REHOBOTH BEACH WASTEWATER TREATMENT PLANT

EFFLUENT DISPOSAL STUDY

Final Report

July 2005

Effluent Disposal Study for the Rehoboth Beach Wastewater Treatment Plant

Prepared for:

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EXECUTIVE SUMMARY

I. Background

The Federal Clean Water Act requires states to identify water bodies that do not meet water quality standards and to impose a “Total Maximum Daily Load” (TMDL) on both the point and non-point sources that discharge to the water body. The TMDL is intended to limit the pollutant discharges so that the water quality will improve. In 1996 portions of both the Indian River and the Rehoboth Bay were listed as water quality impaired and thus required the development of a TMDL. The TMDL was issued in August, 1998 and required that “all point source discharges which are currently discharging into the Indian River, Indian River Bay, Rehoboth Bay, and their tributaries shall be eliminated systematically.” Thus, the Rehoboth Beach WWTP, which discharges into the Lewes-Rehoboth canal, was no longer allowed to discharge and had to find an alternate method to discharge its treated wastewater effluent.

Although there was considerable discussion regarding the impacts of the TMDL on the operation of the Rehoboth Beach WWTP, an extended period of negotiations over the details of its implementation resulted in an agreement in the form of a consent order to eliminate the discharge. The consent order provides a timetable for 1) meeting interim permit levels for nitrogen and phosphorus based on a 25% reduction from currently permitted levels; 2) study of alternatives for eliminating the discharge; 3) identifying sources of funding for the project; and 4) implementing the recommended improvements. Trading with non-point sources to reduce or “eliminate” the nutrient load discharged to the Inland Bays was also permitted.

The objective of this study was to evaluate various alternatives for the disposal of treated effluent from the Rehoboth Beach Wastewater Treatment Plant with the primary criteria for an acceptable alternative being that it not result in the discharge of any nitrogen or phosphorus to the inland bays. The various alternatives were evaluated to identify the alternative which was most technically feasible, cost effective and environmentally acceptable.

Preliminary evaluations of effluent discharge alternatives indicate that any proposed solution will most likely be very expensive and would place an economic burden on the City of Rehoboth Beach and its residents. A significant amount of state and federal funding will be required to make the project economically viable. At the same time, growth in the area of Rehoboth Beach and northern Sussex County is creating a demand for additional wastewater treatment capacity. The combined costs to comply with the TMDL and to serve the future needs of the communities in the area prompted the State to encourage a regional solution. A solution that serves the needs of the entire region of northern Sussex County including Rehoboth Beach, would spread the costs over a much larger base and thus could reduce the impact on the individual rate payer.

A total of four alternatives were identified for consideration through discussions with the City, the County and DNREC. These alternatives are briefly described as follows:

- **Land Application**
  Treated effluent is sprayed on agricultural land to irrigate crops and provide nutrients. The effluent percolates through the soil to the groundwater.
- **Rapid Infiltration Beds**
  Treated effluent is flooded on to sand beds allowing the water to percolate down into the groundwater.
- **Subsurface Injection**
  Treated effluent is injected either through a shallow well in an area where the groundwater is contaminated or through a deep well into an aquifer that is confined below the drinking water aquifers.
- **Ocean Outfall**
  Treated effluent is discharged through an outfall and diffuser into the ocean at a depth and distance from the shore that insures public health and environmental standards are met.

Only the ocean outfall alternative offers an opportunity to dispose of treated effluent on a regional basis. If both Sussex County and the City of Rehoboth Beach pursued any of the other alternatives, then each would look for a site as close as possible to their individual wastewater treatment facilities. Large tracts of land suitable for land application or rapid infiltration beds are difficult (if not impossible) to find. This, plus the fact that pumping to a central regional disposal site can add extra capital and operating costs, make such alternatives impractical.

II. Existing Conditions

A. Rehoboth Beach Wastewater Treatment Plant

The Rehoboth Beach Wastewater Treatment Plant (WWTP) is an advanced secondary treatment plant that produces a high quality effluent. The service area is primarily residential with some light commercial consisting of shops and restaurants. Thus, the influent wastewater is typical of domestic wastewater treatment facilities.

The design capacity of the plant is 3.4 mgd, but because of the seasonal nature of the area, the flows vary greatly between the summer and winter with peak flows occurring on summer holiday weekends. The 2003 summer and winter average flows were approximately 2.1 mgd and 0.8 mgd, respectively. The existing WWTP was built in 1989 and was upgraded in 1994 and 1997 to implement biological nutrient removal (BNR) and chemical phosphorus removal.

The current discharge permit for nitrogen and phosphorus is based on a 12 month moving cumulative load of nitrogen and phosphorus discharged in the effluent. The total allowable load (based on the sum of the previous 12 months) is 32,427 pounds of nitrogen and 7,077 pounds of phosphorus. The plant is actually performing at a level which is better than the discharge permit requires. The consent order that enforces the requirements of the TMDL will impose further restrictions on the discharge of nitrogen and phosphorus until it is finally eliminated completely.

B. Sussex County Wastewater Treatment Facilities

Sussex County owns and operates several wastewater treatment facilities serving different areas of the County. These include:

- Wolfe Neck Regional Wastewater Facility (WNRWF)
- Inland Bays Regional Wastewater Facility (IBRWF)

- Piney Neck Regional Wastewater Facility (PNRWF)
- South Coastal Regional Wastewater Facility (SCRWF)

The Wolfe Neck, Inland Bays and Piney Neck RWFs are all aerated lagoon systems with effluent disposal by spray irrigation. The service area of the SCRWF is in the southern portion of the County, outside an area that would realistically be considered as part of a regional solution with the City of Rehoboth Beach. The plant is relevant to this study because it currently discharges its treated effluent through an ocean outfall. The effluent discharge permit imposed by DNREC on this facility will be the model used by DNREC in permitting any additional ocean outfalls. The service areas of the Wolfe Neck and Inland Bays RWFs could conceivably become part of a regional solution. These areas, as well as many of the unsewered areas in northern Sussex County, are growing and will be in need of additional wastewater treatment capacity.

C. Summary of Flows

A summary of the wastewater treatment flow requirements that are considered in this study are presented in Table ES-1.

Table ES-1: Wastewater Treatment Flow Requirements

	Rehoboth Beach	Sussex County	Total
Average Daily	3.4	8.0	11.4
Max Month	6.8	16.0	22.8
Peak Instantaneous	10.2	24.0	34.2

III. Evaluation of Alternatives

A. Land Application

1. Description

Land application involves the spray of treated wastewater effluent over a vegetated site at agronomic rates appropriate for irrigating the crop. It is considered a form of beneficial reuse since the practice involves the indirect recycle of water. This process accomplishes several objectives including irrigation of the crop, additional wastewater treatment and disposal of the effluent through recycling to the groundwater.

2. Summary of Advantages / Disadvantages

Advantages

- Well established and accepted practice in Delaware
- Recharges groundwater
- Preserves agricultural use of land

Disadvantages

- Lack of available land
- High cost of property
- Significant effluent wastewater storage volume required

3. Discussion

Approximately 740 acres of land are required for the disposal of the treated effluent from the City of Rehoboth Beach. Land is becoming increasingly scarce, especially in the vicinity of the City, and the cost of the land is increasing dramatically. Ideally, the land application site selected for effluent disposal would be fairly rectangular or square, have soil conditions that allow good percolation and adequate depth to ground water, be free of wells, streams and structures, be relatively flat and not be wooded. Anything that varies form the ideal increases the amount of property required.

A great deal of effort was expended in attempting to locate an actual site that could be used and which could be purchased or leased. Professional assistance was retained to search for properties and both private properties and land preserved by the Agricultural Land Preservation Act was considered. A group of properties was identified, centered around one property that expressed some interest in selling. The site is approximately 11.5 miles from the Rehoboth Beach WWTP. However, in order for land application to be feasible, the surrounding properties would also have to agree to sell and it was clear that agreement to sell was not going to be obtained. Despite this, the property was pursued and a purchase offer was extended. The offer was not accepted because of the conditions which are required in order to protect the City. In general, there appeared to be considerable objection on the part of individual landowners to the use of their property for the application of treated wastewater effluent.

B. Rapid Infiltration Beds

1. Description

Rapid infiltration involves the percolation of treated effluent into the ground water through a soil bed at a fairly high rate. The basins are typically flooded and then allowed to dry and rest for a period of time. Thus the rapid infiltration beds (RIBs) rotate in and out of service. The soil that provides the bed for percolation of the effluent is typically either sand or the natural soils on the site. A minimal amount of additional treatment is achieved through filtration but the treatment level is less than provided by spray irrigation which involves effluent application rates that are much lower and the use of crops to take up nutrients. Filtration through the soil may remove some minor amount of BOD and solids. A very minor amount of nitrogen, present as organic nitrogen in particulate form, may be removed but ammonia and oxidized nitrogen (nitrate) which are soluble, will pass through to the ground water. Ammonia can be oxidized to nitrate through the process of nitrification by bacteria present in the soil, if sufficient amounts of oxygen is present.

2. Summary of Advantages / Disadvantages

Advantages

- Proven technique for effluent disposal
- Recharges groundwater
- Relatively low impact in terms of amount of land required (compared to land application) and cost

Disadvantages

- Potential to contribute nutrients to Inland Bays through contact with surface water
- Potential for local mounding of groundwater
- Use would prevent public access to land

3. Discussion

Rapid infiltration Beds require less land than does spray irrigation; approximately 300 acres of land would be required. However, for all the same reasons discussed relative to the land application alternative, the land required for this alternative could not be identified. In addition, the rapid infiltration bed alternative involves a permit issue which could potentially disqualify it from any further consideration. The TMDL developed for the inland bays requires that there be absolutely no discharge of nutrients from the Rehoboth Beach WWTP to the inland bays. RIBs, if located within the inland bays watershed, will discharge some amount of nutrients into the ground water which then moves with the ground water toward a receiving stream that then flows to the inland bays. Thus their use would technically be prohibited in the watershed. Ground water modeling would be required to prove that the ground water did not carry nutrients to the inland bays.

C. Underground Injection

1. Description

Underground injection is the disposal of wastewater below ground by pumping or gravity flow to an aquifer. A well is defined as any bored, drilled or driven shaft or dry hole that is deeper than it is wide. There are five classes of wells regulated by EPA and DNREC; however, there are basically two types of underground injection systems that could potentially be used to dispose of the treated effluent from the Rehoboth Beach WWTP. These are Shallow Well Injection (Class V) and Deep Well Injection (Class I).

Deep Wells are wells that inject waste below the lowermost geological formation containing an existing or potential drinking water aquifer defined in the Underground Injection Control (UIC) program as an Underground Source of Drinking Water (USDW). A USDW is an aquifer that is presently used for drinking water, has the potential to be used for drinking water or has a total dissolved solids (TDS) concentration less than 10,000 mg/L. Deep wells inject into aquifers below USDWs and are regulated as Class I wells. A confining geologic layer must be present between the USDW and the contaminated aquifer to protect the USDW from potential contamination. The porosity and permeability in the injection zone must be sufficient to prevent excessive pressure buildup in the aquifer. The depth of Class I wells varies but can be as deep as 12,000 feet or more.

Shallow wells would typically include any system that injects treated wastewater into a shallow aquifer either by pumping into the aquifer or by infiltration. This type of well system is regulated as a Class V well. There are many types of Class V wells including agriculture drainage wells, storm water drainage wells, large capacity septic systems, fossil fuel recovery wells in addition to municipal wastewater effluent disposal wells.

With shallow injection wells, the aquifer is not confined and the injected wastewater effluent is free to migrate as determined by the pressure gradients. The greatest concern with this type of disposal system is the protection of all USDW aquifers and there are two situations under which this type of well may be permittable. The two conditions under which this type of well may be permitted are that either the treated effluent must meet safe drinking water standards or the shallow aquifer must already be contaminated to the point where it would no longer be considered as a potential source of drinking water. This latter situation could possibly exist in coastal areas where salt water has intruded into the shallow drinking water aquifer.

2. Summary of Advantages / Disadvantages

Advantages

- Relatively small land requirement
- Recharge of ground water
- Potential to form barrier to salt water intrusion (shallow well)

Disadvantages

- Extensive pilot testing would be required to determine design requirements and permitability.
- Risk associated with initial testing investment without the assurance of obtaining discharge permits.
- Public acceptance of an unknown disposal method.
- Operational issues related to the potential for plugging of the injection well.

- Long-term risk, based on experience elsewhere, associated with potential to contaminate other aquifers.

3. Discussion

There are no known areas of groundwater contamination in the watershed, within an existing shallow drinking water aquifer, that would allow the injection of treated effluent. Previous test wells have located areas with some level of salt water intrusion as indicated by Total Dissolved Solids levels in the range of several hundred mg/L but not exceeding the 10,000 mg/L level that would classify it as not suitable as a drinking water source. It is also understood that DNREC would never allow an existing USDW aquifer, that could be a potential source of drinking water, to be declassified as a USDW and therefore to be used for shallow well injection.

A potential deep well formation, identified by the Maryland Geologic Survey, exists at a depth of approximately 5,000 feet or greater. This formation known as the Waste Gate Formation is believed to contain very high TDS levels and is confined by impervious layers above. This formation was used as the basis of developing cost estimates for this form of effluent disposal. However, a great deal of information is not known about the geology of the formation and there is considerable technical, financial and environmental risk inherent in pursuing this option.

D. Ocean Outfall

1. Description

This method of effluent disposal is based on the discharge of the treated effluent wastewater into the ocean at a distance offshore and depth where the potential public health and environmental impacts are negligible. The initial dilution and dispersion of the treated effluent insures compliance with all water quality regulations and public health standards

2. Summary of Advantages / Disadvantages

Advantages

- Minimal operating requirements
- Minimal maintenance requirements
- No potential nutrient transport into the inland bays

- Perceived as ultimate solution
- Potential as regional solution

Disadvantages

- Public acceptance
- Permitting issues
- No ground water recharge

2. Discussion

The ocean outfall alternative is the only alternative that can be considered as a regional solution in addition to serving the needs of the City of Rehoboth Beach alone. Dilution modeling of the outfall diffuser was completed under two different scenarios; one with the flows expected from the City alone and two, with the flows from both the City and the County under a regional approach. The modeling indicated that there would be excellent initial and farfield dilution under the various operating conditions and ambient conditions and that the outfall would meet all expected discharge permit and public health requirements. Some improvements at the Rehoboth Beach WWTP and the Sussex County plants would be required in addition to the outfall. Although several outfall locations were considered, the proposed location, based on the modeling effort and other considerations, is to extend 6,000 feet off of Rehoboth Beach as shown in Figure ES-1.

Figure ES-1: Proposed Location of Ocean Outfall and Force Main

E. Costs

A summary of the capital, operations and maintenance, and present worth costs are presented in Table ES-2.

Table ES-2: Alternative Cost Summary

Effluent Disposal Alternative	Capital Cost (2004$)	20-year O&M Present Worth Costs (2004$)	Present Worth Cost (2004$)
Spray Irrigation	$61,300,000	$1,990,000	$63,290,000
Rapid Infiltration Bed	$53,350,000	$1,920,000	$55,270,000
Deep Well Injection	$112,800,000	$2,210,000	$115,010,000
Ocean Outfall			
Rehoboth Beach	$36,630,000	$2,240,000	$38,870,000
Regional – Rehoboth Beach	$16,800,000	$2,240,000	$19,040,000
Regional – Sussex County	$50,100,000	$8,560,000	$58,660,000

IV. Recommended Plan

A. Comparison of Alternatives

A comparison of the various alternatives on the basis of a number of subjective issues is presented in Table ES-3.

Table ES-3: Comparison of Alternatives

Issue	Land Application	RIB	Underground Injection		Ocean Outfall
			Shallow	Deep	
Public Acceptance	+	0	-	-	-
Environmental Impacts	+	-	-	0	0
Nutrient Loading to Inland Bays	0	-	-	+	+
Permitting Issues	+	-	-	-	0
Reliability	0	0	-	-	+
Operability	0	+	-	-	+
Constructability	0	+	-	-	0
Long Term Solution	0	-	0	0	+
Groundwater Recharge	+	+	+	-	-
Land Requirement	-	-	0	0	+
Risk	+	0	-	-	+
Cost	0	0	0	-	+
Summary +	**5**	**3**	**1**	**1**	**7**
0	**6**	**4**	**3**	**3**	**3**
-	**1**	**5**	**8**	**8**	**2**

Notes:
1. A (+) indicates that, in regards to the particular issue the alternative is generally considered to be positive or beneficial.
2. A (0) indicates a neutral response.
3. A (-) indicates that the alternative is negative or detrimental with regards to the issue.
4. [highlight] Indicates an issue, which essentially eliminates the alternative from further consideration.

B. Discussion

It is recommended that the City of Rehoboth Beach pursue an ocean outfall as the method of effluent disposal. Based on evaluations of the various methods of effluent disposal available to the City, an ocean outfall is the only technically feasible approach available to the City that has a realistic potential to be sited and permitted. A summary of the primary reasons for selecting this alternative follows:

- Land Application, while technically feasible, is not a viable option because the land required to implement this option is not available. Also the cost to purchase land, were it to be available, is becoming increasingly expensive.
- Rapid Infiltration Beds would not be permitted within the watershed because they would result in the flow of nutrients through the ground water to the inland bays. In addition, adequate land to site the RIBs could not be located.
- Underground Injection, while technically feasible, is not a practical option because of the cost and risk associated with permitting and developing the wells.
- Preliminary modeling indicates that, even under the worst-case scenario regarding the performance of the wastewater treatment plant and ocean currents, public health requirements are met at or in close proximity to the diffuser.
- Ocean outfalls have a well-documented history of protecting public health and compliance with environmental regulations.
- An ocean outfall can be considered and "ultimate" solution in the sense that, once it is built and in operation, the discharge is immune from future regulatory issues and environmental concerns related to the TMDL program which regulates the discharge of nutrients in the watershed.
- An ocean outfall is the only alternative that has the potential to be a regional solution and thus possibly further reduces the impact on the individual user charges.
- Considering the City of Rehoboth Beach alone, the ocean outfall is the most cost-effective alternative.

C. Impact on User Charges

1. General

The impact of the estimated capital and the operation and maintenance for the ocean outfall and associated improvements on the user charges for both the City of Rehoboth Beach (Rehoboth Beach only solution and Regional solution) and for Sussex County (Regional solution) was determined. The basis of this determination was the current actual rate structure for both the City and the County. Several funding scenarios were considered including:

- No grant funding available
- Grant funding provided to limit user charge increase to 50%

2. Rehoboth Beach Only

Scenario 1 – Finance Entire Capital Project Cost

The capital and operating costs were escalated to 2012 dollars to better determine the impact of the Rehoboth Beach solution. The capital cost for the Rehoboth Beach ocean outfall in year 2012 dollars is $43,740,000. Based on the assumption of no grant funding, the annual costs associated with the Rehoboth Beach Ocean Outfall are summarized in Table ES-4. Table ES-4 includes the projected debt service to repay the loan plus the existing and projected annual operation and maintenance costs for the recommended plan.

Table ES-4: Annual Cost for Ocean Outfall

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$1,750,000
Annual Principal[5]	$1,470,000
Total Annual Cost	$5,360,000

Notes:
1. From Rehoboth Beach 2004 – 2005 budget escalated to 2012 at 3% per year.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to 2012 at 3% per year
4. Based on $43,740,000 * 4% = $1,750,000
5. Principal = $43,740,000 * 0.0736 – Interest ($1,750,000)

The current revenue for the City is approximately $1,661,000 annually. An increase of 223% of the metered sewer rates, North Shores revenue, Dewey Beach revenue and Henlopen Acres revenue would be required to achieve an annual revenue of $5,360,000 (factor of 3.23 times existing rates). Table ES-5 summarizes the revenue associated with an increase of 223%.

Table ES-5: Annual Revenue with 223% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$2,070,000
Metered Sewers – Residential	$1,270,000
North Shores	$420,000
Dewey Beach	$1,480,000
Henlopen Acres	$120,000
Total	$5,360,000[2]

Notes:
1. For detailed computations see Appendix K. All revenue sources were increased by the 223%.
2. Rounded to the nearest ten thousand.

Based on the 2,115 customers with service connections less than 1-inch, an increase of 223% would result in an annual average user charge of $977.46, which is less than the maximum "reasonable" user charge of $1080.76 per the DNREC guidelines.

Scenario 2 – Grant Financing to Limit User Charge Increase to 50%

A more reasonable increase, but still a significant increase to the Rehoboth Beach users and other customers, over the next several years would be an increase of no more than 50% over the current charges. Table ES-6 summarizes the revenue expected with an increase of 50%. As shown in Table ES-6, the revenue is significantly less than the projects $5,360,000 required (see Table ES-4).

Table ES-6: Annual Revenue with 50% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$960,000
Metered Sewers – Residential	$590,000
North Shores	$200,000
Dewey Beach	$690,000
Henlopen Acres	$60,000
Total	$2,500,000[2]

Notes:
1. For detailed computations see Appendix K. All revenue sources were increase by 50%.
2. Rounded to the nearest ten thousand.

With an increase of 50% in user charges, significant grant money would be required to build the Rehoboth Beach Ocean Outfall. With an annual budget of $2,500,000, a grant for 88.7% of the total capital cost, $43,740,000, is required resulting in a loan of approximately, $4,940,000. The annual costs associated with the loan are summarized in Table ES-7.

Table ES-7: Annual Cost for Ocean Outfall with 88.7% Grant Funding

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$198,000
Annual Principal[5]	$162,000
Total Annual Cost	$2,500,000[6]

Notes:
1. From Rehoboth Beach 2004 – 2005 budget escalated to 2012 dollars.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to 2012 dollars
4. Based on $4,940,000 * 4% = $198,000
5. Principal = $4,940,000 * 0.0736 – Interest ($198,000)
6. Rounded to the ten thousand.

3. Regional Solution

The capital and operating costs were escalated to 2012 dollars to better determine the impact of the Regional ocean outfall solution. Table ES-8 summarizes the capital and operating cost for Rehoboth Beach and Sussex County for the Regional Ocean Outfall.

Table ES-8: Regional Solution Capital and Operating Costs

Source	Capital Cost (2012$)	Existing O&M Costs (2012$)	Additional O&M Cost (2012$)	Additional O&M Cost for WWTP (2012$)
City of Rehoboth Beach	$20,060,000	$1,530,000	$189,000	$418,000
Sussex County	$59,820,000	N/A(1)	$720,000	N/A[1]
Total Cost	$79,880,000			

Note:
1. Not available at this time.

A. Impact on Rehoboth Beach User Charges

Scenario 1 – Finance Entire Capital Project Costs

The City of Rehoboth Beach would have to finance its portion of the regional solution. The capital cost for the Rehoboth Beach Ocean Outfall is estimated to be $20,060,000 (year 2012 dollars). Based on the assumption of no grant funding, the annual costs for the City of Rehoboth Beach associated with the Regional Ocean Outfall are summarized in Table ES-9.

Table ES-9: Rehoboth Beach Annual Cost for Regional Ocean Outfall

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$678,000
Annual Principal[5]	$802,000
Total Annual Cost	$3,620,000[6]

Notes:
1. From Rehoboth Beach 2004 – 2005 budget escalated to years 2012 dollars.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to year 2012 dollars.
4. Based on $20,060,000 * 4% = $802,000
5. Principal = $20,060,000 * 0.0736 – Interest ($802,000)
6. Rounded to the ten thousand.

The current revenue for the City is approximately $1,661,000 annually. An increase of 118% of the metered sewer rates, North Shores revenue, Dewey Beach revenue and Henlopen Acres revenue would be required to achieve an annual revenue of $3,620,000. Table ES-10 summarizes the revenue associated with an increase of 118%.

Table ES-10: Annual Revenue with 118% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$1,400,000
Metered Sewers – Residential	$860,000
North Shores	$280,000
Dewey Beach	$1,000,000
Henlopen Acres	$80,000
Total	$3,620,000[2]

Notes:
1. For detailed computations see Appendix K. All revenue sources were increased by the 118%.
2. Rounded to the nearest ten thousand.

Based on the 2,115 customers with service connections less than 1-inch, an increase of 118% would result in an annual average user charge of $660.73, which is less than the maximum "reasonable" user charge of $1080.76 per the DNREC guidelines.

Scenario 2 – Grant Financing to Limit User Charge Increase to 50%

A more reasonable increase but still a significant increase to the Rehoboth Beach users and other customers over the next several years would be an increase of no more than 50% over the current charges. Table ES-11 summarizes the revenue expected with an increase of 50%. As shown in Table ES-11, the revenue is significantly less than the projected $3,620,000 required (see Table ES-10).

Table ES-11: Annual Revenue with 50% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$960,000
Metered Sewers – Residential	$590,000
North Shores	$200,000
Dewey Beach	$690,000
Henlopen Acres	$60,000
Total	$2,500,000[2]

Notes:
1. For detailed computations see Appendix K. All revenue sources were increase by 50%.
2. Rounded to the nearest ten thousand.

With an increase of 50% in user charges, significant grant money would be required to build the Regional Ocean Outfall. With an annual budget of $2,500,000, a grant for 75.5% of the total capital cost, $15,150,000, is required resulting in a loan of approximately, $4,910,000. The annual costs associated with the loan are summarized in Table ES-12.

Table ES-12: Annual Cost for Ocean Outfall with 75.5% Grant Funding

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$164,000
Annual Principal[5]	$196,000
Total Annual Cost	$2,500,000[6]

Notes:
1. From Rehoboth Beach 2004 – 2005 budget escalated to year 2012 dollars.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to year 2012 dollars.
4. Based on $4,910,000 * 4% = $196,000
5. Principal = $4,910,000 * 0.0736 – Interest ($196,000)
6. Rounded to the ten thousand.

B. Impact on Sussex County User Charges

<u>Scenario 1 – Finance Entire Capital Project Costs</u>

The impact to the Sussex County users was determined by the County with the estimated capital cost and operating costs from Table ES-2. The cost estimates were escalated to year 2012 dollars. The capital and O&M costs associated with the WWTP improvements and regional ocean outfall are $59,822,000 and $720,000 (year 2012 dollars). For the determination of the annual debt service associated with the construction of the WWTP plant upgrades and the ocean outfall, a 40-year bond with an interest rate of 5.5% was assumed. Table ES-13 summarizes the Sussex County cost associated with the WWTP improvements and the operation of the ocean outfall.

Table ES-13: Sussex County Annual Costs[1]

Source	Value
Annual Loan Cost (Interest & Principal)	$3,714,000
Additional O&M (WWTP & Regional Ocean Outfall)	$720,000
Total	$4,434,000[2]

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest

Based on the 2006 Budget, the estimated number of users is 15,348. The estimated number of users was increased at 3% per year to 2012. Table ES-14 summarizes the impact of the WWTP and Regional Ocean Outfall solution to the Sussex County users.

Table ES-14: Annual Revenue for WWT Costs[1]

Source	Value
Additional Annual Cost for WWTP & Regional Ocean Outfall[2]	$4,434,000
Number of Users (Year 2012)	18,326
Additional Cost per User for WWTP and Ocean Outfall	$242
2012 Estimated User Charger[3]	$741
Total 2012 User Charge	$983
Percent Increase in User Charge[4]	58%

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest. See Table ES-13.
3. Estimated 2005 user charge of $621 escalated to 2012 at 3% for 6 years
4. Increase = Project User Charge / Current User Charge - 1

<u>**Scenario 2 – 50% Grant Funding**</u>

Table ES-15 summarizes the cost to Sussex County if 50% grant funding is awarded for the Regional Ocean Outfall solution including the cost for upgrading the WWTP.

Table ES-15: Sussex County Annual Costs with 50% Grant Funding[1]

Source	Value
Total Capital Cost (Year 2012 dollars)	$58,820,000
Grant Funding	$29,910,000
Loan	$29,910,000
Annual Loan Cost (Interest & Principal)	$1,857,000
Additional O&M (WWTP & Regional Ocean Outfall)	$720,000
Total	$2,577,000[2]

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest

Table ES-16 summarizes the impact of the WWTP and Regional Ocean Outfall solution to the Sussex County users.

Table ES-16: Annual Revenue for WWT Costs[1]

Source	Value
Additional Annual Cost for WWTP & Regional Ocean Outfall	$2,577,000
Number of Users (Year 2012)	18,326
Additional Cost per User for WWTP and Ocean Outfall	$141
2012 Estimated User Charger[3]	$741
Total 2012 User Charge	$882
Percent Increase in User Charge[4]	42%

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest. See Table ES-13.
3. Estimated 2005 user charge of $621 escalated to 2012 at 3% for 6 years
4. Increase = Project User Charge / Current User Charge - 1

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The City of Rehoboth Beach Wastewater Treatment Plant (WWTP) receives wastewater from the City and surrounding areas of Henlopen Acres and Dewey Beach. The WWTP treats the waste to a very high level removing not only organics and solids, as is typical of a secondary treatment plant, but also removing nitrogen and phosphorus which can stimulate algae growth in the receiving stream.

The original WWTP was completed in November 1987 and was designed to provide a secondary level of treatment. At that time, nutrient removal was not a requirement of the discharge permit. During the next permit review, however, nutrients became an issue and the nitrogen and phosphorus levels were capped based on the performance that the plant was capable of achieving. This was consistent with the "Comprehensive Conservation and Management Plan (CCMP) for Delaware's Inland Bays" which was a plan that established goals for nutrient reductions throughout the Rehoboth Bays watershed. The reductions for the WWTP were based on the baseline load of nitrogen and phosphorus discharged in 1989.

In 1993 the discharge permit issued by the Delaware Department of Natural Resources & Environmental Control (DNREC), for the City of Rehoboth Beach WWTP, expired. The City then entered into a voluntary agreement with DNREC to implement Biological Nutrient Removal (BNR) at the Rehoboth Beach WWTP. The City agreed to undertake this capital project in an effort to do its part to improve water quality in the Inland Bays. A final cap on nutrients was established based on the 1989 baseline load. The final cap was established as a 30% reduction in nitrogen and a 70% reduction in phosphorus to be monitored on a rolling annual average. Interim goals of a 15% and 30% reduction in nitrogen and phosphorus discharge were also established. These percentage reductions equate to the allowable loads shown in Table 1-1.

Table 1-1: Nutrient Loading Goals for the Rehoboth Beach WWTP

	1989 Baseline Load	Interim Reduction	Final Cap
TN	46,324 lbs.	39,375 lbs.	32,427 lbs.
TP	23,589 lbs.	16,512 lbs.	7,077 lbs.

The plant was upgraded in two phases, in 1994 and 1997, to reduce the nitrogen and phosphorus discharge as required by the consent order. By 1998, the WWTP had actually reduced the amount of nitrogen and phosphorus being discharged by 43% and 82%, respectively, thus exceeding the requirements of the permit. Continued operational improvements have achieved further reductions in the amount of nutrients presently discharged by the plant. A summary of performance from recent years is presented in Table 1-2.

Table 1-2: Summary of Performance from Recent Years

Year	Annual Load (#/yr)	
	TN	TP
1998	26,501	4,265
1999	30,133	5,193
2000	25,386	4,390
2001	21,402	4,666
2002	26,404	2,567

During this period of time, DNREC was developing a water quality model of the Inland Bays in response to Federal requirements. The Federal Clean Water Act requires states to identify water bodies that do not meet water quality standards and to impose a "Total Maximum Daily Load" (TMDL) on both the point and non-point sources that discharge to the water body. The TMDL is intended to limit the pollutant discharges so that the water quality will improve. In 1996 portions of both the Indian River and the Rehoboth Bay were listed as water quality impaired and thus required the development of a TMDL. The TMDL was issued in August, 1998 and required that "all point source discharges which are currently discharging into the Indian River, Indian River Bay, Rehoboth Bay, and their tributaries shall be eliminated systematically." Thus, the Rehoboth Beach WWTP, which discharges into the Lewes-Rehoboth canal, was no longer allowed to discharge and had to find an alternate method to discharge its treated wastewater effluent.

Although there was considerable discussion regarding the impacts of the TMDL on the operation of the Rehoboth Beach WWTP, an extended period of negotiations over the details of its implementation resulted in an agreement in the form of a consent order to eliminate the discharge. The consent order provides a timetable for 1) meeting interim permit levels for nitrogen and phosphorus based on a 25% reduction from currently permitted levels; 2) study of alternatives for eliminating the discharge; 3) identifying sources of funding for the project; and 4) implementing the recommended improvements. Trading with non-point sources to reduce or "eliminate" the nutrient load discharged to the Inland Bays was also permitted.

Preliminary evaluations of effluent discharge alternatives indicate that any proposed solution will most likely be very expensive and would place an economic burden on the City of Rehoboth Beach and its residents. A significant amount of state and federal funding will be required to make the project economically viable. At the same time, growth in the area of Rehoboth Beach and surrounding areas of Sussex County is creating a demand for additional wastewater treatment capacity. The combined costs to comply with the TMDL and to serve the future needs of the communities in the area prompted the State to encourage a regional solution. A solution that serves the needs of the entire region of north-central Sussex County including Rehoboth Beach, would spread the costs over a much larger base and thus could reduce the impact on the individual rate payer.

1.2 OBJECTIVES

The primary objectives of this study are as follows:

1. Evaluate technical feasibility of various alternatives for discharging treated effluent.
2. Estimate realistic construction and operating costs for each alternative.
3. Identify the most cost-effective and environmentally acceptable alternative to pursue.
4. Consider the ocean outfall as both a Rehoboth Beach solution and a regional solution to serve portions of Sussex County.

The study approach, as discussed in the next section, was intended to provide sufficient technical documentation and to be sufficiently broad in scope to justify the recommended alternative to the satisfaction of the various permit agencies and public stakeholders. It must be realized that, in order to proceed with the recommended alternative through the permit and design phases of the project, additional technical and environmental information will need to be gathered through field investigations and study.

The impact of the estimated project costs on the user charges in the service area were estimated based on assumptions regarding funding and the sharing of costs among jurisdictions (regional solution). The purpose of this analysis was to allow judgments to be made by the City of Rehoboth Beach and Sussex County regarding the cost-effectiveness of proceeding independently or cooperating in a regional solution.

1.3 APPROACH

A total of four alternatives were identified for consideration through discussions with the City, the County and DNREC. These alternatives are briefly described as follows:

- **Land Application**
  Treated effluent is sprayed on agricultural land to irrigate crops and provide nutrients. The effluent percolates through the soil to the groundwater.
- **Rapid Infiltration Beds**
  Treated effluent is flooded on to sand beds allowing the water to percolate down into the groundwater.
- **Subsurface Injection**
  Treated effluent is injected either through a shallow well in an area where the groundwater is contaminated or through a deep well into an aquifer that is confined below the drinking water aquifers.

- **Ocean Outfall**

  Treated effluent is discharged through an outfall and diffuser into the ocean at a depth and distance from the shore that insures public health and environmental standards are met.

Preliminary designs were completed for each feasible alternative in an effort to develop realistic cost estimates. The environmental impacts and permit requirements were also evaluated. The most cost-effective solution, which minimized environmental impacts and provided a long-term, reliable method of effluent disposal was then identified.

The ocean outfall alternative was considered as a potential solution for the City of Rehoboth Beach alone and as a regional solution to provide capacity for the City and portions of Sussex County. Only the ocean outfall alternative offers an opportunity to dispose of treated effluent on a regional basis. If both Sussex County and the City of Rehoboth Beach pursued any of the other alternatives, then each would look for a site as close as possible to their individual wastewater treatment facilities. Large tracts of land suitable for land application or rapid infiltration beds are difficult (if not impossible) to find. This, plus the fact that pumping to a central regional disposal site can add extra capital and operating costs, make such alternatives impractical.

The estimated project costs were factored into the rate structure of the City and the County to assess the fiscal impact on individual users. The user charges are based on a conceptual plan for sharing the capital and operating costs between the City and the County and on assumptions made regarding the level of funding provided by the State.

1.4 ORGANIZATION OF THE REPORT

The existing wastewater treatment facilities, flows and loads, and the discharge permit requirements are described in Chapter 2, Existing Conditions. Significant effort was expended in attempting to identify actual sites that could be purchased or leased by the City to operate a land application system for effluent disposal. These efforts are described in Chapter 3, Land Search. The four effluent disposal alternatives are then presented as follows:

- Chapter 4 Land Application
- Chapter 5 Rapid Infiltration Beds
- Chapter 6 Underground Injection
- Chapter 7 Ocean Outfall

In each case, the disposal alternative is described, the advantages and disadvantages are presented, the technology and its application elsewhere is reviewed, the environmental and regulatory issues associated with its use are discussed, and a preliminary design is developed. The capital and operating costs of the proposed facility are presented and finally an implementation plan is discussed. The alternatives are compared and a recommended plan is developed in Chapter 8, Evaluation of Alternatives. Chapter 9, Financial Considerations, presents the potential impacts of the project on the user charges and discusses funding of the project.

CHAPTER 2

EXISTING CONDITIONS

2.1 REHOBOTH BEACH

The City of Rehoboth Beach owns and operates one wastewater treatment plant, which discharges to the Lewes-Rehoboth Canal.

2.1.1 Description of Facilities

The Rehoboth Beach Wastewater Treatment Plant (WWTP) is an advanced secondary treatment plant that produces an effluent that exceeds the quality requirements typically dictated for ocean discharge. The service area is primarily residential with some light commercial consisting of shops and restaurants. Thus, the influent wastewater is typical of domestic wastewater treatment facilities.

The design capacity of the plant is 3.4 mgd, but because of the seasonal nature of the area, the flows vary greatly between the summer and winter with peak flows occurring on summer holiday weekends. The 2003 summer and winter average flows were approximately 2.1 mgd and 0.8 mgd, respectively.

The existing WWTP was built in 1989 and was upgraded in 1994 and 1997 to implement biological nutrient removal (BNR) and chemical phosphorus removal. Sludge is aerobically digested and land applied. Figure 2-1 shows a process schematic for the Rehoboth Beach WWTP. The plant currently consists of the following treatment processes:

- Screening
- Grit removal
- Activated sludge process

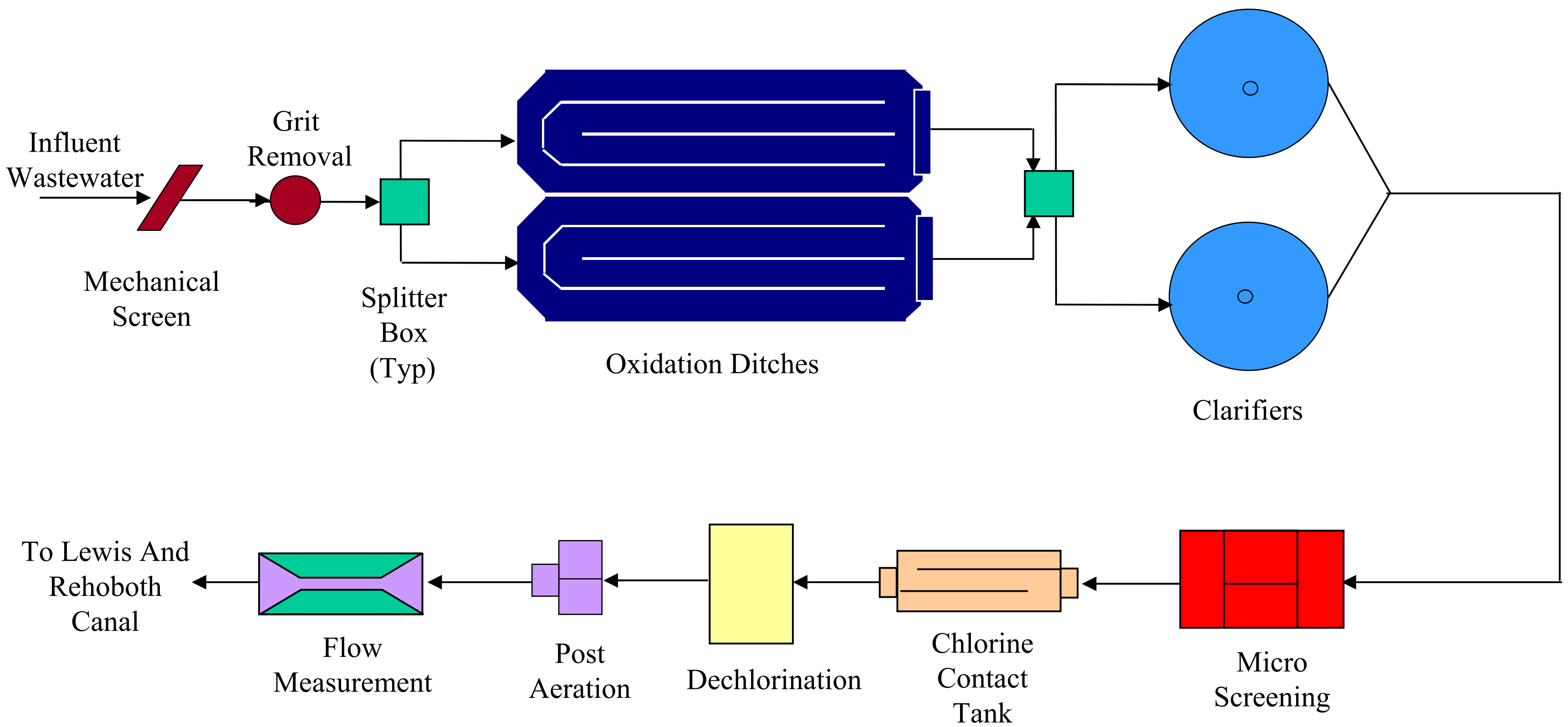


FIGURE 2-1: Rehoboth Beach WWTP Process Flow Diagram

- Barrier oxidation ditches (2) with cyclical aeration and variable speed DO controlled blowers for carbonaceous BOD removal, nitrification and denitrification
    - Final clarifiers (2) – 98-ft diameter, 12-ft side water depth
    - Ferric Chloride addition for chemical phosphorus removal
- Microscreen effluent filtration
- Chlorination
- Dechlorination
- Reaeration

Figure 2-2 shows the existing site plan for the Rehoboth Beach WWTP.

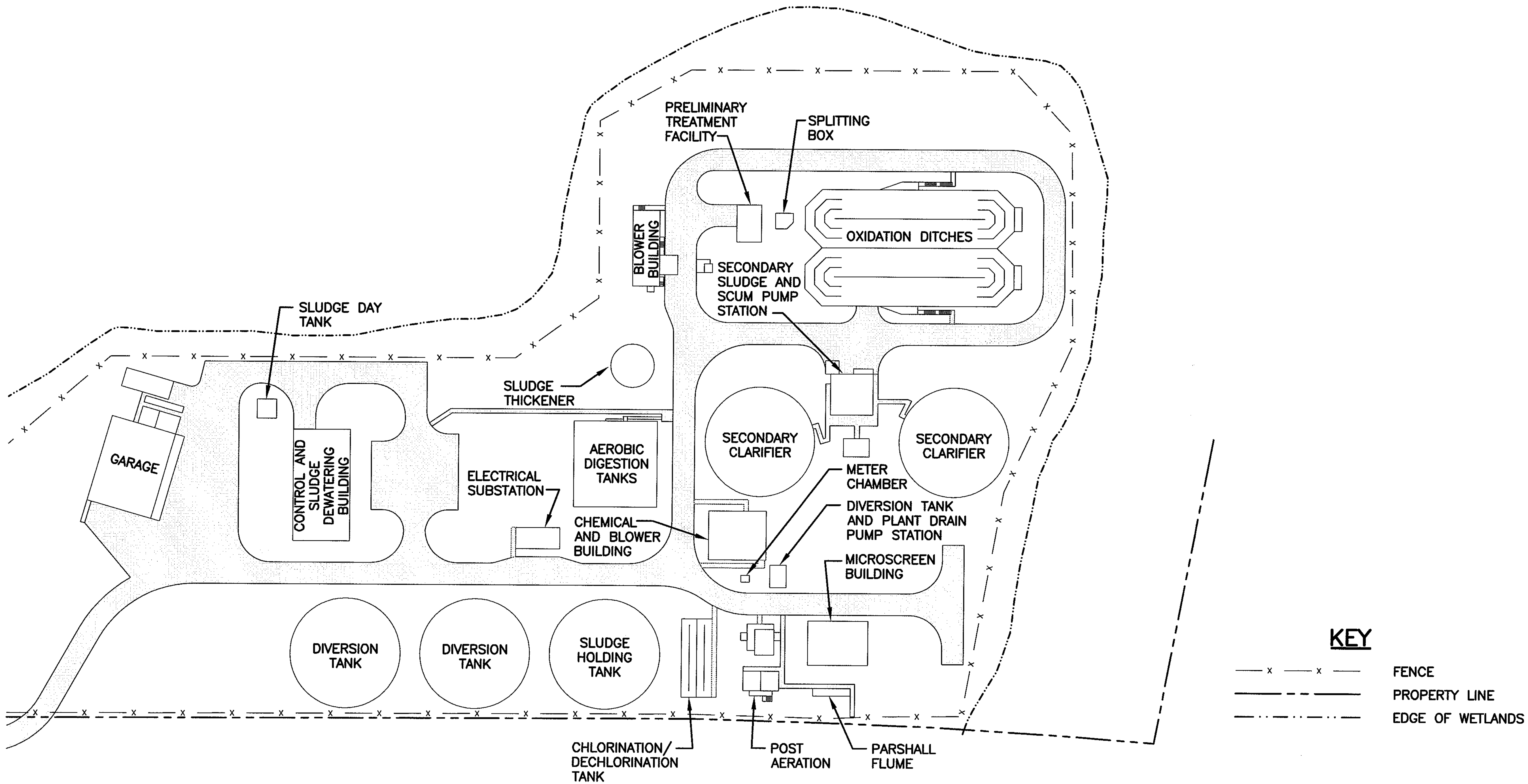
2.1.2 Effluent Requirements

The current NPDES discharge permit limits for the Rehoboth Beach WWTP, issued by DNREC are summarized in Table 2-1. The parameters are as presented in the draft permit dated May 28, 2003, which are as expected to be finalized.

Table 2-1: Rehoboth Beach NPDES Permit Limits

Parameter	Permit Requirement	Unit	Basis
Flow	3.4	mgd	Daily Average
BOD_5	19	mg/L	Daily Average
TSS	15	mg/L	Daily Average
TN	24,300	lbs/yr	Annual rolling average (1)
TP	5,308	lbs/yr	Annual rolling average (1)
DO	> 5.0	mg/L	Continuous
pH	6.0 – 9.0	Std. units	Continuous
Enterococcus	10	Colonies/100mL	Geometric mean

Note:
1. Compliance required within 2 years of permit issuance by either nutrient removal at the WWTP of by effluent trading with non-point sources



SITE PLAN

SCALE: 1"=100'-0"

Stearns & Wheler, LLC
Environmental Engineers and Scientists

BOWIE

DATE:9/04 JOB No.:20212.10

REHOBOTH BEACH
WASTEWATER TREATMENT PLANT
EFFLUENT DISPOSAL STUDY

FIGURE 2-2
REHOBOTH BEACH WWTP
EXISTING SITE PLAN

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2.1.3 Performance

The WWTP has performed very well. Actual effluent data is summarized in Table 2-2.

Table 2-2: Rehoboth Beach WWTP Current Performance Data

Parameter	Average Annual	
	Concentration (mg/L)	Load (lbs/yr)
BOD	2.3	8,820
TN	8.7	33,400
TP	0.5	1,920

Notes:
1. Performance data based on January – December 2003.
2. Annual average flow for 2003 was 1.26 mgd.

It is expected, based on historical records that the flows will increase slowly at a rate of approximately 2.5% per year. The design capacity of the plant (3.4 mgd) is considered adequate and there are no plans to expand the capacity either now or in the future.

2.2 SUSSEX COUNTY WASTEWATER TREATMENT FACILITIES

Sussex County owns and operates several wastewater treatment facilities serving different areas of the County. These include:

- Wolfe Neck Regional Wastewater Facility (WNRWF)
- Inland Bays Regional Wastewater Facility (IBRWF)
- Piney Neck Regional Wastewater Facility (PNRWF)
- South Coastal Regional Wastewater Facility (SCRWF)

The service area of the SCRWF is in the southern portion of the County, outside an area that would realistically be considered as part of a regional solution with the City of Rehoboth Beach. The plant is relevant to this study because it currently discharges its treated effluent through an ocean outfall. The effluent discharge permit imposed by DNREC on this facility will be the model used by DNREC in permitting any additional ocean outfalls. The service areas of the Wolfe Neck and Inland Bays RWFs could conceivably become part of a regional solution. These areas, as well as many of the unsewered areas in northern Sussex County, are growing and will be in need of additional wastewater treatment capacity.

A brief description of each facility and its discharge permit limits are presented below.

2.2.1 Wolfe Neck Regional Wastewater Facility

The Wolfe Neck Regional Wastewater Facility is an aerated lagoon treatment system with a design capacity of 4 mgd. The facility is located just north of Rehoboth Beach. Figure 2-3 shows a process flow diagram for the WNRWF. Wastewater from the West Rehoboth Expansion of the Dewey Beach Sanitary Sewer District is screened prior to entering a series of aerated lagoons (each 23.8 million gallons). Treated effluent is disinfected and then disposed through spray irrigation. An existing site layout is shown in Figure 2-4. The land application site consists of 320 acres that are leased form the State of Delaware's Division of Parks and Recreation. The spray equipment consists of five center pivots spray irrigation systems. The spray fields are farmed for wheat, barley, clover and forage crops.

2.2.2 Inland Bays Regional Wastewater Facility

The Inland Bays Regional Wastewater Facility is an aerated lagoon treatment system with a design capacity of 1.46 mgd. The facility is located near Millsboro, Delaware. Treated effluent is disinfected and then pumped to the land application site. The 208 acre site consists of two center pivot spray systems that irrigate the land for cultivation of corn, barley and wheat crops.

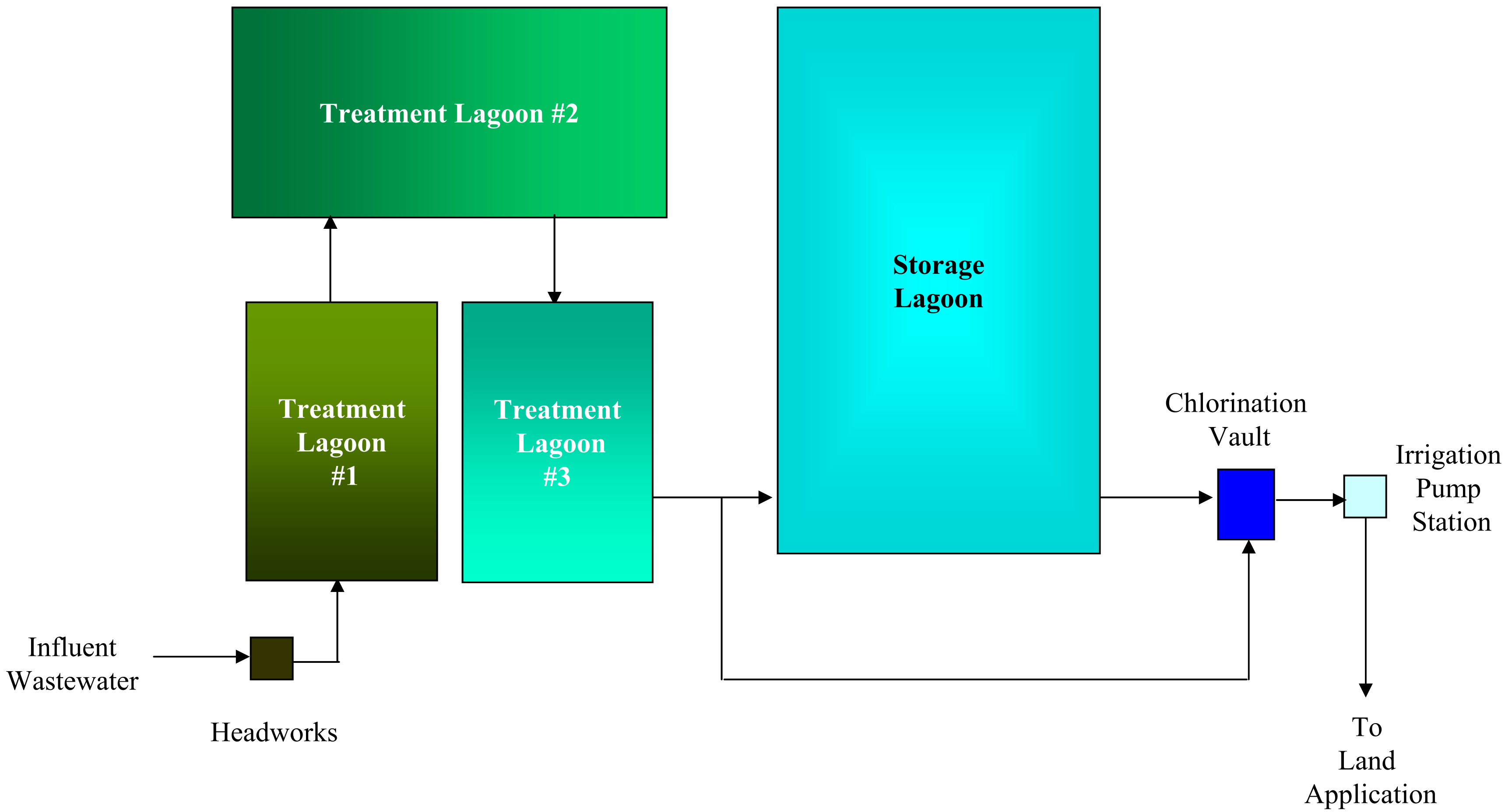
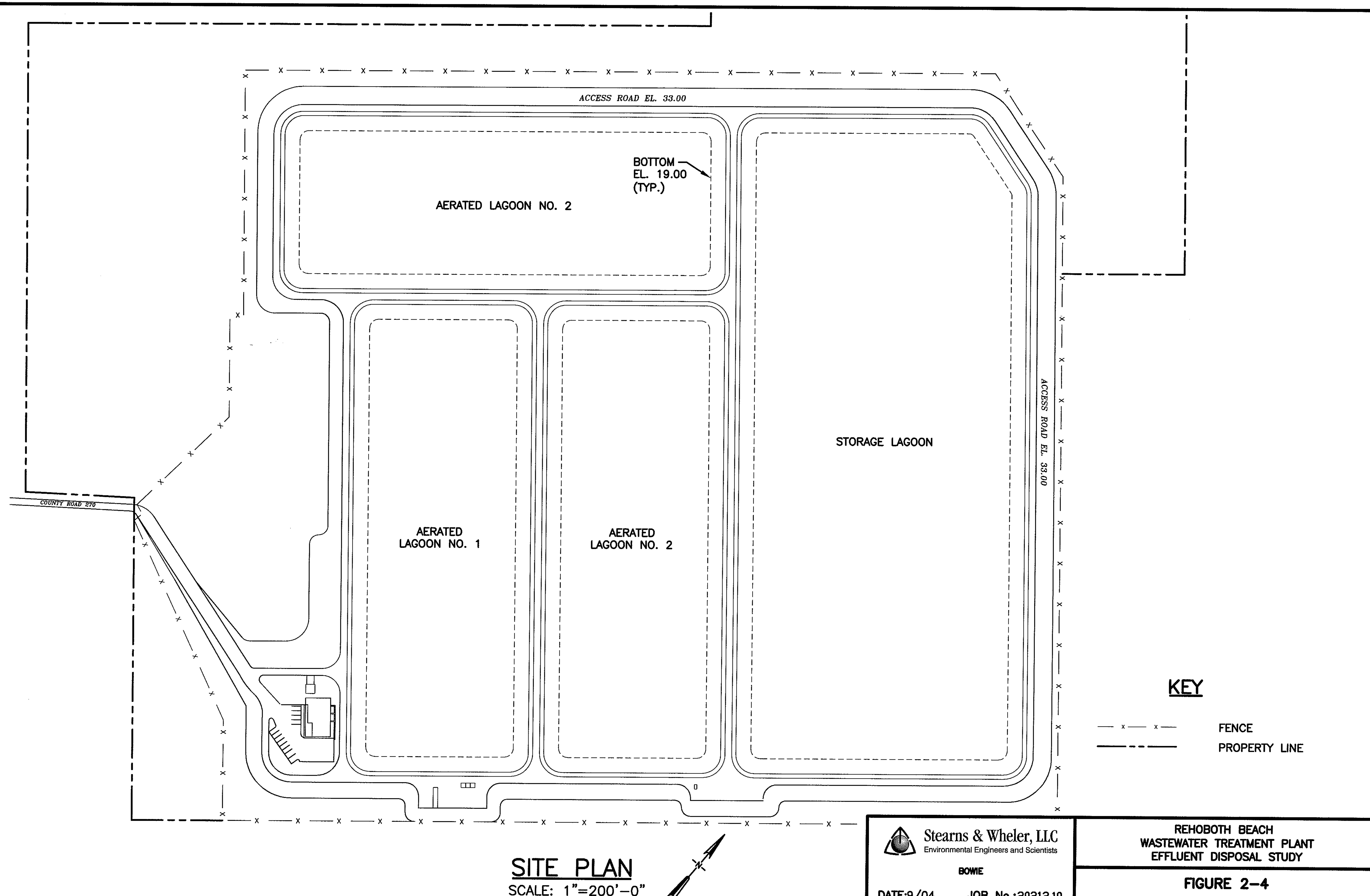


FIGURE 2-3: Wolfe Neck RWF Process Flow Diagram



SITE PLAN
SCALE: 1"=200'–0"

Stearns & Wheler, LLC
Environmental Engineers and Scientists
BOWIE

DATE:9/04 JOB No.:20212.10

REHOBOTH BEACH
WASTEWATER TREATMENT PLANT
EFFLUENT DISPOSAL STUDY

FIGURE 2–4
WOLFE NECK RWF EXISTING SITE PLAN

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2.2.3 Piney Neck Regional Wastewater Facility

The Piney Neck Regional Wastewater Facility is an aerated lagoon system with a design capacity of 0.20 mgd. The facility is located near Dagsboro, Delaware. The treated effluent is disinfected and then land applied on 38 acres that are farmed for corn and rye.

A solid set spray system is used for distributing the effluent. Treated effluent is also sprayed on a 16.7 acre site of loblolly pine.

2.2.4 South Coastal Regional Wastewater Facility

The South Coastal Regional Wastewater Facility is an activated sludge plant located near Frankford, Delaware that currently has a design capacity of 6 mgd. The plant is currently being upgraded to incorporate a new sludge treatment process that will produce a Class A sludge for land application. The wastewater treatment plant is in the process of being upgraded and expanded to a design capacity of 9 mgd. Construction of the expansion is expected to be completed in November of 2006.

Table 2-3: Sussex County RWFs NPDES Permit Limits

Facility	Flow	BOD		TSS	TN
		Daily Ave.	Daily Peak	Daily Ave.	
	mgd	mg/L	mg/L	mg/L	lbs/acre/yr
Wolfe Neck RWF	4.00	50	75	90	396
Inland Bays RWF	1.46	50	75	90	200
Piney Neck RWF	0.20	50	75	90	418 (1)
South Coastal RWF(2)	9.00	15	23	15	N/A(3)

Notes:
1. On spray irrigation fields (350 lbs/acre/yr on loblolly pine)
2. New permit requirements after expansion.
3. No application limit because of ocean outfall discharge.

2.3 SUMMARY OF STUDY CONDITIONS

The objective of the study is to identify the best alternative effluent disposal method for the City of Rehoboth Beach alone and for Rehoboth Beach and Sussex County together as a regional solution. The flows and loads that will be considered as the basis for this evaluation are summarized below.

2.3.1 Rehoboth Beach Only

The design capacity of the existing treatment plant is 3.4 mgd. The discharge permit assumes that the 3.4 mgd is an average day flow. However, the TMDL calculations that form the basis of the nutrient discharge limits for the plant, assume that the average flow for the summer season is 3.4 mgd. This capacity is adequate for the foreseeable future and there are no plans to expand the capacity. The actual flows will vary daily and seasonally and these variations are significant to the design of the infrastructure required for the various alternative disposal methods being considered. Based on historical records, the flow varies seasonally (average summer and winter flow) by a factor of approximately 2.0. Thus when the plant is at the design capacity of 3.4 mgd in the summer, the average winter flow will be approximately 1.7 mgd. Using historical data to estimate the maximum month and peak day peaking factors yields the design flows that are summarized in Table 2-4 below.

Table 2-4: Rehoboth Beach WWTP Design Flows

Condition	Flow (mgd)
Average Day	
Summer	3.4
Winter	1.7
Maximum Month	
Summer	6.8
Winter	3.4
Peak Day (4-hr peak)	
Summer	10.2
Winter	5.1

2.3.2 Regional Solution

Sussex County has estimated their need for wastewater treatment capacity to be 8 mgd on an average daily basis. Table 2-5 summarizes the flow requirements for average design capacity and peak day and peak instantaneous flow based on typical flow peaking factors for peak day and peak instantaneous flow.

Table 2-5: Sussex County RWF Design Flows

	Peaking Factor	Flow
Average Day	N/A	8.0
Peak Day	2.0	16.0
Peak Instantaneous	3.0	24.0

The regional solution must consider both the flow from the Rehoboth Beach WWTP and the Wolfe Neck RWF. Table 2-6 summarizes the flow requirements for the regional solution.

Table 2-6: Combined Flows (Regional Solution)

	Rehoboth Beach	Sussex County	Total
Average Daily	3.4	8.0	11.4
Max Month	6.8	16.0	22.8
Peak Instantaneous	10.2	24.0	34.2

CHAPTER 3

LAND SEARCH

3.1 AREA REQUIREMENTS

3.1.1 Land Application

A significant amount of land is required for land application. The spray area alone would require approximately 500 acres, depending on the nature of the soils. Additional land is required for buffers and setbacks. Thus, if the property has an odd, disjointed shape and there are a number of streams or structures on the property, the land required for buffers could be very significant. Land is also required for an effluent holding pond to temporarily store the effluent prior to spraying. Thus, it was assumed, for the initial land search, that a total of at least 550 acres will be needed with approximately 500 acres of the property suitable for spray application.

Ideally the site selected would be fairly square or rectangular so that the spray fields could be arranged efficiently to make maximum use of the property, using a combination of circular spray rigs or solid set sprinklers. Also, for the reasons cited above, the property would ideally be fairly level and void of streams and structures. However, it is recognized that this is unrealistically restrictive so the property search included smaller properties that, if not contiguous, were at least close to each other. The disadvantage of utilizing multiple properties, aside from the fact that the total area required increases, is that the cost of constructing and operating such a system also increases.

Private property and lands designated, under the Delaware Agricultural Lands Preservation Act, as either a Preservation District or a Preservation Easement were considered in the search. Agricultural Preservation Districts or Easements cannot currently be used for effluent disposal by land application. However, DNREC has indicated that the revisions to the legal requirements governing these properties are under review and it is expected that the law will be changed to allow such use.

3.1.2 Rapid Infiltration Beds

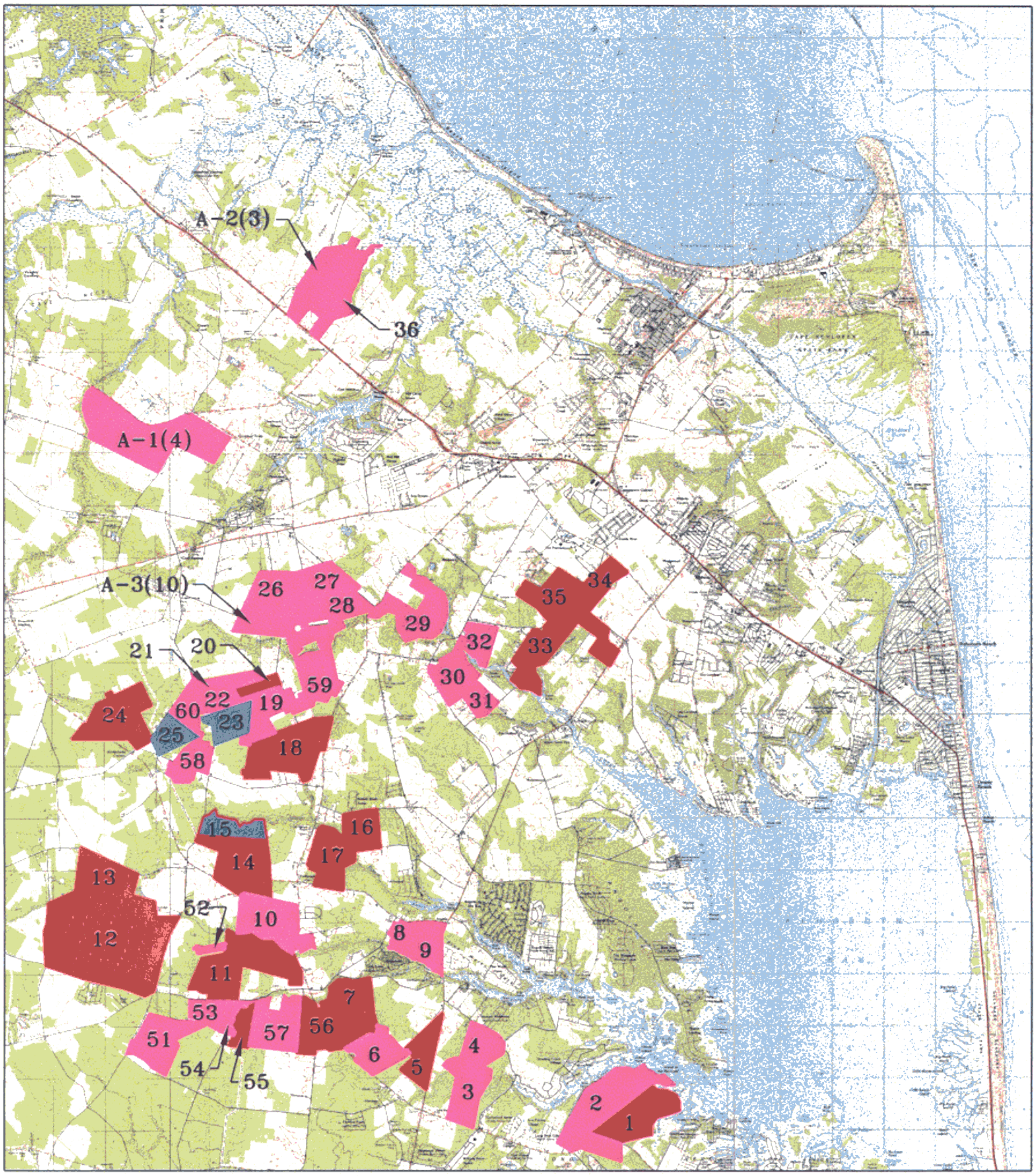
Approximately 175 acres are required for the use of Rapid Infiltration Beds (RIBs) as a method of effluent disposal. This does not include the land required for a storage lagoon and buffers. Although it is certainly easier to find 175 acres as compared to the site requirements for land application, this method of disposal is governed by some environmental restrictions that further complicate the site location.

3.2 APPROACH

A professional realtor was retained to conduct a search of properties in an effort to identify land that may be available for use as a spray irrigation site. The search was conducted by Mr. Skip Valiant, President of Seacoast Realty. Initially the search focused on large properties (greater than 100 acres) located within approximately 10 to 12 miles of the wastewater treatment plant. Beyond this distance, the cost to convey the wastewater to the spray site becomes excessive compared to other feasible alternatives. Because of the lack of response, the search was widened to include smaller properties (less than 100 acres) with the hope of finding contiguous properties that could be grouped into a larger site.

A total of 46 properties were identified in the Sussex County Tax Maps (Areas 234 and 334). The properties ranged in size from 87 acres to 828 acres. The properties are shown on the map in Figure 3-1.

The owner of each potential site was sent a letter, on Stearns & Wheler letterhead, presenting the reason for the inquiry and asking them to respond regarding their interest in pursuing either a sale or lease agreement (copy of typical letter in Appendix A). These initial contacts were made during the period of March through May 2003. Follow-up contacts were made to the owners multiple times, whether by letter and/or phone. The response was discouraging. As shown on



NOT TO SCALE

KEY

- NO INTEREST
- NO RESPONSE
- INTEREST

Stearns & Wheler, LLC
Environmental Engineers and Scientists

DATE:09/04 JOB No.:20212.10

REHOBOTH BEACH
EFFLUENT DISPOSAL STUDY

FIGURE 3-1
SUSSEX COUNTY LAND AVAILABILITY

08/04 BOWIE LB
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Figure 3-1, many owners called to say that they were not interested while others could not be reached and did not respond. Those who expressed some minor interest indicated that they would only consider a lease and that they were concerned with land application because they wanted to continue growing vegetables on the land. It would of course not be allowed to grow crops for direct human consumption on the property if it were used for land application. A few owners expressed some potential interest, but the size of the properties were well below the minimum requirements for land application. There was one owner that expressed definite interest but the property, because of its size, would only possibly be suitable for rapid infiltration beds.

In May 2003 it was decided to expand the search for property beyond the initial search area. These additional property owners were contacted by letter during the period of May to June 2003. The results were again disappointing with no viable candidates identified.

It was then decided to further expand the search by considering lands that are preserved for agricultural use by the Delaware Agricultural Lands Preservation Act. The Agricultural Lands Preservation Foundation was established by the State of Delaware to create incentives to agricultural land owners to preserve their land for farming and not sell to developers. The land may be preserved either as an Agricultural Preservation District or as an easement. The creation of a District requires the landowner to execute a deed restriction that prevents rezoning of the site for development as a subdivision. The landowner receives several tax exemptions as a benefit. This agreement is temporary and typically binds the land to the deed restrictions for a period of 10 years. The property may also be protected through an easement, which basically makes permanent, the deed restrictions described previously for a District.

However, currently the law does not allow the application of treated effluent on lands preserved by the Agricultural Land Preservation Act. In the last several years there have been initiatives in the legislature to remove these restrictions and, according to DNREC, it is expected that eventually the restrictions will be removed.

Three different properties or groups of properties protected by the Agricultural Lands Preservation Act were contacted during the month of August 2003. Each of these three sites were made up of several smaller properties. Any one individual property would not provide enough area to satisfy the land application requirements. However, the properties were contiguous and it was hoped, as was the case with the private properties, that one of property owners would agree to land application thus creating an impetus for adjacent property owners to follow suit. None of the property owners contacted expressed an interest in allowing spray irrigation.

As a last effort to identify a possible site, it was decided to pursue one of the few properties that expressed a possible interest in selling their property. The goal was to get one piece of property committed and under contract hoping that the surrounding sites may also eventually agree thus creating a land application site large enough to meet the needs of the project.

The only property that definitely said that they would be interested in selling was the Glatfelter Pulpwood Company property identified as property No. 25 on the table of properties (Tax Map No. 2-34 5.00 33.00). This site has an approximate area of 115 acres which is not adequate for land application without several adjacent properties also being made available. The site could also be used for a rapid infiltration bed type disposal system but again, only with some additional adjacent properties. A purchase contract was developed by the City, in conjunction with their solicitor, and presented to Glatfelter Pulpwood Company in April 2004 through Mr. Skip Valiant, the agent representing the interests of the City. The purchase offer had by necessity, a number of contingencies to protect the interests of the City. The offer was not accepted. There are a number of issues regarding contingencies that would have to be negotiated with any potential land purchase.

Complete documentation of the land search is provided in Appendix B.

3.3 CONCLUSION

Based on the experience to date, it is concluded that it is very unlikely that the City will be able to identify or purchase the amount of land in a suitable location to allow the construction of a spray irrigation facility or rapid infiltration bed facility to meet the needs of the City of Rehoboth Beach. Efforts to identify potential sites continued throughout the study, but without success.

One of the objectives of this study is to estimate the cost of a spray irrigation facility to serve the needs of the City and in order to meet this objective, it will be assumed that sufficient property in the vicinity of the Glatfelter property is available. This site, along with several of the adjacent properties, will be used as a basis for estimating the capital and operational costs of a spray irrigation system. The Glatfelter property will also be used as a basis for estimating the cost of a Rapid Infiltration Bed system. These cost estimates will be developed to provide a means of comparison to the other alternatives being considered but it is recognized that, because the land is not yet available nor is it likely to be available, the project may not actually be feasible.

3.4 ISSUES

3.4.1 General

Several trends are impacting land use and making it more difficult to acquire the amount of land required. There is tremendous competition among developers for properties near existing coastal communities and the construction of new developments continues to occur further inland. The competition for land continues to drive the purchase price up dramatically.

DNREC is also seeking to acquire large properties to preserve as parkland. Although such properties could potentially be used for spray irrigation, the program increases the competition for the available land. Land use restrictions would prevent the parklands from being used for rapid infiltration beds.

Large commercial operations for logging or farming are leveraging the increased value of their existing properties by selling or trading existing acreage near the coast for larger tracts of land further inland. However most, if not all, of the properties that have had this opportunity presented to them have already been sold to others. The City of Rehoboth Beach is not in a position to respond quickly to an opportunity that would require the City to commit large sums of money to a land acquisition not knowing if the site is even adequate to meet their wastewater disposal needs.

Some property owners would prefer to keep their property undeveloped. The Agricultural Land Preservation Act provides an opportunity for them to set the property aside and still generate some revenue. As discussed previously, legally such properties are not available for use as spray irrigation sites. However, it is our understanding that DNREC intends to change the legal requirements governing the use of such properties and that spray irrigation will eventually be an allowable use.

3.4.2 Specific to Rehoboth Beach

There are several issues which handicap the ability of the City to aggressively pursue real estate opportunities, even if they were to appear. These issues are reflected in the contingencies that were written into the purchase offer in regards to the Glatfelter Pulpwood Company property and are summarized below.

Since there is no single parcel of land large enough to accommodate the required spray irrigation system, several adjacent or nearby lots must be purchased. This would require the City to commit to purchasing one tract of land without knowing if the other lots required to make a workable system are available or can be purchased at a reasonable price.

Because of the magnitude of the capital costs for each of the effluent disposal alternatives under consideration and the relatively small user base in the City of Rehoboth Beach service area, it will be necessary for the State to provide some combination of grants and low interest loans to make the project financially viable. It is also likely that some degree of regional cooperation will be necessary to make the project cost-effective. It is not possible for the City to "up-front" the amount of money that would be required to purchase the land for the project.

CHAPTER 4

LAND APPLICATION

4.1 DESCRIPTION

Land application involves the spray of treated wastewater effluent over a vegetated site at agronomic rates appropriate for irrigating the crop. It is considered a form of beneficial reuse since the practice involves the indirect recycle of water. This process accomplishes several objectives including irrigation of the crop, additional wastewater treatment and disposal of the effluent through recycling to the groundwater.

The additional treatment provided by the land application system is limited but, in the case of the Rehoboth Beach wastewater treatment plant, the effluent is already treated to a very high level. The level of treatment at the plant is greater than other existing land application sites in the state that have been functioning successfully for years.

The rate of application is controlled by a number of factors including primarily the hydraulic capacity of the soil and the nutrient loading which is based on capacity of the crop to utilize nutrients in the effluent. Typically the nutrient load is the limiting factor. However, with the Rehoboth Beach wastewater effluent, the level of nitrogen and phosphorus in the effluent is significantly lower than most other spray irrigation applications. Thus higher hydraulic loading rates may be permitted. A summary of the factors that are considered in the design of a spray irrigation facility are presented below:

- Soil permeability
- Ground water table
- Type of crop
- Weather
- Wastewater characteristics

4.1.1 Summary of Advantages / Disadvantages

Advantages

- Well established and accepted practice in Delaware
- Recharges groundwater
- Preserves agricultural use of land

Disadvantages

- Lack of available land
- High cost of property
- Significant effluent wastewater storage volume required

4.2 ENVIRONMENTAL IMPACTS

Land application has been practiced successfully in Delaware for over 25 years with no adverse effect on the fields, crops or groundwater. The various types of potential impacts are discussed in this section.

4.2.1 Health

The primary health related concern is in regards to the potential for either direct or indirect contact with pathogenic organisms contained in the effluent wastewater. This could potentially occur either by direct contact with effluent which has collected in ponds on the site or in runoff from the site or possibly from contact with aerosols. This risk is essentially nonexistent since the effluent is disinfected prior to application on the field. Epidemiological studies have demonstrated that aerosols pose no increased health concern to the public. There are several regulatory requirements that are intended to protect the public from these potential health risks.

Buffers are required between the spray field and residential area, streams and wells. The amount of buffer required depends on the degree of treatment provided to the wastewater. Typical secondary treated wastewater is required to maintain a 100 to 150 foot buffer. Wastewater that has been treated to a tertiary level, such as the Rehoboth Beach WWTP effluent, is required to maintain a 50-foot buffer or less. Buffers between the spray site and adjacent streams, or waterways that pass through the site, are also protected by water quality guidelines.

4.2.2 Water Quality

Surface Water

Design standards for land application systems prohibit the application of treated effluent at rates that will exceed the hydraulic capacity of the soils. Thus runoff from the site should not be a concern. However, buffers are also required which provide an extra measure of protection to streams passing through the site.

Groundwater

The treated effluent will percolate through the soil and into the shallow aquifer. As it passes through the soil and the roots of the crops, additional treatment of the effluent is achieved. The Rehoboth Beach WWTP provides a higher degree of treatment than is normally achieved for the land application of wastewater effluent. The standard level of treatment is to a secondary level. However, the Rehoboth Beach WWTP provides tertiary treatment which removes additional solids, provides biological nitrogen removal, and chemical phosphorus removal. The nitrate concentration in the percolate must not exceed the state drinking water standard of 10 mg/L. The effluent of the Rehoboth Beach WWTP is typically 6 mg/L Total Nitrogen of which approximately 4 to 5 mg/L is in the form of nitrate.

4.2.3 Soil Conditions

The primary concern with regards to the soils is the addition of salts that can accumulate over time. High concentrations of salts can cause injury to the crops. Also high concentrations of sodium relative to calcium and magnesium can reduce the permeability of the soil by the dispersion of clay materials. This ratio is expressed as the Sodium Absorption Ratio (SAR).

4.3 SITE SELECTION

As discussed in Chapter 3, the availability of land application sites that are suitable for use by the City of Rehoboth Beach, are very limited. As of the date of this report, only one site with limited acreage was identified as a possible site. In order for land application to be viable, additional acreage from nearby or adjoining sites would be required. It is extremely unlikely that they will be available since contacts to date with nearby property owners have resulted in either a negative response or complete lack of interest in selling the property. However, in order to provide a perspective on the feasibility of proceeding with land application as the selected alternative, it is important to develop a cost estimate for a system that is as realistic as possible. Thus, it has been assumed that for the basis of this report, the property identified in Figure 4-1 is the selected site.

4.4 REGULATORY REQUIREMENTS

The regulations concerning the land application of treated effluent are contained in the DNREC document entitled "Guidance and Regulations Governing the Land Treatment of Wastes (Amended October, 1999). The basic requirements are summarized in this section.

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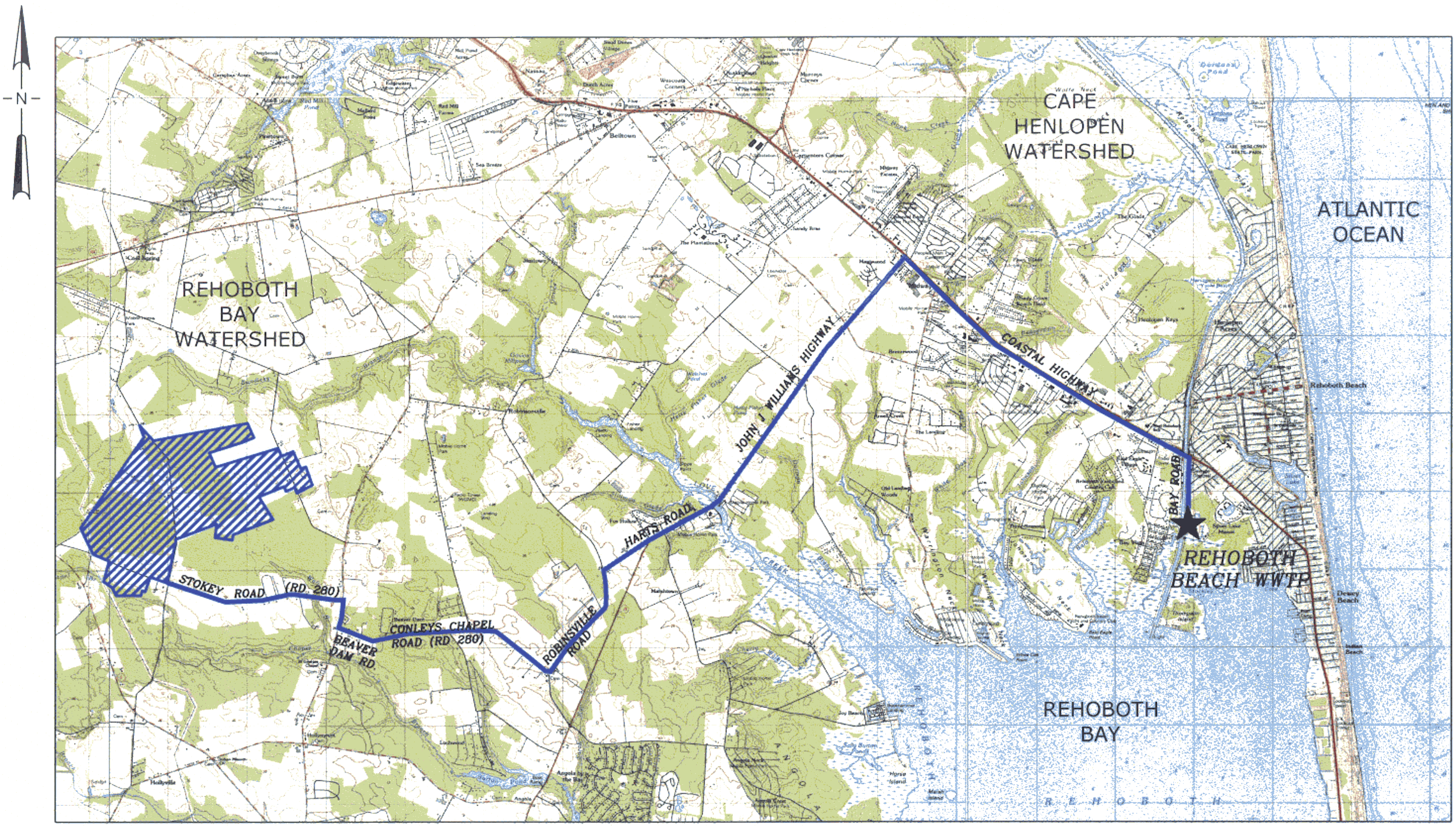

KEY

———	PROPOSED 24" PIPELINE
▨	PROPOSED SPRAY IRRIGATION SITE

SCALE: 1"=6000'-0"

Stearns & Wheler, LLC
Environmental Engineers and Scientists
BOWIE, MD

DATE: 09/04 JOB No.:20212.10

REHOBOTH BEACH EFFLUENT DISPOSAL STUDY
FIGURE 4-1

PROPOSED SPRAY IRRIGATION FIELD LOCATION

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4.4.1 Wastewater Characteristics

The degree of wastewater treatment required depends on the intended use of the site and the amount of public access that will be granted. A summary of the basic effluent requirements for the different categories of access are summarized in Table 4-1.

Table 4-1: Effluent Requirements for Spray Irrigation

Type of Public Access	BOD mg/L		TSS mg/L		Fecal (col/100ml)
	Average	Peak	Average	Peak	
Restricted	50	75	50	90	200
Limited	30		30		200
Unlimited	10		10	20	

Based on the data shown in Table 2-2, the Rehoboth Beach WWTP exceeds the requirements specified for limited public access; however, additional treatment would be required for unlimited public access. In order to qualify for unlimited public access, the existing effluent would require additional treatment including chemical coagulation and flocculation followed by filtration. Limited public access is perfectly acceptable since, if the City were to proceed with land application, the land would be owned or controlled by the City and public access would not be allowed.

4.4.2 Prohibitions

There are a number of restrictions placed on the agricultural use of the land for the protection of human health. The growing of vegetables and the grazing of animals are prohibited on land that is actively used for land application. The concern is for the potential transfer of pathogens and parasitic organisms. Once land application has ceased, then:

- Grazing by animals other than diary cows may be resumed after one month
- Grazing by diary cows may be resumed after one year
- Vegetables may be grown after 18 months

4.4.3 Site Characteristics

Physical Site

Gently sloping sites are preferred because the slope decreases the potential for ponding. However, excessive slopes are not permitted because of the potential for runoff from the site. The slope limits are 7 percent furrow crops, 15 percent for forage crops and 30 percent for forested land.

Soils

The soils, as defined by the USDA Soil Conservation Service, must be characterized with moderately slow permeability (0.02 to 0.6 inches/hour). Poorly drained soils with high groundwater tables or restrictive subsurface layers are generally not acceptable. A detailed soil investigation by a Professional Soil Scientist is required as part of the design and permitting process. The tests required include saturated hydraulic conductivity and a series of tests on the chemical properties of the soil. A hydrogeologic survey of the site by a Professional Geologist is also required to characterize the water table.

4.4.4 Buffers

Buffers are required to provide protection against exposure to aerosols. The amount of buffer required depends on the degree of public access allowed which in turn dictates the effluent quality required. Both Restricted Public Access and Limited Public Access sites require a 150-foot buffer between the edge of the wetted area and all property boundaries or the shoulder of a road. A 100-foot buffer is required between the spray field and any perennial stream or lake. If the watercourse is intermittent, then a 50-foot buffer is required between the water course and the spray field. If the site is designed for Unlimited Public Access, then no buffers are required.

4.4.4.1 Design Criteria

The design wastewater loading rate is a function of precipitation, evapo-transpiration, design percolation rate, the loading of nitrogen and other constituents that could potentially limit the amount applied, depth to groundwater and the average and peak wastewater flows during the different seasons. The final design wastewater loading rate is determined by selecting a rate that satisfies the water balance requirements on the site and the requirement to not exceed the allowable loading of nitrogen, phosphorus and various metals on the site. The maximum allowable wastewater loading rate is 2.5 inches per week and an instantaneous rate of 0.25 inches per hour (DNREC Guidance).

Onsite storage capacity must be provided realizing that, while the wastewater is generated continuously, disposal on the spray fields may be limited by operational issues, inclement weather including rain or freezing conditions and by the water budget specific to the site. Typically, 45 days of storage capacity or more is required. In addition, two days of capacity (at average daily flow) is required to store wastewater (reject wastewater storage) in case the effluent fails to meet the required water quality standards. There is some very limited storage capacity available at the treatment plant. However, in the case of the proposed Rehoboth Beach system, it is impractical to store the full volume of the reject wastewater (6.8 MG) and then recycle it back through the wastewater treatment plant because the plant is located over 10 miles from the spray site. A feasible alternative in this case is to locate several spray fields with the additional buffer required to be classified as a limited or restricted access site. This approach would allow the application of effluent that does not comply with the higher quality effluent standards imposed by the unlimited public access classification.

4.4.4.2 Monitoring Requirements

In order to insure compliance with the permit requirements, various characteristics of the effluent wastewater, the groundwater and the soils are monitored. Typical parameters monitored for the effluent applied to the field include BOD, TSS, COD, NH_4-N, NO_3-N, TKN, TP, Cl, Na, K, Ca, Mg, metals and certain priority pollutants. Groundwater is monitored by the placement of monitoring wells upgradient and downgradient of the spray fields. Representative samples of the soil are analyzed periodically to monitor for changes in the soil chemistry.

4.5 PROPOSED DESIGN

The land application system design will include a spray irrigation system, onsite storage (lagoon), a pump station and an effluent flow conveyance system. In addition, an effluent pump station would be required at the Rehoboth Beach WWTP to provide the hydraulic head necessary to pump effluent to the land application site. The total estimated project cost for this design is provided at the end of this section.

4.5.1 Land Application Site

The site selected for the preliminary layout of the spray irrigation system was based on the single property owner that indicated a willingness to sell his property to the City. However, as mentioned previously, the size of this property is inadequate for a spray irrigation system. Therefore, for effluent spraying to be feasible, it will be necessary to acquire adjacent properties. As mentioned above, adjacent lands are not available to the City for purchase. However, for the purpose of developing cost estimates for this alternative, it is assumed that the City would acquire these lands for constructing an effluent spray irrigation system.

4.5.1.1 Lagoon

The lagoon will provide the effluent storage requirement for the spray irrigation system. The storage volume requirement consists of three components, operational storage, wet weather and emergency storage and water balance storage. Operational storage is the volume required to store effluent wastewater during periods when the spray irrigation system is not in operation, for example weekends. The wet weather and emergency storage provides for periods of excessive rain or snowfall, saturated or frozen soil conditions and equipment failure. Water balance is the difference in storage volume between the potential effluent wastewater loading rate (assuming all influent wastewater is applied to the spray fields) and the maximum allowable hydraulic loading rate.

The design of the lagoon storage system is based on DNREC Guidance and Regulations Governing the Land Treatment of Wastes, 1999. DNREC regulations require a minimum storage period of 15 days but prefer a storage period of 45 to 60 days.

Operational storage is based on storing the entire plant design flow (3.4 mgd) over a 2-day weekend.

Wet weather and emergency storage was calculated based on the following equation:

<u>Wet Weather and Emergency Storage</u> = Delta P x 30.4 days/month/D(allowed) critical

Where:

- Delta P = 30 year variation from 5-year return monthly
- D(allowed) crit. = Maximum allowable hydraulic loading in most critical water balance month.
- A Delta P value of 2.1 inches was assumed for Southern Delaware (DNREC Guidance).

Water balance storage was calculated using the following equation:

<u>Water Balance Storage (in./month)</u> = D(Potential) – D(allowed)

Where:

- D(Potential) = Potential wastewater loading (in./month) assumes all influent wastewater is applied to the spray fields
- D(allowed) = Maximum allowable hydraulic wastewater loading (in./month)

- D(Potential) is based on an assumed maximum design loading rate of 2.4 inches per week This maximum loading rate may occur during the summer when conditions generally facilitate higher loading rates.

D(allowed) is calculated from climatological data (Evaporation + Percolation – Precipitation) obtained for Lewes, DE (the closest city with available climatological data). A percolation rate of 0.48 in/day was assumed for these calculations based on using 10% of the mean saturated hydraulic conductivity of the most limiting layer within the first five feet from the surface (0.2 in./hr.).

Based on the calculations, the total storage volume was broken down as follows:

<u>Total Storage (123 MG)</u> = Operational Storage (43.7 MG) + Wet Weather and Emergency Storage (23.8 MG) + Water Balance Storage (55.1 MG)

The total storage volume calculated above does not include storage for reject wastewater.

With this storage volume, the storage period will be approximately 36 days, assuming the entire plant design flow will be diverted to the lagoon. This storage period is greater than the DNREC's recommended minimum storage period of 15 days but less than the preferred storage period of 45 to 60 days. Assuming a 45-day storage period, the required volume will be approximately 153 MG (assuming the entire plant design flow is diverted to the lagoon). However, this approach may be too conservative since it is anticipated that the Rehoboth Beach WWTP will be able to utilize the spray irrigation system year round. For the Rehoboth Beach WWTP spray irrigation system, a storage volume of 123 MG is recommended.

It should be noted that the neighboring Sussex County WWTP, which is a 2.3 mgd facility has a combined effluent storage volume of 83.8 MG for its spray irrigation system. This is equivalent to approximately 36.4 MG of storage volume per MGD of flow. Based on the 123 MG storage volume provided for the Rehoboth Beach WWTP, the equivalent storage will be 36.2 MG per

MGD (based on a 3.4 mgd design capacity) which is similar to that of the Sussex County WWTP.

The layout of the lagoon is dictated by the groundwater level in that area. Based on groundwater information provided by the Delaware Geological Survey, the high ground water elevation (which occurs during the wet season) is approximately 6 feet below grade. Allowing one foot of separation above the high water level, the bottom of the lagoon will be located approximately 5 feet below grade. In order to achieve the required volume, a 5-foot berm will be constructed around the lagoon to provide a total depth of 10 feet. The 10-foot depth includes 2 feet of freeboard. The approximate area of the storage lagoon is 40 acres.

4.5.1.2 Spray Fields

The entire wetted area is subdivided into individual spray fields. Effluent should be applied once or twice per week per field (DNREC Guidance). This would allow for aeration and drying of the soil profile. The spray field is sized to adequately treat the storage volume discussed above plus seven days of design average daily flow. DNREC requires that sufficient area be provided for the spray fields so that the stored wastewater can be irrigated within a reasonable period of time such that system operation and storage needs are not compromised. The formula for calculating wetted area (spray field area) is as follows:

A(wetted) = A(ADF) + A(OP) + A(WW/E) + A(WB)

where:

- A(wetted) = required wetted field area (acres)
- A(ADF) = area (acres) necessary to treat seven days of average daily flows
- A(OP) = area (acres) necessary to treat the operational storage
- A(WW/E) = area (acres) necessary to treat the inclement weather/emergency storage
- A(WB) = area (acres) necessary to treat the water balance storage

The required area for wet weather and emergency storage and for water balance storage is based on the need to eliminate these storage volumes within a 90-day period. The design hydraulic loading rate used for these calculations is 2.1 inches per week.

Based on the above formula and assumptions, the spray field area was determined as follows:

<u>Wetted Area (496 acres)</u> = A(ADF) (438 acres) + A(OP) (10 acres) + A(WW\E) (34 acres) + A(WB) (14 acres)

Again, for the purpose of comparison, the Sussex County WWTP has a spray field area of 320 acres or 139 acres per MGD of flow (320 acres/2.3 mgd). Based on a spray field area of 496 acres, the Rehoboth Beach WWTP will have an equivalent area of 146 acres per MGD (496 acres/3.4 mgd). It should be noted that this area is approximate and is based on the above assumptions. The assumed loading rates should be verified prior to proceeding with this alternative.

A layout of the spray fields is shown in Figure 4-2. Appendix C contains calculations for the spray irrigation system. The spray irrigation system was laid out using available lengths for the spray irrigation system provided by a single manufacturer, Zimmatic. The spray irrigation utilizes a center pivot spray system which allows irrigation in a circular pattern. It should be noted that this layout is preliminary. A more detail design could result in a more effective overall layout. Also the spray field site is very irregular which results in inefficient use of the property. Based on this preliminary layout which includes a 47 acre-area for the storage lagoon and a 496-acre area for the spray field, the total area of 740 acres will need to be purchased. This would require purchasing property from at least seven property owners.

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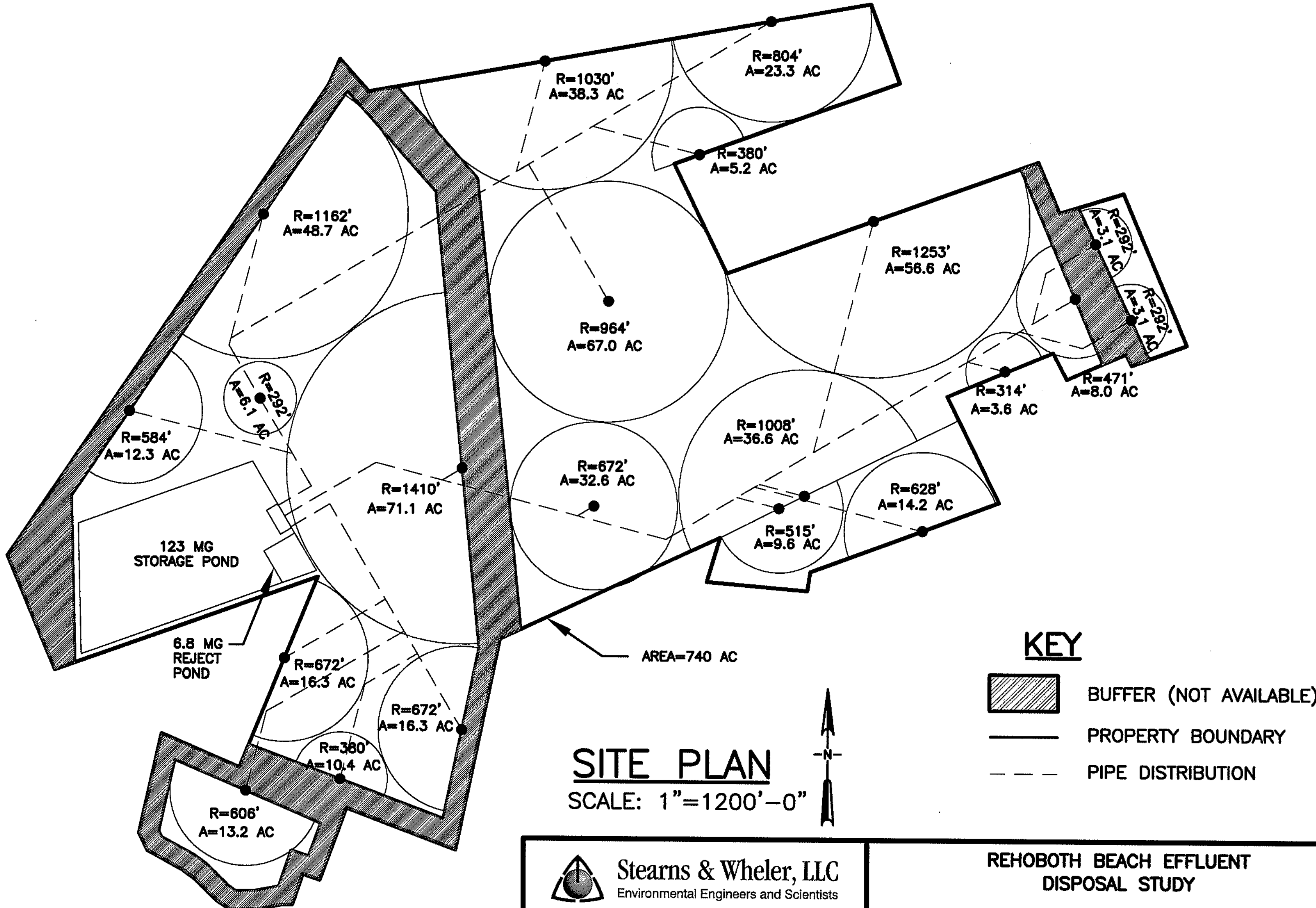

SITE PLAN
SCALE: 1"=1200'-0"

Stearns & Wheler, LLC
Environmental Engineers and Scientists
BOWIE, MD
DATE: 08/04 JOB No.:20212.10

REHOBOTH BEACH EFFLUENT DISPOSAL STUDY

FIGURE 4-2
PRELIMINARY SPRAY IRRIGATION FIELD

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4.5.1.3 Effluent Pumping and Conveyance

Flow from the Rehoboth WWTP will be conveyed through approximately 11.5 miles of 24-inch pipe. There is inadequate hydraulic head available for the flow to be conveyed by gravity. Therefore, effluent pumping will be required. An effluent pump station will be located at the plant site, downstream of the disinfection process. Four vertical turbine pumps (three plus one spare), each with a design capacity of 2,400 gpm will be used to pump effluent wastewater through a 24- inch pipe to the storage lagoon. The pumps will be located above an underground wet well and will be housed inside a building.

4.6 COSTS

An engineering estimate of probable construction cost for spray irrigation is presented in Table 4-2. A detailed cost breakdown is included in Appendix C.

Table 4-2: Estimate of Probable Construction Cost for the Rehoboth Beach WWTP Spray Irrigation System Alternative

Description	Cost
Rehoboth Beach WWTP Effluent Pump Station	$1,000,000
Force Main to Lagoon (Holding Pond)	$15,500,000
Spray Irrigation System	$16,400,000
Land Purchase Price(1)	$18,500,000
Construction Cost (Year 2004 Dollars)(2)	**$51,400,000**
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	**$9,900,000**
Total Project Cost	**$61,300,000**

Notes:
1. Land price estimate based on 740 acres @ $25,000 per acre.
2. Cost includes 30 % contingency.

4.7 SUMMARY

The use of land application for effluent disposal is a proven technology in Delaware and is environmental acceptable. However, a suitable site or group of properties, in reasonable proximity to the wastewater treatment plant, is not available. This has been documented through an extensive property search. Thus, land application is not a practical alternative for the City.

CHAPTER 5

RAPID INFILTRATION BEDS

5.1 DESCRIPTION

Rapid infiltration involves the percolation of treated effluent into the ground water through a soil bed at a fairly high rate. The basins are typically flooded and then allowed to dry and rest for a period of time. Thus the rapid infiltration beds (RIBs) rotate in and out of service. The soil that provides the bed for percolation of the effluent is typically either sand or the natural soils on the site. A minimal amount of additional treatment is achieved through filtration but the treatment level is much less than provided by spray irrigation which involves effluent application rates that are much lower and the use of crops to take up nutrients. Filtration through the soil may remove some minor amount of BOD and solids. A very minor amount of nitrogen, present as organic nitrogen in particulate form, may be removed but ammonia and oxidized nitrogen (nitrate) which are soluble, will pass through to the ground water. Ammonia can be oxidized to nitrate through the process of nitrification by bacteria present in the soil, if a sufficient amount of oxygen is present. A picture of a wastewater treatment plant, with RIBs for effluent disposal, is shown in Figure 5.1.

Figure 5-1: Wastewater Treatment Plant with RIBs

RIBs are essentially ground water recharge systems and the effluent will mix with the groundwater in the shallow aquifer. Nutrients in the effluent will therefore travel with the groundwater and reach any streams or surface water bodies that are recharged by the groundwater.

5.1.1 Summary of Advantages / Disadvantages

Advantages

- Proven technique for effluent disposal
- Recharges groundwater
- Relatively low impact in terms of amount of land required and cost

Disadvantages

- Potential to contribute nutrients to Inland Bays through contact with surface water
- Potential for local mounding of groundwater
- Use would prevent public access to land

5.2 ENVIRONMENTAL CONSIDERATIONS

5.2.1 Health

The rapid infiltration site would have to be closed to the public, which would eliminate direct contact with effluent. The effluent is not sprayed; therefore, there is no risk of aerosols presenting a health hazard to the public. The other source of potential adverse heath affects is through ground water contamination. The treated effluent will continue to be disinfected and thus there is little risk of introducing pathogens to the groundwater. Disinfection does not remove all bacteria and viruses. However, additional removal will be achieved as the water passes through the rapid infiltration bed and through the soils.

5.2.2 Surface Water

Surface waters could be indirectly affected as the groundwater carrying the treated effluent reaches a stream or surface water body. The primary impact would be the potential for the groundwater to carry additional nitrogen and thus encourage eutrophication in the water column. This would in fact be in violation of the TMDL requirements for the watershed, which prohibits the introduction of nitrogen or phosphorus into the Inland Bays from a point source such as the Rehoboth Beach WWTP.

5.2.3 Groundwater

The treated effluent will percolate through the soil and into the shallow aquifer. As the effluent passes through the soil, some minimal amount of additional treatment is achieved. The Rehoboth Beach WWTP provides a higher degree of treatment than is normally provided for rapid infiltration beds. The standard level of treatment is to meet secondary treatment requirements. The Rehoboth Beach WWTP provides tertiary treatment, which removes additional solids, provides biological nitrogen removal and achieves chemical phosphorus removal. The nitrate concentration in the percolate must not exceed the state drinking water standard of 10 mg/L. The effluent of the Rehoboth Beach WWTP is typically 6 mg/L Total Nitrogen of which approximately 4 to 5 mg/L is in the form of nitrate. There are no metals or hazardous waste in the Rehoboth Beach WWTP effluent.

5.2.4 Land

Soils will be disturbed during construction of the facility which will require excavation and the compaction of berms to construct the basins. Excavation will be required to the land for the installation of the distribution piping. However, the disturbances are temporary. Percolation of the effluent through the soils could result in plugging. However, the basins are sized and designed to operate intermittently to allow for a drying period. This restores the capacity of the bed and extends its useful life. If necessary, the soil could be redeveloped to restore its permeability.

5.3 SITE SELECTION

As discussed in Chapter 3, the availability of land suitable for use by the City of Rehoboth Beach for effluent disposal, is very limited. Ideally, since effluent disposal by RIBs can potentially form a barrier to salt water intrusion, the site should be located along the coast. The net flow of groundwater would most likely be toward the ocean and the mounding affect of the effluent would form a barrier to the continued intrusion of salt water into the superficial aquifers. However, land along the coast is at a premium and, except for some parkland, it is not available. Discussions were held with DNREC regarding the possibility of using a portion of the Delaware Seashore State Park for a rapid infiltration bed system. This would not be a permissible use of state lands because public access would be prohibited. Restriction of public access violates the mission of the state parks and in fact is prohibited by deed restrictions.

The land search, described in Chapter 3, identified only one site with limited acreage as a possible site for either land application or rapid infiltration beds. The property, referred to as the Glatfelter property, is located approximately 11.5 miles from the Rehoboth Beach WWTP and would require an effluent pump station and extensive piping to deliver the effluent to the site. This site is the most realistic option at this point, but based on a preliminary design, would require several adjacent properties in order to accommodate a RIB system.

5.4 REGULATORY REQUIREMENTS

DNREC does not have formal written guidance or regulations governing the design of Rapid Infiltration Beds although they are currently under development. The EPA Process Design Manual "Land Application of Municipal Wastewater" (EPA 625/1-81-013) currently serves as a source of guidance.

5.4.1 Wastewater Characteristics

The degree of treatment provided by the existing Rehoboth Beach WWTP exceeds the level that would typically be required for effluent disposal using rapid infiltration beds. As show in Table 2-2, the plant achieves low levels of BOD and TSS and has the ability to remove nitrogen and phosphorus to low levels. Thus, the RIBs would be sized hydraulically to minimize land requirements. However, the RIBs would provide some degree of effluent polishing by removing additional solids, organics and nutrients.

5.4.2 TMDL Limits

Although the treated effluent still contains relatively low concentrations of nitrogen and phosphorus and in some cases, a concentration of nitrogen lower than the ambient groundwater concentration in some locations in Delaware, the project will be subject to a TMDL review. This review is intended to insure that the project complies with the requirement of the TMDL previously developed for the Inland Bays that states that there shall be no contribution of nitrogen or phosphorus from point sources. A nitrogen load calculation and ground water flow analysis will have to be completed to determine if the RIBs would result in any net increase in nutrient flow to the Inland Bays or to streams which flow to the Inland Bays. If there is a contribution of nutrients then the project would not be permitable.

5.4.3 Ground Water Mounding

The wastewater effluent which percolates through the RIB flows initially downward where it creates a mound of ground water beneath the bed. The mound tends to increase during the flooding period of operation but then recedes during the resting period of operation. Excessive mounding can cause several problems. First, mounding can interfere with percolation through the bed thus reducing the effectiveness of the bed. Secondly, if mounding is significant enough, it can cause flooding problems in nearby swales, ditches and basements. Analysis of the potential for mounding, based on the soil characteristics and ground water flows at the specific site is required to demonstrate that ground water mounding will not be a problem.

5.4.4 Hydraulic Loading Rate

Soil tests are required to establish the acceptable hydraulic loading rate. Typically infiltration tests will be conducted. The annual hydraulic loading rate is normally limited to between 4 and 10% for the measured clear water permeability in the soil which is the most restrictive layer.

5.4.5 Site Access

Access to the site should be restricted as the basins flooded with wastewater represent a hazard to the public. The site access, pumping facilities and rapid infiltration beds should be fenced to restrict access.

5.4.6 Monitoring Requirements

In order to insure compliance with the permit requirements, various characteristics of the effluent wastewater, the groundwater, and the soils are monitored. Typical parameters monitored for the effluent applied to the beds include BOD, TSS, COD, NH_4-N, NO_3-N, TKN and TP. Groundwater is monitored by the placement of wells upgradient and downgradient of the RIBs. Representative samples of the soil are analyzed occasionally to monitor for changes in the soil chemistry.

5.5 PRELIMINARY DESIGN

5.5.1 Design Criteria

The rate at which water can be applied to a RIB is a function of the permeability of the underlying soil. Delaware does not provide strict regulations regarding application rate, but refers to EPA guidance. Delaware guidance suggests that 120 to 300 acres are needed for every million gallons per day of discharge. Based on practice, other state programs and EPA guidance, this policy appears to be extremely conservative. EPA guidance provides recommended application rates based on a range of percolation test infiltration rates. Table 5-1 summarizes the application rates and associated land requirement based on percolation rates.

Table 5-1: Application Rates and Land Required for 3.4 MGD Based on Soil Percolation Rates

Percolation Rate[1] (min/in)	Application Rate[1] (gpd/sf)	Area Required (sf)	Area Required (acres)
<1	Not Suitable	-	-
1-5	1.2	2,833,333	65
6-15	0.8	4,250,000	98
16-30	0.6	5,666,667	130
31-60	0.45	7,555,556	174
60-120	0.2	17,000,000	390

Note:
1. Data taken from Table 7-2 from the EPA Process Design Manual for On-Site Wastewater Treatment and Disposal

5.5.2 Facility Design

The majority of the Glatfelter site is comprised of the Evesboro Loamy Sand. The Evesboro is classified as allowing moderately rapid recharge, that is a recharge of 2 to 6 inches per hour or the equivalent 10 to 30 minutes per inch. Using the percolation rate, an application rate of 0.6 gpd/sf is a reasonable estimation based on EPA guidance.

Using the above application rate, the effluent hydraulic loading rate will be 29.3 ft/yr. Based on the Table 5-13 from the EPA Process Design Manual for the Land Treatment of Municipal Wastewater, Table 5-2 summarizes the application rate, drying rates, and cycle for the RIB system during winter and summer conditions.

Table 5-2: RIB Design Parameters for Secondary Effluent[1]

Season	Application Time (days)	Drying Time (days)	Cycle Time (days)
Summer	3	5	8
Winter	3	10	13

Note:
1. Data taken from Table 5-13 from the EPA Process Design Manual for Land Treatment of Municipal Wastewater.

It was also assumed that the winter period extends from November to March (151 days) and the summer period extends from April to October (214 days). Therefore, there will be 12 cycles (151 days/13 days per cycle = 12 cycles) in the winter and 27 cycles (214 days/8 days per cycle = 27 cycles) in the summer for a total of 39 cycles per year. Based on this number of yearly cycles, the hydraulic loading per cycle will be 0.75 ft (29.3 ft/yr/39 cycles per yr = 0.75 ft/cycle). The application rate will be 0.25 ft/d (0.75 ft/cycle/3 days per cycle = 0.25 ft/cycle) based on a 3-day application period.

The application rate can be used to calculate the depth of applied wastewater. Assuming an infiltration rate of 2 in/hr., the maximum depth of applied wastewater over a 3-day period be calculated as follows:

Depth of Applied Wastewater = Application Rate (ft/d) – Infiltration Rate

= 0.25 ft/d – (2 in/h *1ft/12 in.* 24 h/d) = -3.75 ft

According to EPA Process Design Manual, "Land Treatment of Municipal Wastewater", a maximum applied wastewater depth of 12 inches is recommended to minimize clogging and algal growth. In order to ensure that the recommended applied wastewater is not exceeded, it is necessary that the infiltration rate be determined as accurately as possible.

Since the number of cycles varies seasonally, the area for the RIB will be calculated for both summer and winter conditions. The larger of the two areas will control the design. The calculations for the required area for summer and winter conditions are shown below. Additional calculations are summarized in Appendix D.

Winter Period:

Area $= (3.4 \times 10^6$ gal/d * 151 d)/(0.75 ft/cycle*12 cycles*7.48 gal/cf*43560 sf/acre)

= 175 acres

Summer Period:

Area $= (3.4 \times 10^6$ gal/d * 214 d)/(0.75 ft/cycle*27 cycles*7.48 gal/cf*43560 sf/acre)

= 110 acres

The winter period would control the design. The required area for the RIB is 175 acres.

It should be noted that this land requirement does not include lands required for buffers, berms, reserve capacity and ancillary facilities. As discussed in Chapter 3, the Glatfelter property and surrounding properties are to be used for the preliminary design and for determination of the cost estimate. Figure 5-2 shows the possible site location for the RIB system.

Based on the Table 5-14 in the EPA Process Design Manual for the Land Treatment of Municipal Wastewater, a minimum of 3-5 beds are required for the RIB system. The manual also recommends the RIB be sized between 5 – 20 acres for a larger treatment system such as the Rehoboth Beach WWTP. Assuming a minimum of 16 beds is used for the RIB system, each bed will be approximately 10.9 acres. A preliminary layout of the RIB is shown in Figure 5-3. In order to construct the RIB effluent disposal system, approximately 300 acres would have to be purchased.

As with the spray irrigation system, a holding pond for storage and flow equalization would be provided with the RIB system. A storage volume 123 MG which equates to 36 days of effluent at average daily flow was used for the preliminary design.

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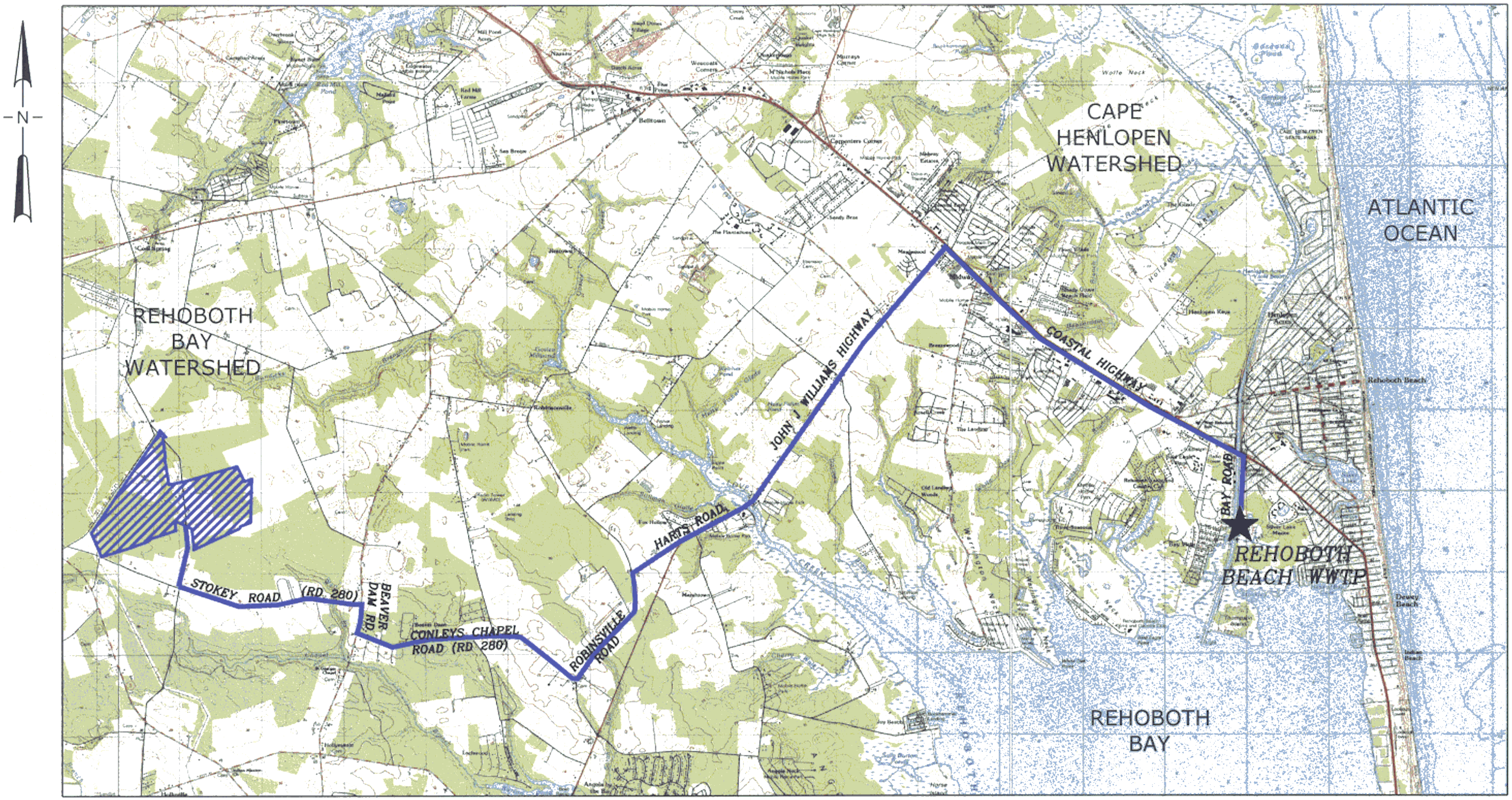

SCALE: 1"=6000'-0"

KEY

- PROPOSED 24" PIPE ROUTE
- PROPOSED RAPID INFILTRATION BED LOCATION

Stearns & Wheler, LLC
Environmental Engineers and Scientists
BOWIE, MD

DATE: 09/04 JOB No.:20212.10

REHOBOTH BEACH EFFLUENT DISPOSAL STUDY

FIGURE 5-2
PROPOSED RAPID INFILTRATION BED LOCATION

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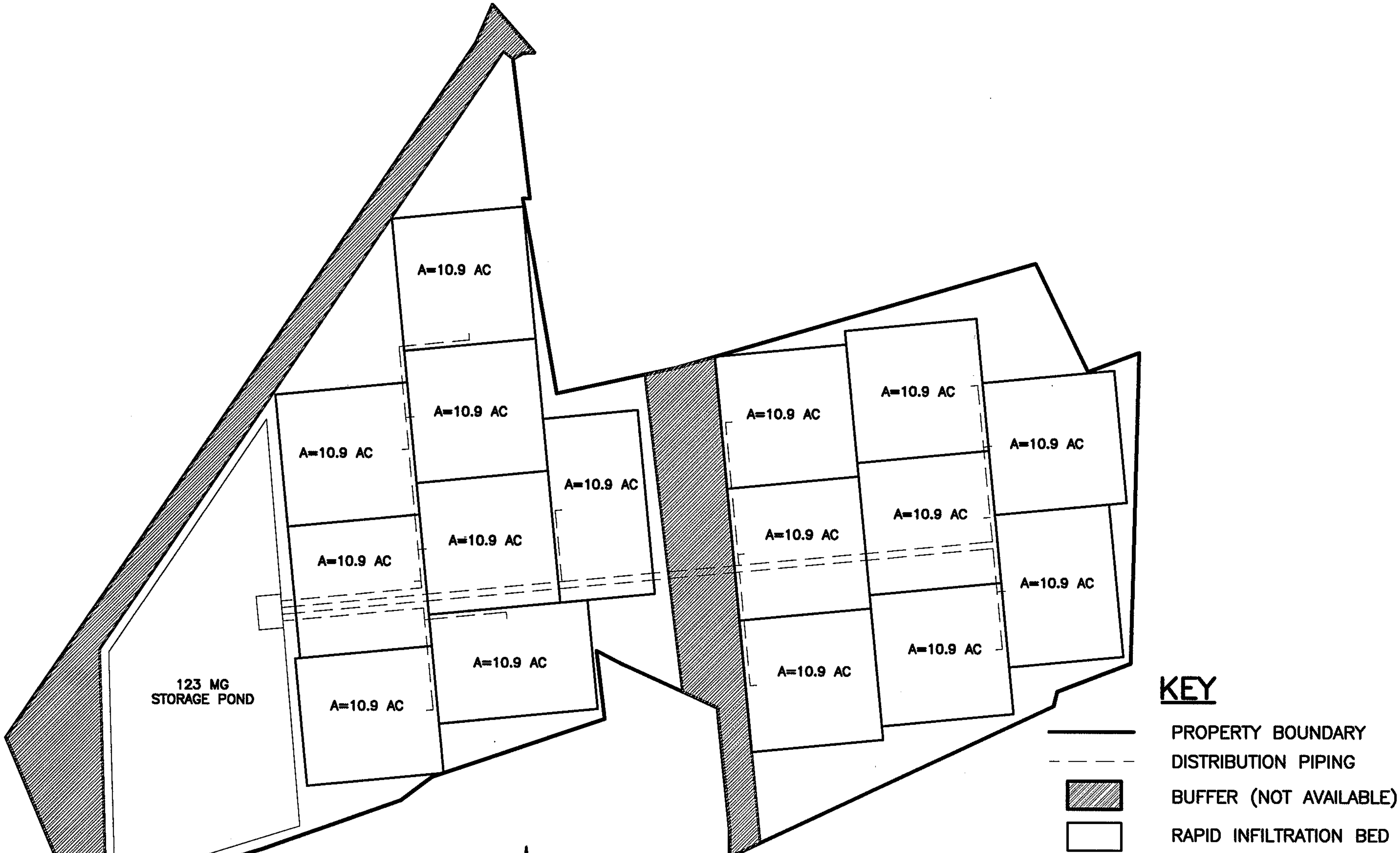

SITE PLAN
SCALE: 1"=800'-0"

Stearns & Wheler, LLC
Environmental Engineers and Scientists
BOWIE, MD
DATE: 09/04 JOB No.:20212.10

REHOBOTH BEACH EFFLUENT DISPOSAL STUDY

FIGURE 5-3
PRELIMINARY RAPID INFILTRATION BED SCHEMATIC LAYOUT

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5.6 POTENTIAL ISSUES

Groundwater Flow Direction and Nutrient Fate: The Glatfelter site is in the Rehoboth Bay Watershed. Groundwater flows toward the coast both directly and indirectly by discharging into Love Creek or Herring Creek. These streams would likely receive the greatest portion of the recharged ground water. Transported nitrogen and, to some extent, attenuated phosphorous would likely enter these water bodies. Significant dilution would occur as a result of the limited volume of effluent that enters the groundwater flow system. However, nitrogen is generally conservative in the subsurface and the mass of nitrogen discharged at the WWTP would likely be transported to the streams.

Groundwater Modeling: Groundwater modeling has been suggested as a possible tool for more precisely defining the fate and migration of treated wastewater and its constituents. Although modeling does have the potential to better define flow patterns, the basic conclusion that the groundwater discharges to proximal surface water bodies with the associated potential for nutrients to be discharged to those water bodies does not change. As stated above, nitrogen is considered to be generally conservative in the subsurface so the potential exists for the majority of nitrogen discharged to enter the surface water system. Groundwater modeling could also provide insight into travel time for the flow from a discharge site to the surface water. Given the approximate water table gradient and aquifer hydraulic conductivity, a flow rate of approximately 1 foot per day is a reasonable estimate. The nearest surface water is approximately 6,000 feet from the site, indicating that the travel time would be many years.

The wastewater treatment plant can produce an effluent total nitrogen of approximately 6 mg/L but could be upgraded to achieve and effluent nitrogen level of between 3 – 5 mg/L. At an effluent total nitrogen concentration of 5 mg/L and an average daily flow of 3.4 MGD, approximately 142 pounds of total nitrogen per day would be released to into the watershed and receiving water. However, it should be noted that many wells in agricultural areas currently have higher levels of nitrogen (in the form of nitrates).

Depth to Water and Groundwater Mounding: Groundwater in the area of the site is found at a depth of approximately 10 feet based on data from wells in the area. Considering just the current average annual flow rate, applying 2.3 MGD of recharged water to the site will result in the mounding of the water table as a function of the actual rate of recharge and the hydraulic conductivity of the underlying receiving formation. Using a published transmissivity value of 10,000 ft^2/day and an average thickness of 100 feet for the Columbia aquifer, a hydraulic conductivity of 100 feet/day can be estimated. If 2.3 MGD is applied over a 90 acre area, a mound of approximately 9.0 feet has the potential to form. The mounding calculation was completed using an analytical calculator referred to as the Hantaxis Model. If basements or septic systems are located in the vicinity of the discharge facility, the potential exists for those structures to be flooded as a result of mounding. Site specific data regarding hydraulic conductivity, depth to water and proximity of potential receptors would be required to verify this potential impact. The mounding will become worse at the maximum month design flow of 3.4 mgd.

Impact on Wells: Information regarding private drinking water supply wells in the area of the proposed RIB application site was requested from DNREC. The information provided by the state indicates that there are approximately 205 wells in the general vicinity of the site. The wells down gradient from the RIBS could potentially be impacted by the application of the treated effluent.

5.7 COSTS

A summary of the engineering estimate of probable construction cost for the RIB is presented in Table 5-3. Appendix D contains more details on the probable cost estimate.

Table 5-3: Estimate of Probable Construction Cost for the Rehoboth Beach WWTP Rapid Infiltration Bed Alternative

Description	Cost
Rehoboth Beach WWTP Effluent Pump Station	$1,000,000
Force Main to Holding Pond	$15,500,000
Rapid Infiltration Bed System	$18,900,000
Land Purchase Price(1)	$7,350,000
Construction Cost (Year 2004 Dollars)(2)	**$42,750,000**
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	**$10,600,000**
Total Project Cost	**$53,350,000**

Notes:
1. Land price estimate based on 296 acres @ $25,000 per acre.
2. Cost includes 30 % contingency. No contingency for land prices.

5.8 SUMMARY

Use of RIBs at the Glatfelter property, for effluent disposal to the ground water, will ultimately result in the discharge to surface water bodies in the watershed. Phosphorus can attenuate to some degree in the subsurface, but significant phosphorus plumes have been identified downgradient of wastewater discharge locations. Nitrogen is generally considered to be conservative in the subsurface environment and the nitrogen discharged from the WWTP would ultimately end up in surface water via the groundwater pathway. Higher levels of treatment can mitigate the impacts of nutrients on surface water but would not completely eliminate the nutrients. Therefore, under the terms of the TMDL, the use of RIBs in the watershed would not be permittable.

A second major issue is the lack of available land to site a RIB facility. After an extensive land search, adequate property available for purchase or lease could not be identified.

CHAPTER 6

UNDERGROUND INJECTION

6.1 DESCRIPTION

Underground injection is referred to as the disposal of wastewater below ground by pumping or gravity flow to an aquifer. A well is defined as any bored, drilled or driven shaft or dry hole that is deeper than it is wide. There are five classes of wells regulated by EPA and DNREC; however, there are basically two types of underground injection systems that could potentially be used to dispose of the treated effluent from the Rehoboth Beach WWTP. These are Shallow Well Injection (Class V) and Deep Well Injection (Class I).

6.2 DEEP WELLS

Deep Wells are wells that inject waste below the lowermost geological formation containing an existing or potential drinking water aquifer defined in the Underground Injection Control (UIC) program as an Underground Source of Drinking Water (USDW). A USDW is an aquifer that is presently used for drinking water, has the potential to be used for drinking water or has a total dissolved solids (TDS) concentration less than 10,000 mg/L. Deep wells inject into aquifers below USDWs and are regulated as Class I wells. A confining geologic layer must be present between the USDW and the contaminated aquifer to protect the USDW from potential contamination. The porosity and permeability in the injection zone must be sufficient to prevent excessive pressure buildup in the aquifer. The depth of Class I wells varies but can be as deep as 12,000 feet or more. According to EPA there are 272 active Class I injection facilities (approximately 529 actual wells) in the United States. Of these 51 are for hazardous waste and 221 are injecting non-hazardous waste. A typical schematic of a deep well facility is shown in Figure 6-1.

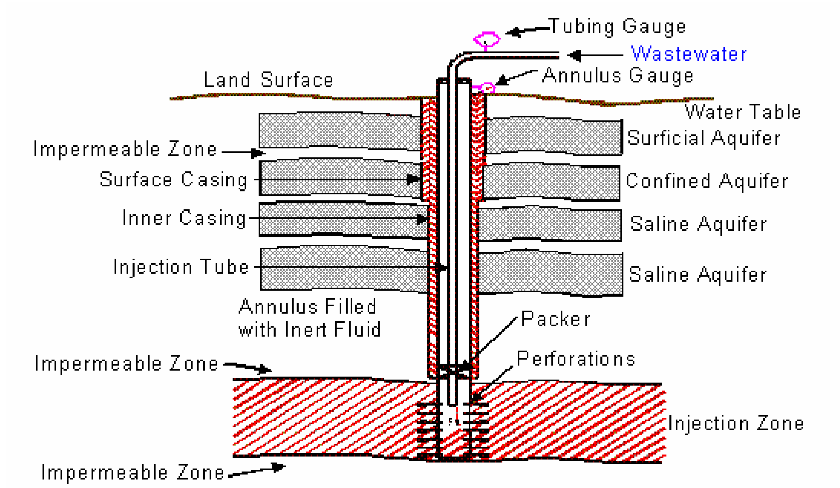

Figure 6-1: Design of Typical Deep Injection Well

6.3 SHALLOW WELLS

Shallow wells would typically include any system that injects treated wastewater into a shallow aquifer either by pumping into the aquifer or by infiltration. This type of well system is regulated as a Class V well. There are many types of Class V wells including agriculture drainage wells, storm water drainage wells, large capacity septic systems, fossil fuel recovery wells in addition to municipal wastewater effluent disposal wells. EPA estimates that there are over 650,000 Class V injection wells in the United States.

With shallow injection wells, the aquifer is not confined and the injected wastewater effluent is free to migrate as determined by the pressure gradients. The greatest concern with this type of disposal system is the protection of all USDW aquifers and there are two situations under which this type of well may be permittable. The two conditions under which this type of well may be permitted are that either the treated effluent must meet safe drinking water standards or the shallow aquifer must already be contaminated to the point where it would no longer be considered as a potential source of drinking water. This latter situation could possibly exist in coastal areas where salt water has intruded into the shallow drinking water aquifer.

If the level of TDS exceeds 10,000 mg/L, then the aquifer would not be permitted as a drinking water source. In this case a shallow well may be used for disposal of the wastewater if it can be located at least ¼ mile inside the boundary of the contaminated plume in the aquifer. There are no existing sites in the watershed that have salt water contamination at the concentration required to make the aquifer eligible for effluent disposal. Furthermore, there is no intent on the part of DNREC to consider the declassification of a USDW aquifer to allow its use for effluent disposal.

Treatment of the effluent to a level that would comply with drinking water standards is technically feasible; however, it would be very expensive and there are currently no water supply issues that would favor this alternative. Delaware Geological Survey has indicated that the drinking water aquifers in the Delaware area provide a plentiful supply of drinking water.

Because shallow injection wells inject water in an unconfined aquifer, there is the potential for the injected water to migrate to existing streams or other surface water bodies. Thus, there is the potential for the groundwater to carry nutrients to the Inland Bays which is prohibited by the TMDL.

6.4 S UMMARY OF ADVANTAGES / DISADVANTAGES

Underground injection has the potential to dispose of the treated effluent within a relatively small site and with little visual impact. The land area required to develop a well field with sufficient capacity may be significant but the site requirements of an individual well and its visual impact are minor. A picture of a typical well head for underground injection is shown in Figure 6-2. However, there are a number of potential disadvantages including:

- Extensive pilot testing would be required to determine design requirements and permittability.
- Risk associated with initial testing investment without the assurance of obtaining discharge permits.
- Public acceptance of an unknown disposal method.

Figure 6-2: Typical Underground Injection Well Head

- Operational issues related to the potential for plugging of the injection well.
- Long-term risk, based on experience elsewhere, associated with potential to contaminate other aquifers.

6.5 REVIEW OF TECHNOLOGY

Underground injection is practiced for a number of reasons including groundwater control, solution mining, waste disposal and for the recovery of geothermal energy. The subsurface injection of wastewater has been practiced since the 1930s by oil companies that utilized this method to dispose of oil field brines and other wastes. The wastes would typically be injected back into depleted underground reservoirs. The Safe Drinking Water Act passed in 1974 included provisions to protect underground sources of drinking water which led to the EPA Underground Injection Control (UIC) program in 1980. Currently there are over 473 Class I wells in the United States (EPA 816-R-01-007). Of these, 123 are for hazardous waste while the remaining 350 are for non-hazardous waste or municipal waste (injecting treated wastewater). A summary of previous experience with several different types of underground injection technologies, in different regions of the country, is presented in the following section. The system in closest proximity to the study area is the Mystic Harbor WWTP which utilizes shallow wells for wastewater disposal.

6.5.1 Florida

Deep well injection of treated wastewater has been practiced in Florida for 25 years. Currently there are approximately 47 injection wells in southern Florida that are regulated as Class I wells. The effluent must either meet primary drinking water standards at the point of discharge or be injected into an aquifer with groundwater containing a TDS concentration equal to or greater than 10,000 mg/L. In Broward County, 18 injection wells dispose of 110 MGD of treated wastewater (an average of 6 MGD or 4,200 gpm per well).

The North Regional Facility of Broward County injects about 60 MGD through four 24-inch injection wells spaced about 300 feet apart. Wastewater is injected into the Boulder Zone, at a depth of about 3,000 feet. The Boulder Zone is a saline aquifer approximately 2,500 feet deeper than the Biscayne Aquifer, the source of water in the area. Prior to injection, the wastewater undergoes secondary treatment. BOD is reduced to approximately 5 mg/L and TSS is reduced to less than 5 mg/L.

There are currently two hurdles to the operation of wells in Broward county. Despite injection into extremely fractured rock, the facility has experienced formation plugging and a build up of injection pressure. This reduces the injection capacity of the system. Various treatments are applied to maintain the injectivity of the system. Batch superchlorination aids in cleaning up biological slimes that collect on the well casing and injection face. Back flushing is used to clear up the vugs and fractures into which the wastewater is being injected. Because of the pressure in the injection zone, the wells will back flush themselves. Physical treatment, that is scraping the casing, has proven to be somewhat effective. Physical and chemical treatment of the injection zone (acidizing or scraping) has not been particularly effective.

Greater levels of treatment are not considered economically feasible. Filtering and high level disinfection, currently not part of the process could amount to a plant upgrade that would cost between $100 and $150 million. There is currently no nutrient removal but that is not considered to be an operational issue.

The second hurdle relates to regulatory and public acceptance of the technology. Although wastewater injection wells have been used for nearly 25 years and are permitted by the State, public opinion is resulting in enhanced scrutiny by EPA and FDEP. EPA has been sued by the Legal Environmental Assistance Foundation (LEAF) because of the potential environmental and health effects of deep well injection. EPA is responding to the suit and FDEP is also evaluating the suitability of the technology. The concern of LEAF is that it can not be demonstrated that the Biscayne Aquifer and the Floridan Aquifer, although not used as a source of potable water in this area is still defined as a USDW, are hydraulically isolated from the injection zone.

The City of Hollywood, Florida is currently investigating the potential use of treated effluent to mitigate salt water intrusion by injection into the Biscayne Aquifer. Because of the use of groundwater in coastal Florida, groundwater levels near the coast have dropped about four feet, resulting in salt water intrusion inland. There is some concern about the Hollywood plan. A pilot test using treated effluent was being considered; however, the current thought is to first complete a pilot test using potable water. The City of Hollywood is proposing injection at a sufficient depth (135 to 165 feet) so that injection will be into water with a TDS concentration greater than 10,000 mg/L, the regulatory threshold defining a USDW. Twelve injection wells are located 1/4 mile apart and each is designed to handle 1 to 1.5 million gallons per day. The aquifer is highly transmissive (between 5 and 10 million ft^2/day) allowing such high injection rates. The Biscayne aquifer is a highly fractured and vugular limestone. It is the opinion of the operator that the greatest hurdle to maintaining an effective injection system is the buildup of biological slimes and plugging. Avoiding iron based tubulars was also recommmended to mitigate buildup of iron bacteria. Physical plugging is not considered to be as significant an issue.

Wastewater injection in Florida is different from a potential wastewater injection project in the Rehoboth Beach area primarily because, in Florida, injection is into consolidated fractured rock rather than unconsolidated sands. Also, injection is through open hole completions rather than through well screens as would be required for Rehoboth Beach.

6.5.2 Massachusetts Military Reservation (MMR)

Since August 1997 MMR has been operating a groundwater pump and treat system that reinjects treated groundwater back into the subsurface using injection wells. The system operates at a flow rate of approximately 350 gpm (.5 MGD). Groundwater extraction is accomplished with ten 8-inch withdrawal wells. Eight operate at 30 gpm and two operate at 57 gpm. Injection is through eight six-inch wells each operating at approximately 44 gpm. The injection wells are spaced in two lines with four wells in each line. Wells in each line are separated by 50 to 100 feet and the two lines are separated by a space of about 500 feet. The two lines of injection wells are located at either end of the line of extraction wells and are approximately 200 feet down gradient. The depth to water at the injection site is approximately 40 feet. Mounding of approximately 0.5 feet has been observed despite the proximity of the injection wells to the withdrawal wells. The wells are 45 to 95 feet deep and are screened over the bottom 40 feet of the well. The well screens have slot sizes of .050 or .030. The injection interval has a hydraulic conductivity of approximately 300 ft/day. The injection wells are constructed of PVC with gravel packed stainless steel screens. Extracted water is treated for VOCs using activated carbon. Water is treated with potassium permanganate to raise the pH in order to precipitate iron and manganese. Prior to precipitation, there are approximately 1.7 mg/L total iron and manganese. Following precipitation, the concentration is reduced to approximately .02 mg/L. The water is filtered through a green sand filter prior to injection. Precipitation is performed ahead of all treatment systems to minimize plugging in the carbon. Biodegradation of petroleum products in the treated plume results in higher than background levels of metals in the influent groundwater.

Despite the precipitation of metals and filtering, some plugging of the injection wells has been observed. The reduction in injectivity has been attributed to encrustation of the well screens and plugging of the aquifer matrix. The plugging has been attributed to possible precipitation as a result of a higher oxygen content in the injected water. No analyses have been performed to characterize the plugging. As the wells inject by gravity flow, the plugging is indicated by an increase in the water level in the wells rather than a build up of injection pressure.

6.5.3 Orange County, CA

As in Hollywood, Florida, excessive pumping of groundwater resources has resulted in a lowering of the water table in coastal areas and subsequent salt water intrusion. As early as the 1950s salt water had migrated as far as five miles inland. A primary area where this has occurred is the Talbot Gap, the buried mouth of an alluvial fan between Newport Beach and Huntington Beach. In a project referred to as Water Factory 21, approximately 22.6 MGD are injected into 23 multipoint injection wells located about 600 feet apart. The 22.6 MGD injected is derived from approximately 14 MGD of treated effluent from the Orange County Sanitation District (OCSD) and 8.6 MGD derived from deep well water. Five MGD from the OCSD undergoes reverse osmosis and the other 9 MGD undergoes carbon adsorption. The resulting product water meets California Department of Health Services primary and secondary drinking water standards. The total treatment process includes chemical clarification, recarbonation, multimedia filtration, granular activated carbon, reverse osmosis, chlorination and blending. Total treatment cost is approximately $6 per 1,000 gallons. Injection is through 150 wells that range in depth from 280 to 700 feet. Some of the injected water flows oceanward creating a saltwater intrusion barrier and most of the injected water flows inland, replenishing well fields.

6.5.4 Long Island, NY

Between the 1960s and 1980s, the Nassau County Department of Environmental Protection and the United States Geologic survey conducted pilot tests on the southern side of Long Island to study the feasibility of injecting treated wastewater to mitigate salt water intrusion. The tests took place in two phases. In both cases, the water underwent tertiary treatment. During the first set of tests in Bay Park, treated water was injected into the Magothy Formation, comprised of unconsolidated silts and fine sands at a depth of approximately 480 feet. Between 200 and 400 gpm were injected into a single 8-inch fiberglass injection well with a stainless steel screen. Injectivity began to decline after about a month but injection continued for about six months before the well needed to be treated. Plugging was attributed to a high suspended solids load in the effluent. Injectivity was restored by letting the well back flow for approximately one hour which served to clear out the pore space adjacent to the well. In the 1980s, similar testing was performed at East Meadow. At that location treated effluent was injected into the Upper Glacial aquifer at a depth of 200 feet and was also recharged via recharge basins. The pilot tests were completed but full scale systems were never implemented because it was determined that salt water intrusion had not become a significant enough issue to warrant proceeding.

6.5.5 Mystic Harbor WWTP, Worcester County, MD

The Mystic Harbor WWTP is permitted for a flow of 250,000 gpd. The plant is a conventional activated sludge plant followed by a constructed wetlands for additional nutrient removal and slow rate sand filters for solids removal. The effluent is disinfected by UV. The effluent is discharged to the groundwater via 12 wells that are approximately 25-feet deep. The wells are remote from the treatment plant site and are located on an island in the bay. The well system has presented some operational challenges. Routine cleaning, generally every couple of weeks, is required to keep them in service. During the cleaning operation, the wastewater is stored in the sand filter basins. The wells tend to clog as a result of physical blinding by the presence of solids and by the growth of biological slimes. Recovery is accomplished by blowing the wells down with air and by injecting chlorine. Currently, there is a project underway to build additional capacity in a new plant which would require expansion of the well fields.

6.5.6 University of Delaware Pilot Study

A pilot study of shallow well injection was completed by the University of Delaware in August 1974 under contract to Sussex County. The study also considered spray irrigation as a means of effluent disposal and to recharge superficial aquifers. One of the benefits noted of shallow well injection was the potential to provide a hydrologic buffer against salt-water intrusion which was recognized as an increasing threat to public water supplies. The test area was in the Cape Henlopen State Park, where a 6-inch diameter recharge well was drilled to a depth of 77 feet. The specific recharge capacity was determined to be 9.9 gpm/ft, which is a moderate value which, over time, would most likely continue to decrease. The drilling logs did not identify an aquifer that was contaminated to a level that would disqualify it as a USDW. However, it was determined that the net flow of groundwater in the area was toward the ocean and that the salt water diffusing landward would recirculate back toward the ocean with the injected plume.

6.5.7 Technology Review Summary

To summarize, there have been successful applications of underground injection elsewhere in the country but each application is based on very different conditions regarding the quantity and quality of water being injected and the characteristics of the geological formation into which it is being injected. Development of an underground injection system for Rehoboth Beach will require extensive site specific testing to determine the appropriate design criteria and permit requirements.

6.6 ENVIRONMENTAL CONSIDERATIONS

6.6.1 General

In 1989, EPA studied the comparative risk associated with a number of treatment technologies including deep well injection and concluded that deep well injection was one of the most desirable alternatives in terms of risk (OSWER Comparative Risk Project, Nov 1989, EPA

540/1-89/003). A study published by EPA in 2001 entitled "Class I Underground Injection Control Program: Study of Risks Associated with Class I Underground Injection Wells (EPA 816-R-01-007) also concluded that the probability of failure has been demonstrated to be low. The existing permitting, testing, construction and monitoring requirements provide adequate protection. A study of Class V wells was also completed (EPA September, 1999) which led to new requirements for cesspools and motor vehicle waste disposal wells. However, an EPA determination issued recently stated that existing regulations regarding Class V wells are adequate to protect drinking water supplies.

6.6.2 Land

The land disturbance resulting from the construction of an individual well is minimal and the impacts are primarily related to construction and are temporary. However, a much larger area is impacted because of the number of wells that could potentially be required. The physical facilities must be protected from access by the public. Therefore, the site could still be available to the public but the individual well sites would have to be fenced. The permanent impacts, other than site access, are minimal because the well sites have a low profile and present very little aesthetic impacts.

6.6.3 Groundwater

Shallow well injection could potentially impact drinking water sources because effluent injection would be into a superficial aquifer. However, by definition, injection would be either into an already contaminated aquifer (which is not the case with Rehoboth Beach) or the injected wastewater would have to meet drinking water quality standards. Although technically feasible, it is not proposed to treat the effluent to that level because of the capital and operating cost required and issues associated with public perception of pumping into a drinking water aquifer.

Deep well injection would directly impact groundwater but, the aquifer affected would not be a potential source of drinking water and the groundwater would be completely isolated from any potential sources of drinking water.

6.6.4 Surface Water

Shallow well injection can impact the quality of surface waters because eventually the groundwater and, therefore, the wastewater effluent carried with it, has the potential to reach a surface water. The effluent that would be injected would be treated to a very high level and disinfected and would receive additional bacterial and virus removal as the ground water filters through the soils; therefore, the concern would not be for public health. The primary concern would be environmental quality because the injected effluent will contain some amount of nutrients that can encourage algae growth in the surface waters.

Deep well injection has little or no potential to impact surface waters since the effluent would be injected beneath a confining layer that prevents movement vertically to the surface.

There is a potential benefit associated with shallow well injection if the site is properly located. A shallow well injection system could provide a buffer against salt water intrusion if the wells are located where the net flow of groundwater is toward the ocean. However, property with the required hydrogeologic characteristics is most likely not available along the coast.

6.6.5 Health

There is a potential for public health issues with underground injection but not due to routine operations. The regulations imposed on this type of disposal technology are stringent and have demonstrated over the past may years to adequately protect public health. However, in the event of a failure of the treatment process or redundant protection systems, there is a potential to contaminate a potential drinking water source. Water quality monitoring would detect this event and the injection well would be taken offline and an emergency response plan (as required by permit) would be initiated.

6.7 REGULATORY ISSUES

Underground Injection is regulated by the Safe Drinking Water Act (SDWA). In response to the SDWA, EPA developed the Underground Injection Control (UIC) Program. The UIC program is explained in 40CFR, Sections 144 through 147. EPA established five classifications of injection wells. Class I wells are for the injection of hazardous waste. In Florida, municipal wastewater injection wells have been classified as Class I wells which is very conservative given the construction, operation and monitoring requirements of Class I wells. Class II wells are used to re-inject oil field brines and for secondary recovery of product. Class III wells are used for solution mining. Class IV wells were originally defined to categorize wells that injected hazardous wastes into USDWs; however, upon implementation of the UIC regulations, Class IV wells were banned. Class V wells are all other wells used to inject non-hazardous substances. A well is loosely defined as any structure that is deeper than it is wide; therefore, many structures including dry wells, domestic wastewater wells, aquifer recharge wells; even septic tanks could be considered Class V wells.

Delaware has primacy for its UIC program and DNREC regulates injection wells in accordance with Part 122, 124 and 146 of the Code. The regulations establish criteria for insuring the mechanical integrity of an injection well so that it does not leak and enforce fairly extensive requirements for construction, operation, monitoring and reporting. A demonstration of the adequacy of the casing and the cement placed to isolate the injection zone will be required. The operating requirements of the permit are designed to limit the allowable injection pressure and volume to assure that fractures are not initiated in the confining zone which could possibly allow the wastewater to migrate. The permit holder must develop a plan to close, plug and abandon a well and must maintain the financial resources required to do so.

Once a permit application has been made, DNREC can either deny the application or issue a draft permit. The permit process then includes a public comment period and provisions for a public hearing. If a final permit is issued, there are procedures established for the permit to be appealed.

6.7.1 Technical Issues

There are a number of unknowns critical to the proper design, construction and operation of an injection well that must be clarified before proceeding. A test well is required in order to obtain the required information. The test well should be sized such that it would become part of the actual operating system when completed. As the well is advanced, analysis of the core samples and water chemistry should be conducted to determine if there are opportunities to develop an injection well at a depth less than the targeted depth which, as will be explained later, is very deep for the Rehoboth Beach situation. The pilot well would be drilled to locate a confined aquifer, below the lowermost USDW aquifer, that is contaminated to a degree that would preclude its classification as a USDW.

Once at the target depth, various geological and hydrogeological studies are required. The primary concern regarding the geology of the formation is the permeability, porosity and thickness of the injection zone. This data is used to calculate the maximum injection rate that the formation can sustain without a build up of excessive pressure. It is also important to confirm the integrity of the confining layer to insure that it is sufficiently impermeable.

Groundwater chemistry is significant because of the potential chemical reactions that could occur between the wastewater effluent and the existing groundwater that could result in the precipitation of dissolved solids, which could potentially clog the well screen and injection zone formation.

Other factors, which contribute to reduced permeability and clogging of the screen, include the physical filtration of solids carried by the injected effluent wastewater and the growth of biological slimes. Biofouling can occur if there is an adequate supply of the necessary substrates including nutrients and carbon, all of which would be present, to a limited degree in the injected effluent wastewater. Dissolved gases have the potential to bind the aquifer as does the possibility that clay colloids in the aquifer are caused to swell by the injected water.

6.8 POTENTIAL APPLICATION AT REHOBOTH BEACH

6.8.1 General

Both shallow and deep injection wells were considered in this evaluation. Shallow well injection is, in many ways, similar to Rapid Infiltration Beds (RIBs) in that the wastewater is discharged to an aquifer that could potentially be a drinking water aquifer. There are several regulatory issues that will eliminate this method of disposal from consideration. Deep well injection is technically feasible; however, there is a great deal of risk associated with committing to the cost required, determine the feasibility, attempt permitting, and the operation of the deep injection wells. The issues associated with both shallow and deep injection wells are discussed in the following sections. Two potential locations for the well field would be the Rehoboth Beach WWTP and Thompson Island as shown on Figure 6-3.

6.8.2 Shallow Injection Wells

6.8.2.1 Description

This section discusses the applicability of shallow injection wells. The two conditions under which shallow well injection could possibly be permitted are 1) the aquifer receiving the treated effluent is already contaminated and the injection zone is located a quarter mile inside the boundary of the contaminated plume or 2) the injected wastewater is treated to a level that meets drinking water standards. The first condition does not currently exist although some degree of saltwater intrusion has occurred. The degree of intrusion is significant enough to have caused

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FIGURE 6-3
POTENTIAL WELL INJECTION SITES

the City to abandon several wells and move their source of groundwater further inland. However, the degree of contamination does not approach the level that would eliminate the aquifer from consideration as a source of drinking water. Thus, in order for shallow well injection to be considered, the wastewater would have to be treated to a level adequate to comply with the safe drinking water regulations. This would require the following additions and modifications to the existing wastewater treatment plant:

- Replace microscreens with sand filters
- Add chemical treatment with flash mixing and flocculation
- Add membrane treatment consisting of reverse osmosis (RO) or ultrafiltration plus RO

Drinking water regulations limit the amount of nitrates to less than 10 mg/L. Even after the proposed tertiary level of treatment, the effluent would still contain some forms of nitrogen and most likely contain as much as 6 mg/L Total Nitrogen. Depending on the direction of groundwater flow, the nitrogen could ultimately enter the Inland Bays which would violate the TMDL requirements for the watershed. This and other issues are discussed further below.

6.8.2.2 Potential Issues

Nutrient Loads. At the WWTP site or the Thompson Island site near the WWTP, groundwater likely recharges the Lewes and Rehoboth Canal or flows directly to the Rehoboth Bay. This is despite the probable subregional flow toward the coast because the canal and bay are immediately adjacent to the proposed injection site. The effluent would have to be treated to drinking water standards but would still contain a minimal level of nitrogen and phosphorus. The limit of technology using conventional processes, for the removal of nitrogen, is 3 mg/L TN. Higher levels of treatment could be obtained using additional treatment steps such as ion exchange, granular activated carbon absorption and breakpoint chlorination. However, there would still be some amount of nitrogen remaining in the effluent. Thus, any nutrients in the treated effluent would reach the Inland Bays which violates the requirements of the TMDL.

Groundwater Mounding. Given the proximity of the coast and the canal and the low elevation of the site, it is likely that groundwater at the WWTP site is between 5 and 10 feet below grade. The analysis conducted for the RIB alternative indicate that discharging groundwater over 90 acres at the Glatfelter site could result in a mound of approximately 9 feet. If wastewater is recharged in the relatively small area on the Thompson Island property, as would be accomplished with wells, very localized mounding could be significant. The mounding could potentially cause flooding on the WWTP property or the proximal Thompson Island property.

6.8.3 Deep Injection Wells

6.8.3.1 Description

Deep well injection requires that the treated wastewater be injected into an aquifer that is not a USDW. The aquifer would have to have TDS concentrations greater than 10,000 mg/L and would have no potential to be used as a drinking water source. Additionally, the aquifer must also be confined meaning that the geological formation above the aquifer constrains any movement of water from the aquifer vertically. Drilling logs to the depth required to definitively evaluate this option are limited. However, there is some limited information available form the Delaware Geological Survey (DGS) and the Maryland Geological Survey (MGS) to allow a very preliminary assessment of its potential. Based on the limited available information the Cheswold and Waste Gate Formations are two possible formations for deep well injection.

6.8.3.2 Cheswold Formation

Based on discussions with the Delaware Geologic Society, the Cheswold Formation is a potential injection zone. The Cheswold is a saline aquifer found at a depth of approximately 900 feet as shown in Figure 6-4. However, the salinity of the formation, although not actually known, is believed to be in the range of several hundred mg/L. This is not nearly enough to be eliminated from consideration as a USDW. There would be considerable investment required to complete

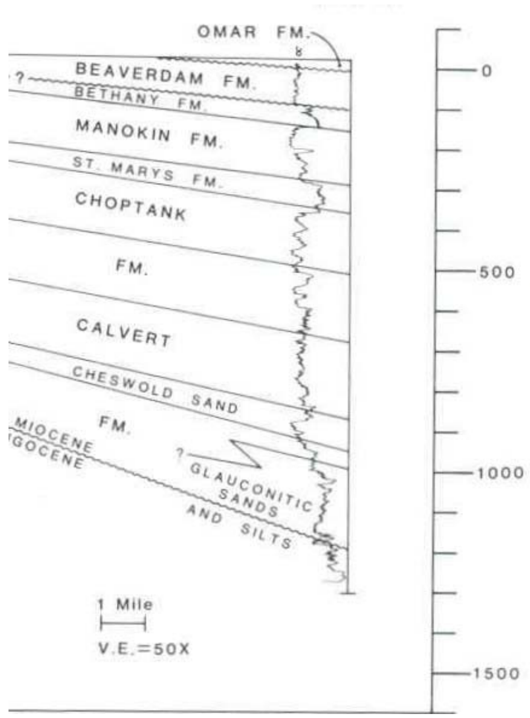


Figure 6-4: Cheswold Formation

the drilling required to verify the salinity. In addition, there is evidence that the Cheswold currently serves as or is being considered as a source of drinking water for other areas in Delaware. Thus, this alternative is eliminated from further consideration.

6.8.3.3 Waste Gate Formation

Test wells drilled in the 1940s by the Ohio Oil Company and a well drilled by the US Department of Energy in 1979, led to the identification of a geologic formation referred to as the Waste Gate Formation. It is actually a lower formation of the Potomac Group which underlies the Eastern Shore of Maryland and a portion of Delaware. At its western edge it is located approximately 3,500 feet deep but the formation dips down toward the coast to a depth of over 5,000 feet. A geologic cross-section is shown in Figure 6-5 (MGS Open File Report, "Waste Gate Formation, Pt I", H. Hansen, 1982). The Potomac Group is a source of drinking water although primarily for the area west of the Chesapeake Bay. The formation below the lower

Delmarva Peninsula is saturated with salt water. The limited samples taken indicate salinities on the order of 42,000 mg/L which is over twice the salinity of ocean water. The Waste Gate formation is separated from the freshwater supplies above by overlapping layers of the Potomac Group and is considered a confined aquifer. The stratigraphy of the Waste Gate formation if very complex with beds of sand lying within a clayey bed that fan out and are either connected to or separated from other sand beds within the formation. These formation characteristics qualify the Waste Gate formation for deep well injection but an accurate prediction of the amount of wastewater that could be injected is not possible until the wells, or at least a test well, is installed. The design criteria and basis of the cost estimate is developed further in a latter section.

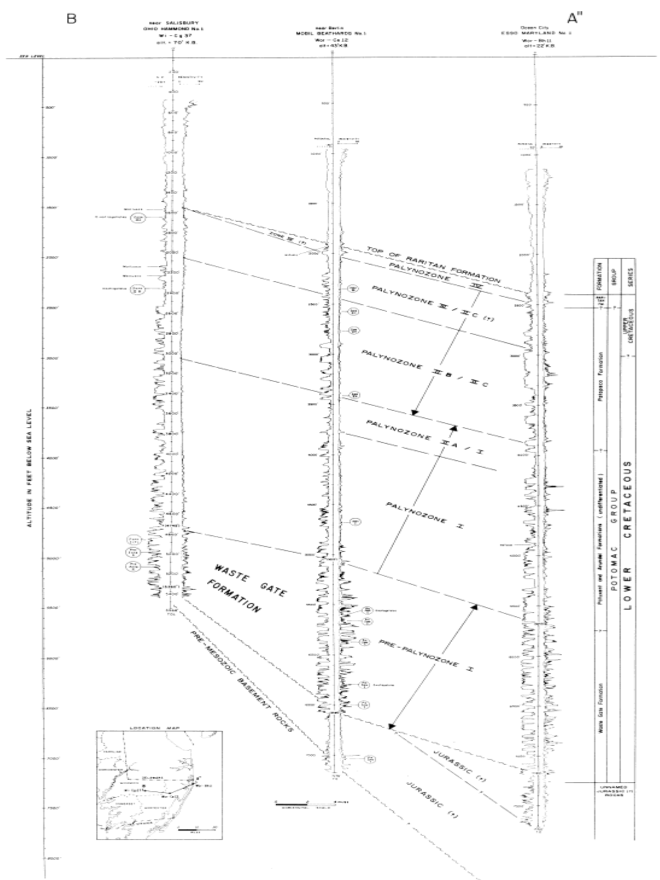


Figure 6-5: Geologic Cross-Section of the Waste Gate Formation from MGS Open File Report "Waste Gate Formation, Pt. I", H. Hansen, 1982

6.8.3.4 Potential Issues

<u>TMDL Compliance</u> There is no potential for ultimate discharge of effluent or nutrients to a surface water since the wastewater is discharged below a confining layer. Thus, compliance with TMDL requirements prohibiting the discharge of nutrients to the Inland Bays is assured.

<u>Groundwater Recharge</u> This method of effluent disposal does not recharge the drinking water aquifer. However, DGS has indicated that there is an abundant supply of water in the drinking water aquifers and that recharge to protect the supply is not a concern. Additionally, the current method of wastewater disposal, as a point source discharge to the canal, does not recharge the groundwater.

<u>Potential contamination</u> Despite best efforts to isolate a well and to seal the well casing to prevent migration from a formation below to the aquifer above, it is not possible to absolutely guarantee that there will never be any cross contamination. The more recent experience in Florida validates this concern. However, continuous monitoring of the well operation should detect the possibility of contamination at which time a response plan for closing the well would be implemented.

<u>Permitting Risk</u> One major hurdle to proceeding with deep well injection is the risk associated with the permitting and design process. Developing the test well to obtain the information required to proceed with design and permitting is very expensive. This money would have to be invested with no guarantee that the project will ultimately be technically feasible or permitted by DNREC.

<u>Public Acceptance</u> A final concern with regards to deep well injection is public acceptance. Even technically feasible and permitted, the injection of treated effluent below ground may generate a strong adverse reaction from the public.

6.9 PRELIMINARY DESIGN

This evaluation of underground injection as an effluent disposal alternative will be based upon using deep wells (Class I) located on the Thompson Island property. It is proposed to drill into the Waste Gate Formation that is a deep confined aquifer that is known to be contaminated with brine. Detailed design and permitting will require the installation of a test well. As the test well is being drilled, core samples and groundwater samples should be analyzed to determine if there are opportunities to develop an injection well at a shallower depth.

6.9.1 Design Criteria

The design criteria is based on the information presented in the Maryland Geological Survey Open File Report. Information regarding the porosity, permeability and compressibility of the aquifer were presented in the report as well as calculation of the allowable injection rate. The allowable injection rate is based on the minimum pressure at which hydraulic fracturing could occur. Hydraulic fracturing must be avoided in order to maintain the integrity of the confining aquifer and to avoid contamination of the aquifer above. The injection rate was based on the assumption that the injection zone in the aquifer was 75 feet thick. The aquifer itself is approximately 1,500 feet thick along the coast. However, the aquifer is comprised of sand seams interspaced with seams of shale and clayey material. For the purpose of this evaluation, it is assumed that each well would find at least two seams of sand such that the total length of injection zone per well would be 150 feet. Figure 6-6 illustrates the cross-section of the deep injection well.

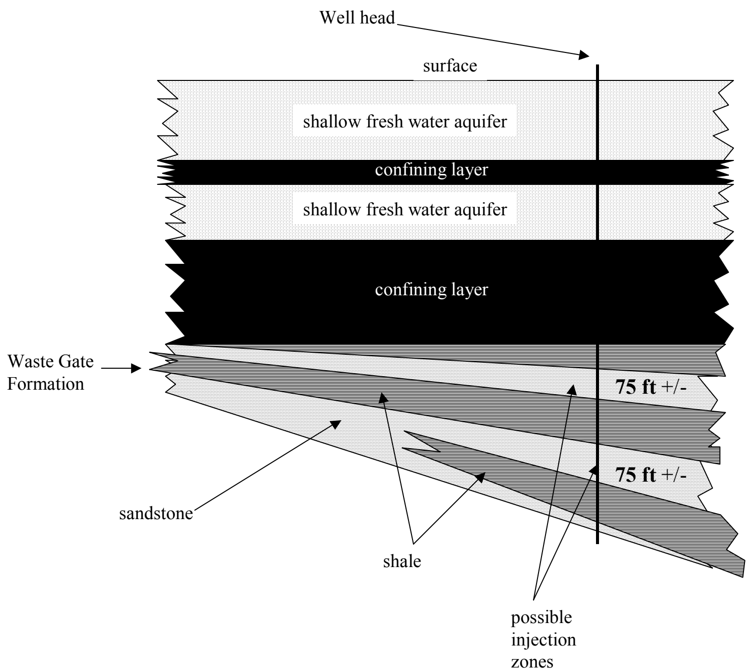


Figure 6-6: Deep Injection Well Cross-Section

The study estimated that the injection rate could be maintained at from 64 to 113 gpm per 75 foot well screen, depending on the location of the well. Thus, each well, with two 75 foot sand seams, could inject approximately 150 gpm. The data varied depending on the well site but this should be a conservative estimate of the injection rate. The actual design value cannot be determined until the test well(s) is/are completed.

6.9.2 Facility Design

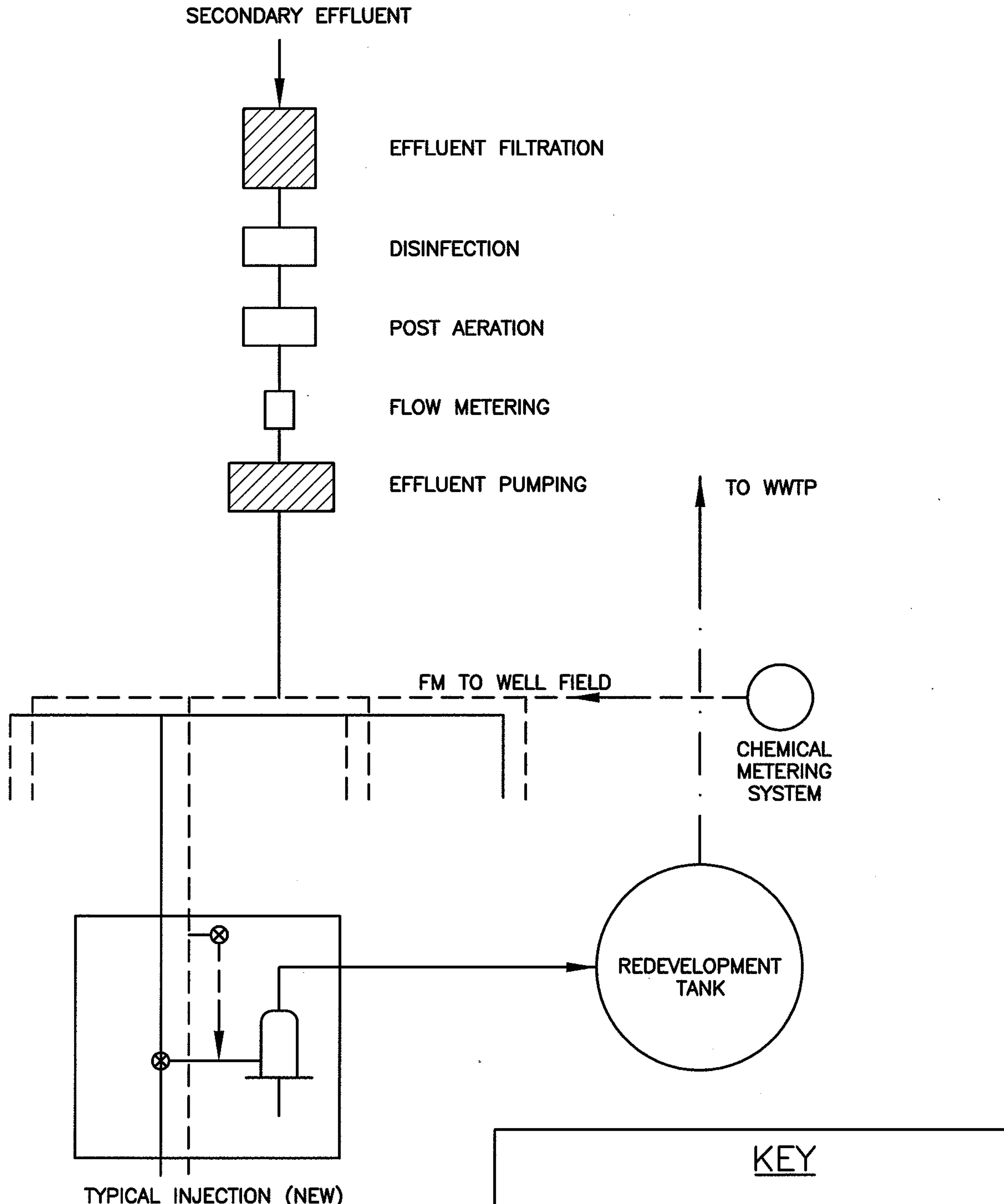
With a design injection rate of 150 gpm, a minimum of 16 wells are required to inject 3.4 mgd on an average daily basis. Providing another 20 – 25% standby capacity, to allow for well redevelopment, brings the total number of wells required to 20.

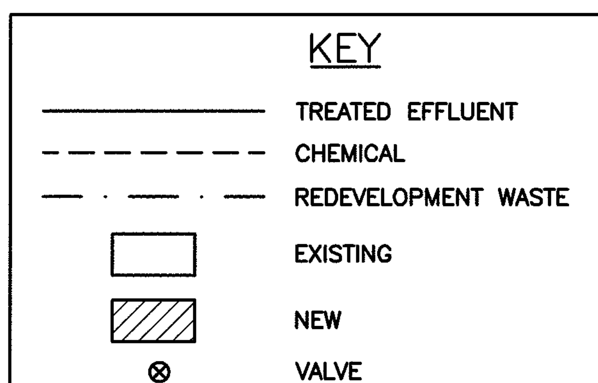
Well spacing is a function of the hydrogeology of the formation. For the purposes of this evaluation, it is assumed that the wells are spaced approximately 400 feet on center. A process schematic is shown in Figure 6-7 and a conceptual layout of the well field is shown in Figure 6-8.

Treated wastewater from the Rehoboth Beach WWTP would be pumped to the well field with low head variable speed pumps located in a new effluent pumping station. The effluent would be distributed by a piping manifold throughout the well field. The number of well pumps operating at any one time would depend on the actual wastewater flow rate which varies daily and seasonally.

To minimize the amount of clogging due to physical blinding of the well screen and formation around the well, it is proposed to add sand filters to the WWTP. The sand filters would replace the existing microscreens. However, as discussed previously, blinding, as evidenced by increased pressure build up on well head, will occur as a result of physical clogging, potential chemical reactions of the wastewater with the groundwater forming precipitates and the growth of biological slimes. As a result, redevelopment of the wells will occasionally be required. The additional well capacity is intended for this purpose. Redevelopment would typically involve the following operations:

- Pump from the well, using the injection pump, into a storage tank for one or two hours
- Inject a chlorine and an acid solution into the well
- Again pump from the well into the storage basin
- Repeat procedure several times
- Pump from redeveloped well into adjacent wells for several hours





PROPOSED DEEP WELL INJECTION PROCESS SCHEMATIC

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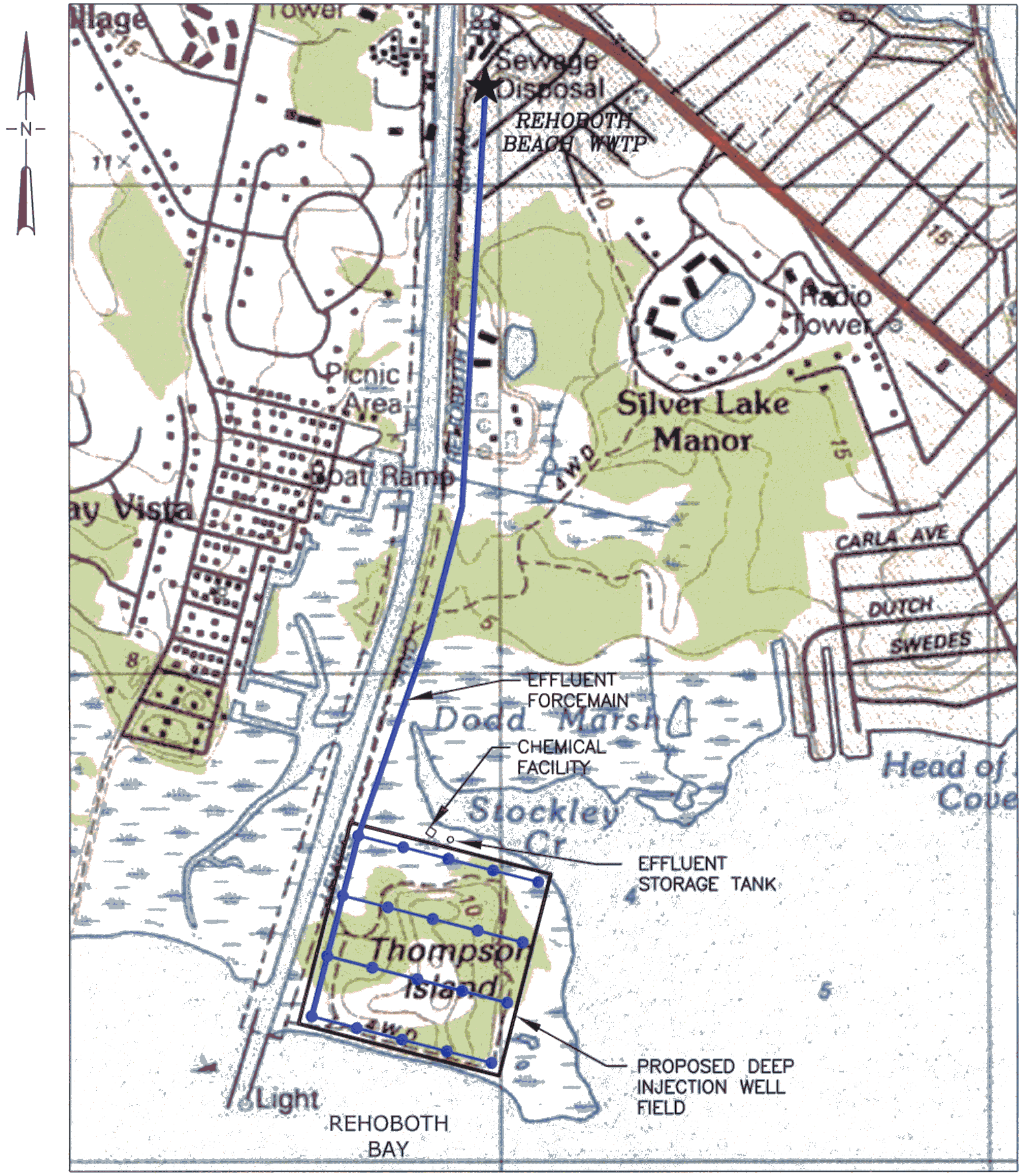
FIGURE 6–7
PROPOSED DEEP WELL INJECTION SCHEMATIC



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KEY

- ● DEEP INJECTION WELL
- ▬ EFFLUENT FORCEMAIN

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FIGURE 6–8
PROPOSED DEEP WELL INJECTION
SITE LAYOUT

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Since the WWTP is adjacent to the proposed well field, it is proposed to provide a small tank, with a minimum 6 hours holding capacity (approximately 1,000 gallons), for storage during well redevelopment. The waste could be neutralized if necessary and bled back into the influent of the wastewater treatment plant.

6.10 COST

The estimated capital cost for the required improvements at the WWTP and for the underground injection wells and appurtenances are shown in Table 6-1. Additional cost information is provided in Appendix E.

Table 6-1: Deep Injection Well Probable Construction Cost Estimate

Description	Cost
Rehoboth Beach WWTP - Effluent Filters	$2,680,000
Rehoboth Beach WWTP – Effluent Pump Station	$1,000,000
Chlorination System	$30,000
Force Main to Well Field	$1,090,000
6,000 ft Deep Injection Well (20 wells @ $4,000,000)	$80,000,000
Well Field Pipe Manifold	$760,000
Well Redevelopment	$410,000
Land Purchase Price(1)	$1,050,000
Construction Cost (Year 2004 Dollars)(2)	**$87,020,000**
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	**$25,800,000**
Total Project Cost	**$112,800,000**

Notes:
1. Land price estimate based on 42 acres @ $25,000 per acre
2. Cost includes 30 % contingency. No contingency on land purchase.

The estimated costs for the deep well injection system are extremely high. There are a number of reasons for this in addition to the anticipated depth of the wells. In the absence of good design data, several fairly conservative design criteria were set regarding the length of the injection zone and the injection rate. Most significant, however, is the cost of the drilling operation. Experience with typical municipal drinking water wells is not applicable. The technology to install the deep wells is similar to that used in the oil drilling industry and there are very few contractors on the east coast capable of performing this work.

6.11 IMPLEMENTATION PLAN

This section outlines the steps that would have to be completed if the City were to proceed with underground injection.

6.11.1 Well Field

Finalize site selection: The evaluation to date has assumed that the well field would be sited on the Thompson Island property. The availability of this site and the terms under which it could be made available form the state would have to be determined.

Permit to Construct: A permit application (Form UIC Application) would have to be completed and submitted for review to the Secretary of DNREC. The information required for the permit is extensive but would be based on the best available information available at the time. The initial well drilled would be the test well to obtain more accurate and detailed design information. If the test was successful, the test well could be developed into an operating injection well. Information that would be obtained from the test well includes geology of the injection zone and confining layers and the hydrogeology and water chemistry in the injection zone. The permit application requires a discussion of the construction and testing procedures to be implemented to insure the mechanical integrity of the well to prevent contamination, a proposed operating plan, a characterization of the treated effluent and contingency plans should problems arise. Mapping would be required to locate all existing wells in the area that could be potentially influenced by the proposed injection system. Maps of the vertical and lateral limits of all drinking water sources in the area and of the geology, would also be required.

Draft Permit: A draft permit would be issued by DNREC which would be subject to public comment. If requested, public hearings would be held.

Permit to Operate: Data from the test well would have to be submitted as well as documentation regarding the demonstration of mechanical integrity of the well and the compatibility of the injected wastewater effluent with the groundwater chemistry. The actual injection procedure would have to be provided and the status of all corrective action plans on any defective wells (if any) in the area would have to be provided.

6.11.2 Wastewater Treatment Plant Improvements

Improvements required at the WWTP include media filtration to filter the treated effluent and effluent pumping. The filtration system would replace the existing microscreens and is required to improve the solids removal performance in order to minimize the potential for blinding the well screens. The effluent pumping system would be a low head system to deliver treated effluent to the manifold distributing water to the individual high pressure well head pumps.

6.12 SUMMARY

Injection wells represent a mature technology and their viability has been adequately demonstrated in other applications around the country. However, every application is different in terms of receiving zone characteristics. Pilot borings to characterize the receiving zone and pilot test well(s) to characterize injection well performance would be needed to complete final design. Improvements at the existing wastewater treatment plant would be required including sand filtration and effluent pumping. Underground injection can be accomplished in an environmentally acceptable manner with negligible risk to surface water quality and minimal risk to potential underground drinking water supplies. Deep well injection, however, is expensive and significant investment is required before accurate design information can be determined and before the ability to obtain permit approval is known. Thus, it is a high risk, high cost alternative.

CHAPTER 7

OCEAN OUTFALL

7.1 DESCRIPTION

This method of effluent disposal is based on the discharge of the highly treated effluent wastewater into the ocean at a distance offshore and depth where the potential public health and environmental impacts are negligible. The initial dilution and dispersion of the treated effluent insures compliance with all water quality regulations and public health standards. Ocean outfalls have been used for many years, both locally and around the world, as a means to dispose of treated wastewater with an excellent record of protecting environmental resources and protecting public health. Public health is protected in several ways, including:

- <u>Advanced Treatment</u> A very high level of treatment is provided prior to discharge. It is anticipated that the same level of treatment provided by the South Coastal RWF, which discharges treated effluent through an ocean outfall off South Bethany in Delaware, will be required for the Rehoboth Beach WWTP. This discharge permit would require effluent filtration be provided to remove additional organics and nutrients and, as is the case with the existing system, a very high level of disinfection would be required.
- <u>Initial Dilution</u> The effluent is discharged through specially designed diffusers that promote the mixing and dilution of the treated effluent with the seawater. A very significant degree of dilution is achieved.
- <u>Farfield Dilution</u> After the initial mixing of the effluent plume with the seawater, the plume continues to mix and dissipate as it travels. The location of the diffuser is such that, even under the worst case operating conditions, the plume is so dilute that public health requirements are met and exceeded before the plume has any possibility of reaching the beach. In fact, in most cases, public health requirements are met at the initial zone of dilution.

The ocean outfall is the one alternative that is under consideration as both a regional solution and as a solution to serve just the City of Rehoboth Beach. Thus, the discussion that follows will present an evaluation of both alternatives.

Summary of Advantages/Disadvantages

Advantages

- Minimal operating requirements
- Minimal maintenance requirements
- No potential nutrient transport into Bay
- Perceived as ultimate solution
- Potential as a regional solution

Disadvantages

- Public acceptance may be difficult
- Permitting issues
- No groundwater recharge

7.2 PROPOSED LOCATION

At the beginning of the study, several alternative locations for the ocean outfall were considered. The locations were based on some earlier work that will be referred to as the LaCato Project. This project was comprised of a series of studies and reports that were completed in the 1970s in an effort to evaluate alternatives for the treatment and disposal of wastewater from a new proposed service area; the John M. LeCato Sanitary and Water District. The service area was generally along the Delaware shore in the vicinity of Cape Henlopen and Dewey Beach.

The LeCato study considered the following options:

1. Long Ocean Outfall – Located 7,000 feet off shore from Cape Henlopen Drive in approximately 60 feet of water. This placed the discharge point just outside or east of the Hen and Chicken Shoals.

2. Short Ocean Outfall – Located 4,200 feet off shore from the Fort Miles Naval Facility which is south of the Long Ocean Outfall location in approximately 35 feet of water. This placed the discharge point inside the southernmost portion of Hen and Chicken Shoals.

3. South Coastal Ocean Outfall – This was the existing ocean outfall near Bethany Beach that is located approximately 6,000 feet offshore in about 42 feet of water.

The dilution studies conducted during the LeCato study indicated that adequate dilution could be achieved at these locations. Thus, as an initial effort to locate the outfall, it was decided to evaluate an outfall located 6,000 feet offshore from the City of Rehoboth Beach. This was an obvious choice for the scenario where the outfall would serve only the City. An outfall located off of Cape Henlopen was also evaluated since it was possible that, for the Regional solution, this location would be more cost-effective considering all of the infrastructure required to pump the wastewater to the outfall. The initial dilution that could be achieved at these location was modeled as described in Section 7.3. In order to better understand the model results, several other scenarios were modeled including, for the Rehoboth Beach outfall, location of the diffuser 6,000 feet, 9,000 feet and 12,000 feet offshore. The purpose of this exercise was to determine if the greater distance provided any discernible benefits. Various diffuser designs were modeled to determine how sensitive the initial dilution was to the number of diffuser ports and the spacing of the ports.

The location of the alternative ocean outfall sites are shown in Figure 7-1 and are described in Table 7-1.

Table 7-1: Alternative Ocean Outfall Site Locations

Location	Coordinates	Application
Cape Henlopen	075º03.82'W 38º46.65'N	Regional
Rehoboth Beach	075º03.42'W 38º43.76'N	Rehoboth Beach and Regional

7.3 DISCHARGE PERMIT REQUIREMENTS

Even though the Rehoboth Beach WWTP is currently providing an advanced level of treatment including nutrient removal, it is expected that DNREC will impose discharge limits on an ocean discharge that are identical to the limits currently imposed on the South Coastal RWF that discharges through an ocean outfall located south of Bethany Beach, Delaware. The limits are summarized in Table 7-2.

Table 7-2: Anticipated NPDES Permit Limits for Ocean Discharge

Parameter	Permit Requirement	Unit	Basis
BOD_5	15	mg/L	Daily Average
TSS	15	mg/L	Daily Average
pH	6.0 – 9.0		

The existing Rehoboth Beach WWTP complies with the anticipated permit conditions. However, the existing plant relies on microscreens for removal of fine solids from the final effluent. The microscreens are quite old and are not a reliable process for permit compliance. It is recommended, therefore, that they be replaced with sand filters to improve performance and future reliability.

The Wolfe Neck RWF, owned by Sussex County would also have to comply with these discharge limits if the County participates in the use of the ocean outfall as a regional solution. The cost to upgrading the existing Wolfe Neck RWF, which is a lagoon treatment system with effluent disposal by land application, is significant.

7.4 DILUTION MODEL

7.4.1 Description of Modeling Effort

The modeling effort utilized two separate models to 1) identify the ambient conditions that most accurately reflect the current vectors (Current Model) and water column conditions in the vicinity of the outfall and 2) estimate the dilution that occurs over time and distance as the discharge plume travels away from the diffuser. The results of the model are used to determine if adequate dilution is achieved by the diffuser design and location to insure compliance with public health and water quality requirements.

7.4.1.1 Current Model

The modeling of the plume of water discharged from an ocean outfall diffuser is very complex. The plume will have a decreasing concentration as it moves away from the diffuser. The actual concentration is influenced by the discharge concentration and the downstream currents that vary over time, depth and horizontal location. Thus, an accurate understanding of the ambient current conditions is essential to the development of an accurate dilution model.

The model requires input regarding the ambient conditions in the ocean at the point of discharge and the effluent discharge and diffuser characteristics. As with any modeling effort, the better the input data, the more accurate the results. Recognizing that the model was sensitive to the assumptions made regarding the ambient conditions in the receiving waters, the University of Delaware, College of Marine Studies was contacted for advice and to provide input regarding the ocean currents in the area of the coast of Delaware. Dr. Richard Garvine with the College of Marine Studies, who is recognized as the expert in ocean currents off the coast of Delaware, was retained to provide the data for the model. Dr. Garvine has written a number of technical articles

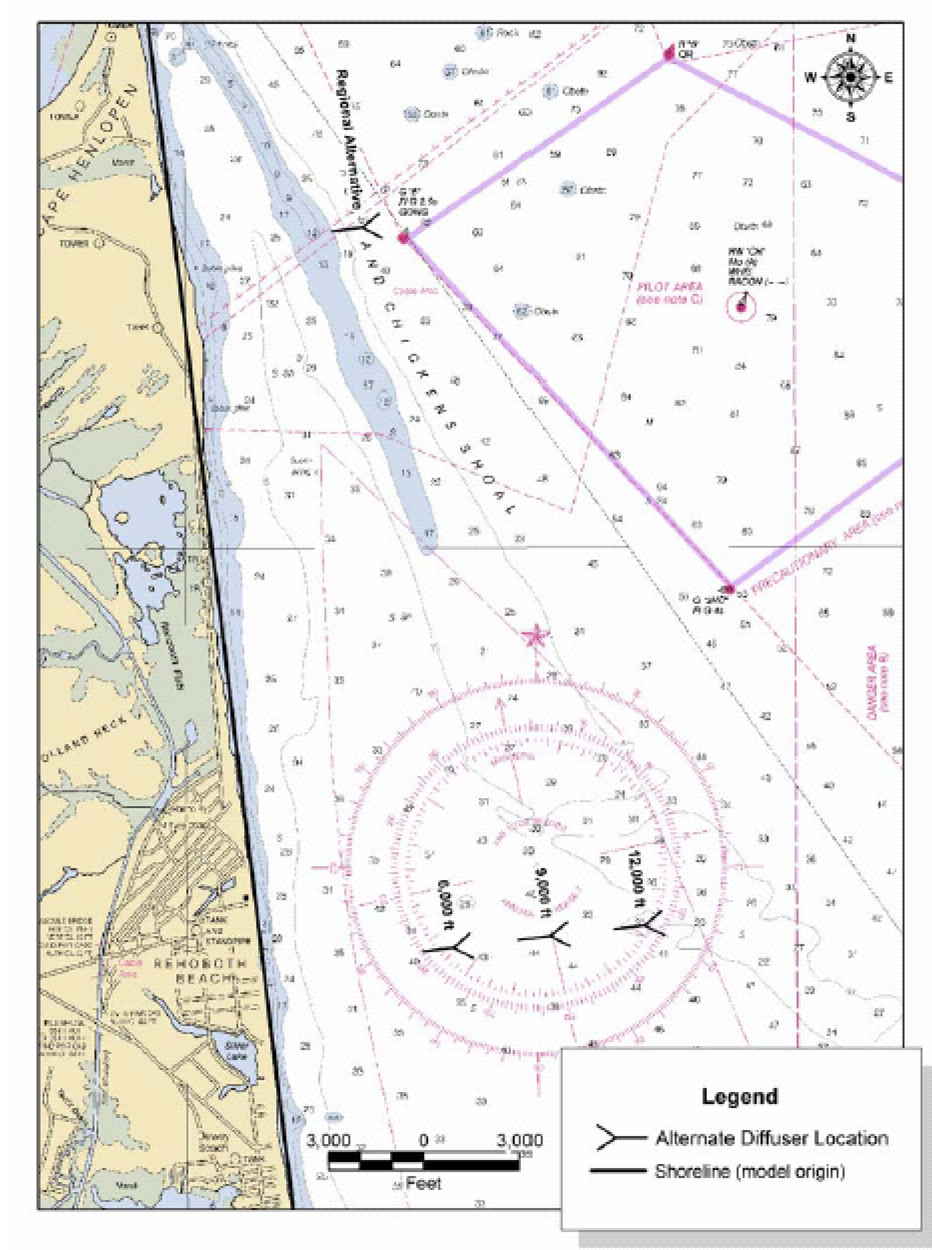


Figure 7-1: Outfall Locations

regarding the Delaware coastal currents and most recently was working as an advisor to Dr. Michael Whitney on his doctoral dissertation at the University of Delaware. The result of the dissertation was a very detailed and highly calibrated model of the Delaware Coastal Current. Given a location of a point off the coast of Delaware, the model can predict, with great accuracy, the current vector at different depths and times. The model is based on the ECOM3d model.

The model considers the dynamic and thermodynamic forces that influence current flow. The major driving forces include the tidal flow, surface winds, and the freshwater discharge from the Delaware Bay. The Delaware Bay current has a very strong influence on the current vector at any specific location in the study area.

The model predicts the current at a particular depth, horizontal location and time by adding together the vectors of the three major components that influence the observed current. The first component is the tidal current which is driven by astronomical forces at a frequency of one cycle per 12 hours (tidal frequency). It is generally uniform in depth and rectilinear in direction, meaning that it traverses back and forth along a line. In the model results, based on the coordinate system established in the report, a negative value implies an onshore current. The other forces are sub-tidal in frequency meaning that they occur at a frequency that is less than one cycle every 12 hours. This includes wind stress acting on the surface of the water and water density variations; the most prominent of which is the fresh water inflow from the Delaware Bay. A sample output of the model, showing the current direction and magnitude, is presented in Figure 7-2. A detailed report describing the model and the applicable results is provided in the Appendix.

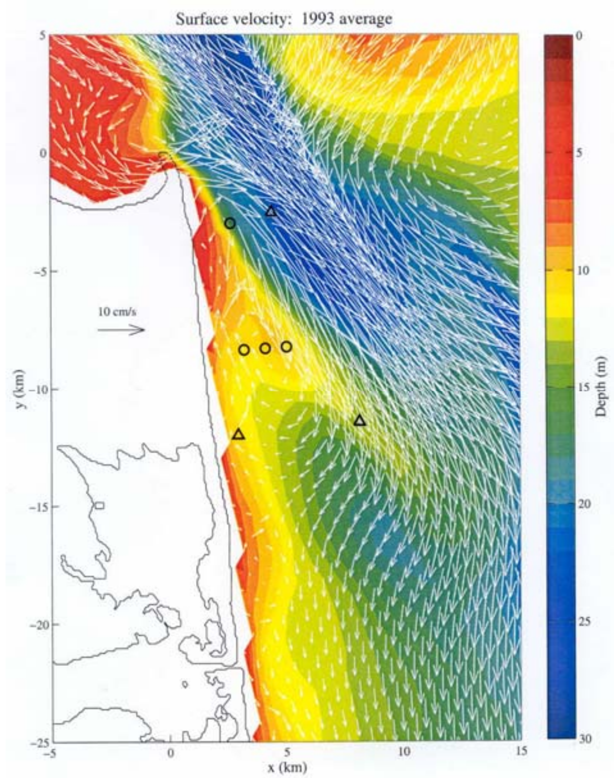


Figure 7-2: Sample Model Output of Current Direction and Magnitude

7.4.1.2 Dilution Model

The Cornell Mixing Zone Expert System (CORMIX-GI version 4.1 GT) model was used to evaluate the diffuser design and to estimate the amount of dilution that could be achieved under different operating conditions. This model is a well recognized model and is approved by EPA for plume modeling. The firm of Lawler, Matusky & Skelly was retained to conduct the modeling. They have specialized expertise in this area and extensive experience with the development and calibration of the CORMIX model.

The model requires the input of a preliminary diffuser design, a description of the effluent discharge characteristics and a description of the ambient conditions in the ocean. The key parameters associated with each of these model requirements are discussed below.

7.4.2 Diffuser Design

A preliminary design for a diffuser was developed for the outfall, based on generally accepted best practices for diffuser design. If an ocean outfall were to proceed to final design, the diffuser design would be refined to optimize its performance. A sensitivity analysis was performed on the preliminary diffuser design to determine the affect that several design parameters had on the dilution achieved. The results of this analysis are presented in Section 7.4.6: Modeling Results of the report. The basic design criteria for the preliminary design of the diffuser, however, is as follows:

- Selection of a Y-Type diffuser to accommodate expected widely varying flows
- Froude number greater than 1 to insure adequate mixing
- Nozzle exit velocity greater than 3 feet per second to avoid sedimentation
- Nozzle exit velocity less than 10 feet to avoid excessive head loss
- Riser spacing between 8 to 15 feet
- Riser spacing ratio (diffuser length / distance between risers) greater than 4
- Between 10 and 15 feet of diffuser length per mgd of flow

Table 7-3 summarizes the characteristics of the preliminary diffuser design for both the Regional and the Rehoboth only design alternatives. A schematic representation of the diffuser is shown in Figure 7-3.

Table 7-3: Preliminary Diffuser Designs for Rehoboth Beach Outfall

	Regional	Rehoboth Beach
Outfall		
Material	HDPE	HDPE
Diameter (in)	36	24
8-hr Peak Flow (mgd)	20.0	6.67
Diffuser		
Type	Y	Y
Length	184	120
Diameter	234	18
Riser		
Number	24	16
Length	1	1.5

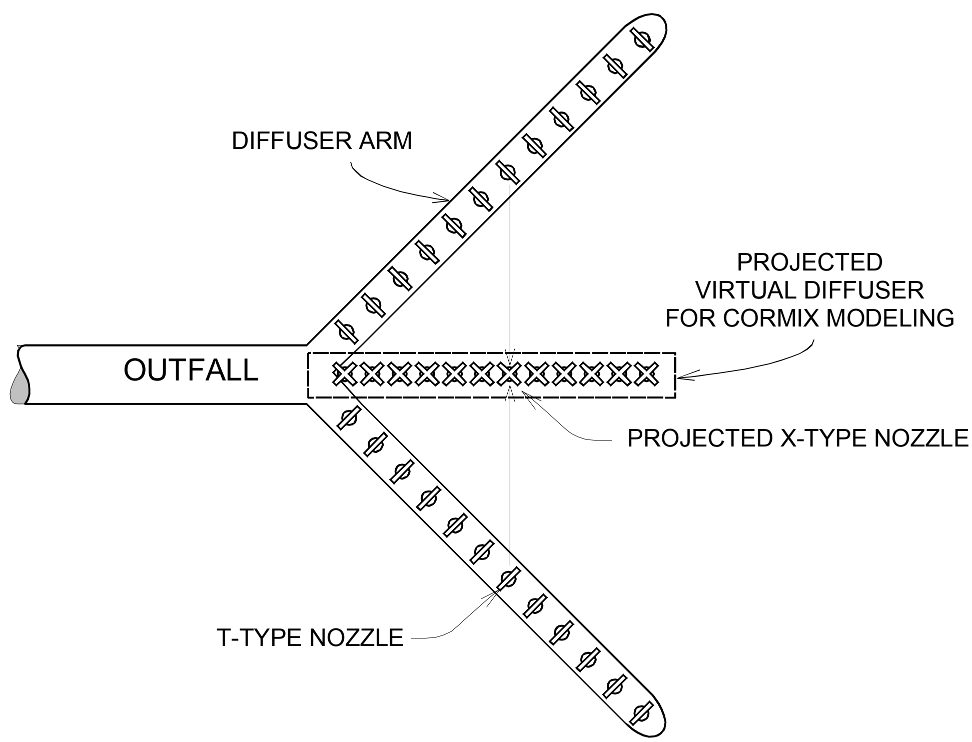


Figure 7-3: Example Diffuser Schematic Diagram

7.4.3 Discharge Characteristics

The average and peak flow rates used for the analysis are summarized in Table 7-4 below. Pollutants in the effluent were assumed to be conservative meaning that there were no biological or chemical processes occurring to transform or consume the pollutants. The only mechanism assumed for decreasing the concentration of a pollutant was through dilution. This assumption is conservative because it is likely that some decay of the organisms present in the effluent will occur. Since the model is primarily interested in the degree of dilution, the concentration of a pollutant was arbitrarily set to 100 mg/L; simply as a point of reference. Results are presented in terms of the dilution ratio achieved.

Table 7-4: Ocean Outfall Design Flow Rates

	Rehoboth Beach	Sussex County	Regional
Average Flow (MGD)	3.4	8.0	11.4
Peak Flow (MGD)	10.2	24.0	34.2

7.4.4 Ambient Conditions

As previously described, the ambient conditions that were selected for the model runs were based on Dr. Garvine's work. Using his current model, a database of parameters that describe the ambient conditions, at or near the outfall diffuser location, was developed. Some early field work of Dr. Garvine was used as the basis of the initial modeling efforts. However, as described in Section7.4.1.1, a more recently developed and field calibrated model of the ocean currents was used as a basis for the dilution modeling results presented in this report. The key parameters include the following:

Average Depth – The average depth is the depth of water that is typical of the body of water receiving the discharge, in the area that is expected to be occupied by the discharge plume.

Discharge Depth – The depth characteristic of the water body in the immediate vicinity of the diffuser. The outfall will be located at the bottom so the discharge depth is equal to the average depth.

Current Velocities – This is the average current speed in the vicinity of the diffuser for a specific current direction. In an effort to be conservative in terms of the conditions represented by the model, data from the summer months (May through September) were used and the velocity data with the greatest onshore component was selected from the monthly averages. Thus the worst-case scenario, with the largest onshore currents in the summer driving the plume, was selected as the basis of the model.

The current velocities and directions used in the model, for the different alternatives considered, are presented in Table 7-5. A graphical representation of the ambient velocity vectors is presented in Figure 7-4.

Table 7-5: Current Velocities and Directions Used in Model

Scenario	Alongshore (cm/s)				Offshore (cm/s)				Vector Sum	
	Tidal Amplitude		Subtidal	Total	Tidal Amplitude		Subtidal	Total	Mag.	Dir.
	Peak	Avg.	Avg.	Avg.	Peak	Avg.	Avg.	Avg.	cm/s	°True
Relocated Regional	-56.4	-37.5	-1.3	-38.8	-15.1	-9.9	-0.8	-10.7	**40.2**	**338**
Rehoboth (6,000 ft)	-44.1	-28.8	-4.4	-33.2	-1.8	-1.3	-1.3	-2.6	**33.3**	**349**
Rehoboth (9,000 ft)	-48.0	-32.6	-3.0	-35.6	-3.0	-2.1	-0.2	-2.3	**35.7**	**349**
Rehoboth (12,000 ft)	-49.6	-33.7	-0.7	-34.4	.0	2.7	1.3	4.0	**34.6**	**0**

Notes:

1. Negative offshore velocities are onshore. Direction is clockwise degrees from true north. Shoreline direction is approximately 353 degrees true north.

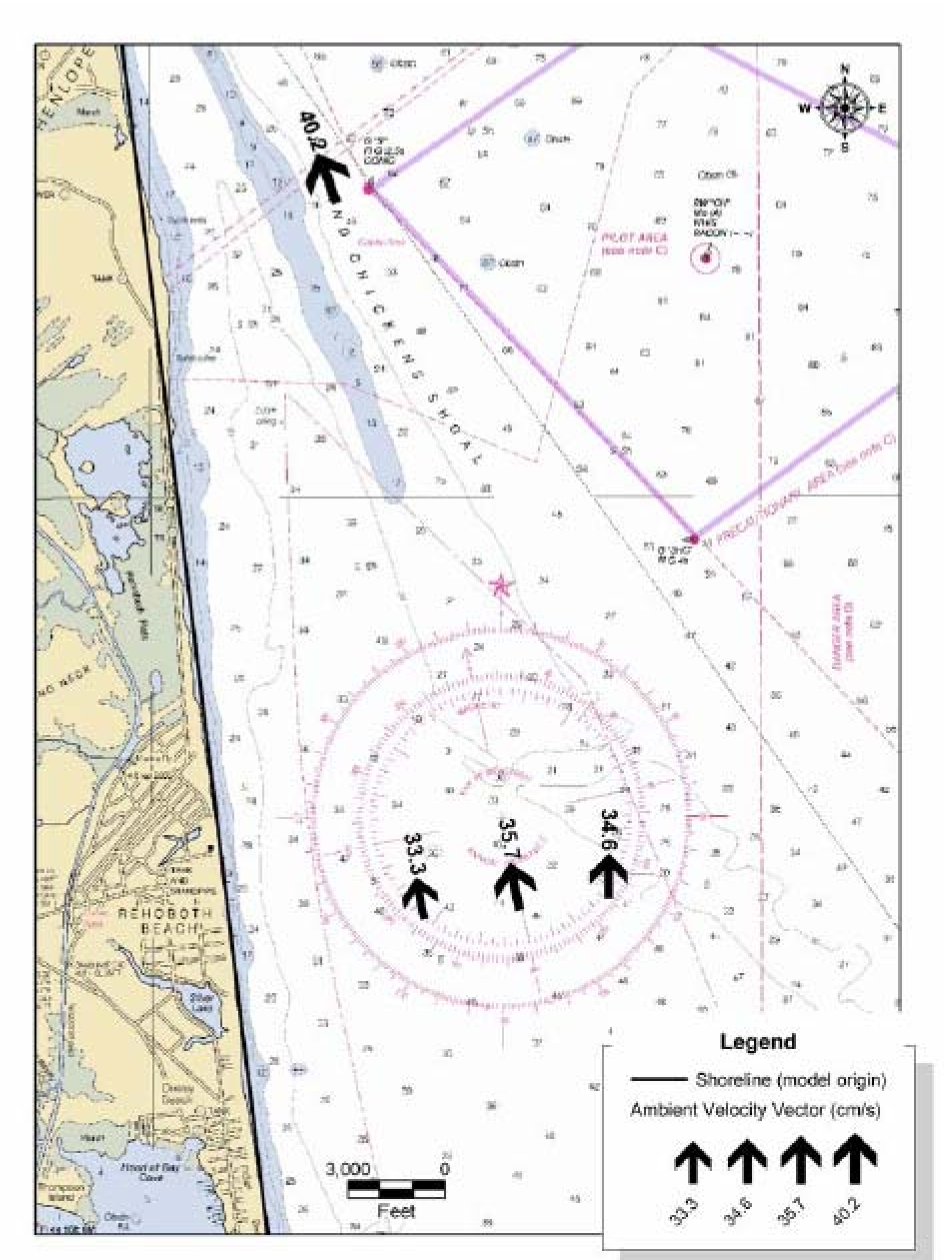


Figure 7-4: Ambient Velocity Vectors

7.4.5 Modeling Results

The results of the modeling effort are presented in tabular form as the distance down current, in feet, to achieve a dilution of 100:1 and as the time required to achieve that dilution, in minutes.

The results are also presented graphically on a bathymetric chart of the area showing the distance and direction of the plume to achieve the 100:1 dilution. The shorter the distance and time to achieve the dilution, the greater the mixing that is provided by the diffuser.

A dilution of 100:1 was selected as the benchmark because it is considered to be more than adequate to achieve water quality objectives in the ocean and to comply with standards of public health for swimming and contact recreation.

7.4.5.1 Rehoboth Beach Only

The model results for the Rehoboth Beach only flows are shown in Table 7-6 and Figure 7-5. The results indicate that the 100:1 dilution is achieved in less than 500 feet and in slightly more than 5 minutes. Also shown are the results of extending the outfall beyond the originally proposed 6,00 feet offshore to a location that is 9,000 and 12,000 feet offshore. The purpose of this exercise was to evaluate the potential benefit, in terms of the dilution achieved, by extending the outfall. The time and distance to the 100:1 dilution was essentially the same at all locations and thus there would no benefit gained by the additional construction cost and operating cost imposed by extending the outfall. While the extended outfall provides a greater distance between the shore and the diffuser for far-field dilution to continue, the distance is not required in light of the very effective mixing achieved at the 6,000 foot location.

Table 7-6: Rehoboth Beach - Distance and Time to Achieve 100:1 Dilution

Scenario	Downcurrent distance to 100:1 dilution (feet)	Time to 100:1 dilution (minutes)
6,000 ft offshore	415	5.4
9,000 ft offshore	432	5.4
12,000 ft offshore	420	5.3

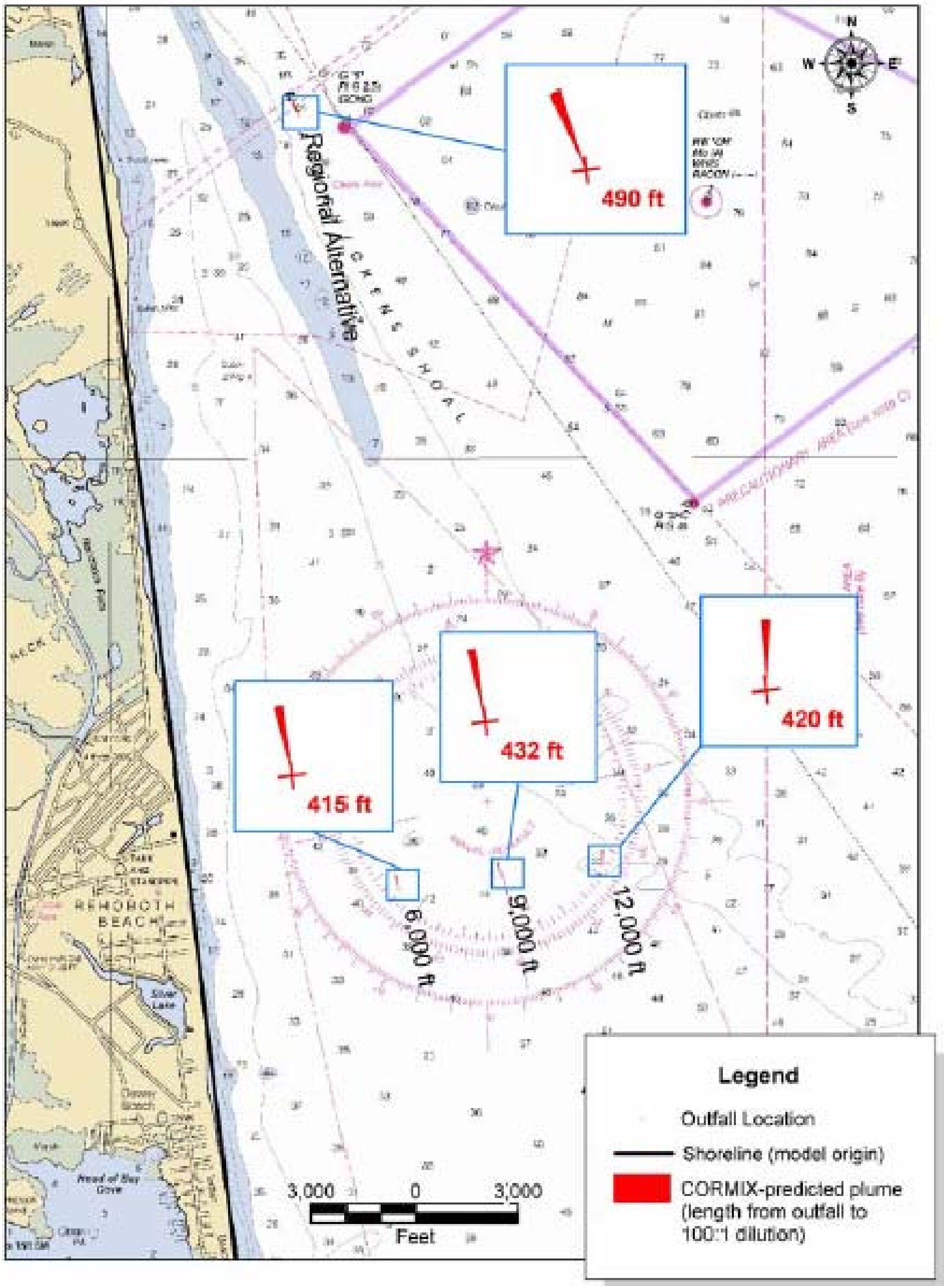


Figure 7-5 (LMS Figure 5): Rehoboth Beach - Plume Length to Achieve 100:1 Dilution

7.4.5.2 Regional Outfall

The model results for regional solution, in which the flows from Rehoboth Beach and Sussex County are combined, are shown in Table 7-7 and Figure 7-6. Recall that two locations were identified for potentially locating a regional outfall. One location is identical to the Rehoboth Beach only alternative and the second is located further north near Lewes. At the Rehoboth Beach location the time and distance required to achieve the 100:1 dilution increased to somewhat less than 11 minutes and 800 feet. This was due to the increased flow rate. The alternative location further north achieved the dilution in 5.5 minutes and slightly less than 500 feet. The Rehoboth Beach location, however, still provides extremely effective mixing with the regional flows considering that, after the plume has reached the 100:1 dilution point, the plume is still approximately one mile offshore.

Table 7-7: Regional Solution - Distance and Time to Achieve 100:1 Dilution

Scenario	Downcurrent distance to 100:1 dilution (feet)	Time to 100:1 dilution (minutes)
Relocated Regional Diffuser	490	5.5

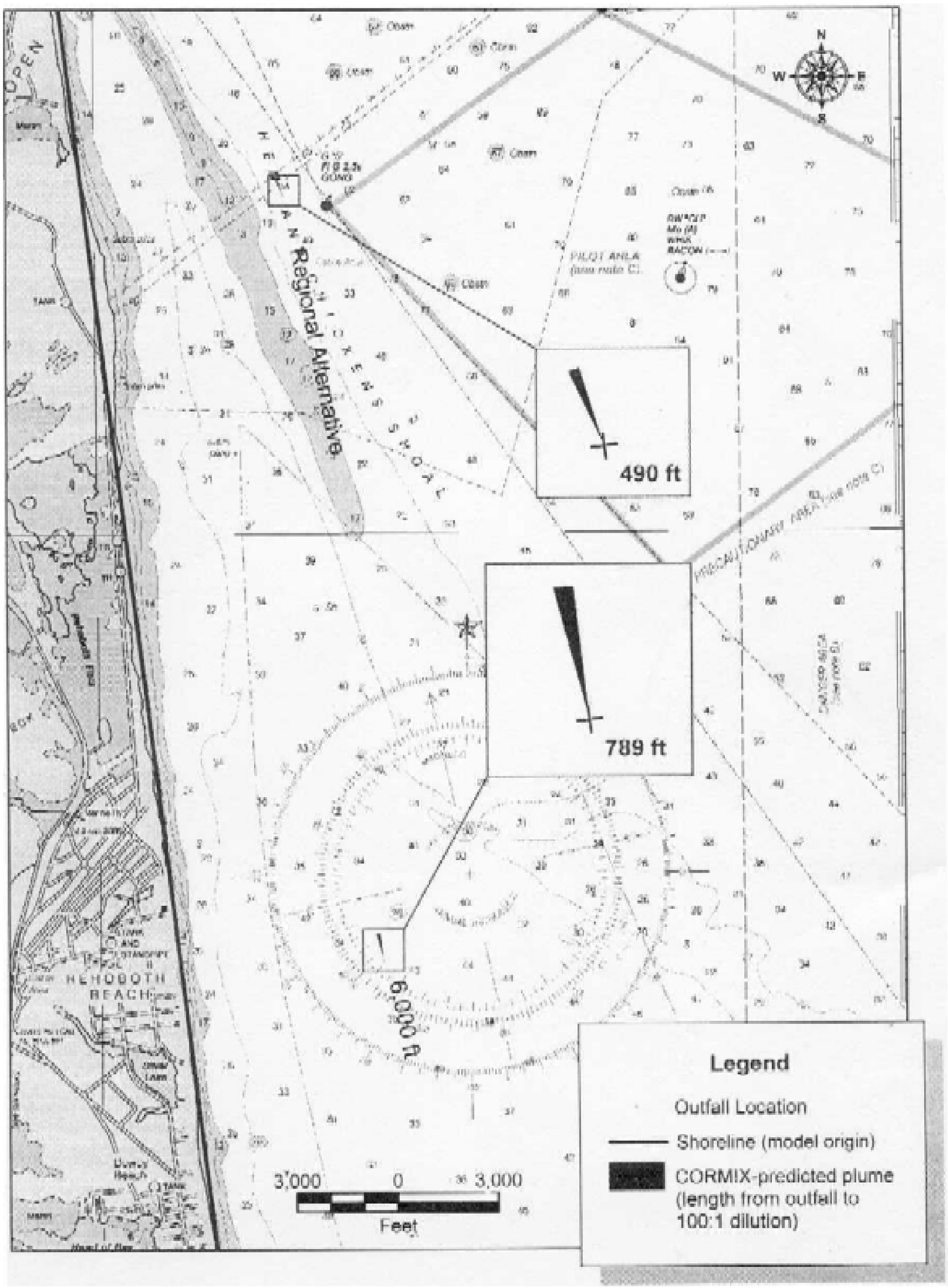


Figure 7-6: Regional Solution - Plume Length to Achieve 100:1 Dilution

7.4.6 Diffuser Sensitivity Analysis

The original diffuser design and the design which is the basis for all of the other model runs for the Rehoboth Beach and Regional flow scenarios, has the following characteristics:

Table 7-8: Original Diffuser Design

Number of Ports:	16
Diffuser Length:	120 feet
Port Spacing:	8 feet

In an effort to evaluate the potential benefits of varying the design, several types of modifications were made. The types of modifications made include first, holding the length of the diffuser constant (120 feet) while varying the number of ports and port spacing and second, to maintain a constant port spacing but vary the number of ports and the overall length of the diffuser. The various design conditions are summarized in Table 7-9. The results, presented in Table 7-9 and in Figures 7.7 and 7.8 for the Fixed Diffuser Length and Fixed Port Spacing Alternative, respectively, indicate that there is no significant improvement in dilution obtained by modifying either the port spacing or the number of ports. The results can not be compared to the results presented in the previous tables for the Rehoboth Beach only and the Regional flow alternatives because the model runs were based on a different set of ambient conditions. However, it is obvious from a comparison of the results in Table 7-9 that there is very little difference between any of the diffuser designs.

Table 7-9: Results of Diffuser Sensitivity Analysis

Set	Number of Ports	Time to Shoreline Intersection (hr)	Minimum Dilution at Shoreline*
Fixed Diffuser Length (120 ft)	12	13.5	69
	14	13.4	69
	16*	13.5	69
	18	13.5	70
Fixed Port Spacing (8 ft/port)	14	13.7	65
	16*	13.5	69
	18	13.2	74
	20	13.0	79

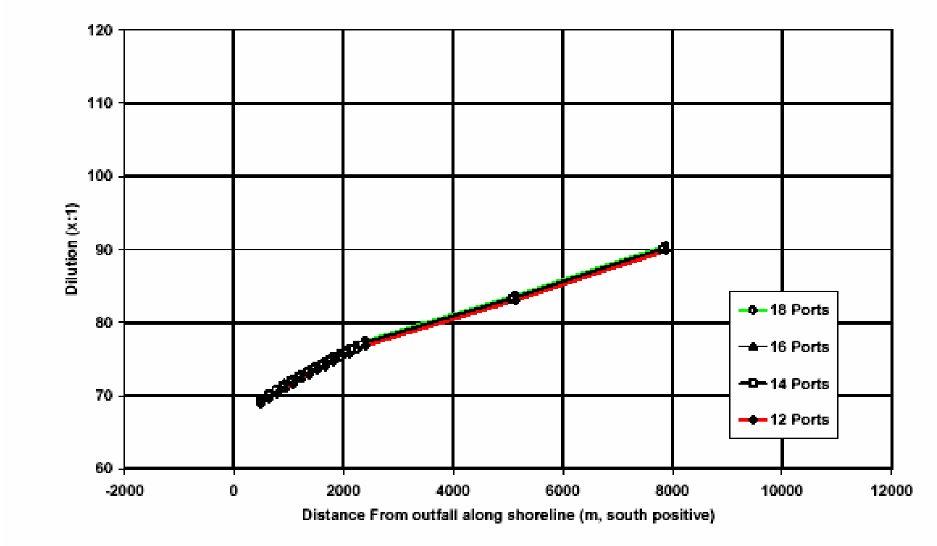


Figure 7-7: Fixed Diffuser Length Alternative

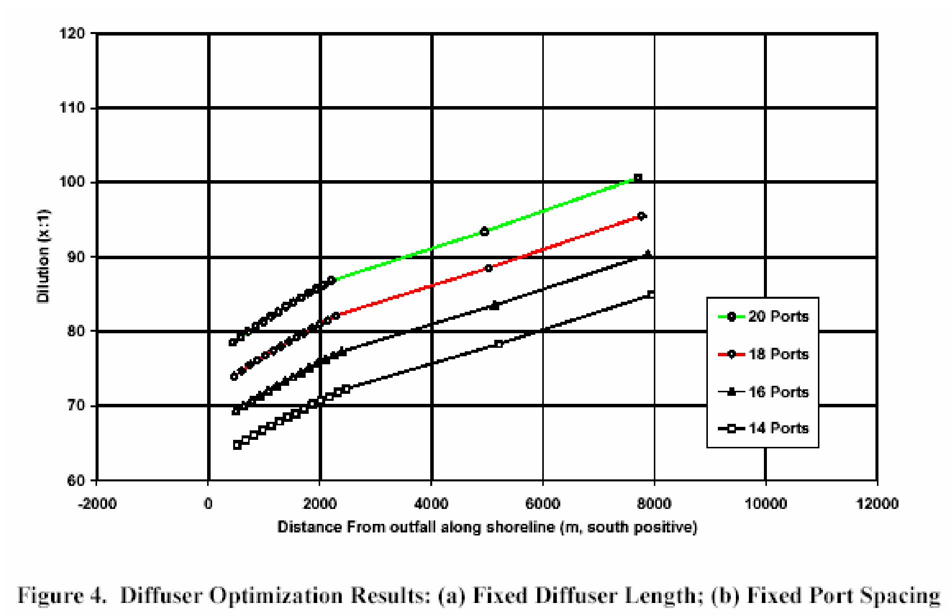


Figure 7-8: Fixed Port Spacing Alternative

7.4.7 Conclusions of the Model

Based on the results of the model, it can be concluded that the outfall and diffuser located 6,000 feet off of Rehoboth Beach, can provide adequate dilution for both the Rehoboth Beach only and the Regional flow scenarios. In fact, the effluent is diluted to the 100:1 level at a point where the plume is still over a mile from the shore. In addition, it is reported in the Garvine study that eddies and gyres around the diffuser location, induced primarily by the strong Delaware Bay currents, further disperse the effluent plume and limit its potential contact with the shore.

7.5 PRIOR EXPERIENCE WITH OCEAN OUTFALLS

Ocean outfalls have been used successfully for the disposal of treated wastewater effluent, from both industrial and municipal wastewater treatment facilities, for many years all around the world. Some of these facilities have provided only preliminary or primary treatment. In the United States, however, most facilities provide secondary treatment.

In Australia, where 80% of the population lives within 5 miles of the coast, there are 141 permitted ocean outfalls. There are 154 permitted ocean outfall discharges from wastewater treatment plants in the United States, on both the west coast, east coast and Hawaii. In the Boston area, one of the larger ocean outfalls discharges up to 500 mgd from the Deer Island WWTP into the Massachusetts Bay. In New Jersey there are 14 permitted outfalls from wastewater treatment plants along the states 127 miles of ocean shoreline. These plants discharge approximately 170 mgd of treated effluent.

The two outfalls closest to the study area are located off the coasts of Bethany Beach, Delaware and Ocean City, Maryland. The Ocean City outfall has been in continuous operation since February 1970. It is located approximately 4,600 feet offshore in water 30 feet deep and has a permitted capacity of 32 mgd. The outfall in Bethany Beach serves the South Coastal Regional Wastewater Facility and has a permitted capacity of 22 mgd (peak flow). It is located 6,000 feet offshore in water 40 feet deep.

EPA conducted a study of the coastal reach between the two outfall locations with the objective of assessing the impact of the outfalls on the water resources. The benthic fish and macroinvertebrate communities were surveyed as a measure of the impact. Analysis of the fish data indicated no significant differences between stations located near or distant from the outfalls. The benthic macroinvertebrate communities showed a trend toward an increasing number of organisms present near the outfall with a decreasing diversity of species during the summer. In the winter, there apparently was no significant difference. Routine water quality and sediment investigations at the outfall sites, and at sites in between, did not detect any changes.

Beaches used for public recreation are monitored to insure that the water quality meets public health requirements with regards to bacteria levels. DNREC routinely monitors its Delaware Bay, freshwater and Atlantic Coastal beaches for enterococcus levels. In 2002 there were several closures at a few Delaware Bay beaches and a few of the freshwater beaches due to bacterial contamination. However, there were no closures of any of the Atlantic Coastal beaches. This includes the beaches in the vicinity of the ocean outfall near Bethany Beach.

In almost all cases, elevated bacteria levels at beaches are associated with stormwater run-off; either as a non-point source or as a point source discharged into the ocean through a storm water outfall. The association of bacteria with higher levels of rainfall is so strong in many cases that, at some beaches health agencies have established a policy of issuing a preemptive advisory regarding potential contamination following a rainfall of a specified magnitude. It can take 24-hours to receive the results of a water quality sample for bacterial contamination. The assumption is that, if the rainfall is significant, then stormwater will contaminate the water; therefore it is prudent not to wait for the sample results.

7.6 ENVIRONMENTAL IMPACTS

The potential environmental impacts may be broadly classified into the following categories:

- Water quality
  - Human Health
  - Aquatic Life
- Biological
  - Benthic Organisms
  - Fisheries

- Physical
- Cultural

The potential impacts may be positive or negative and either short-term or long-term. Also, the potential impacts during construction and operation will differ. The discussion of environmental issues that follows is based on studies completed for other projects that were related either by geographic proximity or that are similar in terms of the type of construction proposed and on discussions with Federal and state regulatory agencies.

One particularly useful source of information was an Environmental Impact Assessment completed in February 2003, conducted by the USCOE, Philadelphia District for a beach replenishment project for Rehoboth Beach and Dewey Beach.

7.6.1 Water Quality Impacts

The most critical issue regarding water quality is to maintain compliance with the water quality criteria that is designated by EPA and DNREC to protect aquatic and human health. The standards are specified in the State of Delaware Surface Water Quality Standards as amended July 11, 2004. Delaware's 2002 305(b) report indicates that all assessed coastal waters fully support both swimming and aquatic life.

7.6.2 Human Health

EPA amended the federal Clean Waters Act in October, 2000 through the passage pf the *Beaches Environmental Assessment and Coastal Health Act* (Beach Act). This act recommended revisions to the bacterial water quality standards which were believed to better protect public health. DNREC has adopted these standards which are more stringent than the previous standards.

The applicable standard, which is summarized below, is for Primary Contact Recreation Marine Waters. The standard is based on enterococcus colonies which is a more reliable indicator of the risk of gastroenteritis illness than other types of bacterial indicator organisms. Table 7-10 summarizes the bacterialogical growth limits.

Table 7-10: Primary Contact Recreation Marine Waters Bacteria Growth Limits

	Single-Sample Value	Geometric Mean
No.of Enterococcus Colonies per 100 ml	104	35

Delaware has an excellent record of compliance with the standards at its Atlantic Ocean beaches. As reported in the annual Natural Resources Defense Council (NRDC) report "Testing the Waters, A Guide to Water Quality at Vacation Beaches" (August 2003), there were no beach closing or advisories at these ocean beaches although there were several associated with the Delaware Bay and freshwater beaches.

The greatest risk to the coastal beaches is associated with stormwater runoff. DNREC has determined that the stormwater resulting from significant rainfall events could potentially pose a health risk. In Rehoboth Beach there are several stormwater outfall pipes discharging in the vicinity of the beach. Because of the delay between sampling for bacterial contamination and the receipt of results, generally 24 hours, it is deemed prudent to base the assessment of risk on the severity of the rainfall event. The assumption is that a rainfall over a predetermined intensity has a significant potential to carry bacterial contamination from surface water runoff into the ocean. This is referred to as a preemptive water quality advisory standard and is not uncommon for coastal beaches, especially near urban or highly developed areas.

The Surface Water Quality Standards also impose limits for pollutants that have been identified as potential carcinogens. The compounds are not likely to be in the Rehoboth Beach effluent because the wastewater has no industrial contribution. Also, the plant is currently in compliance with all the criterion at its existing discharge location.

7.6.2.1 Potential Impact

The effluent from the Rehoboth Beach Wastewater Treatment Plant will be a highly treated effluent with advanced treatment processes in place to remove nutrients, additional solids and to provide a very high degree of disinfection. The discharge permit that is anticipated to apply to an ocean discharge will apply even higher standards and require a greater degree of solids removal from the effluent. This is based on the discharge permit currently applied to the South Coastal WWTP which discharges treated effluent through an ocean outfall located in the vicinity of Bethany Beach. Compliance with this standard would require the replacement of the microscreen system at the Rehoboth Beach WWTP with new effluent sand filters. The Rehoboth Beach WWTP currently utilizes a chlorine disinfection system to comply with its very stringent bacterial standard that is based on the protection of shellfish waters. The current standard is 10 colonies per 100 ml enterococcus and the treatment plant routinely produces an effluent with either no enterococcus or levels of 1 to 2 colonies per 100 ml. Thus, even without the dilution provided by the diffuser, the effluent complies with the applicable bacterial standard for primary contact recreational marine waters.

However, the assessment of potential impacts should reasonably consider a worst-case scenario. As described previously, the ambient conditions considered by the dilution model already has a worst case scenario built into its assumptions, since the current vectors used are the vectors which have the greatest onshore component during the summer season. The worst case scenario that could possibly be experienced at the wastewater treatment plant, would be a failure of both the normal power and the emergency backup power. If this were to happen, the efficiency of the biological treatment processes would be greatly reduced since blowers providing air to the process would not be operable. The treatment plant would essentially function as a primary plant in which the aeration basins and clarifiers become settling basins. In this case, the effluent characteristics that would be expected are equivalent to primary effluent. It should be noted however, that even this worst case scenario is extremely unlikely because, in the event of a power failure, the effluent pumps required to discharge the effluent through the ocean outfall would not be operable and thus there would be no effluent. The disinfection system is provided with backup systems for reliability but even if they were inoperable, a manual system for metering chlorine into the effluent could be utilized.

7.6.3 Aquatic Life

The water quality standards to protect aquatic life focus on the prevention of acute and chronic toxicity. Concentration limits are placed on a number of metals, organic compounds and inorganic compounds. The compounds are not suspected to be present in the Rehoboth Beach WWTP effluent. The wastewater treated at the plant is almost entirely domestic with some light commercial wastes such as from restaurants. One exception is chlorine which is used for disinfection. However, a dechlorination system is in-place at the treatment plant that effectively removes all of the chlorine prior to discharge.

The NPDES permit for the Rehoboth Beach WWTP requires the plant to conduct a chronic biomonitoring test on their effluent annually. The test procedures are outlined in the "Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms" (EPA-821-R-02-014). The treatment plant has never failed a toxicity test and there is no reason to suspect that they would be at risk to fail a biomonitoring test.

7.6.4 Biological

7.6.4.1 Benthic Organisms

Several previous benthic studies have been conducted in the Hen and Chicken Shoals area. These investigations have identified a number of species, the most abundant of which were several amphipods, an isopod, surfclam, dwarf tellin clam and the redlined polychaeate worm. However, in general, the Hen and Chicken Shoals is relatively low in abundance and diversity of benthic species. This is likely due to the nature of the ocean bottom in the area whish is described as homogeneous with little surficial biological activity. In the intertidal zone, which is very dynamic due to wave action and shifting sands, species identified include the mole crab, coquina clam haustorid, amphipod and spionid worm. In the nearshore zone, the biological diversity increases as the water deepens.

Impacts on the benthos in the intertidal and nearshore zone would be limited to the activities associated with construction of the outfall which could disturb approximately 4 acres of seafloor during the dredging and backfill operations to install the pipe. The impacts are expected to be minor and short–term. Recolonization by benthic organisms would occur rapidly after the initial disturbance.

7.6.4.2 Fisheries

Shellfish

Surveys of shellfish in the Hen and Chicken Shoals area found the presence of the Atlantic surfclam but in relatively low densities compared to other areas surveyed off the coast.

Finfish

Finfish found along the Delaware Atlantic coast are primarily seasonal migrants that, in the winter tend to be sparse because they leave the area for the warmer waters further south. In the summer, they are more abundant and are attracted to local estuaries for spawning and nursing. An investigation by Wirth (2001) identified 75 species of finfish throughout the sampling period; 55 of which were found in every season. In the winter there were 20 different species, in the spring there were 29 species and in the summer there were 36 different species collected. Overall, the most abundant species were the clearnose skate, bay anchovy, summer flounder and black sea bass.

The Magnuson-Stevens Fishery Conservation and Management Act of 1996, as amended by the Sustainable Fisheries Act, established specific areas designated as Essential Fish Habitat (EFH) for the protection of specific species of federally managed fish. The Hen and Chicken shoals are located in an EFH in which several species are identified as requiring Fishing Management Plans. Of particular concern is the habitat for the sandbar shark. However, there are no known Federal or state listed threatened or endangered species in the affected area.

The potential impacts are again those associated with construction of the outfall pipe. The potential risks include physical injury either directly by physical contact or indirectly by disrupting the food resources. It is also possible that dredging for the pipeline could temporarily increase turbidity. However, these impacts are expected to be minimal because the benthic organisms are expected to recover quickly.

The type of dredge equipment used and the time of dredging could perhaps be restricted to minimize potential impact on sea turtles and other marine life.

7.6.5 Physical

Sediments in the Hen and Chicken Shoal area are comprised mostly of sand or coarser-grained materials. The coarser grained materials tend to be on the surface. The Total Organic Carbon (TOC) content comprised a small portion of the sediments. Core samples indicate a strata consisting of primarily granular materials (fine and medium sands with trace gravels) and trace amounts of fine-grained materials (silts and clays).

Dredging to install the outfall pipe would have only temporary impacts on the physical environment because the seabed contours would be restored to their original configuration after backfilling. Thus there will be no effects on the near shore wave patterns or sedimentation patterns. The diffuser section of the outfall will be located at or slightly above grade.

A potential hazard exists during the dredging operation due to the previous use of portions of the area for artillery practice. The former Army base at Fort Miles used an area known as the North Firing Range for weapons training and a portion of Hen and Chicken Shoals lies within the northern edge of this range that was abandoned in the 1950's. The USCOE has developed guidance documents (ETL-385-1-1) to minimize the hazards associated with uncovering unexploded ordinance. The plan requires the fitting of a bar screen on the dredge intake and the completion of a magnetometer survey prior to mobilization.

The Delaware Reef Program has established a number of artificial reefs in the Delaware Bay and off the Atlantic coast for the purpose of creating a suitable habitat for an invertebrate community and reef fish that would feed on them. The sites however are not located in the immediate vicinity of the proposed outfall or diffuser.

7.6.6 Cultural

Previous archaeological and cultural resource surveys have been conducted along the Delaware Atlantic coast and have identified a few potential sites of shipwrecks. No potential sites along the proposed alignment of the ocean outfall, however, are known to exist.

7.7 REGULATORY GUIDELINES

The construction of an ocean outfall would require coordination with a number of Federal and State regulatory agencies with different interests and authorities in the review and approval of the project. The following is a summary of the agencies that would be involved and a brief summary of their roles.

7.7.1 Federal Regulatory Impacts

- **US Corps of Engineers (USCOE)**
  The USCOE has review and permit authority that derives from several statutes as described below. The Philadelphia District of the USCOE has jurisdiction for projects in Delaware.

- **Clean Water Act** (Section 404)
  This act established a program to regulate the discharge of dredged and fill materials into the waters of the United States, including wetlands. Permission to proceed with a project involving dredging requires that the permitee document the fact that other alternatives that are less stressful to the environment are not available or practical. The project must avoid or minimize impacts to wetlands and mitigate any impacts that are unavoidable.

- **Marine Protection, Research and Sanctuaries Act** (33USC 1413, Section 103)
  This act is concerned with the ocean discharge of any material that could potentially affect human health. The discharge of sewage sludge was prohibited by amendment to this act. The discharge of treated wastewater is governed, however, by the National Pollutant Discharge Elimination System (NPDES) that is administered by DNREC under the authority of EPA.

- **Rivers and Harbors Act** (33 USC 403, Section 10)
  USCOE approval required for excavation or fill within navigable waters which includes all ocean waters seaward from the coast line for a distance of 3 nautical miles. This legislation also grants the US Fish and Wildlife Service review authority.

The permit process involves filing for a Nationwide Permit (NP-7). If the potential environmental impacts; however, are considered significant, then an Individual Permit (IP-7) will be required. An IP requires additional site and project specific assessment of the potential impacts. During the review process, USCOE coordinates with a number of other federal and state agencies and involves the public through a series of public hearings.

- **Environmental Protection Agency (EPA)**
  - **National Pollutant Discharge Elimination System**
    Section 402 of the Clean Water Act (CWA), established the National Pollutant Discharge Elimination System (NPDES) permit program. Authority to administer the program has been delegated to DNREC and it will be discussed in that context.

    Section 403 of the CWA imposes additional requirements on the issuance of NPDES permits for the discharge of municipal waste to the territorial sea. These requirements are referred to as the Ocean Discharge Criteria. The objective of these requirements is to protect marine resources and prevent unreasonable degradation of the marine environment.

Parallel legislative authority may be found in the Code of Federal Regulations 40 CFR Part 125.

- **Beach Act**

  In October, 2000, the CWA was amended by the Beaches Environmental Assessment and Coastal Health Act (the Beach Act). This act required the states to submit new and revised water quality criteria for their coastal recreational waters. The new standards focused on minimizing the risk to human health of exposure to pathogens. Delaware is in full compliance with this act.

  The legislation also established requirements for monitoring their beaches and provided grant money to establish a monitoring program. Requirements for monitoring and for public health notification were established by the National Beach Guidance and Performance Criteria for Recreational Waters.

- **US Fish & Wildlife**

  The mission of the US Fish & Wildlife Service (USFWS) is to conserve and protect our nation's fish, wildlife and plants and their habitats. There are a number of federal laws that involve the USFWS in the review and permitting process. The most relevant legislation, however, includes:

  - **Endangered Species Act of 1973**

    This act, as amended, authorizes the USFWS to list species as endangered and threatened and to establish programs to protect them.

  - **Fish and Wildlife Act of 1956**

    This act requires the agency to properly manage our marine fisheries, which includes shellfish, and to develop measures to protect them.

- **US Marine Fisheries**

  The National Marine Fisheries or NOAA Fisheries is a division of the Department of Commerce. It is responsible for managing the nation's living marine resources within the United States Exclusive Economic Zone which extends form 3 miles to 200 miles offshore. It also plays an advisory role to the states in the coastal areas. Its authority derives from a number of regulations including the Magnuson-Stevens Act and the Endangered Species Act.

  The Magnuson Fisheries Conservation and Management Act (1996) established regional fishery management councils. The Mid-Atlantic Fishery Management Council (MAFMC) is responsible for the fisheries in the area of interest to this project. Although there are no endangered species in the area, the MAFMC has identified the Hen and Chicken Shoals area as Essential Fish Habitat for several species. The primary concern appears to be for the sandbar shark, which may utilize the shoals as a nursery area, and possibly for a species of sea turtle. However, it is believed that these concerns can be alleviated through proper specification of the construction techniques and scheduling of construction during specific seasons. For example, hopper dredging may be harmful to the sea turtle but mechanical or hydraulic dredging is acceptable.

7.7.2 State Regulatory Issues

7.7.2.1 DNREC

The Water Resources Division, Surface Water Discharge Section of DNREC manages the state's NPDES permit program under the authority of the federal Clean Water Act (Section 402) and the Delaware Code of Law (Title7, Part VII, Chapter 60). The discharge permit conditions expected for the proposed ocean discharge are the same as imposed on the South Coastal Wastewater Treatment Facility which discharges off the coast of Bethany Beach. These permit conditions are described in Section 7-4.

Prior to the construction of any new facilities, a Permit to Construct will be required from DNREC.

7.7.2.2 Coastal Zone Management

The Coastal Zone Management Program was authorized by the Coastal Zone Management Act of 1972. At the federal level, it is administered by the Coastal Programs Division within the National Oceanic and Atmospheric Administration (NOAA). The program is a federal-state partnership designed to manage the nation's coastal resources. However, on a day-to-day basis, the program is administered at the state level; in this case by the Delaware Coastal Management Program (DCMP). The DCMP resides within the Division of Soil and Water Conservation in DNREC.

The Division administers the requirements of the following legislation:

- **Coastal Zone Act**
  Permit application must be made to DNREC for approval to construct. The application includes an environmental impact statement. The project is reviewed for consistency with the state's goals and objectives for the coastal zone.

- **Beach Preservation Act**
  The purpose of these regulations is to "enhance, protect and preserve public and private beaches…". Approval is required by the Division for the construction of any pipelines seaward of the building line. The primary concerns that must be addressed include such factors as the affect of the proposed project on beach erosion and protection from storm damage.

- **Underwater Lands Act**
  A subaqueous land permit is required from the DNREC Division of Water Quality, Wetlands and Subaqueous Lands Section. The permit is for a 20 year period and covers

the pipeline from the point where it is at the mean low water level to 3-miles out in the ocean.

- **Wetlands Act**

  The protection of tidal and non-tidal wetlands is under the jurisdiction of the Wetlands and Subaqueous Lands Section of DNREC. Permit application and approval is required prior to construction. Approval is required for construction at the outfall site and along the route of the forcemain that conveys the effluent to the outfall. Based on the proposed alignment of the pipe and preliminary discussions at a Joint Permit Processing Meeting, there are not expected to be any wetlands impacts.

7.7.2.3 Delaware State Historic Preservation

The Delaware State Historic preservation Office is part of the Division of Historical and Cultural Affairs. The agency is charged with the responsibility of protecting properties of historical significance which would include shipwrecks of the Delaware coast. The area of concern includes all areas along the alignment of the force main and outfall that could potentially be disturbed during construction.

7.7.2.4 Soil & Water Conservation

Prior to construction of the project, the Division of Soil and Water Conservation must issue a Sediment Control and Stormwater Management Permit.

7.7.3 Sussex County

7.7.3.1 Sediment & Erosion Control

Prior to construction of any new treatment of conveyance facilities, a sediment and erosion control permit will be required form Sussex County

7.8 ADDITIONAL INFORMATION AND STUDY REQUIRED

If the ocean outfall is selected as the preferred alternative and the project proceeds to the permitting and design phase, then additional information will be required to support the permit applications and to refine the design of the outfall pipe and diffuser. The information required is summarized in this section.

- **Bathymetric Survey**
  Depth profiles along the alignment of the outfall and diffuser are required. The depth variations that occur seasonally must also be recorded to gain an understanding of how dynamic is the sea floor. This information will assist in the design of the pipe bedding and depth of burial and the elevation to set the diffuser.

- **Sub-bottom Seismic Survey**
  A seismic profile along the alignment of the outfall is requires to properly design the pipe. The profile can be used to adjust the alignment if required.

- **Sub-surface Borings**
  The seismic data will be supplemented by several borings at key locations to better characterize the subsurface geology. This information will assist with the assessment of environmental impacts, particularly regarding the potential for sediment deposition during the dredging operation. It is also necessary for the proper structural design of the pipe bedding and anchoring system which must consider the support and stability of the outfall under a variety of expected service conditions.

- **Biological Baseline Study**
  A quantitative determination of the composition and distribution of benthic organisms and fish species in the vicinity of the outfall is required. This must be characterized seasonally to understand the variation in populations

- **Water Quality Characterization**

  Water quality parameters in the existing water column, in the vicinity of the outfall, must be determined. The critical parameters include dissolved oxygen, temperature, pH, alkalinity, suspended solids, turbidity, algal concentrations and productivity, phosphorus and nitrogen concentration, microbiological organisms and scans for potentially toxic substances including metals and organics. The identification of potentially toxic substances should include both the water column and the sediments.

- **Physical Assessment of Ocean Environment**

  Information regarding seasonal variations in the current velocity and direction, both tidal and sub-tidal and at different depths must be collected. Physical characteristics such as salinity, density and temperature profiles are also needed. It is expected that the work completed by Dr. Garvine at the University of Delaware would satisfy this requirement and that hydrodynamic field studies will not be required.

- **Storm Data**

  Information regarding wave heights and periods and wind velocity is required to better define the structural design criteria of the outfall. This information will allow the calculation of uplift and horizontal forces and of the potential for scour on the ocean bottom.

- **Effluent Plume Analysis**

  Additional computer modeling, as described below, will be required to more fully document permit compliance under a variety of seasonal operating condition, ocean currents and climate conditions.

  - **Mixing Zone Analysis**

    Additional modeling using the Cormix model will be required to refine the design of the diffuser section and to evaluate potential water quality impacts of the discharge. The initial zone of dilution must be evaluated for compliance with federal regulations for Ocean discharge Criteria (40 CFR Section 125.121c) and Delaware's Surface Water Quality Standards (Section 6.5).

- **Far-field Dispersion and Transport**

  Far-field dilution of the plume, due to ambient turbulence and dispersion, must be evaluated under the worst-case scenario of a wind driven current with the most onshore velocity component. Other scenarios must also be evaluated to insure protection of the critical resources including shellfish harvest area and fisheries. A particle tracking model may be required in order to predict the concentrations profiles in the plume.

7.9 PROPOSED DESIGN

7.9.1 Rehoboth Beach Ocean Outfall

7.9.1.1 Rehoboth Beach WWTP Plant Improvements

The Rehoboth Beach WWTP already provides a high level of treatment (advanced treatment for nutrient removal) for its influent wastewater. However, in order to meet the more stringent effluent limits for effluent outfall discharge, improvements to the Rehoboth Beach WWTP would be required. These improvements include effluent sand filters for additional solids, organics and nutrient removal followed by an effluent pumping system. The effluent pump station will provide the hydraulic head required to drive the flow through the ocean outfall pipe and diffuser. The effluent filters and effluent pump station can be located just south of the Microscreen Building. The recommended improvements for the Rehoboth Beach WWTP are shown in Figure 7-9.

7.9.1.2 Ocean Outfall Pipe

The pipeline for the ocean outfall was sized to handle the summer peak flow of 10.2 mgd. The pipe size was selected to maintain a velocity during summer peak flow less than 8 feet per second (fps). A 24-inch pipe was selected based on the velocity criteria. The force main leaving the plant will be 24-inch as will the ocean outfall piping. As discussed previously, the diffuser will be 18-inch. For the purpose of developing cost estimates, HDPE was selected as the pipe material for this alternative.

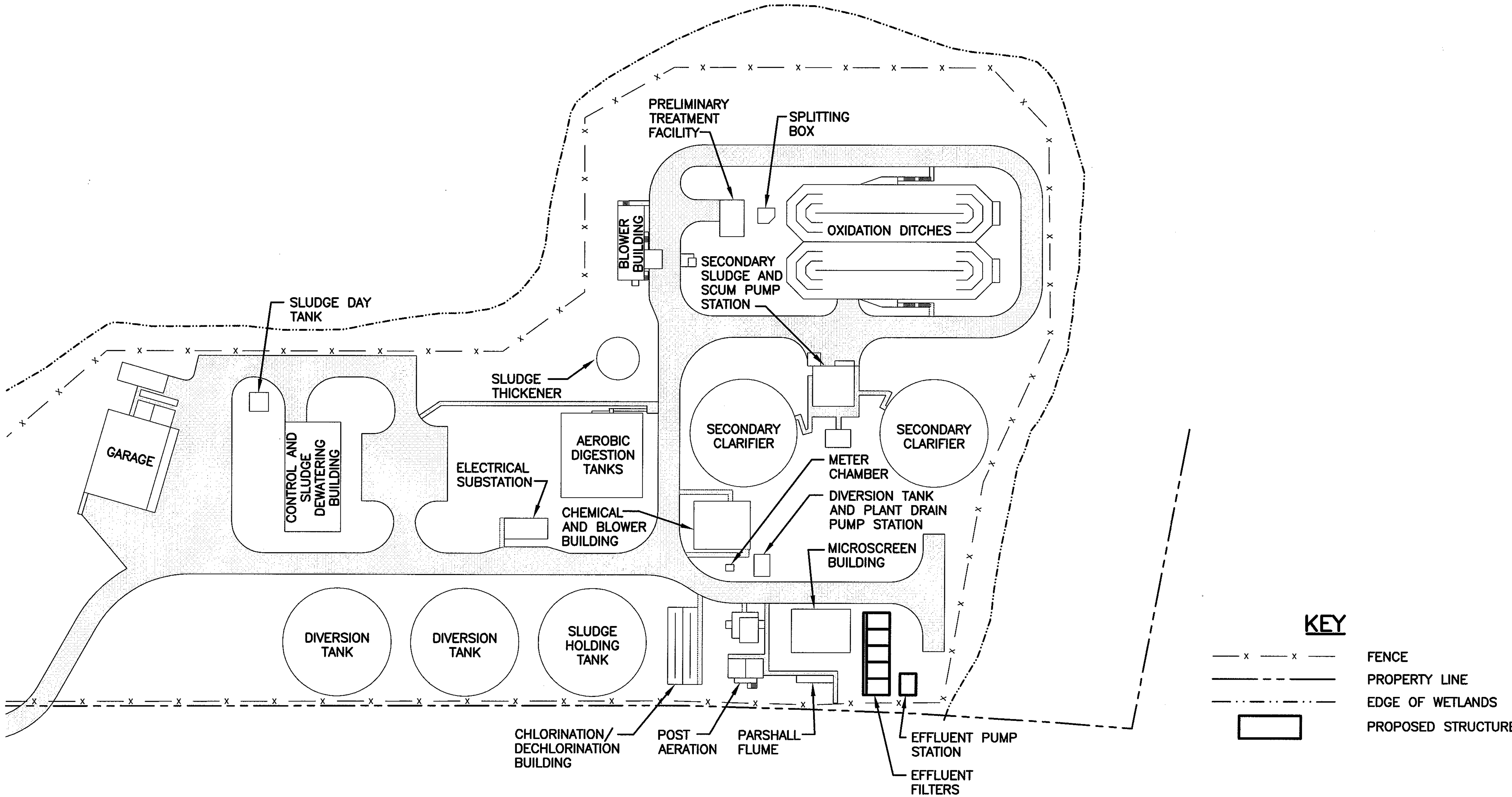
7.9.1.3 Ocean Outfall Trench Cross Section

Figure 7-10 presents a cross-section for the ocean outfall pipe. The following criteria were used to develop the cross-section:

- Pipe trench has a slope of 1.5:1.
- Trench bottom will be 1-foot wider on each side than the pipe diameter.
- Bedding will be laid under the pipe at a depth of 1-foot and will have an overall depth of 1.5-feet.
- 2.5-feet of backfill will be laid over the pipe and bedding.
- 4-feet of ballast rock will be laid over top of the backfill to help keep the pipe submerged.
- Armor rock will be laid over the trench at a 2.5-feet depth and a side slope of 30°.

7.9.1.4 Ocean Outfall Location

Figure 7-11 shows the proposed route of the force main from the Rehoboth Beach WWTP to the ocean outfall location. It was assumed that the force main would run along side the road in an easement. The location of the outfall is discussed in previous sections. Figure 7-12 shows a profile of the ocean outfall pipe.



SITE PLAN
SCALE: 1"=100'-0"

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Environmental Engineers and Scientists
BOWIE
DATE:9/04 JOB No.:20212.10

REHOBOTH BEACH
WASTEWATER TREATMENT PLANT
EFFLUENT DISPOSAL STUDY

FIGURE 7-9
REHOBOTH BEACH WWTP
PROPOSED SITE PLAN

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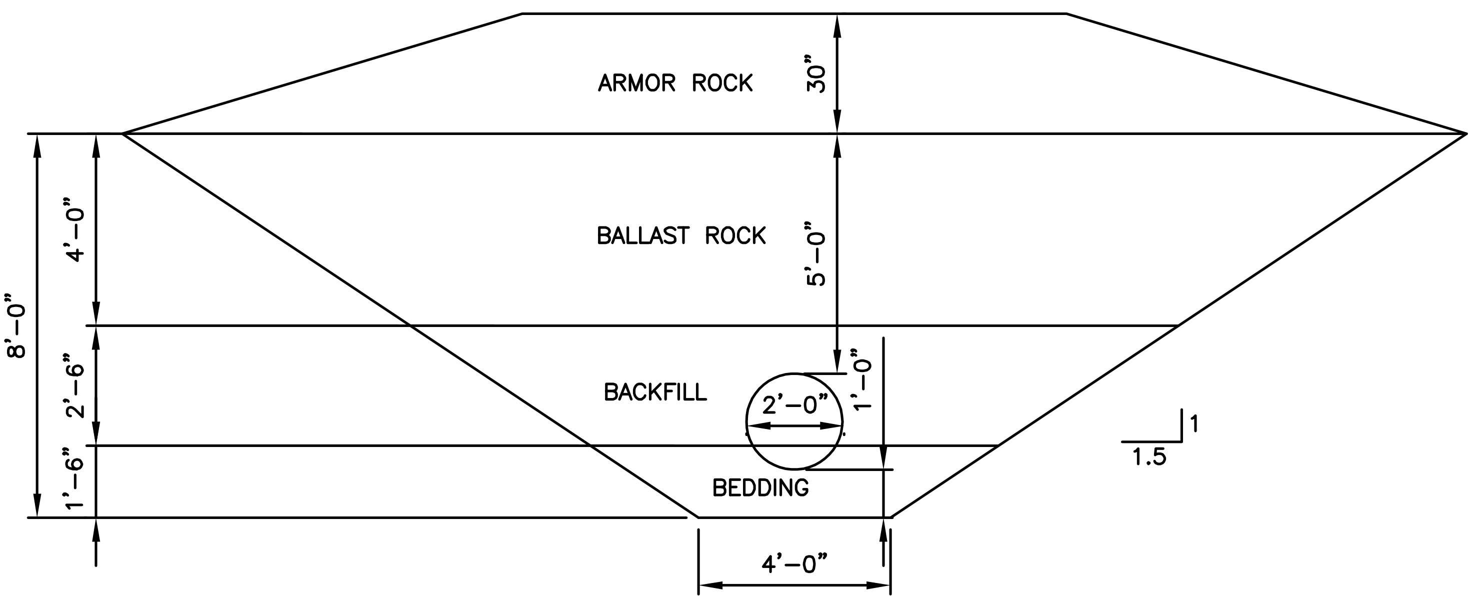
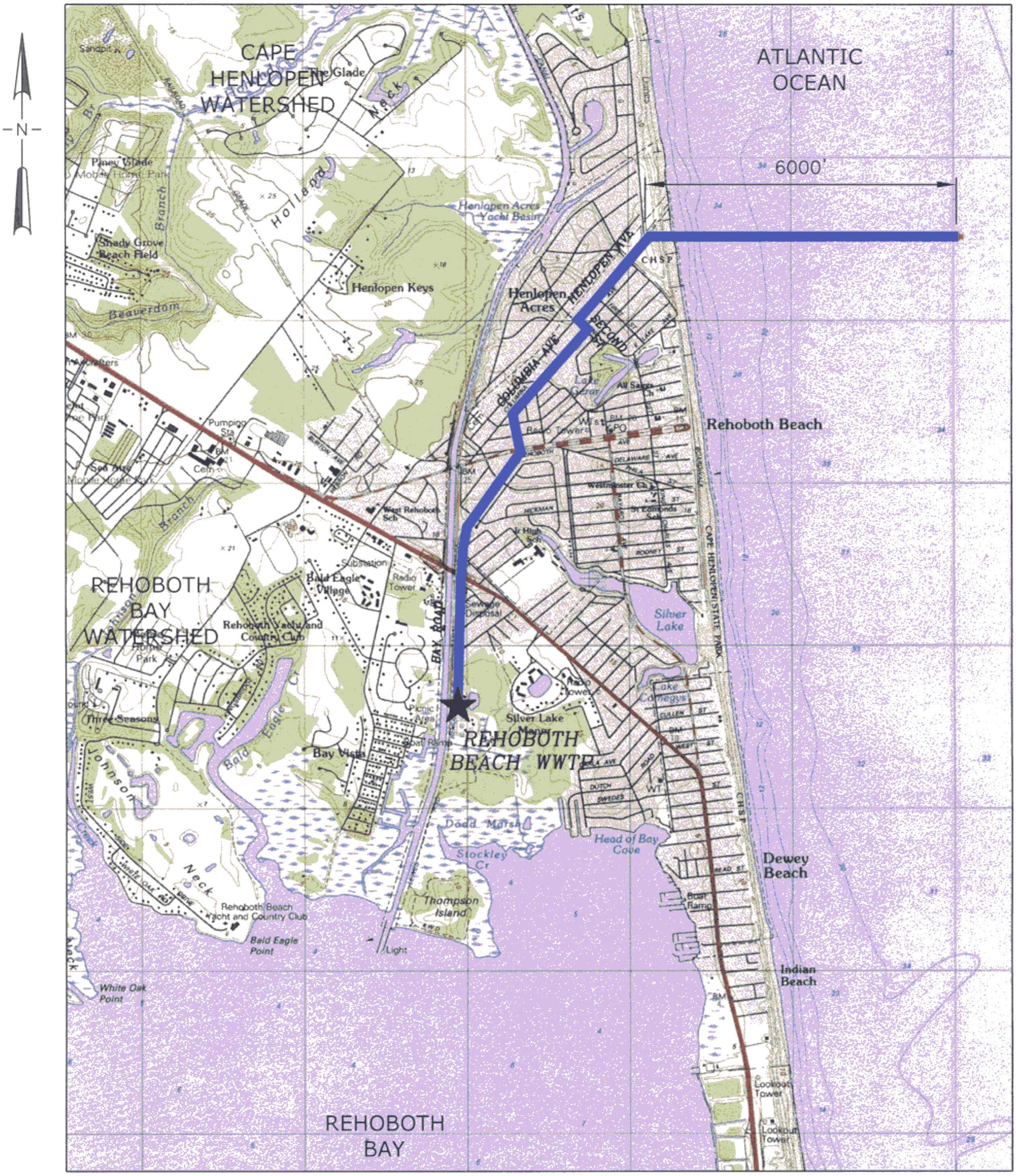


TYPICAL OCEAN OUTFALL CROSS SECTION

SCALE: NTS

Stearns & Wheler, LLC Environmental Engineers and Scientists BOWIE, MD DATE: 10/04 JOB No.:20212.10	REHOBOTH BEACH EFFLUENT DISPOSAL STUDY **FIGURE 7-10** **OCEAN OUTFALL CROSS SECTION**



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KEY

PROPOSED 24" PIPELINE

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REHOBOTH BEACH
EFFLUENT DISPOSAL STUDY

FIGURE 7-11
PROPOSED REHOBOTH BEACH
OCEAN OUTFALL

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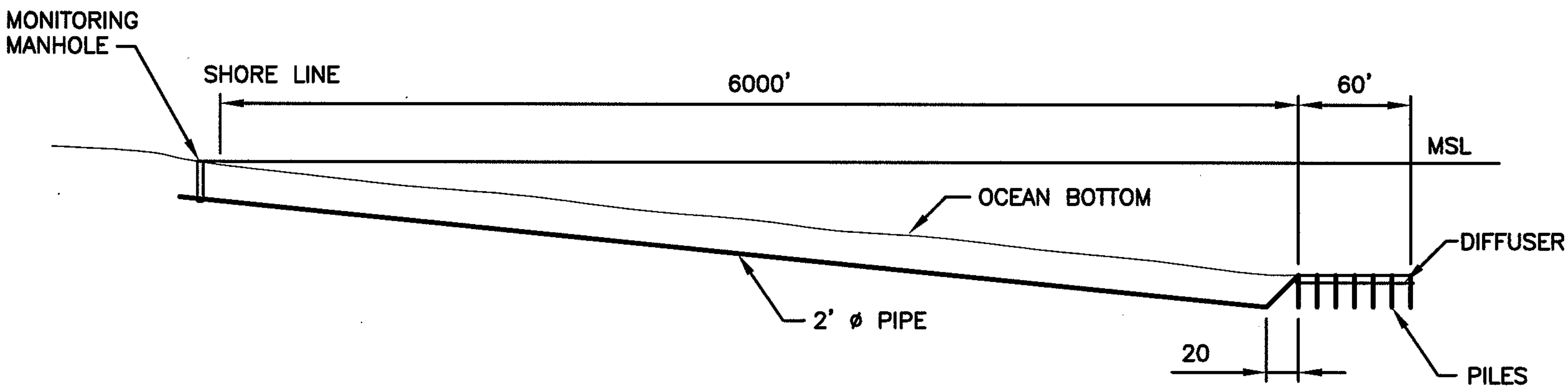

PROFILE
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Stearns & Wheler, LLC
Environmental Engineers and Scientists
BOWIE, MD
DATE: 10/04 JOB No.:20212.10

REHOBOTH BEACH EFFLUENT DISPOSAL STUDY

FIGURE 7-12
OCEAN OUTFALL PROFILE

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7.9.1.5 Rehoboth Beach Ocean Outfall Cost

A summary of the engineering estimate of probable construction cost for the Rehoboth Beach ocean outfall is presented in Table 7-11. Appendix H contains more details on the probable cost estimate.

Table 7-11: Estimate of Probable Construction Cost for the Rehoboth Beach WWTP Ocean Outfall Alternative

Description	Cost
Rehoboth Beach WWTP Effluent Filters	$2,860,000
Rehoboth Beach WWTP Effluent Pump Station	$1,500,000
Effluent Force Main	$2,670,000
Ocean Outfall	$22,100,000
Construction Cost (Year 2004 Dollars)(2)	**$29,130,000**
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	**$7,500,000**
Total Project Cost	**$36,630,000**

Note:
1. Cost includes 30 % contingency.

7.9.2 Regional Ocean Outfall

7.9.2.1 Rehoboth Beach WWTP Plant Improvements

The plant improvements described in Section 7.9.1.1 are also required for the regional ocean outfall solution.

7.9.2.2 Wolfe Neck RWF Plant Improvements

Unlike the Rehoboth Beach WWTP that already provides advance treatment for its influent wastewater, the Wolfe Neck RWF provides only limited secondary treatment through a series of aerated lagoons. Effluent disposal is by spray irrigation on five fields with a total area of 319 acres. In order to achieve the more stringent effluent limits required for an ocean outfall discharge, significant improvements would be required. It would be necessary to provide a more efficient secondary treatment process for BOD_5 and nutrient removal. One biological process that can be easily implemented at this facility is a Biolac system. The Biolac system uses long diffuser chains suspended across a geomembrane-lined basin. Air required for the biological process is pumped through the diffusers by blowers. Sludge is returned from secondary clarifiers to maintain the required mixed liquor in the reactor. The Biolac reactor could be located in one of the existing aerated lagoons at the Wolfe Neck RWF. However, the reactor volume required for the Biolac process is significantly less than the volume of a single aerated lagoon, therefore only a portion of one of the existing lagoons would be utilized for this purpose.

In addition, secondary clarifiers are recommended to provide effluent clarification and to concentrate the solids to maintain the required mixed liquor in the reactor. Other recommended improvements to the facility include a grit removal facility (the existing plant does not have a grit removal system), effluent filters and an effluent pump station. Also a building is recommended to house the blowers and return sludge pumps. A sludge dewatering facility is recommended for sludge handling. For the purpose of developing cost estimates, it is assumed that sludge dewatering will be provided by two 1.5 m belt filter presses. A layout of these improvements is shown in Figure 7-13.

7.9.2.3 Regional Ocean Outfall Pipe

The pipeline for the ocean outfall was sized to handle the Rehoboth Beach WWTP summer peak flow of 10.2 mgd and the Wolfe Neck RWF summer peak flow of 24.0. The pipe size was selected to maintain a velocity of 8 fps for the combined summer peak flow of 34.2 mgd. Based on the required velocity, a 36-inch pipe was selected for the combined force main and the ocean outfall.

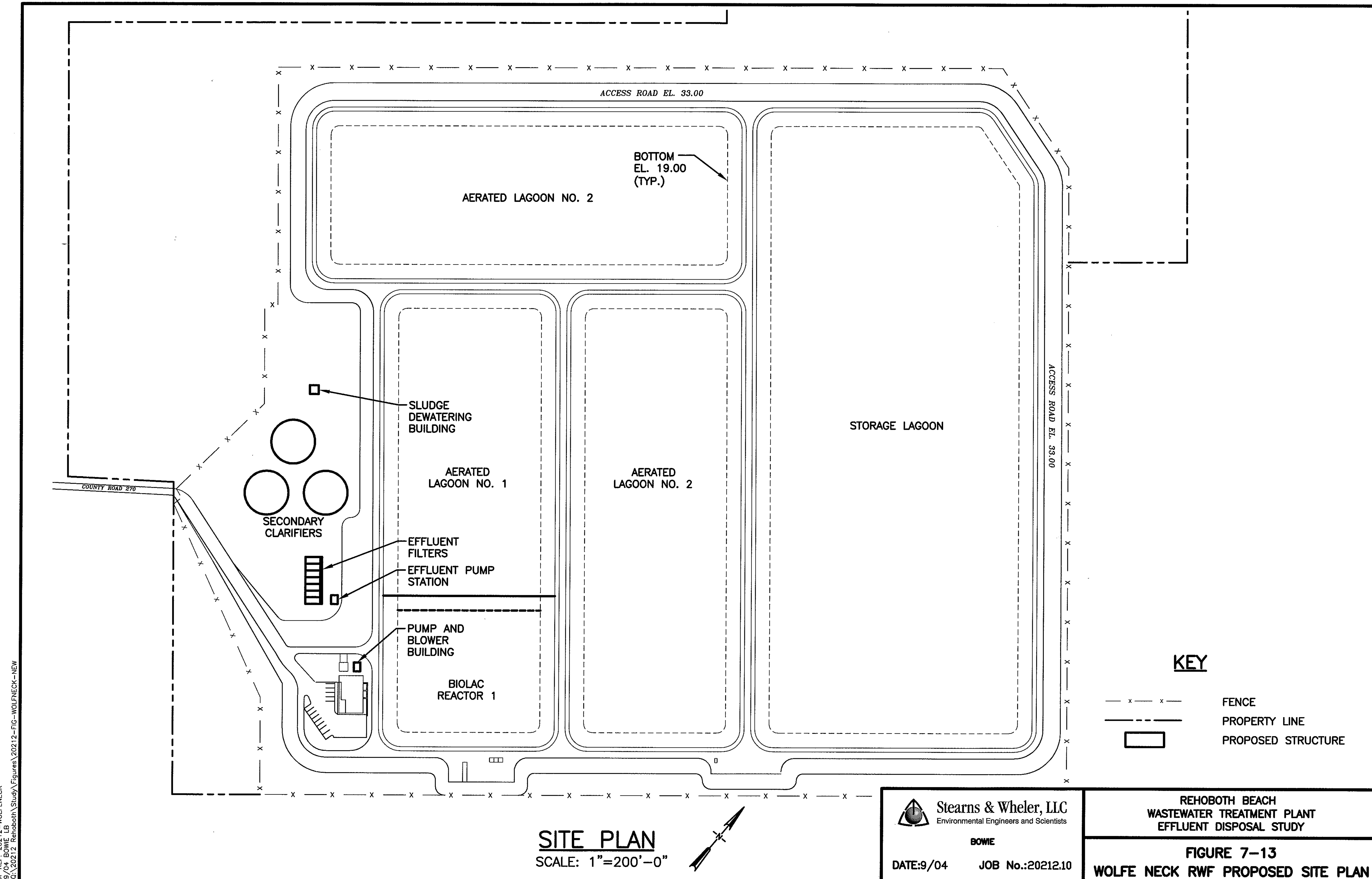
As discussed in Section 7.9.1.2, the force main from the Rehoboth Beach WWTP to the tie-in will be a 24-inch pipe. Based on the summer peak flow of 24.0 mgd, a 30-inch pipe is required for the force main from the Wolfe Neck RWF and the tie-in location. As discussed previously, the ocean outfall diffuser will be 24-inch. For the purpose of developing cost estimates, HDPE was selected as the pipe material for this alternative.

7.9.2.4 Regional Ocean Outfall Cross-Section

The regional ocean outfall trench will have the same general cross section as described in Section 7.9.1.3 and shown in Figure 7-10 except that the ocean outfall pipe will be 36-inch.

7.9.2.5 Regional Ocean Outfall Location

Figure 7-14 shows the proposed routes for the 24-inch force main from the Rehoboth Beach WWTP to the tie-in, the 30-inch force main from the Wolfe Neck RWF to the tie-in, the 36-inch force main from the tie-in to the ocean outfall location and the 36-inch ocean outfall. It was



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KEY

- REHOBOTH BEACH 24" PIPELINE
- SUSSEX COUNTY 30" PIPELINE
- REGIONAL 36" PIPELINE

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Environmental Engineers and Scientists

DATE:09/04 JOB No.:20212.10

REHOBOTH BEACH
EFFLUENT DISPOSAL STUDY

FIGURE 7–14
PROPOSED REGIONAL OCEAN OUTFALL

assumed that the force main would run along side an abandoned railroad bed. The location of the outfall is discussed in previous sections.

7.9.2.6 Regional Ocean Outfall Cost

Tables 7-12 and 7-13 present the cost for the City Rehoboth Beach and Sussex County associated with the regional ocean outfall. The cost of the force main from the tie-in to the ocean outfall and the ocean outfall cost were divided between Rehoboth Beach and Sussex County based on the maximum month flow of 6.8 mgd and 16 mgd, respectively. A summary of the total engineering estimate of probable construction cost for the regional ocean outfall is presented in Table 7-14. Appendix I contains more details on the probable cost estimate.

Table 7-12: Estimate of Probable Construction Cost for the City of Rehoboth Beach for the Regional Ocean Outfall Alternative

Description	Cost
Rehoboth Beach WWTP Effluent Filters	$2,860,000
Rehoboth Beach WWTP Effluent Pump Station	$1,500,000
Effluent Force Main to Tie-In	$1,290,000
Force Main from Tie-In to Ocean Outfall(1)	$580,000
Ocean Outfall(1)	$6,680,000
Construction Cost (Year 2004 Dollars)(2)	**$12,910,000**
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	**$3,780,000**
Total Project Cost	**$16,800,000**

Notes:
1. Cost proportioned based on average daily flow for Rehoboth Beach of 3.4 mgd and for 8.0 mgd for Sussex County.
2. Cost includes 30 % contingency.

Table 7-13: Estimate of Probable Construction Cost for Sussex County for the Regional Ocean Outfall Alternative

Description	Cost
Wolfe Neck RWF - Biolac	$3,880,000
Wolfe Neck RWF – Clarifier	$4,900,000
Wolfe Neck RWF – Operations Building	$2,170,000
Wolfe Neck RWF – Effluent Filters	$4,750,000
Wolfe Neck RWF – Effluent Pump Station	$2,000,000
Effluent Force Main to Tie-In	$3,710,000
Force Main from Tie-In to Ocean Outfall(1)	$1,370,000
Ocean Outfall(1)	$15,720,000
Construction Cost (Year 2004 Dollars)(2)	**$38,500,000**
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	**$11,550,000**
Total Project Cost	**$50,100,000**

Notes:
1. Cost proportioned based on average daily flow for Rehoboth Beach of 3.4 mgd and for 8.0 mgd for Sussex County.
2. Cost includes 30 % contingency.

Table 7-14: Estimate of Probable Construction Cost for the Regional Ocean Outfall Alternative

Description	Cost
Rehoboth Beach WWTP Improvements	$4,360,000
Wolfe Neck RWF Improvements	$17,700,000
Rehoboth Beach Force Main	$1,290,000
Wolfe Neck Force Main	$3,710,000
Force Main from Tie-In to Ocean Outfall	$1,950,000
Ocean Outfall	$22,400,000
Construction Cost (Year 2004 Dollars)(1)	**$51,400,000**
Engineering, Construction Inspection, Administration, Legal and Financial Expenses @ 30%	**$15,400,000**
Total Project Cost	**$66,800,000**

Note:
1. Cost includes 30 % contingency.

CHAPTER 8

EVALUATION OF ALTERNATIVES

8.1 ECONOMIC ANALYSIS

Table 8-1 summarizes the capital costs for each of the effluent disposal alternatives. Detailed breakdown of the cost estimates are included in the individual chapters for each of the alternatives.

Table 8-1: Effluent Disposal Alternative Capital Costs

Effluent Disposal Alternative	Capital Cost (2005$)
Spray Irrigation	$61,300,000
Rapid Infiltration Bed	$53,350,000
Deep Well Injection	$112,800,000
Ocean Outfall	
Rehoboth Beach	$36,630,000
Regional Solution	$66,800,000

Table 8-2 summarizes the assumptions made to determine the operation and maintenance cost associated with the each of the effluent disposal options. Specific assumptions for each alternative are shown on O&M cost sheets in the Appendix.

Table 8-2: Operations and Maintenance Cost Assumptions

Parameter	Value
Electrical Cost ($/KWH)	$0.06
Labor Cost per hour (includes overhead)	$25.00
Maintenance cost (as % of Total Project Cost)	1%
Hypochlorite Chemical Cost	$0.70

A present worth analysis was completed for each alternative to determine the most cost effective solution for the City of Rehoboth Beach. Table 8-3 summarizes the assumptions made to complete the present worth analysis.

Table 8-3: Present Worth Analysis Assumptions

Parameter	Value
Period for Present Worth Analysis	20
Annual Inflation Rate(1)	3.000%
Annual Interest Rate(1)	6.625%
Effluent Annual Interest Rate(2)	3.519%
Conversion Factor For Annual Cost to Present Worth(3)	14.19

Notes:

1. Assume inflation rate and interest rate.
2. Effective interest rate: ((1+Interest Rate)/(1+Inflation Rate))-1
3. Conversion factor: $((1+\text{Effective Rate})^{\text{No. of Years}}-1)/(\text{Effective Rate} * (1+\text{Effective Rate})^{\text{No. of years}})$

A summary of the capital, operations and maintenance, and present worth costs are presented in Table 8-4.

Table 8-4: Alternative Cost Summary

Effluent Disposal Alternative	Capital Cost (2005$)	20-year O&M Present Worth Costs (2005$)	Present Worth Cost (2005$)
Spray Irrigation	$61,300,000	$1,990,000	$63,290,000
Rapid Infiltration Bed	$53,350,000	$1,920,000	$55,270,000
Deep Well Injection	$112,800,000	$2,210,000	$115,010,000
Ocean Outfall			
Rehoboth Beach	$36,630,000	$2,240,000	$38,870,000
Regional – Rehoboth Beach	$16,800,000	$2,240,000	$19,040,000
Regional – Sussex County	$50,100,000	$8,560,000	$58,660,000

The Regional Ocean Outfall has the lowest present worth cost for the City of Rehoboth Beach. The spray irrigation and rapid infiltration bed present worth cost estimates are nearly two times the cost of the ocean outfall. The ocean outfall also has the lowest 20-year O&M present worth cost estimate.

8.2 COMPARISON OF ALTERNATIVES

The environmental impacts, regulatory, and technical issues have been presented in detail in each section of the report that discusses a specific effluent disposal alternative. In this section, the relative merits of each alternative will be presented in order to identify the most feasible alternative. The alternatives are compared in Table 8-5 using a subjective analysis of their relative merits.

8.2.1 Land Application

Land application is an environmentally acceptable method of effluent disposal with a good record of successful use in Delaware. The degree of treatment achieved by the existing Rehoboth Beach WWTP is greater than typically provided by other existing land application facilities. This higher level of treatment provides some regulatory allowances to reduce the size of buffers required and thus make more efficient use of the site. However, an extensive effort to search for land that could be purchased or leased by the City has led to the conclusion that property of sufficient size in reasonable proximity to the Rehoboth Beach WWTP does not exist. This conclusion is evidence of an ongoing trend in coastal Delaware whereby properties, especially the larger tracts of land possibly suitable for land application, are committed to development or, for other reasons, not available. The agricultural sites, if the owner's intent was to continue with farming, did not wish to spray treated effluent because it would prohibit the continued use of the farm for growing vegetable crops for human consumption. Also, development pressure continues to dramatically increase the cost of property. Even if land were available, the City of Rehoboth Beach is at a significant disadvantage in acquiring the property. The competitive real estate market demands the ability to offer a contract with few contingencies and which could be closed relatively quickly. The City of Rehoboth is not in a position financially to acquire the property without grants and loans from the State and without a number of contingencies to insure that the site is acceptable for its intended use.

Thus, land application is not a feasible alternative because a suitable site is simply not available.

8.2.2 Rapid Infiltration Beds

Rapid Infiltration Beds (RIBs) require a significant amount of land although much less than required for land application. The discussions regarding the difficulty in identifying and purchasing a suitable site that is presented in Section 8.2.1 applies also to the RIBs. However, if the City was successful in purchasing a site, there are environmental issues that would most probably prevent the facility from being permitted by DNREC. The permit issue is in regards to the TMDL for the Inland Bays that prohibits the discharge of nutrients from the Rehoboth Beach WWTP into the watershed. In order to be permitted, it would have to be demonstrated, through field investigations and modeling, that there would be no net increase in nutrients introduced into the watershed. Since nitrates are soluble and could be carried by the groundwater, a site would have to be found where the groundwater does not flow into the Inland Bays or into a tributary of the Inland Bays. Realistically, the only such site would be located along the coast with the flow of groundwater toward the ocean. Such properties are not available. The only possible properties are on state park lands, which cannot be used for this purpose because RIBs would prevent public access to the site. There are also potentially serious issues with the mounding of groundwater if RIBs were used. Thus, although not technically prohibited, the use of RIBs for effluent disposal is not a practical solution for the City of Rehoboth Beach.

8.2.3 Underground Injection

Two types of underground injection systems were considered; shallow well injection and deep well injection. Shallow well injection is not feasible because it would only be permitted into an unconfined superficial aquifer that has already been contaminated to the point where it can no longer be considered as a potential source of drinking water. This situation does not exist in the region. Although there are some areas where salt water has intruded into the aquifer, there are no areas where it has reached the level of salinity that would preclude its use as a source of drinking water. In addition, if the required aquifer situation could be located, the potential of the shallow well system to discharge nutrients to the Inland Bays could also prevent this alternative from being permitted. Thus, the wells would have to be located where the net flow of ground water is toward the ocean and away from the Inland Bays.

Deep well injection, while technically feasible, is not a practical alternative for the City. This alternative is potentially the most expensive alternative, depending on the actual depth of the injection wells. There is no assurance that the facility can be permitted after significant investment by the City to drill a pilot well and investigate the hydro-geochemistry of the injection formation. This investment would have to be made as part of the permitting process with no assurance of success making this a very risky alternative.

8.2.4 Ocean Outfall

Ocean outfalls have a well-documented record of success for discharging treated effluent in an environmentally acceptable manner. Preliminary modeling of the proposed outfall, with a diffuser located 6,000 feet off the shore, has shown that the outfall would comply with all environmental and public health requirements. Additional field work and modeling would be required during the final permitting process. However, there are no technical issues or permitting requirements anticipated that could potentially eliminate this alternative from further consideration.

Furthermore, an ocean outfall offers the potential to provide a regional solution serving the needs of both the City of Rehoboth and Sussex County.

Table 8-5: Comparison of Alternatives

Issue	Land Application	RIB	Underground Injection		Ocean Outfall
			Shallow	Deep	
Public Acceptance	+	0	-	-	-
Environmental Impacts	+	-	-	0	0
Nutrient Loading to Inland Bays	0	-	-	+	+
Permitting Issues	+	-	-	-	0
Reliability	0	0	-	-	+
Operability	0	+	-	-	+
Constructability	0	+	-	-	0
Long Term Solution	0	-	0	0	+
Groundwater Recharge	+	+	+	-	-
Land Requirement	-	-	0	0	+
Risk	+	0	-	-	+
Cost	0	0	0	-	+
Summary **+**	**5**	**3**	**1**	**1**	**7**
0	**6**	**4**	**3**	**3**	**3**
-	**1**	**5**	**8**	**8**	**2**

Notes:
A (+) indicates that, in regards to the particular issue the alternative is generally considered to be positive or beneficial.
A (0) indicates a neutral response.
A (-) indicates that the alternative is negative or detrimental with regards to the issue.
Indicates an issue, which essentially eliminates the alternative from further consideration.

8.3 RECOMMENDED PLAN

It is recommended that the City of Rehoboth Beach pursue an ocean outfall as the method of effluent disposal. Based on evaluations of the various methods of effluent disposal available to the City, an ocean outfall is the only technically feasible approach available to the City that has a realistic potential to be sited and permitted. A summary of the primary reasons for selecting this alternative follows:

- Preliminary modeling indicates that, even under the worst-case scenario regarding the performance of the wastewater treatment plant and ocean currents, public health requirements are met at or in close proximity to the diffuser.

- Ocean outfalls have a well-documented history of protecting public health and compliance with environmental regulations.
- An ocean outfall can be considered an “ultimate” solution in the sense that, once it is built and in operation, the discharge is immune from future regulatory issues and environmental concerns related to the TMDL program which regulates the discharge of nutrients in the watershed.
- An ocean outfall is the only alternative that has the potential to be a regional solution and thus possibly further reduces the impact on the individual user charges.
- Based on an analysis of the present worth costs, the ocean outfall is the most cost-effective alternative.

It is recognized that an ocean outfall will be controversial, as would each of the alternatives evaluated for a variety of reasons. One issue that may surface regarding an ocean outfall during the permitting process is that an ocean outfall does not reuse or recharge the groundwater, which should be considered a resource. However, the Delaware Geological Survey has indicated that groundwater resources are very plentiful in Delaware and that reuse is not required from a water supply perspective. Also, the other alternatives which return the treated effluent to the groundwater, do not recharge the aquifer in the area from which the groundwater was originally withdrawn. For example, if Rehoboth Beach utilized rapid infiltration beds for effluent disposal, then the aquifer, which is miles from the area of the well water supply fields, would be recharged.

CHAPTER 9

FINANCIAL CONSIDERATIONS

9.1 REHOBOTH BEACH OCEAN OUTFALL

9.1.1 Current Rehoboth Beach Revenue

The revenue from the collection and treatment of wastewater is comprised of four (4) components. The components are defined below:

- Metered Sewer Wastewater: The metered sewer wastewater is comprised of connections to the wastewater treatment plant that are within city boundaries and are greater than 1-inch connections, connections outside the City boundary, and connections that are 1-inch and less. The 1-inch and less connections are billed on a quarterly basis and all others are billed on a monthly basis. The metered sewer bills are determined based on the water usage to each connection. The water usage is converted to a sewer rate. Table 9-1 summarizes the water usage for the connections described above.

Table 9-1: Water Usage Summary

Month	Monthly Water Usage: In-City + Out of City (gallons)	Average Monthly Water Usage: 1-inch of Less Connections (gallons)[1]	Total
January	2,976,000	5,853,333	8,829,333
February	2,878,000	5,853,333	8,731,333
March	3,391,000	5,853,333	9,244,333
April	4,514,000	9,150,000	13,664,000
May	5,634,000	9,150,000	14,784,000
June	8,500,000	9,150,000	17,650,000
July	8,500,000	17,940,000	26,440,000
August	14,163,998	17,940,000	32,103,998
September	7,943,000	17,940,000	25,883,000
October	7,017,000	6,203,667	13,220,667
November	4,236,999	6,203,667	10,440,666
December	2,566,000	6,203,667	8,769,667
Total Water Usage	**72,319,997**	**117,441,000**	**189,760,997**
Water Contribution, %	**38.1**	**61.9**	

Note:
1. Quarterly water usage values were equally divided between each month.

It is assumed that all the 1-inch of less connections are residential. The percent distribution of the water usage (summarized in Table 9-1) was used to distribute the revenue between residential customers and other metered customers. The distribution of revenue is summarized in Table 9-2.

Table 9-2: Metered Sewer Revenue Distribution

Source	Percent Distribution	Revenue
Total Annual Revenue[1]		$1,035,773
Commercial	38.1%	$394,744
Residential	61.9%	$641,029

Note:
1. Based on the 2003 actual revenue data.

- North Shores Revenue: There are currently 286 units in this service area that generate revenue for the City of Rehoboth Beach. The units are billed on a quarterly basis. The rates vary seasonally (peak vs. non-peak). The units are billed annually for two (2) peak quarters and two (2) non-peak quarters. The revenue generated from the North Shore customers in 2003 was $130,379 based on the 2003 actual budget numbers.

- Dewey Beach and Henlopen Acres: The Dewey Beach and Henlopen Acres customers are billed on a quarterly basis based on the actual metered flow discharged into the City's collection system. The metered flow is taken as a percentage of the total flow treated by the plant and multiplied by the City's total O&M costs. A 15% surcharge is added to the cost. The total 2003 revenue from Dewey Beach and Henlopen Acres was $457,425 and $37,285, respectively.

Table 9-3 summarizes the 2003 wastewater revenue.

Table 9-3: 2003 Wastewater Revenue

Source	2003 Revenue[1] ($)
Metered Sewers – Commercial	$394,744
Metered Sewers – Residential	$641,030
North Shores	$130,379
Dewey Beach	$457,425
Henlopen Acres	$37,285
Total	**$1,660,862**

Note:
1. Based on actual 2003 revenue numbers.

9.1.2 Average Residential User Annual Cost

Several assumptions were made to determine the cost of wastewater collection and treatment for the typical residential user. The first assumption is that the average residential service connections are represented by the service connections that are 1-inch and less. The second assumption is that the wastewater is distributed evenly between all service connections that are 1-inch and less. Based on the 2003 water usage bill summaries, the total number of service connections that are 1-inch and less is 2,115. Based on the revenue summarized in Table 9-3, the average user charge for 2003 is $303.09.

The DNREC guideline for establishing a maximum "reasonable" user charge is 1.5% of the median household income (MHI). The MHI is inflated to the year that the project is actually supposed to start. DNREC provided the projected MHI of $64,016 for Rehoboth Beach for 2008. The impact on Rehoboth Beach users was determined based on year 2012 dollars; therefore, the MHI was escalated to year 2012 dollars at 3% per year for 4 years. The projected MHI in 2012 is $72,051. The maximum "reasonable" user charge based on the DNREC guidelines would be $1080.76. An increase of 257% above the current user charge would be required in order to reach an average user charge of $1080.76.

9.1.3 Impact of Recommended Plan on User Charges

9.1.3.1 Objective

The City of Rehoboth Beach will have to finance the cost of the recommended plan through a combination of loans and grants. The terms of the loan required and the amount of the grant money received to finance the project will obviously impact the user charges levied to recover the cost. The purpose of this section is to assess the impact of the proposed project on the City of Rehoboth Beach user charges under different financing scenarios.

Table 9-4 summarizes the parameters used in determining the debt services for all loan options considered in the cost analysis.

Table 9-4: Cost Analysis Parameters

Parameter	Value
Period for Present Worth Analysis(1)	20 years
Annual Interest Rate(1)	4%
Conversion Factor for Present Worth to Annual Cost(2)	0.0736

Notes:
1. Assumed values for Present Worth Analysis
2. Calculated conversion value: $(Rate*(1+Rate)^{20})/((1+Rate)^{20}-1)$

9.1.3.2 Total Annual Cost

The capital cost for the Rehoboth Beach Ocean Outfall is estimated to be $36,630,000 in year 2005 dollars. The annual operating costs for the associated with ocean outfall are estimated to be $158,000 in year 2005 dollars. Before assessing the true impact of the cost of proceeding with the recommended option, which is the ocean outfall, there are some additional future costs associated with keeping the existing wastewater treatment plant in operation that must also be considered. Committing to the ocean outfall as a long-term solution obviously also commits the City to the continued operation of the existing Rehoboth Beach WWTP which is over 20 years old.

It is reasonable to expect some significant future capital cost to replace major pieces of equipment and to repair existing unit process. A summary of the future costs that may be reasonably expected are included in Table 9-5. The dates at which these improvements will be required are unknown. Thus, the total anticipated costs have been divided evenly over the 20 year life cycle period. These costs will contribute to the annual costs for O&M and for capitalizing the projected cost to determine the total annual cost that must be recovered through the user charges.

Table 9-5: Annual Costs Associated with the Wastewater Treatment Plant

Item	No. of Units	Cost per Unit ($)	Total Cost ($)	Project Cost[1] ($)
Draft Tube Aerators	4	$150,000	$600,000	$960,000
Microscreens[2]	2			
Blowers				
Main Process	3	$25,000	$75,000	$120,000
Aerobic Digester	3	$15,000	$45,000	$72,000
Final Clarifier Drive	2	$50,000	$100,000	$162,000
Pumping Equipment				
Process	20	$20,000	$400,000	$640,000
Collection System	7	$25,000	$175,000	$280,000
Chemical Feed – Pumps	10	$8,000	$80,000	$128,000
Chemical Feed – Tanks	4	$25,000	$100,000	$160,000
Grit System	LS		$800,000	$1,280,000
Instrumentation & Controls	LS		$250,000	$400,000
Concrete Repair				
Headworks[3]	LS		$50,000	$80,000
Oxidation Ditches[3]	LS		$300,000	$480,000
Miscellaneous	LS		$300,000	$480,000
Miscellaneous[4]			$1,000,000	$1,600,000
Total[5]			$4,275,000	$6,840,000
Annual Cost[6]			$213,750	$342,000
Adopted Annual Cost				**$350,000**

Notes:

1. Basis of project costs: Installation – 25%, General Conditions – 5%, Electrical – 15%, Administration/Legal – 5% and Engineering – 10%
2. To be replaced by future effluent sand filters
3. Currently showing signs of pitting
4. Based on $50,000 per year
5. Assumes costs are incurred midway through the 20 year life cycle
6. Annual cost over 20 year life cycle (2005 dollars)

9.1.3.3 Financing Scenarios

Scenario 1 – Finance Entire Capital Project Cost

The capital and operating costs were escalated to 2012 dollars to better determine the impact of the Rehoboth Beach solution. The capital cost for the Rehoboth Beach ocean outfall in year 2012 dollars is $43,740,000. Based on the parameters in Table 9-4 and the assumption of no grant funding, the annual costs associated with the Rehoboth Beach Ocean Outfall are summarized in

Table 9-6. Table 9-6 includes the projected debt service to repay the loan plus the existing and projected annual operation and maintenance costs for the recommended plan.

Table 9-6: Annual Cost for Ocean Outfall

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$1,750,000
Annual Principal[5]	$1,470,000
Total Annual Cost	$5,360,000

Notes:
1. From Rehoboth Beach 2004 – 2005 budget escalated to 2012 at 3% per year.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to 2012 at 3% per year
4. Based on $43,740,000 * 4% = $1,750,000
5. Principal = $43,740,000 * 0.0736 – Interest ($1,750,000)

Section 9.1.1 summarizes the current revenue for the City, which is approximately $1,661,000 annually. An increase of 223% of the metered sewer rates (factor of 3.23 times existing rates), North Shores revenue, Dewey Beach revenue and Henlopen Acres revenue would be required to achieve an annual revenue of $5,360,000. Table 9-7 summarizes the revenue associated with an increase of 223%.

Table 9-7: Annual Revenue with 223% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$2,070,000
Metered Sewers – Residential	$1,270,000
North Shores	$420,000
Dewey Beach	$1,480,000
Henlopen Acres	$120,000
Total	$5,360,000[2]

Note:
1. For detailed computations see Appendix K. All revenue sources were increased by the 223%.
2. Rounded to the nearest ten thousand.

Based on the 2,115 customers with service connections less than 1-inch, an increase of 223% would result in an annual average user charge of $977.46, which is less than the maximum "reasonable" user charge of $1080.76 per the DNREC guidelines.

Scenario 2 – Grant Financing to Limit User Charge Increase to 50%

A more reasonable increase, but still a significant increase to the Rehoboth Beach users and other customers, over the next several years would be an increase of no more than 50% over the current charges. Table 9-8 summarizes the revenue expected with an increase of 50%. As shown in Table 9-8, the revenue is significantly less than the $5,360,000 projected to be required (see Table 9-6).

Table 9-8: Annual Revenue with 50% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$960,000
Metered Sewers – Residential	$590,000
North Shores	$200,000
Dewey Beach	$690,000
Henlopen Acres	$60,000
Total	$2,500,000[2]

Notes:
1. For detailed computations see Appendix K. All revenue sources were increase by 50%.
2. Rounded to the nearest ten thousand.

With an increase of 50% in user charges, significant grant money would be required to build the Rehoboth Beach Ocean Outfall. With an annual budget of $2,500,000, a grant for 88.7% of the total capital cost, $43,740,000 (year 2012 dollars), is required resulting in a loan of approximately, $4,940,000. The annual costs associated with the loan are summarized in Table 9-9.

Table 9-9: Annual Cost for Ocean Outfall with 88.7% Grant Funding

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$198,000
Annual Principal[5]	$162,000
Total Annual Cost	$2,500,000[6]

Notes:

1. From Rehoboth Beach 2004 – 2005 budget escalated to 2012 dollars.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to 2012 dollars
4. Based on $4,940,000 * 4% = $198,000
5. Principal = $4,940,000 * 0.0736 – Interest ($198,000)
6. Rounded to the ten thousand.

9.1.3.4 Sensitivity Analysis

Obviously the user charge decreases as the amount of grant money that is made available increases. Figure 9-1 illustrates the sensitivity of the user charges to the percent of grant money used to fund the project.

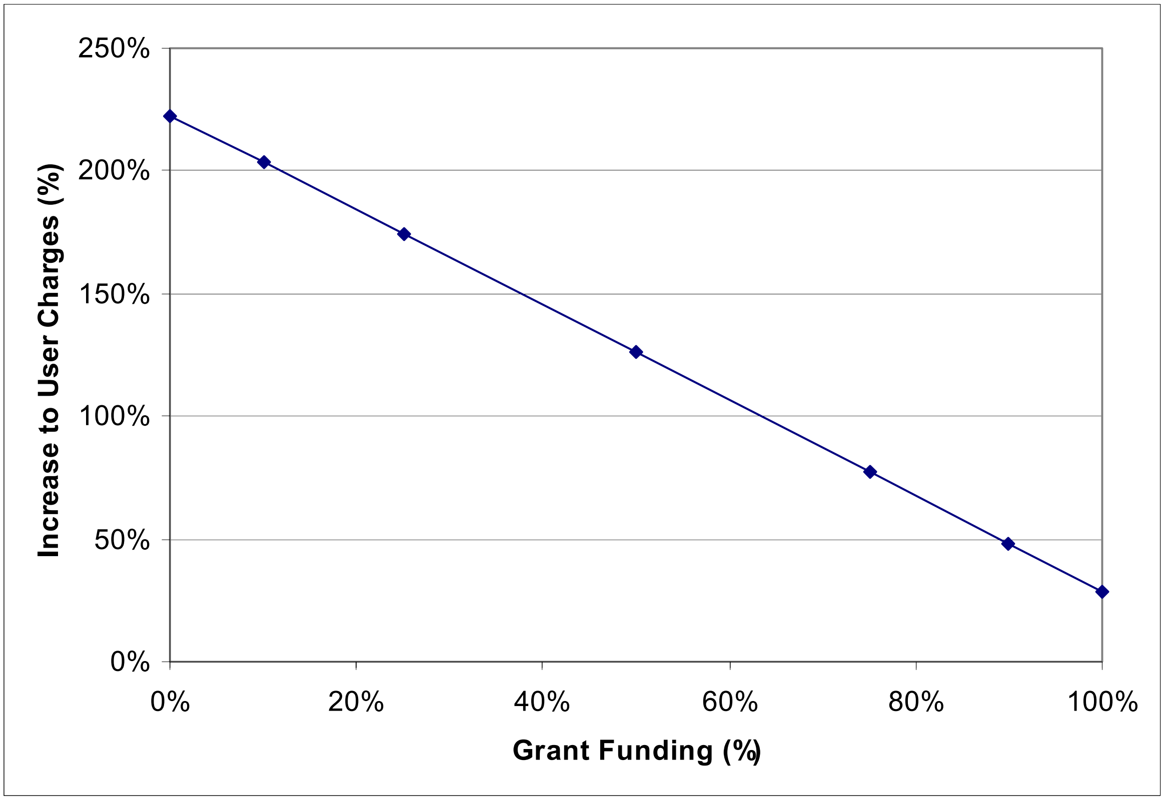

Figure 9-1: Effect of Grant Funding on Increase of User Charges

9.2 REGIONAL SOLUTION OCEAN OUTFALL

9.2.1 Regional Solution Capital and Operating Costs

The capital and operating costs were escalated to 2012 dollars to better determine the impact of the Regional ocean outfall solution. Table 9-10 summarizes the capital and operating cost for Rehoboth Beach and Sussex County for the Regional Ocean Outfall.

Table 9-10: Regional Solution Capital and Operating Costs

Source	Capital Cost (2012$)	Existing O&M Costs (2012$)	Additional O&M Cost (2012$)	Additional O&M Cost for WWTP (2012$)
City of Rehoboth Beach	$20,060,000	$1,530,000	$189,000	$418,000
Sussex County	$59,820,000	N/A(1)	$720,000	N/A[1]
Total Cost	$79,880,000			

Note:
1. Not available at this time.

9.2.2 Impact on Rehoboth Beach User Charges

Scenario 1 – Finance Entire Capital Project Costs

The City of Rehoboth Beach would have to finance its portion of the regional solution. Table 9-10 summarizes the cost analysis parameters used for the analysis of the regional solution.

The capital cost for the Rehoboth Beach Ocean Outfall is estimated to be $20,060,000 (year 2012 dollars). Based on the parameters in Table 9-4 and the assumption of no grant funding, the annual costs for the City of Rehoboth Beach associated with the Regional Ocean Outfall are summarized in Table 9-11.

Table 9-11: Rehoboth Beach Annual Cost for Regional Ocean Outfall

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$678,000
Annual Principal[5]	$802,000
Total Annual Cost	$3,620,000[6]

Notes:
1. From Rehoboth Beach 2004 – 2005 budget escalated to years 2012 dollars.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to year 2012 dollars.
4. Based on $20,060,000 * 4% = $802,000
5. Principal = $20,060,000 * 0.0736 – Interest ($802,000)
6. Rounded to the ten thousand.

Section 9.1.1 summarizes the current revenue for the City, which is approximately $1,661,000 annually. An increase of 118% of the metered sewer rates, North Shores revenue, Dewey Beach revenue and Henlopen Acres revenue would be required to achieve an annual revenue of $3,620,000. Table 9-12 summarizes the revenue associated with an increase of 118%.

Table 9-12: Annual Revenue with 82.5% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$1,400,000
Metered Sewers – Residential	$860,000
North Shores	$280,000
Dewey Beach	$1,000,000
Henlopen Acres	$80,000
Total	$3,620,000[2]

Notes:
1. For detailed computations see Appendix K. All revenue sources were increased by the 118%.
2. Rounded to the nearest ten thousand.

Based on the 2,115 customers with service connections less than 1-inch, an increase of 118% would result in an annual average user charge of $660.73, which is less than the maximum "reasonable" user charge of $1080.76 per the DNREC guidelines.

<u>Scenario 2 – Grant Financing to Limit User Charge Increase to 50%</u>

A more reasonable increase but still a significant increase to the Rehoboth Beach users and other customers over the next several years would be an increase of no more than 50% over the current charges. Table 9-13 summarizes the revenue expected with an increase of 50%. As shown in Table 9-13, the revenue is significantly less than the projected $3,620,000 required (see Table 9-11).

Table 9-13: Annual Revenue with 50% Increase in User Charges[1]

Source	Value
Metered Sewers – Commercial	$960,000
Metered Sewers – Residential	$590,000
North Shores	$200,000
Dewey Beach	$690,000
Henlopen Acres	$60,000
Total	$2,500,000[2]

Notes:
1. For detailed computations see Appendix K. All revenue sources were increase by 50%.
2. Rounded to the nearest ten thousand.

With an increase of 50% in user charges, significant grant money would be required to build the Regional Ocean Outfall. With an annual budget of $2,500,000, a grant for 75.5% of the total capital cost, $15,150,000, is required resulting in a loan of approximately, $4,910,000. The annual costs associated with the loan are summarized in Table 9-14.

Table 9-14: Annual Cost for Ocean Outfall with 75.5% Grant Funding

Source	Value
Existing O&M Costs[1]	$1,530,000
Additional O&M Costs (Ocean Outfall)[2]	$189,000
Additional WWTP O&M Costs[3]	$418,000
Annual Interest[4]	$164,000
Annual Principal[5]	$196,000
Total Annual Cost	$2,500,000[6]

Notes:
1. From Rehoboth Beach 2004 – 2005 budget escalated to year 2012 dollars.
2. For detailed computation see Appendix K.
3. From Table 9-5 Annual Costs Associated with the Wastewater Treatment Plant escalated to year 2012 dollars.
4. Based on $4,910,000 * 4% = $196,000
5. Principal = $4,910,000 * 0.0736 – Interest ($196,000)
6. Rounded to the ten thousand.

9.2.3 Impact on Sussex County User Charges

Sussex County estimated the impact of the additional capital and operating costs on their user charges under two different scenarios as described below:

Scenario 1: All of the costs would be borne locally without the assistance of any state or federal grant money.

Scenario 2: Grant money is provided to pay for 50% of the capital cost.

Note that the typical annual user charge, based on year 2005 costs with 88 feet of front footage charge is $621.

The estimated capital and O&M costs are presented in Table 9-15. The cost estimates were escalated to year 2012 dollars. The capital and O&M costs associated with the WWTP improvements and regional ocean outfall are $59,822,000 and $720,000 (year 2012 dollars). For the determination of the annual debt service associated with the construction of the WWTP upgrades and the ocean outfall, a 40-year bond with an interest rate of 5.5% was assumed. Table 9-16 summarizes the Sussex County cost associated with the WWTP improvements and the operation of the ocean outfall.

Table 9-15: Sussex County Annual Costs[1]

Source	Value
Annual Loan Cost (Interest & Principal)	$3,714,000
Additional O&M (WWTP & Regional Ocean Outfall)	$720,000
Total	$4,434,000[2]

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest

Based on the 2006 Budget, the estimated number of users is 15,348. The estimated number of users was increased at 3% per year to 2012. Table 9-16 summarizes the impact of the WWTP and Regional Ocean Outfall solution to the Sussex County users.

Table 9-16: Annual Revenue for WWT Costs[1]

Source	Value
Additional Annual Cost for WWTP & Regional Ocean Outfall[2]	$4,434,000
Number of Users (Year 2012)	18,326
Additional Cost per User for WWTP and Ocean Outfall	$242
2012 Estimated User Charger[3]	$741
Total 2012 User Charge	$983
Percent Increase in User Charge[4]	58%

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest. See Table 9-15.
3. Estimated 2005 user charge of $621 escalated to 2012 at 3% for 6 years
4. Increase = Project User Charge / Current User Charge - 1

Scenario 2 – 50% Grant Funding

Table 9-17 summarizes the cost to Sussex County if 50% grant funding is awarded for the Regional Ocean Outfall solution including the cost for upgrading the WWTP.

Table 9-17: Sussex County Annual Costs with 50% Grant Funding[1]

Source	Value
Total Capital Cost (Year 2012 dollars)	$58,820,000
Grant Funding	$29,910,000
Loan	$29,910,000
Annual Loan Cost (Interest & Principal)	$1,857,000
Additional O&M (WWTP & Regional Ocean Outfall)	$720,000
Total	$2,577,000[2]

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest

Table 9-18 summarizes the impact of the WWTP and Regional Ocean Outfall solution to the Sussex County users with 50% grant funding.

Table 9-18: Annual Revenue for WWT Costs[1]

Source	Value
Additional Annual Cost for WWTP & Regional Ocean Outfall	$2,577,000
Number of Users (Year 2012)	18,326
Additional Cost per User for WWTP and Ocean Outfall	$141
2012 Estimated User Charger[3]	$741
Total 2012 User Charge	$882
Percent Increase in User Charge[4]	42%

Notes:
1. All cost shown in Year 2012 dollars.
2. Annual Loan Cost based on 40-year bond at 5.5% annual interest. See Table 9-15.
3. Estimated 2005 user charge of $621 escalated to 2012 at 3% for 6 years
4. Increase = Project User Charge / Current User Charge - 1