CONFIDENTIAL

WPCA - Wastewater

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June 5-6,2018

Agenda

- General FGD Treatment Needs
- Physical Chemical Desaturation
- Biological Denitrification by SBR
- Pironox™ process
- Open discussion

Key design considerations for FGD wastewater treatment system design

Influent composition

Discharge requirements

Solids handling

Materials of construction

Unique owner's requirements

MAJOR COST DRIVERS

- **Flow**
- **Solids Load**
- **Specific discharge requirements for Se, BOD, Nitrogen, etc.**

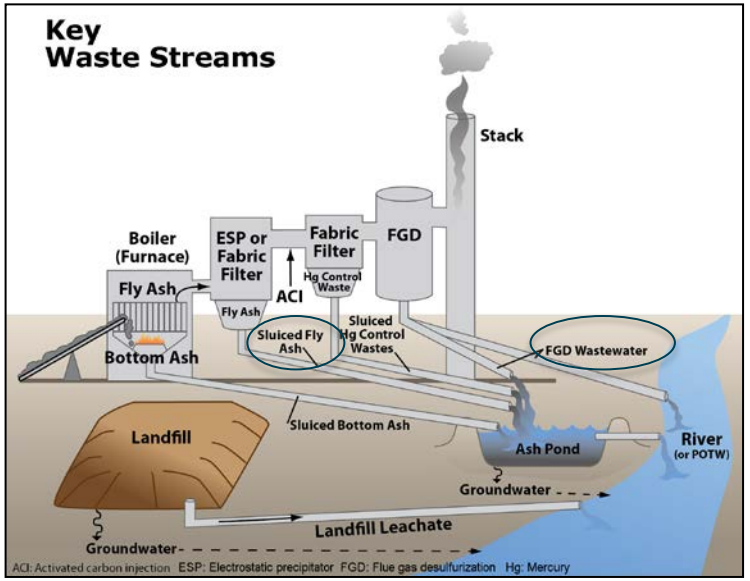
Compliance with Effluent limit guideline regulations

Market driven by EPA Effluent Limit Guidelines (ELG) regulations

- ELG is a program of the Federal Water Pollution Control Act
- ELG Released for comment in April 2013
- Enacted into law Sept 30, 2015 (replaced the 1982 update)
- Updated rule expected to be final in December 2019
- Timing for Compliance with permit cycle beginning July 2018
- Allows for a delayed implementation of up to 8 years
    - Projected project timelines year 2018 - 2023

Primary impacted key Waste Streams:

- Flue Gas Desulfurization purge/waste water
    - Upgrades to wastewater treatment systems
- Wet sluicing of fly ash
    - Conversion to dry ash conveyance



ELG limits

Existing Sources	30 day average	Daily Maximum
Arsenic*, ppb	8	11
Mercury*, ppt	356	788
Selenium, ppb	12	23
Nitrite-Nitrate, ppm as N	4.4	17

New Sources + Incentive Program	30 day average	Daily Maximum
Arsenic*, ppb	N/A	4
Mercury*, ppt	24	39
Selenium, ppb	N/A	5
Nitrite-Nitrate, ppm as N	4.4	17
TDS, ppm	24	50

- **New source is defined as a new structure producing ww after the new ELG limits were published**
- **Incentive Program extends timeline for those who install vapor compression systems.**
- **Individual states may regulate additional parameters in addition to above.**

FGD wastewater characteristics

Contains contaminants from coal, limestone, and makeup water

High TDS, TSS

Elevated heavy metal concentrations

pH 5.0 to 6.5

Supersaturated with gypsum – extreme scale forming condition

High chloride level (10,000 to 50,000 mg/l)

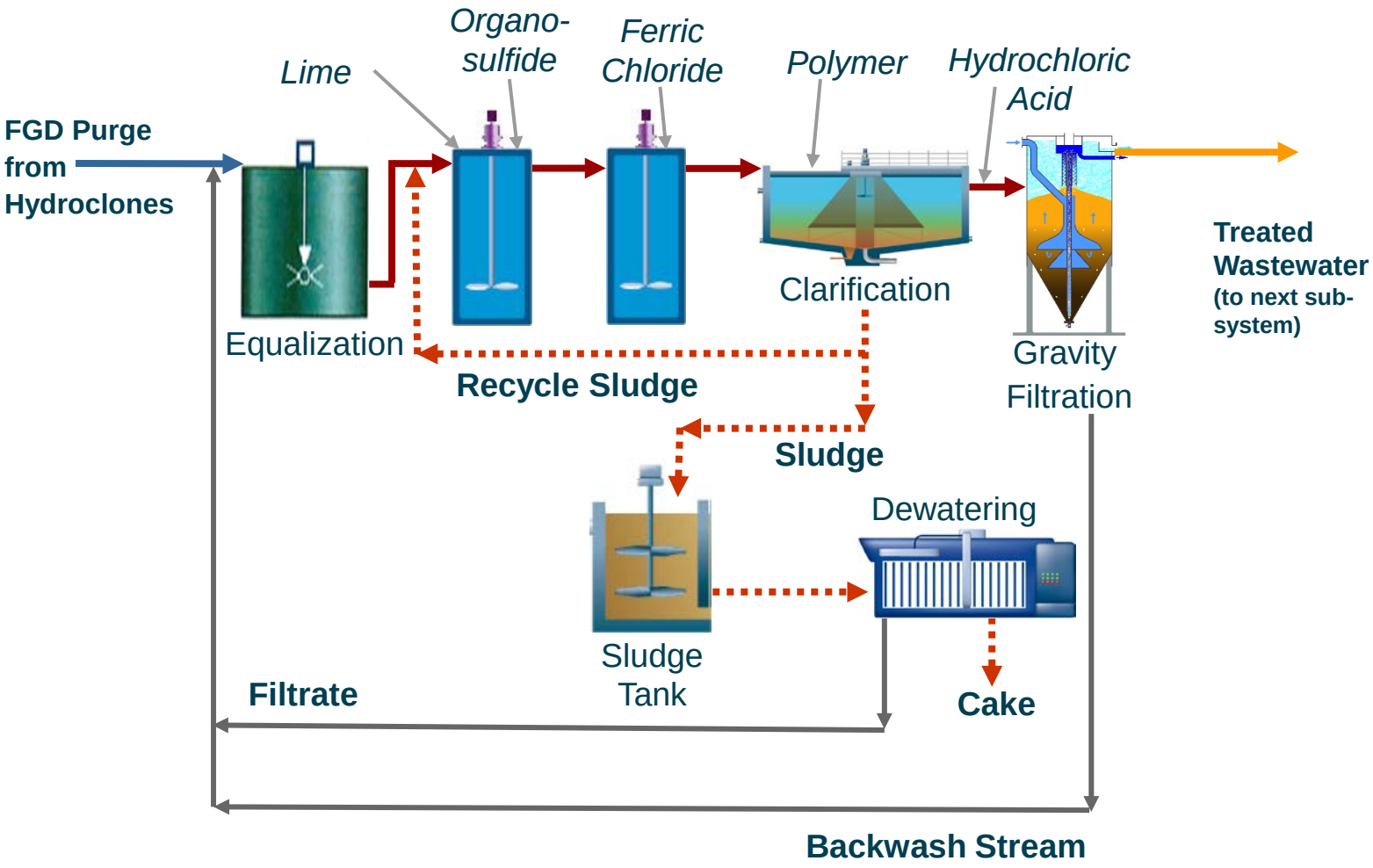
Varying levels of nitrates, nitrites, and ammonia

105 to 130 degrees F

Key design considerations for FGD wastewater treatment system design

Constituent	Typical Influent (mg/l)	Typical Effluent (mg/l)
TSS	6,000 - 40,000	< 15.0
pH	4.5 - 6.0	6.5 - 8.5 (Std. Units)
As	0.05 - 3.0	0.008 mg/l
Cd	0.04 - 0.5	< 0.10
Cr	0.03 - 5.0	< 0.10
Cu	0.1 - 0.85	< 0.10
Hg	0.05 - 0.8	< 0.000359 / 0.000159
Ni	0.3 - 6.0	< 0.05
Pb	0.1 - 3.0	< 0.05
Se	0.2 - 4.0	< 0.012 / 0.0075
Zn	0.4 - 8.0	< 0.10
Cl	10,000 - 50,000	10,000 - 50,000
SO_4	1,500 - 8,000	800 - 2,500
Ca	1,000 - 20,000	5,000 - 25,000
Mg	200 - 5,600	200 - 5,000
NO_2 / NO_3	5 – 100	4.4 / 1.3
Flow Rate	100	4,200

PRIMARY - PHYSICAL CHEMICAL TREATMENT SYSTEM



Equalization

- **Mixed Influent**
- **Surge Capacity**
- **Chemical and Hydraulic Fluctuations**
- **Minimum – 5 hours**

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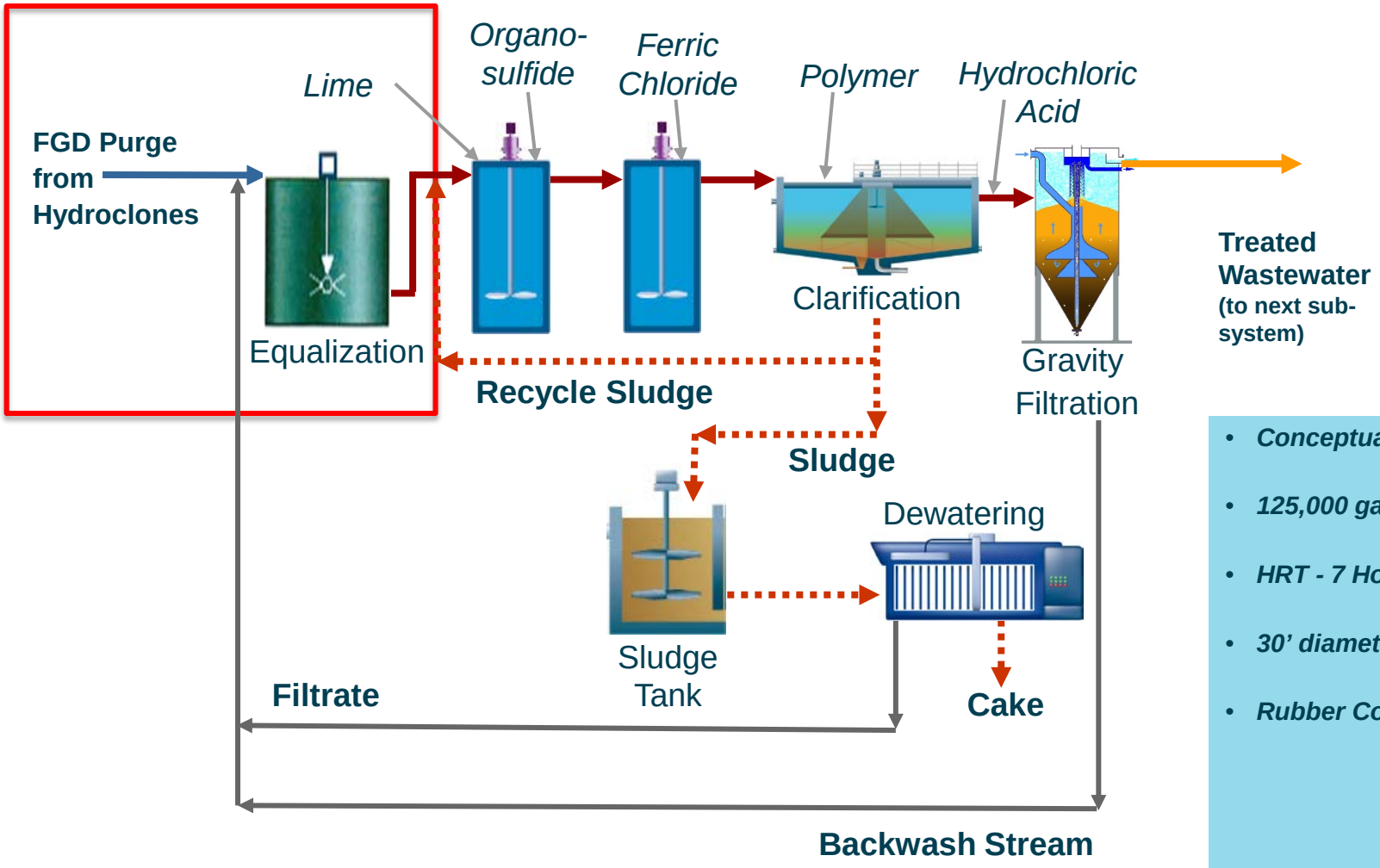

- *Conceptual Design 250 gpm*
- *125,000 gallons*
- *HRT - 7 Hours*
- *30' diameter Concrete*
- *Rubber Coated Mixer*

Physical Chemical Treatment

pH Elevation / Gypsum Desaturation

- Raise pH to 8.5 – 9.2, with Ca(OH)2 or NaOH
- Metals (Al, Fe, Mg) form hydroxides; represent major solids load
- Gypsum desaturates, reduces scaling potential
- Seed reaction tank with recycle sludge from clarifier
  - Sludge recycle = 30% of influent, providing 3.0 to 5.0 wt.% solids in reaction tanks

Heavy Metal Removal

- Most removed as hydroxides at pH 8.5 to 9.2
- Better removal of heavy metals with sulfides (or organosulfides) meets discharge requirements

Oxidation (rare option)

- If COD is due to SO_3^{2-}, and there is a COD effluent limit

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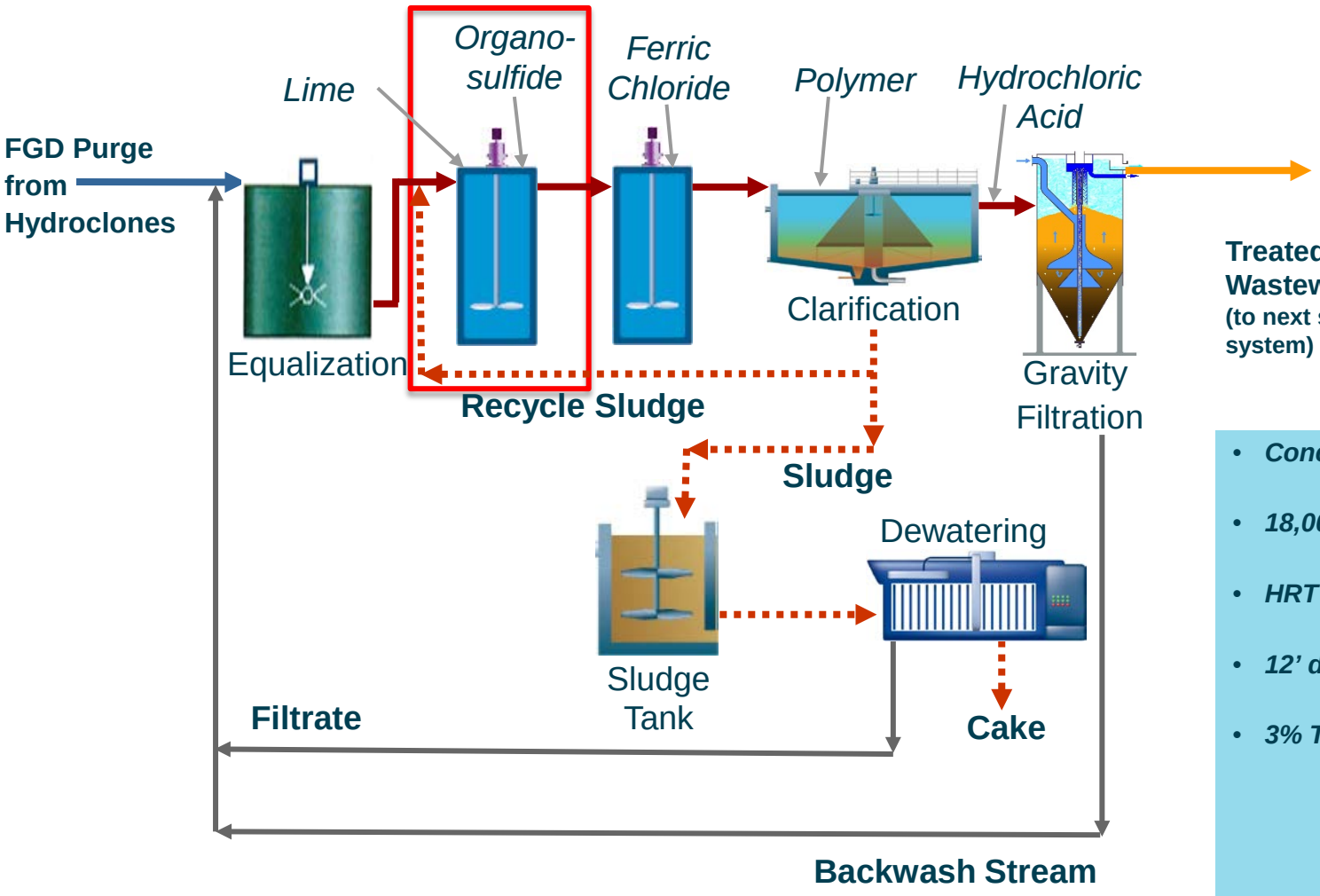

- *Conceptual Design 250 gpm*
- *18,000 gallons*
- *HRT – 50 min*
- *12' diameter FRP*
- *3% TSS*

Metals Removal in clarification

- Oxidation and pH Adjustment
  - Iron and Manganese
- Co-precipitation with Iron Salts
  - Arsenic and Selenite
- Caustic Addition/pH Adjustment
  - Zinc, Cadmium, Lead
- Metal Precipitants
  - Mercury, Copper
- Chemical Softening
  - Calcium and Magnesium

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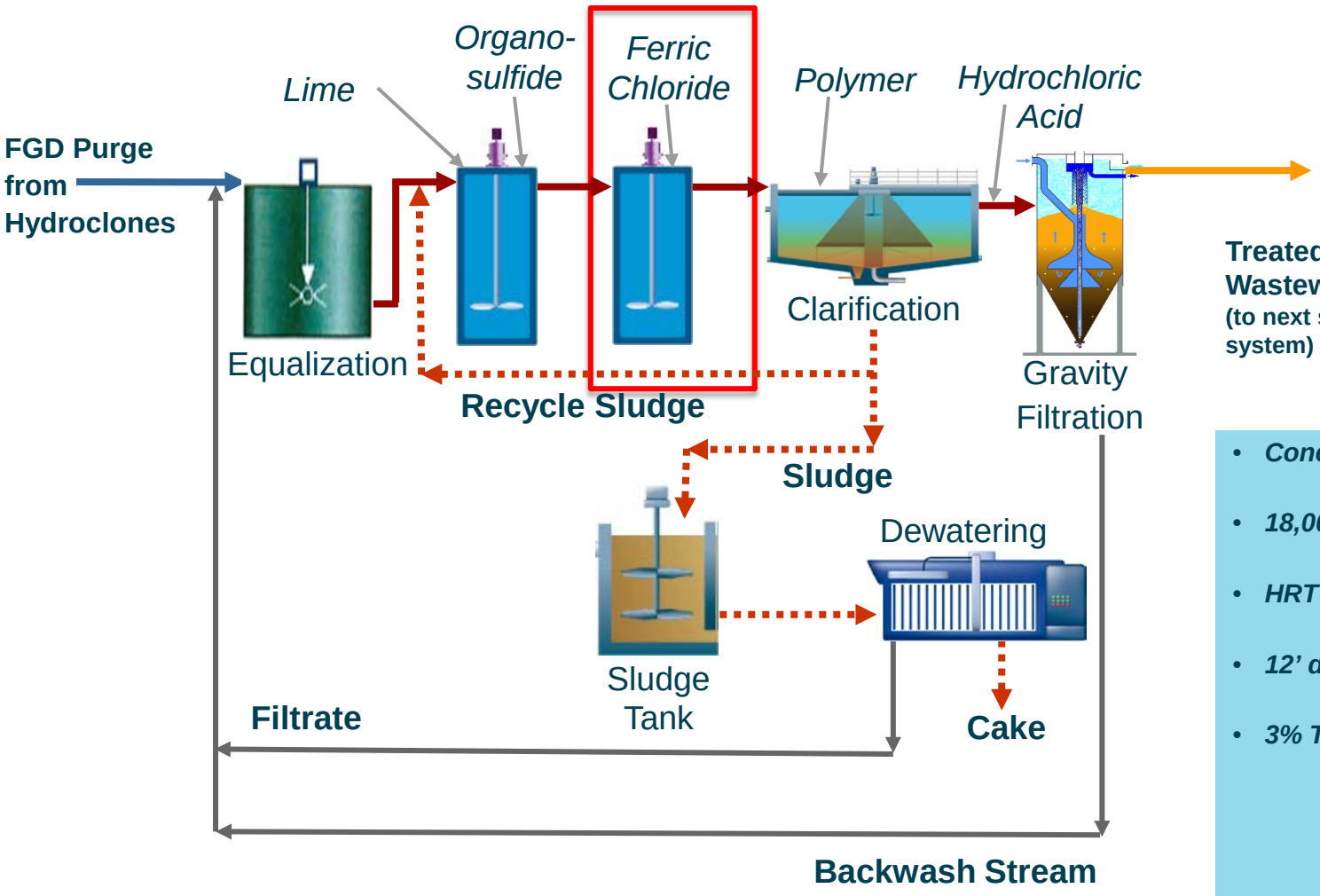

- *Conceptual Design 250 gpm*
- *18,000 gallons*
- *HRT – 50 min*
- *12' diameter FRP*
- *3% TSS*

Clarification

- Application
- < 2500 ppm TSS

- Standard
- Lamella
- Ballasted Floc
- Solids Contact

- 90-99% TSS Removal

- Metals Removal

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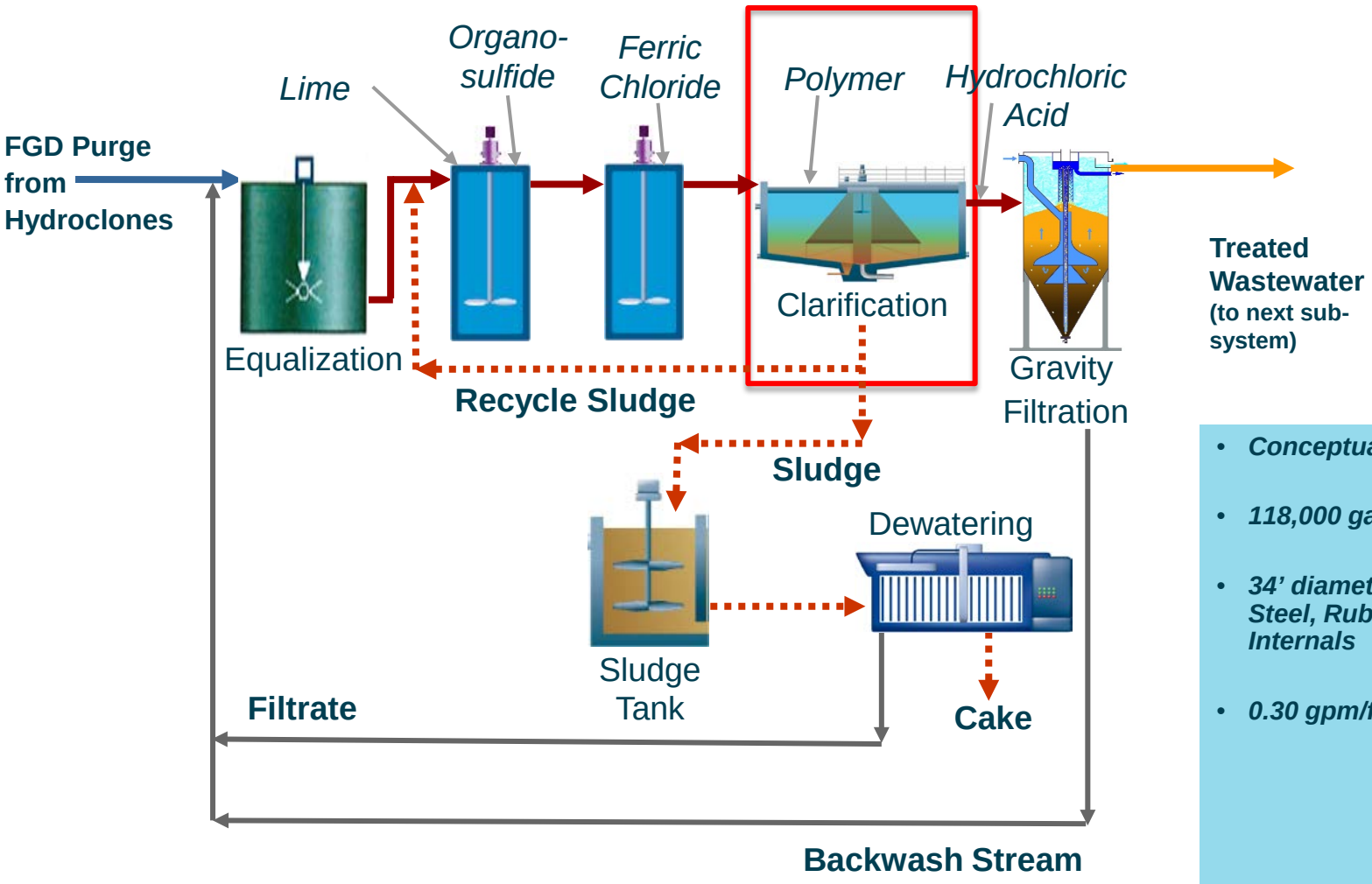

- ***Conceptual Design 250 gpm***
- ***118,000 gallons***
- ***34' diameter Coated Carbon Steel, Rubber Coated Internals***
- ***0.30 gpm/ft2 raise rate***

Filtration

Applications

Direct – Up to 100 ppm TSS

Post Clarification

- **Sand/ Dual Media**
- 70% of particles > 20 micron
- 5-10 gpm per square ft.
- **Multi Media**
- 80% of particles > 10 micron
- 3-5 gpm per square ft.
- Separate Source Backwash 15 gpm/sq. ft.
- **Continuous Backwash**
- 4-6 gpm per square foot
- **Oxidative Media**
- Iron and Manganese
- **Activated Carbon**
- Organics

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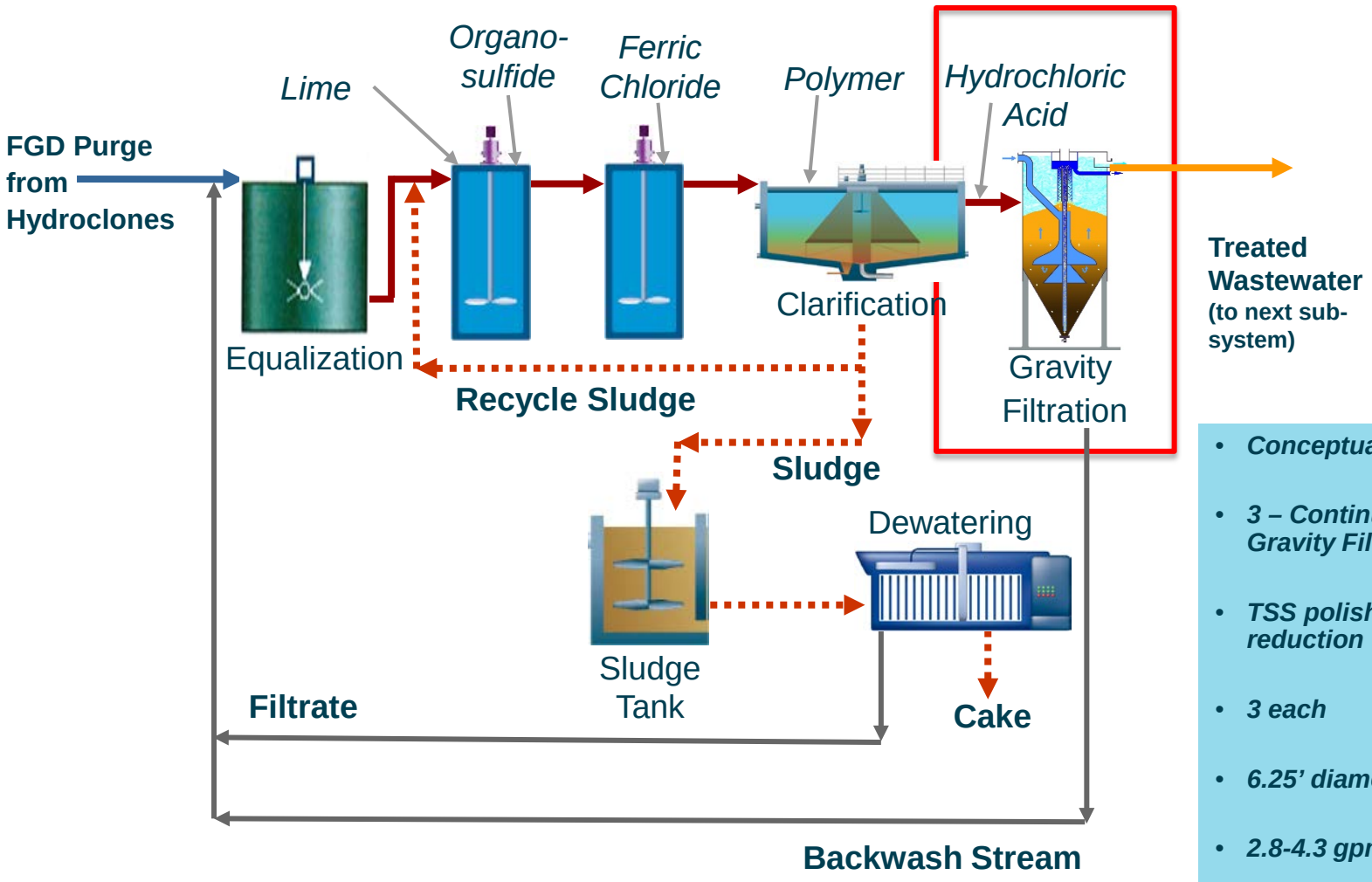


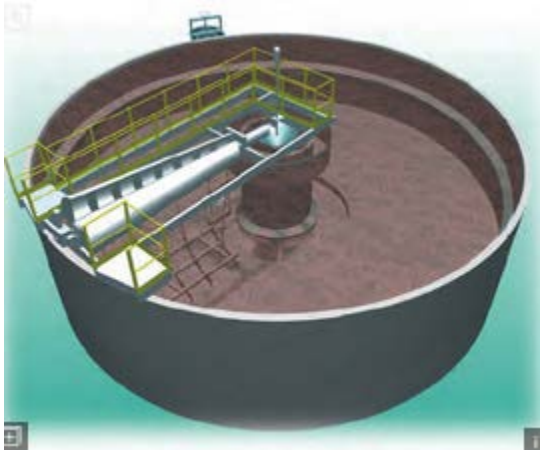
- *Conceptual Design 250 gpm*
- *3 – Continuous Backwash Gravity Filters*
- *TSS polishing and pH reduction*
- *3 each*
- *6.25' diameter FRP*
- *2.8-4.3 gpm/ft2*

Dewatering / Solids Management

- **Thickeners**
- 2-4 pounds TSS / hr. / square ft.
- 3-5 % Solids
- Storage to match press

- **Filter Press**
- 70-90 Pounds/ cu. ft.
- 30-50% Solids
- Typical 3 hr. cycle time

- **Belt Press/Centrifuge**



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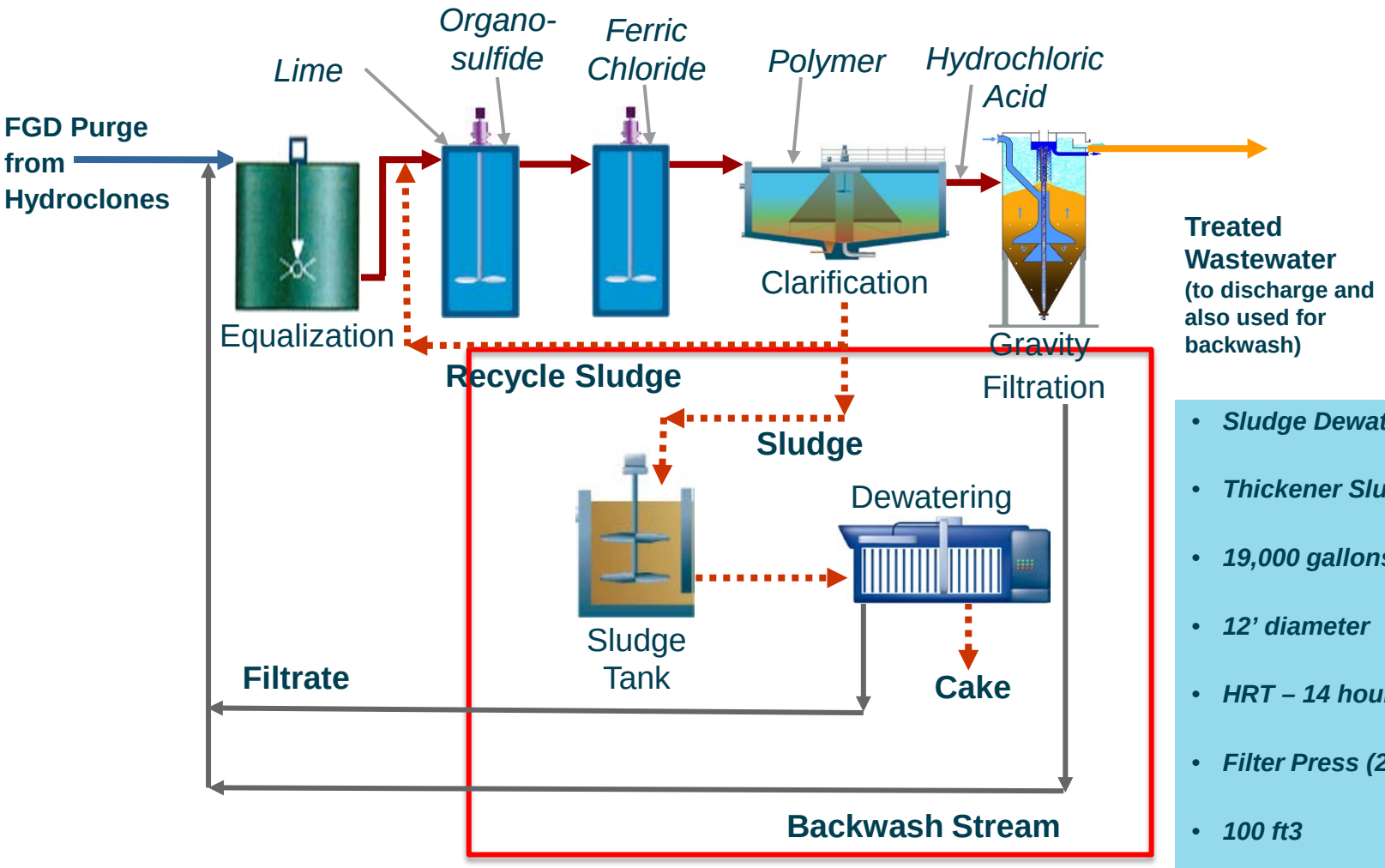
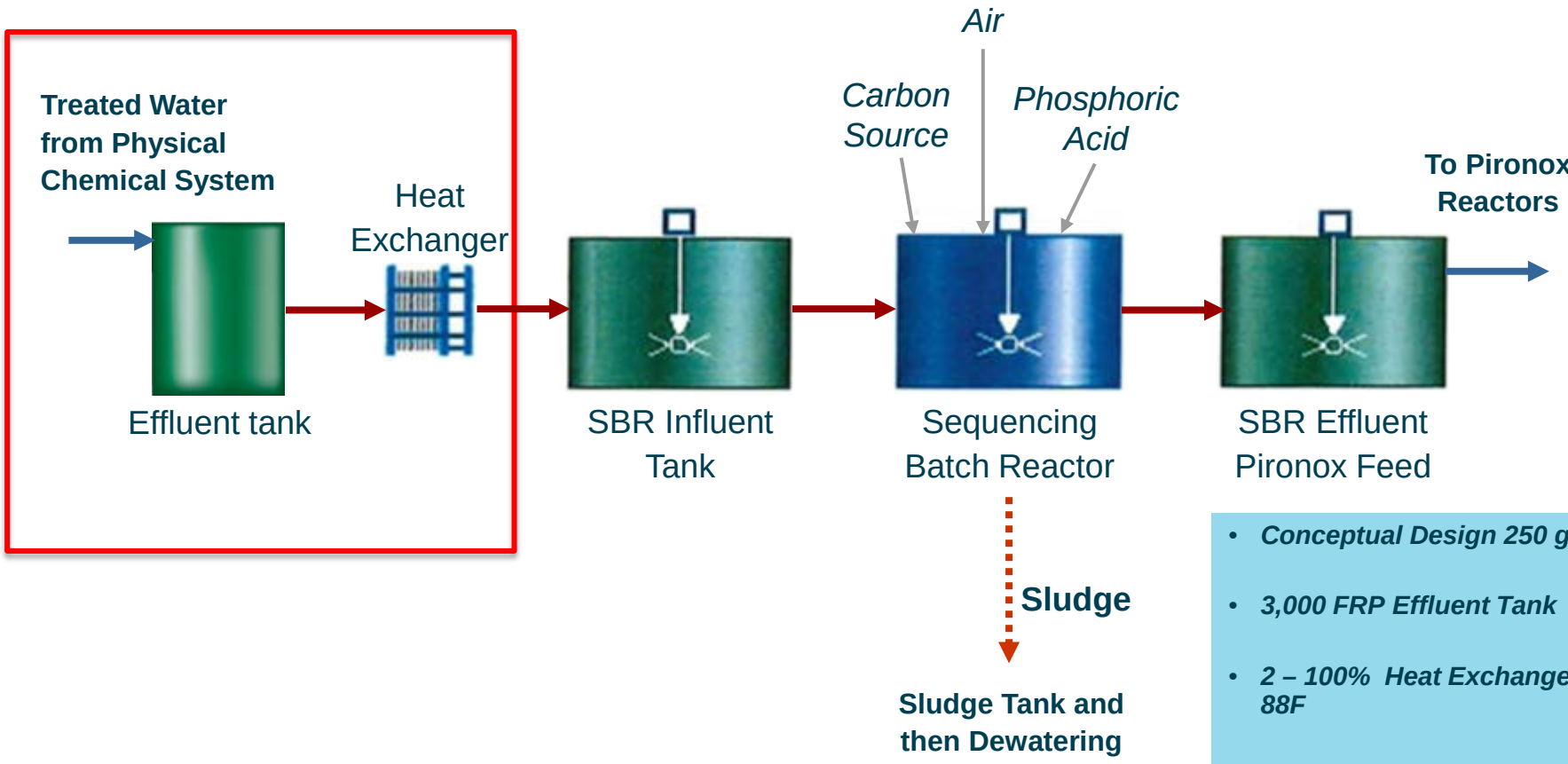


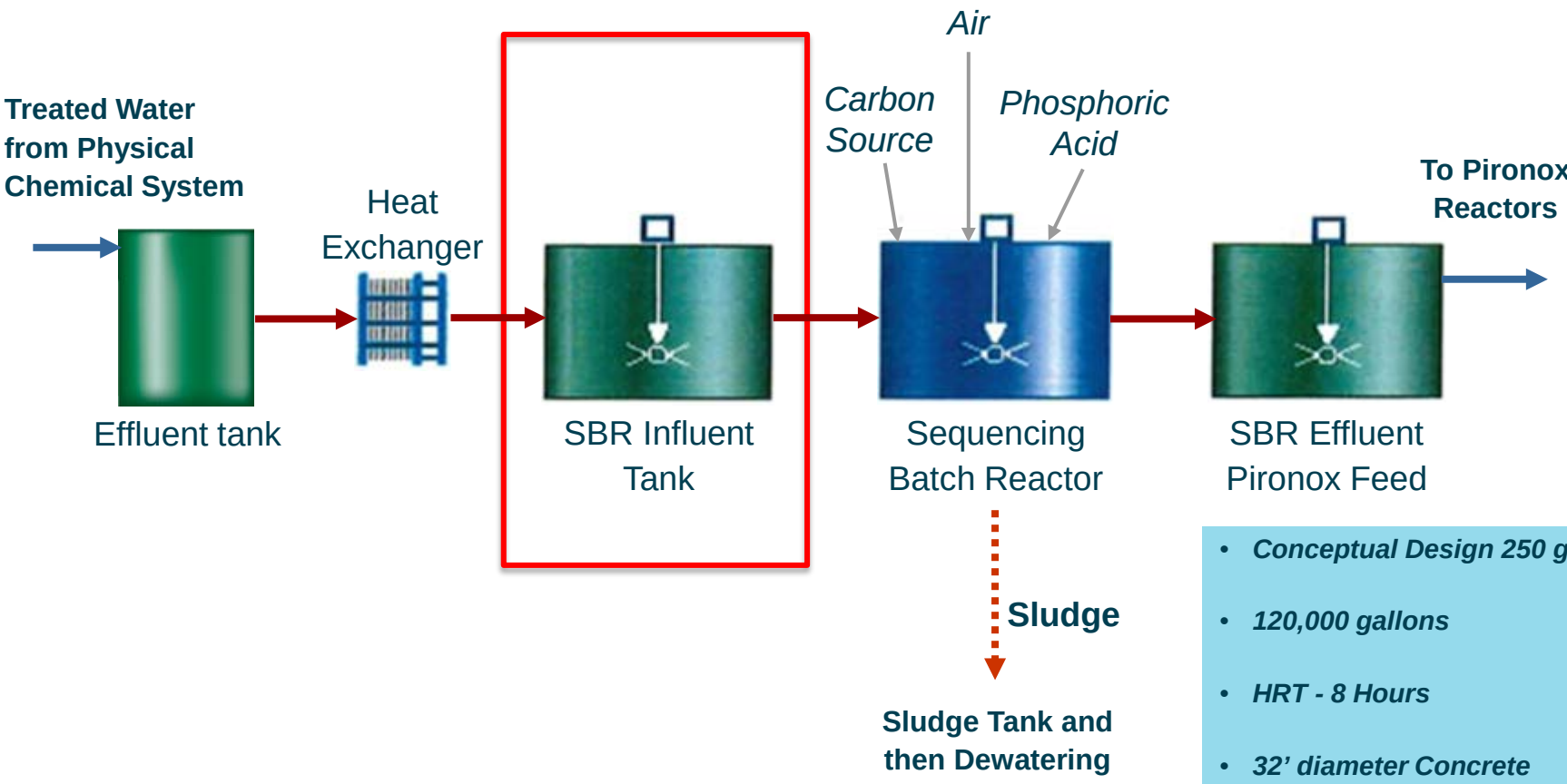
- *Sludge Dewatering*
- *Thickener Sludge Tank (1)*
- *19,000 gallons*
- *12' diameter*
- *HRT – 14 hours*
- *Filter Press (2)*
- *100 ft3*
- *3 Hour Cycle Time, 4 Cycles per Day*

ADVANCED TREATMENT FOR TOTAL NITROGEN REDUCTION



- ***Conceptual Design 250 gpm***
- ***3,000 FRP Effluent Tank***
- ***2 – 100% Heat Exchangers 88F***
- ***Titanium***

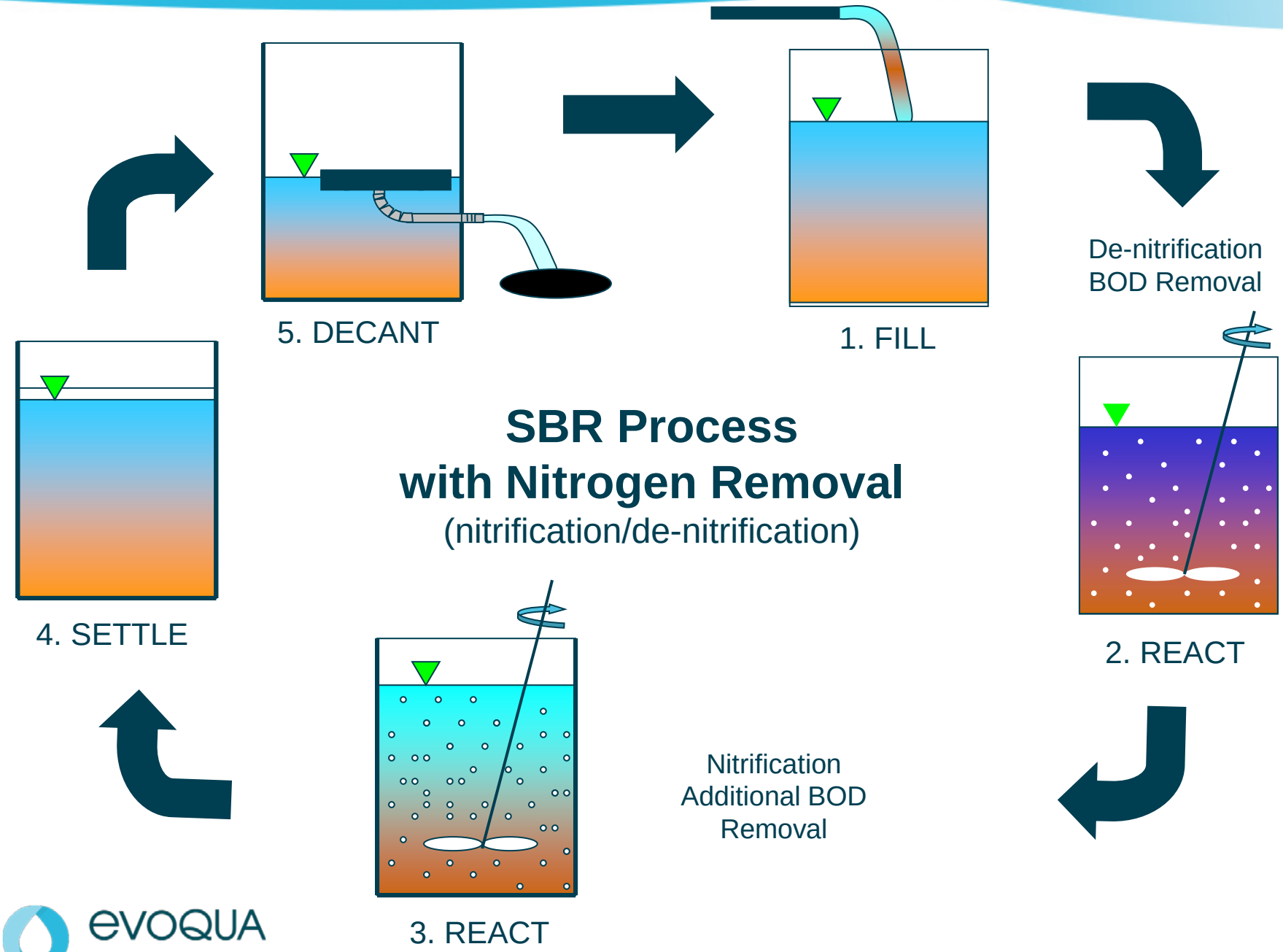
ADVANCED TREATMENT FOR TOTAL NITROGEN REDUCTION



- ***Conceptual Design 250 gpm***
- ***120,000 gallons***
- ***HRT - 8 Hours***
- ***32' diameter Concrete***
- ***Rubber Coated Mixer***

SBR Process with Nitrogen Removal

(nitrification/de-nitrification)



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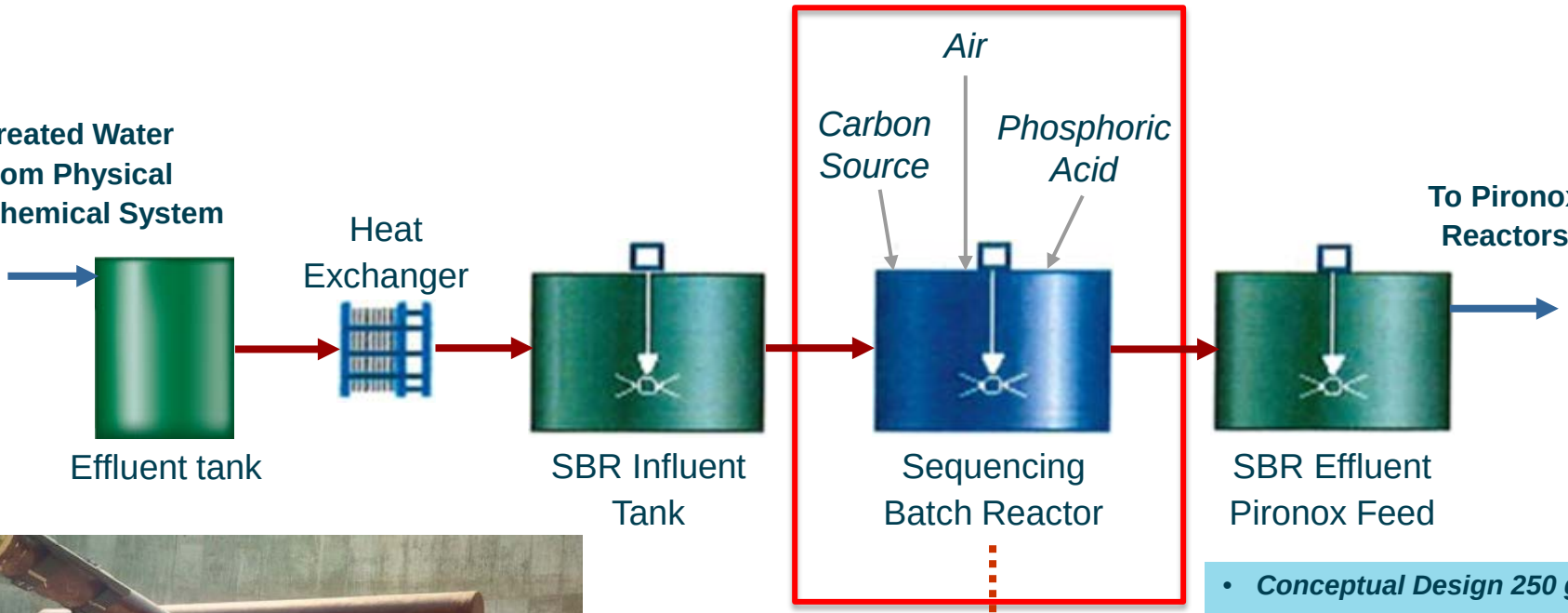
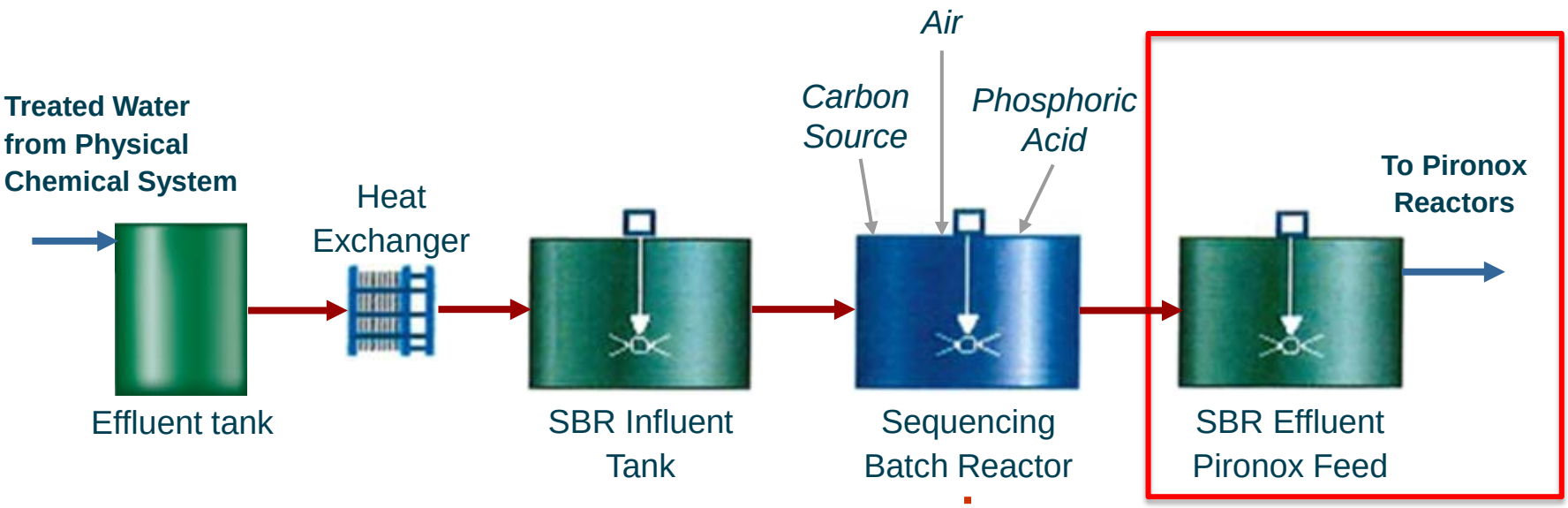


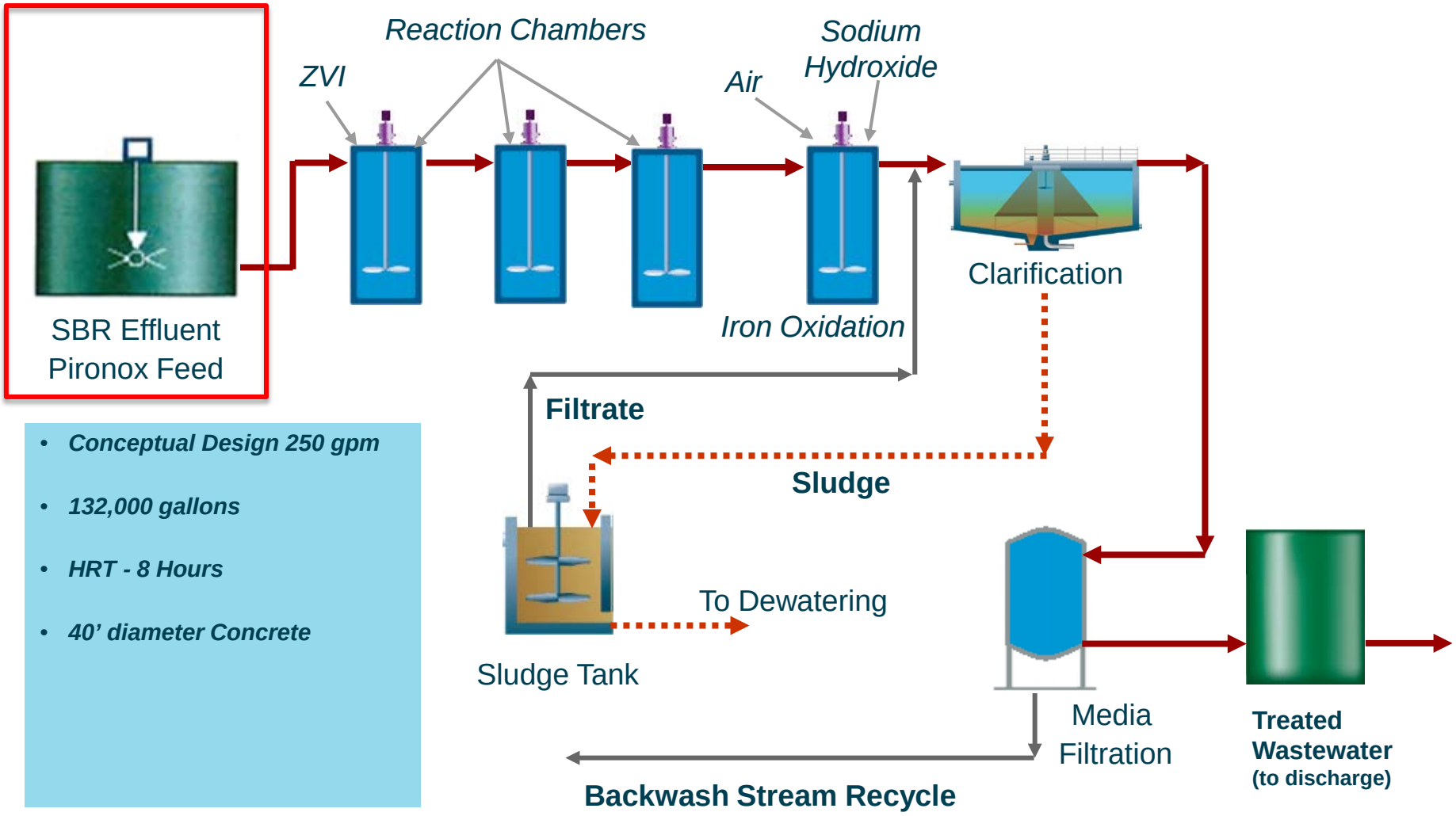
- *Conceptual Design 250 gpm*
- *2 each 186,000 gallons*
- *Batch Time 4-6 Hours*
- *40’ L x 26’ W Concrete*

ADVANCED TREATMENT FOR TOTAL NITROGEN REDUCTION



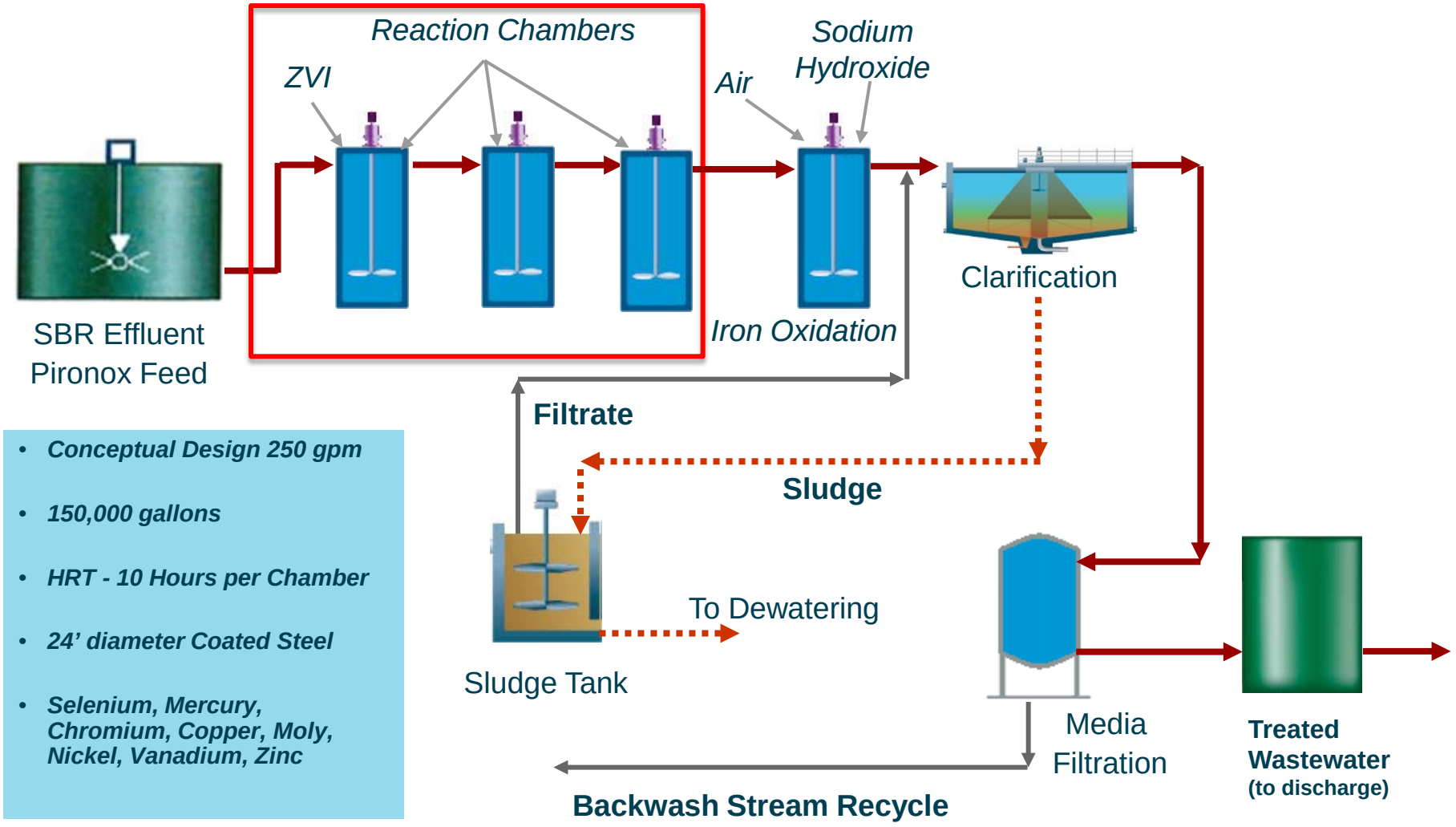
- ***Conceptual Design 250 gpm***
- ***132,000 gallons***
- ***HRT - 8 Hours***
- ***40' diameter Concrete***

POLISHING – PIRONOX FOR REMOVAL OF METAL AND OTHER TRACE CONTAMINANTS



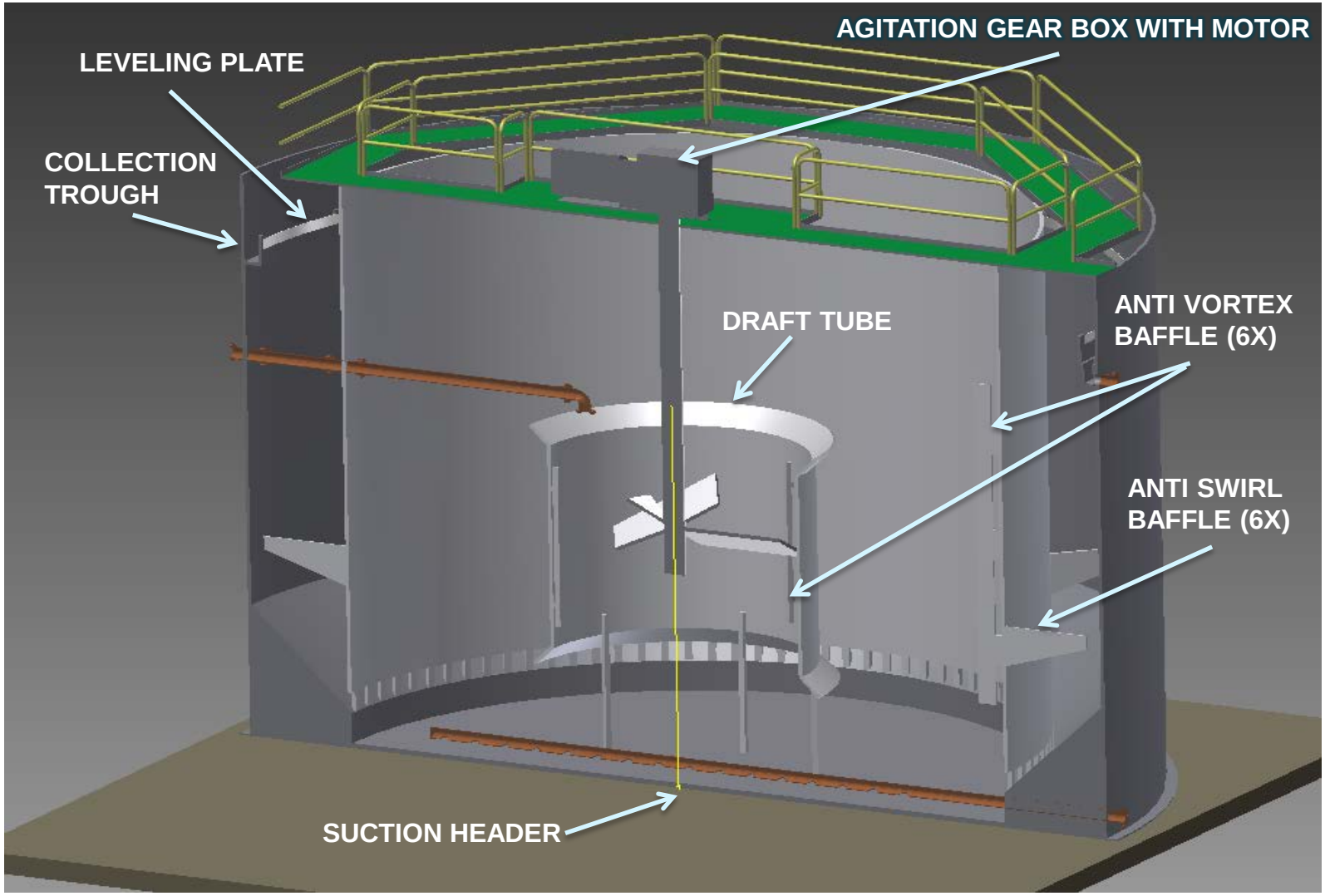
- *Conceptual Design 250 gpm*
- *132,000 gallons*
- *HRT - 8 Hours*
- *40' diameter Concrete*

POLISHING – PIRONOX FOR REMOVAL OF METAL AND OTHER TRACE CONTAMINANTS



- *Conceptual Design 250 gpm*
- *150,000 gallons*
- *HRT - 10 Hours per Chamber*
- *24' diameter Coated Steel*
- *Selenium, Mercury, Chromium, Copper, Moly, Nickel, Vanadium, Zinc*

Field erect PIRONOX Reaction tank 3D model



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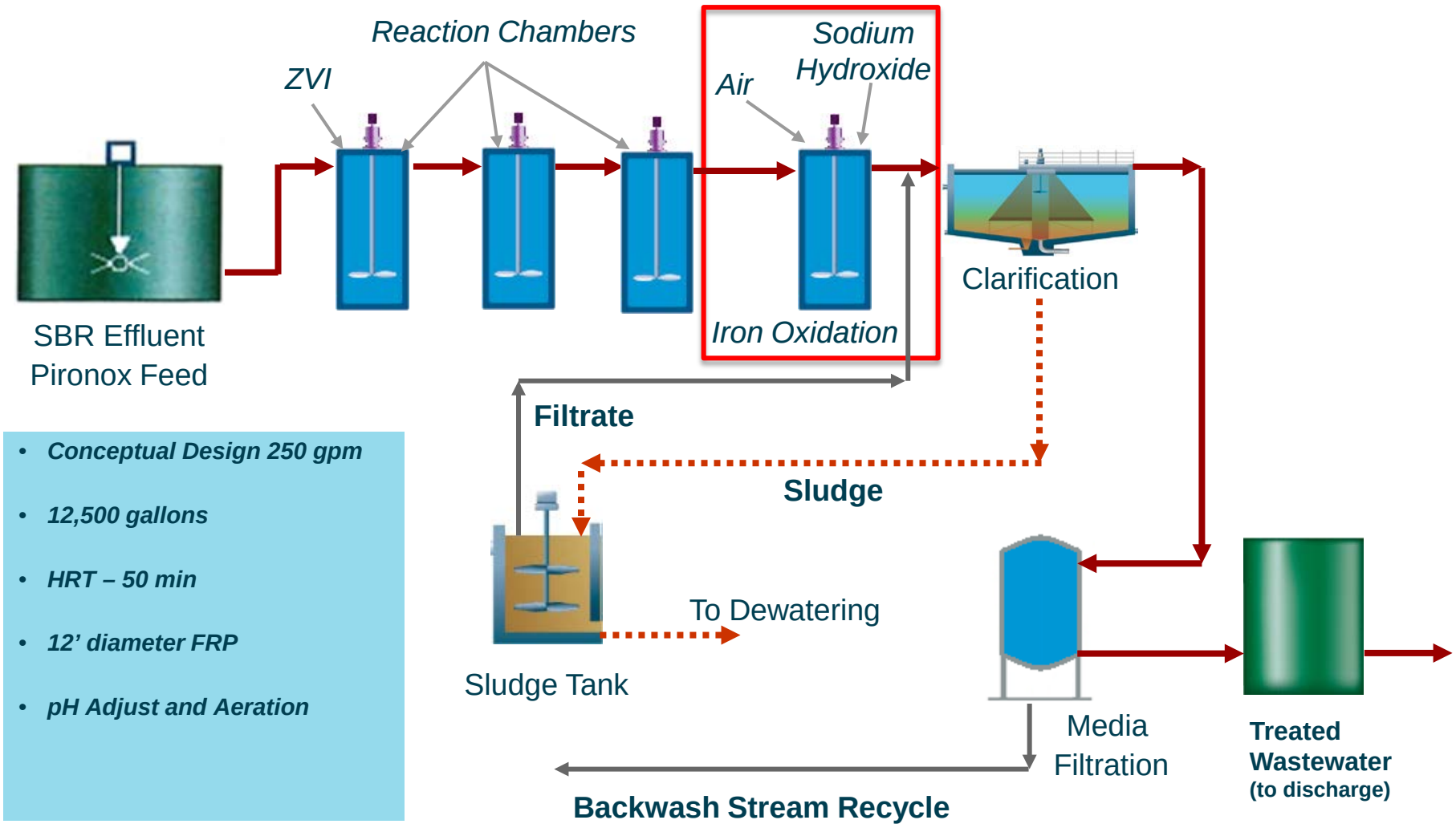
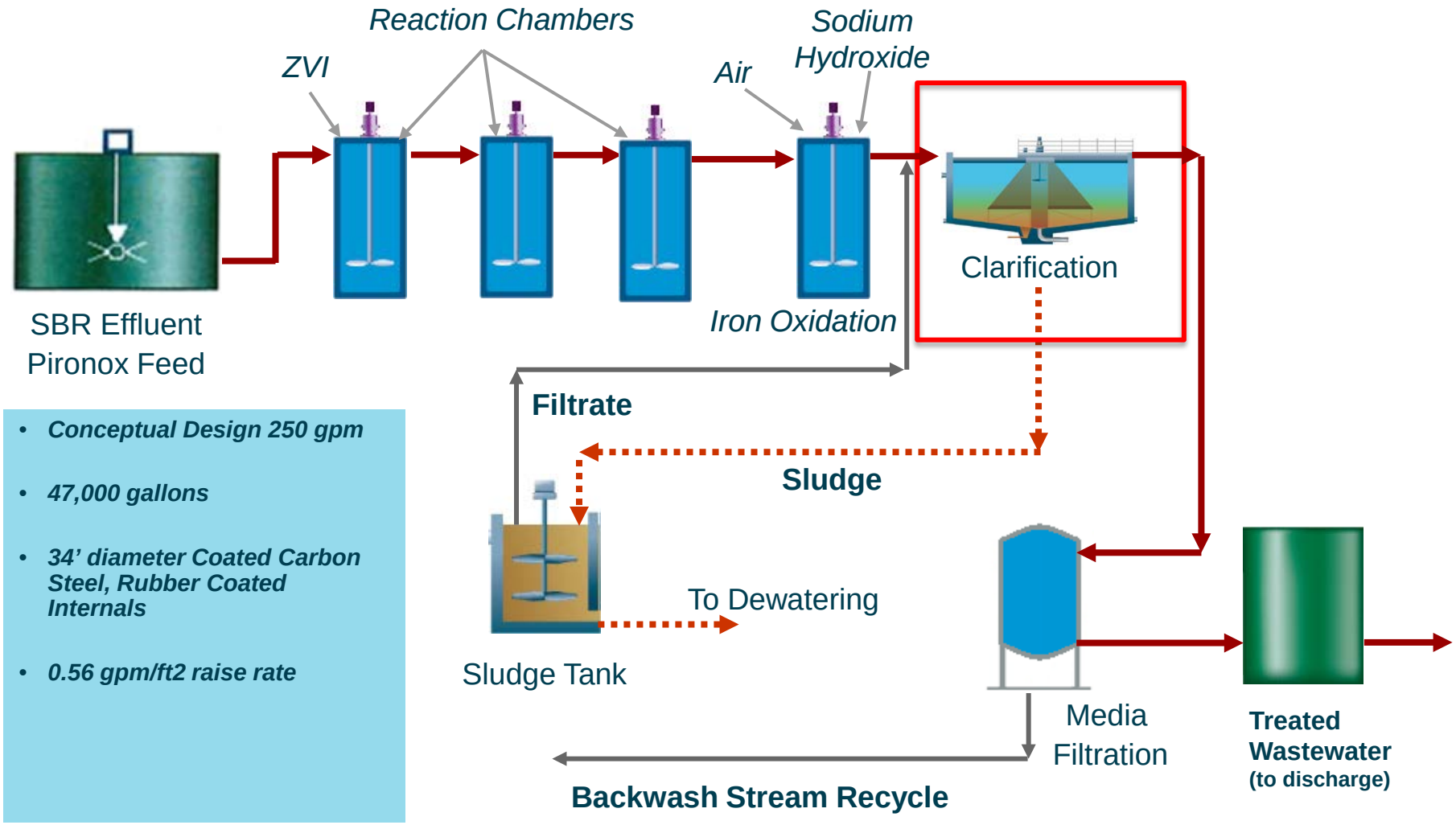


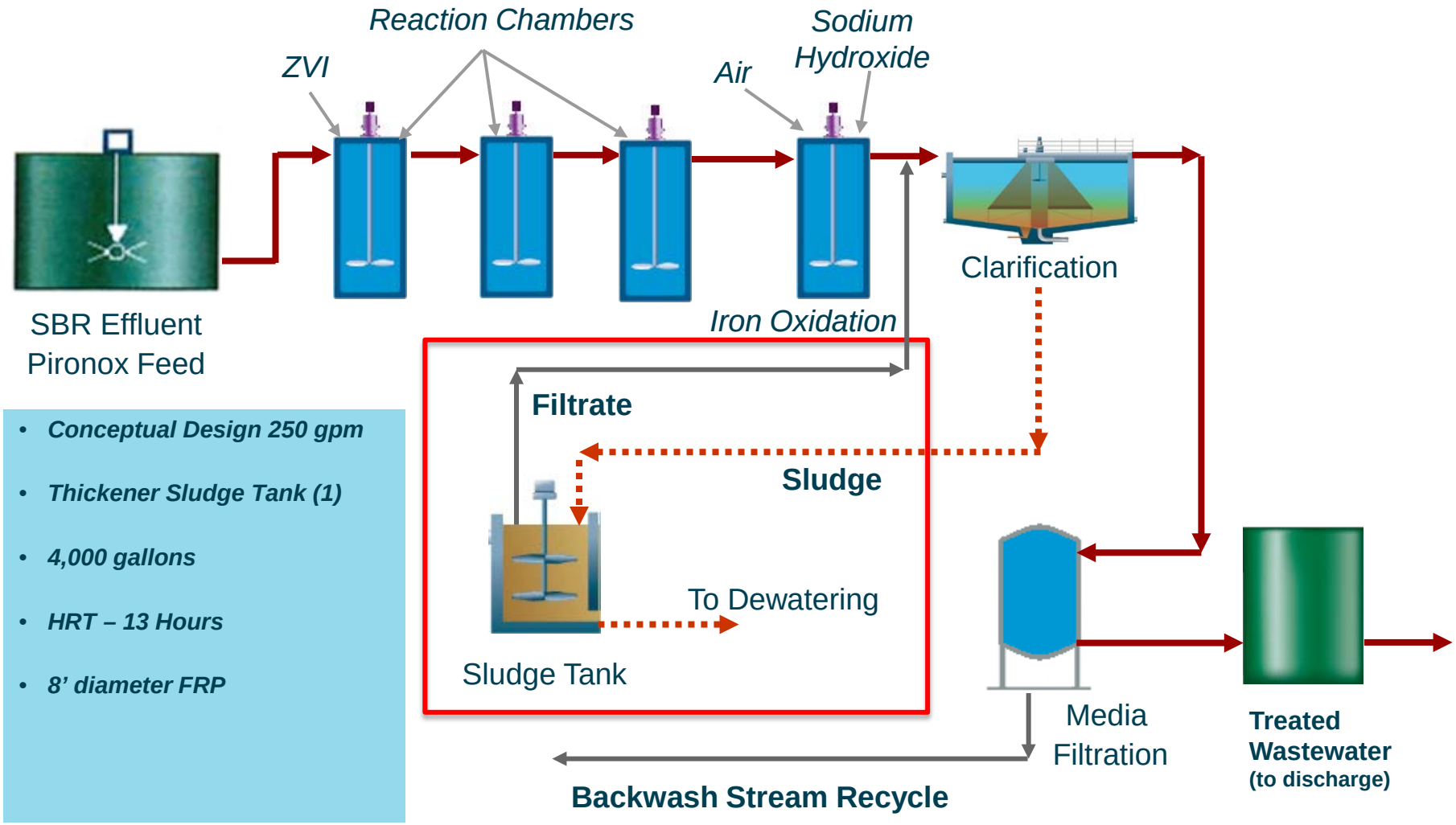
- *Conceptual Design 250 gpm*
- *12,500 gallons*
- *HRT – 50 min*
- *12' diameter FRP*
- *pH Adjust and Aeration*

POLISHING – PIRONOX FOR REMOVAL OF METAL AND OTHER TRACE CONTAMINANTS



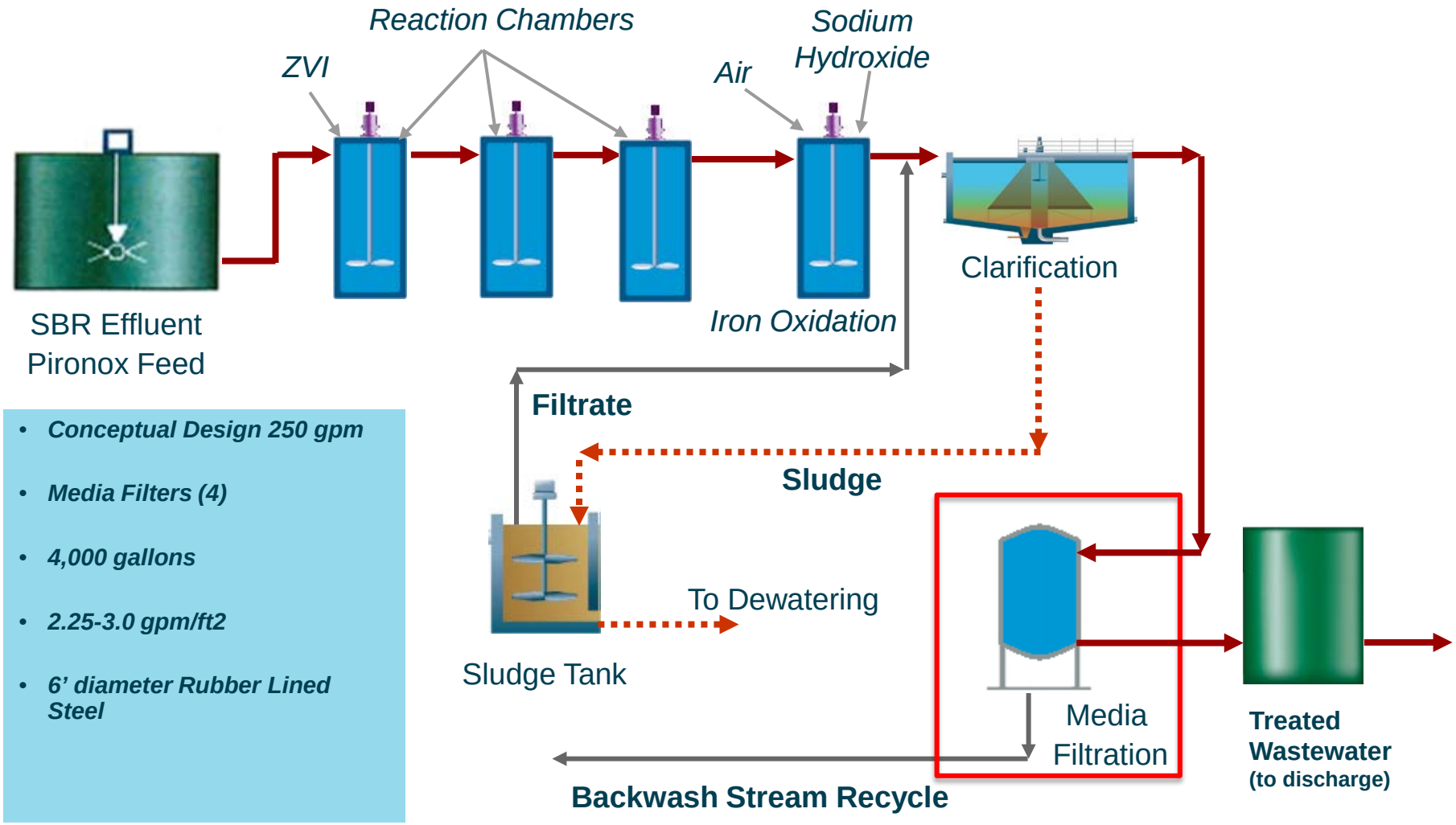
- ***Conceptual Design 250 gpm***
- ***47,000 gallons***
- ***34' diameter Coated Carbon Steel, Rubber Coated Internals***
- ***0.56 gpm/ft2 raise rate***

POLISHING – PIRONOX FOR REMOVAL OF METAL AND OTHER TRACE CONTAMINANTS



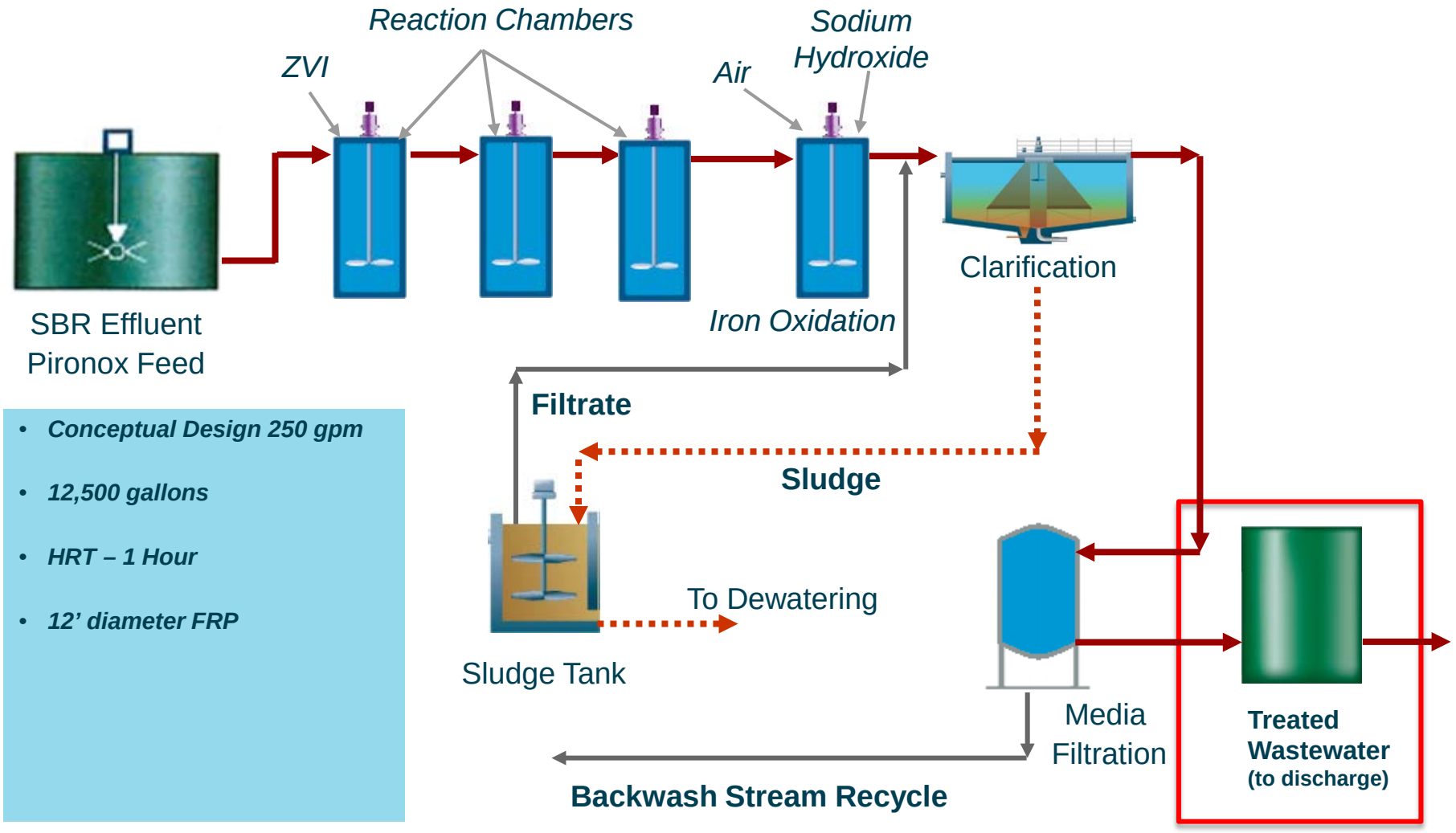
- *Conceptual Design 250 gpm*
- *Thickener Sludge Tank (1)*
- *4,000 gallons*
- *HRT – 13 Hours*
- *8' diameter FRP*

POLISHING – PIRONOX FOR REMOVAL OF METAL AND OTHER TRACE CONTAMINANTS



- ***Conceptual Design 250 gpm***
- ***Media Filters (4)***
- ***4,000 gallons***
- ***2.25-3.0 gpm/ft2***
- ***6' diameter Rubber Lined Steel***

POLISHING – PIRONOX FOR REMOVAL OF METAL AND OTHER TRACE CONTAMINANTS



- ***Conceptual Design 250 gpm***
- ***12,500 gallons***
- ***HRT – 1 Hour***
- ***12' diameter FRP***