Report of the Lewes BPW WWTF Contingency Planning Committee

Executive Summary

The Lewes BPW is exploring alternatives to address the vulnerability to sea level rise and flood damage of its current wastewater treatment facility (WWTF). The BPW identified three main options:

- Option 1: hardening the existing facility
- Option 2: building a new facility
- Option 3: partnering with the county to send Lewes wastewater to an expanded Sussex County WWTF on higher ground at Wolfe Neck.

Following evaluation of the long-range planning report prepared by engineering firm GHD, public comment, site visits, and discussions with Sussex County, the BPW Board agreed to pursue Option 3 as the primary focus to address the challenge of sea level rise to future treatment of Lewes' wastewater. The Board then established the WWTF Contingency Committee ("committee") to evaluate alternative technologies for Options 1 and 2, should the Board and Sussex County be unable to reach agreement on Option 3. This report covers the findings of that committee.

In the time since the GHD report was prepared:

- Findings from a Phase I archeological study at the County facility have called into question the ability to discharge treated effluent into constructed wetlands. If construction of an ocean outfall is required, Option 3 costs will significantly increase.
- The committee evaluated technologies that require less land and have lower capital and operation and maintenance costs than the technologies GHD used for Options 1 and 2.

After extensive research and discussion, the committee concluded that viable technology solutions exist for both Option 1 and Option 2 and that the optimal technology assessed would have significantly lower costs than the GHD report baseline, while ensuring stewardship of the environment. The most environmentally protective, sustainable, and cost-effective technologies for Option 1 or Option 2 scenarios are the AquaNereda Aerobic Granular Sludge (AGS) process equipment for secondary treatment, and Aqua-Disk Cloth Media Filters and ultraviolet disinfection for tertiary treatment. Capital costs are very roughly estimated at $20 million for Option 1 and $40 million for Option 2. These estimates are derived from costs for recently constructed WWTFs and process design estimates from Aqua-Aerobic Systems, Inc. Operating costs are expected to be substantially lower than those described in the GHD report, based on discussions with operators and engineers at existing US AGS plants.

A choice between the two options depends on variables beyond the scope of this report, including a detailed engineering design and cost analysis, availability and cost of land, and community acceptance. Lacking sufficient reason to eliminate one of these options, we present conclusions on both.

Table of Contents

Note: The GHD "Lewes WWTF Long Range Planning Study; Conceptual Evaluation Report, November 28, 2022" and minutes from committee meetings were removed from the report: they are available elsewhere on the Lewes BPW website.

I. Purpose

The Board of Directors ("Board") of the Lewes Board of Public Works (BPW) established the Wastewater Treatment Facility (WWTF) Contingency Committee ("committee") on July 26, 2023 for the purpose of "researching, reviewing and evaluating proven operational technologies for Option 1: Hardening the Existing WWTP and Option 2: Construction of a New WWTP from the GHD Study"[1] not evaluated in the GHD Study, and providing a final report to the Board by January 31, 2024.

No funding was provided for the committee.

II. Process

The Board appointed the following persons to the committee:
Barbara Curtis: Chair and BPW Board member. BA Philosophy, MS Environmental Science; career in environmental management and policy for international manufacturing companies. Full-time Lewes resident.
Earl Webb: BPW Board VP. BS Business; GE Capital - Executive. Full-time Lewes resident.
Austin Calaman: General Manager BPW since 2021, Assistant General Manager for 5 years. B.S. Supply Chain Operations Management.
Daphne Fuentevilla: PhD, Chemical Engineering with a specialty in thermodynamics; Deputy Director of Operational Energy, US Department of the Navy. Adjunct Assistant Professor, University of Maryland in College Park teaching thermodynamics and battery manufacturing. Part-time Lewes resident and BPW customer.
Donna Colton: BS Civil Engineering, MS Water Resources, Registered Professional Engineer; working with Sussex County Soil Conservation. Full-time Lewes resident.
Mark Prouty: MS Environmental Engineering; Professional Engineer (ret.) with a career in water and wastewater treatment plant design and operations. BPW customer.
Sumner Crosby: BS Geology, MS Environmental and Regional Planning. Background in geographic information systems (GIS). He worked for many years at the U.S. Environmental Protection Agency, and in education at the elementary and secondary level. Full-time Lewes resident.
Bob Heffernan: BS Mechanical Engineering, MBA; president of a company that manufactured very accurate flow meters for chemical, municipal, petroleum and semiconductor, laboratory applications. Current owner of a business manufacturing products for home accessibility. Full-time Lewes resident.
Tim Ritzert: City Council ex-officio: BS Political Science; career includes positions in the electric utility and telecommunications industries. Full-time Lewes resident.

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[1] Resolution No. 23-006 creating a committee to examine contingency options for the Lewes BPW Wastewater Treatment Plant. Adopted as amended by the Board of Directors of the Lewes Board of Public Works at its meeting on July 26, 2023.

The committee met eleven times between August 21, 2023 and January 23, 2024. Members reviewed materials available online on Sequencing Batch Reactor ("SBR") and Nereda Aerobic Granular Sludge ("AGS") wastewater treatment technologies. The committee reviewed materials[2] provided and attended webinars held by Aqua-Aerobic Systems, Inc. The webinars covered "AquaNereda Installation Performance Update" and "AquaNereda Retrofits and Upgrades". In addition, the committee meeting on October 23rd was an in-person presentation and Q&A session by Aqua-Aerobic Systems, Inc.

Committee meeting minutes are available on the BPW website.

Other sources of information garnered by a sub-quorum of committee members and discussed at full committee meetings include a tour of the Berlin, MD SBR WWTF; discussions with University of Delaware School of Marine Science and Policy professors Dr. Andrew Wozniak and Dr. Bill Ullman; correspondence and discussions with Hans Medlarz, Sussex County Engineer; interviews with and answers to written questions from managers and design engineers for operations at three US AquaNereda plants (Foley, AL; Whitefish, MT; and Wolcott, KS); and correspondence with Aqua-Aerobic Systems representatives.

III. Background

A. Initial Long-Range Planning Assessment and GHD Report

In March 2022, the BPW held the first of several public meetings exploring concepts to address the vulnerability to sea level rise and flood damage of the current WWTF site. To inform the discussion, Sussex County and BPW jointly contracted with engineering firm GHD to develop and evaluate options to provide increased resilience for wastewater treatment within the BPW's service area up to the year 2050.

The GHD analysis was an engineering study multi-criteria analysis and capital and operating cost assessment covering three main options. Option 1 hardens the existing WWTF with berms and sheet piling and includes upgrades to the current facility. Option 2 replaces the existing facility with a new facility upland. Option 3 leverages a partnership with Sussex County to pump wastewater to a new Sussex County treatment facility located at the Wolfe Neck WWTF site. Both Option 2 and Option 3 would involve decommissioning the Lewes WWTF at a preliminary cost estimated by GHD of ~ $3.5M.

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[2] AquaNereda Aerobic Granular Sludge Technology: Idaho Springs WWTP – Case Study. Evaluating the main and side effects of high salinity on aerobic granular sludge, M. Pronk et al; Applied Microbiology Biotechnology, Springer-Verlag Berlin Heidelberg 2013. Aerobic Granular Sludge Technology – Start-up; Aqua-Aerobic Systems, Inc. Aerobic Granular Sludge Technology – Robustness & Resiliency. Aqua Service: Programs, Parts and Cost Savings Solutions. Aqua-Aerobics Systems, Inc.: Company Profile and Capabilities. City of Whitefish 2016 Wastewater System Improvements Project; Preliminary Engineering Report. Comparison of Nereda to Other Treatment Systems Royal Haskoning website Q&As.

Options 2 and 3 also included sub-options for the discharge of the treated wastewater. Option 2 assessed discharge of treated wastewater via spray irrigation (option 2a), pumping of treated wastewater back to the existing Lewes WWTP outfall discharge point (option 2b), and development of a new ocean outfall piped through Cape Henlopen State Park (option 2c). Option 3 assessed pumping of treated wastewater back to the existing Lewes outfall pipe (option 3a) and discharge of treated wastewater to a constructed wetland (option 3b).

In order to perform the multi-criteria analysis and develop cost estimates, a design basis was established for the three options under which the quality of treated effluent would meet existing Lewes National Pollutant Discharge Elimination System (NPDES) permit limits: the current membrane bioreactor treatment process for Option 1; and activated sludge treatment with tertiary effluent filtration and UV disinfection for Options 2 and 3. The multi-criteria analysis considered permitting and schedule, community and environmental, and operation and maintenance impacts. GHD assumed that moving the outfall to the opposite bank of the canal would not trigger a change in permit limits.

After consideration of the GHD study multi-criteria analysis and cost estimates, testimony at public workshops, and written public comments, Lewes BPW has been pursuing Option 3.

B. Impact of Archaeological Findings

In the summer of 2023, DNREC informed Sussex County of significant findings from a Phase I archaeological study of the Wolfe Neck WWTF and spray irrigation parcel. The impact of the findings will not be fully known until further studies are completed later in 2024. This has created uncertainty for Option 3b (constructed wetlands) as well as for the County's plans to install fixed-head irrigation in managed forests. It is possible that ground disturbance in the open areas surrounding the existing Wolfe Neck treatment plant will be prohibited. Consequently, the County is evaluating a new Option 3c, an ocean outfall from the Wolfe Neck site. This outfall is different from the Option 2c outfall in location, technical risk, and cost. The drilling for a 3c outfall pipe could be shorter and less costly than the 2c option and, in contrast to Option 3a, would remove all effluent from the canal.

GHD is preparing a revised report for the 3c option for Sussex County which will include a revised cost estimate. (The study is not revisiting the multi-criteria analysis included in the original engineering assessment.) Their report is due in early 2024. A significant cost increase is anticipated.

C. Current Status of WWTF Long-Range Planning for Sea Level Rise and Flood Damage Resilience

Lewes BPW is pursuing Option 3 as the primary focus of long-range planning for Lewes' wastewater treatment. However, the Board is holding Options 1 and 2 in abeyance should the BPW not be able to reach an acceptable agreement with the County from both a cost and control perspective. The WWTF Contingency Committee was established to evaluate alternatives and technologies not considered in the GHD study for Options 1 and 2. This report covers the findings of the committee.

D. Decision Timelines

Because of funding opportunities, Sussex County and the BPW targeted December 2023 to collectively reach a 'yes' or 'no' decision on Option 3. Funding considerations and uncertainties caused by the archeological study have extended the decision timelines. While the Lewes WWTF site is vulnerable, the timeline of environmental impacts from sea level rise remains undefined.

The WWTF Contingency Committee report was due on January 31, 2024. A draft was delivered to the Board on January 26, 2024. The report was finalized on March 11, 2024. It provides engineering alternatives not contemplated by the original GHD study to assist the Board in its decision making.

An engineering feasibility study is recommended to obtain site-specific cost estimates for the new Options 1 and 2 contained herein.

Regardless of the BPW decision, it is anticipated that the current Lewes WWTF will remain in operation throughout most or all of this decade. Debt service for the plant is scheduled to be extinguished in 2027.

IV. Criteria for Evaluation of Options 1 and 2

The primary criteria for any WWTF decisions are environmental protection and cost.

Other key criteria include risk vulnerability (e.g., from storm events and sea level rise) and community acceptance. Additional considerations include permit issues, land use and acquisition, difficulty of operating the existing plant, ability of the BPW to affect future treatment of the town's wastewater and its discharge location, quantity and quality of the discharged effluent, and flexibility of the selected site and technology to meet future needs including anticipated new rules (e.g., for per- and polyfluorinated alkyl substances PFAS/PFOS).

This report, like the GHD report, focused on decisions for wastewater treatment through 2050: the average lifespan of WWTF capital equipment and a reasonably foreseeable prediction period for risks. While decisions such as technology can be revisited at the end of their 20-30 year anticipated life, other decisions, such as location and ownership of the Lewes WWTF have much longer impacts and will be much more difficult to revisit. The long-term impact of WWTF location and control decisions elevates the importance of understanding all options under review to make the best choice possible for the community.

V. Technology for Wastewater Treatment at the Lewes BPW

The technology selected for wastewater treatment affects the cost, land use requirements, environmental protection/ water quality, risk profile, community acceptance and future flexibility. GHD assessed Options 1 and 2 based on continued use of the current technology for Option 1[3] and traditional activated sludge technology for Option 2.

A Primer on Wastewater Treatment:
Wastewater treatment generally consists of three stages: a preliminary/primary stage, secondary treatment, and tertiary polishing. Sludge management (the materials removed in each stage) is also an important component when considering costs.

- Preliminary treatment is the physical removal of large solids and debris through processes like screening and grit removal. "Headworks" physically screen plastics and other debris to protect downstream treatment processes from potential damage or interference caused by larger particles. Primary treatment includes sedimentation of settleable solids from the incoming wastewater.

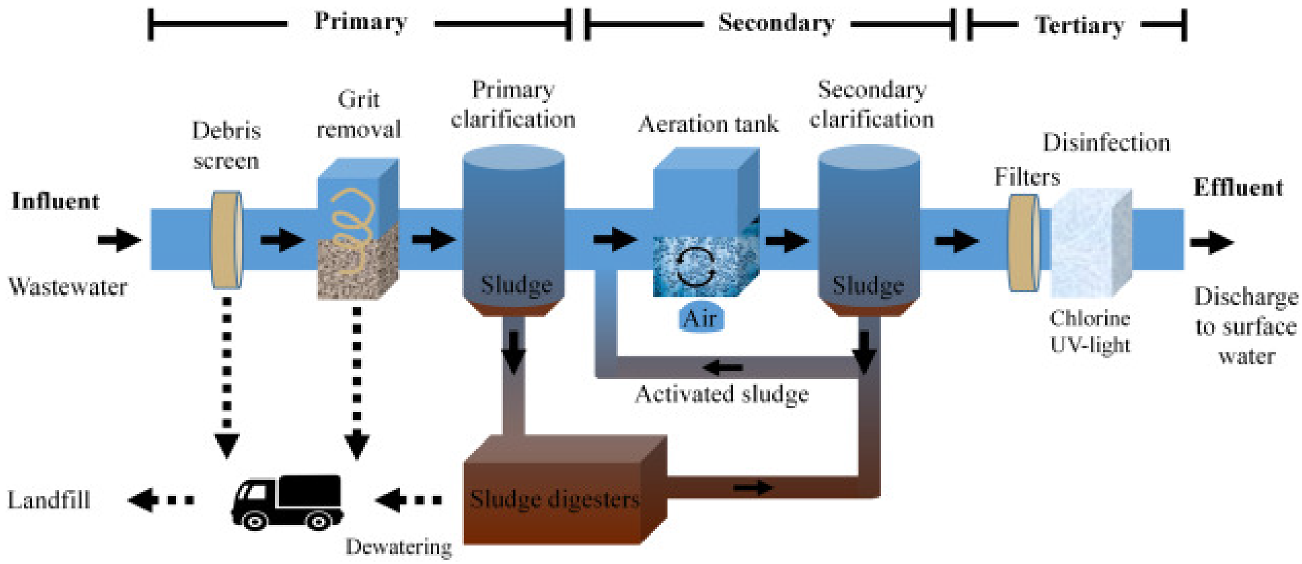
- Secondary treatment is where the bulk of treatment occurs, breaking down organic matter and removing or segregating pollutants in the wastewater. This is typically an aerobic biological process where microorganisms break down organic matter, and often includes activated sludge systems or other biological treatment methods. Biological treatment is highly effective in improving water quality in this secondary stage. Activated sludge systems rely on compressed air from large blowers to supply the needed oxygen to the microbes. However, some treatment approaches use chemical treatments or physical screening in place of or in addition to biological activity.

- Tertiary treatment processes, including filtration, disinfection, and nutrient removal, improve the quality of the effluent by removing remaining impurities. Water may be further treated for clarity and is ready for discharge at the end of this stage.

Removal of solids during the primary and secondary stages results in additional steps for sludge treatment and disposal.

[3] For the current technology hardening and expansion for future growth, GHD anticipated expanding the treatment building into the wetlands, approval for which is problematic. Further, while the current technology produces a high-quality effluent, it is very expensive to operate. The committee looked at more compact technologies with equivalent treatment quality but lower costs.

Figure 1: the treatment process in a typical WWTF.[4]



Most secondary treatment technologies are variations on the activated sludge treatment process illustrated in Figure 2(a) below, including the Wolfe Neck WWTF. The Lewes WWTF currently operates an oxidation ditch (a type of activated sludge process) followed by a membrane bioreactor (MBR) process similar to the one in Figure 2(b) below. Lewes BPW upgraded to this technology to comply with an EPA administrative order requiring compliance with discharge regulations by 2007[5].

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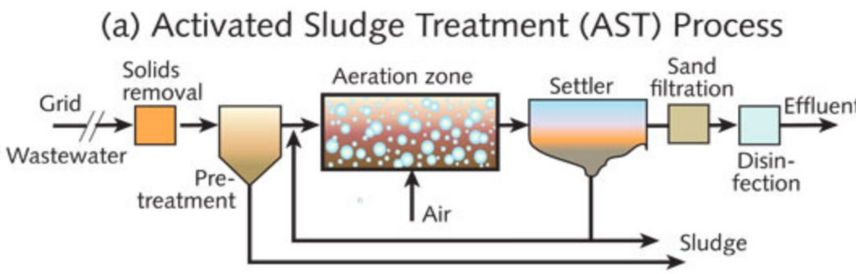
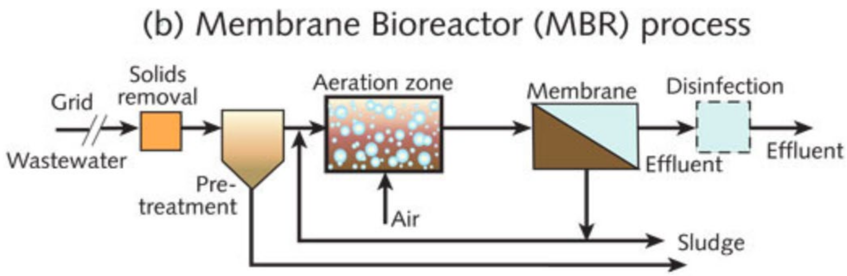
[4] Laura Martín-Pozo, María del Carmen Gómez-Regalado, Alberto Zafra-Gómez, et al. in Emerging Contaminants in the Environment, edited by Hemen Sarma, Delfina C. Dominguez and Wen-Yee Lee 2022. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/waste-water-treatment-plant

[5] https://www.epa.gov/archive/epapages/newsroom_archive/newsreleases/ae35bec1e3fb7bd6852570d60070ff56.html

Figures 2(a) and 2(b)[6]





Existing Discharge Locations and NPDES Permit Limits for Treated Effluent from the Lewes and Sussex County Wolfe Neck WWTFs

The NPDES permit for Lewes specifies discharge into the Lewes-Rehoboth canal. The facility is designed for an average flow rate of 1.50 million gallons per day (mgd), with a maximum monthly flow of 2.25 mgd, a peak hourly flow of 4.40 mgd and a maximum daily flow of 1.80 mgd.

The Lewes and Wolfe Neck NPDES effluent permit limitations are shown below, as both load and concentration numbers. Lewes for discharge to the canal; Wolfe Neck for discharge via spray irrigation on the adjacent 306 acres.

[6] Aditi Pandey and Ravi Kant Singh/ Elixir Chem. Engg. 70 (2014) 23772-23777

Table 1

Parameter	Lewes Permit Limits	Wolfe Neck Permit Limits
Flow (mgd)	1.5	3.1
pH (standard units)	6-9	5.9-9
Enterococcus (average, cfu/100 mL)	10	-
Fecal Coliform (average col/100 mL)	-	200
BOD5 (average, lbs/day)	188	-
BOD5 (average, mg/L)	15	50
Total Suspended Solids (average, lbs/day)	188	-
Total Suspended Solids (average, mg/L)	15	90
Total Nitrogen (average, lbs/day)	100	
Total Nitrogen to fields (lbs/acre/day)	-	396
Total Nitrogen (average, mg/L)	8	-
Phosphorus, Total (average, lbs/day)	25	-
Phosphorus, Total (average, mg/L)	2	-
Sodium (average annual mg/L)	-	<250
Chloride (average annual mg/L)	-	<210

Note that with the exception of a bypass event in 2019, Lewes' effluent discharge has consistently been well within (i.e., lower than maximum) permit limits.

VI. Technology Considerations

The committee evaluated several wastewater treatment technologies not considered in the GHD study. Newer technologies can reduce the footprint required for a WWTF and reduce labor, operations and maintenance costs. This would affect the costs of both Options 1 and 2. The committee also considered the implications and feasibility of discharging treated effluent to the existing Lewes-Rehoboth canal outfall but from the opposite bank, and to adjacent wetlands, Delaware Bay, and nearby uplands. The latter three locations were topics of discussion with professors from the UD School of Marine Science.[7]

Sequencing Batch Reactors (SBR)[8]:
The SBR process is a fill-and-draw activated sludge system: wastewater is added to a single "batch" reactor, treated to remove the undesirable components, then discharged. Equalization, aeration and clarification are all achieved in a single reactor.

Advantages: SBRs operate in cycles, allowing for flexibility in treatment phases. SBRs can offer improved nutrient removal, energy efficiency, reduced chemical usage, reduced capital cost and

[7] Dr. William Ullman and Dr. Andrew Wozniak.
[8] Wastewater Technology Fact Sheet; Sequencing Batch Reactors. US EPA, September 1999.

footprint because there is no need for clarifiers or lagoons, and adaptability to varying influent characteristics.

A delegation of committee members toured the Berlin, MD SBR WWTF that was constructed on the site of an existing operating plant. The delegation was impressed with its compactness, appearance, and efficiency. Although located near a stream that had previously been the discharge point for treated effluent, the governing authority chose to discharge its treated effluent via sprinkler irrigation onto forested lands miles from the site. Although the nearest residential area is about 75 yards away, odor complaints are infrequent. For context, Berlin accepts discharge of septage from private haulers.

At the committee's request, an SBR process design report was prepared by Aqua-Aerobic System, Inc. for Lewes. See Appendix 6.

Considerations: SBRs require more computerized/automated control systems than standard continuous flow activated sludge systems, and their cyclic operation results in intermittent discharge that requires effluent equalization prior to filtration.

Constructed Wetlands:
Advantages: Natural treatment systems like constructed wetlands use vegetation and microorganisms to treat - or further treat - wastewater. They offer a sustainable, low-energy solution with benefits for nutrient removal, may return of water to the aquifer, and encourage habitat creation.

The committee considered discharge of treated effluent from the current site into adjacent wetlands but rejected it when advised that the salinity mismatch would have a negative impact on the type of vegetation supported by the wetlands. Also considered was discharge into nearby uplands and forested areas via fixed-head sprinklers. Note that this latter approach is the treatment and discharge process favored by Sussex County under Option 3b at the Wolfe Neck site (prior to the "hold" caused by the archeological findings).

Considerations: Constructed wetlands have larger footprints, and their effectiveness can be influenced by climate conditions, depth to groundwater and vegetation maintenance.

Tertiary Filtration Technologies:
Advantages: Tertiary treatment options, such as disk filters or cloth media filters, enhance the removal of fine particles, improving effluent quality.

The existing Lewes WWTF provides ultrafiltration as part of the MBR process. Other secondary treatment processes considered by the committee, i.e., sequencing batch reactor (SBR) and aerobic granular sludge (AGS), would require tertiary filtration to achieve comparable water quality.

Considerations: Tertiary filtration adds to operational costs and maintenance requirements. However, both the preliminary treatment system (“headworks”) and the components of the effluent filtration system would be substantially less intricate, labor intensive and costly using cloth media filtration instead of membrane ultrafiltration.

<u>Distributed or Decentralized Systems:</u>
Advantages: Decentralized systems, such as modular treatment units or package plants, can offer flexibility, reduced infrastructure costs, and resilience against system failures.

The committee considered but rejected:

- splitting treatment components onto separate sites to leverage the upcoming headworks rebuild and other improvements anticipated over the next few years; and
- proposing two Lewes WWTFs – the existing WWTF altered such that it would continue to serve the beach side of town until the frequency of sunny day flooding events induced residential retreat from the beach, and a second facility serving the town side. It was the consensus of the committee that retreat from the beach may not occur and should not be a factor in decision-making.

Considerations: Maintenance and monitoring of decentralized systems would require additional manpower, coordination and expertise.

<u>Aerobic Granular Sludge (“AGS”): Nereda Technology</u>
The Nereda process is a newer type of sequencing batch reactor in which durable granules composed entirely of biomass perform both nitrification and denitrification while biologically reducing phosphorus to low levels without chemical addition. The Nereda process has been used in wastewater treatment plants globally since the early 2000s and in the US since 2018, demonstrating a track record for sustainable wastewater management.

Advantages: The process eliminates the need for secondary clarifiers; it has a smaller footprint, reduced energy consumption, reduced labor needs and reduced chemical usage compared to activated sludge systems and other sequencing batch reactors.

At the committee’s request, a process design report was prepared by Aqua-Aerobic Systems, Inc. for the existing Lewes site. See Appendix 4.

Considerations: Tertiary filtration would be needed to achieve the desired effluent quality. The technology employs more complex control systems than traditional activated sludge processes. These control systems reduce everyday manpower needs for system operations but require periodic specialized maintenance.

Following extensive due diligence, the committee reached consensus that the AGS process is the preferred secondary treatment technology for both Option 1 and Option 2.

SBR was a close second option because it is a better-known technology that meets many of the criteria considered by the committee. The chart below shows data for the current treatment system, an SBR system and an AGS system.[9] Although equipment costs for AGS are higher than for SBR, cost savings in size /construction of tanks more than make up for the equipment cost differential.

Table 2

TECHNOLOGY COMPARISON			
	CURRENT	**SBR**	**AGS (NEREDA)**
DESIGN INFLUENT FLOW (average)	1.5 MGD	2.1 MGD	2.1 MGD
HEADWORKS SCREENING	5 mm & 2 mm	6 mm (1/4")	6 mm (1/4")
SECONDARY TREATMENT TECHNOLOGY	Oxidation Ditches	Sequencing Batch Reactor	Aerobic Granular Sludge (Nereda)
EQUIPMENT COST *(excluding tanks)*	existing	$1,833,630	$2,822,460
TREATMENT TANK/BASIN GALLONS	426,000 (408,000 per GHD report)	1,206,000	420,000
HYDRAULIC RETENTION TIME	0.34 DAYS	1.09 DAYS	0.40 DAYS
SECONDARY TREATMENT POWER USE/DAY	?	2650 kWhr @ 0.112 =$296.80	690 kWhr @ 0.112 =$77.28
TERTIARY TREAMENT	MBR	Aqua-Disk	Aqua-Disk
SIZE expressed as GALLONS	92,000	7555*	7555*
POWER USE/DAY	?	20.7 kWhr	20.7 kWhr
EQUIPMENT COST	existing	$482,740	$482,740
DISINFECTION	UV	UV	UV
CHEMICALS COST/ DAY	$967	?	$220
TOTAL POWER USE/DAY	6538 kWhr @ 0.112 = $732.26	6903 kWhr @ 0.112 =$773.14	**1176 kWhr @ 0.112 =$131.71
OPERATORS/ DAY (average)	***6	***4	***2

* Aqua-Disk equipment is 11' x 8' x 12' high with a volume of 3,058 gallons - size converted to gallons to allow footprint comparison
** Excludes headworks, UV disinfection and digestors; AGS technology is reported to reduce energy use by up to 50%
*** Does not include maintenance staff
Power costs: RTS, Demand, KWH and PCA were averaged to a single KWH cost using the December 2023 bill

Next is a brief comparison of Nereda/AGS, activated sludge and membrane bioreactor technologies under criteria applicable to Options 1 and 2. Activated sludge is included in this comparison because it is the technology selected for Option 2 in the GHD study. Membrane bioreactor is included because it is the technology in current use. AGS is included because it is

[9] SBR data is from two sources: the 2017 City of Whitefish, MT predesign and equipment power summary (original plan for an SBR changed to AGS for improved cost, sustainability and footprint); and the AquaNereda SBR Process Design Report for Lewes. AGS data is also from two sources: the Aqua Nereda AGS Design Report for Lewes; and the Wolcott, KS AGS facility documents and interviews. Wolcott startup was January 2022.

the most sustainable, lowest cost, smallest footprint sequencing batch reactor /SBR process evaluated. [10] To a limited extent the AGS evaluation applies to all SBRs.

Cost:
AGS Technology: Is cost-effective due to its compact design and reduced energy consumption. It requires lower capital and has significantly lower operational costs compared to membrane bioreactors (MBRs).
Capital cost for construction of a 2 mgd plant in Wolcott, Kansas in 2020-21 was $35M; annual O&M budget for 2024 is $300K, excluding sludge disposal.

Activated Sludge: Generally have moderate capital costs but may incur higher operational expenses from their larger footprint and energy requirements. The larger footprint also affects land acquisition costs.
Capital cost estimate for Option 2b (new site, discharge to same outfall, new force main, decommission the WWTF) in the 2022 GHD report was $91M; annual O&M was $1M.

Membrane Bioreactors: Have higher capital costs attributed to the membrane technology. They require intensive maintenance and regular replacement, resulting in increased operational expenses.
In the GHD study, an earthen berm, sheet piling, and access ramp would need to be built around the site to continue with this technology, at substantial cost. This would not be needed to protect the AGS process. Annual O&M cost estimate for GHD Option 1 was $2M.

Land Use:
AGS Technology: Allows for a smaller footprint, making it advantageous for sites with limited space.
The treatment complex for an AGS plant with average flow of 2 mgd in Wolcott, Kansas is 90' x 250' including headworks, AGS, sludge buffer tanks, water level correction tank, tertiary filter, rotary drum thickeners, chemical addition and miscellaneous pumping (i.e., around 0.5 acres). Adding an office building, lab, maintenance areas, storage, roads and parking, the size of a site to meet Lewes' future flow (1.75 mgd) is estimated to be 2-3 acres.

Activated Sludge: Usually requires more land due to the larger tank volumes and need for secondary clarifiers.
GHD estimated Option 2b – activated sludge treatment with effluent discharge to the canal – would require 20 acres.

Membrane Bioreactors: MBRs are compact but may necessitate additional space for membrane modules and aeration tanks, leading to a larger footprint compared to AGS.

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[10] Parkson Company, a competitor to Aqua-Aerobic Systems in the water treatment space, now offers their own patented AGS technology. See https://www.parkson.com/products/granite-ags

Water Use:
AGS Technology: Generally exhibits efficient water use, with minimal requirements for backwashing or dilution.

Activated Sludge: May need more water for backwashing and sludge wasting, impacting overall water efficiency.

Membrane Bioreactors: MBRs are water-intensive due to the frequent need for membrane cleaning, leading to increased water consumption.

Reliability:
AGS Technology: Is known for its operational reliability, attributed to the robust nature of aerobic granules that are less affected by shock loads and other disturbances.

Activated Sludge: Can be sensitive to shock loads and variations in influent characteristics, potentially affecting reliability.

Membrane Bioreactors: Experience reliability challenges due to fouling issues, demanding frequent maintenance and membrane replacements.

Environmental Impact:
AGS Technology: Considered environmentally friendly with lower energy and reduced chemical requirements (50-80% lower), contributing to a smaller carbon footprint.

Activated Sludge: Requires more energy and chemicals, affecting its environmental sustainability.

Membrane Bioreactors: Have a higher environmental impact due to the energy-intensive membrane aeration and cleaning processes, although the quality of the effluent produced is excellent.

Ability to Meet Water Quality Standards:
AGS Technology: Effective in meeting stringent water quality standards, due to its nutrient removal capabilities and consistent treatment performance. Tertiary filtration can be added to enhance effluent quality.

Activated Sludge: Can achieve desired water quality standards, but sensitivity to fluctuations may require additional operational adjustments. Tertiary filtration was anticipated in the GHD study for Option 2b.

Membrane Bioreactors: Excel in producing high-quality effluent, meeting strict water quality standards with efficient solids removal through membrane filtration.

In summary, AGS technology stands out as the cost-effective, space-efficient, and environmentally friendly option, offering reliable performance with the ability to meet stringent water quality standards. Activated sludge and membrane bioreactors, while effective in their own right, are labor-intensive and pose challenges in terms of land and/or energy use, water consumption, and environmental impact.

VII. Option 1

After evaluating Option 1 – hardening the existing site to reduce vulnerability to sea level rise and storm event flooding – the committee concluded:

- The MBR is nearing the end of its useful life and is very labor- and energy-intensive. It and the oxidation ditch should be replaced with more sustainable technologies.
- Because of its small footprint, infrastructure for the AGS system could be constructed on site without adversely affecting the functioning and safety of existing operations. There is more than enough open space in the drying beds area. (The drying beds are no longer in use; sludge from the digesters is trucked to a Sussex County facility for drying and landfarming.) Alternatively, the system could be sited east of the oxidation ditch or west of the EQ tank.
- Elevating structures is recommended as more cost-effective and less unsightly than installing a berm or sea wall around the perimeter: tanks for AGS technology are 20-24' high. After installing partially below grade, tank heights would likely be at least 18' above grade, higher than the 12' elevation the BPW Mitigation Committee recommends for critical equipment.
- Platforms could be constructed on top of the new tanks to house blowers and other equipment.
- Excavated soils from installation of the AGS tanks (~ 3,000 cubic yards) could be used to elevate the area for office and other buildings if that is more cost-effective than elevating buildings on pilings.
- A sludge dewatering press could be installed if the County is no longer willing or able to take sludge directly from the digester. The cost of a belt filter press is estimated at around $500K. If a new building is needed (e.g., if a filter press won't fit in the building currently housing the MBRs or elsewhere on the site), that would add to the cost.
- UV disinfection and discharge piping could possibly remain where they are.
- Tertiary filtration (Aqua-Disks) should fit either inside the MBR building or near the AGS basins.
- The oxidation ditch could be repurposed as a shunt tank for unacceptable influent flow (e.g., significant saltwater intrusion) by slightly raising the height of the walls to withstand flood conditions.
- The digester building could be dry floodproofed and pumps/blowers/controls elevated.
- Headworks operations / equipment might be staged on upper floors within the existing building, above the base flood elevation. Alternatively, a new headworks could be built onto the AquaNereda equipment and tanks. Space requirements for the headworks

would be smaller; screening would be 6 mm instead of 5 mm and no 2 mm screen would be needed. An engineering study would determine the best location.

- Access via American Legion Road should be possible during low tide for many years of flooding events. If/when not possible, options include:
    - Temporarily shutting down pumping stations and the plant if the city is evacuated (standard procedure in WWTF emergency plans). Residents would be notified that water and sewer will not be available until further notice.
    - Temporarily accessing via ATV or boat.
    - Accessing via Freeman Highway and the hiking trail off Freeman leading to the site. The trail could be widened for vehicular access during flooding (hikers and bikers would be evacuated so would not be at risk). A higher elevation ramp from the highway could be constructed at a future date if needed.
- Costs for system and site improvements are anticipated to be significantly lower ($20M ±) under Option 1 versus Option 2. Some equipment and structures can be repurposed. Demolition costs would be minimal.
- No environmental impact study would be required if discharge is via the same outfall.[11]
- Engineers can design flood-resistant sites and structures, all but eliminating vulnerability from sea level rise and storm inundation.
- Because the WWTF is already part of the community, there is a greater likelihood of community acceptance for this option.

We recommend Lewes BPW retain an engineering firm familiar with AGS technology to develop a preliminary layout and cost estimate.

VIII. **Option 2**

The GHD study virtually eliminated the lowest cost Option 2 (2b - greenfield site near Lewes with discharge to the canal), primarily because there is no 20+ acre suitable undeveloped site within the city. Infrastructure costs (piping and pumping stations to transport wastewater to and from a distant site), delays for easement acquisition, difficulties and delays coordinating with DelDOT, cost and outcome of environmental impact studies and permit negotiations for a new outfall location, and other difficulties combined to make this an infeasible option.

However, advantages of Option 2b include the ability to control the quantity and quality of our effluent, and a reduction in vulnerability to sea level rise and storm surges by building at a higher elevation site. Open is the question of community acceptance of an alternate site.

The GHD estimated capital cost was $91M for Option 2b. In contrast, new (2018-2021) AGS WWTFs of comparable size have seen capital costs in the range of $35M. Instead of GHD's

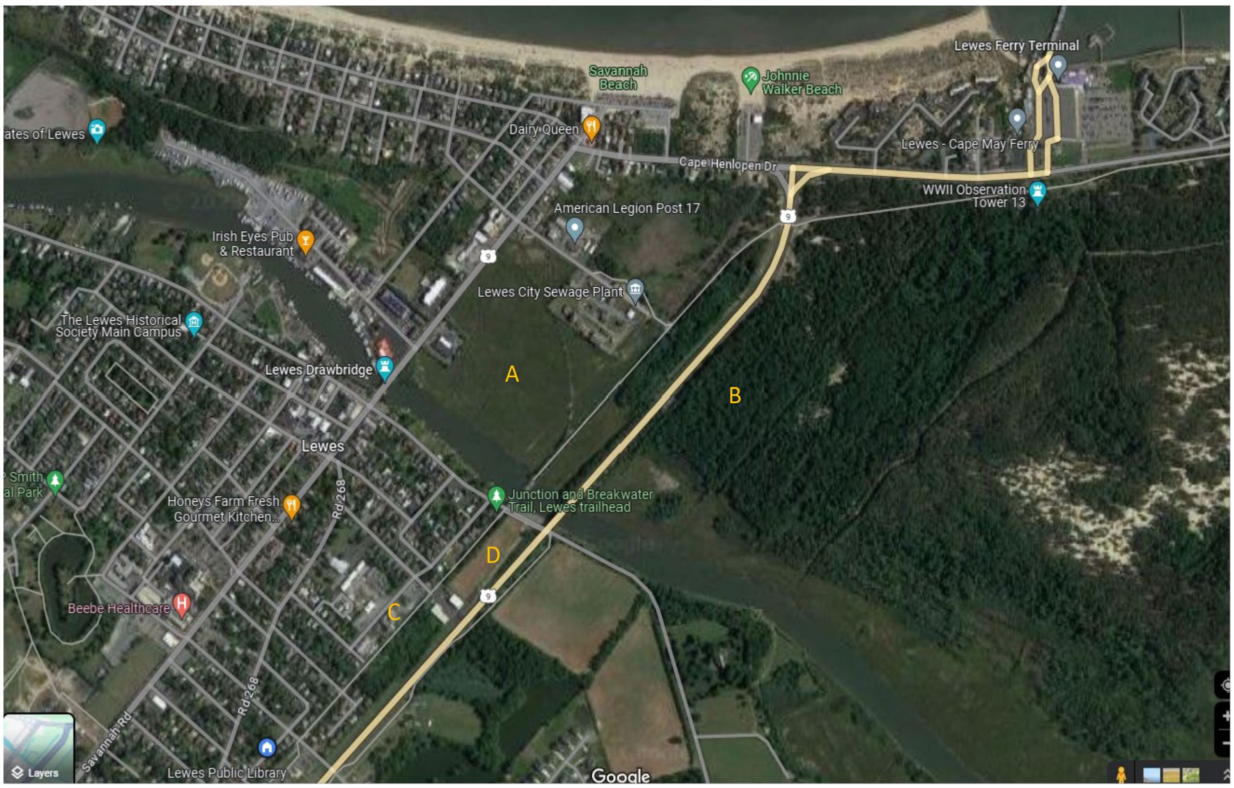
[11] As stated earlier, the committee considered but rejected discharge into the adjacent wetlands. Discharge to uplands was not ruled out (and is desirable), but costs and feasibility were not considered by the committee.

estimated annual O&M costs of $1M for Option 2b, AGS WWTFs are experiencing annual O&M costs in the $300K range.

GHD estimated the cost for a 20-acre site near Lewes at $1M, although no site was identified.

Finding a technology that would provide effluent quality equivalent to that currently achieved but in a significantly reduced footprint – 2-3 acres – was a game changer. The committee identified three sites within the city:

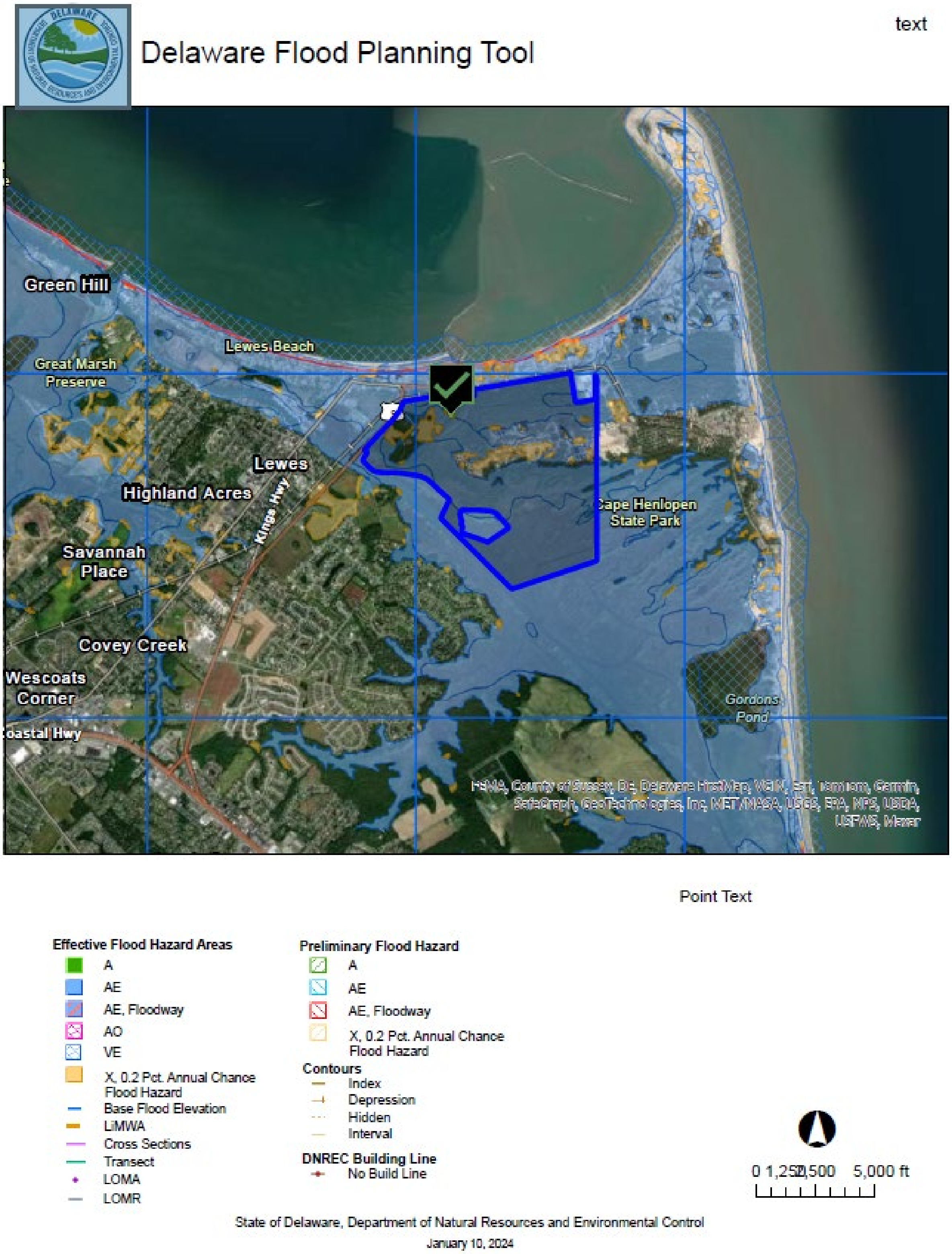
Map 1: Possible sites for WWTF



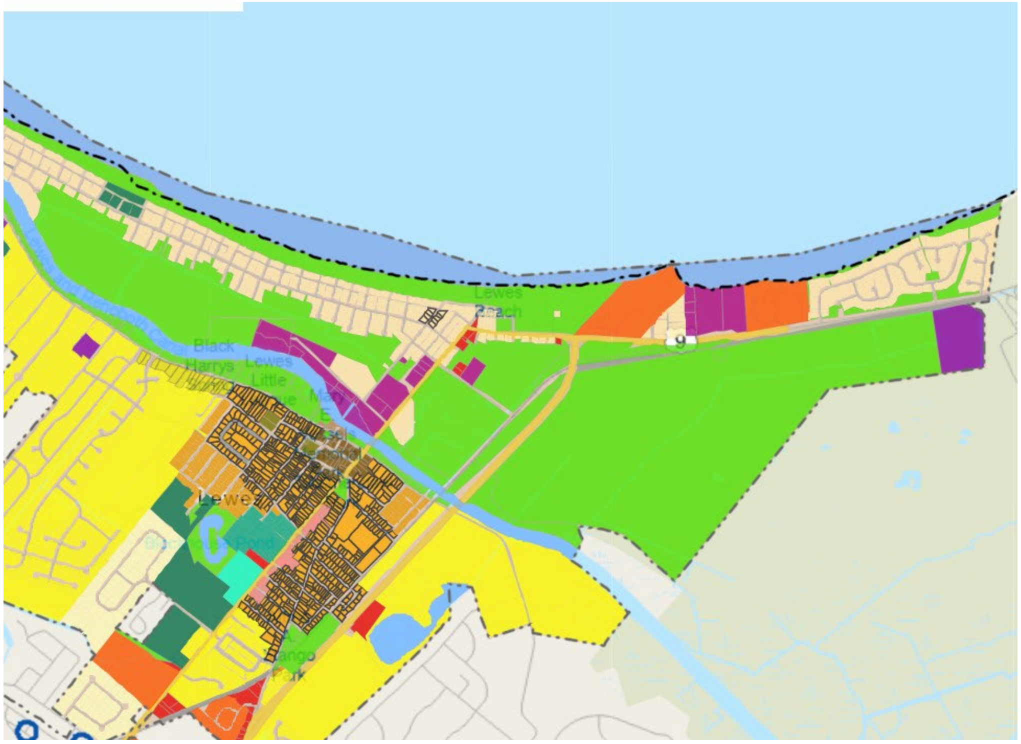
Site labeled "A"

Current site and adjacent wetlands – all within the floodplain; described under Option 1.

Map 2: Lewes flood hazard areas (light blue)



Map 3: Lewes Zoning Map with city boundaries and zoning for Areas A, B, C and D



Site Labeled "B"

Land adjacent to Freeman Highway owned by DNREC and within city limits. Delaware Flood Map insert Map 2 above shows the portion of site B – significantly more than 3 acres – outside the 500-year floodplain (i.e., areas showing vegetation colors instead of blue shading). Possibly swap land with DNREC for the decommissioned existing WWTF site, or lease 3± acres in an agreement similar to the lease Sussex County holds for the Wolfe Neck land. Further investigation would be required to find the highest elevation area. Some buildup of land elevation may be beneficial to reduce future flood vulnerability, given the uncertain science of sea level rise and climate change predictions. Note that the Wolcott Kansas WWTF was constructed in a floodplain at a cost of $35M including earthwork to stabilize the site and elevate it by 17 feet.

Advantages

a. no nearby homes and partially forested area, increasing the likelihood of community acceptance
b. short run for additional piping from the current collection and discharge system, and limited need for additional pump stations
c. possible continued use of current discharge pipe, eliminating need for environmental impact study ("EIS")
d. land acquisition cost not an issue

e. closer to Cape Henlopen Park who has expressed interest in connecting to the BPW WWTF
f. possible use of surrounding area to discharge some or all of the treated effluent via fixed head sprinklers, recharging the groundwater table, reducing land subsidence, and inhibiting saltwater intrusion.

Disadvantages

a. may require raising the site elevation for maximum risk reduction, increasing cost and visibility
b. site currently zoned "open space"; code change or variance needed
c. requires DNREC acceptance / approval
d. land swap would require City approval
e. demolition costs for the current site were estimated by GHD to be in the $3.5M range – applicable to all options except Option 1.

Site labeled "C"

Schley Avenue BPW/City Property: There is sufficient land to build a new AGS WWTF and associated buildings. Development of the Army Reserve site might allow relocation of current operations and equipment from the Schley Ave property.

Advantages

a. Area is already developed commercial property, albeit as a non-conforming use
b. No fill required; good elevation
c. Few homes nearby, raising probability of community acceptance
d. No land purchase expense: land is jointly owned by the City and BPW.

Disadvantages

a. Would require zoning code change or variance
b. Likely public opposition by close neighbors. Architectural creativity and odor control measures could soften resistance
c. EIS would be required for discharge to the canal, although likely an abbreviated version since the change from current outfall would be minimal, i.e., discharge would simply be moved to the opposite bank
d. Piping length, pump stations and easement acquisitions will add to cost, although easements would primarily be along the hiking trail
e. Demolition of the current WWTF site adds to overall cost (~ $3.5M).

Site labeled "D"

Vacant parcel (3+ acres) bordering the canal and between the hiking trail and Freeman Highway: This parcel is of sufficient size to contain the AGS system and other WWTF processes and buildings. It might also provide office space for other BPW needs.

Advantages

a. Good elevation

b. Vacant land, therefore minimal pre-construction site work needed
c. Buffered by Freeman Highway bridge and trail lands
d. Directly across canal from current site, minimizing cost and easement acquisition for additional piping and pump stations

Disadvantages

a. Zoned residential: would require zoning change
b. Likely public opposition by neighbors. Architectural creativity and odor control measures could soften resistance
c. Abbreviated EIS would be required for relocating canal outfall to the opposite bank
d. Property acquisition cost not known
e. Demolition of the current WWTF site adds to overall cost (~ $3.5M)

The committee deemed these three sites to be the most favored locations to construct a new Lewes WWTF. The sites were identified based on size/location. No studies or engineering were conducted to evaluate the feasibility of the individual sites. No real estate professionals were consulted. There may be other parcels more appropriate, including but not limited to the two below.

1. A potential site considered but rejected is the Rapid Infiltration Bed ("RIB") area within Cape Henlopen Park. Elevation is excellent, space is sufficient, site is already in use for wastewater treatment, there are no homes nearby, and DNREC/Cape Henlopen has expressed an interest in being served by the Lewes WWTF (concerns have been noted regarding the sufficiency of treatment provided by the RIBs). Options for discharge from this site include fixed head irrigation, piping to the canal, or discharge via an ocean outfall.

2. A vacant parcel of sufficient size west of the canal.

IX. Discussion and Conclusions

The November 28, 2022 *Lewes WWTF Long Range Planning Study; Conceptual Evaluation Report* prepared for Lewes BPW and Sussex County by consulting engineering firm GHD evaluated three major options for Lewes to respond to sea level rise: Option 1 – harden the existing plant; Option 2 – build a new plant on higher ground; and Option 3 – send all Lewes wastewater to the to-be-expanded Sussex County treatment plant at Wolfe Neck. Were it not for Lewes residents' discomfort with County development decisions and concerns with long-term cost, environmental protection, impact on the canal and other issues, Option 3 would have clearly been the best choice. As the significantly lowest cost option, the BPW deemed it in the best interest of its ratepayers to explore terms of an agreement under Option 3 while holding Options 1 and 2 in abeyance. Attractive from an environmental standpoint were the Option 3 plans to return much of the treated wastewater to the ground via constructed wetlands and to change from seasonal spray irrigation to fixed-head sprinkler irrigation in an area to be converted from agricultural to forest on the County's leased Wolfe Neck property. This would help recharge the water table, decrease land subsidence, and reduce saltwater intrusion.

As the County began to move forward with studies for the Wolfe Neck expansion, an archeological investigation found significant historical artifacts, precluding disturbance to the site pending further studies - and perhaps permanently. Discharge via an ocean outfall became the preferred option for the Wolfe Creek expansion, at a cost to be determined by the County's engineering contractor, GHD.

The WWTF Contingency Planning Committee ("committee") was formed to investigate whether treatment technologies other than those proposed in the original GHD study might make Options 1 and/or 2 more reasonable. This report is a result of those investigations.

Some important considerations:

- <u>Timelines</u>
    - This report and the long-range planning efforts focused on decisions for wastewater treatment through 2050: the average lifespan for WWTF capital equipment and a reasonably foreseeable prediction period for risks. Technology decisions could be revisited at that time. However, decisions regarding location and ownership of the WWTF will have a much longer impact on Lewes.
    - Although sea-level rise is creating vulnerability to storm-event flooding, Lewes has time to plan wisely before making a decision.
- <u>Autonomy and Control</u>
    - Option 3 cedes control of Lewes wastewater costs and environmental impact to Sussex County from this point forward, affecting a timeline far in excess of 2050.
- <u>Environmental Protection</u>
    - With discharge to constructed wetlands removed from Option 3 the environmental benefits of the County's proposed expansion were significantly reduced. Moreover, the technologies recommended in this report for Option 1 or 2 perform better in terms of resource expenditures and sustainability for given output volume and quality.
    - Ocean discharge of treated wastewater is less desirable environmentally: permit limitations are less stringent; fresh water introduced to a saline environment changes water chemistry and ecology with potential impacts on marine life; reuse of treated water and/or recharge of the water table is precluded; and land subsidence is accelerated.
- <u>Cost</u>
    - Cost increases associated with ocean discharge in Option 3 will change the economics of the County's offer. Furthermore, continuing development in

the County will change the capital and operating costs over time. Future decisions and associated costs will no longer be controlled by Lewes.

- Personnel.
    - The recently announced retirement of Sussex County's well-respected engineering manager increases uncertainty in future County decision-making on technology as well as on practical execution of a partnership.

After considerable research and due diligence, the committee concluded that technologies are available that would allow Lewes to continue to manage its wastewater within the city in a safe, sustainable and cost-efficient manner. The committee finds that the optimum technology for Lewes' needs is the AquaNereda Aerobic Granular Sludge (AGS) process equipment for secondary treatment, and Aqua-Disk Cloth Media Filters and ultraviolet disinfection equipment for tertiary treatment. These technologies require less land and have lower operation and maintenance costs than the technologies assumed for Options 1 and 2 in the GHD report and would ensure stewardship of the environment.

The choice between Options 1 and 2 depends on variables beyond the scope of this report, such as a detailed engineering design and cost analysis, availability and cost of land, and community acceptance.

If Option 3 is ultimately selected, we recommend that the BPW Board urge Sussex County to expand the Wolfe Neck facility using this newer, more sustainable, lower energy technology.

The tables below compare the AquaNereda Aerobic Granular Sludge treatment technology to Options 1 and 2 data from the original GHD study:

Table 3: OPTION 1 - Harden Existing Site

	GHD	AQUA-AEROBIC SYSTEMS, INC.
TECHNOLOGY	Oxidation ditch, MBR expansions	Aerobic Granular Sludge (AquaNereda) + Aqua-Disk filters
PROJECT CAPITAL COST	$18M	Estimated to be similar: Aqua-Aerobic equipment cost is ~$3M. Engineering study needed to estimate other capital costs, e.g., costs for concrete tanks, building elevation, piping, other site work and equipment modifications
O&M COSTS	$2M/year	$500K/year ($300K annual reported expenses for 2-year-old Wolcott, KS plant)
LAND	Existing site + expansion into wetlands	Existing site
HARDENING METHOD	Dike around property, larger EQ tank, elevated roadway	Elevate buildings; depth of new tanks 20-24' (partially belowground); elevate pumps, blowers, electrical and other equipment; floodproof digester building
CONTINGENCY	Emergency plan + increase size of EQ basin 600% for storage	Emergency plan: evacuate residents; shut down pump stations. Shunt saltwater to oxidation ditch, bleed into system as appropriate
ACCESS	Elevated road over dike*	Widen hiking trail to allow access from Freeman Highway*
LABOR	6 FTE	2 FTE (+ manager per DNREC rules)
DISCHARGE	Canal	Canal
ENERGY USE	6500 kWhr/day	Estimated 50% lower
CHEMICALS USE	$1K/ day	$0.2K/day
* Anticipate low tide access during storm events, use of ATVs or boats if needed. American Legion Road will flood.		

Table 4: OPTION 2b - Relocation /New WWTF & Utilization of Existing WWT Outfall

	****GHD**	****AQUA-AEROBIC SYSTEMS, INC.**
TECHNOLOGY	Activated sludge + tertiary filtration	Aerobic Granular Sludge (AquaNereda) + Aqua-Disk filters
PROJECT CAPITAL COST	$91M	Estimated at $35-40M (based on $35M capital cost for Wolcott, KS 2 mgd WWTF 2021 in floodplain)
O&M COSTS	$1M+ /year	$300 - 500K/year (reported $300K expenses for 2-year-old Wolcott, KS plant)
LAND	20 acres	2-3 acres
LABOR	6 FTE	2 FTE (+ manager, per DNREC rules)
DISCHARGE	Canal	Canal + possible fixed-head irrigation to uplands (this would add to labor FTEs)

** GHD's numbers are based on data from 2022. Some of that information will need to be updated.
** The AGS construction numbers are from similar sized plants operated by others.

Discussions with three AquaNereda municipal WWTF General Managers in the US and the engineering firm HDR who designed the Wolcott, KS plant were key to understanding and resolving questions about the technology. All indicated without reservation that if they had to choose over again, they would select AquaNereda. They extended invitations to tour their sites and see for ourselves. The Wolcott team toured operating sites in the US, UK and Ireland before making their choice.

Aqua-Aerobic Systems extended an expenses-paid invitation to BPW Board members to visit their Rockford, IL demonstration facility (in operation since 2018) and meet with staff at their research facility and headquarters there. It's worth noting that after monitoring the operation of the AquaNereda demonstration facility for five years, the Four Rivers Sewer Authority in Rockford, IL recently contracted to build a 10 MGD AquaNereda plant. Startup is anticipated in 2025.

There are currently 80 operating Nereda plants in 22 countries globally, with 100 under contract. Nereda technology was originally developed by the Dutch: Royal Haskoning DHV owns the technology and licenses it around the world. Aqua-Aerobic Systems is the US licensee, with 15 projects under contract: seven operational and two in start-up mode.

Advantages over traditional wastewater treatment include

- Small footprint, up to a factor 4 smaller
- Sustainable: significant energy savings; minimal chemicals; no plastic support media
- Excellent effluent quality including biological nutrient removal
- Cost effective with low CAPEX and OPEX

- Easy to operate; automated and resilient.

Please note that nearly all costs provided in this report are rough estimates: the committee had neither the time nor the funding to retain engineering support. The GHD numbers were also reported as rough estimates and are now two years old. We recommend the Board retain an engineering consultant to provide a better estimate of costs and to evaluate site considerations for Options 1 and 2.

Community acceptance would need to be gauged, and permit issues would need to be explored, should the Board determine a deeper exploration of Options 1 and/or 2 are advisable.

The committee stands ready to serve if the Board so desires.