North America's First Full Scale Nutrient Recovery Project – Justification and Benefits

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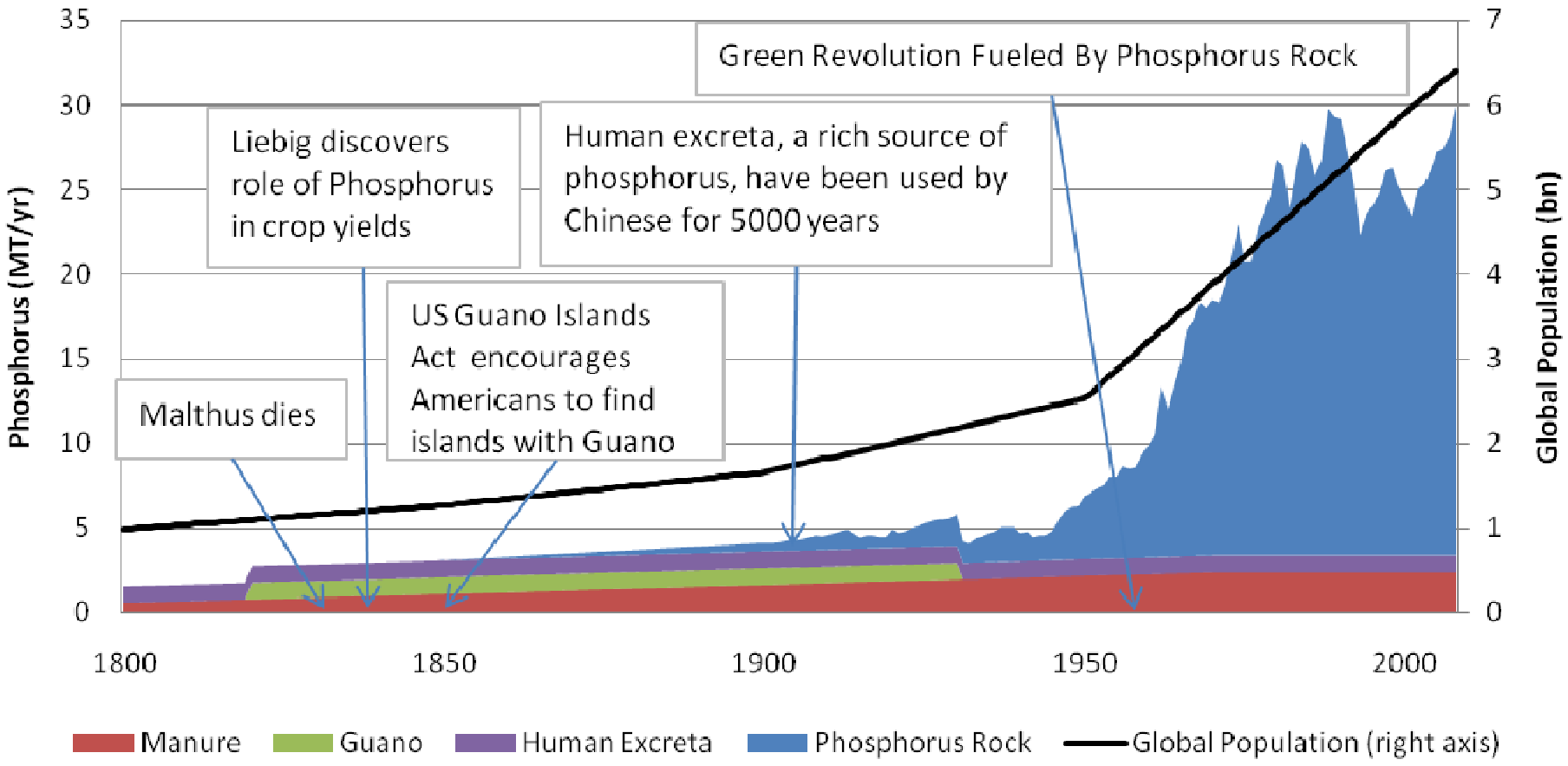
Agenda

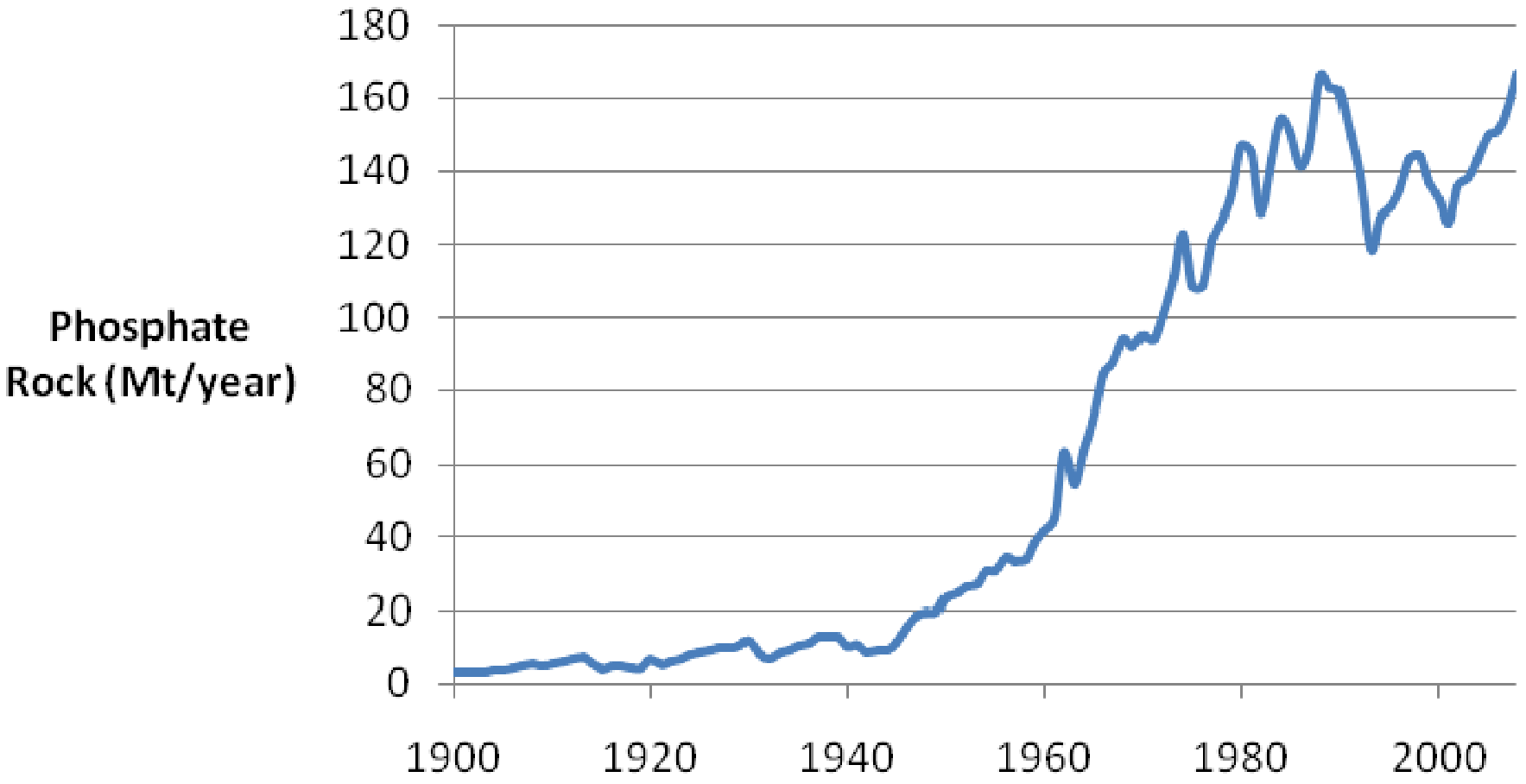
- Global Perspective on Phosphorus
  - Global Phosphorus Supply Challenges
  - Nutrient Recovery From a Global Perspective
- Converting Struvite to Crystal Green® Fertilizer
- Who is Ostara? Where do we fit?
- Clean Water Services' Durham AWWTP Project
  - Why Durham facility?
  - Decision/evaluation points
  - Contract
  - Project Schedule
  - Results

History of Phosphorus-Based Fertilizers



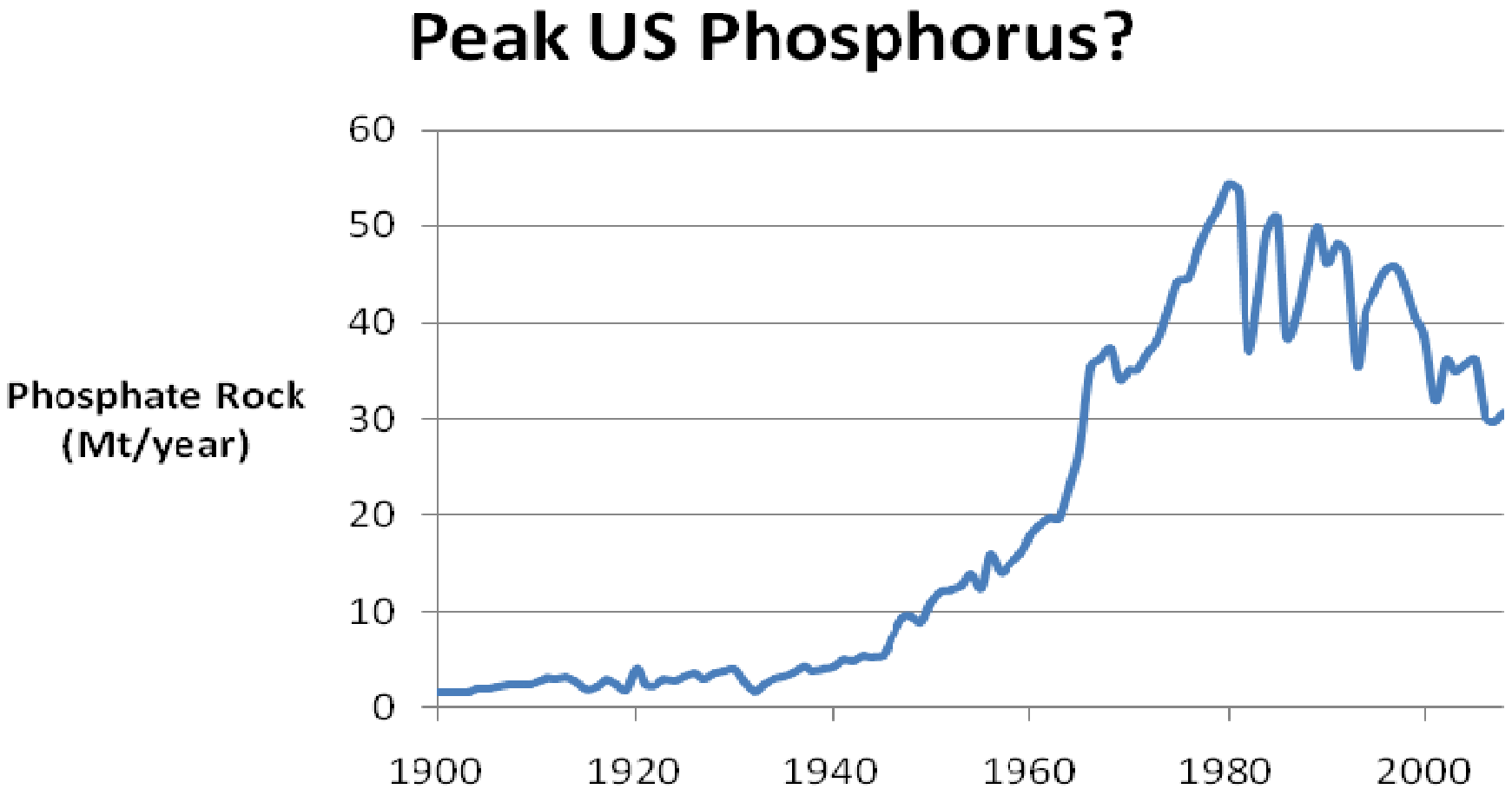
Source: "The Story of Phosphorus: Global Security and Food For Thought", Cordell, et.al. *Global Environmental Change*, Volume 19, Issue 2, May 2009

Historical Global Phosphorus Rock Production



Source: USGS Data on phosphate production October 9, 2007

Historical US Phosphorus Rock Production



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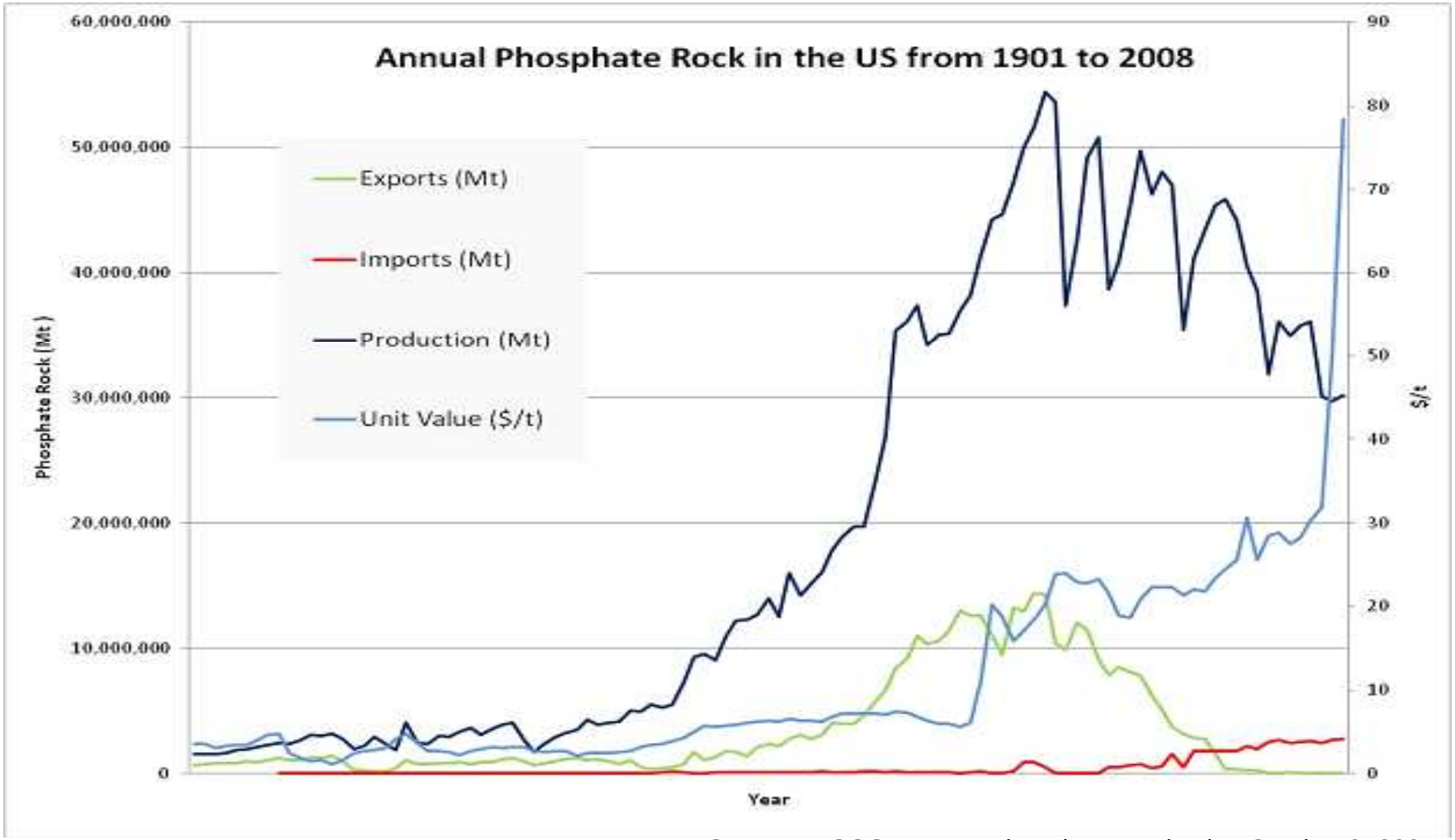
What is the US Future for Phosphorus?



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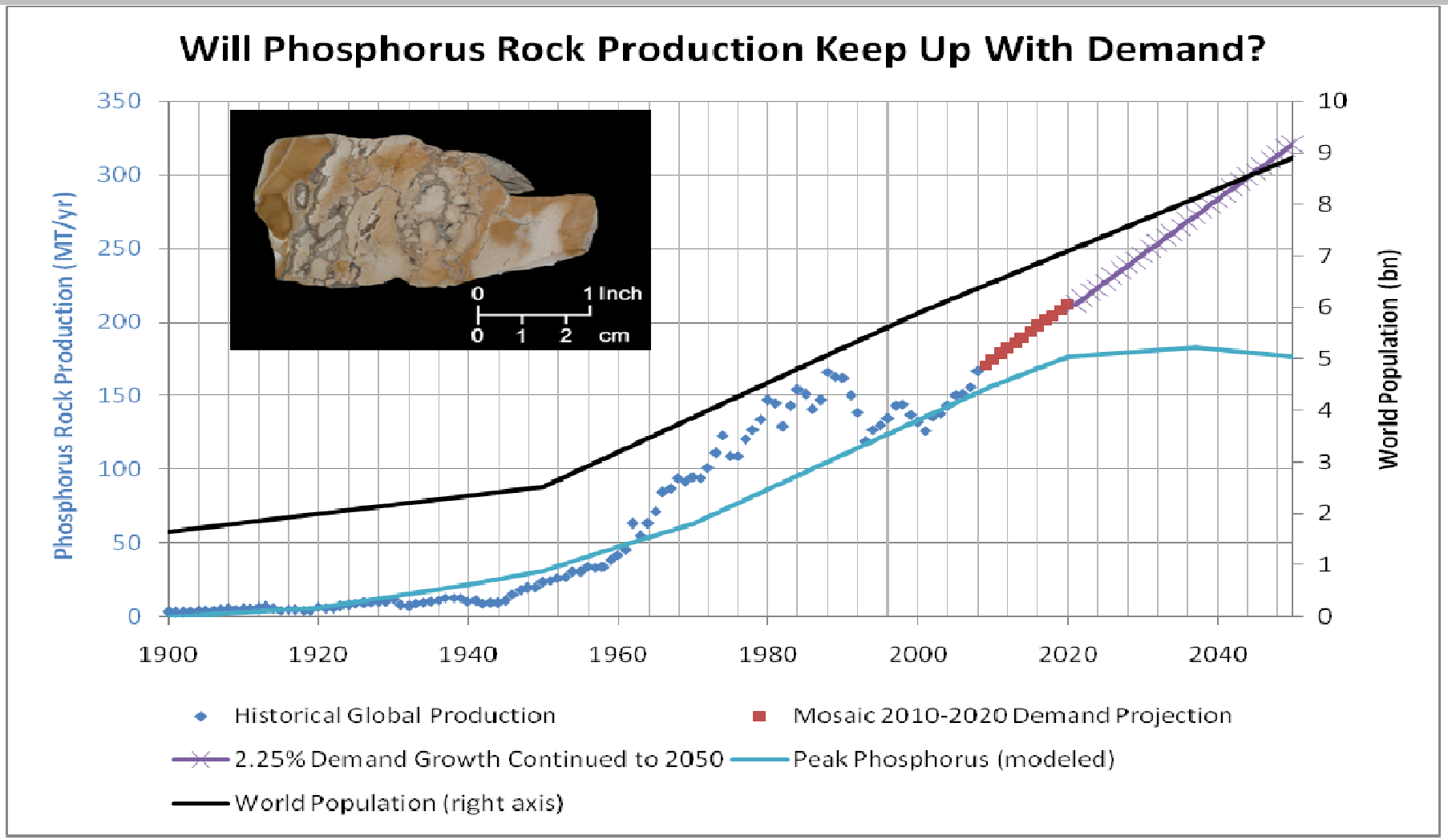
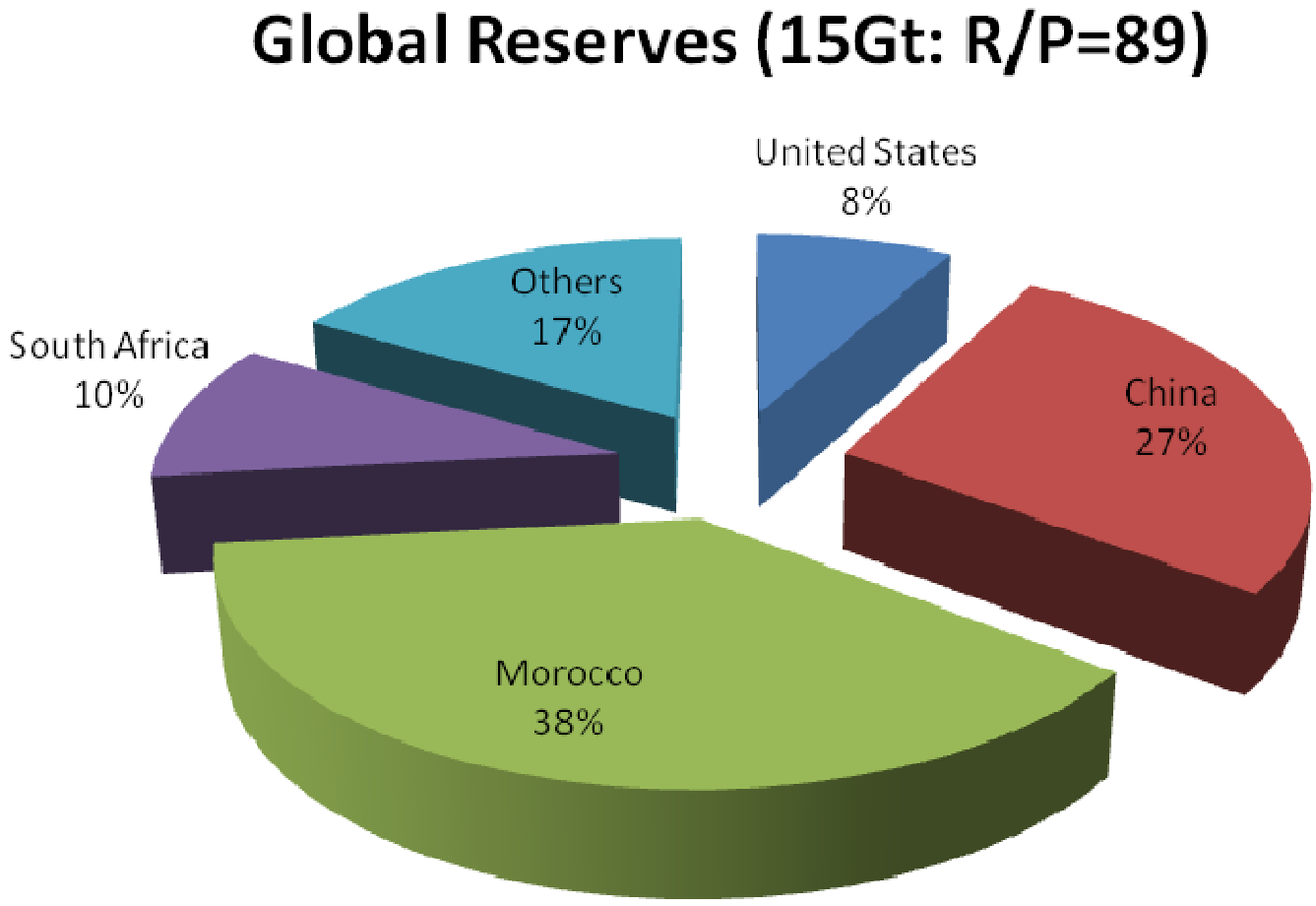


Source: "Taking Stock of Phosphorus…" *www.seekingalpha.com*, June 14, 2010 by Eamon Keane

Global Distribution of Reserves = Concern?



Source: USGS Data on phosphate production October 9, 2007

Global Phosphorus Supply Picture

- Most (>75%) of world phosphorus supply comes from Western Africa, US, and China
  - China has banned export
  - Western Africa is potentially unstable closer to Europe (who has no resources) and
  - US has become importer for first time in history
- Most studies indicate world known and economically accessible phosphate rock reserves **could be depleted in 40-50 years** (Williams and Griffin, 1990) (Herring and Fantel, 1993)
- USGS Reserves (2008) □ 168 million tons used/year **= 105 year supply in US (at current rate of use)**

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Phosphorus is an "Emerging Issue"

From the June 2009 Scientific American Magazine | 28 comments

Phosphorus Famine: The Threat to Our Food Supply

This underappreciated resource--a key component of fertilizers--is still decades from running out. But we must act now to conserve it, or future agriculture could collapse

By David A. Vaccari

From The Times

June 23, 2008

Scientists warn of lack of vital phosphorus as biofuels raise demand

Leo Lewis, Asia Business Correspondent

NEWS SCAN

Scientific American – November 2009

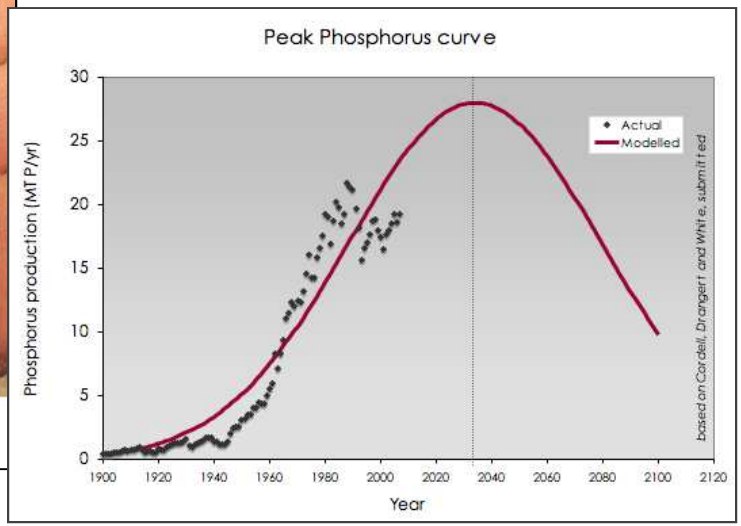
Technology

Sewage's Cash Crop

How flushing the toilet can lead to phosphorus for fertilizers BY KATHERINE TWEED

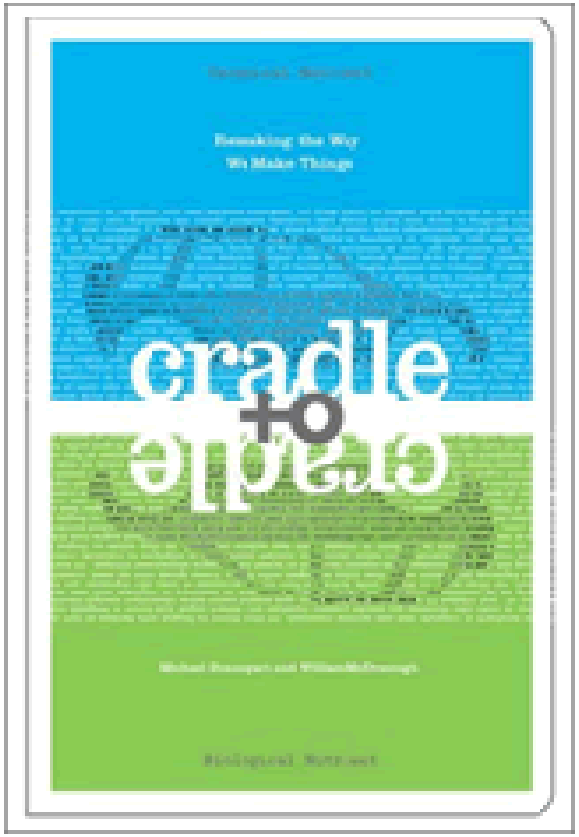
TUCKED AWAY IN OREGON'S WILLAMETTE VALLEY, THREE MASsive metal cones could help address the world's dwindling supply of phosphorus, the crucial ingredient of fertilizers that has made modern agriculture possible. The cones make consistently high-quality, slow-release fertilizer pellets from phosphorus recovered at the Durham Advance Wastewater Treatment Facility, less than 10 miles from downtown Portland. By generating about one ton

WASTEWATER WONDER: Ostara's Crystal Green, a slow-release fertilizer, incorporates phosphorus retrieved from sewage streams.



“Cradle to Cradle” Thinking

*“If we are going to design systems of effluents that go back into the environment, then perhaps we ought to move back upstream and think of all the things that are designed to go into such systems as part of nutrient flows. For example, the mineral phosphate is used as a fertilizer for crops around the world. Typical fertilizer uses phosphate mined from rock, however, and extracting it is extremely destructive to the environment. But phosphate also occurs naturally in sewage sludge and other organic wastes…**What if we could design a system that safely captured the phosphate already in circulation, rather than discarding it as sludge?**”*



- William McDonough & Michael Braungart © 2002

Why Recover Nutrients?

Benefits for the Environment

- Conserve phosphate reserves
- Recycle materials locally
- Reduce eutrophication potential
- Reduce greenhouse gas emissions (potential >8,500 tons CO_2e for a 20 MGD facility)

Environmental Sustainability

What is Struvite?

$$Mg^{2+} + NH_4^{+} + PO_4^{3-} \rightarrow MgNH_4PO_4.6H_2O$$

- Naturally occurring
- Seen in nearly all municipal treatment plants
- Increases O & M costs
- Impacts plant reliability

Sewer pipes from Ephesus (founded 300 B.C.)

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Creating Value from Waste

From **Problems**

To **Solutions**

Crystal Green®

- Certified fertilizer - 5% N, 28% P, 0% K, + 10% Mg
- Premium quality product
  - Slow release rate, high-purity
- Environmentally-Friendly
- Independently tested
- Established sales and marketing

CrystalGreen®
All Ways Green.

Who is Ostara?

- Incorporated May 2005
- Unique business model
  - PEARL™ process systems/service
  - Crystal Green® fertilizer
- Proprietary, proven technology
  - Two full-scale plants operational
    - Clean Water Services (Durham AWWTP)
    - Edmonton Full-scale Demonstration
  - Two full-scale plants under construction
    - York (PA) 2 reactors, fee for service
    - Hampton Roads Sanitation District 3 reactors purchased

Ostara Business Model

- Capital Purchase
  - Traditional Equipment Sale & Installation
  - Typical Payback of 3 – 10 years
- "Treatment Fee" for Service / Performance Contract
  - No capital investment required
  - Performance-based contract
  - Immediate operational savings
- In all cases, Ostara provides guaranteed contract for fertilizer purchase from plant (revenue sharing)

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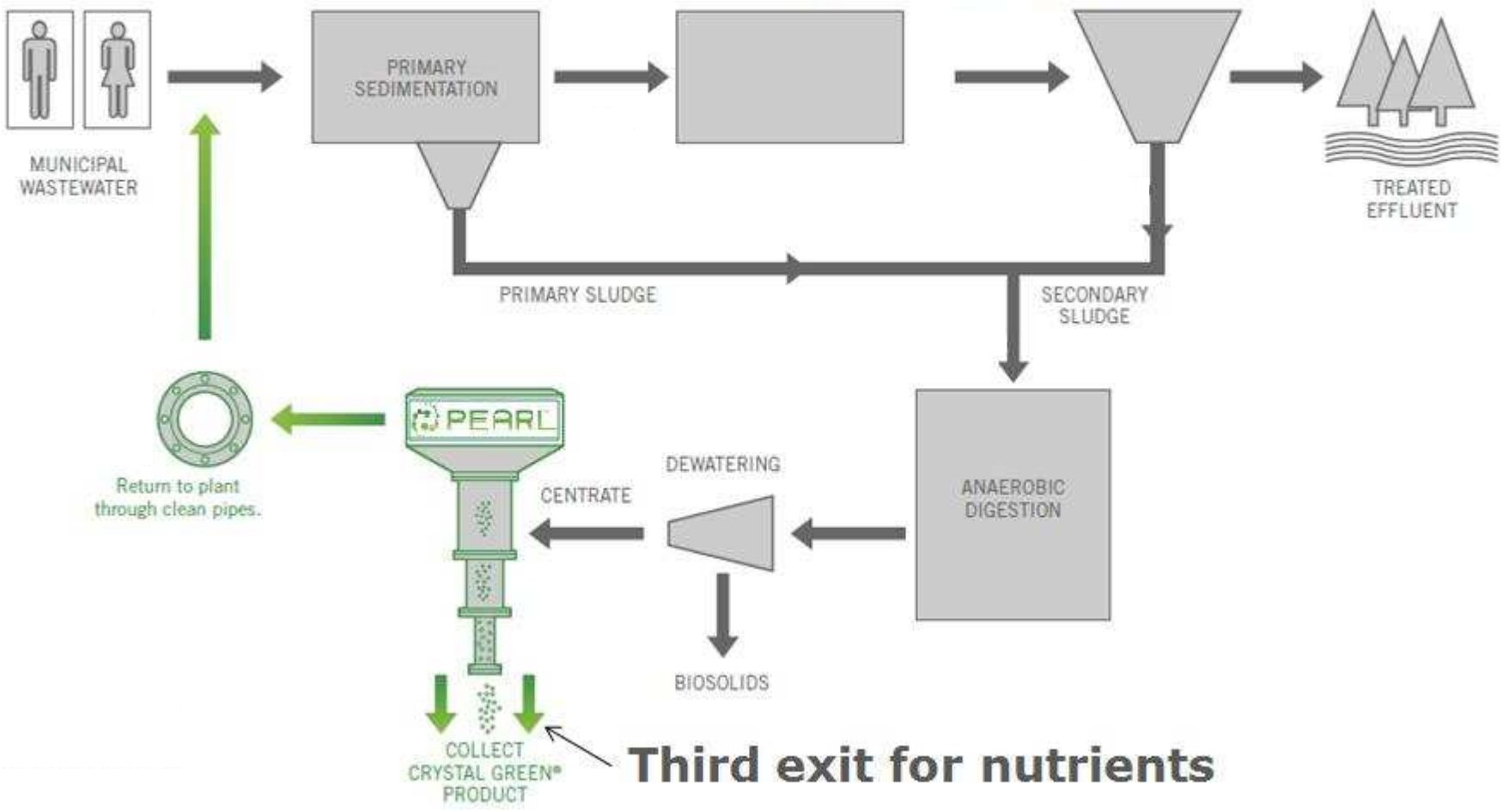
PEARL™ Process in a Wastewater Plant



Process Benefits

- Phosphorus removal >85%
  - Reduced VFA demand (for bio-P)
  - Improved process stability
  - Reduced struvite formation and/or cost of prevention (chemical use and/or labor)
- Nitrogen removal 20 - 40%
  - Reduced aeration and alkalinity for nitrification
  - Reduced carbon demand for denitrification

Durham AWWTP Facility (Tigard, OR)

Why Durham?

- Durham received first US phosphorus TMDL in 1988
- 0.07 mg/l T-PO4 monthly median permit 1994
- Relaxed to 0.10 mg/l in 2004
- 20 MGD dry weather flow
- Struvite problems from EBPR solved (with $)
- Centrate return nutrient load still a problem
- Sidestream treatment options?

Research Phase

- Literature review on struvite recovery
- Second Ostara pilot in US
- Analyzed pilot data
- Visited full size reactor in Edmonton
- Rough cost/benefit analysis
- Refined firm cost to reach < 7 year payback

Decision Points

+ Chemistry works
+ Pilot works
+ Full scale works better than pilot
+ US $1,000,000,000 container nursery industry nearby (fertilizer market)
- Struvite problem at plant resolved already
- Low metal salt dose

Decision Points

+ Innovative public/private partnering

+ Growing revenue stream

+ Larger influent phosphorus reduction than phosphate detergent ban

+ Sustainably produced fertilizer

+ Potential carbon credits (~8,500 tons/year CO_2e reduction)

- New technology risk

Contract Evaluation

- No risk, turnkey, “fee for removal” option not chosen, due to seasonal nutrient removal
- Outright purchase ~$2.5 M, revenue from struvite
- Saved $1.1 million by using decommissioned pump station building
- Incentives to meet 7 year payback and be the first full-scale system

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Building With 3 Reactors Installed

Ready to Use After Drying, No Post Processing

Prill Size Control to Meet Fertilizer Market Demand

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Bagged Onsite for Transport

Project Schedule

- October 2008 - Contract Signed
- April 16, 2009 - Reactor Seeding
- April 27, 2009 - 24 hour operation of 3 reactors
- May 11, 2009 - first harvest!
  - Initial poor centrate quality did not affect product quality
- As of December 31:
  - 160 tons of Crystal Green fertilizer produced
  - 40,000 #P removed from recycle stream
  - 18,000 #N removed from recycle stream

Mike Mengelkoch, Operations Control Analyst:
"It's like having another aeration train on-line removing phosphorus"

Savings Accrued

- 11.8% reduction in dry tons biosolids hauled
  - More than reduction in chemical sludge alone
- 23% reduction in alum use due to lower P load and ongoing improvements in EBPR stability
- Synergistic improvements: Ostara reduces P = better Bio-P = less chemical = more P to Ostara = lower chemical cost + increased revenue
- Opposite is true: Bio-P upset = more chemical $ = less fertilizer revenue

Public/Private Partnership

- Both parties able to make decisions rapidly
- Risk sharing with common goal of optimizing production - benefits both parties
- CWS under no obligation to produce product
- Ostara remotely controls chemical feed, flow rates and harvest set points
- CWS does material handling and maintenance

Lessons Learned

- Pilot new technology
- Visit a full scale system if one exists
- Share risk and reward on the new technology
- Board involvement and support very important
- Be ready for startup issues and continuous improvement
- Cultivate champions in Operations and Maintenance

Further Developments

- "WASSTRIP" Enhancement (CWS Patent)
  - Protect digesters and dewatering equipment from struvite issues
  - Increase facility fertilizer yield
  - Further reduce mass loading of P on process
- Potential for Imported Industrial Waste
  - Increase fertilizer yield / revenue
  - Additional revenue from industrial dischargers
  - Increased ammonia removal potential
- Clean Water Services evaluating for the Rock Creek plant (5+ reactors)

Conclusion

- Nutrient recovery is no longer a concept, it is **reality**
- We are commercially generating a sustainably-produced, high-value, slow-release fertilizer
- Significant lowering (>30%) of process nutrient loading from recycle streams via sidestream treatment
- Finishes the goal of EBPR to remove nutrients
- Provides positive feedback to EBPR by reducing recycle load

Thank You

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