

Water Monitoring Standardisation Technical Committee

National Industry Guidelines for Hydrometric Monitoring:

Draft proposed changes to the groundwater monitoring content of guidelines:
Parts 0-3 & 5

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Draft changes for update cycle 2023-24 to the groundwater monitoring content of guidelines Parts 0-3 & 5

Overview

The Bureau of Meteorology values a highly collaborative and consultative approach, setting in place the Water Monitoring Standardisation Technical Committee¹ (WaMSTeC). WaMSTeC helps coordinate and foster the development of water information standards and guidelines in Australia such as the National Industry Guidelines² for hydrometric monitoring (NIGL). These guidelines cover activities relating to surface water level, discharge and water quality monitoring, groundwater level and water quality monitoring and rainfall monitoring. They contain high-level guidance and targets, and present non-mandatory³ Australian industry recommended practice.

Following a five-yearly review process, the current NIGL are being reviewed and updated to maintain currency and relevancy to support detailed guidance for groundwater monitoring. A subcommittee to attend to the groundwater monitoring content of guidelines Parts 0-3 & 5 was established, with the member listed in Table 2. The groundwater subcommittee has reviewed the existing NIGL with consideration to the potential changes and additions to affect functional refinements in this NIGL revision cycle. Our assessment collectively ranked and prioritised the proposed changes. Noting all subcommittee members are volunteers, the proposed changes were ranked to accommodate availability and capacity of the volunteers. A summary of the proposed changes and prioritisations are listed in Table 3.

General changes and additions the NIGL

The groundwater subcommittee was unequivocal that the groundwater aspects were not readily visible, but also noted that the overall structure of the NIGL was sound. A point of discussion and consideration is the better discovery/visibility and accessibility to the groundwater components of the National Industry Guidelines for hydrometric monitoring.

The current organisation of the NIGL into topics/parts does not allow for ready discovery of the groundwater guidelines components, but it does allow a focus on the commonality of topics/parts which is pertinent to both surface water and groundwater monitoring. The following changes to enhance the visibility of the groundwater aspects are proposed to be implemented in stages either i) as part of the regular revision cycle, or ii) out of the cycle from the 5 yearly review and revisions.

Short-term option

The current NIGL website has a table of the guideline publications, by part, along with the publication date and superseded publication. A relatively straight forward update would be to add a specific table for groundwater with html weblinks direct to the PDF pages with the related groundwater contents. The below represents potential additions to the existing NIGL webpage that could be added to the bottom or the page.

¹ Water Monitoring Standardisation Technical Committee | <http://www.bom.gov.au/water/standards/collaboration/index.shtml>

² National Industry Guidelines for hydrometric monitoring | <http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml>

³ Tier 2 – Non-mandatory standards and guidelines, WaMSTeC Standards Terminology Model v3.0 | http://www.bom.gov.au/water/standards/documents/WaMSTeC_Standards_Terminology_Model_v3.0.pdf

Table 1: Groundwater specific content in guidelines

Title	Designation	Revised link
Glossary	NI GL 100 00–2022	
Primary measured data	NI GL 100 01–2019	
Site establishment and operations	NI GL 100 02–2019	http://www.bom.gov.au/water/standards/documents/NI_GL_100_02-2019.pdf#page=21
Instrument and measurement systems management	NI GL 100 03–2019	
Data editing, estimation and management	NI GL 100 05–2019	

Long term option

A potential future direction for facilitating discovery and visibility of the groundwater aspects of the NIGL is dependent on the willingness to have a clearer separation and demarcation of surface water versus groundwater hydrometric monitoring. This could initially take the form of specific individual landing pages for surface water versus groundwater whilst still referring to the relevant existing NIGL documents. A subsequent longer vision could also be an internal rearrangement of each NIGL part to explicitly have surface water and groundwater chapters or sections. These could also support the direct linking to the specific sections pertaining to groundwater or surface water. Such a revision or update could be conducted on a NIGL part by NIGL part basis.

There is potential to entirely separate the NIGL into corresponding components that are specific to surface water and groundwater. This is not the preferred approach, as there are many commonalities and overlaps between the guidelines for both surface water and groundwater (i.e. Instrument and measurement systems management). Alternatively, where there is no inherent commonality or overlap, a specific groundwater guideline could be developed and designated as a new component. This is currently the approach implemented for surface water monitoring guidelines, i.e. [Application of in-situ point acoustic Doppler velocity meters for determining velocity in open channels](#) (WaMSTeC, 2019e).

Recommended additions to NIGL Part 0 Glossary and terminology use throughout NIGL

The groundwater subcommittee has defined, refined and made consistent the use of proposed additional terminology that specifically pertains to groundwater monitoring where reasonable in this iteration of the NIGL revision. In our assessment of *Part 2 Site establishment and operations* (WaMSTeC, 2019b), examples of new definitions include production intervals, consistent nomenclature for variations of groundwater elevation, groundwater level, groundwater depth, groundwater level elevation or terms such as Geocode. For parsimony and alignment, it is preferred to adopt or adapt terminology and definitions used by other existing and widely accepted guidelines or references where feasible. An example is the National Uniform Drillers Licensing Committee, 'Minimum construction requirements (MCR) for water bores in Australia, 4th edition' (NUDLC, 2020) or where appropriate from 'Hydrometry - Vocabulary and symbols' (I.S.O., 2022).

New supporting terms considered are listed below with proposed definitions and accompanying rationale listed in Table 4.

- | | | |
|--------------------|-----------------------|---------------------------------------|
| • Artesian bore | • Local datum | • Reduced Standing Water Level (RSWL) |
| • Bore / Well | • Monitoring bore | • Reference point |
| • Confined aquifer | • Open Hole | • Response zone |
| • Datum point | • Perforations | • Screen |
| • Filter pack | • Plumbness | • Standing Water Level (SWL) |
| • Geocode | • Production interval | • Unconfined aquifer |
| • Headworks | • Production zone | |
| • Height datum | | |

Where pertinent, the groundwater subcommittee recommends highlighting in **bold**, where there are nested terminologies or definitions used so that it is easier to navigate the Glossary terms. The following expounds in further detail the pertinent rationalisations for key additions to the NIGL Glossary.

NEW SUPPORTING TERMINOLOGY FOR “WATER LEVEL” IN A GROUNDWATER INDUSTRY CONTEXT.

Part 0 Glossary (p29 of 29) | 2.131 | water level

The measured distance to the water surface at a particular time and date, relative to a reference point.

NOTE: In groundwater monitoring practice, this is also known as 'depth to groundwater'.

The above existing definition of “water level” in the NIGL *Part 0* (page 29 of 29) (WaMSTeC, 2022) pertains to both surface water and groundwater levels. Whilst pertinent, to support alignment and consistency with terminology used by the groundwater industry, it is proposed additions be made for disambiguation and clarity. The existing note for groundwater monitoring practice could be revised to replace ‘depth to groundwater’ with ‘Standing Water Level’.

Groundwater level terminology can be expanded and aligned with existing descriptions presently on the Bureau of Meteorology’s website⁴ and the example terminology used with the Bureau’s National Groundwater Information System⁵ (NGIS) which include:

- **depth to water (DTW):** Measurements from the top of the ground surface to the groundwater level. Positive values are below the ground surface. Negative values are above the ground surface and indicate artesian conditions. This term is sometimes called depth below natural surface (DBNS).

⁴ What are the different groundwater level terms? <Frequently Asked Questions: Australian Groundwater Explorer: Groundwater information: Water Information: Bureau of Meteorology (bom.gov.au)> sighted Sept 2023

⁵ Terminology: Australian Groundwater Explorer: Water Information: Groundwater information: Bureau of Meteorology (bom.gov.au) sighted Dec 2023

- **standing water level (SWL):** Measurements from the reference point on the bore (e.g. the top of casing) to the groundwater level. Positive values are below the reference point and negative values are above the reference point.
- **reduced standing water level (RSWL):** The groundwater elevation relative to a geodetic datum, such as the Australian Height Datum (AHD). This is the standard height datum used in Australia which sets mean sea level as zero elevation. Positive values are above mean sea level and negative values are below.

With the above as a basis, and an effort to align with the MCR (NUDLC, 2020), it is recommended to disambiguate from the generic ‘water level’ term currently used by adopting two specific terms to the Glossary, with specific refinements for clarity. These are ‘**Standing Water Level (SWL)**’ and ‘**Reduced Standing Water Level (RSWL)**’.

Proposed new NIGL definition for SWL is:

Standing Water Level (SWL) | For the level of groundwater standing in a bore uninfluenced by pumping in that bore, **SWL** are depth to water measurements taken from a described point of measurement. The point of measurement used can be a formal **reference point** for a bore (e.g. a persistently used, recorded, and maintained point of measurement on the **headworks** to a bore) or an informal reference point such as ground level or Kelly bushing. Positive values are below the reference point and negative values are above the reference point. To support measurement confidence, where persistent bore reference points are used, these should have an accompany maintenance log of changes over time to the reference point. SWL measurements should note if the measurement has a deviation from **plumbness** and if any corrections have been applied to the measurement to convert to vertical distance.

Correspondingly, RSWL has the following proposed refinements.

Reduced Standing Water Level (RSWL) | The groundwater elevation relative to a standard **height datum** surface, such as the Australian Height Datum (AHD), or the Australian Vertical Working Surface (AVWS). Positive values are above the height datum surface and negative values are below. These reduced groundwater elevations can be derived from **SWL** measurements if there is sufficient accompanying information on the bore **reference point** used to measure depth to water and the horizontal and vertical distances relative to a **datum point**.

For those parts of the NIGL where the term “water level” is used in relation to groundwater level (or a similar term), when appropriate, one of the above definitions could be substituted.

NEW TERM “GEOCODE”

The following provides a rationale for defining the term “Geocode” and derivatives “geocoding”, This is used in *Part 1, 2. Metadata (WaMSTeC, 2019a)* and *Part 2, 4.1.1 Site identification and traceability, p9-10 (WaMSTeC, 2019b)*.

There are several existing examples of the term geocode from reputable sources. For the intent and purpose of the NIGL, it is proposed the following definition is used. This has been derived from several sources.

Geocode | A **geocode** is a unique code, such as a pair of coordinates, linked to a position of a location on the Earth's surface. For these guidelines, this is a set of coordinates related to a defined Geospatial referencing system such as the Geocentric Datum of Australia (GDA) 2020⁶ or its precursors.

This has been derived based on several sources, including the Australian Bureau of Statistics (ABS) that use the definition:

Geocode⁷: A geocode is a unique code that can be used to determine the position of a location on the Earth's surface. This unique code is linked to a set of coordinates that defines a geographic element, commonly a point or a polygon, that represents that location. The set of coordinates must be related to a defined Geospatial referencing system such as the Geocentric Datum of Australia 1994.

For example, the location address "ABS House, 45 Benjamin Way, Belconnen ACT 2617" can have the following geocodes:

- 1. The point defined by the latitude: -35.2406 longitude: 149.0678 (GDA1994).*
- 2. The Mesh Block code - 80002993000; the Mesh Block that includes ABS House. This code directly references the polygon coordinate geometry that is associated with that Mesh Block, as defined by the Australian Statistical Geography Standard (ASGS).*

This information can then be used to relate the data to other geographies. Geocodes are used in the ABS to associate statistics with locations.

Esri, a company synonymous with geographic information systems software, similarly describes "geocoding" as,

Geocoding is the process of transforming a description of a location—such as a pair of coordinates, an address, or a name of a place—to a location on the earth's surface.⁸

NEW TERM "PRODUCTION INTERVALS" AND SUPPORT TERMS.

The term "Production intervals" has been used in *Part 2, 4.3.1.1 Selection of (groundwater) sites, p21*. The Groundwater Subcommittee recommends defining this term for the NIGL along with supporting and associated terms highlighted in **bold** text.

As used in *Part 2, 4.3.1.1*, point 3 to describe nested sites to characterise vertical gradients. The section references the *Minimum Construction Requirements for Water Bores in Australia (NUDLC, 2020)*. This publication is presently viewable in edition 4, and also provides a definition of "Production Zone" as

Production zone | The zone within the target formation that produces the water supply requirements for the bore.

This term "Production zone" should be adopted in the NIGL glossary for consistency with the Minimum Construction Requirements. For clarity, the **Production zone** dimensions can vary over time in **Unconfined aquifer** settings as a result of the **SWL** relative to the **screen** interval.

Additionally, the following definition for "Production interval" should be adopted for clarity in *Part 2, 4.3.1.1*, point 3 and to retain the intent to use production interval in the context of characterising vertical gradients and throughout the NIGL.

⁶ ICSM, Intergovernmental Committee on Surveying and Mapping - <https://www.icsm.gov.au/gda2020> | sighted 10/01/2024

⁷ Australian Bureau of Statistics - <https://www.abs.gov.au/ausstats/abs@.nsf/mf/1217.0.55.001#PARALINK16> | sighted 08/11/23

⁸ Esri - <https://desktop.arcgis.com/en/arcmap/latest/manage-data/geocoding/what-is-geocoding.htm> | sighted 08/11/23

Production interval | The length between two depths down a bore from which water is to be produced from the **Production zone**. The top and base of the **Production interval** are recorded from a described depth **Reference point** at the bore. The **Production interval** is dependent on the construction/completion of the bore relative to the **Production zone**. For an **Open hole** bore, the **Production interval** consists of the length of the bore below the end of the bore casing that is within the level of the **Production zone**. For bores with **Perforations** or a **Screen** interval, the **Production interval** consists of the sub-length of the bore's **Response zone** that is situated within the level of the **Production zone**.

Recommended additions to NIGL Part 2 Site Establishment and operations

RECOMMENDED UPDATE TO SECTION 1.4 REFERENCES

The National Uniform Drillers Licensing Committee has release the next edition, the 4th Edition, of the *Minimum Construction Requirements for Water Bores in Australia* (NUDLC, 2020). It is suggested to update the citation and reference in this section (i.e. point #8) to the current edition, i.e. NUDLC (2020).

RECOMMENDATION TO EMPHASISE THE IMPORTANCE OF, AND STATE THE REQUIREMENTS TO, SEEK CULTURAL HERITAGE CLEARANCE PRIOR TO DRILLING AND FIELD MONITORING OR SAMPLING AS PART OF SECTION 4.3.1

As part of the findings of State of the Environment 2021 for inland waters, particularly the finding for “Better water management – which balances competing interests, involves Traditional Custodians and considers climate change”⁹, it would be beneficial for the National Industry Guidelines for hydrometric monitoring to move to a positive stance and incorporate a specific statement to emphasise the importance of, and requirement to seek cultural heritage engagement and clearance prior to drilling, field monitoring or sampling activities. This can be integrated as part of *Section 4.3.1.1 Selection of sites*, as a separate and specific principle extolling this requirement to meet monitoring objectives. As a guideline to support the industry of groundwater professionals, this is also in keeping with the International Association of Hydrogeologists “Indigenous Groundwater Declaration”¹⁰, especially articles 4, 5, 6 and 7 of the IAH declaration. As part of the *Section 4.3.1.2 Site identification and traceability* and *Section 4.3.1.3 Site characteristics* considerations, capturing the engagement and clearance is also beneficial for ongoing accountability and transparency.

Of importance is *Section 4.3.1.3 Site characteristics, Criteria 3*, could be expanded to consider and seek approval/clearance regarding cultural heritage or traditional custodian values especially if a site is adjacent to a location of importance. Proposed wording additions are as follows:

4.3.1.3 Site characteristics	4.3.1.3 Site characteristics
3. Considers public safety and site security	3. Considers <u>and seeks clearances for surrounding cultural heritage values.</u> public safety, and site security

Whilst the immediate focus of the recommendations at present are groundwater site focused, this could be expanded and incorporated into a wider guideline for WaMSTeC that considers both surface and groundwater monitoring sites.

ADDITIONS AND UPDATES TO SECTION 4.3.1.1 SELECTION OF SITES

In the opening of *Section 4.3 Groundwater sites* (WaMSTeC, 2019b), there is benefit from the incorporation of a statement outlining the difficulties in being definitive on groundwater monitoring well network design, such as:

“It is difficult to be completely definitive on how groundwater monitoring well networks should be developed because they depend on many factors including the scale of investigation, site hydrogeological conditions, purpose of investigations, land access availability, land use, and terrain. For this reason, it is imperative that groundwater monitoring well network design be undertaken by, or in consultation with, an appropriately experienced groundwater scientist or equivalently experienced industry practitioner.”

⁹ DCCEEW 2021, State of the Environment 2021, Inland water – Key findings | - <https://soe.dcceew.gov.au/inland-water/key-findings> | sighted 29/02/2024
¹⁰ IAH Australia 2022, Indigenous Groundwater Declaration | <http://declaration.iah.org.au/> | sighted 29/02/2024

It is recommended to update *Section 4.3.1.1* to include a brief outline of typical desktop study elements to identify likely hydrogeological conditions of the site area. This is especially pertinent for the installation of new bores for regional monitoring in data sparse regions. Such site establishments should consider geological and geophysical data to guide any new drilling programs. (p21 of 45) (WaMSTeC, 2019b) Correspondingly, this information would also be worth adding to a future update of *Part 5: Data editing, estimation and management* (WaMSTeC, 2019d).

This update can take the form of an additional principle as part of site establishment to account and document the considerations and rationale for the groundwater monitoring site selection. A proposed example of an additional principle and components for inclusion, can include but are not limited to

Purpose of investigation: Recording the intended purpose of investigation that a monitoring site will contribute will provide contextual insight to the pertinent information that would be beneficial to record and accompany the site establishment and site operations. An important aspect to also capture is the intended scale of investigation the monitoring site will contribute towards. an example being a regional investigation will typically require less detail or can tolerate a greater degree of data uncertainty than local scale assessments.

It is very important for a groundwater monitoring site to have a good understanding of the nearby geology and structural geology features and possible uncertainties. An information review can be done by gathering and summarizing existing literature on geology and hydrogeology, as well as any recent or old geophysical surveys or satellite images. This review and summary can also cover the nearby surface water environment and include other relevant information such as landscape topography, land use and climatic conditions.

This additional principal to *Section 4.3.1.1* to compile accompanying information would support and ratify the usefulness of a selected groundwater monitoring site establishment. It can help inform the ongoing and future operations if there were greater context to initial site establishment. This can also contribute to *Section 4.3.1.2 Site identification and traceability*, point 3 *purpose(s) for monitoring*.

REFINEMENTS TO SECTION 4.3.1.2 | REFERENCE POINTS AND DATUM POINTS

With the proposed additions of SWL, and RSWL, there is likely a need to consider revisions to several existing sections to implement the new terminology proposed. This may also require revised diagrams where pertinent. An example is *Section 4.3.2.1 | Reference points and datum points*.

To obtain a confident vertical measure of the groundwater **standing water level**, it is essential these depth to water measurements are taken from **reference points**. To convert to a **reduce standing water level**, these reference points need to be related to **datum points** with associated **datums**. The geographic coordinates and datum used must be recorded along with a measure of the accuracy of survey used for the reference and datum points to inform data confidence and uncertainty in the measurement.

Groundwater observations may be made relative to headworks features when those features have enduring reference marks which remain reliably fixed with respect to the datum. Examples of such headworks features include top of casing (TOC), top of casing protector (TOCP), and at-ground bore covers. Enduring reference marks include drill holes, non-corrodible nails/ rivets/ screws, or small notches in the casing.

A preferred **height datum** is the Australian Height Datum (AHD), an alternate is the Australian Vertical Working Surface (AVWS). The horizontal datum should also be recorded for the reference or datum points.

Observations may be reported against a **local datum**. A local datum may be established in accordance with the relevant legislation, regulation, or similar. Where a local datum is used, organisations shall connect this datum to recognised geodetic controls such as AHD.

A leading practice approach is to not use Natural Surface or Ground Level unless enduring surveyed reference marks are installed and recorded to mitigate against soil or ground movement or erosion.

ADDITION OF INFORMATION AND DATA PERTINENT TO SITE HISTORY AND OPERATIONS

It is recognised the NIGL should highlight for users to consider maintaining documentation and including any accompanying geological logs of lithology and/or stratigraphy where available as part of site establishment and station history. This can be a ready addition to point 1 of *Section 4.3.1.2 Site identification and traceability*, for example:

Key features of the installation such as drillers logs and construction logs (these should include details such as bottom depths, production intervals, casing diameters, etc.). Where applicable, additional data such as downhole geophysics or bore completion reports should also be referred to or appended to the dataset.	Key features of the installation such as drillers logs and construction logs (these should include details such as bottom depths, production intervals, casing diameters, etc.). Where applicable, additional data such as downhole geophysics <u>logs, lithology logs, stratigraphy logs</u> or bore completion reports should also be referred to or appended to the dataset.
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ADDITION OF GUIDANCE FOR GROUNDWATER SITE MAINTENANCE, CHECKS AND DECOMMISSIONING

It would be beneficial to consider site maintenance, checks along with decommissioning and closure within the NIGL. Existing content exists in NUDLC (2020) in sections 17 and 18. In this instance of revision, the NIGL can refer and redirect readers to the relevant NUDLC (2020) content. Future revisions of the NIGL should consider potential collaborations with NUDLC to ensure the content is fit for needs of both the NIGL and the Minimum Construction Requirements. This could be a new *Section 4.3.2.4 Site maintenance and decommissioning* as associated with *Section 4.3.2 Site operations*.

ADDITION TO 4.3.1.4 SITE DESIGN AND CONSTRUCTION TO ACCOUNT FOR DEPTH TO GROUNDWATER WATER FROM GROUND SURFACE.

For site design, consideration for the SWL depth from ground surface should be accounted in monitoring bore construction. There is the potential for a need for larger casing or liner diameter to accommodate a larger diameter pump to raise a significant hydraulic head back to the surface. Alternatively, a chain gang of pumps may also be employed if other parameters dictate the design and construction of a bore. This could be added to point 7 of *Section 4.3.1.4 Site Design and Construction as shown below*.

7. The monitoring bore shall allow equipment access; e.g., access for pumps and level monitoring equipment.	7. The monitoring bore design <u>shall consider standing water level depth to allow for the necessary equipment access; e.g., requirements for larger diameter pumps for deep water levels</u> and level monitoring equipment.
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Recommended future iterations or out of cycle updates

Where changes were unable to be integrated into the NIGL within this revision's timeframe, they are documented here as potential future change recommendations. The intent is to provide a body of future changes to support a continuity of thought for the WaMSTeC's next groundwater subcommittee.

GROUNDWATER LEVEL DATA UNCERTAINTY – FROM FIELD ACQUISITION PADDOCK TO SCIENCE DATA PRODUCT PLATE.

A re-occurring aspect considered by the groundwater subcommittee was groundwater level data uncertainty in all its various guises. From measurement uncertainty at the instrument and data acquisition processes, to the accompanying metadata associated with location and positioning, and culminating with uncertainty in the processing of data for interpretation. To have the NIGL facilitate and guide the capture of the different elements of data acquisition uncertainty, will assist our industry to be mindful of the implications of data uncertainty in water level data acquisition. It would be of benefit to provide a qualitative measure of confidence in the SWL data acquired for consideration when using the data. It is suggested that an out of cycle update is initiated to begin the process of updating the NIGL to consider water level data uncertainty.

As there are uncertainty elements covering all aspects of the monitoring data collection process, it remains to be determined the best approach to provide guidance towards the uncertainties. One option would be to add to the existing parts and elements already published. Alternately, it may be clearer to add a whole new guideline to the NIGL which specifically discusses and provides guidance on uncertainties for both surface and groundwater monitoring where thematically related, for example, the uncertainties associated with site establishment or reference point surveying, or the uncertainties in processing of monitoring data for interpretation. It would be beneficial to consider the alignment and referencing of the *Guide to the expression of uncertainty in measurement* (I.S.O., 2008) or its successors.

The following parts and sections of the existing NIGL can be revised to incorporate or link to new material to further expound on the aspects of uncertainty identified above.

NIGL Part 1 Primary Measured Data | (WaMSTeC, 2019a)

- *Section 2 Metadata* | Capturing a measure of uncertainty in primary measured data metadata
- *Section 3 Quality coding* | Considering the integration of a qualitative measure of groundwater monitoring data uncertainty related with the quality

NIGL Part 2 Site establishment and operations | (WaMSTeC, 2019b)

- *Section 4.3.1.4* | Capturing uncertainty: Capturing Bore construction uncertainty.
- *Section 4.3.1.4* | Adding guidance for information on bore development post drilling: especially where low flow pumps are installed, ensure adequate bore development, removal of drilling mud as part of site establishment (e.g., important for water chemistry and isotope sampling).
- *Section 4.3.2* | Capturing uncertainty: Capturing measure point surveying uncertainty.
- *Section 4.3.2* | Capturing uncertainty: Capturing instrument/sensor deployment uncertainty.

NIGL Part 3 Instrument and measurement systems management | (WaMSTeC, 2019c)

- *Section 3.3.2* | Capturing uncertainty: Capturing instrument/sensor uncertainty.
- *Section 3.3.2* | Capturing uncertainty: Capturing dip meter uncertainty.

NIGL Part 5 Data editing, estimation, and management | (WaMSTeC, 2019d)

- *Section 2.1* | Identifying the need for groundwater level correction.
- *Section 2.1* | Capturing uncertainty in groundwater level measurement.
- *Section 2.1* | Capturing uncertainty: Capturing processing/correction uncertainty.

- *Section 2.1 | Capturing scale purpose of investigation/intended application of Site and acquired data - as an indication of limits or constraints of data.*

GUIDANCE FOR CONSIDERATION OF SITE SELECTION AS PART OF INTENDED EFFICACY OF THE MONITORING NETWORK

At the 2023 workshop held by Geoscience Australia to outline the intended revisions in this update cycle, feedback was sought from industry regarding other guidelines not covered by the subcommittee. One item raised by the Victorian Department of Energy, Environment and Climate Action (DEECA) was a potential need to provide guidance for site selection and efficacy of monitoring networks. This guidance considers the intended purpose of the monitoring network the site was to be incorporated in. Likewise, such guides would serve to inform the potential future applications of the monitoring network. This guidance would be supportive in either the commissioning or decommissioning of monitoring sites to ensure monitoring network efficacy for a) intended purpose was taken into consideration and b) network integrity was retained.

Initial considerations for the likely basis of this qualitative guidance could be informed by a simulation study of an idealised simplified groundwater system with virtual monitoring network sites. The simulation and virtual monitoring could be used to test the efficacy of depreciating the spatial distribution (both horizontally and vertically) of the monitoring network to a point such that the intended purpose of the monitoring network (e.g. regional groundwater flow/head gradients) is no longer viably monitored by the network. Consequently, the initial guidance would infer that, as complexity of a groundwater system increases, considerations need be made about the distribution of monitoring sites to ensure adequacy of monitoring to support the intended monitoring purpose.

OTHER POTENTIAL UPDATES TO THE NATIONAL INDUSTRY GUIDELINES FOR HYDROMETRIC MONITORING

The addition of groundwater data uncertainty guidance is a high priority to build confidence in the monitoring data acquired. After this priority update, other aspects recommended by the groundwater subcommittee include the following potential changes and additions to the NIGL.

- Rainfall/groundwater recharge guidelines as part of *Part 2 Site Establishment and operations | 4.4*
- Guidance for groundwater telemetry data - standards/quality uncertainty, QA procedures
- Guidance to the use of core drilling and core sampling of monitoring bores to allow for hydraulic/geochemical/geochronological assessment – guidance for application to monitoring bore networks.
- Consideration of potential guidance documents for groundwater related citizen science initiatives or attributes to allow for wetland mapping.
- Continued contextual awareness, alignment, and linkages to other groundwater guideline documentation.

For the last point above, careful consideration is required in the integration and referencing of the guidance documents, noting the intended purpose of the NIGL. Figure 2 presents an initial compilation of the groundwater guideline ecosystem in Australia. Some effort towards the alignment of guidelines has been attempted as part of adopting or aligning glossary terminologies in this iteration. It must be noted that terms and glossary are, at times, unique to the intended purpose of the specific parent guidelines the terminology was developed for.

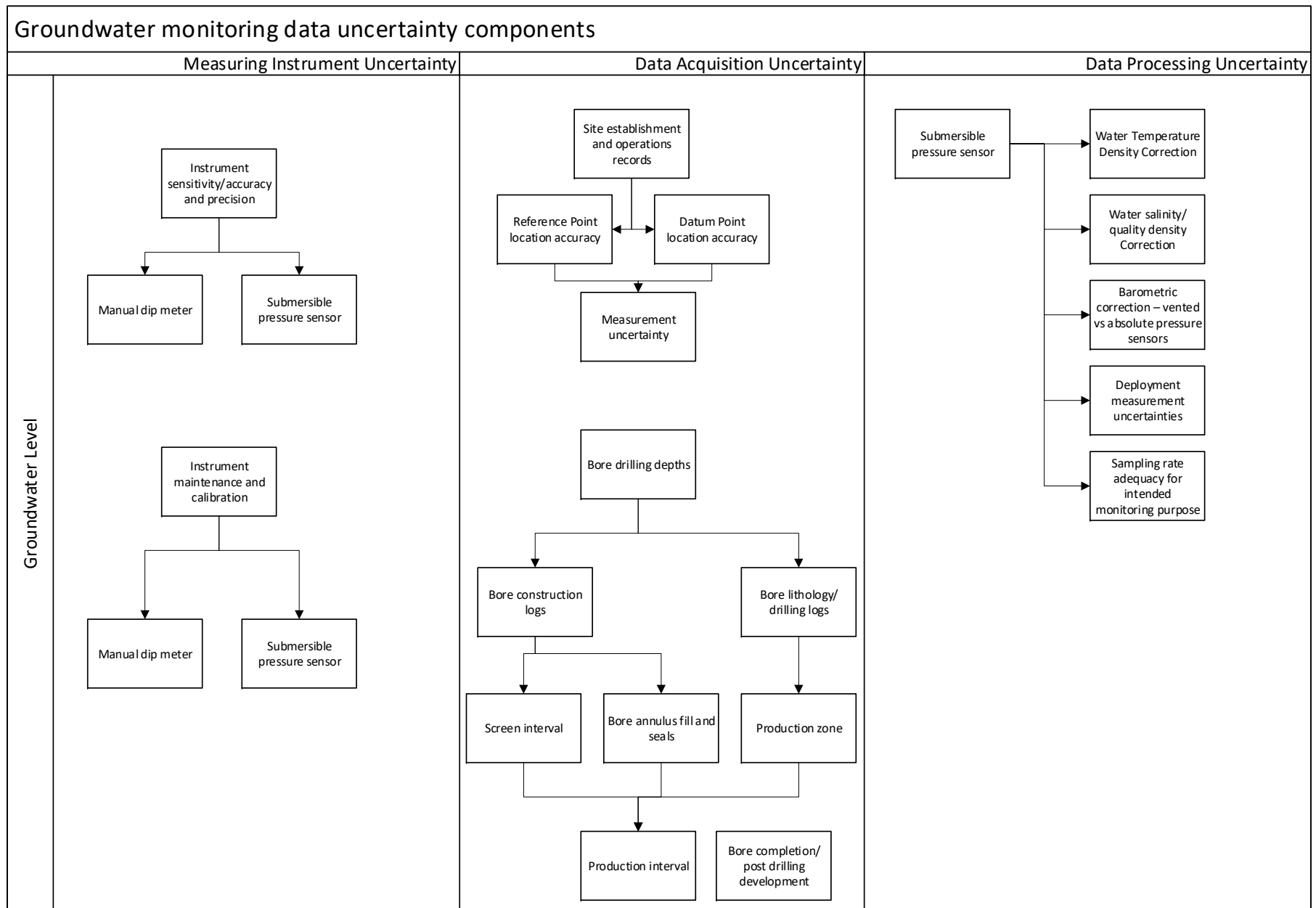


Figure 1: Summary of uncertainty elements at each key stage of groundwater science data collection

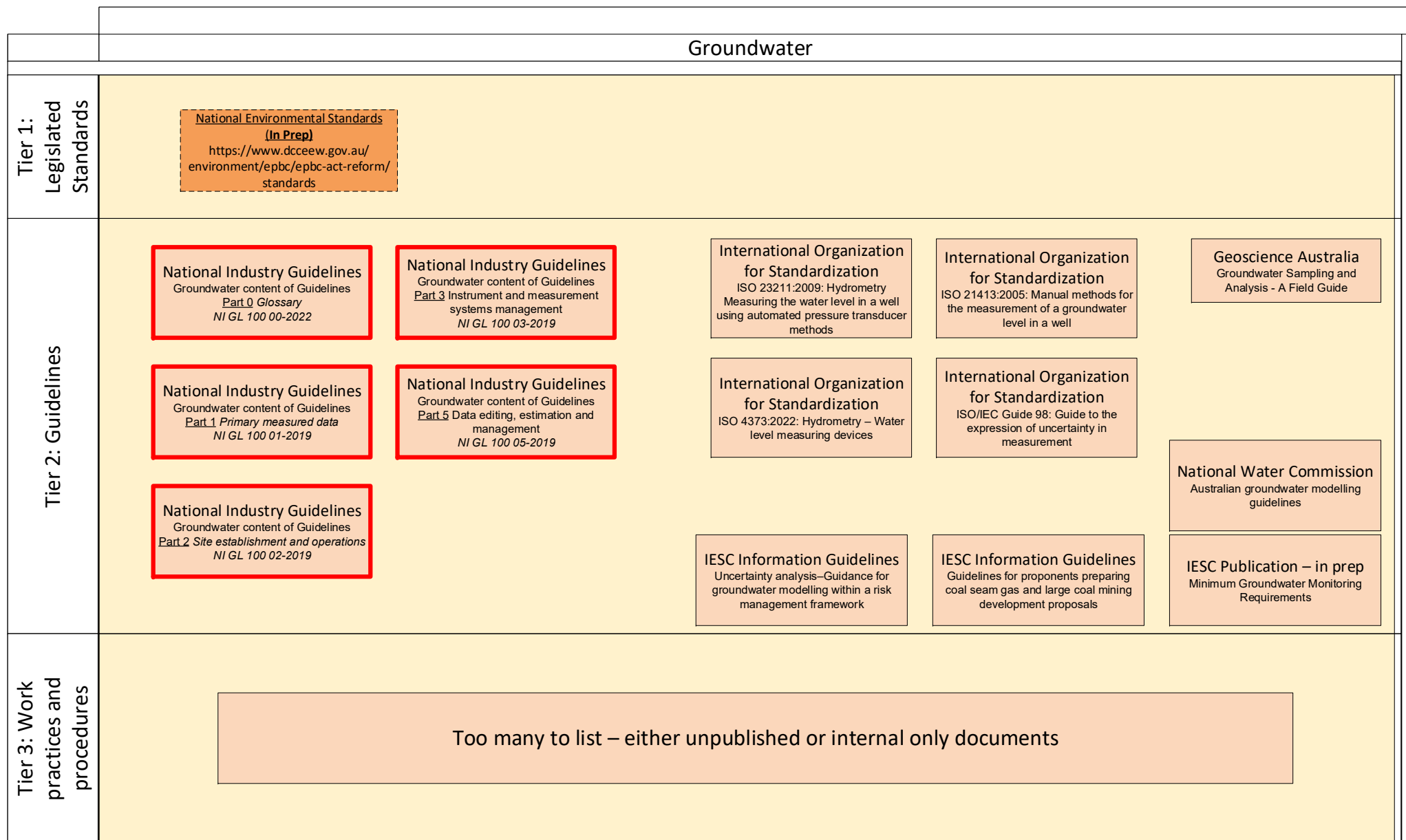


Figure 2: an example map of the guideline ecosystem for groundwater in Australia. WaMSTeC NIGL guidelines pertinent to groundwater are highlighted by a red outline.

Table 2: Groundwater subcommittee contributors:

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Catherine Beesley	The Bureau of Meteorology
Kala Senathirajah	The Bureau of Meteorology
Hashim Carey	Geoscience Australia (groundwater subcommittee sponsor)
Stephen Hostetler	Geoscience Australia (groundwater subcommittee sponsor)

Table 3: Summary of proposed changes

Ranking	Task	Proposed change location in NIGL	Comment
Priority	Refine and make consistent terminology used (i.e., groundwater elevation, groundwater level, groundwater depth, groundwater level elevation)	Part 0 Glossary + all	Recommendations made
Priority	Review and update of Part 0 Glossary (i.e., addition of “geo-code” or “production intervals” as used in Part 2 Site Establishment and operations)	Part 0 Glossary	Recommendations made
Priority	Add information on bore development: especially where low flow pumps are installed, ensure adequate bore development and removal of drilling mud (e.g., important for water chemistry and isotope sampling)	Part 2 Site Establishment and operations 4.3.1.4	Recommendations made
Priority	4.3.1 Installation of new bores for regional monitoring in data sparse regions should consider geological and geophysical data to guide drilling	Part 2 Site Establishment and operations 4.3.1	Recommendations made
Priority	Update part 2 with a brief outline of a typical desktop study information to identify likely hydrogeological conditions of site area	Part 2 Site Establishment and operations 4.3.1	Recommendations made
Priority	Requirement to seek cultural heritage clearance	Part 2 Site Establishment and operations 4.3.1	Recommendations made
Priority	Geographic coordinates for site and datum coordinates explicitly recorded as part of observation site metadata	Part 2 Site Establishment and operations 4.3.1.2	Recommendations made
Secondary	Update part 2 add guidance on well maintenance, checks and decommissioning in keeping with Minimum construction requirements for water bores	Part 2 Site Establishment and operations 4.3.2	Prioritised for this revision cycle - Recommendations made
Secondary	4.3.1.2 Drillers logs should include log of lithology or stratigraphy with depth	Part 2 Site Establishment and operations 4.3.1.2	Prioritised for this revision cycle - Recommendations made
Secondary	4.3.1.4 dot point 7 – depth of hydraulic head may dictate casing diameter (i.e. larger diameter pump needed to lift >heads)	Part 2 Site Establishment and operations 4.3.1.4	Prioritised for this revision cycle - Recommendations made
Priority	Capturing uncertainty: Capturing measure point surveying uncertainty	Part 2 Site Establishment and operations 4.3.2	Proposed out of cycle update
Priority	Capturing uncertainty: Capturing Bore construction uncertainty	Part 2 Site Establishment and operations 4.3.1.4	Proposed out of cycle update
Priority	Capturing uncertainty: Capturing instrument/sensor uncertainty	Part 3 Instrument and measurement systems management 3.3.2	Proposed out of cycle update
Priority	Capturing uncertainty: Capturing dip meter uncertainty	Part 3 Instrument and measurement systems management 3.3.2	Proposed out of cycle update
Priority	Capturing uncertainty: Capturing processing/correction uncertainty	Part 5 Data editing, estimation and management 2.1	Proposed out of cycle update
Priority	Capturing uncertainty: Capturing instrument/sensor deployment uncertainty	Part 2 Site Establishment and operations 4.3.2	Proposed out of cycle update
Secondary	Identifying the need for groundwater level correction	Part 5 Data editing, estimation and management 2.1	Proposed out of cycle update
Secondary	Capturing uncertainty in groundwater level measurement	Part 5 Data editing, estimation and management 2.1	Proposed out of cycle update
Secondary	Considerations to capturing scale purpose of investigation/intended application of Site and acquired data - as an indication of limits or constraints of data.	Part 5 Data editing, estimation and management 2.1	Proposed out of cycle update

Ranking	Task	Proposed change location in NIGL	Comment
Future work	Cross reference relevant documents detailing how to investigate groundwater systems for general or specific purposes		Prioritised for this revision cycle - from 'Priority' to 'future work' – some recommendations made in future works
Future work	Attributes to allow for wetland mapping		
Future work	List of other relevant docs e.g. Subsidence Associated with Coal Seam Gas Production and Draft National Minimum Groundwater Monitoring Guidelines		
Future work	Map the currently available guidelines for groundwater sciences across the jurisdictions to support future directions for WaMSTeC		
Future work	In CSG or mining monitoring bore networks, consider coring some monitoring bores to allow for hydraulic/geochemical/geochronological assessment		
Future work	GW telemetry data - standards/quality uncertainty, QA procedures		
Future work	Rainfall/recharge guideline	<u>Part 2 Site Establishment and operations 4.4</u>	
Future work	Core sampling		
Future work	Guidance for citizen science initiatives?		

Table 4: Additions to Part 0 – Glossary

Term	Definition	Rationale
Artesian bore	A bore in an aquifer where the groundwater is confined under pressure, so that the water level in the bore will rise above the top of the Confined aquifer and ground level (a flowing bore).	Adopt the definition used in NUDLC (2020)
Bore / Well	A hole sunk into the ground and completed for the abstraction of water or for water observation purposes.	Adopt the definition used in NUDLC (2020)
Confined aquifer	An aquifer occurring at depth, in which the upper and lower boundaries are relatively low permeability layers (aquitards) that impede free hydraulic flow of groundwater, except at the recharge area. The groundwater in the confined aquifer may be contained under sufficient pressure to cause it to rise above the top of the aquifer in a bore or even above the level of the ground surface for an Artesian bore .	Derived from Freeze and Cherry (1979), NUDLC (2020) and I.S.O. (2022)
Datum point	A physical point of known vertical position that is defined to a datum surface. The Datum point is used to support the association of other points (i.e. Reference point) and features to a datum surface. A surveying reference mark is an example of a Datum point. Likewise, temporary Datum points may be established using accurate positioning and surveying methods whilst recording and acknowledging the inherent limitations of the temporary Datum points.	New definition and linked to existing definition 2.30 <i>datum</i> in WaMSTeC (2022).
Filter pack	Granular material introduced into the annulus between the borehole and a casing or perforated lining to prevent or control the movement of finer particles from the aquifer into the bore.	Adopt the definition used in NUDLC (2020) for <i>Gravel pack/Filter pack</i> .
Geocode	A geocode is a unique code, such as a pair of coordinates, linked to a position of a location on the Earth's surface. For these guidelines, this is a set of coordinates related to a defined geospatial referencing system or datum such as the Geocentric Datum of Australia (GDA) 2020 ¹¹ or its precursors.	Derived from ABS and ESRI definition and link to the existing definition 2.30 <i>datum</i> in WaMSTeC (2022)
Headworks	The above ground bore construction designed to protect the bore from contamination or damage, and to contain flow in artesian bores.	Adopt the definition used in NUDLC (2020)
Height datum	A geodetic datum for any extensive measurement system of heights on, above, or below the earth's surface. Traditionally, a geodetic height datum defines zero height as the mean sea level at a particular location or set of locations; other heights are measured relative to a level surface passing through this point. Examples of height datums include the Australian Height Datum (AHD) < https://www.icsm.gov.au/australian-height-datum > and the Australian Vertical Working Surface (AVWS) < https://www.icsm.gov.au/australian-vertical-working-surface >	Derived from ICSM.gov.au and ESRI https://support.esri.com/en-us/gis-dictionary/vertical-geodetic-datum and link to 2.9 AHD and the existing definition 2.30 <i>datum</i> in WaMSTeC (2022)
Local datum	The point of reference of the surveying control used exclusively for a specific area. Examples include mine and site establishment grids or a local or regional datum such as the Australian Geodetic Datum 1984 (AGD84) < https://www.icsm.gov.au/datum/australian-geodetic-datum-196684-agd >	Derived from ICSM.gov.au and link to the existing definition 2.30 <i>datum</i> in WaMSTeC (2022)
Monitoring bore	A bore constructed solely to obtain hydrological or water-quality data.	Adopt the definition used in NUDLC (2020)

¹¹ ICSM, Intergovernmental Committee on Surveying and Mapping - <https://www.icsm.gov.au/gda2020> | sighted 10/01/2024

Term	Definition	Rationale
Open Hole	The open-hole method is a low-cost construction method that can be used if the underlying rock and water- bearing formation are consistently firm and stable. Casing is required across the unconsolidated section of the bore and into stable formations. The remainder of the hole is then left un-cased.	Derived description from NUDLC (2020), Section 10, p57
Perforations	A series of slots or openings in a bore casing.	Adopt the definition used in NUDLC (2020) for <i>Screen and Perforations</i>
Plumbness	The horizontal deviation (drift) of the bore centre line from true vertical.	Adopt the definition used in NUDLC (2020)
Production interval	The length between two depths down a bore from which water is to be produced from the Production zone . The top and base of the Production interval are recorded from a described depth Reference point at the bore. The Production interval is dependent on the construction/completion of the bore relative to the Production zone . For an Open hole bore, the Production interval consists of the length of the bore below the end of the bore casing that is within the level of the Production zone . For bores with Perforations or a Screen interval, the Production interval consists of the sub-length of the bore's Response zone that is situated within the level of the Production zone .	Adopt the definition in NUDLC (2020)
Production zone	The zone within the target formation that produces the water supply requirements for the bore.	Adopt the definition in NUDLC (2020)
Reduced Standing Water Level (RSWL)	The groundwater elevation relative to a standard height datum surface, such as the Australian Height Datum (AHD), or the Australian Vertical Working Surface (AVWS). Positive values are above the height datum surface and negative values are below. These reduced groundwater elevations can be derived from SWL measurements if there is sufficient accompanying information on the bore reference point used to measure depth to water and the horizontal and vertical distances relative to a datum point .	Derived from BoM definition and linking to other existing definitions in the glossary i.e. 2.95 <i>reduced level</i> , 2.97 <i>RL</i> , 2.130 <i>water elevation</i> and 2.66 <i>mAHD</i> WaMSTeC (2022)
Reference point	A described physical point of reference from which a water level measurement is recorded. For groundwater monitoring practice, this point is used to measure lengths or depths down a bore and can be associated with a Datum point to allow the Reference point's lateral and/or vertical position to be defined within a datum reference frame. A physical mark on the top of the bore casing could fulfil this requirement. A Reference point can also coincide with a Datum point . Where used formally and persistently for Standing Water Level measurements, this reference point must have an accompanying log of and changes or maintenance over time.	Refinement to 2.96 <i>reference point</i> definition in WaMSTeC (2022)
Response zone	The length between two depths down a bore that is designed to enable groundwater ingress. The top and base of the Response zone are recorded from a described depth Reference point at the bore. Being part of the bore design, the Response zone is ideally within, but does not depend on the targeted Production zone . For an Open hole bore, the Response zone is the zone between the bottom of the bore casing and the bottom of the Open hole . For a bore with a Screen , the Response zones includes the screen and its surrounding Filter pack . The actual Response zone may deviate from the designed Response zone where formation collapse, or seal breaches occur.	New definition
Screen	A specially manufactured filter-like section of bore liner or casing that allows groundwater to enter a bore. A screen has apertures of set sizes to allow water to enter the bore efficiently while blocking out aquifer or filter pack material.	Adopt the definition used in NUDLC (2020)

Term	Definition	Rationale
Standing Water Level (SWL)	For the level of groundwater, at which the water pressure is equal to the atmospheric pressure, standing in a bore uninfluenced by pumping in that bore, SWL are depth to water measurements taken from a described point of measurement. Positive values are below the reference point and negative values are above the reference point. The point of measurement used can be a formal reference point for a bore (e.g. a persistently used, recorded and maintained point of measurement on the headworks to a bore) or an informal point of measurement such as ground level or Kelly bushing. To support measurement confidence, where persistent bore reference points are used, these should have an accompany maintenance log of changes over time. SWL should note if the measurement has a deviation from plumbness and if any corrections have been applied to the measurement to convert to vertical distance.	Derived from BoM definition with additions from NUDLC (2020) and I.S.O. (2022)
Unconfined aquifer	An aquifer in which the upper boundary of the groundwater body is the interface between the Standing Water Level and the atmosphere, with this interface being at atmospheric pressure.	Adapt definition from I.S.O. (2022), similar to definition used in 2 nd Edition Minimum Construction Requirements (NUDLC, 2003)

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