METHOD FOR ACCOUNTING DIN REDUCTION IN WASTEWATER THROUGH MANAGED ALGAL BIOREMEDIATION OPERATIONS – VERSION 1.3

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CONSULTATION PROCESS

This method was developed in consultation with the Reef Credit Methodology Technical Working Group. Members of the working group include representatives from Industry, and subject matter experts. The method approach arose from discussions during the second half of 2021.

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1 PROJECT DESCRIPTION

1.1 GOVERNING DOCUMENTS

Reef Credit Standard (and other supporting procedural and guidance documents issued under the Reef Credit Standard).

Reef Credit Guide.

1.2 REFERENCES

This methodology references the following documents and tools.

- Reef 2050 Long Term Sustainability Plan
- Reef 2050 Water Quality Improvement Plan 2017-2022
- Queensland Environmental Protection Act 1994

1.3 SUMMARY DESCRIPTION OF METHODOLOGY

This methodology quantifies the reduction in Dissolved Inorganic Nitrogen (DIN) in wastewater discharged from a site or facility through managed algal bioremediation solutions. This methodology can only be applied within the catchments of the Great Barrier Reef World Heritage Area (GBRWHA).

The core methodological components are as follows:

- Determine Eligibility: Sets the criteria for eligibility of projects under the methodology and the Reef Credit Standard;
- Establish Project Boundaries and Scope: Provides guidelines for defining the geographical and temporal boundaries of the project, scope of activities and pollutant pools to be accounted for in the project;
- Quantify DIN Reduction: Details how to determine the DIN reductions resulting from project activities at end of catchment for the monitoring period;
- Quantify Uncertainty in DIN Reduction Calculation: Details how to determine uncertainty in DIN reduction calculations resulting from project activities within the catchments of the GBRWHA for the monitoring period;
- Quantify Reef Credit Units: Outlines the steps to determine the number of Reef Credits based on calculated pollutant reductions;
- Project Monitoring: Provides guidelines for the implementation of a monitoring plan and identifies monitored parameters to assess water quality and DIN reduction strategy;
- Project Reporting and Credit Issuance: Outlines requirements for reporting project abatement to the Reef Credit Secretariat and the application process for the issuance of Reef Credits.

1.4 PROJECT ACTIVITIES

The scope of this methodology includes calculating the removal of Dissolved Inorganic Nitrogen (DIN) in wastewater discharged from a site or facility through managed algal bioremediation solutions.

The methodology allows for any wastewater treatment method using live algae (microalgae or macroalgae), where wastewater-effluent is captured, leading to a reduction in DIN across the project area.

There are a number of ways an operator can remove DIN within the project area, extracting DIN in wastewater through managed algal bioremediation solutions, and removing DIN from the system.

The project must provide an *operations management plan* that describes proposed operations management activities for the project duration.

1.5 DEFINITIONS

Additionality – as defined in the Reef Credit Standard (and other supporting procedural and guidance documents issued under the Reef Credit Standard).

Baseline period – Minimum 2 years operational period of the site or facility discharging wastewater, directly preceding the Project application date. This baseline is only used as a reference point for the Project Dynamic Baseline. The baseline period data is not used in the calculation of Reef Credits.

Algal Bioremediation – the use of naturally occurring or deliberately introduced live algae species (microalgae or macroalgae) to biologically consume and break down environmental pollutants, in order to clean wastewater.

Crediting period – as defined in the Reef Credit Standard Definitions and equal to 15 years commencing from project start date.

Dissolved Inorganic Nitrogen (DIN) – is defined as the sum of ammonia, nitrite and nitrate and measured as the sum of nitrogen in ammonia, nitrite, and nitrate.

Dynamic Baseline – Measures ongoing DIN inputs to the algal treatment facility.

Operations Management Plan – as defined in the Reef Credit Standard Reef Credit Project Plan.

Monitoring period - as defined in the Reef Credit Standard but must be equal to a Quarter, as defined by this methodology.

Project application – as defined in the Reef Credit Standard (and other supporting procedural and guidance documents issued under the Reef Credit Standard).

Project application date – the date on which the project proponent submits the project application for a Reef Credit project.

Project area – the area covering the site or facility discharging wastewater, upon which project activities are being undertaken.

Project start date – as defined in the Reef Credit Standard.

Project end date – as defined in the Reef Credit Standard.

Quarter (calendar) – is defined as a period of three calendar months, with Q1 starting on the 1st of January and ending of the 31st of March; Q2 starting on the 1st of April and ending on the 30th of June; Q3 starting on the 1st of July and ending on the 30th of September and; Q4 starting on the 1st of October and ending on the 31st of December.

Reef Credit – as defined in the Reef Credit Standard.

Reef Credit Accounting Zones (RCAZ) – spatially explicit area delineated according to Section 3 of this methodology in which project activities occur and are accounted.

1.6 DOCUMENTATION REQUIREMENTS

This section outlines the documentation required for project application and for issuance of Reef Credits.

1.6.1 PROJECT APPLICATION

When applying for a project, the project documentation must include a Project Description. The Project Description must include:

1. Names of project proponents and names of any individual or entity with interest in the project or enterprise;
2. Project location;
3. Description of project including:
    i. Project area spatial files defining project implementation zones;
    ii. Estimate of average DIN abatement in kg per year;
    iii. Estimate of abatement potential over the crediting period;
    iv. Existing licenses and permits in place confirming regulatory approval for operational facility.

The project application must also include a Project Eligibility Report describing how the project complies with the Reef Credit Standard and the methodology eligibility requirements, and a Reef Credit Project Plan referred to in this Method as an Operations Management Plan.

1.6.2 PROJECT CREDITING

When applying for issuance of Reef Credits, project documentation must include:

1. Project Description;
2. Project Eligibility Report;
3. Project Spatial Report;
4. Operations Management Plan;
5. Project Abatement Report;
6. Monitoring Report;
7. Evidentiary Documents.

In addition to the requirements outlined in this methodology, the proponent must address how the project complies with all Reef Credit Standard rules when applying this methodology. Crediting applications must be accompanied by a third-party verification report prepared in accordance with the Reef Credit Standard.

2 ELIGIBILITY

This section outlines the project eligibility criteria to be eligible to implement this methodology under the Reef Credit Standard. For each of the eligibility criteria, credible evidence in the form of analysis, documentation and/or third-party expert reports is required as part of the project application. In addition, all projects must meet the eligibility criteria outlined in the Reef Credit Standard.

2.1 LOCATION

The proposed project area must be located within the boundaries of Great Barrier Reef NRM Regions.

2.2 PROJECT LAND CHARACTERISTICS

The project area must include:

1. An operational site or facility discharging wastewater on a regular basis;
2. The project proponent must have the legal right to manage and undertake the implementation of project activities;
3. The project proponent must have the legal right to ownership, and distribution, of Reef Credits arising from implementation of project activities; and
4. Sufficient area suitable for accommodating the nominated bioremediation solution.

2.3 PROJECT ACTIVITIES

Project activities must:

1. Remove the quantity of DIN through a managed algal bioremediation solution;
2. Be located within or adjacent to a site or facility discharging wastewater, that was operational during project activities;
3. Be compliant with all Federal, State and Local Government regulations.

2.4 LAND USE CHANGE

The project implementation may involve the construction of infrastructure for the implementation of the managed algal bioremediation solution. The proponent must have obtained any necessary permits and demonstrate that the project will not have a negative impact on catchment water quality relative to the baseline by implementing one or more Reef Credit Accounting methodologies.

2.5 ADDITIONALITY

For a project to qualify as additional, it must initially fulfil the following requirements:

1. The law must not require the proposed project activity/ies;
2. The project activity/ies must be on the ‘positive list’ outlined in the Reef Credit Standard;

3. The project activity/ies must not be on the 'negative list' outlined in the Reef Credit Standard; and
4. The project activity abatement outcomes cannot be used to meet Environmental Authority load limits and Reef Credit claims simultaneously.

Project proponents must demonstrate additionality by applying the Reef Credit Additionality Test. Alternatively, proponents may use the *Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities VT0001 version 3.0*[1]. When applying the tool, project proponents shall consider any activity eligible under this method as an "eligible AFOLU activity". Further, project proponents should substitute "pollutant reductions" for "GHG emissions" and "Reef Credits" for "GHG Credits" and where appropriate "Reef Credit Standard" for "VCS".

3 PROJECT MAPPING

The project area boundaries must be delineated in accordance with the requirements of this section.

For the purposes of stratification of the project area into RCAZ, the project proponent must use GIS datasets.

3.1 GEOSPATIAL CAPTURE

A project proponent may use any of the following sources of data to delineate the boundaries of project zones:

a. Property and infrastructure documentation of the site or facility discharging wastewater;
b. Property title cadastral database; and
c. Environmental Authority boundary information.

3.2 FITNESS FOR PURPOSE

Prior to using a dataset, project proponents should assess the appropriateness of the dataset for the intended use, or its fitness for purpose against criteria that include:

- Operating license of the site or facility discharging wastewater.
- Wastewater Discharge Facility Property documentation and cadastral references of the site or facility discharging wastewater.
- Age.
- Scale.
- Resolution.
- Accuracy.
- Classification, aggregation, generalisation systems (for example, smoothing).

[1] https://verra.org/methodology/vt0001-tool-for-the-demonstration-and-assessment-of-additionality-in-vcs-agriculture-forestry-and-other-land-use-afolu-project-activities-v3-0/

- Integrity of dataset.

3.3 REEF CREDIT ACCOUNTING ZONES

The project area must be stratified into RCAZ according to uniform:

1. Boundary of the site or facility discharging wastewater;
2. Managed algal bioremediation project boundary in context to the boundary of the site or facility discharging wastewater; and
3. Critical Control Points defined within the boundary of the site or facility discharging wastewater for uniform water quality measurement.

The above parameters must be defined for each year of the monitoring period. The wastewater reticulation catchment boundary limits may vary from year to year, however influent and effluent wastewater flows will be monitored at the boundaries of the RCAZ to account for any variation in DIN load resulting from catchment changes.

The geographic boundary of the project area must be identified on a geospatial map consistent with the requirements of this section and submitted at the time of project application.

In addition, evidence that the entire project area was under operation for the duration of the operational period is required at the time of each Reef Credit application claim.

4 OPERATIONS MANAGEMENT PLAN

An Operations Management Plan for the property must be prepared outlining DIN management strategies. The Operations Management Plan must include:

1. Maps of the project area at project commencement;
2. Description of incoming water quality, DIN concentration, and water-quality monitoring program and DIN forms in accordance with relevant legislation for point-source discharge control;
3. Maps of project area and RCAZs for the monitoring period;
4. Description of operations and DIN management activities in each specific crediting (Reef Credit nutrient reduction period) period including reduction rates;
5. Defined activities to ensure compliance with legal and regulatory requirements in relation to any implemented wastewater treatment solution. Additional information on the baseline average DIN load released and the predicted reduction in DIN load from baseline based on the design specifications of the bioremediation treatment solution.

The Operations Management Plan must be kept up to date for the duration of the crediting period and be submitted at the end of each monitoring period with the application for Reef Credits.

5 PROJECT ACCOUNTING

This section outlines the steps which must be followed to determine project DIN reduction as a result of project activities. The method utilises a monitored approach to measure DIN reduction in the monitoring periods. Monitoring must consider significant factors that influence DIN reduction including but not limited to flow variance, water management activities, seasonal impacts such as rainfall, and spatial location.

5.1 RELEVANT NITROGEN POOLS

For this section, relevant nitrogen pools must include all nitrogen sources regulated under the Queensland Government *Environmental Protection Act 1994*. The relevant volumes must reflect the actual Dissolved Inorganic Nitrogen (DIN) content (in kg N/year) of the wastewater treated.

5.2 BASELINE PERIOD CONSIDERATIONS

Proponents must include a summary of monitoring results, and a reference to baseline period data. An explanation of why the baseline was chosen must be provided, including an assessment of the barriers to implementation of the proposed project activities.

Baseline information gathered during the baseline operational period should only be utilised to compare with incoming DIN level measurements and monitoring period DIN reduction calculations.

Project proponents should provide evidence of historical incoming DIN during the previous operational periods. Evidence may include, but is not limited to, independent accredited laboratory analyses, internal water testing records, or consultant records. All DIN water quality data records need to abide by the standards specified in Section 6.1 of this document.

5.3 MONITORING PERIOD CALCULATION

Reef Credits are calculated on a quarterly basis, with each quarter corresponding to a monitoring period. For each calendar year, quarter dates are defined as follow:

- Q_1 – from 1st of January to 31st of March (90 or 91 days in leap years)
- Q_2 – from 1st of April to 30th of June (91 days)
- Q_3 – from 1st of July to 30th of September (92 days)
- Q_4 – from 1st of October to 31st of December (92 days)

5.4 WASTEWATER SAMPLING RULES

The removal of DIN from the system is calculated by the difference between the incoming mass of DIN (i.e. weight in kg) received to the system (RCAZ) and the outgoing mass of DIN discharged from the system.

At least three sampling dates for each calculation period (i.e. each quarter) must be used to determine the average mass of incoming and outgoing DIN.

To be representative of temporal variations in water quality, at least one sample should be collected and analysed every month of a specific quarter, and a defined interval of at least 15 days must separate two consecutives sampling dates.

In addition, at least three sample sets must be collected on three different days of the week (e.g. Monday, Wednesday, and Friday) to avoid any predictable pattern resulting from the operations of the site or facility discharging wastewater.

Finally, the incoming and outgoing water samples – which constitute a sample set – must be collected on the same day and within a two-hour interval to be representative of a sampling date.

Holding time and storage conditions of water samples must follow Department of Environment and Science (DES) guidelines, and standard analytical methods specified in section 6.1 of this document.

5.5 MONITORING PERIOD CALCULATION FOR DIN REMOVAL

This section outlines the procedure to calculate DIN removal in the monitoring period.

DIN removal during a full calendar year must be calculated with the following equation:

$$RN = \sum [Q_{1\text{-}4}]\ RN \qquad \textit{Equation (1)}$$

where:

RN is the total mass of Dissolved Inorganic Nitrogen (DIN) removed from the RCAZ, in kilograms of DIN per calendar year; and

$\sum [Q_{1\text{-}4}]\ RN$ is the sum of the total mass of Dissolved Inorganic Nitrogen (DIN) removed from the RCAZ, in kilograms of DIN per quarter (e.g. Q_1RN, Q_2RN, Q_3RN, and Q_4RN).

The total mass of Dissolved Inorganic Nitrogen (DIN) removed from the RCAZ in each operational period (i.e. each quarter) must be calculated by applying the following equation:

$$[Q_{1\text{-}4}]\ RN = IN - ON \qquad \textit{Equation (2)}$$

where:

$[Q_{1\text{-}4}]\ RN$ is the total mass of Dissolved Inorganic Nitrogen (DIN) removed from the RCAZ, in kilograms of DIN per quarter (e.g. Q_1RN, Q_2RN, Q_3RN, and Q_4RN);

IN is the total mass of incoming Dissolved Inorganic Nitrogen (DIN) received to the RCAZ, in kilograms of DIN per quarter; and

ON is the total mass of outgoing Dissolved Inorganic Nitrogen (DIN) discharged from the RCAZ, in kilograms of DIN per quarter.

The total mass of incoming Dissolved Inorganic Nitrogen received to the RCAZ is calculated according to the following equation:

$$IN = INC * IW * DC \qquad \textit{Equation (3)}$$

where:

IN is the total mass of incoming Dissolved Inorganic Nitrogen (DIN) received to the RCAZ, in kilograms of DIN per quarter;

INC is the mean concentration of incoming Dissolved Inorganic Nitrogen (DIN) received to the RCAZ, in mg L^{-1} of nitrogen per quarter;

IW is the volume of incoming wastewater received to the RCAZ, in megalitre (ML) per quarter, with the procedure to determine *IW* described in section 6.1; and

DC is the number of crediting days in a specific quarter.

The mean concentration of incoming Dissolved Inorganic Nitrogen received to the RCAZ is calculated with the following equation:

$$INC = \sum I\ [NH_3\text{-}N + NO_2\text{-}N + NO_3\text{-}N] \qquad \textit{Equation (4)}$$

where:

INC is the mean concentration of incoming Dissolved Inorganic Nitrogen (DIN) received to the RCAZ, in mg L^{-1} of nitrogen per quarter; and

$\sum I\ [NH_3\text{-}N + NO_2\text{-}N + NO_3\text{-}N]$ is the sum of the mean concentrations of incoming DIN forms, specifically nitrogen in ammonia (NH_3-N), nitrite (NO_2-N), and nitrate (NO_3-N) received to the RCAZ, in mg L^{-1} of nitrogen per quarter.

The total mass of outgoing Dissolved Inorganic Nitrogen discharged from the RCAZ is calculated according to the following equation:

$$ON = ONC * OW * DC \qquad \textit{Equation (5)}$$

where:

ON is the total mass of outgoing Dissolved Inorganic Nitrogen (DIN) discharged from the RCAZ, in kilograms of DIN per quarter;

ONC is the mean concentration of outgoing Dissolved Inorganic Nitrogen (DIN) discharged from the RCAZ, in mg L^{-1} of nitrogen per quarter;

OW is the volume of outgoing wastewater discharged from the RCAZ, in megalitre (ML) per quarter, with the procedure to determine *OW* described in section 6.1; and

DC is the number of crediting days in a specific quarter.

The mean concentration of outgoing Dissolved Inorganic Nitrogen discharged from the RCAZ is calculated with the following equation:

$$ONC = \sum O\ [NH_3\text{-}N + NO_2\text{-}N + NO_3\text{-}N] \qquad \textit{Equation (6)}$$

where:

ONC is the mean concentration of outgoing Dissolved Inorganic Nitrogen (DIN) discharged from the RCAZ, in mg L^{-1} of nitrogen per quarter; and

$\sum O\ [NH_3\text{-}N + NO_2\text{-}N + NO_3\text{-}N]$ is the sum of the mean concentrations of outgoing DIN forms, specifically nitrogen in ammonia (NH_3-N), nitrite (NO_2-N), and nitrate (NO_3-N) discharged from the RCAZ, in mg L^{-1} of nitrogen per quarter.

Note that the mean (i.e. average) concentration of an incoming or outgoing DIN form (i.e. nitrogen in ammonia, nitrite, or nitrate) is defined as the sum of individual concentrations of a particular DIN form, measured on each sampling day, divided by the number of sampling days.

5.6 UNCERTAINTY

The calculation of Nitrogen Reef Credits can be subject to uncertainty. For this reason, three areas of uncertainty – specifically monitoring accuracy, leakage, and wastewater management – are considered in this methodology to reflect the amount of Nitrogen Reef Credits generated by project activities during the monitoring year.

5.6.1. MONITORING ACCURACY

DIN levels, measured by the concentration of DIN and the volume of wastewater entering and exiting the project area, are subject to uncertainty associated with testing methods and the measuring equipment.

A monitoring report must be submitted as a requirement for each monitoring period (see Section 6), and a 2% uncertainty factor is applied to Reef Credit volume due to limits of accuracy of monitoring equipment. This uncertainty factor is in line with industry level error factors of monitoring equipment and testing. Note that this percent deduction still applies to samples analysed through accredited laboratory methods referenced in section 6.1, and that measuring equipment such as flow meters must be calibrated on a regular basis to minimise uncertainty.

5.6.2. LEAKAGE

DIN leakage is considered when a by-product of the managed algal bioremediation solution such as algal biomass is transferred and reused outside the project area.

DIN assimilated through algal uptake is subsequently converted into useful organic metabolites such as chlorophyll, protein, or nucleic acids. Organic nitrogen compounds reused outside the project area are not considered DIN leakage. Minor quantities of intracellular DIN not yet converted to organic compounds may also be present at time of harvest and should be considered when calculating the uncertainty factor associated with leakage. The intended by-products reuse strategy and their estimated quantity, when reused both outside and inside the GBR catchment area, must be provided in the operations management plan to ensure complete transparency.

Extracellular levels of DIN may also be present in by-products following biomass harvest and processing. Efforts should be made to minimise the amount of extracellular DIN in algal by-products, for example by using active dewatering methods, or by rinsing algal biomass in freshwater before reuse. A detailed post-harvest plan listing the processing steps and typical quantities of extracellular DIN must be provided in the operations management plan to ensure complete transparency.

By-products of a managed algal bioremediation solution must also be registered as a resource under the End of Waste Code framework of the *Waste Reduction and Recycling Act* (2011), and be approved as a resource by the Queensland Department of Environment and Science (DES) or the appropriate state regulator before reuse.

For these reasons, an uncertainty factor of 1% must be deducted from Nitrogen Reef Credits, to account for the uncertainty associated with DIN leakage. For reference, this factor considers the following criteria:

- Residual levels of intracellular DIN in the by-products of algal bioremediation.
- Residual levels of extracellular DIN in the by-products of algal bioremediation.
- Nutrient leaching rate after attenuation by take up of plants and soil in case of agricultural reuse.
- Reuse of by-products in non-agricultural applications such as the extraction of active compounds, and biomaterials.
- Reuse of by-products both outside and inside the GBR catchment area.

5.6.3. WASTEWATER MANAGEMENT

Project areas included in this methodology must be closed systems – e.g. municipal wastewater treatment plants, livestock production or processing facilities, or aquaculture facilities – that are subject to licensing requirements. This is to ensure the project area is not subject to any uncertainty with regards to leakage.

5.7 CALCULATION OF MONITORING PERIOD NITROGEN REEF CREDITS

To determine the quantity of Nitrogen Reef Credits generated by project activities during the monitoring year, apply the following equation:

$$RCN = RN - (2\% + 1\%)\, RN \qquad \textit{Equation (7)}$$

where:

RCN is the number of Nitrogen Reef Credits generated at the end of the calendar year as a result of project activities;

RN is the total mass of Dissolved Inorganic Nitrogen (DIN) removed from the RCAZ, in kilograms of DIN per calendar year; and

If RCN is zero, then no Nitrogen Reef Credits are issued for the monitoring year.

6 MONITORING AND RECORD-KEEPING REQUIREMENTS

This section sets out monitoring and record-keeping requirements under this methodology for a registered Reef Credit project.

A monitoring report must be submitted as a requirement for each monitoring period. The project proponent must monitor the RCAZs of the project for compliance with the project operations management plan and document operations management activities and any unplanned disturbances to project area.

The monitoring report must include documentary evidence of DIN reduction events during the monitoring period, this must include:

1. Evidence of equipment calibration.
2. Records of date and time of each DIN measurement for each RCAZ.
3. Records of laboratory analysis documentation for incoming and outgoing water quality measurements.
4. Limit of reporting (LOR) of the methods used to analyse DIN in a water sample.
5. Records of effluent volumes of the facility or system discharging wastewater.
6. Rainfall records.

Records must be kept in relation to each of the requirements set out in section 3.

6.1 DISSOLVED INORGANIC NITROGEN TESTING STANDARDS

Dissolved inorganic forms of nitrogen (i.e. ammonia, nitrite, and nitrate) should be analysed independently by a NATA accredited laboratory or following the Approved Methods for the Sampling and Analysis of Water Pollutants in Australia, specifically;

- APHA (1998) 4500-NH3 to determine ammonia concentration in a water sample.
- APHA (1998) 4500-NO2 to determine nitrite concentration in a water sample.
- APHA (1998) 4500-NO3 to determine nitrate concentration in a water sample.

6.2 SAMPLE COLLECTION, STORAGE CONDITIONS AND HOLDING TIME

For the collection of water samples, storage conditions, and holding time, refer to the documents from the Department of Environment and Science Government below;

DES. 2018. Monitoring and Sampling Manual: Environmental Protection (Water) Policy. Brisbane: Department of Environment and Science Government.

6.3 MONITORING VOLUME OF WASTEWATER IN AND OUT OF PROJECT AREA

The volume of wastewater entering and exiting the project area shall be monitored and measured using “fit-for-purpose” flow meters.

For the installation and calibration of a flow meter, refer to the method described below;

- When a flow meter is installed, it will be commissioned and verified on-site. This will include having the desired units of measure, such as litres per second and total kilolitres as well as

the pulse output information recorded. Furthermore, a manufacturer's calibration certificate shall be supplied with every new flowmeter. Once installed, a test will be performed to verify the performance of the flowmeter in the actual installation.

- Flow meters will be verified in the field at least once a year and in accordance with the manufacturer’s recommendations. A certificate of verification will be provided every time a flow meter is reverified. The certificate will report the method of verification and the pulse output intervals.
- Verification of the flow meter on-site will be by equipment and methodologies that are NATA approved and fully traceable to National Standards. Verification equipment will have a capability test within a range of +/- 2% of the required specification. On-site calibrations will be completed using a volumetric method or a check flow meter.