Combined Work/Quality Assurance Project Plan (CW/QAPP) for Nitrogen Monitoring in Deer Island Treatment Plant Waste Streams

Massachusetts Water Resources Authority

Environmental Quality Department
Report ms 2000-16

Combined Work/Quality Assurance Project Plan (CW/QAPP)

for

Nitrogen Monitoring in Deer Island Treatment Plant Waste Streams

Massachusetts Water Resources Authority
Environmental Quality Department
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Kelly Coughlin, Biologist, ENQUAD

4. Quality Assurance Management
William Andruchow, QA Manager, Department of Laboratory Services

5. Project Description

5.1. Objective and Scope

This plan is written to comply with Part I.8.e.ii of the MWRA's NPDES permit. Per the permit, the MWRA "shall implement a monitoring program to characterize the quality of wastewater streams within the treatment plant. The plan shall be designed to produce data which would facilitate the selection of nitrogen removal technology and to facilitate the design of nitrogen removal facilities, if necessary."

During wastewater treatment most organic nitrogen in sewage influent is metabolized to ammonia-nitrogen. Inorganic nitrogen (ammonia-nitrogen and nitrate/nitrite) in sewage effluent can enrich receiving water bodies, resulting in undesirable growth of algae and reduced dissolved oxygen concentrations. If receiving waters cannot provide adequate dilution to keep inorganic nitrogen levels low and adverse conditions persist, it may become necessary to increase nitrogen removal from wastewater. Biological nitrogen removal processes (BNR), if implemented, will increase nitrogen removal by converting ammonia to nitrate-nitrogen, and convert nitrates to nitrogen gas through denitrification. This plan is designed to monitor the parameters necessary to make informed decisions regarding the implementation of BNR.

Primary treatment plants remove approximately 5 to 10% of total nitrogen from raw wastewater through primary treatment, due to settling of nitrogen-containing solids. Secondary treatment plants, such as the Deer Island Treatment Plant, remove 15 to 30% of nitrogen due to bacterial assimilation and sludge wasting, in addition to settling of solids. Parameters monitored as part of this plan will aid in the selection and design of a system that will further increase overall nitrogen removal should such a system be necessary.

5.2. Data Usage

The nitrogen monitoring project will provide data that will be used to characterize nitrogen levels in wastewater streams within the Deer Island Treatment Plant (DITP), and in addition to other parameters, will be used to evaluate the viability of advanced nitrogen removal options.

Existing monitoring data will be used where available, and additional monitoring will be performed as needed. Data will be collected and evaluated according to procedures used for all NPDES permit required monitoring projects at DITP. Standards for data accuracy are described in Section 9.

Results will be included in DITP monthly operational summary reports, and summarized annually in NPDES fiscal year-end reports.

5.3. Technical Approach

Monitoring carried out as part of this plan will characterize both nitrogen levels and those parameters that may impact nitrogen levels at different locations in the waste stream. In addition to the routine monitoring of influent and effluent locations, recycle streams, primary effluent batteries and secondary effluent batteries will be sampled to measure nitrogen inputs. The parameters at these locations include: temperature, pH, alkalinity, dissolved carbon dioxide, 5-day biochemical oxygen demand (BOD_5), 5-day carbonaceous biochemical oxygen demand ($cBOD_5$), total Kjeldahl nitrogen (TKN), and ammonia.

Should the implementation of an advanced nitrogen removal system be necessary, data collected as part of this monitoring would facilitate the design process. The conditions that must be maintained for optimal functioning of a nitrogen removal system (as they pertain to the parameters included in this monitoring program) are listed below.

1. Temperature: The optimal temperature for nitrification is between 30 and 36 °C, with growth possible between 4 and 50 °C.
2. pH: Optimum pH for nitrification is near 8.0, with the nitrification rate approaching zero below 6 or above 10.
3. Alkalinity: Sufficient alkalinity must be maintained so that pH does not drop during nitrification, thereby inhibiting growth of nitrifying bacteria.
4. Dissolved Carbon Dioxide: Carbon dioxide (as calculated from bicarbonate alkalinity) is required by nitrifying bacteria. Bicarbonate ions are used by nitrifying bacteria to convert ammonia to nitrate and nitrite, and bicarbonate alkalinity could be a limiting factor in wastewater should increased nitrogen removal be required.
5. BOD_5: Concentrations must be low enough to allow growth of nitrifying bacteria (for attached growth reactors) and not be outcompeted by heterotrophic bacteria. Determination of loading rates and the ratio of BOD_5 to other parameters (e.g., TSS or TKN, depending on the BNR system to be employed) can also be important when selecting a system configuration.
6. TKN: TKN includes organic nitrogen and ammonia-nitrogen. Most of the organic nitrogen component of TKN is converted to ammonia-nitrogen during secondary treatment.

7. Nitrate/Nitrite: A form of nitrogen that is the product of biological nitrification of ammonia. It is present at negligible concentrations in raw influent. Nitrate can be converted to nitrogen gas during biological denitrification.
8. Ammonia: Major component of nitrogen in sewage effluent (approximately 60% of total nitrogen in raw wastewater is ammonia), and the primary product of secondary treatment, where organic nitrogen is converted to ammonia. It is a major nitrogen source for marine microorganisms. During nitrification, ammonia is converted to nitrate/nitrite.

5.4. Criteria for Selection of Sampling Locations

Some locations were selected based on existing sampling protocols that are part of current monitoring projects; others were added specifically for this project. Table 1 shows the sampling locations. Two stations were selected to measure the nitrogen levels entering the plant, three were selected to measure nitrogen inputs from recycle streams downstream of the influent locations, and four locations will measure the nitrogen levels following primary treatment (samples from individual batteries will be composited for some analyses). Three sites in the secondary basins indicate nitrogen levels following secondary treatment, and the final effluent site will indicate nitrogen levels immediately prior to discharge through the outfall tunnel.

Table 1. Sampling Locations for DITP Nitrogen Monitoring

Site Id	Description
AB00	South System Raw WW Influent
AD00	North System Raw WW Influent (Grit Facility)
EJ00	Gravity Thickener Overflow
PREF (composite of primary effluent batteries)	Battery A Primary Effluent (Site BA13)
	Battery B Primary Effluent (Site BB13)
	Battery C Primary Effluent (Site BC13)
	Battery D Primary Effluent (Site BD13)
SEEF (composite of secondary effluent batteries)	Secondary Battery A Secondary Effluent (Site SAEL)
	Secondary Battery B Secondary Effluent (Site SBEL)
	Secondary Battery C Secondary Effluent (Site SCEL)
WCCC	Waste Sludge Centrifuge Centrate
DCCC	Digested Sludge Centrifuge Centrate
FEFF	Final Plant Effluent
DEFF	Final Plant Effluent, backup sampling location

5.5. Parameters Monitored

Parameters to be measured for nitrogen monitoring are listed in Table 2. Parameters include total Kjeldahl nitrogen, ammonia, nitrate/nitrite, BOD_5, $cBOD_5$, pH, temperature, alkalinity and dissolved carbon dioxide. Dissolved carbon dioxide will be calculated from the alkalinity test.

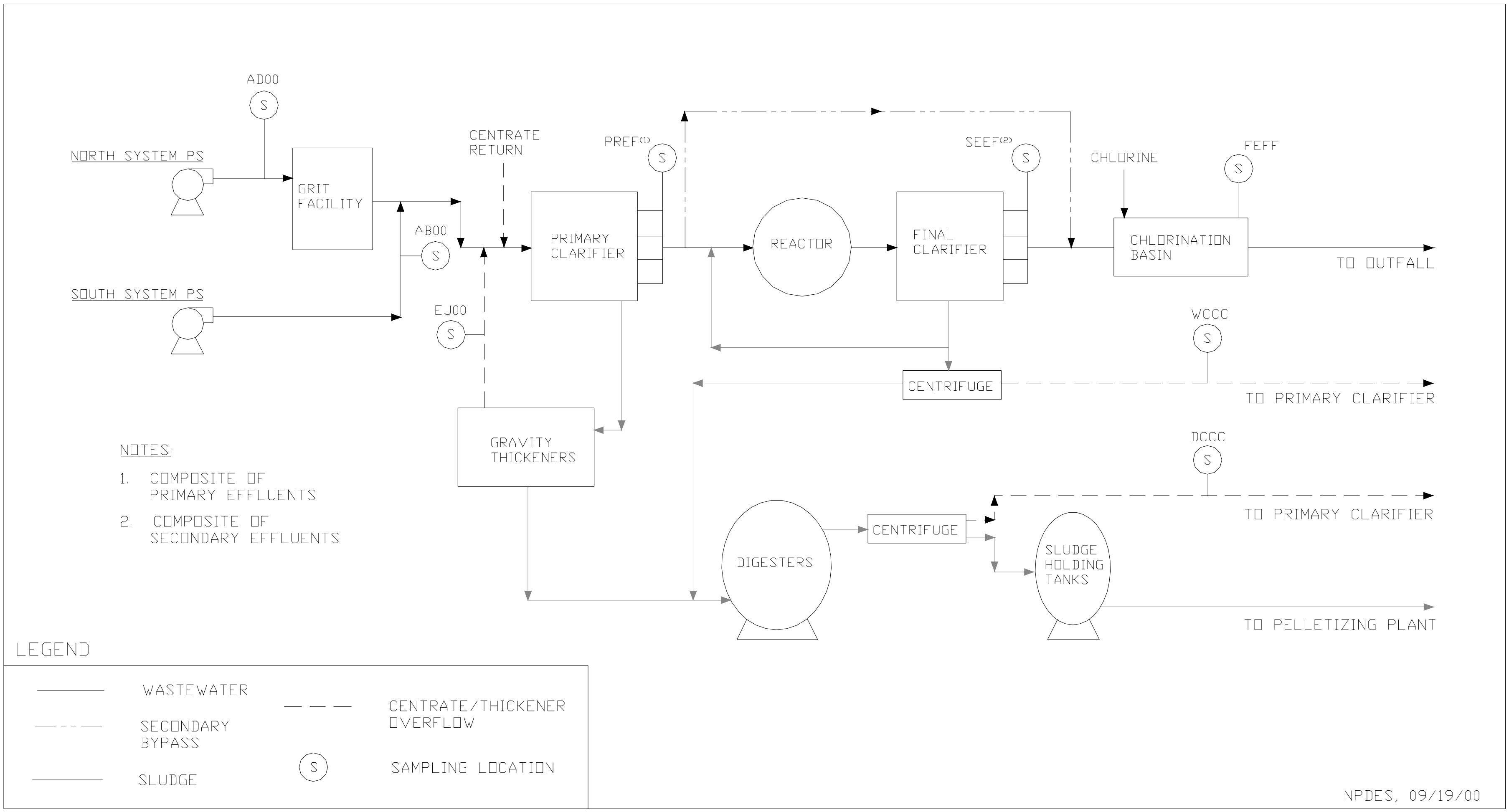
6. Sampling Methodology

24-hour composite samples will be collected at both the North System and South System influent locations, in each of the primary effluent basins, in each the secondary effluent basins, and in the final effluent. Sources of additional nitrogen input within the plant (nitrogen recycle) will also be sampled. Samples collected from each of the primary batteries will be composited into one sample prior to analysis, and the number of battery samples composited will depend on which batteries are in operation at the time of sampling. Samples for the secondary effluent will be composited in a similar manner.

Table 2. Laboratory Analyses for DITP Nitrogen Monitoring

Parameter	LIMS test code	Method	Units	Storage/holding time	Sample Type
Total Kjeldahl Nitrogen	TKN-AQKDT	SM 4500-N_{org} B	mg/L	Refrigerate, H_2SO_4 to pH <2 /28 days	Composite
Ammonia	NH3-AQAAN	EPA 350.1	mg/L	Refrigerate, H_2SO_4 to pH <2 /28 days	Composite
Nitrate/nitrite	NO32AQAAN	EPA 353.2	mg/L	Refrigerate, H_2SO_4 to pH <2 /28 days	Composite
BOD_5	BOD-AQDOX	SM 5210B	mg/L	Refrigerate /24 hours	Composite
$cBOD_5$	CBOD-AQDOX	SM 5210B	mg/L	Refrigerate /24 hours	Composite
pH	PH--AQFLD	Orion 230A pH meter	s.u.	Analyze *in situ*	--
Temperature	TMPCAQFLD	Orion 230A pH meter	° F	Analyze *in situ*	--
Alkalinity	ALK-AQTPO or ALK-AQTPO	EPA 310.1, SM 2320B	mg/L	Refrigerate /14 days	Composite
Dissolved Carbon Dioxide (calculated)	CO2-AQTPO	SM 4500-CO_2 D	mg/L	--	--

Figure 1. Deer Island Nitrogen Monitoring Sampling Locations



7. Sampling schedule

Sampling frequency will vary by location and parameters measured, to allow for data from several existing monitoring projects to be incorporated. The sampling frequency for each parameter group is shown in Table 3. The project codes used by the Laboratory Services' Laboratory Information Management System (LIMS) are also shown.

- <u>BOD and cBOD</u>: BOD_5 and $cBOD_5$ samples will be collected in influent and primary, secondary, and final effluent locations. The influent and final effluent samples will be collected daily, and the primary and secondary effluent samples (with individual batteries composited) collected once per week.
- <u>Temperature and pH</u>: Temperature and pH measurements will be taken at all locations one day per week, with the exception of influent and final effluent locations which will be measured daily. For the primary and secondary effluent samples, measurements will be taken at individual battery locations.
- <u>Nutrients, alkalinity and dissolved carbon dioxide:</u> Total Kjeldahl nitrogen, ammonia, nitrate/nitrite, and alkalinity will be sampled once per week at all locations (with the primary and secondary effluent batteries composited, as described in Section 6). Dissolved carbon dioxide will be calculated from alkalinity.

In order to properly characterize nitrogen and related parameters at different points in the waste stream, every effort will be made to consolidate sampling such that: (1) all locations in the waste stream will be sampled for a given parameter group at approximately the same time (i.e., within several hours) and (2) collection of monthly samples will be synchronized with collection of weekly and daily samples. Samples collected during effluent toxicity sampling weeks (usually the first full week of the month) will be collected on the first day of toxicity sampling.

Table 3. Study organization and frequency of sample collection

Existing monitoring projects will be used and/or modified to meet the requirements of this plan.

Parameters Measured	Sampling Locations	LIMS project codes	Sampling frequency
BOD_5, $cBOD_5$	PREF, SEEF	TP-NUT	Once per week
	AB00, AD00, FEFF	DINPD	Daily
Temperature, pH	EJ00, BA13, BB13, BC13, BD13, SAEL, SBEL, SCEL, WCCC, DCCC	TP-NUT	Once per week
	AB00, AD00, FEFF	DINPD	Daily
Total Kjeldahl nitrogen, ammonia, nitrate/nitrite, alkalinity, dissolved carbon dioxide (calculated)	AB00, AD00, EJ00, PREF, SEEF, WCCC, DCCC	TP-NUT	Once per week
	FEFF	NP-DMR	
	FEFF	NP-DMR	

Sampling location codes are described in Table 1.

8. Project Organization and Responsibilities

Grace Bigornia-Vitale, Senior Program Manager, NPDES Compliance is responsible for overseeing data analysis and reporting.

David Duest, Program Manager, Process Monitoring is responsible for reviewing data for accuracy and for providing guidance to laboratory and DITP staff regarding sample collection and analysis, and for summarizing data for monthly operational reports.

Kelly Coughlin, Biologist, is responsible for making data accessible from Deer Island and LIMS databases for report production and data analysis related to NPDES reporting.

Ethan Wenger, Laboratory Supervisor, has responsibility for overseeing sample collection, delivery of samples for analysis, and pH and temperature measurements.

Nancy McSweeney, Laboratory Supervisor, oversees nutrient and BOD/cBOD analysis of wastewater samples.

Patricia Sullivan, Laboratory Supervisor, is responsible for alkalinity and (calculated) CO2 analyses.

William Andruchow, Laboratory Manager, is the Quality Assurance manager for Laboratory Services and oversees the development of SOPs for laboratory analyses.

9. Data Quality Requirements and Assessments

9.1. Sampling

9.1.1. Precision and Accuracy

Precision and accuracy of effluent sampling procedures are ensured by collection methods documented in the Department of Laboratory Services' Central Laboratory standard operating procedures. The sampling objective is to obtain uncontaminated samples representative of each location. Procedures will follow standard methods that can achieve this objective. All samples will be handled and stored according to procedures described in Section 10.

9.1.2. Completeness

In the event of sample loss or treatment disruption, the Program Manager, Process Monitoring will determine the need for appropriate corrective action (e.g., resampling or sampling in a different location, if necessary). The corrective action taken by the Program Manager and/or other deviations from the sampling plan will be documented in the LIMS system by sample collection staff.

9.1.3. Representativeness

Routine weekly sampling ensures that samples will be representative of wastewater from each process location. Proper handling, storage and analysis of samples will also ensure representativeness, so that the material analyzed reflects the material collected as accurately as possible.

9.2. Field measurements

Data quality requirements and assessments for pH meter and temperature data are documented in Central Laboratory standard operating procedures.

10. Sampling and Analytical Procedures

10.1. Sample Collection

Central Laboratory staff will collect influent and final effluent samples; remaining locations will be sampled by DITP staff. Sampling will be conducted according to Central Laboratory standard operating procedures. Composite samples will be collected in 2.5-gallon glass jars from composite samplers located at each sample location and transferred to smaller containers prior to storage and/or analysis. Measurements for temperature and pH are made *in situ*.

10.2. Laboratory Analytical Procedures

The analytical methods to be employed in this plan are EPA methods approved for NPDES monitoring, and are in accordance with Central Laboratory standard operating procedures. The analytical methods are listed in Table 2.

10.3. Sample custody

All samples will be collected and analyzed by the Central Laboratory. Internal chain of custody forms and sample bottle labels are generated according to procedures set forth in Central Laboratory standard operating procedures. Samples are assigned identification numbers prior to collection, issued to sample collectors and then checked in upon return to the laboratory following collection. Sample custody is tracked throughout the collection, transport, analysis and disposal process.

11. Calibration Procedures and Preventative Maintenance

Field and laboratory instruments are calibrated and maintained according to Central Laboratory standard operating procedures.

12. Documentation, Data Reduction and Reporting

All data will be recorded initially into bound laboratory notebooks or onto established data forms. Sampling logs associated with custody and tracking will be held in the custody of the laboratory supervisor responsible for sample management.

Field measurements and laboratory analytical results will subsequently be entered into the Department of Laboratory Services' Laboratory Information Management System (LIMS). After data has been validated and approved by the Central Laboratory, Deer Island Process Monitoring staff will then export the records from LIMS for inclusion into the Deer Island Treatment Plant Operations Management System (DITP OMS) Oracle database. Monthly data summaries will be produced as part of the Process Control and Engineering Operations Performance Summary and will be reviewed by DITP Process Monitoring and NPDES Compliance staff.

13. Data Validation

The Central Laboratory's data validation and reporting procedures are documented in Section 7.0 of its Quality Assurance Management Plan (QAMP). In addition, the Process Monitoring Manager will review all data for technical reasonableness.

The Review, Validation, and Approval processes described in the QAMP are employed to ensure conformity with Laboratory Services and with client data quality requirements. Reported results must be traceable. Traceability is the characteristic of data that allows a final result to be verified by review of its associated documentation. All laboratory results for a given sample must be traceable throughout the entire analytical process applied to the sample. Traceability is maintained through LIMS (which stores all of the pertinent data associated with the sample) and by the utilization of various logbooks (preparation, analytical, and instrumental), instrument raw data printouts, electronic files, and spreadsheets.

If the data are not consistent with the QC objectives specified in the QAMP or specified in this plan, the data will be marked as invalid and will either be excluded from or flagged as invalid in the DITP OMS database.

14. Performance and System Audits

The Department of Laboratory Services' audit procedures are documented in Section 9.0 of its Quality Assurance Management Plan. A performance audit provides a quantitative assessment of the analytical measurement process. It provides a direct and independent, point-in-time evaluation of the accuracy of the various measurements systems and methods. This is accomplished by challenging each analytical system (method/procedure) with an accepted reference standard for the analyte(s) of interest. The Central Laboratory annually participates in Discharge Monitoring Report (DMR) Performance Efficiency (PE) studies and biannually in the Water Pollution (WP) Performance Efficiency studies. Acceptable performance on these PE samples is required for NPDES self-monitoring analyses and Massachusetts DEP Certification, respectively. In addition, internally administered performance evaluation samples may be submitted to the laboratory sections on a random, as required, basis and for those analytes not present in the WP samples.

A systems audit is a review of laboratory operations to verify that the laboratory has the necessary facilities, equipment, staff and procedures in place to generate acceptable data. It represents a subjective evaluation of the strengths and weaknesses of the Central Laboratory and identifies areas that need improvement. System audits are performed quarterly by the QA Specialist.

15. Corrective Action

The Central Laboratory's corrective action procedures are documented in Section 11.0 of its QAMP. The occurrence of a practice or incident that is inconsistent with the established quality assurance and quality control procedures of the laboratory must be formally addressed with a corrective action response. Any laboratory employee may request corrective actions when necessary.

Section 11.0 of the QAMP details the situations that require corrective action, how corrective actions are initiated, investigated, resolved and documented to ensure a complete and systematic response to each corrective action request. Examples of situations requiring initiation of the corrective action process include mishandling of a sample or its documentation, deficiencies discovered during an internal audit, or use of unapproved modifications to an analytical method.

Upon the initiation of a corrective action, the problem is documented, and a corrective action plan is developed and then approved by the Laboratory Manager and QA manager. After required corrective action has been taken, the information is documented and verified to be effective and sufficient by the Laboratory Manager and QA Manager. All information is maintained in the Corrective Action Logbook.

16. Data Reports

Data will be analyzed and reported annually by ENQUAD staff. Reports will include a schematic of the sampling locations, a table summarizing sampling events, and the following information: location, date collected, total Kjeldahl nitrogen (mg/L), ammonia (mg/L), nitrate/nitrite (mg/L), $cBOD_5$ (mg/L), BOD_5 (mg/L), pH, temperature (º F), dissolved carbon dioxide (mg/L), and alkalinity (mg/L).

Data will also appear monthly in the Deer Island Process Control and Engineering Operations Performance Summary.

17. References

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APPENDIX

See List of MWRA Central Laboratory Standard Operating Procedures