Success Story: How to Include a Wastewater Treatment Plant Backup Discharge into Total Maximum Daily Loads Documents

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The St. Johns County Utility Department proposes to construct the Northwest Wastewater Treatment Plant as a new 100 percent reclaimed wastewater facility, providing advanced wastewater treatment to serve the projected developments in northwest St. Johns County. The Northwest plant will provide advanced wastewater treatment (AWT) with high level disinfection and produce the annual average wastewater quality for TSS:BOD5:TN:TP of 5:5:3:1 mg/L, respectively. The plant is designed to ensure that the effluent discharged to the surface waters contains a minimum dissolved oxygen (DO) concentration of 5.0 mg/L. Table 1 presents the expected plant effluent water quality. The plant will have an off-spec pond to retain effluent that does not meet the targeted wastewater quality for re-treatment. A backup discharge will also be required during periods of wet weather or in other situations when reclaimed water cannot be accepted by customers. Based on the results of the backup discharge effluent outfall alternatives study, the County opted to pursue a backup discharge permit under the Florida APRICOT (A Prototype Realistic Innovative Community for Today) Act, contained in Section 403.086(7), F.S. The discharge location will be in the St. Johns River via the Mill Creek, located less than a mile from the plant site.

To meet the expected growth projections for the plant service area, the first phase of the proposed plant will have a design capacity of 3 million gallons per day (mgd) annual average day flow (AADF). Prior to reaching the full capacity of Phase 1, an additional 3 mgd of capacity will be added under Phase 2, bringing the total plant capacity to 6 mgd, AADF. The plant design flows in mgd and cubic feet per second (cfs) are summarized in Table 2.

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Description of Receiving Water Bodies and Existing Total Maximum Daily Loads (TMDL)

The proposed discharge location for the plant will be to Mill Creek (WBID 2411), a tributary of Sixmile Creek (WBID 2460), and the lower St. Johns River. Figure 1 shows the project location, the discharge location, and the tributary water bodies. Prior to starting the final design of the plant, TMDL for nutrients (nitrogen and phosphorus loads) had been al-

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Table 1. Summary of Anticipated Northwest Wastewater Treatment Plant Effluent Water Quality

Parameter	Unit	Value
BOD_5	mg/L	5
DO	mg/L	5
TSS	mg/L	5
TN	mg/L	3
TP	mg/L	1
Temperature	°C	18-25

Table 2. Design Flows from Northwest Wastewater Treatment Plant (AADF)

Phase	Flow (mgd)	Flow (cfs)
Initial	1.0	1.5
Phase 1	3.0	4.6
Phase 2	6.0	9.3

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located for it in the lower St. Johns River as part of the report, "Basin Management Action Plan (BMAP) for the Implementation of Total Daily Maximum Loads for Nutrients Adopted by the Florida Department of Environmental Protection for the Lower St. Johns River Basin Main Stem."

The TMDL allocation for the plant in the lower St. Johns River is presented in Table 3. The BMAP is regularly revised to reallocate loads to address changing service needs.

Neither the Mill Creek nor the Sixmile Creek sub basins had a published TMDL during the development of the anti-degradation study required for permitting the facility.

Figure 1. Northwest Wastewater Treatment Plant Location and Subbasin Map

Constituent	TMDL Load Allocated in BMAP for Lower St. Johns River Basin, October 2008 (lb/yr)
Total Phosphorus	3,799
Total Nitrogen	12,943

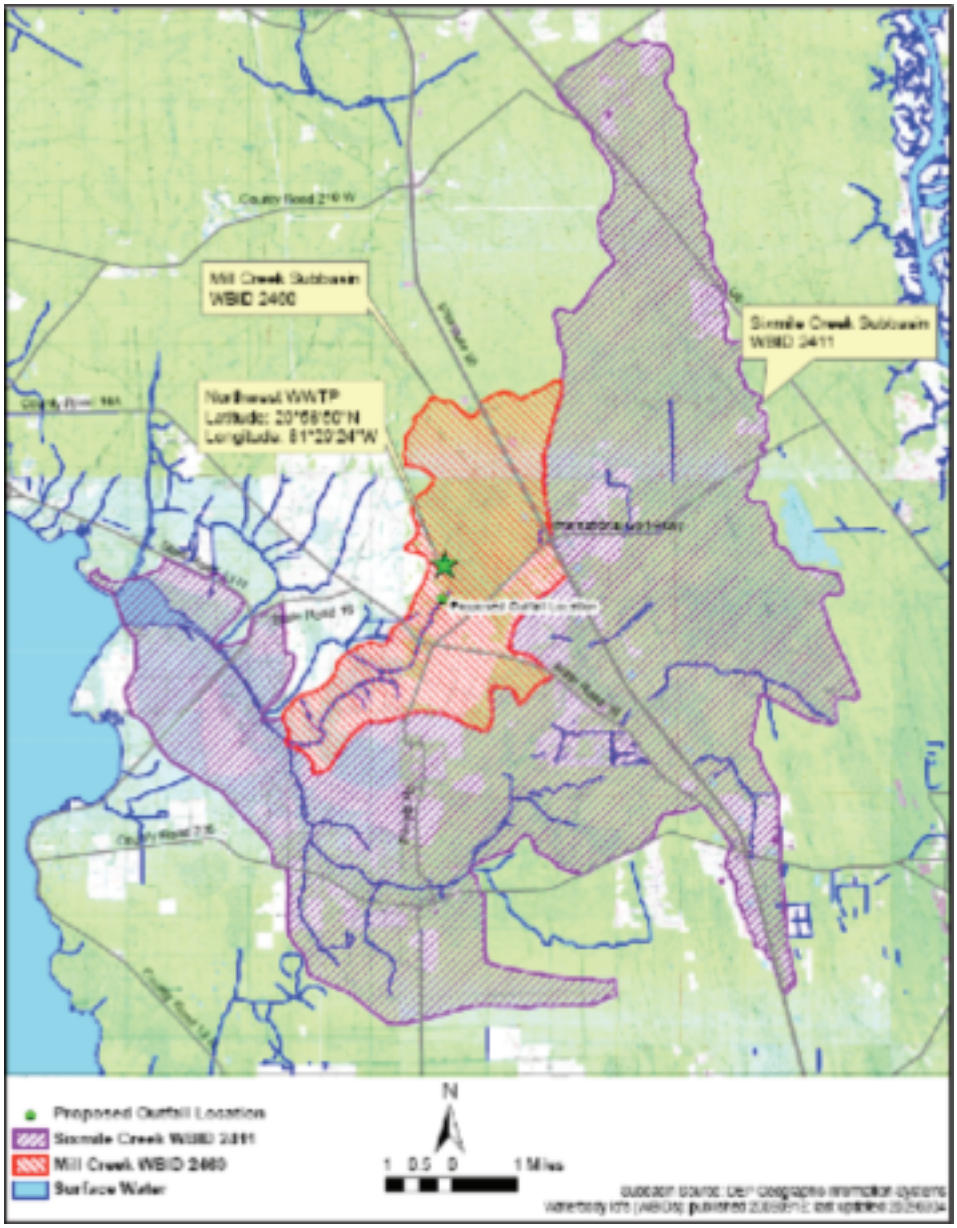

Table 3. Northwest Wastewater Treatment Plant TMDL Load Allocation for Lower St. Johns River

Summary of the Study to Support Plant Discharge in the Sixmile and Mill Creeks

Prior to initiating coordination with the regulatory agencies, the Utility and CDM had performed a technical analysis on the receiving water bodies to evaluate impacts of concern as part of the development of the anti-degradation study required for permitting this facility. A summary of this study is presented below.

Mill Creek Water Quality Background Data

The water quality parameters of concern that were evaluated to determine the effects of the plant APRICOT discharge on Mill Creek are biochemical oxygen demand (BOD_5), dissolved oxygen (DO) total nitrogen (TN), and total phosphorus (TP).

Water quality and other available data were downloaded from the U.S. Environmental Protection Agency (EPA) STORET (storage and retrieval) database. The modern STORET database contains the surface water quality information collected from 2000 to the present by the following regulatory agencies: Division of Environmental Health, Bureau of Water Programs, Florida Department of Environmental Protection (FDEP), Florida Fish and Wildlife Commission, and Florida Lakewatch. Three stations (2132, 2041, and 21430) were located near the crossing of Mill Creek and State Road 16, approximately 4,000 ft downstream of the proposed outfall location. The data points from these three stations ranged from March 20, 2002, to May 5, 2008, with no data points between October 2004 and May 2007. The summary of water quality data from these three sample points is provided in Table 4.

Data in the table were used to characterize the background water quality in Mill Creek at the location of the proposed discharge. These values were used for both low-flow and average flow conditions, since review of the data did not show a significant difference in average DO or BOD concentrations based strictly on water depth (which was used as a surrogate for flow, as flow data was not available).

Modeled Historic Mill Creek Flows

The historical Mill Creek flows, as modeled by the St. Johns River Water Management District Hydrological Simulation Program –

FORTRAN (HSPF), were analyzed to establish an average flow for a 50-year (ranging from 1955 through 2004) data set of hourly rain data acquired from the Jacksonville International Airport, regardless of precipitation levels. In accordance with the flow conditions established above, low flow, average flow, and flood flow (10-, 50-, and 100-year) conditions for the entire Mill Creek Subbasin are presented in Table 5. The flows for the total Mill Creek Subbasin at the confluence with Sixmile Creek were pro-rated appropriately to the proposed outfall location.

It should be noted that the combination of the low-flow condition in Mill Creek and the reduction in reclaimed water demand resulting in a discharge to Mill Creek from the Northwest plant represents a rare scenario. The low-flow condition represents the 10th percentile value for flows on days with a threshold rainfall of 0.05 inch or greater.

Table 4. Mill Creek Background Water Quality Data from STORET

Parameter	Units	Minimum	Maximum	Average	No. of Data Points
BOD_5	mg/L	0.7	6.8	2.6	16
DO	mg/L	2.4	8.5	5.2	36
TSS	mg/L	5	151	28	20
TN	mg/L	0.4	3.0	1.5	31
TP	mg/L	0.1	0.8	0.2	30
pH	-	6.6	7.6	7.0	36
Temperature	°C	11	29	23	36

Table 5. Modeled Historic Conditions for Mill Creek Flow

Location	Low (cfs)	Average (cfs)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)
At confluence with Sixmile Creek	4.0	20.8	1,666	2,282	2,515
At NW WWTP Outfall	2.3	11.8	950	1,301	1,434

Demonstration of "No Cause or Contribute" Relationship to Dissolved Oxygen Violations in Mill Creek

To demonstrate "no cause or contribute" relationship between the DO in Mill Creek and the plant APRICOT discharge, the water quality parameters of concern identified previously were evaluated to compare the effect of the plant effluent on the water quality of the receiving water bodies. The demonstration included BOD sag calculations and dilution calculations of the Mill Creek water quality to the plant effluent water quality at the flow combinations discharging to Mill Creek. The dilution calculations were completed for the initial flow of 1.0 mgd, Phase 1 flow of 3.0 mgd, and Phase 2 flow of 6.0 mgd. For all levels of plant flow, the dilution calculation was conducted for the average flow, 10-, 50-, and 100-year stream flows at the plant outfall location. The in-stream changes and travel time in Mill Creek for total nitrogen (TN) and total phosphorus (TP) were also reviewed.

Biological Oxygen Demand and Dissolved Oxygen

The Mill Creek average background level for Biochemical Oxygen Demand (BOD_5) was generally lower than the permitted plant effluent limit for BOD_5. The average BOD_5 anticipated to be discharged in the wastewater effluent stream was 5 mg/L. The sample values obtained from the available data in Mill Creek indicated an average background level of BOD_5 of 2.6 mg/L, with a minimum of 0.7 mg/L and a maximum of 6.8 mg/L.

The Mill Creek average background level for DO was generally slightly higher than the permitted plant effluent DO concentration. The minimum DO concentration discharged in the wastewater effluent stream will be designed to be 5 mg/L. The sample values obtained from the available data in Mill Creek indicated an average background level of DO of 5.2 mg/L with a minimum of 2.4 mg/L and a maximum of 8.5 mg/L.

The result of the combined concentration of DO showed no negative effect on DO concentration in Mill Creek under all flow conditions at the proposed outfall location as a result of adding the plant effluent flow.

The effect of the BOD discharge on Mill Creek DO was assessed using spreadsheet calculations of processes including first order BOD decay, sediment oxygen demand (SOD) and stream reaeration. The calculations were set up to evaluate an upstream reach of approximately 1 mile and a downstream reach of approximately three miles (to the confluence with Sixmile Creek).

The upstream reach represented the Mill Creek transport system above the proposed outfall location. Values for the processes listed above were assigned such that the calculated DO at the outfall location was equivalent to the average measured DO for Mill Creek (5.2 mg/L, as shown in Table 4).

The first order CBOD decay rate, first order nitrification rate, and the sediment oxygen demand (SOD) were set based on values considered typical of natural streams with relatively low BOD and ammonia levels. The escape coefficient was calibrated so that the calculated first order reaeration rate resulted in a DO of 5.2 mg/L in the upstream reach, under average flow conditions with average inflow concentrations of 5.2 mg/L DO, 2.6 mg/L BOD_5 and 0.12 mg/L for ammonia N. Values of flow depth and velocity were calculated using Manning's equation with channel cross-section geometry, roughness and slope based on hydraulic data presented in an available engineering report for the proposed culvert improvements at State Road 16.

The downstream reach was assigned similar values for SOD and first order BOD decay and nitrification rate, but the calculated reaeration rate was higher based on the increased flow and velocity downstream of the discharge location. The evaluation under average flow conditions (11.8 cfs at the discharge location) suggested that the discharge would only result in DO concentrations of less than 5.0 mg/L in Mill Creek if the discharge was significantly lower than the ambient average DO concentration of 5.2 mg/L. The spreadsheet calculations were done assuming a plant discharge DO concentration of 5.0 mg/L. The calculation results for both the 3 mgd and 6 mgd discharge values showed the DO concentration at initial dilution mixing was 5.1 mg/L. Further downstream, the DO concentration actually increased, to a value of 5.2 mg/L at the confluence with Sixmile Creek due to the reaeration caused by the additional flow.

The evaluation under low-flow conditions (2.3 cfs at the discharge location) again suggested that the discharge may actually increase DO concentrations in Mill Creek. In the upstream reach, the calculations showed that the DO concentration in the creek above the discharge location would likely be lower than the average value of 5.2 mg/L. In the one-mile upstream reach, the DO dropped from 5.2 mg/L to 4.8 mg/L. Assuming a discharge DO concentration of 5 mg/L, the DO concentration

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after initial dilution actually increased from 4.8 mg/L to 4.9 mg/L. For the 3 mgd case, the DO then dropped somewhat as the discharge moves downstream, with a minimum DO of 4.7 mg/L at the confluence with Sixmile Creek. When the discharge was 6 mgd, the minimum DO in Mill Creek was 5.0 mg/L, again at the downstream end of Mill Creek at the confluence with Sixmile Creek. A summary of these calculations is presented in Table 6.

These calculations showed that the additional stream reaeration caused by the additional flow in the creek, and the DO concentration of the discharge, was expected to cancel out any adverse impacts of the additional BOD discharge to the creek. It should be noted that the method of analysis did not include additional dilution from natural inflows downstream of the discharge location in Mill Creek, and therefore was a "worst case" calculation when considering the discharge impacts.

Total Nitrogen and Total Phosphorus

The background levels for TN were generally lower than the maximum permitted plant effluent limit for TN. The maximum TN anticipated to be seen in the wastewater effluent stream was 3 mg/L. The water quality samples obtained from the available data in Mill Creek showed a minimum background level of TP at 0.4 mg/L, an average of 1.5 mg/L, and a maximum of 3 mg/L.

The background levels for TP were generally lower than the maximum permitted NW WWTP effluent limit for TP. The maximum TP anticipated to be seen in the wastewater effluent stream was 1 mg/L. The water quality samples obtained from the available data in Mill Creek showed a minimum background level of TN at 0.1 mg/L, an average of 0.2 mg/L, and a maximum of 0.8 mg/L.

The spreadsheet calculations showed that the travel time from the proposed discharge point to the confluence with Sixmile Creek was 3.2 hours for average flow conditions and 6.0 hours for low-flow conditions without the proposed discharge. When a 3 mgd discharge was added, the travel times range from 2.8 hours (average flow) to 3.8 hours (low-flow). The travel times ranged from 2.6 to 3.1 hours when a 6 mgd discharge was added. Given the limited travel time in Mill Creek, it was unlikely that the discharge would result in additional algal biomass growth in the creek.

Demonstration of No Impact in Sixmile Creek for Northwest Plant Discharge

The study demonstrating no "cause or contribute" relationship to DO violations or adverse impacts in Mill Creek was considered to carry through to the downstream tributary of Sixmile Creek. The mass balance approach showed in Table 6 shows that the plant APRICOT discharge would not impact DO in Sixmile Creek. Additionally, the model used by CDM and the Utility to review the impacts in Mill Creek was provided to EPA to incorporate into the Sixmile Creek basin model used in the development of the TMDL.

Summary of the Regulatory Coordination

Coordination with regulatory agencies for the plant APRICOT backup discharge began in 1999 with the Utility involvement in the lower St. Johns River (LSJR) TMDL stakeholder meetings used to develop the LSJR BMAP. The APRICOT discharge wasteload allocation was incorporated into this final document in 2009. During this time, the Utility and CDM completed the preliminary design and began final design and permitting for the plant. The domestic wastewater facility permit application was submitted to FDEP in April 2009.

Following the permit application submittal, FDEP published a proposed TMDL document for each of the upstream tributaries between the LSJR and the proposed discharge, Sixmile Creek, and Mill Creek. The Sixmile Creek document, "TMDL Not Needed Report Sixmile Creek (WBID 2411); A Natural Condition Assessment for Dissolved Oxygen," proposed delisting of Sixmile Creek based on the findings that natural processes and not a causative pollutant cause the low DO levels in the creek. This study also provided habitat and biological assessments that confirm that it is a healthy environment. The Mill Creek document, "Proposed Total Maximum Daily Loads for Mill Creek WBID 2460 Nutrients and Dissolved Oxygen," proposed TMDL for nutrients and dissolved oxygen in Mill Creek. The proposed document did not include the planned regional beneficial 100 percent reclaimed water facility with limited backup discharge through the Florida APRICOT Act for which the permit application was submitted to the FDEP. The Utility and CDM immediately began coordination with FDEP to discuss how to review and incorporate this discharge into the document.

Meanwhile, EPA reviewed the FDEP proposed TMDL documents for each of the water bodies and determined that a TMDL was required for dissolved oxygen in Sixmile Creek and for nutrients and dissolved oxygen in Mill Creek. In summary, EPA view of both water bodies differed from the FDEP view. The FDEP had determined that a TMDL was not needed for Sixmile Creek, whereas EPA was requiring a TMDL for dissolved oxygen. Additionally, EPA proposed nutrient reductions were approximately 30 percent higher than those proposed by FDEP in Mill Creek, and the limits were proposed as concentrations much lower than advanced wastewater treatment limits.

Technical Letters of Opposition During Public Comment Period

The Utility and CDM reviewed the EPA-proposed TMDL for Mill Creek and Sixmile Creek and immediately prepared letters of public comment to EPA on the proposed TMDL documents to initiate an opportunity to stop the implementation process to further discuss this beneficial reuse project. The letters of opposition included key points which provided the agency with new data on the beneficial reuse project and technical comments for the data on which the proposed TMDLs were based.

Technical Letter of Opposition for Mill Creek

A summary of the technical comments included in the letter for Mill Creek:

- The proposed regional wastewater treat-

Table 6. Dissolved Oxygen Sag Calculations in Mill Creek with 3.0 mgd Northwest Wastewater Treatment Plant Discharge

Location	DO Calculation Results (mg/L)		
	Average Flow (11.8 cfs) w/ Discharge	Low Flow (2.3 cfs) w/o Discharge	Low Flow (2.3 cfs) w/ Discharge
Upstream of Discharge	5.2	4.8	4.8
Discharge Location	5.1	4.8	4.9
Confluence with Sixmile Creek	5.2	3.8	4.7[1]

[1] Without discharge from the plant, DO concentration would be 3.8 mg/L. Discharge from the plant is showing improvement to the existing condition DO concentration.

ment facility modeling results suggested that the wastewater treatment plant discharge was likely to increase the DO concentration in Mill Creek;

- The proposed TMDL did not consider the existing available models and data in Mill Creek, which could provide better indication of the site specific flow and water quality conditions;
- Mill Creek was not modeled by EPA to develop the TMDL due to time conflict. The EPA's intent was to use other comparable TMDL for the establishment of the Mill Creek TMDL. However, the proposed TMDL document did not provide demonstration on why the reference streams were appropriate for Mill Creek, the references were also inconsistent with currently adopted Florida nutrient standards, and adjacent watershed TMDL and proposed TMDL.

As a result, the Utility requested additional time to review the existing data and model with EPA to accurately determine the potential impacts of the proposed plant discharge on the Mill Creek water quality.

Technical Letter of Opposition for Sixmile Creek

A summary of the technical comments included in the letter for Sixmile Creek:

- The documentation provided on the watershed modeling to support the TMDL did not provide sufficient information on the key hydrologic input parameters, base flow concentrations, water budget, and unit loads.
- The documentation provided on the receiving water model to support the TMDL did not provide sufficient information on the model segmentation, kinetic rate parameters, kinetic wave routing to calculate velocity and depth associated with stream flow, and calibration of the model.
- Additional documentation on the models and a copy of the models Loading Simulation Program C++ (LSPC), and the Water Quality Analysis Simulation Program (WASP) was requested to review this information in detail.
- The proposed TMDL was inconsistent with other available data in Sixmile Creek used during the planning and design of the plant, such as "TMDL Not Needed Report Sixmile Creek (WBID 2411): A Natural Condition Assessment for Dissolved Oxygen." This report proposed delisting of Sixmile Creek based on the findings that natural processes and not a causative pollutant cause the low DO levels in the creek. This study also provided habitat and biological assessments that confirmed that it was a healthy environment.

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- As a result, the Utility requested the opportunity to provide a review of the information listed above in detail and to run the models with the proposed plant discharge to demonstrate any impacts to the water quality of the creek.

Meeting with EPA

Within one month of submitting the letters of opposition, CDM and the Utility scheduled a face-to-face meeting with EPA Region 4 in the Atlanta office. At this meeting, the technical data supporting the wasteload allocation was presented. Following the meeting, EPA requested additional input data from the models used for the anti-degradation study that had been prepared for the discharge and additional data from a similar existing plant APRICOT discharge frequency, volume, and duration. The EPA independently reviewed this data and entered it into their models used to develop the TMDL and indicated that the wasteload allocation could be approved for both water bodies. The only step remaining was to have the documents revised with the plant wasteload allocation.

Coordination with FDEP

Several months after this meeting, EPA reproposed the TMDL for Sixmile Creek including the plant discharge. However, FDEP, and not the EPA, promulgated the Mill Creek TMDL for nutrients and dissolved oxygen. Direct discussions began with the TMDL developers from FDEP to discuss the issue. The EPA and FDEP met together to discuss the discharge and the FDEP-proposed TMDL document. It was decided that EPA would allow FDEP to complete the TMDL for Mill Creek as FDEP had previously performed a significant amount of work. A letter with the technical arguments was presented to the Department and approved to be incorporated by appendix to the promulgated TMDL. Since the TMDL had not yet been approved by EPA, the revised TMDL was reviewed by EPA for final approval.

Table 7. Plant TMDL Load Allocation for Sixmile Creek

Constituent	TMDL Allocated for Sixmile Creek August 2010 (mg/L) (6 mgd Discharge)
Total Phosphorus	1
Total Nitrogen	3
BOD	10

Table 8. Plant TMDL Load Allocation for Mill Creek

Constituent	TMDL Allocated for Mill Creek February 2011 (mg/L) (6 mgd Discharge)
Total Phosphorus	1
Total Nitrogen	3
BOD	5

Incorporation of Wasteload Allocation into Sixmile Creek and Mill Creek TMDL

The EPA applied the inputs of the Mill Creek model to the Sixmile Creek model and provided a wasteload allocation in the "Proposed Total Maximum Daily Loads for the Sixmile Creek WBID 2411 Dissolved Oxygen, August 2010." The TMDL allocation for the Northwest plant discharge under the APRICOT Act is presented in Table 7.

Following review and approval from FDEP, and subsequently from EPA, the evaluation of the plant APRICOT discharge in Mill Creek was included by appendix in the TMDL document showing no "cause or contribute" to DO violations in the basin and allowed the future discharge. The TMDL allocation for the plant discharge under the APRICOT Act into Mill Creek is presented in Table 8.

Summary

This study is an example that can be followed to demonstrate that the discharge of a wastewater treatment plant does not impact the quality of the receiving streams and therefore the discharge of the plant can be included in the TMDL documents. As part of this project, an analysis of the plant backup discharge flow with the available water quality background data and stream flow data was completed and was used in conjunction with close coordination with the regulatory agencies responsible to identify an allowable backup discharge for the beneficial reuse facility and to protect the receiving water bodies. The critical success factors for this project included the project specific analysis and evaluation performed early in design, close monitoring of proposed regulations for water bodies in project area, and proactive coordination with FDEP and EPA to provide feedback on proposed regulations, as well as project specific data and modeling results to demonstrate the no impact of the proposed discharge.