Chief Engineer/
Industrial Wastewater Process Leader

# T. Houston Flippin, PE, BCEE

## Experience Summary

Houston Flippin has 35 years of experience in industrial water management. He is a Board Certified Environmental Engineer who is particularly adept at maximizing treatment process performance. This is due to years of conducting, evaluating, and developing full-scale process design and operating guidelines from bench-, pilot-, and full-scale wastewater treatment studies. These studies have evaluated both biological and physical/chemical processes for treating off-gas, water, groundwater, wastewater, and sludge laden with conventional pollutants, priority pollutants, and aquatic toxicants. Houston has used this experience to develop treatment cost savings (capital and operating), while maintaining reliable effluent and emissions compliance, and negotiate more reasonable limits. His hands-on experience and adept communication skills have made him a frequent workshop lecturer, client staff trainer, and negotiator.

**Assignment**

*Senior Process Design Lead/ Evaluation and Optimization*

**Education**

*MS, Environmental and Water Resource Engineering with minor in Chemical Engineering, Vanderbilt University, 1984*

*BE, Civil and Environmental Engineering, Vanderbilt University, 1982*

**Registration**

*Professional Engineer, Alabama (36124), Arkansas (12301), Delaware (15291), Florida (75197), Georgia (031884), Idaho (18867), Illinois (062.053488), Indiana (11100080), Kentucky (21150), Michigan (046604), Mississippi (20817), Ohio (72519), South Carolina (31331), Tennessee (21208), Texas (99149), and Virginia (042268).*

*Board Certified Environmental Engineer: American Academy of Environmental Engineers (99-20004)*

**Experience**

*35 years*

**Joined Firm**

*1984*

**Relevant Expertise**

- *Developing site specific operating guidelines and treatment capacities*
- *Developing cost savings for treatment plants*
- *Training client staff in process operations and troubleshooting*

## Relevant Chemical Industry Experience

### Impact on POTW, American Cyanamid, Barceloneta, Puerto Rico

**Lead Engineer.** Houston was responsible for developing treatability studies that evaluated the impact of herbicide and pesticide wastestreams on publicly owned treatment works (POTWs). Testing indicated no adverse impact on biochemical oxygen demand (BOD) removal, nitrification, and sludge quality at the desired discharge rates. The test results were used to negotiate the allowed discharges of these wastestreams to the POTW without pretreatment.

### Management of Bio-Inhibiting Wastewater, Air Products, Calvert City, Kentucky

**Lead Engineer and Project Manager.** Houston defined operating guidelines for a wastewater treatment system to allow processing of a bio-inhibiting wastestream component.

### Groundwater Treatment Optimization, BASF, Toms River, New Jersey

**Lead Engineer.** Houston developed strategies to optimize the existing equalization, chemical conditioning system, and filtration of contaminated groundwater with minor modifications.

### Treatment Optimization, Borden Chemical Company, Fayetteville, North Carolina and Demopolis, Alabama

**Lead Engineer.** Houston developed operational and capital upgrades for two wastewater treatment systems to address concerns regarding effluent quality.

### Concept Design and Cost Sharing Estimates for Combined Municipal and Industrial Treatment Facility, Calvert City, Kentucky Industrial Complex

**Lead Process Engineer.** Houston directed treatability testing used to develop the process design for a treatment system capable of meeting direct discharge standards and the Miscellaneous Organic Chemical Manufacturing National Emission Standards for Hazardous Air Pollutants (NESHAP), known as the MON, requirements while treating wastewaters from Calvert City municipal wastewater, Rail Car Services, Sekisui Specialty Chemicals, Wacker Chemical Corporation, and Westlake Chemical as well as leachate from Waste Path Services. The combined treatment facility consisted of wasteload monitoring at each facility, screening, equalization, anaerobic treatment of high-strength wastewaters, activated sludge treatment, chlorination, dechlorination, and post aeration. The process design and 60 percent design were developed, and individual sewer use fees were established to support the facility. The economic payback was longer than desired (more than 5 years) for the participating industries to proceed forward with final design of the combined treatment facility.

### Treatment Facility Emissions Control, Celanese Chemicals, Calvert City, Kentucky

**Technical Director**. Houston directed treatability testing used to develop the process design for a treatment system compliant with the MON requirements.

### Process Design of New Treatment Facility, Ciba-Geigy Corporation, McIntosh, Alabama

**Lead Engineer**. Houston was responsible for onsite treatability studies, process design development, and a final report for the treatment of wastewaters discharged from Ciba-Geigy Corporation's largest U.S. organic chemicals manufacturing complex, including pesticides. The project began by evaluating conversion of the existing aerated lagoon system to activated sludge. This conversion was necessary to meet effluent requirements under higher loading conditions and to meet Resource Conservation and Recovery Act (RCRA) closure requirements of onsite surface impoundments. This evaluation involved an activated sludge treatability study evaluating the impact of varying total dissolved solids (TDS) concentrations (0.5 percent to 2.5 percent), temperatures (8°C to 20°C) and RCRA-regulated stream discharge contributions. A process design for the aerated lagoon/activated sludge conversion was developed, presented, and implemented. Houston developed materials for and assisted in the operator training course that preceded startup of the activated sludge plant. A follow-up treatability study was conducted that focused on total Kjeldahl nitrogen, total organic carbon (TOC), acute toxicity, and color reduction through the use of PACT® treatment as compared to tertiary granular activated carbon (GAC) treatment. Special batch treatability testing evaluated alternative source control methods for a highly colored wastestream. A process design was developed to meet revised treatment objectives, a final report was issued, and a new wastewater treatment facility (WWTF) was constructed. Startup assistance and operator training were provided for both WWTFs.

### Process Design, Final Design, and Operational Changes of Treatment Facilities, Clariant Corporation, Charlotte, North Carolina and Elgin, South Carolina

**Supervising Engineer**. Houston directed treatability testing at the Charlotte facility to define operational and capital changes needed in the wastewater treatment system to accommodate new wasteloads. He directed treatability testing at the Elgin facility to develop a process and detailed design of treatment system upgrades required to comply with MON requirements. Houston provided treatment system alternatives analyses in order to select the best process design for advancement into final design.

### Treatment Facility Upgrades and Sidestream Management, Cognis Corporation, Charlotte, North Carolina and Cincinnati, Ohio

**Lead Engineer**. Houston provided treatability testing to develop recommendations for operational and capital upgrades for the Charlotte wastewater treatment system. These upgrades addressed oil/water separation, solids separation, neutralization, high temperature activated sludge treatment, and alternative oxygen transfer systems. He determined beneficial reuse alternatives for select byproduct at the Ohio facility and that the byproduct discharge to the sewer could have compromised compliance with the site's air permit.

### Treatment Facility Alternative Upgrades Evaluation, Confidential Organic Chemical Manufacturer, Central United States

**Supervising Engineer**. This project evaluated process alternatives to meet forecasted production increases. The work included equalization tank modeling to determine flow and loadings, review of possible anaerobic reactor configurations and technologies, modification to the existing activated sludge plant to treat higher loadings and comply with NESHAP regulations, repurposing to use a dissolved air flotation (DAF) for secondary clarification in addition to waste sludge thickening, modifications to the existing secondary clarifiers to improve the inlet distribution tub and flocculating centerwells, and new media and upgrading of the final filter. All projects were evaluated for life cycle costs and justified in terms of economics and process benefits. Overall, the project enabled the client to complete a very complicated process engineering analysis in a short time to ensure detailed design and construction could be accomplished in accordance with the schedule.

### Effluent Toxicity Reduction, Confidential Client, Indiana

**Lead Engineer and Project Manager**. A toxicity identification evaluation (TIE) and toxicity reduction evaluation (TRE) were conducted for a large-volume producer of metal ingots and sheet aluminum. The TIE used Phase I laboratory characterization procedures, single-stream toxicity testing, and resynthesis testing with major wastestreams treated for toxicity removal. Both the water flea *(Ceriodaphnia dubia)* and the fathead minnow were used in acute tests throughout the study. Study results indicated that adsorptive organic compounds associated with an internal waste treatment process were primarily responsible for toxicity. Pure chemical tests with the wastewater treatment polymer used at the site indicated that the polymer might play a role in effluent toxicity. Operational changes were identified that would provide the required effluent toxicity reduction.

**Comprehensive Wastewater Management Services Emerald Performance Materials, Inc, Henry, Illinois and Kalama, Washington**
**Supervising Engineer**. Houston provided comprehensive services, including process wastewater permit negotiations and expert testimony, wastewater characterization and minimization, conceptual level alternatives evaluations, treatability studies, process design development, equipment selection, clarifier optimization, operator training, WWTF startup assistance, and WWTF process troubleshooting and optimization. The treatment systems consisted of coagulation, flocculation, sedimentation, peroxidation, aerobic biological treatment, anaerobic biological treatment, and tertiary filtration.

**Comprehensive Wastewater Management Services, Henkel Corporation, Kankakee, Illinois**
**Lead Engineer**. Houston provided comprehensive services, including wasteload surveying, waste minimization, water conservation, process design and equipment selection for capital upgrades, and WWTF operating guidelines development. He also prepared upgrades to the existing WWTF to accommodate the addition of a new production line.

**Comprehensive Wastewater Management Services, International Specialty Products, Linden, New Jersey; Spartanburg, South Carolina; Winder, Georgia; Huntsville, Alabama; Port Neches, Texas; Texas City, Texas; Calvert City, Kentucky; and San Diego, California**
**Supervising Engineer**. Houston provided comprehensive services, including stormwater and process wastewater permitting, effluent permit negotiations including use of water effects ratio testing wastewater characterization and minimization, conceptual-level alternatives evaluations, treatability studies, process design development, clarifier optimization, operator training, WWTF startup assistance, and WWTF process troubleshooting and optimization.

**Comprehensive Wastewater Management Services, Lubrizol Advanced Materials, Inc, Akron, Ohio; Louisville, Kentucky; Calvert City, Kentucky; Charlotte, North Carolina and Gastonia, North Carolina and Spartanburg, South Carolina**
**Supervising Engineer**. Houston provided comprehensive services, including process wastewater permitting, wastewater characterization and minimization, conceptual level alternatives evaluations, treatability studies, process design development, equipment selection, operator training, WWTF startup assistance, and WWTF process troubleshooting and optimization.

**Effluent Surfactant Reduction, Marietta Corporation, Courtland, New York**
**Lead Engineer**. Houston evaluated the feasibility of a pretreatment system to meet a 0.5 milligrams per liter (mg/L) methylene blue active substances pretreatment limit. The system consisted of phase separation, ultrafiltration, carbon adsorption, and ozonation.

**Pretreatment Alternatives Analyses, Reilly Industries, Lone Star, Texas and Provo, Utah**
**Lead Engineer and Project Manager**. Houston delivered a two-tiered project at these coal tar plants. Treatability studies were conducted, and process designs were developed, for alternative WWTF upgrades to allow the plant to meet more restrictive pretreatment limits. A work plan was developed in cooperation with the Texas Natural Resource Conservation Commission that enabled the POTW to seek permit relief and avoid WWTF upgrades.

**Effluent Toxicity Reduction, Rhodia, Mount Pleasant, Tennessee**
**Lead Engineer**. Houston was responsible for treatability studies, process design development, and a final report for the treatment of herbicide wastewaters. The treatments evaluated the impact of photolytic decomposition, carbon adsorption, and macroreticular resins. A solution was implemented that included minor treatment and recycle of waters. The site was converted to a nearly zero discharge operation.

**Comprehensive Wastewater Management Services, Rohm and Haas, Bristol, Pennsylvania; Louisville, Kentucky; Knoxville, Tennessee; and Moss Point, Mississippi**
**Supervising Engineer**. Houston provided comprehensive services ranging from process wastewater permit negotiations, wastewater characterization and minimization, conceptual level alternatives evaluations, treatability studies, process design development for nitrification facilities, equipment selection, whitewater treatment alternatives, and WWTF process troubleshooting and optimization.

**Treatment Process Troubleshooting and Operator Training, Solvay Advanced Polymers, Marietta, Ohio**
**Lead Engineer**. Houston provided WWTF troubleshooting services and operator training for this facility that included equalization, neutralization, pure oxygen activated sludge treatment, disinfection, and sludge dewatering.

**Comprehensive Wastewater Management Services, Solvay Chemicals, Deer Park, Texas**
**Lead Engineer**. Houston provided treatability testing to define WWTF upgrade measures needed to comply with effluent BOD, TOC, and aquatic toxicity limits. He assisted in equipment selection and operator training. Houston developed a compliance plan and schedule. The treatment system consisted of activated sludge treatment with denitrification and DAF for secondary clarification. Provisions were made for effluent GAC treatment.

**Process Design of New Treatment Facility , Thiokol Corporation, Brigham City, Utah**
**Lead Engineer and Project Manager**. The project involved TIE followed by TRE as a part of treatability studies for a newly designed WWTF. The new WWTF replaced two existing WWTFs that were abandoned. Acidification, air stripping, alkalinization, chemical reduction with sodium thiosulfate, filtration, GAC, ion exchange (anion and cation), macroreticular resin, and metal complexation with ethylenediaminetetraacetic acid (EDTA), were evaluated as a means of achieving effluent toxicity reduction for a selected wastestream. High salinity was identified as the toxicant. The client decided to blend the selected wastestream with other wastestreams causing a decrease in wastewater salinity and an increase in wastewater BOD. Activated sludge treatment, followed by ozonation as a means of toxicity reduction and disinfection, was determined to provide consistent compliance with effluent BOD and toxicity limits. A process design was provided. The newly designed WWTFs included grit removal, equalization, activated sludge treatment, granular media filtration, and ozonation. The final design for the WWTF was reviewed for consistency with the process design.

**Fundamental Different Factor Determination, Union Carbide, Hahnville, Louisiana**
**Lead Engineer**. Houston provided treatability testing to demonstrate that the plant qualified for "fundamentally different factors" in developing effluent limitations. He provided troubleshooting assistance and developed operating procedures to prevent bio-inhibition to activated sludge and viscous sludge bulking.

**Process Design, Final Design and Start-Up of New Treatment Facility, Vi-Jon Corporation, Smyrna, Tennessee**
**Lead Engineer**. Houston designed and oversaw treatability testing for three major production area wastewaters (mouthwash, lotion, and shampoo). He developed a process design of the pretreatment facility to treat wastewaters from these production areas. Pretreatment consisted of zinc precipitation, activated sludge with DAF clarification, and sludge dewatering. Houston provided process oversight during detailed design, equipment procurement, and startup.

**Management of Bio-Inhibiting Wastewaters, Zeneca Fine Chemicals, Mount Pleasant, Tennessee**
**Lead Engineer**. Houston was responsible for treatability studies that evaluated the impact of various organic chemical, herbicide, and pesticide wastestreams on the site's biological WWTF. He developed an approach for screening the impact of new wastestreams on the WWTF. Houston prescribed maximum allowable discharge rates of each process wastestream to prevent upset of the WWTF.

**Odor Control and Treatment Process Optimization, Chemical Industry and City of Springfield, Massachusetts**
**Project Engineer**. This project included odor identification and control, treatability study and process design of upgrades within existing tankage to accomplish nitrification, denitrification, and good sludge settleability. Houston evaluated the impacts of sludge heat treatment on plant performance.

**Treatment Process Optimization, Chemical Industry and Greater Mentor, Ohio**
**Project Engineer**. Houston conducted treatability studies to evaluate the impact of the chemical industry on POTW effluent total suspended solids (TSS) concentrations. He developed operating guidelines that allowed the POTW to accommodate chemical industry discharge while maintaining effluent compliance with both effluent TSS and total phosphorus limits.

**Pretreatment for Odor Control, Dalton Utilities, Dalton, Georgia**
**Senior Consultant**. Houston identified threshold odor numbers for a list of chemicals discharged from the chemical industry. This list, coupled with sampling data, identified which chemicals were responsible for sewer odor complaints. Odor control involved selecting pretreatment limits for these targeted compounds.

**Process Design and Final Design of New Treatment Facility, Globe Manufacturing, Gastonia, North Carolina**
**Project Manager and Lead Engineer**. Houston managed a wastewater pretreatment project where the industrial discharge was cited as the source of the POTW's effluent aquatic toxicity problem. Treatability tests were conducted which screened the effects of the following treatment processes on effluent toxicity reduction: air stripping, cation exchange resin, activated silica, macroreticular resin, granular activated carbon, and biohydrolysis. Results of these tests and further desktop evaluations indicated the biotoxicant was ethylene diamine and that activated sludge treatment would provide the most cost-effective treatment. Continuous flow treatability studies were used to develop the process design for the selected process. Houston submitted a design basis report for the pretreatment facility, reviewed final design drawings and specifications, and provided startup assistance. The pretreatment facility eliminated all acute and chronic toxicity associated with the wastestream discharge at its flow contribution to the POTW.

## Memberships

American Academy of Environmental Engineer

Technical Association of the Pulp and Paper Industry (TAPPI)

Water Environment Federation

Chi Epsilon - National Civil Engineering Honor Society

## Publications/Presentations

1. “Introduction of an Integrated Methanogenic Aerobic Single Sludge (IMASS) System”, with Jason Mullen, Si Givens, Everett Gill and Asher Benedict. 92nd Annual Water Environment Foundation Technical Exhibition & Conference (WEFTEC), Chicago, IL, September 2019.
2. “Sludge Reduction Through Uncoupling: Treatability Surprise and Full-Scale Benefits”, Kasey Moraveck, Jonathan Sandhu and Houston Flippin. 92nd Annual Water Environment Foundation Technical Exhibition & Conference (WEFTEC), Chicago, IL, September 2019.
3. “Two Case Studies of Ultrafiltration in Dairy Wastewater”, Membrane Technology Forum, American Dairy Products, Institute, Minneapolis, MN, June 2019.
4. :Anaerobic Reactor Cover Replacement: Interim Operations and Plan”, 49th Annual Food and Beverage Environmental Conference, American Frozen Food Institute, April 2019.
5. “Bioaugmentation and Base Loading: Alternatives for Biodegradation of Acrylonitrile to Low Levels in Publicly Operated Treatment Facilities”, Asher Benedict, Ken Tuck, Houston Flippin, and Everett Gill. 91st Annual Water Environment Foundation Technical Exhibition & Conference (WEFTEC), Chicago, IL, October 2018.
6. “Total Organic Carbon: Dispelling the Myth Around Reuse”. Michael Mecredy, Houston Flippin and Joe Wong, Presented at the 91st Annual Water Environment Foundation Technical Exhibition & Conference (WEFTEC), New Orleans, LA, October 2018.
7. "Magnesium Hydroxide Addition for Odor and Corrosion Control in Conveyance Systems: Product Selection and Dose Optimization," Gayathri Ram Mohan and Houston Flippin, WEFTEC, October 2018.

8. "Taming Temperamental TDS: Total Dissolved Solids Management Strategy for Industrial Wastewaters," Michael Mecredy, Thomas Steinwinder, and Houston Flippin, Water Environment & Technology (WE&T) Magazine, December 2015.
9. "Operator Essentials: What Every Operator Needs to Know about Leachate," Houston Flippin and Kevin Torrens, Water Environment & Technology (WE&T) Magazine, December 2015.
10. "Biological Treatment of Petroleum Refinery Stripped Sour Water Using the Activated Sludge Process," Rion Merlo, Matthew B. Gerhardt, Fran Burlingham, Carla De Las Casas, Everett Gill and Houston Flippin, WEFTEC, October 2010.
11. "Leachate Management," with K. Torrens and R. Menon, South Carolina May 2010 gathering of the Solid Waste Association of North America.
12. "Chlorination for Filament Control: A Refined Approach," with E. Gill, WEF Industrial Water Quality Conference, Baltimore, Maryland, July 2009.
13. "Reducing the Mystery of Micronutrient Addition," with R. Davis (Empirical Laboratories) and D. Kilgour, WEFTEC, Chicago, Illinois, October 2008.
14. "Case Studies in Petroleum Refineries," Tackling Industrial Wastewater Treatment Challenges Workshop, WEFTEC, Chicago, Illinois, October 2008.
15. "Loss of Effluent Mixing Zone Dilution Credits," prepared by Brown and Caldwell for American Petroleum Institute, June 2008.
16. "Theory, Operation, and Design of Selectors for Activated Sludge," Advanced Biological Wastewater Treatment Technologies Workshop-Innovative Solutions to Difficult Problems, Vanderbilt University School of Engineering and Siemens Water Technologies Corporation, Nashville, Tennessee, August 2008.
17. "Beneficial Use of Dairy, Fountain, and Fruit Beverage Wastes in POTWs," with D. Busch (Dean Foods Dairy Group) and P. Bowen and B. Karas (Coca-Cola North America), WEFTEC, San Diego, California, October 2007.
18. "Beneficial Use of Dairy Wastes in POTWs," with D. Busch (Dean Foods Dairy Group) WEF Industrial Water Quality Conference, Providence, Rhode Island, July 2007.
19. "Comprehensive Denitrification Approach," with V.J. Boero, Kentucky/Tennessee 2006 Water Professionals Conference, Chattanooga, Tennessee, July 2006.
20. "Anaerobic Digestion: A potentially Underutilized Resource," with T. Stigers, Kentucky/Tennessee 2006 Water Professionals Conference, Chattanooga, Tennessee, July 2006.
21. "Pretreatment versus POTW Upgrades," poster presentation with Heinz North America at American Frozen Food Industry sponsored Food Industry Environmental Conference, Monterey, California, March 2005.
22. "Biologically Active Aerated Tank Treatment," presentation given in workshop sponsored by City of Fresno, California for industrial dischargers to POTW, October 2004.
23. "A New Approach to Nitrification/Denitrification of Industrial Wastewater," with W. W. Eckenfelder, and V.J. Boero. 10th Annual WEF Industrial Wastes Technical and Regulatory Conference, Philadelphia, Pennsylvania, August 2004.
24. "Enhanced Activated Sludge Treatment of High Strength Bio-inhibitory Industrial Wastewater," with R. Rhoades, 10th Annual WEF Industrial Wastes Technical and Regulatory Conference, Philadelphia, Pennsylvania, August 2004.
25. "Treatment Alternatives for Removing Ammonia Nitrogen from Landfill Leachate," with R.E. Ash and B.N. Card, Annual Tennessee Solid and Hazardous Waste Conference, Gatlinburg, Tennessee, April 2004.
26. "Alternative Considerations in Sizing Aeration Basins," with W. W. Eckenfelder, Design, Performance and Operation of Biological Treatment Processes Pre-Conference Workshop, Vanderbilt University and USEPA Conference, "Industrial Wastewater and Best Available Treatment Technologies: Performance, Reliability, and Economics", Nashville, Tennessee, February 2003.
27. "Modifying Equalization to Provide Pretreatment of High Strength Wastewaters," with D.A. Moye, 19th Annual North Carolina AWWA/WEF Conference Proceedings, Winston-Salem, North Carolina, November 2002.
28. "Benefits of Using Nitrate as Nutrient in Activated Sludge Treatment Systems," with W. W. Eckenfelder and D.A. Moye, 8th Annual WEF Industrial Wastes Technical and Regulatory Conference, Atlantic City, New Jersey, August 2002.
29. "Biological Treatment of High TDS Wastewaters," with W. W. Eckenfelder and V. J. Boero, Water Environment Federation- Industrial Waste Technical and Regulatory Conference, Charleston, South Carolina, August 2001.
30. "Competitive Performance for Water and Wastewater Utilities," with J.L. Pintenich, Nashville Quality Forum, Nashville, Tennessee, October 1999.
31. "Reclaiming POTW Capacity," with M.L. Roeder, American Society of Civil Engineers-Tennessee Section Annual Meeting, Nashville, Tennessee, October 1999.
32. "Batch Activated Sludge Testing to Determine The Impact of Industrial Discharges on POTW Performance", with J.S. Allen, Proceedings of 1998 WEF Industrial Wastes Specialty Conference, Nashville, Tennessee, March 1998.
33. "Economics of Treating Poorly Degradable Wastewaters in the Chemical Industry," with K.D. Torrens, Proceedings of 1998 WEF Industrial Wastes Specialty Conference, Nashville, Tennessee, March 1998.

34. "Effects of Elevated Temperature on the Activated Sludge Process," with W.W. Eckenfelder, Jr., Proceedings of 1994 TAPPI International Environmental Conference, Portland, Oregon, April 1994.
35. "Toxicity Identification and Reduction in the Primary Metals Industry," presented at Spring AIChE Conference, Atlanta, Georgia, April 1994.
36. "Treatability Studies and Process Design for Toxicity Reduction for a Synthetic Fiber Plant," with J.L. Musterman, Water Science Technology, Vol. 29, No. 9 (1994).
37. "Granular Carbon Adsorption of Toxics," technical review of chapter four in Toxicity Reduction in Industrial Effluents, P. W. Lankford and W. W. Eckenfelder, Jr. (Eds), Van Nostrand Reinhold, 1992.
38. "Diagnosing and Solving a Pulp and Paper Mill's Poor Activated Sludge Settleability Problems Through Treatability Studies," with M. A. Bellanca, Proceedings of 1992 TAPPI Environmental Conference, Richmond, Virginia, 1992.
39. "Hydrogen Peroxide Pretreatment of Inhibitory Wastestream – Bench Scale Treatability Testing to Full Scale Implementation: A Case History," with R. L. Linneman, Proceedings of Chemical Oxidation: Technology for 1990's, Vanderbilt University, Nashville, Tennessee, 1991.
40. "Control of Sludge Bulking in a Carbohydrate Wastewater Using a Biosorption Contactor," with W. W. Eckenfelder, Jr. and M. A. Goronszy, Proceedings of the 39th Annual Purdue Industrial Waste Conference, 1984.

## Research Topics

1. Biodegradation of PCBs and hexachlorobenzene (HCB), research conducted at Eckenfelder Inc.
2. Volatile Organic Compound Emissions from Activated Sludge Systems, research conducted at Eckenfelder Inc.
3. Performance of Selective Bacteria in Industrial Activated Sludge Systems, research conducted at Vanderbilt University
4. Biosorption for Improved Reactor Capacity, research conducted at Vanderbilt University
5. Control of Activated Sludge Bulking Through the Use of a Biosorption Contactor, research conducted at Vanderbilt University

Emerald Performance Materials®
Kalama Chemical

April 17, 2018

PETITIONER'S HEARING EXHIBIT
AS 19-002
11

CERTIFIED MAIL: 7016 1370 0002 2632 1241

Division of Water Pollution Control
Compliance Assurance Section – Mail Code 19
Illinois Environmental Protection Agency
P. O. Box 19726
Springfield IL 62794-9276

**Re: Adjusted Standard 13-2 (NPDES Permit No. IL0001392) – Update Report**

To Whom It May Concern:

The Henry, IL Emerald Performance Materials facility is submitting the following report to show continued compliance with the all of requirements of Adjusted Standard 13-2, which are incorporated into NPDES Permit No. IL0001392 Special Condition 16. AS13-2 Conditions 2(c) and (d) require the plant to generally investigate new production methods and technologies that would generate less nitrification inhibitors (i.e., MBT) and new treatment technologies. AS13-2 Condition 2(e) specifically requires the plant to investigate and submit reports evaluating three alternative treatment ideas: granulated activated carbon (GAC), spray irrigation, and river water dilution.

**Report as to Conditions 2(c) and (d):**

The Henry facility has put together a continuous process improvement project to identify and evaluate potential modifications of the processes and product recipes to recover MBT as well as a few of the key organic nitrogen compounds that serve as the building blocks for most of Emerald's products. The team is comprised of facility personnel, consultants, and process improvement engineers from Emerald corporate services. The approaches taken by this team to evaluate process modifications and alternative treatment options to achieve the final goal of further reducing ammonia in the Emerald WWTF effluent have been unsuccessful since the issuance of AS13-2.

**Report as to Condition 2(e):**

Granulated Activated Carbon (GAC). The pretreatment of plant wastewater using GAC to remove mercaptobenzothiazole (MBT) was evaluated at a bench scale by Brown & Caldwell.

In the bench scale testing, B&C found that GAC would sufficiently reduce MBT concentrations to allow the microorganisms in the plant wastewater treatment system to achieve adequate nitrification. B&C also evaluated the cost of this alternative and found that its estimated cost is 20x higher than the costs incurred by municipal wastewater treatment facilities in Illinois and 11x higher than the average cost of municipal facilities nationwide. The B&C report is Attachment A. Based on these findings, Emerald does not believe GAC is economically reasonable.

Spray Irrigation/Land Application. Emerald investigated the technical feasibility of a spray irrigation (land application) program. A spray irrigation program is not a technically feasible option for the Henry facility's treated wastewater. There are two principal flaws with this option: a lack of symbiosis between wastewater treatment operations and the agricultural needs for nitrogen amendments; and regulatory restrictions. The regulatory restrictions are paramount.

Condition 2(e) of AS13-2 asks for an evaluation of spray irrigation in accordance with 35 IAC Part 372. Those regulations establish design standards and other standards for low-rate land application of secondary and tertiary treated **domestic** wastewater. Emerald's discharge is industrial wastewater and the Part 372 regulations do not allow low-rate land application of the Henry plant treated effluent. Further, presently the discharge from the plant's wastewater treatment system is not subject to regulation as solid or hazardous waste because of the RCRA exemption for wastewater discharges subject to a NPDES permit under 35 IAC 721.104(a)(2) and its federal equivalent 40 CFR 261.4(a)(2). If a portion of the wastewater stream was diverted to spray irrigation, the diverted portion might be considered land disposal of a solid waste, or possibly a hazardous waste. USEPA considered an analogous circumstance at a landfill in Kentucky in 2007 that wanted to discharge treated leachate that was high in ammonia via spray irrigation. USEPA determined that the proposal – even if it was incorporated into the landfill's NPDES permit – would be prohibited land disposal of a hazardous waste. The USEPA determination is included as Attachment B.

Even if the regulations that restrict the land application of the wastewater were revised; spray irrigation would still not be a technically feasible option because there is a lack of symbiosis between wastewater treatment operations and agricultural needs. The Henry facility continuously discharges treated effluent to the Illinois River. The mass of ammonia discharged is not constant, but rather fluctuates with production. This would require frequent analysis and adjustment of the land application rate in order to meet the nitrogen requirements of the crops. And since the nitrogen is present as dissolved ammonia, the only way to get the nutrient to the crops is via irrigation. Crop irrigation and nitrogen needs do not occur continuously during the growing season and cease altogether outside the growing season.

Land application of biosolids and other soil amendments must follow 40 CFR 503 Subpart B regulations. One of the requirements is that soil amendments must only be applied during the active growing season. In this region of Illinois, the growing season is between 175 and 180 days (at most) in duration. The wastewater effluent would have to be discharged to the Illinois River during the other 185 to 190 days when land application is restricted. Emerald owns 80 acres of land, currently leased to a local farmer, onto which the effluent could be land applied. If the 80 acres were planted with corn, which has a fairly high nitrogen demand of 110 pounds of nitrogen per acre per growing season; 8,800 pounds of nitrogen would be required (assuming 100 bushels per acre). This quantity of nitrogen could be supplied by the wastewater effluent in less than 20 days. Thus, even during the growing season, the available cropland could only receive a small portion of the Henry plant's wastewater. For this additional reason, the spray irrigation option is not technically feasible.

River Water Dilution. Treatment of plant wastewater via river water dilution was evaluated at a bench scale by B&C. In the bench scale testing, B&C found that nitrification could be achieved if the plant wastewater were diluted by 90% with river water. See Attachment A. B&C cautioned, however, that the bench scale results might not be sustainable at plant-scale due to fluctuations in MBT production that would cause inconsistent nitrification and cold weather river water temperatures which would interfere with other wastewater treatment processes that require warm wastewater. B&C also evaluated the cost of this alternative and found that its estimated cost (even without including the capital cost of constructing an additional steam boiler, as discussed below) is 40x higher than the costs incurred by municipal wastewater treatment facilities in Illinois and 21x higher than the average cost of municipal facilities nationwide. Based on the B&C report and Emerald's own evaluation, the river water dilution alternative is not technically feasible or economically reasonable. There are three reasons why this option must be rejected: the option is not likely to achieve the desired ammonia removal; the ancillary environmental impacts outweigh the benefits of any reduction in the mass of ammonia discharged; and the economic cost is prohibitive as demonstrated by B&C.

For the reasons described in the B&C report, Emerald seriously doubts that the river water dilution option can consistently achieve the ammonia reductions that were achieved in the bench scale testing. Also, diluting the facility's wastewater by a factor of almost ten will also dilute the chemicals that the microorganisms metabolize. This may compromise the efficiency of the wastewater treatment plant, hampering the microbial degradation of the other contaminants. Thus, purely from the standpoint of the wastewater discharge, the river water dilution option is not technically feasible.

This alternative would also have significant negative cross-media environmental impacts. Temperature is a critical parameter for the microorganisms that digest the organic chemicals in the wastewater. Steam is injected into the wastewater in order to ensure the temperature is maintained within the optimum range at all times of the year. Since the Illinois River temperature is much colder than the optimal treatment system temperature in late fall, winter and early spring, additional steam would have to be injected to maintain the required temperature range. The volume of river water needed to achieve nitrification on a bench scale is nearly ten times the volume of wastewater the facility typically generates and would require the installation of a 140 million Btu per hour boiler to provide the additional steam. Assuming the boiler ran for seven months of the year, was natural gas-fired, equipped with low-$NO_x$ burners and flue gas recirculation, it could emit as much as 38,000 metric tons of $CO_2$e greenhouse gases, 35 tons of nitrogen oxides, and 30 tons of carbon monoxide per year to heat the river water. The atmospheric emissions coupled with the additional heat load discharged to the Illinois River would negate any benefit associated with the potential reduction in ammonia concentration in the effluent.

If you have any questions, please contact David Sikes, HS&E Manager via email at david.sikes@emeraldmaterials.com or call at 309.364.9472.

Respectfully,

Galen Hathcock
Plant Manager

# ATTACHMENT A

Brown AND Caldwell

220 Athens Way, Suite 500
Nashville, TN 37228

T: 615.255.2288
F: 615.256.8332

# Technical Memorandum

| | |
|---|---|
| Prepared for: | Emerald Performance Materials |
| Project Title: | Henry Nitrification Evaluation |
| Project No.: | 149470 |

**Technical Memorandum**

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| Subject: | Evaluation of Nitrification Alternatives for Emerald-Henry, Illinois Facility |
| Date: | April 13, 2018 |
| To: | David Sikes, Environmental, Health and Safety Manager |
| From: | Houston Flippin, P.E., BCEE, Chief Engineer |
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# Section 1: Introduction

## 1.1 Background

The combined wastewater generated at the Emerald Performance Materials - Henry Plant (Emerald) has historically contained high concentrations of Total Kjeldahl Nitrogen (TKN) and ammonia-nitrogen (NH3-N), as well as a known nitrification-inhibiting compound, mercaptobenzothiazole (MBT). This known inhibitor is the compound that serves as the foundational building block of essentially all products at the Emerald Henry Plant.

Both Emerald and Mexichem are co-located at the Henry Plant having at one time been all part of the BF Goodrich Specialty Chemicals plant. Together, these two industries discharge to a shared industrial wastewater treatment facility (IWTF) operated by Emerald (see Figure 1). The wastewaters from Emerald discharge to two equalization tanks: the C-18 Tank and the PC Tank. The wastewaters from Mexichem production discharge to an equalization tank with one Mexichem wastewater (213 Centrate) stream receiving special pretreatment. The wastewaters from the two Emerald tanks, one Mexichem tank, and the Mexichem pretreated wastewater are all discharged to an onsite IWTF. In addition, waters from groundwater recovery, production area stormwater, and utility waters are also treated in the IWTF. The IWTF provides chemical conditioning, primary settling to remove solids, activated sludge treatment to remove biologically degradable materials and tertiary filtration prior to discharge to the Illinois River. The solids from primary settling, Mexichem pretreatment and the waste solids from activated sludge treatment are dewatered using a precoat filter press. The dewatered solids are disposed of off-site. Figure 1 illustrates this wastewater collection and treatment system.

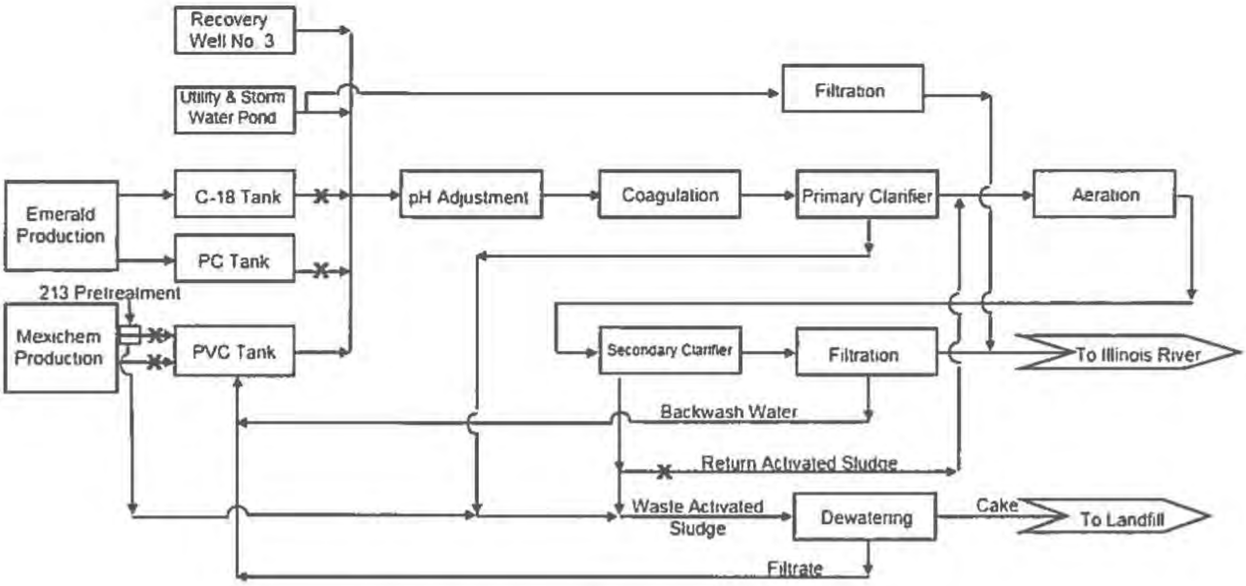



**Figure 1: Block Flow Diagram of Wastestream Sources and WWTF**

Due to the necessity of MBT use in Emerald's production processes, effluent $NH_3$-N removal at the Henry Plant is typically low. Brown and Caldwell (BC), at the request of Emerald, has conducted the studies listed below and described herein to satisfy Condition 2 (e) of Adjusted Standard 13-2 issued by the Illinois Pollution Control Board (IPCB), which has been incorporated into Special Condition 15 of the Plant's National Pollution Discharge Elimination system permit (IL0001392) issued by the Illinois Environmental Protection Agency (IEPA):

1. Provide Granular Activated Carbon (GAC) Treatment on the Polymer Chemicals (PC) wastewater to remove MBT so that nitrification can occur.
2. Provide river water dilution to the primary clarifier effluent so that MBT may be diluted and nitrification can occur.

Emerald also requested BC to investigate the technical and economic viability of each.

## 1.2 Scope of Work

The scope of work for these studies consisted of bench scale treatability testing and developing a preliminary design and cost estimate for each option. Laboratory testing was required to evaluate nitrification potential and feasibility. Based on the results from the bench scale tests, preliminary designs and a class 5 cost estimate were completed to investigate the economic feasibility of achieving nitrification (biological ammonia-nitrogen removal) through these two methods in comparison to $NH_3$-N removal technologies previously considered. Lastly, these costs were compared to the costs imposed by municipalities on industries to provide $NH_3$-N removal.

## Section 2: Laboratory Testing

Fed Batch Reactor (FBR) testing was performed to investigate the ability for nitrification to occur in pretreated and unpretreated wastewater. During an FBR test, a wastewater is fed to a batch reactor with a fixed biomass population. This configuration allows for the fraction of wastewater in the beaker to increase over time based on a chosen food to mass (F/M) ratio. Thus, the nitrification rate as well as the fraction of wastewater inhibitory to the biomass (generally washed return activated sludge (RAS) from the Henry Plant plus dissolved solids (salt) and pure culture nitrifying bacteria (nitrifiers)) can be ascertained from the results. FBR tests were performed on five combinations of biomass and test waters to investigate the viability of GAC treatment and river water dilution in facilitating nitrification in the IWTF. Table 1 outlines the five FBR tests run during this investigation.

Table 1. FBR Tests Performed

| Test | Biomass | Wastewater |
|---|---|---|
| FBR 1 | Washed RAS + TDS Adjusted Nitrifiers | Unpretreated Primary Clarifier Effluent |
| FBR 2 | Washed RAS + TDS Adjusted Nitrifiers | Primary Clarifier Effluent with PC and C-18 pretreated with GAC |
| FBR 3 (Control Rd. 1) | Washed RAS + TDS Adjusted Nitrifiers | River water with NH4Cl |
| FBR 4 | Washed RAS + River water TDS Adjusted Nitrifiers | 10% Unpretreated Primary Clarifier Effluent and 90% River water |
| FBR 5 (Control Rd. 2) | Washed RAS + River water TDS Adjusted Nitrifiers | River water with NH4Cl |

FBR Tests 3 and 5 were run as controls containing the pure culture nitrifiers at different design total dissolved solids (TDS) values. The controls were used to obtain an uninhibited nitrification rate. FBR Test 1 was designed to investigate any possible nitrification experienced with average levels of MBT fed to the current Henry biomass with nitrifying bacteria added. FBR 2 was designed to investigate the ability for nitrification to occur in a test fed GAC treated PC wastewater. FBR Test 4 was performed to investigate if nitrification inhibition would occur if the waste stream remained unpretreated, but heavily diluted with river water.

To simulate the pretreated clarifier effluent, settling tests and GAC tests were performed on combined wastewater collected from the PC and the Cure-Rite® 18 (C-18) equalization tanks. Both these wastewaters are generated through production processes in the Emerald plant. The purpose of these tests was to identify the required solids removal system and to determine the required GAC dose to achieve a target MBT concentration of less than 15 mg/L in the PC wastewater discharge. This settled and GAC treated PC/C-18 wastewater was fed to FBR Test 2.

## 2.1 Return Activated Sludge (RAS) Washing

The RAS samples provided by Emerald Performance Materials were washed as they arrived at BC's Industrial Treatability Laboratory in Nashville, TN. The RAS samples were washed 8,000-fold at a pH of nine in TDS adjusted river water. After this washing, decant from the RAS was characterized to insure MBT was less than 1 mg/L, pH was adjusted to 7.2, and the decant was re-sampled to ensure MBT was at target concentrations. MBT in both samples was less than 0.04 mg/L.

## 2.2 Settling Tests and Granular Activated Carbon Testing (GAC)

Prior to FBR testing, settling and GAC tests were performed on the PC/C-18 WW. The settling tests were performed to size a new inclined plate separator prior to GAC treatment. This would aid in the removal of total suspended solids (TSS) prior to carbon treatment. The GAC testing was performed to quantify the GAC dosage necessary so that PC/C-18 WW would not inhibit nitrification.

The PC and C-18 waste streams were blended proportionally to the current average flow of each stream. After being blended, pH was adjusted to 10 using sodium hydroxide (NaOH). While the pH was at 10, settling tests were performed. Table 2 provides the results from the settling tests.

**Table 2. Settling Test Results**

| HRT (gpd/ft2) | TSS (mg/L) |
|---|---|
| No Settling | 127 |
| 50 | 9 |
| 300 | 63 |
| 600 | 65 |
| 900 | 63 |
| 1,200 | 80 |

The 50 gpd/ft2 test was the only settling test performed that produced a supernatant TSS of 9 mg/L, with a goal of less than 20 mg/L. This was done to mimic the expected TSS quality after treatment with an inclined plate separator. This sample was collected and analyzed for MBT. The resulting MBT is seen in Table 3 as a GAC dosage equal to 0 mg/L.

After settling tests were performed, testing was conducted on the pretreated PC/C-18 WW to determine the concentration of GAC needed to decrease the MBT concentration below 15 mg/L. Table 3 provides the dosages and MBT results from the GAC testing.

**Table 3. GAC Test Results**

| GAC Dosage (mg/L) | MBT (mg/L) |
|---|---|
| 0 | 320 |
| 1,200 | 230 |
| 5,800 | 83 |
| 10,300 | 10[a] |
| 14,900 | 18 |
| 19,400 | 8.4 |
| 24,000 | 0.99 |

*[a] Suspect data point.*

Results from the GAC tests show that the dosage of GAC to achieve less than 15 mg/L MBT is approximately 17,000 mg/L. In the makeup of the pretreated feed for FBR Test 2, a dosage of 20,000 mg/L was used for pretreatment of the PC/C-18 WW prior to the feed makeup. This dose was selected to provide a margin of safety in achieving adequate MBT removal. The Freundlich isotherm developed from the GAC doses is presented in Figure 2.

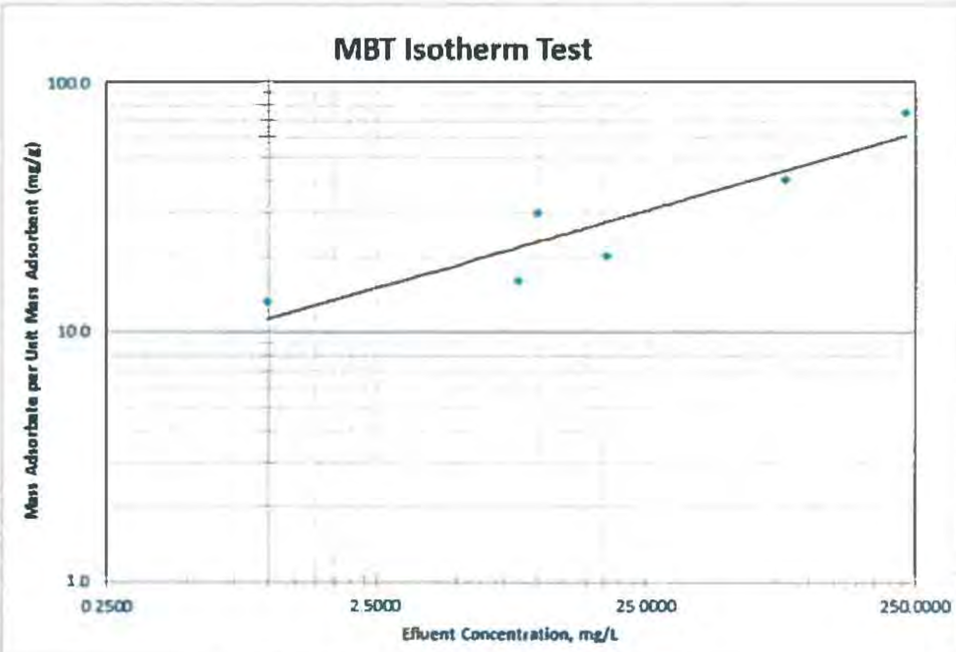



**Figure 2. Freundlich Isotherm for MBT removal**

Calgon Filtrasorb-300 (F-300), Calgon's most popular GAC media for industrial wastewater applications was deemed adequate and therefore used for the testing performed. Virgin F-300 was chosen for this investigation since it offers good adsorptive properties for a wide range of compounds including MBT.

When MBT is the primary compound being removed by GAC, Calgon Carbon recommends their OLC 12X40 product as being their most efficient product. The OLC 12X40 was recommended by Calgon based on GAC performance with benzotriazole (BTA) removal. BTA is similar in chemical structure to MBT. Calgon believed that removal of BTA through carbon adsorption would be similar to that of MBT. The quantity of MBT removed per mass of GAC (X/M) increase in performance was based on Figure 2 provided by Calgon. The 10 percent improvement in MBT removal assumes that a concentration of 320 mg/L MBT would exist in the PC/C-18 WW. Based on Figure 3, F-300 would have a capacity of approximately three grams of BTA/100 grams carbon. The OLC 12X40 would have an approximate capacity of 3.3 grams of BTA/100 grams carbon. This leads to the assumptions that the OLC 12X40 could potentially have a 10 percent better MBT removal compared to the F-300. In addition, the F-300 is 50 percent costlier. Based on these facts, BC assumed that the lower cost and potentially 10 percent better OLC 12X40 would be used in preparing cost estimates for full-scale application.

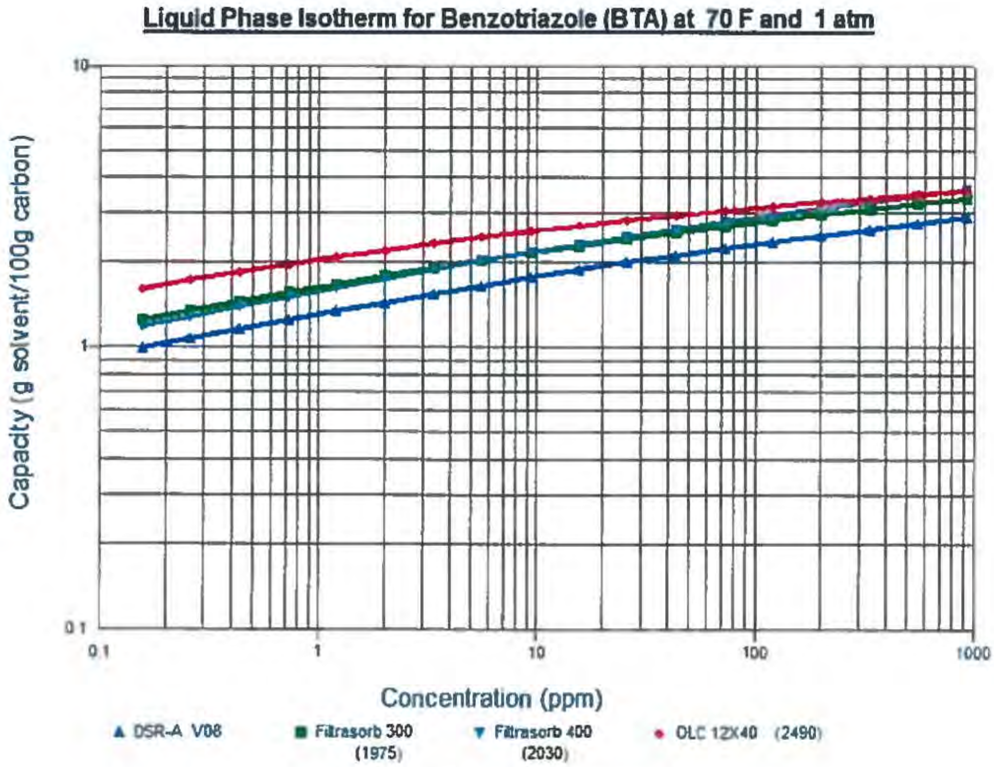



**Figure 3. BTA Removal Isotherm**

## 2.3 Feed Characterization

Following pretreatment, feeds were made for each FBR test. The feed makeup for FBR Tests 1 and 2 were based upon the current average waste stream flows experienced at the Henry facility as illustrated in Table 4. PC and C-18 wastewaters have been previously described as wastewaters that originate from Emerald production. Wastewaters from Mexichem polyvinyl chloride production were collected prior to the Polyvinyl Chloride (PVC) tank and termed PVC wastewater. Mexichem makes a product know as 213. The product is centrifuged to remove water. The water removed is discharged to a pretreatment system that consists of chemical conditioning and gravity settling of the solids. The treated water from this process was termed 213 Centrate.

Feed 1 contained the composition of wastewaters illustrated in Table 4 and was subjected to simulated primary treatment and analyzed. This simulation consisting of coagulant addition (using $FeCl3$), rapid mix, flocculant addition, flocculation and gravity settling at pH 9 as practiced by the plant. Feed 2 was identical to Feed 1 except that the PC and C-18 wastewaters were treated with 20 grams per liter of F-300 GAC. The FBR control tests (Round 1 and Round 2) evaluated feeds composed of tap water, nutrients, alkalinity, and salt. The simulated river water dilution feed was composed of 90% tap water with nutrients, alkalinity, and salt. The other 10% of the feed consisted of Feed 1. The 10:1 dilution was provided in order that the FBR test could operate without nitrification inhibition at least during the beginning of the test. The characteristics of these respective streams are described in Table 5.

**Table 4. Henry Waste Stream Composition**

| Stream | Flow (gpm) | Percent Makeup (%) |
|---|---|---|
| Emerald PC WW | 82 | 18.6 |
| Emerald C-18 | 1.8 | 0.4 |
| Mexichem PVC WW | 345 | 78.3 |
| Mexichem 213 Centrate | 11.7 | 2.7 |

**Table 5. Feed Characterization**

| Test | Sample | TKN (mg/L) | $NH_3$-N (mg/L) | $NO_x$-N (mg/L) | MBT (mg/L) | cBOD (mg/L) | COD (mg/L) |
|---|---|---|---|---|---|---|---|
| FBR 1 | Feed 1 | 60 | 28.1 | 2.13 | 50 | 63.4 | 890 |
| FBR 2 | Feed 2 | 45.8 | 28.2 | 1.68 | 0.09 | <37.5 | 390 |
| FBR 3 | Control Round.1 | 0 | 78.2 | 0 | 0 | NA | 0 |
| FBR 4 | River Water Dilution Feed | 6 | 108.2 | 0.21 | 5 | 6.3 | 74 |
| FBR 5 | Control Round. 2 | 0 | 100.2 | 0 | 0 | NA | 0 |

Note: TKN test does not detect all forms of organic nitrogen. The average effluent flow and $NH_3$-N concentration during 2017 were 0.70 million gallons per day (MGD) and 90 mg/L respectively, yielding an average $NH_3$-N mass of 525 lbs/day.

A Potassium phosphate ($KH2PO4$) buffer containing NaOH was added to the feed of each FBR to provide sufficient alkalinity for complete nitrification. Supplemental $NH_3$-N was added to FBR Tests 3, 4, and 5 so that nitrification rates could be established for each FBR. Using the $KH2PO4$ buffer also provided sufficient phosphorous for each FBR. A micronutrient broth was also added to each FBR's feed to ensure that micronutrient limitations would not exist in any FBR test. The pH in all tests was maintained between 6.7 and 7.5.

## 2.4 FBR Testing

Two rounds of FBR testing were performed to investigate both treatment alternatives. The first round consisted of FBR 1, FBR 2, and FBR 3. Round two consisted of FBR 4 and FBR 5. During the FBR testing, wastewater is fed to a batch reactor with a fixed biomass population. This configuration allows for the fraction of wastewater in the beaker to increase over time based on a chosen F/M ratio. Thus, the nitrification rate as well as the fraction of wastewater inhibitory to the biomass can be ascertained from the results.

The FBR tests were designed to be fed based on the F/M currently targeted at the Henry, IL facility of 0.25 day-1. This was altered for FBR Test 2 so that the flow would match the flow experienced at the current facility and not the F/M outlier due to a drop in COD from pretreatment.

All tests were provided with TDS-adjusted, pure-culture nitrifying bacteria. Nitrifiers were TDS adjusted over several days to match the TDS in the feeds. Baseline nitrification rates were generated from the TDS adjusted nitrifiers. The rates developed were:

- active nitrification rate of 1.16 mg N/mg MLVSS/day for nitrifiers at 11,300 mg/L TDS
- active nitrification rate of 0.39 mg N/mg MLVSS/day for nitrifiers at 1,650 mg/L TDS

Based on these rates, 0.27 grams of nitrifiers at a TDS of 11,300 mg/L was added to FBR Tests 1, 2, and 3. For FBR Tests 4 and 5, 2.1 grams of nitrifiers at a TDS of 1,650 mg/L were added. Prior to FBR testing, the temperature of the biomass and the pure culture nitrifiers was slowly increased to 32 °C. The rates of each individual FBR test were compared with the rates measured in the controls (mg $NH_3$-N removed/mg pure culture nitrifier/day).

The FBR tests progressed in the following manner:

1. The biomass (MLVSS) in each beaker was approximately the same in FBR Tests 1, 2, and 3. This was accomplished by concentrating the biomass via centrifugation to create a slurry of approximately 2.5 percent solids (25,000 mg/L) first. In FBR Tests 4 and 5, the concentration of biomass slurry was approximately 0.5 percent solids (5,000 mg/L).
2. The concentrated biomass slurry was placed in a 2-L beaker along with the nitrifiers, mixed with an overhead mixer and aerated with pure oxygen to maintain dissolved oxygen (DO) greater than 5 mg/L. The 2-L test beakers were then placed in a water bath at 32°C.
3. As the wastewater was fed to the slurry, the volume of the beaker increased. The exposure concentration of the treated wastewater to the biomass (bacteria) increased from zero percent to the target 89 percent wastewater.
4. Samples collected represented effluent samples containing a desired percentage of biologically treated feed wastewater in the presence of the biomass. The sample was centrifuged to remove solids and the biomass were returned to the reactor in order to maintain a consistent mass of biomass in the test reactor. The sample volume was recorded during every sampling event.
5. During testing, samples were collected when treated influent wastewater comprised approximately 13 percent, 26 percent, 48 percent, 72 percent and 89 percent of the collected sample. These samples were then analyzed for indications of nitrification inhibition through $NH_3$-N reduction and nitrate-nitrogen accumulation. Ideally, these values would be identical. In practice, the nitrification rate was calculated as the average between the ammonia-nitrogen reduction rate and the nitrate-nitrogen accumulation rate.

## 2.5 Results

Figures 4, 5, 6, and 7 summarize the results of the FBR testing. All tests in Round 1 and Round 2, except the unpretreated feed FBR, experienced consistent removal of $NH_3$-N through the end. No nitrification was observed between 13% and 60% of the treated wastewater addition for FBR 1, which is consistent with the absence of nitrification in the full-scale facility.

In Round 1, Figures 4 and 5 illustrate that nitrification did not begin until two hours into the test. At this point, 22 percent by volume of treated wastewater was present in the test. This is to be expected since the nitrifiers required some acclimation time after being washed. In a full-scale system, this would not be experienced if a viable colony of nitrifiers existed. Based on the results from $NH_3$-N removal and NOx-N generation, a relative nitrification rate was developed. The control reactor in Round 1 (FBR 3) had an average active nitrification rate of 1.32 mg N/mg MLVSS active nitrifier/day illustrating that the nitrifiers were uninhibited during testing. The simulated clarifier effluent with GAC pretreatment of PC and C-18 wastewaters exhibited minimal impacts on nitrification where an average active nitrification rate of 1.17 mg N/mg MLVSS/day was calculated for FBR test 2. Both rates were greater compared to the initial baseline proving that GAC treatment of the PC/C-18 wastewater would facilitate nitrification of the combined wastewater at the Henry Plant. These results indicate that without pretreatment to remove or greatly dilute MBT, no nitrification would be observed at the Henry Plant.

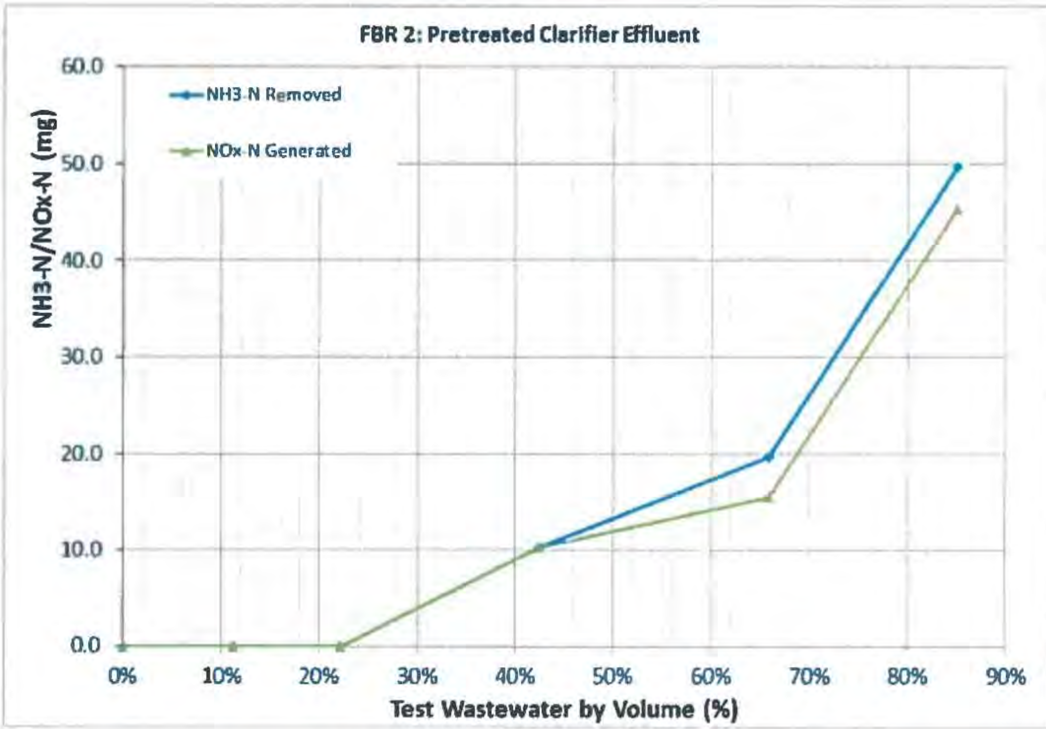



**Figure 4. FBR 2 $NH_3$-N Removal and $NO_x$-N Generation**

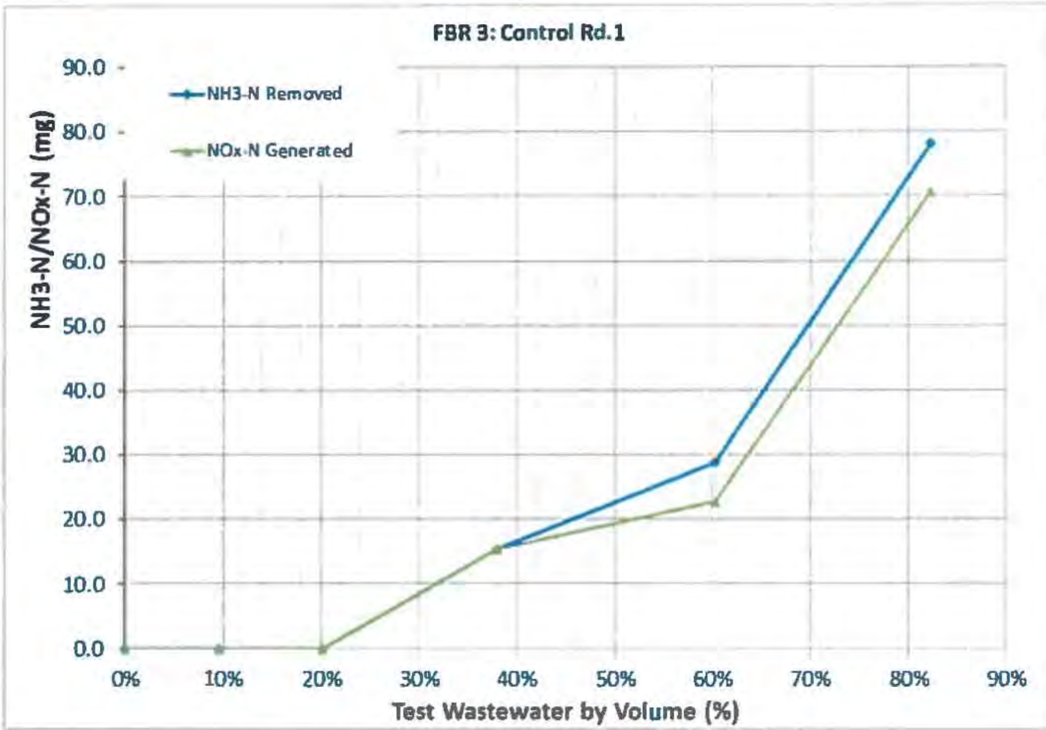



**Figure 5. FBR 3 $NH_3$-N Removal and NOx-N Generation**

In Round 2, Figures 6 and 7 depict $NH_3$-N degrading from the beginning of the test. $NH_3$-N removal was slower at the beginning of the test as the biomass began to get acclimated to the addition of each feed. In round 2, the control reactor (FBR 5 as illustrated in Figure 7) had an average nitrification rate of 0.37 mg N/mg MLVSS active nitrifier/day with an increasing rate during the tests indicating that the nitrifiers were not inhibited during the control test. Utilizing river water to dilute the unpretreated clarifier effluent (FBR 4 as illustrated in Figure 6) by 90 percent did not completely eliminate nitrification inhibition as evidenced by the 20 percent lower average nitrification rate of 0.29 mg N/mg MLVSS active/day. This inhibition was anticipated since the concentration of MBT exceeded the published nitrification inhibition threshold of 3 mg/L during the second half of the test when the test wastewater exceeded 60 percent in volume.

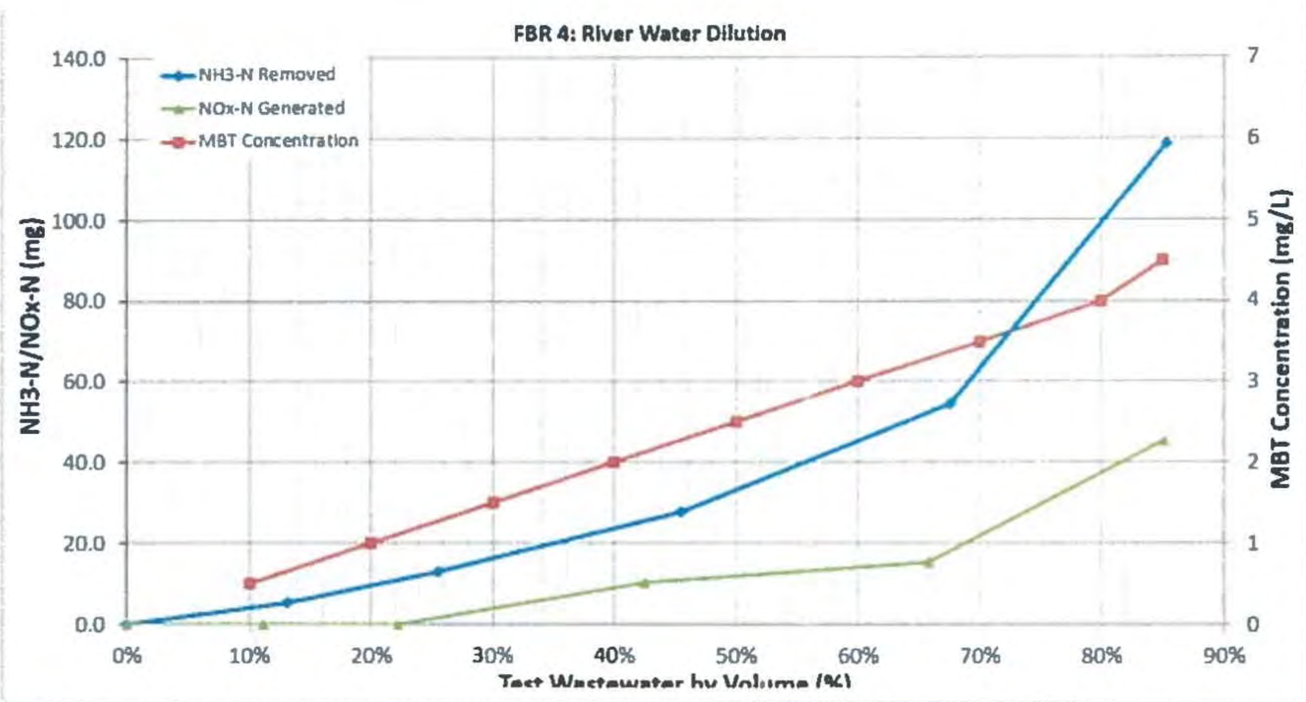



Figure 6. FBR 4 $NH_3$-N Removal and NOx-N Generation

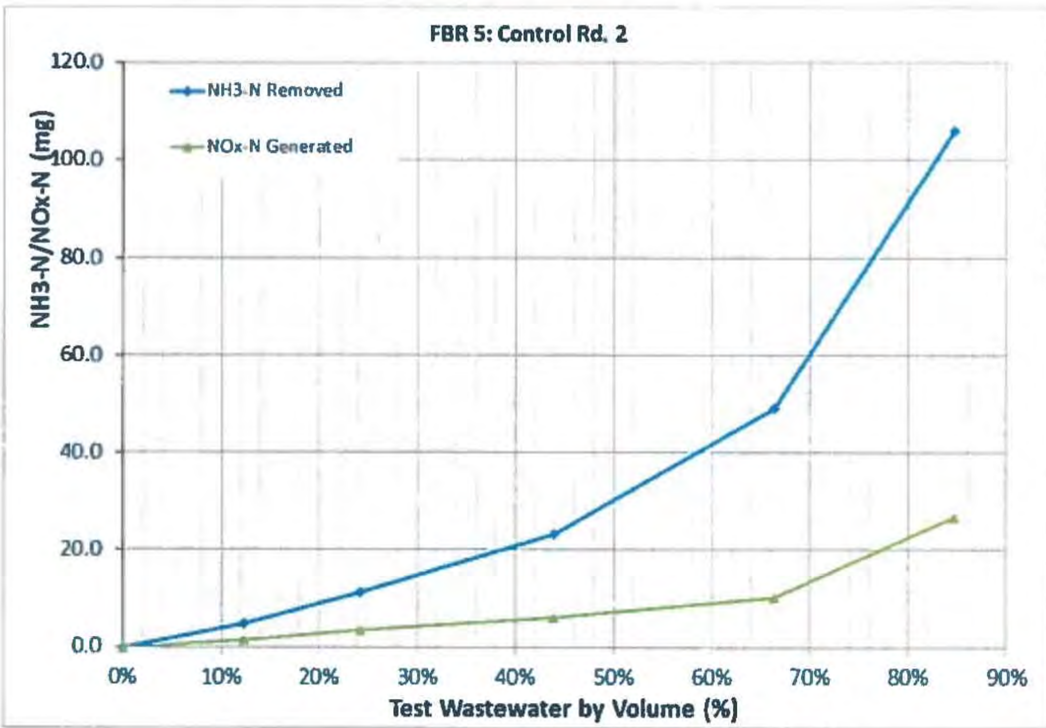


**Figure 7. FBR 5 $NH_3$-N Removal and NOx-N Generation**

Figures 6 and 8 illustrate the buildup in MBT concentration during the FBR tests. Based on published literature and previous testing performed by BC, MBT would be expected to cause nitrification inhibition at approximately 3 mg/L[1]. Based on this result, nitrification inhibition did occur at approximately 3.5 mg/L. Minimal concentrations of MBT were observed in the pretreated clarifier effluent allowing the reactor to nitrify uninhibited.

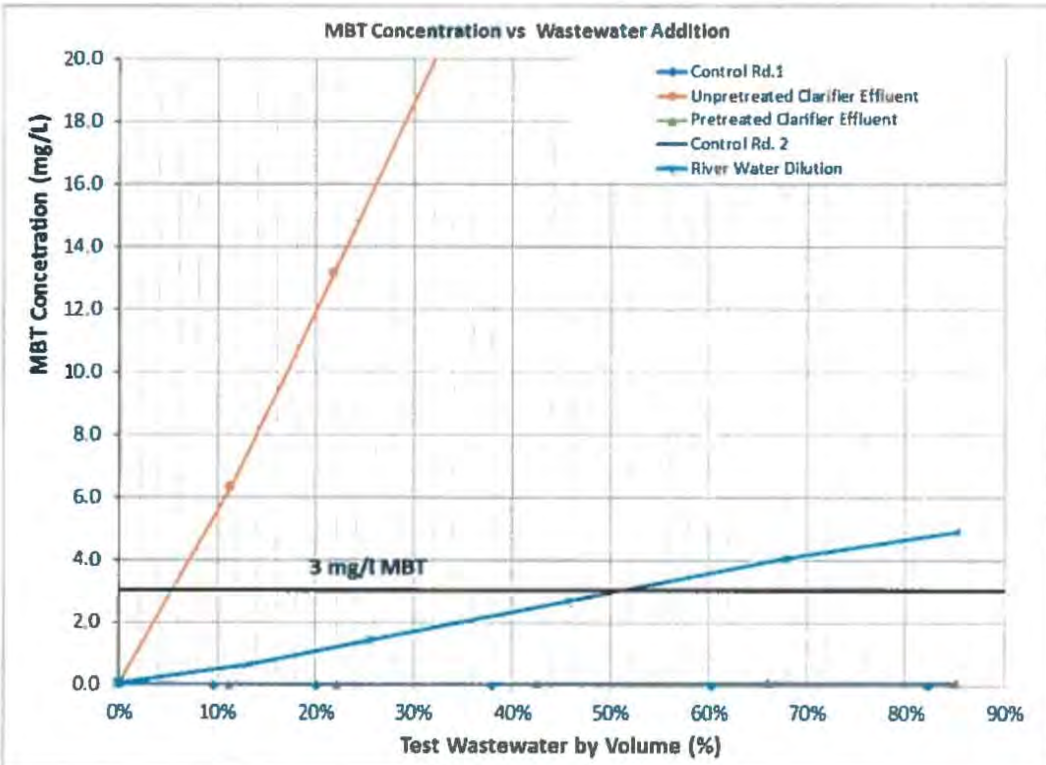



**Figure 8. MBT Concentration**

## 2.6 Summary of Treatability Testing

Based on FBR testing performed, the following conclusions were made:

- The unpretreated wastewater will continue to cause substantial nitrification inhibition due to high concentrations of MBT.
- Pretreatment of the PC/C-18 wastewater utilizing solids separation and GAC would allow the Henry Plant to nitrify in an uninhibited matter following removal of MBT from the biomass through alkaline washing.

1 Hockenbury, M.R., and C.P.L. Grady: J. Water Pollut. Control Fed., vol.49, p 768, 1977.

- Diluting the unpretreated clarifier with river water requires a river water percentage in excess of 90% for uninhibited nitrification to occur. At 90% dilution, the nitrification rate observed could be sustainable as long as the MBT concentration in the PC/C-18 wastewater remained within values tested. The sustainability of this treatment alternative, $NH_3$-N removal, performance is unlikely due to the inherent variability of the influent MBT concentration and the difficulty in maintaining target temperatures in the biological treatment systems while heating a large river water flow (approximately 7 MGD).
- Both the pretreatment option and the river water dilution option would allow biological nitrification. However, neither would be economically reasonable as discussed below.

# Section 3: Conceptual Level Design and Cost Estimates

At the conclusion of treatability testing, BC developed conceptual designs and Class 5 cost estimates to evaluate additional equipment facility changes needed for each alternative. A Class 5 estimate is considered to be a conceptual level estimate and is performed when 0 to 2% of the design has been completed. Accuracy for a Class 5 estimate is expected to fall between -50% to +100% of the cost. Class 5 estimates are used to prepare planning level cost scopes or evaluation of alternative schemes, long range capital outlay planning and can also form the base work for the Class 5 Planning Level or Design Technical Feasibility Estimate. As a result, these estimates are intended only for use as aids in conceptual level treatment selection. In order to develop the cost estimates, the major equipment for each option were established and sized. Equipment costs were developed from vendor quotes as well as BC's cost database. The following assumptions were made in the development of the estimates:

- Adequate power is available
- Easy access to equipment installation locations
- No special requirements for electrical equipment (e.g., explosion proof)
- No buildings are included

A complete breakdown of the capital costs associated each alternative is presented in Attachment A. The major annual operating and maintenance (O&M) costs are summarized in Table 6 and Table 7.

## 3.1 Solids Separation and GAC treatment of PC/C-18 Wastewaters

In this alternative, wastewaters would be discharged to an inclined plate separator (lamella clarifier) sized for an average loading of 50 gpd/sq ft. BC has assumed that current pump conveying the PC/C-18 wastewater is sufficient for future use for conveying wastewater to the clarifier. The sludge from this clarifier would be discharged to the existing plate and frame filter press for dewatering. Effluent from the clarifier will be pumped to a 5,000-gallon poly holding tank that will be pumped to four GAC vessels (containing 40,000 lbs GAC each) operated in series to the existing primary treatment system. The GAC housed in the lead column would be changed approximately every seven days. Sizing of the GAC columns was based on average flow conditions. During peak conditions, the 40,000 lbs GAC vessels would be able to handle additional flow. GAC would need to be replaced more often during increased MBT loads. GAC effluent will flow from the GAC vessels to a 5,000-gallon poly tank. This tank will be used to dampen flow to the primary system, from the surge tank, flow will be pumped to the primary clarifier. A block flow diagram of this system is described in Attachment B.

Based on the new equipment and construction needed for this alternative, the expected total capital cost would be $5,274,000 with a range from $2,637,000 (-50%) to $10,548,000 (+100%). The full capital estimate is described in Attachment A.

The O&M costs only consider the incremental O&M costs associated with the upgraded equipment. If regenerated carbon is used, the X/M will decrease by approximately 30 percent based on estimates provided by Calgon Carbon and the cost of carbon would decrease 50 percent. These prices assume that exhausted carbon will be hauled to Calgon Carbon's regeneration facility in Catlettsburg, Kentucky. BC has assumed that labor costs will not increase in this alternative. Table 6 and Table 7 provides the O&M costs associated with this alternative depending on GAC selection.

Table 6. Virgin GAC (OLC12X40) Treatment O&M Costs

| Parameter | Quantity | Unit Cost | Annual Cost, $/yr |
|---|---|---|---|
| Virgin Granular Activated Carbon | 5,220 lbs/day | $2.00/lb | $3,811,000 |
| Electricity | 60 hp | $0.0495/kwh | $19,400 |
| Maintenance | | 8% of motorized equipment cost | $33,800 |
| Alkalinity Addition | 6000 lbs/day of 50% NaOH | $250/ton | $274,000 |
| Additional Blower Operation | 70 hp | $0.0495/kwh | $22,600 |
| Total | | | $4,160,000 |

Table 7. Regenerated GAC (DSR-A) Treatment O&M Costs

| Parameter | Quantity | Unit Cost | Annual Cost, $/yr |
|---|---|---|---|
| Regenerated Granular Activated Carbon | 7,540 lbs/day | $1.00/lb | $2,752,100 |
| Electricity | 60 hp | $0.0495/kwh | $19,400 |
| Maintenance | | 8% of motorized equipment cost | $33,800 |
| Alkalinity Addition | 6000 lbs/day of 50% NaOH | $250/ton | $274,000 |
| Additional Blower Operation | 70 hp | $0.0495/kwh | $22,600 |
| | | | $3,102,000 |

The O&M costs for GAC treatment is driven by the low adsorptive capabilities of MBT by carbon experienced in the bench scale testing.

The capital cost for this option is approximately $5.3 million with a present worth cost of $27 million assuming a 10-year project duration, zero salvage value, 5% interest and 2% inflation. This investment would result in an approximately 1.9 million pounds of $NH_3$-N being removed over the course of 10 years at an average cost of $14/pound of $NH_3$-N removed. This is 20-fold higher than the costs reported by the Publicly Owned Treatment Works serving Decatur, Illinois; Bloomington, Illinois and Normal, Illinois in 2015 (less than $0.70/pound of $NH_3$-N). This is 11-fold higher than the median cost reported by 15 reporting entities in the 2015 survey conducted by the National Association of Clean Water Agencies ($1.33 per pound of NH3-N removed). Based on this comparison, the removal of $NH_3$-N at the Emerald plant is not economically reasonable.

## 3.2 River Water Dilution System

In this alternative, all the current waste streams will remain routed as they currently are at the facility. The C-18 wastewater, PC wastewater, and PVC wastewater will all be chemically conditioned and be conveyed to the primary clarifier. From the clarifier, the waste stream will be conveyed to the aeration basin. In addition to the waste stream being routed to the aeration basin, a new lift station will be installed to pump river water from the Illinois River to provide a dilution stream to the waste water. The river water will be pumped to the aeration basin at approximately 7 MGD to dilute MBT. It is assumed that the river water requires no treatment. A steam injection will be installed to ensure that the temperature in the aeration basin will remain at 85°F year-round. This is the operating temperature to achieve the required Biochemical Oxygen Demand (BOD) removal based on historical performance. The capital cost of the steam generation and supply system was not added to the capital cost estimates due the excessive size needed for this application (a 140 million BTU/hr boiler output would be necessary which is 40-fold greater than the January 2018 consumption by the entire facility). After the aeration basin, a splitter box will be installed to split flow between three clarifiers. Two new 100-foot clarifiers will need to be installed and put into service along with the existing 60-foot clarifier. In additional to the new clarifiers, two new sludge pumps will be needed to convey the mixed liquor back to the aeration basin or to the existing belt filter press. BC has assumed for this evaluation that the current belter filter press will be sufficient for the future needs of the facility.

The supernatant from the clarifiers will also require filtration after clarification, this will require two, new sand filters (each with 1500 ft2 of filtration area). Effluent from the clarifiers will gravity flow to the new sand filter units. The filtered effluent will then be conveyed back to the Illinois River. Piping would need to be upsized throughout the facility to handle the increased flow. No additional changes would be needed for the rest of the treatment system. A block flow diagram of this system is described in Attachment B.

The sustainability of this treatment alternative $NH_3$-N removal performance is unlikely due to the inherent variability of the influent MBT concentration and the difficulty in maintaining target temperatures in the biological treatment systems while heating a large river water flow (approximately 7 MGD). The addition of river water would be based on percent flow and not MBT concentration. The MBT concentration in the wastewater fluctuates with production. The fluctuation would cause inconsistent nitrification and take several days to remove excess MBT concentrations from the system resulting in several days of low nitrification (high effluent $NH_3$-N concentrations). In addition to fluctuating MBT, the winter months would also negatively impact the treatment system if river water temperature control were not maintained. This river water (approximately 7 MGD) would have to be heated year-round to a target temperature of 85 °F from an initial temperature that varies by more than 40 °F (below 40°F to 79 °F ). Steam injector would be required year-round.

Based on the new equipment and construction needed for this alternative, the expected total capital cost would be $22,600,000 with a range from $11,286,500 (-50%) to $45,146,000 (+100%) excluding the steam supply system. The full capital estimate (excluding steam supply system) is described in Attachment A.

The O&M costs only take into account the new O&M costs associated with the upgraded equipment. BC has assumed that labor costs will not increase in this alternative. Table 8 provides the O&M costs associated with this alternative.

**Table 8. River Water Dilution O&M Costs**

| Parameter | Quantity | Unit Cost | Annual Cost, $/yr |
|---|---|---|---|
| Electricity | 260 hp | $0.0495/kwh | $136,000 |
| Maintenance | | 8% of motorized equipment cost | $288,000 |
| Steam | 22,600 therms/day | $0.446/therm | $3,679,000 |
| Alkalinity Addition | 6000 lbs/day of 50% NaOH | $250/ton | $274,000 |
| Additional Blower Operation | 70 hp | $0.0495/kwh | $22,600 |
| Total | | | $4,400,000 |

The capital cost for this option is approximately $23 million (excluding steam supply system) with a present worth cost of $54 million assuming a 10-year project duration, zero salvage value, 5% interest and 2% inflation. This investment would result in an approximately 1.9 million pounds of NH3-N being removed over the course of 10 years at an average cost of $28 per pound of NH3-N removed. This is 41-fold higher than the costs reported by the Publicly Owned Treatment Works serving Decatur, Illinois; Bloomington, Illinois and Normal, Illinois in 2015 (<$0.70 per pound of $NH_3$-N removed). This is 21-fold higher than the median cost reported by 15 reporting entities in the 2015 survey conducted by the National Association of Clean Water Agencies ($1.33 per pound of $NH_3$-N removed).

In addition to the economical unreasonableness of this alternative, this alternative would increase the heat load to the Illinois River 10-fold which would adversely impact localized water quality. It would also greatly complicate utility and treatment plant operations.

# Attachment A: Capital Cost Estimate

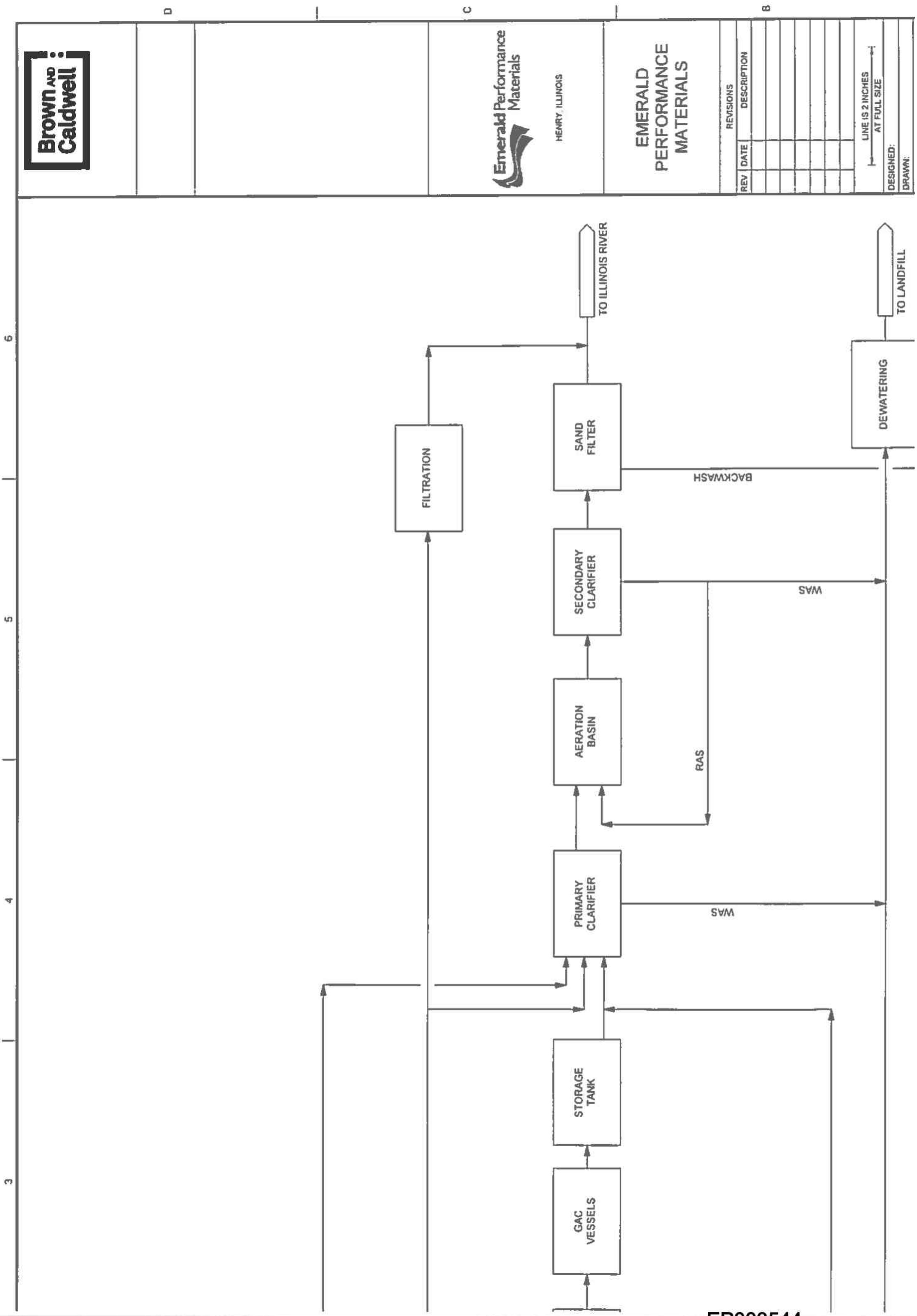
| Alternative 1: Solids Separation and GAC Treatment of PC/C-18 Wastewater Class 5 Capital Cost Estimate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Item | Qty | Unit | Labor $/unit | Materials $/unit | Subs $/unit | Equip $/unit | Total $/unit | Total Net Cost |
| Div 2- Sitework and Earthwork | 3 | % | $ 35,438 | $ 12,656 | $ - | $ 2,531 | $ 12,656 | $ 12,656 |
| Div 3 - Concrete | 8 | % | $ 67,500 | $ 54,000 | $ - | $ 13,500 | $ 54,000 | $ 54,000 |
| Div 5- Metals | 5 | % | $ 16,875 | $ 63,281 | $ - | $ 4,219 | $ 63,281 | $ 63,281 |
| Div 9- Coating | 2 | % | $ 16,875 | $ 16,875 | $ - | $ - | $ 16,875 | $ 16,875 |
| Div 11 - Equipment | | | | | | | | |
| Carbon Vessels ( 40,000 lb, series units) | 2 | ea | $ 16,000 | $ 400,000 | $ - | $ 5,000 | $ 421,000 | $ 842,000 |
| Inclined Plate Separator | 1 | ea | $ 16,000 | $ 190,000 | $ - | $ 3,500 | $ 209,500 | $ 209,500 |
| Inclined Plater Separator Solids Pumps | 2 | ea | $ 8,000 | $ 25,000 | $ - | $ 2,500 | $ 35,500 | $ 71,000 |
| 5,000 Gallon Poly Tank | 2 | ea | $ 8,000 | $ 6,000 | $ - | $ 1,000 | $ 15,000 | $ 30,000 |
| GAC Feed Pump | 2 | ea | $ 8,000 | $ 25,000 | $ - | $ 2,500 | $ 35,500 | $ 71,000 |
| GAC Effluent Pump | 2 | ea | $ 8,000 | $ 25,000 | $ - | $ 2,500 | $ 35,500 | $ 71,000 |
| Div 11 Total | - | - | $ 48,000 | $ 1,532,000 | $ - | $ 33,500 | $ - | $ 1,687,500 |
| Div 15- Mechanical (piping, fittings, valves, etc.) | 20 | % | $ - | $ 337,500 | $ - | $ - | $ 337,500 | $ 337,500 |
| Div 16- Electrical | 25 | % | $ - | $ - | $ 421,875 | $ - | $ 421,875 | $ 421,875 |
| Base Estimate | - | - | $ 253,688 | $ 2,877,313 | $ 421,875 | $ 72,250 | $ 1,854,688 | $ 2,593,688 |
| | | | | | | | | |
| Labor Markup | 8% | | | | | | | $ 20,295 |
| Material / Process Equipment Markup | 8% | | | | | | | $ 230,185.00 |
| Subcontractor Markup | 5% | | | | | | | $ 21,093.75 |
| Construction Equipment Markup | 8% | | | | | | | $ 5,780 |
| Sales Tax | 7.3% | | | | | | | $ 208,605 |
| Material Shipping and Handling | 2% | | | | | | | $ 57,546.25 |
| Subtotal | | | | | | | | $ 3,137,193 |
| | | | | | | | | |
| Contractor General Conditions | 7% | | | | | | | $ 219,603.49 |
| Subtotal | | | | | | | | $ 3,356,796 |

| | | |
|---|---|---|
| Startup, Training, O&M | 1.5% | $ 50,351.94 |
| Subtotal | | $ 3,407,148 |
| | | |
| Contingency | 25% | $ 851,787.02 |
| Subtotal | | $ 4,258,935 |
| | | |
| Builder's Risk, Liability Auto Insurance | 2% | $ 85,178.70 |
| Subtotal | | $ 4,344,114 |
| | | |
| Bonds | 1.5% | $ 65,162 |
| Subtotal | | $ 4,409,276 |
| | | |
| Engineering (Including Surveying) | 15% | $ 661,391 |
| Subtotal | | $ 5,070,667 |
| | | |
| Project Management | 4.0% | $ 202,827 |
| Subtotal | | $ 5,273,494 |
| | | |
| Grand Total | | $ 5,274,000 |
| Low Range (-50%) | | $ 2,637,000 |
| High Range (+100%) | | $ 10,548,000 |

| Alternative 2: River Water Dilution System Class 5 Capital Cost Estimate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Item | Qty | Unit | Labor $/unit | Materials $/unit | Subs $/unit | Equip $/unit | Total $/unit | Total Net Cost |
| Div 2- Sitework and Earthwork | 10 | % | $ 139,073 | $ 49,669 | $ - | $ 9,934 | $ 49,669 | $ 49,669 |
| Div 3 - Concrete | 15 | % | $ 149,006 | $ 119,205 | $ - | $ 29,801 | $ 119,205 | $ 119,205 |
| Div 5- Metals | 8 | % | $ 31,788 | $ 119,205 | $ - | $ 7,947 | $ 119,205 | $ 119,205 |
| Div 9- Coating | 3 | % | $ 29,801 | $ 29,801 | $ - | $ - | $ 29,801 | $ 29,801 |
| Div 11 - Equipment | | | | | | | | |
| Lift Station (Includes Piping and pumps) | 1 | ea | $ 540,000 | $ 2,880,000 | $ - | $ 180,000 | $ 3,600,000 | $ 3,600,000 |
| Clarifier (100' Diameter, includes sludge pumps) | 2 | ea | $ 195,000 | $ 1,040,000 | $ - | $ 65,000 | $ 1,300,000 | $ 2,600,000 |
| Splitter Box | 1 | ea | $ 5,000 | $ 40,000 | $ - | $ 2,000 | $ 47,000 | $ 47,000 |
| Sand Filter (1500 ft^2 filtration area) | 2 | ea | $ - | $ - | $ 850,000 | $ - | $ 850,000 | $ 1,700,000 |
| Clarifier RAS Pump | 4 | ea | $ 12,000 | $ 38,000 | $ - | $ 4,000 | $ 54,000 | $ 216,000 |
| Div 11 Total | - | - | $ 935,000 | $ 5,000,000 | $ - | $ 312,000 | $ - | $ 7,947,000 |
| Div 15- Mechanical (piping, fittings, valves, etc.) | 20 | % | $ - | $ 1,589,400 | $ - | $ - | $ 1,589,400 | $ 1,589,400 |
| Div 16- Electrical | 25 | % | $ - | $ - | $ 1,986,750 | $ - | $ 1,986,750 | $ 1,986,750 |
| Base Estimate | - | - | $ 2,036,668 | $ 10,905,280 | $ 2,836,750 | $ 610,682 | $ 9,745,030 | $ 11,841,030 |
| | | | | | | | | |
| Labor Markup | 8% | | | | | | | $ 74,800 |
| Material / Process Equipment Markup | 8% | | | | | | | $ 872,422.40 |
| Subcontractor Markup | 5% | | | | | | | $ 141,837.50 |
| Construction Equipment Markup | 8% | | | | | | | $ 48,854.56 |
| Sales Tax | 7.3% | | | | | | | $ 790,633 |
| Material Shipping and Handling | 2% | | | | | | | $ 218,105.60 |
| Subtotal | | | | | | | | $ 13,987,683 |
| | | | | | | | | |
| Contractor General Conditions | 7% | | | | | | | $ 979,137.80 |
| Subtotal | | | | | | | | $ 14,966,821 |
| | | | | | | | | |
| Startup, Training, O&M | 1.5% | | | | | | | $ 224,502.31 |
| Subtotal | | | | | | | | $ 15,191,323 |

| | | |
|---|---|---|
| Contingency | 20% | $ 3,038,264.59 |
| Subtotal | | $ 18,229,588 |
| | | |
| Builder's Risk, Liability Auto Insurance | 2% | $ 364,591.75 |
| Subtotal | | $ 18,594,179 |
| | | |
| Bonds | 1.5% | $ 278,913 |
| Subtotal | | $ 18,873,092 |
| | | |
| Engineering (Including Surveying) | 15% | $ 2,830,964 |
| Subtotal | | $ 21,704,056 |
| | | |
| Project Management | 4.0% | $ 868,162 |
| Subtotal | | $ 22,572,218 |
| | | |
| Grand Total | | $ 22,573,000 |
| Low Range (-50%) | | $ 11,286,500 |
| High Range (+100%) | | $ 45,146,000 |

# Attachment B: Block Flow Diagram (BFD)


Brown AND Caldwell
Emerald Performance Materials
HENRY, ILLINOIS
EMERALD PERFORMANCE MATERIALS
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TO ILLINOIS RIVER
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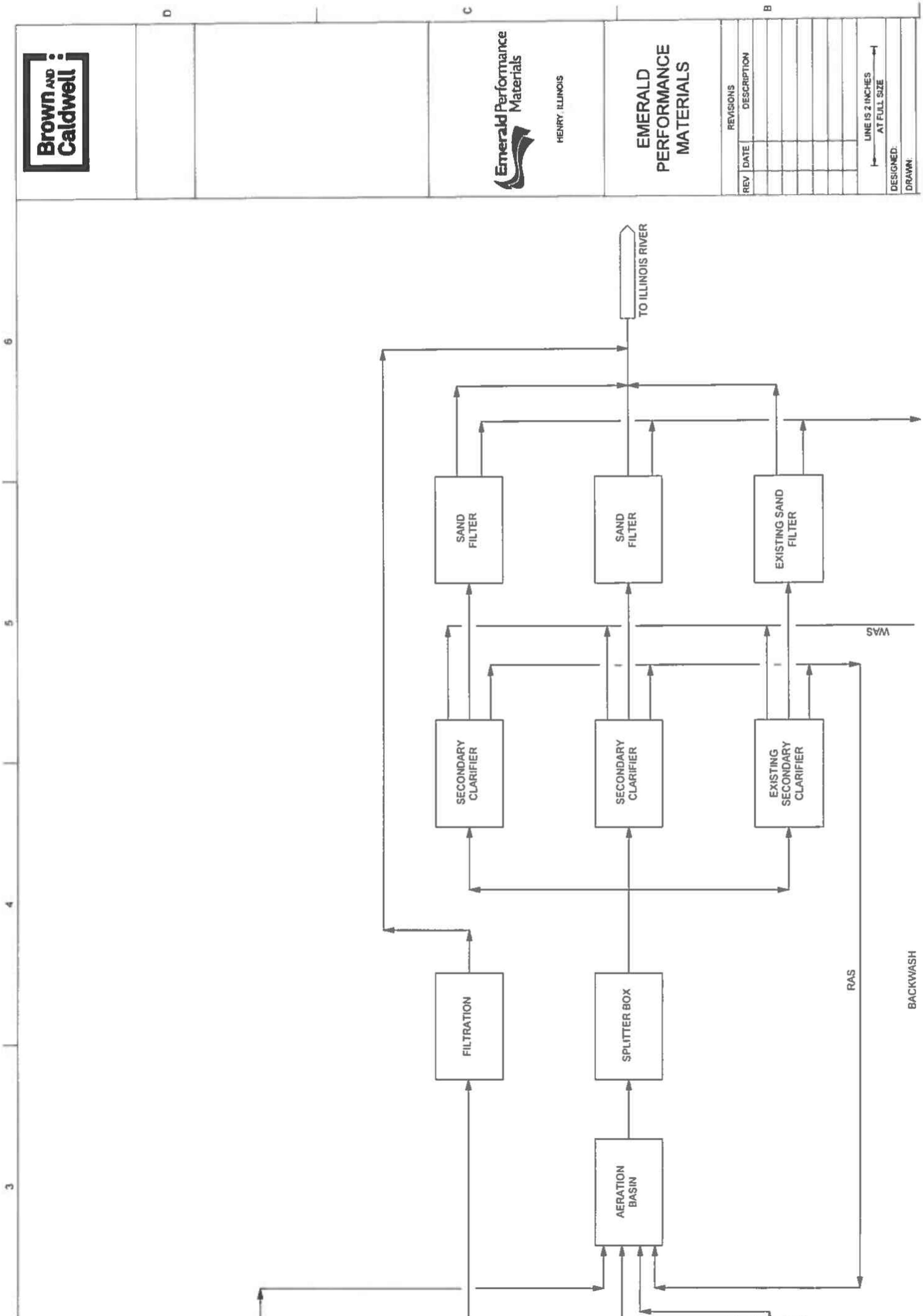
SECONDARY CLARIFIER
WAS
AERATION BASIN
RAS
PRIMARY CLARIFIER
WAS
STORAGE TANK
GAC VESSELS

EP003544



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Brown AND Caldwell
Emerald Performance Materials
HENRY, ILLINOIS
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SECONDARY CLARIFIER
SECONDARY CLARIFIER
EXISTING SECONDARY CLARIFIER
FILTRATION
SPLITTER BOX
AERATION BASIN
RAS
BACKWASH

# ATTACHMENT B

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

JUL 18 2007

Carolyn M. Brown, Esquire
Greenebaum Doll & McDonald PLLC
300 West Vine Street
Suite 1100
Lexington, KY 40507-1665

Dear Ms. Brown:

Thank you for your May 18, 2006 letter, on behalf of Ashland, Inc. (Ashland), in which you request clarification regarding the applicability of the Resource Conservation and Recovery Act (RCRA) regulatory program to a proposed spray irrigation system at Ashland's hazardous waste landfill located in Boyd County, Kentucky. Specifically, you ask that we clarify that the treated effluent permitted under Ashland's state National Pollutant Discharge Elimination System (NPDES) permit would be excluded from being a solid waste under 40 CFR 261.4(a)(2), even if a portion of the treated effluent is managed by spray irrigation to the cap of the hazardous waste landfill. (The regulation at 40 CFR 261.4(a)(2) excludes from the definition of solid waste wastewater discharges that are point source discharges subject to regulation under section 402 of the Clean Water Act (CWA).)

According to your letter, Ashland proposes to use the treated wastewater from the leachate collection system of the landfill for spray irrigation and maintenance of the landfill cap. The landfill leachate is classified as a listed hazardous waste with the hazardous waste code F039.

After reviewing the matter, we have determined that wastewater sprayed onto a landfill cap does not qualify for the Industrial Wastewater Discharge Exclusion under 40 CFR 261.4(a)(2). Although a portion of the effluent will continue to be discharged from Ashland's KPDES-permitted outfall to Chadwick Creek (and thus permitted under Section 402), wastewater that is diverted to land application and is not discharged to waters of the United States is not a point source discharge subject to regulation under the CWA and, therefore, does not qualify for the RCRA exclusion (even if it is part of the KPDES permit). Therefore, the wastewater remains a solid and hazardous waste. Unless it is delisted, the land application of this wastewater will constitute illegal disposal of hazardous waste. We believe a site-specific delisting, if granted, is the most appropriate action for removing the F039 hazardous waste code and allowing the proposed spray irrigation practice to occur.

Thank you for your inquiry regarding RCRA applicability to Ashland's proposed system. All inquiries regarding applicable permit requirements should be directed to Kentucky's Hazardous Waste Program. For other questions on this letter, please contact Jeff Gaines, at (703) 308-8655, or Ross Elliott, at (703) 308-8748.

Sincerely,

Matt Hale

Matt Hale, Director
Office of Solid Waste

cc: April Webb, KDEP
John Jump, KDEP
Bruce Scott, KDEP
Jon Johnston, EPA, Region 4
Kathy Nam, EPA, OGC
Robert Dellinger, EPA, OSW
Robert Hall, EPA, OSW

**GREENEBAUM DOLL & McDONALD PLLC**



May 18, 2006

Matt Hale
Director, Office of Solid Waste (5301W)
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Re: Applicability of Industrial Wastewater Discharge Exclusion

Dear Mr. Hale:

Our firm represents Ashland Inc. (Ashland) which is the owner/operator and permittee for the Route 3 Landfill in Boyd County, Kentucky. Ashland operated the Route 3 Landfill for disposal of hazardous and nonhazardous wastes from Ashland's Catlettsburg Refinery complex. Closure of the landfill was completed in October 2000. Postclosure monitoring was instituted after completion of closure, and the Kentucky Division of Waste Management issued RCRA Postclosure Permit No. KYD-000-615-898 for the landfill in May 2005. The purpose of this letter is to obtain clarification from your office as to the applicability of the RCRA regulatory program to a proposed spray irrigation system for maintenance of the landfill cap. The spray irrigation system will be covered by the Kentucky Pollutant Discharge Elimination System (KPDES) permit for the landfill as explained in more detail below.

A. <u>Background</u>

The Route 3 Landfill has an extensive leachate collection system including sumps. The collection lines combine and discharge to a concrete wastewater treatment tank (WWTU). The influent from the leachate collection system is classified as F039 multi-source leachate. While in

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Louisville, KY Covington, KY Cincinnati, OH Nashville, TN Frankfort, KY Washington, DC Atlanta, GA

the tank, this wastewater is treated by sedimentation and aeration. In addition, a granulated activated carbon treatment system is brought on-site to polish the accumulated wastewater prior to periodic discharge to the KPDES-permitted outfall. There is also a separate treatment system for water (precipitation) collected by an underdrainage system. Both wastewater streams are treated and discharged to Chadwick Creek, pursuant to KPDES Permit No. KY0063096.

When the KPDES permit was renewed in 2005, different limitations were imposed. Ashland has discussed with the Divisions of Water and Waste Management possible amendment of the KPDES permit to allow use of the treated wastewater in a spray irrigation system for landfill cap maintenance during appropriate weather conditions while also continuing to allow discharge of the wastewater to Chadwick Creek. Ashland has undertaken extensive analysis of the wastewater as part of its evaluation of spray irrigation as an option. Testing has shown that the treated effluent is typically non-detect for F039 constituents that would be associated with the facility. In fact, ammonia appears to be the constituent that presents the greatest challenge for continued compliance with the KPDES permit -- of course, the ammonia in the effluent also makes it a good choice for cap maintenance. Although this approach would have environmental benefits in terms of reducing discharges to the creek and promoting healthy vegetation on the cap in lieu of fertilizer applications, a question has arisen as to whether the treated wastewater that is pumped from the WWTU and applied to the cap by the spray irrigation equipment may permissibly be considered excluded from the definition of solid (and thus, hazardous) waste pursuant to 40 CFR 261.4(a)(2). At a meeting in April with representatives of the Divisions and Ashland, it was decided that Ashland would submit this request in order to obtain clarification from EPA on the applicability of the exclusion for industrial wastewater discharges in this situation.

B. <u>Regulatory Provisions</u>

The wastewater collected in the WWTU has been classified as multi-source leachate, which is a listed hazardous waste with waste code F039.[1] However, 40 CFR 261.4(a) identifies certain materials which are not classified as a solid wastes and thus would not be hazardous wastes. Pursuant to 40 CFR 261.4(a)(2), the following are not classified as solid waste:

> Industrial wastewater discharges that are point source discharges subject to regulation under section 402 of the Clean Water Act, as amended.
>
> [*Comment*: This exclusion applies only to the actual point source discharge. It does not exclude industrial wastewaters while they are being collected , stored or

[1] Ashland has considered seeking to delist the wastewater based on analyses obtained to date which typically are non-detect for the constituents of concern.

[redacted]



> treated before discharge, nor does it excluded sludges that are generated by industrial wastewater treatment.]

The Environmental & Public Protection Cabinet, Division of Water has been delegated authority to implement the National Pollutant Discharge Elimination System (NPDES) permitting program under Section 402 of the Clean Water Act (known as the KPDES permit program in Kentucky). As stated above, Ashland presently holds KPDES Permit No. KY0063096 for discharges of treated wastewater to Chadwick Creek. Ashland intends to seek modification of the KPDES permit to add spray irrigation as a means of managing a portion of the wastewater from the landfill as an alternative to discharge to the creek. The spray irrigation would be strictly controlled to assure that appropriate amounts were applied. The wastewater will not be able to percolate into the closed landfill due to the liner that was part of the final cap design. Ashland requests confirmation from EPA that the wastewater at the point of application from the spray irrigation system would no longer be classified as hazardous waste provided that the spray irrigation is included in the KPDES permit. Having completed closure of the landfill, Ashland obviously wants to avoid inadvertently triggering any additional hazardous waste management requirements as a result of implementation of this proposed wastewater management option.

If you have any questions regarding this letter, please do not hesitate to call. We appreciate your attention to this inquiry.

Sincerely yours,

Carolyn M. Brown

CMB/cab

cc: John G. Horne, Esq., KDEP General Counsel
April Webb, Kentucky Division of Waste Management
Dale Burton, Kentucky Division of Waste Management
Jory Becker, Kentucky Division of Water
Nigel Goulding
Joseph A. French, Esq.

707055_2

220 Athens Way, Suite 500
Nashville, Tennessee 37228

T: 615.255.2288
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October 11, 2019

PETITIONER'S HEARING EXHIBIT
AS 19-002
12

Brown AND Caldwell

**Letter Report**
**Privileged and Confidential**

Mr. Thomas W. Dimond
Ice Miller LLP
200 W. Madison Street, Ste. 3500
Chicago, IL 60606-3417

041514

Subject: Expert Report and Response to Recommendations of Illinois Environmental Protection Agency of July 19, 2019

Dear Mr. Dimond:

Brown and Caldwell (BC) is pleased to respond to part of the comments raised by the Illinois Environmental Protection Agency (IEPA) in the July 19, 2019 Recommendation to Deny Emerald Polymer Additives an Adjusted Standard (AS 19-002). This response specifically addresses comments regarding items listed below.

- Use of present worth costs to express costs of ammonia-nitrogen removal
- Projects and associated capital costs installed by others in the State of Illinois partially related to compliance with ammonia-nitrogen regulatory limits excluding Fox River
- In-plant monitoring of ammonia-nitrogen by Emerald
- Request for updates to conceptual level designs and cost estimates for treatment alternatives to remove ammonia-nitrogen from the Emerald Polymer Additives (Emerald) Plant wastewater treatment plant (WWTP) discharge into the Illinois River[1]
- Request for evaluation of land application for Emerald final effluent
- Impact of biotreater volume on effluent ammonia-nitrogen removal

## Cost of Ammonia-Nitrogen Removal

IEPA objected on Page 16 of the Recommendation to BC's comparison of unit cost (dollars per pound of ammonia-nitrogen removed) as a means of judging economic reasonableness of ammonia-nitrogen removal. IEPA also objected, on this same page, to the use of present worth costs (accounting of capital and operating costs) instead of capital costs alone when calculating cost of treatment. BC firmly believes that unit costs and present worth costs are the standard for evaluating true treatment costs. The latest cost document provided by the National Association of Clean Water Agencies (NACWA)[2] reports that the median unit cost of ammonia-nitrogen treatment for 12 agencies was $1.53 per pound of ammonia-nitrogen removed, which is higher than the cost reported

---

[1] Ammonia-Nitrogen Treatment Alternatives for Emerald Performance Materials, LLC submitted by Brown and Caldwell to Drinker, Biddle and Reath, LLP under Privileged and Confidential-Attorney/Client Work Product on July 8, 2013.
[2] 2017 NACWA Financial Survey: A National Survey of Clean Water Agency Financing and Management: Final Report, August 2018.

by the Greater Peoria Sanitation District ($0.81 per pound). The basis for these reported costs includes, in all cases, annual operating and maintenance costs. In some cases, these costs may include capitalized present worth cost (amount of money needed today to fund capital and operating costs for a defined project life). The exclusion of capitalized costs by most NACWA members in these reported unit costs is due to the nature of the municipal wastewater treatment plants. Exclusion of capital costs in unit costs by NACWA members is due to several factors. These include the difficulty in separating capital costs into those required for treatment of flow, biochemical oxygen demand (BOD), total suspended solids (TSS), and ammonia-nitrogen ($NH_3$-N). In municipal plants, the same pieces of equipment contribute to treatment of all four components (flow, BOD, TSS and $NH_3$-N). In the Emerald plant, the costs described herein are focused entirely on $NH_3$-N removal, and therefore, delineation of capitalized present worth costs are straightforward. Contrary to NACWA, IEPA has focused strictly on capital costs of projects that included ammonia-nitrogen removal. Such focus is misguided and results in an incomplete understanding of ammonia-nitrogen removal costs.

IEPA references project capital costs reportedly incurred by others in the State of Illinois when including ammonia-nitrogen removal in their treatment plant upgrades. It should be noted that all of these plants relied upon the lowest cost means of ammonia-nitrogen removal which is single-stage biological nitrification. The Emerald plant provides the same degree of aerobic treatment conditions that allow single-stage nitrification in these IEPA referenced plants (solids retention time in excess of 30 days, surplus alkalinity, and available phosphorus). However, the Emerald plant cannot nitrify within a single stage like these other plants due to the unavoidable presence of a compound in the process wastewater. This compound (mercaptobenzothiazole, MBT) is foundational to the production processes at the Emerald Plant and is consistently present in the primary clarifier effluent at 160 mg/L or higher for days at a time (versus a nitrification inhibition threshold of 3 mg/L[3]). To establish reliable single-stage nitrification, MBT removal from the process wastewater would have to exceed 98 percent which has been demonstrated in prior documents as being complex and cost prohibitive[4]. Each cost example provided by IEPA is discussed below.

1. Geneva, IL (BATES 341 and 353) completed a two-phased project in 2004 for a reported cost of $10.9 million dollars. These costs included multiple upgrades that had nothing to do with ammonia-nitrogen removal including the additions of fine screens, raw sewage pumps, grit tank, primary clarifier, UV disinfection, sludge digestion, sludge dewatering, flood proofing, and remodeling of administration/laboratory facilities. The only upgrades that would be partly linked to ammonia-nitrogen removal would have been addition of aeration tanks, blowers, and a final clarifier. These upgrades also provide increased capacity to treat higher flow, BOD, and TSS (BATES 360 through 369). It is uncertain what portion of these upgrades would be attributed to ammonia-nitrogen removal.
2. Batavia, IL (BATES 437) completed a project in 2001 for a reported cost of $10.8 million. These costs included multiple upgrades that had nothing to do with

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[3] M.R. Hockenbury and C.P.L. Grady in Journal of Water Pollution Control Federation, Volume 49, page 768, 1977.

[4] Evaluation of Nitrification Alternatives for Emerald-Henry, Illinois Facility prepared by Brown and Caldwell and submitted to Emerald Performance Materials on April 13, 2018.

ammonia-nitrogen removal including the additions of influent flow measurement, mechanical bar screen, primary clarifier equipment in existing tanks, intermediate pump station pump, UV disinfection, effluent flow meter, and rehabilitation of sludge digestion. The only upgrades that would be partly linked to ammonia-nitrogen removal would have been addition of aeration tanks, blowers, diffusers, and secondary clarifier. These upgrades also provide increased capacity to treat higher flow, BOD, and TSS (BATES 454 through 456 and 460). It is uncertain what portion of these upgrades would be attributed to ammonia-nitrogen removal.

3. Saint Charles, IL (BATES 1365) completed a project in 2002 for a reported cost of $8.4 million. These costs included multiple upgrades that had nothing to do with ammonia-nitrogen removal including the additions of headworks modifications, new scum troughs, existing aeration basin rehabilitation, baffles in existing secondary clarifiers, excess flow pump station and clarifier rehabilitation, new return activated sludge and waste activated sludge pumps, UV disinfection, and piping and electrical system upgrades. The only upgrades that would be partly linked to ammonia-nitrogen removal would have been the addition of aeration tanks and blower building. These upgrades also provide increased capacity to treat higher flow, BOD, and TSS (BATES 1387 through 1389 and 1397). It is uncertain what portion of these upgrades would be attributed to ammonia-nitrogen removal.
4. Fox River, IL (BATES 437) completed a project in 2007 for a reported cost of $2.0 million. This project did not increase the rated capacity of the plant since it did not increase treatment capacity. It only provided for the installation of two flow equalization basins and associated appurtenances. This plant upgrade provided for more stable process control but did not enhance ammonia-nitrogen removal.
5. Kishwaukee, IL (BATES 00015) completed a project in 2017 for a reported cost of $53 million. These costs included multiple upgrades that had nothing to do with ammonia-nitrogen removal including the additions of two primary clarifiers, anaerobic biological phosphorus removal tanks, fermenter, and UV disinfection. The only upgrades that would be partly linked to ammonia-nitrogen removal would have been additions of aeration tanks and secondary clarifiers. These upgrades also provide increased capacity to treat higher flow, BOD, and TSS (BATES 34 through 45). It is uncertain what portion of these upgrades would be attributed to ammonia-nitrogen removal.
6. Newark, IL (BATES 1571-1573) completed a project in 2001 for a reported cost of $3.0 million. These costs included multiple upgrades to a lagoon-based treatment system to achieve improved performance (BOD and TSS removal). These included additions of a bar screen, reconfiguration of cells, installation of insulated covers and baffles. The only upgrade intended to provide ammonia-nitrogen and additional BOD removal was the addition of two polishing reactors. It is uncertain what portion of the polishing reactor cost would be attributed to ammonia-nitrogen removal.
7. Mount Carmel, IL (BATES 1601 and 1603) completed a project in 2018 for a reported cost of $1.6 million. These costs included replacement and relocation of an effluent line and river outfall structure which had nothing to do with ammonia-nitrogen removal. Additionally, the plant replaced an existing mechanical aeration system with a diffused aeration system. It is uncertain if this replacement improved ammonia-nitrogen removal and what portion of this replacement was attributed to ammonia-nitrogen removal.

In summary, only five of the seven wastewater treatment facilities upgrades referenced above had anything to do with ammonia-nitrogen removal. None of these five treatment plant upgrades were implemented solely to accomplish ammonia-nitrogen removal. They were implemented in large part to better accommodate higher flows, greater BOD removal, greater TSS removal, and/or improved disinfection. Consequently, the costs of these upgrades cannot be legitimately used to compare or evaluate costs of ammonia-nitrogen removal at the Emerald plant.

## In-Plant Monitoring of Ammonia-Nitrogen

IEPA has recommended that Emerald implement an in-plant ammonia-nitrogen ($NH_3$-N) monitoring program in hopes of reducing effluent ammonia-nitrogen through at-source detection and control. This strategy would work if effluent ammonia-nitrogen was strongly related to influent ammonia-nitrogen. However, this is not the case since influent organic nitrogen is the primary contributor to effluent ammonia-nitrogen.

The two primary raw wastewater contributors to the wastewater treatment plant (PVC Tank and PC Tank) were monitored approximately 3 days per week for Total Kjeldahl Nitrogen (TKN) and ammonia-nitrogen ($NH_3$-N) during the period of March 28, 2019 through August 8, 2019. The difference between TKN and $NH_3$-N concentrations represent organic nitrogen. Under normal biological treatment conditions, organic nitrogen is converted to $NH_3$-N. These data are summarized in Figure 1 and discussed below.

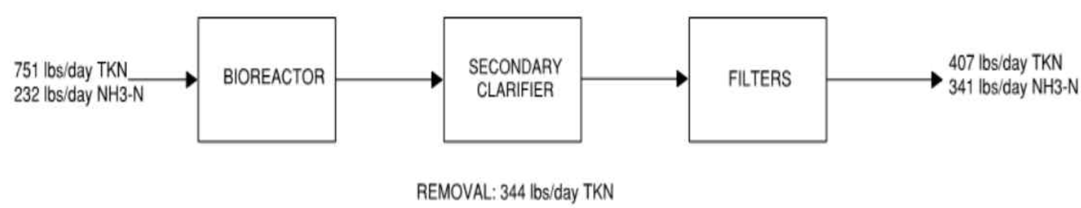


**Figure 1. Average TKN Removal Across Emerald WWTP**

- The PVC tank discharged on average 524 lbs/day TKN and 230 lbs/day $NH_3$-N indicating that only 40 percent of the TKN loading was comprised of ammonia-nitrogen. It should be noted that this discharge stream includes the nitrogen loading of tertiary filter backwash water and sludge dewatering filtrate which is generated when treating both PVC tank and PC tank wastewaters. Nitrification of this stream alone has been considered in prior evaluations[5] and does not offer a means of complying with regulatory effluent limits because it would achieve less than 70 percent reduction in effluent ammonia-nitrogen reduction based on prior sampling results. Recent sampling results continue to demonstrate this finding.
- The PC Tank discharged, on average, 227 lbs/day TKN and 2 lbs/day $NH_3$-N indicating that only 1 percent of the TKN loading was comprised of ammonia-nitrogen.
- Ammonia-nitrogen contributed only 30 percent of the combined TKN loading discharged by the PVC and PC tank (751 lbs/day TKN). Consequently, in-plant monitoring of ammonia-nitrogen only has the ability to influence 30 percent of the

[5] Evaluation of Treatment Alternatives for Reducing Final Effluent Ammonia Load submitted by Brown and Caldwell (formerly Eckenfelder Inc) to Emerald (Formerly BF Goodrich) in February 1997.

potential final effluent $NH_3$-N load. This finding that the bulk of the final effluent $NH_3$-N loading is due to organic nitrogen present in the raw wastewaters and converted to ammonia-nitrogen through biological treatment has been documented throughout the years.[1] Additional sampling of raw wastewater sources to determine the origin of effluent ammonia-nitrogen is not needed.

- The Emerald Wastewater Treatment Plant did provide 46 percent removal of influent TKN reducing the effluent ammonia-nitrogen by 344 lbs/day. This removal was associated with nutrient requirements for the BOD removal accomplished by biological treatment within the plant.
- Any in-plant monitoring would need to focus on TKN monitoring. Unlike $NH_3$-N, there are no direct monitoring probes for TKN in wastewater. Consequently, real-time monitoring and quick response would be impractical.

## Updated Conceptual Level Designs and Cost Estimates

IEPA also faulted Emerald for not updating the costs of all compliance alternatives (Recommendation at 15). Updating costs for every alternative is not necessary because many alternatives are known not to achieve significant effluent ammonia-nitrogen reductions or would have costs in excess of other more effective alternatives. Costs have been calculated for five alternatives considered most likely to be effective and for land application.

Conceptual level cost estimates presented herein were developed using an approach recommended by the Association of the Advancement of Cost Estimating (AACE). The estimates are Class 5 estimates with an accuracy of -50 percent to +100 percent. These estimates were developed by generating equipment costs for each alternative and then applying multiplication factors for direct and indirect costs. The direct costs include freight, tax, purchased equipment installation, installed piping, installed electrical systems, buildings, other structural components, yard improvements, and installed service utilities. Indirect costs include engineering and supervision, construction expenses, legal expenses, and contractors fee.

A contingency multiplication factor is applied to the sum of the direct and indirect costs. The sum of the direct, indirect and contingency results in the fixed capital cost (FCC).

The prior 2013 cost estimates were calculated by using the 2002 cost estimates and applying an escalation factor. Due to inflation and other factors, the 2013 estimates underestimated costs and were not as precise as the Class 5 cost estimate contained herein.

The most economical and reliable processes for ammonia-nitrogen removal at the Emerald Plant would consist of further treating the plant final effluent (not plant raw wastewater influent). BC has updated the design final effluent wasteload based on 2018 information when the plant was reportedly operating at typical production levels. A summary of the design final effluent wasteload is illustrated below in Table 1. This wasteload was used to update the conceptual level designs and cost estimates for the most economically feasible alternatives determined in prior work (see footnote 3). The details around these cost estimates is included as Attachment A.

| Table 1. Design Final Effluent Wasteload for Emerald Wastewater Treatment Plant | | | |
|---|---|---|---|
| | Average | Maximum Monthly | Daily Maximum |
| Flow, gpm | 360 | 412 | 475 |
| Flow, MGD | 0.52 | 0.59 | 0.68 |
| TKN, lbs/day | 407 | 508 | 618 |
| $NH_3$-N, lbs/day | 341 | 449 | 553 |
| COD, lbs/day | 2,300 | | |
| CBOD, lbs/day | 47 | 115 | 312 |
| TSS, lbs/day | 87 | 220 | 485 |
| pH, s.u. | 7.5 | 7.7 | 8.2 |
| Temperature, deg F | 77 | 86 | 66 to 88 Range |
| Alkalinity, mg/L | 940 | | |
| Hardness, mg/L | 360 | | |
| TDS, mg/L | 10,000 | | |
| TDFS, mg/L | 10,000 | | |
| Na, mg/l | 3,100 | | |
| K, mg/L | 3 | | |
| Ca, mg/L | 42 | | |
| Mg, mg/L | 14 | | |
| Chlorides, mg/L | 805 | | |
| Sulfate, mg/L | 5,460 | | |

## Ozonation

Ozonation has been demonstrated to reduce ammonia-nitrogen by 55 percent at an initial pH 11 and final pH 7.6[6]. Consequently, no further ammonia-nitrogen removal was assumed beyond 55 percent. The resulting effluent ammonia-nitrogen concentration would be an order of magnitude higher than the effluent ammonia-nitrogen regulatory limits (3 mg/L monthly average and 6 mg/L daily maximum in 35IAC304.122).

This process oxidizes ammonia-nitrogen to nitrate-nitrogen as does biological nitrification. The difference is that in ozonation only one of three oxygen atoms is used for oxidation while in biological nitrification all oxygen is used for oxidation. Both processes require caustic addition to neutralize the acid formed.

$$4\ O_3 + NH_4^+ \text{ yields } NO_3^- + 2\ H^+ + H_2O + 4\ O_2$$

The process would be installed downstream of the existing sand filter as illustrated in Figure 2 to minimize the oxidant demand associated with effluent TSS.

[6] Treatment of Ammonia Nitrogen Wastewater in Low Concentration by Two-Stage Ozonization, Xianping Luo,et al., International Journal of Environmental Research and Public Health, 2015, Volume 12, pages 11975 through 11987

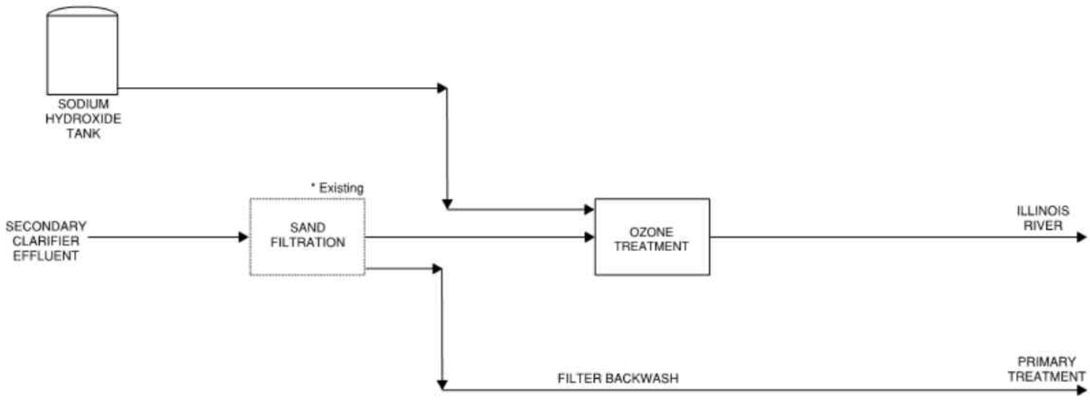


**Figure 2. Ozone Treatment Block Flow Drawing**

## Alkaline Stripping

Alkaline stripping can practically provide up to 95 percent removal of effluent ammonia-nitrogen. However, this degree of removal is inadequate to comply with the regulatory effluent limits.

In this treatment, caustic would be used to raise the filtered effluent to pH 11.5 and passed through an air stripping column packed with media. The column effluent would be lowered to pH 8.5 using sulfuric acid and discharge through the existing outfall as illustrated in Figure 3. The off-gas from the column would pass through an acid scrubber. The acid scrubber would produce a liquid waste (ammonium sulfate) that essentially concentrates the ammonia-nitrogen from one stream (final effluent) into a smaller liquid stream requiring off-site disposal. It is uncertain where this acid scrubber waste (approximately 4,500 gallons per day of 0.9 percent by weight nitrogen) could be disposed making this treatment alternative questionably viable. For purposes of costing this alternative, it was assumed that the waste could be hauled to Greater Peoria Sanitation District for disposal.

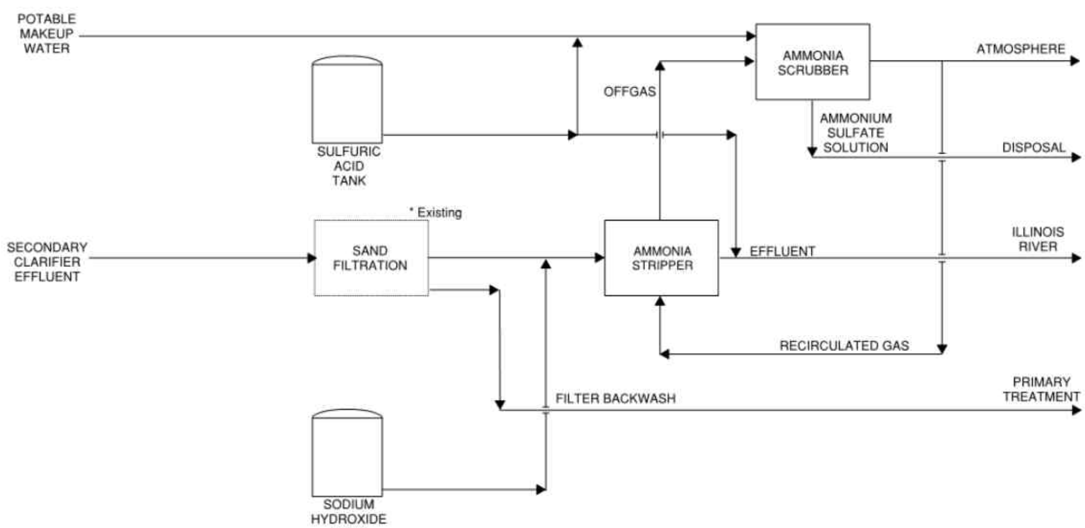


**Figure 3. Alkaline Stripping Block Flow Diagram**

## Tertiary Nitrification

Under normal operating conditions, the secondary clarifier reportedly discharges less than 3 mg/L mercaptobenzothiazole (the reported concentration at which nitrification is significantly inhibited). Under these conditions, tertiary nitrification should be capable of achieving compliance with proposed effluent ammonia-nitrogen limits. It is uncertain how often upstream biological treatment and secondary clarifier upsets would disrupt the performance of tertiary nitrification. The Emerald plant is subject to these upsets periodically due to the poorly degradable nature of the compounds present in the process wastewater and the heavy reliance upon chemical conditioning for secondary clarifier effluent quality control. Pilot-scale demonstration work would be required to demonstrate the reliability of this treatment process.

The process would consist of adding rotating biological contactors (RBCs) downstream of the secondary clarifier as illustrated in Figure 4. Sodium hydroxide would be added to satisfy the alkalinity demand. Heterotrophic bacteria (BOD removing bacteria) and nitrifying bacteria would grow on the fixed film media offered in the RBCs. Excess bacteria would slough off the fixed film and be caught by downstream rotary disk filters. The smaller particles exiting the rotary disk filters would be captured by the existing downstream tertiary filters. The captured solids from both filters would be discharged to the primary treatment system during filter backwashes.

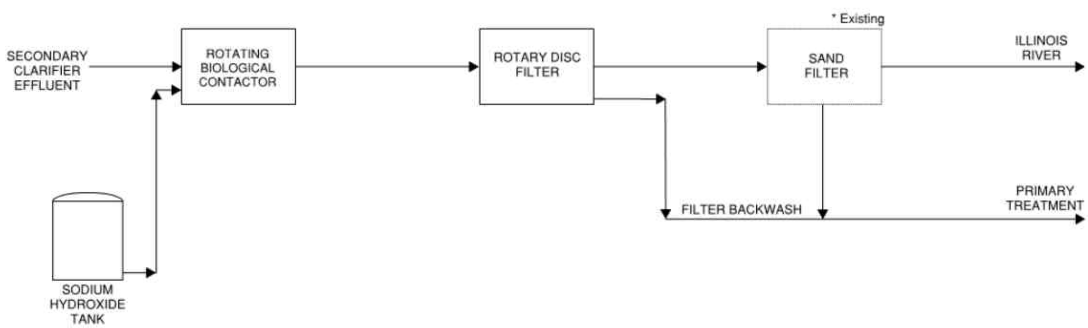


**Figure 4. Tertiary Nitrification Block Flow Diagram**

## Breakpoint Chlorination

Breakpoint chlorination can discharge an effluent in compliance with the effluent ammonia-nitrogen regulatory limits. However, the quantity of treatment chemical addition required increases the effluent salt load by more than 70 percent. Additionally, it is uncertain if this treatment process would form chlorination byproducts which could adversely impact the effluent aquatic toxicity and jeopardize compliance with the effluent acute toxicity criterion (<2.1 percent effluent lethal concentration that results in 50 percent mortality). Further testing would be required to address this uncertainty. In this process, ammonia is oxidized to nitrogen gas using chlorine while producing acid. The process is non-selective in its oxidation and would consume some residual biochemical oxygen demand (BOD) and chemical oxygen demand (COD) as well as some organic nitrogen. Consequently, the dose of chlorine would be approximately 12 pounds chlorine applied per pound of ammonia-nitrogen oxidized and the alkalinity requirement would be approximately 14 pounds of alkalinity applied per pound of ammonia-nitrogen oxidized.

The process would be installed downstream of the existing tertiary filter as illustrated Figure 5. This location would minimize the required chlorine demand.

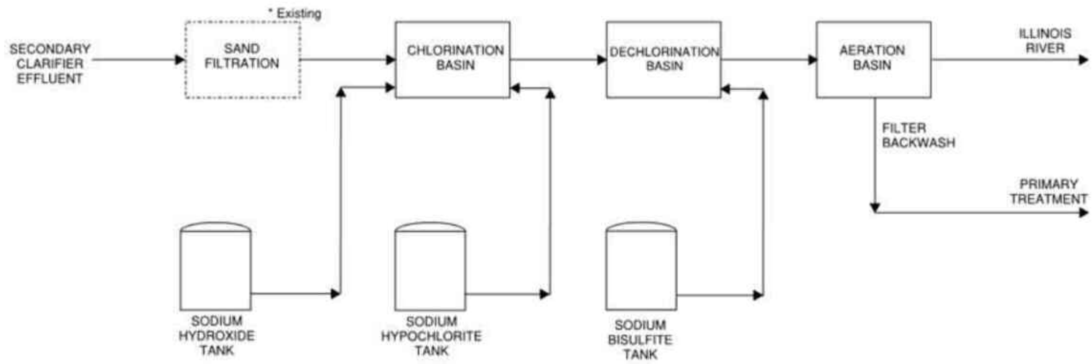


**Figure 5. Breakpoint Chlorination Block Flow Diagram**

## Ion Exchange

Ion exchange can discharge an effluent in compliance with the effluent ammonia-nitrogen regulatory limits. Purolite recommended a hydrogen-based cation exchange resin for this treatment which will remove ammonia ($NH_4^+$) and other cations as well from the wastewater. Caustic will be used to maintain a minimum effluent pH 6.5. Hydrochloric acid will be used to regenerate the resin. In essence, this treatment concentrates the ammonia-nitrogen in one stream (the final effluent) into a smaller stream requiring off-site disposal. It is uncertain where this spent regenerant (ammonium chloride at approximately 4,500 gpd of 0.90 percent by weight nitrogen) could be disposed making this alternative questionably viable. For purposes of costing this alternative, it was assumed that the waste could be hauled to Greater Peoria Sanitation District for disposal.

The process would be installed downstream of the existing sand filter to prevent solids fouling of the ion exchange column as illustrated in Figure 6.

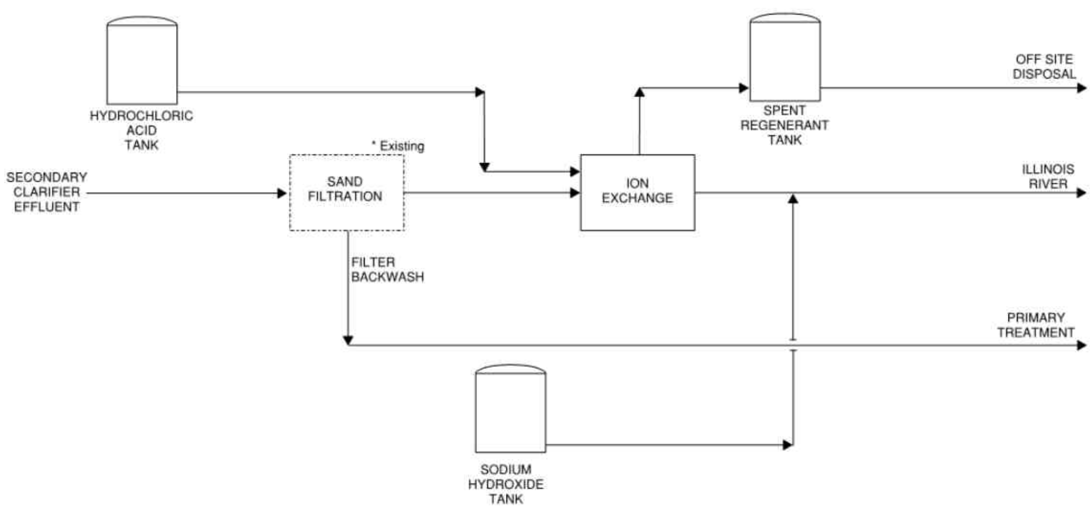


**Figure 6. Ion Exchange Block Flow Diagram**

## Land Application

The Emerald Plant owns 80 acres on land adjacent to the plant that could be used to grow a salt tolerant, high nitrogen uptake hay (e.g., Bermuda grass) which would exert a nitrogen uptake of approximately 350 pounds per acre per year. This nitrogen uptake would support an average of 160,000 gpd (30 percent of the average final effluent flow) over the course of approximately 9 months per year when the ground is thawed. This effluent would be diluted with 360,000 gpd of clarified river water prior to irrigation to minimize salt impacts on plant growth and associated nitrogen uptake. An average root zone TDS of less than 3800 mg/L was targeted. The water not used for plant growth would discharge as groundwater into the Illinois River. Unlike the Akzo Nobel land application system, dilution water addition is required to mitigate salt impacts on the proposed crops. Tiling of this acreage would not be provided, like at Akzo Nobel, since it would not allow collection of the treated water. At the Emerald site, the normal groundwater level is deeper than tiles are installed (greater than 10 feet) and the soil is highly permeable.

The viability of this process would be contingent on being granted a river water withdrawal permit, being granted a permit that allows the river water clarifier to discharge solids removed back to the river, and finding an entity willing to cut and remove the hay at no cost to Emerald. Currently, the acreage is used to grow profitable crops (corn and soybeans). These crops offer a significantly lower nitrogen uptake and salt tolerance.

Combined the process illustrated in Figure 7 would only treat 22 percent of the annual nitrogen load. Furthermore, operation of this system would be complex.

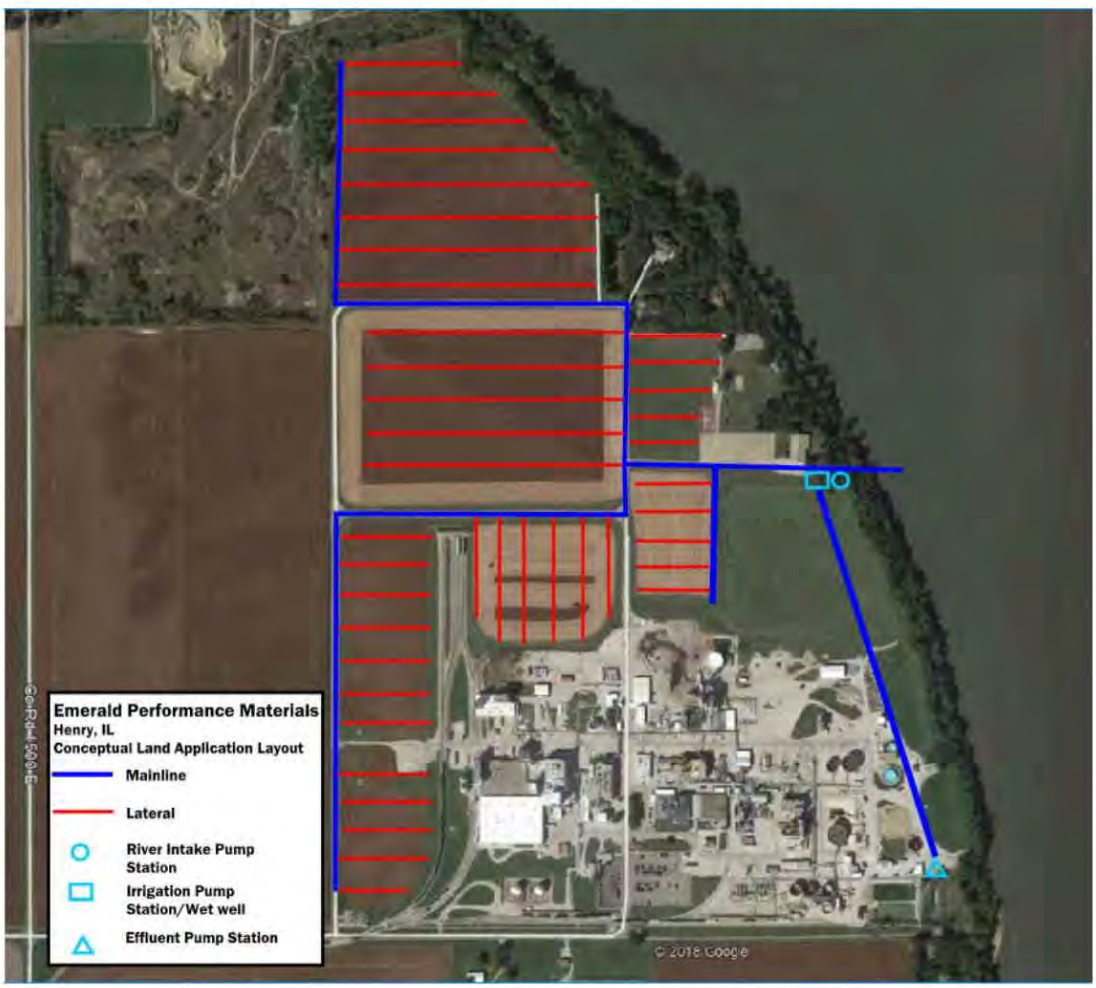


**Figure 7. Land Application Layout Drawing**

## Summary of Treatment Alternatives Performance and Associated Costs

A summary of treatment alternatives performance and associated costs are shown in Table 2. These costs are presented as unit costs in Table 3. These data indicate that tertiary nitrification and ion exchange offer the lowest unit cost for ammonia removal based on annual operations and maintenance costs with ion exchange having a much lower capital cost. These costs, even on an annual operations and maintenance basis, are 4-fold greater than the median unit costs reported by NACWA for others providing ammonia-nitrogen removal. On a present worth basis, Emerald would have to commit a minimum of $12 per pound of $NH_3$-N removed over the next 10 years (approximately 8-fold the median unit costs reported by NACWA.

**Table 2. Treatment Alternatives and Associated Costs**

| Alternative | Achieve Regulatory Limits? | Average $NH_3$-N Removal (lbs/day) | Capital Costs ($ million) | Annual O/M[a] Costs ($ million) | Present Worth[b] ($ million) |
|---|---|---|---|---|---|
| Ozonation | No | 188 | 22 | 0.96 | 30 |
| Alkaline Stripping | No[d] | 324 | 7.3 | 1.4 | 19 |
| Tertiary Nitrification | Uncertain | $\leq$331 | 10 | 0.74 | 17 |
| Breakpoint Chlorination | Yes[c] | 331 | 4.1 | 2.5 | 24 |
| Ion Exchange | Yes[d] | 331 | 6.0 | 1.0 | 14 |
| Land Application | No | 77 | 6.0 | 0.39[e] | 9.2 |

[a] *Annual operations and maintenance costs.*

[b] *Based on 10 years at 4 percent interest and no salvage value. Present worth of annual O/M costs is annual costs times 8.1 Total present worth is present worth of both the annual O/M and capital costs.*

[c] *Uncertain if treatment process would adversely impact compliance with effluent aquatic toxicity criterion.*

[d] *Uncertainty regarding spent regenerant disposal makes treatment alternative questionably viable.*

[e] *Excludes loss of income from current farming of 80 acres.*

**Table 3. Unit Costs of Treatment Alternatives**

| Alternative | O/M Costs ($/pound $NH_3$-N removed) | Present Worth ($/pound of $NH_3$-N removed) |
|---|---|---|
| Ozonation | 14 | 44 |
| Alkaline Stripping | 12 | 16 |
| Tertiary Nitrification | >6.3 | >14 |
| Breakpoint Chlorination | 21 | 20 |
| Ion Exchange | 8.5 | 12 |
| Land Application | 14 | 33 |

## Environmental Impact of Effluent Ammonia-Nitrogen Removal

This section describes the current water quality status of the Illinois River and the sensitivity of Emerald's ammonia-nitrogen discharge on water quality as well as the negative collateral impacts to the environment that removing Emerald's ammonia-nitrogen would create.

As reflected In Emerald's petition for an adjusted standard, the Illinois River over many years has shown no violations of the acute and chronic water quality standards for ammonia-nitrogen downstream of Emerald's discharge. The petition also presents the results of Whole Effluent Toxicity (WET) testing that have repeatedly shown no toxic effects from Emerald's effluent outside the approved zone of initial dilution. These results demonstrate that Emerald's construction and continued use of the current wastewater treatment plant, the multi-port diffuser, replacement of the BBTS Wet Scrubber and other actions have produced an effluent that has no material negative effect on the environment. Additionally, the wastewater treatment plant operated by Emerald is considered by USEPA to provide the best degree of treatment economically achievable (BAT) for these type wastewaters[7].

As described herein, only one of the six treatment alternatives does not require chemical addition to the final effluent. However, this alternative of land application only reduces the annual nitrogen load on the river by 22 percent and requires complexity related to operating and maintaining a river water treatment system, three pumping systems, and an elaborate irrigation system. It also generates hay which has no defined dependable outlet for use. The other five alternatives require extensive chemical addition which will appreciably increase the effluent salt load to the Illinois River. The only two alternatives that can reliably comply with the regulatory limits (breakpoint chlorination and ion exchange) either a) generate an effluent that may cause failure of the existing effluent aquatic toxicity criterion or b) generate a liquid waste whose disposal method, destination, and costs are uncertain. In addition, every alternative will indirectly increase greenhouse gas emissions due to increased power consumption and additional diesel truck traffic. The collateral negative environmental impact of the treatment alternatives (e.g., greenhouse gas emissions and decreased effluent water quality with respect to higher salt levels) is appreciably more adverse than the current effluent ammonia-nitrogen load.

Given that Emerald's effluent has no negative environmental impact and the treatment alternatives have possible negative collateral environmental effects, implementing any of those alternatives and incurring the estimated costs solely for ammonia-nitrogen removal would be a unique and unreasonable requirement.

### Operation of Additional Biotreaters

Ammonia-nitrogen removal at the wastewater treatment facility is a function of solids retention time (SRT) and the extent of BOD removal. The maximum amount of ammonia-nitrogen removal will occur at the lowest achievable SRT that ensures sufficient BOD removal. The wastewater treatment plant is already capable of operating at this condition (SRT of 30 to 60 days depending upon production) with only the North Biotreater in service. Operating additional biotreaters will have no impact on effluent ammonia-nitrogen but will make operations more complicated.

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[7] Code of Federal Register, Title 40, Subpart 414 Organic Chemical, Plastics and Synthetic Fibers.

We appreciate this opportunity to be of service to ICE Miller and Emerald. Please call Houston Flippin at 615.250.1220 if you have any questions or need additional information.

Very truly yours,

**Brown and Caldwell**

T. Houston Flippin

T. Houston Flippin, P.E., BCEE
Industrial Wastewater Process Leader

Si Givens

Si Givens
Vice President

THF:na

cc: Charlie Gregory, Brown and Caldwell

*Limitations:*

*The information contained in this proposal is proprietary and contains confidential information that is of significant economic value to Brown and Caldwell. It is intended to be used only for evaluation of our qualifications to provide services. It should not be duplicated, used, or disclosed, in whole or in part, for any purpose other than to evaluate this proposal. Further, Client is cautioned that electronic files may be compromised by media degradation, file corruption,*

# Attachment A: Capital and Annual Cost Tables for Treatment Alternatives

| | Ion Exchange | | Tertiary Nitrification | | Alkaline Stripping | | Ozonation | | Breakpoint Chlorination | | Land Application | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Selected Percentage | Cost | Selected Percentage | Cost | Selected Percentage | Cost | Selected Percentage | Cost | Selected Percentage | Cost | Selected Percentage | Cost |
| **Direct Costs** | | | | | | | | | | | | |
| Purchased Equipment Delivered | | $ 1,256,445 | | $ 2,583,927 | | $ 1,817,733 | | $ 4,781,859 | | $ 855,271 | | $ 1,265,210 |
| Freight | 3% | $ 38,000 | 3% | $ 78,000 | 3% | $ 55,000 | 3% | $ 143,000 | 3% | $ 26,000 | 3% | $ 38,000 |
| Tax | 6% | $ 79,000 | 6% | $ 161,000 | 6% | $ 114,000 | 6% | $ 299,000 | 6% | $ 53,000 | 6% | $ 79,000 |
| Purchased Equipment Installation | 6% | $ 75,000 | 6% | $ 155,000 | 6% | $ 109,000 | 6% | $ 287,000 | 6% | $ 51,000 | 6% | $ 76,000 |
| Instumentation and Controls (Installed) | 18% | $ 226,000 | 18% | $ 465,000 | 18% | $ 327,000 | 18% | $ 861,000 | 18% | $ 154,000 | 18% | $ 228,000 |
| Piping (Installed) | 16% | $ 201,000 | 16% | $ 413,000 | 16% | $ 291,000 | 16% | $ 765,000 | 16% | $ 137,000 | 16% | $ 202,000 |
| Electrical Systems (Installed) | 10% | $ 126,000 | 10% | $ 258,000 | 10% | $ 182,000 | 10% | $ 478,000 | 10% | $ 86,000 | 10% | $ 127,000 |
| Buildings | [redacted] | $ 80,000 | [redacted] | $ 80,000 | [redacted] | $ 80,000 | [redacted] | $ 160,000 | [redacted] | $ 80,000 | [redacted] | $ 80,000 |
| Structural | 18% | $ 226,000 | 18% | $ 465,000 | 18% | $ 327,000 | 18% | $ 861,000 | 18% | $ 154,000 | 18% | $ 228,000 |
| Yard Improvements | 10% | $ 126,000 | 10% | $ 258,000 | 10% | $ 182,000 | 10% | $ 478,000 | 10% | $ 86,000 | 10% | $ 127,000 |
| Service Utilities (Installed) | 30% | $ 377,000 | 30% | $ 775,000 | 30% | $ 545,000 | 30% | $ 1,435,000 | 30% | $ 257,000 | 30% | $ 380,000 |
| **Direct Cost Subtotal** | | **$ 2,810,445** | | **$ 5,691,927** | | **$ 4,029,733** | | **$ 10,546,859** | | **$ 1,939,271** | | **$ 2,830,210** |
| **Indirect Costs** | | | | | | | | | | | | |
| Engineering and Supervision | 10% | $ 281,000 | 10% | $ 569,000 | 10% | $ 403,000 | 10% | $ 1,055,000 | 10% | $ 194,000 | 10% | $ 283,000 |
| Construction Expenses | 34% | $ 956,000 | 34% | $ 1,935,000 | 34% | $ 1,370,000 | 34% | $ 3,587,000 | 34% | $ 659,000 | 34% | $ 962,000 |
| Legal Expenses | 4% | $ 112,000 | 4% | $ 228,000 | 4% | $ 161,000 | 4% | $ 422,000 | 4% | $ 78,000 | 4% | $ 113,000 |
| Contractor's Fee | 15% | $ 422,000 | 15% | $ 854,000 | 15% | $ 604,000 | 15% | $ 1,582,000 | 15% | $ 291,000 | 15% | $ 425,000 |
| **Indirect Cost Subtotal** | | **$ 1,771,000** | | **$ 3,586,000** | | **$ 2,538,000** | | **$ 6,646,000** | | **$ 1,222,000** | | **$ 1,783,000** |
| Contingency | 30% | $ 1,374,000 | 30% | $ 1,076,000 | 30% | $ 761,000 | 30% | $ 5,158,000 | 30% | $ 948,000 | 30% | $ 1,384,000 |
| **Fixed-Capital Cost (FCC)** | | **$ 6,000,000** | | **$ 10,400,000** | | **$ 7,300,000** | | **$ 22,400,000** | | **$ 4,100,000** | | **$ 6,000,000** |
| **Annual O&M Costs** | | | | | | | | | | | | |
| Energy/Power | $ 2,675 | | $ 5,314 | | $ 68,480 | | $ 55,884 | | $ 6,420 | | $ 43,870 | |
| Power Cost ($/kwh) | $ 0.0657 | | $ 0.0657 | | $ 0.0657 | | $ 0.0657 | | $ 0.0657 | | $ 0.0657 | |
| Chemical | $ 300,048 | | $ 193,489 | | $ 593,339 | | $ 164,670 | | $ 2,116,655 | | $ - | |
| Equipment Maintenance | $ 108,956 | | $ 229,130 | | $ 169,270 | | $ 422,388 | | $ 66,708 | | $ 37,108 | |
| Labor ($/year) | $ 312,000 | | $ 312,000 | | $ 312,000 | | $ 312,000 | | $ 312,000 | | $ 312,000 | |
| Labor Rate ($/hr) | $ 50 | | $ 50 | | $ 50 | | $ 50 | | $ 50 | | $ 50 | |
| Number of Operators | 3 | | 3 | | 3 | | 3 | | 3 | | 3 | |
| Hours per Operator | 8 | | 8 | | 8 | | 8 | | 8 | | 8 | |
| Days | 5 | | 5 | | 5 | | 5 | | 5 | | 5 | |
| Weeks per year | 52 | | 52 | | 52 | | 52 | | 52 | | 52 | |
| Ion Exchange Media | $ 20,000 | | $ - | | $ - | | $ - | | $ - | | $ - | |
| Hauling Disposal | $ 282,072 | | $ - | | $ 282,072 | | $ - | | $ - | | $ - | |
| Contingency (%) | $ - | | $ - | | $ - | | $ - | | $ - | | $ - | |
| Total Annual O&M Cost, $ | $ 1,026,000 | | $ 740,000 | | $ 1,425,000 | | $ 955,000 | | $ 2,502,000 | | $ 393,000 | |
| Total Present Worth of Annual O&M Costs $/yr | $ 8,400,000 | | $ 6,100,000 | | $ 11,600,000 | | $ 7,800,000 | | $ 20,300,000 | | $ 3,200,000 | |
| Capital Cost, $: | $ 6,000,000 | | $ 10,400,000 | | $ 7,300,000 | | $ 22,400,000 | | $ 4,100,000 | | $ 6,000,000 | |
| Total Present Worth Cost, $: | $ 14,400,000 | | $ 16,500,000 | | $ 18,900,000 | | $ 30,200,000 | | $ 24,400,000 | | $ 9,200,000 | |
| Average Ammonia Removed, % | 97% | | 95% | | 95% | | 55% | | 97% | | 22% | |
| Average Amount of Ammonia Removed, lb /day | 331 | | 324 | | 324 | | 188 | | 331 | | 77 | |
| O&M Costs, $/ lb of Ammonia Removed | $ 8.50 | | $ 6.26 | | $ 12.05 | | $ 13.95 | | $ 20.72 | | $ 13.98 | |
| **Total Present Worth Cost, $/lb Ammonia Removed** | **$ 11.93** | | **$ 13.95** | | **$ 15.98** | | **$ 44.12** | | **$ 20.21** | | **$ 32.73** | |