A LOOK INTO WATER CONSERVATION: AN EVALUATION OF LANDSCAPE WATER REGULATIONS

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Abstract

Access to water has always been a critical and often times conflicted issue along Colorado's Front Range. With current and projected population growth in the state of Colorado it can be expected that the importance of the issue will only increase. In order to control future conflicts and costs, communities throughout Colorado have started to update and implement water conservation programs to address demand and delivery issues. A water demand category that has been commonly targeted by community water conservation programs is the designed urban landscape. This study explores the effectiveness of landscape water regulations in urban, landscaped open space as tools for water conservation.

The study examines the effectiveness of landscape regulations using three landscape regulations in the city of Colorado Springs. The three landscape regulations represent city and development landscape regulations and guidelines implemented before and after 1998. The effectiveness of the three regulations is measured from the results of four evaluations (regulation composition, landscape design, landscape installation and maintenance, and landscape water use) that represent the steps necessary for the development and maintenance of water efficient landscapes. The tool of measure in the four evaluations is the application and enforcement of the research based Xeriscape principles in the codes, policies, and guidelines found in the three landscape regulations.

The results indicated that regulation changes that occurred in the City Landscape Code and Policy Manual in the late 1990's effectively created water conserving landscape regulations. The post 1998 landscape regulations used a diverse combination of water-wise principles that were not only suggested by the codes, policies, and guidelines but also enforced through inspections and submittals. The diversity of water-wise principles in the regulations and the balance of citations and enforcement were the major elements that reduced water use and increased conservation in the evaluated landscape tracts.

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Operational Definitions

Community Guidelines - A course of action developed by communities that outline policies, procedures, standards, necessary to achieve a consistent and operational landscape.

Evapotranspiration (E.T.) – Evapotranspiration is the water loss occurring from the processes of evaporation and transpiration. Evaporation occurs when water changes to vapor on either soil or plant surfaces. Transpiration refers to the water lost through the leaves of plants. (USGS, 2008)

Hydrozoning – The design practice of grouping plants by similar water requirements to maximize potential efficiency of irrigation. (CSCP, 1998, p.5)

Landscape Code – A part of the Zoning Code, which is part of the City Code of Colorado Springs. (CSCP, 1998, p.6)

Landscape Policy Manual – A document that contains the policies, procedures, standards, maps, and plant lists necessary to implement landscape code. (CSCP, 1998, p.6)

Landscape Regulation – Controlling, adjusting, and organizing the landscape.

Low Water-Use Plants – Plants that require less than thirty percent (30%) of reference evapotranspiration to maintain optimum appearance. (CSCP, 1998, p.6)

Marginal Prices – Cost of the last unit purchased

Plant Community – A natural association of vegetation that is dominated by one or more prominent species, or characteristic physical attribute. (CSCP, 1998, p.6)

Practical Turf Areas – A landscape design and management concept promoting turf only in those areas of the landscape that are functional. (CSCP, 1998, p.6)

Soil Amendment - Organic and inorganic materials added to soil to improve texture, nutrients, moisture holding capacity, and infiltration rates. (CSCP, 1998, p.6)

Traditional Landscape – A landscape that is composed mostly of high water demanding turfs, such as Kentucky bluegrass. (Medina, 2004, p.GL-1)

Water-Wise – Utilization of water-efficient approaches that incorporates and expands upon the concepts and principles of Xeriscape. (Author, 2008)

Xeriscaping – A method of landscaping that promotes water conservation through seven basic principles. The seven principles are: (**1**) planning and design, (**2**) soil improvements, (**3**) efficient irrigation, (**4**) zoning of plants, (**5**) mulches, (**6**) turf alternatives, and (**7**) proper maintenance. (Medina, 2004, p.GL-2)

CHAPTER 1 - INTRODUCTION

Water is a natural resource that communities depend on for basic survival. Agricultural, domestic, industrial, and ecological processes within communities all rely on its quality and availability. Along the semi-arid eastern slope of Colorado access to this sustaining resource has become a focus and concern for all of the communities. A combination of population increases, less predictable water supplies, and the threat of drought is what has Front Range communities concerned and faced with important water management decisions. In an effort to accommodate new growth and to reduce the costly price tags associated with water acquisition and infrastructure expansion water managers and communities are turning to water conservation based programs and practices that target excessive water use. A common focus of water conservation programs seen along the Front Range is water conservation in the urban landscape.

A method for water conservation that has been gaining popularity in the last decade is the adoption of restrictive, prescriptive, and incentive based landscape regulations into city doctrine. These regulations have even reached beyond public law and have been incorporated into housing development regulations as a tool for saving money and as a new way of marketing to consumers that are beginning to favor sustainable development practices. The emerging landscape regulations range from general landscape conservation technologies to complex fee structures and monetary penalties. Some of the codes, policies, development covenants, and regulations that have been enacted require and enforce the use of water conserving landscape practices based on Xeriscape principles. Colorado Springs, Colorado is one of the communities to enact water conserving regulations of this type in the late 1990's with intentions of reducing landscape water demand while improving upon the natural setting of the city.

The intent of this study is to document the effectiveness of water regulations as a method for water conservation in development open space. Using a case study in Colorado Springs, Colorado an evaluation and comparison of three landscape regulations will be conducted. Evaluation of written regulations, built landscapes, current maintenance practices, and historical water use information will provide useful data that will be compiled into a list of recommendations and guidelines for future regulation development. The methodology that will

be developed for the study will also be a useful water management tool for landscape managers, developers, municipalities, and communities in the future.

Water Conservation

Water conservation, as defined by the Colorado Department of Natural Resources, is the practices, techniques, and technologies that improve the efficiency of water use (CWBC, 2008). The objective of water conservation is the long term increase in the productive use of a water supply without compromising current water demands. The U.S. Environmental Protection Agency provides additional insight into the definition and core principles of water conservation in terms of meeting the needs of future populations and addressing the needs of current concerns:

> *In order to meet the needs of existing and future populations and ensure that habitats and ecosystems are protected, the nation's water must be sustainable and renewable. Sound water resource management, which emphasizes careful, efficient use of water, is essential in order to achieve these objectives. Water efficiency is one way of addressing water quality and quantity goals. The efficient use of water can also prevent pollution by reducing wastewater flows, recycling industrial process water, reclaiming wastewater and using less energy.* (EPA, 1998, p.3)

As communities throughout the United States face water quantity and water quality issues the practice of water conservation becomes increasingly important. The importance of conservation programs is especially evident in the western United States where there is low annual rainfall and where water supplies are often stretched between large levels of agricultural production, domestic growth, industrial processes, and ecological uses (Zeilig, 2004). It is through water education, technology, and regulations that western states have begun to address these issues and have in some cases achieved impressive results in terms of resource, economic, and community benefits (Medina, 2004).

Why We Conserve

Many conservation programs outline the benefits of water conservation as not only the security that water conservation can provide into the future but also the opportunities for conservation practices to expand existing water supplies for other applications such as additional

population growth, economic growth and the stewardship of ecological process (CWCB, 2008). Other benefits of water conservation that have been identified by the Colorado Department of Natural Resources are:

- Avoid or reduce the need to develop or acquire new water supplies
- Postpone, downsize, or avoid altogether the need for new water treatment or wastewater treatment infrastructure
- Reduce operating costs related to water and wastewater treatment and source water production
- Improve supply reliability/margin and mitigation impacts of future droughts.
- Improve public credibility by demonstrating stewardship of natural and financial resources
- Promote sustainable use of finite water supplies

(List adapted from CWBC, 2008, http://cwcb.state.co.us/Conservation/Conservation/)

It would be ideal if all water consumers would adopt the principles of water conservation on their own and recognize why water conservation is important. In reality, it takes a well planned water conservation program and sometimes extreme drought conditions to effectively improve water use efficiency and water use habits within a community. With this in mind many cities throughout Colorado have recently implemented or updated water conservation programs to not only meet existing demands but also prepare for the future.

Scope of Problem

The intent of the study is to document the effectiveness of water conservation regulations in housing and commercial development common areas. The study will assess three separate and different landscape regulations in terms of landscape design, installation, and maintenance and will use the water conserving Xeriscape principles as the basis for evaluation. Through the qualitative analysis of the landscape regulations and their representative landscapes it is the intent of the study to document the strengths and weaknesses of selected regulations and guidelines in the town of Colorado Springs, Colorado. It is anticipated that the methodology applied to the evaluation of the case studies landscape tracts may be applied to other landscape

regulations and landscape tracts, not only within the town of Colorado Springs, but throughout Colorado.

Justification for Study

The Colorado Front Range's rapid population growth, concerns over prolonged drought, and urban landscapes accounting for more than fifty percent (50%) of domestic water use, have communities concerned and looking for answers to current and future water issues (Medina, 2004). It would be beneficial to the Front Range communities to have access to information pertaining to the effectiveness of past regulations and conservation programs in order to craft effective solutions for the future. Although there has been extensive research on the water requirements for specific plant material and the effectiveness of specific landscape practices, such as Xeriscape, little has been documented about the effectiveness of regulations as water conserving tools in development open spaces.

A landscape architect has the necessary background to participate in the evaluation of landscape regulations and practices, and provide useful feedback to communities and the general public. The background of the profession is often diverse in nature and well equipped with design, horticultural, and engineering knowledge to address many of the landscape water issues that are facing the Front Range of Colorado in a creative and ecological way. This diverse knowledge base and the ability to critically evaluate also makes landscape architects key role players in the implementation of water conservation programs through involvement in regulation formation, landscape design, landscape construction, and landscape maintenance. As landscape architects practice along the Front Range it becomes their responsibility as stewards of the landscape to not only craft conservation oriented regulations but to also ensure that these regulations help create efficient landscapes that are both aesthetic and functional.

CHAPTER 2 - BACKGROUND

The literature on water demand and water conservation has expanded significantly in the past decade and has provided considerable insight into some of the water issues our nation is facing. Given the focus of this study, the background section will seek to describe water as a resource in Colorado, further define water conservation, explain current water conservation programs and regulations, describe current landscape practices, and describe the case study location and rationale behind its selection.

Water Demands

Water is a resource that is necessary for the development and maintenance of Colorado's Front Range communities, agricultural practices, economies and ecosystems. Through history great measures have been taken to ensure that the communities and farms located along the Front Range have maintained sufficient water supplies. Some of these measures have included the construction of trans-mountain delivery systems that bring water supplies across the continental divide (USBR, 2008). These existing systems have been sufficient to date for the delivery and storage of water but questions have started to arise in regards to the system's ability to meet future demands. In a report written for the department of the interior, Colorado's Front Range was classified as an area where existing water supplies will not be adequate to meet water demands for people, farms, and for the environment by the year 2025. An illustration of where stressed hydrologic conditions, weather patterns, endangered species locations, and population growth trends converge and create areas where resource conflict is likely, can be seen in (Figure 2-1).

Water conflicts and shortages have been a reality in Colorado for a long time but the situation, because of current growth patterns, has reached a level where action is necessary in order for communities, agricultural practices, and the environment to maintain and coexist (USDI, 2005). The city of Colorado Springs, similar to the majority of communities along Colorado's Front Range, is located within a "hot spot" area that has been classified as having potential for future conflicts.

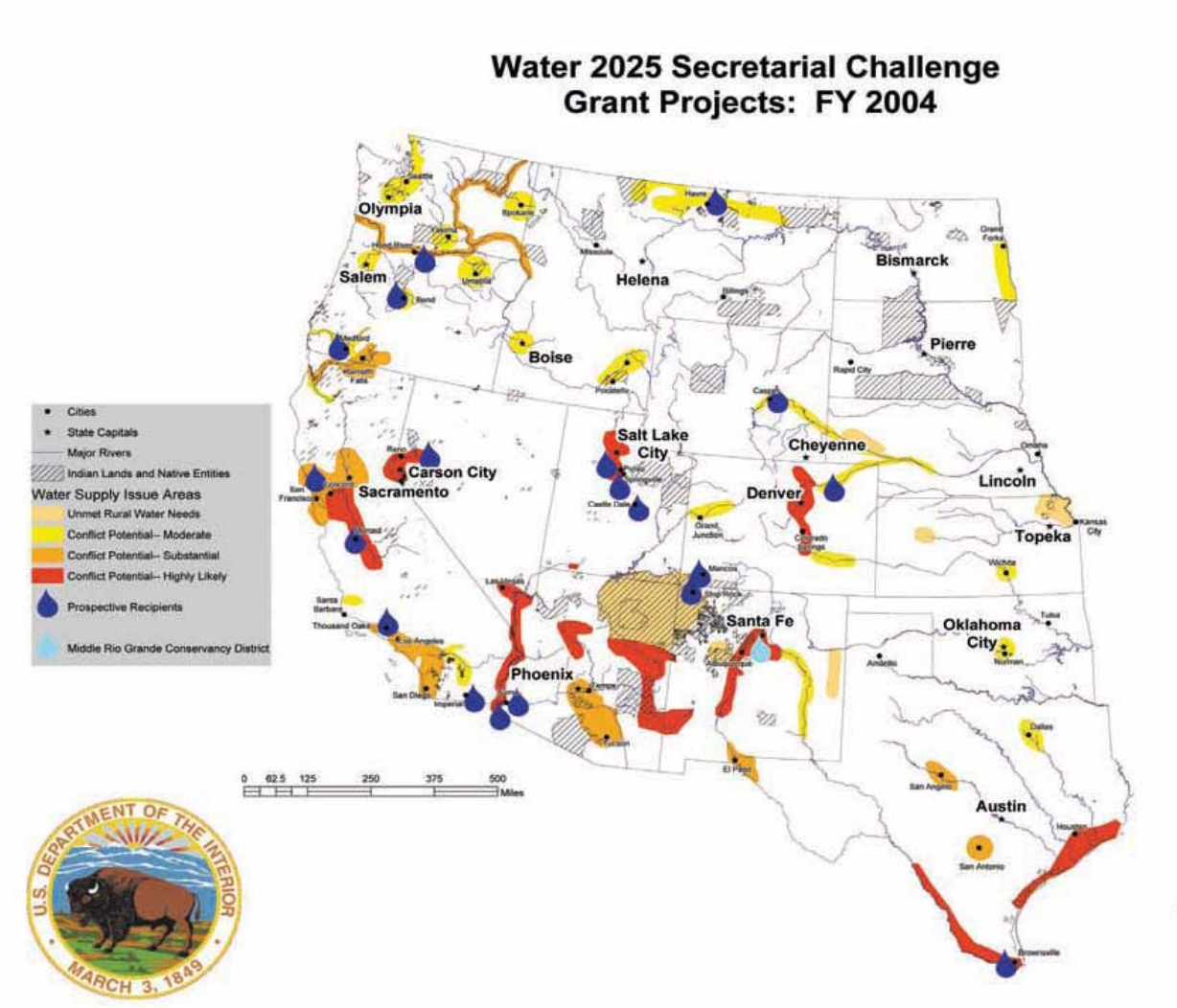

Figure 2-1 Water conflicts in the Western United States (U.S. Department of the Interior, 2004)

The multiple water demands placed on Colorado's water resources that currently compete for water and that have been cited as the source of future conflicts are: agriculture, municipal, recreational, augmentation and replacement, and commercial. Figure 2-2 illustrates the four categories of water demand and how water was distributed in 2002 using information provided by the Colorado State Engineering Office. The figure exemplifies the high amount of water use in agricultural production along the Front Range with eighty-six percent (86%) of all water deliveries being distributed to agriculture use. The figure also indicates that the second largest consumer of delivered water is municipalities at seven percent (7%). What is not represented by the figure is the rapid growth that the municipal water sector is experiencing due to the urban

population growth in the area. Demand growth in the municipal water sector is a trend that is expected to continue as the urban population in the state of Colorado expands from 4,338,789 to 7,798,107 in the next 25 years (Zeilig, 2004). Although water deliveries to businesses, industries and institutions only use two percent (2%) of Colorado's available water resources, they use a substantial portion of municipal water supplies in larger cities like Denver and Colorado Springs (Zeilig, 2004).

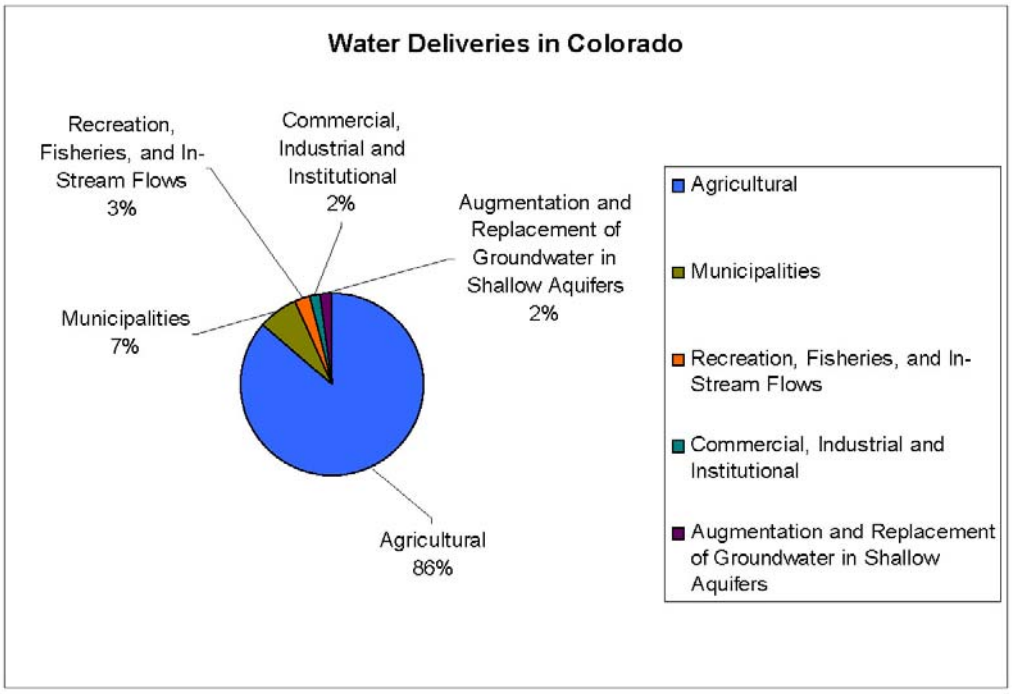

Figure 2-2 Water deliveries in Colorado (Zeilig, 2004)

Water Conservation

Water conservation is a management strategy that communities are implementing in order to cope with growing water demands. Water conservation practices concentrate on increasing the productive use of a water supply in order to satisfy water supply needs without compromising desired water services (CWCB, 2008). Although water conservation practices don't stand alone as the only solution to future water supply demands, they do play an important role in many of the water management strategies that are being implemented along the Front Range. Water conservation practices not only have the ability to improve the efficiency of water use and reduce demand, they also allow water providers the opportunity to avoid or delay the

economic and political costs associated with infrastructure expansion and water acquisition (Nichols, 2001).

As communities look towards water conservation they often see the potential for saving water in the designed landscape that has traditionally utilized high water demanding turfgrass and plants. Research has shown that with the use of water conserving principles in the landscape, a water savings of up to fifty percent (50%) can be achieved (Medina, 2004). The opportunity to conserve water in the urban landscape was realized and has been publicized and marketed widely throughout the Front Range since the early 1980's. The term Xeriscape was coined by Denver Water in 1981 and has been a major piece of Colorado's conservation ethic since its inception (CSU, 2008). Xeriscaping is based on seven principles which require the implementation of water-wise design, use of plant material, and maintenance practices. Although water use on the urban landscape is only a small percentage of the water allocated in Colorado, the potential for water conservation and efficiency improvements in the urban landscape is great (Zeilig, 2004).

Water Conservation Programs

Water conservation programs are often separated into two distinct categories, price and non-price programs. Price programs are based on financial incentives or penalties where non-price programs, emphasizing education in the private and public sector and technical assistance, are designed to inform users and change attitudes and behaviors (Zeilig, 2004). Past research shows that the most successful water conservation programs combine the two methods, implementing incentive based rate structures along side educational and regulatory incentives (Michelson, 2000).

Price Programs

Price programs typically come in the form of one or combination of three pricing structures: (**1**) a uniform price structure; (**2**) increasing block rate structure (a block being a pricing tier that specifies a price for a given range of water use); or (**3**) decreasing block rate structure. Under a uniform price structure users pay a uniform price for all levels of consumption. Increasing block structures have rates that progressively become more expensive as water use increases and moves through the designated water use blocks. Decreasing block

structures operate in an opposite manner of increasing block structures and charge lesser prices for higher quantities of water consumed (Olmstead, 2007).

Many large cities in Colorado are turning to the increasing block rate structures or the implementation of seasonal rate changes of uniform prices to encourage water conservation (Boyd, 2006). For example, the block rate structure in place for residential billing in the city of Colorado Springs is $0.0161 per cubic feet (CF) for water used up to 999 CF and then $0.0278 per CF for water used between 1,000 and 2,499 CF and finally $0.0420 per CF for water used beyond 2,500 CF. The seasonal rate for commercial properties is $0.0142 per CF between the months of November through April and $0.0255 per CF between the growing season months of May through October (CSU 2008). The rationale of the approach behind both price programs is based on the theory that consumers will respond to marginal prices (ie. The cost of the last unit purchased) (Kenney, 2007). Past research shows that customer response to pricing is varied but suggests that it is fairly typical to see a five percent decrease in consumption for every ten percent increase in price (Brookshire, 2002). In a study conducted by the City of Aurora, Colorado it was found that price programs were increasingly effective when combined with a non-price program (Kenney, 2007).

Non-Price Programs

Along with pricing structures water utilities often implement a variety of non-price programs to produce both temporary and permanent reductions in quantity demand (Kenney, 2007). Non-Price programs can be separated into five categories:

1. **Public information** programs focus on distributing information on and emphasizing the importance of water conservation to the general public. How the information is distributed can range from popular media (television, billboards, and newspapers) to xeric demonstration gardens.
2. **Education** programs concentrate on the distribution of information on water conservation through school curriculum.
3. **Retrofit** programs involve distribution rebates and installation of replacement devices to physically reduce residential water use.
4. **Permanent Ordinances and Regulations** that concentrate on reducing water use and changing water use practice through restrictions, and prescriptive practices.

5. **Temporary ordinances and regulations** that restrict certain types and amounts of water use. These ordinances and regulations are usually implemented in times of severe water shortages.
   (Adapted from Michelson, 2000, p. 5-6)

Often the target of Non-Price programs in the municipal and commercial water use sector is the reduction of water use in the designed landscape. Non-Price landscape programs implemented by cities often look at improving water efficiency in traditional turfgrass landscapes that are not only high maintenance but very high in water consumption (Wasowski, 2001). With the implementation of water-wise landscaping practices and educational programs these "traditional landscapes" can be easily retrofitted and managed as water-wise landscapes without sacrificing the aesthetics or functionality of the original landscape designs. Non-Price landscape regulations will be the focus of this study, more specifically the effectiveness of permanent landscape ordinances and regulations in development open space.

Water Use in the Landscape

Residential and commercial landscape watering is estimated to be one of the largest sources of potential urban water conservation. It is estimated that "traditional" business and household landscapes consume between fifty and seventy percent (50%-70%) of overall municipal water and have demands that peak during the summer months when water is already stretched thin across the multiple water sectors (Endter-Wada, 2008). The "traditional" or "conventional" landscape is characterized by large areas of manicured turf accented by ornamental trees and shrubs. The traditional style is typical of the temperate northeast regions of the United States and was brought to the western United States as people from the east settled in the west (Knox, 2003). The traditional style landscape that has been adopted in much of the west and throughout Colorado's suburban and urban landscape is not well adapted to the area's climate and often requires high amounts of water and maintenance (Figure 2-3).

Even though the traditional landscape requires higher levels of economic and natural resources for maintenance, it has been discovered that the public still holds a preference for the traditional urban landscapes that include irrigated, non-native shrubs, trees and turfgrass (Spinti, 2004). In order to challenge these preferences in a constructive way, water conservation

programs must be able to educate and provide working examples of Xeriscapes that are not only functional in terms of economical and resource conservation but also aesthetic and pleasing to the public. Common space landscapes in commercial and residential developments become a great podium for the values of water conservation to be presented in a functional and aesthetic way.

Figure 2-3 Traditional landscape in Briargate Business Campus with large areas covered by high water use turf (Author, 4.11.08)

Xeriscape

Xeriscape is defined as a sustainable landscape that conserves water based on sound horticultural practices while still remaining attractive (Figure 2-4). As mentioned before the term was created in the early 1980's by Denver Water to make water conserving landscaping an easily recognizable concept. The word is a combination of "landscape" and the Greek word "xeros" which means "dry" (www.denverwater.org nd). Common misconceptions of the term Xeriscape are that a xeric landscape is a landscape that is void of design and plant material or a landscape that only utilizes native plant material. Xeriscape is actually a method of landscaping and doesn't have a specific look or plant palette.

A large component of xeric landscaping is the concept of designing the landscape in response to natural and local conditions. Natural landscaping involves plant selection that is based on the climate and environment and site specific characteristics such as exposure, light intensity, soil pH, soil aeration, soil mineral analysis, site drainage, topography, and irrigation water quality. Proper plant selection based on local conditions will result in healthier plants that after establishment will require less water and maintenance (Knox, 2003).

Figure 2-4 Xeric landscape design utilizing native turf and a mix of low and medium water use plants (Author, 4.11.08)

Simply stated, Xeriscape is a landscape that is water-wise: using water conservatively in the landscape without wasting. The seven principles of Xeriscape are listed and described below (CSU, 2008).

1. **Plan and design comprehensively**

   Development of a plan that takes into account both the regional climate and the microclimate of a site, existing vegetation and topography, the proposed use of the property, and the grouping of plants by their water needs.

2. **Evaluate soil and improve if necessary**

   Analyze several samples of soil to determine the soil type(s) of the site so that appropriate amendments can be added. The soil amendments will aid plant growth by improving water penetration and retention.

3. **Create practical turf areas**

   Determine the function of high-water-use turf on the site and limit it to high traffic or recreational areas, drainage swales or other appropriate uses. Avoid narrow areas and steep slopes where irrigation will be inefficient and will make mowing difficult.

4. **Use appropriate plants**

   Select plants for their adaptability to the site and their design characteristics. If water conservation is a design objective, choose native or low water-use plants.

5. **Water efficiently**

   Water only when plants need it and deeply to encourage root growth for a healthier, more drought tolerant landscape. Grouping plants by water need will allow the most water-efficient design of an irrigation system. Management of the system will be as important as its design.

6. **Use organic mulch**

   Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.

7. **Maintain appropriately**

   Preserve the natural beauty and water efficiency of the landscape through regular pruning, weeding, mulching, and irrigation system maintenance.

   (Source: Colorado Springs Utilities Landscape Code and Policy Manual, 1998, p. 17)

There have been several studies in Nevada, Colorado, North Dakota, Arizona and Texas that have set out to understand the true effectiveness of Xeriscape as a water conservation tool. One of the programs, that received national attention, was the National Xeriscape Demonstration Program (NXPD) established by the Bureau of Reclamation. A NXPD study conducted between 1997 and 2004 indicated that for the Front Range of Colorado an average water savings in the 30 percentile range could be obtained through properly designed and maintained Xeriscapes (Medina, 2004). A similar NXPD study conducted in Las Vegas, Nevada had similar findings

that again validate the use of xeric landscaping as an effective tool for water conservation (Sovocol, 2006).

Equipped with the knowledge of the water savings that can be achieved by utilizing xeric landscaping methods, cities and developers alike have been implementing regulations and guidelines requiring the use of the proven methods in the designed landscape. Along the Front Range the changes in regulations can be seen throughout the landscape in the form of native plants, reduced turf area, and increased irrigation efficiency. An observer can expect changes to continue as water conservation methods are proven through current research and as demand grows for water conserving landscapes in the municipal sector.

Case Study: Colorado Springs, Colorado

Located along Colorado's Front Range, the city of Colorado Springs can be found seventy miles south of Denver along Interstate 25 in El Paso County (Figure 2-5). The city's semiarid landscape rests in front of an impressive backdrop of Pike's Peek and the Colorado Rockies and within a varied terrain (5,500-7,500 feet) that contains a mix of ecosystems including eight distinct plant communities (CSCP, 1998). The city's average annual precipitation is 16 inches, eighty percent of which occurs during the irrigation season in the form of heavy thunderstorm downpours (CSU, 2007).

Figure 2-5 Map of Colorado (Google Images, 2007)

According to the 2000 U.S. census the current population of the city is 541,718 and is projected to grow past 900,000 by 2035. The projected growth is at a rate that would make El Paso County the most populated county in the state of Colorado by 2035. Even though populations in the city are projected to reach nearly a million by 2035, current water demand forecasts predict that water supplies for the city are adequate to meet community needs through 2046. However, raw water delivery systems that would service the City and surrounding communities will be at capacity by 2012 (CSU, 2007). In preparation for the costs and burdens associated with the construction of a new delivery system to service the growing populations, the city of Colorado Springs has outlined a conservation plan that will help educate water providers and users on efficient water use and conservation.

Water conservation has been a consideration in the city since its early inception and has placed the city as a water conservation leader in the state of Colorado. Throughout its history Colorado Springs has assisted customers with the installation of new water saving technology and has directed the wise use of water through educational programs (CSU, 2007). As demands

and constraints have changed within the city so have the water conservation programs and approaches to water management decisions. Within its new water conservation plan, submitted to the Colorado Conservation Board in 2007, the City of Colorado Springs has outlined several new water conservation programs to be implemented starting in 2008. The goals of the new water conservation plan include:

- Maintain low residential use per capita, already among the lowest in Colorado and the Southwest.
- Improve understanding of commercial needs and segments in order to reduce commercial use per customer.
- Reduce peak day demand, specifically in areas with high residential use per capita and high peaking factors.
- Develop and maintain regional relationships that encourage water conservation throughout El Paso County and the Fountain Creek watershed.
- Establish a reputation as a national leader in water conservation and efficient water use by implementing programs that are cost effective and sustainable. (Adapted from the Colorado Springs Water Conservation Plan 2008-2012, p. 12)

The new water conservation plan will add to an already impressive program that has been in place for over a decade within the city. In 1996 the city implemented a water resource plan that eventually led to the creation of the 1998 Landscape Code and Policy Manual. It is the landscape regulations that were developed by Colorado Springs Utilities in the Landscape Code and Policy Manual and the landscape ordinances that developed in relation to the manual that will be the focus of the study.

Code and Policy Manual

In 1998 the city of Colorado Springs developed a Landscape Code and Policy Manual that now serves as the foundation for water conservation regulations and guidelines throughout the city. The Colorado Springs Landscape Code and Policy Manual utilized the surrounding plant communities, climatic information, and Xeriscape principles to build a mix of landscape codes, policies, and guidelines that targeted water conservation in the designed landscape.

According to the Colorado Springs Landscape Code and Policy Manual the intent of the Code and Policy framework within the manual was to produce "landscapes that were consistent with climatic and soil conditions and were the most aesthetic and sustainable in the region" (CSCP, 1998, p. 1). The city of Colorado Springs also anticipates landscapes resulting from the framework will be consistent with the surroundings and will be consistent with the principles of Xeriscape (CSU, 1998).

Accompanying the Landscape Code and Policy Manual is a landscape design manual that expands on the information provided by the city's landscape codes and policies. The idea of the Landscape Design Manual is to assist professionals and homeowners in the creation of landscapes that satisfy the cultural and societal values that respond to the regions ecological context (CSU, 1998).

Development Guidelines

There are some developers in Colorado Springs that are also turning towards landscape regulations in their housing guidelines to ensure landscapes that are both water-wise and aesthetically appealing are implemented in their developments. To developers, water-wise landscapes that are implemented and maintained properly mean less money spent on landscape watering for community homeowners and businesses, and an aesthetic that is more representative of the surrounding landscape. Often the developer's guidelines and design requirements are extensions of the landscape regulations set forth by the city, requiring additional amendments, inspections, and the submittal of landscape professional's credentials.

Landscape Tracts

The sites selected for evaluation in Colorado Springs were located north-east of downtown Colorado Springs within the city's Prairie plant community (as defined by the Colorado Springs Landscape Design Manual). The landscape tracts that were selected are all part of the master planned Briargate Development whose original design concept, crafted by La Plata Communities, was to create a master planned community that integrates designed open space and trails throughout the neighborhoods and businesses within the development. It is the designed open space of the two housing communities (Cordera and Pine Creek) and the one business campus (Briargate Business Campus) that became the focus of the study (Figure 2-6).

The design and construction of the Briargate development has spanned over the last twenty-five years, dating back to 1982, and continues on today (La Plata Communities, 2008). The long build out period of the Briargate community has created a mix of landscapes that are representative of different regulation and design eras. The mix of landscapes and regulations within the master planned Briargate development is what made the development a logical choice for the study. The three regulations represented in the Briargate development chosen for the study were: (**1**) city landscape regulations and Briargate guidelines that were developed and enforced before 1998, (**2**) city landscape regulations that were developed and enforced after 1998, and (**3**) city landscape regulations developed and enforced post 1998 in combination with additional specific landscape guidelines written for the Cordera housing development in 2005.

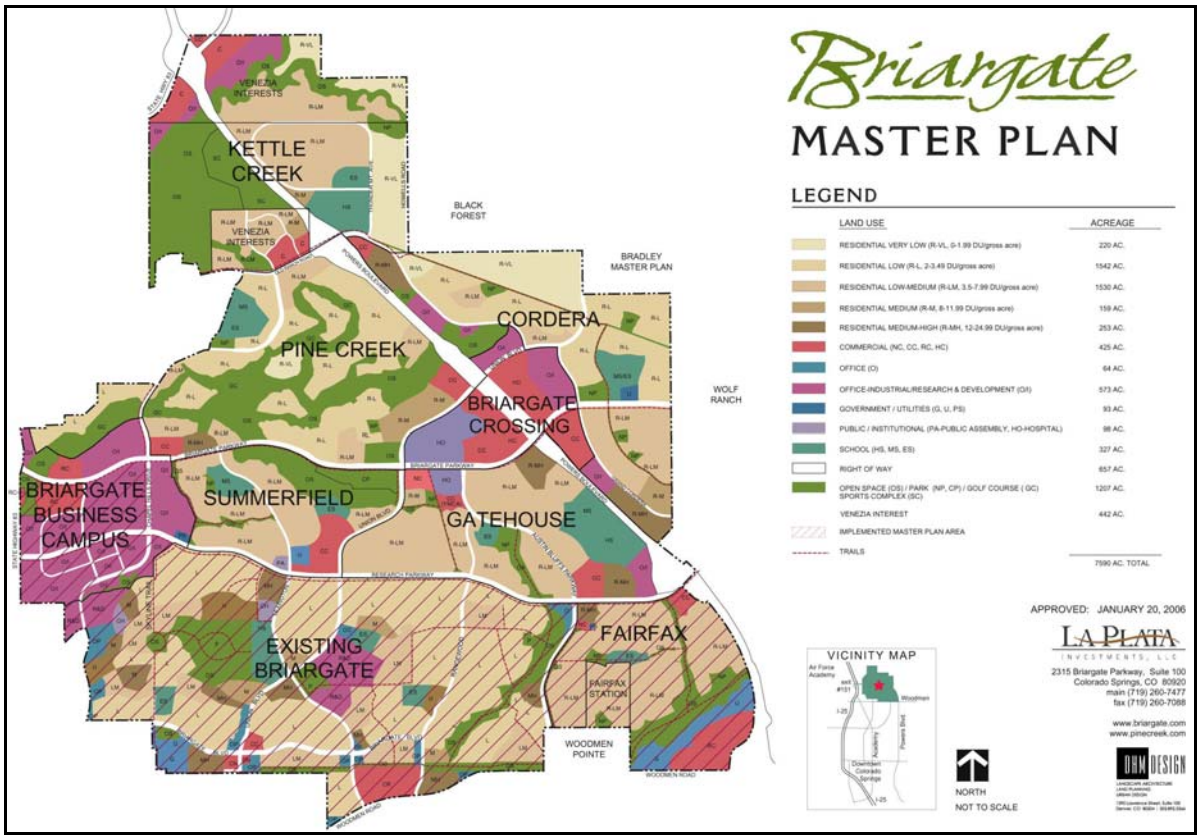

Figure 2-6 Briargate master plan (La Plata Communities, 2008)

The landscape tracts selected in the Briargate development share a host of characteristics which allowed for the control of study variables. All three of the development areas chosen for the study are:

- Adjacent in location
- Within the design manuals Prairie plant community (Figure 2-7)
- Developed by La Plata Communities as components of a master plan
- Exposed to the same climatic conditions
- Represent one of three landscape regulations that are being evaluated by the study

The landscape tracts selected for the study are located in developments also being evaluated by a parallel research study that is discovering the influence of educational programs in residential water use. Responsible Water Use (RWU) is the non-profit research group working with the residents in the Briargate communities to improve water use efficiency and promote water conservation into the future. It was the relationship with RWU that aided in the identification of suitable landscape tracts and the acquisition of necessary documents and data for the proposed research. The specific landscape tracts used for the study were chosen through a collaborative effort with the RWU research group. It was mutually decided to evaluate the landscape right of ways, medians, and entry gardens in the housing communities that were hosting residential education programs sponsored by RWU. This mutual selection was in anticipation of creating a holistic view of a development's water use, private and public landscapes, at the end of the two research projects.

In the end, the decision to select Colorado Springs and the Briargate development for the study was driven by a combination of factors. The main reasons for selection were:

- The city's rich history with conservation practices
- The mix of landscape regulations that can be viewed and measured in the landscape
- Access to data
- The opportunity to contribute information to a city and a developer that are always looking for better and more informed water conservation solutions

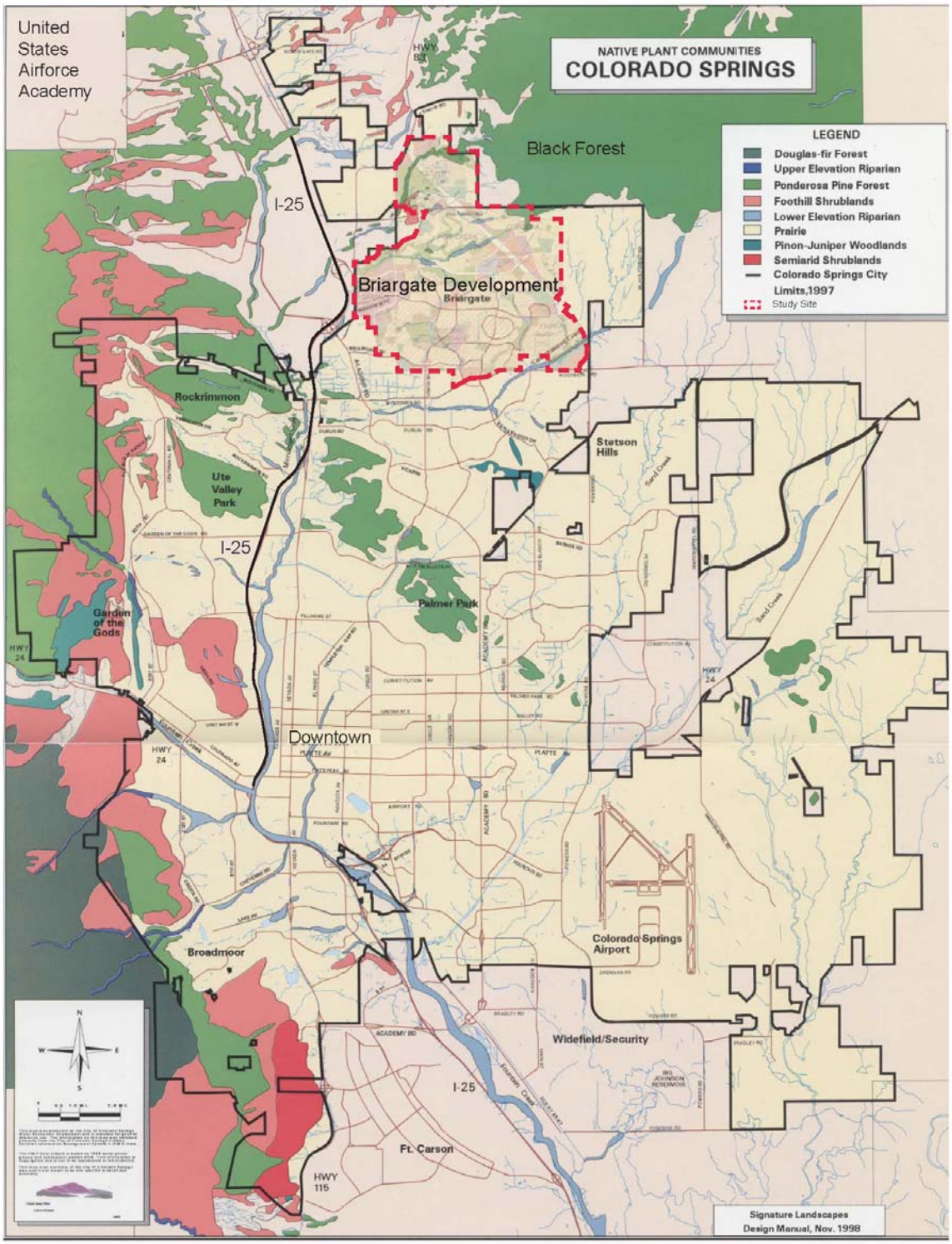

Figure 2-7 Colorado Springs native plant community map and study site location in Prairie plant community (Colorado Springs Landscape and Code and Policy Manual, 1998)

CHAPTER 3 - Methodology

Introduction

As previously mentioned, the intent of this study is to qualitatively assess the effectiveness of water conserving landscape regulations in development open spaces. The study will use a case study and a series of evaluations and comparisons to discover the effectiveness of selected regulations. The strengths and weaknesses of specific landscape regulations will also be identified during the course of the evaluations and comparisons and will be used to develop recommendations for the shaping of future landscape regulations.

To focus the research, a case study in Colorado Springs, Colorado was developed. The case study concentrated on the evaluation of landscape regulations and representative landscape tracts within three master planned landscapes contained within one development. A single developer, La Plata Communities, was used in the study to help control the number of variables that could contribute to landscape water use in the landscape tracts and to expedite the document collection portion of the study.

The three study sites developed by La Plata Communities that were selected for evaluation are: Briargate Business Campus, Pine Creek Master Planned Community, and Cordera Master Planned Community (Figure 2-6). The three communities contain landscape tracts that represent one of the following three landscape regulations; (**1**) city landscape code and policy and development guidelines that were established and enforced before 1998 (Briargate), (**2**) city landscape code and policy established and enforced after 1998 (Pine Creek), and (**3**) a combination of internal development regulations and post 1998 city landscape code and policy (Cordera). The regulations that were selected for the study represent a major change in public policy and code within Colorado Springs in 1998 and a progressive change in community development philosophy enacted by La Plata Communities in 2003 (S. Moorhead, personal communication, February 20th, 2008). These shifts in landscape regulations represent a changing philosophy towards water conservation and an important step towards the sustainable use of water in Colorado Springs.

My intent in performing this study is to discover if current landscape regulations that were shaped around the philosophy of water conservation are functioning as they were envisioned by their creators. By performing a qualitative assessment of the landscape regulations, designs, installations, and maintenance practices I will be able to identify strengths and weaknesses within the three landscape regulations. In order to maintain consistency while evaluating the landscape tracts, a framework for the evaluation and comparison was established for the study. Before the landscape evaluations could be executed, documents had to be collected and specific study sites had to be identified in order to ensure that the study would have access to all of the necessary information.

Document Collection

The first step of the study process was to collect master plans, planting plans, irrigation plans and regulation manuals for the Pine Creek and Cordera housing communities and the Briargate Business Campus. Documents were collected from a variety of sources including the City of Colorado Springs planning office, the community developer, and community managers. Landscape construction documents for Pine Creek and Cordera were reproduced by La Plata Communities and landscape documents for the Briargate Business Campus were reproduced by Keesen Water Management. The City Planning office provided a copy of the Landscape Code and Policy Manual from 1998 and an electronic reproduction of the landscape regulations in place before 1998. La Plata Communities provided copies of the development regulations for both Pine Creek and Cordera. The documents collected were used throughout the study and were instrumental in the identification and evaluation of landscape tracts.

Site Establishment

A careful selection of study sites within the La Plata Communities of Briargate, Pine Creek, and Cordera was conducted in order to control the number of variables contributing to water use in the selected landscape tracts. Variables that were of key concern were: Soil, Slope, Climate, and Eco-Region. A potential study site was defined as an irrigated community landscape tract with a dedicated and identifiable water meter. The selection of study sites was accomplished by completing the following procedure:

1. **Identify regulation and plat boundaries within the selected developments** by using interactive online mapping program provided by the city of Colorado Springs. The online mapping program called *City View* is a public Geographic Information System (GIS) viewing program provided by the City of Colorado Springs that allows the user to identify property boundaries, ownership, the issuance of building permits, parcel information, and perform area and length measurements (CSU 2008). Common spaces within the developments were easily identified using the *City View* viewing system and could be easily referenced when communicating with the other parties involved in the research process.

2. **Identify the location of water meters within community landscape tracts and confirm irrigated landscape area dedicated to identified water meters**. Meter locations were identified from archived irrigation plans and then confirmed by the landscape managers and irrigation technicians in the field. Dates of landscape construction and establishment also were identified in the field in order to estimate the proper square footages of landscape tracts at a given point in time. Date of construction was critical in some cases where irrigation systems were extended from an existing irrigation zone, requiring an increase in the landscape coverage square footage. If the increased square footages were not included in the calculation the water use numbers on a square foot basis would increase significantly. The construction dates and the coverage area for the landscape tracts were both confirmed via conversations with landscape managers on April 11th, 2008.

3. **Select the landscape tracts and meters located within each regulation boundary** that would be used for evaluation. The landscape tracts that were selected were comparable in terms of function, slope, soil and exposure. All three tracts were located in the cities Prairie eco-region, were on minimal slopes, and were built on soils identified as a type of sandy loam by the USGS online *Soil Survey*. All tracts selected had documented water use records for the 2006-2007 growing seasons and had identifiable irrigated landscape coverage areas. The final landscape selections consisted of two landscape tracts in Pine Creek and Cordera and one landscape tract within the Briargate Business Campus (Figure

3-1). The landscape tracts for the Pine Creek Community were located in the Oak Meadow and Orchard Park neighborhoods. The landscape tracts selected in the Cordera community were located at two separate intersections within the community. The first landscape tract, Grand Cordera Parkway, was located at the intersection of Briargate Parkway and Grand Cordera Parkway. The second landscape tract, Happy Meadows Trail, was located at the intersection of Lizard Rock Trail and Happy Meadow Trail. The landscape tract selected for the Briargate Business campus was located along Research Parkway; this particular tract extends through the Business Campus and also runs parallel to low to medium residential housing. The extent of each landscape tract can be seen in Figure 3-2 through Figure 3-5.

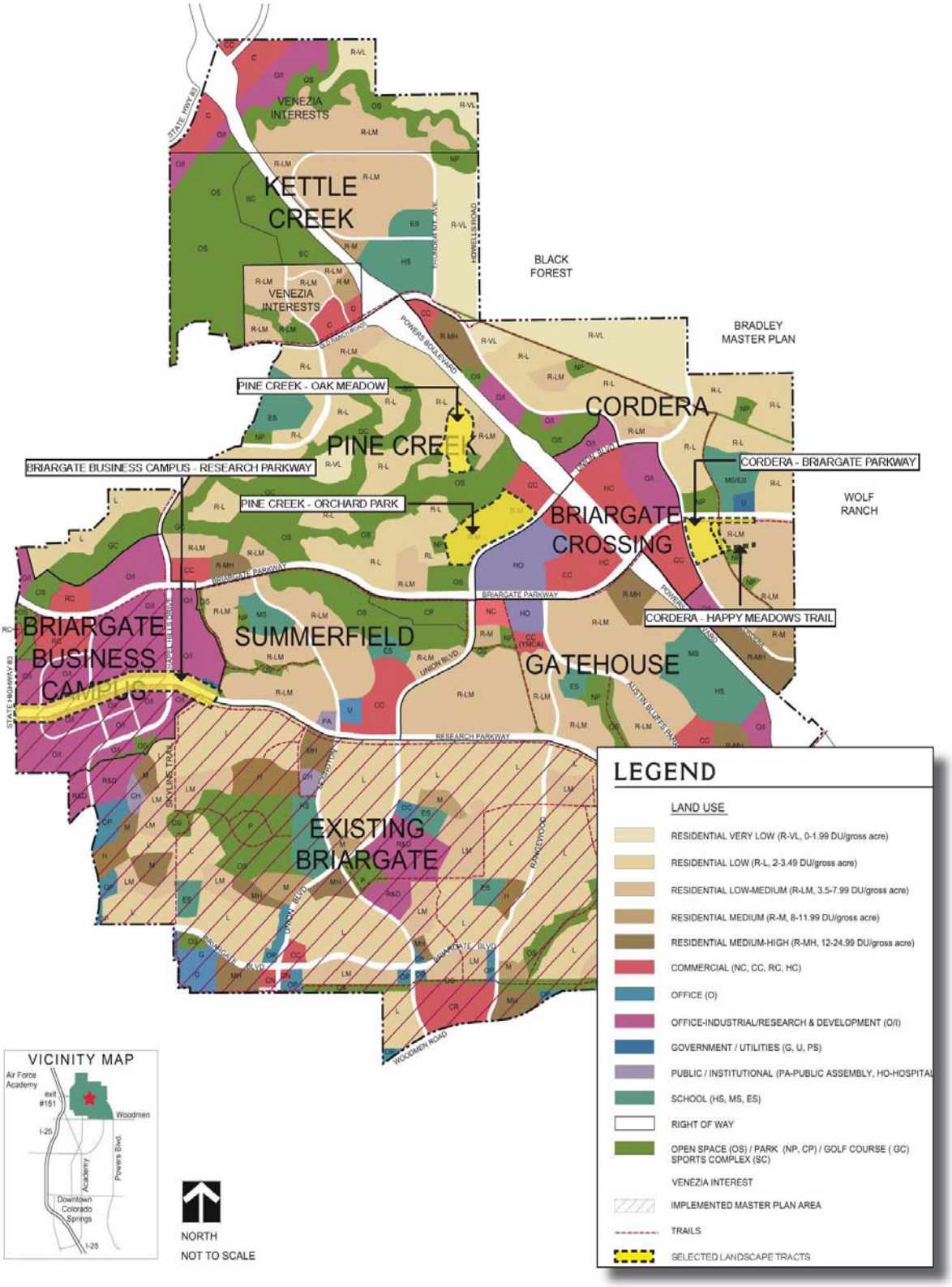

Figure 3-1 Landscape tract location (La Plata Communities, 2008)

Figure 3-2 Pine Creek's Oak Meadow landscape tract evaluation area (Google Earth, 2008)

Figure 3-3 Pine Creek's Orchard Park landscape tract evaluation area (Google Earth, 2008)

Figure 3-4 Briargate Business Campus's Research Parkway landscape tract evaluation area
(Google Earth, 2008)

Figure 3-5 Cordera's Grand Cordera and Happy Meadows landscape tract evaluation areas

(Google Earth, 2008)

4. **Identify the square footage of landscaped area for each of the selected landscape tract meters**, excluding all non-irrigated paved areas within the landscape tracts. The amount of irrigated landscape dedicated to individual water meters in the Briargate, Pine Creek, and Cordera communities was identified by landscape managers in the field using aerial photographs and landscape irrigation documents. After the boundaries were identified by the landscape managers the square footages of the irrigated landscape tracts were calculated using the following methods:

    a. Area take-offs for the Pine Creek Communities (Oak Meadow and Orchard Park) were completed using the Colorado Springs Utilities *City View* mapping program. Figure 3-6 shows an image captured from the *City View* system that depicts the area take-off function.
    b. Because of outdated aerial photographs in the *City View* mapping program, Area take-offs for the landscape tracts in the housing community of Cordera were calculated using scanned images of the approved construction documents. The digital copies were scaled and measured with Autodesk software.
    c. Briargate Business Campus square footages were also acquired from the *City View* online mapping program using the area take-off function.

    Area take-offs for each individual landscape tract were then recorded in the Excel spreadsheets with the historical water use numbers for each landscape tract. The square footages would be used later in the study to establish the water use in inches per square foot for each landscape tract.

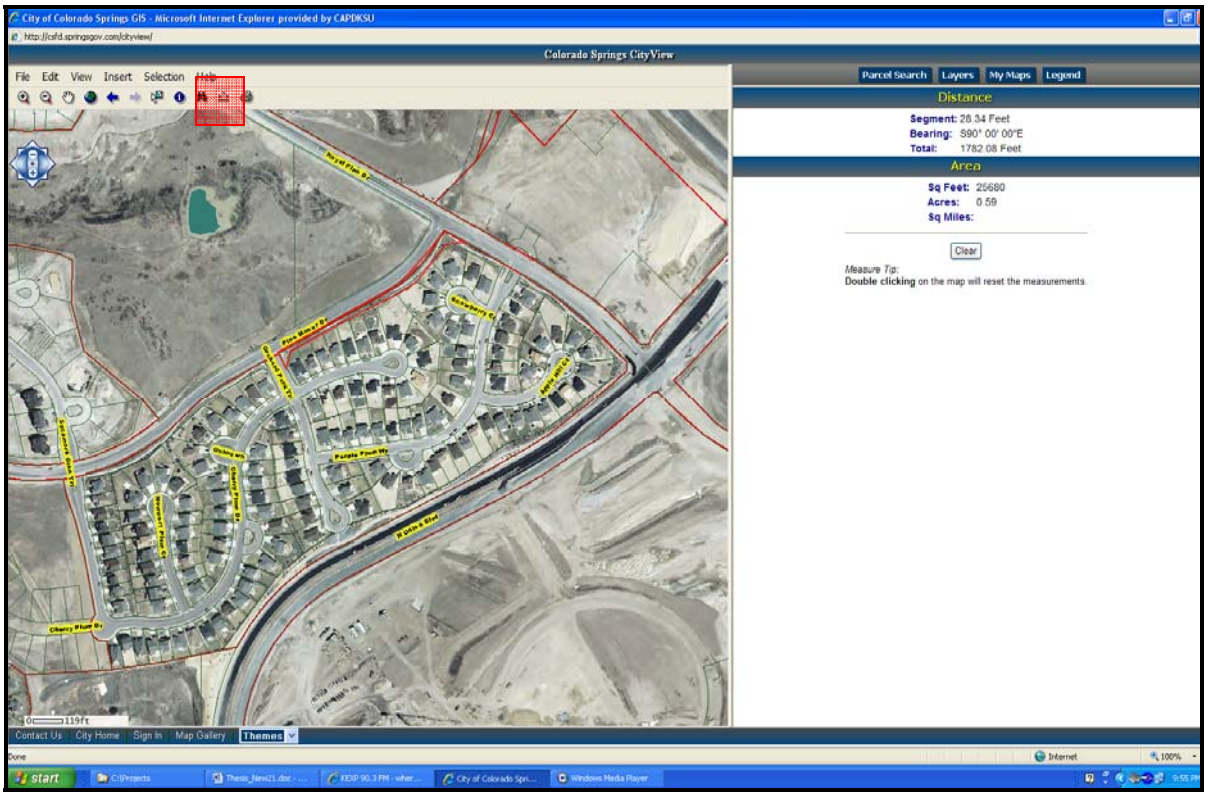

Figure 3-6 Screen capture of *City View* during an aerial area measurement
(http://csfd.springsgov.com/cityview/)

Data Collection

Historical water use data was collected for each meter in the selected landscape tracts. Home owner association management companies and the City of Colorado Springs provided the water use data that was needed for the study. Water use data was collected for the 2005-2007 growing seasons (April-October) for each landscape tract. The historical water use data received from the city of Colorado Springs and the community home association managers was in a variety of forms, ranging from paper bills to Excel spreadsheets, and had to be organized and condensed into a single Excel spreadsheet. Within the Excel spreadsheet, the water use for each month within the growing season, the total water used in each growing season, and an average water use total of the two growing seasons (2006-2007) was calculated and recorded (Figure 3-7). The 2005 data was discarded from the study because not all of the selected landscape tracts had been established by 2005. Adjustments to the water data had to be performed in order to

accommodate for missing data and irregularities within data sets. Missing data was calculated by averaging the water use from the previous two years for the particular month of missing data. The missing data is represented with red text in Table 3-1.

Growing Season Month	Pine Creek Orchard Park 2006	Pine Creek Orchard Park 2007	Pine Creek Orchard Park Monthly Avg.
April	0.00	0.00	0.00
May	5.37	1.42	3.40
June	3.83	4.28	4.05
July	3.15	11.14	7.15
August	2.30	4.40	3.35
September	1.82	2.62	2.22
October	0.51	1.36	0.93
Total Water Use	16.99	25.22	21.10

Table 3-1 Example of Excel spreadsheet expressing historical water use numbers in inches per square foot for a landscape tract located in the Pine Creek housing development. Red numbers indicate an estimated average.

Evaluation

The methodology for the evaluation portion of the study is presented in four categories. Each category of the study represents one of the four steps necessary for the development and maintenance of water efficient landscapes. The study divided the evaluations into the four categories to help identify strengths and weaknesses within the regulations and the landscape development process (Figure 3-7). The four categories of the study are:

1. **Landscape regulations -** It is the intent of the study to discover the strength and weaknesses of the selected landscape regulations in terms of their guidance towards the implementation of the Xeriscape principles. The thought behind the regulation evaluation is that with an increased use of regulations based off of the Xeriscape principles there will be an increase in water conserving landscapes and a decrease in water demand in the city of Colorado Springs.

2. **Landscape designs** (Landscape Evaluation) **-** It is the intent of this category to discover if the selected landscape regulations were being expressed properly in the landscape tract designs. The thought behind this evaluation is that if there

were to be a failure in the design process where landscape regulations weren't expressed properly, the effectiveness of the regulations and the constructed landscape would be in question. If the landscape regulations were expressed properly in the design then it would be assumed that the resulting constructed landscape would reflect the landscape regulations that were in place.

3. **Landscape construction and maintenance** (Landscape Evaluation) **–** It is the intent of this category to discover if the selected landscape regulations are being properly expressed in the installed and maintained landscape. Change orders and oversights are not uncommon in the construction process and can ultimately end up altering the original landscape design. This evaluation will ensure that changes that were made during the construction process did not impact the original intent of the landscape design or regulation. On the same note, the evaluation will also ensure that the constructed landscape is being maintained in a way that allows it to function as a water conserving landscape. If there was compliance between the landscape design, the constructed landscape, and the maintenance of the constructed landscape then it could be expected that the selected landscape would function in a way that was intended by the authors of the landscape regulations.

4. **Landscape water use** - The final evaluation in which historical landscape water use will provide insight into how the built landscape is functioning in terms of a water conserving landscape. The water use of the landscapes should reflect the intentions of the original regulations and the landscape designs, installations, and maintenance practices that resulted by means of regulation compliance.

It is through the process of the category evaluations followed by the comparison of the evaluation results that will allow for the identification of strengths and weaknesses in each regulation. The comparison between the individual landscape tracts and landscape tract water use before and after regulation implementation will also produce insight into the effectiveness of the regulations that have been implemented by the City of Colorado Springs and La Plata

Communities. The overall evaluation process that eventually led to this study's results and recommendations can be seen in Figure 3-7. Information on how each category was evaluated and scored is outlined in the following sections of the thesis.

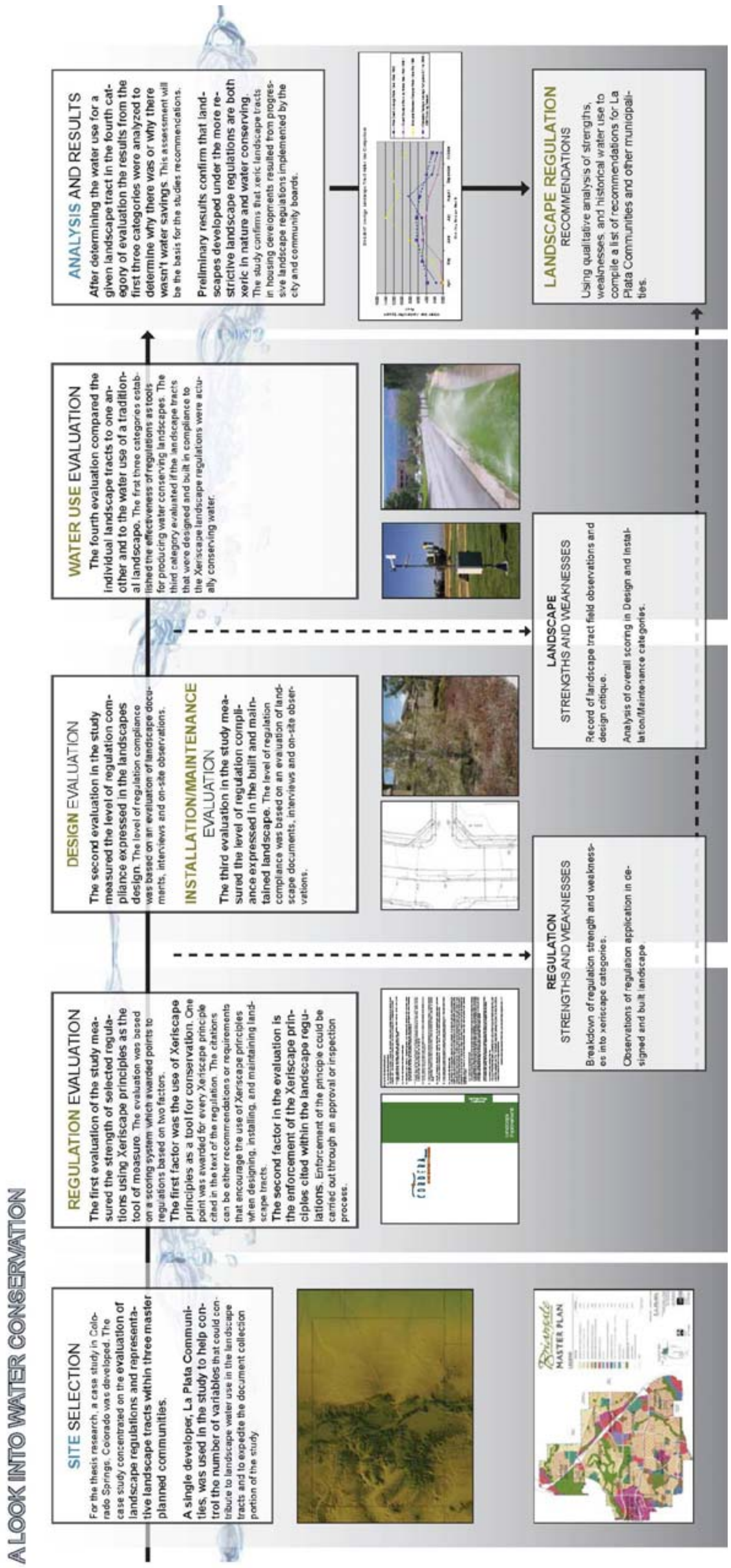

Figure 3-7 Evaluation framework

Landscape Regulations

The first evaluation of the study measured the strength of the three selected landscape regulations using Xeriscape principles as the tool of measure. The seven Xeriscape principles were interpreted and applied into nine separate water-wise categories for the purpose of evaluation. Two of the seven Xeriscape principles (Appropriate Plant Selection and Efficient Irrigation) were divided into two additional categories for a more in depth analysis. The two resulting categories from the division were: Group Plants Accordingly (originating from the Appropriate Plant Selection principle) and Schedule Irrigation Wisely (originating from the Efficient Irrigation principle). The nine overall water-wise categories used for the evaluation are:

1. Planning and Design
2. Group Plants Accordingly/Hydrozoning
3. Appropriate Plant Selection
4. Limit Turf Areas to Those Needed for Practical Uses
5. Use Efficient Irrigation Systems
6. Schedule Irrigation Wisely
7. Soil Analysis and Improvement
8. Use of Mulch
9. Provide Regular Maintenance

A scoring system based off of the nine water-wise categories was then developed to, organize, rank, and evaluate the effectiveness of the three selected regulations. The concept of the system was simple, awarding higher scores to landscape regulations that utilized the established water-wise categories. The scoring used for the evaluation was based on two factors: (**1**) the citation of the Xeriscape principles and (**2**) the enforcement of the citations with submittal and inspection processes.

The first factor was the use of Xeriscape principles, a proven method of improving water efficiency in the landscape as a tool for conservation. One point was awarded for every Xeriscape principle cited in the text of the regulation. The citations could either be recommendations or prescriptive requirements that encouraged the use of Xeriscape principles when designing, installing, and maintaining landscape tracts. The point system for Xeriscape

citations awarded more value to landscape regulations that were deeply rooted in the proven methods of water conservation. The individual codes, policies, and guidelines that were awarded points were then recorded in a word document and can be seen in Appendix A.

The second factor in the evaluation is the enforcement of the Xeriscape principles cited within the landscape regulations. Enforcement of the principle could be carried out through a submittal or inspection process. One point was awarded for every regulation that required approval based on a submittal or inspection of required Xeriscape principles. This type of scoring system awarded value to regulations that ensured the proper implementation of Xeriscape principles.

Overall, the scoring system ranked the three selected landscape regulations based on their potential for producing a water conserving landscape. The scoring matrix used in the evaluation process (Table 3-2) also provided a tool for identifying the individual strengths and weaknesses found within the landscape regulations. The impact of Xeriscape citation and enforcement was then assessed by comparing historical water use information to the landscape tracts final scores. It would be expected that the regulations with higher scores produce landscapes that consumed less water.

Landscape Tract Regulations	Water-Wise Landscaping Categories											
	Planning and Design			Group Plants Accordingly/ Hydrozoning			Appropriate Plant Selection			Limit Turf Areas to Those Needed for Practical Uses		
	C	S	I	C	S	I	C	S	I	C	S	I
Pine Creek City Regulations After 1998	4	1	1	1	1	1	2	1	0	2	0	0
Cordera City Regulations After 1998 + Development Regulations	5	2	1	1	1	1	2	1	0	2	0	0
Briargate Business Campus City Regulations Before 1998	1	2	1	1	0	0	0	0	0	0	0	0

Strength of Regulation Scoring
1 point for citation (C)
1 point for required submittal (S)
1 point for required inspection (I)

Table 3-2 Example of landscape tract regulation scoring showing four of the nine water-wise landscape categories

Landscape Design

The second evaluation in the study measured the strength of regulation compliance expressed in the landscape design. The strength of regulation compliance was based on a scoring

system that awarded points to landscape designs that were reflective of the Xeriscape principles cited and enforced within the landscape regulations. Using the Xeriscape evaluation matrix from the regulation evaluation as a structural base, a simple scoring system based on a 0 point score for non-compliance and a 1 point score for compliance was established for each Xeriscape category. If there wasn't compliance in the landscape design the reason for non-compliance was listed and was used in the construction of future recommendations. Compliance was then expressed in the form of a percentage of the original landscape regulation categories expressed. For example if six of the nine landscape categories where cited in the regulations but only five of the six cited categories were expressed in the landscape design then the landscape design would score a 66%, higher percentages reflecting higher levels of compliance.

The evaluation was developed to discover if regulations were being implemented successfully in the landscape tract designs. Compliance for each water-wise category was measured qualitatively by analyzing approved construction documents and through interviews with individuals involved in the design, construction, and maintenance process. The matrix used for the evaluation of each Xeriscape category can be seen in Table 3-3.

In the case of Briargate Business Campus the only landscape documents that could be located were the original landscape irrigation documents produced by EDAW in 1986. Although the planting schedule was not available on the Mylar construction documents the irrigation zones, irrigation coverage patterns, and the on-site analysis were enough to draw conclusions about the designed landscape and its application to the few regulations that existed at the time.

Landscape Design Evaluation	Water-Wise Landscape Categories			
La Plata Properties	Planning and Design	Group plants accordingly/ Hydrozoning	Appropriate Plant Selection	Limit Turf Areas to Those Needed for Practical Uses
Pine Creek City Regulations after 1998	1*	1	1	1*
Cordera City Regulations after 1998 + Development Guidelines	1*	1	1	1*
Briargate Business Campus City Regulations before 1998	1*	1*	0	0

1 = Regulation compliance
0 = Non-compliance

* Indicates that category was met but could be improved upon - see evaluation forms for more information

Table 3-3 Example of landscape design scoring showing four of the nine water-wise landscape categories

Landscape Installation and Maintenance

The third evaluation in the study measured the level of regulation compliance expressed in the built landscape. The level of regulation compliance was based on a scoring system similar to the one used in the landscape design evaluation, awarding points to built landscapes that were reflective of the Xeriscape principles cited within the landscape regulations. Again, using the Xeriscape evaluation matrix from the policy evaluation as a structural base, a simple scoring system based on a 0 point score for non-compliance and a 1 point score for compliance was established for each Xeriscape category (Table 3-4). Compliance was then expressed in the form of a percentage of the original landscape regulation categories expressed. If there wasn't compliance in the built landscape the reason for non-compliance was listed and was used in the construction of the landscape guidelines.

Landscape Installation and Maintenance	Water-Wise Landscape Categories			
La Plata Properties	Planning and Design	Group plants accordingly/ Hydrozoning	Appropriate Plant Selection	Limit Turf Areas to Those Needed for Practical Uses
Pine Creek City Regulations after 1998	1*	1	1*	1*
Cordera City Regulations after 1998 + Development Guidelines	1*	1	1*	1*
Briargate Business Campus City Regulations before 1998	1*	1*	0	0

1 = Regulation compliance
0 = Non-compliance

* Indicates that category was met but could be improved upon - see evaluation forms for more information

Table 3-4 Example of landscape installation and maintenance scoring showing four of the nine water-wise landscape categories

Regulation compliance in the landscape installation and maintenance (landscape site evaluation) of the landscape tracts was primarily evaluated from on-site inspections and interviews conducted on April 11th and 12th, 2008. The landscape evaluation was conducted by two landscape architecture students using the evaluation form that can be seen in Table 3-5. The evaluation form was constructed using the cited landscape codes, policies and guidelines found in the selected landscape regulations as a base. Interviews were conducted to evaluate compliance in the landscape categories that could not be assessed visually in the field. The scoring category coincides with the compliance score in the landscape design and site evaluation. All three regulations were evaluated using the same evaluation sheet, but only the scores that coincided with the original regulations were recorded in the landscape design and installation sheets.

Briargate Business Campus	Landscape On Site Evaluation Sheet		
Landscape Evaluation Categories	Observations	Photo #'s	Score
1 Planning and Design			
The landscape represents a site adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of plants.	Majority of the designed landscape is planted in high water use turf. Plantings mainly consists of established trees and large shrubs.	BBC 1.1, 1.2, 1.3	0
Mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.	High water use turf located on slopes greater than 6:1	BBC 1.4, 1.5	0
2 Group Plants Accordingly / Hydrozoning			
Plants with similar water needs within each site micro-climate are zoned or grouped together.	Turf grass dominated landscape irrigated with overhead spray irrigation.		0
3 Appropriate Plant Selection			
Landscape reflects the ecological context of the site using diverse plant species that are indicative of local plant communities. Based on the Landscape Code and Policy Manuals Prairie Region Plant Community.	Landscape is not indicative of surrounding landscape. The traditional style landscape doesn't utilize many plants from the surrounding Prairie Eco-region.		0
Develop a project plant list from 1998 Landscape Code and Policy Manual to satisfy site category requirements. At least 60% of the trees and 60% of the shrubs must be signature plants for the chosen plant communities.			0
4 Limit Turf Areas to Those Needed for Practical Uses			
High water use turf is limited to high traffic or recreational areas, drainage swales or other appropriate uses.	High water use turf is used throughout the landscape area.		0
No more than 50% of the entire site is covered in high water use turf.	Over 50% of landscaped right of way consists of high water use turf.		0
Turf is limited to slopes less than 6:1.	Turf located on slopes greater than 6:1		0
Turf is limited to medians greater than 12' in width.			1
Turf is prohibited in configurations that cannot be efficiently irrigated.	Inefficient configurations found throughout the site		0
Turf is prohibited in motor vehicle lot planters that are less than 8' in width.			0
Limited amounts of turf in street right-of-ways where the distance between the curb and detached sidewalk is less than 8'.	Turf in right of way between street and detached sidewalk often times 6 feet or less.	BBC 4.1, 4.2	0
5 Use of Efficient Irrigation Systems			
Method of irrigation matched to size and shape of area and plant material, and for uniformity coverage.	Original landscape plans indicate an irrigation system that was designed to match the size and area of planting beds and turf areas.Evaluation revealded inefficiencies within the irrigation system.		0
Use of rain sensors on all system controllers.	Irrigation controllers utilize rain sensors.		1
6 Schedule Irrigation Wisely			
Established irrigation schedules.			0
7 Soil Analysis and Improvement			
Soil analyzed and amended appropriately.			0
8 Use of Mulch			
Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.	Mulch is very thin in places, most likely not functioning as intended in regulations.		0
9 Provide Regular Maintenance			
Pruning	Turf grass well maintained but the general maintenances in some planting beds is questionable.	BBC 9.1	1
Weeding			0
Mulching	Mulch is very thin in places, most likely not functioning as intended.		0
Irrigation system maintenance	According to 2006 audit the landscape irrigation system is very inefficient.	BBC 9.2	0

Table 3-5 Landscape evaluation checklist and scoring system

The four landscape categories assessed through an interview process were; Use of efficient irrigation system, schedule irrigation regularly, provide regular maintenance, and soil analysis and improvement. Interviews were conducted with landscape managers for the study communities; interview questions that were used for the study can be seen in Table 3-6.

Landscape Category	Interview Questions
Use of efficient irrigation system	Are all shrub beds within the selected landscape tract on drip irrigation?
	Does the system utilize rain sensors?
	Does the system utilize master control valve?
Schedule irrigation regularly	How do you establish individual run times?
	How often do you update run times during the course of the growing season?
Provide regular maintenance	How often are planting beds mulched?
	How often are the irrigation systems maintained?
Soil analysis and improvement	How is the soil quality within the selected landscape tract?
	Do you have any problems maintaining plant material within the tracts?

Table 3-6 Landscape evaluation interview questions

Landscape Water Use

The fourth evaluation compared the historical water use (inches per square foot) of the individual landscape tracts to the scores compiled in the three previous category evaluations. The comparison is intended to uncover the relationship between the regulations rooted in Xeriscape principles and their resulting water use in the landscape tracts. In short, the comparison of historical water use to the individual evaluation scores provided the basis for the qualitative assessment of regulation effectiveness. If water use was high for a particular landscape tract then in theory the evaluation scores would indicate why there was high water use. The first three evaluation categories established the effectiveness of regulations as tools for producing water conservation in the landscape. The fourth evaluation category is to discover if

the landscape tracts that were designed and built in compliance to Xeriscape landscape regulations are in fact conserving water.

Raw water meter data from the selected landscape tracts was organized into an Excel spreadsheet according to landscape tract, year, and growing season month (Table 3-1). Monthly and yearly averages were calculated for each growing season and then recorded in the Excel spreadsheet. In order to measure the effectiveness of the landscape regulations and to complete comparisons between landscape tracts, the water use data was converted from gallons into inches per square foot for each landscape tract. To calculate water use in inches per square foot, the total gallons applied to the landscape tract was first divided by the square footage of the landscape area and then divided by the conversion factor for gallons per square foot to inches per square foot [e.g., *(total gallons applied/square footage)/0.623375*].

Evaluation

The effectiveness of the selected landscape regulations were measured using two different methods. The first method for evaluation compared the landscape tracts historical water use in inches per square foot to the historical turfgrass evapotranspiration (E.T.) rate for Colorado Springs. Evapotranspiration is defined as the sum of evaporation and transpiration from a plant and its surrounding surface area. (USGS, 2008). E.T. averages for turfgrass were gathered from the City of Colorado Springs and were established from data provided by local weather stations. For the purpose of the study the E.T. rate for turfgrass represented the water use of a well maintained and efficiently watered traditional landscape. To perform the first comparison historical E.T. averages were placed into an Excel spreadsheet with the historical landscape water use numbers. The numbers were compared using a simple line graph with the x-axis representing monthly averages and the y-axis representing water use in inches per square feet. The second method established the effectiveness of the landscape regulations by implementing a side by side comparison between the water use of the three selected landscape regulations. It was expected that the policies that scored higher in the previous evaluations, landscapes developed after 1998, would have lower water use than the landscapes that were developed before the 1998 regulation change. The comparison was completed in Excel and then displayed in a line graph to show the difference in water use per growing season month with the

x-axis on the line graph representing the growing season month and the y-axis representing the water use in inches per square foot.

Methodology Limitations

This study was based on an analysis of the regulations implemented in the La Plata Community development in Colorado Springs. In order for the same analysis to be applicable to other locations the site context must be taken into consideration for the analysis. It is the intent for the evaluation framework to be applicable to evaluation of regulations in different areas and regions within Colorado.

CHAPTER 4 - RESULTS AND ANALYSIS

The results for the Colorado Springs case study are separated into four categories that reflect the four categories of evaluation.

1. Regulation
2. Design
3. Installation and Maintenance
4. Water Use

Results will be presented for each of the four categories and then a conclusion about the regulations effectiveness will be discussed in the final section of the chapter. Future recommendations that were compiled from the strengths and weaknesses of the individual categories will also be discussed in the final section.

Regulation Evaluation

The evaluation and scoring of the selected landscape regulations was intended to provide a look into the composition of and philosophy behind each regulation. Each regulation was individually evaluated and analyzed based on composition of water-wise principles and type of policy, code or guideline application (citation, submittal, and inspection). The discussion that follows is based on the regulation evaluation results and from qualitative observations made during the evaluation process.

The results for the evaluation revealed that a drastic change in how the built landscape should be designed, constructed, and maintained occurred with the change in the 1998 city of Colorado Springs regulations. The Briargate Business Campus that was developed before the implementation of the 1998 City Landscape Code and Policy Manual had very few regulations that enforced or even encouraged the use of water-wise landscape practices. In fact, according to the scoring system established for the study only six (**6**) water-wise landscape citations were found within the regulations and guidelines that applied to the Briargate Business Campus landscapes. In contrast, the citation and enforcement of water-wise (Xeriscape) principles in the Cordera (post-1998 + Community Guidelines) and Pine Creek (post-1998) regulations were

found to be well crafted and represented. The Pine Creek and Cordera regulations scored points in each one of the nine Water-Wise Landscape categories that were established for the evaluation, and in many cases scored multiple points within each category. The high scores are an indication that the city's regulations and the development regulations have matured over time and have become more progressive and embedded in the proven methods of water conservation. The maturation of landscape regulations also indicates that Colorado Springs is starting to realize the need to address future water demand issues by reducing water use in the designed landscape.

The total point scores for the landscape tracts was six (**6**) for Briargate Business Campus, thirty (**30**) for Pine Creek, and thirty-six (**36**) for Cordera. According to the scoring system the regulations for Cordera are the strongest and should reflect the highest level of water conservation and efficiency followed by Pine Creek and Briargate Business Campus. The scoring results can be seen in Table 4-1 followed by a brief discussion on each regulations score.

Landscape Tract Regulations	Water-Wise Landscaping Categories																											
	Planning and Design			Group Plants Accordingly/ Hydrozoning			Appropriate Plant Selection			Limit Turf Areas to Those Needed for Practical Uses			Use of Efficient Irrigation Systems			Schedule Irrigation Wisely			Soil Analyses and Improvement			Use of Mulch			Provide Regular Maintenance			Total Score
	C	S	I	C	S	I	C	S	I	C	S	I	C	S	I	C	S	I	C	S	I	C	S	I	C	S	I	
Pine Creek City Regulations After 1998	4	1	1	1	1	1	2	1	0	2	0	0	1	1	2	2	0	0	3	2	0	2	0	0	2	0	1	**30**
Cordera City Regulations After 1998 + Development Regulations	5	2	1	1	1	1	2	1	0	2	0	0	4	1	2	2	0	0	4	2	0	2	0	0	2	0	1	**36**
Briargate Business Campus City Regulations Before 1998	1	2	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**6**

Strength of Regulation Scoring
1 point for citation (C)
1 point for required submittal (S)
1 point for required inspection (I)

Table 4-1 Landscape Tract Regulation Evaluation

Briargate Business Campus – City Regulations an Development Guidelines Before 1998

The Briargate Business Campus (BBC) regulation represents the combination of city regulations and development guidelines that existed before the establishment of the 1998 City Landscape Code and Policy Manual and change in developer philosophy. The original designs for many of the major parkways and streets through BBC date back to 1986 and are representative of typical landscapes that were installed during that era. The evaluation established for the study scored the BBC very low in terms of water-wise landscape principles cited and enforced within the regulation's documents. The BBC score was also very low in comparison to the two regulations that were developed after the implementation of the 1998 City Landscape Code and Policy Manual. The water-wise categories represented by the Pre-1998 City of Colorado Springs Regulations and BBC guidelines can be seen in Figure 4-1.

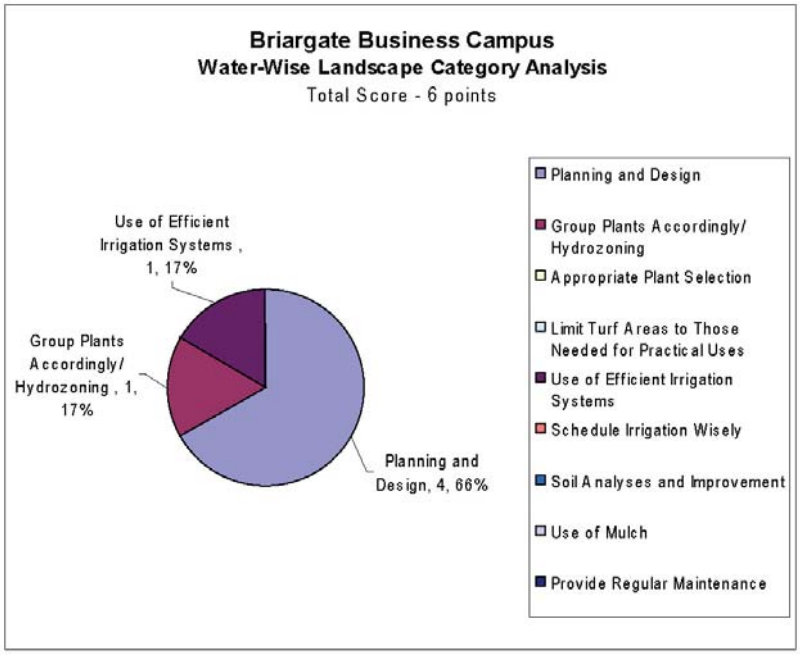

Figure 4-1 Water-Wise Landscape Category Analysis for Briargate Business Campus

The water-wise principles that were found to be present in the BBC regulation were mostly concentrated in the Planning and Design category and were non-existent in six of the eight remaining water-wise categories. Many of the points awarded in the Planning and Design

categories were related to the submittal of construction documents and the inspection of the finished landscape (Appendix A). The submittal and approval of construction documents and the inspection of the finished landscape tracts focuses on the installation of a quality landscape, but without the use of restrictive regulations encouraging and enforcing the use of water-wise landscape practices the resulting landscapes might not always be efficient water consumers.

Another analysis that provided a look into the existing BBC regulation is the division of the regulation scoring into three scoring categories; Inspection, Submittals, and Citation (Figure 4-2). It can be seen in Figure 4-2 that 50% of the Water-Wise Landscape Categories that were awarded points were in the form of citations and another 50% coming from the enforcement of those regulations in the form of submittals and inspections. Although the distribution of policies between the citations, submittals, inspections of water-wise categories is well balanced in the BBC regulations, the fact that so few regulations exist and that only two of those regulations pertain to the use of water-wise principles makes the effectiveness of the regulation in terms of water savings questionable.

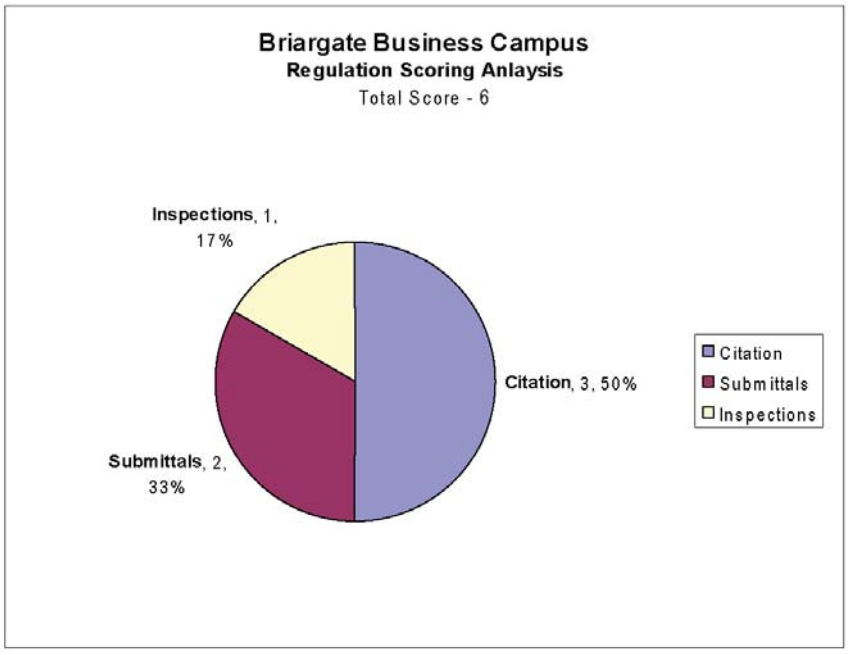

Figure 4-2 Regulation Scoring Analysis for Briargate Business Campus

Pine Creek – City Regulations Established in 1998

The Pine Creek landscape regulation scored very high in the evaluation with strengths in the Use of Efficient Irrigation, Planning and Design, and Soil Analyses and Improvement categories (Figure 4-3). The Pine Creek landscapes were designed and built in 2003 under the City Landscape Code and Policy Manual that was established in 1998.

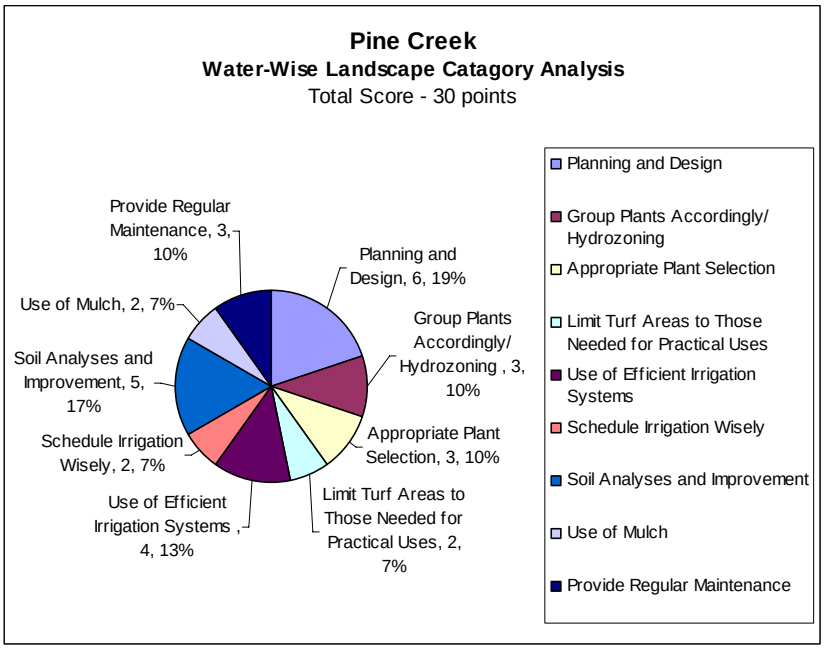

Figure 4-3 Water-Wise Landscape Category Analysis for Pine Creek

The composition of the city regulations that the Pine Creek landscape tracts represent is very diverse, successfully covering all of the water-wise landscape categories in the evaluation. The scoring system and the diverse composition of the regulations both indicate that there should be substantial water savings in the Pine Creek landscape tracts. The Pine Creek scoring analysis also indicates that there is a balance between citations, required submittals and inspections within the Pine Creek regulations (many submittals and inspections covering multiple citations) (Figure 4-4). The numbers indicate that the citations compose 63% of the scores, where 37% of the scores come from required inspections and submittals of the citations. The balance between citations, submittals, and inspections, show that the regulations that were set forth by the city in 1998 were not merely guidelines but are an enforced means of water conservation which should be evident in the landscapes, the landscape designs, and landscape water use.

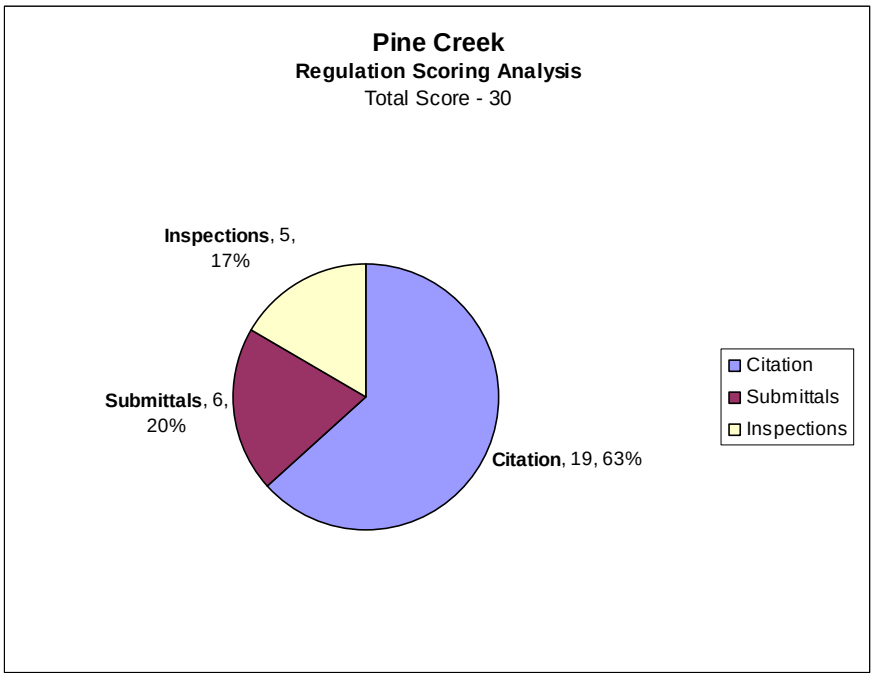

Figure 4-4 Regulation Scoring Analysis for Pine Creek

Cordera – City Regulations Established in 1998 +Development Guidelines

The Cordera landscape tracts are a combination of the 1998 City of Colorado Springs regulations and Cordera Community Guidelines that were developed in 2005. The two regulations combine to create the strongest evaluation score of the three selected landscape regulations. The strong evaluation scores indicate that the Cordera landscape tracts should show substantial water conservation and efficiency. Similar to the Pine Creek regulations, the strength of the Cordera regulations stem from the Planning and Design, Soil Analysis and Improvement, and Use of Efficient Irrigation Systems categories. The category analysis of the Cordera regulations scoring can be seen below in Figure 4-5.

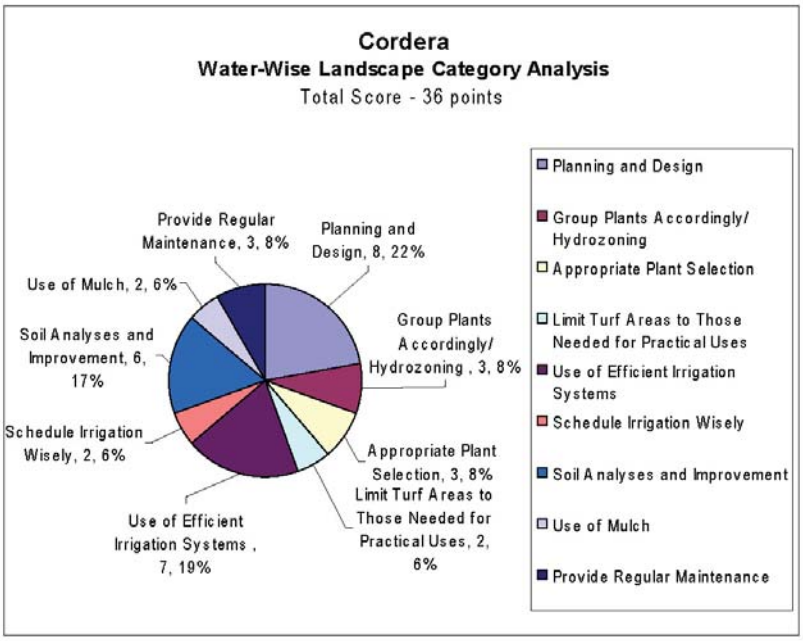

Figure 4-5 Water-Wise Landscape Category Analysis for Cordera

The regulation scoring analysis is similar to that of Pine Creek with a slight increase in the number of water-wise citations. Overall, the Cordera regulations have a balance between citations, inspections, and submittals within the regulations and guidelines that apply to the landscape tracts (many submittals and inspections covering multiple citations) (Figure 4-6). This balance should prove to be an effective way of conserving water in the built landscape.

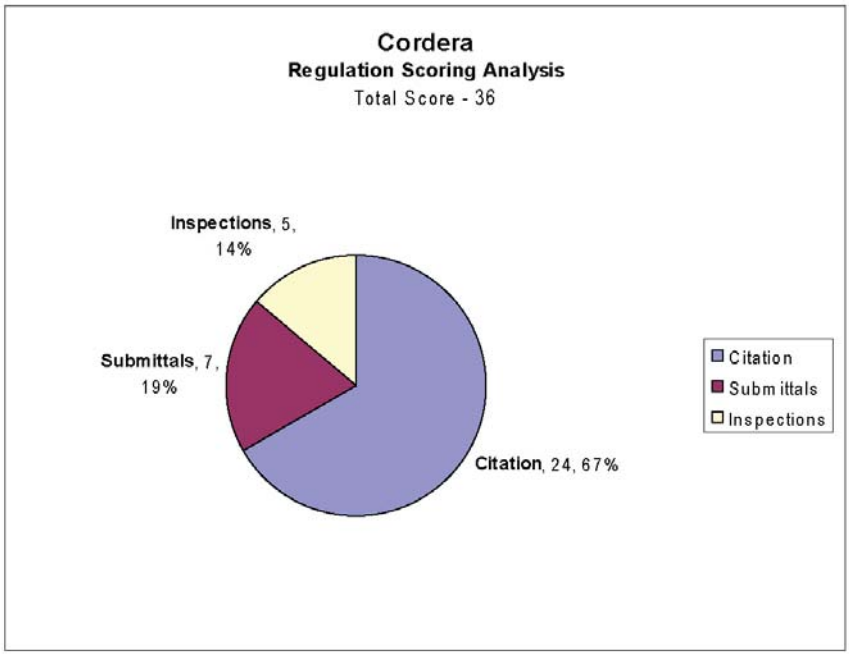

Figure 4-6 Regulation Scoring Analysis for Cordera

Regulation Evaluation Summary

The regulations evaluation shows that as time has progressed landscape regulations not only from the City of Colorado Springs but also from La Plata Communities have become more restrictive and focused on the conservation of water in community landscapes. The city and developers have both turned to proven methods of water conservation and have crafted regulations and guidelines that are diverse in nature and are balanced between citation of water-wise landscape practices and the enforcement of those policies in the designed and built landscape. The evaluation of the regulations indicate that the regulations developed for the Pine Creek and Cordera communities are crafted in a way that should achieve a water-wise design, landscape, and eventually wise water use in community landscapes. The following landscape evaluation results will provide some insight into whether or not the landscapes regulations were effective in producing the expected outcomes.

Landscape Evaluation

The landscape evaluation was separated into two categories for assessment and analysis; (1) the evaluation of the landscape design and (2) the evaluation of the installed and maintained landscape. Each category of the landscape evaluation (design and installation/maintenance)

determines if the landscape regulations implemented by the city of Colorado Springs and by La Plata Communities were being effectively translated into the designed and built landscape. The evaluation of each category used a combination of document reviews, on-site evaluations and interviews to establish the landscapes compliance to the original regulations. The results from the reviews, interviews and on-site evaluations conducted on April 11th and 12th of 2008 can be seen in Tables 4-2 through 4-6 and Figures 4-7 through 4-11. The evaluation sheets were used as a tool for documentation and as a framework for the systematic evaluation of each landscape tract to ensure consistent analysis. The evaluation questions that were used in the "Landscape On-Site Evaluation Sheet" were crafted in a way that would discover if the regulations were being implemented correctly in the landscape. The scoring system found on the far right of the evaluation form coincided with the landscape design and installation/maintenance evaluation forms where a score of 1 point represents compliance and score of 0 points represents non-compliance. The scoring from the on-site evaluation sheet was used as a reference tool to determine overall scores in the landscape design, and installation/maintenance evaluations.

Briargate Business Campus	Landscape On Site Evaluation Sheet		
Landscape Evaluation Categories	Observations	Photo #'s	Score
1 Planning and Design			
The landscape represents a site adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of plants.	Majority of the designed landscape is planted in high water use turf. Plantings mainly consists of established trees and large shrubs.	BBC 1.1, 1.2, 1.3	0
Mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.	High water use turf located on slopes greater than 6:1	BBC 1.4, 1.5	0
2 Group Plants Accordingly / Hydrozoning			
Plants with similar water needs within each site micro-climate are zoned or grouped together.	Turf grass dominated landscape irrigated with overhead spray irrigation.		0
3 Appropriate Plant Selection			
Landscape reflects the ecological context of the site using diverse plant species that are indicative of local plant communities. Based on the Landscape Code and Policy Manuals Prairie Region Plant Community.	Landscape is not indicative of surrounding landscape. The traditional style landscape doesn't utilize many plants from the surrounding Prairie Eco-region.		0
Develop a project plant list from 1998 Landscape Code and Policy Manual to satisfy site category requirements. At least 60% of the trees and 60% of the shrubs must be signature plants for the chosen plant communities.			0
4 Limit Turf Areas to Those Needed for Practical Uses			
High water use turf is limited to high traffic or recreational areas, drainage swales or other appropriate uses.	High water use turf is used throughout the landscape area.		0
No more than 50% of the entire site is covered in high water use turf.	Over 50% of landscaped right of way consists of high water use turf.		0
Turf is limited to slopes less than 6:1.	Turf located on slopes greater than 6:1		0
Turf is limited to medians greater than 12' in width.			1
Turf is prohibited in configurations that cannot be efficiently irrigated.	Inefficient configurations found throughout the site		0
Turf is prohibited in motor vehicle lot planters that are less than 8' in width.			0
Limited amounts of turf in street right-of-ways where the distance between the curb and detached sidewalk is less than 8'.	Turf in right of way between street and detached sidewalk often times 6 feet or less.	BBC 4.1, 4.2	0
5 Use of Efficient Irrigation Systems			
Method of irrigation matched to size and shape of area and plant material, and for uniformity coverage.	Original landscape plans indicate an irrigation system that was designed to match the size and area of planting beds and turf areas.Evaluation revealded inefficiencies within the irrigation system.		0
Use of rain sensors on all system controllers.	Irrigation controllers utilize rain sensors.		1
6 Schedule Irrigation Wisely			
Established irrigation schedules.			0
7 Soil Analysis and Improvement			
Soil analyzed and amended appropriately.			0
8 Use of Mulch			
Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.	Mulch is very thin in places, most likely not functioning as intended in regulations.		0
9 Provide Regular Maintenance			
Pruning	Turf grass well maintained but the general maintenances in some planting beds is questionable.	BBC 9.1	1
Weeding			0
Mulching	Mulch is very thin in places, most likely not functioning as intended.		0
Irrigation system maintenance	According to 2006 audit the landscape irrigation system is very inefficient.	BBC 9.2	0

Table 4-2 Briargate Business Campus On-Site Evaluation Sheet

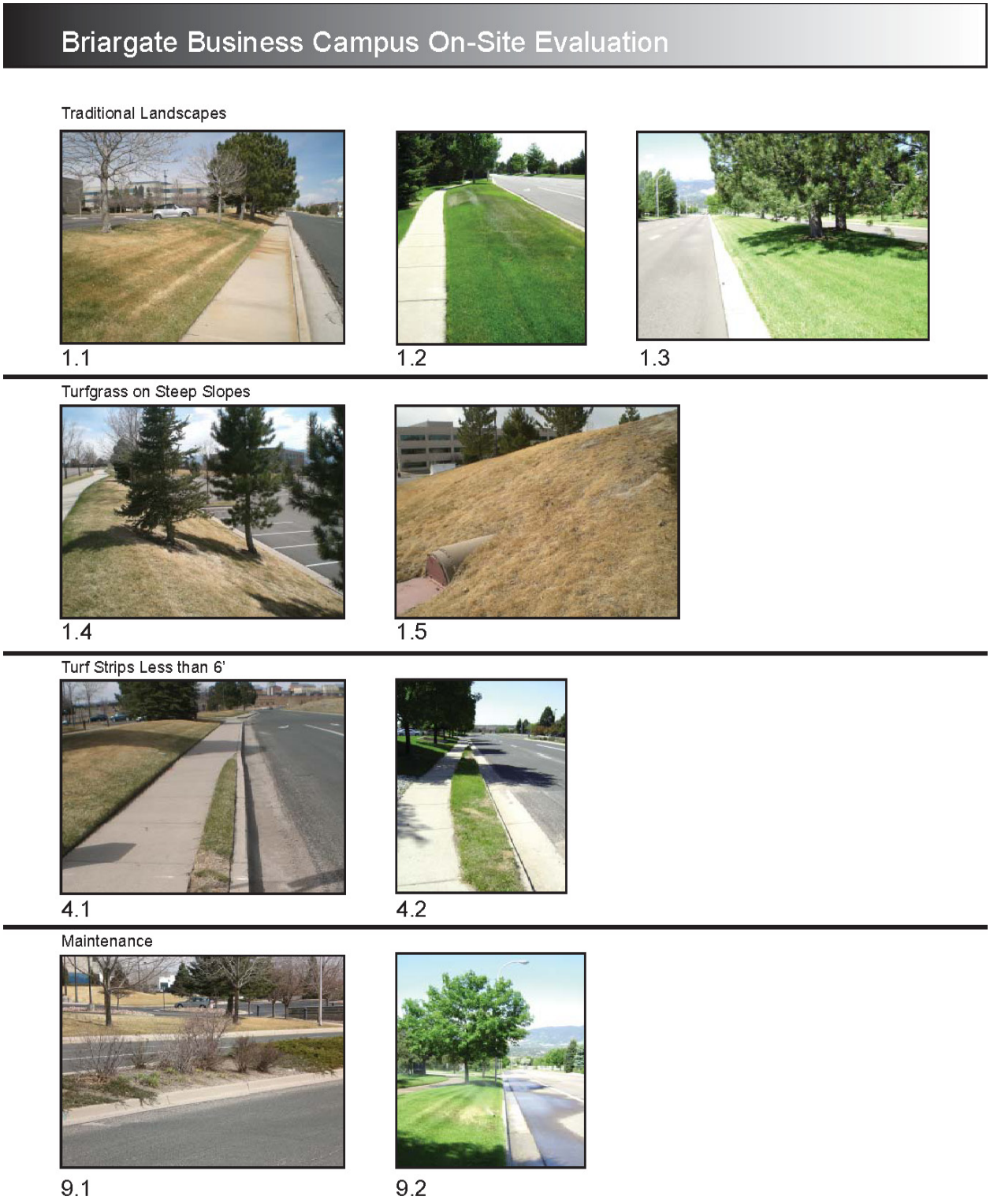

Figure 4-7 Briargate Business Campus On-Site Evaluation Photos (Author, 4.11.08 & 6.11.08)

Pine Creek Oak Meadow	**Landscape** On Site **Evaluation Sheet**		
Landscape Evaluation Categories	Observations	Photo #'s	Score
1 Planning and Design			
The landscape represents a site adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of plants.	The landscape uses a blend of native turf, drought tolerant plants, and turf grass. High water use plantings concentrated around entry ways into the development. Species of trees sometimes different from approved plans.		1
Mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.	No major slopes.		1
2 Group Plants Accordingly / Hydrozoning			
Plants with similar water needs within each site micro-climate are zoned or grouped together.	Plants grouped according to approved designs.		1
3 Appropriate Plant Selection			
Landscape reflects the ecological context of the site using diverse plant species that are indicative of local plant communities. Based on the Landscape Code and Policy Manuals Prairie Region Plant Community.	Native plant communities are represented in some of the plant material, but the overall planting scheme is not indicative of surroundings. Planting scheme does follow the regulations in the Landscape Code and Policy Manual.	Oak Meadow 3.1, 3.2	1
Develop a project plant list from 1998 Landscape Code and Policy Manual to satisfy site category requirements. At least 60% of the trees and 60% of the shrubs must be signature plants for the chosen plant communities.	Landscape was designed and installed according to the Pine Creek and 1998 Colorado Springs regulations.		1
4 Limit Turf Areas to Those Needed for Practical Uses			
High water use turf is limited to high traffic or recreational areas, drainage swales or other appropriate uses.	High water use turf is limited to entry ways and used as a design element within the landscape to balance native turfs.		1
No more than 50% of the entire site is covered in high water use turf.	Less than 50% of the site is covered in high water use turf.		1
Turf is limited to slopes less than 6:1.			1
Turf is limited to medians greater than 12' in width.			1
Turf is prohibited in configurations that cannot be efficiently irrigated.	Opportunities for improvement but the majority of turf areas can be irrigated efficiently.	Oak Meadow 4.1	1
Turf is prohibited in motor vehicle lot planters that are less than 8' in width.			1
Limited amounts of turf in street right-of-ways where the distance between the curb and detached sidewalk is less than 8'.			1
5 Use of Efficient Irrigation Systems			
Method of irrigation matched to size and shape of area and plant material, and for uniformity coverage.	All shrub beds on drip irrigation. Use of pop-up sprays and rotors appropriate to site context. There are no master valves within the Pine Creek community.		1
Use of rain sensors on all system controllers.	Irrigation controllers all utilize rain sensors.		1
6 Schedule Irrigation Wisely			
Established irrigation schedules.	Irrigation adjusted by landscape manager on a need basis. All native turf hand watered in Pine Creek area. System remained off until July and August in 2006.		1
7 Soil Analysis and Improvement			
Soil analyzed and amended appropriately.	According to landscape manager the Pine Creek development has some problems with soil quality and keeping ceratain plant species alive in the poor soils.	Oak Meadow 7.1, 7.2, 7.3	0
8 Use of Mulch			
Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.	Mulches applied only when requested by community home owners association. Mulch depth was sufficient upon evaluation.		1
9 Provide Regular Maintenance			
Pruning	Plant material well maintained.		1
Weeding	Weeding done on a weekly basis with pre-emergent being used routinely.		1
Mulching	Mulch is only applied when home owners association has the money and sees the need. New mulch was laid down in 2007 and has maintained an adequate depth to date.		1
Irrigation system maintenance	System checks four days a week according to landscape manager.		1

Table 4-3 Pine Creek – Oak Meadow On-Site Evaluation Sheet

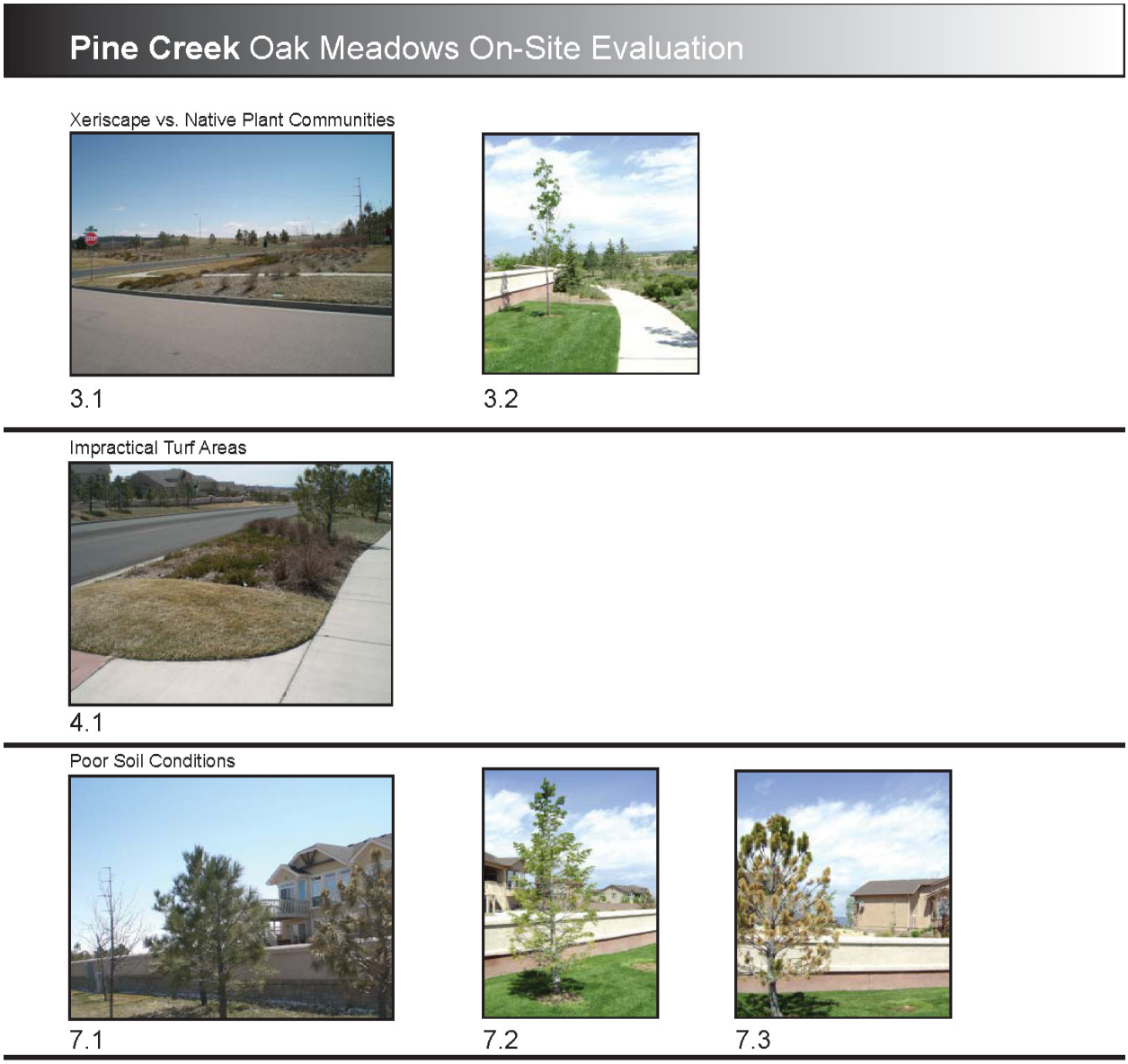

Figure 4-8 Pine Creek - Oak Meadow On-Site Evaluation Photos (Author, 4.11.08 & 6.11.08)

Pine Creek Orchard Park	**Landscape** On Site **Evaluation Sheet**		
Landscape Evaluation Categories	**Observations**	**Photo #'s**	**Score**
1 Planning and Design			
The landscape represents a site adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of plants.	Landscape uses a blend of native turf, drought tolerant plants, and turf grass. High water use plantings concentrated around entry ways into the development. Substitute plant material used in some areas of the landscape tract. The species of plants used as substitutes were similar to original specified plant.		1
Mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.	Overall slopes meet code. Some slopes on Royal Pine Drive are close to 6:1 and show evidence of stress (patchy native turf).	Orchard Park 1.1	1
2 Group Plants Accordingly / Hydrozoning			
Plants with similar water needs within each site micro-climate are zoned or grouped together.	Plants in the landscape tract are grouped according to approved designs.		1
3 Appropriate Plant Selection			
Landscape reflects the ecological context of the site using diverse plant species that are indicative of local plant communities. Based on the Landscape Code and Policy Manuals Prairie Region Plant Community.	Native plant communities are represented in some of the plant material, but the overall planting scheme is not indicative of surroundings.	Orchard Park 3.1, 3.2, 3.3	1
Develop a project plant list from 1998 Landscape Code and Policy Manual to satisfy site category requirements. At least 60% of the trees and 60% of the shrubs must be signature plants for the chosen plant communities.	Landscape was designed and installed according to the Pine Creek and 1998 Colorado Springs regulations.		1
4 Limit Turf Areas to Those Needed for Practical Uses			
High water use turf is limited to high traffic or recreational areas, drainage swales or other appropriate uses.	High water use turf was limited to entry ways and used as a design element within the landscape to balance native turfs.		1
No more than 50% of the entire site is covered in high water use turf.	High water use bluegrass covers less than 50% of the site. There are opportunities within the landscape tract to reduce the amount of high water use turf grass without effecting the aesthetic quality of the site.	Orchard Park 4.1	1
Turf is limited to slopes less than 6:1.			1
Turf is limited to medians greater than 12' in width.			1
Turf is prohibited in configurations that cannot be efficiently irrigated.	Opportunities for improvement but the majority of turf areas can be irrigated efficiently.	Orchard Park 4.2, 4.3	1
Turf is prohibited in motor vehicle lot planters that are less than 8' in width.			1
Limited amounts of turf in street right-of-ways where the distance between the curb and detached sidewalk is less than 8'.			1
5 Use of Efficient Irrigation Systems			
Method of irrigation matched to size and shape of area and plant material, and for uniformity coverage.	All shrub beds on drip irrigation.		1
Use of rain sensors on all system controllers.	All systems utilizing rain sensors.		1
6 Schedule Irrigation Wisely			
Established irrigation schedules.	Irrigation adjusted by landscape manager on a need basis. All native turf hand watered in Pine Creek area. System remained off until July and August in 2006.		1
7 Soil Analysis and Improvement			
Soil analyzed and amended appropriately.	According to landscape manager the Pine Creek development has some problems with soil quality and keeping certain plant species alive in the poor soils.		0
8 Use of Mulch			
Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.	Mulches applied only when requested by community home owners association. Mulch depth was sufficient upon evaluation.		1
9 Provide Regular Maintenance			
Pruning	Plant material well maintained		1
Weeding	Weeding done on a weekly basis with pre-emergent being used routinely.		1
Mulching	Mulch only when home owners association has the money and sees the need. New mulch was placed down in 2007. Mulch depth was good overall.		1
Irrigation system maintenance	System checks four days a week according to landscape manager.		1

Table 4-4 Pine Creek – Orchard Park On-Site Evaluation Sheet

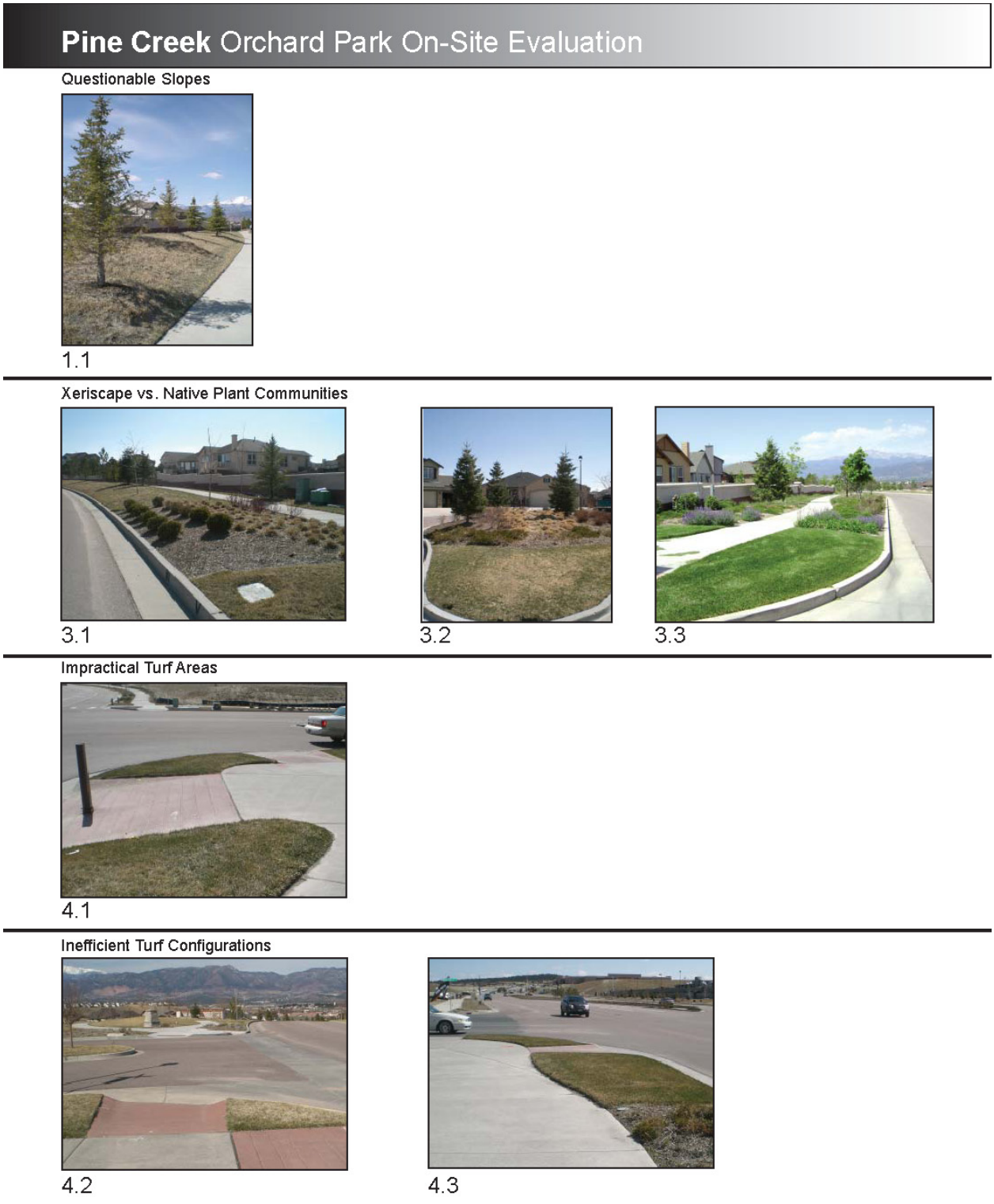

Figure 4-9 Pine Creek – Orchard Park On-Site Evaluation Photos (Author, 4.11.08 & 6.11.08)

Cordera Grand Cordera	**Landscape** On Site **Evaluation Sheet**		
Landscape Evaluation Catagories	Observations	Photo #'s	Score
1 Planning and Design			
The landscape represents a site adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of plants.	Landscape uses a blend of native turf, drought tolerant plants, and turf grass. Landscapes installed according to plan.	Cordera 1.1, 1.2	1
Mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.	No slopes that exceed maximum standard.		1
2 Group Plants Accordingly / Hydrozoning			
Plants with similar water needs within each site micro-climate are zoned or grouped together.	Plants grouped according to approved designs. Approved designs group Plants effectively into hydrozones.	Cordera 2.1, 2.2	1
3 Appropriate Plant Selection			
Landscape reflects the ecological context of the site using diverse plant species that are indicative of local plant communities. Based on the Landscape Code and Policy Manuals Prairie Region Plant Community.	Native plant communities are represented in some of the plant material, but the overall planting scheme is not indicative of surroundings.		1
Develop a project plant list from 1998 Landscape Code and Policy Manual to satisfy site category requirements. At least 60% of the trees and 60% of the shrubs must be signature plants for the chosen plant communities.	Designed and installed according to regulations.		1
4 Limit Turf Areas to Those Needed for Practical Uses			
High water use turf is limited to high traffic or recreational areas, drainage swales or other appropriate uses.	High water use turf was limited to entry ways and used as a design element within the landscape to balance native turfs. Turf not always limited to practical areas.	Cordera 4.1, 4.2	1
No more than 50% of the entire site is covered in high water use turf.			1
Turf is limited to slopes less than 6:1.			1
Turf is limited to medians greater than 12' in width.			1
Turf is prohibited in configurations that cannot be efficiently irrigated.	Opportunities for improvement but the majority of turf areas can be irrigated efficiently.	Cordera 4.3, 4.4	1
Turf is prohibited in motor vehicle lot planters that are less than 8' in width.			1
Limited amounts of turf in street right-of-ways where the distance between the curb and detached sidewalk is less than 8'.			1
5 Use of Efficient Irrigation Systems			
Method of irrigation matched to size and shape of area and plant material, and for uniformity coverage.	All shrub beds on drip irrigation.		1
Use of rain sensors on all system controllers.	Irrigation controllers all utilize rain sensors.		1
6 Schedule Irrigation Wisely			
Established irrigation schedules.	Schedules established on landscape designs and adjusted in the field. Native turf areas are on scheduled irrigation in April and May.		1
7 Soil Analysis and Improvement			
Turf grass soil amended appropriately.			1
Soil analyzed and amended appropriately.	Soil was inspected and amended according to Code Section 315.		1
8 Use of Mulch			
Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.	Mulches applied only when requested by community home owners association. Mulch depth was sufficient upon evaluation.		1
9 Provide Regular Maintenance			
Pruning	Plant material was well maintained and pruned.		1
Weeding	Weeding done on a weekly basis with pre-emergent being used routinely.		1
Mulching	Mulch only when needed. New mulch was laid down in 2007. Mulch depth was good overall.		1
Irrigation system maintenance	System checks four days a week according to landscape manager.		1

Table 4-5 Cordera – Grand Cordera On-Site Evaluation Sheet

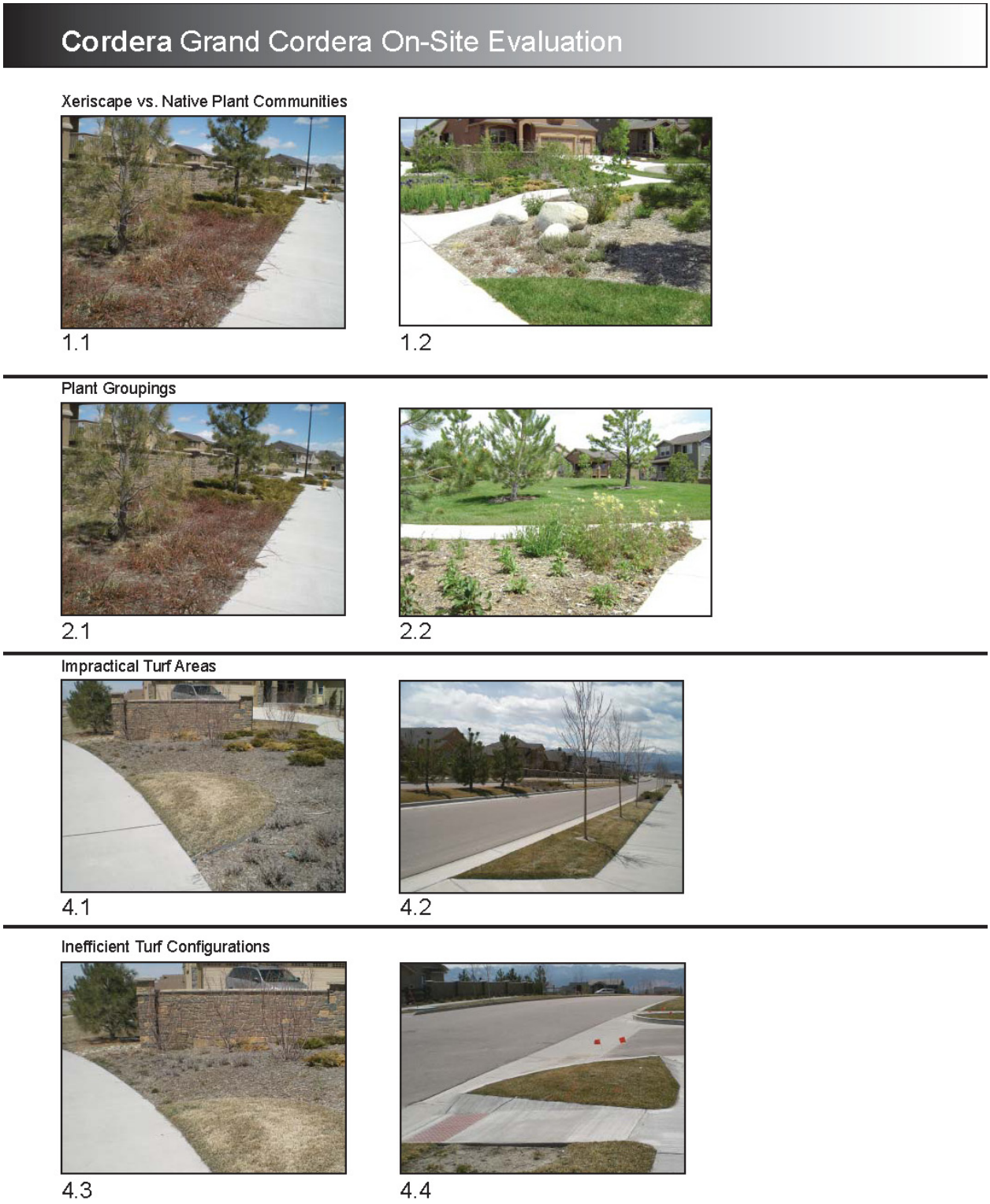

Figure 4-10 Cordera - Grand Cordera On-Site Evaluation Photos (Author, 4.11.08 & 6.11.08)

Cordera Happy Meadows	**Landscape** On Site **Evaluation Sheet**		
Landscape Evaluation Catagories	Observations	Photo #'s	Score
1 Planning and Design			
The landscape represents a site adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of plants.	The designed and built landscape uses a blend of native turf, drought tolerant plants, and turf grass. Landscapes installed according to plan.		1
Mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.	Slopes planted in native turf on Briargate Parkway close to 6:1. These slopes are difficult to maintain according to Timberline Landscape.	Cordera 1.1	1
2 Group Plants Accordingly / Hydrozoning			
Plants with similar water needs within each site micro-climate are zoned or grouped together.	Plants grouped according to approved designs.		1
3 Appropriate Plant Selection			
Landscape reflects the ecological context of the site using diverse plant species that are indicative of local plant communities. Based on the Landscape Code and Policy Manuals Prairie Region Plant Community.	Native plant communities are represented in plant material but overall planting scheme not indicative of surroundings.	Cordera 3.1, 3.2	1
Develop a project plant list from 1998 Landscape Code and Policy Manual to satisfy site category requirements. At least 60% of the trees and 60% of the shrubs must be signature plants for the chosen plant communities.	Design and installed according to regulations.		1
4 Limit Turf Areas to Those Needed for Practical Uses			
High water use turf is limited to high traffic or recreational areas, drainage swales or other appropriate uses.	High water use turf was used around areas of high visibility and throughout design with native turf. Although the bluegrass turf was limited it was still used in areas that wouldn't classify as practical.	Cordera 4.1	1
No more than 50% of the entire site is covered in high water use turf.	Less than 50% of the site is covered in high water use turf.		1
Turf is limited to slopes less than 6:1.			1
Turf is limited to medians greater than 12' in width.			1
Turf is prohibited in configurations that cannot be efficiently irrigated.	Opportunities for improvement in the landscape tract, but the majority of turf areas can be irrigated efficiently.		1
Turf is prohibited in motor vehicle lot planters that are less than 8' in width.			1
Limited amounts of turf in street right-of-ways where the distance between the curb and detached sidewalk is less than 8'.			1
5 Use of Efficient Irrigation Systems			
Method of irrigation matched to size and shape of area and plant material, and for uniformity coverage.	All shrub beds on drip irrigation.		1
Use of rain sensors on all system controllers.	Irrigation controllers all utilize rain sensors.		1
6 Schedule Irrigation Wisely			
Established irrigation schedules.	Schedule established in landscape plans and then adjusted in field by landscape managers.		1
7 Soil Analysis and Improvement			
Turf grass soil amended appropriately			1
Soil analyzed and amended appropriately.	Soil was inspected and amended according to Code Section 315.		1
8 Use of Mulch			
Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.	Mulches applied only when requested by community home owners association. Mulch depth was sufficient upon evaluation.		1
9 Provide Regular Maintenance			
Pruning	Plant material well maintained		1
Weeding	Weeding done on a weekly basis with pre-emergent being used routinely.		1
Mulching	Mulch depth was adequate overall.		1
Irrigation system maintenance	System checks four days a week according to landscape manager.		1

Table 4-6 Cordera – Happy Meadow Trails On-Site Evaluation Sheet

Cordera Happy Meadows On-Site Evaluation

Questionable Slopes

1.1

Xeriscape vs. Native Plant Communities

3.1

3.2

Impractical Turf Areas

4.1

Figure 4-11 Cordera – Happy Meadows On-Site Evaluation Photos (Author, 4.11.08 & 6.11.08)

Landscape Design

The results for the landscape design evaluation came from a combination of sources including approved landscape documents, the landscape evaluation forms, and interviews. The results from the evaluation indicate that all of the landscape tract designs were compliant to their respective regulations. Through the evaluation it was also found that not only did the communities of Cordera and Pine Creek have landscape designs that were compliant (scoring a 100% with all nine water-wise categories being fulfilled) to the regulations and guidelines set forth by the city and developer, they were also utilizing the water-wise principles in creative and aesthetic ways (Table 4-7). It was also discovered that even though the BBC landscape designs were found to be compliant to the landscape regulations for the BBC they did not utilize a diverse mixture of proven water-wise practices and were designed in more traditional landscape style with large areas of high water use turf.

Landscape Design Evaluation	Water-Wise Landscape Categories									
La Plata Properties	Planning and Design	Group plants accordingly/ Hydrozoning	Appropriate Plant Selection	Limit Turf Areas to Those Needed for Practical Uses	Use of Efficient Irrigation Systems	Schedule Irrigation Wisely	Soil Analyses and Improvement	Use of Mulch	Provide Regular Maintenance	**Total Score**
Pine Creek City Regulations after 1998	1*	1	1	1*	1*	1*	1	1	1	9
Cordera City Regulations after 1998 + Development Guidelines	1*	1	1	1*	1*	1*	1	1	1	9
Briargate Business Campus City Regulations before 1998	1*	1*	0	0	1*	0	0	0	0	3

1 = Regulation compliance
0 = Non-compliance

* Indicates that category was met but could be improved upon - see evaluation forms for more information

Table 4-7 Results from Landscape Design Evaluation

Landscape Installation and Maintenance

The results for the Landscape Installation and Maintenance evaluation also came from a variety of sources including the landscape on-site evaluation form, document review, and interviews. The assessment of the landscapes determined that compliance was seen in eight of the nine (88%) water-wise categories for the community of Pine Creek and nine of the nine (100%) water-wise categories in the community of Cordera. The water-wise category that was considered non-compliant in the Pine Creek evaluation was the soil analysis category. Non-compliance was determined from an interview with landscape managers and on-site

observations. Compliance for the Briargate Business Campus had mixed results with only two of the three (67%) landscape categories fulfilling the regulations and guideline requirements (Table 4-8).

Landscape Installation and Maintenance	Water-Wise Landscape Categories									
La Plata Properties	Planning and Design	Group plants accordingly/ Hydrozoning	Appropriate Plant Selection	Limit Turf Areas to Those Needed for Practical Uses	Use of Efficient Irrigation Systems	Schedule Irrigation Wisely	Soil Analyses and Improvement	Use of Mulch	Provide Regular Maintenance	**Total Score**
Pine Creek City Regulations after 1998	1*	1	1*	1*	1*	1*	0	1*	1	8
Cordera City Regulations after 1998 + Development Guidelines	1*	1	1*	1*	1*	1*	1	1	1	9
Briargate Business Campus City Regulations before 1998	1*	1*	0	0	0	0	0	0	0	2

1 = Regulation compliance
0 = Non-compliance

* Indicates that category was met but could be improved upon - see evaluation forms for more information

Table 4-8 Results from Landscape Installation and Maintenance Evaluation

The total point scores for the Landscape Site Evaluation indicate that the landscape tracts in the Pine Creek and Cordera communities are functioning water-wise landscapes that were developed based on Xeriscape methodology and can be expected to conserve water for the communities of Cordera and Pine Creek (Figure 4-12).

Figure 4-12 Cordera and Pine Creek Xeriscapes that were found to be compliant to landscape regulations (Author, 6.11.08)

In contrast, the total point score awarded to the BBC landscape tract indicates that a typical traditional landscape was installed and designed for the BBC and because of inefficiencies that have developed over the years and that surfaced in the evaluation portion of the study, the BBC landscape tracts can be expected to utilize water quantities that are equivalent or above normal traditional water use rates (Figure 4-13). At this point in the study it could be determined that the regulations that were in place in the communities of Pine Creek and Cordera were effective in creating water conserving landscapes through compliant design, installation, and maintenance practices.

Figure 4-13 Briargate Business Campus traditional landscape tracts (Author, 6.11.08)

Water Use

The water use evaluation was based on historical water use information collected from community homeowners associations and landscape managers. The results from the water use evaluation show that the results from the regulation evaluation and the resulting rankings were reflected in the individual landscape tracts water use, Cordera having the lowest water use followed by Pine Creek and Briargate Business Park. For the purpose of the study two comparisons were developed to evaluate the overall effectiveness of the three selected landscape regulations. The first comparison developed for the study compared the landscape tracts water use to the historical E.T. of turfgrass in Colorado Springs. The second comparison developed for the study compared the evaluation results of the three selected landscape regulations to determine if changes made to landscape regulations and guidelines through time made an impact in water use and overall effectiveness of landscape regulations.

Water Use Compared to Historical Turfgrass E.T.

The water use for each landscape tract will be compared to the historical crop coefficient for bluegrass turfgrass in the Colorado Springs area. For the purpose of the study, the bluegrass E.T. will be representative of the traditional landscape that is typically dominated by high-water use-turf.

Briargate Business Campus

The first three evaluations conducted on the Briargate Business Campus landscape tracts determined that although the original landscape regulations encouraged the implementation of a quality landscape there were very few regulations in place that encouraged the implementation of the Xeriscape principles. The resulting landscape designs and landscapes for the Briargate Business campus were dominated by bluegrass and utilized very few water-wise landscape practices. With a traditional landscape installed it could be expected that the Briargate Business Campus would be using a similar amount of water as bluegrass turf or that of a traditional landscape. The comparison between the landscape water use of the Briargate Business Campus (**57.60**) and the historical turfgrass E.T. (**33.77**) reveals that the landscape tracts were using amounts of water that were in excess of the needs of a traditional landscape (Table 14-9).

Growing Season Month	Briargate Business Campus 2006	Briargate Business Campus 2007	Briargate Business Campus Research Parkway 2006	Briargate Business Campus Monthly Average	2006 Colorado Springs E.T.	2007 Colorado Springs E.T.	Colorado Springs Average E.T. for 2006 - 2007
April	0.00	0.00	4.32	0.00	4.26	3.09	3.68
May	4.95	0.61	7.87	2.78	5.39	4.62	5.01
June	9.10	7.41	9.40	8.25	6.89	5.74	6.32
July	13.12	14.73	8.68	13.93	6.41	6.49	6.45
August	13.76	8.17	6.74	10.97	5.31	6.17	5.74
September	10.80	14.28	7.10	12.54	3.41	4.57	3.99
October	8.69	9.57	7.80	9.13	2.25	2.93	2.59
Total Water Use	**60.42**	**54.77**	**51.91**	**57.60**	**33.92**	**33.61**	**33.77**

* All Water Use Numbers Expressed in Inches Per Square Foot
Red numbers indicate missing data that was estimated from previous years water use data

Table 4-9 Historical Water Use Data for Briargate Business Campus: *Analysis of water use in Briargate Business Campus was conducted using two different landscape tract areas because of limited access to 2007 billing information. The 2007 billing for Briargate Business Campus could not be separated into individual meters so water use numbers for the entire Briargate Business Campus were used for the 2007 growing season. In the first analysis, 2006 and 2007 water use data for the entire Campus was utilized. In the second analysis, 2006 water use data for the Research Parkway landscape tract was utilized. In the final analysis the results revealed above average water use in both landscape tracts.*

The water use comparison shows that the landscapes within Briargate are utilizing **70%** more than the estimated E.T. for turfgrass in Colorado Springs, indicating that there are significant inefficiencies within the landscape and irrigation system. Upon further research and analysis of a report compiled by Keesen Water Management, Inc. it was discovered that the irrigation system within the campus is in disrepair and is no longer functioning at efficient levels. The report discusses the need for turf removal in all medians, replacement of pop-up sprays in all planting beds with drip irrigation, the adjustment of irrigation clocks to account for site soils, replacement of rain sensors, and the eventual replacement of the entire irrigation system (Keesen, 2007). Through the evaluation it was not only discovered that the regulations and landscape had very few Xeriscape principles installed, but because of an inefficient irrigation system the traditional style landscape is using even more water than what is required by a turf dominated landscape (Figure 4-14).

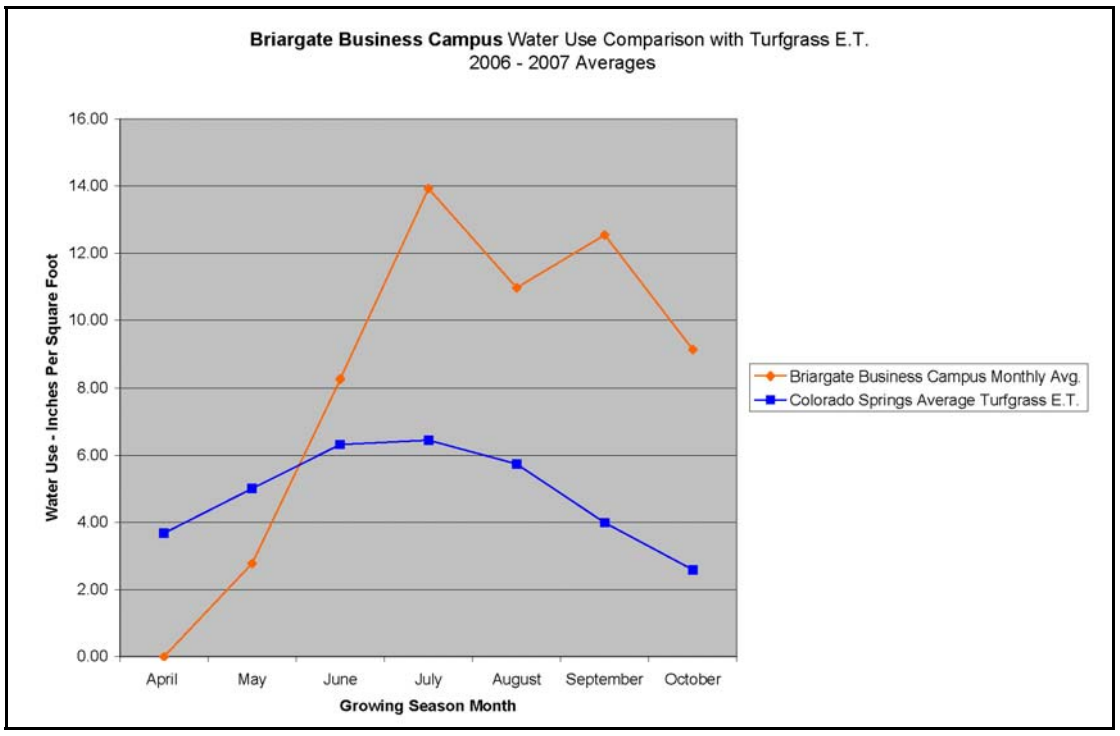

Figure 4-14 Water Use Comparison – Briargate Business Campus landscape tracts using water well beyond the required amount

Pine Creek

Through the first three evaluations measuring the regulations, design, and installation/maintenance of the landscape tract it was determined that the landscape that was designed and installed in the Pine Creek development had a significant number of applied Xeriscape principles. Based on the results of past Xeriscape research studies (Medina, 2004; Sovocal, 2006), it was expected that the landscapes installed in the Pine Creek Community that utilized the Xeriscape principles show a significant water savings when compared to the E.T. rates of a traditional turfgrass dominated landscape tracts. In the analysis of the water use numbers for the landscape tracts in Pine Creek it was discovered that the two landscape tracts that were evaluated in the Pine Creek community where in fact conserving water on a monthly basis but did contain water use spikes that diminished the water savings of the Xeriscape. The analyses of the individual tracts are described below.

Pine Creek's Oak Meadow landscape tract had a total growing season water use average that was above the historical E.T. water use for the area. The numbers indicate that even though the landscape tracts were designed and installed in compliance to the Xeriscape principles in the city regulations they were not performing as water-wise landscapes. Upon closer analysis it was determined that three months within the evaluation, May and June of 2006 and August of 2007, are the cause for the high water use totals for the landscape tracts (Table 4-10). During a follow up interview with the landscape management company for Pine Creek it was discovered that the native landscape tracts that are typically independent of the irrigation system were watered during the months that experienced water use spikes. Without excluding the high water use months from the study, the Oak Meadow landscape tract would be using **11%** more water (**37.46**) than what is typically required by a traditional or turf dominated landscape (**33.77**) and would prove the regulations ineffective in saving water. If the high use months were normalized for the evaluation using typical water use numbers in the months that experienced water spikes, the landscape tracts water use for the 2006 and 2007 growing season would be (**25.18**) with a water savings of **22%**.

This evaluation indicates that in order for regulations to achieve higher levels of conservation and improve overall effectiveness that more consideration should be given to the scheduling of irrigation systems. The scheduling of irrigation system category happened to be one of the lowest scoring water-wise landscape categories for the Pine Creek landscape tract and

also one of the causes for the water-use spikes in the high water use months charted in 2006 and 2007.

Growing Season Month	Pine Creek Oak Meadow 2006	Pine Creek Oak Meadow 2007	Pine Creek Oak Meadow Monthly Avg.	2006 Colorado Springs E.T.	2007 Colorado Springs E.T.	Colorado Springs Average E.T. for 2006 - 2007 Growing Season
April	6.12	0.35	3.24	4.26	3.09	3.68
May	10.68	2.72	6.70	5.39	4.62	5.01
June	8.46	2.92	5.69	6.89	5.74	6.32
July	4.44	2.24	3.34	6.41	6.49	6.45
August	4.49	22.48	13.48	5.31	6.17	5.74
September	2.85	3.49	3.17	3.41	4.57	3.99
October	1.08	2.58	1.83	2.25	2.93	2.59
Total Water Use	**38.14**	**36.78**	**37.46**	**33.92**	**33.61**	**33.77**

* All Water Use Numbers Expressed in Inches Per Square Foot
Red numbers indicate missing data that was estimated from previous years water use data

Table 4-10 Historical Water Use Data for Pine Creek's Oak Meadow

Pine Creek's Orchard Park landscape tracts (**21.10**) showed considerable water savings when compared the average turfgrass E.T. for Colorado Springs (**33.77**) (Table 4-11). A savings of **38%** was calculated for the Orchard Park landscape tract. The savings found fits within the range of expected water use savings by a Xeriscape (20%-50%) and proves the city regulations to be effective in the landscape tracts (Medina, 2004; Sovocal, 2006).

Growing Season Month	Pine Creek Orchard Park 2006	Pine Creek Orchard Park 2007	Pine Creek Orchard Park Monthly Avg.	2006 Colorado Springs E.T.	2007 Colorado Springs E.T.	Colorado Springs Average E.T. for 2006 - 2007 Growing Season
April	0.00	0.00	0.00	4.26	3.09	3.68
May	5.37	1.42	3.40	5.39	4.62	5.01
June	3.83	4.28	4.05	6.89	5.74	6.32
July	3.15	11.14	7.15	6.41	6.49	6.45
August	2.30	4.40	3.35	5.31	6.17	5.74
September	1.82	2.62	2.22	3.41	4.57	3.99
October	0.51	1.36	0.93	2.25	2.93	2.59
Total Water Use	**16.99**	**25.22**	**21.10**	**33.92**	**33.61**	**33.77**

* All Water Use Numbers Expressed in Inches Per Square Foot
Red numbers indicate missing data that was estimated from previous years water use data

Table 4-11 Historical Water Use Data for Pine Creek's Orchard Park

Overall the landscape tracts within the Pine Creek Community functioned as Xeriscapes with a water savings in the expected range. Although there were several months where the water use was higher than expected, the water use on average was lower in each growing season month, with 11 of the 14 months (7 months for each landscape tract) showing a water savings (Figure 4-15). During the water use evaluation it became evident that even though a xeric

landscape might result from the implementation of landscape regulations and guidelines the landscape will not perform as such unless it is managed and maintained properly.

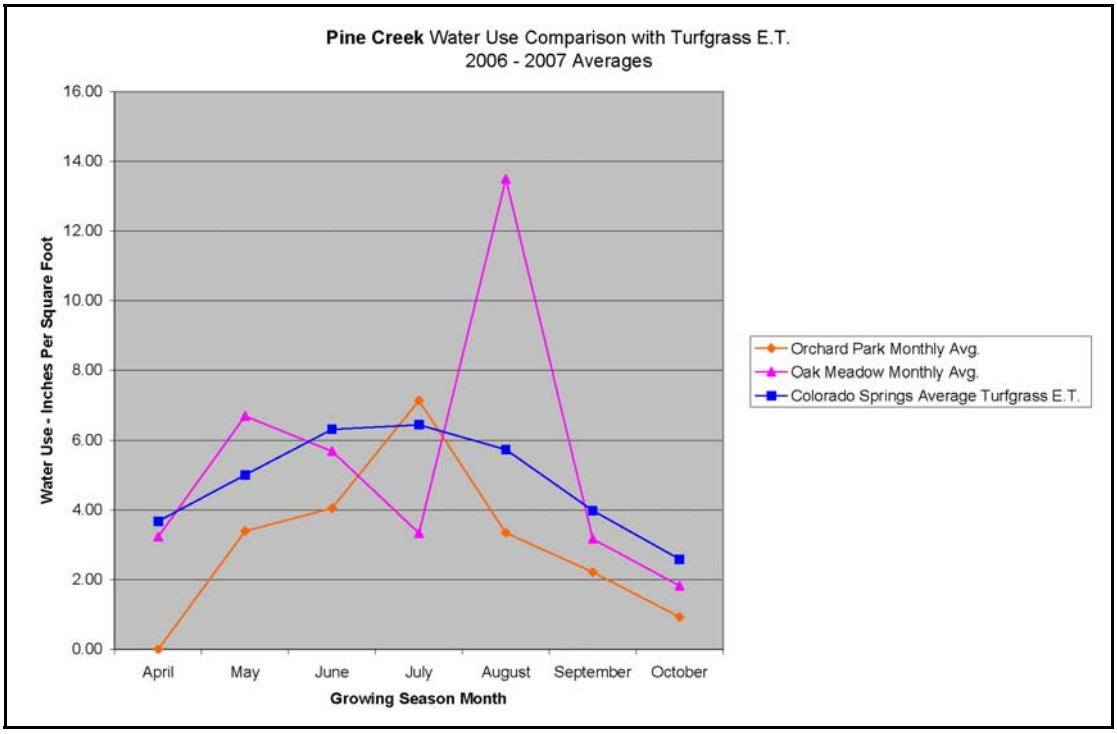

Figure 4-15 Pine Creek Water Use Comparison Chart – Pine Creek landscape tracts functioning as water conserving landscapes except for a few select months that contain water use spikes

Cordera

Through the first three evaluations for Cordera the landscape regulations were found to be very thorough in terms of applied Xeriscape principles in the landscape regulations and guidelines, designs, and installed landscapes. The regulations and guidelines that were implemented in the Cordera landscapes were based on the same city regulations as Pine Creek with the added value of community guidelines that also supported the conservation of water. With the combination of the city regulations and the community guidelines it was expected that water use savings from the Cordera landscape tracts would be comparable to the water savings of Xeriscapes in past research studies. In fact the water use findings indicated that the landscape tracts are functioning as water conserving landscapes showing a water savings of **55%** or greater (Table 4-12). The analysis of the two landscape tracts within the Cordera community showed

similar savings and water use trends. The water use in the Grand Cordera landscape tract showed a water use of **15.05** and water use savings of **55%**.

Growing Season Month	Cordera Grand Cordera 2006	Cordera Grand Cordera 2007	Cordera Grand Cordera Monthly Avg.	2006 Colorado Springs E.T.	2007 Colorado Springs E.T.	Colorado Springs Average E.T. for 2006 - 2007 Growing Season
April	0.00	0.69	0.34	4.26	3.09	3.68
May	0.32	0.56	0.44	5.39	4.62	5.01
June	5.00	4.93	4.97	6.89	5.74	6.32
July	3.07	5.24	4.15	6.41	6.49	6.45
August	3.30	3.51	3.41	5.31	6.17	5.74
September	2.52	0.12	1.32	3.41	4.57	3.99
October	0.75	0.11	0.43	2.25	2.93	2.59
Total Water Use	**14.95**	**15.15**	**15.05**	**33.92**	**33.61**	**33.77**

* All Water Use Numbers Expressed in Inches Per Square Foot
Red numbers indicate missing data that was estimated from previous years water use data

Table 4-12 Historical Water Use Data for Cordera's Grand Cordera

Cordera's Happy Meadow landscape tract was unique in the fact that the landscapes were not installed until the summer of 2006. Because of this the water use data for the 2007 growing season was used exclusively for the Happy Meadows landscape tract. The 2007 water use data shows a water use of **12.35** and a savings of **63%** when compared to the water use of the traditional turfgrass landscape represented by the Colorado Springs E.T. average in the study. This percentage of savings is consistent with the savings seen in the Grand Cordera landscape tract that was also evaluated (Table 4-13).

Growing Season Month	Cordera Happy Meadows 2006	Cordera Happy Meadows 2007	Cordera Happy Meadows Monthly Avg.	2006 Colorado Springs E.T.	2007 Colorado Springs E.T.	Colorado Springs Average E.T. for 2006 - 2007 Growing Season
April	0.00	0.07	0.03	4.26	3.09	3.68
May	0.00	0.65	0.32	5.39	4.62	5.01
June	0.00	1.99	0.99	6.89	5.74	6.32
July	0.02	3.93	1.97	6.41	6.49	6.45
August	2.25	1.92	2.09	5.31	6.17	5.74
September	1.92	1.89	1.91	3.41	4.57	3.99
October	0.22	1.91	1.07	2.25	2.93	2.59
Total Water Use	**4.42**	**12.35**	**8.39**	**33.92**	**33.61**	**33.77**

* All Water Use Numbers Expressed in Inches Per Square Foot
Red numbers indicate missing data that was estimated from previous years water use data

Table 4-13 Historical Water Use Data for Cordera's Happy Meadow

It could be concluded from the analysis that the landscape regulations and guidelines that are in place in the Cordera community are effective tools of water conservation with a consistent savings that is well below the estimated water use for a traditional bluegrass turf dominated landscape tract (Figure 4-16).

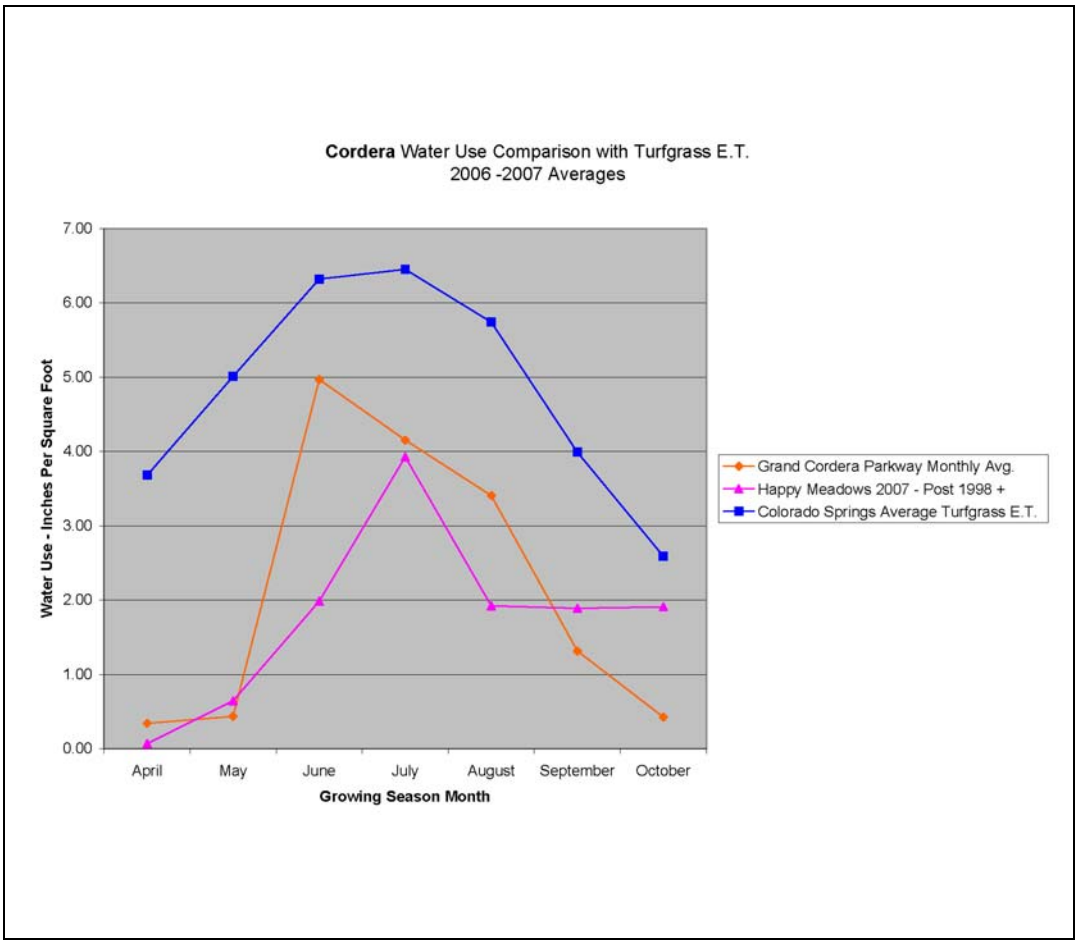

Figure 4-16 Cordera Water Use Comparison Chart – Cordera landscape tracts functioning as water conserving landscapes

Water Use Comparison – Landscape Regulations

Water use comparison between the three landscape regulations shows that a relationship exists between the number of Xeriscape based water conservation principles cited and the amount of water that can be saved within a landscape (Figure 4-17). In the study it was found that as the number of Xeriscape principles applied in the landscape tract increased the water use of the landscape tracts diminished. The comparison between the Landscape tracts of Cordera and Pine Creek indicated that water management practices of Xeriscape landscapes is a very important piece of achieving water conservation. The similarities between the two regulations, landscape designs, and installed landscapes indicated that the water savings between the two landscape tracts would also be similar, but upon evaluation it was discovered that several

management decisions made in the Pine Creek development resulted in several spikes that almost doubled the average water use for the 2006-2007 growing season.

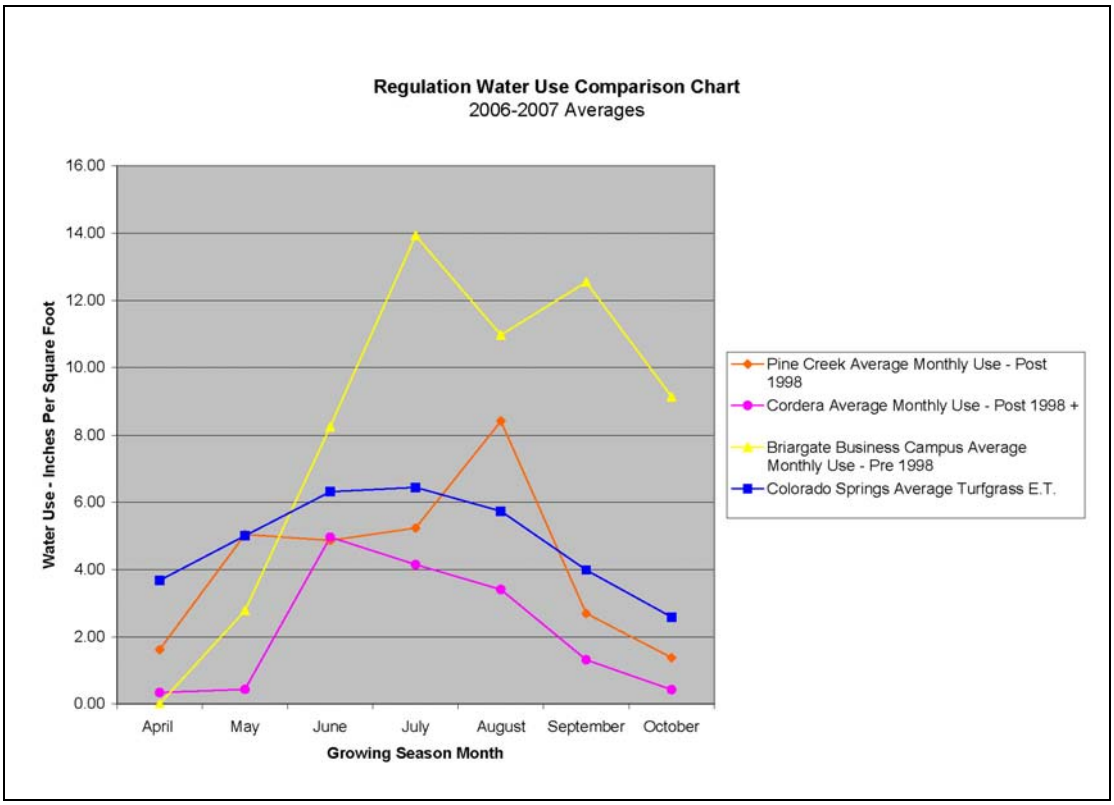

Figure 4-17 Regulation Water Use Comparison Chart – Comparison of all three regulations evaluated in the study

The comparison of the landscape tracts installed after the 1998 landscape code and policy change and the landscape tracts developed before 1998 exemplifies the need for regulations that encourage and enforce water conservation principles. The traditional landscape that resulted from the pre-1998 policies water use during the 2006 and 2007 growing season was often in excess of two times the water use of the landscape tracts that were developed under the current landscape codes and policies that encouraged water conservation. From this comparison it can be determined that both of the landscape regulations established after 1998 can be considered effective tools of water conservation.

Overall Analysis

The Post 1998 Landscape tracts that are based off of the 1998 City Landscape Code and Policy Manual are successful Xeriscapes with water savings varying from 10% to 65%. The city landscape regulations that have formed the Pine Creek and Cordera landscape tracts are diverse in terms of water-wise categories cited within the regulations and are also successful in the enforcement of the citations in the landscape designs and physical landscapes. In contrast the city landscape regulations and La Plata Communities Guidelines before 1998 had very few regulations that focused on water conservation and were mostly oriented towards the implementation of a quality traditional landscape. Overall, the effectiveness of the City of Colorado Springs Landscape Code and Policy Manual that was established in 1998 can be considered an effective tool for water conservation. It was also discovered that the additional landscape guidelines such as the ones produced in the Cordera design and guideline manual that specify additional soil amendments, document submittals, designer qualifications, and irrigation restrictions can also produce additional water savings in the landscape when written in a restrictive manner that holds the landscape designers, installers, and managers accountable for their decisions.

Strengths

There were two important strengths in the successful landscape regulations found in the study. The first strength of the successful landscape regulations was the diversity in the water-wise landscape practices that were enforced in the landscape regulations. The post 1998 landscape regulations that were shown to be a successful tool for water conservation both had diverse regulations that spanned the nine (9) water-wise categories of the study. The second strength that was discovered was the implementation of a regulation that balanced the use of water-wise citations, submittals, and inspections. Again the successful regulations in the study utilized an inspection and submittal system that held designers, contractors and managers accountable for their decisions. Another commonality that both successful landscape regulations shared was the high scoring in the Planning and Design, Use of Efficient Irrigation Systems, and Soil Analysis categories.

Weaknesses

The common weakness in the landscape regulations that were analyzed was the lack of landscape codes, policies, and guidelines that targeted the proper maintenance and scheduling of irrigation systems. It was especially evident in the Pine Creek landscape tract where the evaluations proved that the landscape tract was designed and installed in compliance to all of the Pine Creek Regulations but was still using water in excess of the estimated water use of traditional landscapes. It was discovered that the excess water use was because of management decisions, often times driven by home owner association observations, that were made in the field pertaining to the irrigation of the Xeriscapes. If code, policies, or guidelines could be established to standardize management of the irrigation and Xeriscape then the landscapes would be more likely to perform as they were intended and less likely to be maintained erratically by home owners associations demands.

Another weakness that was identified in the Pine Creek landscape tracts was the lack of proper soil amendments. Although proper procedures regarding the analysis and specification of soils were followed in the design process, the plant material in the field was showing stressed conditions that could be related to poor soil conditions and the lack of proper amendment in the installation process. To improve upon this weakness, inspections pertaining to the amendment and testing of site soils throughout the construction process could be specified in landscape regulations. Additional inspections could help assure that proper amendment practices are implemented correctly in the field.

Future Recommendations

If cities were to undertake the formation of landscape regulations that were intended on saving water in the designed landscape I would recommend creating a restrictive policy that was based off of all of the Xeriscape landscape principles. It is important that future regulations represent all of the Xeriscape principles with not only citations but also enforcement of the citations with required submittals and inspections. Another aspect that I would strongly recommend would be the required submittal of landscape and irrigation management plans to ensure the quality of the landscape is maintained into the future. I cannot stress enough, and it was more than evident in the results of the study, the importance for strict restrictions on the water-wise categories that applied to landscape irrigation.

Overall, the Pine Creek and Cordera landscape regulations, designs, and physical landscapes make excellent examples for the construction of future landscape regulations and guidelines. The diversity of codes, policies, and guidelines provided an important reference and framework for the development of the landscape designs, installation, and maintenance. Diversity is an especially important piece of the Xeriscape methodology because all of the Xeriscape principles function at a much higher level when they are functioning as a system and not just a single remedy. Another facet of the Cordera and Pine Creek regulations that allowed for success was the enforcement of the cited landscape codes, policies, and guidelines. The regulations that were established made sure that installing a water-wise landscape was no longer an option but should be a priority in the common spaces in developments. The submittals and inspections that were part of the city regulations and Cordera community guidelines played a critical role in the near perfect compliance scores that the Cordera and Pine Creek landscape tracts achieved in the landscape design and installation evaluations.

CHAPTER 5 - CONCLUSIONS

This case study examined the effectiveness of three landscape regulations as a method of water conservation in development open space. The landscape regulations and their representative landscape tracts that were evaluated for the study represented several time periods of design, construction, and technology in the city of Colorado Springs. By evaluating the variety of landscape regulations the effectiveness of certain landscape codes, policies, and guidelines were measured and evaluated for future application. The results indicate that the regulations and development guidelines based on the City of Colorado Springs 1998 City Landscape Code and Policy Manual were effective tools of water conservation where as the city landscape regulations and development guidelines developed before the 1998 Code and Policy manual were not in fact functioning as water conserving landscape regulations.

Major Conclusions and Results

Through the case study it was determined that there were several major contributing factors to the success of the post 1998 landscape regulations. The three major factors identified in the results were: (**1**) the diversity of water-wise categories that are represented within applicable landscape regulations, (**2**) the balance of citations and enforcement within the applicable regulations, and (**3**) the enforcement of landscape management plans. The successful landscape tracts utilized all three factors to effectively save significant amounts of water when compared to the pre-1998 landscape tract and the historical E.T. for bluegrass.

Diversity

The diversity of water-wise categories found in the post 1998 landscape regulations was an important trend seen within the effective landscape regulations. The diversity of applied categories insured that the Xeriscape principles found within the landscape tracts were able to function as a sound horticultural system within the landscape tracts. Without all of the water-wise categories being represented in the landscape tract there would be significant voids that would eventually lead to reduced and inconsistent water savings in the landscape tract. An

example of a regulation void would be a landscape design that utilized proper hydrozoning and plant selection but had poor soil conditions, this situation would eventually lead to unhealthy plants and in some cases overwatering because of the stressed conditions.

Balance

The balance of water-wise citations with the enforcement of the citations through inspections and approvals was another trend that was found in successful landscape regulations. The regulations that achieved balance between citation and enforcement were found to have landscape designs and landscape products that complied with the regulations intentions. Pine Creek's and Cordera's landscape regulations are both great examples of citation and enforcement balance. The community's landscape tracts are a testament to this effectiveness with near perfect compliance scores in both the design and installation evaluations. A perfect compliance score could have been achieved in the Pine Creek landscape tracts if one more inspection of the soil amendment process was required in the landscape regulations.

Management

At the beginning of the study it was anticipated that even though landscape regulations would encourage and at times enforce the use of Xeriscape principles that landscape management, specifically the management of irrigation water, would diminish the overall effectiveness of the Xeriscape based regulations. Although the majority of the findings disprove the anticipated results, there were indications that the diverse and balanced regulations/guidelines and Xeriscapes in the Pine Creek and Cordera developments were still vulnerable to management decisions. For example the water use spikes found in the Pine Creek Oak Meadow landscape tract. These results indicate that there is still room for improvement within the codes, policies, and guidelines that deal with the management and scheduling of irrigation systems in development open spaces. It can be assumed that more restrictive regulations on the preparation of landscape management plans and water budgets could lead to more consistent and greater water savings.

The drastic difference between the water use of the pre and post 1998 regulations exemplifies the importance of landscape regulations and the implementation of water conservation programs within communities. The irrigation audit conducted by Keesen Water Management for the system in place at BBC indicated that there were many maintenance issues

within the system that resulted in high water use for the development. The inefficiency within the BBC system is also an indication that regulations pertaining to the maintenance and inspection of irrigation systems are needed to increase the longevity of irrigation systems efficiency over time.

Water-Wise Improvements

Although each water-wise category was fulfilled according to the strict interpretation of the landscape codes policies and guidelines for Pine Creek and Cordera, there were many opportunities to improve upon the efficiency of the landscapes themselves and the management of the landscapes. Irregular turf areas, turfgrass being used in non-practical areas, poor soil amendments, and mulching schedules were all areas that were found to be in compliance to the written regulations but still had potential for improvement. Improvement in the listed water-wise categories could lead to more consistent and additional water savings in the landscape tracts.

Recommendations for Future Research

The study findings indicate that there is a relationship between the use of water-wise landscape regulations and a decrease in water use in the designed landscape. The study's findings along with the study's evaluation scores and methodology could be used not only in the formation of future landscape regulations, but also in the formation of future research projects. Three potential research projects are outlined below:

1. One future research project would be to apply the same methodology that was used to evaluate the Colorado Springs landscape regulations to other regional regulations and landscapes. Additional evaluations could be used to establish a more informed conclusion on the effectiveness of landscape regulations that target water conservation, and could further discover the importance of each of the nine-water-wise landscape categories in those regulations. With the additional data and a greater understanding it is more likely that communities could create successful landscape regulations and eventually save substantial amounts of water.

2. Assess the economic gains that can be achieved by implementing effective water conserving landscape regulations in landscape common areas, taking into account the economic gains that could be achieved by communities, businesses, cities, and water providers. The study could analyze the cost savings that developers could achieve by implementing Xeriscapes in development common areas and the time it would take to achieve a benefit (return) from their investment. The study could also assess the amount of water that could be saved over time within a specific development and what that savings would mean in terms of reducing infrastructure expansion and maintenance costs. If a further understanding of the economic gains, achieved by water-conscious regulations, could be developed it could help stress the value of conservation practices to community governments and the general public.

3. Evaluate the landscape preferences of community residents in regards to living in communities that have implemented Xeriscapes to living in communities that have traditional landscapes. The study could also evaluate the aesthetic strengths and weaknesses in Xeriscapes that have already been established. Results from the preference studies could be used by developers and cities to implement Xeriscapes in a more marketable way.

Summary

Water conservation is quickly becoming a necessity not only in the City of Colorado Springs but throughout Colorado's Front Range. As communities grow and supplies become less predictable, cities will be turning towards conservation measures, including the use of landscape water regulations, to reduce demand and improve water efficiency in the designed landscape. As it was observed in the study, regulations when written and enforced correctly can be powerful water conservation tools and will become a critical piece to future conservation programs in Colorado. It was the intent of the study to provide a base of information to landscape architects, citizens, communities, and developers for the crafting of effective conservation programs that ensure that water savings can be achieved while maintaining the aesthetic standards of communities.

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Appendix A - Landscape Regulation Citations

Strength of Regulation Scoring
1 point for citation (C)
1 point for required submittal (S)
1 point for required inspection (I)

Briargate Business Campus Regulation Evaluation

Planning and Design

- Guideline 2.6

The Architectural Plans and Site Plan may be submitted following Development Plan Review or the applicant may submit them with the Development Plan Review to expedite the process. The applicant shall prepare and submit to the ARC **six** copies of the Site Plans, Architectural Plans and Signage Plan.

- Guideline 2.8

Upon completion of construction, the applicant will submit a Notice of Completion and the ARC will inspect the property within fifteen working days. The purpose of the inspection is to determine if the improvements have been constructed or installed consistent with the approved plans and to determine that all other aspects of site development are in compliance with the Declaration.

- Guideline 3.5

Grading standard for planting beds are minimum slopes at 2% and maximum slopes at 3:1.

- Guideline 5.2.2

The irrigation plan required for ARC review shall be prepared by a qualified irrigation designer.

Group Plants Accordingly / Hydrozoning

- Guideline 5.1

Care should be given to promote water conservation through grouping plants of similar water requirements and proper installation procedures, thus allowing for efficient irrigation design and operation.

Use Efficient Irrigation Systems

- Guideline 5.2.2

Spray irrigation directly on paved surfaces is strongly discouraged.

Pine Creek Regulation Evaluation

Planning and Design

- Code Section 309 C

Provide inspection affidavit by qualified designer.

- Code Section 311 B

The landscape plan shall present a site-adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of signature plants.

- Policy 311 G

Develop a plan that takes into account both the regional climate and the microclimate of the site, existing vegetation and topography, the proposed use of the property, and grouping plants.

- Code Section 312 A

The required landscape plan shall be prepared by a person who meets the qualifications established in the professional qualifications standards of the landscape policy manual.

- Policy 312 1

Professional qualifications needed to prepare required plans. Qualifications shall be certified and submitted with the plan.

- Code Section 313 C

The landscape grading plan shall be consistent with the landscape and irrigation plans and shall ensure: the provision of adequate and proper drainage for survival of plant material, the stockpiling and redistribution of beneficial topsoil, the mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.

Group Plants Accordingly / Hydrozoning

- Policy 311 I

Develop a Schematic Landscape Diagram of the site that shows the general location and type of each plant community and hydrozone to be used. The diagram must be submitted to the city for approval.

- Code Section 312 E

Plants with similar water needs within each site microclimate shall be zoned or grouped together for efficiency of water application, to prevent water waste and to provide optimum application of water to the plants.

- Code Section 312 H

The schematic landscape diagram of plant communities and hydrozones is attached or shown clearly/separately on the plan.

Appropriate Plant Selection

- Code Section 311 D

Where reasonable, the landscape plan shall reflect the ecological context of the site by the use of diverse plant species indicative of local plant communities.

- Policy 311 K

Develop a project plant list from Appendix B to satisfy site category requirements. At least 60% of the trees and sixty percent of the shrubs must be signature plants for the chosen plant communities.

- Code Section 312 H

Climate zone and plant communities to be used noted from Figure 4, Climate Zones for Signature Landscape map, of Policy 311.

Limit Turf Areas to Those Needed for Practical Uses

- Policy 311 G

Determine function of high water-use turf on the site and limit it to high traffic or recreational areas, drainage swales or other appropriate uses.

- Policy 317 2

Restrictions on Use of high water use turf.

- No more than 50% of the entire site shall be covered.
- Prohibited on slopes steeper than 6:1 gradient.
- Prohibited in medians less than 12’ wide.
- Prohibited in configurations that cannot be efficiently irrigated
- Prohibited in motor vehicle lot planters less than 12’ wide.

- Discouraged in street right-of-way where curb and detached sidewalk is less than 8’ wide.
- Discouraged where not utilized for a functional purpose.

Use of Efficient Irrigation Systems

- Code Section 309 C

Provide inspection affidavit by qualified designer.

- Policy 309 3. A

Functional test of the irrigation system shall be performed.

- Code Section 314 B4

Irrigation systems shall conform to the irrigation standards and all other provisions of the Landscape Code and Landscape Policy Manual. Provide all plan information required in Figure 7.

Schedule Irrigation Wisely

- Code Section 314 E

City Planning may require the formulation of an irrigation management plan in conformance with the standards of the Landscape Policy Manual for large complex projects.

- Policy 311 G

Water only when plants need it and deeply to encourage root growth for a healthier, more drought tolerant landscapes.

Soil Analysis and Improvement

- Policy 311 G

Analyze several samples of soil to determine the soil types of the site so that appropriate amendments can be added.

- Code Section 312 H

Soil analysis report, from an established soil analysis laboratory.

- Code Section 312 H

Description of soil preparation and amendments per soil analysis.

- Code Section 315 B

Topsoil shall be stockpiled during construction for use in landscape areas prior to planting.

- Code Section 315 C

Soil amendments to improve water drainage, moisture penetration or retention, and nutrient availability shall be provided as determined by the soil analysis. Tilling of the soil to incorporate amendments and counter any compaction or soil consolidation shall be required for all landscape planting areas. Soil preparation shall be consistent with the cultural needs of the plant species proposed for each site category.

Use of Mulch

- Policy 311 G

Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.

- Code Section 317 E10

Organic mulches shall be required in all non-turf planting areas.

Provide Regular Maintenance

- Code Section 310 A

Landscape must complete a compliance inspection 2 years after the initial landscape installation.

- Policy 311 G

Preserve the beauty and water efficiency of the landscape through regular pruning, weeding, mulching, and irrigation system maintenance.

- Policy 319

Landscape managers shall use accepted maintenance practices in the constructed landscape.

Cordera Regulation Evaluation

Planning and Design

- Guideline 2.2

Plans and specifications showing the nature, kind, shape, color, size, materials and location of all proposed exterior structures and improvements (including landscaping) shall be submitted to the DRB or MC for review and approval PRIOR TO INSTALLATION. Incomplete or illegible submittals will be returned to the applicant without review. Except for the conversion of garages to living space, any interior of a residence may be modified without DRB or MC approval.

- Guideline 2.6

If and when submission of plans to the City, Pikes Peak Regional Building Authority or any other governmental agency is required, those plans must be reviewed and approved by the DRB first. Exceptions to this must be granted in writing from the DRB.

- Code Section 309 C

Provide inspection affidavit by qualified designer.

- Code Section 311 B

The landscape plan shall present a site-adapted design with regard to soil type, microclimate, vegetative cover, efficient water use, grouping of signature plants.

- Policy 311 G

Develop a plan that takes into account both the regional climate and the microclimate of the site, existing vegetation and topography, the proposed use of the property, and grouping plants.

- Code Section 312 A

The required landscape plan shall be prepared by a person who meets the qualifications established in the professional qualifications standards of the landscape policy manual.

- Policy 312 1

Professional qualifications needed to prepare required plans. Qualifications shall be certified and submitted with the plan on Appendix 1.

- Code Section 313 C

The landscape grading plan shall be consistent with the landscape and irrigation plans and shall ensure: the provision of adequate and proper drainage for survival of plant material, the stockpiling and redistribution of beneficial topsoil, the mitigation of slopes that are difficult to vegetate or irrigate, or would result in water runoff onto paved surfaces.

Group Plants Accordingly / Hydrozoning

- Policy 311 I

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The schematic landscape diagram of plant communities and hydrozones is attached or shown clearly/separately on the plan.

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Climate zone and plant communities to be used noted from Figure 4, Climate Zones for Signature Landscape map, of Policy 311.

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- No more than 50% of the entire site shall be covered.
- Prohibited on slopes steeper than 6:1 gradient.
- Prohibited in medians less than 12’ wide.
- Prohibited in configurations that cannot be efficiently irrigated
- Prohibited in motor vehicle lot planters less than 12’ wide.
- Discouraged in street right-of-way where curb and detached sidewalk is less than 8’
- Discouraged where not utilized for a functional purpose.

Use of Efficient Irrigation Systems

- Guideline 4.4.2

Drip irrigation required on all shrub beds.

- Guideline 4.5.2

Low angled spray heads are recommended adjacent to paved areas.

- Guideline 4.5.2

Water efficient irrigation system parts and maintenance practices are encouraged and shall include, but not be limited to the following:

a. Multi programmable irrigation controller

b. Master valve

c. Rain Sensor

d. Check valves

e. Routine maintenance of system

f. Subterranean irrigation

- Code Section 309 C

Provide inspection affidavit by qualified designer.

- Policy 309 3. A

Functional test of the irrigation system shall be performed.

- Code Section 314 B4

Irrigation systems shall conform to the irrigation standards and all other provisions of the Landscape Code and Landscape Policy Manual. Provide all plan information required in Figure 7.

Schedule Irrigation Wisely

- Code Section 314 E

City Planning may require the formulation of an irrigation management plan in conformance with the standards of the Landscape Policy Manual for large complex projects.

- Policy 311 G

Water only when plants need it and deeply to encourage root growth for a healthier, more drought tolerant landscapes.

Soil Analysis and Improvement

- Guideline 4.5.1

All turf areas will be amended with a minimum of three cubic yards per 1000 square feet of an acceptable soil amendment, tilled to a minimum depth of three to four inches.

- Policy 311 G

Analyze several samples of soil to determine the soil types of the site so that appropriate amendments can be added.

- Code Section 312 H

Soil analysis report, from an established soil analysis laboratory.

- Code Section 312 H

Description of soil preparation and amendments per soil analysis.

- Code Section 315 B

Topsoil shall be stockpiled during construction for use in landscape areas prior to planting.

- Code Section 315 C

Soil amendments to improve water drainage, moisture penetration or retention, and nutrient availability shall be provided as determined by the soil analysis. Tilling of the soil to incorporate amendments and counter any compaction or soil consolidation shall be required for all landscape planting areas. Soil preparation shall be consistent with the cultural needs of the plant species proposed for each site category.

Use of Mulch

- Policy 311 G

Apply and maintain organic mulches at appropriate depths in planting beds to assist soils in retaining water, reduce weed growth, and prevent erosion.

- Code Section 317 E10

Organic mulches shall be required in all non-turf planting areas.

Provide Regular Maintenance

- Code Section 310 A

Landscape must complete a compliance inspection 2 years after the initial landscape installation.

- Policy 311 G

Preserve the beauty and water efficiency of the landscape through regular pruning, weeding, mulching, and irrigation system maintenance.

- Policy 319

Landscape managers shall use accepted maintenance practices in the constructed landscape.