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SUBJECT: Western Wake Regional Wastewater Management Facilities
Raw Wastewater Pumping and Conveyance Facilities
PER Technical Memorandum No. 11 – BNR Process Tanks

INTRODUCTION

This Technical Memorandum (TM) is one in a series of TMs being prepared for the Preliminary Engineering Report for the Western Wake Regional Wastewater Management Facilities project. The purpose of this TM is to present the preliminary engineering information and data for the Biological Nutrient Removal (BNR) Process Tanks and Nitrified Recycle (NRCY) Pumping Systems. Biological nutrient removal is proposed to provide an advanced level of secondary treatment for plant flows in order to consistently meet the anticipated NPDES permit effluent limits.

PROCESS REQUIREMENTS

The proposed design capacity of the BNR process tanks is 18.0 mgd, with an anticipated future expansion to 30.0 mgd. The North Carolina Department of Environment and Natural Resources (NCDENR) has issued speculative NPDES permit limits for total suspended solids (TSS), BOD_5, and ammonia. Seasonal (April-October) interim mass loading limits for total nitrogen and total phosphorus were included based on concentrations of 6.0 mg/L and 2.0 mg/L, respectively. A Total Maximum Daily Load (TMDL) allocation may be conducted by NCDENR for the Cape Fear River in the future that would require more stringent limits. The BNR process tanks will be designed to allow expansion to meet future limits. The following limits are assumed for the purpose of preliminary design of the BNR process tanks as shown in Table 11-1.

TABLE 11-1
ANTICIPATED NPDES PERMIT LIMITS

Total Suspended Solids, mg/L	30
BOD_5, mg/L	5/10
Ammonia Nitrogen, mg/L	1/2
Total Nitrogen, mg/L	6
Total Phosphorus, mg/L	2

Summer/winter limits are shown where applicable.

The biological nutrient removal process for the WWWRF will provide a robust design and flexibility to adapt to varying influent conditions to reliably meet potential future effluent nutrient goals. TM 8, Process Design/Mass Balance, provides further discussion of the BNR process design and its flexibility to operate in various BNR process modes.

The proposed design flows for the BNR process tanks for the WWWRF are shown in Table 11-2.

TABLE 11-2
PROPOSED DESIGN FLOWS

Plant Design Flow	Phase 1	Phase 2
Annual Average	15.3	25.5
Maximum Month	18.0	30.0
Peak Instantaneous	47.3	78.8

It is anticipated that a minimum of three parallel trains will be provided for a maximum month design flow of 6 mgd per process train in Phase 1. When the WWWRF is expanded to 30 mgd in Phase 2, two additional BNR process tanks would be constructed.

PROPOSED FACILITIES

The proposed BNR process tanks consist of a minimum of three individual process trains with each train divided into a number of individual treatment cells. Flow from the preliminary treatment facilities will enter a common influent channel for the BNR process tanks and be distributed to all tanks that are in service. Piping will allow return activated sludge (RAS) to be directed to the influent channel or to individual process trains. Each process train will be divided into individual treatment cells by a series of baffle walls, and flow will move sequentially through various treatment conditions to achieve biological nitrification, denitrification and phosphorus removal. Within each treatment train wastewater that has achieved nitrification will be recycled to unaerated cells for denitrification. This nitrified recycle (NRCY) will be accomplished by pumping facilities provided for each treatment train. Flow from the individual treatment trains will be collected in a common effluent channel. Flow will be distributed to the secondary clarifiers by weirs in the effluent channel. Facilities will be provided to adjust the alkalinity of the BNR process to maintain optimum treatment. Chemical feed facilities will also allow supplementation of the denitrification process within the BNR process tanks with a carbon source, such as methanol or acetic acid.

The general configuration of the BNR process tanks is described in Table 11-3.

TABLE 11-3
BNR PROCESS TANKS DESIGN CRITERIA

Number of BNR Tanks	3
Total Volume	14.6 Mgal
Volume per Tank	4.87 Mgal
Width of Each Tank	50 ft.
Water Depth	22 ft.
Total Tank Length (excluding influent & effluent channels)	592 ft.

The influent channel will be designed to maintain low velocities in the channel and flow will be distributed to all BNR process tanks that are in service by means of weirs. Openings for weirs will be equipped with slide gates for isolation of individual trains. The channel will be mixed with a jet mixing system consisting of submersible pumps and jet mixing headers with multiple discharge nozzles. It is important to the treatment process that dissolved oxygen is not introduced into the wastewater at this point in the process, therefore, no aeration capability will be provided in the influent channel. Multiple stop gate frames and stop gates or stop logs will be provided to allow isolation and dewatering of a portion of the influent channel while the remaining portion is in service. Drains will be provided to allow dewatering of the channel when necessary.

An influent step feed channel will be provided for each BNR process tank. The influent step feed channel will allow directing of influent from the preliminary treatment facilities downstream of the RAS denitrification cell to any of the downstream primary anoxic cells as desired. In addition to providing flexibility to operate in various process modes, this feature will be useful for protecting the BNR process during high wet weather flows. Piping will be provided to allow the first cell of each train to operate with RAS only under anoxic conditions to achieve further denitrification of RAS flows. This cell will be provided with mixing capability to maintain suspension of solids.

Each of the BNR process tank cells will be equipped with jet mixing/aeration equipment. This type of aeration consists of a jet mixing system with a submersible pump for recirculation of flow discharging into a jet mixing header with multiple discharge nozzles. The header will also have air piping feeding to each nozzle to allow aeration with the same jet pumping system. One submersible pump will be provided for each cell with uninstalled spare pumps providing redundancy should an installed pump fail.

An automated dissolved oxygen control system will be installed to automatically adjust airflow rates to maintain the desired aeration conditions. Aeration piping and automated control valves will be configured to allow individual process control for each BNR process tank. Aeration capacities and blower equipment are more fully discussed in TM No.13, Aeration Systems.

One of the issues that must be carefully addressed during detailed design is the configuration of baffle walls between individual cells to ensure that there is a free-flowing path along the surface of the tanks to convey floating solids and foam to the effluent end of the tanks. The baffle walls will be designed with a combination of submerged and surface openings to prevent short-circuiting and ensure surface movement to avoid trapping of these materials. At the effluent channel, floating solids and foam will be selectively wasted from the tanks directly to the waste activated sludge thickening facilities and sludge storage tanks for removal from the plant with other biosolids.

The secondary clarifiers and BNR process tanks will be provided with piping, gates and valves to allow each train to be operated independently from the other trains. Additionally, return activated sludge (RAS) piping will be configured such that RAS from each secondary clarifier can be directed to a specific BNR process tank, or such that all RAS is blended with influent flow such that the WWWRF acts as a "single sludge" treatment plant. The BNR process tanks should be constructed such that they can be hydraulically tied together at both the influent and effluent ends with channels or pipes to achieve true flow split and distribution to any combination of BNR tanks and clarifiers.

Nitrified recycle (NRCY) pumping facilities will be provided for each BNR process tank. A total NRCY flow rate of four times the forward flow in each BNR process tank is recommended. Each BNR Process Tank will be designed for a maximum month capacity of 6 mgd and each tank will require a capacity of 24 mgd for NRCY pumping. Flexibility will be provided to withdraw NRCY from any of the post-anoxic or swing cells or from the reaeration cell for each tank. Each BNR process tank will be equipped with three NRCY pumps. The pumps will be constant speed and have individual discharge piping to the discharge points. The NRCY pumps will be a low head/high volume application and may be provided as submersible pumps or as propeller-type pumps. Discharge piping will have the capability of discharging to any of the primary anoxic cells with isolation valves for each cell.

Methanol storage and feed facilities will be required to provide methanol to the post-anoxic cells of the BNR process tanks as a carbon source for biological denitrification. Methanol feed equipment is discussed in detail in TM No. 21, Chemical Storage and Feed Facilities. Provisions will be made to automatically feed methanol in proportion to the influent flow to each treatment train based on the influent flow meter and the number of trains in service. Piping will allow methanol feed to any of the post-anoxic cells to provide process flexibility.

ELECTRICAL REQUIREMENTS

An electrical building will be provided as part of the Blower Building to be located adjacent to the BNR process tanks. This electrical building will house motor control centers, power panels and lighting panels associated with the BNR process tanks. Pumps for the jet mixing/aeration systems and the NRCY pumping systems will be provided at 480 VAC. Lighting and some of the instrumentation components will be provided with 120 VAC power. PLC equipment located in this electrical building will allow monitoring and control of various functions in the BNR process tanks.

INSTRUMENTATION & CONTROLS

The BNR process tanks will be provided with instrumentation to assist operators in providing automated process monitoring and control. The controls for each BNR process train will be independent of the controls for each other train such that each train can operate separately if desired. Run, stop, and fail status will be monitored for each jet mixing/aeration pump. The NRCY pumps will be provided with monitoring and control functionality. The dissolved oxygen (DO) control requirements are more fully described in TM No. 13; however, automated DO control will be critical to maintaining adequate treatment to meet the anticipated permit limits and controlling the cost of operations. There are a number of emerging instrumentation technologies that should ease the management of BNR treatment systems and increase reliability. These technologies should be investigated during detailed design.

COST ESTIMATE

Costs for the proposed facilities are included in Table 11-4 below:

TABLE 11-4

Item	Cost ($)
Sitework	667,000
Structural	9,888,000
Pump and Jet Aeration Mixing Systems	9,260,000
Aeration Control Valves	336,000
NRCY Equipment (Pumps/Piping/Valving)	781,000
Influent Control Gates	330,000
RAS Equipment (Piping/Valving)	188,000
Electrical	560,000
Instrumentation	190,000
Total	**$22,200,000**