

***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**

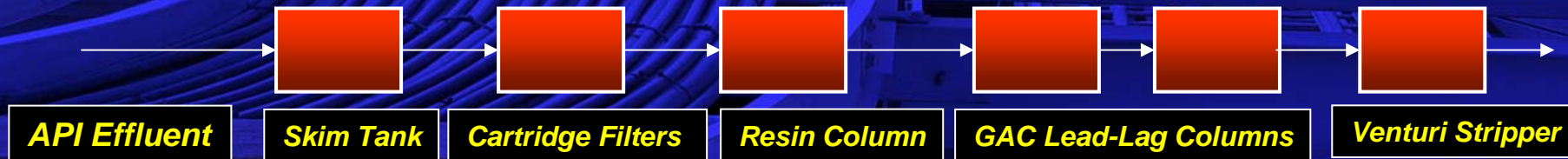
💧 **Venturi Air Stripper**

- **Bulk Removal of Ammonia**

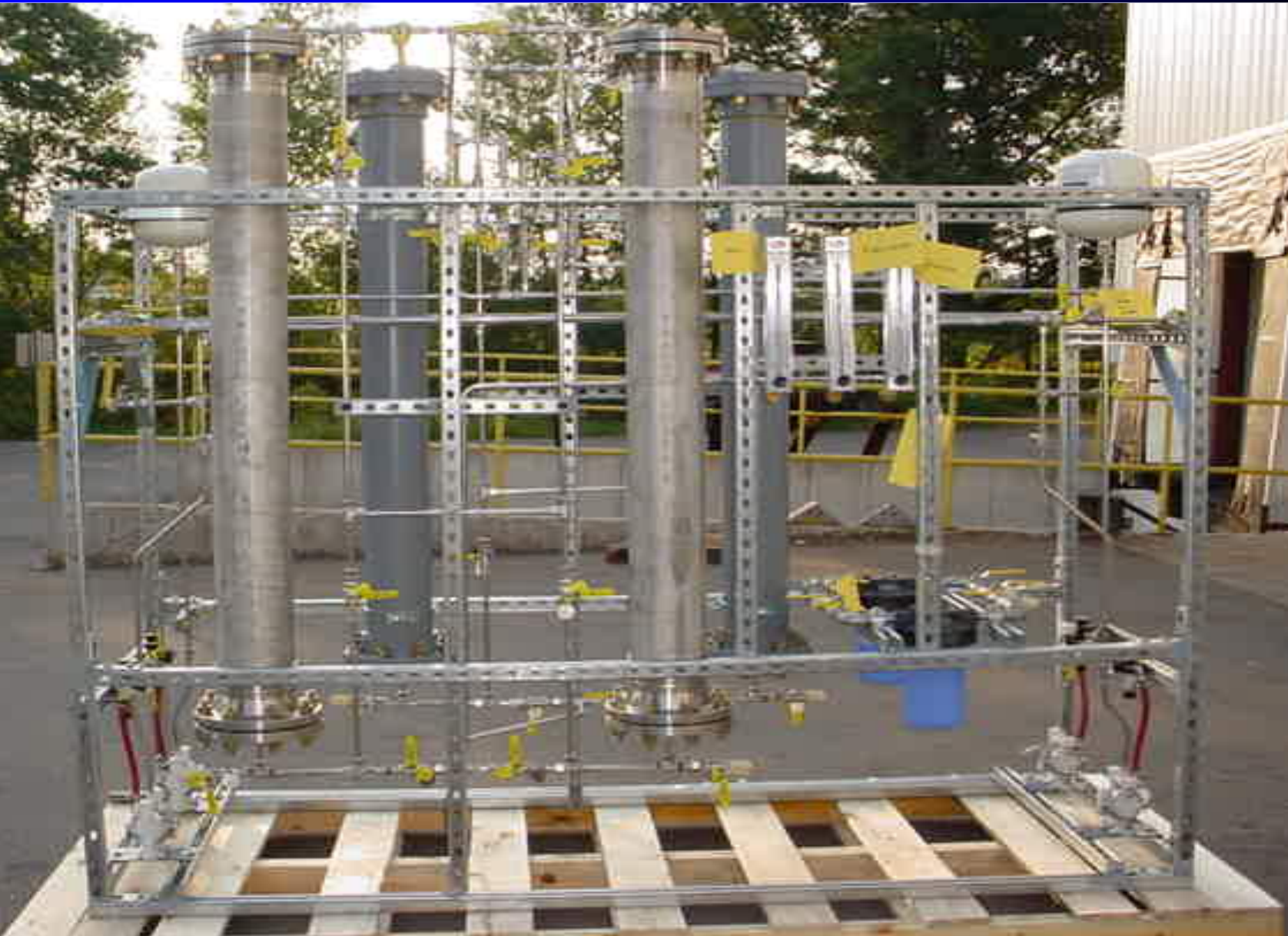
💧 **Design Specifications**

Field Pilot Setup

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

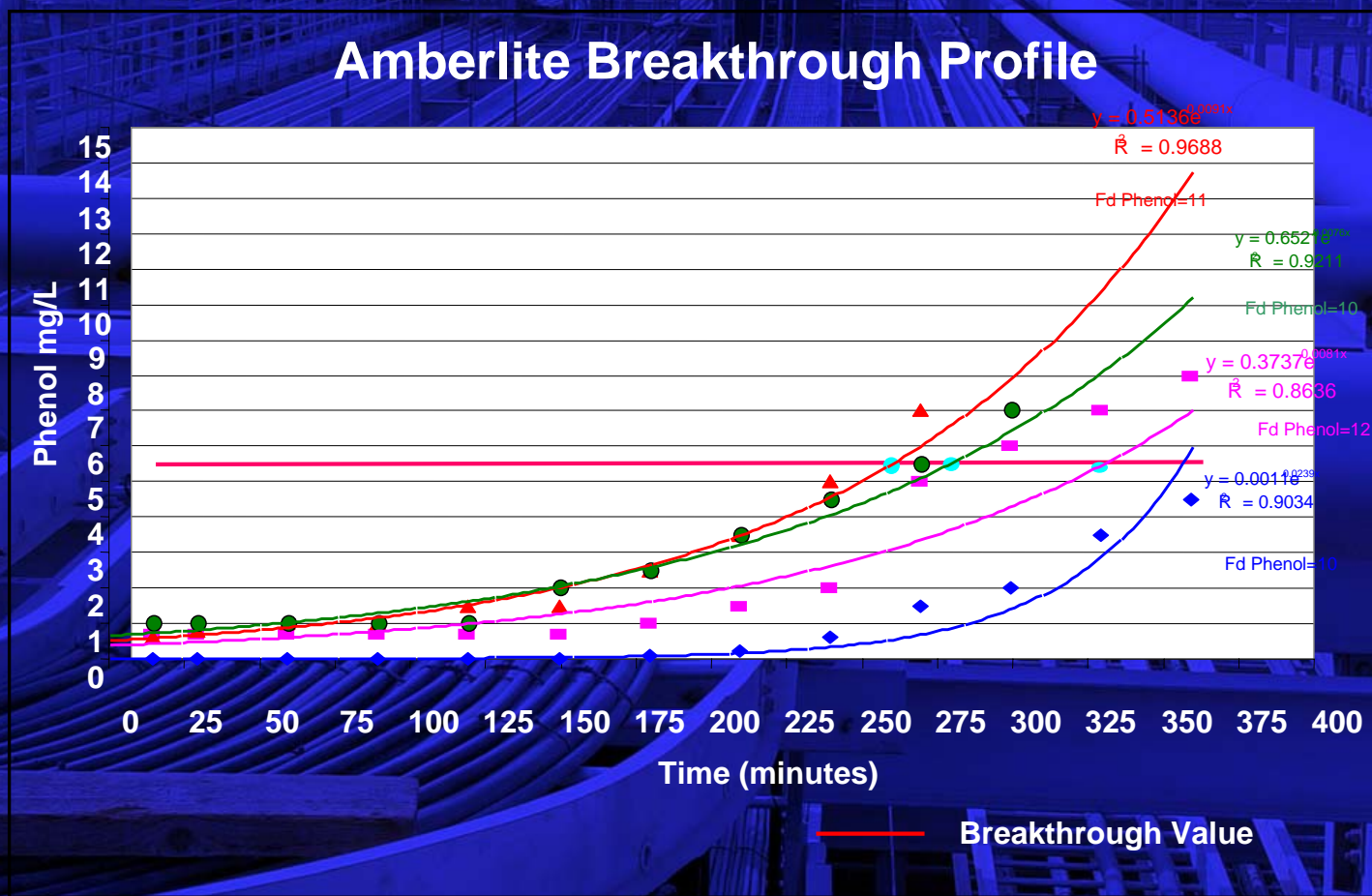


Field Pilot Plant



Resin Pilot Plant Testing – Results

- Resin Column – 1st Goal Confirm:
 - Bulk Removal of Phenol (@17+ BV/Hr Feed)

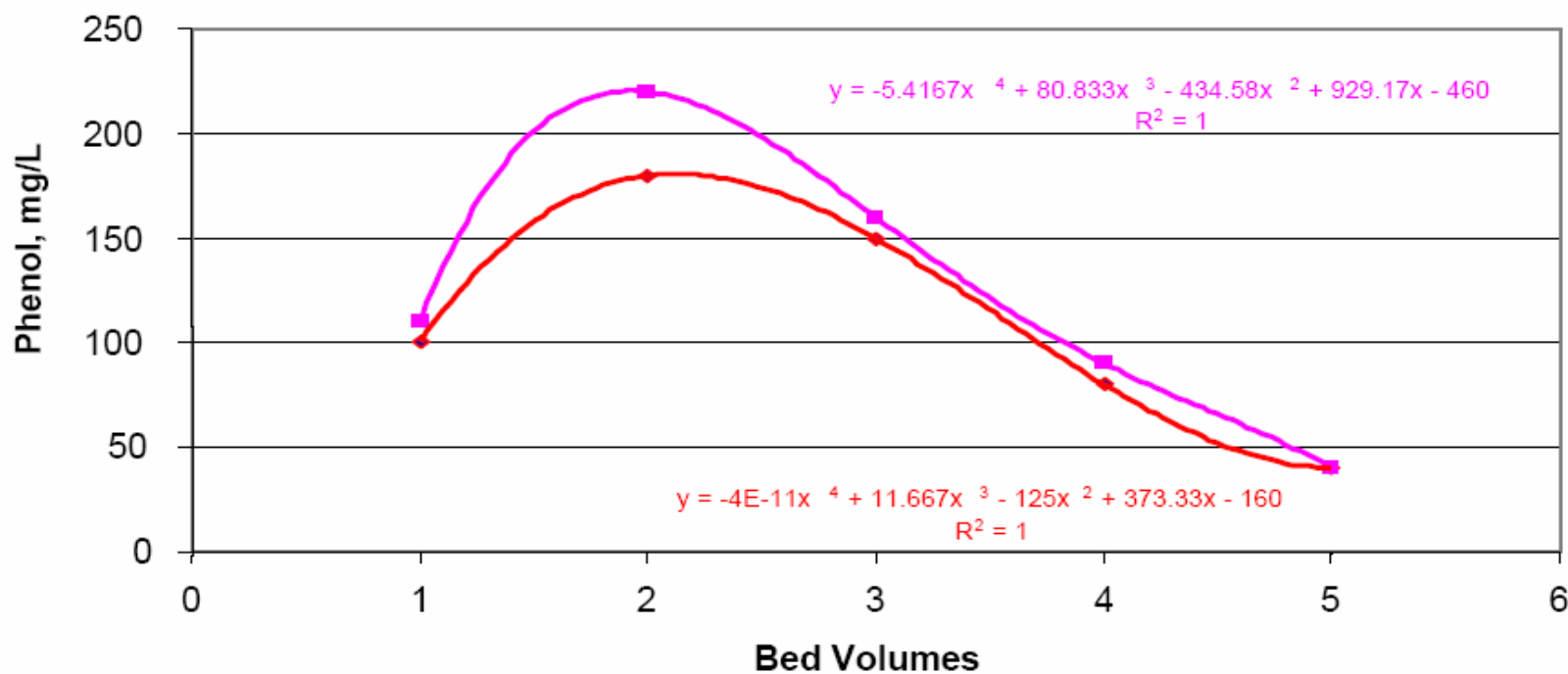


Resin Pilot Plant Testing – Results

💧 **Resin Column – 2nd Goal:**

➔ **Steam Regeneration**

Steam Regenerant Phenol Concentration



◆ 11/30/2003 ■ 12/1/2003 — Best Fit (12/1/2003) — Best Fit (11/30/2003)

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

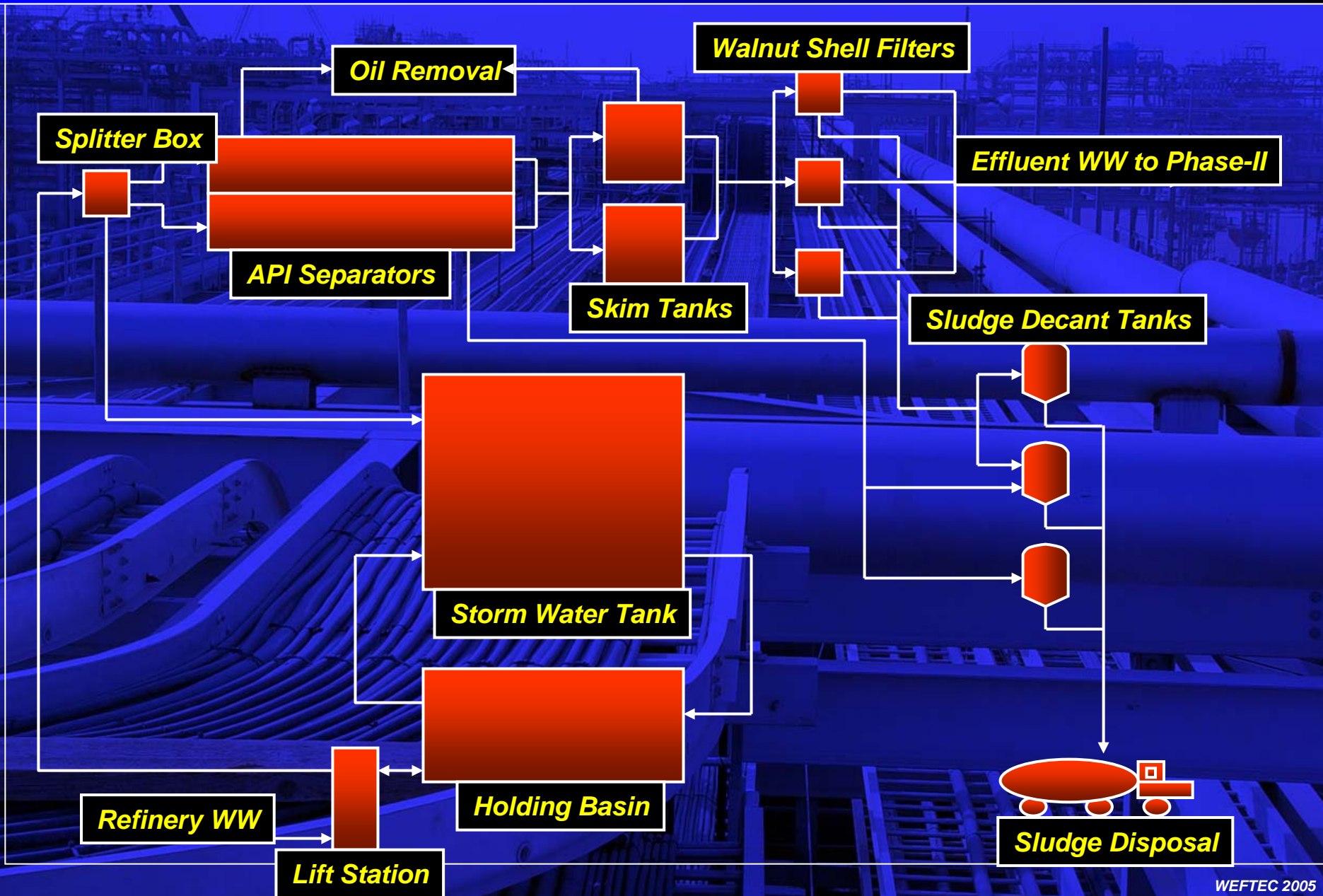
Scale-up For Refinery

Cost Analysis

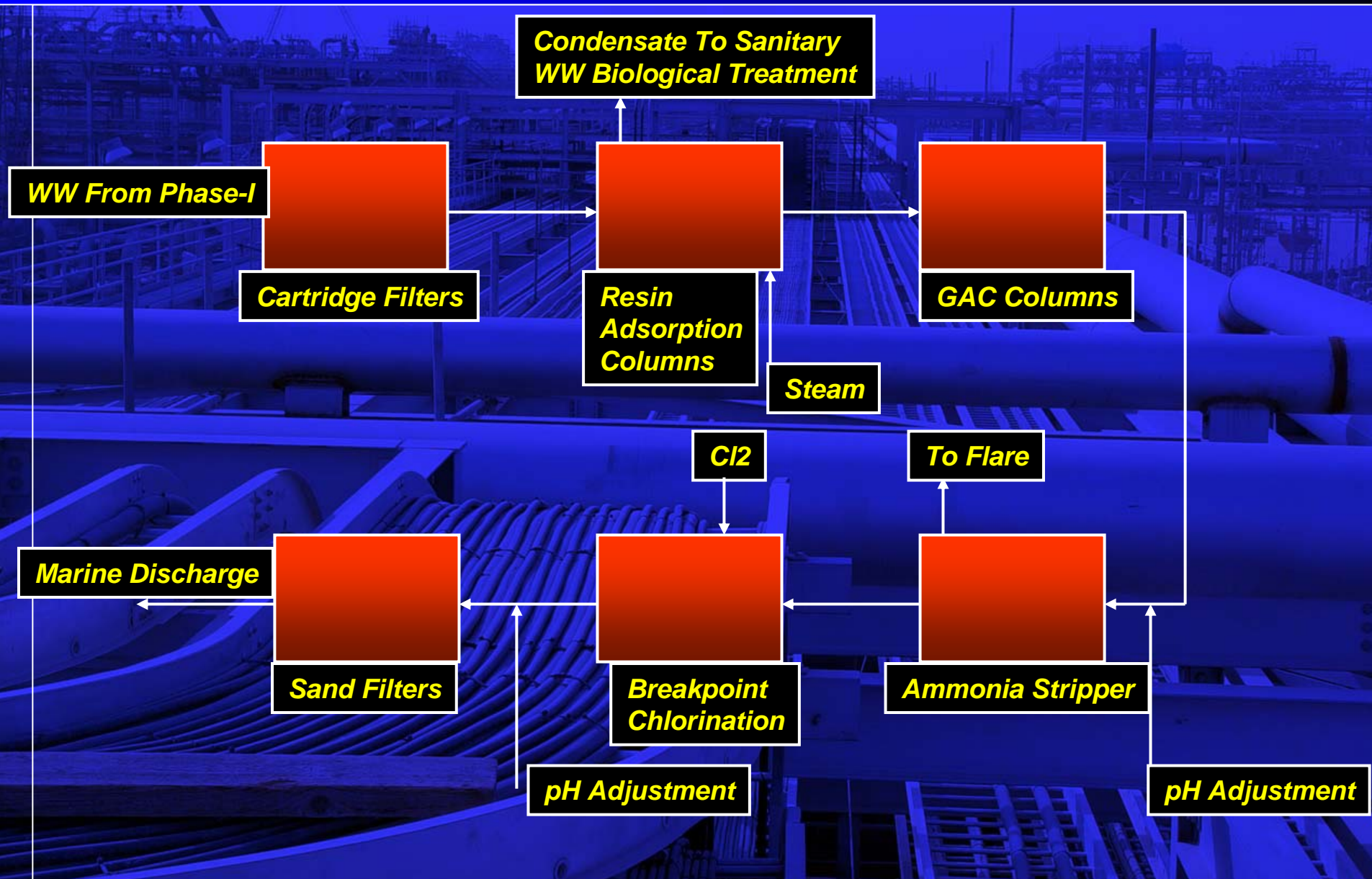
Physical & Biological

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