

# ***Headquarters U.S. Air Force***

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## **A River Used to Run Through It Site 17: A Phytoremediation Case Study**



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**Presented by  
Tom Simpkin, Ph.D., P.E.**

**CH2M HILL**

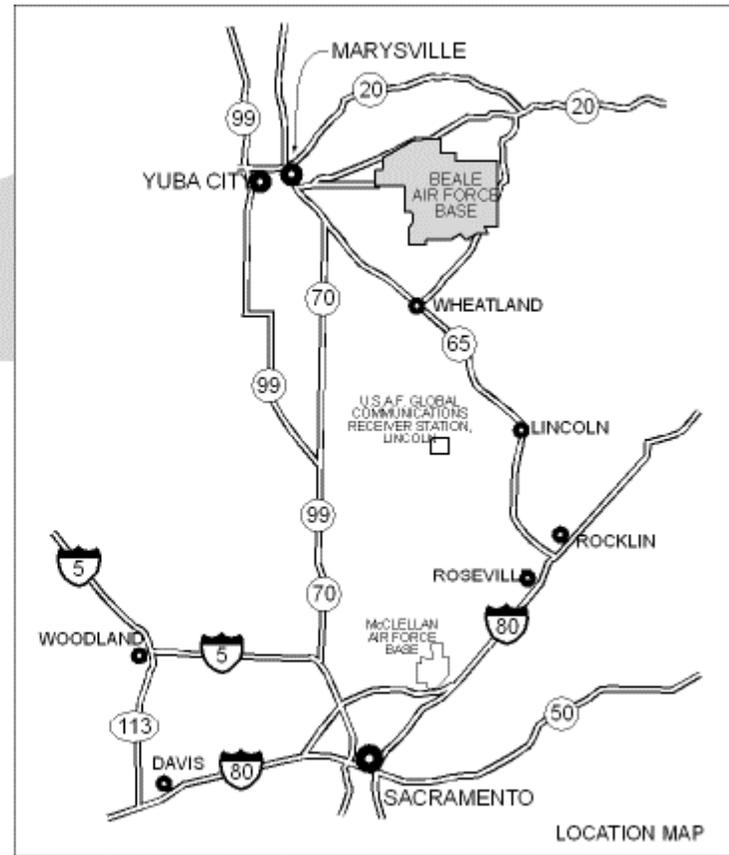
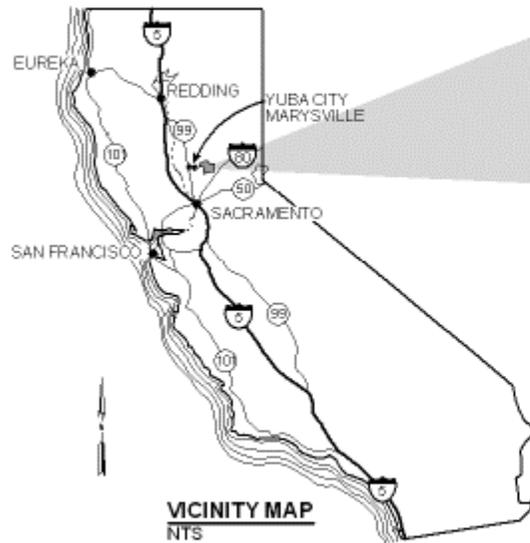
**January 30, 2001**

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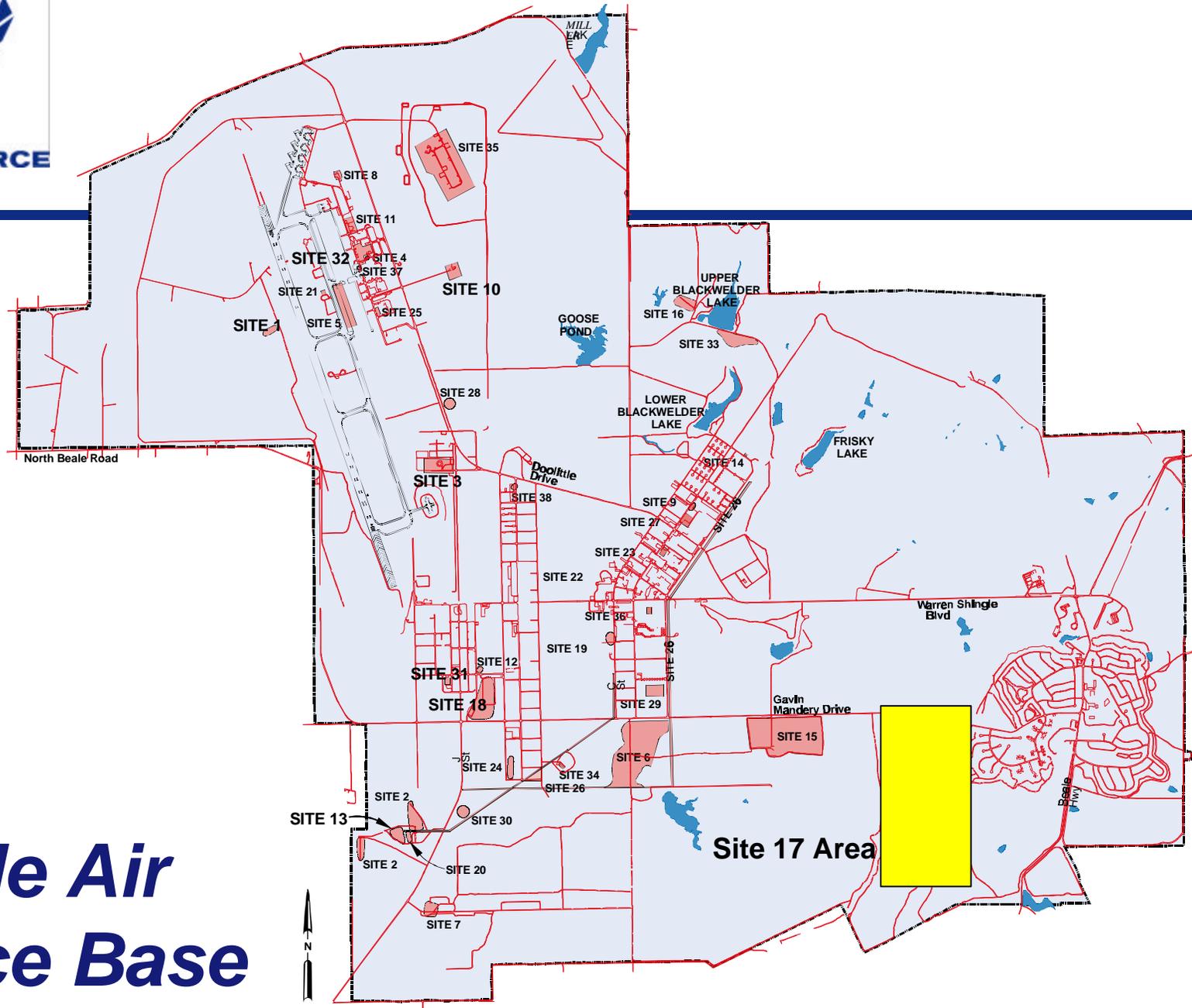
# ***Beale Air Force Base Location***



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# Beale Air Force Base

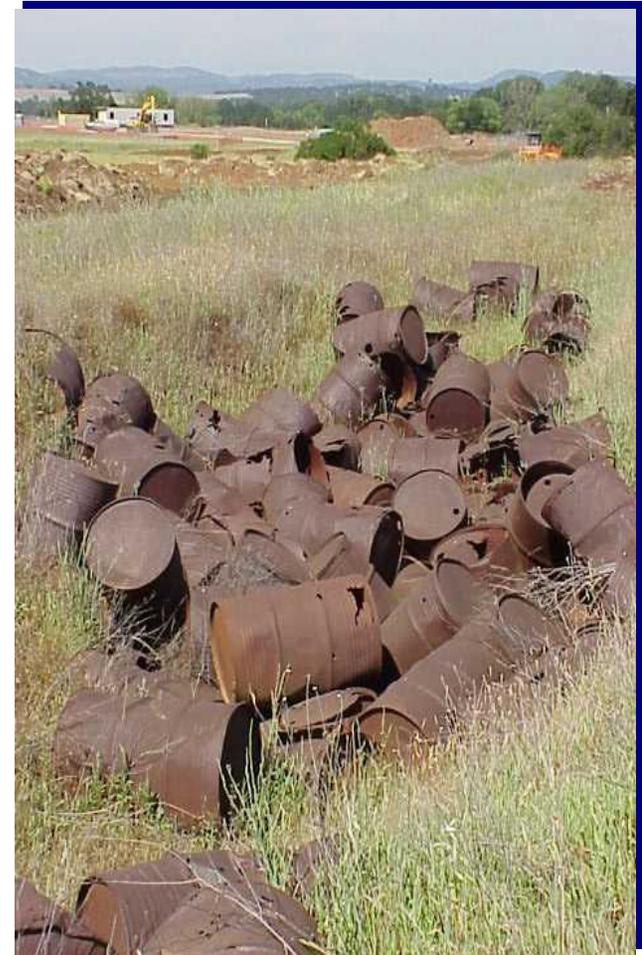
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## *The Setting*

- Disposal trenches near Best Slough
- Over 100 drums found in trenches
- 20 to 30 tons of solvent disposed in trenches
- Trenches located in Riparian Preservation Area
- Diverse mixture of plant communities and habitat
- Several Special Status species present

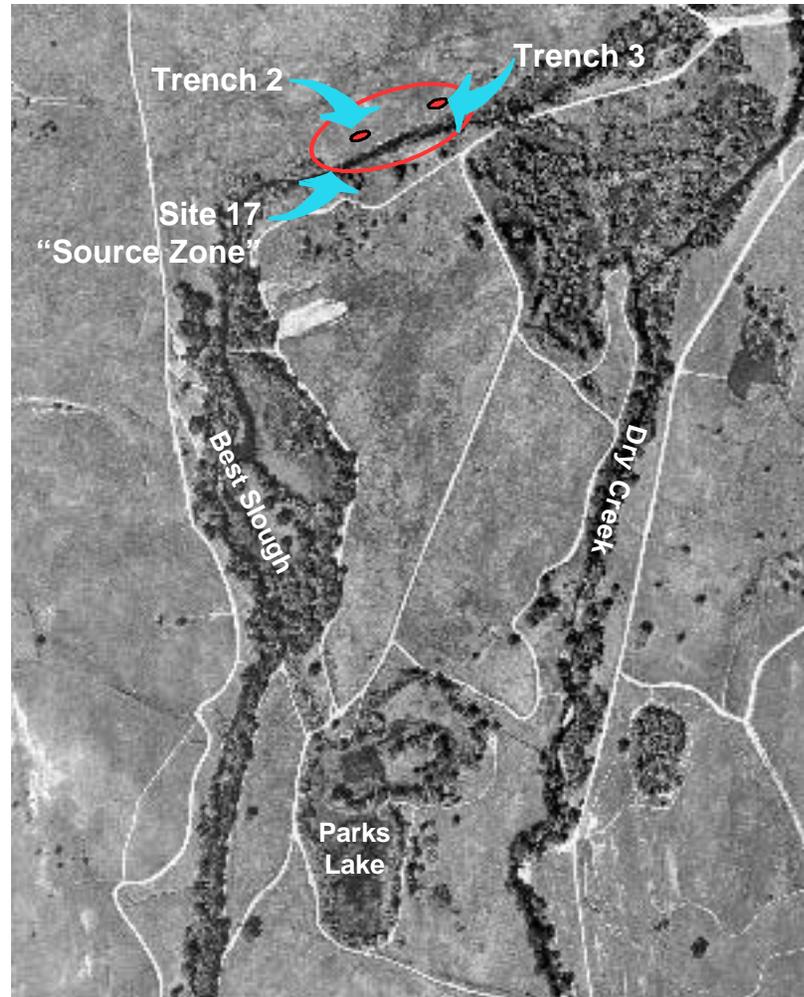


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# Site 17 Plume Area



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# *Hydrogeology*

- 
- **Approximately 35 feet of alluvium overlies bedrock**
  - **Groundwater at 8 to 10 feet**
  - **Bedrock is a marine siltstone/claystone**
  - **Best Slough is a gaining stream most of the year**

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# ***Pre Construction Site Water Balance***

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- **Groundwater inflow—26 gpm**
- **Deep percolation—24 gpm**
- **Discharge to Best Slough—12 gpm**
- **Discharge to Dry Creek—6 gpm**
- **Groundwater outflow—32 gpm**



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# *Extent of Contamination*

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- **About 2 acres of DNAPL area  
(TCE concentrations >10 mg/L)**
- **Groundwater TCE concentrations measured over  
1,000 mg/L**
- **DNAPL verified using Sudan-4 dye**
- **TCE measured in Best Slough (up to 5 µg/L)**
- **4,000-foot dissolved groundwater plume between  
Best Slough and Dry Creek to Parks Lake**

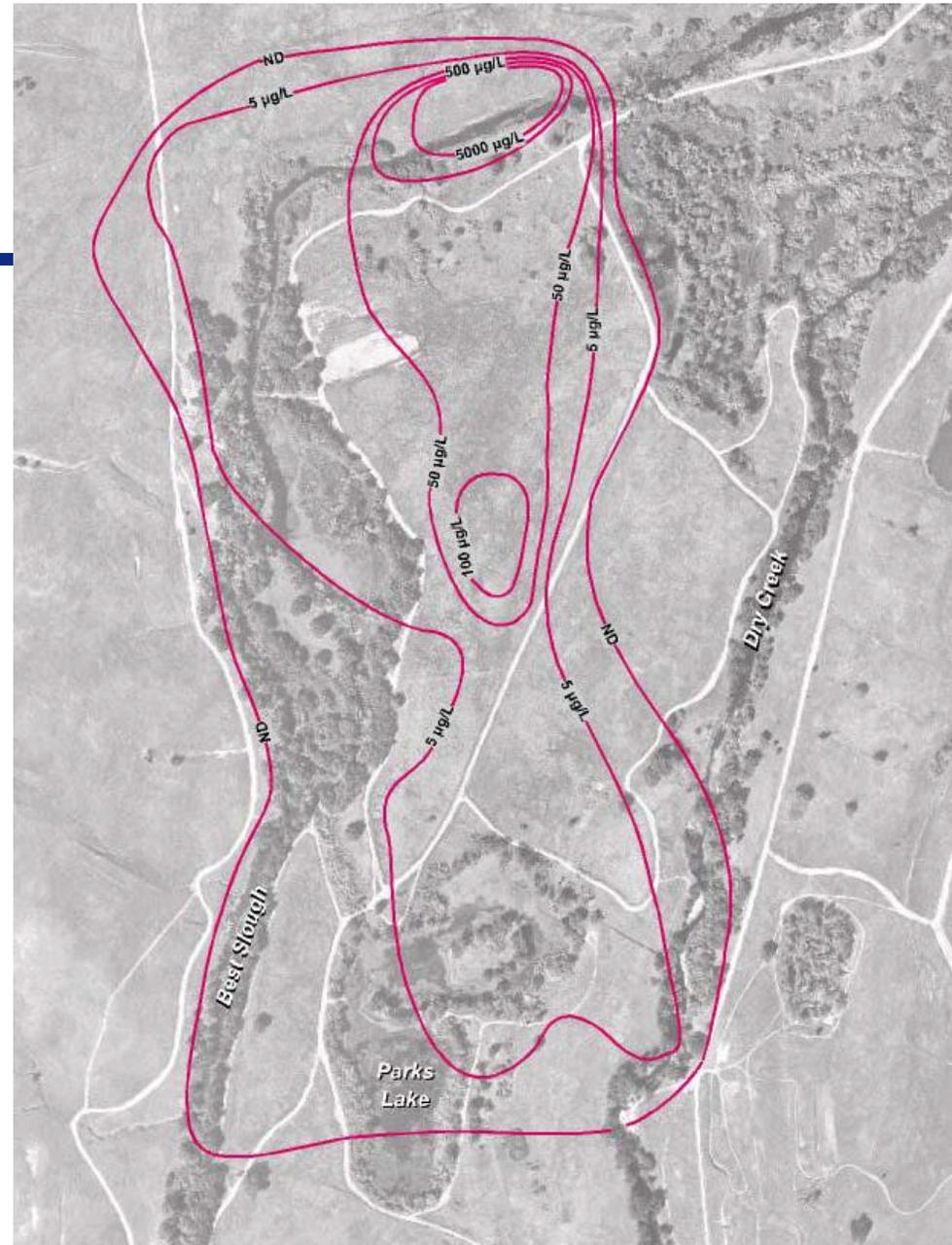
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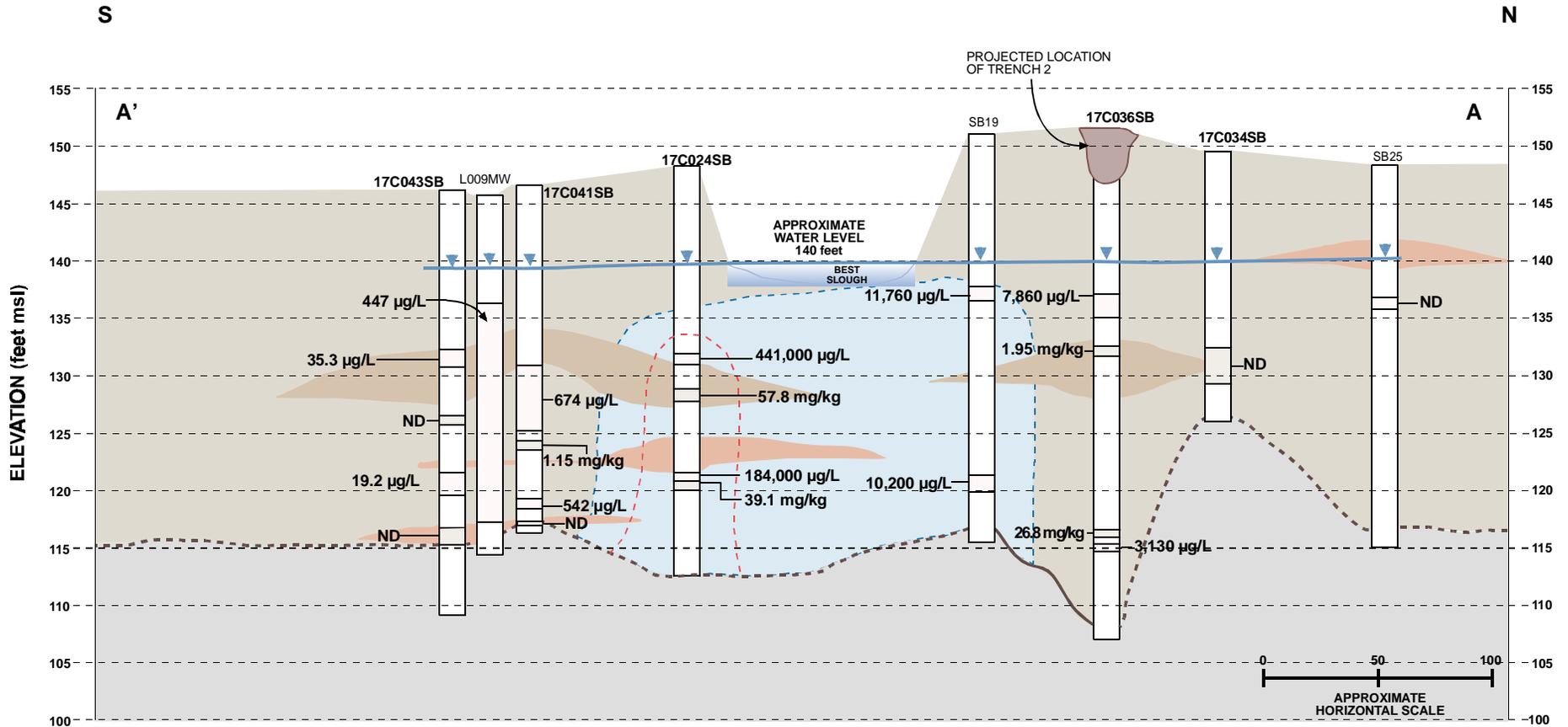
# *Extent of Dissolved Plume*



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# Estimated Vertical Extent of DNAPL



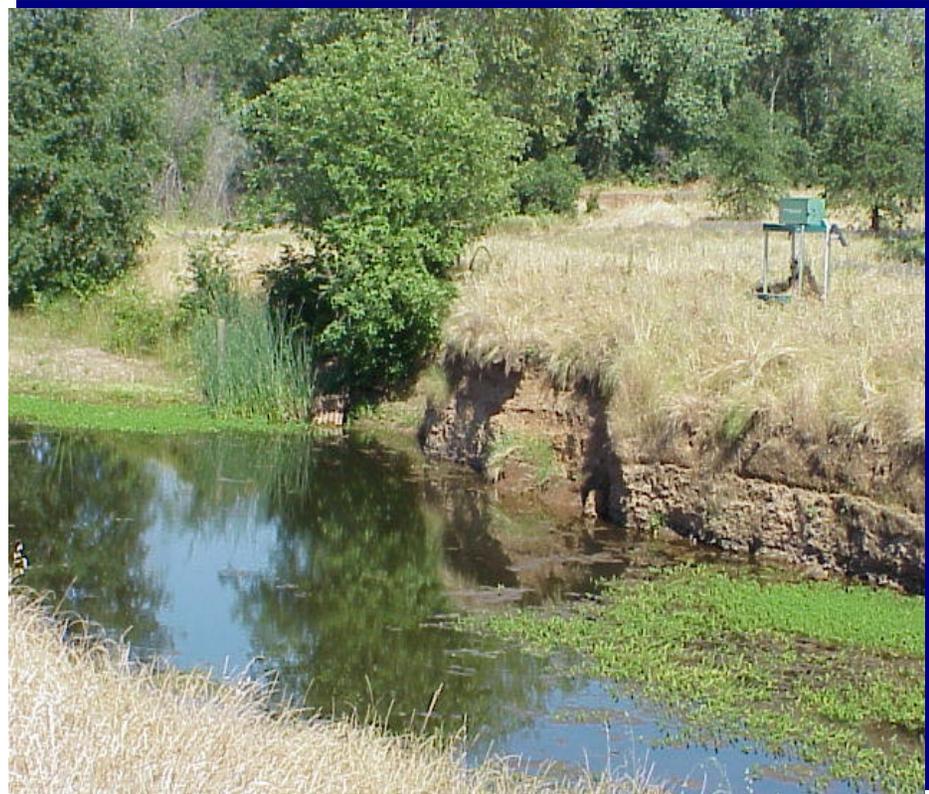
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# *Interim Remedial Action Goals*

- Reduce or eliminate ongoing releases to Best Slough and groundwater
- Protect and enhance established habitat and natural resources
- Low maintenance
- Consistent with final remedy



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# *Remedial Action Development*

- 
- EE/CA in 1996 chose Groundwater Extraction for hot spot removal
  - In 1997, field and bench testing for vapor extraction, air sparging, and zero-valent iron
    - Sparging infeasible
    - Vapor extraction is infeasible
    - Zero-valent iron could remove “most” mass

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# *Remedial Action Development*

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- 1998 investigation revealed extent of DNAPL contamination
- New EE/CA prepared during 1999
  - Screened a host of remedial technologies

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# Remedial Action Development



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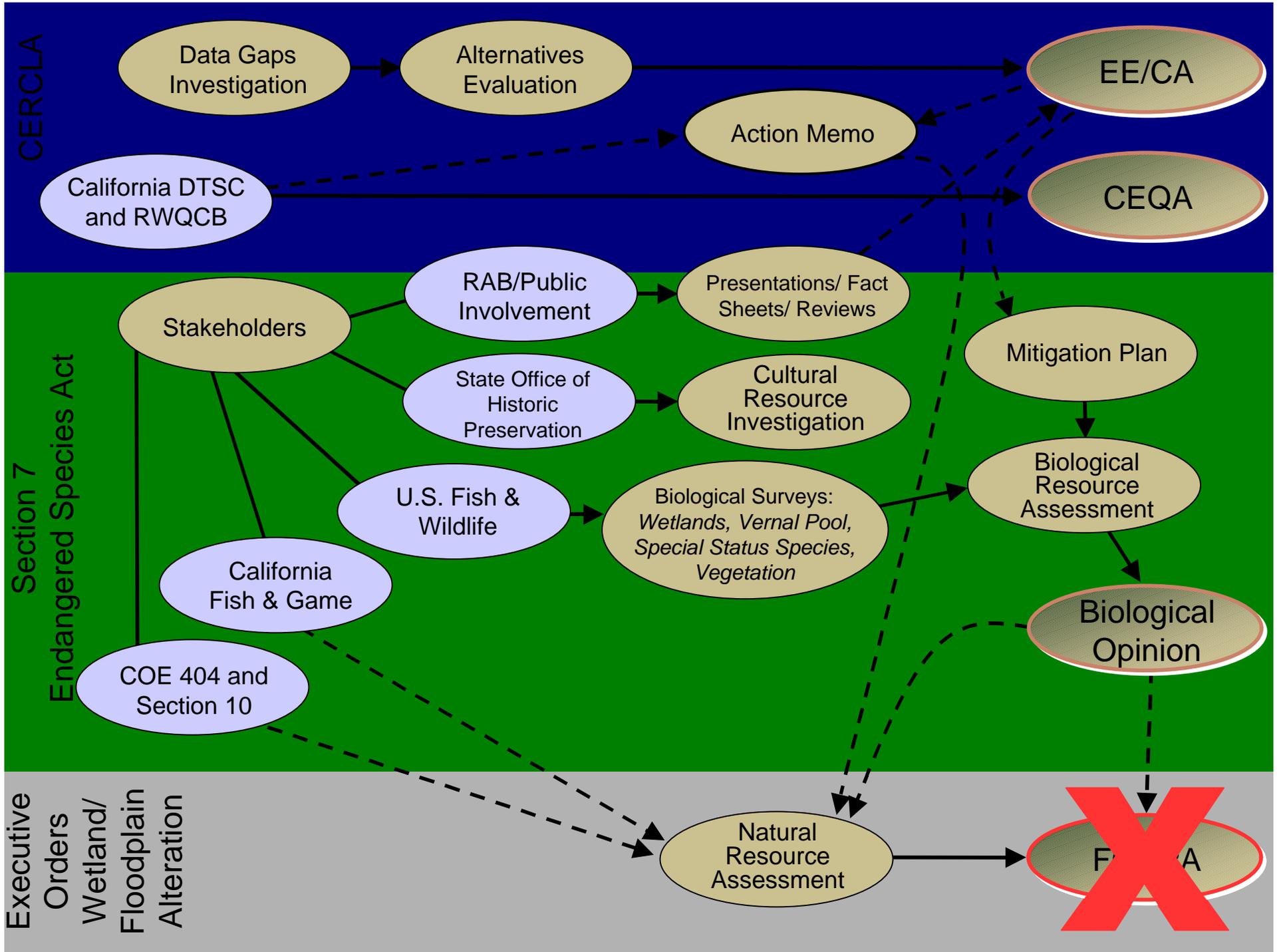
# *Remedial Action Development*

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- **Stakeholders workshop in March 1999**
  - **Project Concept approved by stakeholders**
  - **Special Status species study initiated to comply with Endangered Species Act**
  - **Section 404 permit waived by ACOE**

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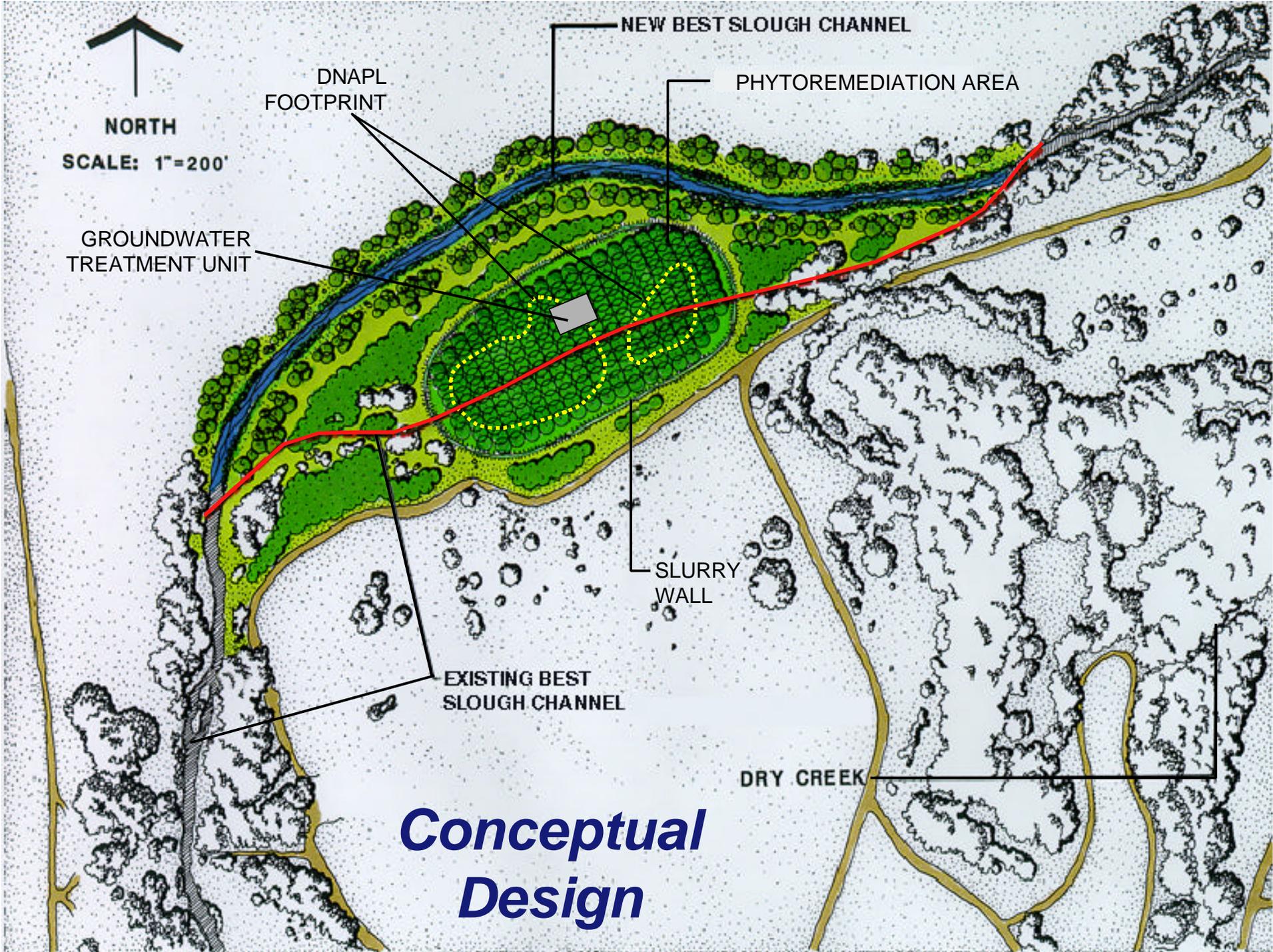
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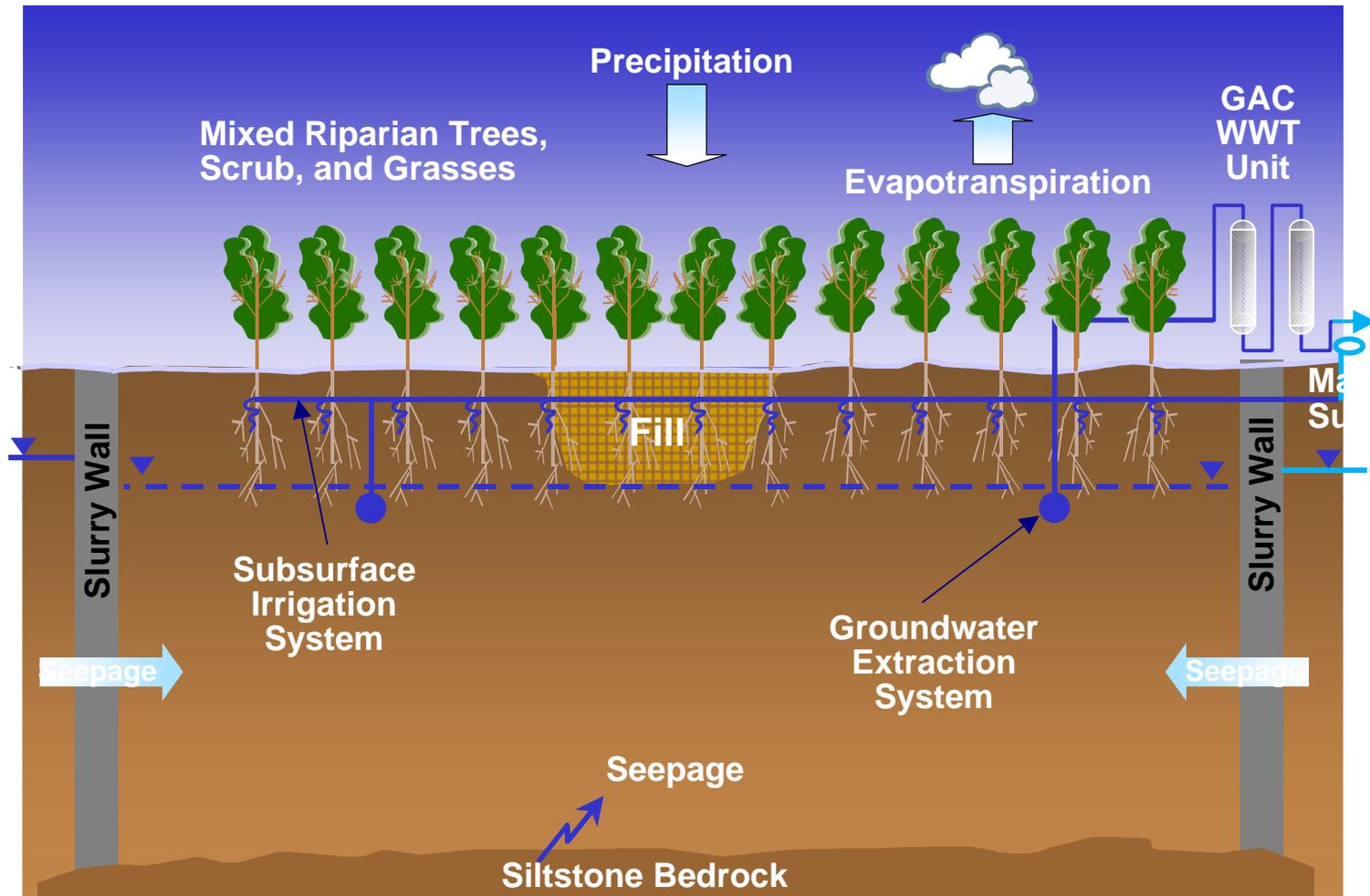


# *Conceptual Design*

- 
- **Reconstruct Best Slough outside and upgradient of source-zone**
  - **Install slurry wall keyed into bedrock around source-zone**
  - **Use a plant-based approach (phytoremediation) to maintain inward gradients toward source-zone through natural uptake**



# Cross Section: The Proposed Solution





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# *Conceptual Design*

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- **Groundwater Modeling**
  - **Modflow-SURFACT**
  - **Thirteen Layers**
  - **124,215 nodes**
  - **Covers over 1000 acres**
  - **Modpath for particle tracking**

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# ***Groundwater Collection Design Criteria***

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- **Maintain inward gradient across slurry wall of 1 foot (i.e. 1 foot difference in groundwater elevation inside and outside of wall)**
- **Recharge rates of 2 gpm to 10 gpm expected**
- **Groundwater collection inside slurry wall using an interceptor trench (drain)**
- **25-foot separation between slurry wall and drains**



# ***Groundwater Collection Design Criteria***

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- **Monitoring wells on either side of the slurry wall to determine gradient**
- **Soil moisture sensors used to determine if irrigation is required**
- **Limit TCE concentrations within collected water to < 25 mg/L**



# *Post Construction Site Water Balance*

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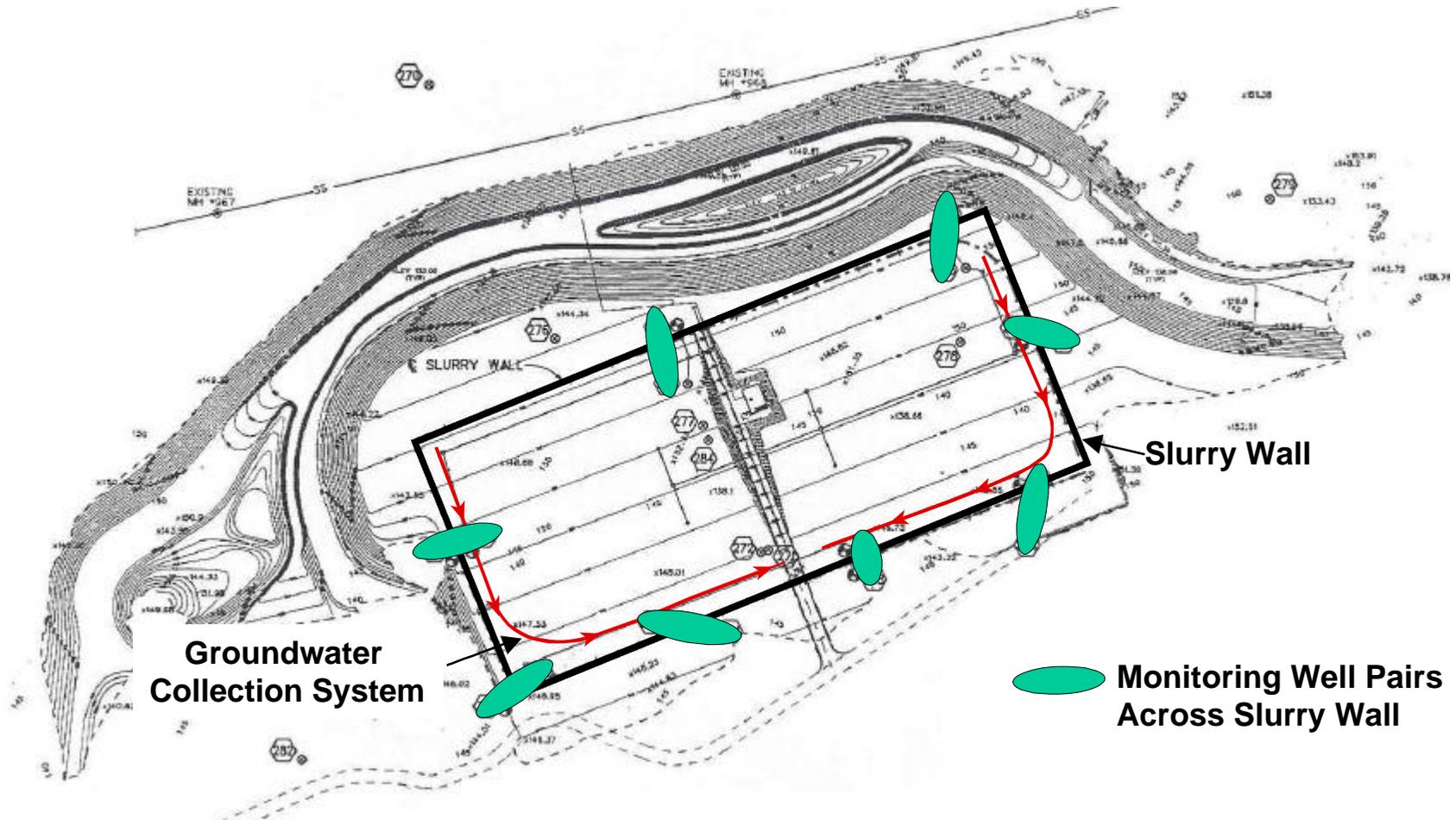
*(Slurry Wall area with mature plants—average conditions)*

- Groundwater inflow—0 to .5 gpm
- Deep percolation—1.5 to 2.5 gpm
- Groundwater outflow—0



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# Monitoring System Across Slurry Wall



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# *Slurry Wall Design Criteria*

- Permeability of  $1 \times 10^{-7}$  cm/sec
- Extends from final grade to 2 feet into bedrock
- Fully encloses the source-zone
- 5 acres in size

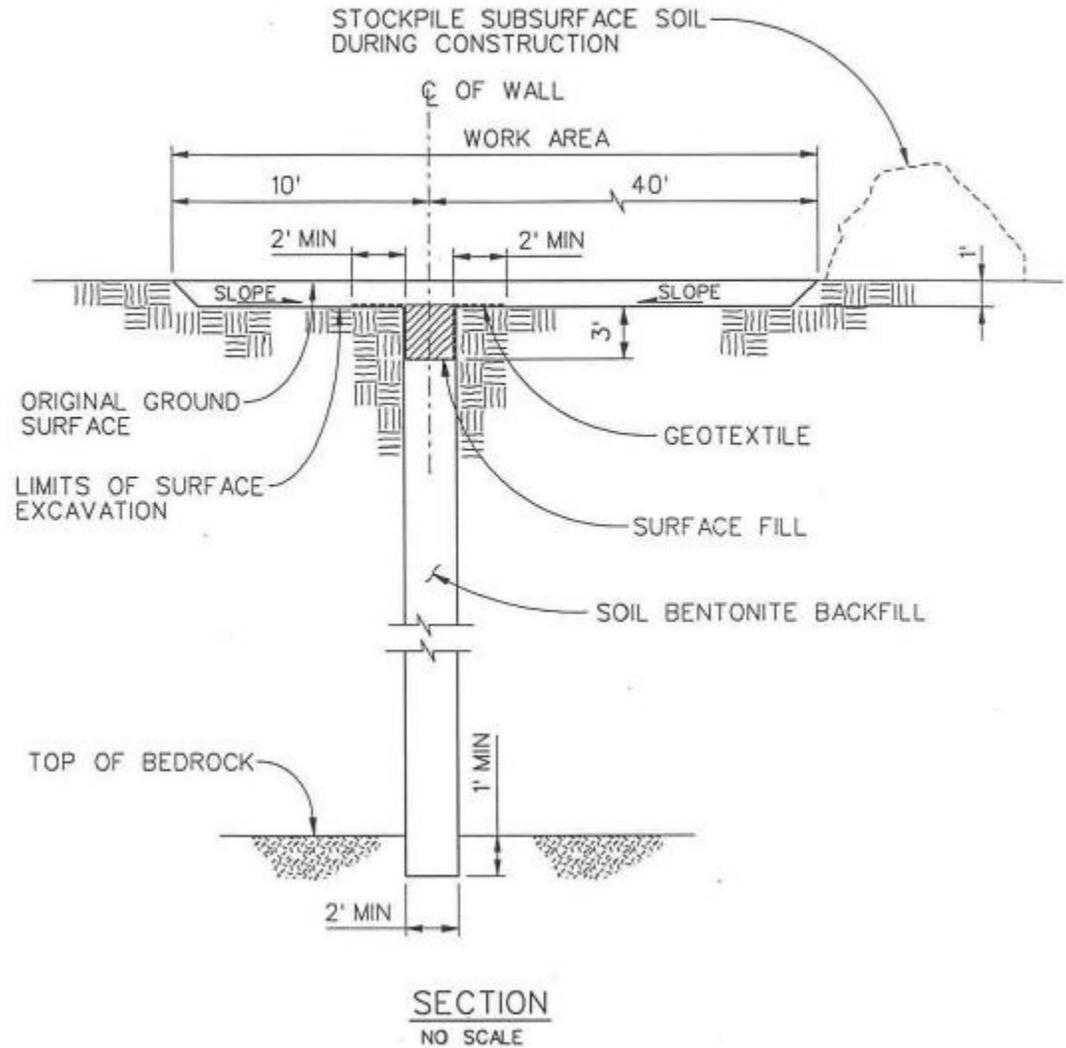


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# Typical Slurry Wall Section



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# *Phytoremediation Design Criteria*

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- Provide high rates of evapotranspiration
- Consist of native species to California
- Tolerate the groundwater contaminants
- Deep-rooted
- Appropriate for soil moisture conditions created by the design



# ***Phytoremediation Plant Selection***

- **Grass-legume-forbs cover**
- **Shrubs and bunch-type grass**
- **Approximately 4,000 grasses and shrubs**
- **Cottonwood (poles) and oak trees (seedlings)**
- **Approximately 2,000 trees**



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# *Irrigation Design Criteria*

- 
- **Surface drip system and subsurface (3 ft bgs) drip system**
  - **Surface drip system will use potable water**
  - **Subsurface drip system will use water collected from drains**
  - **Irrigate up to 8 acres along new Best Slough**
  - **Irrigate 5 acres inside slurry wall**
  - **Soil moisture probes used for operational logic and control**

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# *Treatment System Design Criteria*

- Average design flow of 5 gpm
- Peak design flow of 40 gpm
- LGAC system
- Discharge to sanitary sewer if irrigation not needed
- Discharge limits of 0.5  $\mu\text{g/L}$





# *Instrumentation and Control Design Basis*

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- **Automatic operation and alarms**
- **Gradient measured automatically across the slurry wall**
- **Pumping initiated when gradient is less than 1 foot across slurry wall**
- **Soil moisture probes determine if storage capacity within the soil. No treatment if storage capacity exists**
- **If no storage capacity, then pumped water is treated and discharged to sanitary sewer**



# ***Best Slough Reconstruction Design Basis***

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- **Maintain existing hydrologic capacity**
- **Enhance fish and wildlife habitat**
  - **Add aquatic structures (rootwads, brush bundles, logs)**
  - **Five different planting vegetation zones**
- **Remove Best Slough from contact with source-zone**
- **Natural aesthetically pleasing appearance**

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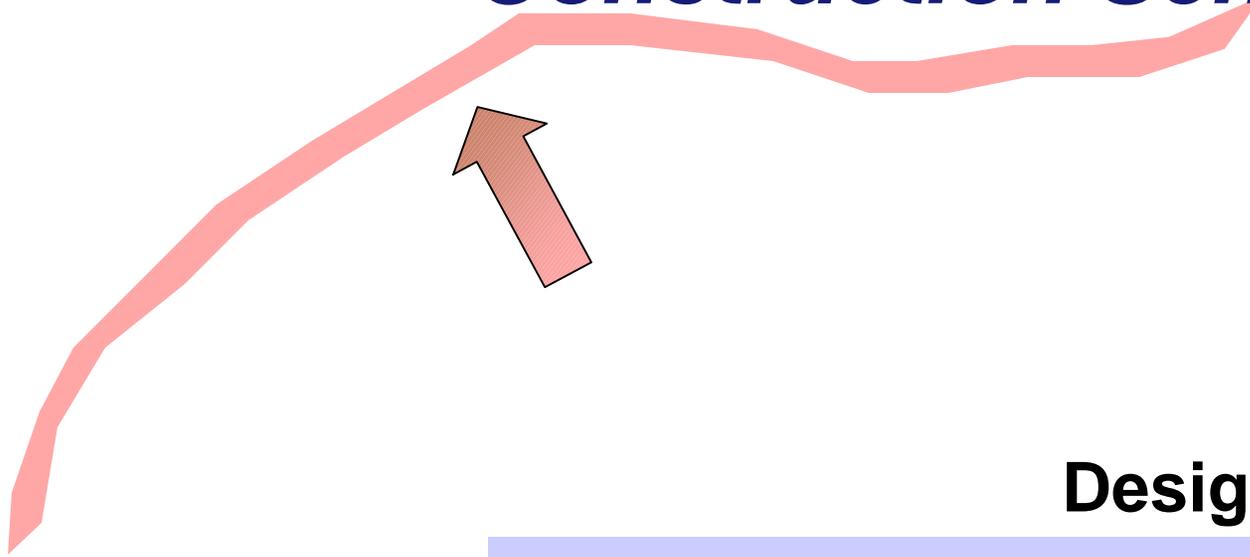
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# *Schedule*

- 
- **March 1999 Stakeholder meeting**
  - **EE/CA completed in November 1999**
  - **Design completed by January 2000**
  - **Funding secured by February 2000**
  - **Risk assessment completed by February 2000**
  - **Remedial Action Contract awarded in March 2000**
  - **Construction started in May 2000**
  - **Startup testing in January 2001**

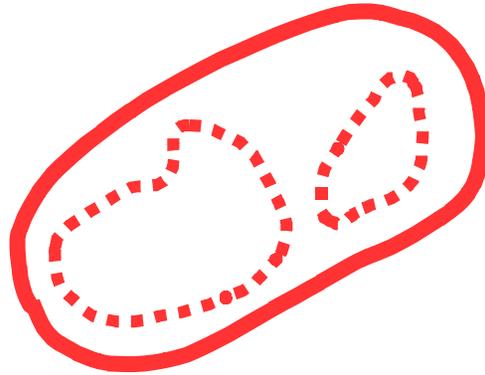
# ***Overview: Construction Schedule***



## **Design Features**

- **Move and realign slough**

# ***Overview: Construction Schedule***



## **Design Features**

- **Move and realign slough**
- **Install drain and slurry wall containment**

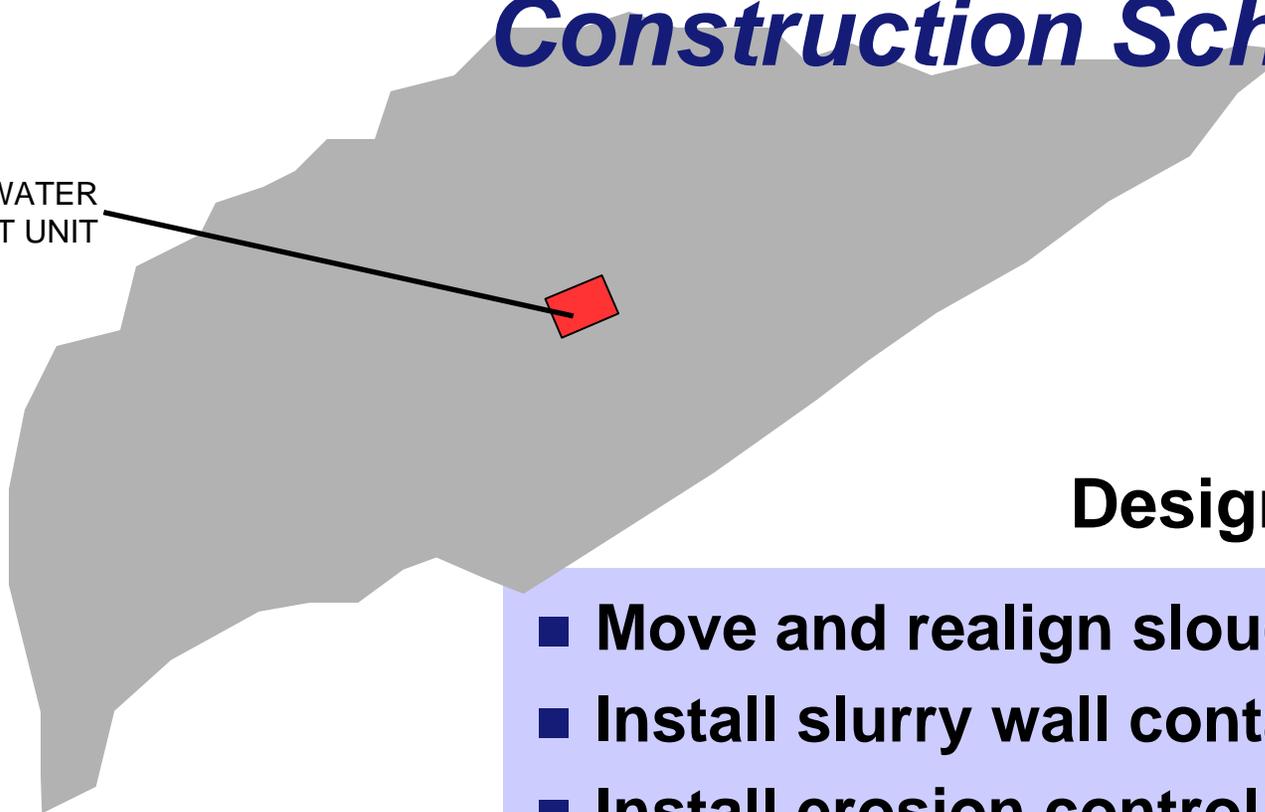
# ***Overview: Construction Schedule***

## **Design Features**

- **Move and realign slough**
- **Install slurry wall containment**
- **Install erosion control and habitat enhancement features**

# Overview: Construction Schedule

GROUNDWATER  
TREATMENT UNIT



## Design Features

- Move and realign slough
- Install slurry wall containment
- Install erosion control and habitat enhancement features
- Final grading of phyto area, install plants inside slurry wall, and groundwater treatment system

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## **2000: A Year of Construction**

**A Photo Review**



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# May—Getting Started

- Carefully transplanted Valley Elderberry bushes



photo: Tad Gantenbein

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# *May—Getting Started*

- **Carefully transplanted Valley Elderberry bushes**
- **Moved fish and reptiles whenever possible**



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## *May—Getting Started*

- **Carefully transplanted Valley Elderberry bushes**
- **Moved fish and reptiles whenever possible**
- **Extended utilities from base housing**



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## *May—Getting Started*

- **Carefully transplanted Valley Elderberry bushes**
- **Moved fish and reptiles whenever possible**
- **Extended utilities from base housing**
- **Began clearing and grubbing**



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# *June — Rerouting Best Slough*

- **Constructed  
Coffer Dam**



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# *June —Rerouting Best Slough*

- **Constructed Cofferd Dam**
- **Rerouted Best Slough**



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# *June —Rerouting Best Slough*

- **Constructed  
Coffer Dam**
- **Rerouted  
Best Slough**
- **Installed sediment  
control measures**



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## *June —Rerouting Best Slough*

- **Constructed Cofferd Dam**
- **Rerouted Best Slough**
- **Installed sediment control measures**
- **Back-filled old channel**



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# ***July—Challenges***

- **New channel excavation challenges**



**Seeps and groundwater control**

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# July—Challenges

- New channel excavation challenges
- Water pumped out of new channel and irrigated over dissolved plume



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*Irrigation Area*





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# ***July—Challenges***

- **New channel excavation challenges**
- **Final grading**



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# August — Containment Area Takes Shape

- Installed groundwater collection system



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# ***August — Containment Area Takes Shape***

- **Installed groundwater collection system**
- **Erosion control**



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# September—Slurry and Habitats

- **Habitat enhancements**



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# September—Slurry and Habitats

- Habitat enhancements
- Slurry wall construction



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# September—Begin Planting

- Habitat enhancements
- Slurry wall construction
- Began planting



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# *October—Racing the Rain*

- **Treatment pad preparation**



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# October—Racing the Rain

- Treatment pad preparation
- Planting



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# October—Racing the Rain

- Treatment pad preparation
- Planting
- Cofferdam Removal



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# ***November—New Best Slough***



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# ***January—New Banks Taking Shape***



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## ***IRA Benefits***

- 
- **Eliminates continuing threat to water resources**
  - **First step in the final long-term remedy**
  - **Enhances important riparian and aquatic habitat**
  - **Economical and low maintenance**
  - **Complies with all the current regulatory requirements for an environmentally complex project**
  - **\$3.5M vs \$18-20M for excavation**



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## ***Site 17 IRA***

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### **■ What's Done**

- 12,761 plants
- 120,000 yd<sup>3</sup> soil moved
- 70,000 hand-placed stakes
- 275 tons of bentonite
- 1,200 feet of subdrains
- 2,000 foot long slurry wall

### **■ What's Next**

- Groundwater treatment plant startup testing
- Final Planting of Cottonwood Poles
- Monitoring
- Operation and Maintenance
- Feasibility Study

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*The End*