir or storm water detention/retention basin enlargements and enhancements to provide storage of captured precipitation. It is assumed that all of the town center and commercial area precipitation is collected, and that all of the residential areas are designed for collection. The estimated infrastructure cost is $42 million.

Based on average precipitation, it is also estimated that up to 990 AF of harvested precipitation per year can be captured and used to offset irrigation demands. The potential precipitation collection volume is based on the total impervious area for planned land use of the site. The overall collection efficiency is assumed to be around 56%. This percentage is lower than the expected capture efficiency for individual systems to account for additional losses anticipated from conveyance to storage ponds and evaporation from storage ponds. On an average year and based on the above-noted assumptions, approximately 60% to 80% of the irrigation water demand could be supplied by the captured rainfall. The cost per AF to construct storage and a non-potable distribution system is $42,000 per AF.

The costs include pump stations, reservoir storage, distribution pipe from the pump stations to all commercial, residential, and school parcels, and transfer pump stations and pipe required to move water collected from smaller basins to larger storage ponds and pump stations. The costs for reservoir storage assume enlargement of storm water detention ponds or raw water storage ponds. With the exception of costs for water transfer pipelines and pump stations to move water from smaller basins to a central storage pond, no costs are assumed for storm water systems including basic construction of the detention ponds. It is assumed that the storm water collection system can be modified during design to optimize collection and storage. The cost estimates provided above do not include costs for additional land that may be required to enlarge detention/retention ponds for storage.

Targeted Regional Precipitation Collection System

For many reasons it may not be feasible to capture precipitation in all parts of the development and deliver water to every lot in the development. As such, costs for a targeted regional collection and non-potable distribution system were also developed to provide an example of the potential benefit of optimizing the available systems. Under this concept, collected precipitation would be distributed through a non-potable system to identified large accounts only, including multifamily, commercial, park, and school sites. In this example, the non-potable system would not be provided for the single-family residential lots. To collect enough precipitation to provide 60% to 80% of the potential irrigation requirements for the targeted areas, a regional precipitation collection system would be required to

collect runoff from all of the town center, business, commercial, and school sites as well as about half of the residential areas. Again, this concept assumes average precipitation conditions and the same collection, storage, and conveyance efficiencies as noted above. The estimated infrastructure cost is $15 million and up to 560 AF of average annual harvested precipitation could potentially be captured and used to offset irrigation demand. The cost per AF to construct storage and a targeted non-potable distribution system is $26,000 per AF.

The cost per AF of precipitation developed is much lower for a targeted regional precipitation collection system than for a full regional collection system. The cost savings are primarily from not providing a non-potable distribution system to all single-family residences. The targeted regional collection system described above is only one possible concept, with many other potential concepts that could be reviewed during the Pilot Project. As Sterling Ranch develops, the precipitation collection areas and customers served could be optimized. The cost estimates provided above do not include costs for additional land that may be required to enlarge detention/retention ponds for storage.

Individual Precipitation Collection Systems

Based on a very preliminary analysis of the Sterling Ranch Development, the following estimated costs were developed for the total cost to install individual site collection, storage, and pumping systems for each single-family residential lot, commercial lot, and school site. The cost for underground or above-grade storage for precipitation collected is the most significant cost for implementing individual collection systems, and is also quite variable depending on size, location, type of storage, and site conditions. Table 3-2 illustrates a range of probable costs.

Table 3-2 Individual Precipitation Collection Systems Opinion of Probable Cost Comparison

Development Area Description	Gross Area	No. of Lots	Opinion of Probable Cost per Lot	Opinion of Probable Cost for Individual Systems (millions)	$ per AF of Water Developed	Potential % of Irrigation Requirement Provided
School Site	53 Acres	N/A	N/A	$0.5	$16,000	30%
Town Center/Business District/ Multifamily	356 Acres	N/A	N/A	$20 -$39	$160,000-$310,000	100%
Residential Low Density	415 Acres	415	$13,000-$25,000	$5.4-$10	$160,000-$305,000	100%
Residential Medium Density	1,196 Acres	5592	$6,500-$11,000	$35- $61	$160,000-$270,000	50%
Total				$61-$111	$148,000-$240,000	

The above table assumes the following:

1. *Potential Precipitation Collection based on preliminary planning impervious area percentages provided by Carroll & Lange-Manhard Engineering.*
2. *Capture efficiencies are assumed to be 80% for Individual Systems.*
3. *The range of costs assumes the cost of below grade storage to be from a low of $1.00 to a high $2.00 per gallon.*
4. *Water Developed is based on average annual precipitation, not firm yield.*

The estimated opinion of probable cost to install individual collection systems on all lots ranges from approximately $61 million to $111 million. Storage costs range from the low of an estimated $1.00 per gallon to $2.00 per gallon estimate for storage. Approximately 410 AF of annual average precipitation

could potentially be collected from roofs only in residential areas, and a combination of roofs and parking lots in commercial or multi-family developments. Since it is assumed that the collected precipitation will be stored in below-grade cisterns, no evaporative losses are assumed. The collected precipitation is assumed to offset the potable water demand for irrigation. Overall, the approximate cost to utilize the precipitation captured with individual systems is roughly $148,000 to $240,000 per AF. It should be noted that the cost to provide cistern or below grade storage is much higher than the cost to excavate ponds. These costs include pump stations, below-grade or above-grade storage, and simple on-site collection piping. It is assumed that for commercial sites, the drainage system will direct parking and roof runoff to the on-site storage location.

ESTIMATED COST PER ACRE-FOOT OF WATER SAVED

The Kassler climate station was used to provide a reasonable representation of the amount of potential precipitation that is available for capture on Sterling Ranch. Since 88% of historical daily precipitation events are less at the 0.50 inches the median monthly precipitation was used to estimate the planning yield of each collection system. Median monthly precipitation provides a more conservative and representative estimate of potential capture since large precipitation events tend to skew the average (TWDB, 2005). The average annual precipitation for the Kassler station is 17.52 inches; the sum of the monthly median precipitation is approximately 15.00 inches which is 86% average annual precipitation. Based on this information the planning yield used for this study is 86% of average annual precipitation. Therefore to estimate the cost per acre-foot of water saved, the average annual potential capture from Table 3-1 is multiplied by 86% to represent the planning yield of each collection system. Appendix F provides the supporting information and statistics for the NOAA Kassler Station.

Table 3-3 compares the estimated potential costs and the potential capture of a regional system, targeted regional system, and individual site collection systems on all lots.

Table 3-3 Precipitation Collection Systems Opinion of Probable Cost Comparison

Precipitation Harvesting System	Potential Capture Avg Annual Yield, (AF/Year)	Potential Capture Planning Yield, (AF/Year)	Capital Cost (millions)	Engineering Costs	Legal Costs	Contingency	Total Costs (millions)	Total Costs for Planning Yield ($ per AF)
Full Regional Collection	**990**	**850**	**$31**	**15%**	**5%**	**15%**	**$42**	**$49,000**
Targeted Regional Collection	**560**	**480**	**$11**	**15%**	**5%**	**15%**	**$15**	**$30,000**
Individual Collection	**410**	**350**	**$45-$82**	**15%**	**5%**	**15%**	**$61-$111**	**$173,000-$309,000**

The above table assumes the following:

1. *Full Regional System includes non-potable distribution to all users, including all residential lots*
2. *Targeted Regional System includes non-potable distribution to targeted users – no distribution to residential lots*
3. *Information presented is preliminary for the purposes of relatively comparing the collection concepts only.*
4. *Potential Capture is based on average annual precipitation and capture efficiencies assumed to be 80%.*
5. *Potential Capture Planning Yield is 86% of average annual yield based on the total median monthly rainfall.*

Based on the above comparison, the cost for individual precipitation collection systems for all lots is much higher than a regional collection system, or the development of potable water. The cost of individual site storage is the major cost contributor.

In comparison to Table 3-3, a typical potable water tap fees for residential water service may range from $15,000 to $30,000 per unit. Considering the water wise per unit consumption compared to the full requirement of a standard tap fee (used a full 0.75 AF of water as required by Douglas County), the typical SFE tap fee for residential service might range between $11,000 and $23,000.

To demonstrate the impact on a per unit basis of the alternatives described above, a per unit cost estimate is provided based on an assumed total of 10,724 dwelling units for the entire development. This includes approximately 6,007 medium density single family and single family attached units and 4,717 high density single family attached and multifamily dwelling units. Based on this preliminary evaluation, average costs per unit may be estimated as:

- $4,000 per dwelling unit for a full regional collection system,
- $5,700 to $10,000 for individual collection systems, and
- $3,200 per unit for a targeted regional collection system.

This is based upon 4,717 high density single family attached and multifamily units only, and does not include medium or low density single family or single family attached units since these areas would not be served by the limited distribution system.

Thus, based on this preliminary evaluation, the **range of potential costs per unit served** by the precipitation harvesting system is from **$3,200 to $10,000**.

OPERATIONS AND MAINTENANCE

The following assumptions were used to prepare an opinion of probable costs for the operation and maintenance of either a regional system for the entire development or individual precipitation collection systems on all lots.

- System maintenance and administration costs are assumed to be 1.5% of the capital construction cost.
- Energy costs are based upon electrical energy costs of $0.10/Kilowatt Hour.
- O & M costs do not include system replacement costs.
- O & M costs are based upon the delivery of precipitation only.

Table 3-4 Operation and Maintenance Comparison, compares the estimated operation and maintenance costs for each approach considered.

Table 3-4 Operation and Maintenance Comparison

Water Supply Description	Potential Capture – firm yield (AF/Year)	Opinion of Probable O&M cost ($/1,000 gal)	Opinion of Probable Annual O&M Cost
Full Regional Collection System	**850**	**$1.60**	**$445,000**
Targeted Regional Collection System	**480**	**$1.05**	**$165,000**
Individual Collection Systems	**350**	**$10.50**	**$1,195,000**
Comparison to Potable Water			
Typical First and Second Tier Unit costs for Potable Water in Douglas County range from $2.16 to $5.94 per 1,000 gallons.			

The above table assumes the following:

1. *Costs in this table are preliminary, and are presented to compare collection concepts.*
2. *Potential Precipitation Collection based on preliminary planning impervious area percentages provided by Carroll & Lange-Manhard Engineering.*
3. *Electricity is assumed to cost $0.10/KwHr.*
4. *Operations and Maintenance costs are assumed to be 1.5% of capital construction costs per year.*
5. *Potential Capture is based on average annual precipitation, not on a firm yield*

The operating costs for the individual collection systems are highest due to the maintenance and operation of the numerous small pumping and filtration systems, as well as the anticipated maintenance for the cisterns to store water. The targeted regional system is much less than the full regional system because of the reduction in infrastructure and the number of customers. The elimination of single-family homes reduces the number of customers by 6,000, and reduces the required infrastructure by about 60%.

Maintenance would include repair of pump stations and filter systems, maintenance and cleaning of storage ponds or cisterns, and repair and maintenance of pipelines, valves, meters, and flow measuring structures.

Because of their preliminary nature, these costs have been provided for comparison purposes only. Information and knowledge gained from the Pilot Project will be necessary to refine and update the preliminary operation and maintenance costs presented above.

4.0 PROMOTION AND IMPLEMENTATION OF WATER CONSERVATION

To describe how the Sterling Ranch Precipitation Harvesting Pilot Project will promote and implement water conservation per Criteria **Objective #7** as referenced to in Section 37-60-115(6)(b)(IV), C.R.S., it is necessary to describe the philosophy behind the land use planning for Sterling Ranch and summarize to the outdoor water demand management strategies included in the Sterling Ranch Water Conservation Plan. Section 37-115(6)(b)(V)(B) states that:

> *… The board shall establish criteria and guidelines for applications and the selection of pilot projects, including … (V) Giving priority to pilot projects that: (B) Promote water conservation.*

From the inception of the project, Sterling Ranch has had a vision of a water-wise, sustainable community. Everything from yard size, plant selection, to the size and creation of the parks and green spaces stem from that initial vision. This vision has included other community design features such as devoting more acreage to community parks and recreational spaces, and the resulting need for more pedestrian friendly interior roads.

To obtain the vision for a sustainable community, Sterling Ranch has integrated cutting-edge water conservation techniques guided by forward thinking water experts to ensure a renewable water source that is both reliable and less expensive to the homeowner. Likewise, Sterling Ranch is committed to setting a new standard for water use while maintaining a water-wise approach to our Colorado lifestyle. This has included studying water use around the country and participating in studies with the CWCB on using water in a holistic manner that reduces water consumed by at least HALF (50%) from historical standards. The Sterling Ranch team is working with award-winning landscape architects who practice "water-wise" conservation principles to ensure landscaping and irrigation that are state-of-the-art.

While Sterling Ranch has had the conservation philosophy integrated into its planning from the start, the Sterling Ranch Precipitation Harvesting Pilot Project Program provides the opportunity to physically measure these conservation practices, identify changes where they may be advantageous to modify for precipitation harvesting, and provide potential guidance to the development as it evolves. In addition, information compiled through the Sterling Ranch Water Conservation Program will provide a unique set of data which other County and regional water providers could use to measure the benefits of water conservation as well as precipitation harvesting.

OVERALL LANDSCAPE AND IRRIGATION DESIGN APPROACH

The landscape and irrigation design philosophy for Sterling Ranch was developed and incorporated at the beginning of the land use planning phase to meet the sustainability goals that were established. The philosophy includes building a community based on a holistic approach to water resources management with water-wise principles at the core. The Sterling Ranch land use plan is based on clustered development with parks, trails, and open space designed with an emphasis on natural habitat restoration and water conservation. Irrigated turf in common areas will generally be limited to recreational sites. The land use plan also integrates site drainage and storm water management to replenish soil moisture in open spaces.

Sterling Ranch has gone above and beyond the typical approach to zoning by providing details about its Single Family Equivalent (SFE) Water Use Target and by committing to water conservation measures that will be implemented through its Water Conservation Program and Water Conservation Plan, including monitoring, evaluation, and enforcement plans. Land use planning affords an opportunity to integrate water conservation throughout the community.

Additionally, the Sterling Ranch land use plan is consistent with the Denver Regional Council of Governments (DRCOG) goal to consolidate urban development, maintain large open space areas, and preserve ecological communities (DRCOG Metro Vision 2035 Plan). Sterling Ranch feels that new development must be planned to meet human needs while protecting natural resources, so that these needs can be met into the indefinite future. A sustainable system can be created by integrating water conservation and outdoor water demand management with a dependable water supply plan.

Five factors are indentified in the Holistic Report (2007) that affect outdoor water demands and were used to guide the landscape and irrigation plan for Sterling Ranch. By implementing the landscape and irrigation designs formulated in the Report as part of the Sterling Ranch Pilot Project, water use data can be collected and the irrigation demands and management practices quantified to compare to the theoretical calculations. The five factors identified to affect outdoor water demands are:

1. Irrigated area
2. Landscaping
3. System performance
4. Water management
5. Provider commitment and public acceptance

Soil analysis, appropriate plant selection, and use of practical turf areas are well known water conservation concepts that are part of the Sterling Ranch approach to the land use plan and will be carried out throughout build out of the community. Irrigation system efficiencies will be optimized through the use of properly designed and located sprinklers, micro-irrigation (drip irrigation), hand watering, and appropriate watering intervals. Mandatory irrigation system audits are part of the way to ensure a successful water conservation program. Sterling Ranch believes that incorporation of these water-wise practices from inception of a community establishes a lifestyle expectation that is natural and easy to implement. The opportunity to prove the ideas presented in the Holistic Report is part of the plan for the development of Sterling Ranch and the Pilot Project Program.

Pairing Precipitation Harvesting with Water Conservation

Precipitation harvesting as a water supply is a sustainable concept that Sterling Ranch and Dominion are committed to advancing in Colorado. The benefits of collecting precipitation for landscape irrigation are outlined in the Holistic Report (2009) and include: 1) reducing the consumption of treated water and subsequent raw water acquisition, 2) reducing the peak summer demand for treated water and thereby facility capacity requirements, 3) reducing untreated storm water influx into the storm water drainage that feeds into the water treatment facility, and 4) reduced dissolved salt concentrations in precipitation delivered to the landscape.

Building precipitation harvesting and water conservation measures into a new development as part of the water supply and water conservation plan avoids the behavioral change necessary for retrofitted water collection and conservation activities.

An analysis described in the Holistic Report showed that pairing precipitation harvesting with outdoor water demand management results in water savings above what water conservation alone can provide. An evaluation of a single-family residence was done with traditional landscaping, moderate conservation, and water-wise landscaping, with and without precipitation harvesting and is shown in Table 4-1. The landscaping scenarios and resulting water demands shown in the table are empirically derived from a review of water demand reporting. The Water-Wise landscaping most closely represents the landscaping requirements for Sterling Ranch. The precipitation harvesting consisted of runoff from a 1,500 sf roof and storage in a 5,000-gallon cistern.

The landscaping scenarios listed show savings from traditional landscaping due to outdoor water demand management conservation measures and savings realized when coupling conservation landscaping with precipitation harvesting. The Water-Wise landscaping shows a 65 percent water savings alone and is bumped up to an 88 percent water savings when coupled with precipitation harvesting. This is the order of magnitude of savings intended for Sterling Ranch.

Table 4-1 Water Savings from pairing precipitation harvesting with outdoor water demand management (Holistic Report, 2007)

Demand Scenario	Irrigated Area	Outdoor Water Demand		Cistern Supply [a]		Supplemental Irrigation Supply Required	Percent of Supply from Precipitation	Savings from Traditional Landscaping
	(sq. ft.)	(AF)	(gal)	(AF)	(gal)	(AF)		
Traditional Landscaping	3,500	0.347[b]	113,000	0	0	0.347	0	---
Traditional Landscaping & Precip. Harvesting	3,500	0.0347	113,000	0.042	13,800	0.305	12%	12%
Moderate Conservation	2,500	0.164	53,600	0	0	0.164	0%	53%
Moderate Conservation & Precip. Harvesting	2,500	0.164	53,600	0.042	13,800	0.122	26%	65%
Water-Wise Landscaping	1,500	0.082	26,600	0	0	0.082	0%	76%
Water-Wise Landscaping & Precip. Harvesting	1,500	0.082	26,600	0.041	13,200	0.041	50%	88%

(a) Cistern supply varies depending on timing of precipitation supply and irrigation demand.
(b) The Traditional landscaping scenario assumes no demand management and equates to 32 gallons per sq. ft. per year water demand, which is higher than the 20 gallons per sq. ft. per year identified in other outdoor water demands studies by the City of Boulder and Colorado State University.

HOMEOWNER AND COMMUNITY WATER CONSERVATION EDUCATION APPROACH

Sterling Ranch's commitment to a water conservation ethic is shown by the amount of resource and participation they have contributed thus far. The public acceptance of the water conservation approach is a challenging factor to track and implement. A survey done by Ciruli Associates in 2006 showed that residents on the Front Range and in Douglas County are willing to support water savings activities including education to reduce water use on their own landscapes. This is an important finding considering that only so much enforcement by the water provider is effective if the public is unwilling to participate.

Sterling Ranch has taken the role of conservation education at the regional and even national level. The Sterling Ranch website posts all aspects of the community including conservation principles and practices from planning to implementation. Because of the unique water supply challenges in Douglas County and the popularity as a place to live, Sterling Ranch has made water conservation a priority from the beginning and part of the overall water plan.

The targeted water requirement per household at Sterling Ranch is less than half of what has been required historically and will require careful adherence to the Water Conservation Plan. Public participation will rely heavily on education, incentives, and tools that individuals can use to monitor their own water use. When someone chooses to purchase a home in Sterling Ranch, they will be exposed to water conservation education from the point of purchase via pre-installed efficient systems and water-wise landscaping or as part of the building process and throughout their residency at Sterling Ranch. An educated water conservation staff will be available to help in the process of reaching approval of required landscape and irrigation design plans that will adhere to efficiency and conservation principles and will follow up with audits and monitoring of the homeowner's water use. The staff will be responsible for developing and updating the education program and can effectively do this through interaction and feedback from the Sterling Ranch homeowners.

Dominion has been a member of and actively involved with the Douglas County Water Resource Authority (DCWRA). DCWRA is a nineteen-member group of water providers and government that is dedicated to water resource conservation, education, public policy initiatives, and the creation of a forum for the discussion of issues related to water to educate residents in Douglas County about the scarcity of water supply in the area and how to use it more efficiently. DCWRA maintains a website that is an educational resource for all members of the Authority.

An additional responsibility of the Sterling Ranch water conservation staff will be to develop and enforce a public community education program and school education program.

QUANTIFYING WATER USE AND WATER SAVINGS

Landscape and irrigation design plans will be required for all new homes to implement the requirements and regulations established for the Sterling Ranch Water Conservation Plan. Homeowners will have flexibility within the established regulations and will be required to submit these plans prior to installation. A general description of the landscape plans, irrigation systems, and water management plans are given in this section.

Landscape Plans

An outdoor residential water use target of 0.08 AF/yr/unit was established for the Sterling Ranch Water Plan by reviewing studies of landscape water use and theoretical irrigation requirement calculations and is explained in more depth in the Plan. This equates to approximately 17.4 gallons per square foot per year (gal/sf/yr) and includes a 33% safety factor. Although Sterling Ranch will have stringent landscaping and irrigation regulations, this safety factor has been added in recognizing the potential for variability among outdoor use resulting from soil and plant conditions and irrigation system maintenance and scheduling, among other factors.

To evaluate the targeted outdoor water use, five sample landscape plans were considered in the Sterling Ranch Water Plan using various amounts of turf, moderate water use plants, and water-wise plants. Four of the sample plans were found to be under the water use target. The calculation used to find the water demand for each sample plan is shown below. Irrigation efficiencies were assumed to be 85% for rotor and 95% for drip, including both surface and sub-surface methods. Based on discussions with landscape experts, the water supply from precipitation is often not considered when using theoretical landscape calculators; this is consistent with the landscape calculator available from the Denver Water Board (Denver Water, 2008). The Denver Water Board calculator and data provided by the TSR Group, (TSR, 2008) was used to develop the required crop coefficients. A Denver reference ET of 33.2 inches was used and no effective precipitation to estimate a dry year scenario and in effect, build in an additional safety factor.

$$\text{Plant Water Requirement (PWR)} = K_c \times ET_o \times \text{Area} \times 0.623$$

$$\text{Theoretical Irrigation Requirement } (IWR_t) = (PWR/IE) - P_{eff} * \text{Area} * 7.48$$

Where:
PWR = Plant Water Requirement; Total water demand (gal/yr)
K_c = Crop coefficient; Used to modify reference evapotranspiration to the water use of a particular plant or group of plants (unitless)
ET_o = Grass reference evapotranspiration (inches/yr)
Area = Plant irrigated area (sf)
0.623 = conversion factor to gallons
IWR_t = Theoretical irrigation water requirement. Total plant water demand that must be provided through irrigation (gal/yr)
P_{eff} = Percent of available precipitation for use by the plant (ft/yr)
IE = Irrigation/sprinkler type efficiency (percent)
7.48 = gallons/cubic foot conversion factor

The Plan 1 for 100% turf was eliminated for inclusion in the Sterling Ranch landscape possibilities because it would exceed the 0.8 AF/yr/unit target. Table 4-2 shows the percentage of turf and plant types for each of the sample plans along with the resulting calculated water use. This calculation does not include natural precipitation or the 33% safety factor that was incorporated to set the outdoor water demand target for Sterling Ranch.

Table 4-2 Planting Percentages for Sample Landscape Plans

Landscape Sample Plan	Blue Grass	Fescue Grass	Moderate Water Use Plants	Water-wise Plants	Small Vegetables	Irrigation Method	Annual Water Use (gal.)	Annual Water Use (AF)
Crop Coefficient	0.9	0.8	0.6	0.3	0.53			
Plan 1	100%					Sub-surface drip	26,127	0.08
Plan 2	33.3%		33.3%	33.3%		Sprinkler on turf; drip on plantings	20,727	0.06
Plan 3		50.0%		50.0%		drip	17,962	0.06
Plan 4		33.3%		67.6%		drip	15,235	0.05
Plan 5		33.3%			67.6%	drip	20,206	0.06

Irrigation Design Plans

Efficient irrigation will be an important aspect of the Sterling Ranch Water Conservation Plan and for the Sterling Ranch Pilot Project. The irrigation system for the demonstration phase of the Pilot Project will be designed and built to demonstrate different irrigation installations, methods, and products. The Pilot Project should also demonstrate proper application of different irrigation controller technology. Results from the Pilot Project will be incorporated into the irrigation design requirements for Sterling Ranch home and business owners. In general, the following guidelines will be used for the design, installation, and operation of the irrigation systems:

- Irrigation systems shall use water-saving technology such as subsurface drip and point source drip irrigation where appropriate.
- Sprinkler irrigation components shall be selected for the highest possible uniformity and efficiency based on Center for Irrigation Technology (CIT) testing results.
- Irrigation controllers shall be EPA Water Sense approved controllers and smart controllers.
- Irrigation systems shall incorporate rain sensors, soil moisture sensors, and wind sensors as appropriate for system and site conditions.
- Irrigation system design shall be completed by a certified irrigation designer.
- Irrigation system installation shall be completed by a certified irrigation contractor.
- An audit of the constructed irrigation system shall be completed by a certified landscape irrigation auditor.
- A detailed irrigation schedule shall be completed for the system. Work shall include the determination of individual sprinklers or drip irrigation zone run times based on the appropriate plant material crop coefficient and precipitation rates and efficiencies determined by the irrigation audit.

Landscape Management Plan

Landscape management is an integral part of the Sterling Ranch Water Conservation Plan. Some efforts will be a one-time occurrence, like reviewing landscape and irrigation design plans for all lots, and others will be ongoing, like water use monitoring. These efforts will take place in the entire development as it evolves and will also be an integral part of the eventual targeted precipitation harvesting system. The

Pilot Project will pair the Sterling Ranch landscape management measures with the precipitation harvesting to show additional water savings that could be realized.

Some of the landscape management measures included in the Water Conservation Plan and that will be implemented as part of the Pilot Project are described herein. An irrigation system design review and audit will be performed that will include an inspection of the system components to ensure proper operation, irrigation scheduling through the controller, and evaluation of the distribution and timing of water application. GreenCO's BMP Manual describes an irrigation audit in detail and provides a checklist and spreadsheets to streamline the process. Educating the homeowner on system controller programming will be part of the plan where it becomes relevant to the Pilot Project as well as the overall Sterling Ranch education program.

Individual water budgets and outdoor metering described in the Water Conservation Plan will provide the homeowner and the Sterling Ranch District with tools to monitor the outdoor water use and will also be part of the Pilot Project where it becomes relevant. High usage will be immediately apparent and followed up with customer service to identify and fix any problem that may be related to the high water use. This could include physical problems like broken sprinkler heads or leaking drip lines, or it could involve education on watering schedules or planting selections.

A tiered water rate structure will be set in conjunction with the water budgets. This and the Waste of Water regulation set forth in the Water Conservation Plan will be part of the landscape management plan and used for the Pilot Project where it applies.

Description of Integration and Metering Between Precipitation Collection System and Irrigation System

The precipitation harvesting system currently envisioned for Sterling Ranch is a mix of collecting regional storm water runoff from impervious areas and individual rooftops that will maximize the benefit of meeting the required water supply for Sterling Ranch. The Pilot Project includes residential, commercial, and regional data collection of precipitation harvesting and outdoor water demand management that can characterize precipitation collection, collection efficiencies, landscape demand and efficiencies and supplemental water supply that is needed to meet the landscape water demand.

Each of these components will be metered with appropriate equipment to be researched and tested in the preliminary phases of the Pilot Project. Precipitation harvesting designs for the new components of the Pilot Project that will replicate a system that could be implemented for all of Sterling Ranch will measure captured precipitation, landscape irrigation water use and supplemental water used to meet irrigation demand. All data collected will be measured either with totalizing flow meters or pressure transducers and stored in a datalogger that can be downloaded. The data can then be added to the Pilot Project database for documentation and further analysis.

5.0 ADMINISTRATION

H.B. 09-1129 identified additional objectives toward advancing the understanding of potential water right impacts from precipitation harvesting in Colorado. Precipitation harvesting pilot projects must operate according to a Substitute Water Supply Plan (SWSP) approved annually by the State Engineer. Each SWSP submitted to the State Engineer at a minimum will follow the guidelines pursuant to C.R.S. §37-92-308(4) and the CWCB criteria for the pilot project:

1. A description of how the plan will operate.
2. The maximum amount of precipitation that will be captured during the year.
3. The timing with which the entire amount of precipitation would accrue to the stream system through overland flow and deep percolation.
4. The potential sources of replacement water that will be available to replace those depletions at the appropriate locations.

SUBSTITUTE WATER SUPPLY PLAN (SWSP)

The Sterling Ranch Pilot Project will be implemented in phases to gain the appropriate information needed to design a precipitation harvesting system. A detailed description of each component of the Pilot Project is described in Section 6. The Pilot Project will operate under an approved SWSP when precipitation harvesting begins (estimated to begin in year 2 of the Pilot Project). Sterling Ranch will operate under the approved SWSP until either a) the Pilot Project is terminated, or b) a permanent augmentation plan is applied for and approved in water court. The relative amount of precipitation captured may change over time with increases in capture areas or construction of additional collection sites. The annual SWSP renewal will account for changes in collection areas and replacement requirements as the development changes through time. An application for a permanent augmentation plan will only occur after Sterling Ranch has sufficient data (minimum 2 years) collected to support a water court application for a precipitation harvesting augmentation plan.

Proposed Operations

The Sterling Ranch boundary is divided by the Plum Creek watershed to the east and the South Platte River watershed to the west. Precipitation capture sites will be located within the Sterling Ranch boundary. The accounting of depletions that accrue to each watershed will be dependent on location of the collection site. Each collection site with an approved SWSP will be assigned a stream depletion location on either the South Platte River or Plum Creek. Figure 5-1 shows the tributary boundaries and the impacted reaches of the South Platte River and Plum Creek.

Initially Sterling Ranch proposes to estimate the annual Pilot Project stream depletions as 100% of the recorded maximum annual precipitation at a nearby climate station times the impervious area within the capture area. This will be the basis for the amount of replacement water that will need to be acquired for approval of the SWSP. Each Pilot Project collection site will be measured separately using float or transducer style recorders quantifying the total precipitation captured at the site on a daily basis.

Replacements to the stream system will be equivalent to the amount captured and will be made by a slug or a constant release of water according to an approved SWSP. Information gathered from the natural conditions component of the Pilot Project will be used to characterize the timing of surface and ground water return flows for the SWSP and subsequent augmentation plan. However, until this information is known, Sterling Ranch proposes that 100% of the depletion occurring at each collection site during the Pilot Project will be replaced to the appropriate stream system within 48 hours. Given the potential small amounts of precipitation captured in the pilot study, Sterling Ranch proposes to make replacements directly to the stream once stream depletions accumulate to 1 af or more in a month, or at least balance at the end of each month. Once sufficient information has been collected ground water return flows will be lagged using AWAS (Alluvial Water Accounting System) and surface returns will be quantified based on established rainfall runoff relationships.

Appropriate accounting forms summarizing capture amounts and replacements will be on a daily basis with monthly summaries submitted to the water commissioner. Information summarized will include dates, calling rights, capture amounts for each basin, replacement source and amounts, transit losses associated with replacement amounts, and river balance account.

Potential Precipitation Capture

An evaluation of the maximum amount of precipitation in a single year that historically occurred at Sterling Ranch will provide the basis for a reasonable amount of replacement water that would be necessary to operate the SWSP when applied to the impervious capture area. The NOAA Kassler climate station is approximately one mile west of Sterling Ranch and was chosen to be representative of precipitation at Sterling Ranch. Readily available records at the Kassler station show that for the years 1950 to 2004 the maximum annual precipitation available for capture in a single year is 28.11 inches (1969 – Appendix E)). Monthly replacement water supplies required were estimated by distributing the annual maximum precipitation based on the average monthly distribution of precipitation for the Kassler station. Table 5-1 summarizes the average monthly rainfall totals, and the maximum annual precipitation distributed monthly for the Kassler station. According to NOAA there is a 99.5% probability that the annual total rainfall at Kassler will be less than this amount[12].

Table 5-1 Kassler Climate Station - Maximum Precipitation (1950-2004) and Estimated Unit Precipitation Harvesting Capture Potential (af/acre)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Monthly Precipitation (in)	0.57	0.74	1.64	2.16	2.85	1.75	1.64	1.62	1.42	1.27	1.16	0.69	17.52
Distribution (%)	3%	4%	9%	12%	16%	10%	9%	9%	8%	7%	7%	4%	100%
Annual Max Precipitation Distributed Monthly (in)	0.92	1.19	2.63	3.47	4.58	2.81	2.63	2.60	2.28	2.04	1.86	1.11	28.11
Estimated Unit Precipitation Capture Potential (AF/Ac)	**0.08**	**0.10**	**0.22**	**0.29**	**0.38**	**0.23**	**0.22**	**0.22**	**0.19**	**0.17**	**0.16**	**0.09**	**2.34**

12 (NOAA, 2009)

The maximum daily events at the Kassler station were reviewed to estimate a maximum daily release rate of replacement supplies. During the months of high potential capture (March– August) the maximum daily rainfall event was 5.08 inches. At 100% replacement, supplies will need to have the ability to be released at a rate of 0.42 AF/day per acre of impervious area assuming a 24 hour release, or 0.21 af/day per acre of impervious area assuming a 48 hour release rate.

The evaluation of potential capture is a conservative estimate of volume of augmentation water supplies necessary for the pilot project. The actual replacement will be based on actual amounts captured. The use of the above values are a conservative estimate since literature review provided capture efficiencies ranging from 80% - 90% for small systems and potentially much less for larger systems.

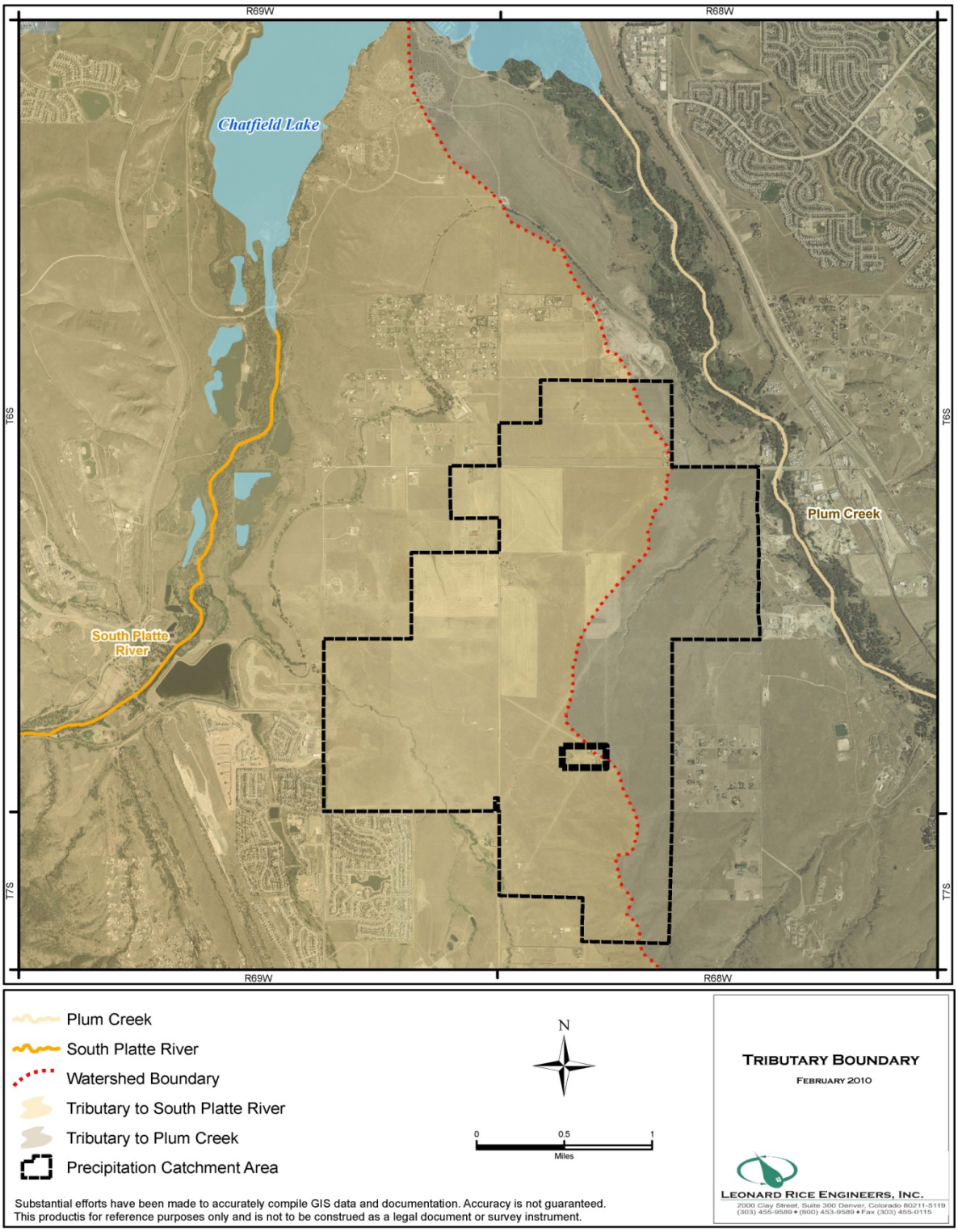
Replacement Sources

The locations of necessary replacements will be above calling rights along the South Platte River and Plum Creek. Sources of replacement water will include but are not limited to transmountain water, developed water, non-tributary ground water, or other fully consumable water decreed for replacement purposes. Sterling Ranch plans to use fully consumptive water stored in its on-site storage facility known as the ARS Pit (when completed), or contract with non-tributary well owners or owners of local storage projects with augmentation water to make releases to the stream system to offset depletions.

At this time it's envisioned that separate replacement water supplies will need to be acquired to meet Plum Creek stream depletions and South Platte River stream depletions. If Plum Creek replacement water is needed, a contract for non-tributary ground water in Plum Creek would be a likely replacement supply for the Pilot Project. At times when a live stream exists between the Plum Creek replacement source discharge site and the South Platte River, it could also be used to meet South Platte River stream depletions. South Platte River stream depletions will likely be replaced with a contract for upstream South Platte consumptive use water, or Sterling Ranch could rely on water supplies available to it through Dominion Water and Sanitation District (Dominion). Dominion, which is the water provider for Sterling Ranch, has a contract with Aurora for consumptive use water (up to 380 af/yr) on the South Platte that Sterling Ranch may rely upon if not required for raw water service to the Sterling Ranch development.

As stated above, replacement water supply contracts will need to be set up to allow releases to offset depletions due to precipitation harvesting in time (within 48 hours or other time frame approved by the water commissioner), location (Plum Creek or South Platte River), and amount (volume as well as flow rate).

Figure 5-1 Precipitation Collection Area and Tributary Boundary



Applicant's SWSP Commitment

Sterling Ranch is fully committed to developing the resources to complete the general guidelines necessary to apply for and operate an SWSP. The engineering and legal support necessary to complete the SWSP and augmentation plan is already retained by Sterling Ranch. The depletions that must be offset to prevent injury to decreed water rights as a result of precipitation harvesting will be replaced in time, location, and amount according to the annual SWSP. The resources necessary to operate the SWSP will be determined and acquired prior to any precipitation harvesting practices taking place.

Sterling Ranch is actively seeking replacement water sources on the South Platte River and Plum Creek, which are the two primary locations that depletions will occur. It is anticipated that Sterling Ranch will acquire replacement sources in the form of transbasin water, reusable effluent, non-tributary ground water, or other fully consumable water decreed for replacement purposes. As the Pilot Project grows and more replacement sources are necessary, additional water supplies will be acquired and summarized in the annual SWSP submittal.

The intent of the Pilot Project is to set precedence, for a reliable sustainable water supply for Sterling Ranch and for new real estate developments across the State. Administering precipitation harvesting has some unique challenges and it is important that Sterling Ranch work with the Division of Water Resources to meet those challenges to set an example for future developments. Sterling Ranch recognizes that this is a learning process for the State of Colorado and is committed to working with the Division of Water Resources to make sure all accounting practices, and information necessary to appropriately administer the Pilot Project is a provided.

6.0 PRECIPITATION HARVESTING PILOT PROJECT

The intent of the Sterling Ranch Precipitation Harvest Pilot Project is to incorporate precipitation harvesting as part of the sustainable water supply for Sterling Ranch and pairing it with advanced outdoor water demand management as an important water conservation practice to set precedence for new real estate developments across the State. The Pilot Project is designed to meet all data requirements described in the January 25, 2010 Guidelines and Criteria[13] as well as the data required to support a water court application for a permanent augmentation plan. The overall design of the Pilot Project is meant to be dynamic and flexible such that as new insight is gained the design of the project will be refined.

As a mixed use development with the potential of a variety of precipitation harvest designs Sterling Ranch proposes to determine the feasibility of precipitation harvesting techniques that are scalable and transferable to the entire development. The pilot project as presented is designed to ultimately collect data to confirm the cost effectiveness of a regional collection system that is closely coupled with advanced outdoor water management and low water use landscaping. However, individual collection systems may be a more effective water supply in some areas of the development where a regional system is not feasible. It is conceived that the final pilot project design will be a combination of representative regional and individual systems as identified and refined by Phase 2. The minimum two year data collection period required under an approved SWSP will begin once a design is reached and implemented on new construction within Sterling Ranch. Since it will take time to plan, design, and construct a representative development, Sterling Ranch proposes to initially collect data from existing sites to support and confirm site specific legal water supply, capture efficiencies and irrigation water demand. The plan is to begin collecting data at a small scale and use that information to refine and optimize future designs for a "new designs" phase, represented as Phase 3.

Pilot Project Objectives

There are four objectives to the Sterling Ranch Precipitation Harvest Pilot Project designed to meet the guidelines and criteria provided by the CWCB.

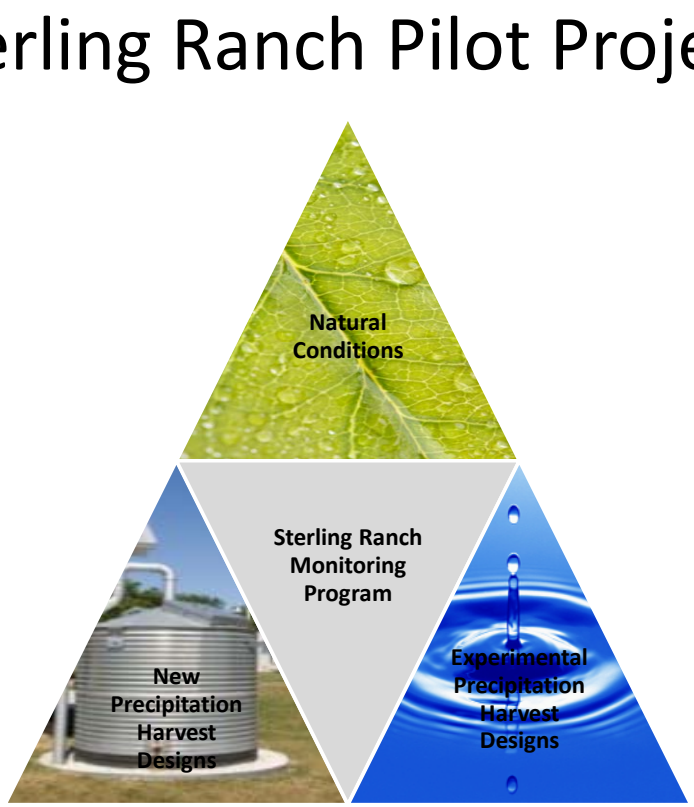
1. Evaluate natural conditions (climate, hydrology, and ET) to quantify the amount of precipitation physically and legally available as a water supply.
2. Evaluate a variety of precipitation collection designs.
3. Evaluate precipitation harvesting paired with advanced outdoor water demand management as a water conservation practice.
4. Create a baseline set of data to support;
    c) An engineering report for a water court application for an augmentation plan to use harvested precipitation and define a defensible water supply.
    d) Develop sound, transferable, and scalable methodologies for use at other locations in the state of Colorado.

13 (CWCB, 2010)

Pilot Project Components

The data requirements of the Pilot Project have been divided into three main components. Each component is important to the success of precipitation harvesting as a viable non-potable water supply in Colorado. At the heart of the Pilot Project is the Sterling Ranch monitoring plan, which connects all components of the Pilot Project together. The monitoring program is the mechanism that will used to provide a baseline set of data, and sound, transferable, scalable methodologies to support engineering decisions defining a defensible water supply.

Figure 6-1 Pilot Project Components



The approach used to describe each pilot program component is similar. The methods, implementation, monitoring, analysis, and schedule and cost of each component of the Pilot Project are described in detail in subsequent sections. The Sterling Ranch Pilot Project will be implemented in phases and the knowledge gained from each phase of the project may be the basis for the final designs and conclusions. Table 6-1 is a summary of Sterling Ranch Pilot Project describing each phase and the evolution of the project as a whole.

Table 6-1 Sterling Ranch Pilot Project Summary

Symbol/Timeline	Description
 Year 1-7	***Phase 1: Natural Conditions –*** *The development of a baseline data set to evaluate the natural variation in climate and hydrology is an important component in determining the physically and legally available precipitation for harvest. Two study basins are proposed to evaluate natural conditions of Sterling Ranch using a comprehensive monitoring plan. An integrated monitoring program measuring climate, precipitation, surface runoff, native ET, and deep percolation to ground water provide the foundation for defining physical yield characteristics, and return flow obligations to prevent injury to other vested water rights and decreed conditional rights.*
 Year 2-7	***Phase 2: Experimental Precipitation Harvesting Designs –*** *Prior to development, an evaluation of several different precipitation collection systems is imperative to provide important information about precipitation harvesting equipment, materials, capture efficiencies, and designs, and is the primary objective of this component of the Pilot Project. There are three parts to the experimental precipitation harvesting designs: 1) Residential, 2) Commercial, and 3) Regional. The Pilot Project will consist of data collection from a combination of these types of systems. Two existing residential sites on Sterling Ranch that qualify under S.B. 09-80 may be used as "Residential Experimental Sites" to evaluate residential precipitation collection designs. A "Commercial Monitoring Site" near Sterling Ranch may be used to monitor and to better understand precipitation capture volumes and capture efficiencies from commercial sites. "Regional Observation Sites" may also be used to evaluate rainfall runoff in urban areas to better understand capture volumes and effective precipitation regionally.*
 Year 3-7	***Phase 3: New Precipitation Harvesting Designs –*** *To represent a mixed use development, and based on favorable results from Phase 2, one to three scenarios will be used to represent precipitation harvesting in the new Sterling Ranch development. A model home would be used to represent a residential system, a commercial complex would be used to represent a commercial system, and a 10-acre neighborhood or equivalent would be used to evaluate regional precipitation harvesting. The precipitation harvesting systems on the new sites will be designed using insight gained from Phase 1 and Phase 2 and will consist of a combination of at least one, if not all, of these scenarios. The new designs will be constructed to incorporate the best equipment, materials, and designs to effectively harvest precipitation in Colorado. The new precipitation harvesting systems can be paired with conservative landscaping and advanced outdoor water demand management using GreenCO best management practices. The minimum two year data collection period under an approved SWSP will begin in this phase.*

PHASE 1: NATURAL CONDITIONS

The development of a baseline data set to evaluate the natural variation in climate and hydrology is an important component in determining the physically and legally available precipitation for harvest. Natural study basins can be used to evaluate the natural condition of Sterling Ranch using standard physically based methods for measurement and standard engineering practices. An integrated monitoring program measuring climate, precipitation, surface water, ET, and ground water data can provide the foundation for the natural conditions of Sterling Ranch. A detailed water budget can be developed from the data to further characterize the natural conditions.

Sterling Ranch, Spring 2009

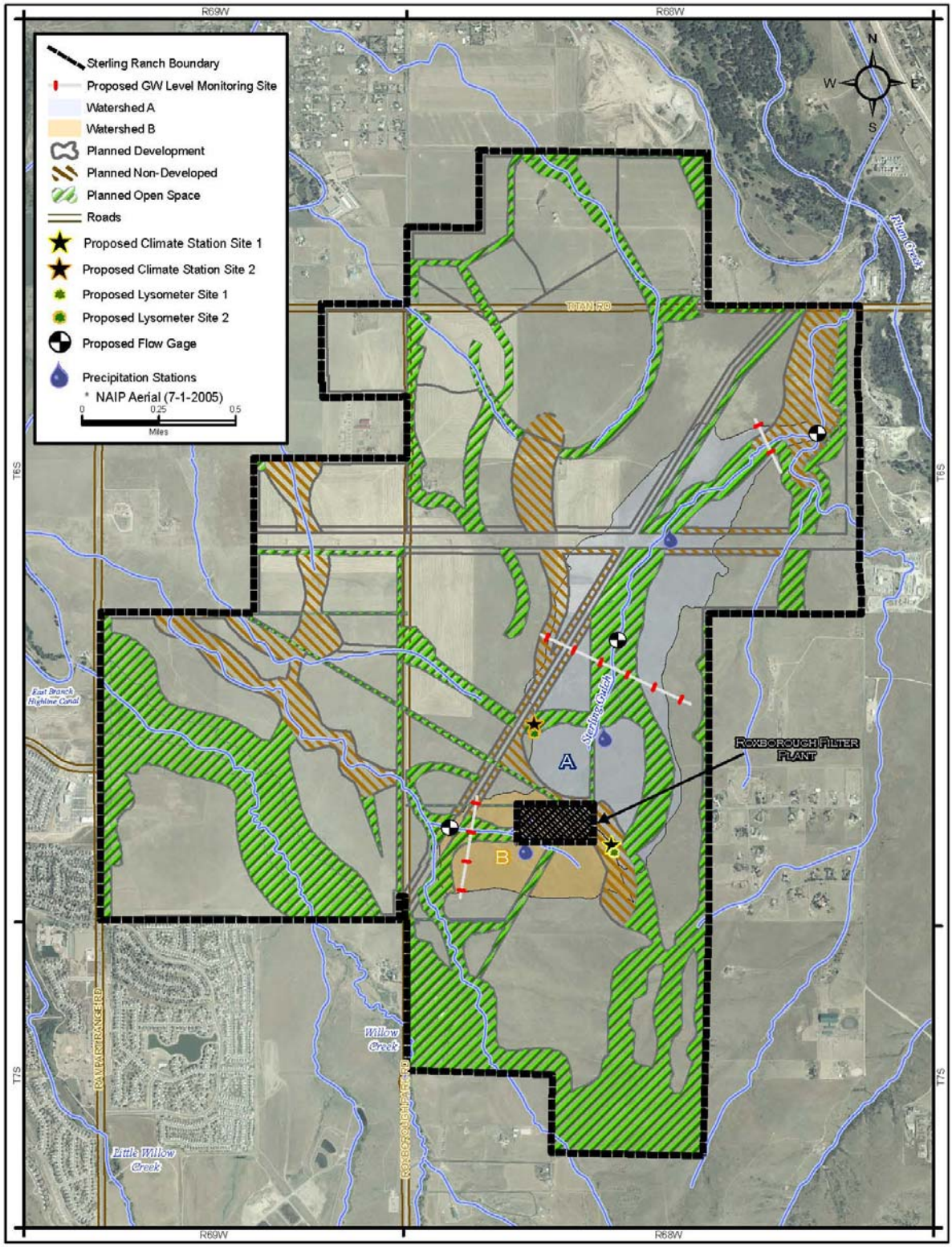
The Concept

The Sterling Ranch development totals approximately 3,000 acres with a variation in natural conditions. Appendix D describes the topography, geology, soils, hydrology, climate, and vegetation characterizing the natural condition of Sterling Ranch. Two study basins were chosen to be representative of natural condition of Sterling Ranch based on the following criteria:

- Study basin must be fully contained within the Sterling Ranch boundary
- No tributary inflow from neighboring basins
- Void as possible of unnatural obstacles (e.g., roads, culverts)
- Within planned open space or non-developed area
- Representative vegetation
- Representative soils
- Representative topography

Figure 6-2 shows the location of the proposed study basins and location of the proposed monitoring stations within the Sterling Ranch boundary. Study basin A is tributary to Plum Creek and study basin B is tributary to the South Platte River. The study basins will be used to evaluate the technical ability to reasonably quantify the site-specific amount of precipitation that, under pre-existing natural vegetation conditions occurs to the natural stream system via surface and ground water return flows. A comprehensive water budget will be developed for each natural study basin utilizing climate, precipitation, ET, surface water, and ground water measurements. To record a baseline data set of the natural condition of Sterling Ranch, the data collected from this component of the Pilot Project will be stored in a centralized database to be used for modeling or further analyses.

Figure 6-2 Proposed Study Basin Map

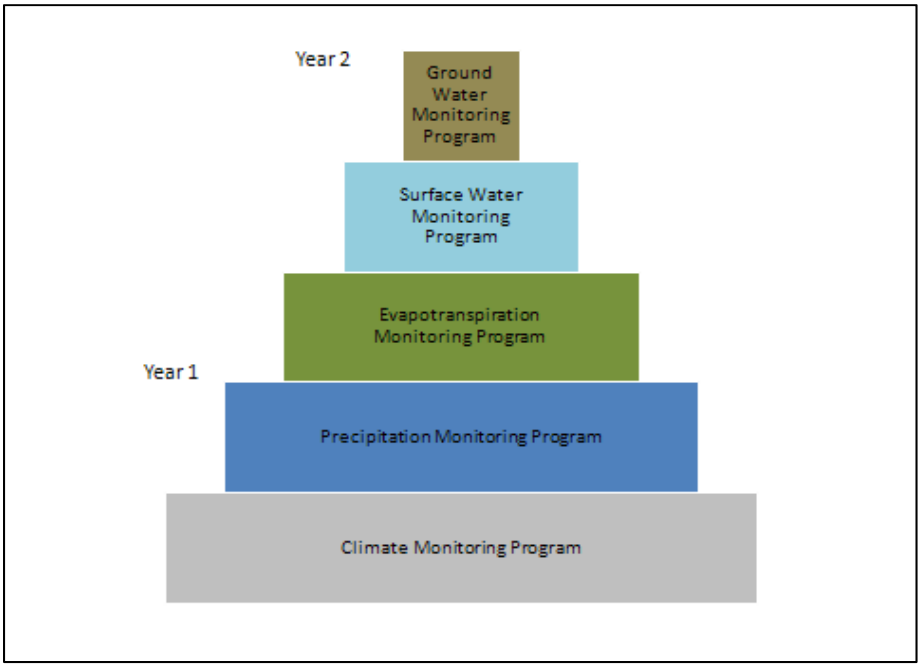


Implementation

The implementation of the Sterling Ranch Monitoring Plan is a process which may span over more than a single year. Although the primary objective of the monitoring programs on the Sterling Ranch property is to quantify total rainfall available for capture, there is a priority to the installation of these programs to maximize the usefulness of the data collected. The proposed implementation is shown in Figure 6-3**.**

1. Climate Monitoring Program
2. Precipitation Monitoring Program
3. Evapotranspiration Monitoring Program
4. Surface Water Monitoring Program
5. Ground Water Monitoring Program

Figure 6-3 Monitoring Plan Schedule



Once all monitoring programs are implemented, natural condition monitoring would need to continue for no less than two complete years while harvested precipitation is applied to a beneficial use as specified in House Bill 09-1129. As development takes place, some of the monitoring programs may be maintained to provide information for the water conservation plan and future water management on the site.

Monitoring

The intent of the Sterling Ranch Monitoring Plan is to establish a baseline data set and sound methodologies for measuring local climate and hydrologic data. Each monitoring program component summarized below is designed to meet the purposes outlined in House Bill 09-1129. Successful implementation of the Precipitation Harvesting Pilot Project requires the collection of data associated with five integrated monitoring programs measuring climate, precipitation, surface water, ET, and

ground water. The data collected will serve as the baseline data set further characterizing the natural condition of Sterling Ranch.

Climate Monitoring Program

House Bill 09-1129 Purposes

- Create a baseline set of data and sound, transferrable methodologies for measuring local weather and precipitation patterns that account for variations in hydrology and precipitation event intensity, frequency, and duration.
- Quantifying preexisting natural vegetation consumption.

The climate monitoring station can provide data for the characterization of local weather and precipitation patterns, as well as estimates of native ET, which all directly impact surface runoff and ground water returns. The climate station data collected will be the cornerstone of the Pilot Project allowing integration between all of the other monitoring programs. The data collected at the Sterling Ranch site will include parameters such as solar radiation, air temperature, wind speed, relative humidity/vapor pressure, and precipitation data.

Daily summarized climate station data will be used to develop empirical reference ET estimates using methods such as the standardized ASCE Penman reference ET equation. The concept of reference crop ET represents the potential ET of a standardized un-stressed crop. ET of other crops can then be estimated by multiplying the reference crop ET by a crop coefficient. Crop coefficients are the ratio of actual ET for a specific crop to the reference ET. This relationship is site-specific and can be developed to empirically estimate native ET at Sterling Ranch.

The data collected at the climate station will also help to characterize local weather and precipitation patterns. Information about the type and season of weather events will provide invaluable planning information necessary to the design and implementation of a precipitation harvesting program. This information also may be used to better understand site-specific physically based processes of the hydrologic cycle when paired with the other monitoring programs.

Although the climate station will be installed for the purposes of this Pilot Project, it is an integral part of Sterling Ranch's conservation and water management plan and may be maintained indefinitely.

CoAgMet Climate Station

Precipitation Monitoring Program

House Bill 09-1129 Purposes

- Quantification of precipitation event intensity
- Quantification of precipitation event frequency
- Quantification of precipitation event duration
- Measure local precipitation patterns

The measurement and quantification of precipitation is the most important parameter to be measured at Sterling Ranch to realize precipitation as a water supply. The physical measurement of precipitation is important in characterizing the native water supply, native water demand, and other hydrologic processes.

The variability of the frequency, duration, and intensity of storm events, spatially and temporally, is significant. Strategic placement of rain gages throughout Sterling Ranch should provide the necessary information to adequately estimate the total precipitation spatially and temporally. Both weighing and tipping style precipitation gages will be considered for collecting this data.

The OTT Pluvio² weighing precipitation gage is one of the main precipitation measuring stations being considered for this site. Recognized worldwide for its precision and performance, the OTT Pluvio² is an all-weather precipitation gage that measures rainfall, snow, or hail. In addition to the OTT Pluvio, tipping bucket style precipitation gages could also be deployed within the study basins and at other strategic locations throughout Sterling Ranch.

Precipitation data ultimately could be used to develop unit hydrographs for each study basin in conjunction with the surface water monitoring program. The modeling of a precipitation event can help to characterize the volume of surface water that accrues as the result of return flows from surface and ground water to the local stream system.

OTT Pluvio² Precipitation Gage

Surface Water Monitoring Program

House Bill 09-1129 Purposes

- Measuring precipitation return flow amounts.
- Evaluate the technical ability to reasonably quantify the site-specific amount of precipitation that, under preexisting, natural vegetation conditions, accrues to the natural stream system via surface and ground water return flows.
- Identify delayed ground and surface water return flow timing to receiving streams.

A surface water monitoring program will be implemented to quantify the site-specific streamflow that accrues to the natural stream system through surface and ground water return flows from native precipitation. Streamflow gages can be used to gather information on the amount and timing of streamflow on intermittent streams within Sterling Ranch in response to precipitation events. Understanding the amount and timing of surface water flow based on a specific rainfall event can help to define the volume of water that returns to neighboring tributaries. Figure 6-2, at the beginning of this section, shows the proposed stream gage locations within the natural study basins on Sterling Ranch.

There are a total of three proposed surface water monitoring stations located within the natural conditions study basins. Monitoring sites will be chosen at locations where the stream channel facilitates the installation of a control structure such as a flume or weir. The current proposed control structures will be complete with stilling wells and pressure transducers to record surface water runoff events.

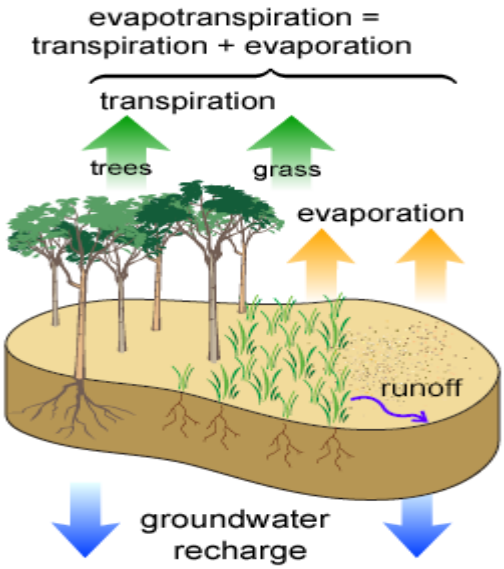
Native Vegetation (ET) Monitoring Program

House Bill 09-1129 Purposes

- Quantify preexisting natural vegetation water consumption
- Identify surface versus ground water return flow split
- Measuring precipitation return flow amounts

ET or evapotranspiration is the term used to describe the net water consumed by both evaporation and plant transpiration. Sterling Ranch proposes to quantify the preexisting ET of the natural vegetation using lysimeters. Figure 6-4 is a schematic of the parameters that can be measured with the ET monitoring program using lysimeters.

Figure 6-4 ET Schematic



Lysimeters can be used specifically to collect data regarding two important aspects of the pilot study; the actual native vegetation ET and the amount of precipitation that percolates through the soil root zone to the ground water table known as ground water recharge or deep percolation. The lysimeters may also provide some insight on site-specific soil moisture storage and surface runoff.

Representative native vegetation communities within the Sterling Ranch boundary have already been surveyed as a part of the zoning process (Appendix D). The dominant vegetation communities within the Sterling Ranch boundary where the majority of development will take place is mid-grass prairie and low-medium density shrublands. These vegetation communities represent the range and seasonality of native ET on Sterling Ranch and will be used in the lysimeters to characterize site specific actual ET of the natural vegetation.

Calibrated crop coefficients will be developed for the representative vegetation communities based on the actual ET data from the lysimeters and nearby climate station data to estimate native ET long term. Long term climate data will be used to quantify the natural vegetation ET.

There are a variety of lysimeter designs that are designed specifically to measure different parameters. Sterling Ranch will work with Colorado State University to evaluate the appropriate lysimeter, and determine the appropriate protocol for installing and maintaining the lysimeters correctly.

Ground Water Monitoring Program

House Bill 09-1129 Purposes

- Measuring precipitation return flow amount
- Identify surface versus ground water return flow split
- Identify delayed ground water return flow and timing to receiving streams

Understanding preexisting ground water interactions on Sterling Ranch is another important component of the water budget. Quantifying the amount, timing, and location of ground water return flows that accrue to any existing local alluvial or bedrock aquifers from precipitation events is important when defining augmentation requirements to local streams. Monitoring wells and ground water level monitoring equipment may be installed if sufficient ground water information does not exist. Aquifer characteristics such as porosity, aquifer thickness, and transmissivity could be defined from existing well logs or supplemental monitoring wells if needed. Figure 6-2, at the beginning of this section, shows the proposed monitoring well locations within the natural study basins on Sterling Ranch. Monitoring wells may be installed at varying depths throughout the channel cross section within the alluvium and within close proximity to surface water monitoring sites.

Deep percolation can be measured directly from the lysimeters and used as an estimate of ground water recharge from precipitation events. Data collected from the ground water monitoring program can be paired with the lysemeter data and used to understand the net ground water recharge to the local alluvial and bedrock aquifers, the split between surface and ground water return flows to the stream and timing of the ground water return flows.

Monitoring Program Maintenance Plan

The instrumentation chosen for each monitoring program would be designed to minimize required maintenance. The design of the monitoring program is modular and the maintenance requirement of each monitoring program is different. Once installed, routine physical inspections of all instrumentation will be conducted. Real-time sensors can be remotely monitored to verify that they are operating correctly. Data-logging sensors will be checked and maintained every time that the data is retrieved.

Analysis

House Bill 09-1129 Purpose

- Compile and analyze the data collected

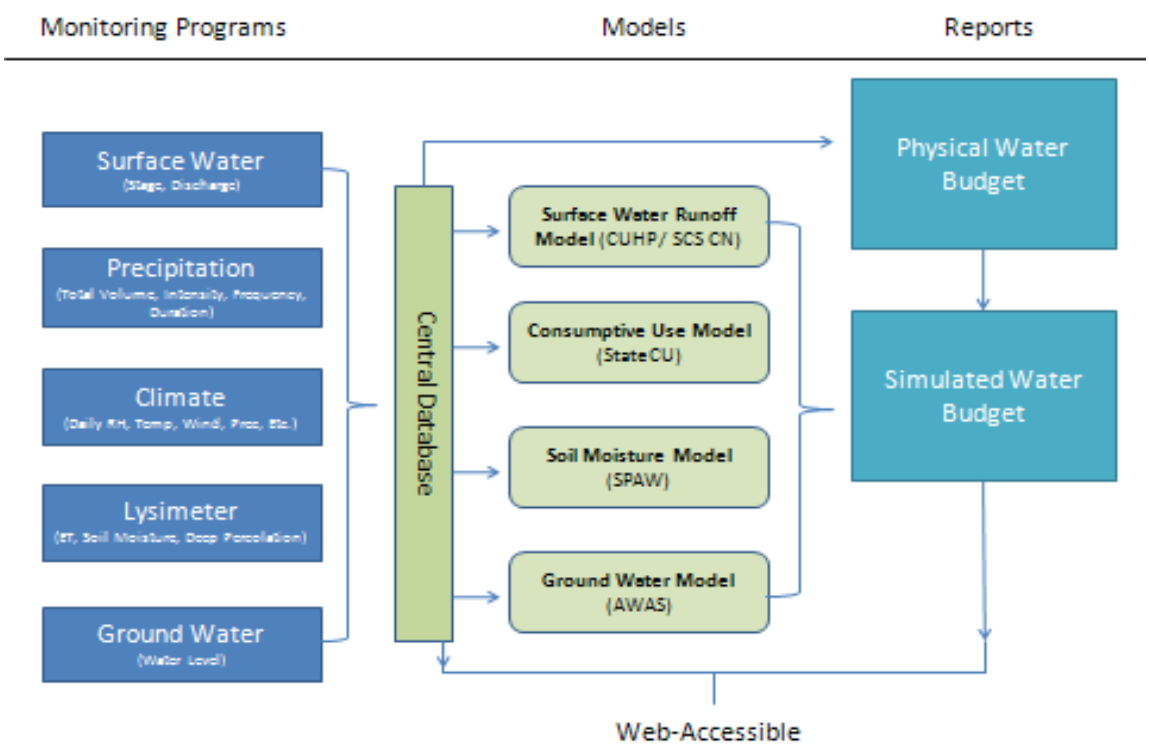
The comprehensive monitoring plan was designed to provide accurate information to answer qualitative and quantitative questions about the natural conditions of Sterling Ranch. The data can be used to develop a daily water budget for each study basin adding to the baseline data set representative of the natural conditions. In addition, the data collected should give site-specific information about the feasibility of precipitation harvesting on the front range of Colorado. At the core of the Sterling Ranch monitoring program is data management. Using a data-centered approach for the collection and analysis of information provides a sound, transferable, and dynamic method to understand and incorporate all types of data collected.

Data Management

To compile and analyze all of the data collected by each monitoring program requires a simple but robust system to manage all data types. Managing data correctly provides high quality, easily accessible data. The data collected at the site will be retrieved from data-loggers and telemetry stations. A centralized database will be used to collect, check, and archive the information observed at Sterling Ranch at varying time steps. The raw archived information will be web-accessible from the central database for summaries and for further analyses. Some data such as precipitation may be available real-time. The proposed central database is designed to format and export the necessary input data to four separate models that will be used to analyze the data. Ultimately, a water budget can be used to report model results and physical measurements for presentation purposes.

Figure 6-5 is a schematic of data management architecture.

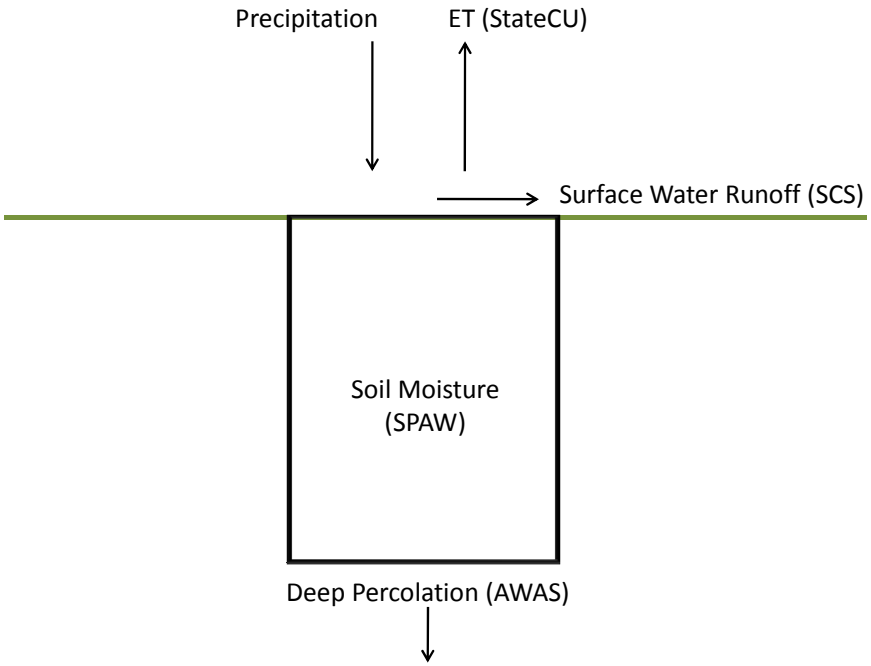
Figure 6-5 Data Management Architecture



Water Budget

A water budget will be developed and used, not only to determine unknown parameters, like ET, but as an accounting tool to understand and analyze physical and simulated observations. Figure 6-6 is a schematic of the water budget for the natural conditions showing the physical and simulated parameters for the site. The water budget will be used to understand and confirm on-site climate and hydrologic processes. Simulations of physical measurements can then be applied to the water budget to characterize the entire site. The water budget's primary use is to quantify the historic consumptive use from preexisting, natural vegetation cover as well as the surface and ground water returns to the stream. This provides the supporting information necessary to determine the volume of water that is physically available from precipitation harvesting and resulting augmentation requirements to prevent injury to vested water rights and decreed conditional water rights.

Figure 6-6 Simplified Water Budget Diagram



Models

Data collected from each monitoring program will be used to calibrate accepted algorithms and equations (models) to represent the native conditions of Sterling Ranch with empirical information, reducing the future monitoring requirements and providing validation and support to the transferability of the process and methods to future applicants. There are several models that can be used to support a regional water budget for Sterling Ranch. Below is a list of proposed models that will be used to better understand the climate and hydrology of the site:

- StateCU – The State of Colorado's Consumptive Use Model will be used to quantify standardized reference ET based on ASCE Penman-Monteith[14].
- CUHP – Urban Drainage Flood and Control District's Colorado Urban Hydrograph Procedure (CUHP) will be used for quantify rainfall runoff[15].
- SCS CN – The SCS (NRCS) curve number method is one of the most commonly used approaches for determining the amount of runoff that is generated from a single rainfall event. [16]
- SPAW – (Soil/Plant/Atmosphere/Water) was developed by the USDA and Washington State University to simulate soil moisture and a daily hydrologic budget model for agricultural fields[17].
- AWAS – Alluvial Water Accounting System was developed by the Integrated Decision Support Group at Colorado State University and is a Glover-based method for quantifying monthly or daily surface water depletions and accretions due to ground water pumping or recharge[18].

External Data Sources

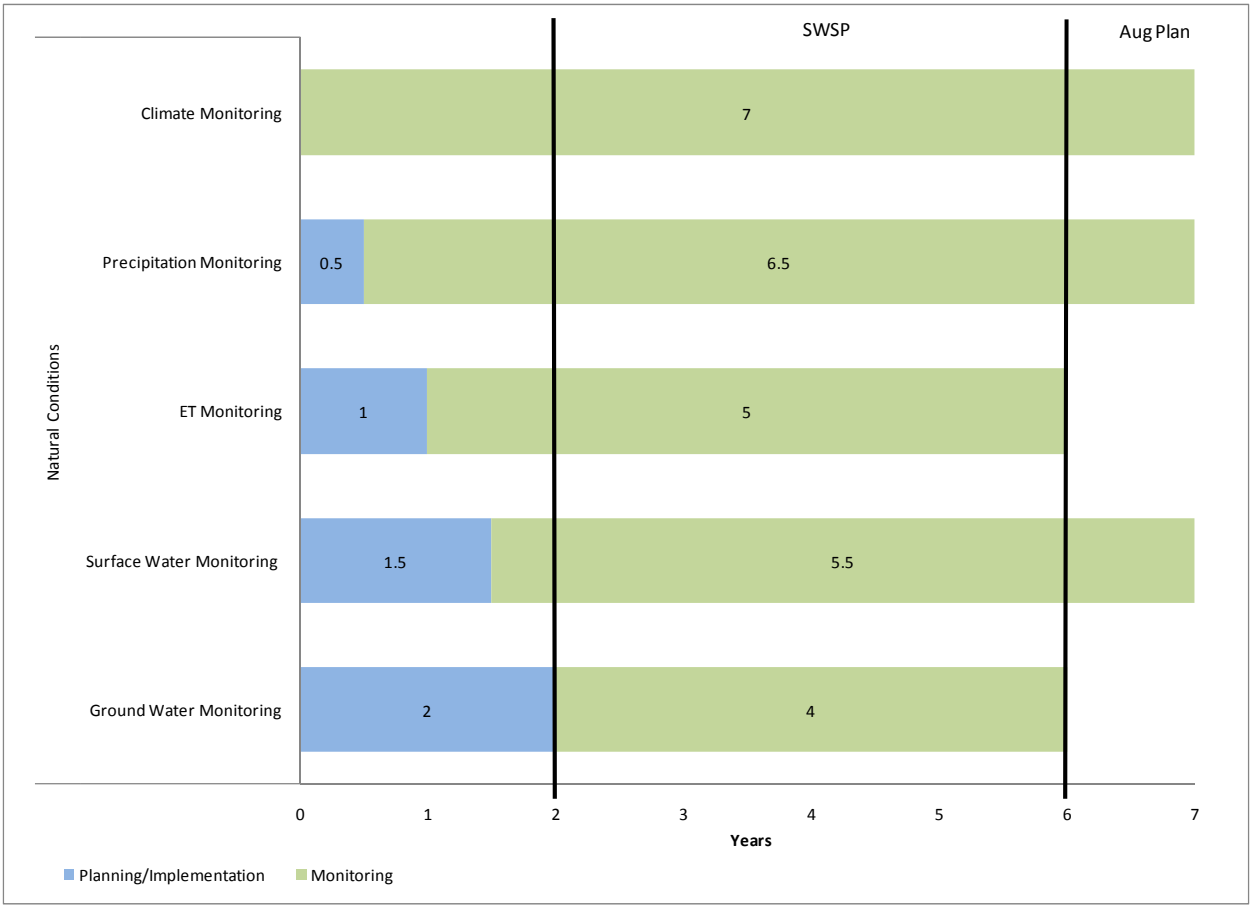
In addition to the data collected at the site, Sterling Ranch will use several external data sources for reference and analyses. Denver Water maintains the Foothills climate station, which is located approximately two miles southwest of Sterling Ranch. Daily data for this station is available on Denver Water's website and includes climate, precipitation, and reference ET estimates. NOAA maintains the Kassler climate station west of Sterling Ranch near the town of Kassler, which has a long-term daily record and is a reliable station. Urban Drainage and Flood Control District (UDFCD) maintains a network of precipitation stations that may also be used to further characterize precipitation events. It is planned that all of these publicly available external data sources be used for reference or quality assurance and quality control (QA/QC) purposes.

14 (CDSS, 2009)
15 (UDFCD, 2010)
16 (NRCS, 1986)
17 (USDA, 2009)
18 (CSU, 2009)

Schedule

Figure 6-7 is an estimate of the planning/implementation and monitoring schedule. The first year will include implementation of the climate and precipitation monitoring programs. The second year will include implementation of the ET, surface, and ground water monitoring programs. It is anticipated that all monitoring programs will run for a minimum of four years to collect sufficient data to support an application for an augmentation plan for Sterling Ranch.

Figure 6-7 Natural Conditions Schedule



PHASE 2: EXPERIMENTAL PRECIPITATION HARVEST DESIGNS

The purpose of Phase 2 of precipitation harvesting designs is to collect information about different types of precipitation harvesting designs, equipment, and materials from existing sites and structures so that Sterling Ranch can immediately begin collecting data that can be used to refine future harvesting designs. Phase 2 may include the construction and monitoring of a precipitation harvesting system paired with water-wise landscape and an advanced irrigation system. This phase also may also collect capture potential data for a regional system by monitoring run-off volumes from existing nearby developments.

The Concept

Prior to development taking place, Sterling Ranch will retrofit existing structures with precipitation harvesting infrastructure and monitoring equipment to better understand the pros and cons of different precipitation harvesting designs, equipment, and materials. Data will be collected from residential, commercial, and regional experimental sites and be used to better understand site-specific precipitation harvesting, specifically;

1. Capture Efficiencies
2. Capture Volumes
3. Implementation Costs
4. Administration
5. Water Quality

Residential Experimental Sites

Senate Bill 09-80 was passed that allows domestic well owners to harvest precipitation for ordinary household purposes, fire protection, livestock watering, and irrigation limited to no more than one acre of lawns and gardens without having to replace the precipitation through an SWSP. There are two existing homes currently in the Sterling Ranch boundary that will qualify under this bill to be retrofitted for precipitation harvesting and provide valuable information for the design of new precipitation harvesting systems for new homes or businesses. The data collected from these sites will also help quantify the site-specific amount of precipitation that can be reasonably harvested. The two sites that we have identified are Allis Ranch and the Colorado Rush. Sterling Ranch is currently applying for precipitation harvesting permits at these sites under S.B. 09-80**.** Figure 6-8 shows the location of the residential experimental sites within Sterling Ranch.

In addition to using the S.B. 09-80 residential experimental sites to better understand capture volumes and efficiencies, these sites will be used as pilot sites for developing a template to administer precipitation harvesting with no potential impact to senior water rights.

The anticipated landscape irrigation water demand for the proposed 1,500 sf water-wise landscape is approximately 26,000 gallons per year. Assuming average precipitation, we are anticipating that the precipitation collection system may provide approximately 50% of the annual irrigation requirement.

Allis Ranch Site

Allis Ranch is located just north of Titan road within the Sterling Ranch boundary. The site has two existing residences that qualify under S.B. 09-80 to harvest precipitation for beneficial uses. The site will be used to evaluate different precipitation collection designs and equipment and pairing of precipitation capture with advanced outdoor water demand management. The site will be re-landscaped to incorporate efficient irrigation design and water-wise plantings as well as advance metering and monitoring equipment.

Colorado Rush Site

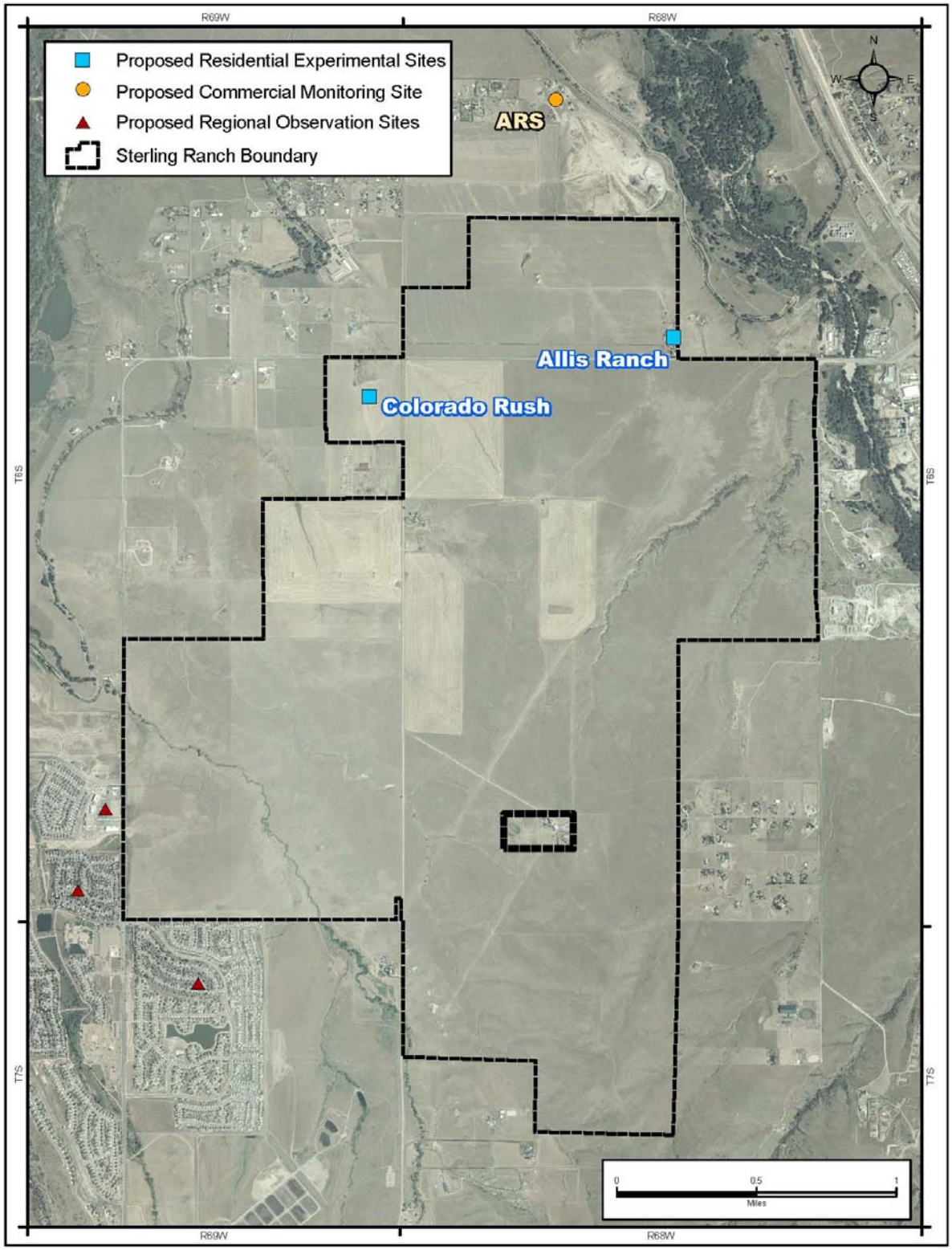
The Colorado Rush site is located south of Titan road off of Roxborough Park road within the Sterling Ranch boundary. The site has one existing residence that would qualify under S.B. 09-80 to harvest precipitation for beneficial uses. The site could also be used to evaluate different precipitation collection designs and equipment and pairing with advanced outdoor water demand management. Different landscaping and irrigation designs could be used here as well as different metering and monitoring equipment.

Commercial Monitoring Site

ARS Commercial Site

There are two large facilities ½ mile north of the Sterling Ranch that are good examples of site-specific precipitation harvesting at a commercial site (Figure 6-9). Although the site does not qualify under S.B. 09-80 to harvest precipitation for beneficial uses, they can be used to collect data about capture efficiencies and capture volumes that can be used to enhance future designs. Only a small amount of the site is paved with no primary drainage corridors. It is anticipated that precipitation could be collected to quantify roof capture and parking lot potential and efficiencies and then released.

Figure 6-8 Sterling Ranch Proposed Experimental Sites



Commercial Buildings on the ARS Site

Regional Observation Sites

Residential neighborhoods and commercial complexes within close proximity to Sterling Ranch could provide site-specific information about regional precipitation collection. Observation sites could include strategic locations within drainage corridors, detention facilities, and at storm drains. Figure 6-9 shows the approximate location of proposed observation sites near Sterling Ranch.

The purpose of collecting data from these sites is to quantify capture volumes from smaller precipitation events. We believe this data is not available from other sources, as current monitoring stations record information on large precipitation events that may result in flooding conditions or concerns. The data collected at these sites would be used to understand the relationship between rainfall runoff and capture volumes. Although the observation sites were not designed as regional capture facilities, they provide a good estimate of site-specific rainfall runoff from both large and small precipitation events.

The data collected at these observation sites would be used to simulate rainfall runoff using EPA's Storm Water Management Model (SWMM) or Urban Drainage Flood Control District's Colorado Unit Hydrograph Procedure (CUHP). CUHP and SWMM are rainfall-runoff simulation models that are used to simulate a single event of runoff quantity in urban areas. With the integration of the data collected from the residential and commercial experimental sites and data from the precipitation monitoring program, a complete estimate of the potential capture volume from regional precipitation harvesting can be made. The information gained from this exercise can then be applied to the Sterling Ranch development allowing for a refined estimate of site-specific regional precipitation harvesting.

Proposed Regional Observation Site West of Sterling Ranch

Implementation

Residential Experimental Sites – Permits for the residential experimental sites will be submitted to the Colorado Division of Water Resources to collect precipitation under S.B. 09-80. Upon approval of the permit, gutters, downspouts, metering devices, a holding tank or cistern, and connection to the irrigation system will be carefully chosen and installed as appropriate for each site. This will be an opportunity to try components from different manufacturers. Exact models will be chosen after researching and speaking to manufacturing representatives. The sites will be re-landscaped to incorporate efficient irrigation and water-wise/low water use plantings as well as metering and monitoring equipment to collect data.

Commercial Experimental Sites – The commercial buildings at the ARS site would be retrofitted with monitoring equipment to quantify the total volume of roof runoff and total precipitation at the site.

Regional Observation Sites – Once key regional observation sites are identified within the community. A monitoring plan would be implemented to best characterize rainfall runoff and capture volumes.

Water Quality

Residential Experimental Sites – Water quality will be monitored throughout the pilot study. A sedimentation trap will be provided to capture dust and debris collected during the initial washing of the roof surface during the start of a precipitation event. In addition, filtration needs will be closely monitored and adjusted to determine the optimal level of filtration required to efficiently distribute the captured water through a drip irrigation system. Several different types of filtration devices will be evaluated. The effect of storage on water quality will also be monitored and evaluated. It is anticipated that water quality samples will be taken and analyzed at different times of the year to document water quality changes, or issues that could develop and impact the design of future precipitation capture systems.

Commercial Monitoring Site – We are not anticipating collecting any water quality data from the commercial sites during this phase of the pilot study.

Regional Observation Sites – We are not anticipating collecting any water quality data from the regional observation sites during this phase of the pilot study.

Monitoring

Residential Experimental Sites – Flows from the rooftop could be collected into one central pipeline before entering the storage cistern where the flow could be measured and recorded with a totalizing flow meter and data logger. Water levels in the storage tank would be monitored with a float or pressure transducer style recorder and water delivered out of the tank would be metered through the pump if that is appropriate, or a gravity outlet pipeline. All water applied to the landscape will be metered, as well as the supplemental water required to make up the irrigation demands not supplied by captured precipitation.

Commercial Monitoring Site – Flow meters would be attached to each of the downspouts on the commercial building recording the volume and duration of runoff from the roofs. A tipping bucket style precipitation gage will also be installed on the roof to establish total precipitation available.

Regional Observation Sites – Site-specific precipitation, stage, and discharge measurements will be collected and used to verify simulated results from future design and planning efforts. The physical characterization of the observation site would also be part of the model input.

Analysis

All data collected under this component of the Pilot Project would be stored and organized in the centralized database to be used for water budgets and other analyses.

The data collected from the monitoring equipment described above would be used to calculate a daily water budget and the following statistics:

- Total precipitation collected and used for irrigation
- Precipitation capture efficiency
- Optimal storage requirements
- Quantity of water used to supplement irrigation
- An evaluation of maintenance requirements and general system operations
- Implementation costs

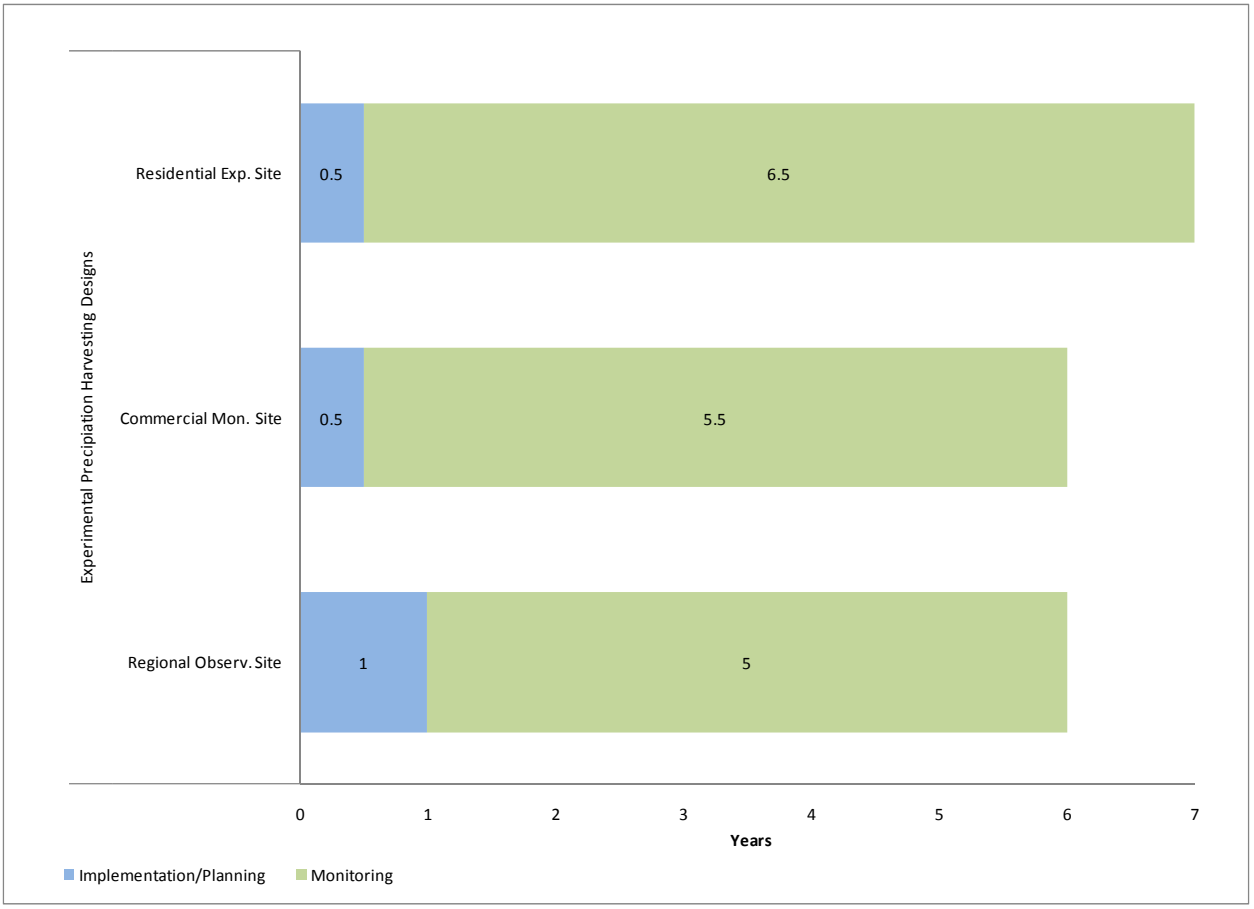
The measured runoff flows from the rooftops can be compared to the total rainfall from the nearest tipping bucket or rain gage. Capture efficiencies can be determined from the difference between these two measurements. The total volume of precipitation can also be calculated and tabulated based on storm event to determine the minimum precipitation event necessary for roof runoff.

The data collected at the observation sites could be used to create a rainfall runoff model quantifying the site-specific effective precipitation in urban areas. Effective rainfall is the amount of rainfall that runs off from a storm event. Understanding this rainfall runoff relationship will provide a valuable planning tool for accurately estimating capture volumes and storage requirements.

Schedule

Figure 6-9 is an estimate of the planning/implementation and monitoring schedule for the Phase 1 of precipitation harvesting designs. Within the first year, the residential experimental sites will be retrofitted with precipitation harvesting infrastructure and monitoring equipment. Also in the first year monitoring will begin at commercial site. The regional observation sites will be selected by the end of the first year and monitoring plan will be implemented.

Figure 6-9 Experimental Precipitation Harvesting Designs Schedule



PHASE 3: NEW PRECIPITATION HARVEST DESIGNS

Phase 3 of the Sterling Ranch Pilot Project is for new designs implemented within Sterling Ranch. The precipitation harvesting systems will be designed using the insight gained from Phase 2 of precipitation harvest designs, incorporating the best equipment, materials, and designs, based on the information gained, to effectively harvest precipitation on a larger scale. With the understanding from Phases 1 and 2, application of the regional, targeted and individual systems will be further understood, and finally validated in Phase 3, offering the most opportunity for Sterling Ranch and their builders to customize the systems as they are most reasonable and beneficial to the community. Each new precipitation harvesting system will be paired with conservation landscaping and advanced outdoor water demand management measures to compare to the theoretical water savings found in the Holistic Report[19]. An SWSP will be submitted for approval prior to implementation of the final designs in this phase. The two-year minimum data collection required under the approved plan will begin upon implementation.

The Concept

As a mixed use development, Sterling Ranch could incorporate several different designs of precipitation harvesting systems. For the purposes of this application and cost estimating, three scenarios were chosen to be representative of the Sterling Ranch development. Any combination of one or more of these scenarios will be implemented at Sterling Ranch and the results from this portion of the Pilot Project will help determine the cost physical and physical and cost effectiveness of precipitation harvesting for the entire Sterling Ranch development and which precipitation harvesting designs are the best. The three scenarios that could be studied at Sterling Ranch are:

1. Residential System
2. Commercial System
3. Regional System

A general description, implementation, monitoring, analyses, and cost of each of these scenarios is summarized below. The designs may change to suit the first stages of the development according to the real estate market. Actual designs would be finalized as the development progresses and building permits are in place.

1. Residential System

Within the first permitted filing at Sterling Ranch, a model home or homes would likely be built. The home could be equipped with a self-contained precipitation harvesting system that would include rooftop capture gutters, filtering, downspouts, cistern, and a pump to deliver water to the irrigation system. Water-wise landscaping and irrigation system would be installed based on GreenCo BMP guidelines. The residential landscaping, advance outdoor water demand management, and outdoor metering would be representative of residential practices throughout Sterling Ranch. The precipitation supply will be supplemented with potable water to ensure an adequate and consistent water supply. The information gained from the residential

19 (Leonard Rice Engineers, Inc.; Meurer and Associates; Ryley Carlock and Applewhite , January 2007)

experimental sites in Phase 2 would be used to optimize the design of the precipitation collection and irrigation systems.

The anticipated landscape irrigation water demand for the proposed 1,500 sf water-wise landscape is approximately 26,000 gallons per year. Assuming average precipitation, we are anticipating that the precipitation collection system will provide approximately 50% of the annual irrigation requirement.

2. Commercial System

One of the first commercial sites to be built at Sterling Ranch could be selected for the Pilot Project and could be anything from a strip mall to a library or school. Precipitation would be collected from rooftops, parking lot, sidewalks, and all other impervious surfaces. The drainage and building plan would be designed to collect all precipitation into a pond or below-ground storage cistern. Water would be pumped from the storage vessel into the irrigation system for all landscaped areas on the lot. The information gained from the commercial monitoring sites in Phase 2 would be used to optimize the design of the precipitation collection system.

Given the high percentage of impervious area and low percentage of landscape anticipated for commercial sites, most of the landscape irrigation water requirement for the site could be provided by an on-site collection system. We are anticipating collecting 75 to 100% of the landscape irrigation needs, based upon average precipitation conditions. Information will be collected to help optimize storage requirements and the need or effectiveness of various water quality components.

3. Regional System

This portion of the Pilot Project could include a number of lots in a neighborhood in the first filing that would be designed to include a precipitation harvesting system that would direct rainfall and snowmelt runoff into a common storage facility. Stored precipitation would be pumped from the pond into a non-potable distribution system that would irrigate the common outdoor demands in the community. The non-potable demands not meet by precipitation would be supplemented by a backup potable water source. The information gained from the regional observation sites in Phase 2 about site-specific rainfall runoff and capture volumes will be used in the engineering estimates to optimize the design of the regional precipitation collection design.

Depending on the layout and design of the pilot regional system, it is anticipated that 50%-100% of the landscape water requirement could be provided by an on-site Regional Collection System. Information will be collected to help optimize storage, conveyance, and water quality for future system design.

Implementation

Residential System – Upon issue of a building permit, the design team would work with the builder to incorporate the precipitation harvesting system into the model homes building and site plans. The landscape architect would work with the builder to coordinate the landscape design in accordance with

the Sterling Ranch Water Conservation Plan requirements and to locate the cistern in an aesthetically appropriate location.

The irrigation system would be designed and installed as required and connected to both the cistern and the potable water supply. A connection to the potable system would be installed with a back flow prevention device that would keep the cistern at the appropriate level to provide enough water for the scheduled irrigations in the event that there isn't enough precipitation.

Commercial System – Upon approval of a commercial building permit, the precipitation harvesting team would again work with the architects and landscape architects to incorporate a drainage plan that would drain the lot to a detention pond or underground cistern. Downspouts from the rooftop could be designed to drain to the site drainage system.

A pump would be installed in the storage facility that would pump water into the irrigation system that will be metered separately from the indoor water use. A connection to the potable water supply would be installed with a backflow prevention device to supplement the precipitation if necessary.

Regional System – As permits are submitted to build in the first filing of Sterling Ranch, the precipitation harvesting team would work with the builder, architects, landscape architects, and system manufacturers to develop a runoff and capture design that would capture rooftop runoff and excess drainage from each residential or commercial lot. The rooftop and lot runoff would be directed to drainage channels that would deliver the water to the storm water drainage system. An example of neighborhood runoff capture is a concrete drain pan, located between houses, which lead to the street.

The first part of implementation would be done when the storm water system is designed and constructed. Runoff from the lots and roads would be captured and directed to a detention pond or other storage facility. The storm water drainage system design would be modified to maximize runoff collection through site grading and layout, as well as pond lining to minimize seepage if necessary. It is anticipated that the recommended detention storage capacity would be larger than that for storm water detention and would be sized according to expected precipitation collection and water demand. A non-potable distribution system would be used to distribute the precipitation to meet regional demands such as parks and common areas in the community.

Irrigation systems at Sterling will be designed and installed as required by the Sterling Ranch Water Conservation Plan according to GreenCO and EPA Water Sense best management practices and specifications. The irrigation schedule will be programmed using a smart controller or manually to adjust for locally calculated seasonal outdoor water demands.

Water Quality

Residential System – Design of the capture and irrigation systems for this phase of the pilot study will incorporate improvements and modifications required to provide adequate water quality for non-potable landscape irrigation use based upon the monitoring and observations of the experimental residential sites constructed in Phase 2 of the pilot study. The systems planned for this phase of the pilot study should be fairly well refined based upon previous work.

Commercial System – The commercial precipitation capture systems will be designed with consideration of current Douglas County and Urban Drainage storm water quality requirements. Coordination with both entities is planned, since underground vessels for long term storage and detention/retention are not common, and currently not covered under current standards or design requirements. We are anticipating incorporating all appropriate Urban Drainage Storm Water Quality BMPs into the design of the collection systems, including BMP's for sand filters, water quality ponds, and underground storage.

Regional System – The regional precipitation capture systems will be designed with consideration of current Douglas County and Urban Drainage water quality requirements. We are anticipating incorporating all appropriate Urban Drainage Storm Water Quality BMPs into the design of the collection systems, including BMP's for sand filters, water quality ponds, and underground storage. Coordination with both entities is planned, since ponds that combine long term storage and detention/retention are not common, and currently not covered under current standards or design requirements. Again, appropriate Urban Drainage Storm Water Quality BMP's will be incorporated into the design of the collection system to ensure adequate water quality if available for release of captured storm water back into the drainage system or for use as a non-potable water source for irrigation.

Monitoring

Residential System – The water level in the cistern would be measured with a pressure transducer and data logger. Supplemental potable water would be measure prior to entering the cistern and collected precipitation could be deduced from these two measurements. A meter will be installed on the irrigation system as required by the water conservation plan.

Commercial System – Similar to the residential system, water levels in the storage vessel will be measured with a pressure transducer and pumping rates will be measure at the pump outlet. Flow from the impervious surfaces will be measured at the inlet to the storage facility either through a flume or pipeline meter. The irrigation will be measured at the outdoor meter as required by all taps in the water conservation plan. Supplemental potable water will be measured in the pipeline connection to the storage vessel with a totalizing flow meter and data logger***.***

Regional System – Total runoff from the collection area will be measured at the inflow point of the detention pond. Rooftop measurements would be collected in other parts of the Pilot Project. Runoff will be directed into the detention pond through storm drainage channels and pipelines. Flow into and out of the detention storage pond can be deduced from stage of the pond, which would be measured with a pressure transducer or staff gage. The volume in the pond could be determined from a stage-storage curve that would be developed using a Global Positioning System.

Each lot will have an outdoor meter to measure irrigation applications. Water pumped from the detention pond into the non-potable system will be measured at the pump station. Potable water required to supplement the captured precipitation will also be metered prior to entering the irrigation system or detention pond.

Analysis

The data collected under this component of the Pilot Project will be stored and organized in the centralized database to be used for water budgets and other analyses.

Residential analyses are explained in Part 1 of the Precipitation Harvesting Designs phase of the Pilot Project and can be used for the regional analysis to determine regional runoff efficiencies. The commercial site runoff efficiency can be determined from the storage data collected at the site and rainfall measurements taken in the vicinity.

For all scenarios, the total volume of precipitation collected can be compared to rainfall runoff volumes from a series of storm events that would allow the development of a unit hydrograph for the site. Once a unit hydrograph is developed, it can be used to predict the potential volume of water from the site for any storm event.

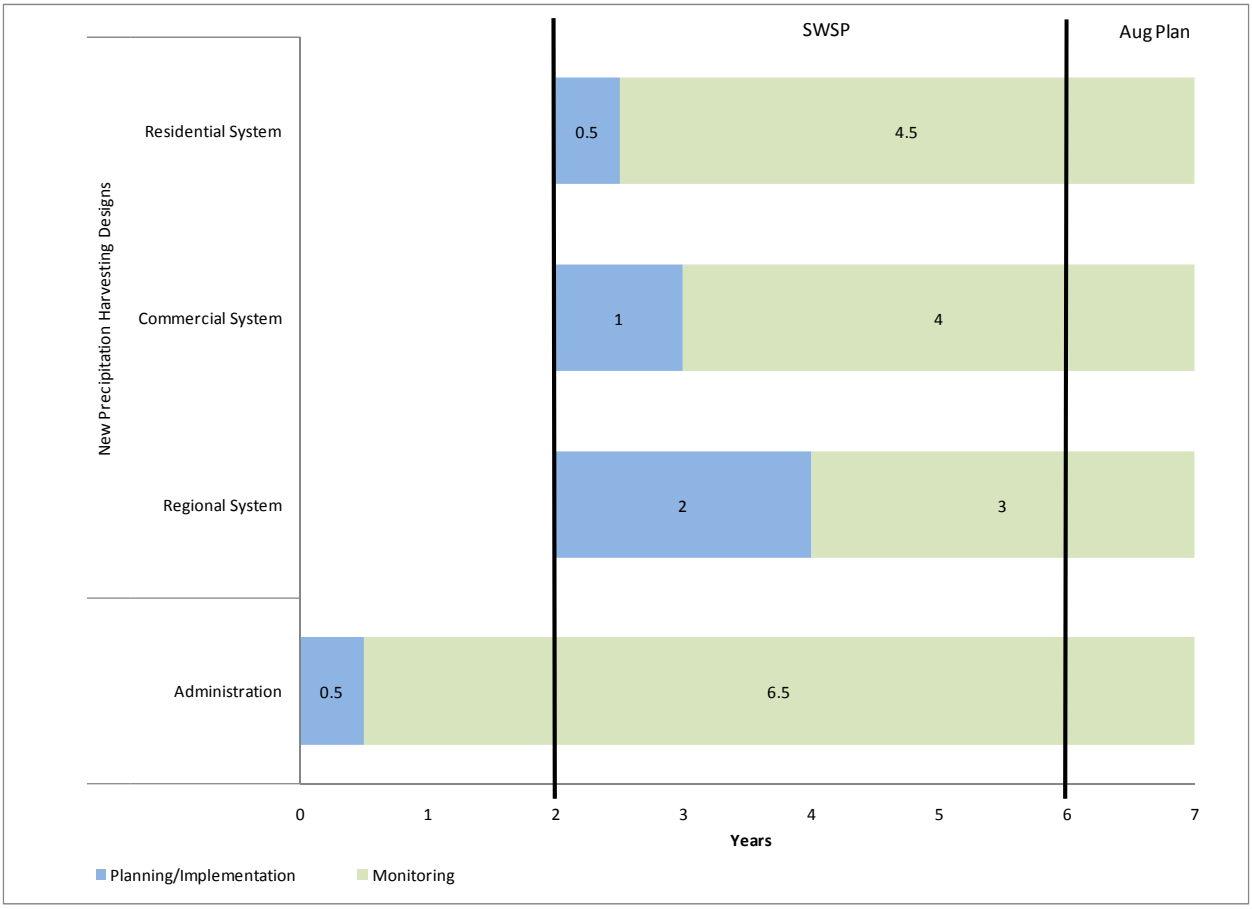
A water budget for the regional system will be developed to balance total precipitation collected, evaporation, inflows, and outflows from the pond on a daily basis. As well as potable water usage compared to precipitation usage.

Irrigation applications will be measured at all sites and irrigation system audits performed to determine application and distribution efficiencies. Irrigation application will be compared to calculated potential water demand from the associated plantings at each site and deficit irrigation effects can be determined for further consideration and possible application.

Schedule

Figure 6-10 is an estimate of the planning/implementation and monitoring schedule. Phase 3 may begin in year two with the planning and implementation of residential, commercial, and regional systems which will actively be harvesting precipitation. Each proposed system that is implemented on new construction as part of Phase 3 will operate under an approved SWSP and be monitored for a minimum of two years.

Figure 6-10 New Precipitation Harvesting Designs Schedule



STERLING RANCH PRECIPITATION HARVESTING PILOT PROJECT EDUCATION CAMPAIGN

Given the underlying approach to water conservation and sustainability at Sterling Ranch, community education and guidance is a fundamental part of the plan for water demand management. The Sterling Ranch Water Conservation Plan targets a limited water demand and includes numerous tools for the homeowner to monitor and manage its water use, both indoor and outdoor. Pairing precipitation harvesting with the outdoor water demand management measures can be included in the planned educational program as well as have specific components of its own.

Being a "Pilot Project" includes a responsibility to educate, not only the residents at Sterling Ranch, but the sponsors, the potential builders within Sterling Ranch, and the rest of the State.

Specific to the Precipitation Harvesting Pilot Project, the following items are planned for the education campaign, but in no way are final or limiting: 1) Website designated to data management and analysis, 2) Sterling Ranch website, 3) Landscape and Agriburbia garden tours, and 4) Water Conservation Plan monitoring tools.

1. All data and results from the native and experimental monitoring will be posted on a designated website as a way to make the data available to parties of the Pilot Project team, as well as the State, and to illustrate the progress and findings of the Project. Reviews and articles will also be posted on the website and numerous links to precipitation harvesting products and concepts. Links to the team member's websites can be attached that show the area of expertise and projects that each are involved in.

2. Sterling Ranch has a website explaining all aspects of the development from inception to current status. The website contains information about the proponents of Sterling Ranch, Project Overview, Economic Impact, News, Conservation, Our County (Douglas), Frequently Asked Questions, and contact information. As the Pilot Project progresses, this site can be used to report results and discussion to the audience that is already familiar with the development, including homeowners, as well as people that are interested in precipitation harvesting. Sterling Ranch is also a member of the Douglas County Water Resource Authority which enables residents of Sterling Ranch to use the tools, information, and links stored on that website.

3. Another component of the Pilot Project education includes accessibility to the Agriburbia garden and landscape area at Allis Ranch. This will be an experimental site for the Pilot Project to demonstrate different precipitation harvesting equipment as well as landscape plantings and garden water demands. A brochure explaining the site may be provided to help guide visitors.

4. The water conservation section of the Sterling Ranch Water Plan explains in detail the numerous tools that are planned to educate and guide the homeowners and allow Sterling Ranch to enforce water demand management measures that are designed to achieve the progressive water targets set for the development. An individual water budget is planned for each residential and commercial lot that will be monitored closely with dual (indoor and outdoor) metering and billing software. The billing software will be designed as an educational tool for the homeowner and a monitoring and enforcement tool for Sterling Ranch. The software can provide information on monthly billing like:

    - A graph of billing rate tiers
    - Compare water use with an average of similar homes and yards
    - Compare current water use with historical data
    - Compare water budgets with actual metered water use
    - Compare higher tier charges with what could have been within the water budget
    - List most likely causes for water budget exceedence and provide a contact for assistance
    - Inform customers of potential leaks
    - Educational message blocks

    Irrigation system audits will be another tool of the educational process in the water conservation plan and may be supplemented with irrigation system scheduling classes. Part of the audit will be to program the system controllers while educating the homeowner on how to do it and where to find a forecasted annual irrigation schedule for the area.

For a large planned community like Sterling Ranch, getting the buy-in of the community builders into the implementation of precipitation harvesting system will be integral to the ultimate success of utilizing precipitation harvest as a water supply. The education campaign will include opportunities for the builders to better understand the equipment, infrastructure, and special installation needs, as well as the benefits and economic impacts associated with the precipitation harvesting. These opportunities could include workshops with equipment suppliers, builders, community planners and engineers to discuss options for different systems and alternatives to test, as well as their participation directly in the Pilot Project. The goal of this part of the education campaign is to gain from the builders' experience and knowledge, help answer their questions early in the design development, and assure their buy-in to the ultimate implementation of the precipitation harvest systems.

The education campaign for Sterling Ranch is designed to adjust to meeting the purposes of educating the homeowner on water demand management and the potential and progress of pairing precipitation harvesting with the outdoor demand. The campaign can also be designed to provide education and reporting to State and County agencies as well as other interested parties.

PILOT PROJECT PROBABLE COST ESTIMATE

The estimated Pilot Project costs for infrastructure, ongoing operations, maintenance, and monitoring associated with implementing the project are summarized below. The opinion of probable costs for the Pilot Projects is preliminary in nature. It is anticipated that if this Pilot Project is selected, costs will be refined as the project moves forward. The Phase 1 costs are the most defined, while the Phase 2 costs are less defined since some of the sites for collecting data have not been selected yet, and the Phase 3 costs are very conceptual and based upon hypothetical developments. As the project moves forward, the costs for Phase 2 and Phase 3 will be updated and refined, which will be reported in the annual status reports as part of the Pilot Project requirements.

Operation, maintenance, and monitoring costs are assumed to be 10% of total costs for Phase 1 and 2. This estimate is higher than normal for typical operation and maintenance due monitoring instrumentation.

Phase 1: Natural Conditions

The opinion of probable cost for implementation of the natural conditions monitoring program includes monitoring programs for climate, precipitation, surface water, ET, and ground water as well as data management and website design.

Natural Conditions – $ 152,600
Annual Operations/Maintenance/Monitoring (10%) – $ 15,260

Phase 2: Experimental Precipitation Harvest Designs

Residential Experimental Sites – The opinion of probable cost to retrofit the current targeted residences with precipitation harvesting system and required monitoring and instrumentation is approximately $23,700 per site, with approximately half of the cost associated with monitoring equipment specific to the Pilot Project. The landscaping and advance outdoor water demand management infrastructure is estimated to cost approximately $8,000 per 1,500 sf site. The equipment and landscaping in this phase is for preliminary data collection as described in Chapter 6. The costs are based on a proposed climate station, monitoring hardware and software, and website/database design fees.

Residential Experimental Sites (both sites) – $ 63,400
Annual Operations/Maintenance/Monitoring (both sites) (10%) – $ 6,340

Commercial Monitoring Site – The opinion of probable cost to retrofit two existing commercial buildings with the appropriate monitoring equipment is $5,000 per building. This assumes minimal monitoring equipment for the purposes of measuring the potential collected flow only, with no intent to capture or use the precipitation at this time.

Commercial Monitoring Sites – $ 10,000
Annual Operations/Maintenance/Monitoring (10%) – $1,000

Regional Observation Sites – The opinion of probable cost to collect sufficient data about rainfall runoff and capture volumes at each regional observation sites is between $5,000 and $10,000 at two to three sites. The estimated cost to develop a rainfall runoff model is $15,000. A more refined cost estimate will be used once regional observation sites are selected. This site information is also for preliminary data collection purposes. The benefit of implementation of these sites will be reviewed during this phase of the Pilot Project

Regional Observation Sites – $30,000 – $60,000
Annual Operations/Maintenance/Monitoring (10%) – $3,000 – $6,000

Phase 3: New Precipitation Harvest Designs

The new precipitation harvest designs phase refers to the initial implementation of precipitation harvesting systems into the Sterling Ranch development. This Phase will begin following Phase 2 assuming appropriate levels of feasibility continue to be identified. Costs for this phase are estimated by using preliminary sizes that will be reevaluated for appropriate scalability at the time actual sites within Sterling Ranch are identified and results from Phase 2 are obtained. These sites will be selected based on builder participation, timing of development and the appropriateness of the site to the Pilot Project and will include any combination of one to all of the following systems.

Residential System – The opinion of probable cost for a single-family new home is approximately $23,700, with approximately half of the cost associated with monitoring equipment specific to the Pilot Project. The opinion of probable cost includes a 5,000 gallon cistern, submersible pump and filter, 4-inch gravity flow pipe, backflow device, and monitoring equipment for each. Landscaping and irrigation costs are assumed part of the development's standard costs with minimal impact due to precipitation harvesting.

The estimated cost of a single-family new home rainwater harvesting system without monitoring is $12,700, with storage resulting in 80% of the cost. Based on the evaluation of the residential rainwater harvesting products and equipment used in Phase 2 it is anticipated that the cost of an individual system can be reduced. Also depending on the results of Phase 2 the system may be scaled down to optimize actual rainwater captured, further reducing the cost of the individual system. Therefore, monitoring costs are expected to be approximately $10,000 per home in the Pilot Project stage. Not all homes in the Pilot Project will have monitoring equipment though they may be included in the regional information collected.

Residential System – $ 23,700
Annual Operations/Maintenance/Monitoring (10%) – $2,370

Commercial System – The opinion of probable cost for a 10-acre commercial site is approximately $451,500. A reduction of costs is possible by using modified storm water detention basin instead of an underground cistern if space is available on site. This estimate does not include landscaping or irrigation infrastructure, but does include a 250,000 gallon cistern, submersible pump and filter, 6-inch gravity flow pipe, backflow device, and monitoring equipment for each.

Commercial System – $ 451,500
Annual Operations/Maintenance/Monitoring (3%) – $13,545

Regional System – The opinion of probable cost for a 10-acre residential development with 45 lots is expected to cost approximately $332,000. The 10-acre site is for comparison purposes at this time and will be refined once development begins and an actual site is identified. The cost estimate includes the following:

- Enlarged detention pond storage and lining
- Non-potable distribution system
- Flow measuring devices, instrumentation, and data loggers to measure flow into and out of the storage facilities
- Non-potable pump station

Residential System – $ 332,000
Annual Operations/Maintenance/Monitoring (3%) – $10,000

TOTAL COST

Table 6-2 is a summary of the opinion of probable costs for the described components of the Pilot Project through the SWSP. A contingency of 25% was used due to the uncertain monitoring costs. The cost of water that will be required for augmentation varies widely and has not been included at this time. Water for use at the Sterling Ranch Development will be in the process of being acquired conjunctively within the Pilot Project timeframe and could be used for augmentation prior to being needed for delivery to future customers. Another difficult cost to estimate is the legal fees that could be required for obtaining a water right through Water Court and therefore was also not included. The cost estimates shown and the costs for water acquisition will be refined, updated, and reported in the annual reports as required by the Pilot Project Program.

Table 6-2 Sterling Ranch Summary of Pilot Project Costs

Pilot Project Through SWSP	Estimated Costs
Phase 1: Natural Conditions	$152,600
Phase 2: Experimental Precipitation Systems	$133,400
Phase 3: New Precipitation Harvesting Systems	$807,200
Total Operations/Maintenance/Monitoring (7yrs)*	$257,075
Subtotal	$1,350,275
Total Engineering and Legal (50%)	$675,138
Subtotal	$2,025,413
Contingency (25%)	$506,353
**Total ** **	**$2,531,766**

* O&M costs roughly estimated based on proposed Pilot Project schedule
** Cost does not include associated augmentation plan or decreed firm yield water supply
***Phase 3 assumes adequate feasibility identified as a result of research in Phases 1 & 2

DELIVERABLES AND REPORTS

Deliverables

Phase 1: Natural Conditions – Quantitative and qualitative information about the natural conditions of Sterling Ranch will be available online. Daily and monthly summaries of raw climate data and water budgets will also be available. The summaries could include local weather and precipitation patterns, as well as lysimeter, surface water, and ground water information.

Phase 2: Experimental Precipitation Harvest Designs – Monthly summaries of monitoring data collected at the existing experimental sites will also be available, and may be web-accessible. A summary water budget for each day can be compiled to show the total precipitation for the day, the amount of precipitation harvested to date, the irrigation demand, and the amount of that irrigation demand being met by precipitation. A monthly summary can also be produced for the commercial monitoring sites showing the total potential capture volume and capture efficiencies for each precipitation event. An annual summary of the data collected from the regional observation sites could be compiled in a report summarizing the modeling efforts, results, and conclusions to date.

Phase 3: New Precipitation Harvest Designs – Sterling Ranch proposes to provide web-accessible daily and monthly summaries of monitoring data collected at the new precipitation harvesting sites. The information necessary for the SWSP can then be summarized in daily and monthly water budgets. Monthly summaries at each site will also include a summary of the total precipitation each day, the total amount of precipitation harvested to date, capture efficiencies, and the necessary stream replacements to date.

Annual Reporting

Sterling Ranch will provide an annual report of the Pilot Project to the CWCB and to the SEO throughout the term of the Project, until a water court decree is obtained or a cessation plan is approved. Annual reports will be provided by July 1st of every year the Pilot Project is operating. In accordance with Section 37-60-115(6)(a), C.R.S. each component of the Pilot Project will be summarized and indicate how data and findings address the pilot program goals including but not limited to:

- A description of the variance from original project as conceptualized at the time of the Pilot Project program application. Include information on any data quality issues that may magnify if results are extrapolated to a larger scale project.
- Precipitation harvesting performance metrics, including:
    - Description of final collection system design with plans and specifications of all system components.
    - Operation and maintenance plans and any issues encountered.
    - Meter data of water flowing into the precipitation collection device and estimated capture efficiency.
- Pilot project implementation plan and estimated water conservation achieved through pairing precipitation harvesting with advanced outdoor water management, including:
    - A description of the applied method used to capture precipitation and any potable water supply with plans and specifications for all system components including any technology utilized (system programmers, ET controllers, etc.).

  - Landscaping plans including measured irrigated acres, plan descriptions, theoretical irrigation water requirement methods, results, and water budgets reflecting application efficiencies.
  - Metered water use from precipitation collection system. Water use will be categorized by use if application varies.
  - Metered water use from other potable water supplies if the precipitation collection is supplemented. Water use will be categorized by use if application varies.
  - Comparison of actual consumptive use by category of use to estimated water budgets. Estimate amount of water conserved as a result of the precipitation harvesting.
  - A landscape maintenance assessment of quality of the landscapes, maintenance issues encountered, and any necessary replacement of plantings. The results of the irrigation system audit and corresponding actions.
  - Cost to date including design, infrastructure, operations, and maintenance costs. Estimated costs to implement precipitation harvesting system per acre-foot of water saved; and comparison of original projected and actual costs from implementing the precipitation harvesting systems. The cost comparison will include institutional, legal, technical/design, infrastructure, and augmentation water supplies.
- A description of the climate and hydrologic data collected to characterize the preexisting, natural vegetation conditions including:
  - A description of the methodology and analysis results toward providing information about the technical ability to reasonably quantify the site-specific amount of precipitation that, under preexisting natural conditions, accrues to the natural stream system via surface and ground water return flows.
  - A description of the baseline set of data and sound, transferrable methodologies used for measuring local weather and precipitation patterns that account for variations in hydrology and precipitation event intensity, frequency, and duration.
  - Descriptions of the methodology and analysis results quantifying preexisting natural vegetation consumption; measuring precipitation return flow amounts; identifying surface versus ground water return flow splits; and identifying delayed ground water return flow timing to receiving streams.
  - Quantification of the amount of precipitation that must be augmented to prevent injury to decreed water rights.
  - Description of the location and methods used to collect climate data measurements, with a summary of data including, at a minimum, temperature and precipitation.

Final Report

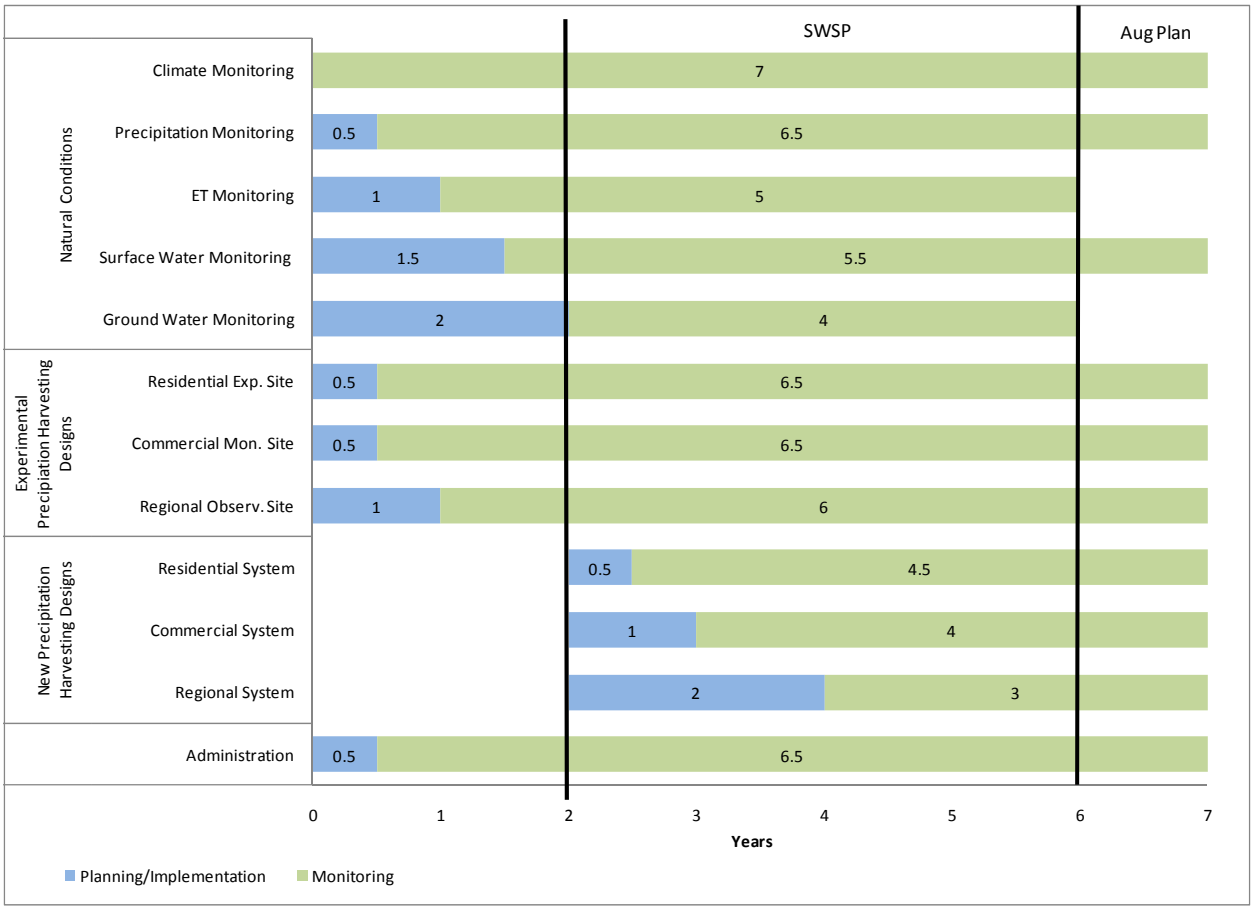
Sterling Ranch will submit a final report to the CWCB and State Engineer at the conclusion of the Pilot Project or by January 15, 2019. The final report will include a compilation of all annual reports and a summary of the project findings. Conclusions from the Pilot Project will include a summary of variations from the originally conceptualized Pilot Project at the time of the application.

PILOT PROJECT SCHEDULE

Although a minimum of two-years of monitoring is required to support a water court application for precipitation harvesting augmentation plan, the planning, implementation, and collection of sufficient data for the Pilot Project will be a process. It is anticipated that it will take longer than the minimum

two year period to provide sound, scalable, transferrable methodologies and information from the Pilot Project to support precipitation harvesting as a water supply. Figure 6-11 is a timeline of the schedule and includes an estimate for planning, implementation, and monitoring of all of the components of the Pilot Project. By the beginning of the first year, the climate and precipitation monitoring program will be implemented and monitoring will be taking place. Also, within the first year the residential experimental sites and commercial monitoring site will be collecting data. Although administration is unnecessary until the second year of the study, the experimental sites will be used to provide valuable insight and a template for accounting practices. An SWSP will be filed and approval obtained to account for the depletions that occur within any precipitation harvesting system prior to implementation on new construction as part of Phase 3. Once sufficient information to support an application for augmentation is collected, an augmentation plan will be filed in water court.

Figure 6-11 Pilot Project Schedule



APPENDIX A – CWCB CRITERIA AND GUIDELINES CHECKLIST

The Criteria Checklist provided below includes a brief discussion of each item in the January 4, 2010 Criteria and Guidelines, and references within the document where additional information about the criteria requirements and our ability to meet those requirements can be found.

1. Pilot Project Sponsor

a. The name and contact information of the pilot project sponsor.

STERLING RANCH

Sterling Ranch, LLC
200 Plaza Drive, Suite 160
Highlands Ranch, CO 80129
(303)202-6800

Harold Smethills – Principal
harolds@sterlingranchcolorado.com
Jack Hoagland – Principal
jackh@sterlingranchcolorado.com
Diane Smethills – Principal
dianes@sterlingranchcolorado.com
Jim Yates – CFO
jimy@sterlingranchcolorado.com

b. A description of how the pilot project sponsor qualifies as an applicant for a new development as defined in Section 29-20-103, C.R.S., for a new planned unit development or new subdivision of residential housing or mixed uses.

Sterling Ranch, LLC filed an application to rezone the property known as Sterling Ranch on February 12, 2009 with Douglas County. Comments were solicited and consolidated by Douglas County staff at the close of the comment period on June 22, 2009. The development plan for Sterling Ranch is authorized by Section 15 – Planned Development District of the Douglas County Zoning Resolution adopted pursuant to the Colorado Planned Unit Development Act of 1972, as amended.

A Water Appeal was filed on August 28, 2009 to appeal the water supply and demand standards set forth in Section 18A of the Douglas County Zoning Resolution. Douglas County staff is currently working with the County's water consultant to perform an initial completeness review. The appeal will be heard by the Planning Commission for a recommendation to the Board of County Commissioners (BCC), and by the BCC, which will include a public comment period. A date for the hearings has not currently been set.

As there is no official preliminary zoning approval in Douglas County, we would interpret the successful changing of the Douglas County Comprehensive Master Plan as representative of such preliminary approval. As such, we interpret Sterling Ranch as being eligible for sponsorship of a rainwater harvesting pilot project for this 2010 selection period. In addition, because Sterling Ranch is actively in the process of applying for zoning, we would interpret these actions to show intent from Sterling Ranch to secure final approval, and intent of Douglas County to continue working with Sterling Ranch in these endeavors.

c. A list of the organizations and/or individuals including those hired or otherwise retained by the entity that will assist in development and implementation of the pilot project and analysis of data, including a written statement of their role and contributions and any applicable professional licensing/certifications (e.g., licensed professional engineer, plumber, landscape irrigation designer, etc.). Applicant must demonstrate its commitment to carrying out the goals of the pilot project through demonstrating adequate staffing (paid or volunteered, in-house or outsourced, consultants, advisors, etc.) and a commitment to make the applicant's resources available to carry out the pilot project.

Sterling Ranch has contracted with several consultants for the planning and preliminary design of the Sterling Ranch development. These resources have been used for the zoning application, including the water plan and

water conservation plan, and for various discussion leading up to the Precipitation Harvesting Pilot Project application development. All aspects of the Sterling Ranch Pilot Project are represented by one or more members of the "Precipitation Harvesting" Team. Each team member will contribute to the Precipitation Harvesting Pilot Project in their area of expertise as it fits into the components of the Pilot Project as described in the application.

Leonard Rice Engineers, Inc. – Water Resources Engineers for Sterling Ranch, Project Manager for Rain Water Harvesting Study

R. Gregory Roush, P.E. – LRE President, Client Principal
Mary Kay Provaznik, P.E. – LRE Project Manager for Sterling Ranch
Val Flory, P.E. – Project Engineer for Rain Water Harvesting Study
Mark Mitisek, H.I.T. – Staff Engineer for Rain Water Harvesting Study
Wayne Eckas, P.E. – Project Engineer for Rain Water Harvesting Study

Braun & Yoshida Architects – Sterling Ranch Site Planner and Architect

Arlo Braun, A.I.A. – Sterling Ranch Architect

Wenk Associates, Inc. – Sterling Ranch Landscape Architects

Bill Wenk, L.A. – Sterling Ranch Landscape Architect
Natalie S. Faber – Sterling Ranch Landscape Architect

Kennedy/Jenks – Sterling Ranch Infrastructure Designers and Planners

Chris Douglass, P.E. – Kennedy/Jenks Project Manager for Sterling Ranch
Gordon C. Muerer – Kennedy/Jenks Vice President, Design Review

Carroll & Lange-Manhard – Stormwater and Drainage Infrastructure Planning and Design

Richard Weed, P.E. – Civil Engineer
Brian Hart – Civil Engineer

Headwaters – Water Resources and Precipitation Harvesting

Beorn Courtney, P.E. – Rainwater Harvesting and Water Conservation Planning and Design

Ryley Carlock & Applewhite – Legal Counsel for Precipitation Pilot Study

Carolyn Burr – Attorney

OneRain – Climate Monitoring and Precipitation Experts

James Logan – OneRain President and COO, OneRain Project Manager for Sterling Ranch
Ilse Gayl – OneRain Owner and CEO
Mike Zucosky – Field Technician for Sterling Ranch Climate Station

Earth Wrights Designs – Precipitation Harvesting Design Expert

Richard Jennings – Rainwater Harvesting Design Consultant

The TSR Group – Data Manager for Sterling Ranch

Matthew C. "Quint" Redmond – Chairman & CEO
Carmen Skeehan – TSR Director of Business Development and Operations, TSR Project Manager for Sterling Ranch
Eric Buehler – GIS and Database Management

2. Application Fees

An application fee of $4,000 and demonstration of ability to provide an annual review fee of $7,000 throughout the pilot project, per Section 37-60-115(6)(b)(I), C.R.S. H.B. 09-1129 limited the CWCB's ability to spend money to implement the Act. **As a result, only those applicants and the fees paid that fall within the Board's authorized spending authority shall be selected.** The CWCB indicated that the spending authority granted by H.B. 09-1129 would be a limiting factor in selecting and awarding projects. The Board will consider the need for the submission of a future budget Change Request if it determines such a request is needed. The annual review fee will be due one year after acceptance as a pilot project.

Sterling Ranch is committed to provide, and has already committed significant resources to the review, education, evaluation, and understanding of precipitation harvesting. As is shown in the pilot project schedule attached, the duration of the pilot project is expected to be approximately seven years. We are enclosing a check for the required application fee of $4,000. We also understand and are committed to the $7,000 annual review fee for the duration of the pilot project.

3. Description of New Development

A description of the proposed new development, per Section 37-60-115(6)(b)(II), C.R.S., including

a. Description of the current conditions of the project site and watershed.

Sterling Ranch is approximately 3,000 acres of contiguous land located on the Front Range of Colorado in northwest Douglas County. The site is a high desert rangeland consisting of two drainages that are tributary to the South Platte River and is south of Chatfield Reservoir. Less than 15%, or approximately 475 acres, have been previously developed or disturbed and the rest is rolling hills with some rocky outcroppings and mid-grass prairie. Several utility corridors, including a pipeline and transmission line corridors also transect the parcel. The Roxborough Filtration Plant is located on 10 acres of the site near the middle of the Sterling Ranch Parcel. Sterling Ranch also includes an occupied residence that is approximately 10 acres north of Titan Road.

Additional Information: Chapter 2 – The Sponsor Development, page 3 and Appendix D

b. Project location map, including identification of location within a Water Division as established in Section 37-92-201, C.R.S., watershed boundaries, location of rainwater catchment area and site where rainwater is applied to non-potable uses, location of climate data measurements, and other pertinent geographic and hydrologic information, per Section 37-60-115(6)(b)(III), C.R.S.

A location map for Sterling Ranch is located on page 5 in **Figure 2-1 – Project Location Map**. The watershed boundaries, data measurement sites and planned development where the rainwater will be applied can be seen on page 6 in Figure 2-2 – Sterling Ranch Planned and Figure 5.1 and page 37.

4. Rainwater Harvesting Collection System

A description of the proposed rainwater harvesting collection system, per Section 37-60-115(6)(b)(II), C.R.S., including:

a. Description of the collection system sizing, design, and maintenance plan.

Precipitation harvesting at Sterling Ranch will be accomplished based on the most feasible outcome found in the scalable components of the Pilot Project. An overall view of two different rainwater collection approaches for Sterling Ranch is discussed in Chapter 3. Regional and Targeted rainwater collection is described where rainwater would be collected through a traditional storm water drainage and storage system and distributed through a non-potable distribution system. A site-specific collection approach is also discussed that would direct rainwater collected from roofs, and possibly parking lots for commercial and school properties, to underground cisterns and pumped onto each site's landscape through the site irrigation system.

The collection system sizing and design for the new portions of the Pilot Project will build on information gained from monitoring the rainfall collection potential and experimenting with harvesting system components and manufacturers at the planned S.B. 09-80 sites. The final design for the precipitation harvesting systems for new sites in the Pilot Project will be based on this data and be representative of the most feasible system that can be

implemented at Sterling Ranch.

A description of the maintenance program will be specific to each harvesting design and will be provided as the Pilot Project progresses.

Additional Information: Chapter 3 - Precipitation Harvesting System Designs, page14 and Chapter 6 – Sterling Ranch Precipitation Harvesting Pilot Project, page 38

b. Estimated average volume of water to be captured each month, based on historical precipitation data.

The potential rainfall that could be collected by month for regional, targeted regional, or individual site collection systems is presented in the following table (Table 3.1 in the application) based on the average precipitation data from the Kassler Weather Station located approximately one mile from Sterling Ranch. A theoretical rainwater capture efficiency of 80% is used for this calculation for the individual site collection system, and 56% for a regional system. The regional capture system efficiency is lower because of anticipated conveyance and storage losses. These assumptions will be verified and refined through the Pilot Project.

Estimated Potential Rainfall Collection for the Sterling Ranch Development
(Based on 1950-2004 precipitation data from the Kassler Weather Station) Acre-Ft

Collection System	Summary - Rainfall Collection by Month												
	Annual	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Full Regional Collection System	990	33.9	40.4	93.4	123.6	159.6	103.2	92.9	89.6	78.1	71.2	64.1	38.5
Targeted Regional Collection System	630	21.7	25.9	59.8	79.1	102.2	66.1	59.5	57.4	50.0	45.6	41.1	24.6
Individual Collection System	420	14.4	17.1	39.5	52.3	67.6	43.7	39.3	37.9	33.1	30.1	27.1	16.3

Additional Information: Chapter 3, page 19; Appendix F.

c. Method for metering inflow and measuring capture efficiencies.

All inflows and outflows to the rainwater storage facilities will be measured independently to determine collected rainfall, delivery for irrigation and supplemental potable water required. Flows from rooftops may be collected and brought into one central pipeline before entering the storage cistern where the flow could be measured and recorded with a totalizing flow meter and data logger. Water levels in the different storage facilities will be monitored with a float or pressure transducer style recorder and water delivery to irrigation systems metered through the pump or a gravity outlet pipeline. All supplemental water required to meet irrigation demands will be metered, as well.

Capture efficiencies will be calculated by measuring and comparing the quantity of collected rainwater used for irrigation to the potential rainwater that could be collected based on precipitation data from the Sterling Ranch climate station or nearby rain gage and area of collection.

Additional Information: Chapter 6 – Sterling Ranch Precipitation Harvesting Pilot Project, all phases.

5. Ability to Meet Local Water Supply Requirements

A description of how the proposed development meets any applicable local government water supply requirement through sources other than precipitation harvesting, per Section 37-60-115(6)(b)(IV), C.R.S.

Applicants for land use approvals in Douglas County are required to provide Douglas County with proof of adequate water supply. The recently updated Water Supply Section 8 of the Douglas County 2030 County Master Plan reflects the County's recognition of the dire need for integrated water resource planning. To meet these needs, and to address the requested information by Douglas County, Sterling Ranch has provided Douglas County with the Sterling Ranch Water Plan, April 23, 2009.

Dominion's conjunctive water supply system is currently being developed for eventual approval in water court using the following concepts:

- South Platte River will be the primary water supply diverted with a junior water right as part of an augmentation plan.
- Augmentation sources, or replacement supplies, on average will consist of 60% tributary sources and 40% non-tributary sources.
- Non-tributary ground water imported from the Central Basin and/or Margin B in the Denver Basin Aquifer will serve as back-up in times of drought, or after limiting times of available surface supplies.
- Both tributary and non-tributary water supplies will be regulated in one or more reservoirs before delivery to demands.

Additional Information: Chapter 2, page 8

6. Renewable Water Supply Challenges for the Site

A description of renewable water supply challenges for the area, per Section 37-60-115(6)(b)(V)(A), C.R.S. Indicate how the proposed project addresses key water needs, for example, as identified in the Statewide Water Supply Initiative or as identified in the Basins Needs Assessments and offers opportunity to collect information from a variety of geographic and hydrologic areas throughout the state. Preference may be given to projects that address larger water supply needs or in the locations with critical water supply challenges.

SWSI has identified that by 2030 a 22% gap between estimated demands and planned and built water projects exists in the South Platte Basin and a 56% gap in the South Metro Sub-basin consisting of Douglas, Arapahoe and Elbert Counties. Douglas County, where Sterling Ranch is located, relies primarily on non-tributary, non-renewable ground water which is predicted to decline in production by 40 to 85% if no further wells are developed. Sterling Ranch has devised a conjunctive use water plan using non-tributary ground water for less than 30% of its supply versus 100% as has historically been done.

Sterling Ranch also proposes to reduce its outdoor water demand by 65 to 88% from traditional outdoor water use by pairing rainwater harvesting with progressive outdoor water demand management measures indentified in the Sterling Ranch Water Plan.

Additional Information: Chapter 2, page 7

7. Water Conservation Promoted and Implemented by Pilot Project

A description of the pilot project implementation plan and how the project will promote and implement water conservation, per Section 37-60-115(6)(b)(V)(B), C.R.S., including:

a. Description of how rainwater harvesting will be utilized on-site and paired with advanced outdoor water demand management techniques to promote water conservation, including:

i. Landscape and irrigation design approach and specific advanced outdoor water demand management practices to be utilized.

The Holistic Report (2007) investigated outdoor water demand management concepts paired with rainwater harvesting as a way to save water. Sterling Ranch was a partner in this effort with the intent to use the data in the Sterling Ranch Water Plan to be implemented as the development is built. The preliminary water conservation plan found in the Water Plan uses water conservation measures, including mandatory water saving landscape plans to meet a target outdoor water demand of 0.08 AF/yr/unit. The measures are as follows:

- Water-wise Home Certification
- Landscape and Irrigation System Regulations
- Individual Water Budgets with Inclining Block Rates
- Dual Metering
- Waste of Water Regulation
- Monitoring and Reporting

Landscape and irrigation design review and audits, soil analysis, appropriate plant selection and use of practical turf areas are some of ways the measures in the water conservation plan will be accomplished. Irrigation system efficiencies will be optimized through the use of properly designed and located sprinklers, micro-irrigation (drip irrigation), hand watering, and appropriate watering intervals. The water conservation plan also discusses ways to encourage and enforce the plan.

Precipitation harvesting systems will be paired with the outdoor water demand management methods to provide a portion of the outdoor water demand and will further reduce the demand for potable water. Outdoor water use will be metered separately and can be compared to tradition outdoor water use to determine water savings. Precipitation collected and applied to the landscape will also be measured and additional water savings can be determined

Additional Information: Chapter 4, page 27

ii. The implementation plan shall provide for metering of all on-site landscape water (harvested rainwater and any supplemental potable water supply) and address any potential cross-connection issues and backflow prevention if the rainwater harvesting system is connected to a backup potable water supply.

Part of the water conservation plan for Sterling Ranch already includes separate metering for outdoor water use. This will be done so homeowners can monitor and manage their own outdoor water use. The new buildings and/or region that will be implemented with precipitation harvesting systems as part of the Pilot Project will provide a connection to the potable water supply to ensure that the outdoor water demand is adequately met in times of low precipitation. All of these connections will be equipped with backflow devices that will prevent untreated rainwater from entering the potable water supply system.

Additional Information: Chapter 3, Figure 3-3, page 18 and Chapter 6, page 63

iii. Irrigation system technology to promote water conservation.

The Sterling Ranch District will require sub-surface drip or highly efficient and properly placed sprinkler head systems for turf. Drip or subsurface systems will also be required for all plantings and narrow turf areas (specific length and width requirements to be determined). This is part of the water conservation plan that will be formally adopted upon zoning approval.

Additional Information: Appendix E – Sterling Ranch Water Conservation Plan Summary

iv. Homeowner/community water conservation education approach.

A targeted water requirement per household has been identified at Sterling Ranch that is less than half of what has been required historically. Public participation will rely heavily on education, incentives, and tools that individuals can use to monitor their own water use. When someone chooses to purchase a home in Sterling Ranch, they will be exposed to water conservation education from the point of purchase and throughout their

residency in the development. It is conceived that an educated water conservation staff will be hired and trained to help in the process of reaching required landscape and irrigation design plan approval and will follow up with audits and monitoring of the homeowner's water use. The staff will be responsible for developing and updating the education program and can effectively do this through interaction and feedback from the Sterling Ranch homeowners.

An on-going responsibility of the Sterling Ranch water conservation staff will be to develop and enforce a public community education program and school education program.

Additional Information: Chapter 4, page 30, Chapter 6, Page 67, and Appendix E

b. Description of metrics that will be used to quantify water usage and an estimate of the projected water savings through rainwater harvesting paired with advanced outdoor water management techniques. These shall include but not be limited to:

i. Landscape plans and water budgets including square footage of irrigated and non-irrigated landscape for common areas and individual homes, description and quantification of landscape plantings, estimated average annual demand in gallons per sf based on historical evapotranspiration rates (water budgets). Landscape plans should reference the *GreenCO BMP Manual*[8] for best practice guidance.

An outdoor residential water use target of 0.08 AF/YR/unit has been established for Sterling Ranch and a water budget for a residential unit assuming 1,500 sf of irrigated area. Five sample landscape plans were evaluated for Sterling Ranch using various amounts of turf, moderate water use plants, and water-wise plants. Water demand for each landscape plan was calculated using the following equations.

$$\text{Plant Water Requirement (PWR)} = K_c \times ET_o \times \text{Area} \times 0.623$$

$$\text{Theoretical Irrigation Requirement } (IWR_t) = (PWR/IE) - P_{eff} * \text{Area} * 7.48$$

Where:
PWR = Plant Water Requirement; Total water demand (gal/yr)
K_c = Crop coefficient; Used to modify reference evapotranspiration to the water use of a particular plant or group of plants (unitless)
ET_o = Grass reference evapotranspiration (inches/yr)
Area = Plant irrigated area (sf)
0.623 = conversion factor to gallons
IWR_t = Theoretical irrigation water requirement. Total plant water demand that must be provided through irrigation (gal/yr)
P_{eff} = Percent of available precipitation for use by the plant (ft/yr)
IE = Irrigation/sprinkler type efficiency (percent)
7.48 = gallons/cubic foot conversion factor

Crop coefficients from the Denver Water Board landscape calculator were used and a reference ETo of 33.2 inches per year. To illustrate a dry year scenario, zero precipitation was considered. Irrigation efficiencies of 85% for sprinkler and 95% for drip, both surface and sub-surface were used. The results are shown in the following table. All but Plan 1 are landscape plans that will be considered at Sterling Ranch.

Estimates shown are preliminary based on currently available information. Actual landscape irrigation demands will be estimated ad refined during the Pilot Project

Water Use for Example Landscape Plans

Landscape Sample Plan	Blue Grass	Fescue Grass	Moderate Water Use Plants	Water-wise Plants	Small Vegetables	Irrigation Method	Annual Water Use (gal.)	Annual Water Use (AF)
Crop Coefficient	0.9	0.8	0.6	0.3	0.53			
Plan 1	100%					Sub-surface drip	26,127	0.08
Plan 2	33.3%		33.3%	33.3%		Sprinkler on turf; drip on plantings	20,727	0.06
Plan 3		50.0%		50.0%		drip	17,962	0.06
Plan 4		33.3%		67.6%		drip	15,235	0.05
Plan 5		33.3%			67.6%	drip	20,206	0.06

Additional Information: Chapter 4, page 30, and Appendix E

ii. Design plans of irrigation systems including, but not limited to, emitter types, controller type, rain sensor and meter type for measuring use of water from the rainwater harvesting collection system and any supplemental potable water supply. A system-wide irrigation audit should be performed within the first season of operation and action taken to address findings. Irrigation plans should reference the *GreenCO BMP Manual* for best practice guidance.

The irrigation system for the Pilot Project will be designed and built to demonstrate different irrigation installations, methods, and products as well as proper application of different irrigation controller technology. In general, the following guidelines will be used for the design, installation, and operation of the irrigation systems:

- Irrigation system designs shall reference the GreenCO BMP Manual Guidelines.
- Irrigation systems shall use water saving technology such as subsurface drip and point source drip irrigation where appropriate.
- Sprinkler irrigation components shall be selected for the highest possible uniformity and efficiency based on Center for Irrigation Technology (CIT) testing results.
- Irrigation controllers shall be EPA Water Sense approved controllers and smart controllers.
- Irrigation systems shall incorporate rain sensors, soil moisture sensors, and wind sensors as appropriate for system and site conditions.
- Irrigation system design shall be completed by a certified irrigation designer.
- Irrigation system installation shall be completed by a certified irrigation contractor.
- An audit of the constructed irrigation system shall be completed by a certified landscape irrigation auditor.
- A detailed irrigation schedule shall be completed for the system. Work shall include the determination of individual sprinklers or drip irrigation zone run times based on the appropriate plant material crop coefficient and precipitation rates and efficiencies determined by the irrigation audit.

Final irrigation system designs will be based on site specific development, with the above guidelines used in their development.

Additional Information: Chapter 4, page 32 and Appendix E

iii. Landscape management plan to include irrigation schedule, maintenance schedules, and other ongoing management aspects. Landscape management plans should reference the *GreenCO BMP Manual* for best practice guidance.

The water conservation plan for Sterling Ranch includes measures that will be part of the landscape management plan. An irrigation system design review and audit will be performed that will include an inspection of the system components to ensure proper operation, irrigation scheduling through the controller, and evaluation of the distribution and timing of water application. GreenCO's BMP Manual describes an irrigation audit in detail and provides a checklist and spreadsheets to streamline the process. Educating the homeowner on system controller programming will be part of the plan where it becomes relevant to the Pilot Project as well as the overall Sterling Ranch education program.

Individual water budgets and outdoor metering will provide the homeowner and the Sterling Ranch with tools to monitor the outdoor water use and may also be part of the Pilot Project where it becomes relevant. High usage will be immediately apparent and followed up with customer service to identify and fix any problem that may be related to the high water use. This could include physical problems like broken sprinkler heads or leaking drip lines, or it could involve education on watering schedules or planting selections.

A tiered water rate structure will be set in conjunction with the water budgets. This and a Waste of Water regulation will be part of the landscape management plan and used for the Pilot Project where it applies.

Additional Information: Chapter 4, page 32 and Appendix E

iv. Connection(s) between the rainwater harvesting collection system and irrigation system should be fully metered. At a minimum, sponsors shall consider automated meter reading/data loggers with immediate feedback to pilot project sponsors on impacts from water management decisions.

Precipitation collection will be measured either with a totalizing flow meter in the collection pipeline or a pressure transducer in the collection cistern at the existing S.B. 09-80 sites to determine collection efficiencies. The data will be recorded in a datalogger and downloaded and evaluated regularly. Precipitation harvesting systems on the new buildings or regions will be monitored in a similar manner using the best techniques and equipment found in the existing sites phase of the Pilot Project.

Additional Information: Chapter 4, page 33, and Phase 2 and 3 of the Pilot Project, Chapter 6, pages 54 & 61

v. Description of homeowner/community water conservation education campaign and training program (i.e., how will the pilot project sponsor support and assist homeowners, community members, and maintenance personnel to make the best water management decisions). These educational programs should be comprehensive to include indoor and outdoor water demand management, water supply, and water quality education.

Specific to the Precipitation Harvesting Pilot Project, the following items may be included for the education campaign, but in no way are final or limiting: 1) Website designated to data management and analysis, 2) Sterling Ranch website, 3) Landscape and Agriburbia garden tours, and 4) Water Conservation Plan monitoring tools, including billing software and irrigation system audits. These efforts are described further in Chapter 6.

Additional Information: Chapter 4, page 30 and Chapter 6, page 67

c. Estimated pilot project costs including:

i. Estimated infrastructure and ongoing operations and maintenance costs associated with implementing the system, and

ii. Estimated cost to implement project per acre-foot of water saved. Considerations should include: institutional, legal, technical/design, infrastructure, and augmentation water supply. Potential cost savings and benefits associated with the project should also be quantified: reduced water rights acquisition, reduced storm water system sizing, water quality benefits, etc.

The design of the Pilot Project phases are planned to take into consideration data collected and analyzed in the previous phases. Therefore, the estimated Pilot Project costs for infrastructure, ongoing operations, and maintenance associated with implementing the project are preliminary in nature. Costs will be refined as the project moves forward and reported in the annual status reports as part of the Pilot Project requirements. The Phase 1 costs are the most defined, while the Phase 2 costs are less defined since some of the sites for collecting data have not been selected yet, and the Phase 3 costs are very conceptual and based upon hypothetical developments. Operation and maintenance costs are assumed to be 10% of total costs for Phase 1 and 2. This estimate is higher than normal for typical operation and maintenance due monitoring instrumentation. The following table shows the estimated cost for each phase of the Pilot Project.

Sterling Ranch Summary of Pilot Project Costs

Pilot Project Through SWSP	Estimated Costs
Phase 1: Natural Conditions	$152,600
Phase 2: Experimental Precipitation Systems	$133,400
Phase 3: New Precipitation Harvesting Systems	$807,200
Total Operations and Maintenance (7yrs)*	$257,075
Subtotal	$1,350,275
Total Engineering and Legal (50%)	$675,138
Subtotal	$2,025,413
Contingency (25%)	$506,353
**Total ** **	**$2,531,766**

* O&M costs roughly estimated based on proposed Pilot Project schedule

** Cost does not include associated augmentation plan or decreed firm yield water supply

***Phase 3 assumes adequate feasibility identified as a result of research in Phases 1 & 2

Cost to implement the project per AF saved will be based on the following table from Chapter 3, as well as additional information that is gathered in Phases 1 and 2 of the Pilot Project.

Precipitation Collection Systems Opinion of Probable Cost Comparison

Precipitation Harvesting System	Potential Capture Avg Annual Yield, (AF/Year)	Potential Capture Planning Yield, (AF/Year)	Capital Cost (millions)	Engineering Costs	Legal Costs	Contingency	Total Costs (millions)	Total Costs for Planning Yield ($ per AF)
Full Regional Collection	**990**	**850**	**$31**	**15%**	**5%**	**15%**	**$42**	**$49,000**
Targeted Regional Collection	**560**	**480**	**$11**	**15%**	**5%**	**15%**	**$15**	**$30,000**
Individual Collection	**410**	**350**	**$45-$82**	**15%**	**5%**	**15%**	**$61-$111**	**$173,000-$309,000**

The above table assumes the following:

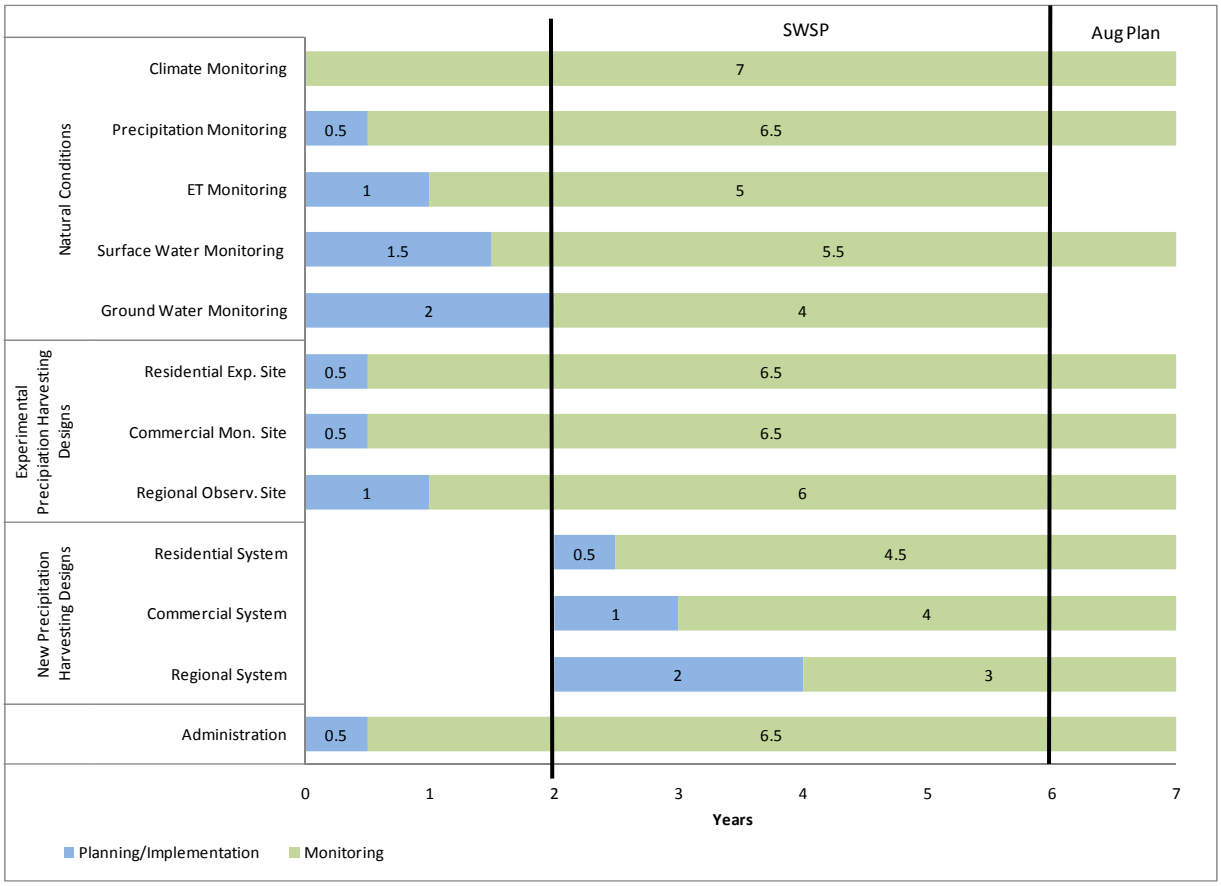
1. *Full Regional System includes non-potable distribution to all users, including all residential lots*
2. *Targeted Regional System includes non-potable distribution to targeted users – no distribution to residential lots*
3. *Information presented is preliminary for the purposes of relatively comparing the collection concepts only.*
4. *Potential Capture is based on average annual precipitation and capture efficiencies assumed to be 80%.*
5. *Potential Capture Planning Yield is 86% of average annual yield based on the total median monthly rainfall.*

Additional Information: Chapter 3, page 14 and Chapter 6, page 69

d. Pilot project implementation schedule for all major project components and data collection. The minimum two year data collection period begins once water collected through rainwater harvesting, under an approved SWSP, is applied to non-potable demands in combination with advanced outdoor demand management. A project sponsor must make a commitment to implement some level of data collection within the first year of receiving approval as a pilot project.

The schedule for implementation of the Sterling Ranch Pilot Project is shown in the following timeline and includes an estimate for planning, implementation, and monitoring of all of the components of the Pilot Project. This schedule is further broken down within Chapter 6 by the phases and components. By the beginning of the first year the climate station monitoring program will be implemented and monitoring will be taking place.

Pilot Project Schedule



Additional Information: Chapter 6, pages 53, 60, 66 and 74.

8. Pilot Project

A description of how the rainwater harvesting pilot project will meet the purposes of the rainwater harvesting pilot program per Section 37-60-115(6)(a), C.R.S. Data collection, reporting, and analysis methods may include but not be limited to:

a. Determining local weather and precipitation patterns that account for variations in hydrology and precipitation event intensity, frequency, and duration.

The natural conditions component of the pilot study will be used to determine local weather and precipitation

patterns that account for variations in hydrology. Specifically the climate, precipitation, and surface water monitoring programs will be used to answer quantitative and qualitative question about hydrology on the site including precipitation event intensity, frequency, and duration.

Additional Information: Chapter 6, Page 44 – Climate Monitoring Program, page 45 – Precipitation Monitoring Program, page 46 – Surface Water Monitoring.

b. Quantifying preexisting, natural vegetation consumption.

The Sterling Ranch Pilot Project proposes to quantify preexisting, natural vegetation consumption using data collected from the ET and climate monitoring programs. The ET monitoring program will use lysimeters to observe and quantify site-specific actual native ET and deep percolation on Sterling Ranch. Data from the climate monitoring program can then be used to empirically estimate reference ET. The observed actual native ET estimate can then be compared to the empirical reference ET estimate providing a basis to calibrate native crop coefficients specific to Sterling Ranch that can be used indefinitely.

Additional Information: Chapter 6, page 44 – Climate Monitoring Program, page 47 – ET Monitoring Program.

c. Measuring precipitation return flow amounts.

Sterling Ranch proposes to characterize the precipitation return flow amounts using observed data from the precipitation, surface, and ground water monitoring programs. During the study period of the pilot project the observed data can be used to compile a comprehensive water budget to account for and characterize precipitation return flow amounts. Methods such as Glover and the SCS Curve Number method will be used to simulate and further quantify precipitation return flow amounts.

Additional Information: Chapter 6, page 45 – Precipitation Monitoring Program, page 46 – Surface Water Monitoring, page 48 – Ground Water Monitoring Program.

d. Identifying surface water versus ground water return flow splits.

The surface water versus ground water return flows spit is dependent on the physical characteristics of the watershed, aquifer properties, and precipitation event intensity, frequency, and duration. Sterling Ranch proposes to characterize surface and ground water return flow splits using observed data from the precipitation, ET, surface water, and ground water monitoring programs and empirical methods such as Glover and the SCS Curve Number to simulate and quantify surface and ground water return flows.

Additional Information: Chapter 6, page 45 – Precipitation Monitoring Program, page 46 – Surface Water Monitoring, page 47 – ET Monitoring Program, page 48 – Ground Water Monitoring Program.

e. Identifying delayed ground water return flow timing to receiving streams.

Sterling Ranch proposes to use the Alluvial Water Accounting System model (CSU, 2009) to calculate delayed ground water return flow timing to receiving streams from precipitation. When supplemented with observed data from the ground water monitoring program, a site-specific understanding of the timing of accretions to receiving streams due to precipitation recharge can be identified.

Additional Information: Chapter 5, page 33

f. Quantifying the amount of precipitation that must be augmented to prevent injury to decreed water rights.

The natural conditions component of the pilot project should provide the necessary information to understand the site-specific amount of precipitation that must be augmented to prevent injury to decreed water rights. Once a baseline of the pre-existing natural vegetation consumption, physical water supply, and return flow requirements are quantified using observed data, water budgets, and models. Sterling Ranch can quantify the amount of precipitation that must be augmented to prevent injury to other vested water rights and decreed conditional rights.

Additional Information: Chapter 5, Page 35 and Chapter 6, page 42

9. SWSP

A summary of an SWSP application that demonstrates the applicant can meet the requirements of the *General Guidelines for Substitute Water Supply Plans Submitted to the State Engineer Pursuant to Section 37-92-308, C.R.S. (2003).* The summary shall contain, at a minimum, an explanation of how the applicant will engage resources necessary to determine: 1) the maximum amount of precipitation that will be captured during the year, 2) the timing with which that entire amount of precipitation would accrue to the stream system through overland flow and deep percolation, 3) the potential sources of replacement water that will be available to replace those depletions at the appropriate locations, and 4) how the plan will be operated. The CWCB will not consider a pilot project for selection if, in consultation with the State Engineer, it determines that the applicant does not have the resources to develop a viable SWSP for approval.

As mentioned, the Sterling Ranch Pilot Project will be implemented in phases to gain the appropriate information needed for final design of a precipitation harvesting system. The Pilot Project will operate under an approved SWSP when precipitation harvesting begins on the new design phase (estimated to begin in year 2 of the Pilot Project) for a minimum of two years as required in the Pilot Program criteria Initially Sterling Ranch proposes to estimate the annual Pilot Project stream depletions as 100% of the recorded maximum annual precipitation at a nearby climate station times the impervious area within the capture area. This will be the basis for the amount of replacement water that will need to be acquired for approval of the SWSP. Ground water return flows will be lagged using AWAS and surface returns will be quantified based on established rainfall runoff relationships.

Sources of replacement will include but are not limited to transmountain water, reusable effluent, developed water, non-tributary ground water, or other fully consumable water decreed for replacement purposes. Sterling Ranch plans to contract with non-tributary well owners or owners of local storage projects with augmentation water to make releases to the stream system to offset depletions.

Appropriate accounting forms summarizing capture amounts and replacements will be on a daily basis with monthly summaries submitted to the water commissioner. Information in the accounting form will include dates, calling rights, capture amounts, replacement source and amounts, transit losses associated with replacement amounts, and river balance account.

Additional Information: Chapter 5, page 33

APPENDIX B – SPONSOR AND TEAM INFORMATION

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APPENDIX C – PLANNING AREAS AND CHARACTER ZONES

As Table C-0-1 shows, the Sterling Ranch development is divided into six planning areas: 1) Open Preserve, 2) Countryside and Hillside District, 3) Villages District Town Center District 4) Special Area 1, School, and 5) Special Area 2, Business.

Each planning area is comprised of character zones which determine the land use, density, and the maximum number of dwellings for each planning area. There are six character zones:

C1: Multi-function Open Space – Includes parks, buffers, storm water detention, agricultural and native areas
C-2: Rural Zone – 20,000 low-density residential – square foot (sf) lot size
C-3: Neighborhood Edge Character Zone – medium low-density residential – 5,000 sf lot size
C-4: Neighborhood General Zone – Urban residential including attached and detached single-family homes with some mixed use – 1,400 sf lot size
C-5: Neighborhood Center Zone – higher density mixed-use, including attached and multi-family residential, retail and offices – 520 sf lot size
C-6: Urban Core Zone – high density mixed use – little to no irrigated area

Additionally, the development is organized into Clustered Development, Traditional Development, and Town Center Development. Figure C-0-1 shows the general distribution of the different types of building lots and development and the planned percent the character zones within each planning area.

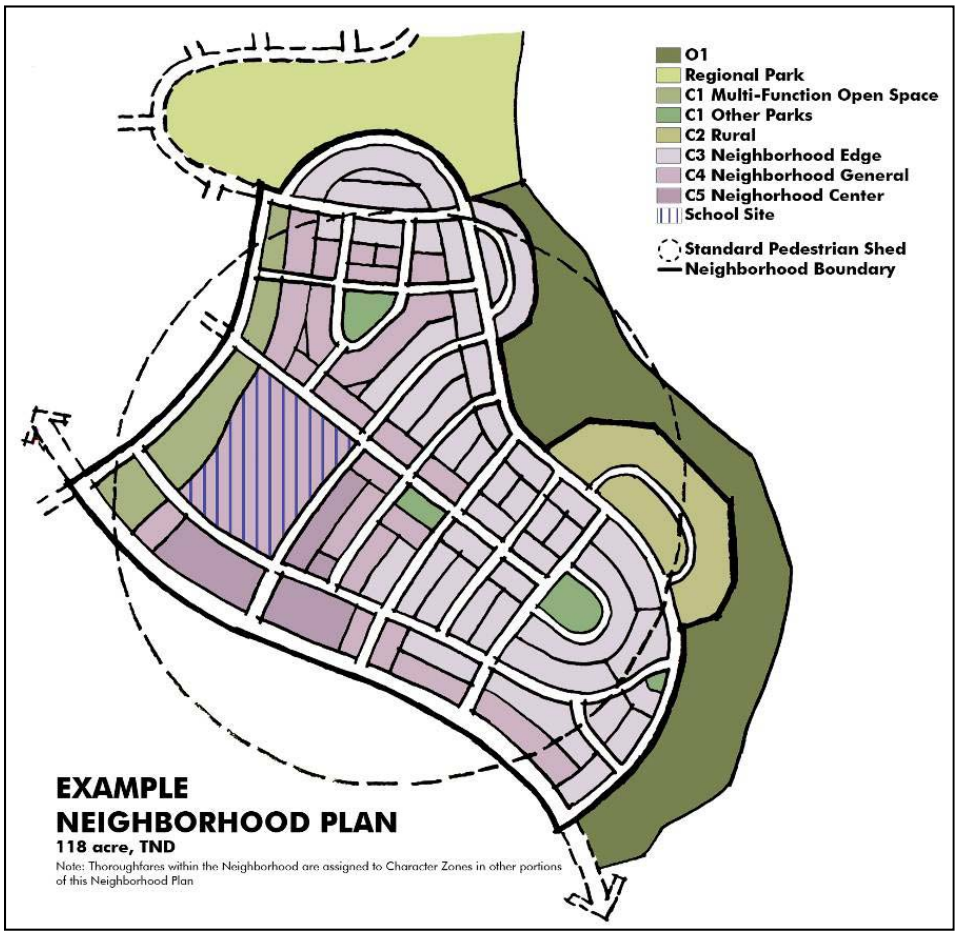
The majority of the development will be distinct villages or neighborhoods. A typical neighborhood plan will look like some variation of the following and will provide a variety of development character, lot sizes, and housing types. There is a wide range of dwelling options envisioned for Sterling Ranch, varying from apartments, condominiums, and town houses in the town center and mixed-use village centers, and narrow-lot cottages, medium-density, low-density single-family detached houses in traditional neighborhoods. Larger custom homes in the hillside areas and equestrian lots. Figure C-0-1 is an example neighborhood plan for Sterling Ranch showing a diverse mixed use community.

Table C-0-1 Sterling Ranch Development Summary

Planning Areas		Neighborhood Type	Character Zones	Percentage	Acres
O1	Open Preserve	-	C-1	-	406
D1	Country Side and Hill Side District	Clustered	C-2	50% Minimum	448
			C-3	20-40%	
			C-4	10-30%	
D2	Villages District	Clustered	C-2	50% Minimum	1,811
			C-3	20-40%	
			C-4	10-30%	
		Traditional	C-2	No-Minimum	
			C-3	20-40%	
			C-4	30-50%	
			C-5	10-30%	
D3	Town Center District	Traditional	C-2	No-Minimum	234
			C-3	20-40%	
			C-4	30-50%	
			C-5	10-30%	
		Town Center	C-4	10-30%	
			C-5	10-30%	
			C-6	40-80%	
SA1	School	-	-	-	72
SA2	Business District	-	-	-	14
-	Parks and Open Space	-	C-1	-	641

- The total site area is 2,985 acres; Parks and Open Space are integrated throughout the development and is not included in the sum of total site area.

Figure C-0-1 Example Neighborhood Plan



APPENDIX D – STERLING RANCH NATURAL CONDITIONS

A high desert rangeland situated at the base of the foothills, Sterling Ranch has been a working ranch for several decades and still is today. The ranch is much the same as it has historically been with rolling hills and rocky outcrop ridges. The site contains approximately 475 acres that have been previously developed or disturbed, which is less than 15% of the property. Several utility corridors, including a pipeline and transmission line corridors also transect the parcel. The Roxborough Filtration Plant is located on 10 acres near the middle of the Sterling Ranch Parcel. North of Titan Road there is an occupied residence that is approximately 10 acres.

This property is unique in that it is the largest **undeveloped parcel in Douglas County** and is truly **representative of the natural condition of the front range of Colorado**. The current native condition of the Sterling Ranch project site can be characterized by its topography, geology, soils, climate, hydrology, vegetation, and existing development.

Topography

Sterling Ranch sits in a valley with foothills to the west and higher ground to the east, rising gently from the east to west up to a ridgeline that runs through the length of the site. The site ranges in elevation from approximately 5,600 feet on the north to 6,000 feet on the south with slopes ranging from 2 to 25%. The major drainages on the site include Willow Creek, which cuts diagonally through the southwest portion of the site flowing to the South Platte River, and Sterling Gulch, which is located on the northeast portion of the site and flows northeast to Plum Creek.

Figure D-0-1 Sterling Ranch, Spring 2009

Geology

The Sterling Ranch is located along the western edge of the Denver Basin regional bedrock aquifer system at a point where the geologic formations comprising the aquifer are exposed at or near the ground surface. The rocky ridge outcrop that divides the property is evidence of this. The Denver Basin aquifer formations that underlie the property (from east to west) are the Denver formation, the Arapahoe formation, and the Laramie-Fox Hills formation. These formations dip steeply to the east in this area and are covered in portions by a thin veneer of soil, alluvium, and clay. The South Platte River to the northwest and Plum Creek to the northeast overlies a saturated alluvial aquifer. The thin layer of discontinuous saturated alluvium may exist in some drainage sub-basins within the Ranch.

Soils

Based on the Natural Resources Conservation Service (NRCS) soil survey of the area, Sterling Ranch is 40% Sandy Loam, 19% Loam, and 41% Clay Loam. Table D-0-1 summarizes the soil types within Sterling Ranch.

Table D-0-1 Sterling Ranch Soils

MUSYM	Soil Type	Texture	Acres	Percent
De	**Denver Clay Loam**	**Clay Loam**	**89**	**3%**
Fo	**Fondis Clay Loam**	**Clay Loam**	**1,021**	**33%**
Rm	**Renohill -Buick Complex**	**Clay Loam**	**172**	**6%**
Bw	**Buick-Santana Loams**	**Loam**	**158**	**5%**
Fu	**Fondis Clay Loam**	**Loam**	**200**	**6%**
Lo	**Loamy Alluvial Land**	**Loam**	**92**	**3%**
Sn	**Santana Loam**	**Loam**	**152**	**5%**
Bl	**Blakeland Sandy Loam**	**Sandy Loam**	**33**	**1%**
Br	**Bresser Sandy Loam**	**Sandy Loam**	**237**	**8%**
Ne	**Newlin Gravelly Sandy Loam**	**Sandy Loam**	**181**	**6%**
Ns	**Newlin Santana Loam**	**Sandy Loam**	**704**	**23%**
Tr	**Truckton Sandy Loam**	**Sandy Loam**	**74**	**2%**
Total			**3,112**	**100%**

Hydrology

Four major watersheds are contained within the Sterling Ranch site: Willow Creek, East Willow Creek, Sterling Gulch, and Chatfield Reservoir. Willow Creek and East Willow Creek watersheds are tributary to the South Platte River and Sterling Gulch is tributary to Plum Creek. Chatfield Reservoir is approximately 2 miles north of Sterling Ranch and is the confluence of both the South Platte and Plum Creek. Willow Creek and Sterling Gulch are intermittent streams with average flows less than 10 cfs.

The majority of the minor drainages on Sterling Ranch are ephemeral drainages with flow from stormflow events or prolonged wet periods. There is also several small surface water ponds used for stock throughout the site.

Climate

Located near the foothills on the front range of Colorado, Sterling Ranch has a wide range of climatic conditions throughout the year. The climatic conditions of Sterling Ranch are best characterized by the Kassler climate station maintained by NOAA.

Table D-0-2 summarizes the average temperature and precipitation based on the Kassler climate station.

Table D-0-2 Sterling Ranch Climate Summary

Season	Winter			Spring			Summer			Fall			Average
Month	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Annual
Mean Temperature (°F)	32.8	31.5	34.4	39.7	48.0	57.2	67.1	73.3	71.4	63.3	52.4	40.3	51.5
Mean Precipitation (in)	0.74	0.61	0.71	1.63	2.17	2.78	1.75	1.61	1.64	1.37	1.3	1.09	17.5
	4%	3%	4%	9%	12%	16%	10%	9%	9%	8%	7%	6%	
Mean Gross Evaporation (in)	1.25	1.25	1.45	2.28	3.74	4.98	6.02	6.23	5.61	4.15	2.91	1.66	41.52

The temperature at Sterling Ranch on average ranges from 73.3 (°F) during the summer months to 31.5 (°F) during winter months, with July historically being the warmest month and January the coldest month. The average growing season is 164 days beginning in late April and ending in late September. The average annual gross evaporation from a free water surface for Water District 8 is 41.52 inches with an average of 6.0 inches during the summer months (CDSS, 2006).

Like most other areas in Colorado, Sterling Ranch receives the majority of its precipitation in April and May usually in the form of snow. With an average annual precipitation of 17.5 inches; spring and summer convective storms provide 67% of precipitation for the area, with 12% of precipitation received during the winter months and 21% received during the fall months.

Vegetation

A Natural Resources Assessment was completed by ERO Resources Corporation for Sterling Ranch. The report summarizes the naturally occurring vegetation throughout the ranch. The site is predominantly mid-grass prairie with a variation of vegetation dependent on topography. ERO mapped 5 different vegetation communities within the Sterling Ranch boundary: mid-grass prairie, medium/high-density shrubland, low-density shrubland, wetland, and riparian areas. Mid-grass prairie is the most dominant vegetation community within the boundary and supports several different grassland species (i.e., blue grama grass, western wheatgrass, etc.) and flowers (i.e., Indian paintbrush and scarlet globemallow). Medium/high-density shrubland areas contain mostly mixed shrub and sub-shrub species, whereas typically the shrubby areas are found on east- or north-facing slopes within the study area. In low-density shrubland areas, there is a mix of mid-grass prairie and shrubby species. The dominant vegetation found in wetland areas are hydrophytic wetland vegetation such as Baltic rush and coyote willow. Riparian areas are found adjacent to creeks, streams, and other water bodies. The plant communities within riparian areas have various understory shrubs and usually support greater levels of plant diversity.

APPENDIX E – STERLING RANCH WATER CONSERVATION PLAN

Excerpted from
Sterling Ranch Water Plan, Headwaters Corporation, January 2009,
updated April 23, 2009.

Section 2: Water Conservation

The term *water conservation* refers to a beneficial reduction in water loss, waste, or use (Vickers, 2001) and the efficient use of water. Water conservation measures or activities are actions, behavioral changes, fixtures and appliances, technologies, and design or process modifications implemented to reduce water loss, waste, or use and to improve efficiency. Dominion[1] has been working independently and with the County on water conservation for many years. Both groups demonstrated leadership in this area as documented in the study entitled "Holistic Approach to Sustainable Water Management in Northwest Douglas County" (2007), which challenged all of Colorado to progress its attitude toward water conservation and sustainable water management. Sterling Ranch, LLC has further advanced the outdoor water conservation concepts from that study in developing a water conservation ethic for the Sterling Ranch community.

This section of the Sterling Ranch Water Plan focuses on the development of a Single-Family Residential (SFR) Water Use Target and associated water conservation activities that will be necessary to achieve the target. Throughout the Sterling Ranch Water Plan, the term *water use* reflects the amount of water delivered to a customer at the customer's connection to the water distribution system (e.g. water tap). This is to be distinguished from the term *water demand* as used in Section 3 of this document to represent the amount of water that enters the raw water distribution system which includes the water use, system losses, and a factor of safety. Sterling Ranch, LLC will incorporate water conservation throughout the development planning and implementation stages as follows:

1. Water Conservation and Water Resources Planning – Water conservation and water demand management planning shall be incorporated at the land use zoning stage to ensure that it can and will be integrated throughout Sterling Ranch.
2. SFR Water Use Target – A Water Use Target and a list of Water Conservation Program activities have been identified for single-family residential properties, the predominant water use sector for Sterling Ranch.
3. Water Conservation Program and Staff – The Sterling Ranch District, in cooperation with Dominion, will manage its water use targets for single-family residential and other sectors through a Water Conservation Program. All water conservation activities will be implemented through the program, which will have its own staff. The program will be integrated with other District departments to ensure staff receives water-conservation related training and that data necessary for monitoring and evaluating the Water Conservation Program are collected.

[1] For clarification, "Sterling Ranch, LLC" is used throughout this section to reference the developer of Sterling Ranch, whereas "Sterling Ranch District" is used to distinguish the retail district(s) that will be the water provider(s) under contract with Dominion and responsible for implementing the Water Conservation Program. This is a unique situation in that the developer, wholesale, and retail water providers will act essentially as one entity; an entity that is committed to creating a sustainable community. This situation allows Sterling Ranch, LLC to envision and commit to the SFR Water Use Target that it will ultimately be responsible for achieving and enforcing through its Water Conservation Program.

4. Water Conservation Plan – A comprehensive Water Conservation Plan will be implemented as addressed in Section 2.3 below. The Water Conservation Plan will provide enforceable water conservation regulations throughout and after build-out. Further, Dominion and the Sterling Ranch District will work with DCWRA in its water conservation education efforts.

Sterling Ranch is seizing the unique opportunity to be an exemplary community for sustainable water conservation planning and implementation. Sterling Ranch, LLC has gone above-and-beyond the typical approach to zoning by providing details about its SFR Water Use Target and by committing to water conservation measures that will be implemented through its Water Conservation Program and Water Conservation Plan, including monitoring, evaluation, and enforcement plans. Land use planning affords an opportunity to integrate water conservation throughout a community. By integrating water conservation into the land use planning, Sterling Ranch, LLC is proactively ensuring that its water conservation mission will not be compromised.

The Water Conservation component (Section 2) of the Sterling Ranch Water Plan was peer reviewed by several water conservation experts: Peter Mayer, Aquacraft, Inc.; Taryn Hutchins-Cabibi, Colorado Water Conservation Board; Paul Lander, Colorado WaterWise Council; Mellissa Elliott, Denver Water; Larry Keesen, Keesen Water Management; and Bart Miller, Western Resource Advocates. All of the peer reviewers were supportive of the water conservation approach for Sterling Ranch and were encouraged that a new development such as this is integrating water conservation planning from the onset. The peer reviewers recognized the Sterling Ranch SFR Water Use Target requires more efficiency from water use than has been seen in many urban areas and they applauded Sterling Ranch for setting such goals with full commitment and accountability to support it. Based on their experience, they indicated that the Water Conservation Program components outlined in this section should allow Sterling Ranch to achieve and maintain its SFR Water Use Target.

2.1 Overview

The Water Conservation section of the Sterling Ranch Water Plan provides an overview of how the SFR Water Use Target was developed based in part on achievements in water conservation and water demand management from other existing communities. It focuses on single-family residential water use, which is the majority of the water use associated with Sterling Ranch. However, the outdoor water use concepts are generally applicable to open space areas and parks. The conservation philosophy will apply to other water use sectors and water conservation goals will be established for other sectors (e.g. industrial, commercial, and institutional) through the Sterling Ranch Water Conservation Program.

Subsequent sections provide the following information:

- Section 2.2: Water Conservation and SFR Water Use Target
- Section 2.3: Key Water Conservation Program Components
- Section 2.4: Water Conservation Program Monitoring, Evaluation, and Enforcement

In addition to incorporating state of the art water conservation measures and programs, Dominion and the Sterling Ranch District will assist Colorado in testing how some of the Best Management Practice concepts being identified by local groups such as the Colorado WaterWise Council (currently under development), GreenCO and the Metro Mayor's Caucus

can be successfully implemented and measured in a new development. Designing data collection and assessment programs from the onset will allow the Sterling Ranch District to develop and share data that is typically very difficult to acquire. The Sterling Ranch water conservation approach directly addresses goals, objectives, and policies set by the County in its 2030 Comprehensive Master Plan.

2.2 Water Conservation and SFR Water Use Target

Located on approximately 3,000 acres in northwest Douglas County, Sterling Ranch will include first and last homes clustered in a development that preserves over 1,100 acres of open space. The irrigated area per single-family detached residence will average 1,500 square feet (sf). Through a progressive water conservation planning and implementation program, it is expected that the single-family residential water use will average 0.22 acre-feet per year per residence (ac-ft/yr/unit) or less. This section presents data from a variety of resources including water industry publications, numerous research studies, the Environmental Protection Agency (EPA), and water provider water use data to describe and support the development of the 0.22 ac-ft/yr/unit SFR Water Use Target for single-family residents.

Water resources planning and water conservation professionals recognize that deciphering water use data is a challenge (SWSI, 2004); it is typically reported as summary data, often averaged over periods of years. Without knowing all of the conditions behind each data set (e.g. average people per household, level of water conservation practiced, mix of new-build and older homes, etc.), which are often not documented, it is difficult to accurately characterize the situation being represented. For example, the Federal 1992 Energy Efficiency Law set maximum water use standards for toilets and showerheads therefore any data after 1994 (when the law came into effect) are likely to include some of the first generation lower water use fixtures).

The researchers have analyzed and presented the data from a variety of sources to illustrate that, even with varying assumptions, reported water use data support that the Sterling Ranch SFR Water Use Target is achievable through efficient technology and design without significant behavioral change on the part of residents. Homes and landscaping will be water efficient from the start and will not require residents to make modifications such as taking shorter showers, watering only on certain days, or removing existing turf to replace it with lower water use landscaping. However, as with other communities in Colorado, Dominion and the Sterling Ranch District may require residents to make such changes during times of drought.

2.2.1 Water Conservation Examples

The Sterling Ranch development will include water efficient technology and design in the initial construction 100% of the residences. Water conservation results from other communities are presented for comparison. Note that some residential data includes both single-family and multi-family residential units. There is no common reporting format for water demand/water use data with and without conservation; Headwaters Corporation has used professional judgment and communication with the water providers listed below to interpret and present data in a consistent format.

- Aurora's water use dropped by approximately 20% to 0.33 ac-ft/yr/unit (2005 through 2007 average) after growing their Water Conservation Program substantially as a result

of the 2002 drought. (source: per capita data provided by Kevin Reidy, Water Conservation Supervisor, Aurora Water)

- Brighton's 2002 through 2006 average annual use was 0.247 ac-ft/yr/unit. Brighton is an older community. Its Water Conservation Program has been driven in large part to help manage daily peak demands. An inclining tiered rate billing structure, irrigation restrictions, public education and toilet and washer rebates have played a large role in its Water Conservation Program. In addition many homeowners use hoses to water their lawns, which often results in lower outdoor water use. (source: per household data was developed by converting per capita data from Brighton's 2008 Water Conservation Plan using 2000 US Census data of 2.92 people per household)
- For Castle Rock, the 2000 through 2004 average was 0.37 ac-ft/yr/unit, including pre- and post-2002 drought years. Since 2004, Castle Rock has developed and begun implementing a comprehensive Water Conservation Master Plan. Recently, Castle Rock has seen a 20% decrease in total per capita use (total of all uses, not just residential) (Per capita data and 2.8 people per single family equivalent estimate was provided by Billy Owens, Program Analyst, Castle Rock. Per capita data was converted to per household data using this information.)
- Centennial Water & Sanitation District was able to bring residential use down from 0.415 ac-ft/yr/unit to 0.337 ac-ft/yr/unit through the implementation of a Water Conservation Program (the first in Colorado to include water budgets). (source: per capita data provided by John Klassen, Centennial Water & San District Water Conservation Coordinator, converted to per household data using the 2006 U.S. Census Bureau estimate of 2.92 people per household)
- 2006 and 2007 total single-family water use in Colorado Springs, which includes existing homes with older fixtures and appliances, was only 0.30 ac-ft/yr/unit. This demonstrates significant water conservation since year 2000 pre-conservation estimates of 0.37 ac-ft/yr/unit. (source: per household data provided by Scott A. Winter, Colorado Springs Utilities Conservation Specialist)
- Denver's use dropped from 0.549 ac-ft/yr/unit in the mid-90's to 0.385 ac-ft/yr/unit in 2005. This corresponds to an enhanced Water Conservation Program and the increased awareness that resulted from the 2002 drought. (source: Aquacraft, 2006)
- Roxborough relies on a two-day weekly watering schedule and incentives to homeowners and builders to encourage water conservation. Residential water use in 2007 was 0.34 ac-ft/yr/unit in Roxborough. (source: personal communication with Larry Moore, Roxborough Water & Sanitation District General Manager; data are estimates)

Few Colorado communities have made water conservation a priority from the design stage. However, there are communities that have instituted water conservation measures from the outset of project development, such as the Civano neighborhood located in Arizona. The developer of this community created detailed standards and monitoring requirements for efficient energy and water use specifically for the Civano community and signed a memorandum of understanding with the City of Tucson to this end. Pulte Homes has since purchased the development and they have agreed to adhere to original rules and regulations.

The average total annual per residence water use (potable and non-potable) for the two phases of the water and energy-efficient Civano community is provided in Table 2-1. The Civano community used significantly less water in 2006 (2007 data is not available at this time) than

other Tucson homes, 38% less for Civano I and 50% less for Civano II (Al Nichols Engineering, Inc., 2007). One difference between the two Civano phases is that Phase I landscape has more foliage and a larger landscaping water budget. However, with the establishment of Phase I vegetation, it is likely that landscaping water needs will decrease.

Table 2-1: Total 2006 Water Use (ac-ft/yr/unit) for Civano and Other Tucson Homes

Civano I	Civano II	Other Tucson homes
0.216	0.173	0.348

Source: Al Nichols Engineering, Inc., 2007.

Civano provides an example of how new development is progressing in other western states and provides a model for how progressive SFR Water Use Targets can be set, monitored, and enforced. The implementation strategy was similar to that proposed for Sterling Ranch in Section 2.4 below. Other communities are making similar efforts in other states.

2.2.2 Sterling Ranch SFR Water Use Target

Sterling Ranch firmly believes that water use can be kept to an average of 0.22 ac-ft/yr/unit or less. Sterling Ranch has identified the key conditions and constraints that will be required to sustain average water use of 0.22 ac-ft/yr/unit. This SFR Water Use Target includes both indoor and outdoor uses and has several safety factors incorporated. Savings will be achieved primarily through the installation of water efficient fixtures and appliances, limited irrigated landscape areas, waterwise plantings, and design and installation efficient irrigation systems for all residences. The supporting calculations rely on published water use data associated with using proven efficient technology and well planned and maintained landscaping to generate water use savings.

The total SFR Water Use Target of 0.22 ac-ft/yr/unit was developed by investigating indoor and outdoor uses independently based on reported water usage data from Section 2.1.1 above. It is important to anticipate the distribution between indoor and outdoor uses as the water supply plan is formulated around replacing the consumptive portions of these uses. Outdoor water use is the primary consumptive use in the residential setting. The majority of water used indoors is returned to the river after being treated at the wastewater treatment plant. Dual metering or another approach that allows comparable data collection (to measure indoor versus outdoor use) will allow the Sterling Ranch District to institute separate water rates for indoor and outdoor uses as well as water budgets that incentivize water conservation. This will also enable enforcement the SFR Water Use Target as needed.

2.2.2.1 Indoor Water Use

The indoor portion of the Sterling Ranch average annual SFR Water Use Target is 0.14 ac-ft/yr/unit; it was developed primarily from studies of water efficient homes. This is higher than the actual household water use measured for homes retrofitted with more water efficient fixtures and appliances in two studies referenced in Tables 2-2 and 2-3 (0.113 and 0.120 ac-ft/yr/unit) and higher than a theoretical water use calculation shown in Table 2-2 (0.134 ac-ft/yr/unit). The

0.14 ac-ft/yr/unit target was chosen by rounding up the results of this theoretical value, which provides a factor of safety as it is higher than actual water use data in the studies. To achieve 0.14 ac-ft/yr indoor water use per household, a Waterwise Home Certification program will be developed and implemented in 100% of homes. Section 2.3 provides information on similar existing programs. As set forth in Sections 2.3 and 2.4, Sterling Ranch, LLC will develop and enforce high efficiency model specifications for all toilets, washing machines, dishwashers, kitchen and bath faucets, and showerheads enforceable through covenants established by Sterling Ranch, LLC and regulations of the Sterling Ranch District, as needed to achieve the SFR Water Use Target.

Indoor water use can vary widely in existing residential neighborhoods as older, high flow fixtures and appliances use significantly more water than newer, more water-efficient alternatives. Fixtures and appliances are assigned flow ratings and water requirements are available from the manufacturer, but data for actual indoor use is sparse. It is difficult to measure household water use by fixture or even by indoor and outdoor total uses as few homes have separate meters for these uses. It is possible to "estimate" indoor and outdoor uses by assuming winter outdoor uses are nonexistent or minimal and then assuming all irrigation season use above this level is outdoor. When examining water conservation savings, many studies and water utilities simply present total annual *differences* in water use over time. Few studies have examined actual indoor water use and savings generated by retrofitting older fixtures and appliances with water efficient models. The studies that do exist are extremely valuable and widely referenced.

A study of three U.S. cities in the Journal of the American Water Works Association (DeOreo et al., 2001) found that by switching out older, higher water use fixtures, per-person indoor water use decreased by an average of 37%. The impact of retrofits is most obvious with toilets, which account for the largest percent (up to 30%) of total indoor residential use. The study found that average water use in toilets decreased by over 50% - from 16,000 gallons (0.049 ac-ft) pre-retrofit to 7,000 gallons (0.021 ac-ft) per year per residence.

It is important to note that indoor water savings can be achieved with little or no behavioral change on the part of residents. When surveyed, study participants have had a high level of satisfaction with retrofitted fixtures and appliances.

Table 2-2 presents the actual average water use for water-efficient fixtures and appliances, as measured in the retrofitted study homes in the study (DeOreo et al., 2001). Another more recent study (EPA, 2005) had similar results with an average of 0.120 ac-ft/yr indoor water use per household. Summary data from this study are shown in Table 2-3.

Table 2-2: Average Indoor Water Use (with efficient fixtures and appliances)

Fixture/Appliance	Retrofit Study Daily Use per Person[1] (gallons/day)	Annual Use per Household (ac-ft/yr/unit)	
		Retrofit Study	Sterling Ranch Estimate
		(average of 2.51 people/residence)[2]	(average of 3.0 people/residence)[3]
Bath	2.7	0.0076	0.0091
Clothes Washer	9.2	0.0259	0.0309
Dishwasher	1.2	0.0034	0.0040
Faucet	8.0	0.0225	0.0269
Shower	8.7	0.0245	0.0292
Toilet	7.9	0.0222	0.0265
Leak	2.2	0.0062	0.0074
Other/unknown	0.1	0.0003	0.0003
TOTAL INDOOR	39.9	0.1126	0.1343

[1] Source: DeOreo et al., 2001.
[2] Per household "Retrofit Study" calculations use average number of people (2.51) per study household.
[3] Per household "Sterling Ranch Estimate" calculations are provided by Headwaters Corporation as a conservative estimate assuming 3.0 people per home, which is higher than Denver Regional Council of Governments and Douglas County estimates (DRCOG, 2006 and Douglas County, 2007).

Table 2-3: EPA 2005 Combined Retrofit Study Results

Average Indoor Water Use per Household		
	(gallons/day/unit)	(ac-ft/yr/unit)
Pre-retrofit	175	0.196
Post-retrofit	107	0.120

Source: EPA, 2005.

2.2.2.2 Outdoor Water Use

The outdoor portion of the Sterling Ranch average annual SFR Water Use Target is 0.08 ac-ft/yr/unit; it was developed primarily from studies of water efficient landscape and theoretical irrigation requirement calculations. This equates to about 17.4 gallons per square foot per year (gal/sf/yr) of applied irrigation water (not including natural precipitation or rainwater harvesting) with 1,500 sf of irrigated landscape per single-family detached residence. This 0.08 ac-ft/yr/unit value includes a 33% safety factor (0.02 ac-ft/yr/unit) which was added onto the estimated actual irrigation needs of 0.06 ac-ft/yr/unit. Though Sterling Ranch and Dominion will have stringent landscaping and irrigation regulations, this safety factor has been added in recognizing the potential for variability among outdoor use resulting from soil and plant conditions and irrigation system maintenance and scheduling, among other factors. The 0.08 ac-ft/yr/unit target is significantly higher than measured outdoor water use from the Front Range YARDX Xeriscape study (0.046 ac-ft/yr) as well several theoretical landscape water use calculations. To achieve 0.08 ac-ft/yr outdoor use per household, Landscape and Irrigation System Regulations, as described below in Section 2.3, will be enforced by the Sterling Ranch District.

Residential outdoor water use occurs primarily during growing season months for irrigation purposes and can easily account for 50% or more of a single-family homes' total water use. Water use can vary greatly depending on climate, lot size, plant type, soil conditions, and irrigation system setup and maintenance, among other things. Metro Water Conservation, Inc. of Denver and the U.S. Bureau of Reclamation, in partnership with nine water utilities completed a study (YARDX, 2004) for the 1997 through 2002 period comparing outdoor water use for traditional (pre-existing) and waterwise landscaping along Colorado's Front Range. The study found that water efficient plots could consistently obtain water savings of 30%, and up to 50%, over more traditional landscaping. Table 2-4 shows median monthly outdoor use data from the YARDX study. Applying the average of 1.44 gallons per square foot per month (gal/sf/mo) for waterwise landscaping to the Sterling Ranch proposed average irrigated area per single-family detached residence of 1,500 sf results in 0.046 ac-ft/yr total outdoor water use. Assuming 2.20 gal/sf/mo (from Table 2-4), traditional landscaping would require 0.071 ac-ft/yr. While Sterling Ranch has developed a SFR Water Use Target which would cover traditional landscaping, through its Water Conservation Program and development approach, Sterling Ranch intends to achieve significantly lower water use than traditional landscape.

Table 2-4: Median Monthly (April-October) Outdoor Water Use

	Traditional Landscaping (gal/sf/mo)	Waterwise Landscaping (gal/sf/mo)
Colorado Springs New Start	2.10	1.73
Colorado Springs Retrofit	1.85	1.42
Denver Retrofit	1.77	1.28
Fort Collins New Start	2.44	1.56
Highlands Ranch New Start	2.46	0.85
Greeley Retrofit	2.86	1.31
Wheat Ridge & Arvada Pre-Existing Xeriscapes	1.91	1.90
AVERAGE Monthly	2.20	1.44

Source: YARDX, 2004. Yield and Reliability Demonstrated in Xeriscape, Final Report, Metro Water Conservation, Incorporated, figure 5-2.

The savings noted above were achieved by installing waterwise landscaping which was defined as including approximately 25% low water use plants, 25% more moderate water use plants and up to 50% traditional turf. The report notes that savings could likely have been increased with less turf area. The study also found that participants were extremely satisfied with the more waterwise landscaping and said they would recommend it to others.

Theoretical irrigation water requirements for sample landscape plans are typically prepared using landscape calculators which are based on evapotranspiration formulas, plant coefficients, and estimated irrigation efficiencies (Irrigation Association, 2005). The fundamental equations can be represented as:

$$\underline{\text{Plant Water Requirement (PWR)}} = K_c \times ET_o \times \text{Area} \times 0.623$$

$$\underline{\text{Theoretical Irrigation Requirement } (IWR_t)} = (PWR/IE) - P_{eff} * \text{Area} * 7.48$$

Where:

PWR = Plant Water Requirement. Total water demand (gal/yr)
K_c = Crop coefficient. Used to modify reference evapotranspiration to the water use of a particular plant or group of plants
ET_o = Grass reference evapotranspiration (inches/yr)
Area = Plant irrigated area (sf)
0.623 = conversion factor to gallons

IWR_t = Theoretical irrigation water requirement. Total plant water demand that must be provided through irrigation (gal/yr)
P_{eff} = Percent of available precipitation for use by the plant (ft/yr)
IE = Irrigation/sprinkler type efficiency (percent)
7.48 = gallons/cubic foot conversion factor

Based on discussions with landscape experts, the water supply from precipitation is often not considered when using theoretical landscape calculators; this is consistent with the landscape calculator available from the Denver Water Board (Denver Water, 2008). The Denver Water Board calculator and data provided by the TSR Group, (TSR, 2008) was used to develop the data in Table 2-5.

Table 2-5: Landscape Irrigation Water Requirements

Plant Type	Inputs			Irrigation Requirements		
	Crop Coefficient (K_c)	System	System Efficiency	ac-ft/ acre/yr	gal/ acre/yr	gal/ sf/yr
Blue grass	0.9	drip	0.95	2.61	849,448	19.5
Blue grass	0.9	rotor	0.85	2.91	949,383	21.8
Blue grass	0.9	spray	0.75	3.3	1,075,967	24.7
Fescue	0.8	drip	0.95	2.32	755,064	17.3
Fescue	0.8	rotor	0.85	2.59	843,896	19.4
Fescue	0.8	spray	0.75	2.94	956,415	22.0
Moderate Water Use	0.6	drip	0.95	1.74	566,298	13.0
Moderate Water Use	0.6	rotor	0.85	1.94	632,922	14.5
Moderate Water Use	0.6	spray	0.75	2.2	717,311	16.5
Native Plants	0.3	drip	0.95	0.87	283,149	6.5
Native Plants	0.3	rotor	0.85	0.97	316,461	7.3
Native Plants	0.3	spray	0.75	1.1	358,656	8.2
Small Vegetables		drip	0.95	1.54	500,940	11.5

Source: All data with the exception of “small vegetables” data is from Denver Water, 2008. Small vegetables data were provided by the TSR Group (TSR Group, 2008).

The data above was then used to develop five residential landscape plans. All of the landscape sample plans assume:

Area = 1,500 sf
P = 0.0 in/yr
ET_o = Denver reference ET of 33.2 in/yr

Landscape Sample Plan 1
The plan assumes all 1,500 sf are planted with fescue turf (K_c = 0.8) and sub-surface drip irrigation system (IE = 95%). The annual Theoretical Irrigation Requirement = 17.3 gal/sf/yr or 0.08 ac-ft/yr per residence. Under this plan, landscaping would require the full Sterling Ranch average outdoor water budget leaving no water available for other uses. While this does not account for water supply from precipitation, it verifies full turf lawns should not be permitted in Sterling Ranch as they may be inconsistent with the outdoor SFR Water Use Target.

Landscape Sample Plan 2
This plan assumes 33.3% of the 1,500 sf is planted with bluegrass turf (K_c = 0.9), 33.3% moderate water use plants (K_c = 0.6), and 33.3% with low water use plants (K_c = 0.3). Rotor heads (IE = 85%) are used for the bluegrass and drip irrigation (IE = 95%) for plantings. The annual Theoretical Irrigation Requirement = 13.8 gal/sf/yr or 0.063 ac-ft/yr per residence. Under this plan, which includes bluegrass, total irrigation needs are well within the Sterling Ranch outdoor SFR Water Use Target of 0.08 ac-ft/yr.

Landscape Sample Plan 3
This plan assumes 50% of the 1,500 sf is planted with fescue turf (K_c = 0.8) and 50% with low water use plants (K_c = 0.3). Sub-surface drip is used for turf areas and sub-surface or above ground drip for plantings (IE = 95%). The annual Theoretical Irrigation Requirement = 11.9 gal/sf/yr or 0.055 ac-ft/yr per residence. Under this plan total irrigation needs are well within the Sterling Ranch outdoor SFR Water Use Target.

Landscape Sample Plan 4
This plan assumes 33.3% of the 1,500 sf is planted with fescue turf (K_c = 0.8) and 66.7% with low water use plants (K_c = 0.3). Sub-surface drip is used for turf areas and sub-surface or above ground drip for plantings (IE = 95%). The annual Theoretical Irrigation Requirement = 10.1 gal/sf/yr or 0.047 ac-ft/yr per residence. Under this plan total irrigation needs are well within the outdoor SFR Water Use Target.

Landscape Sample Plan 5
This plan assumes 33.3% of the 1500 sq-ft is planted with fescue turf (K_c = 0.8) and 66.7% with edible crops through the Agriburbia™ Stewardship program. Sub-surface drip is used for turf areas and sub-surface or above ground drip for plantings (IE = 95%). The annual Theoretical Irrigation Requirement = 13.4 gal/sq-ft or .062 af/yr. Under this plan, total irrigation needs are within the outdoor portion of the SFR Water Use Target of 0.08 af/yr. Additionally, at least 35% of the home's dietary requirements (assume 3 people/home) may be met (TSR, 2008).

The landscaping plans above demonstrate that a variety of landscaping plan combinations could be developed within the Sterling Ranch outdoor SFR Water Use Target. An outdoor SFR Water Use Target of 0.06 ac-ft/yr/unit was selected based upon study data and the theoretical irrigation requirements of Landscape Sample Plans 2 and 3, which Sterling Ranch believes are

reasonable and would provide residents flexibility in their landscaping. As discussed above, a 33% safety factor was added, resulting in a total annual outdoor SFR Water Use Target of 0.08 ac-ft/yr/unit.

General outdoor water use data and concepts that are applicable to irrigated parks as well as park specific data are included in Appendix A.

2.2.3 Safety Margin for Sterling Ranch SFR Water Use Target

Several factors of safety were incorporated in the Sterling Ranch SFR Water Use Target of 0.22 ac-ft/yr/unit. It is anticipated that once built, the average per unit water use will be less than 0.22 ac-ft/yr/unit. These factors of safety include:

- Indoor water use calculations are based on an average of three people per household when the actual average number of people per household will likely be less. According to the Denver Regional Council of Governments (DRCOG, 2006), in 2030, Douglas County is estimated to have 2.74 people per household and Douglas County projections suggest it may be as low as 2.44 people per household (Douglas County Community Development, 2007).
- Sterling Ranch is planned as a first and last home community so an average home may include fewer people than the Douglas County average.
- Many of the studies used to evaluate indoor and outdoor use include data which are more than a decade old. Since that time, the efficiency of indoor water fixtures, irrigation systems, and irrigation control technology (e.g. smart controllers) has improved.
- Sterling Ranch homes will be more water efficient than those included in the studies presented above as 100% of homes will be equipped with highly efficient fixtures, appliances, sprinklers, etc.
- The land use plan dictates that irrigated areas at Sterling Ranch homes will be small (an average of 1,500 sf for single-family detached residences). Waterwise landscaping studies and sample landscaping plan calculations suggest that estimated irrigation needs of 0.06 ac-ft/yr/unit may in fact be high. In addition, a 33% safety factor was added to obtain the outdoor SFR Water Use Target of 0.08 ac-ft/yr/unit for a 1,500 sf landscape.
- Natural precipitation is not accounted for in the outdoor SFR Water Use Target, making this target realistic even during extremely dry periods (rainwater harvesting is *not* included either as it is not currently part of the Sterling Ranch water supply plan).

2.3 Water Conservation Program Components

The Water Conservation Plan for Sterling Ranch will be a stand-alone document implemented as part of the Sterling Ranch Planned Development. The initial version of the Water Conservation Plan will contain the water conservation components set forth in this Section 2.3 and Section 2.4 as needed to achieve the SFR Water Use Target identified in this document, and will be completed prior to the County's approval of the Sterling Ranch Planned Development. The purpose of this Section 2.3 and Section 2.4 is to set forth the basic components and direction of such Water Conservation Plan for single-family residential uses.

The Water Conservation Plan will be updated from time to time as new technology and concepts become available, and components of the Water Conservation Plan may be replaced with new or different components capturing such new technologies and concepts. Also, the Water Conservation Plan may be updated from time to time to provide different conservation measures for different developments within Sterling Ranch, but will contain measures as needed to achieve the SFR Water Use Target identified in this document. The specific conservation measures to be employed for each new development within Sterling Ranch will be established prior to final plat of such development.

Additional water conservation measures geared toward multi-family residential development and toward parks, irrigated open space, non-residential, and school customers will be evaluated and added to the Water Conservation Plan over time as needed to achieve the Water Use Targets identified in this document.

2.3.1 Waterwise Home Certification

Sterling Ranch, LLC will implement a waterwise home certification program for all single-family residences to minimize indoor (and outdoor) water use by requiring that all new homes have high efficiency fixtures and appliances installed prior to occupancy. Sterling Ranch, LLC is committed to developing and enforcing high efficiency model specifications for all toilets, washing machines, dishwashers, kitchen and bath faucets, and showerheads. These requirements will be set forth in the land sales contracts with builders. By installing water efficient fixtures and appliances when homes are built, the Sterling Ranch District will avoid the costs and difficulties associated with retrofitting, which existing communities must deal with. The Sterling Ranch District will also offer a Point of Sale audit that verifies water efficiency and recommend upgrades when homes are re-sold in the future.

Most existing certification programs are voluntary and tend to encourage and promote waterwise construction rather than require it. Sterling Ranch, LLC, by contract with the builders and by requirement in the Covenants, Conditions, and Restrictions (CC&Rs), will institute minimum water efficiency standards for 100% of the homes within Sterling Ranch. Examples of existing certification programs include: The Environmental Protection Agency's (EPA) WaterSense specifications (under development), Castle Rock's Water Wise New Home Criteria, and the Southern Nevada Water Authority's Water Smart Home specifications. A summary of the required indoor components of these programs is provided in Table 2-6. Typically they include specifications for the following indoor uses: fixtures, appliances, water pressure, hot water systems (plumbing and/or point of use), evaporative coolers, water softeners, and water treatment. According to the Southern Nevada Water Authority (SNWA, 2008) "A Water Smart Home may save as much as 75,000 gallons of water each year compared to homes built a decade ago." This statement refers to both indoor and outdoor water conservation measures. Sterling Ranch, LLC will utilize components of existing certification programs, but will develop its own program tailored to its SFR Water Use Target and specific development characteristics.

Table 2-6: Summary of Indoor Fixture and Appliance Specifications Included in Home Certification Programs

Fixture/Appliance	EPA WaterSense Home (Draft Specs)	Southern Nevada Water Smart Home	Castle Rock Water Wise Model Home
water pressure	✓	✓	
toilet	✓	✓	✓
kitchen and bath faucets	✓	✓	
shower heads	✓	✓	
washing machine	✓	✓	✓
dishwater	✓	✓	✓
evaporative cooler	✓	✓	
water softener	✓	✓	
water treatment	✓	✓	
hot water system	✓	✓	

Source: EPA 2008, Castle Rock 2006, SNWA 2007, and SNWA 2008.

2.3.2 Landscape and Irrigation System Regulations

Outdoor water use typically accounts for 50% or more of residential water use and is more consumptive than indoor use. The potential for significant outdoor water savings exists because of the reduced irrigated landscape area in Sterling Ranch (an average of only 1,500 sf of irrigated landscape per unit), waterwise landscape plantings and practice, and well designed and installed irrigation systems. Landscape and irrigation regulations have been adopted in many communities and are also included in home certification programs. Table 2-7 summarizes many of the requirements and regulations for several programs and Front Range communities. This list is not comprehensive but is intended to highlight key program components. The Colorado Department of Local Affairs (DOLA) developed a model landscape ordinance and a related best practices manual for Colorado communities to encourage water efficient planning, specifically focused on Front Range communities. Some of the elements of this ordinance are also listed in Table 2-7.The purpose of the model ordinance is “to protect and enhance the community's environmental, economic, recreational, and aesthetic resources by promoting efficient use of water in the community's public and private landscapes, reducing water waste, and establishing procedures for the design, installation and maintenance of water-efficient landscapes…” (DOLA, 2004).

Sterling Ranch, LLC will require builders to provide landscape plans for each model home/lot size and with 100% inspection of all new homes by the Sterling Ranch District. The Sterling Ranch District will require sub-surface drip or highly efficient and properly placed sprinkler head systems for turf. Drip or subsurface systems will also be required for all plantings and narrow turf areas (specific length and width requirements to be determined. Water budgets based on an average irrigated area of 1,500 square-feet for single-family detached residences will be developed. Landscape and irrigation system specifications will be developed, including components such as those listed in Table 2-7. Landscapers and irrigators will be required to submit **front and backyard** designs for approval. All landscaping and irrigation systems will be verified post installment. The majority of landscaping and irrigation systems will be installed by

Table 2-7: Summary of Outdoor Program and Regulatory Requirements for Single-Family Residential

	EPA WaterSense Home Draft Specs	Southern Nevada Water Smart Home	CO DOLA Model Landscape Ordinance	Castle Rock New Build Regs	Castle Rock Water Wise Model Home	City of Westminster New Build Regs	Denver Water New Build Regs
Landscape							
Water budgets	✓		✓	✓	✓	✓	
Turf restrictions	✓	✓		✓	✓	✓	
Water efficient design and hydrozoning		✓	✓	✓	✓	✓	
Irrigated area restrictions		✓				✓	✓
Ornamental water features restriction	✓	✓	✓		✓		✓
Soil amendment/mulch requirement	✓	✓	✓	✓	✓	✓	✓
Allowable plants list or info		✓		✓	✓	✓	
Irrigation System							
Runoff restrictions	✓	✓	✓	✓	✓	✓	✓
System efficiency requirements	✓		✓	✓	✓	✓	✓
Sprayer requirements/restrictions	✓	✓	✓	✓		✓	✓
Multiple zones			✓	✓	✓	✓	
Drip or subsurface or irrigation requirements	✓	✓	✓	✓	✓	✓	
ET or soil moisture smart controllers	✓			✓	✓	✓	
Rain gage requirement			✓	✓	✓	✓	✓
Controller capability specifications	✓	✓	✓	✓	✓	✓	
Scheduling specifications	✓	✓	✓	✓	✓	✓	✓
Maintenance requirement			✓	✓	✓	✓	✓
Professional Certification Requirements							
Certified Irrigation Designer	✓			✓		✓	
Certified Irrigation Contractor	✓						
Certified Landscape Auditor	✓		✓			✓	
Qualified Water Efficient Landscaper	✓						
Other certification/licensure				✓			

Sources: EPA 2008, SNWA 2007, SNWA 2008, Colorado Department of Local Affairs (DOLA) 2004, Town of Castle Rock 2006, Westminster 2004, Denver 2007

the builders and inspected by the Sterling Ranch District prior to home occupancy. If an inspection is not completed, the Sterling Ranch District will require the installing professional to sign an affidavit certifying plans were followed. These systems will be enforceable by the District through regulations and CC&Rs with any modifications to pre-approved landscape plans to be approved through an Architectural Control Committee (ACC). With pre-approval by the ACC, homeowners will be able to select and make modifications (within their outdoor water budgets and adhering to the regulations) to personalize their landscaping.

2.3.3 Individual Water Budgets with Inclining Block Rates

Conservation-oriented water rates can play an important role in managing water use. Studies have shown that low- and middle-income customers adjust their water use (particularly outdoors) directly as a result of well designed increasing rate structures. Individual water budgets are developed based upon the specific characteristics of individual properties. Water budgets in Sterling Ranch will be paired with inclining block rate (or tiered rate) billing structure where the cost of water increases with increasing use. Customers will be billed monthly, enabling them (and the Sterling Ranch District) to quickly identify excess use issues and work with customers to promptly take corrective action.

The rate at which blocks (or tiers) increase and by how much can motivate customers to monitor and decrease their water use. To encourage reasonable water use, tiers are designed to increase when customers exceed their water budgets or normal water use. Most Colorado water providers utilize tiered rate structures and several have incorporated water budgets, including: Aurora, Boulder, Castle Rock, and Centennial Water and Sanitation District, among others.

In a southwest regional study, Western Resource Advocates (WRA, 2004) noted that "Water rate structures play an essential role in communicating the value of water to water customers, thus promoting long-term efficient use." The study also found that "Increasing block rate structures most effectively communicate this message and encourage efficient water use when compared to other types of rate structures." The widely referenced *Handbook of Water Use and Water Conservation* (Vickers, 2001) states that "Increasing water rates can be a strong incentive for water users to reduce excessive outdoor use". Vickers notes that the Irvine Ranch Water District (California) reduced customer outdoor water use by almost 50% after implementing an increasing block rate structure (Vickers, 2001). In addition to residential accounts, water budgets can also be applied to industrial, commercial, institutional (ICI), parks, and other water users.

In Colorado, Centennial was the first utility to develop an inclining block rate structure tied to individual water budgets (implemented in 2003). Boulder and Castle Rock have followed suit. Typically, water budgets are implemented in communities where there is significant existing development. Sterling Ranch, LLC will be able to streamline this process by using builders' model home options and yard footprints to drive individual water budgets. Customers' water budgets will specify the breakdown between indoor and outdoor components. The Sterling Ranch District, in cooperation with Dominion, will undertake a water rates study to design a block rate structure and associated water budgets that balance demand management with revenue needs.

2.3.4 Dual Metering

Residential units typically have a single water meter that measures all uses at the property – indoor and outdoor. Water utilities using this system can only estimate the volumetric breakdown between indoor and outdoor water use. Unless comparable data can be obtained from another alternative, Sterling Ranch, LLC will require builders to install separate meters on indoor and outdoor residential water lines so that each residential property will have two meters – one that measures indoor use and one that measures outdoor (primarily irrigation) use. Dual meters will enable the Sterling Ranch District to monitor water usage by end use category. Customers' bills will show the actual measured indoor and outdoor use and will compare that consumption to the water budget established for the property. This is expected to encourage residents who exceed their budget allotment to adjust their usage accordingly. At the same time, the utility will know each month which customers are staying within their water budget and which customers are exceeding their budget allotment.

An additional advantage is that the dual metering allows the utility to curtail the outdoor water use of customers in violation of Waste of Water regulations without impacting indoor use or public health and safety standards.

2.3.5 Waste of Water Regulation

Many Colorado utilities have a Waste of Water regulation in place (Denver Water, Centennial, Castle Rock, and Aurora, for example). Frequently these include prohibitions on irrigation system runoff onto sidewalks and streets, watering between mid-day hours, watering on unauthorized days, and failing to repair leaks, among other items. A series of warnings and fines followed by temporary termination of service may be incorporated. The Sterling Ranch District will design and implement a stringent and comprehensive set of Waste of Water regulations to minimize the inefficient use of water and to serve as an enforcement mechanism when customers' water use habitually exceeds the water budget allotment. These regulations will include requirements for customers who regularly exceed their water budget allotment (for example, by more than 50% for two consecutive months or other appropriate metrics to be determined) to complete a water audit with technical assistance from the Sterling Ranch District (customer may be required to pay for the audit). The Sterling Ranch District will then provide a list of modifications to be made by the customer. If not completed within a certain time, a fee will be assessed. Refusal to comply will result in additional fees, followed by a final warning and eventual service shut off or the installation of a flow restrictor on the home. An appeal process for customers who feel that their water use is justified will also be built in, potentially resulting in an adjusted water budget for that customer.

2.3.6 Monitoring and Reporting

Monitoring and evaluation are important components of an effective Water Conservation Program. Data requirements should be established up front, specifying the mechanisms and staff required. In addition to assisting in the evaluation of individual water conservation activities, monitoring results help gage the success of and guide modifications to the overall Water Conservation Program. In the case of Sterling Ranch, examples of monitoring data likely to be collected include: new certified home data specifying fixtures and appliance quantities and approximate installation dates (to keep track of age of fixtures), landscaping and irrigation approval and installation data, customer water budget data, monthly customer water use data,

high water use customer contacts and results, irrigation and other audit data, as well as ICI technical assistance provided, numbers of children served by school programs, etc. for non-residential water use sectors.

A Community Water Budget (per Section 2.4 below) based on the amount of water dedicated by the developer will provide the most important level of monitoring. Individual customers may be under budget while others may choose to be slightly over (and incur the additional water rate costs related to exceeding their budgets); however the entire development should not exceed the SFR Water Use Target on average.

The water use billing database will serve as an important monitoring instrument. Utility databases are often limited in the functionality they can easily provide. Utilities frequently must contract database designers to help extract any data beyond standard needs. Existing utilities who have implemented Water Conservation Programs in recent years often find themselves needing to switch to more robust databases to satisfy their monitoring and customer education needs. This is a time consuming and costly process. For the same reasons, it is usually unrealistic for utilities to collect and enter additional customer data not initially designed for in account setup. Billing database capabilities are useful in quickly flagging problem accounts (e.g. high water use, improperly functioning meters, leaks) and other monitoring purposes, as well as educating customers and encouraging efficient water use. For example, software can be developed to automatically provide information such as the following in customers' monthly bills:

- graph of billing rate tiers;
- compare water use with an average of similar homes and yards;
- compare current use with historical data;
- compare indoor and outdoor budgets with actual metered use;
- compare higher tier charges with what charge could have been within the water budget;
- list most likely causes for water budget exceedence and provide a District contact for technical assistance;
- inform customers of potential leaks; and
- educational message blocks, among other items.

The Sterling Ranch District, in cooperation with Dominion, has the opportunity to develop a customer water billing database up front with the data fields and capabilities it needs for monitoring, education and enforcement of its Water Conservation Program. Database software will be evaluated for its capabilities, flexibility and ease of use for both billing and Water Conservation Program staff.

With each new phase of Sterling Ranch, the Sterling Ranch District will update its Water Conservation Program reporting to include activities initiated to date and actual water use data. Any program modifications made will be documented. A major challenge for water utilities and the water conservation community is the ability to determine water use and savings resulting from Water Conservation Programs. Saturation levels for specific water conservation activities vary and program success is frequently based on annual totals by customer types (residential for example) as data with greater resolution is not attainable. Data collected by the Sterling Ranch District should be very useful in assisting the County, the State and the water conservation community in testing the success of the wide spread implementation and some of

the best management practice concepts being identified by local groups such as the Colorado WaterWise Council and GreenCO. Sterling Ranch, LLC, Dominion, and the Sterling Ranch District will strive to serve as a model for how such programs can be successfully implemented and measured for new development.

In addition, data collected will be used to drive modifications to the Sterling Ranch Water Conservation Plan. Water conservation plans are mandated by the State in the Water Conservation Act of 2004 (HB04-1365) for all water providers who sell 2,000 acre-feet or more annually. They should be updated regularly in response to changes in technology, the regulatory environment, service areas characteristics, and monitoring results. The State requires utilities to update their water conservation plans every seven years. Due to the phased nature of the Sterling Ranch community, Dominion and the Sterling Ranch District will determine if modifications should be made to its Water Conservation Plan prior to construction of each new phase. Sterling Ranch, LLC anticipates a more aggressive schedule, likely making annual revisions to the Plan until the community is fully developed. After that time, the plan will be updated according to the State's requirements or as necessary to address changing or unexpected conditions. In addition, a report documenting plan progress and success, including water use data, will be developed on an annual basis at least until the entire community is established.

2.3.7 New Technology

As new technologies are developed and additional water conservation data obtained, Sterling Ranch, LLC may add new water conservation components to the Water Conservation Plan. With approval from the County, components of the Water Conservation Plan may be replaced with new components reflective of such technologies.

2.4 Water Conservation Monitoring, Evaluation, and Enforcement

Sterling Ranch water conservation implementation and enforcement will be a multi-tiered process. Sterling Ranch, LLC recognizes that successful implementation of a Water Conservation Program will require a significant and ongoing commitment of financial and human resources. For example, Aurora has 13 full-time dedicated water conservation staff and 4 to 6 temporary seasonal employees; Denver Water has 15 full-time staff and another 4 to 5 temporary seasonal employees. A dedicated water conservation staff will be hired for Sterling Ranch and appropriate staff from other departments will receive water conservation specific training. Water conservation staff will be responsible for the development and implementation of: irrigation regulations, landscape and irrigation plan review, residential certification program specifications, review of proposed development for certification program compliance, educational school programs, community public education programs, water budgets, water audits, technical assistance, data evaluation, enforcement of Waste of Water regulations, overall program coordination, and Water Conservation Plan modifications. The Sterling Ranch District and Dominion will collaborate with the DCWRA on water conservation efforts. Staff from other departments likely to be involved include: utility managers, database managers, billing staff, utility maintenance staff, and common area grounds maintenance crews, among others.

Because single-family residences will constitute the majority of water users in Sterling Ranch, the following presents mechanisms to enforce the SFR Water Use Target within this customer type. Additional enforcement mechanisms will be defined for other customer types in Sterling Ranch's landscape and plumbing code/regulations.

1. Waterwise home certification and landscape requirements.
    - Through Waterwise Home Certification program and landscape and irrigation system regulations, Sterling Ranch, LLC will develop indoor and outdoor specifications which will be provided to all builders, who will be responsible for landscaping. These requirements will be set forth in the land sales contracts with the builders.
    - Front and backyard landscape and irrigation plans must be prepared by builders and approved by the Sterling Ranch District. Builders will produce sample landscaping plan designs for each home model and lot size with water associated water use estimates; the Sterling Ranch District will set appropriate water budgets and associated rate structures.
    - At various stages during construction, prior to issuance of water taps and/or Certificates of Occupancy, the Sterling Ranch District will inspect 100% of homes in each development for adherence to irrigation system specifications. If an inspection is not completed by the Sterling Ranch District, the Builder will be required to sign an affidavit that outdoor specifications and approved irrigation system plans were followed for both front and back yards (including soil amendments). Homeowner modifications to the model landscape plans (within outdoor water budgets) must be approved by the ACC.

2. Upon occupancy, incentives provided by individual water budgets and inclining rate tiers will serve as a first-tier enforcement mechanism.
    - The Sterling Ranch District will design water budgets and rate tiers to allow for reasonable use within its SFR Water Use Target, taking residential certification and landscaping restrictions into consideration.
    - Rates will increase for customers using more than their allocated water budget. The Sterling Ranch District database, billing system, and indoor and outdoor meter data will be designed to facilitate water use monitoring and customer education. An example of the steps the Sterling Ranch District will take when water users exceed designated water budgets are:
        - System will automatically detect when a customer has exceeded budget and will move them up into the next billing rate tier.
        - Customers will be billed monthly. Their first bill for tier 2 water use (exceeding their water budget) will include a significantly higher charge and could also include:
            - a graph of the rate tiers and inform them that they exceeded their budget so have moved up
            - what their charge might have been if they had stayed within the upper limits of their budget
            - information on what similar homes with the same model house/yard used on average that month
            - indoor and outdoor budgets as compared to their indoor and outdoor metered use

        - the most likely causes for the increase in use (indoor/outdoor leaks, improperly adjusted sprinkler system, etc) and provide a Sterling Ranch District contact for technical assistance, and
        - information on the budget available for the next billing period.
    - The Sterling Ranch District will attempt to work closely with high water use customers to help them identify and fix the causes for their elevated water use.

3. Community Water Budget Exceedence
    - The (0.22 ac-ft/yr/unit) SFR Water Use Target is intended to serve as a community average with some residences having higher budgets and others lower. Each year, the Sterling Ranch District and Dominion will evaluate and review the Sterling Ranch historical and current year water use, among other relevant data and information.
    - If the community wide residential average exceeds the SFR Water Use Target, the first step will be to investigate the cause for the exceedence. Responses will vary depending on the cause. The following presents potential responses if a significant percentage of homes exceed their water budgets.
        - Indoor and outdoor meter readings will be evaluated to determine where excess water use is occurring.
        - The Sterling Ranch District will contact homeowners about the exceedence and if authorized by the homeowner, will confirm through audits that homes were certified and that efficient fixtures, appliance, landscaping and irrigation systems are installed.
        - Climate conditions will be evaluated, potentially resulting in the creation of additional/modified drought mitigation measures.
        - Irrigation controllers will be checked for proper setup and programming and irrigation systems checked for proper maintenance. Irrigation audits may be completed.
        - If it is determined that customers are using water reasonably, the District will develop more appropriate water budgets.
        - If it is determined that customers are wasting water, Waste of Water regulations will be invoked on a large scale as described above. Additional community education and public relations campaigns will be initiated. A community wide surcharge may be assessed and the excess fees dedicated to new water development.

4. The Sterling Ranch District will invoke Waste of Water regulations for persistent high water users (time period to be defined in the regulation) who are not influenced by rates and technical assistance.
    - If usage is greater than a certain range outside of water budget for a given period of time (to be determined) customers will be reminded of the Waste of Water regulations including the compliance schedule and penalties.
    - A process similar to the following (to be documented in the Waste of Water regulation) will be initiated if water use remains high:
        - Customer is informed of high use and required to contact the Sterling Ranch District to schedule water audit. After a given period of time, the Sterling Ranch District will initiate the contact.
        - The customer will be required to complete a water audit with technical assistance from the Sterling Ranch District (customer may be required to pay

for the audit). The Sterling Ranch District will then provide a list of modifications to the customer.
    - If water use does not decrease to within a certain range of the water budget for a given period of time (to be determined), a fee will be assessed.
    - Continued waste of water will result in a second fee and final warning.
    - Service could then be temporarily shut off or a flow restrictor installed on the residence. Prior to restarting service or removing the flow restrictor, proof of compliance must be provided and a fee assessed to reconnect.

5. Incorporation of New Technology
    - Water efficient technology is continually evolving. To incorporate improved technology, a voluntary Point of Sale audit and rebate program will be developed to encourage old and out of date fixtures and appliances be updated at the time of sale. If the previous customer regularly exceeded outdoor water budgets, a landscaping and irrigation system audit may be required.

APPENDIX F – HISTORIC PRECIPITATION

The NOAA Kassler climate station (4452) is located approximately one mile west of Sterling Ranch at an elevation of 5,586 feet. The station has been operating since 1918 recording daily precipitation data and has very little missing precipitation data. Historic precipitation is very important for determining the potential precipitation available for capture as a viable water supply. Table F1 is the precipitation summary for the NOAA Kassler Climate Station 1950-2004 including monthly average, minimum/maximum, and median.

Average

The average annual precipitation of the NOAA Kassler climate station 1950-2004 is 17.52 inches. The average represents the total volume recorded of all precipitation events regardless of frequency, intensity, or duration. Monthly average precipitation ranges from 0.57 inches in January to 2.85 inches in April.

Minimum/Maximum

Minimum and maximum precipitation is an indication of the variability of annual and seasonal hydrology of the area. Wet years such as 1969 (28.11 inches) represents the maximum historical precipitation available for capture and dry years such as 1956 (10.68 inches) represents the minimum historical precipitation available for capture. Monthly minimums and maximums also allow for planning and optimization of storage operations month to month.

Median

Monthly median precipitation provides a more conservative calculation of system sizing than average precipitation. The median precipitation is usually lower than the average value since large precipitation events tend to skew the average (TBWD, 2005). For planning purposes, median precipitation has been used to estimate water available for potential capture and for sizing storage and infrastructure. The sum of the Kassler monthly median precipitation is 15.34 inches; or approximately 15.00 inches, which is 86% of the average annual precipitation. This represents the planning yield used to estimate the cost per acre-foot of water saved, and the opinion of probable costs of each collection system.

Table F1 Monthly Precipitation Summary Kassler Climate Station (01/1950 - 12/2004)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1950	0.91	0.95	0.80	3.46	4.08	1.12	0.83	0.35	0.84	0.32	1.60	0.11	15.37
1951	0.84	1.25	1.82	1.43	2.10	1.81	2.49	1.90	0.69	1.66	1.02	0.14	17.15
1952	0.00	0.47	1.77	3.49	3.84	0.04	0.93	0.92	0.18	0.09	1.18	0.45	13.36
1953	0.47	1.16	1.51	1.86	2.92	1.16	2.08	0.94	0.10	0.35	0.51	1.51	14.57
1954	0.35	0.50	1.03	0.95	1.12	0.25	2.76	1.19	1.82	0.14	0.89	0.58	11.58
1955	0.22	1.02	1.25	1.27	6.27	1.45	2.48	3.35	0.89	0.46	0.36	0.18	19.20
1956	0.44	0.93	0.99	0.95	2.03	0.35	1.36	1.60	0.00	0.58	0.89	0.56	10.68
1957	0.40	0.58	0.96	4.10	5.46	2.28	1.47	0.89	0.93	2.22	1.14	0.16	20.59
1958	0.69	0.69	1.59	2.29	3.19	1.94	2.86	0.85	1.54	0.56	0.68	0.40	17.28
1959	1.35	1.01	2.81	1.89	3.10	1.39	0.60	0.93	2.66	2.93	0.71	0.56	19.94
1960	0.59	2.57	0.83	1.48	2.70	0.55	0.53	0.38	0.50	3.33	0.40	1.66	15.52
1961	0.27	1.15	2.01	1.23	3.41	1.46	2.66	1.73	5.15	0.84	1.41	0.26	21.58
1962	1.17	1.00	0.62	2.82	0.73	1.97	0.94	0.64	0.59	0.05	0.92	0.26	11.71
1963	0.72	0.36	1.24	0.04	0.97	2.71	0.51	2.39	1.59	0.66	0.74	0.97	12.90
1964	0.36	1.36	1.78	0.93	2.33	1.26	0.49	1.68	0.87	0.13	0.99	0.67	12.85
1965	0.85	1.18	2.00	2.30	1.27	4.05	3.94	2.61	2.95	0.42	0.43	0.64	22.64
1966	0.30	1.27	0.57	1.54	0.62	1.65	1.84	1.09	1.67	1.95	0.67	0.12	13.29
1967	0.72	0.65	0.58	3.70	4.22	4.06	2.45	1.32	1.56	1.91	1.25	1.41	23.83
1968	0.48	1.28	1.00	2.45	1.66	0.32	1.44	1.61	1.02	1.47	1.23	0.49	14.45
1969	0.31	0.36	1.47	0.64	9.64	3.51	1.76	1.64	0.25	6.49	1.04	1.00	28.11
1970	0.28	0.12	3.26	1.38	1.82	2.37	1.76	0.42	2.59	1.54	2.33	0.03	17.90
1971	0.39	1.45	0.90	4.56	2.76	0.79	1.07	0.82	3.31	0.67	0.43	0.38	17.53
1972	0.76	0.74	0.92	1.92	1.92	1.97	1.20	1.86	0.79	0.41	3.48	1.14	17.11
1973	1.44	0.13	2.23	4.23	7.96	0.39	1.57	0.10	3.12	1.31	0.63	2.00	25.11
1974	1.46	1.07	1.28	1.87	0.24	1.86	0.83	0.33	1.38	1.95	1.13	0.91	14.31
1975	0.42	0.61	0.82	1.70	3.38	2.46	0.82	1.87	1.09	0.73	2.31	0.15	16.36
1976	0.53	0.09	1.63	1.56	1.19	1.15	5.05	1.87	2.90	1.57	0.22	0.76	18.52
1977	0.15	0.51	0.71	2.66	0.58	1.68	4.31	1.75	0.07	0.60	0.88	0.38	14.28
1978	0.32	0.56	1.94	2.46	4.22	0.98	0.46	0.21	0.38	1.80	0.38	1.40	15.11
1979	0.84	0.39	3.27	1.91	4.45	2.72	0.66	2.75	0.63	1.39	1.79	1.20	22.00
1980	0.54	0.40	1.44	2.06	3.65	0.00	2.01	1.57	1.23	0.17	1.04	0.04	14.15

1981	0.02	0.59	2.25	0.72	3.55	0.84	1.81	1.13	0.58	1.51	0.49	0.85	14.34
1982	0.30	0.32	0.54	0.56	3.77	2.06	1.06	3.44	2.38	1.26	0.38	1.05	17.12
1983	0.19	0.17	5.64	2.30	3.60	3.82	2.21	1.48	0.22	0.08	3.24	0.87	23.82
1984	0.28	1.18	2.17	2.61	0.82	0.79	2.53	4.86	0.91	5.98	0.54	0.34	23.01
1985	0.52	0.87	1.06	2.70	1.56	1.54	2.37	0.62	2.87	0.44	1.98	0.72	17.25
1986	0.32	0.66	0.80	3.39	2.70	1.60	0.52	0.37	0.70	2.24	1.81	1.43	16.54
1987	1.65	1.80	1.39	1.52	4.85	2.51	0.90	2.29	0.31	1.99	2.43	2.14	23.78
1988	0.35	0.77	1.15	1.10	3.80	1.23	0.88	2.52	1.41	0.07	0.62	1.05	14.95
1989	0.75	0.47	0.74	1.49	2.92	2.92	1.50	1.10	2.19	1.24	0.05	0.97	16.34
1990	0.52	0.38	3.12	1.63	1.65	0.53	2.71	1.13	1.45	0.97	1.40	0.17	15.66
1991	0.77	0.10	0.37	1.58	3.76	2.86	2.74	1.81	0.71	0.99	3.37	0.00	19.06
1992	0.97	0.02	3.35	0.52	1.82	1.61	0.87	3.22	0.05	0.25	1.98	1.08	15.74
1993	0.34	0.77	1.20	2.71	2.20	2.13	0.56	1.01	2.68	2.77	1.44	0.36	18.17
1994	0.42	0.70	2.06	2.57	1.79	2.06	0.76	0.45	1.23	1.06	1.69	0.42	15.21
1995	0.39	0.61	1.99	4.73	5.50	2.70	0.72	1.40	2.69	0.50	0.87	0.16	22.26
1996	1.17	0.20	1.66	1.22	3.32	1.01	0.80	2.08	3.67	0.76	0.87	0.24	17.00
1997	0.37	1.30	0.69	3.77	0.74	2.21	1.59	3.35	2.82	3.27	1.53	1.16	22.80
1998	0.36	0.07	2.70	3.29	0.61	1.67	2.75	1.61	0.52	0.99	1.46	0.66	16.69
1999	0.35	0.32	0.44	6.10	2.79	1.15	1.54	3.88	0.90	0.77	0.48	1.48	20.20
2000	0.80	0.21	1.78	1.49	3.27	1.44	1.04	3.02	2.48	0.52	0.96	0.45	17.46
2001	0.38	0.74	0.64	1.46	3.88	1.21	0.99	2.21	1.66	0.23	1.12	0.64	15.16
2002	0.69	0.13	1.00	0.10	1.79	1.38	3.07	0.75	1.27	1.30	0.31	0.07	11.86
2003	0.18	1.16	7.52	1.38	1.06	1.94	0.41	1.20	0.44	0.36	0.44	0.67	16.76
2004	0.80	1.09	1.01	4.64	1.07	5.54	1.65	2.64	0.86	1.66	1.91	0.63	23.50
Minimum	0.00	0.02	0.37	0.04	0.24	0.00	0.41	0.10	0.00	0.05	0.05	0.00	10.68
Average	0.57	0.74	1.64	2.16	2.85	1.75	1.64	1.62	1.42	1.27	1.16	0.69	17.52
Maximum	1.65	2.57	7.52	6.10	9.64	5.54	5.05	4.86	5.15	6.49	3.48	2.14	28.11
Median	0.44	0.66	1.28	1.87	2.76	1.61	1.47	1.57	1.09	0.97	0.99	0.63	17.00
Planning Yield	0.44	0.66	1.28	1.87	2.76	1.61	1.47	1.57	1.09	0.97	0.99	0.63	15.34[1]

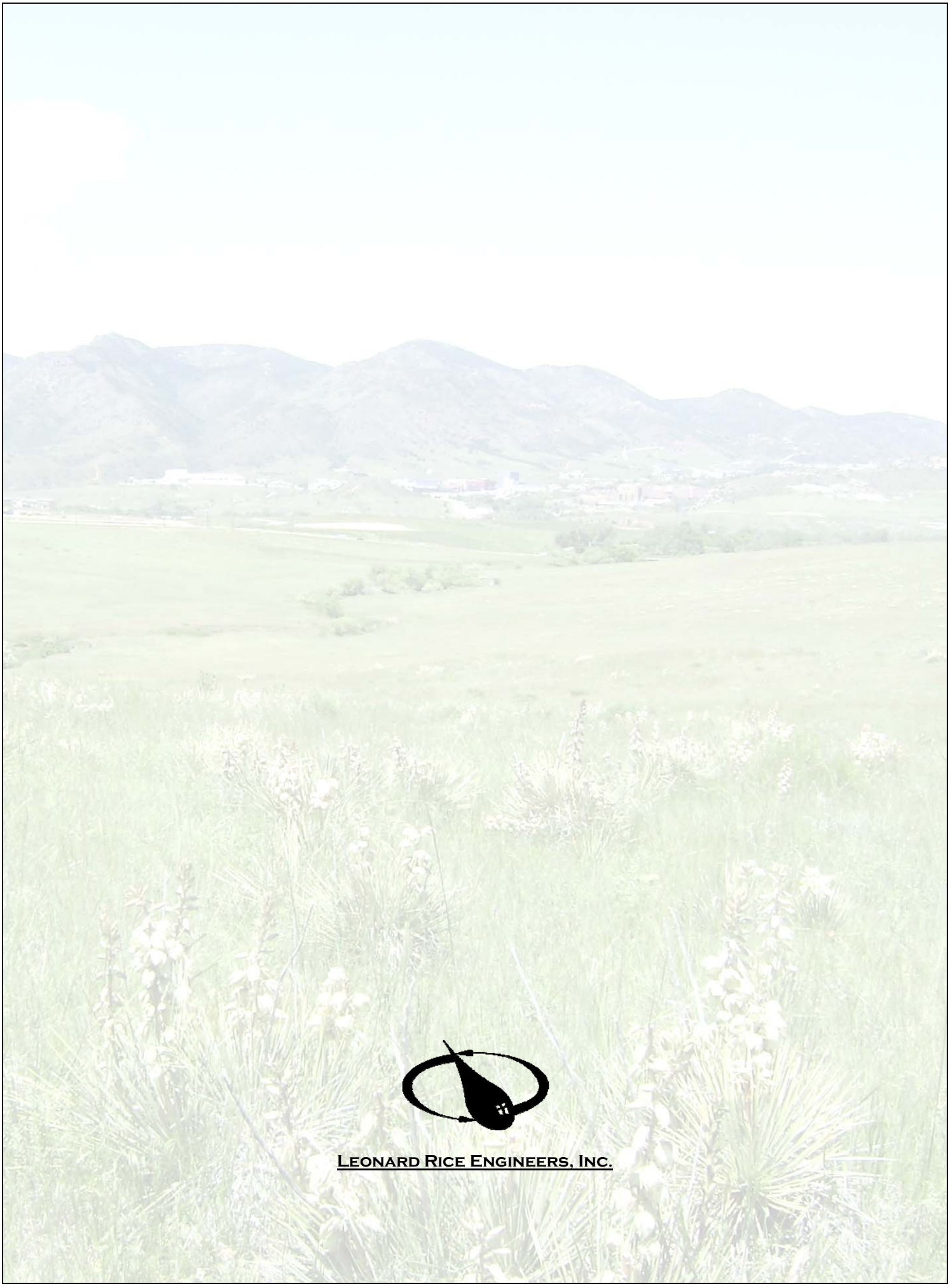
[1] - Annual total based on sum of median monthly values

Kassler Precipitation Characterization

Like most other areas in Colorado, the Sterling Ranch area receives the majority of its precipitation in April and May usually in the form of snow or high intensity rainfall events. During the growing season (April-September) spring and summer convective storms provide 64% of the annual precipitation. During the non-growing season 36% of annual precipitation is received primarily by snow events. The annual distribution of daily precipitation in Table F2 shows that over 88% of the daily events occur as small events (0.01 -0.50 inches).

Table F2 Characteristics of Daily Precipitation Events Kassler Climate Station

Precipitation Range	Percent of Days with Precipitation (1950-2004)		
(in)	Entire Period	Growing Season	Non-Growing Season
0.01 - 0.10	48.2%	48.3%	48.0%
0.11 - 0.50	40.1%	38.1%	44.2%
0.51 - 1.00	8.9%	9.9%	6.90%
1.01 - 1.50	1.8%	2.3%	0.6%
1.51 - 2.00	0.6%	0.9%	0.2%
2.01+	0.4%	0.5%	0.1%



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