Inland Empire Paper Company
NPDES Permit No. WA-000082-5
Permit Condition S5

Technology Selection Protocol for Total Phosphorous, CBOD, and Ammonia

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1.0 INTRODUCTION

Permit Condition S5, Schedule for Compliance for Total Phosphorous, CBOD, & Ammonia BMP Plan, of Inland Empire Paper Company's (IEP) National Pollutant Discharge Elimination System (NPDES) Permit No. WA-000082-5 requires the development of a Technology Selection Protocol by November 1, 2015 that includes the following:

> *A comprehensive technology selection protocol for choosing the most effective feasible technology for seasonally removing the applicable pollutant from the effluent. If pilot testing is a part of the protocol, there will be appropriate provisions for quality assurance and control. The protocol will include a preliminary schedule for construction of the treatment technology. Ecology will recognize the results from pilot testing and full-scale implementation of technologies installed prior to issuance of this permit.*

This report details the results of IEP's significant research and development efforts since 2004 to identify a successful treatment technology to attain the stringent nutrient water quality based effluent limits (WQBEL's) imposed by the Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load (DO TMDL).

2.0 CHEMICAL PRECIPITATION WITH FILTRATION PILOT TRIALS

Upon issuance of the draft TMDL, IEP began investigating advanced phosphorus reduction technologies and their capabilities for attaining the WQBELs specified within the draft TMDL. IEP soon discovered that the data supporting low-level phosphorus performance were based mainly on municipal Waste Water Treatment Systems (WWTS) and that there was little data supporting industrial WWTS, and specifically no data for pulp and paper applications. The lack of data for industrial applications was of serious concern to IEP due to the significant differences in effluent characteristics between municipal and IEP's pulp and paper process.

IEP elected to take a proactive approach in resolving this lack of data by pursuing pilot-scale system trials of low-level phosphorus reduction technologies. Between 2004 and 2005, IEP pilot trialed the following advanced tertiary treatment systems based on chemical coagulation followed by filtration:

- Blue Water Technologies sand filtration
- Parkson Corporations Dyna Sand® Filtration
- USFilter's Trident® multi-media filtration
- Zenon Environmental Inc.'s ZeeWeed® Immersed Membrane
- USFilter's Trident HS® high solids multi-media filtration
- Kruger Incorporated's ACTIFLO® ballasted sand filtration

Results from the Trident HS pilot testing prompted IEP to purchase a 1 MGD demonstration-scale unit in 2007 (see Section 3.0 below). The upscale version of the Trident HS suffered considerable operational problems due to excessive chemical use and high solids overload. In 2009 IEP investigated the following additional ultra-low phosphorous reduction technologies to operate in series with the Trident HS to more effectively handle the chemically precipitated solids associated with nutrient removal:

- Cambridge Water Technology's CoMag™
- Siemens Water Technologies' CONTRAFAST-E

The operation of two technologies in series essentially creates a quaternary treatment system that results in operational complexities and significant increases in both capital and operating and maintenance costs. Additionally, these pre-treatment systems were not immune to the sludge overload conditions that were problematic for the Trident HS system. To date, no pre-treatment separation process has been coupled with the demonstration-scale Trident HS system.

3.0 TRIDENT HS – CHEMICAL PRECIPITATION and FILTRATION OF NUTRIENTS

After extensive pilot testing of six (6) tertiary treatment technologies using chemical precipitation followed by filtration, IEP invested in a 1.0 MGD Trident HS system manufactured by U.S. Filter in 2007. IEP selected U.S. Filter's Trident HS technology based on its success in consistently demonstrating low Total P effluent levels with the least amount of operating difficulties during the competitive pilot studies. Unfortunately, to date the full-scale application of this technology has not performed up to the expectations of the pilot results. After eight years of extensive testing, optimization and modification, this technology has not demonstrated consistent or reliable operations that can provide long term performance necessary to achieve the WQBELs imposed by the DO TMDL. Some of the more significant challenges encountered during the testing of this technology include: the need for an excessive amount of coagulating chemicals, significant amount of solids/rejects produced by the extensive use of chemicals, solids overload of the system, failure of solids removal equipment, operational upsets and poor performance, inability to adapt to changes in IEP's wastewater quality, and fouling and plugging of system components.

In December of 2011, the mixed media filter section of the Trident was determined to be damaged beyond operation. The filter section underdrain, at some point in time, had been compromised and could no longer retain filter media. WesTech, the new parent company of the Trident technology, redesigned the Trident system by replacing the underdrain system with new media retaining nozzles and adding new single tier tube section modules.

After significant modifications to both the tube and multi-media filter sections of the Trident HS system, IEP performed numerous trials to test the modified system operations in 2014 and 2015. The following work plans and research were conducted in an effort to optimize system operations:

- Alum Demand and Dosing with Tube Turbidity Feedback Control

- Alum Demand and Dosing with Conductivity Feedback Control
- Alum Demand and Dosing with Charge Feedback Control
- Alum Demand and Dosing with Other Feedback Controls (streaming potential, organics, sulfate, calcium, silica and aluminum)
- Effects of alkalinity and pH on coagulation
- Polymer Product Selection
- Chemical Cleaning Options

After extensive research and testing, IEP was unable to achieve consistent operations due to solids overload of the filter, inconsistent solids settling, plugging of the new filter section nozzle design, and an inability to adapt to variable effluent conditions. Many of the above problems have plagued the Trident system since its installation in 2007, however the filter section nozzle plugging problem introduces a new and significant challenge. The filter section nozzles were part of a major modification to the system, intended to replace the previously failed underdrain design. The nozzle plugging problem exacerbates proper operation of the system by not allowing sufficient flow during backwash cycles necessary to clean the filter section. This causes a continued deterioration of operation, resulting in extended downtime and a laborious task to remove the filter media and clean the 288 nozzles. This would not be acceptable for full-scale application.

The current lack of performance coupled with the exorbitant cost of operation is unacceptable for long term operation and economic viability. IEP has shifted its attention and resources towards the development and testing of the algae-based nutrient removal system and the WesTech membrane only studies described under Sections 4.0 and 5.0 below.

4.0 ALGEVOLVE/CLEARAS –ALGAE-BASED NUTRIENT REMOVAL SYSTEM

In 2007, IEP was introduced to a company that was developing a new technology using algae to uptake nutrients from wastewater. This intriguing technology is intuitively similar to IEP's secondary activated sludge system and provides an option to the more problematic traditional chemical precipitation technologies. IEP established a business partnership with AlgEvolve to further develop this technology and performed the first pilot scale testing at IEP's site from 2008 to 2009. Sufficient success at the pilot-scale level prompted IEP to build a 60 gpm developmental-scale system in 2011.

IEP and Clearas (formerly AlgEvolve) conducted testing of the demonstration-scale system from 2012 to 2013 with varying levels of success. The membranes purchased for this system unfortunately failed to meet the specified production capacity and were removed from operation. IEP then began the process of evaluating other membrane technologies for integration into the demonstration scale system.

Pilot testing of various membrane technologies to separate algae from IEP's treated wastewater were conducted between May 2014 and March 2015. Four separate membrane separation technologies were evaluated for their technical and economic feasibility within the AlgEvolve treatment system. The basis of the study was to discover a separation

technology that can successfully process the combination of IEP's wastewater and algae, including the important metrics of membrane resistance, ability to be cleaned and recoverability. During the testing important information regarding operational parameters including membrane flux potential, system productivity, flux maintenance options, membrane resiliency and recoverability, and the impact to the biological health of the holistic system were collected. The successful technology selected from these pilot studies will be integrated into IEP's demonstration-scale system for further long term testing to prove the capabilities of the holistic algae/membrane separation arrangement for full-scale application.

The four technologies tested include:

- Microdyn-Nadir/Ovivo – submerged flat sheet
- Koch Puron – submerged hollow fiber
- WesTech/Toray – pressurized outside-in hollow fiber
- Membrane Specialists – pressurized inside-out hollow fiber

Based on final evaluation of the above parameters, IEP selected the Koch Puron membrane for the next stage demonstration-scale integration. The Koch system performed exceptionally well with no significant operational problems. The demonstration-scale system was delivered to IEP in October 2015 with start-up of the integrated system scheduled for November 2015.

Upon successful integration of the new Koch Puron membrane system into the overall operation of the system, IEP will evaluate over a one year period the important metrics of the membrane system necessary for full-scale implementation. During this evaluation period IEP will also perform work plans to evaluate and optimize the following important criteria of the holistic biological and separation system: CO2 sources and utilization, optimum pH conditions, Photobioreactor (PBR) residence times for optimum nutrient uptake, natural versus artificial light benefits, glass versus plastic PBR material benefits, optimum algae growth and nutrient uptake conditions, and algae dewatering technologies.

5.0 WESTECH/TORAY – MEMBRANE ONLY TRIALS

Upon completion of the algae-based membrane pilot trials, the WesTech/Toray membrane pilot system was converted to processing IEP secondary treated final effluent to observe the effect on nutrient reduction with membrane separation only. The WesTech membrane system has been processing IEP secondary final effluent without the use of coagulating chemicals since March 2015 and remains on-site for further evaluation.

Although membrane separation alone does not consistently meet the forthcoming stringent water quality based effluent limits (WQBELs) for TP and CBOD5, the technology has demonstrated that it may be possible to get near these limits. IEP intends to conduct further optimization testing with membrane only and additional testing with low solids generating coagulating chemicals to observe the extent of nutrient reduction to achieve the WQBELs.