Resilient Roots: Sustainable Landscape Design for Colorado's Front Range Residences

Olivia Mosbarger

Colorado State University Honors Program

Fall 2024

Abstract

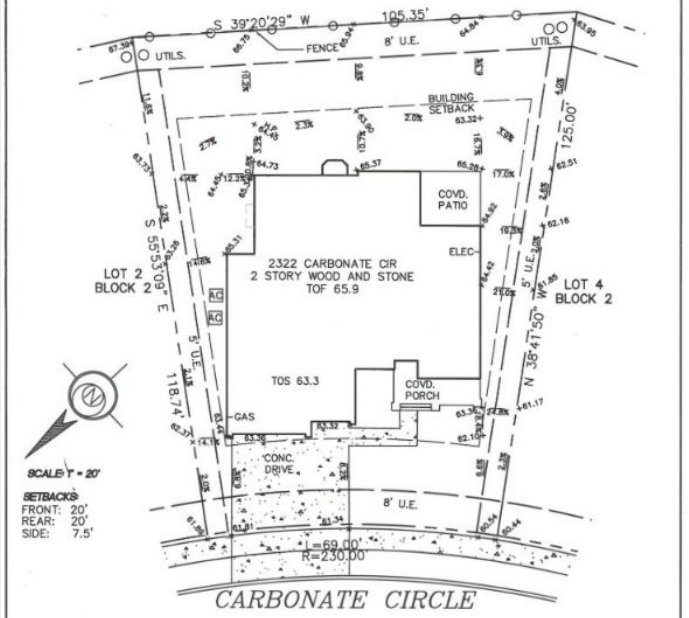
My Honors Thesis, Resilient Roots: Sustainable Landscape Design for Colorado's Front Range Residences, is an accumulation of the skills that I have learned in my landscape design studios throughout my time here at Colorado State University, as well as the addition of knowledge that I have gained in my horticulture, irrigation, entomology, and turfgrass studies. Specifically, I focused on sustainability in Western residential landscapes and how each of these topics (horticulture, irrigation, entomology, turfgrass, etc) can be utilized to help create a more drought-tolerant environment through design. I designed a construction plan for an ideal sustainable residential landscape, which can act as a guide for what methods, plants, and materials are beneficial for the Front Range's climate and natural resources. I also designed an irrigation plan, a planting schedule, and a 3D model to best represent how this plan will look and work for the clients.

Resilient Roots: Sustainable Landscape Design for Colorado's Front Range Residences

by Olivia Mosbarger

GRADING PERFORMANCE CERTIFICATE

LOT 3, BLOCK 2
FLATIRON MEADOWS FILING NO. 8
TOWN OF ERIE, COUNTY OF BOUNDER
STATE OF COLORADO



GRADING CERTIFICATE

I JAY L. AXTELL, JR., A LICENSED PROFESSIONAL LAND SURVEYOR IN THE STATE OF COLORADO HAVE SURVEYED THE FOLLOWING PROPERTY, AND DO HEREBY CERTIFY THAT THE SITE-SPECIFIC GRADING ELEVATIONS ARE ACCURATE AND CONFORM (W) AND MATCH THE GRADING PATTERNS FOR THE PROPERTY AS APPROVED BY THE TOWN OF ERIE COLORADO.

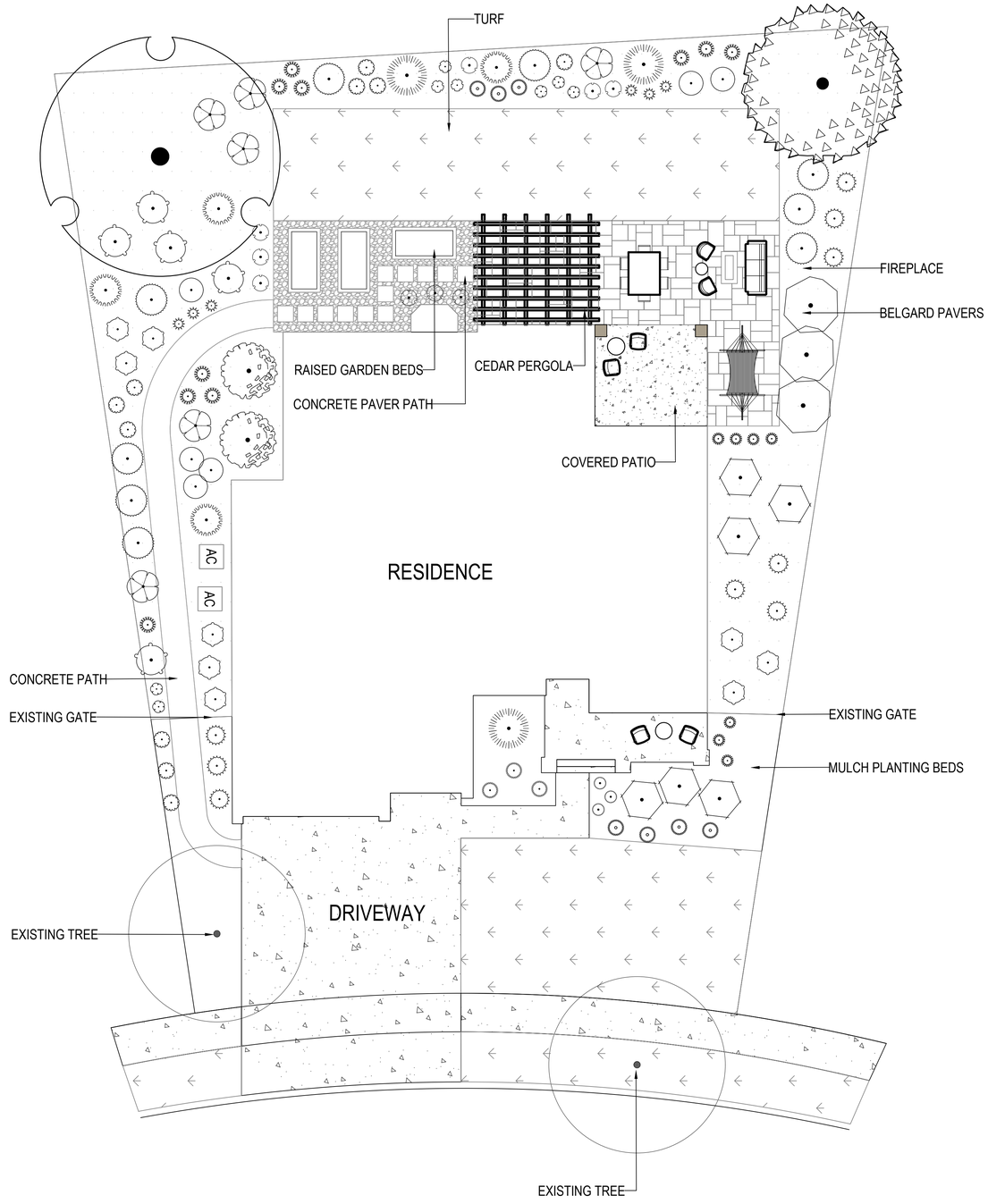
DATE OF OBSERVATION: 04/26/18

STATE OF COLORADO
JAY L. AXTELL
36052
4/30/18
PROFESSIONAL LAND SURVEYOR

NOTICE: ACCORDING TO COLORADO LAW YOU MUST COMMENCE ANY LEGAL ACTION BASED UPON ANY DEFECT IN THIS SURVEY WITHIN THREE YEARS AFTER YOU FIRST DISCOVER SUCH DEFECT. IN NO EVENT, MAY ANY ACTION BASED UPON ANY DEFECT IN THIS SURVEY BE COMMENCED MORE THAN TEN YEARS AFTER THE DATE OF THE CERTIFICATION SHOWN HEREON

PLANT SCHEDULE

SYMBOL	CODE	BOTANICAL / COMMON NAME	CONT	QTY
TREES				
	ACE GRN	Acer tataricum 'GarAnn' / Hot Wings® Tatarian Maple	B&B	1
	JUN SCO	Juniperus scopulorum / Rocky Mountain Juniper	B&B	1
SHRUBS				
	ART LPR	Artemisia abrotanum 'Leprechaun' / Leprechaun Southernwood	#1 Container	9
	EPH EQU	Ephedra equisetina / Bluestem Joint Fir	#3 Container	2
	FAL PAR	Fallugia paradoxa / Apache Plume	#3 Container	3
	PIN BIG	Pinus mugo 'Big Tuna' / Big Tuna Mugo Pine	#10 Container	3
	POT DKS	Potentilla fruticosa 'Fargo' / Dakota Sunspot® Bush Cinquefoil	#3 Container	9
	PRU PAW	Prunus besseyi 'P011S' / Pawnee Buttes® Sand Cherry	#3 Container	6
ANNUALS/PERENNIALS				
	ACH COR	Achillea x 'Coronation Gold' / Coronation Gold Yarrow	#1 Container	10
	AGA YMN	Agastache x 'Summer Sunset' / Summer Sunset Hyssop	#1 Container	3
	AQU DEN	Aquilegia chrysantha 'Denver Gold' / Denver Gold Columbine	#1 Container	4
	BER LYR	Berlandiera lyrata / Chocolate Daisy	#1 Container	9
	CAR DAR	Caryopteris x clandonensis 'Dark Knight' / Dark Knight Bluebeard	#3 Container	6
	DEL FIR	Delosperma x 'P001S' / Fire Spinner® Ice Plant	#1 Container	3
	ECH C12	Echinacea x 'Cheyenne Spirit' / Cheyenne Spirit Coneflower	#1 Container	9
	LAV CUS	Lavandula angustifolia 'Blue Cushion' / Blue Cushion English Lavender	#3 Container	10
	PEN CEN	Penstemon centranthifolius / Scarlet Bugler	#1 Container	6
	PER ABR	Perovskia abrotanoides / Russian Sage	#3 Container	5
	SAL MA2	Salvia nemorosa 'May Night' / May Night Meadow Sage	#3 Container	5
GRASSES				
	BOU BLO	Bouteloua gracilis 'Blonde Ambition' / Blonde Ambition Blue Grama	#1 Container	6
	HEL SEM	Helictotrichon sempervirens / Blue Oat Grass	#1 Container	7
	MUH UN3	Muhlenbergia reverchonii 'PUND01S' / Undaunted® Ruby Muhly	#1 Container	3
	SCH ST2	Schizachyrium scoparium 'Standing Ovation' / Standing Ovation Little Bluestem	#1 Container	7



CONTACT 811 BEFORE YOU DIG
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SAFE DIGGING PARTNER

OLIVIA
MOSBARGER
HONR 499
11/15/2024

HONORS THESIS

2322 CARBONATE CIRCLE,
ERIE, CO 80516

NORTH

L02

TREES

HOT WINGS TATARIAN MAPLE
ACER TATARICUM 'GARANN'

ROCKY MOUNTAIN JUNIPER
JUNIPERUS SCOPULORUM

GRASSES

BLONDE AMBITION BLUE GRAMA
BOUTELOUA GRACILIS 'BLONDE AMBITION'

BLUE OAT GRASS
HELICTOTRICHON SEMPERVIRENS

STANDING OVATION LITTLE BLUESTEM
SCHIZACHYRIUM SCOPARIUM

UNDAUNTED RUBY MUHLY
MUHLENBERGIA REVERCHONII

SHRUBS

BIG TUNA MUGO PINE
PINUS MUGO 'BIG TUNA'

LEPRECHAUN SOUTHERNWOOD
ARTEMISIA ABROTAUM 'SOUTHERNWOOD'

BLUESTEM JOINT FIR
EPHEDRA EQUISETINA

DAKOTA SUNSPOT BUSH CINQUEFOIL
POTENTILLA FRUTICOSA 'FARGO'

PAWNEE BUTTES SAND CHERRY
PRUNUS BESSEYI

APACHE PLUME
FALLUGIA PARADOXA

PERENNIALS

DENVER GOLD COLUMBINE
AQUILEGIA CHRYSANTHA 'DENVER GOLD'

CORONATION GOLD YARROW
ACHILLEA X 'CORONATION GOLD'

SUMMER SUNSET HYSSOP
AGASTACHE X 'SUMMER SUNSET'

DARK KNIGHT BLUEBEARD
CARYOPTERIS X CLANDONENSIS 'DARK KNIGHT'

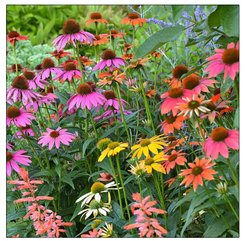
SCARLET BUGLER
PENSTEMON CENTRANTHIFOLIUS

RUSSIAN SAGE
PEROVSKIA ATRIPLICIFOLIA

BLUE CUSHION ENGLISH LAVENDER
LAVANDULA ANGUSTIFOLIA 'BLUE CUSHION'

CHOCOLATE DAISY
BERLANDIERA LYRATA

FIRE SPINNER ICE PLANT
DELOSPERMA X 'P001S'



CHEYENNE SPIRIT CONEFLOWER
ECHINACEA X 'CHEYENNE SPIRIT'

MAY NIGHT MEADOW SAGE
SALVIA NEMOROSA

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2322 CARBONATE CIRCLE,
ERIE, CO 80516

COLORADO STATE UNIVERSITY
EST. 1973
LANDSCAPE DESIGN AND CONTRACTING

L01

PLANT SCHEDULE

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TREES				
	ACE GRN	Acer tataricum 'GarAnn' / Hot Wings® Tatarian Maple	B&B	1
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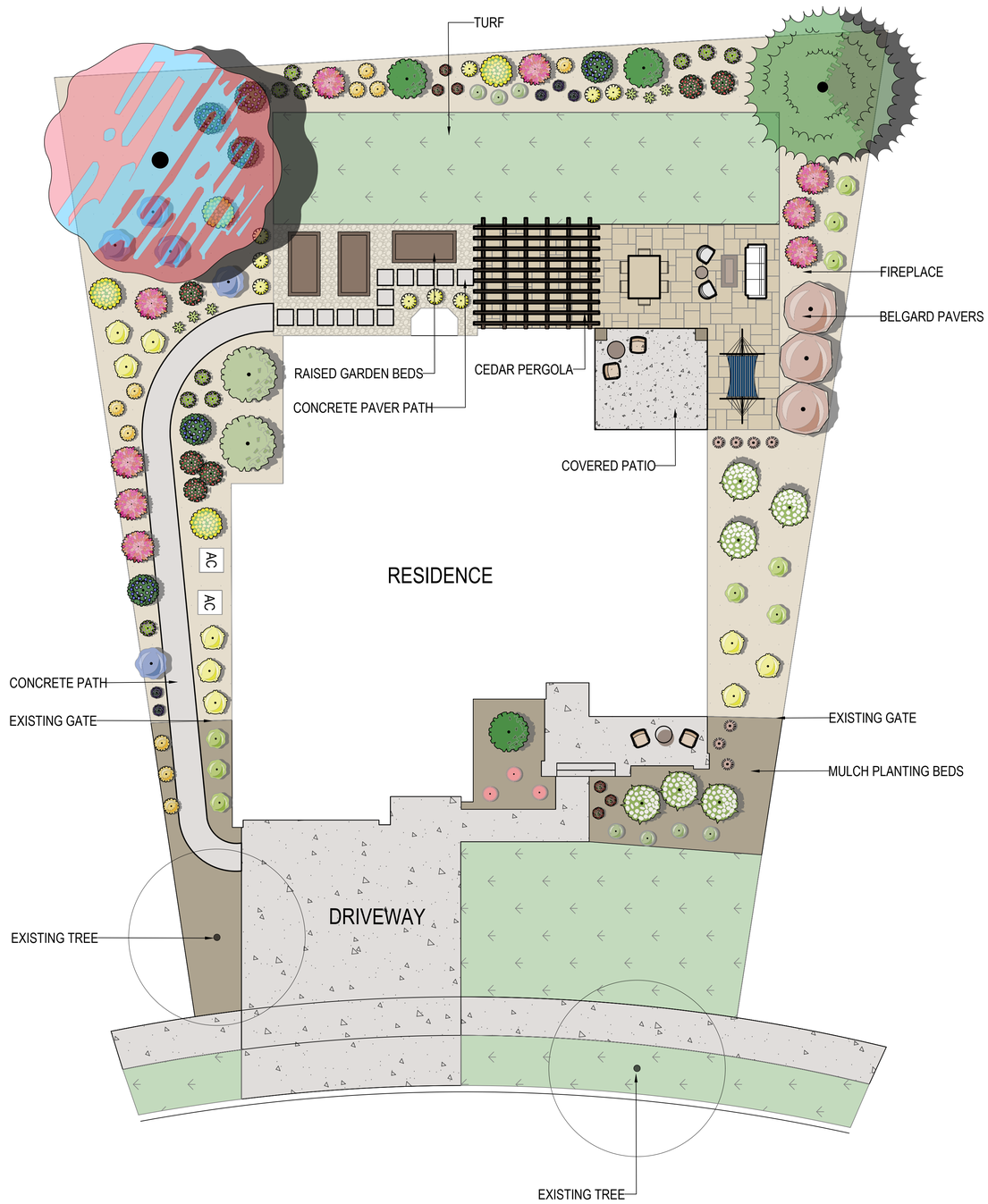

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HONORS THESIS

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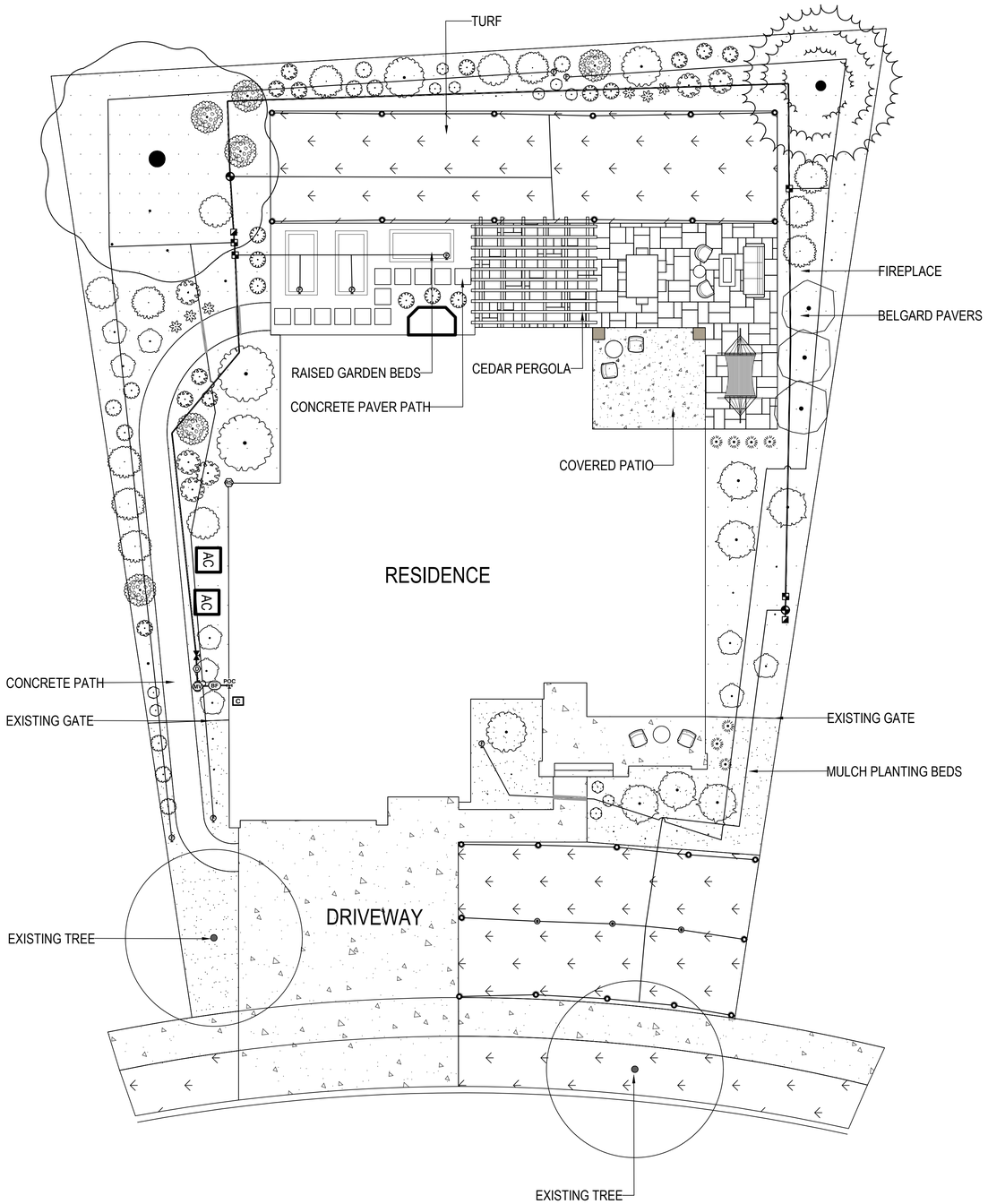
ERIE, CO 80516

NORTH

L02

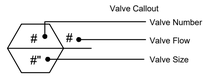


IRRIGATION SCHEDULE

SYMBOL	MANUFACTURER/MODEL/DESCRIPTION	QTY	PSI
14 ADJ 14 F	Rain Bird R-VAN14 1806-SAM-P45 Turf Rotary, 8ft.-14ft. 45-270 degrees and 360 degrees. Hand Adjustable Multi-Stream Rotary w/1800 turf spray body on 6in. pop-up, with check valve and 45 psi in-stem pressure regulator. 1/2in. NPT Female Threaded Inlet.	27	45

SYMBOL	MANUFACTURER/MODEL/DESCRIPTION	QTY
	Rain Bird XCZ-100-PRB-COM Wide Flow Drip Control Kit for Commercial Applications. 1in. Ball Valve with 1in. PESB Valve and 1in. Pressure Regulating 40psi Quick-Check Basket Filter. 5 GPM-20 GPM.	4
F	Rain Bird MDCFCAP Dripline Flush Valve cap in compression fitting coupler.	8

SYMBOL	MANUFACTURER/MODEL/DESCRIPTION	QTY
	Rain Bird PEB 1in., 1-1/2in., 2in., 3in. Plastic Industrial Remote Control Valve. Low Flow Operating Capability, Globe Configuration.	2
	Rain Bird 44-LRC 1in. Brass Quick-Coupling Valve, with Corrosion-Resistant Stainless Steel Spring, Locking Thermoplastic Rubber Cover, and 2-Piece Body.	2
	Shut Off Valve MATCO 514TX	1
MV	Rain Bird EFB-CP 1" 1in., 1-1/4", 1-1/2in., 2in. Brass Master Valve, that is Contamination Proof w/Self-Flushing Filter Screen. Globe Configuration, Reclaimed Water Compatible, and Purple Handle Cover Designates Non-Potable Water Use.	1
D	Drain Valve MATCO 201X	1
BF	Febco 765 3/4" Pressure Vacuum Breaker, brass with ball valve SOV. Install 12in. above highest downstream outlet and the highest point in the downstream piping.	1
C	Rain Bird ESP-2WIRE (120VAC) 50 Station 2-Wire, Indoor/ Outdoor Controller w/ decoder auto-address. For Residential or Light Commercial Use. LNK WiFi Module and Flow Sensor Ready. Use with 2W-1 single station decoders and standard direct burial wire.	1
RS	Rain Bird WR2-RFC Wireless Rain and Freeze Sensor Combo, includes 1 receiver and 1 rain/freeze sensor transmitter.	1
	Irrigation Lateral Line: PVC Class 200 SDR 21	350.2 l.f.
	Irrigation Lateral Line: Polyethylene Pipe SDR-7	448.6 l.f.
	Irrigation Mainline: PVC Class 200 SDR 21	238.4 l.f.
	Pipe Sleeve: PVC Class 200 SDR 21	12.0 l.f.



0 8 16 24 32 feet

1/8" = 1'-0"

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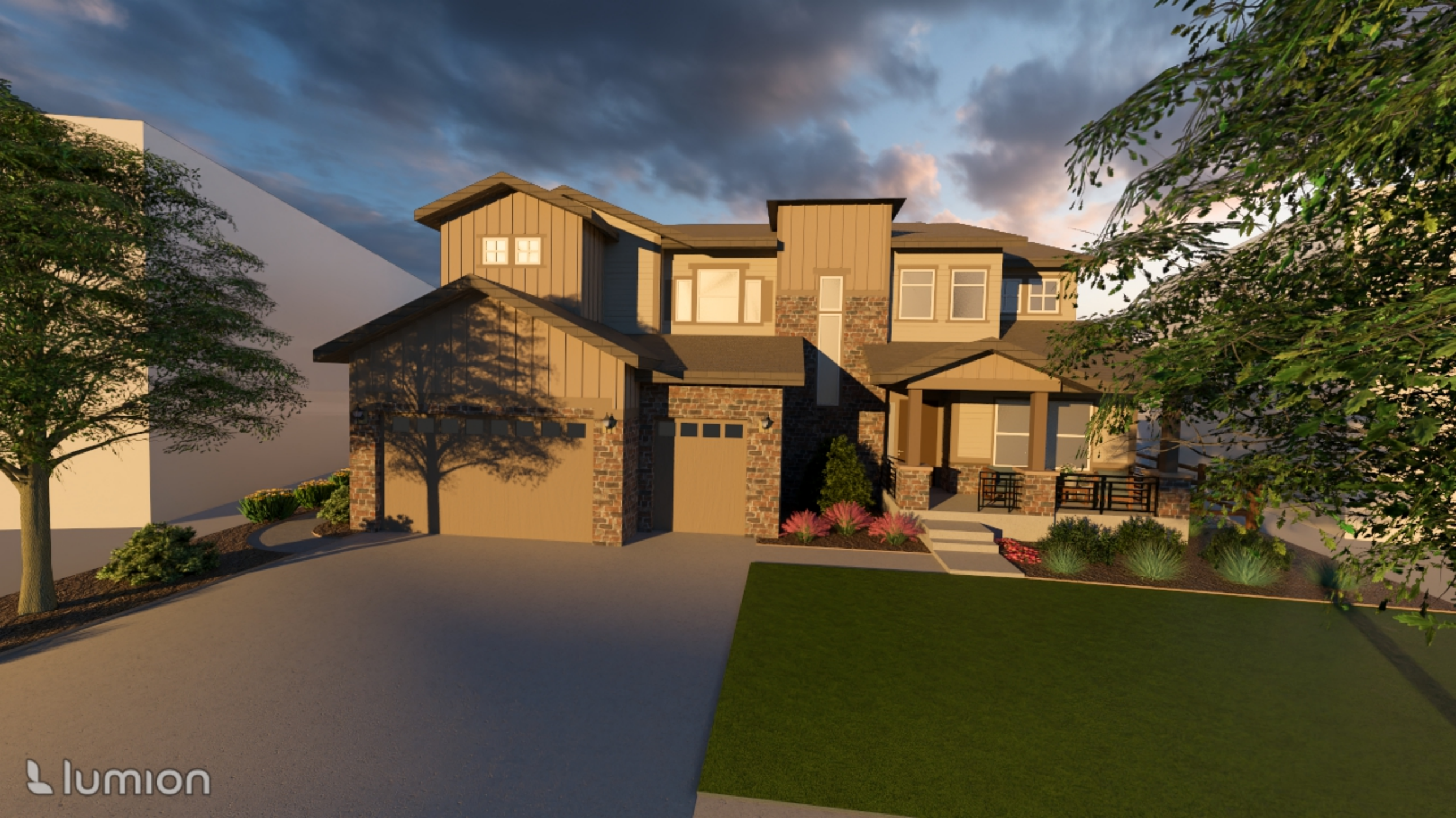
HONORS THESIS

2322 CARBONATE CIRCLE,
ERIE, CO 80516

NORTH

L03


lumion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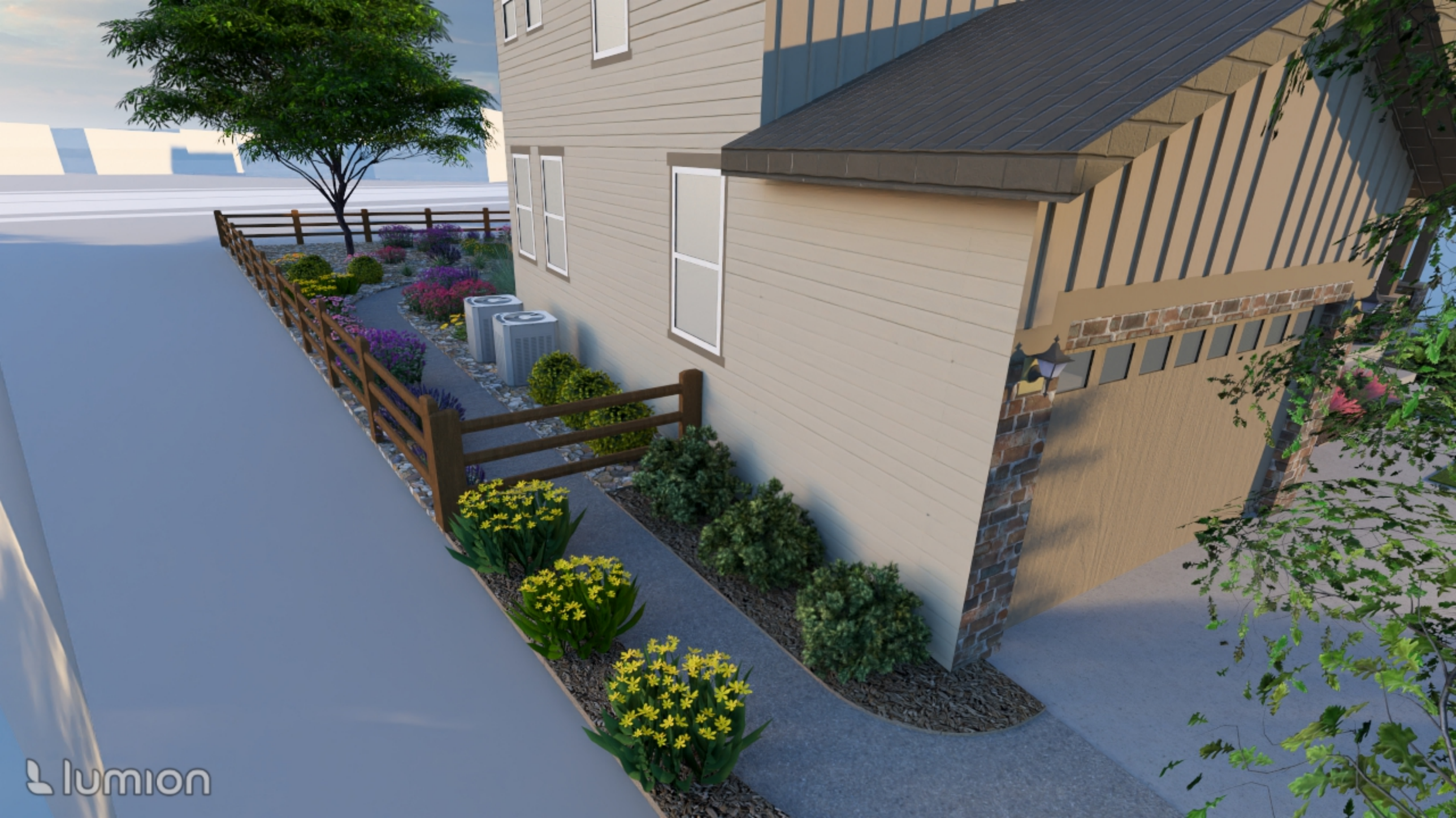
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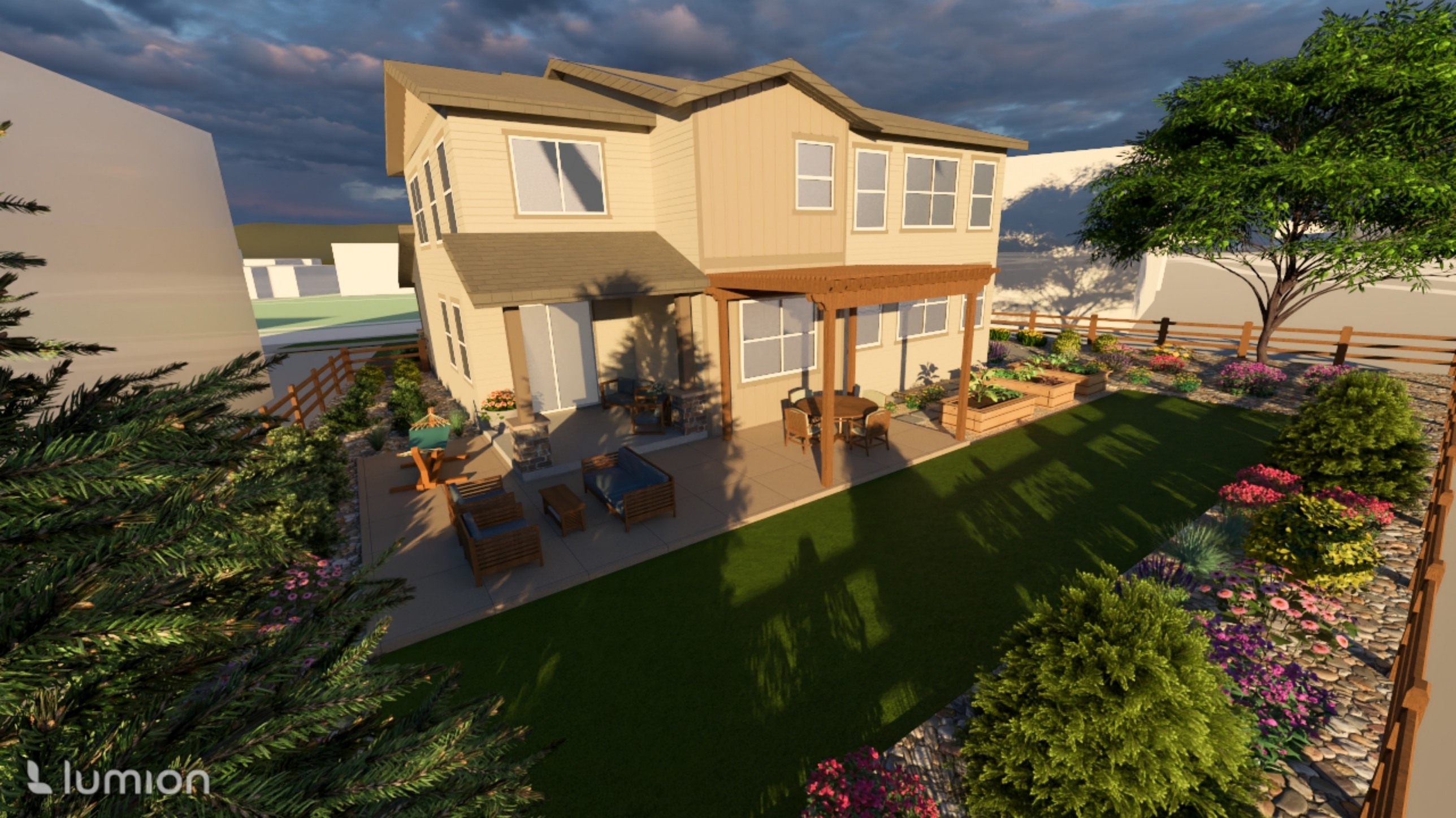
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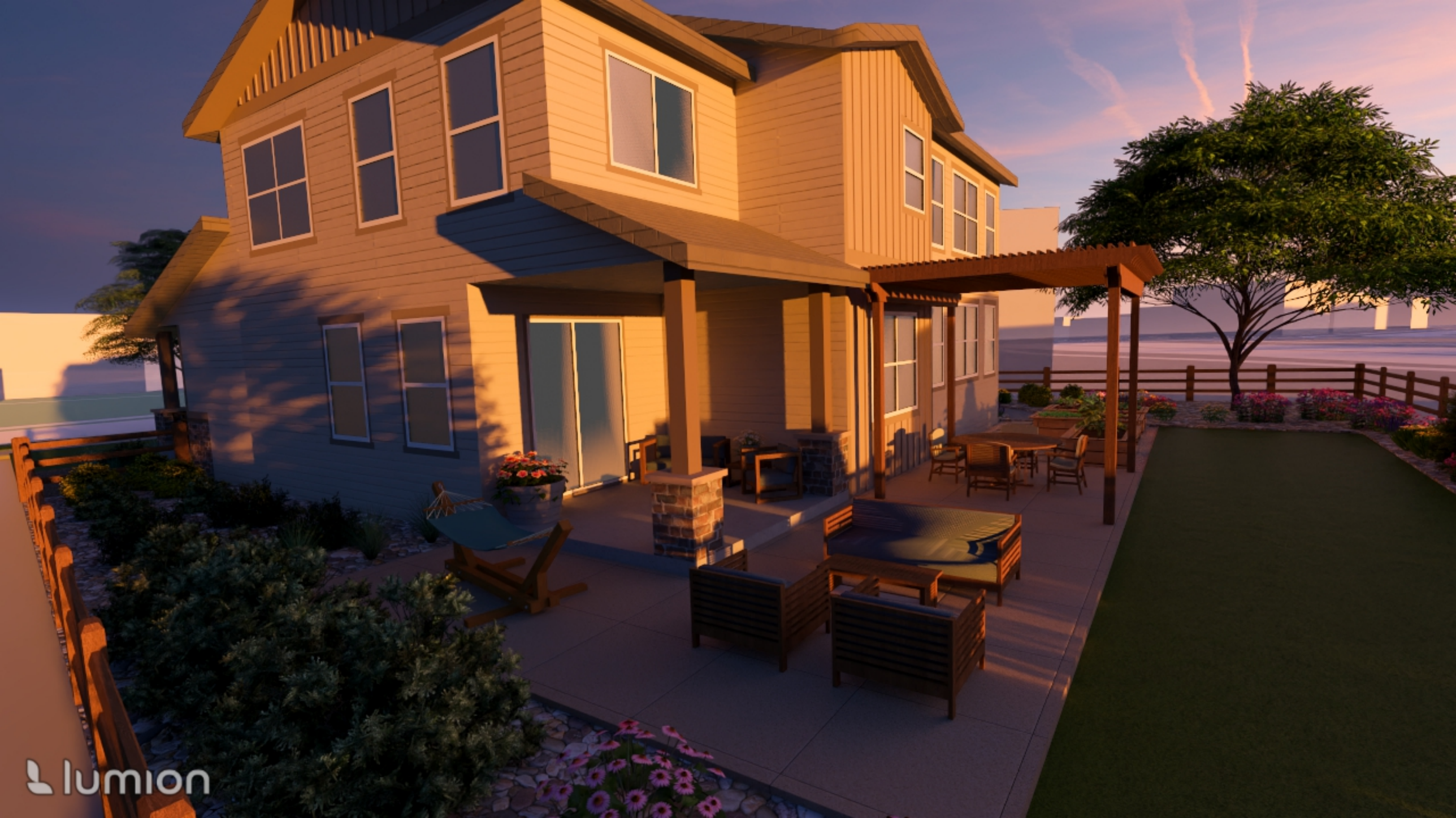
lumion


lumion


lumion

My Honors Thesis, Resilient Roots: Sustainable Landscape Design for Colorado's Front Range Residences, is an accumulation of the skills that I have learned in my landscape design studios throughout my time here at Colorado State University, as well as the addition of knowledge that I have gained in my horticulture, irrigation, entomology, and turfgrass studies. Specifically, I have focused on sustainability in Western residential landscapes and how each of these topics (horticulture, irrigation, entomology, turfgrass, etc) can be utilized to help create a more drought-tolerant environment through design. Throughout my coursework and classes required for my Environmental Horticulture degree I have noticed a trend relating to sustainability in Western, specifically Colorado, landscapes. Sustainability plays a very important role in every region, but it has extremely noticeable impacts in Colorado landscapes and environments. The significance of native and drought-tolerant plants in residential communities, as well as water rights and sustainable irrigation, have played a crucial role in my many horticulture and irrigation courses here at CSU, and are something that should be utilized more in residential landscape designs. The importance of sustainability is continuously growing throughout the country, making this an important topic not only to those involved in horticulture fields, but to all those impacted by climate change. Designing, building, and maintaining sustainable residential landscapes is a crucial step that landscape designers, architects, construction workers, and homeowners can take to help reduce climate change, restore and protect natural resources, and improve quality of life. I want my design and reflection paper to work as guides for designers and students to help show the importance of sustainable design and management in Colorado, as well as combine information that we have learned throughout our courses regarding sustainability.

For my Honors Thesis I have designed a construction plan for an ideal sustainable residential landscape, which can act as a guide for what methods, plants, and materials are beneficial for the Front Range's climate and natural resources. I have also included an irrigation plan, a planting schedule, and a 3D model to best represent how this plan will look and work. In order to complete this Honors Thesis I read and analyzed peer-reviewed journals, asked my professors questions pertaining to their field and experiences, and communicated with my peers to assess what they believe will work best in future residential landscapes along the Front Range.

In order to complete this project, I first started with a base plan provided by my Honors Advisor. The residential property I used is a real house along the Front Range, which allowed me to do some research and information collection on the neighborhood and area that the property is located in. I wanted to make sure that the landscape allowed for a sense of uniqueness and privacy for the homeowners, while still matching the mood and spirit of the rest of the neighborhood. My design program was to create a sustainable landscape, and I pictured designing for a family with children or dogs that enjoy spending time outdoors, which is a common occurrence in residential properties along the Front Range. This meant that I would be focusing on creating outdoor living spaces with the addition of turfgrass and pet/children safe designs/planting schedules. From the base plan provided, design program, and information about the surrounding houses and neighborhood, I created 5 conceptual drawings. After discussing the concepts and asking my Honors advisor for his advice, I narrowed the conceptual drawings down to one. This final concept was then put into AutoCAD and was rendered to create the construction plan. I then talked with classmates, referenced previous design projects and plant identification courses, and met with my Honors Advisor to create a planting schedule for the landscape design. I took skills from my landscape irrigation course and worked with my Honors

Advisor to create an ideal irrigation schedule for the turf and planting in the yard. Finally, I took the plan from AutoCAD and 3D modeled it utilizing SketchUp and Lumion to create a model that designers and students can reference to create sustainable landscapes in the future. The design, planting schedule, irrigation plan, and 3D model were all created with sustainable motives in mind, and will be explained using peer-reviewed literature in the following reflection.

After I designed the initial linework for my project in AutoCAD, it was time to choose the plants for the landscape. Choosing the planting schedule for a design is important, as it helps create the mood, privacy, and "vibe" of the yard. Planting helps create interest in the landscape, drawing the homeowners eyes to different colors and textures, as well as benefiting the environment. There are several steps that designers, landscapers, and homeowners can take to create a more sustainable landscape through their planting choices. Choosing native plants (which require less water, fertilization, and pesticides), irrigating correctly, and preserving existing plants all allow for sustainable practices in the landscape and help protect natural resources such as water and soil.

To choose the "Right Plant for the Right Place" for the project, I chose to use the Plant Select program, native and xeric plants I have used in previous projects, and opinions regarding xeric plants from my classmates. Plant Select is a strongly trusted source in the green industry, specifically here on the Front Range, and has great xeric plants that will be sustainable for my project. I have used Plant Select in the past to find hardy, long lasting, and drought-tolerant plants for projects. As Kintgen, the author of the conference proceeding "Plant Select, A Brief Overview, History and Future of a Plant Introduction Program," explains, the Plant Select process, which is a cooperative program between Colorado State University, Denver Botanic Gardens, and green industry professionals in the Rocky Mountain Region, is utilized to help test

and select the best plants for the Rocky Mountain Region, and relies on several sets of criteria to make its choices. This plant introduction program is extremely useful in finding drought-tolerant, pest-tolerant, and long season plants for Front Range residential landscapes. All of my plant choices utilized in my project and plant schedule are drought tolerant and perfect for Front Range landscapes that receive a fair amount of sunlight. These plants will need minimal irrigation, and will have a high chance of surviving and thriving on this residential property. They are also plants that can be found at local nurseries in Fort Collins and Loveland, helping to cut back on the harmful effects that shipping and traveling to find rare plants can have on fossil fuels and climate change. This will also make it easier for the homeowners to find and pick out the specific plants that they want.

More than ever, it is important to plant xeric and native plants in urban and residential areas to help with water/fertilizer/pesticide use, as well as create a uniform and classic "Colorado" designed landscape. As the article "Ecological Adaptation of the Endemic Shepherdia rotundifolia to Conditions in Its Colorado Plateau Range" explains:

> Water conservation is critical for urban systems in the arid Intermountain West, USA (MW). Low-water landscaping, specifically use of drought-tolerant native species, is an essential tool in urban water conservation (Kjelgren et al. 2009). Low-elevation, drought tolerant IMW native species that require minimal supplemental water offer great potential for low-water landscaping. Native species provide a natural look to the urban landscape and support local native plant industries (McKinney 2002, Kjelgren et al. 2009). Exploiting drought-adapted IMW native species for low water landscaping not only has potential to conserve water but also to increase biodiversity in urban environments. Endemic plant species are key biodiversity elements in sustainable ecosystems. Endemic

> species protection has typically focused on preserving natural habitats in biodiversity hot spots such as national park, wildlife refuges, and national forests (Myers et al. 2000, Brooks et al. 2006). Urban landscapes, particularly low water landscapes (LWLs) in the IMW, are a window of opportunity in promoting biodiversity and preserving endemic species (Alvey 2006). Endemic arid-adapted species used in biologically diverse urban landscapes become commercially viable assets, reduce water use and carbon footprint, support native pollinator species, and educate the public about natural systems (Mee et al. 2003).

My planting plan will help exemplify how native plants can be placed in the urban/residential landscape, and my 3D model helps show how the colors and textures of these plants can still create very lush and eye-catching spaces.

Native plants are not only important to implement along the Front Range to cut back on irrigation, fertilization, and pesticide use, but they also benefit pollinators and bees that are native to the area. This is something that many consumers are starting to look for in their landscapes, and can be a great selling point in the industry. Not only does it allow for water-saving and beautiful yards, but also helps the customers practice sustainable and pollinator friendly acts. One study conducted in Colorado from 2012-2014 shows the importance of native plants to pollinators and how they can help increase the species populations in a short amount of time. This study, titled “Diversity and abundance of wild bees in an agriculturally dominated landscape of Eastern Colorado” by H.S Arathi, Mark W. Vandever, and Brian S. Cade, explored the effects of the loss of natural habitats in Eastern Colorado on pollinators, and how specific conservation acts can help mitigate and recover these populations. By restoring the habitats with native grasses and pollinator friendly plants, they were able to restore the pollinator populations

(specifically bees species) in this area. This study was conducted over 3 years, and helps suggest that recovering this land can help strengthen the pollinator populations in the landscape. In order to help create a sustainable and pollinator friendly landscape, I have included many native grasses and pollinator friendly plants in my design to help encourage not only sustainable and xeric conditions, but to also help pollinators in the area thrive.

Turfgrass is another important plant to research when taking sustainability into account, as a nice looking turfgrass appearance and performance without much irrigation on the Front Range is very important when considering the popularity of turfgrass with customers throughout the United States. While there are many differing opinions regarding the use of turfgrass in the landscape, especially in the semi-arid climate along the Front Range, there is no doubt that there are still drought-tolerant cultivars with nice color and density that can be used at residential homes today. Turfgrass is an important part of our urban landscapes, and can still benefit the environment if chosen and managed correctly. As the authors of "Pertinent Water-Saving Management Strategies for Sustainable Turfgrass in the Desert U.S. Southwest" illustrate, "Turfgrass is a vital component of various landscape ecosystems such as golf courses, sports fields, home lawns, and parks with significant ecological, environmental, and economic importance [1,2]. It also has a transformative effect on the natural ecosystem through soil conservation, enhanced soil water infiltration and groundwater recharge, carbon sequestration, heat dissipation and temperature moderation, and reduced air pollution [2–7]." While turfgrass is important to the environment, it is still important to recognize that there is no perfect turfgrass for every Colorado lawn/turf citation.

Colorado is currently in a transition zone of grass species, which is an area in the middle of the United States where summers can be very warm and winters can be very cold, meaning

cool-season and warm-season grasses will not thrive in either location. Depending on the season, precipitation amount, and many other environmental factors, cool-season turf or warm-season turf may do better one year than the other. This is why it is important to specify a lawn/turf species when developing a final landscape plan/drawing, because certain areas require different kinds of turf. If you don't specify and ask the client questions about their yard and the area that the turf is going in at, you won't be able to specify a turf species to put there, meaning a turf species that won't work in that area could be planted. The choice of turf species depends on the intended use of the turf, what quality the customers are looking for, any problems with soil/water/pests, and their ability for maintenance and care. If you don't specify what kind of turf could work in the area, the wrong kind could be planted that doesn't match up with the space that is being designed for a specific use.

For this property I recommend using Tahoma 31 bermudagrass because it will be a nice looking and traffic tolerant turf while also allowing for responsible water usage. Bermudagrass is a fine and high density turfgrass, which will allow the homeowners to have the green, dense, and uniform lawn that they are looking for most of the year. It is also very traffic tolerant, so any children and/or dogs will not hurt the turf with their time playing outside. Bermudagrass also recuperates very quickly from damage when it is growing, so it will not "wear out" like other turf species. Bermudagrass does not require daily watering (it has a low/moderate water requirement) and it is very drought tolerant and cold hardy, meaning it will be one of the most sustainable options for a family that still likes to spend time in their yard and have a nice, uniform color. I specifically recommend Tahoma 31 for these homeowners because it is more cold hardy than other bermudagrass varieties, requires less water/irrigation, and is very tolerant of wear and use.

Another important part of my residential design is the irrigation plan. Water is an extremely valuable resource in Colorado, so it is important to not only choose water-wise plants and turf species, but also to design efficient irrigation plans. In order to make my design sustainable and save on water for the residence, I have added a RainBird weather-based irrigation control and rain/freeze sensor. These controls will help the irrigation system monitor if there has been rain or freezes in the landscape, in which case it will stop irrigation to save water. As the study "Performance of weather-based residential irrigation controllers in a desert environment" by Malik G. Al-Ajlouni, Dawn M. Vanleeuwen, and Rolston St. Hilaire explains:

> Widespread adoption of "smart" irrigation technology is critical to water conservation in desert urban residential landscapes (St. Hilaire et al, 2008), where landscape irrigation consumes up to 70% of residential water use (Ferguson, 1987). Smart irrigation controllers adjust watering schedules based on site parameters such as weather, plant type, and physical conditions, and operate the irrigation system without repeated human involvement (Irrigation Association, 2007). They are categorized as evapotranspiration (ET) or weather-based if the controller uses ET data and soil-based if the controller uses soil characteristics such as moisture content as a basis for irrigation (Grabow et al, 2008).

In my design I have positioned the rain sensor on a tall and unblocked surface, which will allow the irrigation controller to determine if it is raining or not. My irrigation plan also has 5 zones, meaning each zone will be watered based on the ET rates, needs, and the positioning of the plants and turf in each zone. As the study found, the use of RainBird's smart controllers saved 34% of irrigation water for residential landscapes, helping the residents save money and water while staying sustainable.

Another way for residential landscapes to implement sustainable irrigation plans is to use soil moisture sensors for their irrigation controls. This process is explained in a study titled “Soil moisture sensors for urban landscape irrigation: Effectiveness and reliability” by Russel J. Quails, Joshua M. Scott, and William B. Deoreo, in which they explored the use of soil moisture sensors in the landscape, and its effect on water conservation and irrigation. The study was conducted in Boulder, Colorado in 1997 at 23 different test sites (21 of which were residential test sites). They found that the effort to maintain the moisture sensors was small, and that they were easy to monitor and significantly reduced water consumption in the landscape. The reduction of water consumption that these cause helps the sustainability of residential landscapes in Colorado, and should certainly be considered when designing and managing landscapes along the Front Range.

While my residential property utilizes the municipal water supply to obtain the water used for their irrigation system, greywater usage for irrigation systems is a growing field of research. A study titled “Potential Changes in Chemical Soil Quality Resulting from Graywater Recycling for Landscape Irrigation” by Masoud Negahban-Azar and Sybil E. Sharvelle explores the effects of the use of greywater in the soil of households in California, Arizona, and Colorado. They explain that “greywater is untreated wastewater that does not include water from the toilet or kitchen, and may include water from bathroom sinks, showers, bathtubs, clothes washers, and laundry sinks. (National Academies, 2016).” The study concluded that no negative effects were found in the soil after the use of greywater in the landscape, and that the organic matter and inorganic nitrogen increased in the receiving soil. They stated that “the lack of information on greywater reuse has prevented state officials and regulating agencies from moving forward with encouraging the reuse of greywater,” which is a reason as to why it is not being utilized in many

areas yet. This is certainly another form of irrigation to consider in the future as it gains more traction, especially in arid regions where water is quickly diminishing. Greywater usage in irrigation can help cut down on water consumption and the many issues with water rights, which can help with continuing sustainability in residential landscapes.

After the landscape design is implemented, the continuous use of sustainable management and care is important. Therefore, I will be encouraging the homeowners to utilize IPM, or integrated pest management, to care for their landscape after it is complete. IPM is a decision making process to manage pests in the landscape without relying solely on pesticides. Using only pesticides to deal with problems that arise in the environment is very harmful, not only to the plants and animals, but to humans as well. IPM focuses on using techniques such as biological control, mechanical methods, and cultural practices rather than chemical controls right away. This scientifically proven management method has been growing in popularity since the environmental movement in the 1970s, after the famous book about pesticide use "Silent Spring" was released. IPM has mainly been used in agricultural settings to help farmers manage the pests on their farms and in their crops. As the article "Eight Principles of Integrated Pest Management" explains, a "one-size-fits-all" approach to pest control is not possible, so having biological, mechanical, and cultural principles for crop producers to follow will help them focus on sustainable, outcome-based approaches to pest management. While this is an article regarding integrated pest management in crop producing sectors, it can still apply to the research being completed on IPM in residential settings.

Recent studies have shown that not much is known about IPM in residential settings, but that it can be a very beneficial and sustainable management system in these areas. IPM is a very complex process and involves more steps than a one step pesticide that many homeowners use in

their residential yards. People don't want to take the time to complete all the steps, especially when they believe that their way is still helping and is quicker. The authors of the study "What Do They Know and What Do They DO? A National Evaluation of Landscape Integrated Pest Management Knowledge and Use in the United States" also believe that there is a low adoption of IPM because residential homeowners simply don't know about the process. If homeowners have no knowledge about IPM, or are not taught about it by Extension programs, then they will continue to stick to their DIY pesticide ways. After conducting a study on homeowners across the United States regarding their knowledge of IPM, the authors found that users that are more knowledgeable about IPM are more likely to adopt IPM in their practices. This was proven when respondents that answered that they were fairly knowledgeable about IPM also answered that they practice many of the behaviors associated with it. So training and educating residential homeowners about IPM through Extension resources could increase the likelihood of the homeowners practicing IPM in their landscapes.

Another study conducted in North Carolina titled "Pest Control Practices for the German Cockroach (Blattodea: Blattellidae): A Survey of Rural Residents in North Carolina" also explored residential consumers and their relationship with IPM practices. The study focused on 100 participants in 3 counties in North Carolina and their knowledge on the German cockroach in their homes, which is a serious pest in the area. The study asked consumers about their knowledge of IPM and what pest control management techniques they currently use in their homes. The study concluded that "Based on our findings, we believe that organizing an educational IPM program would increase awareness among residents of the economic, human health and environmental costs and benefits of each control measure and make sustainable IPM implementation more likely to succeed." While IPM is still a growing practice in residential

communities, it is important to spread the word to homeowners about the beneficial impacts that it can have on the area. I had never heard of IPM before taking an entomology course for my major, so I believe that including this management system in my project and letting future clients know about the process can help create a more sustainable landscape. Practicing pest management methods such as biological control or mechanically removing the pests, rather than spraying harmful chemicals, is something that can help change our planet for the better.

Overall, I believe that my "creative activity" has greatly contributed to my knowledge relating to the green industry and design work. I found it very helpful to review information that I have studied in previous courses and combine similar knowledge into one document. It can be easy to forget some of the information relating to sustainability that I learned about several years ago, so I enjoyed reading journals, articles, and past homework assignments to connect these pieces together. It was also very fun connecting the information about sustainable landscapes to a real landscape design, as it helped me picture what the future can look like. I enjoyed practicing skills on AutoCAD/LandFX, SketchUp, and Lumion to provide a design that can be used as a guide for sustainable choices and practices. It was fun getting to see the progress I have made in both my design work and research methods since my first year at CSU, and this thesis has greatly impacted my knowledge in my field.

I had a generally good Honors Thesis experience. While it was stressful at times balancing my other homework and courses with the thesis work, overall I think it was a very beneficial process. I am glad that I got to work with my Thesis Advisor and committee member to create a thesis that would not only benefit me in fulfilling the honors requirements, but also allow me to practice skills that I have learned in studio courses. I think the most influential part of the experience was creating the 3D model of my design, as that is something I haven't worked

on too much in my studio courses. It was something that I was not looking forward to because I thought it would take a long time, but I actually ended up really enjoying the process. I used a program called SketchUp (that I was taught in an internship) to model the house and landscape, and then used Lumion (taught in studio) to render the model and add plants. This thesis has inspired me to continue making these models for future projects. I also found it very useful to get help from my Thesis Advisor on the irrigation plan for my design, as that is something that I had struggled to understand when I took an irrigation course last year. It was interesting getting to design an irrigation plan for a residential property, and I feel like I understand the LandFX methods much better now. Overall I found the thesis to be very beneficial, and I am proud of what I completed.

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