PHYSICAL / CHEMICAL TREATMENT FOR REFINERY WASTEWATER

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Problem

- New Environmental Requirements
- Low Energy Costs - High Maintenance Sensitivity
- Highly Abnormal Refinery Wastewater
  - High Temp (> 50 C) – Bio Difficult
  - High TDS (ave. 18,000 mg/L)
  - High Ammonia (80 mg/L)
  - High Phenol (>60 mg/L)
  - V. High Variability (TDS From 8 – 35,000 mg/L)
  - Frequent Flow interruptions
- High Removal Efficiencies Required
  - Phenol -> 0.1 mg/L (99.8% Removal)
  - Ammonia -> 1 mg/L (98.7% Removal)

Problem

Upstream Process Modifications

Unfeasible

Treat Wastewater As Is

Treatment Options

- **Oil/Water Separation & Biological**
  - Traditional Treatment Method
  - Low Cost

--- HOWEVER ---

  - High Removal Efficiencies Required
  - Operational Considerations
    - Biosystem Sensitivities
    - Solids Settling Requirements
  - Challenging Operating Conditions
    - Feed Modification Very Expensive
  - Unpopular Technology

Treatment Options

Traditional Treatment

--- DECISION ---

Alternative

Physical/Chemical Treatment

Treatment Options

- **Physical / Chemical Treatment**
  - Non Traditional - Unproven
  - Higher Cost
  - More Treatment Steps

--- HOWEVER ---

  - Adaptable to Varying Operating Conditions
  - High Removal Efficiencies Possible
  - Better Start-up / Shut-down
  - Easier to Operate

Design Development Physical/Chemical

- Engaged USFilter/Siemens
  - Treatment Needs Evaluation
  - Literature Search
  - Bench Scale Testing
  - Field Pilot Plant
  - Equipment Design – Economic Evaluation
    - Biological
    - Physical/Chemical

Treatment Needs Evaluation

- BOD/COD/TOC
  - 150 mg/L BOD -> Less Than 25 mg/L
- Ammonia
  - 80 mg/L -> Less Than 1 mg/L
- Phenol
  - 60+ mg/L -> Less Than 0.1 mg/L

Indicator Parameters

Ammonia & Phenol

Literature Search

- **Treatment Options Identified:**
  - **Phenol & BOD/COD/TOC**
    - Steam Stripping
    - Polymeric Resins
    - Carbon Adsorption
  - **Ammonia**
    - Steam Stripping
    - Clinoptilolite Clay
    - Ion Exchange Resin
    - Air Stripping
    - Breakpoint Chlorination

Bench Scale Testing

- **Ammonia**
  - Ion Exchange – Low Exchange Capacity
  - Air Stripper - > 97% Removal
- **Phenol**
  - Polymeric Resins – 1 - 2 mg/L
    - Steam Regeneration Possible
    - Pre Treatment Only
  - Carbon Adsorption - < 0.1 mg/L
    - Steam Regeneration Not Indicated

Polishing Only

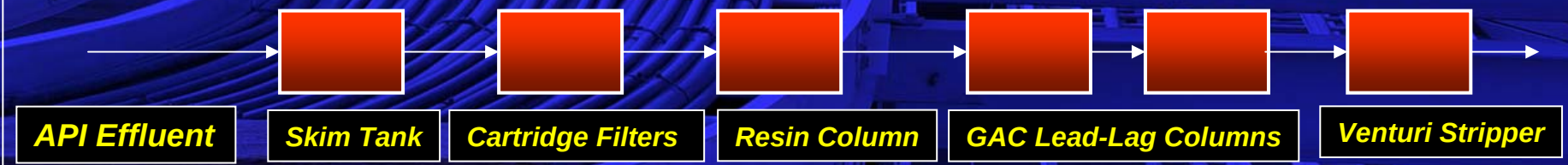
Field Plant Testing - Goals

--- Confirm ---

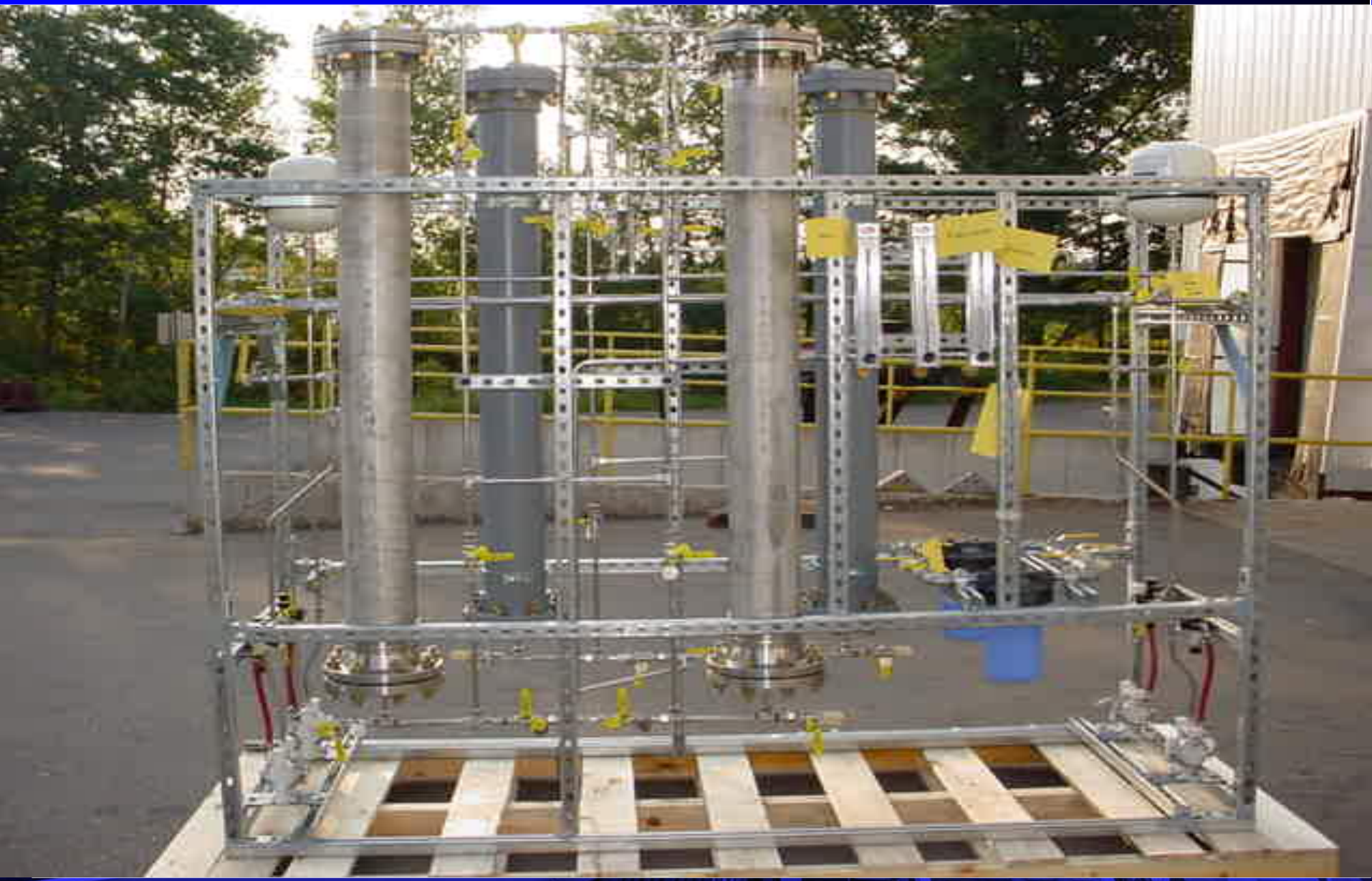
- Resin Column
  - Bulk Removal of Phenol
  - Regeneration Capability – Long Term
- GAC Column
  - Polishing Capability
- Venturi Air Stripper
  - Bulk Removal of Ammonia
- Design Specifications

Field Pilot Setup

- API Separator Effluent
- Skim / Equalization Tank
- 50 micron Cartridge Filter
- Single Resin Column
- 2 GAC Columns – Series
- Venturi Air Stripper



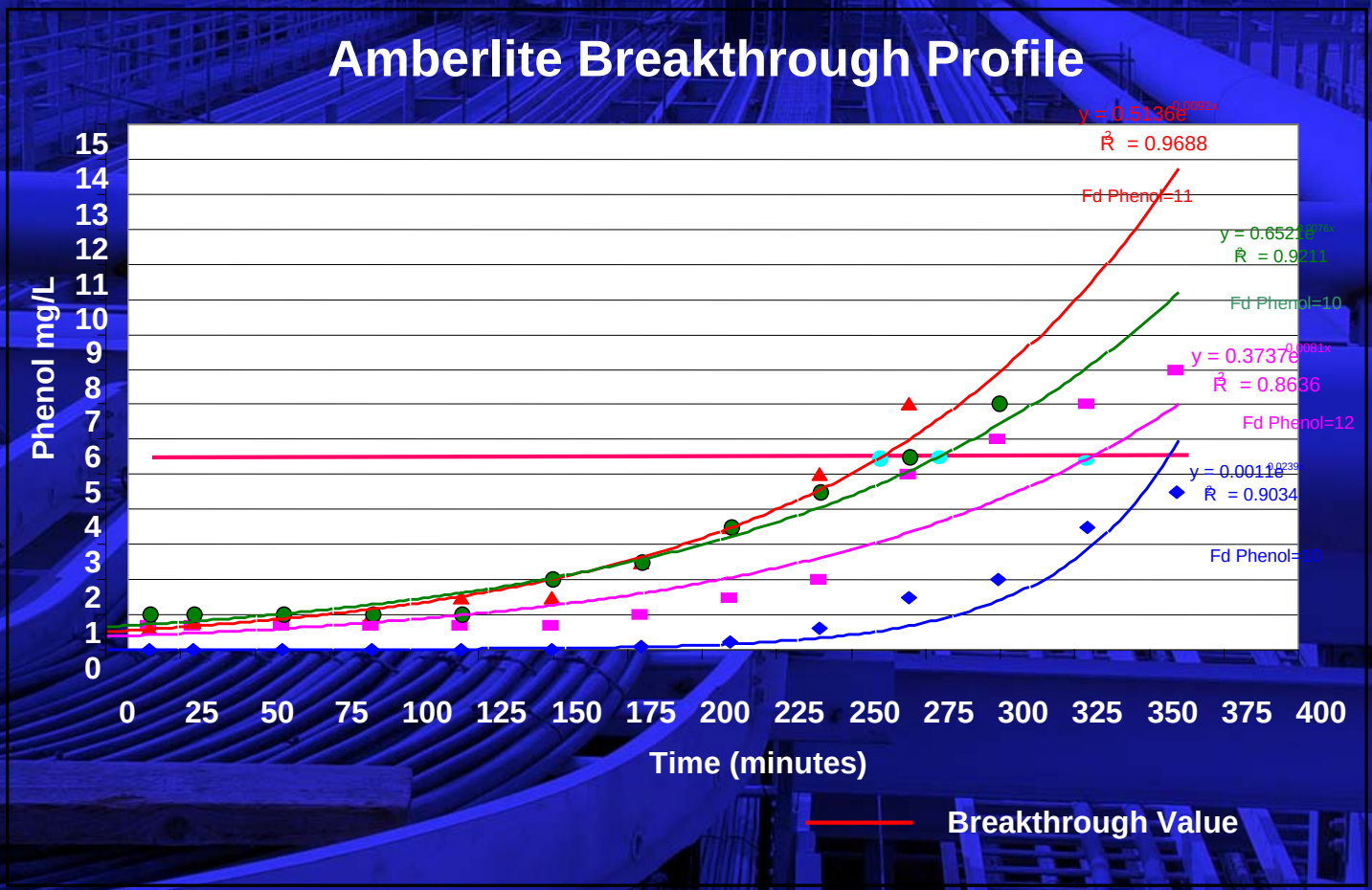
Field Pilot Plant



Resin Pilot Plant Testing – Results

Resin Column – 1st Goal Confirm:

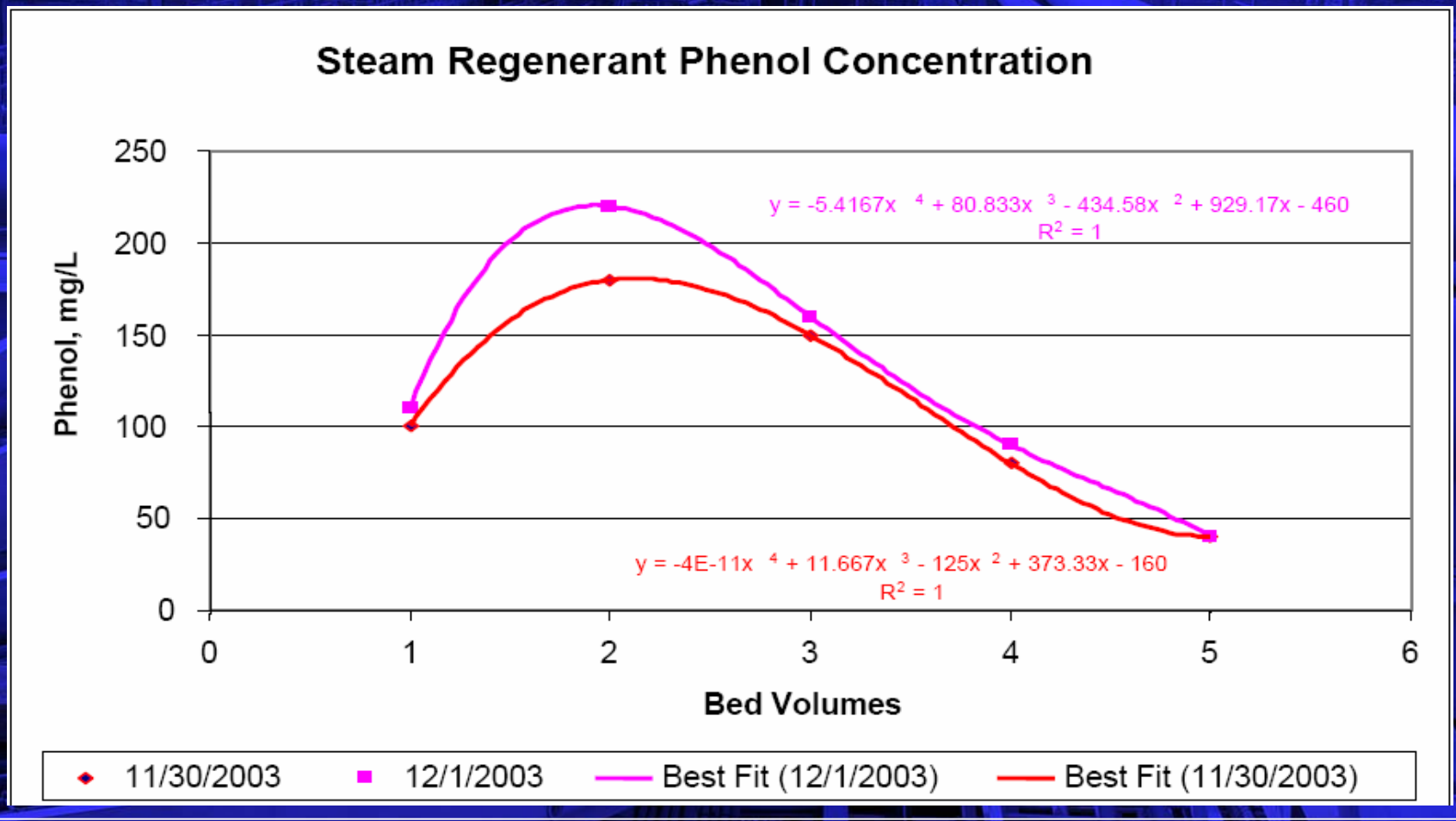
- Bulk Removal of Phenol (@17+ BV/Hr Feed)



Resin Pilot Plant Testing – Results

Resin Column – 2nd Goal:

- Steam Regeneration



Resin Pilot Plant Testing – Results

- **Resin Column**
  - **Regeneration Results:**
    - 60% Removal w/ 4 Bed Volumes
    - Post Regeneration [Phenol] <1.0 mg/L
    - No Change in Removal Capacity With Time
      - Steady State Indicated
  - **Data Indicated Fewer Steam BVs Possible (3)**
    - Insulation Important
    - Higher Temperature
    - Cost Benefit Analysis

Resin Pilot Plant Testing – Conclusions

- **Resin Column Test Goals**
  - Bulk Removal of Phenol - Confirmed
  - Regeneration Capability - Confirmed
  - 12 Hr Run Time w/ 7 BV/Hr Loading

--- Additionally ---

  - Robust System
    - Accommodates Process / Operator Problems

GAC Pilot Plant Testing - Results

GAC Polishing – Confirm Polishing

- Field Setup
  - Feed to GAC From Resin Column
  - Lead / Lag Column Arrangement
    - Switch 1st Column @ Breakthrough of 2nd (0.1 mg/L)

GAC Pilot Plant Testing - Conclusions

- **GAC Polishing**
  - **GAC Polishing Capability – Confirmed**
  - **Design:**
    - **1 BV/Hr = 30 Days Useful Bed Life**
    - **Economics = Multiple Columns in Series**

NH3 Pilot Plant Testing

- **Ammonia – Confirm Bulk Removal**
  - **Field Setup – Venturi Stripper**
    - **API Separator Effluent in Batch Mode**
      - **Removal Coefficients**
    - **Used Removal Coefficients to Simulate Stages**
      - **98% Removal**
      - **Cost Analysis Performed**

Pilot Venturi Stripper

NH3 Pilot Plant Testing - Conclusions

- **Ammonia Removal**
  - **NH3 Removal – Confirmed**
  - **Design**
    - **Multiple Stages Required for 99.9% Removal**
    - **Polishing Potentially Required**

Decision

Design Confirmed

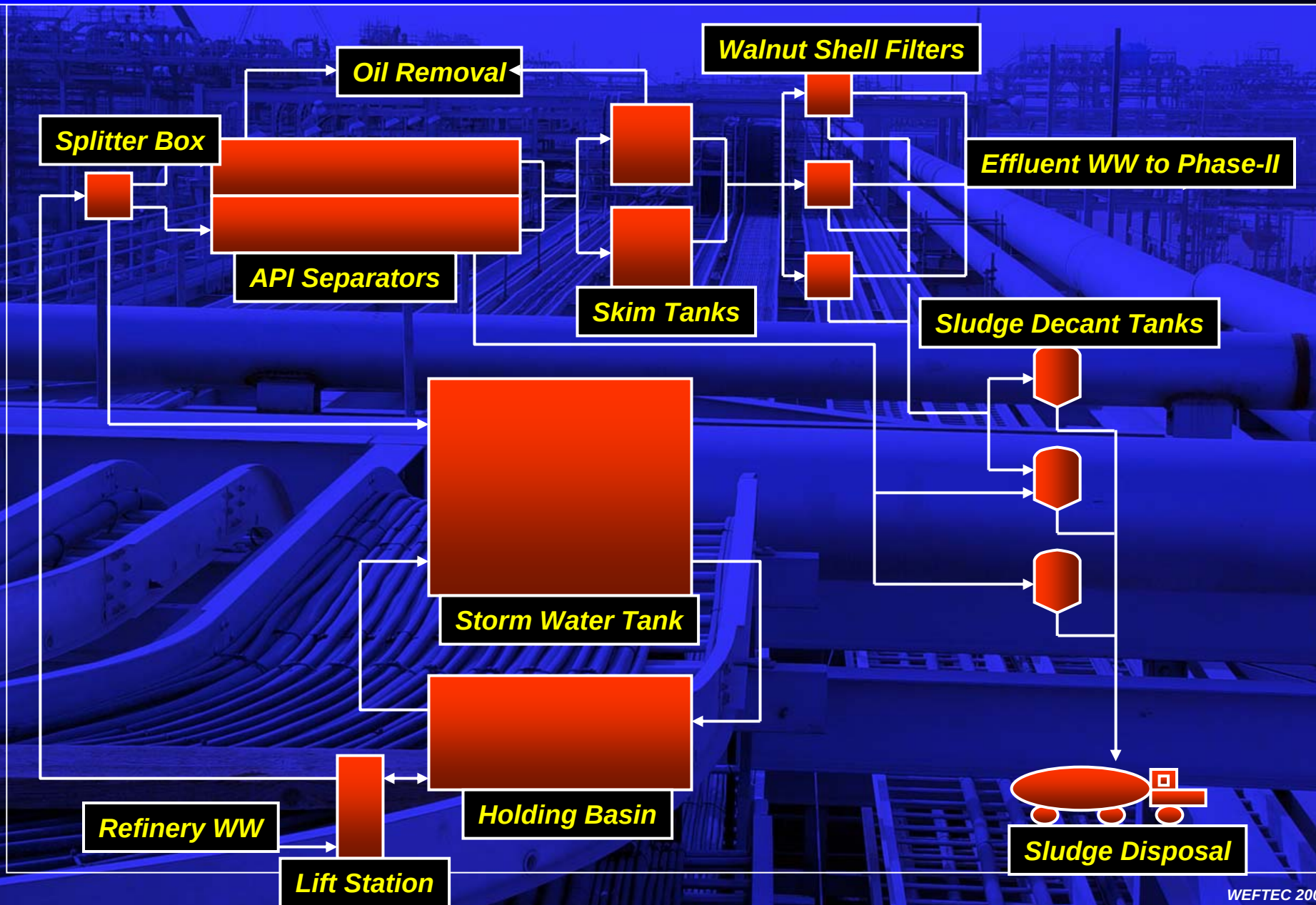
Scale-up For Refinery

Cost Analysis

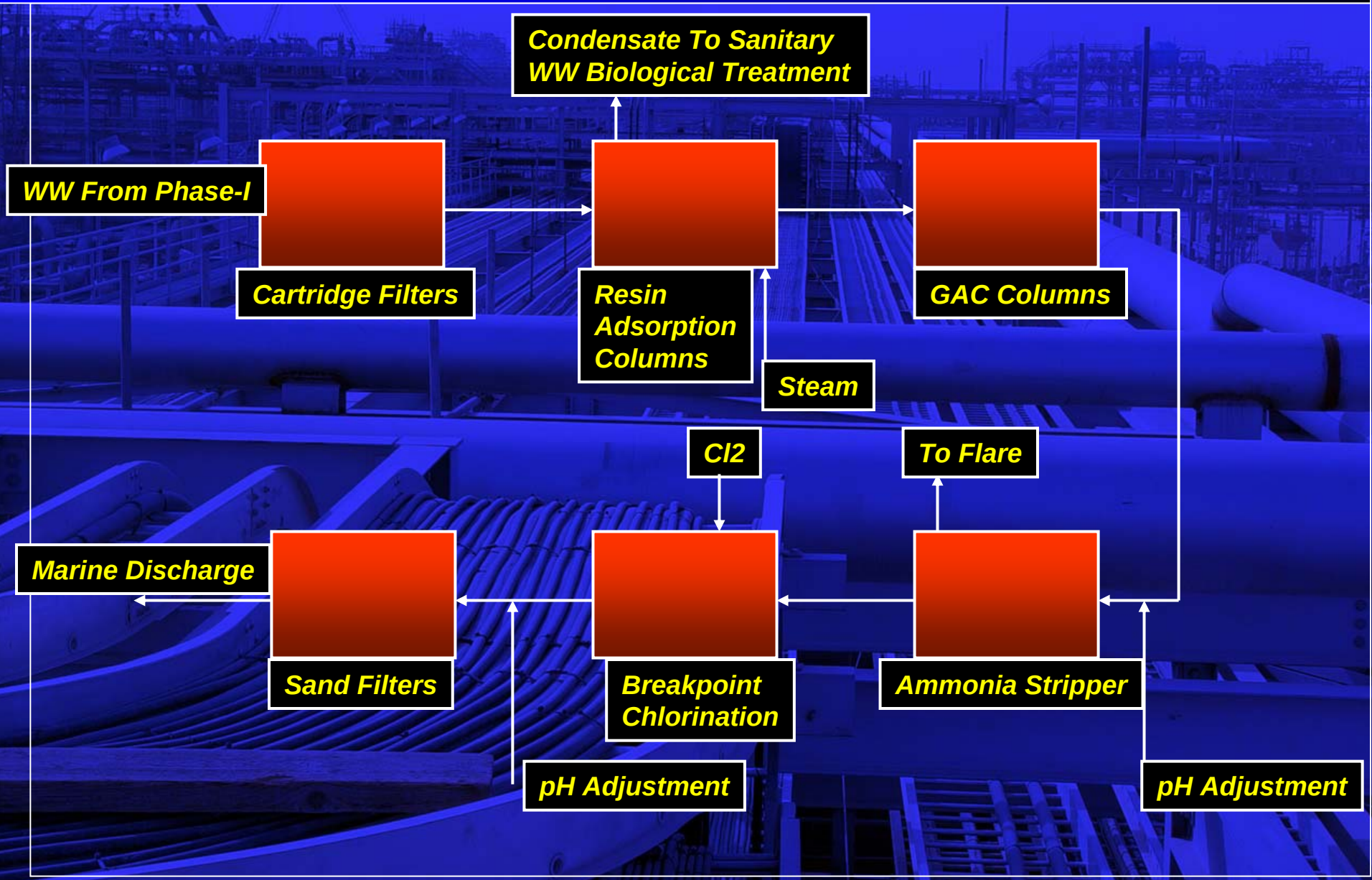
Physical & Biological

Operational Advantages

Primary Treatment Process Design



Physical/Chemical Process Design



Conclusions

- Identified & Demonstrated Feasibility of Physical / Chemical Treatment for:
  - Organic Removal
  - Ammonia Removal
- Evaluated Project Life Cycle Costs
  - Physical/Chemical
    - Slightly Lower Cost
    - More Reliable & Easier To Operate


Thank You