Subsurface Irrigation for Turfgrass Areas

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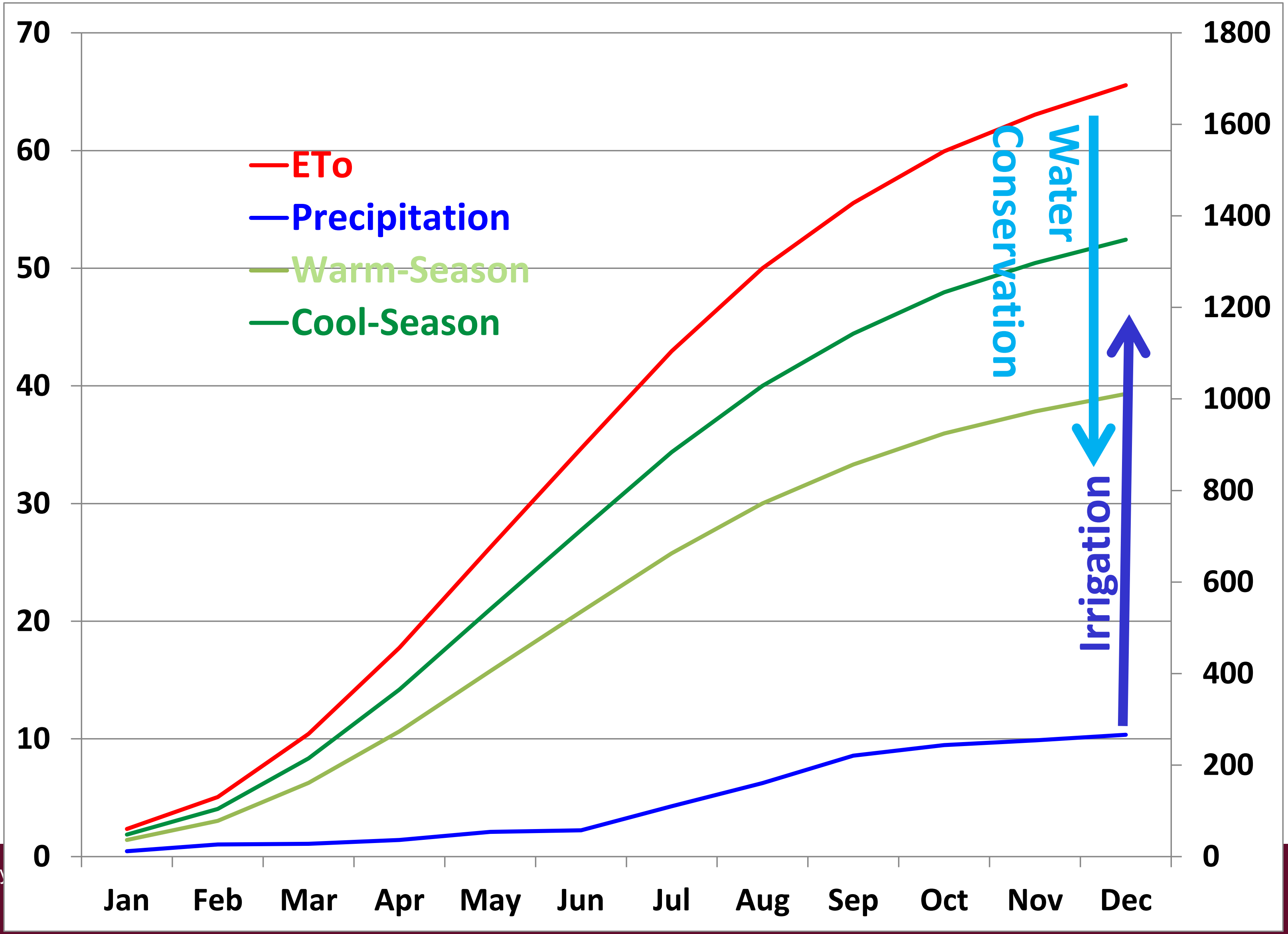
Strategies for Irrigation Water Conservation

1. Artificial Turf
2. Reduce area under irrigation
3. Irrigation with recycled/impaired water
4. Use of low water use turfgrass species
5. Accept quality reduction
6. **Increase irrigation efficiency**
    I. Scheduling
        a) Climate data
        b) Soil water status
    II. Improve Water Distribution

Turfgrass Irrigation Requirement
Las Cruces, NM (2005 – 2009)



Turfgrass Irrigation

Las Cruces		**GCSAA Survey** (Gelernter et al., 2015)
Cool-season	50”	46.4”
Warm-season	38”	

Grass Type	**1000 ft^2**	**1 acre**
WS	23,500 gal	3.1 acre feet
CS	31,100 gal	4.1 acre feet

Turfgrass Irrigation Requirement

$$IR = \sum (A, ETo, ISe, Wq, Kc) \longrightarrow f_{(Kc)} \; Sp, TQ, GDD, PAW, Mi$$

A: Area under irrigation

ETo: (reference) Evapotranspiration

ISe: Irrigation System Efficiency

Wq: Water Quality

Kc: Crop coefficient

SP: Species

TQ: Turf quality

GDD: Growing Degree Days

PAW: Plant available water

Mi: Management Intensity

Irrigation Water Use > Irrigation Water Requirement

Irrigation Water Requirement

$$\mathbf{WR} = \frac{ET_o \cdot K_C \cdot A}{DU \cdot E_{WM} \cdot C_U}$$

without rainfall

$$\mathbf{WR} = \frac{[(ET_o \cdot K_C) - R_E] \cdot A}{DU \cdot E_{WM} \cdot C_U}$$

with effective rainfall

WR = Water Requirement
ET_o = Reference Evapotranspiration
K_C = Landscape Coefficient
A = Area
C_U = Conversion Factor
DU = Distribution Uniformity
E_{WM} = Management Efficiency
R_E = Effective Rainfall

(Irrigation Association, 2001)

Irrigation Water Requirement (2)

$$\mathbf{WR} = \frac{ET_o \cdot K_C \cdot \cancel{A}}{DU \cdot \cancel{E_{WM}} \cdot \cancel{C_U}} \longrightarrow \mathbf{WR} = \frac{ET_o \cdot K_c}{DU}$$

WR = Water Requirement
ET_o = Reference Evapotranspiration
K_C = Landscape Coefficient
DU = Distribution Uniformity
E_{WM} = Management Efficiency
A = Area under Irrigation
C_U = Conversion Factor

$$\left.\begin{array}{l} E_{WM} \\ A \\ C_U \end{array}\right\} \text{Constants}$$

(Irrigation Association, 2001)

Strategies for Irrigation Water Conservation

$$\mathbf{WR} = \frac{ET_o \cdot K_C \cdot A}{DU}$$

1. **Artificial Turf**
2. **Reduce area under irrigation**
3. **Irrigation with recycled/impaired water**
4. **Reduce turf ET**
    - I. **Use of low water use turfgrass species**
    - II. **Plant Growth Regulators**
5. **Accept quality reduction**
6. **Increase irrigation efficiency**
    - I. **Scheduling**
        - a) **Climate data**
        - b) **Soil water status**
    - II. **Improve Water Distribution**
        - a) **Irrigation technology**
        - b) **Soil surfactants**

Strategies for Irrigation Water Conservation

1. Artificial Turf
2. Reduce area under irrigation
3. Irrigation with recycled/impaired water
4. Use of low water use turfgrass species
5. Accept quality reduction
6. **Increase irrigation efficiency**
   I. Scheduling
      a) Climate data
      b) Soil water status
   II. Improve Water Distribution

Irrigation Audit

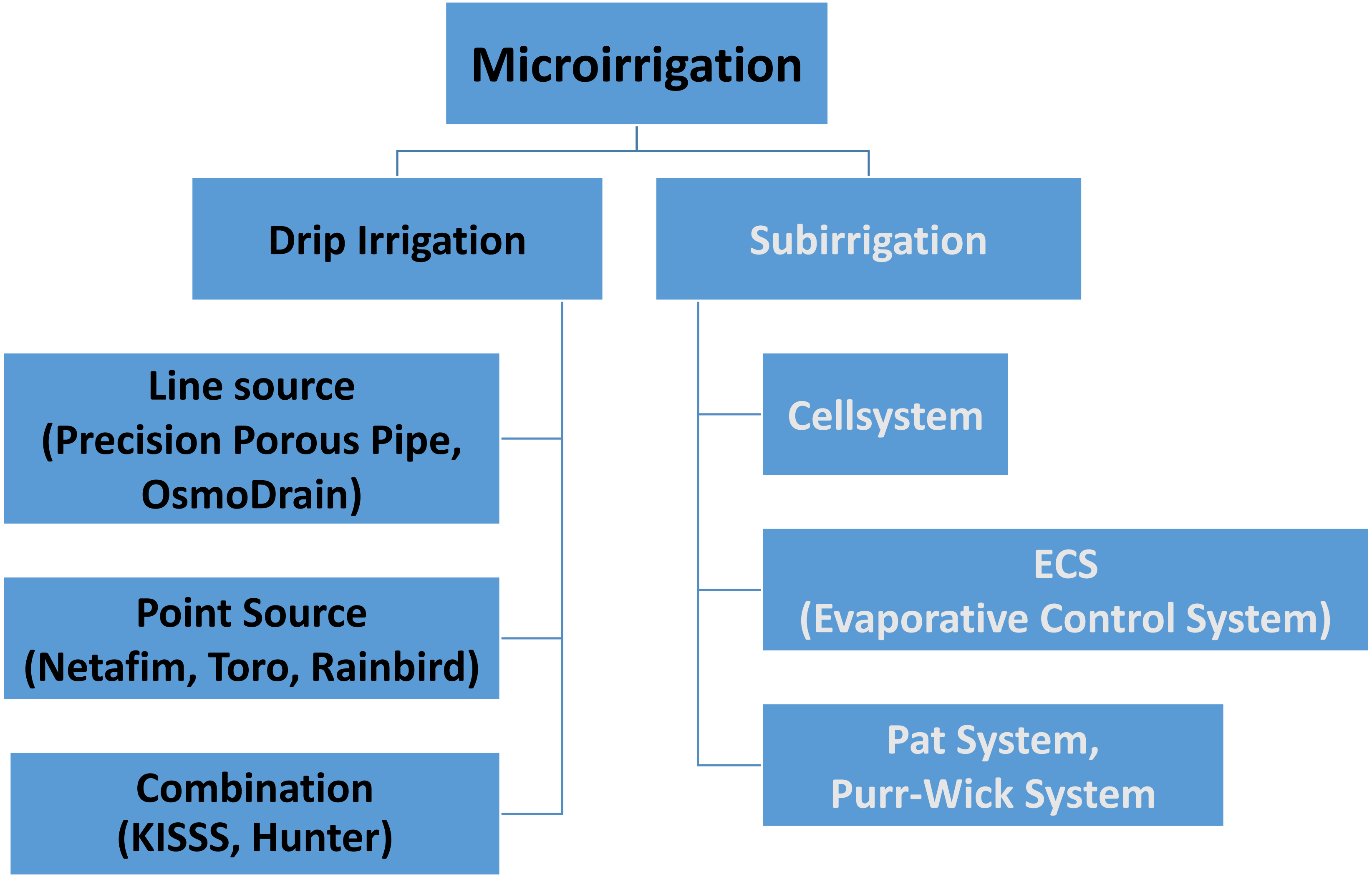
- Determine amount of water per irrigation cycle
- Determine irrigation distribution / efficiency (DU)
- DU should be greater >0.7

Irrigation Efficiency

- Mecham (2004): Summary of uniformity data from over 6800 irrigation audits (Utah, Nevada, Colorado, Arizona, Texas, Oregon, and Florida)
- Average DU of 0.5

↓

The amount of irrigation water doubles compared to what “the grass plant needs” to maintain an adequate quality level

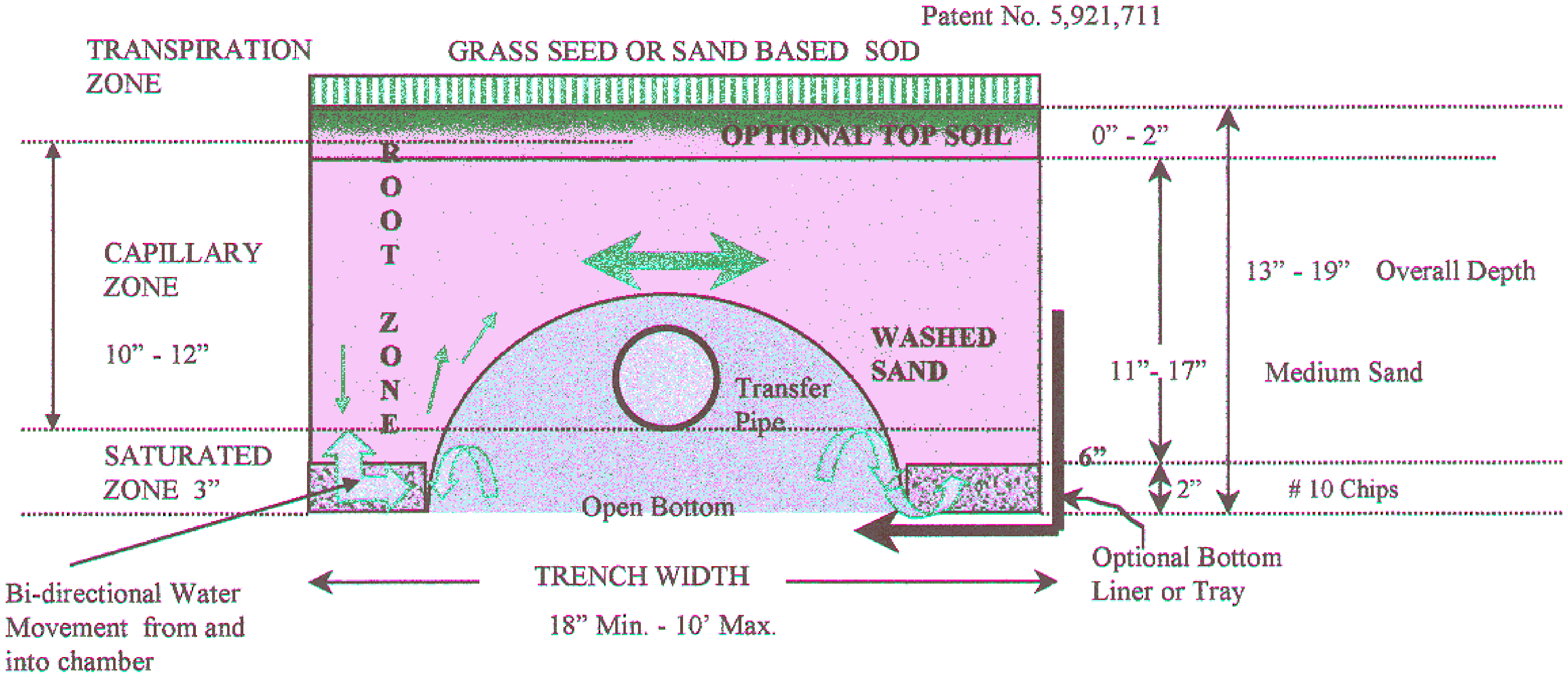


- **Microirrigation**
  - **Drip Irrigation**
    - **Line source (Precision Porous Pipe, OsmoDrain)**
    - **Point Source (Netafim, Toro, Rainbird)**
    - **Combination (KISSS, Hunter)**
  - **Subirrigation**
    - **Cellsystem**
    - **ECS (Evaporative Control System)**
    - **Pat System, Purr-Wick System**

SUBIRRIGATION (SBI)

- Line source system
- Irrigate and drain through one pipe system
- Subgrade sealed by plastic barrier (optional) – “bath tub” analogy
- Sand or sandy rootzone mix
- 30 - 40 cm (12’’ - 16’’) deep
- PAT-System, Cellsystem, EPIC,

ECS / EPIC System



Turf Construction

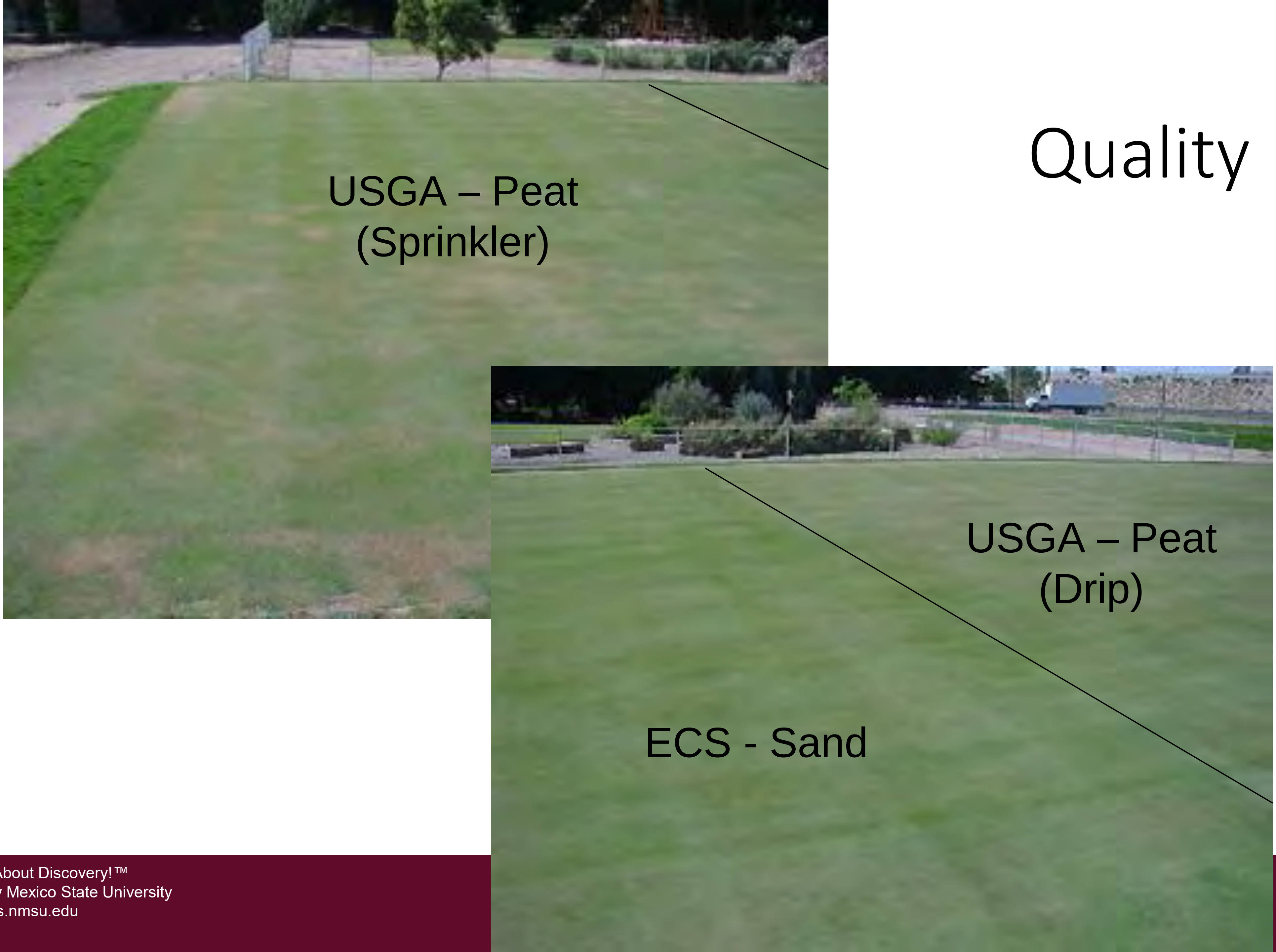
Structural cross section Details

EPIC System

Research area: 4000 m^2
43,000 ft^2

Plot size: 17 m x 17 m
55 ft x 55 ft

Quality



Summary

- SBI turf showed higher quality
- SBI turf showed less LDS
- SBI turf had lower irrigation requirement
- SBI turf is more drought resistant than sprinkler irrigated turf, it uses water more efficiently, thereby needing less water

Subsurface Drip Irrigation for Turfgrass Areas

DL2000® Series PC Dripline

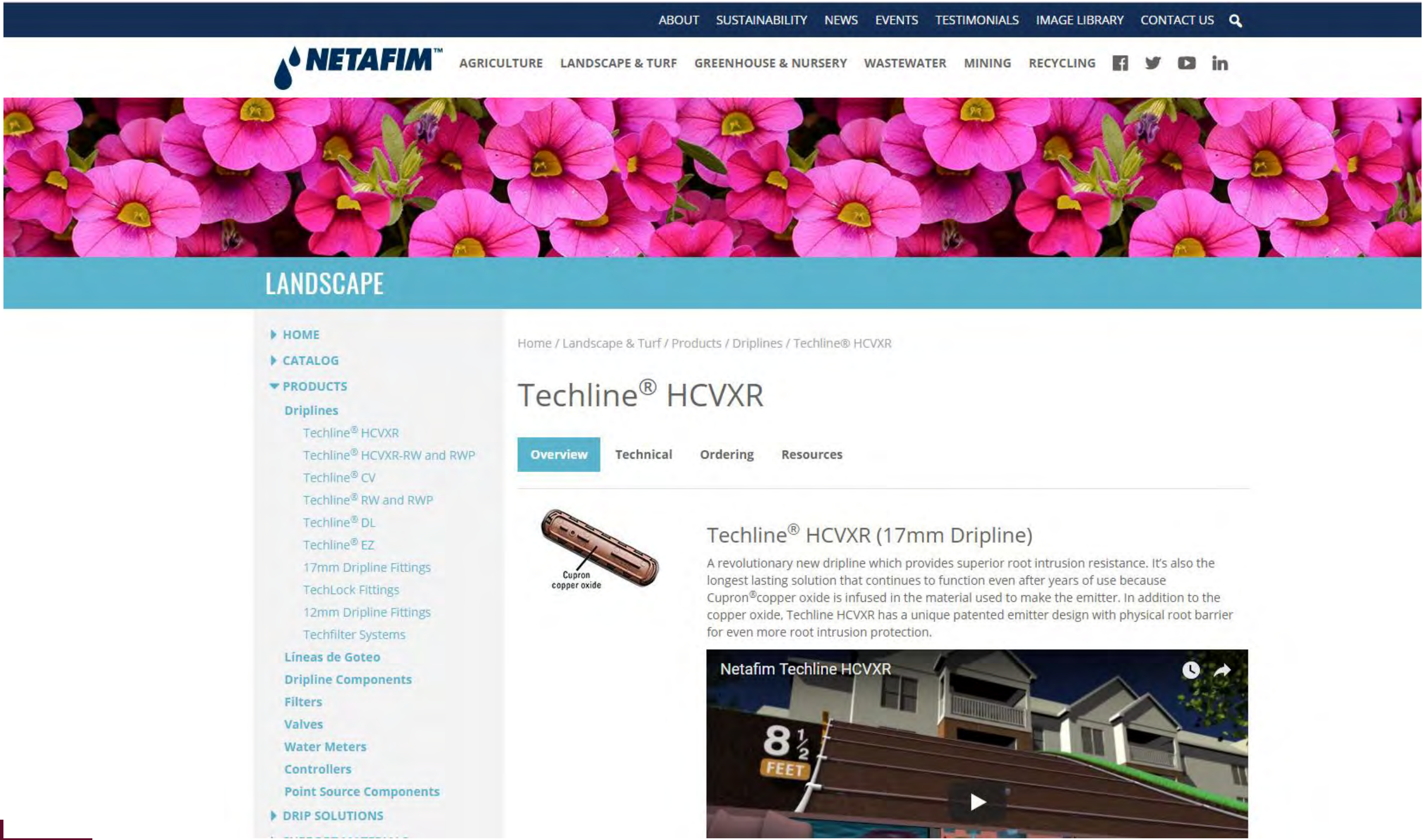
- No filters to change or chemically treated disks to handle
- Irrigation takes place at or below grade so there is minimal water loss due to mist, evaporation, run-off or wind
- Ideal for shrub areas, median strips, public recreation areas and parking islands
- Seven-year warranty against root intrusion

You Are Here: Home > Landscape Irrigation > Products > Drip Tubing & Distribution Components > XFS Sub-Surface Dripline

XFS Subsurface Dripline

With Copper Shield™ Technology

Rain Bird® XFS Dripline with Copper Shield™ for sub-surface drip irrigation is the latest innovation in the Rain Bird Xerigation® Family. Rain Bird's patent-pending Copper Shield Technology protects the emitter from root intrusion, creating a long-lasting, low maintenance sub-surface drip irrigation system for use under turf grass or shrub and groundcover areas.

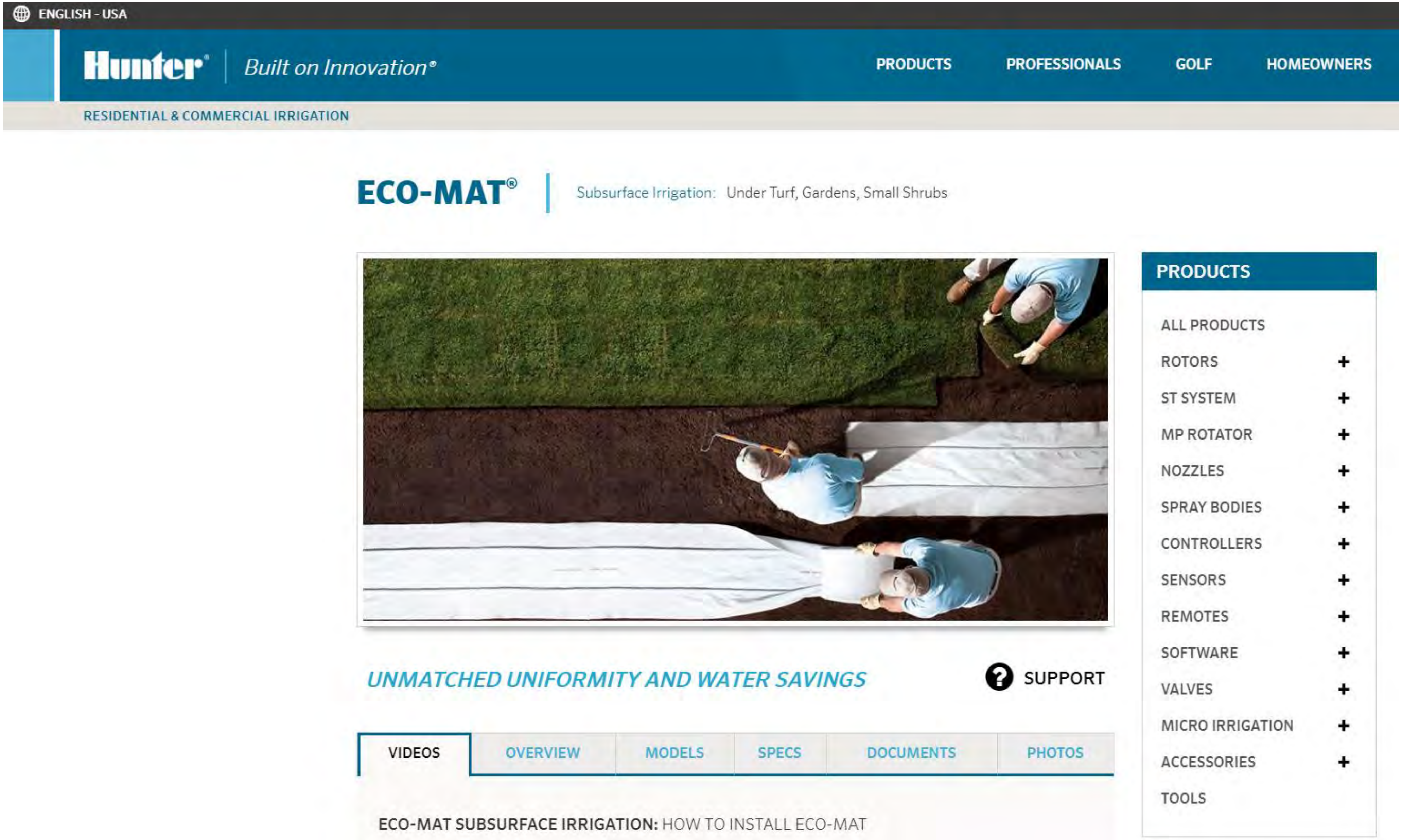


Home / Landscape & Turf / Products / Driplines / Techline® HCVXR

Techline® HCVXR

Techline® HCVXR (17mm Dripline)

A revolutionary new dripline which provides superior root intrusion resistance. It's also the longest lasting solution that continues to function even after years of use because Cupron® copper oxide is infused in the material used to make the emitter. In addition to the copper oxide, Techline HCVXR has a unique patented emitter design with physical root barrier for even more root intrusion protection.



ECO-MAT® | Subsurface Irrigation: Under Turf, Gardens, Small Shrubs

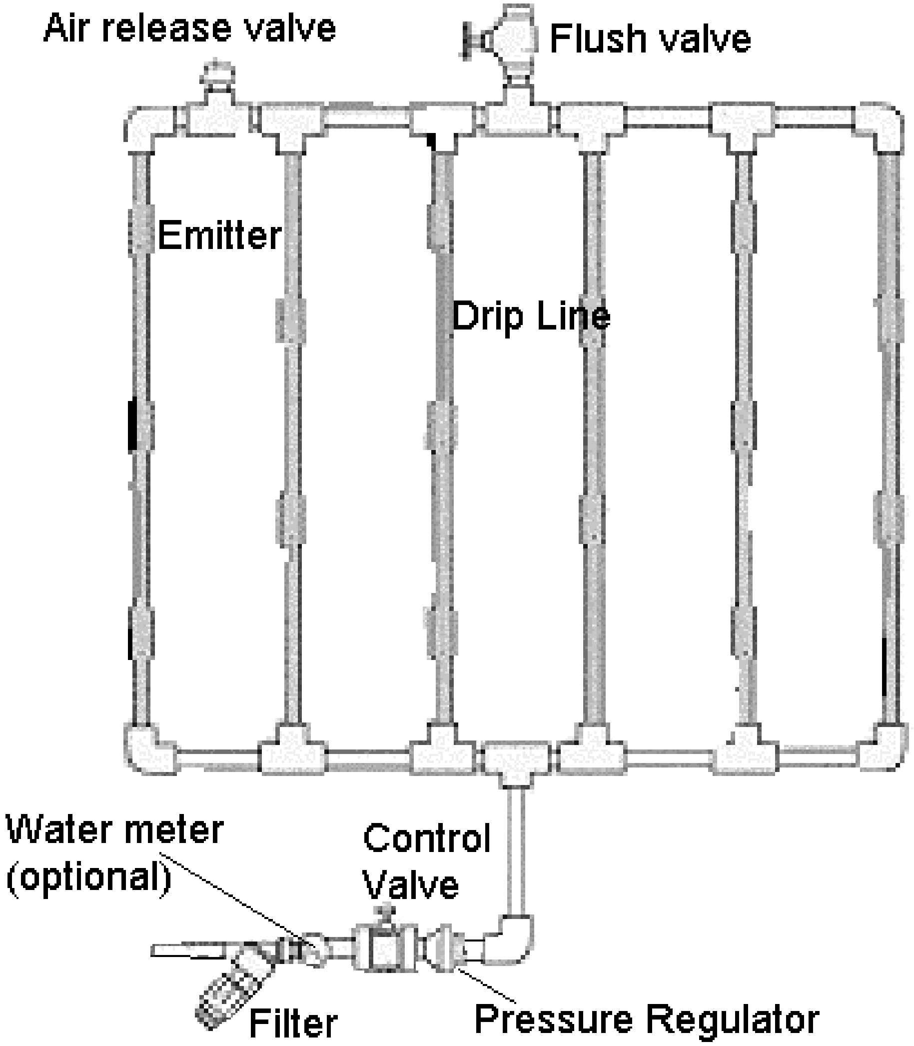
UNMATCHED UNIFORMITY AND WATER SAVINGS

ECO-MAT SUBSURFACE IRRIGATION: HOW TO INSTALL ECO-MAT

SUBSURFACE DRIP IRRIGATION (SDI)

Typical design:

- 4” (10 cm) depth
- 1’ (30 cm) spacing



Toro, 2000

Market acceptance – Concerns:

- Performance / Longevity
- Saline water irrigation
- Establishment
- Maintenance (e.g. Fertilization, Pesticides)

1) Performance of Warm and Cool-Season Grasses under Subsurface Drip and Sprinkler Irrigation

	Warm Season	Cool Season
Species	Bermudagrass; Seashore paspalum; Inland saltgrass; Zoysiagrass;	Alkaligrass; Red fescue; Tall fescue; Perennial ryegrass;
Soil / Installation	Sandy loam; 10 cm depth, 30 cm between lines (and emitters)	
Irrigation	Precision Porous Pipes; Toro DL2000 MP Rotator; Toro Precision^{TM} Series	
	100% ET_o; 50% ET_o	120% ET_o
Water Quality	Potable; Saline I (TDS 1280 ppm, SAR 6.4); Saline II (1800 ppm, SAR 4.0); Saline III (2000 ppm, SAR 8.8)	

Sevostianova et al., 2011

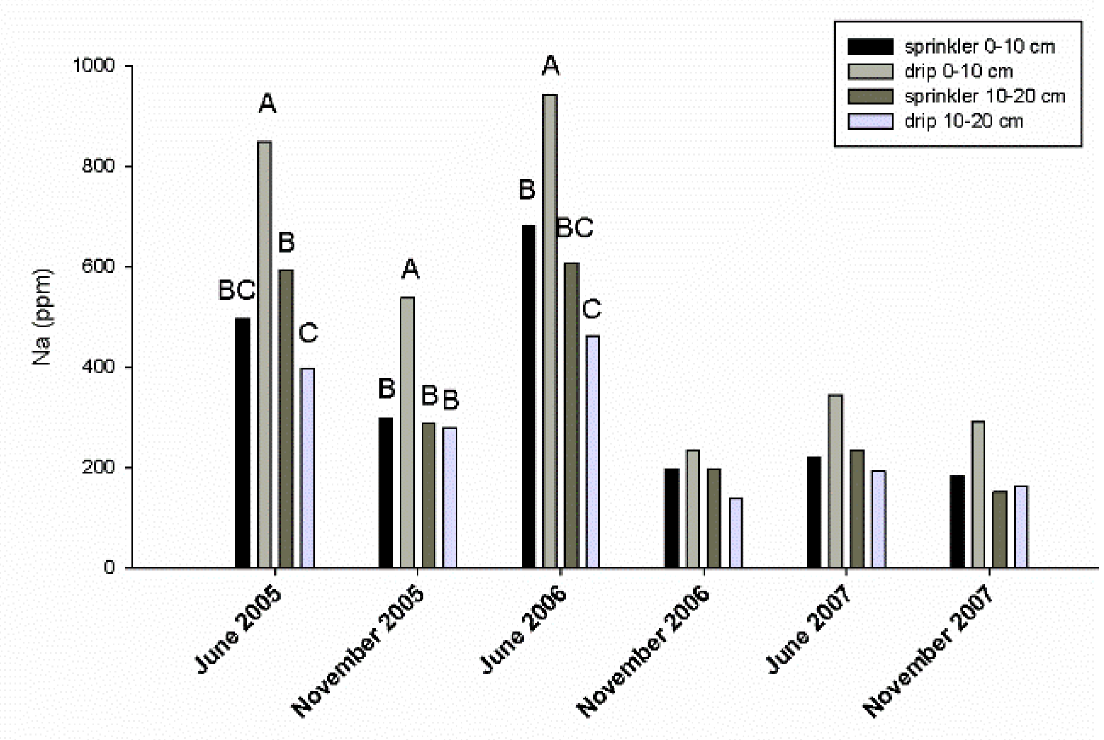
Results

Warm season grasses

- EC, Na, or SAR did not affect turf quality
- Turf quality: Seashore paspalum > Bermudagrass
- Drip irrigation resulted in earlier green-up than sprinkler irrigation but had no effect on summer quality or fall color retention

Cool season grasses

- Changes in soil EC, Na content, and SAR reflected seasonal changes in irrigation and natural precipitation
- Greatest EC and Na values were reached on drip irrigated plots at depths of 0 – 10 cm
- Only tall fescue could be maintained at acceptable quality when irrigated with saline water
- More than one stressor affected quality



Sevostianova et al., 2011

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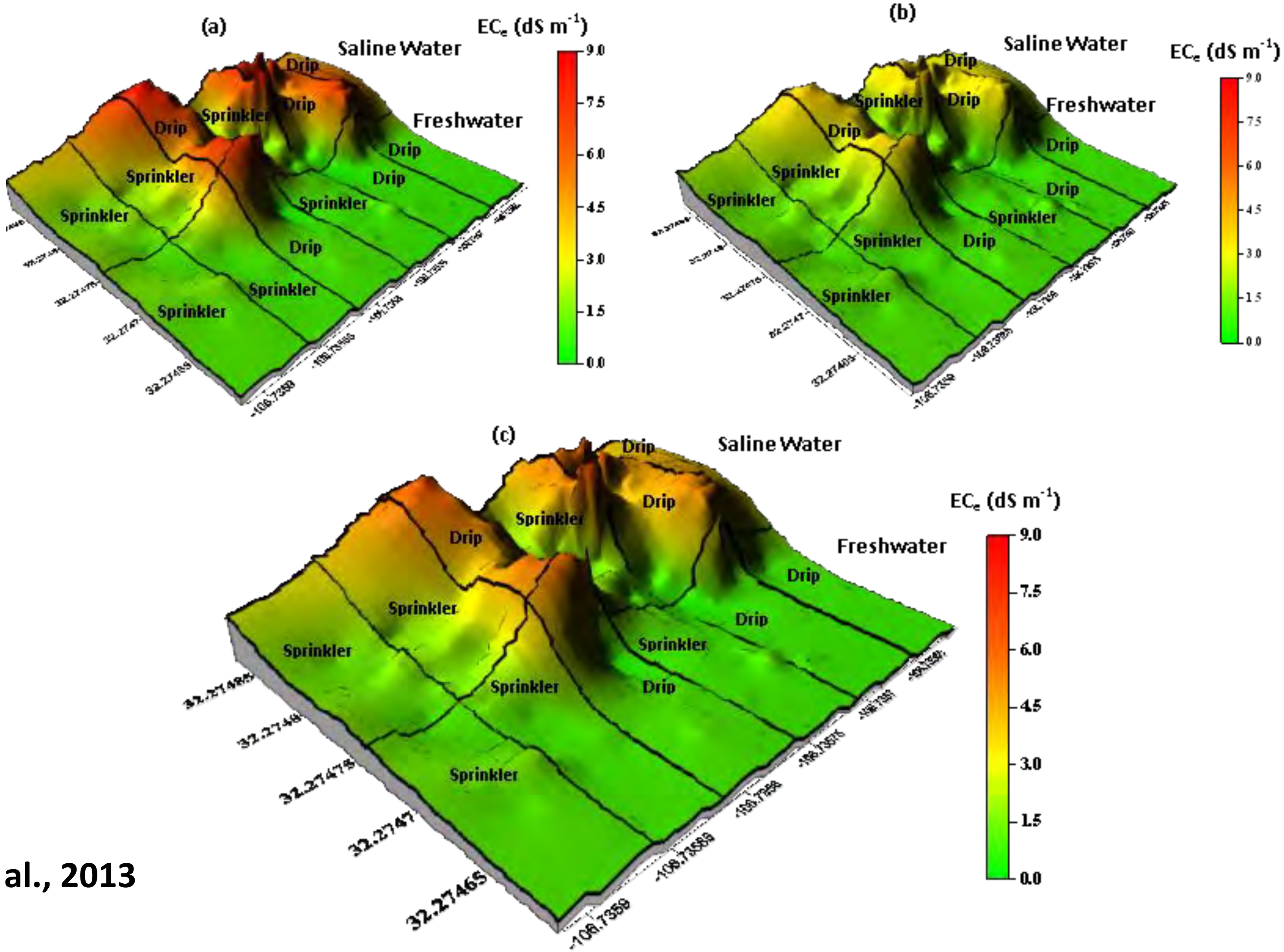
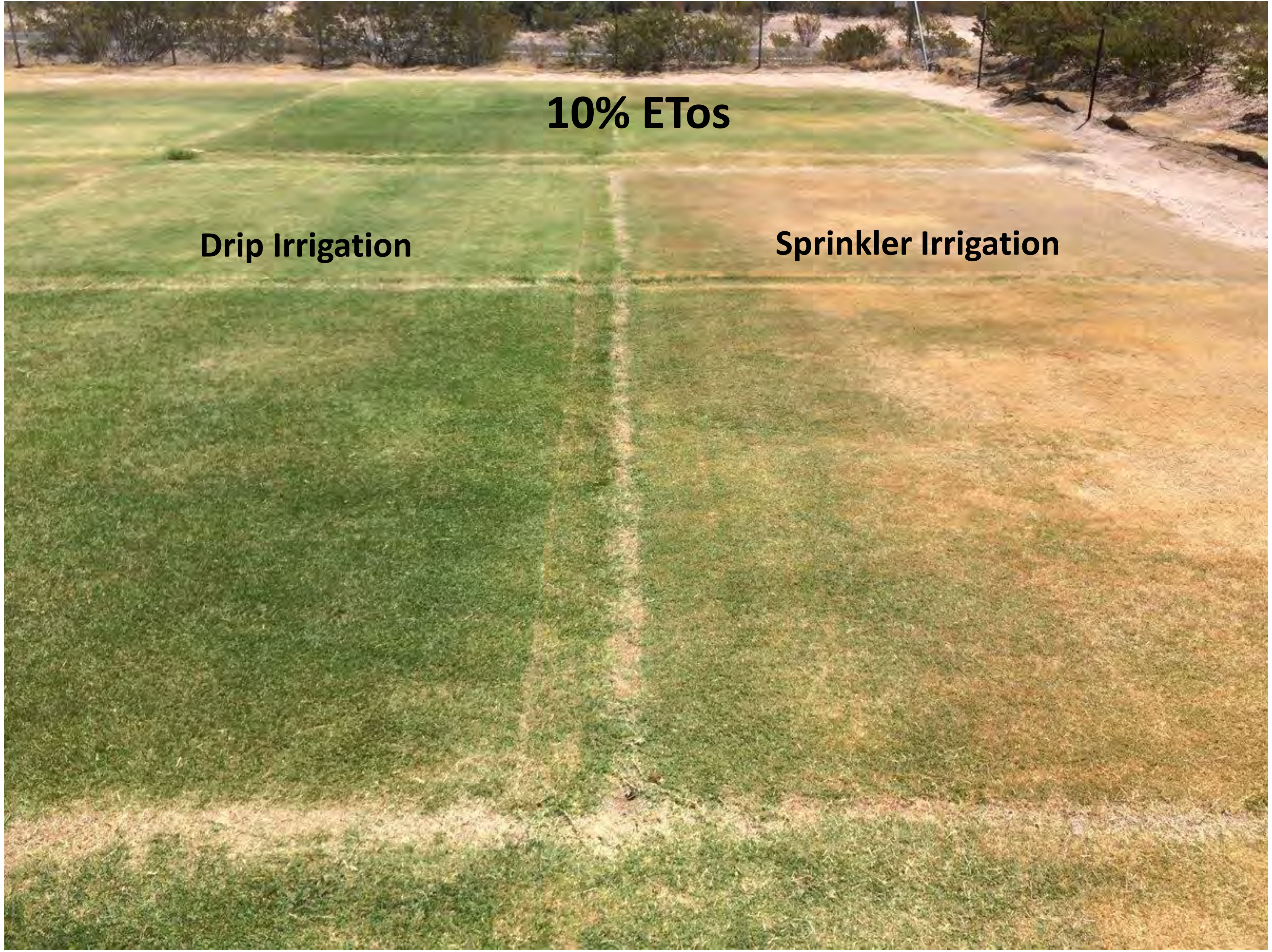
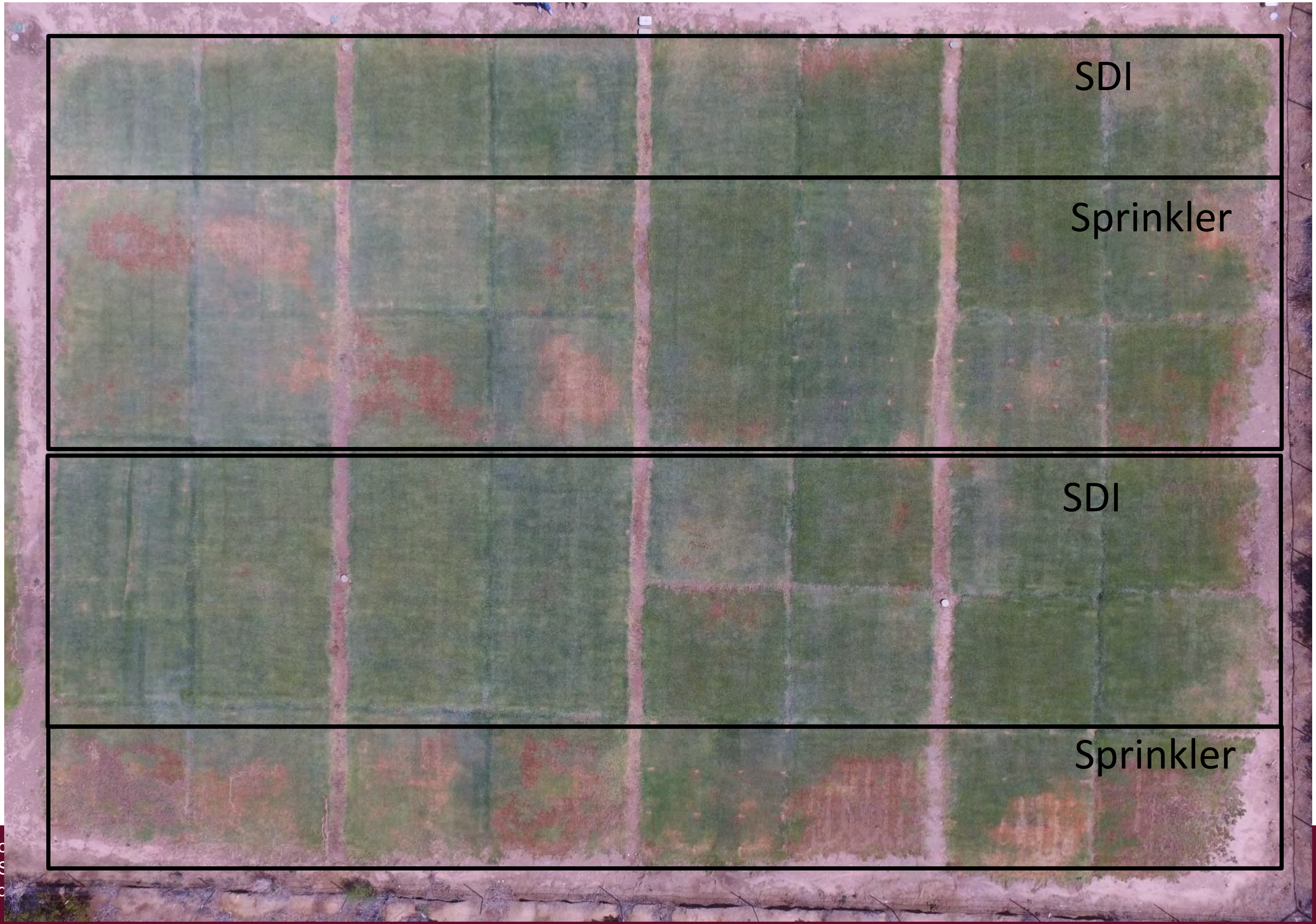


Ganjegunte et al., 2013


10% ETos
Drip Irrigation
Sprinkler Irrigation

Irrigation effect on brown patch (Rhizoctonia sp.) occurrence



2) Establishment of Warm and Cool-Season Grasses under Subsurface Drip and Sprinkler Irrigation

	Warm Season	Cool Season
Species	Bermudagrass 'Princess 77' Seashore paspalum 'Sea Spray'	Tall fescue 'Justice' Kentucky bluegrass 'Barduke'
Seeding	Mar and Jun 2008 and 2009	Sep 2009 and Oct 2010
Irrigation	Toro DL2000 MP Rotator / Toro Precision^{TM} Series 100% ETo	Membrane covered drip system (KISSS America) Toro Precision^{TM} Series 120% ETo
Water Quality	Potable Saline (1800 ppm, SAR 4.0)	

Summary

Warm-season grasses

- Early planting will establish warm season grasses quickly and successfully
- Saline water can be used in combination with sprinkler and drip irrigation for establishment (both seed and sod)
- Warm season grasses establish best under drip irrigation when seeded or sodded early

Cool-season grasses

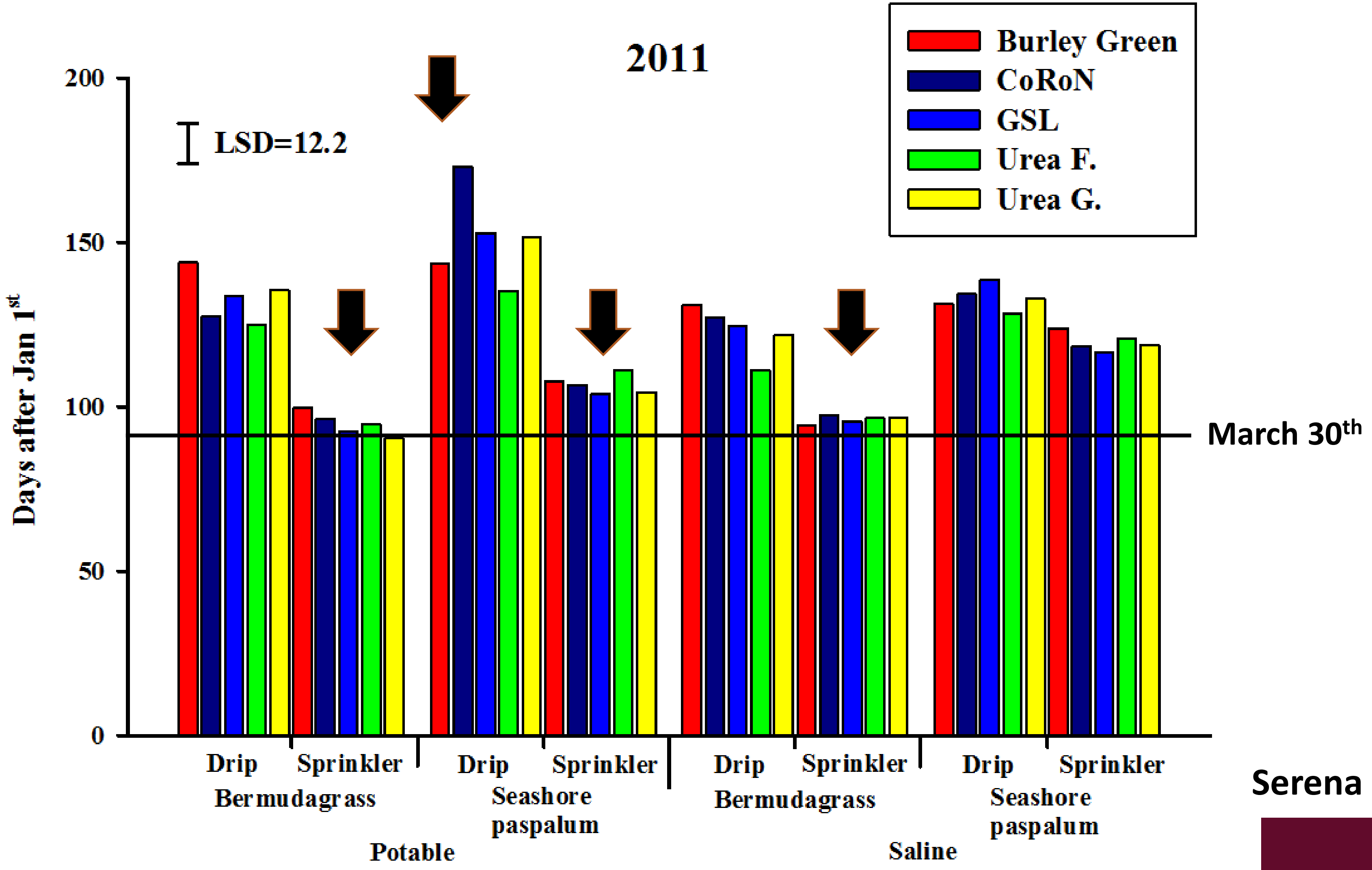
- CS establishment was successful in both years
- Spacing between drip lines needs to be carefully evaluated
- Salinity problems may arise for CS grasses if subsurface drip is used with saline water

Schiavon et al., 2012; 2013; Serena et al., 2014

3) Fertilization of Warm – Season Grasses under Subsurface Drip and Sprinkler Irrigation

	Warm Season	
Species	Bermudagrass; Seashore paspalum;	
Soil / Installation	Sandy loam; 10 cm depth, 30 cm between lines (and emitters)	
Irrigation	Toro DL2000; MP Rotator; Toro Precision^{TM} Series	80% ET_o
Water Quality	Potable; Saline (TDS 1900 ppm, SAR 6);	
Fertilizer	Urea 46-0-0- granular (15 days); Urea foliar (15 days); Burley Green 18-2-3 (every 15 days); CoRoN 28-0-0 (every 45 days); Granular slow release 20-4-8 (every 45 days)	

Results:
Green up (75% green cover)



Serena et al., 2017

References (1)

- Schiavon, M., B. Leinauer, M. Serena, B. Maier, and R. Sallenave. 2014. Plant Growth Regulator and Soil Surfactants' Effects on Saline and Deficit Irrigated Warm-season Grasses: I. Turf Quality, Color Retention, and Soil Moisture Distribution. **Crop Science** doi: 10.2135/cropsci2013.10.0707
- Schiavon, M., B. Leinauer, M. Serena, B. Maier, and R. Sallenave. 2014. Plant Growth Regulator and Soil Surfactants' Effects on Saline and Deficit Irrigated Warm-season Grasses: II. Pigment Content and Superoxide Dismutase Activity. **Crop Science**. doi: 10.2135/cropsci2013.10.0708
- Ganjegunte, G., B. Leinauer, M. Schiavon, and M. Serena. 2013. Using Electro-Magnetic Induction to Determine Soil Salinity and Sodicity in Turf Root Zones. **Agronomy Journal** 105:836–844.
- Sevostianova, E., B. Leinauer, R. Sallenave, D. Karcher, and B. Maier. 2011. Soil Salinity and Quality of Sprinkler and Drip Irrigated Warm-Season Turfgrasses. **Agronomy Journal** 103:1773-1784.
- Sevostianova, E., B. Leinauer, R. Sallenave, D. Karcher, and B. Maier. 2011. Soil Salinity and Quality of Sprinkler and Drip Irrigated Cool-Season Turfgrasses. **Agronomy Journal** 103:1503-1513
- Schiavon, M., B. Leinauer, E. Sevostianova, M. Serena, and B. Maier. 2011. Warm-season turfgrass quality, spring green-up, and fall color retention under drip irrigation. Online. **Applied Turfgrass Science** doi:10.1094/ATS-2011-0422-01-RS.

References (2)

- Serena, M., B. Leinauer, M. Schiavon, B. Maier, and R. Sallenave. 2014. Establishment and Rooting Response of Bermudagrass Propagated with Saline Water and Subsurface Irrigation. **Crop Science** 54: 827-836.
- Schiavon, M., B. Leinauer, M. Serena, R. Sallenave, and B. Maier. 2013. Establishing tall fescue and Kentucky bluegrass using subsurface irrigation and saline water. **Agronomy Journal** 105:183-190.
- Schiavon, M., B. Leinauer, M. Serena, R. Sallenave, and B. Maier. 2012. Bermudagrass and Seashore Paspalum Establishment from Seed Using Differing Irrigation Methods and Water Qualities. **Agronomy Journal** 104:706-714.
- Schiavon, M., M. Serena, R. Sallenave, B. Leinauer, and J. Baird. 2015. Seeding Date and Irrigation System Effects on Establishment of Warm-Season Turfgrasses. **Agronomy Journal**, *107*(3):880-886.
- Sevostianova, E. and B. Leinauer. 2014. Subsurface-Applied Tailored Water: Combining Nutrient Benefits with Efficient Turfgrass Irrigation. **Crop Science 54**:1926-1938. doi:10.2135/cropsci2014.01.0014
- Serena, M., M. Schiavon, R. Sallenave, and B. Leinauer. 2017. Nitrogen fertilization of warm-season turfgrasses irrigated with saline water from varying irrigation systems. 1. Quality, spring green up, and fall color retention. **Journal of Agronomy and Crop Science** 204:252-264.
- Serena, M., M. Schiavon, R. Sallenave, and B. Leinauer. 2017. Nitrogen fertilization of warm-season turfgrasses irrigated with saline water from varying irrigation systems. 2. Carbohydrate and protein content. **Journal of Agronomy and Crop Science** 204:265-273.

System Installation

System Installation

Filter

Installation (home lawn)

Clogged Filter

4 years irrigation with potable water

24 hours in CLR

Installation and Maintenance

Problems

- Planning
- Installation
- Filtration
- Root intrusion
- Manufacturing
- Maintenance

Project: Las Campanas, NM

Problem: Overspray

Las Campanas, NM

- Santa Fe, NM 7,000 ft elevation
- 14” average precipitation
- 36 holes
- Budget constraints
- Irrigation water conservation
- 2015 decision to install SDI
- Supported by USGA, Hunter, Netafim, Rainbird, Toro

Materials and Methods

- 14 tee boxes (back tees): 240 – 760 ft^2
- USGA type construction/rootzone
- Creeping bentgrass + annual bluegrass
- Mowing height

- Hunter ECO-MAT (0.6 gl hr^{-1})
- Netafim XCVXR (0.53 gl hr^{-1})
- Rainbird XFS (0.42 gl hr^{-1})
- Toro DL 2000 (0.5 gl hr^{-1})
- 2 controls (DU 0.69 and 0.79)
- 5 inches deep
- Trenching vs. sod removal

Installation
April 28th 2016

Sod removal

Trenching into existing turf

Installation April 26 – Photo taken August 5th

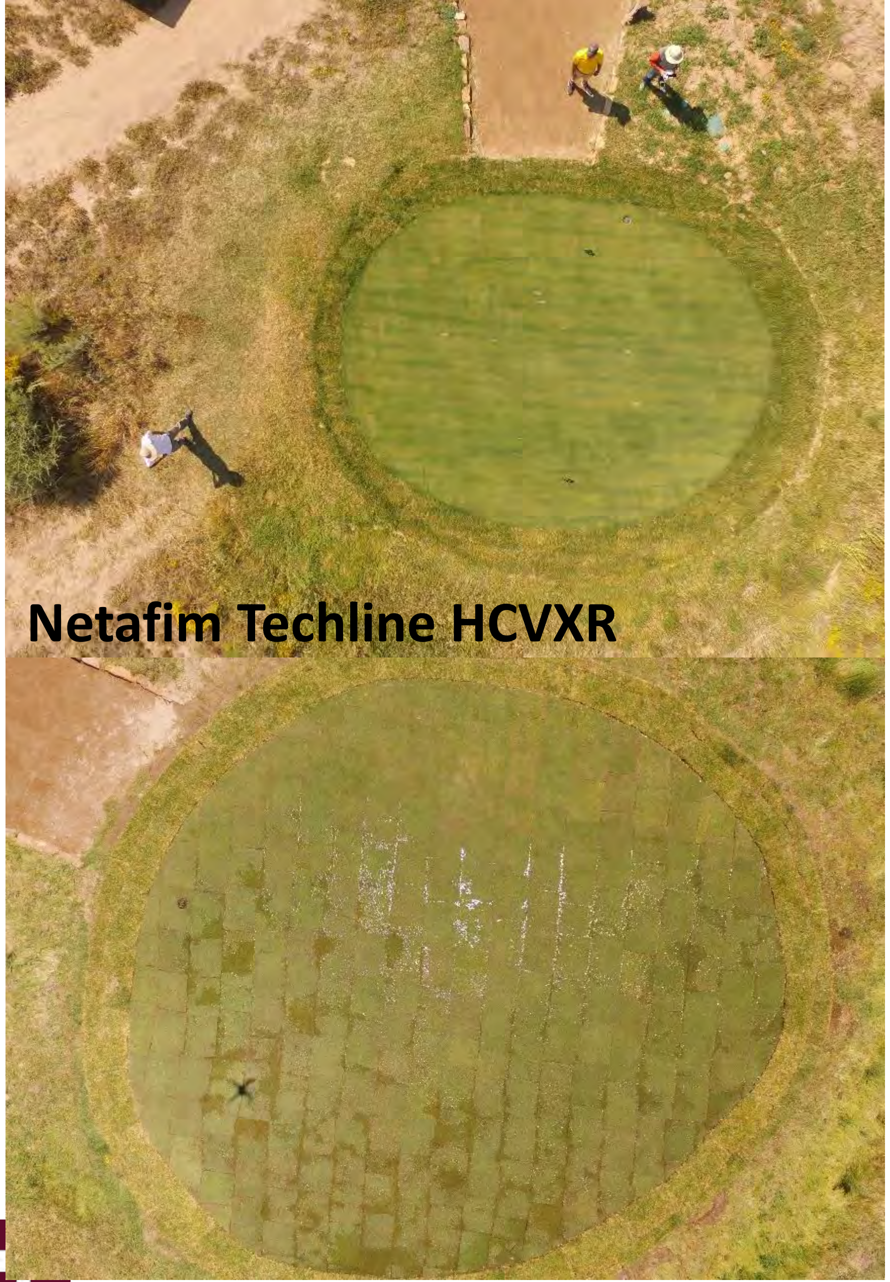
Problem: Drip lines installed too deep

August 5th 2016

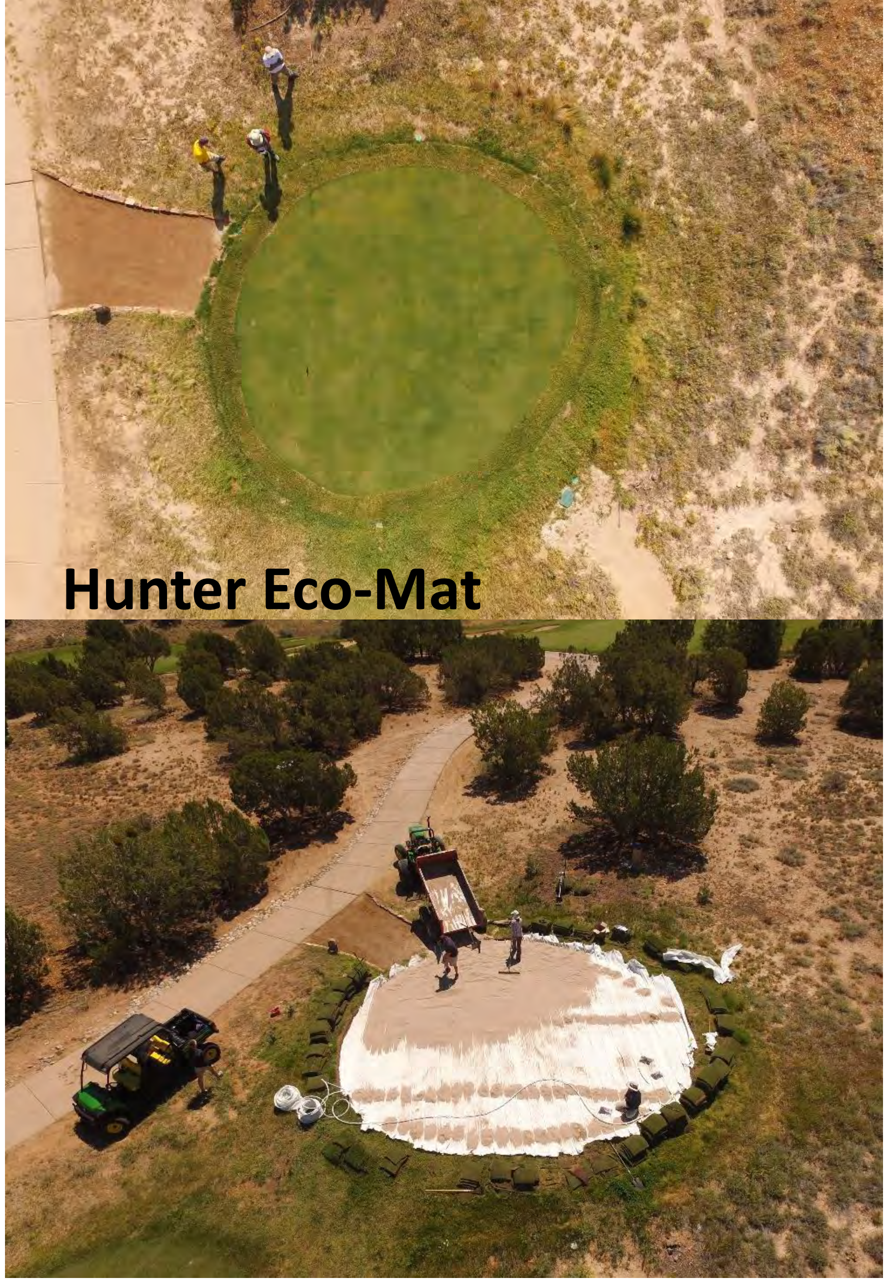
October 5th 2016

Las Campanas, Tee #6

Due to publicity and great success, Hunter and Netafim SDI were added to the test in 2017



Netafim Techline HCVXR



Hunter Eco-Mat

Keeping up with the maintenance

Conclusions

1) Subsurface drip irrigation can be used to irrigate turf efficiently
2) also in combination with saline water
3) is a viable alternative to traditional sprinkler systems if installed, monitored, and maintained properly
4) More education and public outreach needed to promote technology

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2019 NATIONAL CONFERENCE
SANTA FE, NEW MEXICO

On-site Assessment of PVC Installations

Larry Workman

Expert4PVC Consulting

Focus

Solvent Joints

Threaded Joints

Identification

Storage

Training

Health Hazard

Things to look for:

- Evidence of primer (purple, blue, or 1-step)
- Filling of gap between pipe and fitting
- Misalignment of joint
- Snaking of pipeline in trench

Solvent Welding

- Correct type and viscosity for sizes and schedules
- Are applicators the proper size
- Are installers trained

Threaded Joints

- Transition joints MUST be Plastic Male → Metal Female
- Teflon tape / dope is **NOT RECOMMENDED**
- Use non-hardening sealant compatible with both materials and system
  - NSF Listed
  - Oxygen/gas systems (if applicable)

Training of installation crews

- Specify a training session for crew members
  - Not just supervisors; but installers!

    (The guys in the trench)
- Provided by Pipe, Fitting or Cement manufacturer representatives

Product Identification

- PVC Pipe has ID printing approximately every foot
- Fittings must have a “NSF” and “ASTM” spec.
- Accessories must have “NSF” mark and pressure rating

Storage

- Open storage
  - Pipe and fittings can easily reach 150°F above ambient
- Container Storage
  - Internal temperatures can exceed 200°F
  - Stacks of fitting can lead to deformation and warping

Pressure Rating

- PVC fittings **DO NOT** have a pressure rating
  - Generally assumed to correspond to Schedule 40 or 80 pipe
    - However; irrigation should use 50% of the pipe pressure rating

      (due to surges within the systems)
  - Flanges valves and Specialty fittings are generally rated at 150 psi
    - They do NOT corresponding to the pipe ratings
      - Different test methods

Health Hazards

- Flour, sugar & salt do not leach from the batter after cooking
  - Neither does VC monomer after polymerized
- Green and Black olives
  - The use of lye when curing olives
- Cassava (tapioca)
  - If prepared incorrectly produces cyanide

PVC is not a problem!

- As evidence, it is commonly used in
  - IV tubing, oxygen lines etc. in the medical field
  - Most wallpaper, imitation leather

NSF listed PVC pipe & fittings

Are commonly used for water systems

- Potable water
- Deionized water
- Reverse Osmosis systems
- Process water

- **Should NOT be used or TESTED with compressed air or gasses**

Thank You

Larry Workman

Expert4PVC Consulting

www.Expert4pvc.com

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2019 NATIONAL CONFERENCE
SANTA FE, NEW MEXICO

MASTER PLANNING PROJECT SHOWCASE

Presenters:

Jeff Bruce, Doug Macdonald & Steve Hohl

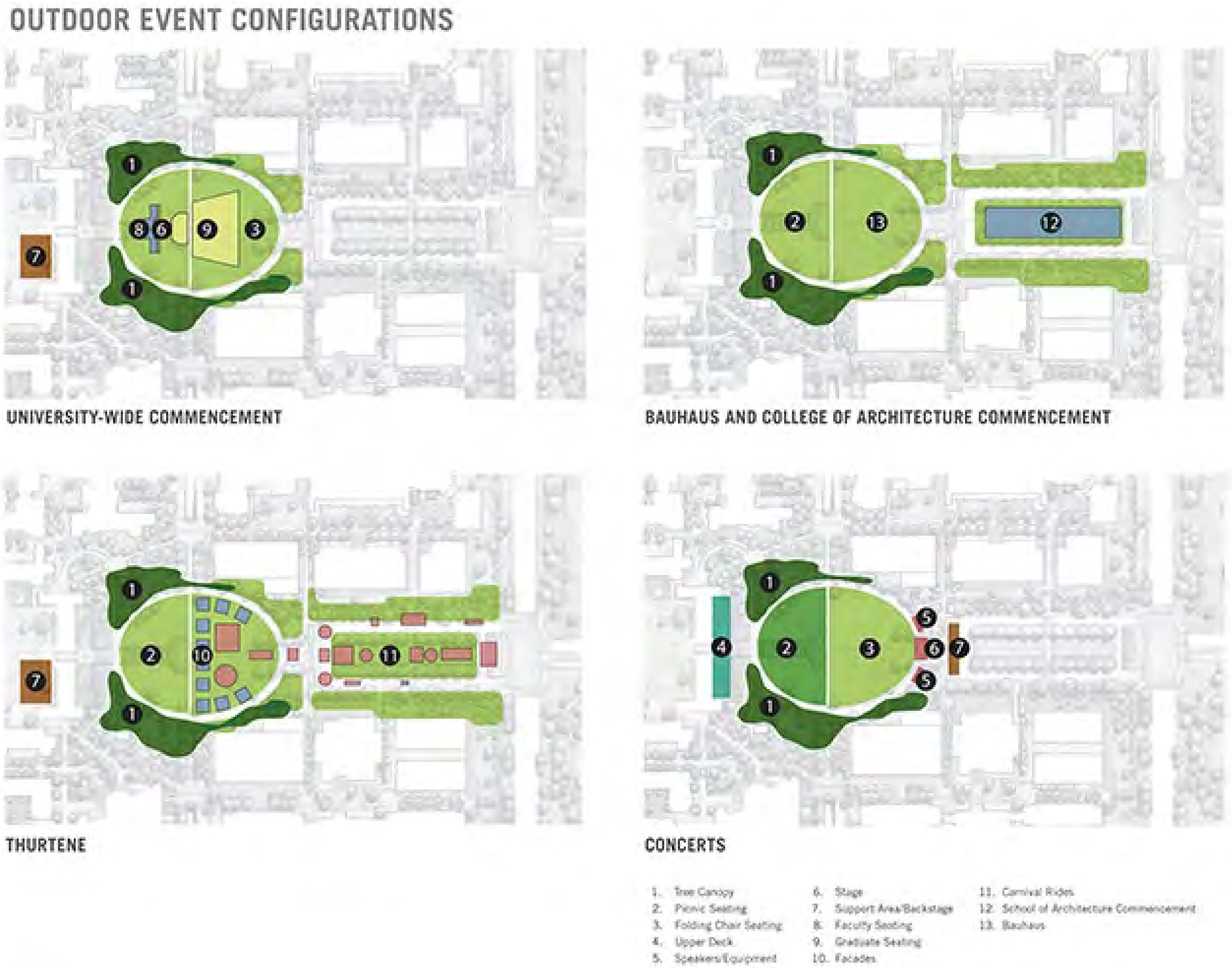
MASTER PLANNING

At the Molecular Level

Washington University East Campus

SOURCE: MICHAEL VERGASON LANDSCAPE ARCHITECTS

SOURCE: MICHAEL VERGASON LANDSCAPE ARCHITECTS



SOURCE: SASAKI ASSOCIATES

SOILS LEGEND :

● Type 1 : Lawn - Turf
Fiber Reinforcement - 4" Min. Depth
12" Min. Soil Depth

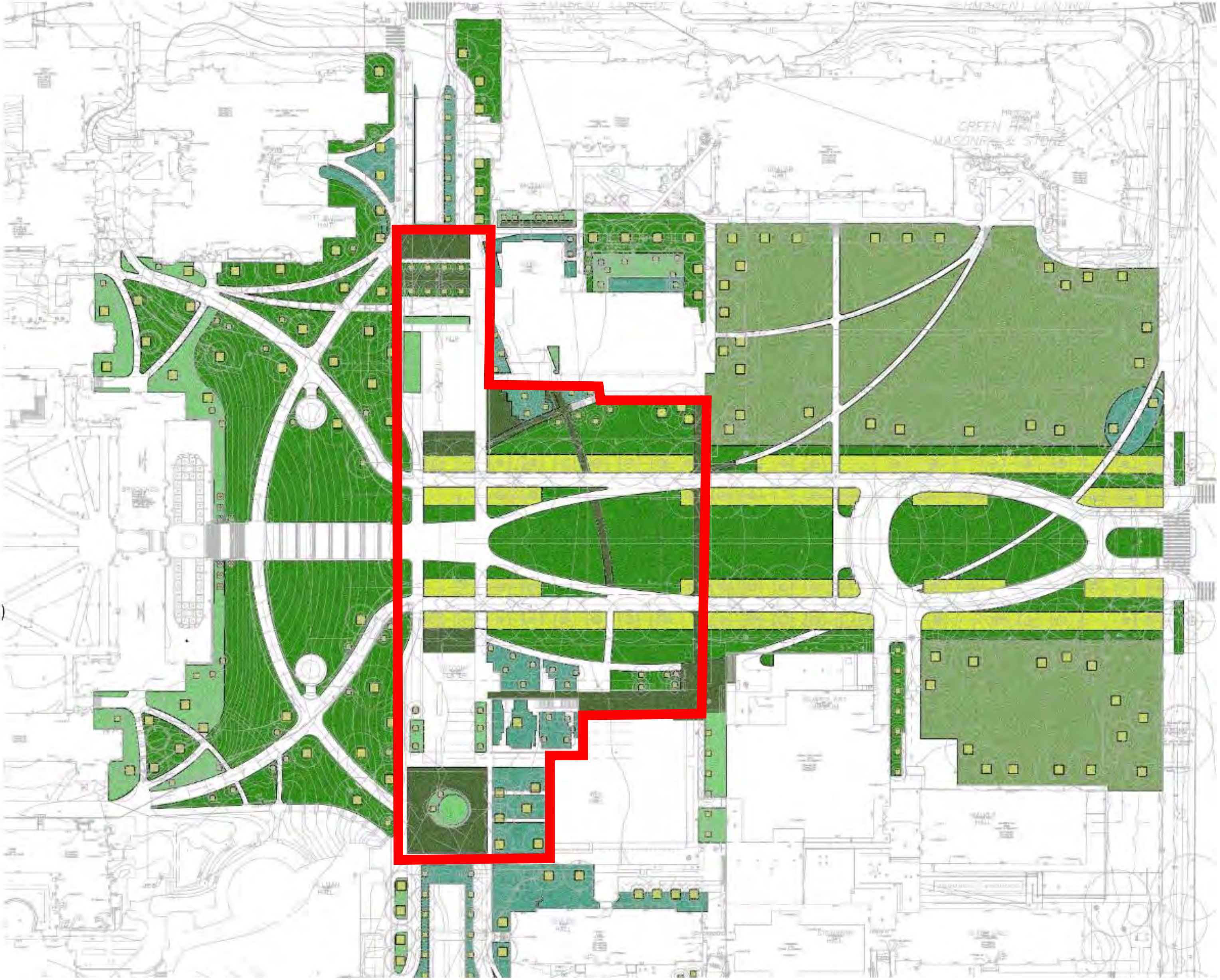
● Type 2 : Planting Bed Soil
Shrub PLanting - 24" Min. Depth
Perennials - 18" Min. Depth

● Type 2 : Tree Pit Soil
42" Max. Depth
Allee Tree Pit - Continuous per plan
Overstory Tree Pit - 15'x15'
Understory / Flowering Tree Pit - 10'x10'

● Type 3: Riparian Planting Soil
24" Min. Depth

● Type 4: Sand-Based Structural Soils
Fiber Reinforcement at Varying Depths

● Type 5: Sandy Loam Native Soil
Passive Program Space (Future Building)
12" Min. Depth



Source: Jeffrey L Bruce & company

Soil profiles

Low to Medium Programmed Use Turf Soil Profile

High Programmed Use Turf Soil Profile (fiber reinforced)

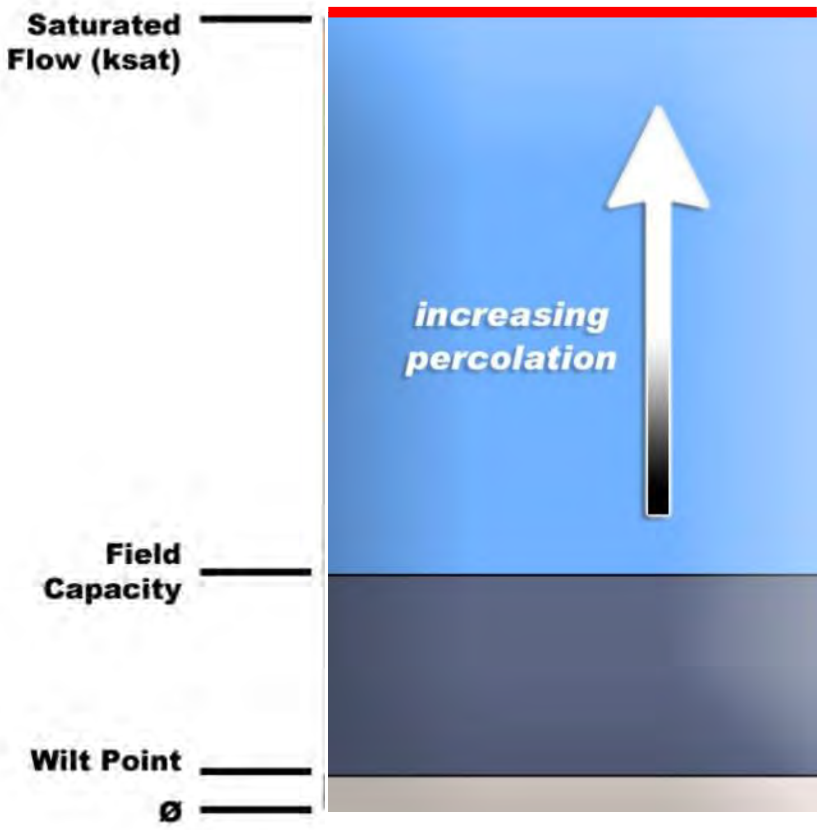
Shrub Soil Profile

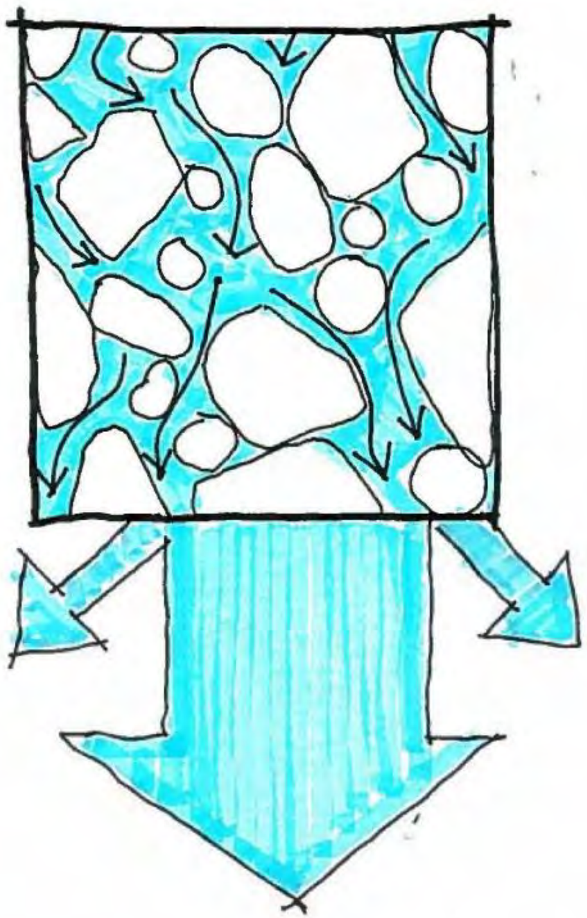
Bio-Retention Planting Soil Profile

Structural Soil Profile

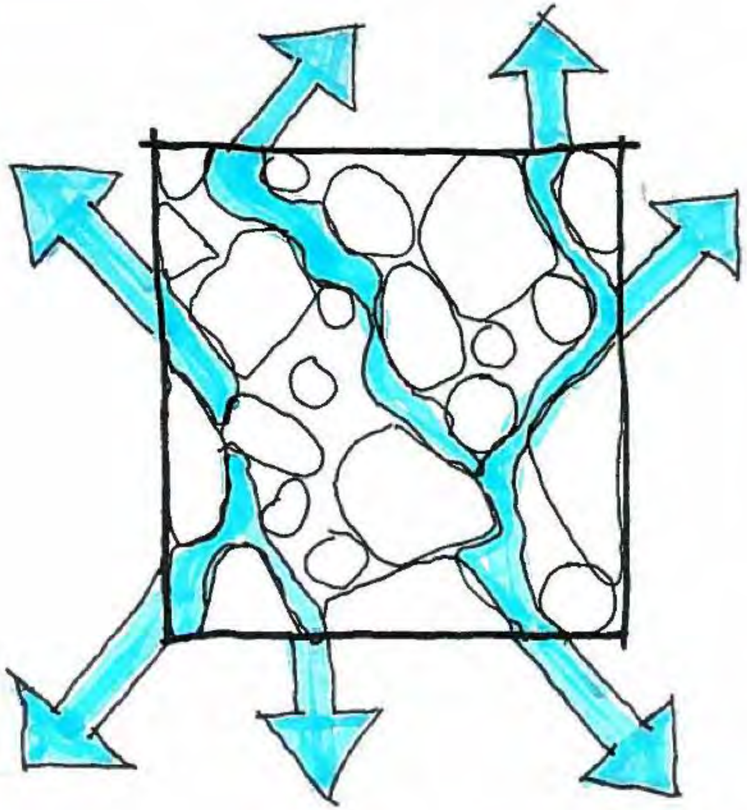
Tree Planting Soil Profile

Saturated vs unsaturated flow





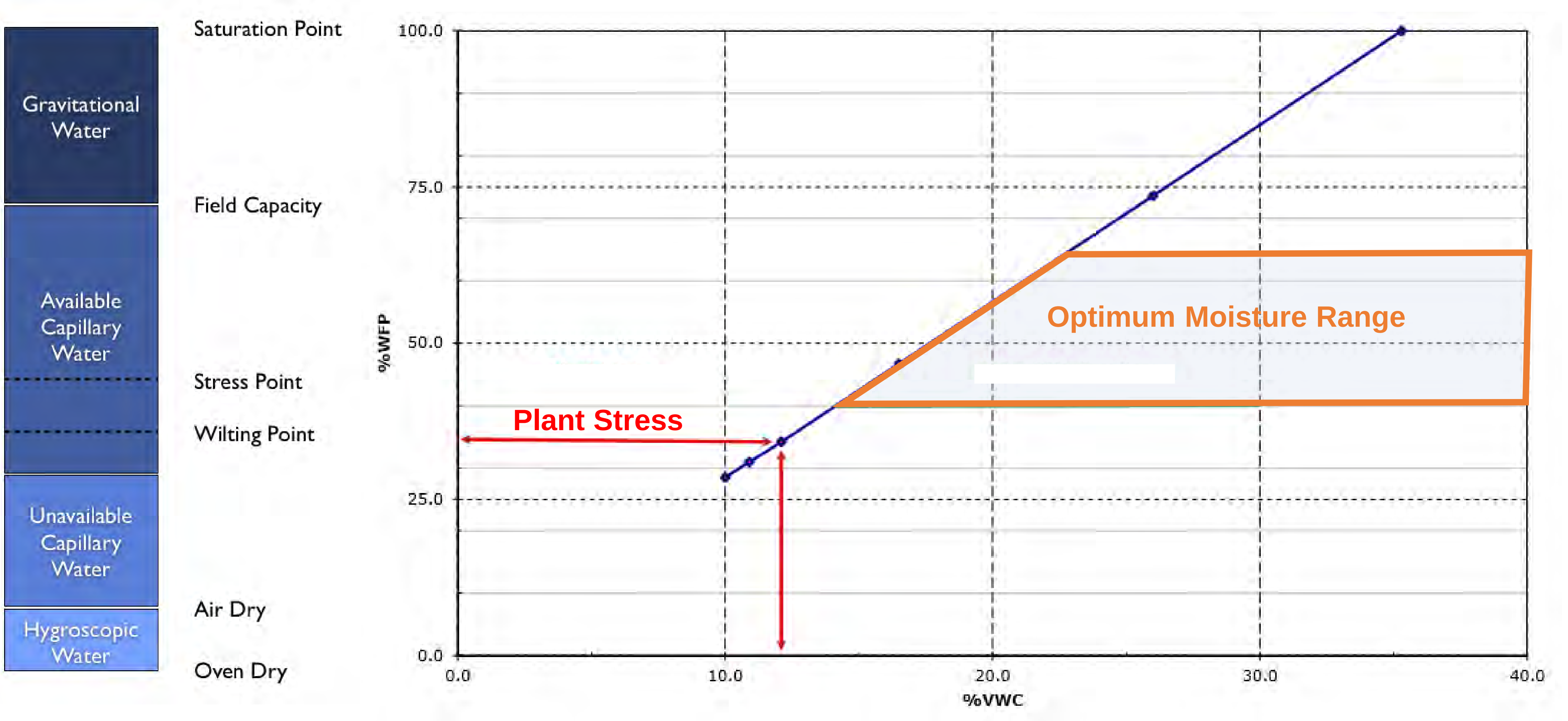
Saturated Flow



Unsaturated Flow

Source: Jeffrey l Bruce & company

Unsaturated flow



Source: C. R. Dixon & associates

Saturated flow events

18 minutes in 90 days

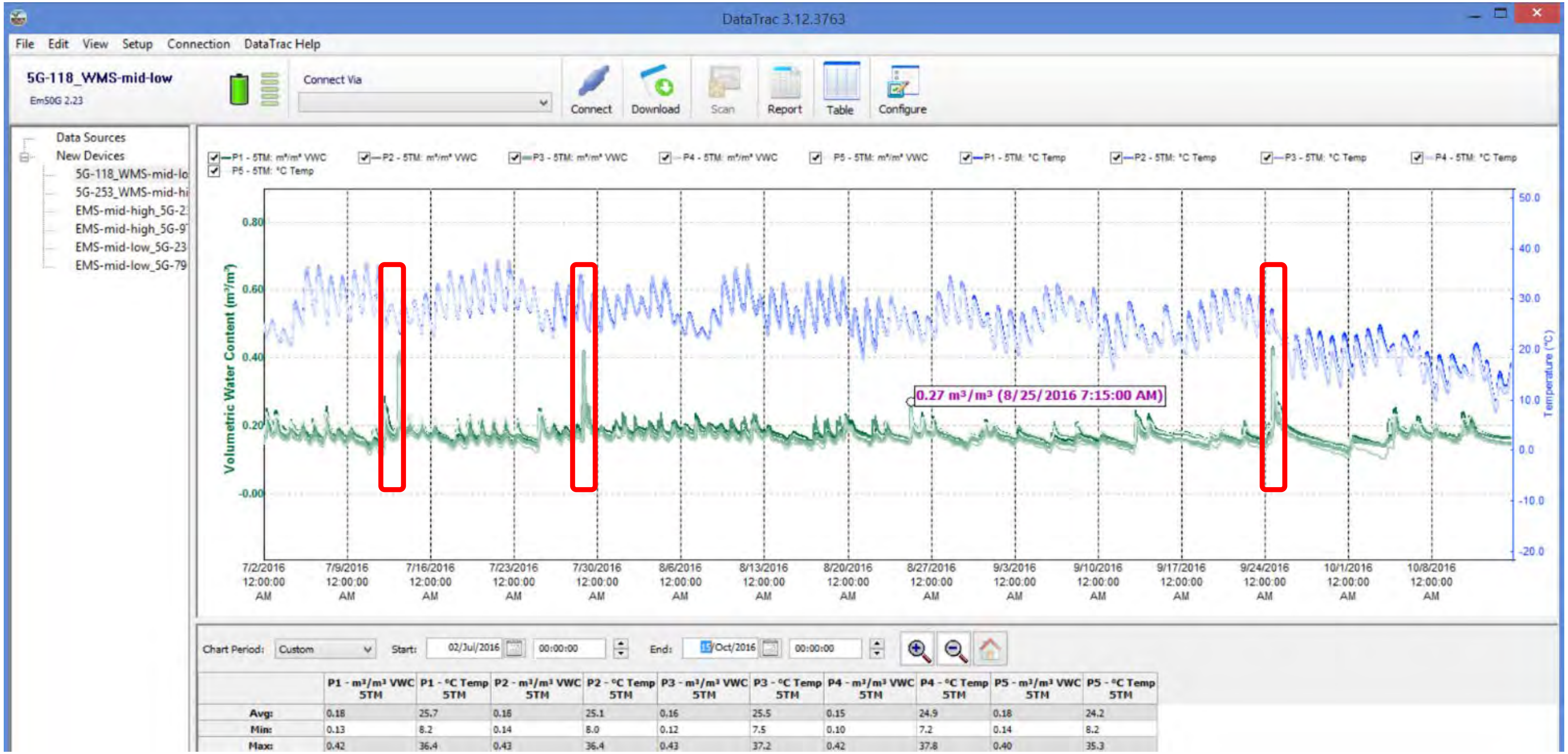


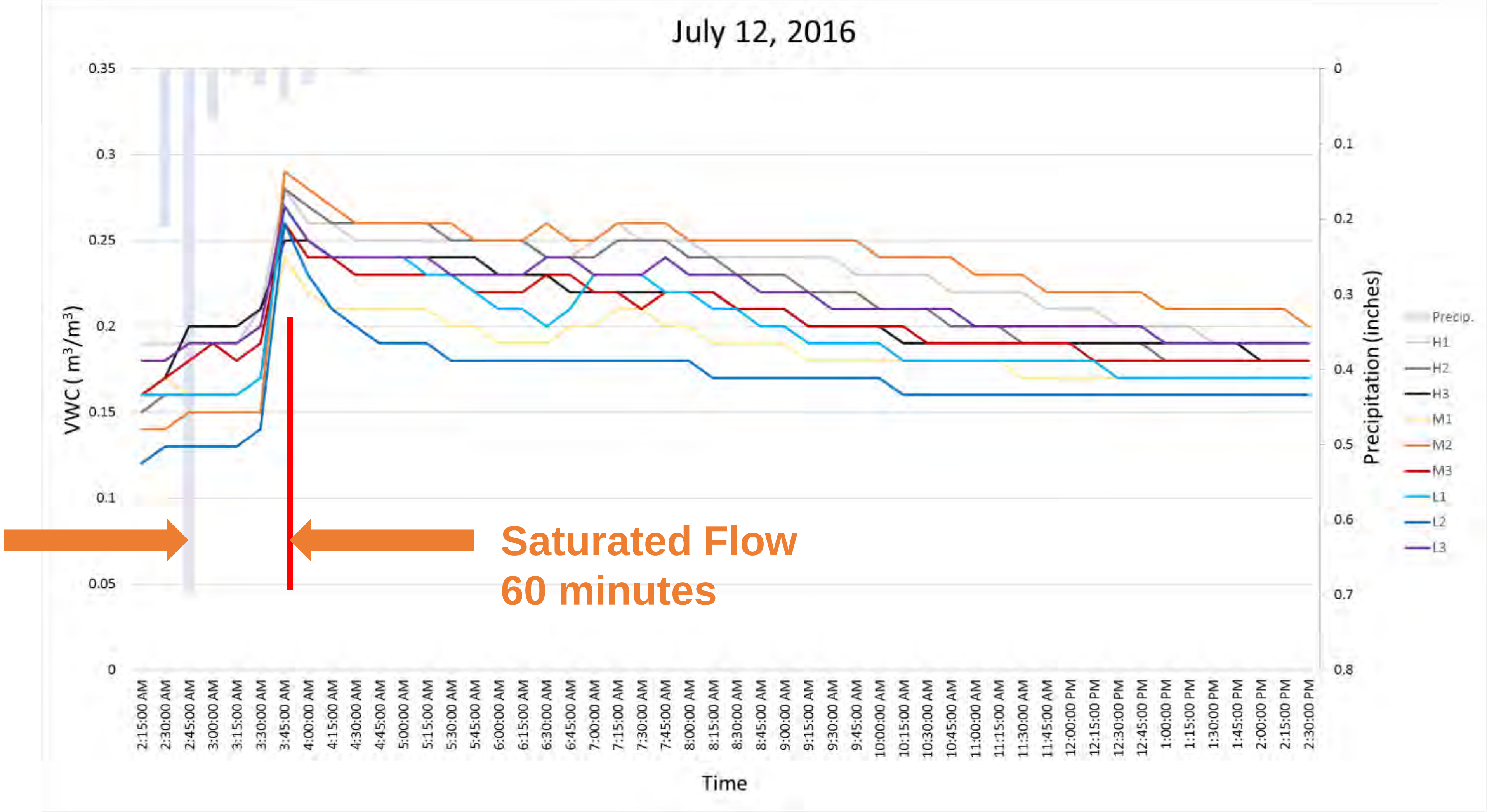
Chart Period: Custom

Start: 02/Jul/2016 00:00:00

End: 15/Oct/2016 00:00:00

	P1 - m³/m³ VWC 5TM	P1 - °C Temp 5TM	P2 - m³/m³ VWC 5TM	P2 - °C Temp 5TM	P3 - m³/m³ VWC 5TM	P3 - °C Temp 5TM	P4 - m³/m³ VWC 5TM	P4 - °C Temp 5TM	P5 - m³/m³ VWC 5TM	P5 - °C Temp 5TM
Avg:	0.18	25.7	0.16	25.1	0.16	25.5	0.15	24.9	0.18	24.2
Min:	0.13	8.2	0.14	8.0	0.12	7.5	0.10	7.2	0.14	8.2
Max:	0.42	36.4	0.43	36.4	0.43	37.2	0.42	37.8	0.40	35.3

Soil Moisture Dynamic

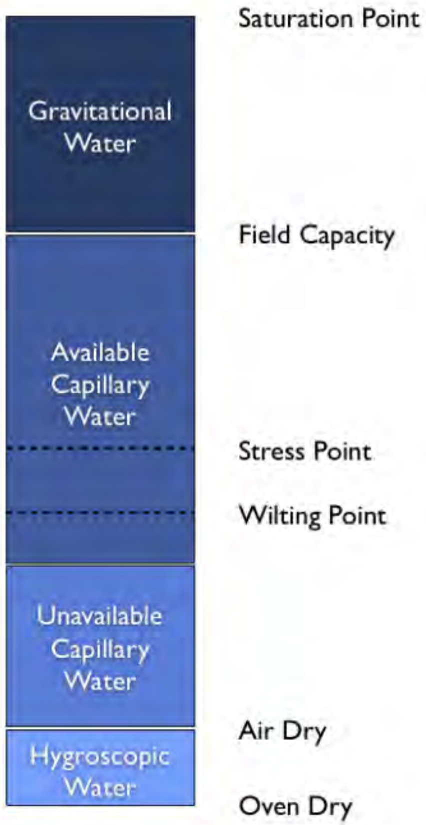


Peak Rainfall

Saturated Flow
60 minutes

1.08 inches of rain

Passive Water Harvesting



Gravitational Water

Available Capillary Water

Unavailable Capillary Water

Hygroscopic Water

Saturation Point

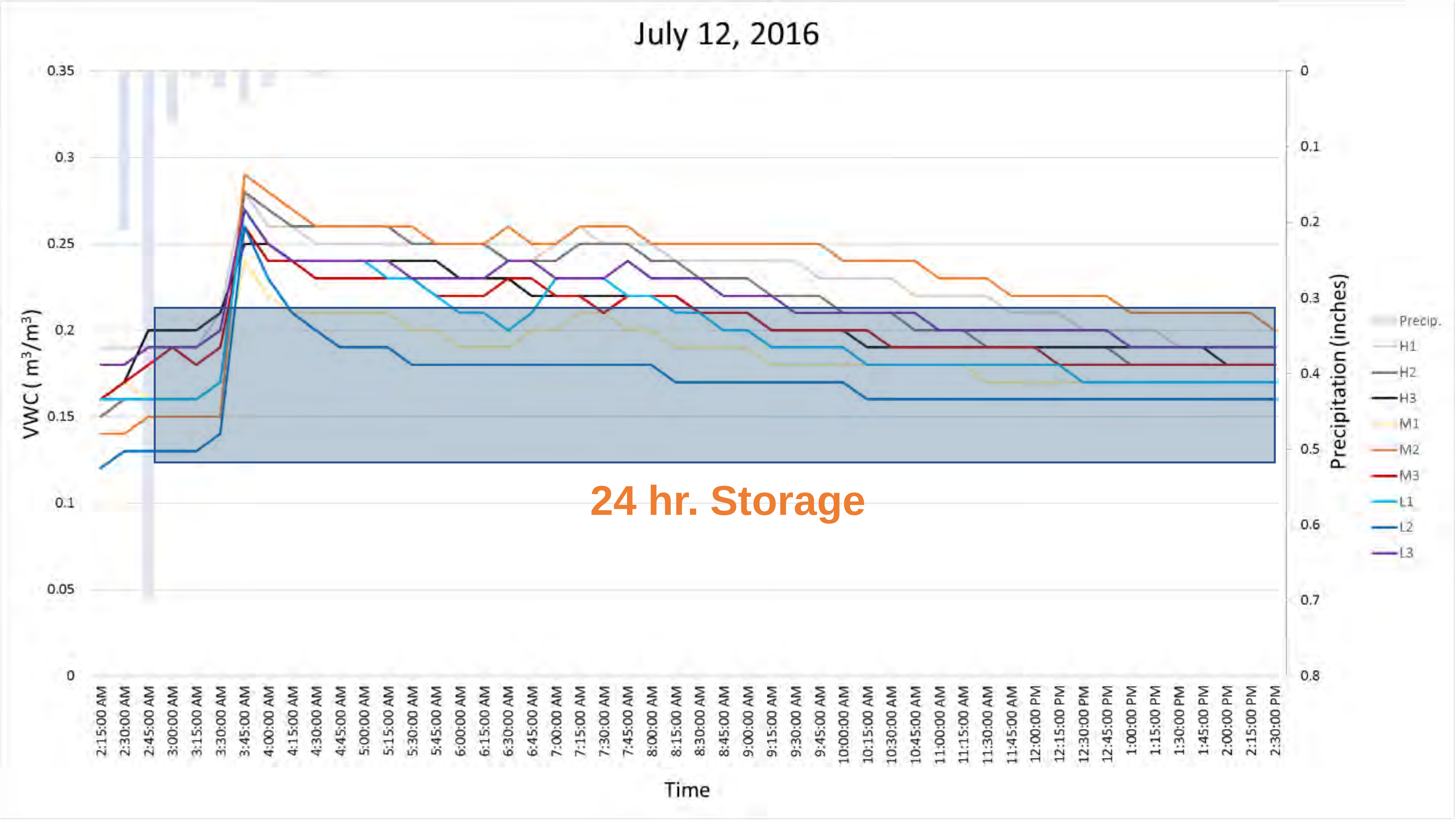
Field Capacity

Stress Point

Wilting Point

Air Dry

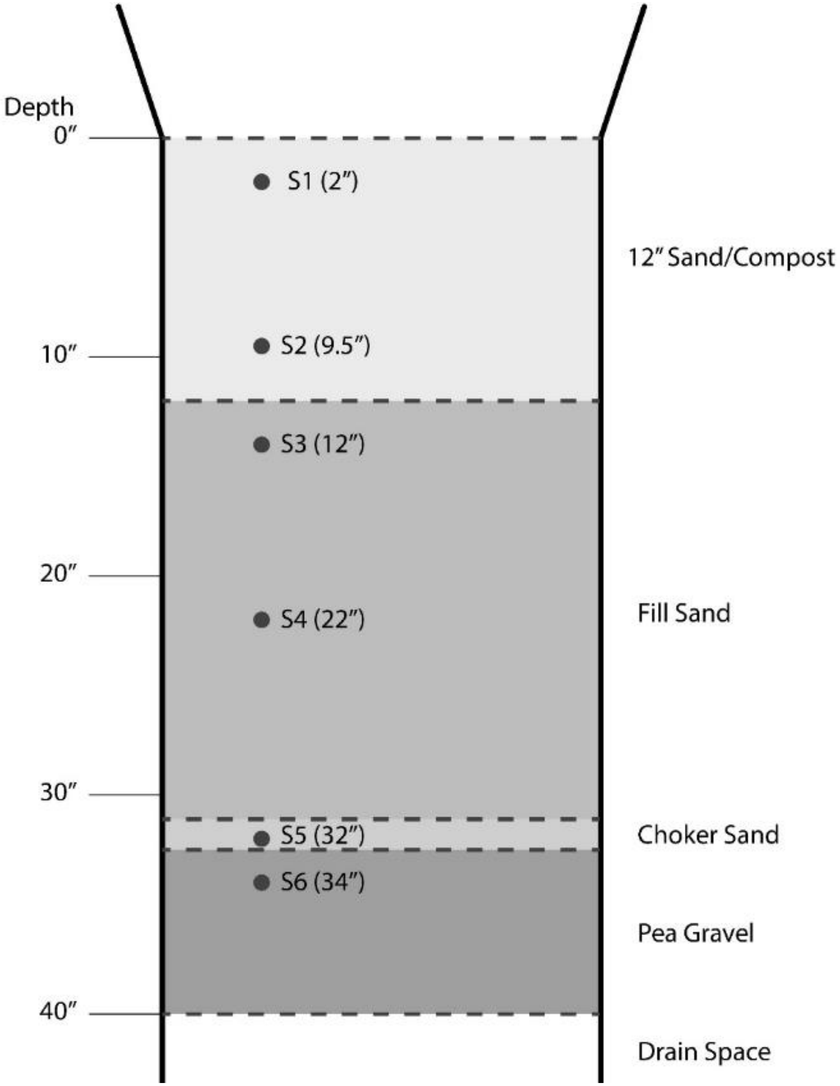
Oven Dry



1.08 inches of rain

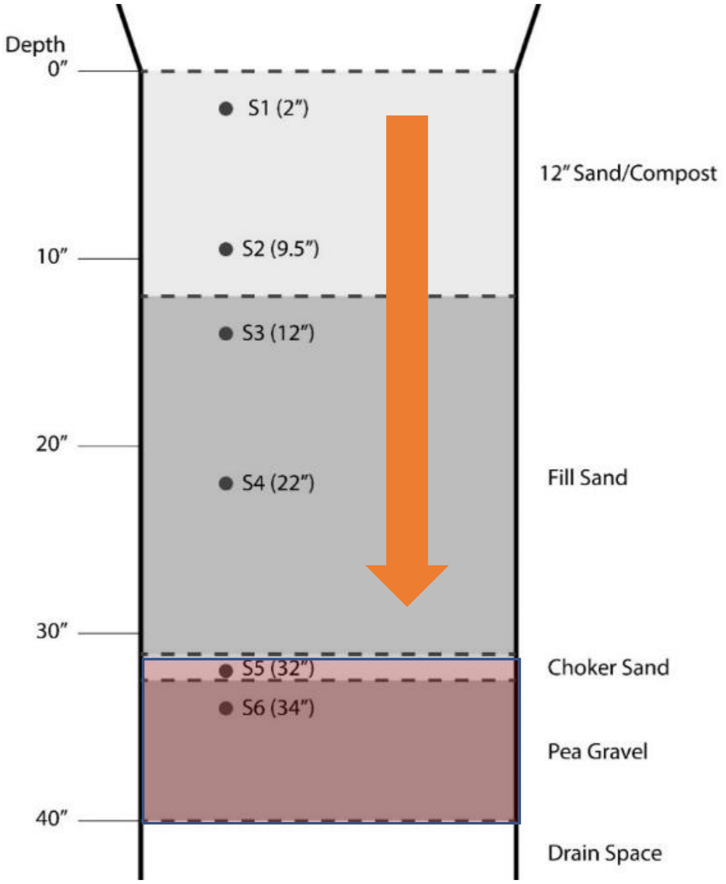
Profile mock-up

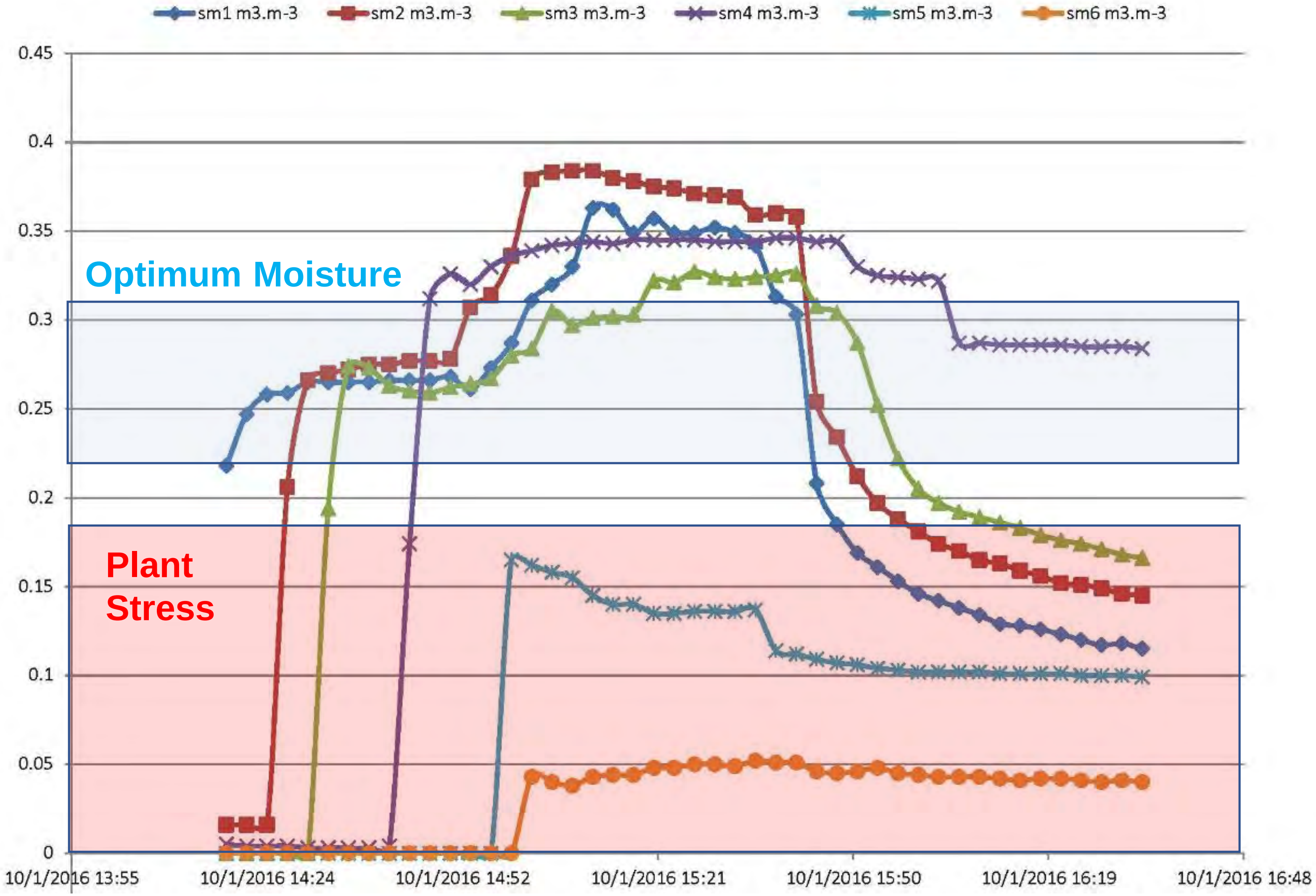
High Programmed Use Turf Soil Profile (fiber reinforced)



Source: Jeffrey L Bruce & company

Profile 1





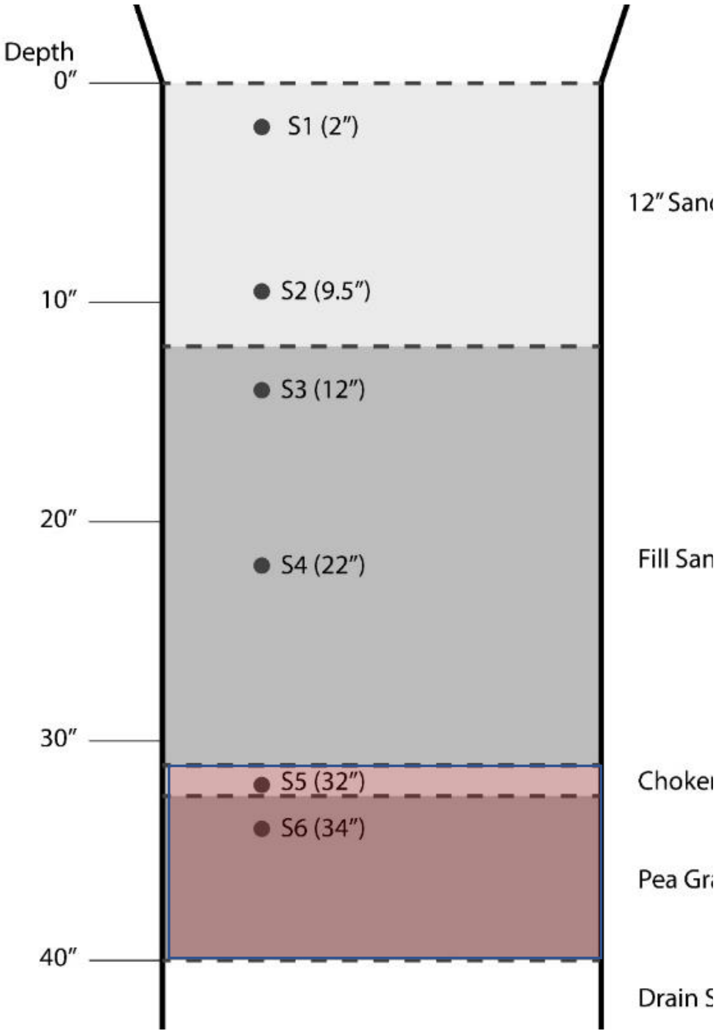
3 Hour Simulation

Source: Jeffrey L Bruce & company

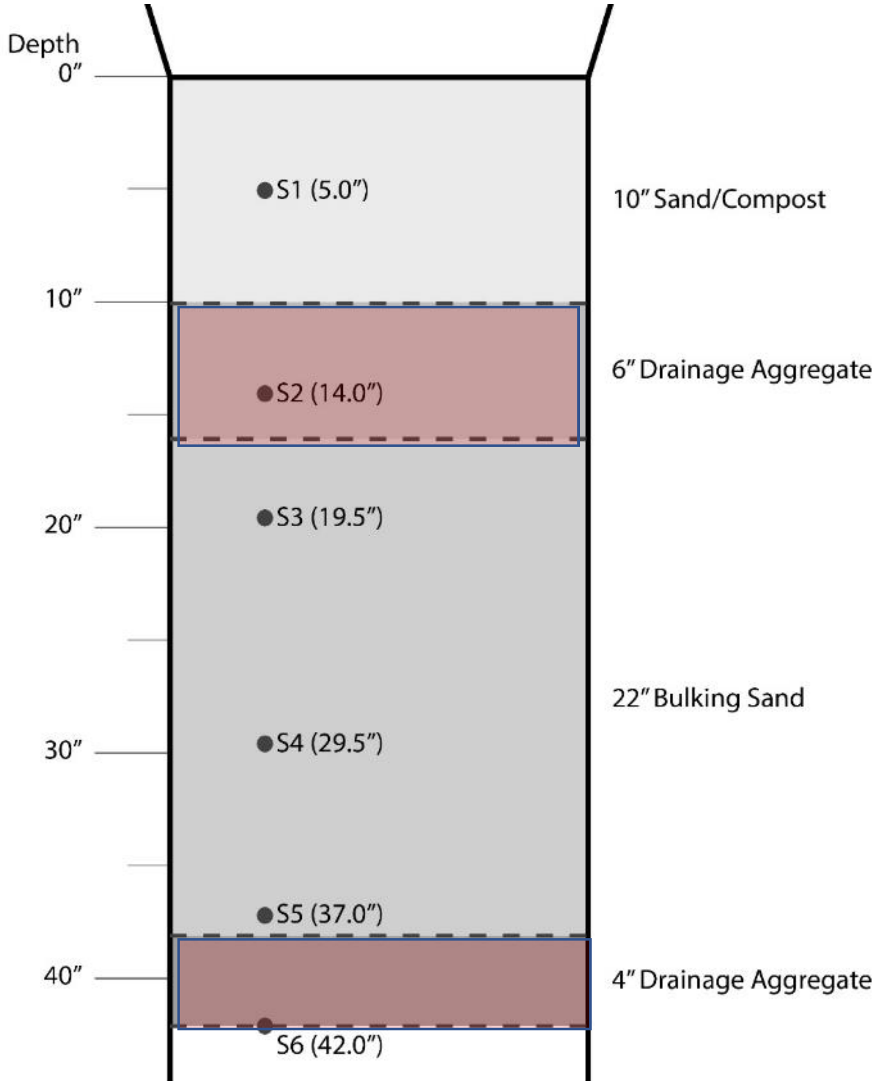
Profile redesign

🟥

Capillary Break



Profile #1

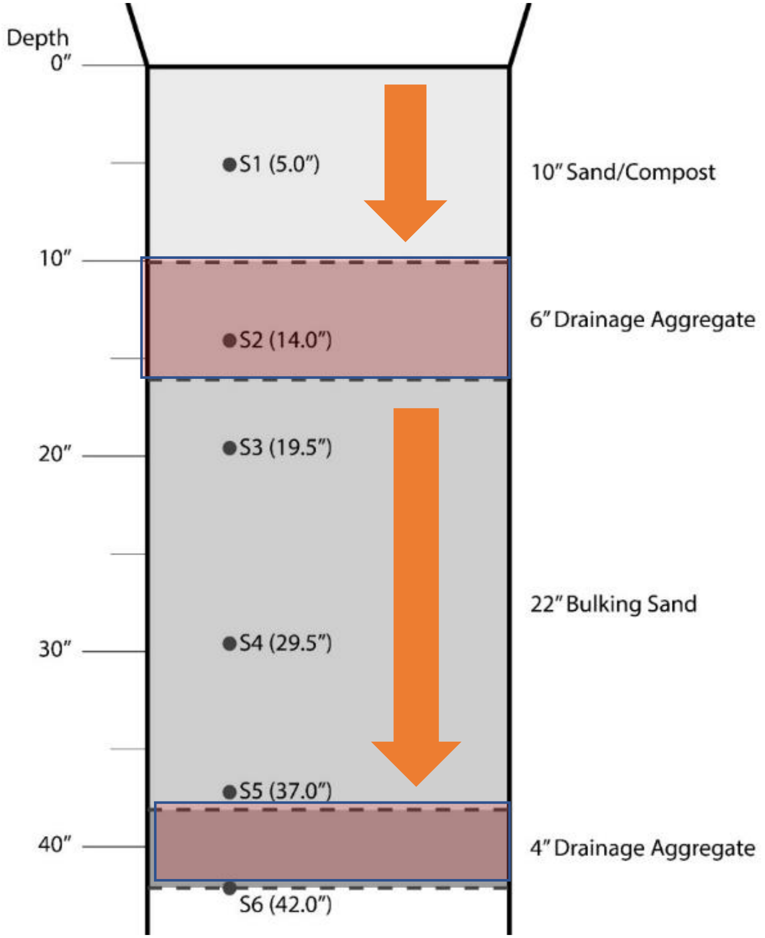


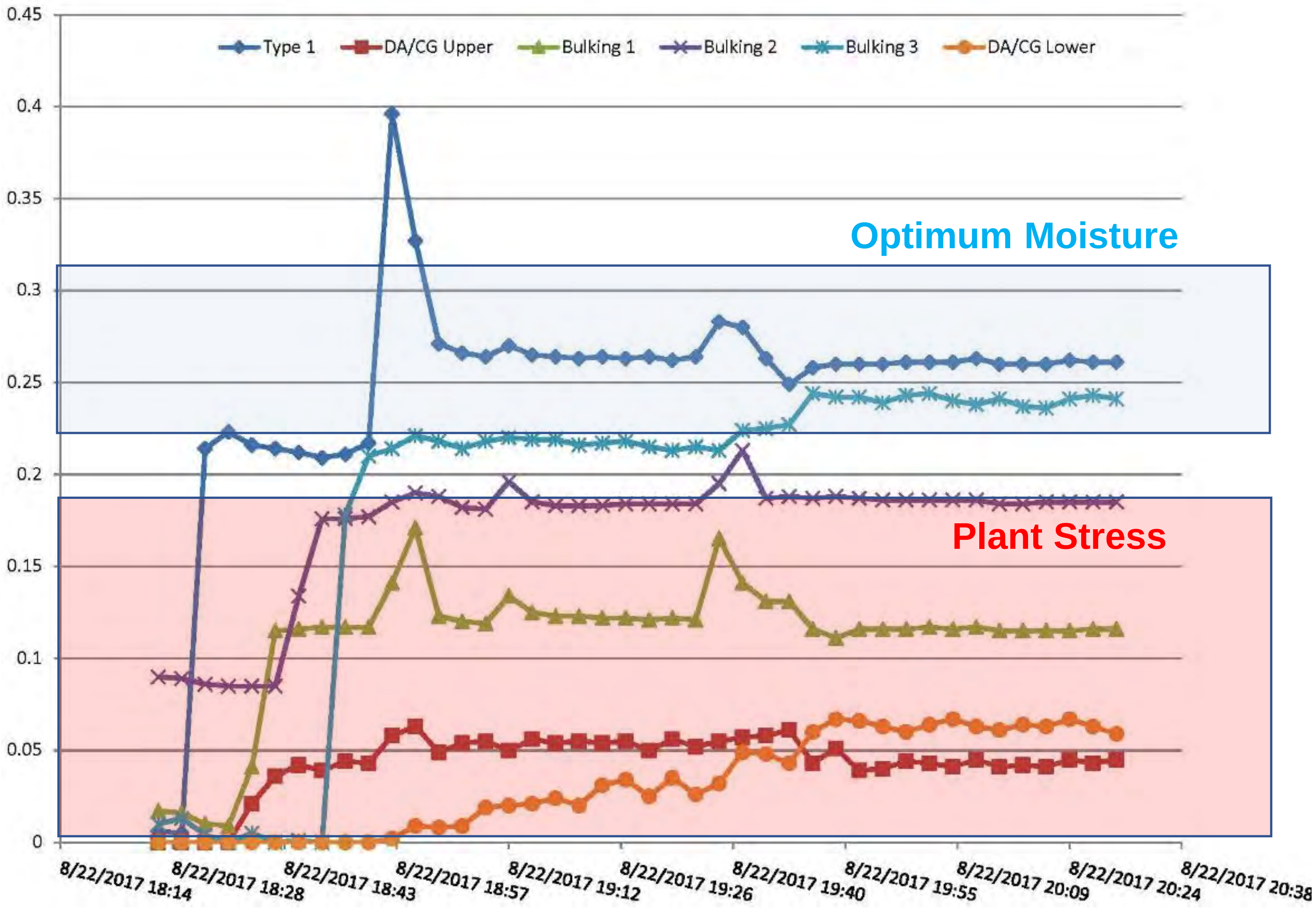
Profile #2

Source: Jeffrey L Bruce & company

Profile 2

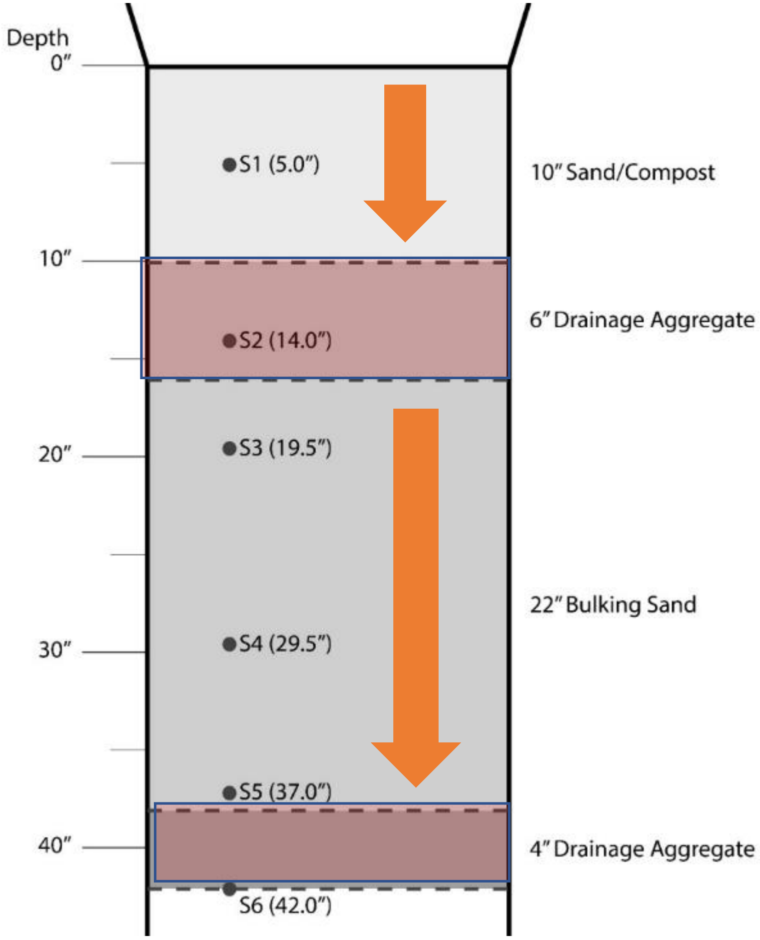
3 Hour Simulation

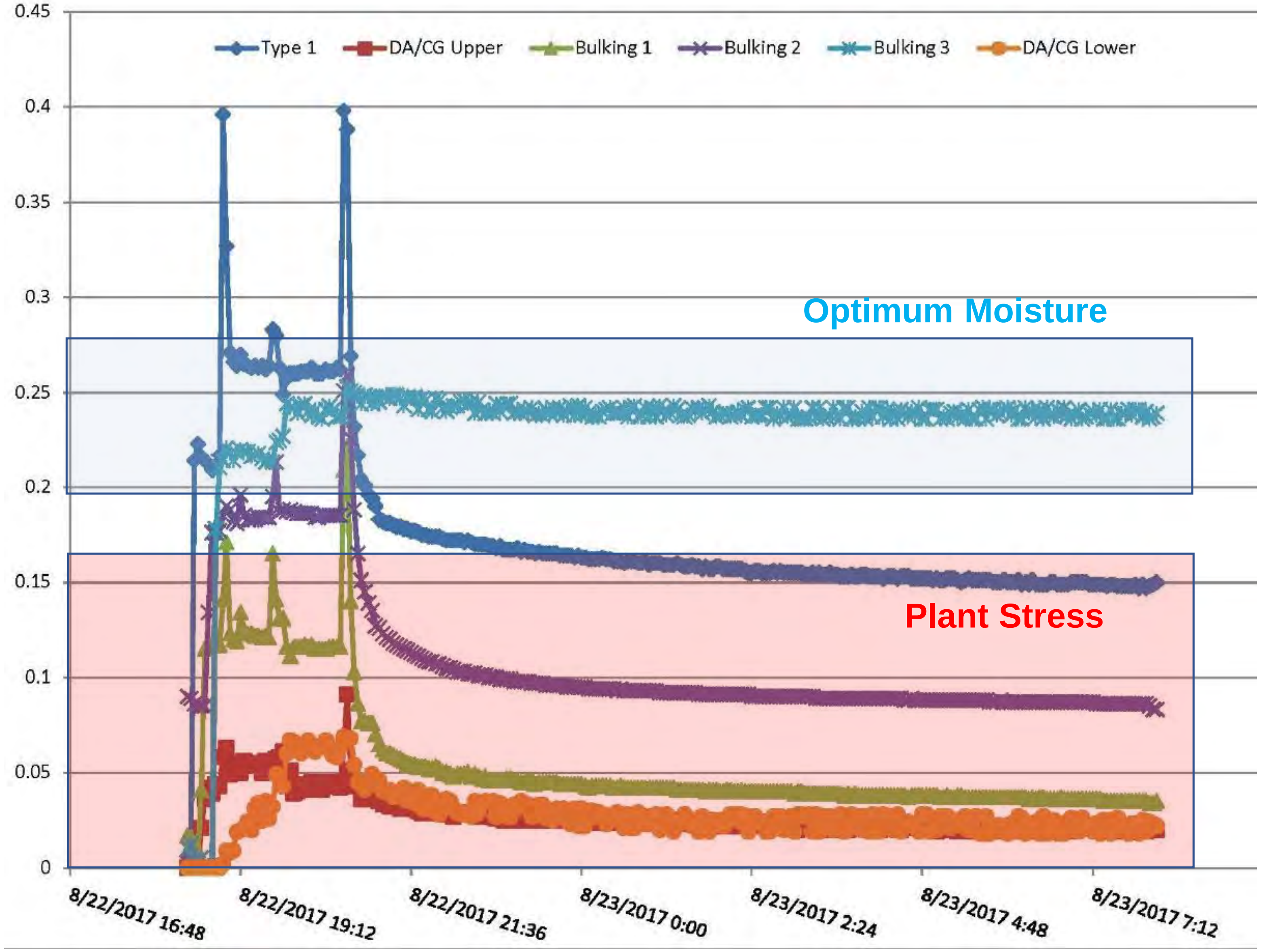




Source: Jeffrey L Bruce & company

Profile 2

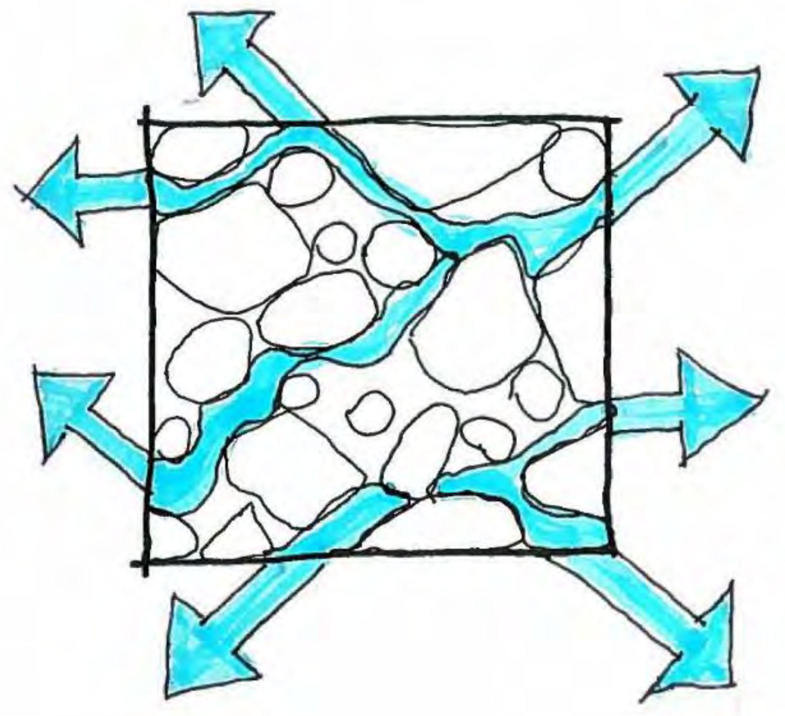


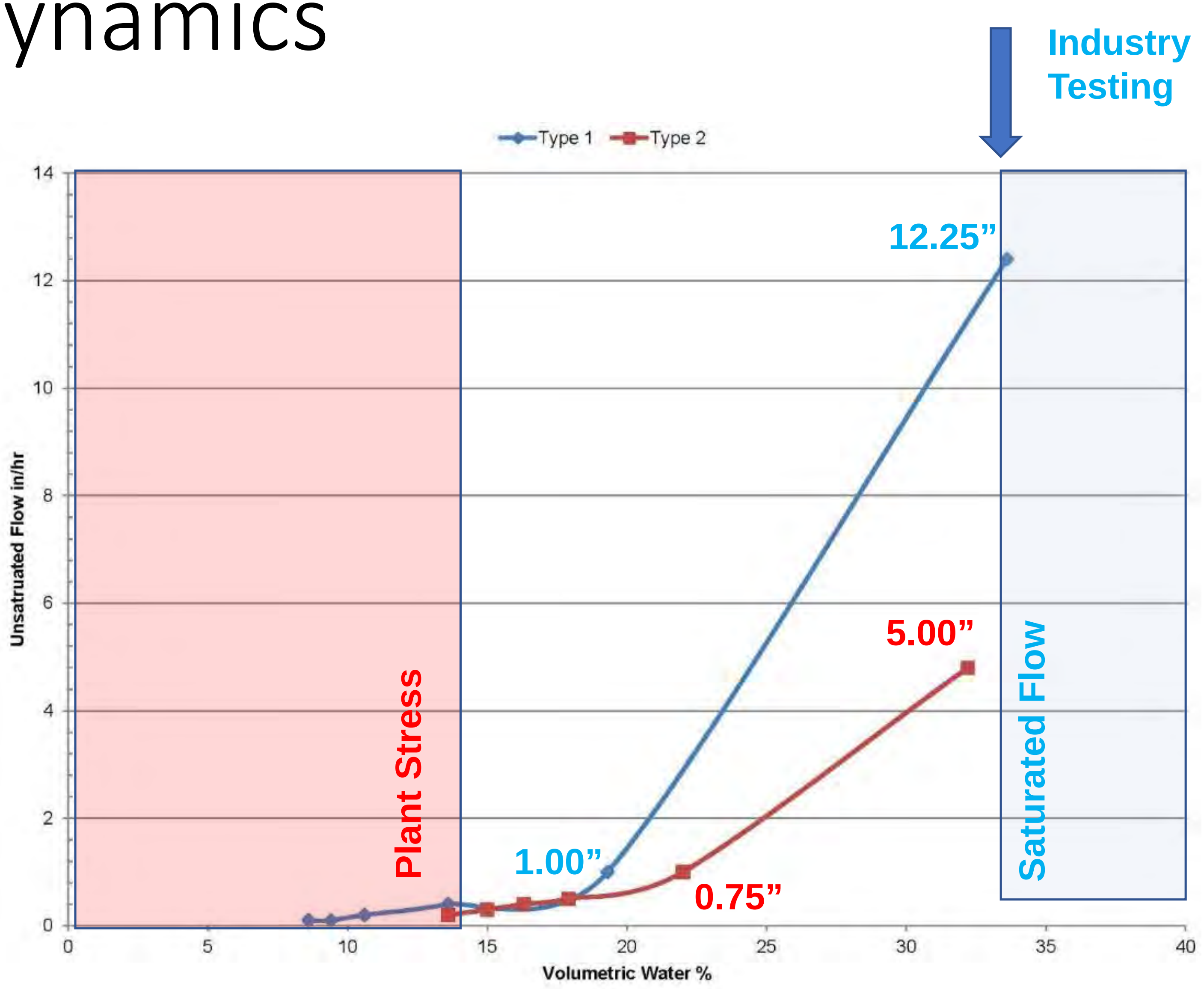


24 Hour Simulation

Source: Jeffrey L Bruce & company

Unsaturated flow dynamics





Source: Jeffrey L Bruce & company

Stormwater function

● Type 1: Irrigation Rotor Heads
Stainless Steel Sleeves

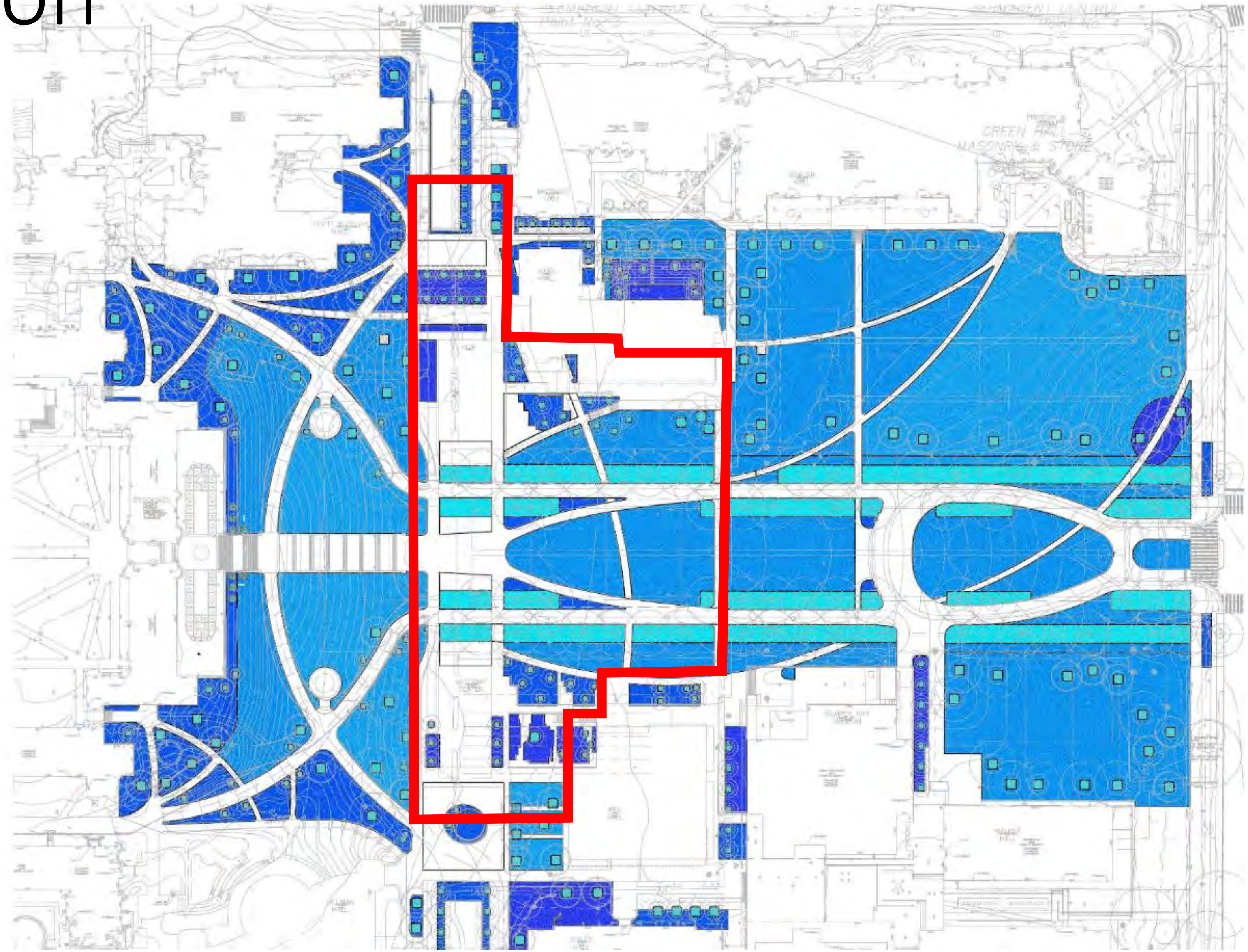
● Type 2: Irrigation Spray Heads

● Type 3: Deep Root Watering Tubes
Typ. 2 Per Tree

175,000 SF

525,000 CF soil volume

This equates to 1,570,905 gallons or 4.83 acre-feet, or 58 acre-inches of storage over the parking facility.



Source: Jeffrey L Bruce & company

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Owner:

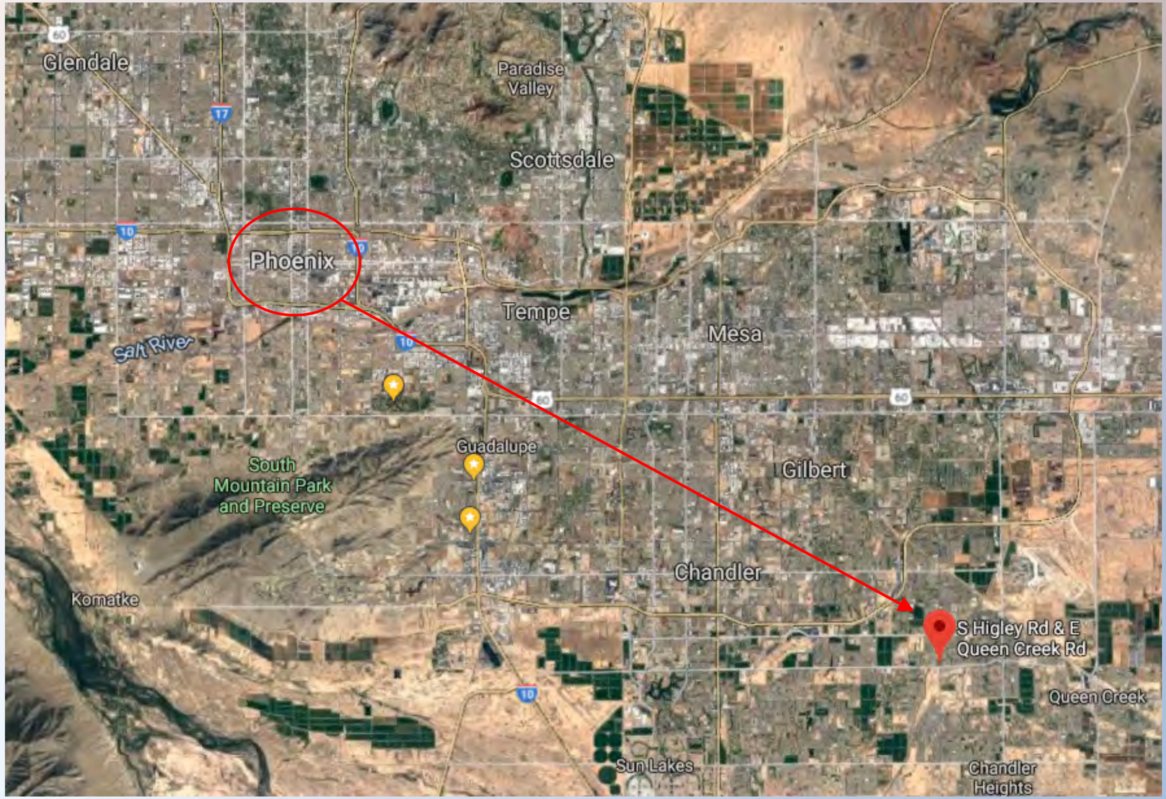
Town of Gilbert, Arizona

Direct Client (Prime Consultant):

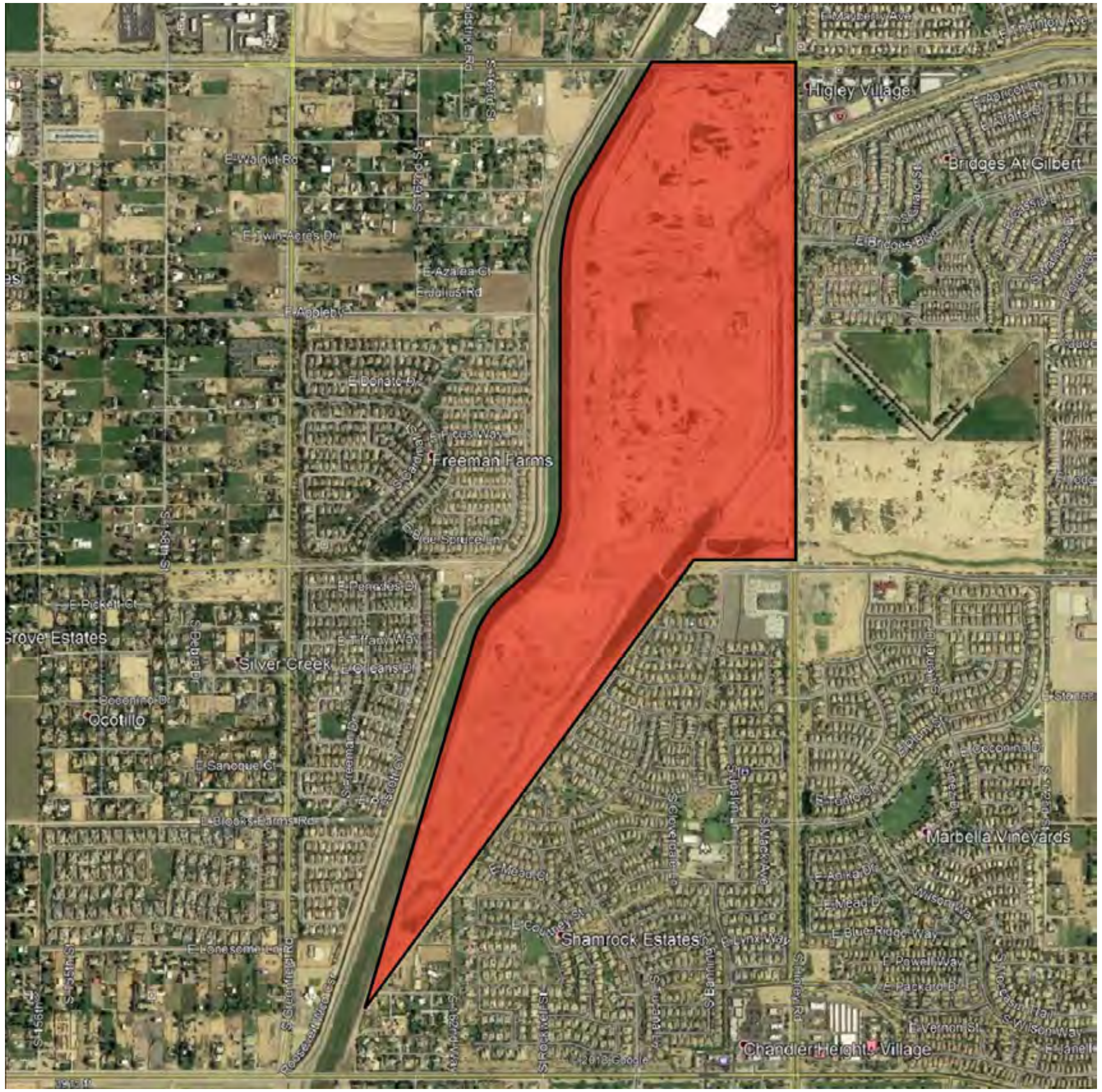
Kimley Horn & Associates, Inc.
Phoenix, Arizona

Location:

South Higley Road & East Queen Creek Road,
Approximately 23 miles southeast of Phoenix



MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK



Project Background Information

- Site Parameters:
  - 317 acre site
    - 270 acres FCDMC basin (flood control)
    - 47 acres Town of Gilbert property
- Project Intent:
  - Master Planning for a Regional Park Amenity
  - Gain Public Support for Bond Funding

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

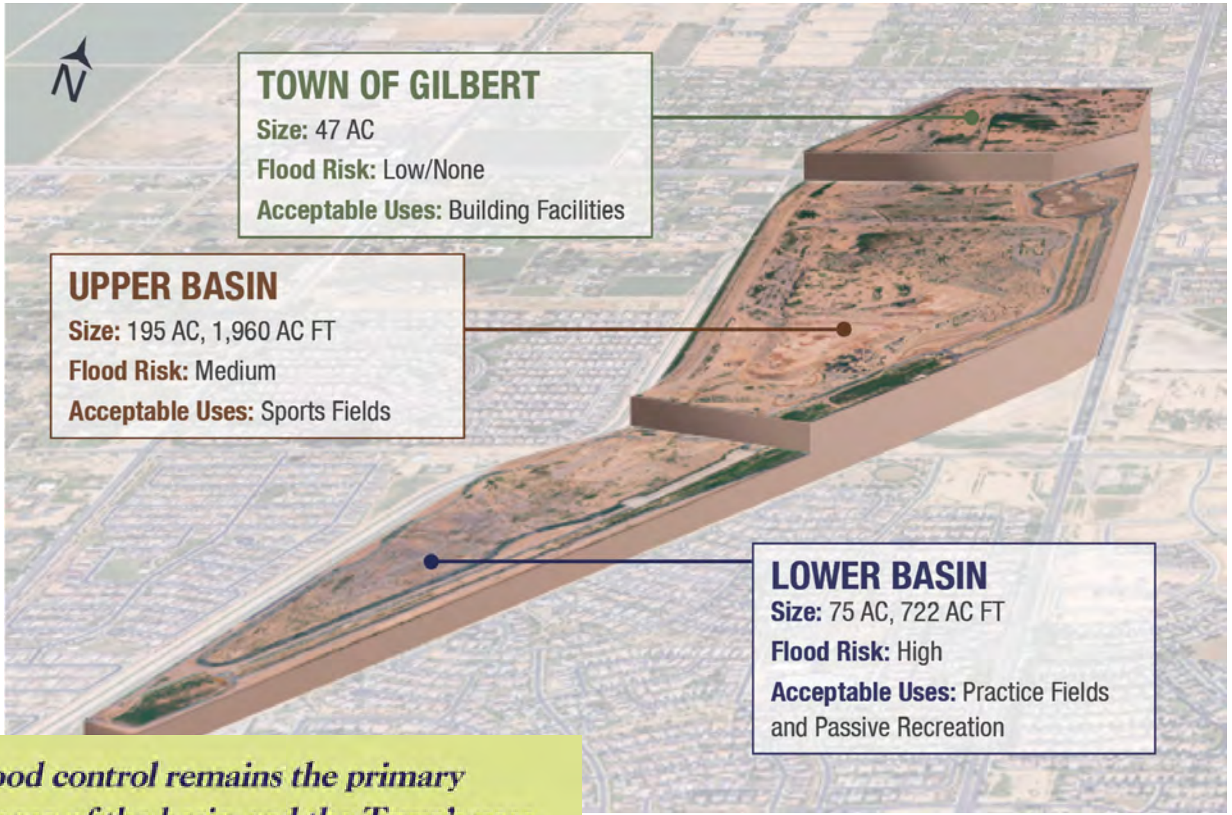
<u>Project Background Information</u>

- Site Programming/Amenities (from public input process):
    - Active-use Turfgrass Sports Fields
    - Passive-use Turfgrass Recreation Areas
    - Pedestrian and Biking Trails
    - Dog Park
    - Amphitheater
    - Picnic Ramadas/Tot Lots
    - Community Fishing/Irrigation Storage Lake

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Project Coordination Efforts

- **FCDMC coordination**
  - Use restrictions
  - Equipment protection
  - Public safety parameters
- **Team coordination**
  - Site amenity space planning
  - Location/Layouts\
- **Three Prelim Concepts > One Final Master Plan**



> *"Flood control remains the primary purpose of the basin and the Town's uses may not materially reduce, diminish, or alter the flood control features of the basin or the capturing, storing, and conveying flood and stormwater." —2015 IGA*

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

IRRIGATION SUPPLY AND DEMAND MODELING

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Supply and Demand Modeling

- Turfgrass Area Calculations
  - Percentage of Landscape Area
  - Peak Season Daily Demand
- Evaporative Loss from Lake (5 acre)
- Daily Water Window Constraints
  - Avoid Public Use Conflicts
- Weekly Watering Day Constraints
  - Site Maintenance/Mowing

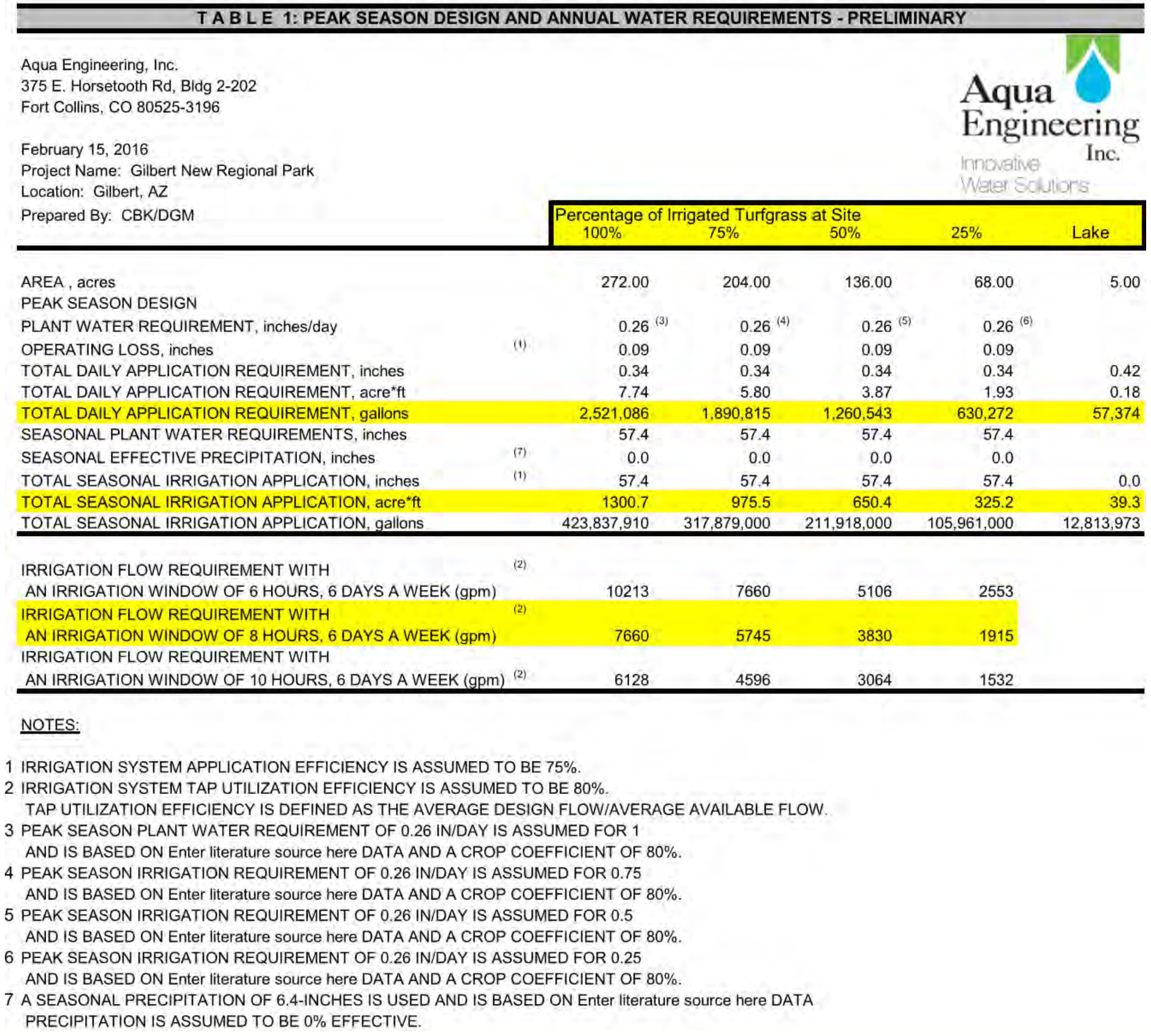


TABLE 1: PEAK SEASON DESIGN AND ANNUAL WATER REQUIREMENTS - PRELIMINARY

Aqua Engineering, Inc.
375 E. Horsetooth Rd, Bldg 2-202
Fort Collins, CO 80525-3196

Aqua Engineering Inc.
Innovative Water Solutions

February 15, 2016
Project Name: Gilbert New Regional Park
Location: Gilbert, AZ
Prepared By: CBK/DGM

	Percentage of Irrigated Turfgrass at Site				
	100%	75%	50%	25%	Lake
AREA , acres	272.00	204.00	136.00	68.00	5.00
PEAK SEASON DESIGN					
PLANT WATER REQUIREMENT, inches/day	0.26 [3]	0.26 [4]	0.26 [5]	0.26 [6]	
OPERATING LOSS, inches [1]	0.09	0.09	0.09	0.09	
TOTAL DAILY APPLICATION REQUIREMENT, inches	0.34	0.34	0.34	0.34	0.42
TOTAL DAILY APPLICATION REQUIREMENT, acre*ft	7.74	5.80	3.87	1.93	0.18
TOTAL DAILY APPLICATION REQUIREMENT, gallons	2,521,086	1,890,815	1,260,543	630,272	57,374
SEASONAL PLANT WATER REQUIREMENTS, inches	57.4	57.4	57.4	57.4	
SEASONAL EFFECTIVE PRECIPITATION, inches [7]	0.0	0.0	0.0	0.0	
TOTAL SEASONAL IRRIGATION APPLICATION, inches [1]	57.4	57.4	57.4	57.4	0.0
TOTAL SEASONAL IRRIGATION APPLICATION, acre*ft	1300.7	975.5	650.4	325.2	39.3
TOTAL SEASONAL IRRIGATION APPLICATION, gallons	423,837,910	317,879,000	211,918,000	105,961,000	12,813,973
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 6 HOURS, 6 DAYS A WEEK (gpm) [2]	10213	7660	5106	2553	
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 8 HOURS, 6 DAYS A WEEK (gpm) [2]	7660	5745	3830	1915	
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 10 HOURS, 6 DAYS A WEEK (gpm) [2]	6128	4596	3064	1532	

NOTES:

1 IRRIGATION SYSTEM APPLICATION EFFICIENCY IS ASSUMED TO BE 75%.
2 IRRIGATION SYSTEM TAP UTILIZATION EFFICIENCY IS ASSUMED TO BE 80%.
TAP UTILIZATION EFFICIENCY IS DEFINED AS THE AVERAGE DESIGN FLOW/AVERAGE AVAILABLE FLOW.
3 PEAK SEASON PLANT WATER REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR 1
AND IS BASED ON Enter literature source here DATA AND A CROP COEFFICIENT OF 80%.
4 PEAK SEASON IRRIGATION REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR 0.75
AND IS BASED ON Enter literature source here DATA AND A CROP COEFFICIENT OF 80%.
5 PEAK SEASON IRRIGATION REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR 0.5
AND IS BASED ON Enter literature source here DATA AND A CROP COEFFICIENT OF 80%.
6 PEAK SEASON IRRIGATION REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR 0.25
AND IS BASED ON Enter literature source here DATA AND A CROP COEFFICIENT OF 80%.
7 A SEASONAL PRECIPITATION OF 6.4-INCHES IS USED AND IS BASED ON Enter literature source here DATA
PRECIPITATION IS ASSUMED TO BE 0% EFFECTIVE.

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Supply and Demand Modeling

- Landscape Water Demand per Acre
    - Active-use Turfgrass
    - Passive-use Turfgrass
    - Desert Planting Canopy
- Enabled Demand Calculations for Several Landscape Concepts

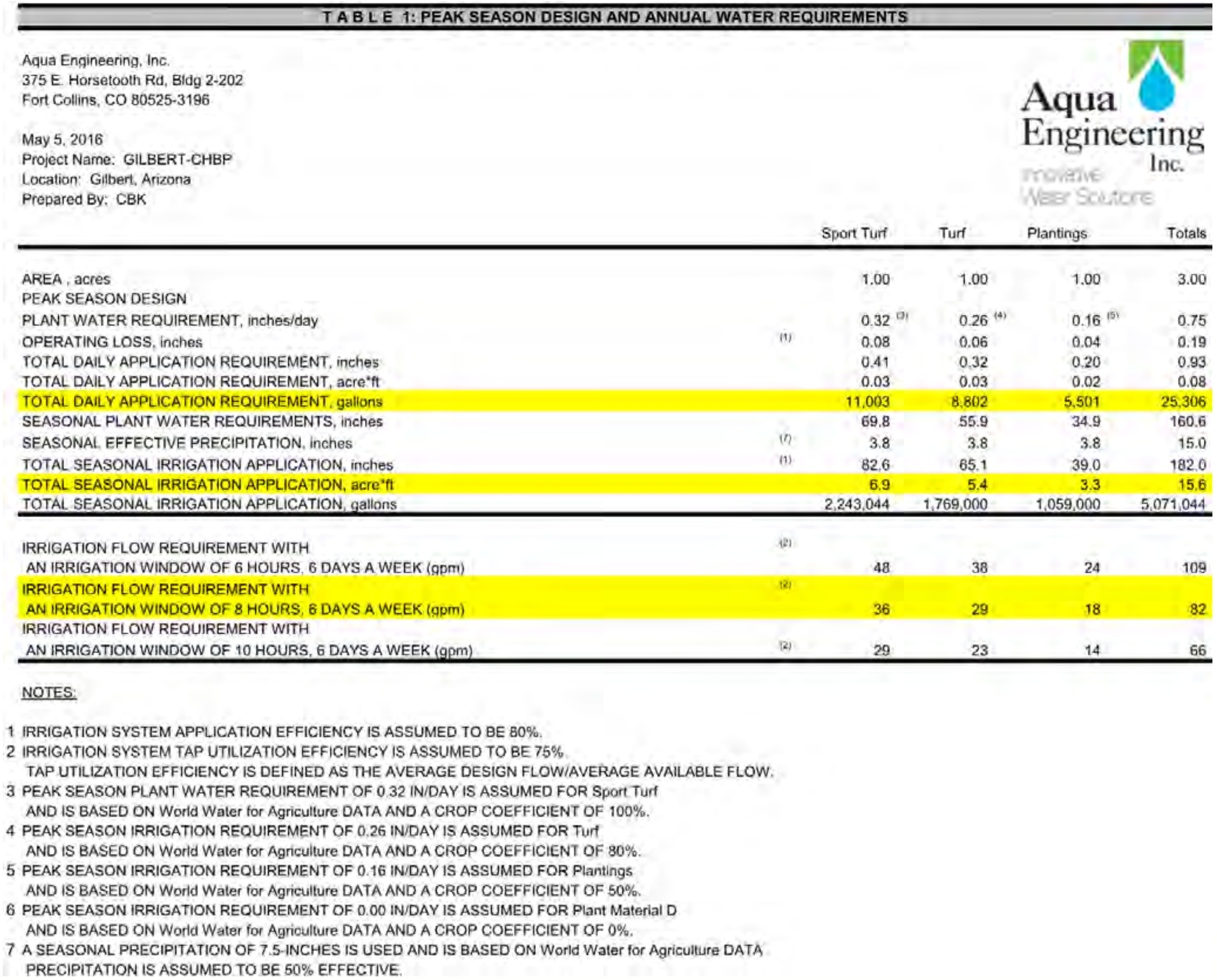


TABLE 1: PEAK SEASON DESIGN AND ANNUAL WATER REQUIREMENTS

Aqua Engineering, Inc.
375 E. Horsetooth Rd, Bldg 2-202
Fort Collins, CO 80525-3196

May 5, 2016
Project Name: GILBERT-CHBP
Location: Gilbert, Arizona
Prepared By: CBK

Aqua Engineering Inc.
Innovative Water Solutions

		Sport Turf	Turf	Plantings	Totals
AREA , acres		1.00	1.00	1.00	3.00
PEAK SEASON DESIGN					
PLANT WATER REQUIREMENT, inches/day		0.32 (3)	0.26 (4)	0.16 (5)	0.75
OPERATING LOSS, inches	(1)	0.08	0.06	0.04	0.19
TOTAL DAILY APPLICATION REQUIREMENT, inches		0.41	0.32	0.20	0.93
TOTAL DAILY APPLICATION REQUIREMENT, acre*ft		0.03	0.03	0.02	0.08
TOTAL DAILY APPLICATION REQUIREMENT, gallons		11,003	8,802	5,501	25,306
SEASONAL PLANT WATER REQUIREMENTS, inches		69.8	55.9	34.9	160.6
SEASONAL EFFECTIVE PRECIPITATION, inches	(7)	3.8	3.8	3.8	15.0
TOTAL SEASONAL IRRIGATION APPLICATION, inches	(1)	82.6	65.1	39.0	182.0
TOTAL SEASONAL IRRIGATION APPLICATION, acre*ft		6.9	5.4	3.3	15.6
TOTAL SEASONAL IRRIGATION APPLICATION, gallons		2,243,044	1,769,000	1,059,000	5,071,044
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 6 HOURS, 6 DAYS A WEEK (gpm)	(2)	48	38	24	109
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 8 HOURS, 6 DAYS A WEEK (gpm)	(2)	36	29	18	82
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 10 HOURS, 6 DAYS A WEEK (gpm)	(2)	29	23	14	66

NOTES:

1 IRRIGATION SYSTEM APPLICATION EFFICIENCY IS ASSUMED TO BE 80%.
2 IRRIGATION SYSTEM TAP UTILIZATION EFFICIENCY IS ASSUMED TO BE 75%.
TAP UTILIZATION EFFICIENCY IS DEFINED AS THE AVERAGE DESIGN FLOW/AVERAGE AVAILABLE FLOW.
3 PEAK SEASON PLANT WATER REQUIREMENT OF 0.32 IN/DAY IS ASSUMED FOR Sport Turf AND IS BASED ON World Water for Agriculture DATA AND A CROP COEFFICIENT OF 100%.
4 PEAK SEASON IRRIGATION REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR Turf AND IS BASED ON World Water for Agriculture DATA AND A CROP COEFFICIENT OF 80%.
5 PEAK SEASON IRRIGATION REQUIREMENT OF 0.16 IN/DAY IS ASSUMED FOR Plantings AND IS BASED ON World Water for Agriculture DATA AND A CROP COEFFICIENT OF 50%.
6 PEAK SEASON IRRIGATION REQUIREMENT OF 0.00 IN/DAY IS ASSUMED FOR Plant Material D AND IS BASED ON World Water for Agriculture DATA AND A CROP COEFFICIENT OF 0%.
7 A SEASONAL PRECIPITATION OF 7.5-INCHES IS USED AND IS BASED ON World Water for Agriculture DATA PRECIPITATION IS ASSUMED TO BE 50% EFFECTIVE.

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Supply and Demand Modeling

- Apply Water Demand Model to Several Landscape Concepts

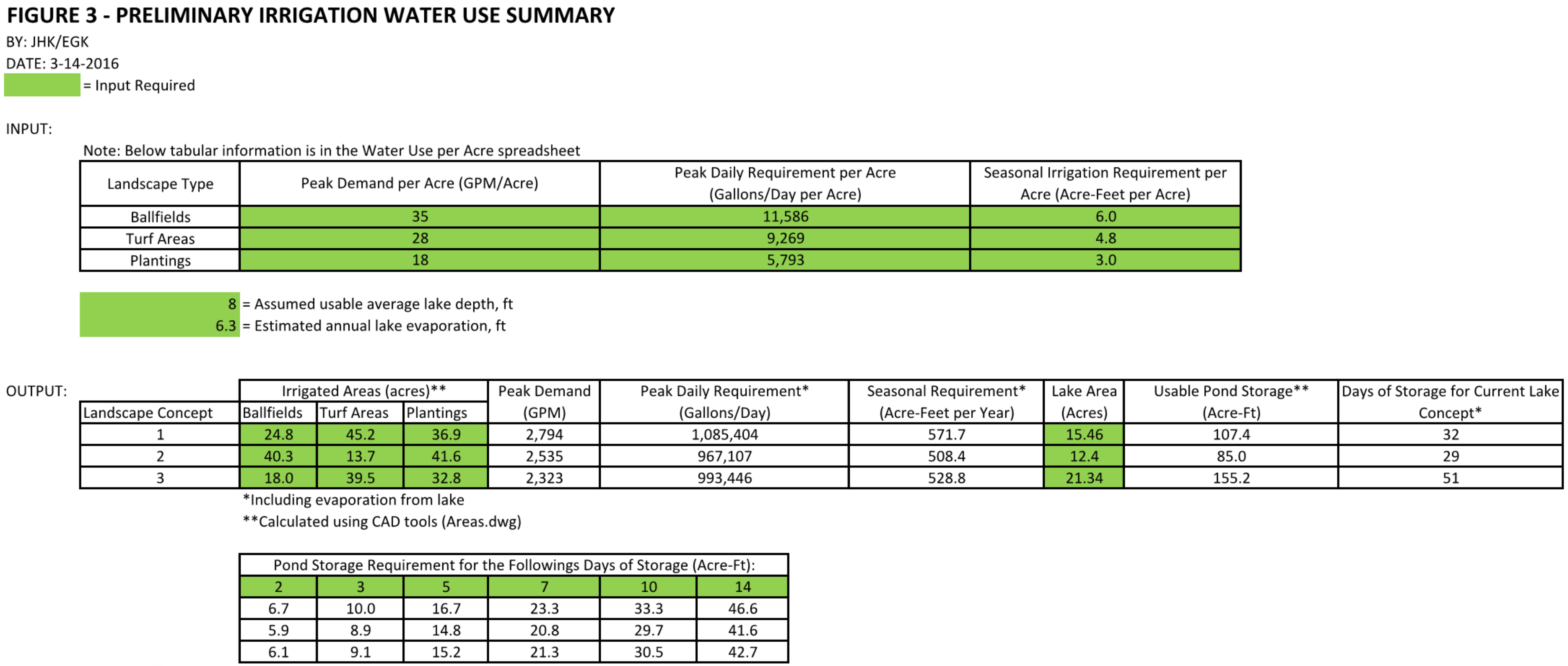


FIGURE 3 - PRELIMINARY IRRIGATION WATER USE SUMMARY

BY: JHK/EGK
DATE: 3-14-2016
🟩 = Input Required

INPUT:

Note: Below tabular information is in the Water Use per Acre spreadsheet

Landscape Type	Peak Demand per Acre (GPM/Acre)	Peak Daily Requirement per Acre (Gallons/Day per Acre)	Seasonal Irrigation Requirement per Acre (Acre-Feet per Acre)
Ballfields	35	11,586	6.0
Turf Areas	28	9,269	4.8
Plantings	18	5,793	3.0

8 = Assumed usable average lake depth, ft
6.3 = Estimated annual lake evaporation, ft

OUTPUT:

	Irrigated Areas (acres)**			Peak Demand (GPM)	Peak Daily Requirement* (Gallons/Day)	Seasonal Requirement* (Acre-Feet per Year)	Lake Area (Acres)	Usable Pond Storage** (Acre-Ft)	Days of Storage for Current Lake Concept*
Landscape Concept	Ballfields	Turf Areas	Plantings						
1	24.8	45.2	36.9	2,794	1,085,404	571.7	15.46	107.4	32
2	40.3	13.7	41.6	2,535	967,107	508.4	12.4	85.0	29
3	18.0	39.5	32.8	2,323	993,446	528.8	21.34	155.2	51

*Including evaporation from lake
**Calculated using CAD tools (Areas.dwg)

Pond Storage Requirement for the Followings Days of Storage (Acre-Ft):					
2	3	5	7	10	14
6.7	10.0	16.7	23.3	33.3	46.6
5.9	8.9	14.8	20.8	29.7	41.6
6.1	9.1	15.2	21.3	30.5	42.7

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Supply and Demand Modeling

- Apply Water Demand Model to Selected Landscape Master Plan
  - Total Peak Season Daily Demand
  - Total Anticipated Annual Demand
  - Total Irrigation Flow Demand
  - Evaporative Loss from Lake
- Determine which water source(s) can meet demand

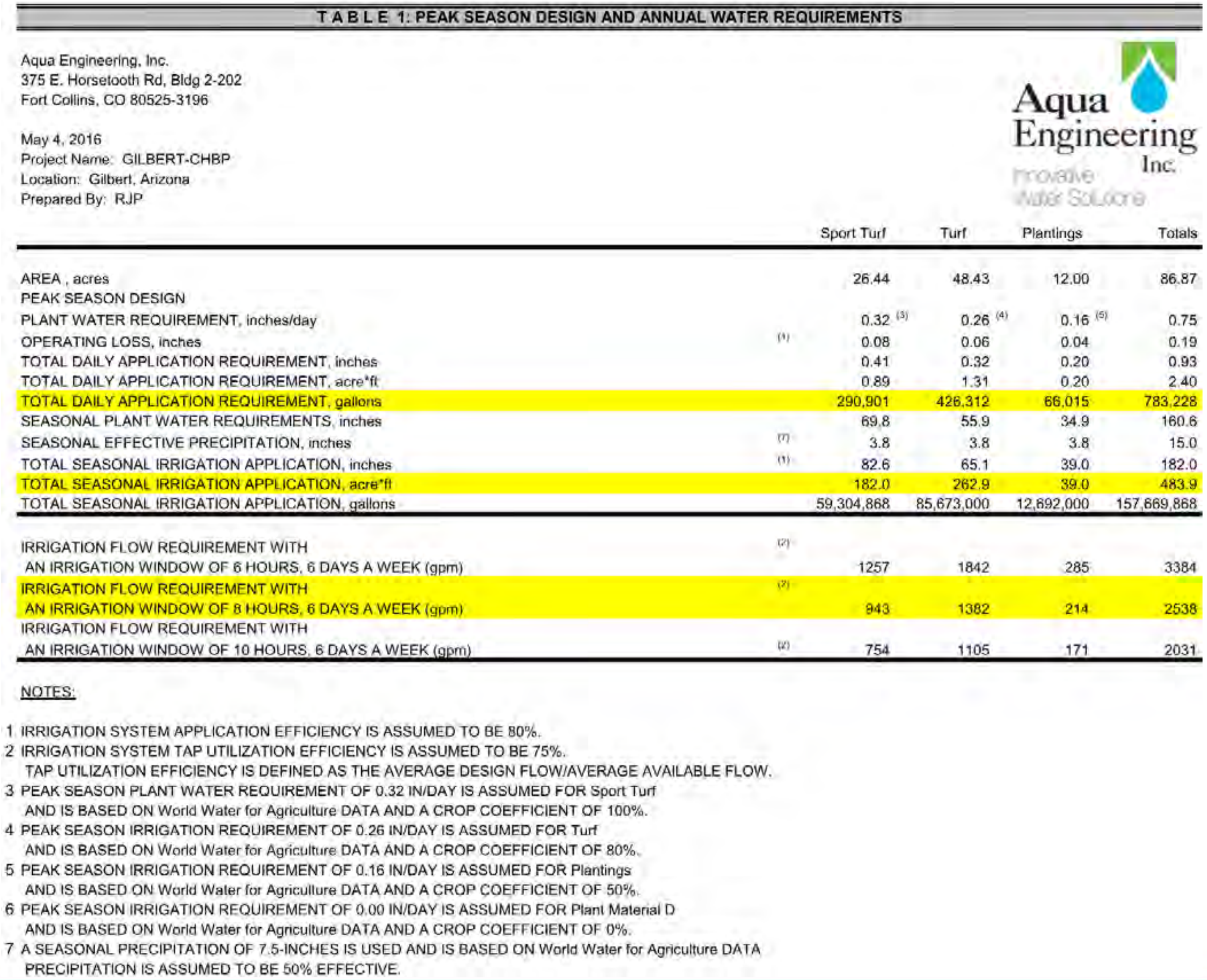


TABLE 1: PEAK SEASON DESIGN AND ANNUAL WATER REQUIREMENTS

Aqua Engineering, Inc.
375 E. Horsetooth Rd, Bldg 2-202
Fort Collins, CO 80525-3196

May 4, 2016
Project Name: GILBERT-CHBP
Location: Gilbert, Arizona
Prepared By: RJP

Aqua Engineering Inc.
Innovative Water Solutions

		Sport Turf	Turf	Plantings	Totals
AREA , acres		26.44	48.43	12.00	86.87
PEAK SEASON DESIGN					
PLANT WATER REQUIREMENT, inches/day		0.32 (3)	0.26 (4)	0.16 (5)	0.75
OPERATING LOSS, inches	(1)	0.08	0.06	0.04	0.19
TOTAL DAILY APPLICATION REQUIREMENT, inches		0.41	0.32	0.20	0.93
TOTAL DAILY APPLICATION REQUIREMENT, acre*ft		0.89	1.31	0.20	2.40
TOTAL DAILY APPLICATION REQUIREMENT, gallons		290,901	426,312	66,015	783,228
SEASONAL PLANT WATER REQUIREMENTS, inches		69.8	55.9	34.9	160.6
SEASONAL EFFECTIVE PRECIPITATION, inches	(7)	3.8	3.8	3.8	15.0
TOTAL SEASONAL IRRIGATION APPLICATION, inches	(1)	82.6	65.1	39.0	182.0
TOTAL SEASONAL IRRIGATION APPLICATION, acre*ft		182.0	262.9	39.0	483.9
TOTAL SEASONAL IRRIGATION APPLICATION, gallons		59,304,868	85,673,000	12,692,000	157,669,868
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 6 HOURS, 6 DAYS A WEEK (gpm)	(2)	1257	1842	285	3384
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 8 HOURS, 6 DAYS A WEEK (gpm)	(2)	943	1382	214	2538
IRRIGATION FLOW REQUIREMENT WITH AN IRRIGATION WINDOW OF 10 HOURS, 6 DAYS A WEEK (gpm)	(2)	754	1105	171	2031

NOTES:

1 IRRIGATION SYSTEM APPLICATION EFFICIENCY IS ASSUMED TO BE 80%.
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7 A SEASONAL PRECIPITATION OF 7.5-INCHES IS USED AND IS BASED ON World Water for Agriculture DATA PRECIPITATION IS ASSUMED TO BE 50% EFFECTIVE.

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

IRRIGATION WATER SOURCE MASTER PLANNING

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

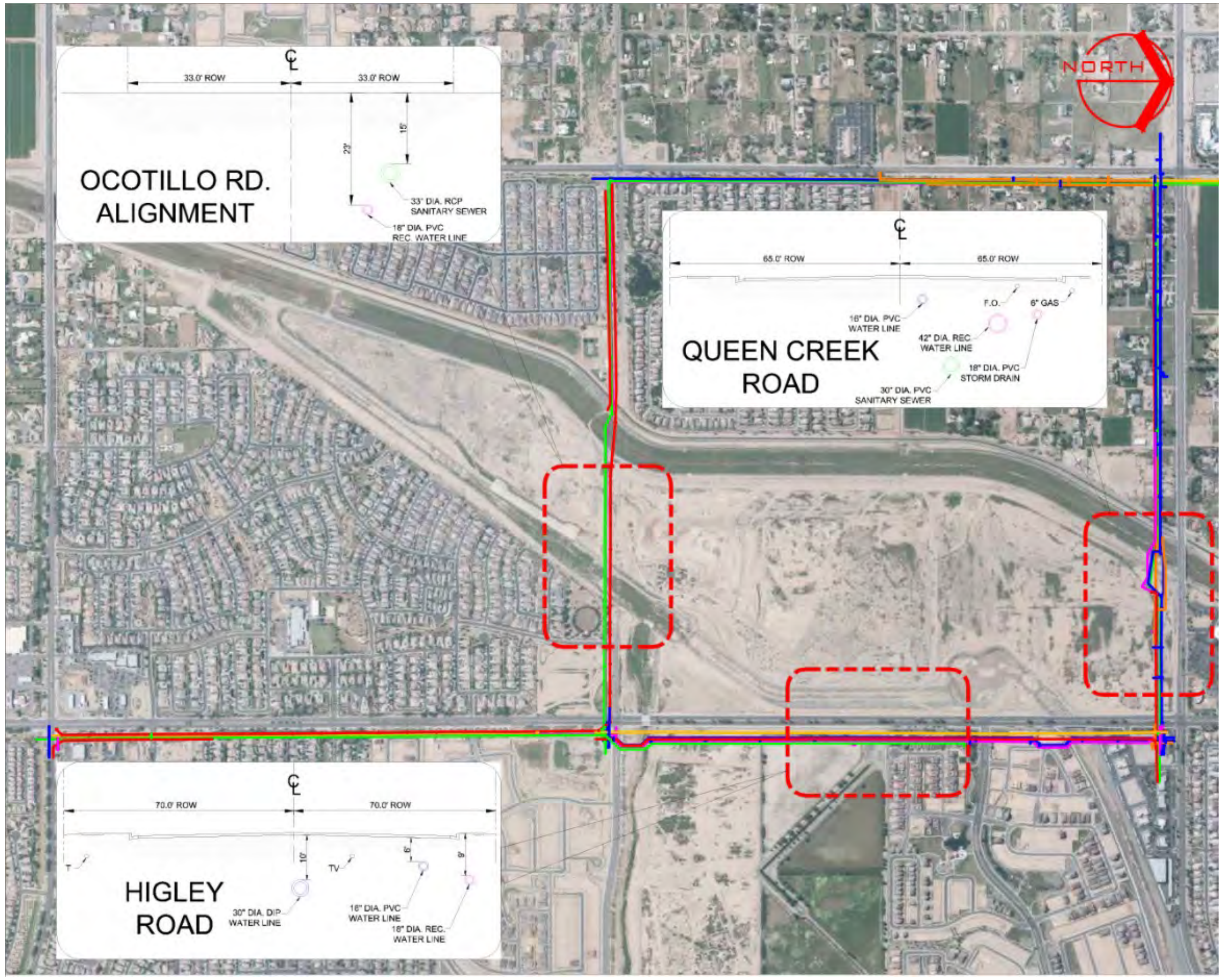
Water Source Master Planning

- Identifying Most Viable Source or Combination of Sources
    - Currently Available
    - Consistent Supply
    - Acceptable Water Quality
    - Cost (Initial and Long Term)
    - Future Value to Town

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Project Coordination Efforts

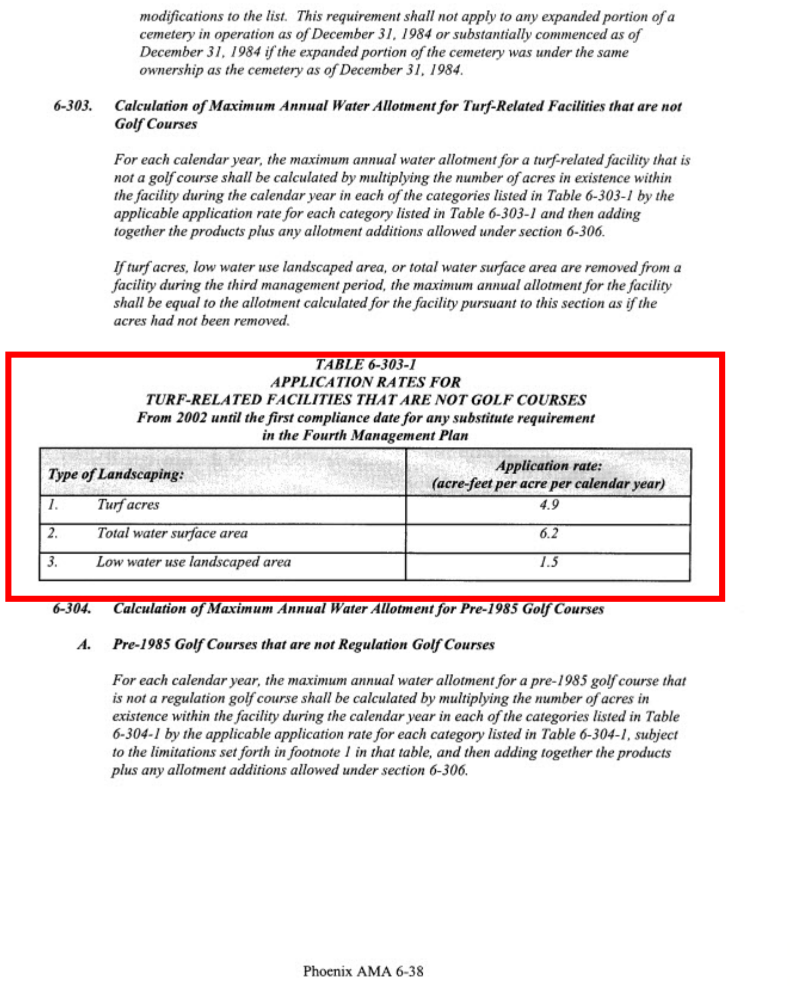
- Water source options
  - Potable Water (Gilbert Muni)
  - Reclaimed Water (Greenfield WTP)
  - Raw Water (SRP & RWCD)
  - Well Water (Gilbert & ADWR)
  - Any of the above in combination…



MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Potable Water Source Research

- Potable Water Source Pros
  - Infrastructure Available
  - Pressurized for Direct Use
  - High Water Quality
- Potable Water Source Cons
  - Expensive
  - Subject to Water Use Restrictions
    - ADWR Third Management Plan



modifications to the list. This requirement shall not apply to any expanded portion of a cemetery in operation as of December 31, 1984 or substantially commenced as of December 31, 1984 if the expanded portion of the cemetery was under the same ownership as the cemetery as of December 31, 1984.

6-303. Calculation of Maximum Annual Water Allotment for Turf-Related Facilities that are not Golf Courses

For each calendar year, the maximum annual water allotment for a turf-related facility that is not a golf course shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-303-1 by the applicable application rate for each category listed in Table 6-303-1 and then adding together the products plus any allotment additions allowed under section 6-306.

If turf acres, low water use landscaped area, or total water surface area are removed from a facility during the third management period, the maximum annual allotment for the facility shall be equal to the allotment calculated for the facility pursuant to this section as if the acres had not been removed.

TABLE 6-303-1
APPLICATION RATES FOR
TURF-RELATED FACILITIES THAT ARE NOT GOLF COURSES
From 2002 until the first compliance date for any substitute requirement in the Fourth Management Plan

Type of Landscaping:	***Application rate: (acre-feet per acre per calendar year)***
1. Turf acres	*4.9*
2. Total water surface area	*6.2*
3. Low water use landscaped area	*1.5*

6-304. Calculation of Maximum Annual Water Allotment for Pre-1985 Golf Courses

A. Pre-1985 Golf Courses that are not Regulation Golf Courses

For each calendar year, the maximum annual water allotment for a pre-1985 golf course that is not a regulation golf course shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-304-1 by the applicable application rate for each category listed in Table 6-304-1, subject to the limitations set forth in footnote 1 in that table, and then adding together the products plus any allotment additions allowed under section 6-306.

Phoenix AMA 6-38

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Reclaimed Water Source Research

- Reclaimed Water Source Pros
  - Infrastructure Available
  - Pressurized for Direct Use or On-site Storage
  - High Water Quality (A+)
  - Less Expensive than Potable
  - ADWR supplementary allowance
- Reclaimed Water Source Cons
  - Shared Use between Three Municipalities affects future supply
  - Lower Availability during Peak Season

GILBERT ARIZONA

mesa·az

TOWN OF QUEEN CREEK ARIZONA

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Raw Water Source Research

- Raw Water Source Pros
  - RWCD Canal near Site
  - Acceptable Water Quality
  - Less Expensive than Potable/Reclaimed

- Raw Water Source Cons
  - Site is outside of RWCD Service Boundary
  - No Existing Infrastructure to Site
  - Not Pressurized
  - Leased Water not Guaranteed
  - Less Control/Ongoing Coordination Required

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

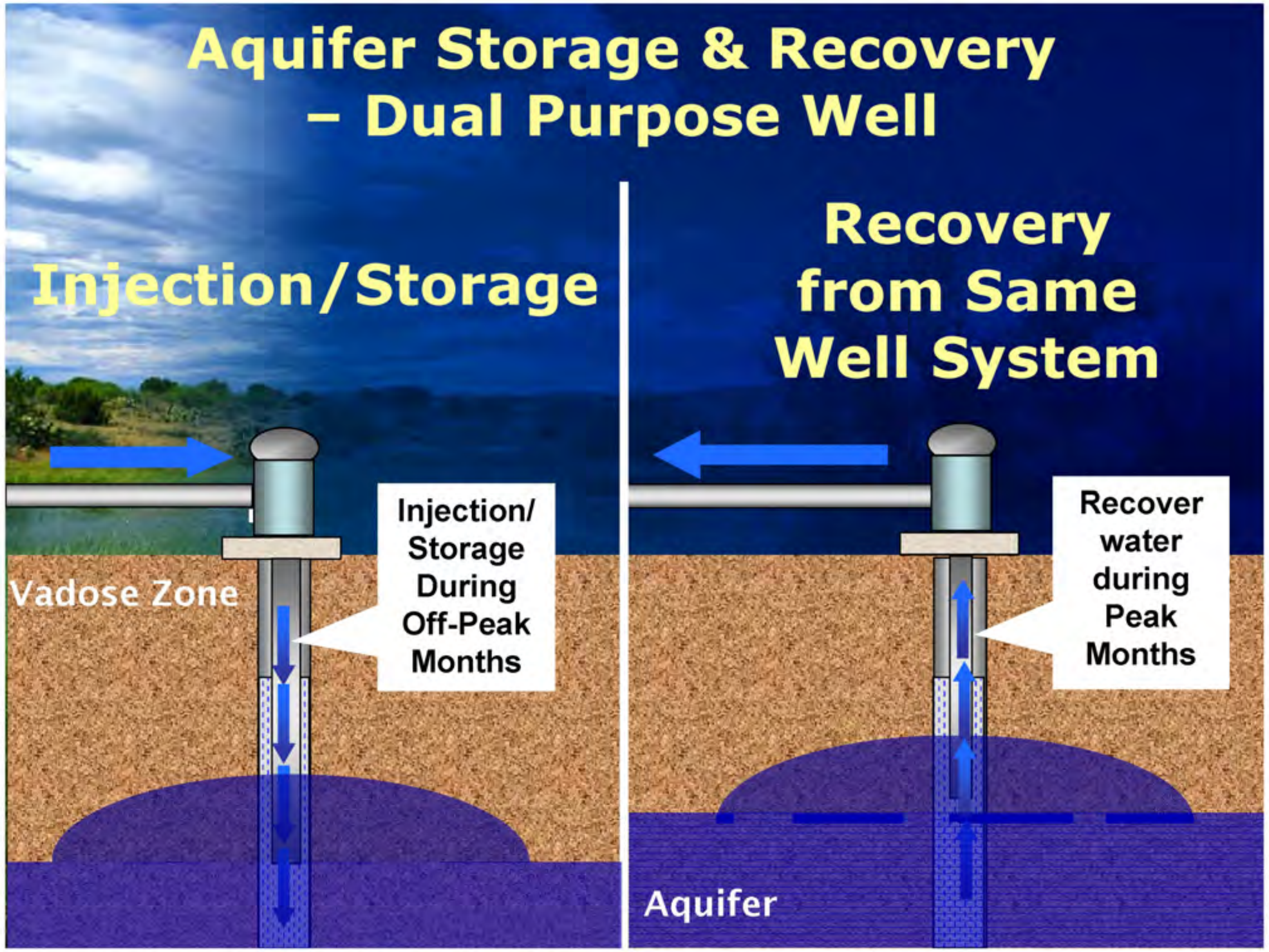
Well Water Source Research

- Well Water Source Pros
    - Off-site Infrastructure Independence
    - Pressurized for Direct Use or On-site Storage via Well Pump
    - Acceptable Water Quality
- Well Water Source Cons
    - Subject to Available Aquifer Credit Balance & Allocation Strategies
    - On-site Infrastructure Expense, Permitting, ADWR approvals

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Water Source Master Planning

- Aquifer Storage and Recovery (ASR) Well Option
  - Availability ✓
  - Consistency ✓
  - Cost (Initial and Long Term) ??
  - Future Value to Town ✓
  - Acceptable Water Quality ✓



MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Water Source Master Planning

- City of Chandler Aquifer Storage and Recovery (ASR) Well Tour

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Water Source Supply & Demand Strategy

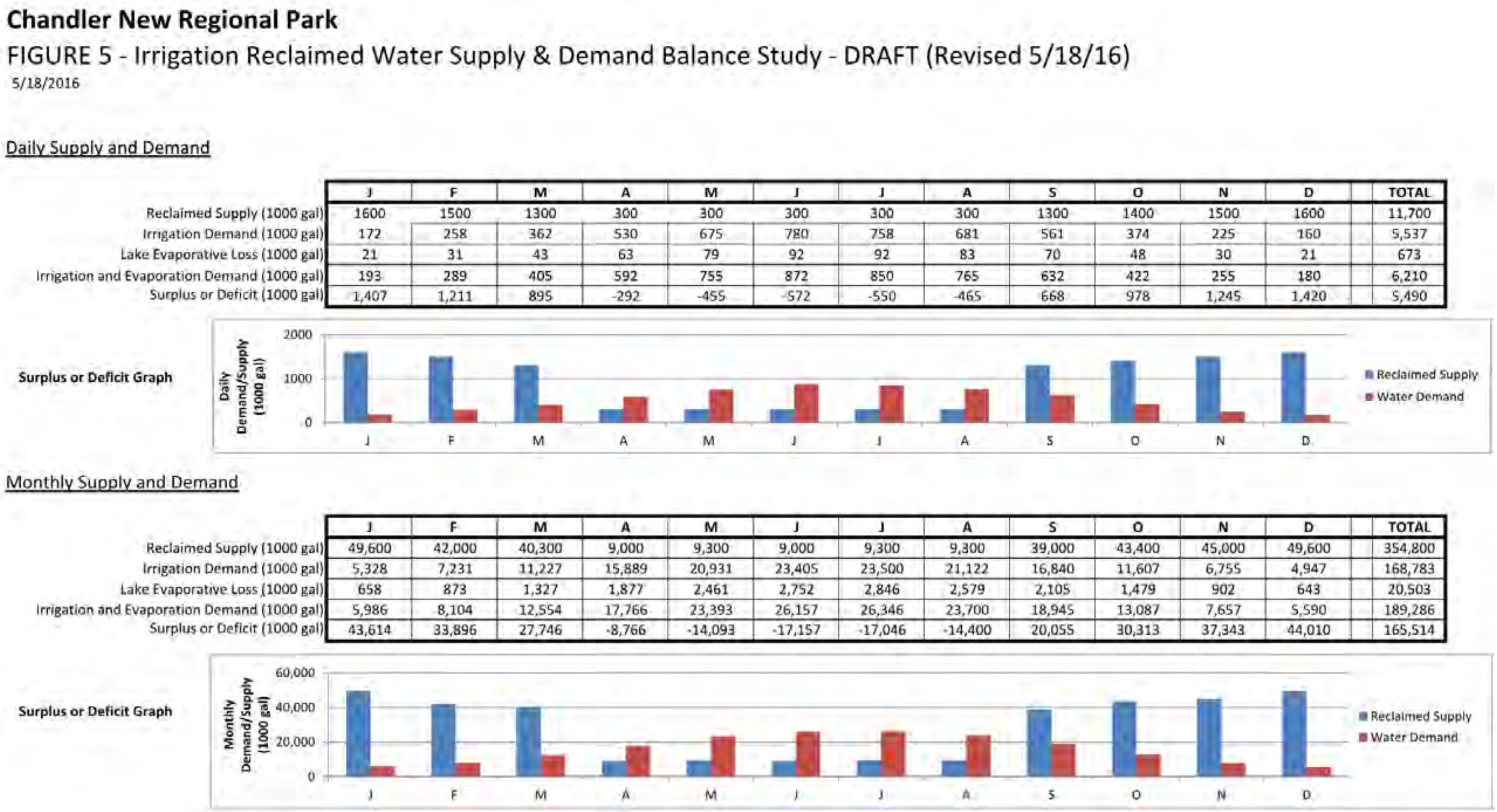
- Aquifer Storage and Recovery (ASR) Well – Primary Irrigation Source

  ### Storage
  - Reclaimed Water into On-site Lake Amenity
    - Seasonal Availability
  - Reclaimed Water Injection into Aquifer
    - Off-peak Surplus
    - Town of Gilbert Storage Credits

  ### Recovery
  - Ground Water into On-site Storage Lake Amenity
    - Peak Season Demand
    - Town of Gilbert Storage Debits
- Potable Water from Hydrant – Emergency Back-up into Lake Amenity

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

Develop Supply & Demand Balance Model for Reclaimed Water with ASR Well Concept



Chandler New Regional Park

FIGURE 5 - Irrigation Reclaimed Water Supply & Demand Balance Study - DRAFT (Revised 5/18/16)

5/18/2016

Daily Supply and Demand

	J	F	M	A	M	J	J	A	S	O	N	D		TOTAL
Reclaimed Supply (1000 gal)	1600	1500	1300	300	300	300	300	300	1300	1400	1500	1600		11,700
Irrigation Demand (1000 gal)	172	258	362	530	675	780	758	681	561	374	225	160		5,537
Lake Evaporative Loss (1000 gal)	21	31	43	63	79	92	92	83	70	48	30	21		673
Irrigation and Evaporation Demand (1000 gal)	193	289	405	592	755	872	850	765	632	422	255	180		6,210
Surplus or Deficit (1000 gal)	1,407	1,211	895	-292	-455	-572	-550	-465	668	978	1,245	1,420		5,490

Surplus or Deficit Graph

Monthly Supply and Demand

	J	F	M	A	M	J	J	A	S	O	N	D		TOTAL
Reclaimed Supply (1000 gal)	49,600	42,000	40,300	9,000	9,300	9,000	9,300	9,300	39,000	43,400	45,000	49,600		354,800
Irrigation Demand (1000 gal)	5,328	7,231	11,227	15,889	20,931	23,405	23,500	21,122	16,840	11,607	6,755	4,947		168,783
Lake Evaporative Loss (1000 gal)	658	873	1,327	1,877	2,461	2,752	2,846	2,579	2,105	1,479	902	643		20,503
Irrigation and Evaporation Demand (1000 gal)	5,986	8,104	12,554	17,766	23,393	26,157	26,346	23,700	18,945	13,087	7,657	5,590		189,286
Surplus or Deficit (1000 gal)	43,614	33,896	27,746	-8,766	-14,093	-17,157	-17,046	-14,400	20,055	30,313	37,343	44,010		165,514

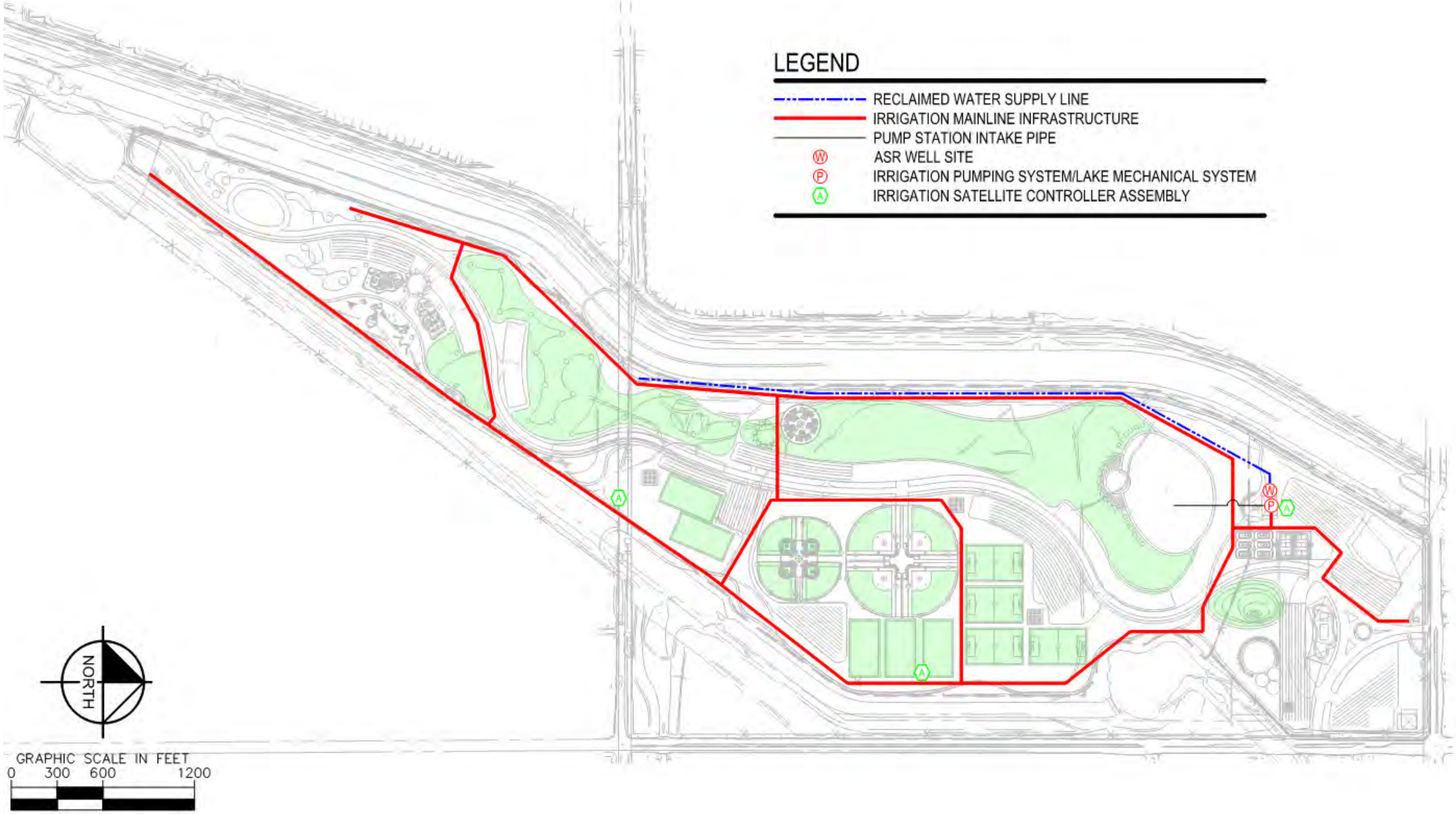
Surplus or Deficit Graph

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

IRRIGATION MASTER PLAN COST MODELING

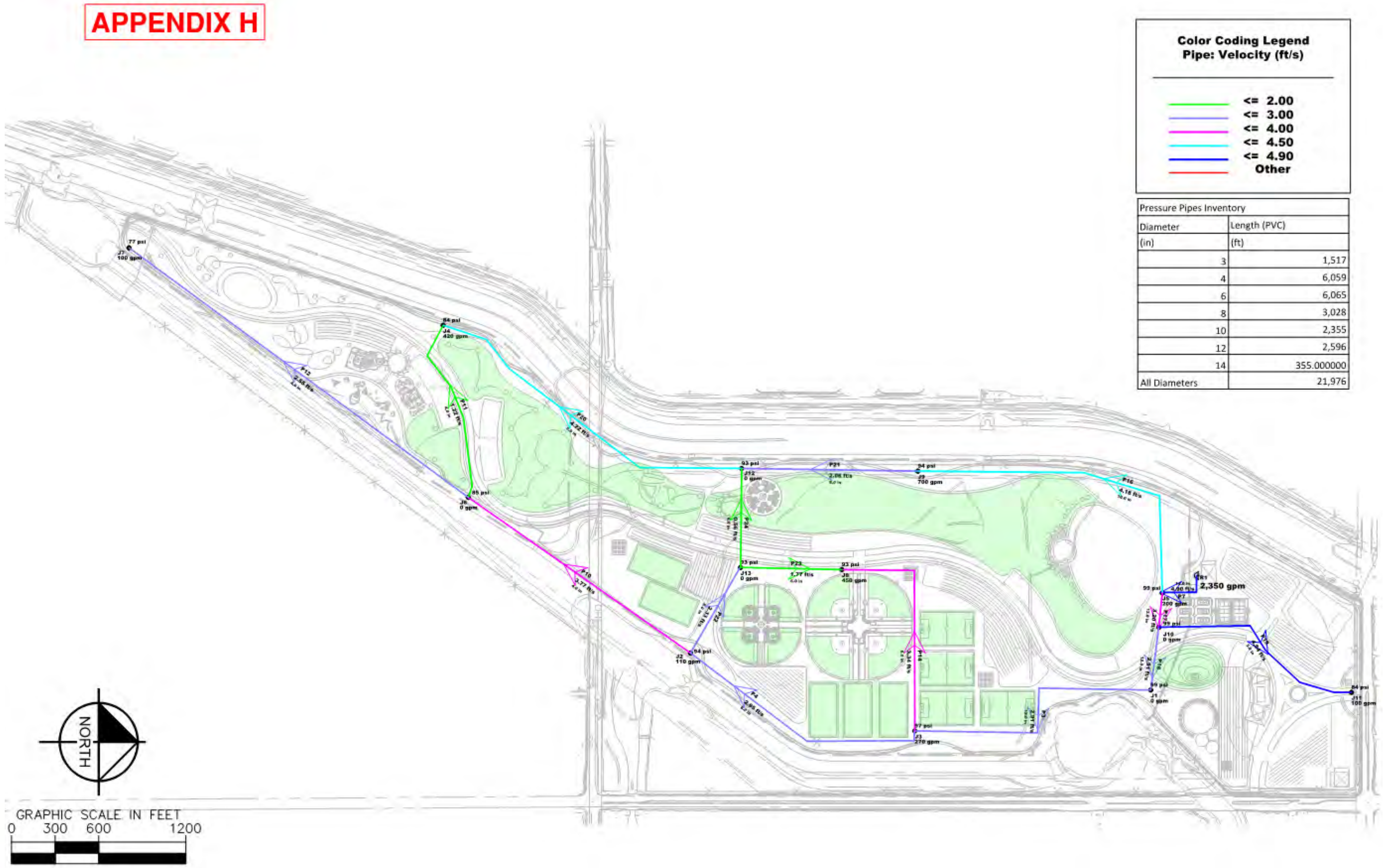
MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

DEVELOP CONCEPTUAL MAINLINE AND CONTROL SYSTEM DIAGRAM



MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

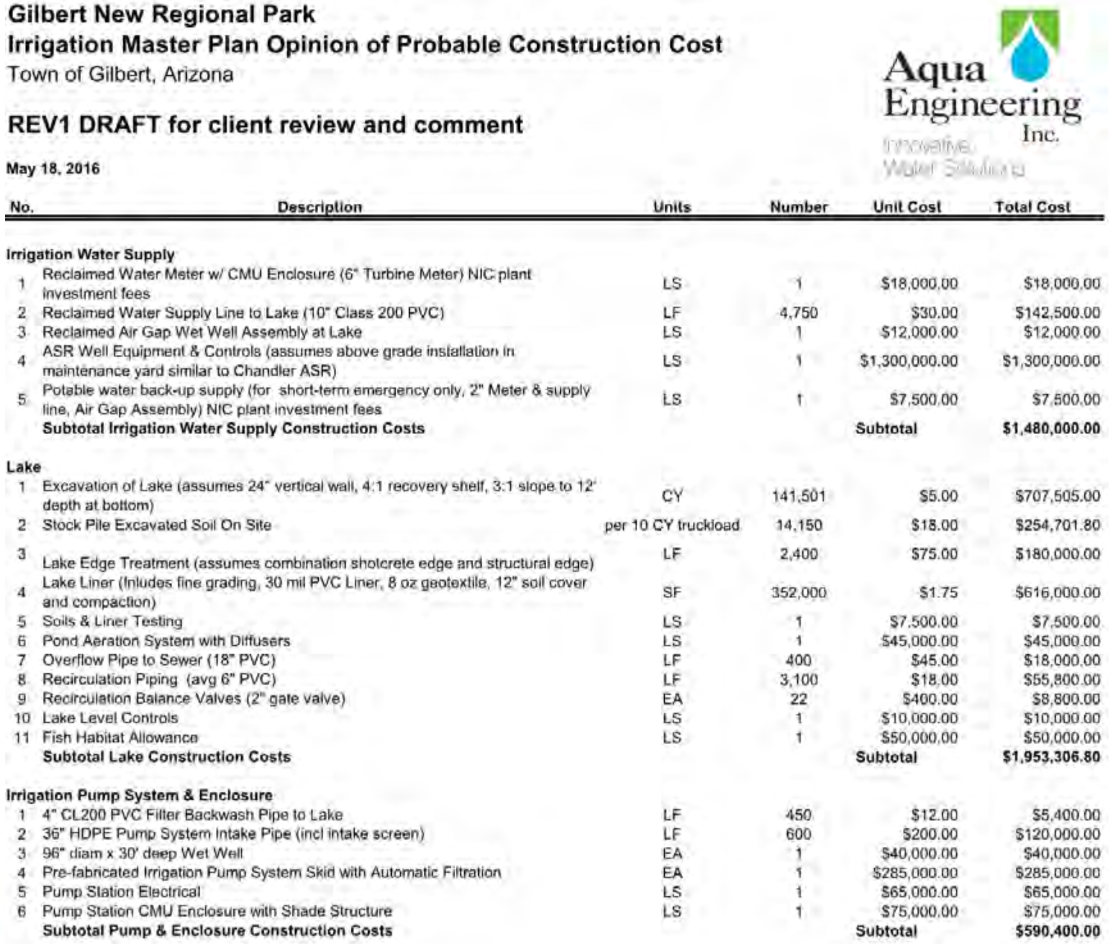
DEVELOP PRELIMINARY IRRIGATION MAINLINE HYDRAULIC MODEL



Pressure Pipes Inventory	
Diameter (in)	Length (PVC) (ft)
3	1,517
4	6,059
6	6,065
8	3,028
10	2,355
12	2,596
14	355.000000
All Diameters	21,976

MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

DEVELOP IRRIGATION MASTER PLAN COST MODEL



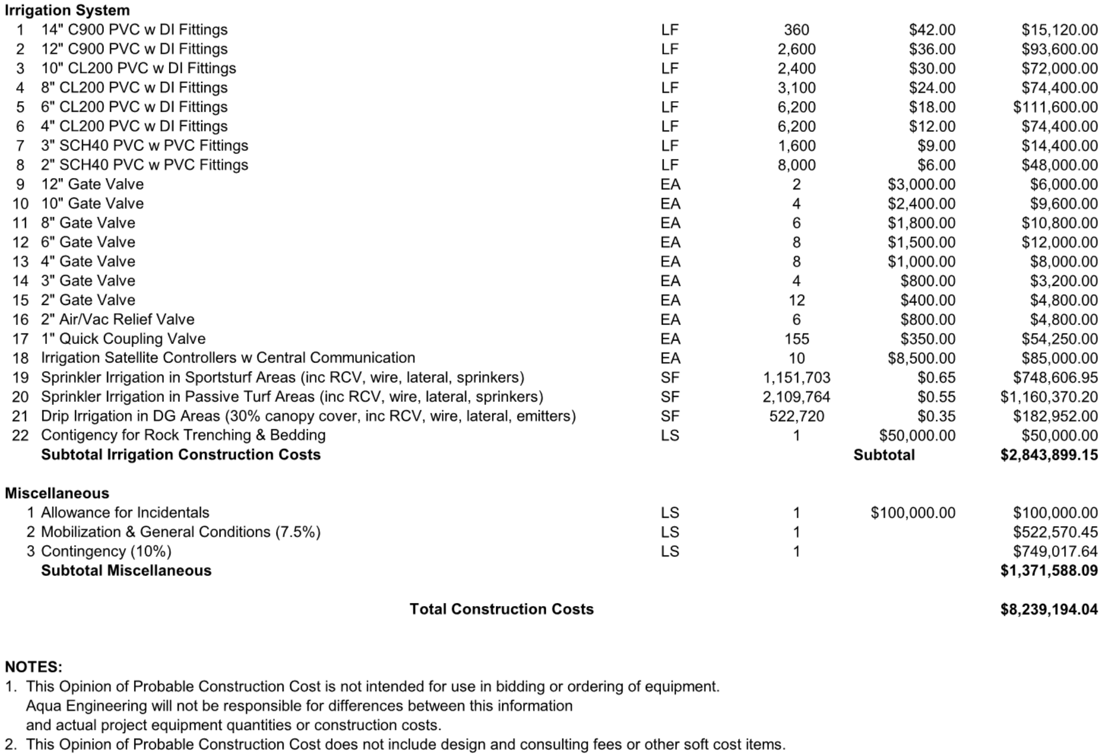
Gilbert New Regional Park
Irrigation Master Plan Opinion of Probable Construction Cost
Town of Gilbert, Arizona

Aqua Engineering Inc.
Innovative Water Solutions

REV1 DRAFT for client review and comment

May 18, 2016

No.	Description	Units	Number	Unit Cost	Total Cost
	Irrigation Water Supply				
1	Reclaimed Water Meter w/ CMU Enclosure (6" Turbine Meter) NIC plant investment fees	LS	1	$18,000.00	$18,000.00
2	Reclaimed Water Supply Line to Lake (10" Class 200 PVC)	LF	4,750	$30.00	$142,500.00
3	Reclaimed Air Gap Wet Well Assembly at Lake	LS	1	$12,000.00	$12,000.00
4	ASR Well Equipment & Controls (assumes above grade installation in maintenance yard similar to Chandler ASR)	LS	1	$1,300,000.00	$1,300,000.00
5	Potable water back-up supply (for short-term emergency only, 2" Meter & supply line, Air Gap Assembly) NIC plant investment fees	LS	1	$7,500.00	$7,500.00
	Subtotal Irrigation Water Supply Construction Costs			**Subtotal**	**$1,480,000.00**
	Lake				
1	Excavation of Lake (assumes 24" vertical wall, 4:1 recovery shelf, 3:1 slope to 12' depth at bottom)	CY	141,501	$5.00	$707,505.00
2	Stock Pile Excavated Soil On Site	per 10 CY truckload	14,150	$18.00	$254,701.80
3	Lake Edge Treatment (assumes combination shotcrete edge and structural edge)	LF	2,400	$75.00	$180,000.00
4	Lake Liner (Inludes fine grading, 30 mil PVC Liner, 8 oz geotextile, 12" soil cover and compaction)	SF	352,000	$1.75	$616,000.00
5	Soils & Liner Testing	LS	1	$7,500.00	$7,500.00
6	Pond Aeration System with Diffusers	LS	1	$45,000.00	$45,000.00
7	Overflow Pipe to Sewer (18" PVC)	LF	400	$45.00	$18,000.00
8	Recirculation Piping (avg 6" PVC)	LF	3,100	$18.00	$55,800.00
9	Recirculation Balance Valves (2" gate valve)	EA	22	$400.00	$8,800.00
10	Lake Level Controls	LS	1	$10,000.00	$10,000.00
11	Fish Habitat Allowance	LS	1	$50,000.00	$50,000.00
	Subtotal Lake Construction Costs			**Subtotal**	**$1,953,306.80**
	Irrigation Pump System & Enclosure				
1	4" CL200 PVC Filter Backwash Pipe to Lake	LF	450	$12.00	$5,400.00
2	36" HDPE Pump System Intake Pipe (incl intake screen)	LF	600	$200.00	$120,000.00
3	96" diam x 30' deep Wet Well	EA	1	$40,000.00	$40,000.00
4	Pre-fabricated Irrigation Pump System Skid with Automatic Filtration	EA	1	$285,000.00	$285,000.00
5	Pump Station Electrical	LS	1	$65,000.00	$65,000.00
6	Pump Station CMU Enclosure with Shade Structure	LS	1	$75,000.00	$75,000.00
	Subtotal Pump & Enclosure Construction Costs			**Subtotal**	**$590,400.00**



	Irrigation System				
1	14" C900 PVC w DI Fittings	LF	360	$42.00	$15,120.00
2	12" C900 PVC w DI Fittings	LF	2,600	$36.00	$93,600.00
3	10" CL200 PVC w DI Fittings	LF	2,400	$30.00	$72,000.00
4	8" CL200 PVC w DI Fittings	LF	3,100	$24.00	$74,400.00
5	6" CL200 PVC w DI Fittings	LF	6,200	$18.00	$111,600.00
6	4" CL200 PVC w DI Fittings	LF	6,200	$12.00	$74,400.00
7	3" SCH40 PVC w PVC Fittings	LF	1,600	$9.00	$14,400.00
8	2" SCH40 PVC w PVC Fittings	LF	8,000	$6.00	$48,000.00
9	12" Gate Valve	EA	2	$3,000.00	$6,000.00
10	10" Gate Valve	EA	4	$2,400.00	$9,600.00
11	8" Gate Valve	EA	6	$1,800.00	$10,800.00
12	6" Gate Valve	EA	8	$1,500.00	$12,000.00
13	4" Gate Valve	EA	8	$1,000.00	$8,000.00
14	3" Gate Valve	EA	4	$800.00	$3,200.00
15	2" Gate Valve	EA	12	$400.00	$4,800.00
16	2" Air/Vac Relief Valve	EA	6	$800.00	$4,800.00
17	1" Quick Coupling Valve	EA	155	$350.00	$54,250.00
18	Irrigation Satellite Controllers w Central Communication	EA	10	$8,500.00	$85,000.00
19	Sprinkler Irrigation in Sportsturf Areas (inc RCV, wire, lateral, sprinkers)	SF	1,151,703	$0.65	$748,606.95
20	Sprinkler Irrigation in Passive Turf Areas (inc RCV, wire, lateral, sprinkers)	SF	2,109,764	$0.55	$1,160,370.20
21	Drip Irrigation in DG Areas (30% canopy cover, inc RCV, wire, lateral, emitters)	SF	522,720	$0.35	$182,952.00
22	Contigency for Rock Trenching & Bedding	LS	1	$50,000.00	$50,000.00
	Subtotal Irrigation Construction Costs			**Subtotal**	**$2,843,899.15**
	Miscellaneous				
1	Allowance for Incidentals	LS	1	$100,000.00	$100,000.00
2	Mobilization & General Conditions (7.5%)	LS	1		$522,570.45
3	Contingency (10%)	LS	1		$749,017.64
	Subtotal Miscellaneous				**$1,371,588.09**
	Total Construction Costs				**$8,239,194.04**

NOTES:

1. This Opinion of Probable Construction Cost is not intended for use in bidding or ordering of equipment. Aqua Engineering will not be responsible for differences between this information and actual project equipment quantities or construction costs.
2. This Opinion of Probable Construction Cost does not include design and consulting fees or other soft cost items.

MASTER PLANNING

Community Development

Background

Original land from Mission San Juan Capistrano

Background

Generations of cattle land and orchard production

Background

Master Planned Community

Several Planning Areas

10,000 Dwelling Units

1,800 Acres of common area

Master HOA

Integrated Irrigation

Background

Background

Water Source is recycled TSE

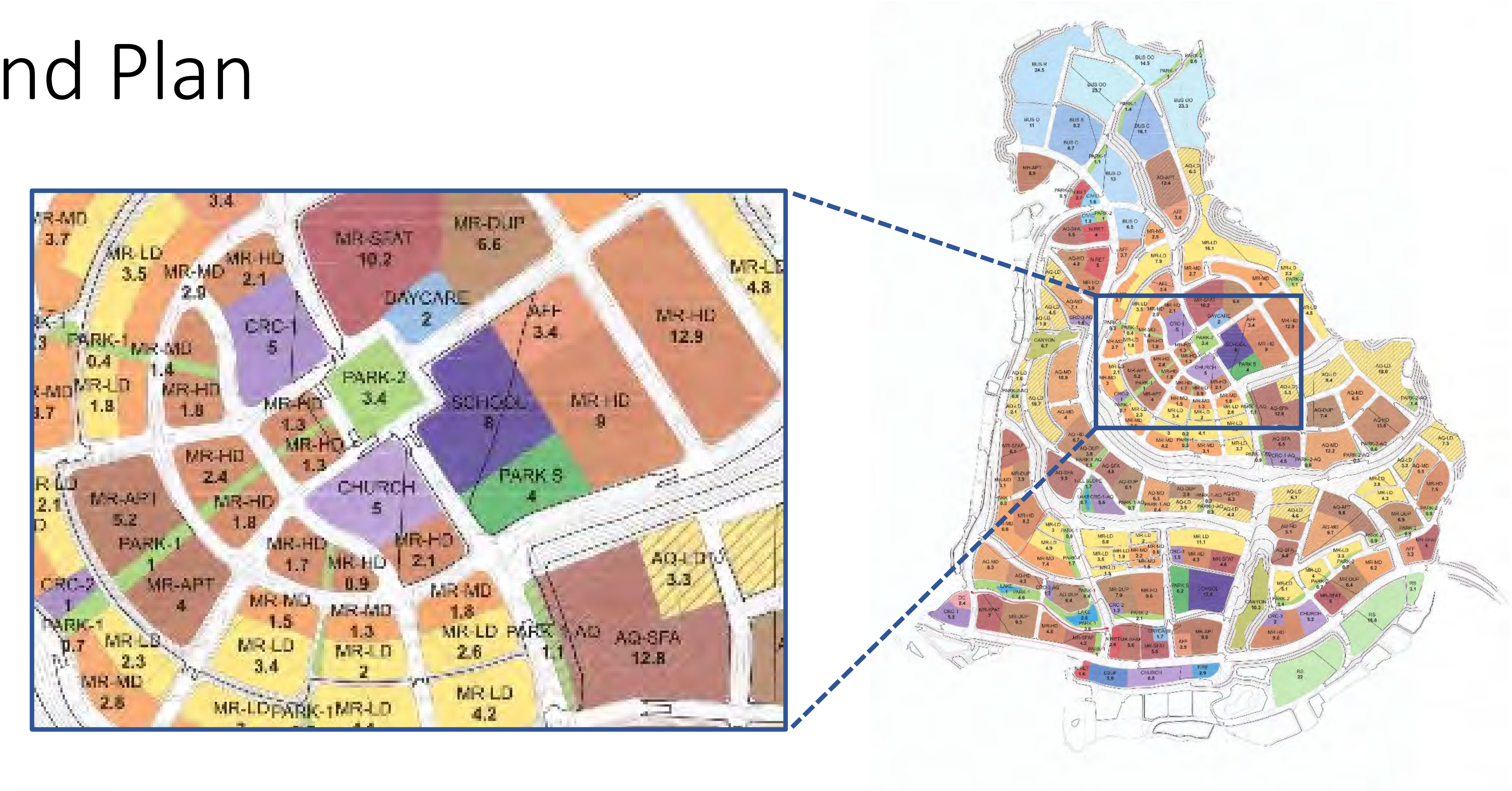
6 MGD to 10 MGD from Chiquita Treatment Facility by local agency

5,000 AF Seasonal Storage for peak summer demand is under construction

Master Planning Planning Area 3

- Volumetric Analysis
- Flow Analysis
- Pressure Zone Studies
  - Two HGL zones
- Meter and Controller Layout
  - Maintenance Responsibility
  - Phasing
  - Construction package breakdown
- GIS data
- Design guidelines
- Plan review
- Construction observation of all HOA landscape

Land Plan


3.4
MR-MD
3.7
MR-LD
3.5
MR-MD
2.9
MR-HD
2.1
MR-SFAT
10.2
MR-DUP
6.6
DAYCARE
2
AFF
3.4
MR-HD
12.9
MR-LD
4.8
CRC-1
5
PARK-1
0.4
MR-MD
1.4
MR-MD
3.7
MR-LD
1.8
MR-HD
1.8
PARK-2
3.4
SCHOOL
8
MR-HD
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CHURCH
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PARK S
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MR-MD
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AQ-LD
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PARK-1
0.7
MR-LD
2.3
MR-MD
2.6
MR-LD
3.4
MR-LD
2
MR-LD
2.6
PARK-1-AQ
1.1
AQ-SFA
12.8
MR-LD
4.2
MR-LD
PARK-1
MR-LD

Approach

Apply known landscape parameter data to categorized gross pad areas to determine quantities of sub-categorized hydrozones resulting in volumetric and flow requirements.

Study data record of existing landscapes with 28 planning categories

Study each category for landscape hydrozones

Example: Market Rate housing tract with low density
10% landscape per gross pad area
60% Warm season turf with overhead spray
20% Low water use shrub massing with inline drip
20% Moderate water use shrub massing with inline drip

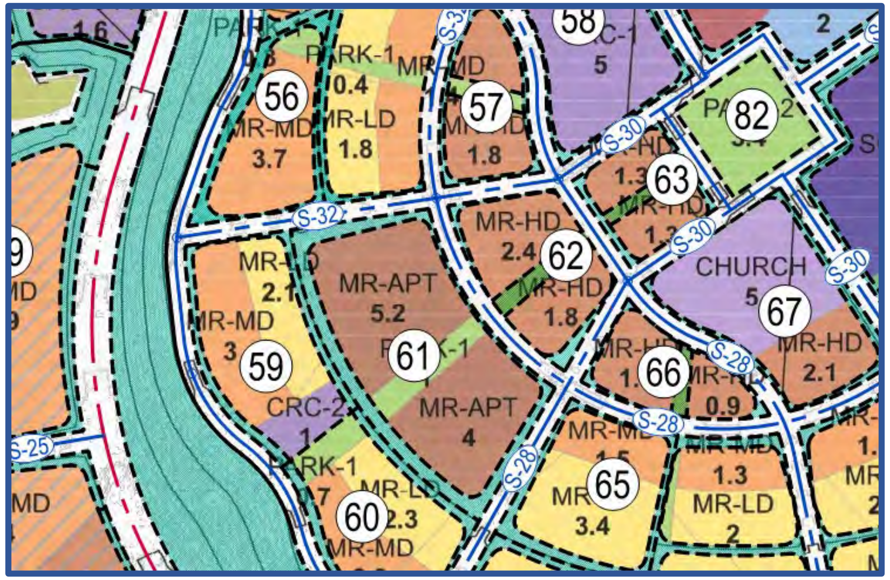
.34 Acres landscape, .20 acres turf, .07 acres low, .07 acres mod water use shrub massings

Result

56
MR-MD
3.7
PARK-1
0.4
MR-LD
1.8
MR-MD
57
MR-MD
1.8
58
5
S-30
S-32
MR-HD
1.3
63
PA
82
2
MR-HD
1.3
S-30
CHURCH
5
67
S-30
MR-LD
2.1
MR-APT
5.2
MR-HD
2.4
62
MR-HD
1.8
MR-MD
3
59
61
K-1
CRC-2
1
MR-APT
4
MR-HD
66
MR-HD
0.9
S-28
MR-HD
2.1
S-28
S-25
MD
PARK-1
60
MR-LD
2.3
MR-MD
S-28
MR
65
3.4
MR-MD
1.3
MR-LD
2
LEGEND

Result – Neighborhood 61

Type	Gross Pad	Net Landscape	Spray Low	Spray Mod	Drip Mod	Turf
MR Apt	5.2	1.56			1.17	0.39
MR Apt	4	1.2			0.9	0.3
Park	1	0.8	0.16	0.16		0.48
Slopes	2.8	2.8	2.24	.56		



Calculate volumetric and flow demand for each hydrozone based on independent water windows

Sum of flow requirement for each provides node flow for hydraulic flow analysis

Neighborhood 61 – 109 gpm.

Results – Planning Area

Net Landscape	Lakes	Spray Low	Spray Mod	Drip Mod	Turf
945.5	4.30	498.36	115.12	142.65	185.07

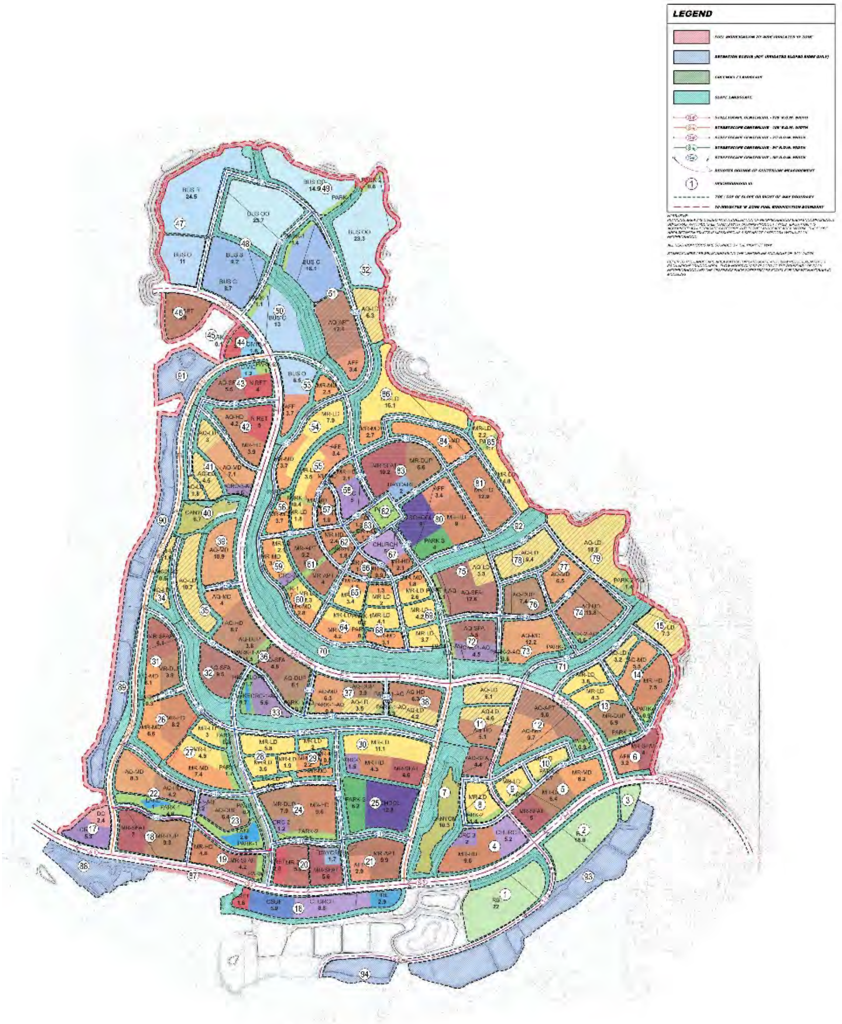
Total Demand: 3,709 AF per year

Peak Day: 5.01 MGD

Peak Month: 476.19 AF

Peak Day Flow: 14,764 GPM

Flow per Acre: 16.32 gpm / Ac.



Results – Meter Layout

Considerations:

Pressure Zones

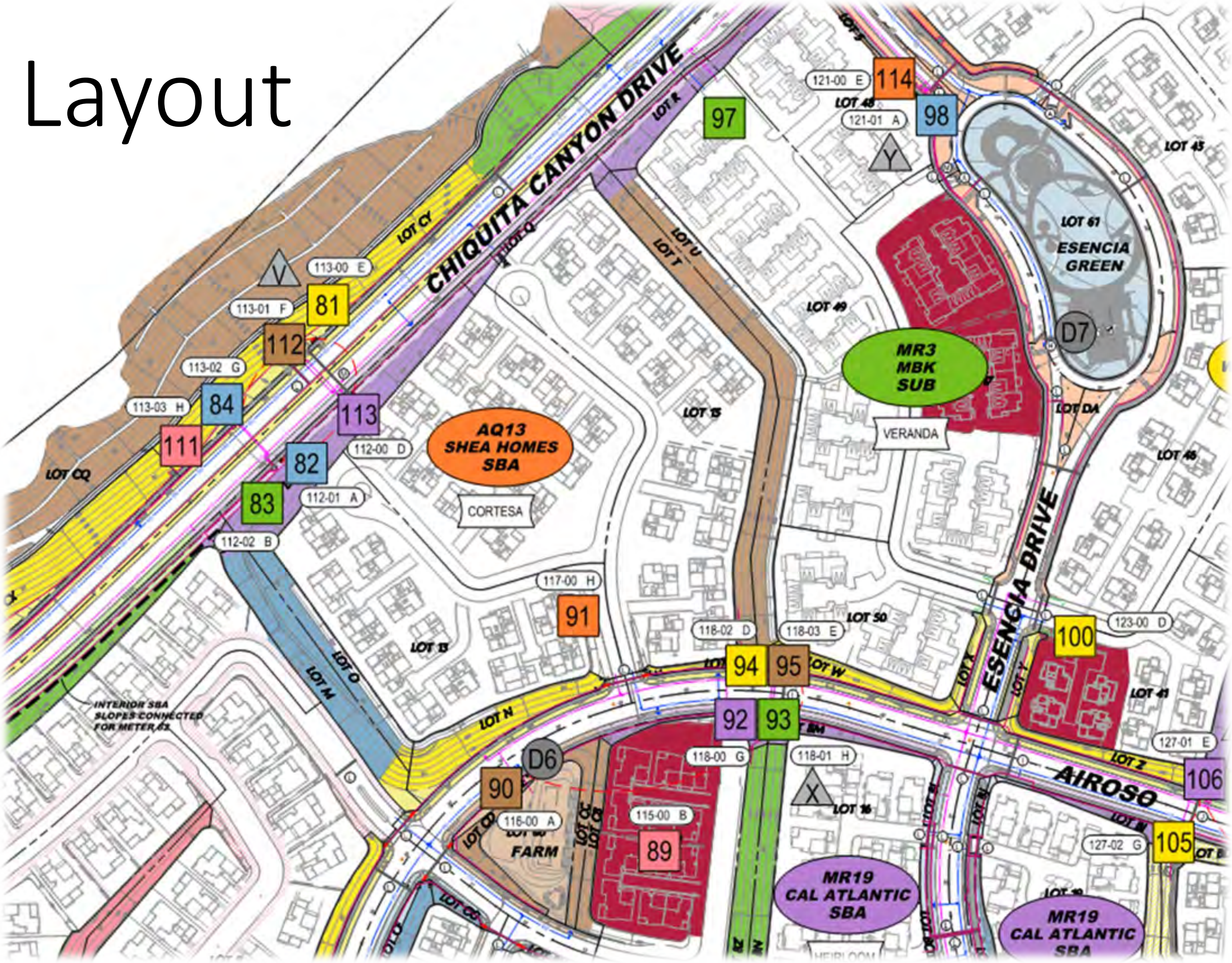
Maintenance Responsibility

Special Benefit Areas (SBA's)

Permitting

Phasing

Construction Document packages



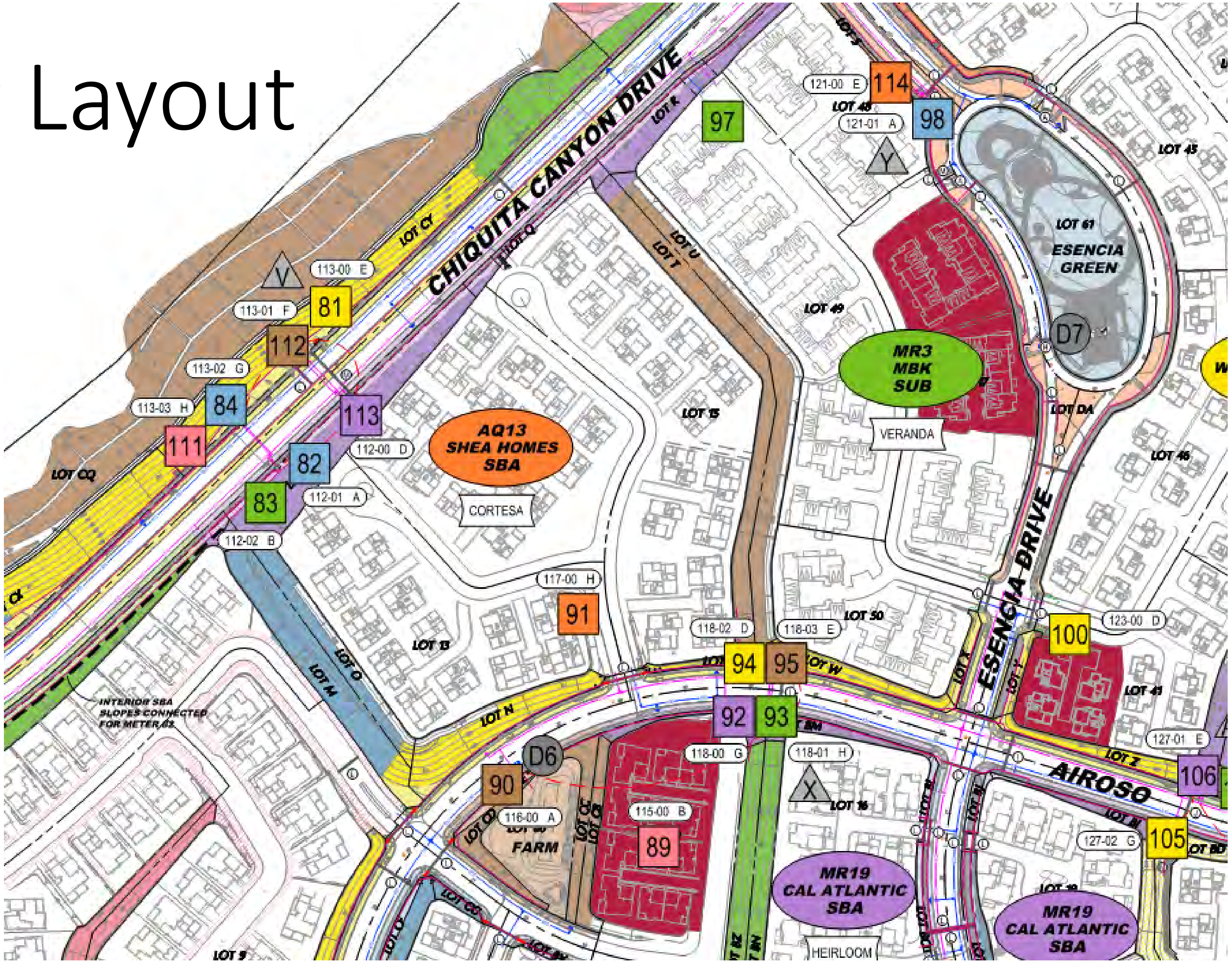
Results – Meter Layout

Special Benefit Areas
Metering Considerations

Meter 82 Slope
Meter 95 Slope

Phasing:
Model locations

Phasing:
Marketing Corridor vs. Tract slopes



Challenges

- Master Plan lock down
- Estimation of landscape area and hydrozones
- Enforcement of plant palette
- Flow creep vs. time
- Contingencies ? ? ?
- Implementation of Design Guidelines