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FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES (FOSNRS) STUDY

Technology Classification, Ranking and Prioritization Workshop

May 28, 2009

SCHOOL OF MINES 1874 COLORADO

AET
Applied Environmental Technology

OTIS ENVIRONMENTAL CONSULTANTS

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Agenda

- Introduction and background
  - FOSNRS Study Overview
  - Task A – This task
- Objectives
- Onsite Nitrogen Reduction Technology Classifications
  - Review of Wastewater Characteristics & Treatment
  - Nitrogen Cycle
- Onsite Nitrogen Reduction Systems Identified to Date
- Nitrogen Reduction Technology Evaluation Methods
- Nitrogen Reduction Technology Testing Priority
- Summary
- Next Steps

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Introduction and Background

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FOSNRS Study Background

- Quality of Florida's surface and groundwater resources are impacted by excess nitrogen
- Onsite sewage treatment and disposal systems (OSTDS) one source of nitrogen
- Laws of Florida, 2008-152, Specific Appropriation 1682 directed FDOH to conduct a study to further develop cost-effective nitrogen reduction strategies for OSTDS
- FDOH ITN No. DOH08-026 identified four primary tasks for the study; to be controlled by RRAC
- The 2008 Florida legislature appropriated $900,000 for Phase I of a multi-year project

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FOSNRS Study Overview

- **Task A:** Technology Evaluation for Field Testing: Review, Prioritization, and Development
- **Task B:** Field Testing of Technologies and Cost Documentation
- **Task C:** Evaluation of Nitrogen Reduction Provided by Soils and Shallow Groundwater
- **Task D:** Nitrogen Fate and Transport Modeling
- **Task E:** Project Management, Coordination and Meetings

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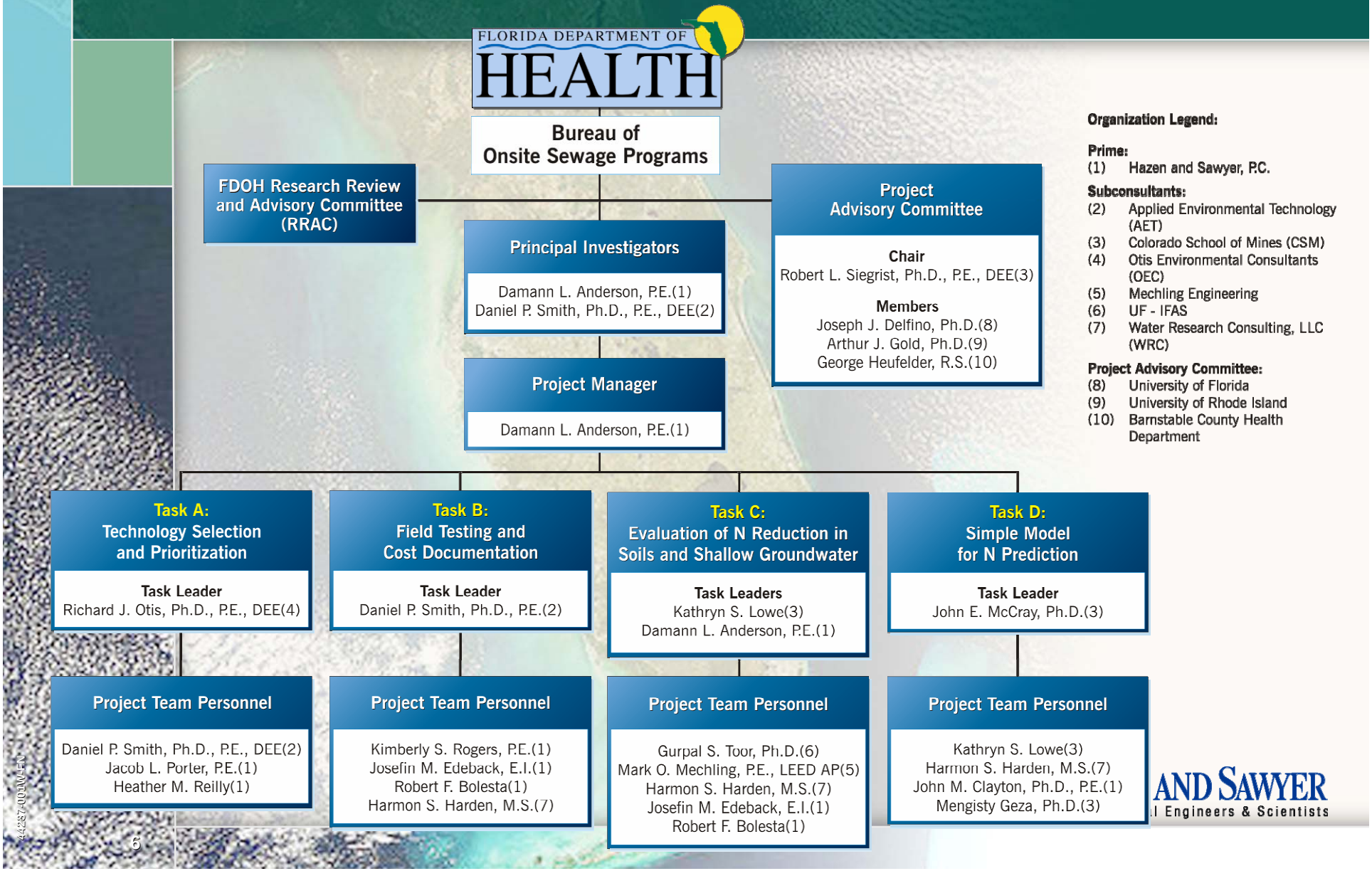
Florida Onsite Sewage Nitrogen Reduction Strategies (FOSNRS) Project Team



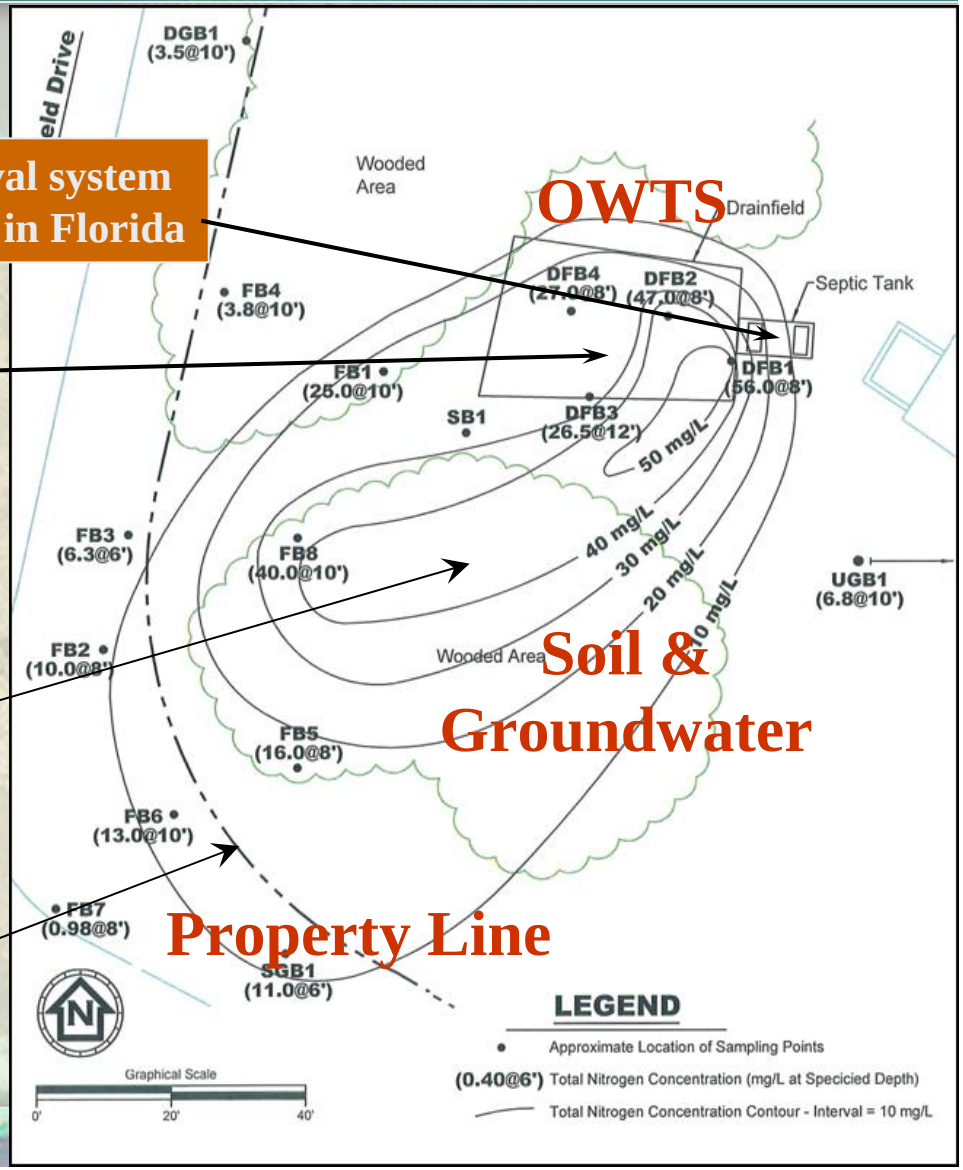
How do tasks relate to N-removal strategies?

Task A – N-removal system options for OWTS in Florida

Task B – OWTS N-removal performance verification

Task C – Evaluation of N reduction in soil & GW in Florida

Task D – Decision tools for setting N-removal goals for OWTS



Focus of this workshop: Task A

- Task A Objectives
  - Evaluate and prioritize technologies for field testing and further development
- Task A Subtasks
  1. Perform literature review to evaluate available onsite nitrogen reduction technologies
  2. Develop technology classification scheme
  3. Formulate criteria for ranking of nitrogen reducing technologies
  4. Rank and prioritize nitrogen reduction technologies for field testing
  5. Test facility design and implementation
  6. Technology Development PNRS II

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Workshop Objectives

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Objectives

- Review the Project Team's proposed onsite nitrogen reduction technology classifications, evaluation criteria, criteria weighting, and ranking methodology.
- Develop consensus on the procedures which will be used to identify and prioritize the technology list for future field testing.

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Review of Wastewater Treatment Fundamentals

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Nitrogen Cycle and N Chemistry Review: Nitrogen Species

- Organic Nitrogen
- Ammonia – NH_4

Total Kjeldahl Nitrogen (TKN)

- Nitrite – NO_2
- Nitrate – NO_3

Total Oxidized Nitrogen

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Onsite N Reduction Technology Classification Nitrogen Cycle and N Chemistry Review

Nitrogen in the Wastewater:

- EPA estimates we discharge ~11.2 grams of nitrogen per person into WW each day
  - 70 - 80% as toilet wastes
  - 10 - 15% is food preparation
  - Household products

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Onsite Wastewater Constituents (WERF, 2008)

	Raw Wastewater	Septic Tank Effluent
$cBOD_5$	337	153
COD	905	324
TN (as N)	63	54
NH_3 (as N)	47	36
TP (as P)	19	10
Alkalinity	-	503
TS	996	855
TSS	405	79

All units in mg/L

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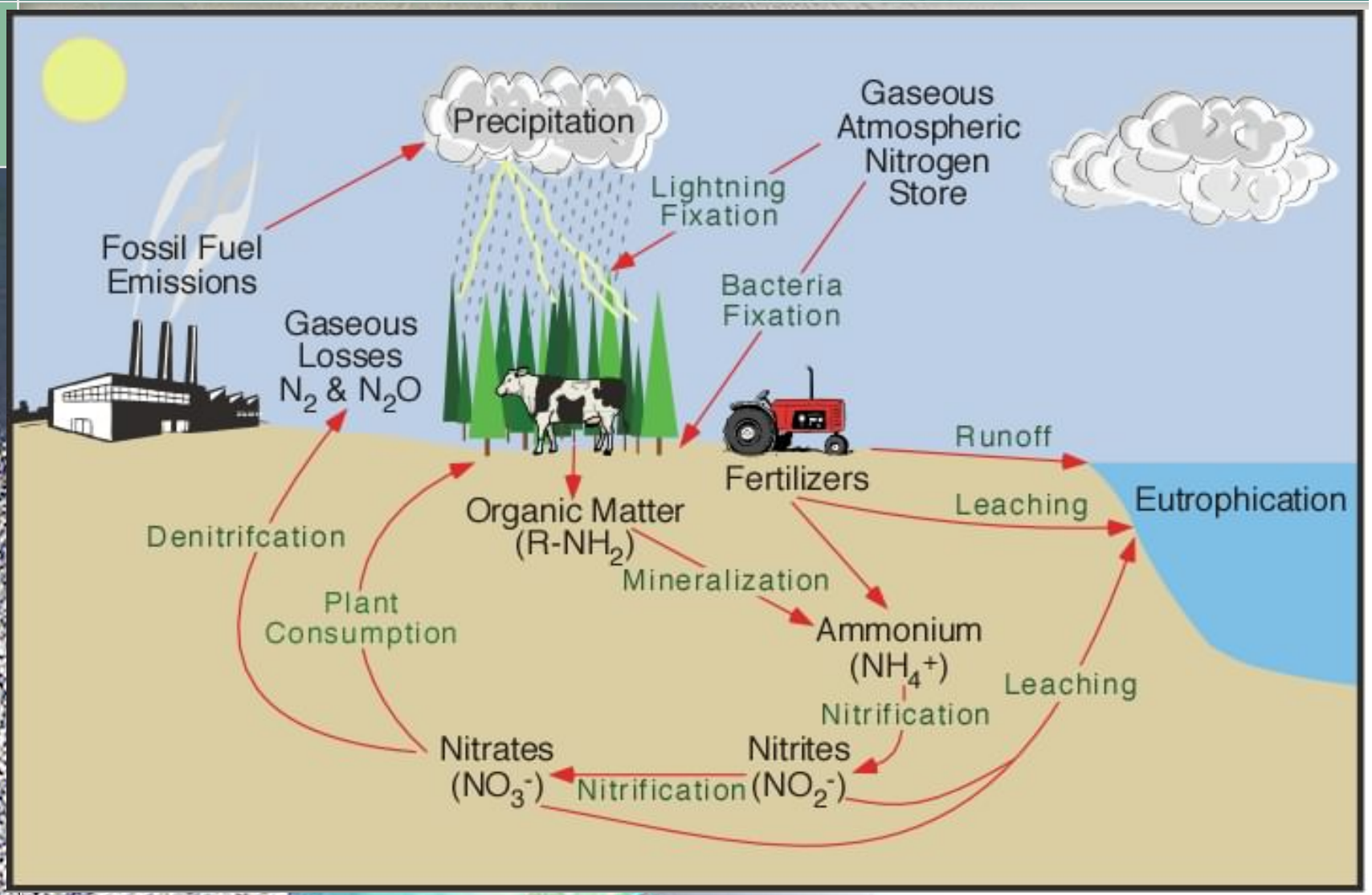
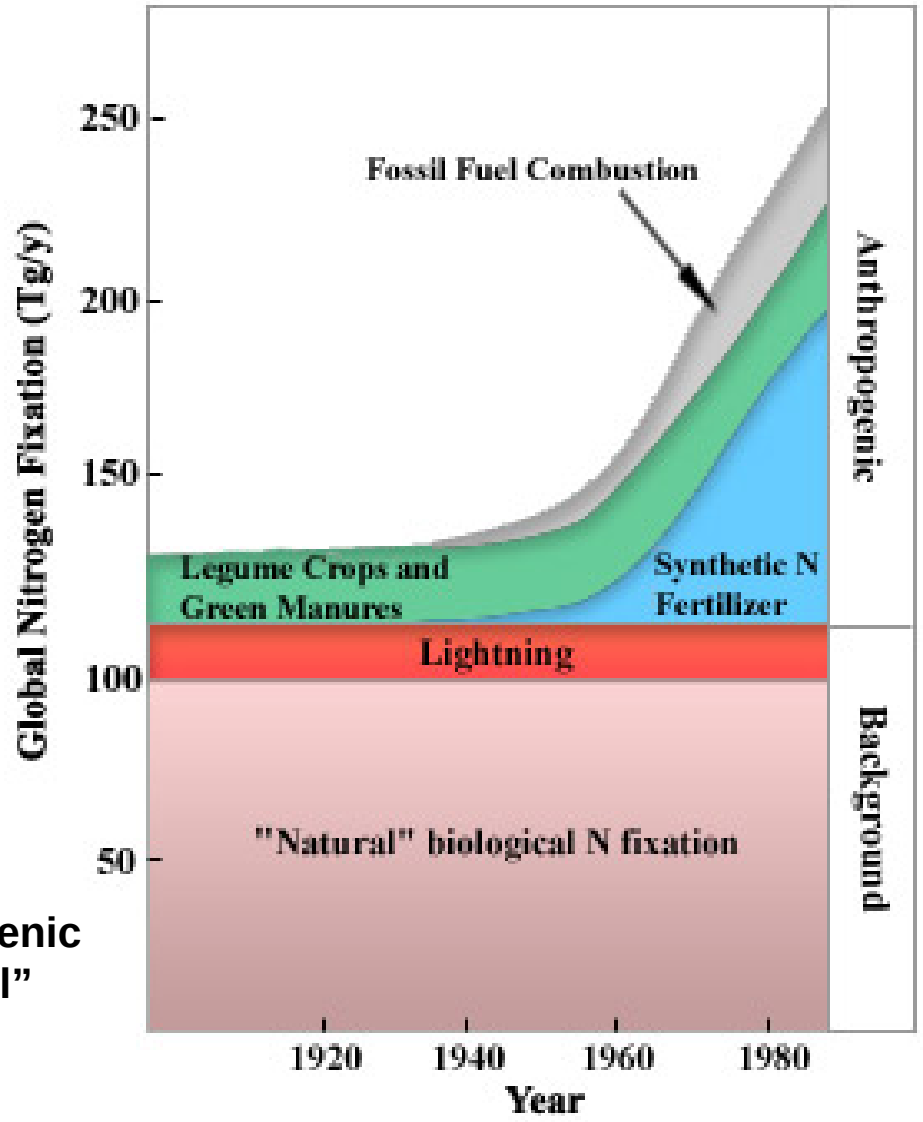
Nitrogen Cycle and N Chemistry Review



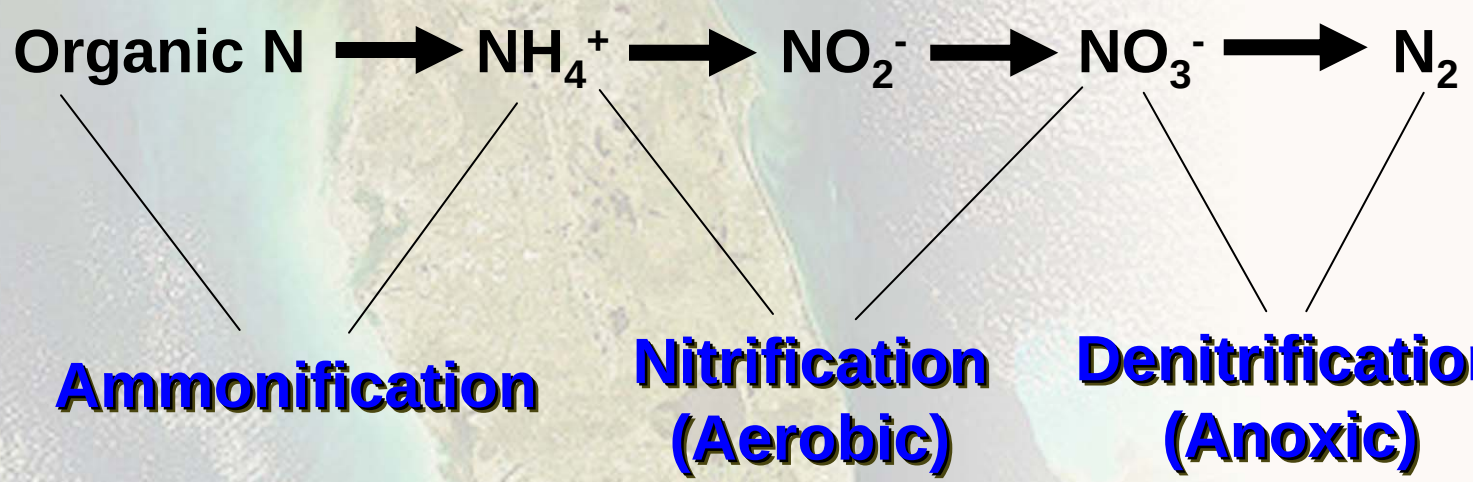
Nitrogen Cycle and N Chemistry Review: Man's Impact on Global N

Anthropogenic Activities Impact



Recent increases in anthropogenic N fixation in relation to "natural" N fixation (Harrison 2003)

Biochemical Transformations



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Nitrogen Cycle and N Chemistry Review

Nitrogen Mineralization (Ammonification):

- Nitrogen incorporated into organic matter can be converted back into organic nitrogen by nitrogen mineralization (decomposition of dead organisms)

$$\text{organic N} \rightarrow NH_4^+$$

- Ammonification converts the organic nitrogen back into ammonium
- Ammonification makes the nitrogen available for use by plants or for further transformation into nitrate (NO_3^-) through nitrification

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Nitrogen Cycle and N Chemistry Review

Nitrification:

- Nitrification is a biological process that converts ammonium into nitrate
- Chemoautotrophic bacteria use the energy released by conversion using inorganic rather than organic carbon compounds to sustain growth
  - Oxygen required
  - Sufficient alkalinity required
  - Sensitive to cold temperatures

$$NH_4^+ \rightarrow NO_3^-$$

- Nitrate produced (- charged) and in soils, not adsorbed but travels with the soil water until captured or taken up by plant roots

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Nitrogen Cycle and N Chemistry Review

Denitrification:

- Denitrification is a biological process that ultimately breaks nitrate down to nitrogen gas
- Process is used by facultative heterotrophic bacteria to obtain their energy for growth
- Under anoxic conditions, heterotrophs, which use organic carbon for energy, use the oxygen from the nitrate molecule to accept the electron received during the degradation of organic carbon

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

- Only nitrogen transformation that removes nitrogen from ecosystems

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Wastewater Treatment: Biological N Removal

Biological Nitrogen Removal

Nitrification: conversion of ammonia to nitrate:

$$NH_4^+ + 2\ O_2 \rightarrow 0.038\ C_5H_7O_2N + 0.96\ NO_3^- + 1.92\ H^+$$

Denitrification: reduction of nitrate to N_2 gas:

Heterotrophic

$$NO_3^- + 0.94\ CH_3OH + 0.94\ H^+ \rightarrow 0.057\ C_5H_7O_2N + 0.44\ N_2 + 2.27\ H_20 + 0.71\ CO_2$$

Autotrophic

$$NO_3^- + S^o + 0.22\ CO_2 + 0.66\ H_2O \rightarrow 0.044\ C_5H_7O_2N + SO_4^{-2} + 0.48\ N_2 + H^+$$

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Wastewater Treatment: Biological N Removal

Primary Treatment

Mineralization of organic N to TKN (mostly ammonia – NH_4)

Nitrification

TKN (Ammonia and organic N) oxidized to nitrate (NO_3) by nitrifying bacteria, requires oxygen

Denitrification

Nitrate converted to N_2 in anoxic environment; requires supply of electron donor

Dispersal

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Onsite Nitrogen Reduction Technology Classifications

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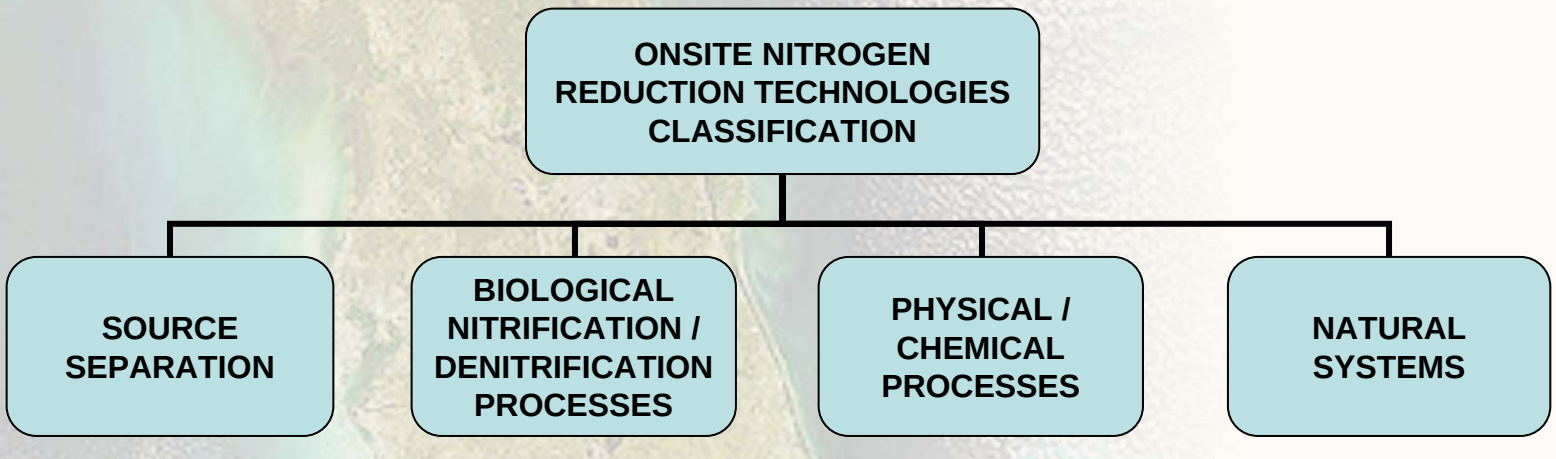
Unit Process Basis for Technology Classifications

- Followed typical wastewater engineering evaluation
- Based on unit operations and processes
  - Physical, Chemical, and Biological processes
  - Source Separation was included due to high nitrogen content of toilet waste stream
  - Natural systems used to classify systems utilizing the assimilative capacity of the receiving environment

Onsite N Reduction Technology Classifications



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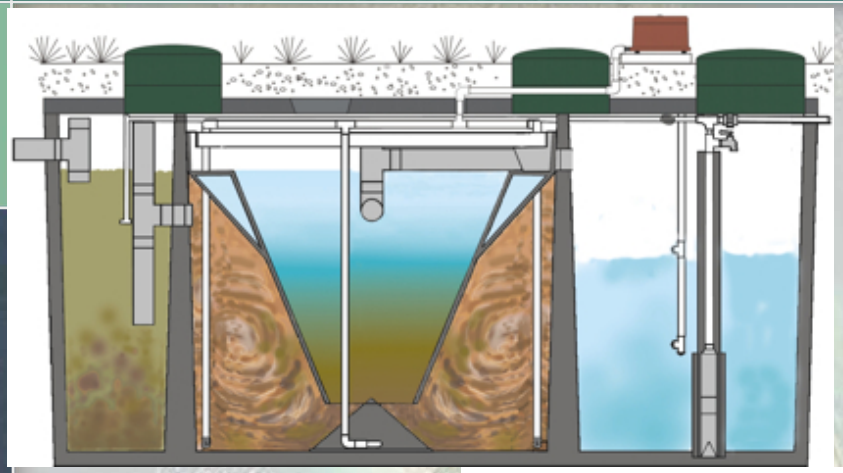
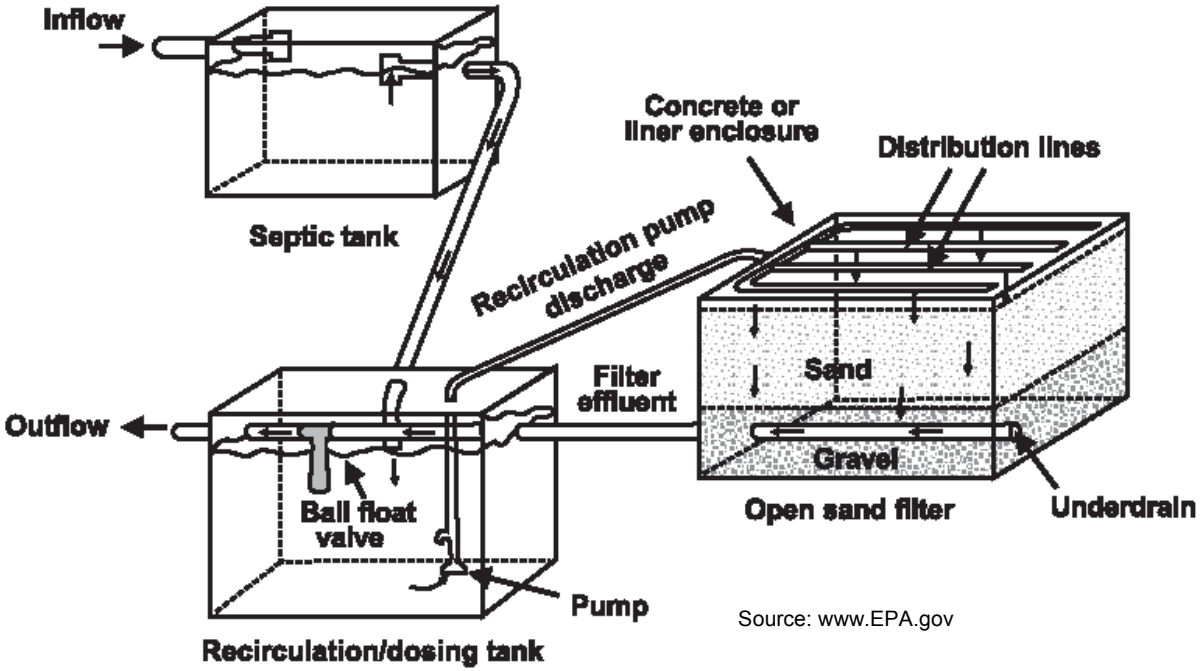
Major Classification Examples

- Source Separation
  - Urine separating toilets; waterless urinals, composting toilets
- Biological Systems
  - Suspended growth; submerged attached growth; attached growth biofilters
- Physical/Chemical Systems
  - Chemical precipitation; adsorption; ion exchange
- Natural Systems
  - Conventional and fill OWTS; landscape irrigation systems; constructed wetlands systems

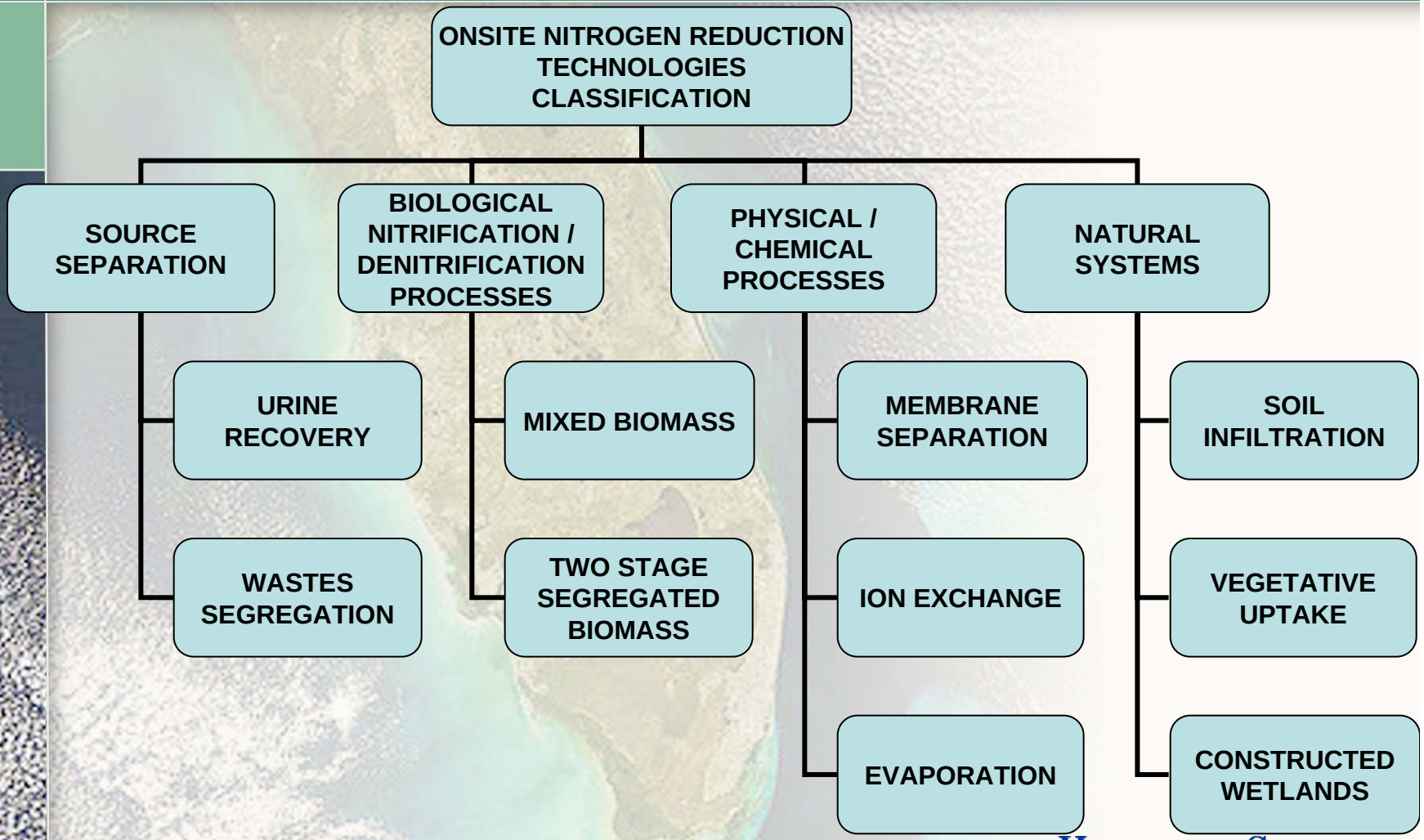
Onsite N Reduction Technology Classification by Process





Source: www.EPA.gov

Technology Classification by Process



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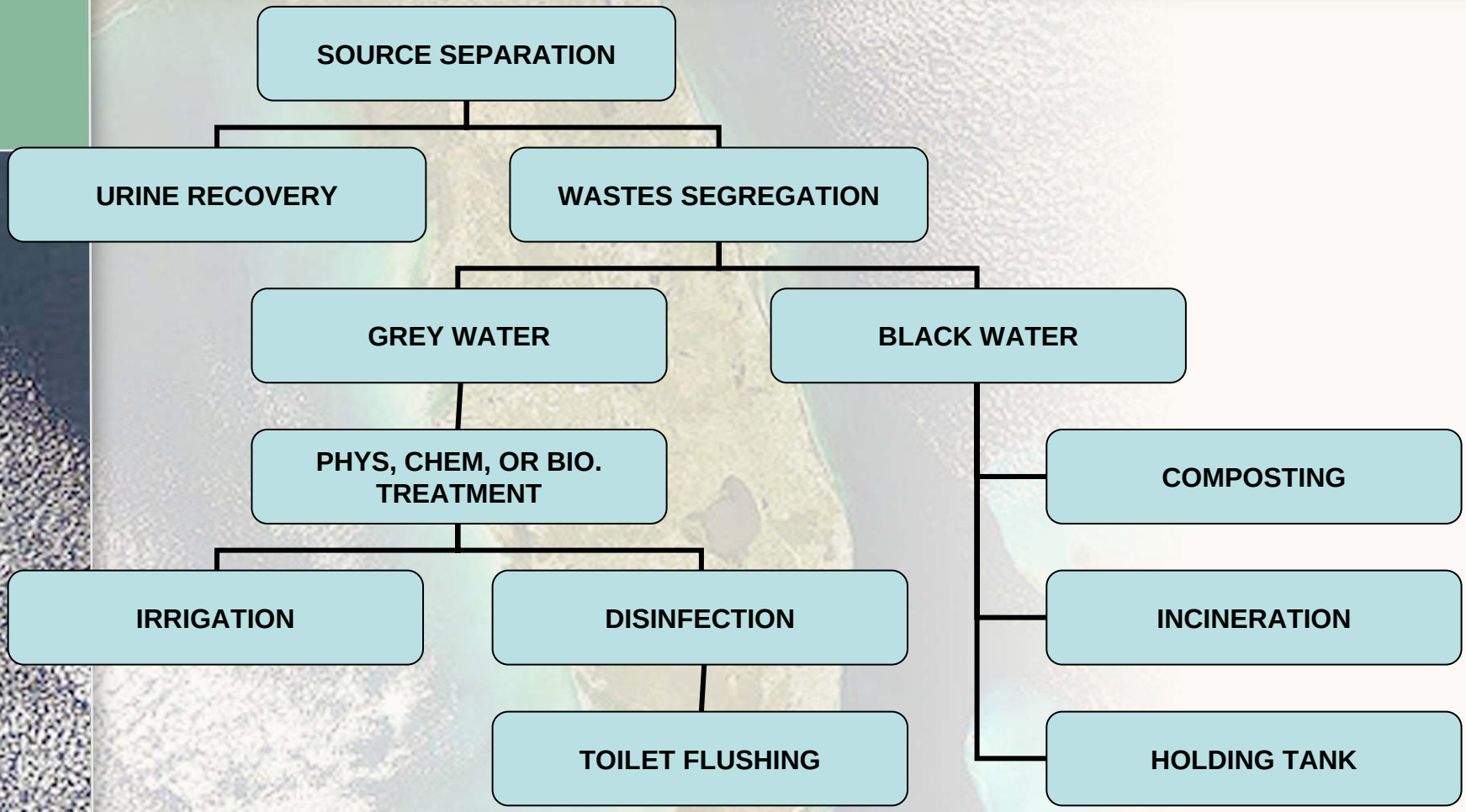
Onsite N Reduction Technology Classification Source Separation Processes



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Onsite N Reduction Technology Classification Wastewater Characteristics

- The domestic sewage from individual households can be divided into 4 individual wastestreams (A, B, C & D)

Source Designation	Wastestream	Daily Volume (gpcd)	Gram / person-day			
			$CBOD_5$	TSS	Total N (as N)	Total P (as P)
A	Non-kitchen sinks, clothes washer, shower, bathtubs	32	11.4	5.2	0.8	0.2
B	Kitchen sinks, dishwasher, garbage grinder	10.3	35.1	38.5	1.7	0.3
C	Toilet: urine separated	17.5	12.5	80	1.1	0.4
D	Toilet: urine	0.6	4.2	0.1	10.9	1.2
Sum		60.4	63.2	124	14.5	2.0

Source: Benetto et al. 2009; Makropoulos et al.,2008; Magid et al., 2006; Memon and Butler, 2006; Tchobanoglous, et al., 2003; EPA, 2002; Lens and Lettinga, 2001; Gunther, 2000; Mayer et al., 1999

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Urine Separating Toilets

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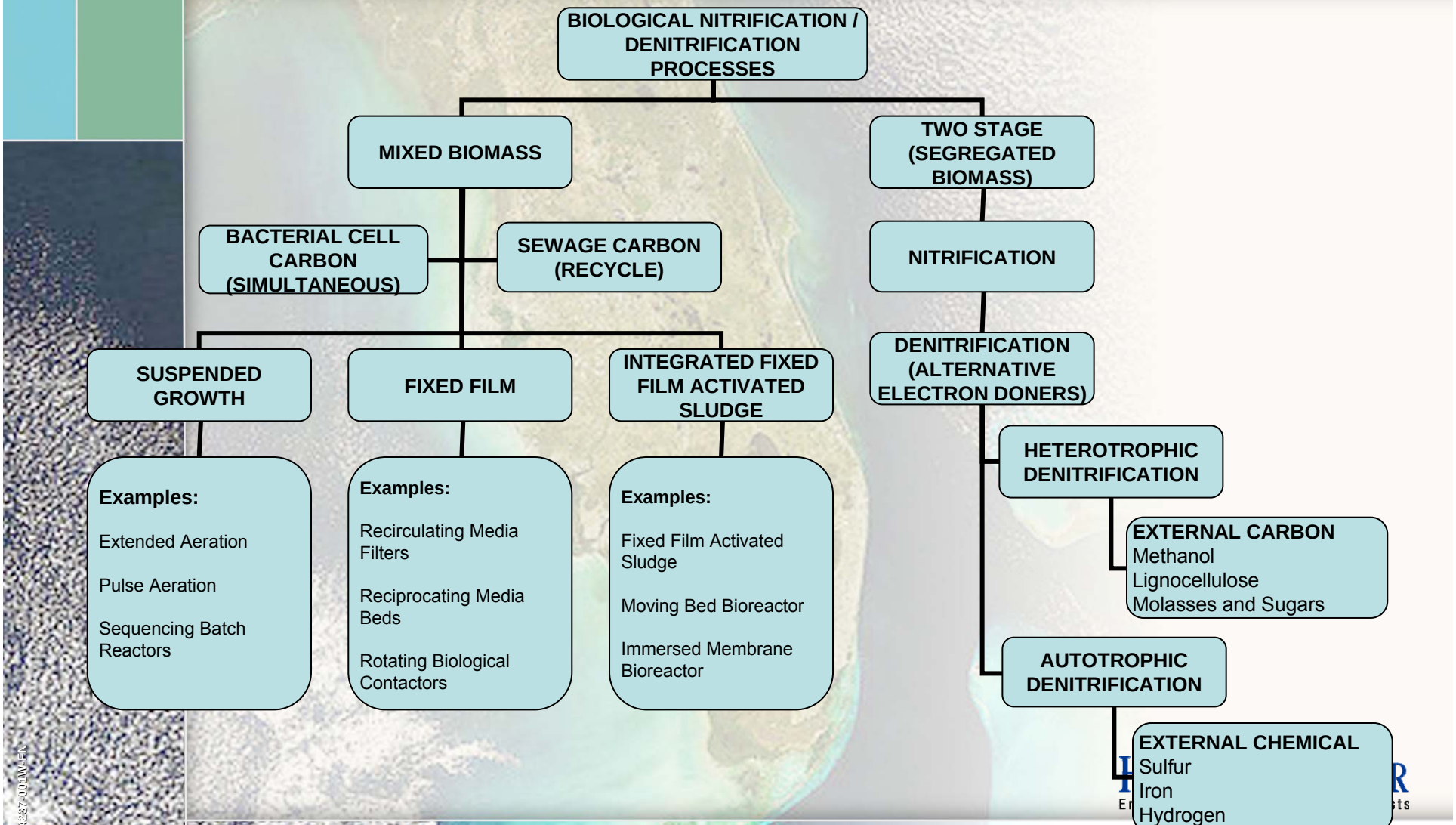
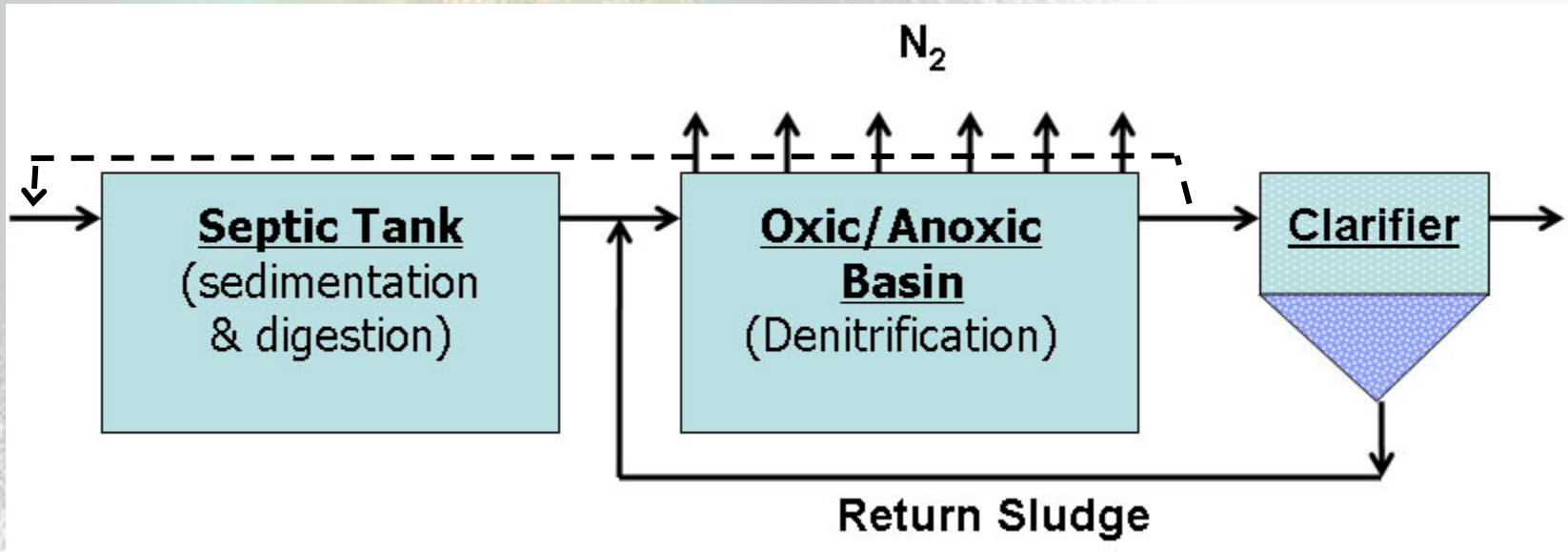
Onsite N Reduction Technology Classification Biological Treatment



Mixed Biomass



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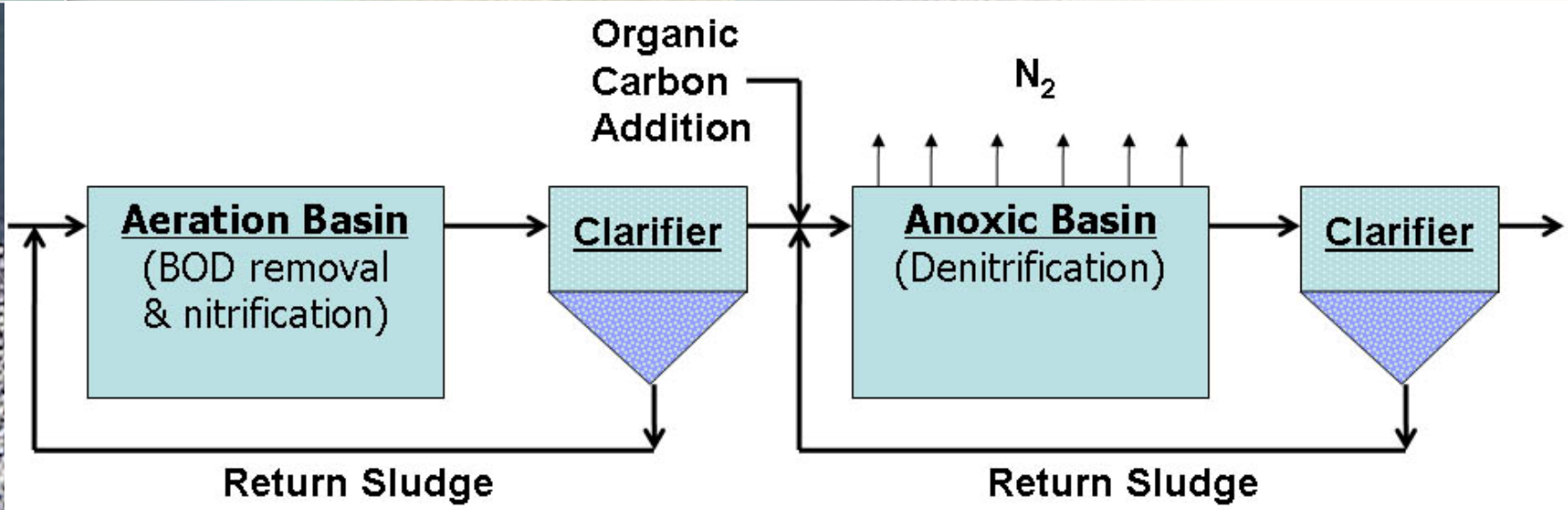
Two-Stage (Segregated Biomass)



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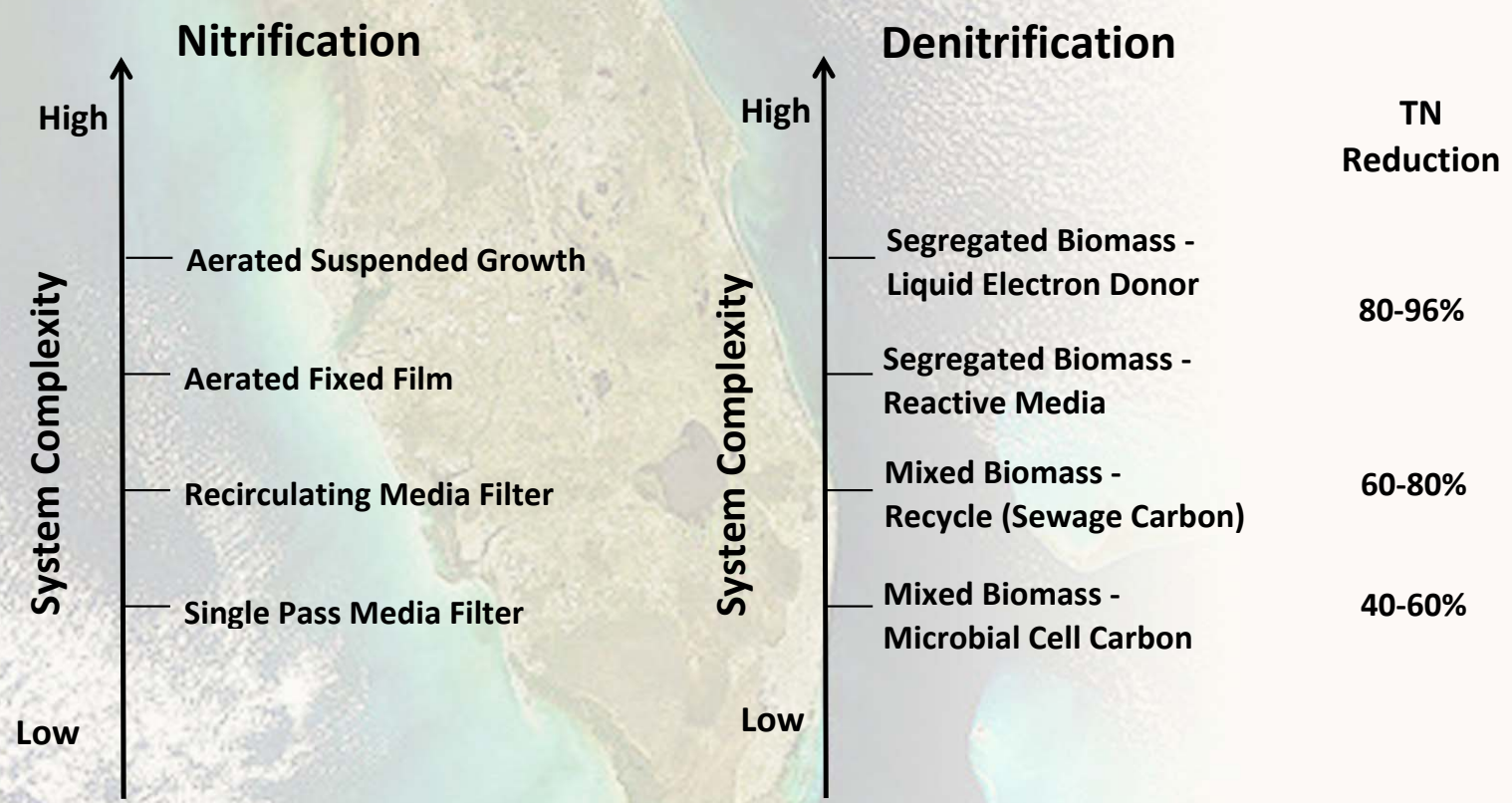
Biological Nitrogen Reduction: System Complexity



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Biological Nitrification Removal Processes

Process	Simultaneous (Mixed Biomass)	Recycle (Mixed Biomass)	External Donor (Two Stage)
Electron Donor	Organic carbon from bacterial cells	Organic carbon from influent wastewater	Cellulose, Sulfur, Iron, Other
Typical Removal	40 - 60%	60 - 80%	70 – 96%
Technologies	o Recirculating media filters w/o recycle o Reciprocating media beds o Extended aeration o Pulse aeration o Moving bed bioreactor o Sequencing batch reactors o Membrane bioreactor	o Recirculating media filters with recycle o Extended aeration with recycle o Moving bed bioreactor o Rotating Biological Contactors	o Heterotrophic suspended growth o Heterotrophic packed bed reactive media o Autotrophic packed bed reactive media

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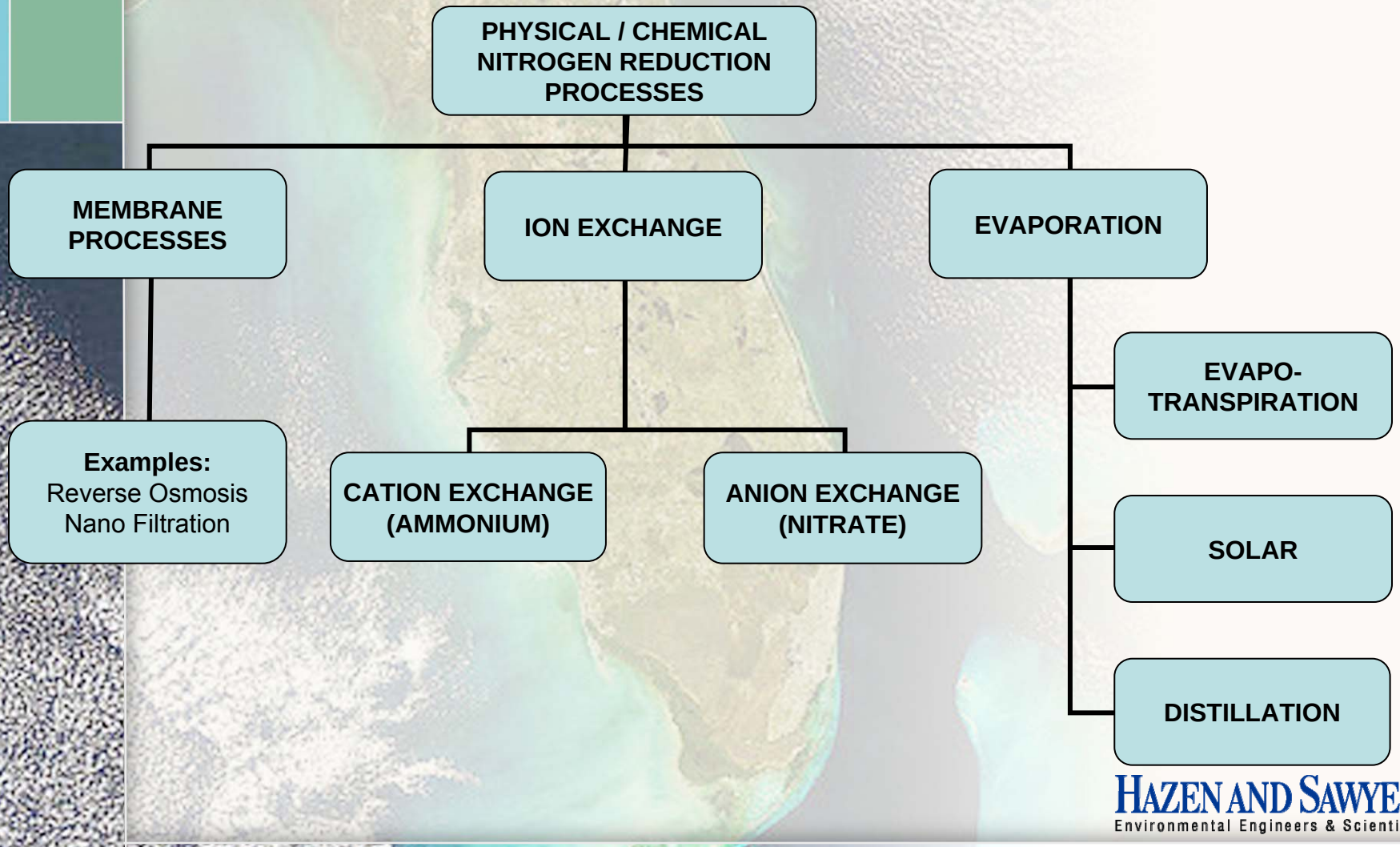
Onsite N Reduction Technology Classification Physical / Chemical Processes



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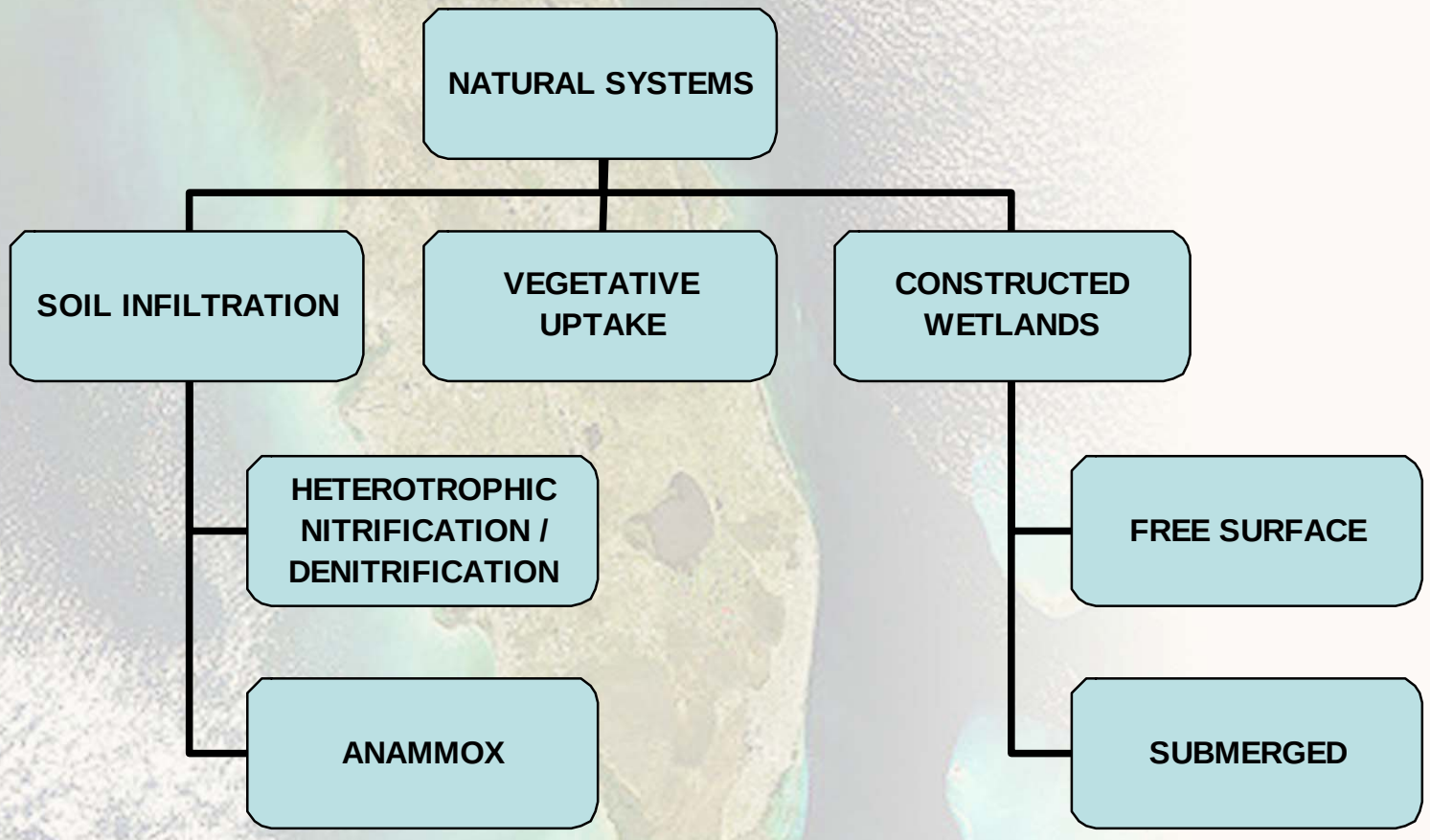
Onsite N Reduction Technology Classification Natural Systems



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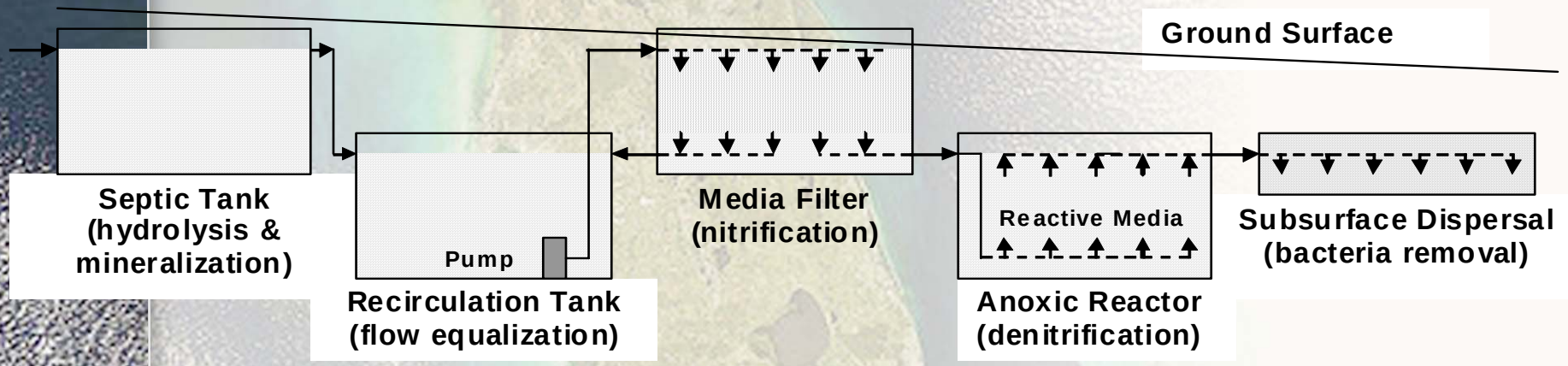
Passive two-stage denitrification system



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Onsite N Reduction Technology Classification
Nitrogen Reduction Technologies Matrix

Description	Components	Daily Volume (gal)	Primary Treatment (septic tank)	Mixed Biomass Nitrification/ Denitrification	Two-Stage Nitrification/ Denitrification	Second Stage Denitrification Biofilter	Natural Systems	Aerobic Biological Treatment	Disinfection	Struvite Precipitation	Final Liquid Application
Domestic wastewater	A+B+C+D	241									Irrigation or Soil Dispersal
											Indoor Reuse
Domestic wastewater minus urine	A+B+C	239									Irrigation or Soil Dispersal
											Indoor Reuse
Blackwater	B+C+D	113									Irrigation or Soil Dispersal
											Indoor Reuse
Black water minus urine	B+C	111									Irrigation or Soil Dispersal
Greywater	A	128									Irrigation or Soil Dispersal
											Indoor Reuse
Urine	D	1.6									Concentrated nutrient solution for crop production

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Onsite Nitrogen Reduction Systems Identified to Date

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Onsite Nitrogen Reduction Studies/Tests/Systems Identified

- How many are there? Many!

Biological

ABJ ICEAS
Activated Carbon
Advantex 20x
Advantex ISF
Advantex RSF
Aerated Fixed Film
Aerated Suspended Growth
Aerocell
AeroDiffuser
Aero-Stream
AES BESTEP- IDEA
Agricultural Residues
AIRR
Alliance
Amphidrome
Anoxic Packed Bed Reactors
Aqua Aire
Aqua Safe

Biological (cont)

AquaKlear
Aquarobic
Ashco-A RSF III
Autotrophic Packed Bed Reactive Media
Bacterial Polyesters
BEST 1
Bi-A-Robi
Bioclere model 16/12
Biocycle, Inc.
Bio-Coir
Biodisc
Bio-fosse
BioGreen
Biokreisel
Biomax
Bionest
Biorotor

Biological (cont)

BioSorb
Black & Gold
Brooks
BTX Biotreater
Cajun Aire
Cardboard
Clearwater
Clearstream
CMS Rotordisk
Coir
Corn Cobs
Cotton
Cromaglass
Crushed brick
Crushed Glass
Delta ECOPOD
Delta Whitewater ATU
EcoFlo

Biological (cont)

Ecoflow ST-650
EcoKasa
Eco-kleen
Ecological systems
Eco-Pod
EcoPure 300
Eljen In-Drain
Envirocycle
EnviroFilter C
Enviro-Guard .75
EnviroSBR
Enviroserver
Eparco
Expanded aggregate
Expanded Clay
Expanded Shale
Extended Aeration
FAST

Biological (cont)

Fine Gravel
Five Star KR505
Glass (crushed)
Glass (sintered)
Glendon biofilter
Gravel
Heterotrophic Packed Bed Reactive Media
Heterotrophic Suspended Growth
HOOT
Horizontal Flow Bioreactor
Hydro-Action
IDEA Bestep
Immersed Membrane Bioreactors
JET BAT
Klargester Biodisc

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Onsite Nitrogen Reduction Studies/Tests/Systems Identified

Biological (cont)

Klargester RBC

Kubota

Limestone

Lotus

Membrane Bioreactor

MicroFast

Mighty Mac

Mixed Biomass Systems

Modified Drainfields (Using Media)

Modulair

Modular Recirculating Peat Filters

Moving Bed Bioreactor

Mudbug

Multi-flo

Navadic

Nayadic

Nibbler

Biological (cont)

NirtoRaptor

Nitrex

NoMound

Onsite Wastewater Mgmt, Inc NITE-LESS

Open Cell Foam

Opoka

Orenco RTF

Paper

Peat

Pirana

Plastic Media

Polonite

Poly (e-caprolactone)

Polystyrene

Pulse Aeration

Puraflo Peat

ReCip® RTS ~ 500 System

Reciprocating Media Beds

Biological (cont)

Recirculating Media Filters

Recirculating Sand Filters

Recirculating Textile Filters

Retrofast

RIGHT

Rock Tank

Rotofix

Rotordisk

Rubber, shredded

RUCK

Sand (stratified)

Sand (uniform)

Sawdust

SCAT Biofilter

Segregated Biomass Denitrification

SeptiTech

Sequencing Batch Reactors

Single Pass Media Filter

Biological (cont)

Singulair

Slag

Solar Air

Stratified Sand Biofilters

Sulfur/Limestone Column

Sulfur/Oyster Shell Filter

SYBR AER

Thomas TRD

Tire Chips

UASB

USBF

Waterloo Biofilter

Whitewater ATU

Woodchip

Zenon

Zeolites

ZeroImpact

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Onsite Nitrogen Reduction Studies/Tests/Systems Identified

Physical / Chemical

Biovac A/S

Columbio

Evapotranspiration

Magenetic Ion Exchange Resin

Nano Filtration

Reverse Osmosis

Ultra Filtration

Wallax

Natural Systems

American Manufacturing Inc.

Annamox

AZTEC Products

Denitrification in Soil

Ecological Systems

Geoflow, Inc.

Lagoons

Netafilm Irrigation, Inc.

SF Wetlands

SSF Wetlands

Wastewater Systems, Inc.

Source Separation

Aerobic MBR

Ammonia Stripping

Anaerobic MBR

Aquatron

Clinoptilolite

Complete Mix Reactors

Constructed Wetlands

EcoSan

Electrochemical Treatment

Electrodialysis/Ozonation

Evaporation

Fluidized Bed Reactors

Freeze-Thaw

Internal Recycle Seeding Reactor

Ion Exchange

Low Intensity Aerobic Treatment

Membrane Bioreactor

Membrane Chemical Reactor

Source Separation (cont)

Microfiltration/Oxidation

Nanofiltration

Novaquatis

Packed Column Nitrification

Passive Anaerobic Digestion (Septic Tanks)

Pellet Reactors

Polymeric Ion Exchange Resins

Precipitation

Reverse Osmosis

Rotating Biological Contactor

Sand Filtration

Shallow Ponds with Riparian Zones

UASB followed by Membrane Filtration

Upflow Anaerobic Sludge Blanket Reactor

Urine Separating Toilets

Waterless Urinals

Wollastonite

Zeolites

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Nitrogen Reduction Technology Evaluation Methods

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N Reduction Technology Evaluation Criteria

- Effluent total nitrogen concentration
- Performance consistency
- Performance reliability
- Construction costs
- Operation and maintenance cost
- Land area requirements
- Energy requirements
- Homeowner acceptance
- BOD/TSS effluent concentration
- Restoration of performance
- Stage of technology development

N Reduction Technology Evaluation Methods

- **Evaluation Criteria**
  - Each criterion is scored against its particular attribute using a scale ranging from 1 to 5
- **Criteria Weighting**
  - To account for relative differences in significance between criteria, weighting factors ranging from 1 to 10 are assigned
- **Technology Scoring**
  - The total score is the sum of the products of the individual criterion scores times the weighting factors for each criterion
- **Technology Ranking**
  - The priority ranking for a technology is determined by its total score. The highest score represents the highest priority ranking.

N Reduction Technology Evaluation Methods
Ranking Criteria & Weighting Factors

Criterion Description	Maximum Score (S)	Level of Significance	Weighting Factor (W)	Total Possible Score (S x W)
Effluent total nitrogen concentration	5	Very High	10	50
Performance consistency	5	Very high	10	50
Performance reliability	5	Very high	10	50
Construction costs	5	High	7	35
Operation and maintenance cost	5	High	7	35
Land area requirements	5	High	7	35
Energy requirements	5	Medium	4	20
Homeowner acceptance	5	Medium	4	20
BOD/TSS effluent concentration	5	Low	2	10
Restoration of performance	5	Low	2	10
Stage of technology development	5	Low	2	10
				325

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N Reduction Technology Evaluation Methods
How We Determined Criteria Weighting

	Effluent Total Nitrogen Concentration	Performance Consistancy	Performance Reliability	Restoration of Performance	Construction Costs	Operation and Maintenance Costs	cBOD/TSS Effluent Concentrations	Homeowner Acceptance	Energy Requirements	Land Area Requirements	Stage of Technology Development	Relative Rank Score	Criterion Rank
Effluent Total Nitrogen Concentration		1	1	1	1	1	1	1	1	1	1	10	Very High
Performannce Consistancy	0		0	1	1	1	1	1	1	1	1	8	Very High
Performance Reliability	0	1		1	1	1	1	1	1	1	1	9	Very High
Restoration of Performance	0	0	0		0	0	0	0	0	0	1	1	Low
Construction Costs	0	0	0	1		1	1	1	1	0	1	6	High
Operation and Maintenance Costs	0	0	0	1	0		1	1	1	1	1	6	High
cBOD/TSS Effluent Concentrations	0	0	0	1	0	0		0	0	0	0	1	Low
Homeowner Acceptance	0	0	0	1	0	0	1		0	0	1	3	Med
Energy Requirements	0	0	0	1	0	0	1	1		0	1	4	Med
Land Area Requirements	0	0	0	1	1	0	1	1	1		1	6	High
Stage of Technology Development	0	0	0	0	0	0	1	0	0	0		1	Low
	0	2	1	9	4	4	9	7	6	4	9		

N Reduction Technology Evaluation Methods Criterion: Effluent Total N Concentration

Effluent TN (mg/L)	Score
< 3	5
3 – 10	4
11 – 15	3
16 – 30	2
> 30	1

N Reduction Technology Evaluation Methods Criterion: Performance Consistency

Variation in Onsite Nitrogen Removal Performance	Score
Physical/Chemical & Source Separation	5
MBR / IMB*	4
Fixed Film	3
IFAS**	2
Activated Sludge Nite/Denite	1

*MBR/IMB: Membrane Bioreactor / Immersed Membrane Bioreactor
**IFAS: Integrated Fixed Film Activated Sludge

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N Reduction Technology Evaluation Methods
Criterion: Performance Reliability

Mean Time Between Service Calls	Score
annually	5
semi-annually	4
quarterly	3
monthly	1

N Reduction Technology Evaluation Methods
Criterion: Construction Cost

Construction Cost ($1000)	Score
< 5	5
5 - 10	4
10 – 15	3
15 – 20	2
> 20	1

N Reduction Technology Evaluation Methods
Criterion: Operation & Maintenance Cost

O&M Annual Cost ($/year)	Score
100 - 200	5
200 - 300	4
300 - 400	3
400 - 500	2
> 500	1

N Reduction Technology Evaluation Methods Criterion: Land Area Requirements

Land Area Required (ft^2)	Score
< 250	5
251-500	4
501-1000	3
1001-2000	2
> 2000	1

N Reduction Technology Evaluation Methods
Criterion: Energy Requirements

Energy Use (kW-hour/year)	Score
< 500	5
500 – 1,000	4
1,000 – 1,500	3
1,500 – 2,500	2
> 2,500	1

N Reduction Technology Evaluation Methods
Criterion: Homeowner Acceptance

Homeowner Acceptance	Score
Acceptable	5
Perceived nuisance	3
Aesthetically displeasing	1

N Reduction Technology Evaluation Methods Criterion: cBOD/TSS Effluent Concentration

Effluent cBOD/TSS (mg/L)	Score
10 / 10	5
20 / 20	4
30 / 30	2
> 50	1

N Reduction Technology Evaluation Methods Criterion: Performance Restoration

90% Performance Restoration Time (days)	Score
< 1	5
1 - 3	4
3 – 7	3
7 – 14	2
> 14	1

N Reduction Technology Evaluation Methods
Criterion: State of Technology Development

Stage of Development	Score
National use	5
State use	4
Demonstration	3
Experimental	2
Conceptual	1

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Nitrogen Reduction Technology Testing Priority

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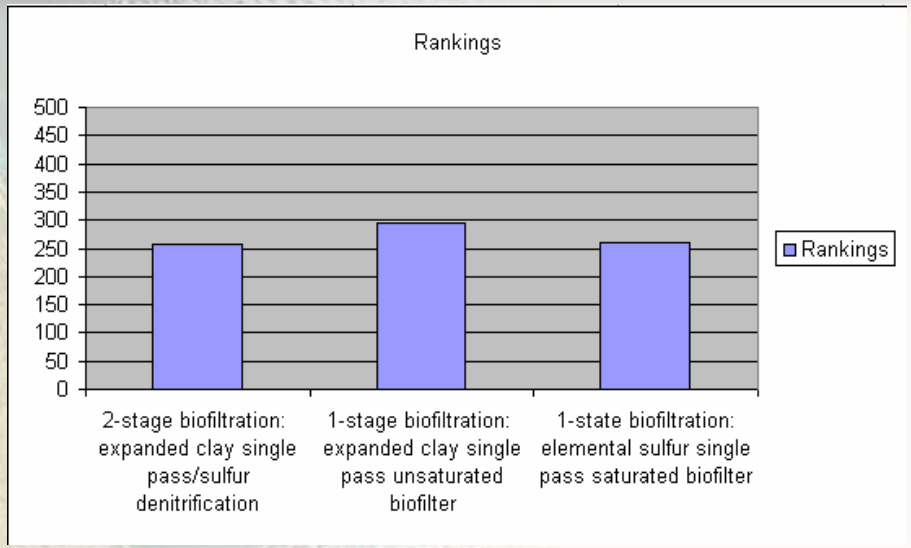
Nitrogen Reduction Technology Testing Priority

- Prioritization will be based on systematic application of the ranking criteria to individual technologies identified in the literature review
- Technologies will be grouped according to the classification scheme developed
  - Source Separation Technologies
  - Biological Treatment Technologies
  - Physical / Chemical Treatment Technologies
  - Natural Systems Technologies
- Each technology will receive individual scores for each evaluation criteria; the weighing criteria will then be used to generate a total score.
- For each classification, the technologies will be ranked according to their total score.

Nitrogen Reduction Technology Scoring and Priority Ranking

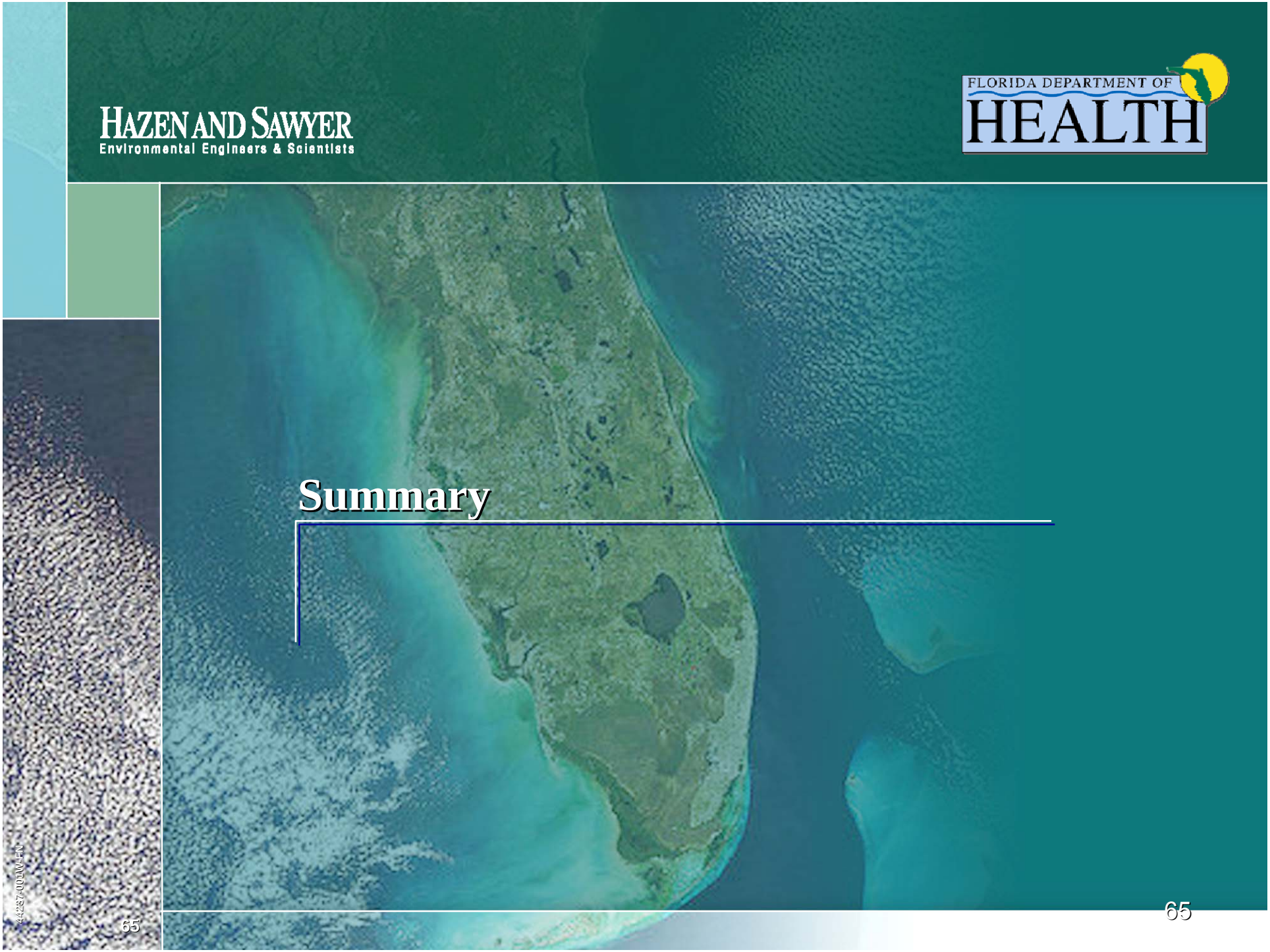
- Excel spreadsheet developed for real-time weight and score adjustment



	A	B	C	D	F	H
1	Criteria #	Ranking Criteria	Weighing Factor	2-stage biofiltration: expanded clay single pass/sulfur denitrification	1-stage biofiltration: expanded clay single pass unsaturated biofilter	1-state biofiltration: elemental sulfur single pass saturated biofilter
2	1	Effluent Nitrogen concentration	10	5	5	5
3	2	Performance consistency	10	3	3	3
4	3	Performance Reliability	10	5	5	5
5	4	Construction cost	7	4	5	5
6	5	Operation and maintenance cost	7	1	5	1
7	6	Land area required	7	5	5	5
8	7	Energy Requirement	4	3	3	3
9	8	Homeowner acceptance	4	5	5	5
10	9	BOD/TSS effluent concentration	2	5	5	5
11	10	Restoration of Performance	2	4	5	3
12	11	Stage of technology development	2	3	4	2
13			0			
14			0			
15				256	295	259

Biological Treatment Technologies Summary (Example)

Technology	Criteria										Total Score (out of 330)
	1	2	3	4	5	6	7	8	9	10	
	Nitrogen effluent concentration	Performance consistency	Reliability	Construction costs	Operation and maintenance cost	BOD/TSS effluent concentration	Homeowner acceptance	Energy requirement	Land area required	Stage of technology development	
	mg/L, Table 2,3,4	Table 5	Table 6,7	$, Table 8	$/year, Table 9	mg/L, Table 10	Table 11	kw-hr/ year, Table 12	1000 ft^2, Table 13	Table 14	
Two stage biofiltration: expanded clay single pass/sulfur denitrification	<3	5	5	7,187	1	5	5	1,209	200	3	285
One stage biofiltration: expanded clay single pass unsaturated biofilter	<1	5	5	3,770	5	5	5	1,209	120	4	315
One stage biofiltration: elemental sulfur single pass saturated biofilter	<1	5	5	3,417	1	5	5	1,209	80	2	278
MicroFAST								3,273			
Waterloo Biofilter								886			
Amphidrome								823			
Geoflow								565			
Recirculating sand filters	20	5	5	2,800	5	5	5	909	120	5	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Summary

Summary

- Questions?
- Let's review criteria, weights agreed on

Review of Ranking Criteria & Weighting Factors

Criterion Description	Maximum Score (S)	Level of Significance	Weighting Factor (W)	Total Possible Score (S x W)
Effluent total nitrogen concentration	5	Very High	10	50
Performance consistency	5	Very high	10	50
Performance reliability	5	Very high	10	50
Construction costs	5	High	7	35
Operation and maintenance cost	5	High	7	35
Land area requirements	5	High	7	35
Energy requirements	5	Medium	4	20
Homeowner acceptance	5	Medium	4	20
BOD/TSS effluent concentration	5	Low	2	10
Restoration of performance	5	Low	2	10
Stage of technology development	5	Low	2	10
				325

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Next Steps

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Next Steps…

- Consensus on technology classification criteria
- Finalize ranking criteria, attribute assignments, initial weighing factors based on today's workshop
- Complete scoring and ranking of technologies based on criteria and weights agreed upon
- Finalize draft report for Tasks A3 - A6, and deliver back to RRAC
- Finalize literature review and deliver to RRAC