HDR

The Nutrient Optimization Challenge

Third Quarter Workshop PNCWA Meeting

HDR

August 12, 2020

AGENDA

- **Puget Sound Nutrient Optimization Plans |** Dave Clark, PE, WEF Fellow
- **Water Research Foundation (WRF) Nutrient Removal Optimization Study |** J.B. Neethling, PhD, PE
- **The Bay Area Nutrient Management Experience |** Mike Falk, PhD, PE
- **Puget Sound Plants and the Optimization Pathway |** Jeff Zahller, PE
- **Innovative Process for Nitrogen Removal Optimization and Intensification |** Bryce Figdore, PhD, PE
- **Nutrient Reduction by Other Means – Reclaimed Water |** Jeff Hansen, PE
- **Q&A**

Puget Sound Nutrient Optimization Plans

Dave Clark, PE, WEF Fellow

NUTRIENT OPTIMIZATION PLANS

- Contents
- Preparation Time
- Monitoring Data
- Implementation Obligations
- Compliance Requirements
- Reporting and Tracking
- Strategic Formulation

ECOLOGY'S PERMITTING OPTIONS

- Puget Sound Nutrient Forum August 7, 2019

1. Individual Permits
2. General Permit
   - Chapter 173-226 WAC

Near-term: Ecology Plans to Continue Individual Permit Renewals & Develop Nutrient General Permit

Long-term: Ecology's Salish Sea Model to Determine Individual Water Quality Based Effluent Limits (WQBELs) for Nitrogen

ECOLOGY'S GENERAL NUTRIENT PERMIT CONVERAGE

- All Point Source Discharges Included in the Salish Sea Model
  - All wastewater sources included as point source discharges in the Salish Sea Model, including Ecology-permitted domestic and industrial facilities, EPA-permitted facilities, and Canadian facilities

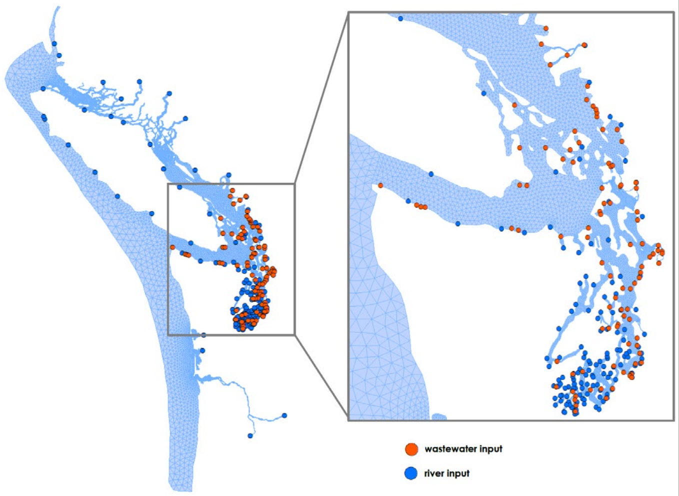


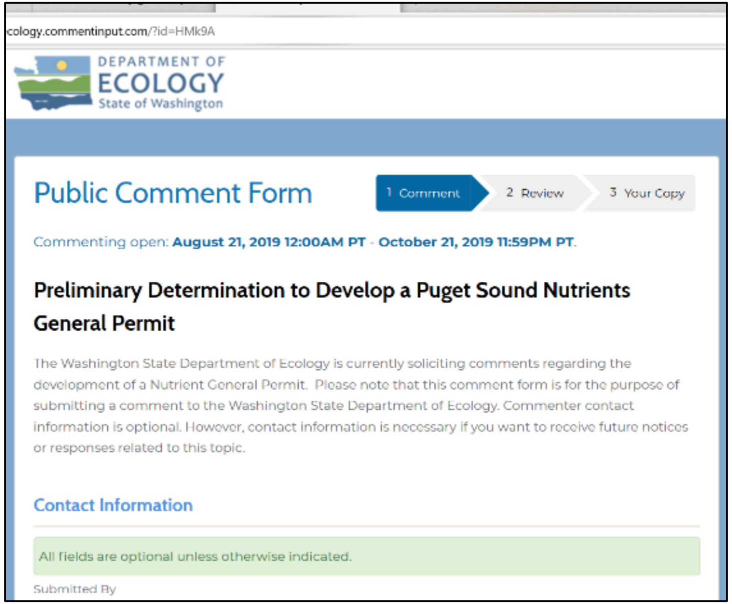
Figure 1 *Map of all Point Source Discharges included in the Salish Sea Model*

(Note: This map includes all wastewater sources included as point source discharges in the Salish Sea Model, including Ecology-permitted domestic and industrial facilities, EPA-permitted facilities, and Canadian facilities.)

https://fortress.wa.gov/ecy/ezshare/wq/permits/NGP_PotentialPermitteeList.pdf

ECOLOGY'S DETERMINATION TO DEVELOP A PUGET SOUND NUTRIENTS GENERAL PERMIT

- Accepted Comments from August 21 to October 21, 2019



cology.commentinput.com/?id=HMk9A

DEPARTMENT OF ECOLOGY State of Washington

Public Comment Form

1 Comment 2 Review 3 Your Copy

Commenting open: **August 21, 2019 12:00AM PT - October 21, 2019 11:59PM PT.**

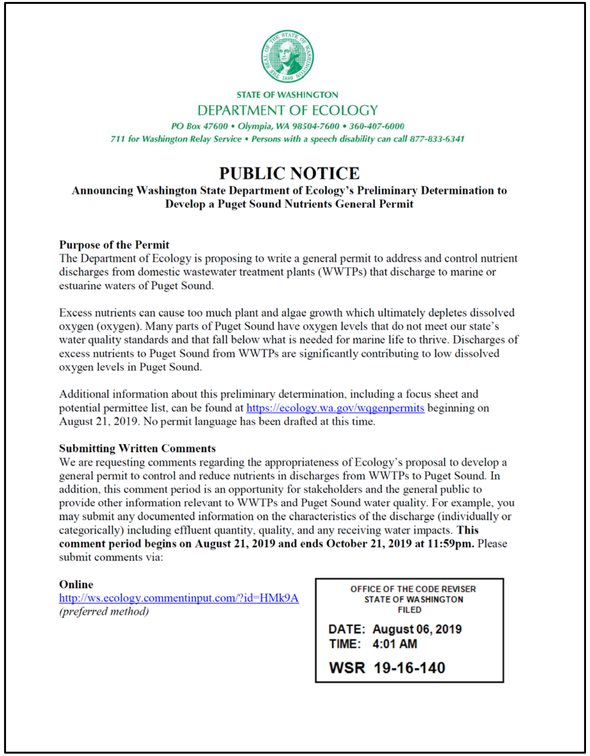
Preliminary Determination to Develop a Puget Sound Nutrients General Permit

The Washington State Department of Ecology is currently soliciting comments regarding the development of a Nutrient General Permit. Please note that this comment form is for the purpose of submitting a comment to the Washington State Department of Ecology. Commenter contact information is optional. However, contact information is necessary if you want to receive future notices or responses related to this topic.

Contact Information

All fields are optional unless otherwise indicated.

Submitted By



STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

PUBLIC NOTICE

Announcing Washington State Department of Ecology's Preliminary Determination to Develop a Puget Sound Nutrients General Permit

Purpose of the Permit
The Department of Ecology is proposing to write a general permit to address and control nutrient discharges from domestic wastewater treatment plants (WWTPs) that discharge to marine or estuarine waters of Puget Sound.

Excess nutrients can cause too much plant and algae growth which ultimately depletes dissolved oxygen (oxygen). Many parts of Puget Sound have oxygen levels that do not meet our state's water quality standards and that fall below what is needed for marine life to thrive. Discharges of excess nutrients to Puget Sound from WWTPs are significantly contributing to low dissolved oxygen levels in Puget Sound.

Additional information about this preliminary determination, including a focus sheet and potential permittee list, can be found at https://ecology.wa.gov/wqgenpermits beginning on August 21, 2019. No permit language has been drafted at this time.

Submitting Written Comments
We are requesting comments regarding the appropriateness of Ecology's proposal to develop a general permit to control and reduce nutrients in discharges from WWTPs to Puget Sound. In addition, this comment period is an opportunity for stakeholders and the general public to provide other information relevant to WWTPs and Puget Sound water quality. For example, you may submit any documented information on the characteristics of the discharge (individually or categorically) including effluent quantity, quality, and any receiving water impacts. **This comment period begins on August 21, 2019 and ends October 21, 2019 at 11:59pm.** Please submit comments via:

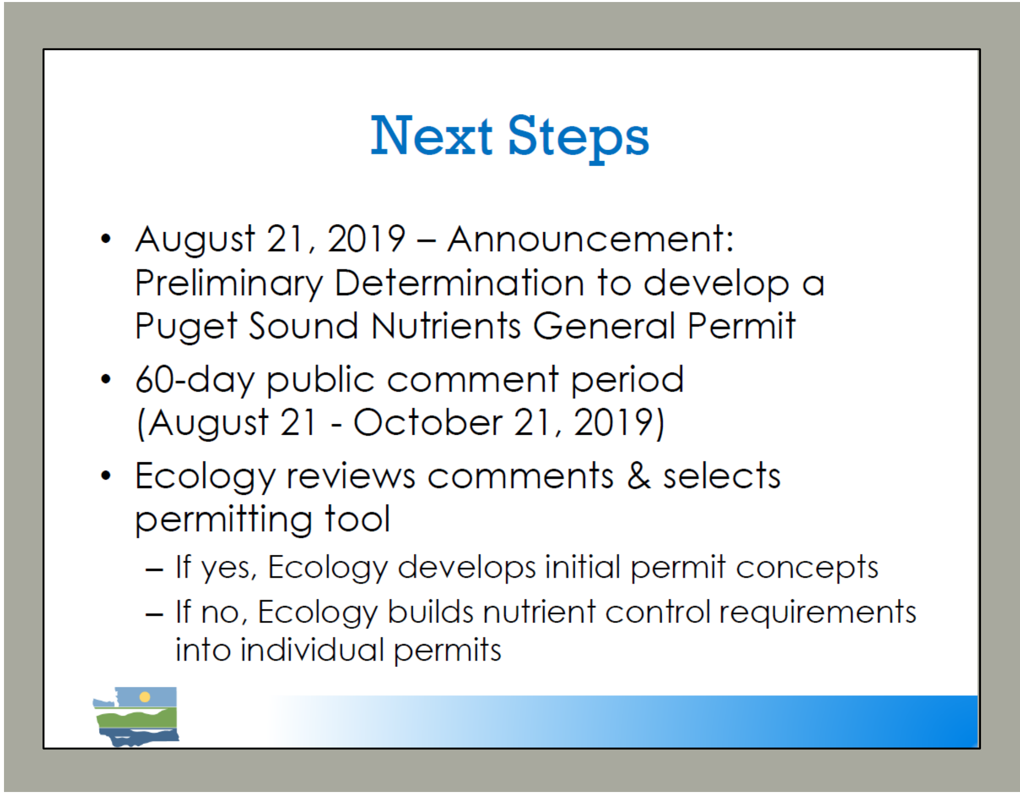
Online
http://ws.ecology.commentinput.com/?id=HMk9A
(preferred method)

OFFICE OF THE CODE REVISER
STATE OF WASHINGTON
FILED
DATE: August 06, 2019
TIME: 4:01 AM
WSR 19-16-140

https://fortress.wa.gov/ecy/ezshare/wq/permits/NGP_PrelimPublicNotice.pdf

ECOLOGY'S ORIGINAL GENERAL PERMIT SCHEDULE

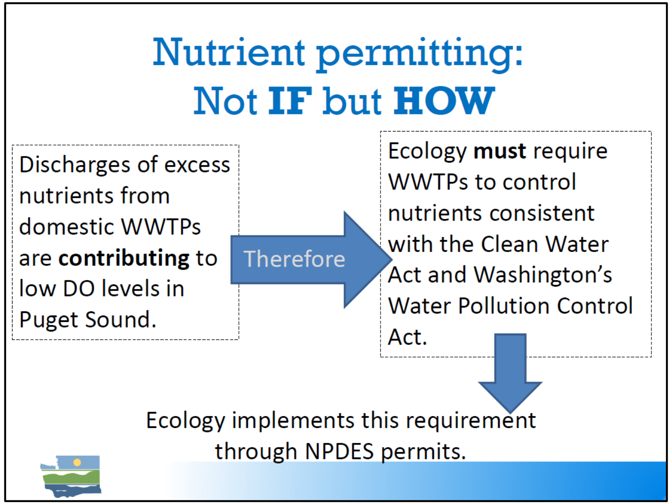
- Public Comment Period
  - August 21 – October 21
- Draft Permit Qtr 1 2020
- Draft Permit for Comment Fall of 2020
- Issue Permit Spring or Summer of 2021



DECEMBER 19, 2019 ECOLOGY NUTRIENT FORUM WEBINAR

ANNOUNCEMENT OF KITSAP COUNTY SUQUAMISH 401 CERTIFICATION NPDES PERMIT

- First Proposed Nitrogen Load Cap and Optimization Requirement



"Consistent with recently issued Suquamish WWTP 401 Certification"

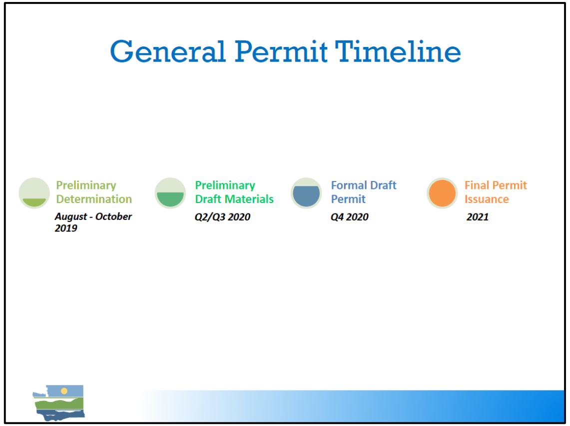
ECOLOGY'S KITSAP COUNTY SUQUAMISH 401 CERTIFICATION LETTER OPTIMIZATION LANGUAGE

4. Planning Requirements: (WAC 173-201A-510(4)(b)(ii), 173-240-060, 173-240-080)

   a. The Permittee must submit an optimization plan identifying achievable improvements for maintaining compliance with the TIN cap no later than nine months following the permit effective date.

ECOLOGY ANNOUNCED DECISION TO DEVELOP NUTRIENT GENERAL PERMIT

- January 30, 2020 Nutrient Forum Meeting
  - Revised Schedule
  - Stakeholder Engagement Process
    - Advisory Committee



ECOLOGY'S PUGET SOUND NUTRIENT GENERAL PERMIT (PSNGP) ADVISORY COMMITTEE (AC)

- April 15, 2020 AC Meeting #1
- May 13, 2020 AC Meeting #2
- June 10, 2020 AC Meeting #3
- July 16, 2020 AC Meeting #4

ECOLOGY'S PUGET SOUND NUTRIENT MANAGEMENT PLAN

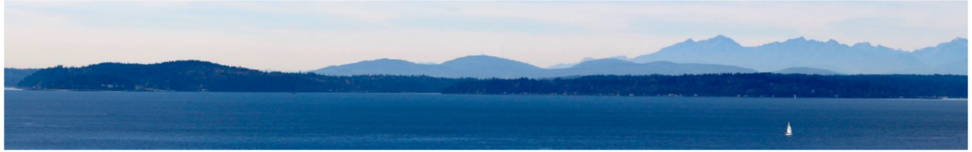
- Ecology's Nutrient Forum Meeting May 7, 2020
  - Salish Sea Modeling
    - Early 2022 Vol 2: Optimization Scenarios
  - Chapter 6 Watershed Nutrient Reduction Targets
    - Load Allocation for Nonpoint Sources
  - Chapter 7 Final Wasteload Allocation
    - Point Source Water Quality Based Effluent Limits (WQBELs)
  - Chapters 9 – 14 Monitoring, Accountability and Financial Support

Puget Sound Nutrient Management Plan Outline

Water Quality Program

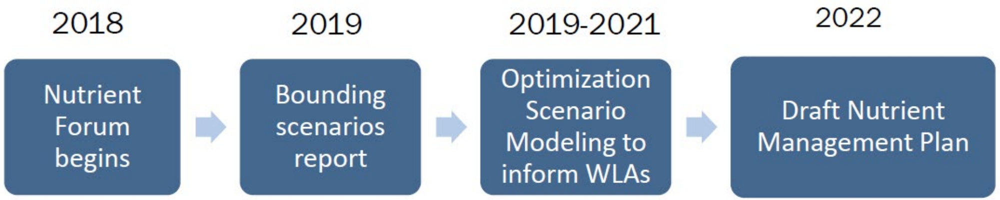
May 2020

DEPARTMENT OF ECOLOGY State of Washington



The Puget Sound Nutrient Management Plan is a comprehensive plan for addressing human nutrient sources to Puget Sound. This Plan is part of the Puget Sound Nutrient Source Reduction Project. The goal of this plan is to meet the marine water quality standards for dissolved oxygen (DO) in Puget Sound.

Puget Sound Nutrient Reduction Project Timeline



Near-term: Ecology Plans to Continue Individual Permit Renewals & Develop Nutrient General Permit

Long-term: Ecology's Salish Sea Model to Determine Individual Water Quality Based Effluent Limits (WQBELs) for Nitrogen

RECENT ECOLOGY DRAFT NPDES PERMITS

- Permit Fact Sheet
  - Nitrogen Load Cap as Maximum Annual Effluent Load Limit
    - Historical Effluent TIN Monitoring Data
    - “Bootstrap” Statistics
      - » Data Replacement Technique Calculates Average Loadings
      - » Use 99th Percentile of “Bootstrap” Calculated Averages for Effluent Limit
  - Permit Compliance Requirements/Consequences Unclear

RECENT ECOLOGY DRAFT NPDES PERMITS

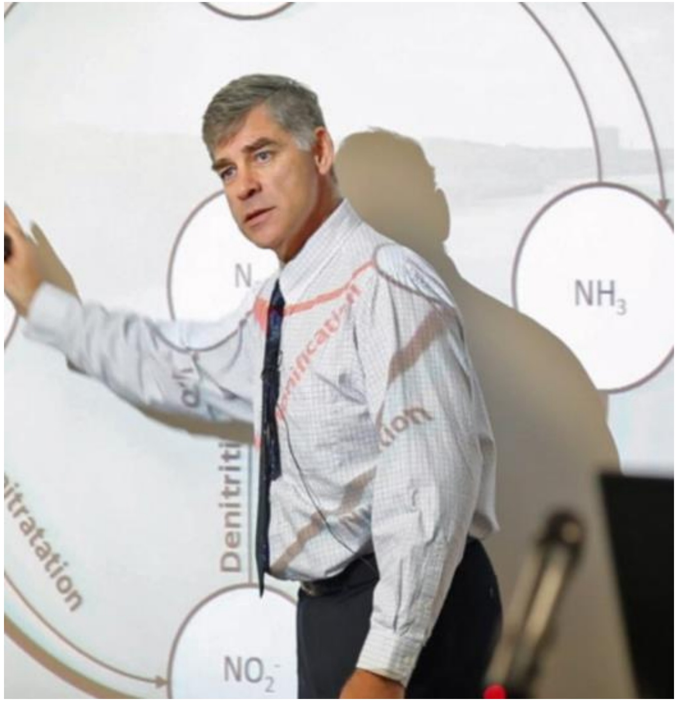
- Permit Section S11. Nutrient Optimization Plan
  - Within 12 months of the permit effective date
  - Must Include:
    - Both Treatment Efficiency Optimization Evaluation and Plan for Future Optimization
  - Must Evaluate:
    - Existing Process for Nutrient Reduction Opportunities
    - Operational Adjustments to Enhance Nitrification and Denitrification Using:
      - Only Minor Retrofits
        - Anoxic Zones, Review of Septage Receiving Policies, Side-stream Management, Minor Upgrades
        - Minor Upgrade: Costs Not Exceeding 5% of Annual Equipment & Supplies Budget

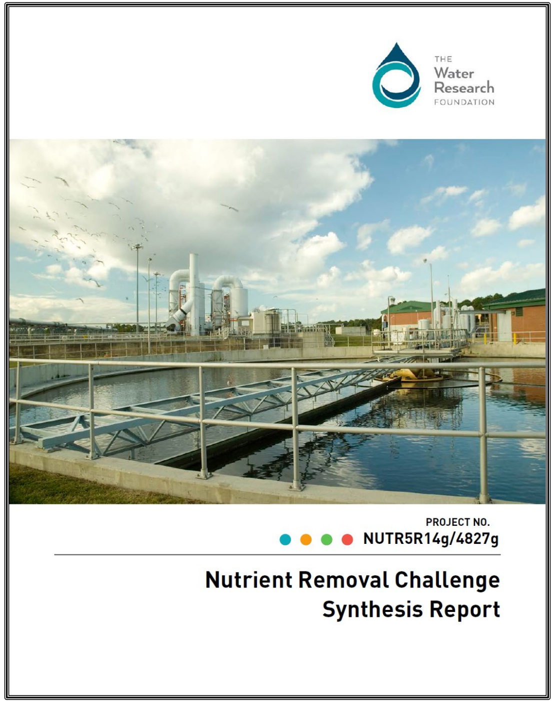
OPTIMIZATION PLAN REFERENCES

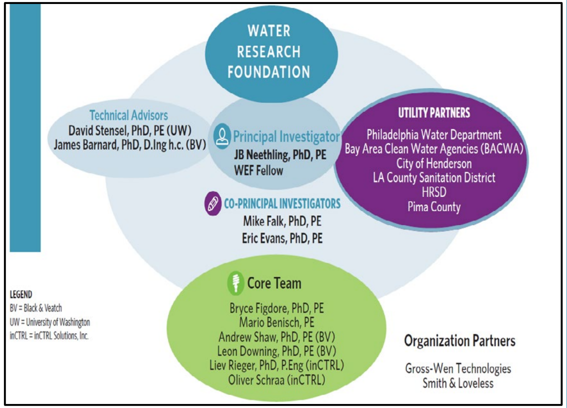
- Water Research Foundation (WRF4973) Nutrient Optimization
- San Francisco Bay and Bay Area Clean Water Association (BACWA)
- Montana
- Iowa

WATER RESEARCH FOUNDATION (WRF)

GUIDELINES FOR OPTIMIZING NUTRIENT REMOVAL PLANT PERFORMANCE (WRF4973)







1. Optimizing Existing Plants for Nutrient Removal
2. Utilizing Full-scale Examples
3. Produce “How-to” Guideline

JB Neethling, PhD, PE, WEF Fellow. Principal Investigator

HDR

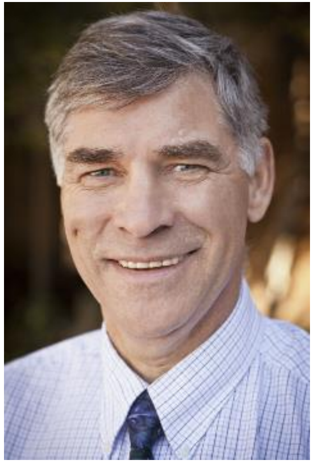
STRATEGIC PREPARATION

- Advance Preparations
  - Opportunity Time in Advance of Permitting
    - Use to Inform Permit Negotiations, Especially Compliance Schedules
- Sound Fundamentals
  - Monitoring Data
    - Representative Influent and Effluent Data
      - Adequate to Support Analysis, Process Modeling, etc.
    - Link with Receiving Water Monitoring
  - Establish Baseline & Accounting
    - Track Trends, Account for Changes, Technology Testing, Service Area Changes, etc.
- Opportunities
  - Consider All Utility Obligations and Objectives
    - Future Capacity Plans and Growth, Wet Weather Compliance, Toxics, Asset Management, etc.
      - Competing Demands Inform Compliance Schedule Needs and Affordability
  - Consider New Technologies and Development Needs
  - Find the Sweet Spot
    - Convergence with Other Needs
      - Navigate to Sweet Spot

THE Water Research FOUNDATION

WATER RESEARCH FOUNDATION (WRF) NUTRIENT REMOVAL OPTIMIZATION STUDY

J.B. Neethling, PhD, PE



WHAT DOES NUTRIENT REMOVAL PLANT OPTIMIZATION MEAN?

- Optimization a treatment plant typically means
  - Reduce the operational cost
  - Improve the performance for reducing nutrients
  - Increase the treatment capacity of the facility
- Optimization for nutrient removal includes
  - Improve reliability of a nutrient removal plant
  - Reduce effluent concentration of a nutrient removal plant
  - Remove some nutrients in a WRRF designed for secondary treatment
  - Implement some other means of nutrient removal (Water reuse, sidestream treatment, etc.)

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ALL OF THE ABOVE

NUTRIENT REMOVAL OPTIMIZATION – REGULATORY APPROACHES

Area	Approach
BACWA	Study 3 strategies Set nitrogen caps Fund science • Six months to submit an optimization scoping plan as a group or individually • One year to submit an evaluation plan • Two years to submit Status report • Three years to submit Status report • Four years to submit final report with planning level cost estimates for each option
Iowa	Nutrient Reduction Strategy Study baseline and optimization Goals: 67% TN and 75% TP Reduction

Area	Approach
Puget Sound	Nutrient Optimization Plan • Efficiency Evaluation • Plan Future Optimization Evaluate opportunities with minor retrofits/operational adjustments
Montana	Pollution Minimization Plan • Process control, training, minor infrastructure changes, etc. • Incorporate PMP and improvement schedule in MPDES permit

NUTRIENT REMOVAL TREATMENT STAGES (WERF, 2019)

	CNR	TNR	ANR
Primary treatment	Optional Chemical addition for P removal	Optional Chemical addition for P removal	Optional Chemical addition for P removal
Conventional treatment	BNR with suspended growth, biofilm, hybrid	Multistage BNR Chemical addition	Multistage BNR Chemical addition
Tertiary treatment	No	Filtration Chemical addition	Filtration Chemical addition
Advanced Treatment	No	No	Molecular separation, advanced oxidation, biofiltration
Other Features	No	Carbon supplement such as fermentation or chemical Sidestream management	Carbon supplement such as fermentation or chemical Sidestream management Brine disposal
Performance Range			
Ammonia, mg N/L	2-5	0.5-2	<0.1
TN, mg N/L	8-15	3-8	<0.2
TP, mg P/L	0.5-2	0.03-0.1	<0.01

CNR = Conventional Nutrient Removal; TNR = Tertiary Nutrient Removal; ANR = Advanced Nutrient Removal

Note: Listed performance is based on best judgment for a typical range of effluent. Performance is highly dependent on site-specific conditions (temperature, weather, influent composition, influent strength, industrial contributions, and solids management practices).

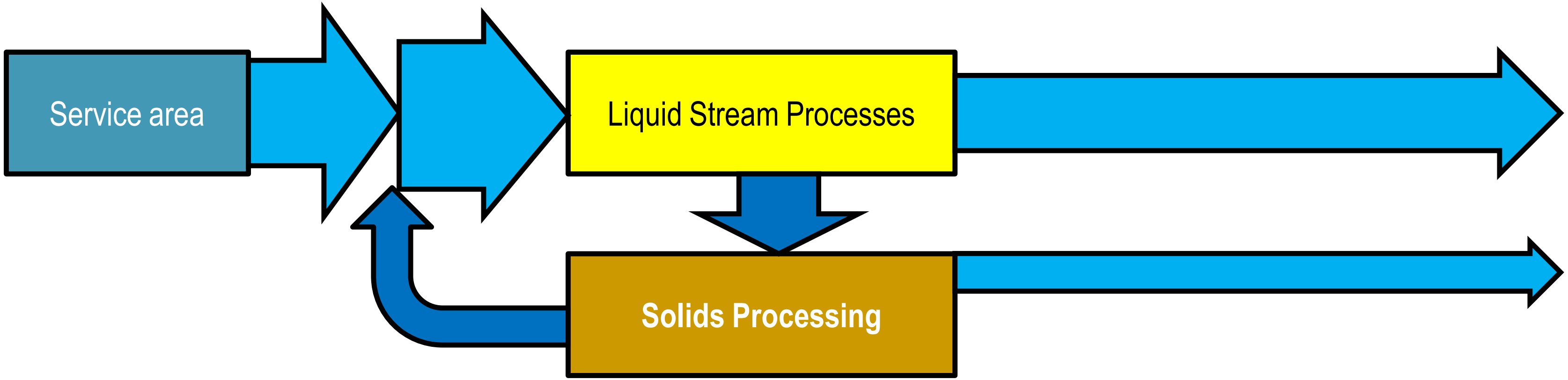
Neethling, J.B., Clark, D.L., Stensel, D.H., Sandino, D.H., and Tsuchihashi, R. (2019). "Nutrient Removal Challenge Synthesis Report." WRF Report NUTR5R14g/4827g.

NUTRIENT REMOVAL OPTIMIZATION STRATEGIES AND TOOLS

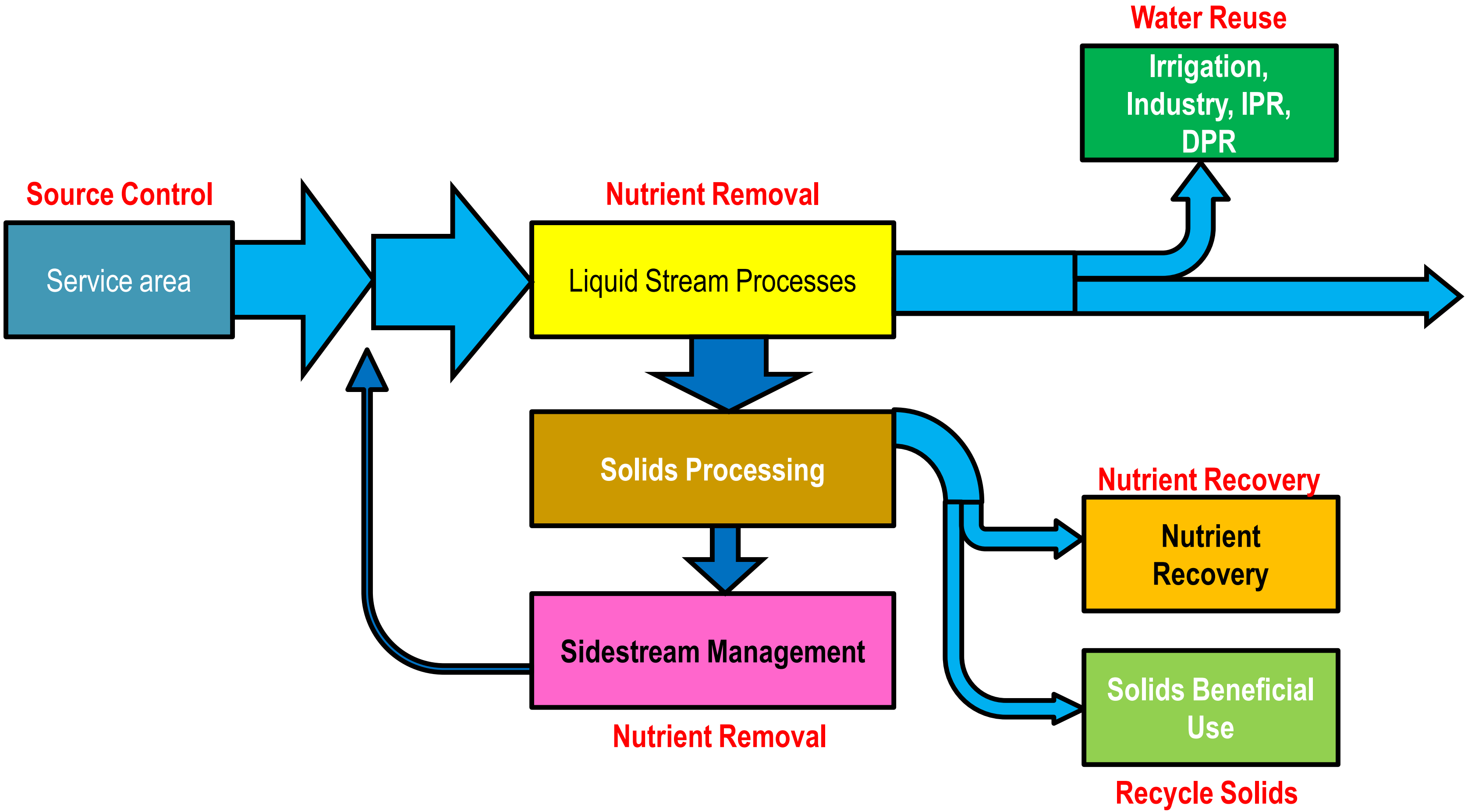
WRF 4973 APPROACH TO NUTRIENT REMOVAL OPTIMIZATION

Category	Optimization Strategy (examples)
Secondary process	Minor/operational changes to remove “some” nutrients. AKA -- “Do the best with what you have”
Nutrient removal process	Reduce operating cost Improve treatment performance (lower effluent) Increase treatment reliability
WRRF optimization for nutrient removal	Manage/treat sidestreams Equipment changes Control changes
Nutrient removal by other means	Direct effluent to reuse Natural treatment systems Source control

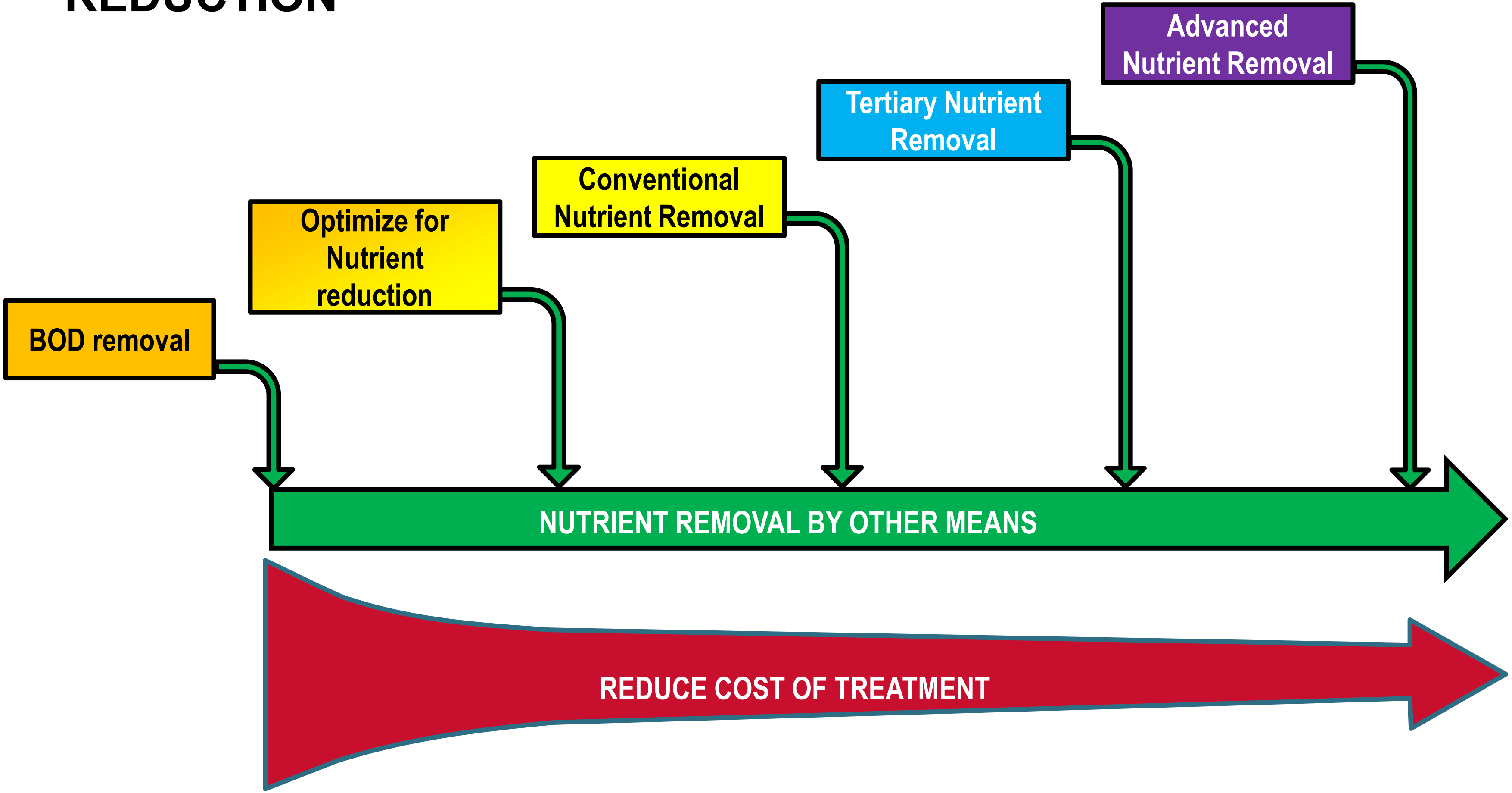
OVERALL NUTRIENT FATE IN A TYPICAL PLANT



CONSIDER OVERALL NUTRIENT REMOVAL POTENTIAL



NUTRIENT REDUCTION PATHWAYS – INCREMENTAL NUTRIENT REDUCTION



TOTAL NITROGEN REDUCTION STRATEGIES FOR A SECONDARY WRRF

Category	Optimization Strategy (examples)
Nitrify* and Denitrify in Modified Activated sludge	Use existing unused basins Step feed Add media (IFAS/MOB/Densification)
Split treatment	Use spare capacity to nitrify a portion of the flow – seed parallel process trains
New technologies	Equipment such as MABR Online control DO/SRT/ABAC
Other Means	Redirect water to reuse Treat sidestream/reject water from dewatering

* Increasing SRT to nitrify is near impossible for high rate secondary process unless there are unused capacity in the process (ex. Industrial load that moved away)

TOTAL NITROGEN REDUCTION STRATEGIES FOR A TERTIARY WRRF – ADD TERTIARY PROCESSES (CIP)

Category	Optimization Strategy (examples)
Tertiary TN removal	Nitrification and Denitrification processes Required carbon addition
Effluent polishing	Wetlands, zeolite
New technologies	Processes like Microvi
Other Means	Horizontal levee

FACT SHEETS AND TOOLS FOR NUTRIENT REMOVAL OPTIMIZATION

Tool / Fact Sheet	Description
Process Technology	Applied process fundamentals to achieve nutrient removal in conventional technologies by retrofit and reconfiguration
Emerging Technologies	New or retrofit for nutrient removal and improved efficiency Emerging process developments New equipment and technologies
Process control	Use of I&C to achieve nutrient removal Use I&C to reduce operational cost
Process simulators	Data needs for models/process evaluation Developing aid to use a process similator
Big data	Incorporate artificial intelligence in operation and trouble shooting

FACT SHEETS AND TOOLS FOR NUTRIENT REMOVAL OPTIMIZATION (CONTINUED)

Tool	Description
Nutrient recovery	Opportunities and implication of nutrient recovery
Business case	Life cycle cost and non-monetary criteria
Decision tree	Guidance to optimize secondary or nutrient removal process Optimization for N, P, or N&P Optimization goals (conventional or tertiary nutrient removal) Nutrient removal by other means
Operator training	Outline for operator training needs Resources for operators
Operator staffing	Impact of nutrient removal on staffing needs
Analytical needs	Sampling and monitoring for nutrient removal processes

NEXT FOR WRF 4973

NEXT STEPS

- Interactive workshops to present findings and get feedback
- Regional and National conferences
  - As opportunities arise
- WRF Sponsored Webinars Series – 2020-2021
  - Multiple series for topic specific webinars – 1-3 hr duration
  - Interactive web tools for quiz, case studies, collaboration
- Send your input/participation
  - Attend webinar
  - Send case study/input to JB Neethling (jb.Neethling@hdrinc.com)

The Bay Area Nutrient Management Experience: A Coordinated Effort across 37 WRRFs

Mike Falk, PhD, PE

San Francisco Bay

Nutrient Enriched, but Not Exhibiting Typical Problems

WRRFs: Largest Source of Nutrient Loads

BACWA
BAY AREA CLEAN WATER AGENCIES

BACWA is a joint powers authority formed by the five largest Bay Area Water Resource Recovery Facilities (WRRFs)

7M+ SERVICE POPULATION → **37** WASTEWATER TREATMENT PLANTS → **~450** MILLION GALLONS PER DAY TREATED EFFLUENT → **2/3's** OF NUTRIENT LOADS TO THE BAY

Working Together for Practical Regulation

BACWA
(wastewater utilities)

Regional Water Board
(regulatory)

San Francisco Estuarine Institute
(science)

Non-Govt Organizations
(NGOs)

The approach in the Bay Area for managing nutrients has received national attention and lauded for its collaboration, as evidenced by receipt of a National Environmental Achievement Award in 2019 from the National Association of Clean Water Agencies (NACWA). NACWA is the nationally recognized leader in legislative, regulatory, and legal clean water advocacy.

1st Nutrients Watershed Permit 2014

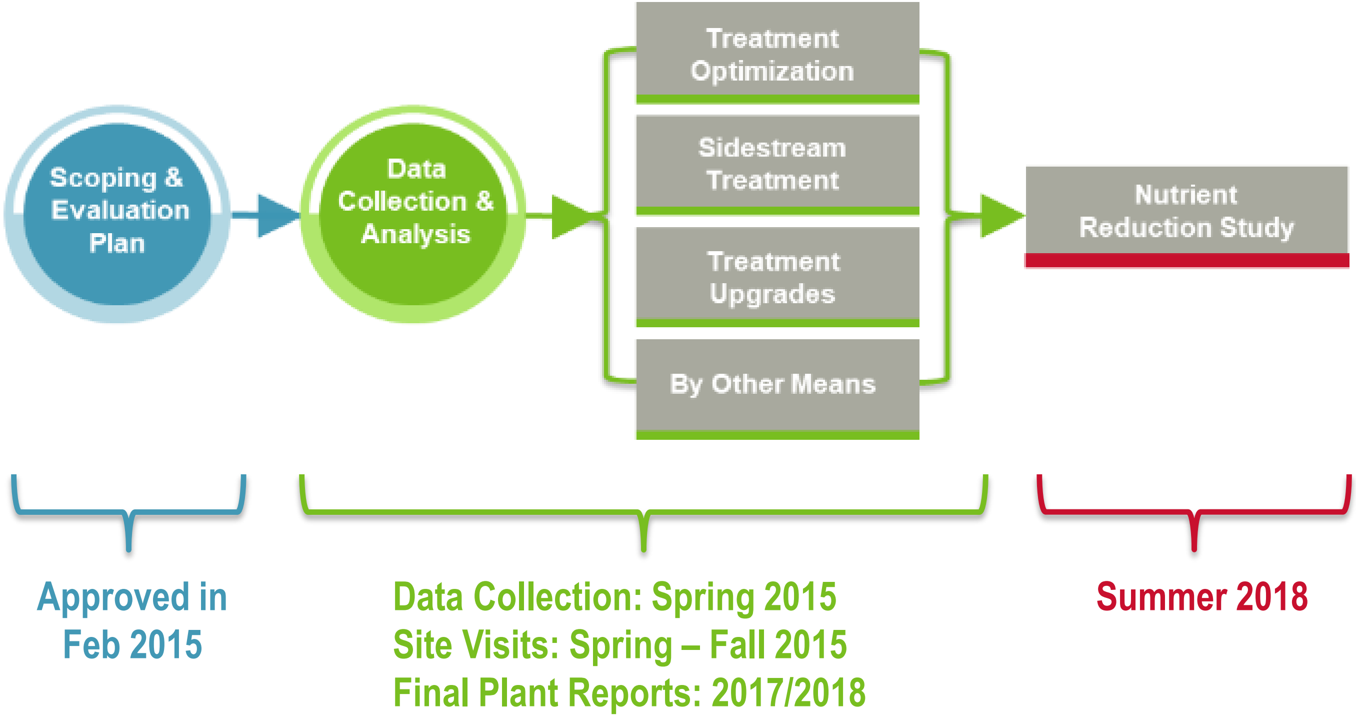
NO LOAD CAPS

SUPPORT FOR SCIENCE
(Baywide Model)

GROUP REPORTING

REGIONAL STUDY

Approach to Regional Study



Regional Study Treatment Levels

Level	Study	Ammonia	TN	TP
Level 1	Optimization / Sidestream	--	--	--
Level 2	Upgrades	2 mg N/L	15 mg N/L	1.0 mg P/L
Level 3	Upgrades	2 mg N/L	6 mg N/L	0.3 mg P/L

Regional Study Key Outcomes

Strategy	TN Load Reduction to the Bay	TP Load Reduction to the Bay	Total Present Value ($ Mil)
Optimization	7%	34%	$266 M
Sidestream Treatment	19%	12%	$766 M
Upgrade Level 2	57%	59%	$9.4 B
Upgrade Level 3	82%	88%	$12.4 B

Regional Study Key Observations

1. Treatment upgrades come with significant cost
2. Nutrient reduction results in:
   - Increase in energy and chemical demands
   - Increase in greenhouse gas emissions
   - Reduction in chemicals of emerging concern discharged to the Bay
   - Reduction in solids produced at treatment plants
3. Each plant is unique and the costs vs. nutrient reduction potential are wide ranging. The information in this study provides a menu to optimize the tradeoffs between costs and nutrient reduction.

2nd Nutrients Watershed Permit 2019

NO LOAD CAPS

INCREASED SUPPORT FOR SCIENCE

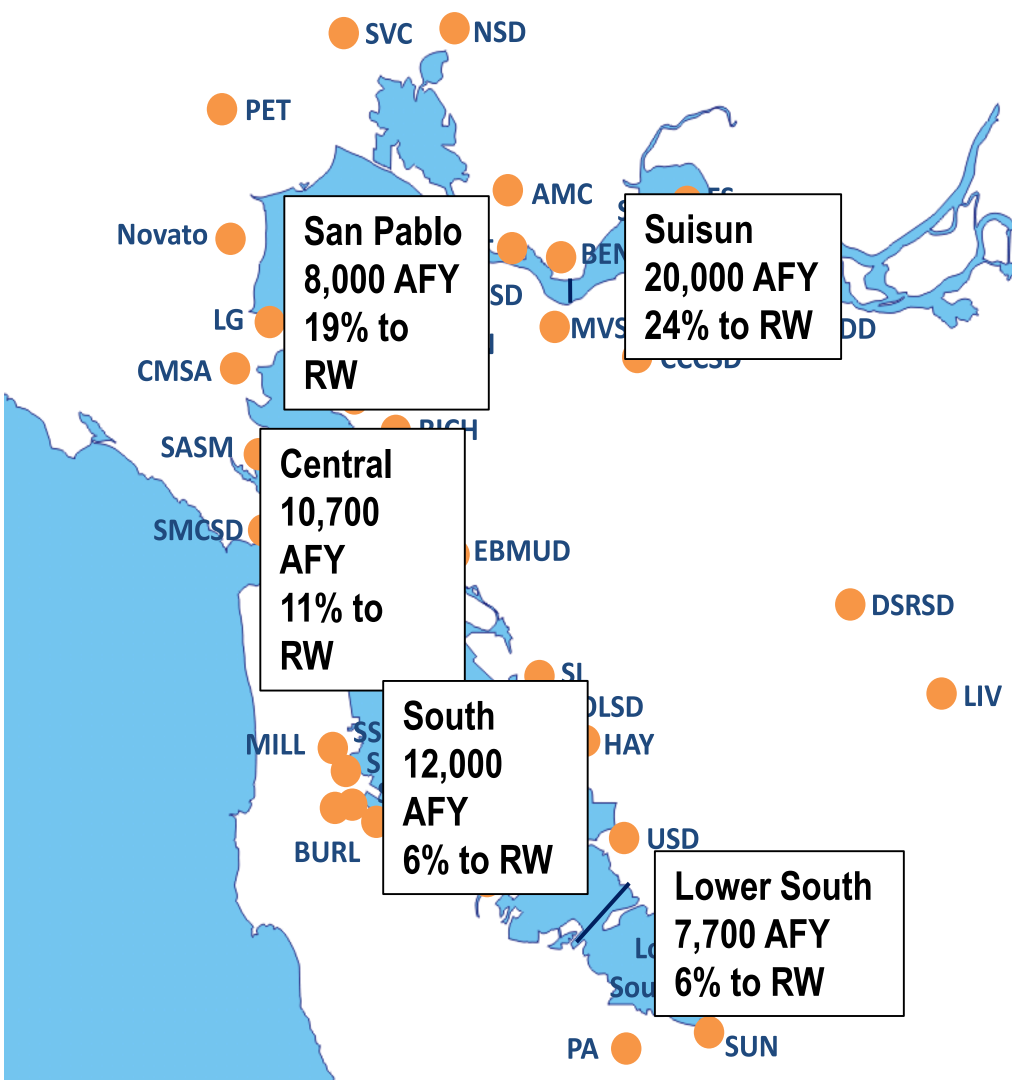
REGIONAL STUDIES: *1) Recycled Water and 2) Nature Based Solutions*

RECOGNIZES EARLY ACTORS

Current Recycled Water Quantities

- ~6% of Baywide plant effluent goes to recycled water
- Recycled water is expected to double by 2035
- The primary application is industrial (~40%)

6% Baywide Flow Reduction ≠ 6% Baywide Load Reduction



NBS Concept: Horizontal Levee has Received Considerable Attention

Background: https://youtu.be/OHt7qtI1kso

Technology Benefits:

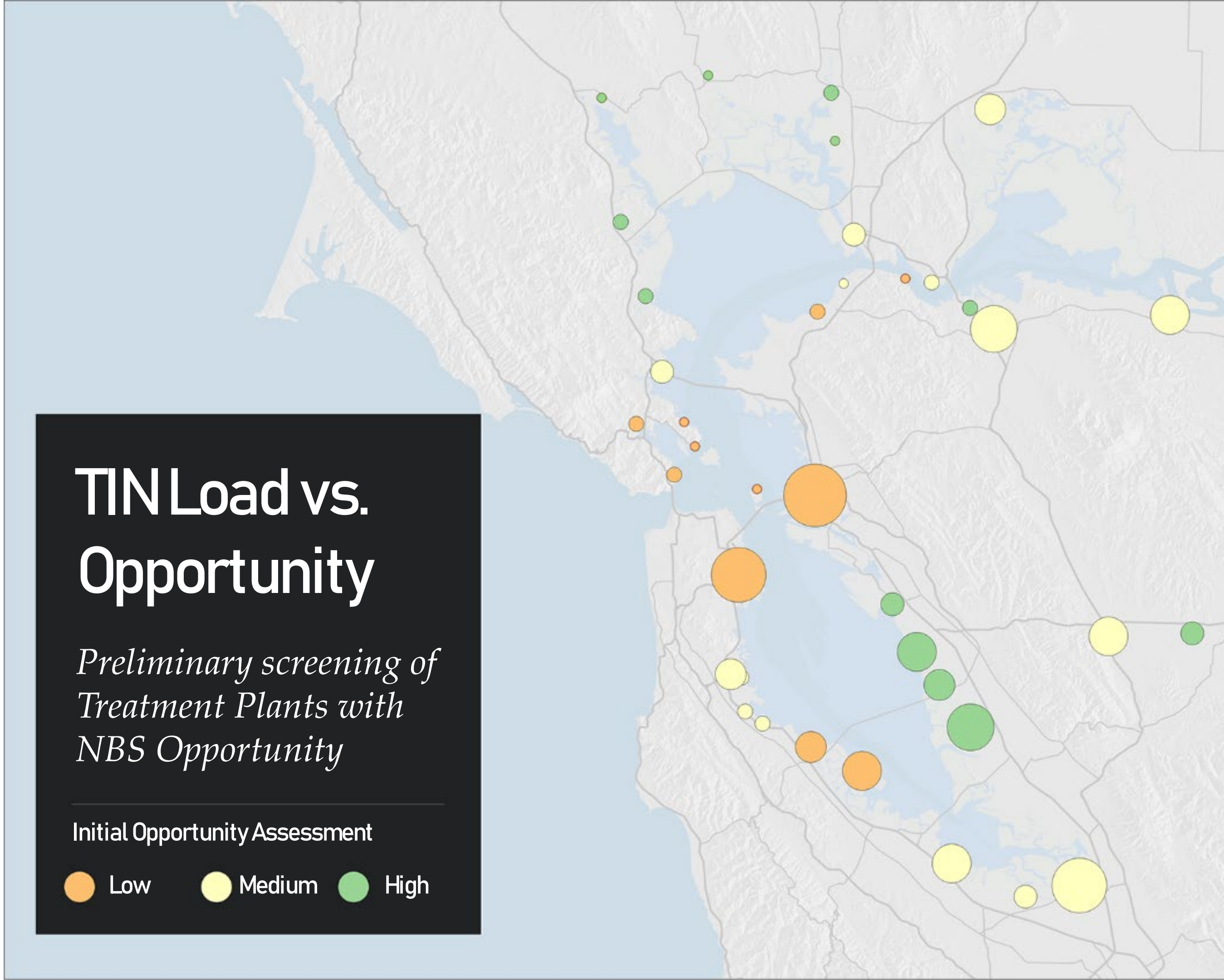
- Nutrient Reduction
- Addresses Sea Level Rise
- Habit Restoration

Horizontal Levees are Currently being Considered for Upwards of 5 Site Locations Across the Bay

Nature Based Solutions (NBS) Potential and Benefits

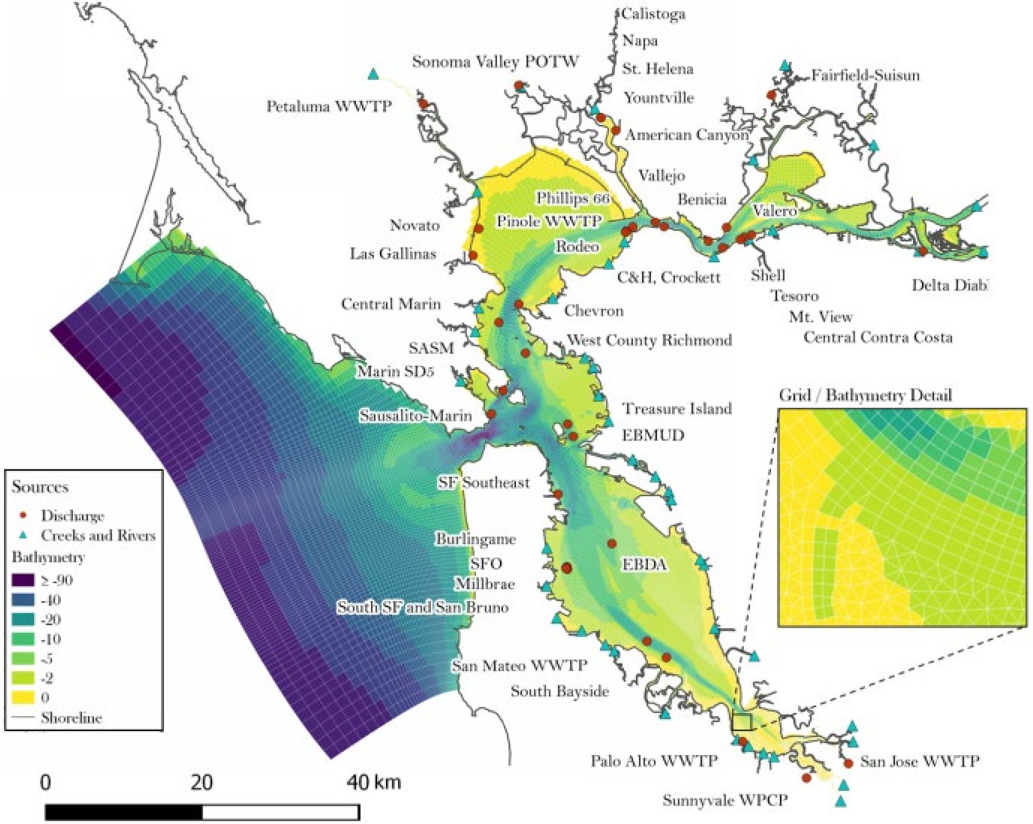
Environmental Benefits:

- Nutrient Reduction
- Addresses Sea Level Rise
- Habit Restoration



Next Steps

1. 2019 Adopted Permit (R2-2019-0017)
   - Recycled Water Opportunities
   - Nature Based Solutions
2. Continue Annual Nutrient Trending
3. Science: Bay Model to Inform Policy



Baywide Model Developed by SFEI for Advancing the Science

SFEI | AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

Puget Sound Plants and the Optimization Pathway

Jeffery Zahller, PE

HOW CAN PUGET SOUND PLANTS 'OPTIMIZE'?

- 78 very different plants
- Plant size, type, and past performance will vary
- Only one plant that "does" BNR (LOTT Alliance, Olympia, WA)
- Where we go with optimization depends on where we start

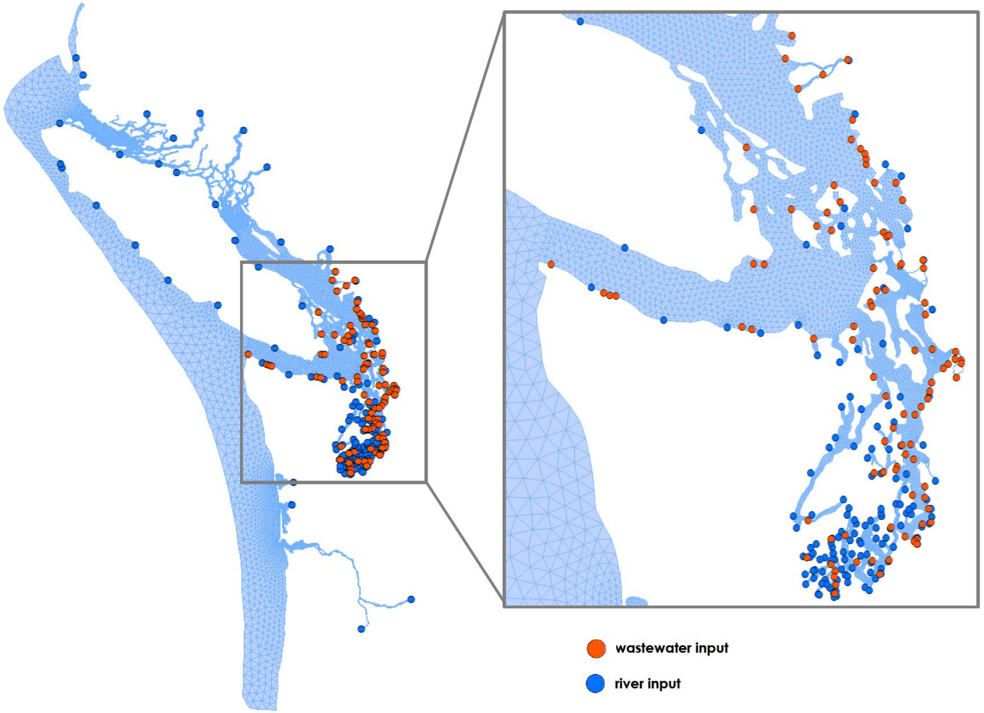


Figure 1 *Map of all Point Source Discharges included in the Salish Sea Model*

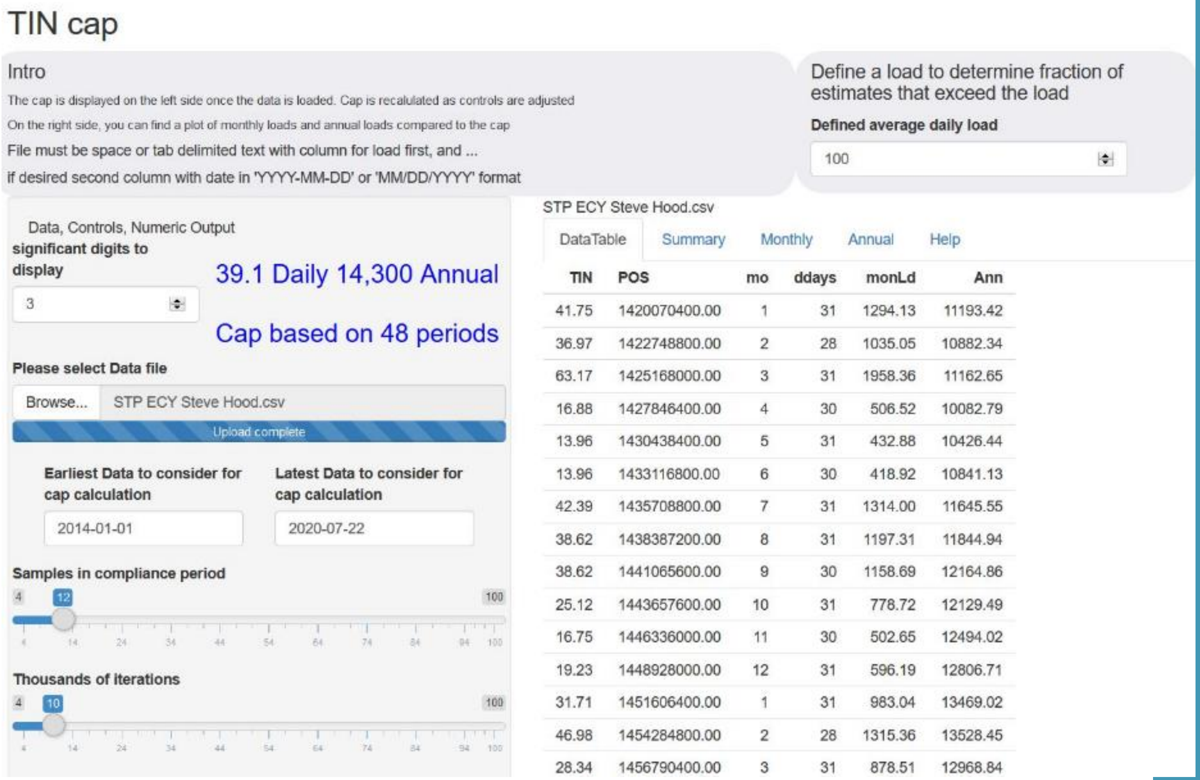
(Note: This map includes all wastewater sources included as point source discharges in the Salish Sea Model, including Ecology-permitted domestic and industrial facilities, EPA-permitted facilities, and Canadian facilities.)

LANGUAGE OF OPTIMIZATION

- S11. Nutrient Optimization Plan
- Within 12 months of the permit effective date the permittee must submit a Nutrient Optimization Plan. The Nutrient Optimization Plan must include both a treatment efficiency optimization evaluation, and a plan for future optimization.
- The treatment efficiency optimization must evaluate the existing treatment process for nutrient reduction opportunities through operational adjustments designed to enhance nitrification and denitrification, and using only minor retrofits such as the incorporation of anoxic zones, review of septage receiving policies and procedures, side-stream management opportunities, and/or minor upgrades. Minor upgrades are those with equipment costs not exceeding 5% of the annual equipment and supplies budget.
- The planning level evaluation must also include estimates for nutrient load reductions from changes already made as a result of treatment efficiency optimization, changes considered for the next year to continue treatment efficiency optimization, and a list of changes that are considered for the future but would require major modifications to implement.
- The Permittee must update the plan each year. If there is no significant change the report may include only what has been implemented in the last year and what will be implemented in the next year.
- Any significant process optimization that is continued from one year to the next must be reflected in an update to the standard operating procedures in the Permittee's Operation and Maintenance manual per permit Section S5.G.

CAP LOAD ANALYSIS

- “Steve Hood” calculator
- Answer you get is a factor of the method itself and the data you input
- Does not take into account your individual circumstances
- Prepare your optimization strategy to address this proactively as DOE sees it as an optimization target



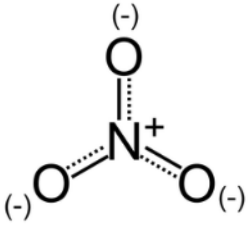
TIN	POS	mo	ddays	monLd	Ann
41.75	1420070400.00	1	31	1294.13	11193.42
36.97	1422748800.00	2	28	1035.05	10882.34
63.17	1425168000.00	3	31	1958.36	11162.65
16.88	1427846400.00	4	30	506.52	10082.79
13.96	1430438400.00	5	31	432.88	10426.44
13.96	1433116800.00	6	30	418.92	10841.13
42.39	1435708800.00	7	31	1314.00	11645.55
38.62	1438387200.00	8	31	1197.31	11844.94
38.62	1441065600.00	9	30	1158.69	12164.86
25.12	1443657600.00	10	31	778.72	12129.49
16.75	1446336000.00	11	30	502.65	12494.02
19.23	1448928000.00	12	31	596.19	12806.71
31.71	1451606400.00	1	31	983.04	13469.02
46.98	1454284800.00	2	28	1315.36	13528.45
28.34	1456790400.00	3	31	878.51	12968.84

PUGET SOUND OPTIMIZATION CATEGORIES

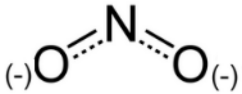
- Imagine three (3) types of generic plants around Puget Sound:
  - **Plant A** – BOD/TSS plant that does not currently do BNR and has significant obstacles to implement
  - **Plant B** – Can do conventional or tertiary BNR (to some degree), but may not utilize that capability
  - **Plant C** – Already doing conventional or tertiary BNR very well already (for a variety of reasons), but not required by permit

PLANT A – NO BNR NOW AND CHALLENGING TO IMPLEMENT

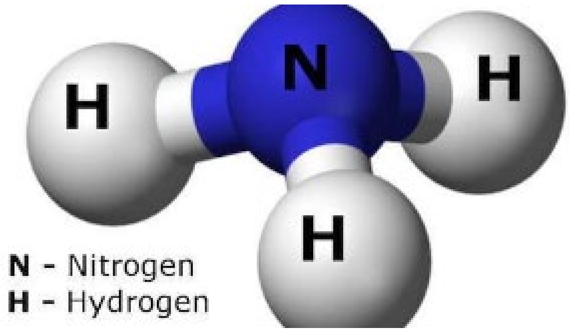
- Not a simple optimization exercise, but a more significant plant upgrade – no obvious "low hanging fruit"
- Example: High purity oxygen plant, limited SRT conventional activated sludge, simple trickling filter or lagoon systems focused on BOD
- *Challenge*: "Optimization" is much harder to achieve without a sizable capital investment (at first glance)



Nitrate

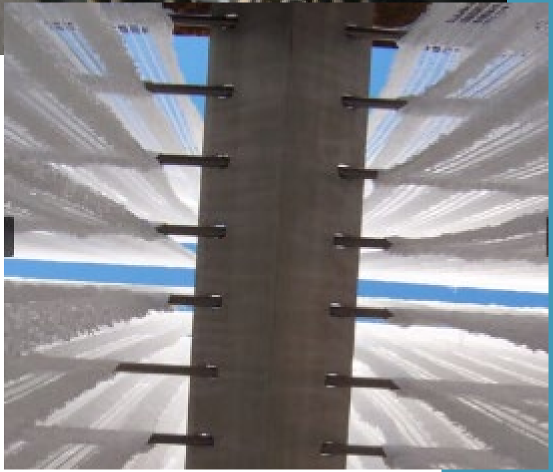


Nitrite



PLANT A – WHAT CAN WE DO?

- Creativity –new technology approach can buy time and show initiative (piloting can be part of a long term plan!)
- Sound Fundamentals
  - Monitoring Data: *you are in control*
  - Establish baseline and accounting: *what have you already been doing to optimize*
- Total Utility Options
  - Nutrient reduction by other means
    - CSO, watershed work, stormwater, reclaimed water

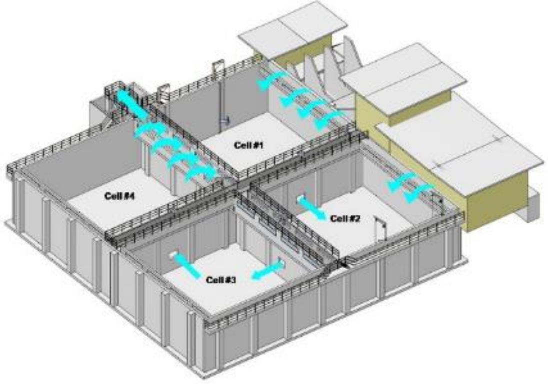


PLANT B – DESIGNED FOR BNR (OR EASY TO MODIFY), BUT NOT USING ALL POTENTIAL TOOLS

- Example: MLE plant running without recycle or low sludge age; multi-stage BNR with tanks our of service
- Example: Conventional plant with concrete/basins in place, but maybe missing recirculation, control, baffling
- *Challenge*: Integrate "optimization" while maintaining capacity for growth; choosing high value ($/BNR) modifications

PLANT B – WHAT CAN WE DO?

- <u>Sound Fundamentals</u> just like **Plant A**. These still apply!
- <u>Define Optimization</u>:
  - Staging BNR to show improvement, but keep capacity
  - Find where *you* want to operate beforehand – short term and long term
  - Utilize a defensible framework (such as WRF)
- Don't forget things outside the fence.



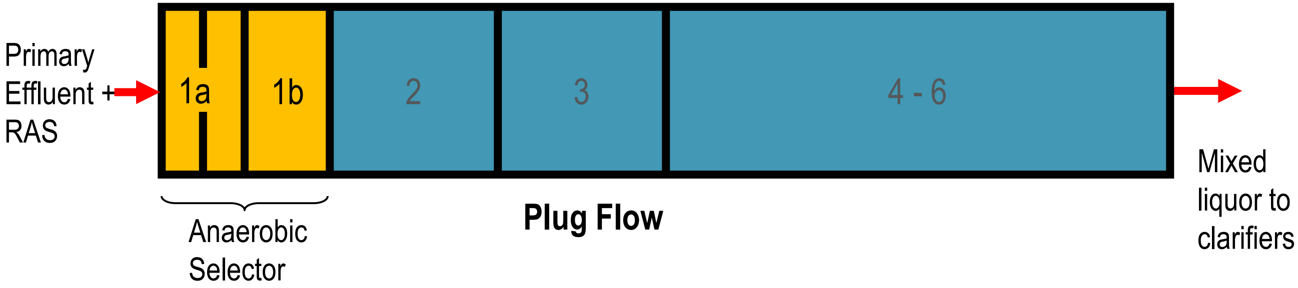
WRF #4973

Table 2. Steps to Develop Guidelines for Nutrient Removal Optimization

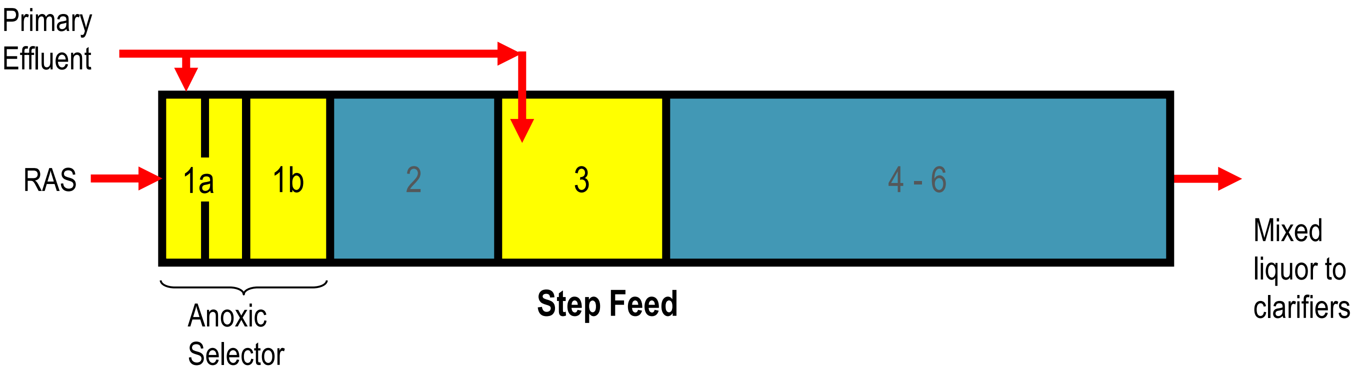
Steps	Description
Identify process configurations and metrics for optimization.	Guidance on operating parameters, criteria, and control setpoints that can be used to monitor progress to optimization.
Implement automation and controls	Select suitable on-line instruments, equipment, installed locations, and control logic for optimal performance
Document experience with process simulators for optimization.	List data needs and strategies that can be tested using process simulators.
Identify low cost upgrades to existing facilities to improve performance	Set cost metrics (such as a $/gpd) as guidance for WRRFs. Identify cost saving opportunities (see next item)
Benefits of optimization	Improved control, setpoints, automation that reduce existing nutrient removal. Conversion from BOD only treatment to nutrient reduction can reduce cost by improving tertiary treatment, reduce solids production, reduced chemical use.
Pitfalls of optimization	Risks of optimization includes leaving stranded assets, punitive regulations, added operator training and monitoring costs. Optimization strategies that use unused capacity (i.e. plant operates below design loading) may lose nutrient efficiency when loads increase to design capacity.
Making a Business Case	Develop evaluation metrics to consider Life Cycle Cost and also non-monetary criteria.
Develop decision tree to WRRF processes to achieve some nutrient reduction	Optimize an existing secondary process to achieve some nutrient reduction or improve performance and reduce cost of an existing nutrient removal process.
Identify opportunities to reduce nutrient discharged to streams by other means.	Nutrient reduction by means such as water reuse, sidestream treatment, groundwater injections, and other.
Reach out to WRRFs, managers, regulators, others.	Use workshops, webinars, and printed documentation to disseminate information. Target professional organizations.

CONVERSION FROM BOD TO NDN

Original BOD Removal Mode

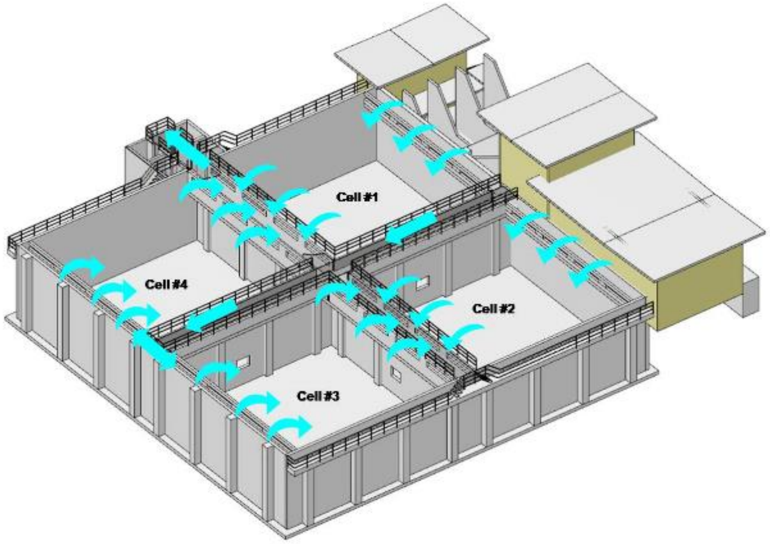


Step Feed Nitrification/Denitrification

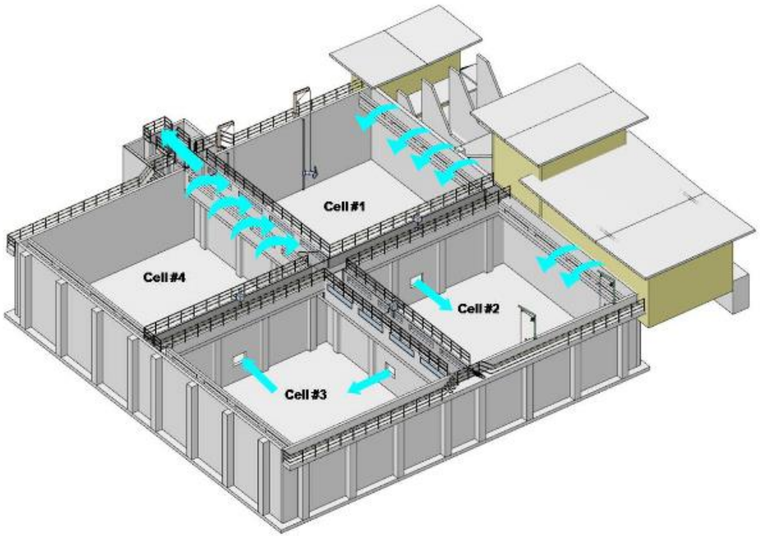


UPDATED DIFFUSERS, BAFFLES, PIPING

PLANT MODIFICATIONS (USE YOUR EXISTING SYSTEM)



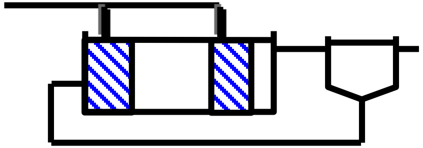
Original Process



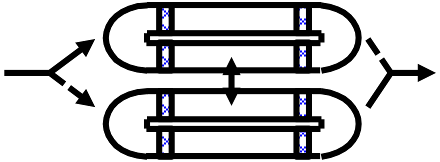
Phased Nitrification/Denitrification (PNDN)

PLANT C – PLANTS RUNNING GOOD BNR NOW (THOUGH NOT REQUIRED)

- Well optimized plant, BNR that exceeds long term design standards
- Example: MBR plant operating spare tankage; operating at very low DO
- Example: Optimized systems like oxidation ditch that is already well tuned
- *Challenge*: "Optimization" has already been done in many ways; risk of backsliding and loss of capacity with a cap



Step Feed



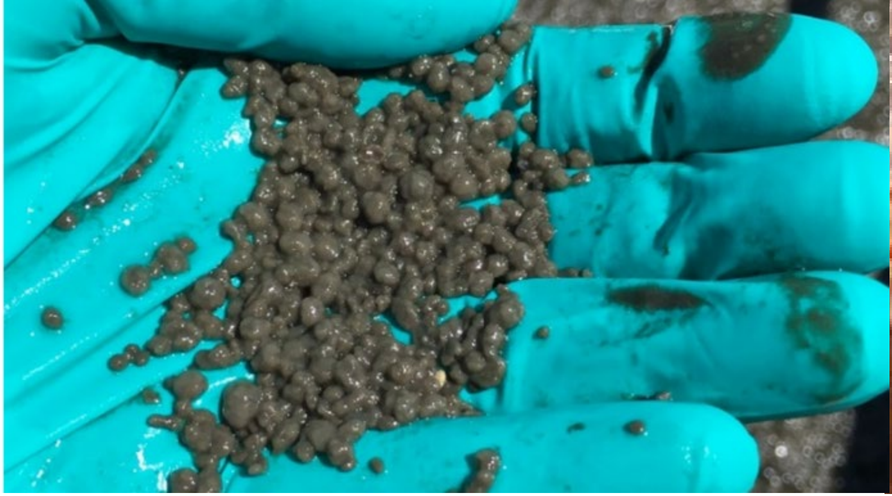
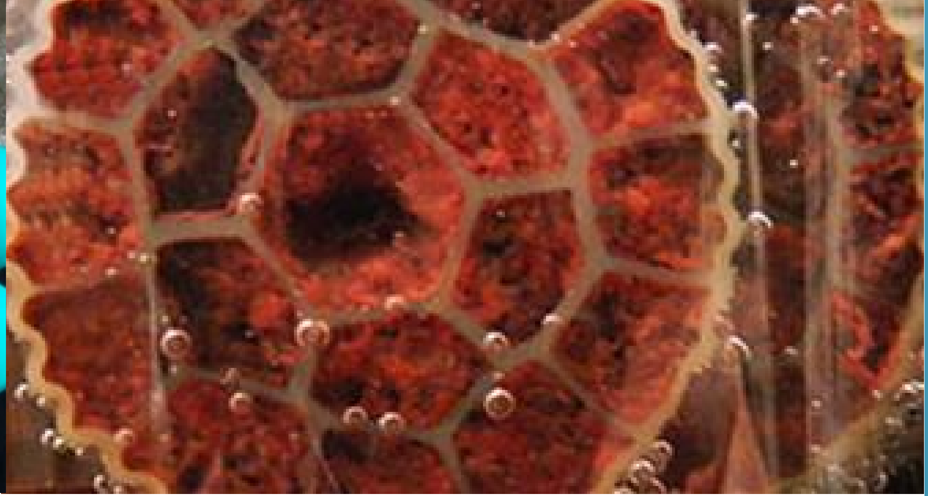
Oxidation Ditch

PLANT C – WHAT CAN WE DO?

- Know Your Data - get credit for your existing work to optimize
- Creativity – like **Plant A**, newer/creative technologies (sidestream, resource recovery)
- Look for Savings in Process – chemical use, power use, seasonal strategies, etc.
- Process Tuning – better instruments, better control, improved accuracy
- Don't assume optimization only means lower effluent nitrogen!

YOU CAN BE PROACTIVE AND MAKE PROGRESS

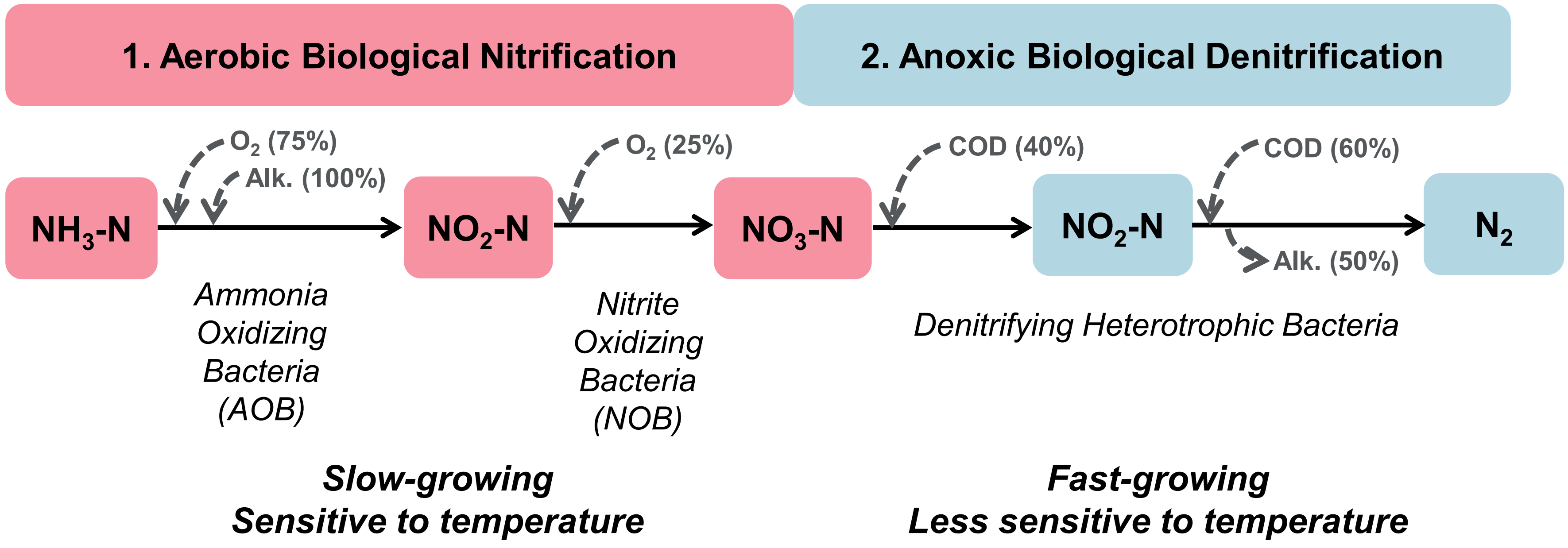
- Utilize an established framework to make your case and back it up with good data
- Take advantage of the DOE descriptions of optimization to find that creative angle - there is always a way to optimize in some form

Innovative Processes for Nitrogen Removal Optimization and Intensification

Bryce Figdore, PhD, PE

Nitrification is the critical path for N removal via biological nitrification-denitrification



N removal potential affected by limiting SRT, temperature, and substrate availability

N removal optimization: Long-SRT Nitrifying or BNR (Type B or C Plants)

Optimization themes involve managing carbon, alkalinity, and aeration energy demands

Denitrification focus
• Create anoxic zone(s) – baffles, etc.
• Add carbon – chemical or "free"
• Create carbon – fermentation
• Low DO simultaneous N-DN
• Deoxygenation zones

Nitrification focus
• Ammonia-based aeration control (ABAC)
• Ammonia vs. NOx (AVN) aeration control
• Operation to promote short-cut N removal

New aeration control approaches for N removal optimization

- **Ammonia-based aeration control (ABAC)**
  - On/Off aeration at fixed DO
  - Continuous aeration at variable DO
  - **Benefits**: Reduce aeration and alkalinity demand

- **Ammonia vs. NOx control (AVN)**
  - Target NH3-N / NOx-N ratio = 1
  - Compatible with continuous or on/off aeration
  - **Benefits**: Best TN removal efficiency point and possible short-cut N removal

Focus on TIN in Puget Sound allows opportunities for ABAC and AVN

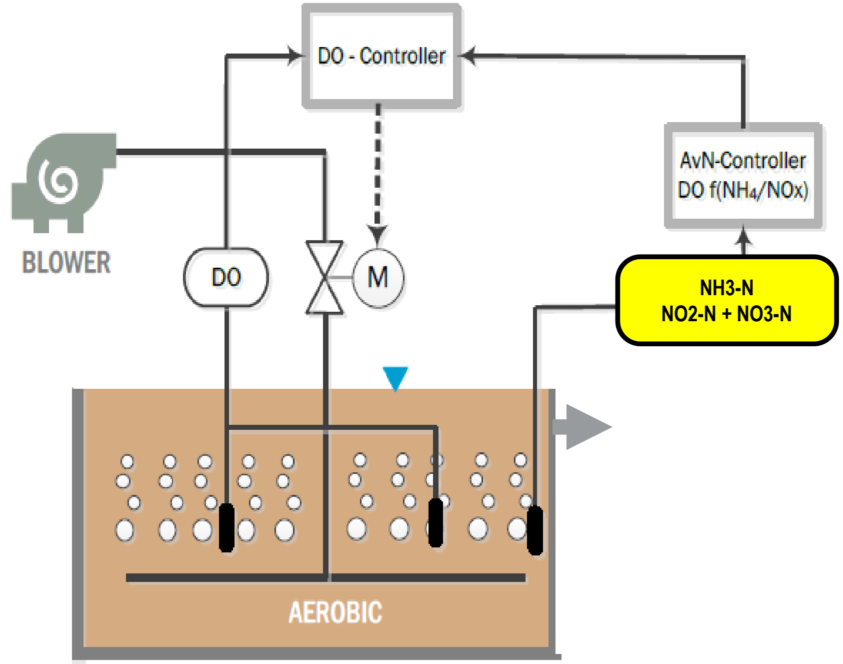
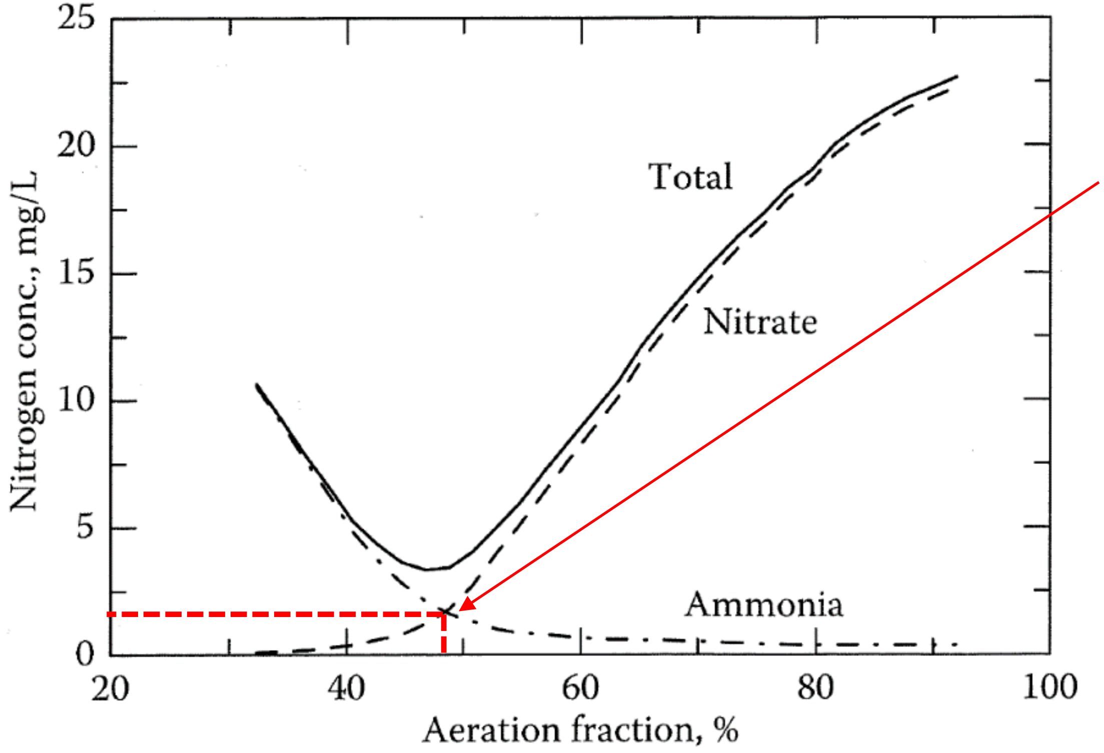


Figure adapted from Regmi et al. (WEFTEC 2017)

AVN aeration control concept

AVN background: Optimal N removal where NH3-N = NO3-N



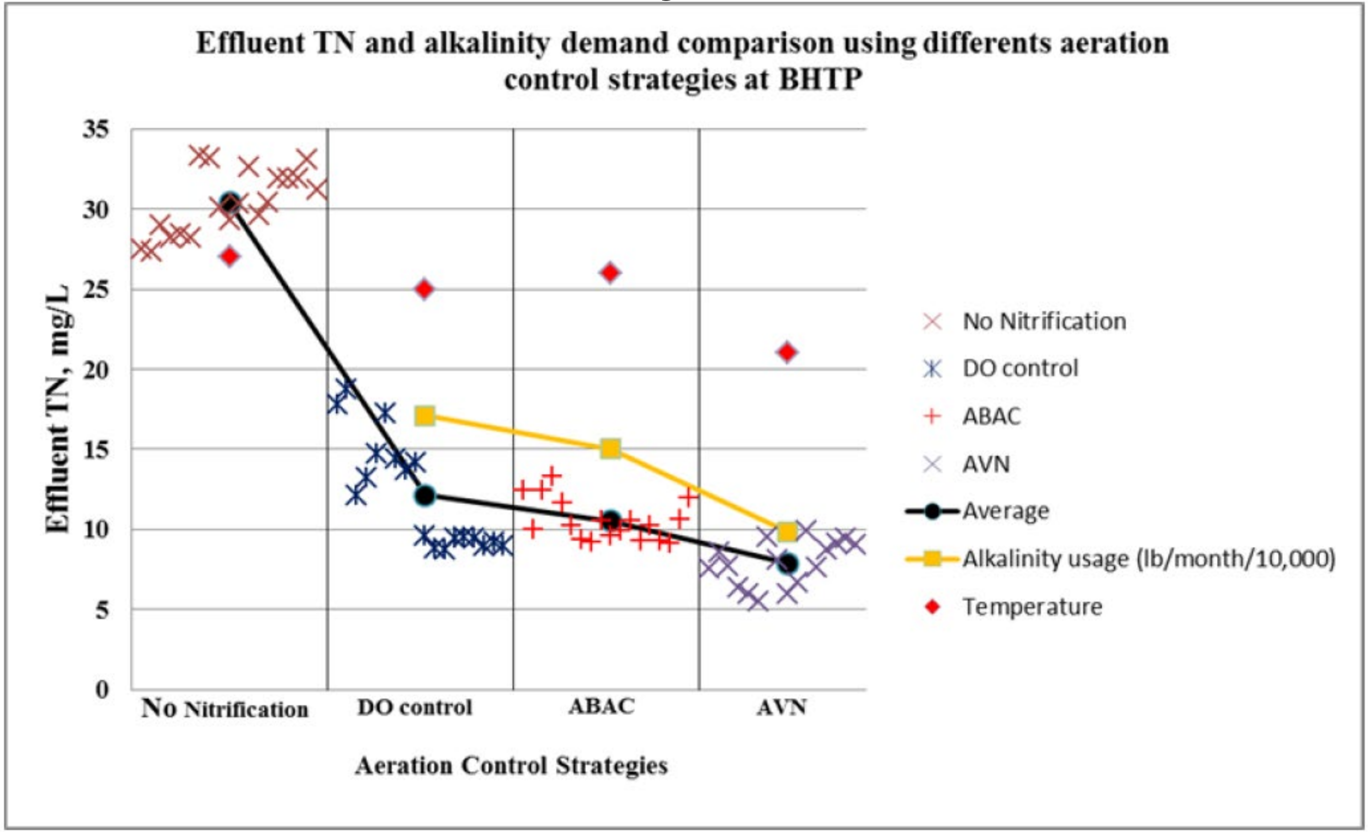
Inflection point at NH3-N = NOx-N:

- **Lowest TN**
- **Minimum energy input per mass N removed**
- **Maximum N removal given influent C:N ratio**

Grady et al. (2011) Biological Wastewater Treatment, 3rd ed.; Intermittently-aerated CSTR; p223

Only nitrify what can be denitrified *(as allowed by permit)*

AVN implementation at HRSD Boat Harbor (25 mgd) optimizes TN removal and reduces alkalinity demand



Data courtesy World Water Works

N removal optimization: Low-SRT Activated Sludge (Type A Plants)

Optimization themes involve process intensification with nitrification focus

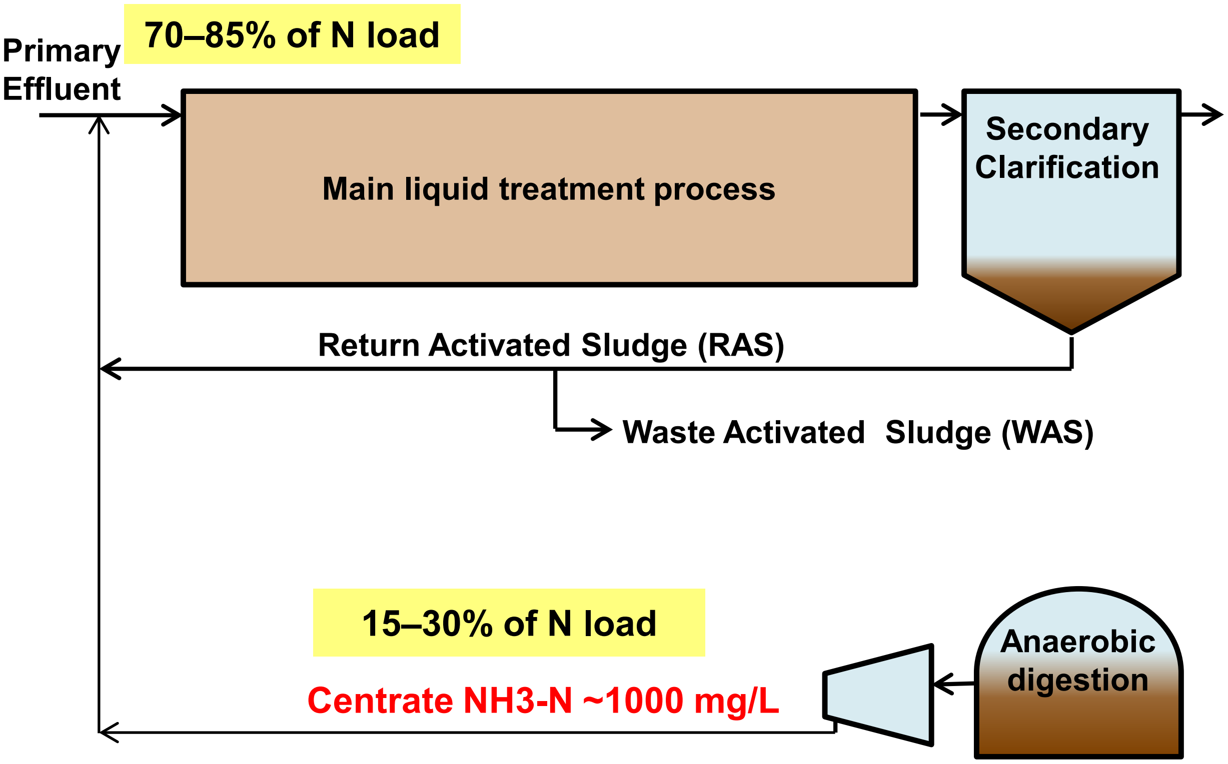
N load management focus

- Sidestream treatment
- Biosolids processes minimizing return N load → aerobic-anoxic digestion, composting, drying, etc.

Nitrification focus

- Increase effective MLSS and SRT
  → Step feed, RAS Re-Aeration, Media, MBR, Granular Sludge
  → i.e., Intensification
- Seasonal operational schemes with swing zones
- Parallel / split treatment
- Bioaugmentation / seeding

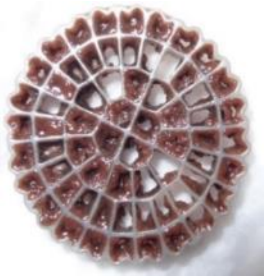
Sidestream N loads: “Low hanging fruit” for separate treatment and overall process optimization



Sidestream deammonification with anammox bacteria

Attached growth

(Anita™MOX)

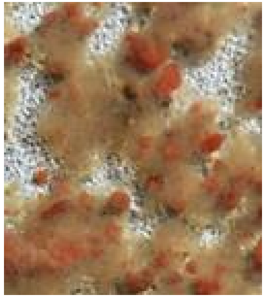


Granular growth

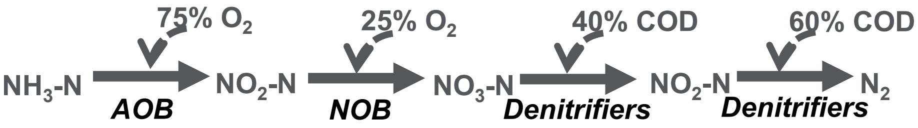
(AnammoPAQ™)

Hybrid floc / granular growth

(DEMON®)



Conventional nitrification-denitrification:



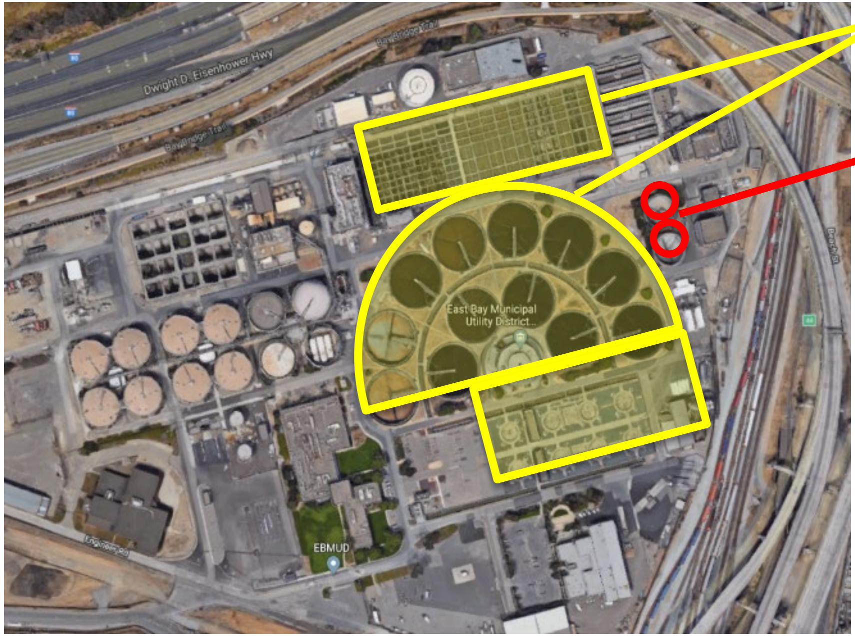
Partial nitritation-anammox (deammonification):

UTILITY BENEFITS

- Remove ~15-30% of N load
- No external carbon required
- Energy efficient – 60% savings vs. conventional N-DN
- Very low footprint (>1.0 kg NH_3-N/m^3-d) --- Small reactor / Repurposed tank

Sidestream deammonification / anammox benefits

- Small footprint, economical first step
- Highly attractive for centralized biosolids / organics facilities
- Potential to re-purpose unused tanks
- SF Bay HPO-AS example below



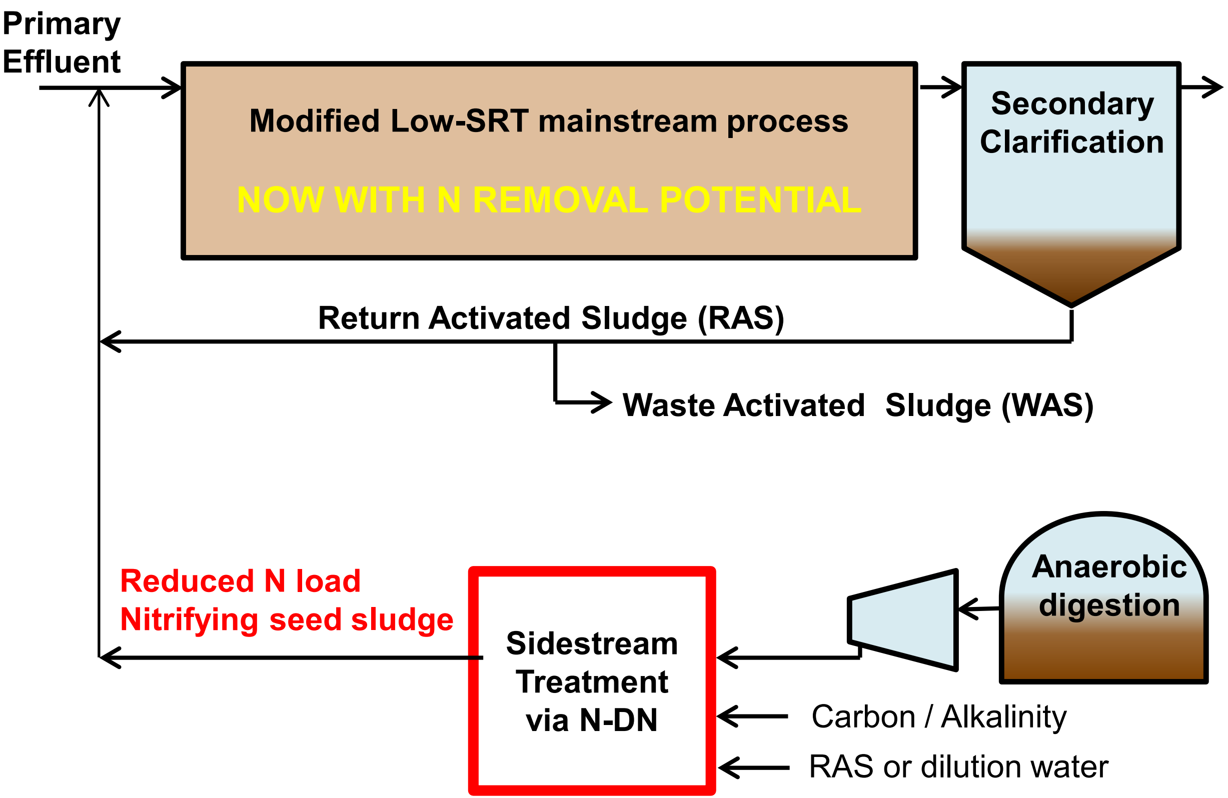
Primary clarifiers and Secondary HPO-AS

Convert to sidestream deammonification

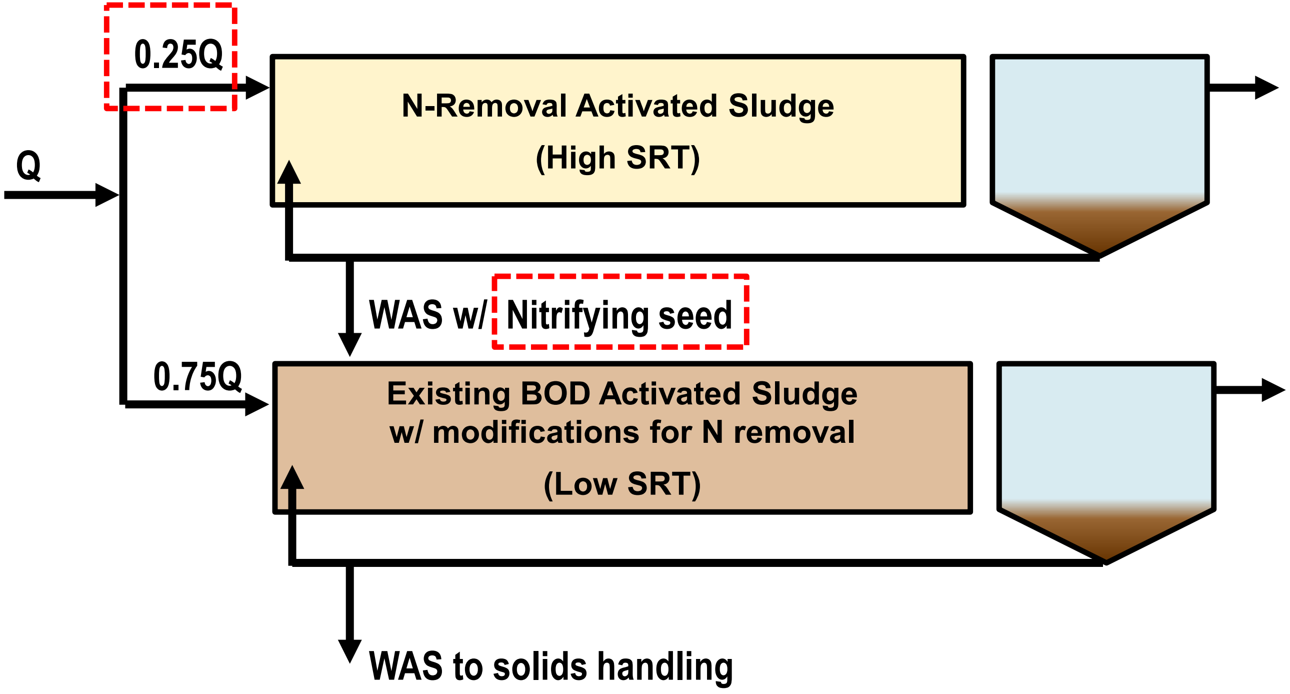
~40% reduction in effluent TN load

(High sidestream load from regional solids and organics treatment)

Sidestream treatment for N removal and nitrification bioaugmentation



Parallel / Split treatment approach provides N removal and nitrification bioaugmentation potential



Nitrogen Removal Intensification Technologies

Granular or densified sludge

MOB™ biocarrier

Microvi MNE™ engineered biocatalyst

inDENSE™

MABR

Technology evaluation may be considered in optimization planning

- **Achieve incremental N removal**
- **Technology demonstration**

Aerobic Granular Sludge

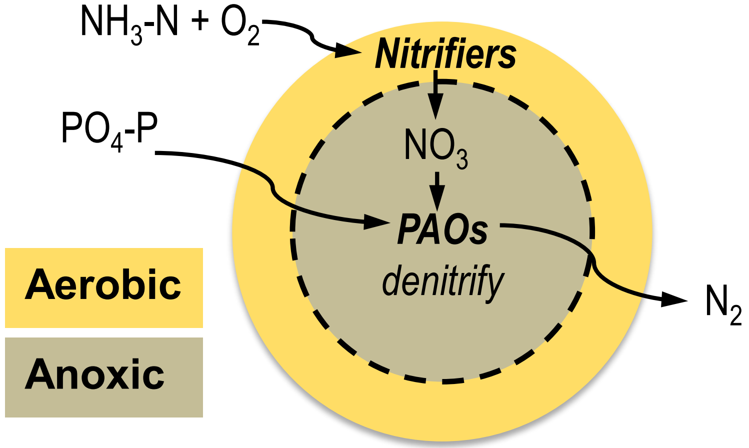
DESCRIPTION:

Granular sludge growth selected in SBR process

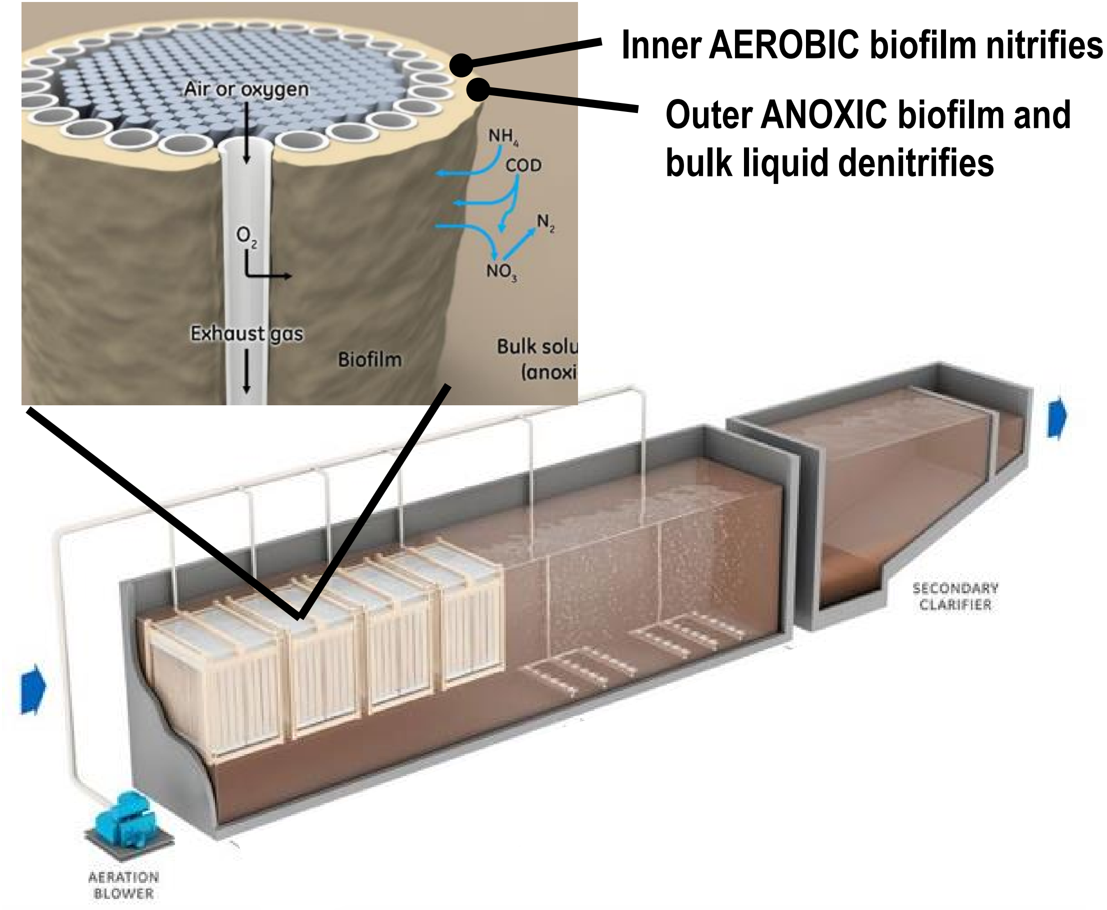
BENEFITS:

- Fast-settling solids
- Increased MLSS
- Small footprint
- Energy efficient

- ***Emerging approaches leverage granular growth principles in flow-through reactors***
- ***Seeding / bioaugmentation potential***



Membrane-Aerated Biofilm Reactors (MABR)



DESCRIPTION:

Membranes used for aeration and biofilm growth

BENEFITS:

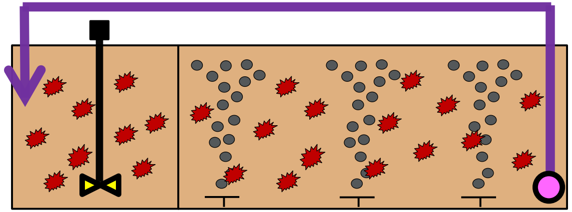
- Efficient aeration - 4x fine bubble
- Simultaneous N-DN
- Complete nitrification not required
- Phased implementation possible

Nuvoda MOB™ mobile organic biofilm

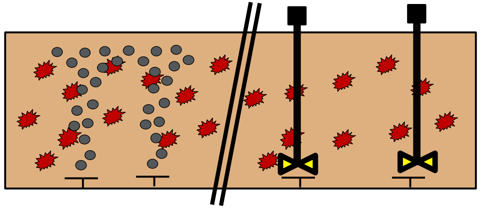
Kenaf media

500-um drum screen

Flexible deployment options



e.g. MLE (Anoxic-Aerobic) Process



e.g. On-Off Aeration

DESCRIPTION:

- Kenaf media added to activated sludge
- Media captured and returned via drum screen on WAS line

BENEFITS:

- N removal at low “apparent” SRT
- Conventional DO concentrations with simultaneous N-DN potential
- Flexible deployment options

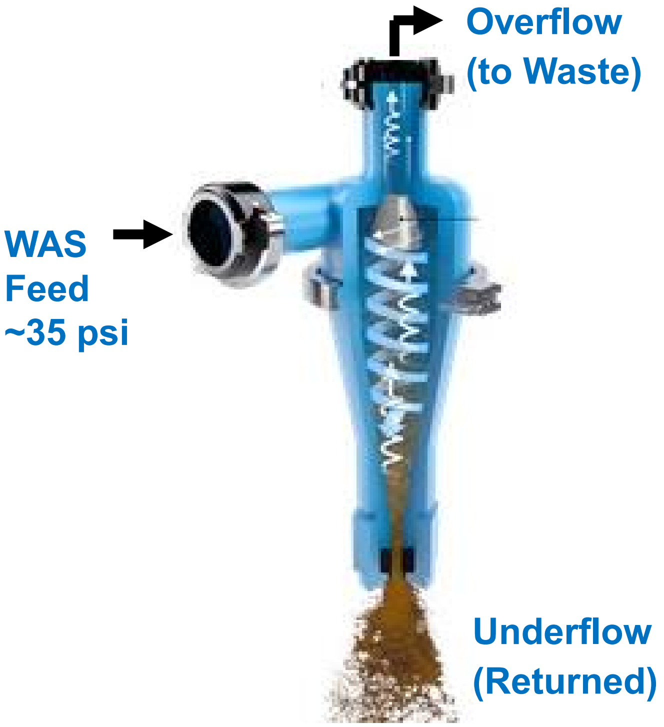
inDENSE™ WAS hydrocyclones

DESCRIPTION:

Hydrocyclone on WAS line for selective wasting of poorly-settling sludge

BENEFITS:

- Improve/stabilize SVI
- Allow for increased MLSS and secondary clarifier solids loadings
- Possible granular sludge selection



Microvi Microniche (MNE™) biocatalyst

DESCRIPTION:

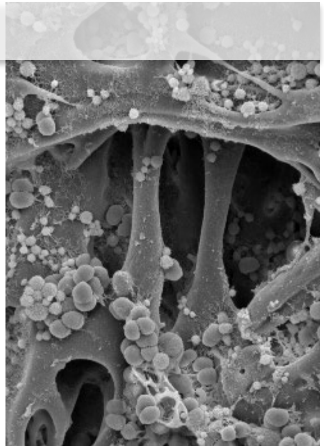
Pure culture of bacteria immobilized on porous polymer carrier.

Nitrification and Denitrification versions available.

BENEFITS:

- High microorganism density
- Low footprint; ~2 hr HRT for Nite
- Metabolically active, non-growing phenotype (cryptic growth)

  → No solids handling costs



“Starting point” impacts N removal optimization approaches and potential role of new technologies


Nutrient Reduction by Other Means – Reclaimed Water

Jeff Hansen, PE

NUTRIENT REDUCTION BY OTHER MEANS – RECLAIMED WATER

- History of reclaimed water in nutrient load management – LOTT
- Multiple benefits of reclaimed water – current practices
- Future opportunities – Puget Sound and elsewhere

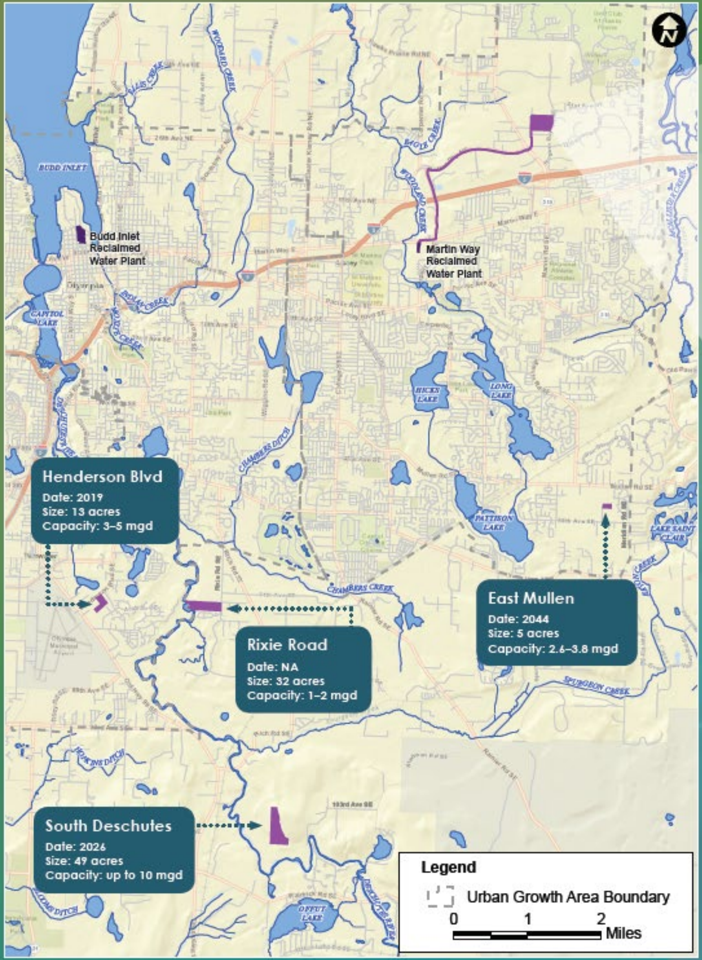
LOTT: HIGHLY MANAGED PLAN

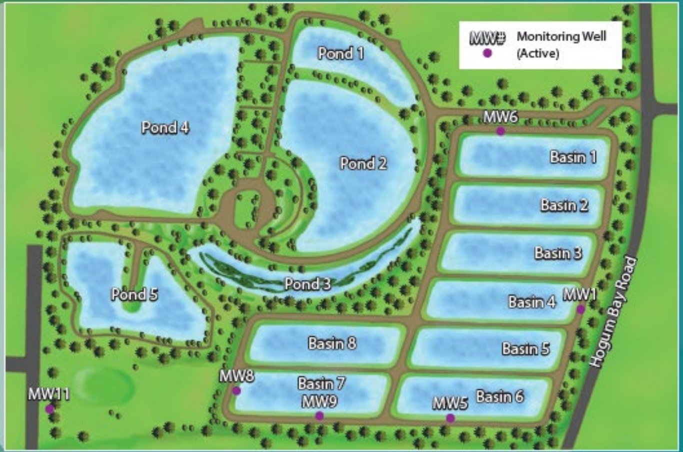
- Long range plan – developed >20 years ago
  - Reclaimed water to divert future flows from marine discharge
- Addresses
  - Capacity constraints at Budd Inlet plant
  - Nutrient loading limitations
- Additional benefits
  - Water resource available to water purveyors
  - Reclaimed water not directly reused will recharge groundwater

Budd Inlet Treatment Plant

Hawks Prairie Wetland Ponds and Recharge Basins

Infiltration Sites *(Existing and Potential Future)*





Hawks Prairie

Date: Online since 2006

Size: 41 acres
25 acres (wetland ponds)
8 acres (basins)

Capacity: 2 mgd (current)
5-8 mgd (future)

Notes

- mgd: million gallons per day
- Dates for futute sites are estimates of when those sites will come online

RECLAIMED WATER: KEY CHALLENGES

Residual chemicals in the news

Drugs found in salmon, from tainted wastewater

- Samples collected in Tacoma and Bremerton show 81 drugs and personal-care products
- Scientists don't know if high levels because of residents' drug use or wastewater-treatment processes
- Findings don't indicate threat to human health

From left, Michael Caputo, Richard Ramsden and Stuart Munsch collect fish in a beach ... Commencement Bay in Tacoma.

SEE DRUGS, 5A

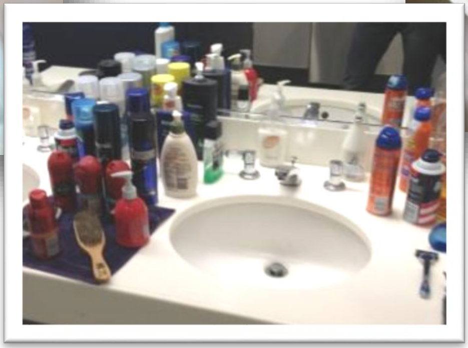
Drugs, household chemicals are a risk 'we haven't fully begun to understand' (The Olympian)

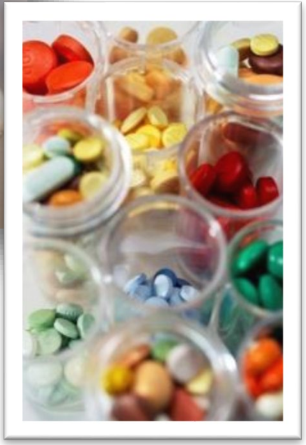
Keep Drugs Out of the Water Supply (Parade)

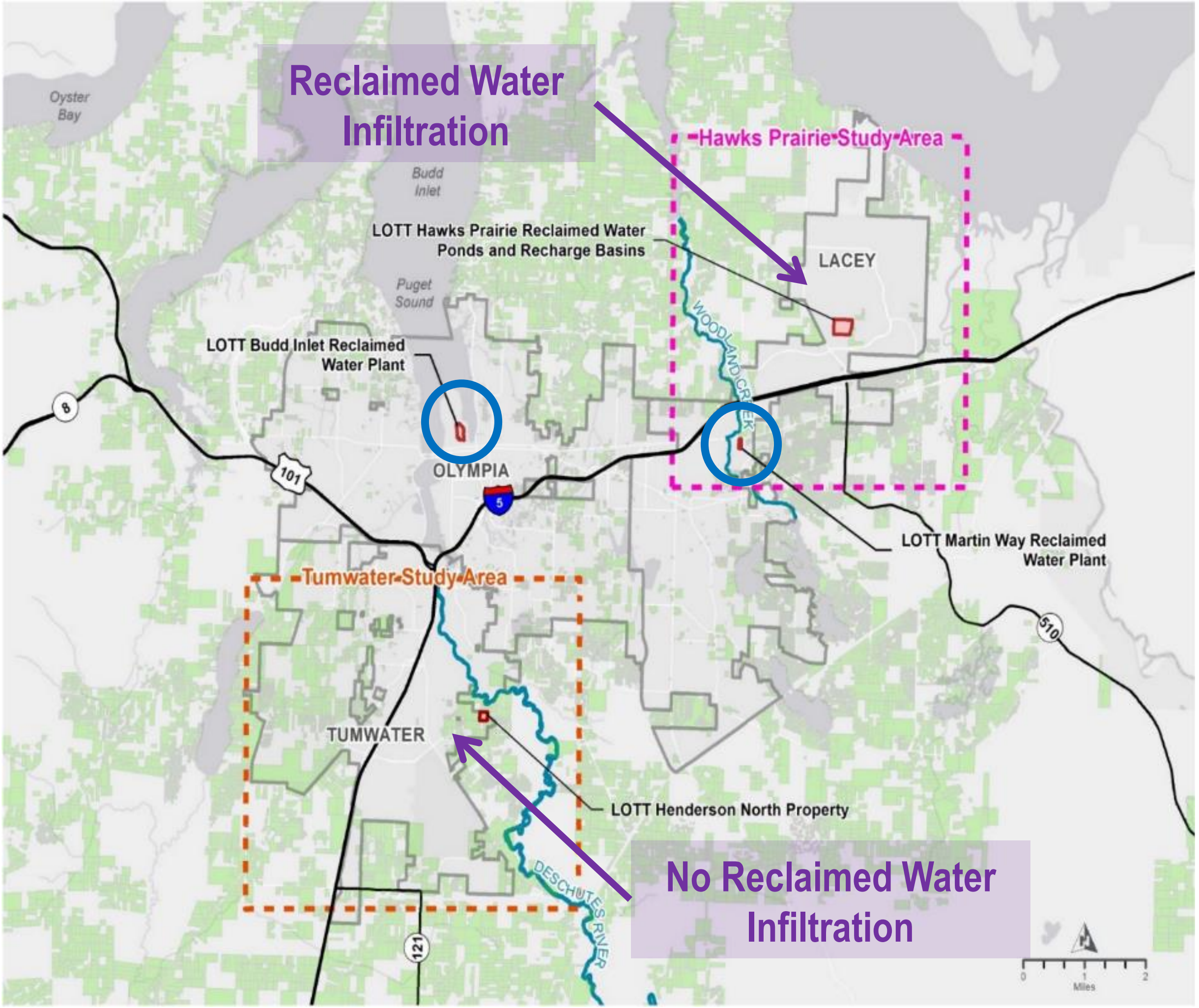
Community concerns

LOTT'S PROACTIVE RESPONSE:
RECLAIMED WATER INFILTRATION STUDY

What are the risks from infiltrating reclaimed water into groundwater because of chemicals that may remain in the water from products people use every day, and what can be done to reduce those risks?







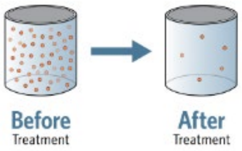
STUDY AREA

- 2 treatment plants
- 2 areas studied
  - With infiltration
  - Without infiltration

SUMMARY OF STUDY RESULTS TO-DATE

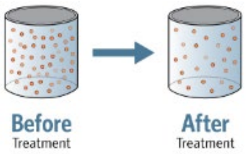
BNR treatment process (high SRT) effective at removing many residual chemicals, though some are recalcitrant

Removal > 85%



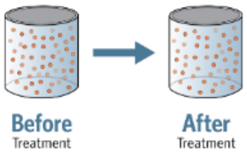
Acesulfame K
Metformin
Atenolol
Cotinine

Removal = 33-85%

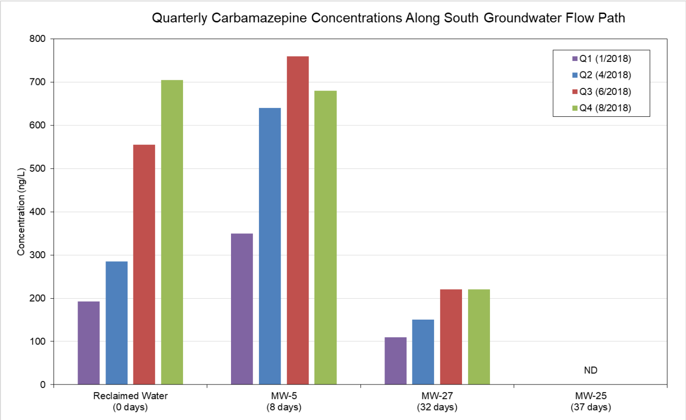


Sucralose
Carbamazepine
Fluoxetine
Lopressor
Primidone
Iohexal
TCPP

No Removal



1,4-Dioxane
Iopromide
TCEP



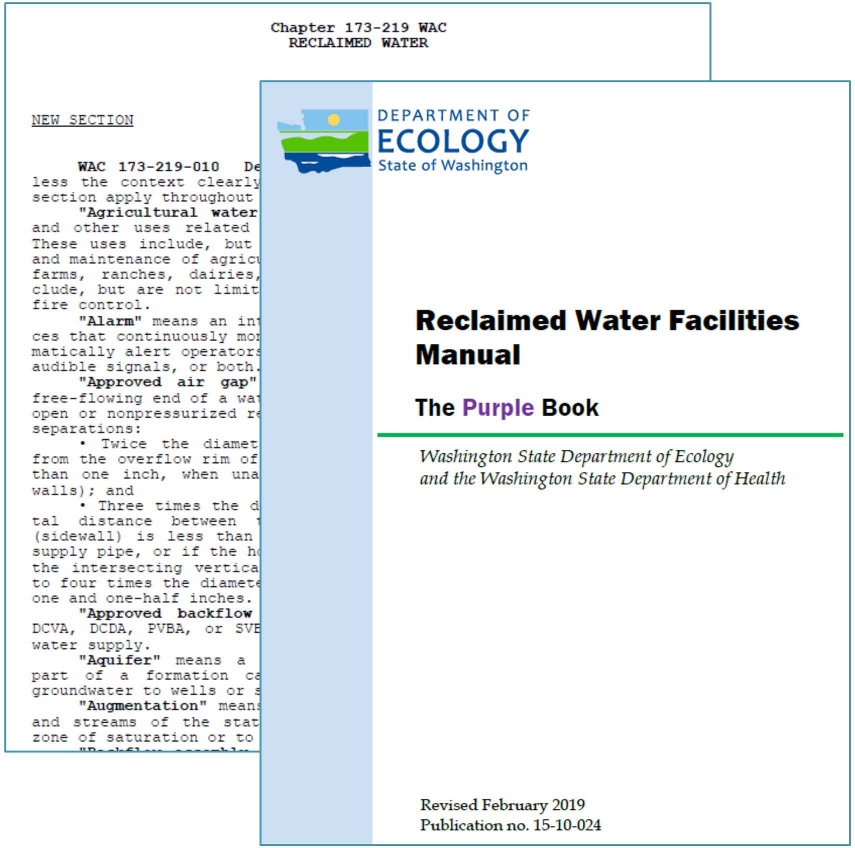
Soil aquifer treatment and dispersion reduces concentrations as reclaimed water travels in groundwater

Risk assessment underway;

Study to be completed early 2021

RECLAIMED WATER: REALIZE MULTIPLE BENEFITS

- Wastewater
  - Divert flow from marine discharge
- Water Supply
  - Reduce peak demand
  - Water rights mitigation
- Environmental
  - Groundwater recharge
  - Stream flow augmentation
  - Wetlands enhancement



RECLAIMED WATER FOR WATER RIGHTS MITIGATION:
LACEY/OLYMPIA WOODLAND CREEK GROUNDWATER RECHARGE FACILITY

- Recharge shallow aquifer to support approval of groundwater rights
- Source water
  - LOTT Martin Way Class A reclaimed water
- Recharge site
  - Woodland Creek Community Park (4.5 acres)
  - Recreational use open space
  - Subsurface infiltration approach used to retain existing use

WOODLAND CREEK GROUNDWATER RECHARGE

- Online since summer 2014
- Typical flow rate: 0.3 – 1.0 mgd
- Interagency coordination
  - Reclaimed Water: LOTT
  - Facility Ownership: Lacey / Olympia
  - Facility Operation: Lacey

FUTURE OPPORTUNITIES RELATED TO PUGET SOUND RESTORATION / ENHANCEMENT

- Ecology Streamflow Restoration efforts (RCW 90.94)
  - Mitigation for withdrawals of permit exempt wells in rural areas
  - Watershed Restoration and Enhancement (WRE) committees developing mitigation plans and identifying projects
- Areas considering reclaimed water
  - WRIA 14 (Shelton)
    - Fairmont WWTP – 0.5 mgd to be used mostly for groundwater infiltration
  - WRIA 15 (Kitsap County)
    - Kingston WWTP – irrigation at golf course and groundwater infiltration
- Potential throughout Puget Sound to address nutrient load management at the same time as mitigating groundwater withdrawals

THIS IS A TREND OCCURRING ELSEWHERE

Hampton Roads Sanitation District

(SWIFT: Sustainable Water Initiative for Tomorrow)

- Reduce nutrient discharge to local rivers and Chesapeake
- Replenish groundwater supply (Potomac Aquifer)
- Combat sea level rise
- Protect from saltwater intrusion
- Bolster economy by increasing water supply

HRSD's Nansemond Treatment Plant in Suffolk, Virginia

Source: https://www.hrsd.com/swift/hrsds-highly-treated-water

Thank you!

Questions? – Contact Steffran Neff

(Steffran.Neff@hdrinc.com)

HDR

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