Table III.2.7.8-1: Design Summary IFAS Fixed Media Alternative

Item	Description
Total Anoxic/Aerobic Volume	11.8 MG
Number of basins	5
Recycle Pumps	
Number	10
Size	24 mgd
Recirculation rate	300 Percent of Raw Feed
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	2.2 MG
Hybrid Media	17 million sq. ft.(?)
Fine Bubble Aeration Grids	20 @ 2 grids per tank
Additional Air	16,000 scfm
Blowers	3 Blowers @ 8000 scfm
New Wet Weather Clarifiers	4-11,130 sq. ft each
PE Pump Station	77 mgd sustained flow 91 mgd peak instantaneous
Ethanol Building	
Storage	40,000 gal
Storage @ Avg. Flow & Dose	16 days
Storage @ Max Flow & Dose	7 days
Chemical Feed Pumps	
Number	3 pumps; chemical metering
Capacity	5- 90 gph
Alkalinity Building	
Storage	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

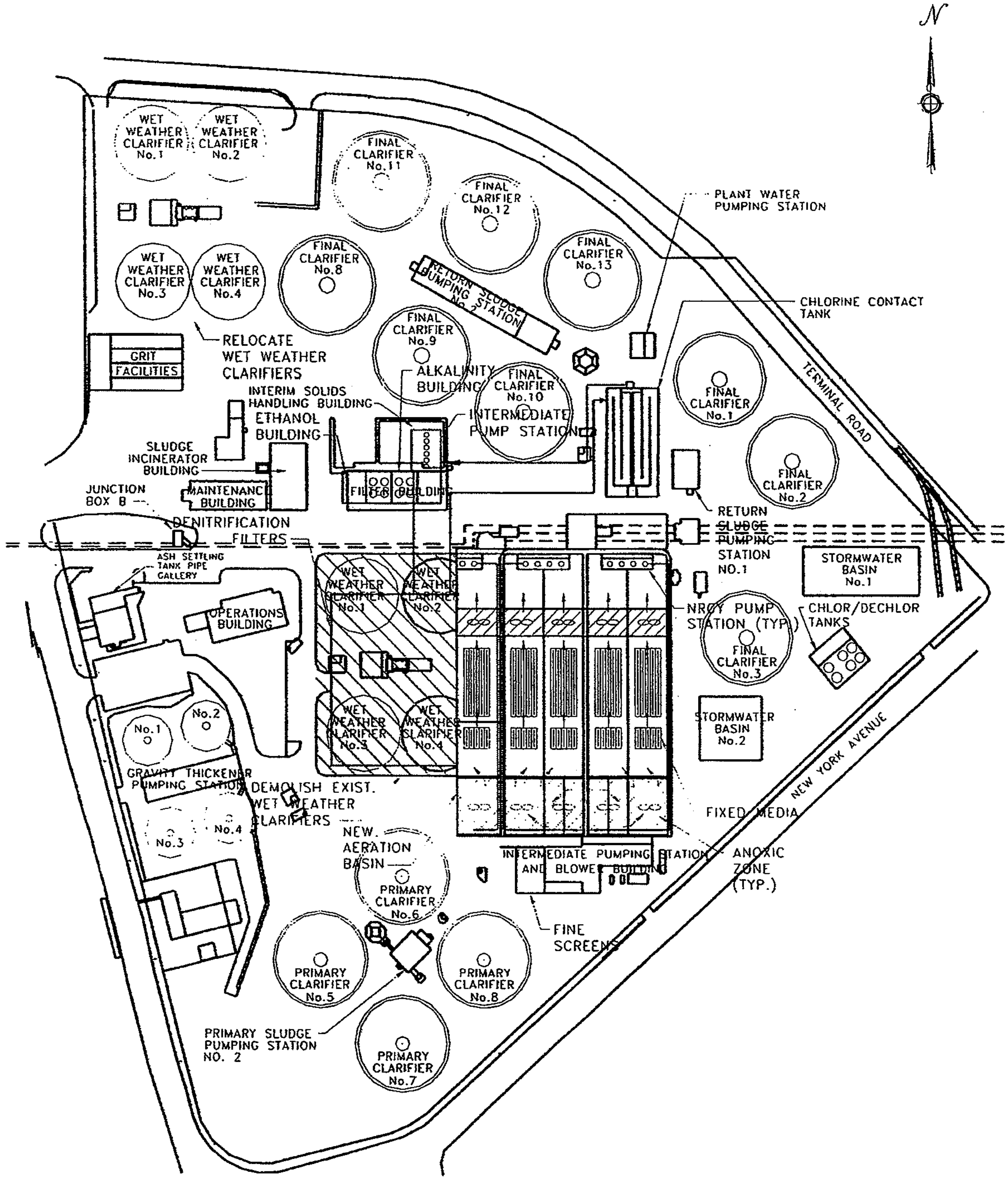

FIGURE III.2.7.9-1 IFAS FIXED MEDIA PROCESS WITH DENITRIFICATION FILTER

Table III.2.7.9-1: Design Summary Denitrification Filters with the IFAS Fixed Media Alternative

Item	Description
Denitrification Filter Complex	
Fluidized Bed Upflow Filters	
Number and Size	12 cells; 1600 sq. ft each
Hydraulic Capacity	77 mgd sustained 91 mgd peak flow
Hydraulic Loading rate	3 gpm/sq. ft sustained 4 gpm/sq. ft peak
Intermediate Pump Station	
Capacity	120 mgd with recycle flow

III.2.8 Alternatives Assessment

The three alternatives for providing biological nitrogen removal at the FPWWTF were assessed based on the following factors:

- Ability to meet 5 mg/L TN limit
- Operational flexibility, redundancy, and complexity
- Reliability
- Constructability
- Hydraulic considerations
- Costs

A comparison of the three alternatives based on these factors is provided below.

III.2.8.1 Ability to Meet 5 mg/L TN Limit

III.2.8.1.1 Pro2D Model

Modeling was completed on CH2M HILL's proprietary plant simulation model Pro2D. The term Pro2D stands for PROfessional PROcess Design. Pro2D is a steady state whole plant simulator that has been developed to perform complete wastewater treatment plant simulations and to calculate full-plant mass balances. Pro2D uses Microsoft Excel as its computational engine, implemented as a series of worksheets in a Microsoft Excel workbook

CH2M HILL prepared a quasi-steady state model of the FPWWTF to analyze plant capacity and predict effluent nitrogen concentrations based on numerous modeling runs that modeled two different processes. The major parameters that were varied include the following:

- Flow
- Temperature
- Aerobic Volume (Mass)
- Solids Loading to Clarifiers
- Dissolved Oxygen in the Anoxic Zone
- Ethanol Consumption

III.2.8.1.2 PBNR Simulator

PBNR is a steady-state simulator for Biological Nutrient Removal (BNR), based on the ASM 2d mathematical model. This simulator allows the user unlimited process flow diagram flexibility, full BNR processes, and supplemental carbon addition. PBNR is incorporated into the whole plant simulator as the biological process module and is linked to the other process modules within Pro2D.

III.2.8.1.3 PClarifier Analyzer

PClarifier is a secondary clarifier design and analysis tool that allows the user to analyze and present clarifier operational information in a variety of ways. PClarifier is a separate file, linked to the core Pro2D file allowing users to utilize common information developed from the whole plant simulator. The results generated from PClarifier are not returned back to the Pro2D file. PClarifier includes the state point flux analysis and Daigger-Roper curves. In addition, a dynamic simulator is included to analyze clarifier blanket behavior during diurnal conditions. These features make PClarifier a complete tool for clarifier analysis for an operational assessment, analysis, or for design.

III.2.8.1.4 Modeling Results

Both step feed and IFAS processes were modeled to predict their performance under varying flow rates, water temperatures, internal (nitrate) recirculation, dissolved oxygen levels in the anoxic zone influent and doses of supplemental carbon (ethanol). Table III.2.8.1-1 presents the modeling results. All model runs were performed using the Pro2D model described above.

Two sets of model runs are presented. The purpose of the first set of model runs (3, 4, 8, 9) was to generally compare the two technologies and the effect of temperature at the maximum daily flowrate. The second set of runs (1a - 4d) was a more controlled assessment to generally estimate the effects of dissolved oxygen (DO) in the anoxic zone and supplemental carbon addition on nitrogen removal efficiency for the average monthly flowrate. This second set of model results are considered to show only general trends with respect to DO and supplemental carbon because the model was run with numerous variables set at constant values for consistency between runs.

The direct model results are presented in the column labeled "TN without safety factor." The total nitrogen (TN) values presented in this column represent the model's predicted plant effluent total nitrogen level under steady state wastewater conditions. Examples of steady state wastewater conditions would include constant BOD and nitrogen strength, constant temperature, constant flow, and absence of slugs of biological inhibitors such as toxic substances.

Because wastewater treatment facilities typically do not experience steady state conditions, a safety factor for design of BNR processes is used to account for wastewater variability. The value of the safety factor used in the model is 1.3. This value is based on experience at fully operational BNR wastewater treatment facilities where actual plant effluent nitrogen levels have been compared to those predicted by the Pro2D model.

The FPWWTF does not operate at steady state. It experiences diurnal and seasonal variations in wastewater flow rates, strength, characteristics, and temperature. Average dry weather flows through the BNR process would be in the range of 45-50 mgd while wet weather flows could be as high 77 mgd for several days, especially when the CSO tunnels are being pumped out. Because stormwater contains very low concentrations of BOD, TSS, and nitrogen, concentrations of these constituents also vary significantly with time. Additionally, wastewater temperatures would vary widely because of the cooling effect stormwater and snowmelt water would have on the wastewater entering the facility. Because of this non-steady state operation, the TN values that include the safety factor are used to predict the effectiveness of a BNR process in meeting the 5 mg/L effluent TN limit.

III.2.8.1.5 Analysis of Model Runs

The following analysis is based on the results that incorporate the safety factor. The results without the safety factor are considered unrealistic because of the variability of the FPWWTF influent, as discussed above.

The initial runs (3,4,8,9) modeled the 77 mgd (maximum daily flow), zero DO in the anoxic zone and no supplemental carbon under spring and summer conditions. The IFAS process produced effluent TN of more than 1 mg/L lower than the Step Feed process and met the permit requirements under these conditions. The recirculation rates for the two processes are different in these runs. (Step feed recirculation is generally less because a proportional amount of flow is "stepped", or "added", at various points in the flowstream and internal recirculation occurs at each step. IFAS typically has recirculation rates from 200 to 400 percent of influent for internal recycle since they are effectively taking all feed forward flow and recirculating it back to the anoxic zone.)

There is a distinct possibility though, that achieving zero DO in the anoxic zone is unrealistic. The second set of runs (1a - 4d) was for the purpose of assessing the effect of DO in the anoxic zone and supplemental carbon addition on nitrogen removal efficiency and was run with numerous variables set at constant values for consistency between runs.

The model runs with 0 and 500 gallons per day of ethanol resulted in effluent nitrogen levels above 5 mg/L. The model runs with 1000 and 1500 gallons per day of ethanol resulted in effluent nitrogen levels below 5 mg/L. The indication from these results is that ethanol would be required for meeting the 5 mg/L TN permit limit over the May through October period.

Comparing Step Feed performance with IFAS performance indicates that, without ethanol addition performance is similar for both processes. However, when ethanol addition is considered, IFAS outperforms Step Feed by approximately 0.5-1.0 mg/L, depending on the ethanol feed rate.

The effect of DO in the pre-anoxic zone influent is indicated by comparing the zero DO model runs with the 6 mg/L DO model runs for each process. The model results indicate that the DO level in the anoxic zone influent has a minor effect on effluent TN level, with performance at zero DO being only slightly better than at 6 mg/L DO.

The modeling results predict that if the ethanol feed rate and nitrate recirculation rates are adjusted properly, the Step Feed and IFAS Floating Media alternatives will achieve the 5 mg/L TN effluent limit on a seasonal basis within the existing aeration tank volume under the following conditions:

1) all the aeration tanks and final clarifiers are on-line;

2) the aerobic/anoxic volume apportionment within the tanks is optimized.

In contrast to the IFAS Suspended Media Process, the IFAS Fixed Media Process alternative is not able to achieve full nitrification to meet a 5 mg/L limit within the existing volume of the aeration basins. Construction of additional aeration basins would be required to implement the IFAS Fixed Media Alternative.

III.2.8.1.6 Conclusions

Based on the modeling results:

1. Both the IFAS and the step feed processes are expected to be able to meet the 5 mg/L monthly permit limit, with the addition of a carbon source.
2. The IFAS process would be expected to outperform the step feed process by 0.5-1 mg/L TN under similar conditions of flow and temperature, and considering the safety factor.
3. The IFAS process would be expected to meet the 5 mg/L TN permit limit more consistently than the step feed process.

Table III.2.8.1-1: Modeling Results Summary FPWWTF BNR Upgrades[3]

Process	Flowrate	Temp.	Ethanol	D.O.	Recirculation Rate	TN without safety factor	TN with safety factor
	MGD	Deg. C	gpd	mg/L	% of Flowrate	mg/L	mg/L
3 Step	77	15	0	0	150	4.6	5.98
4 Step	77	20	0	0	150	4.4	5.72
8 IFAS	77	15	0	0	400	3.7	4.81
9 IFAS	77	20	0	0	400	3.6	4.68
1a Step	50	14	0	0	150	5.6	7.3
1b Step	50	14	500	0	150	4.3	5.6
1c Step	50	14	1000	0	150	3.8	4.9
1d Step	50	14	1500	0	150	3.5	4.5
2a Step	50	14	0	6	150	6.1	7.9
2b Step	50	14	500	6	150	4.6	5.9
2c Step	50	14	1000	6	150	3.8	4.9
2d Step	50	14	1500	6	150	3.4	4.4
3a IFAS	50	14	0	0	150	5.6	7.3
3b IFAS	50	14	500	0	150	4	5.2
3c IFAS	50	14	1000	0	150	2.9	3.8
3d IFAS	50	14	1500	0	150	2.3	2.9
4a IFAS	50	14	0	6	150	5.7	7.4
4b IFAS	50	14	500	6	150	4.0	5.2
4c IFAS	50	14	1000	6	150	3.0	3.9
4d IFAS	50	14	1500	6	150	2.6	3.4

III.2.8.2 Additional Modifications

Within eighteen months of initiation of operation, the NBC will submit a draft engineering analysis that will: evaluate whether the WWTF is able to attain compliance with the Total Nitrogen limitations; evaluate and recommend any operational changes that are necessary to attain compliance; or include a determination that facility modifications are necessary to attain compliance. If additional facilities are required to consistently meet the TN effluent limit or a lower TN effluent limit, denitrification filters with ethanol as a supplementary carbon source have been presented in this amendment as an alternative to remove additional total nitrogen on a seasonal basis.

---

3 Copies of modeling runs are included in Appendix G.

For all three alternatives, the addition of denitrification filters would increase the operational complexity of the system and result in additional operational costs, chemical handling, capital costs and land requirements.

Relocation of the public works garage would be required to accommodate the denitrification filters for the step feed and free floating media alternatives; for the fixed media alternative, the garage would have already been relocated.

In accordance with the Consent Agreement (RIA-371) between the NBC and RIDEM, if additional facilities are required, the NBC will submit a Facility Plan Amendment within twelve months of DEM's approval of the engineering analysis that will evaluate and recommend facility modifications to attain compliance.

III.2.8.3 Operational Flexibility, Redundancy, and Complexity

III.2.8.3.1 Step Feed Alternative

The step feed process is configured for a significant amount of operational flexibility. Internal recirculation pumps in each of the first four passes are provided to recycle nitrates into the anoxic zones to achieve greater denitrification depending on the process needs.

The process provides at least ten treatment trains and, therefore, provides an excellent level of system redundancy. No new aeration basins would be required for this alternative.

Methods for removing scum and foam should be considered during final design, regardless of which alternative is selected.

The step feed process provides a mixed solids gradient across the basins to buffer potential impacts due to inhibitory substances discharged in the wastewater.

Fine screens upstream of the BNR reactors are not required for the step feed process.

However, the process is more complex to operate than the IFAS alternatives due to additional flow splitting requirements and the configuration and number of anoxic zones.

The step feed process is prone to wash out of autotrophs under low temperature and/or low wastewater concentrations during high flows because of the autotrophs slow grow rate.

III.2.8.3.2 IFAS Free Floating Media Alternative

The IFAS process provides at least ten treatment trains and therefore provides an excellent level of system redundancy. No new aeration basins would be required for this alternative.

There is additional biomass on the media to buffer potential impacts of inhibitory substances in the wastewater.

The process is less complex to operate than the step feed process due to the reduced number of zones in each train and reduced flow splitting requirements.

The process includes internal recirculation pumps in each of the basins to recycle nitrates from the end of the aerobic to the pre-anoxic zone to enhance denitrification.

The process is resistant to autotroph washout because autotrophs are attached to the media and remain within the tank during varying flow conditions and can also maintain nitrification better at low temperatures.

Access to the aerobic zones is more difficult with IFAS since the media must be transferred to a standby basin when access to the basin or diffusers is required. Air lift pumps are able to move the media when maintenance is required.

Fine screens upstream of the BNR reactors are required to reduce the potential for fouling and plugging of the media retention screens. The fine screening facility would reduce the amount of material that would accumulate in the aeration zones but would require additional operation cost and complexity.

III.2.8.3.3 IFAS Fixed Media Alternative

The IFAS fixed media process may reduce operational impacts due to inhibitory substances that are discharged into the wastewater due to the additional biomass on the media.

Internal recirculation pumps in each of the basins to recycle nitrates from the end of the aerobic to the pre-anoxic zone are included to enhance denitrification.

The process is resistant to autotroph washout because the autotrophs are attached to the media and remain within the tank during varying flows and can also maintain nitrification better at low temperatures. This resistance, however, is not as great as with the floating media IFAS process.

A significant amount of new aeration tankage is required to nitrify the design loads. The wet weather clarifiers would require relocation or the capacity of the wet weather treatment system would need to be reduced.