Manzanita Village Storm Water and Urban Runoff Biofiltration System

Lisa Stratton

Cheadle Center for Biodiversity and Ecological Restoration (CCBER)
UCSB
Manzanita Village
Project Partners

- UCSB Housing and Residential Services
- Cheadle Center for Biodiversity and Ecological Restoration (Wayne Ferren, Melanie Powers, Moe Gomez)
- Penfield and Smith
- Van Atta Associates
- Valley Crest
- MSI Analytical Lab
1998 El Niño
Main bioswale

Installation of dual conveyance pipe

Coconut net and rock check dams

Topsoil and basins
Main bioswale

Planting

Planting completed September, 2001

September, 2002
Basin 1 – Constructed Wetland

Excavation and survey

Berm and bench construction

Erosion control
Basin 1 – Constructed Wetland

Planting

Planting complete

1-year after planting
Lagoon Park

Main Bioswale

Basin 1 Wetland
Initial Manzanita Swale Design

- Rocky landscape swales
- Drop boxes
- Underground conveyances
- Culverts into Campus Lagoon
Marine Terrace Deposits
Exposed Clay Subsoil

Clay soil

Excavating the bioswales
Manzanita Bioswale Design
Bioswale Cross-section

Anemopsis californica  Euthamia occidentalis
Baccharis douglasii    Frankenia salina
Distichlis spicata    Juncus textilis
Leymus triticoides

Juncus mexicanus
Juncus phaeocephalus

Juncus patens

Basin Bed
Manzanita Bioswales

Layout and planting, September 2002

Planting completed, September 2002

August 2003
Manzanita Bioswales

- 1300 linear feet of swales
- Four swale systems
  - 43 bioswale basins
- Multiple inlets from roof drains
- Experimental plant palettes
<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Manzanita Village Design</th>
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</thead>
<tbody>
<tr>
<td>Slope</td>
<td>2 % Upper Bioswales; 6.5% Main Bioswale</td>
</tr>
<tr>
<td>Base width</td>
<td>4 ft</td>
</tr>
<tr>
<td>Length</td>
<td>Avg 300 ft</td>
</tr>
<tr>
<td>Design depth</td>
<td>Observed Avg 6 in</td>
</tr>
<tr>
<td>Side Slope (H:V)</td>
<td>1:1</td>
</tr>
<tr>
<td>Design Capacity</td>
<td>Not designed</td>
</tr>
<tr>
<td>Max treatment velocity</td>
<td>Not designed</td>
</tr>
<tr>
<td>Max conveyance velocity$^2$</td>
<td>Not designed</td>
</tr>
<tr>
<td>Min residence time</td>
<td>Not applicable due to design</td>
</tr>
<tr>
<td>Shape</td>
<td>parabolic</td>
</tr>
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</table>
**lo-marsh zone**
- Schoenoplectus americanus
- Schoenoplectus californicus

**hi-marsh zone**
- Eleocharis macrostachya
- Eleocharis montevedensis
- Schoenoplectus maritamus
- Schoenoplectus pungens
- Schoenoplectus robustus

**marsh margin**
- Anemopsis californicus
- Baccharis douglasii
- Carex praegracilis
- Distichlis spicata
- Euthamia occidentalis
- Hordeum brachyantherum ssp. brachyantherum
- Juncus acutus
- Juncus bufonius
- Juncus occidentalis
- Juncus patens
- Juncus phaeocephalus
- Juncus textilis
- Leymus triticoides
- Rosa californica
- Schoenoplectus cernus

**hi water line**

\[ \sim 2 \text{ ft} \]
Biofiltration Systems

- Bioswales or Vegetated Swales
- Wetland Basins and Channels
- Constructed Wetlands
Functions of Bioswales and Constructed Wetlands

- Conveyance of storm water and urban runoff
- Biofiltration of pollutants
- Groundwater and water table recharge
- Slow down hydrologic cycle to natural rate
- Sediment & trash traps
- Landscape aesthetics
- Habitats for plants and wildlife
- Education and interpretation
- Research
Water Quality Data

Average concentration of Nutrients at Manzanita Village from Roofs to Ocean

- **PO4**
- **NO3-N + NO2-N**

<table>
<thead>
<tr>
<th>Location</th>
<th>PO4 Concentration (µM)</th>
<th>NO3-N + NO2-N Concentration (µM)</th>
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<tbody>
<tr>
<td>Roofs</td>
<td>300</td>
<td>70</td>
</tr>
<tr>
<td>Lawns</td>
<td>250</td>
<td>100</td>
</tr>
<tr>
<td>Swales</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Basin 1</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Lagoon</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ocean</td>
<td>1</td>
<td>1</td>
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</table>
Experimental plant palette

3 Rushes:
- *Juncus mexicanus*
- *Juncus patens*
- *Juncus phaeocephalus*

3 Sedges:
- *Carex praegracilis*
- *Eleocharis macrostachya*
- *Scirpus maritimus*
Percent decrease in Nitrate + Nitrite over three days for three different rain events

- J. Phaeocephalus
- Control
- 6 Species
- S. maritimus
- E. macrostachya
- J. palens
- J. mexicanus
- 3 Rush
- 3 Sedge
Experimental Work

Nutrient Uptake Experiment - NO3 + NO2
June 30 - July 1

NO3 (µM)

B C D E F G H I

Nutrient Uptake Experiment - PO4
June 30 - July 1

SRP (µM)

B C D E F G H I

30-Jun
1-Jul
2-Jul
Sampling Locations

**Key**

1 = Ocean Road SD
2 = Upper CDS SD
3 = Art building SD
4 = UCEN SD
5 = Anacapa SD
6 = East Campus SD
7 = Bioswale
8 = Lagoon W. Outfall
9 = Lagoon UCEN islands
10 = Lagoon E. Outfall
11 = Lagoon N.
12 = Lagoon W.
13 = Lagoon E.
14 = Campus point

Note: Sites 11-14 (yellow) are only copper sampling sites.
Ammonia

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Dry Conditions</th>
<th>Storm Conditions</th>
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<tbody>
<tr>
<td>Lagoon outfall west</td>
<td>0.3</td>
<td>1.4</td>
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<tr>
<td>Lower CDS</td>
<td>21.8</td>
<td>24.0</td>
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<tr>
<td>Ucen</td>
<td>0.9</td>
<td>8.5</td>
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<tr>
<td>Bioswale</td>
<td>2.2</td>
<td>#N/A</td>
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<tr>
<td>Upper CDS</td>
<td>4.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Sample Location</td>
<td>Nitrite+Nitrate (uM)</td>
<td>Dry Conditions</td>
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<td>----------------------</td>
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<td>Lagoon outfall west</td>
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<td>457.8</td>
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<tr>
<td>Lower CDS</td>
<td>64.3</td>
<td></td>
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<tr>
<td>Ucen</td>
<td>176.4</td>
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<tr>
<td>Bioswale</td>
<td>1.1 #N/A</td>
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<tr>
<td>Upper CDS</td>
<td>415.7</td>
<td>484.8</td>
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### Phosphate (PO4)

<table>
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<tr>
<th>Sample Location</th>
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<th>Storm Conditions</th>
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<tbody>
<tr>
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<td>0.908</td>
<td>0.8</td>
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<tr>
<td>Lower CDS</td>
<td>14.0</td>
<td>9.2</td>
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<tr>
<td>Ucen</td>
<td>6.7</td>
<td>13.4</td>
</tr>
<tr>
<td>Bioswale</td>
<td>#N/A</td>
<td></td>
</tr>
<tr>
<td>Upper CDS</td>
<td>14.9</td>
<td>10.4</td>
</tr>
</tbody>
</table>

#### Sample Location

- Lagoon outfall west
- Lower CDS
- Ucen
- Bioswale
- Upper CDS

#### Phosphate (uM)

- Dry Conditions
- Storm Conditions
2007-08 Stormwater Copper Analysis by Creek Environmental Labs

Copper (ug/L)

- #1 Ocean Storm Drain
- #2 Upper CDS SD
- #3 Art Building SD
- #4 UCEN SD
- #5 Anacapa Outfall
- #6 East Campus SD
- #7 Bioswale

12/18/07 Storm Event
1/04/08 Storm Event
1/23/08 Storm Event

Note: Red line represents EPA CMC for copper. Yellow line represents EPA CCC for copper.
Conveyance of storm water and urban runoff – 75% site

Biofiltration of pollutants – Reduction in nutrients and metals

Groundwater and water table recharge – Supports a diversity of native plants

Slows down hydrologic cycle to natural rate – no erosion, little run-off from dry season or small storms

Sediment & trash traps – Successful w/ maintenance

Landscape aesthetics – High!

Habitats for plants and wildlife - Diversity of birds, reptiles and amphibians observed

Education and interpretation – Signage, tours, classes, presentations

Research – e.g. water quality
Recommendations

- Ideally design development in conjunction with biofiltration system for maximum benefits

- Aim for 10 minute minimum residency time and prioritizing high pollution sources

- Avoid shady sites (poor plant growth)

- Consider mosquito breeding times and treatment options (e.g. pool < 5 days in bioswales and use control measures in marshes)

- Combine with other LID concepts
Thank you

- Nate Simons, Christiana Herr, Darwin Richardson
- CCBER Staff
- UCSB Housing and Residential Services & Design and Facilities Mgmt
- Students of UCSB: Coastal Fund
- Wayne Ferren, VanAtta Associates
- Central Coast RWQCB
Manzanita Village
Hydrologic Connectivity

Urban

Natural
Manzanita Biofiltration System

- **Bioswales**
  - Upper and mid-watershed structures
  - Water accumulation and conveyance
  - Biofiltration

- **Constructed Wetlands**
  - Lower watershed structures
  - Water accumulation
  - Biofiltration
Manzanita Bioswales

Coconut net

Basin and berm design
Bioswale Maintenance

- Vegetation maintenance
- Composting / Mulching
- Sustainability
Monitoring and Experimentation
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<td>Ucen</td>
<td>0.2</td>
<td>9.9</td>
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<tr>
<td>Bioswale</td>
<td>0.9</td>
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<tr>
<td>Upper CDS</td>
<td>7.3</td>
<td>10.9</td>
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</table>
Herr's 2006-2007 Copper Results analyzed by Creek Environmental Labs

- **Upper CDS**: Storm 1 - Storm 2 - Storm 3
- **Lower CDS**: Storm 1 - Storm 2 - Storm 3
- **UCEN**: Storm 1 - Storm 2 - Storm 3 - Dry sample
- **Bioswale**: Storm 1 - Storm 2 - Storm 3 - Dry sample

<table>
<thead>
<tr>
<th>Location</th>
<th>Storm 1</th>
<th>Storm 2</th>
<th>Storm 3</th>
<th>Dry sample</th>
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<tbody>
<tr>
<td>Upper CDS</td>
<td>N/A</td>
<td>Storm 1</td>
<td>Storm 2</td>
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<td>UCEN</td>
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<td>Storm 2</td>
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</tr>
<tr>
<td>Bioswale</td>
<td>Storm 1</td>
<td>Storm 2</td>
<td>Storm 3</td>
<td>Storm 3</td>
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