4/4/13

Jim Quinton
Brian Hildreth
Henry Quathamer
Michael Sause
Kathy
David Sneaf
Dave Sekel
Bryan
John Barndt
Jack Hayes
Ron Hadley
Me

– will utilizing RIBS + Pt. source discharge

– Why are wells (4) ~~closed~~ (sealed) off ?

→ Rip-Rap @ outfall

BPEnvironmental, Inc.

8615 Commerce Drive, Unit One
Easton, MD 21601
Phone (410) 819-0919
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Seaford, DE 19970
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April 1, 2013

Jim Quinton
Allen Harim Foods, LLC
126 N. Shipley Street
Seaford, DE 19973

RE: LIMITED SITE INVESTIGATION SUMMARY
29984 Pinnacle Way
Millsboro, DE 19966
BPE Project #: AL-190-03

Dear Mr. Quinton:

BP Environmental, Inc. (BPE) mobilized to the above-referenced property (SITE) on Wednesday March 13, 2013 to complete a rapid Limited Subsurface Investigation (LSI) of the SITE. The LSI was completed over a 3-day period and included the following:

- The installation of 14 soil borings (SB-01 through SB-14), logging of soil cuttings, and soil sampling and laboratory analysis (see Figure 2);
- The installation of 9 temporary wells (TW-01, TW-03, TW-04, TW-06, TW-08, TW-10, TW-12, TW-13, and TW-14), groundwater sampling and laboratory analysis from these 9 wells;
- The installation of 2 screen point borings (SP-01 and SP-02), groundwater sampling and analysis from these 2 locations;
- The collection of groundwater samples from 7 of the existing permanent monitoring wells (MW-01, MW-04, MW-06, MW-08, MW-11, MW-13 and MW-16) and subsequent laboratory analysis; and
- The collection of four composite soil samples from within the wetted perimeter of the spray irrigation field and laboratory analysis (see Figure 2).

AREAS OF CONCERN AND INVESTIGATION RESULTS

The investigation included assessment of several specific areas of concern (AOCs) as identified in a recently completed Phase 1 Environmental Site Assessment (ESA) by BPE. Specific AOCs and their respective investigation results are summarized below. Soil and groundwater laboratory data was compared to applicable Delaware Department of Natural Resources and Environmental Control (DE DNREC) standards, Environmental Protection Agency (EPA) Regional Screening Levels (RSLs), and/or EPA maximum contaminant levels (MCLs), where applicable.

Spray irrigation field (former sludge application location) AOC:

- To determine the general soil quality of the spray irrigation field (former location of sludge application), BPE segregated the large field into four quadrants. A 5-point composite of shallow soil (<2′ below ground surface [bgs]) was collected from each delineated quadrant and. analyzed for thirteen priority pollutant metals (PPM-13). The results of the laboratory analysis were compared to the DNREC Site Investigation and Restoration Section (SIRS) Screening Level Table (dated January 2013). No concentrations of the metals exceeded their respective SIRS screening levels for soil

- Groundwater samples were collected from 7 of the existing permanent monitoring wells (MW-01, MW-04, MW-06, MW-08, MW-11, MW-13 and MW-16) and analyzed for total dissolved solids (TDS), sodium, chloride, ammonia-N, nitrate, nitrite, nitrate + nitrite-N, total nitrogen, total kjeldahl nitrogen (TKN). In addition, 5 of the monitoring wells (MW-01, MW-04, MW-06, MW-08, MW-11, MW-13 and MW-16) were sampled and analyzed for herbicides and pesticides. The results of the laboratory analysis reveal non-detect concentrations of herbicides and pesticides at all 5 monitor well locations. Concentrations of TDS, sodium, chloride, ammonia-N, nitrate, nitrite, nitrate + nitrite-N, total nitrogen, and TKN in all of the monitoring well samples were below their respective standards, with the exception of nitrate at MW-13 (4.2 mg/L), which exceeds the SIRS screening level of 2.5 mg/L for groundwater. In addition, the concentration of nitrate + nitrite-N at MW-04 was 12 mg/L, which is a potential concern given the Site's documented history of nitrate contamination.

- Temporary well TW-14 was installed on the apparent down-gradient boundary of the spray irrigation field. Groundwater samples were collected for TDS, sodium, chloride, ammonia-N, nitrate + nitrite-N, and nitrate. No concentrations of the analyzed chemicals exceeded their respective federal and state drinking water standards.

Former #6 Oil UST AOC

- Three soil borings (SB-01 through SB-03) and two temporary wells (TW-01 and TW-03) were installed in the vicinity of the former #6 oil UST. Soil samples were collected for gasoline range organics (GRO) (SB-03 only) diesel range organics (DRO), oil range organics (ORO) and polynuclear aromatic hydrocarbons (PAHs) from each soil boring (SB-01 8′-10′, SB-02 8′-10′, and SB-03 9′ – 11′. Results of the laboratory analysis revealed non-detect adsorbed-phase concentrations for the analyzed chemicals. Groundwater samples collected from the temporary wells were analyzed for DRO, ORO, PAHs (TW-01) and for DRO, ORO, PAHs, volatile organic compounds (VOCs), and PPM-13 (TW-03). Both groundwater samples contained non-detect concentrations of DRO and ORO. Several non-carcinogenic PAHs were detected in groundwater obtained from TW-01, whereas both carcinogenic and non-carcinogenic PAHs were detected in the groundwater sample obtained from TW-03. However, no PAH concentrations exceeded their respective state cleanup standards. *Note: PPM-13 and VOC data for TW-03 are discussed below under the Interior Trough Drain AOC.*

Interior Trough Drain AOC

- One temporary well (TW-03) was installed in the vicinity of the interior trough drain. The groundwater sampled collected at TW-03 was sampled for DRO, ORO, PAHs, VOCs, and PPM-13. Laboratory analysis revealed non-detect concentrations of metals. However, tetrachloroethene (PCE) was detected at a concentration of 0.0041 mg/L, which exceeds the DNREC SIRS screening level of 0.001 mg/L. No other VOCs were detected at TW-03.

Abandoned-In-Place Brine UST AOC

- Two soil borings (SB-11 and SB-12), a screen point boring (SP-01) and a temporary well (TW-12) were installed in the vicinity of the abandoned-in-place 20,000 gallon brine UST located near the northern property boundary. Groundwater samples were collected from SP-01 (11′ -15′ bgs) and from TW-12 (screened 5′ – 15′ bgs), which represented locations north-adjacent and northeast-adjacent to the abandoned-in-place UST, respectively. The samples were analyzed for total dissolved solids (TDS), chloride, and sodium. Results of the laboratory analysis reveal a chloride concentration of 560 mg/L at the SP-01 (11′ -15′ bgs), which exceeds the EPA secondary maximum contaminant level (MCL) for chloride (250 mg/L). Further, the concentrations of TDS at SP-01 (11′ -15′ bgs) and TW-12 were 1,200 mg/L and 670 mg/L, respectively. Both of these concentrations exceed the EPA secondary MCL for TDS of 500 mg/L.

Adjacent NPL Site AOC

- Two screen point borings (SP-01 and SP-02) were installed along in the northern portion of the Site to address potential migration of contaminants (TCE, TCE daughter products, and chromium). VOC and total chromium samples were collected at SP-01 23′ - 27′, SP-02 20′ - 24′, and SP-02 30′ - 34′. The results of the laboratory analysis revealed low level concentrations of PCE (0.00071 mg/L) and chloroform (0.0024 mg/L) at SP-01 23′ - 27′, both of which were below their respective DNREC SIRS screening level; although PCE was present at a concentration of only slightly below the DNREC SIRS screening level of 0.001 mg/L. The sample collected at SP-02 23′ – 27′ bgs contained multiple VOCs including acetone (0.16 mg/L), bromodichloromethane (0.012 mg/L), bromoform (0.011 mg/L), chlorodibromomethane (0.023 mg/L), chloroform (0.056 mg/L), and toluene (0.087 mg/L). Concentrations of bromoform and toluene at SP-02 23′ – 27′ bgs exceeded their respective DNREC SIRS screening levels of 0.0079 mg/L and 0.086 mg/L, respectively.

Diesel Release Area AOC

- Two soil borings (SB-04 and SB-05) and one temporary well (TW-04) were installed in the vicinity of a previous diesel release area. Groundwater sampled at TW-04 was analyzed for DRO, ORO, VOCs, and PAHs. Low levels of select VOCs including methylene chloride (0.0010 mg/L), naphthalene (0.00066 mg/L), 1,2,4-trimethylbenzene (0.00057 mg/L) were detected in the groundwater sample. The concentration of naphthalene at TW-04 exceeded the DNREC SIRS screening level of 0.00014 mg/L. In addition, multiple non-carcinogenic PAHs, including 1-methylnaphthalene (0.000021 mg/L) and 2-methylnaphthalene (0.000042 mg/L), and carcinogenic PAHs, including dibenz(a,h)anthracene (0.000016 mg/L) and indeno(1,2,3-cd)pyrene (0.000014 mg/L) were detected. The concentration of dibenz(a,h)anthracene exceeded the DNREC SIRS screening level of 0000029 mg/L.

Hydraulic Oil Release AOC

- Three soil borings (SB-06 through SB-08) and two temporary wells (TW-06 and TW-08) were installed in the vicinity of the hydraulic oil release area. Soil samples collected from borings SB-07 (7′ - 9′) and SB-08 (7.5′ - 9.5′) contained non-detectable levels of DRO, ORO, and PAHs. Groundwater samples collected from temporary wells TW-06 and TW-08 contained minor concentrations of non-carcinogenic PAHs, namely naphthalene, 1-methylnaphthene, and 2-methylnaphthene. All dissolved-phase concentrations were below their respective DNREC SIRS screening levels.

Former AST Fueling AOC

- Two soil borings (SB-09 and SB-10) and a temporary well (TW-10) were installed in the vicinity of the former AST fueling area. No soil samples were collected in this AOC. Groundwater collected at TW-10 contained low level concentrations of VOCs including 1,3-dichlorobenzene (0.00030 mg/L) and methylene chloride (0.00091 mg/L). Several carcinogenic PAHs, including benzo(a)anthracene (0.000012 mg/L) and indeno(1,2,3-cd), pyrene (0.0000087 mg/L), and non-carcinogenic PAHs including naphthalene (0.000046 mg/L), 1-methylnaphthalene (0.000019 mg/L), and 2-methylnaphthalene (0.0000040), were detected. No concentrations exceeded their respective DNREC SIRS screening levels.

Battery Wash Holding Tank System AOC

- BPE installed one soil boring (SB-13) and one temporary well (TW-13) in the vicinity of the holding tank / septic system reportedly utilized to hold battery wash liquids. A soil sample collected at the 5.5′ – 7.5′ interval was analyzed for PPM-13, VOCs, GRO, DRO, ORO, and PAHs. The soil laboratory analytical results revealed low levels of total chromium, lead, nickel, and tert-butyl alcohol (TBA). The groundwater sample collected from TW-13 was analyzed for VOCs, PAHs, PPM-13, GRO, DRO, and ORO. The results of the laboratory analysis revealed non-detect concentrations for all chemicals, with the exception of several non-carcinogenic PAHs, including naphthalene (0.000050 mg/L), 1-methylnaphthalene (0.000021 mg/L), and 2-methylnaphthalene (0.000040 mg/L).

Former Nitrate Remediation System Infiltration Gallery AOC

- One screen point boring (SP-02) was installed in the vicinity of the former nitrate remediation system AOC. Groundwater samples were collected from the 20′ – 24′ bgs and 30′ – 34′ bgs intervals and analyzed for nitrate. Nitrate concentrations were present in both samples at concentrations of 1.5 mg/L and 9.9 mg/L respectively. The nitrate concentration at SP-02 30′ – 34′ bgs exceeds the DNREC SIRS screening level of 2.5 mg/L and is only slightly below the the EPA MCL of 10 mg/L.

Conclusions

The source of the dissolved-phase PCE contamination detected in the central portion of the Site is unknown. Further, the magnitude and extent of the dissolved-phase PCE plume and the presence of PCE at the Site in other phases (i.e. adsorbed-phase, vapor-phase) is unknown. A potential on-site source could be the interior trough drain located in an apparent up-gradient or side-gradient position relative to TW-03. However, further assessment would be needed to define the source, magnitude, and extent of the PCE contamination. Given the potential exposure pathways posed by the PCE contamination (dermal and inhalation to site workers, ingestion to site workers and off-site potable well users), and the limited information on the nature, magnitude, and extent of the PCE contamination, the range of potential environmental liabilities associated with the documented PCE is large.

In addition to PCE, other VOCs, PAHs, and nitrate were detected in groundwater at the Site at concentrations that exceed their respective SIRS screening levels. The potential environmental liabilities associated with these exceedances are unknown at this time.

The elevated chloride and TDS concentrations in the vicinity of the abandoned-in-place brine UST could represent an environmental liability given their proximity to Wharton's Branch, a tributary of the Indian River. The ecological sensitivity of Wharton's Branch is unknown at this time.

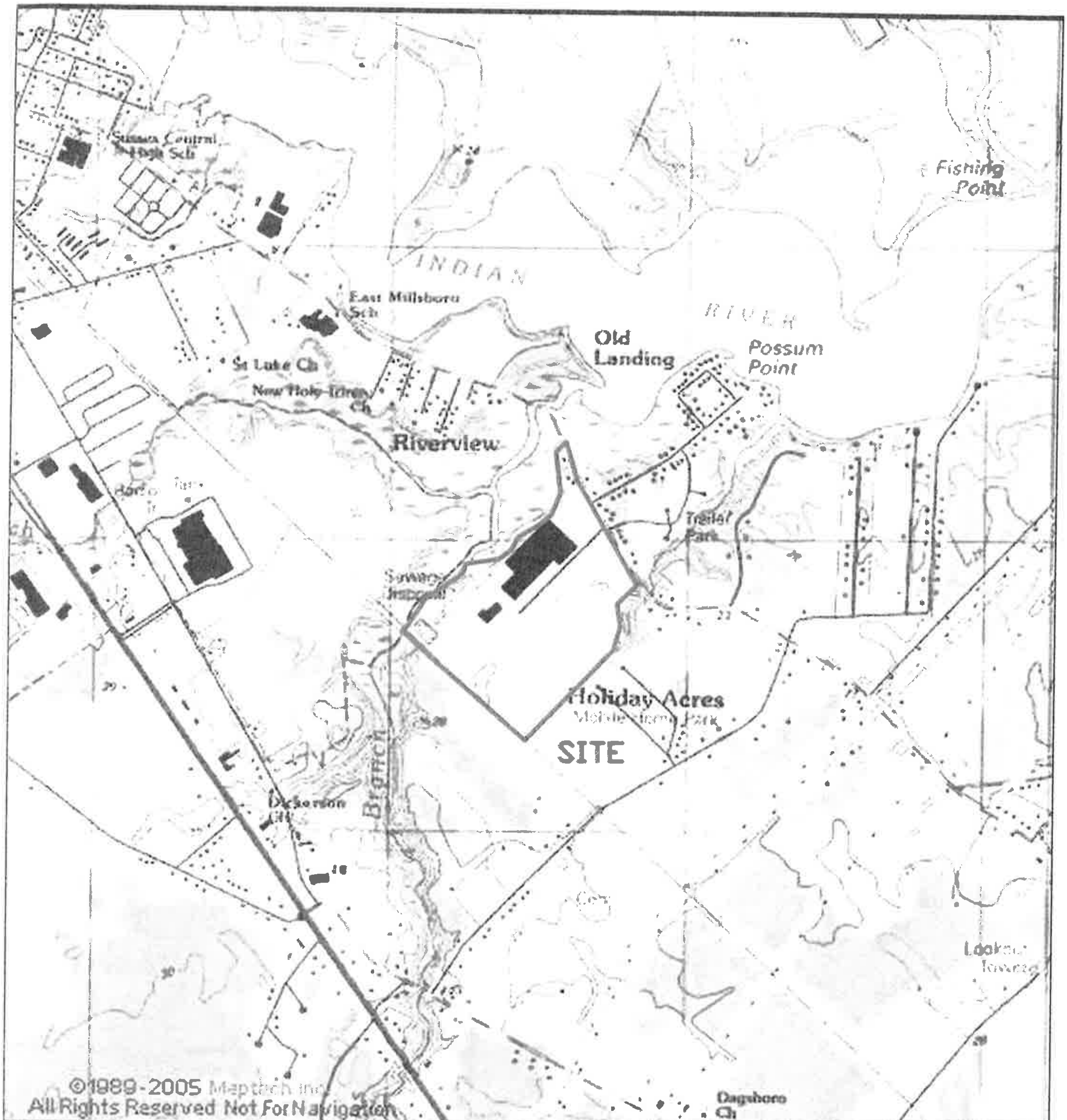
Sincerely,
BP Environmental, Inc.

Gary Lasako
Geologist

Doug Miller, PG
Project Manager

Enclosures: Figure 1: Topographic Map
Figure 2: Site Map with Sampling Locations

cc: BPE Files



Prepared For:

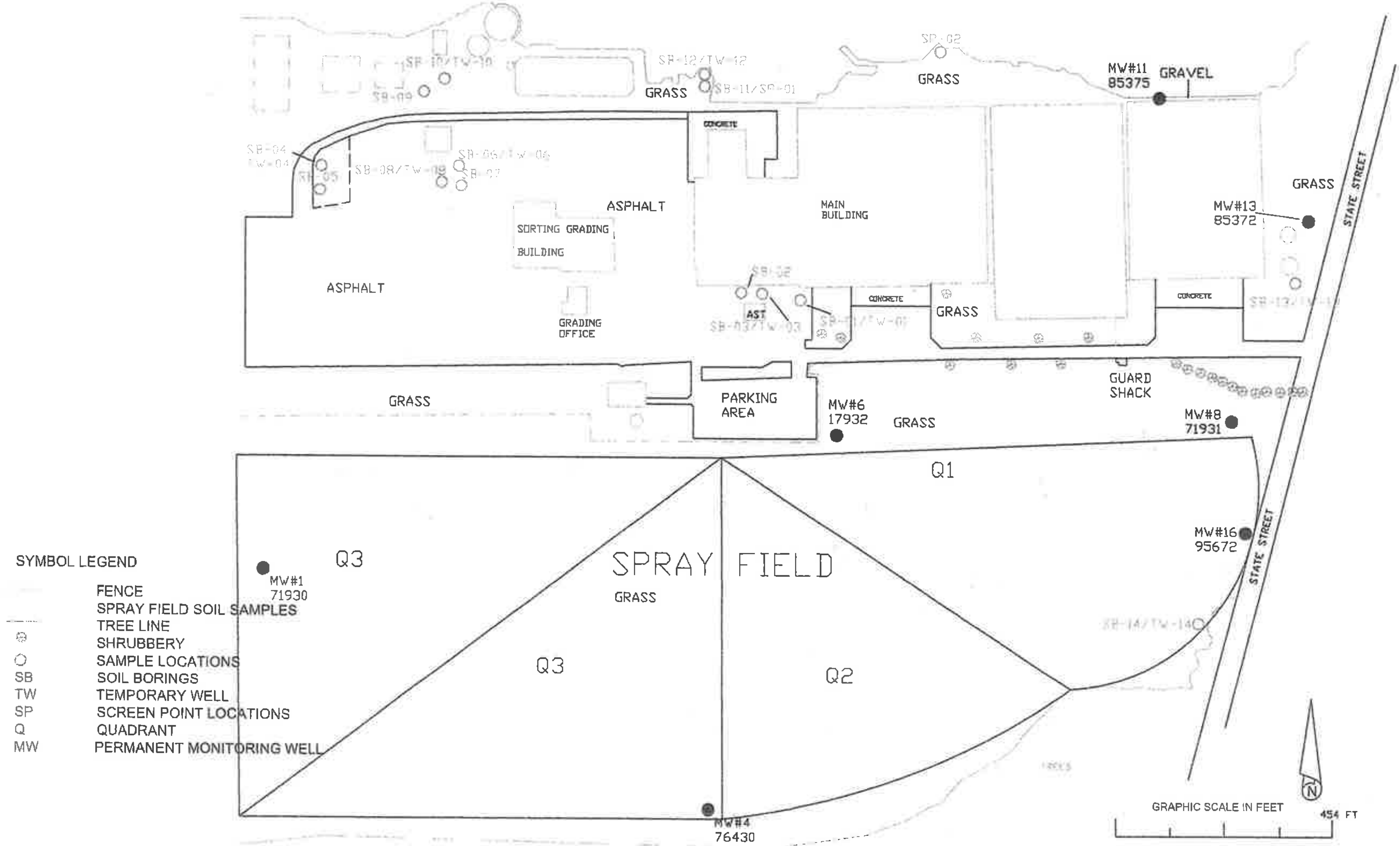
ALLEN HARIM FOODS, LLC
126 N Shipley St, Seaford, DE 19973

BP Environmental, Inc.
8615 Commerce Drive, Unit One
Easton, Maryland 21601

Site:
PINNACLE FOOD GROUP, LLC
29984 PINNACLE WAY
MILLSBORO, DE

Date:03/25/13
Revision Date:
Project: AL-190-03
Drafted by:JP

FIGURE 1- TOPOGRAPHIC MAP
SCALE 1" = 100 FT



SYMBOL LEGEND

	FENCE
	SPRAY FIELD SOIL SAMPLES
	TREE LINE
⊕	SHRUBBERY
○	SAMPLE LOCATIONS
SB	SOIL BORINGS
TW	TEMPORARY WELL
SP	SCREEN POINT LOCATIONS
Q	QUADRANT
MW	PERMANENT MONITORING WELL

Prepared For:	Site:			
ALLEN HARIM FOODS.LLC 126 NORTH SHIPLEY STREET. SEAFORD DE 19973	PINNACLE FOODS GROUP. LLC 29987 PINNACLE WAY MILLSBORO, DE	Date:01/11/12 Revision Date:03/27/13 Project: AL-190-03 Drafted by:JP	FIGURE 2- SITE MAP WITH SAMPLING LOCATIONS SCALE 1" =227 FT	BP Environmental, Inc. 8615 Commerce Drive, Unit One Easton, Maryland 21601

11/09
09/11

- Annual SW [illegible] for nutrients 3.38 / 0.22
- Air cooling vs. water cooling
- Lanes permit & trade

A — Check on date for renewal extension letter

Permit expires: Oct 31, 2013

Renewal application in by: May 3, 2013

Jack, Ron, Blan, Bryan, Dave S., G
Henry P., Michael [illegible], Jason Reale
Jim Quinton

3-13-13

— Cordova TP .05 mg/l chemical treatment
TN. 2.5-3.0 mg/l

— RTBS - (soils) [illegible] Core Samples @ spray area
Parsons Envir. Evaluating today.
2.4 MGD worst case scenario

— 14 mos from "GO" to complete & be on line

[illegible] Need to meet during first week in April

Reid Engineering Company, Inc.

Environmental and Civil Engineering Consultants
• Wastewater • Water /Sewer • Reuse
1210 Princess Anne Street | Fredericksburg, Virginia 22401
540-371-8500 | www.reidengineering.com

DRAFT

Mr. Henry Quathamer
Maintenance/Engineering Manager
Allen Harim Foods, LLC.
12041 Cordova Road
Cordova, MD 21625

SUBJECT: ALLEN HARIM FOODS, LLC – MILLSBORO, DELAWARE NEW WASTEWATER TREATMENT SYSTEM

Dear Henry:

As requested by Allen Harim (AH), Reid Engineering Company (REC) has prepared the attached conceptual design layout drawing and preliminary project cost estimate for a new wastewater treatment system for the proposed new poultry processing plant in Millsboro, Delaware. The proposed wastewater treatment system will provide capacity for a maximum daily wastewater flow volume of 2,400,000 gallons/day, 5 days/week when processing a maximum of 300,000 birds/day.

Wastewater pretreatment will be provided by a new DAF system operated with upstream flow equalization and high efficiency chemical coagulation-flocculation treatment. The new final treatment system must provide capability to produce final effluent in compliance with proposed discharge permit nutrient concentration limits of 5.0 mg/L Total Nitrogen (TN) and 1.0 mg/L Total Phosphorus (TP). DNREC has additionally requested that the new wastewater treatment system provide capability to be operated to reduce final effluent TN and TP concentrations as low as possible.

To provide this very high efficiency wastewater treatment capability and the required wastewater treatment capacity, REC recommends that AH install a new four stage Bardenpho biological nitrogen and phosphorus removal (BNPR) activated sludge final treatment system followed by tertiary deep bed sand filtration and UV disinfection. This state-of-the-art wastewater treatment process has been successfully used by REC at several facilities for treatment of poultry processing plant wastewater to produce very high quality final effluent with TN concentrations of 1.0 to 2.0 mg/L and TP concentrations of 0.10 to 0.30 mg/L. These high efficiency poultry wastewater treatment systems are located in Hurlock Maryland, Cordova Maryland, Glen Allen Virginia and Edinburg Virginia and each has been in operation for many years.

The proposed new final treatment system includes the following components to operate downstream of a new DAF pretreatment system:

1. 7 Day Flow Equalization Basin Reactor #1
2. Nitrification Reactor Tank #2
3. Anoxic Reactor Tank #3
4. Aerobic Reactor Tank #4
5. Clarifier Influent Flow Splitter-Flocculation Tank
6. Two Final Clarifiers
7. Return Activated Sludge Pump Station
8. Waste Activated Sludge Pump Station
9. Tertiary Deep Bed Sand Filters and Enclosure Building
10. UV Disinfection
11. Final Effluent Flow Meter
12. Post Aeration Cascade
13. Retrofit of Old Basins into New Emergency Wastewater Storage Basin
14. Retrofit Existing Above Grade Circular Aeration Basin into New Waste Activated Sludge Storage-Digestion Tank
15. Belt Filter Press Sludge Dewatering System in Existing Building
16. New Plant Site Drain Pump Station
17. New Wastewater Equipment Building

The four stage BNPR activated sludge treatment system includes Flow Equalization Basin (FEB) Anoxic Reactor #1, Aerobic Nitrification Reactor #2, Anoxic Reactor #3 and Aerobic Reactor #4. FEB Anoxic Reactor #1 provides 7 day hydraulic flow equalization upstream of the remainder of the wastewater treatment system; and, is an anoxic basin that provides first stage activated sludge treatment for BOD removal and removal of nitrate nitrogen contained in mixed liquor recycled from downstream Reactor #2. Nitrification Reactor #2 is an aerobic basin that provides second stage activated sludge treatment for ammonia nitrogen removal. Anoxic Reactor #3 provides final nitrate nitrogen removal using supplemental carbon source dosage. Aerobic Reactor #4 provides final BOD and ammonia nitrogen removal and stripping of nitrogen gas produced by denitrification in upstream Anoxic Reactor #3.

The mixed liquor discharged from Reactor #4 flows into a combined Flow Splitter Tank and Flocculation Tank and then into two Final Clarifiers for final settling of biomass and chemically precipitated phosphorus. A Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) Pump Station is provided for the clarifier.

Clarifier effluent will flow by gravity into upflow, continuous backwash, deep sand bed tertiary filters for high efficiency removal of TSS, BOD, Total Nitrogen and Total Phosphorus. Filtered effluent is discharged by gravity into a UV contact channel for final effluent disinfection by UV light contact. Disinfected final effluent is discharged through a final effluent flow meter prior to post aeration by a cascade step aerator and stream discharge.

Waste activated sludge will be pumped into the old treatment system aeration tank which will be converted into a WAS Digestion-Storage Tank. The old clarifier will be operated as a WAS Thickener for gravity thickening of sludge prior to mechanical dewatering on a new Belt Filter Press.

Conceptual layout drawing of the proposed new wastewater treatment system are provided in Appendix #1. A project capital cost estimate for the wastewater treatment system is provided in Appendix #2.

I look forward to meeting with you to review the proposed new wastewater treatment system design, conceptual layout drawings and preliminary project capital cost estimate. If you have questions or need additional information, please advise.

Best Regards,

John H. Reid, PE
President

Appendix #1
Conceptual Layout Drawing

Appendix #2
Preliminary Project Cost Estimate

REID ENGINEERING COMPANY, INC. 1210 Princess Anne Street, Fredericksburg, VA 22401 phone: (540) 371-8500 fax: (540) 371-8576			
Client Name: **Allen Harim Foods**		**Preliminary**	
City: **Millsboro**	State: **DE**	Job No.	
Est. By: JHR	Chk'd By: WHT	Date:	February 19, 2013
DESCRIPTION: **New Final Wastewater Treatment System for 2.40 MGD**		TOTAL	
A. DAF Cell Effluent Pump Station		$	100,000
B. FEB Anoxic Reactor #1		$	1,700,000
C. FEB Anoxic Reactor Effluent Pump Station		$	125,000
D. Nitrification Reactor #2		$	1,250,000
E. Anoxic Reactor #3/Aerobic Reactor #4		$	775,000
F. Final Clarifiers #1 & #2		$	1,400,000
G. RAS/WAS Pump Station		$	140,000
H. New Tertiary Filter System		$	1,000,000
I. UV Disinfection Unit		$	300,000
J. Post Aeration Cascade & Final Effluent Flow Meter		$	100,000
K. Plant Site Drain/Filter Reject Pump Station		$	60,000
L. Misc. Process Piping		$	100,000
M. Chemical Equipment & Piping		$	150,000
N. Modifications to Ex. Sludge Digestor Tanks		$	200,000
O. Wastewater Equipment Building (26x62)		$	200,000
P. Potable Water Piping		$	15,000
Q. Painting		$	50,000
R. Site Preparation & Erosion Control		$	25,000
S. Electrical & Instrumentation		$	450,000
T. Scada Controls		$	100,000
U. Emergency Generator System		$	250,000
V. Finish Grading & Seeding		$	15,000
W. Misc. Metalwork, Pipe Supports, etc.		$	20,000
X. Roadwork & Pavement		$	75,000
Y. Retrofit Ex. Basin into Emergency Storage Lagoon		$	100,000
SUBTOTAL #1		**$**	**8,700,000**
Z. Mobilization, Contingency, Contractor Overhead & Profit @ 15%		$	1,300,000
CONSTRUCTION TOTAL		**$**	**10,000,000**
AA. Engineering by Reid Engineering Company		$	770,000
BB. Soil Boring, Geotech Report & Testing		$	22,000
CC. Surveying		$	8,000
TOTAL PROJECT COST		**$**	**10,800,000**

REID ENGINEERING COMPANY, INC.

1210 Princess Anne Street, Fredericksburg, VA 22401

phone: (540) 371-8500 fax: (540) 371-8576

Client Name:	**Allen Harim Foods**		**Preliminary**	
City:	**Millsboro**	State: **DE**	Job No.	
Est. By: **JHR**		Chk'd By: **WHT**	Date:	February 19, 2013

DESCRIPTION: **New Final Wastewater Treatment System for 2.40 MGD**	Equipment Material	Misc. Eq. Install.	Total
A. DAF Cell Effluent Pump Station			**$ 100,000**
1. Concrete Wet Well		20,000	
2. Self-Priming Pumps, Controls & Level Sensor	33,000	2,000	
3. VFDs for Pumps	20,000	4,000	
4. Pump Suction Piping		6,000	
5. Pump Discharge Piping		8,000	
6. Discharge Header		4,000	
7. Misc		3,000	
B. FEB Anoxic Reactor #1			**$ 1,700,000**
1. Pre-cast Post Tensioned Concrete Tanks (Qty 2)	750,000	50,000	
(160 ft. dia. x 24 ft. SWD x 28 ft. tall, 3.75 MG)			
2. Excavation and Backfill		50,000	
3. Stone Base		20,000	
4. Jet Aeration and Mixing Equipment including Blowers	450,000	40,000	
5. Jet Pump Suction and Discharge Piping		40,000	
6. Air Supply Piping from Blowers		40,000	
7. VFDs for Blowers	60,000	15,000	
8. Nitrate Recycle Line and Valve		30,000	
9. Nitrate Recycle Flow Meter	9,000	1,000	
10. Influent Piping		20,000	
11. Effluent Suction Piping		20,000	
12. Access Stairs and Platform		60,000	
13. Drain Lines		10,000	
14. Tank Interconnect Piping		15,000	
15. Misc.		20,000	
C. FEB Anoxic Reactor Effluent Pump Station			**$ 125,000**
1. Self-Priming Pumps, Controls & Level Sensors	40,000	5,000	
2. VFDs for Pumps	34,000	4,000	
3. Pump Suction Piping		8,000	
4. Pump Discharge Piping		14,000	
5. Discharge Header		5,000	
6. Flow Meter	9,000	1,000	
7. Misc.		5,000	
D. Nitrification Reactor #2			**$ 1,250,000**
1. Excavation/Backfill		20,000	
2. Stone Base		10,000	
3. Pre-cast Post Tensioned Concrete Tanks	600,000	25,000	
(100 ft. dia. x 28.5 ft. SWD x 30 ft. tall, 1.5 MG)			
4. Jet Mix-Aeration Equipment including Blowers	400,000	25,000	
5. Jet Pump Suction and Discharge Piping		30,000	
6. Access Stairs & Walkways		40,000	
7. Air Supply Piping		20,000	
8. Influent and Effluent Piping		25,000	
9. Nitrate Recycle Piping		20,000	
10. Nitrate Recycle Flow Meter	9,000	1,000	
11. Misc.		25,000	

REID ENGINEERING COMPANY, INC.
1210 Princess Anne Street, Fredericksburg, VA 22401
phone: (540) 371-8500 fax: (540) 371-8576

Client Name:	**Allen Harim Foods**		**Preliminary**	
City:	**Millsboro**	State: **DE**	Job No.	
Est. By: **JHR**		Chk'd By: **WHT**	Date:	February 19, 2013
DESCRIPTION:	**New Final Wastewater Treatment System for 2.40 MGD**	Equipment Material	Misc. Eq. Install.	Total
E.	**Anoxic Reactor #3/Aerobic Reactor #4**			**$ 775,000**
1.	Pre-cast Post Tensioned Concrete Tank w/Divider Wall	450,000	25,000	
	(70 ft. dia. x 24.5 ft. SWD x 26 ft. tall = 0.70 MG)			
2.	Excavation and Backfill		15,000	
3.	Stone Base		5,000	
4.	Floating Mixers for Anoxic Reactor #3	50,000	5,000	
5.	Coarse Bubble Diffuser System for Aerobic Reactor #4	30,000	15,000	
6.	Air Supply Blowers	45,000	5,000	
7.	VFDs for Blowers	20,000	5,000	
8.	Air Supply Piping		15,000	
9.	Access Stairs and Perimeter Handrail		40,000	
10.	Influent and Effluent Piping		30,000	
11.	Misc.		20,000	
F.	**Final Clarifiers #1 & #2**			**$ 1,400,000**
1.	Excavation/Backfill		20,000	
2.	Stone Base		20,000	
3.	Concrete Tanks (75 ft. dia. x 17 ft. tall)		700,000	
4.	Clarifier Mechanisms, Weirs & Baffles	300,000	80,000	
5.	Access Stairs & Walkways		50,000	
6.	Influent Piping		50,000	
7.	RAS Suction Piping		40,000	
8.	Scum Piping		30,000	
9.	Drain Piping		16,000	
10.	Effluent Piping		24,000	
11.	Ford-Hall Effluent Trough Cleaning Units		30,000	
12.	Misc.		40,000	
G.	**RAS/WAS Pump Station**			**$ 140,000**
1.	Self Priming RAS Pumps	30,000	3,000	
2.	VFDs for Pumps	24,000	6,000	
3.	RAS Pump Suction Piping		8,000	
4.	RAS Pump Discharge Piping		10,000	
5.	RAS Discharge Headers		10,000	
6.	RAS Flow Meters	9,000	1,000	
7.	WAS Pump	19,000	1,000	
8.	VFD for WAS Pump	8,000	2,000	
9.	WAS Flow Meter	3,500	500	
10.	Misc.		5,000	
H.	**New Tertiary Filter System**			**$ 1,000,000**
1.	Deep Bed, Tertiary Filter Concrete Structure		200,000	
2.	Grout Fill		20,000	
3.	Excavation/Backfill/Earthwork		30,000	
4.	Filter Equipment and Controls (4x2 modules)	375,000	20,000	
5.	Access Stairs, Walkways and Platforms		60,000	
6.	Filter Influent Piping		20,000	
7.	Filter Drain Piping to Reject Pump Station		20,000	
8.	Air Piping to Filters		10,000	
9.	Filter, UV, RAS Pumps & Chemical Enclosure Building (36x56)		200,000	
10.	Compressor Package	20,000	5,000	
11.	Misc.		20,000	

REID ENGINEERING COMPANY, INC.

1210 Princess Anne Street, Fredericksburg, VA 22401
phone: (540) 371-8500 fax: (540) 371-8576

Client Name:	**Allen Harim Foods**			**Preliminary**	
City:	**Millsboro**	State:	**DE**	Job No.	
Est. By: **JHR**		Chk'd By:	**WHT**	Date:	February 19, 2013

DESCRIPTION: **New Final Wastewater Treatment System for 2.40 MGD**	Equipment Material	Misc. Eq. Install.	Total
I. UV Disinfection Unit			**$ 300,000**
1. UV Contact Channel	200,000	50,000	
2. UV Equipment & Hoist		15,000	
3. Grating & Walkways		20,000	
4. Effluent Piping		5,000	
5. Misc.		10,000	
J. Post Aeration Cascade & Final Effluent Flow Meter			**$ 100,000**
1. Concrete Tank for Final Effluent Flow Meter		20,000	
2. Final Effluent Flow Meter Weir & Sensor	15,000	5,000	
3. Concrete Cascade Step Structure		35,000	
4. Influent Piping		5,000	
5. Effluent Piping to Existing Outfall		10,000	
6. Misc.		10,000	
K. Plant Site Drain/Filter Reject Pump Station			**$ 60,000**
L. Misc. Process Piping			**$ 100,000**
1. RAS Force Main to Reactors #1 & #2		30,000	
2. Effluent Outfall from UV to Cascade & 001 Discharge Point		20,000	
3. Misc. Drain Lines		10,000	
4. WAS Force Main to Existing WSST		20,000	
5. Plant Site Drain Pump Station Force Main		10,000	
6. Misc.		10,000	
M. Chemical Equipment & Piping			**$ 150,000**
1. Polymer Mix Tanks (Qty 2)	20,000	4,000	
2. Polymer Tank Mixers (Qty 2)	8,000	2,000	
3. Polymer Pumps and Pump Stand (Qty 1)	9,000	1,000	
4. PVC Polymer Chemical Suction Piping		1,000	
5. PVC Polymer Chemical Discharge Piping to Clarifier Influent		4,000	
6. Magnesium Hydroxide Tank with Mixer (Qty 1)	*	2,000	
7. Mag Tank Slab		2,000	
8. Mag Pumps and Pump Stand (Qty 2)	18,000	2,000	
9. PVC Mag Chemical Suction Piping		1,000	
10. PVC Mag Chemical Discharge Piping to Reactor #2		7,000	
11. Coagulant Bulk Tank	24,000	5,000	
12. Coagulant Pumps & Pump Stand (Qty 2)	18,000	2,000	
13. Carbon Source (CS) Bulk Tank		20,000	
14. Misc.			
*Furnished by Chemical Supplier			
N. Modifications to Ex. Sludge Digestor Tanks			**$ 200,000**
O. Wastewater Equipment Building (26x62)			**$ 200,000**
P. Potable Water Piping			**$ 15,000**
Q. Painting			**$ 50,000**
R. Site Preparation & Erosion Control			**$ 25,000**

REID ENGINEERING COMPANY, INC.				
1210 Princess Anne Street, Fredericksburg, VA 22401				
phone: (540) 371-8500 fax: (540) 371-8576				
Client Name: **Allen Harim Foods**			**Preliminary**	
City: **Millsboro**	State: **DE**		Job No.	
Est. By: **JHR**	Chk'd By: **WHT**		Date: February 19, 2013	
DESCRIPTION: **New Final Wastewater Treatment System for 2.40 MGD**		Equipment Material	Misc. Eq. Install.	Total
S. Electrical & Instrumentation				**$ 450,000**
T. Scada Controls				**$ 100,000**
U. Emergency Generator System				**$ 250,000**
V. Finish Grading & Seeding				**$ 15,000**
W. Misc. Metalwork, Pipe Supports, etc.				**$ 20,000**
X. Roadwork & Pavement				**$ 75,000**
Y. Retrofit Ex. Basin into Emergency Storage Lagoon				**$ 100,000**
SUBTOTAL #1				**$ 8,700,000**
Z. Mobilization, Contingency, Contractor Overhead & Profit @ 15%				**$ 1,300,000**
CONSTRUCTION TOTAL				**$ 10,000,000**
AA. Engineering by Reid Engineering Company				**$ 770,000**
BB. Soil Boring, Geotech Report & Testing				**$ 22,000**
CC. Surveying				**$ 8,000**
TOTAL PROJECT COST				**$ 10,800,000**

REID ENGINEERING COMPANY, INC. 1210 Princess Anne Street, Fredericksburg, VA 22401 phone: (540) 371-8500 fax: (540) 371-8576		
Client Name: **Allen Harim Foods**		**Preliminary**
City: **Millsboro**	State: **DE**	Job No.
Est. By: JHR	Chk'd By: WHT	Date: February 19, 2013
DESCRIPTION: **Flow Equalization Basin for New Wastewater Pretreatment System**		TOTAL
A. Flow Equalization Basin (FEB) Tank		$ 625,000
B. FEB Effluent Pump Station		$ 75,000
C. Misc. Process Piping		$ 10,000
D. Painting		$ 5,000
E. Site Preparation & Erosion Control		$ 5,000
F. Electrical & Instrumentation		$ 125,000
G. Finish Grading & Seeding		$ 2,000
H. Misc. Metalwork, Pipe Supports, etc.		$ 3,000
I. Roadwork & Pavement		$ -
SUBTOTAL #1		**$ 850,000**
J. Mobilization, Contingency, Contractor Overhead & Profit @ 15%		$ 125,000
CONSTRUCTION TOTAL		**$ 975,000**
K. Engineering by Reid Engineering Company		$ 69,000
L. Electrical & Scada by Others		$ 9,000
M. Soil Boring, Geotech Report & Testing		$ 7,000
N. Surveying		$ -
TOTAL PROJECT COST		**$ 1,060,000**

REID ENGINEERING COMPANY, INC.
1210 Princess Anne Street, Fredericksburg, VA 22401
phone: (540) 371-8500 fax: (540) 371-8576

Client Name: **Allen Harim Foods**			**Preliminary**	
City: **Millsboro**	State: **DE**		Job No.	
Est. By: **JHR**	Chk'd By: **WHT**		Date:	February 19, 2013
DESCRIPTION: **Flow Equalization Basin for New Wastewater Pretreatment System**		Equipment Material	Misc. Eq. Install.	Total
A. Flow Equalization Basin (FEB) Tank				**$ 625,000**
1. 300,000 gallon Bolted Stainless Steel EQ Tank			300,000	
2. Excavation and Backfill			20,000	
3. Influent Piping & Valve			10,000	
4. Coarse Bubble Diffuser System		75,000	20,000	
5. Air Supply Blowers		95,000	5,000	
6. VFD's for Blowers		40,000	5,000	
7. Air Supply Piping			20,000	
8. Effluent Suction Piping			15,000	
9. Tank Drain Piping			10,000	
10. Misc.			10,000	
B. FEB Effluent Pump Station				**$ 75,000**
1. New Submersible Pumps, Controls & Level Sensor		42,000	3,000	
2. New Pump Discharge Piping			10,000	
3. New Discharge Header			4,000	
4. VFDs for Pumps			5,000	
5. Flow Meter		5,000	1,000	
6. Misc.			5,000	
C. Misc. Process Piping				**$ 10,000**
D. Painting				**$ 5,000**
E. Site Preparation & Erosion Control				**$ 5,000**
F. Electrical & Instrumentation				**$ 125,000**
G. Finish Grading & Seeding				**$ 2,000**
H. Misc. Metalwork, Pipe Supports, etc.				**$ 3,000**
I. Roadwork & Pavement				
SUBTOTAL #1				**$ 850,000**
J. Mobilization, Contingency, Contractor Overhead & Profit @ 15%				**$ 125,000**
CONSTRUCTION TOTAL				**$ 975,000**

REID ENGINEERING COMPANY, INC. 1210 Princess Anne Street, Fredericksburg, VA 22401 phone: (540) 371-8500 fax: (540) 371-8576					
Client Name:	**Allen Harim Foods**			**Preliminary**	
City:	**Millsboro**	State:	**DE**	Job No.	
Est. By: **JHR**		Chk'd By:	**WHT**	Date:	February 19, 2013

DESCRIPTION: **Flow Equalization Basin for New Wastewater Pretreatment System**	Equipment Material	Misc. Eq. Install.	Total
K. Engineering by Reid Engineering Company			**$ 69,000**
L. Electrical & Scada by Others			**$ 9,000**
M. Soil Boring, Geotech Report & Testing			**$ 7,000**
N. Surveying			
TOTAL PROJECT COST			**$ 1,060,000**

NO.	BY	CHKD	APRV	REVISION	DATE

DRAWN BY:	CDS
DESIGNED BY:	J.H.R.
CHKD BY:	

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John H. Reid P.E.

REID ENGINEERING COMPANY, INC.

1210 Princess Anne Street
Fredericksburg, Virginia 22401
Tel:(540) 371-8500 Fax:(540) 371-8576

PRELIMINARY LAYOUT

ALLEN-HARIM

WASTEWATER TREATMENT SYSTEM

MILLSBORO, DELAWARE

DATE:	2-19-13	PROJECT NO.	
SCALE:	1"=40'	DWG NO:	

The Bardenpho Wastewater Treatment Process

Posted by Civil Engineer On August - 2 - 2010

Article by **Jayant R Row**

Very low effluent concentrations of nitrogen and phosphorus with almost no chemical addition can be achieved by the Bardenpho Process for treating wastewater.

This four stage process was discovered by Barnard of South Africa in the 1980's.

Activated Sludge Needs Further Treatment

An activated sludge process removes carbonaceous pollution in waste water through two main stages. The first is the aeration tank where the raw water is mixed with air or oxygen. This aeration tank has a mixture of the raw water and some of the recycled sludge which acts as a seeding material. In the second part of the process, the aerated mixture is allowed to settle the biological flocculants, separating the sludge that is biological from the treated water. Nitrogenous matter or phosphate requires further treatment for its removal.

The removal of nitrogen and phosphorus from wastewater is nowadays considered essential to protect waterways. Excessive release of wastewater containing nitrogen and phosphorus can encourage the growth of algae and weeds in waterways. This can cause a rapid growth in the population which is not sustainable and hence most of the algae die. These algae decompose due to bacterial action which further reduces the dissolved oxygen so necessary for health of the water. Phosphorous can also cause damage to reverse osmosis installations.

The Background behind the Bardenpho Process of Wastewater Treatment

One method of removal of the nutrients that nitrogen and phosphorus make up in treated wastewater is biological treatment through modifying the sludge system without any addition of chemicals. In this the organic matter of the sludge is used as the energy source and carbon required to remove the phosphorous and nitrogen. This in turn reduces the cost as no chemical addition is involved.

The Bardenpho Process of Wastewater Treatment was developed by James Barnard of South Africa in the 1970's. It is a biological nutrient removal process which goes through four stages. Anaerobic sludge is obtained from the anaerobic treatment tank of the plant and mixed with food waste, grass, or wastepaper. This organic waste material is subjected to anaerobic fermentation for a period of 2 to 4 days at a temperature of 30 to 40 °C. Anaerobic sludge is used to obtain broth for fermentation. The fermentation broth is then sent through alternating anaerobic-aerobic-anoxic cycles in batch reactors.

When under anaerobic conditions, phosphorous is secreted from the microbes that accumulate phosphorous. When the fermentation broth is then subjected to aerobic conditions, the phosphorous is taken up by the accumulating microbes. Nitrifying bacteria oxidize the ammonia nitrogen in this stage. When the final anoxic tank is filled with this broth, the oxidized nitrogen is converted to nitrogen gas by the bacteria.

Nitrogen Removal

Nitrogen in the original wastewater is mainly in the form of ammonia and this ammonia passes through the first two zones without any change. It is only in the third aerobic zone that the sludge has aged sufficiently for complete nitrification to take place and that the ammonia nitrogen gets converted to nitrates and nitrites. When this reaches the anoxic zone, because of the absence of dissolved oxygen, the nitrates are converted by the bacteria to nitrogen gas by using the organic carbon compounds as donors for hydrogen. This nitrogen escapes to the atmosphere. The effluent is then subjected to aeration in the final zone which raises the dissolved oxygen levels and prevents further denitrification.

Phosphorous Removal

This is achieved through a step feed process in which wastewater influent is treated in at least one aerobic zone. This is again processed through at least one anoxic zone. A portion of the effluent from the anoxic zone is then sent to an anaerobic zone along with raw water. Influent from one anaerobic zone is sent to an anoxic zone and then sent to a downstream aerobic zone.

Advantages of the Bardenpho Process

As no chemicals are used, operating costs are lower and there is also no problem with removal of sludge that can come from sludge containing chemicals. Bardenpho Process plants are simple to operate and do not require any retraining of personnel. The sludge that is obtained in the final stages does not require any further treatment and can be easily disposed of.

Disadvantages of the Bardenpho Process

One of the main disadvantages of the Bardenpho process is the number of tanks required, which greatly increases capital cost. Detention times also need to be very strictly monitored and constant evaluation made of the BOD and COD values.

e mde MARYLAND Department of the Environment

Robert L. Ehrlich, Governor; Michael S. Steele, Lt. Governor; Kendl P. Philbrick, Secretary

Volume 1, Number 7 November, 2005

Maryland Goes Beyond Other States in Enhanced Nutrient Removal (ENR)

By Walid Saffouri, P.E.

Click to view larger image and caption

Maryland introduced landmark legislation two sessions ago that requires taking new aggressive steps in removing pollutants from wastewater entering the Bay. Maryland's initital 1983 commitment under the Chesapeake Bay Agreement with six Bay states, prompted the State to establish the Biological Nutrient Removal Program (BNR) to reduce nutrients in treated sewage by the most stringent control mechanism used by any state up to that time. Governor Ehrlich's 2004 Bay Restoration legislation sets a new goal for sewage treatment that is the current state-of-the-art for nutrient removal, referred to as Enhanced Nutrient Removal (ENR). Terms like ENR and BNR have been thrown around in the media for the last few years. But what do they mean?

The primary cause of the Chesapeake Bay's poor water quality and aquatic habitat loss, is elevated levels of nitrogen and phosphorus. Excessive amounts of nitrogen and phosphorus create dense algae blooms that deplete oxygen and light, eventually killing grasses and aquatic species.

Nutrients enter the Bay via rivers and streams from point and nonpoint sources. The vast majority of point source discharges of nutrients are from sewage treatment plants, with smaller contributions from industries. Nonpoint sources of nutrients are runoff from farms, feedlots, lawns, parking lots, streets, and forests; and from air deposition, groundwater, and septic systems.

BNR Program

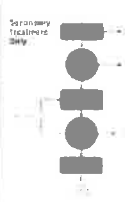
Under the BNR Program, established in 1984, Maryland provided 50 percent of capital costs in grant funding to local governments to upgrade the 66 largest wastewater treatment plants (WWTPs) in the state. The design capacity of these plants is 500,000 gallons per day or more and they represent approximately 95 percent of the municipal wastewater discharge into the Chesapeake Bay from Maryland. The goal of the BNR Program is to reduce nitrogen levels in the treated wastewater (effluent) down to 8 millgrams per liter (mg/l). Without BNR, a typical WWTP discharges nitrogen at a level of about 18 mg/l. To date, Maryland has provided funding for this program to upgrade 45 of the 66-targeted facilities with the BNR process. An additional ~$100 million in State grant funding is needed to complete the remaining BNR upgrades, and the State is committed to providing the funding through annual capital appropriations.

ENR Program

Maryland's Enhanced Nutrient Removal (ENR) Program takes the next step beyond BNR and controls point source nutrient discharge to the Bay by upgrading wastewater treatment plants to the limit of technology for nutrient removal. ENR reduces nitrogen discharge from BNR treatment level of 8 milligrams per liter to 3 mg/l and phosphorus from 3 to 0.3 mg/l. The Bay Restoration Fund will provide grants to local governments for 100% of the cost of upgrading a BNR plant to ENR.

Our Goal

The goal is to remove the Bay and the tidal portions of its tributaries from the impaired waters list, under the Clean Water Act by 2010. To meet this goal, the six Bay states and Washington DC, will have to limit the amount of nutrient loading to a maximum of 183 million pounds per year of (lbs/yr) nitrogen and 12.8 million lbs/yr phosphorus. Maryland's numerical limit is a maximum of 37 million lbs/yr nitrogen and 2.9 million lbs/yr phosphorus. Nutrient reduction from both point and nonpoint sources is necessary to accomplish this goal. To achieve this, Maryland still needs to reduce nitrogen loading by an additional 20 million lbs/yr and phosphorus by 1.1 million lbs/yr.



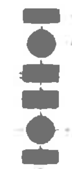
Governor Robert L. Ehrlich's Bay Restoration Fund, which was signed into law in May 2004, is a source of new state funding to upgrade WWTPs from the Biological Nutrient Removal level to the Enhanced Nutrient Removal (ENR) level. The fund provides up to 100 percent in grants. Under ENR, the WWTPs will be upgraded to lower the nutrients in the treated wastewater to 3 milligrams per liter (mg/l) total nitrogen and 0.3 mg/l total phosphorus. These ENR upgrades will allow Maryland to achieve an estimated 7.5 million lbs/yr of additional nitrogen reduction and 0.26 million lbs/yr of phosphorus reduction. This action alone will accomplish about 37 percent of the 20 million lbs/yr nitrogen reduction goal and about 24 percent of the 1.1 million lbs/yr phosphorus reduction goal for Maryland.

Most of the 66-targeted facilities were upgraded from secondary treatment to BNR by retrofitting their existing activated sludge process. The ENR components are being added for additional nutrient removal.

An *Example of Activated Sludge Process for Secondary Treatment* Only is available by clicking on the icon to the left.

This process is known as activated sludge treatment, which treats wastewater as follows:
Wastewater passes through screens, which captures large items. This is followed by a grit removal tank, which slows down the wastewater flow enough to settle relatively heavy particles such as sand. The screens and grit tank represent the preliminary treatment system, also referred to as the "headwork".

BNR

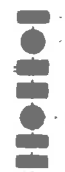


The wastewater flows into a primary clarifier, in which the velocity of wastewater flow is further reduced to allow for lighter particles to settle. After the preliminary and primary treatment systems (physical treatment process), the wastewater is introduced to the biological treatment process in the aeration basin.

In the aeration basin, bacteria take in ammonia and added oxygen to produce nitrates. This biological process removes more biochemical oxygen demand (BOD) and suspended solids. Approximately 90 percent of the sludge is returned to the aeration basin from the final clarifier to allow for more bacteria growth.

Wastewater is once again placed into settling tanks to remove any remaining solids in the final clarifier.

ENR



The final process, disinfection, occurs as the wastewater is brought into contact with oxidizing chemicals (such as chlorine, bromine, ozone, hydrogen peroxide, and related compounds). Chlorine has long been the disinfectant of choice for most systems. It offers reliable reduction of pathogenic microorganisms at reasonable operating costs. Due to the elevated threat of terrorism, however, many communities are changing their disinfection system to Ultraviolet (UV) Radiation (an electromagnetic radiation used for disinfection) to avoid the storage of hazardous oxidizing chemicals at their facilities.

To emde Homepage

An Example of *Activated Sludge Process with BNR Treatment* is available by clicking on the icon to the left.

To achieve BNR, one or two anoxic basins are added to the activated sludge process. In the low-oxygen anoxic basin, the bacteria take in nitrates, returning through the internal recycle from the aeration basin, to produce nitrogen gas, which escapes from the water and is emitted into the surrounding atmosphere. Approximately 90 percent of the sludge is returned to the anoxic basin from the final clarifier to allow for more bacteria to grow and assist in the treatment.

An *Example of Activated Sludge Process with ENR Treatment* is available by clicking on the icon to the left.

To achieve ENR, filters can be added to the BNR process for additional nitrogen and phosphorus removal. An external carbon-source, such as methanol, is added to the filter to increase bacteria growth and further improve treatment.

This process allows Maryland to achieve maximum nutrient removal from wastewater treatment plants and do our part to "save the Bay."

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Editorial Board
Maryland Department of the Environment
1800 Washington Boulevard, Baltimore, MD 21230
http://www.mde.state.md.us

DENITRIFICATION

Enhanced Nutrient Removal (ENR)

Blue Water Technologies, Inc. is the industry leader in the development of technologies for nutrient removal from wastewater. With advanced equipment design, Blue Water offers the Blue NITE™ treatment system for consistently lowering nitrates to <1 mg/L NO_3-N. Using Blue NITE™'s proprietary control system, coupled with new applications of alternative carbon sources, Blue Water provides the most efficient and economically viable treatment solution.

In the Blue NITE™ process, biological activity in the tertiary filtration system converts nitrates to nitrogen gas. Using our unique control system, Blue NITE™ maintains NPDES targets for both nitrate and biochemical oxygen demand (BOD) by accommodating high or fluctuating influent nitrate levels. In addition to installations using traditional carbon sources such as methanol, Blue Water has extensive design and installation experience with the newest alternative carbon sources. These non-explosive options can moderate the capital cost of chemical storage facilities.

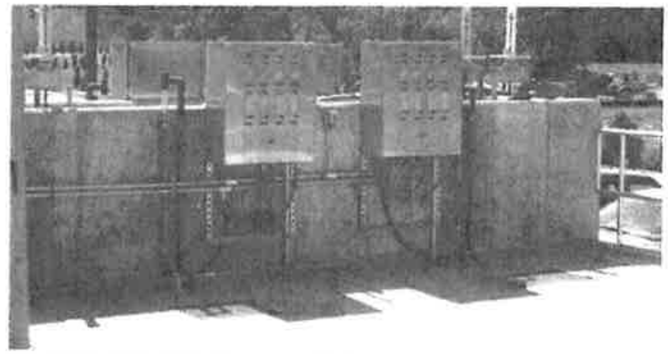
Blue NITE™ can be configured for wastewater or groundwater applications. The modular filter design allows for trouble-free installation of new systems, or capacity increases to existing processes. The filters are also certified for water reuse applications and hold California Title 22 acceptance.

With over twenty years of international installation history and experience, Blue Water is a trusted and capable partner in the wastewater industry, providing economical solutions to municipal and industrial clients alike.

The Blue NITE™ advantage:

- Nitrate removal to < 1 mg/L
- Unique patented control system
- Lowest capital and O & M
- Eliminates upsets and backwash cycling
- Modular end-of-pipe solution
- Alternative carbon sources available
- Total nutrient removal capable
- California Title 22 accepted

Blue NITE™



3.5 MGD (153 L/s) Blue NITE™ in Virginia

How It Works

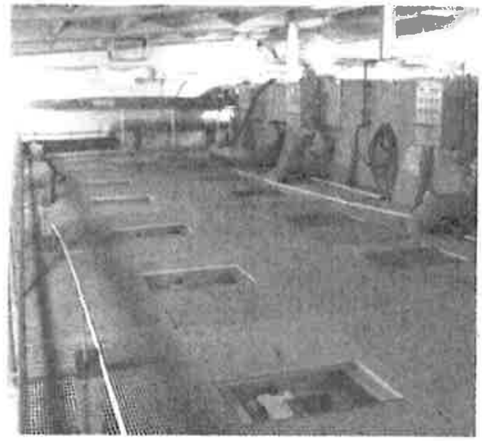
Blue NITE™ systems utilize Blue Water's Centra-flo™ continuous backwash, upflow sand filters. A carbon source is dosed to the wastewater influent prior to entering the sand filters. In the Blue NITE™ system, fixed-film heterotrophic bacteria convert nitrates (NO_3 and NO_2) to atmospheric nitrogen (N_2). The composition of the bacterial population depends largely on the type of carbon source dosed. Bacteria and solids wasting are facilitated by the continuous backwash of the Centra-flo™ filter. The sand washer removes solids and excess biomass, which are directed to a reject line. The clean sand then falls by gravity back to the media bed.

Design hydraulic loading rates to Blue NITE™ filters are dependent on influent nitrate levels, nitrate variability, dissolved oxygen (DO) levels, and expected range in water temperature. Loading rates can also be dictated by the NPDES permit or local regulatory agencies. Blue Water's design parameters coupled with its proprietary control system optimizes system parameters to maintain a healthy, stable biomass for denitrification.

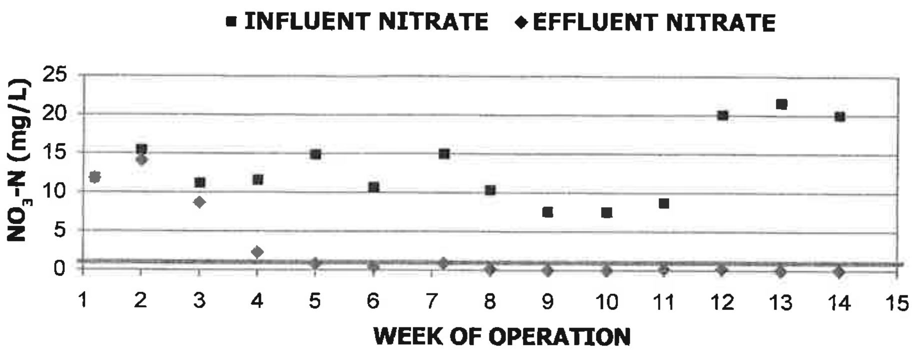
The nitrogen gas produced during operation becomes entrapped by the filter media. This gas is carried down with the sand and is released when the filter airlift transports the sand up to the sand washer. Removal of gas in this fashion has several benefits that include: eliminating false readings in headloss, eliminating the need to backwash because of gas entrainment, and eliminating the "burp" or upset occurrences due to significant nitrogen bubble accumulation typical in static bed filters.

Flexibility - Total Nutrient Removal

In ENR applications with strict NPDES discharge targets, it is often necessary to lower the concentrations of both nitrogen and phosphorus to low levels. Blue NITE™ can be easily configured to accomplish simultaneous removal of nitrogen and phosphorus in the same unit. Biological denitrification to less than 1 mg/L NO_3-N may be performed concurrently with phosphorus removal by Blue Water's Blue PRO® process, which utilizes chemical adsorption to capture 90+% of influent phosphorus. When required, additional phosphorus and solids removal may be accomplished with a second pass configuration of the Blue PRO® process.



4 MGD (175 L/s) Blue NITE™ in Pennsylvania

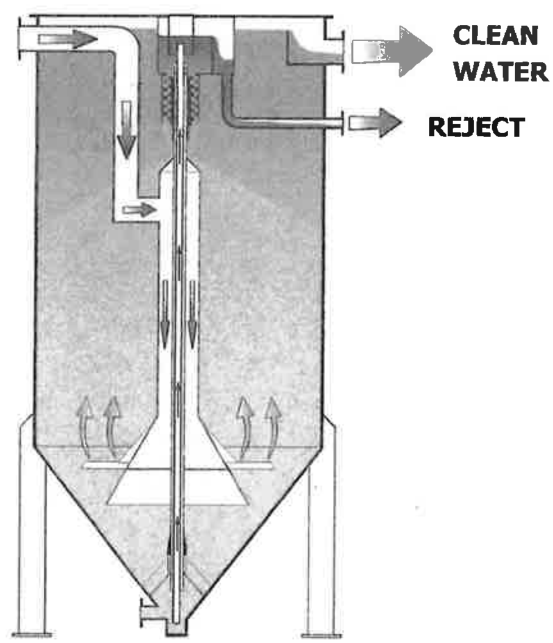


Results from a combined Blue NITE™ denitrification and phosphorus removal installation are shown in the chart to the left, achieving total nutrient reduction in the same vessel.

The chart shows weekly averaged Blue NITE™ results, with process startup and ongoing operation. The red line represents 1 mg/L. After startup effluent nitrate averaged 0.2 mg/L NO_3-N. Total phosphorus was lowered from an average of 5 mg/L to 0.3 mg/L.

At this installation, a second pass with Blue PRO® lowered total phosphorus concentrations <0.050 mg/L P.

INFLUENT → **+ CHEMICAL** →



Blue NITE™

Blue Water's Blue NITE™ technology is covered by one or more patents and patents pending.

The Blue NITE™ process is available in several models and configurations. Contact your Blue Water representative for a comprehensive list.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Biological Nutrient Removal Processes and Costs

Biological Nutrient Removal Processes and Costs

Nitrogen and phosphorus are the primary causes of cultural eutrophication (i.e., nutrient enrichment due to human activities) in surface waters. The most recognizable manifestations of this eutrophication are algal blooms that occur during the summer. Chronic symptoms of over-enrichment include low dissolved oxygen, fish kills, murky water, and depletion of desirable flora and fauna. In addition, the increase in algae and turbidity increases the need to chlorinate drinking water, which, in turn, leads to higher levels of disinfection by-products that have been shown to increase the risk of cancer. Excessive amounts of nutrients can also stimulate the activity of microbes, such as *Pfisteria*, which may be harmful to human health (U.S. EPA, 2001).

Approximately 25% of all water body impairments are due to nutrient-related causes (e.g., nutrients, oxygen depletion, algal growth, ammonia, harmful algal blooms, biological integrity, and turbidity) (U.S. EPA, 2007). In efforts to reduce the number of nutrient impairments, many point source dischargers have received more stringent effluent limits for nitrogen and phosphorus. To achieve these new, lower effluent limits, facilities have begun to look beyond traditional treatment technologies.

Description

Biological nutrient removal (BNR) removes total nitrogen (TN) and total phosphorus (TP) from wastewater through the use of microorganisms under different environmental conditions in the treatment process (Metcalf and Eddy, 2003).

Nitrogen Removal

Total effluent nitrogen comprises ammonia, nitrate, particulate organic nitrogen, and soluble organic nitrogen. The biological processes that primarily remove nitrogen are nitrification and denitrification (Jeyanayagam, 2005). During nitrification ammonia is oxidized to nitrite by one group of autotrophic bacteria, most commonly *Nitrosomonas* (Metcalf and Eddy, 2003). Nitrite is then oxidized to nitrate by another autotrophic bacteria group, the most common being *Nitrobacter*.

Denitrification involves the biological reduction of nitrate to nitric oxide, nitrous oxide, and nitrogen gas (Metcalf and Eddy, 2003). Both heterotrophic and autotrophic bacteria are capable of denitrification. The most common and widely distributed denitrifying bacteria are Pseudomonas species, which can use hydrogen, methanol, carbohydrates, organic acids, alcohols, benzoates, and other aromatic compounds for denitrification (Metcalf and Eddy, 2003).

In BNR systems, nitrification is the controlling reaction because ammonia oxidizing bacteria lack functional diversity, have stringent growth requirements, and are sensitive to environmental conditions (Jeyanayagam, 2005). Note that nitrification by itself does not actually remove nitrogen from wastewater. Rather, denitrification is needed to convert the oxidized form of nitrogen (nitrate) to nitrogen gas. Nitrification occurs in the presence of oxygen under aerobic conditions, and denitrification occurs in the absence of oxygen under anoxic conditions.

chemical flocs with phosphorus. These flocs are then settled out to remove phosphorus from the wastewater (Viessman and Hammer, 1998). However, compared to biological removal of phosphorus, chemical processes have higher operating costs, produce more sludge, and result in added chemicals in sludge (Metcalf and Eddy, 2003). When TP levels close to 0.1 mg/L are needed, a combination of biological and chemical processes may be less costly than either process by itself.

Process

There are a number of BNR process configurations available. Some BNR systems are designed to remove only TN or TP, while others remove both. The configuration most appropriate for any particular system depends on the target effluent quality, operator experience, influent quality, and existing treatment processes, if retrofitting an existing facility. BNR configurations vary based on the sequencing of environmental conditions (i.e., aerobic, anaerobic, and anoxic)[1] and timing (Jeyanayagam, 2005). Common BNR system configurations include:

- Modified Ludzack-Ettinger (MLE) Process – continuous-flow suspended-growth process with an initial anoxic stage followed by an aerobic stage; used to remove TN
- A^2/O Process – MLE process preceded by an initial anaerobic stage; used to remove both TN and TP
- Step Feed Process – alternating anoxic and aerobic stages; however, influent flow is split to several feed locations and the recycle sludge stream is sent to the beginning of the process; used to remove TN
- Bardenpho Process (Four-Stage) – continuous-flow suspended-growth process with alternating anoxic/aerobic/anoxic/aerobic stages; used to remove TN
- Modified Bardenpho Process – Bardenpho process with addition of an initial anaerobic zone; used to remove both TN and TP
- Sequencing Batch Reactor (SBR) Process – suspended-growth batch process sequenced to simulate the four-stage process; used to remove TN (TP removal is inconsistent)
- Modified University of Cape Town (UCT) Process – A^2/O Process with a second anoxic stage where the internal nitrate recycle is returned; used to remove both TN and TP
- Rotating Biological Contactor (RBC) Process – continuous-flow process using RBCs with sequential anoxic/aerobic stages; used to remove TN
- Oxidation Ditch – continuous-flow process using looped channels to create time sequenced anoxic, aerobic, and anaerobic zones; used to remove both TN and TP.

Although the exact configurations of each system differ, BNR systems designed to remove TN must have an aerobic zone for nitrification and an anoxic zone for denitrification, and BNR systems designed to remove TP must have an anaerobic zone free of dissolved oxygen and nitrate. Often, sand or other media filtration is used as a polishing step to remove particulate matter when low TN and TP effluent concentrations are required. Sand filtration can also be combined with attached growth denitrification filters to further reduce soluble nitrates and effluent TN levels (WEF and ASCE/EWRI, 2006).

Choosing which system is most appropriate for a particular facility primarily depends on the target effluent concentrations, and whether the facility will be constructed as new or retrofit with BNR to achieve more stringent effluent limits. New plants have more flexibility and options when deciding

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[1] Anoxic is a condition in which oxygen is available only in the combined form (e.g., NO_2^- or NO_3^-). However, anaerobic is a condition in which neither free nor combined oxygen is available (WEF and ASCE/EWRI, 2006).

Exhibit 3. Comparison of Common BNR Configurations

Process	Nitrogen Removal	Phosphorus Removal
MLE	Good	None
A^2/O	Good	Good
Step Feed	Moderate	None
Four-Stage Bardenpho	Excellent	None
Modified Bardenpho	Excellent	Good
SBR	Moderate	Inconsistent
Modified UCT	Good	Excellent
Oxidation Ditch	Excellent	Good

Source: Jeyanayagam (2005).

The limit of technology (LOT), at least for larger treatment plants, is 3 mg/L for TN and 0.1 mg/L for TP (Jeyanayagam, 2005). However, some facilities may be able to achieve concentrations lower than these levels due to site-specific conditions.

Exhibit 4 provides TN and TP effluent concentrations for various facilities using BNR processes.

Exhibit 4. Treatment Performance of Various BNR Process Configurations

Treatment Plant (State)	Treatment Process Description	Flow (mgd)	Average Effluent Concentration (mg/L)[1]	
			TN	TP
Annapolis (MD)	Bardenpho (4-Stage)	13	7.1	0.66
Back River (MD)	MLE	180	7.6	0.19
Bowie (MD)	Oxidation Ditch	3.3	6.6	0.20
Cambridge (MD)	MLE	8.1	3.2	0.34
Cape Coral (FL)	Modified Bardenpho	8.5	1.0	0.2
Cox Creek (MD)	MLE	15	9.7	0.89
Cumberland (MD)	Step Feed	15	7.0	1.0
Frederick (MD)	A^2/O	7	7.2	1.0
Freedom District (MD)	MLE	3.5	7.8	0.51
Largo (FL)	A^2/O	15	2.3	ND
Medford Lakes (NJ)	Bardenpho (5-stage)	0.37	2.6	0.09
Palmetto (FL)	Bardenpho (4-stage)	1.4	3.2	0.82
Piscataway (MD)	Step Feed	30	2.7	0.09
Seneca (MD)	MLE	20	6.4	0.08
Sod Run (MD)	Modified A^2/O	20	9.2	0.86
Westminster (MD)	MLE-A^2/O	5	5.3	0.79

Sources: EPA (2006); Gannett Fleming (no date); Park (no date).
mgd = million gallons per day
ND = no data
[1] Represents the average of average monthly values from 2003 to 2006, where available.

Nitrogen and phosphorus removal efficiencies are a function of the percentage and content of the mixed liquor recycle rate to the anoxic zone and the RAS recycle rate to the anaerobic zone (WEF and ASCE/EWRI, 2006). The mixed liquor recycle stream supplies active biomass that enables nitrification and denitrification. Optimizing the percentage and content of this recycle stream results in optimal TN removal. The RAS recycle rate should be kept as low as possible to reduce amount of nitrates introduced to the anaerobic zone because nitrates interfere with TP removal. In addition, the type of pump used to recycle the activated sludge is important to avoid aeration and increased DO concentrations in the anaerobic zone (WEF and ASCE/EWRI, 2006).

Costs

BNR costs differ for new plants and retrofits. New plant BNR costs are based on estimated influent quality, target effluent quality, and available funding. Retrofit costs, on the other hand, are more site-specific and vary considerably for any given size category. Retrofit costs are based on the same factors as new plants, in addition to the layout and design of the existing treatment processes.

Exhibit 6 provides capital costs to upgrade wastewater treatment plants in Maryland with BNR. These costs represent retrofits of existing facilities.

Exhibit 6. BNR Upgrade Costs for Maryland Wastewater Treatment Plants

Facilities with BNR (as of 10/30/06)	Design Capacity (mgd)	Treatment Process	Completion Date	Total Capital BNR Cost (2006$)[1]
Aberdeen	2.8	MLE	Dec-98	$3,177,679
Annapolis	10	Ringlace	Nov-00	$14,687,326
Back River	180	MLE	Jun-98	$138,305,987
Ballenger	2.0	Modified Bardenpho	Aug-95	$2,891,906
Broadneck	6.0	Oxidation Ditch	1994	$3,165,193
Broadwater	2.0	MLE	May-00	$6,892,150
Cambridge	8.1	Activated Sludge	Apr-03	$11,740,209
Celanese	1.25	Sequential step feed	Jun-05	$7,424,068
Centreville	0.375	SBR/Land Application	Apr-05	$7,336,020
Chesapeake Beach	0.75	Oxidation Ditch	1992	$2,158,215
Conococheague	2.5	Carrousel	Nov-01	$6,620,888
Cox Creek	15	MLE	May-02	$11,466,657
Cumberland	15	MLE	Aug-01	$12,929,990
Denton	0.45	Biolac	Dec-00	$4,203,767
Dorsey Run	2.0	Methanol	1992	$3,967,307
Emmitsburg	0.75	Overland	1996	$2,562,722
Frederick	8.0	MLE	Sep-02	$11,916,504
Freedom District	3.5	Activated Sludge	1994	$1,462,798
Fruitland	0.50	SBR	Jul-03	$7,546,764
Hagerstown	8.0	Johannesburg Process	Dec-00	$11,190,344
Havre DeGrace	1.89	MLE	Nov-02	$7,596,882
Hurlock	2.0	Bardenpho	Aug-06	$5,200,000
Joppatowne	0.95	MLE	Jul-96	$2,433,205
La Plata	1.0	MLE	Jun-02	$4,952,150

Exhibit 7 shows BNR retrofit costs for wastewater treatment plants in Connecticut.

Exhibit 7. BNR Upgrade Costs for Connecticut Wastewater Treatment Plants

Facilities with BNR	Design Capacity (mgd)	Treatment Process[2]	Year Process In Service	Total Capital BNR Cost (2006$)[1]
Branford	4.5	4-Stage Bardenpho	2003	$3,732,049
Bridgeport East Phase 1	12	MLE*	2004	$2,323,766
Bridgeport West Phase 1	29	MLE*	2004	$2,640,643
Bristol Phase 1	10.75	MLE*	2004	$649,320
Derby	3.03	MLE*	2000	$3,513,514
East Hampton	3.9	MLE*	2001	$860,548
East Windsor	2.5	MLE	1996	$1,407,617
Fairfield Phase 2	9	4-Stage Bardenpho	2003	$14,235,676
Greenwich	12	MLE*	1996	$703,809
Ledyard	0.24	SBR	1997	$4,752,461
Milford BB Phase 1	3.1	4-Stage Bardenpho	1996	$1,407,617
New Canaan	1.5	MLE	2000	$1,570,463
New Haven Phase 1	40	MLE*	1997	$11,134,336
New London	10	MLE*	2002	$3,495,615
Newtown	0.932	MLE*	1997	$1,436,601
Norwalk Phase 1	15	MLE*	1996	$1,548,379
Norwalk Phase 2	15	MLE	2000	$7,042,287
Portland	1	MLE	2002	$1,266,843
Seymour	2.93	MLE*	1993	$379,597
Stratford Phase1	11.5	4-Stage Bardenpho	1996	$1,126,094
Thomaston	1.2	SBR	2001	$1,451,708
University of Connecticut	1.98	MLE	1996	$1,489,259
Waterbury	25	4-Stage Bardenpho	2000	$22,074,225

Source: CT DEP (2007).
mgd = million gallons per day
[1] Total capital BNR upgrade projects financed by the Clean Water Fund through 2006, updated to 2006 dollars using the ENR construction cost index assuming that the year in service date represents the original year dollars (2006 ENR index = 7910.81).
[2] Treatment process with an "*" are designed to meet interim TN limits of 6 – 8 mg/L; all other facilities designed to meet TN limits of 3 – 5 mg/L.

Site-specific factors such as existing treatment system layout and space availability may cause costs to vary significantly between treatment plants with the same design capacities implementing the same BNR configuration. For example, the La Plata and Thurmont wastewater treatment plants in Maryland both have design capacities of 1 mgd and upgraded to a modified Ludzack-Ettinger (MLE) BNR system. However, total capital costs to retrofit the La Plata facility ($5.0 million) exceed those for the Thurmont facility ($3.1 million) by more than $1.8 million.

Exhibit 9. Average BNR Costs for Small Systems: New Plants (2006$)[1]

System	4,000 gpd	10,000 gpd	25,000 gpd	50,000 gpd	100,000 gpd
MLE and Deep Bed Filtration					
Construction	$411,576	$491,753	$649,435	$887,294	$1,280,161
O&M	$45,231	$52,340	$71,217	$93,036	$136,550
Submerged Biofilter Process					
Construction	$330,063	$395,541	$601,328	$1,131,834	(2)
O&M	$23,902	$29,909	$50,379	$74,036	(2)
RBC Process					
Construction	$351,443	$457,010	$704,222	$1,159,896	$1,459,224
O&M	$25,006	$31,747	$53,198	$75,385	$109,584

Source: Foess, et al. (1998).
gpd = gallons per day
[1] Construction costs updated from 1998 dollars using the ENR construction cost index (2006 index = 7910.81); O&M costs updated from 1998 dollars using the Bureau of Labor Statistics consumer cost index (2006 index = 199.8).
[2] Exceeded manufacturer's sizes.

Retrofit opportunities are more limited at smaller facilities; however two retrofit alternatives may exist for nitrogen removal. The MLE process can be retrofitted by adding an anoxic basin upstream of the existing influent point and adding recirculation pumping from the existing aeration basin to the new anoxic basin. Also, deep-bed denitrification filters can be added downstream of an existing package plant. The retrofit involves installation of new pumping facilities to pump secondary effluent to the filters, methanol feed equipment, and chemical feed equipment (for phosphorus removal) (Foess, et al., 1998). O&M costs represent only the incremental costs associated with the additional equipment. **Exhibit 10** summarizes these costs.

Exhibit 10. Average BNR Costs for Small Systems: Retrofits (2006$)[1]

System	4,000 gpd	10,000 gpd	25,000 gpd	50,000 gpd	100,000 gpd
Anoxic Tank for MLE Upgrade					
Construction	$28,062	$32,071	$52,115	$76,168	$80,000
O&M	$14,832	$15,445	$16,425	$22,922	$21,100
Deep Bed Denitrification Filter					
Construction	$145,655	$161,691	$196,434	$217,815	$213,000
O&M	$21,573	$22,309	$24,883	$30,399	$28,600

Source: Foess, et al. (1998).
gpd = gallons per day
[1] Construction costs updated from 1998 dollars using the ENR construction cost index (2006 index = 7910.81); O&M costs updated from 1998 dollars using the Bureau of Labor Statistics consumer cost index (2006 index = 199.8).

Similar to large facilities, unit costs for smaller facilities also tend to decrease as flow increases. **Exhibit 11** summarizes average unit costs across all treatment processes for new plants and retrofits based on the cost information in Exhibits 9 and 10.

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- GIS 4 - FORMOSA RC -
- DATA VERIF.
- BIOC Regs SAN

DEWARNEL

→ Off-set credit from treated storm water characterized as of current conditions.

— seasonality of stream discharge.