EA Engineering, Science,
and Technology

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2 September 2008
Project No. 14550.04

Mr. Ching-Tzone Tien, Ph.D., P.E.
Chief, Groundwater Discharge Permits Division
Maryland Department of the Environment
1800 Washington Boulevard, Suite 455
Baltimore, MD 21230-1708

**Re: Hydrogeologic Report – Willard Farm
Worcester County
Newark, Maryland**

Dear Dr. Tien:

On behalf of the Worcester County Department of Public Works (the County), EA Engineering, Science, and Technology, Inc. (EA) is submitting this Hydrogeologic Report of the Willard Farm Property in Newark, Maryland. The County does not currently own the property, but through the approval of the property owner, authorized EA to conduct infiltration testing and prepare a Hydrogeologic Report. Prior to the purchase of the property, the County is interested in determining the capability of the Willard Farm Property to be utilized as a spray irrigation site. The site would receive treated wastewater from the Newark treatment lagoon. As discussed in the Hydrogeologic Report, the areas of the site proposed for spray irrigation are capable of accepting an infiltration rate of 1.34 inches/week of wastewater. The County requests that the MDE review the Hydrogeologic Report and provide an approval for this site to receive treated wastewater at a rate of 1.34 inches/week.

Enclosed are two (2) copies of the Hydrogeologic Report. This report is not a permit application. A full permit application with associated site layout and coverage area will be submitted to the MDE upon the County's purchase of the property. If you have any questions, please contact Mr. John Ross with Worcester County at 410-641-5251 or EA at 410-641-5341

Sincerely,
EA Engineering, Science, and Technology

Darl Kolar, P.E.
Project Manager

Cc: John Tustin, P.E. Worcester County
John Ross, P.E. Worcester County
Greg Gromicko, P.E. EA Engineering

EA Engineering, Science,
and Technology

Willard Farm Spray Irrigation Site
Hydrogeologic Report
Newark, Maryland

Prepared for:

Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230

Prepared by:

EA Engineering, Science, and Technology
11202 Racetrack Road, Unit 103
Ocean Pines, Maryland 21811

On Behalf of:

Worcester County Department of Public Works
Water and Wastewater Division
1000 Shore Drive
Berlin, Maryland 21811

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August 2008

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LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
cm^2	Square Centimeter(s)
cm/hr	Centimeter(s) Per Hour
EA	EA Engineering, Science, and Technology, Inc.
ft	Foot or Feet
gpd	Gallons per day
ID	Inner Diameter
in.	Inch(es)
in./hr	Inch(es) Per Hour
in./wk	Inch(es) Per Week
MDE	Maryland Department of the Environment
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
USDA	United States Department of Agriculture
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

On behalf of the Worcester County Department of Public Works (the County), EA Engineering, Science, and Technology, Inc. (EA) conducted field infiltration testing at the Willard Farm property, located in Newark, Maryland. The testing was conducted to determine the suitability and infiltration capacity of the site for potential use as a spray irrigation site for municipal wastewater from the Newark wastewater treatment plant (WWTP). Requirements for this type of spray irrigation system, defined as a "slow rate" system, are outlined in the Maryland Department of the Environment (MDE) document entitled *Guidelines for Land Treatment of Municipal Wastewaters*, MDE-WMA-001-07/03, Revised 7/2003. Determination of baseline soil permeability values, in combination with the calculated available acreage, were used to determine the quantity and flow rate of wastewater that the soils on the Willard Farm can accept. This information is to be used to design an appropriate spray irrigation system for application of wastewater on the Willard Farm property.

This hydrogeologic report includes the results of the field investigations that were conducted. The first field testing event was conducted by EA on 15 and 16 July 2008 (Testing Locations S-1 through S-3).

MDE was then onsite on 29 July 2008 to conduct a separate field investigation of the site soil characteristics and profiles. Dr. Ching-Tzone Tien represented MDE and evaluated five locations. Representatives from the County, along with EA, were also onsite to observe MDE's field investigations. The County provided a backhoe to excavate to sufficient depths to allow for MDE to evaluate the soil profile and depth of groundwater. Dr. Tien identified the soil profiles and depth of groundwater. The depth of groundwater ranged from 7 to 9 feet (ft) below ground surface (bgs). This hydrogeologic report does not include the results of MDE's field investigation.

Per the recommendation of Dr. Tien, EA conducted two additional infiltration tests at a depth of approximately 18 inches (in.) bgs. This second field testing event was conducted on 1 August 2008 (Testing Locations S-4 and S-5).

The following report includes the results of the EA field investigations, photo logs, soil boring logs, infiltration data sheets, calculation rates, and graphs.

2. SITE LOCATION AND DESCRIPTION

The Willard Farm property, identified as a potential site for spray irrigation, is shown on Tax Map 40 Parcel 72, located to the northwest of Newark Road and east of the Maryland Delaware Railroad in Newark, Maryland (Figure 1-1). The areal extent of the site is 42 acres. The site is accessed via an unpaved access road from Newark Road. The property consists of a flat open farm field with dense forest along the northern, eastern, and southern property boundaries. The property is currently used by the owner for hay/straw harvesting. The proposed use for the site is to serve as a spray irrigation disposal site for the treated wastewater from the Newark WWTP.

WILLARDS FARM SPRAY IRRIGATION SITE NEWARK MD	SITE PLAN	DESIGNED BY PEL	DRAWN BY JPK	DATE August 2008	PROJECT NO 14450 01
		CHECKED BY DOK	PROJECT MGR. DOK	SCALE 1" = 200'	FIGURE 1-1

3. DESCRIPTION OF LAND-TREATMENT TECHNIQUES

The Newark municipal WWTP is owned and operated by Worcester County Department of Public Works. The WWTP consists of an aerated treatment lagoon, which is divided into two cells. The first cell receives the municipal wastewater which then travels under a baffle/division wall into a second cell. Chlorination occurs in the second cell and the wastewater flows through a chlorine contact tank. Finally, the wastewater is dechlorinated and is discharged via surface flow to an unnamed tributary of Marshall Creek. The Newark WWTP achieves secondary treatment levels and is currently permitted to discharge up to a maximum of 70,000 gallons per day (gpd).

The WWTP operates under Maryland State Discharge Permit No. MD 0020630 and National Pollutant Discharge Elimination System (NPDES) Permit No. 05-DP-0141.

Currently, the Newark WWTP discharges approximately 35,000 to 70,000 gpd of treated wastewater. The County is considering options for spray irrigation on the nearby Willard Farm property to modify the existing system and to eliminate the surface water discharge, thereby reducing nutrients discharged to Newport Bay.

4. GEOLOGY, SOILS, AND HYDROLOGY

4.1 SOILS

The major soils present on this site are as follows: Mettapex fine sandy loam, 0 to 2 percent slopes (MpA), approximately 60 percent of the site; Nassawango silt loam, 0 to 2 percent slopes (NsA), approximately 30 percent of the site; and Nassawango silt loam, 2 to 5 percent slopes (NsB), approximately 8 percent of the site. The remaining 2 percent of the site is composed of other soils such as Othello silt loam (Ot), Fallsington sandy loam (Fa), and Metapeake silt loam, 0 to 2 percent slopes (MkB). The list of the soil mapping units is summarized in Table 4-1 below. Figure 4-1 provides a map of the site soils within and surrounding the Willard Farm property boundary.

TABLE 4-1 LIST OF SOIL MAPPING UNITS

Map Unit Symbol	Map Unit Name	Acres (approx.)*	Percent of Site
MpA	Mettapex fine sandy loam, 0 to 2 percent slopes	13.84	45.5
NsA	Nassawango silt loam, 0 to 2 percent slopes	8.4	27.6
NsB	Nassawango silt loam, 2 to 5 percent slopes	5.82	19.1
Ot, GaC, MdB, and Ma	Othello silt loam, Galestown loamy sand, Metapeake silt loam, and Manahawkin Muck, respectively	0.84	7.8

*Areas are based on the spray field and do not include the area of the 100-ft buffer.

According to the United States Department of Agriculture (USDA), Natural Resources Conservation Services (NRCS), National Survey Handbook, title 430-VI. (http://soils.usda.gov/), Mettapex fine sand loam (MpA) is classified as moderately high to high, with an average infiltration rate between 0.20 to 1.98 inches per hour (in./hr), and classified as well drained soils. Nassawango silt, at both 0 to 2 percent and 2 to 5 percent slopes, are also classified as well drained soils.

Soil boring logs for Testing Locations S-1 through S-3 were prepared and are presented in Appendix A. At location S-1, silt with trace fine sand and organics, light olive brown, was observed from 6 to 16 in. bgs. Silt fine sand with organics and trace clay, yellowish brown dry,

WILLARDS FARM SPRAY IRRIGATION SITE NEWARK, MD	SOILS MAP	DESIGNED BY PEL	DRAWN BY JPK	DATE August 2008	PROJECT NO 14450.01
		CHECKED BY DOK	PROJECT MGR DOK	SCALE 1" = 200'	FIGURE 4-1

loose and homogenous, was present from 16 to 32 in. bgs. From 32 to 51 in bgs silty fine sand, brownish yellow, dry, clay fine sand and clay and sand were observed.

At location S-2, silt with trace fine sand and organics, light yellowish brown dry, soft, homogeneous, were observed from 6 to 14 in bgs. Silt with little fine sand and organics, pale yellow dry, soft, homogeneous, was present from 14 to 32 in. bgs. Silty sand with clay, light yellowish brown (2.5Y 6/3), dry fine sand was present from 32 to 38 in. Well sorted fine sand with little silt, pale yellow (2.5Y 7/4), dry, very loose, homogeneous, was observed from 38 to 47 in.

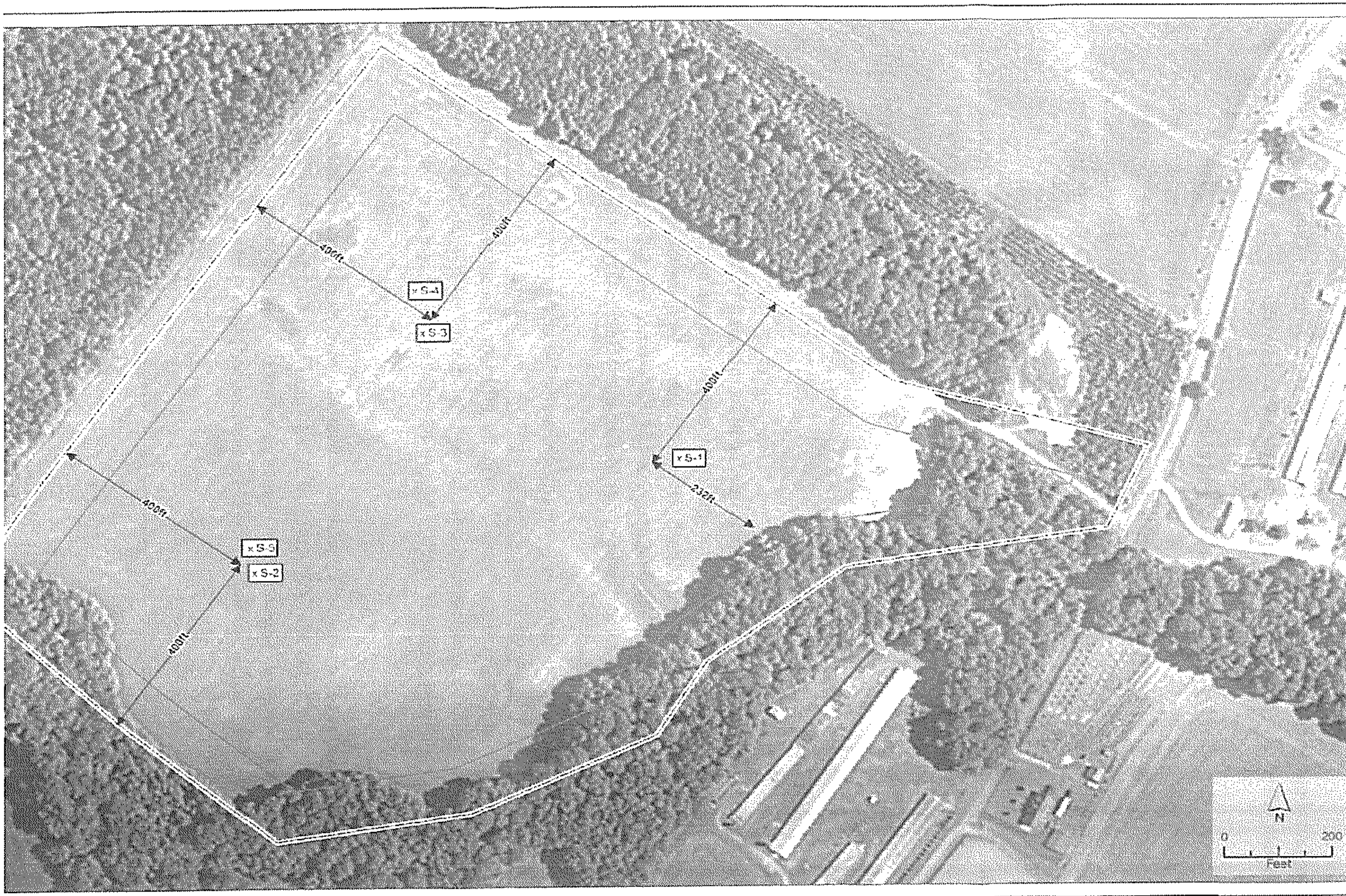
At location S-3, silt with trace fine sand and organics, light olive brown (2.5Y 5/4), dry, soft, homogeneous, was observed from 6 to 22 in bgs, and clay with little silt, light olive gray (5Y 6/2), dry, medium, homogeneous, was observed from 22 to 40 in. bgs. Well sorted fine sand with little silt, light yellowish brown (2.5Y 6/4), dry, very loose, homogeneous, was observed from 40 to 47 in bgs.

4.2 HYDROLOGY

Infiltration testing was conducted to determine the field-measured infiltration rate of water into the soil for spray irrigation. A total of three infiltration tests were completed on the Willard Farm property on 15 and 16 July 2008. Each test was conducted for approximately 4 hours' duration. Test S-1 was located in the field to the west of the entrance, test S-2 was located in the field to the north of the entrance, and test S-3 was located in the field to the east of the entrance.

Two additional tests were conducted on 1 August 2008 on the Willard Farm property and identified as S-4 and S-5. Per the recommendation of MDE, tests S-4 and S-5 were conducted at a depth of approximately 18 in. bgs to better evaluate the infiltration capacity, absent any of the upper soil layers. Test S-4 was conducted adjacent to the location of test S-3, and test S-5 was conducted adjacent to the location of test S-2. Figure 4-2 illustrates the locations of the infiltration tests.

The infiltration testing was conducted in accordance with American Society for Testing and Materials (ASTM) Standard D 3385-03, *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer.* Hand augering was also completed to approximately 4 ft bgs at the test locations to observe and log the soil conditions and characteristics in these areas, as discussed previously.



WILLARDS FARM SPRAY IRRIGATION SITE NEWARK, MD	SITE MAP INFILTRATION TEST LOCATIONS	DESIGNED BY PEL	DRAWN BY JPK	DATE August 2008	PROJECT NO 14450.01
		CHECKED BY DOK	PROJECT MGR DOK	SCALE 1" = 200'	FIGURE 4-2

4.3 DOUBLE RING INFILTROMETER SPECIFICATIONS AND FIELD METHODOLOGY

The double ring infiltrometer, *Turf-Tec Model IN10-W*, consisted of two stainless steel rings. The inner ring was 20 in. in height and the outer ring was 20 in. in height. The inner ring had an inside diameter (ID) of 12 in. and the outer ring had an ID of 24 in. The area of the inner ring was 729 square centimeters (cm^2). The annular space (area) between the inner ring and the outer ring was 2,190 cm^2. The double ring infiltrometer was hammered into the soil with the inner ring driven 6.0 in. into the soil and the outer ring driven 6.0 in. into the soil. Water was poured into the rings to 10 in. from bottom to approximately ¾ to the top of each ring. Water was supplied manually to maintain a constant head within the infiltrometer using a graduated cylinder. Measurements of the water added were recorded at intervals of 5, 10, 15, and 30 minutes. The data sheets for the field test are presented in Appendix B. Photograph documentation of the double ring infiltrometer field tests and soils identified in the soil boring logs were maintained during each testing event and are presented in Appendix C.

4.4 SOIL INFILTRATION RATE EQUATIONS AND CALCULATIONS

The following equations were utilized to determine infiltration rates, as referenced in the ASTM standards:

For the inner ring:

$$V_{ir}=?\ V_{ir}/A_{ir}*?\ t)$$

where:

V_{ir}	=	inner ring incremental infiltration rate in cm/hr
$?\ V_{ir}$	=	volume of the liquid used during time interval to maintain constant head in the inner ring, cm^3
A_{ir}	=	internal area of the inner ring, cm^2
$?\ t$	=	time interval, h

For the outer ring:

$$V_a=?\ V_a/A_a*?\ t)$$

where:

V_a	=	annular space incremental infiltration rate in cm/hr
$?\ V_a$	=	volume of the liquid used during time interval to maintain constant head in the annular space between rings, cm^3
A_a	=	internal area of the inner ring, cm^2
$?\ t$	=	time interval, h

The calculations for each test site are provided in Appendix D.

5. SUMMARY OF HYDROGEOLOGIC REPORT

5.1 INFILTRATION RATES

Average infiltration rates and late time infiltration rates were calculated for each location, as shown in Appendix D. The results of the calculations are summarized in the infiltration rates presented in Table 5-1. Graphical illustrations of the infiltration rates over time for each of the locations are provided in Appendix E. Referenced field methodology in the ASTM standards and *A Field Method for Measurement of Infiltration* (Johnson 1963) advise that inner ring infiltration rates data should be used as a measurement of *in situ* soil conditions.

TABLE 5-1 INFILTRATION RATES

Test Location	Average Inner Ring Infiltration	Late Time Inner Ring Infiltration	Average Outer Ring Infiltration	Late Time Outer Ring Infiltration
S-1	4.57 cm/hr 1.80 in./hr	0.79 cm/hr 0.31 in./hr	13.41 cm/hr 5.28 in./hr	2.03 cm/hr 0.80 in./hr
S-2	1.89 cm/hr 0.74 in./hr	0.58 cm/hr 0.23 in./hr	13.11 cm/hr 5.16 in./hr	2.08 cm/hr 0.82 in./hr
S-5*	0.23 cm/hr 0.09 in./hr	0.15 cm/hr 0.06 in./hr	1.46 cm/hr 0.58 in./hr	0.30 cm/hr 0.12 in./hr
S-3	2.18 cm/hr 0.86 in./hr	0.25 cm/hr 0.10 in./hr	2.87 cm/hr 1.13 in./hr	0.25 cm/hr 0.10 in./hr
S-4*	0.26 cm/hr 0.10 in./hr	0.02 cm/hr 0.01 in./hr	4.76 cm/hr 1.87 in./hr	1.60 cm/hr 0.63 in./hr

* Test Location S-5 was conducted adjacent to Test Location S-2, and Test Location S-4 was conducted adjacent to test location S-3.

The average infiltration rates for soil beneath the inner ring were 4.05 cm/hr (1.80 in./hr), 1.89 cm/hr (0.74 in./hr), and 2.18 cm/hr (0.86 in./hr) for S-1, S-2, and S-3, respectively. It should be noted that S-2 and S-3 contained similar lithology and thus yielded more similar infiltration rates. The lower inner ring infiltration rate observed at S-2 may have been due to its proximity to poorly drained soil area at the northwest part of the property. The outer ring was observed to have a substantially higher infiltration rate, comparable to S-1 and S-3. Slightly different lithology with a greater variation in sediment sizes was also observed at this location.

Test Locations S-4 and S-5 were conducted approximately 18 in. bgs and below the upper topsoil layer. The infiltration tests from S-4 and S-5 resulted in lower infiltration rates. The average infiltration rates for the soil beneath the inner ring were 0.26 cm/hr (0.10 in./hr) for S-4 and 0.23 cm/hr (0.09 in./hr) for S-5.

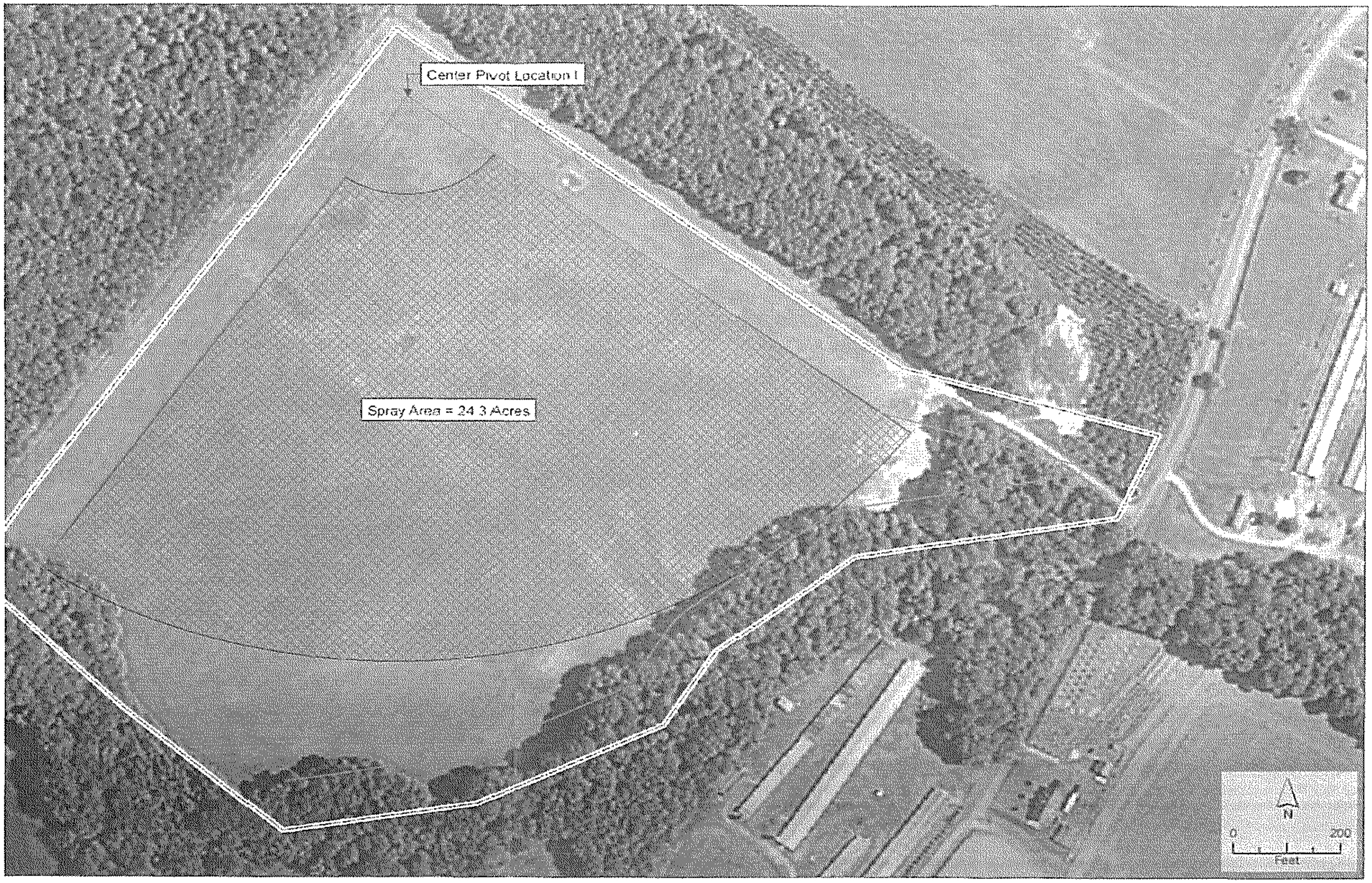
5.2 CONFIGURATIONS

The results of the infiltration tests indicate the presence of soils of lesser permeability in the northern corner of the site (S-4 area). To minimize the spray application in this area, two scenarios are proposed. First would be to position the center pivot unit in the northwestern corner of the site and eliminate the application rate for the first quarter of the arm of the central pivot unit. This would allow the maximum rate to be applied to a majority of the site in which the soils are predominantly more permeable. Figure 5-1 illustrates the location of the center pivot unit in the northern corner in this scenario. The second scenario would consist of locating the center pivot unit in the southern corner of the site. This will result in an arc of the center pivot unit to "cut-off" the corner of the site which consists of the lesser permeable soils. Figure 5-2 illustrates the location of the center pivot unit in the southern corner in this scenario. Further, the topography of the site promotes surface drainage from the north to the south

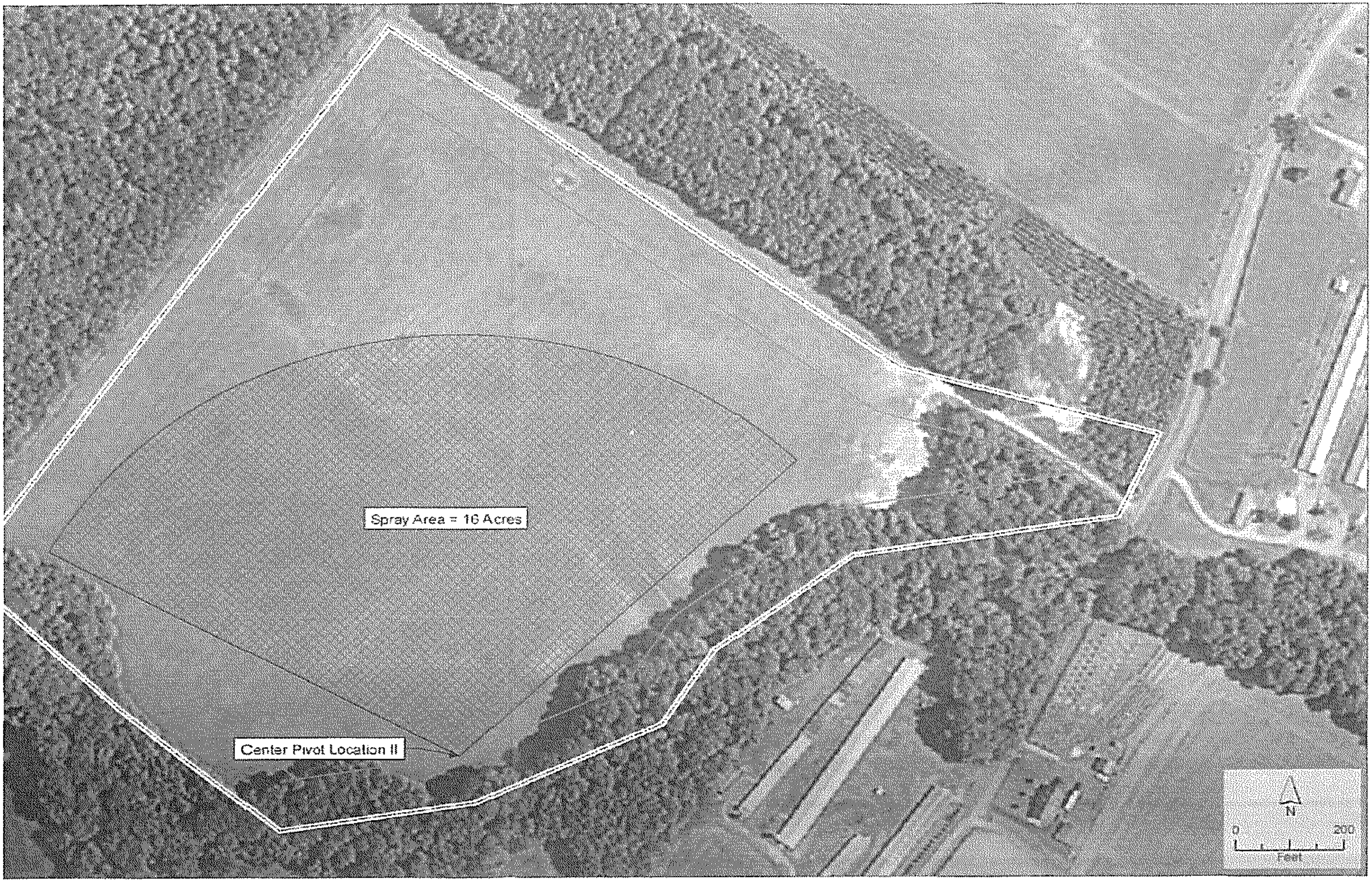
Both scenarios would utilize a single pivot, spray irrigation system on the Willard Property. A single pivot with a radius of 400 ft was estimated as a standard size of spray irrigation. The use of a 400-ft pivot will maximize the spray area, while still allowing a 100-ft buffer zone. The County anticipates the use of a 100-ft buffer based on the dense forestry surrounding the site, which will minimize odor migration and/or spray carry-over. The total area within the 100-ft buffer is approximately 36 acres. The useable spray area associated with the center pivot unit located in the northern corner of the Willard Farm would be approximately 24.3 acres. The location of the center pivot unit in the southern corner of the Willard Farm would result in a reduced spray area of 16 acres.

The proposed pivot would be installed at a location on the Willard Farm property, based on one of the two scenarios mentioned above, and would spray irrigate wastewater over a majority of the pivot radius.

In addition to a spray irrigation system consisting of a center pivot unit, a drip irrigation system also may be considered and could be designed to allow for the irrigation of treated wastewater over a larger area within the 100-ft buffer (i.e., >24.3 acres). The conceptual design and layout of an appropriate spray irrigation system, consisting of a slow release spray irrigation method, will be included with the permit application.



WILLARDS FARM SPRAY IRRIGATION SITE NEWARK, MD	PIVOT LOCATION I	DESIGNED BY PEL	DRAWN BY JPK	DATE August 2008	PROJECT NO 14450.01
		CHECKED BY DOK	PROJECT MGR DOK	SCALE 1" = 200'	FIGURE 5-1



WILLARDS FARM SPRAY IRRIGATION SITE NEWARK, MD	PIVOT LOCATION II	DESIGNED BY PEL	DRAWN BY JPK	DATE August 2008	PROJECT NO 14450 01
		CHECKED BY DOK	PROJECT MGR DOK	SCALE 1" = 200'	FIGURE 5-2

5.3 FLOWRATES

Using the measured infiltration rate for the inner ring at S-4, the *most restrictive* location, the application rate for the entire proposed spray irrigation system was evaluated. In this case, the late time infiltration rate was used (0.02 cm/hr or 0.01 in./hr) as a more conservative measure. Using the most conservative rate of 0.01 in./hr, and an area of approximately 24.3 acres (Pivot Location I), and accounting for an application rate of 4 percent of the steady infiltration rate, as specified in the MDE *Guidelines for Land Treatment of Municipal Wastewaters*, the calculated application flow rate would not be sufficient.

Therefore, the *average* infiltration rate of the more permeable areas of the site, which includes infiltration rates for locations S-1, S-2, and S-5, is 0.20 in./hr. Accounting for an application rate of 4 percent of the steady infiltration rate, as specified in the MDE *Guidelines for Land Treatment of Municipal Wastewaters*, this equates to an infiltration rate of approximately 1.34 inches per week (in./wk).

Using the 0.20 in./hr infiltration rate for the inner ring and applying this rate to the approximate 24.3 acres of available spray irrigation land (Pivot Location I), and accounting for an application rate of 4 percent of the steady infiltration rate, as specified in the MDE *Guidelines for Land Treatment of Municipal Wastewaters*, the calculated application flow rate would be approximately 127,000 gpd. Using the entire available space of 36 acres would result in an application flow rate of approximately 188,000 gpd. Given that the wastewater discharges at a rate of 50,000-60,000 gpd, the data indicate that the Willard Farm property would have sufficient capacity for this wastewater from the Newark WWTP, with available excess capacity.

5.4 NITROGEN BALANCE EQUATION

The calculation of the nitrogen balance was completed in accordance with MDE *Guidelines for Land Treatment of Municipal Wastewaters*. The objective of the calculation is to determine how much wastewater can be applied such that the soil leachate realized at the groundwater table will not exceed the Public Drinking Water Standard. Based on a conservative concentration of 25 milligrams per liter of Total Nitrogen from the treated wastewater from the Newark Plant, 2.27 acre-inches/acre-week is estimated as the wastewater loading. The nitrogen balance equation with assumptions is included in Appendix F.

5.5 CONCLUSION

Based on field testing completed and examination of site soils, it appears that the Willard Farm site could be used for groundwater discharge of the treated wastewater at an application rate of 1.34 in./wk. Utilizing the center pivot location illustrated in Figure 5-1, approximately 127,000 gpd could be discharged over the site while minimizing the application over the northern corner. To achieve this discharge rate, the site will need to be approved for a 100-ft buffer and will need to have adequate storage provided.

REFERENCES

American Society for Testing and Materials (ASTM). 2003. *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer*, D 3385-03.

Johnson, A.I. 1963. *A Field Method for Measurement of Infiltration*. U.S. Geological Survey Water Supply Paper 1544-F, USGPO, Washington, D.C.

Maryland Department of the Environment (MDE). 2003. *Guidelines for Land Treatment of Municipal Wastewaters*. MDE-WMA-001-07/03, Revised 7/2003.

APPENDIX A
SOIL BORING LOGS

EA Engineering, Science, and Technology, Inc

Job. No	14550.04
Client	Worcester County
Location:	Newark, MD
Drilling Method:	Hand Auger
Boring No.	S -1
Sampling Method:	N/A
Sheet	1 of 1

Area of Concern: Testing Location S-1

Location: Newark Spray Irrigation System

Reference Desc:

		Drilling Start	Drilling Finish
Water Level	N/A	NA	NA
Time			
Date	July 15, 2008		
Reference			

Sample Type	Inches Recvrd	Sample No.	PID ppm	Blow Count	Depth in Inches		USCS Log	Surface Conditions: Field
								0-6" SILT with organics, light olive brown (2.5Y 5/3), dry, very soft,
					6			homogeneous
							MH	6"-16" SILT with trace fine sand and organics, light olive brown
					12			(2.5Y 5/4), dry, soft, homogeneous
					18			16"-32" silty fine SAND with organics and trace clay, yellowis brown
								(10YR 5/6), dry, loose, homogeneous
					24			
					30			
								32"-51" silty fine SAND, brownish yellow (10YR 6/6), dry,
					36		SM	loose, homogeneous
					42			
					48			
					54			
								Boring terminated at 54" bgs

Logged by: Patrick Lorem & Barry Brooks

Date: July 15, 2008

Drilling Contractor: N/A

Driller: N/A

EA Engineering, Science, and Technology, Inc.	Job. No. 14550.04	Client: Worcester County	Location. Newark, MD	
	Drilling Method: Hand Auger		Boring No. S - 2	
Area of Concern: Testing Location S-2	Sampling Method: N/A		Sheet 1 of 1	
Location. Newark Spary Irrigation System			Drilling	
Reference Desc:	Water Level	N/A	Start	Finish
	Time		NA	NA
	Date	July 15, 2008		
	Reference			

Sample Type	Inches Recvrd	Sample No	PID ppm	Blow Count	Depth in Inches		USCS Log	Surface Conditions: Field
							MH	0-6" SILT with trace fine sand and organics, light olive gray (5Y 6/2)
					6			dry, very soft, homogeneous
								6"-14" SILT with trace fine sand and organics, light yellowish brown
					12			(2.5Y 6/4), dry, soft, homogeneous
								14"-32" SILT with little fine sand and organics, pale yellow (2.5YR 7/4)
					18			dry, soft, homogeneous
					24			
					30			
							SM	32"-38" silty SAND with clay, light yellowish brown (2.5Y 6/3), dry
					36			very loose, homogeneous
							SW	38"-47" well sorted fine sand with little silt, pale yellow (2.5Y 7/4), dry
					42			very loose, homogeneous
					47			
								Boring terminated at 47" bgs

Logged by:	Patrick Lorem & Barry Brooks	Date:	July 15, 2008
Drilling Contractor:	N/A	Driller	N/A

EA Engineering, Science, and Technology, Inc.	Job. No. 14550.04	Client: Worcester County	Location: Newark, MD
	Drilling Method: Hand Auger		Boring No. S-3
Area of Concern: Testing Location S-3	Sampling Method: N/A		Sheet 1 of 1
Location: Newark Spray Irrigation System			Drilling
Reference Desc:	Water Level: N/A		Start: NA / Finish: NA
	Time:		
	Date: July 15, 2008		
	Reference:		

Sample Type	Inches Recvrd	Sample No.	PID ppm	Blow Count	Depth in Inches		USCS Log	Surface Conditions: Field
							ML	0-6" SILT with trace fine sand and organics, olive (5Y 5/3), dry, soft,
					6			homogeneous
								6"-22" SILT with trace fine sand and organics, light olive brown
					12			(2.5Y 5/4), dry, soft, homogeneous
					18			
							CL	22"-40" CLAY with little silt, light olive gray (5Y 6/2), dry, medium,
					24			homogeneous
					30			
					36			
							SW	40"-47" well sorted fine SAND with little silt, light yellowish brown
					42			(2.5Y 6/4), dry, very loose, homogeneous
					47			
								Boring terminated at 47" bgs

Logged by: Patrick Lorem & Barry Brooks — Date: 16 July 2008

Drilling Contractor: N/A — Driller: N/A

APPENDIX B
INFILTRATION TESTING DATA SHEETS

APPENDIX B.1
INFILTRATION TESTING DATA SHEETS
(TESTING LOCATIONS S-1 THROUGH S-3
JULY 15 & 16 2008)

Project Idenification:	Newark Spray Irrigation		Constants	Area (cm^2)	Depth of liquid (in)	Volume/delta	
Test Location:	Willard Farm - S - 1		Inner Ring	980.3	10	113.11	
Liquid Used:	Regular Tap Water		Annular Spac	1,432.8	10	452.25	
Tested by:	Greg Gromicko, Darl Kolar, Patrick Lorem, Barry Brooks						
Depth to water table:	greater than 4-ft below grade		Penetration	Inner (in)	Outer (in)		
Ground Temperature:	84 degrees F		of Rings:	6	6		

Trial #	Date	Time	Elapsed Time	Flow Readings				Liquid Temp	Infiltration Rate		Remarks
			change in time/	Inner Ring		Annular Space			Inner Ring	Annular Space	
		hr:mm	time elapsed (min)	Reading (in)	Flow (in3)	Reading (in)	Flow (in3)	(Fahrenheit)	(in/h)	(in/h)	
1	7/15/08	1030	0	10.00		10.00					None
		1035	5	9.75	28.28	9.63	169.59	78	0.35	1.42	
2		1035	5	10.00		10.00					
		1040	10	9.75	28.28	9.75	113.06	77.5	0.35	0.95	
3		1040	5	10.00		10.00					
		1045	15	9.75	28.28	9.75	113.06	77	0.35	0.95	
4		1045	5	10.00		10.00					
		1050	20	9.75	28.28	9.75	113.06	77	0.35	0.95	
5		1050	5	10.00		10.00					
		1055	25	9.75	28.28	9.75	113.06	76	0.35	0.95	
6		1055	5	10.00		10.00					
		1100	30	9.81	21.21	9.81	84.80	76.5	0.26	0.71	
7		1100	10	10.00		10.00					
		1110	40	9.63	42.42	9.56	198.99	76	0.26	0.83	
8		1110	10	10.00		10.00					
		1120	50	9.75	28.28	9.75	113.06	76	0.17	0.47	
9		1120	10	10.00		10.00					
		1130	60	9.50	56.56	9.50	226.13	76	0.35	0.95	
10		1130	15	10.00		10.00					
		1145	75	9.56	49.77	9.44	254.39	76.5	0.20	0.71	
11		1145	15	10.00		10.00					
		1200	90	9.50	56.56	9.56	198.99	75.6	0.23	0.56	
12		1200	15	10.00		10.00					
		1215	105	9.63	42.42	9.63	169.59	76	0.17	0.47	
13		1215	15	10.00		10.00					
		1230	120	9.56	49.77	9.50	226.13	75.6	0.20	0.63	
14		1230	30	10.00		10.00					
		1300	150	9.31	78.05	9.31	312.05	76	0.16	0.44	
15		1300	30	10.00		10.00					
		1330	180	9.37	71.26	9.44	254.39	75	0.15	0.36	
16		1330	30	10.00		10.00					
		1400	210	9.37	71.26	9.37	284.92	75.5	0.15	0.40	
17		1400	30	10.00		10.00					
		1430	240	9.37	71.26	9.37	284.92	75	0.15	0.40	

Average Inner Ring Flow Rate	13 in3/min	0.056 gal/min
Average Outer Ring Flow Rate	54 in3/min	0.233 gal/min

						Constants	Area (cm^2)	Depth of liquid (in)	Volume/delta
Project Idenification:		Newark Spray Irrigation							
Test Location:		Willard Farm - S - 2				Inner Ring:	980.3	10	113.11
Liquid Used:		Regular Tap Water				Annular Spac	1,432.8	10	452.25
Tested by:		Greg Gromicko, Darl Kolar, Patrick Lorem, Barry Brooks							
Depth to water table:		greater than 4-ft below grade				Penetration	Inner (in)	Outer (in)	
Ground Temperature:		84 degrees F				of Rings:	6	6	

Trial #	Date	Time	Elapsed Time	Flow Readings				Liquid Temp	Infiltration Rate		Remarks
			change in time/	Inner Ring		Annular Space			Inner Ring	Annular Space	
		hr:mm	time elapsed (min)	Reading (in)	Flow (in3)	Reading (in)	Flow (in3)	(Fahrenheit)	(in/h)	(in/h)	
1	7/15/08	1510	0	10.00		10.00					None
		1515	5	10.00	0.00	9.75	113.06	78	0.00	0.95	
2		1515	5	10.00		10.00					
		1520	10	10.00	0.00	9.75	113.06	77.5	0.00	0.95	
3		1520	5	10.00		10.00					
		1525	15	9.75	28.28	9.50	226.13	77	0.35	1.89	
4		1525	5	10.00		10.00					
		1530	20	9.94	7.07	9.75	113.06	77	0.09	0.95	
5		1530	10	10.00		10.00					
		1540	30	9.75	28.28	9.50	226.13	76	0.17	0.95	
6		1540	15	10.00		10.00					
		1555	45	9.75	28.28	9.50	226.13	76.5	0.12	0.63	
7		1555	15	10.00		10.00					
		1610	60	9.44	63.62	9.25	339.19	76	0.26	0.95	
8		1610	30	10.00		10.00					
		1640	90	9.50	56.56	9.25	339.19	76	0.12	0.47	
9		1640	30	10.00		10.00					
		1710	120	9.50	56.56	9.25	339.19	76	0.12	0.47	
10		1710	30	10.00		10.00					
		1740	150	9.50	56.56	9.37	284.92	76.5	0.12	0.40	
11		1740	30	10.00		10.00					
		1810	180	9.50	56.56	9.37	284.92	75.6	0.12	0.40	
12		1810	30	10.00		10.00					
		1840	210	9.63	42.42	9.44	254.39	76	0.09	0.36	

Average Inner Ring Flow Rate 7 in3/min 0.031 gal/min

Average Outer Ring Flow Rate 48 in3/min 0.206 gal/min

Project Identification:	Newark Spray Irrigation	Constants	Area (cm^2)	Depth of liquid (in)	Volume/delta
Test Location:	Willard Farm - S -3	Inner Ring:	980.3	10	113.11
Liquid Used:	Regular Tap Water	Annular Space	1,432.8	10	452.25
Tested by:	Greg Gromicko, Darl Kolar, Patrick Lorem, Barry Brooks				
Depth to water table:	greater than 4-ft below grade	Penetration	Inner (in)	Outer (in)	
Ground Temperature:	84 degrees F	of Rings:	6	6	

Trial #	Date	Time	Elapsed Time	Flow Readings				Liquid Temp.	Infiltration Rate		Remarks
			change in time/	Inner Ring		Annular Space			Inner Ring	Annular Space	
		hr:mm	time elapsed (min)	Reading (in)	Flow (in3)	Reading (in)	Flow (in3)	(Fahrenheit)	(in/h)	(in/h)	
1	7/16/08	730	5	10.00		10.00					None
		735	5	9.75	28.28	9.75	113.06	78	0.35	0.95	
2		735	5	10.00		10.00					
		740	10	9.75	28.28	9.88	56.53	77.5	0.35	0.47	
3		740	10	10.00		10.00					
		750	20	9.81	21.21	9.94	28.27	77	0.13	0.12	
4		750	10	10.00		10.00					
		800	30	9.81	21.21	10.00	0.00	77	0.13	0.00	
5		800	15	10.00		10.00					
		815	45	9.75	28.28	9.94	28.27	76	0.12	0.08	
6		815	15	10.00		10.00					
		830	60	9.75	28.28	10.00	0.00	76.5	0.12	0.00	
7		830	30	10.00		10.00					
		900	90	9.63	42.42	9.88	56.53	76	0.09	0.08	
8		900	30	10.00		10.00					
		930	120	9.88	14.14	10.00	0.00	76	0.03	0.00	
9		930	30	10.00		10.00					
		1000	150	9.81	21.21	10.00	0.00	76	0.04	0.00	
10		1000	30	10.00		10.00					
		1030	180	9.75	28.28	9.94	28.27	76.5	0.06	0.04	
11		1030	30	10.00		10.00					
		1100	210	9.88	14.14	10.00	0.00	75.6	0.03	0.00	

Average Inner Ring Flow Rate	5 in3/min	0.020 gal/min
Average Outer Ring Flow Rate	5 in3/min	0.022 gal/min

APPENDIX B.2
INFILTRATION TESTING DATA SHEETS
(TESTING LOCATIONS S-4 AND S-5
AUGUST 1 2008)

Project Idenification:	Newark Spray Irrigation		**Constants**	Area (cm^2)	Depth of liquid (in)	Volume/delta
Test Location:	Willard Farm - S - 4		Inner Ring:	980.3	10	113.11
Liquid Used:	Regular Tap Water		Annular Spac	1,432.8	10	452.25
Tested by:	Patrick Lorem & Barry Brooks					
Depth to water table:	greater than 4-ft below grade		Penetration	Inner (in)	Outer (in)	
Ground Temperature:	82 degrees F		of Rings:	6	6	

Trial #	Date	Time	Elapsed Time	Flow Readings				Liquid Temp	Infiltration Rate		Remarks
			change in time/	Inner Ring		Annular Space			Inner Ring	Annular Space	
		hr:mm	time elapsed (min)	Reading (in)	Flow (in3)	Reading (in)	Flow (in3)	(Fahrenheit)	(in/h)	(in/h)	
1	8/1/08	945	0	10.00		10.00					None
		950	5	9.94	7.07	9.81	84.80	78	0.09	0.71	
2		950	10	10.00		10.00					
		1000	15	10.00	0.00	9.69	141.33	77.5	0.00	1.18	
3		1000	10	10.00		10.00					
		1010	25	10.00	0.00	9.81	84.80	77	0.00	0.36	
4		1010	10	10.00		10.00					
		1020	35	9.94	7.07	9.81	84.80	77	0.04	0.36	
5		1020	15	10.00		10.00					
		1035	50	9.94	7.07	9.69	141.33	76	0.03	0.39	
6		1035	15	10.00		10.00					
		1050	65	10.00	0.00	9.75	113.06	76.5	0.00	0.32	
7		1050	15	10.00		10.00					
		1105	80	9.94	7.07	9.69	141.33	76	0.03	0.39	
8		1105	30	10.00		10.00					
		1135	110	10.00	0.00	9.50	226.13	76	0.00	0.32	
9		1135	30	10.00		10.00					
		1205	140	9.94	7.07	9.50	226.13	76	0.01	0.32	
10		1205	30	10.00		10.00					
		1235	170	10.00	0.00	9.50	226.13	76.5	0.00	0.32	
11		1235	30	10.00		10.00					
		105	200	10.00	0.00	9.50	226.13	75.6	0.00	0.32	
12		105	30	10.00		10.00					
		135	230	10.00	0.00	9.50	226.13	76	0.00	0.32	

Average Inner Ring Flow Rate	1	in3/min	0.003	gal/min
Average Outer Ring Flow Rate	32	in3/min	0.139	gal/min

Project Identification:	Newark Spray Irrigation	Constants	Area (cm^2)	Depth of liquid (in)	Volume/delta
Test Location:	Willard Farm - S - 5	Inner Ring:	980.3	10	113.11
Liquid Used:	Regular Tap Water	Annular Spac	1,432.8	10	452.25
Tested by:	Patrick Lorem & Barry Brooks				
Depth to water table:	greater than 4-ft below grade	Penetration	Inner (in)	Outer (in)	
Ground Temperature:	82 degrees F	of Rings:	6	6	

Trial #	Date	Time	Elapsed Time	Flow Readings				Liquid Temp	Infiltration Rate		Remarks
			change in time/	Inner Ring		Annular Space			Inner Ring	Annular Space	
		hr:mm	time elapsed (min)	Reading (in)	Flow (in3)	Reading (in)	Flow (in3)	(Fahrenheit)	(in/h)	(in/h)	
1	8/1/08	230	0	10.00		10.00					None
		235	5	10.00	0.00	10.00	0.00	78	0.00	0.00	
2		235	10	10.00		10.00					
		245	15	9.88	14.14	9.94	28.27	77.5	0.09	0.12	
3		245	10	10.00		10.00					
		255	25	10.00	0.00	9.81	84.80	77	0.00	0.36	
4		255	15	10.00		10.00					
		310	40	9.88	14.14	9.81	84.80	77	0.06	0.24	
5		310	15	10.00		10.00					
		325	55	10.00	0.00	9.81	84.80	76	0.00	0.24	
6		325	30	10.00		10.00					
		355	85	9.88	14.14	9.81	84.80	76.5	0.03	0.12	
7		355	30	10.00		10.00					
		425	115	10.00	0.00	10.00	0.00	76	0.00	0.00	
8		425	30	10.00		10.00					
		455	145	10.00	0.00	9.94	28.27	76	0.00	0.04	
9		455	30	10.00		10.00					
		525	175	9.75	28.28	9.88	56.53	76	0.06	0.08	
10		525	30	10.00		10.00					
		555	205	10.00	0.00	10.00	0.00	76.5	0.00	0.00	
11		555	30	10.00		10.00					
		625	235	9.75	28.28	9.88	56.53	75.6	0.06	0.08	
12		625	30	10.00		10.00					
		655	265	9.88	28.28	9.88	56.53	76	0.06	0.08	

Average Inner Ring Flow Rate	2 in3/min	0.009 gal/min
Average Outer Ring Flow Rate	9 in3/min	0.041 gal/min

APPENDIX C
PHOTOGRAPH LOG

APPENDIX C.1
PHOTOGRAPH LOG
(TESTING LOCATIONS S-1 THROUGH S-3
JULY 15 & 16 2008)

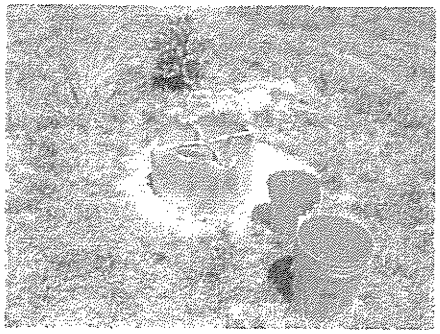


Photo 1. View of infiltrometer, graduated cylinder & refilling bucket at testing location S-1

Photo 2. Installation of double ring infiltrometer at testing location S-1

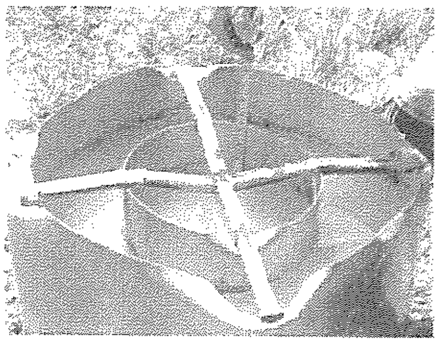


Photo 3. Infiltrometer, filled with water, readings taken from outer ring at testing location S-1

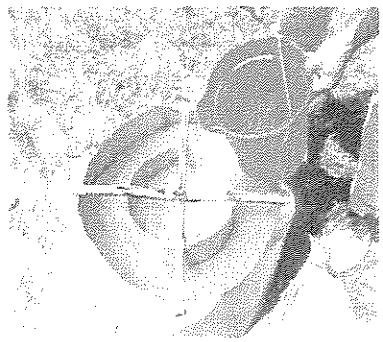


Photo 4. View of double ring infiltrometer refilling of outer Ring at testing location S-1

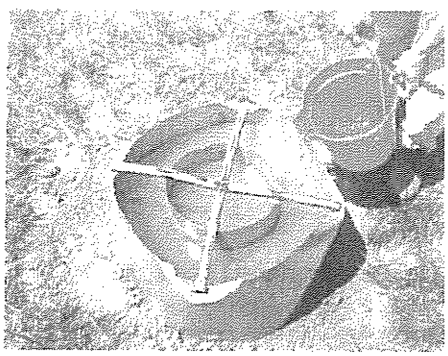


Photo 5: View of double ring infiltrometer refilling of outer Ring at Testing location S-1

Photo 6 View of hand augering at testing location S-1.

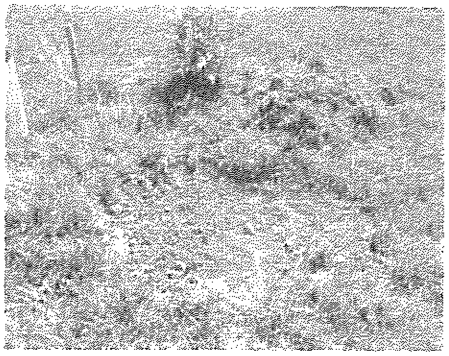


Photo 7 View of testing surface preparation at Testing location S-2 looking North

Photo 8: View of hand augering at testing location S-2 looking west.

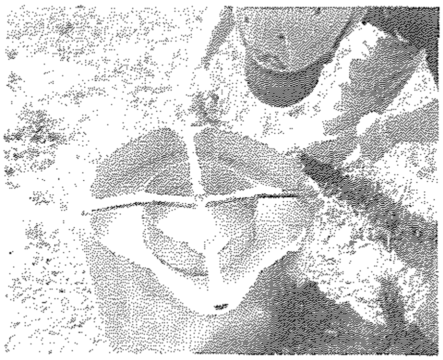


Photo 9 Infiltrometer, filled with water, reading taken from inner ring at testing location S-2

Photo 10: View of hand augering at testing location S-3 looking west

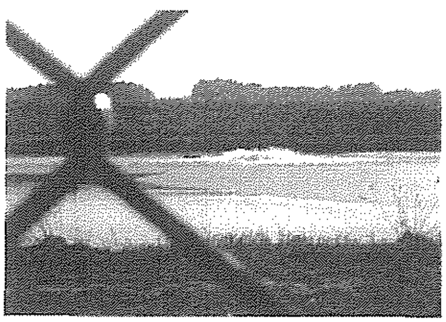


Photo 11 View of storage lagoon about 1.1 miles from the WWTP Willard's Farm

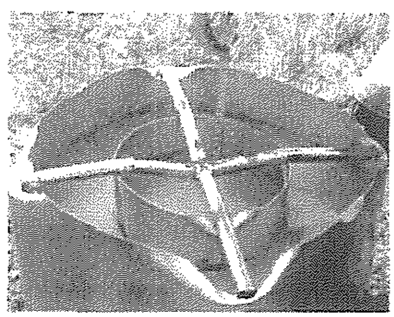


Photo 12: Infiltrometer, filled with water, readings taken from inner ring at testing location S-3

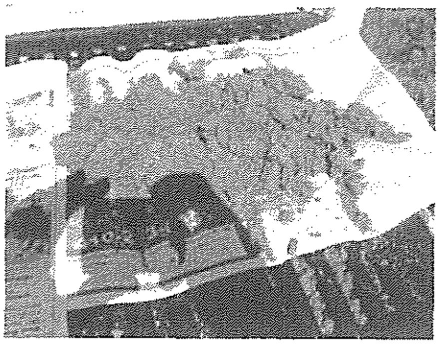


Photo 13: View of Top soil about 6" of depth at testing location S-1

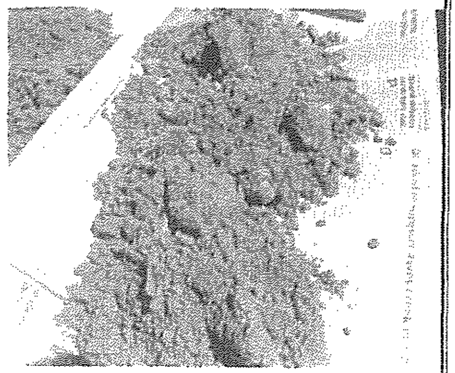


Photo 14: View of bottom soil about 51" of depth at testing location S-1

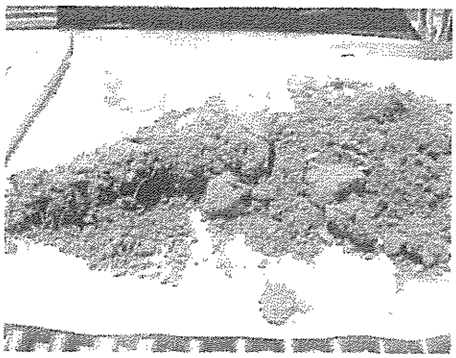


Photo 15: View of Top soil about 6" of depth at testing location S-2

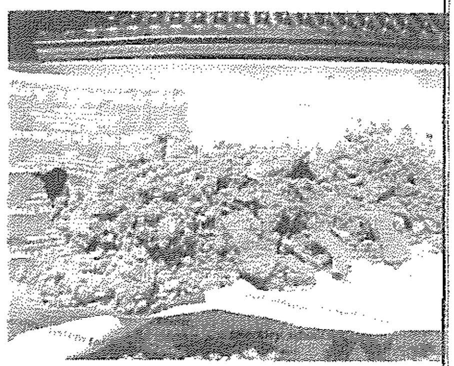


Photo 16: View of bottom soil about 48" of depth at testing location S-2

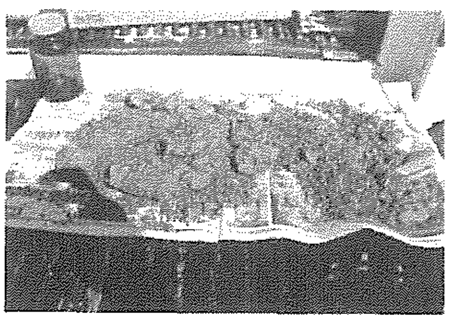


Photo 17: View of Top soil about 6" of depth at testing location S-3

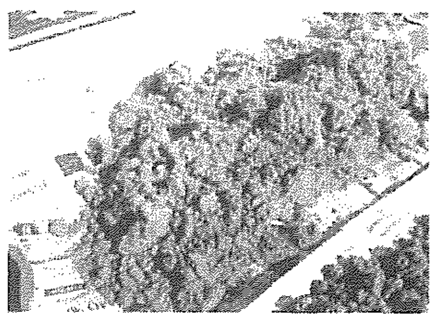


Photo 18: View of bottom soil about 47" of depth at testing location S-3

APPENDIX C.2
PHOTOGRAPH LOG
(TESTING LOCATIONS S-4 AND S-5
AUGUST 1 2008)

Photo 1: View of testing preparation at testing location S-4 looking South

Photo 2: Installation of double ring infiltrometer at testing location S-4

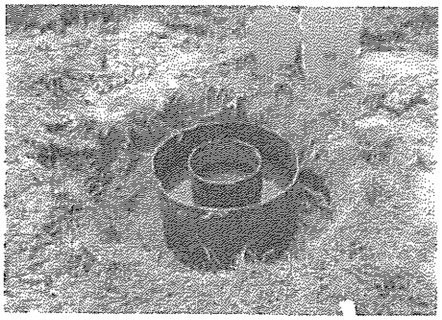


Photo 3: View of infiltrometer, filled with water at testing location S-4

Photo 4: View of testing preparation at testing location S-5 looking South

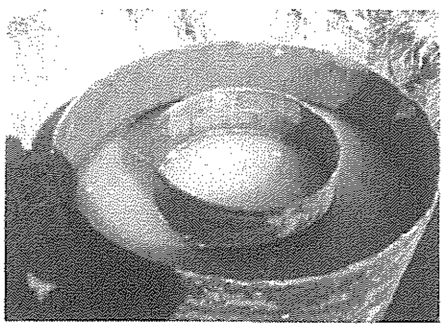


Photo 5: View of infiltrometer, filled with water at testing location S-5

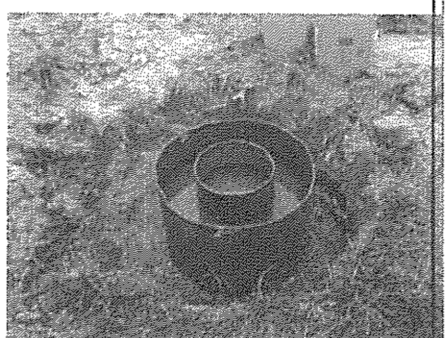


Photo 6: View of infiltrometer, filled with water at testing location S-5

APPENDIX D
INFILTRATION RATE CALCULATIONS

APPENDIX D.1
INFILTRATION RATE CALCUALTIONS
(TESTING LOCATIONS S-1 THROUGH S-3
JULY 15 & 16 2008)

TESTING LOCATION S-1

INFILTRATION RATE CALCULATIONS
INNER RING

(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
28.28	980.3	5	0.0833	1035	0.35	0.0058	0.000096
28.28	980.3	5	0.0833	1040	0.35	0.0058	0.000096
28.28	980.3	5	0.0833	1045	0.35	0.0058	0.000096
28.28	980.3	5	0.0833	1050	0.35	0.0058	0.000096
28.28	980.3	5	0.0833	1055	0.35	0.0058	0.000096
21.21	980.3	5	0.0833	1100	0.26	0.0043	0.000072
42.42	980.3	10	0.1667	1110	0.26	0.0043	0.000072
28.28	980.3	10	0.1667	1120	0.17	0.0029	0.000048
56.56	980.3	10	0.1667	1130	0.35	0.0058	0.000096
48.77	980.3	15	0.2500	1145	0.20	0.0033	0.000055
56.56	980.3	15	0.2500	1200	0.23	0.0038	0.000064
42.42	980.3	15	0.2500	1215	0.17	0.0029	0.000048
49.77	980.3	15	0.2500	1230	0.20	0.0034	0.000056
78.05	980.3	30	0.5000	1300	0.16	0.0027	0.000044
71.26	980.3	30	0.5000	1330	0.15	0.0024	0.000040
71.26	980.3	30	0.5000	1400	0.15	0.0024	0.000040
71.26	980.3	30	0.5000	1430	0.15	0.0024	0.000040

Average 1.79 in/hr or 4.54 cm/hr

Late Time 0.30 in/hr or 0.76 cm/hr

(Yellow = Late time)
Last 2 hrs

INFILTRATION RATE CALCULATIONS
ANNULAR SPACE RING

(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
169.59	1432.8	5	0.0833	1035	1.42	0.0237	0.000395
113.06	1432.8	5	0.0833	1040	0.95	0.0158	0.000263
113.06	1432.8	5	0.0833	1045	0.95	0.0158	0.000263
113.06	1432.8	5	0.0833	1050	0.95	0.0158	0.000263
113.06	1432.8	5	0.0833	1055	0.95	0.0158	0.000263
84.8	1432.8	5	0.0833	1100	0.71	0.0118	0.000197
198.99	1432.8	10	0.1667	1110	0.83	0.0139	0.000231
113.06	1432.8	10	0.1667	1120	0.47	0.0079	0.000132
226.13	1432.8	10	0.1667	1130	0.95	0.0158	0.000263
254.39	1432.8	15	0.2500	1145	0.71	0.0118	0.000197
198.99	1432.8	15	0.2500	1200	0.56	0.0093	0.000154
169.59	1432.8	15	0.2500	1215	0.47	0.0079	0.000132
226.13	1432.8	15	0.2500	1230	0.63	0.0105	0.000175
312.05	1432.8	30	0.5000	1300	0.44	0.0073	0.000121
254.39	1432.8	30	0.5000	1330	0.36	0.0059	0.000099
284.92	1432.8	30	0.5000	1400	0.40	0.0066	0.000110
284.92	1432.8	30	0.5000	1430	0.40	0.0066	0.000110

Average 5.27 in/hr or 13.39 cm/hr

Late Time 0.91 in/hr or 2.31 cm/hr

(Yellow = Late time)
Last 2 hrs

where:

V = Incremental infiltration rate

(delta)V = Volume of liquid used during time interval to maintain constant head

A = Internal area of the inner ring of the annular space

(delta)t = Time interval

TESTING LOCATION S-2

INFILTRATION RATE CALCULATIONS
INNER RING

(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hhmm	in/hr	in/min	in/sec
0.00	980.3	5	0.0833	1515	0.00	0.0000	0.000000
0.00	980.3	5	0.0833	1520	0.00	0.0000	0.000000
28.28	980.3	5	0.0833	1525	0.35	0.0058	0.000096
7.07	980.3	5	0.0833	1530	0.09	0.0014	0.000024
28.28	980.3	10	0.1667	1540	0.17	0.0029	0.000048
28.28	980.3	15	0.2500	1555	0.12	0.0019	0.000032
63.62	980.3	15	0.2500	1610	0.26	0.0043	0.000072
56.56	980.3	30	0.5000	1640	0.12	0.0019	0.000032
56.56	980.3	30	0.5000	1710	0.12	0.0019	0.000032
56.56	980.3	30	0.5000	1740	0.12	0.0019	0.000032
56.56	980.3	30	0.5000	1810	0.12	0.0019	0.000032
42.42	980.3	30	0.5000	1840	0.09	0.0014	0.000024

Average 0.73 in/hr or 1.86 cm/hr

Late Time 0.22 in/hr or 0.55 cm/hr

(Yellow = Late time)
Last 2 hrs

INFILTRATION RATE CALCULATIONS
ANNULAR SPACE RING

(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hhmm	in/hr	in/min	in/sec
113.06	1432.8	5	0.0833	1035	0.95	0.0158	0.000263
113.06	1432.8	5	0.0833	1040	0.95	0.0158	0.000263
226.13	1432.8	5	0.0833	1045	1.89	0.0316	0.000526
113.06	1432.8	5	0.0833	1050	0.95	0.0158	0.000263
226.13	1432.8	10	0.1667	1055	0.95	0.0158	0.000263
226.13	1432.8	15	0.2500	1100	0.63	0.0105	0.000175
339.19	1432.8	15	0.2500	1110	0.95	0.0158	0.000263
339.19	1432.8	30	0.5000	1120	0.47	0.0079	0.000132
339.19	1432.8	30	0.5000	1130	0.47	0.0079	0.000132
284.92	1432.8	30	0.5000	1145	0.40	0.0066	0.000110
284.92	1432.8	30	0.5000	1200	0.40	0.0066	0.000110
254.39	1432.8	30	0.5000	1215	0.36	0.0059	0.000099

Average 5.16 in/hr or 13.09 cm/hr

Late Time 0.81 in/hr or 2.06 cm/hr

(Yellow = Late time)
Last 2 hrs

where:

V = Incremental infiltration rate

(delta)V = Volume of liquid used during time interval to maintain constant head

A = Internal area of the inner ring of the annular space

(delta)t = Time interval

TESTING LOCATION S-3

INFILTRATION RATE CALCULATIONS
INNER RING

(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
28.28	980.3	5	0.0833	735	0.35	0.0058	0.000096
28.28	980.3	5	0.0833	740	0.35	0.0058	0.000096
21.21	980.3	10	0.1667	750	0.13	0.0022	0.000036
21.21	980.3	10	0.1667	800	0.13	0.0022	0.000036
28.28	980.3	15	0.2500	815	0.12	0.0019	0.000032
28.28	980.3	15	0.2500	830	0.12	0.0019	0.000032
42.42	980.3	30	0.5000	900	0.09	0.0014	0.000024
14.14	980.3	30	0.5000	930	0.03	0.0005	0.000008
21.21	980.3	30	0.5000	1000	0.04	0.0007	0.000012
28.28	980.3	30	0.5000	1030	0.06	0.0010	0.000016
14.14	980.3	30	0.5000	1100	0.03	0.0005	0.000008

Average 0.85 in/hr or 2.15 cm/hr

Late Time 0.08 in/hr or 0.20 cm/hr

(Yellow = Late time)
Last 2 hrs

INFILTRATION RATE CALCULATIONS
ANNULAR SPACE RING

(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
113.06	1432.8	5	0.0833	735	0.95	0.0158	0.000263
56.53	1432.8	5	0.0833	740	0.47	0.0079	0.000132
28.27	1432.8	10	0.1667	750	0.12	0.0020	0.000033
0.00	1432.8	10	0.1667	800	0.00	0.0000	0.000000
28.27	1432.8	15	0.2500	815	0.08	0.0013	0.000022
0.00	1432.8	15	0.2500	830	0.00	0.0000	0.000000
56.53	1432.8	30	0.5000	900	0.08	0.0013	0.000022
0.00	1432.8	30	0.5000	930	0.00	0.0000	0.000000
0.00	1432.8	30	0.5000	1000	0.00	0.0000	0.000000
28.27	1432.8	30	0.5000	1030	0.04	0.0007	0.000011
0.00	1432.8	30	0.5000	1100	0.00	0.0000	0.000000

Average 1.13 in/hr or 2.87 cm/hr

Late Time 0.02 in/hr or 0.05 cm/hr

(Yellow = Late time)
Last 2 hrs

where:

V = Incremental infiltration rate
(delta)V = Volume of liquid used during time interval to maintain constant head
A = Internal area of the inner ring of the annular space
(delta)t = Time interval

APPENDIX D.2
INFILTRATION RATE CALCULATIONS
(TESTING LOCATIONS S-4 AND S-5
AUGUST 1 2008)

TESTING LOCATION S-4			INFILTRATION RATE CALCULATIONS INNER RING				
(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
7.07	980.3	5	0.0833	1035	0.09	0.0014	0.000024
0.00	980.3	10	0.1667	1040	0.00	0.0000	0.000000
0.00	980.3	10	0.1667	1045	0.00	0.0000	0.000000
7.07	980.3	10	0.1667	1050	0.04	0.0007	0.000012
7.07	980.3	15	0.2500	1055	0.03	0.0005	0.000008
0.00	980.3	15	0.2500	1100	0.00	0.0000	0.000000
7.07	980.3	15	0.2500	1110	0.03	0.0005	0.000008
0.00	980.3	30	0.5000	1120	0.00	0.0000	0.000000
7.00	980.3	30	0.5000	1130	0.01	0.0002	0.000004
0.00	980.3	30	0.5000	1145	0.00	0.0000	0.000000
0.00	980.3	30	0.5000	1200	0.00	0.0000	0.000000
0.00	980.3	30	0.5000	1201	0.00	0.0000	0.000000

Average 0.10 in/hr or 0.26 cm/hr

Late Time 0.01 in/hr or 0.02 cm/hr (Yellow = Late time) Last 2 hrs

INFILTRATION RATE CALCULATIONS INNER RING							
(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
84.8	1432.8	5	0.0833	1035	0.71	0.0118	0.000197
141.33	1432.8	10	0.1667	1040	0.59	0.0099	0.000164
84.8	1432.8	10	0.1667	1045	0.36	0.0059	0.000099
84.8	1432.8	10	0.1667	1050	0.36	0.0059	0.000099
141.33	1432.8	15	0.2500	1055	0.39	0.0066	0.000110
113.06	1432.8	15	0.2500	1100	0.32	0.0053	0.000088
141.33	1432.8	15	0.2500	1110	0.39	0.0066	0.000110
226.13	1432.8	30	0.5000	1120	0.32	0.0053	0.000088
226.13	1432.8	30	0.5000	1130	0.32	0.0053	0.000088
226.13	1432.8	30	0.5000	1145	0.32	0.0053	0.000088
226.13	1432.8	30	0.5000	1200	0.32	0.0053	0.000088
226.13	1432.8	30	0.5000	1215	0.32	0.0053	0.000088

Average 1.87 in/hr or 4.76 cm/hr

Late Time 0.63 in/hr or 1.60 cm/hr (Yellow = Late time) Last 2 hrs

where:

V = Incremental infiltration rate

(delta)V = Volume of liquid used during time interval to maintain constant head

A = Internal area of the inner ring of the annular space

(delta)t = Time interval

TESTING LOCATION S-5			INFILTRATION RATE CALCULATIONS INNER RING				
(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
0.00	980.3	5	0.0833	1035	0.00	0.0000	0.000000
14.14	980.3	10	0.1667	1040	0.09	0.0014	0.000024
0.00	980.3	10	0.1667	1045	0.00	0.0000	0.000000
14.14	980.3	15	0.2500	1050	0.06	0.0010	0.000016
0.00	980.3	15	0.2500	1055	0.00	0.0000	0.000000
14.14	980.3	30	0.5000	1100	0.03	0.0005	0.000008
0.00	980.3	30	0.5000	1110	0.00	0.0000	0.000000
0.00	980.3	30	0.5000	1120	0.00	0.0000	0.000000
28.28	980.3	30	0.5000	1130	0.06	0.0010	0.000016
0.00	980.3	30	0.5000	1145	0.00	0.0000	0.000000
28.28	980.3	30	0.5000	1200	0.06	0.0010	0.000016

Average 0.09 in/hr or 0.23 cm/hr

ate Time 0.06 in/hr or 0.15 cm/hr (Yellow = Late time) Last 2 hrs

INFILTRATION RATE CALCULATIONS INNER RING							
(delta)V_{ir}	A_{ir}	time (t)	time (t)	Time	V_{ir}	V_{ir}	V_{ir}
in^3	in^2	min	hr	hh:mm	in/hr	in/min	in/sec
0	1432.8	5	0.0833	1035	0.00	0.0000	0.000000
28.27	1432.8	10	0.1667	1040	0.12	0.0020	0.000033
84.8	1432.8	10	0.1667	1045	0.36	0.0059	0.000099
84.8	1432.8	15	0.2500	1050	0.24	0.0039	0.000066
84.8	1432.8	15	0.2500	1055	0.24	0.0039	0.000066
84.8	1432.8	30	0.5000	1100	0.12	0.0020	0.000033
0	1432.8	30	0.5000	1110	0.00	0.0000	0.000000
28	1432.8	30	0.5000	1120	0.04	0.0007	0.000011
56.53	1432.8	30	0.5000	1130	0.08	0.0013	0.000022
0	1432.8	30	0.5000	1145	0.00	0.0000	0.000000
56.53	1432.8	30	0.5000	1200	0.08	0.0013	0.000022
56.53	1432.8	30	0.5000	1201	0.08	0.0013	0.000022

Average 0.58 in/hr or 1.46 cm/hr (Yellow = Late time)

ate Time 0.12 in/hr or 0.30 cm/hr Last 2 hrs

where:

V = Incremental infiltration rate

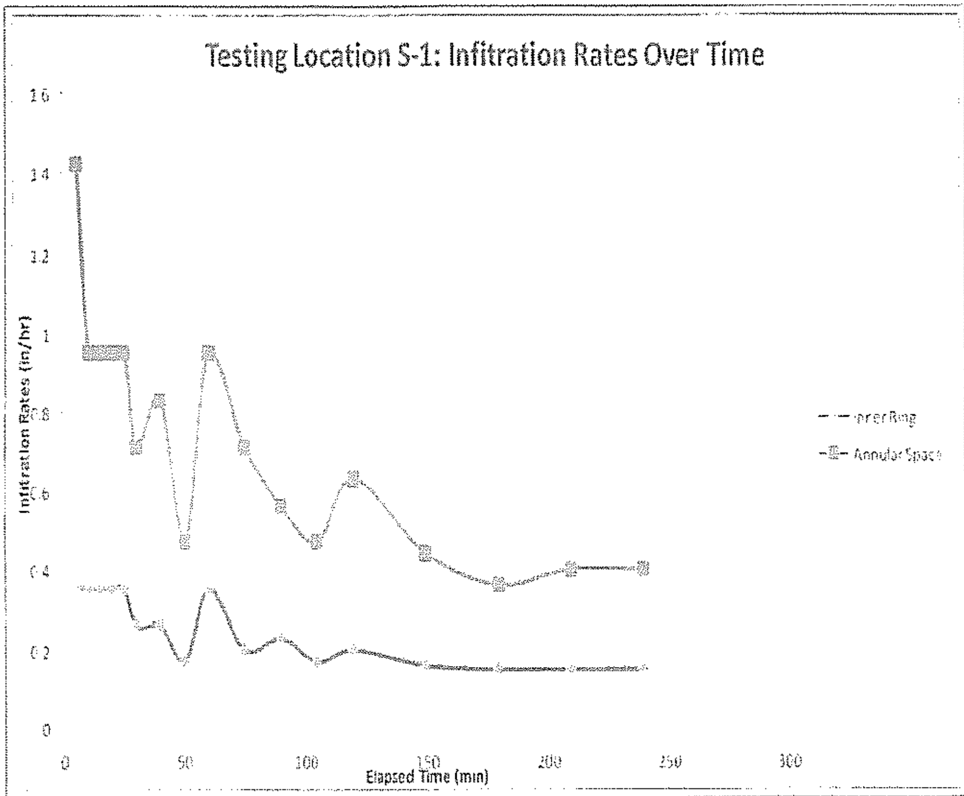
(delta)V = Volume of liquid used during time interval to maintain constant head

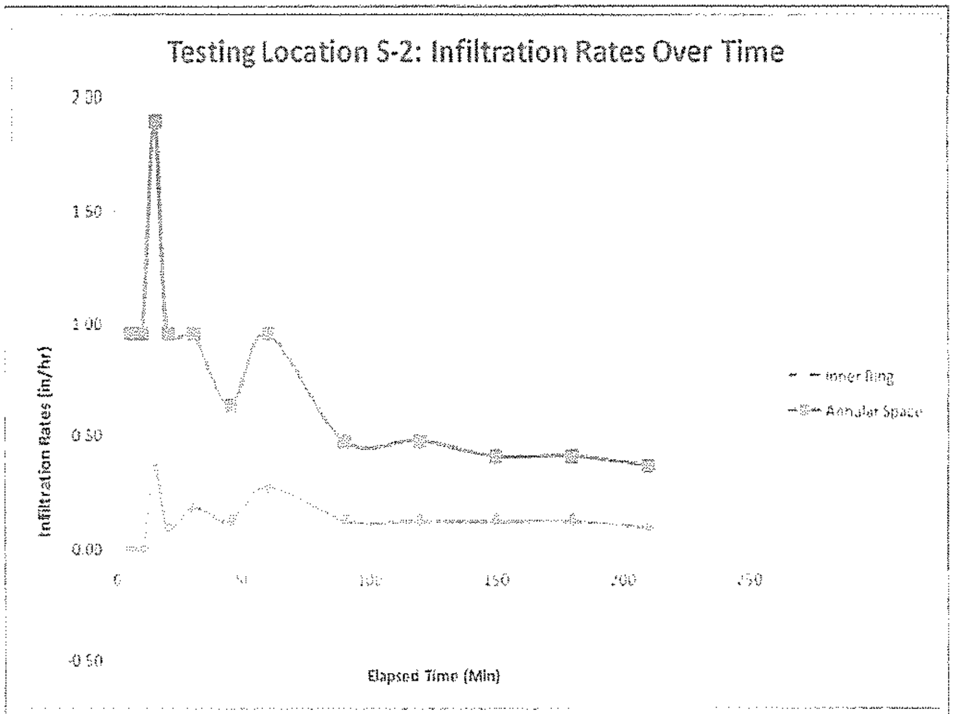
A = Internal area of the inner ring of the annular space

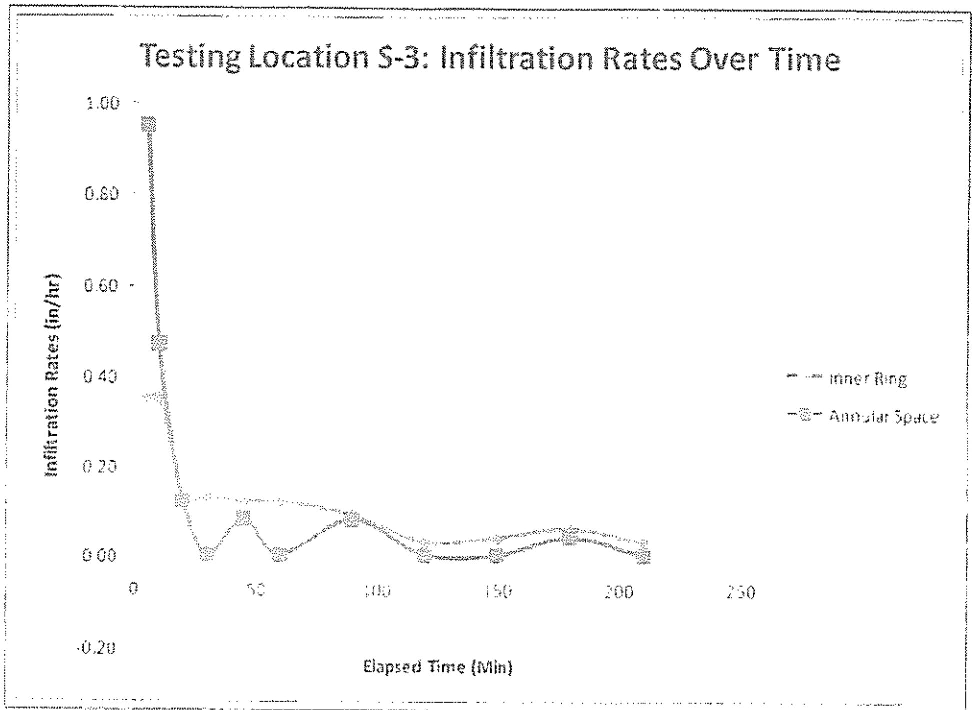
(delta)t = Time interval

APPENDIX E
INFILTRATION RATE GRAPHS

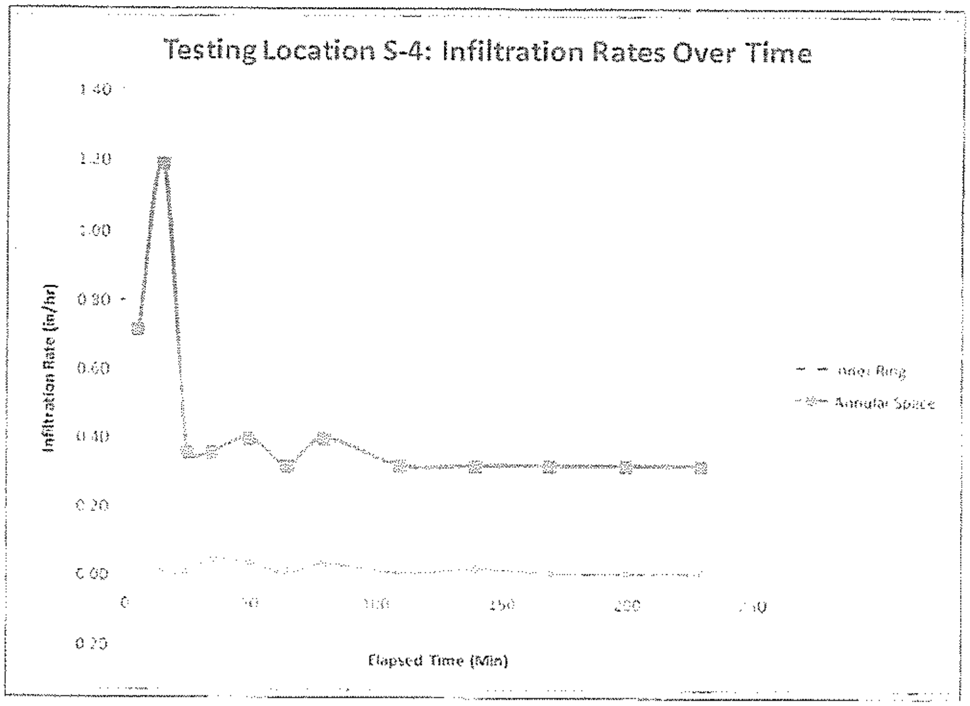
APPENDIX E.1
INFILTRATION RATES GRAPHS
(TESTING LOCATIONS S-1 THROUGH S-3
JULY 15 & 16 2008)

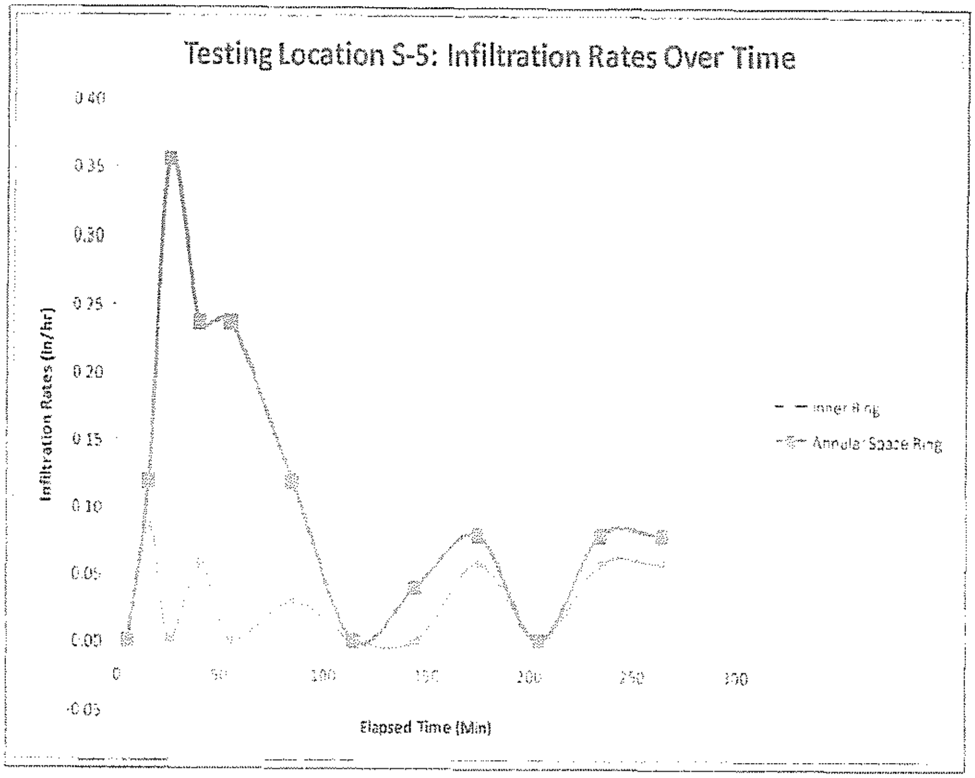

Testing Location S-1: Infitration Rates Over Time
Infitration Rates (in/hr)
Elapsed Time (min)
Inner Ring
Annular Space
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
50
100
150
200
250
300


Testing Location S-2: Infiltration Rates Over Time
Infiltration Rates (in/hr)
Elapsed Time (Min)
Inner Ring
Annular Space
2.00
1.50
1.00
0.50
0.00
-0.50
0
50
100
150
200
250


Testing Location S-3: Infiltration Rates Over Time
Infiltration Rates (in/hr)
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
0
50
100
150
200
250
Elapsed Time (Min)
Inner Ring
Annular Space

APPENDIX E.2
INFILTRATION RATE OVER TIME
(TESTING LOCATIONS S-4 AND S-5
AUGUST 1 2008)


Testing Location S-4: Infiltration Rates Over Time
Infiltration Rate (in/hr)
Elapsed Time (Min)
Annular Space
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
100
150
200



Testing Location S-5: Infiltration Rates Over Time
Infiltration Rates (In/hr)
Elapsed Time (Min)
Inner Ring
Annular Space Ring

APPENDIX F
NITROGEN BALANCE / INTAKE

NITROGEN BALANCE

Assumptions:

Worcester Wastewater Treatment Plant Contains **25** mg/L

Average annual Precipitation for Newark **46.2** inches

Average annual evapotranspiration for Newark **29.8** inches

Objective: To determine how much wastewater, can be applied such that the soil leachate realized at the groundwater table will not exceed Public Driniking Water Standard

Assuming that reed canary grass will be planted, **275** lbs per acre per year of nitrogen will be taken up by cover crop (reed canary grass)

Natural precipitation contains an average of **0.5** mg/L of nitrate-nitrogen

Losses of nitrogen via denitrification and ammonia volatilization are assumed to be zero

Wastewater loading (acre-inch/acre-year)

$$W = \frac{4.43\,C + a(P-ET) - c\,P}{y-a-y(d-n)}$$

where:

W = wastewater loading (acre-inch/acre-year)

C = removal of nitrogen in crop (lbs/acre-year)

a = allowable nitrogen concentration in percolation or runoff water (mg/L)

P = precipitation (acre-inch/acre-year)

ET = potential evapotranspiration (assumes that P + W will allow potential ET to be realized in all cases) (acre-inch/acre-year)

c = concentration of nitrogen in precipitation (mg/L)

y = concentration of nitrogen in wastewater (mg/L)

d = fraction of nitrogen which is denitrified ($\% \times 10^{-2}$)

n = fraction of nitrogen which is volatilized as ammonia ($\% \times 10^{-2}$)

W= 90.61 acre-inches/acre-year

Assuming the annual irrigation season extends from March through November (a period of a pproximately 40 weeks), the average weekly wastewater loading rate would be:

$$\frac{87.88 \text{ acre-inches/acre-year}}{40 \text{ weeks/yr}}$$

= 2.27 acre-inches/acre-week (Nitrogen Weekly loading rate)

COMPLIANCE WORK PLAN
NEWARK SANITARY SERVICE AREA
TRANSITION TO SPRAY IRRIGATION

Prepared For

MARYLAND DEPARTMENT OF THE ENVIRONMENT
1800 WASHINGTON BOULEVARD
BALTIMORE, MD 21230

Prepared By

WORCESTER COUNTY DEPARTMENT OF PUBLIC WORKS
WATER AND WASTEWATER DIVISION
1000 SHORE LANE
OCEAN PINES, MD 21811

October, 2015

COMPLIANCE WORK PLAN
Newark Sanitary Service Area
Transition to Spray Irrigation

Prepared For

Worcester County Department of Public Works
Water and Wastewater Division

A. Purpose

1. The purpose of this work plan is to conduct a detailed soil-hydrogeologic investigation that would provide field data necessary to confirm technical feasibility for wastewater effluent disposal at the proposed Willards Spray Irrigation Site, north of the Newark Service Area in Worcester County. In 2008, MDE and Worcester County investigated the site had a preliminary evaluation completed resulting in a preliminary estimate that the site could accept 56.300 gallons per day of treatment effluent and provided preliminary effluent standards. A copy of that letter and the report completed at that time is included with this plan as Attachment 1.

2. This evaluation will determine total site capacity in accordance with current regulations, policies and guidelines of the Maryland Department of the Environment (MDE) and the Worcester County Department of Public Works (WCDPW). The detailed investigation will include a detailed soil-hydrogeologic report that will provide the necessary data that will be used by the WCDPW to support a State MDE groundwater discharge permit application. The information will also as a basis for the preliminary and final design of the spray irrigation site and final disposal facilities.

B. Location

1. See Exhibit 1 for proposed spray site location.

C. Background Data, Field Work and Data Analysis

1. Collect and review background soil and hydrogeologic data including site data collected by the WCDPW and EA Engineering Science and Technology in 2008.
2. Obtain well construction permits for six 1-inch diameter piezometers and six 4-inch diameter monitoring wells. Exhibit 2 provides a preliminary location of these wells and piezometers. Each of these will be installed to a depth of 25 feet unless field conditions dictate otherwise.
3. Conduct site visit to stake-out locations for piezometers, monitoring wells and test locations. Obtain utility mark out as needed and final adjustments will be made as needed to accommodate field conditions.
4. Coordinate with the WCDPW and MDE to schedule the field work.

5. Drill and install piezometers and monitoring wells needed to monitor water levels and to conduct hydraulic conductivity testing.
6. Drill and prepare two to four test holes for constant head permeability tests, if determined to be necessary.
7. Sample and examine the soil from the selected test locations within the proposed site from additional backhoe test pits as needed.
8. Conduct additional double-ring infiltration tests as determined necessary based on results of the field testing.
9. Submit soil samples to lab for permeability testing.
10. Collect groundwater samples for hydrogeologic report. Submit groundwater samples to lab for analysis of pH, chlorides, total dissolved solids, phosphorus, nitrogen and fecal coliform.
11. Start groundwater background sampling in monitoring wells in accordance with MDE approved monitoring plan in December 2015.
12. Conduct constant head permeability tests and/or slug tests to estimate the hydraulic conductivity of the soils within the proposed site.
13. Measure water levels during a minimum of four site visits during the wet season February-April 2016.

D. Soil-Hydrogeologic Report

1. Prepare a detailed soil-hydrogeologic report for submittal to Worcester County and MDE. Meet with the WCDPW to review the report conclusions prior to submittal.
2. Obtain a base map and elevations from the project surveyor for all monitoring points at the site to aid in the preparation of groundwater flow maps and final report figures.
3. Perform an MDE computer records search inventory of wells within a one-quarter mile radius of the proposed land application spray site. Perform a file records search inventory of wells within a one-quarter mile radius of the proposed land application spray site.
4. Analyze the data collected to determine technical feasibility and site capacity based on Worcester County and MDE regulatory criteria. The task will include a hydrologic balance and nitrogen balance as outlined in MDE guidelines.
5. Meet with WCDPW and MDE to submit the report and discuss the results in May 2016.
6. Prepare MDE groundwater discharge permit application for submittal to Worcester County and MDE in of June 2016.

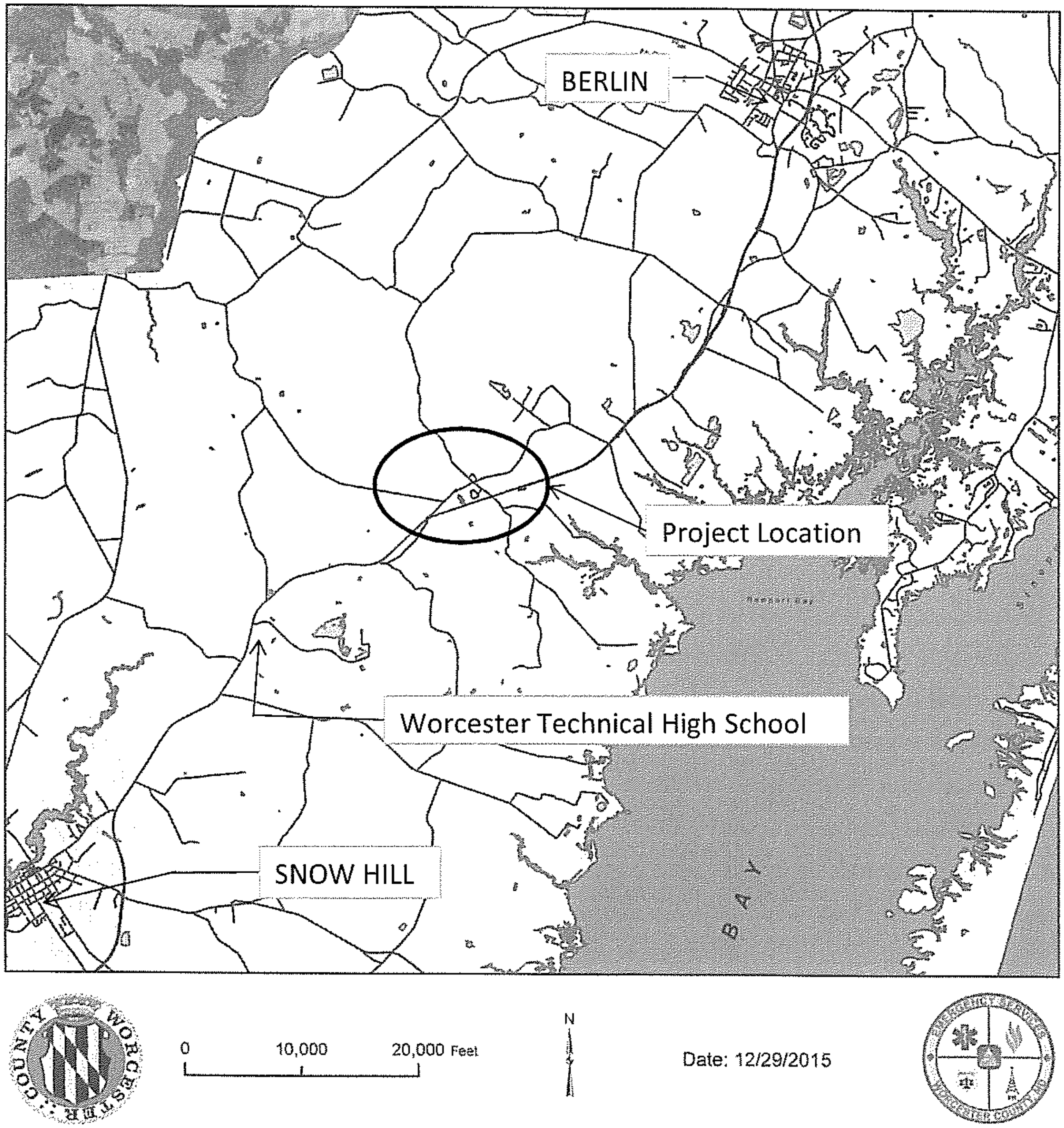
E. Groundwater Background Monitoring

1. Complete groundwater background monitoring period (12 months) in November 2016.

EXHIBIT 1

LOCATION MAP

Newark Site Location Map

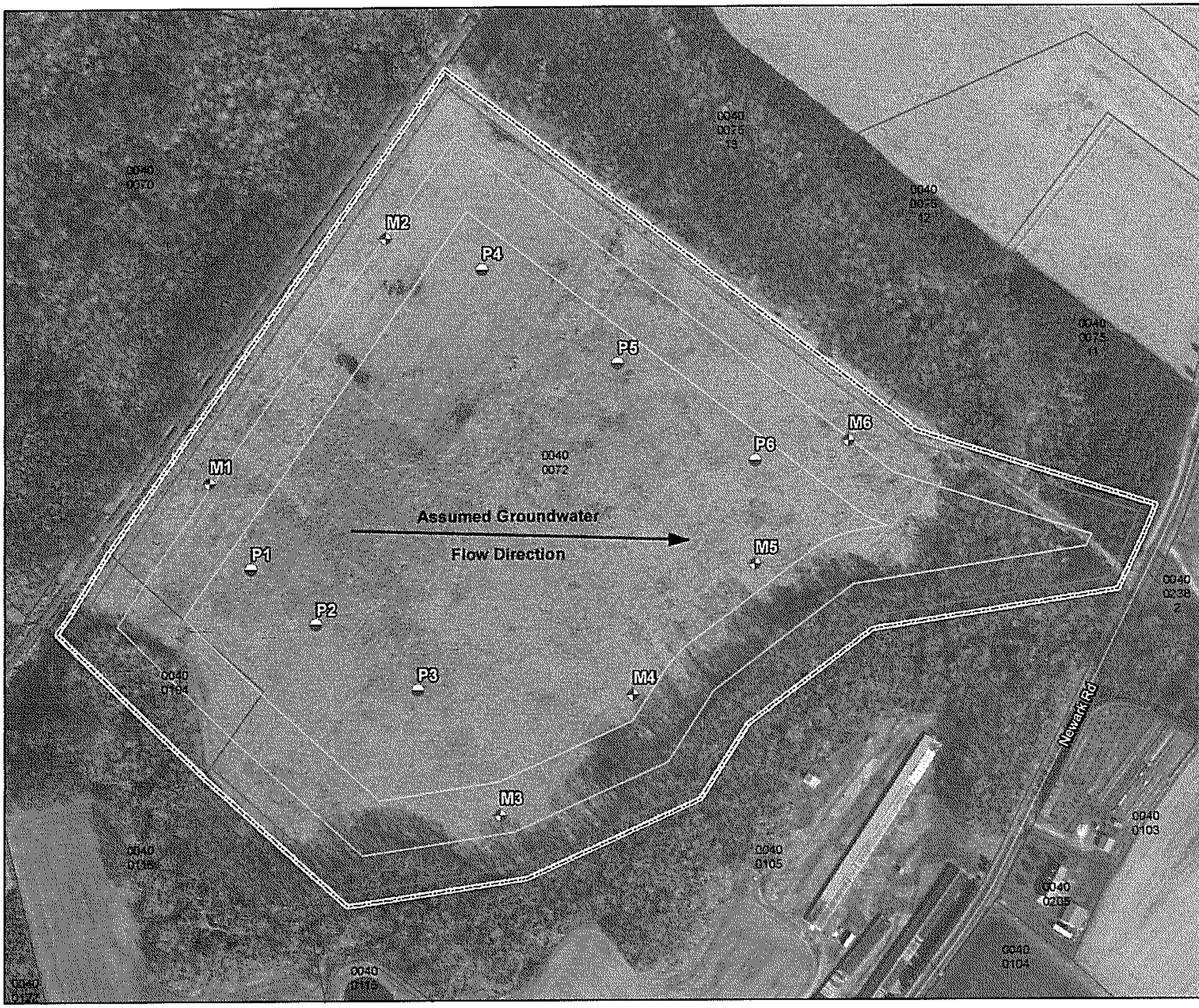


This map provided courtesy of Worcester County, Md. The information depicted on this map is not official and is not to be used for excavation, construction or regulatory purposes. The information provided may not reflect current conditions and should be verified before making important or critical decisions.

The user of this map agrees to hold harmless Worcester County, Md. and Spatial Systems Associates, Inc. for any errors or omissions contained within the mapping system.

EXHIBIT 2

SPRAY SITE MONITORING SYSTEM
WILLARDS SITE



Worcester County Maryland

Exhibit 2
Willards Spray Site Monitoring System

- Willards Property 200' Buffer
- Willards Buffer, 100' Buffer
- Willards Property 25' Buffer
- Willards Property Line
- Approximate Property Lines

Monitoring Locations

- Monitoring Well
- Piezometer

This map is intended for planning purposes only and not for regulatory application
Source: Aerials, Axis Geospatial, March 2013.
Source: Monitoring Locations, Department of Public Works, October 2015.

Department of Development Review and Permitting
Technical Services Division

Drawn By: MDD
Reviewed By: KLH

0 200 Feet
1 inch = 200 feet

Map prepared for the Department of Public Works on October 26, 2015.

Preliminary Engineering Report For Newark Sanitary Service Area Spray Irrigation Project Prepared for:

Worcester County Commissioners Newark Sanitary Service Area

January, 2016

Prepared By:
Worcester County Department of Public Works
Water and Wastewater Division
1000 Shore Lane
Ocean Pines, Maryland 21811

Table of Contents

EXHIBIT 1 – PROJECT PLANNING AREA

EXHIBIT 2 – PERMINIMARY SPRAY SITE REPORT

EXHIBIT 3 – ALTERNATIVE COST ESTIMATES

EXHIBIT 4 - SERVICE AREA ADOPTED BUDGETS

WORCESTER COUNTY DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER AND WASTEWATER SERVICES
PRELIMINARY ENGINEERNG REPORT
NEWARK SPRAY WASTEWATER DISPOSAL

1. INTRODUCTION

To meet the needs for sewage treatment and disposal in the Newark Sanitary Service Area in Worcester County, the Newark Wastewater Treatment Plant was constructed in 1970. The plant is a conventional three-cell aerated lagoon that achieves secondary treatment of wastewater generated in the service area. Following treatment, the facility discharges to an unnamed tributary of Marshall Creek and ultimately to Newport Bay.

Newport Bay has seen a continual degradation of water quality in the past 40 years and as a result, the Maryland Department of the Environment (MDE) has continually issued stricter effluent standards in the watershed to the point where the Newark Wastewater Treatment Plant can no longer comply with the discharge permits issued for this facility.

Recognizing that the discharge from the Newark Treatment Plant would eventually need to be eliminated, the Worcester County Commissioners on behalf of the service area purchased a 42-acre property that came on the market as a result of the real estate downturn. The intent of the property purchase was that it would eventually be used by the service area for spray irrigation of the plant effluent. Preliminary testing on the site completed at the time of the purchase showed that the site would be adequate for disposal of over 50,000 gallons per day which would be adequate for this treatment plant.

In 2015, the Worcester County Commissioners entered into a Consent Order with MDE whereby they agreed to resolve the violations of their discharge permit. Because discharging by spray irrigation significantly relaxes the strict effluent limits, the County agreed to remove the surface water discharge and convert the final effluent disposal in Newark to Spray Irrigation on the purchased site.

This Preliminary Engineering Report (PER) was prepared to describe options evaluated and the final selection for effluent compliance in the Newark Sanitary Service Area.

2. PROJECT PLANNING AREA

The Newark Sanitary Service Area includes the small unincorporated residential community along State Route 113 about halfway between the Towns of Berlin and Snow Hill. In addition to the residential customers, the Newark Service area serves the Worcester County Developmental Center and a number of small commercial establishments. In 2008, the Worcester County Technical High School was also connected to the Newark Wastewater Treatment Plant for sewer service.

a <u>Location</u>. The project planning area is shown on Exhibit 1.

b Environmental Resources Present. The Newark Sanitary Service Area is in a rural part of Worcester County where most activity centers on farming. Environmental resources in the area will be mostly centered on the farming community.

c Growth Areas and Population Trends. The Newark Service Area has very limited potential for growth. The most recent residential development was constructed in 2006 and is still only approximately half filled with houses. There is little expected growth in the service area.

d Community Engagement. Worcester County Code and Maryland Law require Community Engagement throughout the entire process of converting the effluent disposal from surface discharge to spray irrigation. The following summarizes the anticipated portions of the project where public hearings will be held and community comments taken:

1. Water and Sewer Plan Amendment (Already Completed)
Planning Commission - Public Hearing held September 3, 2015
County Commissioner Public Hearing held October 20, 2015

2. Groundwater Discharge Permit - Permit is advertized and public hearing can be requested.
3. Construction Project Public Hearing is required Worcester County Code Section PW5-307 which states:

"The County Commissioners shall hold a public hearing on the cost of the project, which hearing shall be advertised at least once per week for two weeks prior to the hearing in a newspaper of general circulation in the area of the proposed service area. At the hearing the Commissioners may ask for the vote of each property owner in the service area as to whether the project should be constructed but shall not be bound by said vote."

3. EXISTING FACILITIES

The Newark Sewer System consists of conventional gravity sewer lines to a single pump station which pumps wastewater to the Newark Wastewater Treatment Plant.

a Location Map. Exhibit 1 includes a location map and planning area showing the location of the existing wastewater treatment plants. The majority of the customer base is in the Newark area but this facility also provided service to the Worcester Technical High School approximately 3 miles to the south.

b History. The existing Newark Wastewater Treatment Plant was originally constructed in 1970 as a 2-cell anaerobic lagoon. In early the 1990's, divider baffles were added and a surface aerator was installed to assist in BOD reduction and to increase dissolved oxygen (DO) in the plant effluent. As effluent limits continued to tighten, dechlorination facilities were added and supplemental aeration was added to at the effluent chlorine contact chamber, again to boost the effluent DO.

c Condition of Facilities. In general for a 45 year old treatment plant, the Newark facility is in good condition. There is minor erosion of the lagoon embankments but those areas are normally repaired as they arise. The surface aerator motor was recently replaced and the chemical feed pumps were recently replaced. The divider baffles will need to be replaced within the next few years but they continue to function as needed.

d Financial Status of any Existing Facilities. Currently, the Newark Sanitary Service Area has difficulty maintaining a positive cash balance. This small service area has the largest annual average domestic water /sewer bills in the County at slightly over $1,200. The small customer base makes any needed large repair a financial challenge.

e Water/Energy/Waste Audits. The current Newark system is very simple. In evaluating the use of water, energy and waste disposal practices there is no real opportunity for conservation. Water is only used for mixing of needed disinfection chemicals, energy use is limited to pumping needs and a single surface aerator. Bio-solids waste decomposes at the bottom of the treatment pond and in over 40-years of use, remains at a low level.

4. NEED FOR PROJECT

As discussed earlier in this report, the Newark Wastewater Treatment Plant can no longer reliably meet the effluent limits required by their NPDES Discharge Permit. These stringent effluent limits are being driven by the need to improve the water quality in the Newport Bay. By changing the plant effluent from a surface water discharge to spray irrigation, all of the nutrients currently being discharged to Newport Bay will be taken up by the plant growth on the spray site.

a Health, Sanitation, and Security. The current facilities cannot reliably meet permit conditions for treated effluent. However, the treatment plant would produce effluent of an adequate quality for spray irrigation.

b System O&M. Operation and Maintenance of the proposed spray site will require considerably more manpower than the current surface water discharge. However; construction of a new wastewater treatment plant to meet the more stringent effluent limits would also result in a significant increase in O&M activities related to plant monitoring, disposal of plant residuals and electrical power.

c Growth. As discussed earlier, the potential for growth in this service area is limited. The current treatment plant has shown no significant increase in flow for the past 20 years and there are no current plans for growth in this service area.

5. ALTERNATIVES CONSIDERED

a. Description - In developing alternatives for wastewater treatment and disposal, a number of conditions were considered:

- This facility serves a very small population and the rates currently paid by customers are the highest within Worcester County
- Operation and maintenance costs must be minimized in this service area
- Debt payments need to be minimized
- In 2008, the County Commissioners purchased a parcel of land so that it could be made available to the Service Area for effluent disposal
- The County Comprehensive Plan and Master Water and Sewerage Plan identifies land disposal systems as the preferred effluent disposal method and recommends that current surface discharges be abandoned when possible.

- The consent order and agreement between the County Commissioners and MDE was written around the use of spray irrigation for effluent disposal

With the above conditions in mind, construction of a new wastewater treatment plant is not considered an option. First, the Worcester County Comprehensive plan has identified spray irrigation as the preferred method of wastewater treatment plant effluent disposal. Next, the cost of operating an advanced wastewater treatment plant is not considered viable for this small service area. With this in mind, the alternatives considered are limited to the routing of the pipelines between the treatment plant and the spray site and provisions for effluent disposal or holding during the winter season when the spray site will not be available.

1. Routing of pipelines from the treatment plant to the spray site. Both of these options are shown on Exhibit 3 along with the estimated cost for each.

   Option 1A - Railroad Right of way - In this option, the pipeline would be routed along the right of way owned by the Maryland and Delaware Railroad. As the spray site borders the railroad, the pipe would terminate on the spray property along the railroad.

   Option 1B - Newark Road - The pipeline route in this option would follow Newark Road and enter the site along the access road to the spray site.

   Life Cycle Cost Analysis - As shown in Exhibit 3, the lowest life cycle cost approach to the selection of the pipeline route is to follow the route along the existing Delaware and Maryland Railroad.

2. The following options are available for managing effluent from the treatment plant during winter and other periods when spray is not available

   Option 2A - Increasing available storage in the existing treatment pond - This would require increasing the pond embankment on the existing treatment pond to hold additional wastewater. The existing pond was constructed with the ability to hold approximately 60 days storage in its current configuration. For each additional foot of embankment height, approximately 15 days of additional storage could be expected. Therefore, adding 2-feet of additional embankment would increase holding capacity to 90 days which would be considered the minimum acceptable level.

   Option 2B - Construction of a new storage pond - Construction of a new pond would require acquisition of a separate property of a size large enough to install a holding pond. No site has currently bee identified for this but there are several properties near the spray site that could be available. This alternative is considerable more expensive than Option 2A.

   Option 2C - Retaining surface disposal capability during winter months. Although this might be difficult to accomplish, it should be noted that the permitted effluent limits required for winter disposal of plant effluent are considerably relaxed.

b. Design Criteria. The primary design criteria for this project will be to determine the capacity of the individual sites for effluent disposal. In 2008, recognizing the possibility that the Newark Wastewater Treatment Plant would eventually need to remove the surface water discharge, the Worcester County Commissioners purchased the proposed spray site. Prior to the purchase, the Commissioners had a preliminary evaluation completed to estimate the capacity available on this site. A copy or that report is included in Exhibit 2.

c. Environmental Impacts. Although a separate environmental report must be completed, none of the proposed work would not involve significant above grade permanent construction. The spray irrigation of effluent will significantly reduce nutrients discharged to the Maryland Coastal Bays.

d. Land Requirements. Land requirements associated with this project is currently identified and available.

e. Construction Problems. No problems are anticipated during construction of this project..

f. Cost Estimates. Detailed cost estimates for the described alternatives are shown in Exhibit 3. The following summarizes the estimated cost for each are summarized as follows:

Option 1A - Railroad Pipeline Routing
Construction Cost - $352,000
20-year Life Cycle Cost - $395,000
Option 1B - Newark Road Pipeline Routing
Construction Cost - $420,200
20-year Life Cycle Cost - $430,000

Option 2A - Raising Existing Embankments
Construction Cost - $100,650
20-year Life Cycle Cost - $105,000
Option 2B - Construction of a new pond - $660,000
Construction Cost - $660,000
20-year Life Cycle Cost - $663,000
Option 2C - Seasonal Discharge - No Cost*
*Obtaining a seasonal discharge will be difficult and require regulatory approval

g. Advantages/Disadvantages. The identified advantages are summarized as follows:

Pipeline Routes - The pipeline route along the railroad is significantly shorter than the route along Newark Road and is therefore the preferred route. Even though there will be a required payment to the railroad for this route, it will result in a lower life cycle cost.

Effluent Holding - The lowest cost alternative of having a seasonal discharge from the treatment plant is the preferred option. However, it could be difficult to obtain approval for that discharge from the regulatory bdy. Construction of a second holding pond would be only considered if none of the other options were available.

6. SELECTION OF AN ALTERNATIVE

This section discusses the selection of an alternative and discusses the implementation of the proposed project.

a No Action Alternative

Selecting the no action alternative is not considered an option for the following reasons:

- The Worcester County Commissioners as owners of treatment plant are currently under orders from the Maryland Department of the Environment to bring the plant into compliance with the discharge permit issued for the facility
- The treatment plant as constructed is not capable of meeting the discharge limits as required by the current discharge permit
- The process currently used by the plant is not able to be modified to meet the discharge permit limits

b New Wastewater Treatment Plant

Construction of an new wastewater treatment plant was not considered an option for the following reasons:

- There is not enough space either on the current wastewater treatment plant site or the proposed spray site for a new wastewater treatment plant, therefore a new plant site would be needed.
- In looking at the cost of recently constructed advanced treatment plants, the initial construction cost would be from $1.5 to $1.7 million, significantly more that the proposed spray field
- The operating cost of a new advanced wastewater treatment plant would be 2 to 3 times the operating cost of this facility, even when considering the spray irrigation efforts.

c The Selected Alternative

The final selected project was selected based on the following criteria:

<u>Life Cycle Cost</u> - Based on Life Cycle Cost, the pipeline routing along the Delaware and Maryland Railroad was selected and increased storage will be created at the existing wastewater treatment pond by raising the lagoon embankments.

<u>Non-Monetary Factors</u> - Non-Monetary factors considered in this evaluation include:

- Because of the remote location of this facility, retaining the existing lagoon treatment plant was preferred over the installation of newer technology requiring extensive monitoring and operator attention

- Spray irrigation is used throughout the County for wastewater disposal and operators understand and have experience operating these systems

- The proposed spray site is shielded from residential areas by and an established stand of trees

The project is summarized as follows:

- Two (2) New submersible pumps (7.5 Horsepower) will be installed in the existing chlorine contact tank. These pumps will be sized to pump 125 gallons per minute of plant effluent to the spray site, therefore, at full capacity, daily flow can be pumped to the spray field in 6 to 8 hours.
- A new 4" pipeline (approximately 6,000 LF) will be constructed through the treatment plant site to the Maryland and Delaware Railroad right of way and along the railroad to the proposed spray site
- A 250,000 gallon steel ground level storage tank will be constructed at the spray site to hold effluent at the spray site. We expect to relocate a ground level tanks currently owned by Worcester County for this purpose.
- From the holding tank(s), the effluent will be applied to the spray site through a system of irrigation pumps, pipes and sprinkler heads.

Additional project components will include:

- Monitoring and permitting of the spray site
- Minor improvements to the existing treatment plant (rehab of the cell divider baffles, surface aerator and raising the pond embankment to increase storage
- Reimbursement to the Worcester County General Fund for the purchase of the spray site
- Engineering design and construction monitoring
- General Administrative and Bond Closing expenses

Short Lived Assets - As with most wastewater disposal projects, this project contains few short lived assets. The system is designed for a 40-year life span and most components will have a much longer life span. Pumps have a normal operating life of 20 to 40 years and their replacement can be budgeted within the normal operating budget. Spray irrigation components require minor annual repair and with proper maintenance will provide long term service.

Sustainability Considerations - The Newark Sanitary Service Area has been in operation for well over 40 years. The key to the service area retaining its sustainability is to minimize the financial impact of this project on the rates and to keep the operation as simple as possible. As presented, there will be little impact on system operations, grant assistance in the capital construction components will be critical to keeping the system sustainable.

7. PROPOSED PROJECT COSTS

Based on the discussion in Section 6, the following summarizes the project components and provides an estimated project cost:

Item	Units	Quantity	Unit Price	Total Price
Piping to the site	Exhibit 3			$ 352,000
Treatment Plant Upgrades/Rehab	LS	1	$ 50,000	$ 50,000
Additional Storage	Exhibit 3		$ 101,000	$ 101,000

Pumps at the Newark WWTP	EA	2	$ 20,000	$ 40,000
Pump Installation	LS	1	$ 20,000	$ 20,000
Pumps At the spray field	EA	2	$ 10,000	$ 20,000
Spray Field Pump House	LS	1	$ 50,000	$ 50,000
Spray Irrigation Piping and Sprinklers	LS	1	$ 60,000	$ 60,000
Storage tanks (relocated)	EA	2	$ 40,000	$ 80,000
Electrical and Controls	LS	1	$ 80,000	$ 80,000
Permitting and Testing	LS	1	$ 50,000	$ 50,000
Design Engineering	LS	1	$ 80,000	$ 80,000
Construction Oversight	LS	1	$ 50,000	$ 50,000
Monitoring Systems	EA	5	$ 10,000	$ 50,000
Sub-total				$ 1,083,000
Contingency		10%		$ 108,300
Total Estimated Construction Cost				$ 1,191,300
Land Purchase				$ 760,000
Legal/Admin				$ 50,000
Total Project Cost				$ 2,001,300
Use				$ 2,000,000

8. ANNUAL OPERATING BUDGET

The detailed operating budget for the Newark Service Area is included as Exhibit 4 in the rear of this report. That 2015/16 budget is summarized as follows:

REVENUE	
Charges for Services	$119,600.00
Interest & Penalties	$2,500.00
Transfer from Reserves	($2,246.00)
REVENUE TOTALS	$119,854.00
EXPENSE	
Personnel Services	$60,629.00
Supplies & Materials	$15,415.00
Maintenance & Services	$37,354.00
Other Charges Totals	$1,220.00
EXPENSE TOTALS	$119,854.00

In addition to the operating budget, the service area currently has a current outstanding debt of $258,517. This debt results in an annual payment of approximately $22,430. The funds for retirement of the debt is assessed on the customers quarterly bill at $27 per Equivalent Dwelling Unit (EDU) per quarter or $108 per year..

This service area currently serves approximately 111 customers therefore, the average annual water/sewer bill is $997 per customer. Adding $108 for debt retirement results in an average annual charge of $1,105 per customer.

Incurring debt to construct this project would add significant costs to the service area customers. Even at subsidized rates, adding $2,000,000 in debt to this service area results in an additional annual cost of Nearly $82,000 or $395 per customer.

In Summary:

Current Annual O&M Cost Per Customer	$1,077
Current Annual Debt Retirement Cost	$108
Debt Retirement Cost of Proposed Improvements	$739
Potential Annual Cost Per Customer	$1,924

Clearly, grant assistance will be needed to complete this project while maintaining a reasonable annual cost to the service area customers.

9. PROJECT SCHEDULE

The following is a proposed project schedule:

Task Description	Start Date	Finish Date
Water and Sewer Plan		
Planning Commission Review	10/26/2015	11/25/2015
Commissioners Public Hearing	12/25/2015	2/23/2016
Submission and MDE Approval	3/24/2016	6/22/2016
Spray Field Evaluation		
Monitoring Plan - Spray Field	8/12/2015	10/11/2015
Install Wells/Initiate Sampling	12/11/2015	3/10/2016
Monitoring Program for Spray Field	1/10/2016	1/9/2017
Final Report on Spray Field	2/1/2017	3/1/2017
Discharge Permit Approval		
Permit Application/Approval	7/22/2016	10/20/2016
Funding Applications		
Preliminary Engineering Report	7/27/2015	9/25/2015
Environmental Report	5/27/2016	8/24/2016

USDA Funding Application/Award	2/24/2016	5/22/2016
MDE Funding Application/Award	1/31/2016	5/30/2016
Design/Construction		
Preliminary Design	4/30/2016	8/28/2016
Final Design	9/27/2016	11/26/2016
Construction Permits	12/10/2016	3/10/2017
Bidding Phase	5/2/2017	7/1/2017
Construction Phase	7/1/2017	4/27/2018
Start-up/Compliance	4/27/2018	4/27/2019

10. PERMIT REQUIREMENTS

To complete this project, the following permits and approvals will be needed:

1. Water and Sewer Plan Amendment
2. Groundwater Discharge Permit
3. Wastewater Construction Permit
4. Erosion and Sediment Control Permit
5. Notice of Intent to activate the General Permit for Storm Water
6. County Roads Occupancy Permit

11. CONCLUSIONS AND RECOMMENDATIONS

The Worcester County Commissioners are committed to removal of Newark Treatment Plant discharge from the Newport Bay Watershed and converting it to a spray irrigation facility. Property has been acquired and a preliminary evaluation completed on the proposed spray site. The site has an estimated disposal capacity adequate for this service area and a plan has been developed to implement this project. The small size of the service area requires a combination of grant/loan funding assistance to complete this project and maintain a reasonable rate for customers.

12. PROJECT ASSET MANAGEMENT

The following section discusses the asset constructed as a part of this project

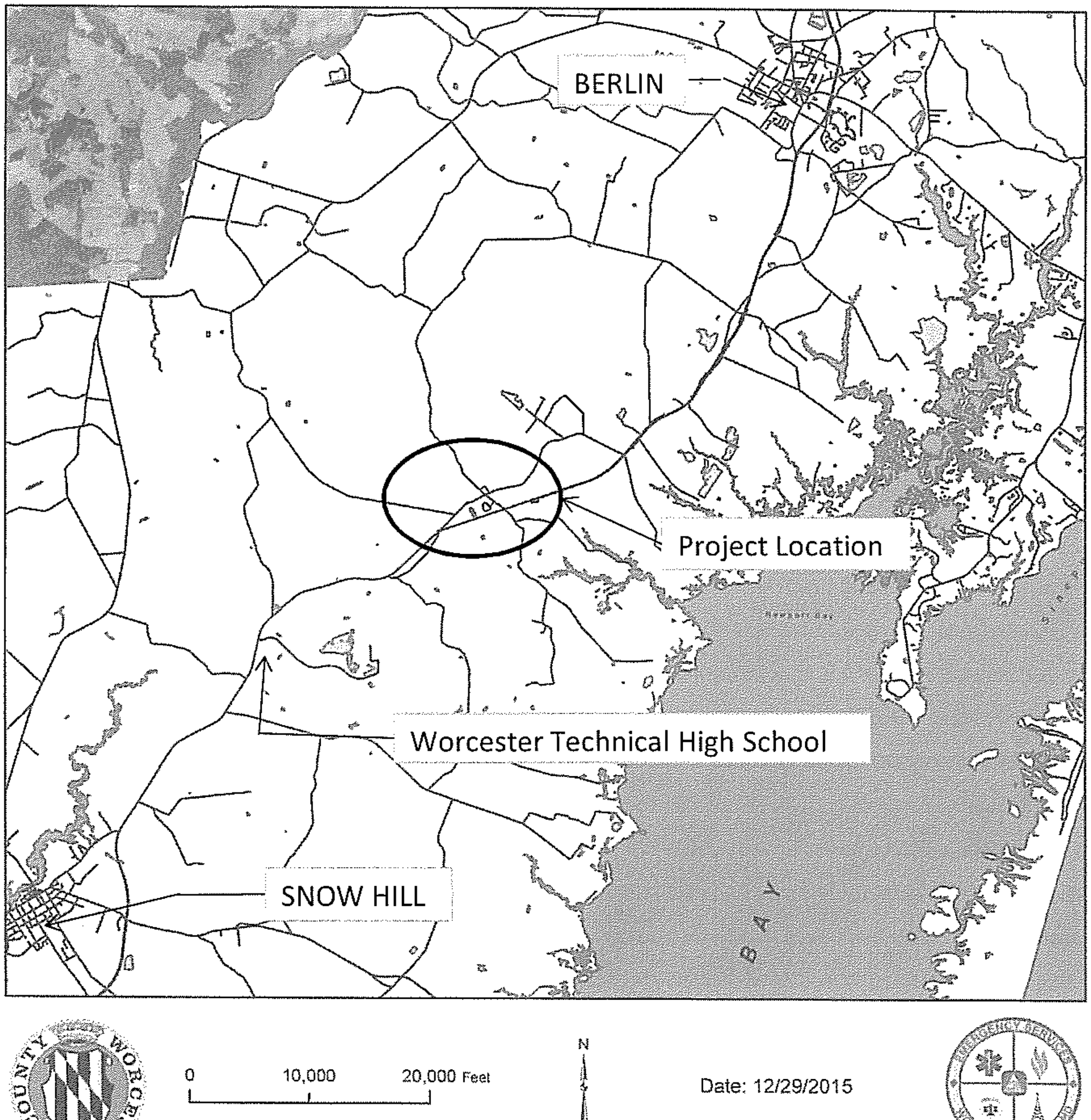
Critical Asset	Condition	Maintenance/Replacement Plan
Raw Water Pump Station	Good - Replaced in 2004 with precast concrete wet well and new discharge pumps	Maintained as a part of daily operator plant inspection. Redundant pumps are installed and pumps are replaced as needed.

Treatment Pond	Fair - Originally constructed in 1970, erosion repairs made as needed	Inspected as a part of daily operator plant inspection. Repairs generally require stabilization with stone revetment
Surface Aerator	Good, motor replaced in 2015, additional aerator anticipated to be installed as a part of this project	Maintained as a part of daily operator plant inspection. Serviced annually with parts replaced as needed.
Chlorine Contact Tank	Good - Originally constructed in 197, cast in place concrete in good condition	Maintained as a part of daily operator plant inspection.
Effluent Pumping System	New - Being constructed as a part of this project	Will be inspected as a part of daily operator duties. Redundant pump to be included. Minimal cost for replacement as needed.
Effluent Holding Tank(s)	Good, relocated water tank from Oean Pines Service Area, no longer in use. Steel structure had regular maintenance minimal surface rust to be repainted as part of this project	Inspected when spray operations are taking place, cleaned annually and repaired as needed.
Spray Irrigation piping	New - Being constructed as a part of this project	Maintained as a part of daily operator plant inspection.

Energy/Water efficiency of these assets and conservation effort plan - The proposed Newark Spray Irrigation Facility is very simple with minimal rotating equipment and few opportunities for energy conservation.

EXHIBIT 1 – PROJECT PLANNING AREA/LOCATION MAP

Newark Site Location Map



Date: 12/29/2015

This map provided courtesy of Worcester County, Md. The information depicted on this map is not official and is not to be used for excavation, construction or regulatory purposes. The information provided may not reflect current conditions and should be verified before making important or critical decisions.

The user of this map agrees to hold harmless Worcester County, Md. and Spatial Systems Associates, Inc. for any errors or omissions contained within the mapping system.

EXHIBIT 2 – PRELIMINARY SPRAY SITE REPORT

EXHIBIT 3 – ALTERNATIVE COST ESTIMATES

Worcester County Department of Public Works
Water and Wastewater Division
Newark Effluent Spray Irrigation
Pipeline Cost Alternatives

Option 1A - Railroad Route

	Units	Quantity	Unit Price	Total Price
Piping to the site	LF	6000	$ 45	$ 270,000
Payment to Railroad	LS			$ 50,000
Sub-total				$ 320,000
Contingency		10%		$ 32,000
Total Estimated Cost				$ 352,000

Option 1B - Newark Road

	Units	Quantity	Unit Price	Total Price
Piping to the site	LF	7600	$ 45	$ 342,000
Road Restoration	LF	4000	$ 10	$ 40,000
Sub-total				$ 382,000
Contingency		10%		$ 38,200
Total Estimated Cost				$ 420,200

Life Cycle Cost Comparison:

Option 1A

Initial Construction Cost	$ 352,000
Annual Pipeline Maintenance	$ 3,000
Railroad Lease	$ 2,500
Salvage Value	$ 70,400

	Term	Rate	Annual Cost PV	Total PV
Present Value	20	3.2%	$42,837.88	$394,837.88

Option 1B

Initial Construction Cost	$ 420,200
Annual Pipeline Maintenance	$ 3,800
Railroad Lease	$ -
Salvage Value	$ 84,040

	Term	Rate	Annual Cost PV	Total PV
Present Value	20	3.2%	$10,742.83	$430,942.83

Worcester County Department of Public Works
Water and Wastewater Division
Newark Effluent Spray Irrigation
Effluent Holding Options

Option 2A - Raise Existing Holding Pond

	Units	Quantity		Unit Price		Total Price
Site Prep	LS	1	$	20,000	$	20,000
General Fill	CY	1000	$	25	$	25,000
Clay Material	CY	250	$	80	$	20,000
Stabilization (Riprap)	Tons	100	$	65	$	6,500
Restoration	LS				$	20,000
Sub-total					$	91,500
Contingency		10%			$	9,150
Total Estimated Cost					$	100,650

Option 2B - New Pond

	Units	Quantity		Unit Price		Total Price
Property	Acres	3	$	20,000	$	60,000
Excavation	CY	25000	$	12	$	300,000
Fill Placement	CY	25000	$	8	$	200,000
Clay Liner	CY	500	$	80	$	40,000
Sub-total					$	600,000
Contingency		10%			$	60,000
Total Estimated Cost					$	660,000

Life Cycle Cost Comparison:

Option 1A

Initial Construction Cost	$	100,650
Annual Pond Maintenance	$	1,000
Salvage Value	$	20,130

	Term	Rate	Annual Cost PV	Total PV
Present Value	20	3.2%	$3,884.70	$104,534.70

Option 1B

Initial Construction Cost	$	660,000
Annual Pond Maintenance	$	5,000
Salvage Value	$	132,000

	Term	Rate	Annual Cost PV	Total PV
Present Value	20	3.2%	$2,726.32	$662,726.32

EXHIBIT 4 – ADOPTED BUDGETS

Attachment 1 - Consent Order and Agreement