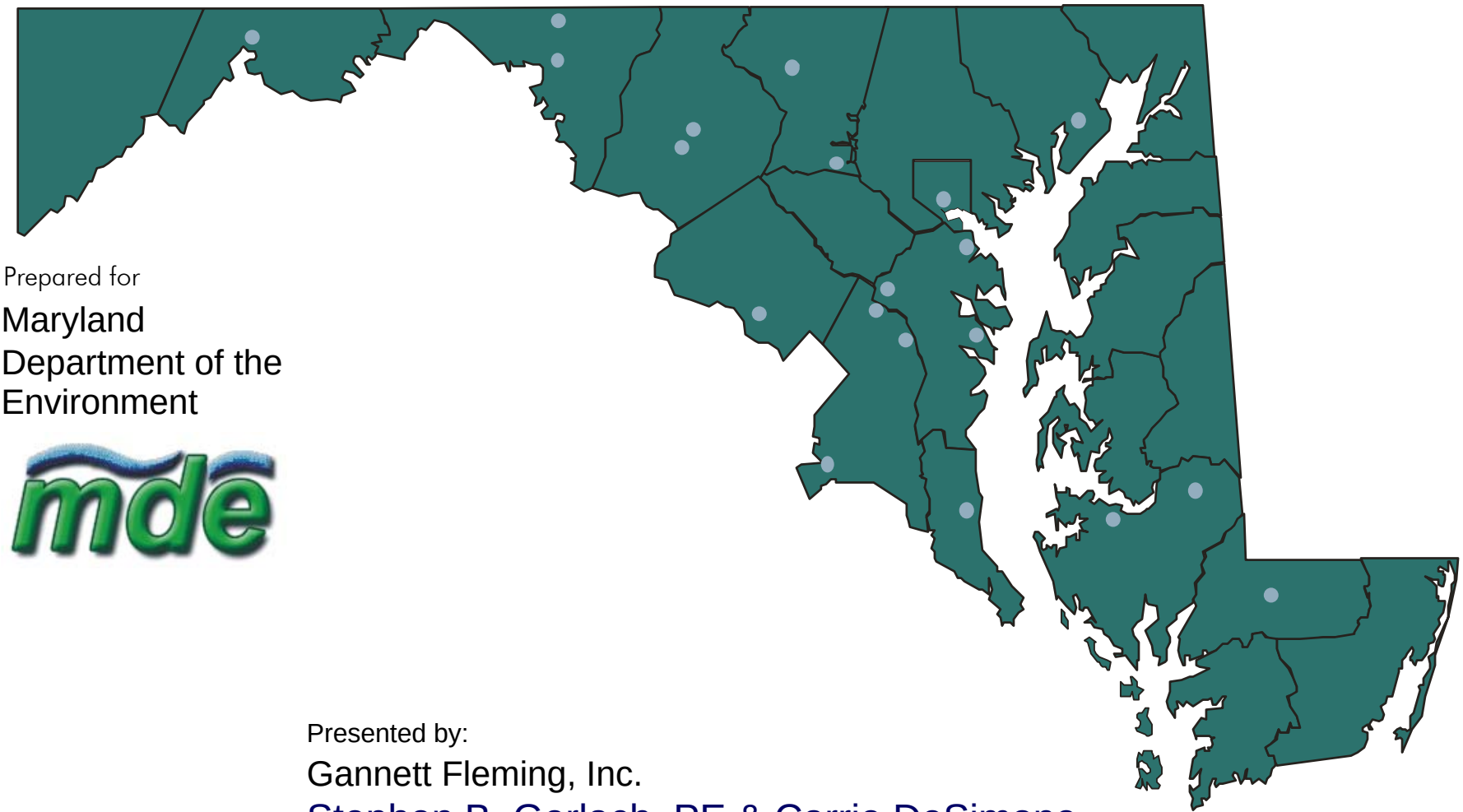
Refinement of Nitrogen Removal from Municipal Wastewater Treatment Plants



Prepared for

Maryland Department of the Environment

Presented by:

Gannett Fleming, Inc.

Stephen B. Gerlach, PE & Carrie DeSimone

In partnership with George Miles Buhr, LLC

What is ENR?

- Enhanced Nutrient Removal
- Reduce nutrient discharges from WWTPs
- Use of state-of-the-art microbial technology to break down nitrogen before discharge
- Next step from BNR

Biological Nutrient Removal Program (BNR Program)

- Implemented in 1983 by the Maryland Department of the Environment (MDE)
- Included 66 plants of capacity ≥ 0.5 MGD
- Plants retrofitted to achieve total nitrogen limits of 8 mg/l
- Goal was 40% reduction of nutrients to Chesapeake Bay (Bay)
- Have exceeded this goal
- Actual reductions from 1985 levels=16.9 million pounds

Purpose of Enhanced Nutrient Removal Study (ENR Study – 2002 – 2004)

- Clear evidence plants could exceed 8 mg/l
- EPA/MDE/Local Governments looking to achieve further nitrogen reductions cost effectively
- Enhancement of BNR Program in compliance with amended 2000 Chesapeake Bay Agreement by further reducing nutrients to the Bay
- GF/GMB asked to evaluate 20 of the largest WWTPs in MD
- Evaluate alternatives for reducing nitrogen in WWTP effluent
- Develop cost estimate for alternatives
- Extrapolate cost estimate to 66 plants in BNR Program which helped establish newly enacted flush tax

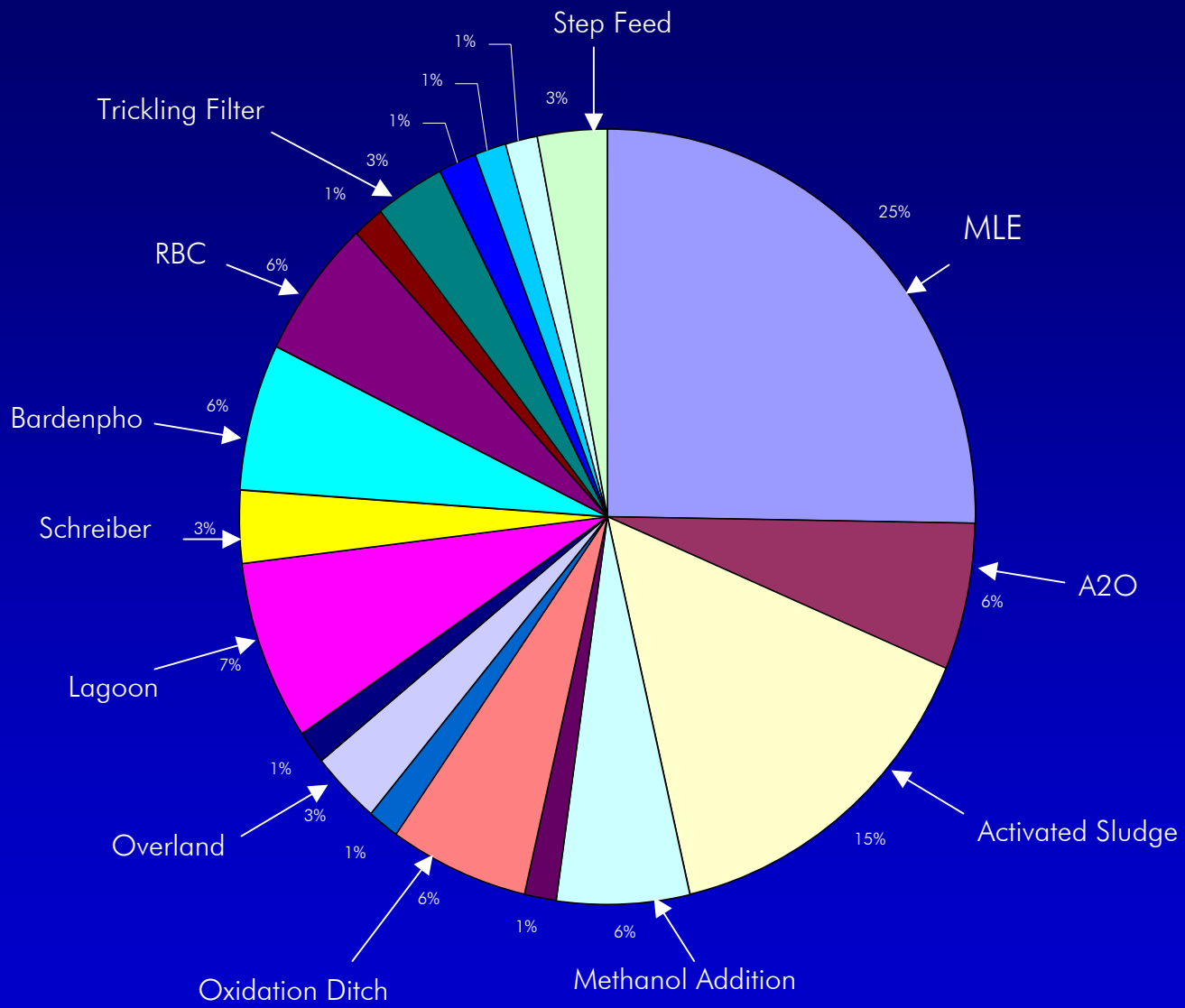

Conococheague WWTP
Cumberland WWTP
Westminster WWTP
City of Frederick WWTP
Sod Run WWTP
Hagerstown WPCP
Freedom District WWTP
Back River WWTP
Ballenger Creek WWTP
Cox Creek WRF
Parkway WWTP
Little Patuxent WRF
Seneca WWTP
Annapolis WRF
Bowie WWTP
Piscataway WWTP
Hurlock WWTP
City of Cambridge WWTP
Marley Taylor WRF
Salisbury WWTP

PLANT	EXISTING BNR PROCESS	RATED FLOW (MGD)
Cambridge	MLE	8.1
Seneca	MLE	20
Piscataway	Step Feed	30
Parkway	Bardenpho (4-Stage)	7.5
Annapolis	Bardenpho (4-Stage)	13
Ballenger	A_2O	6
Marley-Taylor	Schreiber System	6
Freedom District	MLE	3.5
L. Patuxent	Johannesburg	22.5
Cumberland	Step Feed	15
Sod Run	A_2O Modified	20
Westminster	MLE/A_2O	5
Hagerstown	Modified Johannesburg	8
Conococheague	MLE	4.1
Frederick	A_2O	7
Bowie	VT^2	3.3
Cox Creek	MLE	15
Back River	MLE	180
Salisbury	Submerged (A_2O) Trickling Filter	8.5
Hurlock	Bardenpho (4-Stage)	1.65

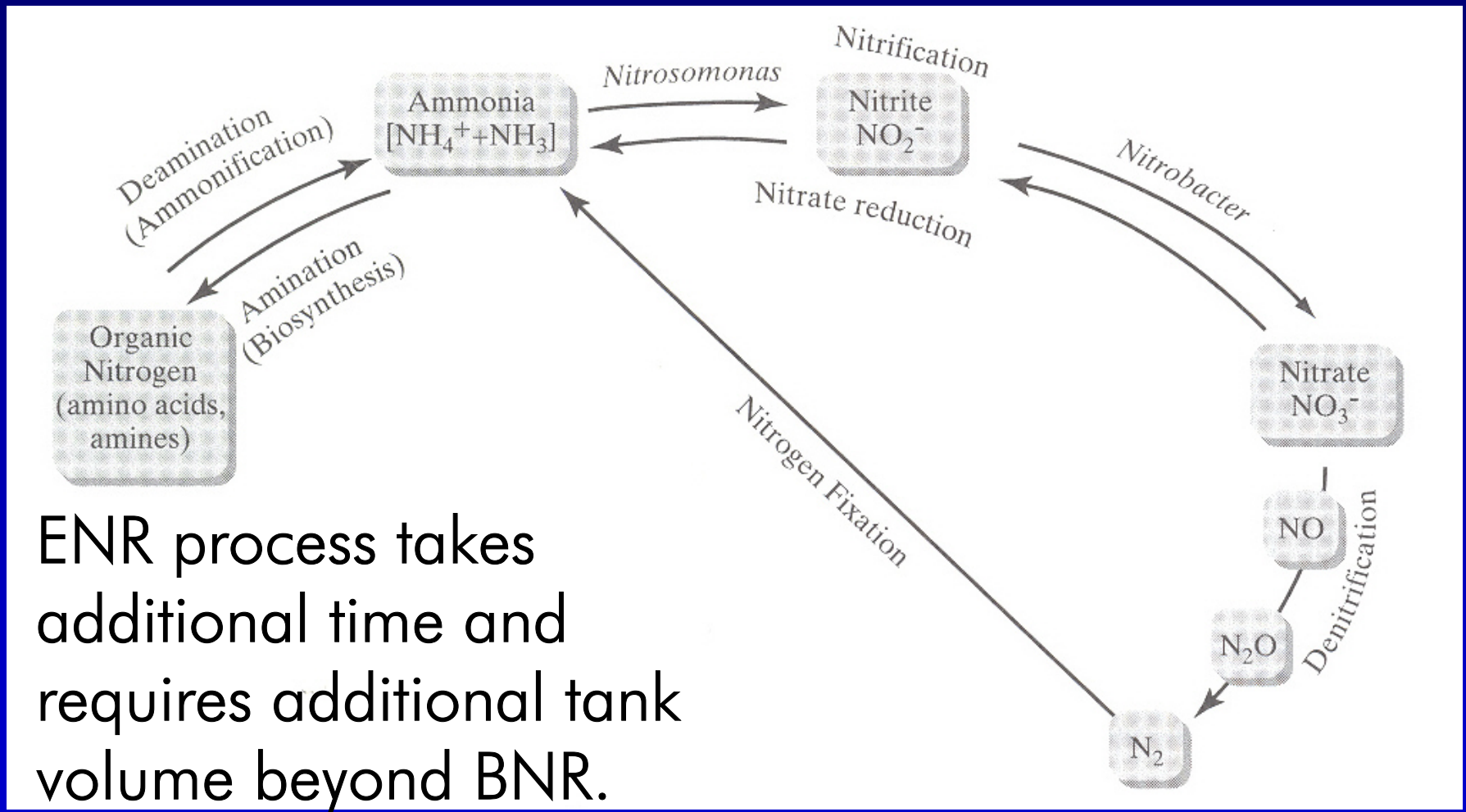
Phase I Approach

- Phase I (2002-2003): Evaluate ways to cost effectively reduce N in plant discharges
- Primary considerations in developing alternatives
  - developed biological models at each facility to estimate nitrogen removal capacity
    - determined tank (reactor) volume requirements for each plant utilizing industry standards and individual plant data
  - site constraints
  - existing plant configuration
  - cost effectiveness of alternatives
- Needed one or two processes that were proven and reliable

Breakdown of BNR Processes in Maryland Phase I Challenge

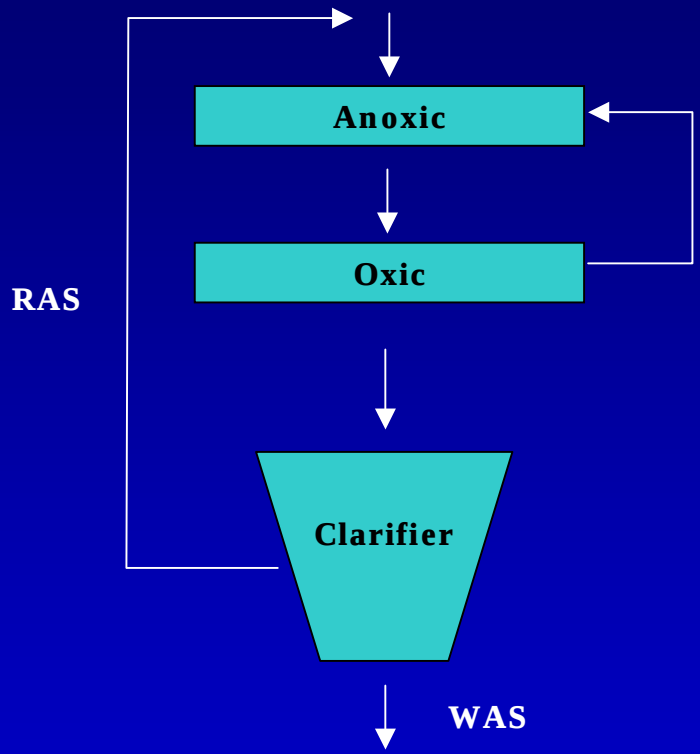


Biological Nitrogen Removal
Nitrogen Cycle



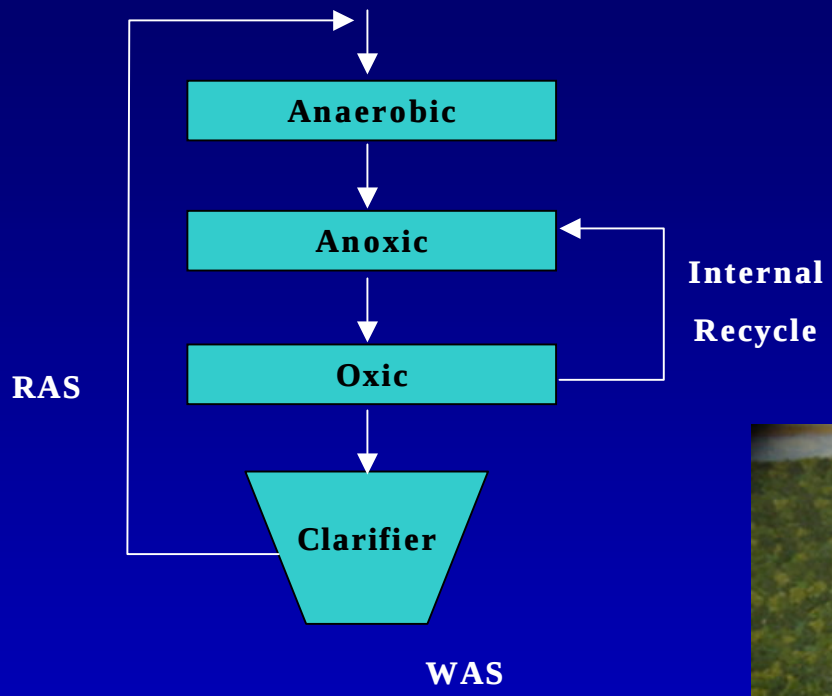
ENR process takes additional time and requires additional tank volume beyond BNR.

Modified Ludzack-Ettinger (MLE Process)



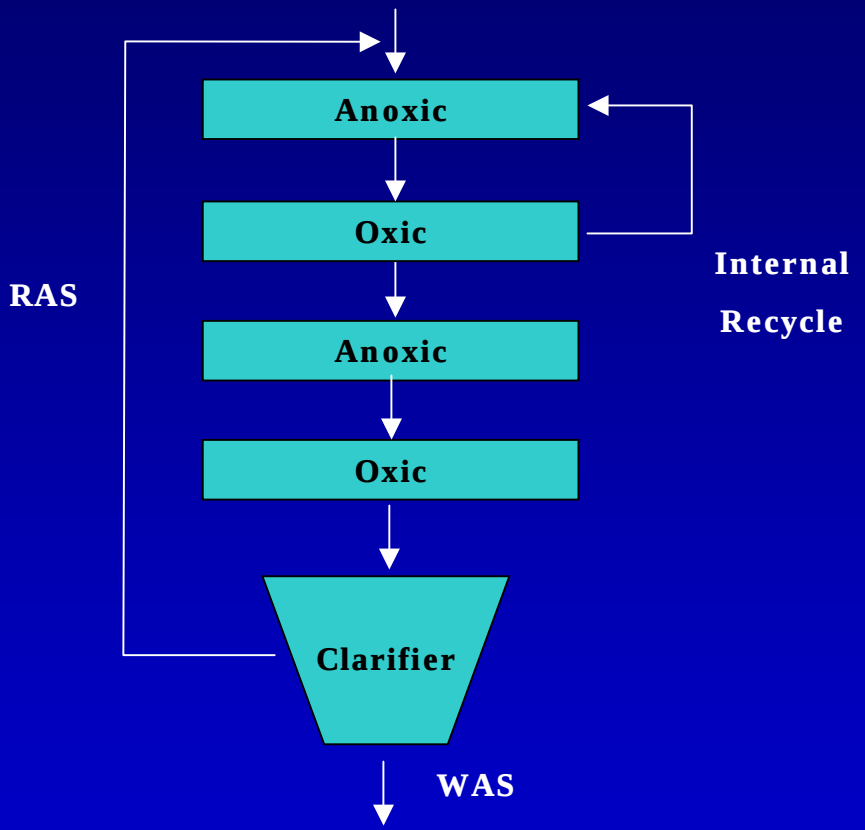
Cox Creek WRF, Anne Arundel Co.
15 mgd

A_2O Process



Sod Run WWTP, Harford Co.
20 mgd

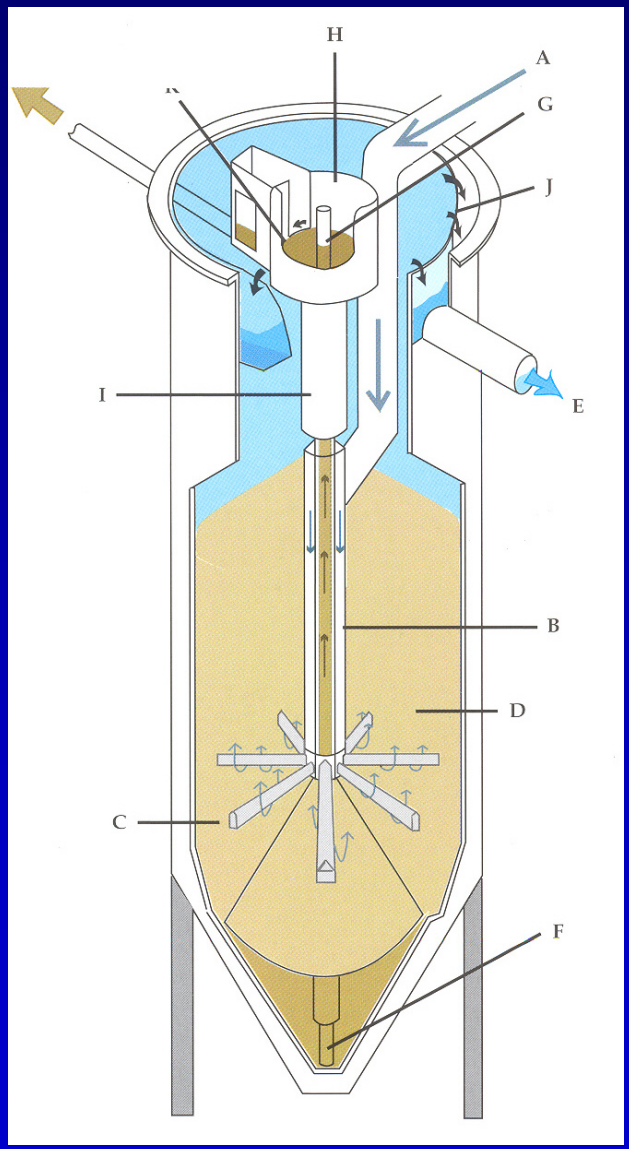
Bardenpho Process



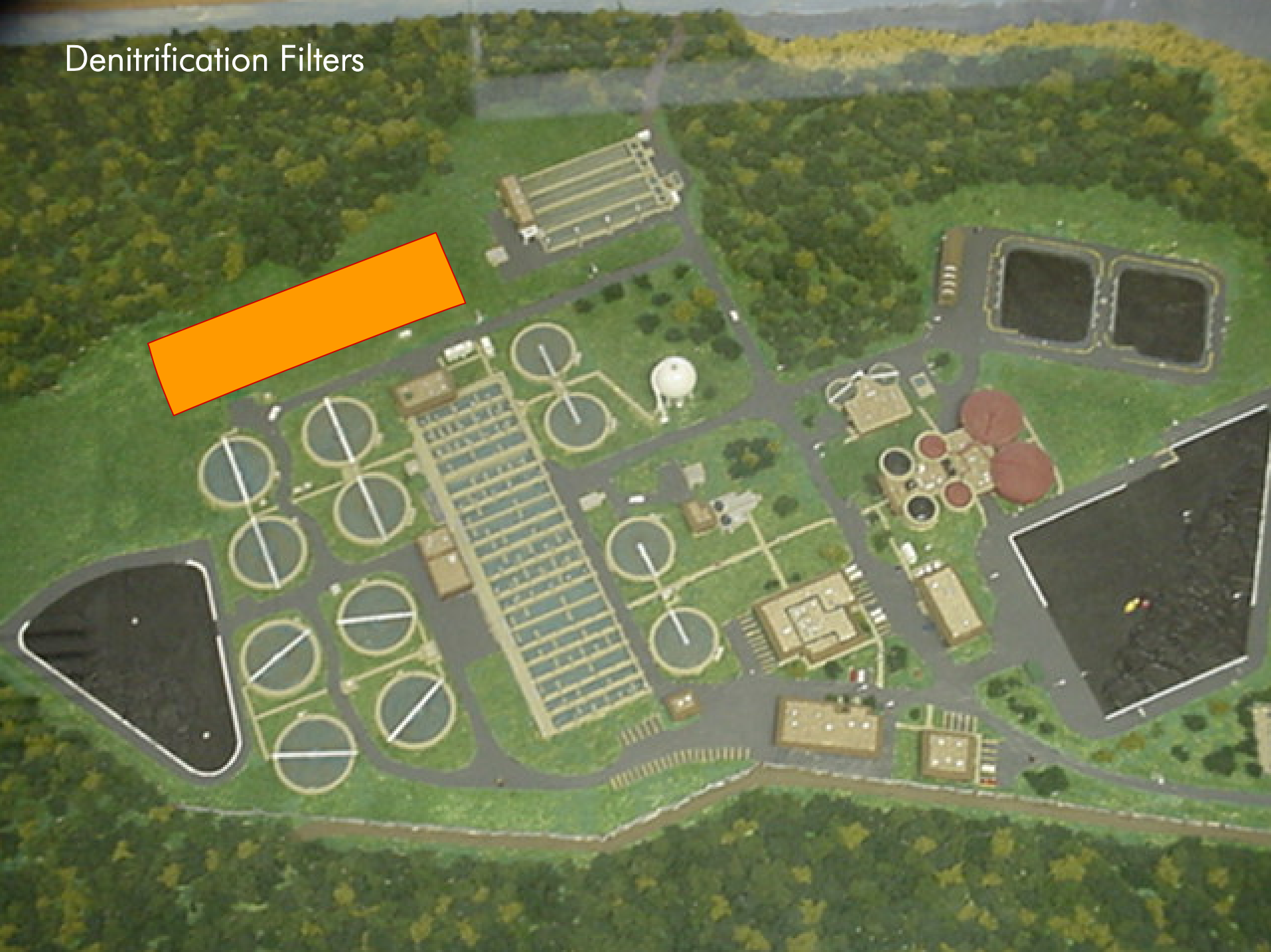
- Demonstrated ability to achieve 3 mg/l
- Least costly option
- Requires existing tank modification or additional tankage


Additional tankage required for Bardenpho

Separate-Stage Denitrification
Denitrification Filters



- Recommended when existing process nearly achieves complete nitrification
- No cost effective space available for additional reactor volume


Denitrification Filters

Phase I
Cost Estimating

- Process Equipment
  - Denitrification filters; Blowers; Pumps; Diffusers
  - Obtained manufacturer cost for several plants
  - Extrapolated equipment costs to other plants
- Other Costs
  - RSMeans estimating tools
- Operation and Maintenance Costs
- Factors applied for disciplines
  - Architectural
  - Civil
  - Mechanical
  - Electrical

STUDY METHODOLOGY
TWO PHASES

- Phase II (2003-2004)
  - Present findings from Phase I to municipalities
  - Request current operational data
  - Discuss planned expansion activities
  - Solicit feed back on report findings
  - Update Phase I data, costs and conclusions

PHASE II FEED BACK

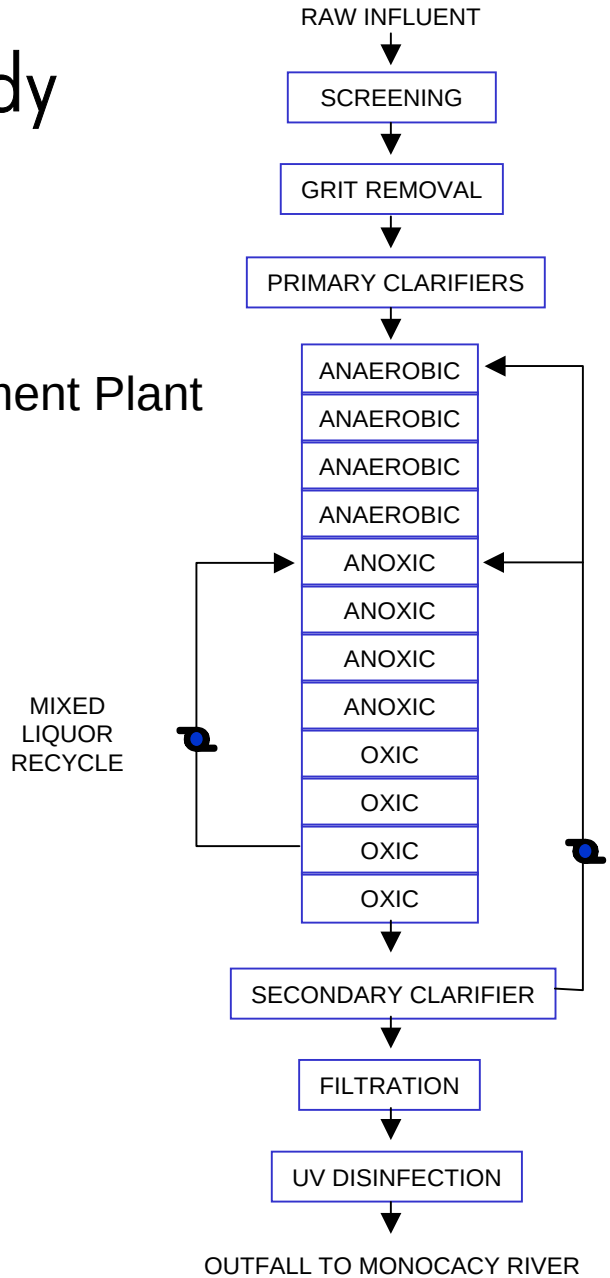
- General acceptance of study recommendations
- "One process is not suitable for every plant"
- "Detailed designs need to be performed for every plant"
- "Costs need to be indexed to Engineering News Record (ENR)"
- "Costs for some facilities are too low"
  - I&C
  - Foundation
  - Engineering

Cost Estimates Revisions

- Moved costs for 2002 ⟶ Sept. 2004
- Applied 10% to site-limited plants such as Cox Creek and Sod Run
- Added $50/ft^2 for geotechnical at select plants
- Added methanol systems for each plant
- Added methanol control at plants with denite filters
  - Nitrate analyzers and loop controllers
- Added lift pumping stations at plants with denite filters

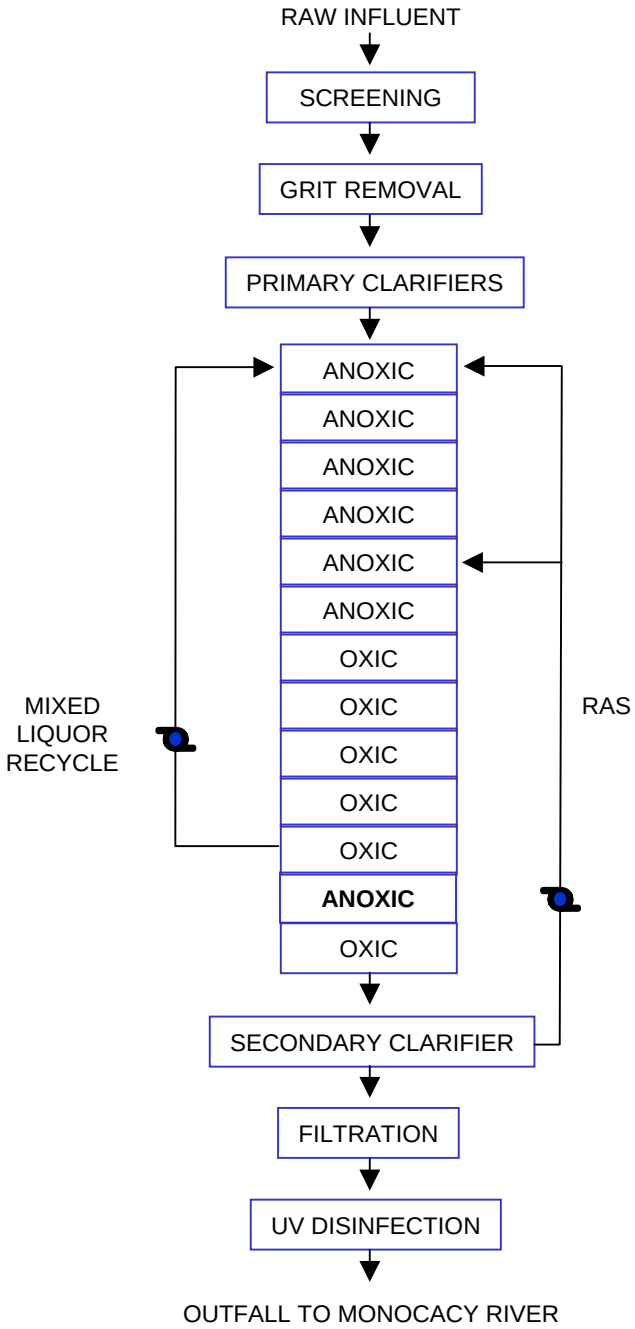
Case Study

Existing Ballenger
Wastewater Treatment Plant
6.0 mgd



- A_2O Process
- BOD:TKN = 7:1
- Influent Avg. TKN – 38
- Current TN Discharge: 146,100 lbs
- Projected TN Discharge: 54,800 lbs
- Reduction of 91,300 lb/yr

Case Study



Proposed Alternate for Ballenger Wastewater Treatment Plant

Sufficient volume for 4-Stage Bardenpho

Add partition walls

Increase MLSS 2500→ 3500

Adequate clarifier capacity

Adequate pump capacity

Increase IR 200%→ 500%

Add additional IR pumps

Add chemical phosphorus removal

Adequate $FeCl_3$ System

Estimated Cost for ENR: $3,800,000

Case Study

Cox Creek Water Reclamation Facility
Anne Arundel County
15 mgd

- Existing MLE Process
- Insufficient Reactor Volume Available
- No Space for Additional Tankage
- Solution – Denitrification Filter (requires demo of digesters)
- Current TN Discharge: 365,300 lb/yr
- Projected TN Discharge: 136,990 lb/yr
- Reduction of 228,310 lb/yr

Case Study

Cox Creek Water Reclamation Facility
Anne Arundel County
15 mgd

ESTIMATED COST FOR
REFINEMENT OF NITROGEN REMOVAL AT
COX CREEK WATER RECLAMATION FACILITY

Item	Cost
Process Mechanical	$9,782,000
Electrical	$2,935,000
Mechanical	$978,000
Architectural	$978,000
Site work	$1,956,000
Subtotal	**$16,629,000**
Study, Design and Construction Phase Engineering (15%)	$2,494,000
Escalation per ENR Cost Index	$1,164,000
Mobilization	$1,663,000
Construction Contingency (25%)	$4,157,000
Total Estimated Cost	**$26,107,000**

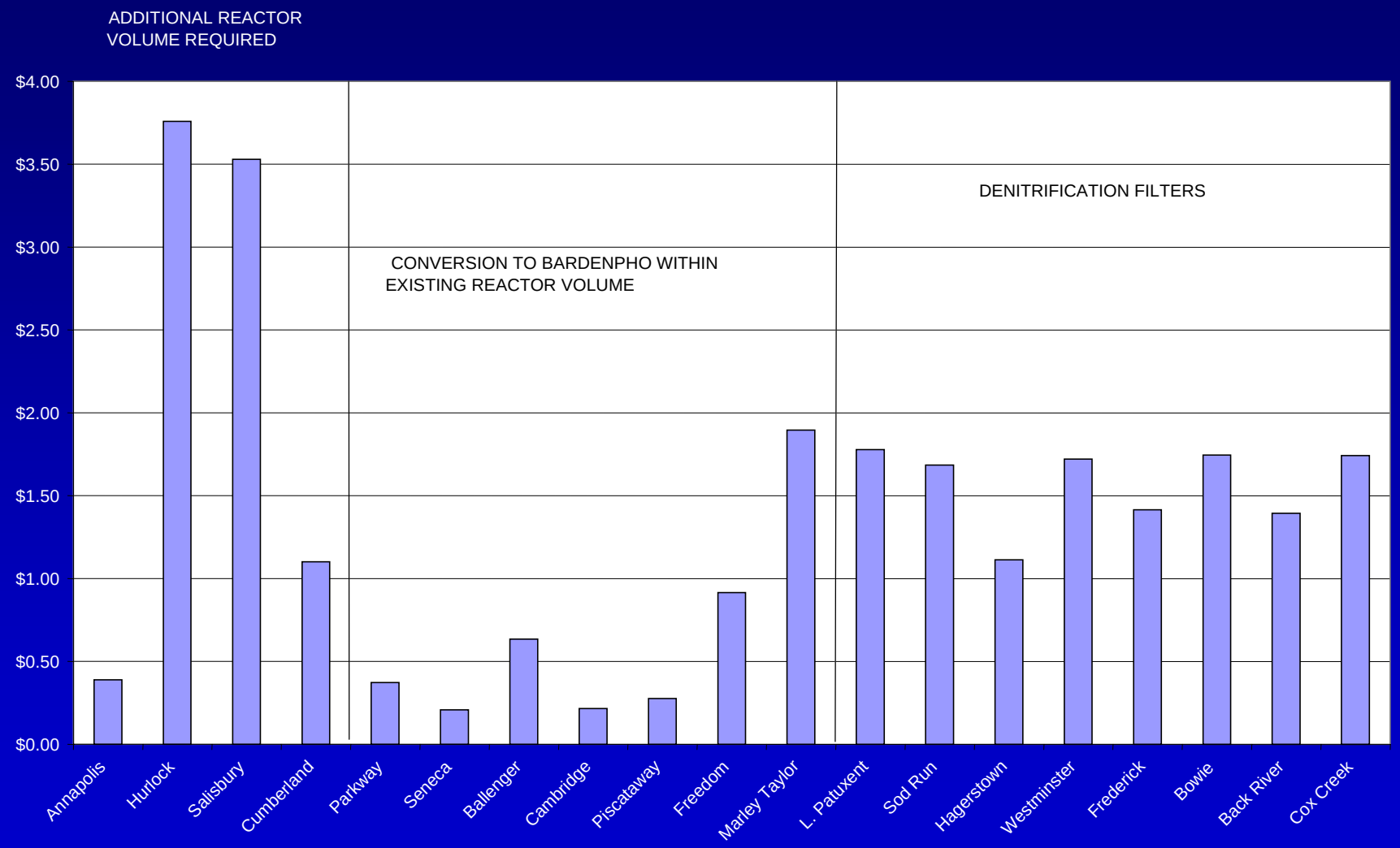
PLANT	EXISTING (OR CURRENTLY DESIGNED) BNR PROCESS	ENR MODIFICATIONS	POUNDS TN REMOVED WITH ENR MODIFICATIONS (1)	ESTIMATED ENR COST (SEPT. 2004 ENG. NEWS RECORD COST INDEX)	COST PER POUND REMOVED (2)	COST PER GALLON TREATED (3)
Cambridge	Modified Ludzack-Ettinger (MLE)	Reconfiguration to Bardenpho	123,257	$1,750,000	$0.96	$0.22
Seneca	Modified Ludzack-Ettinger	Increase in internal Re				
Piscataway	Step Feed	Re				
Parkway	4-Stage Bardenpho	Meth				
Annapolis	4-Stage Bardenpho	Ad				
Ballenger	A_2O	Inc Re				
Marley-Taylor	Schreiber System	Addi				
Freedom	Modified Ludzack-Ettinger	Pro and Reconfiguration to Bardenpho	53,235	$3,472,000		$0.99
L. Patuxe	Johannesburg	Denitrification filter	194,523	$28,000,000		$1.78
Cumberl			228,308	$16,500,000		$1.10
Sod Run			304,410	$22,568,000		$1.13
Westminster	MLE/A_2O	cation filters	76,114	$8,600,000		$1.72
Hagerstown	Modified Johannesburg	ion filters	133,940	$8,900,000	46	$1.11
Conococheague	Modified Ludzack-Ettinger		NA	NA	NA	NA
Frederick	A_2O	De ters	104,528	$9,900,000	6.37	$1.41
Bowie	VT^2 Oxidation Ditch	Denitri	50,228	$1,000,000	$0.55	$1.75
Cox Creek	Modified Ludzack-Ettinger	Denitrificatio	228,308	$26,107,000	$7.69	$1.74
Back River	Modified Ludzack-Ettinger	Denitrification filte	2,739,690	$250,850,000	$6.15	$1.39
Salisbury	A_2O Trickling Filter	NA	333,800	$30,175,000	$5.30	$4.18
Hurlock	4-Stage Bardenpho	Additional reactor volume	50,228	$6,200,000	$8.30	$3.76
		TOTAL	5,714,000	AVE.	$5.90	$1.38
NOTES:				MAX.	$30.29	$4.18
				MIN.	$0.55	$0.21

	Cost per lb. removed	Cost per gal. treated
Avg	$ 5.90	$ 1.38
Max	$30.29	$ 4.18
Min	$ 0.55	$ 0.21

Total Pounds Nitrogen Removed with ENR: 5,714,000

Results

Cost per Gallon of ENR Improvements



CONCLUSIONS

- Single phase implementation of ENR is most cost effective
- Alternative carbon sources add flexibility
- Independent study required to establish best treatment alternative
- Average costs

  $5.90 per pound nitrogen removed

  $1.38 per gallon treated

- Closely matches previous BNR costs

Refinement of Nitrogen Removal from Municipal Wastewater Treatment Plants

Prepared for

Maryland Department of the Environment

QUESTIONS?