The Metropolitan

Water Reclamation District

of Greater Chicago

WELCOME
TO THE JUNE EDITION
OF THE 2012
M&R SEMINAR SERIES

HRSD

BEFORE WE BEGIN

- **SILENCE CELL PHONES & PAGERS**
- **QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION**
- **SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE AT (www. MWRD.org)**
- **Home Page $\Rightarrow$ (Public Interest) $\Rightarrow$ more public interest**
  $\Rightarrow$ M&R Seminar Series $\Rightarrow$ 2012 Seminar Series

HRSD

Charles B. Bott, Ph.D. P.E., BCEE

Career

- Research and Development Manager at HRSD
- Adjunct Professor in the Dept of Civil and Env Eng at Virginia Tech and Old Dominion University
- Associate Professor in the Dept of Civil and Env Eng at the Virginia Military Institute (VMI)
- Consulting Engineer with Parson Engineering Science

Professional

- Registered Professional Engineer: Virginia
- Board Certified Environmental Engineer (BCEE)
- Board of Trustees, Water Environment Federation
- Science and Technical Advisory Committee to the Chesapeake Bay Program Executive Council

Education

- Ph.D in Civil and Env Eng, Virginia Tech;
- MS in Env Eng, Johns Hopkins University
- BS in Civil Eng, Virginia Military Institute, o

Awards

- Winner of the WEF Harrison Prescott Eddy Medal
- Winner of the Water Environment Federation (WEF) Outstanding Young Professional Award

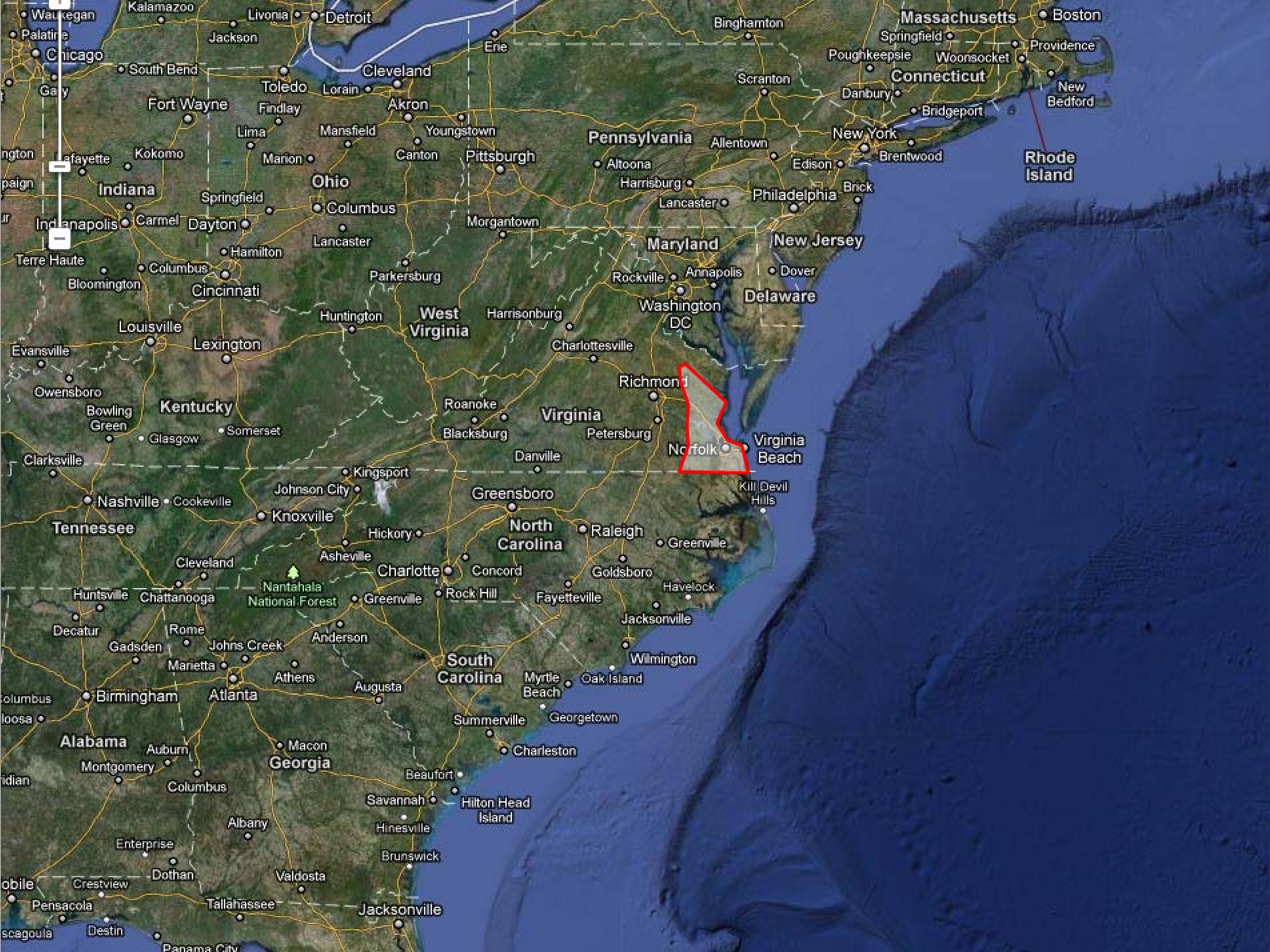
HRSD

Cleaning wastewater every day for a better Bay.

Struvite Recovery at the HRSD Nansemond Treatment Plant

Charles B. Bott, PhD, P.E., BCEE

Hampton Roads Sanitation District



Waukegan
Kalamazoo
Livonia
Detroit
Binghamton
Massachusetts
Boston
Palatine
Jackson
Erie
Springfield
Providence
Chicago
Poughkeepsie
Woonsocket
South Bend
Cleveland
Toledo
Scranton
Connecticut
Gary
Lorain
Danbury
New Bedford
Fort Wayne
Findlay
Akron
Bridgeport
Mansfield
Youngstown
Lima
Pennsylvania
Allentown
New York
Lafayette
Kokomo
Marion
Canton
Pittsburgh
Brentwood
Rhode Island
Altoona
Edison
Ohio
Harrisburg
Indiana
Brick
Springfield
Columbus
Lancaster
Philadelphia
Indianapolis
Carmel
Dayton
Morgantown
Lancaster
Maryland
New Jersey
Hamilton
Terre Haute
Columbus
Dover
Rockville
Annapolis
Parkersburg
Bloomington
Cincinnati
Delaware
Washington DC
Huntington
West Virginia
Harrisonburg
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Charlottesville
Lexington
Evansville
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Owensboro
Roanoke
Kentucky
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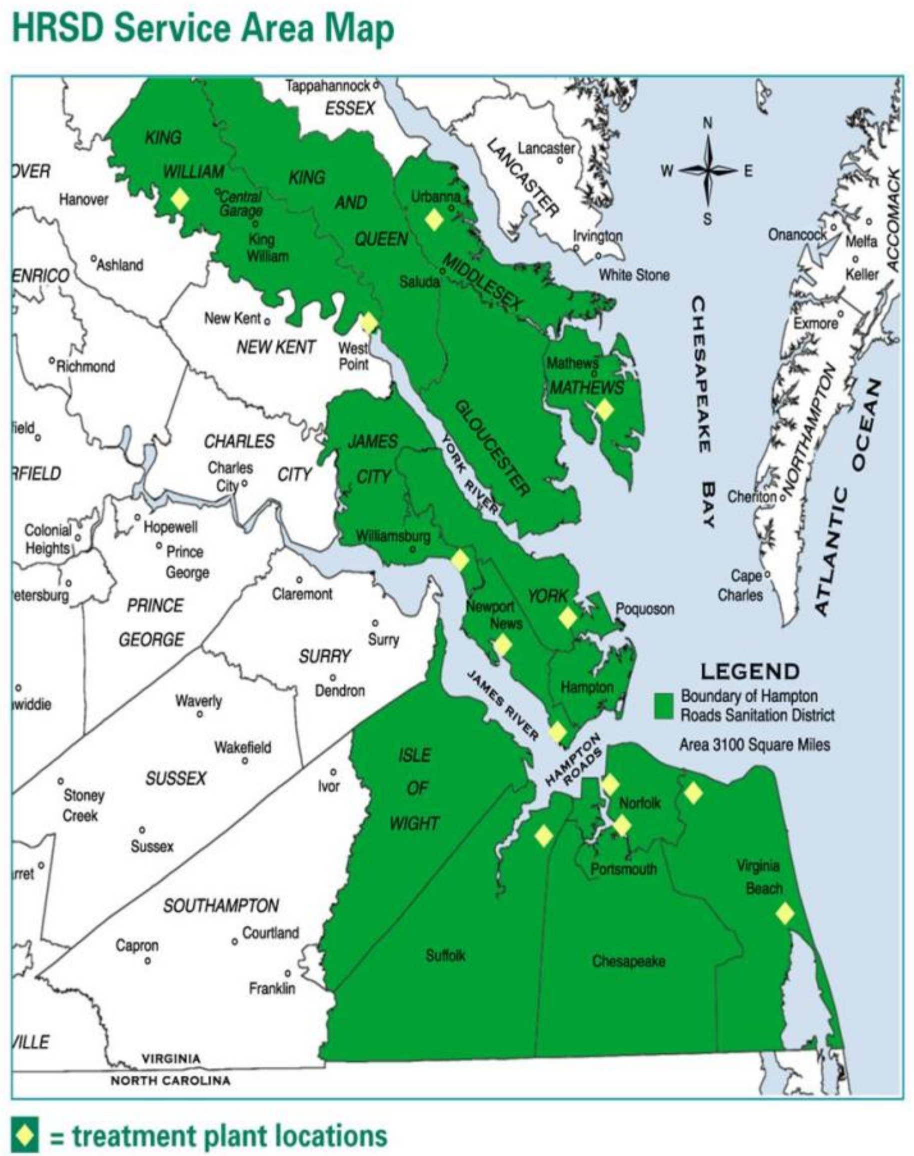
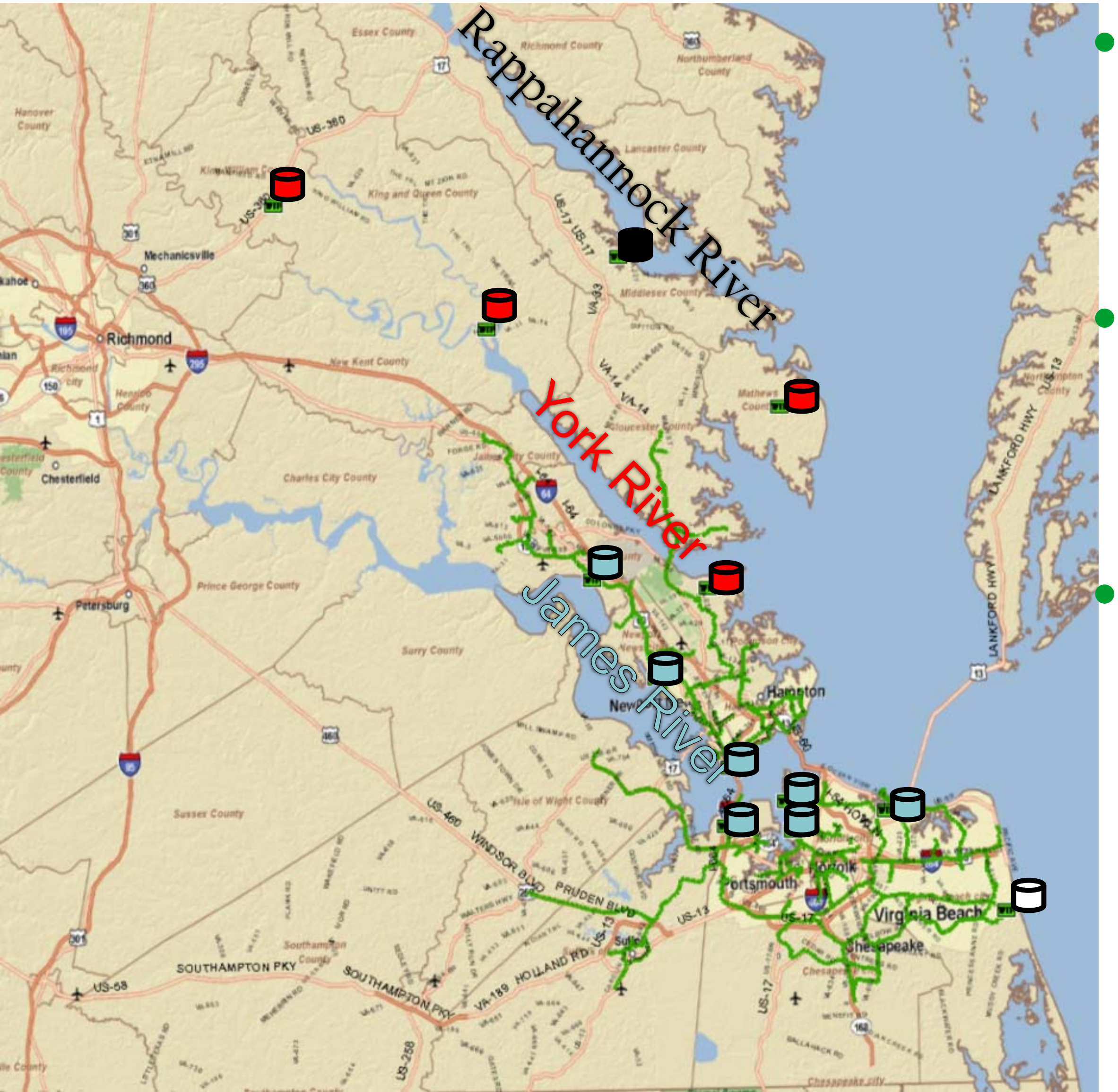
Bowling Green
Somerset
Blacksburg
Petersburg
Glasgow
Virginia Beach
Norfolk
Clarksville
Danville
Kingsport
Kill Devil Hills
Johnson City
Greensboro
Nashville
Cookeville
Knoxville
North Carolina
Raleigh
Tennessee
Hickory
Greenville
Asheville
Cleveland
Charlotte
Concord
Goldsboro
Nantahala National Forest
Havelock
Huntsville
Chattanooga
Greenville
Rock Hill
Fayetteville
Jacksonville
Decatur
Rome
Anderson
Gadsden
Johns Creek
South Carolina
Wilmington
Marietta
Athens
Myrtle Beach
Oak Island
Augusta
Birmingham
Atlanta
Summerville
Georgetown
Alabama
Auburn
Macon
Charleston
Montgomery
Georgia
Columbus
Beaufort
Savannah
Hilton Head Island
Albany
Hinesville
Enterprise
Brunswick
Dothan
Valdosta
Crestview
Pensacola
Tallahassee
Jacksonville
Destin
Panama City

Hampton Roads Sanitation District

- Created in 1940
- Serves 1.6 million people
- Includes 17 jurisdictions – 3,100 square miles
- 9 plants, 4 small plants
- Capacity of 249 MGD



HRSD's Bubble Permit - 2011



- James River
  - 6,000,000 lbs/yr TN
  - 573,247 lbs/yr TP
- York River
  - 288,315 lbs/yr TN
  - 33,660 lbs/yr TP
- Rappahannock River (one plant)
  - 1,218 lbs TN
  - 91 lbs/yr TP

Chesapeake Bay TMDL & VA WIP

- Nitrogen – James River
  - 2011 – 6.0 million pounds/year
    - Major upgrades ongoing at Nansemond, James River, Williamsburg, Army Base
    - Upgrade at Boat Harbor (minimal N removal)
  - 2017 – 4.4 million pounds/year
    - VIP - upgrade for improved denitrification
    - Small upgrade at Williamsburg possible
  - 2021 – 3.4 million pounds/year
    - Upgrade Chesapeake-Elizabeth (full plant)
- Nitrogen – York River ---- No change?
  - Rapid upgrade - denite filters for 2011 compliance
  - Upgrade needed for cost-effective BNR and reliability

HRSD Treatment and BNR R&D Program Focus

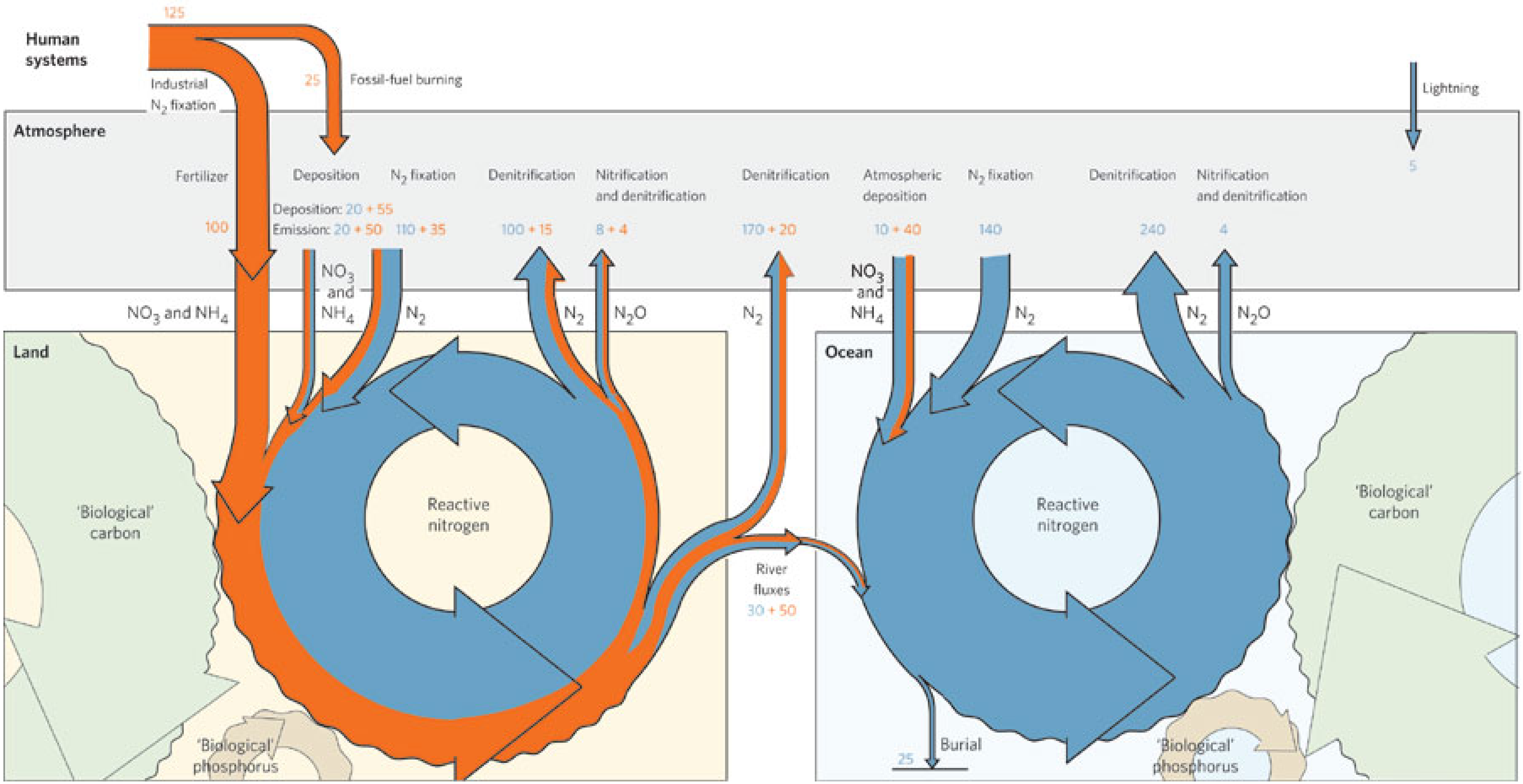
- Resource utilization:
  - Energy
  - Chemicals
  - Labor (operations, maintenance, instrumentation…)
  - Concrete
- Resource recovery
  - Water
  - P
  - N (maybe)
  - CH_4 - biogas
  - Heat
  - Hydraulic energy
  - Chemicals of interest (maybe)
  - Biosolids (N, P, organics)
  - Etc, etc, etc

HRSD

Current HRSD R&D Efforts in BNR:

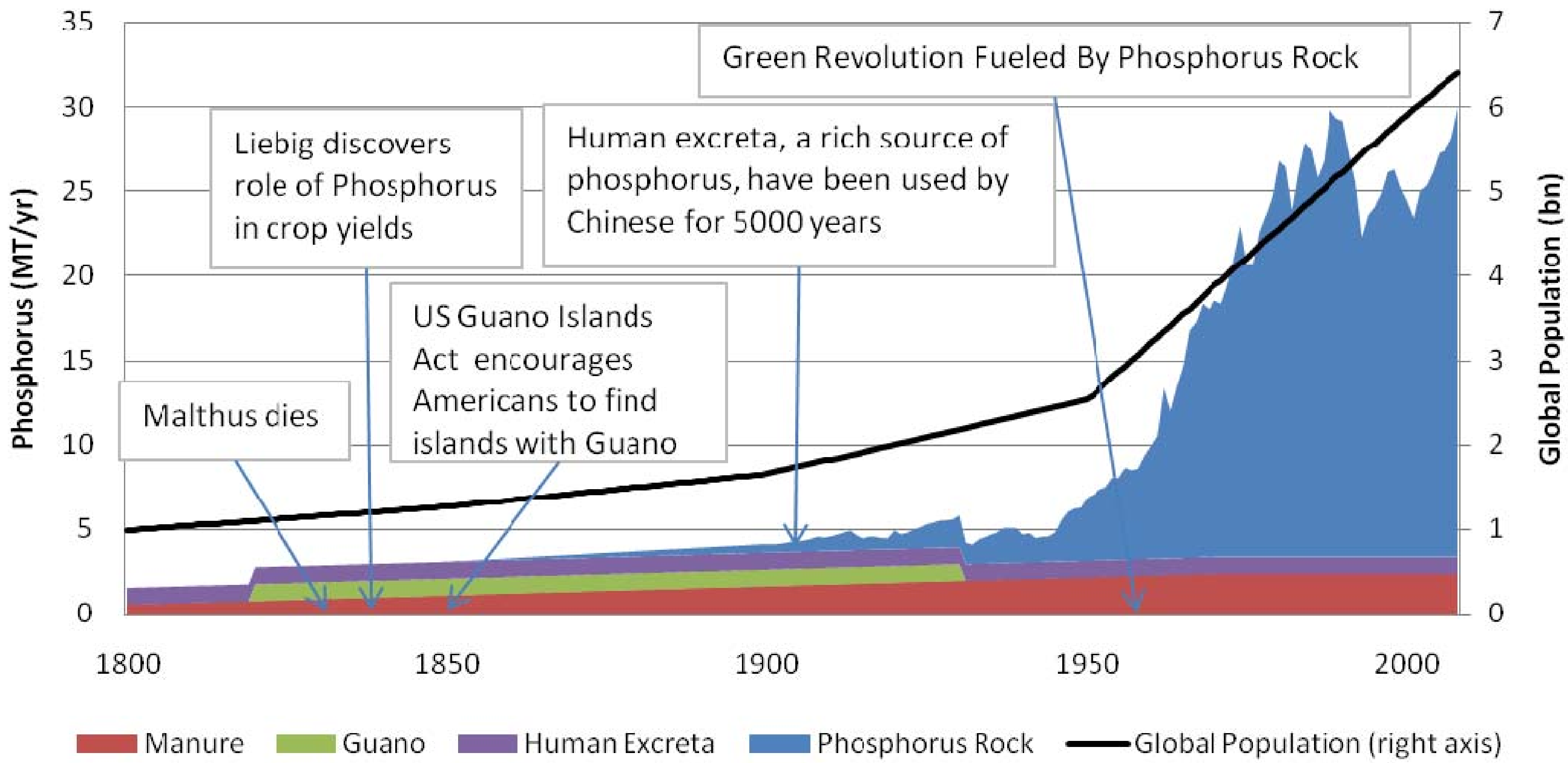
- Struvite avoidance and recovery (labor, energy, chemicals)
- Mainstream Deammonification & Nitritation-Denitritation (energy, chemicals, concrete)
- Supplemental carbon for denitrification (chemicals)
  - AOB conversion of methane to methanol
  - Reduced S compounds
  - Ethanol used for fuel blending
- Ammonia-based DO control systems (energy, chemicals, concrete)
- Cost-effective chemically enhanced primary treatment (chemicals, energy, concrete)
- Algae-based nutrient removal (chemicals, energy)
- Centrate deammonification = partial nitritation + anammox (chemicals, energy)
- Nitrite accum. and excessive chlorine demand (chemicals)
- IFAS process development and modeling (concrete, energy)
- Nitrification inhibition (concrete)
- Improvement of BNR process models (chemicals, energy, concrete)
- Organic nitrogen sources and fate (issue)
- Urine separation (???)

Global N Cycle – Impact of Haber-Bosch



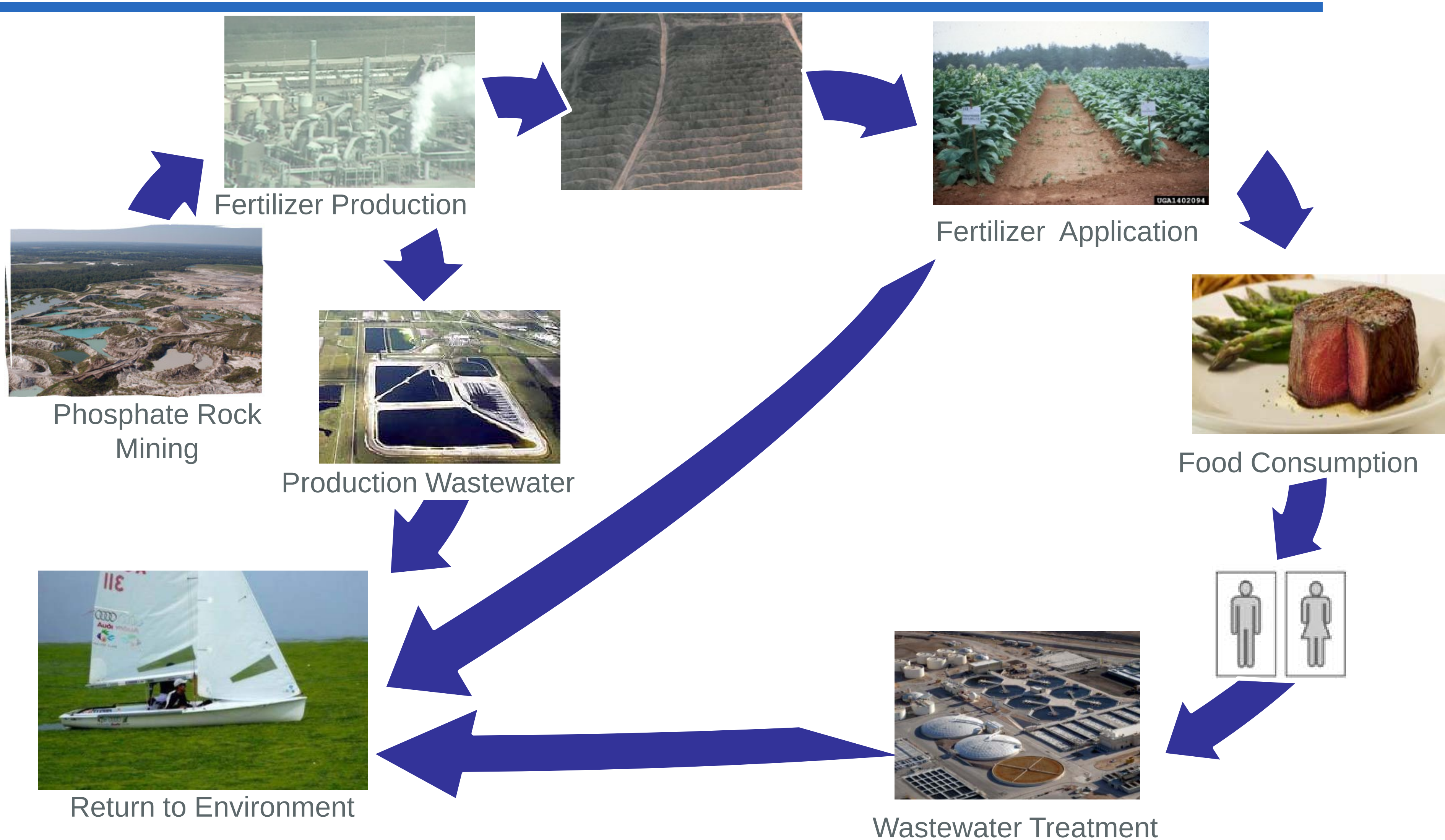
Gruber & Galloway, 2008

History of Phosphorus-Based Fertilizers

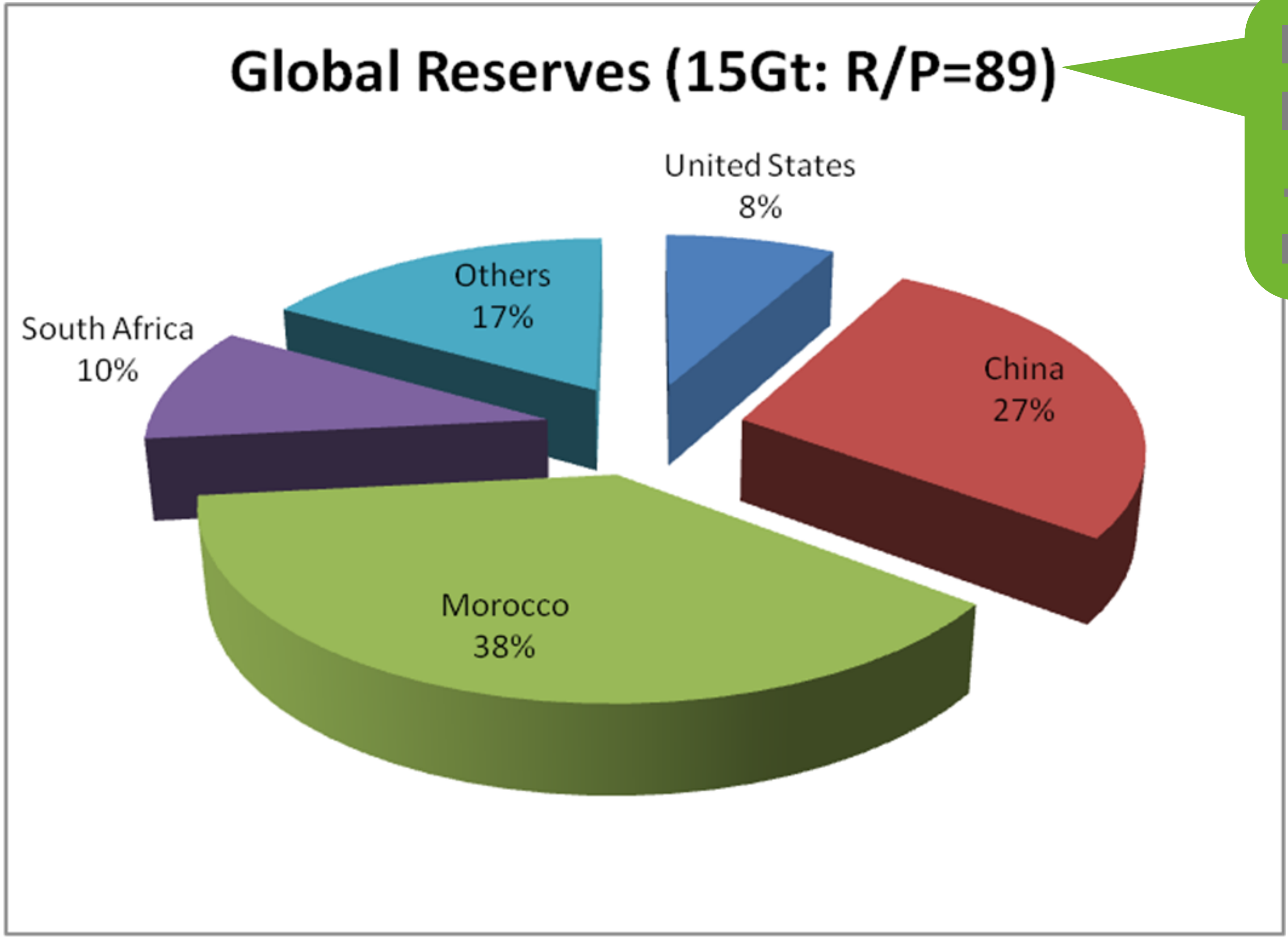


Source: "The Story of Phosphorus: Global Security and Food For Thought", Cordell, et.al.
Global Environmental Change, Volume 19, Issue 2, May 2009

Modern Phosphorus Cycle



Global Distribution of Reserves Raises Questions



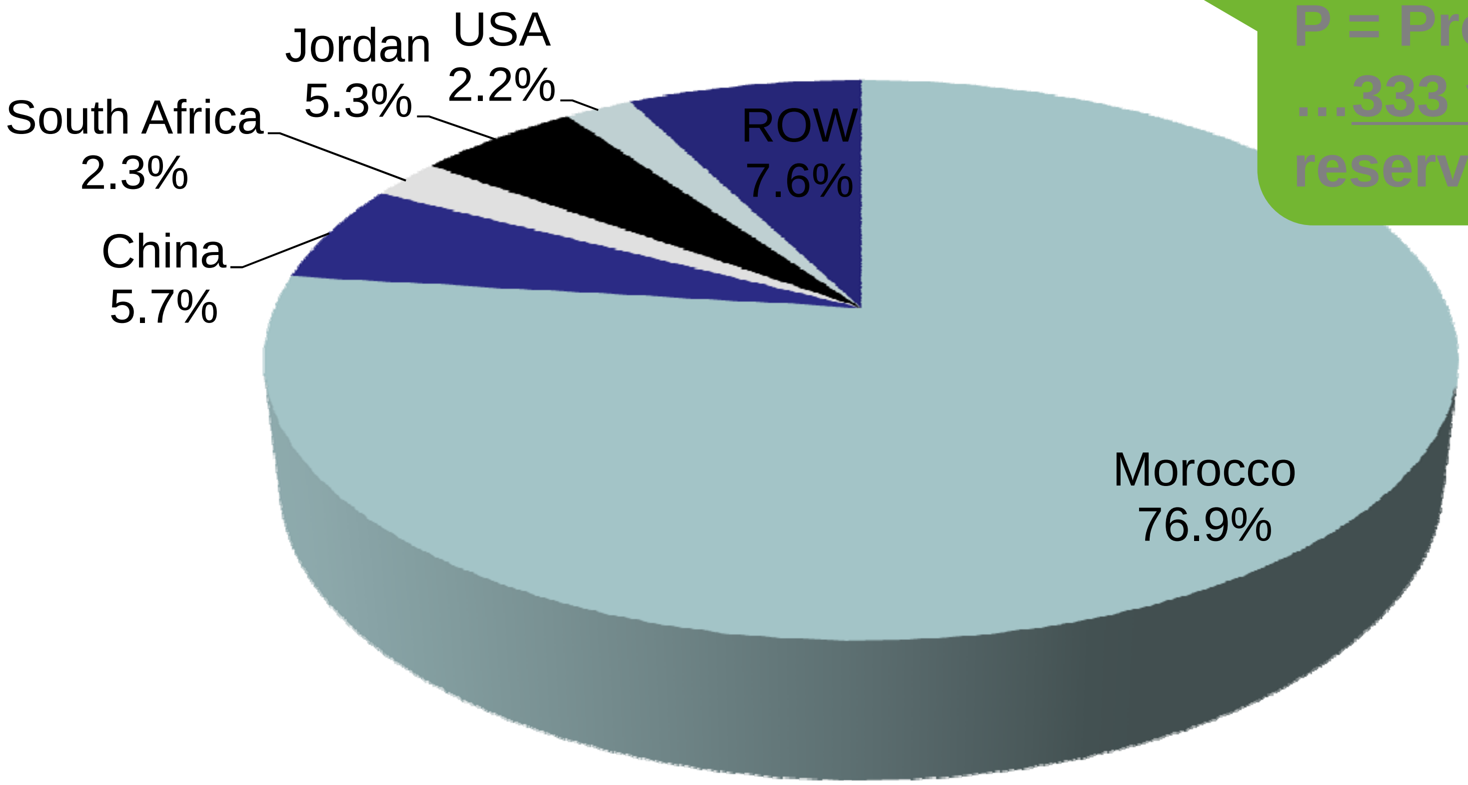
R = Reserves
P = Production
…89 years of reserves

Source: USGS Data on phosphate production October 9, 2007

Disputed Phosphate Reserve Estimate

Global Reserves (60 Gt: R/P = 333)

R = Reserves
P = Production
…<u>333 years</u> of reserves



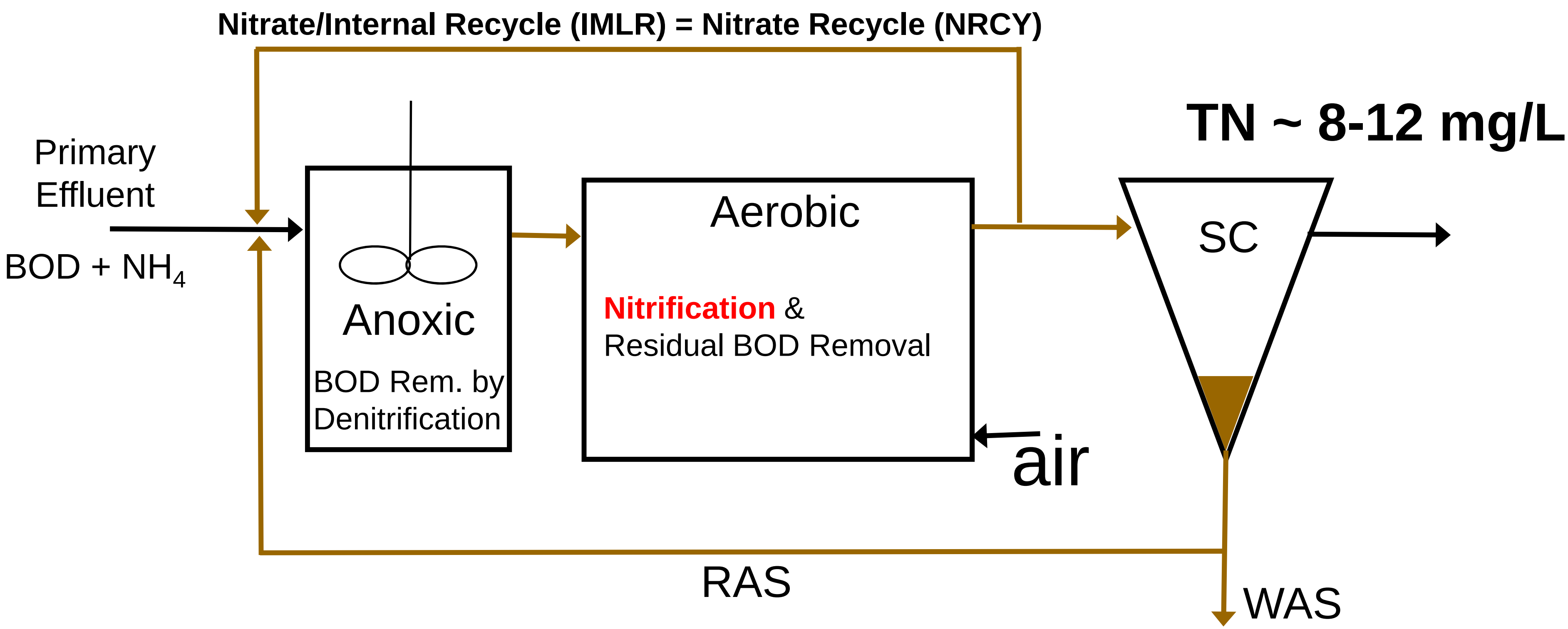
IFDC Report – September 2010

HRSD

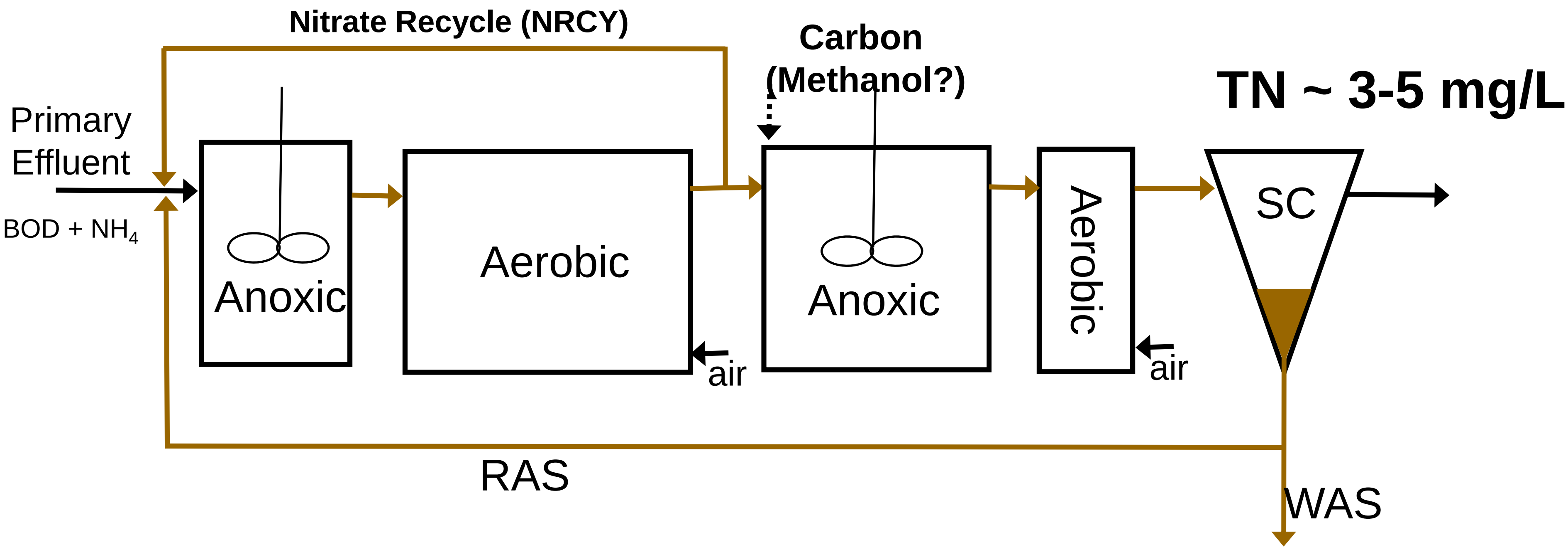
A bit of background….

- Nitrification-Denitrification
- Biological P Removal

MLE Process (N Removal)

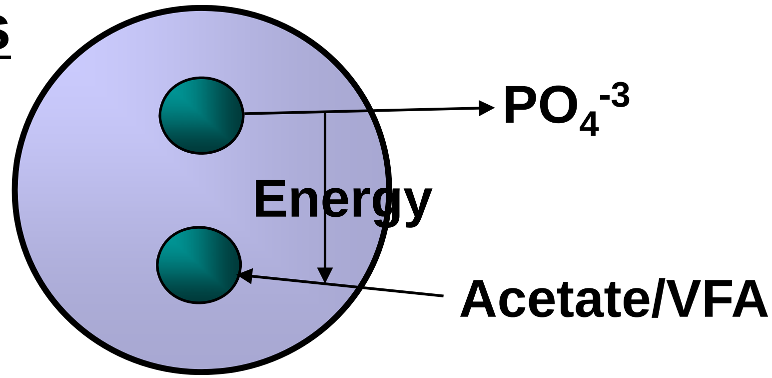


4-Stage Bardenpho (Better N Removal)

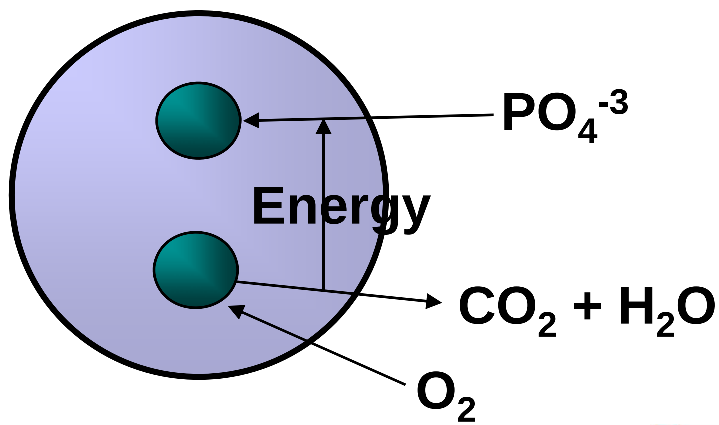


Phosphorus accumulating organisms (PAO's) Unique Anaerobic/Aerobic Metabolism

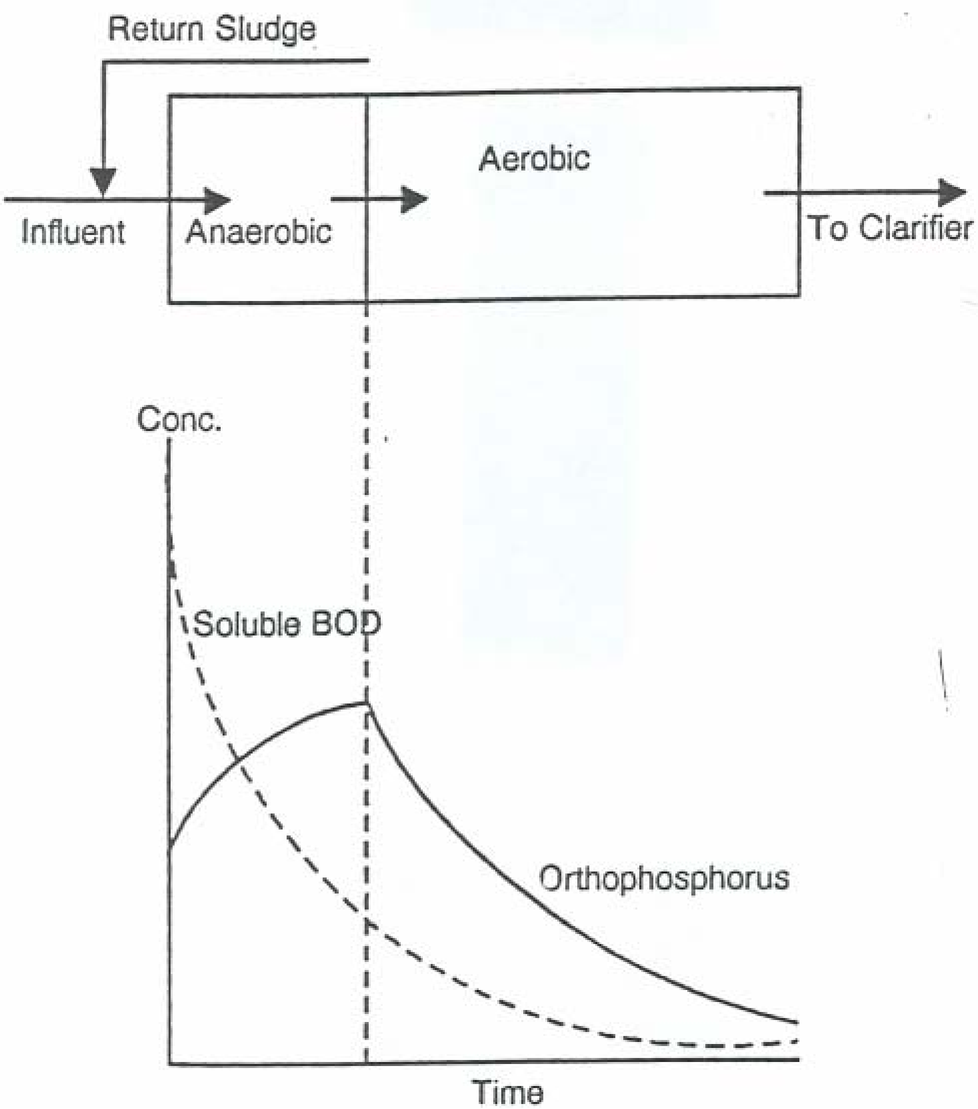
<u>Anaerobic Conditions</u>



<u>Aerobic Conditions</u>

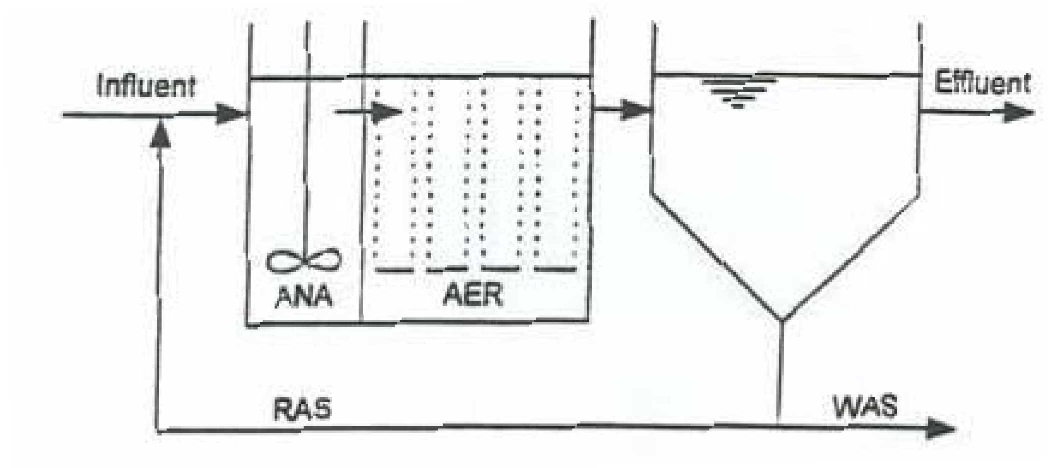


Biological Phosphorus Removal (Bio-P)



Bio-P in A/O Process

A/O Process



ANA = Anaerobic
AER = Aerobic

Addition of an anaerobic selector…

Removal of P Through WAS

- Typical Mixed Liquor
  - 1.5 - 2% (P / MLVSS by weight)

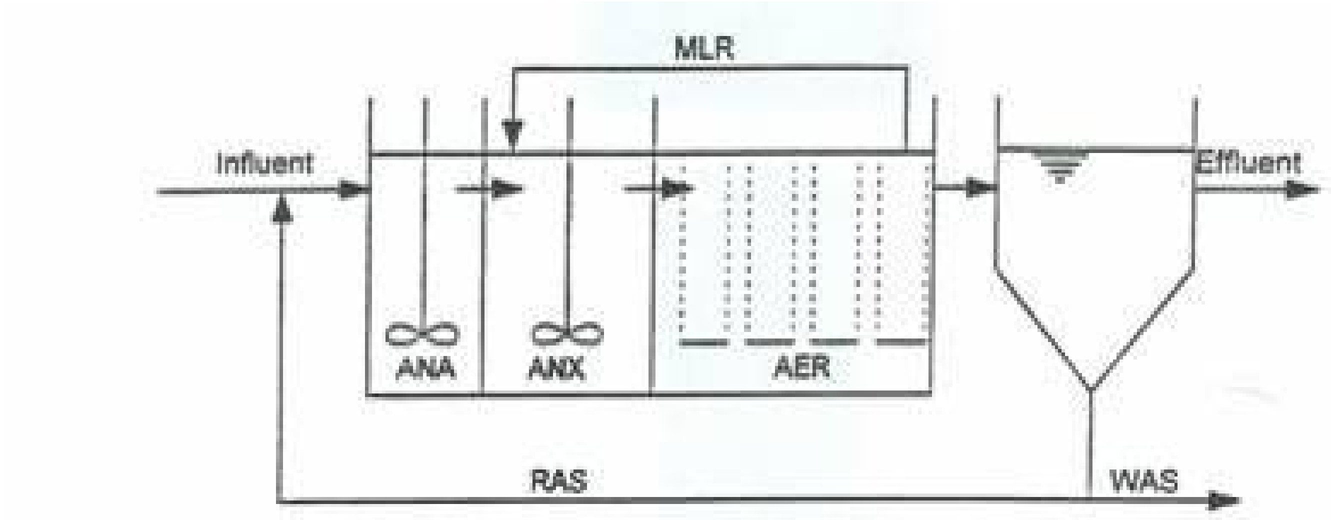
- Bio-P Mixed Liquor
  - Up to 15-35% (P / MLVSS by weight)
  - 5 - 7% Typ.

- Lower SRT/MCRT = better Bio-P
  - Down to about 3 days

Six Key Considerations for Bio-P

- Input of sufficient rbCOD in the form of VFAs to the anaerobic zone.
- Minimization of oxygen and nitrate return to or presence in the anaerobic zone.
- Minimization of post-aerobic P release, either in an over-designed secondary anoxic zone or in the secondary clarifier.
- Operation at solids retention time (SRT) as low as possible (in excess of that required for nitrification).
- DO of ~2 mg/L at head of aerobic zone
- **Careful management of solids handling processes and recycle streams.**

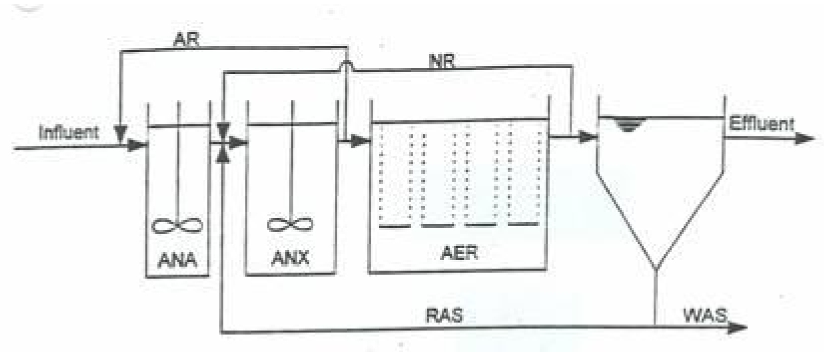
Add Bio-P to MLE…



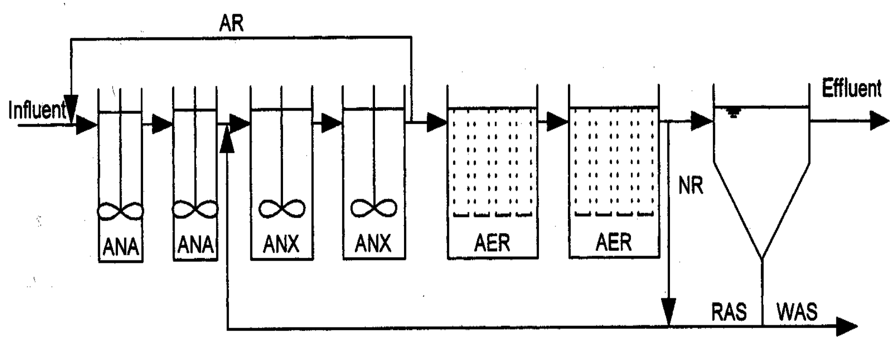
A^2/O or Phoredox Process

ANA = Anaerobic
ANX = Anoxic
AER = Aerobic

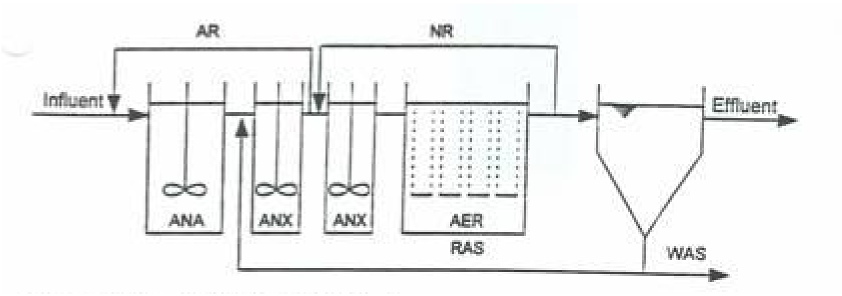
Better P Removal (with Nitrification)



UCT Process

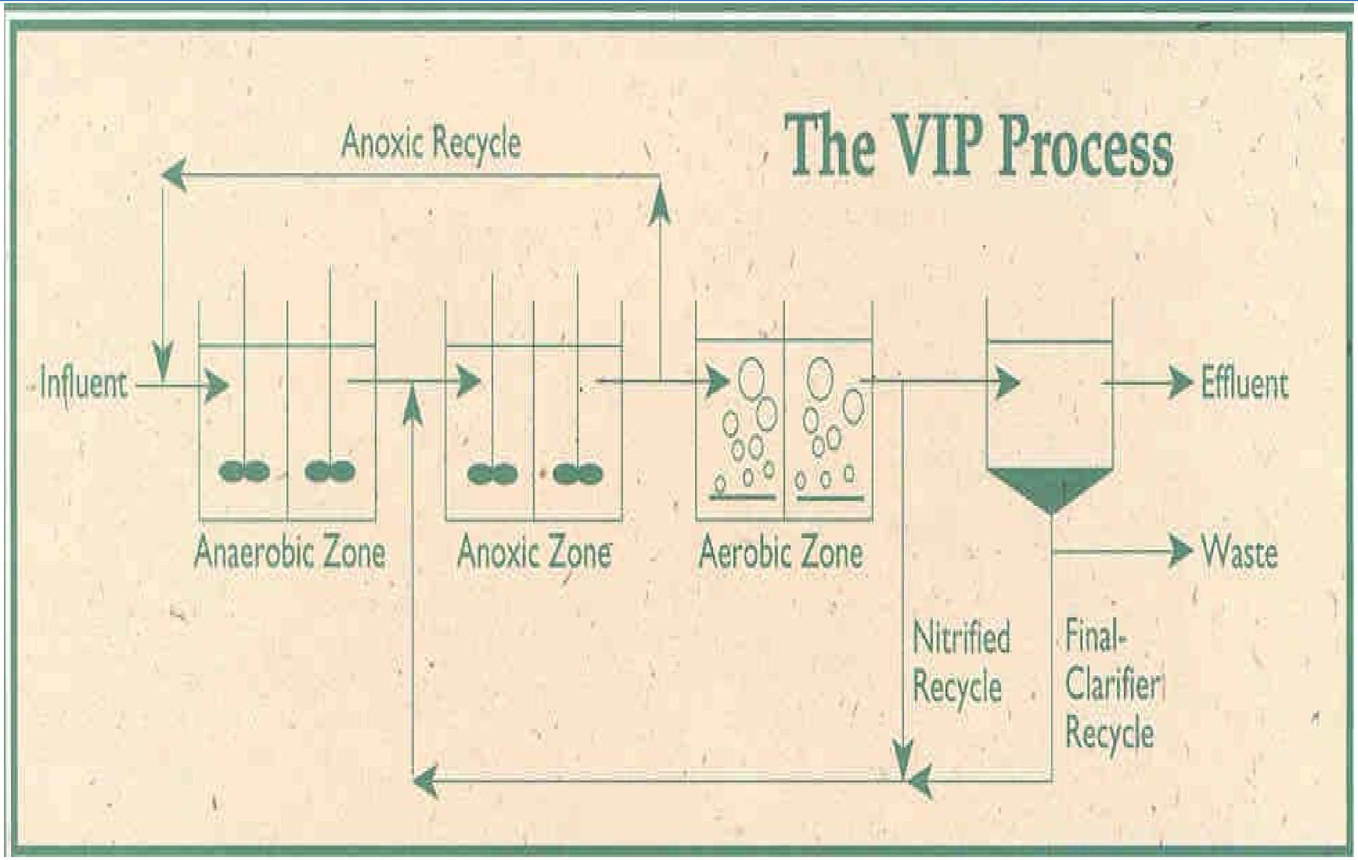


VIP Process



MUCT Process

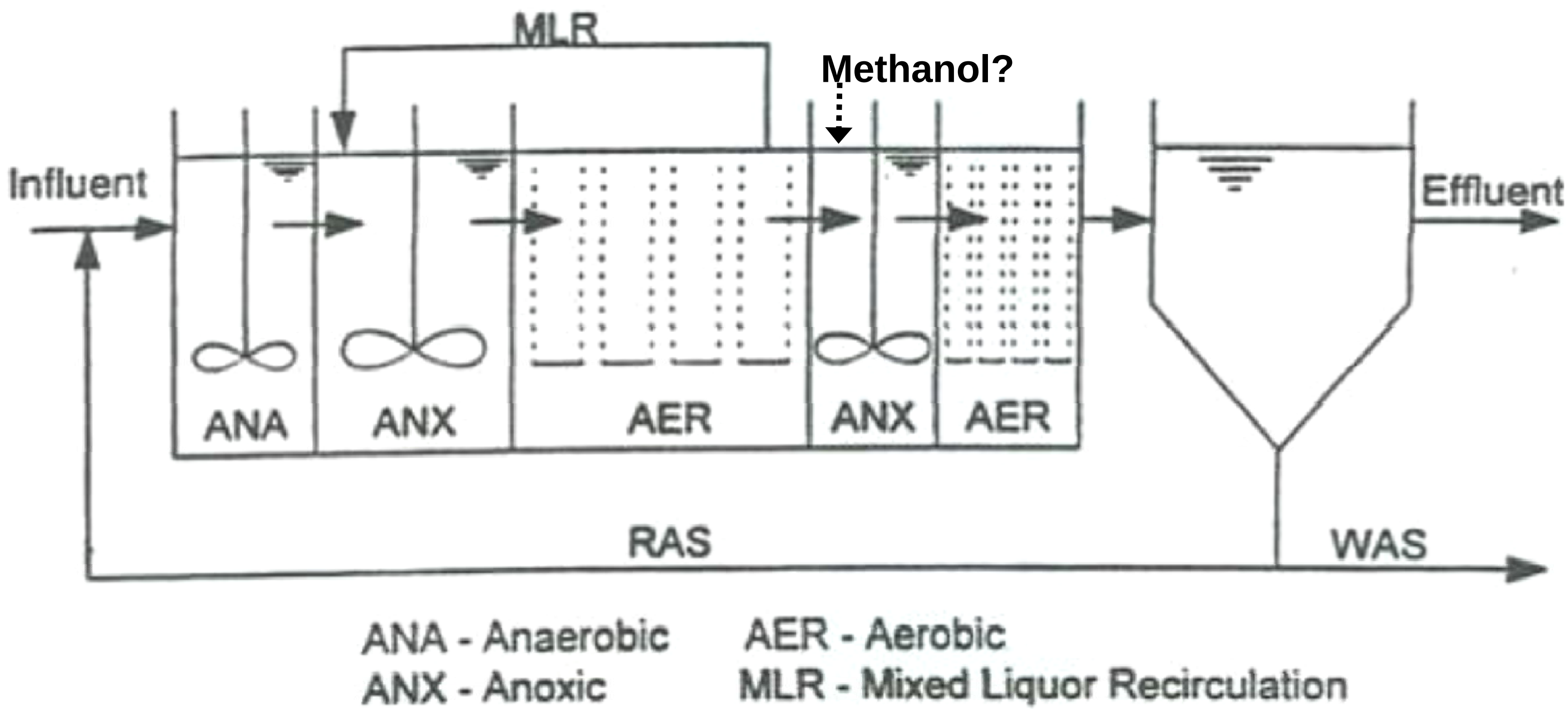
The VIP® Process



- It was developed and patented by HRSD, VT, and CH2M Hill
- Biologically removes Phosphorus and Nitrogen
- Its free for any one to use…

HRSD

5-Stage Bardenpho



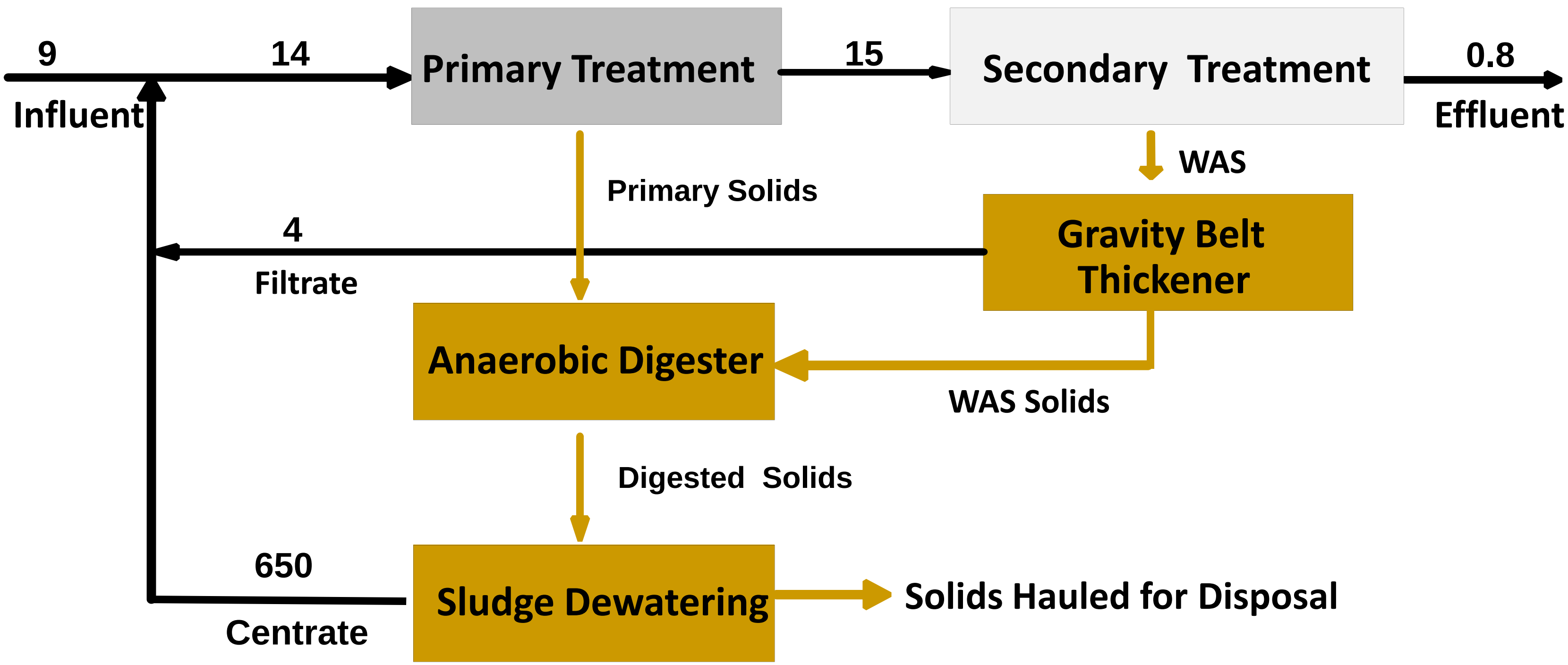
Generally - “5-stage BNR”

Add second anoxic zone to a Bio-P processes (for example VIP + 2, MUCT+2, A2O+2, etc)

HRSD Nansemond Plant

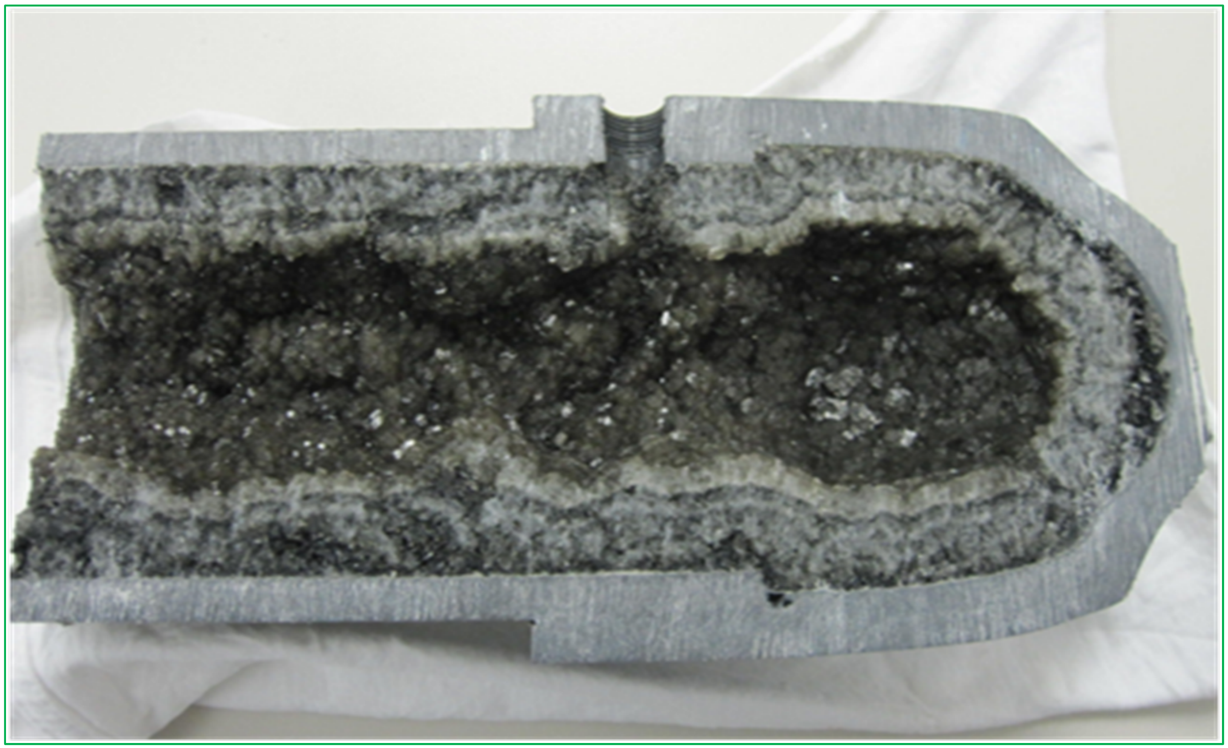
Nansemond Plant (pre 2008)

Phosphorus Profile



Values in mg/L TP

What is Struvite?



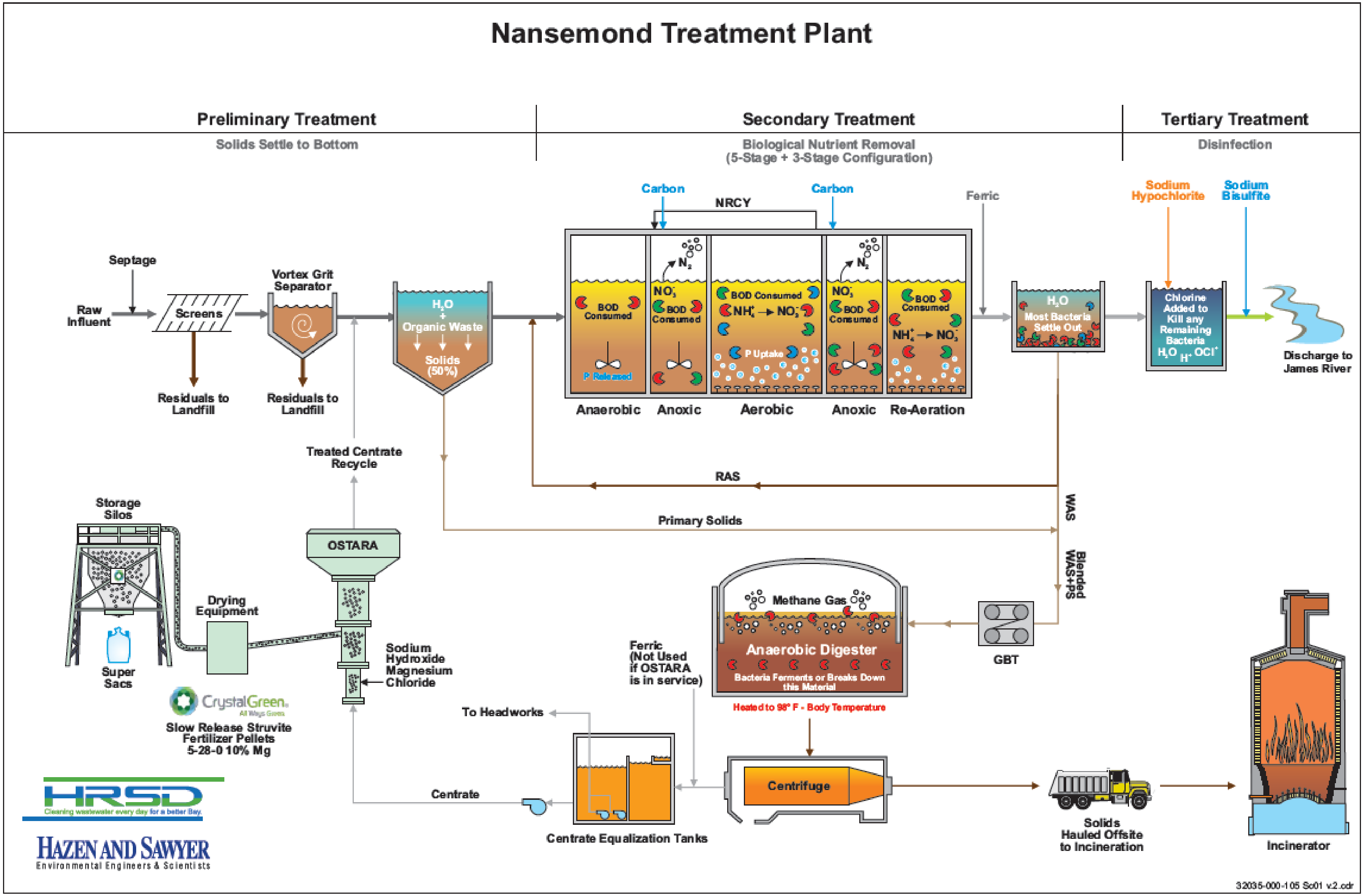
How Bad Can it Get?

Centrifuge Bowl Scoring

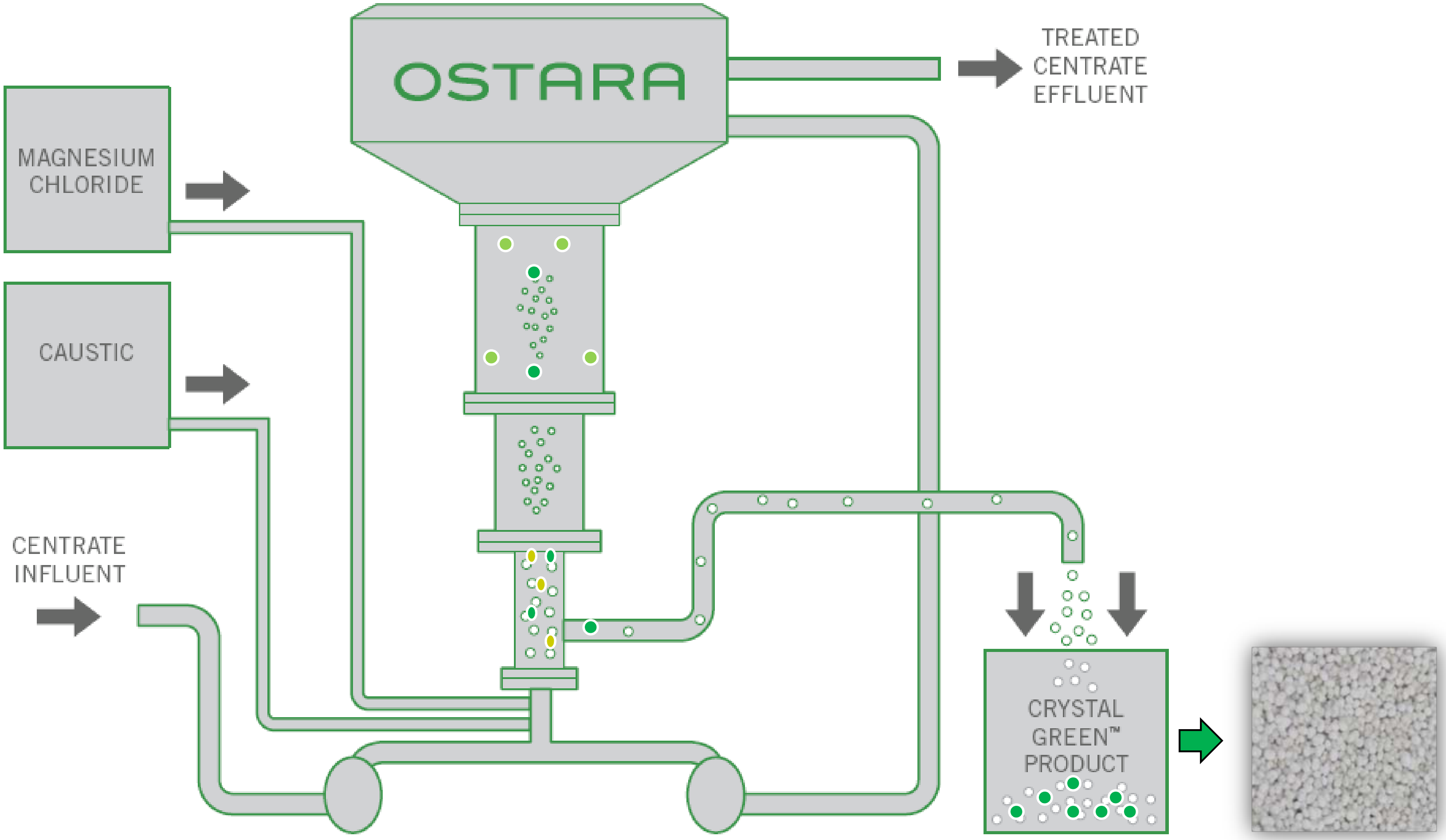
Pipe Restrictions

Nansemond Treatment Plant Upgrade

Process Flow Diagram



What is the Ostara® Process

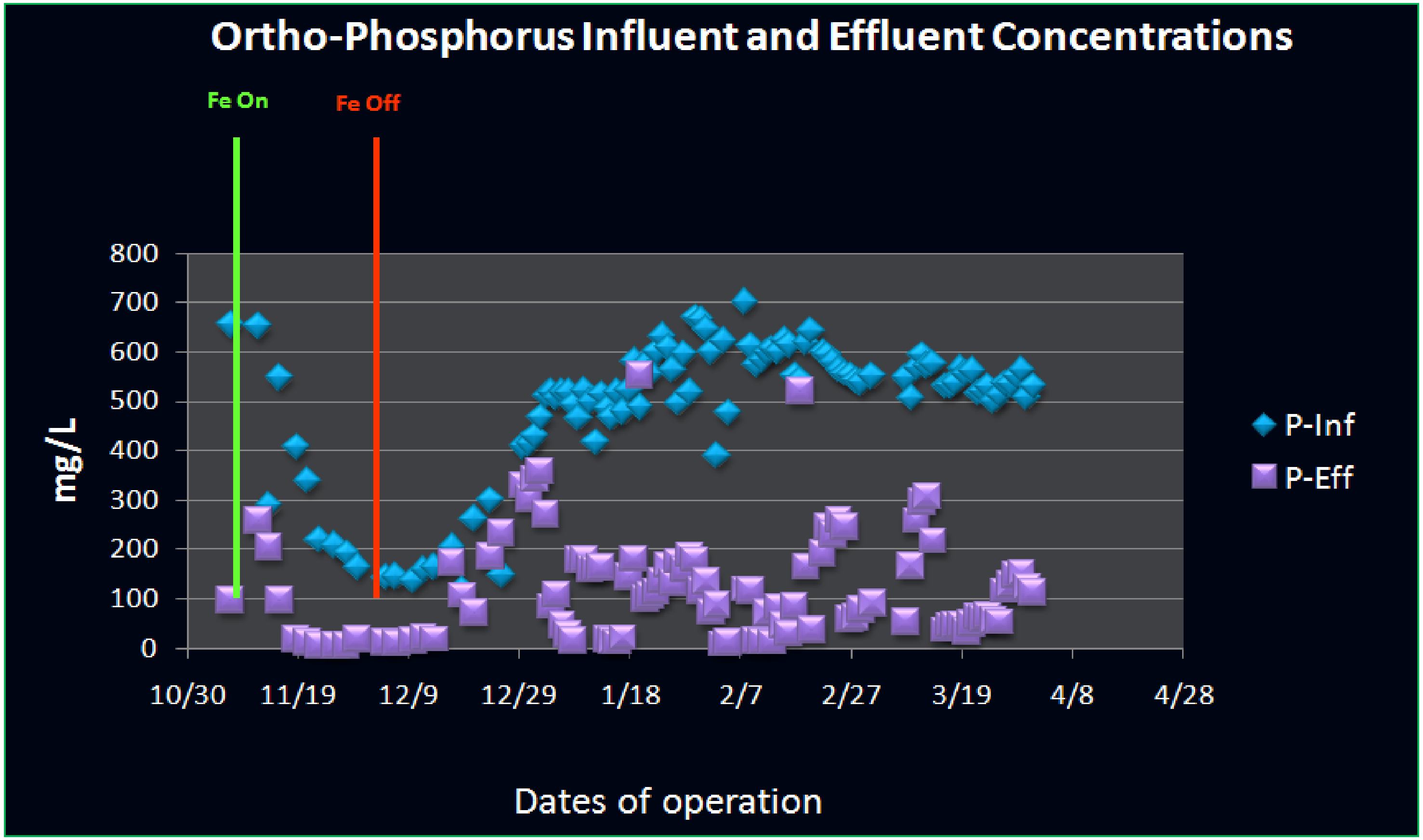


Ready to Use After Drying, No Post Processing

Pilot Testing

- >80 % phosphate recovery
- >42% ammonium recovery
- Higher P removal was achieved at lower pH conditions compared to previous studies
- Good Product quality
  - 2-4mm diameter pellets

Pilot Plant OP Performance



Average P removal 80%

Alternatives Cost Analysis

Cost Description	Do Nothing	Side Stream Chem Trmt	Ostara
Total Annual Savings	0	0	528,000
Total Annual Operating Costs	(392,000)	(429,000)	(91,000)
Net Annual Costs	(392,000)	(429,000)	437,000
Capital Costs			3,926,000
Net Present Worth @ 10 years	(3,027,000)	(3,313,000)	(552,000)
Net Present Worth @ 20 years	(4,885,000)	(5,346,000)	1,520,000

HRSD

Summary of Benefits to Using Ostara Process

- Reduce recycle nutrient loads
- Reduce struvite scale formation
- Reduces phosphate concentration in biosolids
- Reduce sludge volumes (a little)
- Generate a high quality fertilizer that recovers costs
- Stabilize plant bio-P process

Reduced Costs & Improved Reliability

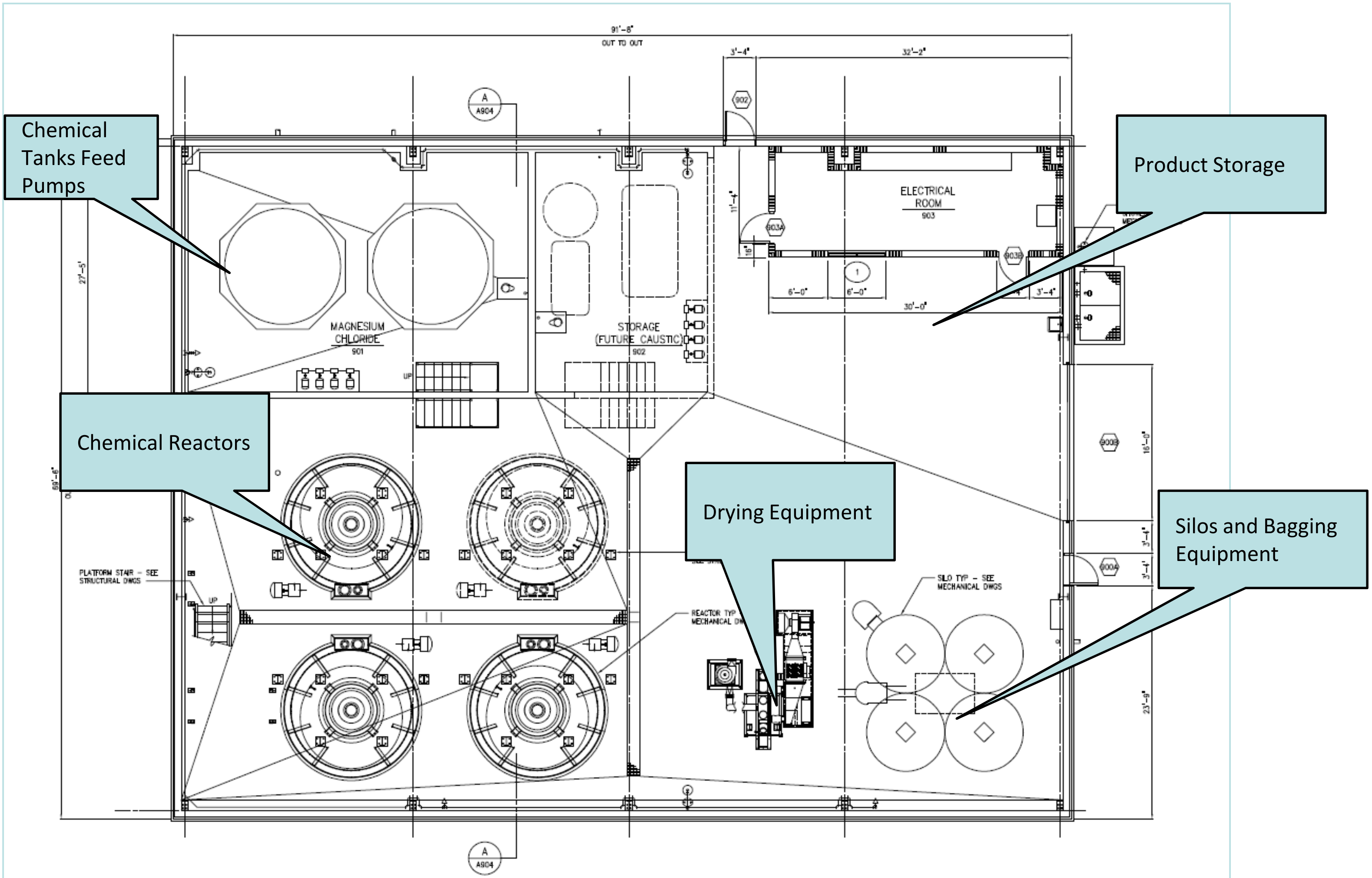
HRSD and Ostara’s Agreement

- 10 year contract with Ostara to purchase all product produced at the facility with increases to purchase price based on the CPI.
- HRSD compensated for materials and operating costs.
- Ostara provides the equipment and process oversight.
- HRSD retains ownership of the building and equipment after contract expires.
- Ostara markets and distributes the fertilizer product under the name as CrystalGreen™. HRSD’s name is not used on any packaging.

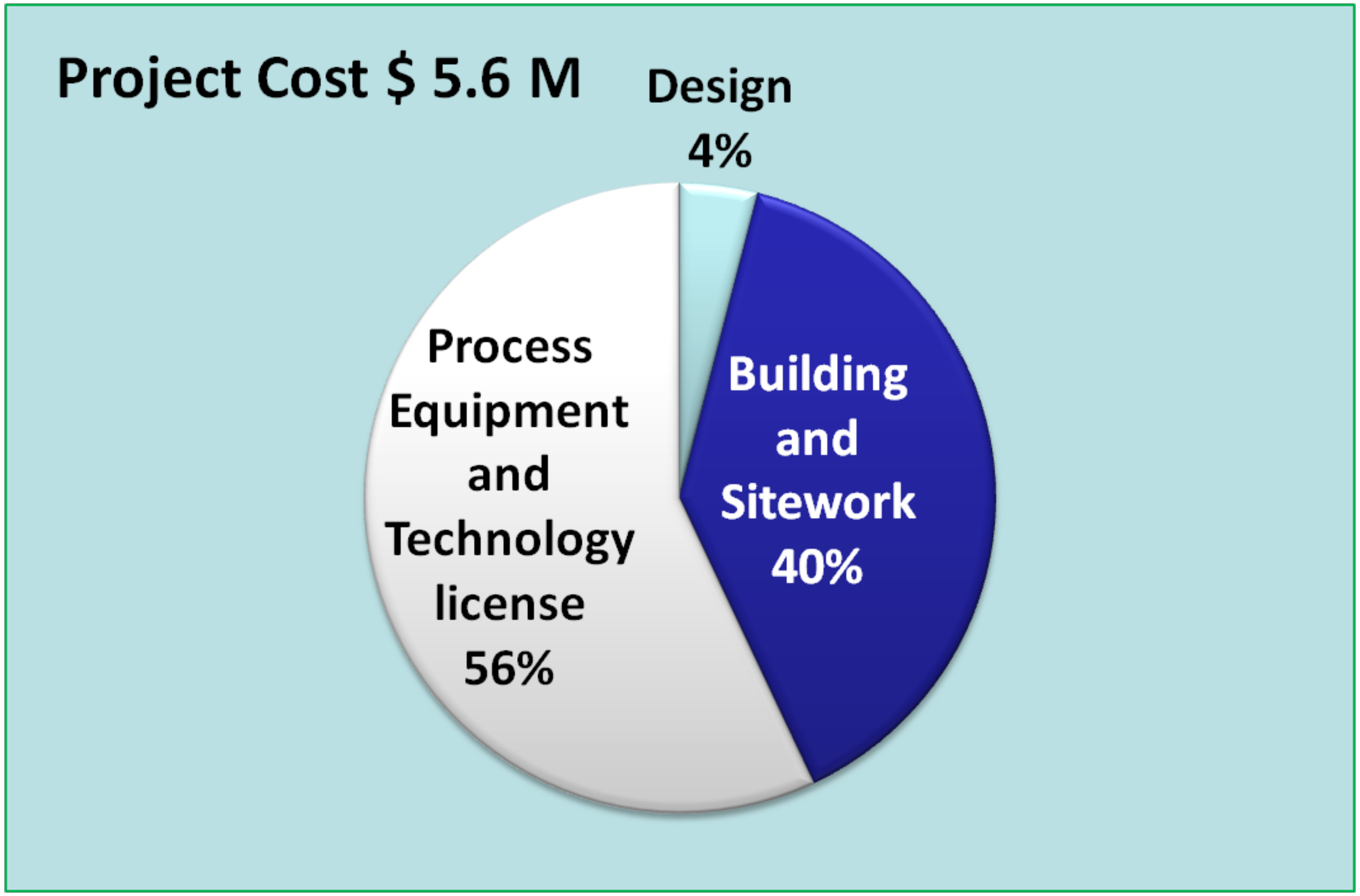
Struvite Recovery Facility Design Parameters

Parameter	Design	Units
Design Flow	110,000	GPD
NH_4 Influent Concentration	650	mg/L as N
PO_4 Influent Concentration	450	mg/L as P
Proposed No of Reactors	3	500 kg/day
Reactor PO_4 Effluent Concentration	72	mg/L PO_4-P
PO_4 Removal Efficiency	84	%
Mass of Phosphorous Removed	346	Lbs/day
Reactor NH_4 Effluent Concentration	479	mg/L NH_4-N
NH_4 Removal Efficiency	26	%
Mass of Nitrogen Removed	157	Lbs/day
Struvite Production Rate	501	Tons/year
Manpower Requirements (FTE)	0.5	5 days/wk

Struvite Facility Layout



Struvite Facility Cost



HRSD

Struvite Facility Construction Schedule

- Proposal Submitted July 2009
- Commission Approval October 2009
- Contract Signed November 2009
- Operational May 2010
- Ribbon-cutting May 27, 2010

HRSD

Complete Ostara System

Crystal Green Storage & Bagging

Dewatering Screen & Dryer

Pearl Reactors

Chemical Storage & Feed

Struvite Recovery Facility Video

Fertilizer Product Locally Available

Available at White's Old Mill Garden Center in Chesapeake, VA

HRSD

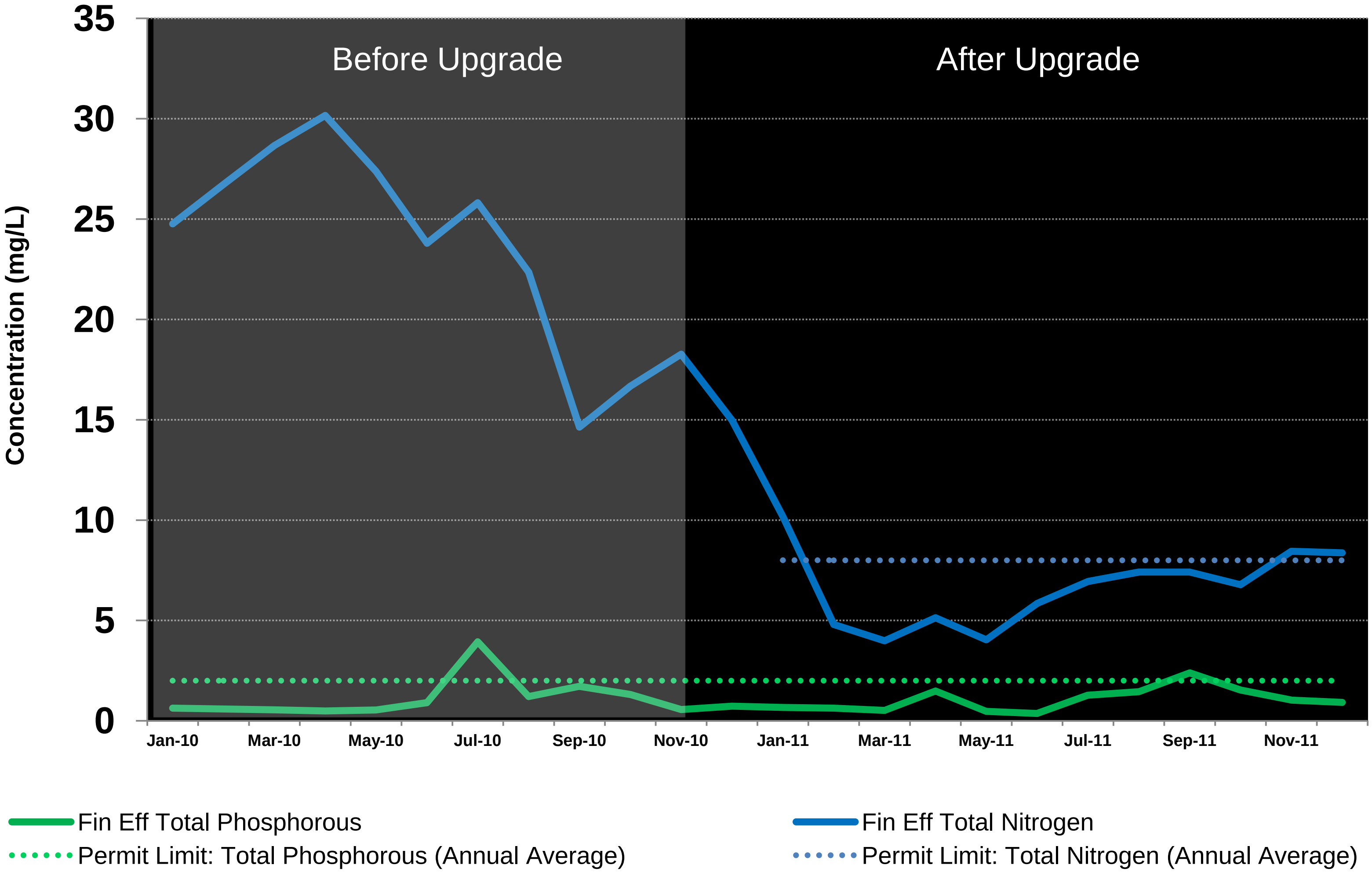
Struvite Recovery Facility Performance

P and N Recovery (mg/L)						
Period	PO4-P			NH3-N		
	Centrate	Ostrate	% Recov	Centrate	Ostrate	% Recov
Design	450	72	84	650	479	26
Dec 2011	440	44	90	787	603	23
YTD	354	44	87	509	385	27
12 Mon Avg	440	44	90	793	609	23

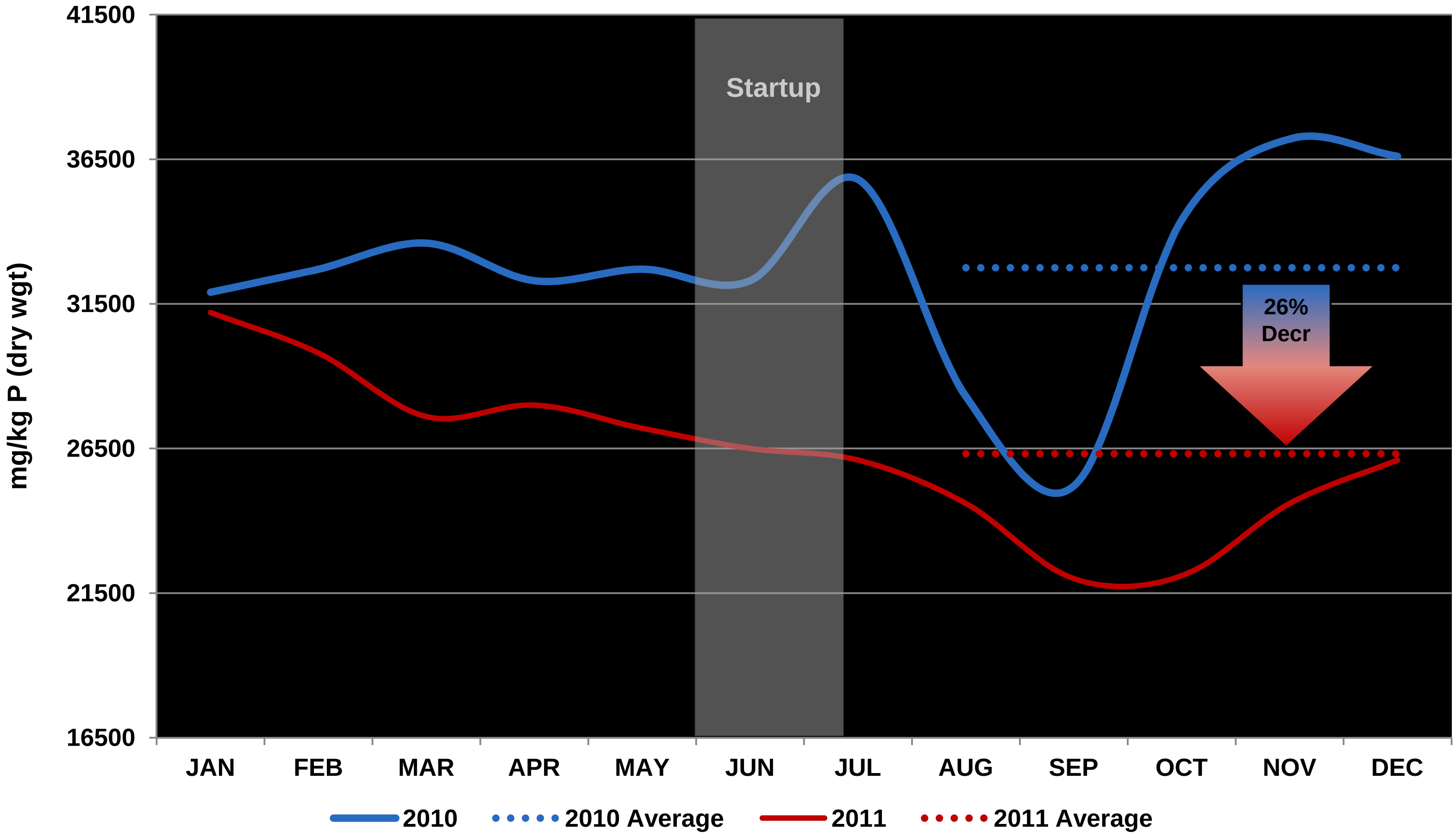
We are currently producing ~1.0 ton/day

HRSD

Nansemond BNR Performance



Phosphorous Reduction in Solids



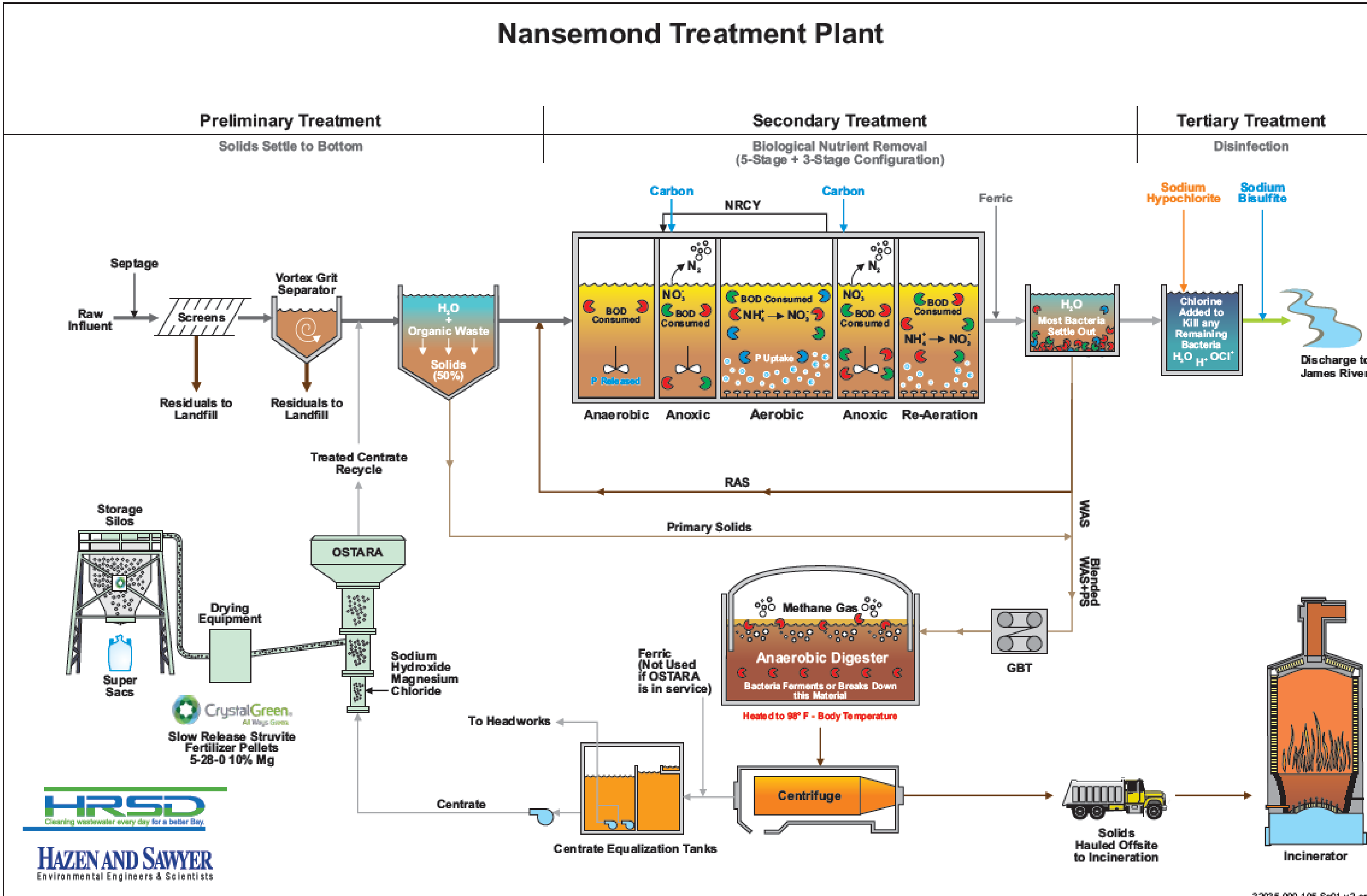
Lesson's Learned

1. Locate facility as close as possible to dewatering facilities
2. Avoid pipe "traps" and standard elbows
3. Provide flush connections on all pipe runs
4. Feed CO_2 to centrate piping to control struvite
5. Construction sequencing of plant upgrade did impact performance
6. BNR and Digester operations are related to struvite recovery

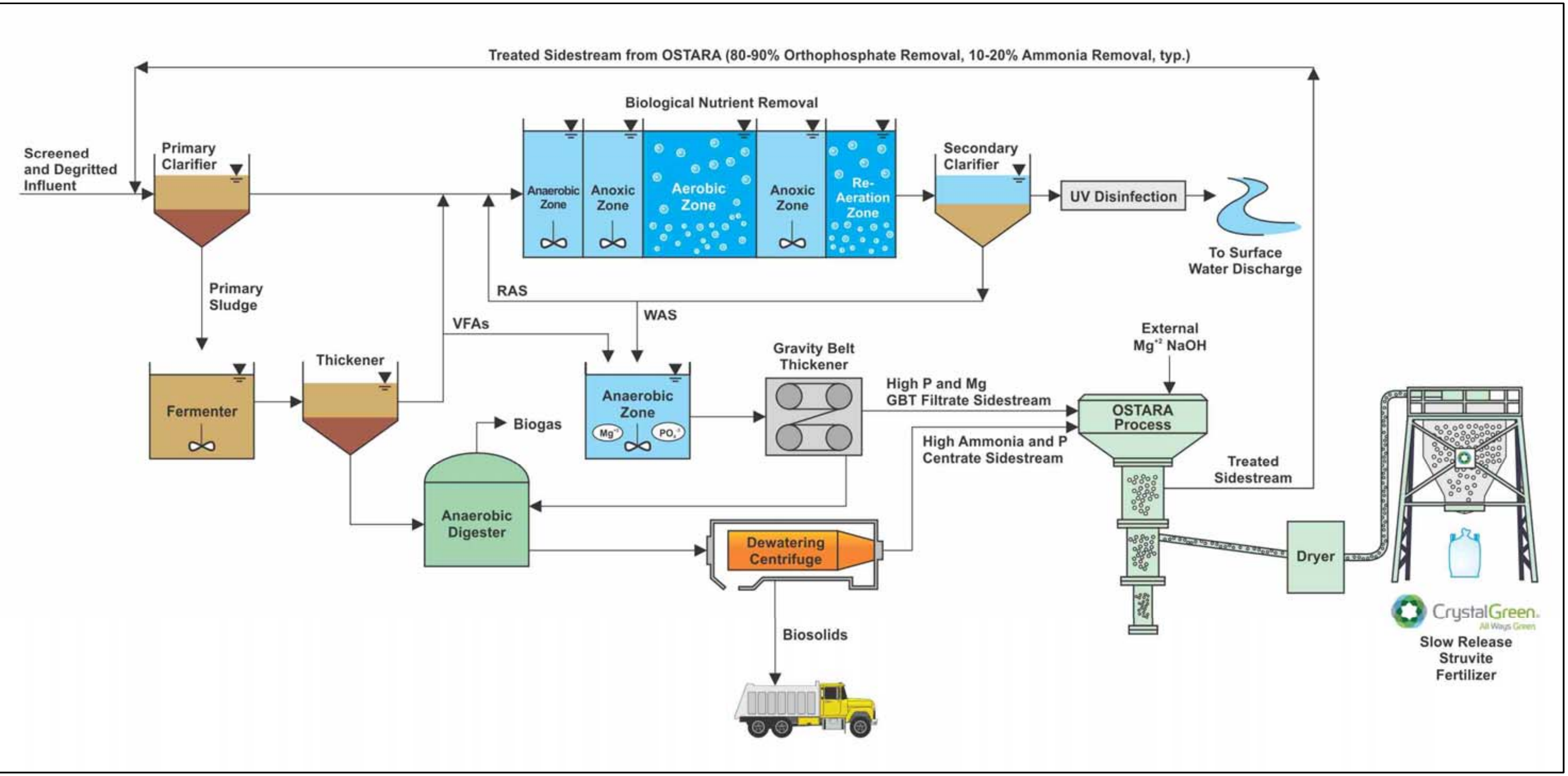
Next Steps

- Install a permanent CO_2 feed system to inhibit struvite formation
- Evaluate WASSTRIP® process

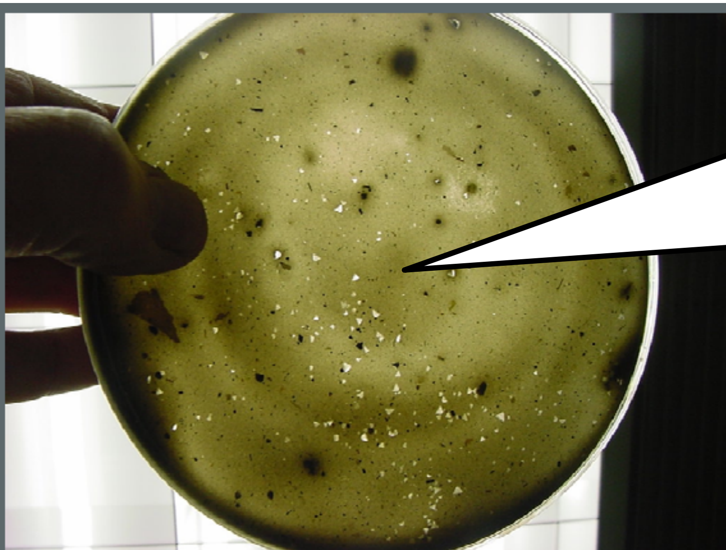
Process Flow Diagram



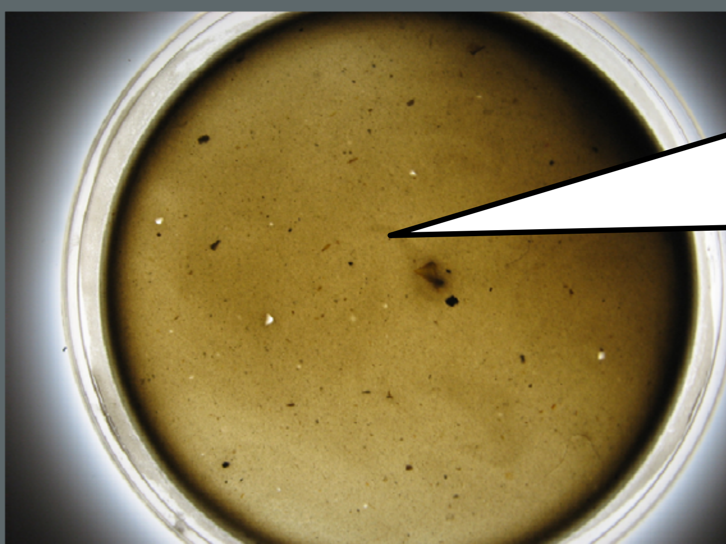
WASSTRIP Evaluation for Nansemond



WASSTRIP Impact – CWS Durham Plant



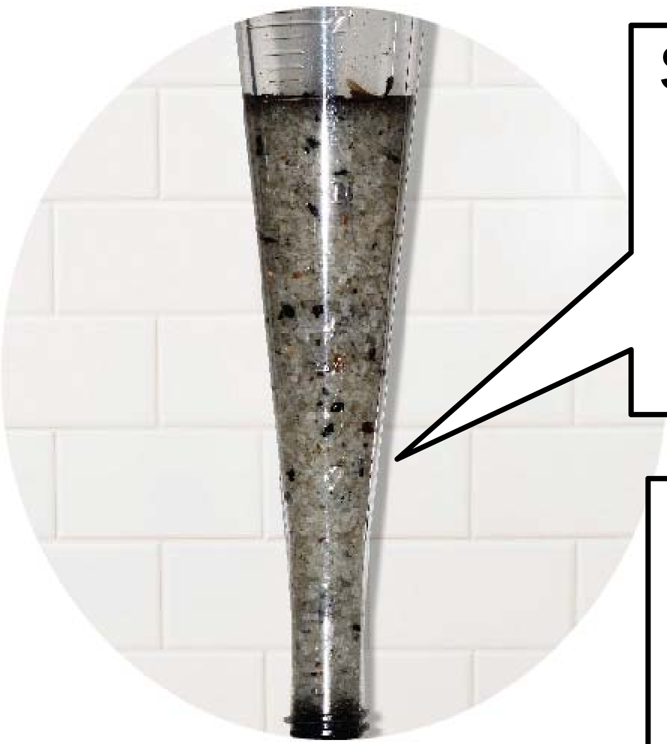
Sludge Sample Prior to WASSTRIP Implementation shows significant struvite crystals



~60 days after WASSTRIP Implementation, drastic reduction in struvite crystals

WASSTRIP Impact

Imhoff cone with washed sludge shows drastic reduction in digester struvite formation



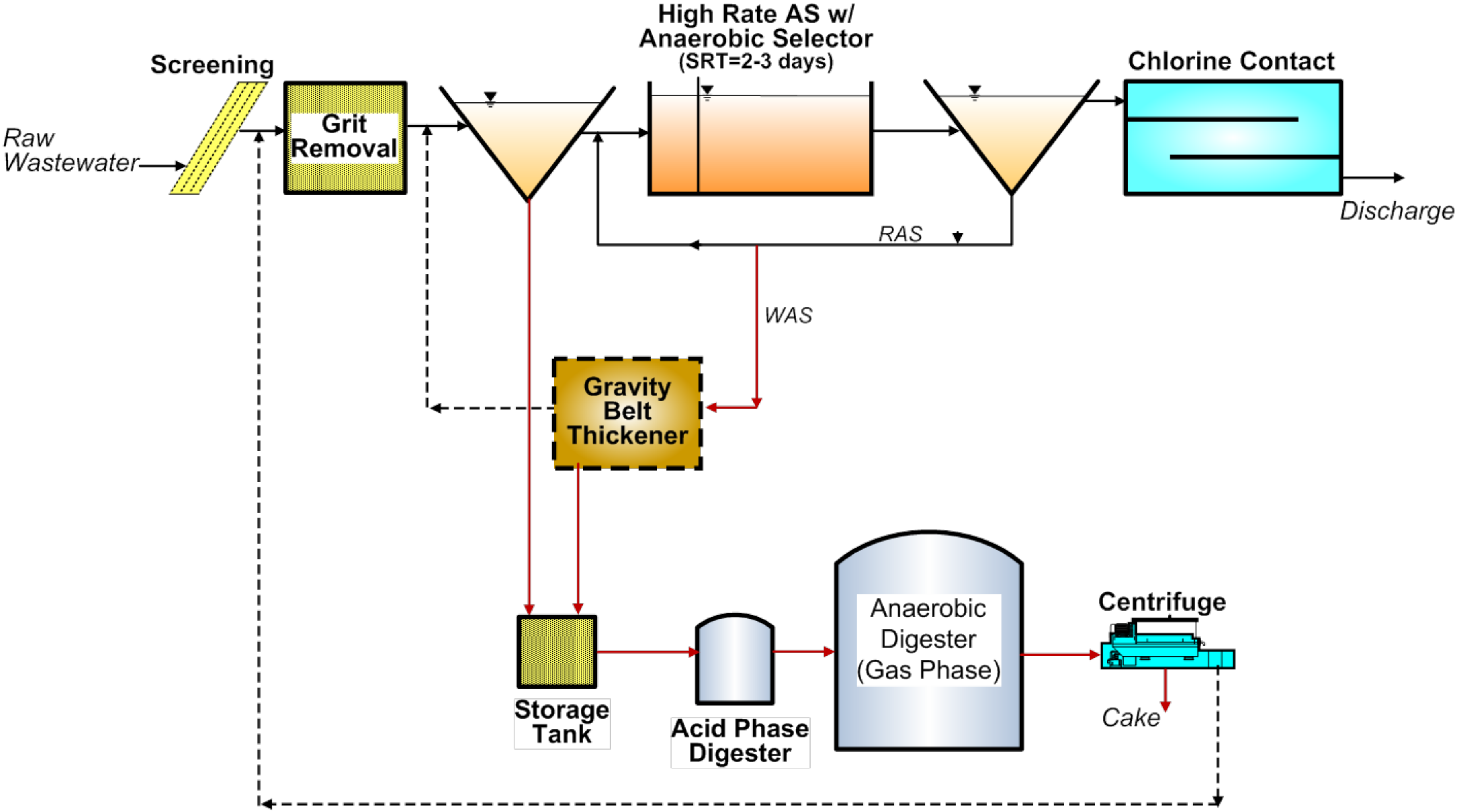
Sludge Sample **prior** to WASSTRIP Implementation with **15 ml/L** of struvite crystals

~60 days **after** WASSTRIP Implementation with **1 ml/L** of struvite crystals

HRSD

HRSD Atlantic Treatment Plant

Current Atlantic Plant



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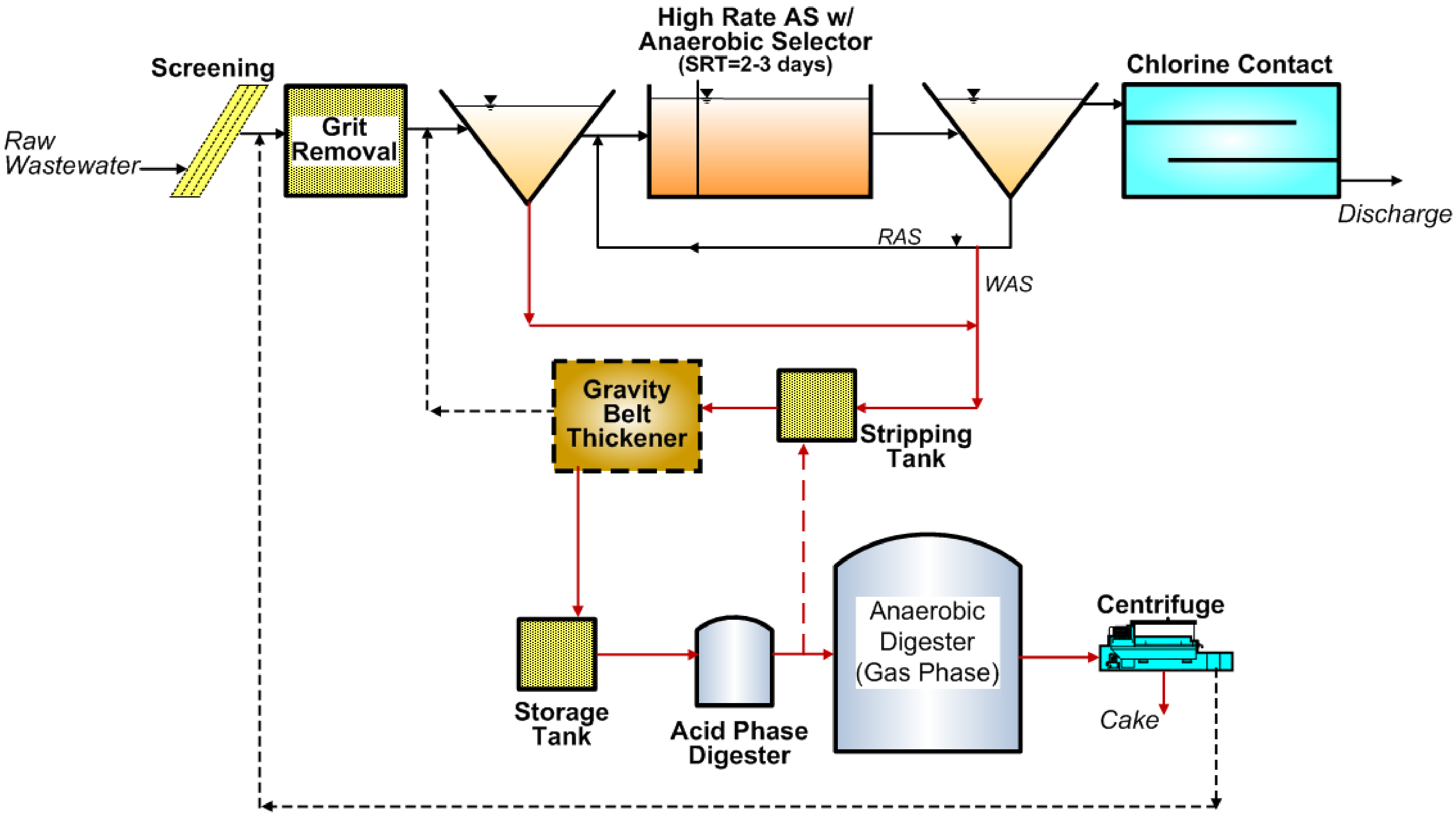
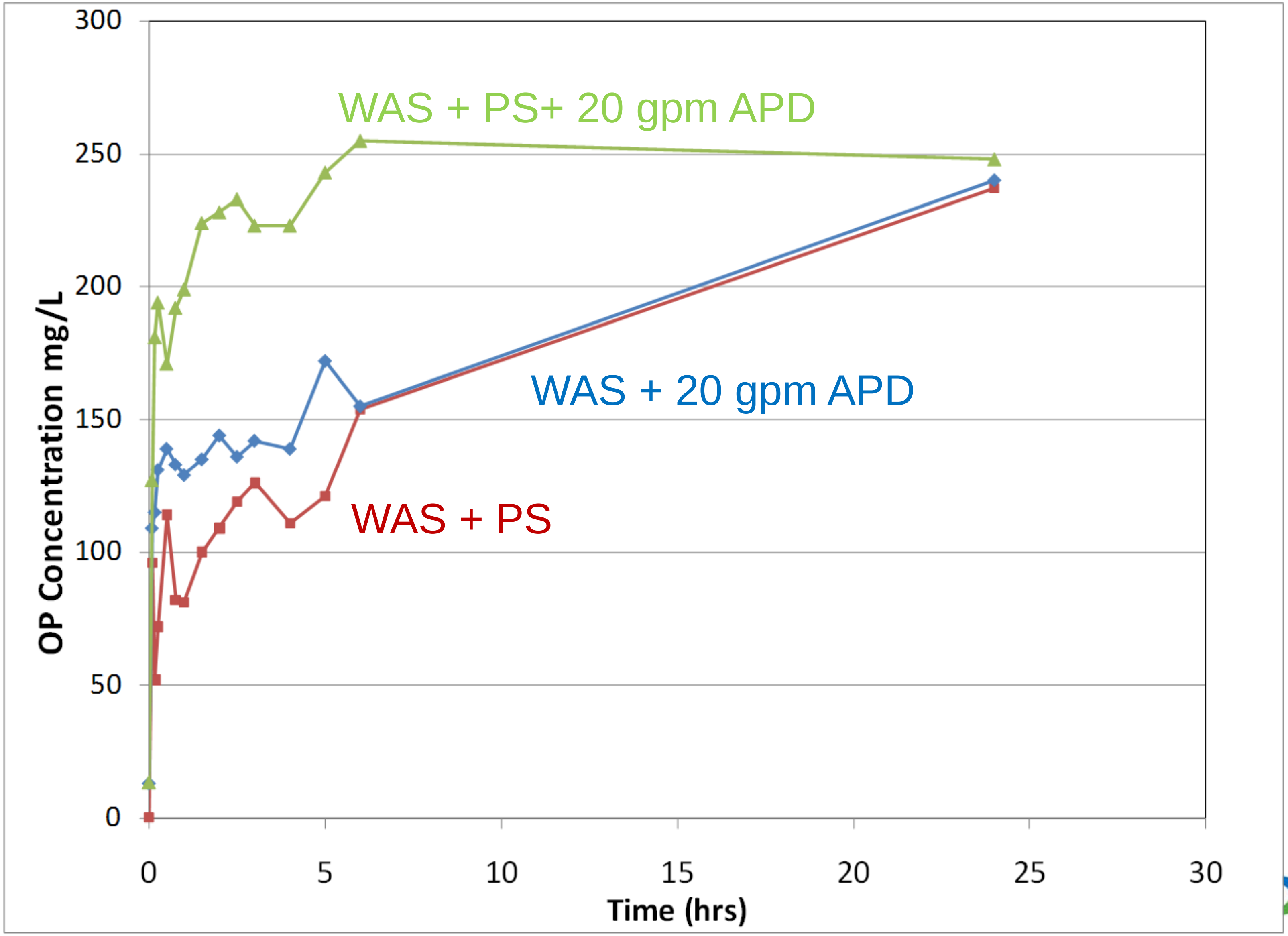
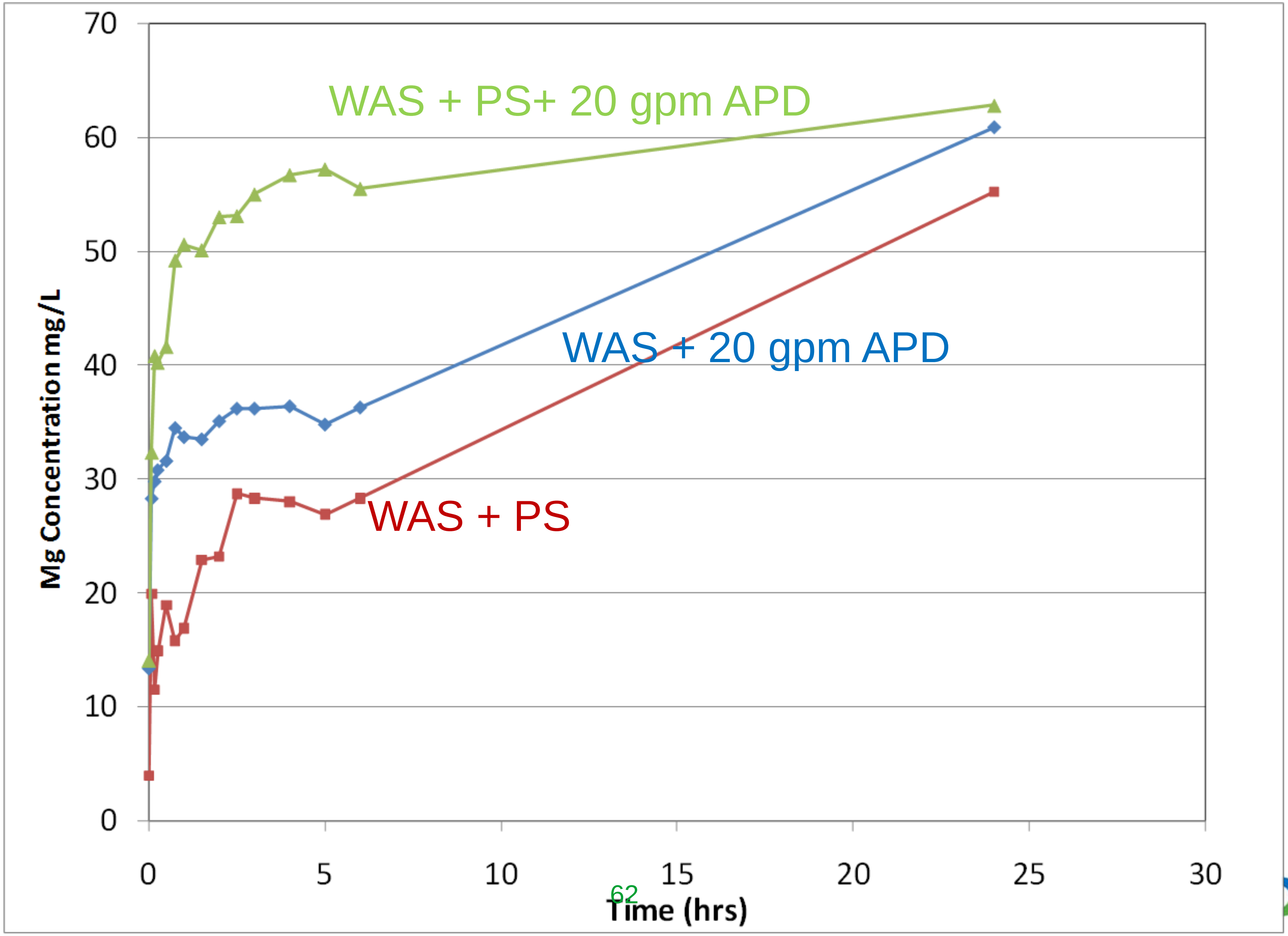
Atlantic with WASSTRIP – No Ostara



OP - Batch Release Rate Measurements



Mg - Batch Release Rate Measurements



Conclusions

- Ostara process makes a clean and marketable product from centrate with minimal post processing
- Plant staff are enthusiastic
- WASSTRIP could eliminate struvite problems and struvite loss in dewatered biosolids

Questions?

Charles B. Bott

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- 757-460-4228