Department of Natural Resources, Mines and Energy

Stream gauging station network site determination and review methodologies

Guideline

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Queensland Government

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Part A - Operational review of existing gauging station network

Purpose

This methodology is to be used to define the scope and quality of surface water monitoring data collected through the Queensland stream gauging (GS) network. It ensures an objective, defensible, consistent and repeatable review of current monitoring locations which comprise DNRME's current Stream Gauging Station Network and the information needs at individual sites.

Background

Height and flow data are treated as separate entities to water quality (WQ) information which may be collected at gauging stations.

Height and flow data

Queensland's GS network has evolved since 1909 from principally a resource assessment network to one which underpins a variety of decisions relating to the state's water resources and their use.

Collection of water quantity data is a statutory requirement under section 38 of the *Water Act 2000* and is used to identify and sustainably allocate and manage future water requirements, protect natural ecosystems and offer security of supply to water users. *Part B – Guidelines for determination of assessment network site density* should be used to assist in identifying the appropriate GS locations to help meet these requirements.

As more GS have been added to the network and with easy access to telemetry (the process of recording and transmitting instrument readings), data collection practices have changed. Additionally there has been an increased demand from clients and a greater community expectation in respect to the purpose and location of particular sites. Uses of the collected data include:

- Underpinning hydrological modelling for individual catchments
- Monitoring compliance against water plan outcomes and objectives
- Informing decisions on routine resource management (e.g. water harvesting announcements)
- Used directly for flood warning or to inform the Bureau of Meteorology's (BoM) flood alert activities
- Calculation of salt, sediment, nutrient and pesticide loads
- Monitoring discharge from environmentally relevant activities (e.g. mine sites, GBR loads programme, CSG discharge, quarries) for compliance or ecosystem protection
- Other contractual/client arrangements (e.g. Border Rivers Commission)
- Groundwater assessment.

The requirements, demand and assumed availability of information is vast; accordingly to review the operational protocol for the network, the importance and purpose of each GS needs to be determined. Consideration of calibration and maintenance schedules may also influence site location and density so it is important that the appropriate number of site visits is completed to ensure the best quality data is recorded and collected.

Policy

Optimum GS coverage will be achieved through a set of criteria (listed in **Table 1**) based on purpose and usage. Sites will be rated against each criterion and scored to determine both their ability to deliver applicable data and overall relevance in GS density. Once defined, the matrix in **Table 2** can be used to establish the appropriate number of visits needed to deliver the nominated result.

The collection of valuable information is also influenced by the characteristics of the GS control. A control is an artificial or natural constriction of the stream channel downstream of the GS that provides a unique relationship between stream discharge and water level. The control directly affects the height—flow (discharge) relationship and can range from "highly stable calibrated weirs" (strong relationship) to "highly variable sand controls" (weak relationship).

When a GS is visited, logger data are downloaded and a streamflow measurement completed to define the height-discharge relationship at that time; they are also taken at other levels (e.g. through flood events), to further define this relationship. Consideration of the two variables—site location and control type—determines the number of visits needed to deliver the nominated data quality. **Table 2** provides an operational guide linking data needs with the control type; they have been categorized into four levels combining characteristic features and stability.

A further consideration which may affect height data quality is the drift between an "actual water level" and the "recorded logger value". Fewer site visits has the potential to return less accurate data, however with the heightened reliability of current instrumentation, this is a rapidly decreasing concern; the use of the **Table 2** matrix ensures there is a justifiable and considered rationale behind any network adjustments. When used in conjunction with **Table 1**, this includes the closure or opening of stations and provides an operational methodology that ensures the data continue to be collected to Australian Data Collection Standards and are fit for the purpose intended.

Water Quality data

WQ data have been collected at most sites since 1968; initially major ions samples (analysed from a Bottle type A) were taken at each site at each visit. In the early 1990's a more structured approach was implemented with the introduction of the Surface Water Ambient Network (SWAN) sampling regime that provides data for assessment of long term condition and trend. This program targets a smaller number of sites, the majority of which are scheduled for sampling four times per year.

It is highly unlikely that the scheduled number of water samples will be collected at every site due primarily to site remoteness and flow regimes at the times of routine visits. If this is the case the network should be reviewed and amended to include a manageable number of sites and/or samples to be taken. Preferably the collection schedule should be compatible with the nominated GS visits previously determined.

When the SWAN network was designed it included the installation of time series water quality probes (initially electrical conductivity (EC) and pH, and later dissolved oxygen (DO)) at approximately 170 locations throughout the state, as part of long term condition and trend monitoring. It also aimed to target specific agendas such as the Great Barrier Reef (GBR) loads programme which saw turbidity probes installed at some sites.

Maintaining WQ probes—primarily EC in the current network—to ensure that good quality data are collected is labour intensive, due largely to siltation of the probes during flood events. This problem is more exaggerated in some areas of the state (e.g. Upper Condamine) where land use or stream characteristics result in large silt loads. Invariably more site visits are required to download data, perform calibration checks and maintain the river end infrastructure.

Generally only sites on the SWAN network should be equipped with time series water quality probes; it is recognised that there are sites operating probes for specific purposes but generally they should align. It is recommended that sites with probes should be visited 2-4 times/year to return high quality data. These visits can be staggered depending on flow events to ensure that probes remain clean and operable; it may even be necessary for additional maintenance depending on the frequency and duration of flood events. Regular visits also ensures that the required number of water samples are collected.

Each regional office will need to make a determination based on flow events regarding the timing of visits to sites with WQ probes; local knowledge about stream behaviour at each location should be used for this assessment. If resources are such that the required data quality cannot be delivered, a review of the network GS density will be required to reduce the number of sites to a manageable level.

DNRME is responsible under section 38 of the *Water Act 2000* to monitor the quality of the state's water resources; however no degree of rigour is specified. Water quality monitoring responsibilities are met through the SWAN network which was originally designed with input from departmental science staff, based on identifiable WQ data needs. This network is now reviewed for assessment purposes with input from the Department of Environment and Sciences.

Section 38 also stipulates the requirement to monitor the available quantity of Queensland's water resources; this is covered in Criterion 1 of **Table 1**. The existing network has developed over time to meet emerging/competing needs so sites may not always be ideally located to assess basic resource yields. The legislative requirement should be balanced with other factors such as period of record, catchment locality, travel times, losses and the ability to measure discharge, to effectively evaluate their suitability.

Incorporated in the review process should be an evaluation of other agency sites including SunWater, Seqwater and the BoM as some of these may be considered more representative, better located or of value to the DNRME network. Both existing and proposed DNRME sites will also be rated for suitability pending the installation of alternative technology, including Doppler's, cameras and property/geographic access for the use of drones and unmanned boats.

The final evaluation of the current and potential network will be based on a risk analysis format with each basin individually reported. DNRME will determine the role it plays in catchment monitoring and a network capable of meeting these needs will then be developed. It is recommended that all gauging stations in Queensland are initially evaluated using the review method (**Table 1**) and secondly against the "Fit for Purpose" matrix (**Table 2A** and **2B**) to determine the ability of sites to remain effective.

Table 1 – Gauging station purpose and use criteria

Criteria		Scoring			
		0	1	2	3
1	Water Resource Assessment (s38 – refer Part B)	No	Y (minor, helpful)	Y (suitable, adds value)	Y (essential)
2	Water Planning Support (modelling)	No	GW only (e.g., connectivity)	Adds value, validates model inputs	All Water Plans
3	Water Management (licensing, water harvesting)	No	Routine	Support water use	Decision making, Trigger levels
4	Reporting and Compliance (ROP, EFAP BoM, NWCF)	No	Routine	Water audits, ecological assessments	Decision making
5	Other agencies requirements (DE&S, BoM)	No	Elementary	Flood info, mines regulation	Key site (FW), licence conditions, environmental evaluations
6	Water Quality (SWAN)				Y

Table 2A – Fit for purpose matrix (quality of data required vs. quality of control = number of visits required)

	Quality of control		
Quality of height and flow data required	Stable control structure	Moderately stable control	Highly unstable control
High 12 - 18	2 visits	3 visits	4 visits
Medium 6 - 11	2 visits	2 visits	3 visits
Low 0 - 5	1 visit	2 visits	2 visits
Height only station	1 visit per year – data considered low quality irrespective of control.		

Table 2B - Definitions and examples of control types

Control type	Definition
Stable control structure (Image 1 and 2)	A weir or structure designed with a theoretical formula that can be used to calculate discharge when head over structure is known (examples include crump profile/broad crested/sharp crested/ogee crest weirs, various flume structures) **or** Permanent rock bar or other structure that requires physical rating to create height/flow relationship (examples include hybrid weirs, culverts, causeways)
Moderately stable control (Image 3)	Can include natural small rock, cobble or gravel or structures that are susceptible to variation due to debris build-up, slime/algal growth or any other factors
Highly unstable control (Image 4)	Natural controls consisting of sand, silt or mud subject to continual change

Image 1 - Typical designed weir

Image 2 – Typical stable rock control

Image 3 – Typical gravel / rock control

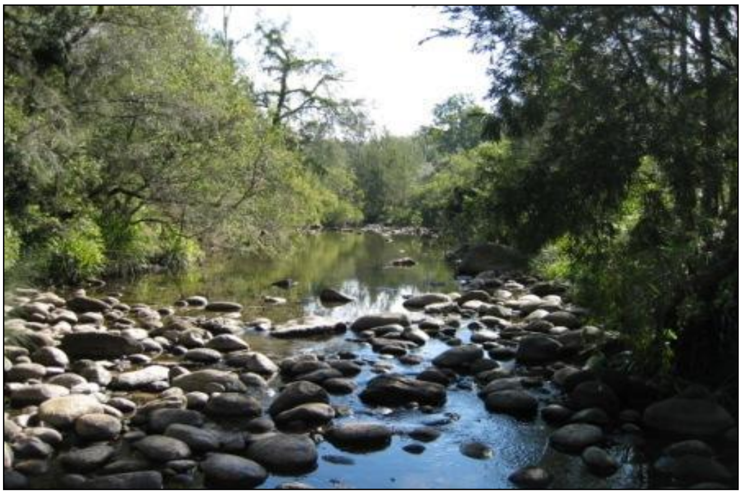

Image 4 – Typical sand / mud control

Part B – Guidelines for determination of assessment network site density

Step 1 – Determine Site Density Requirements

1. Select Basin/Catchment for analysis
2. Place a site at the end of all basins and named sub-basins.
3. Include a suitable site on any tributary (or tributary of a tributary) where the catchment area exceeds 10 % of the total basin (or named sub basin) or is greater than 2,000 km^2.
4. If an area of significantly higher rainfall is identified (i.e. mean rainfall is 25 % above the mean 50 isohyet) and the area represents more than 10 % of the basin or sub-basin then include a site(s) (two if the area is not concentrated) to reflect the different catchment conditions.
5. If a major basin is made up of multiple smaller streams, the method will be: If any one stream drains > 25 % of the total area, site a GS. For the remainder of the basin a site should be added for each 'aggregated' area that exceeds 25 % of the total catchment/basin (i.e. a site will be placed on a small stream that would be representative of the aggregated 25 %).
6. Moderation to be applied; e.g. if the process identifies the need for three sites and the flow data at any of these locations can be derived by either subtraction or addition, then only two sites are required.
7. At the conclusion of each basin appraisal the process should be reviewed in conjunction with the Australian Water Resources Council (AWRC) recommendations (Appendix 1) that state the required minimum number of gauging stations based on catchment area (e.g. In the arid zone, flat, include a site at the end of all tributaries to the Basin or sub-Basin which exceeds 7,000 km^2 up to 20,000 km^2.
8. It is desirable – however not essential to locate a site on the inflow and outflow of all major storages.

Step 2 – Site Prioritization

The assessment needs may be met in a number of ways, for example:

1. A departmental gauging station designed to Quality Management System (QMS) standard, accredited under ISO 9001:2015
2. A gauging station owned by another authority
3. Other methods of flow estimation such as rainfall – runoff modelling.

The accuracy and importance of information from the sites identified in Step 1 will vary. In locations of low water demand and competition, generally accept a higher level of uncertainty than in those locations where demand and competition for water is high.

Step 3 – Sites required to meet other information needs

Involve regional staff to define management, compliance, water harvesting and flood warning requirements; water quality issues should also be addressed.

Related documents

Supporting information for this procedure can be obtained regionally and includes:

- Catchment maps showing all major tributaries and catchment areas

- Basin map displaying climatic zones
- 50-year isohyets for the catchment.