STRUVITE HARVESTED AS A USEFUL BYPRODUCT

Ron Gearhart – Process Coordinator

LIVABILITY

Environment

Economy

Community

Making Boise the Most Livable City in the Country

OUR CITIZENS VALUE IMPROVED OUTCOMES

76% of Boiseans voted “YES” to
Foothills Open Space and Clean Water Levy

Wastewater survey results:
- Invest to recover water, energy, reduce carbon - ~75%
- Willing to pay for better outcomes - ~70%

OPERATIONAL OPPORTUNITIES AND CHALLENGES OF STRUVITE RECOVERY

WEST BOISE WRF

LASTING • INNOVATIVE • VIBRANT

STRUVITE

- Forms in water when ammonium ion (NH_4^+), magnesium ion (Mg^{+2}), and phosphate (PO_4^{-3}) are present
- Specific pH
- Favorable water chemistry (lack of calcium interference, etc);
- Forms $NH_4 MgPO_4 \cdot 6H_2O$ as either dispersed or as a crystal

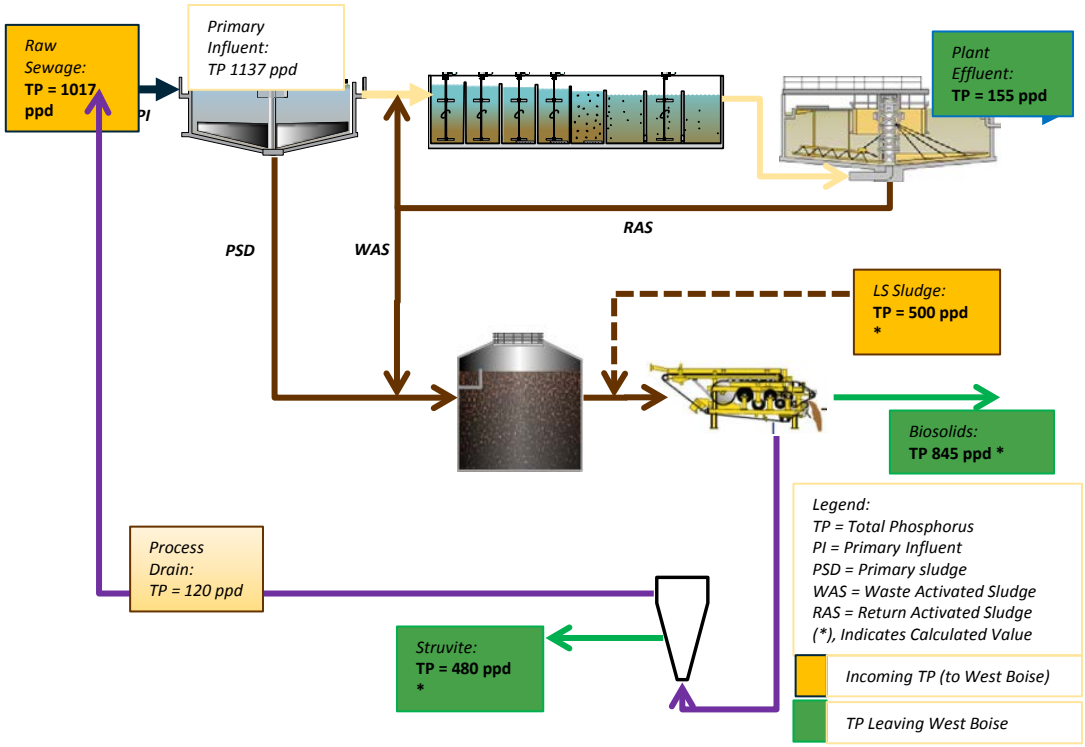
UNINTENTIONAL STRUVITE

Unintentional formation follows Murphy's Law … *as a general rule of thumb*

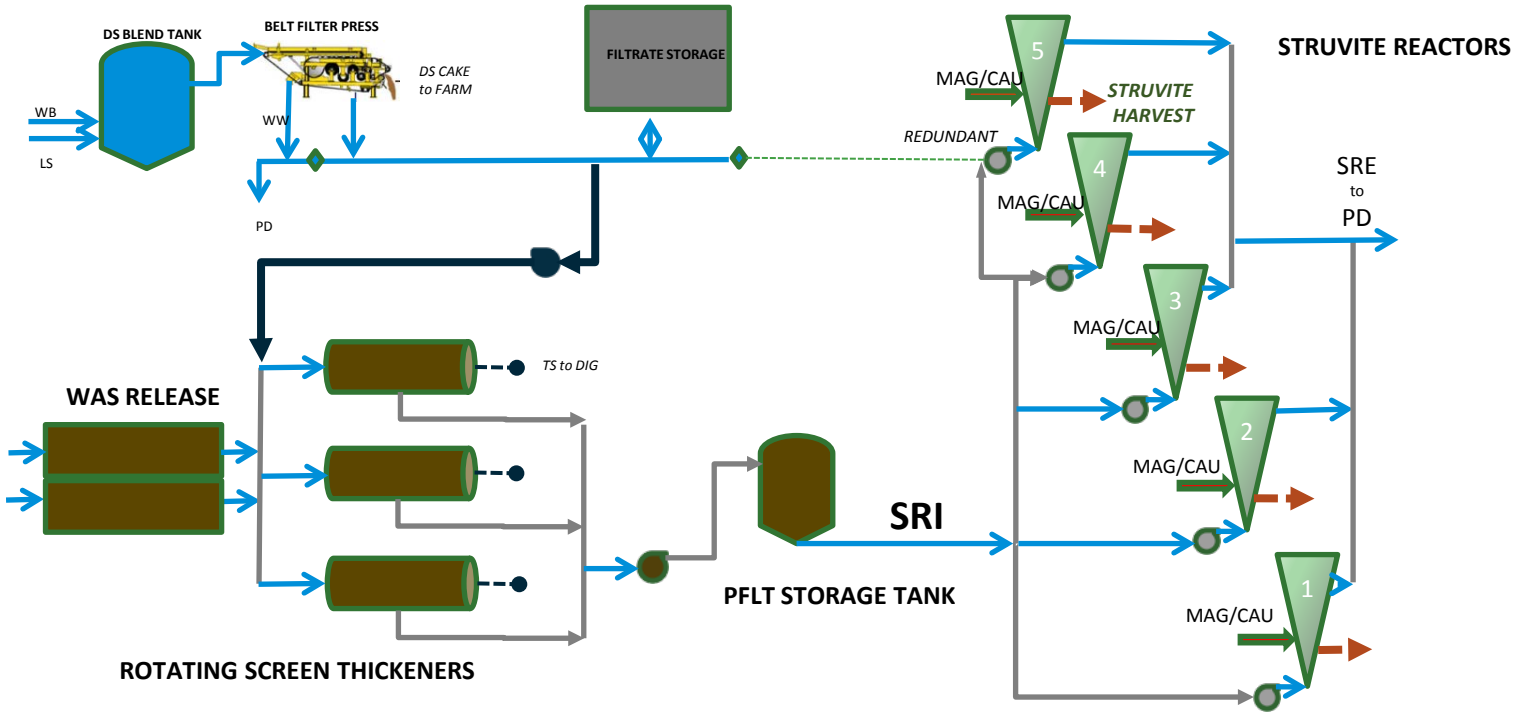
Lower Industry Nutrient Limits Result in operational challenges

PHARMER ENGINEERING

WEST BOISE WRF – PHOSPHORUS MASS BALANCE



COMBINED STRUVITE REACTOR INFLUENT – 2016



Common Struvite Reactor Chemistry

LOWER EFFLUENT NUTRIENT LIMITS RESULT IN HIGHER SIDE STREAM CONCENTRATIONS

- Anaerobic Digester Filtrate Ammonia concentrations approach 1000 mg/L
- Anaerobic Digester Filtrate Dissolved Phosphorous concentrations increased from **80 mg/L to 400 mg/L after EBNR** was implemented at West Boise WRF
- Commissioning of the WAS P release process allowed for 50% release of acquired Phosphorous, resulting in Anaerobic Filtrate of 280 mg/L
- WAS P Release tank Phosphorus concentrations range from 160 mg/L to 200 mg/L
- Side stream treatment critical to permit compliance strategy

REACTOR IMPACTS AND SUCCESS

Parameter	Reactor Influent	Reactor Effluent	Removal
Phosphorous	600 Pounds Per Day	120 Pounds Per Day	80% : 480 Pounds
Ammonia	1350 Pounds Per Day	1080 Pounds Per Day	20% : 270 Pounds

- Side Stream Treatment
  - Reduced Phosphorous impact in Primary Effluent From **4 mg/L to 0.80 mg/L.**
  - Reduced Ammonia impact in Primary Effluent From **8.1 mg/L to 6.5 mg/L**
- Reduction of unintentional struvite formation in pipes, anaerobic digesters, dewatering equipment, and storage basins.
- Reduced phosphorus content of biosolids and subsequent impacts to TMSBAS loadings and site longevity
- Recovery of a recyclable product contributing to the City's sustainability goals by recovering this limited phosphorus-based resource

TRADITIONAL CHEMICAL ALTERNATIVE

- Metal Salts have undesirable consequences
  - Inert solids production increase
  - Unfavorable biosolids impacts
    - Increased solids handling
    - Non-bioavailable phosphorus
    - Increased metal content
  - Additional negative impacts
    - Carbon footprint
    - Compounding chemical use
    - Cost
    - U.V. inefficiencies and maintenance
    - Safety
    - Negative impacts to EBNR

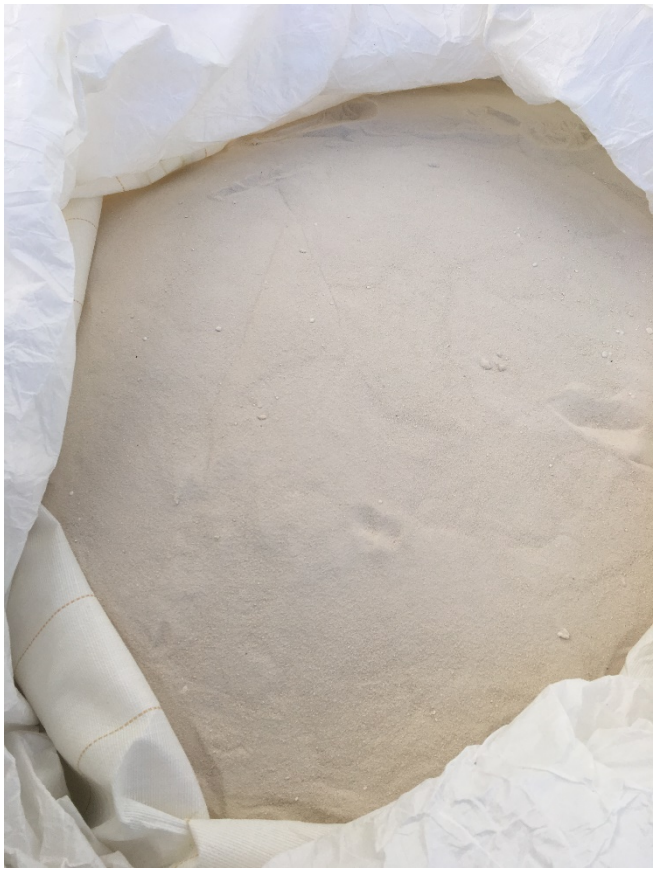
STRUVITE PRODUCTION BENEFITS

- Extracting 480 pounds per day of Phosphorus and subsequent Ammonia (5000 pounds of struvite)
- Reducing nutrient loading in plant recycle stream
- Recovered nutrients have immense fertilizer value
- Limits chemical usage and their negative impacts
- Potential revenue
- Potential cost savings
- Meeting community expectations
- Positive environmental impacts vs Chemicals

STRUVITE PRODUCTION CHALLENGES

- Higher capital cost and footprint
- Additional staff and training
- Complexity, automation
- Product Handling
- Value and Marketing
- Regulatory uncertainty
- **Upsets create chain reaction through entire process**

REGULATORY CONSIDERATIONS



SUMMARY OF NACWA RECOMMENDATIONS

- Struvite does not fit the regulatory definition of sewage sludge
- Clean Water Act promotes beneficial reuse, local autonomy, flexibility and innovation;
  - Exempting struvite from 503 furthers these goals
- Regulating struvite as sewage sludge constitutes an unreasonable burden to producers of struvite

EPA LETTER - 2017

- "…EPA considers products extracted from sewage sludge that are not land applied, land disposed, or incinerated, but instead sold into a commodity market, outside the scope of Part 503".

- "…EPA recognizes that some products…could conceivably be so heavily refined or processed that a significant transformation or change in quality has occurred that it would be unreasonable to describe those products as "derived from sewage sludge".

- "…EPA is willing to consider on a case-by-case basis whether a particular product is 'derived from sewage sludge'".

METALS

Parameter	Average concentration (mg/kg)	Pollutant Concentration Limit from 40 CFR 503.13, Table 3	Maximum concentration (mg/kg)	Ceiling Concentration Limit from 40 CFR 503.13, Table 1
Arsenic	1.33	41	4.32	75
Cadmium	<0.06	39	<0.20	85
Copper	2.0	1500	4.32	4300
Lead	<0.48	300	<1.57	840
Mercury	0.002876	17	0.00961	57
Molybdenum	0.37	--	1.18	75
Nickel	0.30	420	0.65	420
Selenium	<0.82	100	<2.56	100
Zinc	5.04	2800	10.2	7500

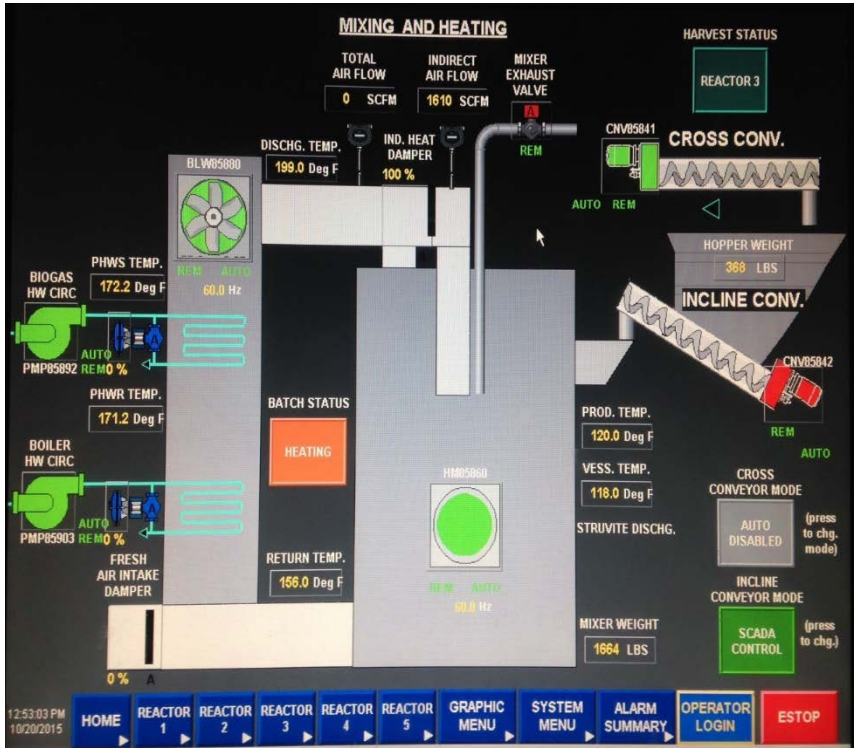
Struvite is a mineral with high purity - metals concentrations are consistently below 503 thresholds

VECTOR ATTRACTION AND PATHOGEN REDUCTION

- No unstabilized primary solids; no organic material; no concern for vector attraction
- Fecal coliform concentrations well below Class A threshold without a pathogen reduction process
- No enteric viruses or viable Helminth Ova detected in raw struvite with no regrowth after up to 6 months

CLASS A HEAT TREATMENT PROCESS

- **Class A**
  - Not necessary, safe, Not a Bio-solid
  - Treatment technology is destructive
    - Material, LIV, revenue, …..
  - Bottleneck to marketing and reuse
  - High energy
    - 26% of West Boise WRF Natural gas consumption
  - Significant O&M cost
  - Storage and documentation of treated material
  - Deterrent to wider industry use
  - Requires manual batching and material handling
  - High failure rate (10-15%)
    - Seasonal
    - Mechanical
    - Product consistency



STRUVITE SUMMARY

- Critical to meeting effluent phosphorus limits
- Recovering nearly 1/3rd of our system phosphorus loading as Struvite
- 5 years of R&D, extensive data collection, process optimization, coordination with EPA HQ
  - First large scale product release in 2017
- P-release tank limits dewatering polymer consumption
- Incidental struvite in digesters reduced (less P and MG)
- Safe and Sustainable resource
- Alternatives – Chemicals……? Additional farm/landfill loads (organic/inorganic). Not the 'Right Way'
- Class A struvite complicated and messy, unnecessary, and a deterrent to others in the industry

QUESTIONS

TWENTY MILE SOUTH BIOSOLIDS APPLICATION SITE

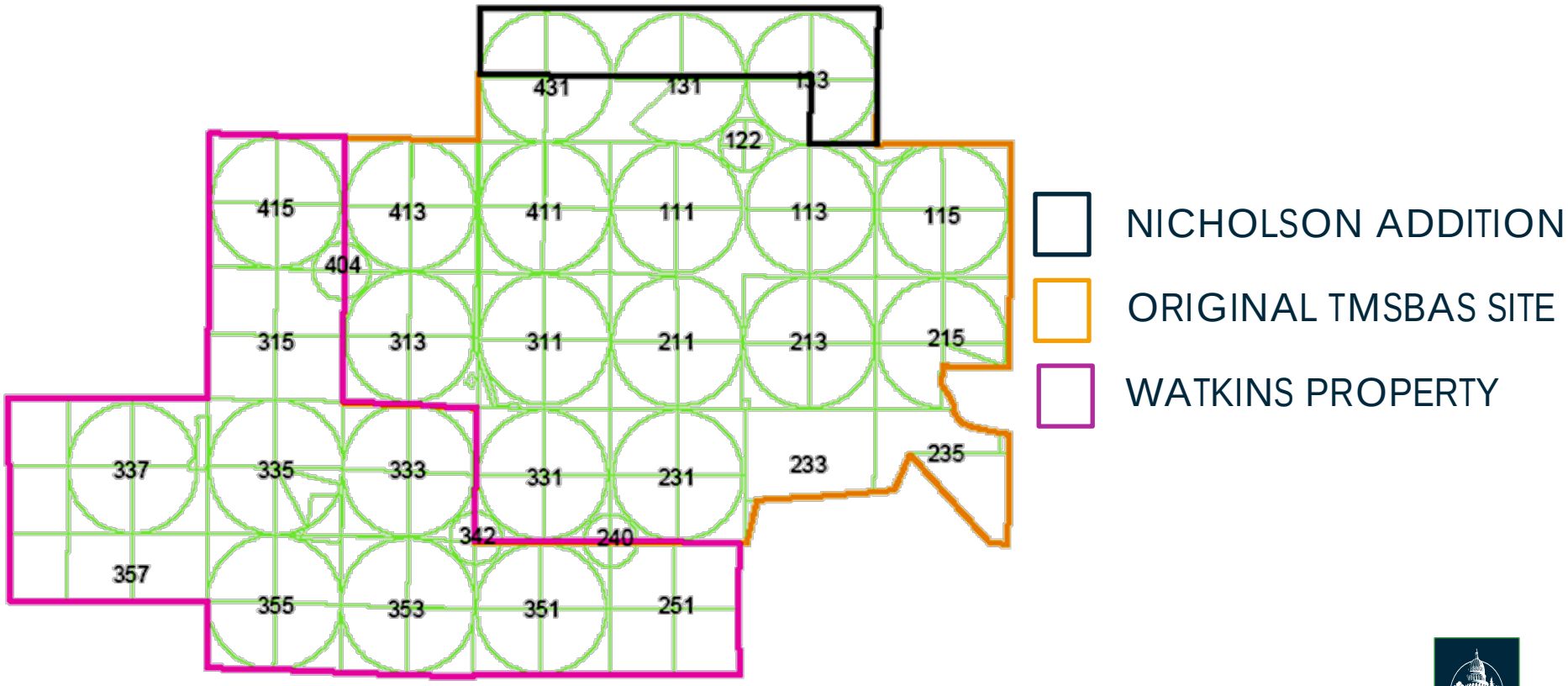
Beneficially Recycling Biosolids to Grow Crops

INTRODUCTION

- The TMSBAS is owned and operated by the City of Boise for the reuse of biosolids generated at the municipality's two WWTFs.
- The original site, consisting of 2,325 acres, was purchased in 1994 and has always been permitted by the EPA for biosolids application.
- EPA Region X is the regulating authority (IDEQ seeking primacy).
- Biosolids reuse on the 1,620 acre Watkins land was not permitted due to language in Boise's NPDES permits (1999, 2001 and 2003 versions.)
- In 2008, the City acquired the 'Nicholson addition' of 280 acres.

INTRODUCTION (CONTINUED)

- In 2013, IDEQ approved a Biosolids Management Plan for the entire 4,225 acres of the TMSBAS, including the original site, the Watkins Property, and the Nicholson addition.

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8450

BACKGROUND

- Primary crops are alfalfa (hay), corn, and winter wheat. All crops are sold to local dairies for feed and the grain is sold to a local elevator.
- In Idaho, about 60% of municipal biosolids are land applied.
- The TMSBAS is the only operation of its kind that we are aware of.
- Some farming tasks such as wheat combining and corn harvesting are done by outside custom harvesters but the City does everything else.
  - This controls and limits our regulatory liability.
  - We also get revenue to help keep sewer rates low for our ratepayers.
  - We strive to be revenue neutral for biosolids recycling operations

TMSBAS IS AN IDEAL LAND APPLICATION SITE

- No surface waters of the US on site.
- Approximately 270 feet to groundwater.
- Few neighbors and partially bordered by BLM.
  - Minimal nuisance complaints.
  - Site security – 4 families live on site.
- Relatively short hauling distance ~20 miles each way to West Boise.
- 23 years of extensive data collection

BIOSOLIDS ARE A NUTRIENT RICH, VALUABLE MATERIAL

SELECT MACRONUTRIENTS AND MICRONUTRIENTS PROVIDED BY THE CITY OF BOISE'S BIOSOLIDS

Nutrient	Provided by 1 dry ton of biosolids (lbs/dry ton)	Provided in a typical application at TMSF* (lbs/acre)
Nitrogen (1st year)	42.5	170
Phosphorus	51.1	204
Potassium	6.1	24
Iron	34.0	136
Boron	0.1	0.4
Copper	1.4	5.4
Zinc	1.3	5.4

*** - Typical application assumed at 4 dry tons/acre.**

BIOSOLIDS ARE A NUTRIENT RICH, VALUABLE MATERIAL

COMMERCIAL FERTILIZER VALUE OF CITY OF BOISE'S BIOSOLIDS

Nutrient	Total Nutrient (% dry wt.)	Plant Available Nutrients from Biosolids (lbs/dry ton)	Equivalent Fertilizer (lbs/dry ton)	Bulk Fertilizer List Price ($/lb)	Nutrient Value ($/dry ton)
Nitrogen (N)1	6.89%	42.5	132.8 NH_4NO_3	$0.27	$36.25
Phosphorus (P)2	2.55%	20.4	46.7 P_2O_5	$0.38	$17.93
Potassium (K)3	0.23%	4.6	5.5 K_2O	$0.33	$1.83
				Total	$56.01

The City of Boise applied 3,634 dry tons in 2015 giving the biosolids a total fertilizer value of $203,556!

1 –Assumes 50% of ammonium & 25% Org-N is available to crop
2 – Assumes 40% of P is plant available in year 1
3 – Assumes 100% of K is plant available

TMSBAS NUTRIENT MANAGEMENT PROGRAM

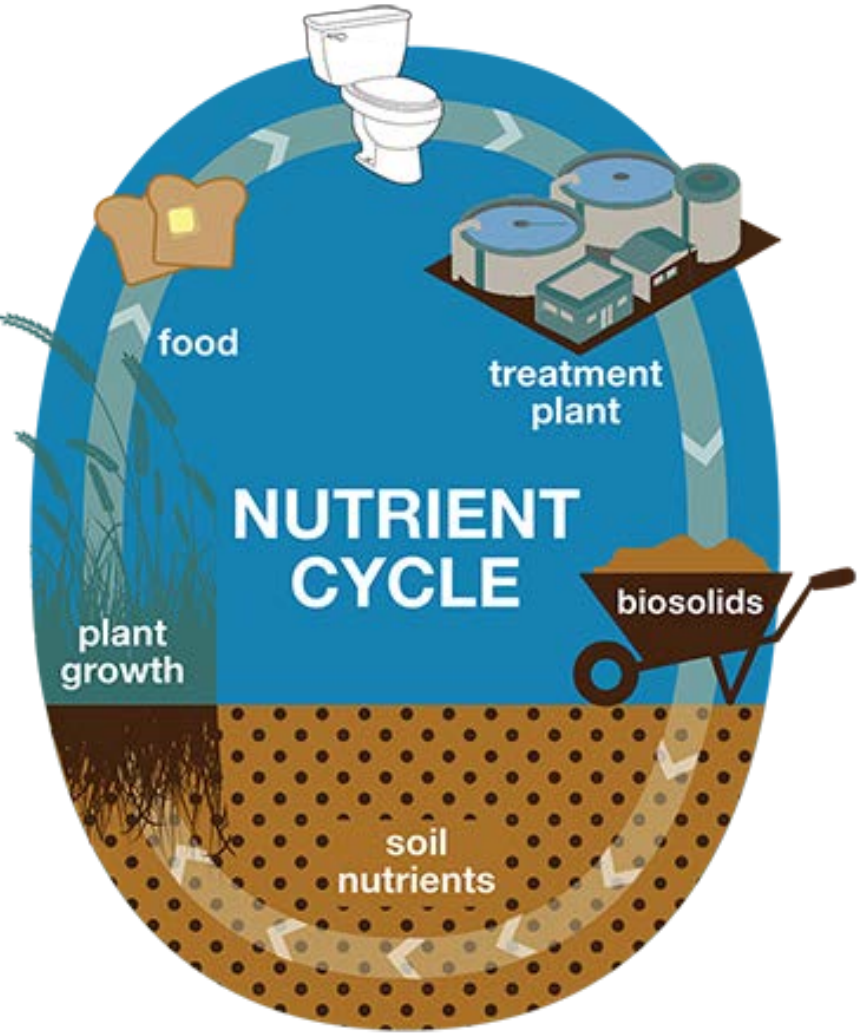
- Main Goal: Want to maintain max nutrients in the soil when the crop is actively growing and end the season with minimal residual nutrients.

- ***What About Phosphorus???***
  - There is uncertainty on how the regulators (EPA, IDEQ) will address P in Idaho, if at all.
  - Very low phosphorus effluent limitations are increasing the concentration of P and volume of biosolids

TMSBAS NUTRIENT MANAGEMENT PROGRAM

- TMSBAS has continued to manage biosolids application based on soil phosphorus levels as follows:
  - Target for a maximum of 30 ppm of Olsen Phosphorus in the 16-24" soil layer through management practices
  - If EPA of IDEQ use NRCS Code 590 or similar to regulate land application of biosolids in the future, the site may be limited based on soil P levels.
  - Regardless of future EPA/DEQ requirements for biosolids application, for the long-term sustainability of the TMSBAS, soil P levels should continue to be managed to keep P in the root zone (top 24" of soil).
  - NRCS Code 590 was referenced in *Phosphorus in Biosolids: How to Protect Water Quality While Advancing Biosolids Use.* WEF Sustainable Residuals Use Subcommittee, May 2014.

SUSTAINABILITY



Graphic Courtesy of Northwest Biosolids

- We are in the business of nutrient recycling.
- Is there a better example of sustainability than using our own treated human waste to produce food?
- The Treasure Valley is an agricultural community and we take pride in owning and operating the largest contiguous farm in Ada County.

BENEFITS OF BIOSOLIDS LAND APPLICATION

- Feeding the soil vs. feeding the plant.
- Reduces or eliminates the need for commercial fertilizers.
- Improves the physical qualities of the soil.
- Keeps biosolids out of landfills.
- Biosolids application sites are managed to protect surface and ground water sources.
- Land application is generally lowest cost option for managing Class B biosolids.

SUSTAINABILITY

- New Office and Maintenance Facility Completed in July, 2016.
  - 56.4 KW solar array on the roof makes this the first Zero Net Energy (ZNE) Commercial Building in Idaho.
  - Cost $3.2 million to construct.
  - Will save approximately $24,000 per year in energy costs.
  - It was estimated that the “extra” investment in the building envelope and solar array will be recouped in about 14 years.
  - From July 2016 to July 2017, the facility produced 165% of the power it consumed. Therefore, this payoff will be even less!

CONTACT INFORMATION

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Photo courtesy of the Nature Conservancy