December 22, 2005

Jon M. Capacasa
Water Protection Division
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Re: Blue Plains Excess Flow Treatment

Dear Mr. Capacasa:

Attached are two documents titled, Legal Analysis and Technical Analysis that respond to your July 28, 2005 letter, which included a request for additional information and analysis regarding excess flow treatment at Blue Plains.. EPA's response to the attached information, analysis and conclusions, particularly the legal analysis and conclusions, will greatly assist us as we proceed with our alternatives evaluation.

We would appreciate the opportunity to meet with you and appropriate members of your staff, including regional counsel, in the event you have additional questions or concerns regarding the information and analysis that has been provided in these documents.

Sincerely,

Jerry N. Johnson
General Manager

Attachments

LEGAL ANALYSIS

TO DECEMBER 22, 2005 LETTER FROM DC WASA GENERAL MANAGER TO CHIEF, WATER PROTECTION DIVISION OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY

The following responds to the two legal questions in Jon Capacasa's July 28, 2005 letter to Jerry Johnson regarding WASA's evaluation of alternatives to treat excess flow while meeting anticipated new nitrogen control requirements called for by the Chesapeake Bay Program.

I. Policy Considerations

The CSO Control Policy does not specifically address EPA's questions, nor is WASA aware of any other case which would serve as precedent. In fact, to WASA's knowledge, this is the first time that a CSO permittee has had to face the very difficult challenge of meeting effluent limits for total nitrogen that reflect limit-of-technology while treating hundreds of millions of gallons of wet weather flow from a combined sewer system. The difficulties inherent in maintaining high levels of denitrification while treating large volumes of wet weather flow under varying temperature and load conditions are well known; and WASA expects that many other CSO communities will face similar challenges in the years ahead as more LTCPs are completed and as new water quality standards for nutrients are adopted and implemented. Therefore, EPA's questions raise significant policy issues that will directly affect the ability of CSO communities nationwide to meet the dual challenges of complying with stringent nitrogen control requirements while treating large volumes of wet weather flow.

Success is assured if the affected CSO communities and the regulatory authorities work together to employ the creativity and innovation that the CSO Policy seeks to promote. WASA is exploring several creative and innovative alternatives, and believes that EPA has the authority, if not the duty, to respond in kind. Indeed, the CSO Policy encourages permittees and permitting authorities to "consider innovative and alternative approaches and technologies that achieve the objectives of [the] Policy and the [Clean Water Act]." CSO Policy at I.F. Among the key objectives and principles of the CSO Policy are

> *[p]roviding sufficient flexibility to municipalities, especially disadvantaged communities, to consider the site-specific nature of CSOs and to determine the most cost-effective means of reducing pollutants and meeting [Clean Water Act] objectives and requirements.*

CSO Policy at I.A.2.

The alternatives under consideration by WASA are entirely consistent with the foregoing, and WASA believes that if EPA judges them with these same objectives and principles in mind, it will concur in the following analysis and conclusions.

II. Overview of Relevant Facts

The Blue Plains permit and WASA's LTCP presently call for WASA to provide complete treatment for peak flows of up to 740 MGD for up to four hours during wet weather events. Flows above this quantity up to 336 MGD are diverted to excess flow treatment which consists of screening, grit removal, primary treatment, and disinfection. The total plant flow during the first four hours is 1,076 MGD. After four hours, the flow to complete treatment is reduced to 511 MGD and excess flow treatment remains up to 336 MGD, for a total plant flow rate of 847 MGD. WASA must empty the tunnels within 59 hours following wet weather events and provide treatment for the contents of the tunnels in accordance with its permit. The LTCP calls for WASA to add four primary clarifiers at Blue Plains to provide the treatment capacity needed to treat excess flow. WASA is confident that it can comply with the above requirements while meeting its existing effluent limits and goals following installation of the primary clarifiers and completion of the remaining upgrades now underway at Blue Plains.

However, the anticipated addition of a new limit in the Blue Plains permit that will require the installation of nitrogen controls at or near the limits of technology will dramatically affect WASA's ability to provide complete treatment for the volumes of wet weather flows presently called for in the LTCP and by the conditions in the current permit. This is a significant change to the assumptions and projections used in the development of the LTCP, the permit, and the consent decree LTCP implementation schedules. As noted above, high wet weather flows can have a significant adverse impact on the denitrification processes. Further, these adverse impacts are magnified significantly under cold water temperatures that regularly prevail during winter snow melt and rainfall events.

WASA's alternatives evaluation is designed to produce the most cost-effective approach to compliance with a new nitrogen limit while achieving the same, if not better overall pollutant load reductions and water quality as the load reductions and water quality projected for the current permit and LTCP. However, the alternatives under consideration involve elements which raise the following legal issues. These issues must be resolved before WASA can conclude its evaluations and present a specific proposal to EPA.

First, would increasing the flow discharged from Outfall 001 due to a reduction in the peak flow factor from 2.0 to 1.5, qualify as a CSO bypass under the CSO Policy?

Second, would treating tunnel pump-out through excess flow treatment be authorized (a) as a CSO bypass if conveyed to Blue Plains through the existing conveyance system and head works, or (b) as a CSO discharge if conveyed to Blue Plains through a new conveyance system that would enter the plant through a new separate head works?

III. Analysis

A. *Increased Flow Discharged From Outfall 001*

The first question (ie, would the increased flow discharged from Outfall 001 qualify as a CSO-related bypass pursuant to the CSO Policy) corresponds to the first question in Jon Capacasa's July 28, 2005 letter.

At the outset, it should be noted that the current Blue Plains permit already authorizes a CSO-related bypass for excess flows above peak flow factors of 2.0 and 1.38 times annual average. Accordingly, the first question is directed only at the increased flow from Outfall 001 that would result from the reduced peak flow factor.

As EPA knows, Section II.C.7 of the CSO Policy ("Maximizing Treatment at the Existing POTW Treatment Plant") builds upon EPA's bypass regulations at 40 CFR 122.41(m) to establish a framework for authorizing bypasses on a case-by-case basis at POTWs receiving combined sewer flows.[1]

An intentional diversion of wet weather flow from any portion of a treatment facility must meet the following criteria in order to be approved as a CSO-related bypass under Section II.C.7 of the CSO Policy. First, the permittee must show that the bypass was unavoidable to prevent loss of life, personal injury or severe property damage. Second, the permittee must show that there was no feasible alternative to the bypass. Third, the bypass may be approved only after consideration of adverse impacts. Finally, the LTCP must provide a justification for the cut-off point at which flows will be diverted from secondary treatment, and a cost-benefit analysis demonstrating that conveyance of wet weather flow to the POTW for primary treatment is more beneficial than other CSO abatement alternatives. The following demonstrates that the increased flow from Outfall 001 that would result from a reduced peak flow factor would clearly satisfy each of these criteria.

With regard to the first criterion, the CSO Policy indicates that "severe property damage" could include adverse affects on the performance of the treatment system, and identifies situations where flows above a certain level wash out the POTW's secondary treatment system as an example of severe property damage. WASA's evaluation indicates that providing complete treatment to flows above a 1.5 peak flow factor would have consequences similar to those described in the above example. Therefore, the effects of Blue Plains flows above this peak flow factor are within the scope of the kinds of damage contemplated by the CSO Policy. The studies completed to date show that flows above a

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[1] It is important to note that now that the CSO Policy has been incorporated into the Clean Water Act, it does more than simply interpret EPA's bypass regulation. Rather, the Policy now serves as it own Clean Water Act authority, and, therefore, can be interpreted to authorize CSO-related bypasses that might otherwise be viewed as beyond the scope of EPA's bypass regulation.

1.5 peak flow factor would undermine Blue Plains' operational stability, risk washing out the nitrifying bacteria, and prevent the plant from consistently meeting a stringent nitrogen limit without a total reconstruction of major processes at the plant. Given the importance attached to nitrogen control at Blue Plains, it would appear that there could be few consequences more severe than damage to the plant's denitrifying processes and its inability to consistently meet its nitrogen limit.

Further, any alternative which incorporates increased flows from Outfall 001 to protect the plant and plant performance must be viewed in light of the CSO Policy's objectives and principles discussed above which necessarily require a broader interpretation of the term "severe property damage" when applied to a combined sewer system. Non-CSO bypasses are generally associated with infrequent, extraordinary events such as hurricanes or large equipment failures, and, therefore, are intended principally to prevent treatment plants from being damaged under the severe conditions resulting from these events. CSO bypasses authorized by the CSO Policy, particularly those that are elements of LTCPs, on the other hand, are intended to serve an entirely different purpose; namely, to meet the Policy's site specificity and cost effectiveness goals by ensuring that wet weather treatment capacity is utilized to the maximum extent possible. The foregoing necessarily means that the excess capacity must be utilized not only in ways that would not damage the plant, but also without significantly interfering with plant operation, particularly interference that would result in permit non-compliance. WASA's studies show that it can not protect the denitrification processes at the plant and cost effectively comply with a nitrogen limit while providing complete treatment for flows above 555 MGD (1.5 peak flow factor). Therefore, the consequences of providing complete treatment to flows above a 1.5 peak flow factor are plainly serious enough for EPA to conclude that they would constitute the kind of severe property damage envisioned by the CSO Policy.

Under the second criterion, the permittee must show that there was no feasible alternative to the bypass. The CSO Policy offers the following explanation of this criterion in the CSO context:

> *[T]he feasible alternatives requirement of the regulation can be met if the record shows that the secondary treatment system is properly operated and maintained, that the system has been designed to meet secondary limits for flows greater than the peak dry weather flow, plus an appropriate quantity of wet weather flow, and that it is either technically or financially infeasible to provide secondary treatment at the existing facilities for greater amounts of wet weather flow.*

59 Fed. Reg. 18,688, 18,694 (April 19, 1994).

Applying the above to Blue Plains, WASA can, of course, show that the secondary and advanced treatment systems are properly operated and maintained. Further, as EPA knows, Blue Plains has been designed to treat to levels more stringent than secondary treatment for significant quantities of wet weather flow. With average plant flows currently at approximately 370 MGD, the projected peak dry weather flow is about 425 MGD. Under these conditions, the plant would be providing full treatment, including limit-of-technology nutrient control, for about 130 MGD of wet weather flow at 555 MGD (1.5 peak flow factor). Moreover, WASA believes that any alternative incorporating a 1.5 peak flow factor and a resulting increase in flow discharged from outfall 001 would meet the financial infeasibility test based upon the cost projections that we have shared with EPA. Those projections indicate that it would cost millions of dollars in additional debt service and operation and maintenance costs to provide nutrient removal down to 3.0 mg/l for wet weather flow at a 2.0 peaking factor instead of the proposed 1.5 peaking factor.

The CSO Policy also provides that the bypass may be approved only after consideration of adverse impacts. Presumably, the reference is to adverse water quality impacts rather than adverse plant impacts. In either event, however, any alternative incorporating a 1.5 peak flow factor and a resulting increase in flow discharged from outfall 001 would satisfy this criterion if WASA can show that it would produce the same, if not better water quality conditions projected with the current LTCP derived performance standards while preventing adverse impacts on plant performance.

Finally, the LTCP together with the technical studies completed to date and submitted to EPA provide (1) the technical justification supporting the 555 MGD cut-off point at which the flow would be diverted from full treatment, and (2) the cost-benefit analysis demonstrating that conveyance of wet weather flow to Blue Plains for primary treatment is more beneficial than other CSO abatement alternatives.

B. *Treatment of Tunnel Pump-Out*

The alternatives under consideration involve directing either all or a portion of the wet weather flow from tunnel pump-out through excess flow treatment prior to discharge from Outfall 001 rather than complete treatment prior to discharge from Outfall 002 as currently provided in the LTCP. The alternatives include two possible approaches - conveying tunnel pump-out to Blue Plains using (a) the existing conveyance system and head works, or (b) a new conveyance system which would enter Blue Plains through a new separate head works. Although they have a different legal basis, WASA believes that either approach would be authorized under the CSO Policy.

Under the first approach (existing conveyance system and head works) the legal basis is Section II.C.7 of the CSO Policy (“Maximizing Treatment at the Existing Treatment Plant”), which, as discussed above, establishes several criteria for authorizing bypasses on a case-by-case at POTWs receiving combined sewer flows. But before turning to these criteria, it is important to point that while this particular approach may appear at first glance to offer less treatment and load reduction than would be the case if tunnel pump-out was directed to complete treatment, the opposite is, in fact, true. WASA’s studies and analysis show that the combination of faster tunnel pump-out, enhanced clarification, and the dilute nature of the tunnel contents will produce pollutant removals equivalent to those that would be achieved through complete treatment, and that overall pollutant loads would be less under this approach than they would be if the tunnel contents were sent through complete treatment. The foregoing, together with the cost savings associated with this approach and the CSO Policy's goals of promoting cost effectiveness, innovation, and new technologies, strongly suggest that the cost-benefit criterion is the overriding consideration in evaluating this approach. WASA's analysis, in turn, shows that this approach is without question more cost beneficial than providing complete treatment to the contents of the tunnels.

The other criteria would be easily satisfied once the compelling cost-benefit of this approach is recognized. Applying the broad interpretation of the "severe property damage" criterion as discussed above, EPA can, and should readily conclude that this approach would satisfy this criterion because it enhances overall operation of the Blue Plains processes resulting in greater load reductions at less cost. As discussed above, the second criterion (alternatives) is dependent upon a showing of technical or economic infeasibility which is also satisfied if WASA can demonstrate that this approach would produce greater load reductions at less cost. Obviously, the final criterion would be satisfied because there would be no adverse impacts from this approach.

The only difference between this approach and the existing and proposed bypass authorizations discussed above is that it would provide for treatment of wet weather flow that is captured in the tunnels before being released to the sewer system rather than wet weather flow that is treated at the plant without first being captured in the tunnels. The CSO Policy does not prevent use of the bypass authorization for treating the contents of the tunnels. Although Section II.C.7 refers to "the delivery of flow during wet weather", the reference is not a limitation, but rather is descriptive of the benefits of bypass authorizations under the situations discussed is the section. Therefore, Section II.C.7 can not be construed as limiting bypass authorizations to "flow during wet weather" in cases such as this where the proposed authorization meets all the criterion in Section II.C.7 and clearly advances the principles and objectives of the CSO Policy.

Under the second approach (new pipeline and new separate head works), the discharge of the treated contents of the tunnels from Outfall 001 would be a CSO rather than a bypass because it would be a discharge at a point prior to the POTW. *See*, CSO Policy at I.A. As CSOs, the discharge of the treated contents of the tunnels would be authorized if it met the CSO Policy's technology-based standards and did not cause or contribute to a violation of water quality standards. The evaluation completed to date indicates that this approach would meet both of these criteria. First, it would easily meet the technology-based requirements established by the CSO Policy because the tunnel contents would receive treatment far above the minimum primary clarification, solids disposal and disinfection requirements at Section II.C.4.a of the Policy. Second, as reflected in the modeling and analysis submitted to date, this approach would not cause or contribute to a violation of water quality standards.

IV. **Conclusion**

Based on the foregoing, WASA believes that the above legal questions should be answered in the affirmative, and, therefore, are not an obstacle to selecting the most cost-effective approach to treating excess flow while meeting the anticipated new nitrogen control requirements.

TECHNICAL ANALYSIS

TO DECEMBER 22, 2005 LETTER FROM DC WASA GENERAL MANAGER TO CHIEF, WATER PROTECTION DIVISION OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY

Introduction

At the workshop held on August 10, 2005, EPA requested clarification and documentation of several aspects of the strategic process engineering planning. The specific questions and issues raised were:

1. Why doesn't the total flow from Outfall 002 shown on Table 2 (handout at workshop) decrease when the peaking factor is reduced from 2.0 to 1.5?
2. Does reducing the peaking factor from 2.0 to 1.5 provide the capability to treat more wet weather flow?
3. What steps does WASA take during a wet weather event and what effect does that have on treatment performance? What are the lingering effects and how long does it take to return to normal operations?
4. What are the effects of storm events on treatment performance?
5. Provide a more specific plan, including costs, to address meeting the proposed TN limit of 4.2 mg/l.
6. Provide updates on the continuing research on the bioavailability of organic nitrogen.

This document provides WASA's responses to these requests for technical information. We note that the research defined in Question 6 is ongoing and updates on this project will be provided separately.

Thus far, WASA has presented two options for CSS tunnel pump out and treatment at the stakeholder workshops. As pointed out at the September 12, 2005 workshop, the enhanced clarification facility option will require a Section VII modification to the LTCP Consent Decree. The options presented are:

- Pump Out to Blue Plains Complete Treatment Processes. This is the pump out and treatment plan included in the Long Term Control Plan. The strategic planning has identified that this scheme has a detrimental impact on achieving higher levels of nitrogen removal as it extends the period of high flows after a wet weather event.
- Pump Out to Blue Plains Enhanced Clarification Facility. This option, as generally presented at the workshops, would use a new force main to deliver flows to the enhanced clarification facility that is provided for treatment of Excess Flow. This option minimizes the detrimental impacts of extended high flows on nitrogen removal.

However, because there will be a more stringent nitrogen removal requirement under the Chesapeake Bay Program, a modification to the LTCP will be necessary. In order to establish the overall effective modification, WASA is studying several other options to provide cost effective conveyance and treatment of the captured CSS flows, while meeting the need for higher levels of nitrogen removal.
These additional options include, at this point, the following:

- Pump Out to Blue Plains Enhanced Clarification Facility Via the Existing Interceptor System. This option would utilize the existing interceptor system to convey flows to the enhanced clarification facility. This option would utilize the capacity of the interceptor system and enhanced clarification facility to pump out the tunnel in a shorter period of time.
- Pump Out Directly to Enhanced Clarification Facility at Blue Plains. This option would extend the tunnel to Blue Plains and provide a new pump station to convey flows to the enhanced clarification facility. This option would result in Outfall 001 becoming CSO rather than a CSO Related Bypass.

WASA considers the three options that utilize the enhanced clarification facility for CSS tunnel pump out to be advantageous because they minimize the detrimental impacts of extended high flows on nitrogen removal. WASA is exploring the costs, technical and water quality attributes of each of these options and will be providing further information to EPA on its findings.

Additionally, as WASA finalizes these studies, other alternatives may develop that can achieve results comparable to those options already being considered.

Response to Questions

Question 1: Why doesn’t the total flow from Outfall 002, shown on Table 2, decrease when the peaking factor is reduced from 2.0 to 1.5?

Response: Table 1, distributed at the workshop, shows the projected flows and loads for the alternative peaking factors. The intent of the table is to provide a comparison of mass loading for selected parameters at the rated capacity of Blue Plains. The confusion results from showing the same flow and loads for Outfall 002 for both peaking factors. It is true that if the peaking factor were reduced from 2.0 to 1.5, approximately 500 million gallons per year less flow would be discharged from Outfall 002. This would reduce the annual average flow by about 1.4 mgd to 368.6 mgd.

However, the permitted flow for Blue Plains is 370 mgd through Outfall 002 and WASA would not propose reducing the permitted flow for Outfall 002 below 370 mgd. Thus, the annual average flow and associated loads were not reduced for the lower peaking factor. The impact of reducing the peaking factor is that it provides a nominal increase in treatment capacity for the Blue Plains service area.

Table 1. Preliminary Estimates of Anticipated Loading to the Potomac River for Various Scenarios

Currently Approved LTCP

Construction of 4 Additional Primary Clarifiers

Plant Peaking Factor of 2.0, (370/740/511)

TN goal of 7.5mg/L at Outfall 002

		Outfall 001	Outfall 002	To Potomac River
Annual Flow Volume	(MG)	1,331	135,050	136,381
TSS Load	(Mlbs/yr)	1.2	5.6	6.8
BOD Load	(Mlbs/yr)	0.9	7.9	8.8
TN Load	(Mlbs/yr)	0.2	8.4	8.6
TP Load	(Mlbs/yr)	0.02	0.2	0.22

Alternative A - Peaking Factor of 2.0

Construction of ECF for treatment of Excess Flow (Outfall 001 Flow)

Plant Peaking Factor of 2.0, (370/740/511)

TN limit of 4.2mg/L at Outfall 002 (per EPA letter 7/28/05)

		Outfall 001	Outfall 002	To Potomac River
Annual Flow Volume	(MG)	1,331	135,050	136,381
TSS Load	(Mlbs/yr)	0.2	5.6	5.8
BOD Load	(Mlbs/yr)	0.4	7.9	8.3
TN Load	(Mlbs/yr)	0.1	4.7	4.8
TP Load	(Mlbs/yr)	0.002	0.2	0.202

Alternative B - Peaking Factor of 1.5

Construction of ECF for treatment of Excess Flow (Outfall 001 Flow)

Plant Peaking Factor of 1.5, (370/555/511)

TN limit of 4.2mg/L at Outfall 002 (per EPA letter 7/28/05)

		Outfall 001	Outfall 002	To Potomac River
Annual Flow Volume	(MG)	1,826	135,050	136,876
TSS Load	(Mlbs/yr)	0.2	5.6	5.8
BOD Load	(Mlbs/yr)	0.5	7.9	8.4
TN Load	(Mlbs/yr)	0.2	4.6	4.8
TP Load	(Mlbs/yr)	0.003	0.2	0.203

Numbers presented in this table are based on the best available information as of 8/4/2005 and are subject to change based on new information.

Distributed at August 10, 2005 Tier II Workshop

Question 2: Does reducing the peaking factor from 2.0 to 1.5 provide the capability to treat more wet weather flow?

Response: Yes, for the option presented at the workshop. The plant currently has the capability to treat 740 mgd through complete treatment for up to 4 hours as well as provide primary treatment for 336 mgd of excess flow for a total of 1,076 mgd. After 4 hours, the flow to complete treatment is reduced to 511 mgd to protect the biological processes. After this 4-hour period, the treatment capacity is 511 through complete treatment plus 336 mgd of excess flow, for a total of 847 mgd. This condition applies to a peaking factor of 2.0. Flows exceeding the 847 mgd limit that are pumped by the pump stations upstream of Blue Plains during severe storms would be discharged from CSO Outfall 003 at Bolling Field.

If the 4-hour peaking factor is reduced to 1.5, WASA could provide the capability to treat additional flows after the 4-hour period either by increasing the capacity of the enhanced clarification facility, as described at the workshop, or providing additional tunnel storage.

Question 3: What steps does WASA take during a wet weather event and what affect does that have on treatment performance? What are the lingering affects and how long does it take to return to normal operations?

Response: Each day, the plant operations staff measure process variables, assess the condition and performance of the plant, and make changes to maintain process performance and permit compliance. The key measurements in the two biological processes are: sludge settleability, mixed liquor concentrations, and sludge blanket levels in the sedimentation basins. Sludge wasting rates are changed daily to maintain mixed liquor concentrations at the target levels in the secondary and nitrification/denitrification processes to both maximize treatment and ensure preparation for a wet weather event.

Preparation for a Storm Event

When a wet weather event is predicted, even closer attention is paid to the process. The biological process that occurs in the reactors is controlled by sludge wasting rate and the biological mass cannot be adjusted in a matter of hours; rather it takes days for the secondary process and weeks for the nitrification/denitrification process. For that reason, the mixed liquor is consistently maintained at the level that would be required to prevent washout of the sludge in the sedimentation basins at the peak flow rate defined in the permit.

The capacity of the sedimentation basins to handle peak wet weather flows depends on the settling characteristics of the mixed liquor. Plant operators measure the rate at which the sludge settles on a daily basis. When a wet weather event is predicted, the number of reactors that are switched into various wet weather modes depends on how well the sludge is settling. The intent of the wet weather modes is to hold some solids in the reactors to prevent overloading the sedimentation basins and consequent solids washout.

For the secondary reactors, approximately 12 hours before the peak flow is to arrive at the plant, the influent gate to Pass 1 is closed and secondary effluent is fed to passes 2, 3 and 4. Figure 1 shows the operating modes for the secondary reactors.

For the nitrification/denitrification reactors, if the settling rate is poor and a storm is predicted that day, 6 reactors are placed in return only operating mode and 6 reactors are placed in wet weather operating mode. The return only mode stores return sludge, which continues to be fed to the reactor. Since no secondary effluent is fed to the reactor, the reactor is essentially off line and provides no nitrification or nitrogen removal. In wet weather operating mode, the influent gate to Stage 1 of the reactor is closed, return sludge continues to be fed to Stage 1, and all of the secondary effluent is fed into Stage 2. As sludge is stored in Stage 1, the capacity of the reactor to nitrify and denitrify is reduced. Figure 2 shows the operating modes for the nitrification/denitrification reactors.

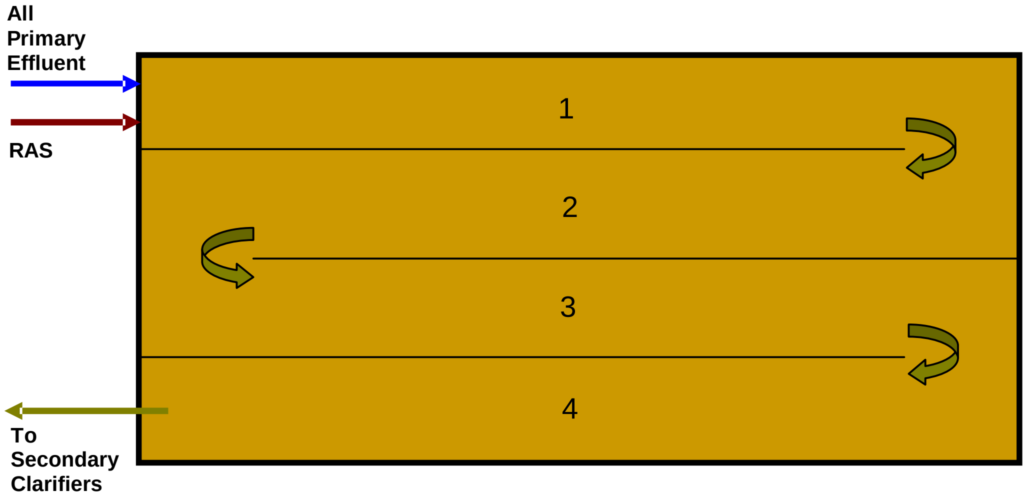
Lingering Affects of a Storm Event

After the peak flow subsides, pairs of secondary reactors are put back into dry weather mode every 8 hours. The reason for placing the reactors back slowly is to prevent overloading the sedimentation basins with the solids that were stored in the reactors during the storm. The secondary treatment process can handle sustained high flows up to 450 mgd in normal operating mode.

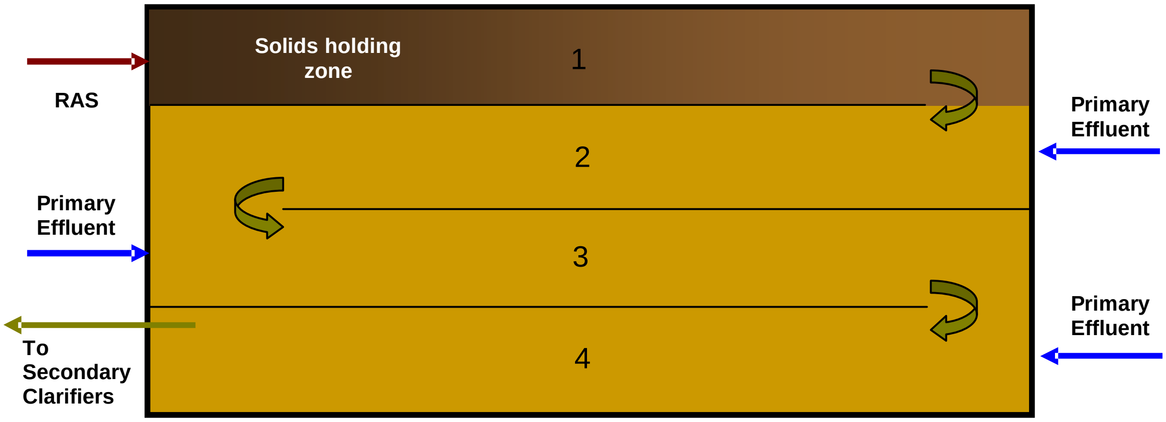
In the nitrification/denitrification process, once the storm is over and lower flows are projected for more than a day, the 6 reactors that are in return only mode are placed in wet weather mode, 2 at a time (one odd and one even) over a 24-hour period. Once all the reactors are in wet weather mode and no storms are predicted, pairs of reactors (one even, one odd) are placed in normal mode every 8 hours. It is noted that it takes 3 days after the storm to get the 6 reactors in return only mode back in wet weather mode and another 2 days to return all of the 12 reactors to dry weather mode. Nitrogen removal is reduced during this 5-day period after the storm event.

The LTCP calls for Blue Plains to operate at a sustained high flow rate of 450 mgd after the storm has passed to empty the tunnel. The CSS tunnel pump out rate would be adjusted so that the plant influent flow would not exceed a rate of 450 mgd. The projected time to empty the combined sewer tunnels, which is the period of sustained high flow, is 2 1/2 days. If the tunnel pump-out is treated by the enhanced clarification facility rather than the nitrification/denitrification system, the time to return the nitrification/ denitrification reactors to normal mode would be reduced. The impacts these lingering effects of a storm event on nitrogen removal are described in the response to Question 4.

Figure 1
Operating Modes for Secondary System

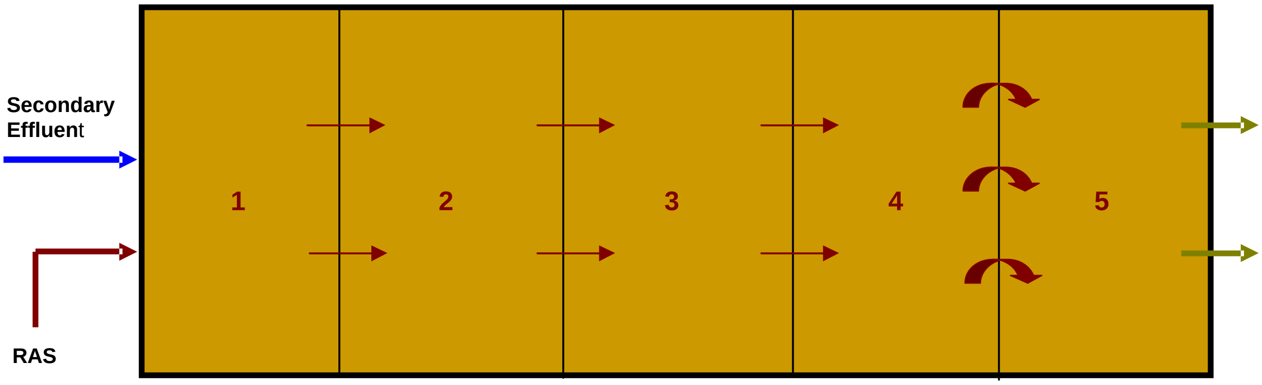


Normal Operating Mode (NOM)

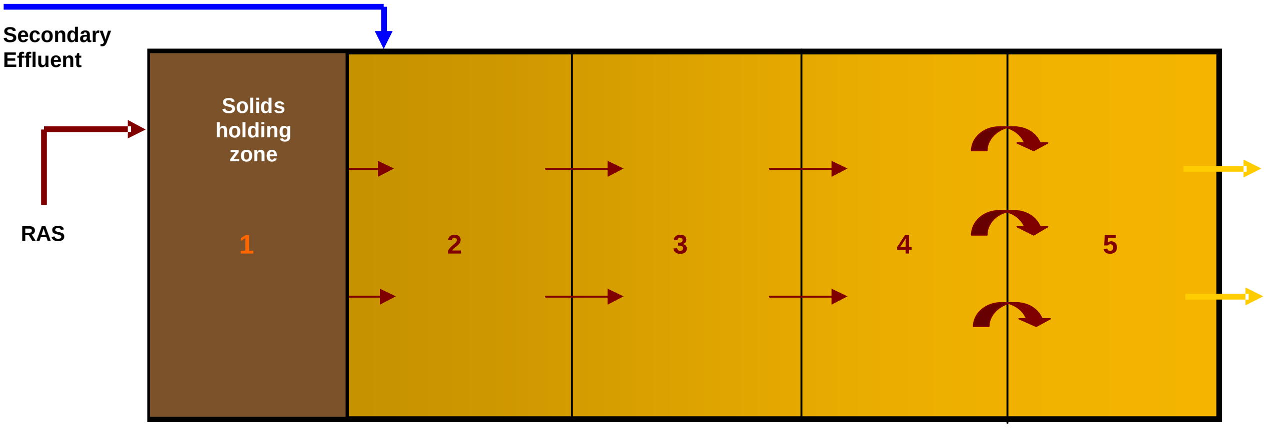


Wet Weather Operating Mode (WOM)

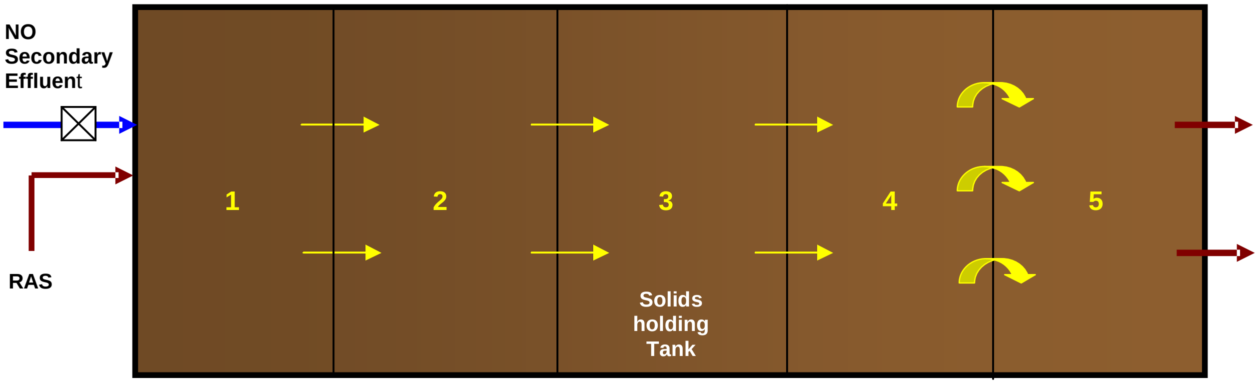
Figure 2
Operating Modes for BNR System



Normal Operating Mode (NOM)



Wet Weather Operating Mode (WOM)



Return Only Operating Mode (ROM)

Question 4: What are the affects of storm events on treatment performance?

Wet Weather Operation Model

A wet weather operation model was developed using the calibrated BioWin plant model to simulate the effect of wet weather events on nitrogen removal. The model was constructed with sufficient detail in the biological reactors to accurately simulate the plant operational response, as described in Question 3, and predict the treatment performance. The temperature selected was 15 ^{o}C, which is the average temperature for May, the month during which the storm was predicted.

The process model was used to evaluate the treatment performance for various scenarios to reflect different peaking factors for complete treatment, as well as treatment options for the CSS tunnel pump out. The scenarios result in different peak flows through complete treatment as well as different durations of sustained high flow.

In each scenario, all dry weather flow (i.e., plant influent flow up to 511 mgd) receives complete treatment. For the first four hours after the plant influent flow exceeds 511 mgd, a peak flow rate is required to be treated through the complete treatment process. The ratio of the peak flow rate to the average annual rated capacity in mgd (i.e., 370 mgd) is called the peaking factor (PF). Plant influent flows above those that are provided complete treatment are called excess flow and will be treated in an Enhanced Clarification Facility and discharged to the river via Outfall 001. Enhanced clarification will use a physical-chemical process that is effective in removing particulate matter from the wastewater. The process is appropriate for treatment of wet weather flows because it takes a short time initiate. An ideal clarifier was used into the model to mimic the expected performance of the enhanced clarification system.

The Long Term Control Plan calls for pumping flows out of the CSS tunnel into the collection system to provide complete treatment at Blue Plains after the storm event. The tunnel-pump-out (TPO) would occur over 59 hours to ensure that the plant influent flow did not exceed 450 mgd. An alternative scenario that was presented at the workshops would pump the CSS tunnel contents directly to the enhanced clarification facility for treatment and discharge through Outfall 001. This scenario allows emptying the tunnel in a shorter period of time because the pump out rate is not constrained by the plant influent flow rate. The following four scenarios were evaluated:

1- The excess flow is treated in an Enhanced Clarification Facility (ECF) and discharged to Outfall 001, and the remaining flow, including CSS tunnel-pump-out (TPO), is treated through complete treatment and discharged to Outfall 002. Two flow scenarios were evaluated:

   a. Peak 4-hr flow to the biological processes = 740 MGD; PF = 2.0, and TPO through Outfall 002

   b. Peak 4-hr flow to the biological processes = 555 MGD; PF = 1.5, and TPO through Outfall 002

2- The excess flow is treated in the ECF and discharged to Outfall 001, and the remaining flow is treated through complete treatment and discharged to Outfall 002. The tunnel-pump-out flow is treated in the ECF and discharged through Outfall 001. Two flow scenarios were evaluated:

   a. Peak 4-hr flow to the biological processes = 740 MGD; PF = 2.0, and TPO through Outfall 001

   b. Peak 4-hr flow to the biological processes = 555 MGD; PF = 1.5, and TPO through Outfall 001

The operational modes both preceding and after a wet weather event are also important to consider. The operations can be classified into 3 phases:

1. Dry Weather – Phase 1
2. Wet Weather – Phase 2
3. Recovery – Phase 3

Table 2 presents the operational modes associated with each phase for the secondary and nitrification/denitrification reactors for the four scenarios. Figure 3 shows the switching of the 12 nitrification/ denitrification reactors over time from Phase 1 through Phase 3.

Phase 1 is the normal dry weather flow mode. The model begins with 1 day of normal dry weather flow (i.e., 370 mgd).

Phase 2 comprises the wet weather event during which reactors are switched into wet weather mode to hold solids in the reactors to prevent washout. The 5-day wet weather period includes instances of plant influent peak flows, followed by several days of sustained plant influent at a rate of 450 mgd. The projected hourly influent flow to Blue Plains for the 5-day wet weather period was obtained from the sewage collection system model that was developed under the LTCP.

Phase 3, the recovery phase, begins when the wet weather event has ended and the combined sewer storage tunnel has been pumped-out. The recovery phase entails switching the reactors from the wet weather modes back to dry weather modes. For purposes of modeling, normal flow (i.e., 370 mgd) was assumed for the 4-day recovery period

Figures 4 and 5 show the wastewater flow through the biological processes for the 10 days simulated in the model for Scenario 1. Specifically, Figure 4 corresponds to Scenario 1.a, the current 4-hour maximum peak flow rate of 740 mgd (PF=2.0) while Figure 5 corresponds to Scenario 1.b, the proposed 4-hour maximum peak flow rate of 555 mgd (PF=1.5). While this figure shows 521 mgd of ECF capacity, other conveyance options may require a lower capacity for the ECF.

Table 2. Operation Modes for Process Modeling Simulations for the Wet Weather Flow Scenarios

Phase 1: Dry weather phase				**Phase 2: Wet weather phase**				**Phase 3: Recovery phase**			
Scenario 1.a PF = 2.0 (TPO to 002)	**Scenario 1.b PF = 1.5 (TPO to 002)**	**Scenario2.a PF = 2.0 (TPO to 001)**	**Scenario2.b PF = 2.0 (TPO to 001)**	**Scenario 1.a PF = 2.0 (TPO to 002)**	**Scenario 1.b PF = 1.5 (TPO to 002)**	**Scenario2.a PF = 2.0 (TPO to 001)**	**Scenario2.b PF = 2.0 (TPO to 001)**	**Scenario 1.a PF = 2.0 (TPO to 002)**	**Scenario 1.b PF = 1.5 (TPO to 002)**	**Scenario2.a PF = 2.0 (TPO to 001)**	**Scenario2.b PF = 2.0 (TPO to 001)**
East Secondary Process – Reactors 3&4											
NOM – *EPE* to stage1, *RAS* to stage1	**NOM** – *EPE* to stage1, *RAS* to stage1	**NOM** – *EPE* to stage1, *RAS* to stage1	**NOM** – *EPE* to stage1, *RAS* to stage1	**WOM** – *EPE* to stages 3a & 3b, *RAS* to stage1	**WOM** – *EPE* to stages 3a & 3b, *RAS* to stage1	**WOM** – *EPE* to stages 3a & 3b, *RAS* to stage1	**WOM** – *EPE* to stages 3a & 3b, *RAS* to stage1	Back to **NOM**	Back to **NOM**	Back to **NOM**	Back to **NOM**
East Secondary Process – Reactors 5&6											
NOM – *EPE* to stage1, *RAS* to stage1	**NOM** – *EPE* to stage1, *RAS* to stage1	**NOM** – *EPE* to stage1, *RAS* to stage1	**NOM** – *EPE* to stage1, *RAS* to stage1	**WOM** – *EPE* to stage2, *RAS* to stage1	**WOM** – *EPE* to stage2, *RAS* to stage1	**WOM** – *EPE* to stage2, *RAS* to stage1	**WOM** – *EPE* to stage2, *RAS* to stage1	Back to **NOM**	Back to **NOM**	Back to **NOM**	Back to **NOM**
West Secondary Process – Reactors 1&2											
NOM – *WPE* is step-fed to stages1 through4, *RAS* to stage1	**NOM** – *WPE* is step-fed to stages1 through4, *RAS* to stage1	**NOM** – *WPE* is step-fed to stages1 through4, *RAS* to stage1	**NOM** – *WPE* is step-fed to stages1 through4, *RAS* to stage1	**WOM** – *WPE* is step-fed to stages 3 & 4, *RAS* to stage1	**WOM** – *WPE* is step-fed to stages 3 & 4, *RAS* to stage1	**WOM** – *WPE* is step-fed to stages 3 & 4, *RAS* to stage1	**WOM** – *WPE* is step-fed to stages 3 & 4, *RAS* to stage1	Back to **NOM**	Back to **NOM**	Back to **NOM**	Back to **NOM**
Nitrification/Denitrification Process – Reactors (1 – 12)											
NOM – *SE* to stage1, *RAS* to stage1	**NOM** – *SE* to stage1, *RAS* to stage1	**NOM** – *SE* to stage1, *RAS* to stage1	**NOM** – *SE* to stage1, *RAS* to stage1	6 reactors in **ROM** – No *SE*, *RAS* to stage1 & 6 reactors in **WOM** – *SE* to stage2, *RAS* to stage1	All reactors in **WOM** – *SE* to stage2, *RAS* to stage1	6 reactors in **ROM** – No *SE*, *RAS* to stage1 & 6 reactors in **WOM** – *SE* to stage2, *RAS* to stage1	All reactors in **WOM** – *SE* to stage2, *RAS* to stage1	6_**ROM** reactors back to **WOM** – 2 reactors every 24 hrs Then 12_**WOM** reactors back to **NOM** – 2 reactors every 8 hrs after sustained flows are over	12_**WOM** reactors back to **NOM** – 2 reactors every 8 hrs after sustained flows are over	6_**ROM** reactors back to **NOM** – 2 reactors every 24 hrs & 6_**WOM** reactors back to **NOM** – 2 reactors every 8 hrs	12_**WOM** reactors back to **NOM** – 2 reactors every 8 hrs after sustained flows are over

NOM = Normal Operation Mode; **WOM** = Wet weather Operation Mode; **ROM** = Return only Operation Mode; **EPE** = East Primary Effluent; **WPE** = West Primary Effluent; **SE** = Secondary Effluent; **RAS** = Return Activated Sludge.

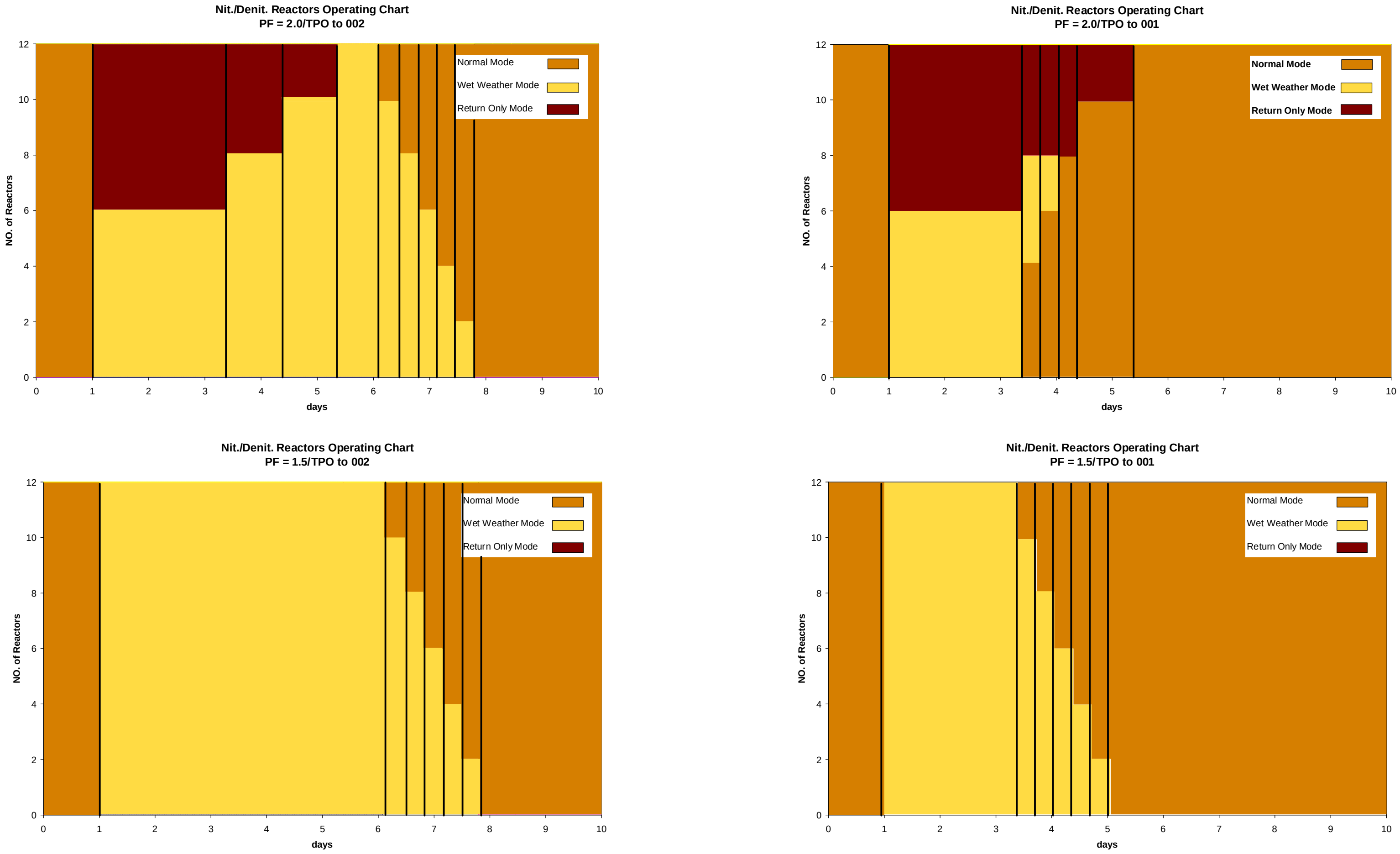


Figure 3. Number of Nitrification/Denitrification Reactors by Mode over Time

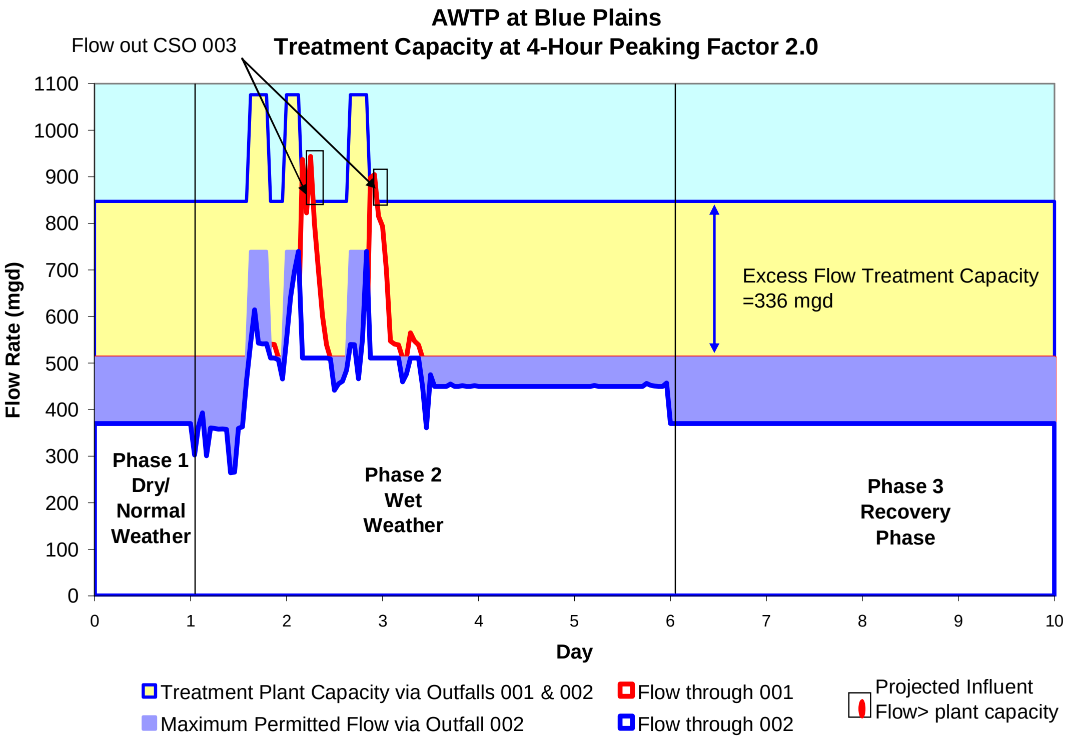
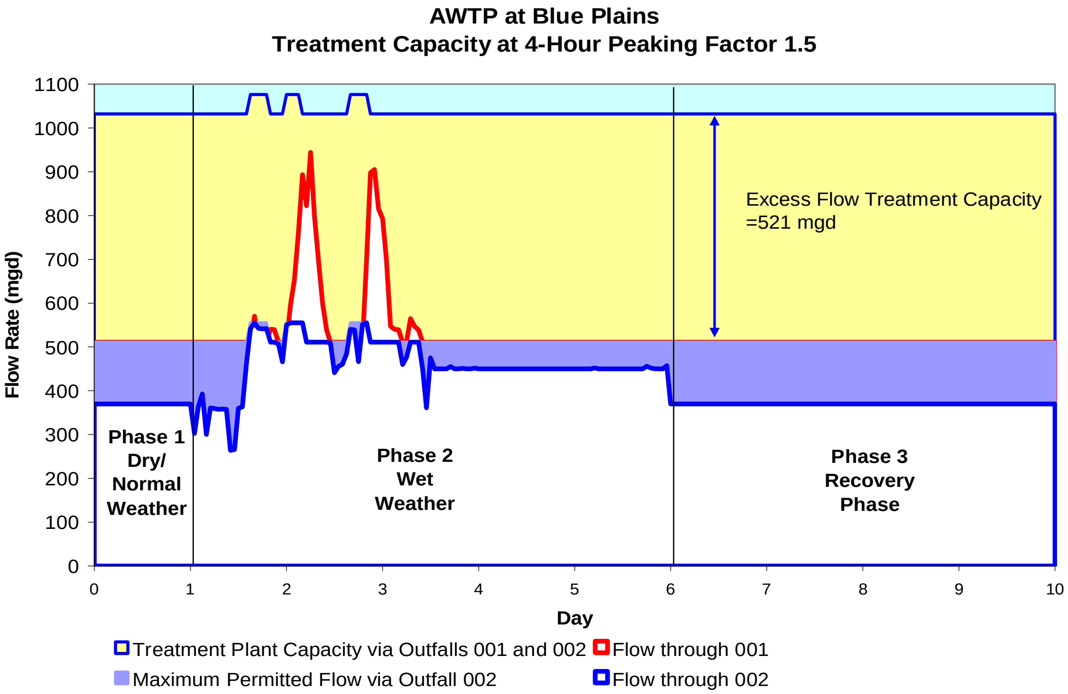


Figure 4. Scenario 1.a PF=2.0 TPO via 002 Wastewater Flow



(Note: Other CSS conveyance options may not require 521 mgd Excess Flow capacity)

Figure 5. Scenario 1.b PF=1.5 TPO via 002 Wastewater Flow

Dynamic Simulation Results – TN discharges

Scenario 1.a: 4-hour Peaking Factor = 2.0, TPO to 002

Figure 6 shows the results of the modeling run for TN discharge loads through Outfall 002 and Outfall 001 during the simulation period. The time increments are 4 hours and the load is shown in the rate of pounds per day (lb/d). In the initial dry weather mode, the plant operated at 370 MGD and the effluent TN loading from Outfall 002 was approximately 11,600 lbs/d. During the wet weather event, the TN discharge through Outfall 002 significantly increased due to reducing nitrification capacity as a result of switching some of the nitrification/denitrification reactors and stages into solids holding tanks. In addition, the TN discharged remained high because sustained high flows from emptying the tunnels after the wet weather event extended the time required to switch reactors back to normal operation. The plant performance was slowly improving as reactors were switched back from return only to wet weather operation and eventually to dry weather operation. A total of 263,000 pounds of TN were discharged from Outfalls 001 and 002 over the simulated 10-day period. The peak nitrogen load shown corresponds to a maximum effluent TN concentration of approximately 10 mg/l from the nitrification/denitrifcation system.

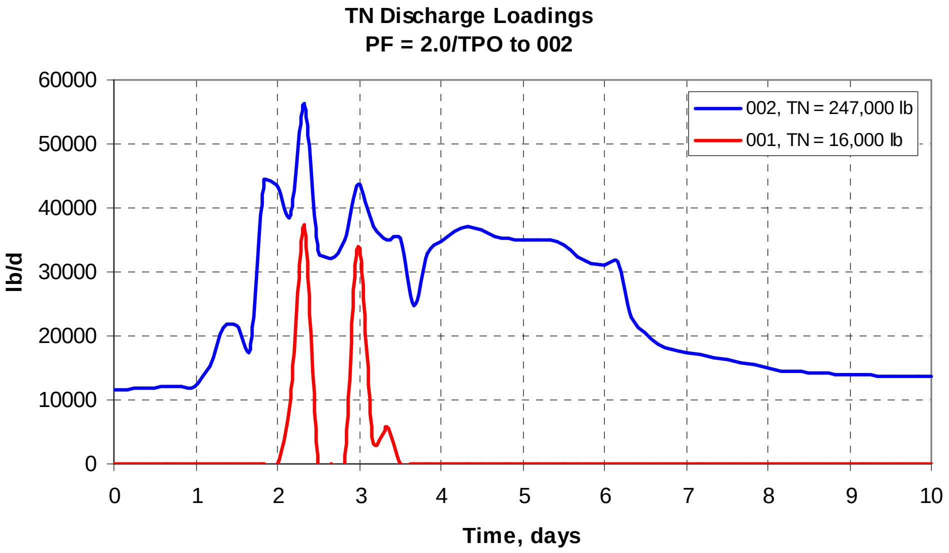


Figure 6. Nitrogen Discharged Via Outfalls 001 and 002 for Scenario 1.a

The TN discharged through Outfall 001 during the wet weather event was approximately 16,000 pounds while the TN discharged through Outfall 002 during the 10 days of simulation was approximately 247,000 pounds. If wet weather had not occurred, the plant TN discharge would have been 116,000 pounds from Outfall 002. An estimated additional 131,000 pounds of TN was discharged via Outfall 002 as a result of the wet weather event.

As expected, total nitrogen load increased as the flow through the system increased. The treated excess flow during the storms (days 2 and 3 on Figure 6) resulted in a nitrogen load to the river from Outfall 001 only during the wet weather event and the loads were directly proportional to flow discharged.

On the other hand, the variation in total nitrogen discharged from Outfall 002 was related to cascading effects of the wet weather event. Prior to the storm, the nitrogen concentration from the nitrification/denitrification system increased as reactors were switched to wet-weather and return-only modes. The result of using these modes to store solids was reduced reactor volume and thus reduced capacity to remove nitrogen. Once the wet weather peak reaches the nitrification/denitrification system (day 2 on Figure 6), the nitrogen load increased due to a combination of higher flow and higher concentration. Following the storm, the total nitrogen load discharged through Outfall 002 decreased but remained at higher than normal loads due to the sustained high plant influent flow from the combined sewer storage tunnel pump-out. During the recovery phase (days 8 to 10 on Figure 6), the total nitrogen discharge concentration returned to normal levels as the reactors were sequentially switched back into dry weather mode. Consequently, as the flow and concentration returned to normal levels, the total nitrogen loading to the river also returned to dry weather values.

Scenario 1.b: 4-Hour Peaking Factor = 1.5, TPO to 002

Figure 7 shows the effect of reducing the 4-hour peaking factor from 2.0 to 1.5 (i.e. 740 mgd to 555 mgd) on TN discharge loads through Outfalls 001 and 002. As shown on the figure, the TN load through Outfall 002 for the simulation period was reduced to a total of 195,000 pounds. The reduction of the peak flow through the nitrification/denitrification process enabled the plant to maintain more process reactor capacity on-line to remove nitrogen during wet weather.

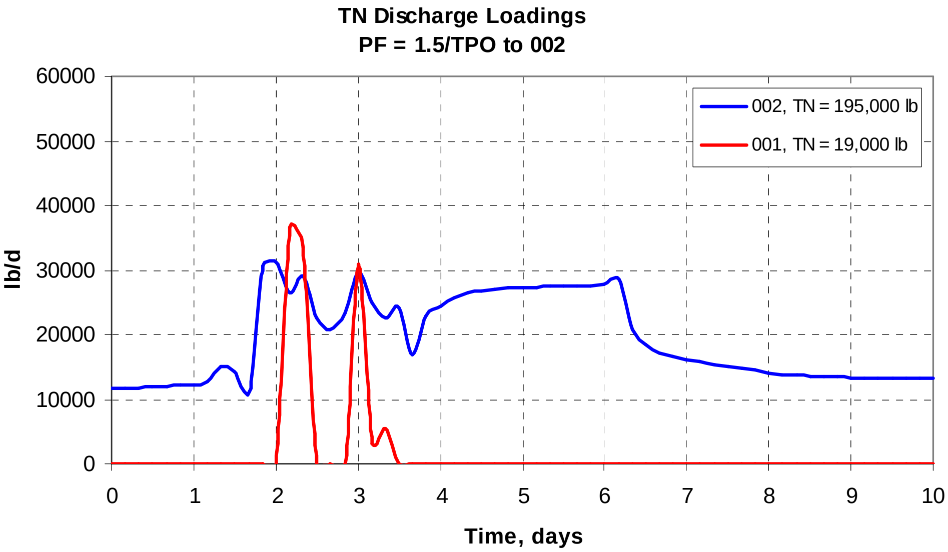


Figure 7. Nitrogen Discharged Via Outfalls 001 and 002 for Scenario 1.b

Despite the fact that TN load through Outfall 001 increased to 19,000 pounds, as compared to 16,000 pounds for Scenario 1.a, the total TN discharged through Outfalls 001 and 002 was approximately 49,000 pounds less than Scenario 1.a. The positive effect of reducing the 4-hour peaking factor from 2.0 to 1.5 on process performance is observed in the TN values.

The maximum effluent TN concentration from the nitrification/denitrification system dropped from approximately 10 mg/l to approximately 7.5 mg N/L.

The patterns of nitrogen loading in scenarios 1.a and 1.b were similar. That is, the nitrogen discharge through Outfall 001 increases in direct proportion to excess flow during the peak wet weather while the nitrogen discharge through Outfall 002 varies through the wet weather and recovery phases. Scenario 1.b yielded a greater total nitrogen load to the river through Outfall 001 than Scenario 1.a due to the increased excess flow volume.

On the other hand, the TN discharge from Outfall 002 for Scenario 1.b was less than for Scenario 1.a because the nitrification/denitrification system was more stable due to the reduction in peak flow through the system. Prior to the storm, the nitrogen concentration from the nitrification/denitrification system increased because the twelve reactors were switched to wet-weather modes, as opposed to switching six of the reactors to return only mode, as required to handle the 740 mgd peak. As described previously illustrated in Figure 2, the return only mode prevents overloading the sedimentation basins, which, while protecting the overall process, reduces the process reactor capacity and results in reduced nitrogen removal capacity. During the storm, when the peak flow reached the nitrification/denitrification system, the nitrogen load through Outfall 002 increased due to a combination of higher flow and higher nitrogen concentration. However, the difference between Scenario 1.a and Scenario 1.b (Figures 6 and 7) is that both the peak flow and the peak concentration are less for the reduced peak flow and therefore the peak nitrogen load is significantly less. Following the storm, the reactors remained in wet weather operation to handle the sustained high flow to Blue Plains from pump-out of the CSS storage tunnels. During this period, the total nitrogen load discharged through Outfall 002 was directly proportional to the flow. During the recovery phase (days 8 to 10 on Figure 7), the total nitrogen discharge concentration returns to normal levels as the reactors were sequentially switched back into normal dry weather mode. Consequently, as the flow and concentration returned to normal levels, the total nitrogen loading to the river also returned to dry weather values.

Scenario 2.a: 4-Hour Peaking Factor = 2.0, TPO to ECF & 001

The hourly plant influent flows used for Scenario 1 included flow from the CSS tunnel pump-out (TPO) in the plant influent flow after the storm event as this flow was routed through complete treatment. Scenario 2 removes the TPO from the plant influent flow and directs the TPO flow to an enhanced clarification facility with discharge via Outfall 001. Figure 8 shows the total plant influent hourly flows used for modeling Scenario 2. Specifically, for Scenario 2, after the wet weather event (between day 4 and day 6), the flow rate through the nitrification/denitrification system was variable and averaged approximately 400 mgd while the flow rate during the same period for Scenario 1 remained constant at 450 mgd.

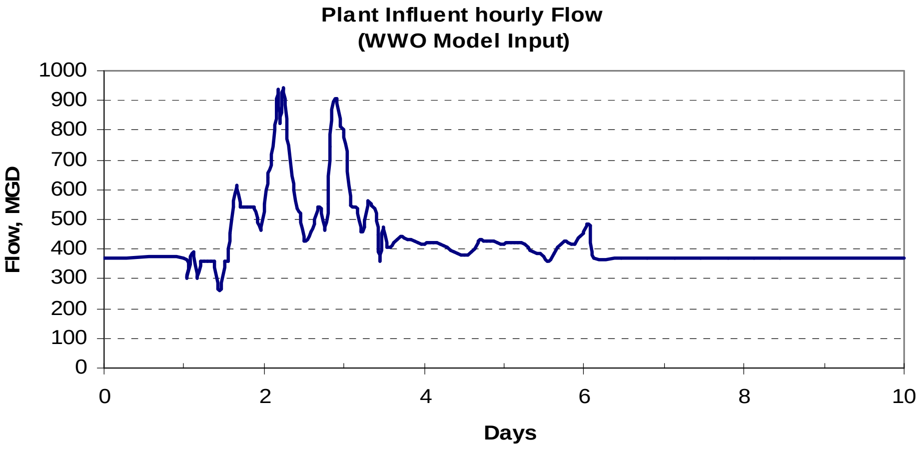


Figure 8. Plant Influent Flows used to Model Scenarios 2.a and 2.b

The TN discharge loads through the plant Outfalls 001 and 002 are shown on Figure 9 for Scenario 2.a. Scenario 2.a assumes a 4-hour peak flow rate through complete treatment of 740 mgd (PF of 2.0) and treatment of TPO through enhanced clarification and discharged through Outfall 001. A total TN load of approximately 240,000 pounds was discharged to the river during the 10 day simulation period. This equates to 23,000 pounds less of TN load discharged to the river compared to Scenario 1.a. because the biological process was more stable and recovered from the wet weather event more quickly.

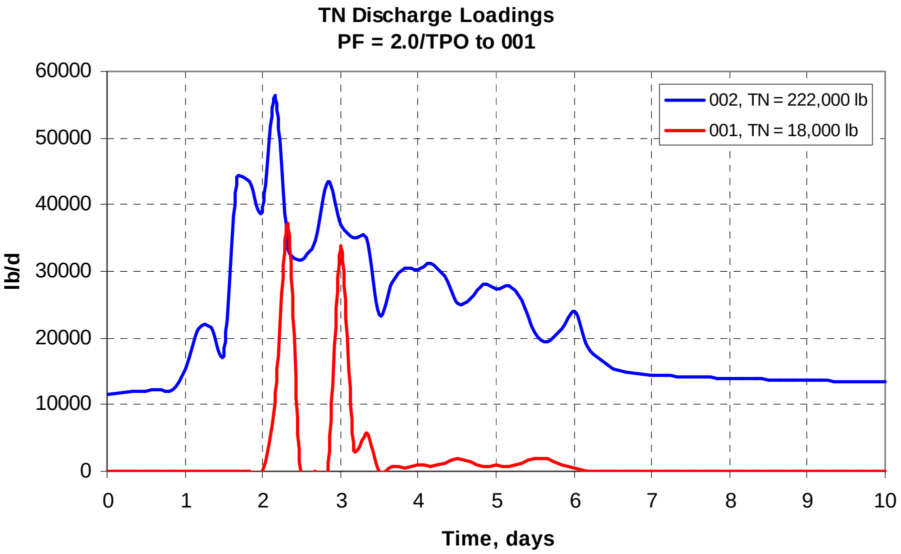


Figure 9. Nitrogen Discharged Via Outfalls 001 and 002 for Scenario 2.a.

The effluent TN load through Outfall 001 increased by 2,000 pounds over Scenario 1.a, as a result of treating the TPO in the enhanced clarification facility, while the TN load through Outfall 002 was reduced by 25,000 pounds over Scenario 1.a. The nitrogen loading through Outfall 002 prior to and during the wet weather event was the same for Scenario 2.a as for

Scenario 1.a because the conditions are the same. The new condition for Scenario 2 is that the 450 mgd high flow rate is not sustained for two and a half days as it is for Scenario 1. The positive impact on nitrogen removal is shown by TN discharge rate decline in the days following the storm. By day 6, all reactors were in dry weather mode under Scenario 2.a. and the total nitrogen concentration was lower than it was for the same day of Scenario 1.a.

Scenario 2.b: 4-Hour Peaking Factor = 1.5, TPO to ECF & 001
The TN discharge loads through plant Outfalls 001 and 002 are shown on Figure 10 for Scenario 2.b. Scenario 2.b assumes a 4-hour peak flow rate through complete treatment of 555 mgd (peaking factor of 1.5) and treatment of TPO through enhanced clarification and discharge through Outfall 001. A total TN discharge load of approximately 193,000 pounds was discharged to the river through Outfalls 001 and 002 during the simulation period, which was the lowest total load to the river of the four scenarios. Reducing the peaking factor and directing TPO flows to Outfall 001 allowed for a more stable operation and quicker recovery of the process from wet weather operations, which reduced the impact of the wet weather event on TN loads to the river through Outfall 002.

The patterns of nitrogen loading in scenarios 2.a and 2.b are similar. That is, the nitrogen discharged through Outfall 001 increased in direct proportion to excess flow during the peak wet weather flows and TPO after the wet weather event, while the nitrogen discharged through Outfall 002 varies through the wet weather and recovery phases.

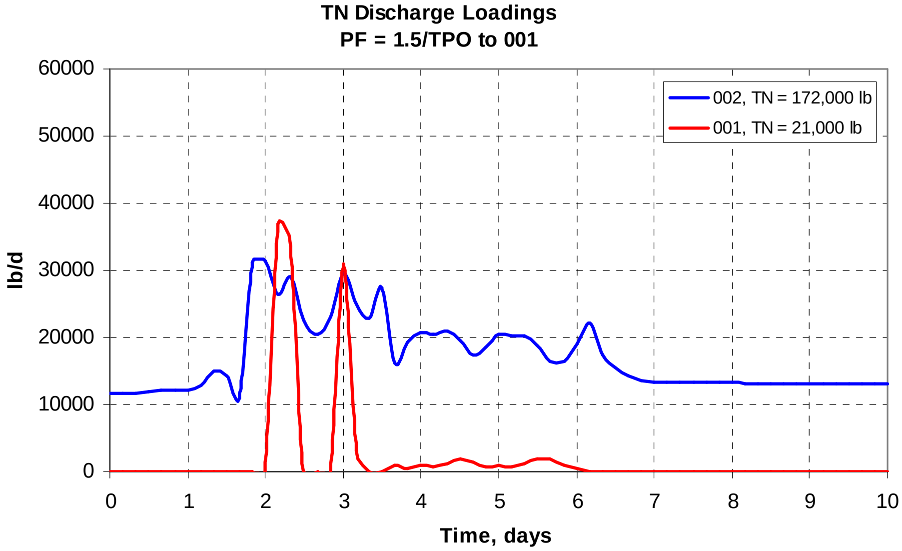


Figure 10. Nitrogen Discharged Via Outfalls 001 and 002 for scenario 2.b

While Scenario 2.b yielded a greater TN load to the river through Outfall 001 than the other scenarios, this increase was more than offset by the significantly lower TN discharged from Outfall 002 compared to the other scenarios. The nitrification/denitrification system was more stable because of the reduced peaking factor and the system recovered from wet weather event more quickly due to elimination of sustained high flow of 450 mgd.

Prior to and during the storm, the nitrogen loading for Scenario 2.b was the same as that for Scenario 1.b because both scenarios reflected the lower peak flow rate of 555 mgd. Following the storm, the pattern of nitrogen load from Outfall 002 is similar to that of Scenario 2.a because it is related to switching reactors back into normal mode. However, the estimated load is less because of the reduced peak flow during the wet weather event. During the recovery phase, the total nitrogen discharge concentration returns to normal levels.

In each of the scenarios, the TN discharge rate was slightly higher at the end of the dynamic simulation period than at the beginning. Comparing the MLSS concentrations for these two points showed that at the end of the simulation the MLSS concentration was higher than that at the beginning. However, the ratios of the different types of microorganisms (i.e. Heterotrophs, autotrophs, and anoxic methanol degraders) also changed. The model showed a shift in the biomass species where the heterotrophs concentrations increased, and the autotrophs & the anoxic methanol degraders concentrations decreased, which caused a slight degradation in nitrogen removals. The shift may have been due to heterotrophic biomass carry over from the secondary system to the nitrification/denitrification system as a result of the wet weather event.

Summary

Table 3 quantifies the TN discharge loads for each scenario. The simulation was performed to illustrate the challenges that wet weather events present at Blue Plains. These numbers are specific to the wet weather event simulated and should not be extrapolated to other events.

Table 3. Predicted Total Nitrogen Discharge to the Potomac River for the Simulated Wet Weather Event

	Scenario	Outfall		Total Load To River
		001	002	
		TN, lb	TN, lb	TN, lb
1	**1-a** PF = 2.0, TPO to 002	**16,000**	**247,000**	**263,000**
	1-b PF = 1.5, TPO to 002	19,000	195,000	214,000
2	**2-a** PF = 2.0, TPO to 001	**18,000**	**222,000**	**240,000**
	2-b PF = 1.5, TPO to 001	21,000	172,000	193,000

The following conclusions can be drawn from the modeling results:

- Wet weather flows negatively impact TN removal due to limiting the capacity of nitrification in the Nitrification/Denitrification process. The limitation results from switching some of the stages and entire reactors to solids holding zones. In addition, switching back the reactors to normal operation, i.e. recovery period, is directly related to the magnitude and duration of the plant influent flows through complete treatment. Minimizing peak flows both during and after a storm results in a stable process that achieves the highest TN removal.

- Reducing the plant influent 4-hour peaking flow from 740 MGD (PF=2.0) to 555 MGD (PF=1.5) provides for more on-line process reactor capacity during wet weather, a more stable operation, and a quicker recovery period, which results in significant reduction in the total TN load to the river.

- Treating the tunnel pump out flow separately in an enhanced clarification facility, and then discharging this flow through Outfall 001 reduces the impact of the high sustained flows after the wet weather event, providing for a quicker recovery period, and hence lower TN loads to the river through Outfall 002.

Question 5: Provide a more specific plan, including costs, to address meeting the proposed TN limit of 4.2 mg/l.

Response: In a letter to DC WASA, dated July 28, 2005, EPA provided its rationale for a total annual nitrogen load limit of 4,766,000 pounds for the next permit. At the rated capacity of 370 mgd, that load corresponds to a concentration of 4.2 mg/l.

The facilities required to achieve a lower TN discharge have to reflect additional flows and load that are anticipated in the future. The added nitrogen load from digester recycle is expected to increase the loading to nitrification/denitrification process by 30%. Additional flows are expected from the ongoing upgrade of the upstream pump stations that will restore their capacity to pump storm flows. The LTCP will capture combined sewer flows for treatment at Blue plains.

The strategic planning has identified the need for two construction projects to maintain a TN discharge of 7.5 mg/l to handle the increased flows and loads described above. These are the Nitrification/Denitrification Upgrade project and the Secondary BNR Upgrade project. These projects have a combined cost of $110 million and are presently in WASA's Capital Improvement Program, however the latter project is not scheduled to start until 2013.

The following table presents the list of facilities and preliminary capital costs considered at this point to be necessary to achieve higher levels of nitrogen removal with the alternative peaking factors for flow to complete treatment. These facilities are needed to improve the biological processes and to solve the hydraulic problems. We have reviewed the ability of the plant to meet a TN permit condition of 4.0 mg/l with various improvements. Given the

TN = 5.0	PF = 2.0 $ million	PF = 1.5 $ million
Enhanced Clarification Facility	130	210
Digester Centrate Treatment Facility	65	65
Secondary Clarifiers	155	-
Spent Washwater Treatment	55	-
TN = 3.0		
New Nitrification/Denitrification Reactors	220	220

current level of uncertainty on a number of issues, we currently believe that the facilities proposed for the TN permit limit of 3 would be required for a TN permit condition of 4.0 mg/l. These uncertainties include:

- Temperature impacts on settling velocity and capacity
- Seeding efficiency of digester centrate treatment
- Lower microorganism growth rates than now assumed during the coldest months of the year
- Permit conditions for operation at cold temperature (less than 12 degree C)
- Requirement to treat CSS tunnel pump out through complete treatment
- Permit conditions related to wet years (50 mgd base flow increase due to infiltration and impact of cold water)
- Permit conditions related to non-biodegradable organic nitrogen

Many of these issues are presently under study in various WASA research projects. The manner in which these issues and boundary conditions are defined in the NPDES permit requirement for nitrogen removal could require additional facilities to be constructed. For example, the process modeling has been performed using a minimum monthly wastewater temperature of 12^{o}C. WASA anticipates there may be several weeks during the coldest month when temperature excursions below 12^{o}C will be experienced. Treatment of CSS tunnel pump out in the nitrification/denitrification process increases the likelihood of this to occur. Should the plant be required to meet low nitrogen levels below a wastewater temperature of 12^{o}C then additional reactor capacity or alternative denitrification processes may be required beyond that now proposed. This additional capacity would be required to ensure complete nitrification of the wastewater during extreme cold conditions. The additional reactor volume required would be dependent on and/or a function of the temperature below 12^{o}C that the plant would be required to operate.