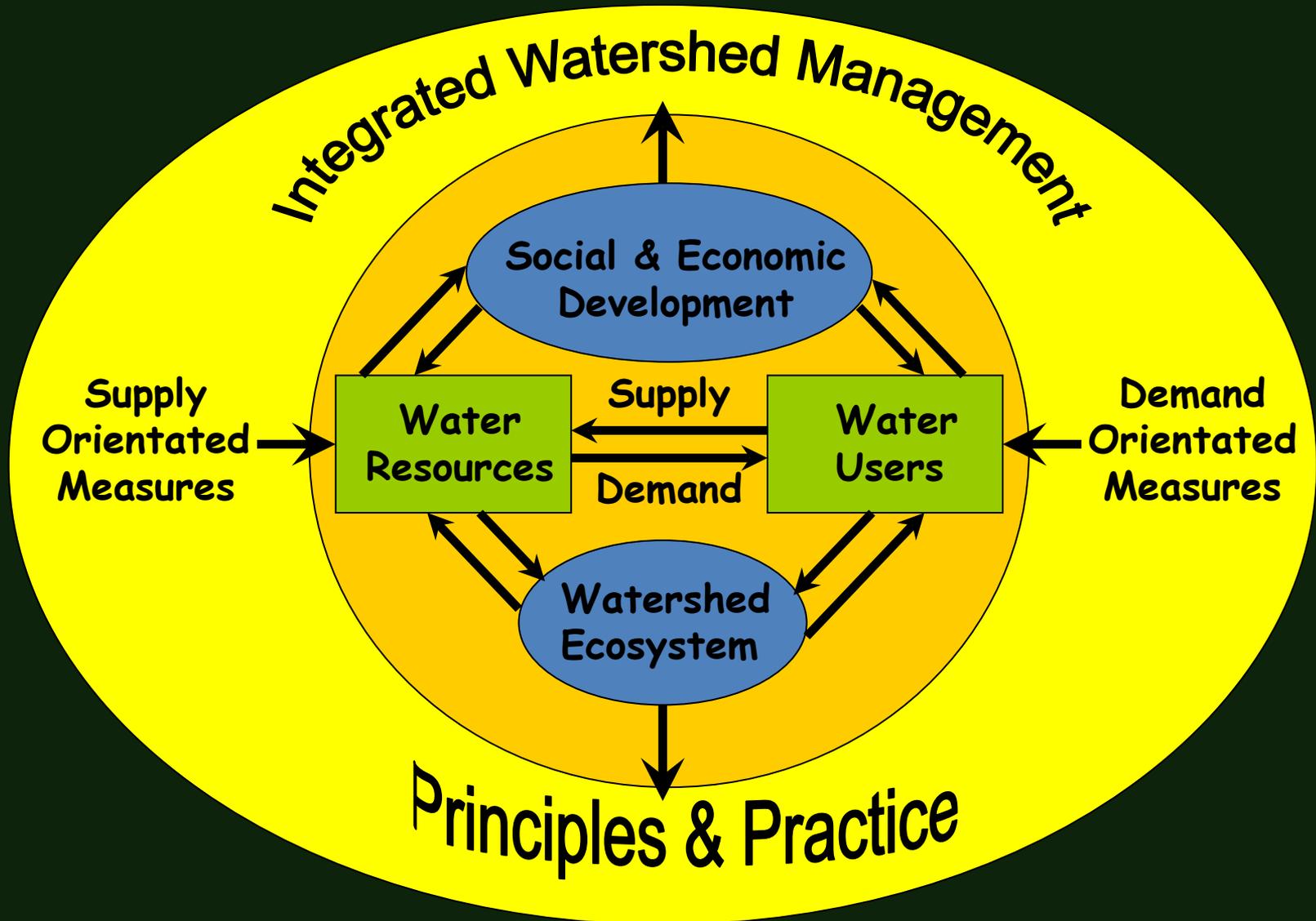


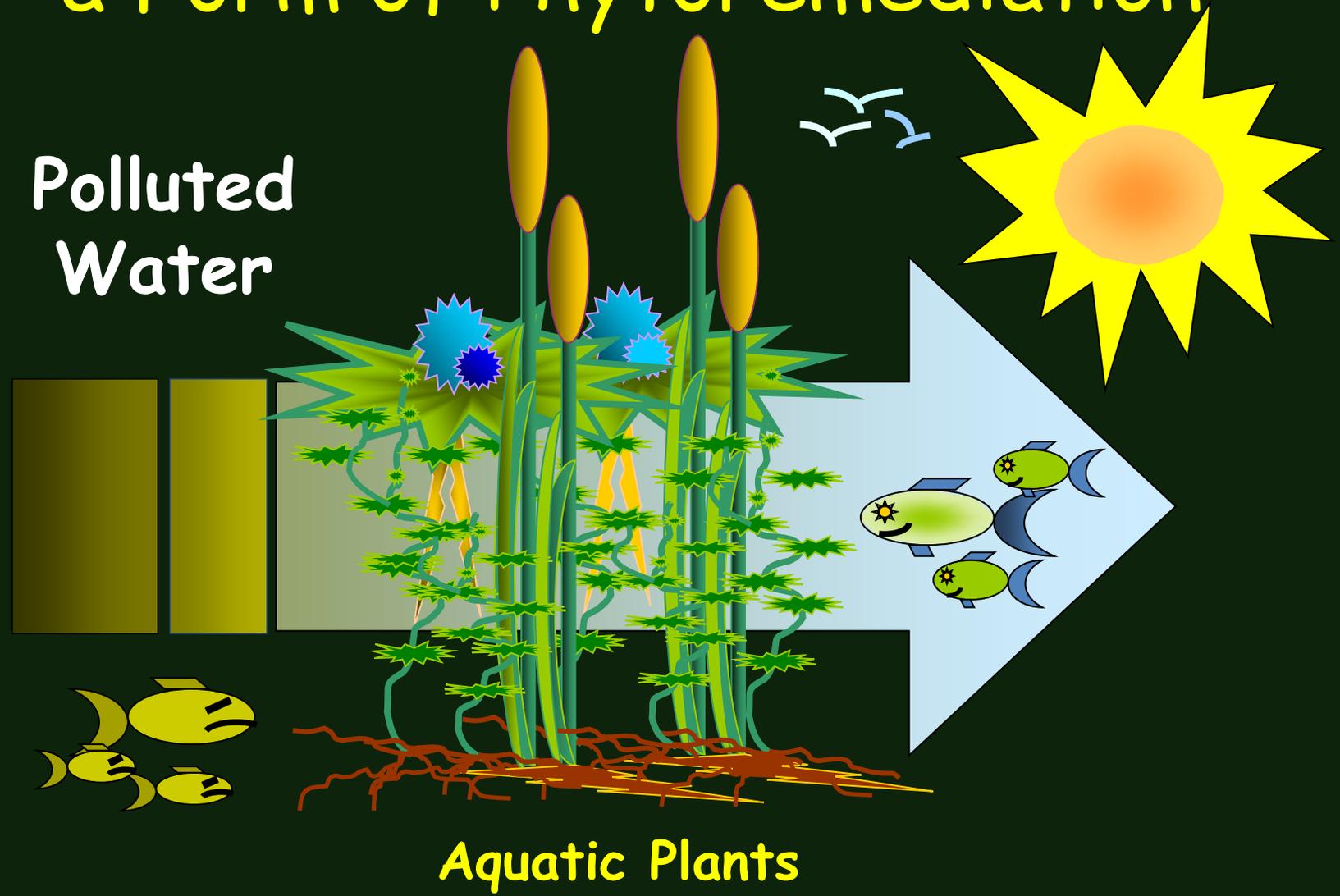
The Role of Humboldt State University's Environmental Resource Engineering Department in Developing and Infusing into Application A Low Cost Natural Wastewater Treatment-Constructed Wetland

R.A. Gearheart, Ph.D. P.E
Emeritus Professor
Environmental Resource Engineering Department
Humboldt State University
Arcata, California

Integrated Watershed Management

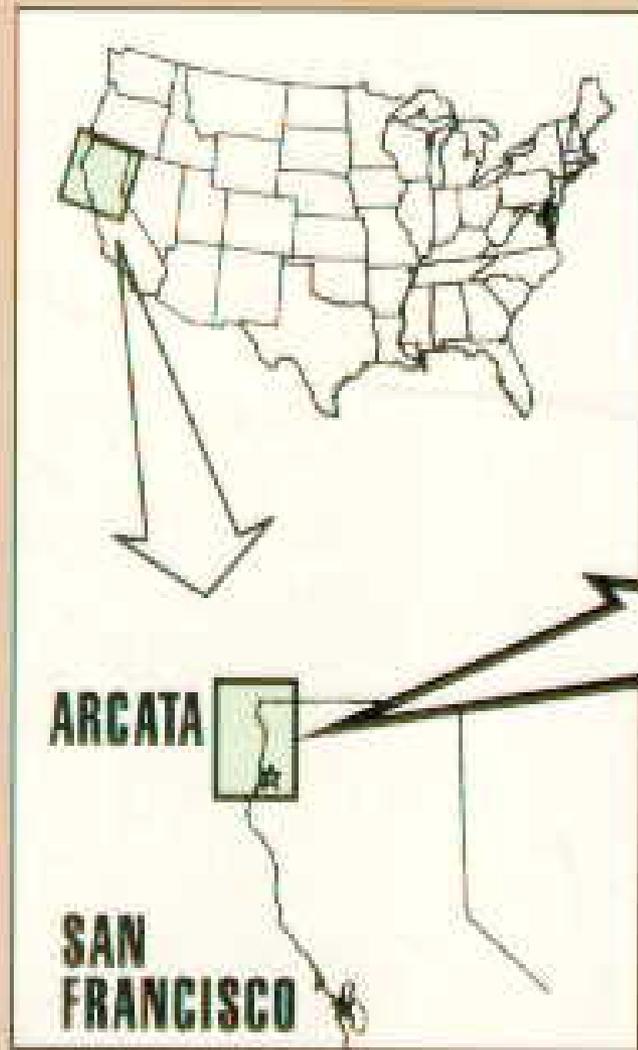


Wetland Treatment a Form of Phytoremediation



Polluted
Water

Aquatic Plants



The Story

- This a story of how students and faculty members have played a role in collaborating with local communities and professionals in solving an infrastructure requirement which required innovation and public policy modification-
- Community issue-related to wastewater treatment and reclamation and reuse of treated effluent-watersheds which have contributed to eutrophic bodies of waters (lakes, rivers, and canals).

**Humboldt State University
Environmental Resources
Engineering Department**

City of Arcata

Research

Application

Innovation

**Technology
Transfer**

City of Arcata's Wetland Treatment System and Marsh and Wildlife Sanctuary



Arcata Treatment Effect on Water Quality

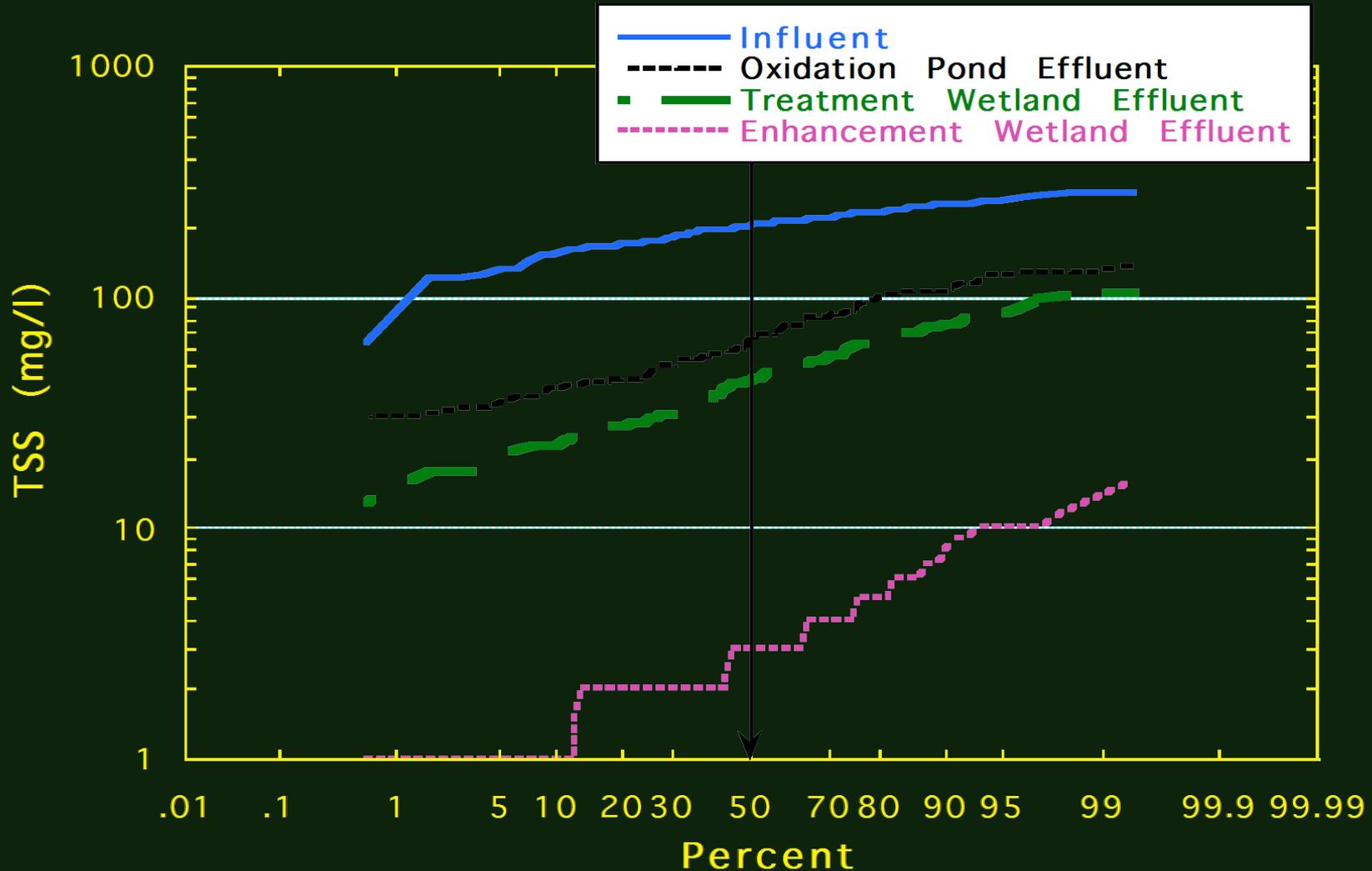
Raw



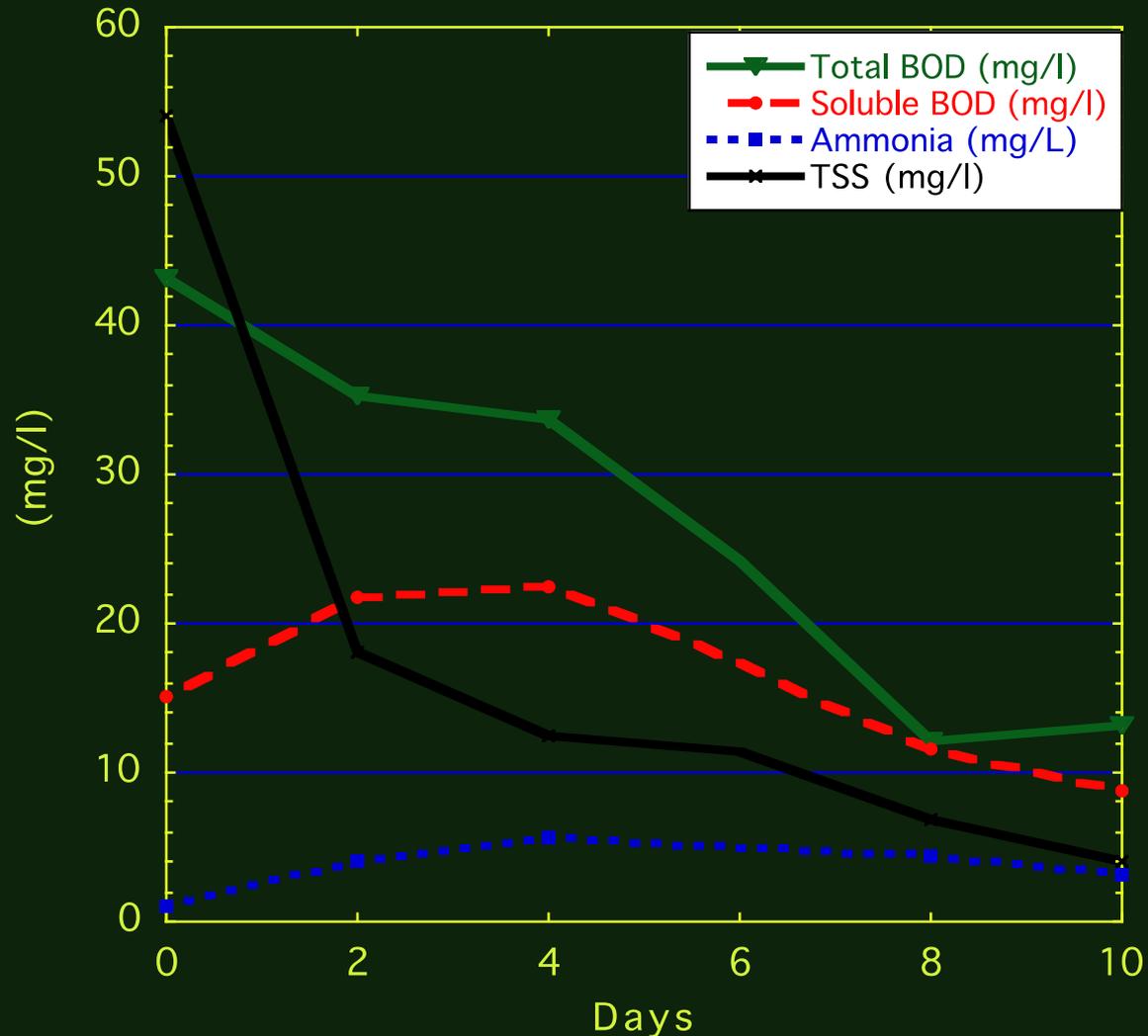
Wetland Effluent



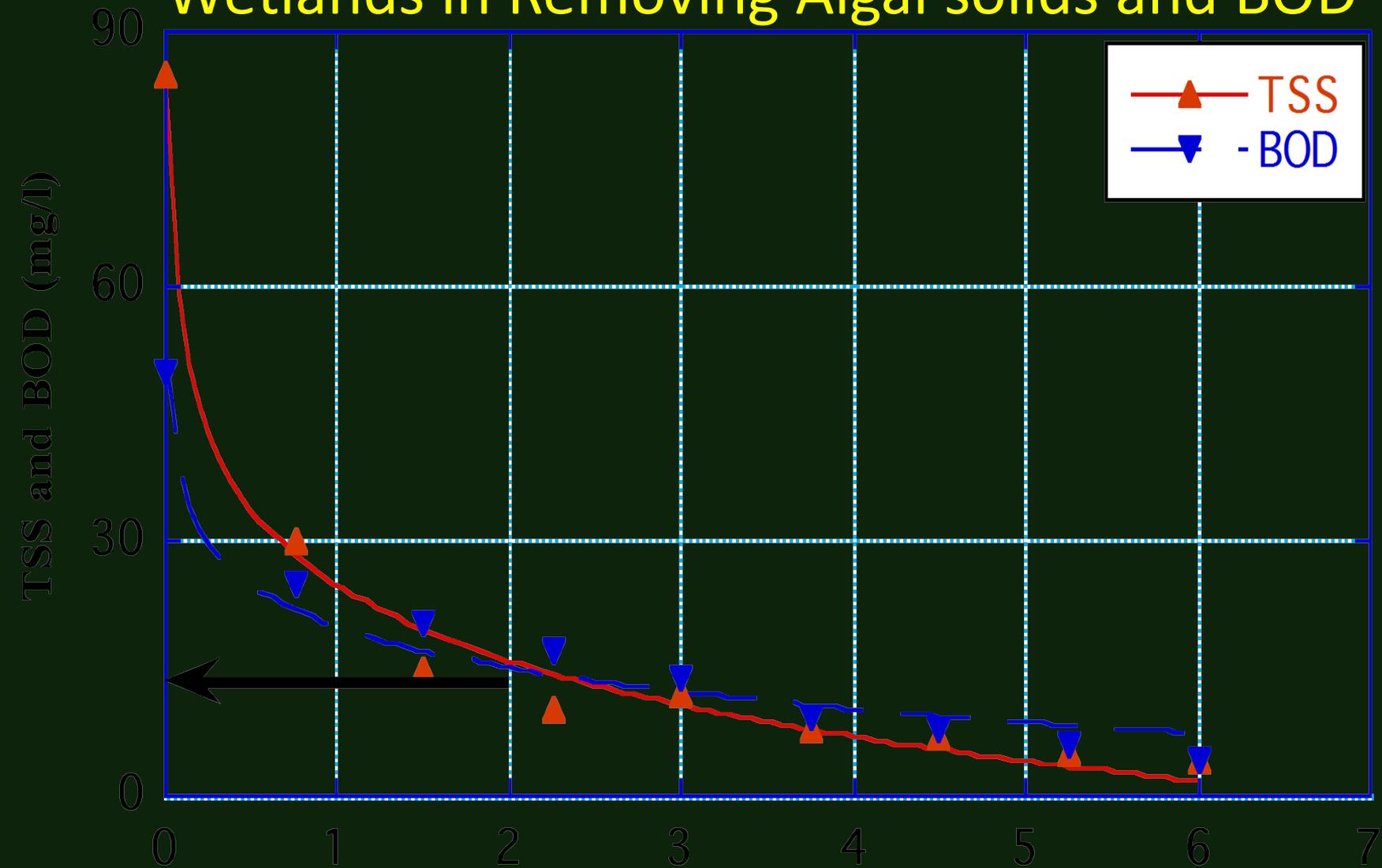
Probability Distribution of 20 years of sequential process TSS data (City of Acata wetland treatment)



Effectiveness of Free Water Surface Constructed Wetlands in Removing Algal solids (TSS) and BOD



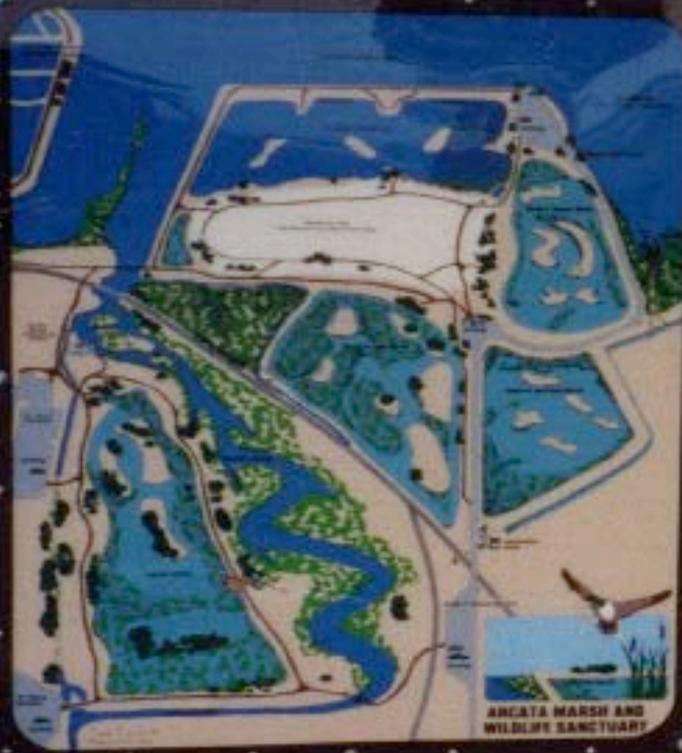
Effectiveness of Free Water Surface Constructed Wetlands in Removing Algal solids and BOD



Wetland Treatment Capability

- Effective
- Efficient
- Reliable
- Complex staged biogeochemical cycles
- Sustainable

Public Access and Environmental Education-Average 300 people/day



Welcome to the Arcata Marsh and Wildlife Sanctuary

RULES AND REGULATIONS

- THE SANCTUARY IS OPEN FROM 6:00 A.M. UNTIL ONE HOUR AFTER SUNSET
- DOGS MUST BE ON A LEASH AT ALL TIMES WHILE AT THE SANCTUARY
- PLEASE REMAIN ON TRAILS AND ROADWAYS
- BOATING IN THE BAY IS RECOMMENDED AT TIDES HIGHER THAN L 3.2
- ACCESS TO THE MARSHES, LAKES AND OUTER BAYS IS PROHIBITED UNLESS AUTHORIZED IN WRITING BY ARCATA'S ENVIRONMENTAL SERVICES DIRECTOR
- HUNTING IS PROHIBITED WITHIN 100 YARDS OF THE LAND AND OPEN WATER ADJACENT TO THE SANCTUARY
- FISHING IS RESTRICTED TO THE POSTED AREA OF KLUFF LAKE ARTIFICIAL LURES AND PLUGS ONLY
- HORSES AND MOTORIZED VEHICLES ARE RESTRICTED TO THE STREETS AND PARKING AREAS
- NO AERIAL OBSTRUCTIONS SUCH AS KITES, HANG GLIDERS, AND MODEL AIRPLANES ARE ALLOWED

Visit the Arcata Marsh Interpretive Center

Open 9 am to 5 pm daily

Located on South G Street

For more information call the City of Arcata's
Environmental Services Department at 822-9184



Wildlife Habitat, Bird Watching, and Environmental Education



Wetland Stormwater Treatment System The Potawat Indian Health Facility in Arcata California Designed by HSU Graduates in Collaboration with Award Winning Architects from Seattle



Friends of the Arcata Marsh (FOAM)

- The Friends of the Arcata Marsh (FOAM) is a nonprofit organization.
- Its primary objective to advance the scientific knowledge and the education of the public concerning alternative treatment and reuse of wastewater.
- Training and supervising docents, sponsoring public lectures, developing exhibits, and maintaining a library were specific tasks listed in the original by-laws.

Role AMWS Played Constructed Wetland

- Example-on the ground demonstration
- Workshops-
- EPA Policy assessment/guidelines
- Graduates working in the area of constructed wetlands
- General public-papers, TV, magazines, etc
- Technical papers

Examples of Wetland Projects as a Result of HSU Faculty and Student Involvement

- Local-California/Western States
 - City of Arcata
 - Apache Nitrogen Products/Arizona
 - Upper Klamath Lake
- International
 - Egypt
 - Mexico
 - China

University Participation

Student and Faculty

- Thirty engineering senior projects
- Twenty five theses
- Over 200 class projects
- Over 500 field trips
- Twenty technical papers
- Three major government publications
(EPA, Bureau of Reclamation, USAID)

Graduate Wetland Design Class



Northcoast Application

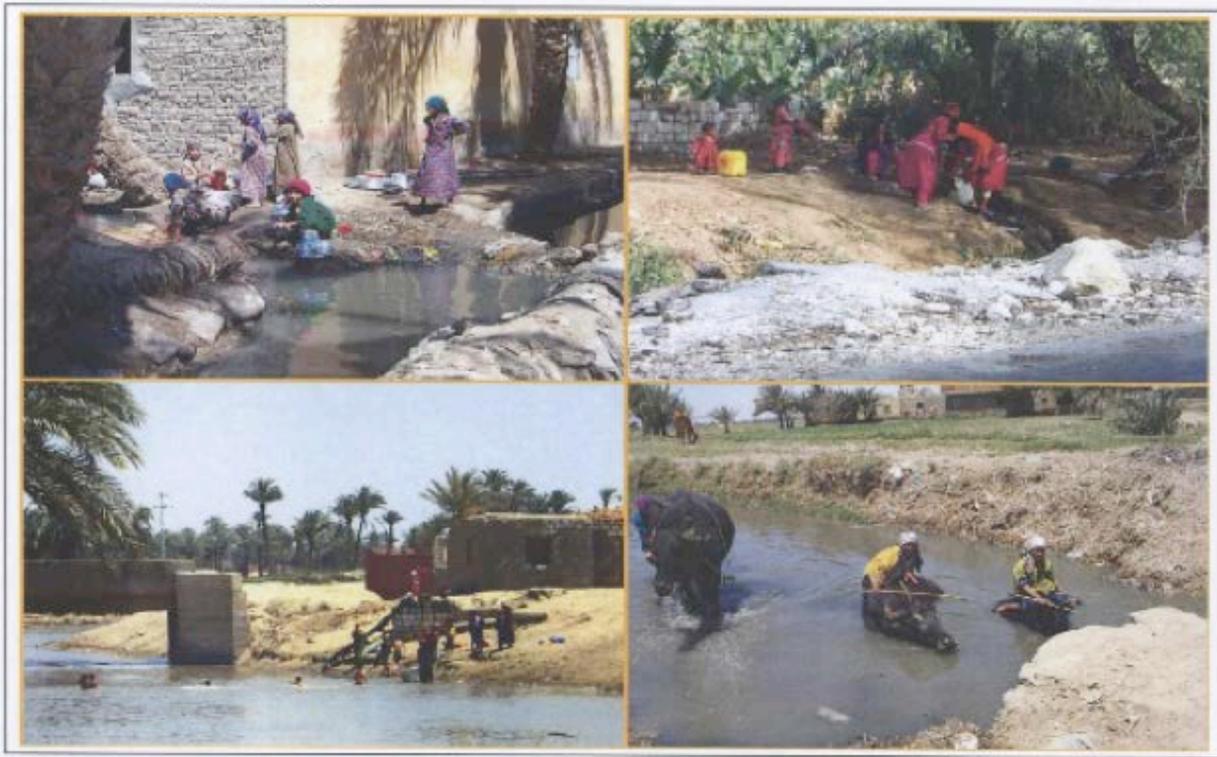
- City of Arcata –Marsh and Wildlife Sanctuary
- McKinleyville Community Service District
- Manila Community Service District
- Garberville Community Service District
- City of Willits
- City of Petaluma
- Hayfork Community Service District
- City of Eureka-Wildlife Wetland
- Covelo-Round Valley

Sites in California and Arizona

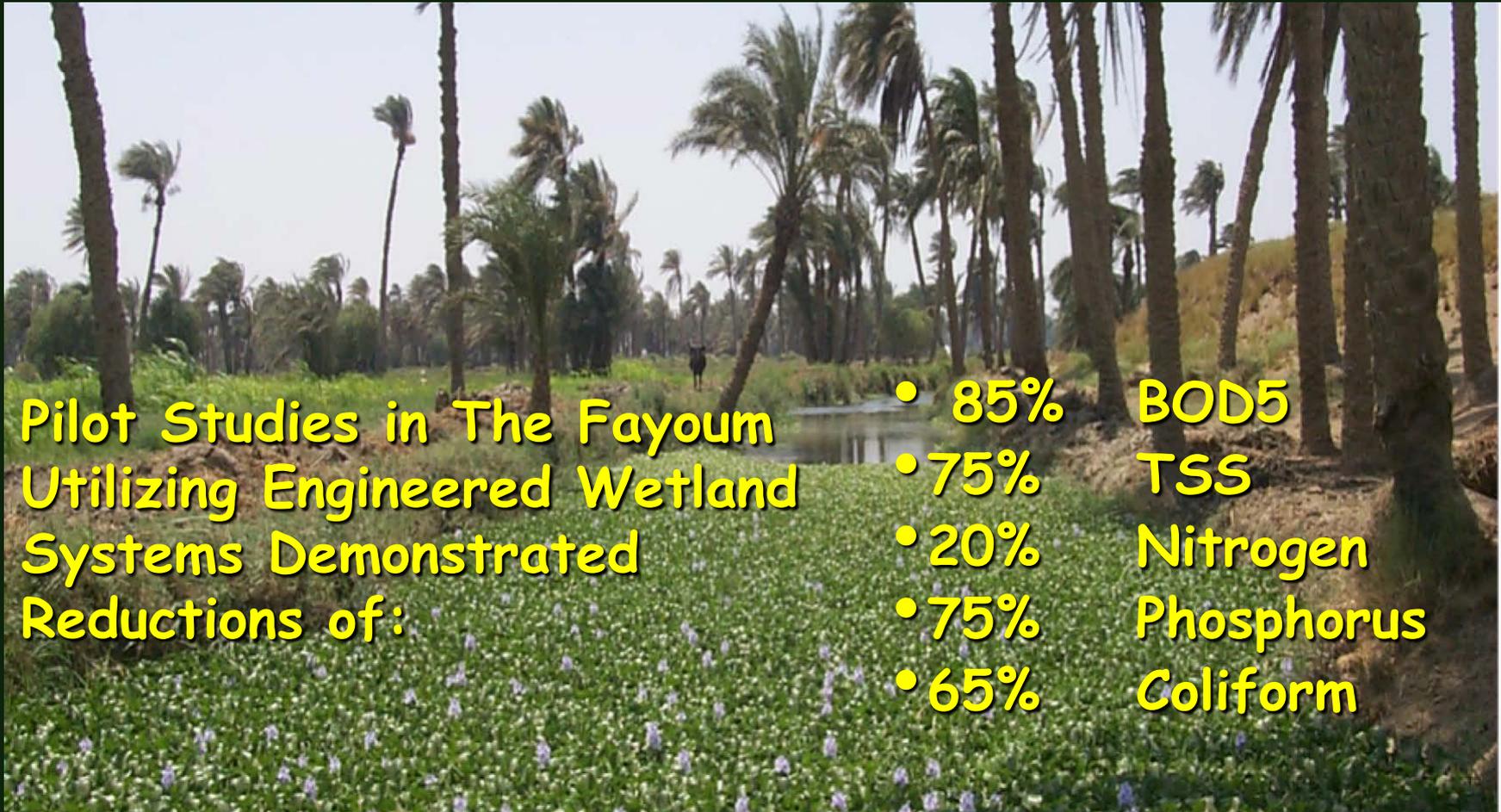
- Hayward California
- Truckee California
- Apache Nitrogen-Benson Arizona
- Las Galinas-Marin County
- Mountainview-Contra Costa County

Some Causes of Poor Lake Water Quality Quality Lake Qarun Egypt





Utilizing Existing Drainage Canals and Natural Occurring Aquatic Plants



Pilot Studies in The Fayoum
Utilizing Engineered Wetland
Systems Demonstrated
Reductions of:

- 85% BOD5
- 75% TSS
- 20% Nitrogen
- 75% Phosphorus
- 65% Coliform

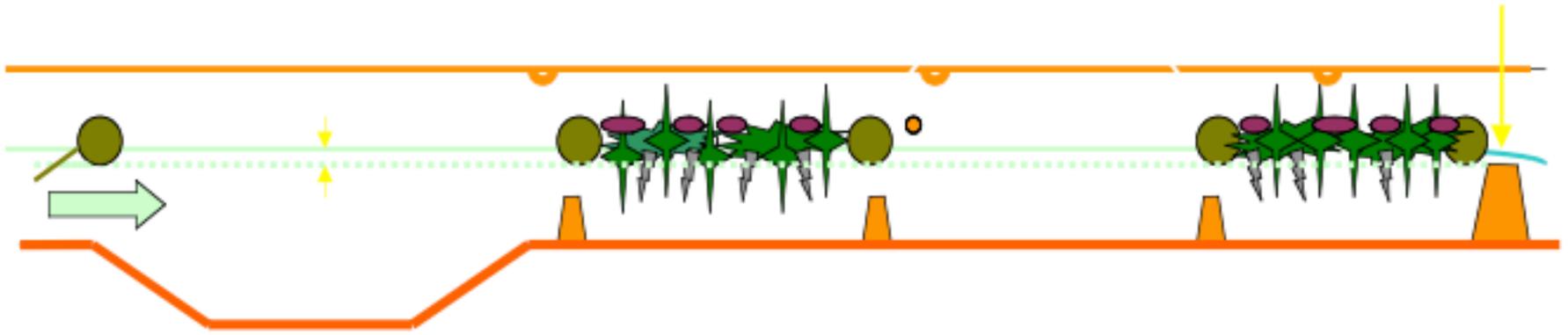
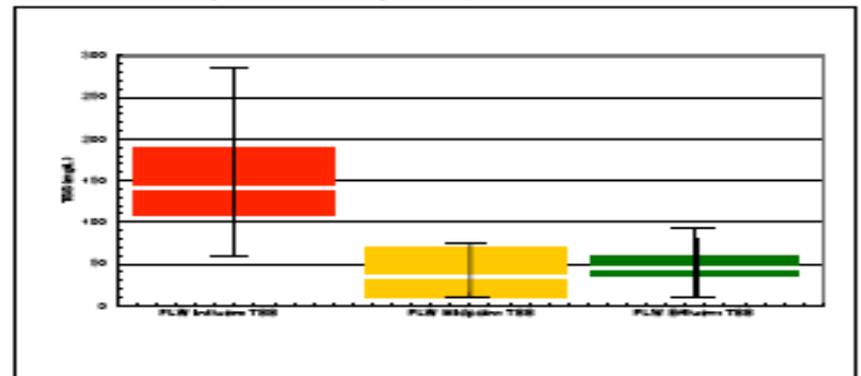
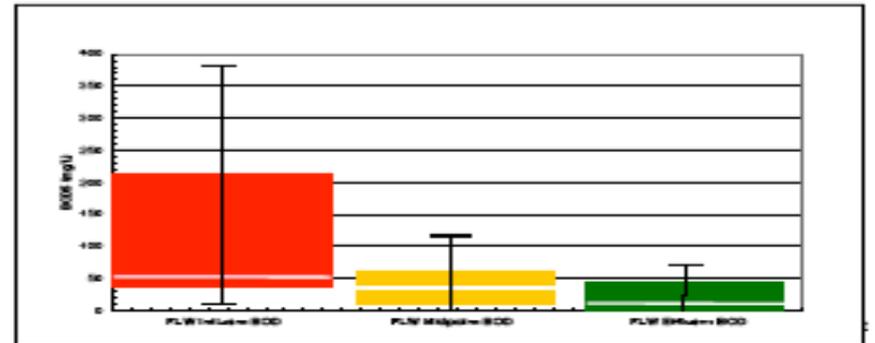


Figure 10. BOD_5 Concentrations in Qalbana Floating Leaved Wetland Pilot In-Stream Treatment System with and without Irrigation Input



Potential Drain Terminus Wetland

- Route discharge of major drains to Lake Qarun through constructed wetland treatment systems engineered to:

Reduce

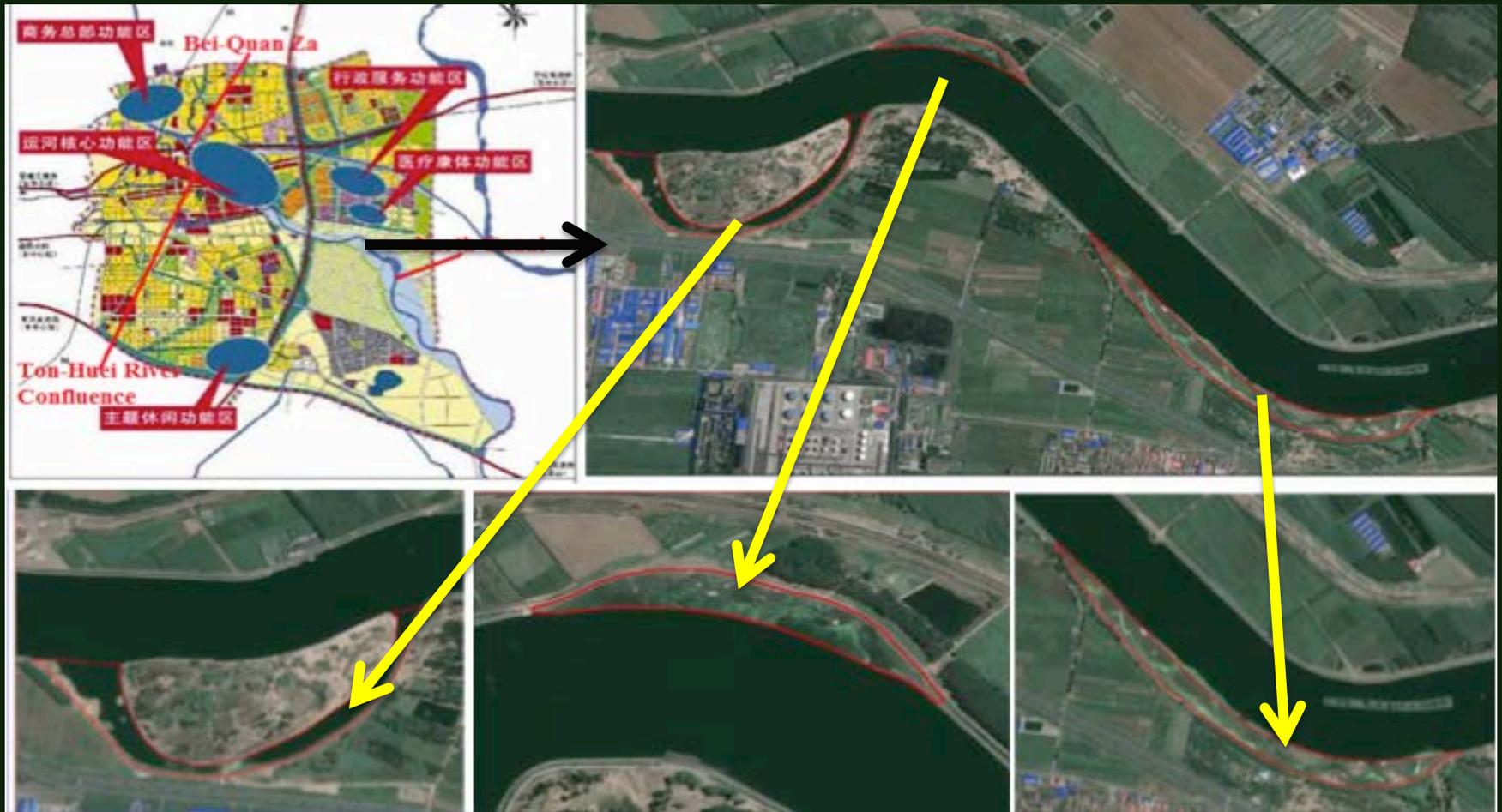


- Suspended Sediment;
- Nutrients;
- BOD;
- Toxic materials, and;
- Pathogenic organisms

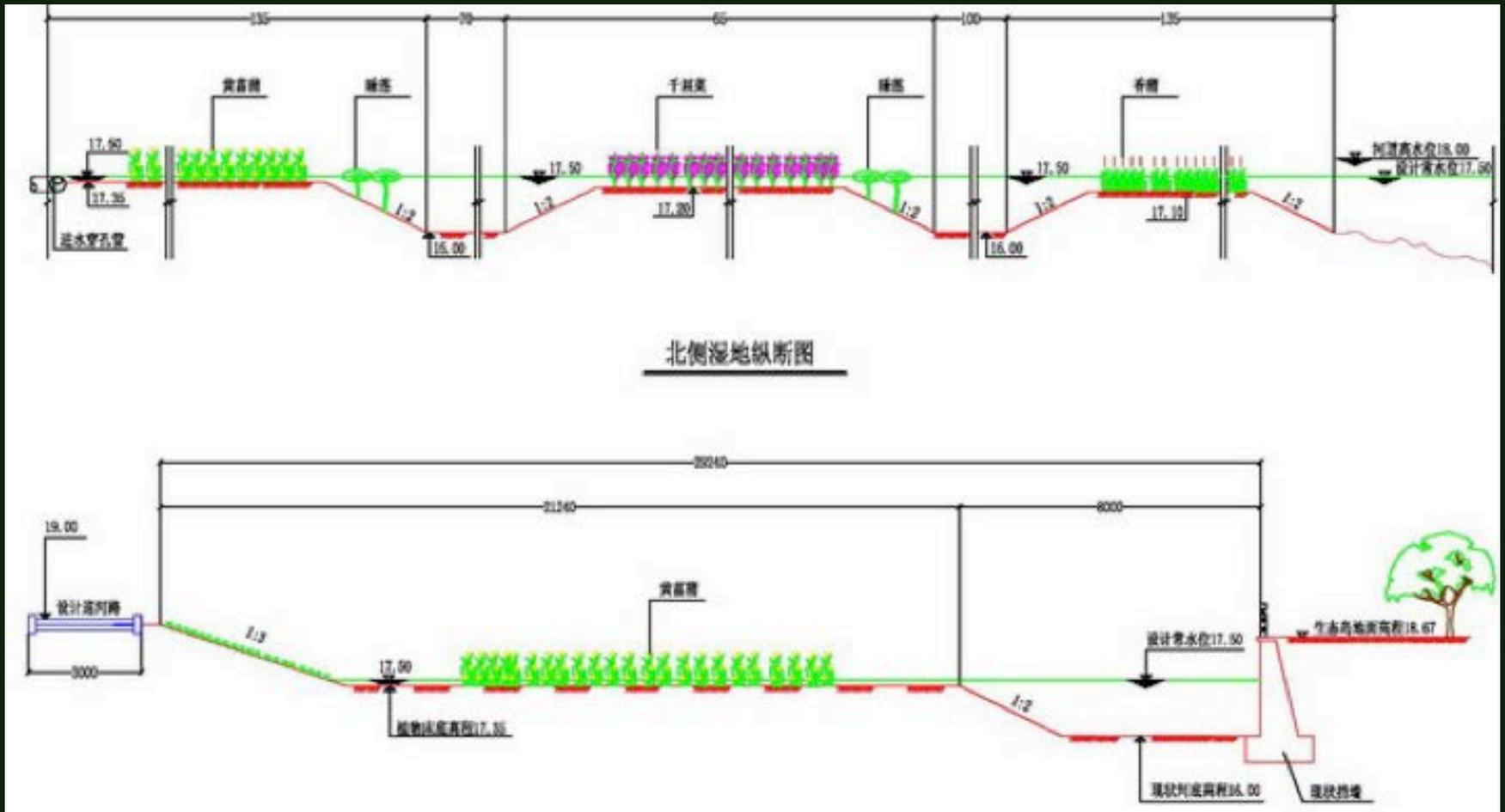
Enhance

- Wildlife Habitat
- Local Fisheries
- Potential for Eco-Tourism

Beijing North Canal

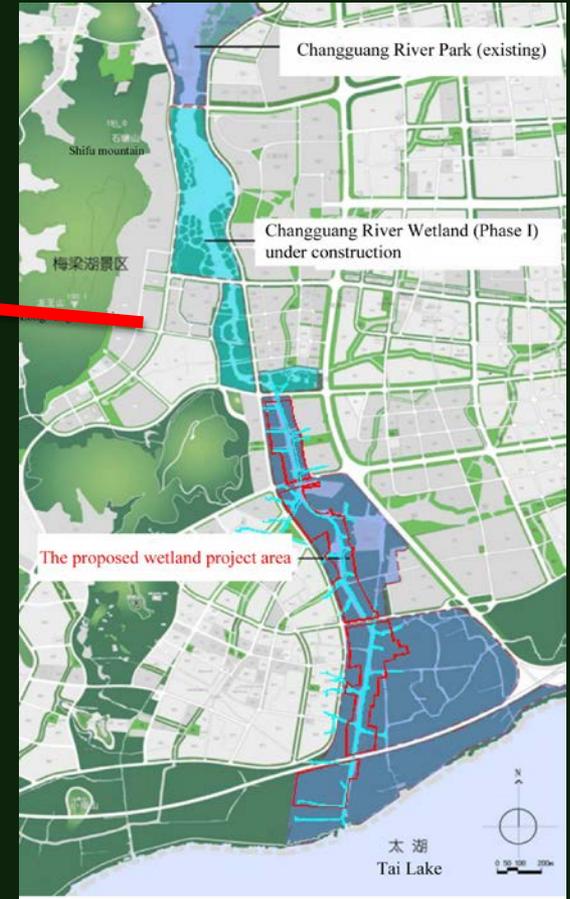


Marginal Wetland Constructed Along the Edge of the North Canal



Tiahu-Eutrophic Lake-Wetland System

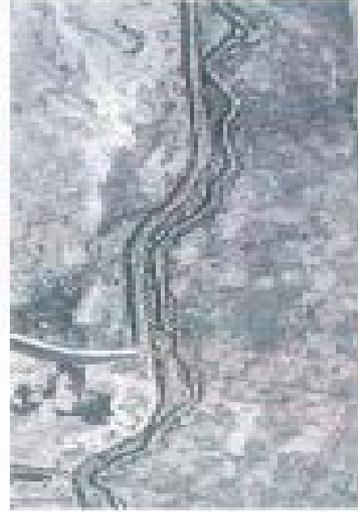
Wuxi, China



Wood River and Upper Klamath Lake Wetland Restoration



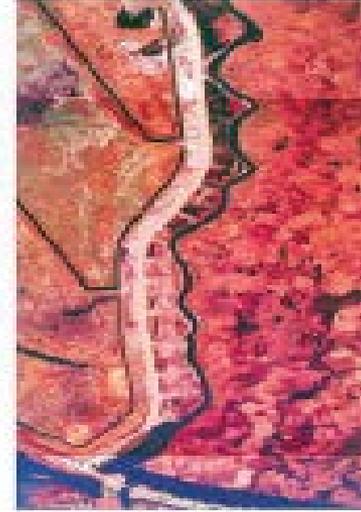
1941



1960



1993



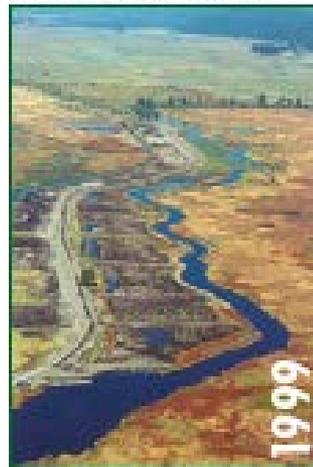
1999

Backfill of dredged channel underway.



1999

Construction completed in upstream reach.



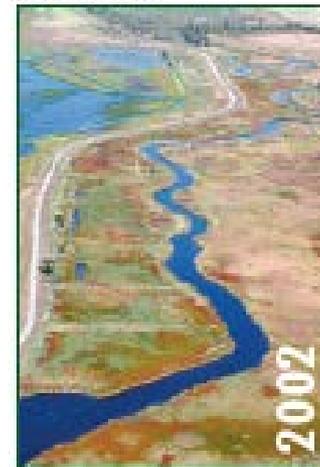
1999

Early in second growing season.



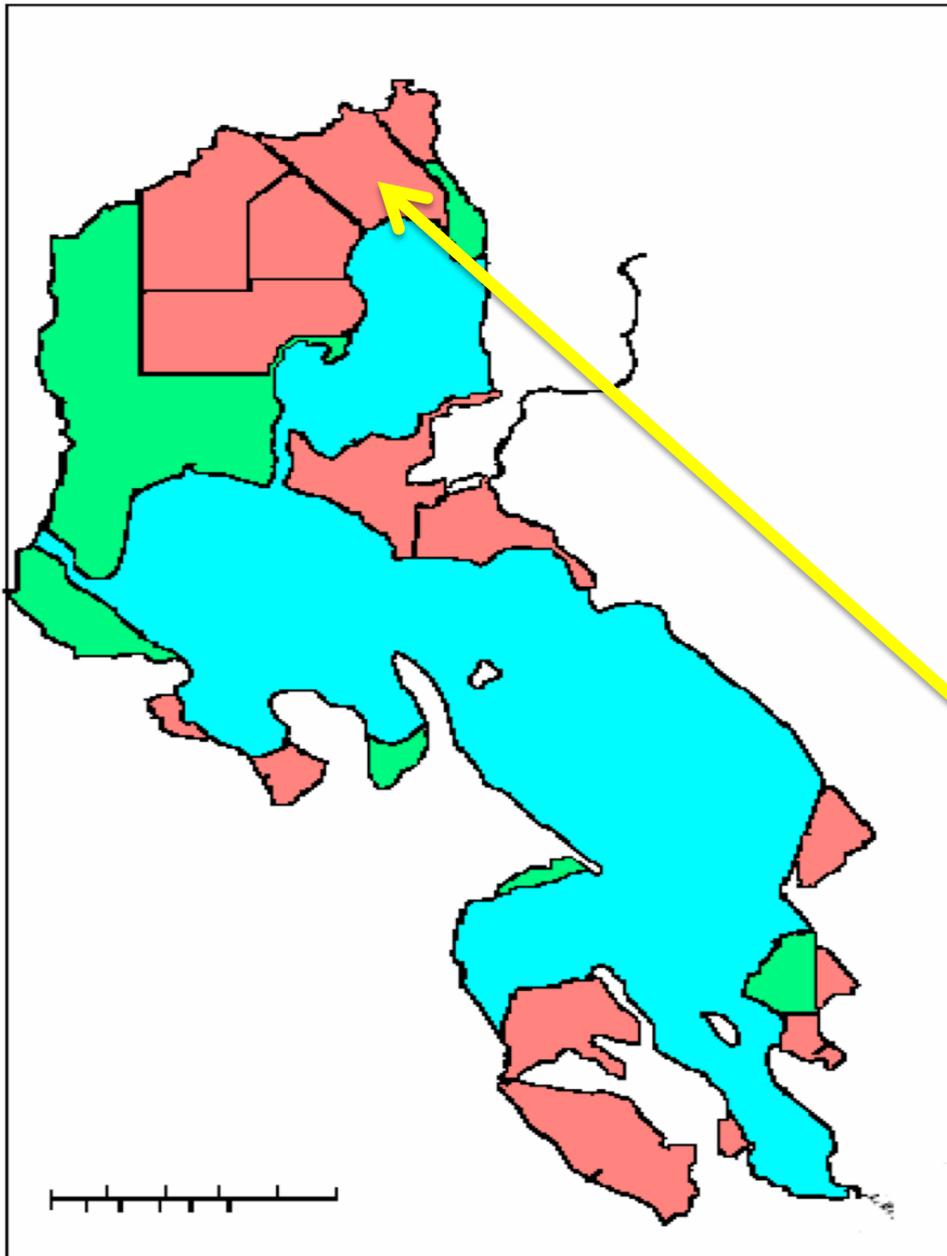
2001

Third growing season.



2002

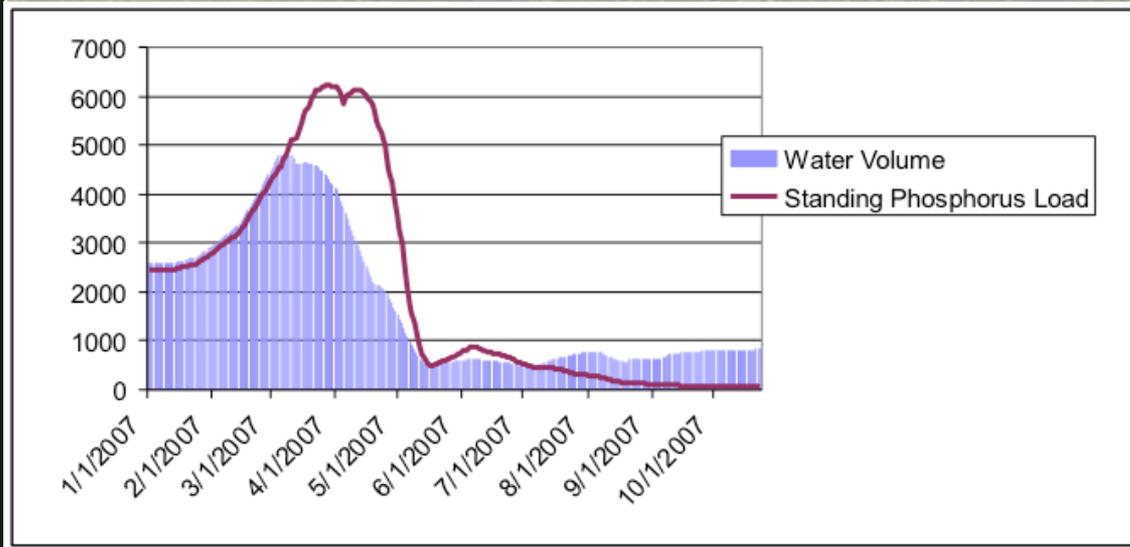
Wood River Ranch Restored Wetlands Dikes left in place



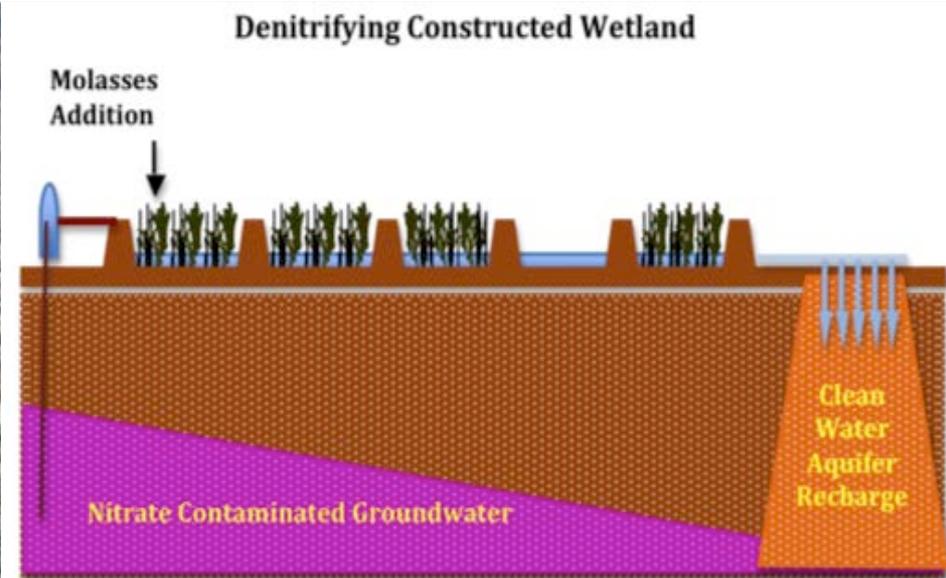
-  Diked / drained former wetland.
-  In-lake wetland.



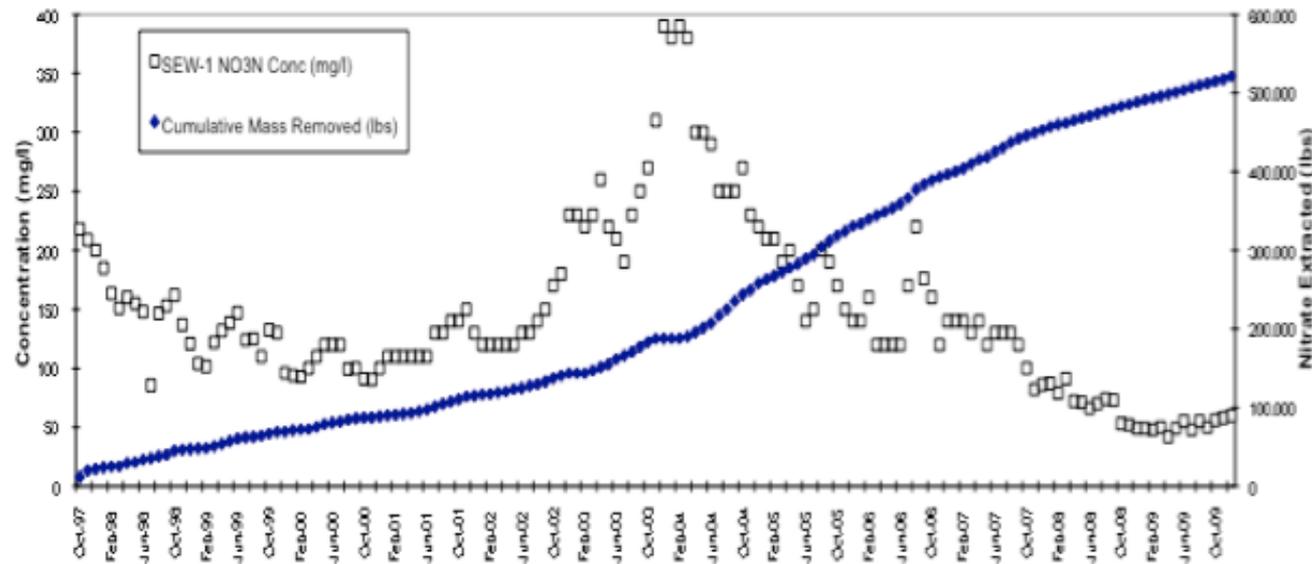
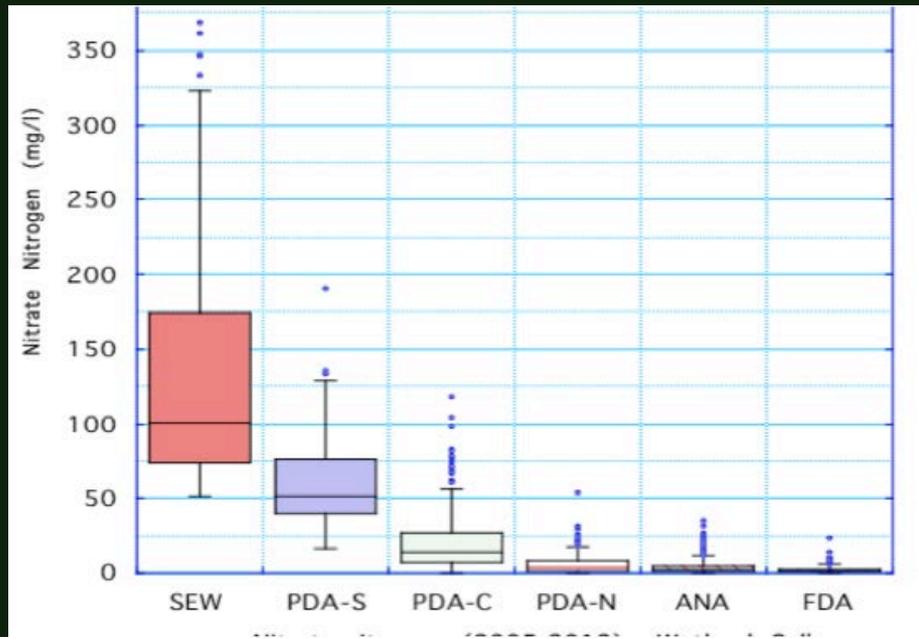
Potential Nutrient Processes – Wood River Wetland 2007



Constructed Wetland to Remove Nitrates from Industrial Contaminated Groundwater Arizona-Denitrifying Bacteria/Wetlands



Long Term Effectiveness of Denitrifying Wetlands at Apache Nitrogen Products



Weekly Report from Apache Nitrogen's Wetland Nitrate Treating Wetland-Weekly reports since 2003

Apache Nitrogen Products Wetland Report #24 Dated June 14, 2013

Date	Time	SEW-1 Meter (gpm)	SEW-1 Totalizer Reading (gal)	Total Gallons since last report	Parshall Flume discharge rate (gpm)	Parshall Flume (totalizer)	EVP (inch)	EVP since last report (inch)	RG (inch)	Temperature (F)	MW-10 (ft BMP)	DCP-12 (ft BMP)
06/14/13	14:52	190	36,786,250	1,055,050	20.76	269958630	2	2	0	98	15.83	

Timer is now running 12 hours per day

SEW-1	Totalizer	Calculations
Pounds of nitrate removed since last report		
708		
	36,786,250	
0		

Treatment Cell	Water Depth (ft)	Molasses (gal)	B-52 (lbs)	Temp (C)	pH	EC
SEW-1	N/A	N/A	N/A			
PDA-S	2.60	0.00	0.00	19.7		
PDA-C	2.90	0.00	0.00	17.5		
PDA-N	2.20	0.00	0.00	16.0		
ANA	4.90	0.00	0.00	19.2		
FDA	2.20	0.00	0.00	17.3		

average pond temp

17.9

NITRATES (mg/L)							
Date	SEW-1	PDA-S	PDA-C	PDA-N	ANA	FDA	EFF
6/11/2013	84.9	57	26.3	12.2	1.66	1.35	0.91
6/14/2013	76.1	54.3	23.8	11.6	2.12	1.79	0.986
Average	80.5	55.7	25.1	11.9	1.9	1.6	0.9

DISCHARGE	
Sulfur odor	Slight
Distance from discharge	flowing past Apache rd
Discharge point	Normal Discharge
B-52 added	zero

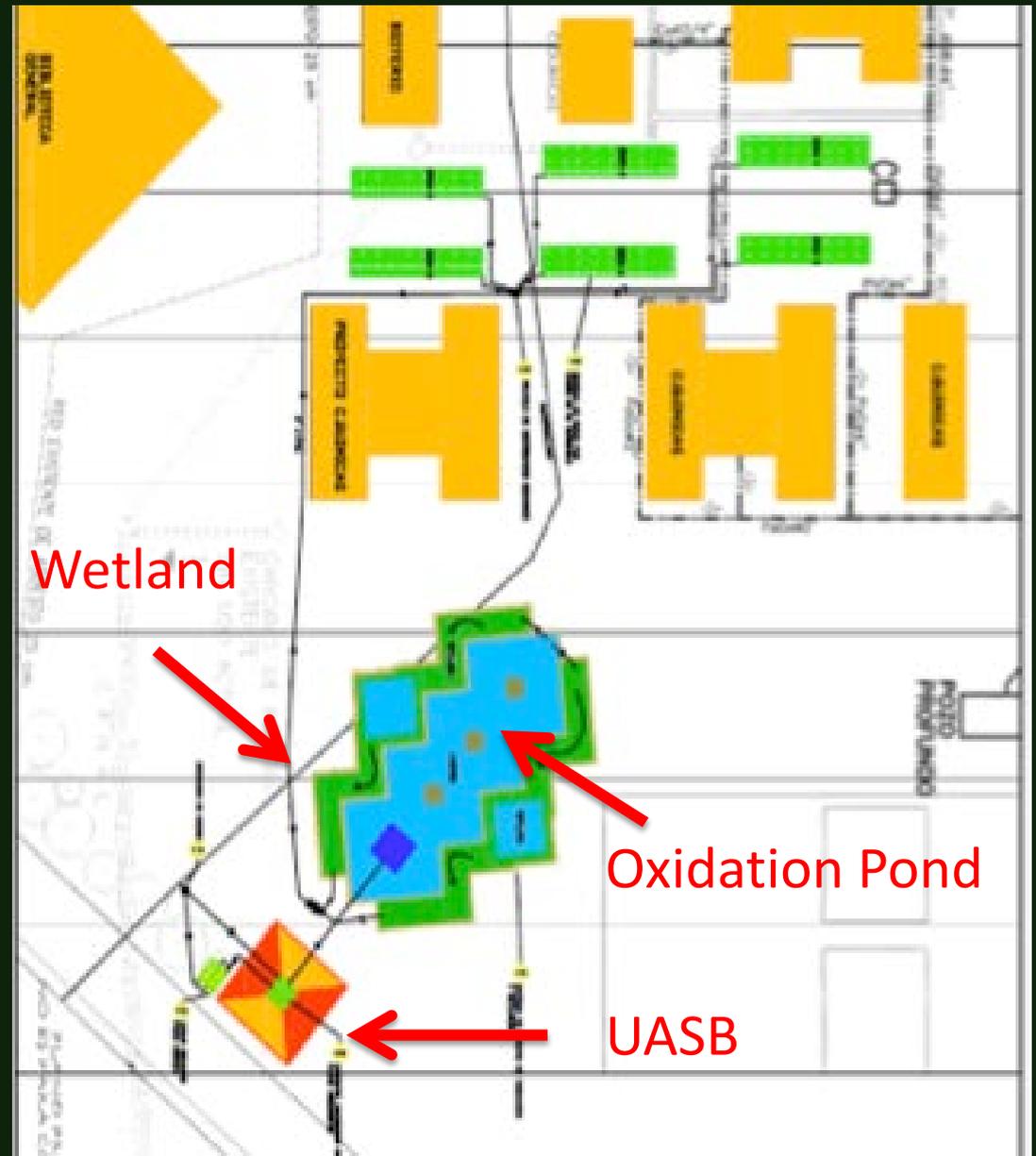
Denitrification Wetland

Benson Arizona, Apache Nitrogen Products



Universidad Autónoma Benito Juárez de Oaxaca, (UABJO)

- The need to support village level health and agriculture in the Oaxaca Valley-600 villages
- Reliance on miaz for food and products
- Need for fertilizer and water for irrigation
- Need for improved health-sanitation/water
- Need for training women and children in agricultural skills



UAJBO On-Campus Demonstration Wetland Treatment System

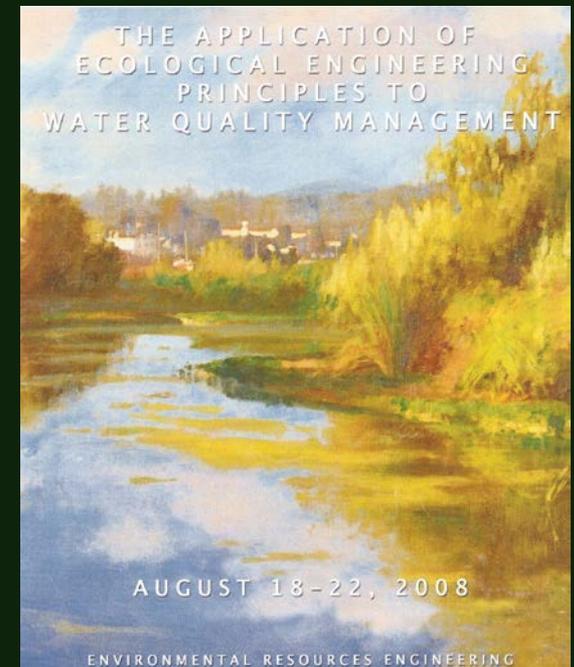
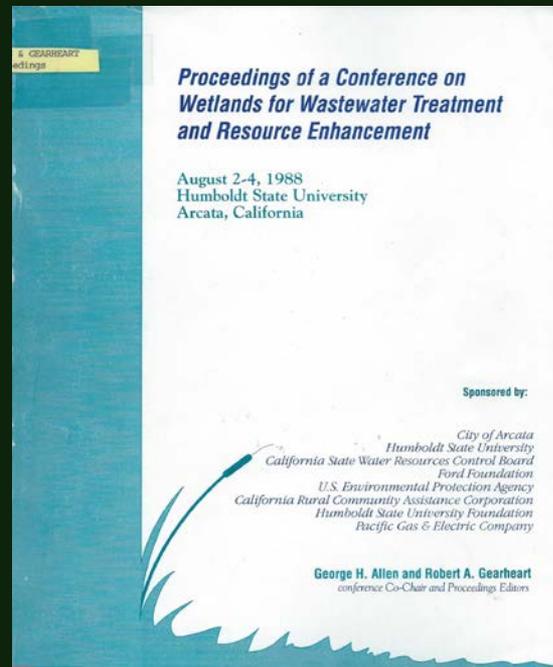
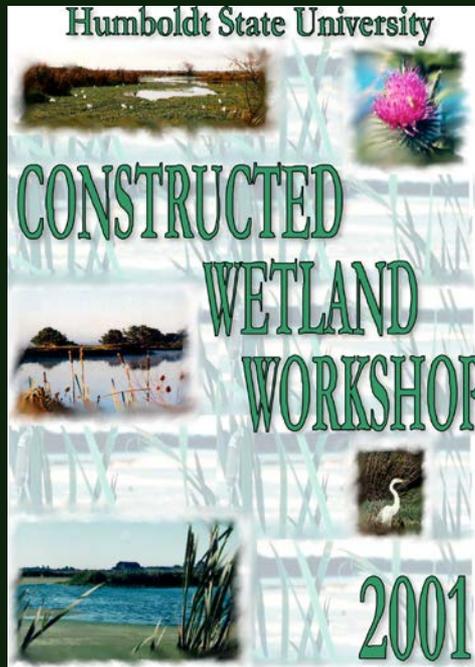


HSU Engineers Without Borders Receiving Commendation from the President of UABJO and Francisco Toledo

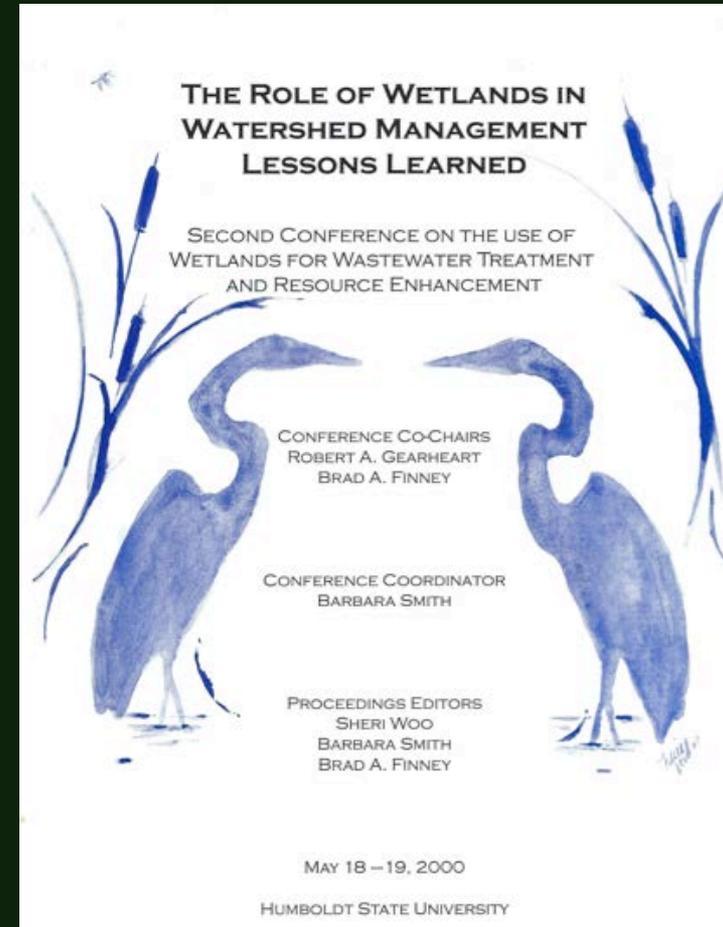


HSU Wetland Design

- From 1988 to 2008 - ten one week technology transfer workshops attended by over 500 engineers, scientists, decision makers, regulators, public works staff, students and citizens.



A Lessons Learned Conference in 2000 resulted in a conference proceedings circulated to many professionals.



Wetland Workshop



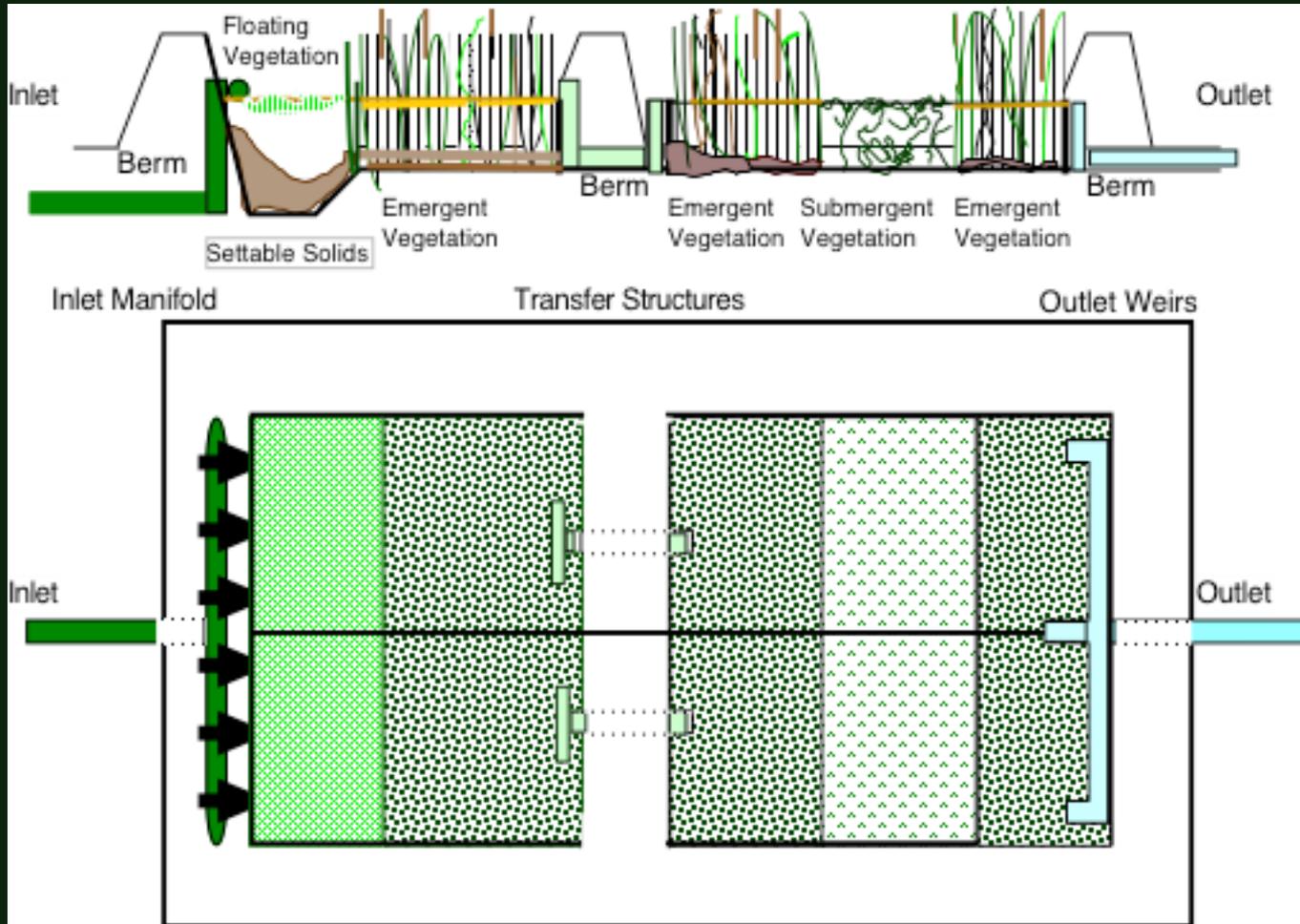
Colorado Lagoon-Long Beach

- The city's worst water was in Colorado Lagoon, which was the sole location to receive an "F" grade during that time period for both its north and south water-testing locations.
- Heal the Bay identified the Colorado Lagoon as one of California's 10 "beach bummers" - the beach locations with the worst water quality in the state.

The Friends of Colorado Lagoon (FOCL)

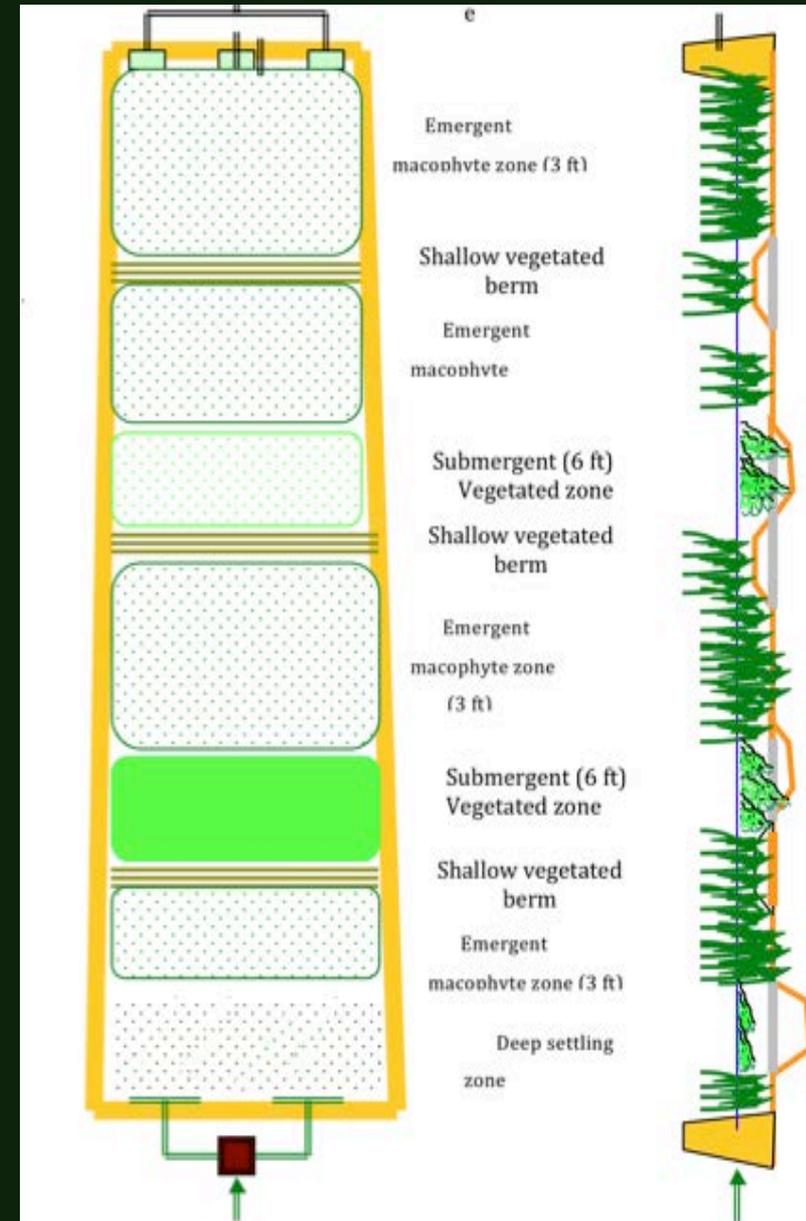
- Promote cooperative solutions to ensure a healthy balance between recreation, flood management, water quality, saltwater marshes, wildlife habitat and native plants in Colorado Lagoon.
- Their primary goal is to protect public health and environmental resources.

Conceptual Design-Wetland Cells in Series with Alternating Zones of Vegetation and Open Water



New Design Concept Ecological Components Constructed Cells in Arcata

- Open water
- Emergent Vegetation
- Submergent vegetation
- Floating vegetation



Long term Benefits Associated with Wetlands

- Future water storage capacity
- Increased treatment capacity
- Carbon sequestration
- Potential to meet future discharge requirements
 - Early life stage organisms
 - Synergetic organics and metals toxicity

Ancillary Wetland Benefits

- Wetland habitat-limiting habitat in SF Bay
 - Wildlife Sanctuary
- Passive Recreation-wide range of public use
- Human Sanctuary
- Environmental Education
 - Knowledge Sanctuary
- Open space/greenbelts/corridors/connections
- Space Sanctuary

So what is it about wetland treatment systems?

- Is it their biogeochemical effectiveness ?
- Is it their simplicity?
- Is it their elegance?
- Is it their biological complexity?
- Is their attraction for public use?
- Is it the diversity of disciplines involved?
- Is it because there is an element of imagination and creative vision involved?

Paradigm Shift to Sustainability

PRESENT

Technical

- Technological Standard
- Sophisticated Equipment
- Capitalization
- Complex Operations

Societal/Economic

- Healthy Individual
- Centralization
- Technology Based
- Societal Cost
- Subsidized

Resource/Environment

- Resource Protection
- Energy Intense
- Discharge/Disposal
- Technological Approaches

FUTURE

Performance Standard
Appropriate Equipment
Sustainable
Simple Operations

Healthy Community
Decentralization
Community Based
Community Opportunity
Self Supporting

Resource Enhancement
Low Energy Needs
Reuse/Reclamation
Ecological Approaches

Conclusions

Infusing to Application

- Many faculty and students actively involved-
- Many engineers and decision makers involved-
- Several EPA wetland design publications-
- Many technical publications/papers-
- Several long term case studies-
- Many national and international site visits-
- HSU graduates in engineering firms and agencies
- Five HSU graduates have Ph.D.s, and are active in wetland research
- Policy change to include constructed wetlands-
- HSU patent for use of wetlands/perchlorates
- Demonstrated the collaborate role of HSU, City of Arcata
State and Federal Agencies and Professionals in the field

2013 Annural Crop of Marshians

This Yea

Four HSU Faculty

Three Undergraduates

Five Graduate Students

Two Yearlings



After hanging around in wetlands for 35 years I am just beginning to see the light

