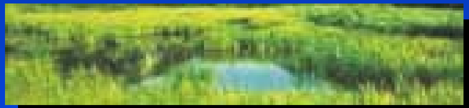
CONSTRUCTED WETLANDS:
An Overview of the Technology



Presentation For:

Peconic River Remedial Alternatives Workshop

December 12 & 13, 2000

Presented by:

Walter H. Eifert
Principal Hydrologist

ROUX ASSOCIATES, INC.
Environmental Services and Management

What Is A Constructed Wetland?

Definition:

A designed and man-made complex of:

- Saturated Substrates
- Emergent and Submergent Vegetation
- Animal Life
- Water That Simulates Natural Wetlands

Present Treatment Applications

- Municipal and Industrial Wastewaters
- Acid Mine Drainage
- Landfill Leachates
- Agricultural Runoff
- Urban Stormwater

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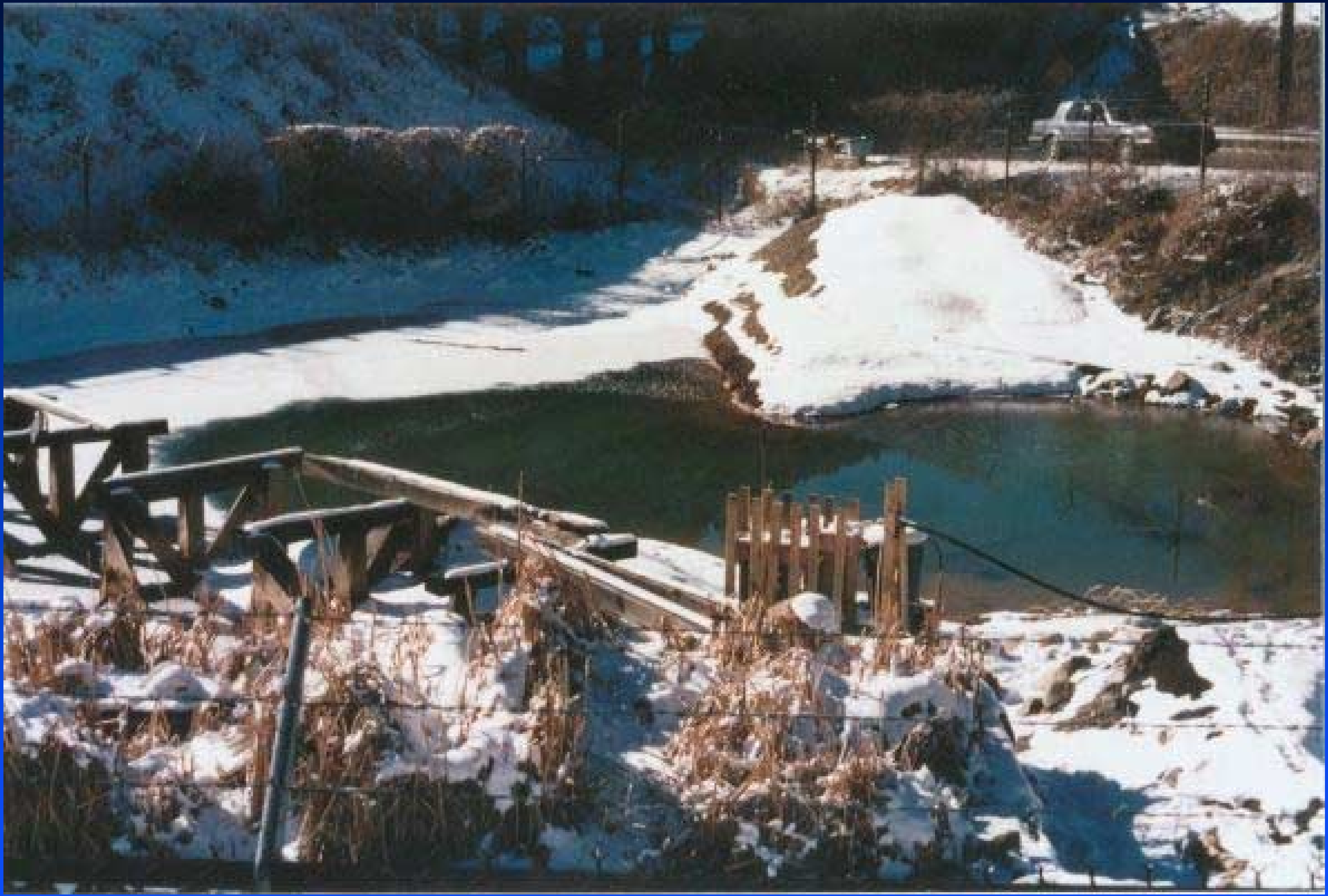
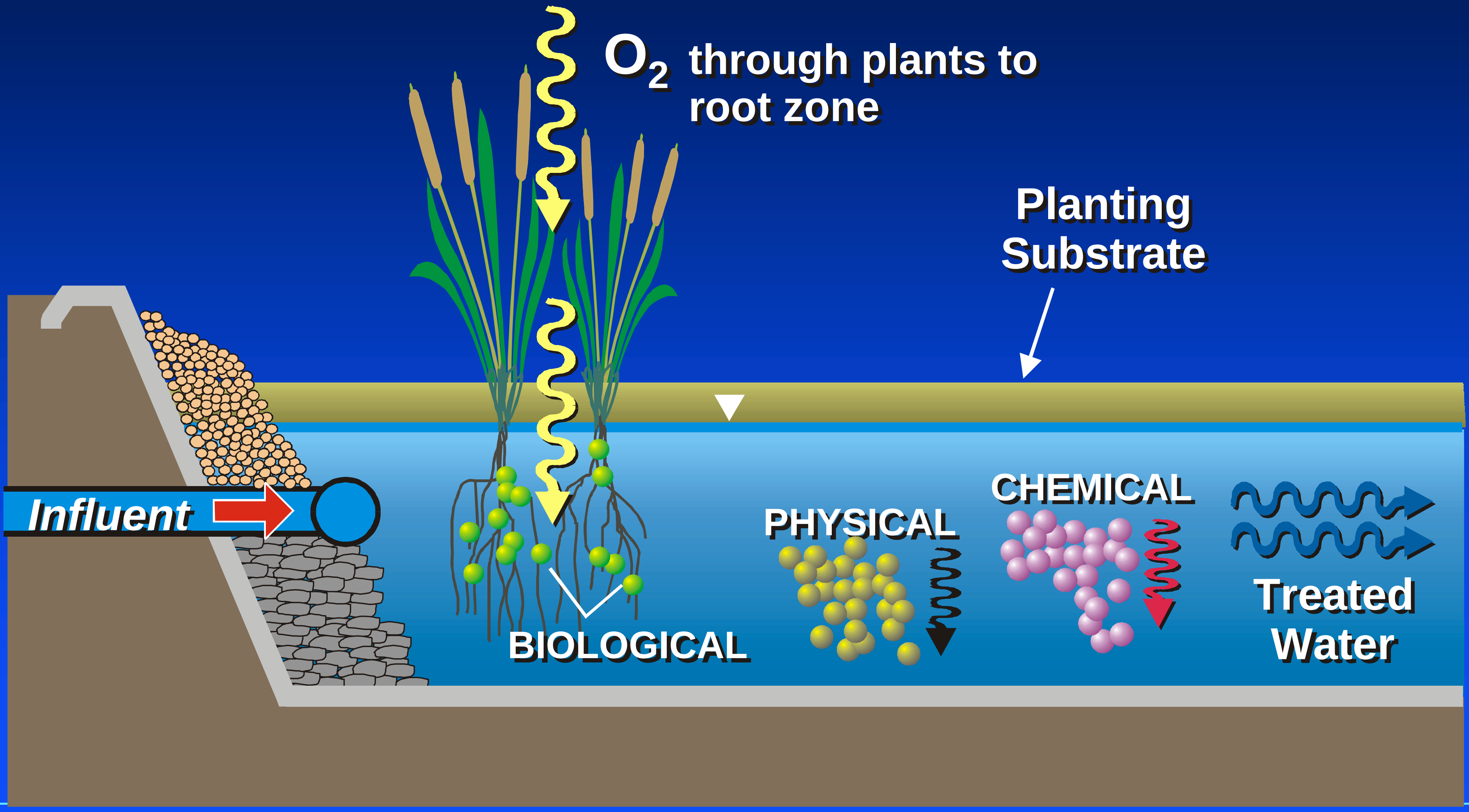


Contaminant Removal Mechanisms:
Multiple Processes At Work



Specific Removal Processes

PHYSICAL	CHEMICAL	BIOLOGICAL
Sedimentation	Precipitation	Bacterial Metabolism
Filtration	Adsorption	Plant Metabolism
Adsorption	Hydrolysis	Plant Absorption
Volatilization	Oxidation/Reduction	Natural Die-Off

Types of Contaminants Removed

- *Organic Substances*
- *Nutrients*
- *Heavy Metals*
- *Suspended and Colloidal Materials*
- *Pathogens*

Types of Constructed Wetlands

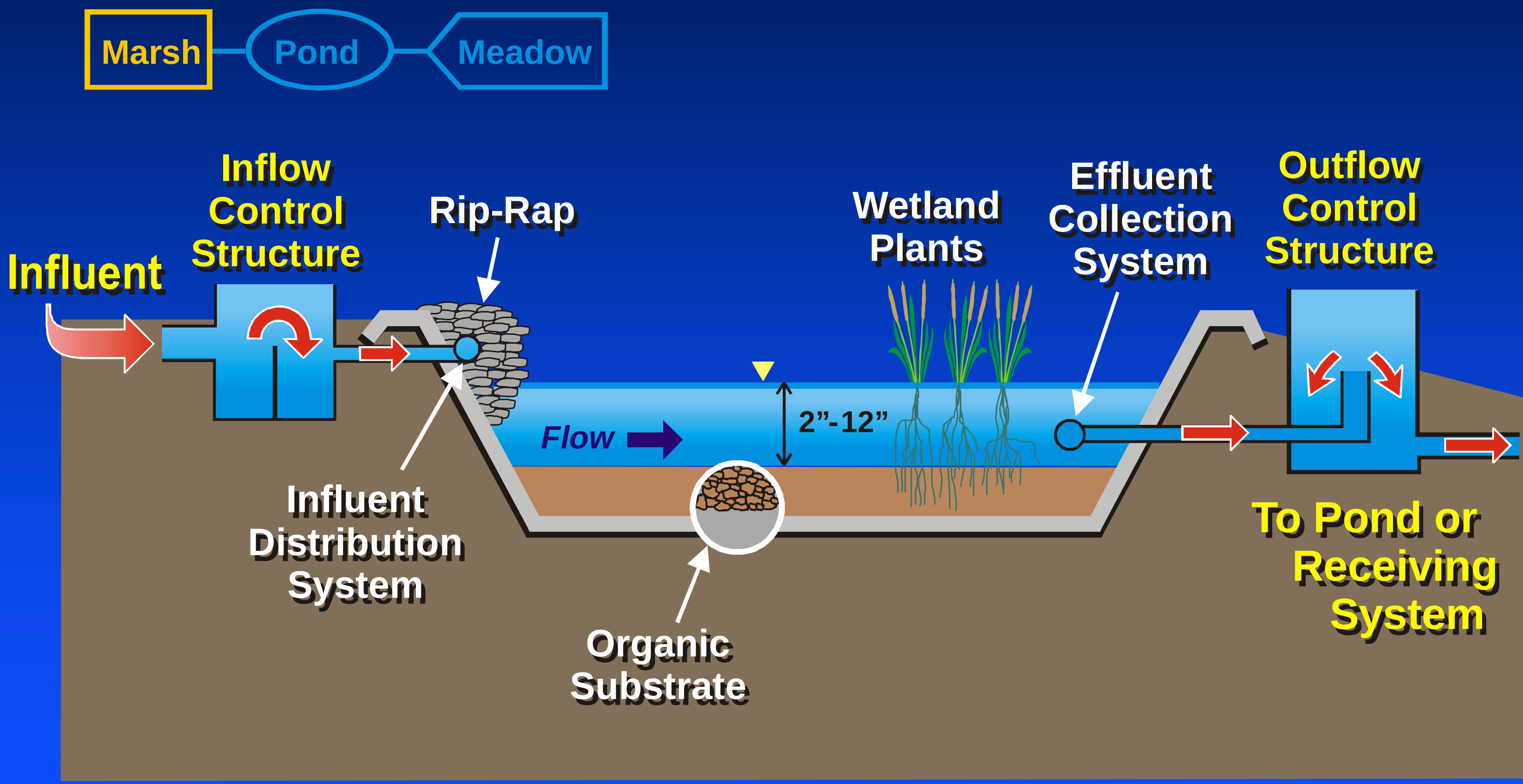
1. **Free Water Surface Systems**

   Marsh - Pond - Meadow Sequence

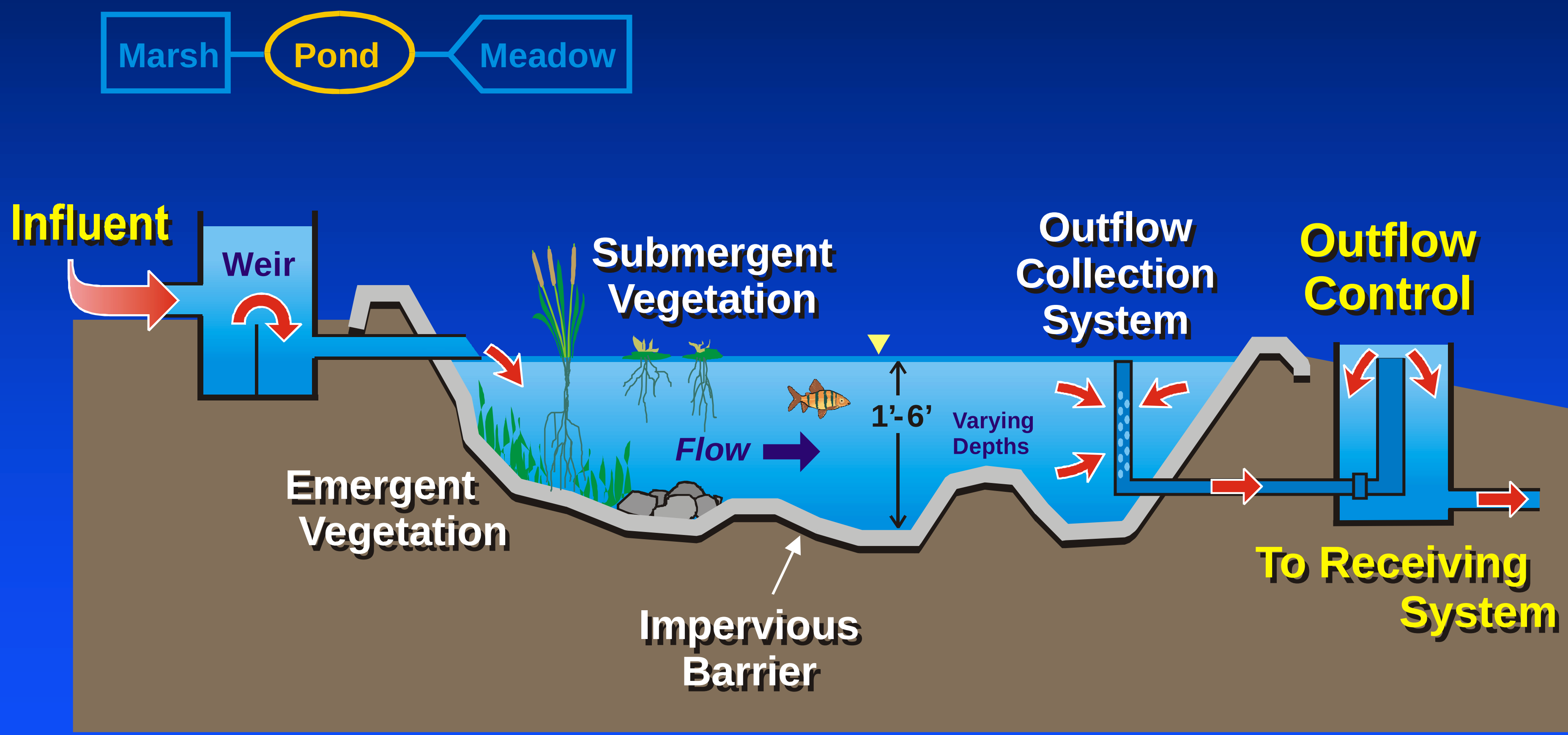
2. **Subsurface Flow Systems**

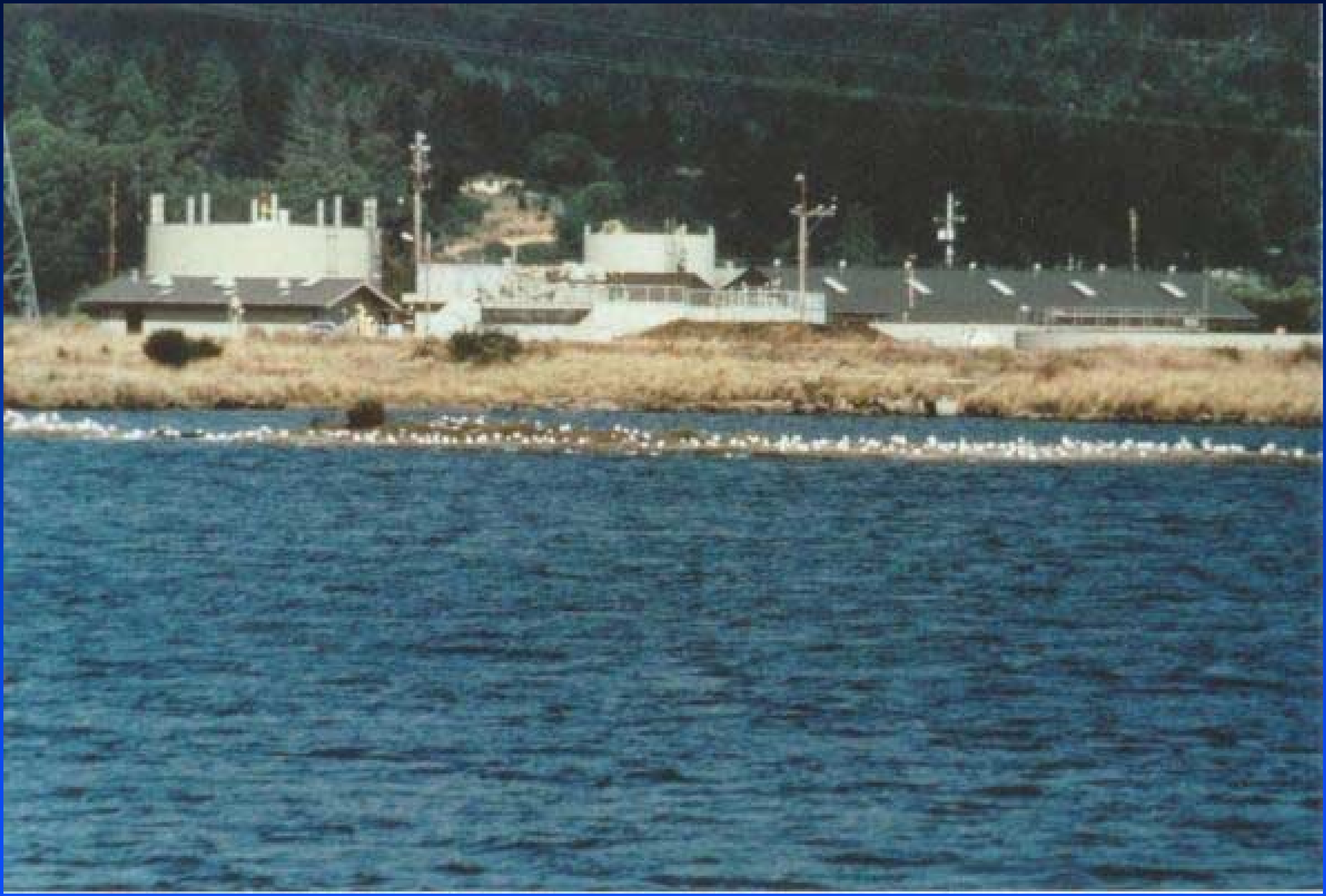
   Engineered cells containing gravel, soil and.or sand treatment media

Free Water Surface Wetland: *Marsh Component*



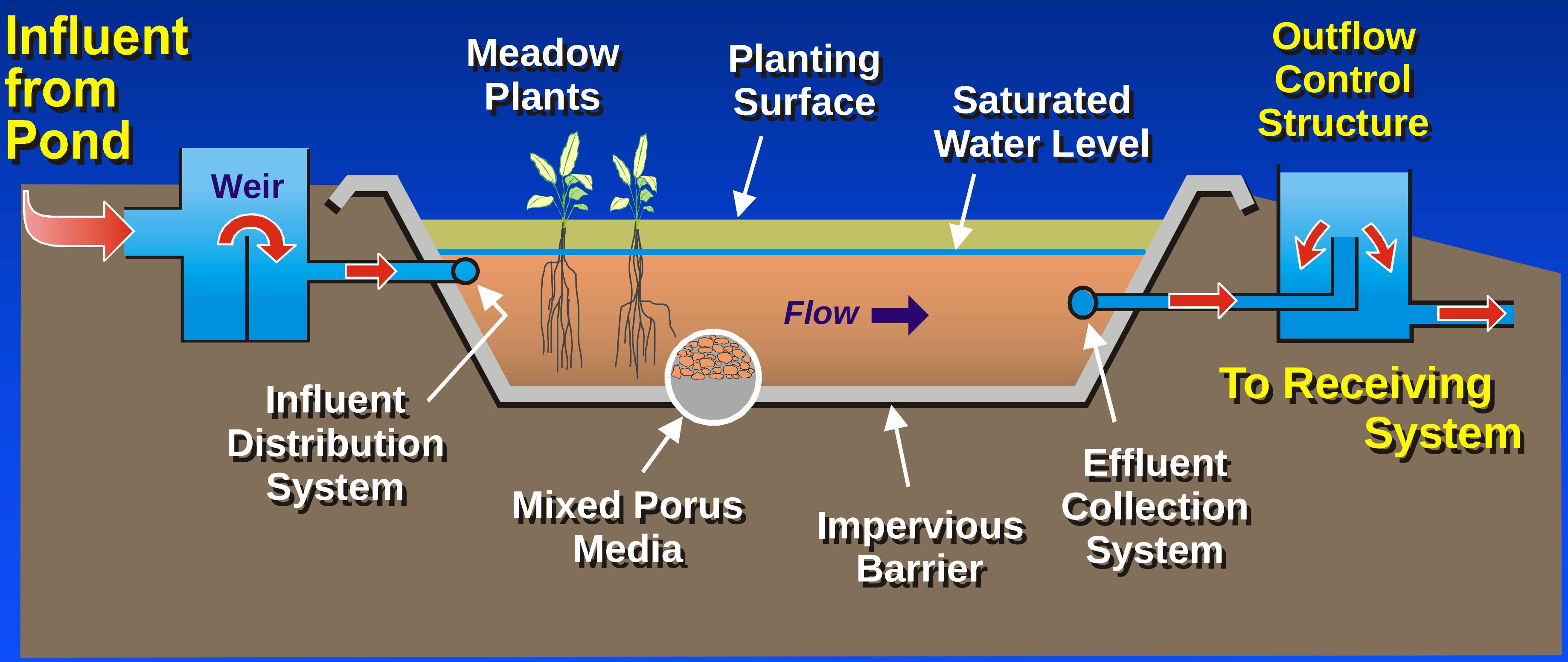
Free Water Surface Wetland: *Open Water Pond*



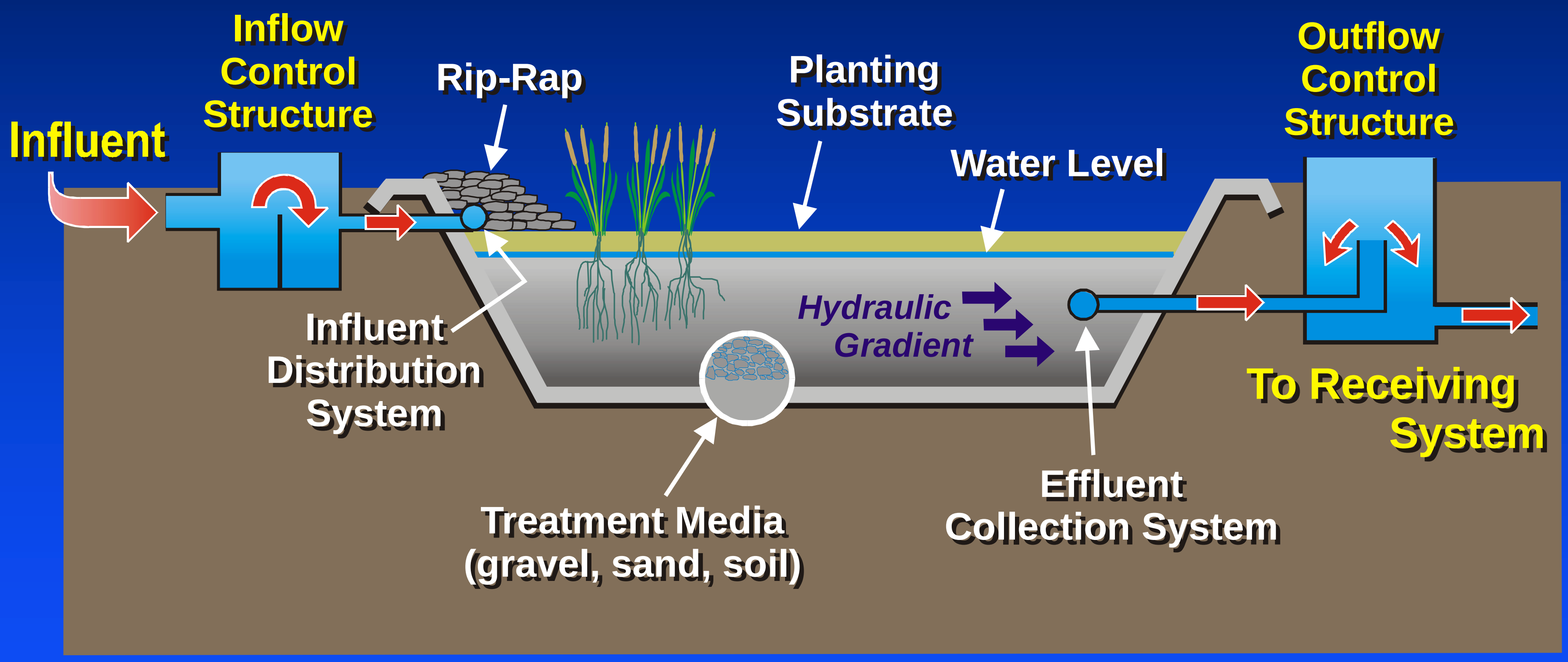


Free Water Surface Wetland: *Meadow*

Marsh — Pond — Meadow



Subsurface Flow Systems



CASE STUDIES

BASF, Williamsburg, Virginia

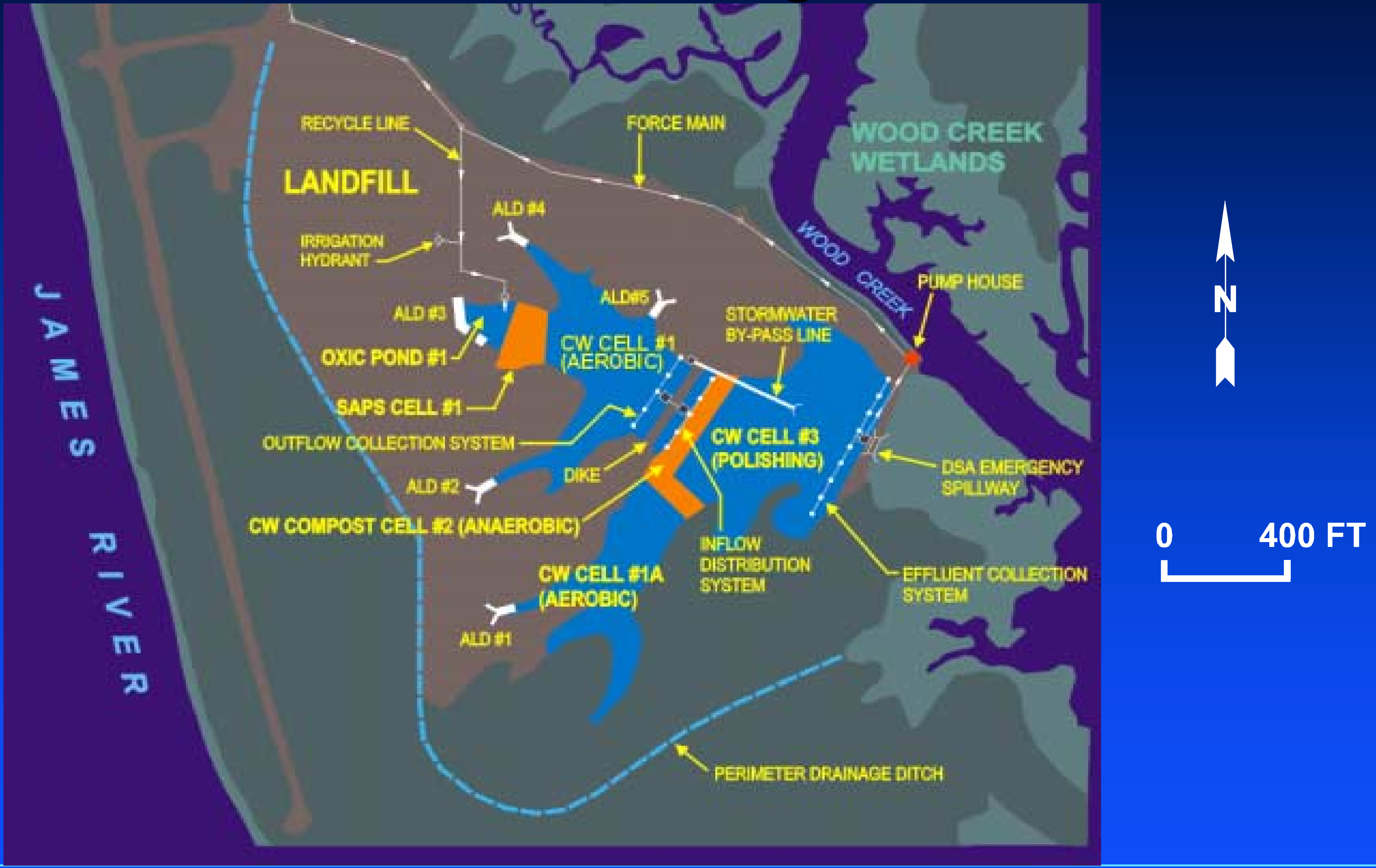
City of Glen Cove, New York

Designed and Currently Operate BASF, Williamsburg CW

- COC's: Zinc, Iron, and Acidity
- Typical Zinc influent: 800 mg/L
- Typical Zinc effluent: 0.10 to 1.5 mg/L
- Treatment Target - 2.0 mg/L
- Performance to Date: $\geq$ 99.9%
- Flow range: 125,000 to 150,000 gpd
- Completed construction January, 1999

BASF, Williamsburg Pre-Construction Photo

BASF, Williamsburg CW Site Plan



ROUX

BASF, Williamsburg

BASF, Williamsburg

BASF, Williamsburg

BASF, Williamsburg

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BASF, Williamsburg

BASF, Williamsburg

BASF, Williamsburg

City of Glen Cove, New York
Stormwater Treatment Constructed Wetlands

COCs:	TSS, Nitrogen, Lead, and Copper
Typical Nitrogen Influent:	4.24 mg/l
Projected Nitrogen Removal:	45 lbs/day
Treatment Design Flow Rate:	Base Flow = 8 cfs First Flush = 25 cfs
First Flush Hydraulic Retention Time:	12 Hours
Hydraulic Design Flow Rate:	450 cfs
Construction Completion Expected:	April 2001

STUDY AREA SITE PLAN

300 FT

ROUX

PRECONSTRUCTION
Debris Waste and Iron Stained Seep Area

PRECONSTRUCTION
Severely Eroded Hillside

UNDER CONSTRUCTION
Stop Log Structure and Diversion Channel

POST- CONSTRUCTION
Completed Micropool

Advantages of Constructed Wetland Treatment Systems

- Inexpensive to construct
- Very low operation and maintenance costs
- Easy to maintain
- Can be designed to provide habitat enhancements and contaminant mitigation
- Tolerant of fluctuating hydraulic and contaminant loading rates
- Provide increased educational opportunities

Potential Disadvantages of Constructed Wetland Treatment Systems

- Require relatively large land areas
- Lack precise design criteria
- Potential vector control concerns

Constructed Wetlands:
Nature's Way

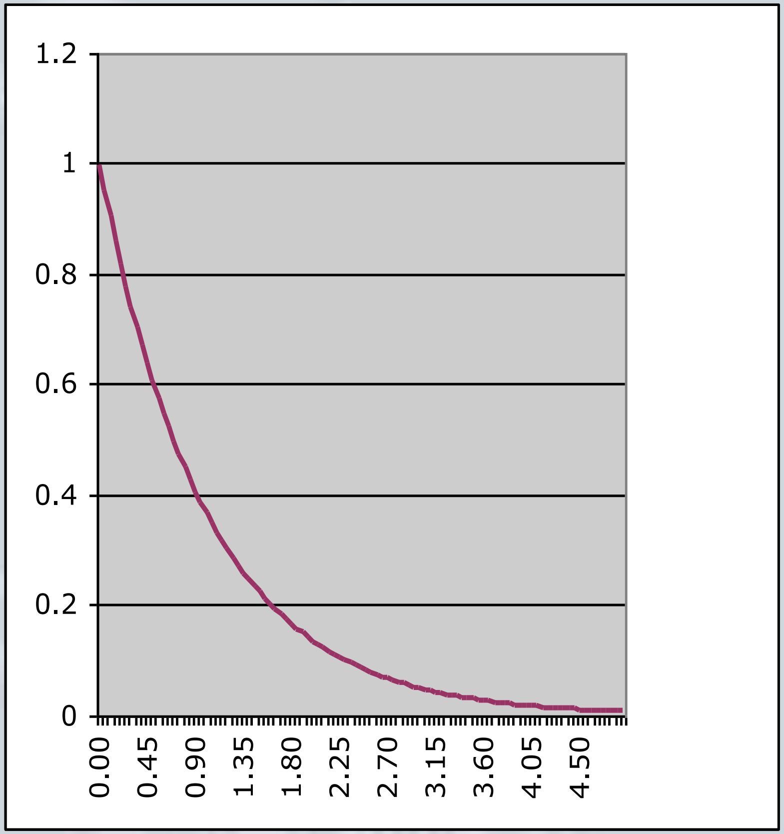
Curt Kerns, M.S., R.P.Bio., C.F.S.

CK Ventures Ltd.

13325 Prospect Drive

Ladysmith, B.C. V9G 1G9

250-245-7525



# of Buckets	Salinity ppt	Reduction %	Total water used L
1	10	50%	5
2	5	25%	10
3	2.5	13%	15
4	1.25	6%	20
5	0.625	3%	25
6	0.3125	2%	30
10 L aquarium starting with 20 ppt salinity			
using a 5 L bucket to reduce salt content			

Exponential Decay Function

Types of Constructed Wetlands

- Free Water Surface
- Vegetated Submerged Bed
- Lineal
- Stormwater
- Vegetative Tertiary Filter
- Lagoons (sort of)

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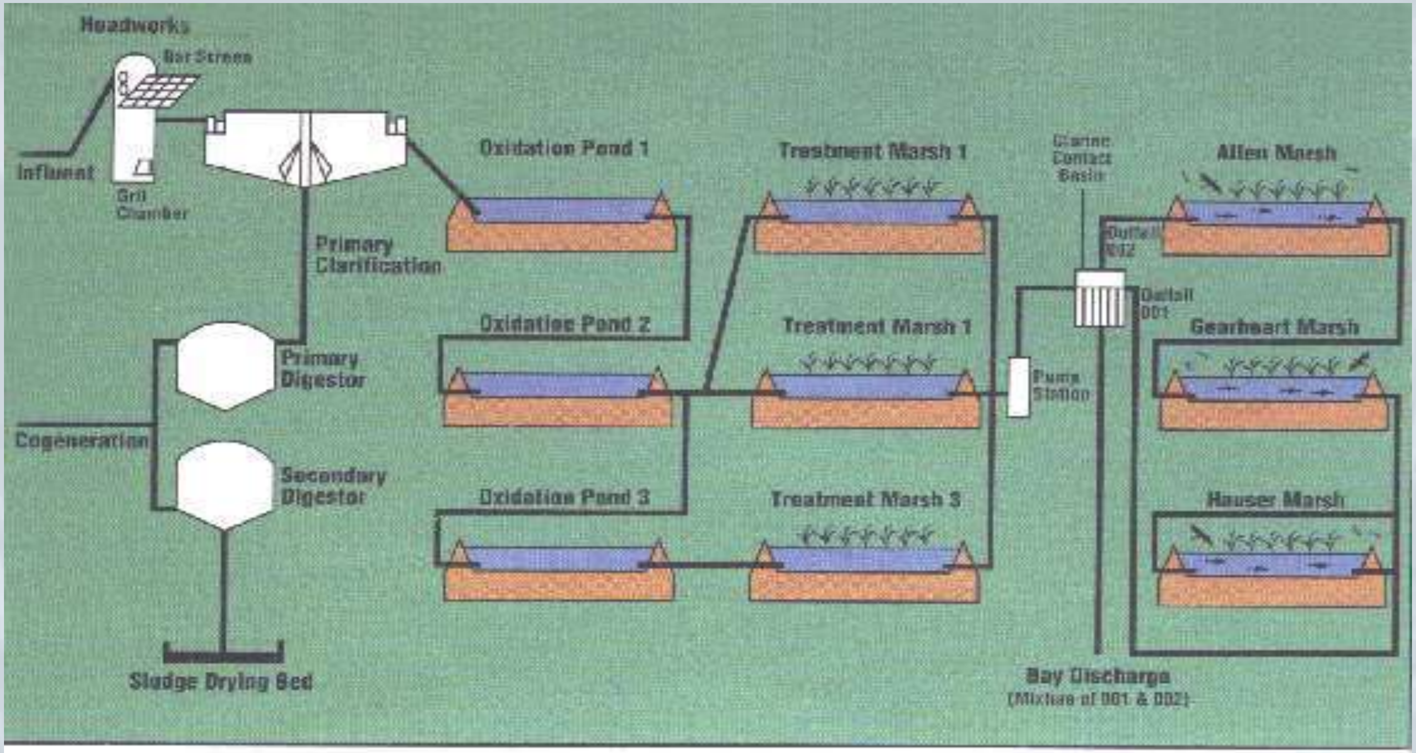
Wetlands have a myriad of functions:

- Remove and detoxify substances carried by and dissolved in water including POPs
- Nutrient & carbon sinks
- Sequester heavy metals
- Slow water release from storm events
- Recharge aquifers
- Vital wildlife habitat
- Express human and economic values

Multiple Pathways – Vast surface area

Arcata Marsh and Wildlife Sanctuary, Lagoons

Arcata Marsh and Wildlife Sanctuary, Wetlands


Headworks
Bar Screen
Influent
Grit Chamber
Primary Clarification
Primary Digester
Cogeneration
Secondary Digester
Sludge Drying Bed
Oxidation Pond 1
Oxidation Pond 2
Oxidation Pond 3
Treatment Marsh 1
Treatment Marsh 1
Treatment Marsh 3
Pump Station
Outfall 002
Outfall 001
Allen Marsh
Gearheart Marsh
Hauser Marsh
Bay Discharge
(Mixture of 001 & 002)


Stage in Treatment Plan
BOD (mg/l) Biochemical Oxygen Demand
SS (mg/l) Suspended Solids
TIN (mg/l) Total Inorganic Nitrogen
Influent
Primary Treatment
Oxidation Pond
Treatment Marshes
Enhancement Marsh
1
2
3
4
5
200
150
100
50
0
mg/l

Arcata Marsh And Wildlife Sanctuary

Design Specifications

Design Population	19,056 persons	
Average Annual Flow	8,700 m3-day	(2.3 mgd)
Peak Flow	7x	
BOD Loading	1,900 kg-day	(4100 lbs/day)
TSS Loading	1,500 kg-day	(3400 lbs/day)
Treatment Marsh Area	3 ha	7 gal/ft^2-day
Constructed Wetland Area	12.5 ha	1.7 gal/ft^2-day
Total Area per Capita	8.2 m^2/person-day	


Welcome to the Arcata Marsh
and Wildlife Sanctuary
RULES AND REGULATIONS
Visit the Arcata Marsh Interpretive Center
Open 9 am to 5 pm daily
Located on South G Street
ARCATA MARSH AND
WILDLIFE SANCTUARY
Otter Records
5. 22. 2002

Welcome

Arcata, CA Constructed Wetland Ponds

Arcata, CA Constructed Wetland Ponds

Over 200,000 visitors per year

A young visitor

Multi-Use

Can be located in a variety of locales

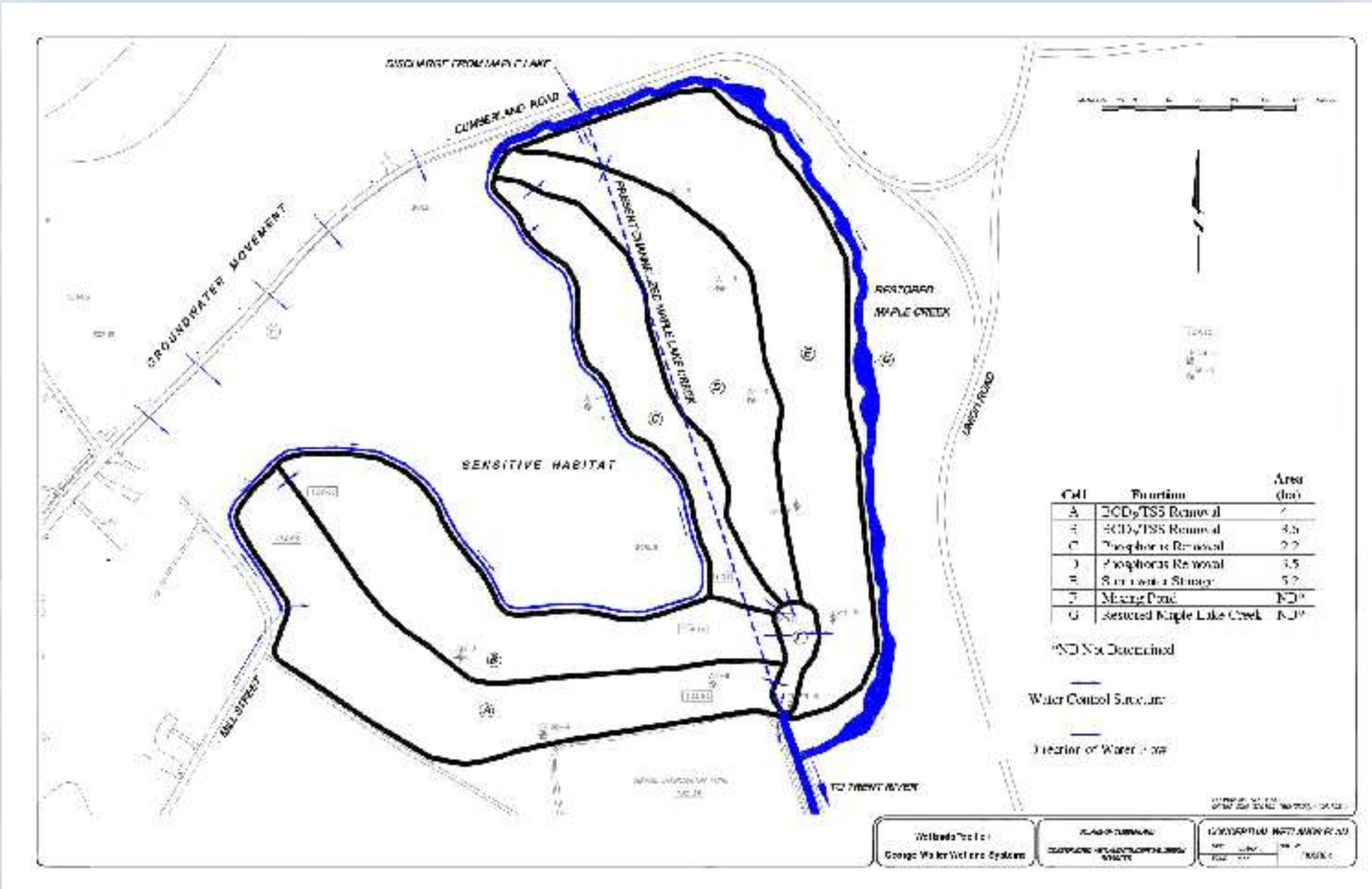
Interpretive Centre

75 acre Expansion Planned

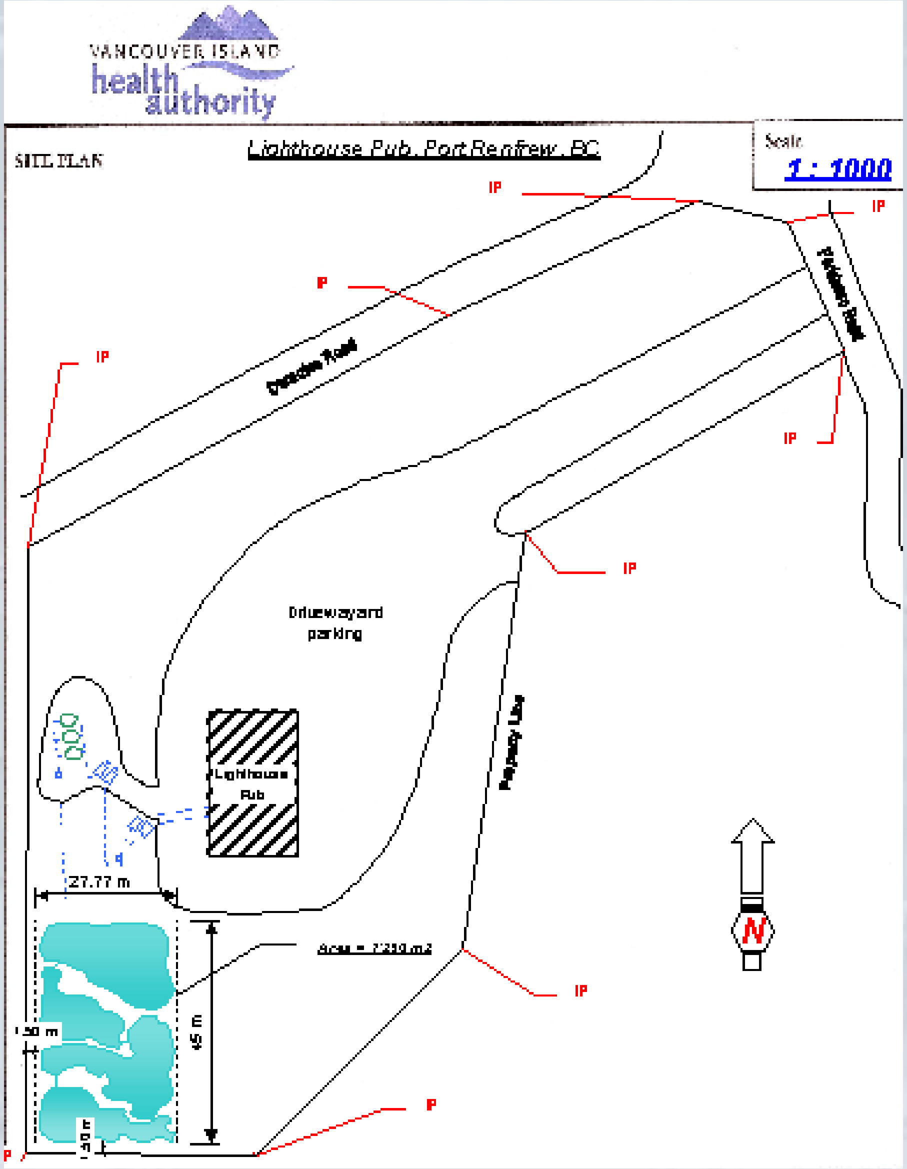
Prince George, BC
Constructed Wetland

Prince George, BC
Constructed Wetland

Constructed Wetland Prince George, BC
Control Structure



Cumberland, BC Conceptual Plan



Lighthouse Pub, Port Renfrew

Types of Constructed Wetlands

- Free Water Surface
- Vegetated Submerged Bed
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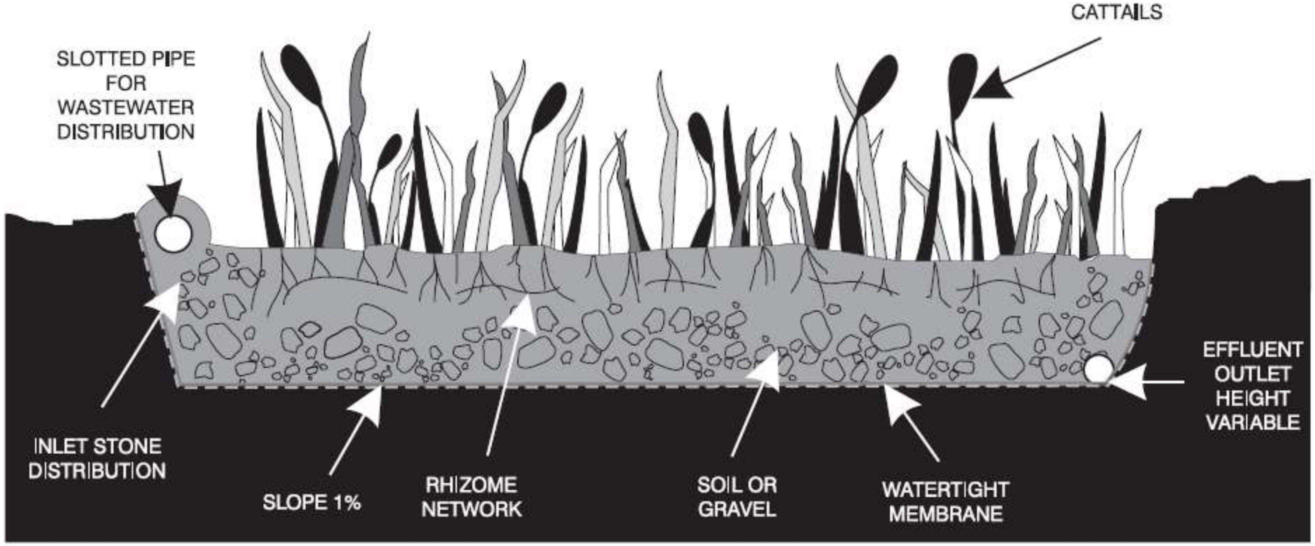

Source: Toms Creek Project, VA.

Vegetated Submerged Bed

Types of Constructed Wetlands

- Free Water Surface
- Vegetated Submerged Bed
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Ditch that flooded, carried polluted water

Linear Constructed Wetland

Lineal Constructed Wetland with Arrowhead *Sagittaria sagittifolia*

Types of Constructed Wetlands

- Free Water Surface
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Stormwater Wetland, Arcata, CA

Types of Constructed Wetlands

- Free Water Surface
- Vegetated Submerged Bed
- Lineal
- Storm
- Vegetative Tertiary Filter
- Lagoons (sort of)

Vegetative Tertiary Filter

Installed in after a failed Type I in shallow clay soils

A Proud Homeowner
VTF installed on Cherry Point Road, Cobble Hill, BC

VTF 8 months after planting
Duncan, BC

Port Renfrew Hotel Gunnera ***VTF*** Last Year

Port Renfrew Hotel Gunnera ***VTF*** Now

Front Yard VTF Dispersal Area

Review

Wastewater treatment follows an exponential decay function

Surface area to volume ratios vital

FWS Constructed Wetlands have wide applicability

Lineal constructed wetlands also have wide applicability

Stormwater wetlands will become the norm

Over 50 Vegetative Tertiary Filters installed in BC

2009 Conservation Forum Proceedings: Recycled Water/Plant/Soil Compatibility

A Conversation on the Successful Use of Recycled Water & Drought Tolerant Plants in Park Settings

County of Los Angeles Department of Parks and Recreation

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Keynote Speaker

Reverse osmosis filtration at a desalination plant (Photo: Terry J Alcorn ©)

HISTORY OF SALINITY MANAGEMENT ISSUES FACING SOUTHERN CALIFORNIA

Richard Atwater, General Manager of the Inland Empire Utilities Agency
and Chair of the Southern California Salinity Coalition

INTRODUCTION

The Metropolitan Water District of Southern California initiated a comprehensive salinity management study in 1997. The purpose of the study was to identify problems and issues facing the MWD service area in phase 1. And then in phase 2 develop strategies and an action plan to address the salinity management problems. Key strategies were to reduce salinity impacts to allow greater recycled water use and enhance the salt balance of the watersheds within the MWD service area. Key elements of the action plan included:

1. Desalination (brackish and seawater)
2. Brine Disposal
3. Wastewater Collection Systems
4. Watershed/Source Control
5. Research and Development Program

BACKGROUND

One of the most valuable commodities of our nation's resources is pure high quality water. However, this critical resource is being threatened each year through the influx of salts. Though salts are naturally occurring minerals and are integral to survival, in too high of quantities, it can kill as exemplified by the Dead Sea in the Middle East. Currently, large portions of the nation's water supply are being threatened by an influx of salt originating from human, industrial and even natural processes. Salt accumulation has a detrimental effect on water quality, because it limits the use for drinking, agriculture and other water uses. Farmers must have quality water to grow their crops. Industry must have low saline water for production. Even residential areas will seek alternative and more expensive water supplies when high saline levels begin to affect taste. The cost impact to this country is enormous. According to the U.S. Bureau of Reclamation figures, the Lower Colorado River Basin suffers an estimated $750 million a year in economic damage as a result of saline Colorado River Water. Approximately $382.5 million of that damage occurs to residential areas, $180 million to infrastructure utilities and $37.5 million to industry.

To address the salinity problems, a Coalition of stakeholders concerned with salinity was formed in southern California under the leadership of the MWD with different functions and interests was formed, but with a mutual goal to address this difficult problem. Various methods of reducing salts are being examined. One method of reducing salts in urban water supplies is by controlling and improving the source of water used by cities. California, with one of the most intricate water systems in the world, depends heavily on an imported water supply. The bulk of the state's population – over 20 million – live in southern California cities. Much of this population is dependent on flows from the Colorado River, a water source with (on average) over twice the salts of northern California water sources. To control the salt levels, the salt laden Colorado River water is blended with the typically less salty State Water Project water from the Sacramento-San Joaquin Delta. However, with less export of fresh water occurring from the north due to environmental and urban needs, salt levels in Southern California continue to rise. Further, the salt levels from both the SWP and the Colorado River continue to rise to due increasing agricultural return flows and urban discharge. The end result is a problem growing in intensity. Walt Pettit, former executive director of the California State Water Resource Control Board has said "Salinity in the Central Valley and southern California is probably the biggest water problem in the state that isn't being adequately addressed." This concern is mirrored in many other states throughout the nation as sources of good quality water decrease due to increasing salt levels.

WHAT CAN BE DONE?

The solutions to this ever-growing problem are available. The Salinity Coalition views the best approach as a multi-prong solution. One of the most effective forms of salt removal is the use of desalination facilities. Desalting, a form of water treatment, can be used to remove salts from groundwater, reclaimed water, and ocean water. Due to the abundance of water systems dependent upon groundwater wells and to the relative cost compared to desalting reclaimed water and ocean water, the desalination of groundwater will be the highest priority to any long-range plan to insure clean and reliable water. Under groundwater desalination, water is pumped from the ground and then sent through various treatment processes, typically reverse osmosis, where the salts are separated out of the potable water and discharged into a saline brine pipeline. The discharge pipeline is then sent to a wastewater treatment facility for further treatment and eventually discharged to the ocean. Due to the need to convey the brine from the desalting facility to the wastewater treatment plant, new brine pipelines must be constructed.

However, the impacts of the increased salts are still not alleviated once the salts are remove from the water supplies. As brines are discharged, they are sent to the Publicly Owned Treatment Works (POTWs). The POTWs will often receive brines loads not from just the desalination facilities but also from industrial wastewater dischargers. The cost impacts of the combined brine discharges can be significant. Direct and indirect costs are incurred by POTWs on multiple fronts, which include loss of hydraulic capacity of sewerage systems, the degradation of POTWs infrastructure from corrosion, the loss of reclaimed water use due to higher salt loads, the lowering of value and ability to reuse biosolids, and the significant regulatory cost of objectionable pollutants often discharged with brines. Further with a growing populace investing in water softeners for home use, salt is added through the use of regenerative water softeners to the sewer system further exacerbating the salt loading problems.

Other sources of salt loading include the non-point source salt loads from agriculture and urban uses. These salts, though not sent to wastewater treatment plants, permeate into the ground through the natural recharge process of water in rivers and streams and further degrade groundwater supplies. Their origins can often be traced to lawn and landscape fertilizers, manure from confined animal facilities, and agricultural fertilizers. The salt added to agricultural lands is further complicated by the fact that the very nature of irrigation can add salt to water supplies by flushing salts from the soil and into water sources.

The Salinity Coalition plan for the nation is based on simple, progressive, but attainable goals. It is comprised of measures that address salt loading and the removal of salts using a multiple approaches. These areas and the costs for the program are presented below.

Salinity Management Coalition Components

Desalination – Due to numerous factors over many years various regions with underground water storage basins have significant salt contamination. Desalting the groundwater is a key to any long-range plan to insure clean and reliable water. Desalting is needed not only for groundwater but also reclaimed water and ocean water. The water produced could be stored to drought proof the nation. In order to truly have a reliable water supply, the country needs to move aggressively to desalt and store imported water supplies. The Salinity Management program will:

- Remove salinity in underground basins through desalination technologies
- Reduce salts in wastewater sources to allow greater recycling and reuse

Brine Disposal – With an aggressive desalination program, the resulting brine generated from such a massive effort will need to be conveyed to treatment facilities and eventually to the ocean. The Salinity Management program proposes to construct new brine pipelines in order to transport salts from desalination and industrial discharge locations and thereby reverse the salt loading trends to our environment.

Wastewater Collection Systems – Any program to remove salts from our nation's water supply must also include measures to manage saline discharges to wastewater collection systems. The Salinity Management program will support funding to separate high saline discharges from the wastewater collection systems and thereby reduce treatment, biosolids and reclaimed water use costs. The goal is to fully recycle and reuse wastewater for irrigation, recharge of groundwater aquifers and other non-potable uses.

Watershed/Source Control – With increased urbanization, it is essential that growth occurs in balance with the environment. The impacts of urbanization are felt through increased nonpoint source salt contributions. The Salinity Management program calls for the establishment of effective watershed management activities to control nonpoint source salt loads to our nations streams and rivers. Funding would be used to help determine the sources of salt loading in watersheds and thereafter implement best management practices to control the salt loads.

Research and Development Programs – A final component, but still a necessary factor for effective implementation, is the support of desalination research and development. The Salinity Management Program proposes the funding support of research and development partnerships to reduce costs associated with importing TDS from imported water, groundwater, recycled water, and agricultural drainage. Emphasis will be placed on the support of pilot scale demonstration projects, which may result from the research and development activities.

Salinity Management Coalition Activities

- Advocate source protection programs to reduce the salt increases in wastewater and imported supplies
- Promote new technology and research on methods to control and remove salinity in our water supplies
- Develop public education programs on the issues related to salt contamination of our watersheds and to ensure recycled water salinity is usable for irrigation purposes
- Host workshops and other forums with state and federal officials to collaborate on actions to reduce the impacts from salinity

Richard W. Atwater has over thirty years experience in water resources management in the western United States. He has pioneered many award-winning water projects and implemented numerous innovative water resource management programs that meet today's high standards for quality, reliability and cost-effectiveness. Mr. Atwater has testified extensively before the United States Congress and the California Legislature on water policy issues. Mr. Atwater was also President of Bookman-Edmonston Engineering, Inc., a water resources consulting firm founded in 1959, with a consulting practice throughout the western US. His previous experience included managing the Resources Division for Metropolitan Water District of Southern California where he was responsible for the District's water supply contracts (Colorado River and State Water Project) and the local water resources programs. From 1981 to 1985, Mr. Atwater was the Assistant to the Commissioner of the Bureau of Reclamation, Department of the Interior in Washington, D.C.

Session 1 | RECYCLED WATER - ADDRESSING THE ISSUES

Reclaimed water has been safely used for irrigating William R. Mason Regional Park, Irvine, CA for several decades.

EFFECTS OF RECLAIMED WATER ON SOIL: CHEMICAL CONTENT DIFFERENCES FROM PURVEYOR TO PURVEYOR

Laosheng Wu, Professor of Soil & Water Science, CE Water Management Specialist, Department of Environmental Sciences, University of California-Riverside

A sign showing that the landscape is irrigated by reclaimed water at William R. Mason Regional Park, Irvine, CA.

WATER REUSE

Increasing demands on limited water resources have made wastewater reclamation for municipal irrigation an attractive option for extending water supplies in the semiarid Southwest. To meet these increasing water demands, water reuse has become an integral part of comprehensive water management plans. In California, over 500,000 acre-feet (AF) of reclaimed water are put to beneficial use annually (CSWRCB, 2003). It is predicted that an additional 2 million AF will be used by 2030.

While current wastewater reclamation technology is capable of producing finished water of any desirable quality, the amount of impurities (pollutants) in reclaimed wastewater after conventional treatments may accentuate the potential impact on water reuse. Some of the pollutants are of agronomic importance; while others are of environmental and human health importance.

Salinity

Salinity is frequently expressed in terms of total dissolved solids (TDS) or electrical conductivity (EC) of the water, but plants respond primarily to TDS. An approximate relationship between EC and TDS can be described by (Tanji et al. 1990):
1 dS/m » 700 mg/l (TDS).

The salinity level in reclaimed wastewater is invariably higher than in the source water, making it less attractive aesthetically for certain types of reuse. But the salinity of reclaimed water sometimes are lower than other irrigation water sources such as groundwater. Problems due to salinity may also be alleviated with proper irrigation management and selection of tolerant plant species.

Sodicity

Sodicity is often evaluated by the sodium adsorption ratio (SAR) of soil solution, soil extract, or irrigation water. It is defined as:

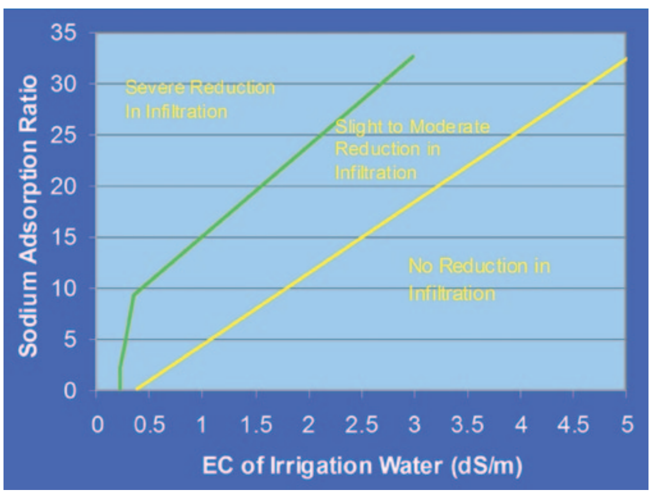
$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

where Na+, Ca++, and Mg++ denote the concentrations of respective cations of the water (meq/L). A high SAR can cause soil infiltration problems. Generally, irrigation water with high SAR value (i.e. SAR > 9) can cause severe restrictions on permeability when applied to fine textured clay soils over a period of time. But the sodic (SAR) effect of water is often evaluated together with salinity. At the same SAR level, soil is more susceptible to dispersion in a low salinity water than in a high salinity water.

Potentially toxic elements – boron, chloride, sodium

High levels of boron, chloride, and sodium in irrigation water are potentially harmful to plants. Boron is by far the most likely element to harm plants irrigated with reclaimed wastewater. Small amounts of boron (i.e. <0.5 mg/kg) are essential for plant growth, however, at only slightly higher concentrations (> 0.5 mg/l in irrigation water), it may become toxic to plants. Plant tolerance to boron in soils varies widely. Concentrations of boron in reclaimed wastewater principally originate from household detergents and cleansing agents, and are not expected to be high enough to cause immediate harm to plants. However, boron may accumulate in the root zone through long-term use of reclaimed wastewater.

Chloride and sodium ions are major dissolved constituents of the water. In addition to their role in salinity, both chloride and sodium may be harmful to plants at high concentration (FAO Irrigation and Drainage Paper 48, 1992).



Effect of electrical conductivity (EC) and sodium adsorption ration on water infiltration.

Nutrients

Reclaimed water can serve as a source of nutrients essential for plant growth, i.e. N, P, and K. These nutrients are beneficial to plants, but if not properly managed, they may cause many problems, such as nutrient imbalances, eutrophication of surface waters, and contamination of groundwater. Among them, N is the most noteworthy because the inputs could be significant in a reclaimed wastewater irrigation operation. It is imperative that fertilization practices be adjusted to account for the added inputs from wastewater to avoid over-application that may result in adverse impacts on water quality.

Chlorine residues

Chlorine residues are inherent to reclaimed wastewater and will gradually dissipate as the finished water is in storage. Excessive amounts of available free chlorine may cause leaf-tip burn and damage some sensitive crops if still present at the time of application. For turf grass where water applications are frequent, the grass may become discolored over time and exhibit a slight yellow tinge. No scientifically based threshold values for plant injury are available, but < 5 mg/L is considered to be safe.

Pathogens

Through proper treatment and disinfection of wastewater, pathogens will be inactivated. Pathogens are the greatest health concern in using reclaimed wastewater for irrigation is directed to pathogens. Reclaimed wastewater has been used for irrigation for many decades and thus far no scientific investigation has found that reclaimed wastewater irrigation has contributed to human illness. Although pathogens have the potential to reach the field, but many factors, including crop type, irrigation method, cultural and harvesting practices, and environmental conditions (temperature, humidity) can affect transmission of disease. Proper agronomic management can reduce and minimize the potential for disease transmission.

Pharmaceutically-active chemicals and endocrine disruptors

Residues of over the counter and prescription drugs including antiphlogistics (such as ibuprofen and naproxen), lipid regulators, and beta-blockers have been found in treated wastewater effluents. Among the pharmaceutically active ingredients, the residues of antibiotics and hormone-like compounds have attracted the most attention. Although conventional wastewater treatment is not designed specifically to remove these potentially harmful chemicals, the treatment processes nevertheless effectively reduce their concentrations in the treated effluents. Field study and soil and groundwater survey these compounds have very limited mobility.

MANAGEMENT PRACTICES TO REDUCE ADVERSE EFFECT OF RECLAIMED WATER

Salinity Management-Leaching Requirement

When leaching is not required, the water needed for normal plant growth is equal to evapotranspiration (ET). However, additional water is often required for leaching in order to keep salinity in check. This leaching requirement (LR) is dependent on the salinity of irrigation water (ECw, dS/m) and the crop tolerance to soil salinity (ECe, dS/m).

Soil Amendment

Amendment requirements for irrigation water (to obtain 1 meq/L of calcium) to reduce water penetration and redistribution problems:

- GYPSUM: 230 lbs per acre-foot
- SULFURIC ACID: 130 lbs per acre-foot (calcareous soils only)
- N-pHuric 10/55: 148 -242 lbs per acre-foot (calcareous soils only)

Amendment requirements for soil to reduce water penetration and redistribution problems: soil application (tons required per acre to replace 1 meq/100 g of exchangeable sodium in 6 inches of soil:

- GYPSUM: 0.9 tons
- SULFURIC ACID: 0.5 tons
- SULFUR: 0.2 tons
- N-pHuric 10/55: 0.5-0.9 tons

SUMMARY

- Quality of recycled water varies greatly from place to place.

Photo courtesy of Inland Empire Utilities Agency

- Generally recycled water contains higher TDS and more contaminants than the corresponding fresh water.
- High salinity and sodium, and some toxic elements in recycle water affect crop growth and soil quality.
- Irrigation management and soil amendments may alleviate some of the adverse effects.
- PPCPs & DBPs have relatively low mobility. But to reduce their potential risk, over irrigation should be avoided.

REFERENCE

Laosheng Wu, Weiping Chen, Christine French, and Andrew Chang. 2009. Safe Application of Reclaimed Water Reuse in the Southwestern United States. UC DANR peer-reviewed Publication 8357.

Dr. Laosheng Wu is a Professor of Soil & Water Science and Water Management Extension Specialist in the Environmental Sciences Department at University of California-Riverside. He earned his B.S. degree from Zhejiang University, China, M.S. degree from Oregon State University, and Ph.D. degree from University of Minnesota.

IMPACT OF IRRIGATION WITH RECYCLED WATER ON LANDSCAPE

Bahman Sheikh, Water Reuse Consultant

Plants vary in their requirement for light, water and nutrients as well as their susceptibility to adverse environmental conditions. Although many plants can tolerate a wide range of conditions, others have distinct preferences for particular climate and soils, and do not thrive very well elsewhere. The natural distribution of plants is determined by the interaction of many environmental factors and these include intensity and duration of light, temperature regimes, soil properties, availability of plant nutrients, quantity of rainfall and of applied water, quality of applied water, wind, flooding and fire, and biotic interactions such as competition for space and sunlight with other plants, grazing by plant eating animals and microbes causing plant diseases.

The City of Torrance uses recycled water at Columbia Park. Photo courtesy of Central Basin.

Most recycled waters do not inherently contain excessively high levels of salinity even though they typically contain about 150 to 400 mg/L (ppm) more salts than potable waters from which they originated. The salinity of waters may affect plants due to osmotic hazards and they may suffer reduced growth rates and foliar damages and in the severest cases, death. Plants have a wide range of tolerance to salinity and many of them could be irrigated with recycled waters without any impact at all. Water quality of recycled waters may have impacts on plants, soils and irrigation systems. Water quality assessment and management in irrigated agriculture is much more established than in landscape irrigation, except for turf irrigation. Thus, a significant portion of this literature review explored technology transfer from irrigated crop production to irrigated landscape management in terms of evaluating water quality, problem diagnosis, and suggesting management options. However, a major difference exists in the goals between agricultural crops and landscape plants in that the former is based on harvested crop yields and the latter on aesthetic quality and appearance.

If communities utilize sodium chloride-based water softeners, the recycled water may contain elevated sodium and chloride ions compared to the potable water supply. Use of cleaning agents such as detergents may also elevate boron concentrations in recycled waters. Plants differ in their sensitivity to specific ions of sodium, chloride and boron. Sensitive plants typically exhibit foliar leaf damages and in the more severe cases, defoliation and death. Excessive levels of sodium may also cause an imbalance in mineral nutrition of plants such as calcium deficiency.

Another constituent of concern in recycled waters is excessive nitrogen in the form of dissolved ammonia or ammonium ions and nitrates. The presence of these forms of nitrogen is highly dependent upon the wastewater treatment processes employed. Ammonia or ammonium ions in applied waters are eventually oxidized into nitrate ions in the soil. Other forms of nitrogen such as organic nitrogen and nitrite occur in smaller concentrations. Nitrogen in recycled water used for irrigation is of concern because nitrates not taken up by plant roots may leach below the root zone and contribute to nitrate contamination in underlying groundwater basins. Nitrate leaching losses may be minimized if N content in the recycled water is taken into account as contributing to the nitrogen requirement of plants, by reducing the applied nitrogen fertilizer rate.

SALINITY AND SODICITY

Soil permeability exhibited by water infiltration rates into the soil surface and passage of water through the soil profile is affected by the combined effects of sodicity and salinity in the applied water. Sodicity is usually evaluated by the Sodium Adsorption Ratio (SAR, a ratio of sodium to calcium plus magnesium) and salinity by electrical conductivity (EC, specific electrical conductivity). A moderate level of SAR and low EC may result in reduced soil permeability of some soil types. In contrast, the detrimental effects of moderate levels of SAR on soil permeability may be partially overcome by moderate levels of EC. In some treatment processes for recycled waters additives are used that elevate SAR (e.g., using sodium hypochlorite for disinfection) and/or bicarbonate and carbonate concentrations (e.g., using lime to neutralize water pH). The graphic on this page shows that nearly all recycled waters produced in California have a combination of salinity and sodicity that puts them in the safe range in terms of impacts on soil permeability.

A second sodicity parameter known as Residual Sodium Carbonate (RSC, difference between sum of bicarbonate and carbonate ions minus sodium ion) is used to evaluate detrimental effects that cause dispersal of soil organic matter resulting, for instance, in dark unsightly matting on turf in golf courses, and reduced water infiltration rates into turf soils.

SALINITY CONTROL IN THE ROOT ZONE

Management options are available to reduce the impacts of salts. Important among these options are:

- Accounting for the recycled water nitrogen content as contributing to the nitrogen requirement of the plants and thereby reducing nitrogen fertilizer application rates.
- Injecting an acid or calcium amendment to the high-SAR or a high-RSC water to prevent dispersion of soil organic matter and poor water infiltration rates.
- Where salinity or specific ions may have detrimental impact to plant performance, they could be replaced by more tolerant plants.

The soil is the medium from which plants take up water and essential mineral nutrients, and provides plants with its rooting system as means of support. Salts have a tendency to build up on the root zone of actively transpiring plants because more or less pure water is lost to the atmosphere through evaporation and transpiration while dissolved mineral salts in the applied water are left behind in the soil solution. The presence of dissolved mineral salts has an osmotic effect on plants and some of its constituents like sodium, chloride, and boron cause specific ion toxicities to plants. It is necessary to maintain a salt balance in the root zone to obtain satisfactory plant performance, especially under semiarid climatic conditions when natural rainfall may be insufficient to leach salts out of the root zone. In surface-irrigated soils

Photo courtesy of N. Denison © 2006

(e.g., sprinklers) with no drainage impediments, the upper root zone is the zone of salt leaching while the lower root zone is the zone of salt accumulation. The graphic below illustrates the impact of salinity of irrigation water on "yield" of biomass for crops of various sensitivity and tolerance to salt. The purple arrow represents the range of salinities typically encountered in recycled water. Since that range of salinity corresponds with nearly 100 percent yield, it is logical to assume that the impact on appearance and survival of landscape species would be negligible as long as the root zone of the soil is maintained well-drained.

Fortunately, most landscape plants have a denser rooting system in the surface depths where soil salinity tends to be lowest. Soil water is extracted from the more saline deeper root zone only when the available soil water becomes limiting in the less saline portions. The extent of accumulation of salts in the lower root zone is regulated by the Leaching Fraction (LF), the ratio of depth of drainage water to depth of applied water. The depth of drainage water may be obtained from the difference between applied water and water lost to the atmosphere from transpiration by plants and surface soil evaporation. In freely draining soils, a comparatively small depth of drainage may be sufficient to keep the root zone in salt balance. A LF of 0.15 to 0.2 is usually adequate to maintain salt balance for irrigation of most plant species and for typical recycled water water salinities.

Metropolitan State Hospital uses recycled water for their irrigation. Photo courtesy of Central Basin.

PROBLEM DESCRIPTION, DIAGNOSIS AND POTENTIAL MANAGEMENT SOLUTIONS

A problem encountered in landscapes may be due to multiple abiotic and biotic causes or factors, and thus accurate diagnosis and seeking appropriate solutions are challenging. Abiotic stress factors that may cause plant injury or diseases include salinity, mineral deficiencies and excesses, moisture and temperature extremes, wind, air pollutants, and herbicides. Biotic stress factors that may cause plant injury or diseases include insects, mammals and birds, bacteria, fungi, nematodes, and viruses.

Irrigation and drainage problems can cause plants suffering from water stress or presence of dry or wet areas, excessive ponding, waterlogging and runoff. The diagnosis of these problems, respectively could be insufficient irrigation, poor uniformity of water application system, high SAR and low EC water, soil compaction and slow water penetration. Potential solutions for these problems could be increased duration and/or rate of irrigation to satisfy plant ET, improved uniformity with change in spacing of lateral lines and sprinkler heads, adding soil amendment (usually gypsum), reducing machine and foot traffic, and decreasing irrigation application rate and/or duration.

Photo courtesy of bludgeoner86 @ Flikr.

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Session 2 | SUITABLE PLANT MATERIALS

California buckeye *(Aesculus californica)* grove (Photo courtesy of Carol Bornstein)

WATER-WISE CALIFORNIA NATIVE AND EXOTIC PLANTS FOR RECYCLED IRRIGATION

Carol Bornstein, Native Plant Specialist

INTRODUCTION

As demand for California's increasingly limited water supply continues unabated, water agencies and municipalities must seek new sources for landscape and agricultural irrigation. Recycled water is being promoted as one answer. A key question has yet to be satisfactorily answered, however: Which water-thrifty California native and non-native landscape plants can be successfully grown using recycled water? An informal survey of designed landscapes in the greater Santa Barbara area was conducted to address this question. It was determined that a wide array of trees, shrubs, succulents, and herbaceous species are thriving with recycled irrigation but that the results may not be applicable to other regions of the state. Numerous plants were illustrated in this presentation and are itemized on the accompanying list.

California fuschia *(Epilobium canum)*. Photo courtesy of Carol Bornstein.

METHODS

Addresses for landscapes irrigated with recycled water were obtained from the cities of Santa Barbara and Goleta. An informal survey of thirteen sites was made during the summer. The landscapes varied from highly manicured residential and commercial sites to public parks and naturalistic restoration sites. Healthy, well established plants were photographed and plant lists were compiled for each site. After the physical survey, the landscape managers of several sites were contacted and asked the following questions:

- How many years has the landscape installation been in place?
- How would you describe the soil?
- Was the soil amended at planting time? If so, what was used?
- Is the site fertilized? If so, how often and with what product(s)?
- Is the soil and water supply regularly tested and routinely monitored?
- What kind of irrigation system is used?
- What is the irrigation schedule?
- Is the planted area periodically leached and if so, how often?
- What problems, if any, have you had with the landscape?

In addition to the survey, a literature search was conducted to obtain lists of plants that are recommended for recycled irrigation. Comparisons between these lists and firsthand observations were made.

Cleveland sage hybrid *(Salvia* x *clevelandii)* irrigated by reclaimed water at Rio de Los Angeles State Park. Photo: Drew Ready.

Sunflowers *(Helianthus annuus)* irrigated by reclaimed water at Rio de Los Angeles State Park. Photo: Drew Ready.

RESULTS AND DISCUSSION

Despite considerable repetition of several species throughout the survey sites, a reasonably diverse selection of native and non-native plants are growing successfully with recycled irrigation in Santa Barbara area landscapes. Due to limitations of the survey, it was not possible to ascertain which species were tried and failed. It was interesting to note that many of the successful plants were included on the plant lists resulting from the literature search.

The surveyed sites reflect a variety of soils (from sandy to clay loam to highly manipulated soils on top of a landfill), fertilization practices (none to occasional), irrigation regimes, ages, and microclimates but do share one thing in common - proximity to the recycled water distribution lines. As a result, all of the sites fall within the cool coastal strip of Sunset zone 24.

Site managers for the most part had few problems with recycled water, except for the landfill location. There, the salt content of the water is highly variable depending upon time of year and chlorine is problematic, necessitating use of potable water to leach the soils from time to time.

Although the plants included in the survey are considered to be drought-tolerant (able to thrive on natural rainfall once established), many of these landscapes continue to be irrigated as much as 3 times a week during the summer months. With the exception of newly installed plants that require supplemental irrigation during the establishment phase, one must question such unnecessary irrigation, regardless of whether the source is potable or recycled water. In contrast, one of the surveyed sites (composed entirely of California native species) is irrigated only once a year and the plants were in good condition.

CONCLUSIONS

Based on this very informal survey, it is inappropriate as well as impossible to recommend the attached list of water-thrifty native and non-native plants for recycled irrigation in other parts of California. The tremendous diversity of climates and soil types around the state, coupled with widely varied planting, irrigation, fertilization, and mulching practices, points to the need for rigorous, science-based research trials in each geographic region where recycled water is available for landscape use. Without such experimentation, water purveyors and their customers must continue to rely primarily upon anecdotal information when selecting plants for recycled irrigation.

The author would like to thank the following people for their assistance with this survey:

Abel Landeros, *Head Gardener, Santa Barbara Zoo*
Alison Jordan, *Water Conservation Coordinator for the City of Santa Barbara*
George Johnson, *Creeks Supervisor, City of Santa Barbara*
Ginger Kaufman, *Recycled Water/Cross Connection Specialist for the City of Goleta*
Lee Douglas, *Plowboy Landscapes, Santa Barbara*
Mike Gonella, *Chair, Environmental Horticulture Department, Santa Barbara City College*
Steen Hudson, *Executive Director, Elings Park, Santa Barbara*

Carol Bornstein is one of Southern California's most highly respected native plant specialists. She co-authored the award-winning book, California Native Plants for the Garden, with Dave Fross and Bart O'Brien and is currently collaborating with them and Cachuma Press on a book about lawn alternatives. Carol earned her B.S. in Botany from the University of Michigan and her M.S. in Horticulture from Michigan State University and was horticulturist at the Santa Barbara Botanic Garden for 28 years.

DROUGHT AND SALINITY TOLERANCE OF TURFGRASSES

David A. Shaw, Farm Advisor,
U.C. Cooperative Extension, San Diego County

This presentation will cover the turfgrasses available and commonly used in California, their water use and drought tolerance, and tolerance of salinity. Also discussed are turfgrass management issues and research and educational programs that focus on enhancing turfgrass quality under saline and drought conditions. These topics are of concern because of the demand for quality turfgrass while utilizing water with increased salt content (such as recycled water) especially in areas where turf is under-irrigated or drainage is minimal.

References for this presentation and the tables of information are located on the Salinity Management Guide CD. In addition, a new publication Managing Turfgrass During Drought (available for free download at http://anrcatalog.ucdavis.edu/Items/8395.aspx) contains detailed information on turfgrass water use and drought tolerance as well as management strategies under drought conditions.

There are many turfgrass species available and capable of growing in southern California. There are significant differences between these species and within cultivars of the same species in terms of color, density, texture, and playability. There are also differences in their tolerance to drought and salinity as well as their water use under non-limiting conditions. There are also differences in resource needs and management practices. These factors are considered when selecting a grass for a particular turf application or use. Turfgrass areas range from those strictly aesthetic, to golf course roughs, fairways, greens and tees, to sports facilities. Each of these areas may utilize a different grass species and management level.

Evapotranspiration (ET) rates, drought tolerance, grass type, and tolerance to soil salinity for the major turfgrass species have been assessed through research trials *(Table 1)*. In terms of water use and drought tolerance, the warm season grasses are superior to the cool season grasses. This is because warm season grasses have the ability to store carbon dioxide in leaf tissues and can continue photosynthesis even when stomata are more closed under mild water stress conditions. This is characteristic of "C4" plants as opposed to the physiology of cool season grasses or "C3" plants which do not have the capability to store carbon dioxide. Considering both ET rate and drought tolerance, Bermudagrass, seashore paspalum, and buffalograss have low water use rates and high drought resistance. Tall fescue, a cool season grass, has high water use rates and medium drought resistance. In contrast, ryegrasses and bluegrasses have high water use rates and fair or poor drought resistance.

All of the warm season grasses are moderately tolerant to tolerant of soil salinity while the majority of the cool season grasses are sensitive or moderately sensitive. The mechanisims of salinity tolerance are physiological in nature and include the shunting of photosynthates from top to root growth, osmotic adjustment via ionic substitution and redistribution, and increased organic acids in cell sap. Tolerant species may have to ability to exclude salt, have less sodium and chloride uptake, and higher potassium, magnesium, and calcium levels in plant tissues. In addition, tolerant grasses have proline levels that are 8-15 times the concentration of that in sensitive species.

Generally, warm season grasses are more water conserving and salt tolerant than cool season grasses. This is why Bermudagrass, seashore paspalum, or other warm season species is selected for use at many facilities. Since theses grasses can out compete the cool season species, they will often become established as weeds in cool season turf and gradually take over the sward. Hence kikuyugrass and common bermudagrass have become widely grown, but not necessarily by choice.

While water needs and salinity tolerance is important, there are many other factors to consider in the turfgrass selection process. These include the use of

Table 1. Grass type, ET rate, drought tolerance, and tolerance to soil salinity for turfgrass species commonly used in California.

Turfgrass Species	Grass Type	ET Rate	Drought Tolerance	Turfgrass Tolerance to Soil Salinity (ECe)
Annual Bluegrass	CS	Very High	Poor	Sensitive < 3 dSm-1
Colonial Bentgrass	CS	Very High	Poor	
Bluegrass	CS	Very High	Fair	
Annual Ryegrass	CS	Very High	Poor	Moderately Sensitive 3-6 dSm-1
Creeping Bentgrass	CS	Very High	Fair	
Red Fescue	CS	Medium	Fair	
Hard Fescue	CS	Medium	Fair	
Perennial Ryegrass	CS	High	Fair	Moderately Tolerant 6-10 dSm-1
Tall Fescue	CS	Very High	Medium	
Kikuyugrass	WS	High	Good	
Zoysia grass	WS	Low	Excellent	
Creeping Bentgrass 'Seaside'	CS	Very High	Fair	Tolerant >10 dSm-1
Alkaligrass	CS	-	-	
Bermudagrass	WS	Low	Superior	
St. Augustinegrass	WS	Medium	Good	
Seashore paspalum	WS	Medium	Excellent	

the grass and the maintenance needs including planting, mowing, fertilizing, dethatching, and renovation. However, the major drawback of using warm season grasses is their winter dormancy period when the grass stops growing and loses its green color. Development of cultivars that maintain color in the winter continues to be a research priority for the industry.

Research and education have a major role in turfgrass management. New or improved cultivars are introduced relatively frequently and there is coordinated performance testing through the National Turfgrass Evaluation Program. Grasses cultivars can be developed through selective mutation, cross breeding of cultivars, and even genetic engineering at a much faster rate than that of other horticultural crops and the resulting products can be introduced into the industry fairly quickly. Currently, university and industry researchers are continuing to develop salt tolerant species/cultivars, warm season turfgrasses with good winter color, and cultivars with reduced management and resource needs. In the near future, we will see improved cultivars of *Paspalum vaginatum* (seashore paspalum), *Distichlis spicata* (salt grass), and other salt tolerant species.

In summary, salinity tolerance and water use data is available for the major turfgrass species. This information is critical for facility managers utilizing recycled water. Warm season grasses are generally more salt tolerant than cool season turfgrasses. Salt 'burn' (often seen on leaf tips and margins in broad leaf plants affected by salinity) is not usually seen in turfgrass because of mowing practices. However, the effects of salinity in turf are (generally) reduced growth, recuperative ability, and disease resistance. More research is needed done on the effects of salinity in combination with stress from mowing, excessive play and wear, and drought. Minimizing winter dormancy (or increasing green color retention) in warm season grasses is a research priority. Winter dormancy is probably the major factor that keeps more facilities from utilizing these drought and salinity tolerant grasses.

Many turfgrass species are available for use in different turf applications.

Seashore paspalum *(Paspalum vaginatum)* - using salt to control weeds!

David A. Shaw is a U.C. Cooperative Extension Farm Advisor in San Diego County. Dave has a Master's Degree in Water Science and a B.S. Degree in Plant Science, both from U.C. Davis. Dave provides educational and research programs for commercial clientele in the turfgrass and landscape industries. Educational programs focus on soil and water management, pest management, cultural practices, toxicology and environmental safety, and economics to promote healthy plant materials and commodities. Current research projects encompass recycled water use, irrigation needs of ornamental plants, integrated pest management, and weed control.

RECLAIMED WATER USE IN THE NURSERY SETTING

Debbie Evans, Tree of Life Nursery

Much remains to be seen about the result of using reclaimed water in a nursery setting with container plants.

HYPOTHETIC CONSEQUENCES IN PROPAGATION

Conventional wisdom is that high quality plants of any category require the use of high quality water for propagation – all species, all types. The particles found in any irrigation water is a concern, and propagation nurseries working with small sized plants already filter and purify well and city water because the quality is not high enough for propagation. Since reclaimed water has fairly high concentrations of these particles also, its use in propagation would inhibit plant growth, especially in small sizes.

If reclaimed water were to be used in nurseries, it would not be possible to use reclaimed water on small sizes or on propagation material, without extensive testing over a long period of time.

HYPOTHETIC CONSEQUENCES IN MAINTENANCE OF LARGER CONTAINER PLANTS

It would be possible to maintain larger sized plants with reclaimed water, but even 1 and 5 gallon plants that are sufficiently robust to tolerate reclaimed water when planted out, would probably show signs of salt stress in the containers due to salt build up in a matter of weeks.

This would necessitate the use of a dual system even for maintenance of larger sized containers so that there could be times to rinse the plants with clean fresh water to leach out build up of salts.

Why is salt content in reclaimed water an issue in the maintenance of larger sizes of nursery stock?

In a nursery setting, plants, even highly efficient plants that can tolerate reclaimed water in the landscape, are limited to only the size of the nursery container itself to recruit nutrients. As a result, it is necessary to water the nursery containers frequently.

When nursery stock is watered the water is absorbed by the plant, lost into the ground and evaporated into the air. All of those processes decrease the amount of water available and often leaves a higher concentration of salts in the container.

Since the container creates a small, enclosed system to support the roots and size of the plant, and because water is frequently applied, salts would build up very quickly in that very small and enclosed system. The only way to help any plant survive this abuse would be to water with fresh water in order to allow the soil to leach out some of the salts left behind by reclaimed water.

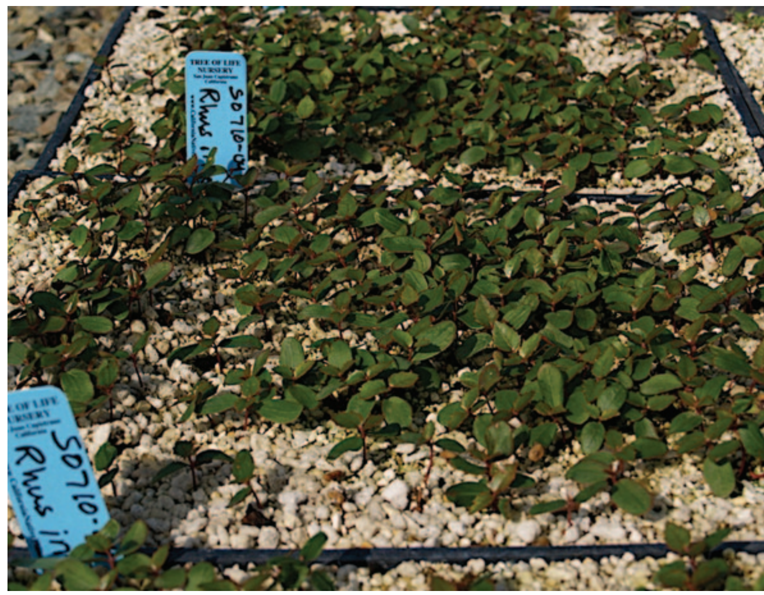
Many nurseries already do “reclaim water” onsite through their own means. Nurseries are not allowed to let water run off their properties as it is, and they collect it in large basins and allow particles to settle out. They then blend this “reclaimed water” with more fresh water to use in their operations. In these cases, the target pollutants are fertilizers and pesticides used during nursery production. It is unknown how such methods would work with reclaimed water to begin with, as the particles in reclaimed water varies greatly as would treatment methods. Of course, a huge consideration, as with all water/plant issues, is salt content.

HYPOTHETIC CONSEQUENCES OF RECLAIMED WATER FOR PLANT CHOICES

If reclaimed water were adopted even for just the maintenance of larger sized container plants, the plant palette would become much more restricted. The most sensitive species would be plants originating from forest or woodland environments.

The plant palette would probably be restricted to salt tolerant plants. In the “native” genre, this would be primarily plants that originate from the desert scrub areas as well as some special coastal species.

We would guess that the remaining palette of plants that would tolerate reclaimed water in maintenance practices for our own nursery would be less than half of our most popular varieties. Plants like Ribes viburnifolium, Ceanothus Yankee Point and Arctostaphylos would not tolerate reclaimed water in the nursery.



RECOMMENDATIONS

Research must be conducted into the actual contents of reclaimed water and its effects on container plants using soil-less mixes, (soil-less mix is a standard, widespread, horticultural practice used to prevent disease and to create uniform crop growth.)

Debbie is Marketing Coordinator at Tree of Life Nursery. She shares the nursery’s passion for all things California and conveys the message about native plants to landscape architects, planners, land managers and restoration specialists. Debbie holds a Bachelor of Science degree in linguistics from the UC San Diego.

Session 3 | RECYCLED WATER DESIGN CONSIDERATIONS

Storage lake for reclaimed water at Tilman Water Reclamation Plant (Photo: Drew Ready)

RETROFIT OF IRRIGATION SYSTEMS FOR RECYCLED WATER USE – PROCESS, ISSUES AND CHALLENGES

Mark Bush, P.E., Project Manager, Tetra Tech Inc.

The conversion of a site from its existing potable water source to recycled water for irrigation usage requires that several elements be evaluated to address the potential challenges ranging from suitability of recycled water use, operational requirements, State and Local Health Agency's requirements, as well as problems that are commonly encountered during construction. The presentation focuses on the common factors used to evaluate a site in order to determine the on-site modifications that will be required.

RECYCLED WATER SERVICE AREA

The first step is to identify potential users for recycled water. By taking a "big picture" overview of your service area and identifying the "green areas". From an aerial advantage, users with large turf areas can be identified, these potential sites include, but are not limited to, parks, golf courses, schools and landscaped parkways and medians. Once potential users are identified, then the suitability and the feasibility of serving recycled water can be assessed. The feasibility of a site conversion includes addressing the suitability of recycled water such as recycled water constituents, chemistry of soils, types of plants and turf, and intended use. In addition the recycled water service limits should be delineated and the separation of the proposed site from adjacent properties reviewed to ascertain the risk of potential future cross-connections. The locations of these potential users can then be referenced back to the existing recycled water infrastructure and the feasibility of serving these sites evaluated. Converting irrigation usage to recycled water is one of the quickest ways to reduce demands on a potable water system.

RECYCLED WATER SUITABILITY

Each site should be assessed for the suitability of recycled water use. Recycled water has a greater concentration of minerals, total dissolved solids and salt than potable water. The amount of these constituents is dependent on the quality of recycled water. Protection of the public health for each site must be at the forefront and conversions need to meet the applicable local, state and federal safety standards. For example, summarized below are some examples of issues, which should be considered for different types of usages:

1. Agricultural – identify food crops for direct human consumption, assess if there is any impact to food color.

2. Nurseries – identify exotic plants that are sensitive to the constituents in the water.

3. Golf Courses greens – review the construction of the greens and their drainage. If drainage is an issue this could lead to salt accumulation. Greens are sensitive to stress because of how tightly they are maintained, an accumulation of salt will cause "browning."

4. Storage Ponds – identify if there is direct human contact and the type of activities occurring at the pond. The nutrients in recycled water could cause acceleration of eutrophication, the natural aging process of a pond which decreases the dissolved oxygen concentration, and the growth of algae blooms. This could result in objectionable odors or loss of aquatic life.

5. Baseball diamonds – the maintenance and usage of the irrigation system needs to be investigated. Sites irrigated with recycled water require the designation of a site supervisor that assures compliance at all times. If the public volunteers to maintain the site and the person/people performing this change regularly, then this site might not be suitable for conversion. The watering of the dirt infield should also be considered. If the public might be performing this activity, then these connections should be kept on potable water.

OPERATIONAL REQUIREMENTS

Once the site is found suitable to utilize recycled water, then the operational requirements for the existing system's pressure and flow requirements need to then be compared to the available system pressure and flow constraints that will be delivered by the recycled water system. The existing irrigation system design should be reviewed to understand the design pressure and flow requirements. The pressure and flow requirements are typically set by the type of sprinkler heads, the number of heads per station and the number of stations operated concurrently. If the recycled water system operates at a lower pressure than the domestic system this could result in reduced coverage and/or increased irrigating times. If the pressure delivered by the recycled water system is significantly higher than the potable water system this could result in damage to the irrigation system (overpressurized) or cause the sprinkler to vaporize, atomizing the water and resulting in a fine mist which impacts the precipitation rate. A pressure reducing valve may need to be considered for this situation. If an irrigation pump is used, then the change in suction pressure needs to be evaluated to see if there will be any impacts to the performance of the pump. There will also be delivery time restrictions with the use of a recycled water system. Irrigation may only occur during periods of least use of the approved area by the public, this is typically between 9 p.m. and 5 a.m. Depending on the area to be irrigated this could result in increased flow demand. If the area being irrigated is not generally accessible to the public, the restriction may not apply.

DESIGN CONSIDERATIONS

After the suitability and operational requirements of recycled water are considered and the site is found feasible to convert then the design aspects for the actual conversion are considered. These included the following:

1. Water Meters
    a. The location and size of the recycled water meter should be determined. The size will be based on the usage at the site. The location will need to meet the Department of Health separation requirements from existing potable water as well as operational requirements.
    b. The question "Does the existing potable meter need to remain?" needs to be answered. If it does, the new demands should be verified to determine if it can be downsized.
    c. Recommend strainers be installed to protect the recycled water flow meter.
2. Backflow Protection – the appropriate level of backflow protection needs to be assessed at the site for all sources of water.
    a. Domestic water systems require the highest level of protection utilizing a reduced pressure principle backflow prevention assembly (RP). All potable water sources that remain at the site will require an RP assembly be installed.
    b. Fire systems require double check assemblies. More commonly we have found that an aboveground double check assembly is required with the Depart-

Reclaimed water feature in the Japanese garden at Tilman Water Reclamation Plant (Photo: Drew Ready)

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ment of Public Health for ease of inspection.

c. Recycled water system may also require backflow protection. Provide a back flow device on the recycled water system if one of the following conditions exist: on-site fertilizer injection, pumping of back-up pond water or site is subject to submergence (storm water detention basins)

3. On-Site Modifications. The existing site plumbing is then assessed to determine the on-site modifications that will be required including: piping modifications; quick couplers; hose bibs; drinking fountains; overspray and ponding; signage and identification of potable, non-potable and recycled water facilities. Summarized below are some of the common on-site modifications that need to be performed in order to convert an irrigation system to recycled water:

   a. Separation requirements per the Department of Public Health.

   b. Quick couplers on potable and recycled water systems should be keyed differently.

   c. No hose bibs should be installed on a recycled water system.

   d. Hose bib vacuum breakers should be installed on hose bibs connected to the potable water system.

   e. Drinking fountains should be located such that direct or indirect (windblown) irrigation spray is mitigated.

   f. Overspray/ponding should be minimized and/or corrected.

   g. Protection of existing domestic water wells should be consulted with the Department of Health representative and well site owner/operator.

   h. Clear identification of the recycled water, potable water and non-potable water system will be required throughout the site. This can be done with painting and labeling of exposed pipes, tagging of valves, branding and/or color of valve box lids and signage. There is specific language, symbols and color requirements established by the Department of Public Health that need to be complied with for identification.

i. Piping modifications should be installed using colored pipe and warning tape.

j. Capping and/or abandonment of domestic water lines that are no longer required.

k. May want to consider constructing new dedicated domestic water lines to serve the following:

- Baseball diamonds infields
- Golf Course Greens (if required)
- Ponds (depends on type of use)

l. Early involvement of the local and state Department of Health representatives and water purveyor is essential. The approach for conversion and the site specific modifications can be discussed and a consensus obtained from all parties on how to proceed prior to preparing the design. Depending on the complexity of the site, a preliminary cross-connection test may be conducted to assess the potential of existing cross-connections between the irrigation system and the potable system.

CONSTRUCTION ISSUES

The retrofit process is very dynamic and the owner and agencies should be prepared for changes. During construction, several unknowns may come to light including but not limited to:

1. Lack of separation (common trenches).
2. Unrelated health or plumbing code requirements. The local and state representatives may find code compliance issues at the site that are not related to the conversion to recycled water.
3. Unknown cross-connections.

There are some ways to minimize additional modifications during construction and these include:

1. Accurate system as-builts for the entire property.
2. Knowledgeable maintenance personnel, including staff responsible for plumbing, fire and irrigation – typically there is someone responsible for the maintenance and repair for each of these systems.
3. Involvement of regulatory agencies early and often throughout the process.
4. Identify majority of modifications during the investigation phase.

TESTING

Once the on-site modifications have been completed, the local and state Department of Health representatives will require a cross-connection test and a coverage test to ensure that the recycled water system is separate. After a successful conversion the site will be subjected to annual cross-connection surveys in order to validate that the water systems at the site have remained separated. The protective devices will also require testing to verify the operation.

Mr. Mark Bush has over 11 years of professional experience in water, wastewater and recycled water engineering. He has been responsible for the completion of over 60 miles of potable water, recycled water and sewer mains, 12 potable water and recycled water pump stations and 10 potable and recycled water reservoirs. Mr. Bush has been involved in several recycled water conversion projects including public parks, schools, landscaped medians, business parks and golf courses for the last five years.

Session 4 | DESIGN STUDY: OBREGON COUNTY PARK

Reclaimed water is being successfully used to irrigate turf and native plant gardens at Rio de Los Angeles State Park. (Photo: Drew Ready)

THE EUGENE A. OBREGON PARK – GREEN PILOT PROJECT
DESIGN CONSIDERATIONS IN REINVENTING A PARK

By Blake Warner, Supervising Landscape Architect,
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The Eugene A. Obregon Park GREEN PILOT PROJECT is Project of the Parks and Recreation Development Division and was developed in collaboration with the East Field Agency who manages and maintains the park.

The Goal of the GREEN PILOT PROJECT was to create a conceptual site design for an existing Los Angeles County park, incorporating environmentally responsible practices to reduce the County's "Carbon Footprint" and promote environmental stewardship as directed in the 2009 County of Los Angeles Strategic Plan. Park sites are unique in the opportunities they present for environmental efficiencies. The research conducted for this project explores efficiencies suitable for the County park system – both new parks and existing park upgrades.

Obregon Park is an existing 11-acre Neighborhood Park with the following major amenities; Community Recreation Building, Gymnasium, Pool Building, Seasonal Outdoor Pool, Softball Fields, Batting Cage, Basketball Court, Handball Courts, Children's Play Area, Outdoor Exercise Equipment, Exercise Path, Picnic Areas and BBQ's. All site improvement recommendations preserve the existing park improvements where ever possible.

Three major areas of efficiencies were evaluated in developing design strategies utilizing existing standards. The U.S. Green Building Council's LEED EB checklist was utilized in evaluating building and site efficiencies, the California Assembly Bill 1881 (AB 1881) Model Water Efficient Landscape Ordinance for potable water reduction efficiencies and the County of Los Angeles Low Impact Development Standards for on site stormwater management efficiencies.

Building and Site Efficiencies

Park buildings are typically under 10,000 square feet in size and can be designed or retrofitted to include a number of environmental efficiencies including; energy and atmosphere, materials and resources, indoor environmental quality, water efficiencies, sustainable sites components and an educational component. The careful analysis of a project site and the construction budget must be considered in the successful implementation of energy efficiencies. When properly designed, the conservation and cost savings utilizing building efficiencies can be significant.

Potable Water Reduction Efficiencies

Potable water efficiencies come in the form of low flow fixtures inside buildings and new planting strategies and irrigation equipment technologies in the landscape which can bring significant savings in water usage.

In addition to exploring efficiencies in irrigation systems utilizing potable water, the use of reclaimed water to irrigate park sites provides current cost savings from 15%-50% depending on the water purveyor. As potable water costs increase, the cost savings of reclaimed water could be much more significant.

On-site Stormwater Management Efficiencies

On site stormwater management techniques to manage rainfall and irrigation run-off by incorporating stormwater best management practices (BMP) such as a bio-swale(s), vegetated swale(s), dry creek(s), French drain(s), detention basin(s), cisterns/rain barrel(s), and pervious pavement. The retention of water on-site reduces the flow of water in the stormwater system and recharges local groundwater reservoirs.

Building and Site Efficiencies identified for implementation at Obregon Park include:

- Photovoltaic Array on the Gymnasium Roof. A 50 kW system has the potential of producing 40% of the daily electricity usage.
- Solar Pool Heating System. A 16,844 therm system would heat the pool.
- Solar Water Heating System. A 2,500 therm system has the capacity to heat water for approximately 200 shower sessions in the pool building. This system would be coupled with a conventional back up system.
- Passive Down-Draft Cool towers (2). The towers will be located at the northeast and south exterior wall of the existing gymnasium building.
- Solar Site Lighting
- Heat island reduction in the parking lots
- Sustainable Purchasing
- Bicycle Racks
- Solid Waste Management Policy
- Green Cleaning Policy

Potable Water Reduction Efficiencies identified the Maximum Applied Water Allowance (MAWA) for the site and identified turf and plant alternatives, irrigation system design strategies and explored alternative methods of water conservation in the form of recycled water. The current park design planting configuration consists of 97% turf and 3% plants. This design generates an estimated total water use over twice the maximum allowance under AB 1881. An evaluation of the site was conducted to identify:

- Active recreational areas such as sports fields in open sunny locations where warm season grasses can be utilized.

Concept plan for Obregon County Park
(Drawing courtesy of Blake Warner)

- Passive Picnic areas where traditional cool season grasses would be used.
- Passive non-pedestrian areas suitable for drought tolerant plantings would be appropriate.

The revised planting coupled with a new efficient irrigation system includes 75% turf (40% warm season grasses and 35% cool season grass) and 25% drought tolerant plants with a moderate water requirement. The revisions resulted in a 58% reduction of estimated water use – well within the maximum allowance.

The current strategy for the use of recycled water for irrigating in parks in the County of Los Angeles Department is to utilize recycled water wherever trunk line infrastructure delivery systems are available in close proximity to parkland. It is well-known that many species of turfgrass are tolerant of the increased salinity found in recycled water. However, many species of trees and shrubs are susceptible to certain attributes of recycled water over the course of many years.

The State Model Water Ordinance (AB 1881) provides an additional 30% water usage in their Maximum Applied Water Allowance for landscapes utilizing recycled water. Due to the increased sensitivity of shrub material to the long term effects of recycled water, the project team increased the amount of turf grass in the design of parks utilizing recycled water.

In the case of Obregon Park, the trunk line infrastructure delivery system of recycled water to the park is likely five years or more in the future. However, the use of recycled water as a park model was explored with the following recommendations: 95% turf (40$ warm season grasses and 35% cool season grass) and 5% drought tolerant plants with a moderate water requirement. The additional water allowance for the use of recycled water places this model within the maximum allowance of AB 1881.

On-site Stormwater Management Efficiencies were developed on a tier system to assist in developing priorities for implementation:

- Tier 1 Improvements – address immediate on-site stormwater issues on the site such as water ponding, damage to property caused by water, health and safety concerns that may arise from standing water.
- Tier 2 Improvements – address enhancements to the site utilizing LID standards that would serve as an environmental benefit retaining stormwater on site.
- Tier 3 Improvements – address the removal of all storm water systems transporting runoff water off-site to on-site infiltration basin/ basins effectively capturing all runoff water on-site.
- Tier 4 Improvements – begin to address local and regional stormwater recharge concepts by diverting off-site stormwater from the surrounding storm drains into large subsurface chambers located on the park site.

The stormwater recommendations for Obergon Park include Tier 1 and Tier 2 improvements. These elements provide low impact development strategies to demonstrate the possibilities and environmental benefits to the site and include; vegetated buffers, unit pavers, drywells, bioretention areas and permeable concrete in the parking lots.

Blake Warner is a Supervising Landscape Architect and the Architecture and Design Section Head for the County of Los Angeles Department of Parks and Recreation. Prior to joining the County of Los Angeles, she spent over ten years in the private sector designing a variety of park projects from small neighborhood parks to regional scale sports parks. Blake has a B.S. Degree in Landscape Architecture with a minor in Irrigation Science from California Sate Polytechnic University, Pomona.

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