Ministry of Environment and Climate Change Strategy

SURFACE WATER QUALITY STEWARDSHIP TOOLBOX

Stewardship Water Quality Data QA/QC Guidelines

This document must remain at a high technical level as the importance of QA/QC does not allow for the process to be simplified. Please contact ENV staff if any aspect of this process is unclear.

Data Quality Assurance/Quality Control (QA/QC) is an important part of data collection. Currently, the British Columbia Ministry of Environment and Climate Change Strategy (ENV) uses the Environmental Monitoring System (EMS) as its central database for water quality, sediment, and biological monitoring data. Data entry to EMS requires that Ministry data quality standards are followed. Data quality starts in the planning phase of a project (e.g., site selection and bottle preparation) and continues at every stage (e.g., field data collected from meters or grab samples sent away to laboratory) until data are successfully transferred to the provincial water monitoring data storage platform (i.e., EMS).

The Environmental Protection Division (EPD) operational policy includes post-sampling water quality data control procedures. Applying these provincial procedures to external groups increases the reliability of data collected by water quality stewards. This is done through a series of steps that ensure data collected are as close to provincial standards as possible. Data that do not go through a reliable QA/QC check can end up being rejected from analysis due to uncertainties that could be avoided if QA/QC is performed**. Data that do not have supporting QA/QC are considered unreliable and will be given a lower data grade by ENV staff.**

Lab Samples

Data transfer to EMS will occur automatically for lab samples collected in partnership with ENV, where ENV uses EMS for the preparation of laboratory requisition forms. Transfer to EMS will occasionally occur in sampling led by other partners who have agreed, as part of a partnership with ENV, to request upload to EMS on laboratory provided Chain of Custody forms that the partners prepare. Field data can be added to EMS lab requisition forms or lab Chain of Custody forms for automatic upload by the lab where EMS field parameter codes are specified.

Field Data

Field data must always go through QA/QC procedures by the sampler prior to upload to EMS; currently upload can be only completed by ENV staff or some external parties who are specially trained in EMS electronic data transfer protocols. In the next version of a provincial data storage system, the intent is to have built in data validation/flagging features allowing third parties to upload data directly to the provincial database, indicating the data went through QA/QC by non-ENV individuals.

The following steps (Figure 1) are ENV data QA/QC procedures that water quality stewards are recommended to follow to maintain quality data. **If lab sample collection is not occurring, Steps 2 and 3 and any references to requisitions or Chain of Custody forms does not apply.** Note that field sampling procedures, field meter calibration procedures, and advice on selection of specific tests, all of which can

affect the precision and accuracy of data, are not covered here (see Stream Field Meter Monitoring Procedure and Calibration Procedure information sheets that are part of this Toolbox). **Field samples only need to follow Steps 1 and 4 (not Step 2 and 3)**.

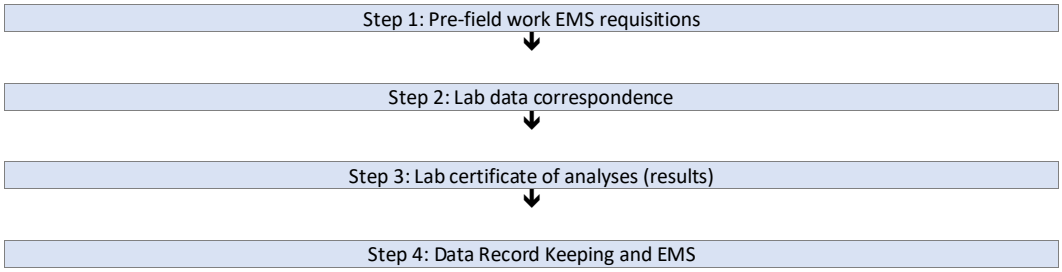

Fig. 1: Steps to follow for QA/QC projects. This can vary based on parameters being recorded, the use of lab tests, or ENV partnership.

Step 1: Pre-field work preparation and EMS requisitions/Chain of Custody forms

- Confirm EMS Site Coordinates
    - Use GPS, then confirm coordinates with Google Earth to prevent transcription errors when creating new EMS monitoring sites. Latitude (lat) and longitude (long) should be expressed as Universal Transverse Mercator (UTM) systems (Easting and Northing) or decimal degrees, both of which are accepted by EMS. EMS stores lat/long to 6 decimal degrees.
    - If an EMS ID does not exist for a site in question, a request to add a site may be made to ENV water quality staff. This prevents creation of duplicate sites at the same location and ensures that all data for one location are entered under one unique station ID. Once a site is established, it should not be moved more than 5 m from the original site location, or a new EMS ID must be created.
- (**Lab Samples Only**) Obtain EMS requisition forms from ENV staff or request lab Chain of Custody forms from lab directly if not partnering with ENV on sampling
    - Ensure you have two copies (one to send to lab, one for record keeping) of all requisitions to be used and fill in all data fields on both copies.
        - Date (yyyy-mm-dd), time (24 hour) and sample depth are transcribed from field notes and added manually on the EMS requisition form/chain of custody forms prior to sending samples away.
        - The only data that gets filled in the requisition/chain of custody form by hand are the field recorded measurements such as temperature, pH, dissolved oxygen, and specific conductance. Parameter codes for these fields depend on the field meter used. Contact ENV staff in the field planning phase and they can include codes in automatically generated forms.
        - Hand-entering data increases risk of transcription error; write clearly, double check units and decimal points at every stage. Always keep a record (hardcopy or photo of the original field sheet).
        - Keep one copy of completed requisitions as this is the only way to check that all data are entered by the lab.
- Calibration Records

- Handheld field instruments used for collecting data need to have detailed calibration records (i.e., date of calibration, pre/post calibration readings, expiry data of calibration standards used) kept. This serves as an early warning system for instrument problems and is used for troubleshooting erroneous data. Calibration records should be kept and submitted with data to trained personnel who are uploading field data.

- Field Data Entry
    - Prepare handwritten or digital field sheets so data are entered in a consistent format and samplers have fields in which to record site information (e.g., EMS ID, Site name), date/time, sampler names, conditions (changes site to site, note any obvious influence on water quality), weather, units, field instruments used to collect data (identify with unit serial #), and any additional notes.
    - Immediately after data are collected, while monitoring observations are still fresh, field sheets should be checked by the sampler for completeness, clarity, and data entry errors (e.g., wrong units, missing decimals, lack of field notes, readability, if the data are in the expected range for a given parameter, sites labelled with full name and EMS ID, dates/times correct).
    - Submission of data to ENV staff (or partner agencies trained to upload data into EMS) requires data to be in a consistent clear electronic format. Transcription errors can occur at this stage; review QA/QC transcribed data relative to raw field data prior to submission to ENV.

Step 2: Laboratory Data and EMS Correspondence (Laboratory Samples Only)

- Once samples are delivered to the lab, confirmation emails will be sent to the ENV staff contact on the requisition or contact person on the Chain of Custody form. <u>Where ENV staff have created the requisition forms, ENV will complete the following steps</u>
    - Sample receipt email – confirming the samples have been received by the lab. Review to ensure all samples were received and documented correctly. Retain this email until data have been uploaded to EMS and reviewed.
    - EMS notification email – confirming that lab data have been successfully uploaded to EMS (if project is conducted in partnership with ENV). Review for any upload error messages as soon as possible. This email's reply address is the EMS Helpdesk. Keep these emails until data has been reviewed. Most errors will be fixed by the lab within a few days and results will be re-uploaded will occur, along with a follow-up EMS notification email indicating successful upload. If you do not receive an email confirming a successful (re)upload, please contact the lab to ensure the errors were corrected.
    - Lab Certificate of Analyses (COA) – including the water quality sampling results and laboratory QA/QC information (in both Excel format and pdf attachments). Ensure all results and QAQC tabs are included.
- Keep the first two emails until the data has been reviewed and accepted. The attachments in the third email must be saved to the appropriate project folder; perform Step 3

Step 3: Laboratory Certificate of Analyses (COA) (Laboratory Samples Only)

- Review lab-provided Excel file. Instructions on what to look for in each tab of the COA are below. Note: Not every tab is used in every COA
    - **Cover page** – Ensure the dates and site information are correct for the job referenced.
    - **Results summary** – This sheet contains the lowest detection limit, units, and water quality parameter results. This is where a preliminary assessment is done for errors (e.g., incorrect result typos, missing less than (<) detection sign or the result copied to the wrong parameter). Check that field results and dates/times have been transcribed correctly by the lab against field sheets or requisitions.
    - **Detailed report** – This sheet has summary information needed for QC on sample data.
        - Review any results that have a red X in the QC Evaluation or Hold Time Evaluation columns.
        - Review any detection limits that have qualifiers. Further details can be found in the QC evaluation, Hold Time Exceedance, and Detection Limit tabs.
        - Check to see if the data are within range of what you would expect to see of the water body.
        - Use historic sampling ranges or, if not available, the BC government document "Guidelines for Interpreting Water Quality Data" is a good source of information on some typical ranges for common parameters.
        - Review the results for obvious outliers. An outlier is an extreme result in a data set which could be due to natural conditions or possibly a lab error.
        - Assess results for any blanks, replicates, or split samples to identify potential sample contamination, field sampling, or lab processing issues.
        - Compare any field results with lab results for similar parameters to identify if results appear to be compatible or within acceptable ranges.
    - **Duplicates** – These are lab duplicates; ensure that the lab data quality objectives have been met and are consistent with the ENV Lab Manual for those tests.
    - **Quality Control** – The lab's QC plot and evaluation legend is at the bottom of the page; check these to ensure they have been met.
    - **Method** – Describes the lab method for each parameter.
        - When working with more than one lab, for split sampling or when there are multiple sampling parameters, use this information to ensure consistent analysis methods are being used. It may also help to check that the requisition was filled out with the correct method.
    - **Hold time exceedances** – Hold times can be exceeded due to samplers not getting samples shipped in time, or issues with the shipper or the lab not processing the sample in time. The dates on this tab will help determine if the issue is with the lab or if it was received late from the shipper. This will help identify source(s) of the exceedance and the subsequent follow up action required.
    - **Detection Limits** – Ensure detection limits are less than Water Quality Guidelines (WQG) or Water Quality Objectives (WQO), preferably by one order of magnitude.
        - This is something that you should check with the lab before analysis. However, there are instances where the results come back with a higher detection limit, primarily due to sample or matrix interference such as turbidity.
        - Keep this in mind when reviewing detection limits and not to assume they will be as low as you were initially told.

- Addressing Errors
    - Prior to the next sampling date, address any identified QC issues so that they are not carried to the next set of samples. There are a variety of problems that may arise from sampling, shipping, and lab processing.
    - Depending on the type of blanks, replicates, or split samples, identify how the field sampling or lab processing issues will be addressed
    - If the hold times are exceeded because of the date received, verify with the shipper. If the hold time exceedance is due to the lab, contact the lab and report it to the Senior Provincial Laboratory Specialist or other laboratory contract if not collected in partnership with ENV.
        - In both cases, work with the service provider and ENV staff to ensure that issues are resolved for future sampling.
    - If there is a sample or matrix interference which increases the detection limits, you may want to ensure that samples are not tainted with disturbed sediments from the bottom if samples are taken from shallow water. Marine water may affect detection limits as well.
    - It is important that lab issues are identified quickly as the lab may be able to rerun samples within holding time to correct some analytical issues. As well, extra field sampling could be considered.
        - Ensure that EMS data are updated and corrected if needed following re-analysis of samples or extra field sampling.
    - Ensure that all issues, investigation avenues, and resolutions are recorded so that information can be used when interpreting data and writing reports.

Step 4: Data Record Keeping and EMS

- There are a few ways to set up the data for QA/QC, further analysis, and processing
    - Errors are minimized if data are downloaded directly from EMS for use in either Excel (e.g., pivot tables) or using statistical software (recommended) such as R.
    - Higher data transcription error rates occur when manually creating your own project Excel spreadsheet using the COA as the source, thus this is not recommended.
- Setting up data for further analysis may be conducted as the sampling progresses (to quickly see data outliers and address issues) or at the end of a field season. Data can be downloaded from EMS for historical data (if available) for a given project. If the checks in Step 3 were not completed when the results were received in the past from the lab, they should be completed now, if possible
    - Step-by-step directions for data download from EMS are given in the EMS training manual. In the EMS system users can pick and choose what data and headings are needed. Ensure that the download path is correct, and that the data are changed from their original format (.csv) to an Excel workbook (.xlsx).
    - Ensure your data spreadsheet includes the details outlined in Table 1 below.
- Data Processing, Assessment, Interpretation, and Final QC
    - Before any data are interpreted some additional QC should be completed. It is recommended that you do a 5 to 10% spot check of data sourced from EMS vs. the COA to ensure that the data sets are consistent.
    - While major outliers would have been identified and potentially resolved earlier, further analysis of outliers should be done. Information on statistical evaluation of

outliers is available in Guidelines for Interpreting Water Quality Data and in the ENV electronic resource library.

- If downloading old data and there is a potential error, contact ENV water quality staff to try to locate the original results in ENV archives (e.g., field books or hardcopy lab COAs) or the electronic COAs to see if it can be resolved. Any errors should be corrected in EMS by ENV staff. Note outliers in older data may also be associated with a higher detection limit used at the time and cannot be corrected.
- Technical reports should include a section summarizing data QA/QC and describing how those issues have been resolved or impact the interpretation of the data.

Table 1. Information that should be included in the data spreadsheet per tab

Meta Data Tab	Laboratory Data Tab	QC/QA Tab
Information of lab used	Source	Site ID
What equipment used (e.g., YSI meter) and that it is calibrated before use (usually documented in a separate sheet in lab)	Waterbody name	EMS #
Definitions	Site ID	Requisition #
	Sample Type (replicate or duplicate clearly labelled) *	Sample Date
	Longitude / Latitude	Lab Name
	Date sampled	Lab Sample ID
	Time sampled	Lab Arrival Time
	Location Name	Hold Times - if they are met or not
	Lab Sample ID	Lab QC/QA Results – met or not
	Comments – this is a good place to record why there was no sample data or any field observations.	Check for data outliers
	All parameters tested	Data in EMS
		EMS matches lab report
		EMS sites coordinates confirmed
		Check the BC Sampling Guide for information in regards to blank and replicate samples BC Field Sampling Guide
		Duplicate check
		QA/QC Date
		QA/QC Person Name

* replicate analyses are an important QC approach for analytical uncertainty (BC Field Sampling Guide page 16)