Introduction
Robert Adair, HLWSF
The Harris County Story
Alisa Max, PE, Harris County PID
Nick Russo, Harris County PID
Justin Taack, TCEQ
Houston Area Focus
Charlie Penland, PE, LEED AP, Walter P Moore & Associates
Margaret Robinson, PLA, ASLA, LEED AP, Asakura Robinson
Steve Albert, PE, CFM, Sherwood Design Engineers

Introduction
Robert Adair, HLWSF
San Antonio
Karen Bishop, San Antonio River Authority
Tiffany Price, Bender Wells & Clark
Austin
Andy Johnston, PE, CFM, CPESC, Halff & Associates
Dallas-Fort Worth
Mikel Wilkins, PE, ISI ENV-SP, Verdunity
Oklahoma
Zach Roach, Ideal Homes
LID O&M Considerations: Policy and Practicality
David Batts, Construction EcoServices

Introduction
Robert Adair, HLWSF
Arkansas
Becky Roark, Illinois River Watershed Partnership
Louisiana
Dana Brown, PLA, ASLA, LEED AP, CSI, AICP, Dana Brown Associates
New Mexico
George Radnovich, ASLA, Sites Southwest
Low Impact Development Application
AFG Parking Lot Renovation

**Before**

- 12,400 SF Building
- Outlet Drain (Surface Overflow)
- Time of Concentration 3 Minutes
- 1.2 Acre Roof and Parking Lot Runoff Flows Over Pavement Directly to Outlet Drain

**After**

- 12,400 SF Building
- Bio-Swale / Rain Garden
- Time of Concentration 15 Minutes
- Roof Drains to Bio-Swale / Rain Garden
- Pavement Drains to Bio-Swale
- Water Treatment Path = 420’

Steve Albert, P.E., CFM
AFG Parking Lot Renovation
Before Construction

Concrete Pavement...

... Moves Water Fast ...

...But Puddles Remain

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AFG Parking Lot Renovation
Rain Tank Installation

- 2-3” Hardwood Mulch
- 8-12” Engineered Soil
- 4-6” Pea Gravel
- Fabric Mesh
- Rain Tank

Tank Modules: 5 x 7 x 3 High = 105 Total Modules

Plan View of Rain Tank in Swale

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AFG Parking Lot Renovation
Rain Tank Under Bio-Swale

Section - Bio-Swale

Engineered Fill

Rain Tank

Pump Sump

1.5’ Deep

Section - Engineered Fill and Rain Tank

Engineered Fill and Rain Tank at Low Point of Bio-Swale

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Steve Albert, P.E., CFM

AFG Parking Lot Renovation
Immediately After Construction

Continuous Rock Channel Along 400’ Flow Path

Parking Lot Runoff Enters Swale at Curb Openings
AFG Parking Lot Renovation
How it Works in a Rain Event
STORMWATER RUNOFF REDUCTIONS

**LID Design Storm: 2-Year, 15 Min. (1.1 In.)**
- Peak Flow Rate Reduction: 97%
- Total Runoff Reduction: 17%

**Extreme Short Storm: 100-Year, 15 Min.**
- Peak Flow Rate Reduction: 90%
- Total Runoff Reduction: 16%

**Long Duration Pond Storm: 2-Yr., 24 Hr.**
- Peak Flow Rate Reduction: 53%
- Total Runoff Reduction: 13%

**Extreme Pond Design Storm: 100-Yr., 24 Hr.**
- Peak Flow Rate Reduction: 27%
- Total Runoff Reduction: 7%
AFG Parking Lot Renovation
Focal Point Soil Infiltration Testing

Infiltration Testing Verified Soil Conductivity
Engineered Fill Rate of Flow > 60 l n./ Hr.

Low Point Over Rain Tank
After 0.64” Rain in < 1 Hour
Drains in a Few Hours

Hydraulic Conductivity Test Device

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AFG Parking Lot Renovation Appearance Two Years Later

Rain Tank Under Grasses

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Maple Court Subdivision Redevelopment
Bellaire, TX

Each Front Yard Rain Garden Holds 1” of Runoff

Focal Point Filter 4’ x 4’
Overflow

Maple Court

Connecting Pipe

Roadway Basin

Outfall

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Bellaire, TX Subdivision Redevelopment
Basin Excavation

Roadway Basin

Lot Basins

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Bellaire, TX Subdivision Redevelopment
Rain Tanks and Rock Fill

Junction of Connecting Pipe With Rain Tank

Hi!
Bellaire, TX Subdivision Redevelopment
Rock Fill and Fabric Wrap
Bellaire, TX Subdivision Redevelopment
Preliminary Grading of Surface Ponds

Home Builder Completes Surface Pond Grading Using Any Shape to Hold the Required Volume

Steve Albert, P.E., CFM
Stonebrook Subdivision Development
Harris County, TX

Overflow For All Ponds
Outfall
Perimeter Bio-Swale
WETLAND POND
High Performance Filter

Steve Albert, P.E., CFM
Harris County, TX Subdivision Development
Bio-Swale and Filter Excavation

Bio-Swale Excavation

Filter Excavation

High Performance Bio-Filter

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Harris County, TX Subdivision Development
Bio-Swale Initial Stabilization

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LID Infiltration Application
Schlumberger Midland Office Building

8 Infiltration Island Bio-Swales

2 Infiltration Channel Bio-Swales

2 Infiltration Ponds Interconnected

Site Overflow to I-20 Only When Greater Than a 10 Year Storm

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LID Infiltration Application
Soil Infiltration Data

Custom Soil Resource Report for
Midland County, Texas
Midland Office Building

AfB—Amarillo fine sandy loam, 1 to 3 percent slopes

Map Unit Setting
Landscape: Plateaus
Elevation: 2,500 to 4,500 feet
Mean annual precipitation: 17 to 22 inches
Mean annual air temperature: 57 to 66 degrees F
Frost-free period: 180 to 220 days

Map Unit Composition
Amarillo and similar soils: 99 percent
Minor components: 1 percent

Description of Amarillo
Setting
Landform: Plains, playa slopes
Down-slope shape: Convex, concave
Across-slope shape: Linear
Parent material: Loamy eolian deposits from the blackwater draw formation of pleistocene age.

Properties and qualities
Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water ($K_c$): 0.57 to 1.98 in/hr
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate: Maximum content: 60 percent
Maximum salinity: Non saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 8.8 inches)

Interpretive groups
Farm/land classification: Not prime farmland
Land capability classification (irrigated): 3e
Land capability classification (non-irrigated): 3e

Hydrologic Soil Group: B
Ecological site: Sandy Loam 12-17” PZ (R077DYO47TX)

Typical profile
0 to 10 inches: Fine sandy loam
10 to 44 inches: Sandy clay loam
44 to 64 inches: Sandy clay loam

Rate of Infiltration
0.6 to 2.0 Inch/ Hour

Type B Soil

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## LID Infiltration Application Cost Comparison to Traditional Design

### Onsite Storm Sewer System
- **1,200 Ft. Pipe 15”-30”**
- **14 Structures**

### Low Impact Development System
- **Cost:** $70,000

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Unit</th>
<th>No. of Units</th>
<th>Cost per Unit</th>
<th>Total Amount</th>
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<tbody>
<tr>
<td>Grading bio-swales and detention ponds</td>
<td>CY</td>
<td>2,800</td>
<td>4</td>
<td>11,200</td>
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<tr>
<td>Infiltration trench (rock and fabric)</td>
<td>LF</td>
<td>800</td>
<td>15</td>
<td>12,000</td>
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<td>18” ADS N-12 storm sewer</td>
<td>LF</td>
<td>150</td>
<td>30</td>
<td>4,500</td>
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<tr>
<td>24” ADS N-12 storm sewer</td>
<td>LF</td>
<td>400</td>
<td>45</td>
<td>18,000</td>
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<tr>
<td>Rock channel stabilization</td>
<td>CY</td>
<td>200</td>
<td>35</td>
<td>7,000</td>
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<tr>
<td>Inlet</td>
<td>EA</td>
<td>6</td>
<td>2,500</td>
<td>15,000</td>
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<tr>
<td>Headwall</td>
<td>EA</td>
<td>2</td>
<td>500</td>
<td>1,000</td>
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<tr>
<td>12” ADS N-12 culvert</td>
<td>LF</td>
<td>40</td>
<td>20</td>
<td>800</td>
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### Traditional Piped Drainage System
- **Cost:** $85,000 (Or Much Greater if More Inlets Used)

<table>
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<tr>
<th>Item Description</th>
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<th>No. of Units</th>
<th>Cost per Unit</th>
<th>Total Amount</th>
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</thead>
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<tr>
<td>Grading for drainage swale</td>
<td>CY</td>
<td>500</td>
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<td>12” ADS N-12 storm sewer</td>
<td>LF</td>
<td>120</td>
<td>20</td>
<td>6,400</td>
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<tr>
<td>15” ADS N-12 storm sewer</td>
<td>LF</td>
<td>150</td>
<td>25</td>
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<tr>
<td>18” ADS N-12 storm sewer</td>
<td>LF</td>
<td>450</td>
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<tr>
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<td>LF</td>
<td>340</td>
<td>45</td>
<td>6,300</td>
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<tr>
<td>30” ADS N-12 storm sewer</td>
<td>LF</td>
<td>140</td>
<td>60</td>
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<td>Inlet</td>
<td>EA</td>
<td>14</td>
<td>2,500</td>
<td>35,000</td>
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</table>

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LID Infiltration Application
Visual Comparison to Traditional Design

Rendering by Project Lead
English + Associates Architects

Schlumberger
Midland Office Building
Proposed Site Drainage

Post-Construction Photo

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LID Infiltration Application
Infiltration Trench Detail

Basin

3'

6'

6"

2’-4” Recycled Concrete

8 Oz. Non-Woven Fabric

Completed Pavement Edge
At Channel Bio-Swale
Lab Sample Result: Infiltration Rate = 0.016 Inches/ Hour
< 1% of NRCS Value!
LID Infiltration Application
Field Bio-Swale Infiltration Test

Infiltration Test Data
Sept. 11, 2013

West bio-Swale used for test - drawdown within rock-filled section of swale
Therefore, adjust water drop measurements by void factor = 0.45
Pre-fill and soak began at 11:00 a.m. on 9/10 and concluded on 9/11 at 11:10 a.m.
56,500 gallons of water was delivered to swale = 0.17 Ac-Ft
(Which equals the volume of the bio-swale filled to the High Water Level)

<table>
<thead>
<tr>
<th>Clock Time</th>
<th>Time Diff.</th>
<th>Measure</th>
<th>Unadjusted Level Drop</th>
<th>Adjusted Level Drop</th>
<th>Flow Rate Per Hour</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:13</td>
<td></td>
<td>43.80</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>11:42</td>
<td>0.48</td>
<td>45.40</td>
<td>1.60</td>
<td>0.72</td>
<td>1.49</td>
<td></td>
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<tr>
<td>13:12</td>
<td>1.50</td>
<td>51.40</td>
<td>6.00</td>
<td>2.70</td>
<td>1.80</td>
<td></td>
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<tr>
<td>13:42</td>
<td>0.50</td>
<td>54.00</td>
<td>2.60</td>
<td>1.17</td>
<td>2.34</td>
<td></td>
</tr>
<tr>
<td>14:52</td>
<td>1.17</td>
<td>59.50</td>
<td>5.50</td>
<td>2.48</td>
<td>2.12</td>
<td></td>
</tr>
</tbody>
</table>

Time from 11:42 to 2:52 is all in rock - use overall period

<table>
<thead>
<tr>
<th>Time</th>
<th>Flow Rate</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:42</td>
<td>14.10</td>
<td></td>
</tr>
<tr>
<td>14:52</td>
<td>6.35</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Average 2” / Hour Confirms Design!
LID Infiltration Application
Infiltration / Bio-Swale Island Construction

Infiltration Trench Construction

Curb Openings

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LID Infiltration Application

Infiltration / Bio-Swale Channel Construction

Silt Problems

Infiltration Trench Construction

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LID Infiltration Application
Infiltration / Bio-Swale Islands Completed

Completed Island

Island Group

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And, It Works!
System Functioned Better Than Expected for Several Large Rain Events Both During and After Construction
LID Infiltration Application
Infiltration Pond Completion

Interconnected Infiltration Ponds

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Low Impact Development
It Can Be The “Easier Way”

We Have Design Options...

“Easier” Requires A Longer “Run”
Low Impact Development
Making it Work for Owners and Developers

- **Owners/ Developers Will Adopt LID Design if it is Cost-Effective**
- Reduced capital costs for sewers, streets, detention, and maintenance offset increased engineering and landscaping costs
- **LID Incentives in Jurisdictions (including Harris County, TX) Increases Value**
- **All Development Sites Benefit from Easy to Apply Methods**
Questions?

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salbert@sherwoodengineers.com