Subsurface Irrigation for Turfgrass Areas

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@NuMex_Turf
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

<table>
<thead>
<tr>
<th>Las Cruces</th>
<th>GCSAA Survey (Gelernter et al., 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool-season</td>
<td>50”</td>
</tr>
<tr>
<td>Warm-season</td>
<td>38”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grass Type</th>
<th>1000 ft²</th>
<th>1 acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS</td>
<td>23,500 gal</td>
<td>3.1 acre feet</td>
</tr>
<tr>
<td>CS</td>
<td>31,100 gal</td>
<td>4.1 acre feet</td>
</tr>
</tbody>
</table>
Turfgrass Irrigation Requirement

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

- **A**: Area under irrigation
- **ETo**: (reference) Evapotranspiration
- **ISE**: Irrigation System Efficiency
- **Wq**: Water Quality
- **Kc**: Crop coefficient

**f_{(Kc)}**: 
- **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

\[ \text{WR} = \frac{ET_o \cdot K_C \cdot A}{DU \cdot E_{WM} \cdot C_U} \]

without rainfall

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

with effective rainfall

\[ \text{WR} = \text{Water Requirement} \]
\[ \text{ET}_o = \text{Reference Evapotranspiration} \]
\[ K_C = \text{Landscape Coefficient} \]
\[ A = \text{Area} \]
\[ C_U = \text{Conversion Factor} \]
\[ DU = \text{Distribution Uniformity} \]
\[ E_{WM} = \text{Management Efficiency} \]
\[ R_E = \text{Effective Rainfall} \]

(Irrigation Association, 2001)
Irrigation Water Requirement (2)

\[ WR = \frac{ET_o \cdot K_c \cdot A}{DU \cdot E_{WM} \cdot C_U} \quad \rightarrow \quad WR = \frac{ET_o \cdot K_c}{DU} \]

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

Constants

(Irrigation Association, 2001)
Strategies for Irrigation Water Conservation

\[ WR = \frac{ET_o \cdot K_c \cdot A}{DU} \]

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 m²
43,000 ft²

Plot size: 17 m x 17 m
55 ft x 55 ft
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 shub areas, median stripes, public recreation areas and parking islands
- Seven-year warranty against root intrusion
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.
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

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

Sevostianova et al., 2011
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

Results

Sevostianova et al., 2011
Sevostianova et al., 2011
Ganjegunte et al., 2013
Irrigation effect on brown patch (Rhizoctonia sp.) occurrence
2) Establishment of Warm and Cool-Season Grasses under Subsurface Drip and Sprinkler Irrigation

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

<table>
<thead>
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<th>Warm Season</th>
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<tr>
<td><strong>Species</strong></td>
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<td><strong>Irrigation</strong></td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
</tr>
<tr>
<td><strong>Fertilizer</strong></td>
</tr>
</tbody>
</table>
Results:
Green up (75% green cover)

Serena et al., 2017
References (1)

References (2)


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.
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
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
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
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 | Bruce & company
Unsaturated flow

Source: C. R. Dixon & associates
Saturated flow events

18 minutes in 90 days
Soil Moisture Dynamic

1.08 inches of rain

Peak Rainfall

Saturated Flow 60 minutes

July 12, 2016

1.08 inches of rain
Passive Water Harvesting

1.08 inches of rain

24 hr. Storage
Profile mock-up

High Programmed Use Turf Soil Profile (fiber reinforced)

- S1 (2"
- S2 (9.5"
- S3 (12"
- S4 (22"
- S5 (32"
- S6 (34"

Source: Jeffrey L Bruce & company
Profile 1

3 Hour Simulation

Source: Jeffrey L Bruce & company
Profile redesign

Capillary Break

Profile #1

Source: Jeffrey L Bruce & company
Profile 2

3 Hour Simulation

Optimum Moisture

Plant Stress

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

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.
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
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
Project Background Information

- 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
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
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>
<thead>
<tr>
<th>TABLE 1: PEAK SEASON DESIGN AND ANNUAL WATER REQUIREMENTS - PRELIMINARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqua Engineering, Inc.</td>
</tr>
<tr>
<td>375 E. Horsetooth Rd, Blvd 2-202</td>
</tr>
<tr>
<td>Fort Collins, CO 80525-3186</td>
</tr>
<tr>
<td>February 15, 2018</td>
</tr>
<tr>
<td>Project Name: Gilbert New Regional Park</td>
</tr>
<tr>
<td>Location: Gilbert, AZ</td>
</tr>
<tr>
<td>Prepared By: CBK&amp;DM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage of Irrigated Turfgrass at Site</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>90%</th>
<th>Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA, acres</td>
<td>272.00</td>
<td>204.00</td>
<td>136.00</td>
<td>68.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>PEAK SEASON DESIGN</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>PLANT WATER REQUIREMENT, inches/day</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>OPERATING LOS, inches</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>TOTAL DAILY APPLICATION REQUIREMENT, inches</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>TOTAL DAILY APPLICATION REQUIREMENT, acre-it</td>
<td>7.40</td>
<td>5.80</td>
<td>3.87</td>
<td>1.93</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>EVAPORATIVE LOSS FROM LAKE (5 ACRE)</td>
<td>2,221,086</td>
<td>1,840,815</td>
<td>1,260,543</td>
<td>630,272</td>
<td>57,374</td>
<td></td>
</tr>
<tr>
<td>DAILY WATER WINDOW CONSTRAINTS</td>
<td>130.07</td>
<td>97.55</td>
<td>60.44</td>
<td>326.2</td>
<td>36.3</td>
<td></td>
</tr>
<tr>
<td>TOTAL SEASONAL IRRIGATION APPLICATION, acre-it</td>
<td>423,857</td>
<td>317,879</td>
<td>211,918</td>
<td>105,961</td>
<td>12,813</td>
<td></td>
</tr>
<tr>
<td>IRRIGATION FLOW REQUIREMENT WITH</td>
<td>10213</td>
<td>7600</td>
<td>5108</td>
<td>2653</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AN IRRIGATION WINDOW OF 6 HOURS, 6 DAYS A WEEK (gpm)</td>
<td>10213</td>
<td>7600</td>
<td>5108</td>
<td>2653</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRRIGATION FLOW REQUIREMENT WITH</td>
<td>7863</td>
<td>5345</td>
<td>3839</td>
<td>1916</td>
<td></td>
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</tr>
<tr>
<td>AN IRRIGATION WINDOW OF 5 HOURS, 6 DAYS A WEEK (gpm)</td>
<td>7863</td>
<td>5345</td>
<td>3839</td>
<td>1916</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRRIGATION FLOW REQUIREMENT WITH</td>
<td>6128</td>
<td>4596</td>
<td>3064</td>
<td>1632</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AN IRRIGATION WINDOW OF 10 HOURS, 6 DAYS A WEEK (gpm)</td>
<td>6128</td>
<td>4596</td>
<td>3064</td>
<td>1632</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. IRRIGATION SYSTEM APPLICATION EFFICIENCY IS ASSUMED TO BE 70%.
2. IRRIGATION SYSTEM TAP UTILIZATION EFFICIENCY IS ASSUMED TO BE 80%.
3. TAP UTILIZATION EFFICIENCY IS DEFINED AS THE AVERAGE DESIGN FLOW/AVAILABLE AVAILABILITY FLOW.
4. PEAK SEASON PLANT WATER REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR 10%.
5. AND IS BASED ON Enter Irrigation source here DATA AND A CROP COEFFICIENT OF 80%.
6. PEAK SEASON IRRIGATION REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR 0.5.
7. AND IS BASED ON Enter Irrigation source here DATA AND A CROP COEFFICIENT OF 80%.
8. PEAK SEASON IRRIGATION REQUIREMENT OF 0.26 IN/DAY IS ASSUMED FOR 0.5.
9. AND IS BASED ON Enter Irrigation source here DATA AND A CROP COEFFICIENT OF 80%.
10. A SEASONAL PRECIPITATION OF 6.4-INCHES IS USED AND IS BASED ON Enter Irrigation source here DATA.
11. PRECIPITATION IS ASSUMED TO BE 6% EFFECTIVE.
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
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:**

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

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

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

**OUTPUT:**

<table>
<thead>
<tr>
<th>Landscape Concept</th>
<th>Irrigated Areas (acres)**</th>
<th>Peak Demand (GPM)</th>
<th>Peak Daily Requirement* (Gallons/Day)</th>
<th>Seasonal Requirement* (Acre-Feet per Year)</th>
<th>Lake Area (Acres)</th>
<th>Usable Pond Storage** (Acre-Feet)</th>
<th>Days of Storage for Current Lake Concept*</th>
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<tr>
<td>1</td>
<td>24.8</td>
<td>45.2</td>
<td>36.9</td>
<td>2,794</td>
<td>1,085,404</td>
<td>571.7</td>
<td>15.46</td>
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<td>2</td>
<td>40.3</td>
<td>13.7</td>
<td>41.6</td>
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<td>987,107</td>
<td>508.4</td>
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<td>3</td>
<td>18.0</td>
<td>39.5</td>
<td>12.8</td>
<td>2,323</td>
<td>993,446</td>
<td>528.8</td>
<td>21.34</td>
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</table>

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

Pond Storage Requirement for the Following Days of Storage (Acre-Feet):

<table>
<thead>
<tr>
<th></th>
<th>7</th>
<th>10</th>
<th>14</th>
<th>7</th>
<th>10</th>
<th>14</th>
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</thead>
<tbody>
<tr>
<td>6.7</td>
<td>10.0</td>
<td>16.7</td>
<td>23.3</td>
<td>33.3</td>
<td>46.6</td>
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<td>5.9</td>
<td>8.9</td>
<td>14.8</td>
<td>20.8</td>
<td>29.7</td>
<td>41.6</td>
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<tr>
<td>6.1</td>
<td>9.1</td>
<td>15.2</td>
<td>21.3</td>
<td>30.5</td>
<td>42.7</td>
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</table>
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
MASTER PLANNING SHOWCASE – CHANDLER HEIGHTS BASIN PARK

IRRIGATION WATER SOURCE MASTER PLANNING
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
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...
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
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
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
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
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 ✓
Water Source Master Planning

- City of Chandler Aquifer Storage and Recovery (ASR) Well Tour
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
Develop Supply & Demand Balance Model for Reclaimed Water with ASR Well Concept
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
## Develop Irrigation Master Plan Cost Model

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

<table>
<thead>
<tr>
<th>REV1 DRAFT for client review and comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 18, 2016</td>
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</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Units</th>
<th>Number</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Irrigation Water Supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Recycled Water Meter w/ CMU Enclosure (6&quot; Turbine Meter) 18 cubic-feet NIC plant investment fees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Recycled Water Supply Line to Lake (10&quot; Class 260 PVC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Recycled Air Gap Wet Well Assembly at Lake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Air Gap Equipment &amp; Controls (assumes above grade installation in remaining area similar to Chandler AGR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Probable water backup supply for Whenever emergency only, 2&quot; Meter &amp; supply riser, Air Gap Assembly (NIC plant investment fees)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Subtotal Irrigation Water Supply Construction Costs</td>
<td></td>
<td></td>
<td>$1,460,000</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Lake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Excavation of Lids (assumes 24&quot; vertical wall, 4&quot; recovery setback, 3.1 times to 12&quot; depth at bottom)</td>
<td>CV</td>
<td>141,501</td>
<td>$3.00</td>
<td>$424,503</td>
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<tr>
<td></td>
<td>Stock Pile Enclosure Soil Site per 10 CY truckload</td>
<td>LF</td>
<td>4,180</td>
<td>$18.00</td>
<td>$75,240</td>
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<tr>
<td>7</td>
<td>Lake Edge Treatment (assumes combination shotcrete edge and structural edge)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Lake Liner (includes fine grading, 30 mil PVC Liner, 8 oz geotextile, 10&quot; silt cover and compaction)</td>
<td>SF</td>
<td>500,000</td>
<td>$1.75</td>
<td>$875,000</td>
</tr>
<tr>
<td>9</td>
<td>Silt &amp; Livestock, Fish Pre-Entrainment, Fish Pre-Entrainment</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>Point Aeration System with Diffusers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Overhead Pipe to Screen (1&quot; PVC)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>12</td>
<td>Reinforcement Piping (avg 8&quot; PVC)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>13</td>
<td>Reinforcement Balance Valves (2 gate valve)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Lake Level Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Fish Habitat Allowance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Subtotal Lake Construction Costs</td>
<td></td>
<td></td>
<td>$1,953,308</td>
<td></td>
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<tr>
<td>16</td>
<td>Irrigation Pump System &amp; Enclosure</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>17</td>
<td>4&quot; CL200 PVC Filter Backwash Pipe to Lake</td>
<td>LF</td>
<td>480</td>
<td>$12.00</td>
<td>$5,760</td>
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<tr>
<td>18</td>
<td>26&quot; HDPE Pump System Intake Pipe (w/ Intake screen)</td>
<td>LF</td>
<td>500</td>
<td>$200.00</td>
<td>$100,000</td>
</tr>
<tr>
<td>19</td>
<td>1&quot; dia x 30' deep Well</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td>Pre-fabricated Irrigation Pump System Skid with Automatic Filtration</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>21</td>
<td>Pump Station Electrical</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>22</td>
<td>Pump Station CMU Enclosure with Sludge Structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Subtotal Pump &amp; Enclosure Construction Costs</td>
<td></td>
<td></td>
<td>$590,800</td>
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</table>

### Irrigation System

<table>
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<th>Number</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>14&quot; C300 PVC w/ DI Fittings</td>
<td>LF</td>
<td>300</td>
<td>$42.00</td>
<td>$12,600</td>
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<tr>
<td>24</td>
<td>12&quot; C300 PVC w/ DI Fittings</td>
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<td>250</td>
<td>$38.00</td>
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<td>25</td>
<td>10&quot; CL200 PVC w/ DI Fittings</td>
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<td>2,400</td>
<td>$30.00</td>
<td>$72,000</td>
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<tr>
<td>26</td>
<td>8&quot; CL200 PVC w/ DI Fittings</td>
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<td>3,100</td>
<td>$24.00</td>
<td>$74,400</td>
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<tr>
<td>27</td>
<td>6&quot; CL200 PVC w/ DI Fittings</td>
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<td>6,200</td>
<td>$18.00</td>
<td>$111,600</td>
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<td>28</td>
<td>4&quot; CL200 PVC w/ DI Fittings</td>
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<td>0,200</td>
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<td>29</td>
<td>3&quot; SD400 PVC w/ DI PVC Fittings</td>
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<td>1,600</td>
<td>$9.00</td>
<td>$14,400</td>
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<td>30</td>
<td>2&quot; SD400 PVC w/ DI PVC Fittings</td>
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<td>8,000</td>
<td>$6.00</td>
<td>$48,000</td>
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<tr>
<td>31</td>
<td>12&quot; Gate Valve</td>
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<td>2</td>
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<td>10&quot; Gate Valve</td>
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<td>33</td>
<td>8&quot; Gate Valve</td>
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<td>$1,500.00</td>
<td>$9,000.00</td>
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<td>34</td>
<td>6&quot; Gate Valve</td>
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<td>$1,500.00</td>
<td>$12,000.00</td>
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<td>35</td>
<td>4&quot; Gate Valve</td>
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<td>36</td>
<td>3&quot; Gate Valve</td>
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<td>37</td>
<td>2&quot; Gate Valve</td>
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<td>$400.00</td>
<td>$4,800.00</td>
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<td>38</td>
<td>1 1/2&quot; Anti-Relief Valve</td>
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<td>$300.00</td>
<td>$1,800.00</td>
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<tr>
<td>39</td>
<td>1&quot; Quick Coupling Valve</td>
<td>EA</td>
<td>100</td>
<td>$250.00</td>
<td>$25,000.00</td>
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<td>40</td>
<td>Irrigation Security Controllers w/ Central Communication</td>
<td>LA</td>
<td>60</td>
<td>$5,800.00</td>
<td>$348,000</td>
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<tr>
<td>41</td>
<td>Sprinkler Irrigation in Sportsturf Areas (inc RCV, w/ lateral, sprinklers)</td>
<td>SF</td>
<td>1,151,703</td>
<td>$0.65</td>
<td>$749,606.95</td>
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<tr>
<td>42</td>
<td>Sprinkler Irrigation in Passive Turf Areas (inc RCV, w/ lateral, sprinklers)</td>
<td>SF</td>
<td>2,105,764</td>
<td>$0.55</td>
<td>$1,100,370.20</td>
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<tr>
<td>43</td>
<td>Drip Irrigation in DG Areas (30% canopy cover, inc RCV, w/ lateral, emitters)</td>
<td>SF</td>
<td>522,720</td>
<td>$0.35</td>
<td>$185,852.00</td>
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<tr>
<td>44</td>
<td>Conduits for Rock Trenching &amp; Bidding</td>
<td>LS</td>
<td>1</td>
<td>$50,000.00</td>
<td>$50,000.00</td>
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<tr>
<td></td>
<td>Subtotal Irrigation Construction Costs</td>
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<td>$2,343,899.15</td>
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### Miscellaneous

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<th>No.</th>
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<th>Number</th>
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<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>Allowance for Incidentally</td>
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<td>$100,000.00</td>
<td>$100,000.00</td>
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<td>46</td>
<td>Mobilization &amp; General Conditions (7.5%)</td>
<td>LS</td>
<td>1</td>
<td>$522,570.45</td>
<td>$522,570.45</td>
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<tr>
<td>47</td>
<td>Contingency (10%)</td>
<td>LS</td>
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<td>$749,017.04</td>
<td>$749,017.04</td>
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<td>Subtotal Miscellaneous</td>
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<td>$1,371,588.09</td>
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</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Net Landscape</th>
<th>Lakes</th>
<th>Spray Low</th>
<th>Spray Mod</th>
<th>Drip Mod</th>
<th>Turf</th>
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</thead>
<tbody>
<tr>
<td>945.5</td>
<td>4.30</td>
<td>498.36</td>
<td>115.12</td>
<td>142.65</td>
<td>185.07</td>
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</tbody>
</table>

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