Waste Water Treatment Unit for LNG Mega Trains Challenges

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DELIVERING LNG TO THE WORLD

QATARGAS

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Key Drivers for Wastewater Management / Minimization

- Qatargas long-term aim to minimize water discharge and adopt best industry practices on sustainable wastewater use and reuse.

- Direction from Qatar Ministry of Environment (MoE) (and predecessor SCENR) to eliminate discharges to sea. Enshrined in State of Qatar Environmental Regulations (Exec. By-Law No.4 [2005] of Law No. 30, 2002).

- Qatargas Consent To Operate (Environmental Permits):
  - Previously discharge to sea allowed until RLC Treated Industrial Water (TIW) network operational
  - Now alternative QG disposal option to be evaluated (completed as part of feasibility study) and to be implemented as part of Compliance Action Plan (CAP)

- QP mandate to reduce injection rates to the Qatargas operated subsurface injection reservoir. QG exploring alternate use/disposal options for volumes reduced.

- Requirement to demonstrate steady progress with regulatory water discharge minimization requirements to QG Lenders.

Background – Agreements with the MoE & QP

- **2004:** Provision to discharge clean process streams included in QG2 and QG3&4 Consent to Construct issued by the MoE (formerly the SCENR) until the RLC Wastewater utilization facilities become operational.

- **2007**: RLC commences development of a Treated Industrial Water (TIW) network to receive all "irrigation water quality" treated wastewater from industrial facilities operating in the RLC for reuse for irrigation and landscaping. TIW expected to be constructed and operational by 2011 (initial forecast).

- **2008**: Waste Liquid Injection (WLI) Permits issued by QP/RLC for QG2 and QG3&4 wells. Injection rate allowance reduced by 37% from 6,000 m^3/day (design) to 3,800 m^3/day (permitted).

Background – Agreements with the MoE & QP

- **2009**: MoE permits discharge to sea of treated wastewater process streams until such time that MoE and RLC agree on a sustainable disposal option. Allowance included in 2010 QG2 and QG3&4 CTOs.

- **Nov. 2011**: QG2 and QG3&4 CTO renewals prohibiting discharge to sea. RLC informs tentative time frame for TIW delayed to 2016.

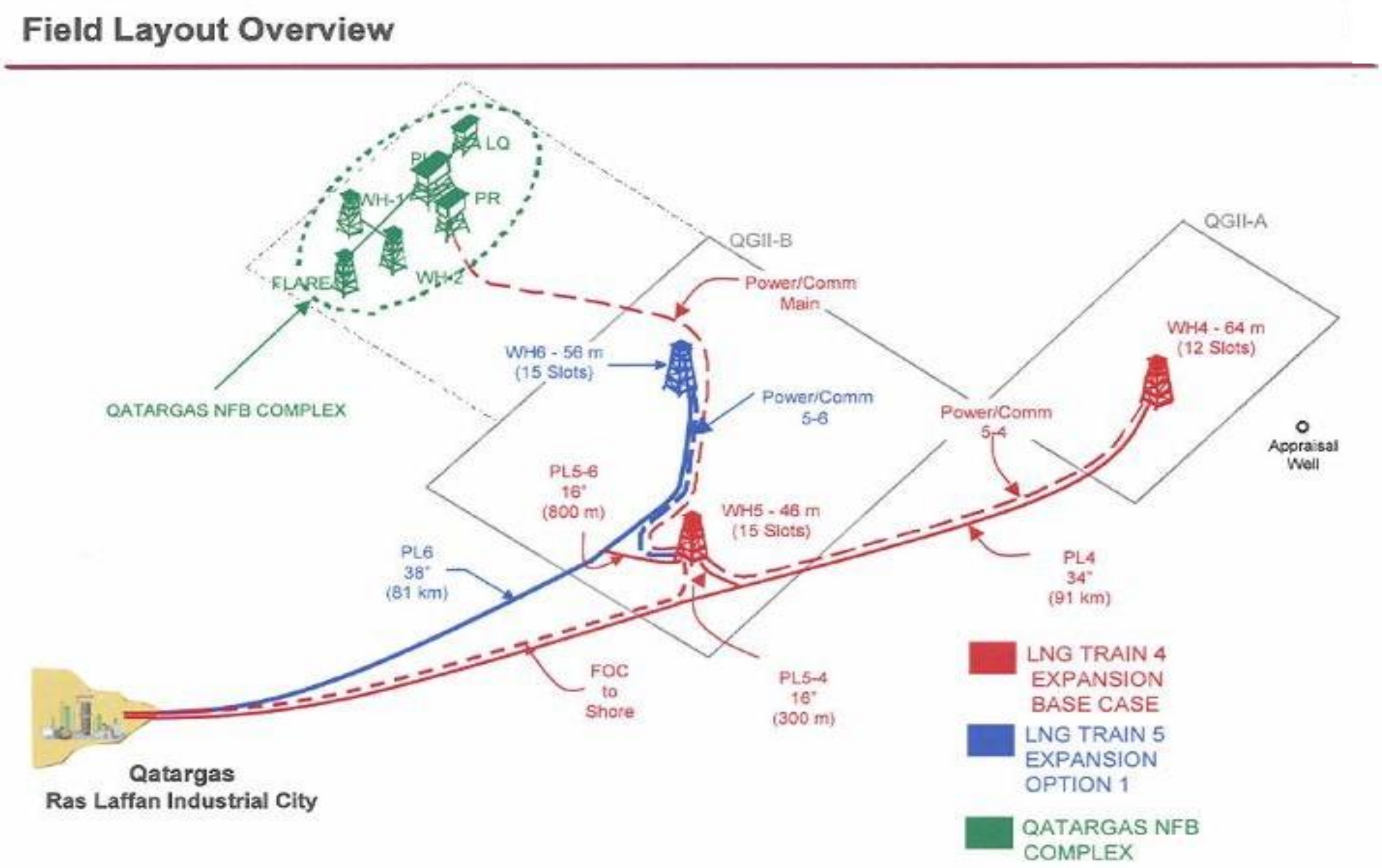
- **Feb. 2012**: CTOs revised to allow discharge to sea, Qatargas agreed to a time-bound Compliance Action Plan (CAP) to implement a sustainable and engineered wastewater reuse and disposal solution.

Mega Trains Waste water disposal routes

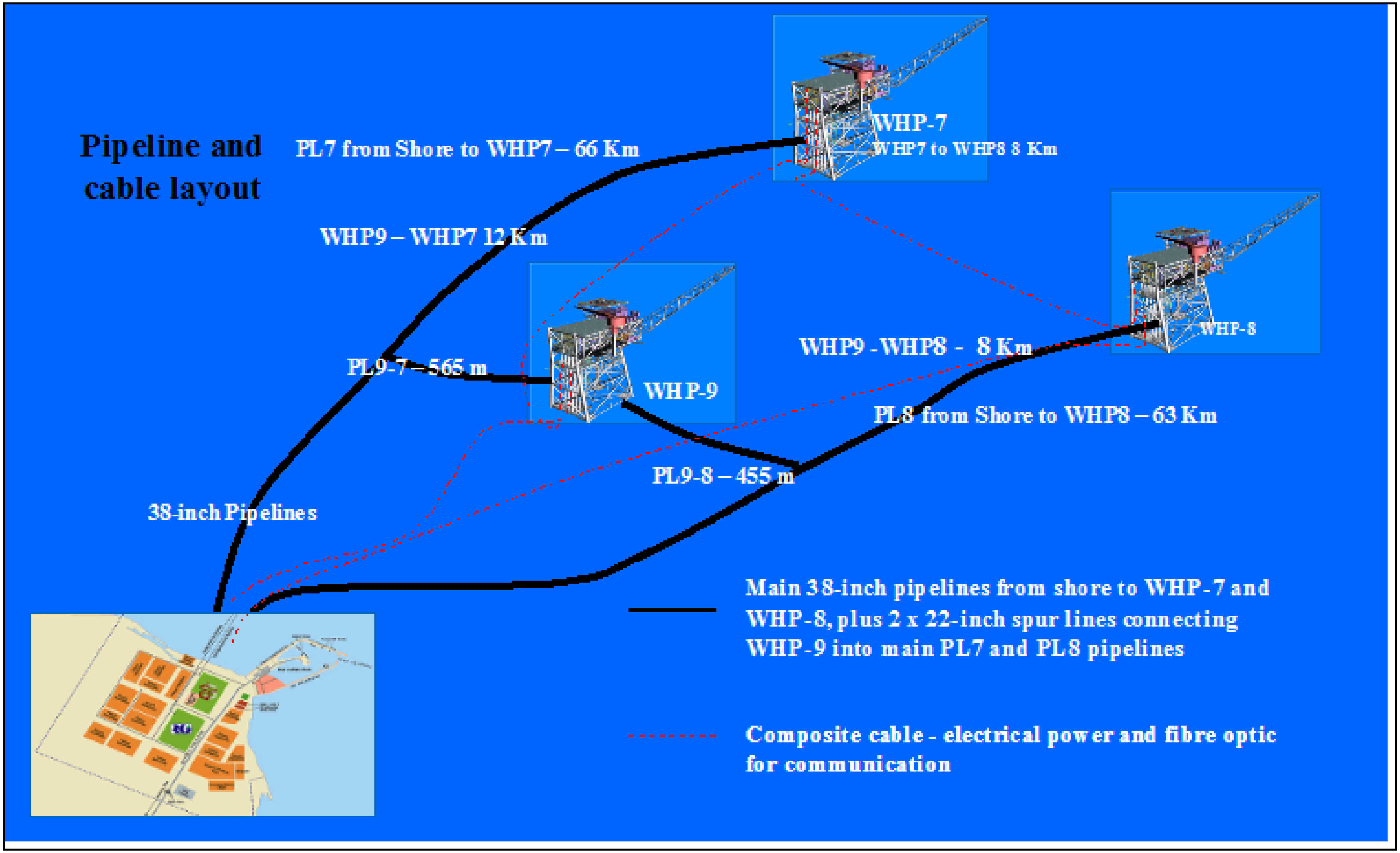
- QG2 and QG3&4 clean process streams (boiler blow down and condensate regeneration water) discharged to RLC surface water ditches from storm water ponds 2,700 M^3/day (per CTO allowance until RLC TIW network or alternative QG disposal option implemented)

- Produced and plant process water at QG2 and QG3&4 is injected to a sub surface formation via a network of six subsurface injection wells (3,500 M^3/day)

QG-2 Offshore Production Platforms – Sealines Overview

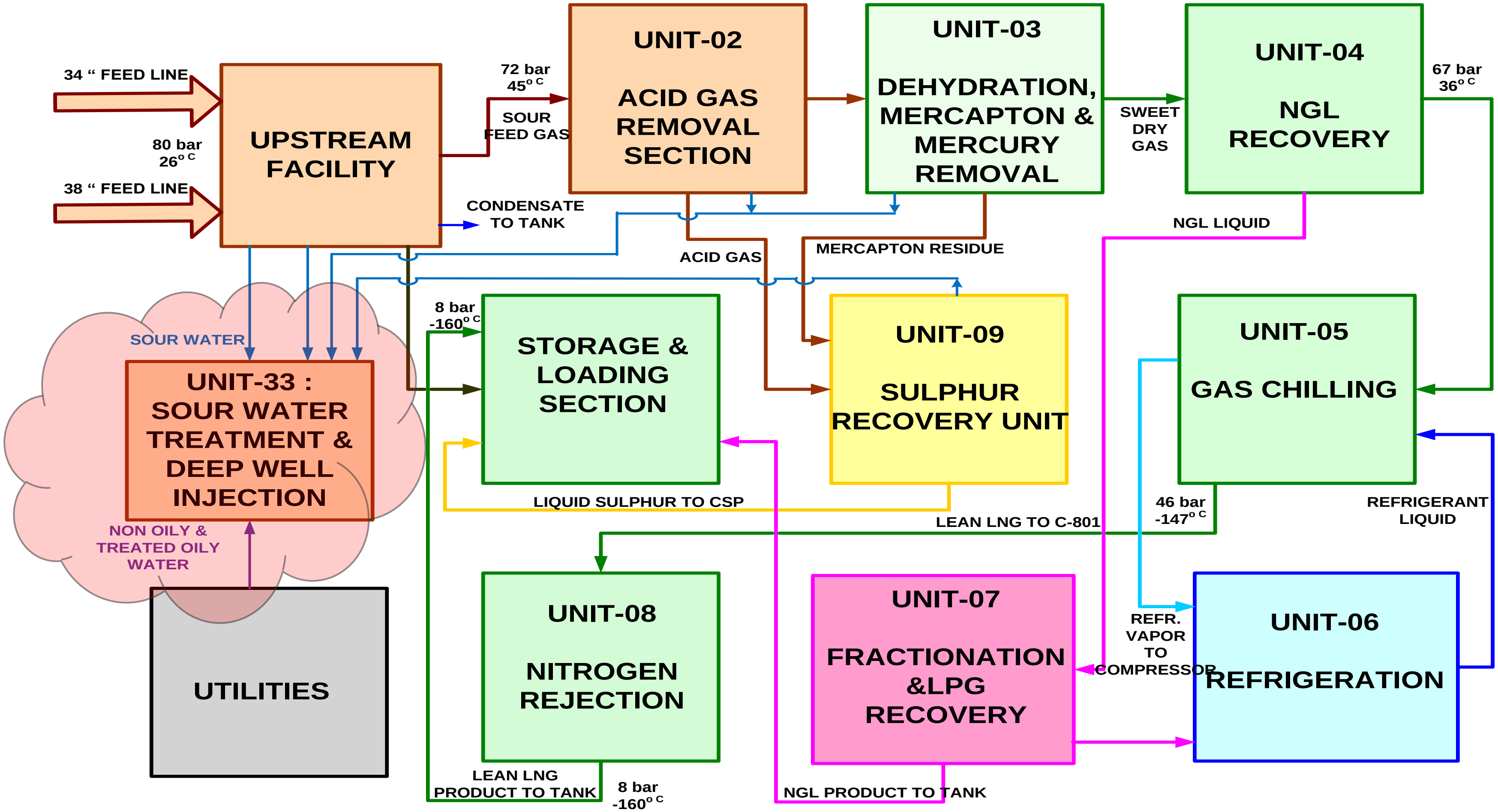


QG-3&4 Offshore Production Platforms – Sealines Overview



LNG Mega Trains Process Block Diagram

Loss of unit 33 leads to loss of LNG production



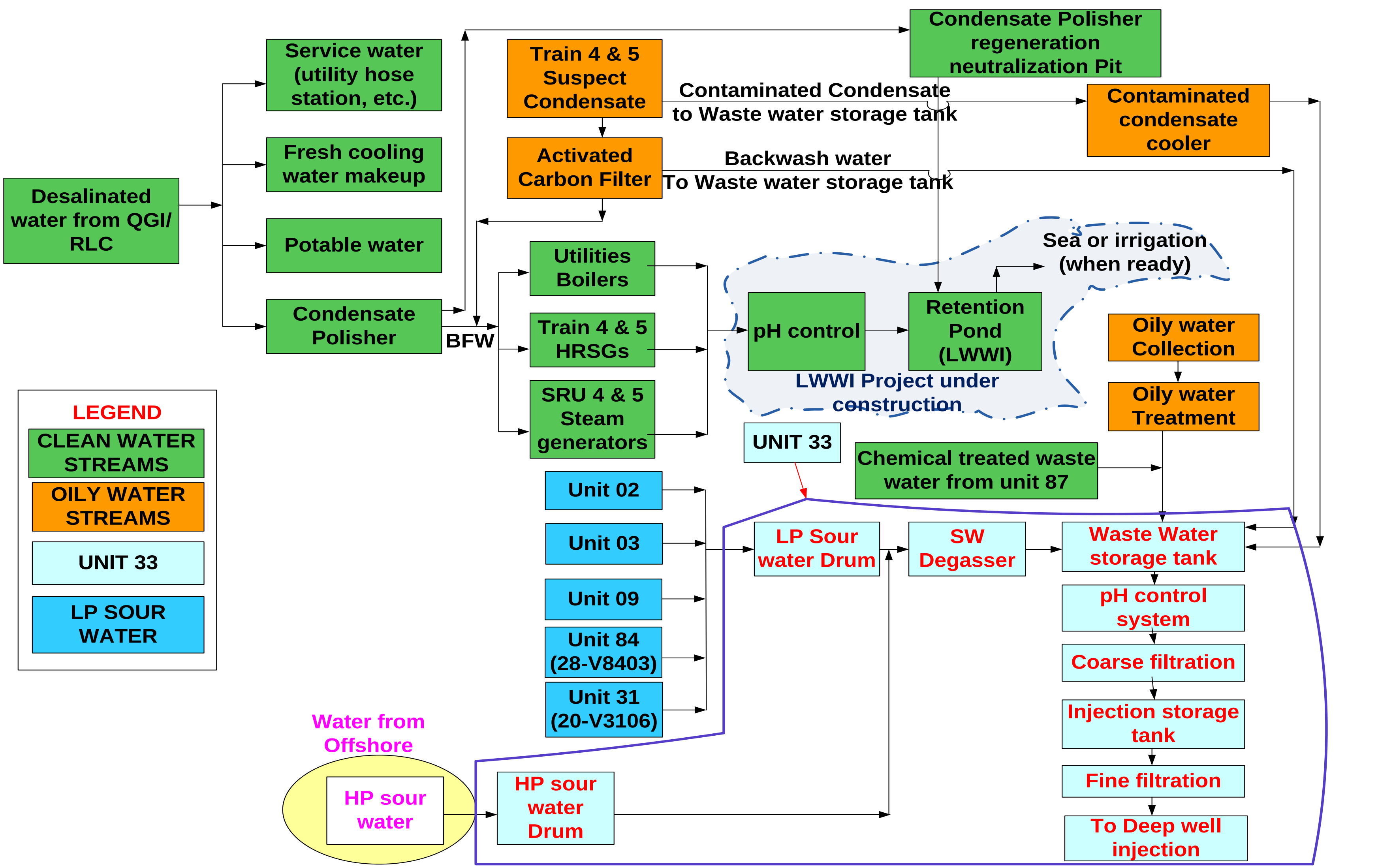
Waste Water Sources

LNG Mega trains use desalinated water as source of fresh water mainly for steam generation and other uses:

- Sources of waste water:
  - Sour water from offshore – HP sour water (containing KHI,MEG,CI and H_2S)
  - Sour water from the onshore facilities – LP sour water(containing H_2S)
  - Non-sour and oily water from units. (free of H_2S)

Following slide explains the link between fresh water and waste water.

QG2, QG3&4 water and waste water flow diagram



Waste Water Reduction Study – Strategies

- Various Waste water treatment strategies:
  - Re-Use: Suitable streams combined to meet irrigation water spec with minimum treatment
  - Recycle: Suitable streams combined to produce either Desalinated water or Polished water with proper treatment technology
  - Disposal: Minimize flow to deep well injection. HP sour water and reject effluent to meet the injection water specification
- Twelve options were identified using the above three strategies as guidelines.

Shortlisted Options:

Option-1: De-oiling,H_2S removal; filtration stages (MMF & nutshell), MBR unit. MBR outlet to irrigation water tank if the re-use option is selected or RO unit to produce Desalinated water if recycle option is selected;

Option-2: De-oiling H_2S removal; Lime softening, extended aeration. filtration stages (MMF & ACF). Outlet to irrigation water tank if the re-use option is selected or RO unit to produce Desalinated water if recycle option is selected.

Option-3 three streams are treated separately. de-oiling H_2S removal; MBR and RO units to produce desalinated water. The condensate polisher and Boiler Blow down are mixed with oily water and passes through corrugated Plate Interceptor (CPI), MMF to produce irrigation water.

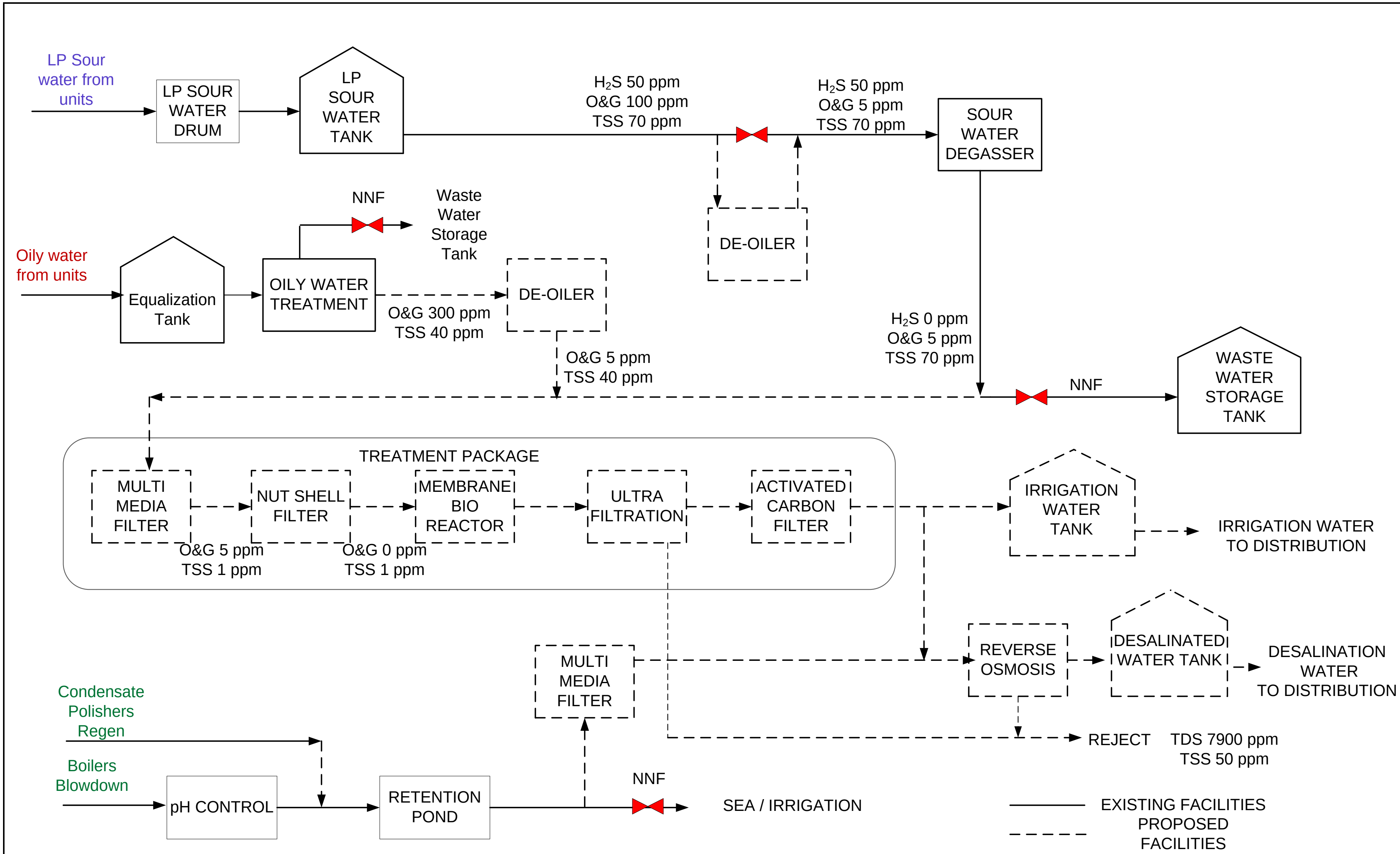
- Option 1 is selected (to meet study objective of 50% injection water reduction)
- Option 2 not selected as lime softening requires more chemicals (higher chemical and sludge disposal costs).
- Option-3 does not have the flexibility since the streams are treated after segregation

Waste Water Reduction – Shortlisted Options

	Option 1		Option 2		Option 3	
Type of Water Non Sour	Treatment Technology		Treatment Technology		Treatment Technology	
- Non Oily Water	Multimedia Filter	Reverse Osmosis	Multimedia/Activated Carbon Filter	Reverse Osmosis	Multimedia Filter	
- Oily Water	De-Oiler + Multimedia Filter		Lime softening / Extended aeration / Filtration		CPI/De-oiler + Multimedia filter	
LP sour water	De-Oiler + Multimedia Filter Membrane Bio-Reactor Ultrafiltration Activated Carbon Filter					De-Oiler / Reverse Osmosis
Design Injection Volume Reduction	QG2 - 57.6% QG3&4 - 60.1%	QG2- 53.1% QG3&4 - 58.2%	QG2 - 53.9% QG3&4 - 53.8%	QG2- 47.4% QG3&4 - 47.2%	QG2 - 52.5% QG3&4 - 53.4%	QG2- 53.4% QG3&4 - 50.9%
	REUSE	RECYCLE				

Based on Techno-Economic feasibility study, Option 1 is selected

Waste Water Reduction – selected option



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KHI Removal – Introduction/Objectives

Introduction:

- QG2 and QG3&4 : wet gas from offshore through subsea pipelines. Pipelines dosed with Corrosion Inhibitor (CI) throughout the year
- 110 to 120 days/year Kinetic Hydrate Inhibitor (KHI) is injected.
- QG2 injecting MEG and KHI during hydrate season Offshore and Onshore depending on ambient condition)
- All chemicals end up in water from offshore and are injected in to the onshore deep wells.

Objective :

Remove KHI from HP Sour water

- QG2: KHI residual onshore is 0.75%wt (with 17.5% residual MEG)
- QG3&4: KHI residual onshore is 1.5%wt

Bench Scale tests:

- Identify Best Applicable Technology (BAT) to remove residual KHI.
- Qatargas/WPQ/TAMUQ collaborated to identify possible removal methods.

KHI Removal – Bench Scale Tests

Various removal methods attempted (KHI in De Ionized Water and Seawater). Following were successful.

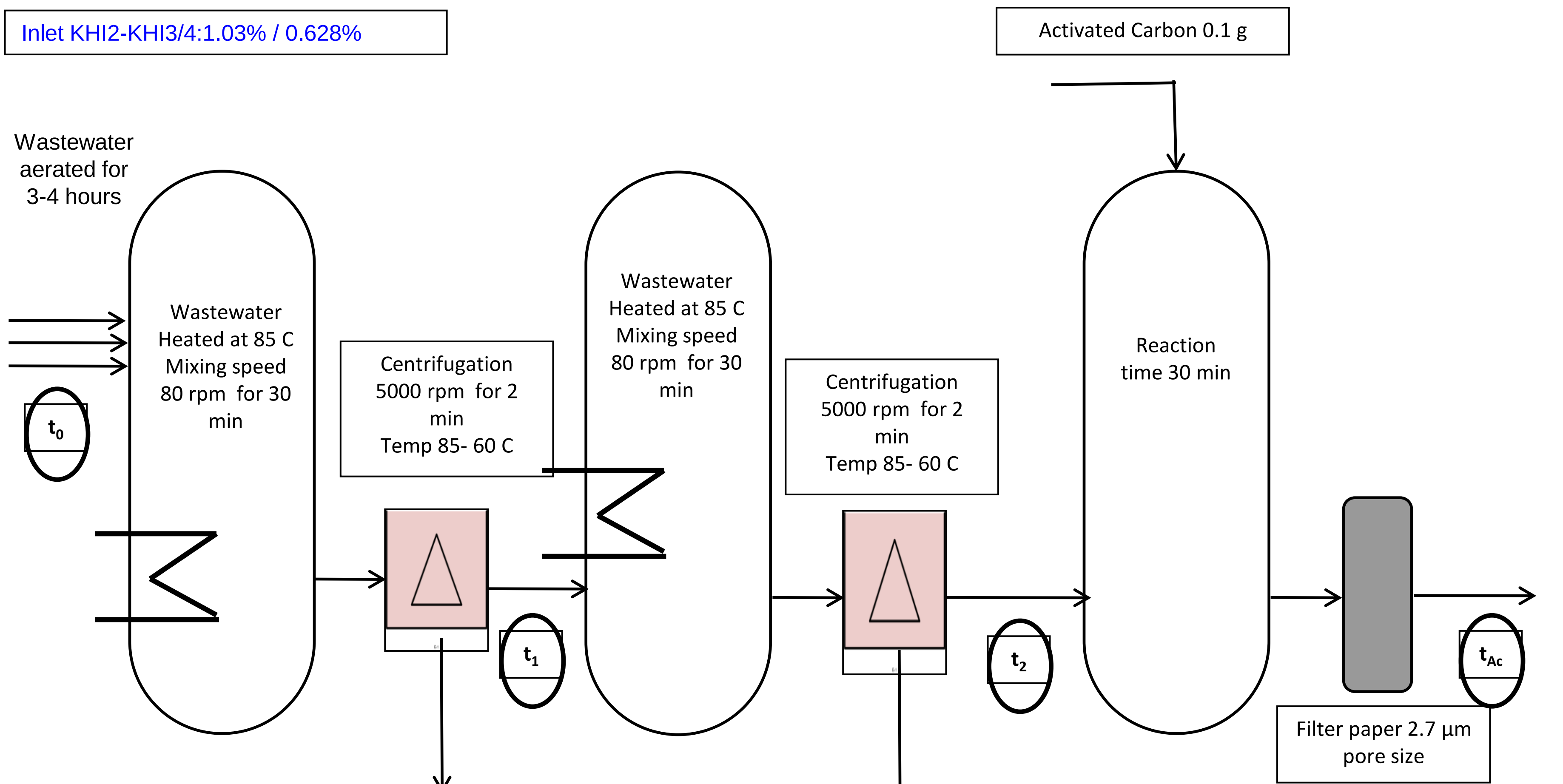
a) Heating and Centrifugation

b) Heating and coagulation

Produced water inside of hydrate season of QG2 and QG3&4 treated by above methods (Details provided in the following slides)

KHI Removal – Bench Scale Methodology 1

Removal of KHI from wastewater : Heating/Centrifugation & Activated Carbon



KHI2-KHI3/4 Efficiency ~ 47% / 51.5%

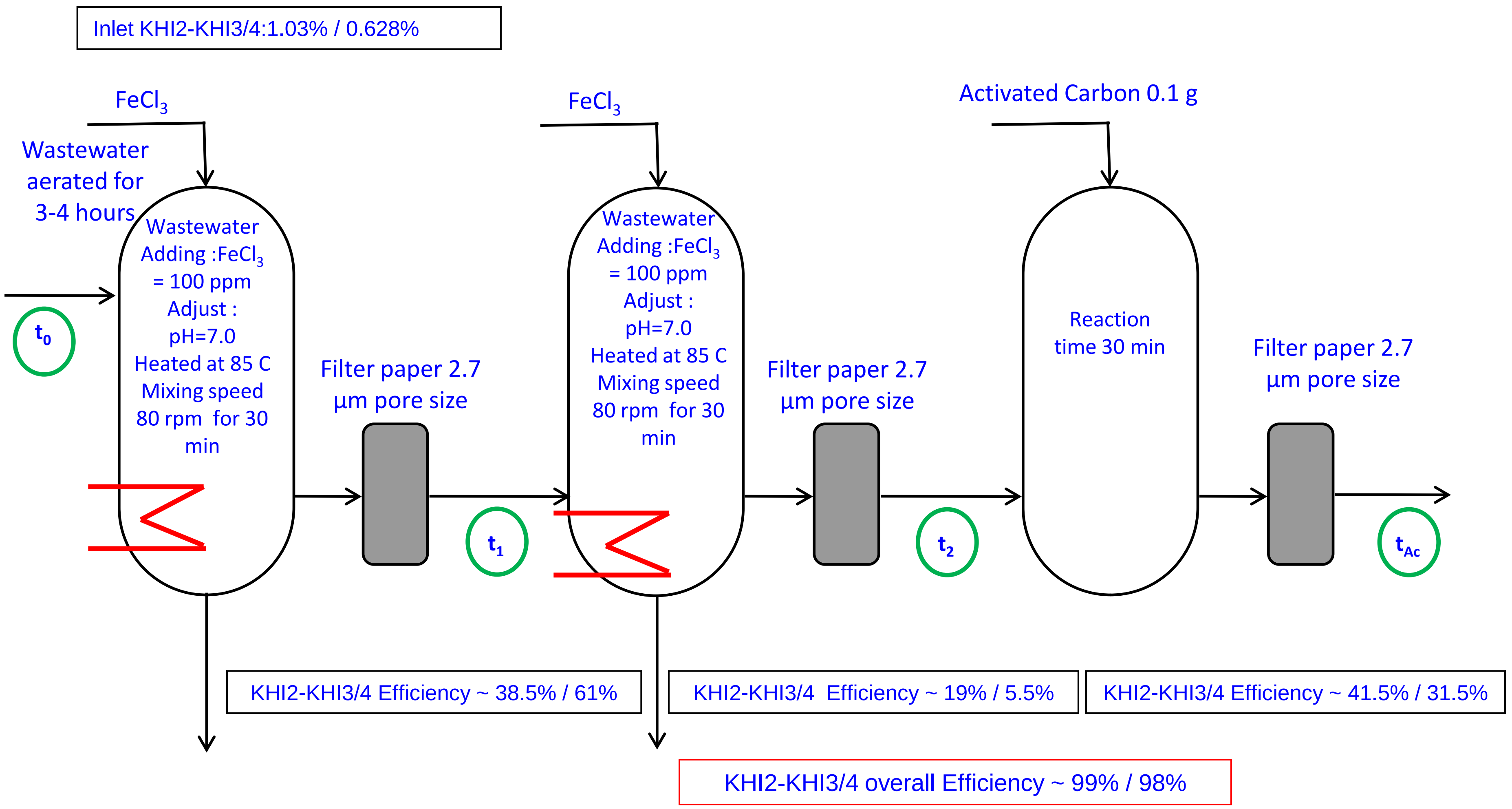
KHI2-KHI3/4 Efficiency ~ 13% / 3.5%

KHI2-KHI3/4 Efficiency ~ 31% / 37%

KHI2-KHI3/4 overall Efficiency ~ 91% / 92%

KHI Removal – Bench Scale Methodology 2

Removal of KHI from wastewater : Heating/Coagulation & Activated Carbon



Conclusion & Path Forward

Conclusion:

- Recycling part of LP sour and Non sour water flow rate will enhance sustainable reuse of wastewater, otherwise currently discharged to the sea.
- Removing chemicals from HP sour water will enhance the injection aquifer reservoir capacity

Path Forward:

- 50% Injection reduction targeted for completion by 2015.
- Pilot tests to be performed at site during hydrate season (probable duration Dec 2012 – April 2013). This will help in arriving at full scale engineering solution for KHI removal.

Thank you