Although the pilot study generally demonstrated adequate denitrification capability, there were periods when denitrification was not fully completed, as shown in Figure III.2.5.2.11-1. Design of the denitrification zone volumes in the BNR reactors has to be balanced with the design of the nitrification process and the competition between heterotrophic and autotrophic bacteria such that the anoxic zones are not oversized. Supplemental carbon addition was not included in the IFAS pilot plant, but it may be necessary in the full-scale design to provide process flexibility to changes in wastewater characteristics. When wastewater temperature is low, more aerobic volume will be needed for the nitrification process; during these periods, supplemental carbon will be needed to maintain the denitrification process in the smaller anoxic volumes at a level that will reliably achieve the draft permit limits of 5 mg/L total nitrogen. Modeling results suggest that without the addition of a carbon source, effluent total nitrogen limits of only approximately 7 mg/L could be achieved.

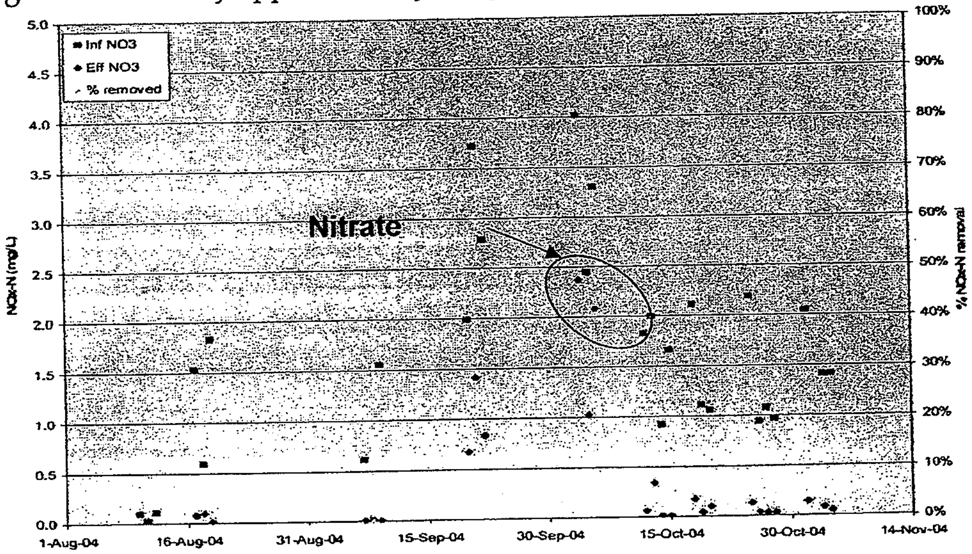

FIGURE III.2.5.2.11-1: PILOT STUDY POST-ANOXIC ZONE NITRATE LEVELS

III.2.5.2.12 Nitrification

The IFAS media provides an environment for both heterotrophic and autotrophic bacteria to proliferate in the reactor. The slower growing autotrophic bacteria are in competition with the faster growing heterotrophs for oxygen. One of the important features of the IFAS process is its resilience to wash-out of the autotrophic bacteria, since a portion of the population is maintained on the media. As with other fixed film processes that nitrify, a portion of the nitrifying population sloughs off as the organisms multiply and is suspended in the reactor.

The specific growth rate (mu) has been estimated in the pilot to be 0.9 $days^{-1}$ and the decay rate (k) was estimated to be 0.06 $days^{-1}$. Normally, the specific growth rate ranges between 0.25 and 1 day^{-1}. Therefore, the measured specific growth rate and decay coefficient from the pilot testing are reasonable kinetic values for the process and are applicable to the process model.

The pilot unit was able to achieve effluent total nitrogen levels of 5 mg/L on a relatively consistent basis with one period of performance excursion. Therefore, it is highly probable that with proper design considerations previously described, a full-scale facility at Field's Point could achieve equal levels of nitrogen removal. The Hydroxyl pilot study report states that, throughout the study, nitrification was consistently achieved. There was, however, an excursion from full nitrification that was not readily explainable. This excursion can be seen in Figure III.2.5.2.12-1, which shows the effluent ammonia concentration changing from approximately 0.3 mg/L to 4 mg/L NH_4-N during the period roughly between October 18th and October 28th. The loss in nitrification efficiency would have been an effluent permit non-compliance issue in the full-scale facility based on the nitrate levels in the effluent shown in Figure III.2.5.2.12-2. In the design of the full-scale facility, it will be important to incorporate the design considerations previously described, such as provision of swing zones, supplemental alkalinity, supplemental carbon source, and control of DO levels, to allow the full-scale facility to maintain nitrification capability under the variable conditions that are expected at FPWWTF.

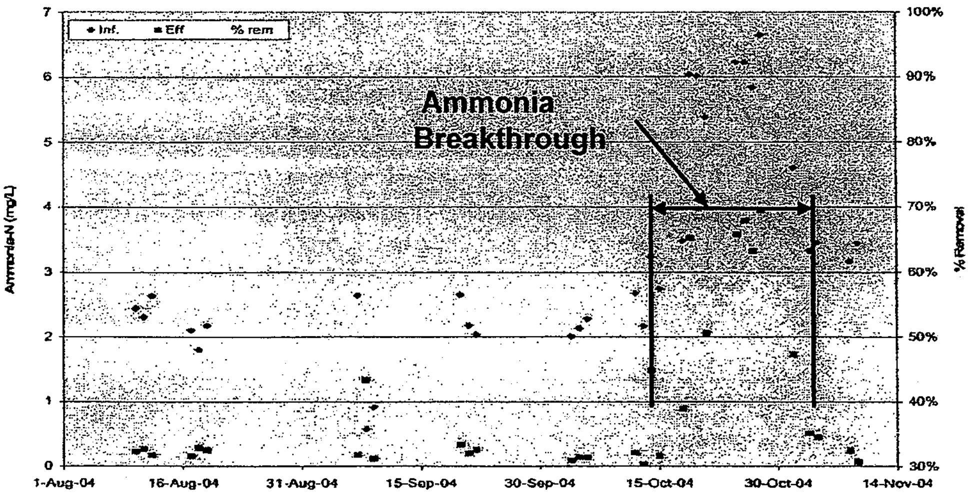

FIGURE III.2.5.2.12-1: PILOT STUDY AERATION TANK AMMONIA LEVELS

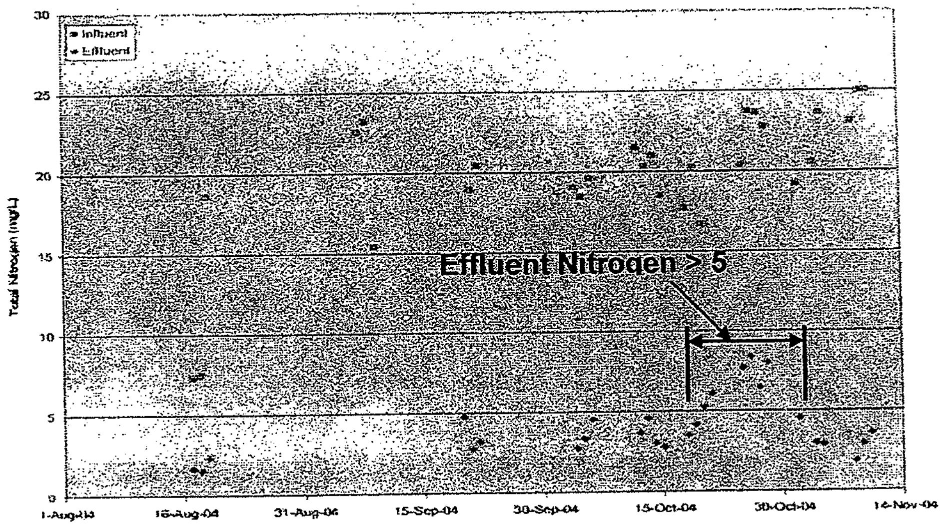

FIGURE III.2.5.2.12-2: PILOT STUDY INFLUENT AND EFFLUENT TOTAL NITROGEN

III.2.6 Step Feed Process

The Step Feed Process uses several cells in series to form a plug flow pattern for mixed liquor but a step feed pattern for primary effluent. All return activated sludge is admitted to the process at the first cell, but the primary effluent is distributed among all the cells. All outflow from the process exits from the last cell. Anoxic zones are located in each cell at the primary effluent addition point and aerobic zones are located downstream of the anoxic zones. Mixed liquor is not recirculated from the last cell to the first cell as is done with the IFAS systems. For a more detailed description of the Step Feed Process, refer to Appendix C.

III.2.7 Development of Alternatives

This section presents the design criteria and design flows and loads used to develop the alternatives and describes the facilities that would be required to implement each alternative in a full-scale upgrade to the FPWWTF.

III.2.7.1 Design Criteria

The alternatives were developed to meet the design criteria listed in Table III.2.7.2-1. The design criteria are based on achieving the anticipated seasonal effluent nitrogen permit limit of 5 mg/L TN on monthly basis. The seasonal limit will apply during the months of May through October.

Table III.2.7.2-1: Design Criteria

Item	Description
Effluent Total Nitrogen Concentration (mg/L TN)[1]	5.0
Design Minimum Wastewater Temp (°C)	14 - Seasonal Basis[2]
Max Sludge Volume Index (SVI) (ml/g)	150
Max Final Clarifier Underflow Rate (gpd/sq. ft.)[3]	500

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[1] The effluent total nitrogen concentration permit limit is 5.0 mg/L as a monthly average from May 1 through Oct 31. To reliably meet this limit, a target concentration of 3.6 mg/L total nitrogen was used for process modeling.

[2] Design wastewater temperature for nitrification from May 1st to October 31st

[3] The underflow rate is the return sludge flow rate per unit of floor area.

The temperature design criterion in Table III.2.7.2-1 was developed by analyzing FPWWTF aeration tank temperature data over the period from May 1, 1998 through May 31, 2001. The design seasonal temperature (14 deg. C) represents the temperature that was lower than 84% of all the temperatures recorded for April 1999, 2000 and 2001. Fourteen degrees Centigrade was selected as the design temperature because nitrification must be started up in April to be operational in May. Using this temperature for developing the BNR alternatives provides a sufficient safety factor for assuring that the BNR processes will operate satisfactorily at occasionally lower temperatures.

An SVI of 150 ml/g represents a satisfactorily settling sludge, and a clarifier underflow rate of 500 gpd/sq. ft. represents the upper limit of withdrawing settled sludge out of the final clarifiers while maintaining proper return sludge solids concentrations. Using these criteria, a clarifier effluent TSS of 15 mg/L can be expected.

DO entering the anoxic zones of the BNR process tends to reduce nitrogen removal efficiencies. The aeration tank influent DO concentration at the FPWWTF is typically above zero mg/L and has been recorded to be as high as 6 mg/L. To consider this effect, the model was run with BNR reactor influent DO levels set at zero DO and 6 mg/L DO. In general, nitrogen removal efficiencies are expected to be higher at lower DO levels.

III.2.7.2 Design Flows and Loads

Table III.2.7.3-1 presents the primary effluent (same as aeration influent) flow and BOD, TSS, and nitrogen loads used for developing the BNR alternatives.

The values shown in the table represent current loads and do not include increases from future growth in the service area. NBC has indicated that no load increases based on population growth are expected during the planning period.

The data in Table III.2.7.3-1 were derived as follows:

III.2.7.2.1 Monthly Average Flow

The monthly average flow is the average of the daily primary effluent flow from January 1, 2000 to March 1, 2001. Primary effluent flows include the FPWWTF influent flow plus plant recycle flows such as gravity thickener overflow, scrubber blow down water, ash settling tank overflow, and belt filter press filtrate and wash water.

III.2.7.2.2 Maximum Monthly Average Flow

The value for maximum monthly average flow was set by the maximum sustained flow anticipated during storm events or when the combined sewer overflow (CSO) tunnels are being pumped out. The FPWWTF is designed to handle a monthly maximum flow of 77 mgd. Currently, this flow rate can persist into the facility for several hours during storm conditions, but it will rarely persist for a full day. When the CSO tunnel system is operational, however, the tunnels will be pumped out at a rate that, when added to the facility's normal influent flow rate, will create a primary effluent flow of 77 mgd. This flow rate will continue until the tunnel is pumped out. In the case of back-to-back storms, the combination of the tunnel pumpage from the first storm, the normal wastewater flow, and the runoff from the second storm may create a primary effluent flow rate of 77 mgd for up to three days.

Because the flow rate of 77 mgd may be sustained over periods of 1-3 days, this flow rate, instead of the average flow rate, is being used as the design flow.

III.2.7.2.3 Peak Hourly Flow

The value for peak hourly flow was set by the NBC's permit requirement that the FPWWTF treat primary effluent flows between 77 and 91 mgd for 1 hour during storm events.

Table III.2.7.3-1: Primary Effluent Design Flows and Loads

Parameter	Monthly Average	Maximum Monthly Average	Peak Hourly
Flow (mgd)	50	77	91
BOD (lb/day)	40,500	53,000	–
TSS (lb/day)	24,900	40,000	–
NH3-N (lb/day)	4,800	6,000	–
TKN (lb/day)	8,000	10,000	

III.2.7.2.4 Primary Effluent BOD, TSS Loads

The BOD and TSS loads shown in Table III.2.7.3-2 were developed by evaluating daily primary effluent load data from the period between January 1, 2000 and July 31, 2001. Available primary effluent BOD and TSS data consisted only of concentrations. To arrive at daily loading values, the primary effluent flow values and the BOD/TSS concentration values for each day of the year were converted to a daily load in pounds using the following calculations:

Daily BOD load (lb) = Flow (mgd) x Daily BOD (mg/L) x 8.34

Daily TSS load (lb) = Flow (mgd) x Daily TSS (mg/L) x 8.34

Once the daily values for BOD and TSS were generated, they were averaged by two methods:

1. By month to arrive at twelve monthly averages, which were then averaged to arrive at an annual monthly average, and

2. By calculating rolling 30-day averages and averaging them to obtain one, annual, 30-day, daily average. These calculated maximums are presented in Table III.2.7.3-2.

Table III.2.7.3-2: Development of Maximum Month Design BOD and TSS Loadings

	Max Month Average	Max 30-day Rolling Average	Safety Factor	Design based on Max Month Average	Design based on Max 30-day Rolling Average	Selected for Design Maximum Month Average
BOD, lb/d	45,100	46,752	1.15	51,864	53,765	53,000
TSS, lb/d	35,209	38,320	1.1	38,730	42,152	40,000

As Table III.2.7.3-2 shows, the maximum 30-day rolling average BOD and TSS loads were slightly higher than those generated by using the maximum month average BOD and TSS loads. The design maximum month and 30-day rolling average BOD loads in the table were calculated by multiplying the maximum month average and the maximum 30-day rolling average BOD loads by a safety factor of 1.15. Likewise, the maximum month average and the 30-day rolling average TSS loads were multiplied by a safety factor of 1.1. The resulting design maximum loads were evaluated and the maximum loads presented in Table III.2.7.3-2 were selected for developing the BNR alternatives.

III.2.7.2.5 Primary Effluent Nitrogen Loads

Nitrogen loads for NH_3-N and TKN were determined by analyzing primary effluent nitrogen data from April 2001 through June 2001. Primary effluent nitrogen data were not available before April 2001. As with the BOD and TSS data, the nitrogen data consisted of concentrations of NH_3-N and TKN. Daily concentration values and primary effluent flows were converted to daily loadings as follows:

Daily Loading (lbs.) = Concentration (mg/L) X Flow (mgd) X 8.34

The calculated daily loadings were averaged to arrive at a "Monthly Average" value, which is presented in Table III.2.7.3-3.

Table III.2.7.3-3: TKN Loadings

	Monthly Average	Max Monthly Average
TKN, lb/d	8000	10,000

The "Maximum Monthly Average" was calculated by adding 25% to the Monthly Average. This added 25% also provides sufficient safety factor to handle maximum daily nitrogen loadings during the maximum month.

An alkalinity dose of 40 mg/L was assumed for the three evaluated alternatives. This dose should be confirmed during final design.

III.2.7.3 Step Feed Alternative

In the step feed alternative, the existing aeration basins are modified to provide a five-stage step-feed process. The step-feed process uses several cells in series to form a plug flow pattern for mixed liquor with a step-feed pattern for primary effluent. Each cell contains seven zones. The zones are configured for series operation such that the effluent from Zone 7 of each cell meets the influent from Zone 1 of the next cell. There are two trains, each consisting of five cells in series, for a total of ten cells. All return activated sludge is added to the process at the head end of the plug flow train. Anoxic zones are located at the influent end of each cell, where the primary effluent is added. The third anoxic zone can be operated as a swing zone in either anoxic or aerobic configuration. Aerobic zones are located downstream of the anoxic zones. Depending on process needs, mixed liquor could be recirculated from an aerobic zone to an anoxic zone within a cell. The final zone in each pass is a re-aeration zone.

The proposed layout of the facilities required for the step feed alternative is shown in Figure III.2.7.4-1. New facilities required include a new primary effluent pump station, modifications to the existing aeration basins, additional blowers, a new ethanol feed system, and an alkalinity feed system. The existing complete mix basins would be converted to two parallel plug flow step feed trains with the ability to remove any one of the ten basins or cells from service. An anoxic zone and a dual anoxic/aerobic zone (swing) would be constructed at the head end of each train followed by aerobic zones. Primary effluent would be routed to the existing effluent end of each basin through a submerged pipe within each of the existing basins. A new primary effluent pump station would be required to provide additional head for proper flow splitting and to overcome hydraulic losses across baffle walls and through the primary effluent piping. The anoxic volume would be approximately 20 percent of the total basin volume with approximately 10 percent of the volume in the first anoxic zone and 10 percent of the volume in the second zone. The third zone would be a swing zone for both anoxic and aerobic configurations. The remaining basin volume would be aerobic and broken into four separate nitrification stages with the final zone being a re-aeration zone. Internal through-wall recirculation pumps would be installed within the first four passes of each basin to provide for additional nitrate recycle. The design parameters and new facilities required for the step feed alternative are summarized in Table III.2.7.3-1.

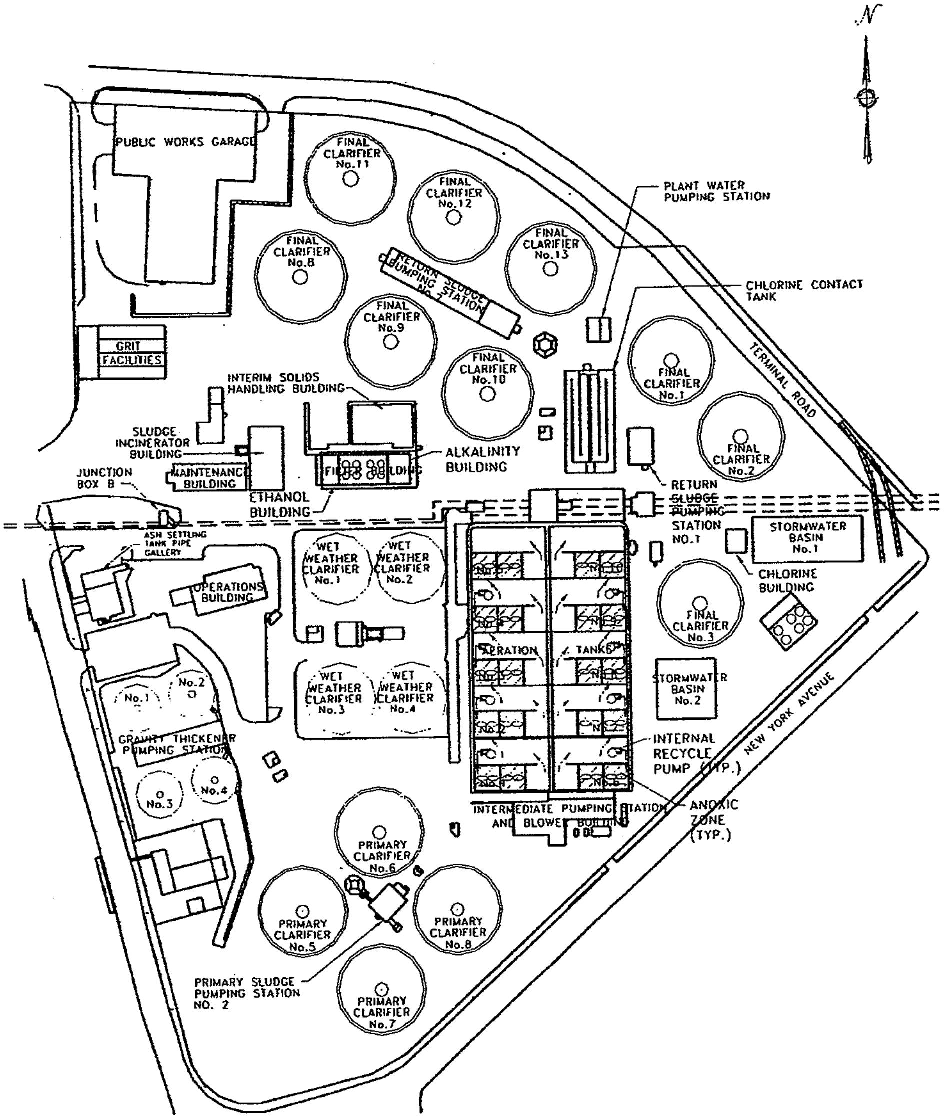

FIGURE III-2.7.4-1: STEP FEED ALTERNATIVE

Table III.2.7.4-1: Design Summary for Step Feed Alternative (within existing volume)

Item	Description
Total Anoxic/Aerobic Volume	9.8 MG
Number of Basins	10 basins
Five Pass Step Feed	7 zones
Internal Recirculation Pumps	
Number	8
Size	25 mgd each
Recirculation Rates	Pass 1 - 150 Percent Raw Feed Pass 2- 100 Percent Raw Feed Pass 3 – 75 Percent Raw Feed Pass 4-5 -0 Percent Raw Feed
Volume per Basin	980,000 gallons
1st Anoxic Zone (10 percent)	98,000 gallons
2nd Anoxic Zone (10 percent)	98,000 gallons
1st Aerobic Zone (swing zone)	294,000 gallons
2nd Aerobic Zone	147,000 gallons
3rd Aerobic Zone	147,000 gallons
4th Aerobic Zone	147,000 gallons
5th Reaeration Zone	49,000 gallons
Total Volume of Air Required	40,000 scfm
Existing Total Blower Capacity	24,150 scfm
Existing Blower Ratings	1 @ 3000 scfm 2 @ 4525 scfm 2 @ 6050 scfm
Additional Facilities Required	
New Anoxic/Aerobic Volume	None
Fine Bubble Aeration Grids	20 @ 2 grids per tank
Additional Air	16,000 scfm
Blowers, including one standby	3 @ 8000 scfm
PE Pump Station	77 mgd sustained flow 91 mgd peak instantaneous
Ethanol Storage and Feed System	
Storage Volume	40,000 gal
Storage @ Avg. Flow & Dose	16 days
Storage @ Max Flow & Dose	7 days
Chemical Feed Pumps	3 pumps; chemical metering
Number	5- 90 gph
Capacity	
Alkalinity Storage and Feed System	
Storage Volume	20,000 gal
Storage @ Avg. Flow & Dose	20 days
Storage @ Max Flow & Dose	10 days
Chemical Feed Pumps	
Number	3 pumps; chemical metering
Capacity	2- 30 gph