TETRA TECH

EPA's Expert Review Panel Report on Onsite Nitrogen Reduction Technology (and more)

Victor A. D'Amato, PE

complex world | CLEAR SOLUTIONS™

Presentation outline

- OWTS Expert Panel charge and membership
- Baseline loadings from on-site systems
- BMP definitions and qualifying conditions
  - Proprietary and non-proprietary technologies
  - *Exsitu* (pretreatment) and *insitu* (soil treatment) technologies
- Research and management recommendations
- WERF project, case studies and decision tool

OWTS Panel Charge




- Initially convened in January 2012
- Review available science on the nitrogen removal performance of treatment practices
- Provide concise definitions and percent reductions for nitrogen load reduction practices
- Provide a definition for each treatment practice and qualifying conditions
- Only address treatment technologies, not soil “attenuation”

List of Panelists

Panelist	Organization
Jim Anderson	University of Minnesota
Eric Aschenbach	Virginia Department of Health
Jason Baumgartner	Delaware Department of Natural Resources and Environmental Control
Derrick Caruthers	Delaware Department of Natural Resources and Environmental Control
Marcia Degen	Virginia Department of Health
Kitt Farrell-Poe	University of Arizona
Joshua Flatley	Maryland Department of the Environment
Robert Goo	U.S. Environmental Protection Agency
Rick Hertges	West Virginia Health and Human Services
Mike Hoover	North Carolina State University
Joyce Hudson	U.S. Environmental Protection Agency
Randy Miles	University of Missouri
Jeff Moeller	Water Environment Research Foundation
Dave Montali	West Virginia Department of Environmental Protection
Sushama Pradhan	North Carolina State University
Jay Prager	Maryland Department of the Environment

Other Authors and Contributors

- Robert Adler – *EPA Region 1*
- Jay Conta – *Virginia Tech*
- Rich Piluk – *Anne Arundel County Health Department*

Staff/Contractor Support

- Ning Zhou – *Virginia Tech*
- Jeremy Hanson – *Chesapeake Research Consortium*
- Victor D’Amato, Jim Kreissl, Mark Sievers – *Tetra Tech*

Baseline Load – Current Model

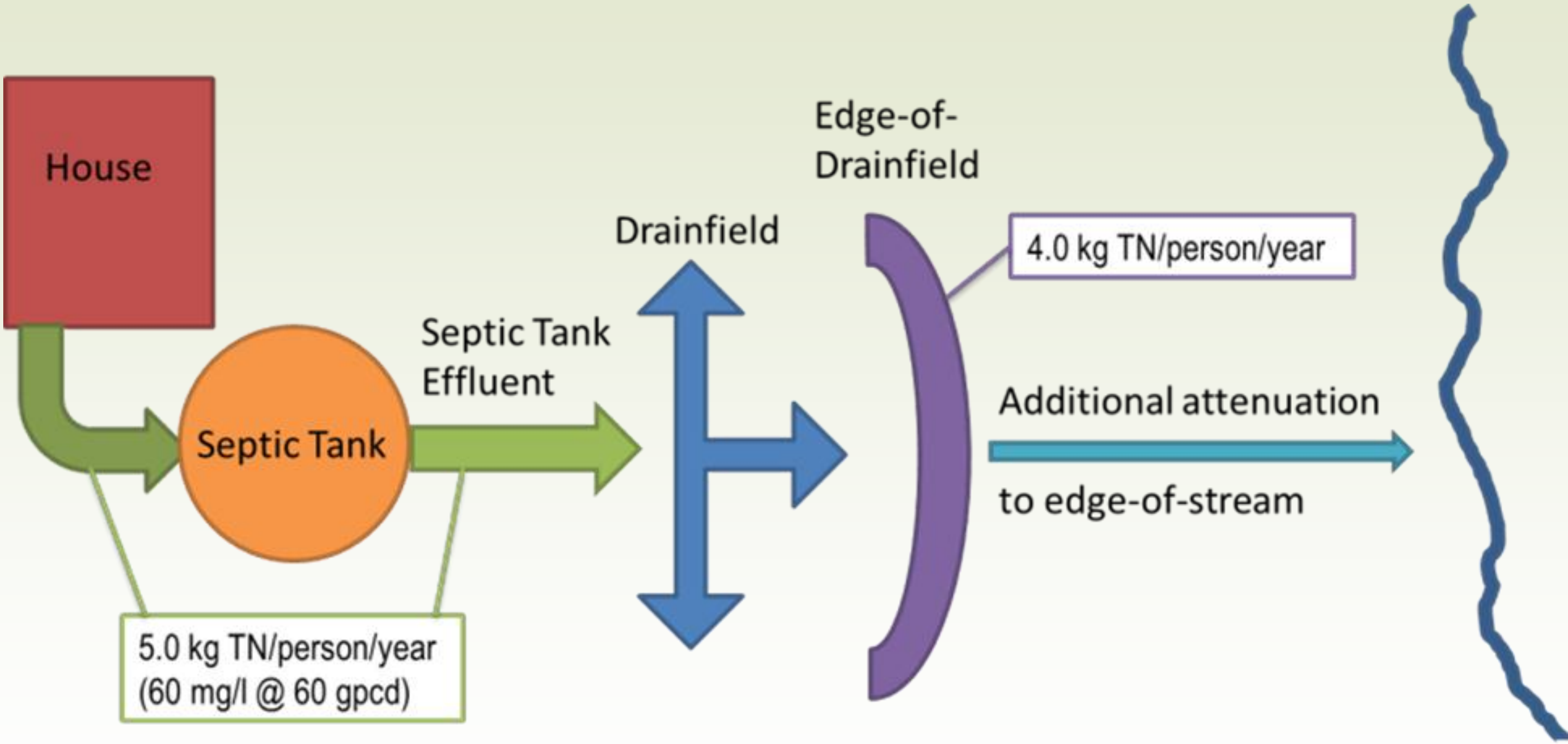



- 4 kg TN/person/year at edge-of-drainfield
  - Assumed flow of 75 gpcpd
  - TN concentration of 39 mg/L
- 60 percent **attenuation** between drainfield and edge-of-stream
- Three BMPs
  - Connection to central sewer (100 percent reduction from on-site sector)
  - 50 percent denitrification system (50 percent reduction)
  - Routine septic tank pump-out (5 percent reduction)

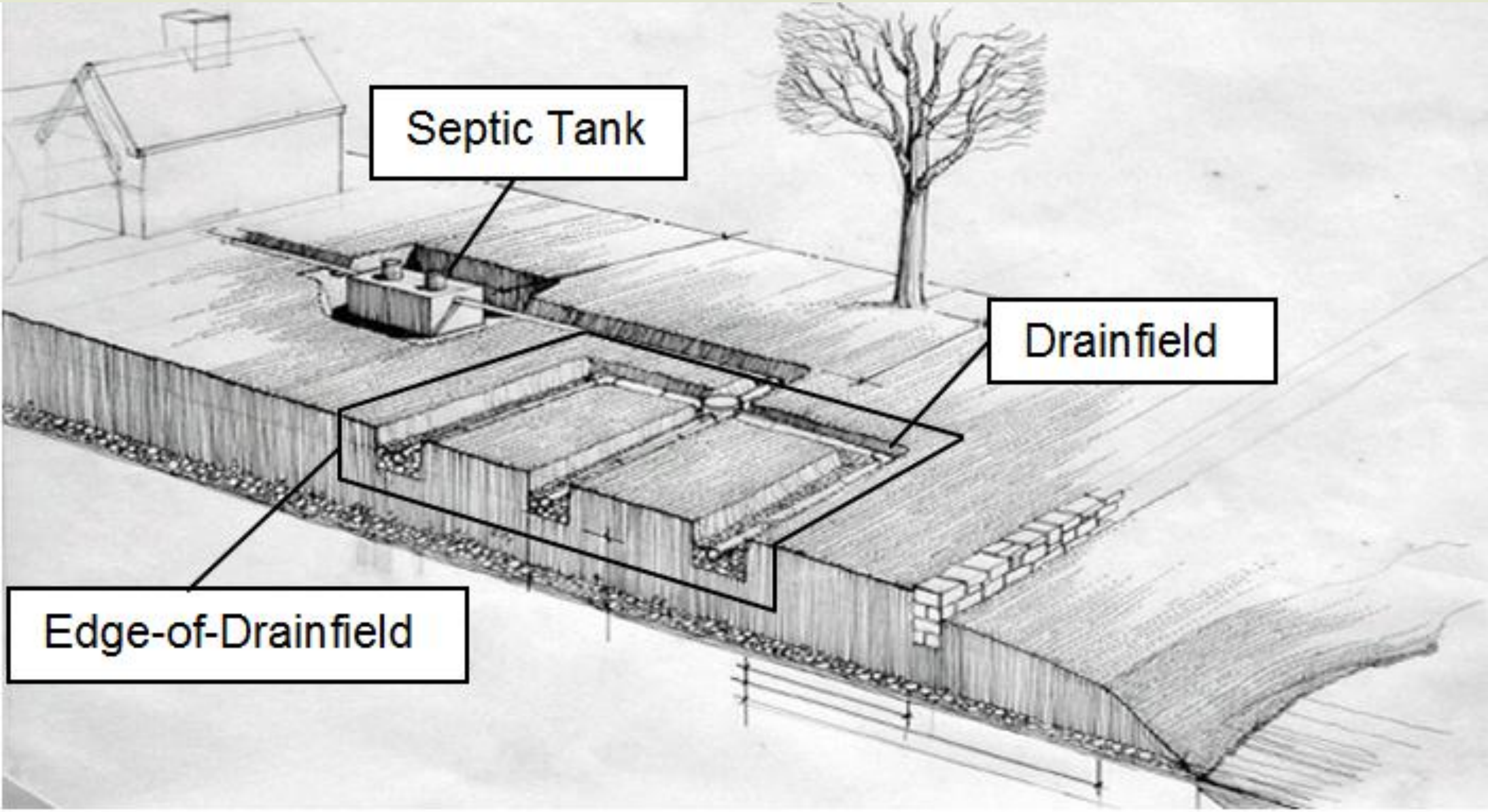
Baseline Load Recommendations

- 5 kg TN/person/year in raw wastewater and STE
  - Assumed flow of 60 gpcpd
  - TN concentration of 60 mg/L in septic tank effluent (STE)
- 4 kg TN/person/year at edge-of-drainfield
  - 20 percent reduction in drainfield, average
- No attenuation recommendation

Baseline Load Recommendations



Baseline System



Source: Joubert et al. (2005)

Systems with BMPs

- *Exsitu* BMP
  - BMP efficiency assessed at end of process prior to soil
  - Reduction based on baseline effluent TN of 5 kg/person/year
- *Insitu* BMP
  - Reduction based on baseline edge-of-drainfield TN of 4 kg/person/year
- Combined *Insitu* and *Exsitu* BMPs
  - Reduction based on baseline edge-of-drainfield TN of 4 kg/person/year
  - Assume consistent TN reduction across the soil treatment system, regardless of *exsitu* effluent characteristics

Best Management Practices



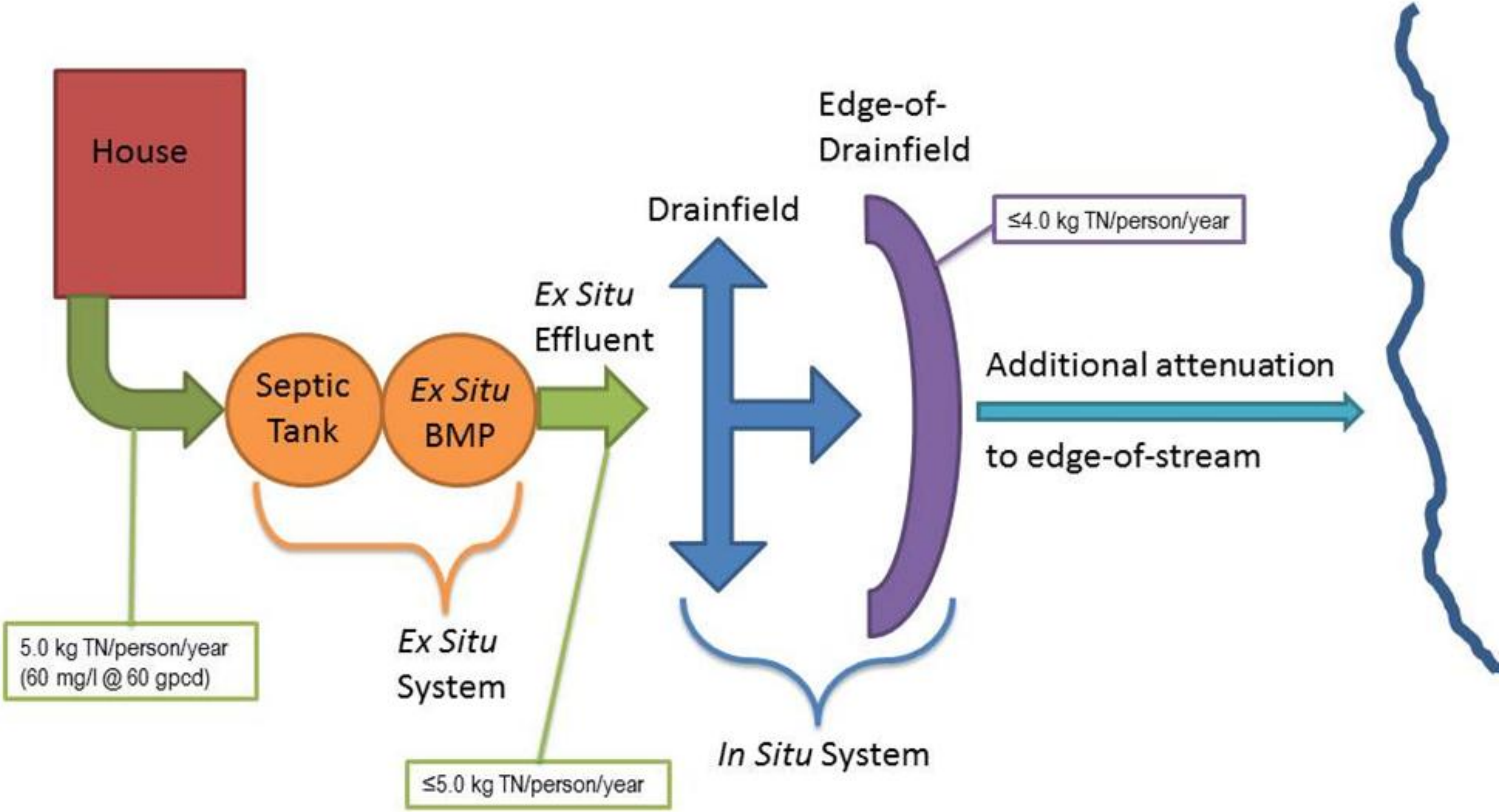

Exsitu (or pretreatment) system components

- NSF Standard 40 Class I secondary systems
- Intermittent (single-pass) media filters
- Constructed wetlands (vegetated submerged beds)
- Recirculating media filters (RMFs)
- Anne Arundel County Integrated Fixed-Film Activated Sludge (IFAS)
- Proprietary *ex situ* treatment systems

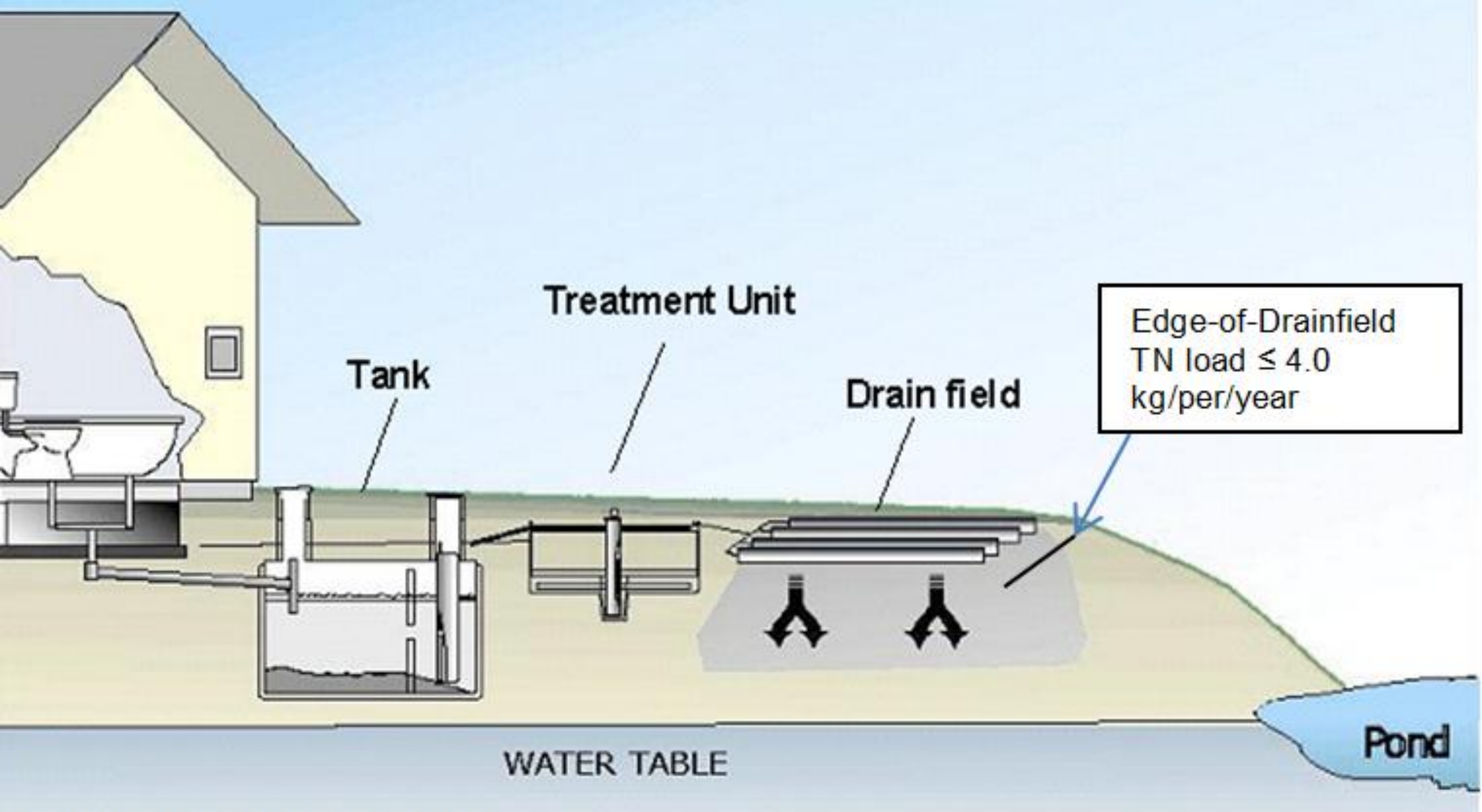
Insitu (soil treatment) system components

- Shallow-placed, pressure-dosed dispersal
- Elevated sand mounds
- Permeable reactive barriers

Residential System with BMP



System with *Exsitu* BMP



Source: Joubert et al. (2005)

Best Management Practices



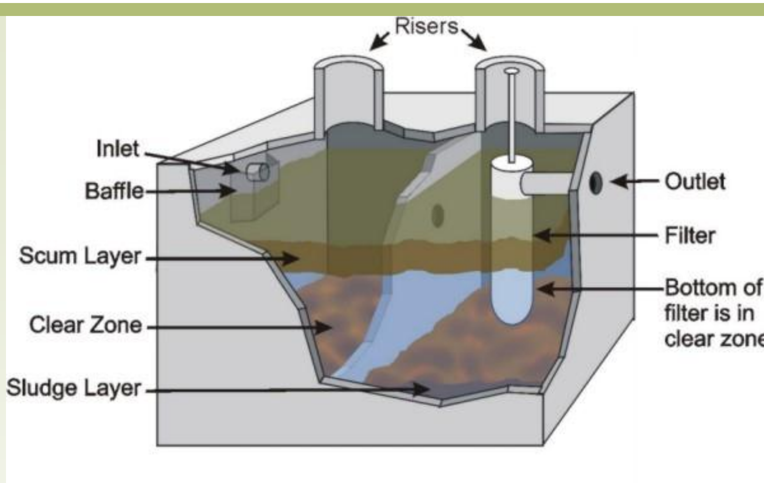

- Proprietary BMPs
  - Developed, marketed, and constructed by a manufacturer
  - Manufacturer responsibility for design, installation, management
  - Standardized design and construction and little variability
  - Recommend two-step credit assignment protocol: **provisional testing** (e.g., NSF Standard 245) followed by third-party **field testing**
  - TN reduction credit of 50 percent, unless managed according to min. EPA Level 3
- Nonproprietary BMPs
  - Designed on case-by-case basis for each site using nonspecific and readily available materials and mechanical equipment
  - Local design and material variations common
  - Two-step protocol for new systems goes through WWTWG

Exsitu BMP Summary

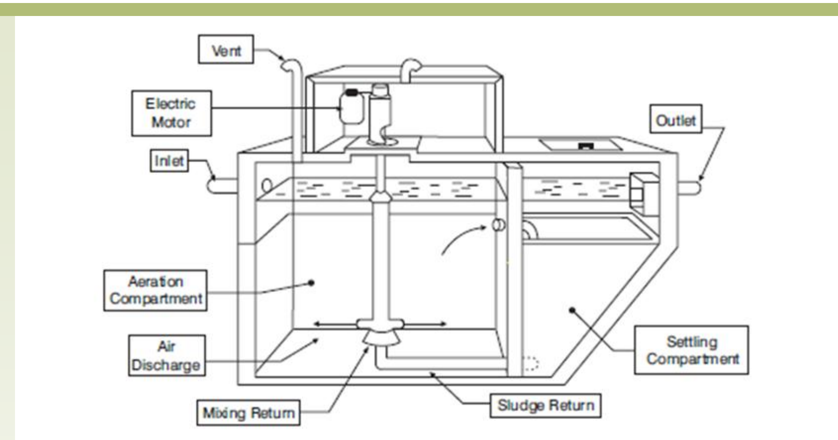



Best Management Practice	Qualifying Conditions	*Ex Situ* Reduction Credit[1]
Septic tank (baseline practice)	N/A	0
NSF 40 Class I Equivalent Secondary Systems	• Certified as Class I under NSF International Standard 40 or equivalent (e.g., CAN/BNQ 3680-600, CEN Standard 12566-3) • Design, installation, and operation in accordance with manufacturer recommendations and state or local regulation	20%
Intermittent media filters	• Timer-based flow equalization with 12–24 doses/day • 2’ depth media ES = 0.5-1.0 mm; UC ≤ 4.0; < 0.5% passing #200 sieve • HLR ≤ 2 gpd/sf • OLR ≤ 5 lb BOD/1000 sf • Uniform, pressurized distribution ≤ 6 sf/orifice	20%
Constructed wetlands	• 2’ depth media ES = 40–80 mm inlet/outlet; ES = 20–30 mm treatment zone • OLR ≤ 1.2 lb BOD_5/1000 sf-day; SA ≥ 54 sf/PE • Length ≥ 50 ft • Outlet structure for variable flooding depth • 6” top layer of planting media	20%

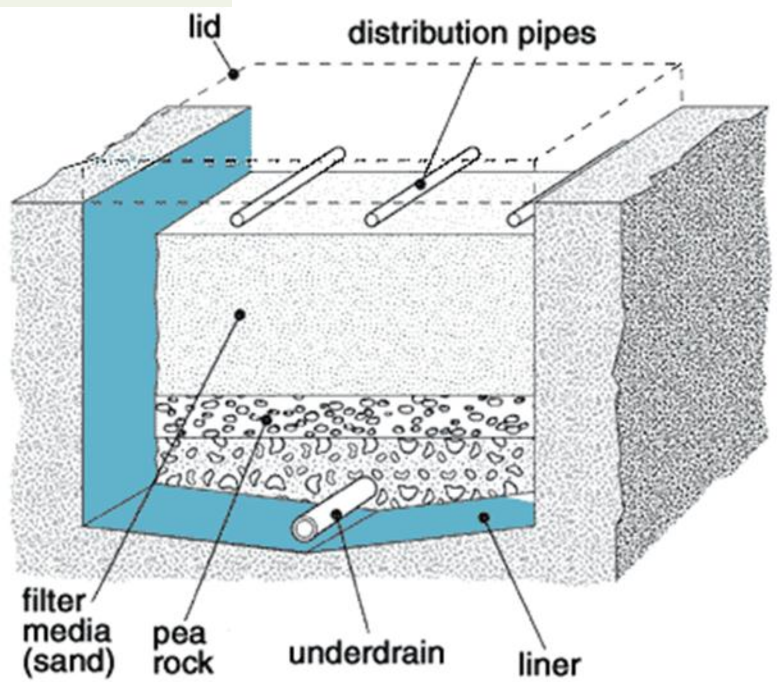
Exsitu BMPs



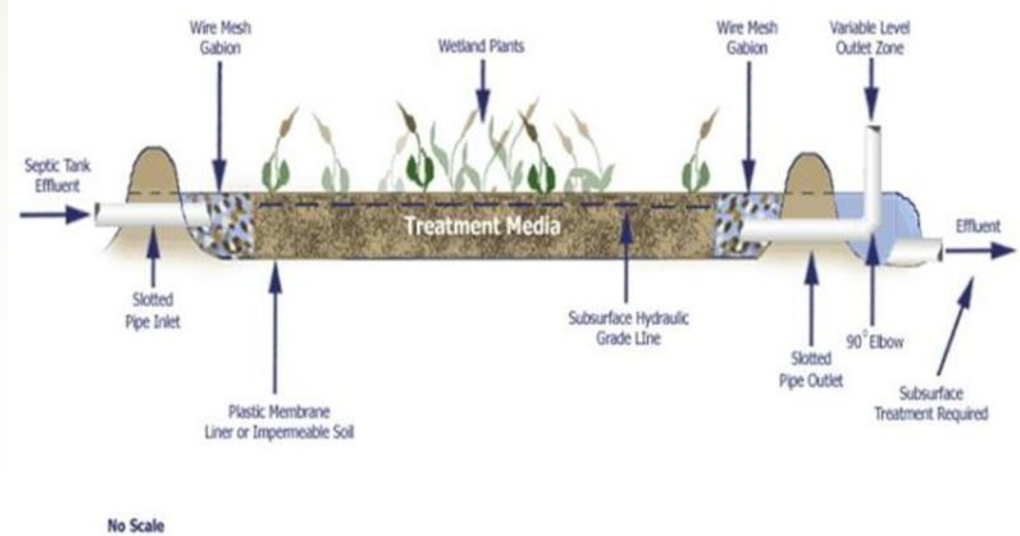
Risers
Inlet
Baffle
Scum Layer
Clear Zone
Sludge Layer
Outlet
Filter
Bottom of filter is in clear zone



Vent
Electric Motor
Inlet
Outlet
Aeration Compartment
Air Discharge
Mixing Return
Sludge Return
Settling Compartment



lid
distribution pipes
filter media (sand)
pea rock
underdrain
liner

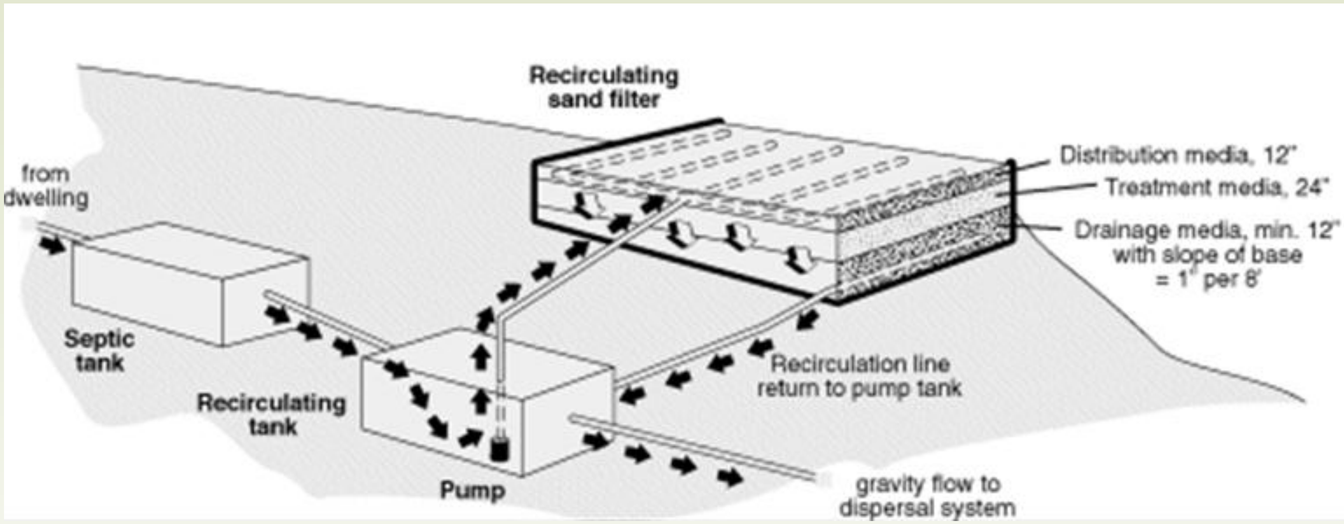


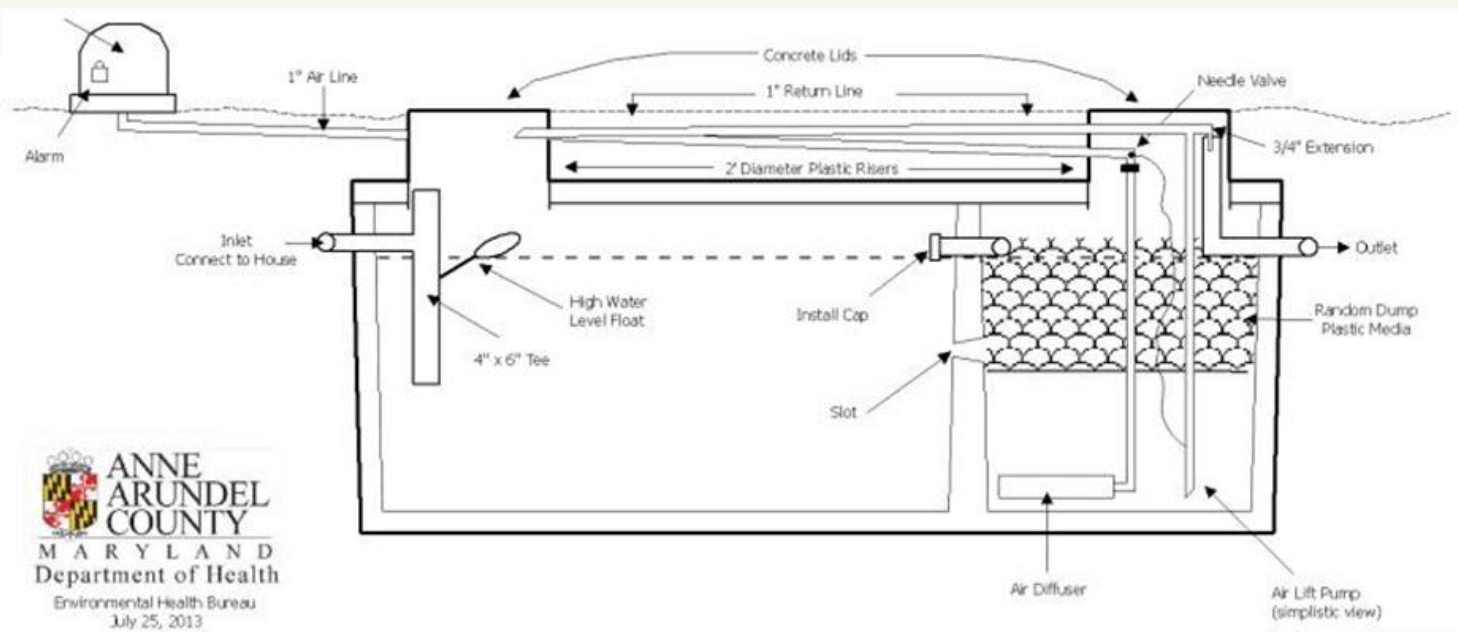
Wire Mesh Gabion
Wetland Plants
Wire Mesh Gabion
Variable Level Outlet Zone
Septic Tank Effluent
Treatment Media
Effluent
Slotted Pipe Inlet
Subsurface Hydraulic Grade Line
Slotted Pipe Outlet
90° Elbow
Subsurface Treatment Required
Plastic Membrane Liner or Impermeable Soil
No Scale

Exsitu BMP Summary

Best Management Practice	Qualifying Conditions	*Ex Situ* Reduction Credit[1]
RMF	• Timer-based flow equalization with 24–48 doses/d • 2’ depth media • Sand media: ES = 1.0–5.0 mm; UC ≤ 2.5; < 0.5% passing #200 sieve; HLR ≤ 5 gpd/sf; OLR ≤ 5 lb BOD/1000 sf • Gravel media: ES = 5.0–20 mm; UC ≤ 2.5; < 0.5% passing #200 sieve; HLR ≤ 15 gpd/sf; OLR ≤ 15 lb BOD/1000 sf • Uniform, pressurized distribution ≤ 6 sf/orifice • Device capable of recirculating 3–5 times forward flow back to anoxic zone	50%
Anne Arundel County IFAS	• 2-day HRT anoxic chamber • 1-day HRT aerobic chamber with ≥ 600 sf surface area fixed-film media • Aeration device capable of maintaining 3.0 mg/L DO • Device capable of recirculating ≥ 3 times forward flow back to anoxic zone • Alarm for aeration device fault	50%
Proprietary treatment systems	• NSF Standard 245 certification • Technology-specific • Percent removal based on qualifying third-party testing	≥ 50%

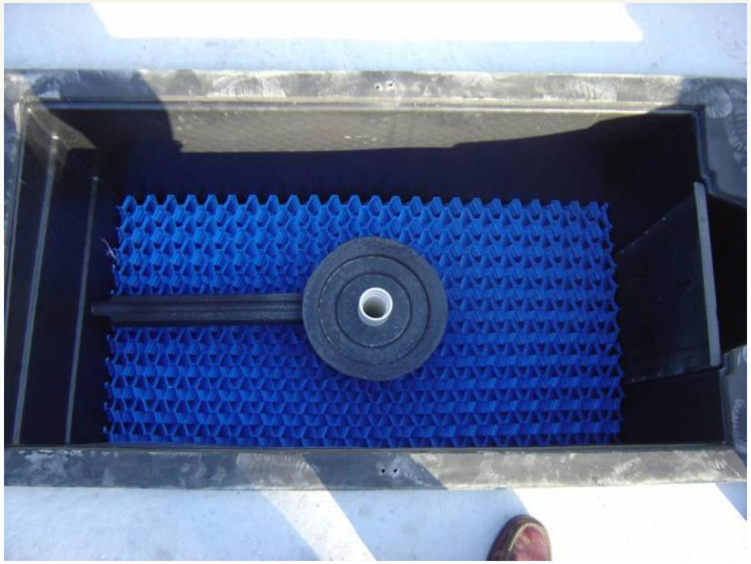
Exsitu BMPs





ANNE ARUNDEL COUNTY
MARYLAND
Department of Health
Environmental Health Bureau
July 25, 2013

Exsitu BMPs

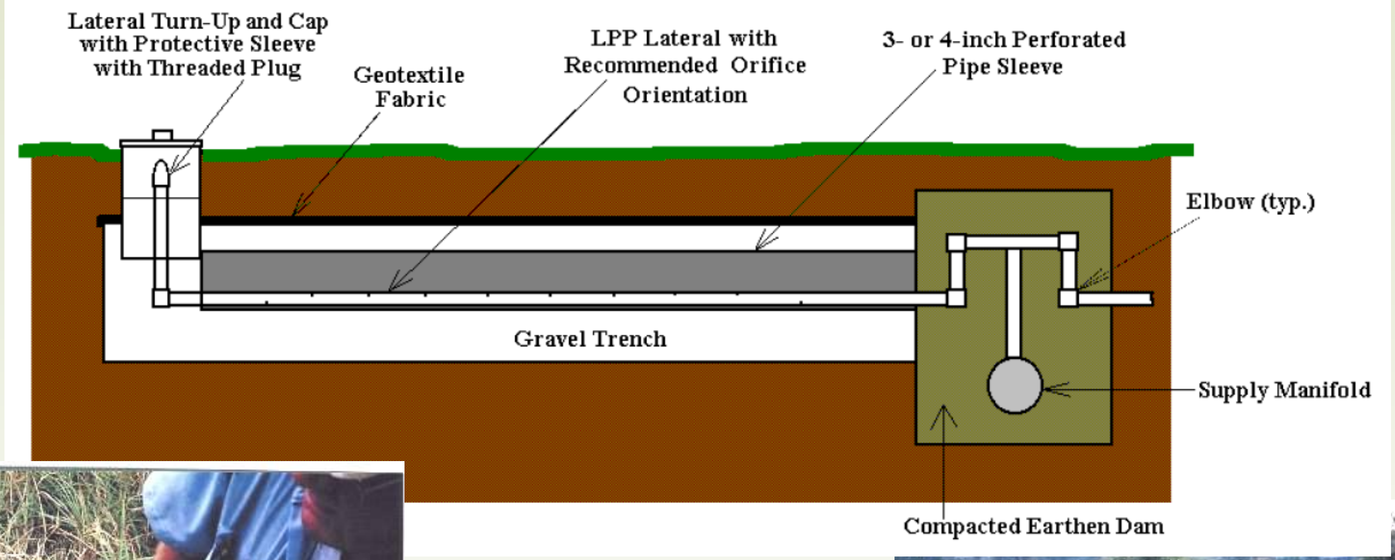


Insitu BMP Summary

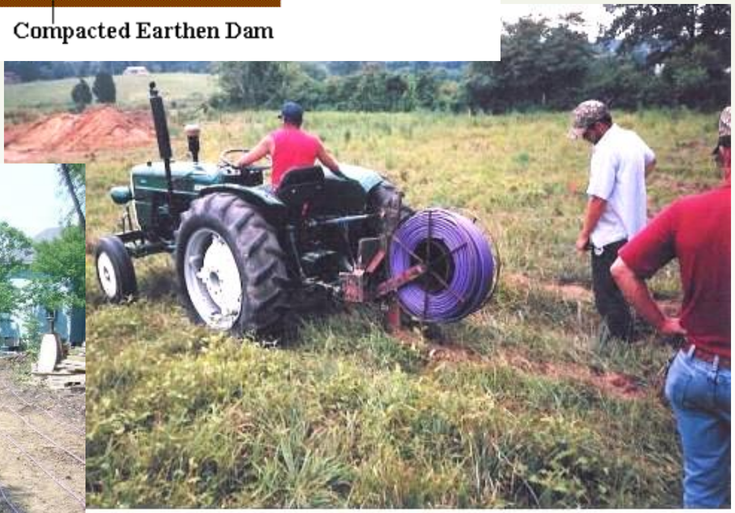



Best Management Practice	**Qualifying Conditions**	***In Situ* Reduction Credit**[1]
Conventional system (baseline practice)	N/A	20%
Shallow-placed, pressure-dosed dispersal	• Drip or LPD within 12” of grade in A or A/B horizon • Credit not provided for sand or loamy sand soils • Lines placed on contour • Drip requires: prefiltration system, automatic flush cycle, flow equalization, air release valves • LPD requires: working pressure head of 2–5’, dosing volume of 7–10 times distribution system piping, lateral flushing provisions, max flow variation of 10% for each lateral	50%
Elevated sand mounds	• Installation within intact A or A/B horizon • Credit not provided for sand or loamy sand surface soils under mound • Scarify surface of soil under mound • Uniform, pressurized distribution ≤ 6 sf/orifice • 1–2’ layer of sand: ASTM C33; ≤ 20% by weight > 2 mm; D10 = 0.15 to 0.3 mm; UC = 4 to 6 • Max. top of sand ALR = 1 gpd/sf for STE, 2 gpd/sf for secondary • 6–12” loamy surface layer	50%
Permeable reactive barriers	• Site-specific	Case-by-case

Insitu BMPs



Lateral Turn-Up and Cap
with Protective Sleeve
with Threaded Plug
Geotextile
Fabric
LPP Lateral with
Recommended Orifice
Orientation
3- or 4-inch Perforated
Pipe Sleeve
Elbow (typ.)
Gravel Trench
Supply Manifold
Compacted Earthen Dam



Combined *Exsitu* and *Insitu* BMPs

In Situ Practice / *Ex Situ* Practice	Conventional Baseline	Shallow, Pressure Dosed	Elevated Mound
Septic tank baseline	4.0 kg/p/yr (0%)	2.5 kg/p/yr (38%)	2.5 kg/p/yr (38%)
NSF 40 Class I Secondary Systems	3.2 kg/p/yr (20%)	2.0 kg/p/yr (50%)	2.0 kg/p/yr (50%)
Intermittent Media Filter	3.2 kg/p/yr (20%)	2.0 kg/p/yr (50%)	2.0 kg/p/yr (50%)
Vegetated Submerged Bed	3.2 kg/p/yr (20%)	2.0 kg/p/yr (50%)	2.0 kg/p/yr (50%)
Anne Arundel Co. IFAS	2.0 kg/p/yr (50%)	1.25 kg/p/yr (69%)	1.25 kg/p/yr (69%)
Recirculating Media Filter	2.0 kg/p/yr (50%)	1.25 kg/p/yr (69%)	1.25 kg/p/yr (69%)

Research and Management Recommendations

- Alkalinity control
  - Critical for effective nitrification (50 mg/L recommended in final effluent)
  - R&D for simple, inexpensive alkalinity control would help optimize TN removal and could justify higher credits in future
- BMP sampling
  - Not recommended to be mandatory for verification
  - Widespread BMP implementation offers opportunity for data collection
- Data sharing and reciprocity
  - EPA-OWM offered to facilitate
- Variable baseline and BMP performance by soil type
  - Consider including soil type as predictor of TN reduction performance
  - Defer to future attenuation expert panel

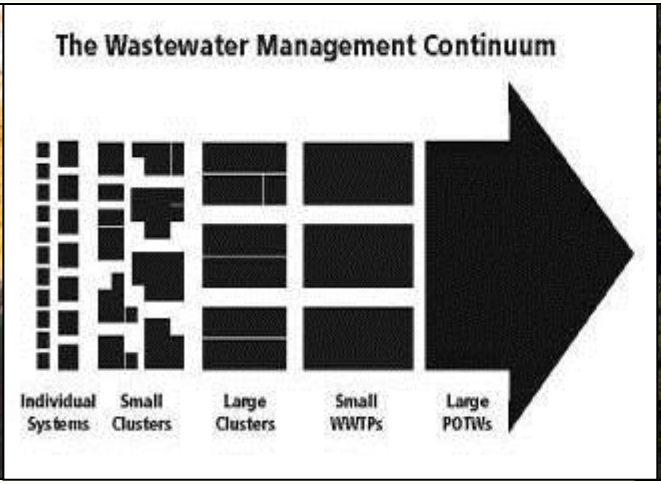
Attenuation

- Measured Nutrient Loads in Falls Lake Watershed Catchments Compared to Septic System Generated Loads (NCDENR 2010)

		Septic-Generated Nutrients		Measured Load in Stream		Percent Septic Load Delivered to Stream	
Basin	Stream Order*	TN (lb/d/mi^2)	TP (lb/d/mi^2)	TN (lb/d/mi^2)	TP (lb/d/mi^2)	TN (%)	TP (%)
Rhodes Creek	unk.	-	-	0.57	0.012	-	-
Seven-Mile Creek	4th	30.4	3.9	0.139	0.0068	0.46	0.18
Cabin Branch	8th	30.2	3.86	0.57	0.0178	1.89	0.46
Crooked Creek	2nd	27.0	3.45	1.53	0.0286	5.67	0.83
Beaverdam Creek	unk.	3.83	0.42	0.20	0.024	5.1	5.7
New Light Creek	unk.	4.68	0.60	0.37	0.033	8.0	5.4
Honeycut Creek	unk.	15.5	1.99	0.33	0.025	2.2	1.3
Cedar Creek	unk.	29.7	3.81	0.66	0.039	2.2	1.0
AVERAGE		**20.2**	**2.6**	**0.55**	**0.023**	**3.6**	**2.1**

Distributed systems

- Infrastructure planning, design, management using systems at various scales, based on community context
  - For stormwater: low-impact design, BMPs
  - For wastewater: onsite to cluster to centralized
  - Centralized oversight generally preferred
  - Part of a green-to-gray built/natural infrastructure strategy



"Distributed" Systems

- Centralized system - offsite disposal
- Cluster septic system - offsite dispersal
- Cluster septic system - onsite dispersal
- Individual septic system - onsite dispersal

Pay as you grow

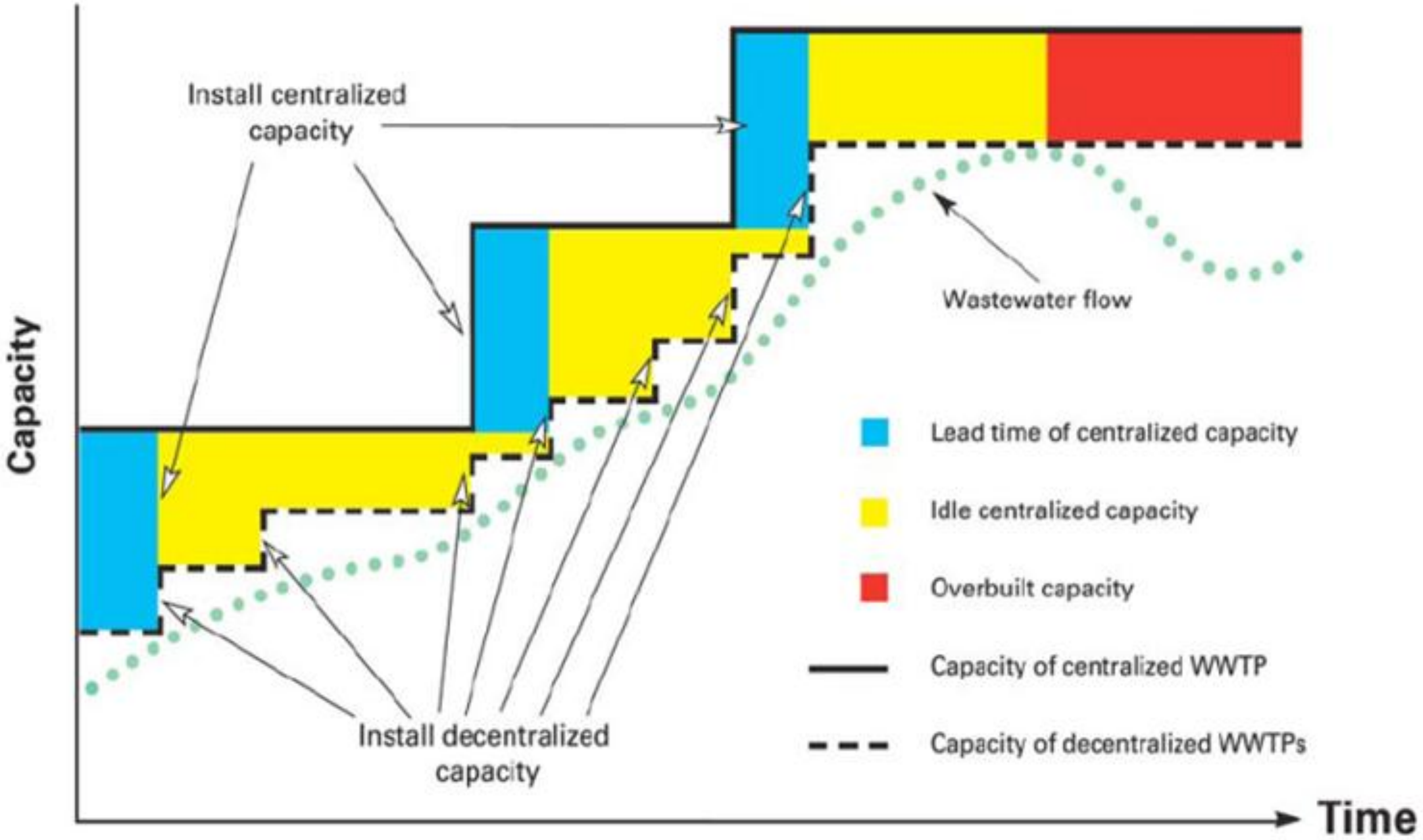
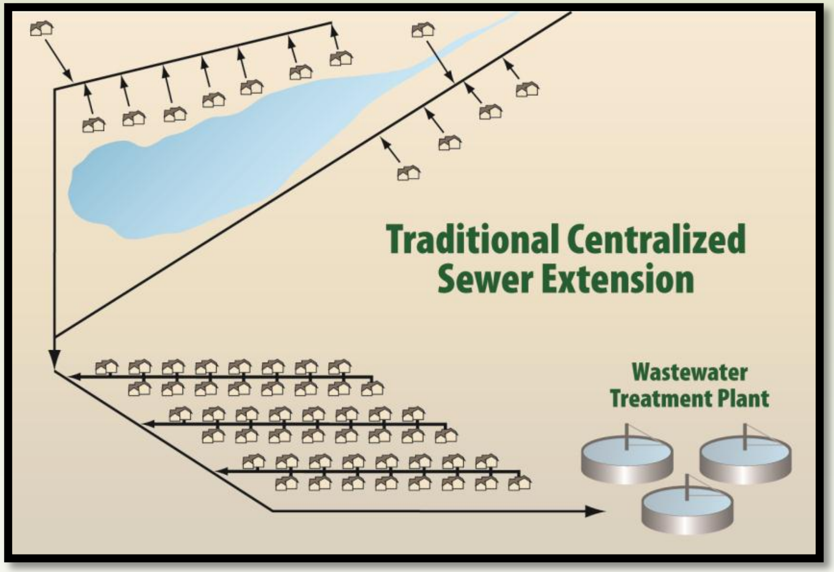


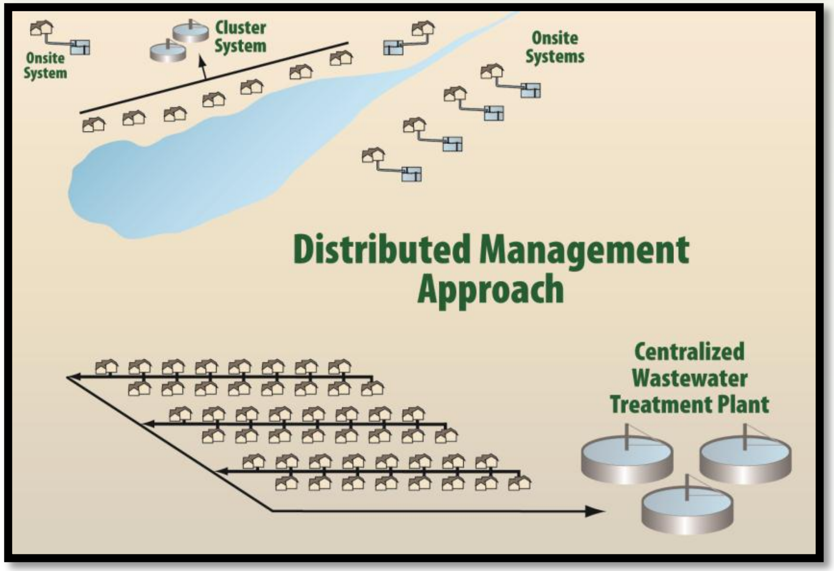
Figure 8-1: Flow Versus Capacity for Centralized and Decentralized Wastewater Systems. WWTP stands for Wastewater Treatment Plant.

Efficiency

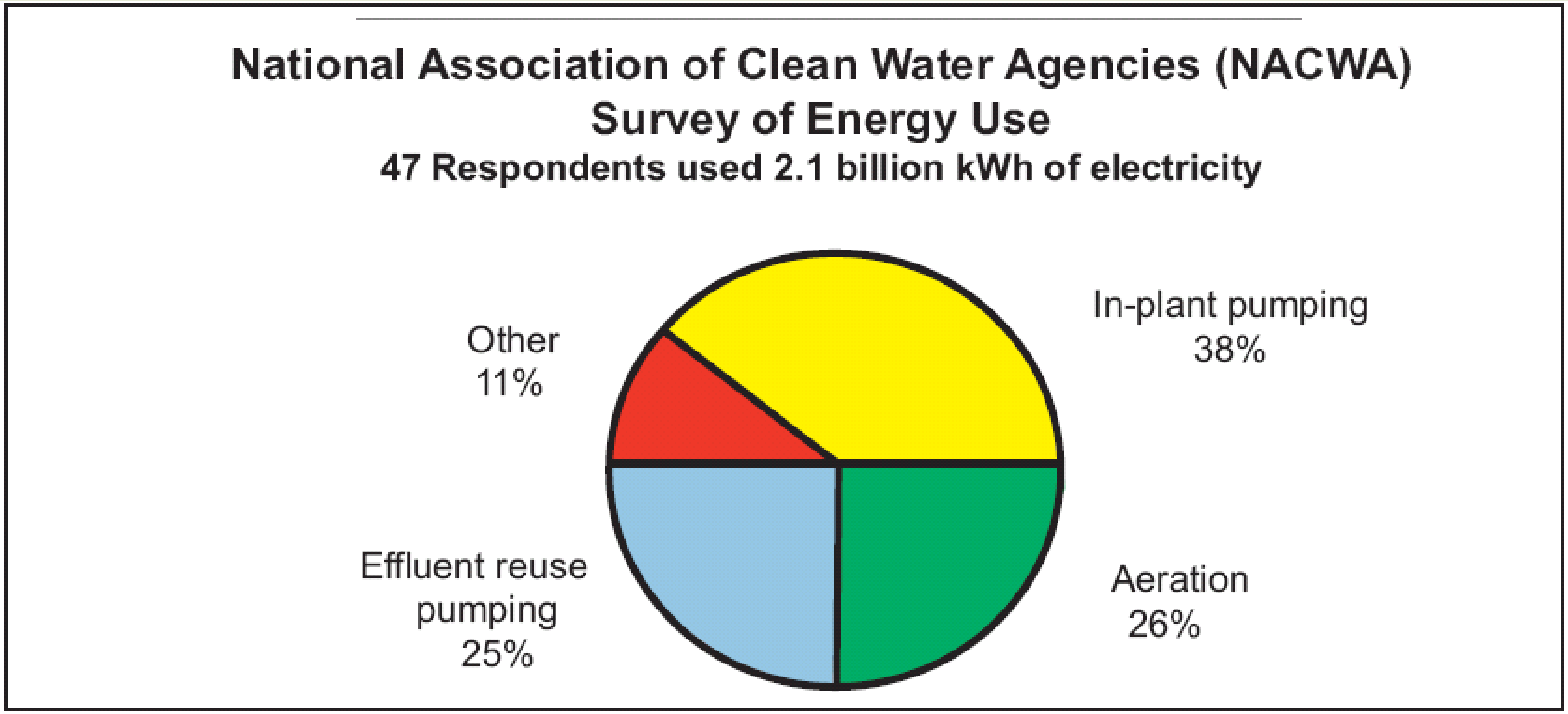



- Treatment close to the source and/or reuse requires less energy
- Urban reuse retrofits are more feasible
- Smart, clean and green technology
  - Smart
    - Remote monitoring of multiple systems
    - Responsive to user feedback
  - Clean
    - Resource recovery within facilities
    - Match water quality to intended reuse
  - Green
    - Efficient/passive ecological treatment
    - Landscape/facility integration
    - Relatively infiltration-resistant



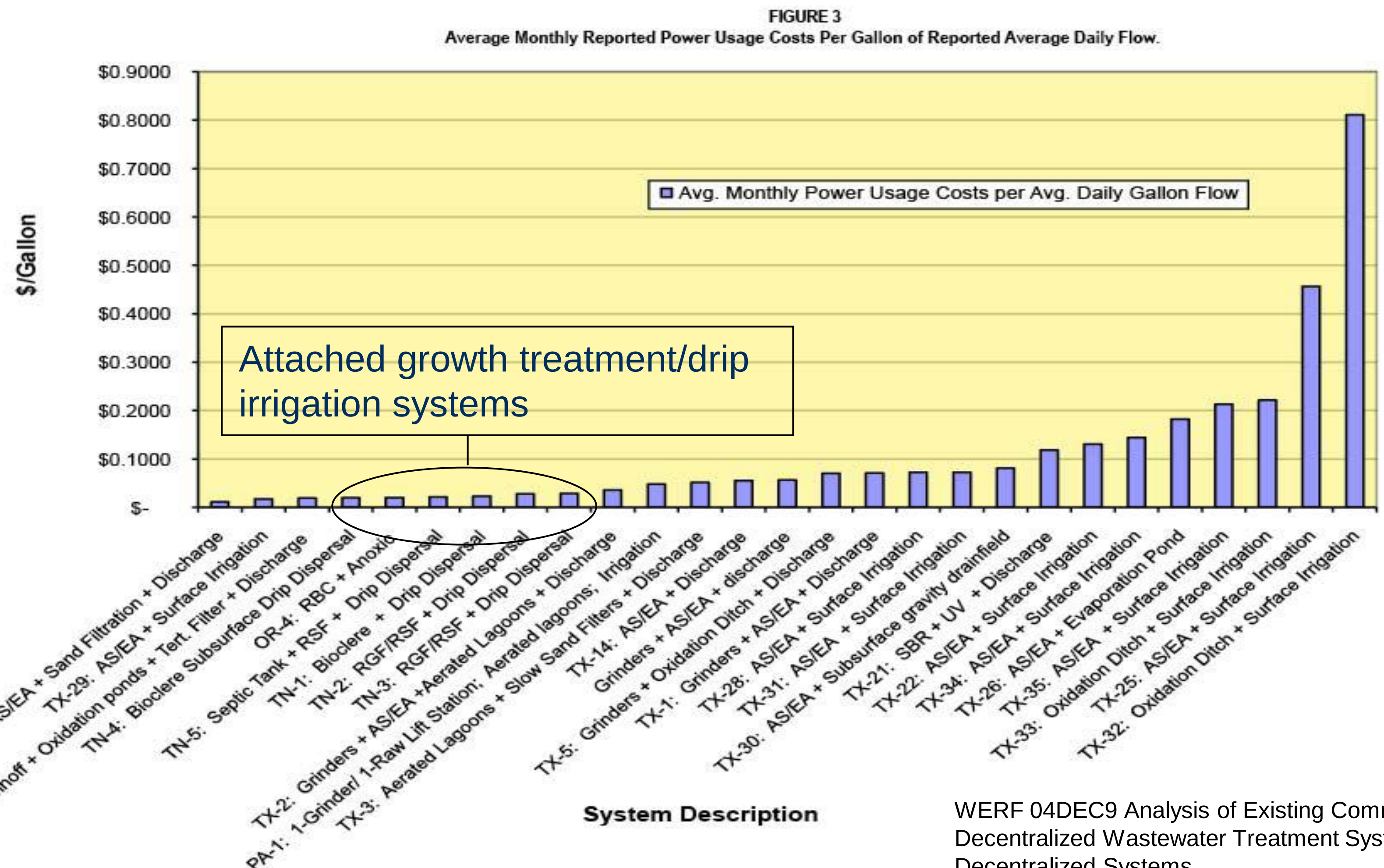


Wastewater utility energy use



T. Jones, “Water-Wastewater Committee: Program Opportunities in the Municipal Sector: Priorities for 2006,” presentation to CEE June Program Meeting, June 14, 2006, Boston, MA. Available online at http://www.cee1.org/cee/mtg/6-06_ppt/jones.pdf.

Power demands of decentralized systems



WERF 04DEC9 Analysis of Existing Community-Sized Decentralized Wastewater Treatment Systems
Decentralized Systems

Electrical energy demand for 5,000 gpd decentralized reuse systems

System Type	Reuses	Power	Units
Conventional Gravity Septic System	Aquifer Recharge	0.0	kWh/MG
Pumped / Pressurized Drainfield System	Aquifer Recharge	200.0	kWh/MG
Gravity Collection to Recirculating Filter	Irrigation	520.0	kWh/MG
Gravity Collection to RF and UV Disinfection	Unrestricted	580.0	kWh/MG
Pressure Sewer to RF and UV	Unrestricted	780.0	kWh/MG
California WWTPs (CEC, 2005)	Not Specified	1,500 to 5,800	kWh/MG

When to Consider Distributed Systems in Urban and Suburban Areas

- Water Environment Research Foundation (WERF) funded research project
  - Identify examples of distributed infrastructure approaches in areas where traditional approach would be centralized
  - Study critical path details and decision processes for how these projects were planned and implemented
  - Set forth information using case studies, tools and other communications pieces that help communities make decisions
- Products
  - Case studies and white papers
  - Excel- based MCDA decision-support tool

Distributed System Applications

- **Green Buildings/Sustainable Sites**
  - Integration into buildings/landscapes
  - Resource recovery and reuse
  - Education and recreation
- **Independent Communities**
  - Maintain fiscal control
  - Preserve community character
  - Underserved communities
- **Utility Optimization**
  - Managed distributed systems
  - Sewer mining
  - Satellite reuse
- www.werf.org/distributedwater
  - Includes decision-support tool

Case Studies Listed by Type

Green Building/Sustainable Sites (GB)

- Battery Park City, New York City (UO)
- Couran Cove Island Resort, Queensland, Australia (IC)
- Currumbin Ecovillage, Queensland, Australia (IC)
- Dockside Green, Victoria, British Columbia, Canada (UO)
- Philip Merrill Center, Annapolis, Maryland
- Sidwell Friends School, Washington, D.C.
- Workplace6 Recycled Water Factory, Sydney, Australia (UO)

Independent Communities (IC)

- Bethel Heights, Arkansas
- Gillette Stadium, Foxborough, Massachusetts (GB)
- Lake Elmo, Minnesota
- Piperton, Tennessee
- Warren, Vermont
- Weston Solar Aquatics, Weston, Massachusetts (GB)
- Wickford Village, Rhode Island

Utility Optimization (UO)

- LOTT Alliance, Lacey, Olympia, and Tumwater, Washington
- Loudoun Water, Loudoun County, Virginia (IC)
- Mobile Area Water and Sewer System, Mobile, Alabama
- Pennant Hills Golf Club, Sydney, Australia
- Sand Creek, Aurora, Colorado
- University of North Carolina at Chapel Hill, North Carolina (GB)

Dockside Green, Victoria, B.C.




- Water-centric brownfield redevelopment
- On-site, closed-loop treatment provides ***fit-for-purpose***, reclaimed water supply
  - Toilet flushing, landscape irrigation, green roof watering, and natural stream/pond
- Stream/pond complex
  - Provides residential access, enhancing unit value, ecological function and biodiversity
- On site press for sludge dewatering to feed co-located gasification plant


Courtesy: Dockside Green and Aqua-Tex Scientific

Bethel Heights, Arkansas

- Rapidly-growing population on individual septic systems
- City selected two ***cluster systems*** phased-in to meet increasing demand with growth
  - Septic tank effluent pump (STEP)
  - Modular geotextile packed bed filters
  - Irrigation of hay fields (shipped out of nutrient-rich watershed)
  - Park/greenway irrigation

Sydney Water - Pennant Hills Golf Club




- Privately-driven ***sewer mining*** project
- Conveyance costs associated with centralized reuse systems rendered satellite users uneconomic
- MBR treatment system produces 172,000 gallons of high quality water per day
- Treated water is used to irrigate the 22 hectares (55 acres) of greens, tees and fairways.



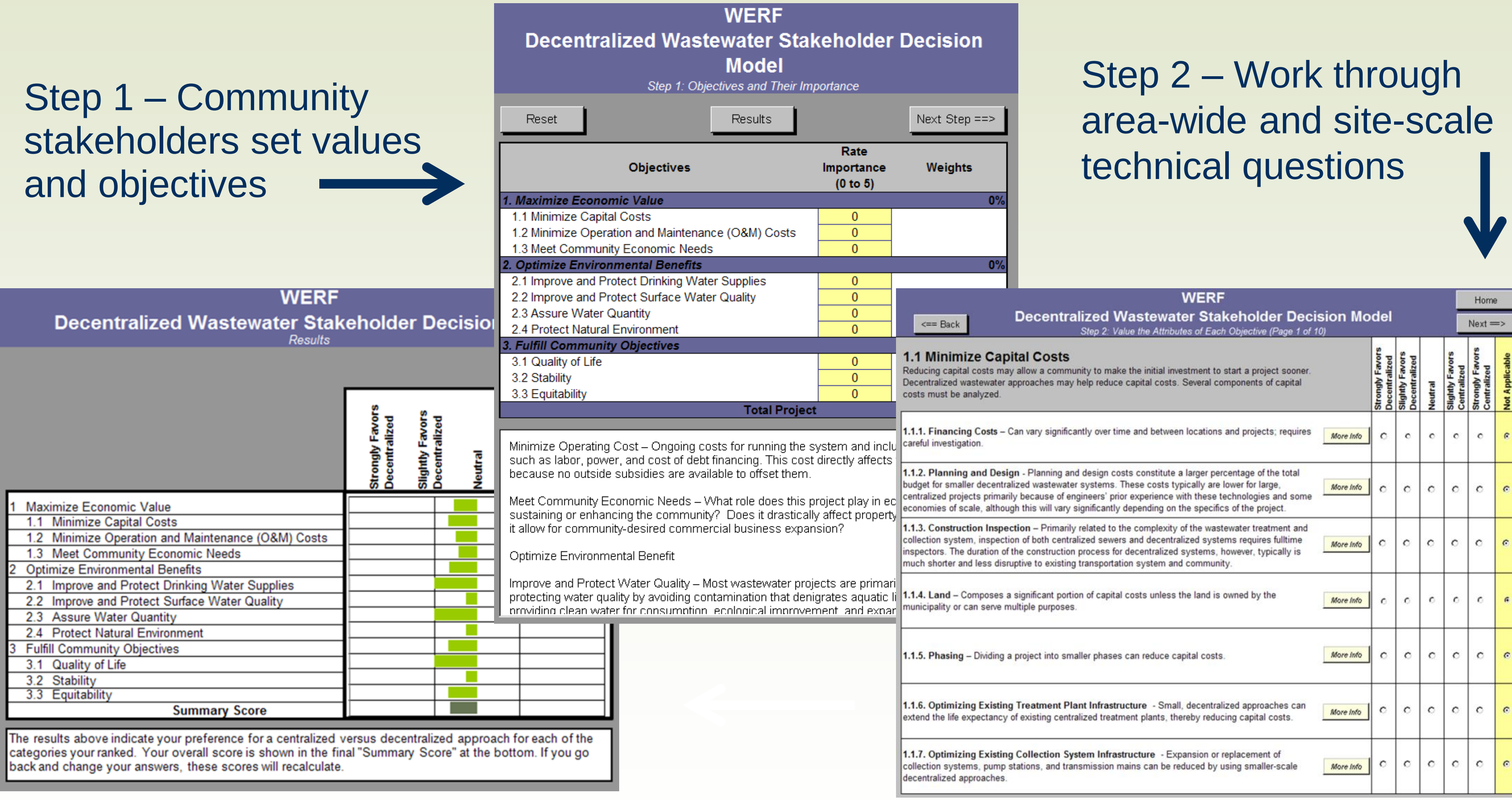

Loudoun Water, Loudoun County, VA

- **Loudoun Water**
  - Water and wastewater utility for Loudoun County, VA (DC suburb/exurb)
  - Developers construct facilities to Loudoun Water standards at no cost to Loudoun Water
- **Management highlights**
  - RME Level IV (operation) for commercial facilities
  - RME Level V (ownership and operation) for communities
  - Financially self-sustaining

Wastewater Stakeholders Decision Model

Step 1 – Community stakeholders set values and objectives

Step 2 – Work through area-wide and site-scale technical questions



Step 3 – Results provide transparent basis for informed decisions

Wastewater Stakeholders Decision Model Attributes

Economic	Environmental	Societal
Maximize Economic Value	Optimize Environmental Benefit	Fulfill Community Objectives

Economic

Maximize Economic Value

Minimize Capital Costs
- Planning and Design
- Land
- Phasing
- Existing Treatment
- Existing Collection
- Financing

Minimize Operating Costs
- Financing Cost
- Labor
- Power
- Byproducts
- Other

Meet Community Economic Needs
- Availability
- Adaptability
- Externalities

Environmental

Optimize Environmental Benefit

Water Quality
- Avoidance
- Removal

Water Quantity
- Water Balance
- Sustain Flow

Natural Environment
- Biodiversity
- Disturbance
- Global Warming

Societal

Fulfill Community Objectives

Quality of Life
- Health
- Outdoor Environment
- Built Environment

Stability
- Dependable
- Resilient
- Safe

Equitability
- Serves All Equally
- Charges Everyone Fairly

Additional information

- Online training modules: https://engineering.purdue.edu/~iwla/webinars/wastewater2010/index.html
- http://water.epa.gov/infrastructure/septic/
- www.werf.org/distributedwater
- www.werf.org/decentralizedoutreach

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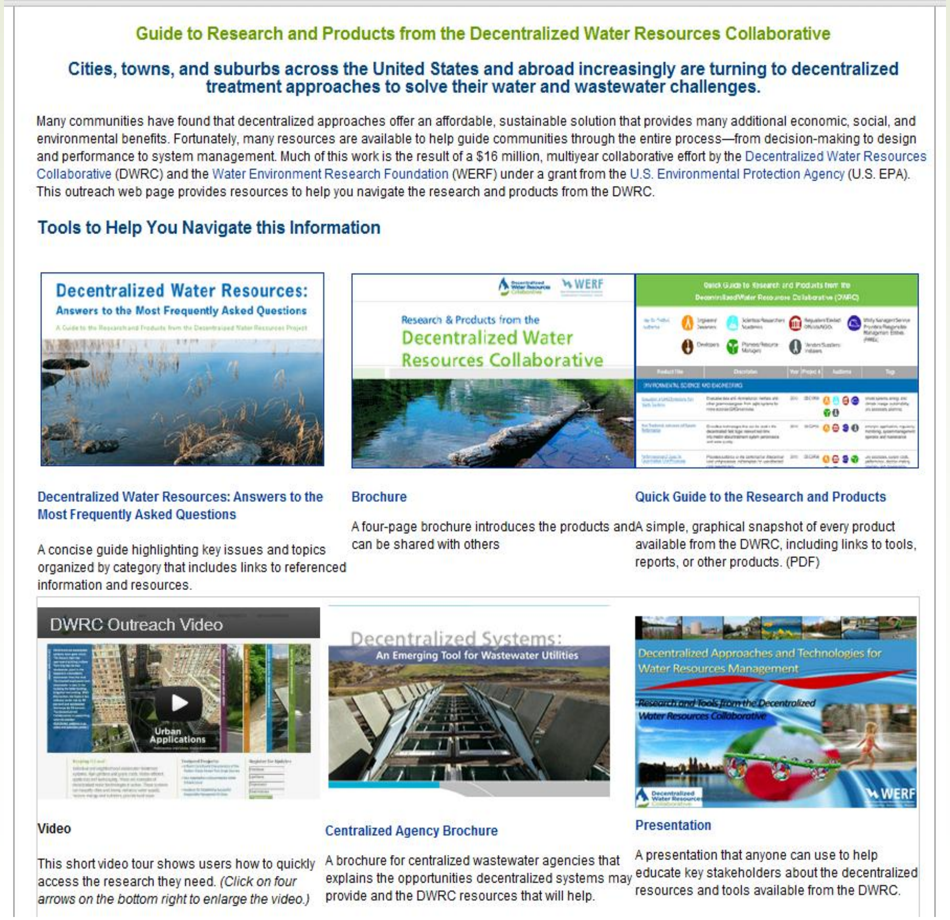

Guide to Research and Products from the Decentralized Water Resources Collaborative

Cities, towns, and suburbs across the United States and abroad increasingly are turning to decentralized treatment approaches to solve their water and wastewater challenges.

Many communities have found that decentralized approaches offer an affordable, sustainable solution that provides many additional economic, social, and environmental benefits. Fortunately, many resources are available to help guide communities through the entire process—from decision-making to design and performance to system management. Much of this work is the result of a $16 million, multiyear collaborative effort by the Decentralized Water Resources Collaborative (DWRC) and the Water Environment Research Foundation (WERF) under a grant from the U.S. Environmental Protection Agency (U.S. EPA). This outreach web page provides resources to help you navigate the research and products from the DWRC.

Tools to Help You Navigate this Information

Decentralized Water Resources: Answers to the Most Frequently Asked Questions

A concise guide highlighting key issues and topics organized by category that includes links to referenced information and resources.

Brochure

A four-page brochure introduces the products and can be shared with others

Quick Guide to the Research and Products

A simple, graphical snapshot of every product available from the DWRC, including links to tools, reports, or other products. (PDF)

Video

This short video tour shows users how to quickly access the research they need. *(Click on four arrows on the bottom right to enlarge the video.)*

Centralized Agency Brochure

A brochure for centralized wastewater agencies that explains the opportunities decentralized systems may provide and the DWRC resources that will help.

Presentation

A presentation that anyone can use to help educate key stakeholders about the decentralized resources and tools available from the DWRC.