(02) Lessons Learned from a Wetlands Restoration Project

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BIO of Calvin Speight Jr.

- Project Executive Outcomes
  - Principal Owner
- Cost, schedule, and risk integration of major projects
- 30 years of experience (Finance, integrated with Project Management and Lean Six Sigma)
- Specialized in Energy, Infrastructure, and Environment
- *“Something You Don't Know About Me is that I have visited 5 continents”*

Abstract

- Megaprojects like power plants often face the risk of disrupting fragile ecosystems
- Regulatory bodies have the authority to insist that remediation be a component of the permitting process
- While serving as a cost engineer at a nuclear power plant, the author supported marine mitigation projects, including a wetlands restoration
- While maintaining the anonymity of the location, this paper will discuss the work breakdown structure of the project and reveal techniques applicable to nuclear plants, as well as watershed management projects around the world
- Part one will discuss the regulatory justification and challenges. Part two will discuss economic analysis and estimation procedures used. Part three will review cost and schedule control
- Finally, metrics for success will recommended for this unique class of project

Outline

- Introduction
- Regulatory Justification and Challenges
- Economic Analysis and Estimation
- Cost and Schedule Control
- Metrics for Success
- Conclusion
- Appendix: Wetland Types, Project Team, 2008-09 Schedule

INTRODUCTION

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Introduction

- As a cost engineer at a nuclear power plant from 2002-2007, part of my duties included a wetlands restoration

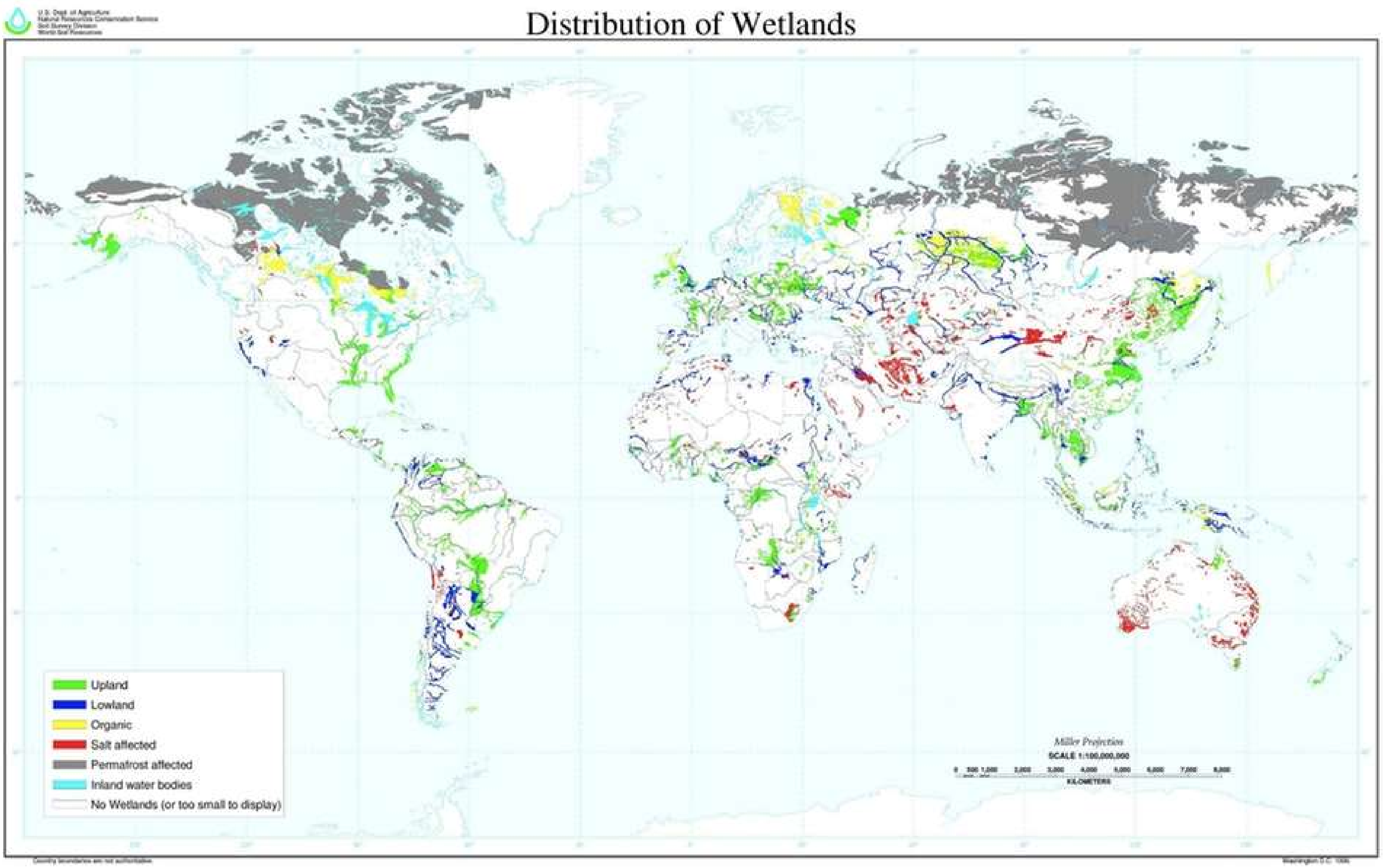
- We will discuss the work breakdown structure of the project and reveal applications to nuclear plants and watershed projects

- Motivation was a professional interest in infrastructure issues

- Such discussion revolves around the built environment, as opposed to natural infrastructure, like wetlands

- **Potential impacts on wetlands and watersheds stand to be framed more robustly through this presentation**

Wetlands Exist Globally



Source: U.S. Dept. of Agriculture

Peru: Wetlands of International Importance (13)

South America: Peru	Administrative Region	Hectares
Complejo de humedales del Abanico del río Pastaza	Loreto	**3,827,329**
Reserva Nacional Pacaya-Samiria	Loreto	**2,080,000**
Lago Titicaca	Puno	**460,000**
Paracas	Ica	335,000
Reserva Nacional de Junín	Junín, Pasco	53,000
Bofedales y Laguna de Salinas	Arequipa, Moquegua	17,657
Manglares de San Pedro de Vice	Piura	3,399
Santuario Nacional Los Manglares de Tumbes	Tumbes	2,972
Humedal Lucre - Huacarpay	Cusco	1,979
Lagunas Las Arreviatadas	Cajamarca	1,250
Santuario Nacional Lagunas de Mejía	Arequipa	691
Laguna del Indio - Dique de los Españoles	Arequipa	502
Zona Reservada Los Pantanos de Villa	Lima	263
Total		**6,784,041**

Note: 1 hectare = 2.47105 acre

Source: https://rsis.ramsar.org

REGULATORY JUSTIFICATION AND CHALLENGES

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Definition & Ecosystems Services

- **What are wetlands?**
  - "the term "wetlands" means those areas that are inundated or saturated by surface or ground **water** at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for **life** in saturated **soil** conditions."
  - **Definition per U.S. Environmental Protection Agency and the U.S. Army Corp of Engineers**

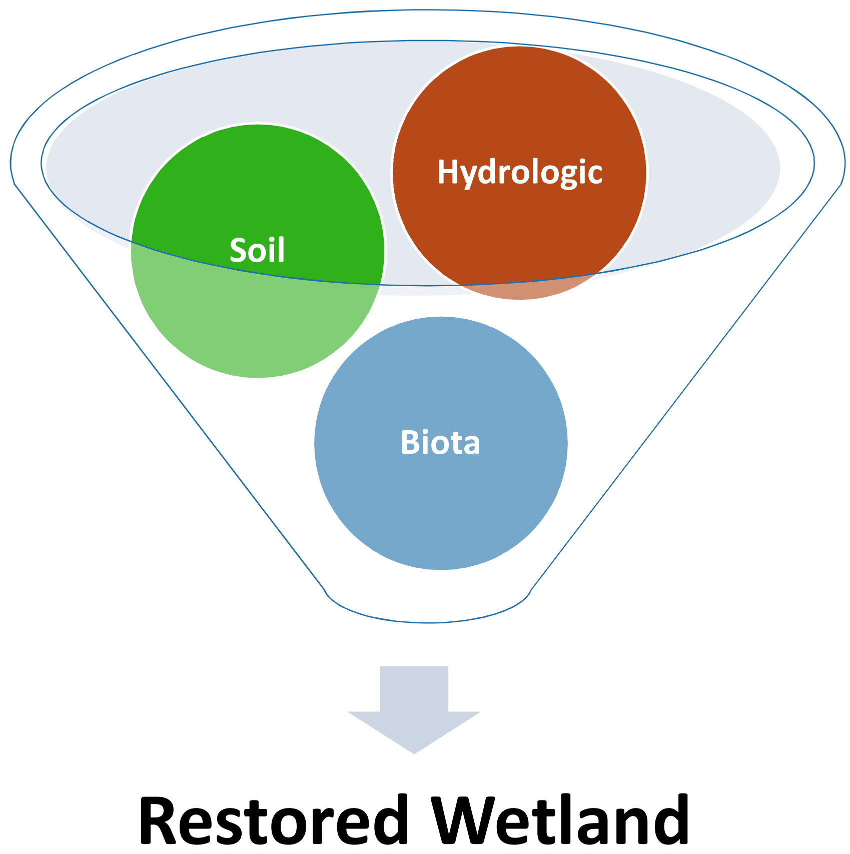
- **Why restore wetlands?**
  - provide sanctuaries for migratory birds, newly hatched fish and shellfish
  - **moderate the impact of floods due to storms**
  - biodiversity protection by supporting a great diversity of species
  - **improve water quality by capturing sediment and filtering pollutants**
  - enhance tourism through hiking, fishing and hunting
  - green infrastructure can be a lower cost alternative to "grey" infrastructure made from concrete

Critical Success Factors for Wetlands Restoration

- The foundational factor is **hydrology** which describes duration, flow, amount, and frequency of water on a site.

- Waterlogged **soil** is conducive to the growth aquatic plant life.

- **Biota** describes the wildlife that thrives in this transitional habitat where land and water meet.



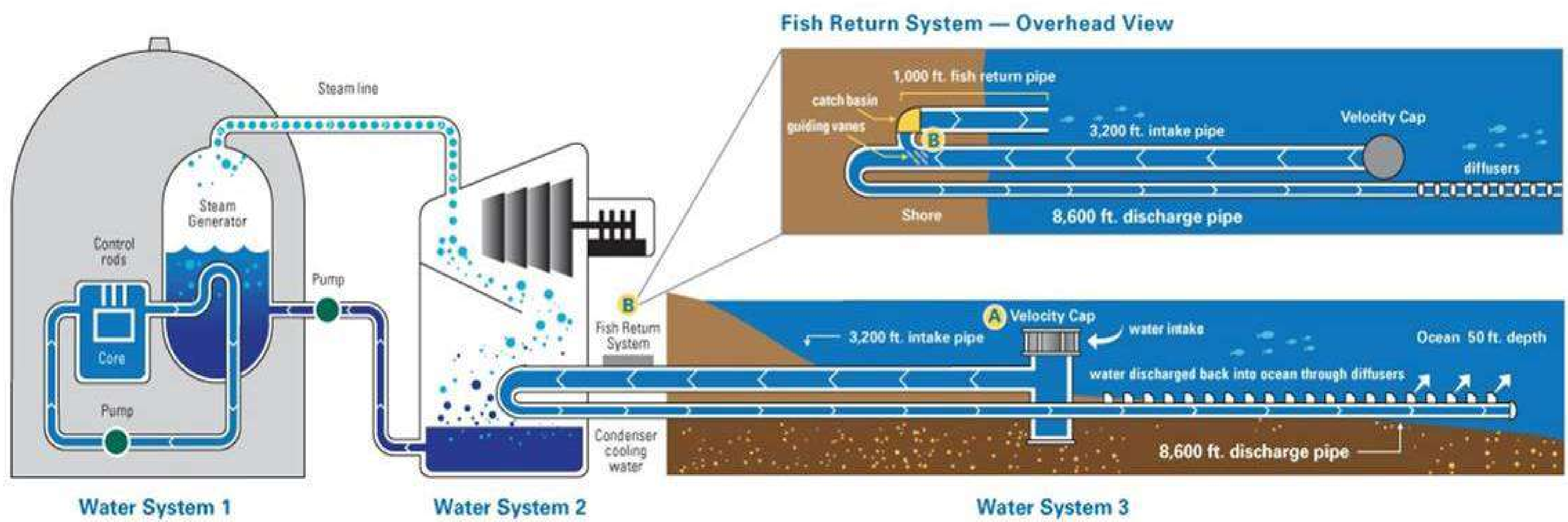
Connection to Nuclear Power - Permitting

- Back in 1973, the nuclear station was denied a construction permit by a state regulatory body
- The rationale was based on nuclear safety issues that were under the purview of the U.S. Nuclear Regulatory Commission
- The nuclear plant agreed to restore 127 acres (51.4 hectares) of wetlands with the following scope:
  - *Restoring tidal wetlands areas*
  - *Constructing berms and associated drainage and slope protection measures*
  - *Vegetating dredge disposal areas*
  - *Constructing nesting sites*
  - *Constructing nesting sites*
  - *Improving beach access along the river*
  - *Excavating & maintaining the river inlet channel to maintain tidal exchange*
- ***From the resolution*** **of the decision to restore the wetlands to the final construction of the nuclear station took over a decade**

Note: 1 hectare = 2.47105 acre

Connection to Nuclear Power – Thermal Pollution

- **At issue was that the planned reactors circulate a total of 2,400 million gallons (9,085 million liters) per day of ocean water**
- The water is heated to approximately 19°F (7.22°C) above ambient as it flows through the condensers and is discharged back into the ocean
- This so-called "thermal pollution" was believed to disrupt fisheries as well as seaweed.



Megacommunity™ Approach to Permitting

Megacommunity: Five Critical Elements		
Element	**Definition**	**Role**
Tri-Sector Engagement	A megacommunity's triple-sector nature addresses the fact that civil society is often left out of the public–private equation	Pre-condition
Overlapping in Vital Interests	Shared issues and localized impact naturally result in an overlap of vital interests	Pre-condition
Convergence	There must be a convergence of commitment toward mutual action	Design
Structure	There must be a set of protocols and organizing principles that bring a degree of order	Design
Adaptability	They are open to new members and entrants, continually poised for new activities, and deliberately open to change in their objectives and methods	Design

"Leaders of many organizations must work together toward common goals, without any one of them being in control of the whole system. A megacommunity initiative therefore combines focused conversation, deliberate development of leadership capabilities, and results oriented action in an open-ended network of leaders from multiple organizations." – Mark Gerencser

Who Pays for this Type of Project?

- The nuclear organization established a trust fund that covered the project and maintenance
- While some firms repair the damage themselves, others turn to so-called "mitigation banks"
- **These financial institutions give credence to the notion that infrastructure deficits are due not to lack of funding, but a lack of imagination**

ECONOMIC ANALYSIS AND ESTIMATION

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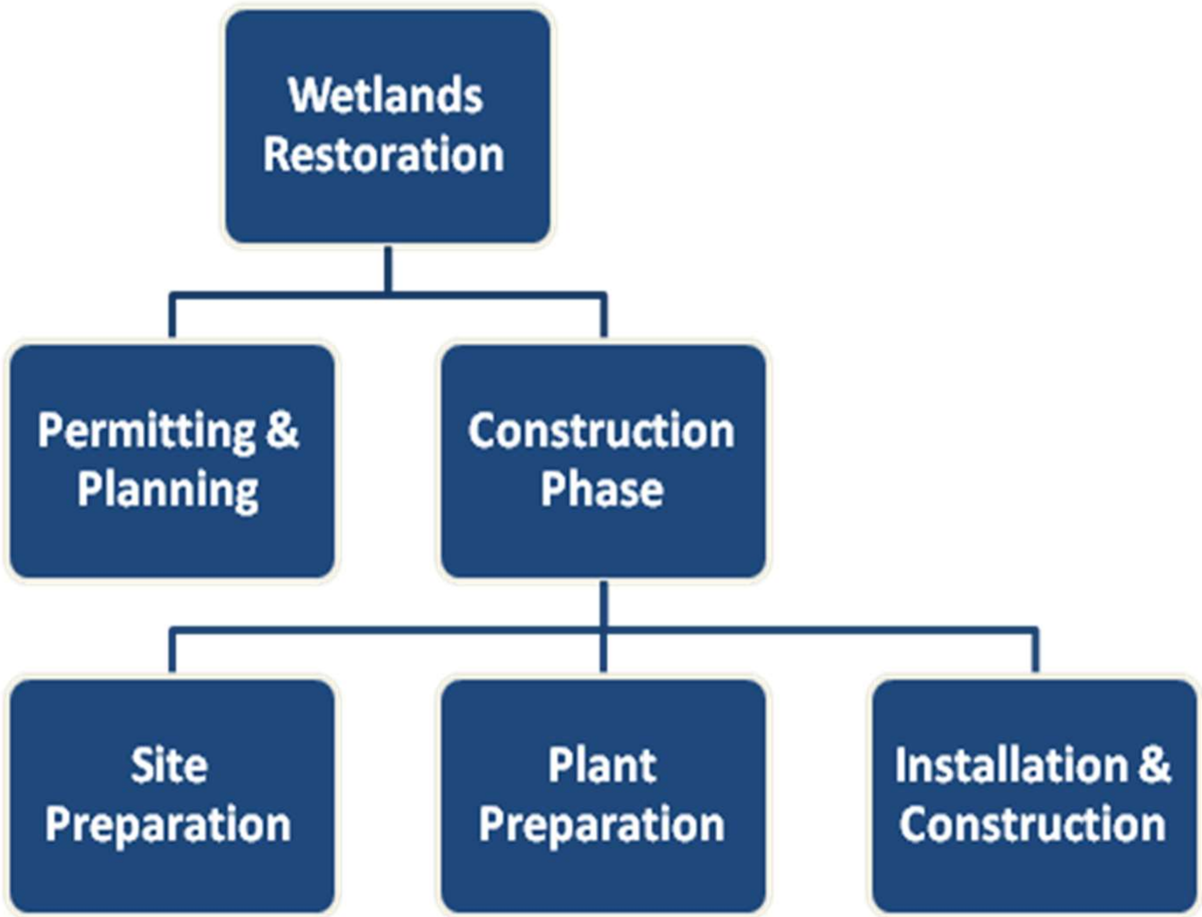
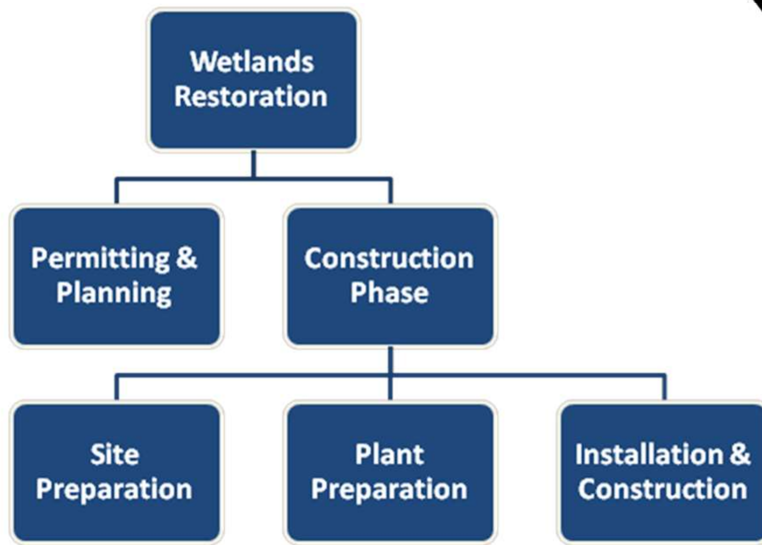
WBS for Wetlands Restoration Project



WBS: Permitting & Planning



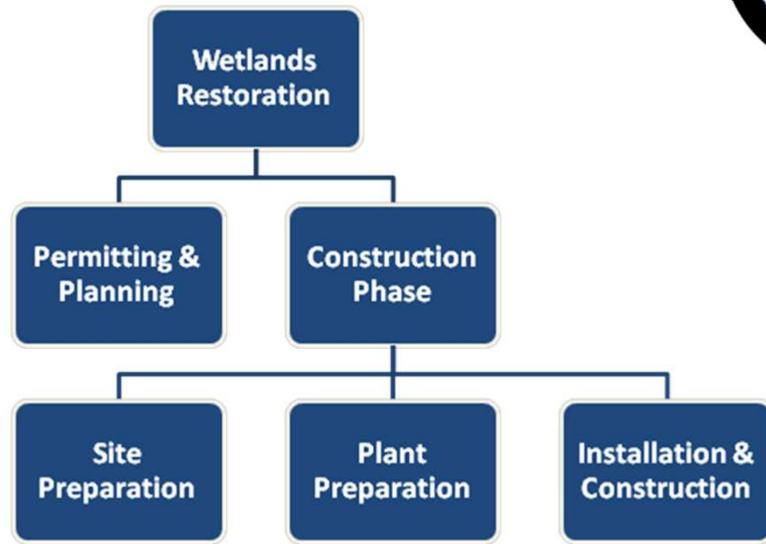
Per Baylands Report:

- Site survey, hydrologic study, biological assessments
- Prepare restoration plan
- Prepare environmental documents and circulate for public and agency review
- Apply for and obtain authorizations from regulators

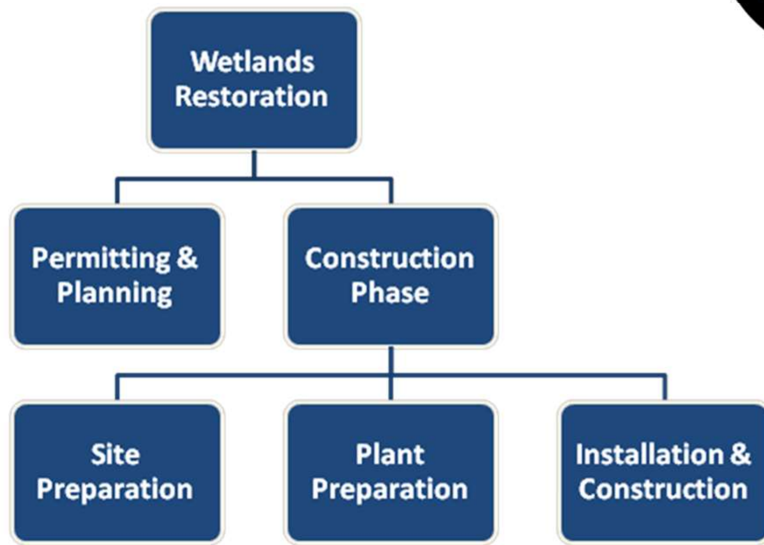
WBS: Construction, Site Preparation

Per John Steere, site preparation involved:

- removing non-native species
- removing piles of soil, debris and trash
- enriching soil with nutrients;
- removing polluted soils
- bringing in appropriate soils or substrates (e.g. clay or sand)



WBS: Construction, Plant Preparation



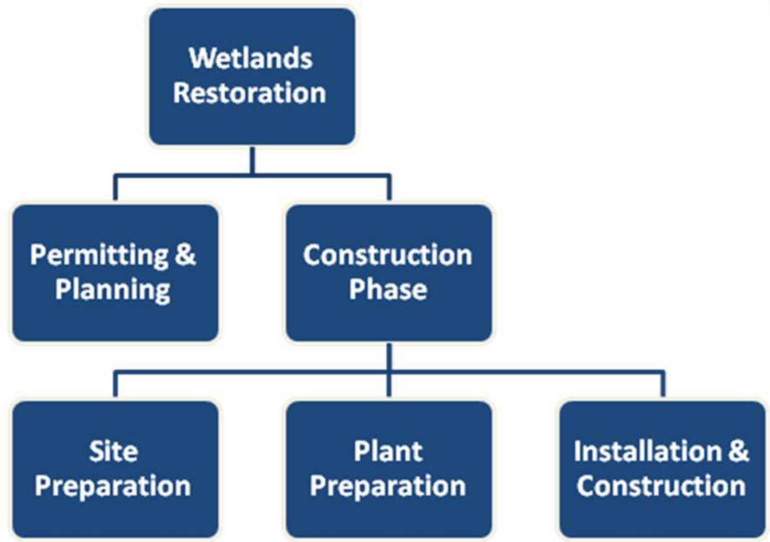
Plant preparation involved:

- collecting seeds
- propagating plants
- collecting plugs (newly-grown whole plants with soil)

WBS: Construction, Installation & Construction

Installation & construction involved:

- constructing water control structures
- installing bank/edge stabilization structures
- placing and grading new soil
- planting plugs, seeds or newly-grown plants
- installing plant protections (tubes, screens, etc.)



Wetlands Cost Estimation

Wetlands Restoration Estimation Analysis (at 2006 Dollars)						
	Unit of Measure	Cost ($)/Unit	# of Units	Baylands/ Steere Estimate	Actual Cost	Actual vs. Baylands/Steere
Site Access, Mobilization, Demolition	acre	$1,845	127	$234,291	$2,395,000	$2,160,709
Earthwork	cu. Yds.	$6	2,000,000	$12,298,739	$17,674,000	$5,375,261
River Berms	linear ft.	$37	5,280	$194,812	$1,881,000	$1,686,188
Nesting Sites (4)	cu. Yds.	$6	125,000	$768,671	$1,109,000	$340,329
Utility Relocation/Protection	N/A			$75,000	$139,000	$64,000
Re-vegetation	plugs/acre	$2.46	10,000	$3,123,880	$4,722,000	$1,598,120
Sub-total				$16,695,392	$27,920,000	$11,224,608
Contingencies (20%)	Percentage			$3,339,078	$5,584,000	$2,244,922
Engineering/Environmental Services (25%)	Percentage			$5,008,618	$4,800,000	-$208,618
Construction Management (6%)	Percentage			$1,502,585	$2,298,240	$795,655
Total				$26,545,674	$40,602,240	$14,056,566

- **The final cost for all activities was calculated by the nuclear organization to be $(US) 40.6 M**
- **This analysis will compare the actual estimate with a cost estimate that blends the Baylands Report with Steere cost guidance**
- **"Contingency," "Engineering & Environmental Services" and "Construction Management" line-items are based on percentages (for Baylands / Steere estimate only)**

1 United States Dollar (USD) = 3.27 Sol as of June 2018

Site Access, Mobilization, Demolition

Estimate vs. Actual Cost

- Used acres for unit of measure, $1,845 per unit for 127 acres (0.404685 hectares/acre) resulting in $234,291
- The actual cost of $2,394,000 is nearly ten-fold

Variance Explanation

- The difference can be explained by a lack of proprietary information required for a detailed estimate
- Moreover, the uncertainty of this project phase is reflected in the disparity

Note: 1 hectare = 2.47105 acre

1 United States Dollar (USD) = 3.27 Sol as of June 2018

Earthwork

Estimate vs. Actual Cost

- Based on cubic yards (0.764554 m^3 /yd^3), at $6.00 per unit, resulting in $12,298,739
- The actual cost was $17,674,000
- Percentage difference is 44%

Variance Explanation

- Difference was based on schedule delays that drove up labor costs
- Labor, equipment, and on occasion, materials, can become comingled

Note: 1 hectare = 2.47105 acre

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River Berms

Estimate vs. Actual Cost

- Based on linear feet (0.30480 meters), at $37.00 per unit, resulting in $194,812, versus an actual cost of $1,881,000
- Once again, nearly a ten-fold difference

Variance Explanation

- In this case, the "River Berms" used concrete and other engineered materials, compared to just soil

Note: 1 hectare = 2.47105 acre

1 United States Dollar (USD) = 3.27 Sol as of June 2018

Estimate vs. Actual Cost

- Once again, based on cubic yards, at $6.00 per unit, resulted in $768,671 compared to an actual cost of $1,109,000
- Percentage difference is 44%

Variance Explanation

- A noticeable trend throughout this exercise is that the simpler tasks resulted in relatively smaller variances

Note: 1 hectare = 2.47105 acre

1 United States Dollar (USD) = 3.27 Sol as of June 2018

Re-vegetation

Estimate vs. Actual Costs

- Based on plugs/acre, at $2.46 per unit, 10,000 units/acre, resulting in $3,123,880, as opposed to an actual cost of $4,722,000

- Percentage difference is 51%

Variance Explanation

- Once again, the unit rate for "Re-vegetation" factored in discrete labor for required crews

Note: 1 hectare = 2.47105 acre

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Economies of Scale

- One must account for increased complexity of natural and public policy variables

- **Through an interdisciplinary approach, project managers, construction managers, engineers, biologists and other experts work in harmony**

- Finally, more robust “constructability” reviews and value analysis would have enhanced estimation

AACE Recommended Practices Needed by Utilities

- **AACE® International Recommended Practice No. 34R-05**
  BASIS OF ESTIMATE
- **AACE International Recommended Practice No. 17R-97**
  COST ESTIMATE CLASSIFICATION SYSTEM
- **AACE® International Recommended Practice No. 27R-03**
  SCHEDULE CLASSIFICATION SYSTEM
- **AACE® International Recommended Practice No. 48R-06**
  SCHEDULE CONSTRUCTABILITY REVIEW
- **AACE® International Recommended Practice No. 78R-13**
  ORIGINAL BASELINE SCHEDULE REVIEW – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION

COST AND SCHEDULE CONTROL

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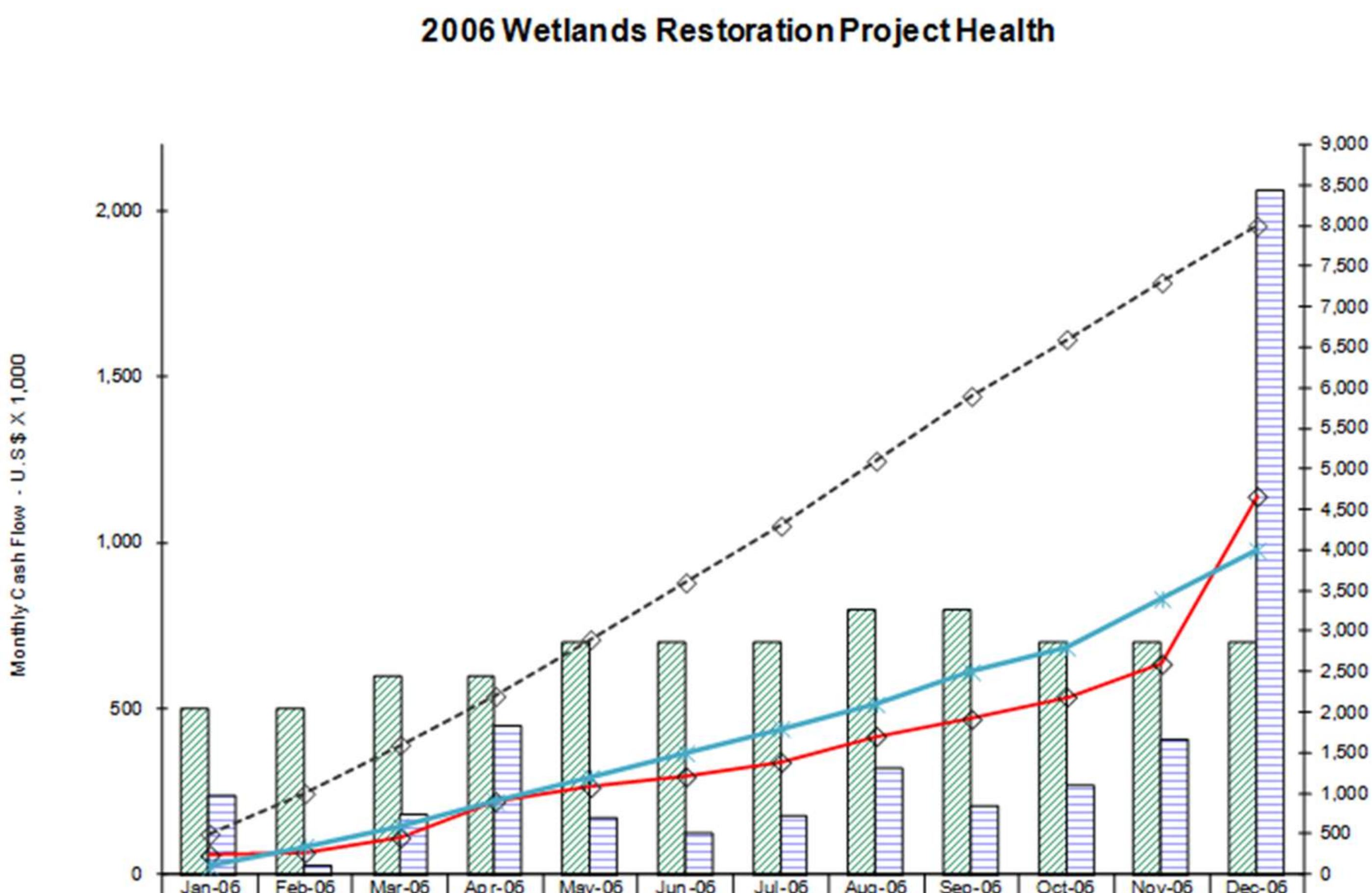
- This section will show how political risk can impact the performance this unique class of project
- We calculate the cost performance index (CPI) by dividing the EV of $4,000,000 by AC of $4,664,000, yielding 0.86. For each dollar invested, the return was $0.86
  - **CPI = EV/AC; CPI = BCWP/ACWP**
- We calculate the schedule performance index (SPI) by dividing the EV of $4,000,000 by PV of $8,000,000, yielding 0.50. The project is now 50% behind schedule
  - **SPI = EV/PV; SPI = BCWP/BCWS**
- The estimate at completion (EAC) is calculated by dividing the budget at completion (BAC) by the CPI, yielding $9,328,000, or $1,328,000 over budget
  - **EAC_{CPI} = BAC/CPI**
- **What is going on here?**

1 United States Dollar (USD) = 3.27 Sol as of June 2018

Wetlands Restoration Earned Value Graph



	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
Budget (Plan)	500	500	600	600	700	700	700	800	800	700	700	700
Actual	242	27	185	448	175	129	180	320	211	272	409	2066
Cum Plan	500	1,000	1,600	2,200	2,900	3,600	4,300	5,100	5,900	6,600	7,300	8,000
Cum Actual	242	269	454	902	1,077	1,206	1,386	1,706	1,917	2,189	2,598	4,664
Cum Earned	100	350	600	900	1,200	1,500	1,800	2,100	2,500	2,800	3,400	4,000

Corrective Action

- Permitting delays either delayed work, or made efforts less effective

- **Also natural cycles like weather and bird migration patterns played a role as well**

- Worked with treasury staff to defer budget into the future years

- **Increased visits provided an impetus for the project manager to more candid assessment of milestone completion**

METRICS FOR SUCCESS

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Goals for Success

- **Restored wetlands need years, or even decades to replicate former biological function**

- Project evaluation should include taking into account rain patterns, invasive species (non-native) and sea levels

- Project design should also address other variables, such as natural subsidence and sediment accumulation and removal

Metrics for Success

- **Wetlands would be considered successfully restored when monitoring demonstrates that the degree and duration of flooding has increased over the baseline**

- Performance standards may be based on functional, conditional assessment methods hydrological, biota, and soil measures

- From a management perspective, separate biologist teams for plants and animals will improve the natural interactions needed for a healthy wetland

How is this Habitat Maintained?

- The wetland itself will be maintained up to 40 years
- Keeping the river inlet free of silt improve existing wetlands and contiguous habitats
- **As a general guideline on maintenance cost, plan to spend 3% - 5% of total construction cost per year ($1.2M - $2.0M)**
- In order to prevent effort and funding from being wasted, maintenance may require:
  - the control and eradication of invasive species
  - the repair and upkeep of berms and other structures
  - the replacement of plants

1 United States Dollar (USD) = 3.27 Sol as of June 2018

Was it Worth the Effort?

- **2011, this wetland is almost fully replenished with aquatic plants**
- **Further, almost 200 species of birds have returned to the wetland, as well as millions of fish**
- **Finally, visitor facilities are nearly complete, accessible for a nominal fee**

CONCLUSION

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Conclusion: Lessons Learned

- A megacommunity approach could have resolved nearly a decade of stalemate.
- **Economic analysis and estimation procedures used revealed that unlike a traditional construction project, natural habitats are subject to complexity and uncertainty.**
- One can conclude that the true estimate may not be known until the project nears completion.
- We reviewed cost and schedule control using earned-value. Permitting delays and natural phenomena like bird migrations disrupted a schedule based on overly optimistic assumptions.
- **Unlike a traditional construction project, natural habitats are subject to complexity and uncertainty.**
- Permitting delays and natural phenomena like bird migrations disrupted the schedule.
- **Critical success factors like hydrology, soils, and biota must be viewed from a systems standpoint.**
- Healing of the wetland may take decades.

Resources

Gerencser, Mark, et al
Summer 2006
"The Megacommunity Manifesto," s+b
www.strategy-business.com/press/article/06208: How to bring together multiple organizations to develop solutions to complex problems.

Interagency Workgroup on Wetland Restoration: National Oceanic and Atmospheric Administration, Environmental Protection Agency, Army Corps of Engineers, Fish and Wildlife Service, and Natural Resources Conservation Service
2003
An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement

Southern California Edison Company
November 2005
San Dieguito Wetlands Restoration Project Final Restoration Plan Submitted To: California Coastal Commission

Steere, John
2005
Estimating Wetland Restoration Costs at an Urban and Regional Scale: The San Francisco Bay Estuary Example
San Francisco Bay Joint Venture
1330 Broadway Ave., Suite 1100
Oakland, CA 94612

U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif.
1999
Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project.

QUESTIONS/COMMENTS?
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APPENDIX

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Five Types of Wetlands

Five major wetland types are generally recognized:

1. **Marine** (coastal wetlands including coastal lagoons, rocky shores, and coral reefs)

2. **Estuarine** (including deltas, tidal marshes, and mangrove swamps)

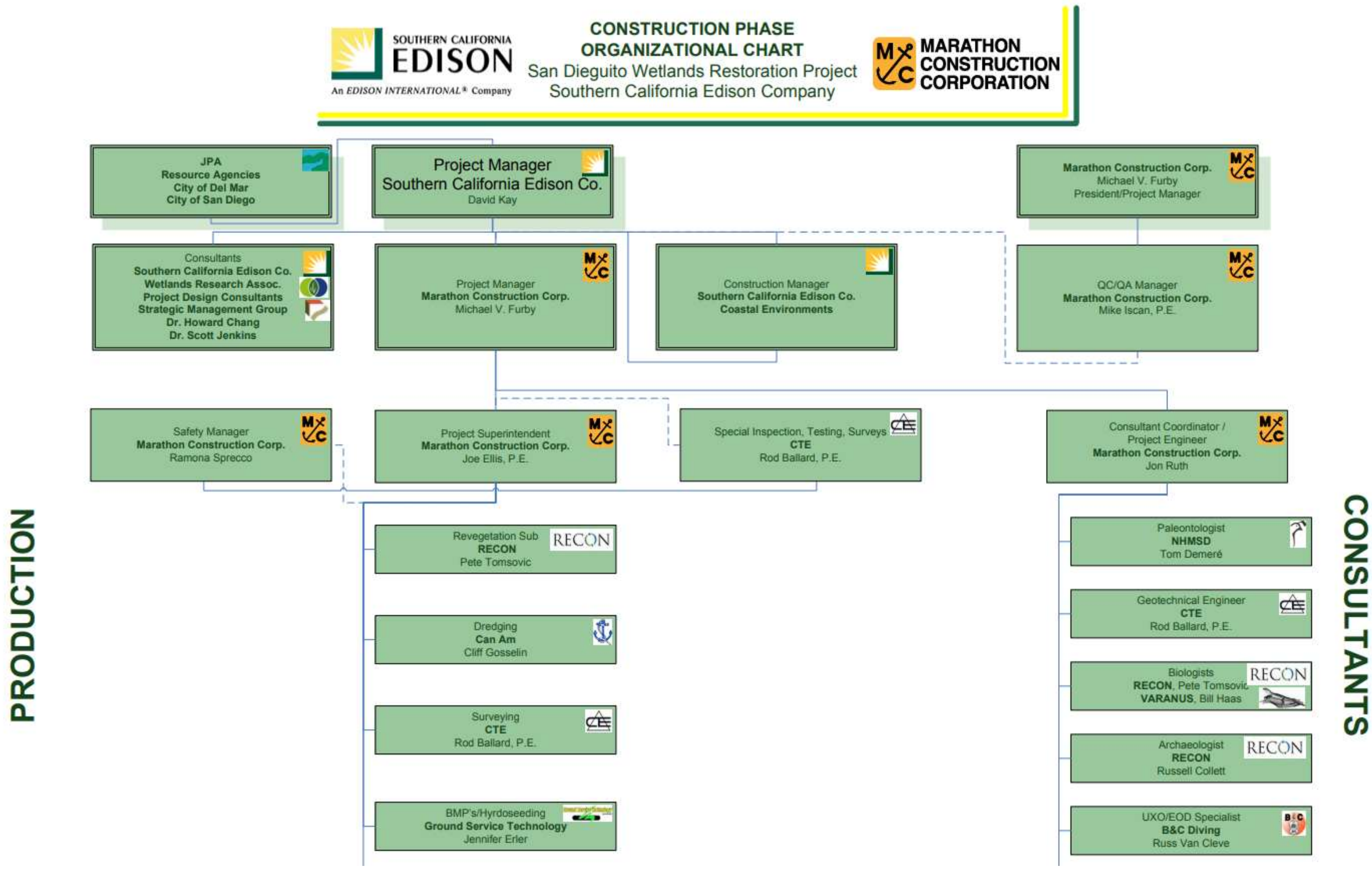
3. Lacustrine (wetlands associated with lakes)

4. Riverine (wetlands along rivers and streams)

5. Palustrine (meaning “marshy” – marshes, swamps and bogs)

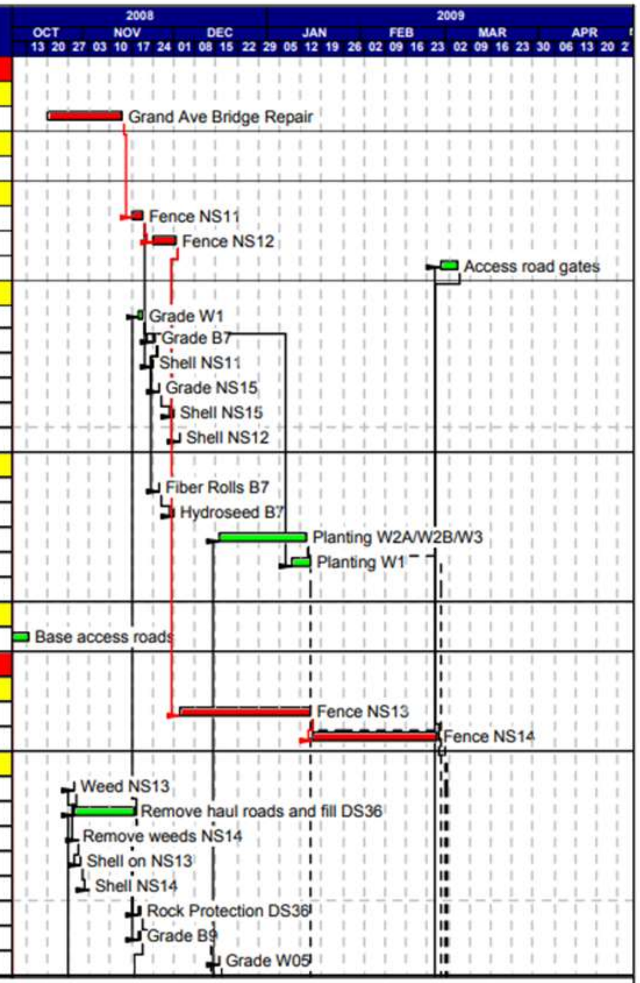
Source: Adapted from The Ramsar Convention on Wetlands

Wetlands Project Team



P6 Schedule for Construction Phase: 2008-2009

Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish
Area 2A					
Bridge Repair					
1510	Grand Ave Bridge Repair	20d	20d	20OCT08 *	14NOV08
Flushing					
1380	Area 2A Flushing	365d	365d	04JAN10 *	27MAY11
Fencing					
1450	Fence NS11	5d	5d	17NOV08	21NOV08
1460	Fence NS12	5d	5d	24NOV08	02DEC08
1500	Access road gates	5d	5d	27FEB09	05MAR09
Grading					
1390	Grade W1	3d	3d	19NOV08	21NOV08
1410	Grade B7	2d	2d	24NOV08	25NOV08
1420	Shell NS11	1d	1d	24NOV08	24NOV08
1400	Grade NS15	1d	1d	26NOV08	26NOV08
1440	Shell NS15	1d	1d	01DEC08	01DEC08
1430	Shell NS12	1d	1d	03DEC08	03DEC08
Planting					
1540	Fiber Rolls B7	1d	1d	26NOV08	26NOV08
1520	Hydroseed B7	1d	1d	01DEC08	01DEC08
1470	Planting W2A/W2B/W3	20d	20d	16DEC08	14JAN09
1480	Planting W1	5d	5d	09JAN09	15JAN09
1210	Cordgrass Panting W1	10d	10d	30MAY11	10JUN11
Access Roads					
1490	Base access roads	5d	5d	08OCT08	14OCT08
Area 2B					
Fencing					
1250	Fence NS13	30d	30d	03DEC08	15JAN09
1320	Fence NS14	30d	30d	16JAN09	26FEB09
Grading					
1230	Weed NS13	1d	1d	29OCT08	29OCT08
1270	Remove haul roads and fill DS36	15d	15d	29OCT08	18NOV08
1300	Remove weeds NS14	1d	1d	30OCT08	30OCT08
1240	Shell on NS13	1d	1d	31OCT08	31OCT08
1310	Shell NS14	1d	1d	03NOV08	03NOV08
1260	Rock Protection DS36	2d	2d	19NOV08	20NOV08
1290	Grade B9	2d	2d	19NOV08	20NOV08
1220	Grade W05	1d	1d	16DEC08	16DEC08



Start date	08OCT08
Finish date	10JUN11
Data date	08OCT08
Run date	09OCT08
Page number	1A

Marathon Construction
San Dieguito Wetland Restoration

- Early bar
- Progress bar
- Critical bar
- Summary bar
- Start milestone point
- Finish milestone point