Re-Thinking Wastewater Landscapes:

Constructed Wetlands for Urban-Ecological Mutualism

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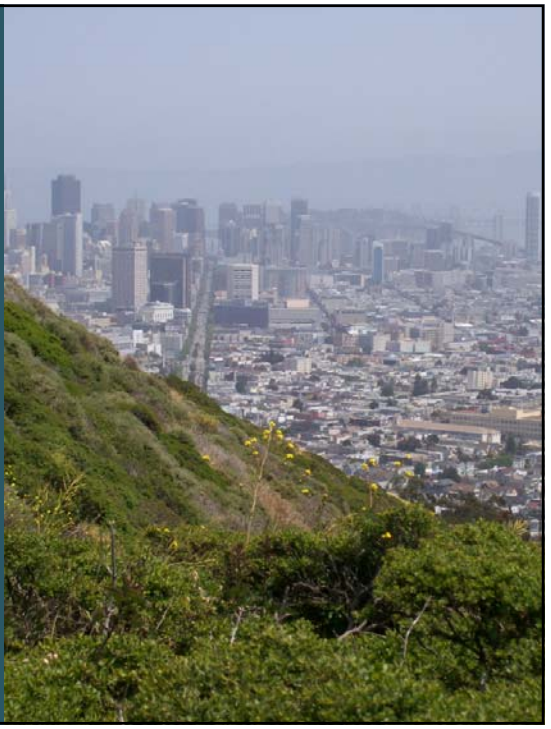
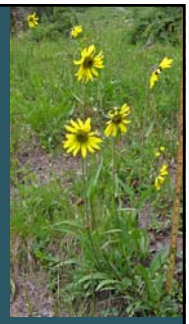
Waternet, Amsterdam
September 29, 2008

Overview

- My background
- Key concepts
- Case studies
  - Urban systems
  - Multi-functional
- Design ideas
  - San Francisco
  - China
  - Taiwan



My Background



- B.A. in Ecology
  - ant-plant mutualism
- Dual Masters (MCP/MLA), Environmental Planning
  - bridging ecosystems and urban systems
- San Francisco Public Utilities Commission
  - water cycle management agency
- UC Berkeley Travel Grant
  - sustainable urban water management

Why Re-Think Wastewater Infrastructure?

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  - Urban population increase
  - Climate change - rainfall, sea level

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- Pipes, tanks, chemicals are expensive to install, maintain
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- Changing needs require adaptability
  - Urban population increase
  - Climate change - rainfall, sea level
- Limited urban space requires multi-functional land use

Key Concepts
for Sustainable Urban Water Management

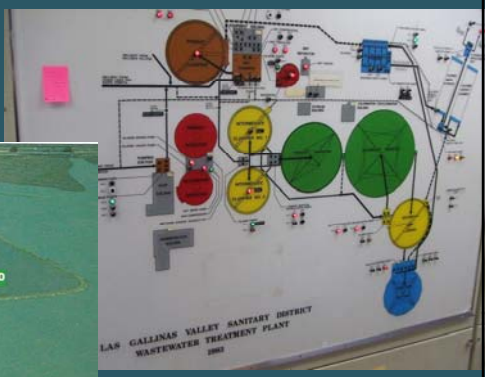
- Mutualism: +/+ interactions, synergy, everyone wins
- Natural Processes: renewable energy and materials
- Multiple Benefits: water treatment, education, recreation, habitat, ecosystem services
- Decentralized: can adapt for local needs
- Adaptive: resilient to change over time, space

Advantages of Constructed Wetlands ("Engineered Nature")

- Low-energy (solar-powered) water treatment
- Renewable materials
- Creates valuable wetland habitat
- Creates community amenity - recreation, education
- Adaptable over time and space
- Applicable on large and small scales

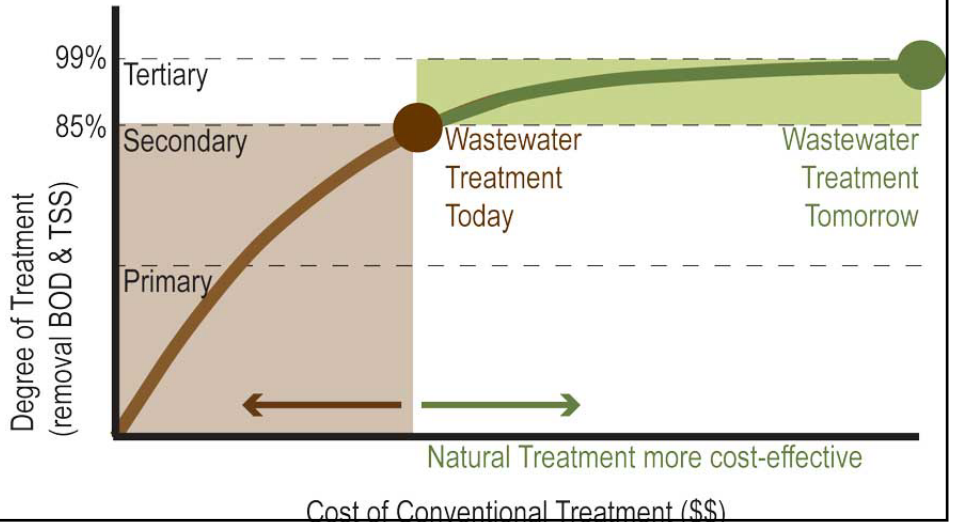
Conventional vs. Natural Treatment Systems

Less energy and infra-structure…



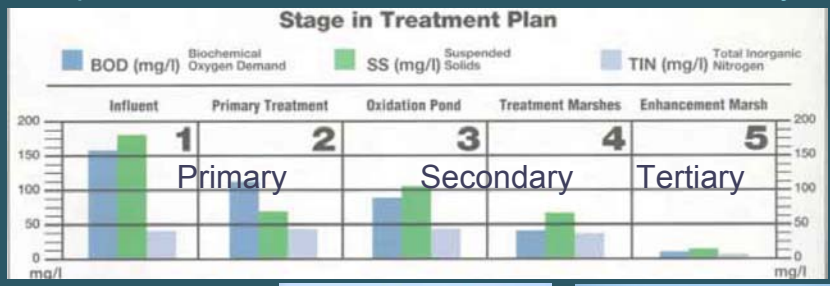
…But requires more space and time

Advantages of "Engineered Nature"



Tertiary Treatment ('Polishing')

Further removes nutrients, organic matter, & suspended solids; can be wildlife & recreation amenity



Tertiary Treatment Wetlands (Centralized Systems)

- Martinez, CA
- Discovery Bay, CA
- Petaluma, CA
- Marin, CA
- Palo Alto, CA
- Hayward, CA
- Arcata, CA

- Honfleur, France
- Caen, France
- Grou, Netherlands
- Everstekoog, Netherlands
- Empuriabrava, Spain
- Chia-Nan University, Taiwan

San Francisco Bay Area

Honfleur WTP, France

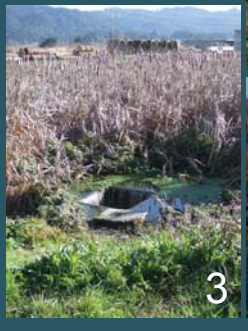
Caen, France

Grou WTP, Netherlands

Complete Treatment Wetlands (Centralized Systems)

- Arcata Marsh, California (constructed wetlands)
- Delhi AIWPS Pond System, California (ponds)

Arcata Marsh, California



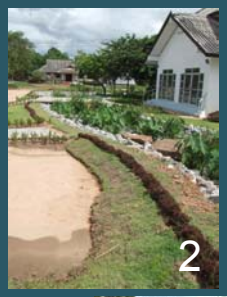
- Municipal wastewater treatment
- 19,000 residents
- 8,700 m3/day
- 35 hectares, plus recreation

Algae/AIW Pond System, CA

Community-Scale Wetlands (Decentralized Systems)

- Ubolratana Dam, Thailand
- Phayao, Thailand
- Het Groene Dak, Utrecht, NL
- Lanxmeer, Culemborg, NL

Ubolratana Community, Thailand



- Community & market wastewater
- 660 residents
- 300 m3/day
- 2 ha

Fishwater Treatment, Thailand

- Fish processing wastewater treatment
- 10 fish producers
- 10 m3/day
- 0.15 acres

Het Groene Dak, Utrecht

Lanxmeer, Culemborg

Habitat Improvement Wetlands

- Parc du Chemin de L'Ile, France
- Birdwatching Ecotourism, Taiwan
- Empuriabrava, Spain

Parc du Chemin de L'Ile, Nanterre, France

Proposed Designs

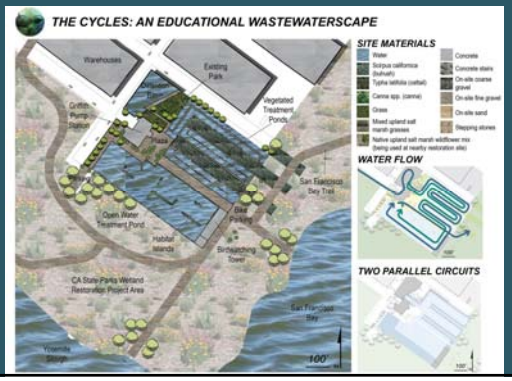
- San Francisco: "The Cycles: An Educational Wastewater Experience"
- China: Grand Canal water treatment
- California: Mare Island municipal WTP
- Taiwan: Eco-tourism bird sanctuary
- Portugal: Stormwater treatment wetlands

My Master's Thesis:

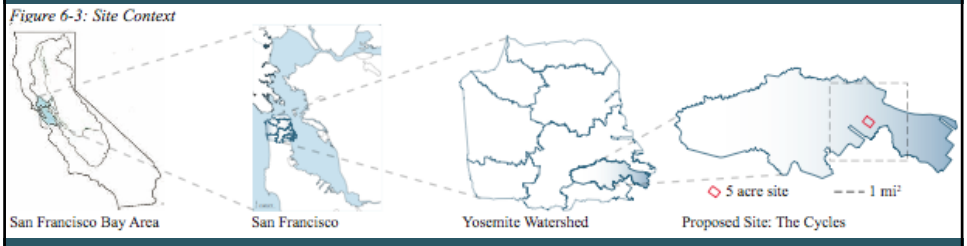
Re-Thinking Wastewater Landscapes:

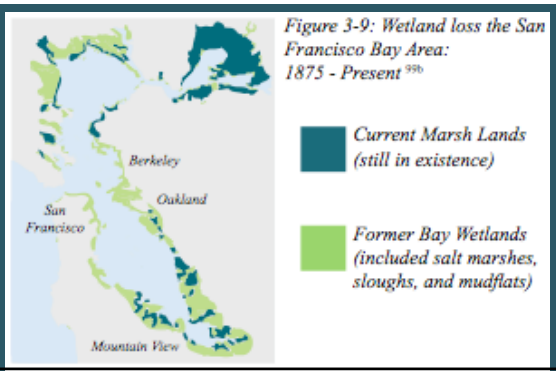
Constructed Wetlands for Urban-Ecological Mutualism in San Francisco

May 2008

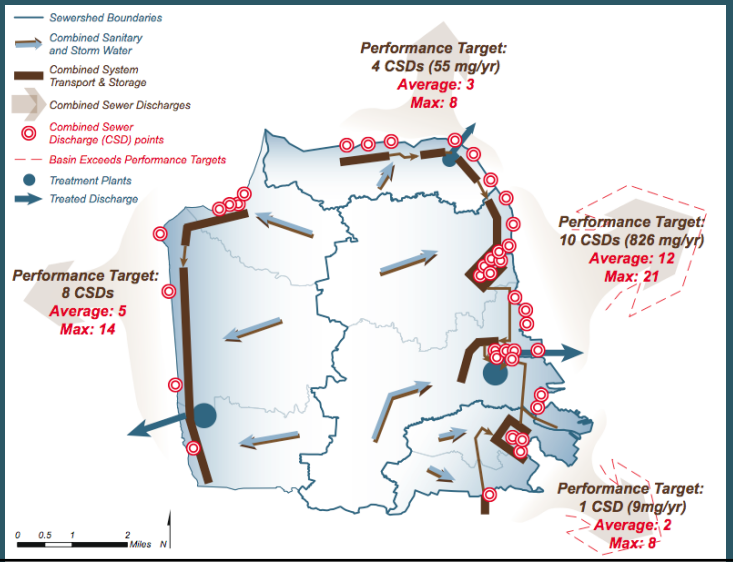


San Francisco Context



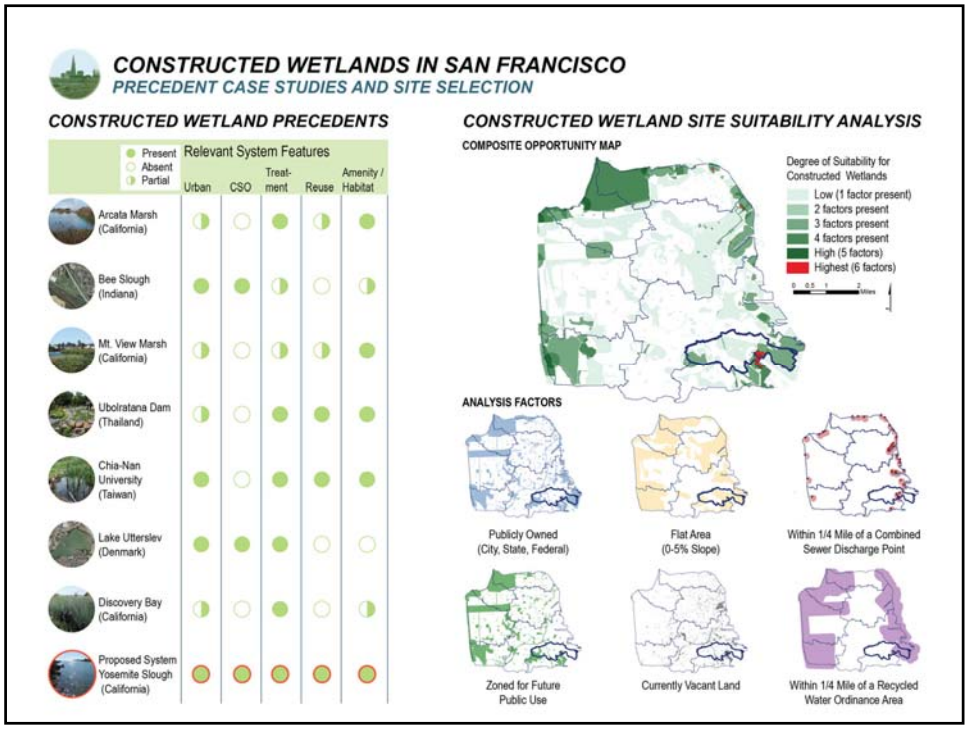


San Francisco's Wastewater Challenges



Masters Thesis: "The Big Idea"

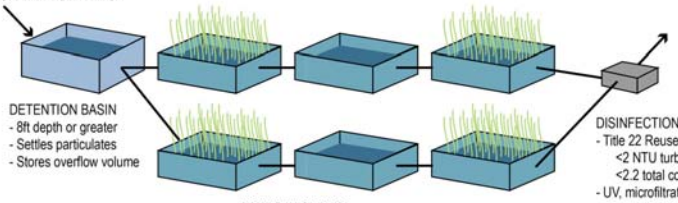
- Demonstrate decentralized, ecological, adaptive treatment in an urban area
- Create functional AND beautiful landscape
  - Reduce combined sewer discharges (CSD) in wet weather
  - Treat local greywater in dry weather
  - Meet local recycled water needs (flushing, irrigation)
  - Create community amenity - education, recreation, birdwatching, wildlife habitat



Site Context

CONSTRUCTED WETLAND ENGINEERING PRINCIPLES

ENGINEERING PRINCIPLES

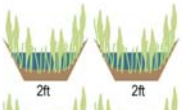
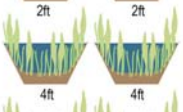
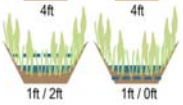


DETENTION BASIN
- 8ft depth or greater
- Settles particulates
- Stores overflow volume

PONDS-IN-SERIES
- Alternate vegetated and open water cells
- Two parallel circuits for maintenance
- Open water mixing zone every 100 feet

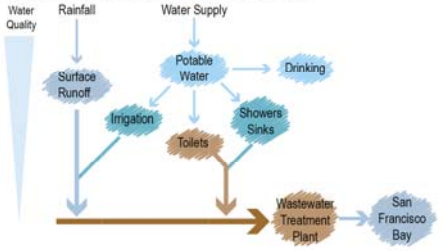
DISINFECTION FOR REUSE
- Title 22 Reuse Standards:
  <2 NTU turbidity
  <2.2 total coliform
- UV, microfiltration, or ultrafiltration

PRINCIPLES APPLIED TO SITE

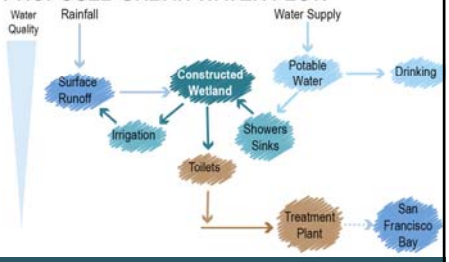
SCENARIO		CAPACITY	VOLUME	DURATION	TREATMENT
Average Conditions		0.9 mgd 100% Hunters Point recycled supply	3.3 mg	3.5 days	83% (87 to 15 mg/L COD)
Wet Weather (CSDs)		2.6 mgd	6.5 mg 100% CSD reduction	2.5 days	71% (87 to 2 5 mg/L COD)
Dry / Maintenance Condiions		0.5 mgd	1.6 mg	3.5 days	83% (87 to 15 mg/L COD)

NEW PARADIGMS FOR WASTEWATER TREATMENT
CLOSING URBAN WATER LOOPS

EXISTING URBAN WATER FLOW

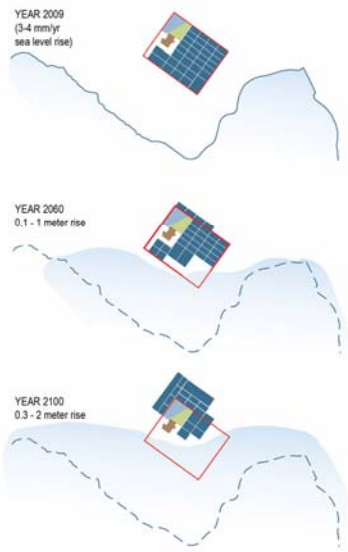


PROPOSED URBAN WATER FLOW

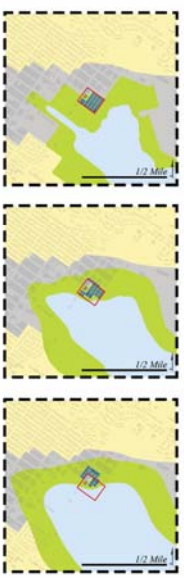


NEW PARADIGMS FOR WASTEWATER TREATMENT
ADAPTIVE INFRASTRUCTURE

ADAPT AND EVOLVE



MAINTAIN A GREEN BUFFER

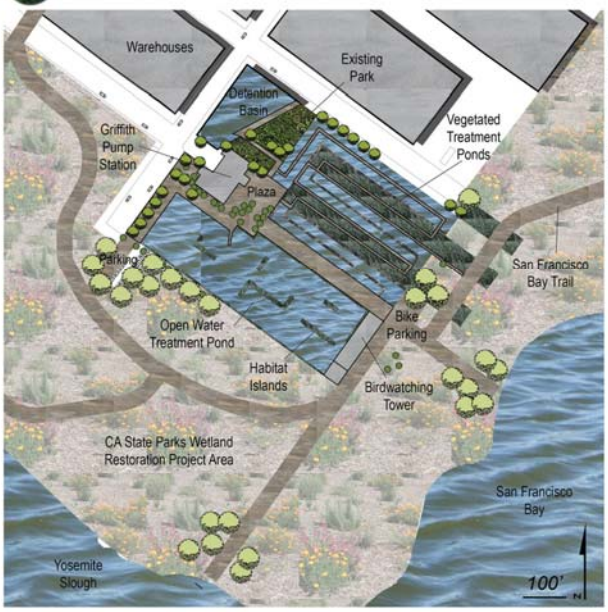


Open space buffer protects people from sea level rise, and protects Bay ecosystem from urban impacts

Wetland cells begin migration upland, existing pump station infrastructure remains stationary

Planners use future path of wetland buffer to guide land acquisition, discouraging hardscape waterfront development

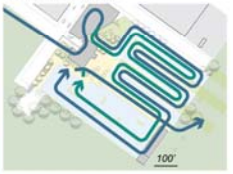
THE CYCLES: AN EDUCATIONAL WASTEWATERSCAPE



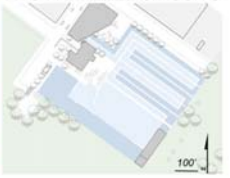
SITE MATERIALS

- Water
- Scirpus californica (bulrush)
- Typha latifolia (cattail)
- Canna spp. (canna)
- Grass
- Mixed upland salt marsh grasses
- Native upland salt marsh wildflower mix (being used at nearby restoration site)
- Concrete
- Concrete stairs
- On-site coarse gravel
- On-site fine gravel
- On-site sand
- Stepping stones

WATER FLOW

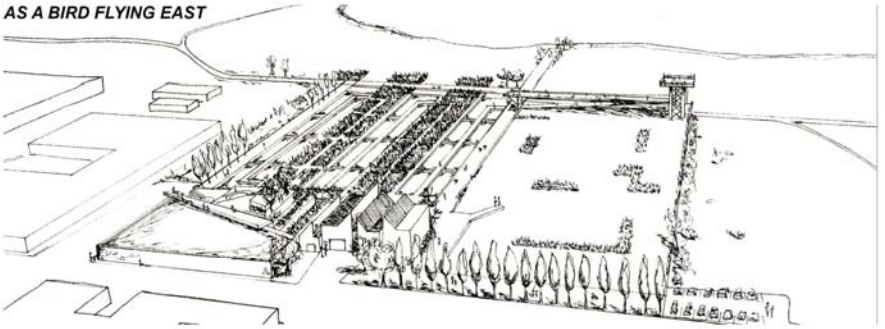


TWO PARALLEL CIRCUITS

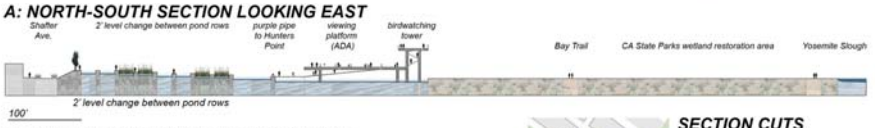


THE CYCLES: AN EDUCATIONAL WASTEWATERSCAPE

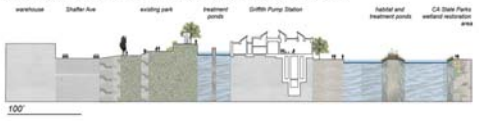
AS A BIRD FLYING EAST



A: NORTH-SOUTH SECTION LOOKING EAST

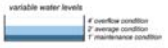


C: PUMP STATION DETAIL LOOKING EAST

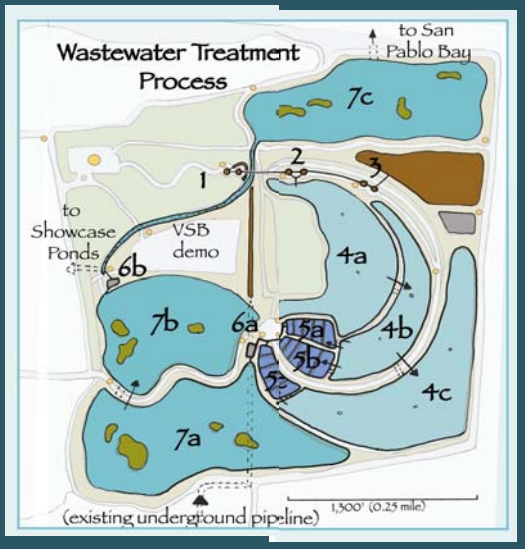


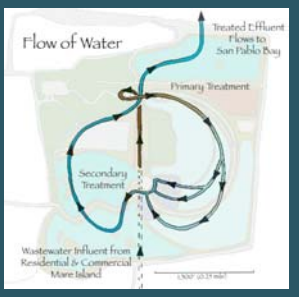
SECTION CUTS

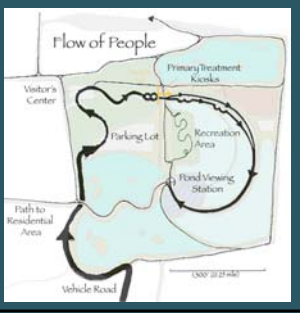
VARIABLE WATER LEVELS



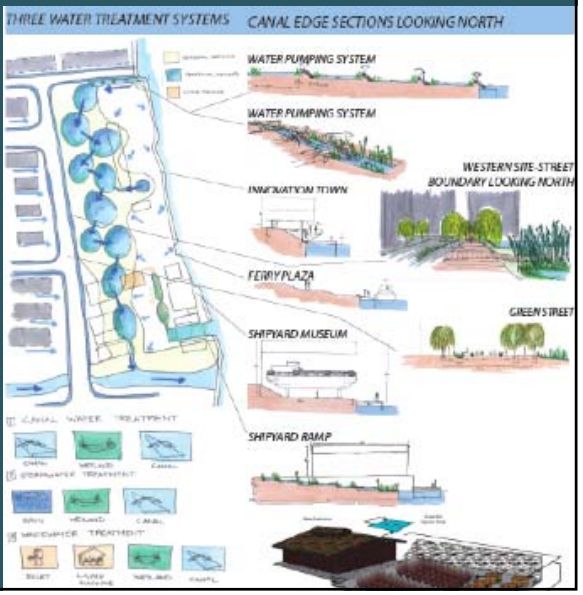
Mare Island Treatment Wetland (CA)



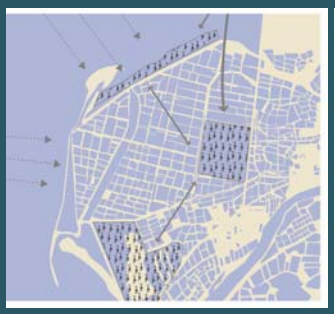


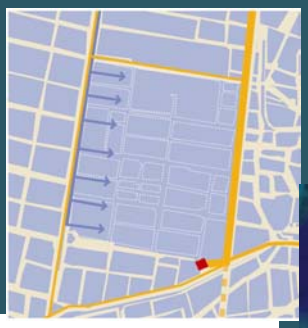


China's Grand Canal



Spoonbill Habitat Ponds, Taiwan





Treatment Marshes: 2 shallow vegetated marshes (85m3 each), 4 day residence, crushed limestone lining, sequesters inorganic nitrogen, reduces BOD/TSS. Open water fosters *Gambusia affinis* for mosquito control. Emergent vegetation palette: *Iris versicolor, Colocasia esculenta, Typha latifolia, Canna americanualis, Cyperus alternifolius, Cyperus haspan, and Ludwigia repens*. Mosquitoes are controlled by eliminating stagnant open water.

Chlorine Contact Tank: 1 chlorine contact tank (20m3), 1hr residence, de-chlorinated with sulfur dioxide before returning to Visitor's Center toilets for re-use.

TREATMENT WETLANDS

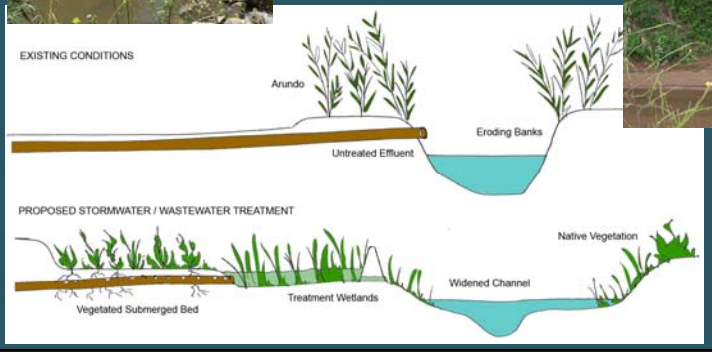
Design flow (3): 8,705 m3/day (2.3mgd), reduces fish/spoonbill fecal coliform and suspended solids. Provides sustainable technology education for tourists, creates varied habitats, serves as research laboratory for nearby NT University students, and filters Chiqu lagoon tidal waters.

Oxidation pond: 120,800 m2 (32ac), 2-3 day residence, 1.2m depth, solar-powered fountains and algae oxygenate water to oxidize biodegradable organic matter.

Treatment pond: 30,150 m2 (7.4ac), 2 day residence, 1.2m depth, dense salt-tolerant vegetation (*Typha angustifolia, mangroves Kandelia candel, Avicennia marina, and Lumnitzera racemosa*) (7). Mangroves have proven effective at sequestering nutrients and heavy metals from wastewater influent in Asia. (8)

Enhancement marshes 1-3: 204,500 m2 (50ac), 9 day residence, 1-2m depth, varied local vegetation (*Paspalum vaginatum, Sesuvium portulacastrum, Suaeda nudiflora, Chenopodium album, Zoysia matrella, Phragmites communis, and Phuchea indica*) (7), protected habitat islands for local birds, interpretive paths and educational signage. *Aquaculture in Marsh 3*: oyster farming panels, carp and tilapia, and milkfish, grouper, and mullet for export as fish fry (1). Mosquitoes are controlled by eliminating stagnant open water.

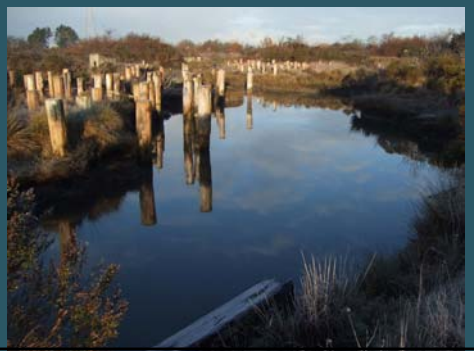
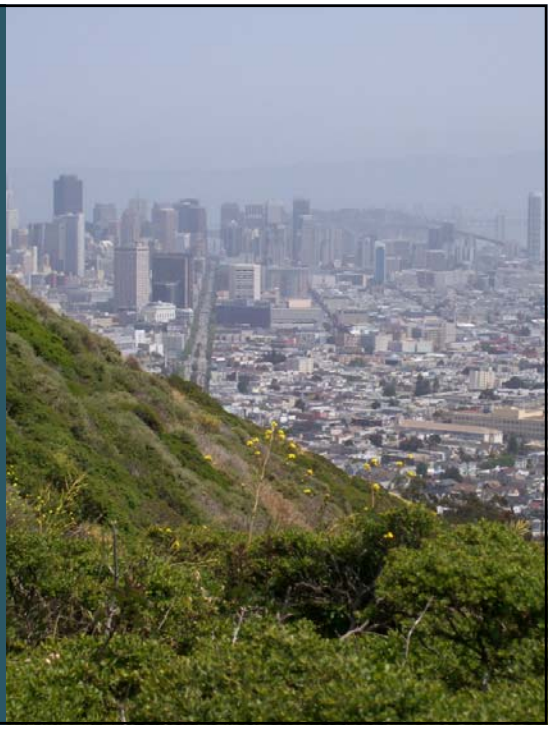
Rural Portugal - urban storm-sewer runoff treatment



Summary

"Engineered Nature" / Waterharmonica Concept

- Existing systems worldwide
- Feasible in urban areas
- Benefits humans and ecosystems
- Sustainable 'soft' technology (energy, materials)
- And beautiful - can integrate function AND form!



Questions?